FINAL
HABITAT MITIGATION AND MONITORING PLAN
PERMIT NO. SPL-2008-00816-MB
Rosemont Copper Project

Prepared for:

HUDBAY

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and

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Revised September 12, 2017
Project Number: 1049.112

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EXECUTIVE SUMMARY

Rosemont Copper Company (Rosemont, or "the applicant"), a wholly-owned subsidiary of Hudbay Minerals (Hudbay), proposes to develop an open pit copper mining and processing facility known as the Rosemont Copper Project (Project) on lands managed by the U.S. Forest Service, Coronado National Forest (CNF). Because there are identified Project impacts to potential waters of the United States (WOTUS) within the Project area, the applicant submitted a Clean Water Act (CWA) Section 404 permit application to the U.S. Army Corps of Engineers (Corps). This Habitat Mitigation and Monitoring Plan (HMMP) is presented as part of CWA Section 404 individual permit requirements, and documents the proposed compensatory mitigation proffered by the applicant that meets or exceed the requirements of the 2008 Mitigation Rule.

The mitigation proposed in this HMMP is anchored by the Sonoita Creek Ranch project, a landscape scale mitigation project that could change the perception of ephemeral stream mitigation projects and provide a showcase for arid system restoration techniques. Ensuring that the best practices are being utilized is paramount, and the technical and academic communities have provided, and will continue to provide, key collaboration in this venture. Researchers with the USDA Walnut Gulch Experimental Watershed (WGEW) provided invaluable assistance with field data and reference information for the design of the Sonoita Creek Ranch restoration project, and translating that data into a landscape scale project in southern Arizona will provide a showcase for the research performed there. Input from Dr. Brian Bledsoe, along with previous experience at the Vermejo project, ensured that the restoration design team had the best chance to successfully put the restoration design theories into practice.

The Rosemont Copper Project will directly impact approximately 40.4 acres of ephemeral dry washes and five spring features. Approximately half (19.2 acres) of the direct impacts to ephemeral dry washes will occur in Barrel and Wasp canyons, which are relatively broad, lower-gradient ephemeral washes, that also serve as numbered, maintained Forest Service roads. The other components of the direct impacts include 20.9 acres of smaller tributary ephemeral channels within the Project, and approximately 0.25 acre of ephemeral channel associated with the construction of the utility lines. In addition, the Project will result in some reduction in stormwater flows to lower Barrel and Davidson canyons downstream of the project. However, additional evaluation shows that these flow losses are likely significantly overstated in the Final Environmental Impact Statement for the Project. Finally, the Project will temporarily impact approximately 1.1 acres of ephemeral washes as a result of the construction of the power and water lines from the Sahuarita area to the Project site. These dry washes will be restored to their natural contours following the completion of the utility line construction.

Rosemont has been able to avoid greater impacts to WOTUS by adopting dry stack tailings technology, which allows the entire Project footprint to be contained in a single drainage basin (Barrel Canyon). Minimization of additional indirect impacts has been achieved through redesign of the concurrent and post-closure stormwater management system, which will prevent the ponding of stormwater on the surface of the tailings and waste rock landform, and divert as much stormwater flows as practicable into downstream receiving waters. While the 2008 Mitigation Rule does not necessarily allow for direct mitigation credit for this minimization effort, it allows for the effort to be factored into the calculation of required mitigation.[1]

The applicant reviewed the hierarchy of mitigation types outlined in the 2008 Mitigation Rule. While mitigation banks and in-lieu fee programs are the preferred mitigation type, neither was available when permitting began so mitigation parcels for permittee-responsible mitigation were obtained. The vast majority of lands in the watershed of the Project are public lands and not available for acquisition. The applicant pursued potential mitigation opportunities in the watershed with Pima County and the Bureau of Land Management, but no practicable lands or projects were identified. Opportunities for compensatory mitigation near the Rosemont Project were proffered by the applicant in early discussions, but the Corps expressed concern about the proximity of the Project. As such, a high value offsite parcel (Sonoita Creek Ranch) was acquired outside of the Cienega Creek watershed, but within the larger watershed draining to the Santa Cruz River. The Rosemont Project and the mitigation parcels are located in the Santa Cruz River watershed, which has the 6-digit hydrologic unit code (HUC) designated by the U.S. Geological Survey (USGS) as HUC 150503. Study Reach B of the Santa Cruz River is the nearest downgradient traditionally navigable water to the Rosemont Project site.

The final compensatory mitigation package, after avoidance and minimization, includes two components that provide key conservation elements and opportunities for restoration, enhancement, establishment, and preservation of dry wash habitat: Sonoita Creek Ranch and onsite stock tank removal. An evaluation of the mitigation benefits afforded by these parcels using the Mitigation Ratio Setting Checklist (12501.1-SPD) (MRSC) and other guidance from Corps staff was completed for each of the mitigation components, per resource type. That evaluation indicates that the complete mitigation package should more than adequately compensate for the impacts to potential WOTUS by the Rosemont Project.

Details regarding the opportunities for functional lift afforded by these mitigation actions are provided as follows.

[1] The definition of "compensatory mitigation refers to "offsetting unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved." 33 CFR §332.2. Preamble language to the 2008 Mitigation Rule makes clear that: "Use of various techniques to offset losses of hydrologic functions, such as integrated storm water management facilities, is considered to be an action to minimize effects in accordance with 40 CFR part 230, Subpart H. [The] District engineer can consider the use of such features when determining the appropriate amount of compensatory mitigation required for DA permits." 73 Fed. Reg. 19594, 19621 (April 10, 2008).

MITIGATION PARCELS

Sonoita Creek Ranch

The restoration of Sonoita Creek represents the core of the Rosemont Project HMMP package, and provides a unique opportunity to return a major Santa Cruz River tributary to its historic floodplain and secure a valuable conservation parcel on the landscape. The 1,580+-acre Sonoita Creek Ranch is located approximately 12.5 miles south of the Project area, between Sonoita and Patagonia, Santa Cruz County, Arizona, along State Route (SR) 82. The broad historic floodplain of Sonoita Creek occupies the western portion of the ranch, with the foothills of the Canelo Hills on the eastern portion. The parcel includes an approximately 4.8-mile channelized reach of Sonoita Creek, a tributary of the Santa Cruz River. This parcel offers substantial opportunities for aquatic resource mitigation and has significant conservation values, including an approximately 590 acre-feet per annum (AFA) surface water right (from Monkey Spring north of the parcel), two existing ponds and associated wetlands supported by spring surface water, and both riparian and intermountain wildlife connectivity potential.

Beyond the substantial surface water resources and conservation values, the most significant mitigation opportunity is the restoration effort at this site which includes the reestablishment of Sonoita Creek to its historic floodplain and rehabilitation of the existing channel. Significant reaches of Sonoita Creek have been artificially channelized since at least the 1940's for cultivation of the floodplain. The Nature Conservancy, owner and manager of the Patagonia-Sonoita Creek Preserve downstream of the mitigation site, have identified goals for the Sonoita Creek watershed including, among other things, reducing channelization of the creek. This proposed restoration activity addresses that goal and others.

Per the Biological Opinion completed for the Project, the two existing ponds on the parcel will be renovated to support the recovery of sensitive aquatic species. The final designs will be completed in cooperation with relevant agencies but will, at a minimum, include a passive flow-through design that supports a consistent water level and reconnection to the Sonoita Creek system.

Domestic livestock grazing will be excluded from the parcel with wildlife-friendly fence that permits access for native wildlife. Removal of livestock grazing will also allow for some vegetation enhancement along the existing ephemeral washes and riparian buffer.

In summary, implementation of the mitigation program at Sonoita Creek Ranch will provide the following compensatory mitigation:

- *reestablishment* of 57.4 acres of ephemeral channels through the historic floodplain at the site
- *reestablishment* of 34.6 acres of floodplain and xeroriparian buffer habitat associated with the reestablished channels through the agricultural fields and historic floodplain

- *rehabilitation* of 11.2 acres of Sonoita Creek channel and associated buffer
- *enhancement* of 6.0 acres of existing pond habitat, including open water and wetlands
- *enhancement* of 21.9 acres of existing ephemeral channel with the removal and exclusion of livestock grazing and construction of wildlife-friendly fence
- *enhancement* of 66.3 acres of existing riparian buffer habitat with the removal and exclusion of livestock grazing and construction of wildlife-friendly fence
- *rehabilitation* of 117.8 acres of Sonoita Creek floodplain uplands through recontouring, tilling, and seeding

In-Lieu Fee Project

While Rosemont believes that the proposed mitigation is more than adequate to fully compensate for the unavoidable impacts to potential WOTUS, Rosemont is prepared to submit a one-time payment to a Corp-approved in-lieu fee (ILF) project (or program), if needed, to adequately compensate for impacts to regulated resources. Specifically, Rosemont would purchase any required credits from the Lower San Pedro River Wildlife Area ILF Project, sponsored by the Arizona Game and Fish Department.

Stormwater Flow Mitigation

In order to mitigate for the net potential reduction of an estimated 2 AFA in downstream stormwater flows resulting from the Project, Rosemont will remove four stock tank impoundments within the general Project area, returning those flows to McCleary and Barrel canyons and thereby the downstream canyon. All four impoundments will be graded or otherwise breached to ensure regular downstream flows and sediment transport. This mitigation effort is anticipated to more than offset any potential flow reductions resulting from the Project.

Summary of Mitigation

A summary of the mitigation credits, as calculated using the South Pacific Division's MRSC, to be realized by the implementation of this HMMP is provided in the following table. Rosemont and its contractors used the MRSC to complete the calculations and understand the Corps may revise them.

Summary of Mitigation Credits Provided by All Mitigation Elements

Mitigation Component		Impacted Potential WOTUS								
		Barrel/Wasp Canyons (19.2 ac)			Sonoita Creek Fill (8.9 ac)			Rosemont Headwaters (21.2 ac)		
Description	Size (ac)	Acres Applied	Ratio	Mitigation Credits	Acres Applied	Ratio	Mitigation Credits	Acres Applied	Ratio	Mitigation Credits
Sonoita Creek Ranch										
Reestablished channel	57.4	48.0	2.5:1	19.2	9.4	1.95:1	4.8			
Reestablished channel buffer	34.6				22.0	5.4:1	4.1	12.6	6.4:1	2.0
Rehabilitated channel and buffer	12.1							11.2	6.2:1	1.8
Enhanced ephemeral washes	21.9							21.9	4.2:1	5.2
Enhanced ephemeral wash buffer	66.3							66.3	7.2:1	9.2
Enhanced ponds	6.0							6.0	3.7:1	1.6
SCR rehabilitated floodplain uplands	117.8							12.9	9.2:1	1.4
Total				**19.2**			**8.9**			**21.2**
Other available mitigation elements										
LSPRWA ILF Project	50								4.8:1	

SITE PROTECTION AND LONG-TERM MANAGEMENT

Rosemont anticipates that they will record or cause to be recorded a Restrictive Covenant over the mitigation parcels during the implementation and establishment phases of the mitigation projects. Once a suitable conservation partner has been identified and accepted by the Corps, Rosemont may protect the mitigation parcels by recording a Conservation Easement with the third-party conservation partner. Should participation of a third-party property manager include establishment of a conservation easement conferring rights to the third-party manager, any subsequent conservation easement recorded on the mitigation parcels would incorporate by reference the requirements of the relevant Restrictive Covenant.

Rosemont will be responsible for long-term management of the mitigation parcels, including routine inspections, assessment of site uses, fence repair and replacement, routine maintenance, and reporting. If a mitigation parcel, or parcels, are conveyed to a third-party manager, that manager will be responsible for ensuring the long-term management of that parcel or parcels as a mitigation site.

Rosemont will be responsible for funding the long-term management and maintenance through the development of a Dedicated Account. Details of the funding for the mitigation effort will be provided once the permit decision has been made.

1 INTRODUCTION

Rosemont Copper Company (Rosemont, or "the applicant"), a wholly owned subsidiary of Hudbay Minerals (Hudbay), proposes to develop an open pit copper mining and processing facility known as the Rosemont Copper Project (Project). On October 11, 2011, the applicant submitted a Clean Water Act (CWA) Section 404 permit application to the U.S. Army Corps of Engineers (Corps) requesting a Section 404 individual permit to discharge fill materials into potential waters of the U.S. (WOTUS) in connection with Project activities (Corps File No. SPL-2008-00816-MB).

This Habitat Mitigation and Monitoring Plan (HMMP) is presented as part of CWA Section 404 individual permit requirements and complies with the Corps' and the U.S. Environmental Protection Agency's (EPA) "Final Rule for Compensatory Mitigation for Losses of Aquatic Resources" (33 C.F.R. Parts 325 and 332 and 40 C.F.R. Part 320; published in 73 Fed. Reg. 19594-19705), hereinafter referred to as the 2008 Mitigation Rule. This HMMP has also been completed in conformance with the South Pacific Division (SPD) "Final 2015 Regional Compensatory Mitigation and Monitoring Guidelines."

The mitigation proposed in this HMMP is anchored by the Sonoita Creek Ranch project, a landscape scale mitigation project that could change the perception of ephemeral stream mitigation projects and provide a showcase for arid system restoration techniques. Ensuring that the best practices are being utilized is paramount, and the technical and academic communities, have provided, and will continue to provide, key collaboration in this venture. Researchers with the USDA Walnut Gulch Experimental Watershed (WGEW) provided invaluable assistance with field data and reference information for the design of the Sonoita Creek Ranch restoration project, and translating that data into a landscape scale project in southern Arizona will provide a showcase for the research performed there. Input from Dr. Brian Bledsoe, along with previous experience at the Vermejo project, ensured that the restoration design team had the best chance to successfully put the restoration design theories into practice.

2 PROJECT DESCRIPTIONS

This section provides a description of both the project requiring mitigation (the Rosemont Copper Project) and the proposed compensatory mitigation projects. A thorough project description for the Rosemont Copper Project is provided in the Section 404 permit application materials and the Final Environmental Impact Statement (FEIS) completed for the Project.

2.1 Rosemont Copper Project

2.1.1 Location

The Project is located approximately 30 miles southeast of Tucson, west of State Route (SR) 83 in Pima County, Arizona (**Figures 1 and 2**). The Project is within the Cienega Creek watershed (HUC 15050302), a subwatershed of the Santa Cruz River.

2.1.2 Description

The Rosemont deposit is estimated to consist of 667 million tons of proven and probable mineral reserves, and the Project is expected to produce approximately 243 million pounds of copper per year for approximately 21 years. The average annual production of molybdenum and silver is projected to be 5.4 million pounds and 2.9 million ounces, respectively. A description of the significant Project components is provided as follows.

2.1.2.1 Mining

Mining of the ore will be through conventional open-pit mining techniques that include drilling and blasting. The blasted rock will then be excavated using electric or hydraulic shovels and loaded into haul trucks for transport. Ore will be transported to the Primary Crusher and non-ore material will either go to the Waste Rock Storage Area or to the Dry Stack Tailings Facility for the construction of the buttress around the tailings facility.

Mining operations will be carried out in the open pit with benches that are 50 feet in height. The pit will be constructed to meet the standards required for stability, as identified by Rosemont's geotechnical engineering analysis, and will conform to Mine Safety and Health Administration standards.

2.1.2.2 Ore Processing

Ore will be processed by conventional sulfide milling. Once the ore is crushed, it will be transported from the primary crusher to the mill via a conveyor system. The copper and molybdenum concentrates from the milling operations (sulfide material) will be shipped offsite for further processing. Silver will be produced as a by-product of the offsite processing of the concentrates.

2.1.2.3 Waste Rock and Tailings

Waste rock, or non-ore material, will be placed in the Waste Rock Storage Area or used to construct a buttress around the Dry Stack Tailings Facility. Tailings material, the primary waste stream from the milling operation, will be dewatered at the Plant Site facilities, conveyed to the tailings facility, and placed by radial stacker. Water from the dewatering process will be reused in the milling process. Both the Waste Rock Storage Area and the Dry Stack Tailings Facility will be located entirely within Barrel Canyon drainage.

2.1.2.4 Ancillary Facilities

The ancillary facilities necessary to support the mining and processing operations include an administration building, change house, warehouse with lay down yards, metallurgical/analytical laboratory, light vehicle and process maintenance building, mine truck shop, equipment washes and lube facility, powder magazines and ammonium nitrate storage, tank farms, and a main guard shack with truck scale. Also included are reagent storage as well as fuel and lubricant storage and dispensing facilities for mine and process equipment.

2.1.2.5 Surface Water Management Approach

Surface water management facilities include diversions around the Plant Site and Open Pit areas, stormwater and process water ponding areas within the Plant Site, and temporary ponding and permanent conveyance structures for controlling stormwater generated within the Waste Rock Storage Area and the Dry Stack Tailings Facility. Permanent diversion structures will carry at least the 100-year, 24-hour storm event.

2.1.2.6 Primary and Secondary Access and Utility Alignments

Primary access to the Project site will be from SR 83. Utility alignments will be from the west. A Utility Maintenance Road will generally follow the water supply system and power line alignment.

2.1.3 Avoidance and Minimization

The development of the Rosemont Project design included a significant effort to avoid and minimize impacts to potential WOTUS. These efforts include:

1. The use of dry stack tailings rather than conventional tailings, requiring a much smaller footprint and allowing the Project to be contained within a single drainage basin, in this case Barrel Canyon, to minimize impacts to potential WOTUS; and

2. Stormwater management designs that maximize the discharge of stormwater downstream of the Project.

As noted in the preamble to the 2008 Mitigation Rule, "it may be desirable to require some on-site mitigation measures to address water quality and quantify functions, and to require off-site mitigation to compensate for habitat functions." (73 FR 19601) The avoidance and minimization efforts described here apply directly to the protection of water quality and quantity functions and should be considered by the Corps when determining the compensatory mitigation required for the Project.

2.1.3.1 Dry Stack Tailings

Contributing significantly to the Project's reduced footprint is the use of dry stack tailings. Rosemont completed a tailings siting study in 2006 (Vector Arizona 2006) to identify potential locations for the development of a tailings facility. The study focused on conventional (slurry) tailings, but also evaluated the potential benefits of the use of dry stack tailings. The study concluded that conventional tailings facilities would result in a larger footprint than a comparable dry stack tailings facility, predominantly because development of a conventional tailings facility requires the construction of a significant downgradient dam to contain the "wet" tailings material. Additionally, conventional tailings cannot be integrated into a single landform but must be a structure separate from waste rock disposal.

The sizes of the conventional tailings facilities evaluated in the siting study were up to 2,700 acres. Under the selected alternative design, the total area of dry stack tailings material and associated buttress is approximately 1,000 acres, a difference of up to 1,700 acres that would otherwise be impacted through the use of conventional tailings.

Instead of restricting the dry stack tailings and waste rock facilities to a single drainage basin (i.e., Barrel Canyon), the use of conventional tailings storage would have required development in another drainage basin, such as Sycamore Canyon or east of SR 83 in upper Davidson Canyon, with waste rock being deposited in Barrel Canyon. This would have significantly increased the geographic scope of the Rosemont Project.

2.1.3.2 Stormwater Management

Starting in the initial years of operation, Rosemont will begin reclamation of the outer slopes of the dry stack tailings and waste rock facilities, and will continue concurrent reclamation during the life of the mine. Reclamation will include surface grading and planting of native vegetation. The early and ongoing concurrent reclamation program will ensure downstream water quality that meets state water quality standards. The water quality benefits, and the minimization of temporal flow losses, realized with this approach will occur almost immediately, in contrast to other reclamation approaches that wait until the end of the mine's operational usefulness.

Stormwater management features have been designed to route as much surface water runoff as practicable to Lower Barrel Canyon after closure. This is accomplished by grading the final landform, which is comprised of the reclaimed buttress surrounding the dry stack and waste rock facilities, to preclude the storage of stormwater on the top areas or benches. Stormwater channels will deliver water off of the landform, and another stormwater channel will be constructed in the Plant Site area after closure to route more runoff downgradient.

During pre-mining and active mining, and as required by stormwater discharge permits, no stormwater that comes into contact with ore stockpiles, tailings, or processing facilities would be allowed to discharge offsite. At a minimum, operational stormwater storage is designed for the 100-year, 24-hour storm. Runoff from the area above the Plant Site would be maintained using a permanent diversion channel to direct water into upper McCleary Canyon instead of being routed through the Plant Site and captured in either stormwater ponds or process ponds. Water from the diversion channel would pass under the primary access road through culverts designed to carry the 100-year, 24-hour rainfall event; larger flows would pass over the road. A similar diversion south of the pit would direct runoff to several retention ponds located at the toe of the waste rock facility, where stormwater would be allowed to infiltrate.

The maximum loss of runoff to the watershed would occur during the first 10 years of active mining, when runoff within the plant site, waste rock, and tailings footprints is retained onsite and recycled. The loss of runoff to the watershed would vary during this period but is calculated to approach a reduction in annual average runoff of about 30 to 40 percent as measured at the USGS Gage 09484580 on the SR 83 bridge, as compared with undeveloped baseline conditions. Because reclamation would occur concurrently during active mining, the amount of runoff to the watershed would gradually be increased as areas are reclaimed. By year 10 of active mining, portions of the outer shell of the tailings and waste rock facilities would be reclaimed. Past year 15 of active mining, reclamation would begin on the upper benches of the waste rock and tailings facilities.

Runoff generated on the reclaimed landform and, post-closure, at the Plant Site would be allowed to discharge downstream. A limited area on the west side of the landform would be routed to the Open Pit at closure. Benches with stormwater conveyance channels will be constructed on the landform to carry stormwater to drop structures. Runoff routed to these drop structures will either be discharged into natural washes (Barrel Canyon or a tributary) or discharged into a diversion channel located along the toe of the waste rock and tailings facilities and then discharged. At a minimum, the bench channels and channels located along the toe of the landform are designed to carry the 500-year, 24-hour peak flow and the drop structures are designed to carry the 1,000-year, 24-hour peak flow.

The stormwater channels at closure will total over 80 acres in the area, and will function to convey stormwater flows to the downstream receiving waters in a manner similar to the existing ephemeral channels (**Figure 3**). The final configuration of these stormwater channels will be approved by the Forest Service as part of the Project's reclamation and site water management plans. It is expected that natural development of xeroriparian habitat will occur over time in association with these channels. As such, these stormwater channels will provide comparable functions currently provided by the onsite ephemeral channels, e.g. stormwater and sediment conveyance, wildlife habitat, organic carbon transport, etc. These 80 acres of created channel, which provide for replacement functions, are not included in mitigation calculations but are above and beyond the compensatory mitigation described in this document. Per Corps guidance, the District Engineer should "consider the use of such features when determining the appropriate amount of compensatory mitigation" (73 FR 19621) for this permit.

2.1.4 Impacts to Potential WOTUS

2.1.4.1 Direct Impacts

The Rosemont Project will directly impact approximately 40.4 acres of ephemeral washes (**Figure 4**). Approximately half (19.2 acres) of these direct impacts result from fill of waste rock and tailings material in Barrel and Wasp canyons, which are relatively broad, lower-gradient ephemeral washes. The other components of the direct impacts include 20.9 acres of smaller tributary ephemeral channels within the parcel, and approximately 0.25 acre of ephemeral channel associated with the construction of the utility lines. The impacts include fill for the plant facilities, access and haul roads, utilities, and associated infrastructure. In addition, impacts include five springs, of which only one (Rosemont Spring) both occurs in its natural state (with flows of less than a gallon a minute) and supports modest riparian-type vegetation. Of the remaining features identified as springs, two (Unnamed Springs No. 2 and 3) are seeps that likely are seasonally dry as evidenced by lack of riparian vegetation. The remaining two (Bee Spring and Mueller) were developed (man-made) to fill water sources for livestock use.

The Project will also temporarily impact approximately 1.1 acres of ephemeral washes as a result of the construction of the power and water lines from the Sahuarita area to the Project site. These washes will be restored to their natural contours following the completion of the utility line construction.

2.1.4.2 Reduction of Stormwater Flow Downstream

The discharge of fill from the Project will result in some loss of stormwater flows to the ephemeral system in Barrel and Davidson canyons. Modeling completed for the FEIS estimates that the baseline average annual flow at USGS Gage 09484580 on the SR 83 bridge is 1,404 acre-feet per annum (AFA), and that post-mining flows would be reduced by an estimated 242 AFA (or 17.2%) to a post-mining average annual discharge of 1,162 AFA (FEIS, p. 435). This loss of flow would be attenuated further downstream as the area of watershed flowing to Davidson Canyon increased, resulting in an estimated 4.3-percent loss of stormwater flows at the furthest downstream reach of Davidson Canyon (FEIS, Table 76). The FEIS acknowledges that this estimated is likely high owing to the lack of consideration of channel losses in the modeling effort (FEIS, p. 535).

In addition, it should be noted that the modeling completed for the pre-mining condition for the FEIS did not contemplate the multiple stock tanks and catchments that currently occupy the Project area. Using the same calculation methodology as used for the FEIS, the total annual average volume flowing to these features within the Project area is estimated to be approximately 240 AFA (Tetra Tech 2017), effectively reducing the pre-mining discharge at the USGS gage to approximately 1,164 AFA. When considering the impounding effects of these features, the difference in pre- and post-mining stormwater discharge at the USGS gage is estimated to be only 2 AFA (i.e. 1,164 AFA pre-mining minus 1,162 AFA post-mining).

Further demonstrating the highly conservative nature of the original models, the actual stormwater flowing to Barrel and Davidson canyons are far smaller (average flow volumes of 32 to 188 AFA as measured at the SR 83 gage from 2009 through 2016) than what was modeled for the FEIS. The anticipated reductions in flow resulting from the Project would therefore be commensurately much smaller as well, making the likely impacts to Barrel and Davidson canyon washes considerably less than was described in the FEIS.

2.2 Mitigation Projects

2.2.1 Sonoita Creek Ranch

The restoration of Sonoita Creek provides a unique opportunity to return a major Santa Cruz River tributary to its historic floodplain and secure a valuable conservation parcel on the landscape. The 1,580+-acre Sonoita Creek Ranch is located approximately 12.5 miles south of the Project area, between Sonoita and Patagonia, Santa Cruz County, Arizona, along SR 82. The broad historic floodplain of Sonoita Creek occupies the western portion of the ranch, with the foothills of the Canelo Hills on the eastern portion. The parcel includes an approximately 4.8-mile channelized reach of Sonoita Creek, a tributary of the Santa Cruz River. This parcel offers substantial opportunities for aquatic resource mitigation and has significant conservation values, including approximately 590 AFA surface water (from Monkey Spring north of the parcel), two existing ponds and associated wetlands supported by spring surface water, and both riparian and intermountain wildlife connectivity potential.

Beyond the substantial surface water resources and conservation values, the most significant mitigation opportunities are the restoration proposals for this site which include the reestablishment of Sonoita Creek to its historic floodplain and rehabilitation of the existing channel. Significant reaches of Sonoita Creek have been artificially channelized since at least the 1940s for cultivation of the floodplain. The Nature Conservancy, owner and manager of the Patagonia-Sonoita Creek Preserve downstream of the mitigation site, have identified goals for the Sonoita Creek watershed including, among other things, reducing channelization of the creek. This proposed restoration activity addresses that goal and others.

Per the Biological Opinion completed for the Project, the two existing ponds on the parcel will be renovated to support the recovery of sensitive aquatic species. The final designs will be completed in cooperation with relevant agencies but will include a passive flow-through design that supports a consistent water level and reconnection to the Sonoita Creek system.

Domestic livestock grazing will be excluded from the parcel with wildlife-friendly fence that permits access for native wildlife. Removal of livestock grazing will also allow for some vegetation enhancement along the existing ephemeral washes and riparian buffer.

2.2.2 In-Lieu Fee Payment

There are currently six Corps-approved in-lieu fee (ILF) mitigation projects offering credits for sale in Arizona. The Arizona Game and Fish Department (AGFD) is the ILF sponsor for three of these projects: 1) the Arlington Wildlife Area, located along the Gila River near Gillepsie Dam; 2) the Chevelon Wildlife Area Wetlands, located within the floodplains of Chevelon Creek and the Little Colorado River southeast of Winslow, Arizona; and 3) the Lower San Pedro River Wildlife Area (LSPRWA), a riparian corridor located north of Mammoth, Arizona. The three remaining ILF projects with credits currently available are the Prescott Creeks Preservation Association, a nonprofit organization located in Prescott, Arizona; the La Paz County Endangered Species Fund, located along the Lower Colorado River within La Paz County, Arizona, and managed in partnership between the Corps, U.S. Fish and Wildlife Service (USFWS), and La Paz County; and the North Simpson Farms project implemented by the Tucson Audubon Society (TAS) near Marana, Arizona.

The Corps prioritizes compensatory mitigation projects with service areas that include impacts to waters of the U.S. (U.S. Army Corps of Engineers 2012), though the scope and extent of service areas vary depending on the ILF project. The only two ILF projects that include the Project in their respective service areas are the AGFD's LSPRWA (**Figure 5**) and the TAS's North Simpson Farms project. Because TAS has previously stated that they would not sell credits for the Rosemont Project, Rosemont proposes to meet its compensatory mitigation obligation, in part and as necessary, through purchase of credits from the LSPRWA ILF Project. This ILF project currently has 50 advance credits available for purchase (Bill Miller, Corps, pers. comm.).

Stretching across approximately 7 miles of the Lower San Pedro River, the LSPRWA ILF Project has the potential to support high-value mesoriparian and hydroriparian habitats, and provides regional conservation benefits. While the mitigation measures proposed within the LSPRWA ILF Project are not focused on the type of xeroriparian habitat associated with the ephemeral drainages to be impacted by the Project, the habitats within the mitigation site that will be preserved, enhanced, and restored are more rare within the regional landscape, have higher productivity, and possess higher wildlife values than the impacted xeroriparian habitats (Lowery, Stingelin, and Hofer 2016). **Table 1** provides a brief summary of the proposed mitigation areas within the LSPRWA ILF Project.

Table 1. Description of Mitigation Areas within the LSPRWA ILF Project

Proposed Treatment	Acreage	Description
Riparian Restoration Area	677	The Riparian Restoration Area of the LSPRWA ILF Project includes approximately 677 acres, adjacent to the San Pedro River. Most of the Riparian Restoration Area is currently composed of river floodplain vegetated by stands of tamarisk. The replacement of tamarisk with native cottonwood, willow, and mesquite will create habitat suitable for native wildlife, including the endangered southwestern willow flycatcher and threatened yellow-billed cuckoo, and maintain these functions during the anticipated die-off of non-native tamarisk when the tamarisk leaf beetle arrives along this reach of the San Pedro River.
Wetland Establishment Area	2	The Wetland Establishment Area encompasses approximately 2 acres of floodplain adjacent to the San Pedro River. The establishment of emergent wetlands in this area will provide a valuable and rare aquatic resource that has the potential to benefit special status species.

Per the 2008 Mitigation Rule (§332.4(c)(ii)), additional discussion of any necessary ILF components of the proposed mitigation package is limited to **Sections 5** and **7** of this mitigation plan.

2.2.3 Stormwater Flow Mitigation

As described in **Section 2.1.4.2**, the Project will result in some reduction in stormwater flows to lower Barrel and Davidson canyons downstream of the project. However, as noted above, additional evaluation shows that these flow losses are likely significantly overstated in the FEIS for the Project. Regardless, Rosemont has proposed mitigation for potential downstream effects, as described here.

In order to mitigate for the net potential reduction of 2 AFA in downstream stormwater flows resulting from the Project, Rosemont will remove three impoundments within the general Project area, returning those flows to McCleary Canyon and thereby the downstream Barrel and Davidson canyons. The three impoundments are the Gunsight Pass Tank, McCleary Canyon Stock Tank, and Rosemont Crest Tank. The estimated average annual stormwater flow flowing to these impoundments is 39.3 AFA (Tetra Tech 2017). Rosemont will also remove a fourth stock tank (Barrel Canyon East); although a portion of the watershed contained by this stock tank will be affected by the Waste Rock Storage Area, the remainder of flows in the watershed will be returned to the Barrel Canyon system.

All four impoundments will be graded or otherwise breached to ensure regular downstream flows and sediment transport. Given the nearly 20:1 ratio of reestablished downstream flows to potential reduction in flows, this mitigation effort is anticipated to more than offset any potential flow reductions resulting from the Project.

3 OBJECTIVES

Habitat mitigation measures and monitoring objectives will involve a combination of techniques, including reestablishment and rehabilitation of aquatic and riparian habitats, and enhancement of aquatic habitat including wetlands and ephemeral systems. **Attachment 1** provides summary tables describing the existing conditions at the Project site along with the mitigation objectives for the mitigation sites. Further discussion of the mitigation objectives is provided in **Sections 3.1 and 3.2**.

3.1 SONOITA CREEK RANCH

Water & Earth Technologies (WET) has developed a detailed design report describing the reestablishment of the Sonoita Creek channel and floodplain, the key component of the mitigation effort (**Attachment 2**). The Sonoita Creek Ranch project is designed to reduce historical impacts to the Sonoita Creek by returning two reaches of the creek to a more natural alignment and reestablishing the benefits associated with typical unconstrained channel morphology in the area. The unconstrained mitigation channel morphology will provide significant hydrologic and habitat functions. Specifically, moderate to high flows will have the ability to access a functional floodplain that is wetted during more frequent overtopping events. This contrasts with the current condition where fewer events can overtop the incised, constrained channel. Shallow, out-of-bank flow serves to dissipate flow energy and reduce flow velocities during flood events. This reduces channel erosion and promotes deposition of material. In addition to energy dissipation, this will increase infiltration and groundwater recharge along the Sonoita Creek valley throughout the Sonoita Creek Ranch project area. Broader inundation and short-term subsurface water storage will support shallow groundwater in the riparian corridor that in turn will increase availability to streamside vegetation, thus improving habitat.

The proposed channel system design does not include construction of any weirs, hardened diversion structures, levees, or headgates. Mitigation channel designs use a complex trapezoidal channel design with multiple overbank benches that will transition to match the existing Sonoita Creek cross section and channel invert elevation at the upstream and downstream tie-in locations. The complex trapezoidal channels have bottom widths ranging from 40 to 50 feet and stepped channel bench features extending horizontally from a point, 2.0 feet above the channel invert. The channel benches range in width from 23 to 92 feet. A 10:1 (H:V) side slope projects upward from the outer limits of the channel benches to intercept existing ground. The wide, shallow cross-sectional geometry will allow ephemeral channel dynamics and development of a braided planform within the constructed channel through natural fluvial processes. Initial maintenance following the first few events after construction may be necessary; however, the channel is designed to be self-sustaining and the need for long-term, perpetual maintenance is expected to be minimal or unnecessary.

3.2 Stormwater Flow Mitigation

The removal of selected stock tanks at the Rosemont Project site (Project Site) is anticipated to restore an estimated 39.3 AFA of storm flows to the natural system. The anticipated benefit to be accrued from the stock tank removal and associated storm flow restoration is the maintenance of downstream storm flows and sediment transport functions. Restoration of these flows is anticipated to offset or eliminate the reduction of storm flows recorded at the USGS gage on SR 83.

4 SITE SELECTION

The 2008 Mitigation Rule includes a specific order in which five general classes of compensatory mitigation options must be considered: 1) mitigation banks, 2) ILF programs, 3) permittee-responsible mitigation under a watershed approach, 4) permittee-responsible mitigation through onsite and in-kind mitigation, and 5) permittee-responsible mitigation through offsite and/or out-of-kind mitigation. All five of these general classes of compensatory mitigation were considered when developing the mitigation approach for the Rosemont Project.

Mitigation banks are the Corps' preferred method of mitigation. However, there are currently no approved mitigation banks in Arizona so this approach is not possible for Rosemont.

An ILF program includes a sponsoring entity that assumes responsibility for overseeing the mitigation site in exchange for a fee. It is the second most preferable form of mitigation. However, at the time that Rosemont initiated CWA Section 404 permitting, there were no ILF projects in the state with a service area that included the Project area. As such, Rosemont secured offsite mitigation parcels to meet the compensatory mitigation obligations of the CWA Section 404 permit. Since that time, additional ILF programs have been established in southern Arizona and Rosemont proposes to purchase credits, if necessary, from the AGFD's LSPRWA ILF Project in partial fulfilment of its compensatory mitigation obligations.

4.1 Watershed Overview

Rosemont arrived at the specific parcels discussed in the following sections through an extensive acquisition effort that was part of the larger mitigation package development. Recognizing the rule preference for a watershed-based approach to compensatory mitigation, Rosemont sought parcels and projects located within the watershed impacted by the Project. Barrel Canyon lies in the upper reaches of the Davidson Canyon watershed, which is, in turn, part of the Cienega Creek watershed, which is ultimately tributary to the Santa Cruz River. As shown in **Figure 6**, the vast majority of lands in the Cienega Creek watershed are public (federal, state, or county) and not generally available for acquisition. A number of private lands packages within the watershed were examined for conservation and mitigation potential. Several of the sites were within the urban core of Pima County and too small or off channel with little potential for stream or other aquatic resource mitigation. Other parcels that were examined, while potentially providing good conservation/preservation lands, did not provide opportunities for the enhancement, restoration, or rehabilitation of aquatic resources required by the Corps. Rosemont also sought opportunities for aquatic resource mitigation projects with BLM (on the Las Cienegas National Conservation Area) and Pima County (within the Cienega Creek Natural Preserve) but none were available or feasible.

Rosemont purchased properties within Davidson Canyon that are near to the site, have aquatic resources (i.e., springs) and were thought to be able to provide some mitigation. However, because the Rosemont Project is in the headwaters of the drainage, there was a concern that the mitigation parcels within the Davidson Canyon drainage would be impacted by site activities, and so these parcels were dropped from the list of possible mitigation options for the Section 404 permit.

Rosemont was also able to secure the purchase rights to the Pantano Dam property, which represents an opportunity to secure a rare and valuable surface water right and restore a portion of the lower Cienega Creek watershed. Assets of the property include approximately 1,122 AFA of surface water rights in Cienega Creek, along with an approximately 2-acre parcel which includes the Pantano Dam as well as lands up- and downstream of the dam within Pima County's Cienega Creek Natural Preserve. This parcel includes open water and riparian vegetation associated with the pooling of water behind the dam. Per the Biological Opinion, Rosemont will return surface flows currently diverted to a golf course to the Cienega Creek channel, with benefits to the Cienega Creek Nature Preserve. The channel below the dam ultimately discharges to the Santa Cruz River. Although the Pantano Dam represents a substantial opportunity to restore surface water flows to the natural system, this parcel is not currently part of the Section 404 permit compensatory mitigation package.

Having exhausted high value opportunities in the Davidson/Cienega Creek watershed, Rosemont is also including here Sonoita Creek Ranch, which is located along Sonoita Creek, a major tributary to the Santa Cruz River, in an adjacent watershed to Cienega Creek. As described above, this parcel is within the Santa Cruz River watershed (HUC 150503).

4.2 LANDSCAPE SETTING AND POSITION

4.2.1 Sonoita Creek Ranch

Sonoita Creek Ranch is an approximately 1,580+-acre parcel located approximately 12.5 miles south of the Rosemont Project. This parcel includes approximately 4.8 miles of Sonoita Creek, a significant tributary of the Santa Cruz River, the nearest identified traditionally navigable water to the Rosemont Project. The site currently supports substantial aquatic resources, including 6 acres of ponds with associated wetlands. Historically, Sonoita Creek flowed through a system of channels in a broad floodplain vegetated with riparian and wetland habitats, but is now largely incised in a single active channel (Minckley 1968), and that is true of the reach through Sonoita Creek Ranch. The proposed mitigation project will allow for the reestablishment of the riparian floodplain system through a substantial reach of Sonoita Creek.

Sonoita Creek Ranch is located approximately 5 miles north of the perennial reach of Sonoita Creek at the Patagonia-Sonoita Creek Preserve, and approximately 14 miles south of the perennial reach of Cienega Creek at the Las Cienegas National Conservation Area (**Figure 7**). The mitigation parcel's location and ability to support open water and perennial riparian vegetation associated with the ponds makes it a valuable connectivity piece providing a refuge stop-over site for riparian dependent wildlife species moving between these two locations.

In addition, the Sonoita Creek Ranch is located in the Patagonia to Santa Rita Linkage as identified by the Arizona Wildlife Linkages Workgroup (AGFD 2009). The linkages were identified to provide for the safe movement of wildlife minimizing further habitat fragmentation and ensuring the survival of wildlife. Restoration of riparian habitat from agricultural fields and the broader floodplain will promote safe wildlife passage along Sonoita Creek between areas downstream such as the Patagonia-Sonoita Creek Preserve and upstream to the Las Cienegas National Conservation Area.

By comparison, while the Project Site and the riparian areas contained within are likely used by wildlife for movement, they are located within an area defined as a wildland block (**Figure 8**; Beier et al. 2008). Wildland blocks are large areas that are relatively unfragmented and contain little to no anthropogenic impedance to wildlife movement. Riparian corridors, like those associated with Sonoita Creek, are unique in that they provide refugia along disturbed areas (i.e. SR 82) allowing for wildlife shelter, usage, and movement. They also allow for lateral movement between two habitat blocks that are separated by open or disturbed areas.

The Patagonia-Sonoita Creek preserve is owned and managed by The Nature Conservancy (TNC) as an important natural area due to its perennial flow, native fish, rare invertebrates, high quality riparian forest, and cienegas (The Nature Conservancy 2014). The aquatic habitats in this preserve are supported by surface and subsurface flows, and shallow groundwater that is stored within the upstream alluvial deposits of Sonoita Creek (Montgomery & Associates 1999). TNC's action plan for the Sonoita Creek watershed is described at the website[2]. The TNC website notes that, "Upstream of the Town of Patagonia are remnants of other natural floodplain communities that were once more common along streams of the Southwest, but are increasingly rare today – sacaton grasslands and mesquite bosques. Also, two of the finest remaining springs in Arizona are found in the watershed of Sonoita Creek – Monkey Spring and Cottonwood Spring. Several rare plants and animals inhabit the

[2] https://www.miradishare.org/projectDetails/tnc-thenatureconserva-2014-00334/

flowing waters, stream valley woodlands, grasslands, and mountain forests of the Sonoita Creek watershed."

One of TNC's objectives for the Sonoita Creek Watershed is described as follows[3]:

> "Maintain and, as feasible, restore through land acquisition, cooperative agreements, and habitat management the natural ecological processes (*flooding, spreading out of floodwaters within the floodplain, stream channel migration,* fire, *reproduction of rare plants and animals, wildlife dispersal*) of the Sonoita Creek watershed, with special emphasis on cottonwood-willow and *other riparian forests, springs, cienegas, sacaton grasslands, mesquite bosques, desert grasslands, and globally endangered and threatened plant and animal species*." (Emphasis added.)

The mitigation project at Sonoita Creek Ranch directly addresses the action plan objectives identified in the preceding paragraph, particularly those marked in italics.

TNC's action plan identifies specific conservation targets and threats for the watershed, and these include: perennial springs that "provide a continuous supply of surface and groundwater to Sonoita Creek," sacaton grassland/mesquite bosque floodplain terraces, and wildlife movement corridors. The primary threats identified by TNC include groundwater pumping, increased sediment, invasive species, and stream channelization. The proposed mitigation actions at the Sonoita Creek Ranch mitigation parcel will help to reduce the identified threats to the Patagonia-Sonoita Creek Preserve by protecting a portion of the upgradient watershed from residential development and potential groundwater development, increasing sediment capture and storage on the floodplain, removal and management of invasive species, and restoring the natural fluvial geomorphology of the Sonoita Creek system thereby increasing the functions and services provided.

In addition to regional goals by the TNC, Santa Cruz County in 2004 adopted a comprehensive plan for land development within the county; this plan was since readopted in 2016 (Santa Cruz County Board of Supervisors 2016). The comprehensive plan is separated into sections with Sonoita Creek Ranch located within what is defined as the Northeast Santa Cruz County Character Area. The comprehensive plan lists five goals for this area, three of which are aided by implementation of the HMMP at Sonoita Creek Ranch:

- "Open space and natural terrain remain dominant features of the landscape and viewsheds are protected."
- "Wildlife habitat and wildlife movement corridors are recognized and preserved through the use of established and innovative land management tools."

[3] https://www.miradishare.org/reports/resultsChainProgress/tnc-thenatureconserva-2014-00334/

- "Water supplies are protected and conserved."

The Town of Patagonia's Flood and Flow Committee has recently issued its *Final Sonoita Creek Watershed Management Plan, Phase 1* report (NextGen Engineering 2017). Although this plan is in a very nascent stage, it identifies a series of goals based on stakeholder input, several of which apply to the Sonoita Creek Ranch mitigation project, including: integrated flood management, healthy ecosystems, access to nature, and responsible land and resource management.

Furthermore, Sonoita Creek lies within the Cienega Creek Groundwater Basin, which includes upper Cienega Creek and Sonoita Creek (ADWR 2009). Groundwater recharge is provided to the basin primarily through mountain front recharge and from streambed infiltration. Two primary sources of streambed infiltration are Cienega Creek and Sonoita Creek. Enhancing the channel area and stability will aid in providing recharge to the groundwater aquifers within the Cienega Creek Basin.

Sonoita Creek Ranch has been a high priority conservation property for the AGFD for a number of years (AGFD 2009). In 2008, AGFD applied to the USFWS's Cooperative Endangered Species Conservation Fund for $1 million to help purchase the Sonoita Creek Ranch through the Recovery Land Acquisition Grants Program and had been actively seeking partners for matching funds to accomplish the acquisition.[4] The AGFD's interest in the property demonstrates its conservation value. The property includes a substantial perennial water supply, has significant agricultural and grazing uses ongoing, and was under threat of subdivision development. In its application to the Cooperative Endangered Species Conservation Fund, AGFD describes the region as "a well-known core area for biodiversity in southeastern Arizona" and the Ranch property particularly as having "rich riparian values."[5] With Rosemont owning the property and proposing to use the parcel for compensatory mitigation, the conservation of this biologically-diverse area will occur and the intent to preserve the area from future development will be accomplished.

4.2.2 Stormwater Flow Mitigation

The removal of selected stock tanks at the Project Site will occur immediately adjacent to the Project, providing maximal benefit to offset any potential reductions in downstream flows. Three of the impoundments are located within the headwaters of McCleary Canyon and the fourth in Trail Canyon so that stormwater flows through these features will ultimately discharge to Barrel Canyon downstream of the Project.

[4] Rosemont Copper Project Cooperating Agency Coordination Meeting, Meeting Notes (May 26, 2009). AGFD's application is included here. The minutes and attachments are available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5293381.pdf

[5] AGFD application, p. 1.

4.3 Site-Specific Information

The 2008 Mitigation Rule identifies those criteria that inform the ecological suitability of a mitigation parcel:

(i) Hydrological conditions, soil characteristics, and other physical and chemical characteristics;
(ii) Watershed-scale features, such as aquatic habitat diversity, habitat connectivity, and other landscape scale functions;
(iii) The size and location of the compensatory mitigation site relative to hydrologic sources (including the availability of water rights) and other ecological features;
(iv) Compatibility with adjacent land uses and watershed management plans;
(v) Reasonably foreseeable effects the compensatory mitigation project will have on ecologically important aquatic or terrestrial resources (e.g., shallow sub-tidal habitat, mature forests), cultural sites, or habitat for federally- or state-listed threatened and endangered species; and
(vi) Other relevant factors including, but not limited to, development trends, anticipated land use changes, habitat status and trends, the relative locations of the impact and mitigation sites in the stream network, local or regional goals for the restoration or protection of particular habitat types or functions (e.g., re-establishment of habitat corridors or habitat for species of concern), water quality goals, floodplain management goals, and the relative potential for chemical contamination of the aquatic resources. (33 CFR § 332.3(d))

The mitigation parcels brought forward in this HMMP are responsive to these considerations. A summary of these considerations is provided as follows; additional details are provided in other sections of this HMMP.

4.3.1 Sonoita Creek Ranch

The Sonoita Creek Ranch parcel:

- supports substantial existing aquatic resources while emphasizing the reestablishment of the ecologically important riparian channel and floodplain system in Sonoita Creek;
- provides habitat diversity with a variety of ephemeral drainages, riparian habitat, and the spring-fed perennial ponds which are a very rare feature on the desert landscape;
- provides both riparian and intermountain habitat connectivity;
- is a large (1,580+ acre) parcel with a substantial certificated surface water right (approximately 590 AFA; further described in **Section 5.2.3**);
- is located in the Cienega Creek groundwater basin;
- is fully compatible with adjacent land uses (it is adjacent to Forest Service lands); and
- provides habitat for federally-listed threatened and endangered species, including the jaguar.

In addition, protection of this parcel will prevent its development into residential real estate tracts[6].

4.3.2 Stormwater Flow Mitigation

Removing the stock tanks at the Rosemont Site will:

- provide direct replacement of onsite stormwater flows; and
- ensure habitats or habitat connectivity that may be dependent upon those flows in lower Barrel and Davidson canyons are maintained.

5 BASELINE INFORMATION

This section provides baseline ecological information for the Rosemont Project impact site and the Sonoita Creek Ranch mitigation site.

5.1 Rosemont Project Site

The Project Site is situated approximately 30 miles southeast of Tucson and 14 miles north of the town of Sonoita, west of SR 83 (**Figure 9**), on the east slope of the Santa Rita Mountains. Elevations within the Project Site range from approximately 4,400 to 5,600 feet above mean sea level (amsl). The Project is within the Cienega Creek watershed (HUC 15050302), a subwatershed of the Santa Cruz River.

The Rosemont Project area has been used by Euro-Americans for mining and grazing since at least the late 1870s (Ayers 1984). The first known mining claim activity was by J.K. Brown, who founded the Narragansett claim in 1879 (Ayers 1984). The first documented cattle ranching operation in the Rosemont area was started by Edward Vail in 1883 as the VR Ranch (Ayers 1984). Evidence for early Spanish and Mexican period occupation of the Rosemont area is sparse (Ayers 1984). Spanish and Mexican mineral exploration and ranching activities may have occurred in the Rosemont area but most certainly on a limited scale of which little evidence is left (Ayers 1984). There is simply no documentary evidence of mining or cattle ranching in the Rosemont area prior to the late 1800s (Ayers 1984).

Large-scale mining operations in the Rosemont area ceased by 1919, but small-scale prospecting continued into the early 1960s (Ayers 1984). To this day, ranching operations continue in the area. The Rosemont area supported two towns, "Old" Rosemont and New Rosemont, several mines, and a smelter. The towns had populations of approximately 150 to 250 people at varying years, with the population of "Old" Rosemont decreasing during the early 1900s while New Rosemont grew.

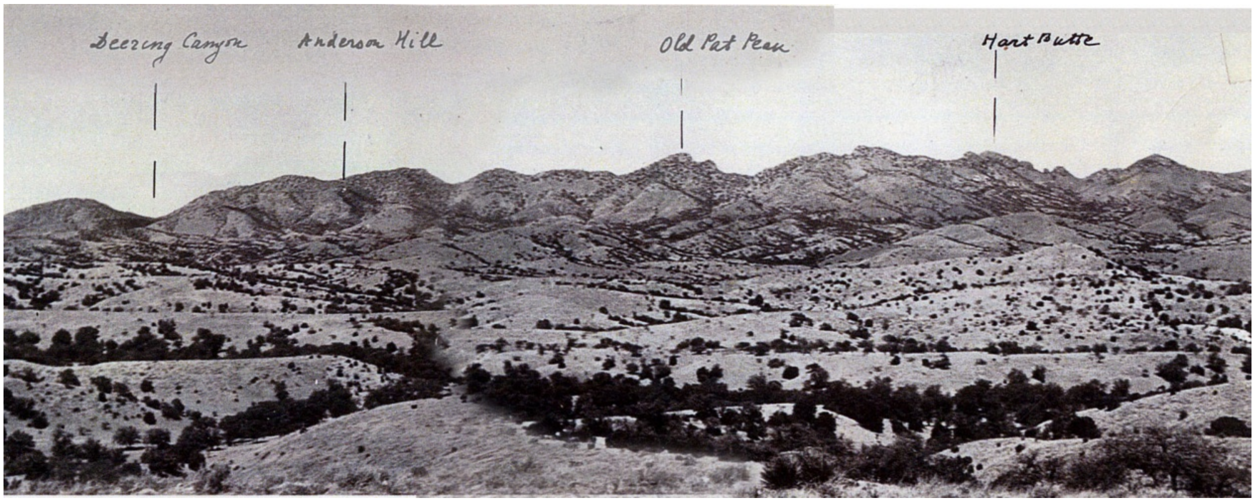
[6] Rosemont Copper Project Cooperating Agency Coordination Meeting, Meeting Notes (May 26, 2009). AGFD's application is included here. The minutes and attachments are available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5293381.pdf.

Mining, ranching, and recreational uses have undoubtedly altered the landscape within the Project site and near vicinity. A comparison of photographs taken in 1906, 1982, and 1990 near the former Rosemont Hotel site in Barrel Canyon reveals a substantial increase in woody species, especially juniper, during this period (Bahre 1991). The 1906 photograph shows that the landscape was already disturbed by mining, smelting, and grazing activities. Junipers had been cut for use as fuel, fence posts, and mine timbers. And grazing practices in the late 1800s likely reduced the density of grasses. Unfortunately, no known photographs document the vegetation in this area prior to this period. However, it is likely that before Euro-American use of the area, wildfire provided natural control of woody species, such as juniper. Bahre (1991) concludes that fire suppression and livestock grazing are the most significant factors contributing to the increase in woody species since the early 1900s. In any case, the density and stature of woody species currently present onsite do not reflect conditions from 100 years ago and likely do not represent pre-settlement characteristics of the Project area. **Photos 1 and 2** illustrate the changes in vegetation cover over the past 100 years.

Rosemont Hotel circa 1906

Rosemont Hotel Site, 2004 (Photo B. Schmalzel)

Photo 1. View of the Rosemont Hotel circa 1906 and 2004



Panoramic View of Ridgeline, Popoff, 1940

Panoramic View of Ridgeline, 2004 (Photograph, B. Schmalzel)

Photo 2. Views of the Santa Rita Ridgeline from the East circa 1939 and 2004

5.1.1 Existing Vegetation

Observations of vegetation cover types in the Project Area are consistent with the mapping by Brown and Lowe (Brown and Lowe 1980). The two biomes present on the site are Madrean evergreen woodland and semidesert grassland. General and riparian habitat was described by WestLand (WestLand Resources Inc. 2010).

Madrean evergreen woodland covers the higher elevations within the Project Site, generally in the western and southern areas. This community is characterized by open woodlands or savanna, with trees interspersed with grasses and forbs. Dominant tree species include Emory oak (*Quercus emoryi*), alligator juniper (*Juniperus deppeana*), one-seed juniper (*Juniperus monosperma*), and Mexican pinyon (*Pinus cembroides*). Common shrub species in this community include velvet mesquite (*Prosopis velutina*), whitethorn acacia (*Vachellia constricta*), and skunkbush (*Rhus aromatica*). Parry's agave (*Agave parryi*), beargrass (*Nolina microcarpa*), banana yucca (*Yucca baccata*), several species of cactus, and a variety of grasses and forbs are also present. Although trees dominate this habitat, the understory grasses are diverse and abundant and include the following species: green sprangletop (*Leptochloa dubia*), *Muhlenbergia* species, dropseed (*Sporobolus* sp.), wolfstail (*Muhlenbergia phleoides*), plains lovegrass (*Eragrostis intermedia*), cane beardgrass (*Bothriochloa barbinodis*), and slim tridens (*Tridens muticus*). This vegetation is quite variable in its distribution and structure, and on several of the slopes the dominant woody species is mountain mahogany (*Cercocarpus montanus*).

Within the Madrean evergreen woodland biome, agave, yucca, and cacti characterize the grassland habitats. On south facing slopes, grass-covered open areas are interspersed with trees and succulents, including one-seed juniper, catclaw acacia (*Senegalia greggii*), Palmer's agave (*Agave palmeri*), beargrass, soaptree yucca (*Yucca elata*), Engelmann's prickly pear (*Opuntia engelmannii*), cane cholla (*Cylindropuntia spinosior*), and ocotillo (*Fouquieria splendens*). Although this habitat shares many of the same grass species with the wooded hillsides, the dominant grasses on the south-facing hillsides are green sprangletop, blue grama (*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), cane beardgrass, Lehmann's lovegrass (*Eragrostis lehmanniana*), Rothrock's grama (*Bouteloua barbata* var. *rothrockii*), tanglehead (*Heteropogon contortus*), and slim tridens.

Semidesert grassland covers the lower elevations of the property, primarily in the northern and eastern portions of the Project area. This community is characterized by open grasslands with widely scattered shrubs and cacti. Dominant shrubs include velvet mesquite, catclaw acacia, burroweed (*Isocoma tenuisecta*), and ocotillo. Soaptree yucca, several species of cacti, and a variety of grasses and forbs are also present. At middle elevations, the semidesert grassland grades into the Madrean evergreen woodland within a wide transition zone.

Available historical information suggests that the vegetation communities within the property have changed significantly due to human activity. As described in the FEIS (p. 180, Table 17), the erosion potential for the entire watershed is addressed by a combination of the erosion potential of various soils and the state of vegetation on the watershed. There are two vegetative conditions to consider: the historic climax plant community and the current conditions. The historic climax plant community represents the plant community that existed at the time of European immigration and settlement. It is the plant community that was in dynamic equilibrium with its environment and was best adapted to the unique combination of environmental factors associated with the site. As noted above, the Project site is visibly degraded from the historic climax plant community, primarily because of the substantial cover of juniper and mesquite present, which resulted from historical fire prevention strategies and overgrazing by cattle (FEIS, p. 189). Once the canopy cover of these species increases to more than 25 percent, site instability and soil erosion can occur.

The "General Ecosystem Survey for the Coronado National Forest" further compares the current condition of the watershed with the historic climax condition (FEIS, p. 189). In general, vegetation basal area currently represents approximately 5 percent of the surface, whereas under historic climax conditions, it would represent 15 to 25 percent of the surface, though with less woody vegetation. Likewise, bare soil would represent 20 to 45 percent of the surface under historic climax conditions, but it currently represents 30 to 60 percent of the surface.

5.1.2 Hydrology and Soils

The primary drainages to be impacted by the Rosemont Project are in Barrel, Wasp, and McCleary canyons, though the impacts in McCleary Canyon will be limited. Direct impacts to these three drainages comprise approximately 19.2 acres of the total 40.4 acres of direct impact. Barrel and Wasp canyons are relatively broad, lower-gradient ephemeral washes. Pima County, through the Sonoran Desert Conservation Plan, used satellite photos to map Barrel and Wasp canyons as Important Riparian Areas, portions of which were described by Pima County as "Hydroriparian or Mesoriparian." However, review and field reconnaissance by WestLand (WestLand Resources Inc. 2010) shows that the character of the riparian vegetation is best described as xeroriparian, with Barrel, Wasp, and McCleary canyons showing nearly pure "upland" vegetative character when using Johnson et al.'s (1984) concept of riparian habitat as a continuum from the wettest hydroriparian habitats (wetlands) to the driest xeroriparian habitats associated with desert washes. Although indicator species in these large washes are largely upland in character, vegetation densities are greater on the margins of these washes than in the surrounding upland.

In addition, within the Project area, the washes in both Barrel and Wasp canyons function as designated Forest Service Roads (FR 4058 and FR 231). These roads/washes are used for recreation that typically includes camping and off-highway vehicle (OHV) use. They are regularly maintained by the grazing lessee and usually passable by two-wheel-drive sedans. There are 235 miles of roads and trails that cross the FEIS Study Area. (FEIS, p. 188)

The smaller tributaries of Barrel and Wasp canyons comprise approximately 20.9 acres of direct impact from the Rosemont Project. These washes are all generally small, first order streams, much narrower than Barrel and Wasp canyons with steeper gradients, often bedrock controlled, with little access to an adjoining floodplain. Vegetation associated with these washes is likewise xeroriparian, with species typically associated with the adjoining uplands. The 0.25 acre of ephemeral washes impacted by the utility line construction are similar to these smaller washes.

The U.S. Forest Service (FEIS, p. 190) has recently undertaken a comprehensive and consistent assessment of watershed conditions on all national forests. The Coronado National Forest (CNF) completed the assessment in the Rosemont Project area in 2011. The assessment includes soils, forest cover, forest health, terrestrial invasive species, and rangeland condition, all of which are indicative of soil and vegetation conditions. The Davidson Canyon watershed, which includes the Project area, was assessed for 12 specific indicators of watershed health in the Project area. The results of these 12 indicators were then used to assign an overall condition classification. The Davidson Canyon watershed was found to be "Functioning - at risk", which is an assessment of the overall state of the watershed, based on the combined individual indicator values. It indicates that the Davidson Canyon watershed has only moderate geomorphic, hydrologic, and biotic integrity relative to its natural potential condition.

Baseline surface water quality data collected by Rosemont shows that levels of certain constituents (including lead and copper) in the Project area drainages are above the state's established surface water quality standards for the designated use. The Rosemont and Davidson Canyon areas have a history of late 19th- and early 20th-century copper, zinc, lead, and silver mining (FEIS, p. 164), evidence of the elevated mineral content of the area.

5.2 SONOITA CREEK RANCH

Sonoita Creek Ranch is located approximately 12.5 miles south of the Project Site, approximately six miles south of the town of Sonoita, Arizona and two miles north of Patagonia, Arizona, east of SR 82 (**Figure 10**). The western foothills of the Canelo Hills lie within the eastern portions of the ranch. Elevations within the ranch range from approximately 4,200 to 4,600 feet amsl. The ranch is within the Sonoita Creek watershed (HUC 15050301), a subwatershed of the Santa Cruz River. Typical ground photos are provided in **Attachment 3**.

The current use of the ranch is a mixture of ranching, open space, and agriculture. Within the central part of the ranch, Sonoita Creek has been channelized in a straight north-south alignment between a large (approximately 115-acre) agricultural field and SR 82, effectively isolating the channel of Sonoita Creek from its historic floodplain. The channelization of Sonoita Creek continues south of the agricultural field to the mitigation property boundary. Review of historic aerial photography shows that this configuration dates back to at least the 1940s. A ranch house, out buildings, and corrals occupy the northern part of the main mitigation parcel.

The CNF abuts the eastern boundary of the ranch. The CNF system lands are generally characterized as undeveloped open space used for cattle grazing. Lands to the north and south of the ranch include open space, scattered residences and ranches, and agriculture. Much of this area has been subdivided for anticipated low-density residential development. A perennial spring, Monkey Spring, is located approximately 0.8 miles north of the main mitigation parcel and provides perennial surface water to the ranch. Certificated water rights from Monkey Spring are associated with the ranch for irrigation and stock watering purposes (described further in **Section 5.2.3**). A privately-owned property directly to the north of the ranch also owns water rights to Monkey Spring.

Water from Monkey Spring enters the site from the north and is used to fill two ponds for storage of irrigation water for the approximately 115-acre agricultural field in the west-center of the property. Historically, the fields were likely used to grow common crops such as alfalfa, milo, and corn.

5.2.1 Existing Vegetation

As mapped by Brown and Lowe (Brown and Lowe 1980), the ranch contains two vegetative cover types: Madrean evergreen woodlands in the higher elevations on the eastern portions of the ranch and semidesert grassland in the lower elevations on the western portions. Dominant tree species of Madrean evergreen woodlands include Emory oak, alligator juniper, one-seed juniper, and Mexican pinyon. Common shrub species include velvet mesquite, whitethorn acacia, and skunkbush. Grasses are abundant in Madrean evergreen woodlands and include species such as green sprangletop, dropseed, and plains lovegrass.

Semidesert grassland communities are found in the lower elevations of the ranch. Some areas within this vegetation community are nearly barren, with an abundance of sand, rock, or gravel, while other areas have sparse to dense vegetation cover including succulents, grasses, shrubs, scattered trees, and herbaceous cover. Common shrubs include velvet mesquite, catclaw acacia, burroweed, and ocotillo. A variety of other yucca and cacti species also occur intermittently.

The wetlands associated with the ponds are of note in that they have forested and emergent vegetative components as well as high species diversity. The forested areas generally occur on the wetland edges and include trees such as Arizona sycamore (*Platanus wrightii*), velvet ash (*Fraxinus velutina*), and Goodding's willow (*Salix gooddingii*). Commonly observed emergent vegetation included species such as barnyardgrass (*Echinochloa crus-galli*), common cattail (*Typha latifolia*), fragrant flatsedge (*Cyperus odoratus*), common spikerush (*Eleocharis palustris*), cloaked bulrush (*Scirpus pallidus*), and swamp smartweed (*Persicaria hydropiperoides*). Additionally, both wetlands have an open water component with submerged aquatic vegetation.

Riparian vegetation adjacent to existing ephemeral drainages occurs on the ranch along Sonoita Creek, Corral Canyon, and their major tributaries. Oak (*Quercus* sp.), Arizona sycamore, velvet ash, Goodding's willow, Arizona walnut (*Juglans major*), and desert willow (*Chilopsis linearis*) were commonly observed during field assessments, though mesquite was dominant, particularly in the northern part of the ranch.

Large meadows of big sacaton grass (*Sporobolus wrightii*) are present in the Sonoita Creek floodplain south of the agriculture fields and in the broad, flat areas where drainages flowing off the Canelo Hills discharge into the Sonoita Creek floodplain. These large sacaton bottoms contain interspersed velvet mesquite, desert willow, velvet ash, and Arizona walnut. Again, mesquites become more prominent as one moves north.

The approximately 115 acres of agricultural fields exhibit varying densities and degrees of maturity of mesquites, likely indicators of time lapse since the fields were last cultivated. The most recently-cultivated fields are characterized by tall, dried stalks of Johnson grass (*Sorghum halepense*) with almost no mesquite saplings. The next older fields have no grass stalks and numerous small, multi-stemmed mesquite saplings, which indicate simultaneous establishment, likely within a year or two of the last cultivation of the field. Progressively larger mesquites indicate fields with longer periods without cultivation, culminating in a relatively old field at the north end of the property, in which there is a diversity of mesquite sizes; the largest mesquites are approximately 20-feet tall and up to 12 inches in diameter.

5.2.2 Hydrology and Soils

Monkey Spring, a perennial spring located approximately 0.8 miles north of the ranch, provides a perennial water source to the interior of the ranch. Water is distributed via canal from Monkey Spring to a pair of ponds where it can then be diverted to the agriculture fields for irrigation or allowed to flow into the second pond for storage. The distribution canal consists of concrete-lined and earthen-lined stretches. Any excess water diverted to the agriculture fields, but not used for irrigation, travels the length of the fields (over 1.1 miles) in a concrete-lined canal and then discharges into a series of ponds used for livestock watering.

In April 2015, Rosemont installed a flow monitoring station within the irrigation canal upstream of the two onsite ponds to ascertain the volume and regularity of surface water from Monkey Spring flowing to the Sonoita Creek Ranch irrigation system. The flow monitoring indicates that Monkey Spring flows discharging to Sonoita Creek Ranch continue to be 5 to 12 percent higher than that allocated by the Certificate of Water Right for the property (WestLand Resources Inc. 2017). Details of the certificated water right are provided in **Section 5.2.3**. It should be noted that an additional water source can contribute flows to the monitored irrigation channel as well. The property to the north has an irrigation system with flows coming from a separate spring called Cottonwood Spring. The irrigation system includes a ditch which can overflow into the Monkey Spring irrigation ditch. Although reported as a rare occurrence, it is possible that flows from Cottonwood Spring are captured by the flow monitoring station and in the data reported.

Surface water flowing from Monkey spring support the two onsite ponds and the associated wetlands and robust riparian vegetation surrounding the ponds. The ponds have historically acted as storage reservoirs for irrigation activities at Sonoita Creek Ranch, and the water levels in the ponds, particularly the southernmost pond, can drop significantly during periods of intense irrigation in the dry summer months (May and June). When the fields both on and offsite are not being irrigated, the flows are discharged into the stock tanks south of the agricultural field.

Other surface water features on the ranch include ephemeral drainages, most notably Sonoita Creek and the Corral Canyon drainage. Sonoita Creek originates south of Sonoita in the northern foothills of the Canelo Hills, flows southward paralleling the east side of SR 82 as it travels through the ranch, flows through the town of Patagonia, impounds in Patagonia Lake, and ultimately discharges into the Santa Cruz River near Rio Rico, Arizona. Sonoita Creek is channelized along much of its reach, though the 100-year floodplain is modeled to encompass the entirety of the valley floor (**Figure 11**). Fremont cottonwoods (*Populus fremontii*) begin to appear along Sonoita Creek at the southern end of the mitigation site.

The Corral Canyon drainage also originates in the Canelo Hills and directs stormwater westward, along with its numerous tributaries, onto the Sonoita Creek floodplain south of the agriculture fields. Several smaller, ephemeral drainage features parallel Corral Canyon, flowing west toward the agricultural field. Channel structure is lost as the drainages reach the existing access road east of the agricultural fields and flows are directed southward, east of and along the unpaved access road. Several large washes flow into the property from the west, originating on the southeastern slopes of the Santa Rita Mountains and flowing under SR 82. These washes include those in Adobe, Wood, and Big Casa Blanca canyons.

Soil characteristics generally reflect the landscape position on the ranch. As the topography transitions from the hills on the east side of the property to the Sonoita Creek floodplain, the soils transition from a gravelly or cobbly loam to a sandy loam with some clay components. Clay and clay loam soils, indicative of wetland development and extended ponding of water, were observed in the wetland areas. Soils with a clay component were also observed within portions of the fallow agricultural fields.

5.2.3 Summary of Water Rights

As previously noted, Sonoita Creek Ranch has a certificated water right of approximately 590 AFA, associated with Certificate of Water Right No. 33-26063.0001 for Monkey Spring. Surface water rights in Arizona are based on the doctrine of prior appropriation, or "first in time, first in right," and the priority date is based on when a water was first put to beneficial use. A certificated, or perfected, surface water right is superior to all other surface water rights with a later priority date. The water right for Monkey Spring, reissued on November 15, 2013, certifies the priority right to October 30, 1973.

The certificated water right for Sonoita Creek Ranch is 75 percent of 785 AFA based upon measured spring discharge at the time of the Certificate of Diversion. Specifically, the water right is broken down as 588.75 AFA for irrigation purposes and 657,000 gallons (approximately 2.02 AFA) for stock watering. Cumulatively, approximately 590.77 AFA of certificated water right is appurtenant to Sonoita Creek Ranch.

Because the output from Monkey Spring is seasonally consistent, the percentage of water right is determined by usage times and not actually a measurement of flow volume. Sonoita Creek Ranch has water delivered for 15 hours a day from Tuesdays through Fridays (morning and nights), 19 hours on Saturday, 21 hours on Mondays, and 24 hours on Sundays for a total of 124 hours a week. The time Sonoita Creek Ranch receives water is slightly less than 75 percent of the hours per week (124 hours of 168 hours, or 74 percent of the time).

As noted above, flow monitoring indicates that Monkey Spring flows discharging to Sonoita Creek Ranch continue to be 5 to 12 percent higher than that allocated by the Certificate of Water Right for the property (WestLand Resources Inc. 2017).

5.3 Lower San Pedro River Wildlife Area ILF Project

The information in this section regarding the baseline ecological conditions at the LSPRWA ILF Project is provided in Lowery, et al (2016).

5.3.1 Existing Vegetation

Habitat within the LSPRWA ILF Project is generally divided into San Pedro River floodplain (40%), adjacent upland (50%) and agricultural fields (10%). The riparian habitat is in fair to good condition, with stands of invasive salt cedar (*Tamarix* spp.) interspersed with the native species. The vegetative communities within the riparian habitat are as follows:

- *Fremont Cottonwood-Goodding's Willow Gallery Forest* – This is a lowland, forested riparian association that occurs on low- to mid-elevation bars within and along the channel where flood-recurrence intervals vary widely, but typically range between 2 and 5 years. The vegetation is characterized by young to middle-aged stands of Fremont cottonwood and Goodding's willow with moderate to closed canopies (usually greater than 60 percent cover).
- *Mixed Riparian* – This category describes vegetation where Fremont cottonwoods and Goodding's willows are present but are co-dominant with other species, primarily saltcedar (*Tamarix ramosissima)*, but also Mexican elder *(Sambucus mexicana),* and seep willow (*Baccharis salicifolia)*. No single species comprises more than 80 percent of the total composition. Vegetation density is variable.
- *Riparian Strand* – Riparian strand vegetation occurs within the active channel and floodplain of the river on sandy/cobbly channel bars where more extreme moisture conditions occur and where scouring or depositional flows may be relatively common. Vegetation is composed of

short-lived successional species or plants adapted to periodic flooding, scouring, or soil deposition.

- *Velvet Mesquite Forest (Bosque)* – River terraces on the lower San Pedro River are dominated by a Mesquite *(Prosopis velutina)* Forested association (Brown 1994). This vegetation community occurs on mesic areas of floodplains, streambanks, and intermittently flooded arroyo terraces, alkali sinks and washes, and extends into the upland on dry terraces above streams and arroyos.
- *Saltcedar Mixed* – Young and mature saltcedar can be found throughout the floodplain where it is intermixed with cottonwoods and willows. It can also be found on the river terraces where it grows with mesquites. Both saltcedar and athel trees (*T. aphylla)* are found along the river channel. This community will be the focus of the restoration effort at the LSPRWA ILF Project.

5.3.2 Hydrology

The portion of the San Pedro River flowing through the LSPRWA ILF Project area is considered to be intermittent to perennial, depending on the location, a circumstance also described as interrupted flow. According to data from USGS stream gauges in the general vicinity of the LSPRWA ILF Project, months of lowest flow on the river tend to be in May and June, while highest flows tend to occur in the summer monsoon season during August and September. Stream flows in the San Pedro River follow the bimodal pattern of precipitation in this region, with intense and localized storm events in the summer and more gentle but sustained winter flows.

With regard to groundwater, data available from the Arizona Department of Water Resources (ADWR) identifies two major water-bearing units in the Lower San Pedro basin based on their ability to transmit and supply groundwater: 1) the streambed alluvium that forms the San Pedro River's channel and floodplain; and, 2) the alluvial basin-fill sediments that fill the valley. The streambed alluvium is more permeable than the basin-fill, but the alluvium's limited areal extent makes it an important local aquifer in the central valley along the San Pedro River floodplain. The alluvial basin-fill sediments are composed of a younger basin-fill, older basin-fill, and basal conglomerate and form the basin's principal aquifer because of its high permeability and large volume.

5.4 Stormwater Flow Mitigation

Three of the four stock tanks to be removed are located in the upper McCleary Canyon watershed (**Figure 12**). The dominant vegetation assemblage in this area is Madrean Evergreen Woodland, as described in **Section 5.2.1**. Barrel Canyon East Tank is located within Semidesert Grassland.
Rosemont Crest Tank, McCleary Canyon Stock Tank, and Barrel Canyon East Tank are all impoundments of ephemeral headwater washes while Gunsight Pass Tank was constructed in uplands. All of the tanks are ephemeral in nature.

6 MITIGATION WORK PLAN

6.1 SONOITA CREEK RANCH

Sonoita Creek Ranch provides a unique opportunity to both secure a valuable conservation parcel on the landscape and return a major Santa Cruz River tributary to its historic floodplain. The Sonoita Creek Ranch parcel is comprised of multiple subdivided parcels from the Rail X Ranch, Sonoita Creek Ranch, and South Sonoita Creek Ranch, all of which had been designated for residential development. Implementation of this mitigation plan will ensure that this important habitat link will remain in place. The mitigation project at Sonoita Creek Ranch is comprised of the following primary components:

1. *Reestablishment* of the Sonoita Creek riparian floodplain and channel, to include both WOTUS and associated riparian and upland buffer
2. *Rehabilitation* of the existing Sonoita Creek channel, to address erosion, failed stabilization efforts, and other effects of artificial channel confinement
3. *Enhancement* of two existing ponds to support recovery efforts for federally listed species
4. *Enhancement* of existing WOTUS and associated riparian buffer through the exclusion of livestock grazing and the installation of wildlife-friendly fencing
5. *Rehabilitation* of floodplain uplands, including recontouring, tilling, and seeding the existing agricultural field with native species

Details of these components are provided in the following sections. **Figure 13** provides a representation of all of these elements.

6.1.1 Reestablishment of Sonoita Creek Floodplain and Channel

The reestablishment of the Sonoita Creek floodplain and channel is described in the detailed design report developed by WET (**Attachment 2**). The cut-and-fill of floodplain material has been balanced so there will be no need to export soil offsite. The excess cut material will be deposited in designated repository locations. Additional description of the project is provided below, excerpted from the WET report.

On the Rail X Ranch property, Sonoita Creek has been confined between a fallow agricultural field to the west and the hillside to the east. To restore an unconstrained channel morphology to this area, a constrained reach of the Sonoita Creek channel will be abandoned and a constructed channel (the RX Channel) will divert flows from Sonoita Creek approximately 250 feet downstream of its confluence with the channel draining Adobe Canyon. This channel will meander through the agricultural field area, conveying Sonoita Creek flows through a 2,380-foot long single meandering constructed channel.

Development on the Sonoita Creek Ranch property has confined a significant reach of Sonoita Creek to a straightened alignment that lies between SR 82 on the west and an irrigated agricultural field on the east. In this area, another channelized reach of Sonoita Creek will be abandoned and Sonoita Creek flows will be diverted into the constructed SCR Channel. The SCR Channel is an 11,461-foot long mitigation channel beginning just north of the agricultural field. There are three existing ephemeral drainages east of Sonoita Creek that no longer have a direct flow path to Sonoita Creek since they are intercepted by an access road located along the eastern edge of the agricultural field. During construction of the SCR Channel, the three tributary channels will be extended to flow directly into the SCR Channel. The SCR Channel rejoins Sonoita Creek south of its confluence with Big Casa Blanca Canyon. Material excavated during construction of the SCR Channel and the three tributaries will be distributed among six soil repositories.

6.1.2 Rehabilitation of Sonoita Creek

As noted by WET (**Attachment 2**), decades of artificial confinement have resulted in a configuration of Sonoita Creek that maximizes flow velocities, causing the channel to be incised and unstable due to scour and degradation. Rosemont proposes to complete channel improvements on the existing Sonoita Creek to rehabilitate the channel.

Beginning at the confluence of Sonoita Creek and the SCR Channel, the east bank of Sonoita Creek will be modified to include a floodplain bench perched 2 feet above the existing channel bottom. The purpose of the bank widening is to reduce specific stream energy and the resulting high level of ongoing bank erosion, and to create a riparian zone which is currently non-existent in this reach. This reach of Sonoita Creek is currently extremely confined with vertical or near vertical banks 6 to 9-feet high that are actively sloughing and eroding. As proposed in the new design, the greater width, lower bank height, and flatter bank slopes will reduce flow velocity and associated bank erosion.

The bank improvements will begin at the Sonoita Creek – SCR Channel confluence and continue downstream for approximately 2,511 feet. The channel bench begins at a 100-foot width, and gradually transitions to a 25-foot wide bench at the downstream end of the bank improvement area, where Sonoita Creek has access to its floodplain. The existing bank heights in this area are relatively low (2 to 4-feet high). All the soil excavated from the bank improvement will be placed in the designated repositories.

6.1.3 Rehabilitation of Sonoita Creek Floodplain Uplands

Beyond the reestablished channel and associated buffer habitat, the remainder of the agricultural field and Sonoita Creek floodplain will be rehabilitated through recontouring, tilling, and seeding (see next, **Section 6.1.4**). This area includes the repositories for material excavated for the RX and SCR

Channels, which will more effectively connect the hillslopes on the east side of the parcels with the rest of the floodplain.

6.1.4 Seeding Plan

The primary goal of the seeding plan for Sonoita Creek Ranch is to establish native vegetation communities capable of maintaining and supporting themselves in perpetuity with little to no maintenance or artificial irrigation. The seeding plan applies to the reestablished channels and associated buffer, as well as the floodplain uplands. Components of the seeding plan include control of undesirable species, topsoil salvage, seeding of the reestablished riparian floodplain, and transplant of sacaton. These components are discussed further below.

6.1.4.1 Control of Undesirable Species

Portions of the agricultural fields are currently infested with stands of Johnson grass, a perennial noxious weed. Left untreated, Johnson grass will tend to proliferate, particularly in moist soils. Therefore, before the start of earthwork associated with the reestablishment of ephemeral channels and riparian floodplain, stands of Johnson grass as well as other undesirable perennial vegetation will be treated with contact herbicide. Treatment will be localized, i.e. only undesirable species will be treated. Where practicable, treatments will be made twice during the growing season, approximately six weeks apart, to ensure eradication. It is anticipated that each treatment will require two days.

Following the completion of earthwork operations and the application of native seed (described below), the restored project site will be closely monitored for weed species. Should undesired plant species such as Johnson grass or tumbleweed extensively colonize it, the site will be evaluated to determine if work to control the establishment of these plant types is warranted. Additional discussion of the performance standards and monitoring program are described in the appropriate sections that follow.

6.1.4.2 Topsoil Salvage

Topsoil typically contains a greater proportion of organic matter when compared to deeper soil strata. Decomposed organic matter contributes to the retention of moisture and nutrients within the soil. Seed from desirable native plant species (as well as undesirable noxious or nonnative species) are also found within topsoil. Topsoil contains native strains of microorganisms, such as mycorrhizal associations, that are beneficial to soil structure and native flora. For these reasons, it is desirable to salvage topsoil where practicable. Therefore, prior to the start of heavy earthmoving activities, topsoil from pre-selected areas within the field will be salvaged to an average depth of 12 inches. The soil will be stockpiled during construction, then spread over the surfaces of grades outside of the constructed channels following the completion of earthwork.

6.1.4.3 Seeding of Reestablished Riparian Floodplain

The primary goal of the seeding plan is to establish a self-sustaining native riparian vegetation community. Prior to the introduction of agriculture, the field appears to have been a "Loamy Bottom" ecological site, as described by the Natural Resources Conservation Service (NRCS). This supposition is supported by field observations of the site. Therefore, the project seed mix has been developed with the intention of restoring the flora of the project site to that historic condition, incorporating a mix of native forbs, grasses, shrubs, and trees that are consistent both with the NRCS Loamy Bottom description as well as field observations. The project seed mix is shown in **Table 2**.

In addition to the development of an appropriate seed mix, several other factors are critical to the success of the revegetation effort, including:

- *Preparation of the rough grades*. Following earthwork construction and the application of salvaged topsoil as described above, the rough grades will be properly prepared prior to the application of seed. First, site soils from numerous locations throughout the project will be sampled and tested for horticultural properties. Next, the soils will be amended as necessary following the recommendations of the horticultural analysis. These soil amendments will be tilled into the soil surface. Third, the grades will be tilled parallel to the contour and left in a roughened condition to promote rainfall retention and infiltration. Finally, in order to promote good seed-soil contact the seed will be applied while site soils remain loose and friable following tilling operations.
- *Confirmation of seed quality prior to application*. Seed will be obtained from local sources, where possible, to take advantage of local genotypes. All seed will be properly contained and labeled showing the plant species, seed purity, type and date of testing, seed origin, and weed content. Seed will be tested within 9 months prior to application and Certificates of Analysis from a legitimate seed testing laboratory will be required in addition to seed tags.
- *Timing of seed application*. If practicable, seeding will occur in late June, prior to the onset of annual monsoon rains, or in December, prior to the winter rainy season. However, while applying seed just before the onset of rainy seasons is desirable, it is by no means required to ensure seed germination. The proposed seed mix (**Table 2**) contains a diverse mix of species that can collectively respond (i.e., germinate) to a wide range of environmental conditions. In addition, high quality native seed can remain viable in the soil for years when correctly applied.
- *Appropriate seed application techniques*. Seed will be applied by means of specialized equipment designed for the purpose such as seed drill or hydraulic equipment.
- *Appropriate mulching of seeded areas*. Only mulch that is certified to be weed-free will be permitted. Since it has been shown to better resist soil evaporation and loss from wind, natural straw or

fabricated wood mulch will be used. Mulch will be crimped into the soil and/or tackified (i.e., glued into place) using a high-quality, non-toxic product.

All areas disturbed by construction activities (including the agricultural field) will be seeded.

Table 2. Proposed Seed Mix and Pounds per Acre of Seed for the Reseeded Area on Sonoita Creek Ranch

Scientific Name	Common Name	Pounds PLS/Acre
Graminoids		
Aristida purpurea	purple threeawn	0.25
Bothriochloa barbinodis	cane bluestem	0.29
Bouteloua curtipendula	sideoats grama	2.28
Bouteloua rothrockii	Rothrock's grama	0.09
Digitaria californica	Arizona cottontop	0.22
Leptochloa dubia	green sprangletop	0.16
Setaria macrostachya	plains bristlegrass	1.52
Sporobolus airoides	alkali sacaton	0.07
Sporobolus cryptandrus	sand dropseed	0.06
Graminoid Totals		***4.94***
Forbs		
Baileya multiradiata	desert marigold	0.16
Eschscholzia californica ssp mexicana	Mexican poppy	1.52
Kallstroemia grandiflora	Arizona poppy	0.89
Lesquerella gordonii	Gordon's bladderpod	0.40
Penstemon parryi	Parry's beardtongue	0.94
Plantago ovata	Indian wheat	2.00
Sphaeralcea ambigua	desert globemallow	0.16
Forb Totals		***6.07***
Woody (Subshrubs, Shrubs, Trees)		
Atriplex canescens	four wing saltbush	0.50
Chilopsis linearis	desert willow	0.50
Lycium andersonii	desert wolfberry	0.29
Prosopis velutina	velvet mesquite	0.25
Rhus trilobata	skunkbush sumac	8.71
Vachellia constricta	whitethorn acacia	0.50
Woody Totals		***10.75***
Seed Mixture Total		***21.76***

Riparian habitats are, by their very nature, dynamic environments. Scour of the reconstructed channel bottom will destroy some plants regardless of vegetative maturity. However, as described elsewhere in this HMMP, the geometry of the reconstructed channel will reduce flow velocities within the channel, thereby minimizing stream bank erosion. Outside of the reconstructed channels, the steps described above will minimize soil erosion resulting from sheet flow across the floodplain during storm events.

6.1.4.4 Transplant of Big Sacaton

Rosemont proposes to transplant up to 820 individuals of big sacaton as part of the restoration efforts. Prior to disturbance, Rosemont and its contractors will identify those individuals suitable for transplant and mark them in the field. Transplanted individuals will be treated with appropriate amendments or fertilizer, and irrigated with DriWater gel packs, providing a slow-release source of irrigation for each plant.

6.1.5 Enhancement of Two Ponds

There are two ponds at the northeastern end of the agricultural fields that are supplied by flows from Monkey Spring. The northernmost pond, which is the higher of the two, fills first and overflows into the lower pond. Overflow water from the lower pond is controlled by an existing structure that diverts water into the irrigation canal serving the agriculture fields. Both ponds are also plumbed at their downstream ends to facilitate draining for pond maintenance.

Rosemont will renovate the ponds with the intent to support recovery efforts for sensitive species, including, as appropriate, Gila chub, Gila topminnow, northern Mexican gartersnake, and Huachuca water umbel. Preliminary modification of the ponds will allow for a passive flow-through system to keep the surface water from stagnating or increasing in salinity (**Figures 14 and 15**). The pond system will be allowed to function largely as it currently does. Overflow outlets will be installed at the downstream end of both ponds allowing for surface water flow-through. The southern pond will discharge by overflowing into the constructed SCR Channel, thereby providing a consistent source of surface water at approximately one cubic feet per second (cfs), recharging groundwater and ultimately supporting a more mesic habitat in the vicinity of the discharge point.

In addition, harmful non-native fish and wildlife species will be eradicated from the pond system and portions of the ponds may be made shallower and planted with native aquatic species, including willow trees (*Salix* spp.). None of these preliminary activities will result in impacts to the fringe wetlands associated with the ponds.

6.1.6 Enhancement of Existing WOTUS and Buffers

In order to enhance the habitat connectivity function of the onsite ephemeral potential WOTUS (including the unaltered portions of Sonoita Creek) and associated 50-foot buffers, all portions of the mitigation parcel will be fenced in association with mitigation activities, to exclude domestic livestock while allowing wildlife movement into and through the parcel. In addition, a wildlife barrier fence will be constructed along the western boundary of the property to direct wildlife to the SR 82 crossings of Big Casa Blanca Canyon and Smith Canyon to reduce the risk of vehicle-wildlife collisions. The total perimeter fence length of Sonoita Creek Ranch is approximately 70,020 linear feet, of which approximately 19,616 feet is existing fence to be upgraded, 24,526 feet is new fence to be constructed, and the remaining 25,878 feet will be wildlife barrier fence along the highway. The fence will be maintained, and as needed replaced, during routine inspection and maintenance activities (**Section 9.2**).

The fence to be used at Sonoita Creek Ranch is that typically used at AGFD-managed parcels, and consists of multi-strand barbed wire with the bottom and top strands barbless to reduce injury to wildlife while passing through the fence. Barbed strands are necessary to ensure control of local livestock that may be attracted to the resources within the ranch and that have become accustomed to testing and exploiting fencing limits and weaknesses.

With the exception of the wildlife barrier fence along SR 82, the entire perimeter fence around Sonoita Creek Ranch will be made wildlife-friendly as part of the initial mitigation activities at the site. Where feasible, existing fence posts will be utilized and the top and bottom strands of barbed wire will be replaced to match AGFD designs. Establishment of this fence will enhance wildlife habitat associated with existing potential WOTUS and associated buffer by facilitating wildlife movement into and out of Sonoita Creek Ranch. In addition, some degree of enhancement of forage resources for wildlife will be realized by removing the competing livestock.

Existing gates on the ranch will allow access for monitoring, inspection, and maintenance purposes. Property boundary signage will be utilized to further inhibit trespass and unauthorized access, as needed.

Thirteen swinging flood gates or water bars will be installed as part of the boundary fencing of Sonoita Creek Ranch. These flood gates will be installed on the larger drainages, i.e. on Sonoita Creek where it crosses the parcel boundary and on upper Corral Canyon as the drainage crosses into the ranch from CNF lands. Swinging flood gates are important because fences across large, active drainages are subject to significant damage or destruction during flood events. Swinging flood gates are built by suspending horizontal or vertical bars across the width of the drainage with narrow spacing. The bars are sized and spaced to prevent wildlife or livestock from pushing through, but will move with sufficient force from floodwater or a buildup of flood debris. **Figure 16** shows the AGFD's recommendation for designing a wildlife compatible fence across active water crossings. **Figure 13** illustrates the locations of swinging flood gates at Sonoita Creek Ranch.

The remaining drainages that cross the property boundary are not anticipated to generate enough flow to require swinging flood gates. At these crossings, breakaway fences will be constructed (**Figure 13**). Crossings with breakaway fences will be inspected for any damage as part of the routine inspection and maintenance plan.

6.2 Stormwater Flow Mitigation

The four stock tanks to be removed were originally built to capture and contain surface water for livestock. Careful removal or breaching of the earthen dams will have beneficial effects on the hydrological function of the streams by restoring their natural geomorphology and flow regimes. Sediment that has been stored in the stock tanks will be distributed downstream, where it can aggrade incised channels. Vegetation along stream channels that has been deprived of water by the upstream impoundments will be benefited by restoration of natural flow regimes.

A description of the stock tank removal effort is provided as **Attachment 4**.

7 DETERMINATION OF CREDITS

The *Mitigation Ratio Setting Checklist* (12501.1-SPD) (MRSC) was completed for each of the mitigation components, per resource type. The completed MRSCs are provided as **Attachment 5**. A discussion of the rationale used for completing the MRSCs is provided in subsequent sections, and a summary of the calculated mitigation follows.

7.1 Functions

7.1.1 Background

Because a Corps-approved functional/condition assessment method has not been developed for ephemeral washes in Arizona, *Step 2* of the MRSC was utilized to develop a qualitative comparison between the impacted aquatic resources and those resources used for mitigation.

Included with the MRSC Instructions (12501.2-SPD) is a sample list of functions that may be utilized to compare the functional loss associated with the impact site with the functional gain at the mitigation sites. The functions provided are derived from Hydrogeomorphic Approach (HGM) models and most appropriately associated with wetlands, though Levick, et al. (2008) described how these functions might apply to intermittent and ephemeral washes. These functions specifically are:

- short- or long-term surface water storage;
- subsurface water storage;
- moderation of groundwater flow or discharge;
- dissipation of energy;

- cycling of nutrients;
- removal of elements and compounds;
- removal of particulates;
- export of organic carbon; and
- maintenance of plant and animal communities.

Per the provisions in the MRSC Instructions (12501.2-SPD), Rosemont worked with the Corps to develop and utilize a substitute list of physical/hydrological, biochemical, and habitat functions that are more directly attributable to the ephemeral streams that are being considered at both the impact site and the mitigation sites.

For each of the functions and associated benefits discussed below, the factor(s) that affect the capacity or degree to which a resource performs that function has been identified. These factors provide a way to qualitatively assess the potential for each mitigation feature to perform the identified function. For example, the capacity to which a stream provides the benefits related to the subsurface flow function is a direct result of the amount and duration of water conveyed by the stream and the volume of porous sediments beneath the stream. Therefore, a stream that has the potential to convey more water for a longer duration over deep sediments has higher potential to provide benefits related to subsurface flow than a small ephemeral headwater stream underlain by bedrock.

- **Surface Water Storage.** Long- and short-term surface water storage replenishes soil moisture, provides seasonal ponded areas for nutrient transformation, provides seasonal habitat for aquatic organisms and amphibians, reduces peak flood discharges, and can improve downstream water quality through temporary retention (Smith et al. 1995). The ability of a stream to provide this function is influenced by the surface area exposed to flows, the gradient of the stream, and the presence of off-channel storage within the floodplain. Therefore, the volume of potential storage is indicated by the presence of an active floodplain and depressional features within the floodplain (Fischenich 2006). In addition, pool features within the stream itself can provide for in-channel storage. For these reasons, among others, smaller channels with narrow floodplains and steep gradients often have lower surface water storage potential compared to larger channels (Levick et al. 2008).
- **Subsurface Flow.** The storage and flow of subsurface water in ephemeral streams maintains biogeochemical processes through alteration of aerobic and anaerobic zones, soil moisture, riparian habitats, and animal biodiversity (Fischenich 2006; Smith et al. 1995). These processes occur in the hyporheic and parafluvial zones (Levick et al. 2008) of streams where subsurface moisture interacts with or is supported by groundwater and the capacity to perform this function is dependent on the volume of substrate in these zones. Headwater streams with

shallow depths to bedrock have lower capacity to perform this function than do streams with moderately deep hyporheic/parafluvial zones.

- **Energy Dissipation.** The composition of channels and floodplains of streams affect the level of energy of the water that moves through that stream. Lower stream energy typically results in slower velocities which reduces downstream particulates (Smith et al. 1995), prevents excessive erosion, and maintains water quality (Levick et al. 2008). The energy of water in a stream is determined by the slope, geometry, and roughness of the channel. Headwater streams with high roughness can reduce energy; however, in ephemeral desert streams without substantial bedrock grade control, erosive flows can occur. Streams with lower gradients, more sinuosity, and larger floodplains can better dissipate stream flow energy over a larger area and act as depositional environments.
- **Groundwater Recharge.** The recharge of groundwater systems by streams maintains groundwater dependent habitats such as riparian habitats and base flows (Smith et al. 1995) in groundwater fed streams and wetlands within the same groundwater basin. Groundwater recharge is a measure of the amount of surface water transmitted to deep groundwater storage basins. The amount of recharge is dependent on the porosity and depth of the substrate underlying the wetted surface area of streams as well as the stream gradient. Groundwater recharge is highest in mid catchment or "mountain front" recharge areas (Levick et al. 2008), as lower reaches often have higher rates of evapotranspiration and higher reaches are bedrock constrained.
- **Sediment Transport.** Appropriate sediment transport is important for maintaining natural sediment regimes and disturbance processes throughout the watershed as well as promoting appropriate rates of erosion and deposition for downstream channel forms (Fischenich 2006). Sediment transport capacity is controlled by sediment mobility, flow magnitudes and flow frequency (Fischenich 2006). While headwater streams collectively provide important sediment sources for downstream waters (Levick et al. 2008), individually their capacity to transport sediments is relatively small due to the immobility of their sediments (e.g. bedrock) and lower flow volumes. Lower gradient streams store sediment in low- to mid-flow events, but can be significant sources of sediment during high flow events. For this reason, such streams can be an important buffer in the storage and transport of sediment throughout the river system.
- **Biogeochemical.** Biogeochemical functions in ephemeral streams include cycling, removal, detention, and export of elements, compounds and particulates (Levick et al. 2008; Smith et al. 1995). The capacity of a stream to perform these functions is based largely on organic matter inputs and water-sediment contact (redox potential). The greater the organic inputs, water-sediment contact surface, and water-sediment contact time (Fischenich 2006) the greater the capacity for biogeochemical processes to occur. Small headwater streams concentrate and

store nutrients, while complete removal of nutrients (e.g. nitrogen) often relies on anaerobic conditions dependent on prolonged moisture (Levick et al. 2008). Nutrient "spiraling" is a process associated with streams during which nutrients are consumed and regenerated for reuse after being displaced downstream and therefore is dependent upon an intake stream system (Webster and Patten 1979). Particulate detention is a physical process that is dependent on the ability of a stream to store particulates in depositional areas (Levick et al. 2008; Smith et al. 1995), such as a floodplain. It is expected that nutrient processing increases with greater contact with sediments which occurs in lower gradient streams. In addition, pollutants are often retained in the lower gradient stream beds.

- **Organic Carbon Export.** The export of organic carbon enhances the deposition and mobilization of metals, supports biogeochemical processes (Smith et al. 1995) and is the primary source of energy for downstream foodwebs (Levick et al. 2008). Headwater streams and floodplain channels are the most important sources of carbon as they store large amounts of carbon from plant matter which are transported to downstream waters during storm events (Fisher and Likens 1973). Much of this carbon is derived from upland and riparian habitats adjoining the stream. Given the greater edge effect associated with headwater streams, they are important sources of organic carbon that is then deposited in lower gradient streams.
- **Habitat Connectivity/ Structure.** Streams that support significant riparian habitat maintain plant and animal communities that are more diverse and are distinct from surrounding uplands and provide corridors promoting regional biodiversity (Levick et al. 2008; Fischenich 2006; Smith et al. 1995). These benefits are largely a product of increased cover and nutrient sources. Species diversity is determined by depth to groundwater, watershed size, as well as soil, elevation, and climate conditions. In smaller streams, species composition and diversity is similar to the surrounding uplands and becomes more distinct and more diverse with increasing availability of water and flood intensity (Levick et al. 2008).

Using these functions, an assessment was made for each of the mitigation sites in comparison to the impact areas at the Project Site. As described above, two types of ephemeral streams occur within the Project Site. The first are tributaries to Barrel and Wasp canyons and others that are small, first order drainages with steep gradients, near surface bedrock, and little access to an adjoining floodplain. These tributaries drain into larger wash systems typified by those within Barrel and Wasp canyons. These are lower gradient ephemeral washes with vegetation densities that are greater along the edges of the washes and consisting of drier xeroriparian species.

In addition, the mitigation project at Sonoita Creek Ranch results in the loss of two channelized reaches of Sonoita Creek. The impacts to these portions of Sonoita Creek were also assessed in comparison to the mitigation offered at the site.

For each restoration and enhancement activity within the mitigation areas, the functions that will be achieved with the mitigation activity were evaluated in relation to the function within the impact areas that will be lost with development. This provides a qualitative evaluation of the equivalency, improvement, or loss of function associated with the specific mitigation measures.

A brief narrative description of the functional improvements to be realized at the mitigation parcels is provided in the following sections, followed by a summary of mitigation credits to be provided by the mitigation program.

Revised mitigation ratio setting checklist worksheets are included with **Attachment 5**.

7.1.2 Sonoita Creek Ranch

The scope of the Sonoita Creek restoration project is fully described in **Section 6.1** of this HMMP. This project represents a unique opportunity to realize considerable environmental lift by returning a major Santa Cruz River tributary to its historic floodplain, as well as securing a valuable conservation parcel.

Sonoita Creek has been channelized through the mitigation parcel since at least the early 20th century, which has resulted in channel incision and effective isolation of the channel from its historic floodplain. The proposed restoration project will return Sonoita Creek flows to the riparian floodplain, which is well recognized as a critical component of a functioning stream (Opperman et al. 2010; Kondolf et al. 2013). Existing washes, riparian, and upland habitats will be enhanced by the exclusion of livestock grazing while promoting wildlife movement through the parcel.

7.1.2.1 Reestablishment of Sonoita Creek Floodplain and Channel

The reestablished riparian floodplain system, including ephemeral channels and associated riparian habitat, have been designed to replicate, to the extent practicable, the form and function (gradient, sinuosity, composition, etc.) of the previous system that existed within the Sonoita Creek floodplain prior to the channelization of Sonoita Creek into its current configuration.

The extent of WOTUS created by the constructed channels is defined by the ordinary high water mark (OHWM). The OHWM may be difficult to identify in a constructed channel before natural processes develop the geomorphic characteristics of a naturally functioning system that define OHWM in the arid west, e.g. the active channel boundary (Lichvar and McColley 2008). Curtis, et al (2011) observed that the determination of OHWM based on particular flood events is problematic in the arid west, with OHWM-defining flood flows ranging from < 1- to 15.5-year flood event. For the purpose of determining the OHWM for the constructed (reestablished) channels at Sonoita Creek Ranch, the aerial extent of flood inundation for the 5-year/24-hour flood event was determined by the Corps to represent the OHWM-defining event. It is noted, however, that the actual extent of WOTUS reestablished at Sonoita Creek could ultimately be greater.

The detailed design for the constructed channels at Sonoita Creek Ranch is provided in **Attachment 2**. The unconstrained channel morphology designed for the project provides significant hydrologic and habitat functions. Specifically, as designed the shallow channel morphology will allow flows to access a functional floodplain which is wetted during frequent overtopping events when compared to the events that overtop the existing incised, constrained channel. Shallow, meandering out-of-bank flow will serve to dissipate flow energy and reduce flow velocities during flood events, which will both reduce erosion and promote deposition of material. In addition, flood peaks will be attenuated through increased infiltration along the stream course and short-term storage of water in the riparian corridor. The shallower flow regime and short-term subsurface water storage will support shallow groundwater in the riparian corridor, which remains available to streamside vegetation, improving habitat.

When comparing the reestablished floodplain and channel system at Sonoita Creek Ranch with the 19.2 acres of the larger drainages (Barrel and Wasp canyons) that will be impacted by the Rosemont Project, one of the largest distinctions is the extent of alluvium (i.e. subsurface water storage). Review of recent aerial photography shows the width of the broad Sonoita Creek floodplain ranging from approximately 900 to 1,500 feet in the vicinity of the Sonoita Creek Ranch mitigation site. This estimate is based on the geomorphology of Sonoita Creek on and near the mitigation parcel, and the assumed floodplain prior to development of SR 82 and the agricultural field, and largely reflected by the FEMA-mapped 100-year floodplain (**Figure 11**). By comparison, the width of the floodplain of the relatively confined Barrel Canyon (the largest drainage to be impacted by the Rosemont Project) is generally less than 100 feet (FEIS, p. 410). Review of four ADWR logs (from 1981 to 2008) indicate that the depth of alluvium associated with Sonoita Creek ranges from 20 to over 300 feet, while the alluvium within the drainages at the Project Site is generally on the order of 2- to 4-feet thick (FEIS, p. 410).

Sonoita Creek at Sonoita Creek Ranch drains a watershed of approximately 91 square miles, while the combined watersheds of the impacted Barrel and Wasp canyons have a watershed of less than 6 square miles. With a total watershed area of 260 square miles, Sonoita Creek occupies a place in the landscape more similar to Cienega Creek (414 square miles) than Barrel Canyon. Like Sonoita Creek, Cienega Creek is a significant tributary of the Santa Cruz River, and supports perennial flows and riparian gallery forests along a portion of its reach. As described above, Sonoita Creek and Cienega Creek occur in adjacent watersheds and straddle the same groundwater basin.

Comparison can also be made between the current channelized reach of Sonoita Creek and the reestablished channels proposed in this HMMP. As described elsewhere in this HMMP, the channelized reaches of Sonoita Creek are currently performing most functions poorly and the proposed restoration project will return this system to a more natural configuration, allowing storm flow access to the adjacent floodplain.

The 2008 Mitigation Rule allows for mitigation credit for non-aquatic riparian buffer habitat "where necessary to ensure the long-term viability of" aquatic resources (33 C.F.R. § 332.3(i)), and that is certainly the case for the reestablished riparian habitat within the Sonoita Creek floodplain. It is important to note that this mitigation component goes well beyond the simple "preservation" of buffer habitat. The return of Sonoita Creek flood flows to its currently isolated floodplain will restore function to a substantial floodplain resource that is over 4.8 miles in length, thereby meeting TNC goals (**Section 4.2.1**).

Given the shallow flow design of the floodplain restoration effort, it is not reasonable to segregate the function of the defined reestablished channels from the adjacent reestablished riparian habitat. The aquatic functions supported by the ephemeral channels apply equally to the adjacent riparian floodplain habitat, with the understanding that the riparian habitat will not be inundated by storm flows with the same regularity as the channel itself. Significantly, the riparian floodplain habitat will be reestablished on the large volume of alluvium within Sonoita Creek, promoting groundwater recharge and hydrologic connectivity to the downstream perennial reach of Sonoita Creek.

Work completed by Fry, et al (1994) on arid systems in Arizona indicates that a minimum of a 75-foot buffer is appropriate, at least on larger drainages. Fry, et al. (1994) note that buffer widths between 75 and 100 feet (which includes some uplands) provide for the protection of high functioning streams, the maintenance of mildly disturbed streams, and the enhancement of more severely disturbed streams. In order to promote flood attenuation, one of the key functions of the restored riparian floodplain, Fischer and Fischenich (2000) recommend riparian buffers from 60 to 500 feet to intercept overland flow and increase flood travel time, to reduce flood peaks. Based on this, acreages for riparian buffers along the reconstructed channels of Sonoita Creek were calculated utilizing a conservative 50-foot buffer width.

7.1.2.2 Rehabilitation of Sonoita Creek

Rehabilitation of the Sonoita Creek channel will result in a more stable channel, thereby reducing bank erosion and excessive sediment transport while promoting groundwater infiltration and wildlife habitat development. While direct rehabilitation measures will be completed, key to the rehabilitation of the main channel of Sonoita Creek will be the construction of the SCR Channel as part of the reestablishment of the Sonoita Creek floodplain.

7.1.2.3 Enhancement of Ponds

The ponds and associated overflow channels are the only perennial features at the mitigation site, and there are no perennial surface water features at the impact site. Although this mitigation is out of kind with the impacts to potential WOTUS, the enhancement of these ponds will support federally-listed species, as well as aquatic and terrestrial wildlife in general. The value of enhancing aquatic habitat for the benefit of sensitive species, including species listed under the Endangered Species Act, is well recognized by the 2008 Mitigation Rule (e.g. see language at § 332.3(j)(3)) and the MRSC (Example #7 notes the higher function of a habitat that supports the federally-endangered least Bell's vireo). Moreover, the 2008 Mitigation Rule is clear that compensatory mitigation "may be designed to holistically address requirements under multiple programs and authorities for the same activity" and more specifically, that "[c]ompensatory mitigation projects may also be used to provide compensatory mitigation under the Endangered Species Act ..." 33 C.F.R. §332.3(j); 40 C.F.R. §230.93(j).

7.1.2.4 Enhancement of Ephemeral Channels and Riparian Buffer

Enhancement of all onsite ephemeral washes and riparian buffer (including the existing Sonoita Creek channel, Corral Canyon, and the other tributaries on the east side of the property) will be accomplished by the construction of wildlife-friendly fence and exclusion of livestock grazing. The functions to be enhanced within the potential WOTUS at Sonoita Creek Ranch as a result of the exclusion of grazing are wildlife connectivity (through the construction of wildlife-friendly fencing) and wildlife habitat (through the anticipated modest increase in forage production).

As described above, the buffer width for mitigation credit is estimated at 50 feet.

7.1.3 Lower San Pedro River Wildlife Area ILF Project

As described by Lowery, et al (2016), activities proposed at the LSPRWA ILF Project include the reestablishment of a mesquite bosque within old agricultural fields and restoration of native riparian species where invasive salt cedar occurs. The perennial nature of the stream system at this site provides the full suite of hydrologic functions at a high level, as well as physical and habitat functions. The proposed activities are anticipated to substantially improve the full suite of evaluated functions.

7.1.4 Stormwater Flow Mitigation

Removal of the four selected impoundments at the Rosemont Project will reestablish ephemeral flows in these channels, improving sediment transport and hydrologic connectivity. This effort will include physical manipulation of the channels both above and below the existing impoundments as necessary to address head cutting, channel incision, and bank stability.

7.2 Mitigation Site Location

Step 4, mitigation site location, requires a determination as to whether the mitigation site, or sites, is within the watershed of the impact site. Per direction from Arizona Corps staff (in a meeting on February 26, 2014), Rosemont understands that the watershed of concern is that defined by the USGS 8-digit Hydrologic Unit Code (HUC 8). Sonoita Creek Ranch and the LSPRWA ILF Project are outside the watershed (HUC 8) of the Project Site though all of the parcels are located in the same

HUC 6 (Santa Cruz River). The stock tank removal project is, of course, within the same HUC 8 as the Project.

7.3 No Net Loss of Aquatic Resource Surface Area

As previously noted, the total area of potential WOTUS lost as a result of the Rosemont Project is 40.4 acres plus the loss of approximately 8.9 acres of loss of Sonoita Creek at the mitigation parcel. The mitigation package provided in this HMMP includes reestablishment of approximately 57.4 acres of WOTUS at Sonoita Creek Ranch through the construction of channels in the Sonoita Creek floodplain. As such, the mitigation package provided by Rosemont will result in a net increase in the area of WOTUS as well as an increase in functions and services to existing WOTUS.

7.4 Type Conversion

7.4.1 General Discussion

Step 6 of the MRSC requires a determination as to whether out-of-kind mitigation is appropriate or warranted. As noted in the preamble to the 2008 Mitigation Rule,

> "[t]he term 'in-kind' in § 332.2 [§ 230.92] is defined to include similarity in structural and functional type; therefore, the focus of the in-kind preference is on classes of aquatic resources (e.g., forested wetlands, perennial streams)." (73 FR 19601)

As such, any mitigation that includes ephemeral washes (the class of aquatic resource impacted at the Project Site) would be considered in-kind by the Rule.

The MRSC Instructions (12501.2-SPD) allow that

> "out-of-kind mitigation can be appropriate if the proposed mitigation habitat type serves the aquatic resource needs of the watershed/ecoregion. In considering out-of-kind mitigation, project managers should consider whether impacts or mitigation would consist of rare or regionally significant habitat types (e.g., vernal pools)."

Rare or regionally-significant habitat types in southern Arizona would include perennial water features, such as the ponds at Sonoita Creek Ranch and the perennial systems at the LSPRWA ILF Project.

The aquatic resources to be impacted at the Rosemont Project are almost exclusively ephemeral washes. These washes do not represent rare or regionally significant habitat types as ephemeral washes are common in southern Arizona.

7.4.2 Sonoita Creek Ranch

The proposed restoration activities at Sonoita Creek Ranch offer a rare opportunity to return a landscape scale aquatic feature to a more natural function. Unlike the ephemeral washes impacted at the Rosemont site, Sonoita Creek represents a substantial riparian corridor between the Santa Rita Mountains and the Canelo Hills. The perennial reach of Sonoita Creek begins immediately downstream of Patagonia (approximately 3.4 miles downstream of the mitigation parcel), flowing through the Patagonia-Sonoita Creek Preserve and into Patagonia Lake.

The reestablished riparian floodplain habitat will allow the existing mesquite/sacaton association to extend through the current agricultural field, which is currently dominated in places by Johnson grass. The mesquite/sacaton association, which currently occupies less than five percent of its original distribution, is "recognized for [its] important ecological functions and landscape values - absorbing flood flows, controlling soil erosion, and intercepting and retaining sediments. As the most productive of semi-arid grassland communities, they provide abundant forage for livestock and habitat for wildlife" (Tiller et al. 2012). Efforts are ongoing at the Las Cienegas National Conservation Area to better understand the distribution and ecology of this important habitat (Tiller et al. 2012). The reestablished riparian buffer associated with the constructed channels will be comparable to the resource along unimpacted reaches of Sonoita Creek.

In addition, the enhanced ponds, characterized by perennial surface flows and high-density vegetation, represent extremely rare habitats on the arid landscape. These ponds have significant value in providing an opportunity to promote the recovery of sensitive aquatic species (AGFD 2009).

The enhanced ephemeral washes and associated buffer habitat are comparable to the smaller washes associated with the Rosemont impact site, and therefore represent in-kind mitigation.

Mitigation of the channelized portions of Sonoita Creek with the more sinuous reestablished channels results in an in-kind, albeit improved, condition.

7.4.3 Lower San Pedro River Wildlife Area ILF Project

While the xeroriparian and upland vegetation communities of the Project Area play an important role in desert ecology, they are more common and provide less functional value when compared to the riparian areas along the Lower San Pedro River offered by this ILF.

The mitigation areas of the LSPRWA ILF Project provide opportunities for restoration, enhancement, preservation, and long-term management along the Lower San Pedro River. Upon achievement of the mitigation success criteria, the riparian restoration area within the LSPRWA ILF Project would provide high quality riparian habitat deemed both rare and important within Arizona.

7.4.4 Stormwater Flow Mitigation

The proposed mitigation for potential reductions in downstream flows are comparable to those potential reductions. As such, no adjustment is made for type conversion.

7.5 Summary of MRSC Evaluation

A summary of mitigation credits provided by this HMMP is provided in **Table 3**.

Table 3. Summary of Mitigation Credits Provided by All Mitigation Elements

Mitigation Component		Impacted Potential WOTUS								
		Barrel/Wasp Canyons (19.2 ac)			Sonoita Creek Fill (8.9 ac)			Rosemont Headwaters (21.2 ac)		
Description	Size (ac)	Acres Applied	Ratio	Mitigation Credits	Acres Applied	Ratio	Mitigation Credits	Acres Applied	Ratio	Mitigation Credits
Sonoita Creek Ranch										
Reestablished channel	57.4	48.0	2.5:1	19.2	9.4	1.95:1	4.8			
Reestablished channel buffer	34.6				22.0	5.4:1	4.1	12.6	6.4:1	2.0
Rehabilitated channel and buffer	12.1							11.2	6.2:1	1.8
Enhanced ephemeral washes	21.9							21.9	4.2:1	5.2
Enhanced ephemeral wash buffer	66.3							66.3	7.2:1	9.2
Enhanced ponds	6.0							6.0	3.7:1	1.6
SCR rehabilitated floodplain uplands	117.8							12.9	9.2:1	1.4
Total				**19.2**			**8.9**			**21.2**
Other available mitigation elements										
LSPRWA ILF Project	50								4.8:1	

8 SITE PROTECTION INSTRUMENT

The mitigation parcels are comprised of property that will be solely owned by Rosemont. A Restrictive Covenant will be provided to the Corps in draft form within 30 days of the start of construction of the Project. The most current Restrictive Covenant form (**Attachment 6**) will be utilized as the site protection instrument, with any potential issues negotiated between Rosemont and the Corps prior to final execution. Additional attachments and information requested by the Corps, such as title reports, any necessary easement rights, or aerial and ground photo coverage, will be provided to the Corps.

The site protection instrument will be recorded within 30 days of receipt of comments from the Corps acceptable to Rosemont, or notification that the form of the draft document submitted is acceptable to the Corps. The recordation of the site protection instrument(s) shall ensure the long-term protection of the mitigation site.

Rosemont will provide 60-day advance notice to the Corps before any action is taken to void or modify the instrument, management plan, or long-term protection mechanism, including transfer of title to, or establishment of any other legal claims over, the compensatory mitigation site.

The Restrictive Covenant is intended to remain in place until the implementation and establishment phases of mitigation are complete. Once a suitable conservation partner has been identified and accepted by the Corps, Rosemont may protect the mitigation parcels by recording a Conservation Easement with the third-party conservation partner. Should participation of a third-party manager include establishment of a conservation easement conferring rights to the third-party manager, any subsequent conservation easement recorded on the mitigation parcels would incorporate by reference the requirements of the Restrictive Covenant recorded in accordance with the requirements of the approved final HMMP.

Acceptable long-term uses of the mitigation lands are described in **Section 12.2** of this HMMP.

9 MAINTENANCE PLAN

Maintenance activities at the mitigation parcels will be completed by a qualified organization(s) retained by Rosemont. If Rosemont conveys ownership of the mitigation site to another party, the maintenance requirements would remain with Rosemont unless also conveyed to the new owner.

In general, “inspections” refer to routine evaluations of the property to ensure that it is still secure and functioning property, i.e. fence inspections, ensuring the property is free of litter, etc. Maintenance activities are typically completed as a result of inspections. By contrast, “monitoring” (**Section 11**) refers to the routine assessment activities completed to ensure that the established performance standards (**Section 10**) are met.

9.1 Property Inspections

Property inspections shall occur at least once every three months. A key element of the maintenance program will be the regularly scheduled inspections to identify maintenance needs and ensure that no uses prohibited by the conservation easements or other approved instruments are occurring within the mitigation parcels. Minor maintenance activities may be carried out during these visits; however, any need for more intensive maintenance activities will be identified for follow-up action. Information collected during the general inspection will be documented on a standard form(s) and summarized in the annual report (**Section 11.3**).

9.2 Fence Repairs or Replacement

Fencing is proposed as a mitigation measure for the Sonoita Creek ranch mitigation parcel. It is estimated that portions of the fence will need to be repaired each year due to fallen trees, vandalism, livestock breaking through a fence, or other means by which small sections of the fence are damaged. The full length of all fences will be inspected twice per year during the 15-year monitoring period for each parcel. If inspections indicate that the fence inspection schedule requires or allows for modification, that modification will be reviewed with the Corps. All fence repairs will be made within two weeks of identifying the problem. Most minor fence repairs would be made during semi-annual fence inspections.

9.3 General Maintenance

General maintenance of the mitigation parcels will facilitate achievement of mitigation objectives identified in **Section 3**. For documentation and reporting purposes, maintenance activities will be categorized into two types, "minor" and "major." A minor maintenance activity (MIMA) is one that can be completed within an estimated two weeks and does not need to be reported to the Corps. MIMAs may include but are not limited to repairs such as tree limb damage, wildlife disturbance, minor fence repairs, clearing of vegetation from fencelines that may cause future damage, small-scale re-vegetation of wildcat roads or trails from trespassers, picking up of trash, or other minor cleanup activity.

A major maintenance activity (MAMA) is one that would take more than an estimated two weeks to be completed. Examples of MAMAs may include but are not limited to severe fence or swinging gate damage from flood events or severe fence damage from wind or rain, or other unforeseen major maintenance activity. All MAMAs will be reported to the Corps within 24 hours of identification, and documented in the annual report (**Section 11.3**). Maintenance activities (MIMAs and MAMAs) completed will be documented on standard forms.

9.4 Site Specific Maintenance

9.4.1 Sonoita Creek Ranch

The restoration and enhancement designs at Sonoita Creek Ranch are designed to function as passively and be as maintenance free as possible. Maintenance considerations for individual mitigation components at Sonoita Creek Ranch are as follows:

- Constructed channels and riparian buffer – as noted in the design prepared by WET (**Attachment 2**), the constructed channels are designed to require no maintenance. Areas of erosion will be addressed as part of regular monitoring activities described in **Section 11.1**.
- Ponds – the pond enhancements are designed to be as passive and self-sustaining as practicable, with no pumps or complex controls. Flows between ponds and from the southern pond to the SCR Channel will be via gravity.

9.4.2 Stormwater Flow Mitigation

Maintenance of the stock tank removal sites is anticipated to be minimal. These sites will be inspected for excessive erosion and to ensure proper stormwater flow.

10 ECOLOGICAL PERFORMANCE STANDARDS

10.1 Sonoita Creek Ranch

The ecological performance standards for the Sonoita Creek Ranch mitigation parcel are provided in **Attachment 7**, a completed *Worksheet for SPD Uniform Performance Standards for Compensatory Mitigation Requirements* (12505.2-SPD). This worksheet also identifies interim performance standards for Years 5 and 10, as well as the ultimate Year-15 standards described as follows. Detailed discussion for the selection of the performance standards are provided in the following sections.

10.1.1 Reestablished Sonoita Creek Floodplain Channels

The performance standards established for the RX and SCR channels are reflective of the design goals of restoring Sonoita Creek to an unconstrained channel system that can exhibit dynamic channel morphology, dissipate energy, and provide stormwater access to a functional floodplain. These performance standards are described below.

- *Channel complexity* – Channel complexity is achieved with any of the following: bar formation and/or bar destruction, cut-bank development, channel cutoff-chutes, general topographic variation to the active channel and floodplain benches, and variability of channel width.

Channel complexity will be assessed annually, as well as during the 5-year topographic surveys, described in **Section 11.1.1.4**.

- *Floodplain access* – This performance standard is met when the RX and SCR channels show evidence of inundation to their respective floodplain benches during a 10-year, 24-hour storm. Inundation of the floodplain benches shall be assessed by review of gage data along with visual observations of high-water marks and other indicators that will be made during the annual channel inspection.

- *Limit lateral migration* – The reestablished channels have been designed and located to allow for the natural lateral migration that would be expected in this type of system. The RX and SCR channels will be allowed to migrate laterally within a given area (**Figures 17 and 18**). The migration limits provide ample room for natural lateral migration while protecting important infrastructure such as the gas pipeline, SR 82, and the ponds. In addition, a 30-foot buffer inside the lateral migration boundaries will be established to function as an action trigger. The limits of this buffer will be staked at the end of construction to facilitate inspection. If lateral migration is observed to occur past this buffer, adaptive management measures will be evaluated.

- *Limit vertical incision* – Complex mechanisms such as debris deposition and extreme flow events can combine to cause vertical erosion in arid, ephemeral channels. Sometimes a major runoff event that results in channel down-cutting will be followed by subsequent events that redeposit sediment and fill in the channel. Therefore, should localized incision occur in the reestablished channels, it may be self-healing over time and may not require mitigation. The occurrence of vertical erosion will be monitored and documented. Adaptive management measures will be evaluated if it is determined that the main channel has become entrenched and disconnected from the benches and floodplain, i.e. channel floodplain benches will no longer be inundated during a 10-year, 24-hour storm runoff event. If erosion is observed in any reach, a hydraulic model will be run on these reaches of concern using the 10-year, 24-hour discharge, and the resulting surface water profile will be compared to the new channel geometry to determine if peak flows can still access the floodplain benches.

10.1.2 Sonoita Creek Floodplain Seeding

The conceptual framework used here for understanding potential vegetation dynamics is the state-and-transition model (Bestelmeyer et al. 2009), keyed to Natural Resources Conservation Service (NRCS) ecological sites. The state-and-transition model is based on the recognition that the vegetation of an ecological site can adopt more than one state, moving among the states depending on the history of weather, fire, grazing management, road development, and other factors. In the NRCS system of land classification, land under consideration is categorized to an ecological site based on its landscape position, topography, and soils, without reference to its present vegetation. The floodplain at Sonoita Creek Ranch is classified in the Loamy Bottom ecological site, characterized by a landscape position in a valley or swale, flat or gently undulating slope, with deep loam or silty loam soils, at 4,000- to 5,000-foot elevation. Included in the Loamy Bottom ecological site guide is a state-and-transition model which identifies the following potential states:

- Sacaton Grassland (sacaton grass cover 25 to 80 percent, mesquite cover 0 to 15 percent, annuals 0 to 20 percent)
- Mesquite, Sacaton (sacaton cover 5 to 40 percent, mesquite and other shrubs cover 5 to 20 percent)
- Eroded Sacaton (active rills and gullies, sacaton cover 20 to 50 percent, mesquite cover 0 to 15 percent, reduced flooding)
- Eroded Mesquite (severe gully and streambank erosion, mesquite cover 20 to 80 percent, other shrubs and cacti 0 to 10 percent, no flooding)
- Annuals (a trace of sacaton, dominated by annual forbs and grasses, shrubs 0 to 10 percent cover)
- Exotics (dominated by Johnson grass and/or bermudagrass, mesquite cover 1 to 15 percent).

The Sacaton Grassland state is described as the Historic Climax Plant Community, but requires regular fire to minimize establishment of mesquite, with a water table <20 feet and/or regular flooding. In the absence of fire, mesquite increases until the site transitions to the Mesquite, Sacaton state. The eroded, annuals, and exotics states are produced by prolonged drought, overgrazing, and/or the loss of flooding by the stream due to channel incision.

The proposed mitigation measures in this HMMP include cessation of farming and grazing, reestablishment of Sonoita Creek to its pre-diversion floodplain, and seeding of native species on the floodplain. These significant changes to the ecology and hydrology will allow the newly-established vegetation to evolve according to the state-and-transition model described here, and the model is useful to describe a realistic target for the restoration effort.

The dominant grass species big sacaton (*Sporobolus wrightii*), with varying numbers of mesquites, is common on the Sonoita Creek floodplain south of the agricultural fields. Sacaton will be included in the seed mix for the restored floodplain but is known to be difficult to establish from seed without irrigation. We expect sacaton to colonize the site gradually, but a realistic target state in 15 years is Mesquite, Sacaton.

For the success criteria below, the mid-point of the range of perennial grass canopy cover presented in the Loamy Bottom ecological site guide for the Mesquite, Sacaton state was selected, with the understanding that sacaton alone will not attain that cover value in 15 years. The target values for native and exotic species cover are drawn from the U.S. Army Corps of Engineers Unified Performance Standards (U.S. Army Corps of Engineers 2014). Density and frequency of woody vegetation is based on the anticipated growth, survivorship, and recruitment of individuals. Transplant survivorship and species diversity standards are based on anticipated results in a disturbed system.

Given the above, the performance standards identified for the riparian floodplain seeding effort within the identified monitoring period of 15 years are as follows:

1. absolute canopy cover of native (annual and perennial) species ≥15 percent (per NRCS Ecological Guide)
2. relative cover of native species ≥75 percent (SPD Unified Performance Standards)
3. absolute cover of exotic species ≤10 percent (SPD Unified Performance Standards)
4. density of woody tree and shrub species in the channel cut area: 250/acre
5. frequency of woody tree and shrub species in the repositories: 10 percent
6. survival rate of transplanted big sacaton, including recruits: ≥50 percent
7. species diversity: 5 native species >3 percent of relative cover

The minimum absolute cover values of woody species in the floodplain and constructed channel represent lower limits for the woody cover expected at the appropriate NRCS ecological sites: Loamy Bottom, 12- to 16-inch precipitation zone, Mesquite, Sacaton state; and Sandy Wash, 12- to 16-inch precipitation zone, respectively.

10.1.3 Rehabilitated Sonoita Creek and Buffer

The performance standards for the rehabilitated reach of Sonoita Creek and associated buffer are the same as those for the reestablished channels and seeded floodplain, as described in **Sections 10.1.1 and 10.1.2**, respectively.

10.1.4 Enhanced Ponds

The enhanced ponds will have effectively achieved their designed performance criteria once construction has been completed. Monkey Spring flows into the ponds will continue to be monitored to ensure that the ponds maintain base water levels to support sensitive species.

10.1.5 Enhanced Existing WUS and Riparian Buffer Habitat

Sonoita Creek Ranch has not been intensively grazed so a substantial response in vegetation resulting from the exclusion of grazing is not anticipated. However, it is anticipated that the buffer area adjacent to the ephemeral washes at the site will still experience recovery following livestock grazing exclusion, and these areas would be expected to achieve performance criteria comparable to the Sonoita Creek floodplain as these areas are both classified as Loamy Bottom or Loamy Swale ecological sites by NRCS.

The performance standards for enhanced buffer areas at Sonoita Creek Ranch, therefore, are established as follows:

- Absolute canopy cover of native (annual and perennial) species: ≥ 15 percent
- relative cover of native species: ≥ 75 percent
- absolute cover of exotic species: ≤ 10 percent

Monitoring methods are discussed in **Section 11**.

10.2 Stormwater Flow Mitigation

The removed stock tanks will have achieved the desired performance standard at the completion of the activity. Regular inspections for signs of erosion will occur as described in **Section 9.4.2**.

11 MONITORING

11.1 Sonoita Creek Ranch

Rosemont will conduct annual monitoring at the Sonoita Creek Ranch for a period of up to 15 years to document the performance standards identified in **Section 10.1** of this HMMP. If performance standards are met sooner than 15 years, the monitoring may be modified if approved by the Corps. Specific monitoring protocols for each mitigation element with a non-construction performance standard are outlined below.

11.1.1 Reestablished Sonoita Creek Floodplain Channels

The goals of the monitoring effort are to measure and detect changes to the constructed system, to review measured data for a greater understanding of the system, and to ensure that the restored lands have a clear trajectory toward project goals. The desired goals are not oriented around a single, fixed and invariable endpoint (e.g. a static channel), but rather they emphasize a system design focused on restoring hydrologic and geomorphic processes to achieve a dynamic state (Palmer et al. 2005). This mitigation project will also provide the opportunity to generally improve the science and practice of ephemeral stream restoration as a result of its construction and subsequent monitoring program that emphasizes the reestablishment of dynamic hydrologic and geomorphic processes (Ralph and Poole 2003).

The continual evaluation of measured data will support adaptive management decisions, and show whether project goals are being met. As previously stated, the goals of this project are to reestablish natural ecological functions that are impaired at Sonoita Creek due to historic man-induced impairments. The reestablished channels (RX Channel and SCR Channel) are designed to dissipate energy, provide stormwater access to overbank areas, provide additional transmission losses to alluvium, provide sediment storage and sediment transport functions, and to reintroduce Monkey Spring flows back into Sonoita Creek. The monitoring effort described in this section focuses on hydraulics and geomorphology of the reestablished channel system as the foundation for achieving these goals.

An additional goal is to allow Sonoita Creek the ability and freedom to evolve geomorphologically. Therefore, this project considers and defines the acceptable limits of channel migration. Natural channel dynamics for this type of arid, ephemeral stream typically include channel migration, bar formation and braiding. Defining an acceptable level of channel morphology has always been a challenge, and nowhere is this challenge greater than in arid ephemeral systems.

11.1.1.1 Monitoring Methods, Locations, and Frequency

Monitoring of the re-established channels for function and performance will occur throughout the 15-year monitoring period. Hydrologic monitoring will consist of installing a network of automated rainfall and streamflow gages. Channel geomorphology will be assessed both quantitatively and qualitatively. Field observations will be made in addition to comparing channel topography to the original as-built topography. This will quantify incremental changes through time. Measurement of precipitation, stream stage and discharge will occur at fixed locations, while observations of channel conditions will be made throughout the system.

It is understood that ephemeral system restoration work includes a dynamic system that may need an equally dynamic monitoring regime to ensure that the adaptive management process is effective and that pertinent information is collected. This could include a determination that the system is fully functioning or that changes to the system are required to ensure functionality with minimal maintenance. It is anticipated that the Corps will be an important partner in this process and provide collaboration and guidance regarding concerns or successes. Additional discussion of adaptive management is provided in **Section 13**.

11.1.1.2 Network of Rain/Stream Gages

Three permanent monitoring stations will be installed and maintained to measure rainfall and streamflow (**Figure 19**) for the duration of the 15-year monitoring period. The stations are positioned at strategic locations to measure precipitation, stream stage and discharge to help understand flow behavior throughout the reestablished channel system. The northern gage will be located at the RX Channel, in the upper 1/3 of the channel reach. The middle gage will be located at the SCR Channel, in the lower 1/3 of the channel just upstream from its confluence with Big Casa Blanca Canyon. The southern gage will be located at Sonoita Creek at the southernmost extent of the project near the concrete low-water crossing that is controlling channel grade. Instrumentation and station design for the Sonoita Hydrologic Monitoring Network will be consistent with the rainfall and runoff gages already installed by Rosemont in the Rosemont Project area. This equipment design allows for data consistency and ease of station maintenance.

Each remote rain/stage station consists of a standpipe enclosure: a 12-inch diameter, 10-foot tall aluminum tube that is set vertically in a concrete base (**Figure 20**). A collection funnel with a 1-mm tipping bucket rain gage completes the standpipe at the top along with a mast where the solar panel and satellite antenna are mounted. Control electronics are housed in a water-tight canister that sits below-grade inside the standpipe. The station is battery-powered with a solar charging system, is well-grounded and includes lightning protection for the electronics.

Each station also includes a buried conduit for wires to a riser pipe stilling well on the stream bank, housing the pressure transducer (PT) for measuring stream stage. The riser pipe provides a hydraulic intake below the stream bed and allows the PT to be located in a cool environment below the existing lowest-flow point (thalweg) of the channel (**Figure 21**). The 2-inch galvanized, horizontal, screened intake is located under the stream bed, which allows for hydraulic connectivity to the surface-water through the stream bed sediments, pebble drain layer and fine screen. The sub-surface PT installation works well based on experience at previously-installed Project area stations that exhibit minimal riser pipe scour with no clogging of the PT by sediment.

A data-logging transmitter, located in the standpipe canister will be programmed to sample, store and transmit all sensor data via a commercial satellite. Data will be transmitted on a one-minute frequency only during hydrologic events. One-minute data values will be transmitted when the tipping bucket tips or when a depth of water is detected in the channel. The stations will also transmit measurements on a scheduled basis, when no change in conditions is measured, every six hours as a check that stations are functioning properly. Data will be downloaded from the satellite data provider and stored in a database managed by Water & Earth Technologies, Inc. Data will be available for view at a secure internet site in tabular, graphical, or a map-based interface.

The channel in the vicinity of the PT at each rain/stage station will be surveyed in order to develop a relationship between stage in the wash (in feet above the PT) and discharge in the wash (in cubic feet per second). At least three channel cross sections at each station will be surveyed using a tape, level and rod. The set of channel cross sections will be used to develop hydraulic models of the channel near each station using the Army Corps of Engineers, Hydrologic Engineering Center River Analysis System (HEC-RAS) software.

Channel cross-section elevations and simulated water-surface elevations are all relative to an established arbitrary datum. The established datum at each station is the elevation of the PT riser pipe with the cap removed. Channel bed elevations and elevations of overbank areas will be surveyed in relation to the local datum.

Stream stage will be measured by the PT instrumentation at each station. The stage-discharge rating curve will be applied by the base station software and compute the estimated discharge (cfs). Given the dynamic nature expected in channel systems of this type, a survey check of the stream channels near each station will be performed annually (post-monsoon) and the stage-discharge ratings will be updated, if required, based on the level of change found in the channel. Time-series data describing stormwater events in stream stage (in feet) and discharge (in cfs) will be available for each flow event.

11.1.1.3 Channel Inspection Surveys

A field inspection of the reestablished channels will be conducted annually. The field visit will be scheduled relatively soon after the annual monsoon season dissipates so that evidence of flow, erosion features, and aggradation features are still relatively fresh and obvious to experienced field personnel. The purpose of these annual inspections is to observe and record changes to the reestablished channels.

Lateral channel migration will be compared to the allowable migration limits; vertical incision will also be observed. The annual channel survey will consist of walking through all of the lands reclaimed during this mitigation project in order to observe not only the reestablished channels but also the soil repositories. The entire length of restored channels will be traversed and the general channel conditions documented. Documentation will include: observations of channel bed and bank stability, channel bed composition, evidence of erosion and aggradation such as cut-bank and bar formation and channel braiding. At a minimum frequency, channel observations will be documented at a reach length equal to 20 times the channel width, or approximately every 1,000 feet. The spatial extent of obvious, elevated soil moisture from the reintroduced Monkey Spring flows will also be recorded.

Permanent photo points will be established during construction in locations that focus on the reconstructed channels in straight reaches and at channel bends. At a minimum, there will be at least 3 permanent photo points at the RX Channel, and 12 permanent photo points at the SCR Channel. Additionally, there will be at least 2 permanent photo points oriented for panoramic photos of the RX

Channel and its repositories, and at least 6 permanent photo points oriented for panoramic photos of the SCR Channel and its repositories. During the annual inspections, hi-resolution photos will be collected at the photo points taken from the same angle using the same magnification. Recent photos will be compared to photos from past inspections with differences described in an annual report. A report summarizing the state of the channel system, including high-resolution photos, will be prepared after each annual survey.

If severe weather results in a precipitation event measured at the Sonoita gages that are equal to or larger than the NOAA atlas 25-year, 24-hour storm, and which also produces a runoff depth greater than three feet in any channel, a field inspection will occur within approximately 96 hours, depending on site accessibility. Field inspections made in response to a 25-year, 24-hour storm in conjunction with a major runoff event will focus on changes to the reestablished channels such as channel avulsions or significant channel migration towards vital infrastructure such as the gas pipeline, highway, or ponds.

11.1.1.4 Channel Topographic Surveys

As-built topography of the reestablished channel system will be surveyed at the end of construction; this survey will be used as a benchmark of comparison for the 15-year monitoring period. Future topographic surveys will be completed every five years during the monitoring period, and each survey will be compared against the as-built survey and previous 5-year surveys. Changes in channel geomorphology will be quantified from the comparative results of the topographic surveys. A summary report quantifying changes to the channel profile and horizontal alignment will be prepared after each topographic survey. The monitoring schedule is shown in **Table 4**.

The channel topographic surveys will have a spatial extent large enough to completely encompass every reach of reestablished channel and extend at least 500 feet upstream and downstream of the tie-ins with the existing Sonoita Creek channel. The channels will be surveyed with enough precision to produce topographic mapping with a one-foot contour interval. The topographic surveys will be completed with aerial or ground based LiDAR, aerial drone surveys, survey grade GPS units, or other means that may become available with new technology provided that they are capable of producing topographic mapping of at least a 1-foot contour interval.

11.1.1.5 Monitoring Schedule

The monitoring schedule for the reestablished floodplain riparian channels is provided in **Table 4**.

Table 4. Monitoring Schedule

Monitoring Type	Frequency	Location
Rainfall	Continuous	3 Gages
Runoff	Continuous	3 Gages
Channel Conditions	Once annually and within 96 hours of a 25-yr, 24-hr storm producing a depth greater than 3 feet	Entire channel
Station Survey check	Once annually	Channel near each rain/stage station
Channel Topography	Once every 5 years	Entire channel

11.1.2 Riparian Floodplain Seeding

Following the tilling and planting of the former farm fields, 30 transects (50 m long) will be established in the restored floodplain to evaluate changes in vegetation. To avoid clustering, the transects will be distributed in five approximately 1,100-foot long sections of the seeded floodplain. Two transect locations will be chosen randomly within each section, one on either side of the constructed channel.

Vegetation surveys will be conducted annually. At each transect, canopy cover of all species and ground cover will be evaluated with the line-point intercept method along the center line of each belt transect (Herrick et al. 2005). Woody species density and frequency will be measured in 100-square-meter belt transects that are centered on the line-point intercept cover transects. Photos will be taken at select locations on each transect.

11.1.3 Rehabilitated Sonoita Creek

The monitoring protocols for the rehabilitated reach of Sonoita Creek and associated buffer will be the same as those described for the reestablished channels (**Section 11.1.1**) and seeded floodplain (**Section 11.1.2**).

11.1.4 Enhanced Ponds

To ensure that the depth of water in the ponds remains relatively consistent, Rosemont will continue to monitor the surface water from Monkey Spring flowing to the ponds after construction of the passive flow system. The flow meter upstream of the northernmost pond will be accessed quarterly to ensure that the flow volume assured by the water right continues to flow to the ponds. As previously noted, the flow monitoring conducted to date indicates that Monkey Spring flows discharging to

Sonoita Creek Ranch range from 5 to 12 percent higher than that allocated by the Certificate of Water Right for the property (WestLand Resources Inc. 2017).

11.1.5 Enhanced Ephemeral Channels and Buffer

Eight transects (50 m long) will be randomly located in the buffer zones of enhanced tributary streams of Sonoita Creek (Corral Canyon and four unnamed tributaries to the north) to evaluate changes in vegetation. Corral Canyon is much larger than the other tributary streams, and the stream length will be divided into four sections, with one transect allocated to each section.

Vegetation surveys will be conducted annually. At each transect, canopy cover of all species and ground cover will be evaluated with the line-point intercept method along the center line of each belt transect (Herrick et al. 2005). Photo points will also be established at each transect and photos taken during each survey.

11.2 Stormwater Flow Mitigation

The proposed stock tank removal at the Project Site was originally contemplated as part of the Surface Water Mitigation Plan (SWMP; Rosemont Copper Company 2014) developed by Rosemont in support of the CWA Section 401 state water quality certification for the Project (ADEQ LTF No. 55425). The SWMP supports the determination by the Arizona Department of Environmental Quality (ADEQ) that the Project will have no adverse effect on the currently designated downstream Outstanding Arizona Waters (OAW) in Davidson Canyon and Cienega Creek.

The SWMP includes a robust monitoring program that includes both baseline data collection and data collection efforts during the construction and operations phases of the Project. Monitoring will include: precipitation; surface water quantity and quality; groundwater levels and quantity; water quality and flow from springs; downstream geomorphology; and sediment transport.

Data collected during the monitoring effort will be used to develop and refine a site-specific surface watershed model, which will be used to estimate the average annual flow volume at the USGS Gage 09484580 on the SR 83 bridge. The model will be refined annually with the previous year's data and rerun to assess the difference between runoff from the watershed in an undeveloped condition compared with runoff from Project development, i.e. the "runoff deficiency."

Depending on the nature and scale of the runoff deficiency, a suite of potential mitigation measures will be assessed. These measures include:

- Modification of onsite stormwater management (via culverts, temporary channels, etc.) to facilitate downstream runoff of stormwater flows;

- Reallocation of senior water rights within the watershed modify surface water use within the watershed;
- Closure of stock well in upper Davidson Canyon;
- Removal of Questa Spring stock watering apparatus;
- Closure of earthen stock tanks; and
- Introduction of groundwater to the surface water system.

The annual runoff deficiencies (if any) and the corresponding mitigation measure will be tracked by Rosemont to ensure no downstream effects to any OAW.

11.3 Reporting

Annual reporting will be provided to the Corps for all mitigation activities for which monitoring is required, including maintenance activities. The annual monitoring report (Report) will cover a full calendar year and shall be received by the Corps on or before April 1st of the following year. The first Report may not cover a full calendar year and is dependent on the timing of receiving the Section 404 permit and initiating mitigation activities.

The Report will provide a concise summary of the monitoring, inspection, and maintenance activities completed during that calendar year and discuss any planned maintenance or management activities for the upcoming year. Based on the observations of the previous year, the Report may also include suggestions of adaptive management changes that could be incorporated into the HMMP. At a minimum, the annual Report shall also include the following:

- information from the four quarterly site inspections;
- photo documentation from the mitigation parcels to document habitat development and existing conditions;
- summary of performance standard data collected at Sonoita Creek Ranch (until performance standards have been achieved); and
- a recent aerial photograph annotated with observations and location of actions taken during the year in compliance with the HMMP.

Monitoring for performance standards will continue until performance standards are met, or until criteria developed as part of adaptive management are met.

12 LONG-TERM MANAGEMENT PLAN

Rosemont is responsible for the long-term management activities at all of the mitigation parcels in accordance with the requirements of the governing Section 404 permit. Rosemont anticipates that they will record or cause to be recorded a Restrictive Covenant over the mitigation parcels that transfers responsibility for long-term management and maintenance to a third-party conservation entity. If Rosemont conveys ownership of the mitigation parcels to another party, the management and maintenance activities would remain with Rosemont unless these responsibilities are also conveyed to the new owner. Management and maintenance activities for the mitigation parcels are summarized below.

12.1 LONG-TERM MANAGEMENT NEEDS

Long-term management needs associated with the mitigation parcels are limited. In short, the mitigation projects proposed in this HMMP (e.g. the constructed channels, pond enhancements, etc.) are specifically designed to function passively and with as little maintenance as possible.

12.2 ALLOWABLE USES

The mitigation parcels will be open to public access for certain allowed uses including hiking, bird-watching, educational purposes, and scientific study. Hunting and fishing will not be allowed on any of the mitigation parcels. Any educational or scientific study proposed within the area must be consistent with the overall purposes of the mitigation parcels as determined by Rosemont, the Corps, and the third-party manager (if identified). The general public will not be allowed to bring vehicles off road on the mitigation parcels.

12.3 PROPERTY INSPECTIONS

Property inspections shall occur at least once quarterly. A key element of the management program will be the regularly-scheduled inspections to identify maintenance needs and ensure that no uses prohibited by the Restrictive Covenants are occurring within the mitigation parcels. Minor maintenance activities may be carried out during these visits; however, any need for more intensive maintenance activities will be identified for follow-up action. Information collected during the general inspection will be documented.

12.4 FENCE REPLACEMENT AND MINOR FENCE REPAIRS

The access control fences will be maintained and replaced as needed. All fences subject to this management plan are estimated to have a 30-year life. In addition to replacement needs, it is estimated that the fence each year will need to be repaired due to fallen trees, vandalism, livestock breaking through a fence, or other means by which small sections of the fence are damaged. The full length of all fences will be inspected at least semi-annually for as long as mitigation parcels are maintained for mitigation purposes. If inspections indicate that the fence inspection schedule requires or allows for modification, that modification will be reviewed with the Corps. Any repairs that are needed to restore the integrity of a fence to its original specifications will be made within two weeks of identifying the problem. Most minor fence repairs would be made during quarterly site inspections.

12.5 Signage

Signage may be placed, as needed, at access points and/or around the perimeter of the mitigation parcels in accordance with the requirements of this HMMP and the site protection instrument recorded in accordance with the CWA Section 404 permit. The placement and maintenance of informative signs shall not be in direct or potential conflict with the preservation of the natural condition of the mitigation parcels. Signs may be placed on all gates and other reasonably potential points of public access to the mitigation parcels, and at all property or fence corners as necessary to meet the intent of this HMMP. Appropriate signage may identify the entities responsible for the management of the lands, use and access rules, potential hazards, and responsible contacts in case of emergency.

12.6 General Maintenance

This task will include both "minor" and "major" maintenance activities (MIMA; MAMA) to facilitate achievement of management objectives. MIMAs are those maintenance activities that do not require more than two weeks for repair, do not have any material effect on the expected schedule for achievement of success criteria, and would not require implementation of adaptive management measures. MIMAs do not need to be reported to the Corps. A simple count of MIMAs shall be included in the annual report (**Section 11.3**).

MAMAs are defined as those maintenance activities that will take more than two weeks to complete, may materially affect the likelihood that success criteria will be achieved, or require implementation of adaptive management procedures. All MAMAs will be reported to the Corps within 24 hours of discovery of the problem along with a plan and schedule to complete the MAMA. All MAMAs shall be documented in the annual maintenance report.

Maintenance tasks can include but are not limited to small-scale re-vegetation of wildcat roads and trails, repairing breaks in a fence, replacing damaged sections of a fence, constructing and repairing vehicle gates/walk-throughs for either vehicles or pedestrians, removal of common household trash that has been illegally discarded, clearing of vegetation that threatens the integrity of a fence, removal of trespass livestock, and correcting of any unforeseen problem.

Vegetation management and manipulation to enhance the natural condition of the mitigation parcels or to further scientific endeavors that is allowed in the site protection instruments and/or that is otherwise agreed to by the Corps, Rosemont, and the third-party manager is allowed.

12.7 Reporting Requirements

An annual inspection and maintenance report covering a particular calendar year shall be received by the Corps on or before April 1st of the following year. The report shall document all inspection activities, the number of MIMAs conducted, and the number and types of MAMAs completed on the mitigation parcels in the preceding year. This report will provide a concise summary of the inspection and maintenance activities completed during that calendar year and discuss any planned management activities for the upcoming year. Based on the inspection and maintenance activities, the report may also suggest adaptive changes to the HMMP, which would then require approval by the Corps.

Attachments to the report will include information and observations made from the inspections. The report shall include a recent aerial photograph annotated with observations and location of actions taken during the year in compliance with the HMMP. The reports and any supporting documentation can be submitted via email or copied onto digital media (CD, DVD, or other media) and then sent to the Corps.

12.8 Long-Term Funding

A long-term management account will be established similar in form and function to accounts that have been accepted by the Corps and third-party managers for previously approved mitigation projects. While the 2008 Mitigation Rule does not specifically require funding of management and maintenance activities in perpetuity, the rule leaves determination of the adequacy of funding for long-term management and maintenance to the discretion of the district engineer. The estimated funding for long-term maintenance and management shall provide for funding in perpetuity.

Funding and financial assurance mechanisms will be provided for three distinct phases of mitigation implementation:

- Phase 1 – Construction and Development
- Phase 2 – Establishment Period (First 15 years)
- Phase 3 – Long-Term Management and Maintenance (Year 16 onward).

Funding for Phases 1 and 2 will be directly paid by Rosemont, backed by an appropriate financial assurance mechanism. Funding for the long-term Phase 3 will be accomplished through the establishment of a dedicated account or similar financial instrument subject to approval by the Corps (referred to in the balance of this document as the Dedicated Account) and Rosemont will pay into that account adequate funds to cover the normal management and maintenance activities described above. It is currently anticipated that the Dedicated Account will be funded by a series of annual payments made by Rosemont over a 15-year period commencing with the production of copper concentrates (effectively coinciding with the Phase 2 Establishment Period). The payment schedule may be modified, but only with prior approval of the Corps. Until the Dedicated Account is fully funded, Rosemont shall provide all funds necessary to conduct required annual management, maintenance, and monitoring activities. Prior to the time that the Dedicated Account is fully funded, the monies from the Dedicated Account will not be used for any management, maintenance, or monitoring activities. Fence replacement actions completed during the Dedicated Account establishment period will be funded by Rosemont with funds other than the funds used to establish the Dedicated Account.

An alternative financial assurance mechanism to that described above may be utilized if approved in advance by Rosemont and the Corps.

13 ADAPTIVE MANAGEMENT PLAN

Factors other than those anticipated in the development of the proposed restoration and management measures outlined in this HMMP can adversely affect planned achievement of the mitigation goals. This poses a challenge to the reviewer and the public with regard to the efficacy of the mitigation measures outlined in this HMMP. During the 1970s, C.S. Holling formally described a novel means to approach the management of environmental systems. Termed adaptive management (AM), the fundamental theory underlying this approach is that the manager and stakeholders explicitly acknowledge both the environmental uncertainty inherent in the system of interest and the uncertainty in the ability to manage and manipulate the system to achieve desired outcomes.

Adaptive management is inherently "outcome-driven" by using results from past management actions, as measured through monitoring, to inform and drive future management decisions. Thus, AM is a fundamentally different approach to land management problems than an "up-front", process-driven permitting process. The incorporation of AM into the 2008 Mitigation Rule explicitly acknowledges this uncertainty and allows for the management flexibility necessary to achieve CWA purposes. This HMMP considers and integrates AM into this implementation schedule during the three phases of mitigation implementation.

During Phase 1 (Construction and Development), Rosemont will document existing site conditions and the as-built condition of the mitigation parcels to provide detailed measures of baseline conditions. These data will then be compared to ecological function and success criteria measures collected during annual monitoring efforts (Phase 2, the Establishment Period) to document changes in site condition and trend. These data will be provided to the Corps in the annual reports.

Should, at any time during this monitoring process, Rosemont or the Corps become aware of changes in site condition or other factors which might materially affect the ability of any mitigation site to achieve the desired future condition outlined in this HMMP, the "identifying" party shall notify the other and schedule a meeting to review the identified issue and develop a strategy to address the issue in the context of the requirements of this HMMP. Following this meeting, a formal adaptive management action proposal will be prepared by Rosemont and submitted to the Corps for approval. Upon approval, the agreed upon adaptive management activities will be implemented in accordance with the schedule provided in the approved adaptive management action proposal. Rosemont is responsible for the costs of implementation of any adaptive management action proposal during this period.

Adaptive management approaches for specific mitigation measures are addressed as follows.

13.1 SONOITA CREEK RANCH

Adaptive management allows the managers to respond to channel evolution based on the channel behavior that is observed and measured. Additionally, the state of the practice in stream restoration will also evolve during the next 15 years, with new research and best management practices (BMPs) identified. Thus, management of the Sonoita Creek Mitigation Project may change not only in response to channel behavior, but also in response to new technology and practices in land or system management. The monitoring program allows managers to detect and quantify changes to the system. Should the re-established channel system fail to meet performance standards, then corrective actions will be implemented after discussion with and the agreement of the Corps.

The relationship between the monitoring plan and adaptive management allow changes to be made during the 15-year monitoring period. For instance, after the first monsoon season, it may become apparent that changes to monitoring requirements and/or frequencies may be necessary to adequately evaluate changes to the channel system. Management of the Sonoita Creek Mitigation Project may be more intensive during the first few years following construction since the site will be responding to the construction activities, and since vegetation communities will not have fully matured. Subsequently, during the 15-year monitoring period, monitoring and management may become more passive as the channel system will have had time for adjustment and some maturation will have occurred within the vegetative communities. Rosemont will work with the Corps in determining appropriate adaptive management and monitoring requirements during the post-construction period.

13.1.1 Reestablished Sonoita Creek Floodplain Channels

A possible repair for excessive lateral migration outside of the migration corridor could consist of an earthwork-only repair that re-aligns the re-established channel, such that lateral adjustment at the limits of the migration corridor is minimized. Other options might include vegetative bioengineering controls along the streambank to arrest future migration. Options might also include armoring the streambank with riprap to prevent channel migration (e.g., buried riprap).

Should channel incision become excessive to the point that floodplain access is no longer available, then repair actions will occur. This may include realigning the channel and creating a preferable channel gradient. If necessary, other longitudinal grade control options could be considered.

13.1.2 Sonoita Creek Floodplain Seeding

If interim performance standards related to vegetation development are not being met, a number of options are available. For instance, if native vegetation cover is consistently low, additional seeding, soil amendments, or even irrigation may be warranted. If exotic species are overrepresented within the mitigation area, they may be treated with herbicide or mechanically removed.

13.1.3 Rehabilitated Sonoita Creek and Buffer

The adaptive management approaches for the rehabilitated reach of Sonoita Creek and associated buffer are the same as those for the reestablished channels and seeded floodplain, as described in **Section 13.1.2 and 13.1.3**, respectively.

13.1.4 Enhanced Ponds

The pond system will be modified to be as passive as possible, minimizing the potential need for adaptive management. However, adaptive management may be required if routine inspections or monitoring identify issues that may need to be addressed. For example, if measurements of Monkey Spring flows entering the property show a substantial reduction from baseline measurements, coordination with the upstream property owner to ensure that the water right agreement is being met may be warranted.

13.1.5 Enhanced Existing WUS and Riparian Buffer Habitat

Similar to the riparian floodplain seeding, adaptive management approaches for addressing performance standard shortfalls for the vegetative development in the enhanced ephemeral washes and associated buffer habitat may include seeding, amendments, or exotics control.

13.2 Stormwater Flow Mitigation

Adaptive management measures are not anticipated to be necessary for the removal of the stock tanks. If inspections show excessive erosion, some degree of erosion control measures (e.g. rock placement, additional earthwork, etc.) may be required.

14 FINANCIAL ASSURANCE

Rosemont will be responsible for funding the long-term management and maintenance of the mitigation effort. Details of the funding for the mitigation effort will be provided once the permit decision has been made.

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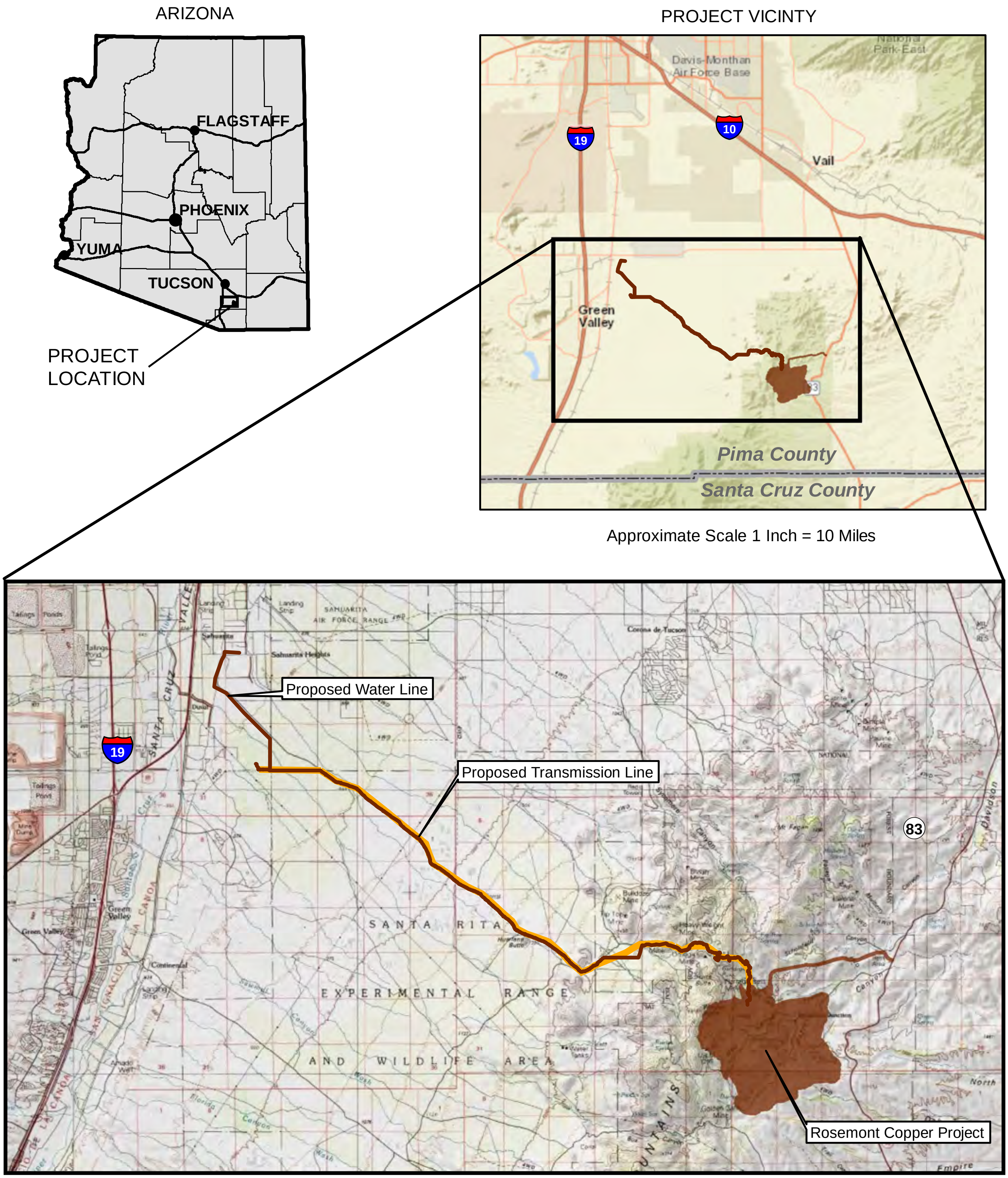
FIGURES



Portion of T17S, R14E,
Portion of T18S, R14 - 16E,
Portion of T19S, R15 & 16E,
Pima County, Arizona,
Fort Huachuca USGS 1:100,000 Quadrangle
Image Source: ArcGIS Online USA Topo

ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017

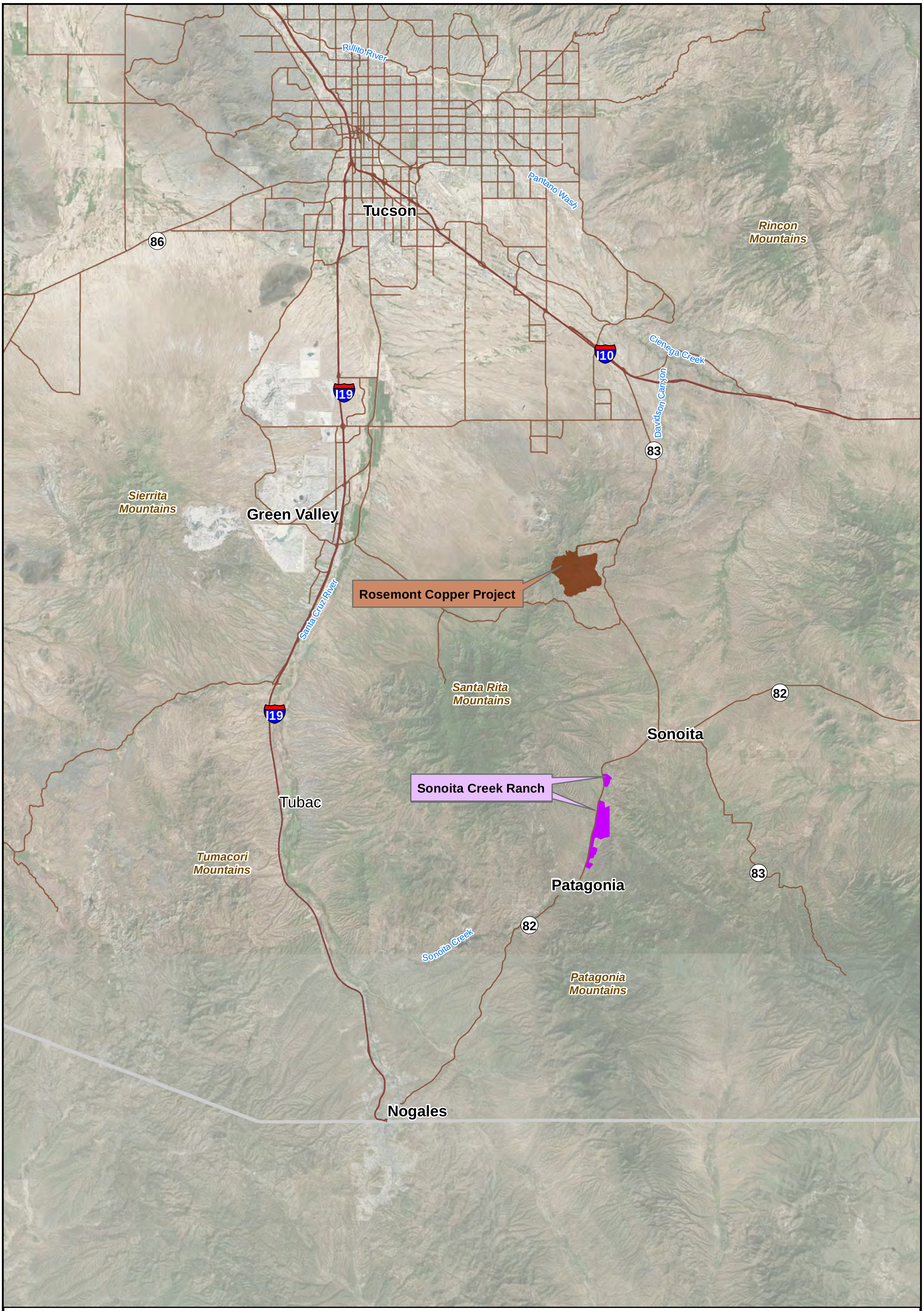
VICINITY MAP
Figure 1

N

0 8,000 16,000
Feet

WestLand Resources

CORPS FILE NO. SPL-2008-00816-MB



Pima & Santa Cruz Counties, Arizona,
Photo Source: ArcGIS Online NAIP 2015 Orthophoto

Legend

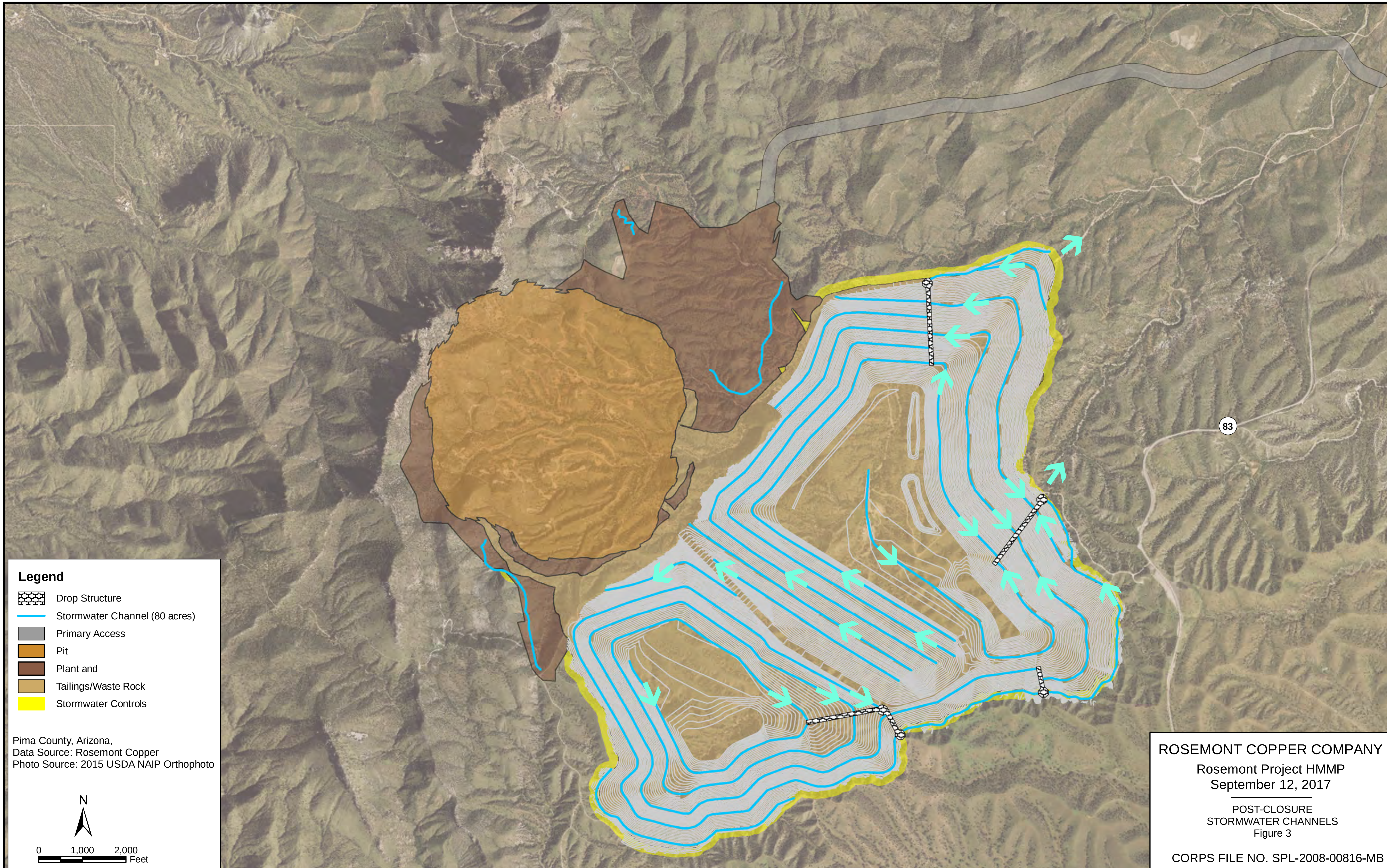
- Rosemont Copper Project
- 404 Mitigation Parcel
- International Border

ROSEMONT COPPER COMPANY

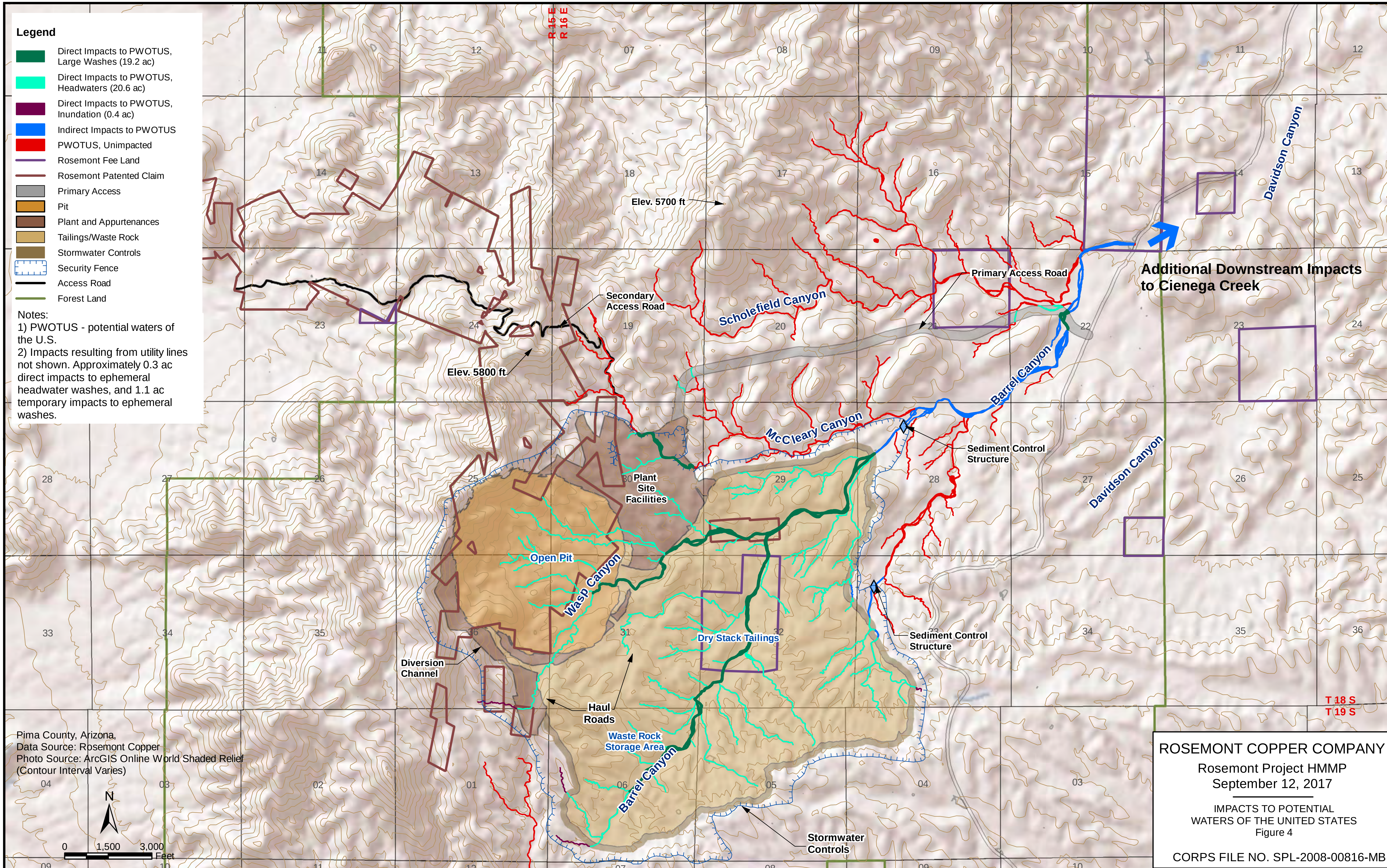
Rosemont Project HMMP
September 12, 2017

PROJECT SETTING
Figure 2

CORPS FILE NO. SPL-2008-00816-MB



83
Legend
Drop Structure
Stormwater Channel (80 acres)
Primary Access
Pit
Plant and
Tailings/Waste Rock
Stormwater Controls
Pima County, Arizona,
Data Source: Rosemont Copper
Photo Source: 2015 USDA NAIP Orthophoto
N
0 1,000 2,000 Feet
ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017
POST-CLOSURE
STORMWATER CHANNELS
Figure 3
CORPS FILE NO. SPL-2008-00816-MB


Legend
Direct Impacts to PWOTUS, Large Washes (19.2 ac)
Direct Impacts to PWOTUS, Headwaters (20.6 ac)
Direct Impacts to PWOTUS, Inundation (0.4 ac)
Indirect Impacts to PWOTUS
PWOTUS, Unimpacted
Rosemont Fee Land
Rosemont Patented Claim
Primary Access
Pit
Plant and Appurtenances
Tailings/Waste Rock
Stormwater Controls
Security Fence
Access Road
Forest Land
Notes:
1) PWOTUS - potential waters of the U.S.
2) Impacts resulting from utility lines not shown. Approximately 0.3 ac direct impacts to ephemeral headwater washes, and 1.1 ac temporary impacts to ephemeral washes.
R 15 E
R 16 E
Elev. 5700 ft
Elev. 5800 ft
Secondary Access Road
Primary Access Road
Scholefield Canyon
Davidson Canyon
Additional Downstream Impacts to Cienega Creek
Barrel Canyon
McCleary Canyon
Sediment Control Structure
Plant Site Facilities
Open Pit
Wasp Canyon
Dry Stack Tailings
Sediment Control Structure
Diversion Channel
Haul Roads
Waste Rock Storage Area
Stormwater Controls
T 18 S
T 19 S
Pima County, Arizona,
Data Source: Rosemont Copper
Photo Source: ArcGIS Online World Shaded Relief
(Contour Interval Varies)
N
0 1,500 3,000 Feet
ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017
IMPACTS TO POTENTIAL WATERS OF THE UNITED STATES
Figure 4
CORPS FILE NO. SPL-2008-00816-MB

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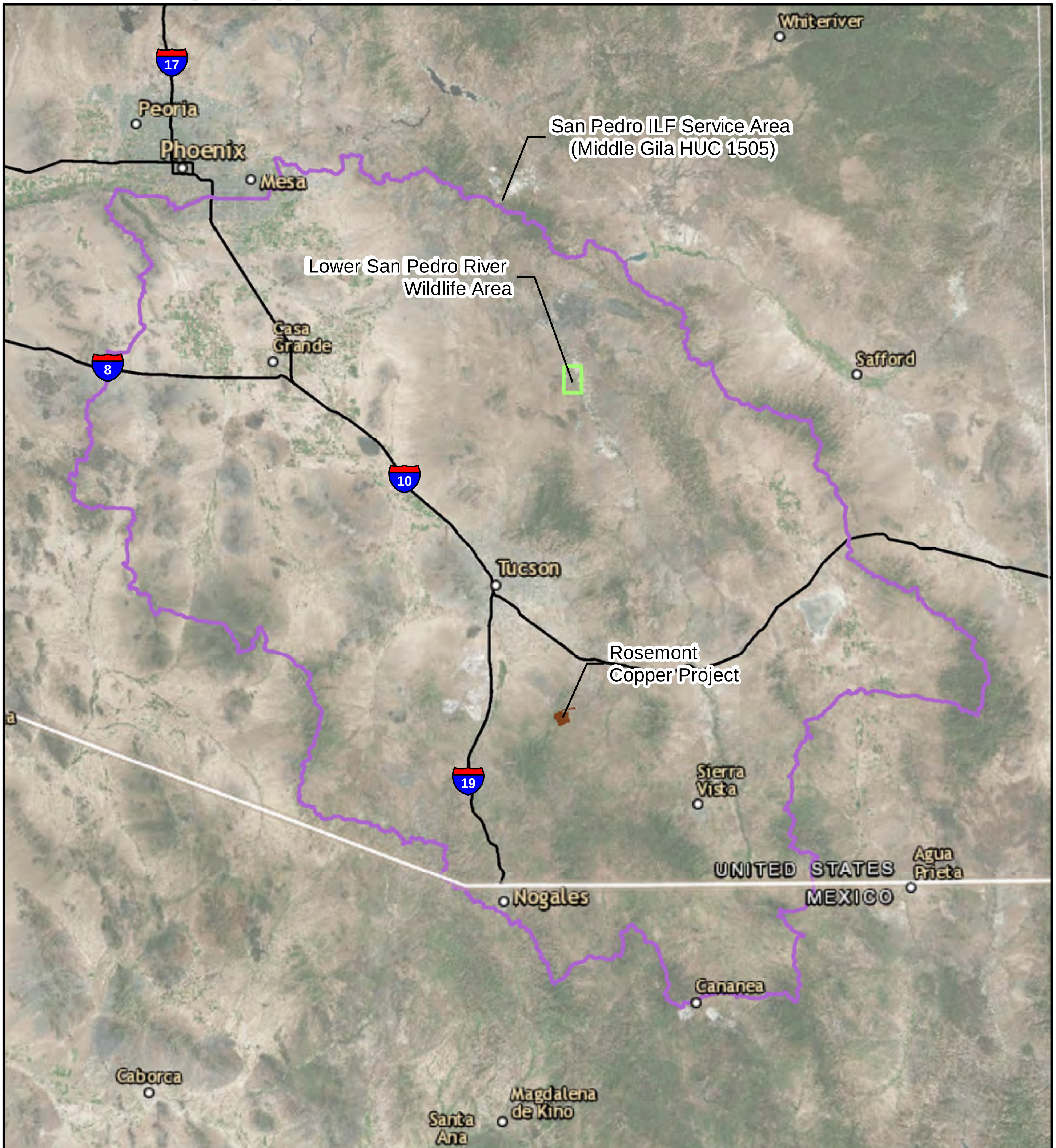


Image Source: ArcGIS Online World Imagery

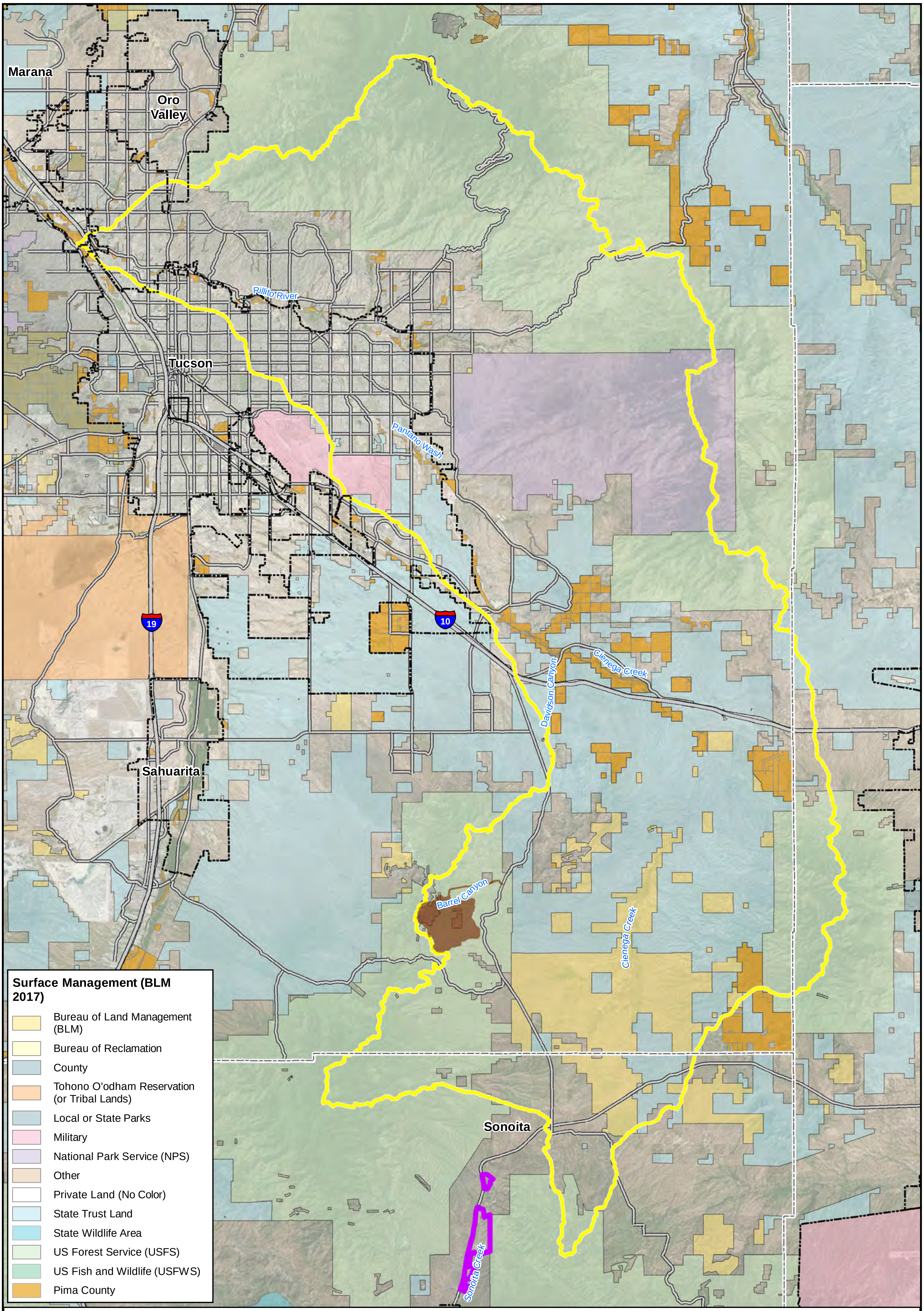
ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017

LSPRWAILF PROJECT
SERVICE AREA
Figure 5

CORPS FILE NO. SPL-2008-00816-MB

WestLand Resources

0 14 28 Miles
0 28 56 Kilometers
N



Pima & Santa Cruz Counties, Arizona,
Photo Source: ArcGIS Online NAIP 2015 Orthophoto

Legend

- Rosemont Copper Project
- 404 Mitigation Parcel
- Rillito Hydrologic Unit #15050302

N

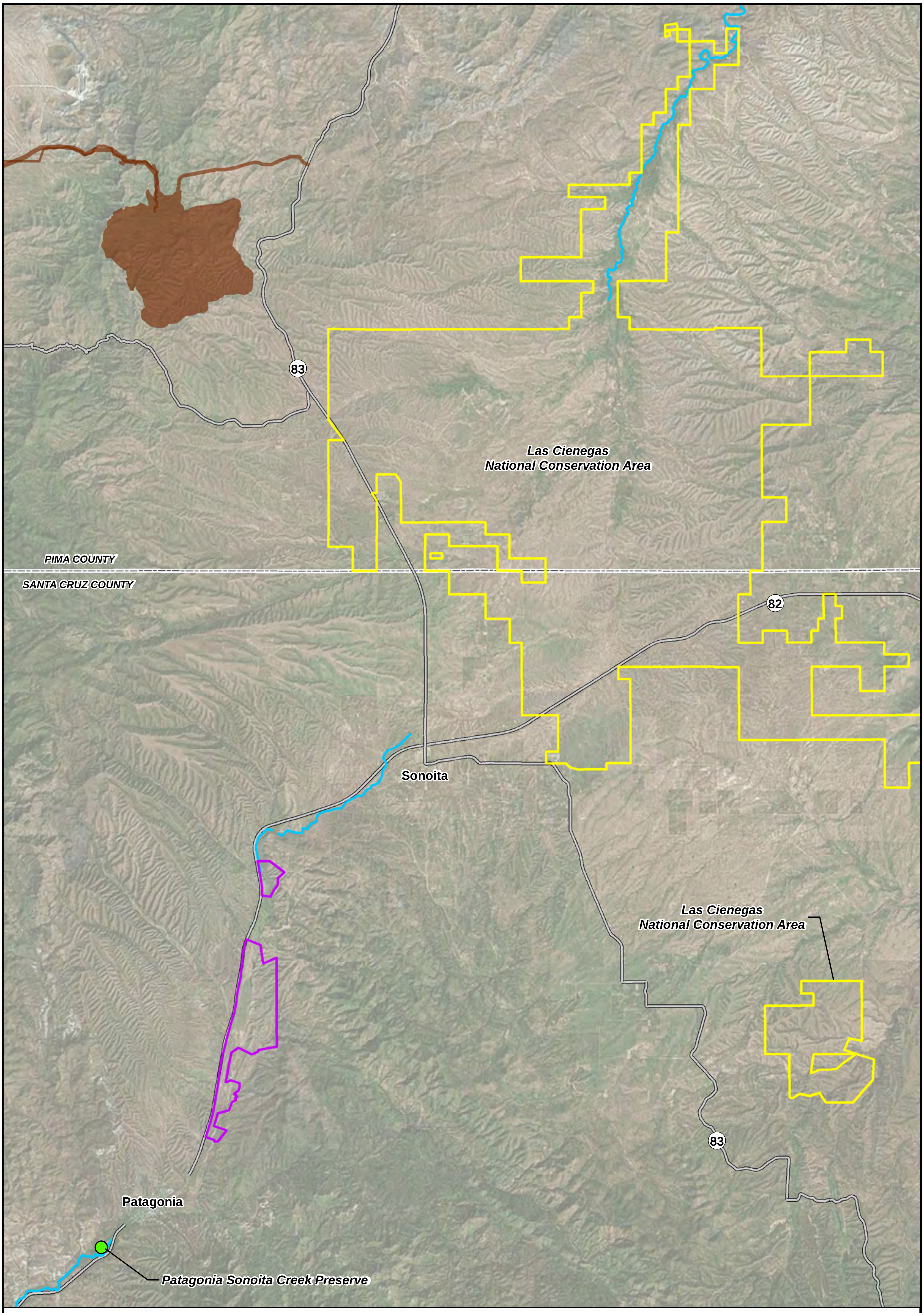
0 12,000 24,000 Feet

ROSEMONT COPPER COMPANY

Rosemont Project HMMP
September 12, 2017

ROSEMONT COPPER PROJECT AND ASSOCIATED HUC 8
Figure 6

PERMIT NO. SPL-2008-00816-MB



Pima & Santa Cruz Counties, Arizona,
Data Source: ALRIS & BLM
Photo Source: ArcGIS Online NAIP 2015 Orthophoto

Legend

- Rosemont Copper Project
- Sonoita Creek Ranch
- Perennial Stream (ALRIS)

N

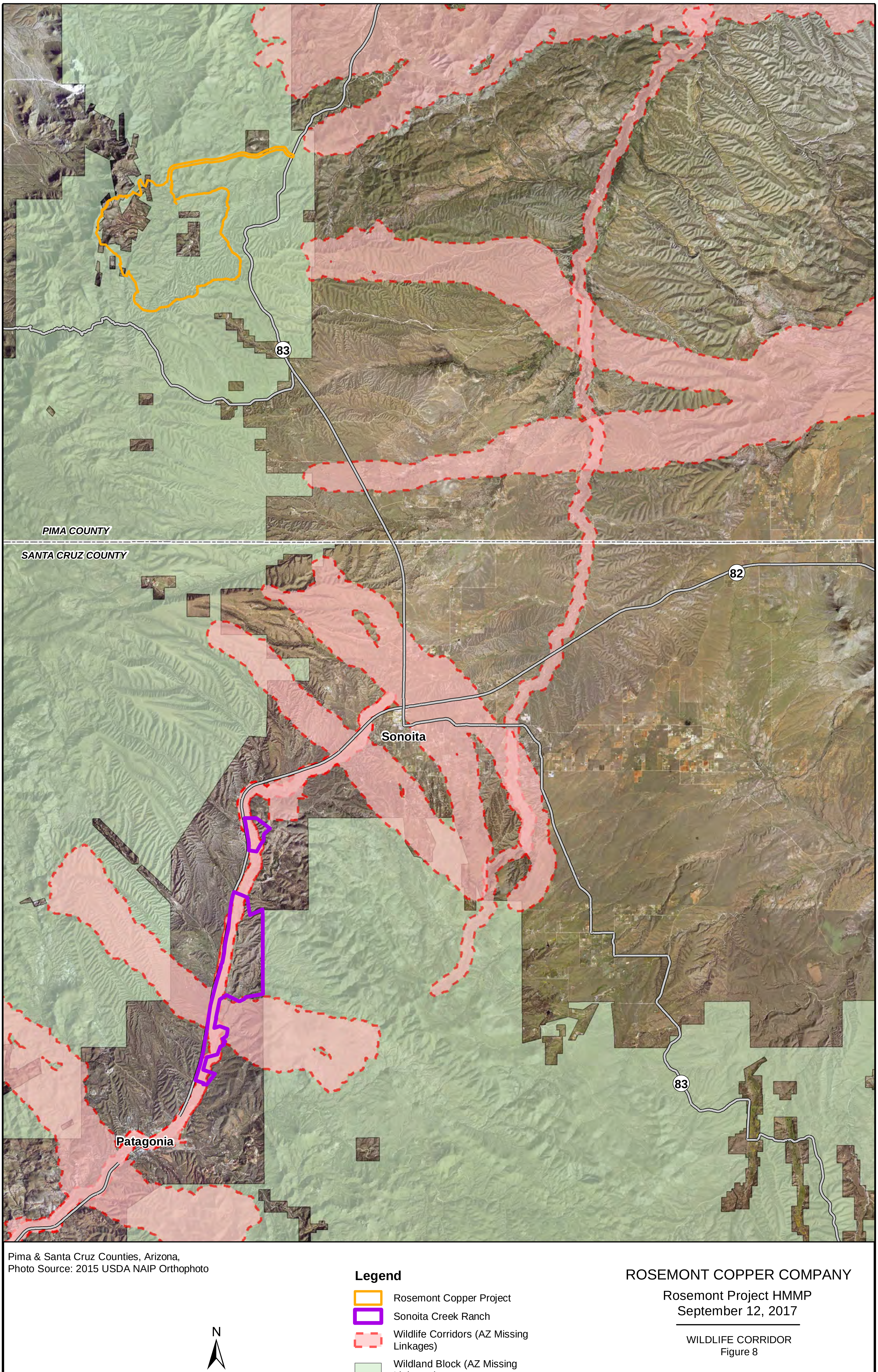
0 5,000 10,000 Feet

ROSEMONT COPPER COMPANY

Rosemont Project HMMP
September 12, 2017

SONOITA CREEK RANCH SETTING
Figure 7

CORPS FILE NO. SPL-2008-00816-MB



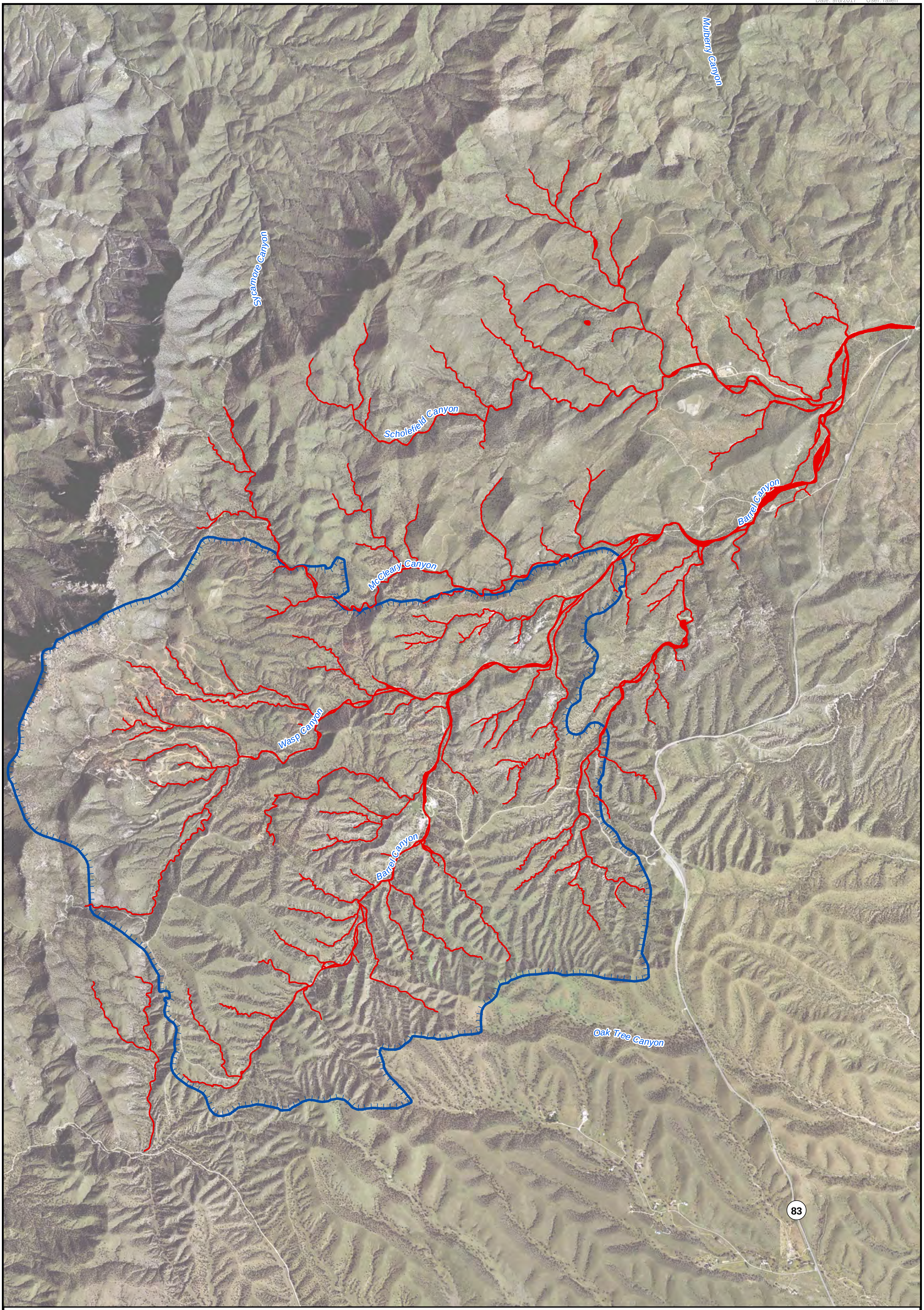
Pima & Santa Cruz Counties, Arizona,
Photo Source: 2015 USDA NAIP Orthophoto

ROSEMONT COPPER COMPANY

Rosemont Project HMMP
September 12, 2017

WILDLIFE CORRIDOR
Figure 8

CORPS FILE NO. SPL-2008-00816-MB



Pima County, Arizona
Data Source: Rosemont Copper
Photo Source: 2015 USDA NAIP Orthophoto

N

0 1,250 2,500 Feet

Legend

Potential Waters of the U.S.

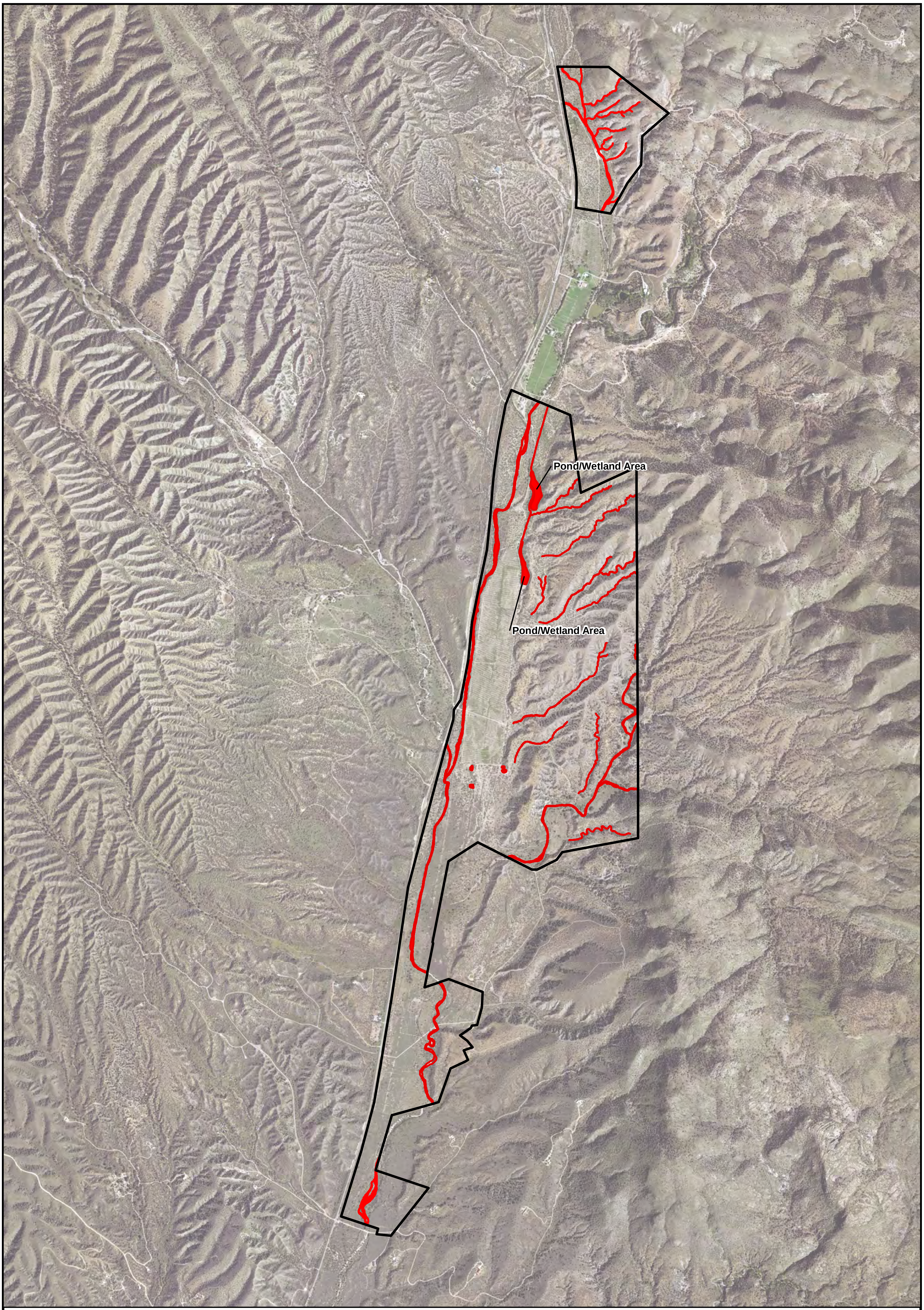
Proposed Security Fence

ROSEMONT COPPER COMPANY

Rosemont Project HMMP
September 12, 2017

ROSEMONT PROJECT SITE
Figure 9

CORPS FILE NO. SPL-2008-00816-MB



T21S, R16E, Portions of Sections 3, 4, 9, 16, 20, 21, 28, 29, 32, & 33.
Santa Cruz County, Arizona
Photo Source: 2015 USDA NAIP Orthophoto

Legend

Sonoita Creek Ranch

Potential Waters of the United States

N

0 1,200 2,400 Feet

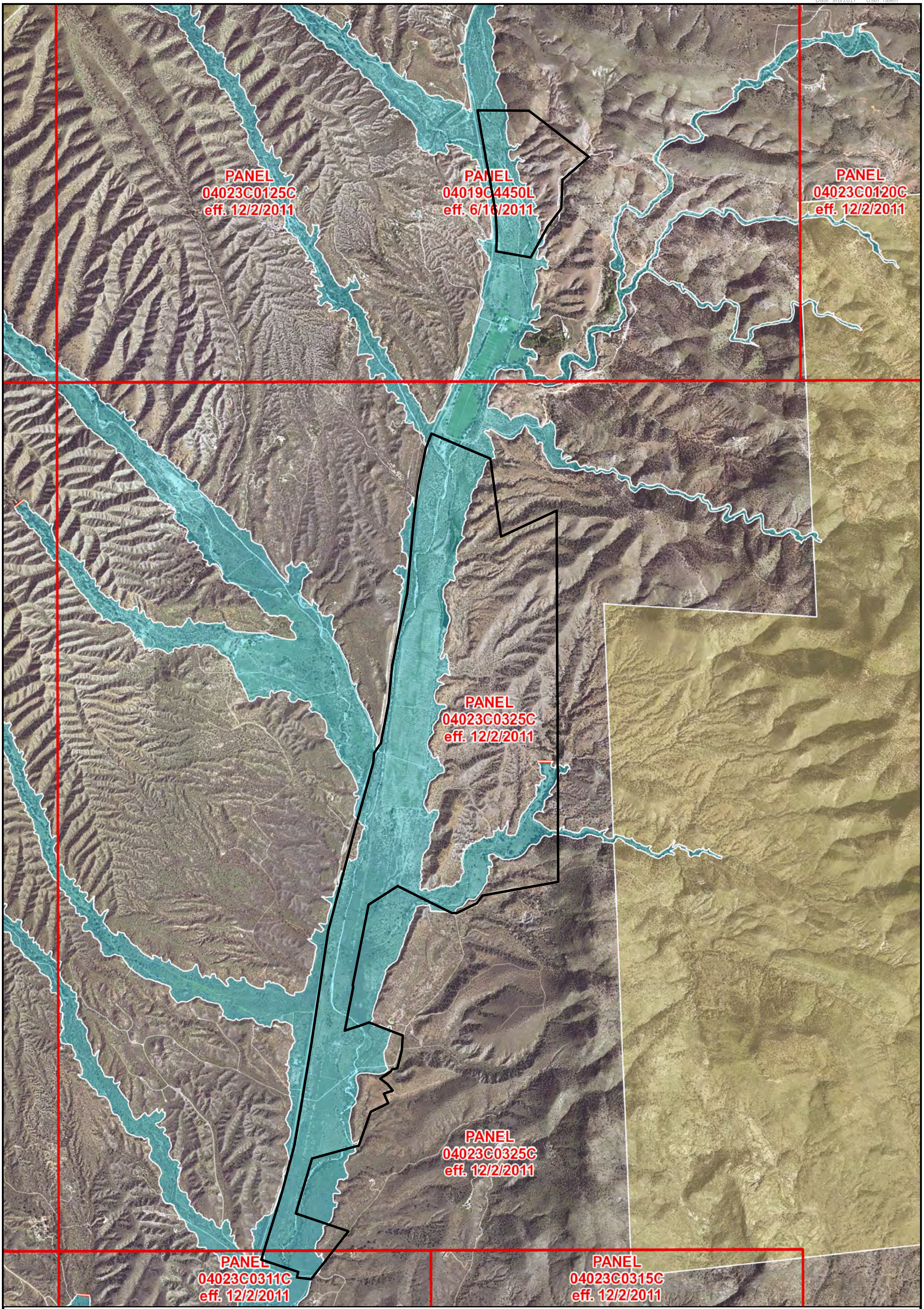
ROSEMONT COPPER COMPANY

Rosemont Project HMMP
September 12, 2017

SONOITA CREEK RANCH
EXISTING CONDITIONS
Figure 10

CORPS FILE NO. SPL-2008-00816-MB

Date: 9/8/2017 User: rallen



T21S, R16E, Portions of Sections 3, 4, 9, 16, 20, 21, 28, 29, 32, & 33.
Santa Cruz County, Arizona
Data Source: FEMA NFHL Server
(https://hazards.fema.gov/gis/nfhl/rest/services)
Photo Source: 2015 USDA NAIP Orthophoto

N

0 1,200 2,400 Feet

Legend

Sonoita Creek Ranch

Flood Hazard Zone Type

1% Annual Chance Flood Hazard

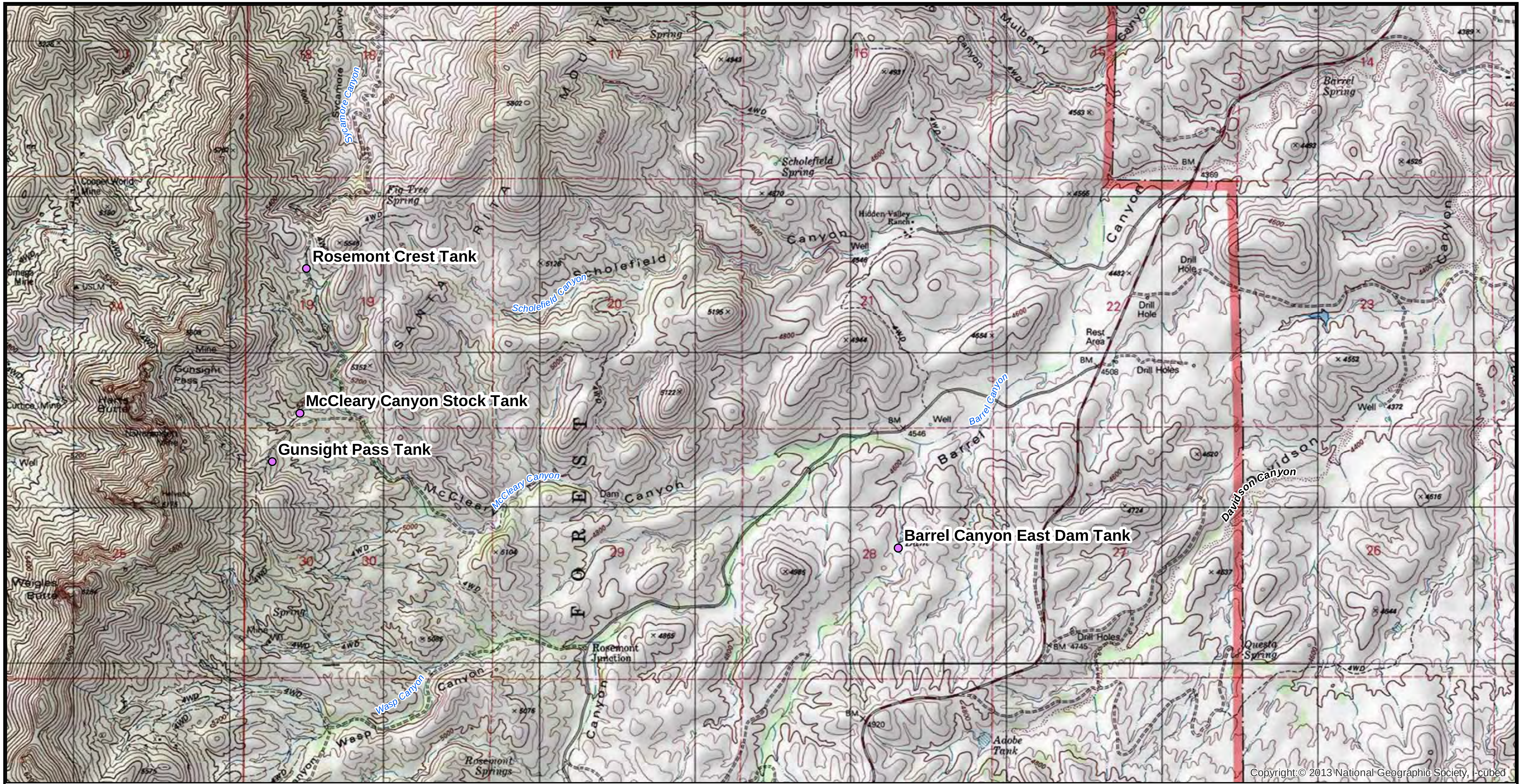
Area of Undetermined Flood Hazard

ROSEMONT COPPER COMPANY

Rosemont Project HMMP
September 12, 2017

SONOITA CREEK RANCH
FEMA FLOOD HAZARD
Figure 11

CORPS FILE NO. SPL-2008-00816-MB



Pima County, Arizona
Data Source: Rosemont Copper
Photo Source: ArcGIS Online (USA TOPO)

N

0 1,000 2,000 Feet

Legend

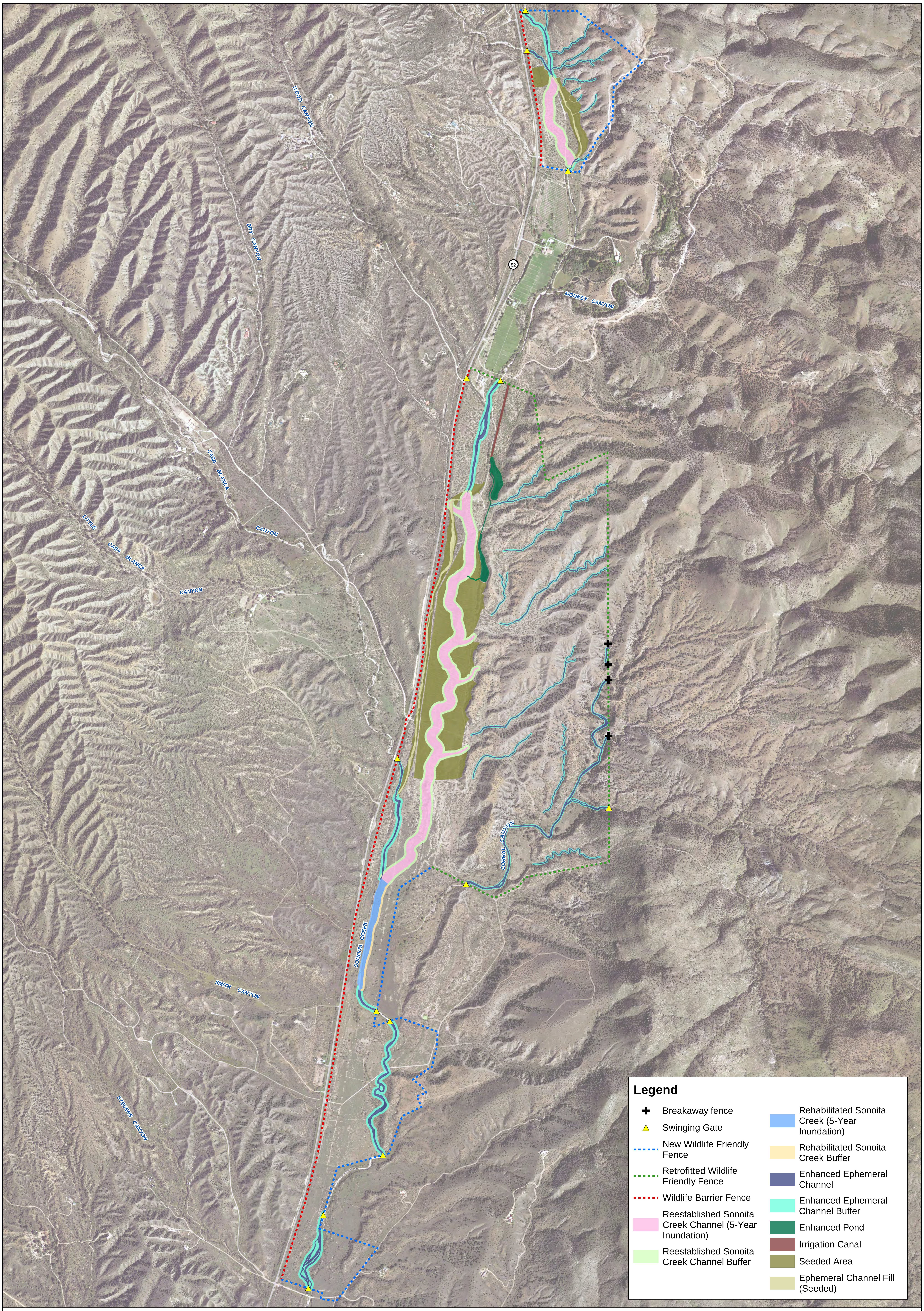
● Earthen Dam to be Removed

ROSEMONT COPPER COMPANY

Rosemont Project HMMP
September 12, 2017

Rosemont Site Earthen Dam Removal
Figure 12

CORPS FILE NO. SPL-2008-00816-MB



T21S, R16E, Portion of Sections 3, 4, 9, 16, 20, 21, 28, 29, 32, & 33,
Santa Cruz County, Arizona
Photo Source: 2015 USDA NAIP Orthophoto

Note: All riparian buffers are 50 ft.

N

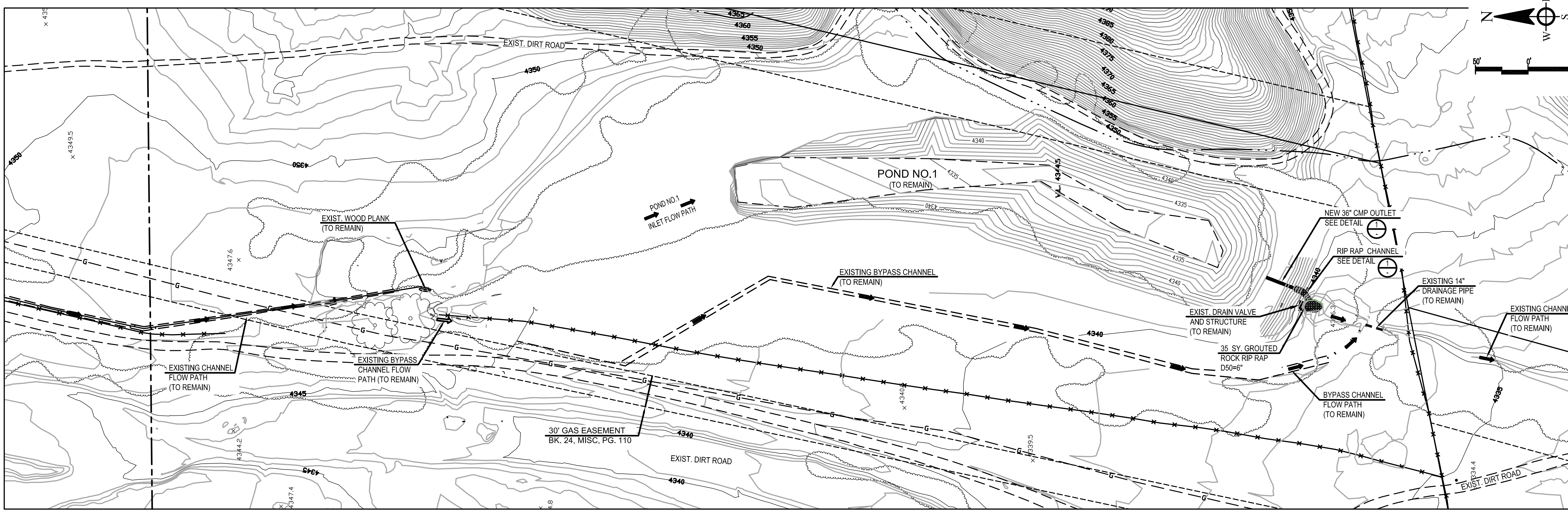
0 1,200 2,400
Feet

ROSEMONT COPPER COMPANY

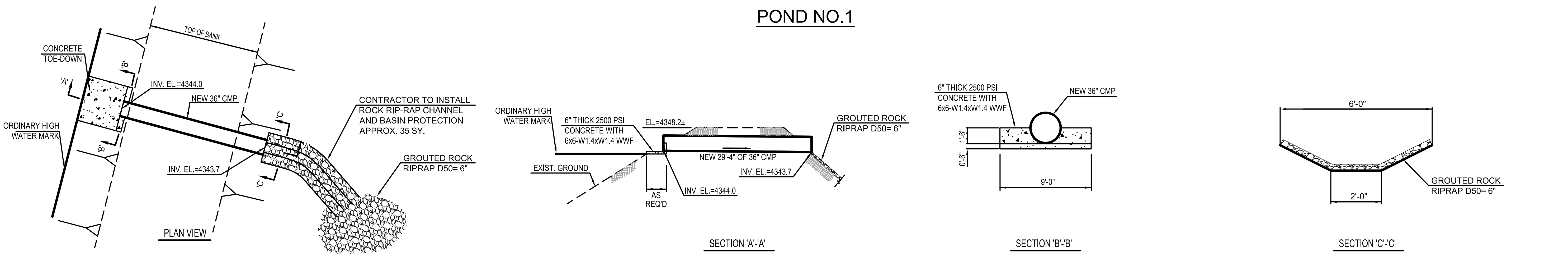
Rosemont Project HMMP
September 12, 2017

SONOITA CREEK RANCH
POST MITIGATION IMPLEMENTATION
Figure 13

CORPS FILE NO. SPL-2008-00816-MB



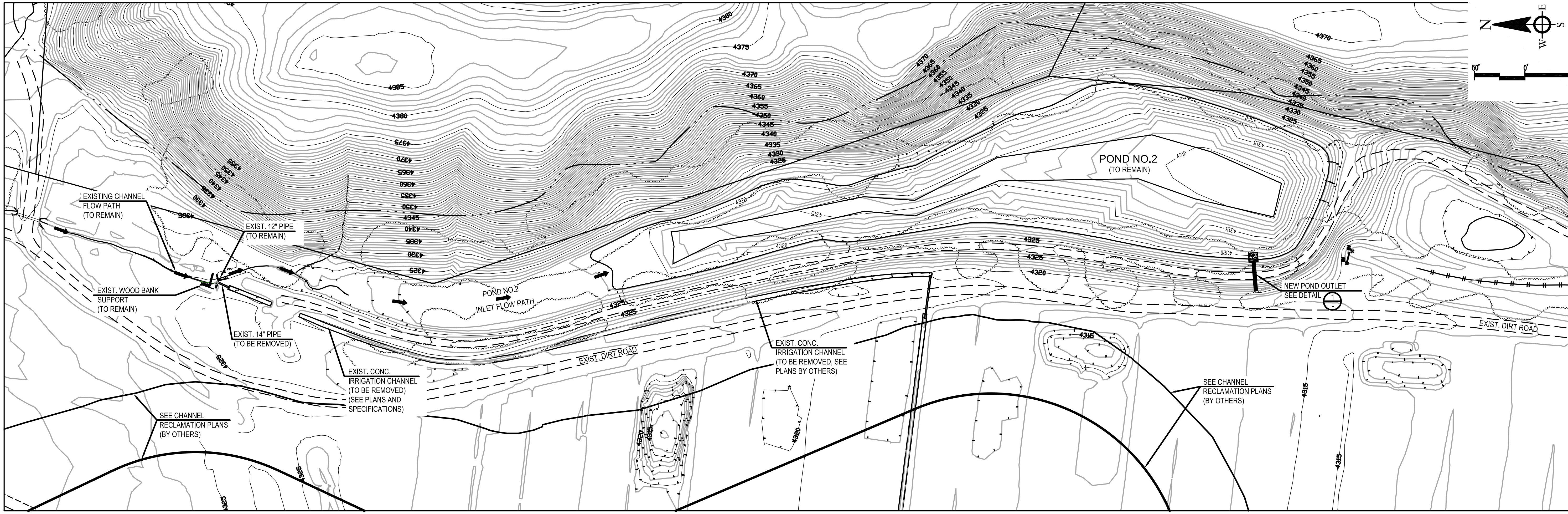
POND NO.1



POND OUTLET DETAIL
N.T.S.

NOT FOR CONSTRUCTION

ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017
POND NO.1 LAYOUT SHEET
Figure 14



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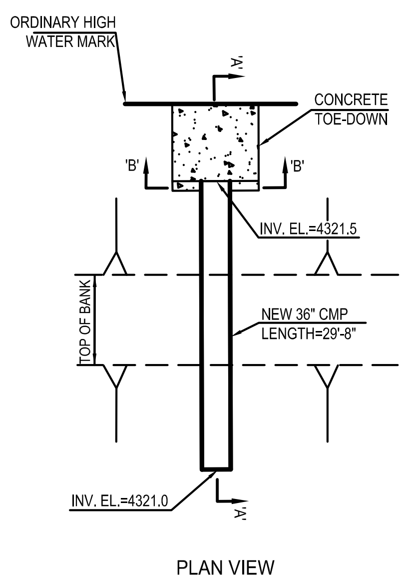
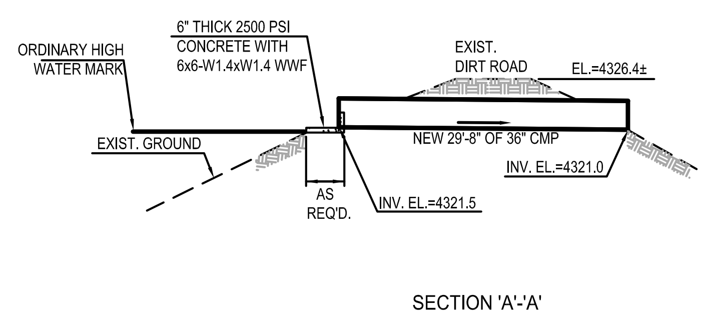
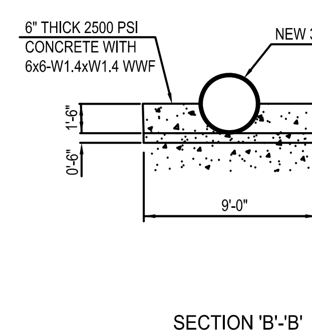


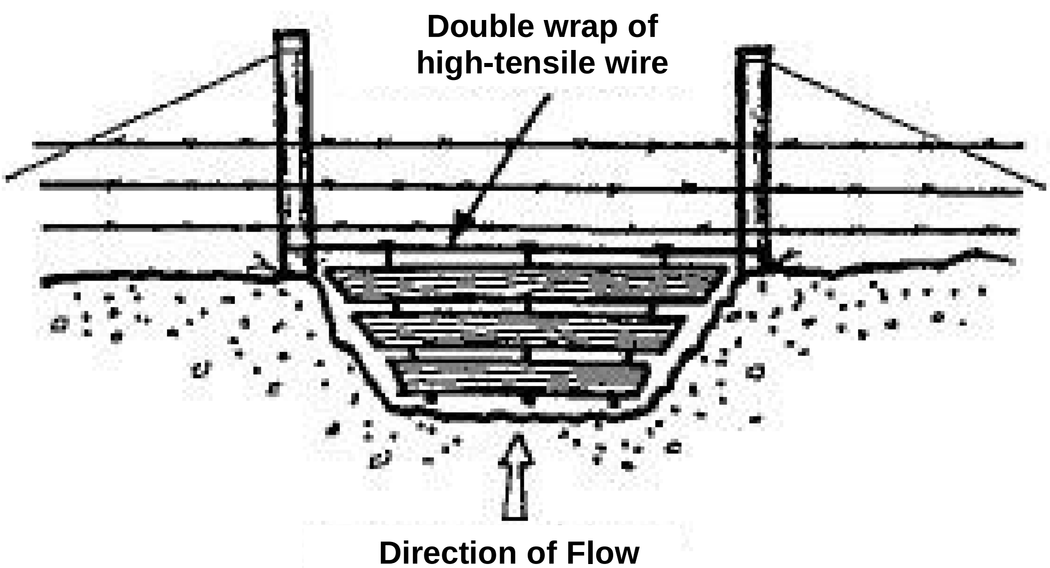


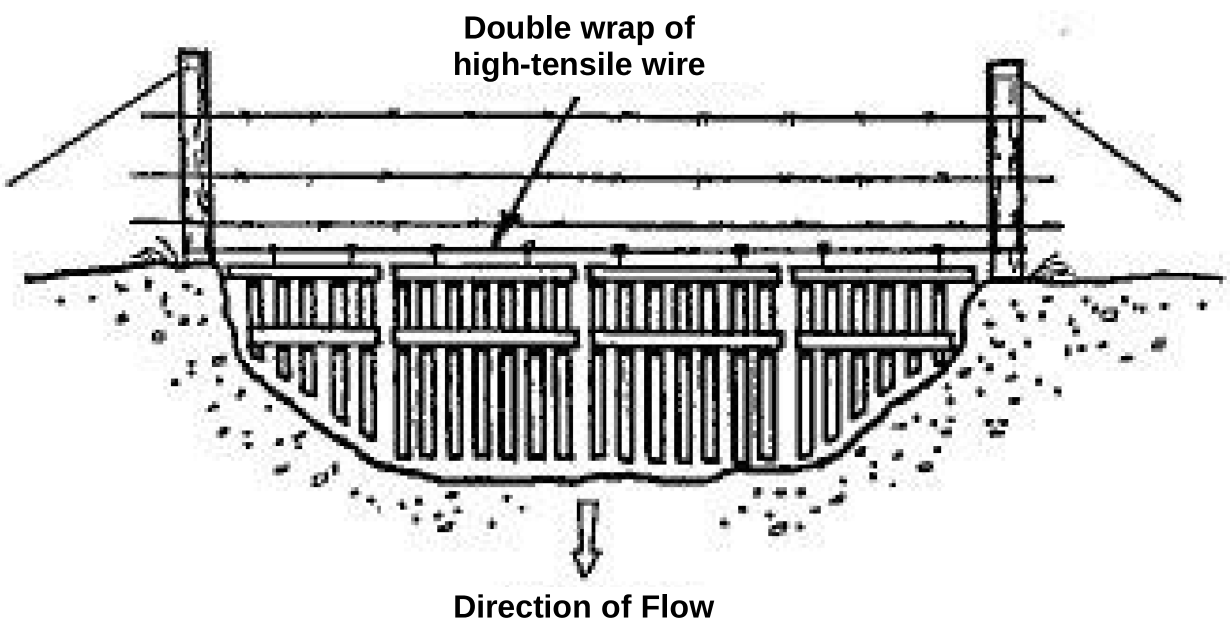


NOT FOR CONSTRUCTION

1 POND OUTLET DETAIL
N.T.S.

ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017
POND NO.2 LAYOUT SHEET
Figure 15





Source: Arizona Game & Fish Department.
September 2011, Revision. Wildlife Compatible Fencing

ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017

STANDARD SWINGING
FLOOD GATES DETAIL
Figure 16

CORPS FILE NO. SPL-2008-00816-MB

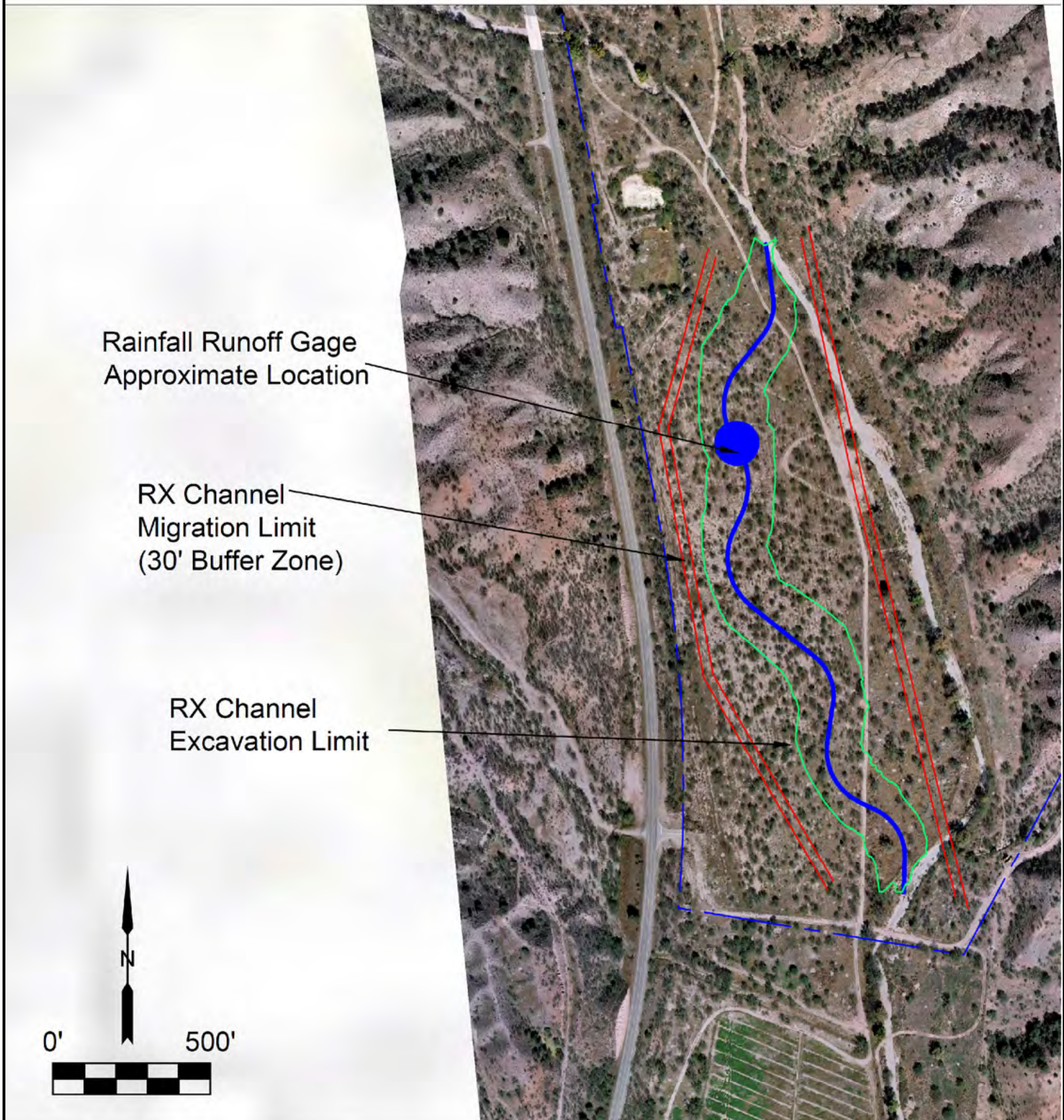


Image Source: Water & Earth Technologies

ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017

RX CHANNEL MIGRATION LIMIT
Figure 17
CORPS FILE NO. SPL-2008-00816-MB

WestLand Resources

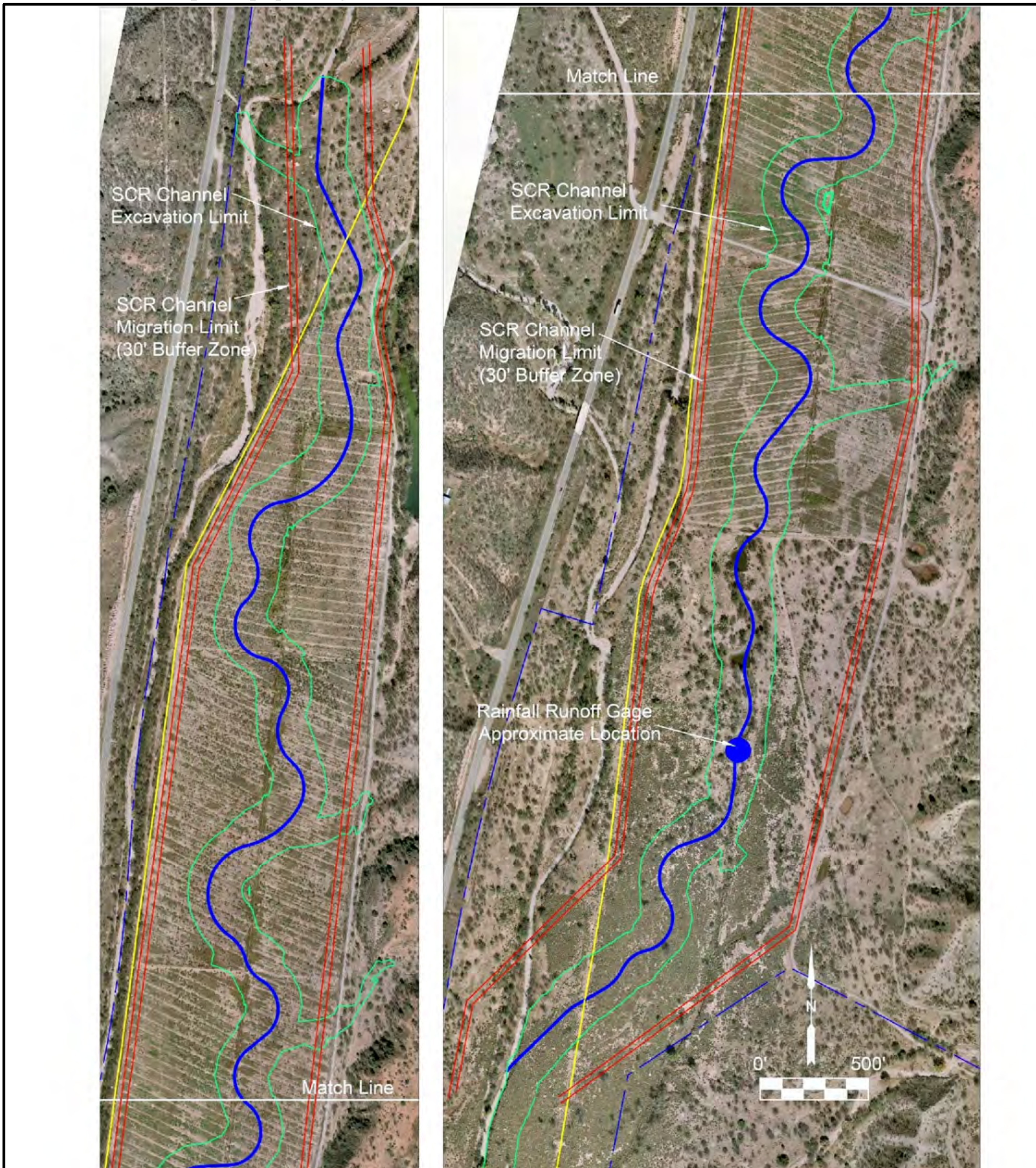


Image Source: Water & Earth Technologies

WestLand Resources

ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017

SCR CHANNEL MIGRATION LIMIT
Figure 18
CORPS FILE NO. SPL-2008-00816-MB

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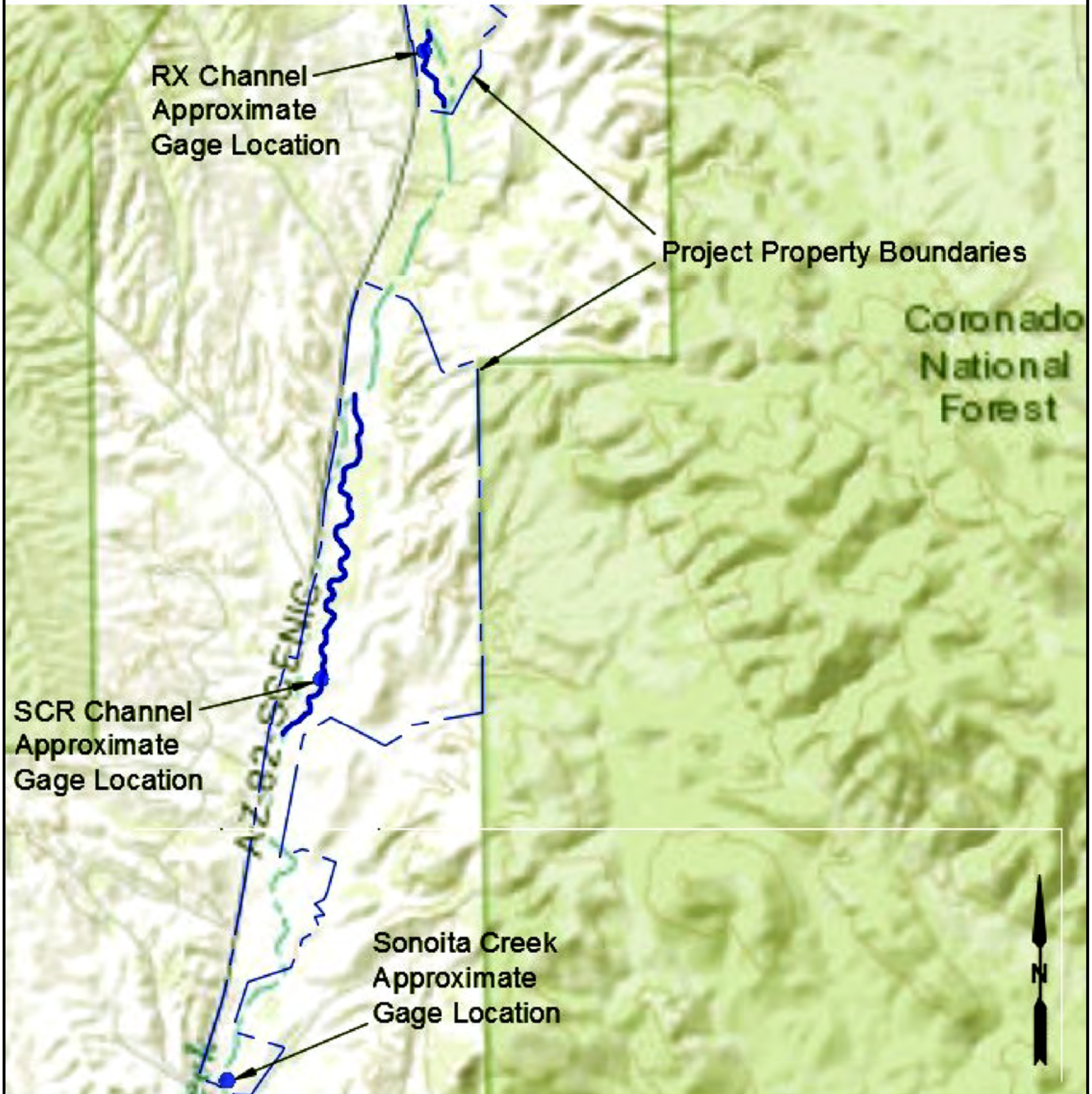

Image Source: Water & Earth Technologies

ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017

RAINFALL RUNOFF GAGE LOCATIONS
Figure 19

CORPS FILE NO. SPL-2008-00816-MB

WestLand Resources

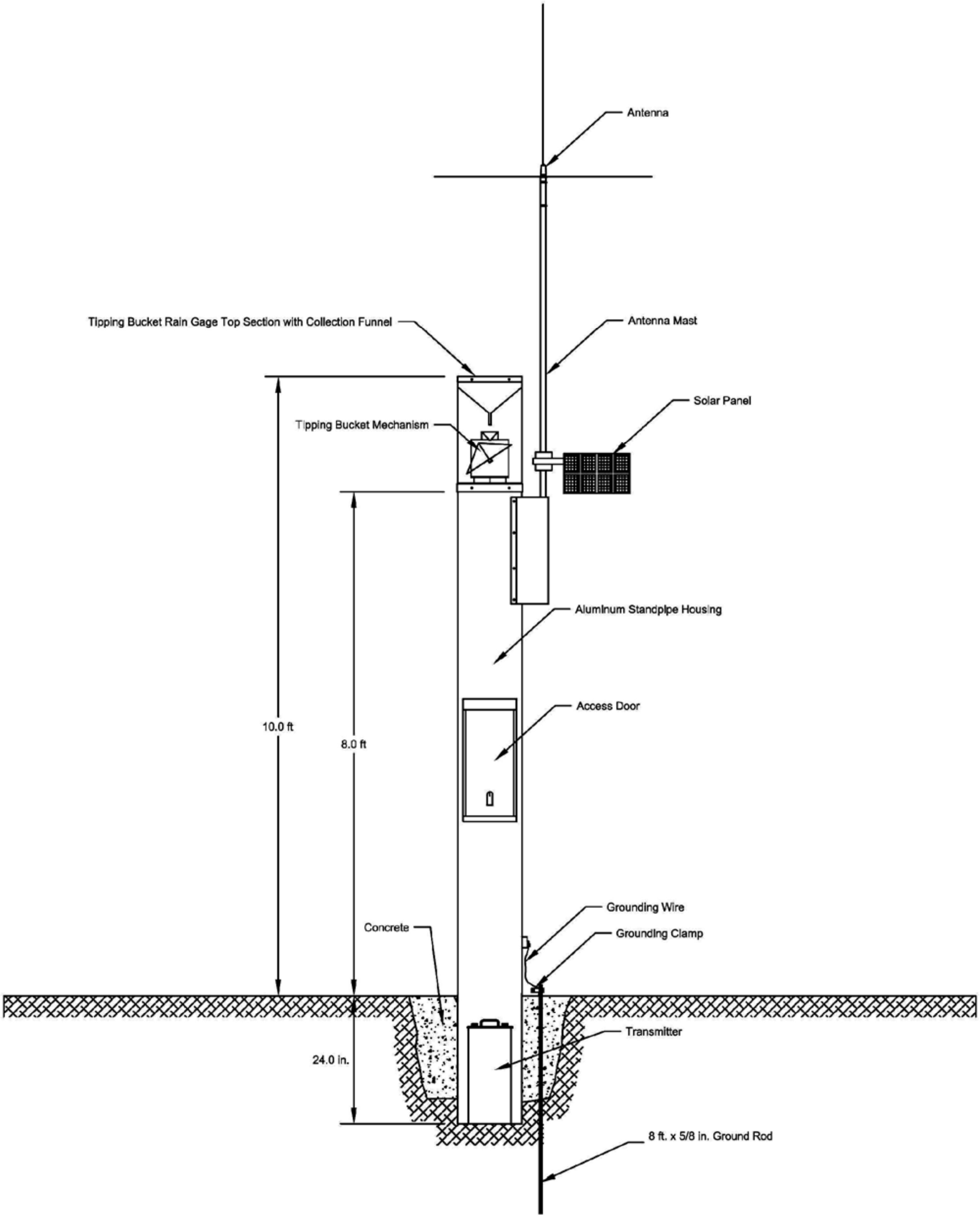

Image Source: Water & Earth Technologies

ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017

STANDPIPE DETAIL SCHEMATIC
Figure 20

CORPS FILE NO. SPL-2008-00816-MB

WestLand Resources

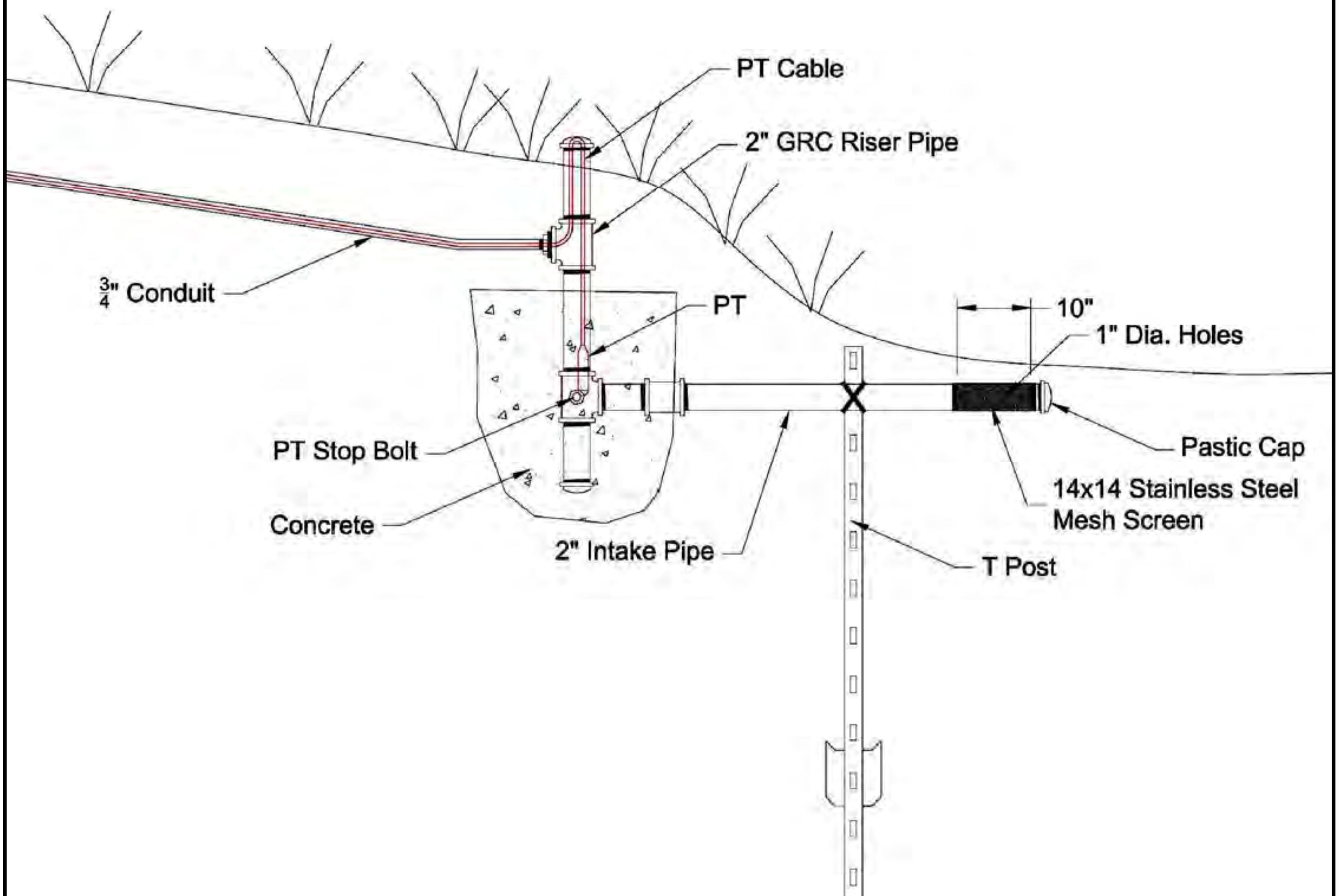

Image Source: Water & Earth Technologies

WestLand Resources

ROSEMONT COPPER COMPANY
Rosemont Project HMMP
September 12, 2017

RISER DETAIL SCHEMATIC
Figure 21

CORPS FILE NO. SPL-2008-00816-MB

ATTACHMENT 1

Mitigation Objectives

Attachment 1: Mitigation Objectives Tables

Table 1-1: Impact Site Description (Rosemont Copper Project)

Pre-Construction Site Conditions							Post-Construction Site Conditions			
Site No.*	**Habitat Types**	**Vegetation Communities**	**Cowardin**	**HGM**	**Hydrology**	**FCAM CRAM (if used)**	**Activity**	**Permanent Loss (ac)**	**Indirect Loss (AFA)**	**Temporary Loss (ac)**
Non-Wetland Waters of the U.S.										
1	Xeroriparian	Madrean evergreen woodland/ Semidesert grassland	R4SB	Riverine	Ephemeral	N/A	Mine features	19.2	2	0
1	Xeroriparian	Madrean evergreen woodland/ Semidesert grassland	R4SB	Riverine	Ephemeral	N/A	Mine features	20.9	0	0
2	Xeroriparian	Madrean evergreen woodland/ Semidesert grassland	R4SB	Riverine	Ephemeral	N/A	Utility line and roadway	0.25	0	1.1
							TOTAL	**40.4**	**N/A**	**1.1**

*Site 1 occurs at the primary mine site on the east side of the Santa Rita Mountain divide and is divided into large, low-gradient drainages and smaller, higher-gradient drainages. Site 2 represents the utility line on the west side of the Santa Rita Mountains.

Table 1-2: Mitigation Site Description (Sonoita Creek Ranch)

Site No.	Pre- Construction Site Conditions	Post-Construction Site Conditions							
	Habitat Types	**Habitat Types**	**Vegetation**	**Hydrology**	**Mitigation Method**	***Acres***	**Cowardin**	**HGM**	**FCAM CRAM (if used)**
		Wetland Waters of the U.S.							
1	Open water pond and wetland	Open water pond and wetland	Saltgrass series	saturated	EN	6.0	L1UB4	Slope	
					TOTAL	**6.0**			
		Non-Wetland Waters of the U.S.							
2	Fallow ag field	Xeroriparian	Semidesert grassland	ephemeral	RE	57.4	R4SB	Riverine	
3	Xeroriparian/fallow ag field	Xeroriparian	Semidesert grassland	ephemeral	RH	11.2	R4SB	Riverine	
4	Xeroriparian	Xeroriparian	Madrean evergreen woodland/ Semidesert grassland	ephemeral	EN	21.9	R4SB	Riverine	
					TOTAL	**93.4**			
		Buffer Habitats							
5	Fallow ag field	Xeroriparian	Mesquite/sacaton association	upland	RE	34.6	N/A	N/A	
6	Xeroriparian	Xeroriparian	Madrean evergreen woodland/ Semidesert grassland	upland	EN	66.3	N/A	N/A	
					TOTAL	**100.9**			
		Non-Aquatic Mitigation Excluding Buffer Areas							
7	Fallow ag field	Native grassland	Madrean evergreen woodland/ Semidesert grassland	upland	EN	117.8	N/A	N/A	
					TOTAL	**117.8**			

Table 1-3: Mitigation Site Description (Rosemont Site Pond Removal)

Site No.	Pre- Construction Site Conditions	Post-Construction Site Conditions							
	Habitat Types	Habitat Types[2]	Vegetation[3]	Hydrology	Mitigation Method	*AFA*	Cowardin[4]	HGM[5]	FCAM CRAM[6] (if used)
		Non-Wetland Waters of the U.S.							
1	Xeroriparian	Xeroriparian	Madrean evergreen woodland	ephemeral	RE	39.3	R4SB	Riverine	
					TOTAL	**39.3**			

ATTACHMENT 2

Detailed Engineering Design of the Sonoita Creek Mitigation Project

Final Design of the Sonoita Creek Mitigation Project

Prepared for:

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HUDBAY

Prepared by:

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Water & Earth TECHNOLOGIES
Water Resources and Environmental Consulting

September 8, 2017

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1 Introduction

Water & Earth Technologies, Inc. (WET) provided engineering analysis and design services to Rosemont Copper Company (Rosemont) to develop a mitigation project at the Sonoita Creek Ranch and Rail X Ranch properties. This mitigation project is designed to restore an ephemeral stream in Santa Cruz County, which will mitigate impacts to ephemeral washes at the Rosemont Copper Project (Project) located in Pima County. Both the SCR Project and the ephemeral washes impacted by the Project are in the Santa Cruz River watershed. Both also lie within the Cienega Creek groundwater basin (ADWR, 2009). The United States Army Corps of Engineers (USACE) is the primary permitting agency for the mitigation work. In addition to this design report, mitigation work associated with the SCR Project is displayed on the SCR Project Drawings.

Natural ephemeral streams in the arid southwest have some common tendencies that result from climatic and geologic influences. Annual peak discharges normally result from summer “monsoonal” rains that are highly variable both spatially and temporally. Additionally, most ephemeral streams in the arid southwest have very high sediment loads. Natural ephemeral streams in this region that have moderate to high ecological functionality usually have a degree of channel complexity that includes channel point and medial bars, occasional braiding, access to a floodplain, and an obvious riparian/mesoriparian zone (buffer) adjacent to the channel. However, these types of features are virtually absent along Sonoita Creek throughout the SCR Project site; this absence is due to historic man-made physical alterations.

Sonoita Creek has been physically altered over much of its length along State Route 82 between Sonoita and Patagonia to accommodate the highway, smaller access and private roads, utilities, and agricultural and ranching developments in the valley. Alterations include realigning, straightening and deepening the channel, armoring the banks, and berming the banks to prevent flows from impinging upon roads and fields. The flow capacity of the existing Sonoita Creek is highly variable and depends upon the degree to which the channel has been incised or bermed. In the most altered reaches, instead of a shallow, broad channel with moderate capacity and extensive use of overbanks to convey flood flows, flows within Sonoita Creek are confined to a high-capacity incised channel that maximizes flow velocity and minimizes energy dissipation and infiltration. This high flow velocity condition results in elevated specific stream power, which exacerbates both vertical incision and bank instability through scour and degradation.

At present, the ecological functionality of Sonoita Creek throughout the SCR Project area is limited due to historic man-made alterations and will remain limited indefinitely because of the self-perpetuating high capacity channel. The mitigation concept presented in this detailed engineering design is to re-establish 16,352 feet of the Sonoita Creek channel, floodplain and riparian buffer by constructing two separated restored reaches about 8,000 feet apart, one 2,380-foot reach on the Rail X Ranch (RX) property, and a longer 13,972-foot reach farther downstream (south) on the SCR property, plus four reconstructed tributaries that have a combined total length of 2,533 feet. These properties, a former platted and zoned housing development (including homesites), are currently owned by Rosemont. Though historical mapping and aerial photography of the original Sonoita Creek channel are not available for the period prior to the man-made physical alterations, the mitigation concept is to re-establish the hydrologic and geomorphic processes in the channel system with geometries based on undisturbed Sonoita Creek reference reaches and references reaches from the nearby Walnut Gulch Experimental Watershed (WGEW). Thus, the channel restoration will be analogous to the pre-disturbance channel form, but not an exact reconstruction of the pre-disturbed channel system.

Where each restored reach ties in with the current Sonoita Creek alignment, the existing invert of Sonoita Creek will be matched. Differences in channel cross-sectional geometry will be blended gradually over a transition zone. The existing, incised Sonoita Creek channel will be backfilled where it would be redundant with the restored reaches. By backfilling the old channel, particularly in the vicinity of tie-ins, and matching existing channel invert elevations, the level of functional uncertainty is significantly reduced. The restored channel reaches are designed with a broad, complex cross-sectional geometry which includes a lower-capacity "low flow" channel with stepped benches to form a functioning riparian zone to convey larger storm runoff flows. Features of the restored channel will serve to increase inundation frequency and extent, thus increasing transmission "losses" in the restored reach (to attenuate flood flows and maximize recharge in the alluvium adjacent to the channel). Project benefits are further described in Section 1.2.

This mitigation project will provide the opportunity to generally improve the science and practice of large-scale ephemeral stream restoration as a result of its construction and subsequent monitoring program that emphasizes the re-establishment of dynamic hydrologic and geomorphic processes. The project is a special opportunity and is only possible due to a number of unique circumstances that ultimately resulted from the proposal to mine copper at the Rosemont Project. The Sonoita Creek Ranch and Rail X Ranch have essentially become subdivided into numerous housing parcels. It was only due to strategic purchases by Rosemont of the fragmented real estate that the altered and impaired reaches of Sonoita Creek can be restored at the watershed scale – starting from the valley beginning near the Adobe Canyon flow contribution, all the way through to the southern SCR Project area where Sonoita Creek reverts back to a natural, complex stream.

2 Existing Conditions and Project Description

The reaches of Sonoita Creek that will be restored through the SCR Project have been altered by historic and/or ongoing manipulation of the valley landform and the channel (Figure 1). At the Rail X Ranch, Sonoita Creek lies on the far side of the valley from Highway 82, beyond an expanse of land that is no longer actively cultivated but which appears to have been leveled in the past. Vegetation in this area includes non-native species. It is likely that the channel was straightened and relocated to its current location at the base of the hills. Two small, artificial ponds, which also include invasive species (bullfrogs) on the RX property, will be removed (backfilled) as part of the SCR Project. These two ponds are fed by Cottonwood Spring. There will be no impact to Monkey Spring by removing and reclaiming these two ponds.

Figure 1. Straightened Reach of Sonoita Creek (looking upstream) with Concrete Armored Streambank (Courtesy of Westland Resources)

On the SCR Property, the existing Sonoita Creek is constrained on both sides: by an active agricultural field and a buried 4.5-inch steel high-pressure gas transmission line on one side and by Highway 82 on the other side. Sonoita Creek flows through an impaired, incised, straightened, bermed and armored reach along the edge of the agricultural field with little ability to provide ecological function. High, steep or near vertical channel banks result in limited to nonexistent riparian area, artificially elevated specific stream power, and artificially limited channel infiltration/recharge (Figure 2). Sonoita Creek has been completely disconnected from three of its east-bank tributaries as well as a functional floodplain.

Figure 2. Sonoita Creek Armored Bank with Toe Scour and Limited Ecological Function (Courtesy of Westland Resources)

As part of the SCR Project, degraded reaches of Sonoita Creek will be replaced by restored reaches that are relocated into the center of the valley and designed to mimic natural stream reaches, both visually and functionally, in terms of form, dynamics and ecological function. Excess soil material excavated during restored channel construction will be placed in soil repositories designed to mimic natural geomorphic landforms. These geomorphic landforms will be revegetated with native species.

Specific to the SCR property, the agricultural field, which essentially covers the entire width of the valley floor, will be retired from cultivation and returned to native vegetation. The restored channel will be relocated away from the Highway towards the center of the valley and reconnected with the three east-bank tributaries that are currently truncated. Moving the channel away from the highway will provide a safer wildlife corridor as well as reduce the risk to the highway and its embankment from flood flows and scour. The restored channel will take a meandering course through the currently cultivated area.

As the restored channel accesses the center of the valley and then reunites with the existing Sonoita Creek channel, it will cross a buried gas pipeline in two locations. The existing channel already crosses the pipeline downstream of the Project area, and that crossing will remain. At the crossings associated with the restored channel, the pipeline will be lowered by its owner, Kinder Morgan, based upon their criteria for pipeline depth at channel crossings. Additional information about the pipeline crossings, the Kinder Morgan project that will lower the pipeline, and an independent scour analysis to determine the recommended pipeline depth, are included in Section 6.3 of this report.

A water right for Monkey Spring is part of the purchase of the SCR property. The apportioned spring flow has been used to irrigate the field and provide stock watering for horses and cattle, but will be retired from agricultural uses and will be routed into the restored Sonoita Creek as part of the SCR Project. Two large existing ponds, constructed in series, will remain to convey the spring flow to the restored channel. The spring typically flows at approximately 1 cfs and, at a minimum, will locally contribute recharge to the alluvium in the restored riparian corridor.

The restored channel reaches were designed primarily as ephemeral channels that will convey runoff in response to precipitation events. Significant care was taken in determining the flow recurrence interval that governed the channel sizing, including determining the peak design flows for channel design. Although hydraulic structures and conveyance channels are typically designed for the 100-year storm, this approach would oversize the restored channels, which are designed for ecological mitigation and not hydraulic efficiency or flood control. The new channel alignment and geometry were designed to re-establish sediment transport continuity and hydrologic connectivity to the floodplain. The channel designs are based upon a geomorphic size correlating with a 10-year storm.

There are many research scientists, scholars, and engineers (e.g., Miller 1997) that attribute channel form for most ephemeral streams in the arid southwest with a 10-year storm. This is acknowledged as somewhat different than "bankfull discharge" or "dominant discharge", which occurs on a recurrence interval of about 1 to 2.4-years. Bankfull discharge and the somewhat smaller recurrence storms are generally considered responsible for channel forming in many other hydrologic systems outside of the arid southwest. The 100-year floodplain throughout the Project area has not been mapped using detailed analysis for FEMA floodplain delineation due to its rural character. However, the floodplain information that is available indicates the 100-year flow in Sonoita Creek would inundate the majority of the valley even under existing conditions, i.e., incised, high-capacity Sonoita Creek. The SCR Project will not change that condition, nor alter inundation outside of the project area, except to the extent that flood flows downstream of the project could be attenuated by the high infiltration and energy dissipation that the restored channel reaches will provide. Multiple methods, including both theoretical hydrologic modeling methods and empirical methods based upon analyses of rainfall and runoff data, were utilized to increase confidence in the design peak flows. The hydrological analyses conducted are summarized in Section 3.

It is difficult to definitively establish 1) either the historic (natural) characteristics of Sonoita Creek or 2) the changes to those characteristics that would have occurred naturally over the time period coinciding with development in the valley had that development not occurred. However, the design process did incorporate an analysis of 'reference reaches' selected to represent the characteristics of existing channels with stable geometry, desirable vegetation and valuable contributions to ecological resources in the riparian corridor. Channel cross sections were identified and surveyed in the central and southern portions of the SCR Project area that were functioning ecologically at a high level. In addition, data are available for a nearby stream system, Walnut Gulch that is similar to Sonoita Creek in many ways but has not experienced the same development pressure and physical alteration. The watershed surrounding Walnut Gulch has been studied since 1953 as one of the United States Department of Agriculture (USDA) Agricultural

Research Service (ARS) Southwest Watershed Research Center's outdoor laboratories, with research focusing on hydrology, erosion and sedimentation, remote sensing and decision support systems. The Walnut Gulch Experimental Watershed (WGEW) surrounds Tombstone, Arizona and is the most highly instrumented semi-arid experimental watershed in the world (USDA ARS, 2003). The restored channel design has a cross-sectional geometry that emulates both the ecologically functional reaches of Sonoita Creek and those of Walnut Gulch with similar hydrologic regime, gradient and watershed area.

The restored Project area channel geometry includes a low-flow channel with floodplain benches suitable for riparian zone revegetation. Staff at the WGEW have provided major contributions to the understanding of ephemeral systems and were also consulted as part of mitigation project. WGEW staff provided topographic data of Walnut Gulch as well as engaging in discussions related to hydrology and channel geomorphology at Walnut Gulch. Information about how work at the WGEW was utilized to support the SCR Project design process is included in Section 3.2.1.

Input to the channel design process was also provided by Dr. Brian Bledsoe P.E., Ph.D. Dr. Bledsoe is a Professor in the School of Environmental, Civil, Agricultural and Mechanical Engineering at the University of Georgia, with over 27 years of experience as an engineer, hydrologist, and environmental scientist in the private and public sectors (http://bledsoe.engr.uga.edu/). He completed his Ph.D. at Colorado State University in 1999 in hydraulics and river mechanics, subsequently becoming a tenured professor in civil and environmental engineering. Additionally, he has authored numerous papers and reports on fluvial geomorphology, sediment transport, and flow-ecology relationships, and has worked throughout the U.S. on perennial, intermittent and ephemeral stream systems. Dr. Bledsoe attended several site visits, and provided input into the development and implementation of the field sampling and surveying program. Following the field program, Dr. Bledsoe provided direction regarding the hydrologic, hydraulic, and sediment transport analyses that helped shape the channel design.

The restored channel reaches are not intended to permanently remain in an "as-built" condition, but instead are designed to function, geomorphically and ecologically, like an unconstrained stream reach. The restored channels will not be armored or hardened, but free to migrate and change under the influence of events, including flood flows. Additional information regarding how the channels may evolve over time after their construction is included in Section 6.5.

2.1 Historical Overview

Sonoita Creek's current stream morphology is the product of natural geological and climatic characteristics and processes, including human activities, that are responsible for the current watershed topography, soils and vegetation conditions. Beginning near the fairgrounds area in Sonoita, AZ, Sonoita Creek drains extensive areas of the Santa Rita Mountains as well as local portions of the Canelo Hills through a narrow valley of unconsolidated silt, sand and gravel alluvium up to 90 feet thick (Ledbetter, 2011). Mountainous bedrock uplands and bajadas with sparse vegetation limit infiltration and provide abundant sediment supply in the headwaters. Infiltration in valley areas composed of unconsolidated alluvium is high during both precipitation and flow events. Transmission losses of 17-29% have been reported for arid region ephemeral streams like Sonoita Creek, thus contributing to discontinuities in channel flow in response to specific rainfall events (Sutfin, 2013). Over much of its length, and throughout the SCR Project area, Sonoita Creek is a sediment transport limited system with abundant sediment supply relative to the sediment transport capacity. Natural bar formation and sediment aggradation processes will favor development of braided channel morphology in unconstrained reaches of Sonoita Creek and its larger, low-gradient tributaries. Aggradation in wide braided washes typically results in the development of secondary, perched channels as well as shifting subordinate braids that can persist indefinitely between large flow events, significantly redistributing accumulated sediments (Sutfin, 2013).

Beginning with settlement in the late 1800's, Sonoita Creek has been impacted by grazing, railroad and road construction as well as groundwater development for irrigation and municipal water supply (Ledbetter, 2011). A railroad built in 1882 followed the entire length of Sonoita Creek. Most of the track was removed after the railroad was abandoned but vestiges of the railroad that confine the creek remain. Additionally, other man-made confinements remain that include elevated road berms in the floodplain, channelization of tributaries, disconnection of some tributaries, and channel bank armoring. These artificial confinements prevent overflow channel development and lateral migration, thereby disrupting natural fluvial geomorphological processes that would otherwise encourage the regeneration of riparian vegetation habitat diversity (FWS, 1994).

2.2 Project Benefits

The SCR Project is designed to eliminate historical impacts to the existing channel of Sonoita Creek and to re-establish the benefits associated with typical unconstrained channel morphology. The restored channel will provide significant hydrologic and habitat functions. Specifically, moderate to high flows will access a functional floodplain that is wetted during more frequent overtopping events compared to the current condition, as few events can overtop the incised, constrained channel. Shallow, out-of-bank flow will dissipate flow energy and reduce flow velocities during flood events affecting the restored channel. This will reduce channel erosion and promote deposition of material. In addition to energy dissipation, overbank inundation will increase infiltration and groundwater recharge along Sonoita Creek throughout the SCR Project area. Broader inundation and short-term subsurface water storage will support shallow groundwater in the riparian corridor, thus increasing the availability of moisture to streamside vegetation and improving habitat.

The restored channel design does not include the construction of any weirs, hardened diversion structures, levees, or headgates. Instead, the initial cross section of the restored channel is a complex compound channel with multiple overbank benches that will transition to match the existing Sonoita Creek cross section and channel invert elevation at the upstream and downstream tie-in locations. The complex trapezoidal channels have bottom widths ranging from 40 to 50 feet and stepped channel bench features extending horizontally from a point 2.0 feet above the channel invert, as supported by measurements of undisturbed references reaches on Sonoita Creek and the nearby WGEW. The channel benches range in width from 23 to 92 feet. A 10:1 (H:V) side slope projects upward from the outer limits of the channel benches to intercept existing ground. The wide, shallow cross-sectional geometry will allow ephemeral channel dynamics to occur, resulting in the development of a braided planform within the constructed channel through natural fluvial processes. Initial maintenance following the first few events after construction may be necessary; however, the channel is designed to be self-sustaining. After the first few years (while vegetation establishes and the restored channel adjusts) long-term maintenance is expected to decrease significantly.

2.3 Project Overview

Sonoita Creek will be backfilled at two separate, existing reaches (RX & SCR) with a restored channel constructed in each location (Figure 3). The total length of restored channel is 16,352 feet comprised of 2,380 feet of RX Channel and 11,461 feet of SCR Channel, plus an additional 2,511 feet of channel restoration downstream of the SCR/Sonoita Creek confluence. In addition to re-establishing portions of Sonoita Creek, four small tributary channels (W1, E1, E2, E3) will be constructed to reconnect these unnamed ephemeral drainages, located in the hills to the east of the restored channels, with Sonoita Creek. The total length of tributary reconstruction is 2,533 feet.

The RX Channel begins approximately 150 feet downstream of the confluence of Sonoita Creek and Adobe Canyon, deviating from the existing stream course and meandering along the valley floor and then returning to the existing alignment at the southern end of the RX property. Material excavated from the restored channel will be used to backfill the altered and impaired reach of Sonoita Creek, as well as backfill for two, small artificial ponds.

The SCR Channel begins approximately 2,300 feet downstream of the Wood Canyon inflow to Sonoita Creek, and upstream from a 90-degree channel bend that features deteriorated gabion baskets installed to halt channel migration further towards the highway and utility lines. The SCR Channel migrates down centrally through an agricultural field and then returns to the existing alignment downstream of the Big Casa Blanca Canyon inflow. Channel restoration occurs along the existing alignment for 2,511 feet downstream of the SCR Channel Sonoita Creek Confluence. Monkey Spring will be reconnected with Sonoita Creek by conveying discharge from a series of existing ponds (reservoirs) through a constructed drainage into the SCR Channel. Material excavated from the SCR Channel will be used to backfill the existing straightened reach of Sonoita Creek, to reshape the leveled and terraced agricultural field for the purpose of altering the former irrigation features, and to create four (4) separate geomorphic landforms, which will function as alluvial/colluvial deposits at the base of the hillslopes along the east edge of the valley.

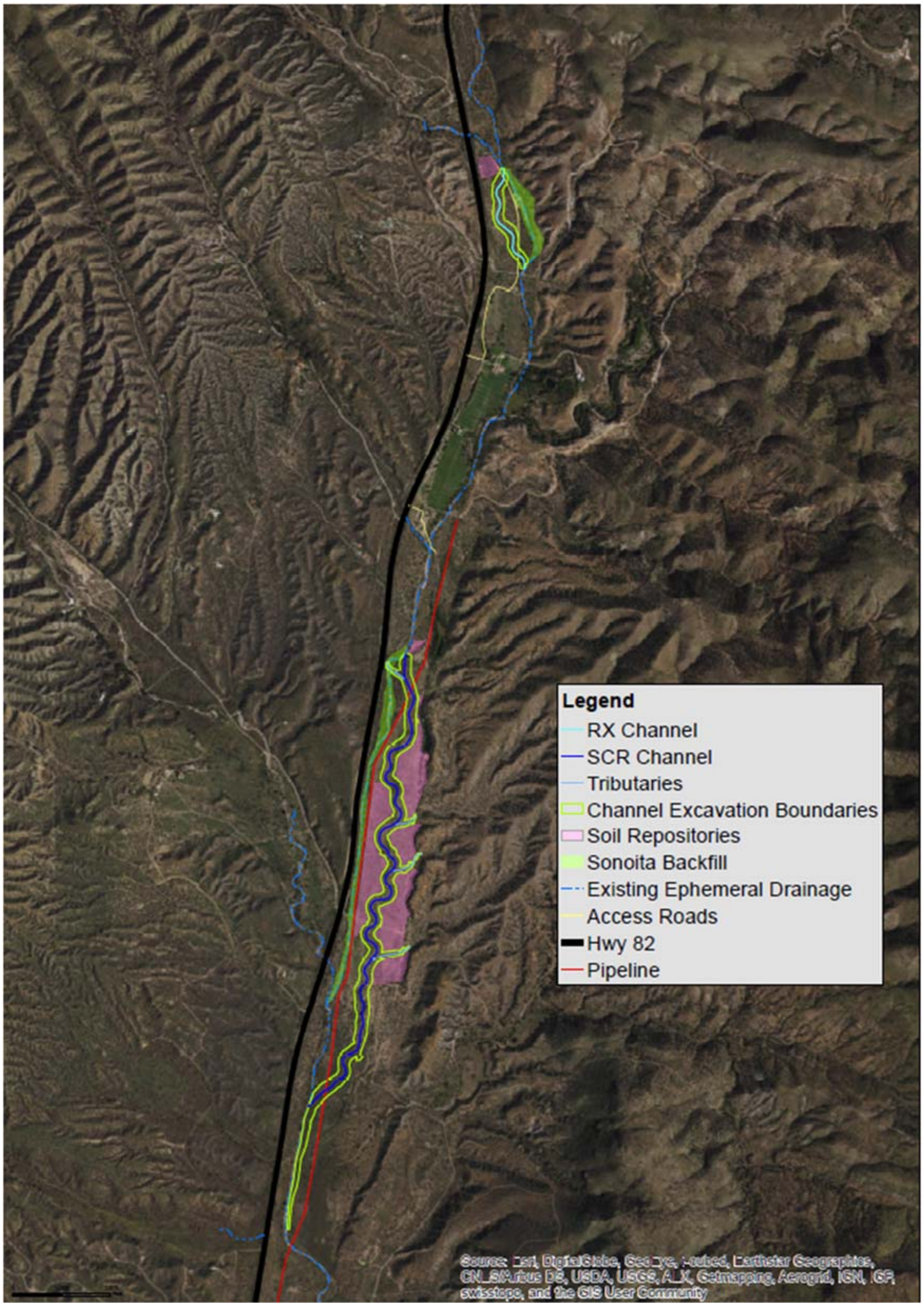


Figure 3. Sonoita Creek Channel Layout

3 Hydrologic Analysis

Hydrologic modeling was performed to estimate peak discharge values for storms having selected recurrence frequencies at relevant design points within the Sonoita Creek watershed. Accurate discharge estimates with their associated storm return interval are important for properly sizing the restored channels. The conclusion of the hydrologic analysis (flows used for design) is based on several different methods including: three (3) rainfall-runoff models, an empirical area-runoff model, and a forensic rainfall-runoff model of an actual storm event. Bolstering the theoretical hydrology models is a comparison to measured flow data from Walnut Gulch, which is in the same region as the SCR Project and has many similar watershed characteristics to those in the SCR watershed (see Figure 6).

The Arizona Department of Water Resources (ADWR) State Standards Workgroup developed the State Standard for Hydrologic Modeling Guidelines (ADWR, 2007) to support consistency in hydrologic analyses in Arizona, particularly with respect to floodplain delineation and management activities. The modeling methods used for the SCR Project are compliant with these guidelines. The State Standard is largely based upon criteria described in the Arizona Department of Transportation (ADOT) "Highway Drainage Design Manual - Hydrology." (March 1993). The State Standards allow for the use of many different hydrologic models for rainfall-runoff modeling in Arizona, using NOAA Atlas 14 precipitation values. Mean point rainfall values for the centroid of the watershed were used, along with the appropriate depth-area reduction factors taken from Table 3.0 of the State Standards (ADWR, 2007). Mean point rainfall values from NOAA Atlas 14 were also reviewed for several other locations in the watershed (Table 1). Generally, the point precipitation values are very similar except for increased precipitation values at the highest points in the watershed (Top of Fort Canyon, Top of Casa Blanca). These two points have elevations, 8,634-feet and 7,887 feet, respectively, which are much higher than the mean elevation for the entire watershed (5,090-feet). Point rainfall values at these high-elevation locations are not representative of the watershed as a whole. Calculating design discharges using these higher point rainfall values would artificially inflate the channel inundation area from which mitigation credits are calculated.

Table 1. Rainfall Sensitivity in Sonoita Creek Watershed

Location	Latitude	Longitude	Elevation (ft)	10-yr, 24-hr Point Precipitation (in)	Lower Bound (90%) (in)	Upper Bound (90%) (in)
Centroid	31.6540	-110.7320	4,594	3.30	2.98	3.64
Top of Fort Canyon	31.7069	-110.8414	8,634	4.46	4.02	4.93
Top of Casa Blanca Canyon	31.6918	-110.8414	7,887	4.45	4.01	4.93
Sonoita Creek Ranch	31.6085	-110.7200	4,315	3.22	2.90	3.56
Top of Dark Canyon	31.5891	-110.6557	5,538	3.22	2.91	3.53
Top of Sonoita Creek	31.6739	-110.6608	4,855	3.16	2.86	3.46

Initially, Sediment, Erosion, Discharge by Computer Aided Design (SEDCAD) 4.0 (Civil Software Design, 1998) and the U.S. Army Corps of Engineers Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) were used to determine peak discharge rates for various statistical recurrence intervals. Additional hydrologic analyses were conducted including the Clark Time-Area Method (CTAM), USGS regional flood regression equations, and a rainfall-runoff analysis for a July 27, 2014 storm event that occurred at the SCR Project site. In addition, hydrologic relationships developed for the WGEW were analyzed to establish that the theoretical hydrologic models were producing runoff estimates consistent with real-world measurements of watershed response. These additional hydrologic models and analyses were used as multiple lines of evidence in evaluating peak discharges for the SCR Project.

As described below, the statistical peak discharges estimated with SEDCAD are generally bracketed by discharges computed with the other hydrologic methods. The discharges used for channel design and inundation area calculations were those derived using SEDCAD. Modeling results demonstrated that discharge has a non-linear relationship with watershed area, with the unit discharge per acre typically decreasing with increased watershed area. This relationship is supported by reviewed literature (Goodrich et al. 1997).

3.1 SEDCAD Hydrologic Modeling to Determine Design Peak Flows

SEDCAD was used to determine a range of peak discharges expected from statistical precipitation events. SEDCAD shares many similarities with other hydrologic models, like HEC-HMS, that are recommended for use by such organizations such as ADWR and ADOT. SEDCAD uses Soil Conservation Service (SCS) curve numbers (CN) for watersheds to quantify the total runoff volume from storm precipitation and the unit hydrograph (UH) method to describe hydrologic response. The SEDCAD model uses a double triangle dimensionless UH shape, which is parameterized based on the time of concentration. Peak flow estimates determined using the SEDCAD model, employing the double triangle dimensionless UH, were preferred for the SCR Project as described below. Runoff hydrographs from semi-arid watersheds are often characterized by a sharp rising limb, a fairly narrow peak, and followed by a longer receding limb. To account for delayed response due to interflow (water that moves through the unsaturated zone that returns to the surface), the double triangle UH provides this delayed response shape by providing a two-segment trailing limb of the hydrograph (Ward et al. 2004). A medium response time double triangle was used, which defines the appropriate double triangle shape for semi-arid land cover, based on SEDCAD users' manual guidance. The SEDCAD model and the double triangle UH have been successfully applied with satisfactory results in many semi-arid watersheds.

Three separate SEDCAD models were developed to predict flow along Sonoita Creek: one for the RX Channel: one for the SCR Channel: and one for the Sonoita Creek bank improvements downstream of the Big Casa Blanca Canyon flow contribution. Three additional models were developed to predict flow for the three tributaries (Tributary 1 – 3) that will be reconnected with Sonoita Creek during construction of this mitigation project. A seventh SEDCAD model was run to compare flows predicted during an Flood Insurance Study (FIS) downstream of the SCR Project area at the confluence with Harshaw Creek. An FIS is a report prepared by the Federal Emergency Management Agency (FEMA) that summarizes an analysis of the flood hazards in a community or basin. An eighth SEDCAD model simulated a 100-year storm without areal reduction factors applied in order to determine a conservative flow estimate for use in determining pipeline scour and pipeline reburial depths.

For modeling, watershed areas above the approximate channel take-off point were delineated using USGS topographic mapping. The composite curve number for the watershed (80.2) was determined using NRCS soil mapping for the watershed area coupled with vegetative cover estimates from aerial photography. The longest flowpath used to determine time of concentration was measured from the USGS topographic mapping. Peak flows for the modeled watersheds were calculated using 24-hour NRCS Type II storms, with the major portion of the 24-hour event occurring over a 1-hour period. Sonoita Creek falls within the region for which the NRCS Type II distribution is specified for modeling (NRCS, 1986). The Type II rainfall distribution contains an intense period of rain that produces the majority of the total storm rainfall, regardless of the storm duration. The Type II storm is therefore well-suited for modeling the high-intensity summer monsoonal rainstorms which drive ephemeral channel function at Sonoita Creek. The rainfall amounts used in the SEDCAD models came directly from the NOAA Atlas 14 point-precipitation database for the SCR Project area. However, due to the watershed size, areal reduction factors were applied to the modeled rainfall amounts to account for spatial variability. Areal reduction factors were applied in accordance with ADWR State Hydrology Guidelines. Peak discharge for the 2-, 5- and 10-year, 24-hour design storms are reported in Table 2.

Table 2. Design Discharges at the RX Channel, SCR Channel, and Sonoita Creek Bank Improvements

Channel ID	2-yr, 24-hr Peak Discharge (cfs)	5-yr, 24-hr Peak Discharge (cfs)	10-yr, 24-hr Peak Discharge (cfs)
RX Channel	1,486	2,496	3,377
SCR Channel	1,463	2,513	3,486
Sonoita Creek Bank Improvements	2,150	3,691	5,065

3.2 Rainfall-Runoff Analysis

As an additional check for the design peak flow estimates, a rainfall-runoff analysis of the July 27, 2014 storm event was conducted that occurred in the SCR Project area (Appendix D). An ALERT rain gage in the Santa Cruz County Flood Control District (SCCFCD) network recorded a 24-hour total of 2.76 inches on July 27, 2014 (station 2520 Sonoita Creek Precipitation, located near the mouth of Big Casa Blanca Canyon, tributary to Sonoita Creek at the SCR Project site). Based on rainfall data from NOAA Atlas 14, this storm was between a 2-year (2.30 inches) and a 5-year (2.86 inches), 24-hour storm event.

A forensic hydraulic analysis of high water marks was conducted independent of the rainfall analysis. Peak discharges for the 2-year, 24-hour and the 5-year, 24-hour storm were estimated for the high-water mark location using the SEDCAD method. Peak discharge was also estimated for the July 27, 2014 rainfall event using the measured rainfall total, distributed as a Type II rainfall event as a model input. Peak discharges were then simulated in the U.S. Army Corps of Engineers Hydrologic Engineering Center-River Analysis System (HEC-RAS) model at the high-water mark location. The HEC-RAS simulation showed close agreement between the observed high-water marks in the field (approximately 2 feet deep) and the simulated flow depths of 1.84 feet and 2.39 feet corresponding to the 2-year, 24-hour discharge and 5-year, 24-hour discharge, respectively, computed using SEDCAD.

3.2.1 Comparison of Sonoita Creek to Walnut Gulch Experimental Watershed

Analyses were completed on data from the Walnut Gulch Experimental Watershed (WGEW) for comparison to the modeled results on Sonoita Creek. Given its close proximity and similar climatic and physical conditions, the WGEW provides some hydrologic and geomorphic analogs to Sonoita Creek while representing an ephemeral stream channel with significantly fewer impacts from development and watershed disturbance (Exhibit 1). The WGEW is less than 40 miles away from the SCR Project (measured from Flume 6 at WGEW). Flume 6 at WGEW has a watershed area of 36.7 square miles, while the watershed area at the SCR Channel in Sonoita Creek is 38.7 square miles. Both channels have longitudinal gradients on the order of 1 percent and have channel bed substrate characterized as coarse sand. Walnut Gulch has numerous reaches exhibiting broad, shallow channel forms with significant channel braiding near to, and downstream of, Flume 6.

Data and analyses comparing Walnut Gulch to Sonoita Creek supports the proposed hydrology and geomorphology at SCR and the expectation that complex channel features similar to those seen adjacent to Flume 6 at WGEW will develop due to flow events in the re-established Sonoita Creek. Cattle grazing and recreation are the primary land uses in the WGEW, with some historic mining. Vegetation is typical of the transition between the Chihuahuan and Sonoran deserts. Approximately one-third of the WGEW watershed is currently classified as grassland, but as much as 95% of the watershed is reported to have been in grassland in the early 1900's. Grasslands have tended to persist on the eastern side of the watershed, where soils are more clay rich than on the western side. The vegetative cover on the remaining areas is variably sparse shrubs and bushes. Like Sonoita Creek, Walnut Gulch is underlain by very thick, coarse-grained alluvium, which hosts substantial groundwater reserves. Ephemeral channels have very high transmission losses. Mean annual precipitation on the WGEW is 12 - 14 inches per year, compared to a mean annual precipitation at SCR of 18 – 20 inches per year (ADWR, 2009).

WGEW scientist Miller sought to develop a GIS-based inventory of stream channel characteristics over the entire WGEW (Miller, 1997). He surveyed channel reaches (3 to 5 cross sections in each reach) at over 200 locations throughout the watershed, encompassing headwater low-order channels and larger channels including one 6th order wash. Reaches that were obviously manipulated or degraded were avoided. Although many researchers have found that width/depth ratios remain constant throughout a watershed, even as stream order increases (typically research has focused on perennial streams in wetter climates), Miller found that channel morphology in Walnut Gulch is not consistent throughout the watershed. Specifically, bankfull cross-sectional area remained relatively consistent while width/depth ratio markedly increased for higher order channels; i.e., average channel width increased much more than average channel depth as streams combined. Miller explained that higher order streams with abundant sediment supply and clay-poor soils adjusted to increased stream power by widening, rather than incising. Banks with little cohesive material and sparse vegetation were more susceptible to erosion, with material redistributed to the channel bed maintaining broad, shallow channels (Miller 1995). Miller reported the development of braided channel morphology including bars and "islands" within broad, shallow higher-order channels. Miller also reported that some cross sections displayed "a series of terraces and channel islands."

There is substantial similarity between the WGEW and the Sonoita Creek watershed, particularly in the reaches of Sonoita Creek that are included in the final design. Findings from Miller and the WGEW support a Sonoita Creek design that includes a broad, shallow channel free to braid. The final design is dynamic and will accommodate the natural development of bars, benches and islands within the primary channel footprint.

USGS Regional Regression equations are generally thought to under-predict peak discharge for the smaller storm recurrences (i.e., 2-year, 5-year, and 10-year storms) therefore, measured discharge from Walnut Gulch was compared with predicted discharge using the USGS Regional Regression Equations. The entire data set of runoff at Flume 6 was chosen for this comparison due to its close match with the SCR Channel on a watershed area basis (36.7 square miles vs 38.7 square miles). A Weibull Plotting Position statistical analysis was performed on the peak discharges from the annual maximum series for 55 years of record (Table 3, Figure 4 and Appendix C). This analysis shows that the USGS Regional Regression Equations do under-predict the observed discharges at Walnut Gulch for the small recurrence storms (i.e., 2-year, 5-year, 10-year storms).

Table 3. Discharge Comparison of Gage Data and USGS Regional Regression Equations at Flume 6 on Walnut Gulch

Return Interval	Flume 6 Weibull Analysis Discharge (cfs)	Flume 6 USGS Regional Regression Discharge (cfs)	SCR Channel SEDCAD Analysis (cfs)
2-Year	1,129	676	1,463
5-Year	2,248	1,738	2,513
10-Year	3,667	2,827	3,486
25-Year	5,773	4,710	4,920
50-Year	6,537	6,541	6,075
100-Year	6,794	8,743	7,345

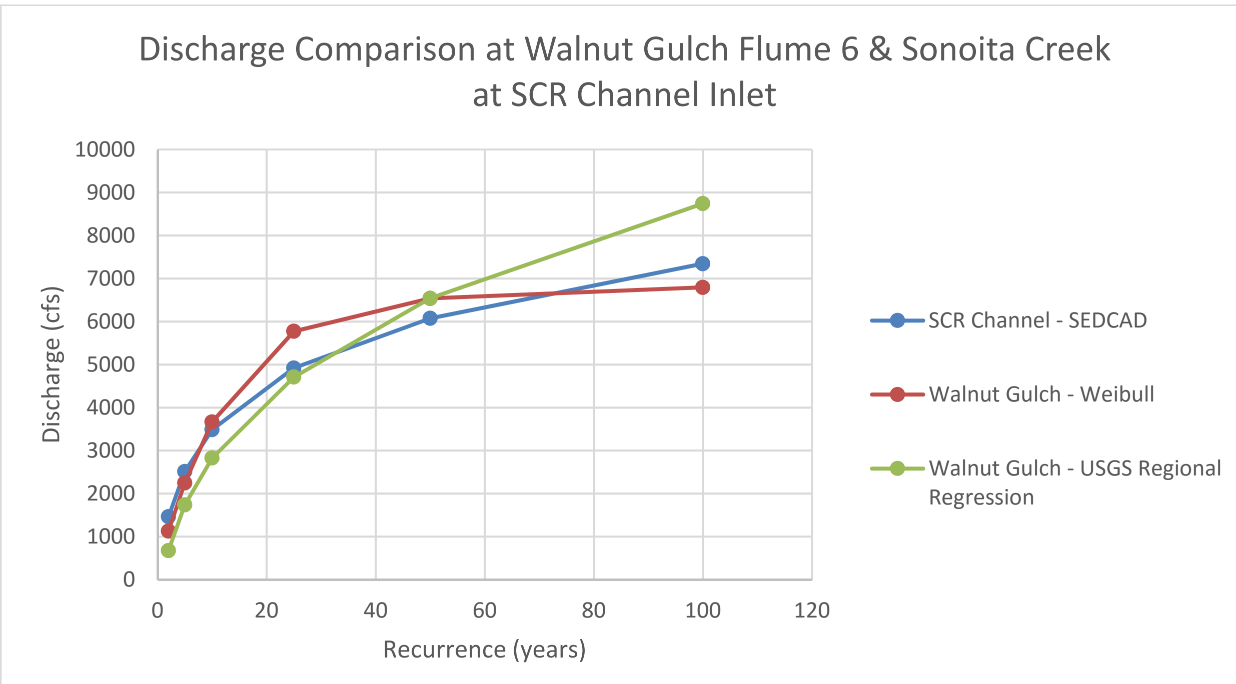


Figure 4. Discharge Comparison of Gage Data and USGS Regional Regression Equations at Flume 6 on Walnut Gulch & Sonoita Creek at SCR Channel Inlet

This analysis demonstrates that the USGS Regional Regression Equations under-predict discharge for the smaller design storms such as the 2-year, 5-year, and 10-year storm for systems with characteristics similar to Sonoita Creek and Walnut Gulch. Furthermore, the statistical analyses of measured data in Walnut Gulch are remarkably similar to the modeled discharge in Sonoita Creek using SEDCAD. Given the many similarities between Walnut Gulch and Sonoita Creek, the analysis further supports the SEDCAD hydrologic values used for channel design.

3.3 Evaluation of Design Peak Flows through Alternative Hydrologic Analysis

The results of four (4) additional hydrologic modeling or analyses methods were compared to the SEDCAD peak flow estimates to corroborate peak discharge estimates produced by the initial modeling efforts in SEDCAD.

1. The Sonoita Creek SEDCAD hydrologic modeling method was used to calculate peak flows at the closest cross section on Sonoita Creek for which FIS values were available. This comparison occurs downstream of the SCR Project area at the confluence with Harshaw Creek.
2. SEDCAD peak flow values for the SCR Project were compared to peak flows developed using CTAM.
3. SEDCAD peak flows were compared with the SCS Unit hydrograph method utilized in HEC-HMS.
4. USGS regional flood regression equations (Paretti et al., 2014) were compared to the SEDCAD peak discharge estimates.

3.3.1 Comparison of Design Flow Methodologies to Flood Insurance Study Values

A hydrologic modeling analysis was performed to ensure that the flows calculated at design points in the SCR Project area were fundamentally compatible with design flows used for regional floodplain delineation and management. For this purpose, peak flows on Sonoita Creek at its confluence with Harshaw Creek were calculated using both HEC-HMS and SEDCAD. These flow values were compared to values cited in the FIS (FEMA, 2011, volume 1 of 3, table page 25) for that location.

The Harshaw Creek confluence lies about 2 miles downstream of the SCR Project area, but is the most upstream cross section on Sonoita Creek that was studied using detailed methods in the FIS. The FIS documentation provides 10-year, 50-year, 100-year and 500-year recurrence interval flows from 24-hour duration storms in Sonoita Creek at this confluence (watershed area is 137.80 square miles) (Table 4). Flows calculated with the SEDCAD model, utilizing the double triangle UH method and the suggested depth-area reduction factor, were in close agreement with those cited in the FIS at the Harshaw Creek confluence. The 100-year, 24-hour peak discharge for Sonoita Creek at its confluence with Harshaw Creek, as estimated with SEDCAD, was 17,448 cfs or just 1% higher than the FIS 100-year flow value of 17,253 cfs.

Table 4. Comparison of Peak Discharges at the Confluence of Sonoita Creek and Harshaw Creek from FIS and SEDCAD.

Location Harshaw Cr.	Recurrence Interval Storm		
	10-year, 24-hour (cfs)	50-year, 24-hour (cfs)	100-year, 24-hour (cfs)
FIS Reported	5,374	12,879	17,253
SEDCAD Model	8,525	14,539	17,448

3.3.2 Clark Time-Area Method

The CTAM considers the spatial characteristics of a watershed to develop a synthetic unit hydrograph. This model is particularly useful in areas where there is a deficit of rainfall-runoff data. The model describes the relationship between the travel time to the watershed outlet and the area of that portion of the basin that may contribute runoff during that travel time. This relationship is based on the estimated velocity of the direct runoff.

Two (2) unit hydrographs were developed for the SCR Project using the Clark Time-Area Method: one for the confluence of Harshaw Creek with Sonoita Creek (Point 1) and the other for the watershed contributing to the take-off point of the Sonoita Creek Ranch (SCR) design channel (Point 2). The watershed areas for these sites are 137.8 mi^2 and 38.7 mi^2, respectively.

Point 1 was chosen as a calibration location since there was a previous model developed for this location by FEMA for an FIS, Section 3.3.1 provides a comparison between the results of the SEDCAD hydrologic model and the FIS values at this location. For the SCR design watershed at Point 2, the model developed for Point 1 was applied and various 24-hr rainfall events were analyzed. Details of this analysis are provided in Appendix B. The resulting values of peak discharge at Point 2 in the Project area, as compared to the values developed from the SEDCAD hydrologic analysis, are shown in Table 5.

Table 5. Comparison of Peak Discharges at the Sonoita Creek Ranch location for SEDCAD and Clark Time-Area Methods

Return Interval	SEDCAD (cfs)	Clark Time-Area Method (cfs)	% Difference in Values
2-Year	1,463	1,578	8%
5-Year	2,513	2,648	5%
10-Year	3,486	3,620	4%
25-Year	4,920	5,041	3%
50-Year	6,075	6,181	2%
100-Year	7,345	7,428	1%

3.3.3 SEDCAD & HEC-HMS SCS Unit Hydrograph Comparison

The SEDCAD 4.0 (Civil Software Design, 1998) and HEC-HMS 3.5 (USACE, 2010) hydrologic modeling methodologies were compared for a range of peak discharges expected from standard precipitation events. Both hydrologic modeling methods used Soil Conservation Service (SCS) curve numbers (CN) for watersheds to quantify the total runoff volume from storm precipitation and the unit hydrograph (UH) method to describe hydrologic response. HEC-HMS modeling utilized the SCS dimensionless triangular UH. This UH is parameterized by a lag time, which, based on guidance from the HEC-HMS documentation, should be 60% of the time of concentration of the watershed. The SEDCAD model uses a double triangle dimensionless UH shape, which is also parameterized based on the time of concentration.

Peak discharge estimates from SEDCAD and from HEC-HMS are compared in Table 6. The total volume of runoff from the watersheds is identical for the two UH methods; however, as shown in Table 2, for equivalent total runoff volume, the standard SCS UH (in the HEC-HMS model) predicts peak discharges 34-37% higher compared to the double triangle UH method used in the SEDCAD model. In developing design flows for the SCR Project, it is important not to overestimate the peak flows at given recurrence intervals and thereby overestimate the frequency at which the mitigation channels will convey flow. Therefore, the lower, double triangle UH peak values estimated by the SEDCAD model were used for channel design guidance (Appendix A).

Table 6. Rainfall and Discharge at the Sonoita Creek Ranch Mitigation Channel Inlet Point for Design Storm Events

	NRCS Type II Design Storm				
	2-yr, 24-hr	**5-yr, 24-hr**	**10-yr, 24-hr**	**50-yr, 24-hr**	**100-yr, 24-hr**
Rainfall (inches) (area reduction factor applied)	1.75	2.17	2.51	3.32	3.69
Double Triangle UH Method Peak Discharge (cfs)	1,463	2,513	3,486	6,075	7,345
SCS UH Method Peak Discharge (cfs)	2,004	3,425	4,721	8,147	9,851

3.3.4 USGS Equations & Regression

USGS regional regression equations quantify empirical relationships between discharge and watershed area specific to this region in Arizona, developed from gage data at 73 sites in Arizona hydrologic region 5, the Southeastern Basin and Range, which includes the SCR Project area. The equations are provided in Appendix C. As noted, the USGS regional regression equations report smaller flow values than those estimated by SEDCAD for the smaller recurrence storms (2, 5, 10 year) (Table 7).

Table 7. Comparison of Peak Discharges for SEDCAD & USGS Regional Regression Equations at the Sonoita Creek Ranch Inlet Point for Selected Recurrence Intervals

Return Interval	SEDCAD (cfs)	USGS Regional Regression Equations (cfs)	% Difference in Values
2-Year	1,463	693	-53%
5-Year	2,513	1,783	-29%
10-Year	3,486	2,899	-17%
25-Year	4,920	4,830	-2%
50-Year	6,075	6,706	10%
100-Year	7,345	8,962	22%

An analysis using both the Log-Pearson Type III (LPIII) and by Weibull Plotting Position of gage data at Patagonia, the nearest USGS gage to the SCR Project site on Sonoita Creek, indicates that the regression equations also underestimate the peak flows associated with more frequent recurrence intervals for that data set. Details of that analysis are included in Appendix C.

3.4 Hydrologic Event for Channel Design

In general, channel design guidelines were based on the hydraulics from the 2-year, 5-year, and 10-year storms. Channel capacity was sized for the 10-year storm. Additional analyses, including incipient motion analysis, were based on the 2-year storm. Inundation area was calculated for the 2-, 5-, and 10-year storms. For channel design, the SEDCAD predicted peak discharges from the 2-year, 24-hour, the 5-year, 24-hour and the 10-year, 24-hour rainfall events at several locations in the Sonoita Creek watershed were used. Locations of interest are shown in Table 8. Flows were estimated for Sonoita Creek on the Rail X Ranch just below its confluence with Adobe Canyon and for Sonoita Creek at the beginning of the SCR Channel (Figure 5). Watershed delineations and hydrologic design points are shown in Figure 5 and their hydrologic characterizations are presented in Table 8.

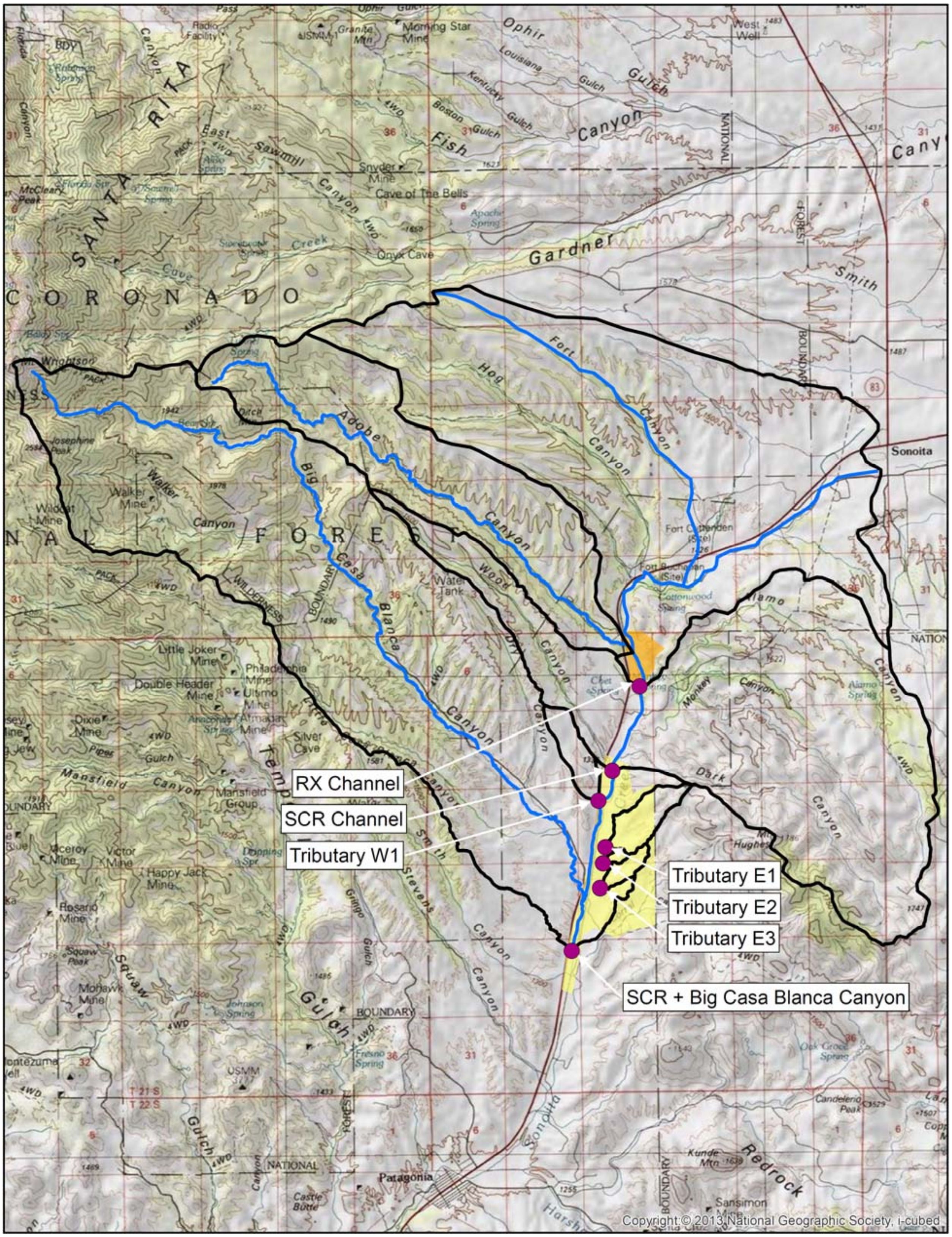


Figure 5. Watershed Delineations and Locations Used for Hydrologic Monitoring

Table 8. Channel Design Watershed Characteristics

Watershed Location	Watershed Area (square miles)	SCS Curve Number	2-Year, 24-Hour Peak Discharge (cfs)	5-Year, 24-Hour Peak Discharge (cfs)	10-Year, 24-Hour Peak Discharge (cfs)
RX Channel	24.4	80.20	1,486	2,496	3,377
SCR Channel	38.7	80.15	1,463	2,513	3,486
Tributary W1	0.40	80.20	104	162	212
Tributary E1	0.45	82.03	153	231	296
Tributary E2	0.04	81.37	23	34	42
Tributary E3	0.15	81.53	56	84	107
Sonoita Creek Bank Improvements	65.98	84.20	2,150	3,691	5,065

4 Field Investigation

WET and Habitat Management Inc. (HMI) conducted a field investigation during June 2015 with initial guidance from Dr. Bledsoe. The primary objective of the field investigation was to collect sufficient survey data from ecologically functional reaches of Sonoita Creek and its floodplain to use as an analog for the restored channel cross-section design. Nine (9) reference sites, spanning the entire SCR Project area, were selected as survey locations to characterize the existing Sonoita Creek (Exhibit 2). Channel cross-sectional reference reach surveys were completed at seven (7) sites. Six (6) of the seven (7) reference reaches included a vegetation survey, and five (5) of the seven (7) reference reaches also included soil core sampling.

These reference reaches were selected due to their relatively well-connected floodplains with diverse, functional riparian vegetation when compared to reaches with an obvious legacy of channel and floodplain modifications. The reference reaches were surveyed to quantify channel cross-sectional geometry and gradient so that natural channel characteristics could be used to guide channel design (see Section 5). The cross sections traversed the channel, floodplain, and upland areas adjacent to the channel. Vegetation surveys and soil core samples were collected along these cross sections to characterize changes in vegetation community and soil types, with an emphasis on identifying and characterizing biological benchmarks observed at the reference sites. Three (3) cross sections were surveyed at each reference reach.

In addition to the channel cross-section surveys, samples of the channel bed material were collected for use in sediment transport analysis. The reference reach survey, coupled with hydrologic and hydraulic analyses, were used to develop the channel cross section used in the restoration design.

4.1 Cross-Section Surveys

Channel cross-section surveys followed the methods described by Harrelson et al. (1994). Each cross section was photo documented to capture channel characteristics. A rod and level survey was performed to quantify the shape and relative elevations of the streambed and overbank at each cross section.

The following major channel features, if present, were surveyed and identified with a description:

- Benchmark
- Left bench/floodplain
- Left bankfull
- Left bank
- Left edge of water
- Differences in bed configurations across bed
- Thalweg
- Right edge of water
- Right bank
- Right bankfull
- Right bench/floodplain
- Recent high-water marks

The cross-sectional and longitudinal geometry of the existing channel reaches were measured so that hydraulic characteristics could be modeled using HEC-RAS. Quantifying channel capacity and flow velocities, both within the channel and in overbank areas, is fundamental to estimating sediment transport capacity and identifying the channel-forming flows and geomorphological processes that produce typical stream reaches in the SCR Project environment.

At each study reach, a permanent benchmark was established by driving rebar into the ground flush with the existing ground surface and capping with an orange survey cap. These benchmarks were typically placed close to the base of a tree set back from the active channel. A self-leveling level, tape and survey rod were used to measure ground surface points in each of three (3) cross sections defining each reference reach. Streambed cross-section elevations were determined relative to the elevation datum assigned to the benchmark. During construction, these temporary benchmarks may be tied into highly accurate elevation datum, and the surveyed cross sections assessed for geometry changes.

The ground surface measurements were correlated with the locations of core holes as well as marked changes in vegetation or surface roughness. During the channel measurement field work, the ephemeral channels were dry. Channel gradient was therefore assumed to be representative of hydraulic gradient for modeling. Channel cross-section survey data are contained in Appendix E.

4.2 Channel Substrate Sampling

Channel bed substrate was sampled at seven (7) locations distributed throughout the SCR Project area. The channel bed was sampled for particle size distribution using two (2) different methods: pebble counts and laboratory sieve analysis. Each pebble count survey included a minimum of 400 particle observations per reference reach. The reference reach was traversed in a zig-zag pattern with specific sampling locations determined by using a sampling frame. Each particle was measured with a gravelometer template that has 0.5 phi increment sieve sets that span the particle size range of 2 mm to 180 mm. The D16, D50, and D84 particle sizes were determined for each reference reach (Table 9).

Table 9. Reference Reach Pebble Count Summary

Reference Reach	D16 (mm)	D50 (mm)	D84 (mm)
2	2.3	4.4	12.5
3	2.1	6.7	38.3
6	2.0	4.3	6.6
6.1	2.8	5.3	5.9
6.2	2.5	8.0	9.1
6.5	2.6	4.9	5.6
8	2.4	4.0	4.7
Average for all Samples	2.4	5.4	20.8

In addition to the pebble counts, samples of the channel bed were collected and delivered to a soils lab for particle size analysis. The sieve analysis was conducted in accordance with the standardized test method ASTM C136. Furthermore, two (2) of the samples that were analyzed with a sieve analysis were also analyzed with the hydrometer test to ascertain the silt and clay content. Laboratory analyses results are available in Appendix H.

As expected, there is a difference between particle size distributions measured with pebble counts versus laboratory sieve analysis. The laboratory sieve analysis results yield smaller values for the D16, D50, and D84 sizes. The reason for this discrepancy is most likely the bias towards selecting larger particles when conducting pebble counts. Laboratory sieve analysis results are considered a more accurate representation of the channel bed and were thus used for sediment transport analyses. Results of the channel bed sampling program indicate that Sonoita Creek, and its major tributaries (Adobe Canyon, Big Casa Blanca Canyon), are predominantly sand bed channels with some gravel and cobble (Table 10). Silts and clays (particles passing the #200 sieve) are virtually absent, composing an average of 2.3% of the channel bed.

Table 10. Sieve Analysis Summary

Reference Reach	D16 (mm)	D50 (mm)	D84 (mm)
2	0.4	2.0	9.9
6	0.5	2.3	13.2
6.5	0.7	3.5	17.7
8	0.3	1.3	5.3
Average for all Samples	0.5	2.3	11.5

4.3 Vegetation and Soil Survey

HMI prepared a soil and vegetation sampling plan based on WET's conceptual channel alignment design and evaluation of a NRCS Order 3 soil survey for Santa Cruz County, Arizona. The plan considered the proposed constructed centerline, excavation extents, likely soil repository locations, and the preliminary estimated volumes of excavated soil and subsoil materials that would be generated. This information, coupled with the NRCS soil survey, allowed for a representative soil-sampling plan that considered separate sampling categories depending upon the final management of the excavated soil. Additionally, samples were collected in representative reaches of the existing Sonoita Creek channel as reference data to inform the final channel design, both structurally and aesthetically. Samples were collected to characterize the surface soils on the channel benches as well as the exposed soils on the vertical cut banks.

In 2017, WET revised the restored channel planform based on results of the fieldwork and additional analysis, as well as input from Rosemont and regulatory agencies. No additional soil samples were collected. Soil samples were analyzed for agronomic and engineering properties. Averaged agronomic results are presented in Table 11, and the Sonoita Creek Soil Characterization Report is available in Appendix F1.

Table 11. Revised Channel Alignment Core Sample Averaged Agronomic Results

Sample ID	Soil Map Unit Symbol	Design Cut Depth	pH	Electrical Conductivity	Sodium Absorption Ratio	Nitrate Nitrogen	Phos-phorus	Potas-sium	Organic Matter	Lime	Coarse Frag-ments	Very Fine Sand	Sand	Silt	Clay	Texture
		inches	*s.u.*	*mmhos/cm*	*calculated*	-------------- *mg/kg* --------			----- % -----		----------------- % -----------------					
Channel Core #1	Pm	36.1	7.6	3.0	0.4	63.3	4.2	328.7	2.2	3.9	4.8	26.5	37.1	39.5	23.5	L
Channel Core #2	Pm	86.5	7.8	1.3	0.2	3.1	1.9	157.0	0.9	4.9	14.6	27.7	54.0	26.3	19.7	SL
Channel Core #3	Pm	70.1	7.8	1.0	0.2	5.6	1.6	184.6	1.1	4.9	6.0	26.5	41.6	35.2	23.2	L
Channel Core #4	Pm	72.1	7.7	1.3	0.2	11.8	1.3	200.5	1.1	5.2	3.3	47.0	31.2	41.7	27.1	CL
Channel Core #5	Pm	59.0	7.8	0.8	0.2	1.2	1.6	148.3	1.0	5.6	19.8	17.5	50.8	28.2	21.0	L
Channel Core #6	GbB	51.8	7.9	0.9	0.2	11.7	3.6	195.9	0.7	4.4	13.6	13.2	65.9	21.1	13.0	SL
Channel Core #7	GbB	60.0	7.9	0.5	0.2	1.8	2	117	0.4	3.68	42	7	72	16	12	SL
Channel Core #10	Pm	92.0	7.5	1.0	0.3	2.1	3.1	216.9	1.3	3.0	19.9	21.9	50.8	33.0	16.3	L
Channel Core #12	Pm	86.0	7.6	2.2	0.2	67.9	6.3	178.3	1.0	3.0	19.1	18.1	55.4	31.8	12.8	SL
Channel Core #14	GbB	45.0	7.6	2.2	0.6	1.7	2.6	164.4	1.1	2.4	9.0	22.2	46.9	33.3	19.8	L
Channel Core #15	GbB	48.0	7.7	0.4	0.2	2.4	5	178	0.6	1.4	17	12	70	16	14	SL
Channel Core #20	GbB	70.5	7.4	3.2	0.2	125.9	5.9	269.1	1.4	2.8	5.2	42.9	36.7	41.6	21.7	L
Channel Core #21	GbB	43.6	7.8	0.5	0.1	2.2	4.5	185.3	0.9	3.0	10.4	26.1	47.3	36.5	16.2	L
Revegetation Thresholds	Marginal Suitabilit		8	4	6	20	20	300	2		15				CL, SiCL, SC	
	Unsuitable		8.8	8	10	10	15	140	1	10	35				S, LS, SiC, C	

Laboratory analytical results suggest that the soils throughout the SCR Project area will be generally suitable for revegetation. Due to higher fertility and organic matter in the upper soil horizons, it is recommended that topsoil be stripped and stockpiled away from the area to be disturbed by restored channel construction prior to other mitigation construction activities. Following topsoil placement, soil samples will be collected and analyzed to determine if additional soil amendments will be required to optimize soil conditions and revegetation potential.

While soil amendments are generally not preferred in arid environments due to the possibility of increasing non-native survival, it is expected that soil amendments will need to be added to the replaced topsoil based on current analyses. The estimated amendment quantities, based on the field investigation, are shown in Table 12. The amendment quantities in Table 12 will likely change after topsoil placement/final grading based on field samples of the final-graded soil material.

Table 12. Recommended Soil Amendment Applications

Amendment	Pounds/Acre	
	Replaced Topsoil	Channel Excavation
Nitrogen	20	20
Phosphorus	130	160
Potassium	40	90

The Sonoita Creek Vegetation Characterization Report is available in Appendix F2. This report summarizes the results of vegetation sampling in five (5) representative reaches of the current channel. The report also provides recommendations of commonly observed plant species for use in revegetation as well as recommended shrub and tree densities for planting and thinning activities along the newly constructed channel segments.

5 Channel Design

The restored channel designs reflect a process that considered and integrated reference reach channel characteristics, hydraulics, sediment transport, as well as ecological functionality. The channel alignment was selected to better utilize the width of the valley for floodplain connectivity and habitat, particularly in the area of the existing agricultural field, while minimizing crossings of the Kinder-Morgan pressurized gas utility. The alignment was also required to avoid existing natural and historical resources, match existing inverts at the upstream and downstream ends of the restored reaches, and avoid impacts to private property and infrastructure including the highway, all while minimizing excavation and placement of excess material. Channel alignments, profiles, and cross-sectional geometry were developed and then input into HEC-RAS to evaluate hydraulic parameters such as flow velocity, flow width, Froude number, specific stream power, shear stress, etc. The hydraulic parameters from the restored channels were then compared with the reference reaches in the existing Sonoita Creek as a reality-check on the design channel's likely stability, behavior and trajectory. Multiple iterations were analyzed before finalizing the channel design.

The design sought to recreate the wide, shallow cross-sectional shape that is characteristic of natural or lightly disturbed channels of the region like those analyzed in Walnut Gulch. This design promotes long-term dynamic stability and sediment balance while allowing space for lateral migration and development of geomorphic complexity created by episodic scour and deposition. The channel design is based upon an integration of analytical (analysis of water and sediment continuity) and analog (local reference reaches with connected and ecologically functional floodplains) approaches, that promote system-level stability with minimal or no channel maintenance.

Restored channel planforms were developed with a sinuosity that mimics the measured sinuosity of natural, least-altered reaches of Sonoita Creek. Sinuosity is a ratio calculated by dividing the sinuous channel length by the straight-line distance between channel endpoints. Typical values of sinuosity observed in the least altered reaches of Sonoita Creek ranged from 1.1 to 1.4. The restored channels have a sinuosity that ranges from 1.1 to 1.2.

Radius of curvature (R_C) for the bends were determined by a ratio related to the bankfull width (B_W) of the channel. Values for R_C typically fall within the range of $2.4*B_W$ and $3.4*B_W$. (Williams, 1986). The restored channel gradients closely match the channel gradients of Sonoita Creek at their respective tie-ins. Restoration channel profiles are low-gradient, with concave profiles (slope decreasing in the downstream direction) that are free of gradient and stream power discontinuities, thereby promoting sediment and energy balance.

5.1 Reference Reaches Surveyed at Sonoita Creek Ranch

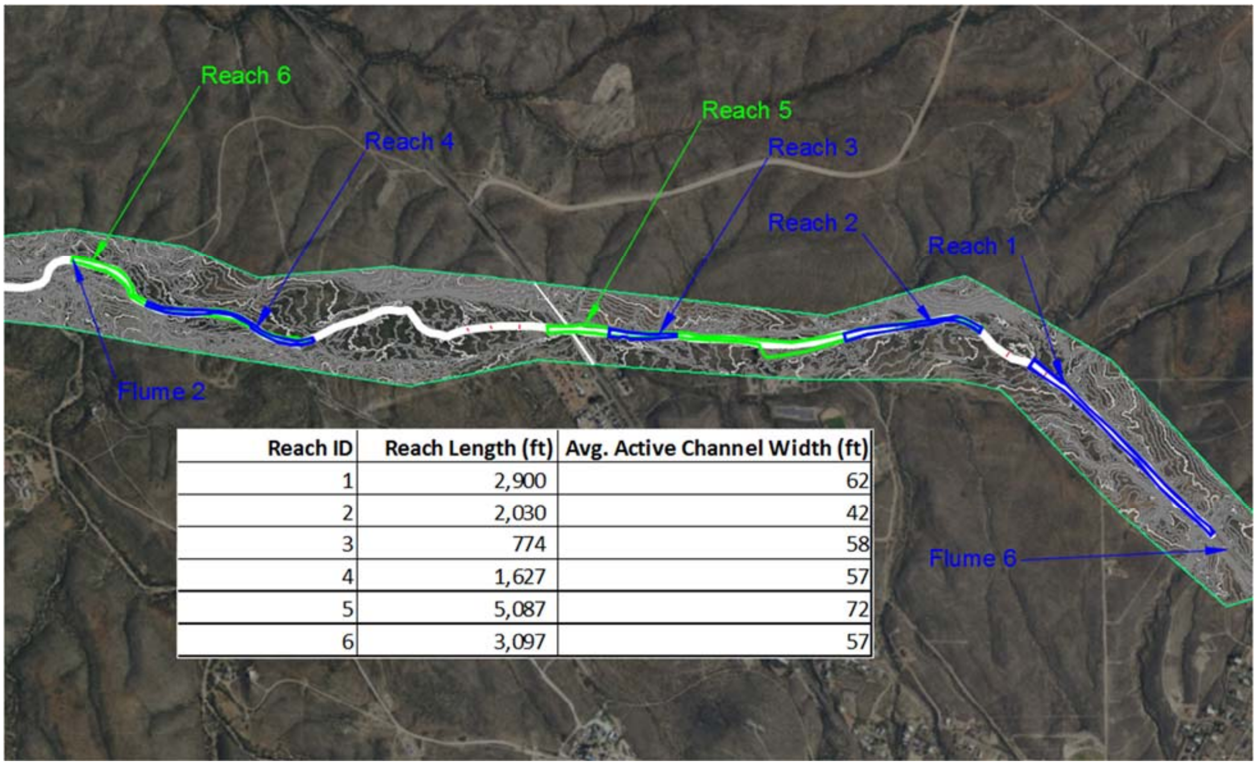
The cross-sectional geometry of the restored channel designs emulates the Sonoita Creek reference reach channel cross sections identified and surveyed during the field investigation. The two (2) reference reaches used for channel design are Site 6 and Site 8 (Exhibit 2), located in the main stem of Sonoita Creek. Site 6 is located near the ranch headquarters and is roughly 2,000 feet upstream from the location where Sonoita Creek was historically straightened to flow adjacent, and essentially parallel, to the highway. Site 8 is located near the southern end of the SCR Project in a complex, highly ecologically-functional reach with numerous secondary channels and microtopographic complexity that supports diverse floodplain plant communities including Fremont cottonwood trees. This reach of Sonoita Creek will be preserved.

The two (2) reference reach sites in Sonoita Creek are characterized by self-formed geometry, relatively large channel widths, frequent floodplain access by flows, and relative channel equilibrium. Channel braiding and perched overbank channels were also observed at both of these sites. These two sites possessed the highest ecological function of all the reference sites and were used to develop the final restored channel designs. The RX Channel and SCR Channel cross-sectional shape is based on reference reaches at Site 6 and Site 8. Furthermore, a power-scaled relationship for downstream hydraulic geometry was developed from the reference reaches and applied to the restored channel designs (Section 5.3). Channel bottom widths in the reference reaches range from approximately 40 feet up to 70 feet with an average bottom width slightly greater than 50 feet. Typically, at least one, and usually both sides of the existing channel have horizontal bench and floodplain features that lie 1 to 3 feet above the active channel bottom. The combined right and left bench widths range from approximately 28 feet up to 175 feet.

5.2 Reference Reaches Developed from WGEW Data

In addition to the reference reaches surveyed within the SCR Project area, Walnut Gulch channel patterns, profiles and hydraulic geometry were also reviewed to inform the design. WGEW staff provided WET with LiDAR data that included the topography of the Walnut Gulch main stem and its surrounding topography from Flume 6 downstream to Flume 1. Active channel widths were measured from the LiDAR topography and aerial imagery. Average widths were calculated as the quotient of the polygonal area (created from tracing both edges of the channel) by the centerline length. This procedure was completed for four (4) smaller reaches and for two (2) larger reaches between Flume 2 and Flume 6 (Appendix E). Channel widths were measured along the single thread reaches. The measured average active channel widths range from 42 feet up to 72 feet and are comparable to the designed channel widths for the SCR Project.

Walnut Gulch has many channel features similar to the SCR Project reference reaches, such as floodplain benches and bar formation with secondary channels perched roughly 1 to 3 feet above the main stem thalweg. Significant variation in channel shape occurs longitudinally along the channel that is caused by a variety of factors (both man-made and natural) such as channel constrictions and expansions, as well as grade control structures.



Reach ID	Reach Length (ft)	Avg. Active Channel Width (ft)
1	2,900	62
2	2,030	42
3	774	58
4	1,627	57
5	5,087	72
6	3,097	57

Figure 6. Walnut Gulch Average Channel Widths

5.3 Downstream Hydraulic Geometry

To develop a discharge-scaled design cross section that emulates the reference reaches, downstream hydraulic geometry relationships were determined for the reference reaches in existing Sonoita Creek and then applied to the restored channel designs. Downstream hydraulic geometry describes a mathematical (power scaling) relationship between discharge and channel width and other cross-sectional attributes as they vary longitudinally along the river system. WET developed the relationship from the reference reaches in Sonoita Creek, and then applied that relationship to the 10-year peak discharge in the restored channels, adjusting them to better emulate the reference reaches.

The surveyed channel cross sections were modeled with HEC-RAS, and downstream hydraulic geometry relationships were determined. Hydraulic geometry relationships can be expressed mathematically as:

$$W = a * Q^b$$

Where: W = width (ft)

a = field calibrated constant

Q = discharge

b = exponent (typically 0.5)

Discharge and width are known variables. The b-exponent was set to 0.5, and the equation was solved for a. The hydraulic geometry a-constant value is greater for relatively wide channels, and smaller for relatively narrow channels. Factors that affect the hydraulic geometry a-value include vegetation cover, soils, sediment load, and historical storm events. The hydraulic geometry a-value for the two (2) reference reaches ranged from 2.5 to 4.5 for the 10-year, 24-hour storm and averaged 3.9 and 3.2 for Site 6 and Site 8, respectively. Hydraulic geometry relationships were determined for the restored channel for the 10-year storm event. The hydraulic geometry a-value ranged from 3.4 to 3.9 for the restored channel segments on the RX and SCR properties (Table 13).

Table 13. Hydraulic Geometry a-Values for Selected Channel Segments (English Units of feet and cfs for width and discharge)

Channel Segment	Average Hydraulic Geometry a-value (10-year, 24-hour storm)
Reference Site 6	3.9
Reference Site 8	3.2
RX Channel	3.7
SCR Channel	3.4

The restored channel cross sections were developed both to emulate the reference reaches and to be practical to construct. The restored channel cross sections include an active channel with a bottom width ranging from 40 to 50 feet, and floodplain benches perched 2 feet above the channel bottom to be consistent with the reference reaches surveyed at Sonoita Creek. The bankfull width is 62 feet at this drainage area, and R_C for the alignment ranges from 149 feet to 210 feet. The floodplain features range from 23 feet wide to 77 feet wide for a typical channel cross section. The hydraulic geometry a-value for the design channels falls within the range of a-values calculated for the reference reaches in the existing Sonoita Creek channel. Furthermore, the 2-foot bench height is also within the range of measured bench heights at the reference reaches.

The restored channel geometry will evolve over time in accordance with natural processes in ephemeral channels. The magnitude and direction of change (channel size increasing or decreasing) is highly dependent on the temporal sequence of actual storm events that occur following channel construction. A series of frequent, small storm events could lead to temporary aggradation and a net decrease in channel capacity, while moderate to large storms may maintain or temporarily increase the channel size. Such dynamic adjustments are characteristic of natural alluvial channels in arid regions.

5.4 RX Channel Design

The final design for the RX Channel has a complex channel geometry, also developed to emulate the reference reaches surveyed in Sonoita Creek at Site 6 and Site 8. The reference reaches were chosen due to their relatively high ecological function within a generally impaired channel system.

The restored channel cross-section consists of a trapezoidal-shaped active channel with a 40-foot bottom width that is centered about the channel centerline shown on Drawing Sheet 4. The active channel has 3:1 sideslopes that extend upwards for 2 vertical feet to the shoulder of the channel bench. The bankfull width for the RX Channel is 52 feet. R_C ranged from 160 to 242 feet. In a straight reach, the channel bench projects horizontally for 50 feet on each side of the channel for a total bench width of 100 feet; however, the bench widths on each side of the channel vary as the channel meanders. On every bend, the bench located on the inside of the bend will be at its maximum width of 77 feet while the opposite bench on the outside of the bend will be at its minimum width of 23 feet. As the channel transitions out of the bend into a straight reach, the floodplain widths are adjusted such that the combined floodplain width is always 100 feet.

Additionally, the effective channel sinuosity is decreased during the high flow events that overtop the floodplain benches, which reduces bank impingement forces on the outside of each meander bend during large storms. All of the material excavated from the RX Channel will be placed nearby on the Rail X Ranch in two (2) soil repositories. No additional soils will be imported into this area. The downstream end of the constructed channel where it ties back in to Sonoita Creek is shown in Exhibit 9.

5.5 SCR Channel

The SCR restored channel design utilizes the full width of the agriculture field to allow for a more complex planform. This channel has a bedslope at the takeoff point that closely matches the bedslope of Sonoita Creek (1.3%) at that location. At the downstream tie-in, the SCR Channel bedslope of 0.8% also matches the bed slope of the existing Sonoita Creek channel at that location. The downstream tie-in is shown in Exhibit 10. The cross section of the restored SCR Channel is essentially a scaled-up version (based on hydraulic geometry) of the restored RX Channel with a 50-foot bottom width, and a total floodplain width of 100 feet perched 2 feet above the active channel bed. The bankfull width for the SCR channel is 62 feet. R_C ranges from 153 to 390 feet.

In addition to storm runoff, the restored SCR channel will convey flows from Monkey Spring that currently irrigate the agricultural field. The average daily flow rate of Monkey Spring to the SCR Project is 1 cfs (Westland, 2015). The Monkey Spring flow contribution to the restored channel will provide hydration for riparian vegetation and generally increase the sub-surface moisture in the channel. Over time this will provide more groundwater recharge, and some interaction with shallow groundwater.

The material excavated from the restored SCR Channel will first be used to backfill the existing, redundant portion of Sonoita Creek. The remainder of the material will be distributed amongst six (6) soil repositories located within the SCR reach area. The agricultural field will be retired from cultivation and reclaimed with native species. The original floodplain has been highly altered by agricultural development for several decades, with surface grading to level the field and with a central concrete-lined ditch to convey irrigation water. It is predominantly covered with non-native Johnsongrass and volunteer mesquite trees. The ecological function of the agricultural field will improve with the SCR Project by replacing non-native grasses with native species such as Giant Sacaton. Furthermore, the agricultural field will be recontoured and ripped prior to seeding, which will result in microtopographic features such as small ridges and depressions that will allow for greater diversity of plant species to colonize the area.

6 Hydraulic Analysis

A hydraulic modeling analysis of the Sonoita Creek channel system was performed using the U.S. Army Corps of Engineers HEC-GeoRAS Version 10.1 utilizing HEC-RAS River Analysis System Version 4.1.0 (USACE, 2010). The hydraulic model calculates water surface elevations throughout the channel system that would occur for design discharges developed from the hydrologic model (Appendix G).

Cross sections with a maximum spacing of 300 feet were digitized using AutoCAD from 1-foot topographic survey data developed during the fall of 2015. A channel Manning's n value of 0.035 was used to describe the coarse sand/gravel channel substrate. The selected Manning's n value was compatible with values used for the hydraulic analysis described in the FIS "level 3 hydraulic modeling," in the State Standard for Hydrologic Modeling Guidelines. Steady flow simulations were performed using downstream normal flow boundary conditions using the existing downstream channel slope (0.01 foot/foot). Each of the restored channels was modeled with discharge resulting from the 2-year, 24-hour storm, 5-year, 24-hour storm, and 10-year, 24-hour storm. Output from these simulations is provided in Appendix G. Results from the hydraulic analysis were used to develop inundation mapping, and to provide input parameters for additional analyses including: hydraulic geometry, incipient motion analysis, scour analysis, and specific stream power calculations.

6.1 Inundation Area

Based on the hydraulic analysis for the selected design flows, the total inundation areas for the 5-year, 24-hour, and the 10-year, 24-hour events were calculated and are presented in Table 14. Total channel areas presented on Exhibits 3 - 8 were calculated using the inundation boundaries developed using the water surface elevations from the HEC-GeoRAS hydraulic analyses.

Table 14. Channel Inundation Areas

Channel	2-Year, 24-Hour Storm Inundation Area (acres)	5-Year, 24-Hour Storm Inundation Area (acres)	10-Year, 24-Hour Storm Inundation Area (acres)
RX Channel	8.57	8.69	9.49
SCR Channel	50.84	54.62	57.40
Channel System Total	**59.41**	**63.31**	**66.89**

6.2 Channel Bed Incipient Motion Analysis

An incipient motion threshold analysis was conducted on the existing RX Channel, SCR Channel, and the reference reaches in existing Sonoita Creek to evaluate the potential for sediment mobilization and a naturally dynamic channel with the restored hydraulic geometry. To test for incipient motion, channel shear stress was computed, followed by a calculation of dimensionless shear stress using particle diameters measured in the field. Shear stress is the force that flowing water imparts on channel bed particles. Dimensionless shear stress is a metric derived from shear stress that can be used to test for mobility of the bed particles. Based on field and laboratory analyses, the channel bed substrate in Sonoita Creek is composed of sand-sized particles with some gravels and cobbles. The average D16, D50, and D84 particle sizes for the reference reach samples are 0.5 mm, 2.3 mm, and 11.5 mm, respectively, as determined with laboratory sieve analysis (Table 10).

WET analyzed Sonoita Creek for incipient motion of the channel bed material that would occur during the 2-year storm. Shear stress in the channel was calculated for the discharge from the 2-year design storm. Shear stress was calculated for the main channel (ignoring shear stress for the over bank areas) using HEC-RAS. The equation to calculate shear stress is shown below:

$$\tau = \gamma * d * s$$

Where: τ= shear stress (lb/ft^2);

γ = unit weight of water (lb/ft^3);

d = channel hydraulic depth (ft); and

s = channel slope (ft/ft).

Dimensionless shear stress was calculated using shear stress calculations derived from the previous equation. Dimensionless shear stress was calculated for the average D50 and D84 fractions of the channel bed material using the equations below:

$$\tau^*_{D50} = \frac{\tau}{1.65 * \gamma * D50}$$

$$\tau^*_{D84} = \frac{\tau}{1.65 * \gamma * D84}$$

Where: τ_{D50}*= Dimensionless shear stress for the channel bed D50 particle size;

τ_{D84}*= Dimensionless shear stress for the channel bed D84 particle size;

D50 = particle size that is larger than 50 percent of all particles in the sample (ft); and

D84 = particle size larger than 84 percent of all particles in the sample (ft).

To test for bed mobility, dimensionless shear stress was calculated at cross sections spaced no greater than 300 feet apart in the SCR and RX Channels, and at the Site 6 and Site 8 reference reaches. If dimensionless shear stress is equal to or greater than critical dimensionless shear stress of 0.03, then mobilization is expected (Parker, 2008). In all cases, dimensionless shear stress is substantially greater than 0.03 during the 2-year storm.

Therefore, normal channel evolution and sediment transport are expected to continue in the restored reaches of Sonoita Creek (RX Channel and SCR Channel). The larger storms (10-year, 25-year events, etc.), which are generally responsible for channel shaping in the arid southwest, will also result in discharge with sufficient energy to drive channel-forming processes. The minimum dimensionless shear stress, and average dimensionless shear stress for all modeled cross sections for D50 and D84 particle sizes, are shown in Table 15 and Table 16, respectively.

Table 15. Minimum and Average Dimensionless Shear Stress for the D50 Particle Size (2-year, 24-hour peak discharge)

Channel	τ* (minimum)	τ* (average)
Site 6 Reference Reach	N/A	1.96
Site 8 Reference Reach	N/A	1.80
RX Channel	0.77	1.35
SCR Channel	0.57	1.08

Table 16. Minimum and Average Dimensionless Shear Stress for the D84 Particle Size (2-year, 24-hour peak discharge)

Channel	τ* (minimum)	τ* (average)
Site 6 Reference Reach	N/A	0.39
Site 8 Reference Reach	N/A	0.36
RX Channel	0.15	0.27
SCR Channel	0.11	0.22

6.3 Scour Analysis

Construction of the SCR Channel will cross an existing gas pipeline in two (2) locations. The gas pipeline is a 4.5-in steel high-pressure gas transmission line that is buried at least 2 to 5-feet deep throughout the SCR Project area. The restored channel construction will expose the gas pipeline at these crossings, thus a pipeline lowering will be necessary.

Ultimately, the principal pipeline owner (Kinder Morgan) will determine scour depths and the final lowered pipeline depth. Kinder Morgan's standard practice is to bury lines under stream crossings at a depth 5 feet below the maximum scour depth for the 100-year storm. Kinder Morgan has committed to lowering the gas line for the SCR Project, as KM Project L2020 Sonoita Ck Replacement. Their cost estimate is included as Appendix I (KM Estimate Number: CE 1602040).

WET independently calculated scour depth at the crossing locations and agrees with Kinder Morgan's practice that the pipeline be buried a minimum of 5 feet below the calculated maximum scour depth resulting from the 100-year, 24-hour storm. Maximum scour depth was determined by both the Lacey method (1931, USDA NRCS 2007) and the Blench method (1970, USDA NRCS 2007). The Blench method produces greater maximum scour depths and was chosen as the applicable method to ensure conservatism when determining minimum burial depths for the gas pipeline.

A separate hydrologic analysis was used for the scour depth calculations that resulted in a much higher peak discharge. The 100-year storm was modeled in SEDCAD, but without applying an areal reduction factor to the rainfall. The discharge used for the scour depth calculations was 11,546 cfs, which provides sufficient conservatism for engineering design. For comparison, the

100-year, 24-hour discharge with areal reduction is only 7,345 cfs. Based on the field sampling program, an average D50 particle size of 2.3 mm was used for the scour depth calculations. Though the 100-year, 24-hour design storm flows overbank, the channel top width (instead of flow width) was used for the scour calculations, also erring on the side of conservatism. The maximum scour depth for the 100-year, 24-hour design storm for the pipeline crossings is 6.6 feet. Therefore, following Kinder-Morgan's practice, WET recommends that the gas pipeline be lowered a minimum of 11.5 feet below the SCR Channel invert.

6.4 Channel Erosion

Excessive system-level channel erosion and incision is not expected following construction of the SCR Project. First, Sonoita Creek and its tributaries are transport-limited streams with significant sediment supply. The bedload supply to the SCR Project area is largely intact, and some additional sediment sources (Tributary 1, 2, and 3) will be reconnected to the restored channel system. The restored channel reaches also tie in with the existing Sonoita Creek at a matching elevation, and with channel gradients that closely match, thereby precluding nick points. Based on the above conditions, systemic large-scale channel incision is not expected. While localized scour is expected, system-level bed degradation/incision would likely only be driven by changes not associated with the SCR Project such as: climate change or channel base-level changes outside of the SCR Project.

The restored channels are sized based on analytical and physical analog approaches. Furthermore, the restored channels will be constructed with complexity (active channel-floodplain benches) from the start, as opposed to the artificially straightened reaches of Sonoita Creek, which are in a state of self-perpetuating incision and bank erosion. Finally, the restored channels, particularly the SCR Channel, are located near the center of the Sonoita Creek valley and moved away from vital infrastructure such as the highway and the gas pipeline. Therefore, the restored channels can behave as dynamic and functional ephemeral streams with significant opportunity for lateral migration within the constructed channel footprint without threatening existing infrastructure.

6.5 Channel Evolution

The channel restoration effort at Sonoita Creek Ranch will result in a dynamic system that is not intended to remain fixed in form. The constructed channels are designed as a base for the trajectory of natural channel processes to occur. The constructed channel will begin initially as an earthen channel with specific dimensions detailed in the design drawings. Generally, the restored channel will be constructed as an active channel, with horizontal floodplain benches located 2-vertical feet above the active channel invert as described above. The first rainfall-runoff event, and subsequent events, will result in changes to the channel geometry and bed composition as well as to the vegetative composition.

Given the sediment transport capacity indicated by the incipient motion and specific stream power analyses, the first few storms will mobilize a significant volume of sandy material with some coarser material including cobbles throughout the active channel bed. The bed material in the constructed channel is expected to change to a gradation comparable to the existing reaches of Sonoita Creek. Additionally, some aggradation will likely express itself with the formation of bars and islands, which will result in some channel braiding consistent with natural systems of the region. Aggraded reaches with bar features may become colonized with vegetation. The ability to not only transport sediments, but to also store sediments, is an important function of ephemeral streams that is impaired in the existing system.

Channel geometry is expected to evolve, particularly after large channel-shaping flow events. Large channel-shaping events for systems of this type can generally be considered having at least a 10-year recurrence interval. Such storms will result in cut-bank (erosion) and bar formation (aggradation). Small storms will likely develop a thalweg within the active channel that periodically shifts from side to side within the channel.

The floodplain bench widths will change as a result of normal processes of erosion and aggradation. Additionally, the floodplain bench height may change in some locations due to erosion and re-deposition of material. The first storm event that inundates the floodplain benches will likely initiate the formation of secondary hi-flow channels. The floodplain benches will be seeded and planted with native species following construction.

Another driver of channel evolution that is unique to this SCR Project is Monkey Spring. Decades ago Monkey Spring was diverted away from Sonoita Creek and has subsequently been consumed as irrigation water for agriculture. One of the components of this mitigation plan is to reconnect Monkey Spring with Sonoita Creek. The direct connection of Monkey Spring will help recharge groundwater. Initially, Monkey Spring will improve soil moisture near its confluence with the restored SCR Channel. However, the effects of Monkey Spring on the Sonoita Creek area (increased soil moisture) will continue to progress downstream for some time until a quasi-equilibrium state is achieved. An increase in riparian and mesoriparian vegetation will accompany the wetted front as it progresses downstream.

7 Hydraulic Analysis of Existing Sonoita Creek

Hydraulic analyses were conducted on Sonoita Creek with its existing, pre-restored, channel geometry and characteristics, and model parameters were compared to both re-established reaches of Sonoita Creek (RX Channel, SCR Channel). The hydraulic analyses of existing Sonoita Creek were performed with the same modeling (HEC-RAS) that was used to analyze the RX Channel and SCR Channel as described in Section 6. Dimensionless shear stress and channel flow velocity are the two hydraulic variables, calculated at numerous cross-sections along existing Sonoita Creek, that were averaged and compared with average values calculated for the RX Channel and SCR Channel. The results indicate that the RX Channel and SCR Channel have lower average dimensionless shear stress and lower average velocities (Table 17). Hydraulic conditions at existing Sonoita Creek favor erosion/incision, which is corroborated by field observations indicating bank erosion (and numerous erosion control structures), containment of flows within deep, high capacity channel reaches providing limited access to a floodplain, and a general lack of channel complexity including depositional features. Mapping of existing Sonoita Creek used in the hydraulic analysis, and hydraulic calculations from HEC-RAS for existing Sonoita Creek, are shown in Appendix J.

Table 17. Comparison of Hydraulics of Existing Sonoita Creek with RX Channel and SCR Channel for the 2-Year, 24-Hour Peak Discharge

Channel Reach	Average Flow Velocity (ft/s)	Average τ* (D50)	Average τ* (D84)
Existing Sonoita at RX	6.1	1.41	0.28
RX Channel	5.6	1.35	0.27
Existing Sonoita at SCR	7.3	1.86	0.37
SCR Channel	5.3	1.08	0.22

8 Soil Repositories

Material excavated from the restored channels will be used to backfill the existing Sonoita Creek and placed in soil repositories. The excavated soil will be placed in small repositories located close to the channel excavation. Material excavated from the RX Channel will be used to backfill the existing reach of Sonoita Creek being replaced, and the remaining material will be placed in a single soil repository located in the RX. Similarly, material excavated from the SCR mitigation channel will be placed amongst six (6) soil repositories at the SCR property.

The soil repositories were designed using a combination of Natural Regrade with GeoFluv™ and Autodesk Civil3D. The primary design criteria governing the geomorphic soil repository design were drainage density and channel shear stress. Drainage density is a measurement of channel network length per unit of watershed area. Drainage density was determined by delineating an undisturbed reference watershed in the SCR Project site (Tributary 3). The total length of channels within the watershed area was determined using 1-foot contour mapping. A drainage density of 171 feet per acre was calculated for the area. For the geomorphic soil repository design, a drainage density of 170 feet per acre or greater was used as a design criterion.

The soil repositories were designed using geomorphic reclamation principles that produce topography with a natural appearance. The soil repositories have an undulating topography created by small upland swales that effectively break up the hillslope and reduce slope lengths, conveying stormwater runoff from the upland area to the valley bottom along a concave channel profile. The concave profile helps promote stability and mitigate the risk of headcutting that results from convex channel profiles. Furthermore, the complex topography resulting from the swales creates numerous, varying aspect changes and microclimates that promote vegetation species diversity. Throughout the geomorphic soil repositories, secondary ridges and valleys were designed to alternately connect to upland swales, to shorten slope lengths, and provide flow paths with concave slopes to convey water to the primary drainage channels. All major drainages and ridge lines were designed with a concave profile.

8.1 Rail X Soil Repositories

At Rail X, soil excavated from the RX Channel will be used to backfill two existing small ponds (RX Repository 1) and the remainder of the material placed as backfill in the existing reach of Sonoita Creek (RX1) being replaced by the RX Channel (RX Repository 2). RX 1 and RX 2 have relatively flat gradient of 3.2 percent and 2.7 percent, respectively. Sonoita Creek will be backfilled so that positive drainage will occur across the backfill towards the re-established channel (RX Channel). The two (2) repositories have a combined area of 15.1 acres.

8.2 SCR Soil Repositories

Soil excavated from the SCR Channel will be used to backfill existing Sonoita Creek, and the remainder of the material will be placed amongst six (6) soil repositories (SCR 1 thru SCR 6). SCR 1 is an abandoned gravel pit that will be backfilled and reclaimed. SCR 2 thru 5 abut existing hillsides at the eastern edge of the Sonoita Creek valley. The existing hillside has gradients that range from approximately 30 to 50 percent. The soil repositories are located in the lower 1/3 of the slope and have average gradients ranging from 4.5 to 6.7 percent. These soil repositories have comparatively low gradients compared with the surrounding terrain, and form a stable concave profile. SCR 6 is in the agricultural field with an average gradient of 1.2 percent. The agricultural field has been significantly manipulated to support cultivation, and current vegetation consists primarily of non-native grasses such as Johnsongrass. The native Giant Sacaton communities are non-existent within the agricultural field. Reclamation of the agricultural field will include Giant Sacaton transplants as well as seeding of other native species. Erosion potential of the fill material placed in the agricultural field is very low due to the mild gradient. The backfilled zone of existing Sonoita Creek and the six (6) repositories have a combined area of 101 acres.

9 Conclusion

The SCR Project is a very rare opportunity to re-establish natural functions at an effective, large, watershed scale to an arid ephemeral stream. The SCR Project concept is to re-establish Sonoita Creek in two (2) restored reaches along with associated floodplain and riparian buffers that were abandoned due to man-made alterations such as channel realignment and straightening. The restored reaches will allow for frequent overbank flow, which will improve energy dissipation and encourage groundwater recharge as well as increasing available moisture in the riparian zone. In addition to improving the ecological functionality of Sonoita Creek, the restored channels will be free to migrate and develop complex channel features without threatening existing infrastructure. The restored channels will develop braids and shallow islands of coarser material anchored by vegetation and other features. These types of features are observed in other regional channels with similar characteristics, including the nearby Walnut Gulch near Tombstone, Arizona. The restored channel designs include several transitional zones (floodplain benches) elevated off the channel bottom that will support diverse vegetation communities and encourage habitat complexity. Perennial flow from Monkey Spring will be retired from irrigation and routed into the restored SCR Channel for added ecological benefit. This project will improve the plant community diversity, particularly in the agricultural field, and a mosaic of habitat types are likely to arise from floodplain dynamics and microtopography.

The restored channel reach designs are based on both analytical and analog approaches, and multiple lines of evidence derived from field monitoring and physically-based modeling. Design streamflow values were developed using SEDCAD hydrologic modeling supported by flow estimates calculated using four (4) different models and by calibrating measured runoff to rainfall. The mitigation channel geometry is a discharge-scaled analog based on surveyed reference reaches located within the SCR Project area and corroborated by comparisons to channel geometry data from Walnut Gulch. The restored channel reaches will mobilize the measured bed particles to ensure adequate sediment transport capability and a naturally dynamic system. This SCR Project will provide significant ecological lift to the most impaired portions of Sonoita Creek that do not otherwise have the ability to develop into a functional ephemeral stream.

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Appendix A

SEDCAD Modeling

1. Sonoita Creek Mitigation Project. RX Channel. 2-Year, 24-Hour Design Storm
2. Sonoita Creek Mitigation Project. RX Channel. 5-Year, 24-Hour Design Storm
3. Sonoita Creek Mitigation Project. RX Channel. 10-Year, 24-Hour Design Storm
4. Sonoita Creek Mitigation Project. SCR Channel. 2-Year, 24-Hour Design Storm
5. Sonoita Creek Mitigation Project. SCR Channel. 5-Year, 24-Hour Design Storm
6. Sonoita Creek Mitigation Project. SCR Channel. 10-Year, 24-Hour Design Storm
7. Sonoita Creek Mitigation Project. SCR Channel. 25-Year, 24-Hour Design Storm
8. Sonoita Creek Mitigation Project. SCR Channel. 50-Year, 24-Hour Design Storm
9. Sonoita Creek Mitigation Project. SCR Channel. 100-Year, 24-Hour Design Storm
10. Sonoita Creek Mitigation Project. Sonoita Creek Bank Improvements. 2-Year, 24-Hour Design Storm
11. Sonoita Creek Mitigation Project. Sonoita Creek Bank Improvements. 5-Year, 24-Hour Design Storm
12. Sonoita Creek Mitigation Project Sonoita Creek Bank Improvements. 10-Year, 24-Hour Design Storm
13. Sonoita Creek Mitigation Project. Tributary W1. 2-Year, 24-Hour Design Storm
14. Sonoita Creek Mitigation Project. Tributary W1. 5-Year, 24-Hour Design Storm
15. Sonoita Creek Mitigation Project. Tributary W1. 10-Year, 24-Hour Design Storm
16. Sonoita Creek Mitigation Project. Tributaries E1 – E3. 2-Year, 24-Hour Design Storm
17. Sonoita Creek Mitigation Project. Tributaries E1 – E3. 5-Year, 24-Hour Design Storm
18. Sonoita Creek Mitigation Project. Tributaries E1 – E3. 10-Year, 24-Hour Design Storm
19. Sonoita Creek Mitigation Project. Sonoita Creek at Harshaw Creek Confluence. 100-Year, 24-Hour Design Storm
20. Sonoita Creek Mitigation Project. SCR Channel Pipeline Crossing. 100-Year, 24-Hour Design Storm. No Areal Reduction Factor

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Sonoita Creek Mitigation Project

RX Channel

2-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

Copyright 1998 -2010 Pamela J. Schwab

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	2 yr - 24 hr
Rainfall Depth:	1.930 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Rail X Channel Design Point

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	15,631.000	15,631.000	1,486.32	547.64

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Structure Detail:

Structure #1 (Null)

Rail X Channel Design Point

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	15,631.000	2.166	0.000	0.000	80.200	M	1,486.32	547.640
	Σ	**15,631.000**						**1,486.32**	**547.640**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.91	1,160.00	39,851.26	5.110	2.166
#1	**1**	**Time of Concentration:**					**2.166**

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Sonoita Creek Mitigation Project

RX Channel

5-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	5 yr - 24 hr
Rainfall Depth:	2.400 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Rail X Channel Design Point

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	15,631.000	15,631.000	2,495.72	861.07

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Structure Detail:

Structure #1 (Null)

Rail X Channel Design Point

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	15,631.000	2.166	0.000	0.000	80.200	M	2,495.72	861.074
	Σ	**15,631.000**						**2,495.72**	**861.074**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.91	1,160.00	39,851.26	5.110	2.166
#1	**1**	**Time of Concentration:**					**2.166**

Sonoita Creek Mitigation Project

RX Channel

10-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 24 hr
Rainfall Depth:	2.770 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Rail X Channel Design Point

#1
Null

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	15,631.000	15,631.000	3,377.02	1,132.05

Structure Detail:

Structure #1 (Null)

Rail X Channel Design Point

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	15,631.000	2.166	0.000	0.000	80.200	M	3,377.02	1,132.047
	Σ	**15,631.000**						**3,377.02**	**1,132.047**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.91	1,160.00	39,851.26	5.110	2.166
#1	**1**	**Time of Concentration:**					**2.166**

Sonoita Creek Mitigation Project

SCR Channel

2-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	2 yr - 24 hr
Rainfall Depth:	1.750 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	SCR Channel Design Point

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	1,462.94	693.06

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Structure Detail:

Structure #1 (Null)

SCR Channel Design Point

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	1,462.94	693.058
	Σ	**24,769.520**						**1,462.94**	**693.058**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**

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Sonoita Creek Mitigation Project

SCR Channel

5-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	5 yr - 24 hr
Rainfall Depth:	2.170 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	SCR Channel Design Point

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	2,512.60	1,109.80

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Structure Detail:

Structure #1 (Null)

SCR Channel Design Point

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	2,512.60	1,109.797
	Σ	**24,769.520**						**2,512.60**	**1,109.797**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**

Sonoita Creek Mitigation Project

SCR Channel

10-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 24 hr
Rainfall Depth:	2.510 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	SCR Channel Design Point

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	3,485.82	1,484.58

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Structure Detail:

Structure #1 (Null)

SCR Channel Design Point

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	3,485.82	1,484.580
	Σ	**24,769.520**						**3,485.82**	**1,484.580**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**

Sonoita Creek Mitigation Project

SCR Channel

25-Year, 24-Hour Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 24 hr
Rainfall Depth:	2.970 inches

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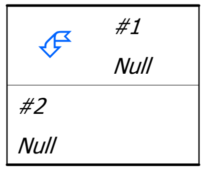
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	1.035	0.339	
Null	#2	==>	End	0.000	0.000	



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	1.43	191.00	13,349.20	3.58	1.035
#1	**Muskingum K:**					**1.035**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	4,919.59	2,031.81
#2	14,119.560	38,889.080	7,053.20	3,159.97

Structure Detail:

Structure #1 (Null)

Structure #2 (Null)

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	4,919.59	2,031.807
	Σ	**24,769.520**						**4,919.59**	**2,031.807**
#2	1	14,119.560	2.774	0.000	0.000	79.630	M	2,821.92	1,128.158
	Σ	**38,889.080**						**7,053.20**	**3,159.965**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**
#2	1	8. Large gullies, diversions, and low flowing streams	5.73	4,101.00	71,627.40	7.170	2.774
#2	**1**	**Time of Concentration:**					**2.774**

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Sonoita Creek Mitigation Project

SCR Channel

50-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	50 yr - 24 hr
Rainfall Depth:	3.320 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	SCR Channel Design Point

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	6,075.39	2,472.40

Structure Detail:

Structure #1 (Null)

SCR Channel Design Point

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	6,075.39	2,472.404
	Σ	**24,769.520**						**6,075.39**	**2,472.404**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**

Sonoita Creek Mitigation Project

SCR Channel

100-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	100 yr - 24 hr
Rainfall Depth:	3.690 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	SCR Channel Design Point

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	7,344.73	2,956.21

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Structure Detail:

Structure #1 (Null)

SCR Channel Design Point

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	7,344.73	2,956.212
	Σ	**24,769.520**						**7,344.73**	**2,956.212**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**

Sonoita Creek Mitigation Project

Sonoita Creek Bank Improvements

2-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	2 yr - 24 hr
Rainfall Depth:	1.720 inches

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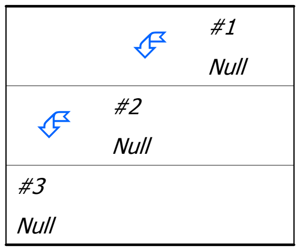
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	1.035	0.339	
Null	#2	==>	#3	0.249	0.305	
Null	#3	==>	End	0.000	0.000	Sonoita Creek Bank Improvements



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	1.43	191.00	13,349.20	3.58	1.035
#1	**Muskingum K:**					**1.035**
#2	8. Large gullies, diversions, and low flowing streams	0.79	19.00	2,394.00	2.67	0.249
#2	**Muskingum K:**					**0.249**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	1,396.11	665.66
#2	14,119.560	38,889.080	2,035.29	1,028.69
#3	3,341.000	42,230.080	2,150.45	1,153.20

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Structure Detail:

Structure #1 (Null)

Structure #2 (Null)

Structure #3 (Null)

Sonoita Creek Bank Improvements

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	1,396.11	665.663
	Σ	**24,769.520**						**1,396.11**	**665.663**
#2	1	14,119.560	2.774	0.000	0.000	79.630	M	778.65	363.031
	Σ	**38,889.080**						**2,035.29**	**1,028.694**
#3	1	3,341.000	0.828	0.000	0.000	84.200	M	680.58	124.511
	Σ	**42,230.080**						**2,150.45**	**1,153.205**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**
#2	1	8. Large gullies, diversions, and low flowing streams	5.73	4,101.00	71,627.40	7.170	2.774
#2	**1**	**Time of Concentration:**					**2.774**
#3	1	8. Large gullies, diversions, and low flowing streams	6.25	1,397.00	22,353.00	7.490	0.828
#3	**1**	**Time of Concentration:**					**0.828**

Sonoita Creek Mitigation Project

Sonoita Creek Bank Improvements

5-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	5 yr - 24 hr
Rainfall Depth:	2.140 inches

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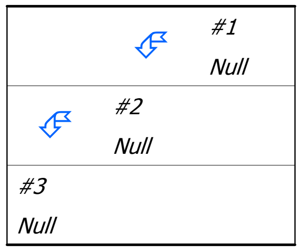
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	1.035	0.339	
Null	#2	==>	#3	0.249	0.305	
Null	#3	==>	End	0.000	0.000	Sonoita Creek Bank Improvements



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	1.43	191.00	13,349.20	3.58	1.035
#1	**Muskingum K:**					**1.035**
#2	8. Large gullies, diversions, and low flowing streams	0.79	19.00	2,394.00	2.67	0.249
#2	**Muskingum K:**					**0.249**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	2,431.32	1,078.18
#2	14,119.560	38,889.080	3,521.31	1,671.29
#3	3,341.000	42,230.080	3,691.06	1,860.99

Structure Detail:

Structure #1 (Null)

Structure #2 (Null)

Structure #3 (Null)

Sonoita Creek Bank Improvements

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	2,431.32	1,078.182
	Σ	**24,769.520**						**2,431.32**	**1,078.182**
#2	1	14,119.560	2.774	0.000	0.000	79.630	M	1,374.77	593.109
	Σ	**38,889.080**						**3,521.31**	**1,671.291**
#3	1	3,341.000	0.828	0.000	0.000	84.200	M	1,080.77	189.701
	Σ	**42,230.080**						**3,691.06**	**1,860.993**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**
#2	1	8. Large gullies, diversions, and low flowing streams	5.73	4,101.00	71,627.40	7.170	2.774
#2	**1**	**Time of Concentration:**					**2.774**
#3	1	8. Large gullies, diversions, and low flowing streams	6.25	1,397.00	22,353.00	7.490	0.828
#3	**1**	**Time of Concentration:**					**0.828**

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Sonoita Creek Mitigation Project

Sonoita Creek Bank Improvements

10-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 24 hr
Rainfall Depth:	2.470 inches

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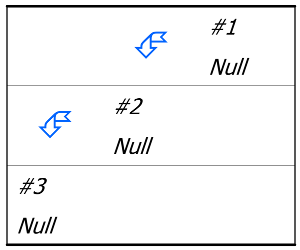
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	1.035	0.339	
Null	#2	==>	#3	0.249	0.305	
Null	#3	==>	End	0.000	0.000	Sonoita Creek Bank Improvements



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	1.43	191.00	13,349.20	3.58	1.035
#1	**Muskingum K:**					**1.035**
#2	8. Large gullies, diversions, and low flowing streams	0.79	19.00	2,394.00	2.67	0.249
#2	**Muskingum K:**					**0.249**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	3,366.94	1,439.03
#2	14,119.560	38,889.080	4,850.68	2,234.21
#3	3,341.000	42,230.080	5,064.97	2,479.28

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Structure Detail:

Structure #1 (Null)

Structure #2 (Null)

Structure #3 (Null)

Sonoita Creek Bank Improvements

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	3,366.94	1,439.031
	Σ	**24,769.520**						**3,366.94**	**1,439.031**
#2	1	14,119.560	2.774	0.000	0.000	79.630	M	1,917.40	795.180
	Σ	**38,889.080**						**4,850.68**	**2,234.211**
#3	1	3,341.000	0.828	0.000	0.000	84.200	M	1,423.43	245.073
	Σ	**42,230.080**						**5,064.97**	**2,479.283**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**
#2	1	8. Large gullies, diversions, and low flowing streams	5.73	4,101.00	71,627.40	7.170	2.774
#2	**1**	**Time of Concentration:**					**2.774**
#3	1	8. Large gullies, diversions, and low flowing streams	6.25	1,397.00	22,353.00	7.490	0.828
#3	**1**	**Time of Concentration:**					**0.828**

Sonoita Creek Mitigation Project

Tributary W1

2-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	2 yr - 24 hr
Rainfall Depth:	2.300 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	256.200	256.200	103.62	13.02

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Structure Detail:

Structure #1 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	256.200	0.411	0.000	0.000	80.200	M	103.62	13.021
	Σ	**256.200**						**103.62**	**13.021**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	3.32	268.00	8,084.00	5.460	0.411
#1	**1**	**Time of Concentration:**					**0.411**

Sonoita Creek Mitigation Project

Tributary W1

5-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	5 yr - 24 hr
Rainfall Depth:	2.860 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	

#1
Null

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	256.200	256.200	162.42	19.76

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Structure Detail:

Structure #1 (Null)

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	256.200	0.411	0.000	0.000	80.200	M	162.42	19.758
	Σ	**256.200**						**162.42**	**19.758**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	3.32	268.00	8,084.00	5.460	0.411
#1	**1**	**Time of Concentration:**					**0.411**

Sonoita Creek Mitigation Project

Tributary W1

10-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 24 hr
Rainfall Depth:	3.300 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	256.200	256.200	211.80	25.47

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Structure Detail:

Structure #1 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	256.200	0.411	0.000	0.000	80.200	M	211.80	25.471
	Σ	**256.200**						**211.80**	**25.471**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	3.32	268.00	8,084.00	5.460	0.411
#1	**1**	**Time of Concentration:**					**0.411**

Sonoita Creek Mitigation Project

Tributaries E1, E2, E3

2-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	2 yr - 24 hr
Rainfall Depth:	2.300 inches

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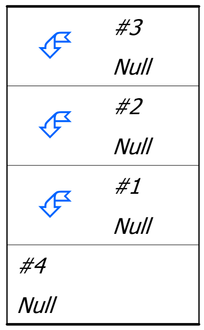
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#4	0.593	0.319	Tributary E1
Null	#2	==>	#4	0.514	0.319	Tributary E2
Null	#3	==>	#4	0.335	0.319	Tributary E3
Null	#4	==>	End	0.000	0.000	



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	1.00	64.10	6,410.00	3.00	0.593
#1	**Muskingum K:**					**0.593**
#2	8. Large gullies, diversions, and low flowing streams	1.00	55.59	5,559.00	3.00	0.514
#2	**Muskingum K:**					**0.514**
#3	8. Large gullies, diversions, and low flowing streams	1.00	36.20	3,620.00	3.00	0.335
#3	**Muskingum K:**					**0.335**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#3	96.850	96.850	55.66	5.39
#2	25.150	25.150	23.14	1.72
#1	285.190	285.190	153.40	16.28
#4	401.520	808.710	242.43	40.58

Structure Detail:

Structure #3 (Null)

Tributary E3

Structure #2 (Null)

Tributary E2

Structure #1 (Null)

Tributary E1

Structure #4 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#3	1	96.850	0.188	0.000	0.000	81.530	M	55.66	5.395
	Σ	**96.850**						**55.66**	**5.395**
#2	1	25.150	0.065	0.000	0.000	81.370	M	23.14	1.719
	Σ	**25.150**						**23.14**	**1.719**
#1	1	285.190	0.269	0.000	0.000	82.030	M	153.40	16.281
	Σ	**285.190**						**153.40**	**16.281**
#4	1	401.520	1.110	0.000	0.000	77.630	M	74.80	17.182
	Σ	**808.710**						**242.43**	**40.578**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	6.13	442.00	7,210.00	7.420	0.269
#1	**1**	**Time of Concentration:**					**0.269**
#2	1	8. Large gullies, diversions, and low flowing streams	5.13	82.00	1,600.00	6.790	0.065
#2	**1**	**Time of Concentration:**					**0.065**
#3	1	8. Large gullies, diversions, and low flowing streams	4.62	202.00	4,370.00	6.440	0.188
#3	**1**	**Time of Concentration:**					**0.188**
#4	1	8. Large gullies, diversions, and low flowing streams	1.00	119.93	11,993.00	3.000	1.110
#4	**1**	**Time of Concentration:**					**1.110**

Sonoita Creek Mitigation Project

Tributaries E1, E2, E3

5-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

Copyright 1998 -2010 Pamela J. Schwab

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	5 yr - 24 hr
Rainfall Depth:	2.860 inches

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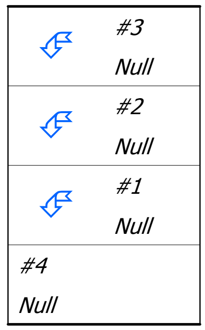
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#4	0.593	0.319	Tributary E1
Null	#2	==>	#4	0.514	0.319	Tributary E2
Null	#3	==>	#4	0.335	0.319	Tributary E3
Null	#4	==>	End	0.000	0.000	



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	1.00	64.10	6,410.00	3.00	0.593
#1	**Muskingum K:**					**0.593**
#2	8. Large gullies, diversions, and low flowing streams	1.00	55.59	5,559.00	3.00	0.514
#2	**Muskingum K:**					**0.514**
#3	8. Large gullies, diversions, and low flowing streams	1.00	36.20	3,620.00	3.00	0.335
#3	**Muskingum K:**					**0.335**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#3	96.850	96.850	83.72	8.06
#2	25.150	25.150	33.69	2.57
#1	285.190	285.190	231.25	24.20
#4	401.520	808.710	380.39	61.73

Structure Detail:

Structure #3 (Null)

Tributary E3

Structure #2 (Null)

Tributary E2

Structure #1 (Null)

Tributary E1

Structure #4 (Null)

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#3	1	96.850	0.188	0.000	0.000	81.530	M	83.72	8.064
	Σ	**96.850**						**83.72**	**8.064**
#2	1	25.150	0.065	0.000	0.000	81.370	M	33.69	2.575
	Σ	**25.150**						**33.69**	**2.575**
#1	1	285.190	0.269	0.000	0.000	82.030	M	231.25	24.203
	Σ	**285.190**						**231.25**	**24.203**
#4	1	401.520	1.110	0.000	0.000	77.630	M	124.80	26.891
	Σ	**808.710**						**380.39**	**61.733**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	6.13	442.00	7,210.00	7.420	0.269
#1	**1**	**Time of Concentration:**					**0.269**
#2	1	8. Large gullies, diversions, and low flowing streams	5.13	82.00	1,600.00	6.790	0.065
#2	**1**	**Time of Concentration:**					**0.065**
#3	1	8. Large gullies, diversions, and low flowing streams	4.62	202.00	4,370.00	6.440	0.188
#3	**1**	**Time of Concentration:**					**0.188**
#4	1	8. Large gullies, diversions, and low flowing streams	1.00	119.93	11,993.00	3.000	1.110
#4	**1**	**Time of Concentration:**					**1.110**

Sonoita Creek Mitigation Project

Tributaries E1, E2, E3

10-Year, 24-Hour Design Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

Copyright 1998 -2010 Pamela J. Schwab

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 24 hr
Rainfall Depth:	3.300 inches

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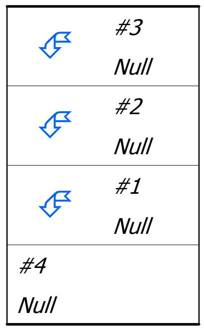
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#4	0.593	0.319	Tributary E1
Null	#2	==>	#4	0.514	0.319	Tributary E2
Null	#3	==>	#4	0.335	0.319	Tributary E3
Null	#4	==>	End	0.000	0.000	



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	1.00	64.10	6,410.00	3.00	0.593
#1	**Muskingum K:**					**0.593**
#2	8. Large gullies, diversions, and low flowing streams	1.00	55.59	5,559.00	3.00	0.514
#2	**Muskingum K:**					**0.514**
#3	8. Large gullies, diversions, and low flowing streams	1.00	36.20	3,620.00	3.00	0.335
#3	**Muskingum K:**					**0.335**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#3	96.850	96.850	107.29	10.31
#2	25.150	25.150	42.28	3.30
#1	285.190	285.190	295.65	30.85
#4	401.520	808.710	498.12	79.71

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Structure Detail:

Structure #3 (Null)

Tributary E3

Structure #2 (Null)

Tributary E2

Structure #1 (Null)

Tributary E1

Structure #4 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#3	1	96.850	0.188	0.000	0.000	81.530	M	107.29	10.311
	Σ	**96.850**						**107.29**	**10.311**
#2	1	25.150	0.065	0.000	0.000	81.370	M	42.28	3.296
	Σ	**25.150**						**42.28**	**3.296**
#1	1	285.190	0.269	0.000	0.000	82.030	M	295.65	30.853
	Σ	**285.190**						**295.65**	**30.853**
#4	1	401.520	1.110	0.000	0.000	77.630	M	167.85	35.249
	Σ	**808.710**						**498.12**	**79.709**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	6.13	442.00	7,210.00	7.420	0.269
#1	**1**	**Time of Concentration:**					**0.269**
#2	1	8. Large gullies, diversions, and low flowing streams	5.13	82.00	1,600.00	6.790	0.065
#2	**1**	**Time of Concentration:**					**0.065**
#3	1	8. Large gullies, diversions, and low flowing streams	4.62	202.00	4,370.00	6.440	0.188
#3	**1**	**Time of Concentration:**					**0.188**
#4	1	8. Large gullies, diversions, and low flowing streams	1.00	119.93	11,993.00	3.000	1.110
#4	**1**	**Time of Concentration:**					**1.110**

Sonoita Creek Mitigation Project

Sonoita Creek at Harshaw Creek Confluence

100-Year, 24-Hour Storm

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	100 yr - 24 hr
Rainfall Depth:	3.373 inches

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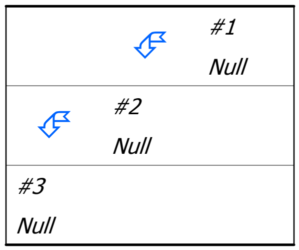
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	1.035	0.339	
Null	#2	==>	#3	1.943	0.306	
Null	#3	==>	End	0.000	0.000	Sonoita Cr @ Harshaw Cr Confluence



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	1.43	191.00	13,349.20	3.58	1.035
#1	**Muskingum K:**					**1.035**
#2	8. Large gullies, diversions, and low flowing streams	0.80	150.00	18,750.26	2.68	1.943
#2	**Muskingum K:**					**1.943**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	6,254.32	2,540.66
#2	14,119.560	38,889.080	8,951.89	3,955.36
#3	50,292.900	89,181.980	17,447.88	10,099.14

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Structure Detail:

Structure #1 (Null)

Structure #2 (Null)

Structure #3 (Null)

Sonoita Cr @ Harshaw Cr Confluence

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	6,254.32	2,540.656
	Σ	**24,769.520**						**6,254.32**	**2,540.656**
#2	1	14,119.560	2.774	0.000	0.000	79.630	M	3,601.90	1,414.700
	Σ	**38,889.080**						**8,951.89**	**3,955.356**
#3	1	50,292.900	5.317	0.000	0.000	84.180	M	9,792.14	6,143.780
	Σ	**89,181.980**						**17,447.88**	**10,099.140**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**
#2	1	8. Large gullies, diversions, and low flowing streams	5.73	4,101.00	71,627.40	7.170	2.774
#2	**1**	**Time of Concentration:**					**2.774**
#3	1	8. Large gullies, diversions, and low flowing streams	1.79	1,375.00	76,757.00	4.010	5.317
#3	**1**	**Time of Concentration:**					**5.317**

Sonoita Creek Mitigation Project

SCR Channel Pipeline Crossing

100-Year, 24-Hour Design Storm

No Areal Reduction

Brennan/Spotts

Water & Earth Technologies, Inc.
1225 Red Ceder Circle
Suite A
Fort Collins, CO 80524

Phone: (970) 225-6080

Copyright 1998 -2010 Pamela J. Schwab

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	100 yr - 24 hr
Rainfall Depth:	4.850 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	SCR Channel Design Point

#1   *Null*

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	24,769.520	24,769.520	11,546.26	4,560.08

Structure Detail:

Structure #1 (Null)

SCR Channel Design Point

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	24,769.520	2.917	0.000	0.000	80.150	M	11,546.26	4,560.081
	Σ	**24,769.520**						**11,546.26**	**4,560.081**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.72	1,410.00	51,889.45	4.940	2.917
#1	**1**	**Time of Concentration:**					**2.917**

Appendix B

Clark Time-Area Method

1.0 Introduction

The Clark Time Area Method (CTAM) considers the spatial characteristics of a watershed to develop a synthetic unit hydrograph for a watershed (Clark, 1945 and e.g., Saghafian et al., 2002 and USACE, 2010a). The model describes the relationship between the travel time to the watershed outlet the area of that portion of the basin that may contribute runoff during that travel time. This relationship is based on the estimated velocity of the direct runoff. Two (2) unit hydrographs were developed for the Sonoita Creek Mitigation Project (SCR Project) using the Clark Time-Area Method (CTAM): one for the confluence of Harshaw Creek with Sonoita (Point 1) and the other for the watershed contributing to the take-off point of the Sonoita Creek Ranch (SCR) design channel (Point 2). The watershed areas for these sites are 137.8 mi^2 and 38.7 mi^2, respectively. Point 1 was chosen as a calibration location (to determine the relationship between the storage coefficient and time of concentration) since there was a previous model developed for this location by FEMA for a Flood Insurance Study (FIS) (FEMA, 2011, Volume 1 of 3, table page 25). The results of the HEC-HMS and SEDCAD hydrologic models were compared with the FIS values at this location.

Methods and procedures for the development and application of these unit hydrographs are described in subsequent sections.

2.0 METHODS AND PROCEDURES

The time-area hydrographs were developed using the tools of Spatial Analyst in ArcGIS. Until recently, time-area methods have been underutilized in engineering application because of the significant computational power needed to determine the method's parameter set. Software programs like ArcGIS are able to work with sizable spatial data sets and this type of analysis can now be performed on a large-scale basis. ArcGIS is a geographical information system used to compile and analyze spatial data. Spatial Analyst is an ArcGIS extension that provides modeling tools for both vector and raster data sets. Data sets were obtained from publicly available sources including a digital elevation model (DEM), a hydrography data set and the land cover data set. The watershed was divided into two categories, overland flow areas and channel flow areas. Depending on the category, a separate equation was used to determine velocities and travel times within each grid cell. Each grid cell had dimensions of 10 feet x 10 feet.

2.1 Overland Flow Travel Times

Overland flow times were calculated by first approximating velocity using Manning's equation for overland flow (Equation 1).

$$V = kS^{0.5} \qquad \text{(Equation 1)}$$

Where: V= Velocity (ft/s)

k= Conveyance for overland flow based on land use

S = Slope (%)

Each of these parameters were determined on a per grid cell basis to calculate the velocity at every location in the watershed. Overland flow travel times were calculated using Equation 2.

$$T = \frac{1}{60*V} \text{ (min/ft)} \qquad \text{(Equation 2)}$$

2.2 Channel Flow Travel Times

Similar to the calculations for overland flow travel time, velocities and travel times for in-channel flow were estimated using Manning's equation (Equation 3).

$$T_i = 2.235 \times \left[\frac{n_i}{R_i^{0.67}}\right] \times \left[\frac{1}{S_i^{0.5}}\right] \times \frac{1}{60} \text{ (min/ft)} \qquad \text{(Equation 3)}$$

Where: $\left[\frac{n_i}{R_i^{0.67}}\right]$ = Channel Resistance Coefficient (CRC)

S_i = Slope (ft/ft) for Channel Segment (Cell)

A channel resistance coefficient of 0.024 was chosen for all channel segments in the catchment. This value is associated with a wide meandering channel with a semi-gravely bottom and shurbs on the overflow banks, as observed for the channels on the SCR site.

2.3 Unit Hydrograph Development

Using both the overland flow travel times and the in-channel flow travel times, a composite travel time grid was created. From that grid, the accumulated time path from each cell in the watershed to the outlet was calculated. Travel times were grouped into 30 minute increments to develop the isochronal map shown in Figure 1 (for Point 1). A histogram of the number of cells contained in each isochrone was produced (Figure 2) and was used to develop the unit hydrograph.

The unit hydrograph was developed by determining the relative cumulative area curve (RCAC) based on the areas in each isochrone. This acts as an S-curve commonly used in unit hydrograph development. The area of each isochrone was calculated by multiplying the grid cell count from the histogram by the dimensions of each cell (10'x10'). The RCAC is then computed by dividing the accumulated area by the total area of the watershed. The resulting RCAC resembles an S-Curve that could be used to develop a unit hydrograph for a pure time-area method; however, no storage effects are accounted for. At this point the Clark Method was applied to effectively route the resultant hydrograph through a linear reservoir.

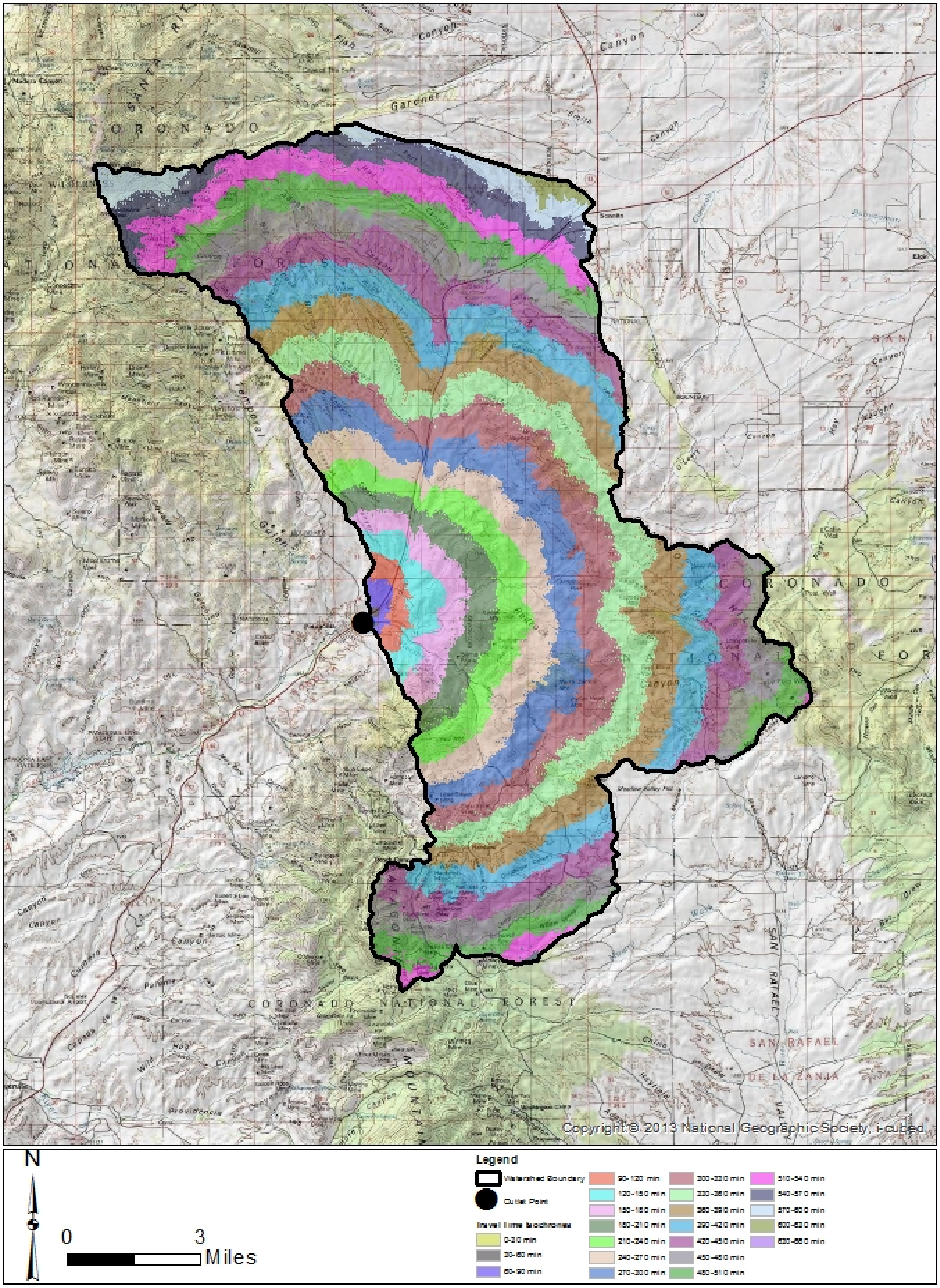


Figure 1. Time Travel Isochrones for Point 1 (Harshaw Confluence)

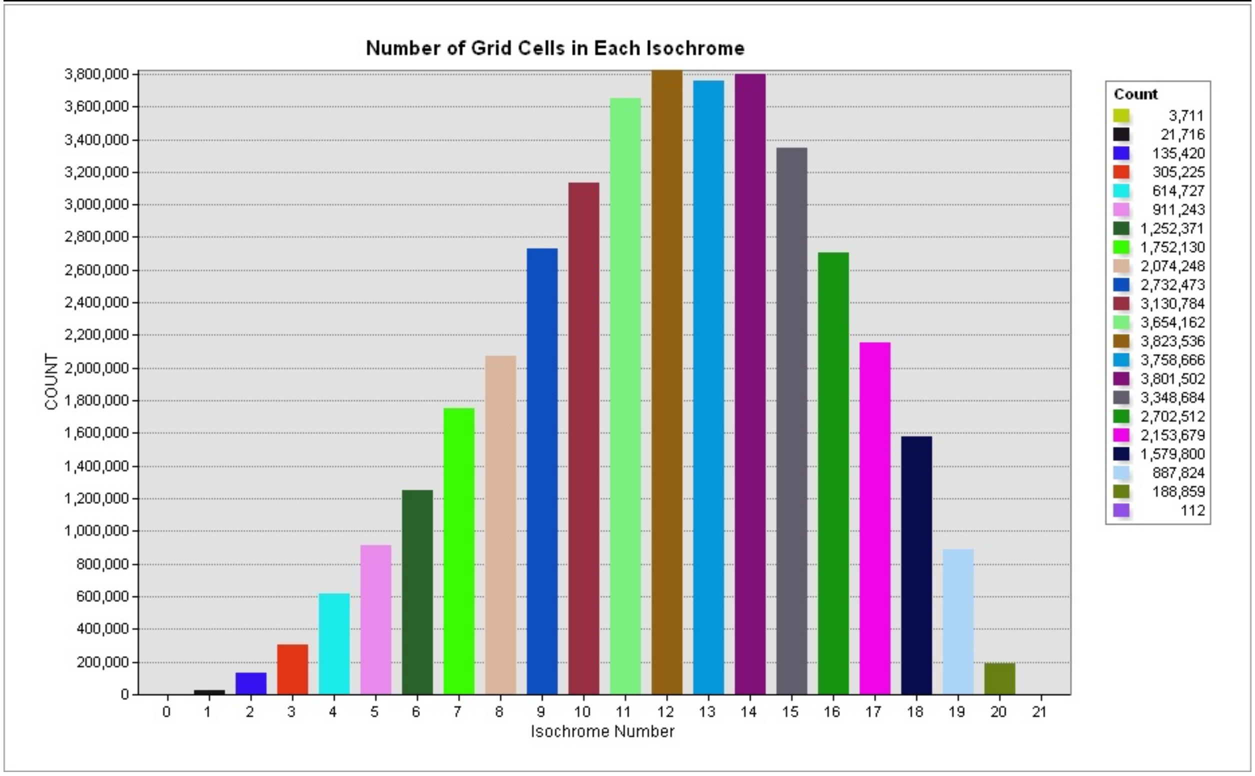


Figure 2. Histogram of Number of Grid Cells in Each Isochrone

The linear reservoir routing assumes that the storage *S* is linearly proportional to the outflow *O*. This is often expressed by Equation 4.

$$S = RO \qquad \text{(Equation 4)}$$

Where: *S*= Storage

R= Storage coefficient

Combined with the continuity equation given by Equation 5, an expression for calculating the routed hydrograph is given by Equation 6.

$$\bar{I} - \left(\frac{O_1+O_2}{2}\right) = \left(\frac{S_2-S_1}{\Delta t}\right) \qquad \text{(Equation 5)}$$

Where: $\bar{I}$ = mean inflow during the time interval Δt

O_1 = Outflow at start of time interval Δt

O_2 = Outflow at end of time interval Δt

S_1 = Storage at start of time interval Δt

S_2 = Storage at end of time interval Δt

$$O_2 = C\bar{I} + (1 - C)O_1 \qquad \text{(Equation 6)}$$

Where: $C = \frac{2\Delta t}{2R+\Delta t}$

Parameter R, or the storage coefficient is estimated as a proportion of the time of concentration. To determine appropriate values for this parameter, previous modeling efforts by FEMA were consulted as a reference flow. Parameter calibration analysis was performed after rainfall was applied. Discussion of parameter calibration is presented in a subsequent section. Equation 6 was applied to the RCAC to develop the Routed Relative Time-Area curve (RRTA).

The development of the unit hydrograph assumes that precipitation of uniform intensity falls on the basin for a long period of time until an equilibrium condition is established. At this point, it is assumed that the runoff rate at the basin outlet is equal to the net precipitation rate. In order to convert the RRTA to a S-hydrograph, all of the ordinates are multiplied by the equilibrium flow rate Q_e as defined by Equation 7.

$$Q_e = \frac{A}{D} \text{ (ft}^3\text{/s)} \qquad \text{(Equation 7)}$$

Where: A= Basin Area (Acres)

D = Desired Unit Hydrograph Duration (hrs)

The chosen duration for the unit hydrograph was 0.5 hrs (30 minutes). Using Equation 7, an equilibrium flow rate of 178,298 cfs was calculated for Point 1. Once the S-hydrograph was developed, it was lagged 30 minutes (duration of unit hydrograph) in time and then subtracted from the unlagged S-hydrograph to produce the final 30-minute unit hydrograph. The final unit hydrograph for Point 1 is presented in Figure 3.

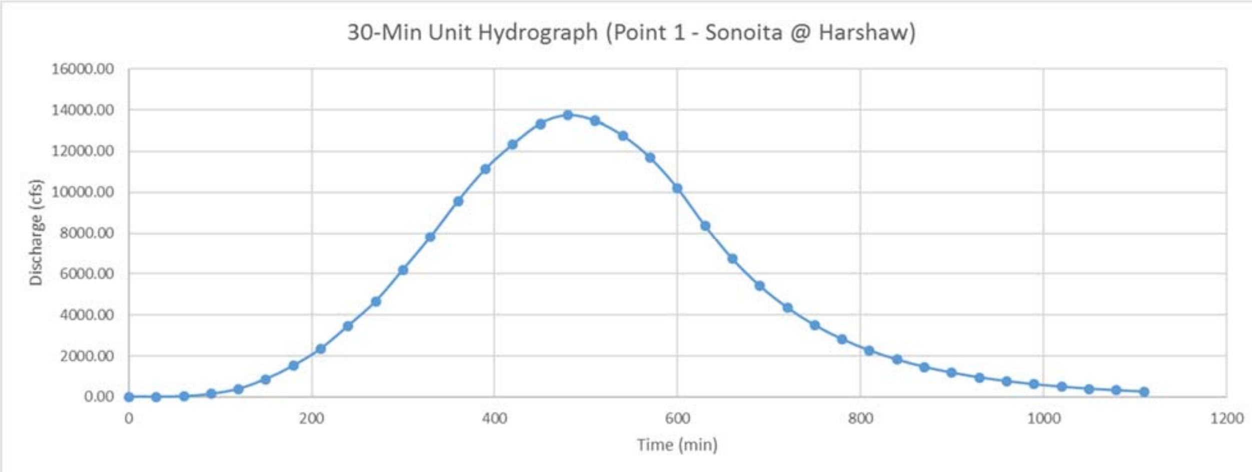


Figure 3. Final Unit Hydrograph for Point 1

2.4 Direct Runoff Hydrograph

Once the unit hydrograph was developed, a 30-minute synthetic hyetograph for the precipitation was produced. For the SCR Project, the 24-hr storm discharges were used for design, so 24-hr area reduced point precipitation totals were distributed using the NRCS Type II rainfall distribution. The final distribution did not account for abstractions. The NRCS curve number method was applied to the hyetograph. The SCS method divides the total rainfall into three parts, initial abstraction, continuous abstraction and excess rainfall. Continuous abstraction is the amount of rainfall that is lost as infiltration from the total rainfall. The final 30 minute hyetograph for the 100-yr, 24-hr storm, with the curve number of 82.4 (Point 1) applied, is shown in Figure 4. The total rainfall amount for this storm is 3.373 inches, which results in a total *excess* rainfall amount of 1.71 inches over the watershed modeled with curve number 82.4.

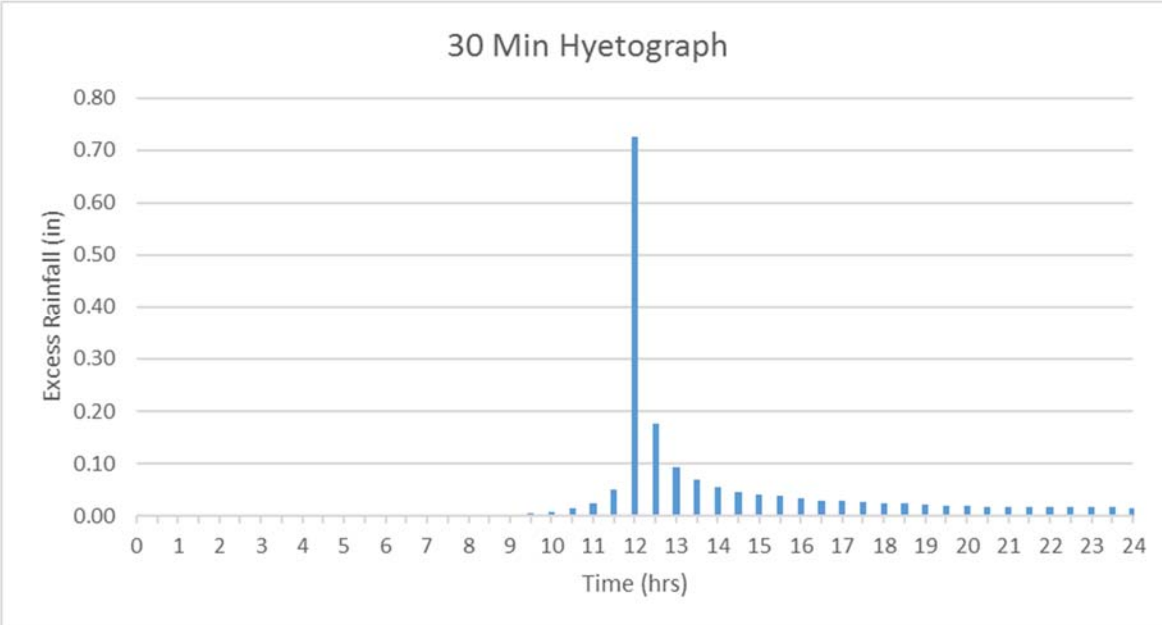


Figure 4. 30 Minute 100-yr, 24-hr Excess Rainfall Hyetograph

The 30-minute excess rainfall hyetograph was then applied to the unit hydrograph using the convolution equation as described by Equation 8.

$$Q_n = \sum_{m=1}^{n \leq M} P_m U_{n-m+1} \qquad \text{(Equation 8)}$$

Where: Q = runoff ordinate

P= rainfall pulse

U= unit hydrograph ordinate

The final direct runoff hydrograph for the 100-yr, 24-hr storm for Point 1 is shown in Figure 5.

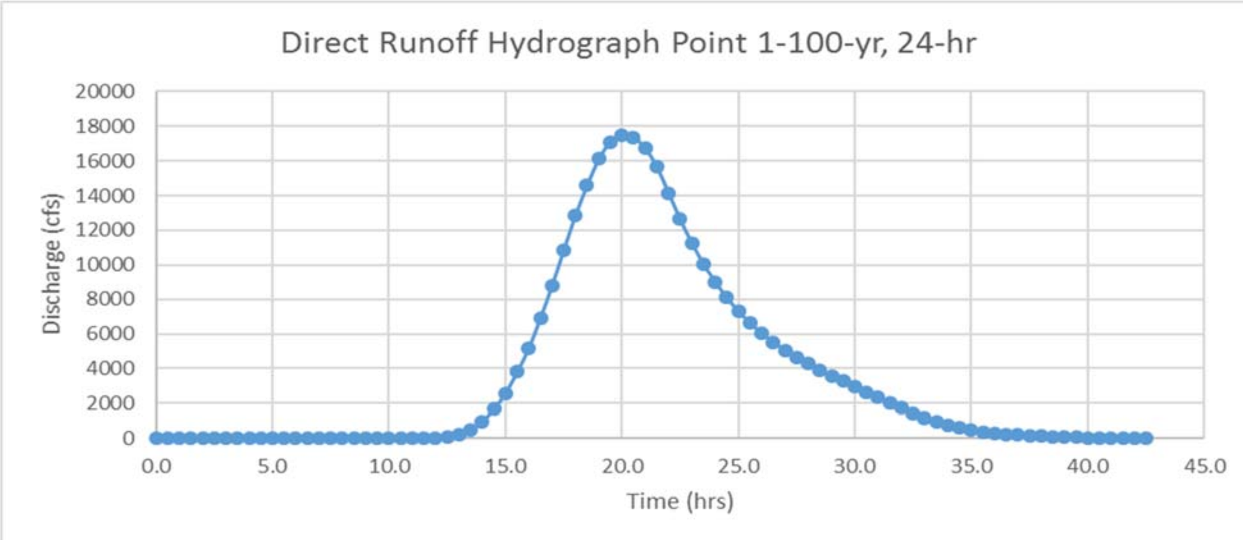


Figure 5. Direct Runoff Hydrograph for 100-yr, 24-hr Storm @ Point 1

2.5 Parameter Calibration

Upon completion of the direct runoff hydrograph, a parameter analysis was conducted to determine an appropriate value for the storage coefficient R as a fraction of the time of concentration. The FIS study estimated a peak discharge of 17,253 cfs for a 100-yr, 24-hr storm. The time of concentration for the watershed to Point 1 was calculated in ArcGIS as the longest travel time from any point in the watershed to the outlet. This value was determined to be 10.58 hrs. An R value of 2.3 gave a peak flow value of 17,480 cfs (within 1% of the FIS value). The fraction of the time of concentration required to calculate this R value would be 0.2174. Therefore, an expression for R was empirically derived and applied for the Point 2 (SCR Design) analysis as expressed by Equation 9.

$$R = 0.2174t_c \qquad \text{(Equation 9)}$$

3.0 RESULTS & CONCLUSIONS

The same methods as described in Section 2, were applied to the SCR design watershed (Point 2) to develop the 30-minute unit hydrograph, shown in Figure 6. The time of concentration for the SCR watershed was calculated using ArcGIS to be 6.03 hrs. Using Equation 9, an R Value of 1.31 was calculated and was used in Equation 6 to route the RCAC through a linear reservoir to produce the final unit hydrograph for Point 2, shown in Figure 7.

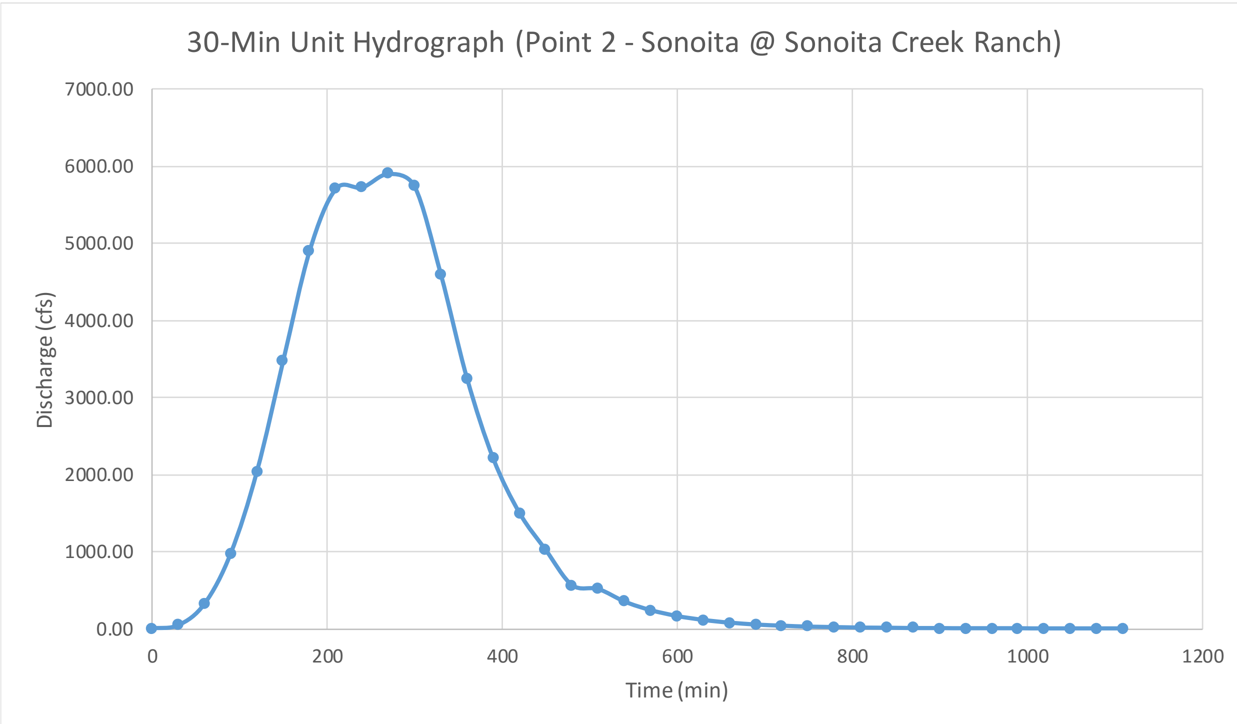


Figure 6. Final Unit Hydrograph for Point 2

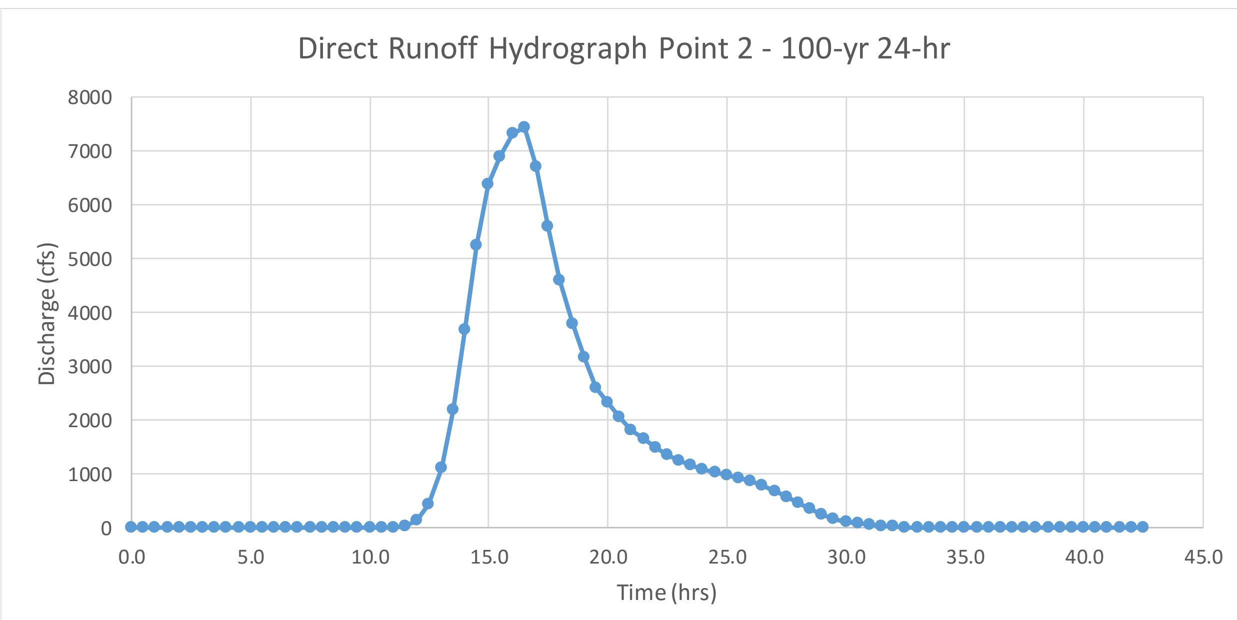


Figure 7. Direct Runoff Hydrograph for 100-yr, 24-hr Storm @ Point 2

Various 24-hr rainfall events were analyzed and the resulting values of peak discharge compared to the values developed from earlier modeling efforts. Table 1 compares these results.

Table 1. Summary of Peak Discharges from Two Design Methods for Sonoita Creek at Sonoita Creek Ranch

Event	Total Rainfall (Area Reduced) (inches)	Peak Discharge (Clark) (cfs)	Peak Discharge (SEDCAD) (cfs)
100-YR 24-hr	3.69	7428.09	7344.73
25-YR-24-hr	2.97	5040.84	4919.59
20-YR-24-hr	2.87	4723.57	4598.62
10-YR-24-hr	2.51	3620.1	3485.82
5-YR-24-hr	2.17	2647.78	2512.6
2-YR-24-hr	1.75	1577.68	1462.94

For every 24-hr event, the Clark method produced results that were comparable to values determined using SEDCAD, adding confidence to the reliability of that method for developing the design peak discharges.

Appendix C

USGS Equations & Regression

1.0 Introduction

The USGS regional regression equations quantify empirical relationships between discharge and watershed area specific to this region in Arizona, developed from gage data at 73 sites in Arizona hydrologic region 5. The USGS regional regression equations used in this analysis are shown below:

2-Year Storm: $Q_2 = 10^{\left(6.363-4.386(Drainage\ Area)^{-0.06}\right)}$

5-Year Storm: $Q_5 = 10^{\left(5.868-3.506(Drainage\ Area)^{-0.08}\right)}$

10-Year Storm: $Q_{10} = 10^{\left(5.778-3.218(Drainage\ Area)^{-0.09}\right)}$

25-Year Storm: $Q_{25} = 10^{\left(5.757-2.988(Drainage\ Area)^{-0.10}\right)}$

50-Year Storm: $Q_{50} = 10^{\left(5.696-2.795(Drainage\ Area)^{-0.11}\right)}$

100-Year Storm: $Q100 = 10^{\left(5.651-2.634(Drainage\ Area)^{-0.12}\right)}$

While the USGS regional regression equations report smaller flow values for the smaller recurrence storms (2, 5, 10 year), there is evidence that the USGS values under-represent discharge in those ranges at the downstream gage located on Sonoita Creek at Patagonia (USGS 09481500 Sonoita Creek near Patagonia, AZ) (Table 1). Specifically, a Log-Pearson Type III (LPIII) and a Weibull Plotting Position analyses were conducted on the instantaneous peak flow data recorded at the gage, and discharge was computed for several recurrence intervals and compared to the USGS regression equation applied at that point (Figure 1). Again, the USGS regional regression equation significantly under-predicts gage data for storms events up to about the 10-year storm event.

Table 1. Discharge Comparison of Gage Data and USGS Regional Regression Equations at USGS Gage on Sonoita Creek near Patagonia

Return Interval	USGS Gage Data LPIII Analysis (cfs)	USGS Gage Data Weibull Plotting Position Analysis (cfs)	USGS Regional Regression Equation (cfs)
2-Year	2,911	3,140	1,513
5-Year	5,861	5,334	3,814
10-Year	8,220	7,332	6,143
25-Year	11,562	14,320	10,132
50-Year	14,263	16,160	13,900
100-Year	17,094	17,080	18,349

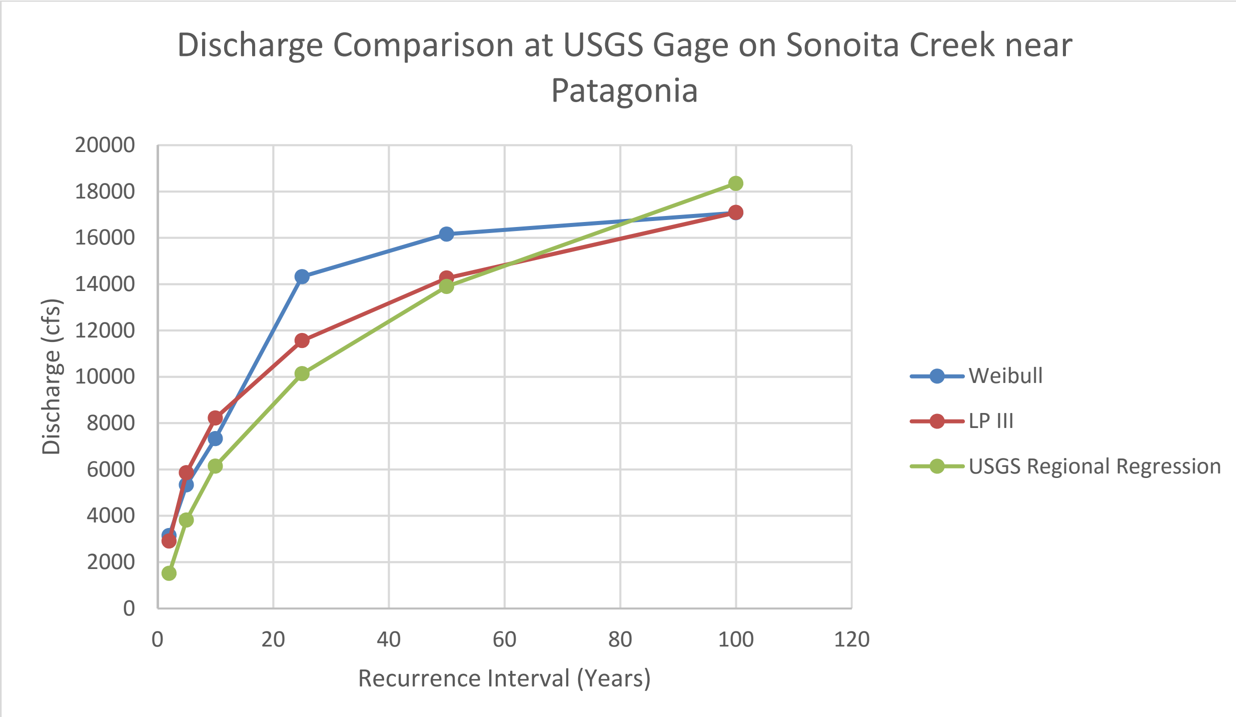


Figure 1. Discharge Comparison of Gage Data and USGS Regional Regression Equations at USGS Gage on Sonoita Creek near Patagonia

The SEDCAD method predicts discharges that are in close agreement with the Clark Time-Area Method and with the USGS regression equations for the 10-year and 25-years storms, which are the recurrence intervals most influential in channel forming processes and most critical for channel design for the SCR Project. Peak discharge values from SEDCAD, CATM, and the USGS regional regression equations are compared below in Table 2. The local gage (as analyzed with LPIII) exceeded the regional USGS flood regression by 34% and 14% for the 10-year and 25-year peak discharges, respectively, while the SEDCAD values used for channel design only exceed the USGS flood regression by 20% and 2% for the 10-year and 25-year peak discharges, respectively. The values used for channel design, and for inundation area calculations, are those derived from the SEDCAD double triangle unit hydrograph.

Table 2. Comparison of Peak Discharges (cfs) for SEDCAD, CTAM & USGS Regional Regression Equations at the Sonoita Creek Ranch Inlet Point for Selected Recurrence Intervals

Return Interval	SEDCAD (cfs)	Clark Time-Area Method (cfs)	USGS Regional Regression Equations (cfs)
2-Year	1,463	1,578	693
5-Year	2,513	2,648	1,783
10-Year	3,486	3,620	2,899
25-Year	4,920	5,041	4,830
50-Year	6,075	6,181	6,706
100-Year	7,345	7,428	8,962

Appendix D

Rainfall Analysis and Discharge Estimation for the July 27, 2014 Flow Event on Sonoita Creek

Rainfall Analysis and Discharge Estimation for the July 27, 2014 Flow Event on Sonoita Creek

Prepared For:

HUDBAY

Rosemont Copper Project

Prepared By:

Water & Earth Technologies

March 9, 2015

Contents

Figures

1.0 Introduction

Water & Earth Technologies, Inc. (WET) is providing engineering analysis and design services to Hudbay in developing a project intended as mitigation for ephemeral stream channels impacted by the Rosemont Copper Project (Project). The Sonoita Creek mitigation project involves retiring agricultural land adjacent to Sonoita Creek from cultivation and implementing a variety of stream restoration measures to reduce or reverse the adverse impacts of historic straightening and entrenchment of the ephemeral stream channel. Conceptual design for the project has been completed using design discharges developed theoretically, since no stream gages exist on the reach of Sonoita Creek considered for restoration. A relatively large storm event which occurred on July 27, 2014 provides an opportunity to "reality check" the watershed response predicted by the project's hydrologic and hydraulic modeling results, using rainfall data recorded during the storm by a precipitation gage in the project area and using high water marks left by the resulting flow event in Sonoita Creek.

2.0 Rainfall Analysis for the July 27, 2014 Flow Event

On July 27, 2014 a significant monsoon storm occurred in the vicinity of the proposed mitigation and stream restoration project on Sonoita Creek. ALERT data from the Santa Cruz County Flood Control District were obtained to determine the magnitude of the storm. The ALERT network for the county is shown in Figure 1, with the project area circled in red.

The ALERT precipitation gage closest to the project site is gage #2520, located at Casa Blanca Canyon and Hwy 82. This gage recorded a 24-hour total of 2.76 inches on July 27, 2014. Based on this amount of measured rainfall, the NOAA Atlas 14 table relevant to the project site (for the Patagonia, Arizona area) (Figure 2) indicates that this storm was between a 2-year (2.3 inches) and 5-year (2.86 inches), 24-hour event.

3.0 Peak Discharge Reconstruction

The peak discharge occurring at the project site during the 2014 monsoon season (most likely as a result of the July 27, 2014 storm) was estimated based upon a forensic hydraulic analysis of high water marks observed in the Sonoita Creek channel. Data for a hydraulic model were collected during a site visit that was conducted in January, 2015 to assess field conditions and identify effects of the 2014 monsoon season. During this visit, a concrete road crossing and structural control on the south (downstream) side of the project location was identified as a favorable location for estimating peak discharge based upon post-event hydraulic evidence.

Figure 3 and Figure 4 are photos from the site visit that show the road crossing. The width of the concrete crossing estimated from the photos is approximately 15 feet. On the downstream side of the crossing there is an immediate drop off of approximately 1 foot to the earthen channel. High water marks were identified in the field and can be clearly seen in the photo (Figure 4). Maximum water depth was approximately 2 feet on the left side (looking downstream) of the cross section, where the concrete road crossing is lowest The right side of the stream cross section at the concrete crossing is slightly higher and high water marks there were shallower at just over 1 foot.

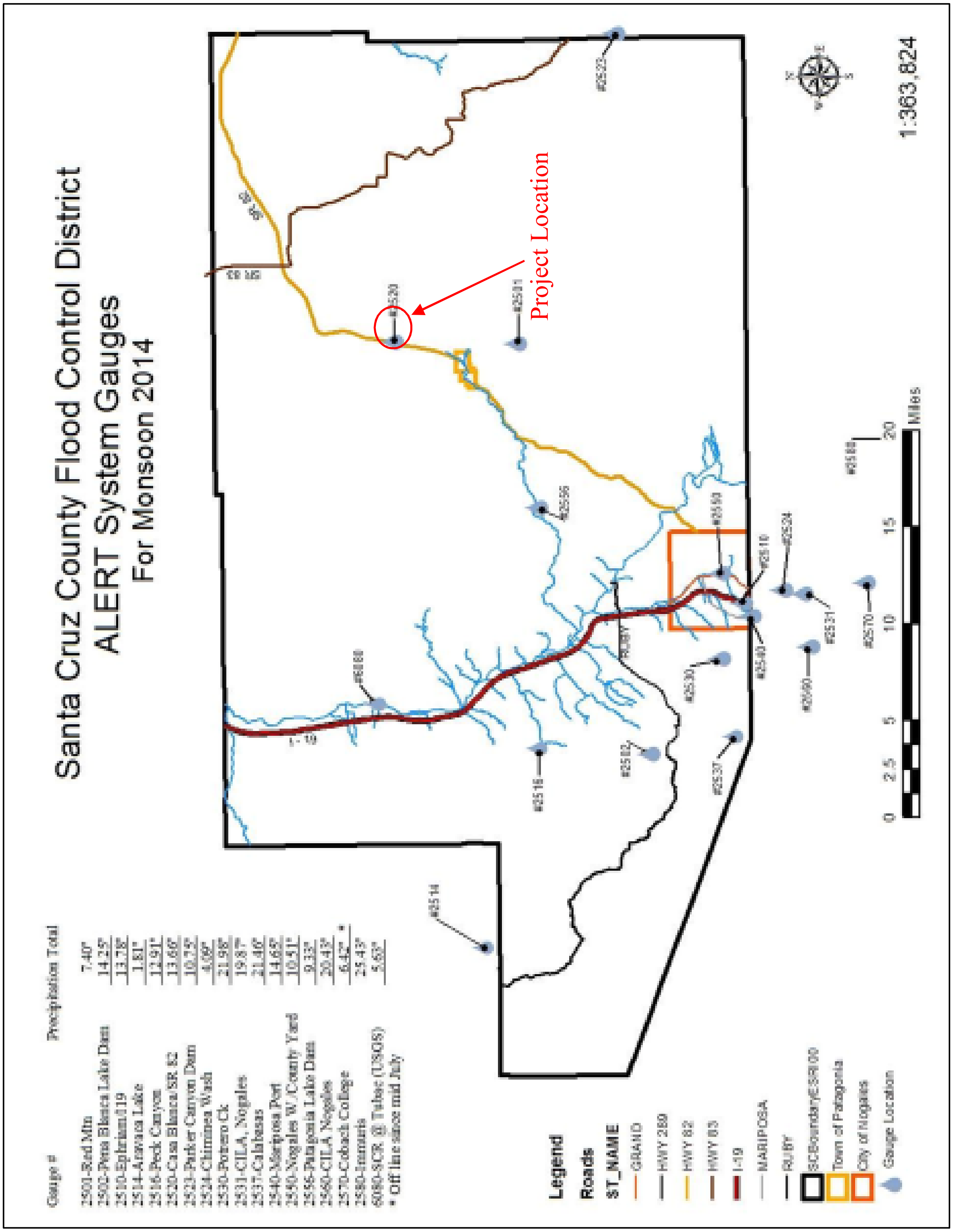


Figure 1. ALERT Network for Santa Cruz County

NOAA Atlas 14, Volume 1, Version 5
Location name: Patagonia, Arizona, US*
Coordinates: 31.6541, -110.7323
Elevation: 4594 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.339 (0.303-0.382)	0.435 (0.388-0.490)	0.565 (0.502-0.634)	0.660 (0.585-0.740)	0.786 (0.690-0.880)	0.878 (0.765-0.988)	0.972 (0.837-1.10)	1.06 (0.907-1.21)	1.18 (0.988-1.35)	1.27 (1.05-1.48)
10-min	0.516 (0.461-0.582)	0.663 (0.591-0.746)	0.860 (0.764-0.965)	1.00 (0.890-1.13)	1.20 (1.05-1.34)	1.34 (1.16-1.50)	1.48 (1.27-1.67)	1.62 (1.38-1.84)	1.80 (1.50-2.06)	1.94 (1.60-2.25)
15-min	0.640 (0.572-0.721)	0.821 (0.732-0.925)	1.07 (0.947-1.20)	1.25 (1.10-1.40)	1.48 (1.30-1.66)	1.66 (1.44-1.86)	1.83 (1.58-2.07)	2.01 (1.71-2.27)	2.23 (1.86-2.56)	2.40 (1.98-2.79)
30-min	0.861 (0.770-0.972)	1.11 (0.986-1.25)	1.44 (1.27-1.61)	1.68 (1.49-1.88)	2.00 (1.75-2.24)	2.23 (1.94-2.51)	2.47 (2.13-2.79)	2.70 (2.30-3.06)	3.00 (2.51-3.44)	3.24 (2.66-3.75)
60-min	1.07 (0.953-1.20)	1.37 (1.22-1.54)	1.78 (1.58-1.99)	2.08 (1.84-2.33)	2.47 (2.17-2.77)	2.76 (2.41-3.11)	3.06 (2.63-3.45)	3.34 (2.85-3.79)	3.71 (3.11-4.26)	4.01 (3.30-4.65)
2-hr	1.18 (1.06-1.32)	1.50 (1.35-1.69)	1.93 (1.72-2.16)	2.26 (2.00-2.52)	2.71 (2.39-3.03)	3.06 (2.67-3.42)	3.42 (2.95-3.85)	3.78 (3.22-4.28)	4.27 (3.56-4.88)	4.66 (3.82-5.37)
3-hr	1.24 (1.11-1.38)	1.55 (1.40-1.74)	1.97 (1.77-2.20)	2.30 (2.06-2.57)	2.77 (2.46-3.09)	3.13 (2.75-3.50)	3.52 (3.04-3.95)	3.91 (3.33-4.42)	4.45 (3.70-5.09)	4.88 (3.97-5.65)
6-hr	1.42 (1.27-1.60)	1.77 (1.59-2.00)	2.23 (1.98-2.50)	2.60 (2.31-2.92)	3.13 (2.75-3.52)	3.56 (3.08-4.01)	4.01 (3.42-4.54)	4.47 (3.76-5.10)	5.11 (4.19-5.89)	5.63 (4.52-6.56)
12-hr	1.66 (1.50-1.85)	2.08 (1.87-2.32)	2.59 (2.31-2.89)	3.01 (2.68-3.35)	3.60 (3.17-4.00)	4.06 (3.55-4.54)	4.55 (3.92-5.12)	5.06 (4.29-5.73)	5.75 (4.77-6.59)	6.30 (5.12-7.29)
24-hr	1.85 (1.67-2.03)	2.30 (2.09-2.54)	2.86 (2.59-3.15)	3.30 (2.98-3.64)	3.91 (3.51-4.31)	4.37 (3.91-4.82)	4.85 (4.32-5.35)	5.33 (4.72-5.89)	5.98 (5.25-6.63)	6.48 (5.65-7.37)
2-day	2.04 (1.86-2.25)	2.54 (2.31-2.80)	3.14 (2.85-3.46)	3.64 (3.30-4.01)	4.34 (3.92-4.78)	4.89 (4.39-5.39)	5.47 (4.88-6.03)	6.07 (5.37-6.71)	6.89 (6.03-7.67)	7.55 (6.54-8.44)
3-day	2.22 (2.02-2.45)	2.77 (2.52-3.06)	3.43 (3.12-3.79)	3.98 (3.61-4.39)	4.76 (4.29-5.24)	5.37 (4.82-5.92)	6.02 (5.36-6.65)	6.70 (5.92-7.41)	7.63 (6.66-8.49)	8.38 (7.23-9.36)
4-day	2.41 (2.19-2.66)	3.00 (2.73-3.31)	3.72 (3.39-4.11)	4.33 (3.92-4.77)	5.18 (4.67-5.71)	5.86 (5.25-6.46)	6.58 (5.85-7.26)	7.33 (6.46-8.11)	8.37 (7.29-9.31)	9.20 (7.93-10.3)
7-day	2.90 (2.64-3.20)	3.62 (3.29-3.99)	4.51 (4.10-4.98)	5.23 (4.74-5.77)	6.22 (5.62-6.87)	7.00 (6.29-7.73)	7.81 (6.97-8.64)	8.63 (7.66-9.58)	9.77 (8.56-10.9)	10.7 (9.25-11.9)
10-day	3.37 (3.08-3.70)	4.21 (3.85-4.62)	5.21 (4.75-5.72)	6.00 (5.47-6.58)	7.06 (6.41-7.75)	7.87 (7.11-8.64)	8.70 (7.81-9.58)	9.53 (8.50-10.5)	10.6 (9.39-11.8)	11.5 (10.1-12.8)
20-day	4.66 (4.28-5.08)	5.82 (5.35-6.35)	7.14 (6.55-7.79)	8.14 (7.46-8.87)	9.43 (8.61-10.3)	10.4 (9.44-11.3)	11.3 (10.2-12.3)	12.2 (11.0-13.4)	13.4 (12.0-14.7)	14.2 (12.7-15.7)
30-day	5.88 (5.41-6.39)	7.33 (6.75-7.97)	8.93 (8.20-9.70)	10.1 (9.27-11.0)	11.6 (10.6-12.6)	12.6 (11.5-13.7)	13.6 (12.4-14.9)	14.6 (13.3-15.9)	15.8 (14.3-17.3)	16.7 (15.0-18.3)
45-day	7.27 (6.70-7.88)	9.05 (8.33-9.82)	10.9 (10.0-11.8)	12.2 (11.2-13.3)	13.9 (12.7-15.1)	15.0 (13.7-16.3)	16.1 (14.7-17.6)	17.1 (15.6-18.7)	18.4 (16.6-20.1)	19.3 (17.3-21.2)
60-day	8.51 (7.84-9.21)	10.6 (9.75-11.5)	12.7 (11.7-13.8)	14.2 (13.1-15.4)	16.1 (14.7-17.4)	17.3 (15.9-18.8)	18.5 (16.9-20.1)	19.6 (17.9-21.4)	21.0 (19.0-22.9)	21.9 (19.8-24.0)

Figure 2. NOAA Atlas 14 Point Precipitation Data

Figure 3. Road Crossing (First of Two Photos; Downstream to the Left)

Figure 4. Road Crossing (Second of Two Photos; Downstream to the Right) with Visible High Water Marks and Debris Accumulations

The concrete road crossing lies within the reach that was included in the HEC-RAS hydraulic model developed for the Sonoita Creek Project. Figure 5 shows the HEC-RAS model schematic and the location of the road crossing.

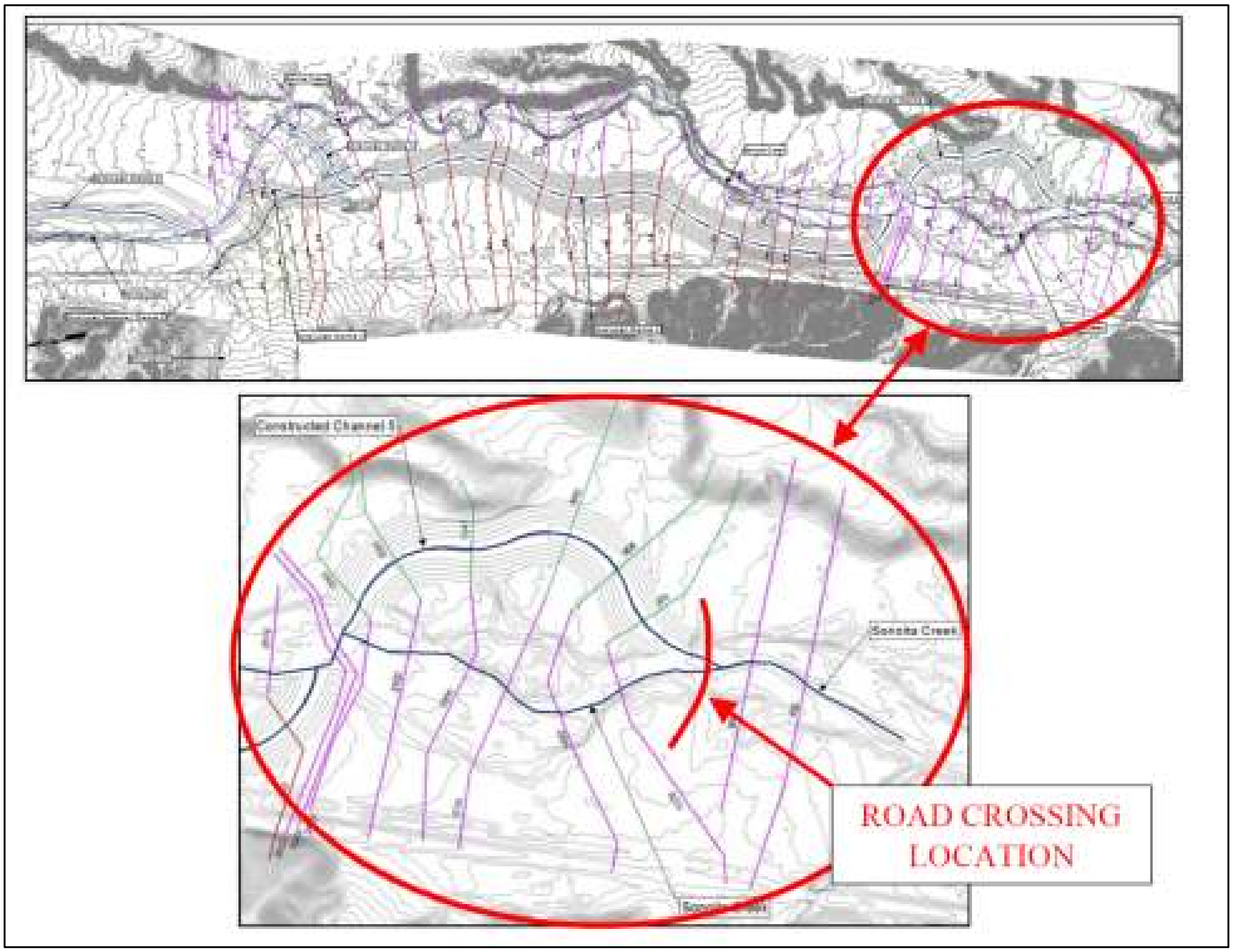


Figure 5. Road Crossing Location

For computational simplicity, a smaller HEC-RAS model focusing on the southern end of the project site was developed. Three cross sections were added to represent the road crossing, defined by an entrance section, exit section and drop off section. Manning's n values were adjusted for the concrete crossing to 0.020. Values of Manning's n for the remaining channel sections remained at 0.035, as they had been in the previous model. Based on field observations and the presence of the drop-off downstream of the concrete road crossing, the HEC-RAS model for the road crossing was set to make "mixed flow regime" calculations rather than assuming that flow through the reach will be uniformly sub-critical (deep and relatively slow). Supercritical (shallow, high-velocity) flow is a possibility in the vicinity of a drop for some discharges, and in this case the model did predict from the flow energy calculations that the drop at the concrete road crossing would result in transitions between flow regimes for the modeled discharge. Except for enabling the model to consider mixed flow regimes, the hydraulic reconstruction for the July storm used the same methods that were employed for the original study:

- The point precipitation value of 2.76 inches was reduced by applying an aerial reduction factor of 0.747 to get a value of 2.06 inches.
- The adjusted rainfall was modeled in SEDCAD to determine the associated peak discharge. The SEDCAD-predicted discharge through the section from the July rainfall was 3,667 cubic feet per second (cfs).
- The peak discharge estimated by SEDCAD was simulated using the HEC-RAS hydraulic model and the resulting depth of flow in the cross section was compared to the observed depth of flow based upon the high water marks. The 2-year, 24-hour discharge of 2,346 cfs and the 5-year, 24-hour discharge of 4,004 cfs were also modeled. The profile view of the water surface elevations through the modeled reach are shown for all three discharges in (Figure 6).

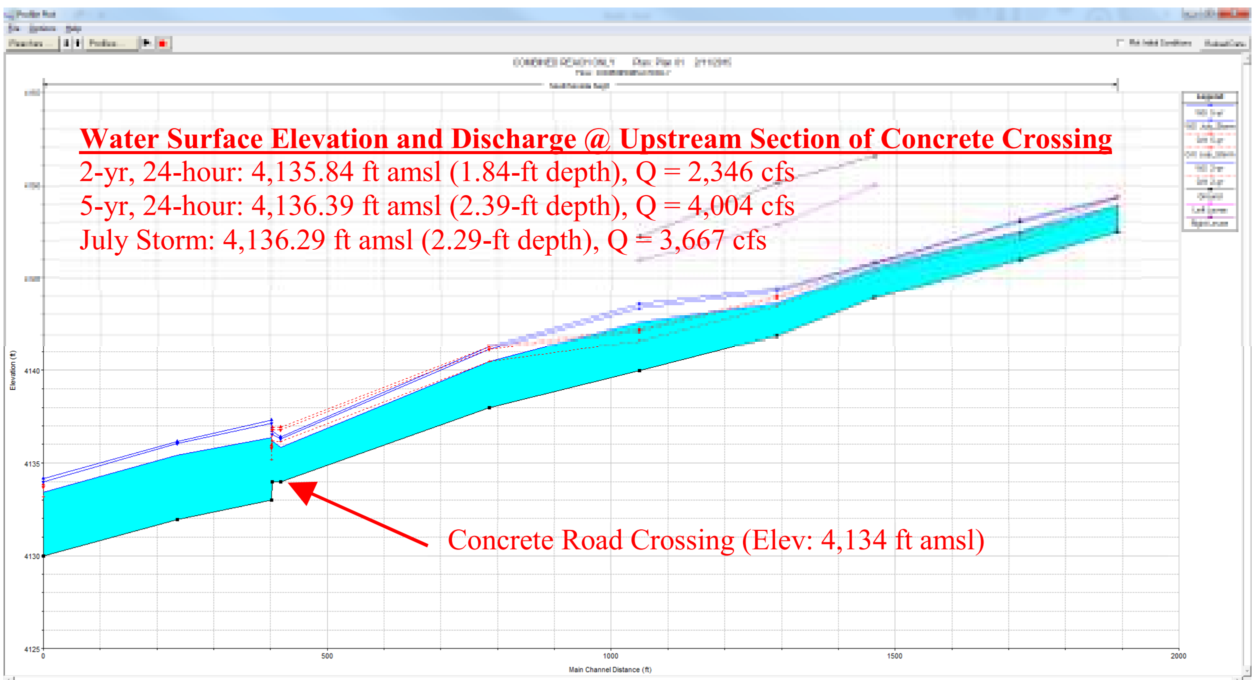


Figure 6. HEC-RAS Model Output: Water Surface Elevation Profile Plots

The depth of flow for the modeled peak discharge corresponds closely with the flow depth inferred from high water marks observed in the field, even though the peak discharge was determined independently through hydrologic modeling of the gage-recorded rainfall. The close correlation between the hydraulic model and field observations of high water marks also lends confidence to the determination that the July storm was indeed between a 2-year and 5-year event.

4.0 Summary

Data for the July 27, 2014 storm and flow event in Sonoita Creek were available for comparison with the simulated watershed response that was developed theoretically for the preliminary design of the proposed Sonoita Creek mitigation/restoration project. Data from a nearby ALERT rain gage and from measurement of high water marks visible in the field were used to independently characterize watershed response using the same methods that were used for the project's theoretical hydrologic and hydraulic simulations. The results of this analysis indicate that the recurrence for the July 27 storm was between the 2-year, 24-hour and the 5-year, 24-hour theoretical events for rainfall, and that the expected depth of flow from such an event predicted theoretically is very comparable to the depth of flow observed in the field.

5.0 References

DEC Data Systems, 2001, DataWise Online Reports for the Santa Cruz County ALERT System, DWReports Ver. CS490-B. On the web at: http://floodalert.co.santa-cruz.az.us/perl/SensorDataDisplayOptions.pl

US Army Corps of Engineers (USACE) Hydraulic Engineering Center, 2010, HEC-RAS River Analysis System, Hydraulic Reference Manual. On the web at: (http://www.hec.usace.army.mil/software/hec-ras/documents/HEC-RAS_4.1_Reference_Manual.pdf, last accessed 12-23-2011).

U.S. Department of Commerce National Oceanic and Atmospheric Administration, 2004, revised 2011, NOAA Atlas 14: Precipitation-Frequency Atlas of the United States, Volume 1 Version 5.0: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah). On the web at:
http://www.nws.noaa.gov/oh/hdsc/PF_documents/Atlas14_Volume1.pdf

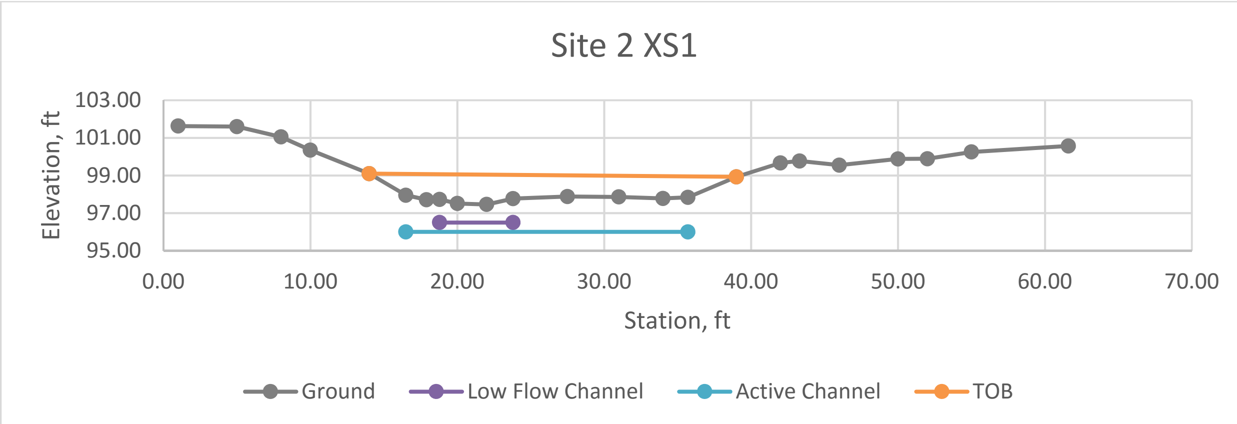
Appendix E

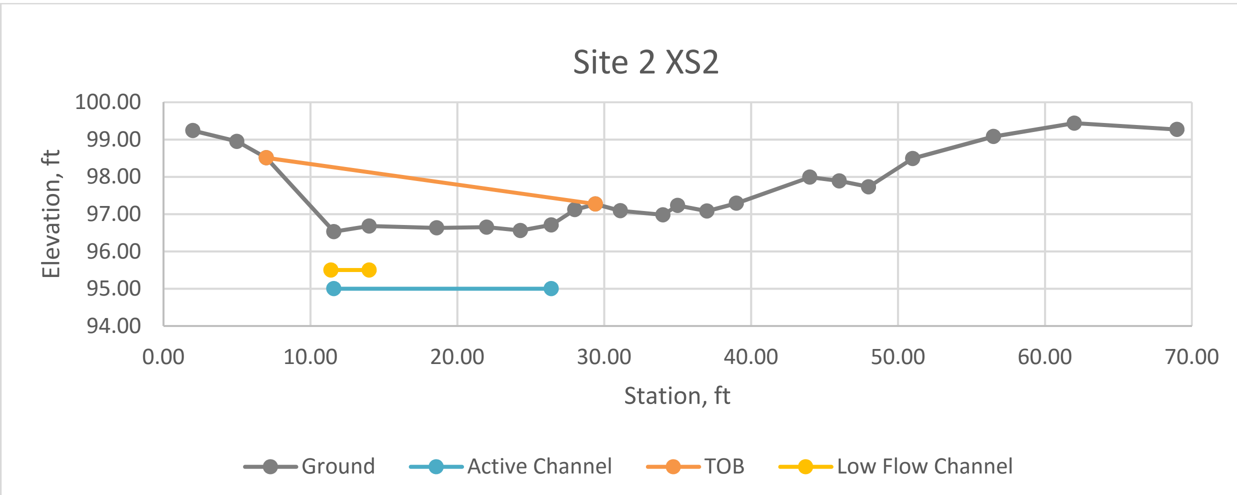
Sonoita Creek Reference Reach Surveys

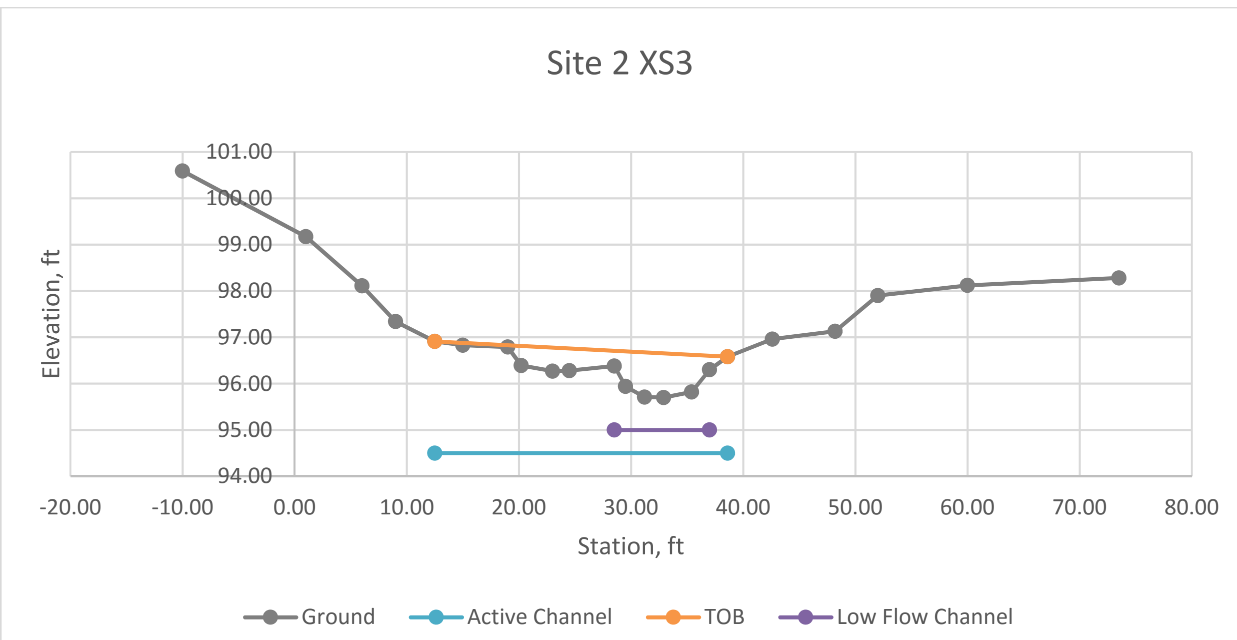
1. **Site 2**
2. **Site 3**
3. **Site 6**
4. **Site 6.3**
5. **Site 6.5**
6. **Site 7**
7. **Site 8**

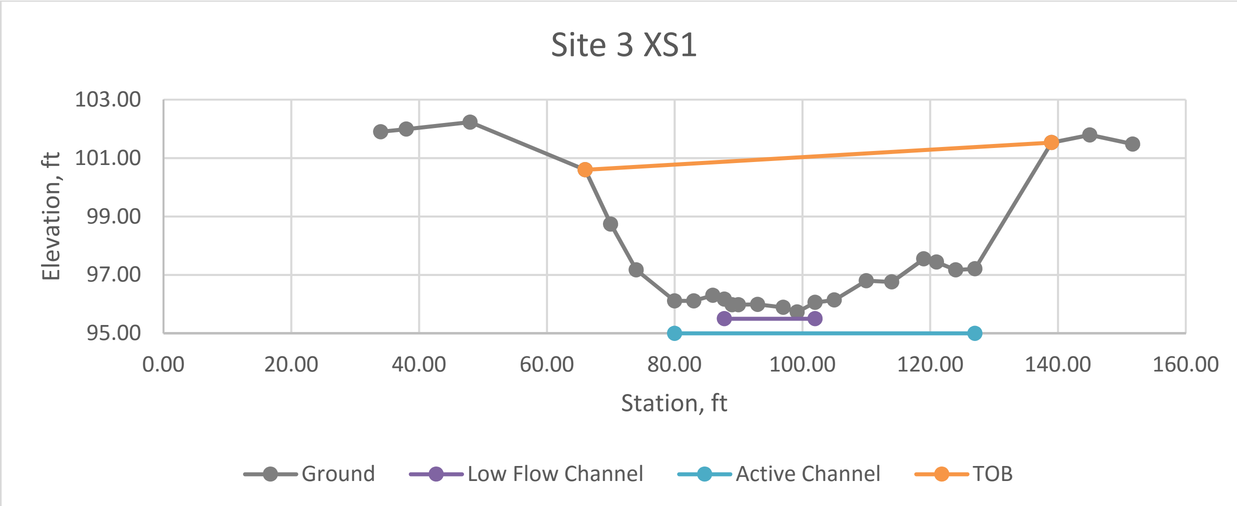
Appendix E

Sonoita Creek Reference Reach Survey





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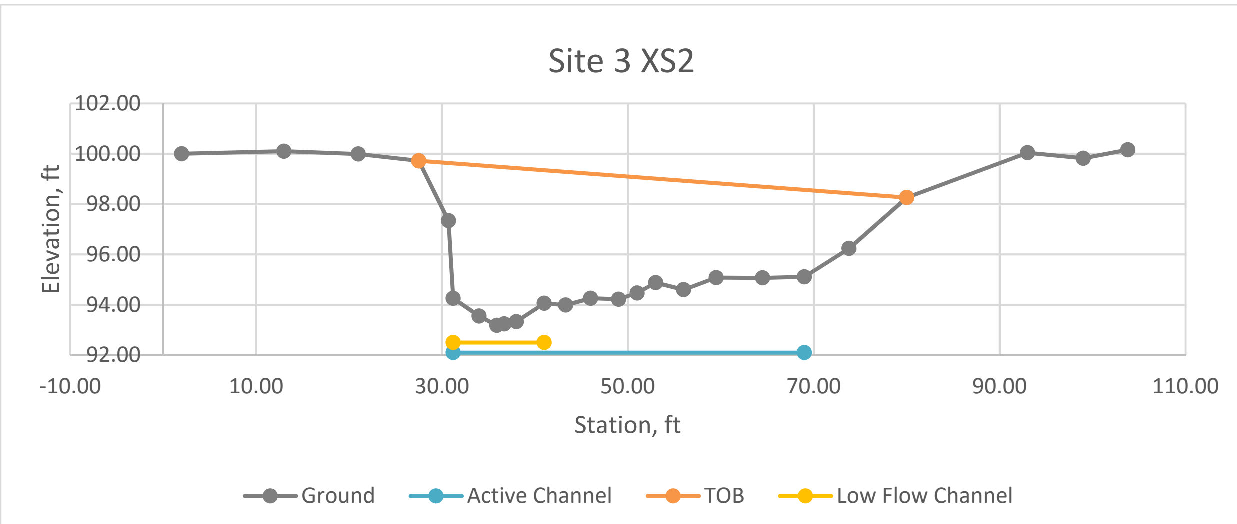
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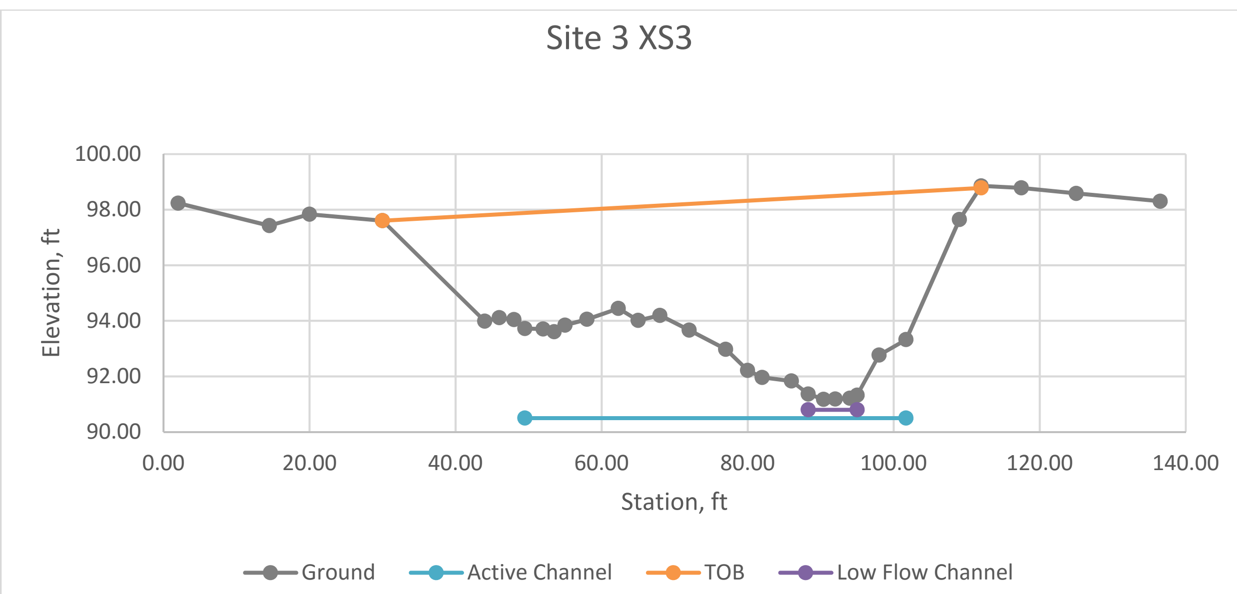
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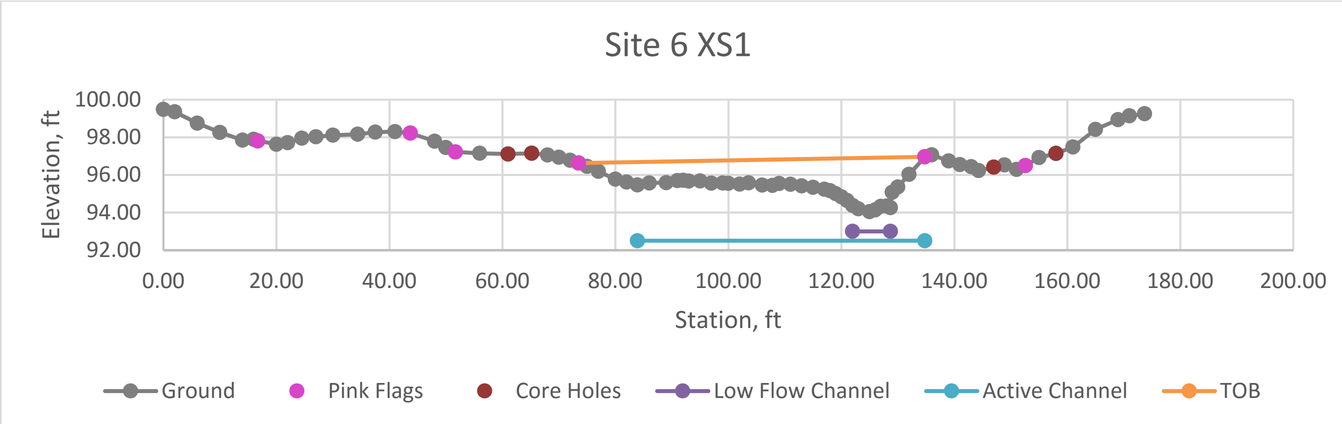
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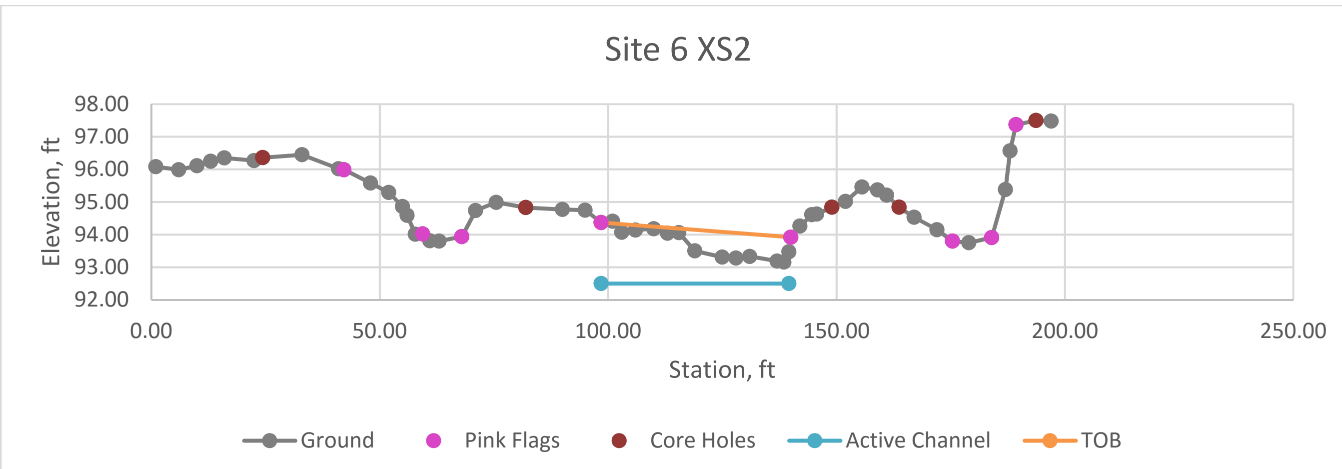
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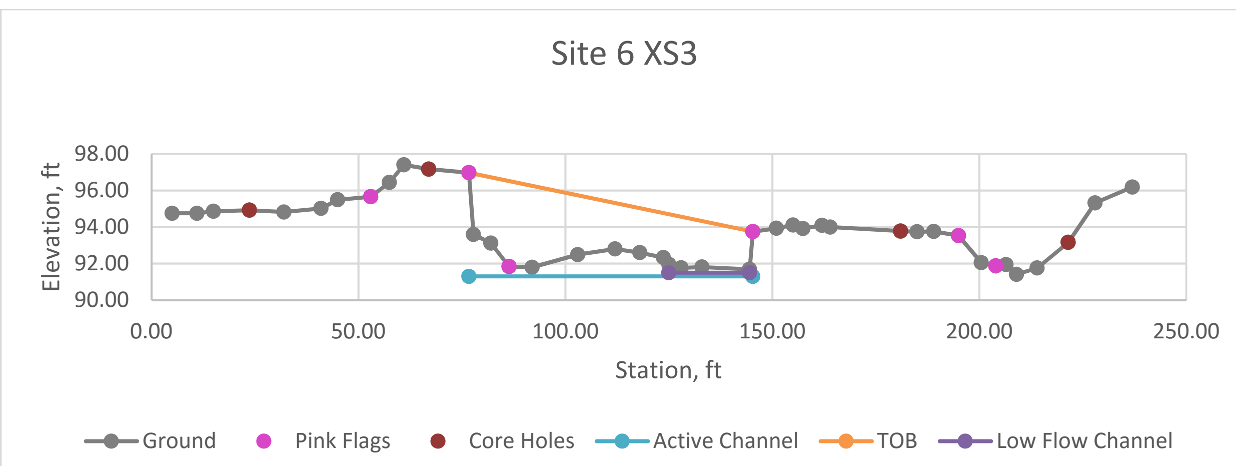
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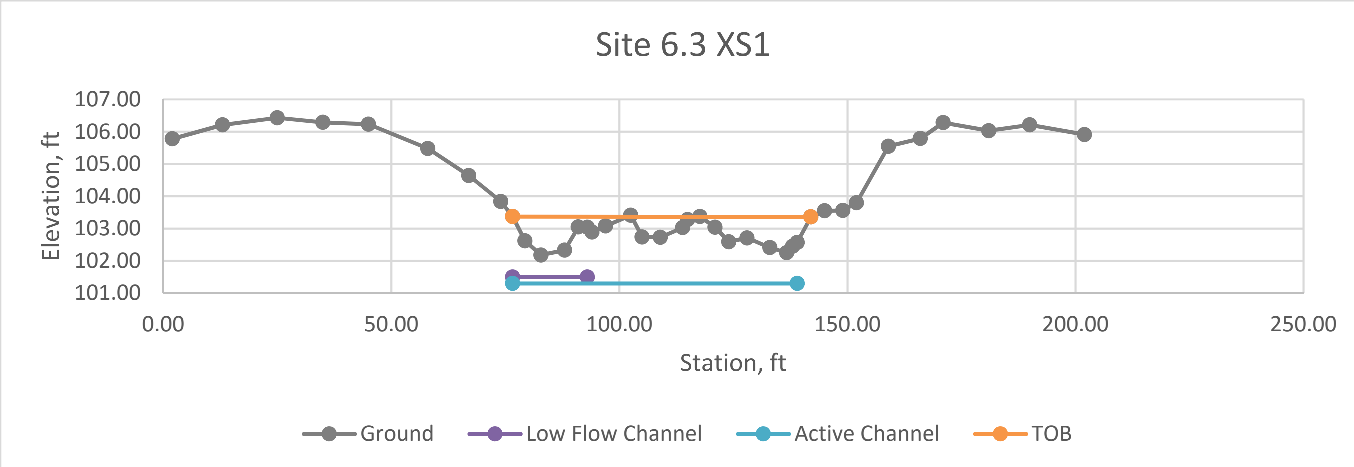
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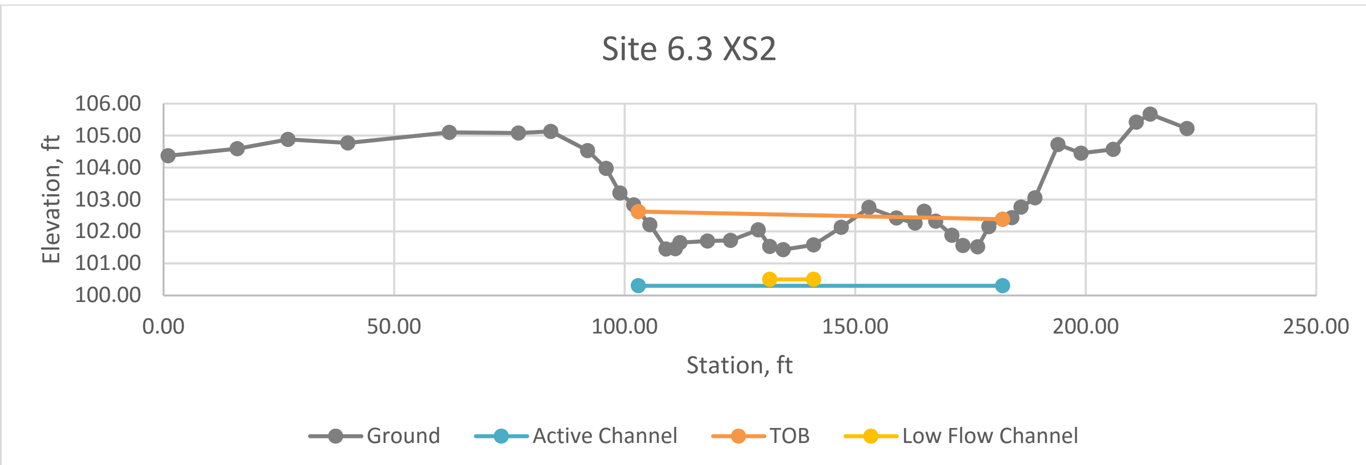
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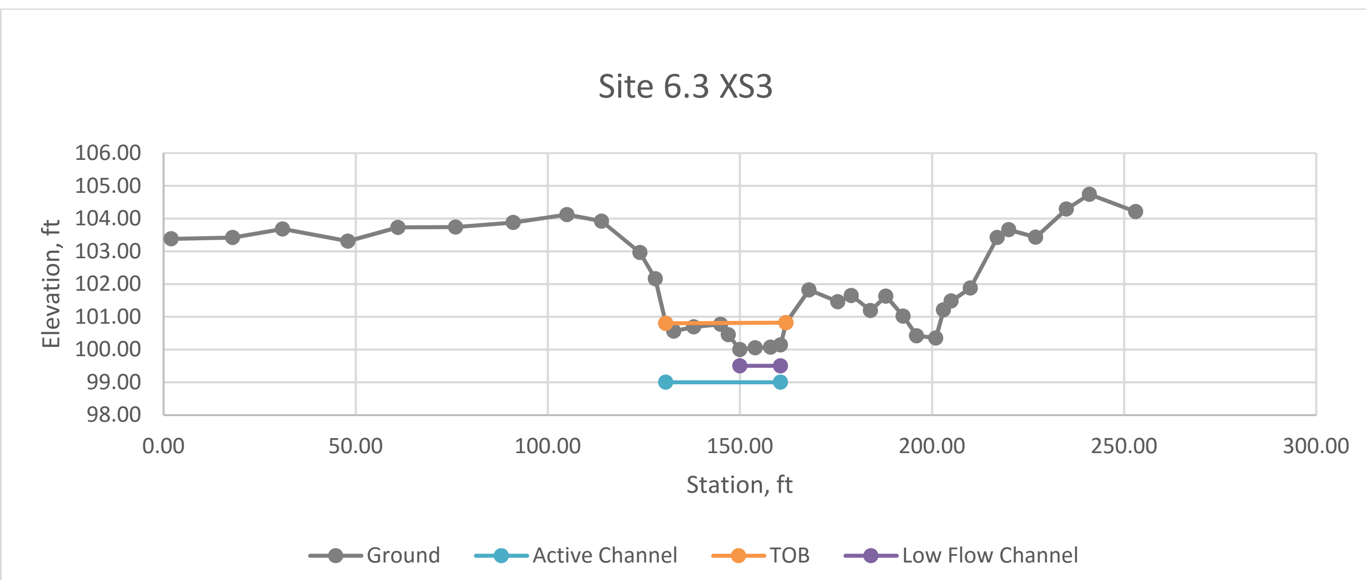
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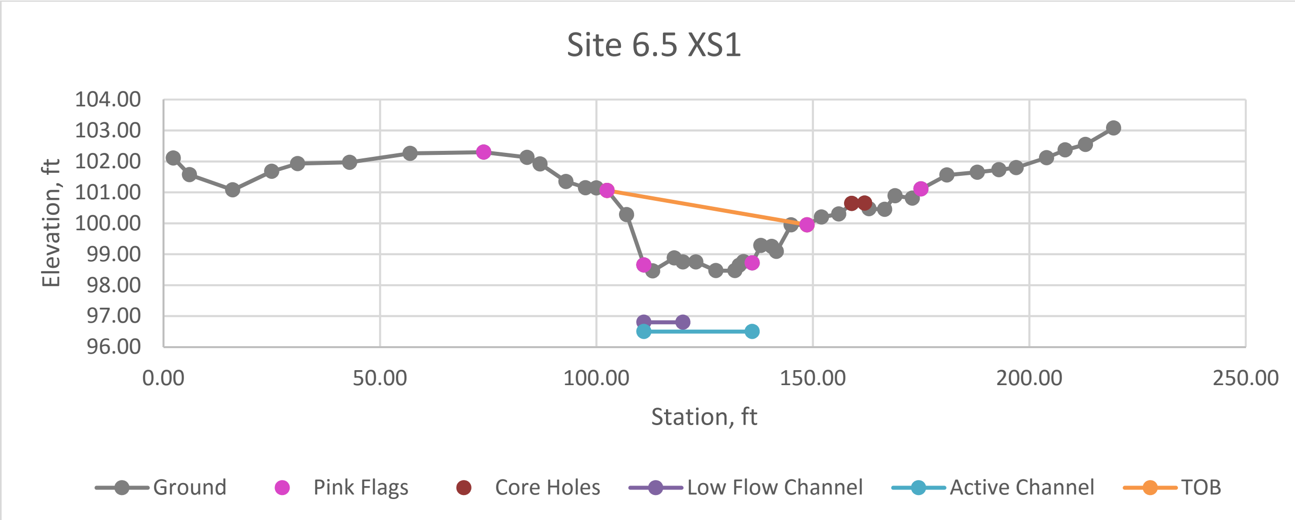
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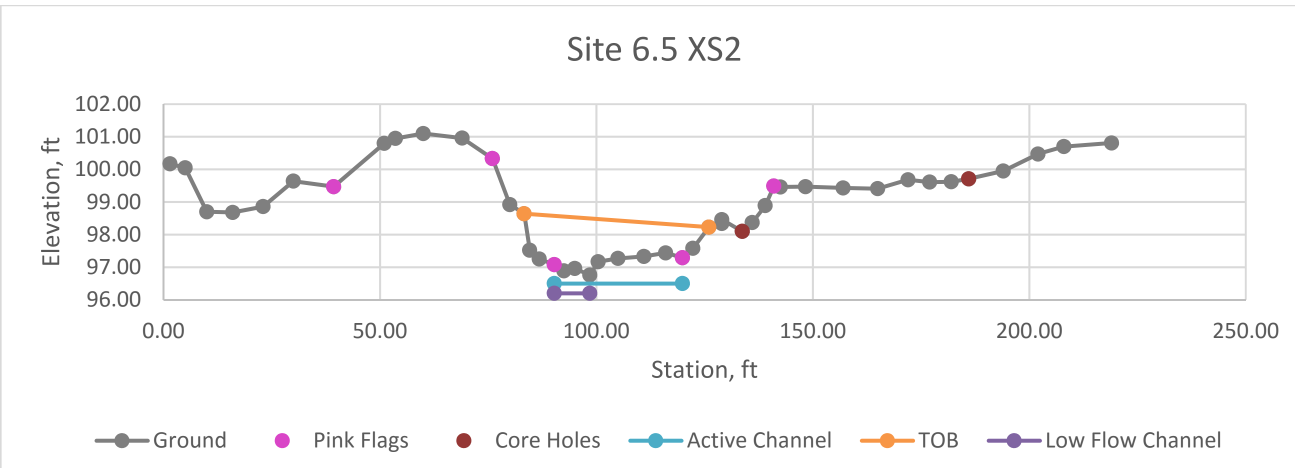
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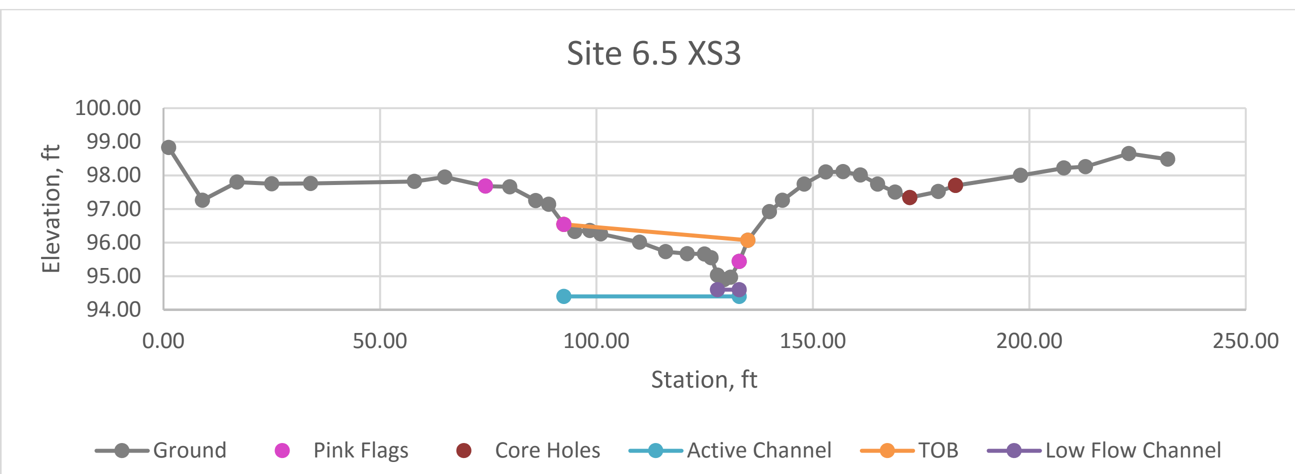
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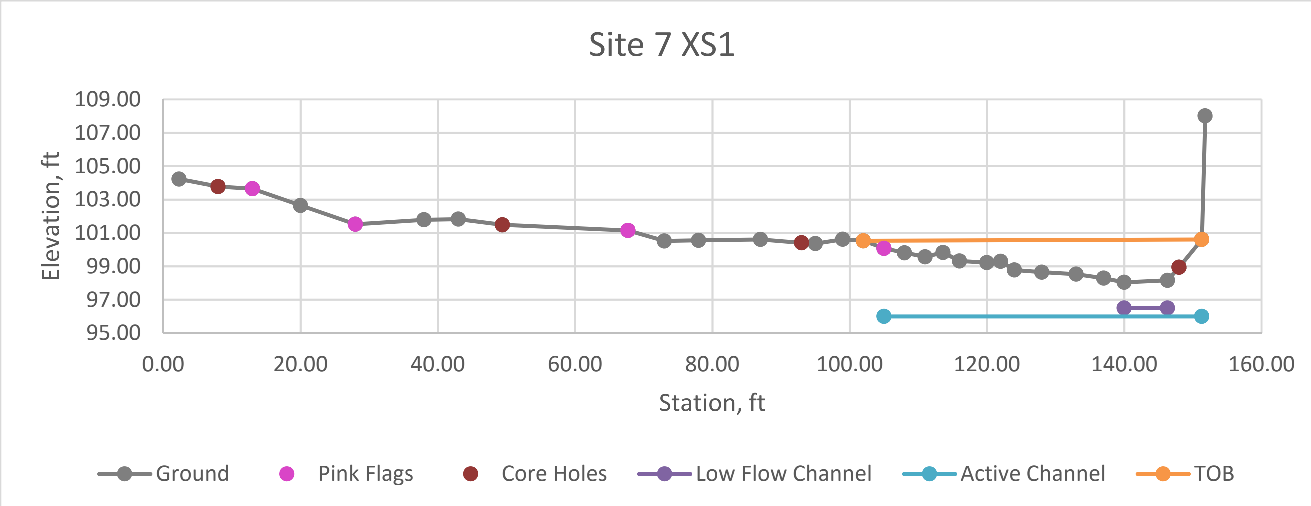
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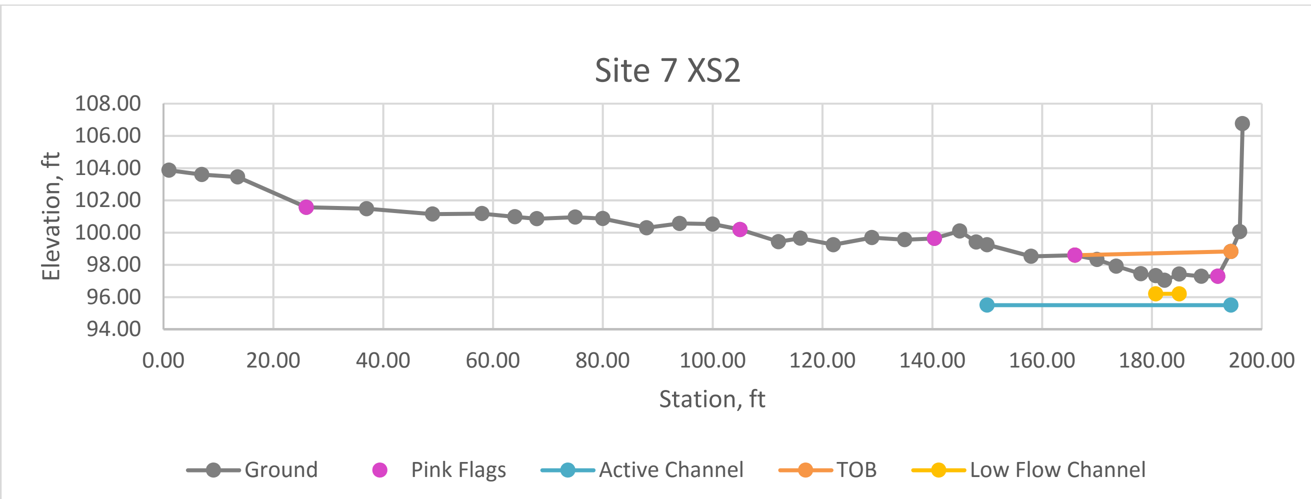
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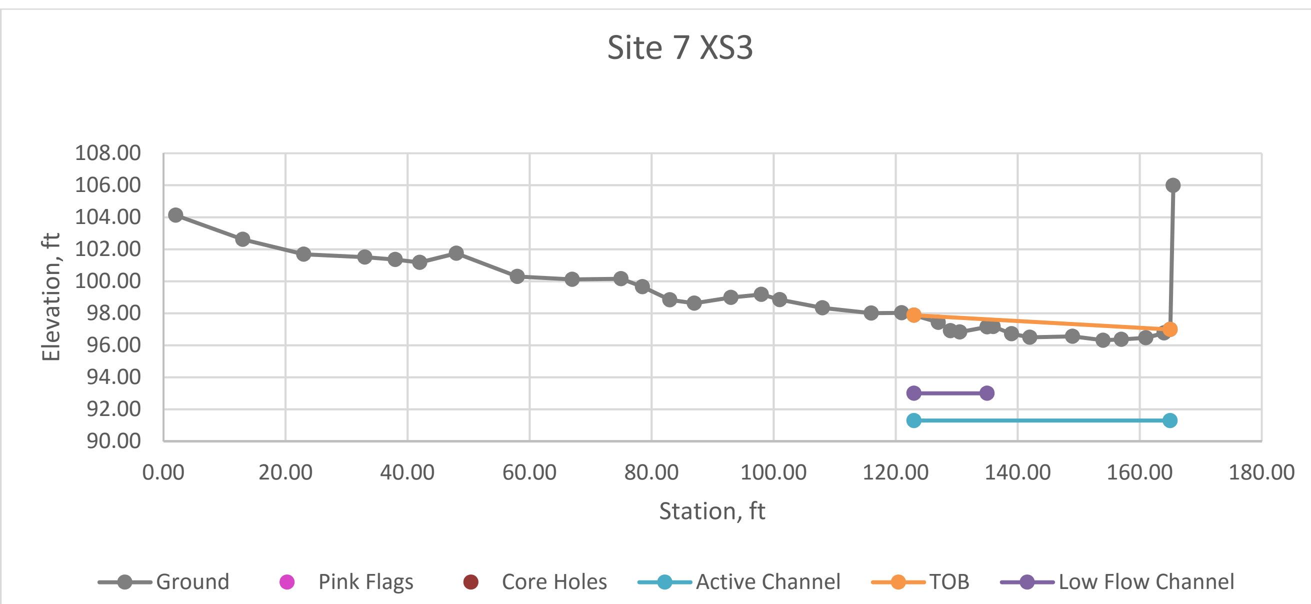
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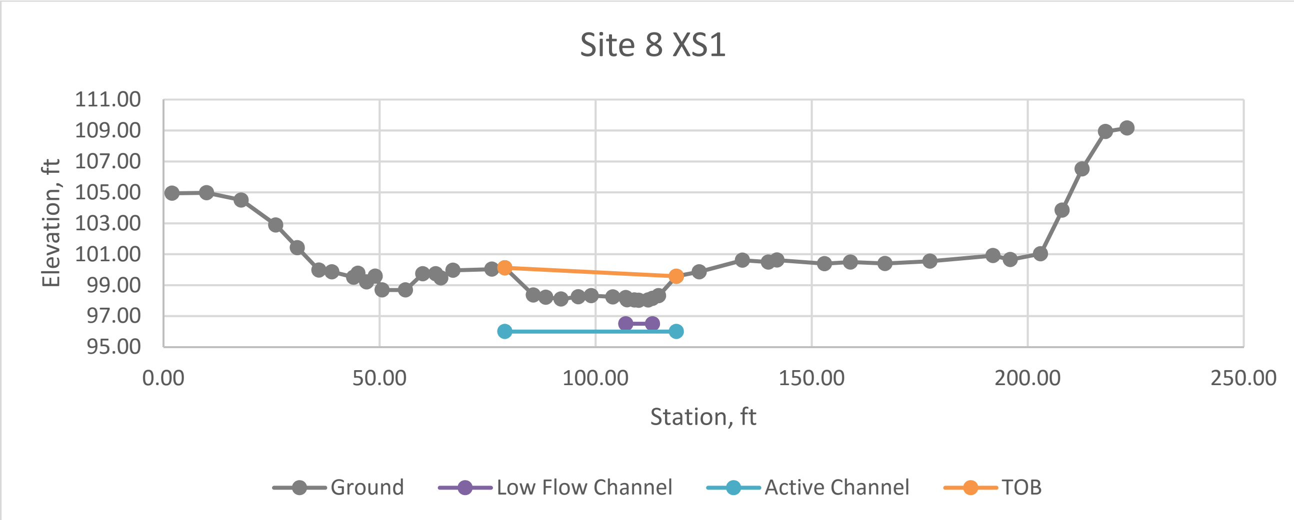
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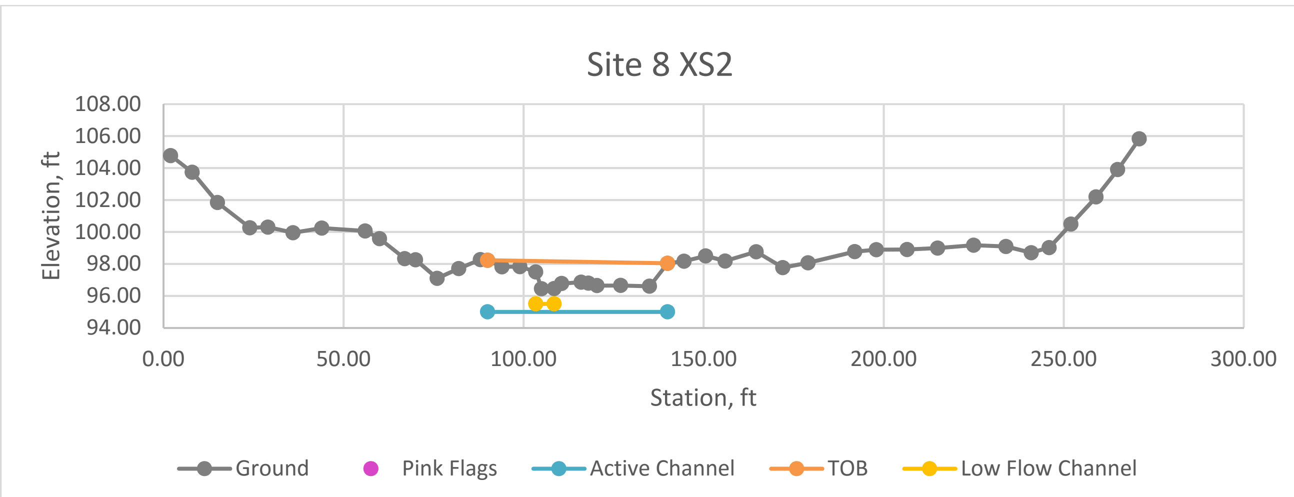
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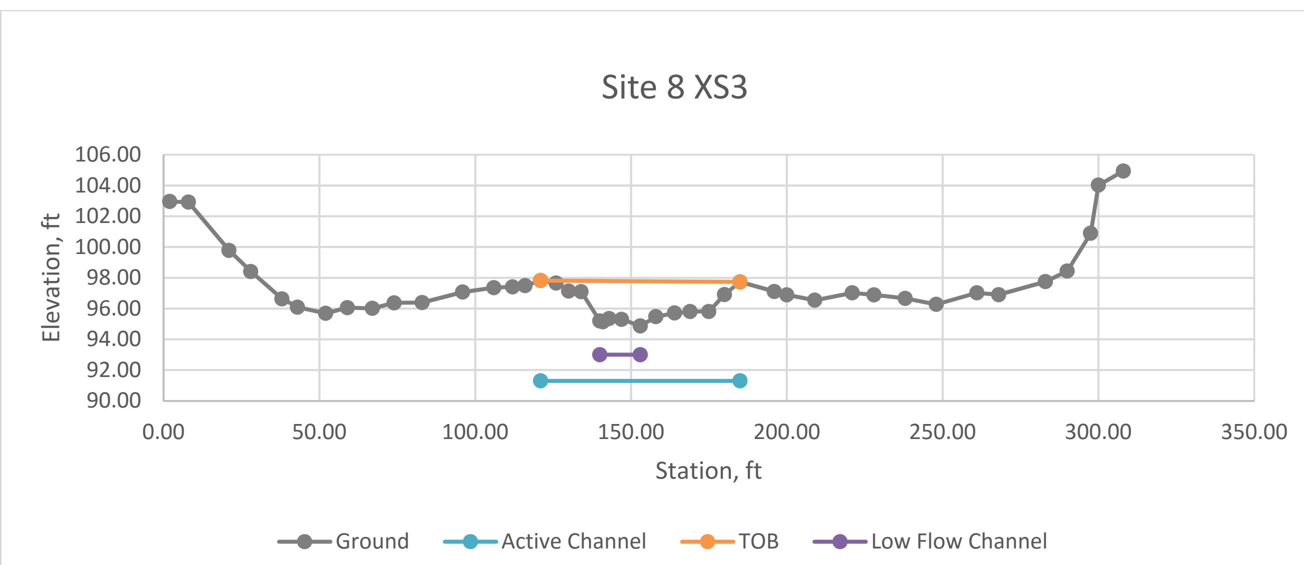
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94.00
92.00
90.00
Elevation, ft
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
Station, ft
Ground
Active Channel
TOB
Low Flow Channel

Appendix F

Sonoita Creek Soils & Vegetation Characterization

1. Appendix F1: Sonoita Creek Mitigation Project Soil Characterization Report
    - Attachment A: NRCS Soil Series Descriptions
    - Attachment B: Agronomic Laboratory Data
    - Attachment C: Complete Engineering Analysis Data
    - Attachment D: SPAW Hydraulic Conductivity Model Results
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2. Appendix F2: Sonoita Creek Mitigation Project Vegetation Characterization Report
    - Attachment A: Vegetation Cover Data
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Appendix F1

Sonoita Creek Mitigation Project
Soil Characterization Report

Sonoita Creek
Mitigation Project

Soil Characterization Report

April 25, 2016

Revised March 15, 2017

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1 INTRODUCTION

Rosemont Copper (Rosemont) contracted with Water & Earth Technologies, Inc. (WET), Westland Resources, Inc., and Habitat Management, Inc. to develop a design for the Sonoita Creek Mitigation Project (SCR Project). The SCR Project includes constructing, extending, and/or improving various reaches of the ephemeral Sonoita Creek stream channel. Constructed channel reaches will act in parallel with the existing Sonoita Creek channel, concurrently conveying stormwater flows. The existing Sonoita Creek will remain undisturbed over most of its length, except for specific transitional areas where constructed channels will either diverge from or converge with Sonoita Creek. Areas disturbed during construction activities will be revegetated to match the adjacent vegetation communities.

The SCR Project is located about 5.5 miles northeast of Patagonia and 7 miles south of Sonoita in Santa Cruz County, Arizona (Figure 1). The SCR Project area is on private land owned by Rosemont and is being conducted as mitigation for anticipated disturbances associated with the development of the new Rosemont Project. The Rosemont Project site is north of the SCR Project area and within the same overall Santa Cruz watershed.

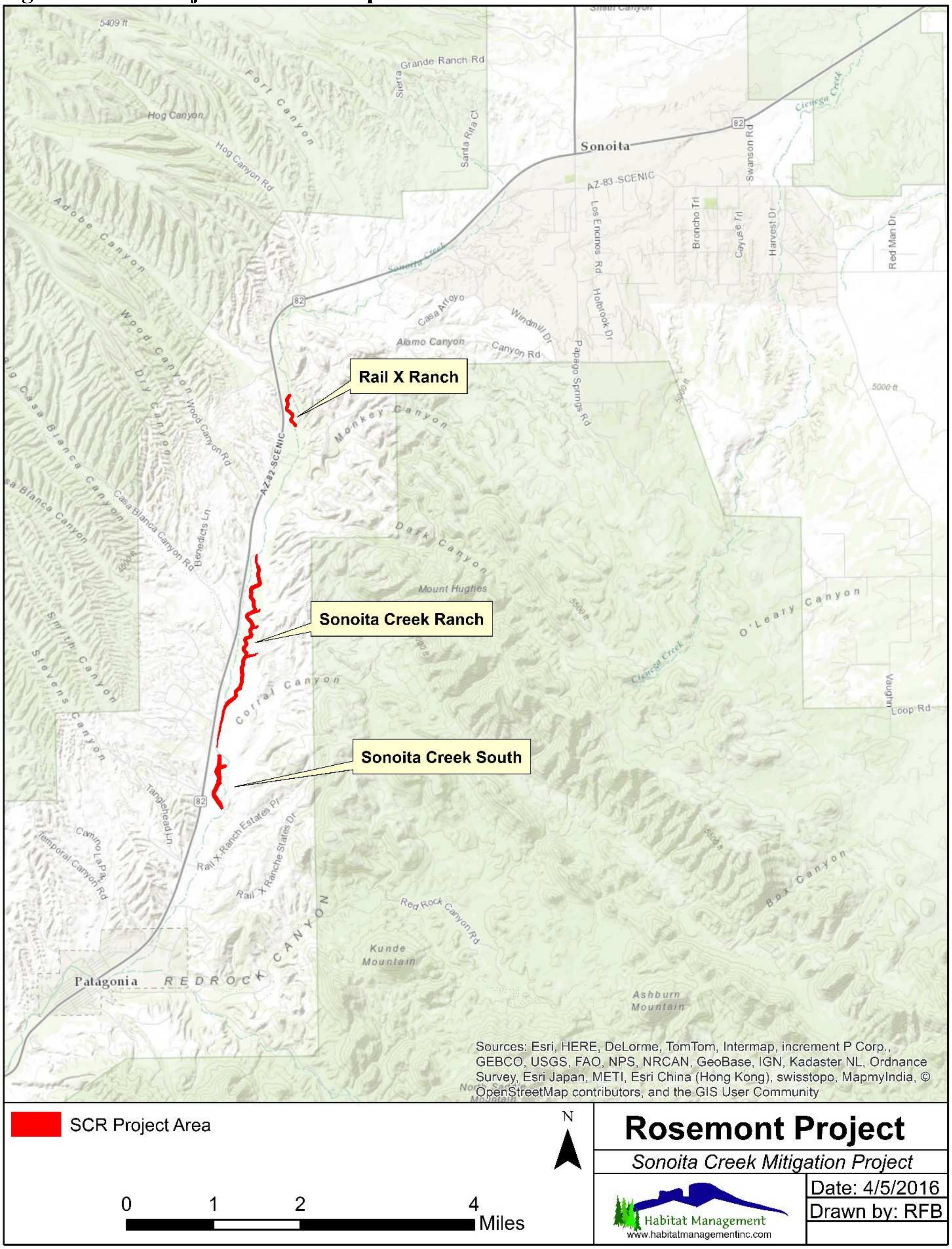
This report summarizes the methods and results associated with a baseline soil survey conducted by Habitat Management in the summer of 2015. The results of soil sampling efforts including field and laboratory data were used to develop preliminary soil amendment recommendations and a topsoil stripping plan for inclusion in the SCR project design specifications. These data will also inform the engineering design and revegetation species selection; however, these recommendations are discussed elsewhere.

2 METHODS

Habitat Management prepared a soil sampling plan based on WET's preliminary constructed channel alignment design and evaluation of a NRCS Order 3 soil survey for Santa Cruz County, Arizona. The plan considered the proposed constructed centerline, excavation extents, likely soil repository locations, and the preliminary estimated volumes of excavated soil and subsoil materials that would be generated. This information coupled with the NRCS soil survey allowed for a representative soil sampling plan that considered separate sampling categories depending upon the final management of the excavated soil. Additionally, samples were collected in representative reaches of the existing Sonoita Creek channel as reference data to inform the final channel design both structurally and aesthetically. Samples were collected to characterize the surface soils on the channel terraces as well as the exposed soils on the vertical cut banks.

In January 2016, WET produced a revised constructed channel alignment based on input from Rosemont and regulatory agencies. This new alignment was shorter and less braided than the original alignment. No additional soil samples were collected. However, while the original designs were used in developing the sampling plan, the revised designs were incorporated in the results and recommendations sections of this report.

Figure 1: SCR Project Location Map



2.1 NRCS Order 3 Soil Series

Preliminary evaluations were completed prior to field work using an NRCS Order 3 soil survey for Santa Cruz County, Arizona (SCS, 1979). This survey suggested that the soils along the new channel alignment corridor, potential soil repository locations, and the existing channel consisted of four major NRCS Order 3 mapping units (Figure 2). Soils were sampled and analyzed from all of the representative map units to determine limiting agronomic, engineering, and construction properties to support revegetation and engineering design assumptions.

The actual disturbed soil acres for the entire SCR project area are approximately 178.8 acres with 72% Pima and 28% Grabe-Comoro Complex (Table 1). Centerline soil coring was conducted in 18 locations along the designed channel centerline to depths below the channel invert elevations. Soils samples were analyzed for agronomic and engineering parameters to determine the suitability of the excavated channel invert soils to support vegetation and engineering estimates of riparian flow conditions.

Table 1: Affected Area Soil Map Units

Project Area	Location	Soil Map Unit Symbol	Acres	Cubic Yards
Rail X Ranch	Channel	GbB	9.4	15,222
	Repository	GbB	0.4	583
Sonoita Creek Ranch	Channel	GbB	6.5	10,523
		Pm	49.6	79,977
	Repository	GbB	9.3	14,949
		Pm	76.3	123,040
Sonoita Creek South	Channel	GbB	19.6	31,569
		Pm	1.3	2,061
	Repository	GbB	4.4	7,144
		Pm	2.1	3,399
Total			**178.8**	**288,467**
		Pima	**129.2**	**72.3%**
		Grabe-Comoro	**49.6**	**27.7%**

2.1.1 Pima Soils (Pm)

The Pima soils are the primary soil type in the SCR project area dominating the floodplain especially on the east side of the Sonoita Creek drainage. Pima soils are deep, well drained soils formed in stream alluvium (**Error! Reference source not found.**). These soils support diverse grassland and shrubland vegetation communities and are commonly used for irrigated cropland.

2.1.2 Grabe-Comoro Complex (GbB)

The Grabe-Comoro complex is the primary soil type on the west side of the Sonoita Creek floodplain and the second most common soil type in the SCR project area. This complex is a relatively equal mix of Grabe and Comoro soil series (**Error! Reference source not found.**). Both soils are very deep, well drained sandy loams/loams formed in stratified alluvium.

2.1.3 White House Associations (WtF and WoE)

White House-Hathaway association (WtF) and White House-Caralampi complex (WoE) are both found on the slopes on the east side of the Sonoita Creek floodplain. These soils will be encountered in the geomorphic repository areas, but not within the channel excavation. All of these soils series are well drained alluvial soils formed in fan piedmonts (Attachment A). White House soils have a thick clayey B horizon and are found on slopes of 10 to 20%. Hathaway soils are gravelly sandy loams or gravelly sandy clay loams on 20 to 45% slopes. Caralampi soils are gravelly to very gravelly sandy clay loams found on 20 to 35% slopes. These areas will not be used for soil borrow, thus no samples were collected in these soil map units.

2.2 Sampling Locations & Methods

Habitat Management visited the SCR project area to characterize and collect soil samples on June 1-13, 2015. Samples collected along the constructed channel alignment and the proposed soil repository locations were collected with a Giddings Probe. Existing channel terraces were sampled with a hand auger and vertical cut banks were sampled with a shovel. Specific methods used for each sampling category are detailed below.

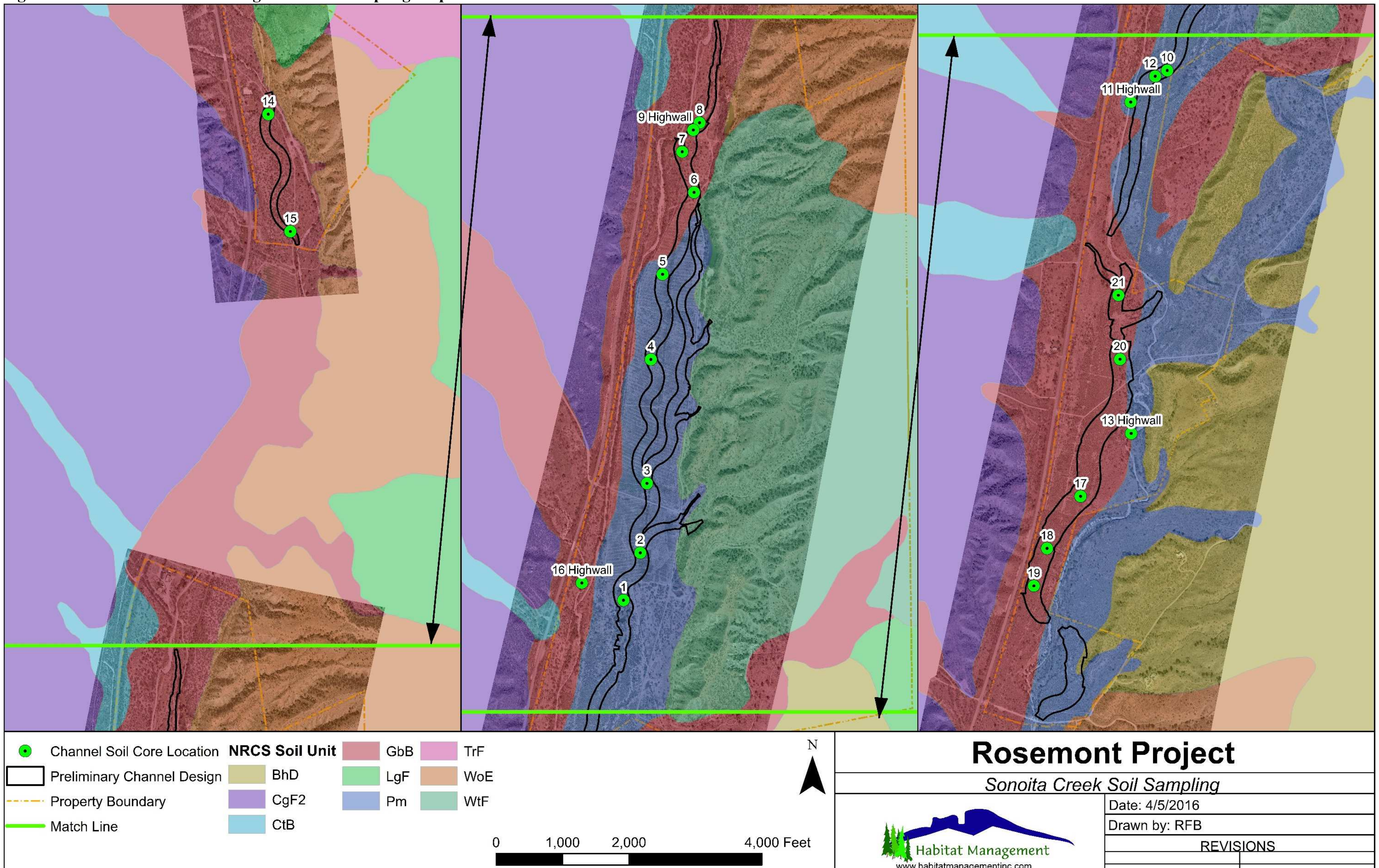
2.2.1 Constructed Channel Alignment Soil Sampling

Sample locations were selected down the centerline of the preliminary constructed channel alignment (Figure 2). An attempt was made to space the sample locations relatively evenly along each section of the channel alignment with adjustments made to ensure representative sampling of various surface conditions and from all NRCS Order 3 soil map units.

Seventeen core locations were selected with up to five soil horizons (A, Bt, Bk, C, and Cr) sampled per soil core. The Giddings Probe was used to sample the complete soil profile to below the depth of the designed maximum channel depth or when the probe was refused due to large cobble. In most cases, the cored soil was separated into multiple samples by soil horizon and then an additional collated sample was collected from the entire depth of excavation using a larger auger bit in the same hole. A total of 87 samples were shipped for laboratory agronomic and texture analysis. Composite core samples collected from 5 of the core locations were also tested for engineering parameters, including particle size distribution and standard proctor analysis.

Bulk density was tested in 12 of the core locations. An attempt was made to collect a bulk density sample from selected major B and/or C horizons observed in the soil profile that exhibited high density characteristics; however, only samples that held together when extracted could be used. Soil peds selected for bulk density testing were wrapped in plastic mesh in the field and shipped in sealed plastic containers to maintain their structural integrity and field moisture content. Twenty-three samples from 14 core locations were shipped to the laboratory for bulk density testing.

Figure 2: Constructed Channel Alignment Soil Sampling Map



The sampling plan was developed under the assumption that all of the topsoil and subsoil materials that will be excavated from along the new channel alignment will be placed in the soil repositories within the SCR project area. The laboratory testing of these samples were used to determine the engineering and agronomic suitability parameters of this excavated material for soil handling and placement, revegetation planning, and amendment selection if subsoil materials are suitable for revegetation.

2.2.2 Geomorphic Repository Soil Sampling

The soil excavated from new constructed channels will be placed near the channel in designated soil repositories. These soil repositories will be designed and graded as geomorphic landforms and will be covered with topsoil or other suitable growth media. If the excavated soil materials from the channel construction are not suitable growth media or there is an inadequate quantity to completely cover the geomorphic soil repositories, then topsoil may also be salvaged from the soil repository locations prior to placement of excavated materials.

Habitat Management sampled two preliminary locations where these soil repositories may be placed to evaluate the suitability of the topsoil (Figure 3). Six representative samples were collected from the north repository area and five were collected from the south repository area. The A and Bt horizons of each sample were segregated for separate analyses.

2.2.3 Sonoita Creek Representative Reach Soil Sampling

Surface soil samples were collected along three transects in each of five representative reaches of the existing Sonoita Creek channel to evaluate the potential soil variability across the width of the channel (Figure 4). Seven reaches were selected by WET to represent the range of flow regimes and vegetation communities in the SCR project area, but only five (Reaches 2, 6, 6.5, 7, and 8) were designated for agronomic soil sampling. The transect locations were located within each reach to represent the range of characteristics within the reach and run perpendicular to the channel. Each transect traversed from the upland community on one side of the channel to the upland on the other side and included all mesic and hydric communities in between. The locations of transitions from one community to the next were noted along each transect.

Agronomic soil cores were collected from each of the terraces encountered along the transects located on either side of the active channel. Terraces were identified based on hydrologic, geomorphic, and/or vegetative transitions and identified as either T1, T2, or T3 terraces. The quantity of samples collected depended on the number of terraces observed along each transect and ranged from two to four samples per transect. Samples were collected to a depth of 12 inches and split into 6-inch increments (0-6” and 6-12”) for laboratory analysis. A total of 100 samples were shipped to the laboratory.

2.2.4 Sonoita Creek Vertical Cut Bank Sampling

Several locations along the existing Sonoita Creek channel have eroded vertical cut banks that are potentially prone to mass wasting during high flow events. These cut banks allow for the large-scale visualization of the soil profile in-situ. Buried horizons, cobble or sand lenses, depositional patterns, and average rooting depths can be observed over a broader area than is possible with soil coring. Additionally, design plans for channel construction and enhancement include the opportunity to cut some of these vertical banks back to a more stable configuration that will sustain vegetation (slopes between 5:1 and 10:1, vertical: horizontal).

Soil samples were collected on four such cut banks (Samples 9, 11, 13, and 16 on Figure 2). Samples were collected from each of the exposed primary soil horizons and tested for texture and agronomic properties. All of these sample locations, with the exception of Sample 9, were also tested for bulk density from selected major B and/or C horizons observed in the soil profile exhibiting high density characteristics.

2.3 Laboratory Analysis

Agronomic soil samples were shipped to Energy Laboratories in Helena, MT and engineering soil samples were shipped Ninyo and Moore Laboratory in Tucson, AZ. Analytical parameters and analysis methods are listed Table 2.

Table 2: Laboratory Soil Analyses & Methods

Analysis	Method
pH (saturated paste)	Ag Handbook 60; Method 21a, p. 102 and Method 2, p. 84 with this change – the saturated paste should be allowed to set for at lLeft 2 hours after the last adjustment (addition of water or soil)
EC (saturated paste)	Ag Handbook 60; Methods 2, 3 & 4 pp. 84-90
SAR (saturated paste)	Calculated from soluble Ca, Mg, and Na. Ag Handbook 60; p. 26
Saturation percent	Ag Handbook 60; Method 27a, p. 197
Calcium Carbonate %	Ag Handbook 60; Method 23c, p. 105
% Organic matter	Walkley-Black,ASA Mono. No. 9, Pt. 2, Method 29-3.5.2
Nitrogen (nitrate)	ASA Mono. No. 9, Pt. 2, method 33-3.2
Phosphorous	pH >7.4-Olsen; pH<7.4-Bray
Potassium	Part 2. ASA. Method 24-5.5 pp. 422 (AA or ICP)
Texture (sand, very fine sand, silt, clay)	Hydrometer or pipette; C.A. Black, ed. 1965, Methods of Soil Analysis. Part 1. ASA. Methods 43-5 or 43-4, pp. 562-566
% Coarse fragment	Volume of fragments > 2mm or sieve #10.
Bulk Density	Clod Method, ASA Mono. No. 9, Pt. 1, method 30-4
Standard Proctor Compaction Test	ASTM D 698 A
Engineering Particle Size Analysis & Distribution	ASTM D6913

Figure 3: Geomorphic Repository Soil Sampling Map

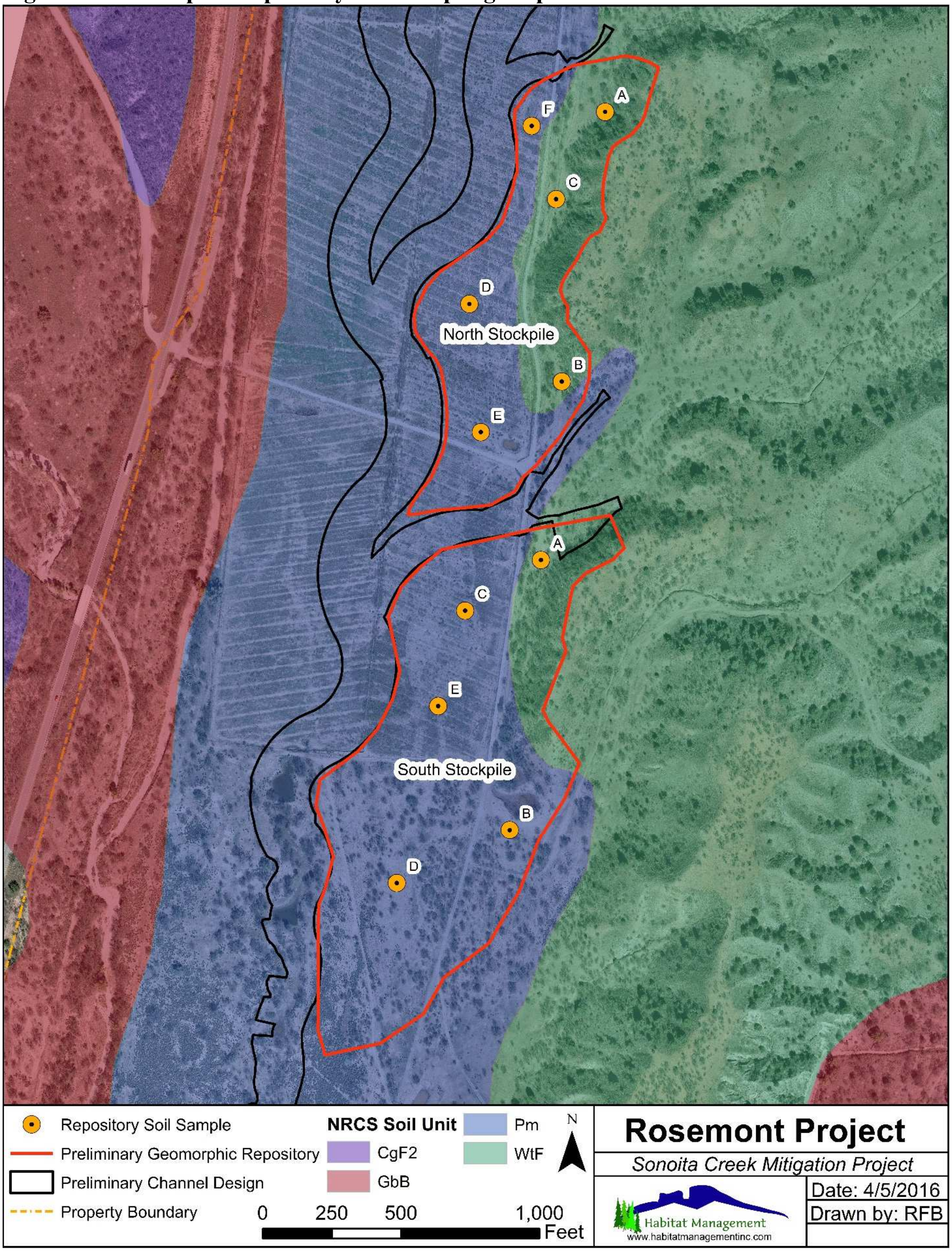
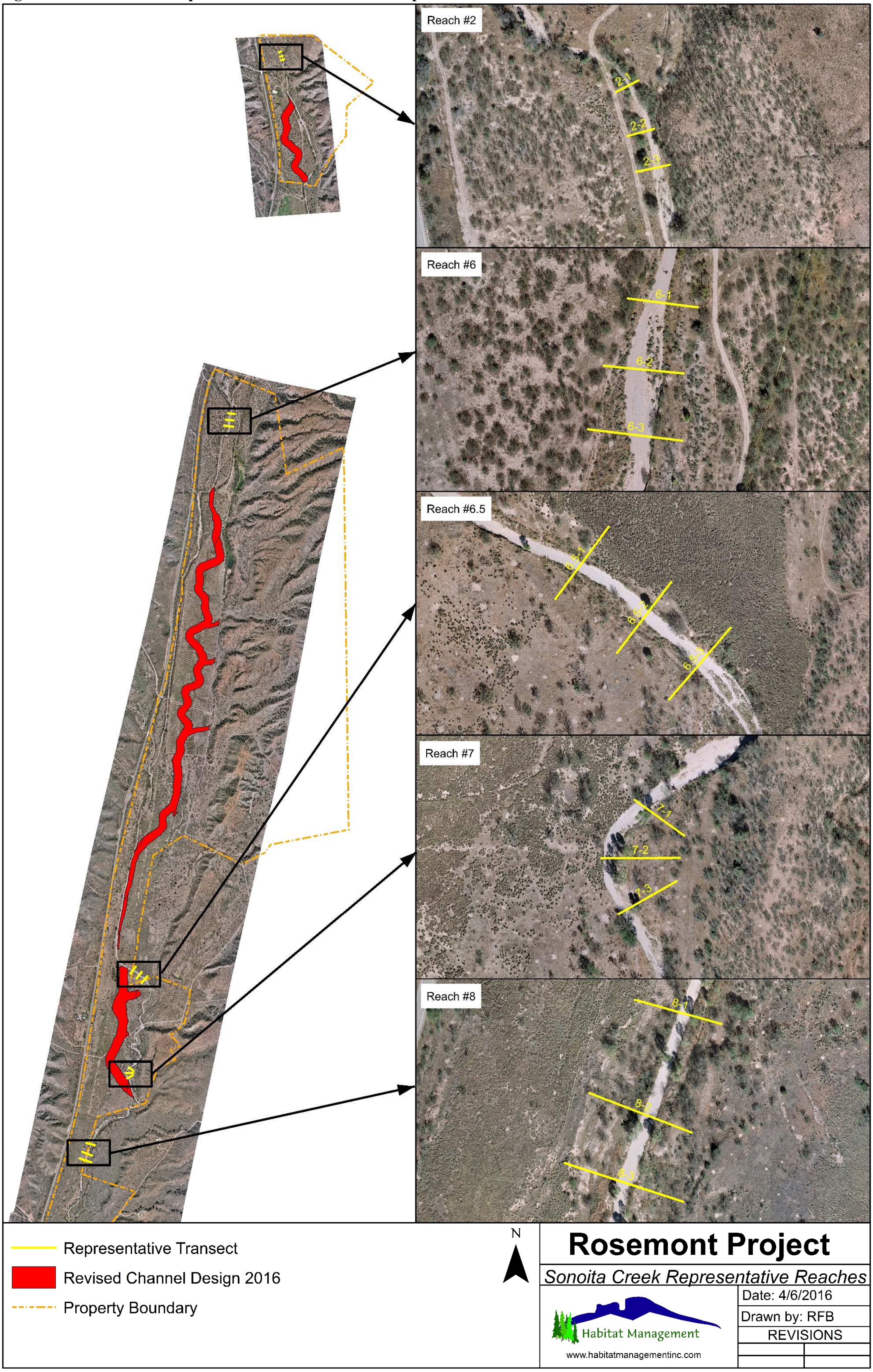


Figure 4: Sonoita Creek Representative Reach Transect Map



2.4 2016 Design Revisions

The 2016 revisions to the channel alignment resulted in several of the channel core locations no longer falling along the designed centerline (Figure 5). Additionally, because this new alignment is much shorter, several of the sample locations are no longer even within the scope of the project. Seven of the original samples are still within the construction boundaries and six more are within 200 feet and within the same NRCS soil map unit (Table 3). Only these 13 samples were used for the discussions and recommendations in this report.

Table 3: Core Sample Locations in Relation to the Revised Channel Alignment

Channel Core #	Distance from Revised Centerline	Distance from Excavation Extent
1	9 ft Left	
2	111 ft Left	4 ft Left
3	108 ft Left	31 ft Left
4	143 ft Right	68 ft Right
5	54 ft Left	
6	9 ft Left	
7	24 ft Left	
8	Upstream of Revised Channel Alignment	
10	303 ft Left	192 ft Left
12	240 ft Left	116 ft Left
14	131 ft Right	14 ft Right
15	39 ft Right	
17	Downstream of Revised Channel Alignment	
18	Downstream of Revised Channel Alignment	
19	Downstream of Revised Channel Alignment	
20	9 ft Left	
21	70 ft Right	

The geomorphic soil repositories in the revised design include almost all of the north area sampled for this report as well as the north half of the south area (Figure 6). Additional geomorphic repository areas were included in the revised design especially in the vicinity of the abandoned agricultural field on Sonoita Creek Ranch. The samples presented in this report include nine of the repository samples as well as four of the channel cores and one of the cut bank cores that now fall within the repository boundaries (Table 4). Four of the six repository areas in the Sonoita Creek Ranch portion of the project area are represented in the data as well as the repository in the Sonoita Creek South portion of the project area. The Rail X Ranch repository areas are both found on the slopes on the east side of the Sonoita Creek floodplain and will not be salvaged for topsoil borrow, thus no samples were collected from this White House-Caralampi complex (WoE) soil map unit.

Table 4: Geomorphic Repository Sample Locations in the Revised Design

Current Repository	Sample ID
Rail X Ranch	
Northwest	-
Northeast	-
Southeast	-
Sonoita Creek Ranch	
North	Highwall Core #9
West	Channel Core #4
Northeast	-
Central Northeast	-
Central Southeast	North Stockpile A
	North Stockpile B
	North Stockpile C
	North Stockpile D
	North Stockpile E
	North Stockpile F
	Channel Core #3
Southeast	South Stockpile A
	South Stockpile C
	South Stockpile E
	Channel Core #2
Sonoita Creek South	
South	Channel Core #17

Figure 5: Revised Channel Design Map with Soil Sample Locations

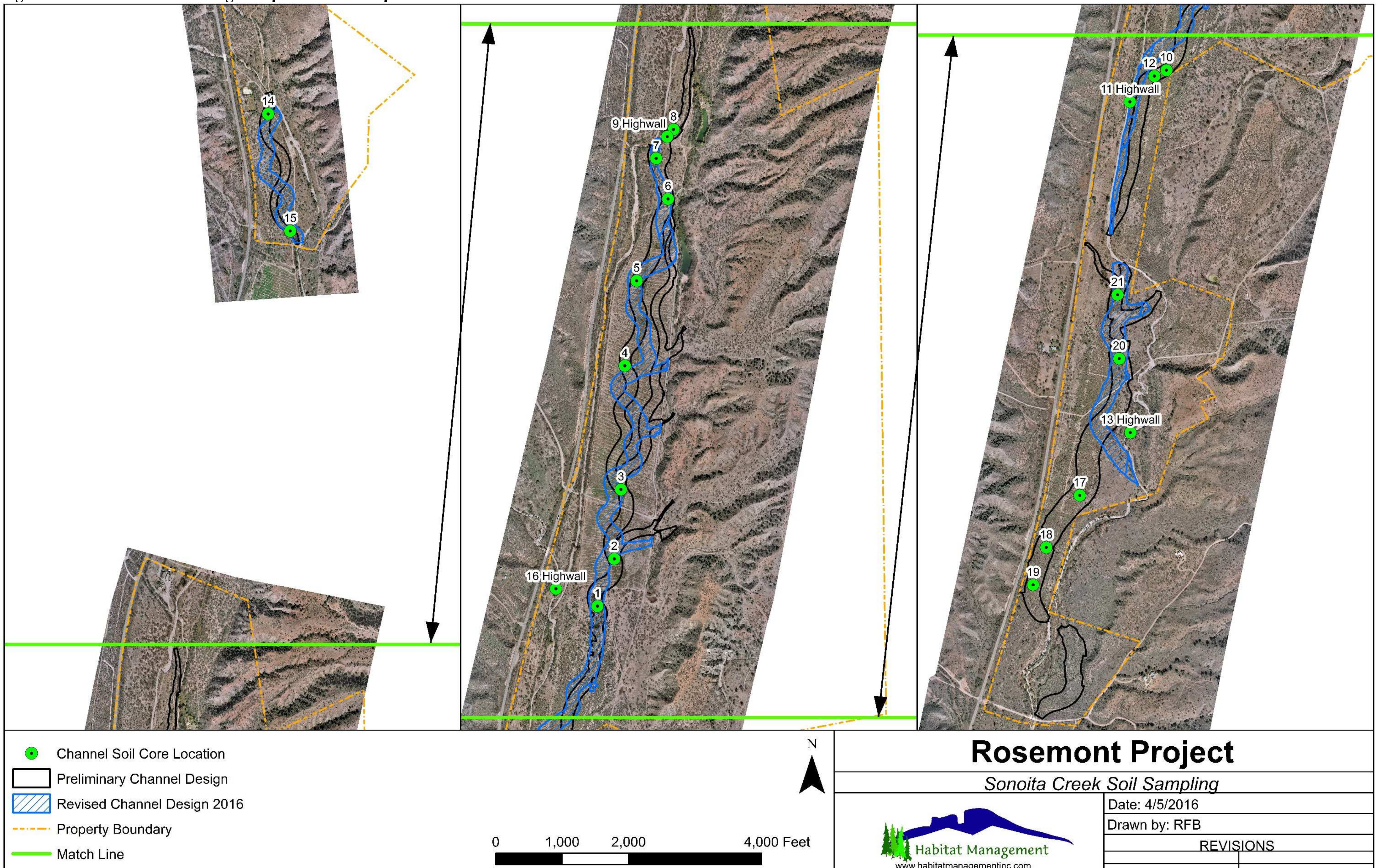
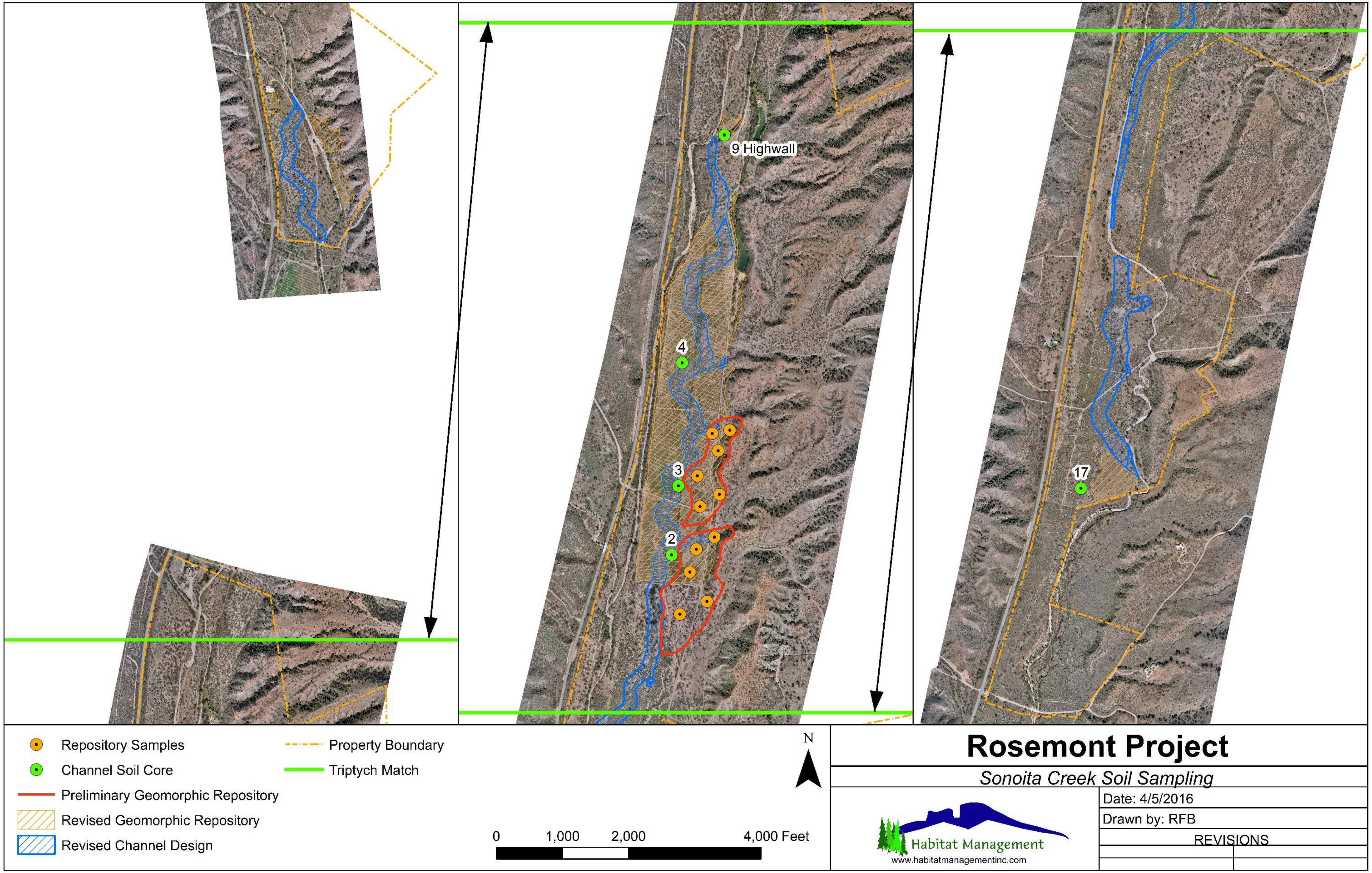


Figure 6: Revised Geomorphic Repository Design Map with Soil Sample Locations



3 RESULTS

The results presented in this section include only those samples still contained within the footprint of the revised design. Data from agronomic laboratory analyses, including all samples collected, are included in Attachment B. Data from engineering laboratory analyses, including all samples collected, are included in Attachment C. Field notes associated with each sample location are included in Attachment E.

3.1 Constructed Channel Alignment Soils

3.1.1 Agronomic Results

The revised channel construction design was used to extract a subset of the data representing the 13 core locations that are still pertinent to the design alignment. The data set was further reduced to include only samples collected to the estimated excavation depth at each core location. Weighted averages were calculated for each of the agronomic parameters to represent the mixed soil that will be excavated during construction (Table 5). These results were compared to standard revegetation growth media suitability standards to determine whether they would be suitable for growth media placement on the soil repositories and what, if any, soil amendments would be required. Additionally, the soil surfaces exposed after excavation of the channel were evaluated to identify if any particular soil horizon may be unsuitable for revegetation. Soil amendments for these areas were also evaluated since these surfaces will not be covered with salvaged topsoil materials.

The majority of the soils sampled had suitable agronomic characteristics for revegetation success. As would be expected, the A horizon soils were most suitable to support revegetation. The primary deficiency in all of the soils sampled was low fertility (nitrogen, phosphorus, potassium, and organic matter). However, fertility and organic matter deficiencies can be easily corrected with soil amendments such as compost, other organic amendments, and chemical fertilizers.

Several of the sample locations had marginally high percentages of coarse fragments (**Error! Reference source not found.**). Coarse fragment percentage was highly variable between samples, and sometimes within horizons in a single sample location which is indicative of a fluvial depositional environment. Coarse fragments ranged from 2% to 80% across all samples and averages with a single sample ranged from 3.3% to 42%. Coarse fragment percentages greater than 15% are marginally suitable for revegetation and percentages greater than 35% are generally unsuitable for revegetation. Mixing all of the soil horizons in the geomorphic soil repositories will likely result in an overall marginally suitable soil; however, it may be necessary to segregate extremely gravelly soils and ensure that they are buried deeper in the repositories. High coarse fragment soil strata that are exposed in the channel excavation cut slopes may adversely impact vegetation establishment; however, limited surface mixing with up-gradient soil fines that will occur during excavation may improve these gravely strata.

A few of the samples that were collected also had marginally high levels of salinity (measured as electrical conductivity) and alkalinity (measured as pH) and a few samples had marginally high clay content (Attachment B). These issues will likely be mitigated by mixing soils for the repository piles because the weighted averages suggested suitable soils. Nonetheless, these

Table 5: Revised Channel Alignment Core Sample Averaged Agronomic Results

Sample ID	Soil Map Unit Symbol	Design Cut Depth	pH	Electrical Conductivity	Sodium Absorption Ratio	Nitrate Nitrogen	Phos-phorus	Potas-sium	Organic Matter	Lime	Coarse Frag-ments	Very Fine Sand	Sand	Silt	Clay	Texture
		inches	*s.u.*	*mmhos/cm*	*calculated*	------------- *mg/kg* --------			----- *%* -----		---------------- *%* ----------------					
Channel Core #1	Pm	36.1	7.6	3.0	0.4	63.3	4.2	328.7	2.2	3.9	4.8	26.5	37.1	39.5	23.5	L
Channel Core #2	Pm	86.5	7.8	1.3	0.2	3.1	1.9	157.0	0.9	4.9	14.6	27.7	54.0	26.3	19.7	SL
Channel Core #3	Pm	70.1	7.8	1.0	0.2	5.6	1.6	184.6	1.1	4.9	6.0	26.5	41.6	35.2	23.2	L
Channel Core #4	Pm	72.1	7.7	1.3	0.2	11.8	1.3	200.5	1.1	5.2	3.3	47.0	31.2	41.7	27.1	CL
Channel Core #5	Pm	59.0	7.8	0.8	0.2	1.2	1.6	148.3	1.0	5.6	19.8	17.5	50.8	28.2	21.0	L
Channel Core #6	GbB	51.8	7.9	0.9	0.2	11.7	3.6	195.9	0.7	4.4	13.6	13.2	65.9	21.1	13.0	SL
Channel Core #7	GbB	60.0	7.9	0.5	0.2	1.8	2	117	0.4	3.68	42	7	72	16	12	SL
Channel Core #10	Pm	92.0	7.5	1.0	0.3	2.1	3.1	216.9	1.3	3.0	19.9	21.9	50.8	33.0	16.3	L
Channel Core #12	Pm	86.0	7.6	2.2	0.2	67.9	6.3	178.3	1.0	3.0	19.1	18.1	55.4	31.8	12.8	SL
Channel Core #14	GbB	45.0	7.6	2.2	0.6	1.7	2.6	164.4	1.1	2.4	9.0	22.2	46.9	33.3	19.8	L
Channel Core #15	GbB	48.0	7.7	0.4	0.2	2.4	5	178	0.6	1.4	17	12	70	16	14	SL
Channel Core #20	GbB	70.5	7.4	3.2	0.2	125.9	5.9	269.1	1.4	2.8	5.2	42.9	36.7	41.6	21.7	L
Channel Core #21	GbB	43.6	7.8	0.5	0.1	2.2	4.5	185.3	0.9	3.0	10.4	26.1	47.3	36.5	16.2	L
Revegetation	Marginal Suitabilit		8	4	6	20	20	300	2		15				CL, SiCL, SC	
Thresholds	Unsuitable		8.8	8	10	10	15	140	1	10	35				S, LS, SiC, C	

Table 6: Revised Channel Alignment Core Sample Engineering Results

Sample ID	Depth	Standard Proctor			Mechanical Sieve Analysis (ASTM classifications)																
					Coarse Gravel				Fine Gravel				Coarse Sand		Medium Sand			Fine Sand			
		Maximum Dry Density	Optimum Moisture	Rock Content	3"	1.5"	1.25"	1"	3/4"	1/2"	3/8"	1/4"	#4	#8	#10	#16	#30	#40	#50	#100	#200
	inches	*lb/cf*	*%*	*%*	*% Passing*																
Channel Core #4	0-108	107.5	16.5	4.0					100	99	99	97	96	96	95	93	90	88	85	76	62.7
Channel Core #10	0-120	111.7	16.3	25.0	100	97	96	92	90	85	82	78	75	74	70	66	62	60	57	49	36.9
Channel Core #15	0-48	122.0	11.0	7.0				100	99	98	96	95	93	92	88	82	76	71	63	38	22.4
Channel Core #21	0-96	109.5	17.1	20.0		100	98	96	93	90	87	83	80	79	76	70	64	60	54	41	30.2

results should be considered when selecting appropriate soil amendments and revegetation species. Recommended soil amendments are included in Section 4.2. Post-excavation channel cut slope soils will be sampled and analyzed to determine soil amendment rates. Saline, alkaline and high clay content soils will be identified and amended as necessary.

3.1.2 Engineering Results: Standard Proctors & Bulk Density

Four of the five samples submitted for standard proctor analyses were still within the revised design. The standard proctor analyses showed an average maximum dry density of 112.7 pounds per cubic foot and optimum moisture content of 15.2% (Table 6). The rock content results for the standard proctor analyses varied from 4% to 25% and were consistent with the results found in the mechanical sieve analysis as well as the coarse fragment analysis from the agronomic testing. Based on soil descriptions that were characterized during the laboratory analysis, the soils excavated during channel construction are generally clayey sand with gravel per the unified soil classification system (USCS).

Nine of the bulk density sample locations are still within the revised design (Table 7). The bulk density averaged 1.3 tons per cubic yard and ranged from 1.2 to 1.5 tons per cubic yard. These analyses will assist engineers in developing the final repository designs. They will also be helpful for construction contractors in selecting appropriate excavation equipment and estimating schedules and costs for construction.

Table 7: Revised Channel Alignment Core Sample Bulk Density Results

Sample ID	Collection Date	Depth	Bulk Density	
		inches	*g/cc*	*ton/cy*
Channel Core #1	6/6/2015	0-6	1.6	1.4
		67-96	1.5	1.2
Channel Core #2	6/7/2015	3-10	1.7	1.4
		58-80	1.6	1.3
Channel Core #3	6/7/2015	4-12	1.7	1.4
		58-94	1.6	1.4
Channel Core #4	6/8/2015	0-3	1.5	1.3
		22-45	1.6	1.3
Channel Core #5	6/8/2015	4-12	1.8	1.5
Channel Core #10	6/10/2015	24-57	1.4	1.2
Channel Core #12	6/10/2015	34-56	1.6	1.3
		79-86	1.7	1.4
Channel Core #20	6/13/2015	60-78	1.5	1.3
		78-108	1.8	1.5
Channel Core #21	6/13/2015	35-63	1.4	1.2
Average			**1.6**	**1.3**
Minimum			**1.4**	**1.2**
Maximum			**1.8**	**1.5**

3.1.3 Engineering Results:-Saturated Hydraulic Conductivity

The actual disturbed soil acres for the entire SCR project area are approximately 178.8 acres with 72% Pima and 28% Grabe-Comoro Complex (Table 8). The Pima soil map unit has a Hydrologic Soil Group (HSG) classification of Group C and the Grabe-Comoro complex map unit has a Group A classification. However, due to the incised nature of the existing Sonoita channel and the channel bed material, it may not be valid to do a direct comparison of Order 3 NRCS soil mapping and HSG determinations to current channel conditions.

The baseline soil characterization, sampling, and laboratory analysis was designed to address the infiltration rate within the channel invert elevation after construction. Centerline soil coring was conducted in 18 locations along the designed channel centerline to depths below the channel invert elevations. This was done to best represent undisturbed soils that will be present in the channel after construction. Soils samples were analyzed for agronomic and engineering parameters to determine the suitability of the excavated channel invert soils and the final constructed channel soil surface to support vegetation and engineering estimates of riparian flow conditions. HSG was estimated from the diagnostic soil physical laboratory results including texture, bulk density, and structure.

HSG was also determined from modeling hydraulic conductivity from laboratory analytical results for texture, organic matter, bulk density, coarse fragments, and electrical conductivity. This data was used to populate the Soil-Plant-Air-Water (SPAW) soil water characteristics model (Saxton and Willey 2006) to estimate the hydraulic conductivity of the excavated soil horizon at the channel invert elevation and the undisturbed soil horizon immediately below the invert elevation. The modeled saturated hydraulic conductivity value was used to determine the HSG from the National Engineering Handbook (Part 630, Chapter 7, Table 7.2). The HSG values for each soil core invert elevation are contained in Table 8 and illustrate that there is an even split between B and C Group HSG soils after channel construction. Attachment D contains the saturated hydraulic conductivity model results for each of the centerline soil coring results between the upper depth and the lower invert depths. The HSG shift from a texture-based estimation (to predict Soil Hydraulic Group with seven A classifications) to the saturated hydraulic conductivity SPAW model (with all B and C classifications) suggest that the reconstructed channel will support riparian vegetation without significant gravitational and lateral losses of ephemeral channel flow.

3.2 Geomorphic Repository Topsoil

The repository soil sample data that are currently located within the revised geomorphic repository design boundaries were combined with the data from the top horizons of the channel cores that now located within the revised repository designs and evaluated for suitability.

Table 8: Revised Channel Alignment Soil Hydrologic Group Estimates & Saturated Hydraulic Conductivity Model

Core #	Soil Series	Invert Channel Cut Depth (inches)	Lower Horizon Depth (inches)	Very Fine Sand (wt%)	Coarse Fragments (%)	Sand (%)	Silt (%)	Clay (%)	Texture	Texture Estimated Hydrologic Soil Group	SPAW Model Saturated Hydraulic Conductivity	SPAW Model Hydrologic Soil Group*
1	Pm	36	53	10	7	58	26	16	SL	B	0.59	B
2	Pm	87	96	9	51	70	16	14	SL	A	0.49	B
3	Pm	70	94	13	11	62	22	16	SL	B	0.13	C
4	Pm	72	77	35	<2	38	42	20	L	C	0.09	C
5	Pm	46	59	3	41	66	18	16	SL	A	0.27	C
6	GbB	52	80	5	40	64	22	14	SL	A	0.47	C
7	GbB	7	23	5	43	68	18	14	SL	A	0.74	B
8	GbB	36	48	10	47	72	13	15	SL	A	0.26	C
9	GbB	5	20	60	14	30	53	17	SiL	C	0.23	C
10	Pm	92	96	15	17	76	13	11	SL	B	0.96	B
11	Pm	45	50	26	<2	40	37	23	L	C	1.22	B
12	Pm	86	102	9	41	70	9	21	SCL	A	0.66	B
13	Pm	82	90	29	2	24	40	36	CL	C	0.27	C
14	GbG	45	48	5	37	70	16	14	SL	A	0.31	C
15	GbB	40	48	18	7	42	32	26	L	C	1.05	B
16	GbB	64	72	11	26	62	18	20	SCL	C	0.52	B
20	GbB	70	78	61	<2	14	48	38	SiCL	C	0.36	C
21	GbB	44	63	11	7	48	30	22	L	C	0.78	B

* SPAW Hydrologic Soil Group assumes soils are deeper than 40 inches to a water impermeable layer or water table

KEY

Green	Center line depth of excavation above water line
Blue	Center line depth of excavation below water line
Yellow	**Hydrologic Soil Group A:** Rock fragments >35%, <10% clay, >90% sand or: Saturated Hydraulic Conductivity >1.42 inches/hr
Gray	**Hydrologic Soil Group B:** 10% < clay < 20% and 50-90% sand or: Saturated Hydraulic Conductivity >0.57 inches/hr but <1.42 inches/hr
Orange	**Hydrologic Soil Group C:** 20% < clay < 40% and less than 50% sand or: Saturated Hydraulic Conductivity >0.06 inches/hr but <0.57 inches/hr

The abandoned agricultural field in the Sonoita Creek Ranch portion of the SCR project area is the largest repository area with six separate geomorphic landforms in the design (Figure 6). The samples presented here describe the Sonoita Creek Ranch west, central southeast, and southeast repositories (Table 9). The native Pima and Grabe-Comoro soils have deep topsoil of a higher quality than most other areas sampled. They are classified as NRCS Prime Farmland soils, if irrigated. The topsoil has very high organic matter, suitable to marginally suitable fertility, and low gravel content making these soils ideal for revegetation success. The soils were historically selected for agricultural management and use, including leveling for regular irrigation and hay cropping. These geomorphic repository areas also extend up the slopes on the east side of the canyon and into the White House Hathaway Association soils. These soils are much rockier and much less suitable for revegetation success. Current designs suggest that there will not be enough topsoil stripped from the channel excavation to cover the geomorphic repositories in this portion of the SCR project. Thus, the soils in the agricultural field would be ideal for closing this deficit.

The soils encountered in the Sonoita Creek Ranch north repository, located north of the agricultural field, have been disturbed by shallow gravel excavations and are not as ideal for revegetation as the agricultural soils. However, these available topsoils are still generally suitable and would work for topsoil cover, if needed. The native Sonoita Creek South repository, at the far south end of the SCR project are Pima and Grabe-Comoro soils and are high quality soils for capping the soil repository.

3.3 Sonoita Creek Representative Reach Soil Sampling

The representative reach sampling was completed to evaluate the current surface soils along the existing Sonoita Creek channel. These data will be used in conjunction with surface topography and rock distribution data collected by others to inform the engineering design process. These data can also be used in developing the revegetation design by providing information on the soil chemistry, fertility, and texture on the existing terraces and comparing these to vegetation data. Some reaches sampled had only one terrace and others had up to three terraces. Terrace width ranged from 9 to 96 feet and tended to be widest on the T2 terraces (Attachment B).

3.3.1 Agronomic Results

The soils along the existing Sonoita Creek Channel were relatively similar to those observed along the new channel design with slightly alkaline pH, low EC and SAR and generally low fertility (Table 10). The terrace soils tended to have more sand and a greater component of coarse fragments than was observed in the new channel alignment. This would be expected along an active drainage channel compared to the irrigated fields or pastures that the new channel will traverse. The similarity of these soils supports the feasibility of developing a similar vegetation community along the newly constructed channel segments.

3.3.2 Texture Analysis

The texture data from the surface samples (0-6”) was evaluated to determine if there were differences in coarse fragment content between reaches, or terrace types (T1 vs T2 vs. T3), or both. Coarse fragment content ranged from 1% to 47.1% across all samples and averaged 14.3%. It was slightly less variable when averaged across transects within each reach, ranging from 3.8% to 42% (Table 11). Analysis of variance (ANOVA) statistics showed no significant differences between the terrace types within each reach or between types of terraces on the whole and no interaction effect was found between reach and terrace type.

Table 9: Revised Geomorphic Repository Averaged Core Sample Results

Sample ID	Soil Map Unit Symbol	Depth	pH	Electrical Conductivity	Sodium Absorption Ratio	Nitrate Nitrogen	Phos-phorus	Potas-sium	Organic Matter	Lime	Coarse Frag-ments	Very Fine Sand	Sand	Silt	Clay	Texture
		inches	*s.u.*	*mmhos/cm*	*calculated*	------------- *mg/kg* --------			----- *%* -----		---------------- *%* ----------------					
Sonoita Creek Ranch North Repository																
Highwall Core #9	GbB	0-20	7.8	1.05	<0.1	29.8	5	367	0.35	4.27	47	32	55	32	13	SL
Sonoita Creek Ranch West Repository																
Channel Core #4	Pm	0-22	7.7	0.9	0.2	22	2	260	2.2	3.89	2	47	22	48	30	CL
Sonoita Creek Ranch Central Southeast Repository																
North Stockpile A	WtF	0-12	6.4	0.35	0.2	2.9	4	270	1.15	0.36	53.5	3	63	17	20	SCL
North Stockpile B	WtF	0-10	6.7	1.05	<0.1	34.5	19	408.5	4.05	0.87	51.5	12	66	13	21	SCL
North Stockpile C	WtF	0-10	7.6	0.4	0.15	1.25	6.5	194.5	1.5	1.2	64.5	7.5	51	13	36	SC
North Stockpile D	Pm	0-28	7.8	0.8	<0.1	16	6.5	285	1.95	5.1	3.5	49	31	46	23	L
North Stockpile E	Pm	0-31	7.9	1.2	0.15	3.35	2	153.5	1.05	4.72	7.5	35.5	44	37	19	L
North Stockpile F	Pm	0-25	7.8	0.4	<0.1	7.55	3	233	1.65	4.65	6.5	35.5	29	45	26	L
Channel Core #3	Pm	0-21	7.7	0.9	0.2	14	3	298	2.3	3.86	2	31	30	42	28	CL
Sonoita Creek Ranch South																
South Stockpile A	WtF	0-10	6.5	0.6	<0.1	8.05	12.5	267.5	2.2	0.77	50.5	16	66	13	21	SCL
South Stockpile C	Pm	0-38	7.8	1.05	0.1	7.1	2	219.5	1.95	5.6	13	29.5	27	44	29	CL
South Stockpile E	Pm	0-29	7.7	2.1	0.25	7.8	2.5	212.5	1.45	5.56	4	28	38	39	23	L
Channel Core #2	Pm	0-25	7.7	1.1	0.1	5.7	3	234	1.7	4.02	4	48	50	26	24	SCL
Sonoita Creek South Repos																
Channel Core #17	GbB	0-13	7.9	0.6	<0.1	7.4	10	595	1.6	3.25	3	24	38	38	24	L
Revegetation	Marginal Suitability		8	4	6	20	20	300	2		15				CL, SiCL, SC	
Thresholds	Unsuitable		8.8	8	10	10	15	140	1	10	35				S, LS, SiC, C	

Table 10: Averaged Agronomic Soil Results by Terrace Type

Terrace	Depth	Collection Date	Terrace Width	Saturation Percentage	pH	Electrical Conductivity	Sodium Absorption Ratio	Nitrate Nitrogen	Olsen Phosphorus	Available Potassium	Organic Matter	Lime	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay
	inches		*feet*	*%*	*s.u.*	*mmhos/cm*	*calculated*	-------------- *mg/kg* --------------			----- *%* -----		----------------- *%* -----------------				
Reach #2																	
T1	0-6	6/5/2015	19.2	29.8	7.5	0.4	0.08	2.1	3.5	163.3	0.6	1.3	13.3	7.3	80.0	11.0	9.0
	6-12	6/5/2015	19.2	28.5	7.4	0.4	0.10	3.1	4.0	157.8	0.5	1.2	20.8	7.0	78.0	13.5	8.5
T1-T2	0-6	6/5/2015	6.0	33.8	7.7	0.7	<0.1	6.4	10.0	432.0	2.4	3.3	3.0	18.0	60.0	24.0	16.0
	6-12	6/5/2015	6.0	33.9	7.7	0.7	0.20	4.7	5.0	199.0	1.7	4.3	5.0	14.0	52.0	28.0	20.0
T2	0-6	6/5/2015	19.0	30.4	7.4	0.6	<0.1	3.9	5.3	285.7	1.4	1.5	16.0	10.0	72.0	17.3	10.7
	6-12	6/5/2015	23.2	29.5	7.5	0.6	<0.1	2.2	5.0	282.5	1.0	1.5	26.0	8.0	73.0	16.0	11.0
Reach #6																	
T1	0-6	6/2/2015	31.3	31.3	7.8	0.6	0.02	4.1	3.3	211.5	1.0	4.3	25.0	17.7	70.0	19.0	11.0
	6-12	6/2/2015	31.3	27.2	7.9	0.5	0.13	2.9	2.2	130.0	0.5	4.1	42.5	12.8	76.2	13.8	10.0
T1-T2	0-6	6/1/2015	21.4	39.3	7.7	0.9	<0.1	24.0	5.0	321.0	2.3	5.3	8.0	35.0	56.0	31.0	13.0
	6-12	6/1/2015	21.4	38.6	7.6	0.9	<0.1	26.0	8.0	321.0	2.9	5.4	22.0	26.0	58.0	27.0	15.0
T2	0-6	6/2/2015	31.6	29.9	7.8	0.6	0.02	2.9	3.6	213.0	1.0	4.1	26.0	19.2	67.6	19.8	12.6
	6-12	6/2/2015	31.6	32.0	7.9	0.4	0.12	2.2	2.0	149.8	0.9	4.9	20.0	21.8	62.4	23.8	13.8
Reach #6.5																	
T1	0-6	6/2/2015	43.7	39.7	7.7	0.7	0.10	18.1	6.5	279.0	1.6	3.4	3.3	27.5	55.5	30.3	14.3
	6-12	6/2/2015	43.7	35.2	7.8	0.7	0.10	11.0	5.8	257.3	1.3	3.3	16.8	25.3	57.5	28.3	14.3
T1-T2	0-6	6/3/2015	28.7	28.7	7.9	0.3	<0.1	1.3	3.0	190.0	0.5	2.3	5.0	6.0	77.0	13.0	10.0
	6-12	6/3/2015	28.7	27.8	8.0	0.3	0.10	1.5	2.0	138.0	0.4	2.3	12.0	3.0	80.0	11.0	9.0
T2	0-6	3/22/2015	64.4	33.5	7.7	0.6	0.02	6.6	7.2	415.8	1.2	2.8	15.2	19.2	58.0	26.8	15.2
	6-12	3/22/2015	64.4	32.6	7.7	0.6	0.06	6.7	4.8	293.6	1.1	2.8	20.6	15.6	61.6	23.4	15.0
Reach #7																	
T1	0-6	6/4/2015	43.4	36.3	7.9	0.6	0.17	8.3	6.0	226.3	1.4	3.0	32.0	26.7	61.3	26.0	12.7
	6-12	6/4/2015	43.4	31.1	7.9	0.5	0.17	4.4	4.7	165.7	0.9	2.4	33.0	15.3	70.0	18.0	12.0
T2	0-6	6/4/2015	60.3	31.8	7.6	0.7	0.07	3.9	7.7	258.7	1.0	1.9	42.0	14.5	71.3	17.3	11.3
	6-12	6/4/2015	60.3	28.5	7.8	0.6	0.13	2.8	5.0	213.7	0.9	1.8	48.0	12.0	73.3	14.3	12.3
T3	0-6	6/3/2015	7.8	42.4	7.7	0.6	0.10	8.6	8.0	435.0	2.3	2.6	11.5	25.0	45.5	32.0	22.5
	6-12	6/3/2015	7.8	46.4	7.7	0.7	0.10	9.0	7.0	358.0	2.2	2.7	9.5	25.5	38.0	34.5	27.5
Reach #8																	
T1	0-6	6/4/2015	53.4	35.7	7.6	0.5	0.13	8.9	7.8	224.8	1.4	2.8	12.0	23.0	62.2	24.0	13.8
	6-12	6/4/2015	53.4	32.5	7.7	0.5	0.13	7.5	4.7	185.5	1.1	2.6	18.7	14.5	65.3	21.0	13.7
T1-T2	0-6	6/4/2015	15.8	28.8	7.6	0.6	0.10	3.2	5.0	151.0	1.0	1.9	44.0	8.0	70.0	17.0	13.0
T2	0-6	6/4/2015	39.9	30.2	7.7	0.5	0.08	4.6	5.5	173.3	1.0	2.2	27.8	14.0	69.8	17.8	12.5
	6-12	6/4/2015	39.9	27.6	7.7	0.4	0.13	3.0	3.8	120.8	0.3	1.8	29.3	9.0	75.5	13.8	10.8
Revegetation Thresholds		Marginal Suitability			8	4	6	20	20	300	2		15				
		Unsuitable			8.8	8	10	10	15	140	1	10	35		70		50

3.3.3 Vegetation Analysis

Vegetation data were also collected on the representative reaches at the same time as the soil sampling. Results of that effort are detailed in a separate report, but summarized here as they pertain to the soil analysis. Vegetation data were collected at one-foot intervals along each transect and averaged for each morphological feature encountered (T1 terrace, T2 terrace, T3 terrace, and transition slopes between each type of terrace). Vegetation cover was highly variable between reaches, but less so between terraces within each reach (Table 11). Vegetation cover was statistically analyzed by reach, terrace type, and soil coarse fragment content. There was no difference in vegetation cover between terrace types and there was no correlation between vegetation cover and coarse fragment content in the soils. There was also no correlation between coarse fragment content in the soil samples and surface rock cover. There was a difference in vegetation cover between reaches, but there was no interaction effect between reach and terrace type.

Table 11: Average Vegetation Cover and Coarse Fragments by Reach & Terrace Type

Reach	Terrace	Grass Cover (%)	Forb Cover (%)	Shrub Cover (%)	Vegetation Cover (%)	Ground Cover (%)	Rock Cover (%)	Coarse Fragments (%)
2	T1	9.6	5.1	3.9	18.5	63.68	7.46	11.0
	T2	15.6	4.7	4.7	25.0	25.69	0.03	15.7
6	T1	7.7	2.7	7.6	18.1	72.72	8.36	25.0
	T2	2.6	5.9	4.5	13.1	81.86	2.74	23.0
6.5	T1	12.6	15.7	2.0	30.4	87.79	1.41	3.8
	T2	26.3	7.9	1.1	35.3	94.85	4.08	15.0
7	T1	1.7	3.2	0.9	5.8	72.99	5.68	31.7
	T2	6.7	4.7	0.5	11.9	89.48	2.42	42.0
	T3	1.1	3.2	0.0	4.3	73.23	9.13	11.5
8	T1	16.0	14.3	2.7	33.0	85.99	4.05	11.7
	T2	14.9	3.1	6.8	24.8	83.06	3.91	27.5
	T3	14.0	8.1	12.2	34.2	86.46	11.36	44.0

3.4 Sonoita Creek Vertical Cut Bank Soils

The cut bank soils were relatively uniform throughout the SCR project area. There were no major cobble or sand lenses observed. Additionally, the relatively low and consistent grade of Sonoita Creek has minimized the prevalence and extent of major depositional features in the soil profile. The agronomic and bulk density results (Table 12) are consistent with the results found in the other areas sampled, which further illustrates the relative uniformity of the soils in this area.

Table 12: Vertical Cut Bank Soil Profile Results

Sample ID	Soil Map Unit Symbol	Depth	pH	Electrical Conductivity	Sodium Absorption Ratio	Nitrate Nitrogen	Phos-phorus	Potas-sium	Organic Matter	Lime	Coarse Frag-ments	Very Fine Sand	Sand	Silt	Clay	Texture	Bulk Density
		inches	*s.u.*	*mmhos/cm*	*calculated*	-------------- *mg/kg* --------			----- *%* -----		----------------- *%* -----------------						*ton/cy*
Highwall Core #9	GbB	0-5	7.7	1.5	<0.1	52	3	569	0.5	5.26	60	14	30	53	17	SiL	
	GbB	5-20	8	0.6	0.1	7.6	7	165	0.2	3.27	4	80	80	11	9	LS	
	GbB	20-29	8	0.5	0.1	6	1	84	0.4	3.56	3	65	86	7	7	LS	
	GbB	29-40	7.8	0.5	0.1	5.9	2	108	0.2	2.74	2	68	76	13	11	SL	
	GbB	40-61	8	0.3	0.2	1.3	1	75	0.4	3.14	2	28	78	13	9	SL	
	GbB	61-83	7.9	0.4	0.2	1.9	1	66	0.3	2.8	4	80	80	11	9	LS	
	GbB	83-96	8	0.4	0.2	1.8	1	61	0.3	2.89	1	64	86	5	9	LS	
Highwall Core #11	Pm	0-12	7.6	0.9	<0.1	21	28	537	1.2	3.16	2	17	78	13	9	SL	
	Pm	12-25	7.8	1.1	<0.1	23	18	585	1	3	2	17	76	15	9	SL	
	Pm	25-32	7.8	1	0.1	21	16	464	0.8	1.76	7	24	57	28	15	SL	
	Pm	32-50	7.8	0.6	0.2	8.8	19	330	1.1	1.7	2	28	48	33	19	L	1.20
	Pm	50-66	7.8	1.5	0.3	34	9	302	1.3	2.16	2	26	40	37	23	L	
	Pm	66-78	7.7	0.3	0.2	1.8	9	297	1.1	2.75	2	44	32	59	9	SiL	1.25
Highwall Core #13	Pm	0-25	7.8	0.6	0.1	7.7	6	369	0.7	3.07	2	26	48	38	14	L	
	Pm	25-44	7.7	0.8	0.4	14	12	271	2.1	3.33	2	56	14	56	30	SiCL	
	Pm	44-58	7.5	2.3	0.4	32	8	201	1	1.8	12	16	40	36	24	L	1.33
	Pm	58-68	7.7	0.9	0.3	9.8	4	112	0.4	1.86	67	5	76	12	12	SL	
	Pm	68-90	7.7	0.6	0.2	4.8	3	212	0.4	2.54	11	23	56	24	20	SCL	
	Pm	90-106	7.6	1	0.2	10	2	278	0.5	4.6	2	29	24	40	36	CL	1.40
Highwall Core #16	GbB	0-30	7.6	0.7	0.1	8.4	6	150	0.7	1.11	52	6	66	22	12	SL	
	GbB	30-56	7.9	0.7	0.2	5.9	3	125	0.4	1.63	24	22	60	26	14	SL	
	GbB	56-72	7.6	0.7	0.5	8.9	3	274	0.9	1.61	12	26	34	36	30	CL	1.44
	GbB	72-88	7.3	1	0.3	14	8	196	0.4	1.28	26	11	62	18	20	SCL	
	GbB	88-114	7.5	0.4	0.3	3.4	6	136	0.2	1.39	4	35	46	34	20	L	

4 DISCUSSION & RECOMMENDATIONS

The results of the soil sampling suggest that the soils throughout the SCR project area will be suitable for revegetation. Due to improved fertility and organic matter in the upper soil horizons, it is recommended that topsoil be stripped and stockpiled from the channel construction alignment prior to final excavation. Additionally, it is likely that soil amendments will need to be added to this topsoil as well as the cut surfaces along the channel for optimum revegetation conditions.

4.1 Topsoil Stripping Plan

Topsoil should be salvaged from areas that will be disturbed during construction including channel excavation areas, geomorphic soil repository areas, and contractor staging areas. Topsoil stripping should occur after the completion of clearing and grubbing activities, but prior to excavation or construction support activities. Topsoil salvage should only occur when the soil moisture content is less than field capacity to prevent loss of topsoil structure and avoid excessive compaction.

Topsoil should be stripped to an average depth of 12 inches and stockpiled in approved areas adjacent to where it will be placed. Stockpiles should be graded and bermed to prevent loss of topsoil from erosion. Topsoil should not be stripped from any slopes steeper than 4:1 (horizontal: vertical). Potential topsoil stripping areas are shown on Figure 7 and estimated topsoil quantities are presented in Table 13.

Salvaged topsoil should be placed and graded to an average depth of 12 inches over the surface of the rough-graded geomorphic soil repositories. Topsoil should also be placed on contractor staging areas and decommissioned roads. After placement and final grading, topsoil should be sampled and sent to an agronomic laboratory to determine final soil amendment requirements for each portion of the SCR project area.

Table 13: Estimated Topsoil Quantities by SCR Project Area

Project Area	Location	Soil Map Unit Symbol	Acres	Cubic Yards
Rail X Ranch	Channel	GbB	9.4	15,222
	Repository	GbB	0.4	583
Sonoita Creek Ranch	Channel	GbB	6.5	10,523
		Pm	49.6	79,977
	Repository	GbB	9.3	14,949
		Pm	76.3	123,040
Sonoita Creek South	Channel	GbB	19.6	31,569
		Pm	1.3	2,061
	Repository	GbB	4.4	7,144
		Pm	2.1	3,399
Total			**178.8**	**288,467**

4.2 Soil Amendment Recommendations

After topsoil placement, soil samples should be collected and analyzed to determine amendment requirements. However, estimated amendment requirements can be calculated from the data that are available in this report. It should be noted that the recommended amendment quantities presented here will change after topsoil placement and final grading are complete.

Soil amendment recommendations are summarized in Table 14. The geomorphic soil repositories, as well as the staging areas and roads, will be treated with 12 inches of topsoil. Thus, recommended amendments for these areas are based on the top 12 inches of the soils sampled in the constructed channel alignment cores as well as the repository areas. The revegetation surface along the excavated channel will not receive any topsoil placement. Therefore, the recommended amendments for these areas are based on the soil data at the anticipated depth of cut from the constructed channel alignment cores.

Table 14: Recommended Amendment Applications

	Pounds/Acre	
Amendment	**Topsoil**	**Channel Excavation**
Nitrogen	20	20
Phosphorus	130	160
Potassium	40	90

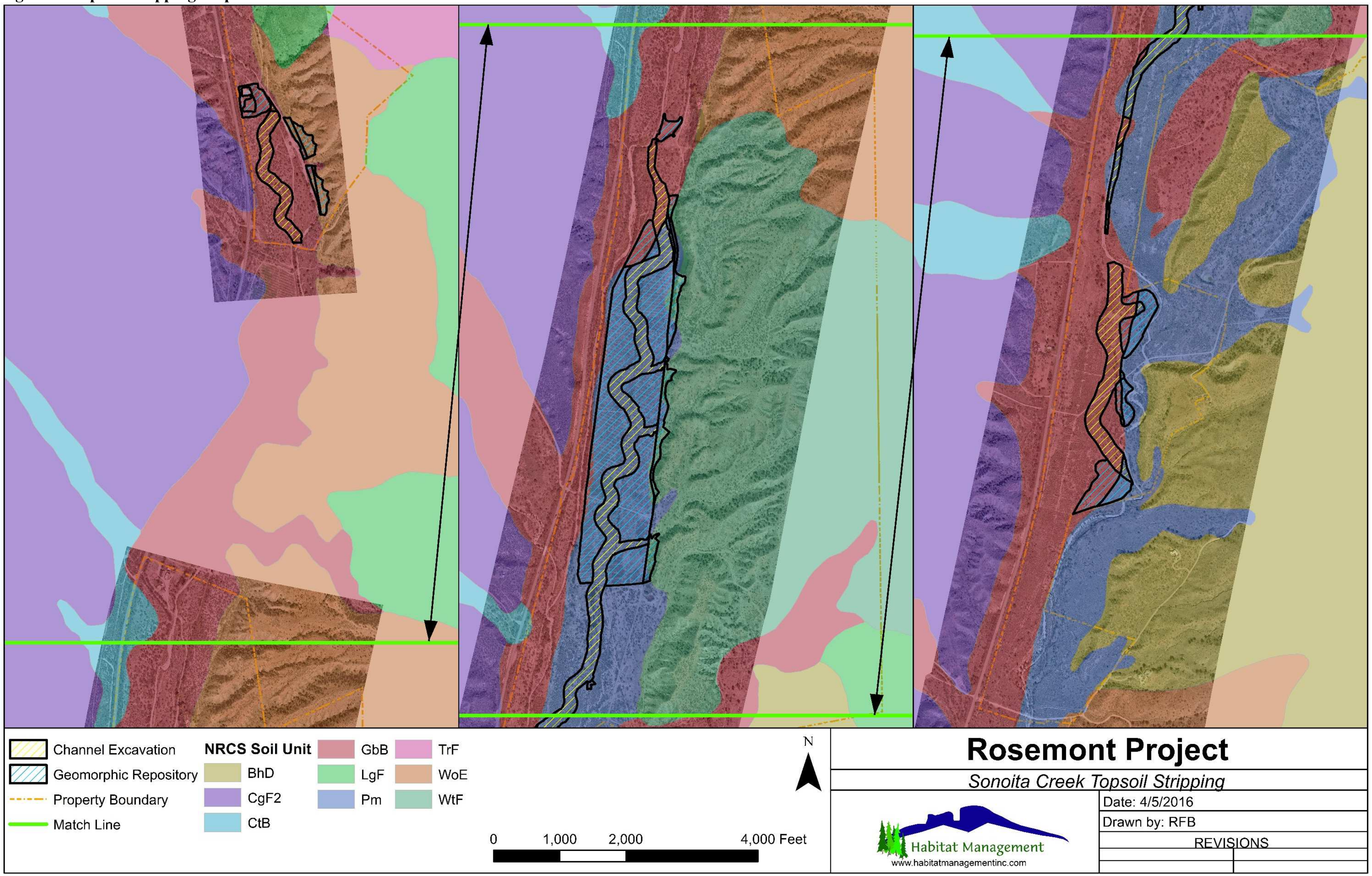
5 REFERENCES

Soil Survey of Santa Cruz and Parts of Cochise and Pima Counties, Arizona. 1979. M.L. Richardson (SCS), S.D. Clemmons (USFS) and J.C. Walker (USFS). USDA & USFS in cooperation with Arizona Agricultural Experiment Station.

Soil Water Characteristics Program and SPAW Model (version 6.02.75). K.E. Saxton. USDA Agricultural Research Service in cooperation with Department of Biological Systems Engineering, Washington State University. http://hydrolab.arsusda.gov/SPA/Index.htm.

National Engineering Handbook. Part 630. Chapter 7, Hydrologic Soil Groups. 2007. USDA NRCS. 210-VI-NEH, May 2007.

Figure 7: Topsoil Stripping Map



Attachment A: NRCS Soil Series Descriptions

Pima Series
Grabe Series
Comoro Series
White House Series
Hathaway Series
Caralampi Series

PIMA SERIES

LOCATION PIMA AZ+NM
Established Series
Rev. YHH/RCH
07/2008

The Pima series consists of deep, well drained soils formed in stream alluvium. Pima soils are on alluvial fans and flood plains and have slopes of 0 to 3 percent. The average annual precipitation is about 10 inches and the mean annual temperature is about 65 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, calcareous, thermic Typic Torrifluvents

TYPICAL PEDON: Pima silty clay loam--cultivated (colors are for dry soil unless otherwise noted).

Ap--0 to 4 inches; yellowish brown (10YR 5/4) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, friable, moderately sticky and slightly plastic; common fine roots; many very fine tubular pores; slightly effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary (4 to 8 inches thick).

A1--4 to 10 inches; brown (10YR 5/3) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, friable, moderately sticky and slightly plastic; many fine roots; many fine tubular pores; slightly effervescent; moderately alkaline (pH 8.0); clear smooth boundary (6 to 8 inches thick).

A2--10 to 25 inches; brown (10YR 5/3) silty clay loam, very dark grayish brown (10YR 3/2) moist; massive; slightly hard, friable, moderately sticky and slightly plastic; common fine roots; many fine tubular pores; slightly effervescent; moderately alkaline (pH 8.0); clear smooth boundary (10 to 16 inches thick).

C1--25 to 37 inches; brown (10YR 5/3) silty clay loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, moderately sticky and slightly plastic; many fine tubular pores; few very fine lime filaments; strongly effervescent; moderately alkaline (pH 8.0).

C2--37 to 60 inches; light yellowish brown (10YR 6/4) silty clay loam, dark yellowish brown (10YR 3/4) moist; massive; slightly hard, friable sticky and slightly plastic; many fine tubular pores; few fine lime filaments; strongly effervescent; moderately alkaline (pH 8.0).

TYPE LOCATION: Cochise County, Arizona; about 6 miles southwest of Bowie; 3000 feet east and 500 feet north of SW corner section 8, T. 14 S., R. 29 E.

RANGE IN CHARACTERISTICS:

Soil Moisture - Intermittently moist in the soil moisture control section in some part during July to September and December to February. Typic aridic moisture regime.

Rock fragments (particle-size control section) - less than 35 percent gravel.

Thickness of dark epipedon - 20 to more than 40 inches.

A horizon
Hue: 10YR or 7.5YR.
Value: 4 or 5 dry, 2 or 3 moist.
Chroma: 2 or 3 dry and moist.
Texture: Silt loam, silty clay loam, loam or clay loam. Particle-size control section averages more than 18 percent clay and less than 15 percent sand coarser than very fine sand.
Organic matter: More than 1 percent to more than 20 inches; decreases irregularly or remains high in deep layers.
Reaction: Neutral to moderately alkaline.
Carbonates: Slightly or strongly effervescent.
Stratification: Thin strata of contrasting textures are common.

C horizon
Hue: 10YR or 7.5YR.
Value: 4, 5 or 6 dry, 3, 4 or 5 moist.
Chroma: 2, 3 or 4 dry and moist.
Texture: Silt loam, silty clay loam, loam, clay loam, and fine sandy loam; particle size control section averages more than 18 percent clay and less than 15 percent sand coarser than very fine sand.
Reaction: slightly or moderately alkaline.
Carbonates: Strongly or violently effervescent; lime filaments occur in some pedons.
Stratification: Thin strata of contrasting textures are common.

COMPETING SERIES: These are the Glendale (AZ) and Rift (AZ) series. Glendale soils have less than 1 percent organic matter. Rift soils are moist in the soil moisture control section for less than 20 days cumulative during July-September and occur in the Mohave Desert.

GEOGRAPHIC SETTING: Pima soils are on alluvial fans and flood plains. Elevations range from 1,100 to 5,400 feet. Slopes range from 0 to 3 percent. These soils formed in stratified and mixed alluvium from volcanic, granitic, metamorphic and sedimentary rock. The climate is warm and dry. The average annual precipitation is 6 to 12 inches occurring as summer thunderstorms and winter rain and snow. The mean annual temperature is 54 degrees F. Frost-free season is 180 to 240 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Anthony, Brazito, Gila, Grabe Hantz, and Queencreek and the competing Glendale soils. Anthony soils are coarse-loamy. Queencreek soils are sandy-skeletal. Brazito soils are sandy. Gila and Grabe soils are coarse-silty. Hantz soils are fine.

DRAINAGE AND PERMEABILITY: Well drained; runoff is medium; moderately slow permeability.

USE AND VEGETATION: Used for grazing and irrigated cropland. Alfalfa, cotton, grain, and vegetables are major irrigated crops. Native vegetation is mesquite, quailbush, creosotebush, squawbush, alkali sacaton, sixweeks grama, Indianwheat, alfileria, and annual weeds and grasses.

DISTRIBUTION AND EXTENT: Southern Arizona and southern New Mexico. Pima soils are moderately extensive. This soil occurs in LRR-D, MLRAs 40, 41, and 42.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Middle Gila Area, Arizona, 1917

REMARKS: Diagnostic horizons and features recognized in the Pima Series are:

1) No diagnostic horizons are recognized

2) Stratification is common feature in massive horizons

Fluvial feature **-** Irregular decrease in organic carbon in the zone from 25 to 60 inches (C1, C2 horizons)

Classified according to Soil Taxonomy, Second Edition, 1999.

Type location was moved from Santa Cruz County to Cochise County, Arizona.

ADDITIONAL DATA: NSS Laboratory sample S44AZ-003-001.

National Cooperative Soil Survey

U.S.A.

GRABE SERIES

LOCATION GRABE AZ+NM
Established Series
Rev. CWG/HHS/PDC
06/2008

The Grabe series consists of very deep, well drained soils that formed in stratified alluvium. Grabe soils are on flood plains and alluvial fans and have slopes of 0 to 3 percent. The mean annual precipitation is about 11 inches and the mean annual air temperature is about 64 degrees F.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, calcareous, thermic Typic Torrifluvents

TYPICAL PEDON: Grabe loam - irrigated cropland (colors are for dry soil unless otherwise noted).

Ap1--0 to 10 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and moderately plastic; few very fine roots; common very fine and fine tubular pores; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary (8 to 14 inches thick).

Ap2--10 to 16 inches; grayish brown (10YR 5/2) loam, dark brown (7.5YR 3/2) moist; weak fine subangular blocky structure; hard, friable, slightly sticky and moderately plastic; few very fine roots; common very fine and fine tubular pores; strongly effervescent; moderately alkaline (pH 8.0); clear wavy boundary (6 to 14 inches thick).

C1--16 to 26 inches; grayish brown (10YR 5/2) very fine sandy loam, dark brown (7.5YR 3/2) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; common very fine and fine tubular pores; strongly effervescent; moderately alkaline (pH 8.0); clear wavy boundary (9 to 20 inches thick).

C2--26 to 62 inches; grayish brown (10YR 5/2) loam, dark brown (7.5YR 3/2) moist; massive; slightly hard, friable, moderately sticky and moderately plastic; few very fine roots; common very fine and fine tubular pores; strongly effervescent; moderately alkaline (pH 8.0).

TYPE LOCATION: Graham County, Arizona; 6 miles northeast of Safford; 1,300 feet north and 1,450 feet west of the southeast corner of section 17, T.6 S, R.25 E.

RANGE IN CHARACTERISTICS:

Soil Moisture - Intermittently moist in some part of the soil moisture control section during July - September and December - March. Driest during May and June. The epipedon is moist in some part less than 90 days (cumulative) when the soil temperature is above 41 degrees F. in 7 out of 10 years. Typic aridic soil moisture regime.

Soil temperature - 59 to 72 degrees F.

Stratification- usually thin strata of finer or coarser material

Reaction - neutral to moderately alkaline

Organic matter - Greater than 1 percent in the surface that decreases irregularly with depth

A and C horizons
Hue: 7.5YR, 10YR
Value: 4 through 6 dry, 2 through 4 moist
Chroma: 2 through 4, dry or moist
Texture: loam, silt loam, very fine sandy loam containing less than 15 percent medium, coarse and very coarse sand.

Calcium carbonate: slightly to strongly effervescent as disseminated or as filaments and segregations

COMPETING SERIES: These are the Anthony (AZ), Excelsior (CA), Gila (AZ), Ireteba (NV), Junction (UT), Rucker (AZ), Tobler (UT) and Victorville(CA) series. Anthony, Excelsior, Tobler, and Gila soils contain less than 1 percent organic matter in the surface. Anthony and Rucker soils are coarse sandy loam, sandy loam or fine sandy loam with more than 15 percent medium or coarser sand in the control section. Ireteba soils contain horizons of distinct lime accumulations. Junction and Tobler soils have hue redder than 7.5YR and Junction soils contain gypsum. Excelsior, Victorville, Ireteba, and Junction are dry in some part of the soil moisture control section for more than 20 days cumulative between July and September.

GEOGRAPHIC SETTING: Grabe soils are on flood plains and alluvial fans at elevations of 2,500 to 5,500 feet. Slopes range from 0 to 3 percent. These soils formed in stratified alluvium from mixed sources. The mean annual precipitation is 10 to 12 inches. The mean annual air temperature is 57 to 70 degrees F. The frost-free period is 160 to 275 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Rucker soils and the Arizo, Brazito, Glendale and Hantz soils. Brazito soils are sandy. Glendale soils are fine-silty. Hantz soils are fine textured. Arizo soils are sandy-skeletal.

DRAINAGE AND PERMEABILITY: Well drained; medium or slow runoff; moderate permeability.

USE AND VEGETATION: Used for irrigated cropland, wildlife habitat and livestock grazing. Vegetation includes mesquite, catclaw, burroweed, threeawn, Arizona cottontop, bush muhly, and annual grasses.

DISTRIBUTION AND EXTENT: Southern Arizona. Grabe soils are extensive. This soil occurs in LRR-D, MLRAs 40, 41, and 42.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Santa Cruz County Area, Arizona; 1971.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from 0 to 16 inches (Ap1, Ap2 horizons)

Entisol feature - the absence of diagnostic subsurface horizons

Fluvial feature - Irregular decrease in organic carbon in the zone from 16 to 62 inches (C1, C2 horizons)

Classified according to Soil Taxonomy, Second Edition, 1999.

Updated competing series section, 3/18/08, CEM

National Cooperative Soil Survey

U.S.A.

COMORO SERIES

LOCATION COMORO AZ+NM
Established Series
Rev. CWG/JEJ/PDC/CEM/WWJ
07/2006

The Comoro series consists of very deep, well or somewhat excessively well drained soils formed in stratified alluvium. Comoro soils are on alluvial fans and flood plains and have slopes of 0 to 8 percent. The mean annual precipitation is about 14 inches and the mean annual air temperature is about 65 degrees F.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, calcareous, thermic Ustic Torrifluvents

TYPICAL PEDON: Comoro sandy loam - irrigated cropland. (Colors are for dry soil unless otherwise noted.)

Ap--0 to 8 inches; brown (7.5YR 5/2) sandy loam, dark brown (7.5YR 3/2) moist; weak fine and medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many fine irregular pores; slightly alkaline (pH 7.5); clear smooth boundary. (5 to 8 inches thick)

C1--8 to 19 inches; brown (7.5YR 5/3) sandy loam, dark brown (7.5YR 3/3) moist; weak medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; many very fine and fine roots; many very fine and fine tubular pores; moderately alkaline (pH 8.0); clear wavy boundary. (5 to 12 inches thick)

C2--19 to 46 inches; light brown (7.5YR 6/3) fine sandy loam, brown (7.5YR 4/3) moist; massive; slightly hard, very friable, nonsticky and nonplastic; common very fine and fine roots; many fine and very fine tubular pores; slightly effervescent; moderately alkaline (pH 8.2); clear wavy boundary. (20 to 40 inches thick)

C3--46 to 60 inches; light brown (7.5YR 6/3) sandy loam, brown (7.5YR 4/3) moist; massive; slightly hard, very friable, nonsticky and nonplastic; common very fine and fine roots; many very fine and fine tubular pores; slightly effervescent; moderately alkaline (pH 8.0).

TYPE LOCATION: Cochise County, Arizona; about 2 miles north of Elfrida; 2,500 feet east and 2,000 feet south of the northwest corner of section 9, T.20 S., R.26 E.

RANGE IN CHARACTERISTICS:

Soil Moisture - Intermittently moist in some part of the soil moisture control section during July-September and December-February. Driest during May and June. The epipedon is moist in some part less than 90 days (cumulative) when the soil temperature is above 41 degrees F. in 7 out of 10 years. Ustic aridic soil moisture regime.

Soil Temperature - 59 to 72 degrees F.

Stratification- Usually thin strata of finer or coarser material

Rock Fragments - averages less than 35 percent in the control section

Organic matter - more than 1 percent in the surface that decreases irregularly with depth. Commonly dark colored to a depth of 36 inches or more.

Reaction - neutral to moderately alkaline; can range to slightly acid in the upper part

A horizon
Hue: 10YR, 7.5YR
Value: 3, 4 or 5 dry, 2 or 3 moist
Chroma: 1, 2 or 3, dry or moist
Calcium carbonate: none to strongly effervescent

C horizon
Hue: 10YR, 7.5YR
Value: 3 through 6 dry, 2, 3 or 4 moist
Chroma: 1 through 4, dry or moist
Texture: Sandy loam, coarse sandy loam, fine sandy loam, loamy sand (less than 18 percent clay)
Calcium carbonate: Slightly to violently effervescent as disseminated or as filaments. Some areas on alluvial fans, in swales, and along narrow drainageways do not effervesce.

COMPETING SERIES: These are the San Jose and Ubik series. San Jose soils have soil temperatures of about 58 to 62 degrees F., hue redder than 7.5YR from the influence of red sandstone and shale, and occur on the Great Plains as part of MLRA 70. Ubik soils are loam, very fine sandy loam and silt loam in the control section.

GEOGRAPHIC SETTING: Comoro soils are on alluvial fans and flood plains. Elevations range from 2,200 to 5,200 feet. Slopes range from 0 to 8 percent. These soils formed in stratified alluvium from predominantly granite and rhyolite sources. The mean annual precipitation is 12 to 16 inches occurring as summer thunderstorms and winter rain. The mean annual air temperature is 57 to 70 degrees F. Frost-free period is 160 to 240 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Bodecker, Elgin, McAllister, and Stronghold series and the competing Ubik series. Bodecker soils have sandy-skeletal control sections. Elgin, McAllister, and Stronghold soils are on fan terraces.

DRAINAGE AND PERMEABILITY: Well or somewhat excessively well drained; medium runoff; moderately rapid permeability.

USE AND VEGETATION: Used for livestock grazing and irrigated cropland. Vegetation is catclaw, mesquite, yucca, burroweed, three-awn, grama grasses, Arizona cottontop, bush muhly and annual grasses. Irrigated crops are cotton, small grains, sorghum and alfalfa.

DISTRIBUTION AND EXTENT: Southern Arizona. Comoro soils are extensive. This soil occurs in LRR-D, MLRAs 40, 41, 42.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Santa Cruz County, Arizona; 1930.

REMARKS: Formerly part of the Rucker series that included both typic aridic and ustic aridic soil moisture regimes. The type location for Comoro was moved in 1981 to a typic aridic area in Graham County, Arizona. The Comoro concept has a long history of use and familiarity to ranching, research and soil survey. It is extensively referenced in many documents, publications and thesis. This historical use has prompted us to structure the series as close to the original concept as possible and necessitates moving the type location to a ustic aridic (12 - 16 inch pz) soil moisture regime with a change in classification. Rucker soils have a limited extent and will reflect a typic aridic (<12 inch pz) moisture regime.

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from 0 to 8 inches (Ap horizon)

Entisol feature - the absence of diagnostic subsurface horizons

Classified according to Soil Taxonomy Second Edition, 1999.

National Cooperative Soil Survey

U.S.A.

WHITE HOUSE SERIES

LOCATION WHITE HOUSE AZ+NM
Established Series
Rev. MLR/JEJ
05/2011

The White House series consists of very deep, well drained soils that formed in fan alluvium from mixed sources. White House soils are on fan terraces and have slopes of 0 to 60 percent. The mean annual precipitation is about 14 inches and the mean annual air temperature is about 62 degrees F.

TAXONOMIC CLASS: Fine, mixed, superactive, thermic Ustic Haplargids

TYPICAL PEDON: White House gravelly loam - rangeland. (Colors are for dry soil unless otherwise noted.)

A--0 to 3 inches; brown (7.5YR 5/4) gravelly loam, dark brown (7.5YR 3/2) moist; weak thin platy structure parting to moderate fine granular; slightly hard, friable, nonsticky and slightly plastic; many very fine and fine roots; common fine irregular pores; 15 percent gravel; moderately acid (pH 5.6); clear smooth boundary. (2 to 8 inches thick)

Bt1--3 to 9 inches; reddish brown (5YR 5/4) clay loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky structure; hard, friable, moderately sticky and moderately plastic; common fine and very fine roots; few fine and very fine tubular pores; few faint clay films on faces of peds; 2 percent fine gravel; slightly acid (pH 6.2) clear smooth boundary. (5 to 18 inches thick)

Bt2--9 to 22 inches; reddish brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) moist; moderate medium and coarse prismatic structure; hard, firm, moderately sticky and moderately plastic; common fine and very fine roots; few very fine irregular and tubular pores; many distinct clay films on faces of peds; 2 percent fine gravel; neutral (pH 7.0); clear wavy boundary. (9 to 26 inches thick)

Btk1--22 to 26 inches; dark red (2.5YR 3/6) clay, dark red (2.5YR 3/6) moist; moderate medium and coarse subangular and angular blocky structure; hard, firm, moderately sticky and moderately plastic; common fine roots; few fine tubular pores; many distinct clay films on faces of peds; common pressure faces; common medium slickensides; 2 percent gravel; 9 percent calcium carbonate equivalent; strongly effervescent; moderately alkaline (pH 8.0); clear wavy boundary. (3 to 10 inches thick)

Btk2--26 to 39 inches; mixed red (2.5YR 4/6) and pink (5YR 7/4) clay loam, dark red (2.5YR 3/6) and light reddish brown (5YR 6/4) moist; weak medium subangular blocky structure; hard, friable, sticky and plastic; few fine roots; few very fine and fine tubular pores; common faint clay films on faces of peds; 5 percent gravel; common medium irregular calcium carbonate masses; 10 percent calcium carbonate equivalent; strongly effervescent; moderately alkaline (pH 8.0); gradual wavy boundary. (6 to 15 inches thick)

Bk1--39 to 49 inches; mixed yellowish red (5YR 5/6) and pink (5YR 7/4) sandy clay loam, yellowish red (5YR 4/6) and light reddish brown (5YR 6/3) moist; massive; hard, friable, slightly sticky and moderately plastic; few very fine tubular and irregular pores; 10 percent medium and coarse gravel; few fine and medium calcium carbonate masses; 2 percent calcium carbonate equivalent; slightly effervescent; moderately alkaline (pH 8.0); gradual wavy boundary. (8 to 12 inches thick)

Bk2--49 to 60 inches; mixed yellowish red (5YR 5/8) and pink (5YR 7/3) very gravelly sandy clay loam, yellowish red (5YR 4/6) and light reddish brown (5YR 6/3) moist; massive; hard, friable, moderately sticky and moderately plastic; few very fine irregular pores; 35 percent medium and coarse gravel; few fine calcium carbonate masses; 2 percent calcium carbonate equivalent; slightly effervescent; moderately alkaline (pH 8.0).

TYPE LOCATION: Santa Cruz County, Arizona; 1.3 miles east southeast of Highway 83 and .1 mile south of the El Paso Natural Gas pipeline in the San Ignacio Del Babocomari Grant, 3 miles south and 4.5 miles east of Sonoita in Section 11, T. 21 S., R. 17 E.

RANGE IN CHARACTERISTICS:

Soil Moisture: Intermittently moist in some part of the soil moisture control section during July-September and December-February. Driest during May and June. Ustic aridic soil moisture regime.

Soil Temperature: 59 to 70 degrees F.

Rock Fragments: averages less than 35 percent in the control section

Organic matter: averages 1 percent or more in the surface

Reaction: moderately acid through moderately alkaline

A horizon
Hue: 2.5YR, 5YR, 7.5YR
Value: 3 through 6 dry, 2 to 6 moist
Chroma: 2 through 6 dry, 1 to 6 moist

Bt horizons
Hue: 2.5YR, 5YR, 7.5YR
Value: 3 through 6, dry or moist
Chroma: 2 through 8, dry or moist
Texture: clay loam, clay, sandy clay loam, sandy clay (averages more than 35 percent clay and more than 30 percent sand)

B, Bk or C horizons
Hue: 2.5YR through 10YR
Value: 3 through 8 dry, 3 through 7 moist
Chroma: 2 through 8, dry or moist
Texture: sandy clay loam, clay loam, clay
Some pedons contain thin layers of coarse sandy loam, loamy sand, or loamy coarse sand at depths greater than 25 inches.

COMPETING SERIES: This is the Antbed (T) (TX) series. Antbed soils are on alluvial flats and have less than 30 percent sand and 0 to 5 percent gravel throughout.

GEOGRAPHIC SETTING: White House soils are on fan terraces and have slopes of 0 to 60 percent. These soils formed in fan alluvium from mixed sources. Elevations range from 2,990 to 5,540 feet. The mean annual precipitation is 12 to 16 inches. The mean annual air temperature is 57 to 67 degrees F. The frost-free period is 160 to 250 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Forrest and Bernardino soils. In addition is the Caralampi soil. Caralampi soils are loamy-skeletal. Forrest and Bernardino soils have calcic horizons.

DRAINAGE AND PERMEABILITY: Well drained; slow or medium runoff; slow or very slow permeability.

USE AND VEGETATION: White House soils are used for livestock grazing and wildlife habitat. A few areas are used for homesites and other urban uses. Present vegetation is grama grasses, plains lovegrass, wolftail, curly mesquite, tobosa, and mesquite.

DISTRIBUTION AND EXTENT: Southern Arizona and New Mexico. This series is extensive. MLRAs are 38 and 41.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Pima County (Tucson Area) Arizona; 1931.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from 0 to 3 inches (A horizon)
Argillic horizon - the zone from 3 to 39 inches (Bt1, Bt2, Btk1, Btk2 horizons)

Classified according to Soil Taxonomy, Second Edition, 1999; Keys to Soil Taxonomy, Eleventh Edition, 2010
Revised for the correlation of AZ661, 2/2009, WWJ
Revised for the correlation of Graham County, AZ, Southwestern Part; March, 2011, WWJ

National Cooperative Soil Survey

U.S.A.

HATHAWAY SERIES

LOCATION HATHAWAY AZ+NM
Established Series
Rev. JEJ/HHS/CLG/CEM
10/2007

The Hathaway series consists of very deep, well drained soils that formed in fan alluvium from mixed sources. Hathaway soils are on fan terraces and have dominant slopes of 10 to 40 percent. Mean annual precipitation is about 18 inches and the mean annual air temperature is about 61 degrees F.

TAXONOMIC CLASS: Loamy-skeletal, mixed, superactive, thermic Aridic Calciustolls

TYPICAL PEDON: Hathaway gravelly loam - rangeland. (Colors are for dry soil unless otherwise noted.)

A--0 to 8 inches; dark grayish brown (10YR 4/2) gravelly loam, very dark brown (10YR 2/2) moist; moderate fine subangular blocky structure (immediate surface is single grained); soft, friable, slightly sticky and slightly plastic; many fine roots; many fine interstitial pores; strongly effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary. (7 to 16 inches thick)

Bk1--8 to 24 inches; pale brown (10YR 6/3) gravelly loam, brown (10YR 4/3) moist; massive; slightly hard, friable, slightly sticky and moderately plastic; few fine roots; few fine tubular pores; few fine irregular calcium carbonate masses; violently effervescent; more than 15 percent calcium carbonate; moderately alkaline (pH 8.2); gradual wavy boundary. (8 to 20 inches thick)

Bk2--24 to 60 inches; light gray (10YR 7/2) pinkish gray (7.5YR 6/2) and light reddish brown (5YR 6/3) stratified very gravelly loamy sand and sand, grayish brown (10YR 5/2), brown (7.5YR 5/2), and reddish brown (5YR 5/3) moist; massive; slightly hard, very friable, nonsticky and nonplastic; few fine roots; common medium irregular calcium carbonate masses; many very fine and fine interstitial pores; violently effervescent; more than 15 percent calcium carbonate; moderately alkaline (pH 8.2).

TYPE LOCATION: Santa Cruz County, Arizona; about 6 miles east and 2 1/2 miles north of Sonoita; about 300 feet west of the southeast corner of section 1, T. 20 S., R. 17 E.

RANGE IN CHARACTERISTICS:

Soil Moisture - Intermittently moist in some part of the soil moisture control section during July-September and December-February. Driest during May and June. Aridic ustic soil moisture regime.

Soil Temperature - averages 59 to 67 degrees F.

Rock Fragments - averages 35 to 50 percent in the particle-size control section; but can have as much as 85 percent in any one subhorizon

Organic Matter Content - averages 1 to 3 percent in the upper 7 inches

Depth to the calcic horizon - 5 to 20 inches

Reaction - slightly or moderately alkaline. Calcium carbonate equivalent averages 15 to 40 percent; can be as much as 55 percent in any one subhorizon

A horizon
Hue: 10YR, 7.5YR
Value: 3 through 5 dry, 2 or 3 moist
Chroma: 1 through 3, dry or moist

B horizon
Hue: 10YR, 7.5YR, 5YR
Value: 4 through 7 dry, 3 to 6 moist
Chroma: 1 to 4, dry or moist
Texture: loam, sandy loam, loamy sand, sand, fine sandy loam

COMPETING SERIES: These are the Tascosa (TX) series. Tascosa soils are moist in the soil moisture control section during May and June and are typical of the Blackwater Draw Ogallala Formation in the Canadian Breaks and Southern High Plains.

GEOGRAPHIC SETTING: Hathaway soils are at elevations of 2,500 to 6,200 feet, on nearly level to steep slopes of fan terraces. Slopes are dominantly 10 to 40 percent, and range from 2 to 70 percent. The soils formed in fan alluvium from mixed sources of limestone, rhyolite, granite, dacite, andesite, tuff, quartzite, sandstone, and shale. Hathaway soils occur in warm, semiarid, continental climate. The mean annual air temperature is 57 to 66 degrees F. The mean annual precipitation is 15 to 20 inches. About 55 percent of the precipitation occurs during July, August, and September; 35 percent in December and January. The frost-free period is 160 to 230 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Blacktail, Carbine, Cazador, Cherrycow, and Terrarossa. Blacktail, Cherrycow, and Terrarossa soils have argillic horizons. Carbine is shallow to a petrocalcic horizon. Cazador are in lower portions and do not have a calcic horizon or rock fragments.

DRAINAGE AND PERMEABILITY: Well drained; medium to rapid runoff; moderate to moderately rapid permeability.

USE AND VEGETATION: These soils are used mainly for livestock grazing. Small areas are used for homesites. Vegetation is mostly grass with some scattered brush. The grasses are black, sideoats, and hairy gramas; curly mesquite, bush muhly, threeawn, fluffgrass, and slim tridens. The brush in dominantly mesquite and wait-a-bit, with widely spaced creosote, whitethorn, beargrass, yucca, cacti, and ocotillo.

DISTRIBUTION AND EXTENT: Southeastern Arizona and central Arizona. Hathaway soils are moderately extensive. MLRA 41.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Santa Cruz County Area, Arizona; 1971.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Mollic epipedon - the zone from 0 to 8 inches (A horizon)

Calcic horizon - the zone from 8 to 60 inches (Bk1, Bk2 horizons)

Classified according to Soil Taxonomy, Second Edition, 1999; Keys to Soil Taxonomy, Tenth Edition, 2006.

National Cooperative Soil Survey

U.S.A.

CARALAMPI SERIES

LOCATION CARALAMPI AZ+NM
Established Series
Rev. MLR/CCC/PDC/CEM
05/2011

The Caralampi series consists of very deep, well drained soils formed in fan and slope alluvium from granitic and volcanic rock. Caralampi soils are on fan terraces and hills. Slopes range from 1 to 50 percent. The mean annual precipitation is about 14 inches and the mean annual air temperature is about 62 degrees F.

TAXONOMIC CLASS: Loamy-skeletal, mixed, superactive, thermic Ustic Haplargids

TYPICAL PEDON: Caralampi very gravelly sandy loam - rangeland. (Colors are for dry soil unless otherwise noted.)

A--0 to 2 inches; brown (7.5YR 4/4) very gravelly sandy loam, dark reddish brown (5YR 3/4) moist; weak fine granular structure; slightly hard, friable, nonsticky and nonplastic; common very fine and fine roots; common irregular pores; 40 percent gravel; slightly acid (pH 6.2); abrupt smooth boundary. (1 to 5 inches thick)

BAt--2 to 5 inches; brown (7.5YR 4/2) very gravelly sandy clay loam, dark brown (7.5YR 3/2) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and moderately plastic; common very fine and fine roots; many irregular pores; few faint clay films in tubular pores; 55 percent gravel; slightly acid (pH 6.5); clear wavy boundary.

Bt1--5 to 9 inches; dark reddish brown (5YR 3/4) very gravelly sandy clay loam, dark reddish brown (5YR 3/4) moist; weak fine and medium subangular blocky structure; slightly hard, friable, moderately sticky and moderately plastic; many very fine and fine roots; common irregular and fine tubular pores; few faint clay films on faces of peds; 50 percent gravel; slightly acid (pH 6.1); abrupt wavy boundary.

Bt2--9 to 13 inches; yellowish red (5YR 4/6) very gravelly sandy clay loam, dark red (2.5YR 3/6) moist; moderate medium subangular blocky structure; hard, friable, moderately sticky and moderately plastic; many very fine and fine roots; common irregular and fine tubular pores; common faint clay films on faces of peds and in pores; 50 percent gravel; slightly acid (pH 6.1); clear wavy boundary.

Bt3--13 to 23 inches; yellowish red (5YR 4/6) and reddish yellow (5YR 6/6) gravelly sandy clay loam, yellowish red (5YR 4/6) moist; weak fine and medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common fine roots; few very fine tubular pores; common faint clay films on faces of peds; 40 percent gravel; slightly acid (pH 6.5); clear wavy boundary. (Combined thickness of the Bt horizons is 12 to 29 inches)

BCt1--23 to 31 inches; reddish brown (5YR 5/4) very gravelly sandy loam, reddish brown (5YR 4/4) moist; common fine faint pink (5YR 7/3) and light reddish brown (5YR 6/3) features, light reddish brown (5YR 6/4) moist; massive; hard, friable, slightly sticky and slightly plastic; few very fine and fine roots; few very fine tubular pores; few faint clay films in pores; 50 percent gravel; slightly acid (pH 6.5); clear wavy boundary.

BCt2--31 to 42 inches; light reddish brown (5YR 6/4) very gravelly sandy loam, reddish brown (5YR 4/4) moist; massive; hard, friable, nonsticky and slightly plastic; few very fine roots; few faint clay films in pores; 50 percent gravel; slightly acid (pH 6.5); clear wavy boundary. (Combined thickness of the BC horizons is 6 to 21 inches)

C--42 to 60 inches; light brown (7.5YR 6/4) gravelly sandy loam, brown (7.5YR 4/4) moist; massive; hard, friable, nonsticky and nonplastic; 30 percent gravel; slightly acid (pH 6.5).

TYPE LOCATION: Santa Cruz County, Arizona; 2.5 miles north-northwest of Nogales, Arizona; about 2,800 feet north and 1,600 feet west of the southeast corner of section 36, T. 23 S., R. 13 E.

RANGE IN CHARACTERISTICS:

Soil moisture - Intermittently moist in some part of the soil moisture control section during December-March and for more than 20 days cumulative during July-September. Driest during May and June. Ustic aridic soil moisture regime.

Soil temperature - 59 to 69 degrees F.

Rock fragments - 35 to 80 percent

Calcium carbonate - Noneffervescent in the upper part, may have slight to strong effervescence below 40 inches

Organic matter content - Greater than 1 percent in the upper 10 inches

A horizon
Hue: 10YR, 7.5YR, 5YR
Value: 3 through 5 dry, 3 or 4 moist
Chroma: 2, 3, or 4, dry or moist
Reaction: neutral to moderately acid

Bt horizons
Hue: 5YR, 2.5YR
Value: 3 through 5, dry or moist
Chroma: 3, 4, or 6, dry or moist
Texture: sandy clay loam, clay loam, sandy loam, loam (more than 18 percent clay)
Reaction: slightly acid to slightly alkaline

BC, Bk and C horizons
Hue: 7.5YR, 5YR
Value: 3 through 7, dry or moist
Chroma: 2, 3, 4, or 6, dry or moist

Texture: sandy loam, coarse sandy loam, sandy clay loam
Reaction: slightly acid to moderately alkaline

COMPETING SERIES: These are the Coxwell (NM), Hartpeak (CA), Holliday (NM), Hoppswell (NV), Hyrhy (AZ), Maloy (AZ) and Monza (NM) series. Hartpeak and Hoppswell soils are moist in the soil moisture control section for less than 20 days cumulative between July and September. Coxwell and Monza soils are moderately deep to bedrock. Holliday soils contain less than 18 percent clay. Hyrhy soils are inactive. Maloy soils contain dominantly cobble size rock fragments in the control section.

GEOGRAPHIC SETTING: Caralampi soils are on strongly sloping to steep fan terraces and hills. Slopes range from 1 to 50 percent. Elevations range from 2,800 to 5,380 feet. These soils formed in fan and slope alluvium derived from granite, rhyolite, andesite, dacite, and related tuff, and agglomerates. Mean annual air temperature ranges from 57 to 68 degrees F. and the mean annual precipitation ranges from 12 to 16 inches. The frost-free period is 180 to 260 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Riveroad, Comoro, and White House soils. Riveroad and Comoro soils do not have argillic horizons. White House soils are clayey.

DRAINAGE AND PERMEABILITY: Well drained; medium to rapid runoff; moderately slow permeability.

USE AND VEGETATION: These soils are used for livestock grazing, wildlife habitat and urban development. Vegetation is curlymesquite, sprucetop grama, hairy grama, sideoats grama, threeawn, cane beardgrass, wolftail, and plains lovegrass. Brush species are mesquite, catclaw, mimosa, calliandra, range ratany, and a few oak and cacti.

DISTRIBUTION AND EXTENT: Southern Arizona. Caralampi soils are moderately extensive. MLRA 38 and 41.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Santa Cruz County Area, Arizona; 1971.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from 0 to 2 inches (A horizon)
Argillic horizon - The zone from 2 to 42 inches (BAt, Bt1, Bt2, Bt3, BCt1, BCt2)

Classified according to Soil Taxonomy Second Edition, 1999; Keys to Soil Taxonomy Eleventh Edition, 2010

Revised for the correlation of Graham County, AZ, Southwestern Part, March 2011, WWJ

National Cooperative Soil Survey

U.S.A.

Attachment B: Agronomic Laboratory Data

Table B1: Complete Channel Core Data

Sample ID	Collection Date	Soil Map Unit Symbol	Depth	Saturation Percentage	pH	Electrical Conductivity	Calcium	Magnesium	Sodium	Sodium Absorption Ratio	Nitrate Nitrogen	Olsen Phosphorus	Available Potassium	Organic Matter	Lime	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay	Texture
			inches	*%*	*s.u.*	*mmhos/cm*	*------------ meq/L ------------*			*calculated*	*------------- mg/kg -------------*			*----- % -----*		*----------------- % -----------------*					
Channel Core #1	6/6/2015	Pm	0-27	47.6	7.6	2.3	18.1	2.77	1.45	0.4	56	5	397	2	4.25	4	32	30	44	26	L
	6/6/2015	Pm	27-53	33.1	7.5	5.2	40.4	14.8	1.64	0.3	85	2	126	2.9	2.93	7	10	58	26	16	SL
	6/6/2015	Pm	53-67	30.7	7.5	4.4	34	15.3	0.87	0.2	69	2	112	0.5	2.31	23	16	64	22	14	SL
	6/6/2015	Pm	67-96	34.1	7.7	2.3	18	7.62	0.62	0.2	19	2	139	0.6	5.24	7	27	50	34	16	L
Channel Core #2	6/7/2015	Pm	0-25	42.9	7.7	1.1	7.7	2.91	0.3	0.1	5.7	3	234	1.7	4.02	4	48	50	26	24	SCL
	6/7/2015	Pm	25-37	37.9	7.8	1.6	12.5	5.37	0.34	0.1	1.2	1	119	0.8	5.74	5	27	46	32	22	L
	6/7/2015	Pm	37-58	33	7.9	1.4	10.1	4.35	0.49	0.2	1.2	1	122	0.4	4.86	26	21	54	27	19	SL
	6/7/2015	Pm	58-80	32.6	7.8	1.2	8.61	3.72	0.57	0.2	3.1	2	137	0.7	4.44	10	17	58	26	16	SL
	6/7/2015	Pm	80-96	24.6	8	0.9	5.27	2.21	0.76	0.4	2.3	2	112	0.6	8.82	51	9	70	16	14	SL
	6/7/2015	Pm	0-96	34.9	7.8	1.2	8.87	3.65	0.44	0.2	3.5	2	145	1	4.78	25	20	50	30	20	L
Channel Core #3	6/7/2015	Pm	0-21	46.3	7.7	0.9	6.56	2.64	0.49	0.2	14	3	298	2.3	3.86	2	31	30	42	28	CL
	6/7/2015	Pm	21-36	42.9	7.8	1	7.25	2.99	0.32	0.1	3.5	1	161	0.7	5.12	3	32	38	38	24	L
	6/7/2015	Pm	36-58	37.8	7.8	1	7.3	3	0.33	0.2	1.5	1	137	0.6	5.37	9	26	44	34	22	L
	6/7/2015	Pm	58-94	28.2	7.8	0.9	6.71	2.77	0.37	0.2	1.1	1	104	0.2	5.38	11	13	62	22	16	SL
	6/7/2015	Pm	0-94	39	7.8	1	6.8	2.82	0.42	0.2	4.9	2	189	0.8	4.78	9	19	44	32	24	L
Channel Core #4	6/8/2015	Pm	0-22	47.1	7.7	0.9	6.08	2.44	0.3	0.2	22	2	260	2.2	3.89	2	47	22	48	30	CL
	6/8/2015	Pm	22-45	43.8	7.7	1.4	10	4.28	0.51	0.2	11	1	176	0.7	5.87	6	40	32	40	28	CL
	6/8/2015	Pm	45-77	43.6	7.8	1.6	12.7	5.43	0.5	0.2	4.1	1	173	0.6	5.59	2	53	38	38	24	L
	6/8/2015	Pm	77-108	39.1	7.8	1.6	12.4	5.23	0.41	0.1	2.2	2	154	<0.2	6.46	2	35	38	42	20	L
	6/8/2015	Pm	0-108	45.3	7.7	1.4	10.7	4.43	0.46	0.2	10	2	216	1	5.34	2	37	28	44	28	CL
Channel Core #5	6/8/2015	Pm	0-12	50.8	7.7	0.8	5.56	2.24	0.15	<0.1	1.9	4	230	2.5	4.62	4	38	28	48	24	L
	6/8/2015	Pm	12-33	36.6	7.8	0.5	3.62	1.54	0.24	0.2	1	1	136	0.9	5.9	23	15	50	27	23	SCL
	6/9/2015	Pm	33-46	33.1	7.8	0.8	5.49	2.34	0.34	0.2	1	1	125	0.4	7.02	8	17	58	22	20	SCL
	6/7/2015	Pm	46-59	25.5	7.9	1.5	11.3	4.4	0.85	0.3	1	1	116	0.2	4.76	41	3	66	18	16	SL
Channel Core #6	6/7/2015	GbB	0-29	29.5	8	0.6	3.68	0.57	0.12	<0.1	3.4	3	248	0.4	3.99	5	12	74	16	10	SL
	6/8/2015	GbB	29-45	34.1	7.8	1.1	8.53	1.31	0.63	0.3	22	5	104	1.3	5.41	18	19	52	30	18	L
	6/8/2015	GbB	45-80	23.2	7.8	2	13.7	2.85	1.68	0.6	23	3	190	0.2	3.63	40	5	64	22	14	SL
	6/8/2015	GbB	0-80	26.7	7.8	1.6	14.1	2.15	0.61	0.2	18	3	143	0.5	4.52	34	12	65	21	14	SL
Channel Core #7	6/9/2015	GbB	0-7	28	7.9	0.6	5	0.81	0.13	<0.1	6.7	6	246	0.8	3.11	24	14	66	22	12	SL
	6/9/2015	GbB	7-23	22.1	8	0.6	3.95	0.71	0.88	0.6	1	2	117	0.2	4.04	43	5	68	18	14	SL
	6/9/2015	GbB	0-60	23.7	7.9	0.5	4.26	0.77	0.39	0.2	1.8	2	117	0.4	3.68	42	7	72	16	12	SL

Table B1 (continued): Complete Channel Core Data

Sample ID	Collection Date	Soil Map Unit Symbol	Depth	Saturation Percentage	pH	Electrical Conductivity	Calcium	Magnesium	Sodium	Sodium Absorption Ratio	Nitrate Nitrogen	Olsen Phosphorus	Available Potassium	Organic Matter	Lime	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay	Texture
			inches	*%*	*s.u.*	*mmhos/cm*	------------ *meq/L* ------------			*calculated*	-------------- *mg/kg* --------------			----- *%* -----		----------------- *%* -----------------					
Channel Core #8	6/9/2015	GbB	0-36	39.1	7.8	0.4	2.38	0.73	0.34	0.3	1	2	164	0.6	5.31	9	22	36	39	25	L
	6/9/2015	GbB	36-48	24	8.1	0.4	1.9	0.65	0.93	0.8	1	1	116	0.3	4.99	47	10	72	13	15	SL
	6/9/2015	GbB	48-61	21	8.1	0.4	1.8	0.58	0.82	0.8	1	1	113	0.3	3.37	45	5	72	13	15	SL
	6/9/2015	GbB	61-76	21.4	8.1	0.4	1.88	0.59	0.75	0.7	1	1	122	0.2	3.62	30	5	73	14	13	SL
	6/9/2015	GbB	76-89	20.6	8.1	0.4	1.89	0.54	0.66	0.6	1	1	103	0.2	3.87	26	6	74	13	13	SL
Channel Core #10	6/10/2015	Pm	0-24	42.4	7.2	0.6	4.93	0.8	0.12	<0.1	3	5	489	2.7	2.12	2	18	38	39	23	L
	6/10/2015	Pm	24-57	39.2	7.7	0.4	3.29	0.46	0.47	0.3	1.6	2	125	1.2	4.4	2	38	40	43	17	L
	6/10/2015	Pm	57-85	24.5	7.6	2.2	22.7	3.3	1.72	0.5	1.8	3	121	0.6	2.24	57	8	68	21	11	SL
	6/10/2015	Pm	85-96	25.5	7.9	0.6	4.61	0.83	0.84	0.5	3.1	2	102	0.3	1.9	17	15	76	13	11	SL
	6/10/2015	Pm	0-120	36.1	7.7	0.8	6.51	0.97	0.53	0.3	2	3	196	1.2	3.68	40	25	44	37	19	L
Channel Core #12	6/10/2015	Pm	0-14	34.8	7.9	0.4	2.2	0.43	0.08	<0.1	3.5	6	335	0.9	3.66	2	27	66	25	9	SL
	6/10/2015	Pm	14-34	51.2	7.8	0.5	3.87	0.64	0.54	0.4	6.5	13	183	2.1	2.82	38	28	24	61	15	SiL
	6/10/2015	Pm	34-56	34.1	7.5	3.1	25.4	6.54	1.35	0.3	80	5	154	0.7	3.09	13	20	60	27	13	SL
	6/10/2015	Pm	56-86	28.4	7.5	3.6	33.5	5.58	0.93	0.2	130	3	120	0.6	2.74	19	6	68	19	13	SL
	6/10/2015	Pm	86-102	26.8	7.6	2.4	20.5	3.43	1.34	0.4	68	2	130	0.3	1.58	41	9	70	9	21	SCL
	6/10/2015	Pm	0-144	35.9	7.6	2.7	22.7	3.97	0.93	0.2	83	4	187	1	3.08	16	22	56	27	17	SL
Channel Core #14	6/11/2015	GbB	0-9	31.5	7.6	0.5	3.57	0.77	0.11	<0.1	2.7	5	354	1.6	1.94	16	20	46	34	20	L
	6/11/2015	GbB	9-26	44.4	7.6	2.3	25.5	4.05	0.6	0.2	1	2	147	1.4	3.07	3	38	26	50	24	SiL
	6/11/2015	GbB	26-48	25.8	7.5	2.9	25.1	9.86	4.63	1.1	1.8	2	90	0.7	1.92	11	9	66	18	16	SL
	6/11/2015	GbB	48-72	21.7	7.7	2.5	22.1	6.14	3.9	1	1.9	2	127	0.2	1.38	37	5	70	16	14	SL
	6/11/2015	GbB	0-72	31.4	7.6	2.6	26.5	7.03	2.9	0.7	1.9	2	138	1	2.38	21	8	50	30	20	L
Channel Core #15	6/11/2015	GbB	0-10	28.8	7.5	0.8	5	1.26	0.14	<0.1	12	12	398	1.1	1.15	17	15	70	18	12	SL
	6/11/2015	GbB	10-40	25.1	8	0.4	2.83	0.53	0.22	0.2	1.4	4	186	0.3	1.38	22	9	76	14	10	SL
	6/11/2015	GbB	40-48	36.9	7.7	0.4	2.56	0.72	0.35	0.3	1.5	5	240	1.2	1.32	7	18	42	32	26	L
	6/11/2015	GbB	0-48	25.4	7.7	0.4	2.87	0.7	0.23	0.2	2.4	5	178	0.6	1.4	17	12	70	16	14	SL
Channel Core #17	6/12/2015	GbB	0-13	44.3	7.9	0.6	4.37	0.58	0.12	<0.1	7.4	10	595	1.6	3.25	3	24	38	38	24	L
	6/12/2015	GbB	13-29	29.1	7.9	0.5	4.54	0.65	0.26	0.2	6.1	4	114	0.4	2.35	21	16	70	16	14	SL
	6/12/2015	GbB	29-54	30.7	8	0.5	3.56	0.63	0.35	0.2	2.8	2	134	0.3	3.32	36	19	68	20	12	SL
	6/12/2015	GbB	54-74	29.7	7.9	0.5	3.89	0.66	0.32	0.2	5.4	6	213	0.5	2.6	36	16	64	22	14	SL
	6/12/2015	GbB	74-102	22.3	8.1	0.3	1.93	0.54	0.39	0.4	1.5	2	117	0.2	1.8	49	5	86	6	8	LS
	6/12/2015	GbB	0-120	30.5	7.8	0.5	4.01	0.65	0.38	0.2	4.3	4	178	0.6	2.97	29	19	64	20	16	SL

Table B1 (continued): Complete Channel Core Data

Sample ID	Collection Date	Soil Map Unit Symbol	Depth	Saturation Percentage	pH	Electrical Conductivity	Calcium	Magnesium	Sodium	Sodium Absorption Ratio	Nitrate Nitrogen	Olsen Phosphorus	Available Potassium	Organic Matter	Lime	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay	Texture
			inches	*%*	*s.u.*	*mmhos/cm*	------------ *meq/L* ------------			*calculated*	-------------- *mg/kg* --------------			----- *%* -----		------------------ *%* ------------------					
Channel Core #18	6/12/2015	GbB	0-12	50.4	7.7	0.4	3.24	0.46	0.24	0.2	1	2	250	1.3	4.36	6	37	22	48	30	CL
	6/12/2015	GbB	12-47	27.5	7.9	0.4	2.49	0.49	0.54	0.4	1	1	88	0.4	1.85	27	9	70	16	14	SL
	6/12/2015	GbB	47-76	59.7	7.8	0.8	5.61	1.14	1.24	0.7	1	2	281	0.6	3.21	10	11	34	32	34	CL
	6/12/2015	GbB	76-114	34.5	7.9	0.5	3.42	0.82	1.02	0.7	1	3	100	0.2	4.75	5	30	56	26	18	SL
	6/12/2015	GbB	114-132	30.6	7.9	0.4	2.9	0.72	0.66	0.5	1	2	112	0.2	3.28	44	14	62	20	18	SL
	6/12/2015	GbB	0-132	38.4	7.8	0.6	3.98	0.76	0.93	0.6	1	2	174	0.4	3.07	20	14	50	26	24	SCL
Channel Core #19	6/12/2015	GbB	0-24	53.4	7.4	0.5	4.07	0.78	0.12	<0.1	2.4	5	490	2	3.19	2	42	20	48	32	SiCL
	6/12/2015	GbB	24-50	40.4	7.7	0.5	3.51	1	0.29	0.2	1.5	3	155	1.1	3.22	6	24	42	38	20	L
	6/12/2015	GbB	50-72	26.3	7.8	0.8	4.79	1.37	0.99	0.6	1	3	118	0.4	2.35	43	8	74	16	10	SL
	6/12/2015	GbB	72-97	60.6	7.8	0.8	4.53	1.21	1.87	1.1	1	4	258	0.5	4.39	2	47	17	47	36	SiCL
	6/12/2015	GbB	97-132	26.3	7.9	0.6	3.45	0.95	0.86	0.6	1	3	105	0.2	3.49	20	3	70	18	12	SL
	6/12/2015	GbB	0-132	45.2	7.8	0.6	3.85	1.01	0.96	0.6	1.5	3	241	0.8	3.47	21	16	42	34	24	L
Channel Core #20	6/13/2015	GbB	0-18	38.1	7.4	0.8	6.03	1.22	0.14	<0.1	5.2	7	437	1.3	3.2	2	45	52	36	12	L
	6/13/2015	GbB	8-42	57.6	7.4	4.3	42.1	6.65	1.19	0.2	190	8	242	2.1	2.75	7	58	16	53	31	SiCL
	6/13/2015	GbB	42-60	35.1	7.3	4.1	34.2	5.25	0.7	0.2	150	3	181	0.7	2.78	5	22	54	30	16	SL
	6/13/2015	GbB	60-78	36.1	7.6	2	14.8	2.01	0.42	0.1	84	2	220	0.5	2.2	5	26	48	34	18	L
	6/13/2015	GbB	78-108	59.9	7.6	0.9	6.23	1.13	0.45	0.2	27	2	275	0.5	2.65	2	61	14	48	38	SiCL
	6/13/2015	GbB	0-108	48.7	7.4	2.4	20.4	3.23	0.64	0.2	90	3	266	0.9	2.68	4	33	34	40	26	L
Channel Core #21	6/13/2015	GbB	0-23	31.5	7.8	0.5	3.76	0.58	0.12	<0.1	1.9	4	235	0.7	3.26	16	25	53	35	12	SL
	6/13/2015	GbB	23-35	41.8	7.8	0.4	3.2	0.46	0.25	0.2	2.7	5	132	1.2	3.44	2	39	36	44	20	L
	6/13/2015	GbB	35-63	32.9	7.7	0.4	3.36	0.54	0.25	0.2	2.4	5	127	1.1	1.76	7	11	48	30	22	L
	6/13/2015	GbB	63-96	24.6	7.8	0.4	2.97	0.54	0.31	0.2	2.1	3	100	0.4	1.09	48	4	67	19	14	SL
	6/13/2015	GbB	0-98	30	7.7	0.4	3.61	0.55	0.28	0.2	4.1	6	224	0.8	2.14	15	13	58	26	16	SL

Table B2: Complete Repository Data

Sample ID	Collection Date	Soil Map Unit Symbol	Depth	Saturation Percentage	pH	Electrical Conductivity	Calcium	Magnesium	Sodium	Sodium Absorption Ratio	Nitrate Nitrogen	Olsen Phosphorus	Available Potassium	Organic Matter	Lime	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay	Texture
			inches	*%*	*s.u.*	*mmhos/cm*	------------ *meq/L* ------------			*calculated*	-------------- *mg/kg* --------------			----- *%* -----		----------------- *%* -----------------					
North Stockpile A	6/5/2015	WtF	0-4	28.4	7	0.4	2.4	0.98	0.2	0.2	3.4	5	279	1.3	0.36	56	2	64	18	18	SL
		WtF	4-12	28.6	6.2	0.3	1.81	0.84	0.21	0.2	2.4	3	261	1	0.35	51	4	62	16	22	SCL
North Stockpile B	6/5/2015	WtF	0-4	48.7	6.6	1.3	9.85	1.69	0.2	<0.1	51	24	436	5.1	1.03	53	12	70	12	18	SL
		WtF	4-10	36	6.8	0.8	6.91	1.28	0.2	0.1	18	14	381	3	0.7	50	12	62	14	24	SCL
North Stockpile C	6/5/2015	WtF	0-4	41.9	7.5	0.4	3.45	0.51	0.23	0.2	1.1	2	158	1.2	1.08	64	4	52	12	36	SC
		WtF	4-10	42.8	7.7	0.4	3.65	0.56	0.18	0.1	1.4	11	231	1.8	1.31	65	11	50	14	36	SC
North Stockpile D	6/6/2015	Pm	0-10	52.3	7.8	0.8	5.66	2.11	0.12	<0.1	19	12	402	2.9	4.97	2	57	24	52	24	SiL
		Pm	10-28	41.3	7.8	0.8	5.12	2.21	0.23	0.1	13	1	168	1	5.23	5	41	38	40	22	L
North Stockpile E	6/6/2015	Pm	0-10	41.1	7.9	0.6	4.06	1.75	0.24	0.1	5.1	3	189	1.2	4.29	4	38	40	40	20	L
		Pm	10-31	37.8	7.9	1.8	14.8	6.27	0.54	0.2	1.6	1	118	0.9	5.14	11	33	48	34	18	L
North Stockpile F	6/6/2015	Pm	0-13	46.9	7.7	0.5	3.88	1.46	0.09	<0.1	13	5	300	2.2	4.34	4	38	34	42	24	L
		Pm	13-25	45.6	7.9	0.3	1.98	0.9	0.13	0.1	2.1	1	166	1.1	4.95	9	33	24	48	28	CL
South Stockpile A	6/6/2015	WtF	0-4	36.4	6.3	0.7	4.57	1.03	0.13	<0.1	9.7	18	274	3	0.87	58	18	68	8	24	SCL
		WtF	4-10	28.5	6.7	0.5	3.34	0.96	0.16	0.1	6.4	7	261	1.4	0.67	43	14	64	18	18	SL
South Stockpile B	6/6/2015	WtF	0-3	38.5	6.9	0.6	4.12	1.27	0.11	<0.1	3.8	7	582	3	1.01	59	19	58	20	22	SCL
South Stockpile C	6/6/2015	Pm	0-13	46.2	7.8	0.7	5.09	2.02	0.18	0.1	11	3	277	2.4	4.03	19	27	34	36	30	CL
		Pm	13-38	49.7	7.8	1.4	12	4.7	0.32	0.1	3.2	1	162	1.5	7.17	7	32	20	52	28	SiCL
South Stockpile D	6/6/2015	Pm	0-12	38.3	7.8	0.7	4.83	1.88	0.26	0.1	1	2	212	1.4	3.87	11	24	38	38	24	L
		Pm	12-24	37.3	7.8	1.9	18	7.04	0.56	0.2	1	1	115	0.6	5.2	7	46	40	40	20	L
South Stockpile E	6/6/2015	Pm	0-16	45.3	7.9	0.7	5.52	0.77	0.44	0.2	6.6	3	345	2	3.89	5	19	26	44	30	CL
		Pm	16-29	37.3	7.6	3.5	31.1	4.78	1.15	0.3	9	2	80	0.9	7.23	3	37	50	34	16	L

Table B3: Complete Representative Terrace Data

Transect	Stream Side (looking downstream)	Terrace	Collection Date	Terrace Width	Depth	Saturation Percentage	pH	Electrical Conductivity	Calcium	Magnesium	Sodium	Sodium Absorption Ratio	Nitrate Nitrogen	Olsen Phosphorus	Available Potassium	Organic Matter	Lime	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay	Texture	Soil Map Unit Symbol
				feet	*inches*	*%*	*s.u.*	*mmhos/cm*	------------ *meq/L* ------------			*calculated*	-------------- *mg/kg* --------------			----- *%* -----		----------------- *%* -----------------						
Reach #2																								
T2-1	Left	T1-T2	6/5/2015	6	0-6	33.8	7.7	0.7	5.3	0.78	0.14	<0.1	6.4	10	432	2.4	3.33	3	18	60	24	16	SL	WoE
					6-12	33.9	7.7	0.7	5.61	0.82	0.42	0.2	4.7	5	199	1.7	4.3	5	14	52	28	20	L	WoE
	Right	T1	6/5/2015	18.1	0-6	29.8	7.8	0.4	3.82	0.66	0.1	<0.1	1.2	3	134	0.8	1.22	12	9	78	12	10	SL	WoE
					6-12	29.4	7.8	0.4	3.56	0.7	0.15	0.1	4.9	6	136	1.1	1.15	29	8	78	12	10	SL	WoE
T2-2	Left	T2	6/5/2015	10.5	0-6	35.1	7.3	0.6	5.18	0.65	0.15	<0.1	4	4	232	2.2	1.94	2	14	68	20	12	SL	WoE
	Right	T1	6/5/2015	20.6	0-6	26.5	7.2	0.5	3.09	0.44	0.2	0.2	2.9	3	129	0.2	0.96	29	<1	86	6	8	LS	WoE
					6-12	26.3	7.1	0.5	3.64	0.46	0.31	0.2	2.3	2	130	0.4	1.12	29	4	84	8	8	LS	WoE
		T2	6/5/2015	22.2	0-6	27.6	7.7	0.7	5.35	0.84	0.11	<0.1	2.4	6	230	1.3	1.6	32	8	72	18	10	SL	WoE
					6-12	30.6	7.6	0.8	6.77	1	0.14	<0.1	2.1	6	245	1.5	1.77	41	7	68	20	12	SL	WoE
T2-3	Left	T1	6/5/2015	24.5	0-6	32.8	7.5	0.5	3.92	0.59	0.09	<0.1	2.5	3	273	1	1.95	2	10	72	18	10	SL	WoE
					6-12	30.2	7.5	0.5	3.75	0.52	0.1	<0.1	2	3	236	0.4	1.77	3	9	74	16	10	SL	WoE
	Right	T1	6/5/2015	13.6	0-6	30.2	7.6	0.3	2.17	0.41	0.12	0.1	1.7	5	117	0.4	0.93	10	3	84	8	8	LS	WoE
					6-12	28	7.5	0.3	2.42	0.45	0.14	0.1	3.2	5	129	0.2	0.92	22	<1	76	18	6	SL	WoE
		T2	6/5/2015	24.2	0-6	28.6	7.4	0.4	2.37	0.53	0.1	<0.1	5.3	6	395	0.8	1.06	14	8	76	14	10	SL	WoE
					6-12	28.4	7.4	0.3	1.79	0.41	0.09	<0.1	2.3	4	320	0.5	1.22	11	9	78	12	10	SL	WoE
Reach #6																								
T6-1	Left	T1	6/1/2015	21.7	0-6	39.9	7.8	0.6	5.38	0.78	0.13	<0.1	12	4	200	1.7	5.25	6	35	60	29	11	SL	GbB
					6-12	32.1	7.9	0.5	5.22	0.76	0.23	0.1	8.8	3	104	1	4.6	17	26	66	23	11	SL	GbB
		T2	6/1/2015	42.8	0-6	26.6	7.8	0.5	5	0.64	0.14	<0.1	4.6	5	116	0.6	3.17	32	13	84	9	7	LS	GbB
					6-12	26.5	7.9	0.3	2.71	0.34	0.17	0.1	1	2	108	0.6	3.6	24	9	82	9	9	LS	GbB
	Right	T1	6/1/2015	9.1	0-6	28.3	7.9	0.7	6.41	1.08	0.13	<0.1	3.5	5	147	0.7	4.31	28	9	76	15	9	SL	GbB
					6-12	26.9	8	0.5	4.09	0.65	0.17	0.1	1.9	3	117	0.4	4.21	40	6	82	9	9	LS	GbB
		T1-T2	6/1/2015	21.4	0-6	39.3	7.7	0.9	6.52	1.11	0.11	<0.1	24	5	321	2.3	5.25	8	35	56	31	13	SL	GbB
					6-12	38.6	7.6	0.9	8.33	1.49	0.19	<0.1	26	8	321	2.9	5.36	22	26	58	27	15	SL	GbB
T6-2	Left	T1	6/2/2015	30.5	0-6	25.9	7.5	0.6	5.82	1.01	0.24	0.1	1	1	109	0.3	4.22	56	2	84	7	9	LS	GbB
					6-12	24	7.9	0.3	2.09	0.43	0.22	0.2	1	1	81	0.2	5.12	51	<1	82	9	9	LS	GbB
		T2	6/2/2015	41.2	0-6	29.5	7.9	0.6	5.17	0.78	0.14	<0.1	2	4	224	1.4	4	34	19	66	21	13	SL	GbB
					6-12	28.5	7.9	0.6	4.89	0.73	0.22	0.1	2.1	4	222	1.1	4.78	59	14	70	19	11	SL	GbB
	Right	T1	6/2/2015	29.3	0-6	33.7	7.7	0.5	4.28	0.82	0.14	<0.1	1	3	214	1.4	4.17	3	29	56	29	15	SL	GbB
					6-12	26.8	7.7	0.6	5.39	0.83	0.18	0.1	1	2	104	0.7	4.16	57	3	78	11	11	SL	GbB
		T2	6/2/2015	7.6	0-6	30.4	7.6	0.7	7.09	1.19	0.17	<0.1	1.9	6	182	1.3	4.57	49	9	74	15	11	SL	GbB
					6-12	34.4	7.8	0.4	2.75	0.72	0.14	0.1	2.2	1	113	1.1	6.53	2	29	50	33	17	L	GbB
T6-3	Left	T1	6/2/2015	47.5	0-6	33.3	8	0.5	4.41	0.61	0.12	<0.1	3.1	4	304	1.1	4.3	21	25	66	22	12	SL	GbB
					6-12	28.4	8	0.5	3.75	0.55	0.15	0.1	2.3	3	244	0.6	3.9	41	16	69	19	12	SL	GbB
		T2	6/2/2015	24.1	0-6	31.2	7.9	0.4	3.4	0.79	0.16	0.1	1.4	1	195	0.8	3.9	3	31	54	30	16	SL	GbB
					6-12	35.9	7.9	0.4	3.07	0.93	0.26	0.2	1.9	1	111	0.9	4.6	3	33	54	30	16	SL	GbB
	Right	T1	6/2/2015	49.8	0-6	26.5	7.9	0.7	5.37	0.79	0.15	<0.1	3.9	3	295	0.6	3.6	36	6	78	12	10	SL	GbB
					6-12	25.2	8.1	0.3	2.79	0.38	0.23	0.2	2.3	1	130	0.2	2.9	49	<1	80	12	8	LS	GbB
		T2	6/2/2015	42.2	0-6	31.9	7.9	0.6	4.36	0.92	0.13	<0.1	4.4	2	348	0.9	5	12	24	60	24	16	SL	GbB
					6-12	34.5	7.9	0.5	4	0.88	0.17	0.1	3.9	2	195	0.7	4.8	12	24	56	28	16	SL	GbB

Table B3 (continued): Complete Representative Terrace Data

Transect	Stream Side (looking downstream)	Terrace	Collection Date	Terrace Width	Depth	Saturation Percentage	pH	Electrical Conductivity	Calcium	Magnesium	Sodium	Sodium Absorption Ratio	Nitrate Nitrogen	Olsen Phosphorus	Available Potassium	Organic Matter	Lime	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay	Texture	Soil Map Unit Symbol
				feet	*inches*	*%*	*s.u.*	*mmhos/cm*	------------ *meq/L* ------------			*calculated*	-------------- *mg/kg* --------------			----- *%* -----		----------------- *%* -----------------						
Reach #6.5																								
T6.5-1	Left	T1-T2	6/3/2015	28.7	0-6	28.7	7.9	0.3	2.39	0.42	0.11	<0.1	1.3	3	190	0.5	2.29	5	6	77	13	10	SL	Pm
					6-12	27.8	8	0.3	2.11	0.35	0.16	0.1	1.5	2	138	0.4	2.27	12	3	80	11	9	LS	Pm
		T2	6/3/2014	71.6	0-6	39.9	7.7	0.5	3.68	0.6	0.08	<0.1	6.2	8	661	1.4	3.47	2	35	38	43	19	L	Pm
					6-12	30.6	7.7	0.5	3.94	0.6	0.14	<0.1	4.4	4	259	0.9	2.99	2	15	60	25	15	SL	Pm
	Right	T1	6/3/2015	39.1	0-6	38.9	7.7	1.2	9.1	1.49	0.17	<0.1	33	10	256	1.8	3.83	5	25	66	21	13	SL	GbB
					6-12	27.6	7.7	0.9	6.43	0.98	0.26	0.1	19	6	152	1	2.66	35	9	70	19	11	SL	GbB
		T2	6/3/2015	70.9	0-6	28.7	7.8	0.5	3.66	0.57	0.08	<0.1	1.4	4	300	0.9	2.65	17	16	70	19	11	SL	GbB
					6-12	27.3	7.8	0.5	4.08	0.63	0.14	<0.1	1.5	4	227	0.9	2.77	29	14	72	15	13	SL	GbB
T6.5-2	Left	T1	6/3/2015	62.2	0-6	31	7.9	0.4	2.6	0.49	0.16	0.1	2.9	5	315	0.8	2.27	4	8	74	16	10	SL	Pm
					6-12	31.3	7.9	0.4	3.49	0.53	0.11	<0.1	2.5	5	244	0.7	2.31	3	11	76	14	10	SL	Pm
		T2	6/3/2015	13	0-6	41.8	7.5	0.6	4.32	0.78	0.13	<0.1	14	12	437	2.1	2.8	3	24	44	35	21	L	Pm
					6-12	49.8	7.6	0.7	4.75	0.73	0.21	0.1	15	7	424	2	3.15	2	27	32	43	25	L	Pm
	Right	T1	6/2/2015		0-6	47.1	7.7	0.8	6.85	1.18	0.22	0.1	33	8	335	2.4	3.73	2	45	46	40	14	L	GbB
					6-12	33.4	7.7	0.8	6.28	0.97	0.33	0.2	17	4	146	1.5	3.4	27	20	56	30	14	SL	GbB
		T2	6/2/2015	77.8	0-6	27.9	7.8	0.6	4.96	0.86	0.13	<0.1	1.7	5	227	0.7	2.8	22	12	68	19	13	SL	GbB
					6-12	28.3	7.9	0.5	4.12	0.67	0.14	<0.1	1.4	3	199	0.6	2.77	26	14	72	18	10	SL	GbB
T6.5-3	Left	T1	6/2/2015	73.5	0-6	41.7	7.7	0.3	2.87	0.42	0.21	0.2	3.3	3	210	1.4	3.7	2	32	36	44	20	L	Pm
					6-12	48.4	7.8	0.5	4.11	0.69	0.18	0.1	5.5	8	487	2.1	5	2	61	28	50	22	SiL	Pm
	Right	T2	6/2/2015	88.9	0-6	29.4	7.9	0.7	5.19	0.99	0.18	0.1	9.5	7	454	1	2.3	32	9	70	18	12	SL	Pm
					6-12	27	7.8	0.7	4.62	0.83	0.31	0.2	11	6	359	1.2	2.43	44	8	72	16	12	SL	Pm
Reach #7																								
T7-1	Left	T1	6/3/2015	37.3	0-6	40.6	8.1	0.6	4.37	0.95	0.35	0.2	1	4	228	1.9	3.58	5	39	56	32	12	SL	Pm
			6/3/2015		6-12	33.4	8	0.5	4.33	0.95	0.31	0.2	1	5	200	1.2	2.84	31	27	64	22	14	SL	Pm
		T2	6/3/2015	39.6	0-6	28.8	7.8	0.3	2.44	0.52	0.14	0.1	1.8	4	170	0.6	1.95	23	8	74	14	12	SL	Pm
			6/3/2015		6-12	29.6	7.8	0.4	2.78	0.57	0.13	0.1	2.5	4	177	0.7	2.02	17	17	72	15	13	SL	Pm
		T3	6/3/2015	10.8	0-6	47.1	7.6	0.6	4.32	0.79	0.12	<0.1	14	12	622	3.7	2.53	6	29	40	35	25	L	Pm
			6/3/2015		6-12	54.7	7.6	0.6	4.46	0.84	0.11	<0.1	14	9	455	3.4	2.58	2	30	24	43	33	CL	Pm
	Right	T3	6/3/2015	4.7	0-6	37.7	7.8	0.6	4.71	0.75	0.32	0.2	3.2	4	248	0.9	2.68	17	21	51	29	20	L	GbB
			6/3/2015		6-12	38.1	7.8	0.7	5.86	0.94	0.33	0.2	4	5	261	0.9	2.75	17	21	52	26	22	SCL	GbB
T7-2	Left	T1	6/4/2015	50.4	0-6	33.4	7.9	0.5	3.89	0.91	0.26	0.2	4.9	6	154	0.9	2.52	89	23	62	24	14	SL	Pm
			6/4/2015		6-12	29.7	8	0.4	3.34	0.7	0.23	0.2	4.9	5	156	0.7	2.47	63	16	68	20	12	SL	Pm
		T2	6/4/2015	78.9	0-6	35.4	7.7	0.5	3.64	0.55	0.11	<0.1	5.1	8	227	0.9	1.84	45	21	66	22	12	SL	Pm
			6/4/2015		6-12	29.3	7.8	0.5	3.88	0.58	0.13	<0.1	2.3	4	177	0.9	1.94	70	14	68	18	14	SL	Pm
T7-3	Left	T1	6/4/2015	42.4	0-6	34.9	7.7	0.7	5.03	0.92	0.24	0.1	19	8	297	1.4	3	2	18	66	22	12	SL	Pm
			6/4/2015		6-12	30.3	7.8	0.5	3.59	0.71	0.18	0.1	7.4	4	141	0.7	1.8	5	3	78	12	10	SL	Pm
		T2	6/4/2015	62.5	0-6	31.1	7.4	1.4	11.3	2.71	0.37	0.1	4.7	11	379	1.5	1.97	58	<1	74	16	10	SL	Pm
			6/4/2015		6-12	26.7	7.8	0.8	5.74	1.22	0.48	0.3	3.6	7	287	1.2	1.47	57	5	80	10	10	SL	Pm

Table B3 (continued): Complete Representative Terrace Data

Transect	Stream Side (looking downstream)	Terrace	Collection Date	Terrace Width	Depth	Saturation Percentage	pH	Electrical Conductivity	Calcium	Magnesium	Sodium	Sodium Absorption Ratio	Nitrate Nitrogen	Olsen Phosphorus	Available Potassium	Organic Matter	Lime	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay	Texture	Soil Map Unit Symbol
				feet	*inches*	*%*	*s.u.*	*mmhos/cm*	------------ *meq/L* ------------			*calculated*	-------------- *mg/kg* --------------			----- *%* -----		----------------- *%* -----------------						
Reach #8																								
T8-1	Left	T1	6/4/2015	32.1	0-6	36.3	7.8	0.5	4.31	0.83	0.26	0.2	8.7	6	195	1.3	3.31	6	25	66	22	12	SL	Pm
			6/3/2015		6-12	30.5	7.8	0.5	3.94	0.74	0.25	0.2	7.5	4	163	1	2.78	16	16	70	20	10	SL	Pm
		T1-T2	6/4/2015	15.8	0-6	28.8	7.6	0.6	4.62	0.65	0.19	0.1	3.2	5	151	1	1.87	44	8	70	17	13	SL	Pm
		T2	6/4/2015	17.3	0-6	25.9	7.6	0.4	3.12	0.47	0.11	<0.1	1.3	4	131	0.5	1.42	28	2	80	9	11	SL	Pm
			6/4/2015		6-12	25.2	7.7	0.3	2.26	0.32	0.16	0.1	1	4	121	0.3	1.5	32	1	80	10	10	SL	Pm
	Right	T1	6/4/2015	81.3	0-6	24.2	7.8	0.3	2.83	0.4	0.24	0.2	1.5	3	120	0.6	1.19	35	5	80	10	10	SL	GbB
			6/4/2015		6-12	24.4	7.9	0.2	1.94	0.3	0.19	0.2	1.3	2	103	0.4	1.35	36	4	82	8	10	LS	GbB
T8-2	Left	T1	6/4/2015	27.4	0-6	39.5	7.6	0.6	5.01	1	0.2	0.1	11	11	301	1.9	3.54	2	26	56	29	15	SL	Pm
			6/4/2015		6-12	34	7.6	0.6	4.76	0.84	0.22	0.1	6.9	7	204	0.9	3.11	2	22	64	23	13	SL	Pm
		T2	6/4/2015	38	0-6	26.3	7.8	0.3	2.75	0.32	0.11	<0.1	1.6	3	89	0.4	1.64	36	2	81	10	9	LS	Pm
			6/4/2015		6-12	26	7.8	0.2	1.84	0.22	0.09	<0.1	2	2	84	0.3	1.79	33	3	82	9	9	LS	Pm
	Right	T1	6/4/2015	96	0-6	32.1	7.6	0.6	4.65	0.8	0.16	0.1	5.6	8	251	1.3	2.58	22	14	62	23	15	SL	GbB
			6/4/2015		6-12	31.3	7.6	0.5	3.79	0.61	0.17	0.1	3.3	6	205	1.1	2.69	20	15	62	23	15	SL	GbB
T8-3	Left	T1	6/4/2015	36.1	0-6	30.6	7.7	0.4	2.86	0.71	0.15	0.1	2.5	5	158	0.4	2.38	2	5	80	10	10	SL	Pm
			6/4/2015		6-12	32.2	7.7	0.5	3.78	0.83	0.22	0.1	7.2	4	202	1.1	2.59	2	6	72	17	11	SL	Pm
		T2	6/4/2015	43.9	0-6	44.1	7.6	0.6	4.46	0.89	0.19	0.1	11	9	347	2.5	3.92	2	50	44	40	16	L	Pm
			6/4/2015		6-12	34.6	7.7	0.4	3.35	0.6	0.21	0.2	5.9	4	160	0.4	2.65	2	23	64	25	11	SL	Pm
	Right	T1	6/4/2015	47.7	0-6	51.7	7.4	0.7	5.44	0.96	0.23	0.1	24	14	324	2.8	3.89	5	63	29	50	21	SiL	GbB
			6/4/2015		6-12	42.6	7.6	0.7	5.07	0.76	0.22	0.1	19	5	236	1.9	3.21	36	24	42	35	23	L	GbB
		T2	6/4/2015	60.4	0-6	24.3	7.8	0.6	4.64	0.64	0.24	0.2	4.4	6	126	0.6	1.79	45	2	74	12	14	SL	GbB
			6/4/2015		6-12	24.5	7.8	0.5	4.35	0.59	0.27	0.2	3.2	5	118	<0.2	1.4	50	<1	76	11	13	SL	GbB

Table B4: Complete Vertical Cut Bank Data

Sample ID	Collection Date	Soil Map Unit Symbol	Depth	Saturation Percentage	pH	Electrical Conductivity	Calcium	Magnesium	Sodium	Sodium Absorption Ratio	Nitrate Nitrogen	Olsen Phosphorus	Available Potassium	Organic Matter	Lime	Coarse Fragments	Very Fine Sand	Sand	Silt	Clay	Texture
			inches	*%*	*s.u.*	*mmhos/cm*	*----------- meq/L -----------*			*calculated*	*------------- mg/kg -------------*			*----- % -----*		*---------------- % ----------------*					
Highwall Core #9	6/9/2015	GbB	0-5	51.6	7.7	1.5	11.1	1.41	0.13	<0.1	52	3	569	0.5	5.26	14	60	30	53	17	SiL
	6/9/2015	GbB	5-20	24.7	8	0.6	4.4	0.62	0.18	0.1	7.6	7	165	0.2	3.27	80	4	80	11	9	LS
	6/9/2015	GbB	20-29	25.8	8	0.5	3.19	0.51	0.19	0.1	6	1	84	0.4	3.56	65	3	86	7	7	LS
	6/9/2015	GbB	29-40	22.5	7.8	0.5	3.48	0.7	0.2	0.1	5.9	2	108	0.2	2.74	68	2	76	13	11	SL
	6/9/2015	GbB	40-61	28.3	8	0.3	1.92	0.43	0.17	0.2	1.3	1	75	0.4	3.14	28	2	78	13	9	SL
	6/9/2015	GbB	61-83	23	7.9	0.4	2.64	0.47	0.31	0.2	1.9	1	66	0.3	2.8	80	4	80	11	9	LS
	6/9/2015	GbB	83-96	25.7	8	0.4	2.42	0.53	0.25	0.2	1.8	1	61	0.3	2.89	64	1	86	5	9	LS
Highwall Core #11	6/10/2015	Pm	0-12	33.2	7.6	0.9	4.78	1.55	0.11	<0.1	21	28	537	1.2	3.16	2	17	78	13	9	SL
	6/10/2015	Pm	12-25	31.8	7.8	1.1	5.8	1.42	0.18	<0.1	23	18	585	1	3	2	17	76	15	9	SL
	6/10/2015	Pm	25-32	33.8	7.8	1	6.5	1.03	0.23	0.1	21	16	464	0.8	1.76	7	24	57	28	15	SL
	6/10/2015	Pm	32-50	37.9	7.8	0.6	4.37	0.79	0.32	0.2	8.8	19	330	1.1	1.7	2	28	48	33	19	L
	6/10/2015	Pm	50-66	40.8	7.8	1.5	10.7	1.88	0.78	0.3	34	9	302	1.3	2.16	2	26	40	37	23	L
	6/10/2015	Pm	66-78	45.2	7.7	0.3	2.23	0.45	0.21	0.2	1.8	9	297	1.1	2.75	2	44	32	59	9	SiL
Highwall Core #13	6/11/2015	Pm	0-25	34.4	7.8	0.6	5.01	1.1	0.21	0.1	7.7	6	369	0.7	3.07	2	26	48	38	14	L
	6/11/2015	Pm	25-44	56.5	7.7	0.8	5.94	2.01	0.7	0.4	14	12	271	2.1	3.33	2	56	14	56	30	SiCL
	6/11/2015	Pm	44-58	40.2	7.5	2.3	20.2	4.47	1.41	0.4	32	8	201	1	1.8	12	16	40	36	24	L
	6/11/2015	Pm	58-68	25.1	7.7	0.9	7.22	1.51	0.62	0.3	9.8	4	112	0.4	1.86	67	5	76	12	12	SL
	6/11/2015	Pm	68-90	34.4	7.7	0.6	4.26	0.8	0.4	0.2	4.8	3	212	0.4	2.54	11	23	56	24	20	SCL
	6/11/2015	Pm	90-106	52.5	7.6	1	8.38	1.33	0.49	0.2	10	2	278	0.5	4.6	2	29	24	40	36	CL
Highwall Core #16	6/11/2015	GbB	0-30	25.7	7.6	0.7	4.95	1.28	0.18	0.1	8.4	6	150	0.7	1.11	52	6	66	22	12	SL
	6/11/2015	GbB	30-56	31.4	7.9	0.7	4.36	1.5	0.36	0.2	5.9	3	125	0.4	1.63	24	22	60	26	14	SL
	6/11/2015	GbB	56-72	42.7	7.6	0.7	5.13	1.05	0.84	0.5	8.9	3	274	0.9	1.61	12	26	34	36	30	CL
	6/11/2015	GbB	72-88	31.1	7.3	1	7.82	1.4	0.59	0.3	14	8	196	0.4	1.28	26	11	62	18	20	SCL
	6/11/2015	GbB	88-114	36	7.5	0.4	3.01	0.64	0.44	0.3	3.4	6	136	0.2	1.39	4	35	46	34	20	L

Attachment C: Complete Engineering Analysis Data

Bulk Density Data
Standard Proctor & Sieve Analysis Data

Table C1: Channel Core Bulk Density Data

Sample ID	Collection Date	Depth	Bulk Density
		inches	g/cc
Channel Core #1	6/6/2015	0-6	1.62
		67-96	1.48
Channel Core #2	6/7/2015	3-10	1.66
		58-80	1.59
Channel Core #3	6/7/2015	4-12	1.69
		58-94	1.63
Channel Core #4	6/8/2015	0-3	1.52
		22-45	1.58
Channel Core #5	6/8/2015	4-12	1.79
Channel Core #10	6/10/2015	24-57	1.40
Channel Core #12	6/10/2015	34-56	1.56
		79-86	1.72
Channel Core #17	6/12/2015	13-29	1.49
		74-102	2.08
Channel Core #18	6/12/2015	47-76	1.60
		76-114	1.53
Channel Core #19	6/12/2015	24-39	1.25
		72-97	1.60
Channel Core #20	6/13/2015	60-78	1.54
		78-108	1.78
Channel Core #21	6/13/2015	35-63	1.37

Table C2: Vertical Cut Bank Bulk Density Data

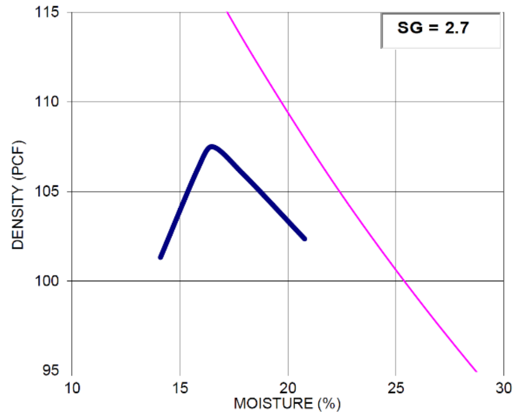
Sample ID	Collection Date	Depth	Bulk Density
		inches	g/cc
Highwall Core #11	6/10/2015	32.4-50.4	1.42
		66-78	1.48
Highwall Core #13	6/11/2015	44.4-57.6	1.58
		90-105.6	1.66
Highwall Core #16	6/11/2015	56.4-72	1.71

SAMPLE INFORMATION:

LOCATION: CORE#4
DEPTH (INCHES): 0"-108"
LAB TECHNICIAN: NAG

MECHANICAL SIEVE ANALYSIS		METHOD ASTM C136	
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76		
1.5"	38		
1.25"	31.5		
1"	25		
3/4"	19	100	
1/2"	12.5	99	
3/8"	9.5	99	
1/4"	6.4	97	
No. 4	4.8	96	
No. 8	2.36	96	
No. 10	2.00	95	
No. 16	1.18	93	
No. 30	0.60	90	
No. 40	0.425	88	
No. 50	0.3	85	
No. 100	0.15	76	
No. 200	0.075	62.7	

PROCTOR[1]	METHOD ASTM D 698 A
MAXIMUM DRY DENSITY (PCF)	107.5
OPTIMUM MOISTURE CONTENT (%)	16.5
ROCK CONTENT (%)[2]	4.0



ATTERBERG LIMITS	ASTM D4318	
	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

SOIL DESCRIPTION

CL : LEAN CLAY WITH SAND

REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON NO.4 SCREEN

*INDICATES OUT OF TOLERANCE

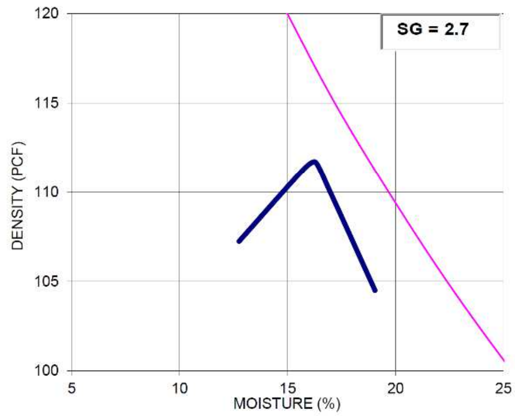
Ninyo & Moore		SOILS/AGGREGATE DATA SHEET	LAB NO.
PROJECT NO.	DATE SAMPLED	HABITAT / LABORATORY TESTING PHOENIX, AZ	TUC15-23
604790001	6/30/2015		

SAMPLE INFORMATION:

LOCATION: CORE #10
DEPTH (INCHES): 0"-120"
LAB TECHNICIAN: NAG

MECHANICAL SIEVE ANALYSIS			METHOD ASTM C136
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76	100	
1.5"	38	97	
1.25"	31.5	96	
1"	25	92	
3/4"	19	90	
1/2"	12.5	85	
3/8"	9.5	82	
1/4"	6.4	78	
No. 4	4.8	75	
No. 8	2.36	74	
No. 10	2.00	70	
No. 16	1.18	66	
No. 30	0.60	62	
No. 40	0.425	60	
No. 50	0.3	57	
No. 100	0.15	49	
No. 200	0.075	36.9	

PROCTOR[1]	METHOD ASTM D 698 A
MAXIMUM DRY DENSITY (PCF)	111.7
OPTIMUM MOISTURE CONTENT (%)	16.3
ROCK CONTENT (%)[2]	25.0



ATTERBERG LIMITS	ASTM D4318	
	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

SOIL DESCRIPTION

SC : CLAYEY SAND WITH GRAVEL

REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON NO.4 SCREEN

*INDICATES OUT OF TOLERANCE

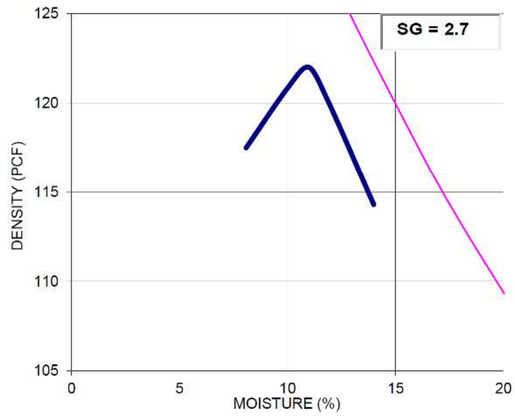
Ninyo & Moore		SOILS/AGGREGATE DATA SHEET	LAB NO.
PROJECT NO.	DATE SAMPLED	HABITAT / LABORATORY TESTING PHOENIX, AZ	TUC15-23
604790001	6/30/2015		

SAMPLE INFORMATION:

LOCATION: CORE #15
DEPTH (INCHES): 0"-48"
LAB TECHNICIAN: NAG

MECHANICAL SIEVE ANALYSIS		METHOD ASTM C136	
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76		
1.5"	38		
1.25"	31.5		
1"	25	100	
3/4"	19	99	
1/2"	12.5	98	
3/8"	9.5	96	
1/4"	6.4	95	
No. 4	4.8	93	
No. 8	2.36	92	
No. 10	2.00	88	
No. 16	1.18	82	
No. 30	0.60	76	
No. 40	0.425	71	
No. 50	0.3	63	
No. 100	0.15	38	
No. 200	0.075	22.4	

PROCTOR[1]	METHOD ASTM D 698 A
MAXIMUM DRY DENSITY (PCF)	122.0
OPTIMUM MOISTURE CONTENT (%)	11.0
ROCK CONTENT (%)[2]	7.0



ATTERBERG LIMITS	ASTM D4318	
	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

SOIL DESCRIPTION

SC : CLAYEY SAND

REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON NO.4 SCREEN

*INDICATES OUT OF TOLERANCE

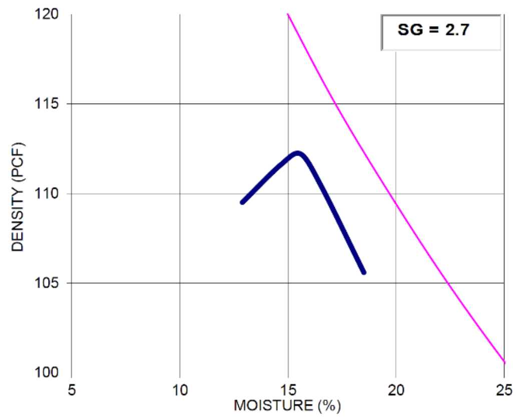
Ninyo & Moore		SOILS/AGGREGATE DATA SHEET	LAB NO.
PROJECT NO.	DATE SAMPLED	HABITAT / LABORATORY TESTING PHOENIX, AZ	TUC15-23
604790001	6/30/2015		

SAMPLE INFORMATION:

LOCATION: CORE #19
DEPTH (INCHES): 0"-144"
LAB TECHNICIAN: NAG

MECHANICAL SIEVE ANALYSIS		METHOD ASTM C136	
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76		
1.5"	38		
1.25"	31.5	100	
1"	25	97	
3/4"	19	95	
1/2"	12.5	91	
3/8"	9.5	89	
1/4"	6.4	85	
No. 4	4.8	82	
No. 8	2.36	81	
No. 10	2.00	77	
No. 16	1.18	72	
No. 30	0.60	67	
No. 40	0.425	63	
No. 50	0.3	59	
No. 100	0.15	48	
No. 200	0.075	39.0	

PROCTOR[1]	METHOD ASTM D 698 A
MAXIMUM DRY DENSITY (PCF)	112.2
OPTIMUM MOISTURE CONTENT (%)	15.6
ROCK CONTENT (%)[2]	18.0



ATTERBERG LIMITS	ASTM D4318	
	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

SOIL DESCRIPTION

SC : CLAYEY SAND WITH GRAVEL

REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON NO.4 SCREEN

*INDICATES OUT OF TOLERANCE

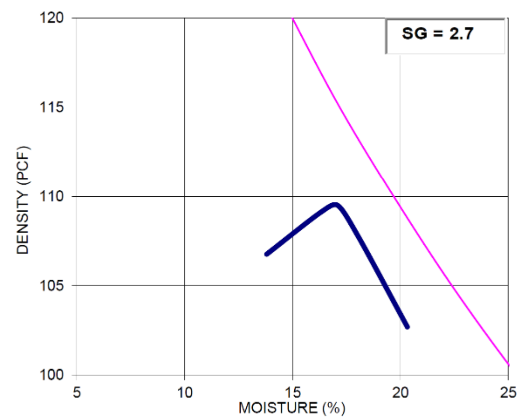
Ninyo & Moore	SOILS/AGGREGATE DATA SHEET		LAB NO.
PROJECT NO.	DATE SAMPLED	HABITAT / LABORATORY TESTING PHOENIX, AZ	TUC15-23
604790001	6/30/2015		

SAMPLE INFORMATION:

LOCATION: CORE #21
DEPTH (INCHES): 0"-96"
LAB TECHNICIAN: NAG

MECHANICAL SIEVE ANALYSIS		METHOD: ASTM C136	
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76		
1.5"	38	100	
1.25"	31.5	98	
1"	25	96	
3/4"	19	93	
1/2"	12.5	90	
3/8"	9.5	87	
1/4"	6.4	83	
No. 4	4.8	80	
No. 8	2.36	79	
No. 10	2.00	76	
No. 16	1.18	70	
No. 30	0.60	64	
No. 40	0.425	60	
No. 50	0.3	54	
No. 100	0.15	41	
No. 200	0.075	30.2	

PROCTOR[1]	METHOD: ASTM D 698 A
MAXIMUM DRY DENSITY (PCF)	109.5
OPTIMUM MOISTURE CONTENT (%)	17.1
ROCK CONTENT (%)[2]	20.0



ATTERBERG LIMITS	METHOD: ASTM D4318	
	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

SOIL DESCRIPTION

SC : CLAYEY SAND WITH GRAVEL

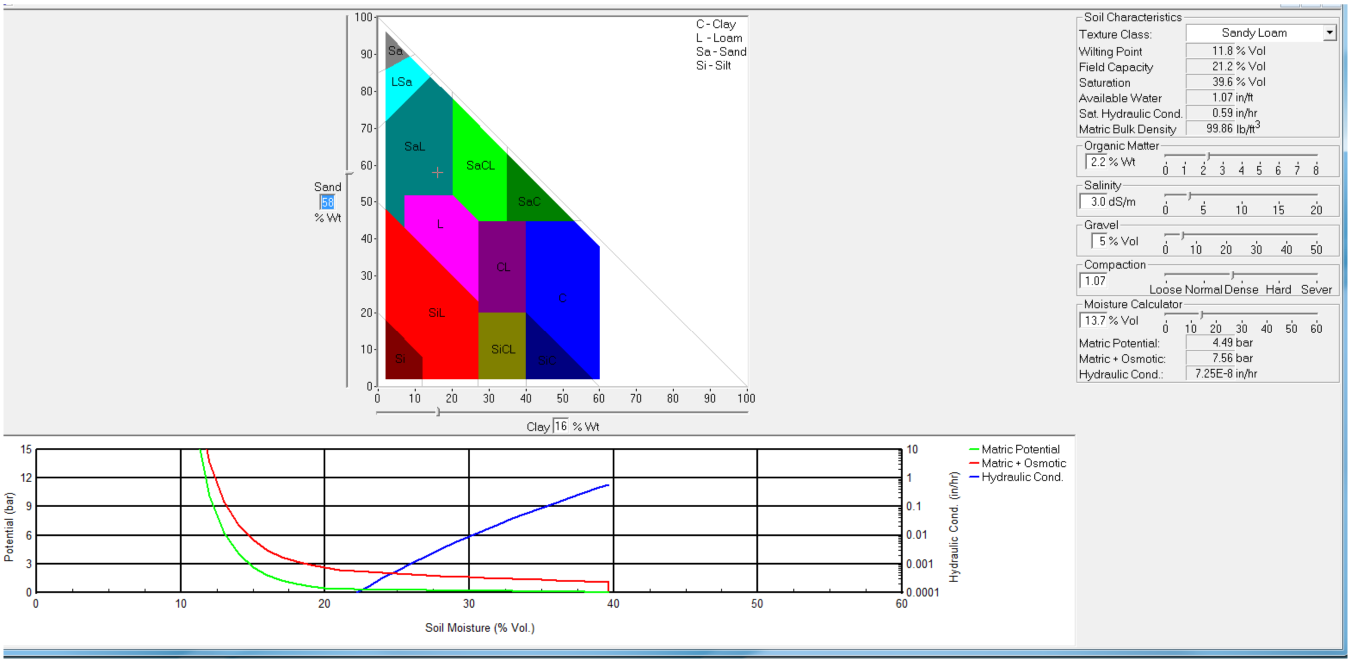
REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON NO.4 SCREEN

*INDICATES OUT OF TOLERANCE

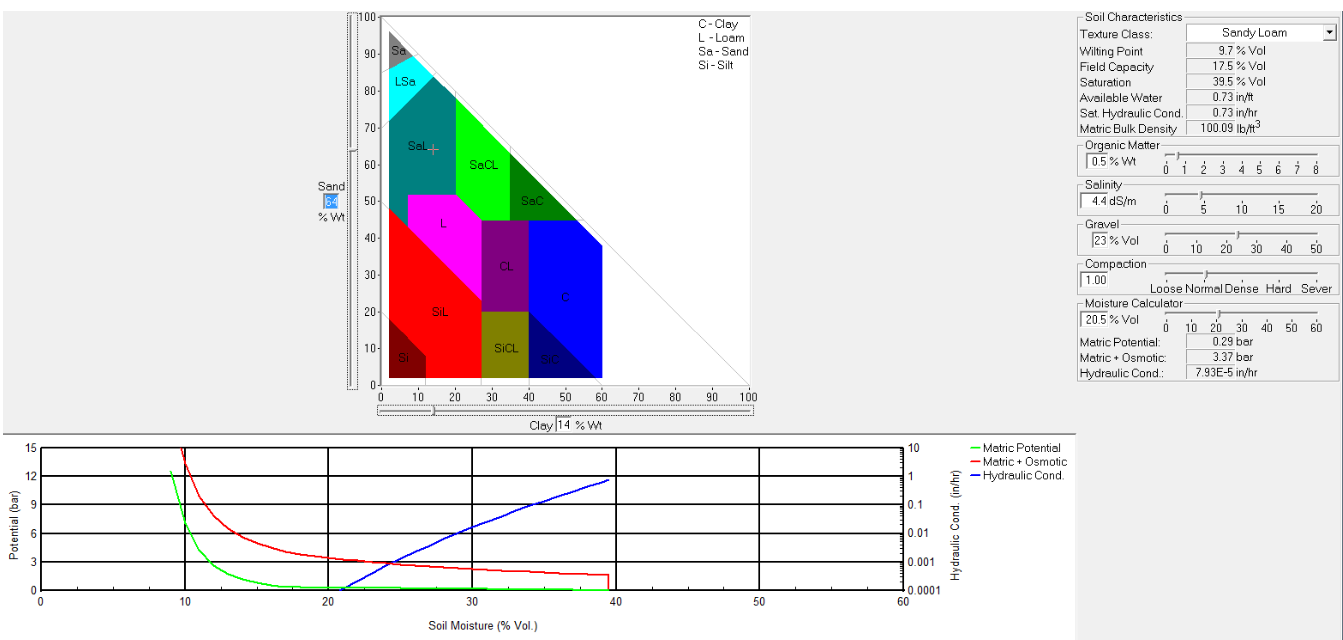
Ninyo & Moore		SOILS/AGGREGATE DATA SHEET	LAB NO.
PROJECT NO.	DATE SAMPLED	HABITAT / LABORATORY TESTING PHOENIX, ARIZONA	TUC15-23
604790001	6/30/2015		

Attachment D: SPAW Hydraulic Conductivity Model Results

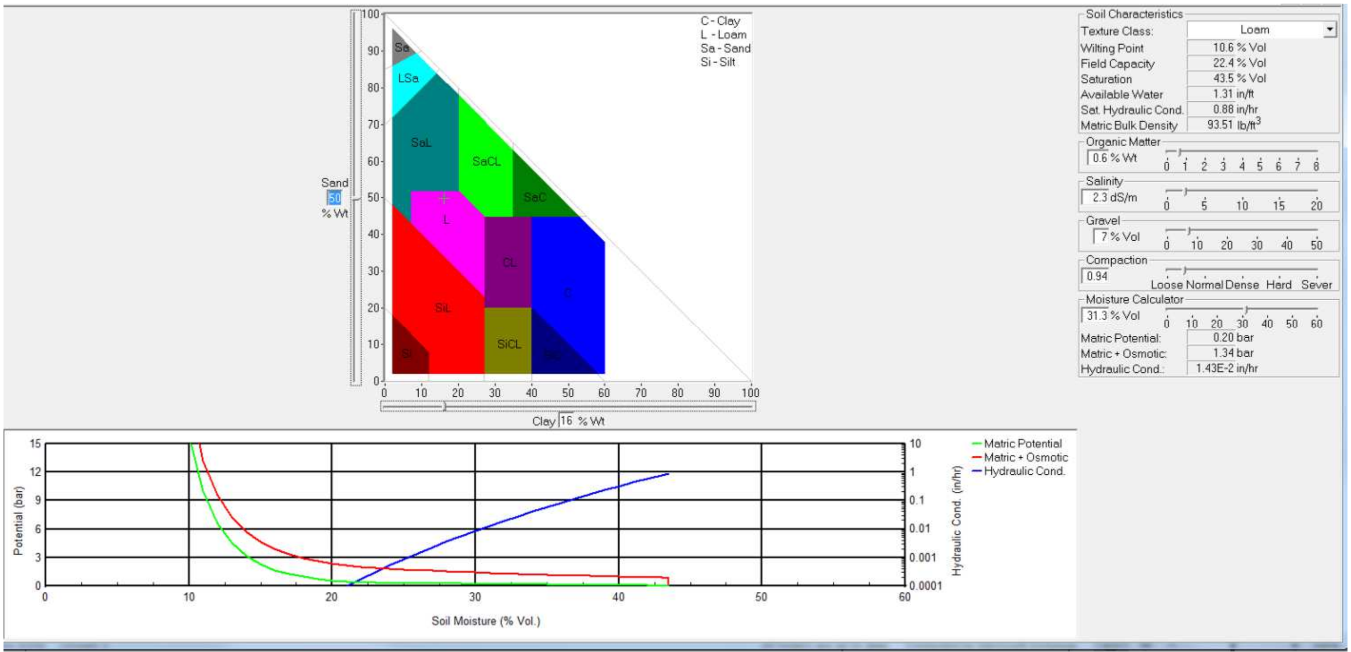
Rosemont Core #1: 36" – 53" Invert Elevation: Hydrologic Soil Group B



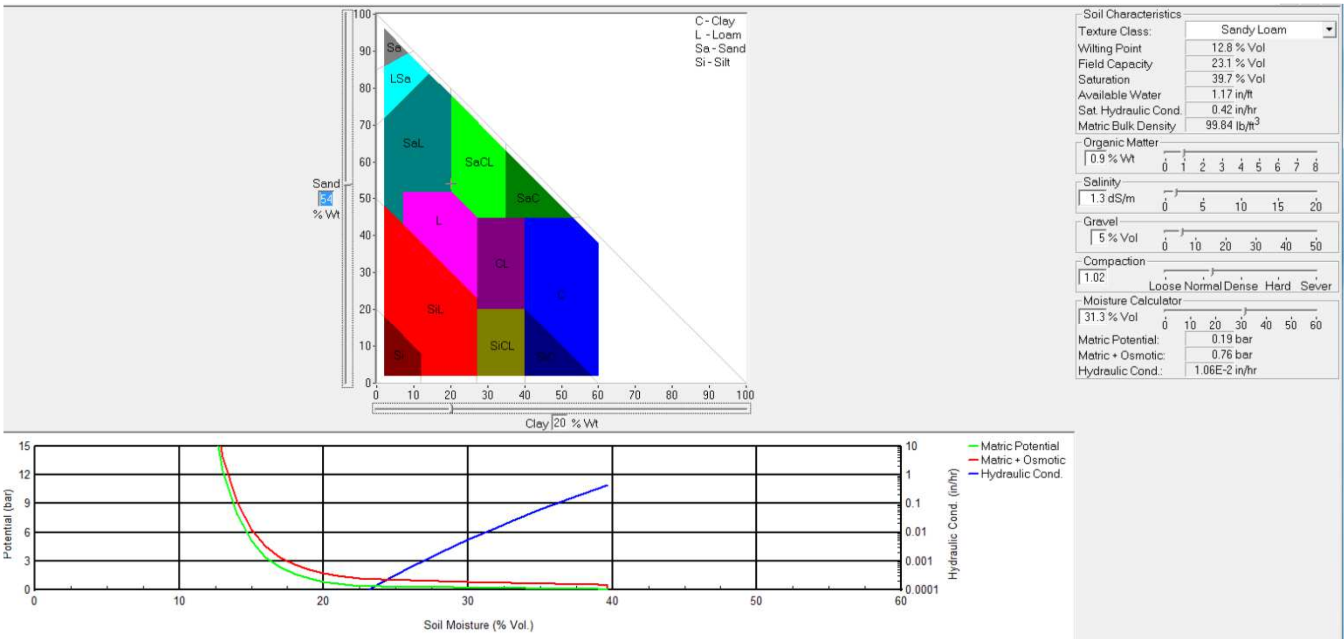
Rosemont Core #1: 53" – 67" Below Invert Elevation: Hydrologic Soil Group B



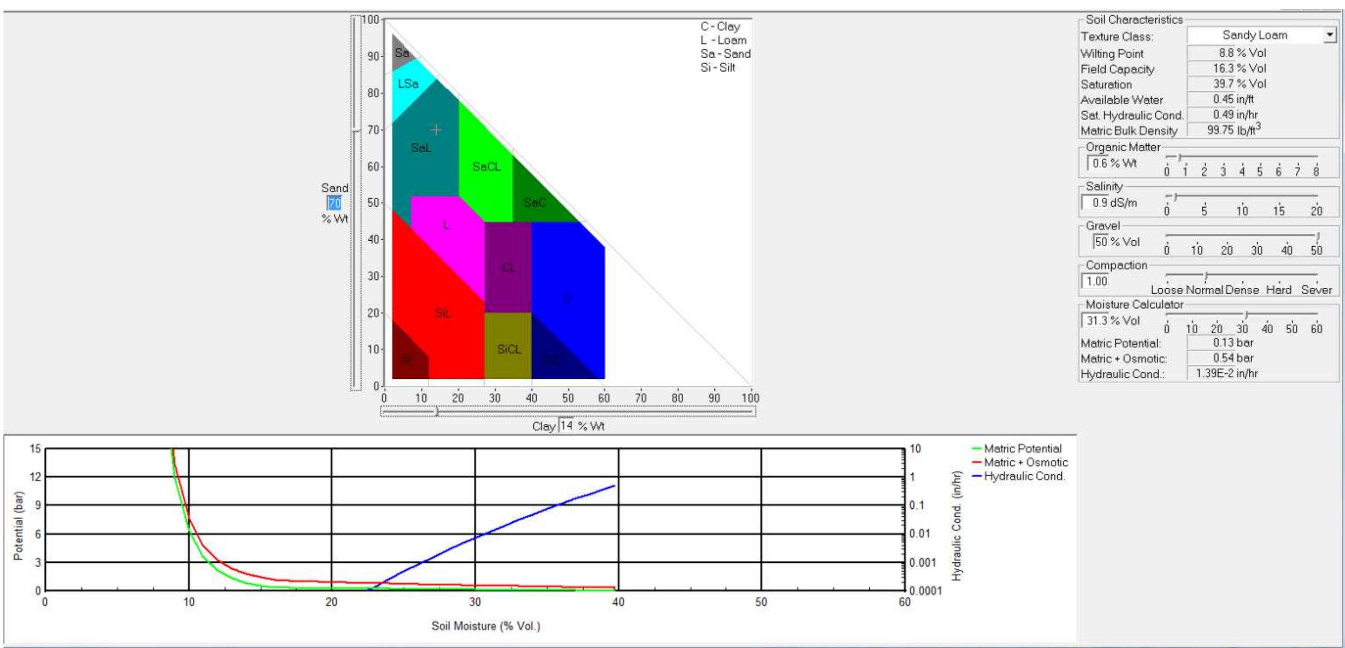
Rosemont Core #1: 67" – 96" Below Invert Elevation: Hydrologic Soil Group B



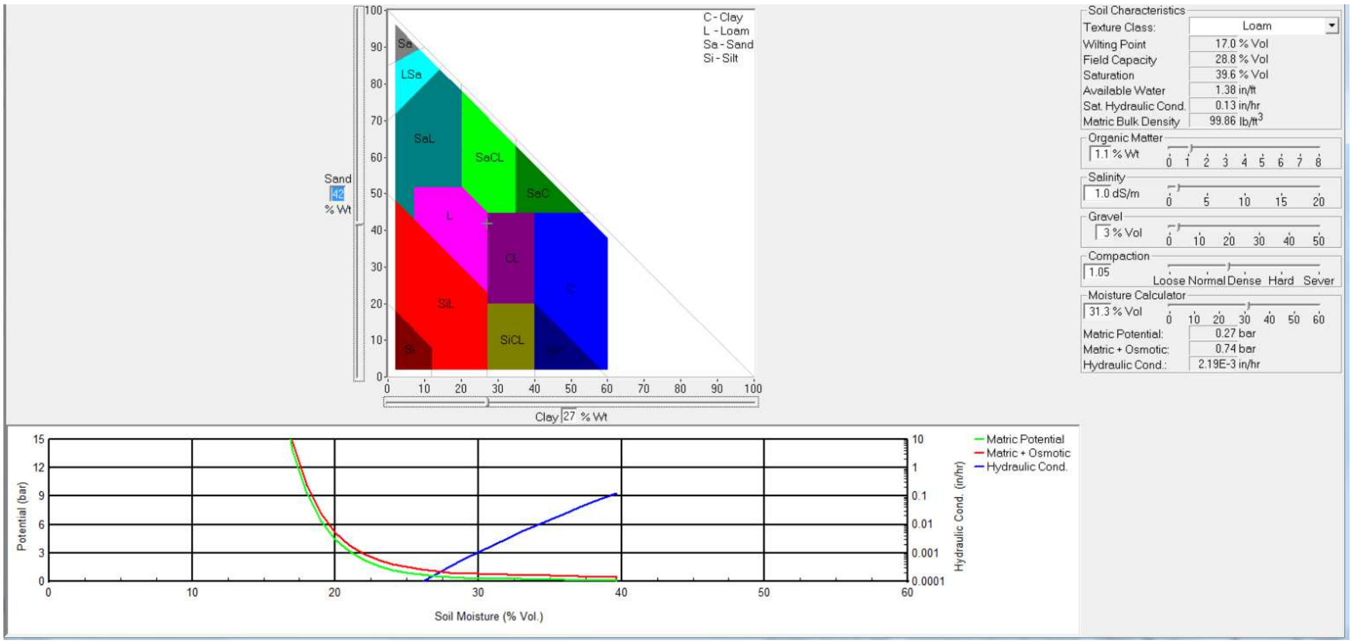
Rosemont Core #2: 80" – 87" Invert Elevation: Hydrologic Soil Group B



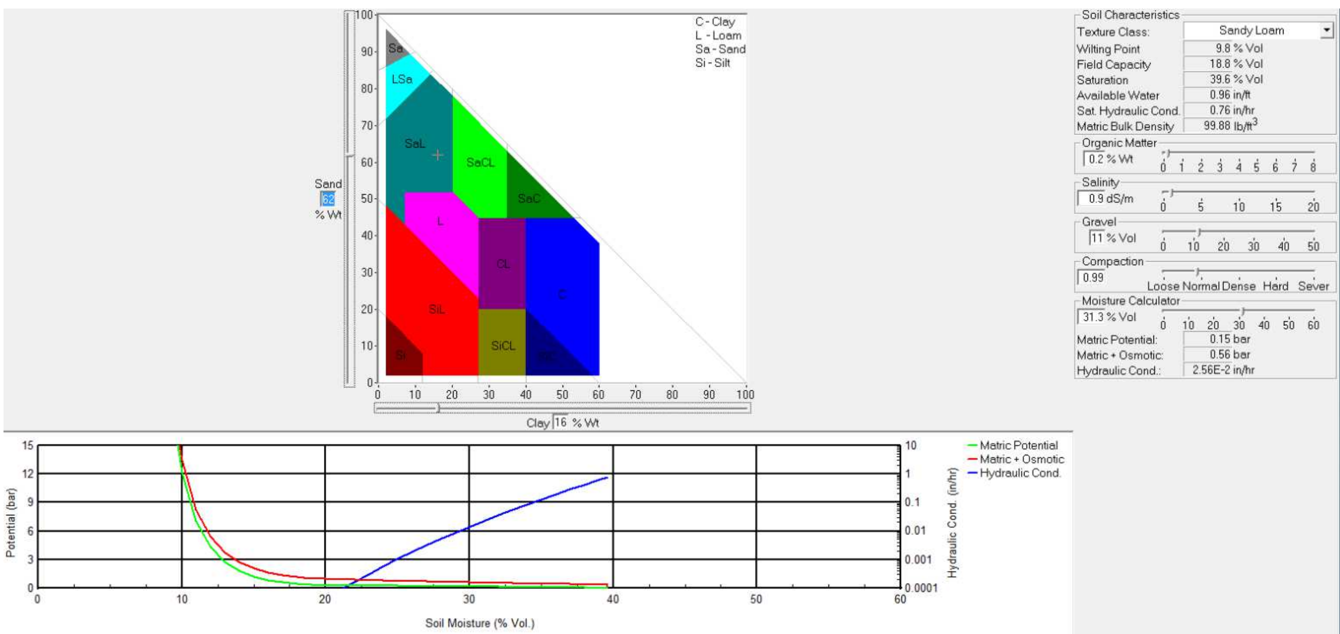
Rosemont Core #2: 87" – 96" Below Invert Elevation: Hydrologic Soil Group B



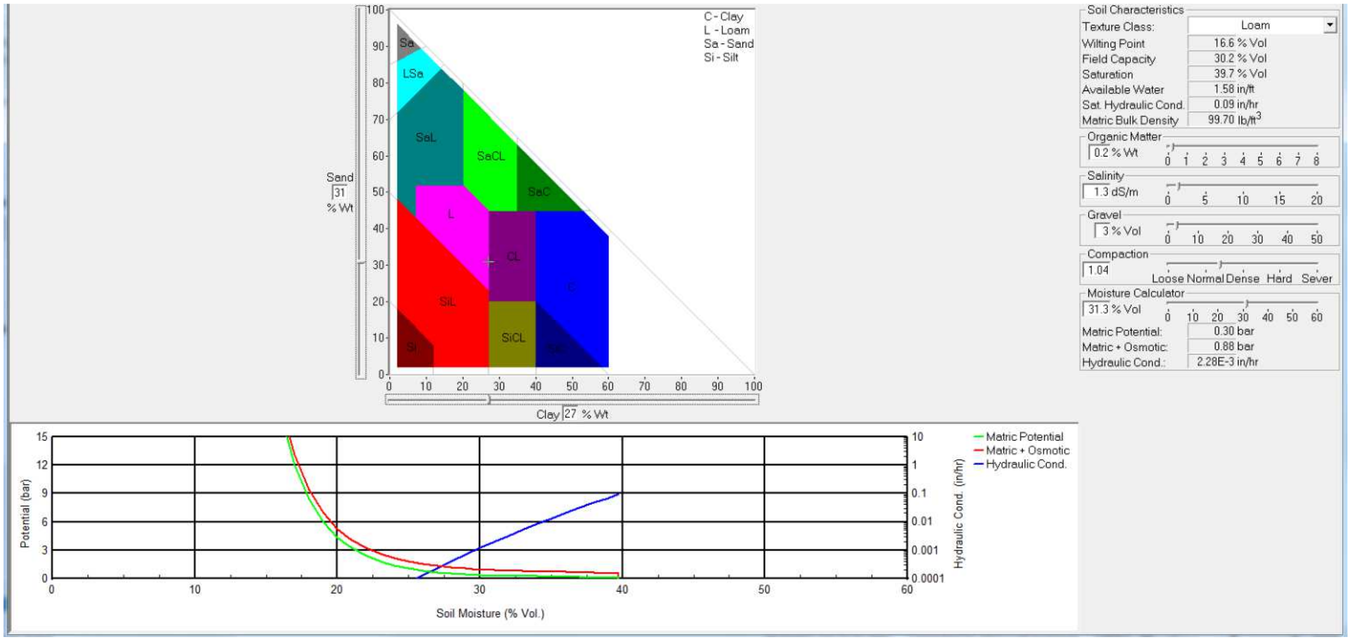
Rosemont Core #3: 58" – 70" Invert Elevation: Hydrologic Soil Group C



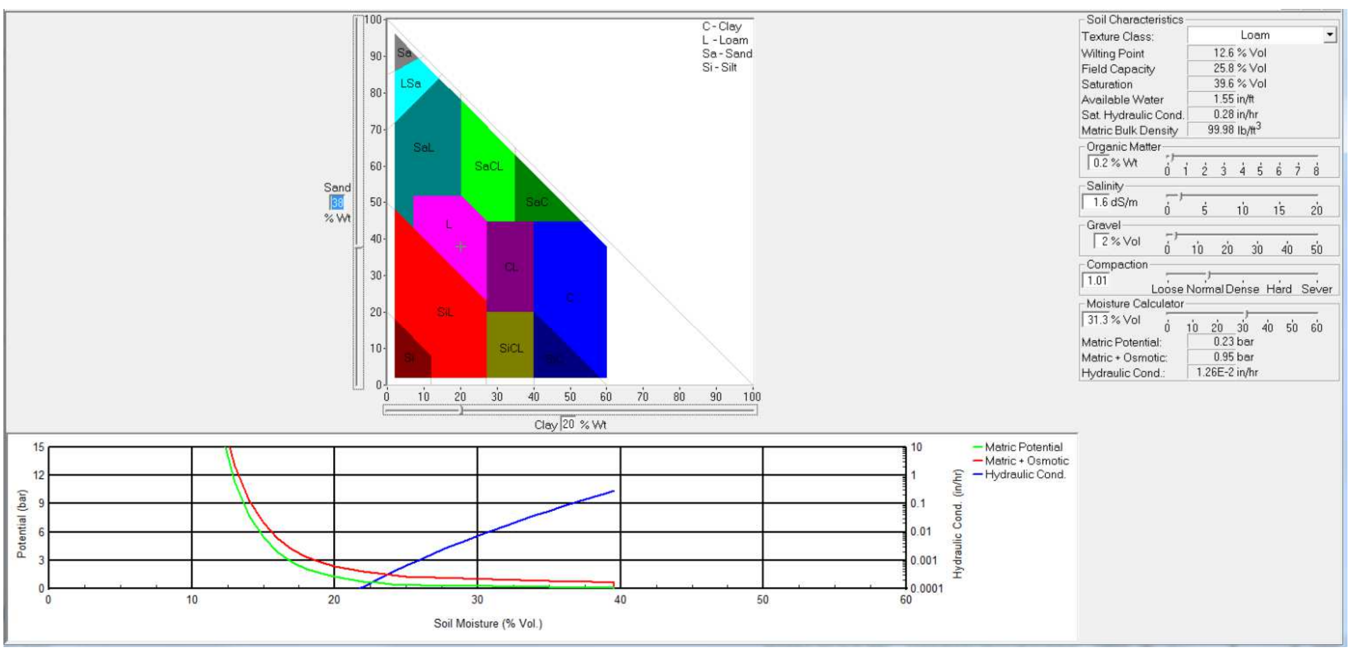
Rosemont Core #3: 70" – 94" Below Invert Elevation: Hydrologic Soil Group B



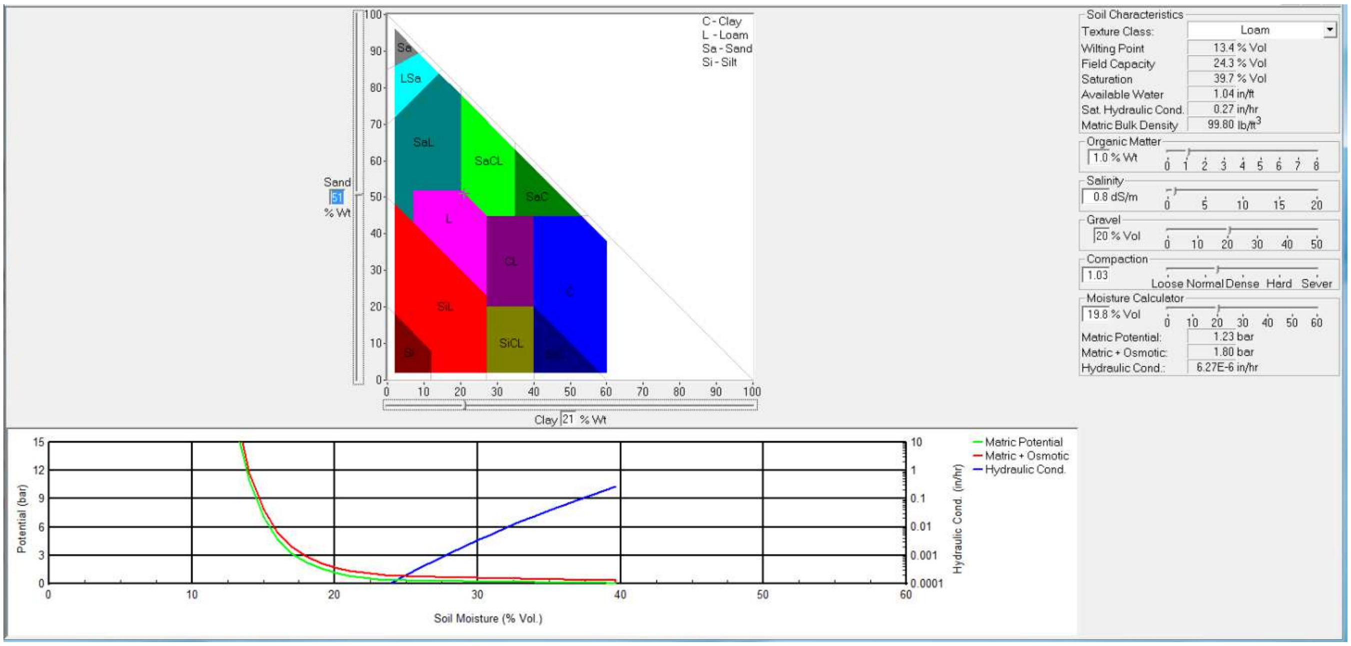
Rosemont Core #4: 45" – 77" At Invert Elevation: Hydrologic Soil Group C



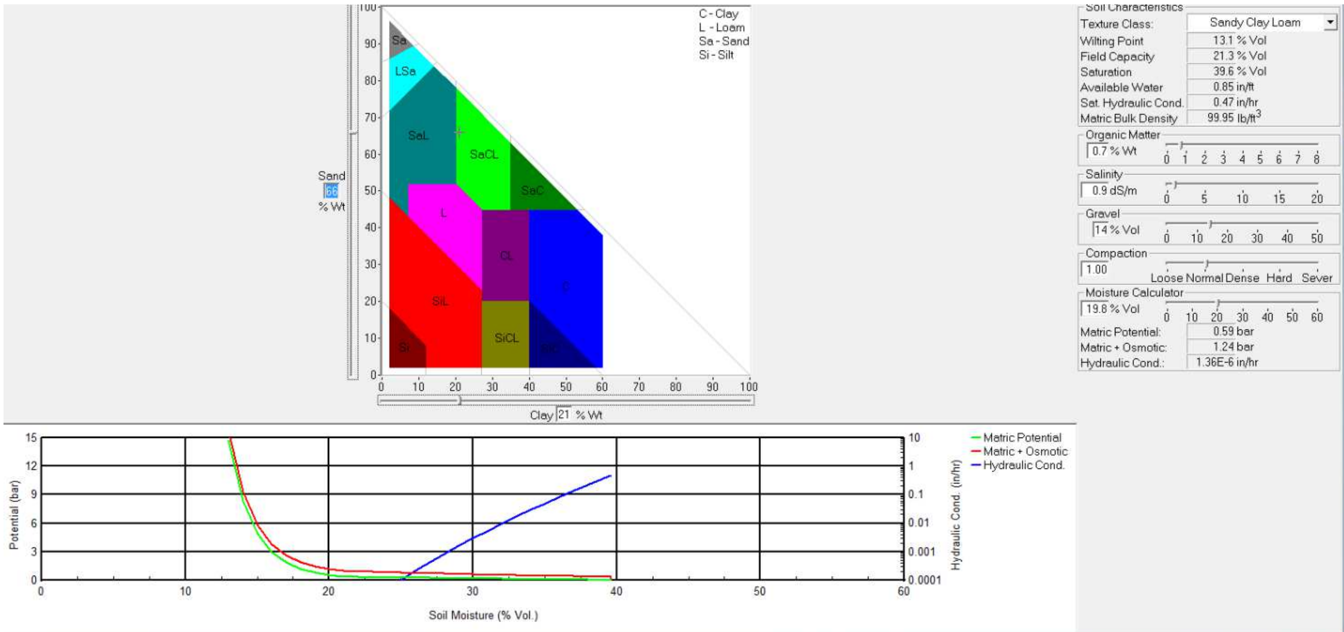
Rosemont Core #4: 77" – 108" Below Invert Elevation: Hydrologic Soil Group C



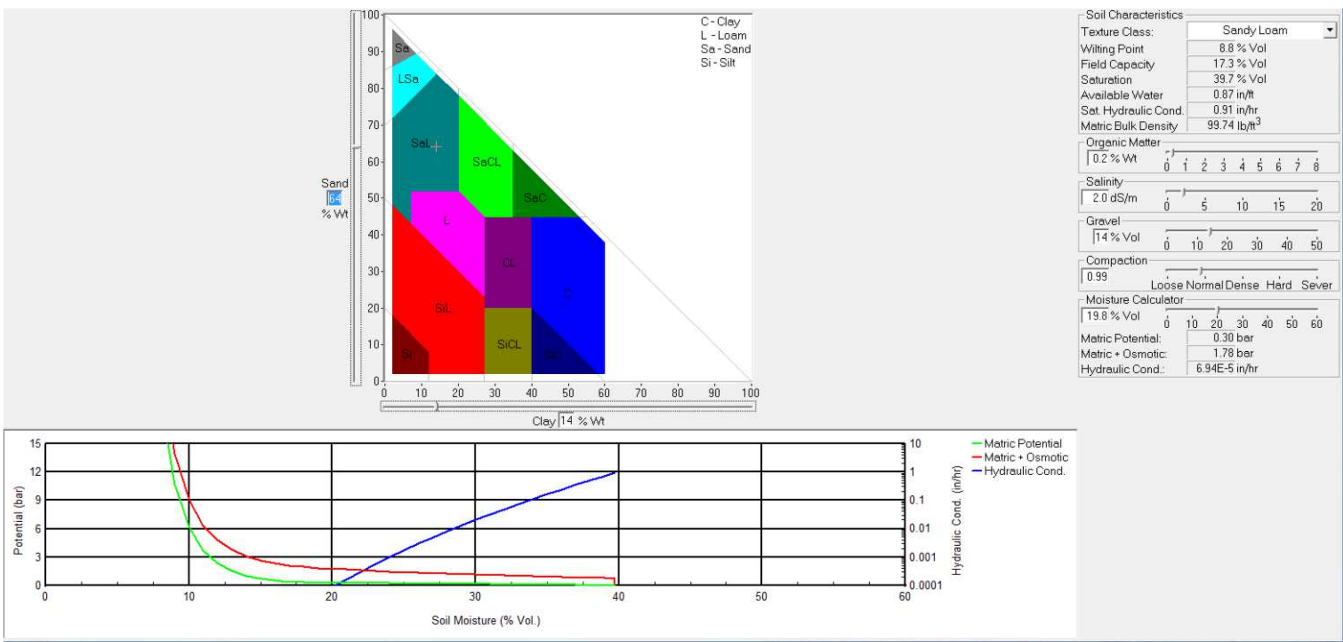
Rosemont Core #5: 46" – 59" Invert Elevation: Hydrologic Soil Group C



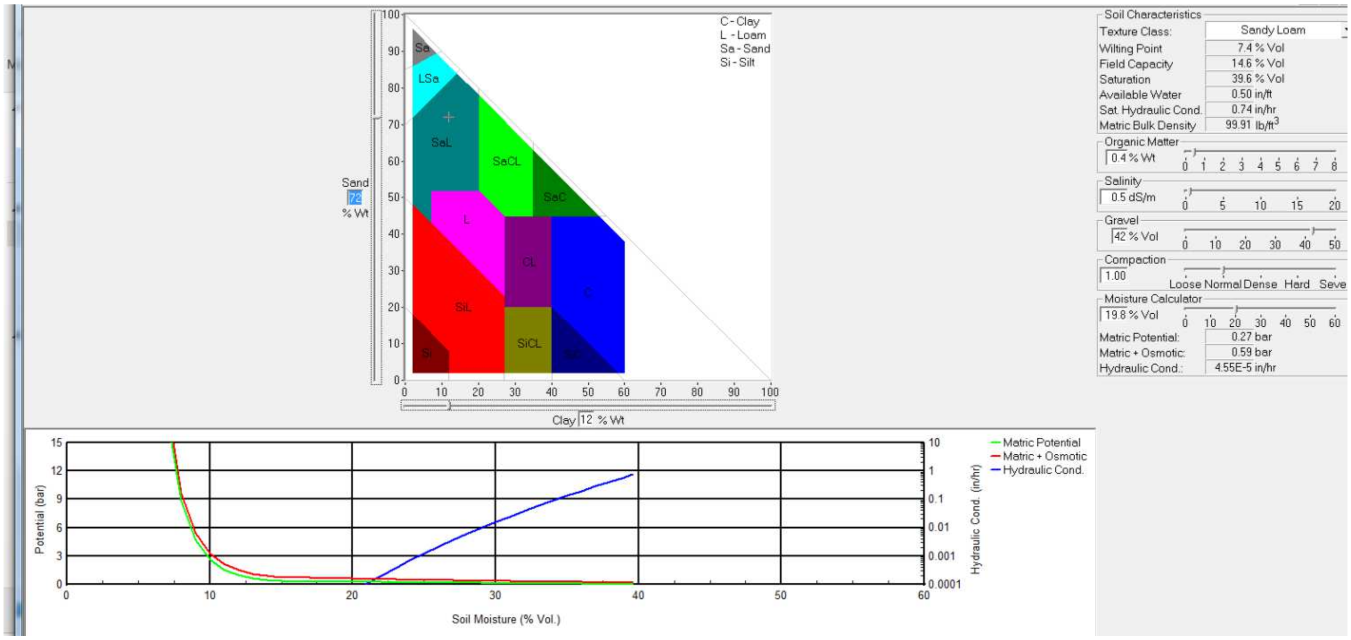
Rosemont Core #6: 45" – 52" Invert Elevation: Hydrologic Soil Group B



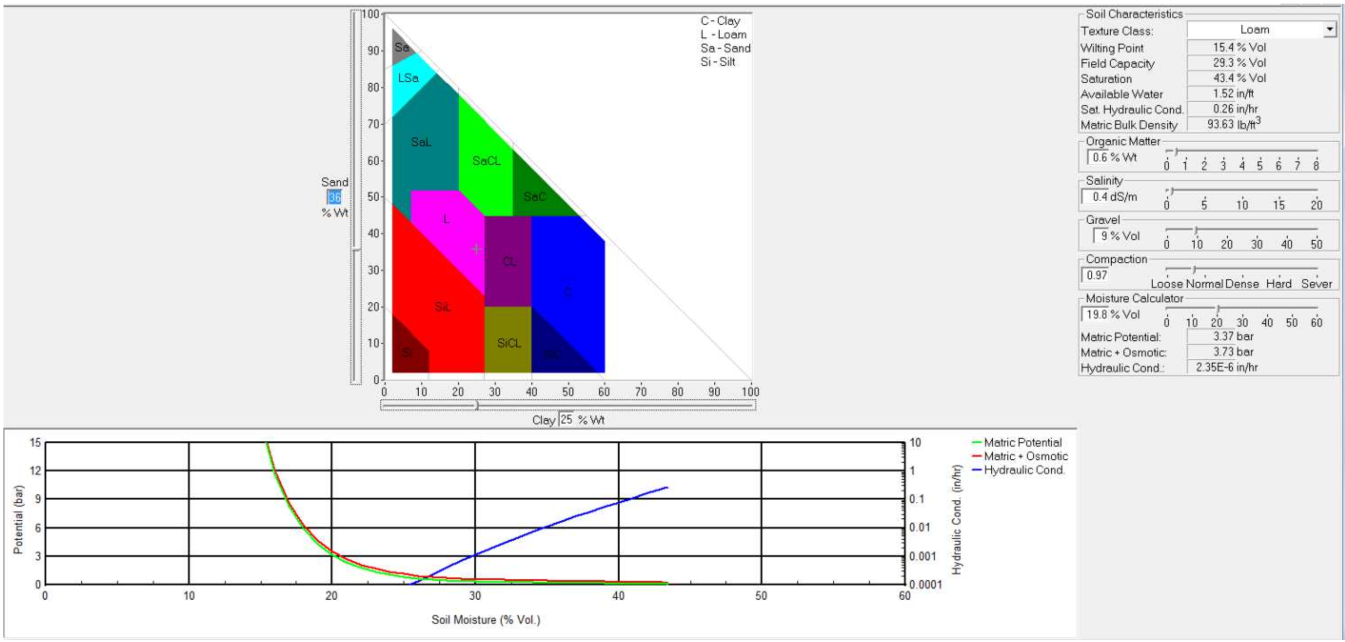
Rosemont Core #6: 52" – 80" Below Invert Elevation: Hydrologic Soil Group B



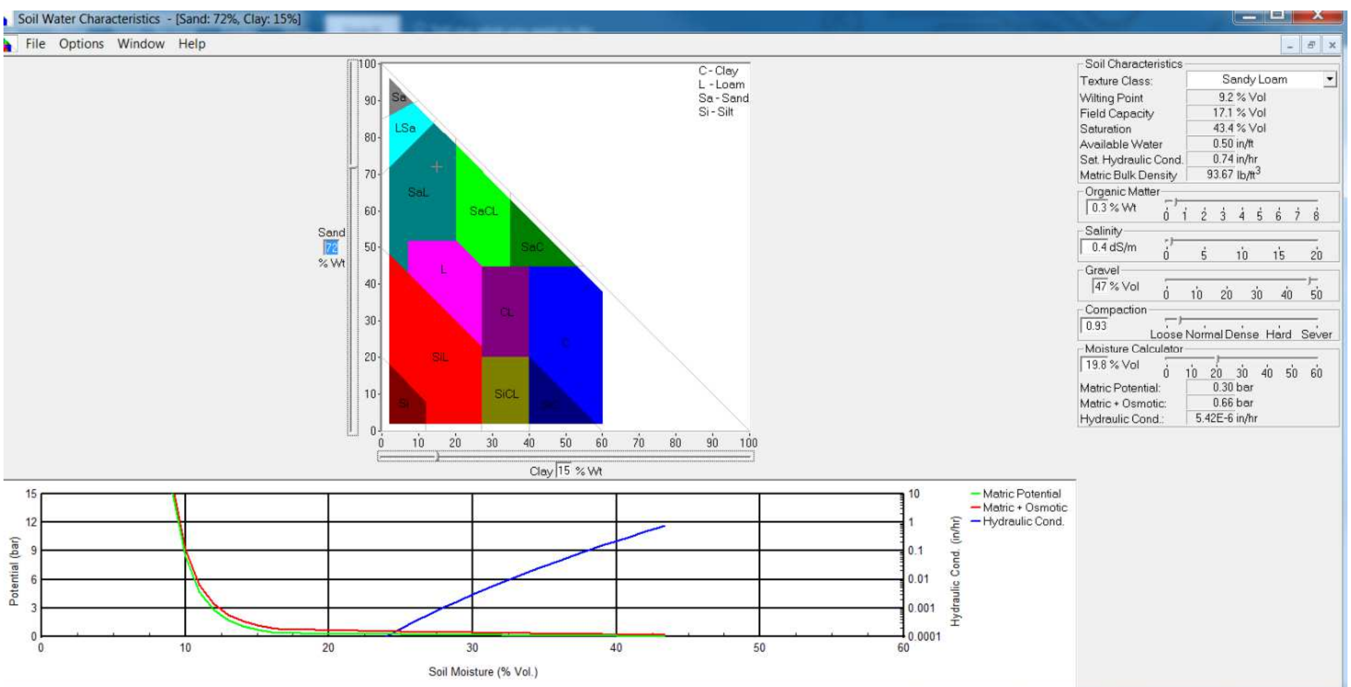
Rosemont Core #7: 23" – 60" Invert Elevation: Hydrologic Soil Group B



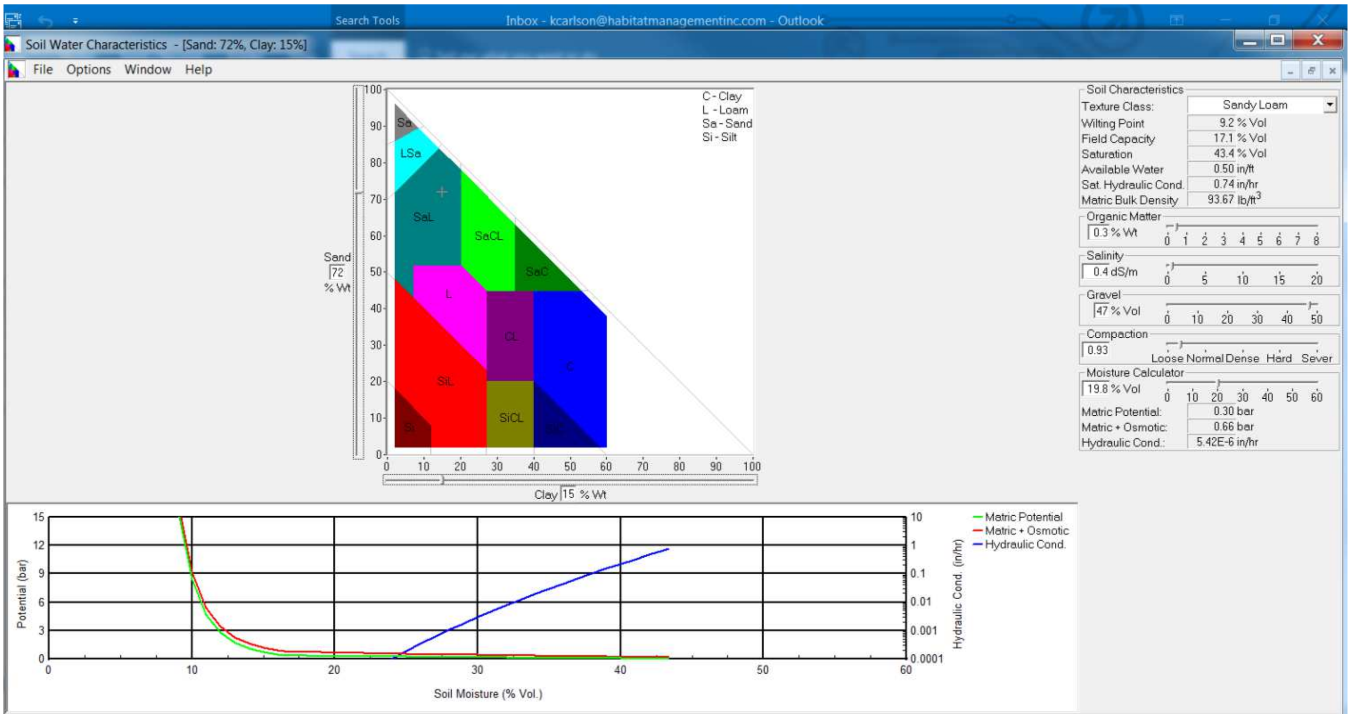
Rosemont Core #8: 0” –36” Invert Elevation: Hydrologic Soil Group C



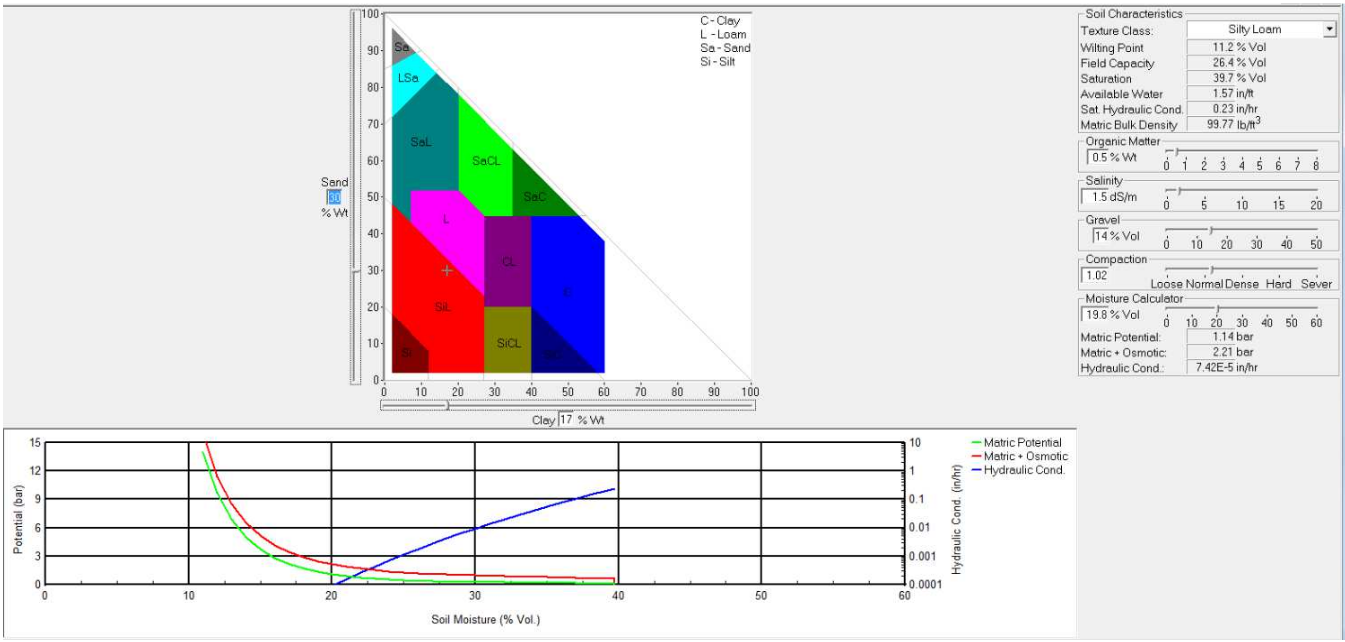
Rosemont Core #8: 36” – 48” Below Invert Elevation: Hydrologic Soil Group B



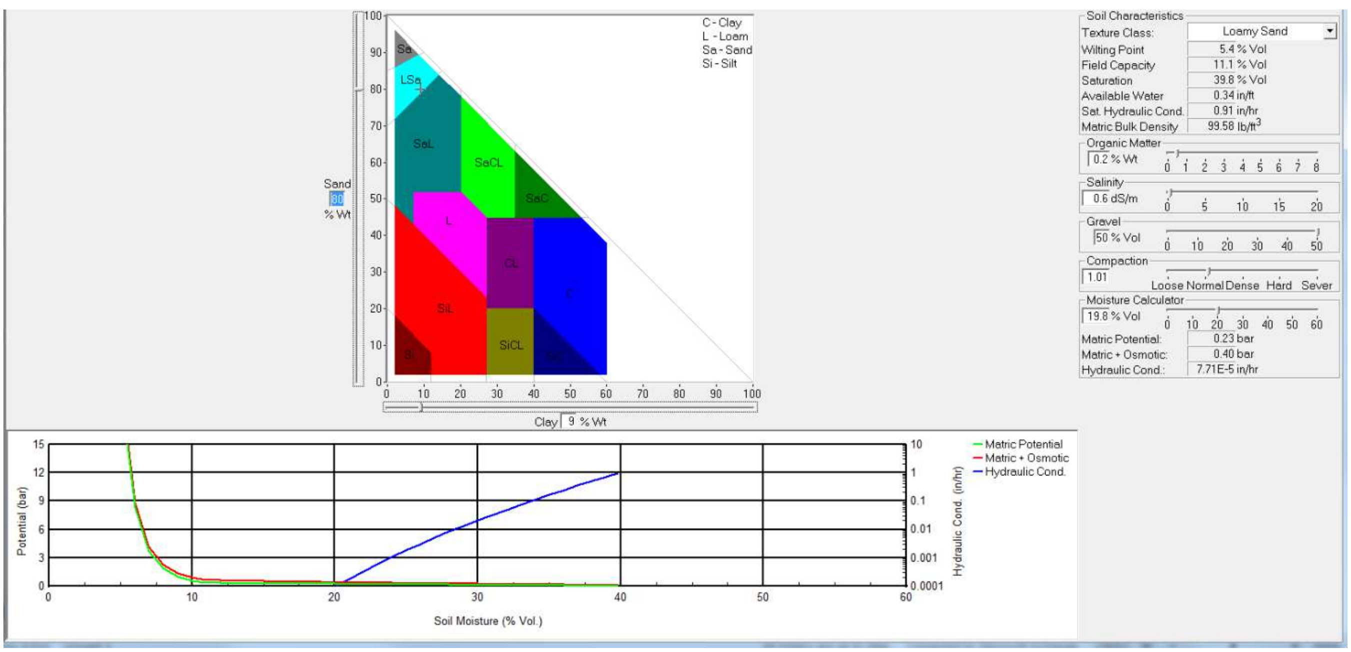
Rosemont Core #8: 48" – 61" Below Invert Elevation: Hydrologic Soil Group B



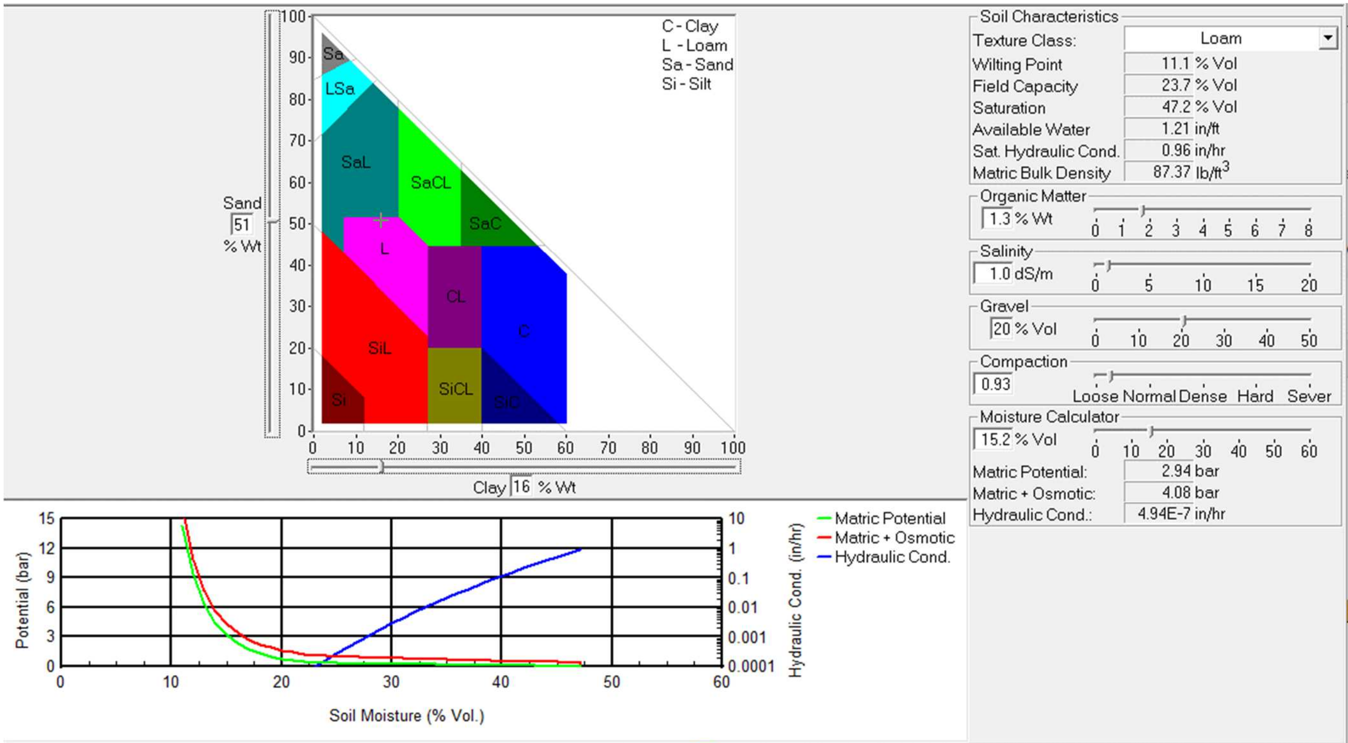
Rosemont Core #9: 0" –5" Invert Elevation: Hydrologic Soil Group C



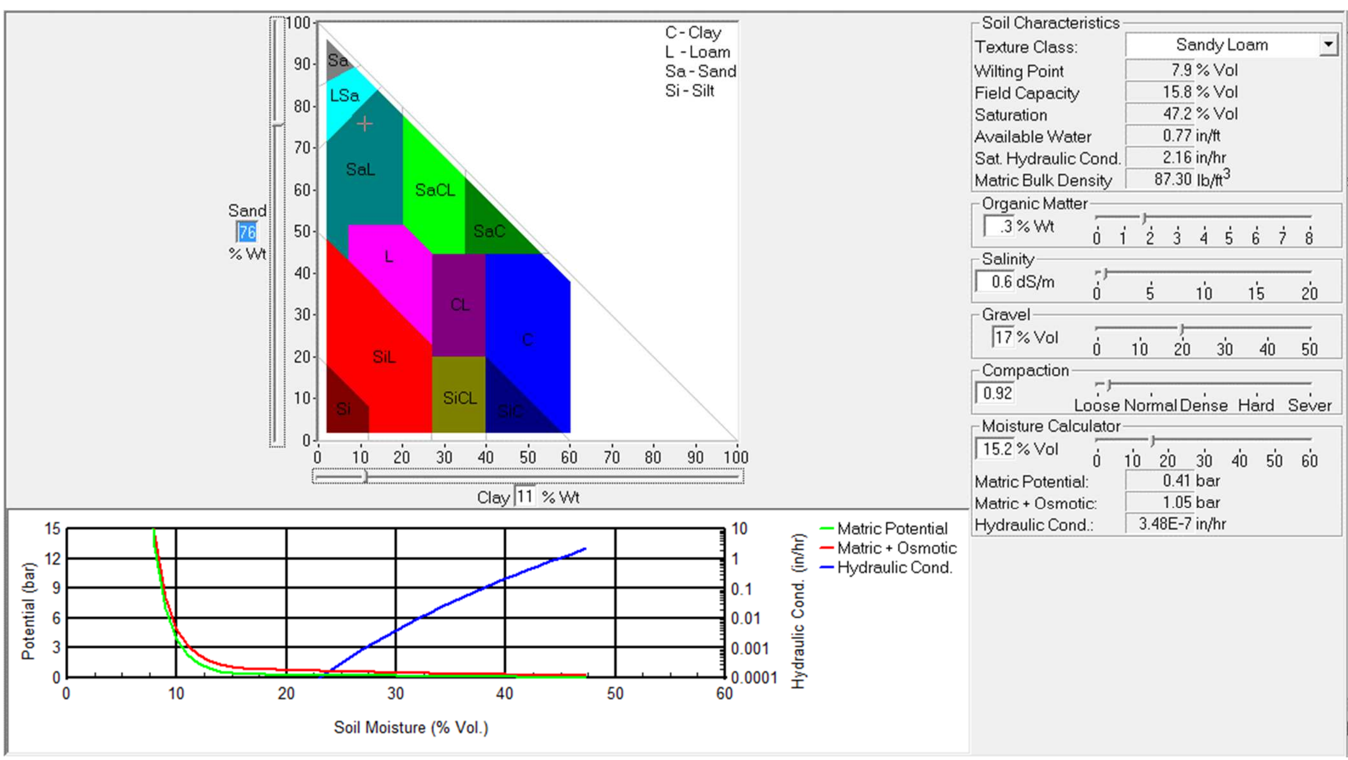
Rosemont Core #9: 5" –20" Invert Elevation: Hydrologic Soil Group B



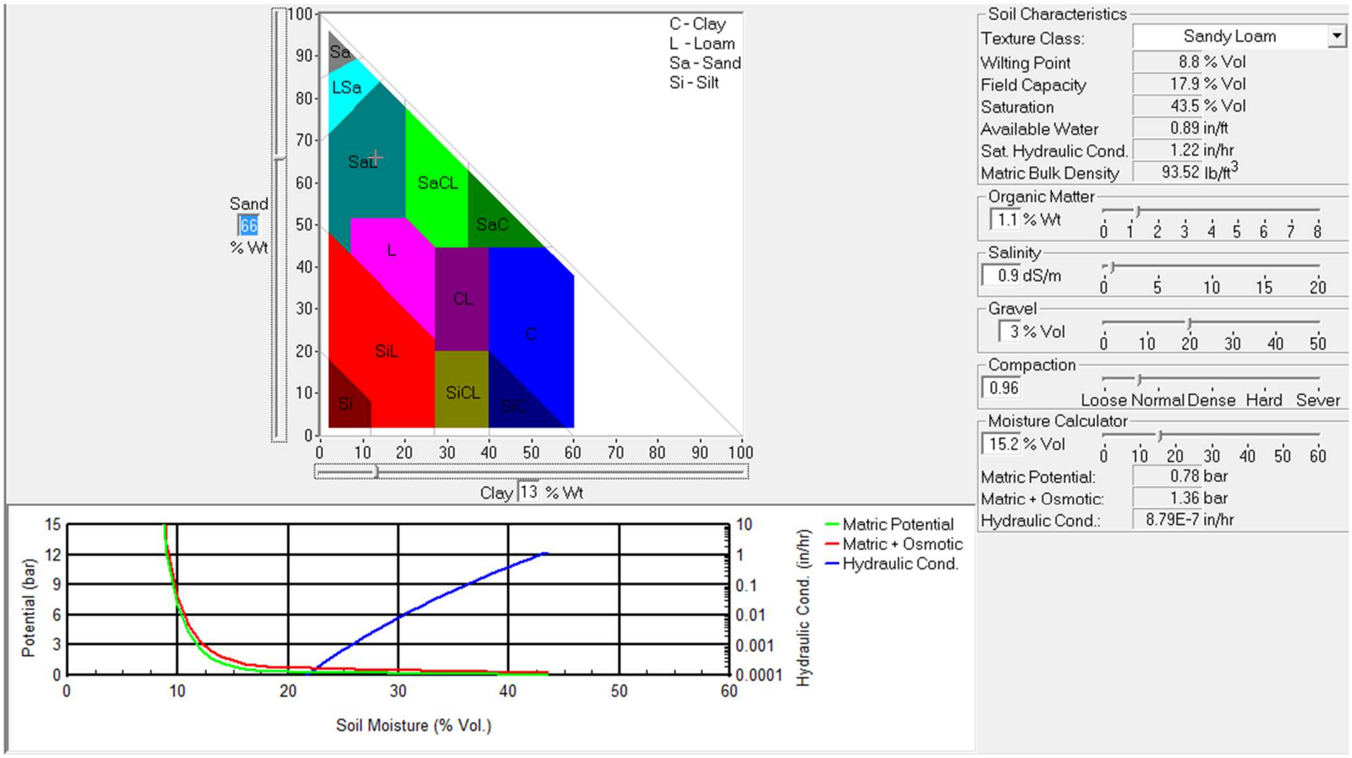
Rosemont Core #10: 85" –92" Invert Elevation: Hydrologic Soil Group C



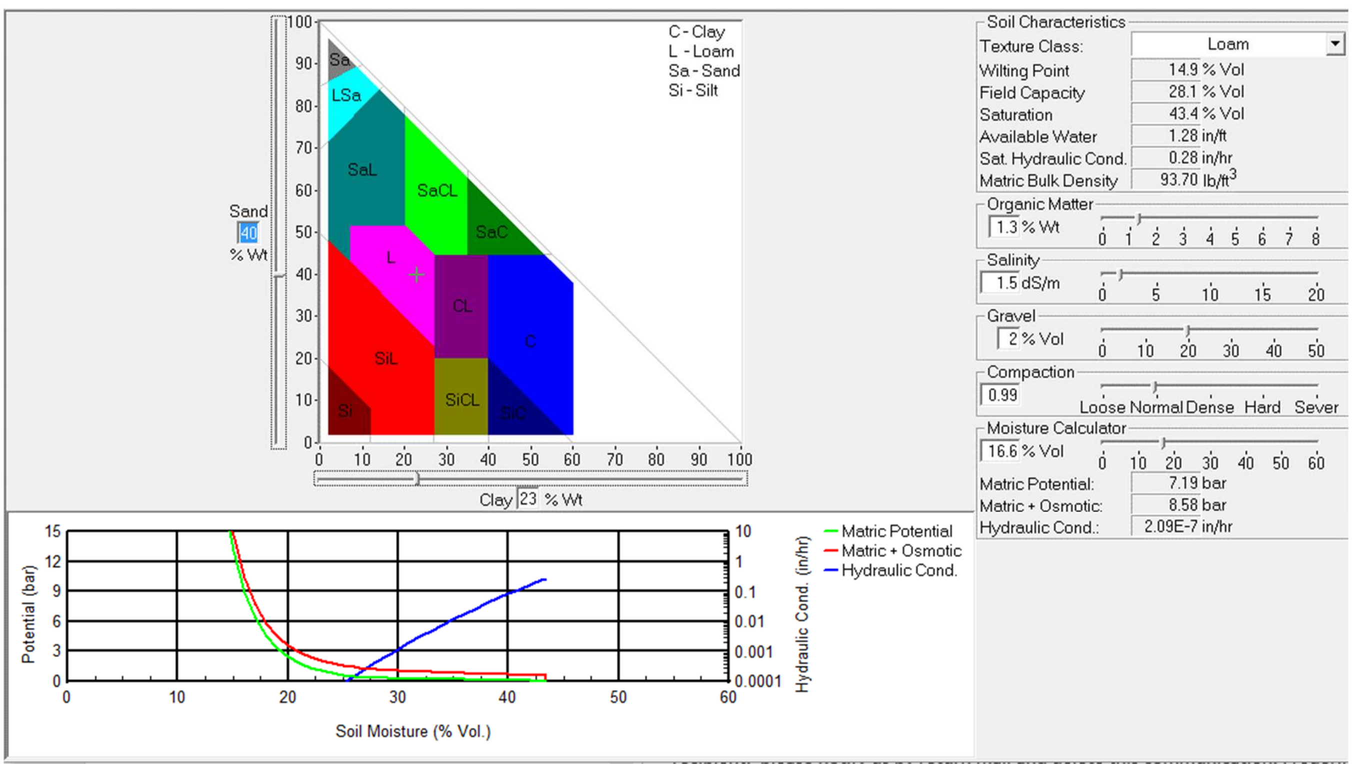
Rosemont Core #10: 92" – 96" Below Invert Elevation: Hydrologic Soil Group B



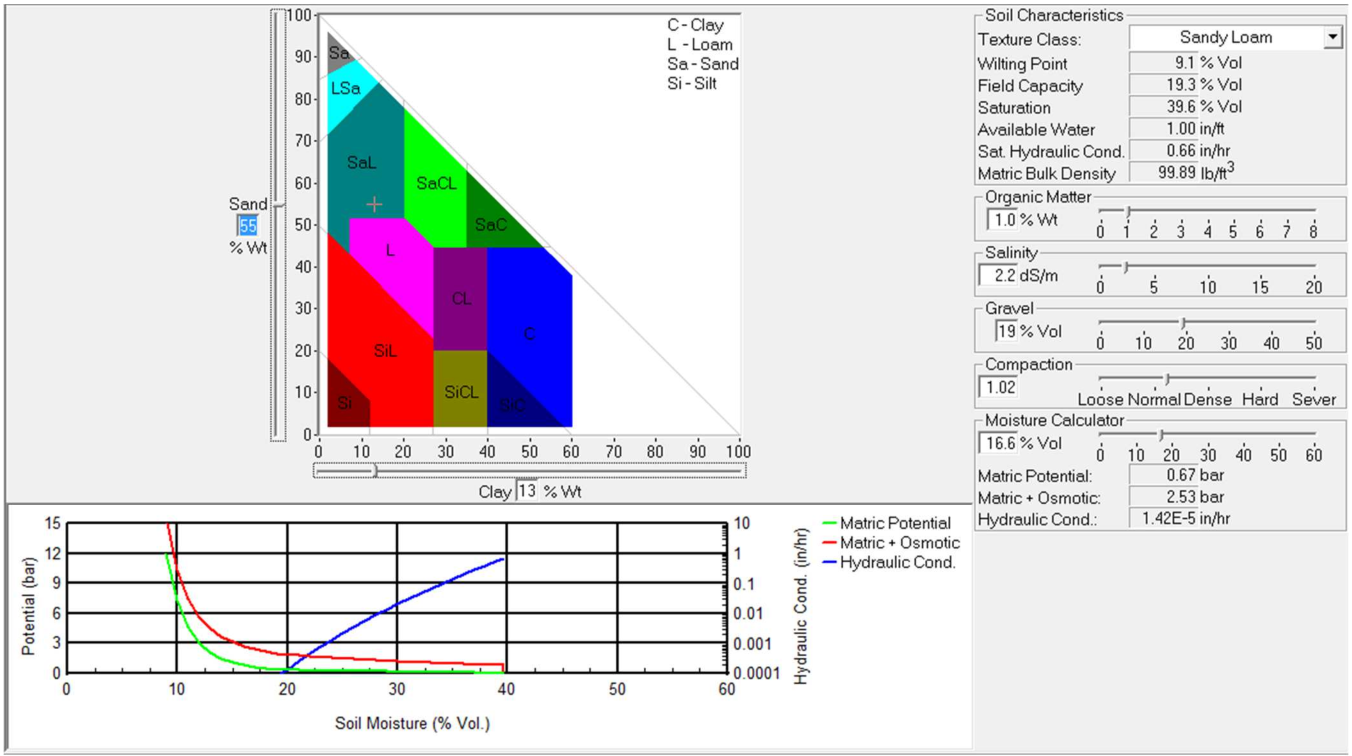
Rosemont Core #11: 32" –45" Invert Elevation: Hydrologic Soil Group B



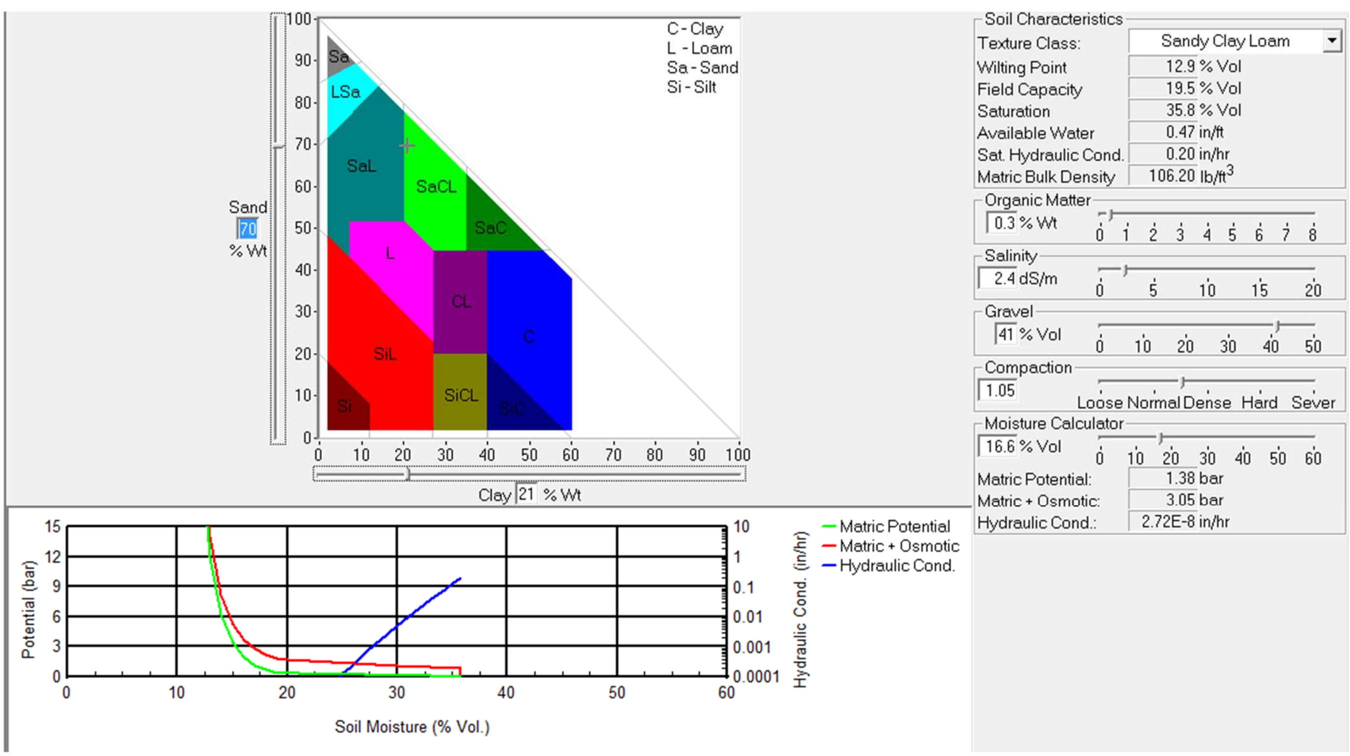
Rosemont Core #11: 45" –60" Below Invert Elevation: Hydrologic Soil Group C



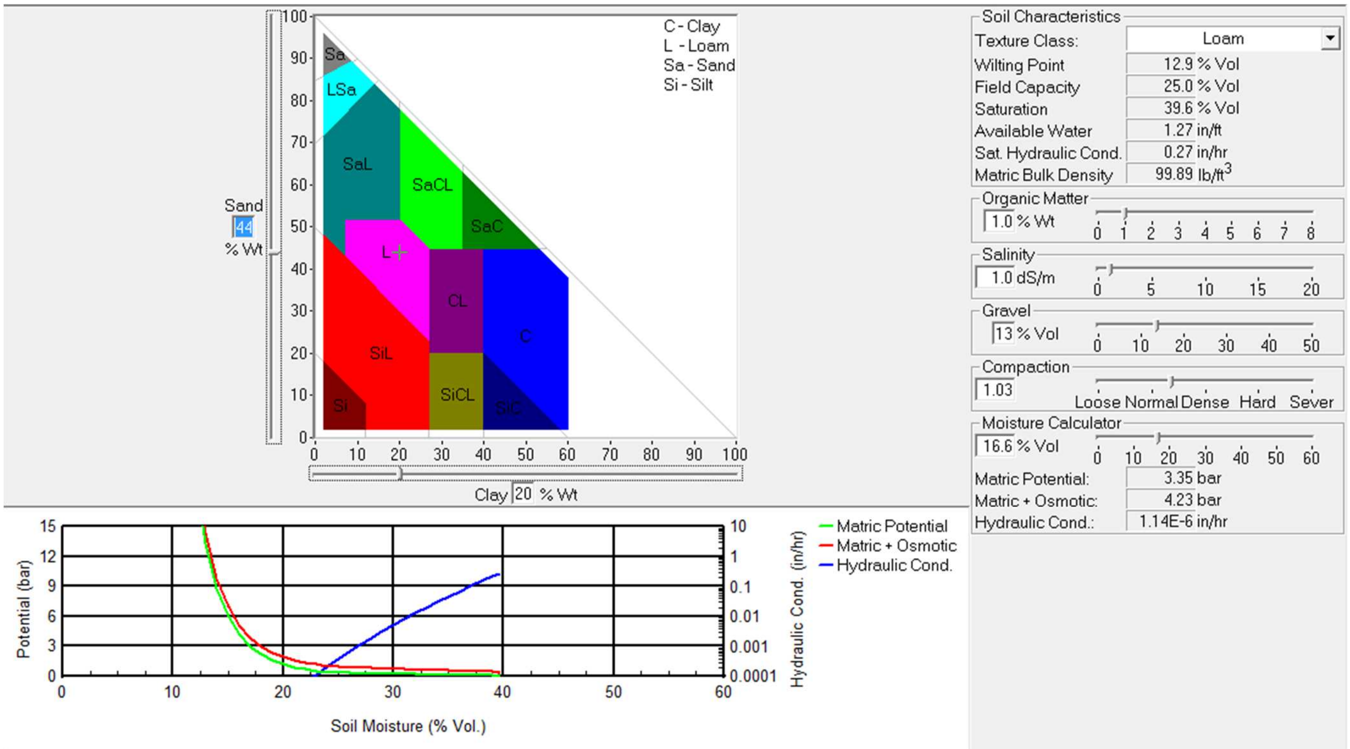
Rosemont Core #12: 56" –86" Invert Elevation: Hydrologic Soil Group B



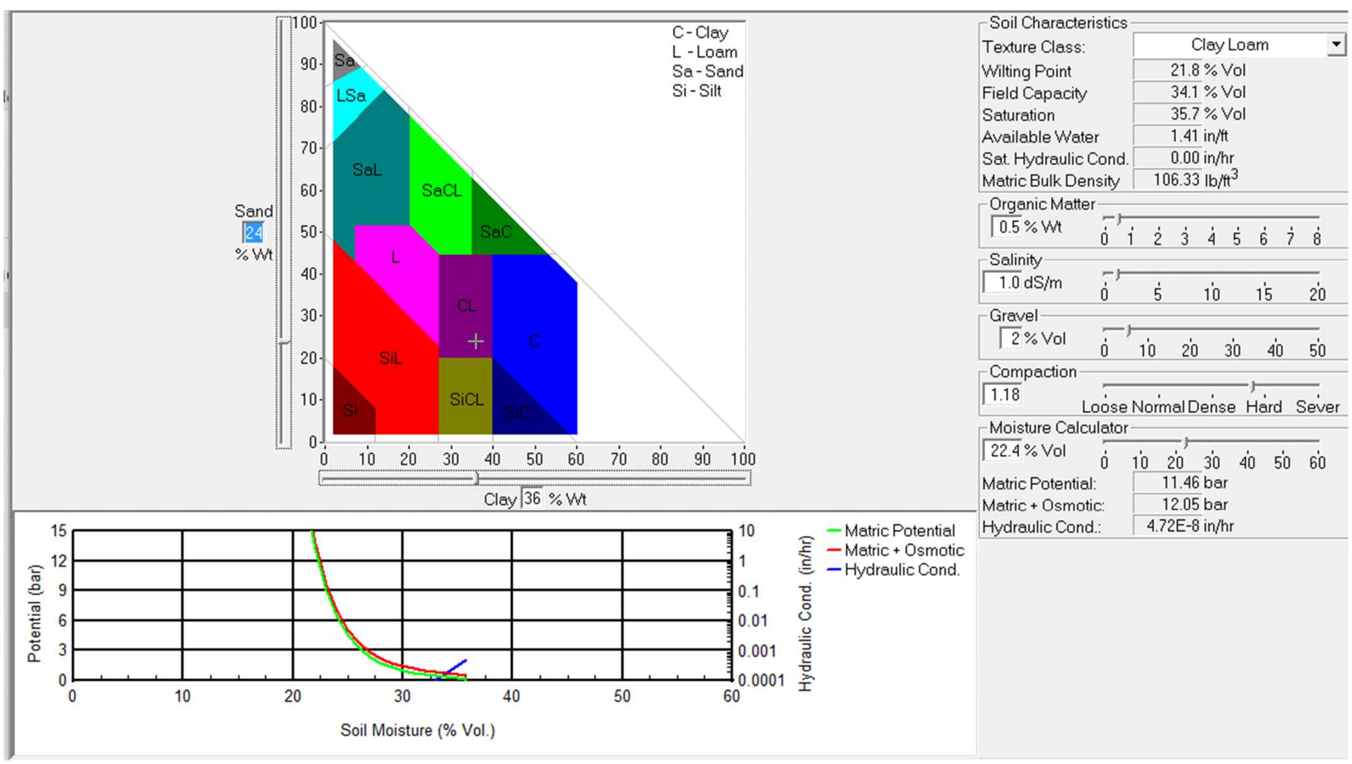
Rosemont Core #12: 86" –102" Below Invert Elevation: Hydrologic Soil Group C



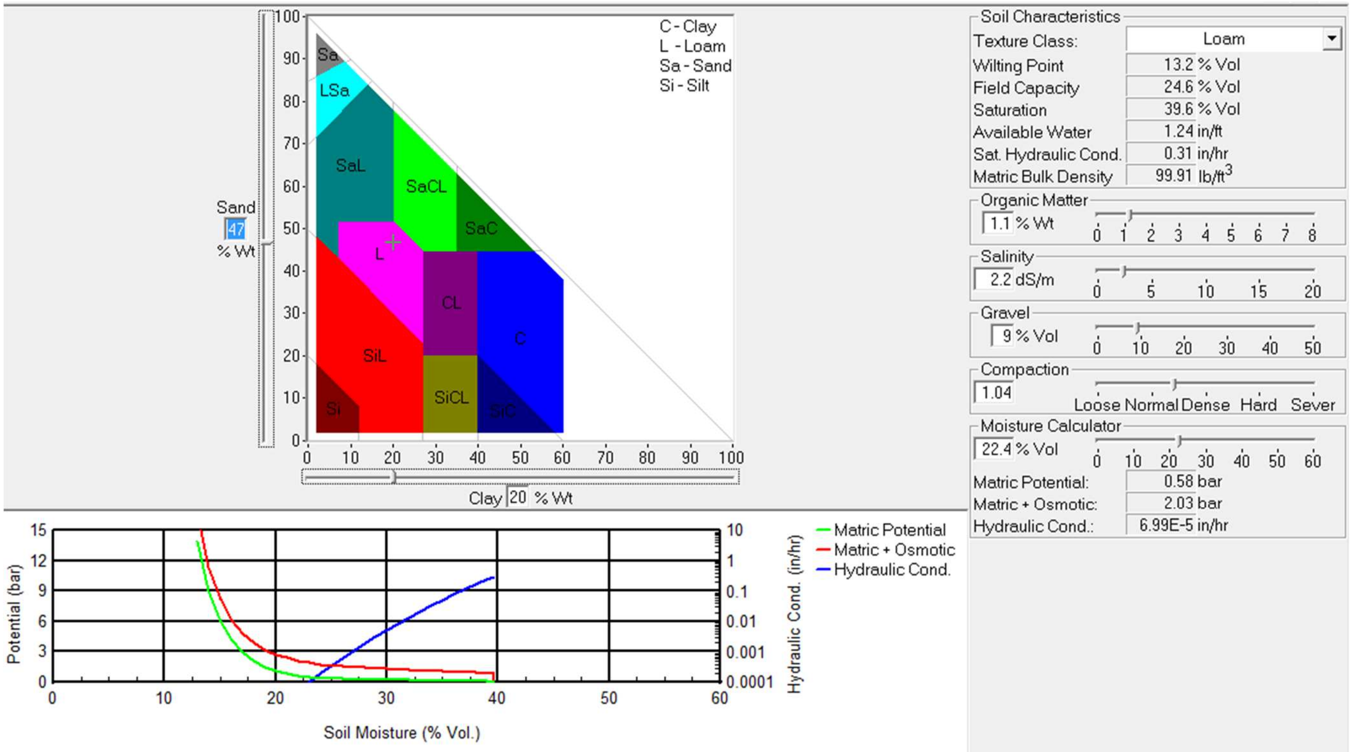
Rosemont Core #13: 82" –90" Invert Elevation: Hydrologic Soil Group C



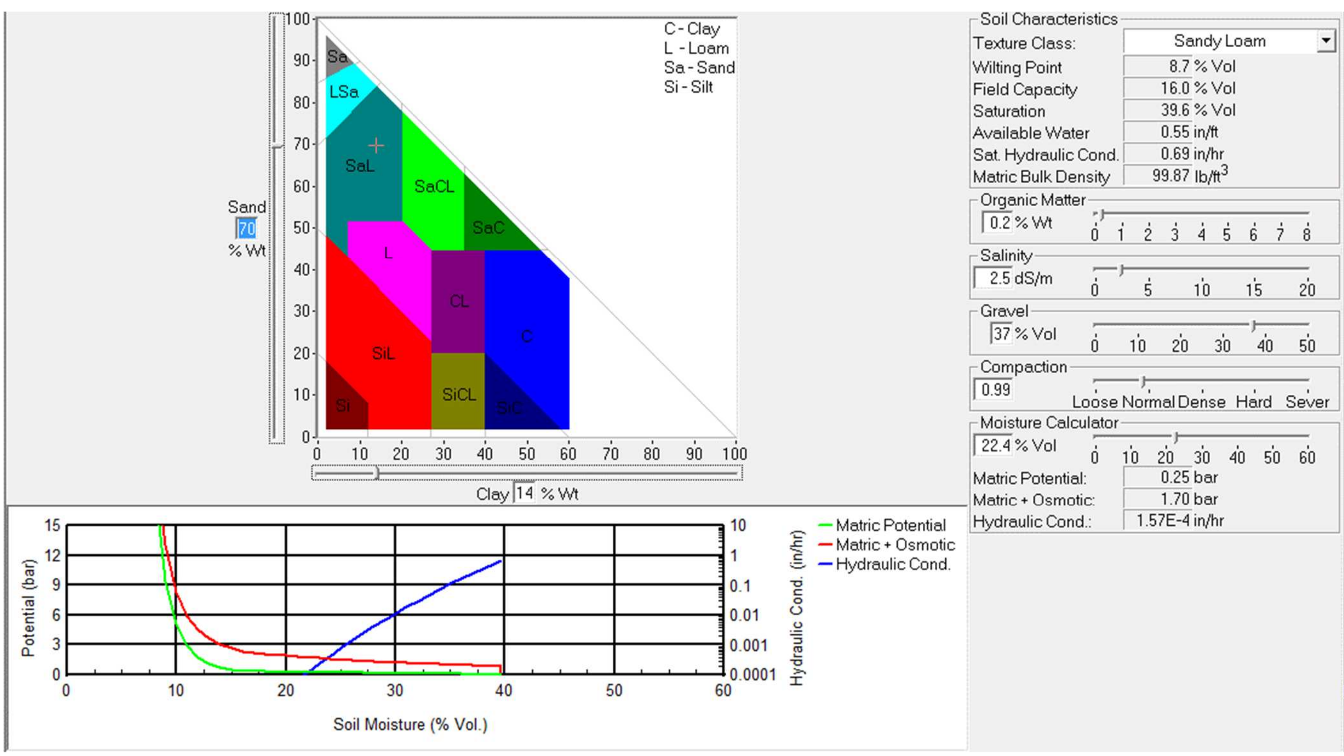
Rosemont Core #13: 90" –106" Below Invert Elevation: Hydrologic Soil Group D



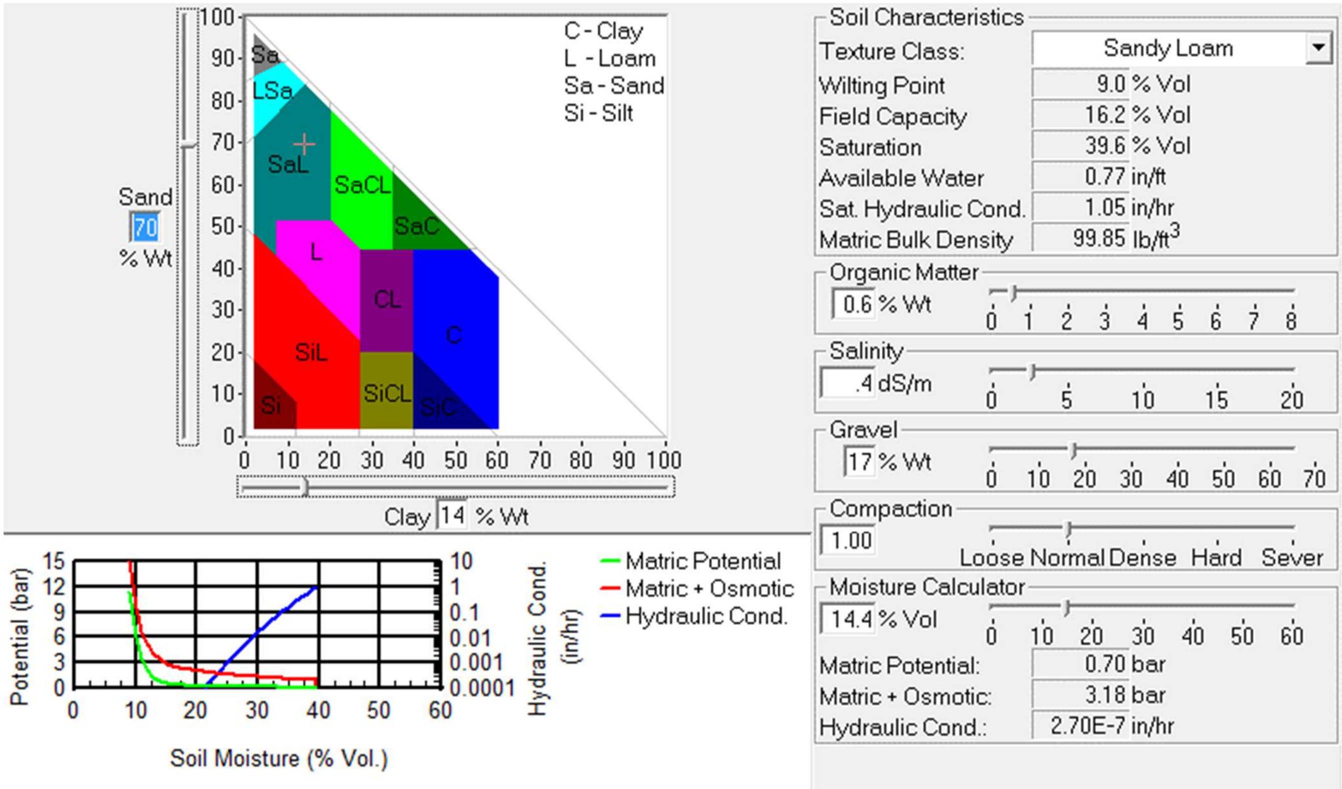
Rosemont Core #14: 26" –45" Invert Elevation: Hydrologic Soil Group C



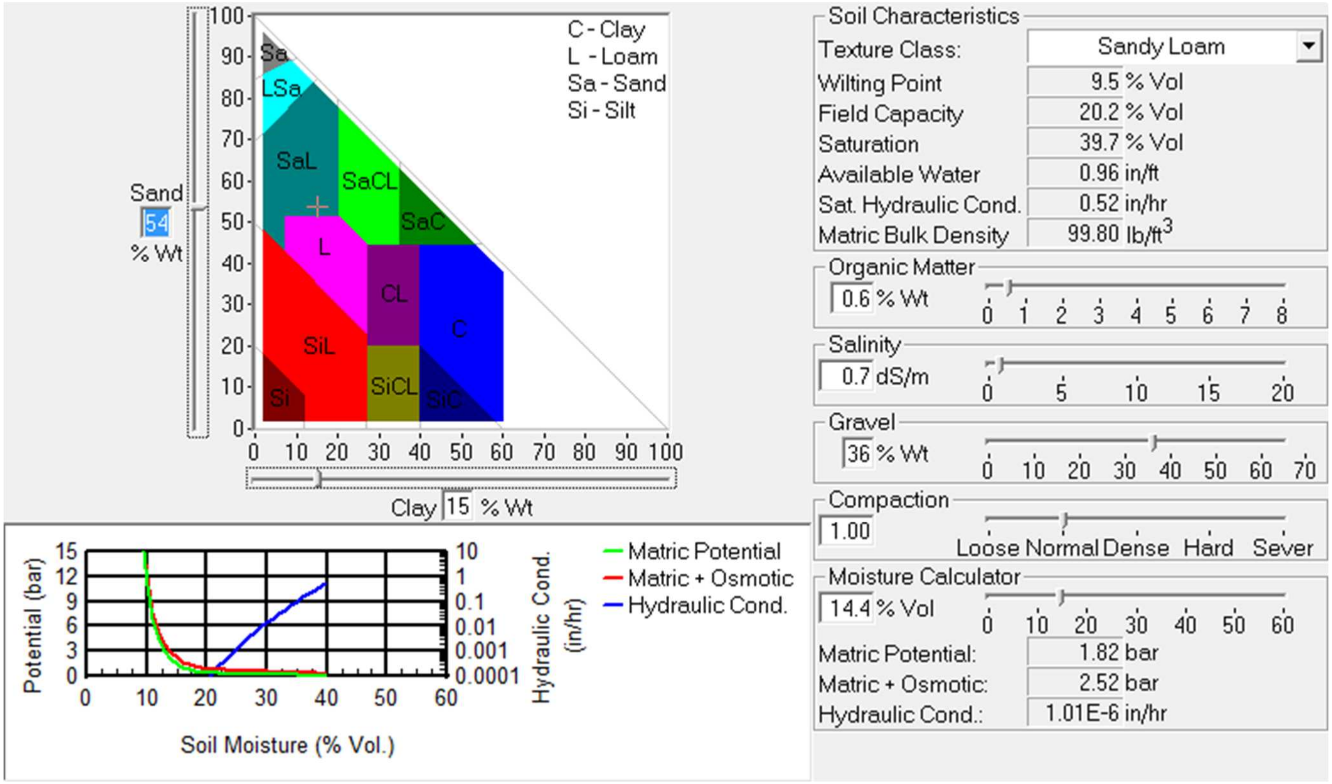
Rosemont Core #14: 45" –72" Below Invert Elevation: Hydrologic Soil Group B



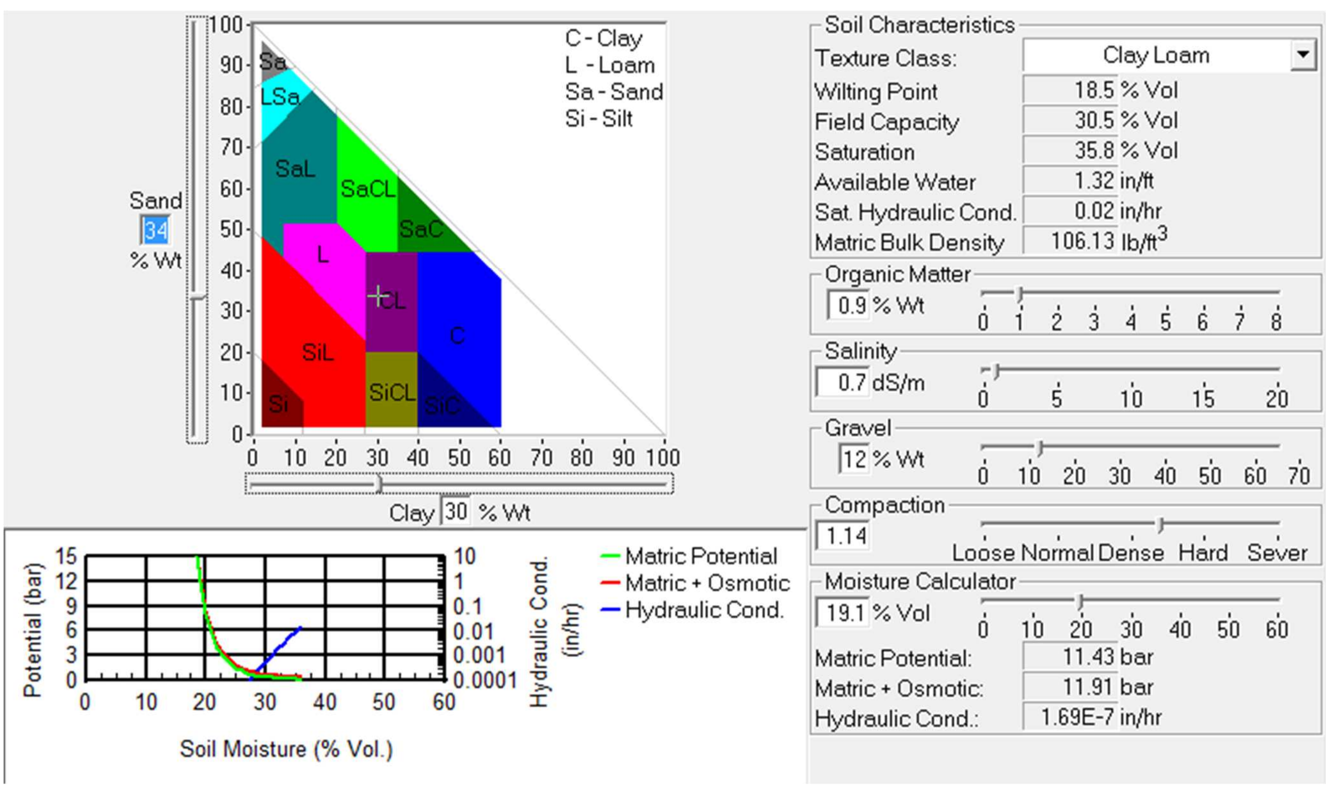
Rosemont Core #15: 40" –48" Invert Elevation: Hydrologic Soil Group B



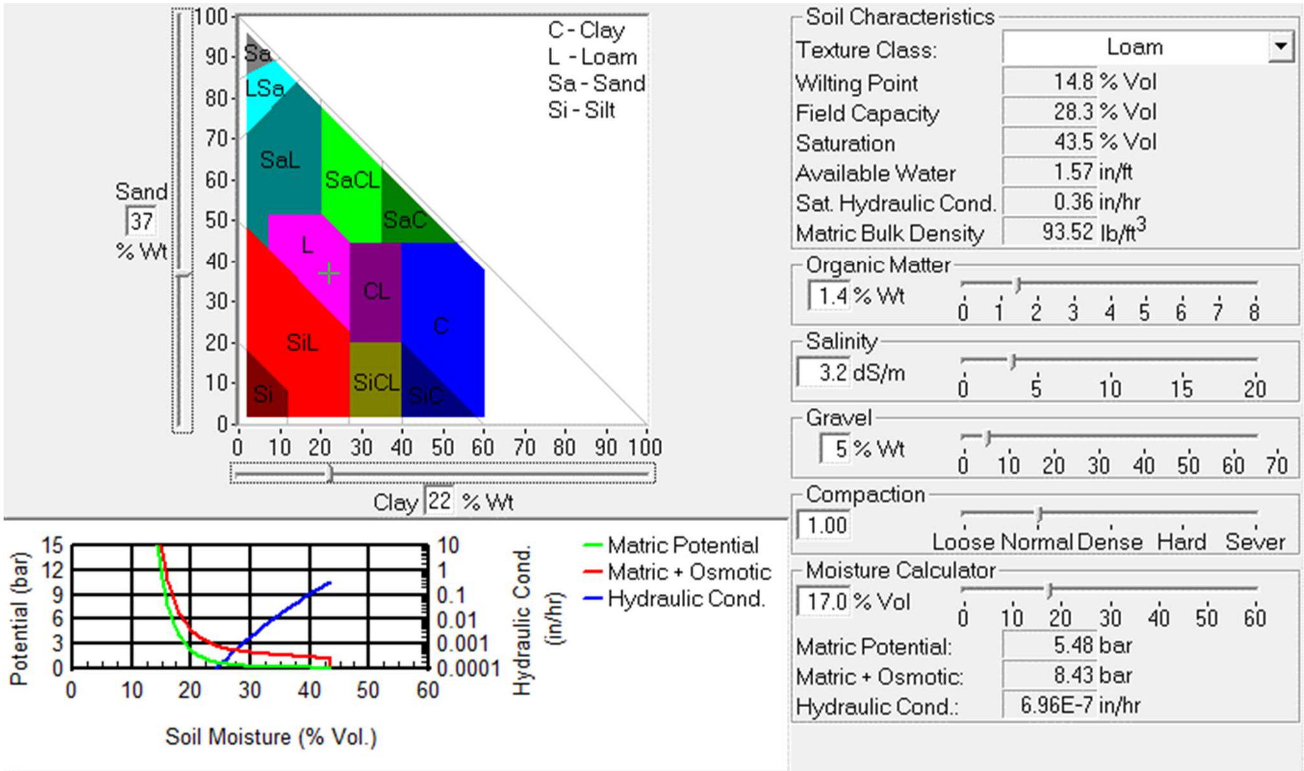
Rosemont Core #16: 56” –64” Invert Elevation: Hydrologic Soil Group B



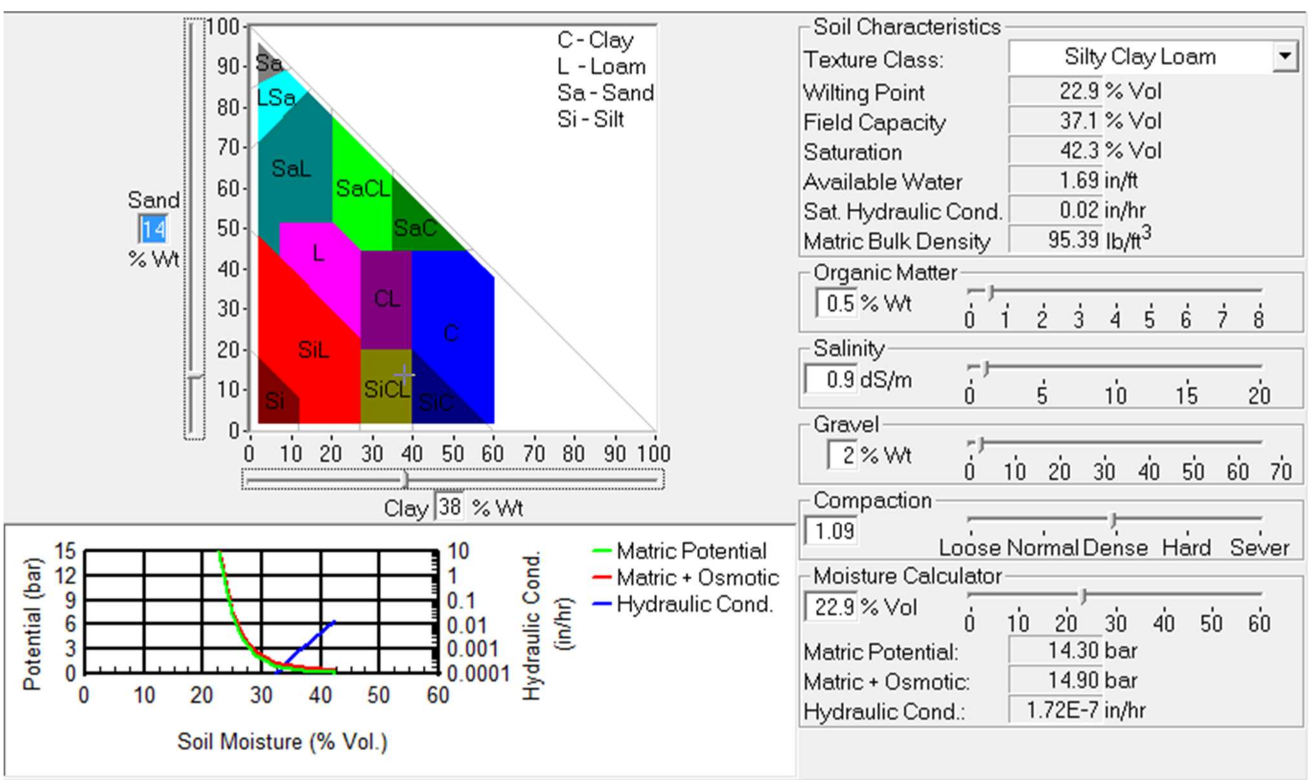
Rosemont Core #16: 64” –72” Below Invert Elevation: Hydrologic Soil Group D



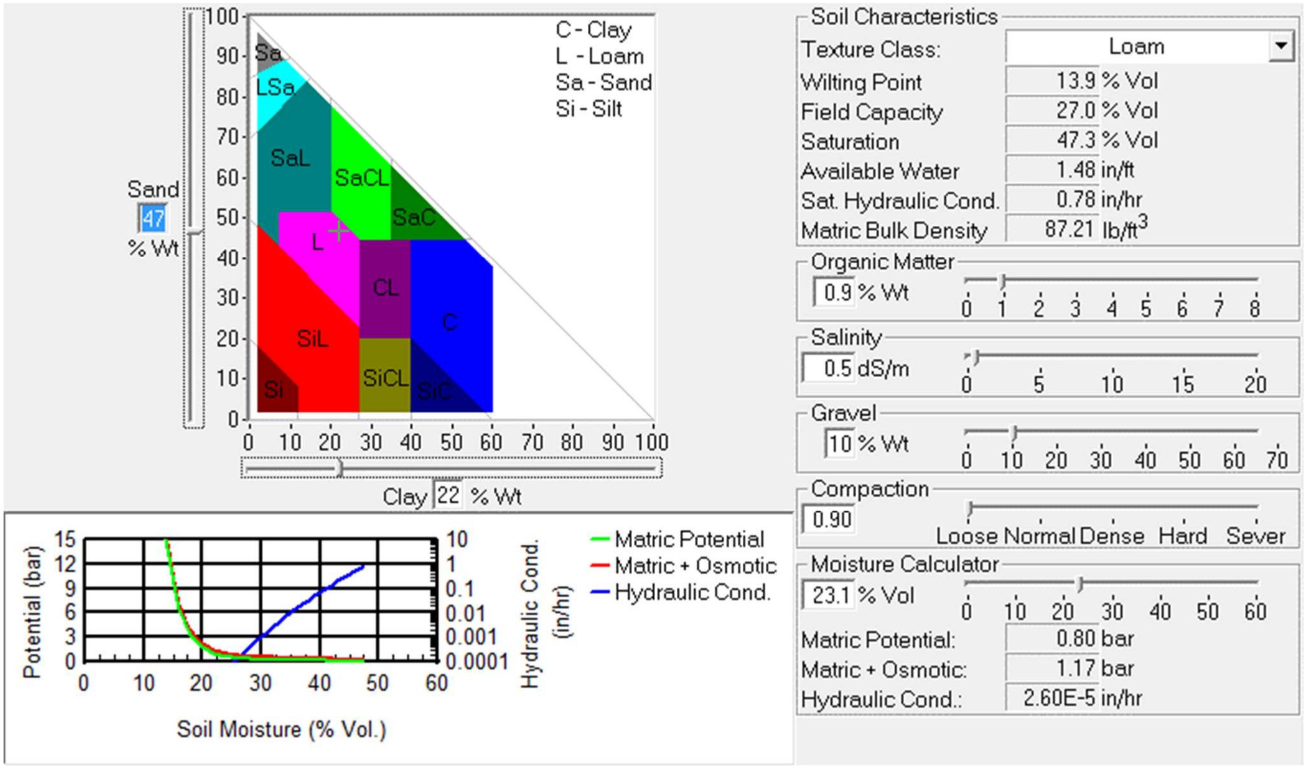
Rosemont Core #20: 60" –70" Invert Elevation: Hydrologic Soil Group C



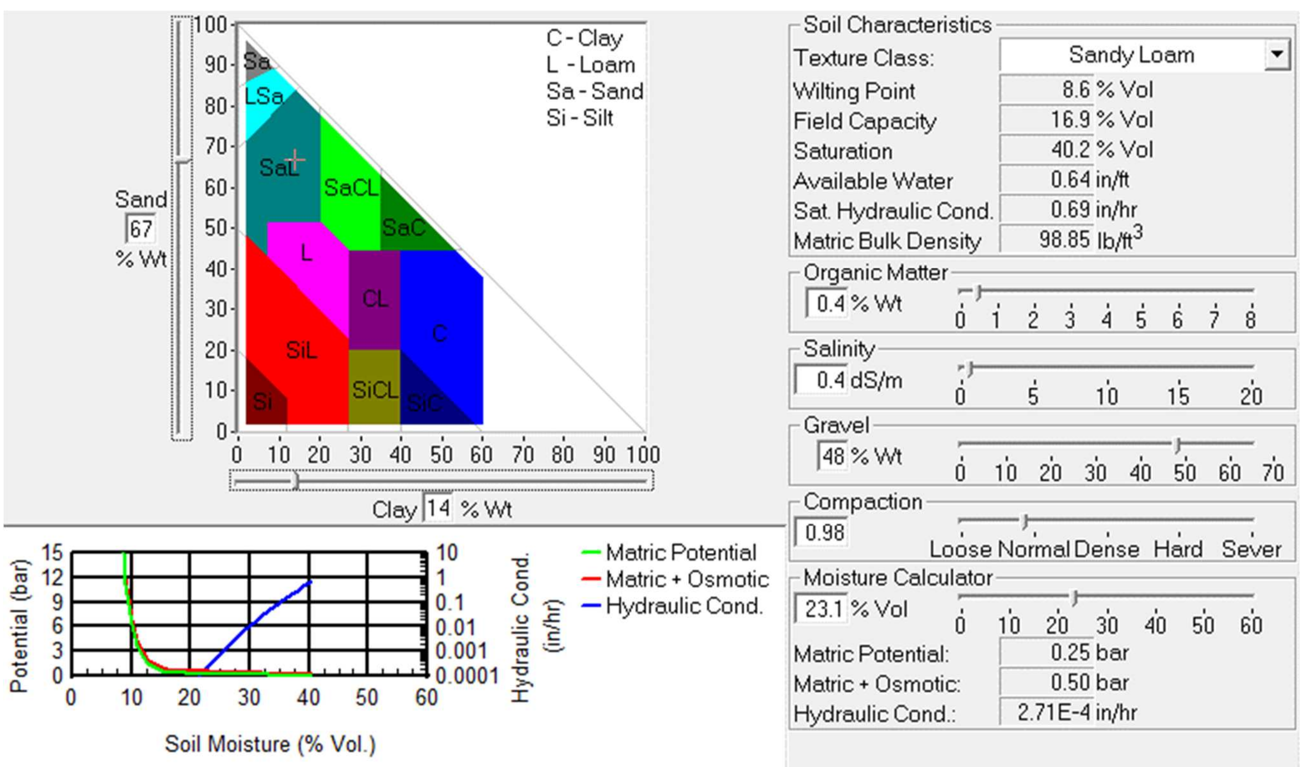
Rosemont Core #20: 70" –108" Below Invert Elevation: Hydrologic Soil Group D



Rosemont Core #21: 35” –44” Invert Elevation: Hydrologic Soil Group B



Rosemont Core #21: 44” –63” Invert Elevation: Hydrologic Soil Group B



Attachment E: Field Notes

Channel Cores
Repository (Stockpile) Cores
Representative Reach Samples
Vertical Cut Bank (Highwall) Samples

SOIL SURVEY FORM

Soil type 2:15-6:00

Area **Rosemont - Sonoita Channel** Date 2/6/15 Photo #:

Classification

Location Channel Core #1

Native Vegetation Pasture abandoned - Mesquite Climate

Parent Material alluvium

Physiography

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope	Moisture	Redoximorphic
Aspect	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*

Permeability

Additional Notes:

File #: 4.8' invert

Stop #: By Ponds in old Channel

Run #	Depth
Run #1	0-47"
Run #2	47-58
Run #3	58-83
Run #4	83-96
Run #5	Bulk Density
Run #6	BD#1 0-6"
Run #7	BD#2 67-96"

Density

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features Bulk	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6	AP	/	/	5yr 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
1	6 / 17	A1	/	/	5yr 3/1	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
1	17 / 27	A2	/	/	5y 2.5/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
2	27 / 53	C1	/	/	5yr 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
3	53 / 67	C2	/	/	5yr 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
4	67 / 96	C3	/	/	5yr 4/4	SL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 8 Lower

SOIL SURVEY FORM

Soil

Soil type 9:00 - 10:45			Additional Notes: Channel invert @
Area **Rosemont - Sonoita Channel**	Date 6/7/15	Photo #:	File #: 7.9'
Classification			Stop #:
Location Channel Core #2	Location #27		Run # Depth
Native Vegetation Abandoned Pasture	Climate		Run #1 0-50'
Parent Material Alluvium.			Run #2 50-72
Physiography Flood Plain			Run #3 72-96
Relief Flat	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness @ 37' Roundish	Run #5
Slope 0-1%	Moisture	Redoximorphic @ 80" Angular	Run #6 Engineering
Aspect —	Root Distribution	% Clay*	Run #7 10:45 - 11:45
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	~~Mottles~~ Sample BD	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 3	Ap			5yr 3/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
1	3 / 10	A1			5yr 3/3	SiCL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
1	10 / 25	Ac			5yr 3/4	ScL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
2	25' / 37'	C1			5yr 3/3	L	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
3	37 / 58	C2			5yr 3/4	SaL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	30% round
4	58 / 80	C3			5yr 3/4	LSa/Sa	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
5	80 / 96	CR			2.5yr 4/4	Rock	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	65% Angular
6	0 / 96"	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

6 Bot las

SOIL SURVEY FORM

Setup 12:55 - 1:15   1:15 - 2:05   Engineering 2:05 - 3:10

Soil type: Pima			Additional Notes:
Area: **Rosemont - Sonoita Channel**	Date: 6/7/15	Photo #:	File #:
Classification			Stop #:
Location: Channel Core #3 . . Way Point #26			Run # / Depth
Native Vegetation: Abandoned pasture irrigated			Run #1: 0-52
Parent Material: Alluvium			Run #2: 52-94
Physiography: Flood Plain			Run #3
Relief: Flat	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness: Rock Starts @ 30"	Run #5
Slope: 0-2%	Moisture	Redoximorphic	Run #6
Aspect: SW	Root Distribution	% Clay*	Run #7: Invert 8.29
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features / Density	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 4	Ap	/	/	5yr 2.5/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<2%
1	4 / 12	A1	/	/	5yr 2.5/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
1	12 / 21	A2	/	/	5yr 2.5/2	L	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	21 / 36	C1	/	/	5yr 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<2%
3	36 / 58	C2		/	5yr 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
4	58 / 94	C3	/	/	2.5yr 4/4	GRSL	GR SBK SGR MA	N W M S L S SH H EH	/	*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
5	0 / 94	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 8 Lab

+ + + + +

SOIL SURVEY FORM

8:00 - 8:30 Travel & Set-up

Soil type: Pima — Ag - 8:30 - 9:35

Area: **Rosemont - Sonoita Channel** — Date: 6/8/15 — Photo #:

Classification:

Location: Core #4 — Placement #2

Native Vegetation: Pasture - Old channel — Climate: Mesquite —

Parent Material: alluvium — was irrigated

Physiography: Flood plain

Relief: Flat — Drainage: — Salt or alkali:

Elevation: — Ground Water: — Stoniness: Small angular gravels

Slope: 0 - 1% — Moisture: — Redoximorphic: 22" - 35"

Aspect: — Root Distribution: — % Clay*:

Erosion: — % Coarse fragments*: — % Coarser than V.F.S.*:

Permeability:

Additional Notes: 9:35 - 10:35

File #: Engineering

Stop #:

Run #	Depth
Run #1	0 - 45"
Run #2	45 - 77"
Run #3	77 - 108"
Run #4	
Run #5	
Run #6	
Run #7	

Invert elevation

708' → 8.32' = 100"

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Bulk Density	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 3	Ap	\	\	5yr 2.5/1	SiCl	GR SBK SGR MA	N W M S L S SH H EH	\	*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	\
1	3 / 9	A1	\	\	5yr 2.5/1	SiCl	GR SBK SGR MA	N W M S L S SH H EH	\		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	\
1	9 / 22	A2	\	\	5yr 3/2	SiCl	GR SBK SGR MA	N W M S L S SH H EH	\		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	\
2	22 / 45	C1	\	\	5yr 3/3	SiCl	GR SBK SGR MA	N W M S L S SH H EH	\	*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
3	45 / 77	C2	\	\	5yr 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	\		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	\
4	77 / 108	C4	\	\	2.5yr 4/3	L	GR SBK SGR MA	N W M S L S SH H EH	\		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	\
5	0 / 108	mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 9

SOIL SURVEY FORM

10:35 - 11 Travel 11 - 1145

Soil type: Pima Ag Sample 11:15 - 12:15

Area: Rosemont - Sonoita Channel | Date: 6/8/15 | Photo #:

Classification:

Location: Core #5

Native Vegetation: Abandoned Pasture + mesquite | Climate:

Parent Material: alluvium

Physiography: Flood Plain

Relief: flat | Drainage: | Salt or alkali:

Elevation: | Ground Water: | Stoniness: Starts @ 12" → 33" CR 46-59

Slope: 0-1% | Moisture: | Redoximorphic:

Aspect: | Root Distribution: | % Clay*:

Erosion: | % Coarse fragments*: | % Coarser than V.F.S.*:

Permeability:

Additional Notes:

File #:

Stop #:

Run #	Depth	
Run #1	0 - 46"	Push
Run #2	46 - 59	rotary
Run #3		
Run #4		refusal w/
Run #5		carbide auger
Run #6		
Run #7	Sample Ag only	

Not alluvial gravels 46 - 59

Sample Number	Depth Upper/Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features Bulk	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0/4	A	/	/	5yr 2.5/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
1	4/12	B	/	/	5yr 3/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
2	12/33	C1	/	/	5yr 3/2	SCL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
3	33/46	C2	/	/	2.5yr 4/3	SCL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
4	46/59	CR	/	/	2.5yr 4/4	SL Gr	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Plot 9

A

A

SOIL SURVEY FORM

1:40 - 3:30

Air / Vacuuming 3:30 - 4:30
4:30 - 5:30 Failed
Ag Core

Soil type: 1:15 - 1:40 - Set up

Area: **Rosemont - Sonoita Channel** | Date: 6/8/15 | Photo #:

Classification:

Location: Core #6 Pipeline crossing

Native Vegetation: Mesquite / dry pasture | Climate:

Parent Material: Alluvium

Physiography: Valley floor

Relief: Flat | Drainage: | Salt or alkali:

Elevation: | Ground Water: | Stoniness: Angular gravel @45

Slope: 0 - 1% | Moisture: | Redoximorphic: - 80"

Aspect: — | Root Distribution: | % Clay*: Not alluvial

Erosion: | % Coarse fragments*: | % Coarser than V.F.S.*:

Permeability:

Additional Notes: Channel Invert

File #: 2 8.1

Stop #:

Run #	Depth	
Run #1	0 - 45	Rush
Run #2	45 - 55	Rock Rotary
Run #3	55 - 73	Rocky
Run #4	73 - 80	Rocky
Run #5		
Run #6		Sand layer on
Run #7		Dune AC over
		Buried A over
		Angular residuum

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 29	AC dune	/	/	5yr 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	29 / 45	2A	/	/	5yr 2.5/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10
3	45 / 80	Cr1	/	/	2.5yr 3/6	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	45%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Hole Collapsed at 84".

Box 9

8:15 - 9:00

Engineering Core - 0-60 - Collapse

SOIL SURVEY FORM

Soil type: Ag Core 7:30 - 8:15

Area: Rosemont - Sonoita Channel

Date: 6/9/15

Photo #:

Classification:

Location: Core #7 Placemark 30

Native Vegetation: Mesquite

Climate:

Parent Material: alluvial (colluvial)

Physiography: flood plain

Relief: Flat

Drainage:

Salt or alkali: Caliche @ 10"+

Elevation:

Ground Water:

Stoniness: Calcareous gravel

Slope: 0-2%

Moisture: Dry

Redoximorphic: @ 10" angular

Aspect: —

Root Distribution:

% Clay*:

Erosion:

% Coarse fragments*:

% Coarser than V.F.S.*:

Permeability:

Additional Notes: inverted @ 8.57

File #:

Stop #:

Run #	Depth
Run #1	0-23" angular gravels @ 10"
Run #2	
Run #3	Hole Collapse @
Run #4	12" due to gravels
Run #5	
Run #6	
Run #7	

Adjacent to gravel pit

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 7	A			5YR 2.5/2	sicl	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
2	7 / 23	Cr			2.5YR 4/3	gr SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	55%
3	0 / 60	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 9 Lay

SOIL SURVEY FORM 2 Locations

Engineering Core 11:15-1:00

Soil type ag Core 10:00 — 11:15			
Area **Rosemont - Sonoita Channel**		Date 6/9/15	Photo #:
Classification #8 Core			
Location Gravel Pit Floor - on centerline of Channel			
Native Vegetation Gravel Pit		Climate	
Parent Material alluvial			
Physiography Pit			
Relief	Drainage	Salt or alkali	
Elevation	Ground Water	Stoniness	
Slope	Moisture	Redoximorphic	
Aspect	Root Distribution	% Clay*	
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Additional Notes: Run Texture & Coarse frag only on Bulk Density

File #:

Stop #:

Run #	Depth	
Run #1	0 - 36"	
Run #2	36 - 48	Gravel lens
Run #3	48 - 61	" "
Run #4	61 - 76	" "
Run #5	76 - 89"	Refusal
Run #6		
Run #7	Engineering	SL refusal

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features Bulk Density	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 36					L	GR SBK SGR MA	N W M S L S SH H EH		*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
2	36 / 48				SL	GR	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
3	48 / 61				SL	GR	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
4	61 / 76				SL	SGr	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	40%
5	76 / 89				SL	SGr	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	40%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box D

SOIL SURVEY FORM

Travel to site 7:30 - 8:00 w/ Corey Dickline

Ag - 800 - 8:30 - Setup

Soil type PM			
Area **Rosemont - Sonoita Channel** 8:30 - 9:20	Date 6/10/15	Photo #:	
Classification			
Location Core #10			
Native Vegetation Alkali Sacaton	Climate		
Parent Material Alluvial			
Physiography Flood Plain			
Relief Flat	Drainage	Salt or alkali	
Elevation	Ground Water	Stoniness	
Slope 0-2%	Moisture	Redoximorphic	
Aspect —	Root Distribution	% Clay*	
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Additional Notes: Engineering 9:20 - 10:20

File #:

Stop #:

Run #	Depth	
Run #1	0-45"	
Run #2	45-57"	gravels angular
Run #3	57-69	"
Run #4	69-96	96-69 = 35
Run #5		
Run #6	96-120	Large Cobble
Run #7		4-6" Diameter

refusal @ 120"

31.61121

-110.71827

Bott

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features Density	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 9	A	/	/	5yr 2.5/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
1	9 / 24	AC	/	/	5yr 3/2	SCL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
2	24 / 57	2A	/	/	5yr 4/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
3	57 / 85	C1	/	/	5yr 3/2	SL Gr	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	60%
4	85 / 96	C2	/	/	5yr 4/3	LS→SL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10-15%
5	0 / 120	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 10

Box 11

SOIL SURVEY FORM

Engr. 1:30 – 3:15

Soil type: ag 1:00 – 1:30			
Area: **Rosemont - Sonoita Channel**	Date: 6/10/15	Photo #:	
Classification			
Location: Deep Core # 12			
Native Vegetation: alkali Sacaton	Climate		
Parent Material: alluvium			
Physiography: flood plain			
Relief: Flat	Drainage	Salt or alkali	
Elevation	Ground Water	Stoniness: Corse granular gravel @ 56" (4" deep)	
Slope: 0 – 1%	Moisture	Redoximorphic	
Aspect: —	Root Distribution	% Clay*	
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0 – 46"
Run #2	46 – 69
Run #3	69 – 86
Run #4	86 – 96
Run #5	96 – 102
Run #6	0 – 144" Engineering
Run #7	

31.6107
−110.71885

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 14	AC	/	/	2.5yr 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	/	Sand Dep.	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	14 / 34	2A	/	/	5yr 2.5/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	40%
3	34 / 56	2Bt	/	/	2.5yr 3/1	SC	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
4	56 / 79	C1	/	/	2.5yr 4/3	SL (gr)	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
4	79 / 86	C2	/	/	5yr 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
5	86 / 102	CR	/	/	7.5yr 3/3	Cobble gravel	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	75%
6	0 / 144	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 11
Lab

SOIL SURVEY FORM

10:00 — 12:00   9g& Engineering

Soil type: North Map

Area: **Rosemont - Sonoita Channel**   Date: 6/11/13   Photo #:

Classification: 31°38'22.62"N, 110°42'44.39"W

Location: Cone #14 -

Native Vegetation: Mesquite & shortgrass   Climate:

Parent Material: Alluvium

Physiography: Bench Deposits

Relief: Flat   Drainage: Salt or alkali:

Elevation: Ground Water: Stoniness:

Slope: 0-2%   Moisture: Redoximorphic:

Aspect: —   Root Distribution: % Clay*:

Erosion: % Coarse fragments*:   % Coarser than V.F.S.*:

Permeability:

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-44"
Run #2	44-48"
Run #3	48-59
Run #4	59-72
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper/Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0/9	A	—	—	5yr 3/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
2	9/26	Bt	—	—	5yr 3/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
3	26/48	Bk	—	—	5yr 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	Threads CaCO3 F M N Co Cr C D I P R S T	10%
4	48/72	Cr	—	—	5yr 4/3	Gravel SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	45%
5	0/72	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Rox 12 Lab

SOIL SUVREY FORM

Engineering:

Soil type: ag = 12:[illegible] - 2:30			Additional Notes:
Area: Rosemont - Sonoita Channel	Date: 6/11/15	Photo #:	File #:
Classification: 31° 38.5.12"N, 110° 42', 40.77" W			Stop #:
Location: Cove #15 North Map			Run # / Depth
Native Vegetation: Mesquite & Short grass	Climate:		Run #1: 0-36
Parent Material: Alluvium			Run #2: 36-48
Physiography: Bench alluvial			Run #3:
Relief: flat	Drainage:	Salt or alkali:	Run #4:
Elevation:	Ground Water:	Stoniness: gravel @ 9"-36	Run #5:
Slope: 0-2%	Moisture:	Redoximorphic: in sandy matrix	Run #6:
Aspect: —	Root Distribution:	% Clay*:	Run #7:
Erosion:	% Coarse fragments*:	% Coarser than V.F.S.*:	
Permeability:			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 10	A			5YR 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	10 / 40	AC			5YR 4/3	SL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	30%
3	40 / 48	C			5YR 2.5/1	CL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
4	0 / 48	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box Lab 12

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Eng- 9:00 - 10:00
Ag- 8 - 9:00

SOIL SURVEY FORM

Setup 7:30 - 8:00

Soil type: Ag Core			Additional Notes: Invert elevation 15.5'
Area: **Rosemont - Sonoita Channel**	Date: 6/12/15	Photo #:	File #:
Classification			Stop #:
Location: Core #17 - South Map			Run # / Depth
Native Vegetation: Alk. Sacaton + Mesquite	Climate		Run #1: 0-42
Parent Material: Alluvial			Run #2: 45-54
Physiography: Flood Plain			Run #3: 54-102
Relief: Flat	Drainage	Salt or alkali	Run #4: Hole Collapse @ 72"
Elevation	Ground Water	Stoniness: Gravel @ 20" Pure gravel	Run #5: due to pea gravels -
Slope: 0-1%	Moisture	Redoximorphic: @ 74-102"	Run #6: loose
Aspect	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	Refusal @ 120" due to Big Cobble
Permeability			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	~~Surface Features~~ Bulk density	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 13	A		/	5yr 2.5/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	13 / 29	B+K		/	5yr 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	A	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
3	29 / 54	C1		/	5yr 4/3	FSL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	40%
4	54 / 74	C2		/	5yr 3/3	GFSL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	40%
5	74 / 102	CR		/	5yr 4/4	LS Rock	GR SBK SGR MA	N W M S L S SH H EH	/	*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	65%
6	0 / 120	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 13
Lab

SOIL SURVEY FORM

Ag 10-12:00 Eng 12:45 - 2:30

Soil type

Area **Rosemont - Sonoita Channel** Date 8/12/15 Photo #:

Classification

Location Core #18 - South Map

Native Vegetation Alkalai Sacaton - Mesquite Climate

Parent Material Alluvial

Physiography Flood plain

Relief Flat | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness

Slope 0-1% | Moisture | Redoximorphic

Aspect | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Additional Notes: Invert elevation @ 13.1

File #:

Stop #:

Run #	Depth
Run #1	0 - 45"
Run #2	45 - 72"
Run #3	72 - 96
Run #4	96 - 116
Run #5	116 - 132
Run #6	
Run #7	

Root 13 Lab

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	~~Mottles~~ BD	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
* 1	0 / 12	A	/	/	5yr 2.5/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C ~~G~~ D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N ~~Co~~ Cr C D I P R S T	<5%
* 2	12 / 47	AC	/	/	5yr 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A ~~C~~ G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N ~~Co~~ Cr C D I P R S T	20%
* 3	47 / 76	2Bt	/	/	5yr 3/2	CL	GR SBK SGR MA	N W M S L S SH H EH	*	/	V A C ~~G~~ D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	Filaments CaCO3 F M N Co Cr C D I P R S T	<5%
* 4	76 / 114	C1		/	5yr 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	*	/	V A ~~C~~ G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N ~~Co~~ Cr C D I P R S T	<5%
* 5	114 / 132	CR	/	/	5yr 3/3	SL Gr	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C ~~G~~ D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N ~~Co~~ Cr C D I P R S T	55%
* 6	0 / 132	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Ag - 2:45 - 4:00 Engr - 4:00

Soil type				Additional Notes:	Depth of involved
Area	Rosemont - Sonoita Channel	Date 6/12/15	Photo #:	File #:	= 11.0 and 10.6
Classification				Stop #:	
Location	Core #9 South end			Run #	Depth
Native Vegetation	Alkali Sacaton, mesquite	Climate		Run #1	0-48'
Parent Material	alluvial			Run #2	48-68
Physiography	Flood plain			Run #3	68-97
Relief	Flat	Drainage		Salt or alkali: Loose	Run #4: 97-132 refusal @
Elevation		Ground Water		Stoniness: Sandy Gravel @	Run #5: 132 - hole
Slope	0-1%	Moisture		Redoximorphic: 50-72" ±	Run #6: Collapse.
Aspect		Root Distribution		% Clay*: 97-132	Run #7
Erosion		% Coarse fragments*		% Coarser than V.F.S.*	
Permeability					

Rock Lab

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	~~Surface Features~~ BD	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 12	A			5yr 3/1	SiCL	GR SBK SGR MA	N W MS L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
1	12 / 24	Bt			5yr 2.5/1	SiCL	GR SBK SGR MA	N W MS L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
2	24 / 39	Btk			5yr 3/2	L	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
2	39 / 50	2A			5yr 3/2	L	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
3	50 / 72	C1			5yr 3/3	SL gr	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
4	72 / 97	C2			5yr 2.5/1	CL	GR SBK SGR MA	N W MS L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
5	97 / 132	C3			5yr 4/3	SL gr	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	30%
6	0 / 132	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Eng - 9:15 - 10:00

ag 8:15 - 9:15

SOIL SURVEY FORM

Soil type			Additional Notes: Invert elevation
Area **Rosemont - Sonoita Channel**	Date 6/13/15	Photo #:	File #: = -2.26'
Classification			Stop #: Core next to channel
Location Core #20			Run # / Depth
Native Vegetation alkalai Sacaton / mesquite	Climate		Run #1 0-48"
Parent Material Alluvium			Run #2 48-78"
Physiography Flood Plain			Run #3 78-108"
Relief Flat	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness Gravel Starts @ 42" 6" thick (48")	Run #5
Slope 0-1%	Moisture	Redoximorphic	Run #6
Aspect —	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	~~Surface Features~~ BD	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 18	AC			5yr 4/3	L	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
2	18 / 31	2A			5yr 3/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
2	31 / 42	2B+			5yr 3/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
3	42 / 60	2Bk			5yr 4/3	SL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
4	60 / 78	C1			5yr 3/3	L	GR SBK SGR MA	N W M S L S SH H EH		*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
5	78 / 108	C2			5yr 2.5/2	CL	GR SBK SGR MA	N W M S L S SH H EH		*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
6	0 / 108	Mix					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 1, Lab

SOIL SURVEY FORM

Drive 10-10:30 10:30-11:35

Soil type

Area **Rosemont - Sonoita Channel** Date 6/13/15 Photo #:

Classification

Location Core #21

Native Vegetation Alkali Sacaton Mesquite Climate

Parent Material alluvium

Physiography Flood Plain

Relief Flat Drainage Salt or alkali

Elevation Ground Water Stoniness

Slope 0-1% Moisture Redoximorphic

Aspect — Root Distribution % Clay*

Erosion % Coarse fragments* % Coarser than V.F.S.*

Permeability

Additional Notes: Invert elevation @ 8.5'

File #:

Stop #:

Run #	Depth
Run #1	0 - 60"
Run #2	60 - 81"
Run #3	81" - 96
Run #4	
Run #5	
Run #6	
Run #7	

Bot
Lab

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	~~Surface Features~~ BD	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 8	AC1	/	/	5yr 4/4	GSL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
1	8 / 23	AC2	/	/	5yr 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	23 / 35	2A	/	/	5yr 2.5/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
3	35 / 63	2B	/	/	5yr 3/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
4	63 / 96	C1	/	/	5yr 4/3	GSL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	55%
5	Mix	0-96					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 2:30 – 3:00

Area **Rosemont - Sonoita Channel**	Date 6/5/15	Photo #:	Additional Notes:
Classification			File #:
Location North Stockpile Sample A			Stop #:
Native Vegetation Mesquite, Oak	Climate		**Run #** / **Depth**
Parent Material Colluvium			Run #1 0 4
Physiography Top of Slope			Run #2 4 17
Relief Steep	Drainage	Salt or alkali	Run #3
Elevation	Ground Water	Stoniness	Run #4
Slope 33%	Moisture	Redoximorphic	Run #5
Aspect	Root Distribution	% Clay*	Run #6
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	Run #7
Permeability			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0/4	A			5YR 3/3	gr. SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	55%
2	4/17	AC			2.5YR 3/3	grv. SCL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	55%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Bork Lab
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SOIL SUVEY FORM

Soil type 5:30 – 4:15		Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/5/15	Photo #: 107, 379, 380 Ken's Camera 384
		File #:
Classification		Stop #:
Location North Stockpile SAMPLE B		Run # / Depth
Native Vegetation Juniper, Mesquite, Lonicera ?	Climate	Run #1 0 4
Parent Material Colluvium		Run #2 4 10
Physiography Top of slope		Run #3
Relief / Drainage	Salt or alkali	Run #4
Elevation / Ground Water	Stoniness	Run #5
Slope / Moisture	Redoximorphic	Run #6
Aspect / Root Distribution	% Clay*	Run #7
Erosion / % Coarse fragments*	% Coarser than V.F.S.*	
Permeability		

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 4				5YR 2.5/1	Gr SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	55%
2	4 / 10				5YR 3/4	Gr SCL	GR SBK SGR MA	N W M S L S SH H EH	✓	✓	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	40%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 7 Labs
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SOIL SURVEY FORM

Soil type 4:15 - 4:45

Area **Rosemont - Sonoita Channel**		Date 6/5/2015	Photo #: 101, 382, 383 [illegible] Camera
Classification			
Location North Stockpile SAMPLE C			
Native Vegetation Lonicera, Yucca		Climate	
Parent Material Residuum			
Physiography Mid-slope			
Relief	Drainage	Salt or alkali	
Elevation	Ground Water	Stoniness	
Slope 20-30%	Moisture	Redoximorphic	
Aspect W	Root Distribution	% Clay*	
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Rot X Lab

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
* 0-4"		A			2.5YR 3/4	Sandy Loam	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
* 4-10"		AC			2.5YR 3/4	Sandy Loam	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type: Pima 9:15 - 9:50

Area: **Rosemont - Sonoita Channel** | Date: 6/6/15 | Photo #:

Classification:

Location: Stockpile North Sample D

Native Vegetation: Abandoned irrigated Pasture | Climate:

Parent Material: alluvial fine

Physiography: Flood Plain

Relief: | Drainage: | Salt or alkali:

Elevation: | Ground Water: | Stoniness:

Slope: 0-2% | Moisture: Dry | Redoximorphic:

Aspect: — | Root Distribution: | % Clay*:

Erosion: — | % Coarse fragments*: | % Coarser than V.F.S.*:

Permeability:

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-28"
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 4	Ap			10YR 3/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
1	4 / 10	A1			10YR 3/2	✓	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
2	10 / 28"	Ab			10YR 2/3	✓	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 2 Lab

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SOIL SURVEY FORM

Soil type	Pima 9:50 - 10:25
Area	Rosemont - Sonoita Channel
Date	6/6/15
Photo #:	
Classification	
Location	North Stockpile Sample E
Native Vegetation	Abandoned Irrigated Pasture
Climate	
Parent Material	alluvial
Physiography	flood Plain
Relief	
Drainage	
Salt or alkali	
Elevation	
Ground Water	
Stoniness	
Slope	0 - 2%
Moisture	Dry
Redoximorphic	
Aspect	—
Root Distribution	
% Clay*	
Erosion	
% Coarse fragments*	
% Coarser than V.F.S.*	
Permeability	

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0 - 31
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 3	Ap	/	/	5yr 3/3	✓	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0
1	3 / 10	A1	/	/	5yr 2.5/2	✓	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0
2	10 / 31	A2	/	/	5yr 3/3	✓	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 2 Rock

SOIL SURVEY FORM

Soil type: Pima 10:25 – 10:50

Area: **Rosemont - Sonoita Channel**

Date: 6/6/15

Photo #:

Classification:

Location: North Stockpile Sample F

Native Vegetation: Abandoned Pasture – irrigated

Climate:

Parent Material: alluvium

Physiography: Flood plain

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 0 – 1%	Moisture Dry	Redoximorphic
Aspect —	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0 – 39"
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

3 of 7

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 5	Ap	/	5yr 7.5/2	→	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
1	5 / 13	A1	/	5yr 3/2	→	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	13 / 25	A2	/	5yr 7.5/1	→	CL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type	7:20 - 7:50
Area	**Rosemont - Sonoita Channel**
Date	6/6/15
Photo #:	
Classification	
Location	Stockpile South Sample A
Native Vegetation	Mesquite, yucca grass
Climate	
Parent Material	residuum
Physiography	Mid slope
Relief	
Drainage	
Salt or alkali	
Elevation	
Ground Water	
Stoniness	Cobbly surface
Slope	20-30%
Moisture	Dry
Redoximorphic	
Aspect	W
Root Distribution	
% Clay*	
Erosion	
% Coarse fragments*	
% Coarser than V.F.S.*	
Permeability	

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-4"
Run #2	4-10"
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 4	A			5YR 3/3	SCL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	55%
2	4 / 10	AC			5YR 2.5/2	SL	GR SBK SGR MA	N W M S L S SH H EH	—	✓	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	40%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Rock way

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SOIL SURVEY FORM

Soil type 7:50 - 8:10

Area **Rosemont - Sonoita Channel** | Date 6/6/15 | Photo #:

Classification

Location Stockpile South Sample B

Native Vegetation Mesquite, grass | Climate

Parent Material residuum

Physiography Mid Slope

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness Cobble Surface

Slope 20-30% | Moisture Dry | Redoximorphic

Aspect W | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run # Depth

Run #1

Run #2

Run #3

Run #4

Run #5

Run #6

Run #7

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 3	A			5YR 3/2	Loam	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
N/A	/	CR					GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 7
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SOIL SURVEY FORM

Soil type: Pima 11:30-12

Area: **Rosemont - Sonoita Channel** Date: 6/6/15 Photo #:

Classification:

Location: South Stockpile Sample C

Native Vegetation: abandoned irrigated Pasture Climate:

Parent Material: alluvium

Physiography: Flood plain

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope: 0-1%	Moisture	Redoximorphic
Aspect: —	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*

Permeability:

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-38"
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 3	Ap	/	/	5yr 3/1	CL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
1	3 / 13	A1	/	/	5yr 3/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	13 / 38	A2	/	/	5yr 2.5/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box X

X

SOIL SURVEY FORM

Soil type Pima	10:50 – 11:30		Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/10/15	Photo #:	File #:
Classification			Stop #:
Location South Stockpile Sample D			Run # / Depth
Native Vegetation	Climate		Run #1 0 – 2'
Parent Material Alluvium			Run #2
Physiography Flood Plain			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness @ 24"	Run #5
Slope 0-1%	Moisture Dry	Redoximorphic	Run #6
Aspect	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 4	Ap	/	/	5yr 3/1	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0
1	4 / 12	A1	/	/	5yr 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	2%
2	12 / 24	A2	/	/	5yr 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 7 Lab

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SOIL SURVEY FORM

Soil type Pima 115-133

Area **Rosemont - Sonoita Channel** Date 6/6/15 Photo #:

Classification

Location South Stockpile Sample E

Native Vegetation Abandoned Pasture - Mesquite invasion Climate

Parent Material alluvial - Fine

Physiography Flood plain

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness

Slope | Moisture | Redoximorphic

Aspect | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0 - 32"
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6	AP	/	/	5yr 3/1	CL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
1	6 / 16	A1	/	/	5yr 2.5/1	CL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
2	16 / 29	A2	/	/	5yr 4/4	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	0%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 8
Lab
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SOIL SURVEY FORM

Soil type 1:30 – 3 4:00		Additional Notes: Hand Dig
Area **Rosemont - Sonoita Channel**	Date 6/9/15 Photo #:	File #:
Classification		Stop #:
Location Gravel Pit Highwall Sample #9		Run # Depth
Native Vegetation Mesquite	Climate	Run #1
Parent Material alluvial		Run #2
Physiography		Run #3
Relief / Drainage	Salt or alkali	Run #4
Elevation / Ground Water	Stoniness	Run #5
Slope / Moisture	Redoximorphic	Run #6
Aspect W / Root Distribution	% Clay*	Run #7
Erosion / % Coarse fragments*	% Coarser than V.F.S.*	
Permeability		

Sample Number	Depth Upper/Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 0.4	A			5yr 3/2	SiCL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	0.4 / 1.7	C1				Co SL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	75%
3	1.7 / 2.4	C2				Gr LS	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	60%
4	2.4 / 3.3	C3				Co LS	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	65%
5	3.3 / 5.1	C4				SL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
6	5.1 / 6.9	C5				LS Gr	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	80%
7	6.9 / 8.0	C6				C LS	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	70%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Bot 10

Lab

SOIL SURVEY FORM

Soil type: Ag + Eng. 10:30 – 11:00	Additional Notes:
Area: **Rosemont - Sonoita Channel** — Date: 6/10/15 — Photo #:	File #:
Classification	Stop #:
Location: Highwall #11	Run # — Depth
Native Vegetation: grass — Climate	Run #1
Parent Material: alluvial	Run #2
Physiography: Channel Bank	Run #3
Relief: Steep — Drainage — Salt or alkali	Run #4
Elevation — Ground Water — Stoniness	Run #5
Slope: Vertical — Moisture — Redoximorphic	Run #6
Aspect: W — Root Distribution — % Clay*	Run #7
Erosion: Mass Wasting — % Coarse fragments* — % Coarser than V.F.S.*	
Permeability	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features Bulk Density	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 1'	A	/	/	5yr 3/3	LS	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	1 / 2.1	BT	/	/	5yr 4/3	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
3	2.1 / 2.7	Bc	/	/	5yr 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	Small grain gravel
4	2.7 / 4.2	C1	/	/	5yr 4/1	L	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
5	4.2 / 5.5	C2	/	/	5yr 4/2	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
6	5.5 / 6.5	C3	/	/	5yr 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 11
Bank

5b

SOIL SURVEY FORM

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Soil type: Highwall Sample 7:25 – 9:30

Area: **Rosemont - Sonoita Channel** | Date: 6/10/15 | Photo #:

Classification:

Location: Core #13 (South Map) Placemark 60

Native Vegetation: | Climate:

Parent Material:

Physiography:

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness: Cobble 1/2–4" (rounded angular)
Slope	Moisture	Redoximorphic: Starts @ 4.8 – 5.4
Aspect	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*
Permeability		

Additional Notes:

File #:

Stop #:

Run # / Depth

Run #1

Run #2

Run #3

Run #4

Run #5

Run #6

Run #7

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	~~Surface Features~~ Bulk Density	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 2.1'	AC	/	/	5yr 4/3	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	2.1 / 3.0	2A	/	/	5yr 2.5/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	3.0 / 3.7	2Bt	/	/	5yr 2.5/1	SiCL	GR SBK SGR MA	N W M S L S SH H EH	/	? X	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
3	3.7 / 4.8	2Btk	/	/	5yr 2.5/1	L	GR SBK SGR MA	N W M S L S SH H EH	/	*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
4	4.8 / 5.7	C1	/	/	5yr 3/3	SL Gravel	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	>75%
5	5.7 / 7.5	C2	/		5yr 4/3	SCL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
6	7.5 / 8.8	C3	/		5yr 3/3	CL	GR SBK SGR MA	N W M S L S SH H EH	/	*	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	Threads $CaCO_3$ F M N Co Cr C D I P R S T	5%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 12

Lab

SOIL SURVEY FORM

ag= 3:00 - 5:00

Soil type

Area **Rosemont - Sonoita Channel** | Date 6/11/15 | Photo #:

Classification

Location Highwall #16

Native Vegetation Mesquite, grass | Climate

Parent Material

Physiography

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness

Slope | Moisture | Redoximorphic

Aspect | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run # Depth

Run #1

Run #2

Run #3

Run #4

Run #5

Run #6

Run #7

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	~~Surface Features~~ Bulk density	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 2.5	AC	/	/	5yr 3/2	SiCL gravelly	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
2	2.5 / 4.7	2A	/	/	5yr 3/1	SL	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
3	4.7 / 6.0	2Bt	/	/	5yr 3/2	SiCL	GR SBK DRZ SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
4	6.0 / 7.3	C1	/	/	5yr 3/1	L	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
5	7.3 / 9.5	C2	/	/	7.5yr 4/3	L	GR SBK SGR MA	N W M S L S SH H EH	/		V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 13

Lay

SOIL SURVEY FORM

7:45 – 8:10

Soil type

Area: Rosemont - Sonoita Channel | Date: 6/5/15 | Photo #:

Classification

Location: T2-1-R Bench A

Native Vegetation: Hack Beary, Bluestem | Climate

Parent Material: Cobbly alluvium

Physiography: T-1 Terrace

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness

Slope: 0–2% | Moisture: Dry | Redoximorphic

Aspect: E | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Box 6 Lab

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
2	6 / 12				5YR 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 8:10 – 8:40			Additional Notes:
Area Rosemont - Sonoita Channel	Date 6/5/15	Photo #:	File #:
Classification			Stop #:
Location T-2-1-L Bench AB			Run # / Depth
Native Vegetation		Climate	Run #1 0-6
Parent Material			Run #2 6-12
Physiography T1 Terrace transition to T2			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness Cobble @ 10"	Run #5
Slope 12-25%	Moisture	Redoximorphic	Run #6
Aspect W	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	1
Permeability			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 2.5/1	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
2	6 / 12				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Rov6 Lab
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SOIL SURVEY FORM

Soil type: 8:40 – 9:05

Area: **Rosemont - Sonoita Channel** | Date: 4/5/15 | Photo #:

Classification:

Location: TJ-2-R Bench A

Native Vegetation: Mesquite, Hackberry Hordeum | Climate:

Parent Material: alluvium

Physiography: T-2 terrace

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness: 6" gravelly
Slope: 0-3%	Moisture: Dry	Redoximorphic
Aspect: E	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6"
Run #2	6-12"
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5yr 3/2	grav SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	6 / 12				5yr 3/2	grav SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Rock 6 Lbs

SOIL SURVEY FORM

Soil type 9:05–9:25			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/5/15	Photo #:	File #:
Classification			Stop #:
Location T2-2-R Bench B			Run # / Depth
Native Vegetation Rabbit Brush, Poppy, Alk Sac	Climate		Run #1 0–6"
Parent Material alluvium			Run #2 6–12"
Physiography T-1 Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness 6" gravels	Run #5
Slope 0–2%	Moisture Dry	Redoximorphic	Run #6
Aspect E	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6			5YR 3/3	5YR 3/3	LS	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	6 / 12				5YR 3/3	LS	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 6
Lab
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SOIL SURVEY FORM

Soil type: 9:25 - 9:45

Area: Rosemont - Sonoita Channel

Date: 6/5/15

Photo #:

Classification:

Location: Transect 2-2-L Bench A

Native Vegetation: Mesquite

Climate:

Parent Material: Quartzite Bedrock Outcrop

Physiography: High T2 - No T1 terrace - Slope up to T2

Relief:

Drainage:

Salt or alkali:

Elevation: 12-20%

Ground Water:

Stoniness: Refusal @ 6"

Slope:

Moisture: Dry

Redoximorphic: on Bedrock

Aspect: West

Root Distribution:

% Clay*:

Erosion:

% Coarse fragments*:

% Coarser than V.F.S.*:

Permeability:

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5-Yr 3/1	L	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N ~~Co Cr~~ C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 6 Lab X

SOIL SURVEY FORM

Soil type: 9:45 - 10:00

Area: Rosemont - Sonoita Channel | Date: 6/5/15 | Photo #:

Classification:

Location: T2-3-L Bench A

Native Vegetation: Mesquite per grama | Climate:

Parent Material: alluvium

Physiography: T-1 Terrace Slope

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 12-15%	Moisture Dry	Redoximorphic
Aspect West	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

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Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0" / 6"				5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
2	6" / 12				5YR 3/4	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type	10:15- 10:30
Area	Rosemont - Sonoita Channel
Date	6/5/15
Photo #:	
Classification	
Location	T2-3-R- Bench B
Native Vegetation	Hackberry
Climate	
Parent Material	alluvium
Physiography	T1 Terrace
Relief	
Drainage	
Salt or alkali	
Elevation	
Ground Water	
Stoniness	
Slope	0-3%
Moisture	
Redoximorphic	
Aspect	E
Root Distribution	
% Clay*	
Erosion	
% Coarse fragments*	
% Coarser than V.F.S.*	
Permeability	

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12'
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/3	S	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	6 / 12				5YR 3/4	S	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 6
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SOIL SURVEY FORM

Soil type 10:30 – 10:40			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/5/15	Photo #:	File #:
Classification			Stop #:
Location TR-3-R Block A			Run # Depth
Native Vegetation Mesquite, Juniper & grass	Climate		Run #1
Parent Material alluvium			Run #2
Physiography T2 Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-1%	Moisture	Redoximorphic	Run #6
Aspect E	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Bottle Lab

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
X 1	0/6				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
X 2	6/12				5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM 3:00 - 3:45

Soil type			Additional Notes:
Area Rosemont - Sonoita Channel	Date 6/1/15	Photo #:	File #:
Classification			Stop #:
Location Transect 6-1-Left Bench A			Run # Depth
Native Vegetation Mesquite Stipa, Poppy	Climate		Run #1 0-6
Parent Material alluvium Terrace 2			Run #2 6-12
Physiography			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness gravel @ 11"	Run #5
Slope 0-1%	Moisture Dry	Redoximorphic	Run #6
Aspect —	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	Refusal @ 11"
Permeability			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6	AC1			2.5YR 3/4	LS	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5% gravel
2	6 / 12	AC2			2.5YR 3/4	LS	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5% gravel
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 1 Lab

SOIL SURVEY FORM

Soil type 3:45 - 4:15			Additional Notes:
Area Rosemont - Sonoita Channel	Date 6/1/15	Photo #:	File #:
Classification			Stop #:
Location T6-1 — Left Bench B			Run # / Depth
Native Vegetation Mesquite, Rabbit, poppy	Climate		Run #1 0-6"
Parent Material Alluvium			Run #2 6-12
Physiography T1 - Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness gravel @ 10"	Run #5
Slope 0-1%	Moisture Dry	Redoximorphic	Run #6
Aspect —	Root Distribution	% Clay*	Run #7
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6	AC			2.5Y 3/4	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
2	6 / 12	AC			2.5Y 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 1

SOIL SURVEY FORM

Lab Box 1

Soil type 4:15 4:45		Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/1/15 Photo #:	File #:
Classification		Stop #:
Location TG-1- Right Bench B		Run # Depth
Native Vegetation Sacaton, Rabbits Poppy	Climate	Run #1 0-6"
Parent Material		Run #2 6-12"
Physiography T/ Terrace		Run #3
Relief / Drainage	Salt or alkali	Run #4
Elevation / Ground Water	Stoniness gravelly @ 6"	Run #5
Slope 0-1% / Moisture Dry	Redoximorphic —	Run #6
Aspect — / Root Distribution —	% Clay*	Run #7
Erosion — / % Coarse fragments*	% Coarser than V.F.S.*	
Permeability —		

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				2.5yr 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A ~~C~~ G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20% gravel
2	6 / 12				2.5yr 4/3	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	30% grav.
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

4:45 - 5:15

Soil type	
Area: Rosemont - Sonoita Channel	Date: 6/1/15 — Photo #:
Classification	
Location: T6 - 1 - R Bench A	
Native Vegetation: Sacaton, Poppy, Rabbit + Mesquite	Climate
Parent Material: Alluvium	
Physiography: Gentle Slope on to T2 Terrace	
Relief	Drainage — Salt or alkali
Elevation	Ground Water — Stoniness: gravel @ 10"
Slope: 3-8%	Moisture: Dry — Redoximorphic
Aspect: E	Root Distribution — % Clay*
Erosion: —	% Coarse fragments* — % Coarser than V.F.S.*
Permeability: —	

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6"
Run #2	6-12"
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper/Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0/6				2.5YR 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
2	6/12				2.5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box

SOIL SURVEY FORM

Soil type: 8:30 - 9:05

Area: Rosemont - Sonoita Channel | Date: 6/2/15 | Photo #:

Classification:

Location: Transect 6-2, Left, Bench A

Native Vegetation: Rabbit, Mesquite, Posey | Climate:

Parent Material: alluvium

Physiography: Terrace 2

Relief:	Drainage:	Salt or alkali:
Elevation:	Ground Water:	Stoniness: 6" + gravelly
Slope: 0-1%	Moisture: Dry	Redoximorphic:
Aspect: —	Root Distribution:	% Clay*:
Erosion: —	% Coarse fragments*:	% Coarser than V.F.S.*:

Permeability: Rapid

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6	Ac			2.5yr 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
2	6 / 12	Ac			2.5yr 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 1

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SOIL SURVEY FORM

9:05 - 9:30

Soil type			
Area Rosemont - Sonoita Channel		Date 6/2/15	Photo #:
Classification			
Location Transect 6-2 left Bench B			
Native Vegetation Rabbit, Mult		Climate	
Parent Material Alluvial Island Gravel Bar			
Physiography Island gravel Bar			
Relief	Drainage	Salt or alkali	
Elevation	Ground Water	Stoniness from Surface	
Slope 0-5%	Moisture Dry	Redoximorphic	
Aspect SW	Root Distribution	% Clay*	
Erosion Active Deposits	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6"
Run #2	6-12"
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Large Cobble (6x8") on Surface

Sample Number	Depth Upper Lower "	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				2.5Y 4/3	Sand gr/cob	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	~~F C M vf f m co vc~~	~~vf f m co vc~~	~~F M N Co Cr C D I P R S T~~	50%
2	6 / 12				2.5Y 3/4	LS grav	GR SBK SGR MA	N W M S L S SH H EH	/	/	~~V A C G D~~ S W I B	NE VS SL M ST VE	~~F C M~~ vf f m co vc	~~vf f m~~ co vc	~~F M N Co Cr~~ C D I P R S T	50%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Dor 1

SOIL SURVEY FORM

9:30 – 9:55

Soil type			
Area: Rosemont - Sonoita Channel	Date: 6/2/15	Photo #:	
Classification			
Location: Transect 6-2-R Bench B			
Native Vegetation: Rabbit, Mesquite, grasses	Climate		
Parent Material: Alluvium			
Physiography: Alluvial Island gravel bar			
Relief	Drainage: Dry	Salt or alkali: —	
Elevation	Ground Water: —	Stoniness: Cobble on Surface	
Slope: 0-3%	Moisture: —	Redoximorphic	
Aspect: E	Root Distribution: —	% Clay*	
Erosion: — Active	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Lab Box 1

Sample Number	Depth Upper / Lower "	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				2.5Y 3/2	S	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	>50%
2	6 / 12				2.5Y 4/4	LS	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	>50%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 9:55 – 10:25			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/2/15	Photo #:	File #:
Classification			Stop #:
Location Transect 6-2-R Bench A			Run # / Depth
Native Vegetation Mesquite, Saki, grass	Climate		Run #1 0-6
Parent Material Alluvium			Run #2 6-12
Physiography Terrace 2			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-1%	Moisture	Redoximorphic	Run #6
Aspect —	Root Distribution	% Clay*	Run #7
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability —			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	SiL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
2	6 / 12				5YR 3/2	SiL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

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SOIL SURVEY FORM

Soil type 7:45 – 8:10

Area **Rosemont - Sonoita Channel** Date 6/5/15 Photo #:

Classification

Location T2-1-R Bench A

Native Vegetation Hack Beary, Bluestem Climate

Parent Material Cobbly alluvium

Physiography T-1 Terrace

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness

Slope 0-2% | Moisture Dry | Redoximorphic

Aspect E | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Box 6 Lab

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
2	6 / 12				5YR 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 8:10 – 8:40

Area **Rosemont - Sonoita Channel** | Date 6/5/15 | Photo #:

Classification

Location T-2-1-L Bench AB

Native Vegetation | Climate

Parent Material

Physiography T1 Terrace transition to T2

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness Cobble @ 10"

Slope 12-25% | Moisture | Redoximorphic

Aspect W | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5Y 2.5/1	L	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
2	6 / 12				5Y 3/2	L	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

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SOIL SURVEY FORM

Soil type 8:40 — 9:05

Area **Rosemont - Sonoita Channel** | Date 4/5/15 | Photo #:

Classification

Location T2-2-R Bench A

Native Vegetation Mesquite, Hackberry Hordeum | Climate

Parent Material alluvium

Physiography T-2 terrace

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness 6" gravelly

Slope 0-3% | Moisture Dry | Redoximorphic

Aspect E | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6"
Run #2	6-12"
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5Yr 3/2	grav SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	6 / 12				5Yr 3/2	grav SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

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SOIL SURVEY FORM

Soil type 9:05-9:25			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/5/15	Photo #:	File #:
Classification			Stop #:
Location T2-2-R Bench B			Run # / Depth
Native Vegetation Rabbit Brush, Poppy, Alk Sacaton	Climate		Run #1 0-6"
Parent Material alluvium			Run #2 6-12"
Physiography T-1 Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness 6" gravels	Run #5
Slope 0-2%	Moisture Dry	Redoximorphic	Run #6
Aspect E	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6			[illegible]	5YR 3/3	LS	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	6 / 12				5YR 3/3	LS	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 4
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SOIL SURVEY FORM

Soil type: 9:25 – 9:45

Area: **Rosemont - Sonoita Channel** | Date: 6/5/15 | Photo #:

Classification:

Location: Transect 2-2-L Bench A

Native Vegetation: Mesquite | Climate:

Parent Material: Quartzite Bedrock Outcrop

Physiography: High T2 - No T1 terrace - Slope up to T2

Relief: | Drainage: | Salt or alkali:

Elevation: 12-20% | Ground Water: | Stoniness: Refusal @ 6"

Slope: | Moisture: Dry | Redoximorphic: on Bedrock

Aspect: West | Root Distribution: | % Clay*

Erosion: | % Coarse fragments* | % Coarser than V.F.S.*

Permeability:

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5 YR 3/1	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 6
Lab
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SOIL SURVEY FORM

Soil type: 9:45 - 10:00

Area: Rosemont - Sonoita Channel | Date: 6/5/15 | Photo #:

Classification:

Location: T2-3-L Bench A

Native Vegetation: Mesquite per grama | Climate:

Parent Material: alluvium

Physiography: T-1 Terrace Slope

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 12-15%	Moisture Dry	Redoximorphic
Aspect West	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*

Permeability:

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0" / 6"				5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
2	6" / 12				5YR 3/4	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 6

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SOIL SURVEY FORM

Soil type 10:15 - 10:30			Additional Notes:
Area Rosemont - Sonoita Channel	Date 6/5/15	Photo #:	File #:
Classification			Stop #:
Location T2-3-R- Bench B			Run # / Depth
Native Vegetation Hackberry	Climate		Run #1 0-6
Parent Material alluvium			Run #2 6-12'
Physiography T1 Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-3%	Moisture	Redoximorphic	Run #6
Aspect E	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/3	S	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	6 / 12				5YR 3/4	S	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type: 10:30 – 10:40

Area: **Rosemont - Sonoita Channel**

Date: 6/5/15

Photo #:

Classification:

Location: T2-3-R Bench A

Native Vegetation: Mesquite, Juniper, Grass

Climate:

Parent Material: Alluvium

Physiography: T2 Terrace

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 0-1%	Moisture	Redoximorphic
Aspect E	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*

Permeability:

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Bottle Lab

	Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
X	1	0 / 6				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	–	–	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
X	2	6 / 12				5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	–	–	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 10:50 – 11:25			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/2/15	Photo #:	File #:
Classification			Stop #:
Location Transect 6-3-Left Bench A			Run # Depth
Native Vegetation Rabbit	Climate		Run #1 0-6
Parent Material alluvium			Run #2 6-12
Physiography Terrace or overflow channel - Cobble on surface			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-1%	Moisture Dry	Redoximorphic	Run #6
Aspect —	Root Distribution	% Clay*	Run #7
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability —			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/4	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
2	6 / 12				5YR 4/2	gr L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	30%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 2

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SOIL SURVEY FORM

Soil type 11:25 12:00

Area **Rosemont - Sonoita Channel** | Date 6/2/15 | Photo #:

Classification

Location Transect 6-3-L Bench B

Native Vegetation Mesquite, Sacaton, Poppy | Climate

Parent Material Alluvium

Physiography Terrace Levy

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness Rock @ 12"

Slope 0-12% - Flat on top | Moisture | Redoximorphic

Aspect E-W | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Lab Box 2

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6"
Run #2	6-12"
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

	Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
X	1	0 / 6"				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
X	2	6" / 12"				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	✓	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
		/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type: 2:30 – 2:50

Area: Rosemont - Sonoita Channel | Date: 6/2/15 | Photo #:

Classification:

Location: TG-3-R Bench B

Native Vegetation: Mesquite, rabbit, | Climate:

Parent Material: alluvium

Physiography: alluvium gravel bar Island

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 0-2%	Moisture	Redoximorphic
Aspect —	Root Distribution	% Clay*
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*
Permeability /		

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1 1	0-6
Run #2 2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/4	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
2	6 / 12				5YR 3/4	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	40%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 2

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SOIL SURVEY FORM

Soil type 2:55- 3:15	Additional Notes:
Area Rosemont - Sonoita Channel Date 6/2/15 Photo #:	File #:
Classification	Stop #:
Location Transect 6-3-R Bench A	Run # / Depth
Native Vegetation Mesquite, Globe Mallow Climate SAK	Run #1 0-6
Parent Material Alluvial	Run #2 6-12
Physiography T2 Terrace Slope	Run #3
Relief / Drainage / Salt or alkali	Run #4
Elevation / Ground Water / Stoniness	Run #5
Slope 5-12% / Moisture / Redoximorphic	Run #6
Aspect E / Root Distribution / % Clay*	Run #7
Erosion Colluvium / % Coarse fragments* / % Coarser than V.F.S.*	
Permeability	

Lab Box 2

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
+ 1	0 / 6				5YR 3/4	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
+ 2	6 / 12				5YR 3/4	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM Drive to So Map 3:15-4:00

4:00 - 4:50

Soil type			Additional Notes:
Area Rosemont - Sonoita Channel	Date 6/2/15	Photo #:	File #:
Classification			Stop #:
Location Transect 6.5-3 R Bench A			Run # / Depth
Native Vegetation Mesquite, Poppy, Rabbit-green	Climate		Run #1 0-6
Parent Material Alluvium			Run #2 6-12
Physiography T2 Terrace			Run #3
Relief	Drainage	Salt or alkali depth Ca	Run #4
Elevation	Ground Water	Stoniness 4" gravelly	Run #5
Slope 0-2%	Moisture Dry	Redoximorphic	Run #6
Aspect SE	Root Distribution	% Clay*	Run #7
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability —			

Lab Box 2

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1 ×	0/6				6YR 4/2	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
2 ×	6/12				5YR 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 4:50 – 5:20			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/2/15	Photo #:	File #:
Classification			Stop #:
Location Transect 6.5-3.L - Bench A			Run # / Depth
Native Vegetation Alkali Sacaton		Climate	Run #1 0-6
Parent Material Silty Alluvium			Run #2 6-12
Physiography Flat Flood Plain – Low Energy			Run #3
Relief Hummocky	Drainage Drain paths	Salt or alkali	Run #4
Elevation	Ground Water No	Stoniness None	Run #5
Slope 0-3%	Moisture Dry to 10"	Redoximorphic —	Run #6
Aspect SW	Root Distribution Deep –	% Clay*	Run #7
Erosion –	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability Slow			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	SiL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
2	6 / 12				5YR 3/3	SiL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 2

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SOIL SURVEY FORM

Walk into Site

Soil type 8:15 - 8:50		Additional Notes:
Area Rosemont - Sonoita Channel	Date 6/3/15 Photo #:	File #:
Classification		Stop #:
Location Transect 6.5-2-R	Bench A	Run # Depth
Native Vegetation Poppy, Green Rabbit, Mesquite	Climate	Run #1 0-6
Parent Material Alluvium - Gravel / Silts		Run #2 6-12
Physiography T 2 Bench		Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-1%	Moisture Dry	Redoximorphic	Run #6
Aspect —	Root Distribution	% Clay*	Run #7
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Lab + Box 2 + +

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
2	6 / 12				5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 8:50 - 9:15

Area **Rosemont - Sonoita Channel** | Date 6/3/15 | Photo #:

Classification

Location Transect 6.5-2-R Bench 13

Native Vegetation Green Rabbit Poppr | Climate

Parent Material Alluvial Silty Gravel

Physiography Terrace

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 0-3%	Moisture	Redoximorphic
Aspect E.	Root Distribution	% Clay*
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*
Permeability —		

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
2	6 / 12				5YR 3/1	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab
Box 2
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SOIL SURVEY FORM

Soil type 9:15 – 9:30

Area **Rosemont - Sonoita Channel** | Date 6/3/15 | Photo #:

Classification

Location Transect 6.5-25 L Bench B

Native Vegetation Alk. Sacaton. Mesquite | Climate

Parent Material alluvial Levy –

Physiography Alluvial Levy –

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 0-5%	Moisture	Redoximorphic
Aspect W N E	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*
Permeability		

Additional Notes:

File #:

Stop #: ~~—~~ Levy channel

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	~~vf f m co vc~~	~~F M N Co Cr C D I P R S T~~	/
2	6 / 12				5YR 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	~~vf f m co vc~~	~~F M N Co Cr C D I P R S T~~	/
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Box 3
Lab
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X

SOIL SURVEY FORM

Soil type 9:30 – 9:55			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/3/15	Photo #:	File #:
Classification			Stop #:
Location Transect 6-5-2-L Bench A			Run # / Depth
Native Vegetation Alk. Sacaton 100% cover	Climate		Run #1 0-6
Parent Material alluvial			Run #2 6-12
Physiography Silty Alluvium			Run #3
Relief Some Scour	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-3%	Moisture Damp Soil @ 9"	Redoximorphic	Run #6
Aspect West	Root Distribution in Clay Loam	% Clay*	Run #7
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 2.5/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
2	6 / 12				5YR 3/2	L-CL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

lab Box 3

SOIL SURVEY FORM

Move to Transect 1 9:55 - 10:15

Soil type 10:15 – 10:40	Additional Notes:
Area **Rosemont - Sonoita Channel** / Date 6/3/15 Photo #:	File #:
Classification	Stop #:
Location TLe-S-1-R Bench A	Run # Depth
Native Vegetation Mesquite, Poppy, Green Ec… Climate	Run #1 0-6
Parent Material Alluvium - Cobbly surface	Run #2 6-12
Physiography T2 Terrace -	Run #3
Relief / Drainage / Salt or alkali	Run #4
Elevation / Ground Water / Stoniness	Run #5
Slope 0-3% / Moisture / Redoximorphic	Run #6
Aspect E / Root Distribution / % Clay*	Run #7
Erosion / % Coarse fragments* / % Coarser than V.F.S.*	
Permeability	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
2	6 / 12				5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 3 + +

SOIL SURVEY FORM

Soil type 10:40 - 11:00	Additional Notes:
Area **Rosemont - Sonoita Channel** — Date 6/3/15 — Photo #:	File #:
Classification	Stop #:
Location T6-5-1-R Bench B	Run # — Depth
Native Vegetation Green [illegible], poppy, mesquite — Climate	Run #1 0-6
Parent Material	Run #2 6-12
Physiography T-1 Terrace, Eroded parallel to channel	Run #3
Relief — Drainage — Salt or alkali	Run #4
Elevation — Ground Water — Stoniness	Run #5
Slope 0-3% — Moisture — Redoximorphic	Run #6
Aspect S — Root Distribution — % Clay*	Run #7
Erosion — % Coarse fragments* — % Coarser than V.F.S.*	
Permeability	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
2	6 / 12				5YR 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	—
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Las Box 3 ★ ★

SOIL SURVEY FORM

Soil type 11:00 – 11:20			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/3/15	Photo #:	File #:
Classification			Stop #:
Location T6-5-1-L Bench B			Run # / Depth
Native Vegetation	Climate		Run #1 0-6
Parent Material alluvium T-2 Bench			Run #2 6-12
Physiography High transition to all Sacaton			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-3%	Moisture	Redoximorphic	Run #6
Aspect West	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/4	SL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	6 / 12				5YR 3/4	SL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 3

SOIL SURVEY FORM

Soil type 11:20 - 11:40		Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/3/15 | Photo #:	File #:
Classification		Stop #:
Location T 6-5-1-L Bench A		Run # | Depth
Native Vegetation Alkali Sacaton 100%	Climate	Run #1 0-6
Parent Material Alluvium - Loamy silt		Run #2 6-12
Physiography Low-energy		Run #3
Relief | Drainage	Salt or alkali	Run #4
Elevation | Ground Water	Stoniness	Run #5
Slope 0-1% | Moisture	Redoximorphic	Run #6
Aspect | Root Distribution	% Clay*	Run #7
Erosion | % Coarse fragments*	% Coarser than V.F.S.*	
Permeability		

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	SiL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
2	6 / 12				5YR 3/2	SiL	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 3 * *

SOIL SURVEY FORM

Walk - 1:30 - 2:00

2:00 - 2:35

Soil type			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/3/15	Photo #:	File #:
Classification			Stop #:
Location Transect 7-1-K Bench A			Run # / Depth "
Native Vegetation Mesquite	Climate		Run #1 0-6
Parent Material Alluvium			Run #2 6-12
Physiography T3 Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-2%	Moisture Dry to 6"	Redoximorphic	Run #6
Aspect W	Root Distribution Moist ≥ 6" in	% Clay*	Run #7
Erosion —	% Coarse fragments* CL	% Coarser than V.F.S.*	
Permeability —			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5R 2.5/1	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
2	6 / 12				5R 2.5/1	L/CL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Loc 6 Box 3

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Lab Box 3

SOIL SURVEY FORM

Soil type 2:35 - 3:00			Additional Notes:
Area Rosemont - Sonoita Channel	Date 6/3/15	Photo #:	File #:
Classification			Stop #:
Location T7-1-L Bend B			Run # / Depth
Native Vegetation Mesq. A Saccaton, Poppy	Climate		Run #1 0-6
Parent Material alluvium -			Run #2 6-12
Physiography T2 Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-1%	Moisture Dry	Redoximorphic	Run #6
Aspect W	Root Distribution	% Clay*	Run #7
Erosion -	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability -			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/3	gr SL	GR SBK SGR MA	N W M S L S SH H EH	-	-	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	6 / 12				5YR 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	-	-	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 3:00 – 3:20

Area **Rosemont - Sonoita Channel** Date 6/3/15 Photo #:

Classification

Location T7-1-L Bench C

Native Vegetation Cottonwood – Climate

Parent Material Alluvial

Physiography T1 Terrace –

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness

Slope 0-1% | Moisture | Redoximorphic

Aspect — | Root Distribution | % Clay*

Erosion — | % Coarse fragments* | % Coarser than V.F.S.*

Permeability —

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
2	6 / 12				5YR 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lady Bot

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SOIL SURVEY FORM

Soil type 3:20 - 3:50			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/3/15	Photo #:	File #:
Classification			Stop #:
Location T7-1, R Bench A			Run # / Depth
Native Vegetation Poppy, Alkali Sacaton, Bermuda	Climate		Run #1 0-6
Parent Material Colluvium (worn from Vertical Cut			Run #2 6-12
Physiography			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation ~~20~~	Ground Water	Stoniness	Run #5
Slope 20%	Moisture	Redoximorphic	Run #6
Aspect E.	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Lab Prot

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
2	6 / 12				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Walk to Site 7:15-7:40

7:40- 8:05

Soil type			Additional Notes:
Area: Rosemont - Sonoita Channel	Date 6/4/15	Photo #:	File #:
Classification			Stop #:
Location: Transect #7-2; L - Bench A			Run # / Depth
Native Vegetation: Rabbit Brush, Benny	Climate		Run #1: 0-6
Parent Material: Alluvium-Cobbly to Sil			Run #2: 6-12
Physiography: T2 Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness: Cobbly - 0-6	Run #5
Slope: 0-1%	Moisture: Dry	Redoximorphic	Run #6
Aspect: W	Root Distribution	% Clay*	Run #7
Erosion: –	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability: –			

Lab Box 4

Sample Number	Depth Upper/Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 4				5YR 3/2	Cobbly Loam	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
2	4 / 12				5YR 3/2	Cobbly Loam	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	>50%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

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SOIL SURVEY FORM

Soil type 8:05 – 8:30

Area **Rosemont - Sonoita Channel** Date 6/4/15 Photo #:

Classification

Location T7-2-L Bench B

Native Vegetation Sunflower, Poppy, Mesquite Climate Green Rabbitbrush

Parent Material alluvium Gravel

Physiography T-1 Terrace

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness Smaller gravels throughout
Slope 0-1%	Moisture Dry	Redoximorphic
Aspect —	Root Distribution	% Clay*
Erosion Overland channel flow	% Coarse fragments	% Coarser than V.F.S.*

Permeability

Additional Notes:
File #:
Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Extremely gravel to stoney

Sample Number	Depth Upper/Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0/6				5YR 3/4	GR LS	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	30%
2	6/12				5YR 4/3	GR LS	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Rox

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SOIL SURVEY FORM

Soil type 8:30 - 8:35

Area **Rosemont - Sonoita Channel** Date 6/4/15 Photo #:

Classification

Location T7-2-L

Native Vegetation Vertical — Climate

Parent Material Bank Face - No Sample

Physiography

Relief — Drainage — Salt or alkali

Elevation — Ground Water — Stoniness

Slope Vertical — Moisture — Redoximorphic

Aspect — Root Distribution — % Clay*

Erosion — % Coarse fragments* — % Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	
Run #2	
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 8:35 - 9:05

Area Rosemont - Sonoita Channel

Date 6/4/15

Photo #:

Classification

Location Transect 7-3, L - Bench A

Native Vegetation

Climate

Parent Material alluvium

Physiography T2 Terrace

Relief

Drainage

Salt or alkali

Elevation

Ground Water

Stoniness Coarse Gravels

Slope 0-1%

Moisture dry

Redoximorphic From surface

Aspect —

Root Distribution

% Clay*

Erosion

% Coarse fragments*

% Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5yr 3/3	gravelly sand	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
2	6 / 12				5yr 3/2	gravelly sand	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	50%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 4

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SOIL SURVEY FORM

Lab Box 4

Soil type 9:05-9:25			Additional Notes:
Area Rosemont - Sonoita Channel	Date 6/4/15	Photo #:	File #:
Classification			Stop #:
Location T7-3-L Bench B			Run # / Depth
Native Vegetation		Climate	Run #1 0-6
Parent Material alluvial-			Run #2 6-12
Physiography T1-Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness Sandy-	Run #5
Slope 0-2%	Moisture Dry	Redoximorphic	Run #6
Aspect SW	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	S	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
2	6 / 12				5YR 3/2	S	GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Drive to 8
Walk Back - 9:25 - 10:00

Soil type			Additional Notes:
Area: Rosemont - Sonoita Channel	Date: 6/4/15	Photo #:	File #:
Classification			Stop #:
Location: T7-3-R			Run # / Depth
Native Vegetation		Climate	Run #1
Parent Material			Run #2
Physiography: Vertical Bank No Sample			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope	Moisture	Redoximorphic	Run #6
Aspect	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 10:09 – 10:30

Area **Rosemont - Sonoita Channel** | Date 6/4/15 | Photo #:

Classification

Location Transect 8-1-R Bench A

Native Vegetation Mesquite | Climate

Parent Material alluvial

Physiography T-1 Terrace Below Stake - Rail Embankment

Relief –	Drainage	Salt or alkali	
Elevation –	Ground Water	Stoniness	
Slope 0-2%	Moisture Dry	Redoximorphic	
Aspect S	Root Distribution	% Clay*	
Erosion –	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability –			

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Lab Box 4

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				7.5YR 3/2	Coarse S	GR SBK SGR MA	N W M S L S SH H EH	–	–	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
2	6 / 12				7.5YR 3/2	LS	GR SBK SGR MA	N W M S L S SH H EH	–	–	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
	/						GR SBK SGR MA	N W M S L S SH H EH	–	–	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 10:30 – 11:00			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/4/15	Photo #:	File #:
Classification			Stop #:
Location T8-1-L Bench C			Run # / Depth
Native Vegetation Cottonwood, Willow (Brach)	Climate		Run #1 0-6
Parent Material Alluvium			Run #2 6-12
Physiography T-1 Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness Refusal @ 10"	Run #5
Slope 0-1%	Moisture Dry	Redoximorphic	Run #6
Aspect —	Root Distribution	% Clay*	Run #7
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	~~V A C G D~~ S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F ~~M N~~ Co Cr C D I P R S T	70%
2	6 / 12				5YR 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	—	—	~~V A C G D~~ S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f ~~m~~ co vc	F ~~M N~~ Co Cr C D I P R S T	25%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

4 + 4 bags Rock

SOIL SURVEY FORM

Soil type 11:00 – 11:15			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/4/15	Photo #:	File #:
Classification			Stop #:
Location T8-1-L Bench BC			Run # / Depth
Native Vegetation Mesquite, Willow (Brachy)		Climate	Run #1 0-6
Parent Material Cobbly alluvium			Run #2 6-12
Physiography Transition between T1 & T2 terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness Cobbly Refusal	Run #5
Slope 12-30%	Moisture	Redoximorphic @ 6"	Run #6
Aspect W	Root Distribution	% Clay*	Run #7 Very
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	Cobbly Slope
Permeability			

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C ~~G D~~ ~~S~~ W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f ~~m~~ co vc	F M N ~~Co Cr~~ C D I P R S T	50%
–	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

La5 Box 5

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SOIL SURVEY FORM

11:15 – 12:35

Soil type	
Area	Rosemont - Sonoita Channel
Date	6/4/15
Photo #:	
Classification	
Location	T8-1-L Bench A
Native Vegetation	Mesquite, grama
Climate	
Parent Material	alluvium
Physiography	T2 Terrace
Relief	
Drainage	
Salt or alkali	
Elevation	
Ground Water	
Stoniness	
Slope	0-2%
Moisture	Dry
Redoximorphic	
Aspect	SW
Root Distribution	
% Clay*	
Erosion	
% Coarse fragments*	
% Coarser than V.F.S.*	
Permeability	

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
0	0 / 6				5YR 3/3	S	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	30%
1	6 / 12				5YR 3/2	S	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	30%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab / Box 5 + 4

SOIL SURVEY FORM

Soil type 12:30 – 1:20			Additional Notes:
Area Rosemont - Sonoita Channel	Date 6/4/15	Photo #:	File #:
Classification			Stop #:
Location T8-2-L Bench B			Run # Depth
Native Vegetation Mesquit	Climate		Run #1 0-6
Parent Material alluvium, sacaton, acacia			Run #2 6-12
Physiography T2 terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-2%	Moisture	Redoximorphic	Run #6
Aspect SW	Root Distribution	% Clay*	Run #7
Erosion	% Coarse fragments*	% Coarser than V.F.S.*	T2 Terrace below
Permeability			T3 Terrace slope

Lab Box 5

	Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
*	1	0 / 6				5YR 3/3	grav SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
*	2	6 / 12				5YR 3/3	grav SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	20%
								GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
								GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
								GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
								GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
								GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
								GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 1:20 — 1:35

Area **Rosemont - Sonoita Channel** | Date 6/4/15 | Photo #:

Classification

Location T8-2-L Bench C

Native Vegetation Chenopod, Desert Willow | Climate Cottonwood

Parent Material Alluvium

Physiography T1 Terrace - Loamy

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 0-2%	Moisture	Redoximorphic
Aspect SW	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 2.5/2	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	6 / 12				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab 3 of 5 *

SOIL SURVEY FORM

Soil type 1:35 – 2'00			Additional Notes:
Area **Rosemont - Sonoita Channel**	Date 6/4/15	Photo #:	File #:
Classification			Stop #:
Location T8-2-R (P) Bench			Run # / Depth
Native Vegetation Mesquite, Desert (willow)	Climate		Run #1 0-6
Parent Material alluvium			Run #2 6-12
Physiography T-1 Terrace			Run #3
Relief	Drainage	Salt or alkali	Run #4
Elevation	Ground Water	Stoniness	Run #5
Slope 0-5%	Moisture	Redoximorphic	Run #6
Aspect —	Root Distribution	% Clay*	Run #7
Erosion overland flow	% Coarse fragments*	% Coarser than V.F.S.*	
Permeability from channel			

Lab Box 5

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
* 1	0 / 6				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	5%
* 2	6 / 12				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	10%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 2:00 – 2:25

Area **Rosemont - Sonoita Channel** Date 6/4/15 Photo #:

Classification

Location T8-3-6 Bench B (Rodney Bench B)

Native Vegetation Alkai Sac Mesquite Desert Willow Climate

Parent Material Fine alluvium

Physiography T2 Terrace

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 0-2%	Moisture Dry	Redoximorphic
Aspect	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*
Permeability		

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/3	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
2	6 / 12				5YR 3/2	SL	GR SBK SGR MA	N W M S L S SH H EH	/	/	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	/
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 5

*

*

SOIL SURVEY FORM

Soil type: 2:25 - 2:50

Area: Rosemont - Sonoita Channel | Date: 6/4/15 | Photo #:

Classification:

Location: T8-3-L Bench C (Romus Bench C)

Native Vegetation: Chenopodium, [illegible] | Climate: ~~[illegible]~~

Parent Material: Fine alluvium

Physiography: T1 Terrace

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope: 0-1%	Moisture	Redoximorphic
Aspect: —	Root Distribution	% Clay*
Erosion	% Coarse fragments*	% Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Lab

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
Box 5 1	0 / 6				5YR 3/2	LS	GR SBK SGR MA	N W M S L S SH H EH	X	X	~~V A C G D S W I B~~	NE VS SL M ST VE	F C M vf f m co vc	~~vf f m co vc~~	~~F M N Co Cr C D I P R S T~~	X
Box 5 2	6 / 12				5YR 3/3	LS	GR SBK SGR MA	N W M S L S SH H EH	X	X	~~V A C G D S W I B~~	NE VS SL M ST VE	F C M vf f m co vc	~~vf f m co vc~~	~~F M N Co Cr C D I P R S T~~	X
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

SOIL SURVEY FORM

Soil type 2:50-3:10

Area **Rosemont - Sonoita Channel** Date 6/4/15 Photo #:

Classification

Location T8-3-R Bench C

Native Vegetation Mesquite, Alkali Sac- | Climate

Parent Material Alluvium fine

Physiography T1 Terrace

Relief	Drainage	Salt or alkali
Elevation	Ground Water	Stoniness
Slope 0-2%	Moisture Dry	Redoximorphic
Aspect —	Root Distribution	% Clay*
Erosion —	% Coarse fragments*	% Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/3	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	<5%
2	6 / 12				5YR 3/2	L	GR SBK SGR MA	N W M S L S SH H EH	—	—	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	15%
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
							GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

Lab Box 5 * *

SOIL SURVEY FORM

Soil type 3:10 - 3:30

Area **Rosemont - Sonoita Channel** | Date 6/4/15 | Photo #:

Classification

Location T8-3-R Bench B

Native Vegetation Mesquite, Sacaton, Antennaria | Climate

Parent Material Alluvium

Physiography T2 Terrace

Relief | Drainage | Salt or alkali

Elevation | Ground Water | Stoniness

Slope 0-3% | Moisture Dry | Redoximorphic

Aspect S | Root Distribution | % Clay*

Erosion | % Coarse fragments* | % Coarser than V.F.S.*

Permeability

Additional Notes:

File #:

Stop #:

Run #	Depth
Run #1	0-6
Run #2	6-12
Run #3	
Run #4	
Run #5	
Run #6	
Run #7	

Sample Number	Depth Upper / Lower	Horizon Designation	Thickness Avg (a) Max (b) Min (c)	Dry Color	Moist Color	Texture	Structure	Consistence	Mottles	Surface Features	Boundary	Effervescence	Roots	Pores	Concentrations	Rock Fragments
1	0 / 6				5YR 3/2	gr LS	GR SBK SGR MA	N W M S L S SH H EH	X	X	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	25%
2	6 / 12				5YR 3/3	gr LS	GR SBK SGR MA	N W M S L S SH H EH	X	X	V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	35%
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	
	/						GR SBK SGR MA	N W M S L S SH H EH			V A C G D S W I B	NE VS SL M ST VE	F C M vf f m co vc	vf f m co vc	F M N Co Cr C D I P R S T	

LW5 Box 5

Appendix F2

Sonoita Creek Mitigation Project
Vegetation Characterization Report

Sonoita Creek
Mitigation Project

Vegetation Characterization Report

February 2017

Prepared for:

Hudbay Minerals, Inc.
Rosemont Project
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TABLE OF CONTENTS

1 INTRODUCTION

Rosemont Copper (Rosemont) contracted with Water & Earth Technologies, Inc. (WET), Westland Resources, Inc., and Habitat Management, Inc. to develop a design for the Sonoita Creek Mitigation Project (SCR Project). The SCR Project includes constructing, extending, and/or improving various reaches of the ephemeral Sonoita Creek stream channel. Constructed channel reaches will act in parallel with the existing Sonoita Creek channel, concurrently conveying stormwater flows. The existing Sonoita Creek will remain undisturbed over most of its length, except for specific transitional areas where constructed channels will either diverge from or converge with Sonoita Creek. Areas disturbed during construction activities will be revegetated to match the adjacent vegetation communities.

The SCR Project is located about 5.5 miles northeast of Patagonia and 7 miles south of Sonoita in Santa Cruz County, Arizona (Figure 1). The SCR Project area is on private land owned by Rosemont and is being conducted as mitigation for anticipated disturbances associated with the development of the new Rosemont Project. The Rosemont Project site is north of the SCR Project area and within the same overall Santa Cruz watershed.

This report summarizes the methods and results associated with a baseline vegetation survey conducted by Habitat Management June 2 – 5, 2015. Vegetation data collected include vegetation cover and shrub density. This information was used to select preliminary revegetation species and develop planting density recommendations.

2 METHODS

Vegetation cover, species richness, and woody plant density data were collected along three transects in each of five representative reaches of the existing Sonoita Creek channel to evaluate the potential vegetation variability across the width of the channel and between reaches (Figure 2). Seven reaches were selected by WET to represent the range of flow regimes and vegetation communities in the SCR Project area, with five (Reaches 2, 6, 6.5, 7, and 8) being designated for vegetation sampling. These reaches and transects were the same as those used to evaluate soils. The transects were located within each reach to represent the range of characteristics within the reach and run perpendicular to the channel. Each transect traversed from the upland community on one side of the channel to the upland on the other side and included all mesic and hydric communities in between. The locations of transitions from one community to the next were noted along each transect. Vegetation data were separated for each of the terraces, as well as the slopes between terraces encountered along the transects located on either side of the active channel. Terraces were identified based on hydrologic, geomorphic, and/or vegetative transitions and identified as either T1, T2, or T3 terraces (Figure 3).

Figure 1: SCR Project Location Map

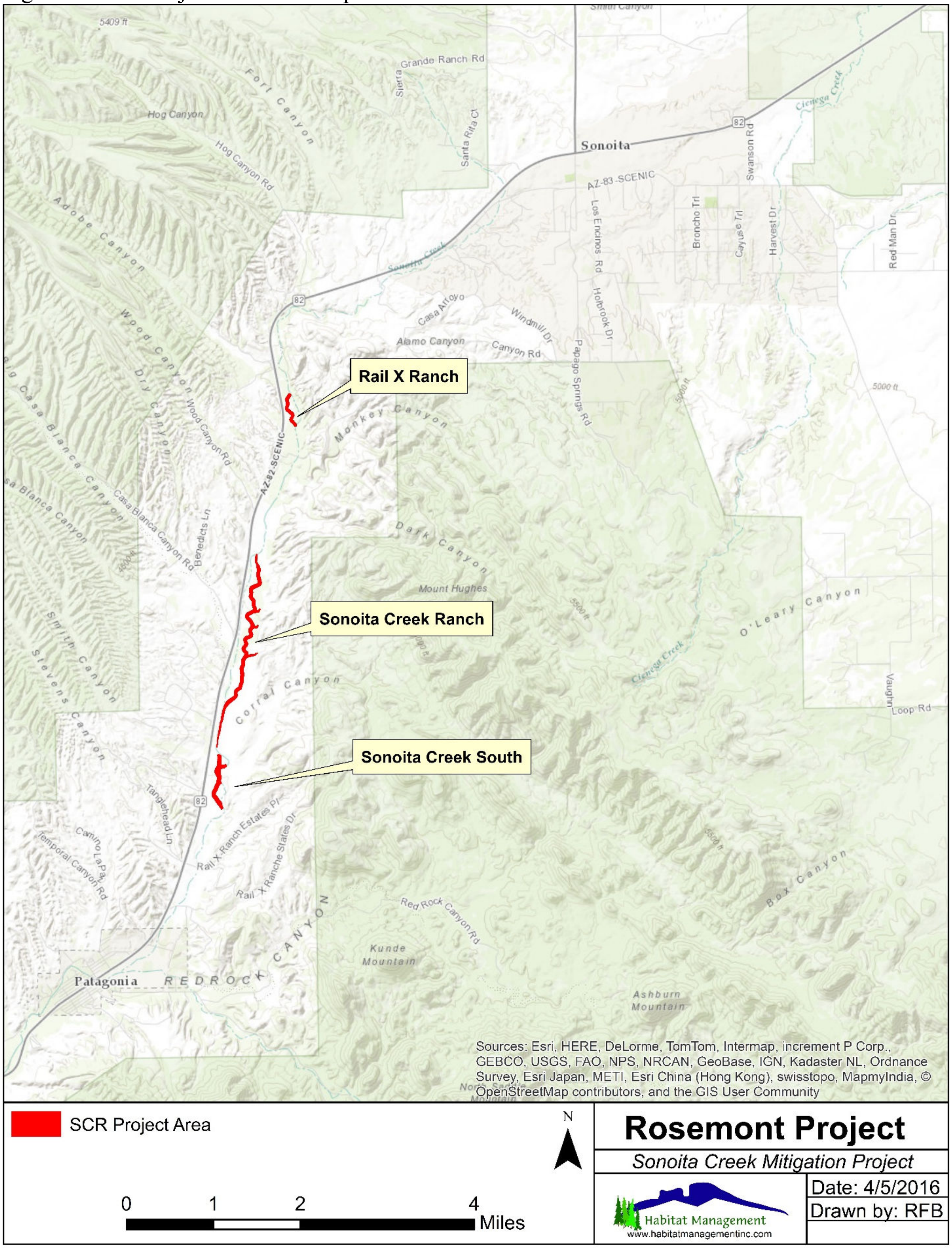


Figure 2: Representative Reach Transect Map

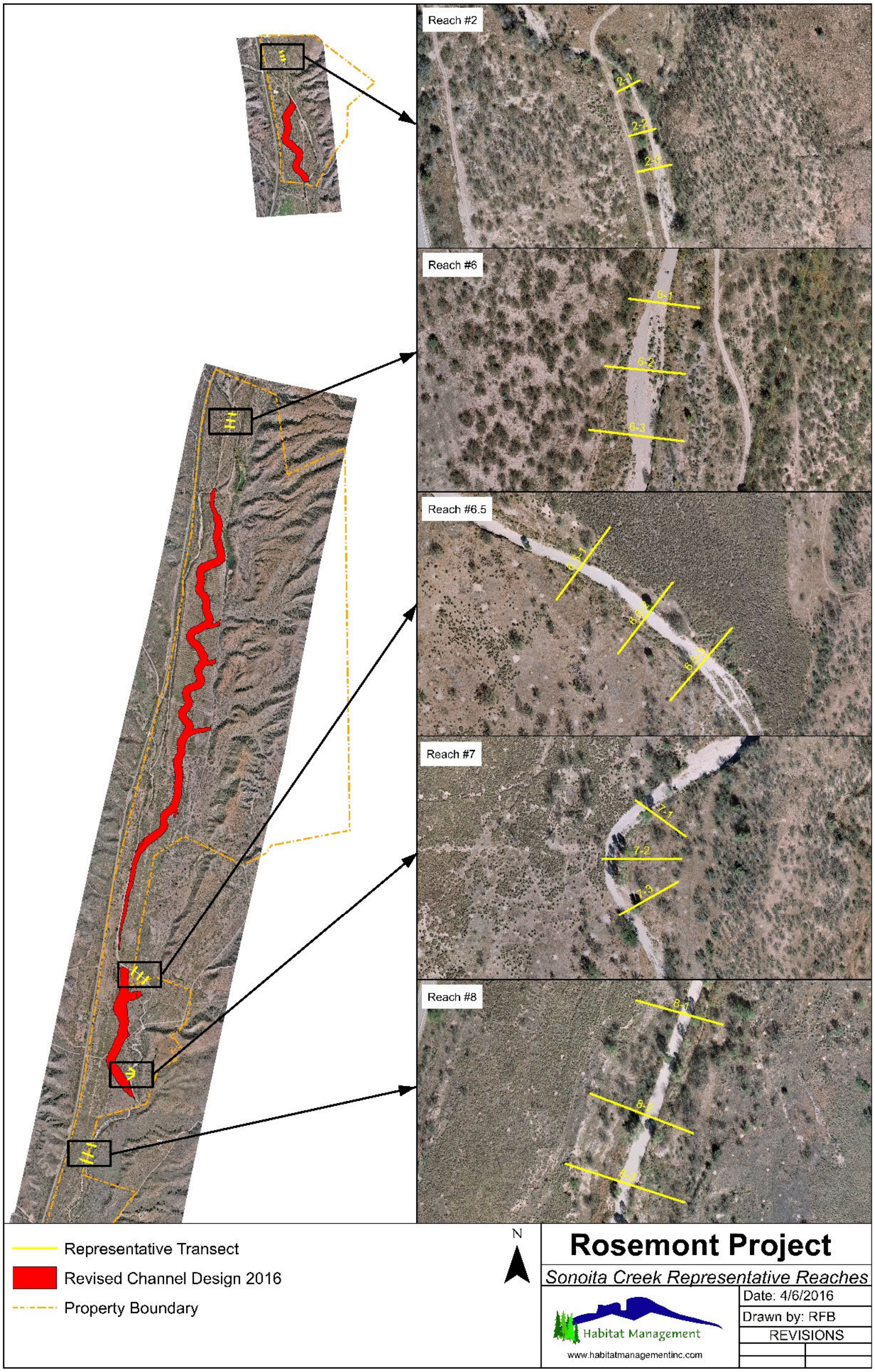
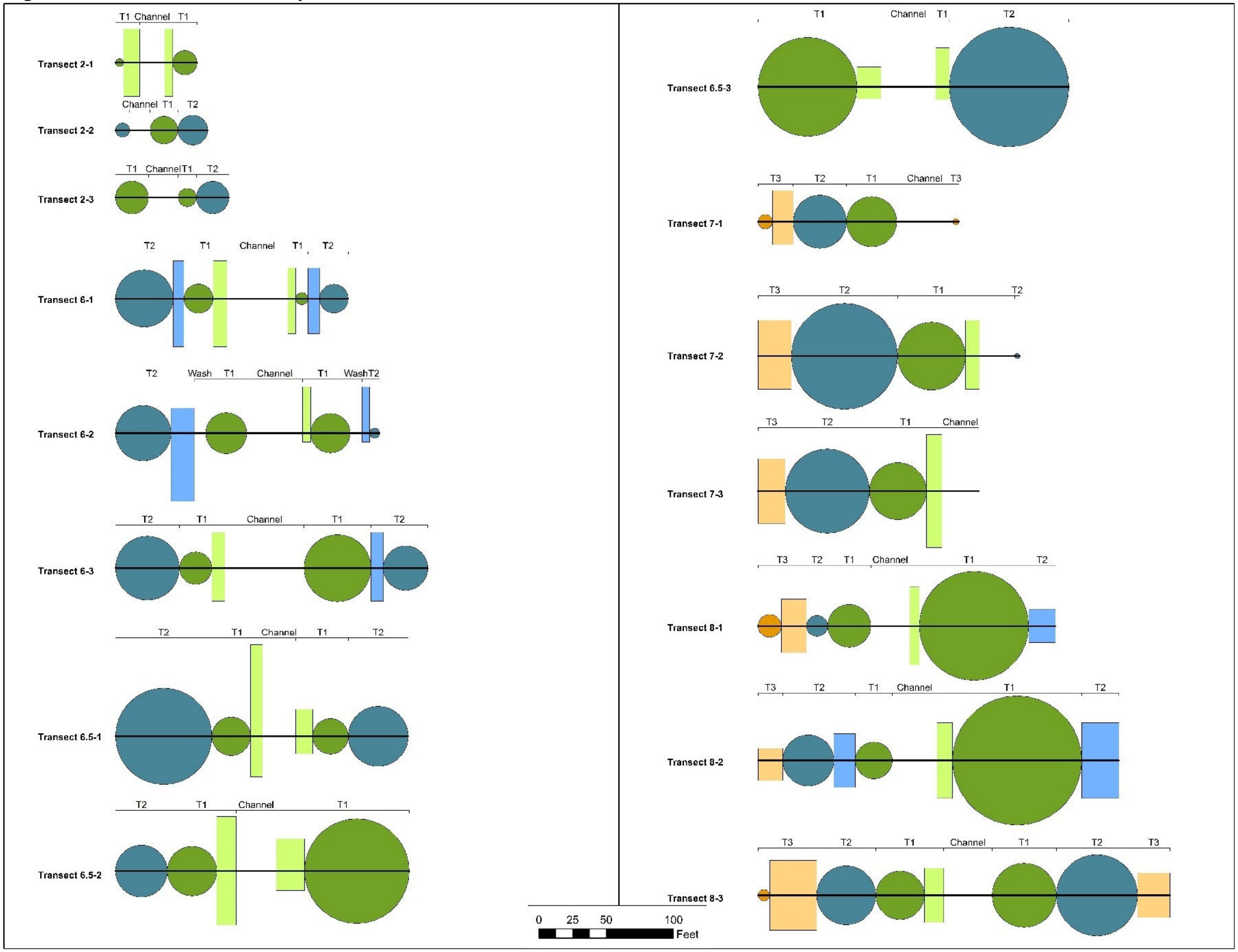

Reach #2
2-1
2-2
2-3
Reach #6
6-1
6-2
6-3
Reach #6.5
Reach #7
7-1
7-2
7-3
Reach #8
8-1
8-2
8-3
Representative Transect
Revised Channel Design 2016
Property Boundary
N
Rosemont Project
Sonoita Creek Representative Reaches
Date: 4/6/2016
Drawn by: RFB
REVISIONS
Habitat Management
www.habitatmanagementinc.com

Figure 3: Terrace and Plot Layout



2.1 Vegetation Cover

A point-intercept laser sampling device was used to collect vegetation cover data along each transect at one-foot intervals and 0.5-meters away from the transect on the downstream side. Each observation was recorded as either the plant species encountered, bare ground, litter, or rock. Data were evaluated for separately each terrace type (T1 terrace, T2 terrace, or T3 terrace) encountered along the transect, as well as for the transect on the whole. Data collected on transition slopes between each terrace type were grouped with the terrace above.

To evaluate absolute cover, monitoring data collected on any given terrace type were compiled for the transect (e.g., the T1 terraces on the east and west sides of the channel) and divided by the total number of data points taken for that terrace type. Also, observations from all terrace types were compiled and divided by the total number of observations along the entire transect. Because the terrace widths vary, the cover values reported for each terrace type represent differing levels of precision and cannot be averaged to obtain the total reported for the transect.

2.2 Species Richness

All species rooted within one meter on either side of the transect were recorded as a measure of species richness. These data are reported by terrace type and by reach.

2.3 Woody Species Density

Woody species density was recorded in plots on each terrace and on the transition slopes between each terrace. The shape and size of plots varied based on the landform and its size. A circular plot was used on each terrace with the diameter of the plot equal to the width of the terrace. A rectangular plot was used on the transition slopes that was as wide as the slope. The plot on the transition slope between the channel bed and the T1 terrace was placed such that it extended upstream and downstream for a distance equal to ± 6 inches in elevation. The same plot length and placement was used for all of the transition slopes with the only difference being the width of the plot unless a physical barrier was encountered. All woody species were counted in each plot and recorded as one of four basal diameter classes (0-1, 1-3, 3-6, or > 6 inches). The area covered by each plot was recorded to estimate density.

As with the cover data, woody species density was evaluated by terrace type (compiled for the transect), as well as the entire transect. These data are subject to varying levels of precision and cannot be averaged to obtain the total reported for the transect.

3 RESULTS & DISCUSSION

Vegetation cover, ground cover, species richness, and woody plant density are summarized in this section. Vegetation cover data are presented in Attachment A and woody plant density data are presented in Attachment B. Some reaches sampled had only one terrace while others had up to three terraces. The transect end points were placed such that the T3 terraces were often not sampled in their full width.

3.1 Vegetation Cover

T1 and T2 terrace widths including transition slopes leading up to the terraces ranged from 21 to 150 feet (Figure 3, Table 1). T3 terraces ranged from 18 to 67 feet wide, but these were generally not sampled in their entirely.

Table 1: Terrace Widths and Data Points Collected (Linear Feet)

Reach	Transect	T1 Terrace			T2 Terrace			T3 Terrace		
		Transition Slope C-T1	Terrace T1	Data Points	Transition Slope T1-T2	Terrace T2	Data Points	Transition Slope T2-T3	Terrace T3	Data Points
2	2-1	18.0	24.1	43						
	2-2		20.6	21		32.7	32			
	2-3		38.1	38		24.2	24			
6	6-1	16.2	30.8	47	16.5	64.2	79			
	6-2	6.0	59.8	65	22.9	48.8	71			
	6-3	9.7	73.9	83	9.2	80.5	90			
6.5	6.5-1	21.6	55.1	77		116.1	116			
	6.5-2	35.3	114.5	150		38.5	38			
	6.5-3	27.7	73.5	102		88.9	88			
7	7-1		37.3	38		39.6	39	15.3	15.5	31
	7-2	10.5	50.4	61		82.9	83	24.7		24
	7-3	11.4	42.4	54		62.5	62	20.2		20
8	8-1	7.1	113.4	121	19.9	15.8	35	18.6	17.3	35
	8-2	11.4	123.4	134	43.6	38.0	82	18.3		18
	8-3	14.4	83.8	98		104.3	104	58.8	8.7	67

Total vegetation cover was highly variable between reaches with average vegetation cover totaling only 8.3 ± 2.3% across all transects in Reach 7 and peaking at 29.9 ± 3.3% % in Reach 6.5 (Figure 4). The total vegetation cover observed on the T1 and T2 terraces was comparable and also highly variable (Figure 5). However, when vegetation cover is broken down by life form, there is less variability in the native cover between reaches and terraces (Figure 6).

Figure 4: Average Vegetation Cover Across Reaches (Mean ± Standard Error)

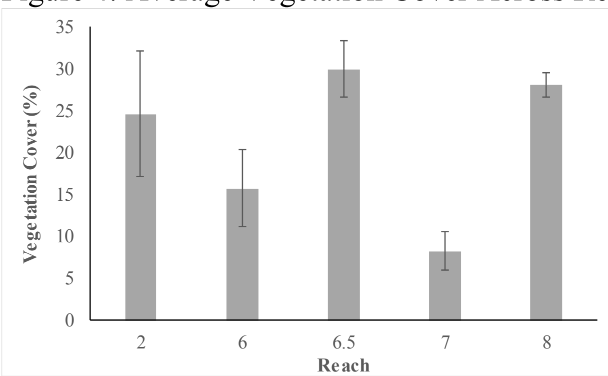


Figure 5: Average Vegetation Cover on (A) T1 Terraces and (B) T2 Terraces

(A) (B)

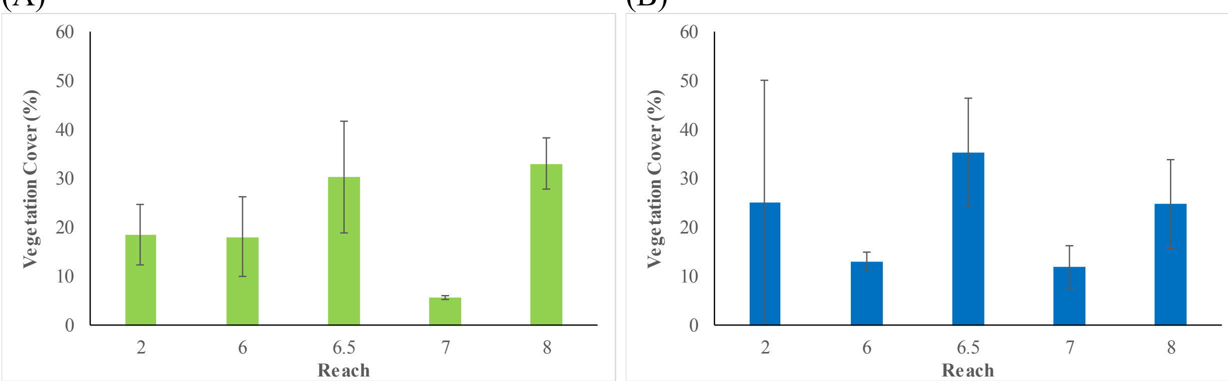
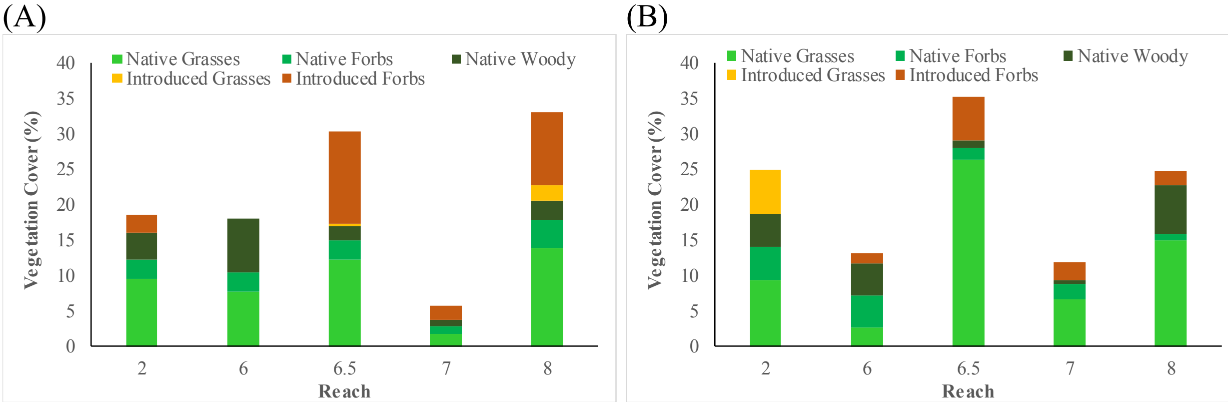


Figure 6: Average Vegetation Cover on (A) T1 Terraces and (B) T2 Terraces by Life Form

(A) (B)



Vegetation cover was statistically analyzed by reach, terrace type, and soil coarse fragment content. There was no difference in total vegetation cover or native vegetation cover between terrace types and there was no correlation between vegetation cover and coarse fragment content in the soils. There was a difference in vegetation cover between reaches, but there was no interaction effect between reach and terrace type.

3.2 Ground Cover

Total ground cover (including vegetation, litter, and rock was somewhat less variable than vegetation cover and also quite high for a riparian system (Figure 7). Ground cover was more than 50% litter on almost all terraces on all reaches (Figure 8) which suggests that these reaches have not experienced overbank flooding recently. We would also expect greater ground cover on T2 terraces than T1 terraces, but this was not observed. Ground cover was statistically analyzed by reach and terrace type. There was no difference in total ground cover or litter cover between terrace types and while there was a difference between reaches, there was no interaction effect between reach and terrace type.

Figure 7: Average Ground Cover Across Reaches and Terraces

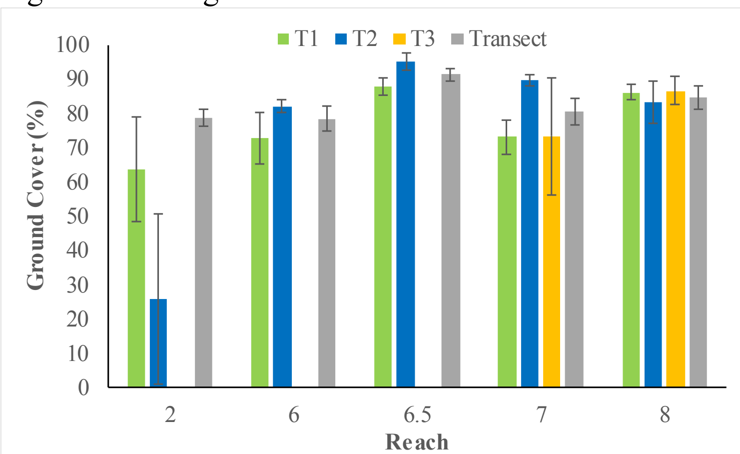
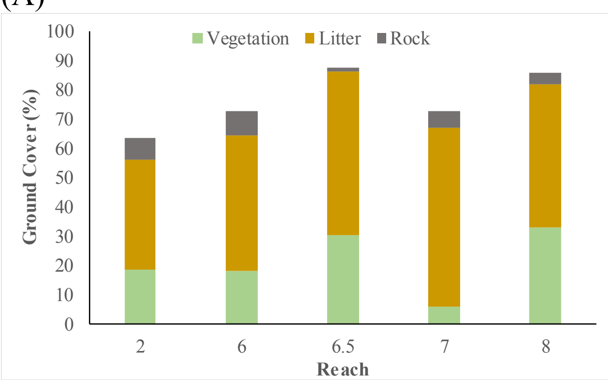
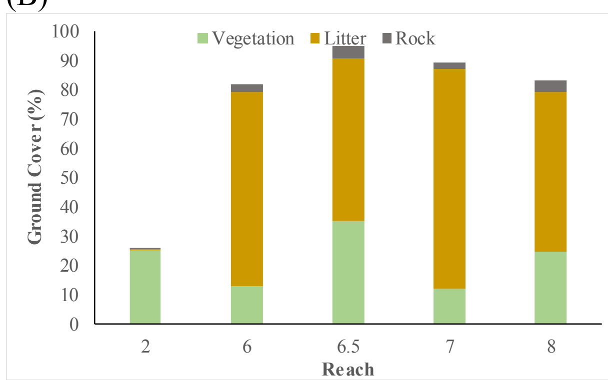


Figure 8: Average Ground Cover on (A) T1 Terraces and (B) T2 Terraces

(A)



(B)



3.3 Species Richness

A total of 67 species were observed during cover sampling including 19 grasses, 38 forbs, six shrubs, and four tree species (Table 2). An additional three shrubs and three tree species were observed during woody density sampling. Of the total 73 species observed, 57 were native and 16 were introduced. There were 16 species observed in all 5 reaches and on all three terrace types including three native perennial grasses (*Elymus elymoides* or squirreltail, *Pleuraphis jamesii* or James' galleta, and *Sporobolus airoides* or alkali sacaton), one introduced perennial grass (*Cynodon dactylon* or Bermudagrass), four native annual forbs (*Eriastrum diffusum* or miniature woollystar, *Eriogonum polycladon* or sorrel buckwheat, *Mentzelia albicaulis* or whitestem blazingstar, and *Plantago patagonica* or woolly plantain), three introduced annual

Table 2: Complete Species List by Reach and Terrace Type

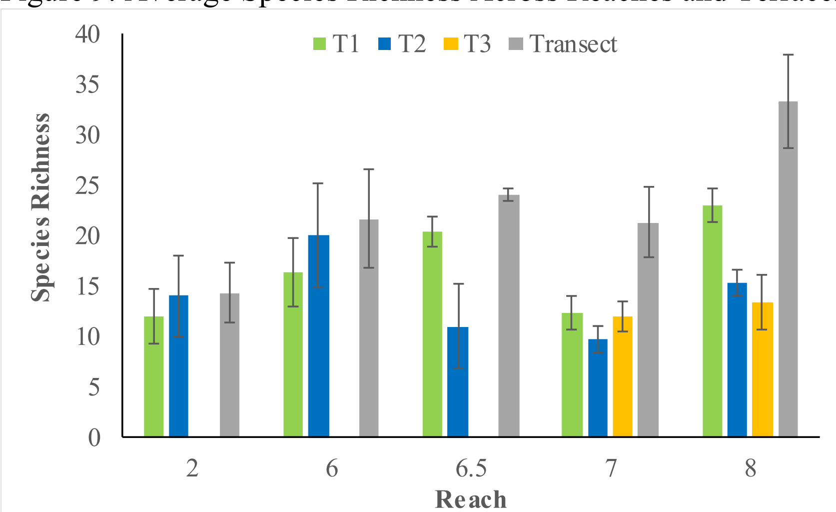
		Reach					Terrace		
Species	**Common Name**	**2**	**6**	**6.5**	**7**	**8**	**T1**	**T2**	**T3**
Native Annual Grass									
Vulpia octoflora	sixweeks fescue					33.3	6.7		
Native Perennial Grass									
Achnatherum hymenoides	Indian ricegrass					33.3	6.7		16.7
Bothriochloa barbinoides	cane bluestem					33.3			16.7
Bouteloua curtipendula	sideoats grama	100.0	33.3	33.3		100.0	26.7	42.9	33.3
Bouteloua dactyloides	buffalograss	33.3	33.3					14.3	
Bouteloua rothrockii	Rothrock's grama	33.3					6.7		
Bouteloua sp.	gramagrass					33.3			16.7
Cenchrus spinifex	coastal sandbur		33.3	33.3	33.3	66.7	26.7	7.1	
Elymus elymoides	squirreltail	66.7	66.7	100.0	66.7	100.0	66.7	35.7	16.7
Pleuraphis jamesii	James' galleta	66.7	66.7	66.7	66.7	100.0	66.7	57.1	50.0
Poa fendleriana	muttongrass		33.3	33.3		33.3	13.3	14.3	
Setaria macrostachya	large-spike bristlegrass		33.3		33.3	33.3		14.3	16.7
Sporobolus airoides	alkali sacaton	100.0	100.0	33.3	100.0	100.0	73.3	71.4	50.0
Sporobolus contractus	spike dropseed	66.7				33.3	20.0	7.1	
Sporobolus cryptandrus	sand dropseed	100.0	100.0	66.7	33.3		53.3	42.9	
Sporobolus wrightii	big sacaton		100.0	100.0	66.7	100.0	33.3	50.0	50.0
Unknown grass #1	unknown grass #1				33.3	33.3	13.3		
Introduced Perennial Grass									
Cynodon dactylon	Bermudagrass	66.7	33.3	66.7	100.0	100.0	60.0	7.1	16.7
Sorghum halepense	Johnsongrass		66.7			66.7	20.0	7.1	
Native Annual Forbs									
Amaranthus sp.	pigweed				33.3			7.1	16.7
Chamaesyce maculata	spotted sandmat		33.3					7.1	
Cleome serrula	Rocky Mountain beeplant		33.3	33.3	66.7	66.7	33.3	7.1	
Eriastrum diffusum	miniature woollystar	100.0	100.0	66.7	33.3	66.7	40.0	42.9	33.3
Eriogonum polycladon	sorrel buckwheat	66.7	100.0	66.7	33.3	100.0	46.7	42.9	33.3
Gaura parviflora	velvetweed		33.3		33.3	100.0	13.3	14.3	33.3
Helianthus annuus	annual sunflower		66.7	33.3	66.7	100.0	46.7	28.6	16.7
Helianthus petiolaris	prairie sunflower					33.3	6.7		16.7
Lepidium densiflorum	common pepperweed				33.3	33.3	6.7	7.1	16.7
Lepidium virginicum	intermediate pepperweed		33.3					7.1	
Lupinus concinnus	bajada lupine	33.3				33.3	13.3		
Mentzelia albicaulis	whitestem blazingstar	100.0	100.0	100.0	100.0	66.7	86.7	57.1	50.0
Plantago patagonica	woolly plantain	66.7	66.7	33.3	33.3	33.3	33.3	21.4	16.7
Pseudognaphalium leucocephalum	white cudweed		66.7	100.0	33.3	100.0	40.0	21.4	16.7
Introduced Annual Forbs									
Chenopodium album	lambsquarters		100.0	100.0	66.7	100.0	66.7	42.9	
Datura sp.	jimson weed		33.3	33.3	33.3	33.3	20.0		16.7
Salsola tragus	prickly Russian thistle	66.7	100.0	66.7	66.7	66.7	66.7	28.6	16.7
Sida abutifolia	spreading fanpetals	33.3	100.0	33.3	33.3	33.3	20.0	21.4	33.3
Solanum elaeagnifolium	silverleaf nightshade		66.7	66.7			6.7	21.4	
Unknown forb #1	unknown forb #1	100.0	100.0	100.0	100.0	66.7	60.0	71.4	66.7
Unknown forb #2	unknown forb #2	33.3		100.0	100.0	100.0	60.0	71.4	100.0
Unknown forb #3	unknown forb #3		33.3	66.7	33.3		20.0	7.1	16.7
Unknown forb #5	unknown forb #5			100.0	33.3	100.0	40.0	28.6	33.3
Native Perennial Forbs									
Argemone pleiacantha	southwestern pricklypoppy		100.0	100.0	66.7	100.0	60.0	57.1	33.3
Cucurbita digitata	fingerleaf gourd					33.3		7.1	16.7
Cucurbita foetidissima	Missouri gourd			33.3			6.7	7.1	
Machaeranthera pinnatifida	lacy tansyaster	33.3	66.7	66.7	33.3	100.0	20.0	57.1	33.3
Mirabilis linearis	narrowleaf four o'clock					33.3	6.7		
Mirabilis sp. #1	four o'clock	100.0	100.0	100.0	100.0	100.0	73.3	85.7	66.7
Mirabilis sp. #2	four o'clock	66.7		33.3	33.3		13.3	21.4	16.7
Sphaeralcea ambigua	desert globemallow	33.3	66.7	33.3	66.7	33.3	6.7	28.6	50.0
Stephanomeria pauciflorc	brownplume wirelettuce					33.3			16.7
Verbena bracteata	bigbract verbena			33.3	66.7	33.3	20.0	7.1	16.7
Introduced Perennial Forbs									
Convolvulus sp. #1	bindweed		33.3					7.1	
Convolvulus sp. #2	bindweed					100.0	6.7	7.1	33.3
Marrubium vulgare	horehound					33.3	6.7		
Rumex crispus	curly dock				33.3	33.3		14.3	
Unknown forb #4	unknown forb #4	33.3	33.3	100.0	33.3	33.3	33.3	28.6	16.7
Native Shrubs									
Acacia constricta	whitethorn acacia		100.0				20.0	7.1	
Acacia greggii	catclaw acacia	33.3	66.7			100.0	13.3	21.4	33.3
*Amelanchier utahensis**	Utah serviceberry					33.3		7.1	
Baccharis sp.*	baccharis		33.3					7.1	
Chilopsis linearis	desert willow				33.3	100.0	33.3	7.1	16.7
Cylindropuntia sp.*	cholla			33.3	33.3		6.7	7.1	
Ericameria nauseosa	rubber rabbitbrush		100.0				20.0	14.3	
Hymenoclea sp.	burrobrush			100.0	100.0	100.0	40.0	35.7	50.0
Opuntia sp.	pricklypear cactus	33.3					6.7		
Native Trees									
Celtis laevigata	sugarberry	33.3					6.7		
Fraxinus velutina	velvet ash			33.3		33.3	13.3		
*Juglans nigra**	black walnut	33.3						7.1	
*Juniperus monosperma**	oneseed juniper	33.3						7.1	
Populus fremontii	Fremont cottonwood				33.3	33.3	13.3		
Prosopis velutina	velvet mesquite	66.7	100.0	100.0	66.7	66.7	40.0	57.1	50.0
*Sapindus saponaria**	wingleaf soapberry		66.7					14.3	
Total Species		**29**	**41**	**37**	**40**	**53**	**57**	**57**	**41**

* Only observed in woody density counts.

forbs (*Salsola tragus* or prickly Russian thistle, *Sida abutifolia* or spreading fanpetals, and unknown forb #1), three native perennial forbs (*Machaeranthera pinnatifida* or lacy tansyaster, *Mirabilis* sp. #1 or four o'clock, and *Sphaeralcea ambigua* or desert globemallow), one introduced perennial forb (unknown forb #4), and one native tree (*Prosopis velutina* or velvet mesquite). There were an additional 16 species that were observed on all three terrace types including two native perennial grasses, four native annual forbs, three introduced annual forbs, three native perennial forbs, one introduced perennial forb, and three native shrubs.

There was more variability between reaches than there was between terraces within a given reach (Figure 9). Statistical analyses of species richness found no significant difference between terrace types when all data were combined, but there was a difference between reaches. There was no interaction effect between reach and terrace type.

Figure 9: Average Species Richness Across Reaches and Terraces



3.4 Woody Species Density

Woody species density was collected in variable-sized plots, with counts being converted to plants per acre for comparisons. Average total woody density ranged from a low of 148 plants/acre on T2 terraces in Reach 8 to a high of 2,823 plants/acre on the channel to T1 transition slope in the same reach (Figure 10). In general, woody density was greater on the transition slopes than on the associated terrace above the slope and was greater on T1 terraces than T2 terraces. Differences in density between terrace types were more pronounced than differences between reaches.

Shrubs were the largest component of the woody density on all terrace types (Figure 11) with a greater density of shrubs than all sizes of trees combined. Shrubs were also the largest component within each reach except for Reach 2 (Figure 12). In Reach 2, there was an almost even distribution of shrubs and each size of tree species resulting in almost four times as many trees and shrubs. Burrobrush (*Hymenoclea* sp.) was the most common woody species observed followed by velvet mesquite (*Prosopis velutina*) and desert willow (*Chilopsis linearis*). Sugarberry (*Celtis laevigata* also called hackberry), rubber rabbitbrush (*Ericameria nauseosa*) and catclaw acacia (*Acacia gregii*) were commonly observed.

Table 3: Woody Density Plot Sizes (Square Feet)

		T1 Terrace		T2 Terrace		T3 Terrace	
		Transition Slope	Terrace	Transition Slope	Terrace	Transition Slope	Terrace
Reach	**Transect**	**C-T1**	**T1**	**T1-T2**	**T2**	**T2-T3**	**T3**
2	2-1	900	285				
	2-2		333		474		
	2-3		616		460		
6	6-1	948	435	929	1,799		
	6-2	246	1,405	1,424	1,378		
	6-3	495	2,404	469	2,627		
6.5	6.5-1	1,291	1,194		5,581		
	6.5-2	2,325	5,812		1,164		
	6.5-3	803	4,243		6,207		
7	7-1		1,093		1,232	612	109
	7-2	536	1,995		4,902	1,260	
	7-3	958	1,412		3,068	970	
8	8-1	412	6,000	498	196	744	235
	8-2	638	7,828	2,186	1,134	439	
	8-3	576	2,811		4,379	2,602	59

Figure 10: Woody Species Density Across Reaches and Terraces

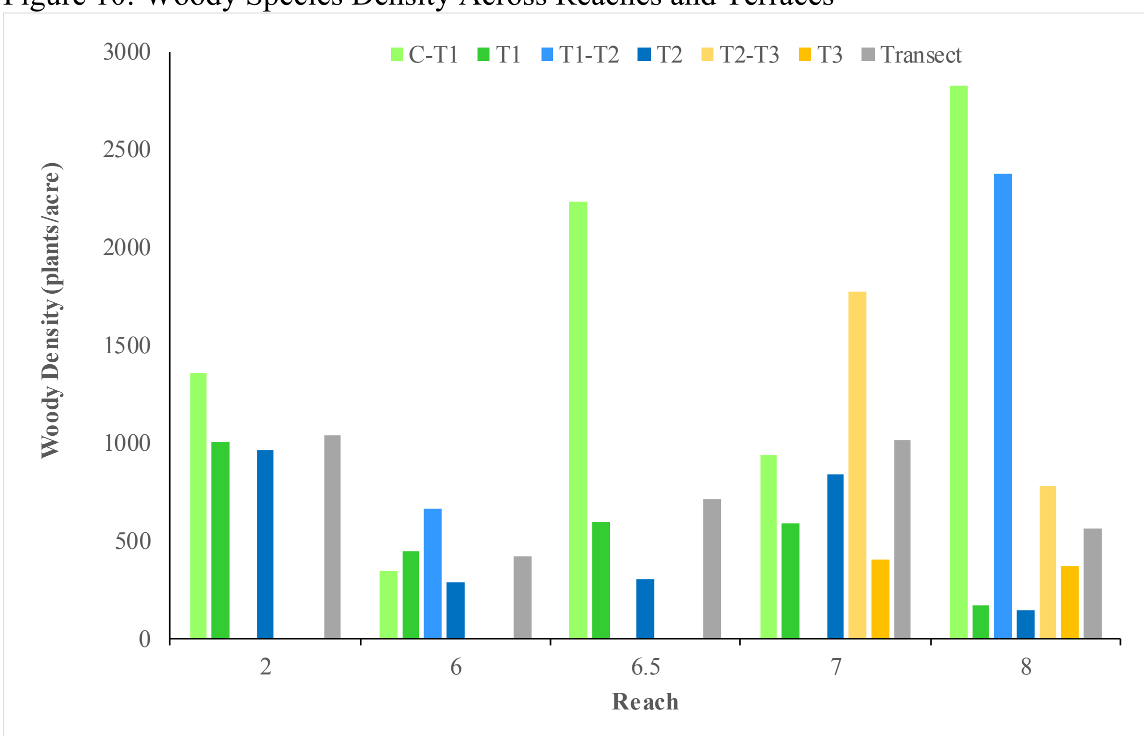


Figure 11: Average Woody Species Density by Stem Size Across Terraces

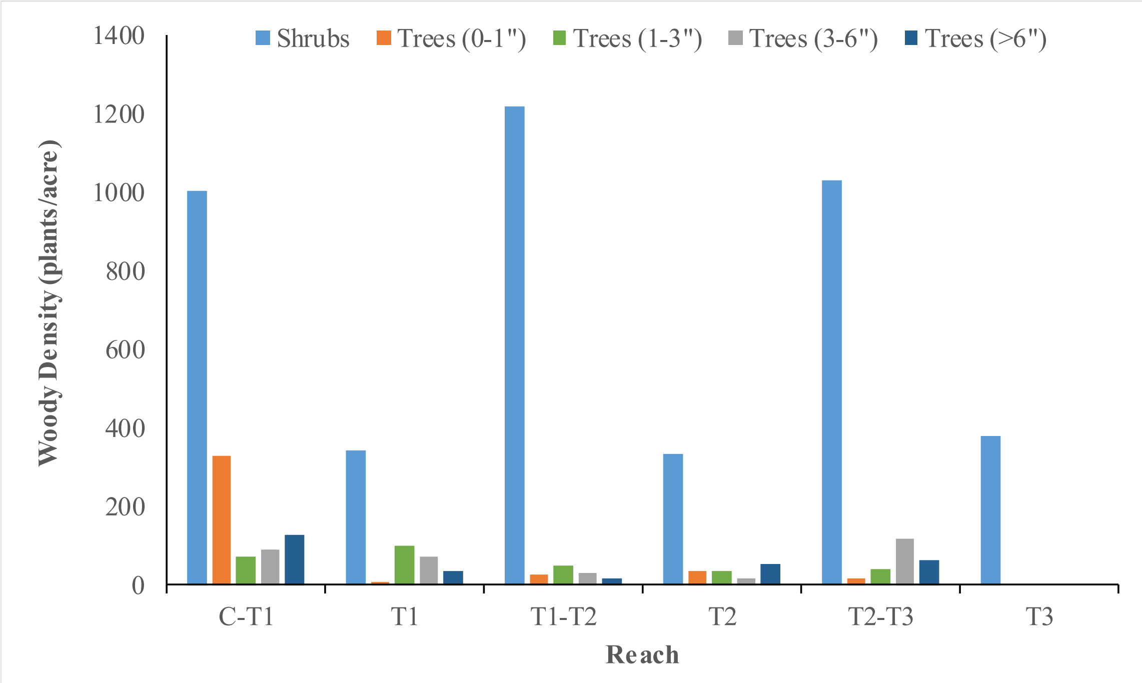
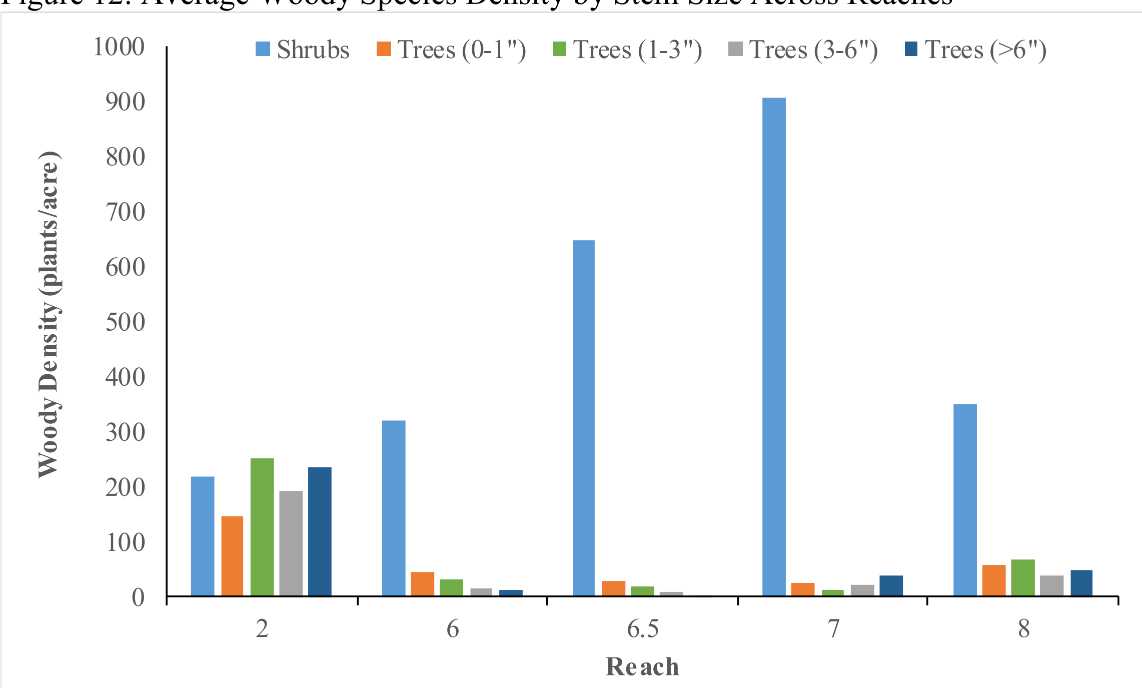


Figure 12: Average Woody Species Density by Stem Size Across Reaches



4 CONCLUSIONS & RECOMMENDATIONS

The results of the vegetation sampling suggest that there is a well-developed and diverse community present along the current channel with many potential species to draw on for seed mixture development. Several of the most commonly observed species that are known to be commercially available are included in Table 4. There is not a substantial difference between the different terrace types, so the mitigation project would not necessarily require different seed mixtures for the T1 terrace and the T2 terrace or upland areas. However, it may be advisable to adjust the quantities of some species and create two slightly different mixtures.

The woody density calculations can help to inform planting density and spacing along the constructed channel and in the upland areas of the SCR Project area. The average density of shrubs ranged from around 1,000 shrubs/acre on the transition slopes to around 300 shrubs/acre on the flat terraces. Tree density was highest immediately adjacent to the channel averaging around 600 trees/acre on the transitions slopes up to the T1 terrace across all reaches and dropped down to between 150 and 250 trees/acre farther away from the T1 Terrace.

Table 4: Recommended Species for Seed Mixture Development

Species	**Common Name**
Native Perennial Grasses	
Achnatherum hymenoides	Indian ricegrass
Bouteloua curtipendula	sideoats grama
Bouteloua rothrockii	Rothrock's grama
Elymus elymoides	squirreltail
Pleuraphis jamesii	James' galleta
Sporobolus airoides	alkali sacaton
Setaria macrostachya	large-spike bristlegrass
Sporobolus cryptandrus	sand dropseed
Native Perennial Forbs	
Argemone pleiacantha	southwestern pricklypoppy
Machaeranthera pinnatifida	lacy tansyaster
Sphaeralcea ambigua	desert globemallow
Verbena bracteata	bigbract verbena
Native Shrubs	
Acacia constricta	whitethorn acacia
Acacia greggii	catclaw acacia
Ericameria nauseosa	rubber rabbitbrush
Hymenoclea sp.	burrobrush
Native Trees	
Chilopsis linearis	desert willow
Prosopis velutina	velvet mesquite

Attachment A: Vegetation Cover Data

Table A1: Reach 2 Vegetation Cover Data

Species	Common Name	2-1	2-2		2-3		Average Absolute Cover			Average Relative Cover			Frequency		
Species	**Common Name**	**T1**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**Transect**	**T1**	**T2**	**Transect**	**T1**	**T2**	**Transect**
Native Perennial Grass															
Bouteloua curtipendula	sideoats grama	9.3	4.8	9.4		P	4.7	4.7	5.6	25.3	18.8	22.8	66.7	100.0	100.0
Bouteloua dactyloides	buffalograss			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	33.3
Bouteloua rothrockii	Rothrock's grama	P					0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Elymus elymoides	squirreltail			P	P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	50.0	66.7
Pleuraphis jamesii	James' galleta	4.7		P			1.6	0.0	1.6	8.4	0.0	6.3	33.3	50.0	66.7
Sporobolus airoides	alkali sacaton	P	P		5.3	P	1.8	0.0	1.1	9.5	0.0	4.4	100.0	50.0	100.0
Sporobolus contractus	spike dropseed		4.8	6.3	P		1.6	3.1	1.9	8.6	12.5	7.7	66.7	50.0	66.7
Sporobolus cryptandrus	sand dropseed	P		3.1	P	P	0.0	1.6	0.6	0.0	6.3	2.6	66.7	100.0	100.0
Total Native Perennial Grass		*14.0*	*9.5*	*18.8*	*5.3*	*P*	*9.6*	*9.4*	*10.8*	*51.7*	*37.5*	*43.7*	*100.0*	*100.0*	*100.0*
Introduced Perennial Grass															
Cynodon dactylon	Bermudagrass			12.5	P		0.0	6.3	2.5	0.0	25.0	10.2	33.3	50.0	66.7
Total Introduced Perennial Grass				*12.5*	*P*		*0.0*	*6.3*	*2.5*	*0.0*	*25.0*	*10.2*	*33.3*	*50.0*	*66.7*
Native Annual Forbs															
Eriastrum diffusum	miniature woollystar	P		P	P	P	0.0	0.0	0.0	0.0	0.0	0.0	66.7	100.0	100.0
Eriogonum polycladon	sorrel buckwheat		P		P		0.0	0.0	0.0	0.0	0.0	0.0	66.7	0.0	66.7
Lupinus concinnus	bajada lupine				P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Mentzelia albicaulis	whitestem blazingstar	P	P	9.4	7.9	P	2.6	4.7	3.5	14.2	18.8	14.2	100.0	100.0	100.0
Plantago patagonica	woolly plantain			P	P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	50.0	66.7
Total Native Annual Forbs		*P*	*P*	*9.38*	*7.89*	*P*	*2.6*	*4.7*	*3.5*	*14.2*	*18.8*	*14.2*	*100.0*	*100.0*	*100.0*
Introduced Annual Forbs															
Salsola tragus	prickly Russian thistle	4.7			2.6	P	2.4	0.0	2.1	13.1	0.0	8.5	66.7	50.0	66.7
Sida abutifolia	spreading fanpetals			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	33.3
Unknown forb #1	unknown forb #1	P	P	P	P	P	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0
Unknown forb #2	unknown forb #2			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	33.3
Total Introduced Annual Forbs		*4.7*	*P*	*P*	*2.6*	*P*	*2.4*	*0.0*	*2.1*	*13.1*	*0.0*	*8.5*	*100.0*	*100.0*	*100.0*
Native Perennial Forbs															
Machaeranthera pinnatifida	lacy tansyaster			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	33.3
Mirabilis sp. #1	four o'clock	P		P	P		0.0	0.0	0.0	0.0	0.0	0.0	66.7	50.0	100.0
Mirabilis sp. #2	four o'clock	P			P	P	0.0	0.0	0.0	0.0	0.0	0.0	66.7	50.0	66.7
Sphaeralcea ambigua	desert globemallow			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	33.3
Total Native Perennial Forbs		*P*		*P*	*P*	*P*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*66.7*	*100.0*	*100.0*
Introduced Perennial Forbs															
Unknown forb #4	unknown forb #4				P	P	0.0	0.0	0.0	0.0	0.0	0.0	33.3	50.0	33.3
Total Introduced Perennial Forbs					*P*	*P*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*33.3*	*50.0*	*33.3*
Native Shrubs															
Acacia greggii	catclaw acacia			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	33.3
Opuntia sp.	pricklypear cactus	P					0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Total Native Shrubs		*P*		*P*			*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*33.3*	*50.0*	*100.0*
Native Trees															
Celtis laevigata	sugarberry	11.6					3.9	0.0	3.9	20.9	0.0	15.7	33.3	0.0	33.3
Prosopis velutina	velvet mesquite		P	9.4	P	P	0.0	4.7	1.9	0.0	18.8	7.7	66.7	100.0	100.0
Total Native Trees		*11.6*	*P*	*9.38*	*P*	*P*	*3.9*	*4.7*	*5.8*	*20.9*	*18.8*	*23.4*	*100.0*	*100.0*	*33.3*
Total Vegetation Cover		**30.2**	**9.5**	**50.0**	**15.8**	**0.0**	**18.5**	**25.0**	**24.6**	**100.0**	**100.0**	**100.0**			
Rock		2.3	9.5	0.1	10.5		7.5	0.0	5.4						
Litter		48.8	14.3	0.4	50.0	0.9	37.7	0.7	48.5						
Bare		18.6	66.7		23.7	0.1	36.3	0.1	21.5						
Total Ground Cover		**81.4**	**33.3**	**50.5**	**76.3**	**0.9**	**63.7**	**25.7**	**78.5**						
Total Hits		43	21	32	38	24									
Total Species		**13**	**6**	**17**	**15**	**9**	**11.3**	**13.0**	**14.3**						

Table A2: Reach 6 Vegetation Cover Data

		6-1		6-2		6-3		Average Absolute Cover			Average Relative Cover			Frequency		
Species	**Common Name**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**Transect**	**T1**	**T2**	**Transect**	**T1**	**T2**	**Transect**
Native Perennial Grass																
Bouteloua curtipendula	sideoats grama		P					0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Bouteloua dactyloides	buffalograss						P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Cenchrus spinifex	coastal sandbur					P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Elymus elymoides	squirreltail	P	P				P	0.0	0.0	0.0	0.0	0.0	0.0	33.3	66.7	66.7
Pleuraphis jamesii	James' galleta			4.6		3.6	P	2.7	0.0	1.3	15.2	0.0	8.3	66.7	33.3	66.7
Poa fendleriana	muttongrass				P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Setaria macrostachya	large-spike bristlegrass		P					0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Sporobolus airoides	alkali sacaton	P	2.5	6.2	2.8	1.2	P	2.5	1.8	2.2	13.6	13.6	13.9	100.0	100.0	100.0
Sporobolus cryptandrus	sand dropseed	P	2.5	P		3.6	P	1.2	0.8	1.1	6.7	6.5	7.0	100.0	66.7	100.0
Sporobolus wrightii	big sacaton		P	1.5		2.4	P	1.3	0.0	0.6	7.3	0.0	4.0	66.7	66.7	100.0
Total Native Perennial Grass		*P*	*5.1*	*12.3*	*2.8*	*10.8*	*P*	*7.7*	*2.6*	*5.2*	*42.7*	*20.1*	*33.3*	*100.0*	*100.0*	*100.0*
Introduced Perennial Grass																
Cynodon dactylon	Bermudagrass					P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Sorghum halepense	Johnsongrass				P	P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	66.7
Total Introduced Perennial Grass					*P*	*P*		*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*33.3*	*33.3*	*66.7*
Native Annual Forbs																
Chamaesyce maculata	spotted sandmat		P					0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Cleome serrula	Rocky Mountain beeplant			P				0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Eriastrum diffusum	miniature woollystar	2.1	P		P	1.2		1.1	0.0	0.5	6.1	0.0	2.9	66.7	66.7	100.0
Eriogonum polycladon	sorrel buckwheat	P	P		4.2	P	2.2	0.0	2.1	1.1	0.0	16.4	7.1	66.7	100.0	100.0
Gaura parviflora	velvetweed		P					0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Helianthus annuus	annual sunflower		P			P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	66.7
Lepidium virginicum	intermediate pepperweed		P					0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Mentzelia albicaulis	whitestem blazingstar	P	P	P		P	P	0.0	0.0	0.0	0.0	0.0	0.0	100.0	66.7	100.0
Plantago patagonica	woolly plantain	P	P			P		0.0	0.0	0.0	0.0	0.0	0.0	66.7	33.3	66.7
Pseudognaphalium leucocephalum	white cudweed				P	1.2	1.1	0.4	0.4	0.4	2.2	2.8	2.4	33.3	66.7	66.7
Total Native Annual Forbs		*2.1*	*P*	*P*	*4.2*	*2.4*	*3.3*	*1.5*	*2.5*	*2.0*	*8.4*	*19.3*	*12.5*	*100.0*	*100.0*	*100.0*
Introduced Annual Forbs																
Chenopodium album	lambsquarters	P	P	P			P	0.0	0.0	0.0	0.0	0.0	0.0	66.7	66.7	100.0
Datura sp.	jimson weed					P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Salsola tragus	prickly Russian thistle	P	P		1.4	P	P	0.0	0.5	0.2	0.0	3.6	1.6	66.7	100.0	100.0
Sida abutifolia	spreading fanpetals	P	P		P	P		0.0	0.0	0.0	0.0	0.0	0.0	66.7	66.7	100.0
Solanum elaeagnifolium	silverleaf nightshade		P				P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	66.7
Unknown forb #1	unknown forb #1		2.5	P		P	P	0.0	0.8	0.5	0.0	6.5	3.4	66.7	66.7	100.0
Unknown forb #3	unknown forb #3	P	P					0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	33.3
Total Introduced Annual Forbs		*P*	*2.5*	*P*	*1.4*	*P*	*P*	*0.0*	*1.3*	*0.8*	*0.0*	*10.0*	*4.9*	*100.0*	*100.0*	*100.0*
Native Perennial Forbs																
Argemone pleiacantha	southwestern pricklypoppy		P	P		P	P	0.0	0.0	0.0	0.0	0.0	0.0	66.7	66.7	100.0
Machaeranthera pinnatifida	lacy tansyaster		P			3.6	P	1.2	0.0	0.6	6.7	0.0	3.7	33.3	66.7	66.7
Mirabilis sp. #1	four o'clock	P	1.3		2.8	P	2.2	0.0	2.1	1.1	0.0	16.1	7.2	66.7	100.0	100.0
Sphaeralcea ambigua	desert globemallow		P			P	P	0.0	0.0	0.0	0.0	0.0	0.0	33.3	66.7	66.7
Total Native Perennial Forbs		*P*	*1.3*	*P*	*2.8*	*3.61*	*2.2*	*1.2*	*2.1*	*1.7*	*6.7*	*16.1*	*10.9*	*100.0*	*100.0*	*100.0*
Introduced Perennial Forbs																
Convolvulus sp. #1	bindweed		P					0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Unknown forb #4	unknown forb #4		P					0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Total Introduced Perennial Forbs			*P*					*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*33.3*	*33.3*
Native Shrubs																
Acacia constricta	whitethorn acacia	P	P	1.5		2.4		1.3	0.0	0.6	7.3	0.0	4.0	100.0	33.3	100.0
Acacia greggii	catclaw acacia			P			P	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	66.7
Ericameria nauseosa	rubber rabbitbrush	P		15.4	4.2	3.6	5.6	6.3	3.3	4.7	35.0	24.9	30.0	100.0	66.7	100.0
Total Native Shrubs		*P*	*P*	*16.9*	*4.23*	*6.02*	*5.56*	*7.6*	*3.3*	*5.4*	*42.3*	*24.9*	*34.0*	*100.0*	*100.0*	*100.0*
Native Trees																
Celtis laevigata	sugarberry							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Fraxinus velutina	velvet ash							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Populus fremontii	Fremont cottonwood							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Prosopis velutina	velvet mesquite		1.3		1.4		1.1	0.0	1.3	0.7	0.0	9.6	4.5	0.0	100.0	100.0
Total Native Trees		*P*	*1.27*	*P*	*1.41*	*P*	*1.11*	*0.0*	*1.3*	*0.7*	*0.0*	*9.6*	*4.5*	*100.0*	*100.0*	
Total Vegetation Cover		**2.1**	**10.1**	**29.2**	**16.9**	**22.9**	**12.2**	**18.1**	**13.1**	**15.8**	**100.0**	**100.0**	**100.0**			
Rock		2.1	1.3	16.9	1.4	6.0	5.6	8.4	2.7	5.4						
Litter		53.2	68.4	33.8	62.0	51.8	67.8	46.3	66.0	57.1						
Bare		42.6	20.3	20.0	19.7	19.3	14.4	27.3	18.1	21.7						
Total Ground Cover		**57.4**	**79.7**	**80.0**	**80.3**	**80.7**	**85.6**	**72.7**	**81.9**	**78.3**						
Total Hits		47	79	65	71	83	90									
Total Species		**14**	**29**	**12**	**11**	**23**	**20**	**16.3**	**20.0**	**21.7**						

Table A3: Reach 6.5 Vegetation Cover Data

Species	Common Name	6.5-1		6.5-2		6.5-3		Average Absolute Cover			Average Relative Cover			Frequency		
		T1	T2	T1	T2	T1	T2	T1	T2	Transect	T1	T2	Transect	T1	T2	Transect
Native Perennial Grass																
Bouteloua curtipendula	sideoats grama						1.1	0.0	0.4	0.2	0.0	1.1	0.6	0.0	33.3	33.3
Cenchrus spinifex	coastal sandbur			P				0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Elymus elymoides	squirreltail	P		P		P	1.1	0.0	0.4	0.2	0.0	1.1	0.6	100.0	33.3	100.0
Pleuraphis jamesii	James' galleta	P	0.9	0.7				0.2	0.3	0.4	0.7	0.8	1.2	66.7	33.3	66.7
Poa fendleriana	muttongrass					P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Sporobolus airoides	alkali sacaton		2.6					0.0	0.9	0.5	0.0	2.4	1.8	0.0	33.3	33.3
Sporobolus cryptandrus	sand dropseed	2.6	P	P				0.9	0.0	0.3	2.9	0.0	1.2	66.7	33.3	66.7
Sporobolus wrightii	big sacaton		25.9		47.4	33.3		11.1	24.4	14.3	36.6	69.1	49.3	33.3	66.7	100.0
Total Native Perennial Grass		*2.6*	*29.3*	*0.7*	*47.4*	*33.3*	*2.3*	*12.2*	*26.3*	*15.9*	*40.2*	*74.5*	*54.7*	*100.0*	*100.0*	*100.0*
Introduced Perennial Grass																
Cynodon dactylon	Bermudagrass	1.3		P				0.4	0.0	0.2	1.4	0.0	0.6	66.7	0.0	66.7
Total Introduced Perennial Grass		*1.3*		*P*				*0.4*	*0.0*	*0.2*	*1.4*	*0.0*	*0.6*	*66.7*	*0.0*	*66.7*
Native Annual Forbs																
Cleome serrula	Rocky Mountain beeplant					P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Eriastrum diffusum	miniature woollystar		P	0.7				0.2	0.0	0.2	0.7	0.0	0.6	33.3	33.3	66.7
Eriogonum polycladon	sorrel buckwheat			P		P	P	0.0	0.0	0.0	0.0	0.0	0.0	66.7	33.3	66.7
Helianthus annuus	annual sunflower					1.0	1.1	0.3	0.4	0.4	1.1	1.1	1.2	33.3	33.3	33.3
Mentzelia albicaulis	whitestem blazingstar	2.6		2.0		P	P	1.5	0.0	0.9	5.0	0.0	3.0	100.0	33.3	100.0
Plantago patagonica	woolly plantain			P				0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Pseudognaphalium leucocephalum	white cudweed	P		P		P		0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	100.0
Total Native Annual Forbs		*2.6*	*P*	*2.7*		*1.0*	*1.1*	*2.1*	*0.4*	*1.4*	*6.9*	*1.1*	*4.8*	*100.0*	*66.7*	*100.0*
Introduced Annual Forbs																
Chenopodium album	lambsquarters	P		P		P		0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	100.0
Datura sp.	jimson weed					P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Salsola tragus	prickly Russian thistle	P		P				0.0	0.0	0.0	0.0	0.0	0.0	66.7	0.0	66.7
Sida abutifolia	spreading fanpetals	P						0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Solanum elaeagnifolium	silverleaf nightshade			P			P	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	66.7
Unknown forb #1	unknown forb #1	P	0.9	2.0		P	2.3	0.7	1.0	1.1	2.2	3.0	3.6	100.0	66.7	100.0
Unknown forb #2	unknown forb #2	9.1	P	8.0	7.9	14.7	5.7	10.6	4.5	7.4	34.9	12.8	25.4	100.0	100.0	100.0
Unknown forb #3	unknown forb #3	1.3		0.7				0.7	0.0	0.4	2.2	0.0	1.2	66.7	0.0	66.7
Unknown forb #5	unknown forb #5	P	0.9	P	P	2.0		0.7	0.3	0.5	2.2	0.8	1.8	100.0	66.7	100.0
Total Introduced Annual Forbs		*10.4*	*1.7*	*10.7*	*7.9*	*16.7*	*8.0*	*12.6*	*5.9*	*9.3*	*41.4*	*16.6*	*32.0*	*100.0*	*100.0*	*100.0*
Native Perennial Forbs																
Argemone pleiacantha	southwestern pricklypoppy	P	P	P		P	1.1	0.0	0.4	0.2	0.0	1.1	0.6	100.0	66.7	100.0
Cucurbita foetidissima	Missouri gourd	P	P					0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	33.3
Machaeranthera pinnatifida	lacy tansyaster	P	P				P	0.0	0.0	0.0	0.0	0.0	0.0	33.3	66.7	66.7
Mirabilis sp. #1	four o'clock	1.3	1.7	0.7			P	0.7	0.6	0.7	2.2	1.6	2.4	66.7	66.7	100.0
Mirabilis sp. #2	four o'clock						P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Sphaeralcea ambigua	desert globemallow						1.1	0.0	0.4	0.2	0.0	1.1	0.6	0.0	33.3	33.3
Verbena bracteata	bigbract verbena					P	P	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	33.3
Total Native Perennial Forbs		*1.3*	*1.7*	*0.7*		*P*	*2.3*	*0.7*	*1.3*	*1.0*	*2.2*	*3.8*	*3.6*	*100.0*	*66.7*	*100.0*
Introduced Perennial Forbs																
Unknown forb #4	unknown forb #4	1.3	0.9	P		P	P	0.4	0.3	0.3	1.4	0.8	1.2	100.0	66.7	100.0
Total Introduced Perennial Forbs		*1.3*	*0.9*	*P*		*P*	*P*	*0.4*	*0.3*	*0.3*	*1.4*	*0.8*	*1.2*	*100.0*	*66.7*	*100.0*
Native Shrubs																
Hymenoclea sp.	burrobrush	1.3		2.7			P	1.3	0.0	0.9	4.4	0.0	3.0	66.7	33.3	100.0
Total Native Shrubs		*1.3*		*2.7*			*P*	*1.3*	*0.0*	*0.9*	*4.4*	*0.0*	*3.0*	*66.7*	*33.3*	*100.0*
Native Trees																
Chilopsis linearis	desert willow					P		0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Fraxinus velutina	velvet ash			P				0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Prosopis velutina	velvet mesquite	P		P		2.0	3.4	0.7	1.1	0.9	2.2	3.2	3.0	100.0	33.3	100.0
Total Native Trees		*P*		*P*		*1.96*	*3.41*	*0.7*	*1.1*	*0.0*	*2.2*	*3.2*	*0.0*	*100.0*	*33.3*	*33.3*
Total Vegetation Cover		**20.8**	**33.6**	**17.3**	**55.3**	**52.9**	**17.0**	**30.4**	**35.3**	**29.1**	**100.0**	**100.0**	**100.0**			
Rock		2.6	0.9	0.7		1.0	11.4	1.4	4.1	2.6						
Litter		61.0	62.9	74.7	42.1	32.4	61.4	56.0	55.5	58.7						
Bare		15.6	2.6	7.3	2.6	13.7	10.2	12.2	5.1	8.8						
Total Ground Cover		**84.4**	**97.4**	**92.7**	**97.4**	**86.3**	**89.8**	**87.8**	**94.9**	**90.4**						
Total Hits		77	116	150	38	102	88									
Total Species		**19**	**13**	**21**	**3**	**17**	**16**	**19.0**	**10.7**	**24.0**						

Table A4: Reach 7 Vegetation Cover Data

		7-1			7-2			7-3			Average Absolute Cover				Average Relative Cover				Frequency			
Species	**Common Name**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**Transect**	**T1**	**T2**	**T3**	**Transect**	**T1**	**T2**	**T3**	**Transect**
Native Perennial Grass																						
Cenchrus spinifex	coastal sandbur							P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Elymus elymoides	squirreltail	P		P	P						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	0.0	33.3	66.7
Pleuraphis jamesii	James' galleta				3.3	2.4	P	P	1.6		1.1	1.3	0.0	1.0	18.9	11.2	0.0	12.6	66.7	66.7	33.3	66.7
Setaria macrostachya	large-spike bristlegrass						P				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Sporobolus airoides	alkali sacaton	P	2.6		P	P		1.9	1.6		0.6	1.4	0.0	0.8	10.7	11.7	0.0	9.7	100.0	100.0	0.0	100.0
Sporobolus cryptandrus	sand dropseed							P	1.6		0.0	0.5	0.0	0.2	0.0	4.5	0.0	3.0	33.3	33.3	0.0	33.3
Sporobolus wrightii	big sacaton		10.3	P			P				0.0	3.4	0.0	1.2	0.0	28.6	0.0	14.9	0.0	33.3	66.7	66.7
Unknown grass #1	unknown grass #1	P									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Total Native Perennial Grass		*P*	*12.8*	*P*	*3.3*	*2.4*	*P*	*1.9*	*4.8*		*1.7*	*6.7*	*0.0*	*3.3*	*29.5*	*56.0*	*0.0*	*40.1*	*100.0*	*100.0*	*66.7*	*100.0*
Introduced Perennial Grass																						
Cynodon dactylon	Bermudagrass			3.2	P			P			0.0	0.0	1.1	0.3	0.0	0.0	25.0	3.7	66.7	0.0	33.3	100.0
Total Introduced Perennial Grass				*3.2*	*P*			*P*			*0.0*	*0.0*	*1.1*	*0.3*	*0.0*	*0.0*	*25.0*	*3.7*	*66.7*	*0.0*	*33.3*	*100.0*
Native Annual Forbs																						
Amaranthus sp.	pigweed					P	P				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	33.3
Cleome serrula	Rocky Mountain beeplant				P			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	0.0	0.0	66.7
Eriastrum diffusum	miniature woollystar									P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Eriogonum polycladon	sorrel buckwheat							P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Gaura parviflora	velvetweed									P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Helianthus annuus	annual sunflower				P			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	0.0	0.0	66.7
Lepidium densiflorum	common pepperweed									P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Mentzelia albicaulis	whitestem blazingstar	P	P	P		P	P	P	1.6	P	0.0	0.5	0.0	0.2	0.0	4.5	0.0	3.0	66.7	100.0	100.0	100.0
Plantago patagonica	woolly plantain								P	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	33.3
Pseudognaphalium leucocephalum	white cudweed									P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Total Native Annual Forbs		*P*	*P*	*P*	*P*	*P*	*P*	*P*	*1.6*	*P*	*0.0*	*0.5*	*0.0*	*0.2*	*0.0*	*4.5*	*0.0*	*3.0*	*100.0*	*100.0*	*100.0*	*100.0*
Introduced Annual Forbs																						
Chenopodium album	lambsquarters				P			P	P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	33.3	0.0	66.7
Datura sp.	jimson weed			P							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Salsola tragus	prickly Russian thistle				P			P		P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	0.0	33.3	66.7
Sida abutifolia	spreading fanpetals									P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Unknown forb #1	unknown forb #1	P	P	P		P	P		P	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	100.0	100.0	100.0
Unknown forb #2	unknown forb #2	2.6	7.7	9.7	P	P	P	3.7	P	P	2.1	2.6	3.2	2.7	36.5	21.5	75.0	32.1	100.0	100.0	100.0	100.0
Unknown forb #3	unknown forb #3									P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Unknown forb #5	unknown forb #5							P		P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3	33.3
Total Introduced Annual Forbs		*2.6*	*7.7*	*9.7*	*P*	*P*	*P*	*3.7*	*P*	*P*	*2.1*	*2.6*	*3.2*	*2.7*	*36.5*	*21.5*	*75.0*	*32.1*	*100.0*	*100.0*	*100.0*	*100.0*

Table A4: Reach 7 Vegetation Cover Data (continued)

		7-1			7-2			7-3			Average Absolute Cover				Average Relative Cover				Frequency			
Species	**Common Name**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**Transect**	**T1**	**T2**	**T3**	**Transect**	**T1**	**T2**	**T3**	**Transect**
Native Perennial Forbs																						
Argemone pleiacantha	southwestern pricklypoppy			P	3.3	P					1.1	0.0	0.0	0.4	18.9	0.0	0.0	4.8	33.3	33.3	33.3	66.7
Machaeranthera pinnatifida	lacy tansyaster					P					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Mirabilis sp. #1	four o'clock	P	P	P	P	4.8		P	P		0.0	1.6	0.0	0.8	0.0	13.5	0.0	9.6	100.0	100.0	33.3	100.0
Mirabilis sp. #2	four o'clock					P	P				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	33.3
Sphaeralcea ambigua	desert globemallow						P			P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	66.7
Verbena bracteata	bigbract verbena	P								P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3	66.7
Total Native Perennial Forbs		*P*	*P*	*P*	*3.3*	*4.8*	*P*	*P*	*P*	*P*	*1.1*	*1.6*	*0.0*	*1.2*	*18.9*	*13.5*	*0.0*	*14.4*	*100.0*	*100.0*	*100.0*	*100.0*
Introduced Perennial Forbs																						
Rumex crispus	curly dock								P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3
Unknown forb #4	unknown forb #4			P							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Total Introduced Perennial Forbs				*P*					*P*		*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*33.3*	*33.3*	*66.7*
Native Shrubs																						
Hymenoclea sp.	burrobrush	2.6		P	P	P	P		1.6		0.9	0.5	0.0	0.6	15.1	4.5	0.0	6.7	66.7	66.7	66.7	100.0
Total Native Shrubs		*2.6*		*P*	*P*	*P*	*P*		*1.6*		*0.9*	*0.5*	*0.0*	*0.6*	*15.1*	*4.5*	*0.0*	*6.7*	*66.7*	*66.7*	*66.7*	*100.0*
Native Trees																						
Chilopsis linearis	desert willow				P						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Populus fremontii	Fremont cottonwood				P						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Prosopis velutina	velvet mesquite		P							P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	66.7
Total Native Trees			*P*		*P*					*P*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*33.3*	*33.3*	*33.3*	*33.3*
Total Vegetation Cover		**5.3**	**20.5**	**12.9**	**6.6**	**7.2**	**0.0**	**5.6**	**8.1**	**0.0**	**5.8**	**11.9**	**4.3**	**8.3**	**100.0**	**100.0**	**100.0**	**100.0**				
Rock				3.2	11.5	2.4	4.2	5.6	4.8	20.0	5.7	2.4	9.1	4.7								
Litter		73.7	69.2	67.7	59.0	77.1	91.7	51.9	79.0	20.0	61.5	75.1	59.8	67.5								
Bare		21.1	10.3	16.1	23.0	13.3	4.2	37.0	8.1	60.0	27.0	10.5	26.8	19.5								
Total Ground Cover		**78.9**	**89.7**	**83.9**	**77.0**	**86.7**	**95.8**	**63.0**	**91.9**	**40.0**	**73.0**	**89.5**	**73.2**	**80.5**								
Total Hits		38	39	31	61	83	24	54	62	20												
Total Species		**9**	**6**	**11**	**13**	**11**	**10**	**14**	**11**	**14**	**12.0**	**9.3**	**11.7**	**21.3**								

Table A5: Reach 8 Vegetation Cover Data

		8-1			8-2			8-3			Average Absolute Cover				Average Relative Cover				Frequency			
Species	**Common Name**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**Transect**	**T1**	**T2**	**T3**	**Transect**	**T1**	**T2**	**T3**	**Transect**
Native Annual Grass																						
Vulpia octoflora	sixweeks fescue	0.8									0.3	0.0	0.0	0.2	0.8	0.0	0.0	0.6	33.3	0.0	0.0	33.3
Total Native Annual Grass		*0.83*									*0.3*	*0.0*	*0.0*	*0.2*	*0.8*	*0.0*	*0.0*	*0.6*	*33.3*	*0.0*	*0.0*	*33.3*
Native Perennial Grass																						
Achnatherum hymenoides	Indian ricegrass	P		P							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3	33.3
Bothriochloa barbinoides	cane bluestem									4.5	0.0	0.0	1.5	0.4	0.0	0.0	4.4	1.3	0.0	0.0	33.3	33.3
Bouteloua curtipendula	sideoats grama	1.7	P		5.2	P	P			P	2.3	0.0	0.0	1.3	6.9	0.0	0.0	4.8	66.7	66.7	66.7	100.0
Bouteloua sp.	gramagrass			P							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Cenchrus spinifex	coastal sandbur					4.9		1.0			0.3	1.6	0.0	0.7	1.0	6.6	0.0	2.5	33.3	33.3	0.0	66.7
Elymus elymoides	squirreltail	P	P		P			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	33.3	0.0	100.0
Pleuraphis jamesii	James' galleta	7.4	P		14.2	11.0	11.1	3.1	1.9	1.5	8.2	4.3	4.2	6.6	24.9	17.4	12.3	23.5	100.0	100.0	66.7	100.0
Poa fendleriana	muttongrass	P	P								0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	0.0	33.3
Setaria macrostachya	large-spike bristlegrass		5.7								0.0	1.9	0.0	0.3	0.0	7.7	0.0	1.2	0.0	33.3	0.0	33.3
Sporobolus airoides	alkali sacaton	2.5		11.4	1.5	1.2	P		P	3.0	1.3	0.4	4.8	1.9	4.0	1.6	14.1	6.8	66.7	66.7	100.0	100.0
Sporobolus contractus	spike dropseed							P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Sporobolus wrightii	big sacaton		20.0		P			4.1	P	10.4	1.4	6.7	3.5	2.6	4.1	26.9	10.2	9.2	66.7	66.7	33.3	100.0
Unknown grass #1	unknown grass #1	P									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Total Native Perennial Grass		*11.6*	*25.7*	*11.4*	*20.9*	*17.1*	*11.1*	*8.2*	*1.9*	*19.4*	*13.5*	*14.9*	*14.0*	*13.8*	*41.0*	*60.2*	*40.9*	*49.3*	*100.0*	*100.0*	*100.0*	*100.0*
Introduced Perennial Grass																						
Cynodon dactylon	Bermudagrass	6.6			P			P			2.2	0.0	0.0	1.4	6.7	0.0	0.0	5.0	100.0	0.0	0.0	100.0
Sorghum halepense	Johnsongrass	P						P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	0.0	0.0	66.7
Total Introduced Perennial Grass		*6.61*			*P*			*P*			*2.2*	*0.0*	*0.0*	*1.4*	*6.7*	*0.0*	*0.0*	*5.0*	*100.0*	*0.0*	*0.0*	*100.0*
Native Annual Forbs																						
Cleome serrula	Rocky Mountain beeplant		P					P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	0.0	66.7
Eriastrum diffusum	miniature woollystar		P	P				P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	33.3	66.7
Eriogonum polycladon	sorrel buckwheat			2.9		P			1.0	P	0.0	0.3	1.0	0.3	0.0	1.3	2.8	1.1	0.0	66.7	66.7	100.0
Gaura parviflora	velvetweed	P			P				P	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.7	33.3	33.3	100.0
Helianthus annuus	annual sunflower	P	P	P	P			P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	33.3	33.3	100.0
Helianthus petiolaris	prairie sunflower							P		P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	33.3	33.3
Lepidium densiflorum	common pepperweed	P	P								0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	0.0	33.3
Lupinus concinnus	bajada lupine	P									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Mentzelia albicaulis	whitestem blazingstar				P			4.1			1.4	0.0	0.0	0.5	4.1	0.0	0.0	1.8	66.7	0.0	0.0	66.7
Plantago patagonica	woolly plantain							P			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Pseudognaphalium leucocephalum	white cudweed	1.7				P		P			0.6	0.0	0.0	0.3	1.7	0.0	0.0	1.2	66.7	33.3	0.0	100.0
Total Native Annual Forbs		*1.7*	*P*	*2.9*	*P*	*P*		*4.1*	*1.0*	*P*	*1.9*	*0.3*	*1.0*	*1.1*	*5.8*	*1.3*	*2.8*	*4.1*	*100.0*	*100.0*	*66.7*	*100.0*

Table A5: Reach 8 Vegetation Cover Data (continued)

		8-1			8-2			8-3			Average Absolute Cover				Average Relative Cover				Frequency			
Species	**Common Name**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**Transect**	**T1**	**T2**	**T3**	**Transect**	**T1**	**T2**	**T3**	**Transect**
Introduced Annual Forbs																						
Chenopodium album	lambsquarters	P	P		3.0	P		18.4	1.9		7.1	0.6	0.0	3.0	21.6	2.6	0.0	10.9	100.0	100.0	0.0	100.0
Datura sp.	jimson weed	P									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Salsola tragus	prickly Russian thistle	P						2.0			0.7	0.0	0.0	0.2	2.1	0.0	0.0	0.9	66.7	0.0	0.0	66.7
Sida abutifolia	spreading fanpetals			2.9							0.0	0.0	1.0	0.2	0.0	0.0	2.8	0.6	0.0	0.0	33.3	33.3
Unknown forb #1	unknown forb #1			2.9		P					0.0	0.0	1.0	0.2	0.0	0.0	2.8	0.6	0.0	33.3	33.3	66.7
Unknown forb #2	unknown forb #2	0.8	P	P	4.5	1.2	11.1	2.0	1.0	4.5	2.4	0.7	5.2	2.2	7.4	2.9	15.2	7.8	100.0	100.0	100.0	100.0
Unknown forb #5	unknown forb #5		P	P	P			P	1.0		0.0	0.3	0.0	0.1	0.0	1.3	0.0	0.4	66.7	66.7	33.3	100.0
Total Introduced Annual Forbs		*0.8*	*P*	*5.7*	*7.5*	*1.2*	*11.1*	*22.4*	*3.8*	*4.5*	*10.2*	*1.7*	*7.1*	*6.0*	*31.1*	*6.8*	*20.8*	*21.3*	*100.0*	*100.0*	*100.0*	*100.0*
Native Perennial Forbs																						
Argemone pleiacantha	southwestern pricklypoppy	P	P		P	P	P	2.0	P		0.7	0.0	0.0	0.2	2.1	0.0	0.0	0.9	100.0	100.0	33.3	100.0
Cucurbita digitata	fingerleaf gourd		P	P							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	33.3
Machaeranthera pinnatifida	lacy tansyaster	P				P	P		1.0	P	0.0	0.3	0.0	0.1	0.0	1.3	0.0	0.4	33.3	66.7	66.7	100.0
Mirabilis linearis	narrowleaf four o'clock							1.0			0.3	0.0	0.0	0.1	1.0	0.0	0.0	0.4	33.3	0.0	0.0	33.3
Mirabilis sp. #1	four o'clock	1.7	P	P	0.7	1.2	P		P	P	0.8	0.4	0.0	0.6	2.4	1.6	0.0	2.3	66.7	100.0	100.0	100.0
Sphaeralcea ambigua	desert globemallow			P							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Stephanomeria pauciflora	brownplume wirelettuce			P							0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3
Verbena bracteata	bigbract verbena							1.0			0.3	0.0	0.0	0.1	1.0	0.0	0.0	0.4	33.3	0.0	0.0	33.3
Total Native Perennial Forbs		*1.7*	*P*	*P*	*0.7*	*1.2*	*P*	*4.1*	*1.0*	*P*	*2.2*	*0.7*	*0.0*	*1.3*	*6.5*	*2.9*	*0.0*	*4.5*	*100.0*	*100.0*	*100.0*	*100.0*
Introduced Perennial Forbs																						
Convolvulus sp. #2	bindweed			P	P				P	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	33.3	66.7	100.0
Marrubium vulgare	horehound	P									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Rumex crispus	curly dock								1.0		0.0	0.3	0.0	0.1	0.0	1.3	0.0	0.4	0.0	33.3	0.0	33.3
Unknown forb #4	unknown forb #4				P						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Total Introduced Perennial Forbs		*P*		*P*	*P*				*1.0*	*P*	*0.0*	*0.3*	*0.0*	*0.1*	*0.0*	*1.3*	*0.0*	*0.4*	*66.7*	*33.3*	*66.7*	*100.0*
Native Shrubs																						
Acacia greggii	catclaw acacia			5.7	0.7				P	P	0.2	0.0	1.9	0.5	0.8	0.0	5.6	1.8	33.3	33.3	66.7	100.0
Hymenoclea sp.	burrobrush		14.3		P	3.7		P		P	0.0	6.0	0.0	1.3	0.0	24.2	0.0	4.6	66.7	66.7	33.3	100.0
Total Native Shrubs			*14.3*	*5.7*	*0.7*	*3.7*		*P*	*P*	*P*	*0.2*	*6.0*	*1.9*	*1.8*	*0.8*	*24.2*	*5.6*	*6.4*	*66.7*	*100.0*	*66.7*	*100.0*
Native Trees																						
Chilopsis linearis	desert willow	1.7	P	P	0.7			4.1			2.2	0.0	0.0	1.0	6.5	0.0	0.0	3.5	100.0	33.3	33.3	100.0
Fraxinus velutina	velvet ash	P									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Populus fremontii	Fremont cottonwood	P									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	33.3
Prosopis velutina	velvet mesquite				0.7	2.4	27.8			3.0	0.2	0.8	10.3	1.4	0.8	3.3	30.0	4.9	33.3	33.3	66.7	66.7
Total Native Trees		*1.7*	*P*	*P*	*1.5*	*2.4*	*27.8*	*4.1*		*3.0*	*2.4*	*0.8*	*10.3*	*2.4*	*7.3*	*3.3*	*30.0*	*8.5*	*100.0*	*66.7*	*100.0*	*33.3*
Total Vegetation Cover		**24.8**	**40.0**	**25.7**	**31.3**	**25.6**	**50.0**	**42.9**	**8.7**	**26.9**	**33.0**	**24.8**	**34.2**	**28.1**	**100.0**	**100.0**	**100.0**	**100.0**				
Rock		3.3	5.7	11.4	3.7	1.2	16.7	5.1	4.8	6.0	4.0	3.9	11.4	4.8								
Litter		58.7	45.7	45.7	54.5	59.8	27.8	33.7	57.7	49.3	48.9	54.4	40.9	51.7								
Bare		13.2	8.6	17.1	10.4	13.4	5.6	18.4	28.8	17.9	14.0	16.9	13.5	15.5								
Total Ground Cover		**86.8**	**91.4**	**82.9**	**89.6**	**86.6**	**94.4**	**81.6**	**71.2**	**82.1**	**86.0**	**83.1**	**86.5**	**84.5**								
Total Hits		121	35	35	134	82	18	98	104	67												
Total Species		**26**	**18**	**17**	**20**	**14**	**8**	**23**	**14**	**15**	**23.0**	**15.3**	**13.3**	**33.3**								

Attachment B: Woody Plant Density Data

Table B1: Reach 2 Woody Density Data

Species	Common Name	Basal Diameter (inches)	2-1 C-T1	2-1 T1	2-2 T1	2-2 T2	2-3 T1	2-3 T2	Average Density (Stems/Acre) C-T1	Average Density (Stems/Acre) T1	Average Density (Stems/Acre) T2	Average Density (Stems/Acre) Transect
Native Shrubs												
Acacia greggii	catclaw acacia			152.8		735.2			0.0	50.9	367.6	156.2
Ericameria nauseosa	rubber rabbitbrush				261.6		70.7		0.0	110.8	0.0	49.5
Opuntia sp.	pricklypear cactus		48.4						48.4	0.0	0.0	12.3
Native Trees												
Celtis laevigata	sugarberry	0-1	435.6						435.6	0.0	0.0	110.3
		1-3	290.4	917.1			70.7		290.4	329.3	0.0	160.5
		3-6	290.4	764.2		91.9			290.4	254.7	46.0	152.8
		>6	193.6	152.8					193.6	50.9	0.0	61.3
Juglans nigra	black walnut	1-3				91.9			0.0	0.0	46.0	18.0
Juniperus monosperma	oneseed juniper	>6						94.7	0.0	0.0	47.4	13.5
Prosopis velutina	velvet mesquite	0-1				183.8			0.0	0.0	91.9	36.0
		1-3			261.6	183.8			0.0	87.2	91.9	72.0
		3-6					212.1		0.0	70.7	0.0	40.5
		>6	96.8			551.4	141.4		96.8	47.1	275.7	159.5
Total Stems/Acre			**1355.2**	**1986.9**	**523.2**	**1838.0**	**494.9**	**94.7**	**1355.2**	**1001.7**	**966.4**	**1042.2**
Area (Square Feet)			900	285	333	474	616	460				

Table B2: Reach 6 Woody Density Data

Species	Common Name	Basal Diameter (inches)	6-1 C-T1	6-1 T1	6-1 T1-T2	6-1 T2	6-2 C-T1	6-2 T1	6-2 T1-T2	6-2 T2	6-3 C-T1	6-3 T1	6-3 T1-T2	6-3 T2	Average Density (Stems/Acre) C-T1	Average Density (Stems/Acre) T1	Average Density (Stems/Acre) T1-T2	Average Density (Stems/Acre) T2	Average Density (Stems/Acre) Transect
Native Shrubs																			
Acacia constricta	whitethorn acacia				93.8	72.6		31		63.2		18.1		16.6	0.0	16.4	31.3	50.8	32.3
Acacia greggii	catclaw acacia							31	30.6	31.6		18.1		33.2	0.0	16.4	10.2	21.6	17.0
Baccharis sp.	baccharis													16.6	0.0	0.0	0.0	5.5	2.4
Hymenoclea sp.	burrobrush											217.4	835.9		0.0	72.5	278.6	0.0	50.9
Ericameria nauseosa	rubber rabbitbrush		367.6	200.3	140.7		177.1	403	397.7	94.8	176	253.7	92.9	182.4	240.2	285.7	210.4	92.4	211.6
Opuntia sp.	pricklypear cactus		45.9					31							15.3	10.3	0.0	0.0	6.8
Native Trees																			
Celtis laevigata	sugarberry	0-1												16.6	0.0	0.0	0.0	5.5	2.4
Prosopis velutina	velvet mesquite	0-1			93.8	48.4		31		31.6		72.5		33.2	0.0	34.5	31.3	37.7	35.2
		1-3			93.8	48.4								16.6	0.0	0.0	31.3	21.7	16.5
		3-6			93.8						176			16.6	58.7	0.0	31.3	5.5	14.3
		>6			46.9				30.6		88	18.1		16.6	29.3	6.0	25.8	5.5	14.1
Sapindus saponaria	wingleaf soapberry	0-1				24.2			30.6						0.0	0.0	10.2	8.1	6.8
		1-3				96.9									0.0	0.0	0.0	32.3	14.1
Total Stems/Acre			**413.5**	**200.3**	**562.8**	**290.5**	**177.1**	**527.0**	**489.5**	**221.2**	**440.0**	**597.9**	**928.8**	**348.4**	**343.5**	**441.7**	**660.4**	**286.7**	**424.4**
Area (Square Feet)			948	435	929	1799	246	1405	1424	1378	495	2404	469	2627					

Table B3: Reach 6.5 Woody Density Data

Species	Common Name	Basal Diameter (inches)	6.5-1			6.5-2			6.5-3			Average Density (Stems/Acre)			
			C-T1	T1	T2	C-T1	T1	T2	C-T1	T1	T2	C-T1	T1	T2	Transect
Native Shrubs															
Acacia greggii	catclaw acacia										14	0.0	0.0	4.7	2.6
Cylindropuntia sp.	cholla		33.7									11.2	0.0	0.0	1.8
Hymenoclea sp.	burrobrush		1889.5	1349.8	124.9	2473.1	352.3		1735.9		694.8	2032.8	567.4	273.2	644.7
Native Trees															
Fraxinus velutina	velvet ash	0-1				37.5						12.5	0.0	0.0	3.1
		1-3				18.7						6.2	0.0	0.0	1.6
		>6				18.7						6.2	0.0	0.0	1.6
Chilopsis linearis	desert willow	0-1				243.6						81.2	0.0	0.0	20.3
		1-3	33.7			37.5			54.2		7	41.8	0.0	2.3	7.5
		3-6				18.7					7	6.2	0.0	2.3	2.9
Prosopis velutina	velvet mesquite	0-1	33.7		7.8	18.7						17.5	0.0	2.6	5.2
		1-3		73					54.2		28.1	18.1	24.3	9.4	10.1
		3-6			15.6		7.5				14	0.0	2.5	9.9	7.7
		>6								10.3	7	0.0	3.4	2.3	2.6
Total Stems/Acre			**1990.6**	**1422.8**	**148.3**	**2866.5**	**359.8**	**0.0**	**1844.3**	**10.3**	**771.9**	**2233.8**	**597.6**	**306.7**	**711.5**
Area (Square Feet)			1291	1194	5581	2325	5812	1164	803	4243	6207				

Table B4: Reach 7 Woody Density Data

Species	Common Name	Basal Diameter (inches)	7-1				7-2				7-3				Average Density (Stems/Acre)					
			T1	T2	T2-T3	T3	C-T1	T1	T2	T2-T3	C-T1	T1	T2	T2-T3	C-T1	T1	T2	T2-T3	T3	Transect
Native Shrubs																				
Acacia greggii	catclaw acacia								17.8						0.0	0.0	5.9	0.0	0.0	3.3
Cylindropuntia sp.	cholla								8.9						0.0	0.0	3.0	0.0	0.0	1.7
Hymenoclea sp.	burrobrush		1076	212.1	3630	399.6	487.6	524	1599.5	1210	363.8		440.1		425.7	533.3	750.6	1613.3	399.6	902.8
Native Trees																				
Fraxinus velutina	velvet ash	1-3					162.5								81.3	0.0	0.0	0.0	0.0	3.3
Chilopsis linearis	desert willow	3-6	79.7												0.0	26.6	0.0	0.0	0.0	9.5
		>6						21.8				30.8			0.0	17.5	0.0	0.0	0.0	3.9
Populus fremontii	Fremont cottonwood	0-1			71.2										0.0	0.0	0.0	23.7	0.0	4.8
		3-6					81.3								40.7	0.0	0.0	0.0	0.0	1.7
		>6	39.9				568.9				45.5				307.2	13.3	0.0	0.0	0.0	18.7
Prosopis velutina	velvet mesquite	0-1		141.4										44.9	0.0	0.0	47.1	15.0	0.0	21.3
		1-3			71.2				17.8				14.2		0.0	0.0	10.7	23.7	0.0	10.4
		3-6		35.4			162.5		8.9				14.2		81.3	0.0	19.5	0.0	0.0	12.0
		>6			142.4					69.1				89.8	0.0	0.0	0.0	100.4	0.0	17.4
Total Stems/Acre			**1195.6**	**388.9**	**3914.8**	**399.6**	**1462.8**	**545.8**	**1652.9**	**1279.1**	**409.3**	**30.8**	**468.5**	**134.7**	**936.1**	**590.7**	**836.8**	**1776.2**	**399.6**	**1010.9**
Area (Square Feet)			1093	1232	612	109	536	1995	4902	1260	958	1412	3068	970						

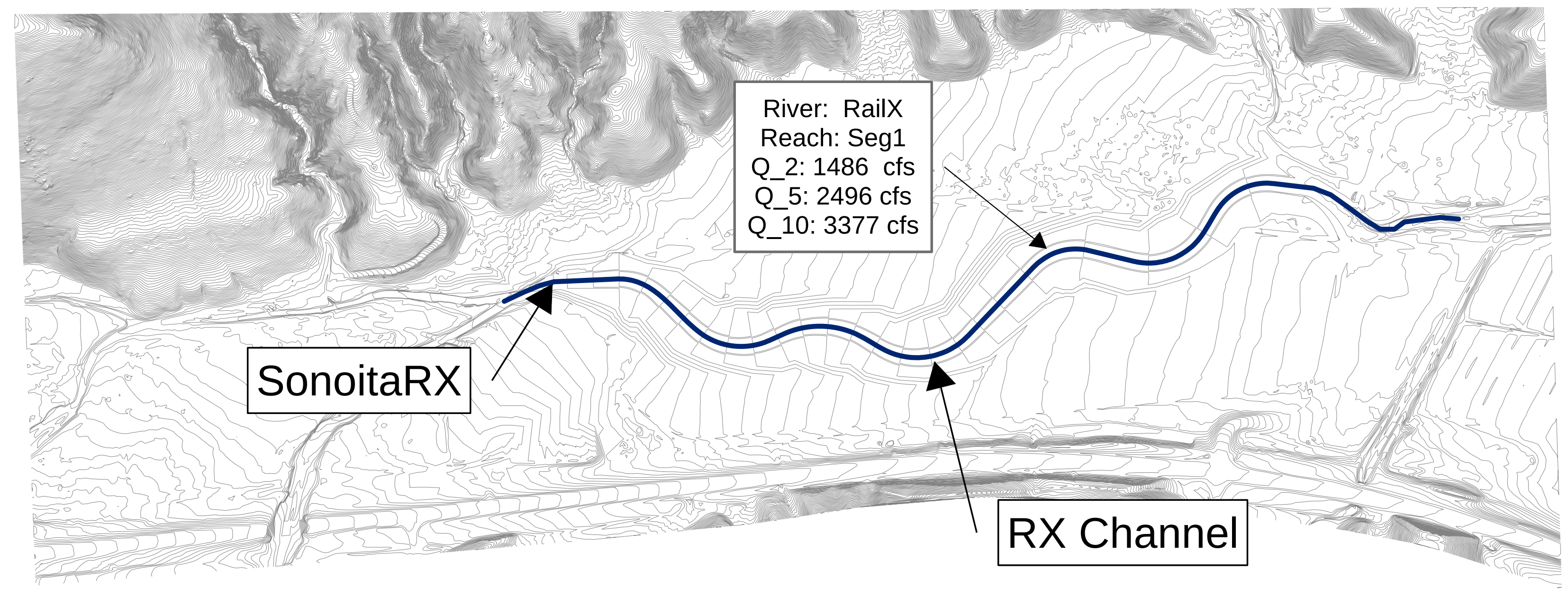
Table B5: Reach 8 Woody Density Data

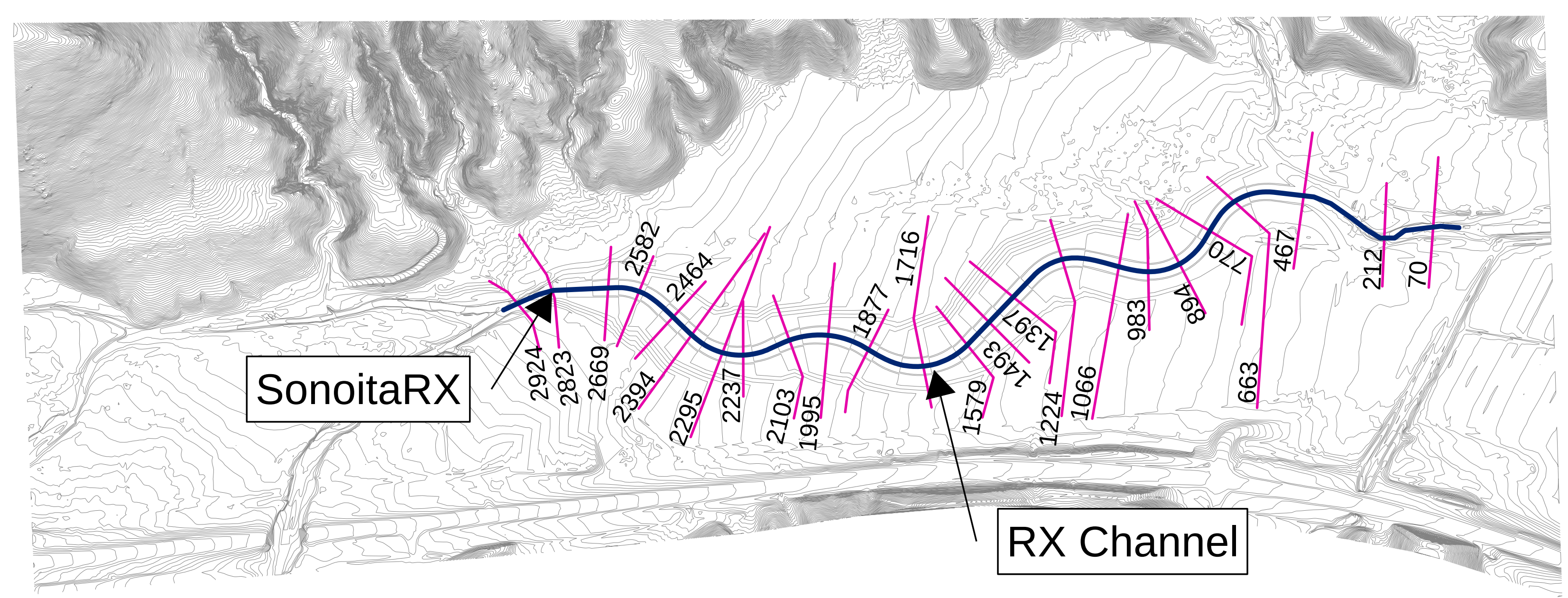
Species	Common Name	Basal Diameter (inches)	8-1 C-T1	8-1 T1	8-1 T1-T2	8-1 T2	8-1 T2-T3	8-1 T3	8-2 C-T1	8-2 T1	8-2 T1-T2	8-2 T2	8-2 T2-T3	8-3 C-T1	8-3 T1	8-3 T2	8-3 T2-T3	8-3 T3	Average Density (Stems/Acre) C-T1	T1	T1-T2	T2	T2-T3	T3	Transect
Native Shrubs																									
Acacia greggii	catclaw acacia						175.6				39.9	76.8				9.9	67	738.3	0.0	0.0	20.0	28.9	80.9	369.2	18.5
Amelanchier utahensis	Utah serviceberry	0-1				222.2													0.0	0.0	0.0	74.1	0.0	0.0	1.8
Hymenoclea sp.	burrobrush				3323.9					94.6	1135.8			4235	31		1004.5		1411.7	41.9	2229.9	0.0	334.8	0.0	320.5
Opuntia sp.	pricklypear cactus			7.3													100.4		0.0	2.4	0.0	0.0	33.5	0.0	10.2
Native Trees																									
Chilopsis linearis	desert willow	0-1												3176.3					1058.8	0.0	0.0	0.0	0.0	0.0	58.5
		1-3	211.5	87.1															70.5	29.0	0.0	0.0	0.0	0.0	25.1
		3-6	211.5	29			58.5		136.6	11.1			99.2				67		116.0	13.4	0.0	0.0	74.9	0.0	24.1
		>6	422.9	29			58.5			77.9	19.9	38.4		75.6		19.9	16.7		166.2	35.6	10.0	19.4	25.1	0.0	40.7
Fraxinus velutina	velvet ash	1-3		14.5															0.0	4.8	0.0	0.0	0.0	0.0	3.6
Populus fremontii	Fremont cottonwood	>6		21.8															0.0	7.3	0.0	0.0	0.0	0.0	5.4
Prosopis velutina	velvet mesquite	0-1									19.9								0.0	0.0	10.0	0.0	0.0	0.0	1.2
		1-3			87.5					66.8	59.8					29.8	184.2		0.0	22.3	73.7	9.9	61.4	0.0	39.1
		3-6		14.5							59.8	38.4	496.1			9.9			0.0	4.8	29.9	16.1	165.4	0.0	15.7
		>6													15.5				0.0	5.2	0.0	0.0	0.0	0.0	1.4
Total Stems/Acre			**845.9**	**203.2**	**3411.4**	**222.2**	**292.6**	**0.0**	**136.6**	**250.4**	**1335.1**	**153.6**	**595.3**	**7486.9**	**46.5**	**69.5**	**1439.8**	**738.3**	**2823.1**	**166.7**	**2373.3**	**148.4**	**775.9**	**369.2**	**565.7**
Area (Square Feet)			412	6000	498	196	744	235	638	7828	2186	1134	439	576	2811	4379	2602	59							

Appendix G

HEC-RAS Analysis

1. Rail X Channel Hydraulic Modeling Schematic (HEC-RAS)
2. RX Channel – 2-Year, 24-Hour Storm
3. RX Channel – 5-Year, 24-Hour Storm
4. RX Channel – 10-Year, 24-Hour Storm
5. Sonoita Creek Ranch (SCR) Channel Hydraulic Modeling Schematic (HEC-RAS)
6. SCR Channel – 2-Year, 24-Hour Storm
7. SCR Channel – 5-Year, 24-Hour Storm
8. SCR Channel – 10-Year, 24-Hour Storm





Water & Earth TECHNOLOGIES

LEGEND

Channel Centerlines

RX Channel Cross Section

NOT FOR CONSTRUCTION

SCALE

0 500 1,000 ft

RAILX DIVERSION
HYDRAULIC MODELING
SCHEMATIC (HEC-RAS)

DATE

09/08/17

APPENDIX G
EXHIBIT 1

HEC-RAS Plan: Plan 01 River: RailX Reach: Seg1 Profile: 2-YR

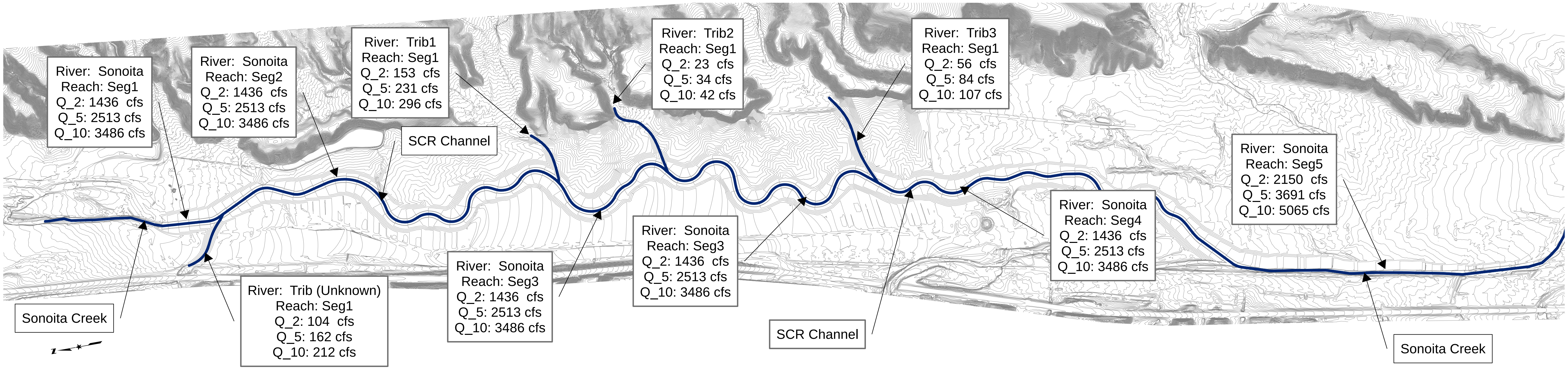
Reach	River Sta	Profile	Q Total	Frctn Slope	Vel Chnl	Top Width	Hydr Depth C	Froude # Chl	Shear Chan	Flow Area Ch
			(cfs)	(ft/ft)	(ft/s)	(ft)	(ft)		(lb/sq ft)	(sq ft)
Seg1	2924.91	2-YR	1486.00		8.89	71.78	2.58	0.97	2.01	167.13
Seg1	2823.121	2-YR	1486.00	0.013078	8.33	83.82	2.22	0.98	1.85	178.43
Seg1	2669.14	2-YR	1486.00	0.014156	6.52	142.84	1.59	0.91	1.26	227.76
Seg1	2582.536	2-YR	1486.00		6.51	168.69	1.35	0.99	1.33	228.30
Seg1	2464.922	2-YR	1486.00	0.014170	5.98	171.38	1.45	0.88	1.10	248.53
Seg1	2394.169	2-YR	1486.00	0.013799	6.61	169.79	1.32	1.01	1.38	224.95
Seg1	2295.392	2-YR	1486.00	0.013064	5.84	175.35	1.45	0.85	1.04	254.51
Seg1	2237.844	2-YR	1486.00	0.013646	6.42	166.76	1.39	0.96	1.28	231.44
Seg1	2103.553	2-YR	1486.00	0.014031	6.01	173.74	1.42	0.89	1.11	247.35
Seg1	1995.47	2-YR	1486.00	0.013036	6.51	168.42	1.36	0.99	1.33	228.32
Seg1	1877.508	2-YR	1486.00	0.012678	5.75	174.59	1.48	0.83	1.01	258.23
Seg1	1716.664	2-YR	1486.00	0.012305	6.39	168.42	1.38	0.96	1.27	232.51
Seg1	1579.711	2-YR	1486.00	0.012706	5.73	169.52	1.53	0.82	0.99	259.49
Seg1	1493.039	2-YR	1486.00		6.52	168.97	1.35	0.99	1.33	227.88
Seg1	1397.478	2-YR	1486.00	0.005629	4.72	178.48	1.76	0.63	0.64	314.56
Seg1	1224.981	2-YR	1486.00	0.005395	4.61	179.60	1.80	0.61	0.61	322.65
Seg1	1066.033	2-YR	1486.00	0.005472	4.59	180.19	1.80	0.60	0.60	323.98
Seg1	983.9642	2-YR	1486.00	0.007140	4.64	180.00	1.78	0.61	0.62	320.18
Seg1	894.6443	2-YR	1486.00	0.005081	5.53	172.63	1.56	0.78	0.92	268.67
Seg1	770.0112	2-YR	1486.00	0.003604	3.49	413.64	1.78	0.46	0.35	314.77
Seg1	663.7029	2-YR	1486.00	0.006199	4.15	190.78	1.88	0.53	0.48	358.21
Seg1	467.4075	2-YR	1486.00	0.009560	6.00	150.27	1.65	0.82	1.06	247.77
Seg1	212.4454	2-YR	1486.00	0.007914	7.24	203.34	2.47	0.81	1.35	160.14
Seg1	70.88236	2-YR	1486.00		7.81	193.33	3.34	0.75	1.43	158.26

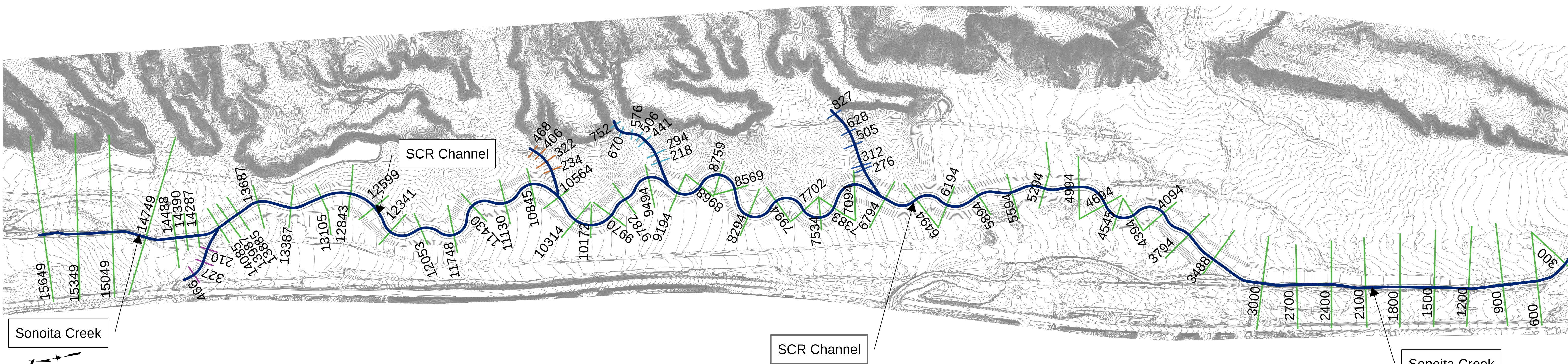
HEC-RAS Plan: Plan 01 River: RailX Reach: Seg1 Profile: 5-YR

Reach	River Sta	Profile	Q Total	Frctn Slope	Vel Chnl	Top Width	Hydr Depth C	Froude # Chl	Shear Chan	Flow Area Ch
			(cfs)	(ft/ft)	(ft/s)	(ft)	(ft)		(lb/sq ft)	(sq ft)
Seg1	2924.91	5-YR	2496.00	0.009685	9.66	163.37	3.81	0.87	2.08	246.59
Seg1	2823.121	5-YR	2496.00	0.012167	9.13	129.11	3.05	0.92	2.00	265.70
Seg1	2669.14	5-YR	2496.00	0.014381	8.02	154.65	2.01	1.00	1.77	311.22
Seg1	2582.536	5-YR	2496.00		7.63	179.65	1.82	1.00	1.65	327.04
Seg1	2464.922	5-YR	2496.00	0.014122	7.38	181.53	1.86	0.95	1.53	338.39
Seg1	2394.169	5-YR	2496.00	0.013011	7.67	181.65	1.79	1.01	1.68	325.34
Seg1	2295.392	5-YR	2496.00	0.012631	6.96	187.06	1.92	0.89	1.35	358.83
Seg1	2237.844	5-YR	2496.00		7.59	178.00	1.85	0.98	1.63	328.91
Seg1	2103.553	5-YR	2496.00	0.013847	7.26	185.80	1.85	0.94	1.49	343.72
Seg1	1995.47	5-YR	2496.00	0.013026	7.67	179.41	1.81	1.00	1.67	325.47
Seg1	1877.508	5-YR	2496.00	0.012514	7.00	186.56	1.91	0.89	1.37	356.54
Seg1	1716.664	5-YR	2496.00	0.012487	7.46	180.12	1.86	0.97	1.57	334.36
Seg1	1579.711	5-YR	2496.00	0.012623	7.09	179.96	1.96	0.89	1.40	351.91
Seg1	1493.039	5-YR	2496.00	0.008573	7.50	180.95	1.84	0.98	1.59	332.71
Seg1	1397.478	5-YR	2496.00	0.005607	5.63	192.47	2.31	0.65	0.83	443.71
Seg1	1224.981	5-YR	2496.00	0.005511	5.50	193.63	2.34	0.63	0.79	453.77
Seg1	1066.033	5-YR	2496.00	0.006053	5.55	193.65	2.32	0.64	0.81	449.47
Seg1	983.9642	5-YR	2496.00	0.007193	5.84	192.74	2.22	0.69	0.91	427.74
Seg1	894.6443	5-YR	2496.00	0.009629	6.21	271.61	2.12	0.75	1.04	387.79
Seg1	770.0112	5-YR	2496.00	0.003099	6.51	412.37	1.67	0.89	1.24	292.81
Seg1	663.7029	5-YR	2496.00	0.003039	2.58	676.39	2.08	0.31	0.18	402.72
Seg1	467.4075	5-YR	2496.00	0.009450	7.32	246.50	2.11	0.89	1.45	320.73
Seg1	212.4454	5-YR	2496.00	0.006627	8.09	282.85	3.12	0.81	1.56	202.56
Seg1	70.88236	5-YR	2496.00		7.86	358.11	4.08	0.69	1.36	202.12

HEC-RAS Plan: Plan 01 River: RailX Reach: Seg1 Profile: 10-YR

Reach	River Sta	Profile	Q Total	Frctn Slope	Vel Chnl	Top Width	Hydr Depth C	Froude # Chl	Shear Chan	Flow Area Ch
			(cfs)	(ft/ft)	(ft/s)	(ft)	(ft)		(lb/sq ft)	(sq ft)
Seg1	2924.91	10-YR	3377.00	0.006774	9.32	208.55	4.74	0.75	1.80	307.38
Seg1	2823.121	10-YR	3377.00	0.009779	9.03	225.12	3.89	0.81	1.80	340.66
Seg1	2669.14	10-YR	3377.00	0.013485	8.77	162.84	2.40	1.00	1.99	385.17
Seg1	2582.536	10-YR	3377.00	0.013605	8.27	188.20	2.17	0.99	1.83	408.31
Seg1	2464.922	10-YR	3377.00	0.013561	8.26	189.12	2.16	0.99	1.83	408.88
Seg1	2394.169	10-YR	3377.00	0.012374	8.20	191.28	2.15	0.99	1.81	411.74
Seg1	2295.392	10-YR	3377.00	0.012315	7.72	195.39	2.24	0.91	1.58	437.16
Seg1	2237.844	10-YR	3377.00	0.013611	8.26	186.74	2.19	0.98	1.82	409.05
Seg1	2103.553	10-YR	3377.00		8.23	193.06	2.12	1.00	1.83	410.09
Seg1	1995.47	10-YR	3377.00	0.012511	8.25	188.41	2.17	0.99	1.82	409.52
Seg1	1877.508	10-YR	3377.00	0.012426	7.78	195.50	2.22	0.92	1.61	434.24
Seg1	1716.664	10-YR	3377.00	0.012535	8.21	188.47	2.18	0.98	1.80	411.30
Seg1	1579.711	10-YR	3377.00	0.012661	7.94	187.77	2.26	0.93	1.67	425.18
Seg1	1493.039	10-YR	3377.00	0.007369	8.25	189.24	2.16	0.99	1.82	409.44
Seg1	1397.478	10-YR	3377.00	0.005011	5.62	393.82	2.73	0.60	0.78	550.10
Seg1	1224.981	10-YR	3377.00	0.005713	6.09	204.11	2.72	0.65	0.92	554.66
Seg1	1066.033	10-YR	3377.00	0.006440	6.28	202.57	2.65	0.68	0.99	537.70
Seg1	983.9642	10-YR	3377.00	0.007845	6.58	278.01	2.55	0.73	1.10	508.09
Seg1	894.6443	10-YR	3377.00	0.010291	7.15	274.65	2.39	0.82	1.33	444.43
Seg1	770.0112	10-YR	3377.00	0.002771	7.12	415.11	1.91	0.91	1.42	340.20
Seg1	663.7029	10-YR	3377.00	0.002706	2.70	681.34	2.50	0.30	0.19	496.12
Seg1	467.4075	10-YR	3377.00	0.009579	8.10	304.13	2.49	0.90	1.68	378.72
Seg1	212.4454	10-YR	3377.00	0.007162	8.92	282.85	3.49	0.84	1.82	226.91
Seg1	70.88236	10-YR	3377.00		8.75	358.11	4.42	0.73	1.63	218.88





LEGEND
- Channel Centerlines
- Sonoita Cross Section
- Trib (Unknown) Cross Section
- Trib1 Cross Section
- Trib2 Cross Section
- Trib3 Cross Section

Water & Earth TECHNOLOGIES

NOT FOR CONSTRUCTION

SCALE

0 850 1,700 ft

SCR CHANNEL
HYDRAULIC MODELING
SCHEMATIC (HEC-RAS)

DATE

09/08/17

APPENDIX G
EXHIBIT 2

HEC-RAS Plan: 100yr Profile: 2-YR

River	Reach	River Sta	Profile	Q Total	Frctn Slope	Vel Chnl	Top Width	Hydr Depth C	Froude # Chl	Shear Chan	Flow Area Ch
				(cfs)	(ft/ft)	(ft/s)	(ft)	(ft)		(lb/sq ft)	(sq ft)
Trib3	Seg1	827.2344	2-YR	56.00	0.010531	2.89	56.60	0.51	0.72	0.36	13.25
Trib3	Seg1	628.7606	2-YR	56.00	0.013801	3.04	29.58	0.62	0.68	0.37	18.44
Trib3	Seg1	505.9296	2-YR	56.00	0.000820	4.03	26.44	0.53	0.98	0.70	13.89
Trib3	Seg1	312.9844	2-YR	56.00	0.000184	0.80	54.64	1.29	0.12	0.02	70.38
Trib3	Seg1	276.5123	2-YR	56.00	0.005129	0.64	60.41	1.45	0.09	0.01	87.46
Trib2	Seg1	752.9471	2-YR	23.00	0.026030	3.56	17.59	0.37	1.04	0.62	6.45
Trib2	Seg1	670.196	2-YR	23.00	0.025226	3.29	20.31	0.34	0.99	0.54	6.98
Trib2	Seg1	576.9335	2-YR	23.00	0.025434	3.28	20.73	0.34	0.99	0.53	7.01
Trib2	Seg1	506.3176	2-YR	23.00	0.023410	3.29	20.70	0.34	1.00	0.54	7.00
Trib2	Seg1	441.4057	2-YR	23.00	0.023603	2.62	32.32	0.27	0.88	0.37	8.79
Trib2	Seg1	294.6573	2-YR	23.00	0.000929	3.15	23.29	0.31	0.99	0.51	7.30
Trib2	Seg1	218.6689	2-YR	23.00	0.007252	0.66	39.31	0.89	0.12	0.02	34.91
Trib1	Seg1	468.199	2-YR	153.00	0.017513	5.04	44.15	0.88	0.94	0.92	27.93
Trib1	Seg1	406.1938	2-YR	153.00	0.018370	5.03	37.21	0.82	0.98	0.94	30.44
Trib1	Seg1	322.6423	2-YR	153.00	0.002273	5.04	36.77	0.82	0.98	0.94	30.33
Trib1	Seg1	234.15	2-YR	153.00	0.006197	1.61	62.69	1.51	0.23	0.08	94.80
Trib (Unknown)	Seg1	466.2262	2-YR	104.00	0.000910	2.62	64.86	0.61	0.59	0.28	39.63
Trib (Unknown)	Seg1	327.7465	2-YR	104.00	0.000184	1.04	64.31	1.55	0.15	0.03	100.00
Trib (Unknown)	Seg1	210.0018	2-YR	104.00	0.004319	0.70	78.05	1.90	0.09	0.01	148.39
Sonoita	Seg1	15649.92	2-YR	1463.00	0.009010	8.00	50.71	3.61	0.74	1.46	182.91
Sonoita	Seg1	15349.92	2-YR	1463.00	0.009254	9.90	47.70	3.10	0.99	2.36	147.83
Sonoita	Seg1	15049.92	2-YR	1463.00	0.007459	7.26	232.66	2.95	0.74	1.28	186.65
Sonoita	Seg1	14749.92	2-YR	1463.00	0.009221	6.94	291.21	2.53	0.77	1.23	184.01
Sonoita	Seg1	14488.66	2-YR	1463.00	0.010786	5.65	179.09	1.45	0.83	0.98	258.96
Sonoita	Seg1	14390.09	2-YR	1463.00	0.010872	5.61	179.42	1.45	0.82	0.96	260.64
Sonoita	Seg1	14287.69	2-YR	1463.00	0.010835	5.68	179.12	1.44	0.83	0.99	257.72
Sonoita	Seg2	14085.41	2-YR	1463.00	0.010764	5.61	178.64	1.46	0.82	0.96	260.72
Sonoita	Seg2	13987.69	2-YR	1463.00	0.010735	5.65	179.40	1.44	0.83	0.98	258.91
Sonoita	Seg2	13885.09	2-YR	1463.00	0.011000	5.59	179.28	1.46	0.82	0.96	261.52
Sonoita	Seg2	13687.7	2-YR	1463.00	0.010759	5.75	178.58	1.43	0.85	1.02	254.63
Sonoita	Seg2	13387.76	2-YR	1463.00	0.010388	5.51	180.66	1.47	0.80	0.92	265.73
Sonoita	Seg2	13105.65	2-YR	1463.00	0.009927	5.60	180.72	1.45	0.82	0.96	261.42
Sonoita	Seg2	12843.04	2-YR	1463.00	0.009875	5.34	182.60	1.50	0.77	0.86	274.06
Sonoita	Seg2	12599.34	2-YR	1463.00	0.010231	5.59	179.68	1.46	0.82	0.96	261.66
Sonoita	Seg2	12341.8	2-YR	1463.00	0.010131	5.40	186.80	1.45	0.79	0.89	270.88
Sonoita	Seg2	12053.7	2-YR	1463.00	0.009318	5.44	189.21	1.42	0.81	0.91	268.70
Sonoita	Seg2	11748.95	2-YR	1463.00	0.008311	5.11	190.24	1.51	0.73	0.79	286.46
Sonoita	Seg2	11430.28	2-YR	1463.00	0.008595	5.13	183.89	1.55	0.73	0.79	284.98
Sonoita	Seg2	11130.41	2-YR	1463.00	0.008409	5.31	181.65	1.52	0.76	0.85	275.53
Sonoita	Seg2	10845.91	2-YR	1463.00	0.008495	5.06	184.22	1.57	0.71	0.77	288.85
Sonoita	Seg3	10564.98	2-YR	1463.00	0.008703	5.35	181.24	1.51	0.77	0.86	273.56
Sonoita	Seg3	10314.44	2-YR	1463.00	0.008334	5.14	183.62	1.55	0.73	0.79	284.46
Sonoita	Seg3	10172.97	2-YR	1463.00	0.008319	5.20	181.93	1.55	0.74	0.81	281.31
Sonoita	Seg3	9970.864	2-YR	1463.00	0.008283	5.16	181.92	1.56	0.73	0.80	283.71
Sonoita	Seg3	9782.968	2-YR	1463.00	0.008081	5.31	171.62	1.61	0.74	0.83	275.56
Sonoita	Seg3	9494.702	2-YR	1463.00	0.008038	5.07	182.89	1.58	0.71	0.77	288.50
Sonoita	Seg4	9194.717	2-YR	1463.00	0.007838	5.16	182.68	1.55	0.73	0.80	283.43
Sonoita	Seg4	8968.387	2-YR	1463.00	0.008013	5.04	178.93	1.62	0.70	0.75	290.26
Sonoita	Seg4	8759.382	2-YR	1463.00	0.008233	5.19	186.42	1.51	0.74	0.81	281.85
Sonoita	Seg4	8569.583	2-YR	1463.00	0.008127	5.12	178.53	1.60	0.71	0.78	285.47
Sonoita	Seg4	8294.718	2-YR	1463.00	0.007808	5.15	186.10	1.53	0.74	0.80	283.91
Sonoita	Seg4	7994.717	2-YR	1463.00	0.008043	4.96	182.54	1.62	0.69	0.73	294.81
Sonoita	Seg4	7702.151	2-YR	1463.00	0.008352	5.37	176.06	1.55	0.76	0.86	272.59
Sonoita	Seg4	7534.427	2-YR	1463.00	0.007807	5.00	189.28	1.55	0.71	0.75	292.68
Sonoita	Seg4	7383.796	2-YR	1463.00	0.007992	5.18	173.85	1.63	0.72	0.79	282.64
Sonoita	Seg4	7094.718	2-YR	1463.00	0.008028	5.16	181.11	1.57	0.73	0.80	283.54
Sonoita	Seg5	6794.718	2-YR	1463.00	0.008118	5.10	181.91	1.58	0.72	0.77	287.03
Sonoita	Seg5	6494.718	2-YR	1463.00	0.007978	5.13	186.66	1.53	0.73	0.79	285.03
Sonoita	Seg5	6194.717	2-YR	1463.00	0.008435	5.04	182.47	1.59	0.70	0.75	290.35
Sonoita	Seg5	5894.717	2-YR	1463.00	0.008364	5.32	185.93	1.48	0.77	0.86	274.87
Sonoita	Seg5	5594.126	2-YR	1463.00	0.008010	4.57	262.63	1.39	0.68	0.65	306.72
Sonoita	Seg5	5294.718	2-YR	1463.00	0.008314	5.21	183.33	1.53	0.74	0.82	280.87
Sonoita	Seg5	4994.718	2-YR	1463.00	0.008184	5.19	193.17	1.59	0.72	0.80	271.08
Sonoita	Seg5	4694.718	2-YR	1463.00	0.007829	5.16	182.97	1.55	0.73	0.80	283.35
Sonoita	Seg5	4545.83	2-YR	1463.00	0.008929	4.98	183.29	1.60	0.69	0.74	293.51
Sonoita	Seg5	4394.717	2-YR	1463.00	0.007615	5.66	179.74	1.44	0.83	0.98	258.60
Sonoita	Seg5	4094.718	2-YR	1463.00	0.008835	4.55	186.99	1.72	0.61	0.60	321.89
Sonoita	Seg5	3794.718	2-YR	1463.00	0.006776	6.39	175.69	1.30	0.99	1.30	228.81
Sonoita	Seg5	3488.9	2-YR	1463.00	0.005237	3.99	190.91	1.92	0.51	0.44	366.73
Sonoita	Seg5	3000	2-YR	2150.00	0.007747	5.97	161.66	2.23	0.71	0.95	360.05
Sonoita	Seg5	2700	2-YR	2150.00	0.007113	6.51	156.91	2.11	0.79	1.15	330.45
Sonoita	Seg5	2400	2-YR	2150.00	0.009808	5.43	301.14	2.17	0.65	0.79	351.13
Sonoita	Seg5	2100	2-YR	2150.00	0.003233	6.98	337.59	1.29	1.08	1.56	157.09
Sonoita	Seg5	1800	2-YR	2150.00	0.002998	2.52	490.38	2.17	0.30	0.17	314.95
Sonoita	Seg5	1500	2-YR	2150.00	0.001210	7.93	134.88	2.01	0.99	1.73	271.15
Sonoita	Seg5	1200	2-YR	2150.00	0.001209	1.39	564.78	2.04	0.17	0.05	228.52
Sonoita	Seg5	900.0001	2-YR	2150.00	0.006918	8.15	125.47	2.10	0.99	1.80	263.93
Sonoita	Seg5	600	2-YR	2150.00	0.005979	4.17	461.34	1.90	0.53	0.49	208.76
Sonoita	Seg5	300	2-YR	2150.00		7.86	351.46	2.69	0.84	1.55	185.53

HEC-RAS Plan: 100yr Profile: 5-YR

River	Reach	River Sta	Profile	Q Total	Frctn Slope	Vel Chnl	Top Width	Hydr Depth C	Froude # Chl	Shear Chan	Flow Area Ch
				(cfs)	(ft/ft)	(ft/s)	(ft)	(ft)		(lb/sq ft)	(sq ft)
Trib3	Seg1	827.2344	5-YR	84.00	0.014243	4.05	57.04	0.53	0.98	0.70	13.98
Trib3	Seg1	628.7606	5-YR	84.00	0.013799	3.46	33.27	0.73	0.71	0.46	24.27
Trib3	Seg1	505.9296	5-YR	84.00	0.000475	4.40	30.13	0.63	0.97	0.78	19.10
Trib3	Seg1	312.9844	5-YR	84.00	0.000110	0.71	70.19	1.69	0.10	0.01	118.50
Trib3	Seg1	276.5123	5-YR	84.00	0.004847	0.60	75.90	1.85	0.08	0.01	140.14
Trib2	Seg1	752.9471	5-YR	34.00	0.023984	3.79	19.29	0.46	0.98	0.64	8.97
Trib2	Seg1	670.196	5-YR	34.00	0.024617	3.74	22.26	0.41	1.03	0.66	9.08
Trib2	Seg1	576.9335	5-YR	34.00	0.023645	3.59	23.01	0.41	0.99	0.60	9.46
Trib2	Seg1	506.3176	5-YR	34.00	0.021891	3.60	23.03	0.41	0.99	0.61	9.43
Trib2	Seg1	441.4057	5-YR	34.00	0.023226	2.77	50.38	0.31	0.87	0.39	11.80
Trib2	Seg1	294.6573	5-YR	34.00	0.000373	3.58	25.68	0.37	1.04	0.62	9.49
Trib2	Seg1	218.6689	5-YR	34.00	0.006520	0.51	53.28	1.26	0.08	0.01	67.10
Trib1	Seg1	468.199	5-YR	231.00	0.017540	5.69	47.57	1.06	0.97	1.10	36.03
Trib1	Seg1	406.1938	5-YR	231.00	0.017451	5.61	42.67	0.96	1.01	1.11	41.15
Trib1	Seg1	322.6423	5-YR	231.00	0.001625	5.40	43.24	0.99	0.96	1.02	42.74
Trib1	Seg1	234.15	5-YR	231.00	0.005862	1.56	77.95	1.91	0.20	0.07	148.54
Trib (Unknown)	Seg1	466.2262	5-YR	162.00	0.000430	1.67	76.11	1.30	0.26	0.09	96.53
Trib (Unknown)	Seg1	327.7465	5-YR	162.00	0.000142	1.01	80.98	1.98	0.13	0.03	160.66
Trib (Unknown)	Seg1	210.0018	5-YR	162.00	0.004302	0.73	94.88	2.33	0.08	0.01	220.93
Sonoita	Seg1	15649.92	5-YR	2513.00	0.005510	11.39	53.94	4.09	0.99	2.85	220.66
Sonoita	Seg1	15349.92	5-YR	2513.00	0.004216	5.23	397.32	3.31	0.51	0.64	233.93
Sonoita	Seg1	15049.92	5-YR	2513.00	0.005910	7.71	377.19	3.74	0.70	1.33	238.51
Sonoita	Seg1	14749.92	5-YR	2513.00	0.007934	7.20	447.16	3.27	0.70	1.21	237.98
Sonoita	Seg1	14488.66	5-YR	2513.00	0.010794	6.84	190.82	1.93	0.87	1.30	367.42
Sonoita	Seg1	14390.09	5-YR	2513.00	0.010851	6.80	191.21	1.93	0.86	1.29	369.77
Sonoita	Seg1	14287.69	5-YR	2513.00	0.010826	6.86	190.87	1.92	0.87	1.31	366.29
Sonoita	Seg2	14085.41	5-YR	2513.00	0.010794	6.80	190.57	1.94	0.86	1.28	369.78
Sonoita	Seg2	13987.69	5-YR	2513.00	0.010748	6.84	191.22	1.92	0.87	1.31	367.22
Sonoita	Seg2	13885.09	5-YR	2513.00	0.010974	6.77	191.22	1.94	0.86	1.27	371.24
Sonoita	Seg2	13687.7	5-YR	2513.00	0.010756	6.95	190.11	1.90	0.89	1.35	361.74
Sonoita	Seg2	13387.76	5-YR	2513.00	0.010382	6.66	193.61	1.95	0.84	1.23	377.48
Sonoita	Seg2	13105.65	5-YR	2513.00	0.009885	6.76	193.00	1.93	0.86	1.27	371.91
Sonoita	Seg2	12843.04	5-YR	2513.00	0.009849	6.45	195.11	2.00	0.80	1.15	389.70
Sonoita	Seg2	12599.34	5-YR	2513.00	0.010264	6.76	191.46	1.94	0.86	1.27	371.57
Sonoita	Seg2	12341.8	5-YR	2513.00	0.010157	6.52	201.52	1.91	0.83	1.19	385.29
Sonoita	Seg2	12053.7	5-YR	2513.00	0.009231	6.60	200.49	1.90	0.84	1.22	380.88
Sonoita	Seg2	11748.95	5-YR	2513.00	0.008273	6.11	206.61	1.99	0.76	1.03	411.40
Sonoita	Seg2	11430.28	5-YR	2513.00	0.008579	6.19	198.56	2.04	0.76	1.05	405.91
Sonoita	Seg2	11130.41	5-YR	2513.00	0.008370	6.40	194.37	2.02	0.79	1.12	392.76
Sonoita	Seg2	10845.91	5-YR	2513.00	0.008495	6.11	197.99	2.08	0.75	1.01	411.34
Sonoita	Seg3	10564.98	5-YR	2513.00	0.008689	6.47	193.48	2.01	0.80	1.15	388.46
Sonoita	Seg3	10314.44	5-YR	2513.00	0.008337	6.21	196.61	2.06	0.76	1.05	404.86
Sonoita	Seg3	10172.97	5-YR	2513.00	0.008233	6.30	194.42	2.05	0.77	1.08	399.18
Sonoita	Seg3	9970.864	5-YR	2513.00	0.008192	6.18	194.83	2.09	0.75	1.04	406.41
Sonoita	Seg3	9782.968	5-YR	2513.00	0.008214	6.38	186.39	2.11	0.77	1.10	393.70
Sonoita	Seg3	9494.702	5-YR	2513.00	0.007985	6.18	196.04	2.07	0.76	1.04	406.75
Sonoita	Seg4	9194.717	5-YR	2513.00	0.007878	6.13	197.36	2.08	0.75	1.02	409.71
Sonoita	Seg4	8968.387	5-YR	2513.00	0.008088	6.12	196.68	2.09	0.75	1.02	410.57
Sonoita	Seg4	8759.382	5-YR	2513.00	0.008155	6.18	201.95	2.01	0.77	1.05	406.92
Sonoita	Seg4	8569.583	5-YR	2513.00	0.008210	6.23	190.40	2.12	0.75	1.05	403.38
Sonoita	Seg4	8294.718	5-YR	2513.00	0.007729	6.20	201.77	2.01	0.77	1.06	405.11
Sonoita	Seg4	7994.717	5-YR	2513.00	0.008083	5.92	197.73	2.15	0.71	0.94	424.15
Sonoita	Seg4	7702.151	5-YR	2513.00	0.008258	6.47	194.71	1.99	0.81	1.16	388.16
Sonoita	Seg4	7534.427	5-YR	2513.00	0.007653	5.90	206.07	2.07	0.72	0.95	426.00
Sonoita	Seg4	7383.796	5-YR	2513.00	0.008056	6.27	187.35	2.14	0.76	1.06	400.85
Sonoita	Seg4	7094.718	5-YR	2513.00	0.008000	6.23	193.74	2.08	0.76	1.06	403.15
Sonoita	Seg5	6794.718	5-YR	2513.00	0.008196	6.15	194.37	2.10	0.75	1.02	408.48
Sonoita	Seg5	6494.718	5-YR	2513.00	0.007758	6.22	202.28	2.00	0.78	1.07	404.09
Sonoita	Seg5	6194.717	5-YR	2513.00	0.008674	5.93	197.14	2.15	0.71	0.94	424.09
Sonoita	Seg5	5894.717	5-YR	2513.00	0.008484	6.68	202.51	1.86	0.86	1.26	375.93
Sonoita	Seg5	5594.126	5-YR	2513.00	0.007599	5.39	271.04	1.92	0.69	0.81	436.06
Sonoita	Seg5	5294.718	5-YR	2513.00	0.008360	6.29	197.01	2.03	0.78	1.08	399.81
Sonoita	Seg5	4994.718	5-YR	2513.00	0.008120	6.34	201.23	2.14	0.76	1.08	375.94
Sonoita	Seg5	4694.718	5-YR	2513.00	0.007917	6.18	196.67	2.07	0.76	1.04	406.62
Sonoita	Seg5	4545.83	5-YR	2513.00	0.008847	6.11	196.36	2.10	0.74	1.01	411.61
Sonoita	Seg5	4394.717	5-YR	2513.00	0.007624	6.65	194.58	1.94	0.84	1.23	377.75
Sonoita	Seg5	4094.718	5-YR	2513.00	0.008828	5.60	199.08	2.25	0.66	0.83	448.81
Sonoita	Seg5	3794.718	5-YR	2513.00		7.52	187.26	1.78	0.99	1.62	334.26
Sonoita	Seg5	3488.9	5-YR	2513.00	0.004815	4.59	209.05	2.62	0.50	0.53	546.98
Sonoita	Seg5	3000	5-YR	3691.00	0.007848	7.11	173.74	2.99	0.73	1.22	518.99
Sonoita	Seg5	2700	5-YR	3691.00	0.007945	8.07	166.42	2.75	0.86	1.61	457.54
Sonoita	Seg5	2400	5-YR	3691.00	0.010166	6.82	409.58	2.75	0.72	1.15	454.34
Sonoita	Seg5	2100	5-YR	3691.00	0.007414	8.24	388.79	1.84	1.07	1.93	225.68
Sonoita	Seg5	1800	5-YR	3691.00	0.002102	4.47	490.02	2.11	0.54	0.54	306.16
Sonoita	Seg5	1500	5-YR	3691.00	0.001248	2.69	532.79	2.39	0.31	0.19	338.38
Sonoita	Seg5	1200	5-YR	3691.00	0.003187	2.38	564.78	2.04	0.29	0.15	228.52
Sonoita	Seg5	900.0001	5-YR	3691.00	0.010385	10.46	386.90	2.22	1.24	2.91	284.10
Sonoita	Seg5	600	5-YR	3691.00	0.007733	5.70	462.15	2.25	0.67	0.86	247.92
Sonoita	Seg5	300	5-YR	3691.00		8.19	847.41	2.72	0.87	1.67	194.92

HEC-RAS Plan: 100yr Profile: 10-YR

River	Reach	River Sta	Profile	Q Total	Frctn Slope	Vel Chnl	Top Width	Hydr Depth C	Froude # Chl	Shear Chan	Flow Area Ch
				(cfs)	(ft/ft)	(ft/s)	(ft)	(ft)		(lb/sq ft)	(sq ft)
Trib3	Seg1	827.2344	10-YR	107.00	0.015568	3.56	59.90	0.67	0.77	0.50	18.90
Trib3	Seg1	628.7606	10-YR	107.00	0.008202	4.80	32.08	0.70	1.01	0.90	22.31
Trib3	Seg1	505.9296	10-YR	107.00	0.000286	2.71	41.56	0.95	0.49	0.26	39.55
Trib3	Seg1	312.9844	10-YR	107.00	0.000077	0.65	82.33	2.00	0.08	0.01	164.42
Trib3	Seg1	276.5123	10-YR	107.00	0.004682	0.56	87.97	2.15	0.07	0.01	189.51
Trib2	Seg1	752.9471	10-YR	42.00	0.008945	4.08	20.13	0.51	1.00	0.72	10.30
Trib2	Seg1	670.196	10-YR	42.00	0.008882	1.76	51.51	0.47	0.45	0.14	11.16
Trib2	Seg1	576.9335	10-YR	42.00	0.002418	3.75	24.50	0.46	0.98	0.63	11.20
Trib2	Seg1	506.3176	10-YR	42.00	0.002513	0.74	46.38	0.46	0.19	0.02	11.21
Trib2	Seg1	441.4057	10-YR	42.00	0.005263	3.32	51.54	0.32	1.04	0.56	12.13
Trib2	Seg1	294.6573	10-YR	42.00	0.000162	1.52	40.22	0.69	0.32	0.09	27.57
Trib2	Seg1	218.6689	10-YR	42.00	0.006094	0.42	64.60	1.55	0.06	0.01	100.29
Trib1	Seg1	468.199	10-YR	296.00	0.017276	6.14	49.93	1.18	1.00	1.24	41.98
Trib1	Seg1	406.1938	10-YR	296.00	0.009057	5.90	46.79	1.07	1.00	1.18	50.19
Trib1	Seg1	322.6423	10-YR	296.00	0.001059	3.75	60.65	1.30	0.58	0.45	79.03
Trib1	Seg1	234.15	10-YR	296.00	0.005590	1.50	89.72	2.21	0.18	0.06	197.94
Trib (Unknown)	Seg1	466.2262	10-YR	212.00	0.000251	1.47	84.56	1.78	0.19	0.06	142.93
Trib (Unknown)	Seg1	327.7465	10-YR	212.00	0.000104	0.91	137.67	2.44	0.10	0.02	212.88
Trib (Unknown)	Seg1	210.0018	10-YR	212.00	0.004156	0.73	142.79	2.69	0.08	0.01	283.64
Sonoita	Seg1	15649.92	10-YR	3486.00	0.007630	11.94	92.36	5.06	0.94	2.92	290.62
Sonoita	Seg1	15349.92	10-YR	3486.00	0.006129	7.26	397.32	3.31	0.70	1.24	233.93
Sonoita	Seg1	15049.92	10-YR	3486.00	0.006470	8.48	433.47	4.16	0.73	1.56	265.15
Sonoita	Seg1	14749.92	10-YR	3486.00	0.008544	8.17	471.60	3.58	0.76	1.52	260.44
Sonoita	Seg1	14488.66	10-YR	3486.00	0.010836	7.65	199.86	2.28	0.89	1.54	455.74
Sonoita	Seg1	14390.09	10-YR	3486.00	0.010840	7.63	200.14	2.28	0.89	1.53	457.00
Sonoita	Seg1	14287.69	10-YR	3486.00	0.010807	7.65	200.06	2.28	0.89	1.54	455.82
Sonoita	Seg2	14085.41	10-YR	3486.00	0.010810	7.62	199.56	2.29	0.89	1.53	457.32
Sonoita	Seg2	13987.69	10-YR	3486.00	0.010710	7.64	200.39	2.28	0.89	1.54	456.04
Sonoita	Seg2	13885.09	10-YR	3486.00	0.010958	7.57	200.42	2.30	0.88	1.51	460.64
Sonoita	Seg2	13687.7	10-YR	3486.00	0.010732	7.77	198.95	2.25	0.91	1.60	448.46
Sonoita	Seg2	13387.76	10-YR	3486.00	0.010386	7.43	203.62	2.30	0.86	1.45	469.23
Sonoita	Seg2	13105.65	10-YR	3486.00	0.009828	7.57	202.32	2.28	0.88	1.51	460.61
Sonoita	Seg2	12843.04	10-YR	3486.00	0.009843	7.17	204.94	2.37	0.82	1.34	485.90
Sonoita	Seg2	12599.34	10-YR	3486.00	0.010288	7.61	200.27	2.29	0.89	1.52	458.31
Sonoita	Seg2	12341.8	10-YR	3486.00	0.010147	7.25	213.25	2.26	0.85	1.39	481.09
Sonoita	Seg2	12053.7	10-YR	3486.00	0.009204	7.42	208.93	2.25	0.87	1.46	470.04
Sonoita	Seg2	11748.95	10-YR	3486.00	0.008211	6.77	219.39	2.35	0.78	1.20	514.83
Sonoita	Seg2	11430.28	10-YR	3486.00	0.008549	6.90	209.99	2.41	0.78	1.23	505.45
Sonoita	Seg2	11130.41	10-YR	3486.00	0.008353	7.14	204.14	2.39	0.81	1.32	488.21
Sonoita	Seg2	10845.91	10-YR	3486.00	0.008482	6.82	208.70	2.45	0.77	1.20	511.13
Sonoita	Seg3	10564.98	10-YR	3486.00	0.008649	7.23	202.94	2.38	0.83	1.36	482.44
Sonoita	Seg3	10314.44	10-YR	3486.00	0.008316	6.92	206.63	2.44	0.78	1.24	503.40
Sonoita	Seg3	10172.97	10-YR	3486.00	0.008163	7.04	204.13	2.43	0.80	1.28	495.32
Sonoita	Seg3	9970.864	10-YR	3486.00	0.008155	6.87	204.84	2.48	0.77	1.21	507.20
Sonoita	Seg3	9782.968	10-YR	3486.00	0.008276	7.13	197.60	2.48	0.80	1.30	489.23
Sonoita	Seg3	9494.702	10-YR	3486.00	0.007941	6.92	206.13	2.45	0.78	1.23	504.06
Sonoita	Seg4	9194.717	10-YR	3486.00	0.007912	6.80	208.54	2.46	0.76	1.19	512.37
Sonoita	Seg4	8968.387	10-YR	3486.00	0.008054	6.85	209.63	2.43	0.78	1.21	508.57
Sonoita	Seg4	8759.382	10-YR	3486.00	0.008090	6.83	212.39	2.40	0.78	1.21	510.64
Sonoita	Seg4	8569.583	10-YR	3486.00	0.008220	7.01	199.32	2.49	0.78	1.26	497.20
Sonoita	Seg4	8294.718	10-YR	3486.00	0.007659	6.87	214.09	2.37	0.79	1.23	507.35
Sonoita	Seg4	7994.717	10-YR	3486.00	0.008121	6.60	208.78	2.53	0.73	1.11	527.86
Sonoita	Seg4	7702.151	10-YR	3486.00	0.008111	7.23	206.98	2.33	0.83	1.37	482.25
Sonoita	Seg4	7534.427	10-YR	3486.00	0.007541	6.48	218.83	2.46	0.73	1.08	538.19
Sonoita	Seg4	7383.796	10-YR	3486.00	0.008102	7.03	197.77	2.51	0.78	1.26	496.00
Sonoita	Seg4	7094.718	10-YR	3486.00	0.008026	6.96	203.50	2.46	0.78	1.24	501.20
Sonoita	Seg5	6794.718	10-YR	3486.00	0.008252	6.91	203.79	2.48	0.77	1.22	504.82
Sonoita	Seg5	6494.718	10-YR	3486.00	0.007595	6.93	214.08	2.35	0.80	1.25	502.83
Sonoita	Seg5	6194.717	10-YR	3486.00	0.008843	6.53	208.27	2.56	0.72	1.08	534.17
Sonoita	Seg5	5894.717	10-YR	3486.00	0.008503	7.66	214.99	2.12	0.93	1.59	455.03
Sonoita	Seg5	5594.126	10-YR	3486.00	0.007327	5.94	277.59	2.34	0.68	0.92	542.51
Sonoita	Seg5	5294.718	10-YR	3486.00	0.008359	7.02	207.50	2.39	0.80	1.28	496.50
Sonoita	Seg5	4994.718	10-YR	3486.00	0.008085	7.12	207.54	2.55	0.79	1.29	460.53
Sonoita	Seg5	4694.718	10-YR	3486.00	0.008011	6.89	207.07	2.44	0.78	1.22	506.18
Sonoita	Seg5	4545.83	10-YR	3486.00	0.008784	6.89	206.20	2.46	0.77	1.22	506.25
Sonoita	Seg5	4394.717	10-YR	3486.00	0.007651	7.31	205.71	2.32	0.85	1.40	476.98
Sonoita	Seg5	4094.718	10-YR	3486.00	0.008796	6.35	208.28	2.64	0.69	1.01	548.83
Sonoita	Seg5	3794.718	10-YR	3486.00		8.21	196.62	2.16	0.99	1.81	424.42
Sonoita	Seg5	3488.9	10-YR	3486.00	0.004880	4.84	225.07	3.20	0.48	0.55	719.93
Sonoita	Seg5	3000	10-YR	5065.00	0.008160	8.48	179.14	3.33	0.82	1.67	597.22
Sonoita	Seg5	2700	10-YR	5065.00	0.008644	8.48	369.97	3.30	0.82	1.68	566.24
Sonoita	Seg5	2400	10-YR	5065.00	0.009691	8.33	410.76	2.97	0.85	1.68	490.65
Sonoita	Seg5	2100	10-YR	5065.00	0.008914	7.85	454.65	2.50	0.88	1.58	308.68
Sonoita	Seg5	1800	10-YR	5065.00	0.003957	6.13	490.02	2.11	0.74	1.02	306.16
Sonoita	Seg5	1500	10-YR	5065.00	0.001461	3.69	532.79	2.39	0.42	0.35	338.38
Sonoita	Seg5	1200	10-YR	5065.00	0.002940	2.63	567.41	2.80	0.28	0.17	320.37
Sonoita	Seg5	900.0001	10-YR	5065.00		14.35	386.90	2.22	1.70	5.48	284.10
Sonoita	Seg5	600	10-YR	5065.00	0.008064	6.82	462.71	2.51	0.76	1.19	276.11
Sonoita	Seg5	300	10-YR	5065.00		8.23	903.54	3.09	0.83	1.62	221.19

Appendix H

Laboratory Analysis

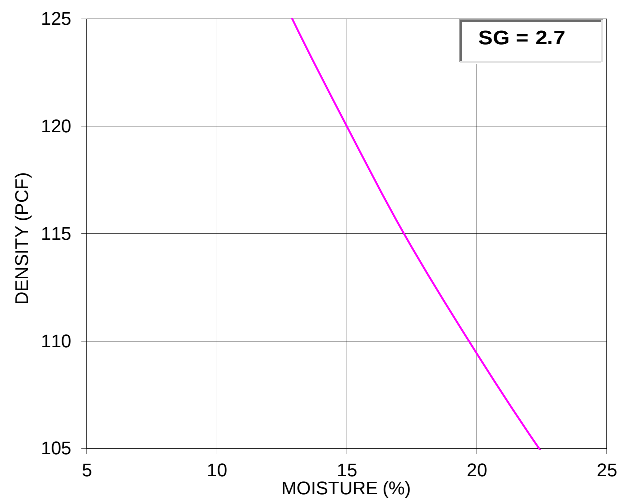
1. Sample #2 Sieve Analysis
2. Sample #6 Fines Sieve Analysis
3. Sample #6 Medium Sieve Analysis
4. Sample #6.5 Sieve Analysis
5. Sample #8 Sieve Analysis
6. Figure B-1 Sample #2 Sieve Analysis and Hydrometer
7. Figure B-2 Sample #8 Sieve Analysis and Hydrometer

SAMPLE INFORMATION:

LOCATION: SAMPLE # 2
DEPTH (FT): --
LAB TECHNICIAN: HJG

MECHANICAL SIEVE ANALYSIS		METHOD: ASTM C136	
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76		
1.5"	38		
1.25"	31.5		
1"	25	100	
3/4"	19	96	
1/2"	12.5	89	
3/8"	9.5	83	
1/4"	6.4	72	
No. 4	4.8	64	
No. 8	2.36	57	
No. 10	2.00	50	
No. 16	1.18	36	
No. 30	0.60	23	
No. 40	0.425	16	
No. 50	0.3	10	
No. 100	0.15	4	
No. 200	0.075	3.6	

PROCTOR[1]	METHOD: ASTM D 698 C
MAXIMUM DRY DENSITY (PCF)	NOT TESTED
OPTIMUM MOISTURE CONTENT (%)	NOT TESTED
ROCK CONTENT (%)[2]	



ATTERBERG LIMITS	METHOD: ASTM D4318	
	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON 3/4 INCH SCREEN

*INDICATES OUT OF TOLERANCE

Ninyo & Moore		SOILS/AGGREGATE DATA SHEET	LAB NO.
PROJECT NO.	DATE SAMPLED	WATER & EARTH TECHNOLOGIES/LABORATORY TESTING TUCSON, ARIZONA	34449
604789001	6/2/2015		

SAMPLE INFORMATION:

LOCATION: SAMPLE # 6 FINES
DEPTH (FT): --
LAB TECHNICIAN: HJG

MECHANICAL SIEVE ANALYSIS — METHOD: ASTM C136

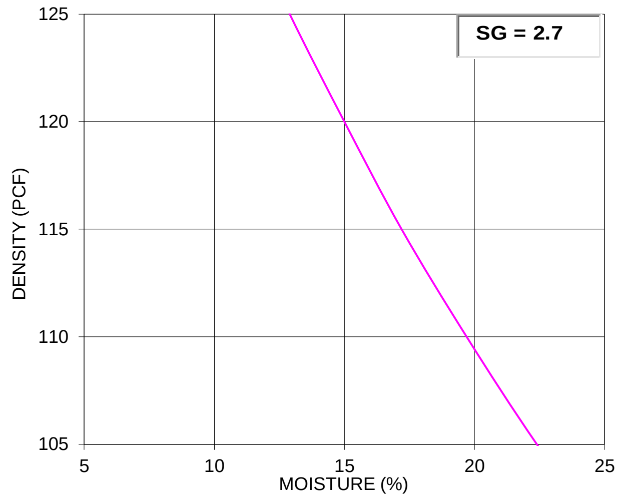
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76	100	
1.5"	38	97	
1.25"	31.5	96	
1"	25	95	
3/4"	19	93	
1/2"	12.5	90	
3/8"	9.5	86	
1/4"	6.4	77	
No. 4	4.8	71	
No. 8	2.36	62	
No. 10	2.00	61	
No. 16	1.18	43	
No. 30	0.60	24	
No. 40	0.425	15	
No. 50	0.3	8	
No. 100	0.15	2	
No. 200	0.075	1.1	

ATTERBERG LIMITS — ASTM D4318

	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

PROCTOR[1] — METHOD: ASTM D 698 C

MAXIMUM DRY DENSITY (PCF)	NOT TESTED
OPTIMUM MOISTURE CONTENT (%)	NOT TESTED
ROCK CONTENT (%)[2]	



REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON 3/4 INCH SCREEN

*INDICATES OUT OF TOLERANCE

Ninyo & Moore	SOILS/AGGREGATE DATA SHEET	LAB NO.
PROJECT NO. 604789001 / DATE SAMPLED 6/2/2015	WATER & EARTH TECHNOLOGIES/LABORATORY TESTING TUCSON, ARIZONA	34455

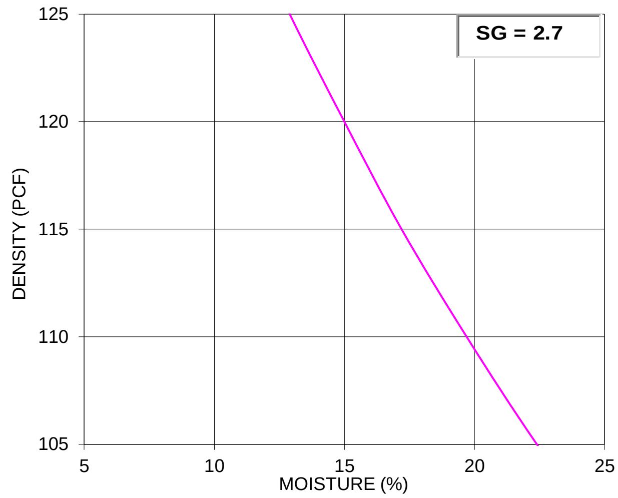
SAMPLE INFORMATION:

LOCATION: SAMPLE # 6 MEDIUM
DEPTH (FT): --
LAB TECHNICIAN: HJG

MECHANICAL SIEVE ANALYSIS		METHOD ASTM C136	
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76		
1.5"	38	100	
1.25"	31.5	95	
1"	25	93	
3/4"	19	86	
1/2"	12.5	75	
3/8"	9.5	68	
1/4"	6.4	57	
No. 4	4.8	53	
No. 8	2.36	48	
No. 10	2.00	41	
No. 16	1.18	31	
No. 30	0.60	20	
No. 40	0.425	15	
No. 50	0.3	10	
No. 100	0.15	4	
No. 200	0.075	1.9	

ATTERBERG LIMITS	ASTM D4318	
	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

PROCTOR[1]	METHOD ASTM D 698 C
MAXIMUM DRY DENSITY (PCF)	NOT TESTED
OPTIMUM MOISTURE CONTENT (%)	NOT TESTED
ROCK CONTENT (%)[2]	



REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON 3/4 INCH SCREEN

*INDICATES OUT OF TOLERANCE

Ninyo & Moore	SOILS/AGGREGATE DATA SHEET	LAB NO.
PROJECT NO. 604789001 / DATE SAMPLED 6/2/2015	WATER & EARTH TECHNOLOGIES/LABORATORY TESTING TUCSON, ARIZONA	34452

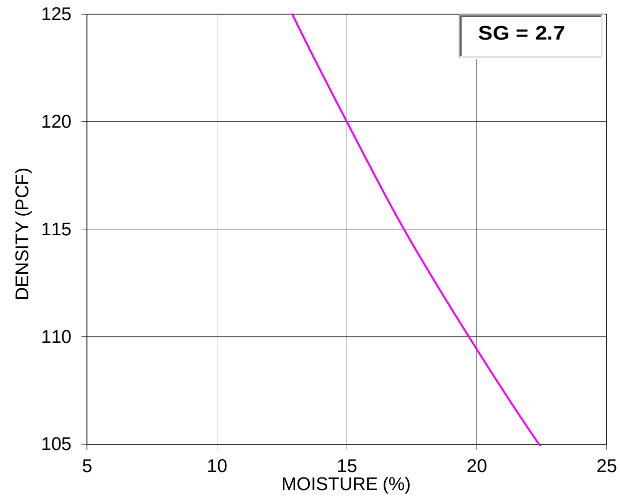
SAMPLE INFORMATION:

LOCATION: SAMPLE # 6.5
DEPTH (FT): --
LAB TECHNICIAN: HJG

MECHANICAL SIEVE ANALYSIS		METHOD ASTM C136	
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76		
1.5"	38	100	
1.25"	31.5	88	
1"	25	87	
3/4"	19	85	
1/2"	12.5	79	
3/8"	9.5	73	
1/4"	6.4	61	
No. 4	4.8	54	
No. 8	2.36	45	
No. 10	2.00	37	
No. 16	1.18	23	
No. 30	0.60	14	
No. 40	0.425	10	
No. 50	0.3	7	
No. 100	0.15	3	
No. 200	0.075	1.3	

ATTERBERG LIMITS	ASTM D4318	
	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

PROCTOR[1]	METHOD ASTM D 698 C
MAXIMUM DRY DENSITY (PCF)	NOT TESTED
OPTIMUM MOISTURE CONTENT (%)	NOT TESTED
ROCK CONTENT (%)[2]	



REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON 3/4 INCH SCREEN

*INDICATES OUT OF TOLERANCE

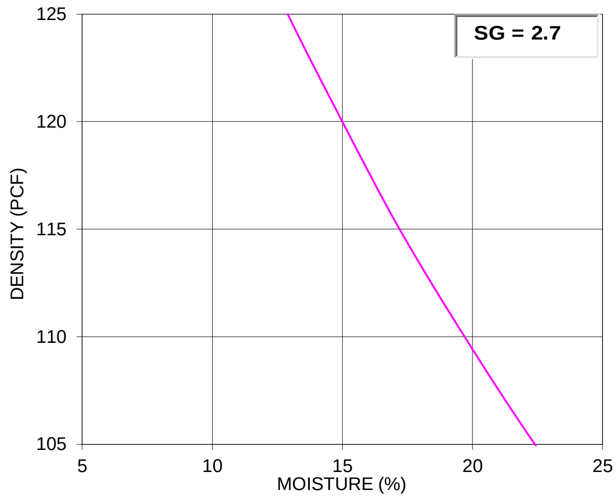
Ninyo & Moore	SOILS/AGGREGATE DATA SHEET	LAB NO.
PROJECT NO. / DATE SAMPLED	WATER & EARTH TECHNOLOGIES/LABORATORY TESTING TUCSON, ARIZONA	34451
604789001 / 6/2/2015		

SAMPLE INFORMATION:

LOCATION: SAMPLE # 8
DEPTH (FT): --
LAB TECHNICIAN: HJG

MECHANICAL SIEVE ANALYSIS		METHOD ASTM C136	
SIEVE SIZE		% PASSING	
US STD	METRIC	RESULTS	SPEC
3"	76		
1.5"	38		
1.25"	31.5		
1"	25	100	
3/4"	19	99	
1/2"	12.5	96	
3/8"	9.5	94	
1/4"	6.4	88	
No. 4	4.8	82	
No. 8	2.36	78	
No. 10	2.00	68	
No. 16	1.18	47	
No. 30	0.60	30	
No. 40	0.425	21	
No. 50	0.3	14	
No. 100	0.15	7	
No. 200	0.075	3.6	

PROCTOR[1]	METHOD ASTM D 698 C
MAXIMUM DRY DENSITY (PCF)	NOT TESTED
OPTIMUM MOISTURE CONTENT (%)	NOT TESTED
ROCK CONTENT (%)[2]	

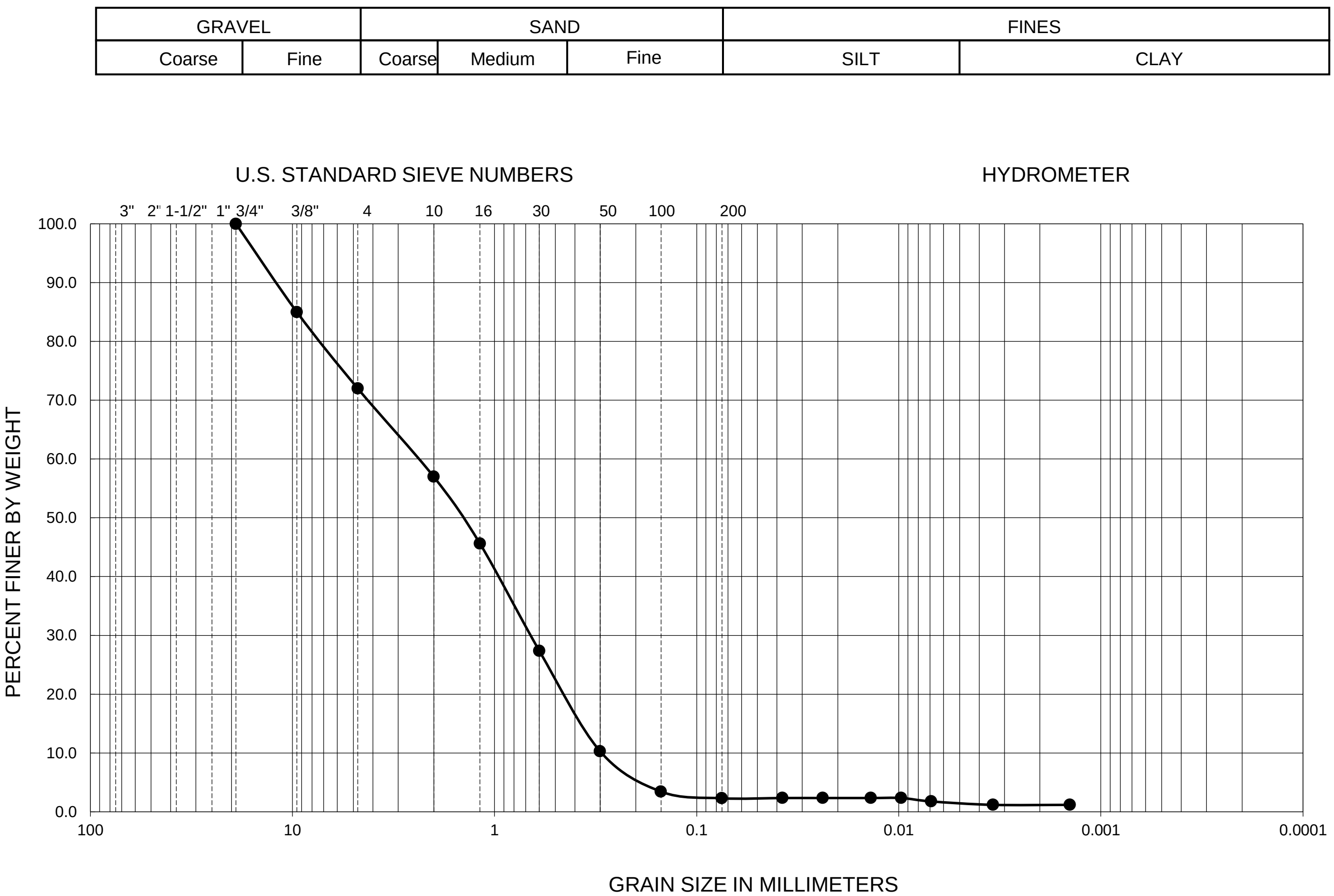


ATTERBERG LIMITS	ASTM D4318	
	RESULTS	SPEC
LIQUID LIMIT (LL) (%)	--	
PLASTIC LIMIT (PL) (%)	--	
PLASTICITY INDEX (PI) (%)	NOT TESTED	

REMARKS: [1] MAXIMUM DENSITY AND OPTIMUM MOISTURE WERE NOT CORRECTED FOR ROCK CONTENT
[2] ROCK CONTENT CALCULATED FROM MATERIAL RETAINED ON 3/4 INCH SCREEN

*INDICATES OUT OF TOLERANCE

Ninyo & Moore	SOILS/AGGREGATE DATA SHEET		LAB NO.
PROJECT NO.	DATE SAMPLED	WATER & EARTH TECHNOLOGIES/LABORATORY TESTING TUCSON, ARIZONA	34453
604789001	6/2/2015		

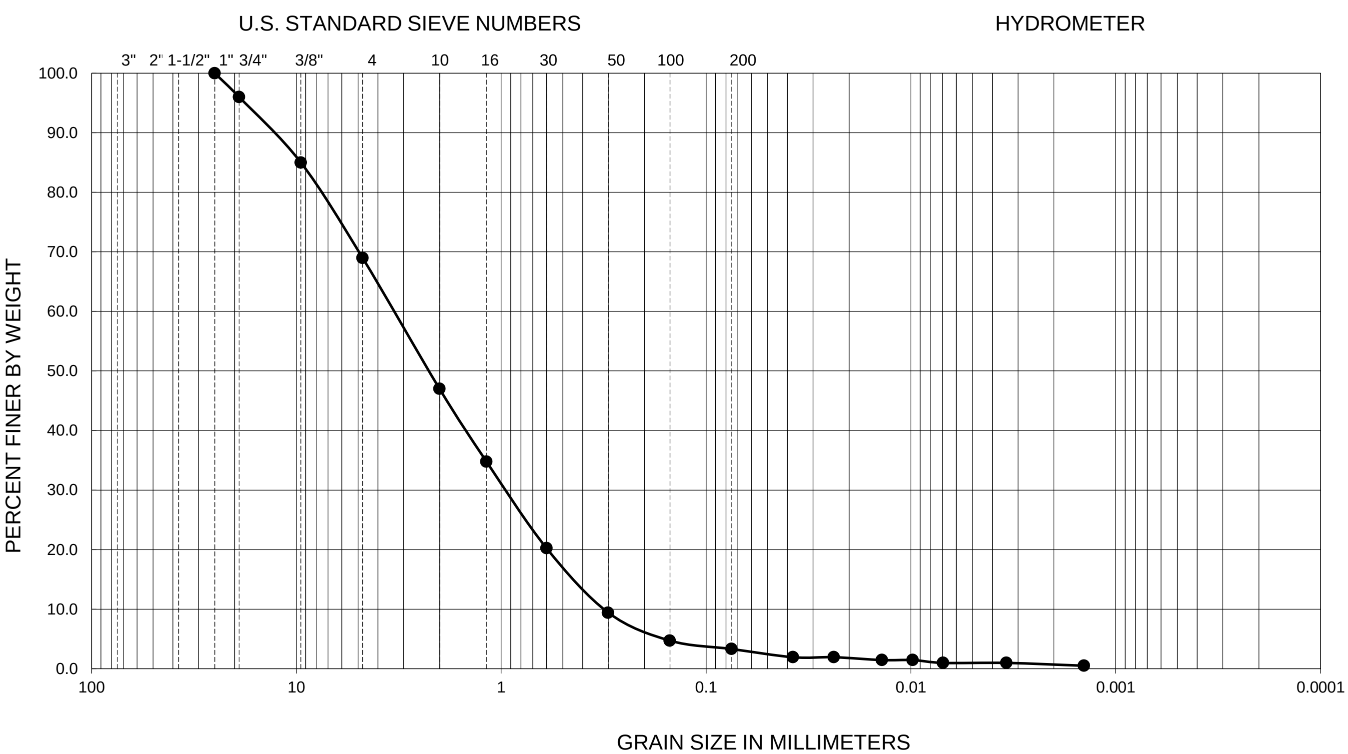


Symbol	Sample Location	Specific Gravity	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	2	2.519	--	--	--	--	--	--	--	--	2	--

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	WATER & EARTH TECHNOLOGIES/LABORATORY TESTING TUCSON, ARIZONA	B-1
604789001	7/15		

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Specific Gravity	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	8	2.500	--	--	--	--	--	--	--	--	3	--

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	WATER & EARTH TECHNOLOGIES/LABORATORY TESTING TUCSON, ARIZONA	B-2
604789001	7/15		

Appendix I

Kinder Morgan Pipeline Replacement Cost Estimate

Project Estimate Package Transmittal Letter

Project Name:	L2020 Sonoita Ck Replacement
Estimate Number:	CE1602040
Date:	2/26/2016
Revision Number:	-
LEVEL:	Screening Level: ____ Developmental Level: ____ AFE level: X
Estimate Total:	**$ 817,538**
Project Manager:	Vickie Gibson
Project Sponsor:	Vickie Gibson
Notes:	
Includes:	SCOPE: X ESTIMATE: X SCHEDULE: ____ SKETCH: X
Form:	Estimate Form Revision 8.3 (Draft) 02/10/16
File Path:	J:\Project Management\PM TOOLS\PROJECT COST ESTIMATES\2016 Cost Estimates\CE1602040 L2020 Sonoita Ck Replacements\Estimates\[CE1602040 L2020 Sonoita Ck Replacements 3-16-16.xlsb]Ln 2020

KINDER MORGAN

PROJECT NAME	L2020 Sonoita Ck Replacement		
COMPANY NAME	El Paso Natural Gas Company	**COMPANY NO.**	5205
REQUESTED BY	Vickie Gibson	**PREPARED BY**	Scheller
ESTIMATE NO.	CE1602040	**ORIGINAL EST. DATE**	02/26/16
REVISION NO.	-	**CONSTRUCTION CONTINGENCY**	10.0%
REVISION DATE	-	**OVERHEAD**	16.0%
PROJECT MANAGER	Vickie Gibson	**AFUDC**	0.0% 0.0%
		TAX GROSS UP	28.0%

Known Construction Environment & Attributes, Material & Labor basis. Estimate Assumptions:

<u>Measurement:</u>

<u>Compression:</u>

<u>Pipeline:</u>
Material Pricing based off recent quotes and/or recent KM purchases.
Material Pricing assumes standard pricing and standard shipping. Expedited material/freight is NOT included in estimate.
This is a reimbursable project

KINDER MORGAN

PROJECT NAME	L2020 Sonoita Ck Replacement
COMPANY NAME	El Paso Natural Gas Company
REQUESTED BY	Vickie Gibson
ESTIMATE NO.	CE1602040
REVISION NO.	-
REVISION DATE	
PROJECT MANAGER	Vickie Gibson
STATE	Arizona
COUNTY	Santa Cruz

COMPANY NO.	5205	
PREPARED BY	Scheller	
ORIGINAL EST. DATE	02/26/16	
CONSTRUCTION CONTINGENCY	10%	
OVERHEAD	16%	
AFUDC RATE (Debt / Equity)	0.00%	0.00%
TAX GROSS UP	28.00%	
PROJECT TYPE	Reimbursable	
IN-SERVICE	Sep-16	

Ln 2020 SCOPE: Existing pipe to be replaced is 4.5"od with 0.220"Wt, Grade A. Two sections of pipe replacement, Location 1 at MP 25+1500 for a distance of approx 260 feet. Location 2 at MP 26+4900 for a distance of 320 feet. The existing pipe was installed in 1948 and is assumed brittle requiring pipeline replacement instead of line lowering. The new pipe will have a 15' o/s of original ROW.

Removal SCOPE: Remove existing pipe in two locations.

ASSET CAPABILITIES: Vol @ ### psi

Minimum	MMCFD
Maximum	MMCFD

	Pressure
Minimum	psig
MAOP	550 psig
Normal Operating	psig
Delivery Pressure	psig

Metrics:

Dia (Inch) =	4.5
Length (Miles) =	0.11
Aggregate Base Lay (Per Ft) =	$70,141
Total Cost (Per Ft) =	$1,344
Contractor Cost (DIM) =	$332,726
Directs + Contingency Cost (DIM) =	$1,062,153

ESTIMATE SUMMARY

	Ln 2020	Tab 12	Tab 13	Tab 14	Removal	TOTAL
MATERIAL (INCL SALES TAX)	$ 15,300				$ -	$ 15,300
COMPANY LABOR COST	$ 400				$ -	$ 400
PM, ENG, LAND, ENVIRO - EXPENSE	$ 5,000				$ -	$ 5,000
PRIMARY CONSTRUCTION CONTRACTOR	$ 164,400				$ 23,400	$ 187,800
SECONDARY CONTRACTOR	$ 213,800				$ -	$ 213,800
PROFESSIONAL ENGINEERING	$ 3,200				$ -	$ 3,200
INSPECTION SERVICES	$ 21,100				$ -	$ 21,100
RADIOGRAPHY SERVICES	$ 11,100				$ -	$ 11,100
ENVIRONMENTAL CONTRACTOR	$ 23,000				$ -	$ 23,000
ELECTRICAL & INSTRUMENTATION	$ -				$ -	$ -
RIGHT OF WAY CONTRACTOR	$ -				$ -	$ -
SURVEY CONTRACTOR	$ 19,400				$ -	$ 19,400
OUTSIDE LEGAL SERVICES	$ -				$ -	$ -
ROW & DAMAGES	$ -				$ -	$ -
PERMIT FEES	$ -				$ -	$ -
GAS LOSS	$ 400				$ -	$ 400
SUBTOTAL	$ 477,100				$ 23,400	$ 500,500
CONSTRUCTION CONTINGENCY	$ 47,710				$ 2,340	$ 50,050
AFUDC	$ -				$ -	$ -
SUBTOTAL	$ 524,810				$ 25,740	$ 550,550
CAPITALIZED OVERHEAD (BURDEN)	$ 83,970				$ 4,118	$ 88,088
TAX GROSS-UP	$ 170,500				$ 8,400	$ 178,900
ESCALATION	$ -				$ -	$ -
RISK INSURANCE	$ -				$ -	$ -
ESTIMATED TOTAL COST	**$ 779,280**				**$ 38,258**	**$ 817,538**

	Ln 2020	Tab 12	Tab 13	Tab 14	Removal
Price/Ton:	$0				
(If Applicable) Escalated Price/Ton:					
Contingency:	10%	10%	10%	10%	10%
In-Service Date:	Sep-16	Sep-16	Sep-16	Sep-16	Sep-16

ASSUMPTIONS

Include (Yes/No)	Assumptions
Yes	See Assumptions Tab

Revision	Date	Notes	Approval	Name	Date
			Project Manager		
			Project Manager Director		
			Project Controls		
			Vice President		

AUTHORITY LEVELS:	
< $25,000,000	PM, PM Director, Project Controls
> $25,000,000	PM, PM Director, Project Controls, VP

Escalation Rates FV=PV(1+i)^n	
Material:	0.0%
Other:	0.0%

Estimate Form Revision 8.3 (Draft) 02/10/16

KINDER MORGAN

PROJECT NAME	L2020 Sonoita Ck Replacement		
COMPANY NAME	El Paso Natural Gas Company	COMPANY NO.	5205
REQUESTED BY	Vickie Gibson	PREPARED BY	Scheller
ESTIMATE NO.	CE1602040	ORIGINAL EST. DATE	02/26/16
REVISION NO.	-	CONSTRUCTION CONTINGENCY	10%
REVISION DATE	01/00/00	OVERHEAD	16%
PROJECT MANAGER	Vickie Gibson	AFUDC RATE (Debt / Equity)	0.00% / 0.00%
STATE	Arizona	TAX GROSS UP	28.00%
COUNTY	Santa Cruz	PROJECT TYPE	Reimbursable
		IN-SERVICE	Sep-16

ASSET CAPABILITIES: Vol @ ### psi
Minimum MMCFD
Maximum MMCFD

Metrics:		
Dia (Inch) =	4.5	Dia (Inch)
Length (Miles) =	0.11	Length (Miles)
Contractor Cost (per Ft) =	$284	Contractor Cost (per Ft)
Total Cost (Per Ft) =	$1,344	Total Cost (Per Ft)
Contractor Aggrigate Base Lay (Per Ft) =	$70,141	Contractor Aggrigate Base Lay (Per Ft)
Contractor Base Lay, Class 1 (Per Ft) =	$70,000	Contractor Base Lay, Class 1 (Per Ft)
Contractor Base Lay, Class 2 (Per Ft) =	$70,005	Contractor Base Lay, Class 2 (Per Ft)
Contractor Base Lay, Class 3 (Per Ft) =	$70,010	Contractor Base Lay, Class 3 (Per Ft)
Contractor Cost (DIM) =	$332,726	Contractor Cost (DIM)
Directs + Contingency Cost (DIM) =	$1,062,153	Directs + Contingency Cost (DIM)
ROW Cost ($/Rod) =	$0	ROW Cost ($/Rod)
ROW Cost ($/Mile) =	$0	ROW Cost ($/Mile)
ENV Cost ($/Mile) =	$209,472	ENV Cost ($/Mile)

ESTIMATE SUMMARY

	Ln 2020		Target (Low)	Target (High)	TOTAL		Pipe Target (Low)	Pipe Target (High)	
	$	% (D + C)	05-West		$	% (D + C)	05-West		
MATERIAL (INCL SALES TAX)	15,300	2.9%	12.54%	25.63%	15,300	2.9%	12.5%	25.6%	MATERIAL (INCL SALES TAX)
TOTAL COMPANY COST	400	0.1%	0.24%	0.36%	400	0.08%	0.24%	0.36%	TOTAL COMPANY COST
PM, ENG, LAND, ENVIRO - EXPENSE	5,000	1.0%	0.10%	0.15%	5,000	0.95%	0.10%	0.15%	PM, ENG, LAND, ENVIRO - EXPENSE
PRIMARY CONSTRUCTION CONTRACTOR	164,400	31.3%	41.24%	55.22%	164,400	31.3%	41.2%	55.2%	PRIME CONTRACT
SECONDARY CONTRACTOR	213,800	40.7%	0.26%	0.34%	213,800	40.74%	0.26%	0.34%	SECONDARY CONTRACTOR
PROFESSIONAL ENGINEERING	3,200	0.6%	1.13%	1.99%	3,200	0.61%	1.13%	1.99%	PROFESSIONAL ENGINEERING
INSPECTION SERVICES	21,100	4.0%	2.49%	4.38%	21,100	4.02%	2.49%	4.39%	INSPECTION SERVICES
RADIOGRAPHY SERVICES	11,100	2.1%	0.81%	1.22%	11,100	2.12%	0.81%	1.22%	RADIOGRAPHY SERVICES
ENVIRONMENTAL CONTRACTOR	23,000	4.4%	1.92%	5.28%	23,000	4.38%	1.91%	5.28%	ENVIRONMENTAL CONTRACTOR
ELECTRICAL & INSTRUMENTATION	-	0.0%	0.00%	0.00%	-	0.00%	0.00%	0.00%	ELECTRICAL & INSTRUMENTATION
RIGHT OF WAY CONTRACTOR	-	0.0%	0.57%	1.27%	-	0.00%	0.57%	1.27%	RIGHT OF WAY CONTRACTOR
SURVEY CONTRACTOR	19,400	3.7%	0.59%	1.90%	19,400	3.70%	0.59%	1.90%	SURVEY CONTRACTOR
OUTSIDE LEGAL SERVICES	-	0.0%	0.07%	0.58%	-	0.00%	0.07%	0.58%	OUTSIDE LEGAL SERVICES
ROW & DAMAGES	-	0.0%	4.18%	9.27%	-	0.00%	4.18%	9.27%	ROW & DAMAGES
PERMIT FEES	-	0.0%	0.00%	0.00%	-	0.00%	0.00%	0.00%	PERMIT FEES
GAS LOSS	400	0.1%			400	0.08%			GAS LOSS
SUBTOTAL	**477,100**				**477,100**		**SUBTOTAL**		
CONSTRUCTION CONTINGENCY	47,710				47,710		CONSTRUCTION CONTINGENCY		
AFUDC	-				-		AFUDC		
SUBTOTAL	**524,810**				**524,810**		**SUBTOTAL**		
CAPITALIZED OVERHEAD (BURDEN)	83,970				83,970		CAPITALIZED OVERHEAD (BURDEN)		
TAX GROSS-UP	170,500				170,500		TAX GROSS-UP		
ESCALATION	-				-		ESCALATION		
RISK INSURANCE	-				-		RISK INSURANCE		
ESTIMATED TOTAL COST	**779,280**				**779,280**		**ESTIMATED TOTAL COST**		

ASSUMPTIONS

Include (Yes/No)	Assumptions
Yes	See Assumptions Tab

Revision	Date	Notes	Approval	Name	Date
			Project Manager		
			Project Manager Director		
			Project Controls		
			Vice President		

AUTHORITY LEVELS:	
< $25,000,000	PM, PM Director, Project Controls
> $25,000,000	PM, PM Director, Project Controls, VP

Escalation Rates	
Material:	0.0%
Other:	0.0%

Estimate Form Revision 8.3 (Draft) 02/10/16

$	779,280	Ln 2020 Total
$	817,538	AFE Total

KINDER MORGAN

Estimate Form Revision 8.3 (Draft) 02/10/16

TITLE: **L2020 Sonoita Ck Replacement**

Ln 2020 SCOPE: **Existing pipe to be replaced is 4.5"od with 0.220"Wt, Grade A. Two sections of pipe replacement, Location 1 at MP 25+1500 for a distance of approx 260 feet. Location 2 at MP 26+4900 for a distance of 320 feet. The existing pipe was installed in 1948 and is assumed brittle requiring pipeline replacement instead of line lowering. The new pipe will have a 15' o/s of original ROW.**

Requested By:	**Vickie Gibson**	Total Miles:	0.11
Estimate # :	**CE1602040**	Diameter:	4.500
Date:	**02/26/16**	Design Press:	550
Prepared By:	**Scheller**	Price / Ton:	$0
		SMYS:	42,000
Project Manager:	**Vickie Gibson**		

Size/Dia	Wt		Description	Quantity	Units	Unit Cost	Cost	Total	Tax Total
Diameter	WT					Landed Pipe $/ton incl coating & frt. =			$1,761
			Reroute	0%					
4.500	0.220	1,000	Pipe, Class I	1,000	lf	8.59	8,588		
			Totals:	**2,000**	**0.38**	**Miles**			
			Pipe Coat, FBE w/Powercrete (for HDD)	1,000	lf	4.22	4,219		
			Pipe Freight	7.95	tn	150.00	1,193		
						PIPE (330)		**13,999**	**15,100**
						VALVES (331)		**-**	**-**
FITTINGS & MISCELLANEOUS									
4	-	B	Elbow 45 Deg 0.237" WT. Gr.B, LR, WE	8	ea	15.63	125		
			(00302) Freight Allowance	1	ls	40%	50		
						FITTINGS (332)		**175**	**200**
						MEASUREMENT EQUIPMENT (333)		**-**	**-**
						EFM & SCADA (334)		**-**	**-**
						COMPRESSION EQUIPMENT (335)		**-**	**-**
						PRESSURE VESSELS (336)		**-**	**-**
						DIRECT FIRED HEATERS (337)		**-**	**-**
						HEAT EXCHANGERS (338)		**-**	**-**
						TANKS (339)		**-**	**-**
						PLC HARDWARE & SOFTWARE (385)		**-**	**-**
						MISCELLANEOUS MATERIALS (300)		**-**	**-**
						TOTAL MATERIALS AND SUPPLIES		**14,174**	**15,300**
COMPANY LABOR									
			Operations	6	hr	50.00	300		
						COMPANY LABOR (100)		**300**	**300**
			Payroll Burden	1	ls	46%	138		
						COMPANY BENEFITS (190)		**138**	**100**
			(00200) Land / Employee Expense	0	ea	100	0		
			(00200) Environmental / Employee Expenses	1	ls	2,000	2,000		
						EMPLOYEE EXPENSE (200)		**2,000**	**2,000**
			Employee Food Expense	4	da	50	200		
			Employee Travel (Distance, Airplane)	2	trip	1,000	2,000		
						EMPLOYEE EXPENSE - Project Management (201)		**2,200**	**2,200**
						EMPLOYEE EXPENSE - Procurement (202)		**-**	**-**
			Rental Company Vehicle Expense	2	trip	400	800		
						VEHICLE EXPENSE (500)		**800**	**800**
						TOTAL COMPANY COST		**5,438**	**5,400**
PRIMARY CONSTRUCTION CONTRACTOR									
			String and Test - Class 0 & I and Backfill	1	ls	70,000.00	70,000		
		1	Mob/Demob Spreads:	1	ea	20,000	20,000		
		1	Test Water Test segments:	1,409	Gal	0.10	141		
			Removal of Existing Pipe	0	lf	28,000.00	0		
			Asbestos Handling	0	lf	15.00	0		
			Daily crew travel	1	ls	5,500.00	5,500		
			Mats (ROW, Road Crossings, Etc.)	8	ea	600.00	4,800		
			Extra Depth (cost per 12" depth) 10' Deep	0	lf	5.17	0		
36.000			Hydrotest 4 ea.	1	ls	60,000	60,000		
			Hay Bales / Straw Bales	22	ea	21.00	461		
	(ft)	0	Silt Fence & Silt Barrier - Regular	154	lf	7.00	1,076		
			Mulching, Hay or Straw	1	Acre	1,000	549		
			Safety Fence	329	lf	5.00	1,647		
			Pipeline markers	2	Ea	125	250		
			Seeding/reveg (Install - Minct)	0.00	Acre	1,200	0		
MISCELLANEOUS									
						Individual Item SubTotal - $164,424			
						PRIMARY CONSTRUCTION CONTRACTOR (451)		**164,424**	**164,400**
SECONDARY CONSTRUCTION CONTRACTOR									
MECHANICAL									

KINDER MORGAN						$ 779,280	Ln 2020 Total		
						$ 817,538	AFE Total		
	TITLE:	L2020 Sonoita Ck Replacement		Requested By:	Vickie Gibson			Total Miles:	0.11
Estimate Form Revision 8.3 (Draft) 02/10/16	Ln 2020 SCOPE:	Existing pipe to be replaced is 4.5"od with 0.220"Wt, Grade A. Two sections of pipe replacement, Location 1 at MP 25+1500 for a distance of approx 260 feet. Location 2 at MP 26+4900 for a distance of 320 feet. The existing pipe was installed in 1948 and is assumed brittle requiring pipeline replacement instead of line lowering. The new pipe will have a 15' o/s of original ROW.		Estimate # :	CE1602040			Diameter:	4.500
				Date:	02/26/16			Design Press:	550
				Prepared By:	Scheller			Price / Ton:	$0
								SMYS:	42,000
				Project Manager:	Vickie Gibson				

Size/Dia	Wt	Description	Quantity	Units	Unit Cost	Cost	Total	Tax Total
		Directional Drill - Dirt (HDD)	1,000	lf	135	135,000		
		Mob/Dmob	1	ls	58,000	58,000		
FABRICATION OF ASSEMBLY (Fab, Hydro, Inspection, X-Ray, Co Labor)								
WASTE DISPOSAL								
		Lab Analysis	1	ls	7,500	7,500		
MISCELLANEOUS								
		CNG Rawhide Leasing	1	ls	13,258	13,258		
			Individual Item SubTotal - $213,758					
			SECONDARY CONSTRUCTION CONTRACTOR (452 or 453)				213,758	213,800
		Engineering Design	8	hr	125	1,000		
		Asbuilt Drafting	1	ea	900	900		
		Pipeline Drafting	8	hr	100	800		
		Close-out Package	5	hr	100	500		
			THIRD PARTY CONSULTING / ENGINEERING (454)				3,200	3,200
Construction Days:	20							
1	man	Chief Inspector	20	day	730	14,600		
2	man	Inspection - Damage Prevention	5	day	600	6,000		
20	man-da	Inspection Travel Mileage	50	mi (RT)	25	500		
			INSPECTION SERVICES (455)				21,100	21,100
1	crew	Radiography	5	day	1,700	8,500		
1	crew	Audit Radiography	3	day	850	2,550		
			RADIOGRAPHY SERVICES (456)				11,050	11,100
1	man	(00414) Environmental - Inspection	1	ls	23,000	23,000		
			ENVIRONMENTAL CONTRACTOR (457)				23,000	23,000
			ELECTRICAL & INSTRUMENTATION (458)				-	-
			RIGHT OF WAY CONTRACTOR (459)				-	-
3	man	Construction Survey & As-Built Survey (3-Man Crew)	5	day	3,800	19,000		
15	man-da	Survey Crew Travel Mileage	50	mi (RT)	25	375		
			SURVEY & DRAFTING CONTRACTOR (460)				19,375	19,400
			OUTSIDE LEGAL SERVICES (406)				-	-
			TOTAL OUTSIDE SERVICES				455,907	456,000
			ROW RENTAL (610)				-	-
			RIGHT OF WAY - LAND (921)				-	-
			RIGHT OF WAY - DAMAGES (922)				-	-
			TOTAL RIGHT OF WAY AND DAMAGES				-	-
			PERMITTING (800)				-	-
	Dec-16	Line Pack Gas - Cost of Gas load; Gas only	7	$/MCF	3.50	25		
7.7 Miles		Gas Loss at 550 psi	116.97	$/MCF	3.50	409		
			PURGE AND PACK GAS (924)				434	400
		Contingency	1	ls	10.00%	47,710		
			CONSTRUCTION CONTINGENCY (99100)				47,710	47,710
			TOTAL OTHER (900)				48,144	48,110
		Administrative & General	1	ls	16.00%	83,970		
			CAPITALIZED OVERHEAD (993)				83,970	83,970
			AFUDC (991)				-	-
		Tax Gross Up	1	ls	28.00%	170,458		
			TAX GROSS UP (899)				170,458	170,500
			TOTAL TAB				778,091	779,280
			ARWS TOTAL (LESS BURDEN)					695,310

Summary

MATERIAL (INCL SALES TAX)	15,300
TOTAL COMPANY COST	5,400
OUTSIDE SERVICES (INCL SALES TAX)	456,000
ROW & DAMAGES	-
PERMIT FEES	-
GAS LOSS	400
AFUDC	-
CONSTRUCTION CONTINGENCY	47,710
TAX GROSS UP	170,500
SUBTOTAL	695,310
CAPITALIZED OVERHEAD (BURDEN)	83,970
GROSS ESTIMATED COST	779,280
ESCALATION	-

	KINDER MORGAN					$ 779,280	**Ln 2020 Total**		
						$ 817,538	**AFE Total**		
	TITLE:	**L2020 Sonoita Ck Replacement**		**Requested By:**		**Vickie Gibson**		Total Miles:	0.11
Estimate Form Revision 8.3 (Draft) 02/10/16	**Ln 2020 SCOPE:**	**Existing pipe to be replaced is 4.5"od with 0.220"Wt, Grade A. Two sections of pipe replacement, Location 1 at MP 25+1500 for a distance of approx 260 feet. Location 2 at MP 26+4900 for a distance of 320 feet. The existing pipe was installed in 1948 and is assumed brittle requiring pipeline replacement instead of line lowering. The new pipe will have a 15' o/s of original ROW.**		**Estimate # :**		**CE1602040**		Diameter:	4.500
				Date:		**02/26/16**		Design Press:	550
				Prepared By:		**Scheller**		Price / Ton:	$0
								SMYS:	42,000
				Project Manager:		**Vickie Gibson**			
Size/Dia	**Wt**	**Description**	**Quantity**	**Units**		**Unit Cost**	**Cost**	**Total**	**Tax Total**
						GROSS ESTIMATED COST WITH ESCALATION			**779,280**

	Tax Rate State
	Arizona
ita Ck Replacement	Materials
e to be replaced is 4.5"od with 0.220"Wt, Grade A. Two sections of	7.60%
ment, Location 1 at MP 25+1500 for a distance of approx 260 feet.	Contract
t MP 26+4900 for a distance of 320 feet. The existing pipe was	0.00%
1948 and is assumed brittle requiring pipeline replacement instead	
ing. The new pipe will have a 15' o/s of original ROW.	
Description	**NOTES:**
Reroute	
Pipe, Class I	Shelf Pipe Adjusted to 1000' from 600 ft per PM and Manager 3/16/16
Totals:	
Pipe Coat, FBE w/Powercrete (for HDD)	Added 1000' ARO coating for HDD per PM and Manager 3/16/16
Pipe Freight	Increased from $100 to $150, JGN 3-7-16
Elbow 45 Deg 0.237" WT. Gr.B, LR, WE	
(00302) Freight Allowance	Increased to $50, JGN 3-7-16
Operations	
Payroll Burden	
(00200) Land / Employee Expense	No costs based on Land quote Kelly Sims 2/29/16
(00200) Environmental / Employee Expenses	Based on Env Quote Amy Blythe 3/3/16
Employee Food Expense	added more days per pm 3/9/16
Employee Travel (Distance, Airplane)	added more trips per pm 3/9/16
Rental Company Vehicle Expense	added more trips per pm 3/9/16
TOR	28.08
	34.61
String and Test - Class 0 & I and Backfill	43.26
Mob/Demob Spreads:	Base lay base is from bids please see bid tab per pm 3/9/16 also made Mob/Dmob 20k from 10k (Changed cost from $210,000 to $70,000 Per PM and Manager 3/16/16)
Test Water Test segments:	
Removal of Existing Pipe	See Removal Tab
Asbestos Handling	See Removal Tab
Daily crew travel	
Mats (ROW, Road Crossings, Etc.)	Mats for existing creek crossing
Extra Depth (cost per 12" depth) 10' Deep	Extra depth per Pm (Removed extra depth new scope for HDD per PM and Manager 3/16/16.)
Hydrotest 4 ea.	added hydrotesting per pm 3/9/16 (Added 2 more Hydrotesting from 2 to 4 costs from $30,000 to $60,000 per F
Hay Bales / Straw Bales	
Silt Fence & Silt Barrier - Regular	
Mulching, Hay or Straw	
Safety Fence	
Pipeline markers	
Seeding/reveg (Install - Minct)	No Reseeding customer is taking care of this please see Env. Email
RACTOR	

Description	NOTES:
ita Ck Replacement e to be replaced is 4.5"od with 0.220"Wt, Grade A. Two sections of ment, Location 1 at MP 25+1500 for a distance of approx 260 feet. t MP 26+4900 for a distance of 320 feet. The existing pipe was 1948 and is assumed brittle requiring pipeline replacement instead ing. The new pipe will have a 15' o/s of original ROW.	Tax Rate State Arizona Materials 7.60% Contract 0.00%
Directional Drill - Dirt (HDD)	Added HDD and unit cost from contractor to scope of work per PM and Manager 316/16
Mob/Dmob	
ydro, Inspection, X-Ray, Co Labor)	
Lab Analysis	
CNG Rawhide Leasing	Based on acual cost on Patagonia job 1/3/16 provided by Don Cantrell (operations)
SECO	
Engineering Design	
Asbuilt Drafting	
Pipeline Drafting	
Close-out Package	
Chief Inspector	
Inspection - Damage Prevention	Damage prevention based on Don Cantrell (operations)
Inspection Travel Mileage	
Radiography	
Audit Radiography	
(00414) Environmental - Inspection	Based on Env Quote Amy Blythe 3/3/16
	No costs based on Land quote Kelly Sims 2/29/16
Construction Survey & As-Built Survey (3-Man Crew)	
Survey Crew Travel Mileage	
	Actual Cost Per Mile: = $176,685 Sierrita Cost Per Mile: = $21,500
	No costs based on Land quote Kelly Sims 2/29/16
Line Pack Gas - Cost of Gas load; Gas only	
Gas Loss at 550 psi	
Contingency	
Administrative & General	
Tax Gross Up	

	Tax Rate State
	Arizona
ita Ck Replacement	Materials
e to be replaced is 4.5"od with 0.220"Wt, Grade A. Two sections of ment, Location 1 at MP 25+1500 for a distance of approx 260 feet. t MP 26+4900 for a distance of 320 feet. The existing pipe was 1948 and is assumed brittle requiring pipeline replacement instead ring. The new pipe will have a 15' o/s of original ROW.	7.60%
	Contract
	0.00%
Description	**NOTES:**

TITLE:	L2020 Sonoita Ck Replacement
	Ln 2020

In-Service:	9/30/2016	
State:	Arizona	
Length:	0.11	
Size:	4.50	
Internally Coated:	No	
Greenfield or Looping:		
Union or Non-Union:		
Aggregate Base Lay Cost ($/ft):	$70,141	
$/DIM Contractor (D+C):	$332,726	
$/DIM Project (D+C):	$1,062,153	

#1 Comparison Title

	Current Estimate	#1 Comparison Estimate	Current Estimate % (D+C)	Comparison Estimate % (D+C)	% Difference (Est vs. Comp)	$ Difference (Est vs. Comp)
Material	$15,300	$7,077,900	2.92%	42.84%	-46161%	-$7,062,600
Company Labor	$400	$166,400	0.08%	1.01%	-41500%	-$166,000
PM, ENG, Land, Env. Expense	$5,000	$0	0.95%	0.00%	100%	$5,000
Primary Contractor	$164,400	$4,542,900	31.33%	27.50%	-2663%	-$4,378,500
Secondary Contractor	$213,800	$538,700	40.74%	3.26%	-152%	-$324,900
Professional Engineering	$3,200	$892,400	0.61%	5.40%	-27788%	-$889,200
Inspection Services	$21,100	$497,600	4.02%	3.01%	-2258%	-$476,500
Radiography Services	$11,100	$144,500	2.12%	0.87%	-1202%	-$133,400
Environmental Contractor	$23,000	$341,400	4.38%	2.07%	-1384%	-$318,400
Electrical & Instrumentation	$0	$0	0.00%	0.00%	-100%	$0
Right of Way Contractor	$0	$10,600	0.00%	0.06%	-100%	-$10,600
Survey contractor	$19,400	$106,300	3.70%	0.64%	-448%	-$86,900
Outside Legal Services	$0	$23,400	0.00%	0.14%	-100%	-$23,400
ROW & Damages	$0	$24,000	0.00%	0.15%	-100%	-$24,000
Permit Fees	$0	$0	0.00%	0.00%	-100%	$0
Gas Loss	$400	$0	0.08%	0.00%	100%	$400
Subtotal	**$477,100**	**$14,366,100**			**-2911%**	**-$13,889,000**
Contingency	$47,710	$2,154,915			-4417%	-$2,107,205
AFUDC	$0	$1,139,225			-100%	-$1,139,225
Subtotal	**$524,810**	**$17,660,240**			**-3265%**	**-$17,135,430**
Overhead	$83,970	$2,643,362			-3048%	-$2,559,392
Tax Gross-Up	$170,500	$0			100%	$170,500
Escalation	$0	$0			-100%	$0
Risk Insurance	$0	$0			-100%	$0
Estimated Total Cost	**$779,280**	**$20,303,602**			**-2505%**	**-$19,524,322**

TITLE:	L2020 Sonoita Ck Replacement
	Ln 2020

In-Service:	9/30/2016	
State:	Arizona	
Length:	0.11	
Size:	4.50	
Internally Coated:	No	
Greenfield or Looping:		
Union or Non-Union:		
Aggregate Base Lay Cost ($/ft):	$70,141	
$/DIM Contractor (D+C):	$332,726	
$/DIM Project (D+C):	$1,062,153	

#2 Comparison Title

	Current Estimate	#2 Comparison Estimate	Current Estimate % (D+C)	Comparison Estimate % (D+C)	% Difference (Est vs. Comp)	$ Difference (Est vs. Comp)
Material	$15,300	$7,077,900	2.92%	42.84%	-46161%	-$7,062,600
Company Labor	$400	$166,400	0.08%	1.01%	-41500%	-$166,000
PM, ENG, Land, Env. Expense	$5,000	$0	0.95%	0.00%	100%	$5,000
Primary Contractor	$164,400	$4,542,900	31.33%	27.50%	-2663%	-$4,378,500
Secondary Contractor	$213,800	$538,700	40.74%	3.26%	-152%	-$324,900
Professional Engineering	$3,200	$892,400	0.61%	5.40%	-27788%	-$889,200
Inspection Services	$21,100	$497,600	4.02%	3.01%	-2258%	-$476,500
Radiography Services	$11,100	$144,500	2.12%	0.87%	-1202%	-$133,400
Environmental Contractor	$23,000	$341,400	4.38%	2.07%	-1384%	-$318,400
Electrical & Instrumentation	$0	$0	0.00%	0.00%	-100%	$0
Right of Way Contractor	$0	$10,600	0.00%	0.06%	-100%	-$10,600
Survey contractor	$19,400	$106,300	3.70%	0.64%	-448%	-$86,900
Outside Legal Services	$0	$23,400	0.00%	0.14%	-100%	-$23,400
ROW & Damages	$0	$24,000	0.00%	0.15%	-100%	-$24,000
Permit Fees	$0	$0	0.00%	0.00%	-100%	$0
Gas Loss	$400	$0	0.08%	0.00%	100%	$400
Subtotal	**$477,100**	**$14,366,100**			**-2911%**	**-$13,889,000**
Contingency	$47,710	$2,154,915			-4417%	-$2,107,205
AFUDC	$0	$1,139,225			-100%	-$1,139,225
Subtotal	**$524,810**	**$17,660,240**			**-3265%**	**-$17,135,430**
Overhead	$83,970	$2,643,362			-3048%	-$2,559,392
Tax Gross-Up	$170,500	$0			100%	$170,500
Escalation	$0	$0			-100%	$0
Risk Insurance	$0	$0			-100%	$0
Estimated Total Cost	**$779,280**	**$20,303,602**			**-2505%**	**-$19,524,322**

KINDER MORGAN

$ 38,258	Removal Total	Tax Rate State	Arizona
$ 817,538	AFE Total	Materials	7.60%
		Contract	0.00%

Estimate Form Revision 8.3 (Draft) 02/10/16

TITLE: L2020 Sonoita Ck Replacement

Removal SCOPE: Remove existing pipe in two locations.

Requested By: Vickie Gibson
Estimate # : CE1602040
Date: 02/26/16
Prepared By: Scheller
Project Manager: Vickie Gibson
Est Type: Lateral

Size/Dia	Wt	Grade	Description	Quantity	Units	Unit Cost	Cost	Total	Tax Total	NOTES:
						PIPE (330)		-	-	
						VALVES (331)		-	-	
						FITTINGS (332)		-	-	
						MEASUREMENT EQUIPMENT (333)		-	-	
						EFM & SCADA (334)		-	-	
						COMPRESSION EQUIPMENT (335)		-	-	
						PRESSURE VESSELS (336)		-	-	
						DIRECT FIRED HEATERS (337)		-	-	
						HEAT EXCHANGERS (338)		-	-	
						TANKS (339)		-	-	
						PLC HARDWARE & SOFTWARE (385)		-	-	
						MISCELLANEOUS MATERIALS (300)		-	-	
						TOTAL MATERIALS AND SUPPLIES		-	-	
						COMPANY LABOR (100)		-	-	
						COMPANY BENEFITS (190)		-	-	
						EMPLOYEE EXPENSE (200)		-	-	
						EMPLOYEE EXPENSE - Project Management (201)		-	-	
						EMPLOYEE EXPENSE - Procurement (202)		-	-	
						VEHICLE EXPENSE (500)		-	-	
						TOTAL COMPANY COST		-	-	
PRIMARY CONSTRUCTION CONTRACTOR										
MECHANICAL										
			Removal of Existing Pipe	600	lf	24	14,400			
			Asbestos Handling	600	lf	15	9,000			
						Individual Item SubTotal - $23,400				
						PRIMARY CONSTRUCTION CONTRACTOR (451)		23,400	23,400	
						SECONDARY CONSTRUCTION CONTRACTOR (452 or 453)		-	-	
						THIRD PARTY CONSULTING / ENGINEERING (454)		-	-	
						INSPECTION SERVICES (455)		-	-	
						RADIOGRAPHY SERVICES (456)		-	-	
						ENVIRONMENTAL CONTRACTOR (457)		-	-	
						ELECTRICAL & INSTRUMENTATION (458)		-	-	
						RIGHT OF WAY CONTRACTOR (459)		-	-	
						SURVEY & DRAFTING CONTRACTOR (460)		-	-	
						OUTSIDE LEGAL SERVICES (406)		-	-	
						TOTAL OUTSIDE SERVICES		23,400	23,400	
						ROW RENTAL (610)		-	-	
						RIGHT OF WAY - LAND (921)		-	-	
						RIGHT OF WAY - DAMAGES (922)		-	-	
						TOTAL RIGHT OF WAY AND DAMAGES		-	-	
						PERMITTING (800)		-	-	
						PURGE AND PACK GAS (924)		-	-	
			Contingency	1	ls	10.00%	2,340			
						CONSTRUCTION CONTINGENCY (99100)		2,340	2,340	
						TOTAL OTHER (900)		2,340	2,340	
			Administrative & General	1	ls	16.00%	4,118			
						CAPITALIZED OVERHEAD (993)		4,118	4,118	
						AFUDC (991)		-	-	
			Tax Gross Up	1	ls	28.00%	8,360			
						TAX GROSS UP (899)		8,360	8,400	
						TOTAL TAB		38,219	38,258	
						ARWS TOTAL (LESS BURDEN)			34,140	

Summary

MATERIAL (INCL SALES TAX)	-
TOTAL COMPANY COST	-
OUTSIDE SERVICES (INCL SALES TAX)	23,400
ROW & DAMAGES	-
PERMIT FEES	-
GAS LOSS	-
AFUDC	-
CONSTRUCTION CONTINGENCY	2,340

KINDER MORGAN

$ 38,258	**Removal Total**
$ 817,538	**AFE Total**

Tax Rate State
Arizona
Materials
7.60%
Contract
0.00%

Estimate Form Revision 8.3 (Draft) 02/10/16

TITLE: **L2020 Sonoita Ck Replacement**

Removal SCOPE: **Remove existing pipe in two locations.**

Requested By: **Vickie Gibson**
Estimate # : **CE1602040**
Date: **02/26/16**
Prepared By: **Scheller**
Project Manager: **Vickie Gibson**
Est Type: Lateral

Size/Dia	Wt	Grade	Description	Quantity	Units	Unit Cost	Cost	Total	Tax Total	NOTES:

TAX GROSS UP	**8,400**
SUBTOTAL	**34,140**
CAPITALIZED OVERHEAD (BURDEN)	**4,118**
GROSS ESTIMATED COST	**38,258**
ESCALATION	**-**
GROSS ESTIMATED COST WITH ESCALATION	**38,258**

Description

Project Manager: Vickie Gibson
Estimator: Scheller

Estimate #: CE1602040

Estimate Date: 2/26/2016

Estimated Cost: $608,780

AFUDC Start Date (PreFiling or Board Approval): Jan-13
Begin Construction: Oct-14
In Service Date: Sep-16

			Assets		Installation			Engineering								Inspection				Other					Indirect Costs										
			Pipe / Compressor Unit	Other Assets	MAJCT	MINCT	COMPANY	OTSVC	LABOR	MINCT	EMEXP	Right of Way	Legal	Outreach	Environmental	Site Inspection	Survey	X-Ray	Project Development	Gas Used	Other	Demo/ Removal/ Retirement	Salvage	Total Direct	Escalation Materials	Escalation Labor/Other	Contingency (Escalated)	Overheads (Escalated)	AFUDC Debit (Escalated)	AFUDC Equity (Escalated)		Risk	Total Project, Escalated	Yearly Total	Cumulative
			15,100	200	164,400	213,800	400	0	0	3,200	5,000	0	0	0	23,000	21,100	19,400	11,100	0	400	0	0	0	477,100	0	0	47,710	83,970	0	0		0	608,780		0
	(43)	Aug-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(42)	Sep-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(41)	Oct-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(40)	Nov-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(39)	Dec-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(38)	Jan-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(37)	Feb-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(36)	Mar-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(35)	Apr-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(34)	May-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(33)	Jun-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(32)	Jul-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(31)	Aug-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(30)	Sep-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(29)	Oct-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(28)	Nov-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(27)	Dec-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(26)	Jan-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(25)	Feb-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(24)	Mar-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(23)	Apr-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(22)	May-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(21)	Jun-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(20)	Jul-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(19)	Aug-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(18)	Sep-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(17)	Oct-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(16)	Nov-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(15)	Dec-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(14)	Jan-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(13)	Feb-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(12)	Mar-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(11)	Apr-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(10)	May-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(9)	Jun-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(8)	Jul-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(7)	Aug-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(6)	Sep-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(5)	Oct-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(4)	Nov-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(3)	Dec-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(2)	Jan-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	(1)	Feb-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	0	Mar-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		0
	1	Apr-16	7,550	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,590	0	0	0	1,214	0	0		0	8,804		8,804
	2	May-16	7,550	50	0	0	20	0	0	160	250	0	0	0	1,150	1,055	970	0	0	0	0	0	0	11,205	0	0	0	1,793	0	0		0	12,998		21,802
Beg Construction	3	Jun-16	0	60	32,880	42,760	40	0	0	320	500	0	0	0	2,300	2,110	1,940	2,220	0	0	0	0	0	85,130	0	0	9,542	15,148	0	0		0	109,820		131,622
	4	Jul-16	0	40	41,100	53,450	60	0	0	480	750	0	0	0	3,450	3,165	2,910	2,775	0	0	0	0	0	108,180	0	0	11,928	19,217	0	0		0	139,325		270,946
	5	Aug-16	0	10	49,320	64,140	80	0	0	640	1,000	0	0	0	4,600	4,220	3,880	3,330	0	400	0	0	0	131,620	0	0	14,313	23,349	0	0		0	169,282		440,229
In Service	**6**	**Sep-16**	**0**	**0**	**32,880**	**42,760**	**80**	**0**	**0**	**640**	**1,000**	**0**	**0**	**0**	**4,600**	**4,220**	**3,880**	**2,220**	**0**	**0**	**0**	**0**	**0**	**92,280**	**0**	**0**	**9,542**	**16,292**	**0**	**0**		**0**	**118,114**		**558,342**
	7	Oct-16	0	0	8,220	10,690	80	0	0	640	1,000	0	0	0	4,600	4,220	3,880	555	0	0	0	0	0	33,885	0	0	2,386	5,803	0	0		0	42,074		600,416
	8	Nov-16	0	0	0	0	40	0	0	320	500	0	0	0	2,300	2,110	1,940	0	0	0	0	0	0	7,210	0	0	0	1,154	0	0		0	8,364		608,780
	9	Dec-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	10	Jan-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	11	Feb-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	12	Mar-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	13	Apr-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	14	May-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	15	Jun-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	16	Jul-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	17	Aug-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	18	Sep-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	19	Oct-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	20	Nov-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	21	Dec-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	22	Jan-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
	23	Feb-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0		608,780
			15,100	200	164,400	213,800	400	0	0	3,200	5,000	0	0	0	23,000	21,100	19,400	11,100	0	400	0	0	0	477,100	0	0	47,710	83,970	0	0	0	0	608,780		

KINDER MORGAN

Estimate Form Revision 8.3 (Draft) 02/10/16	TITLE:	L2020 Sonoita Ck Replacement
	Requested By:	Vickie Gibson
	Estimate # :	CE1602040
	Date:	02/26/16
	Prepared By:	Scheller
	Project Manger:	Vickie Gibson

KINDER MORGAN

COST ESTIMATE REQUEST

Instruction: The form is required to be complete prior to beginning an estimate. Please make a best effort to complete all available information. The minimum required information shown in red. See Instructions Tab for additional details.

REQUESTER:	Vickie Gibson	DATE	February 25, 2016 — Form PM20
TO:	PM Cost Est Request	For Project Management Usage Only	
CC LIST:	Kelley Sims	CE NUMBER	PYYMMxx.aa
	Ron Schafer	DATE RECEIVED	
	Don Cantrell, Randy Kimbell	DATE EXPECTED	
PROJECT NAME/DESCRIPTION *	L2020 Sonoita Ck Replacements		
TYPE OF PROJECT	OTHER		
WHAT KINDER MORGAN SYSTEM DOES THE PROJECT TIE TO?*	EPNG L2020		
ESTIMATED DATE REQUIRED FOR START UP*	08/16/16		
ARE MAPS/DRAWING AVAILABLE*	yes		
CUSTOMER INFORMATION		**GAS VOLUMES**	
CUSTOMER NAME *	Hudbay Minerals	AVERAGE DAILY*	MMBTU per Day
CONTACT NAME *	Kim Proctor	MINIMUM	MMBTU per Hour
PHONE *	520-495-3546	MAXIMUM*	MMBTU per Hour
FAX		SWING	MMBTU per Hour
EMAIL ADDRESS	kim.proctor@hudbayminerals.com	**ESTIMATE**	
STATE	AZ	LEVEL*	
COUNTY/PARISH	Santa Cruz	**REGULATORY REQUIREMENTS ***	
DELIVERY/SUPPLY PRESSURE(psig)			
NORMAL*		**GAS QUALITY**	
MINIMUM		ACCEPTABLE	
MAXIMUM		DEHY REQ'D	
OVER PRESSURE REQ'D		FILTER/SEP REQ'D	
CONTROL/REGULATION		TREATING REQ'D	
FLOW		H2S PPM	
PRESSURE		CO2 %	
100% BACKUP*		ODORIZATION REQ'D	
TELEMETRY		ANY DEVIATION FROM COMPANY QUALITY REQUIREMENTS WILL NEED TO BE APPROVED BY OPERATIONS REGIONAL DIRECTOR	
KINDER MORGAN WILL		**KINDER MORGAN WILL PROVIDE**	
FUND	NO	SITE*	YES
OWN	YES	ROW*	YES
OPERATE	YES	POWER	NO
MAINTAIN	YES	COMMUNICATIONS	NO
BE REIMBURSED	YES	SCADA INFO	NO
INCLUDED OVERHEAD	YES		
INCLUDED TAX GROSS-UP	YES		
SYSTEM DESIGN INFORMATION (IF AVAILABLE)			
SYSTEM DESIGN ENGINEER		COMPRESSOR TYPE	
COMPRESSOR SIZING (HP REQ'D)		LATERAL SIZE	
DRIVER TYPE		ANY ADDITIONAL INFORMATION INCLUDE IN REMARKS	

REMARKS: (include any additional information regarding the project)

Existing pipe to be replaced is 4.5"od with 0.220"Wt, Grade A. Two sections of pipe replacement, Location 1 at MP 25+1500 for a distance of approx 260 feet. Location 2 at MP 26+4900 for a distance of 320 feet. The existing pipe was installed in 1948 and is assumed brittle requiring pipeline replacement instead of line lowering.

* ANY FIELDS FOLLOWED BY AN ASTERISK MUST BE COMPLETED.

Revision 2.1 - Date 03/30/05

04/01 Page 1 of 1 PM20

KINDER MORGAN

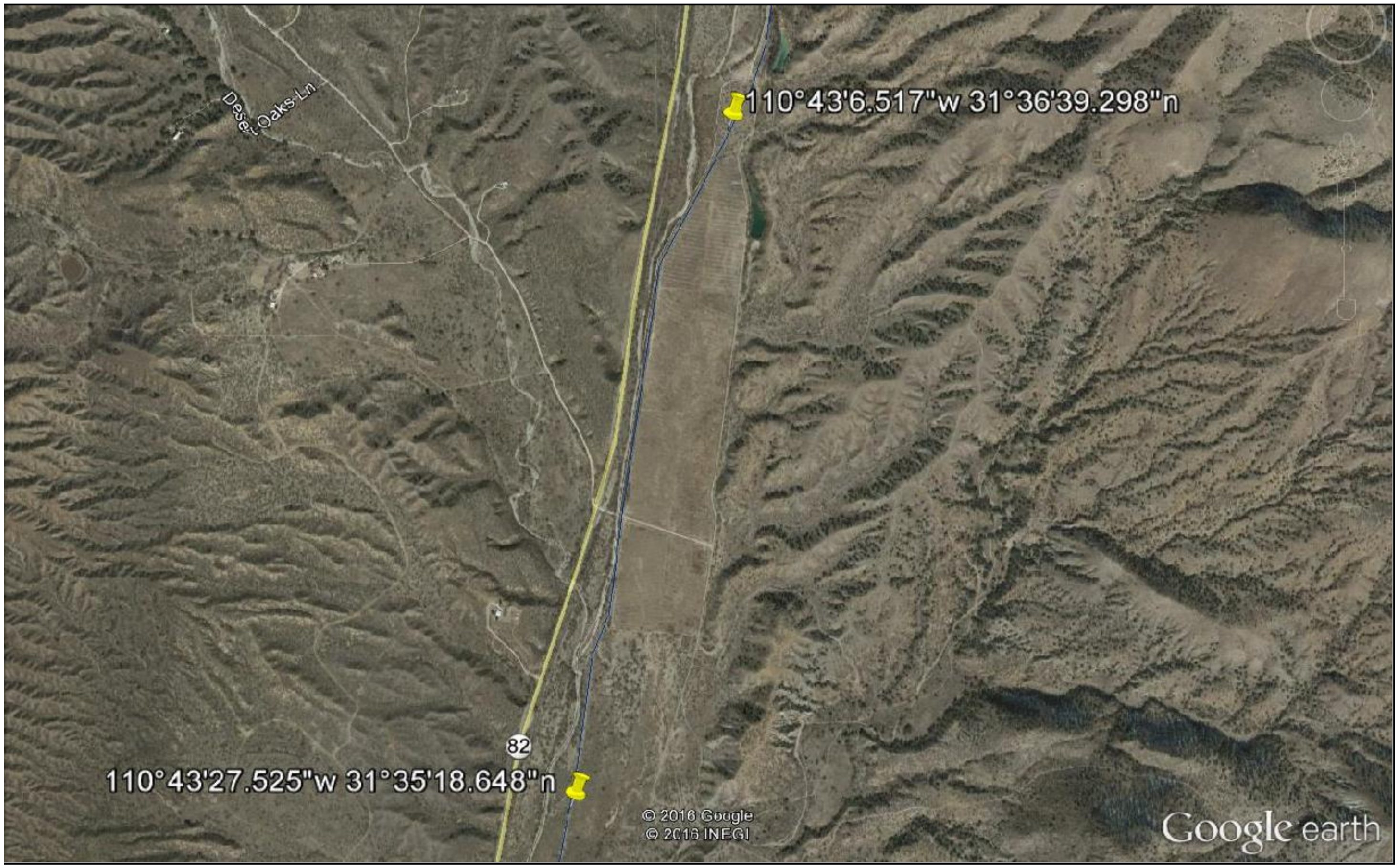
Estimate Form
Revision 8.3 (Draft)
02/10/16

TITLE:	L2020 Sonoita Ck Replacement
Requested By:	Vickie Gibson
Estimate # :	CE1602040
Date:	02/26/16
Prepared By:	Scheller
Project Manger:	Vickie Gibson

KINDER MORGAN

Estimate Form
Revision 8.3 (Draft)
02/10/16

TITLE:	L2020 Sonoita Ck Replacement
Requested By:	Vickie Gibson
Estimate # :	CE1602040
Date:	02/26/16
Prepared By:	Scheller
Project Manger:	Vickie Gibson



KINDER MORGAN

Estimate Form
Revision 8.3 (Draft)
02/10/16

TITLE:	L2020 Sonoita Ck Replacement
Requested By:	Vickie Gibson
Estimate # :	CE1602040
Date:	02/26/16
Prepared By:	Scheller
Project Manger:	Vickie Gibson

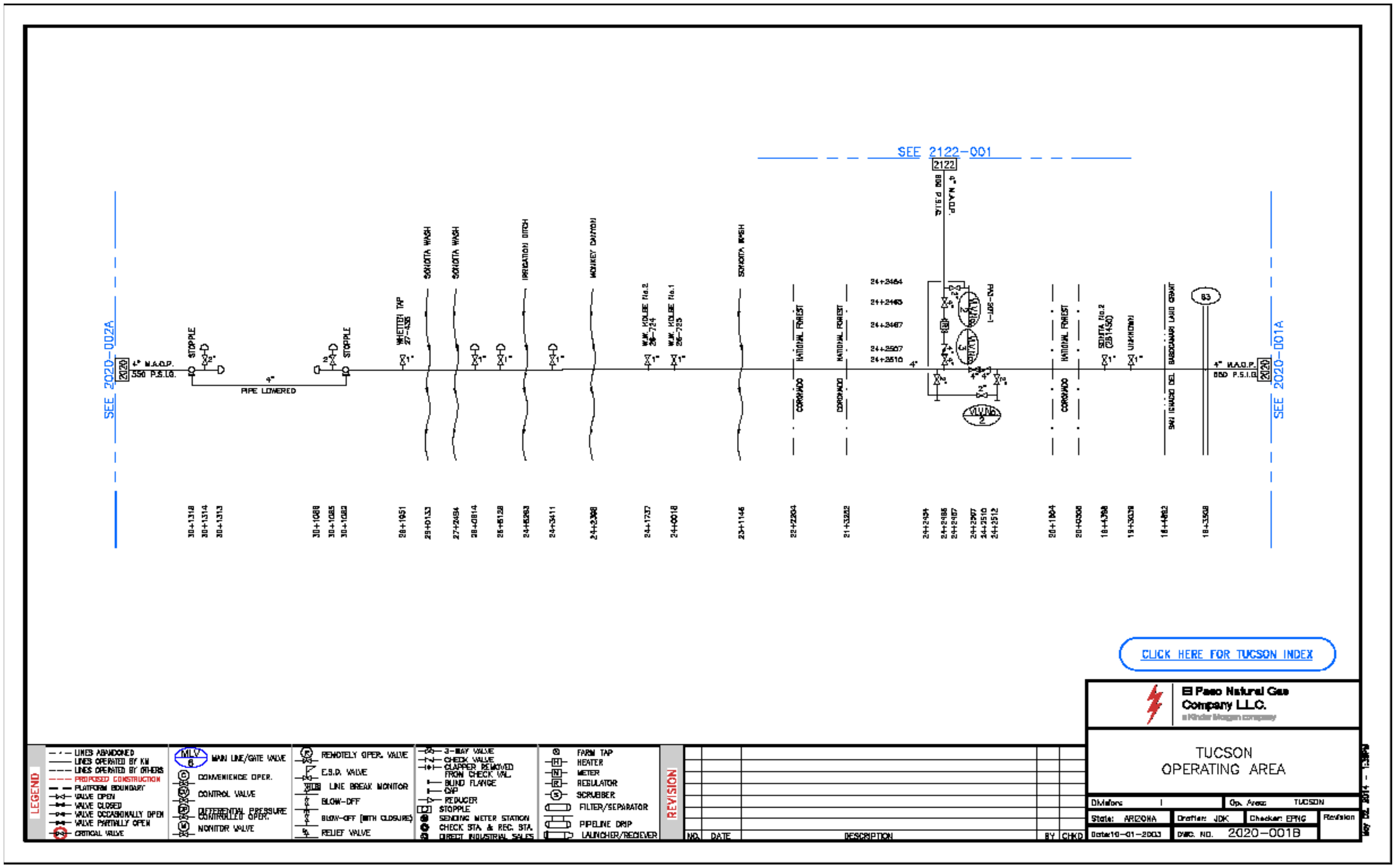


EXHIBIT C WRITABLE SCHEDULE OF VALUES

Kinder Morgan - El Paso Natural Gas Company
AFE 300551
L2043 Replacement MP 0-44+46 to MP 1-47+68

Bid Tab updated Feb 12, 2016
PRICE SCHEDULE

Descriptior: EPNG L2043 Replacement TxDOT Border Loop 375 AFE: 300551
Location: El Paso Texas Bidder Name:

WHC Energy

Item	Description	Unit of Measure	* Estimated Quantity	Contract Unit Price w/o Tax	Total Estimated Amount
A	CONTRACT WORK				
A.1	Line 2043 (Lump Sum Pricing) per SOW				
A.1.a	Mobilization, Areas 2, 3, 4	Lump Sum	1	$80,000.00	$80,000.00
A.1.b	Assist Operations in Isolation of L 2043	Lump Sum	1	$25,000.00	$25,000.00
A.1.c	Safety Program - Training, Recognition Awards, etc.	Lump Sum	1	$10,000.00	$10,000.00
A.1.d	Assist Operations in returning L 2043 into service	Lump Sum	1	$25,000.00	$25,000.00
A.1.e	Demobilization Areas 2, 3, 4	Lump Sum	1	$80,000.00	$80,000.00
A.1.f	**SUBTOTAL FOR GENERAL WORK**	**SUBTOTAL**			**$220,000.00**
A.2	Line 2043 Area 1 OPTION A (LumpSum Pricing) per SOW				
A.2.a	Mobilization, Area 1	Lump Sum	1	$50,000.00	$50,000.00
A.2.b	ROW Site Clearing, Site Preparation and Rough Grading as necessary	Lump Sum	1	$15,000.00	$15,000.00
A.2.c	All activities to remove existing L2043 approximately 134 feet +/-5%, including excavation, removal, cutting, wrapping ends, stacking,and loading	Lump Sum	1	$50,000.00	$50,000.00
A.2.d	All materials and activities to cap remaining sections of L2043 prior to installation of replacment section.	Lump Sum	1	$20,000.00	$20,000.00
A.2.e	Fabricate approximately 209 feet +/- 5% of 10"L2043	Lump Sum	1	$30,000.00	$30,000.00
A.2.f	Fabricate Buena Vista Meter Tie In assembly	Lump Sum	1	$20,000.00	$20,000.00
A.2.g	All activites to install approximately feet +/-5% pf 10" line, including but not limited to excavation, stringing, welding,	Lump Sum	1	$100,000.00	$100,000.00
A.2.h	All activites to install Buena Vista Meter tie in assembly including but not limited to excavation, coating, welding, removal and demolition of existing assembly as required, partial removal and repair of existing wall if required.	Lump Sum	1	$50,000.00	$50,000.00
A.2.i	FBE Coating weld joints, L2043	Lump Sum	1	$10,000.00	$10,000.00
A.2.j	FBE Coating weld joints and uncoated sections of Buena Vista Meter Tie In Assembly	Lump Sum	1	$10,000.00	$10,000.00
A.2.k	L2043 Hydrotesting (8hour post installation test)	Lump Sum	1	$20,000.00	$20,000.00
A.2.l	Buena Vista Meter tie in assembly Hydrotesting (8 hour post installation test)	Lump Sum	1	$20,000.00	$20,000.00
A.2.m	All activities to backfill	Lump Sum	1	$20,000.00	$20,000.00
A.2.n	All activities to tie in replaced section to mainline, excavation, pipe supports, support COMPANY welders	Lump Sum	1	$35,000.00	$35,000.00
A.2.o	All activities to dewater Area 1, if required	Lump Sum	1	$55,000.00	$55,000.00
A.2.p	Cleanup	Lump Sum	1	$10,000.00	$10,000.00
A.2.q	Reseeding, if required	Acre	0.25	$1,000.00	$250.00
A.2.r	Providing 1-1/2" crushed rock gravel, and applying 2 inches thick as required	Square Foot	10,000	$2.50	$25,000.00
	Demobilization Areas 2, 3, 4	Lump Sum	1	$50,000.00	$50,000.00
A.2.s	**SUBTOTAL FOR AREA 1 OPTION A**	**SUBTOTAL**			**$590,250.00**
A.2	Line 2043 Area 1 OPTION B (LumpSum Pricing) per SOW				

EXHIBIT C WRITABLE SCHEDULE OF VALUES

Item	Description	Unit of Measure	* Estimated Quantity	Contract Unit Price w/o Tax	Total Estimated Amount
A.2.a	Mobilization, Area 1	Lump Sum	1	$50,000.00	$50,000.00
A.2.b	ROW Site Clearing, Site Preparation and Rough Grading as necessary	Lump Sum	1	$22,500.00	$22,500.00
A.2.c	All activities to remove existing L2043 approximately 134 feet +/-5%, including excavation, removal, cutting, wrapping ends, stacking,and loading	Lump Sum	1	$35,000.00	$35,000.00
A.2.d	All materials and activities to cap remaining sections of L2043 prior to installation of replacment section.	Lump Sum	1	$15,000.00	$15,000.00
A.2.e	Fabricate approximately 209 feet +/- 5% of 10"L2043	Lump Sum	1	$30,000.00	$30,000.00
A.2.f	Fabricate Buena Vista Meter Tie In assembly	Lump Sum	1	$25,000.00	$25,000.00
A.2.g	All activites to install approximately feet +/-5% pf 10" line, including but not limited to excavation, stringing, welding,	Lump Sum	1	$130,000.00	$130,000.00
A.2.h	All activites to install Buena Vista Meter tie in assembly including but not limited to excavation, coating, welding, removal and demolition of existing assembly as required, partial removal and repair of existing wall if required.	Lump Sum	1	$45,000.00	$45,000.00
A.2.i	FBE Coating weld joints, L2043	Lump Sum	1	$10,000.00	$10,000.00
A.2.j	FBE Coating weld joints and uncoated sections of Buena Vista Meter Tie In Assembly	Lump Sum	1	$10,000.00	$10,000.00
A.2.k	L2043 Hydrotesting (8hour post installation test)	Lump Sum	1	$20,000.00	$20,000.00
A.2.l	Buena Vista Meter tie in assembly Hydrotesting (8 hour post installation test)	Lump Sum	1	$20,000.00	$20,000.00
A.2.m	All activities to backfill	Lump Sum	1	$20,000.00	$20,000.00
A.2.n	All activities to tie in replaced section to mainline, excavation, pipe supports, support COMPANY welders	Lump Sum	1	$20,000.00	$20,000.00
A.2.o	All activities to dewater Area 1, if required	Lump Sum	1	$60,000.00	$60,000.00
A.2.p	Cleanup	Lump Sum	1	$10,000.00	$10,000.00
A.2.q	Reseeding, if required	Acre	0.25	$1,000.00	$250.00
A.2.r	Providing 1-1/2" crushed rock gravel, and applying 2 inches thick as required	Square Foot	10,000	$2.50	$25,000.00
	Demobilization Areas 2, 3, 4	Lump Sum	1	**$50,000.00**	$50,000.00
A.2.s	**SUBTOTAL FOR AREA 1 OPTION B**	**SUBTOTAL**			**$597,750.00**
A.3	**Line 2043 Area 2 (LumpSum Pricing) per SOW**				
A.3.a	ROW Site Clearing, Site Preparation and Rough Grading as necessary	Lump Sum	1	$15,000.00	$15,000.00
A.3.b	All activities to remove existing L2043 approximately 277 feet +/-5%, including excavation, removal, cutting, wrapping ends, stacking,and loading	Lump Sum	1	$80,000.00	$80,000.00
A.3.c	All materials and activities to cap remaining sections of L2043 prior to installation of replacment section.	Lump Sum	1	$45,000.00	$45,000.00
A.3.d	Fabricate approximately 310 feet +/- 5% of 12" L2043	Lump Sum	1	$30,000.00	$30,000.00
A.3.e	All activites to install approximately 310 feet +/-5% pf 10" line, including but not limited to excavation, stringing, welding,	Lump Sum	1	$80,000.00	$80,000.00
A.3.f	FBE Coating weld joints, L2043	Lump Sum	1	$10,000.00	$10,000.00
A.3.g	Shoring adjacent to retaining wall, approximately 200 feet +/-5%	Lump Sum	1	$80,000.00	$80,000.00
A.3.h	L2043 Hydrotesting (8hour post installation test)	Lump Sum	1	$20,000.00	$20,000.00
A.3.h.b	All activities to dewater Area 2, if required	Lump Sum	1	not provided	
A.3.i	All activities to backfill	Lump Sum	1	20000	$20,000.00
A.3.j	All activities to tie in replaced section to mainline, includin	Lump Sum	1	$50,000.00	$50,000.00
A.3.k	Cleanup	Lump Sum	1	$20,000.00	$20,000.00
A.3.l	Providing 1-1/2" crushed rock gravel, and applying 2 inches thick as required	Square Foot	9,000	$2.50	$22,500.00
A.3.m	**SUBTOTAL FOR AREA 2**	**SUBTOTAL**			**$472,500.00**

EXHIBIT C WRITABLE SCHEDULE OF VALUES

Item	Description	Unit of Measure	* Estimated Quantity	Contract Unit Price w/o Tax	Total Estimated Amount
	Line 2043 Area 3 (LumpSum Pricing) per SOW				
A.4.a	ROW Site Clearing, Site Preparation and Rough Grading as necessary	Lump Sum	1	$15,000.00	$15,000.00
A.4.b	All activities to remove existing L2043 approximately 74 feet +/-5%, including excavation, removal, cutting, wrapping ends, stacking,and loading	Lump Sum	1	$60,000.00	$60,000.00
A.4.c	All materials and activities to cap remaining sections of L2043 prior to installation of replacment section.	Lump Sum	1	$45,000.00	$45,000.00
A.4.d	Fabricate approximately 310 feet +/- 5% of 12" L2043	Lump Sum	1	$25,000.00	$25,000.00
A.4.e	All activites to install approximately 83 feet +/-5% pf 10" line, including but not limited to excavation, stringing, welding,	Lump Sum	1	$50,000.00	$50,000.00
A.4.f	FBE Coating weld joints, L2043	Lump Sum	1	$15,000.00	$15,000.00
A.4.g	Shoring adjacent to BNSF Track, approximately 95 feet +/-5%	Lump Sum	1	$80,000.00	$80,000.00
A.4.h	L2043 Hydrotesting (8hour post installation test)	Lump Sum	1	$20,000.00	$20,000.00
A.4.i	All activities to dewater Area 3, if required	Lump Sum	1	$50,000.00	$50,000.00
A.4.j	All activities to backfill	Lump Sum	1	$15,000.00	$15,000.00
A.4.k	All activities to tie in replaced section to mainline, includin	Lump Sum	1	$15,000.00	$15,000.00
A.4.l	Cleanup	Lump Sum	1	$15,000.00	$15,000.00
A.4.m	Providing 1-1/2" crushed rock gravel, and applying 2 inches thick as required	Square Foot	9,000	$2.50	$22,500.00
A.4.n	**SUBTOTAL FOR AREA 3**	**SUBTOTAL**			**$427,500.00**
	Line 2043 Area 4 (LumpSum Pricing) per SOW				
A.5.a	ROW Site Clearing, Site Preparation and Rough Grading as necessary, including bore pits	Lump Sum	1	$15,000.00	$15,000.00
A.5.b	All activities to remove existing L2043 approximately 100 feet +/-5%, including excavation, removal, grouting of casing, cutting, wrapping ends, stacking,and loading	Lump Sum	1	$85,000.00	$85,000.00
A.5.c	All materials and activities to cap remaining sections of L2043 prior to installation of replacment section.	Lump Sum	1	$20,000.00	$20,000.00
A.5.d	Fabricate approximately 140 feet +/- 5% of 12" L2043	Lump Sum	1	$20,000.00	$20,000.00
A.5.e	All activites to install approximately 70 feet +/-5% pf 10" line, including but not limited to excavation, stringing, welding,	Lump Sum	1	$80,000.00	$80,000.00
A.5.f	All activites to bore approximately 70 feet +/-5% pf 10" line, including but not limited to boring, stringing, welding.	Lump Sum	1	$80,000.00	$80,000.00
A.5.g	FBE Coating weld joints, L2043	Lump Sum	1	$10,000.00	$10,000.00
A.5.h	ARO/FBE Coating weld joints, L2043	Lump Sum	1	$10,000.00	$10,000.00
A.5.i	Shoring adjacent to BNSF Track, approximately 95 feet +/-5%	Lump Sum	1	$55,000.00	$55,000.00
A.5.j.a	L2043 Hydrotesting (8hour post installation test)	Lump Sum	1	$20,000.00	$20,000.00
A.5.j.b	Support culvert, to remain in place during construction	Lump Sum	1	$15,000.00	$15,000.00
A.5.k	All activities to dewater Area 4, if required	Lump Sum	1	$60,000.00	$60,000.00
A.5.l	All activities to backfill	Lump Sum	1	$15,000.00	$15,000.00
A.5.m	All activities to tie in replaced section to mainline, includin	Lump Sum	1	$15,000.00	$15,000.00
A.5.n	Cleanup	Lump Sum	1	$10,000.00	$10,000.00
A.5.o	Providing 1-1/2" crushed rock gravel, and applying 2 inches thick as required	Square Foot	3,000	$2.50	$7,500.00
A.5.p	**SUBTOTAL FOR AREA 4**	**SUBTOTAL**			**$517,500.00**
TOTAL	**LUMP SUM CONTRACT PRICE, w Area 1 Option A**				**$2,227,750.00**
TOTAL	**LUMP SUM CONTRACT PRICE, w Area 1 Option B**				**$2,235,250.00**
A.6	**Estimated Taxes***	**Estimated**		**7%**	**$155,942.50**
					$156,467.50

EXHIBIT C WRITABLE SCHEDULE OF VALUES

Item	Description	Unit of Measure	* Estimated Quantity	Contract Unit Price w/o Tax	Total Estimated Amount
A.7	Additional Work				$2,384,217.50
A.7.a	Foreign Pipeline crossings	Per crossing	12	$12,500.00	$150,000.00
A.7.b	Stand by rate for full crew	Per half day	0	$7,500.00	$0.00
A.7.c	Standby rate for minimum crew	Per half day	0	$5,500.00	$0.00
A.7.d	Rock Adder to standard 5' excavation	Per Linear Foot	0	$45.00	$0.00
A.7.e	Rock Adder to standard 15' excavation	Per Linear Foot	0	$100.00	$0.00
A.7.f	Additional excavation and pipe install–non rock excavatio	Per Linear Foot	0	$80.00	$0.00
A.7.g	Additional excavation and pipe install–non rock excavatio	Per Linear Foot	0	$130.00	$0.00
A.7.h	Rebevel Damaged Pipe and Fittings- CONTRACTOR shall provide all labor, equipment, and materials to re-bevel damaged pipe ends resulting from shipping. This does not include any damage found after the CONTRACTOR has accepted delivery of the pipe/fittings:	Per inch	0	$50.00	$0.00
A.7.i	Extra Welds- CONTRACTOR shall provide all labor, equipment, and materials for extra welds as directed by the Company Representative. Price includes all work to cut out weld, re-bevel pipe end, and weld. Extra welds resulting from CONTRACTOR damage or negligence are the CONTRACTOR's risk.	Per inch	0	$215.00	$0.00
A.7.j	Fill- Where additional fill is required and directed by Company Representative, CONTRACTOR shall furnish, haul, and install locally acceptable fill dirt for the access roads and site. Fill material must be approved by Company Representative prior to installation.	Per Cubic Yard	0	$90.00	$0.00
A.7.k	Padding- Where additional sand is required and directed by Company Representative, CONTRACTOR shall furnish, haul, and install (with 95% of Standard Proctor density compaction) sand for use as a fill material.	Per Cubic Yard	0	$90.00	$0.00
A.7.l	Where additional Bore length, exceeding 5% of 70' is requ	Per Linear Foot	0	$150.00	$0.00
A.7.m	Bollards - Where pipe bollards are required and directed by Company Representative, CONTRACTOR shall furnish, install, concrete fill and paint 4" diameter pipe bollards.	Each	1	$450.00	$0.00
	TOTAL BID- Area 1 Option A			WHC	**$2,227,750.00**
	TOTAL BID- Area 1 Option B			WHC	**$2,235,250.00**

START DATE OF March 1, 2016

Contractor: ____________________

Phone: ____________________

Fax: ____________________

Physical Address: ____________________

____

State of Incorporation: ____________________

Taxpayer ID Number: ____________________

EXHIBIT C WRITABLE SCHEDULE OF VALUES

Item	Description	Unit of Measure	* Estimated Quantity	Contract Unit Price w/o Tax	Total Estimated Amount

Bid Submitted by: ______________________________
(Signature)

Name and Title: ______________________________

Note: There will be no additional charge for delayed start if Company notifies Contractor to delay mobilization before initial mobilization commences. A delayed start will extend the completion date by the same amount of days.

** Estimates Taxes are to assist in determining the total evaluated cost of the project. All txes will be paid in accordance with Article 12 of the Agreement.*

KINDER MORGAN

Estimate Form Revision 8.3 (Draft) 02/10/16	TITLE:	L2020 Sonoita Ck Replacement
	Requested By:	Vickie Gibson
	Estimate # :	CE1602040
	Date:	02/26/16
	Prepared By:	Scheller
	Project Manger:	Vickie Gibson

KINDER MORGAN INC.

ENCROACHMENT APPLICATION

Applicant Information

Applicant Name/Company		Contact Name	Title	
Address		City	State	Zip Code
Telephone Number	Fax Number	Cellular Number	E-mail Address	
Applicant's Representative (contractor/consultant) Name		Contact Name	Title	
Address		City	State	Zip code
Telephone Number	Fax Number	Cellular Number	E-mail Address	
Landowner Name (if not applicant)			Landowner consent to works obtained? ☐ Yes ☐ No	

The Applicant hereby applies for permission to construct facilities or equipment under, over, near or crossing the pipeline or within the limits of the pipeline right-of-way under the jurisdiction of Kinder Morgan and in accordance with applicable government regulations. The proposed encroachment is as follows:

Installation Details

☐ Permanent ☐ Temporary | Installation duration if temporary (MM/DD/YY) Date from: Date to: | Roads and Parking Areas ☐ Gravel ☐ Pavement | Within legal highway load limits? If no, list axel load. ☐ Yes ☐ No

Underground Services
☐ Steel pipe/conduit Diameter: ☐ Plastic pipe/conduit Diameter: ☐ Concrete Yards: ☐ Power Voltage: ☐ Other | If steel, will cathodic protection be applied? ☐ Yes ☐ No

Overhead Services ☐ Power ☐ Communications | If power, please state voltage

Description of Encroachment and the construction procedures to be followed (attach extra pages as required to give full description)

Tentative construction date (MM/DD/YY)

Location of Encroachment (e.g. city, county, state road/street or legal description of property)

Please attach any maps, plans, profiles, KMZ files, etc. | Coordinates: GPS (Nad 83) Lat (y): Long (x):

Application Drawing(s) No. (or sketch)

This form constitutes an **APPLICATION ONLY.** The encroachment applied for shall not commence until approved by Kinder Morgan. The facilities or equipment must be constructed in accordance with the guidelines provided by Kinder Morgan.

Name of applicant or applicant's representative (PRINT) | Date (MM/DD/YY) | Signature of applicant or applicant's representative

KM use only

Reviewed by		Date Received (MM/DD/YY)	Date Approved (MM/DD/YY)
Pipeline/lateral name (e.g. 610)	KM/Mile Post #	Encroachment Number	Date Constructed (MM/DD/YY)

KINDER MORGAN

Estimate Form
Revision 8.3 (Draft)
02/10/16

TITLE:	L2020 Sonoita Ck Replacement
Requested By:	Vickie Gibson
Estimate # :	CE1602040
Date:	02/26/16
Prepared By:	Scheller
Project Manger:	Vickie Gibson

Scheller, Steven R (Steve)

From:	Paul Greenwell <PGreenwell@laneydrilling.com>
Sent:	Tuesday, March 15, 2016 1:06 PM
To:	Gibson, Vickie L
Subject:	RE: Rough cost estimate for two 4.5" HDDs

Vickie,

I would estimate that the drills need to be in the 500' range to get to a depth of 20' under the channel which was approx. 160 feet wide. I assumed the soils are jettable. So, I would allow $135.00 per foot ($67,500.00 each) plus a mobilization/de-mobilization cost of $58,000.00. If the soils are hard (un-jettable) which then would require a mud motor, or the gravel layer is really thick there would be an additional costs of $50.00 - $90.00 per foot.

I hope that helps.

Regards,

Paul Greenwell
Laney Directional Drilling Co
VP Estimating
Cell: **713-816-2002**
Office: **281-973-3341**
pgreenwell@laneydrilling.com

From: Gibson, Vickie L [mailto:Vickie_Gibson@kindermorgan.com]
Sent: Friday, March 11, 2016 9:38 AM
To: Paul Greenwell <PGreenwell@laneydrilling.com>
Subject: FW: Rough cost estimate for two 4.5" HDDs

Paul, David Zettlemoyer suggested that I contact you. We are considering whether an HDD or open cut would be the better option at two pipe replacement sections. We are in the cost estimating mode now, and the pipeline replacement would occur at the earliest in October 2016.

I was wondering if HDDs near Tucson would be cost effective. We will need to replace 4.5" pipe where two new creek relocations are proposed. The pipe will need to be a minimum 17.3 feet deep at the channel bottom width of 162 feet at Crossing 1 and 19.6 feet minimum at Crossing 2. We had estimated 260 feet and 320 feet of pipe for the replacement at Crossings 1 and 2, but that was before we realized we would need to be so deep. I have attached a copy of the soils report- clayey sand with gravel. This is not at the location of the current creek and ground water is not anticipated in the new location. Appreciate your help, if you could look at this and provide a very rough cost estimate to perform these two HDDs, we would really appreciate it. There is close access off of a paved roadway.

Paul, please let me know if you need any additional information, and I appreciate your help, Vickie

Vickie Gibson, PE, PMP
Project Manager

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KINDER MORGAN

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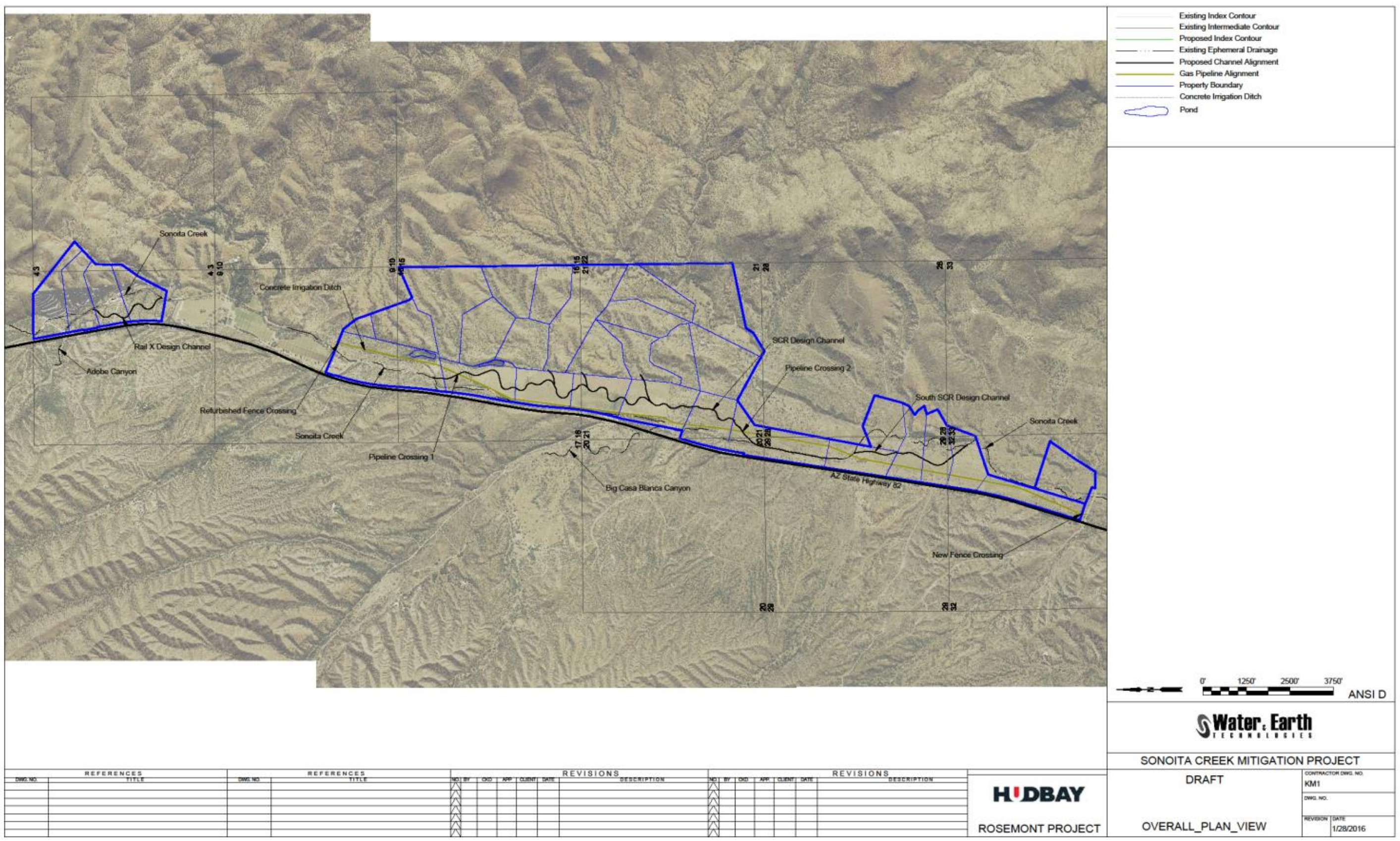
Project Manger:	Vickie Gibson



KINDER MORGAN

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TITLE:	L2020 Sonoita Ck Replacement
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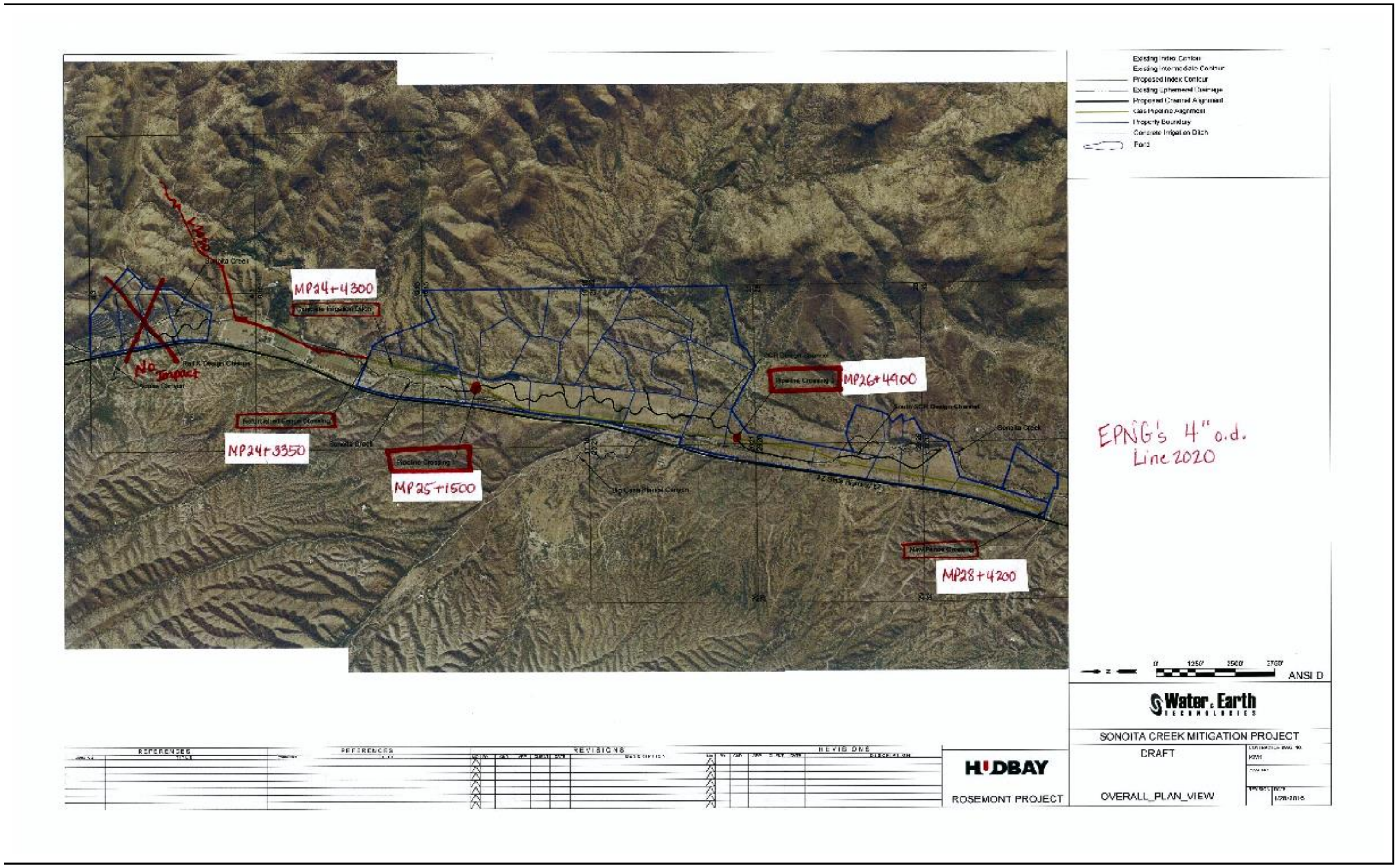
Project Manger:	Vickie Gibson



KINDER MORGAN

Estimate Form
Revision 8.3 (Draft)
02/10/16

TITLE:	L2020 Sonoita Ck Replacement
Requested By:	Vickie Gibson
Estimate # :	CE1602040
Date:	02/26/16
Prepared By:	Scheller
Project Manger:	Vickie Gibson

Scheller, Steven R (Steve)

From: Sims, Kelley B (Kelley)
Sent: Monday, February 29, 2016 11:27 AM
To: Gibson, Vickie L; Scheller, Steven R (Steve)
Subject: RE: Cost Estimate Scoping Meeting L2020 MP 26+4900 and MP 25+1500 replacement lowering due to Rosemont Copper Mine moving Sonita Creek to historic location

Vickie / Steve,
I have a project field visit tomorrow that will probably interfere with my ability to attend this call. I don't believe there will be any land issues or land costs since this is an Owner-driven project. The ROW is 30' wide, and I see no problem acquiring an extra 20' of workspace from the property owner, in whatever configuration is needed, to give us a combined workspace of 50'. Let me know if you have any other questions for me.
Kelley

-----Original Appointment-----
From: Gibson, Vickie L
Sent: Friday, February 26, 2016 11:16 AM
To: Scheller, Steven R (Steve); Schafer Jr, Ronald D; Cantrell, Donald G (Don); Kimbell, Randon L (Randy); Sims, Kelley B (Kelley); Blythe, Amy M (Amy); Hann, Laurie L
Subject: Cost Estimate Scoping Meeting L2020 MP 26+4900 and MP 25+1500 replacement lowering due to Rosemont Copper Mine moving Sonita Creek to historic location
When: Tuesday, March 01, 2016 1:30 PM-2:30 PM (UTC-07:00) Mountain Time (US & Canada).
Where: COS.CSB.0713 and Conf call

Cost Estimate Scoping Meeting L2020 MP 26+4900 and MP 25+1500 replacement lowering due to Rosemont Copper Mine moving Sonita Creek to historic location. Attached are dwgs from Water & Earth Technologies that show details of the proposed creek realignment. Form 1200-07 has been submitted. The Design Engineer is working on providing photos. Hope you will be able to attend the meeting, thanks Vickie 7619-520-4205

<< File: CER L2020 Sonoita Ck crossings.xls >> << File: Encroachment Application MASTER 03-11-15.pdf >> << File: Sonoita Creek Relocation WET Plan Sheets (KS notes) 02-09-16.pdf >> << File: OM1200-07a.docx >> << File: 02020.00-005.00.pdf >>

Join online meeting
https://meet.lync.com/kindermorgan/vickie_gibson/M54GCGP2

Join by Phone
Toll-free number: +1 (866) 715-6499
Toll number: +1 (719) 325-2776
Find a local number

Participant code: 4859647

First online meeting?

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KINDER MORGAN

Estimate Form
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02/10/16

TITLE: L2020 Sonoita Ck Replacement

Requested By:	Vickie Gibson
Estimate # :	CE1602040
Date:	02/26/16
Prepared By:	Scheller
Project Manger:	Vickie Gibson

Project: Line 2020 - Replace & Lower 2 Segments @ MP 25 & 26, Santa Cruz County, AZ
date: 3/3/2016 **cost estimate number:**

Project Activity	Basic Costs per Unit	Units Description	# of units	Empirical Estimate ($1,000s)	Direct Entry ($1,000s)	Project Estimate ($1,000s)	Comments
		total project miles:					Regulatory Determination = Blanket automatic Land Ownership = Private Lands Temporary Workspace is required
PRE-CONSTRUCTION							
FERC & NEPA Process							
Prepare for FERC Pre-Filing request (incl desk-top study)	20K + 0.3K/mile	enter "1" if required:		0		0	
Project Plan/Regulatory Strategy	5K/state & 0.03K/mi	**enter # of states:**		0		0	
Resource Reports	50K + 1.2K/mi	enter "1" if required:		0		0	
EHS Contract Support	15K/mo	enter number of months		0		0	
Data Requests	30% of RR cost	enter "1" if required:		0		0	
NEPA: third party EIS (for >100 miles)	0.9X cost of RR	enter "1" if required:		0		0	
NEPA: third party EIS contracting	15K	enter "1" if required:		0		0	
Applicant-prepared Draft EA	15% X cost of RR	enter "1" if required:		0		0	
NEPA: POD for BLM	20K	enter "1" if required:		0		0	
NEPA: Public meetings	10% of EIS	enter "1" if required:		0		0	
FERC Implementation Plan and construction filing support (e.g., NTP requests)	15% X cost of RR	enter "1" if required:		0		0	
KM Env Dept internal labor		direct entry of estimate for phase				0	
KM Env Dept travel/expenses		direct entry of estimate for phase				0	
FERC & NEPA Process subtotal:				0		0	
Field Surveys							
Cultural Surveys (w/o line changes) - includes reports & clearance	$3K/mi surveyed *(not total project mileage)* & 4K	enter number of miles expected to survey:		0		0	Hudbay Minerals has conducted surveys of entire area
Cultural Surveys increase due to changes/extra mobilizations (can add up to 75%)	add chosen % to above	enter *percent* (not decimal value) to add to above value:		0		0	
Cultural: Access roads	$82/mile	enter number of miles		0		0	
Cultural: CS	8K/location	number of locations		0		0	NA
Cultural: contractor yards	120/acre	number of acres		0		0	
Cultural: Indian Lands Issues/THPO clearance	add 15% to above	enter "1" if Indian lands:		0		0	NA
Cultural: Deep Testing (highly variable)	3K/trench	enter # of trenches		0		0	NA
Cultural: Phase II	assume 10% of original cultural cost	enter "1" to include:		0		0	
Cultural: Phase III	NA		avoidance assumed			0	
T&E Surveys (original) - includes clearance --does *NOT include specialty surveys*	1.7K/mi & 4K	enter expected survey mileage:		0		0	Hudbay Minerals has conducted surveys of entire area
T&E Surveys increase due tochanges/extra mobilizations (can add up to 75%)	add chosen % to above	enter *percent* (not decimal value) to add to above value:		0		0	
T&E: Access roads	$1,000/mile	enter number of miles		0		0	
T&E: CS	350/acre	number of acres		0		0	number of sites @ acres each
T&E: contractor yards	350/acre	number of acres		0		0	number of sites____ @ _____ acres each
Specialty biol surveys - See green tab	from "Specialty Biol Surveys" tab	from "Specialty Biol Surveys" tab		0		0	Construction will be conducted OUTSIDE of the breeding season
Develop Mitigation Plans (i.e., not implementation; incl wetlands, birds...)	from "Mitigation" tab	from "Mitigation" tab		0		0	
Wetland Surveys and delineations (original)	4K/mi & 5K	enter expected survey mileage:		0		0	
Wetlands increase due to changes and extra mobilizations (typically, add on 75%)	add chosen % to above	enter *percent* (not decimal value) to add to above value:		0		0	
Noise Surveys (pre-construction CS and HDD)	10K/location	enter # of CS and HDD locations near NSAs:		0		0	
Paleo surveys	direct entry	direct entry:				0	
Field Surveys subtotal:				0		0	

Detailed Environmental Acct Categories used for scope changes, inspection, wetland itigation, MBT mitigation, 3rd party compliance monitoring..., rather than the Generalized 457 Acct Category for all environmental activities

Sum of Project Estimate ($1,000s)	
DetailedAcct Category	Total
00100	0
00200	2
00414	23
00800	0
50500	0
50501	0
50502	0
50503	0
50504	0
50505	0
50506	0
50507	0
50508	0
50510	0
Grand Total	**25**

KINDER MORGAN

Estimate Form
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02/10/16

TITLE:	L2020 Sonoita Ck Replacement
Requested By:	Vickie Gibson
Estimate # :	CE1602040
Date:	02/26/16
Prepared By:	Scheller
Project Manger:	Vickie Gibson

Scheller, Steven R (Steve)

From:	Blythe, Amy M (Amy)
Sent:	Thursday, March 03, 2016 4:34 PM
To:	Gibson, Vickie L; Scheller, Steven R (Steve)
Cc:	Nielson, Jeffrey G (Jeff); Sims, Kelley B (Kelley)
Subject:	Line 2020 - Replace & Lower Two Segments, Santa Cruz Co., AZ - Env. Permitting cost estimate
Attachments:	L2020 Rep & Lower Project - Env. Permitting Cost Estimate.xlsm

Dear Team,

I spoke with Kim Proctor with Hudbay Minerals and she confirmed the following:
1. Complete biological and cultural survey coverage
2. **No reseeding/restoration required** – they will handle that when their project is completed
3. If our workspace gets into the active channel of Sonoita creek, we can use a Nationwide Permit
4. Shallow ground water will not be an issue
5. No floodplain permit required

Thanks a bunch,

Amy

KINDER MORGAN

Amy Blythe
Environmental Specialist
Two North Nevada Ave
Colorado Springs, CO 80903
719.520.4813 or 575.644.3336
(Child Ambassador – www.worldvision.org)

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KINDER MORGAN

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02/10/16

TITLE:	L2020 Sonoita Ck Replacement
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Date:	02/26/16
Prepared By:	Scheller
Project Manger:	Vickie Gibson

Rawhide LEASING

BILL TO:
El Paso Natural Gas Co. - Kinder Morgan
Tucson Station
8787 N. Pump Station Road
Marana, AZ 85653

INVOICE NO: 17123
DATE: 12/4/2015

SHIP DATE:

FOB: ORIGIN

Vendor Number:

Customer ID	Customer PO	Payment Terms	Due Date
Line - Acct Coding:		Net 30 Days	1/3/2016

Quantity	Item	Description	Unit Price	Extension
	Work Directive # -		Agreement #	
	Patagonia Job			
	Arrive @ job site 11/22 - mobilize and start gas flow 11/23 - de-mobilize and depart 11/24			
	Rental 10 each 3500 psi Cylinders & Regulators			$450.00
	Rental CNG Trailer # 911-55			$3,500.00
	Rental One each RT Regulator Trailer			$1,700.00
	CNG Trailer Transportation - 440 miles R/T @ $3.50/miles			$1,540.00
	Return CNG Trailer to PHX			$1,540.00
	Technician Transportation with RT-30 - 440 miles @ $1.79/mile			$787.60
	Technician Services: Two days @ job site @ $1,700/day			$3,400.00
	CNG - 911-55	Start 2300 psi - finish 2100 psi usage - 9,363 scf @ $2.75/100 scf		$257.48
	CNG - 10 CNG Cylinders - 3,000 scf @ $2.75/100 scf			$82.50
			Subtotal	$13,257.58
			Sales Tax	$0.00
			TOTAL	$13,257.58

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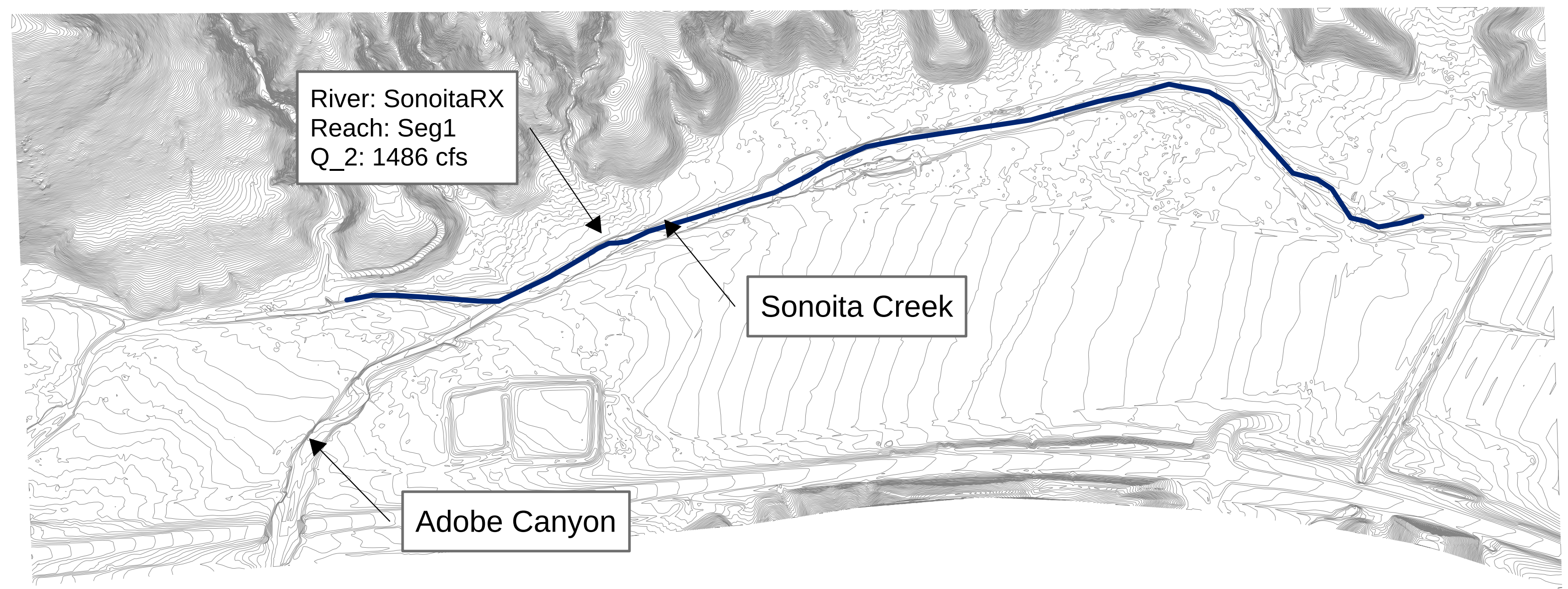
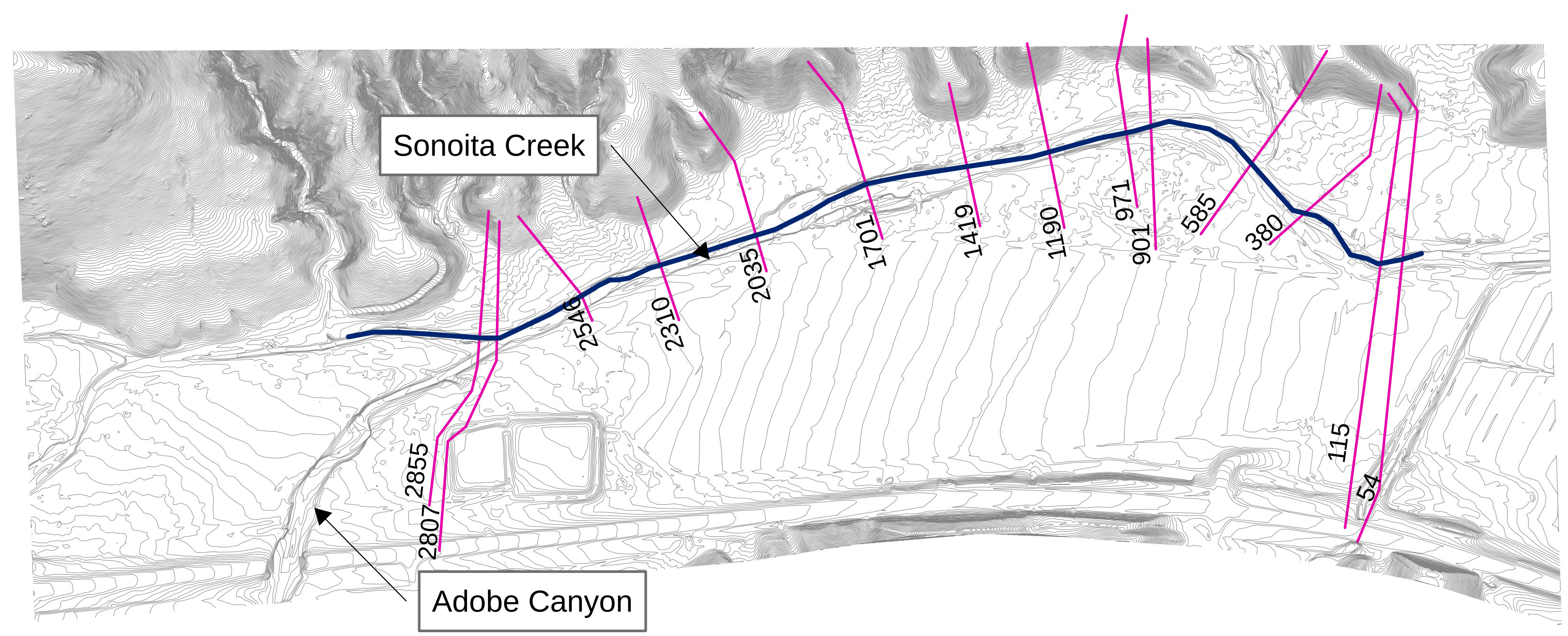
Appendix J

Existing Sonoita Creek Hydraulic Modeling

1. Existing Sonoita At Rail X Hydraulic Modeling Schematic (HEC-RAS)
2. Rail X Existing – 2-Year, 24-Hour Storm
3. Existing Sonoita At SCR Hydraulic Modeling Schematic (HEC-RAS)
4. Existing Sonoita At SCR – 2-Year, 24-Hour Storm





Water & Earth TECHNOLOGIES

LEGEND

Channel Centerlines

SonoitaRX Cross Section

NOT FOR CONSTRUCTION

SCALE

0 500 1,000 ft

EXISTING SONOITA AT RAIL X
HYDRAULIC MODELING
SCHEMATIC (HEC-RAS)

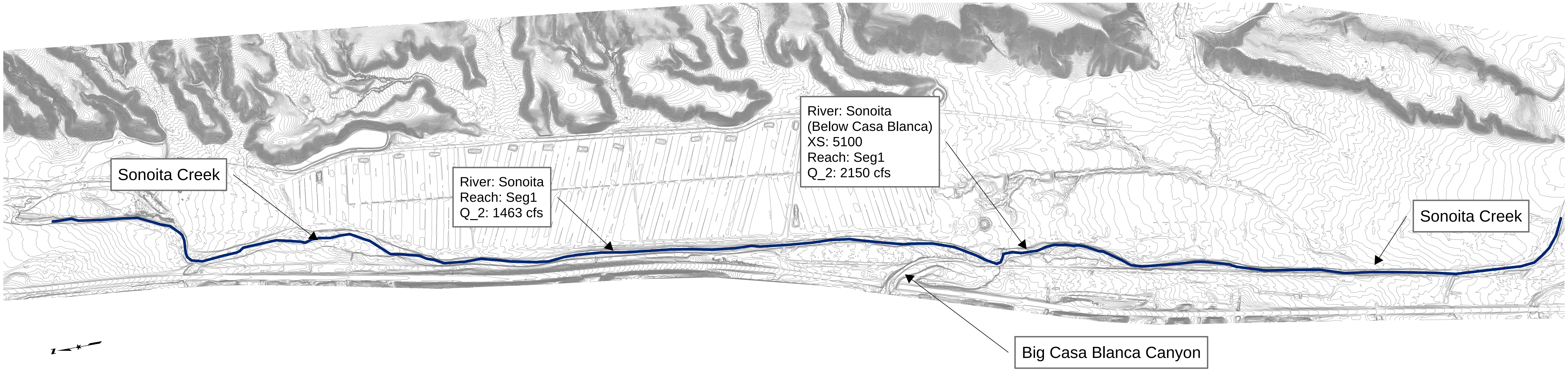
DATE

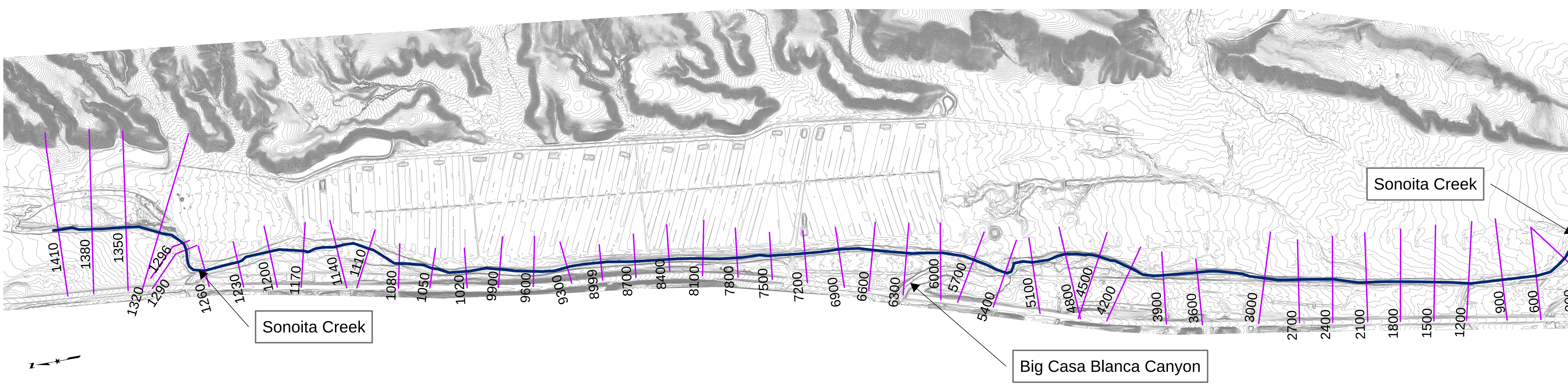
09/08/17

APPENDIX J
EXHIBIT 1

HEC-RAS Plan: RXOnly River: SonoitaRX Reach: Seg1 Profile: 2-yr_24-hr

Reach	River Sta	Profile	Q Total	Frctn Slope	Vel Chnl	Top Width	Hydr Depth C	Froude # Chl	Shear Chan	Flow Area Ch
			(cfs)	(ft/ft)	(ft/s)	(ft)	(ft)		(lb/sq ft)	(sq ft)
Seg1	2855.257	2-yr_24-hr	1486.00	0.006324	5.01	135.91	2.18	0.60	0.67	296.76
Seg1	2807.446	2-yr_24-hr	1486.00	0.010563	6.40	109.71	2.12	0.78	1.11	232.11
Seg1	2546.144	2-yr_24-hr	1486.00	0.009528	7.94	101.90	2.03	0.98	1.73	185.53
Seg1	2310.842	2-yr_24-hr	1486.00	0.009067	5.54	210.42	1.95	0.70	0.85	213.05
Seg1	2035.615	2-yr_24-hr	1486.00	0.010276	6.50	239.30	1.64	0.89	1.24	221.27
Seg1	1701.589	2-yr_24-hr	1486.00	0.009701	5.92	212.93	1.82	0.77	0.99	249.41
Seg1	1419.66	2-yr_24-hr	1486.00	0.011257	6.60	187.61	1.84	0.86	1.23	221.64
Seg1	1190.321	2-yr_24-hr	1486.00	0.009274	6.21	289.79	1.56	0.87	1.15	219.17
Seg1	971.7001	2-yr_24-hr	1486.00	0.009033	5.53	321.83	1.85	0.72	0.86	265.18
Seg1	901.6521	2-yr_24-hr	1486.00	0.011397	6.19	475.39	1.63	0.85	1.13	232.70
Seg1	585.9259	2-yr_24-hr	1486.00	0.016063	6.15	218.86	1.55	0.87	1.13	235.40
Seg1	380.9229	2-yr_24-hr	1486.00	0.008830	6.42	325.57	0.98	1.14	1.44	112.13
Seg1	115.2044	2-yr_24-hr	1486.00	0.005909	4.34	770.54	1.86	0.56	0.53	155.49
Seg1	54.5212	2-yr_24-hr	1486.00		5.38	790.73	1.71	0.73	0.84	158.95





Water & Earth TECHNOLOGIES

LEGEND

Channel Centerlines

Sonoita Cross Section

NOT FOR CONSTRUCTION

SCALE

0 850 1,700 ft

EXISTING SONOITA AT SCR
HYDRAULIC MODELING
SCHEMATIC (HEC-RAS)

DATE

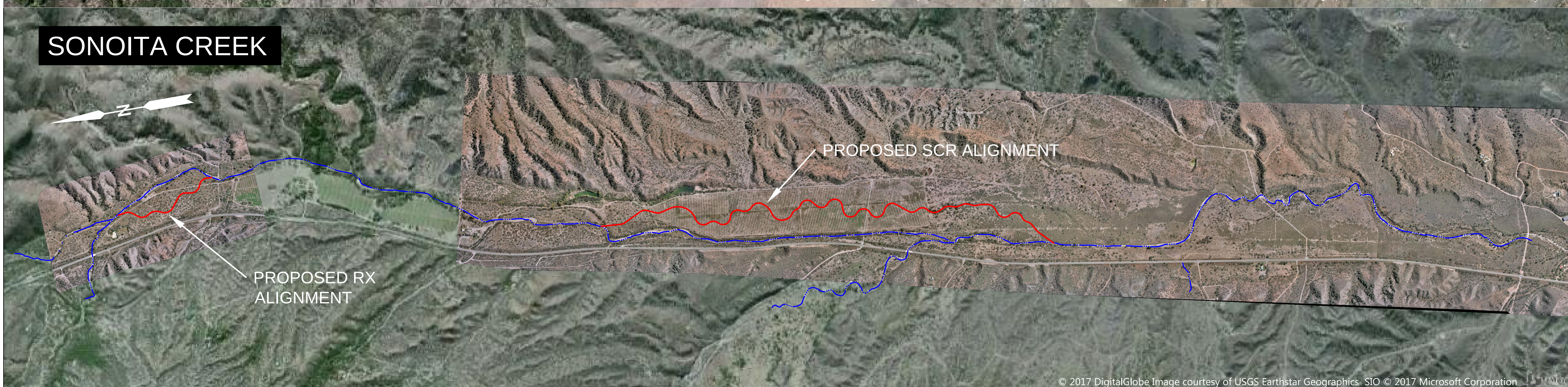
09/08/17

APPENDIX J
EXHIBIT 2

HEC-RAS Plan: Plan 01 River: Sonoita Reach: Seg1 Profile: 2_YR

Reach	River Sta	Profile	Q Total	Frctn Slope	Vel Chnl	Top Width	Hydr Depth C	Froude # Chl	Shear Chan	Flow Area Ch
			(cfs)	(ft/ft)	(ft/s)	(ft)	(ft)		(lb/sq ft)	(sq ft)
Seg1	14100	2_YR	1463.00	0.009029	7.94	50.80	3.63	0.74	1.44	184.20
Seg1	13800	2_YR	1463.00	0.009870	10.05	47.04	3.09	1.01	2.43	145.56
Seg1	13500	2_YR	1463.00	0.009268	6.92	233.15	2.57	0.76	1.22	194.69
Seg1	13200	2_YR	1463.00	0.011689	6.80	115.94	1.86	0.88	1.31	215.17
Seg1	12967.51	2_YR	1463.00	0.010906	6.42	139.52	1.63	0.88	1.21	228.03
Seg1	12900	2_YR	1463.00	0.011648	6.09	137.79	1.74	0.81	1.07	240.06
Seg1	12600	2_YR	1463.00	0.010553	7.40	109.25	1.81	0.97	1.56	197.81
Seg1	12300	2_YR	1463.00	0.010701	6.60	98.75	2.24	0.78	1.16	221.52
Seg1	12000	2_YR	1463.00	0.010750	7.47	109.27	1.79	0.98	1.59	195.86
Seg1	11700	2_YR	1463.00	0.011176	5.20	181.45	1.55	0.74	0.81	281.46
Seg1	11400	2_YR	1463.00	0.007752	6.78	148.66	1.45	0.99	1.41	215.91
Seg1	11100	2_YR	1463.00	0.007548	4.38	176.77	1.89	0.56	0.54	334.39
Seg1	10800	2_YR	1463.00	0.008009	8.22	85.64	2.08	1.01	1.85	177.91
Seg1	10500	2_YR	1463.00	0.006996	6.19	78.84	3.00	0.63	0.93	236.43
Seg1	10200	2_YR	1463.00	0.011132	8.83	54.63	3.03	0.89	1.88	165.72
Seg1	9900	2_YR	1463.00	0.010070	8.77	62.90	2.65	0.95	1.94	166.81
Seg1	9600	2_YR	1463.00	0.009469	7.47	73.63	2.66	0.81	1.40	195.97
Seg1	9300	2_YR	1463.00	0.009889	8.69	58.80	2.86	0.90	1.85	168.42
Seg1	8999.999	2_YR	1463.00	0.008365	8.03	64.30	2.83	0.84	1.59	182.08
Seg1	8700	2_YR	1463.00	0.009317	7.79	60.16	3.12	0.78	1.45	187.79
Seg1	8400	2_YR	1463.00	0.010501	9.31	53.13	2.96	0.95	2.11	157.20
Seg1	8100	2_YR	1463.00	0.008344	8.40	59.10	2.95	0.86	1.71	174.23
Seg1	7800	2_YR	1463.00	0.009564	6.96	78.71	2.67	0.75	1.22	210.07
Seg1	7500	2_YR	1463.00	0.008350	9.33	56.99	2.75	0.99	2.17	156.78
Seg1	7200	2_YR	1463.00	0.008211	6.91	66.87	3.16	0.68	1.13	211.63
Seg1	6900	2_YR	1463.00	0.010844	9.52	51.36	2.99	0.97	2.21	153.60
Seg1	6600	2_YR	1463.00	0.011346	8.58	55.78	3.06	0.86	1.77	170.61
Seg1	6300	2_YR	1463.00	0.003556	8.56	74.25	2.30	0.99	1.93	170.94
Seg1	6000	2_YR	1463.00	0.003716	2.17	305.55	1.45	0.32	0.14	183.40
Seg1	5700	2_YR	1463.00	0.006290	6.74	153.18	1.42	1.00	1.41	217.00
Seg1	5400	2_YR	1463.00	0.005849	4.02	169.51	2.13	0.49	0.44	150.14
Seg1	5100	2_YR	2150.00	0.007357	9.15	70.73	3.32	0.89	1.96	234.89
Seg1	4800	2_YR	2150.00	0.008384	6.09	133.50	2.65	0.66	0.93	353.23
Seg1	4500	2_YR	2150.00	0.008862	8.77	100.43	2.44	0.99	1.99	245.03
Seg1	4200	2_YR	2150.00	0.008442	6.47	123.13	2.70	0.69	1.05	332.15
Seg1	3900	2_YR	2150.00	0.007732	10.02	65.53	3.27	0.98	2.36	214.51
Seg1	3600	2_YR	2150.00	0.007755	7.00	95.68	3.40	0.67	1.14	306.53
Seg1	3000	2_YR	2150.00		10.35	60.97	3.41	0.99	2.48	207.76
Seg1	2700	2_YR	2150.00	0.009799	9.55	131.42	3.60	0.89	2.08	222.91
Seg1	2400	2_YR	2150.00	0.006587	6.00	643.69	1.67	0.82	1.05	207.20
Seg1	2100	2_YR	2150.00	0.001992	3.09	633.79	1.11	0.52	0.32	169.33
Seg1	1800	2_YR	2150.00	0.002621	1.75	606.08	1.39	0.26	0.10	215.92
Seg1	1500	2_YR	2150.00	0.002776	9.60	76.80	2.92	0.99	2.24	223.97
Seg1	1200	2_YR	2150.00	0.001523	1.71	566.52	1.27	0.27	0.09	156.58
Seg1	900.0001	2_YR	2150.00	0.004288	2.45	817.81	1.46	0.36	0.18	219.60
Seg1	600	2_YR	2150.00	0.011970	6.33	247.51	1.37	0.95	1.25	339.84
Seg1	300	2_YR	2150.00		4.91	659.19	1.25	0.78	0.78	278.49

EXHIBITS



0' 2000' 4000' 6000'

Legend	Date
	09/08/17

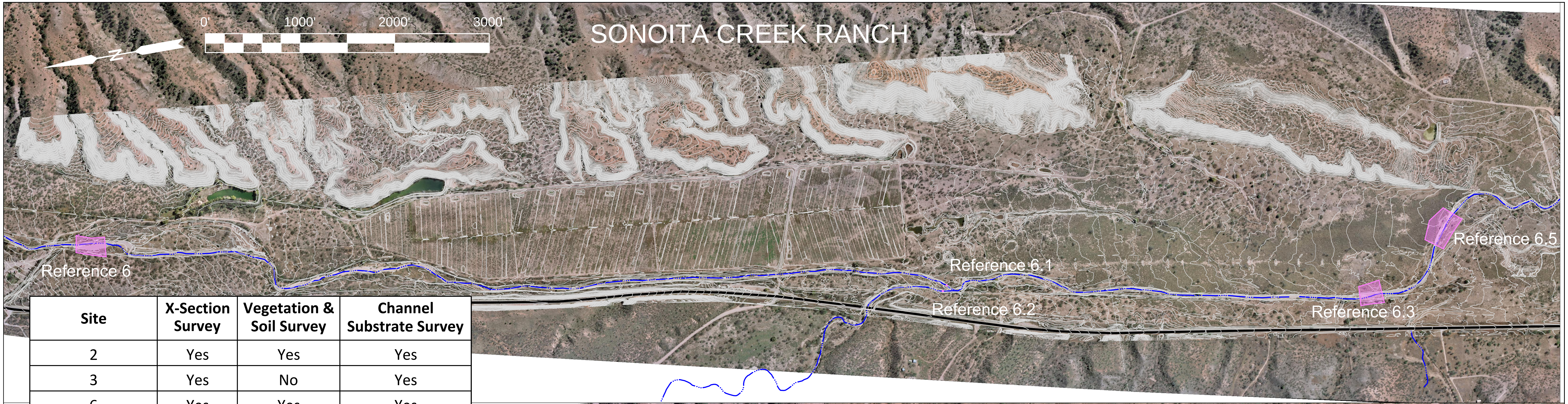
E:\WORK\A626.1-Rosemont-Fill In Sonoita\ACAD\Deliverable DWGS\Report Exhibit 1- walnut gulch vs sonoita.dwg

Water & Earth TECHNOLOGIES

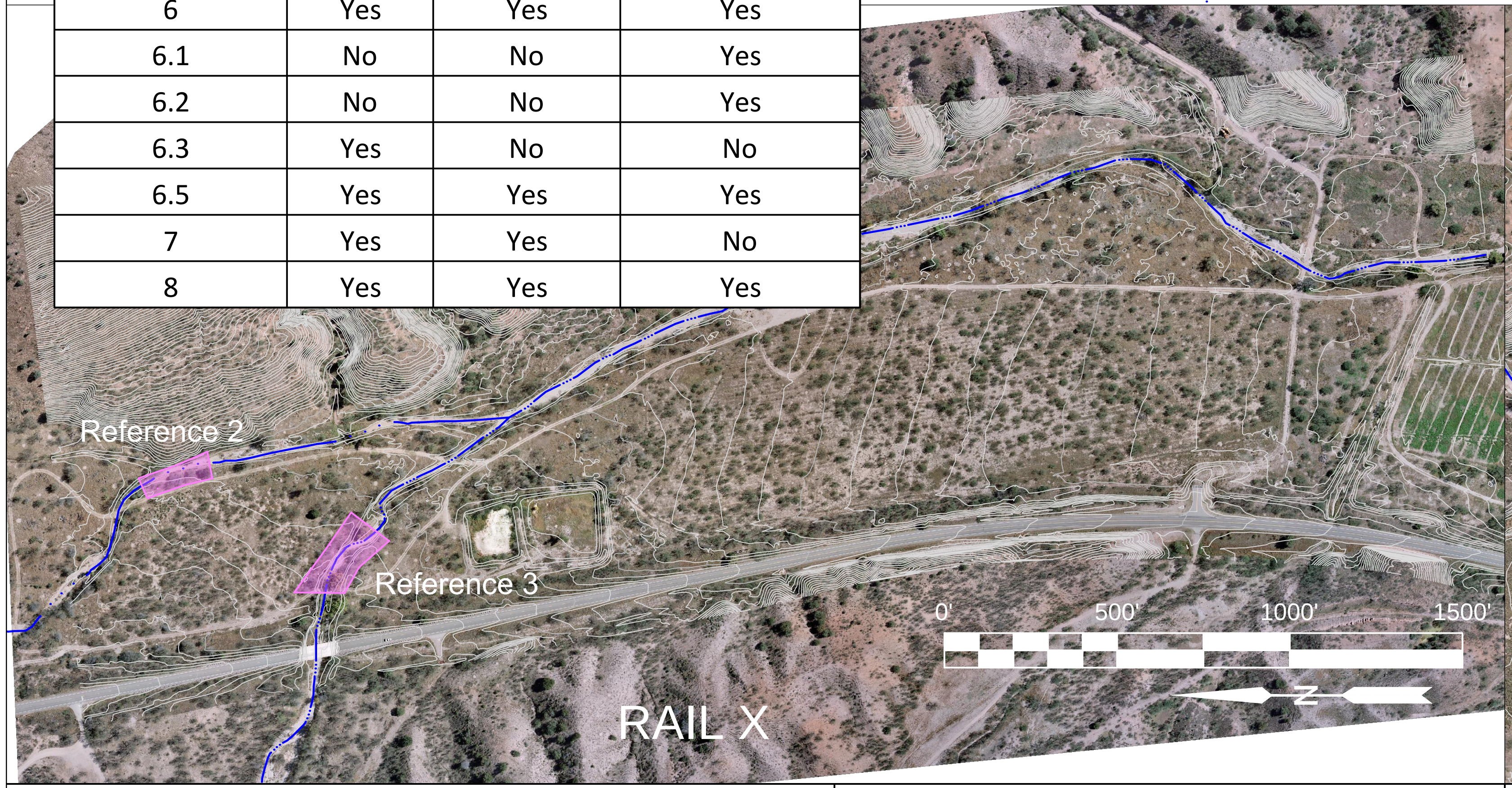
NOT FOR CONSTRUCTION

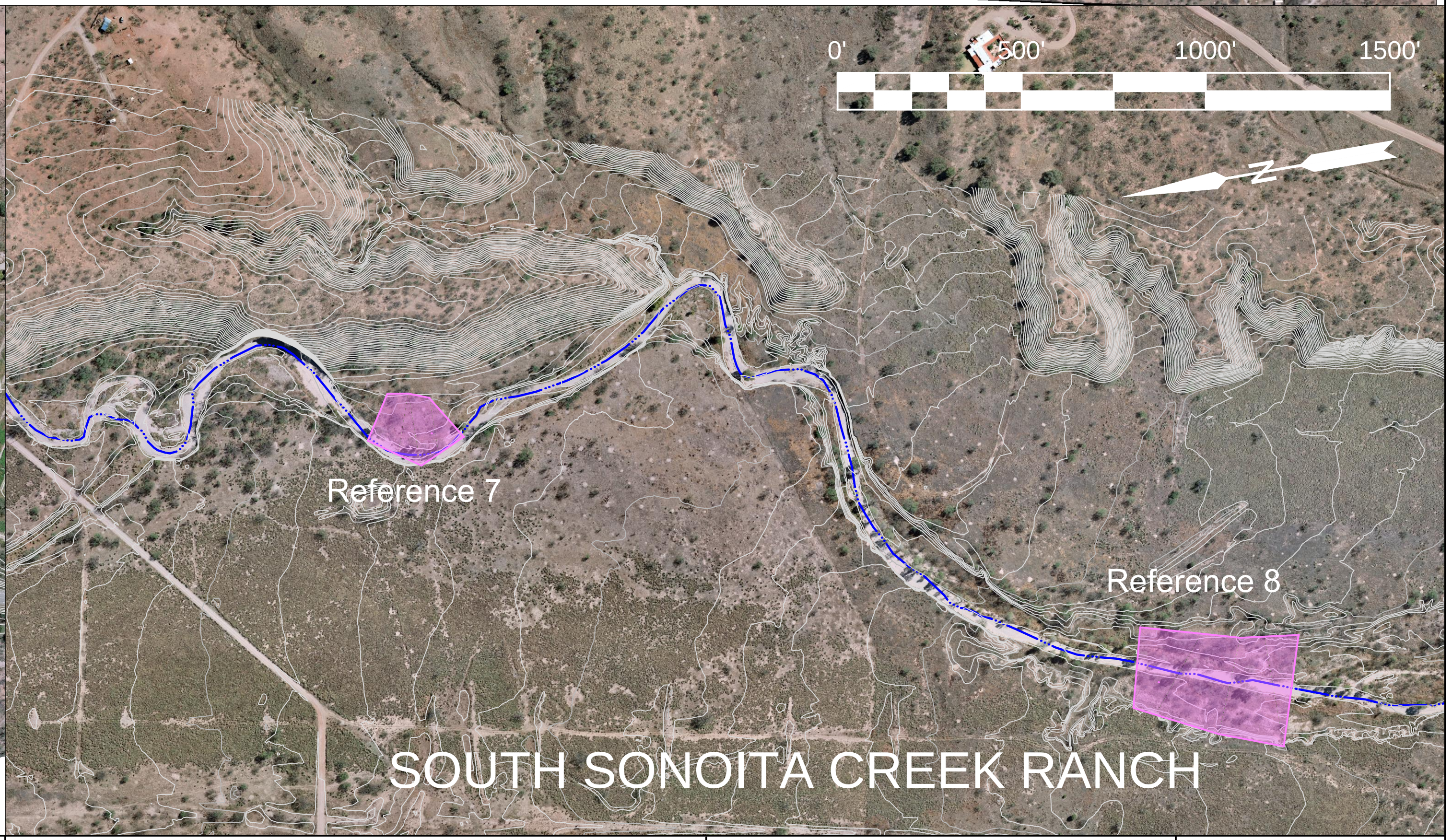
WALNUT GULCH & SONOITA CREEK COMPARISON

EXHIBIT 1



Site	X-Section Survey	Vegetation & Soil Survey	Channel Substrate Survey
2	Yes	Yes	Yes
3	Yes	No	Yes
6	Yes	Yes	Yes
6.1	No	No	Yes
6.2	No	No	Yes
6.3	Yes	No	No
6.5	Yes	Yes	Yes
7	Yes	Yes	No
8	Yes	Yes	Yes





CONTOUR INTERVAL: 2 FEET

Legend

Date
09/08/17

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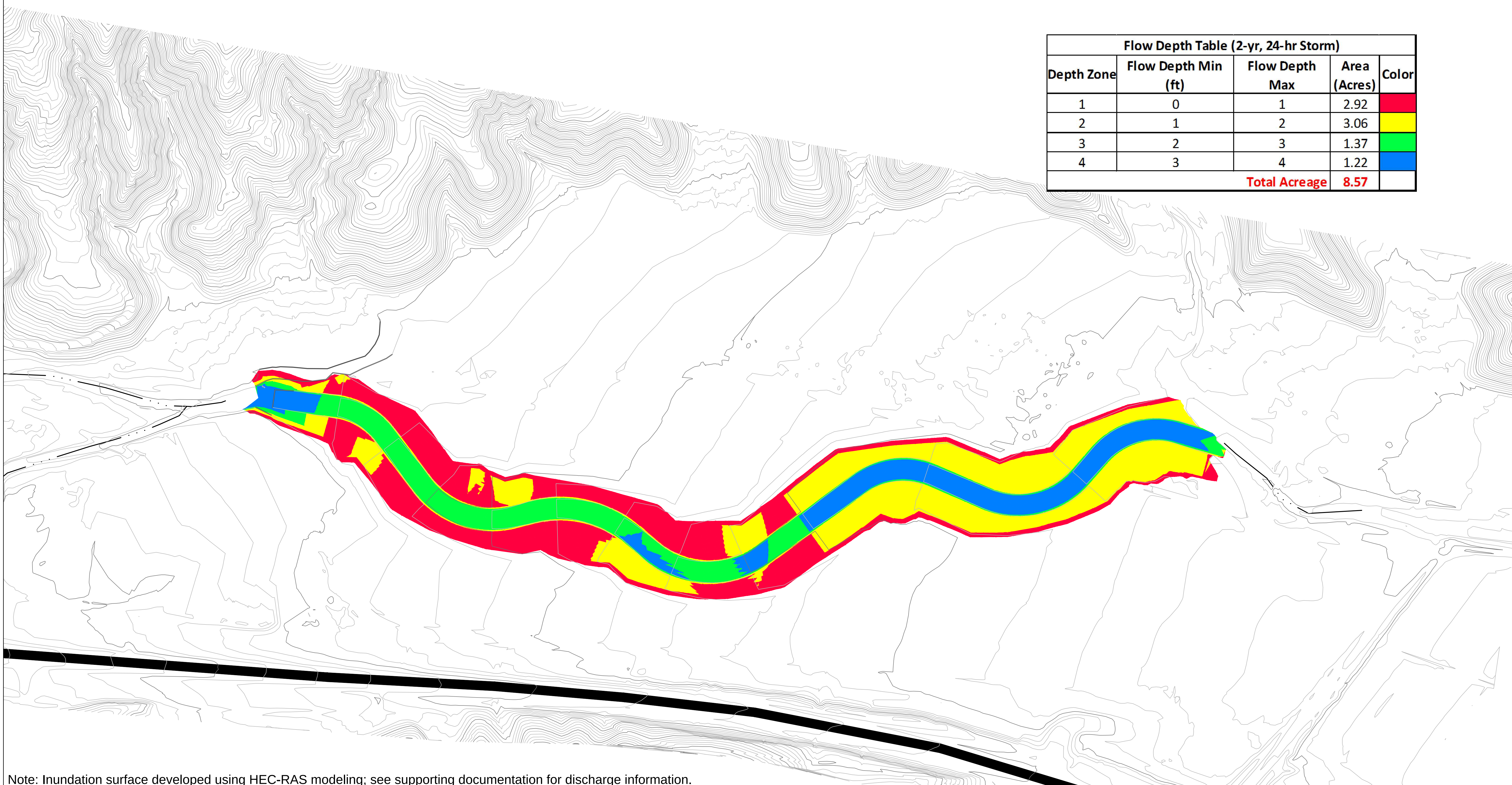
Water & Earth TECHNOLOGIES

NOT FOR CONSTRUCTION

REFERENCE REACH LOCATIONS

EXHIBIT 2



Flow Depth Table (2-yr, 24-hr Storm)				
Depth Zone	Flow Depth Min (ft)	Flow Depth Max	Area (Acres)	Color
1	0	1	2.92	
2	1	2	3.06	
3	2	3	1.37	
4	3	4	1.22	
		Total Acreage	8.57	

Note: Inundation surface developed using HEC-RAS modeling; see supporting documentation for discharge information.

Scale

CONTOUR INTERVAL: 2 FEET

0' 200' 400' 600'

Legend

Date

09/08/17

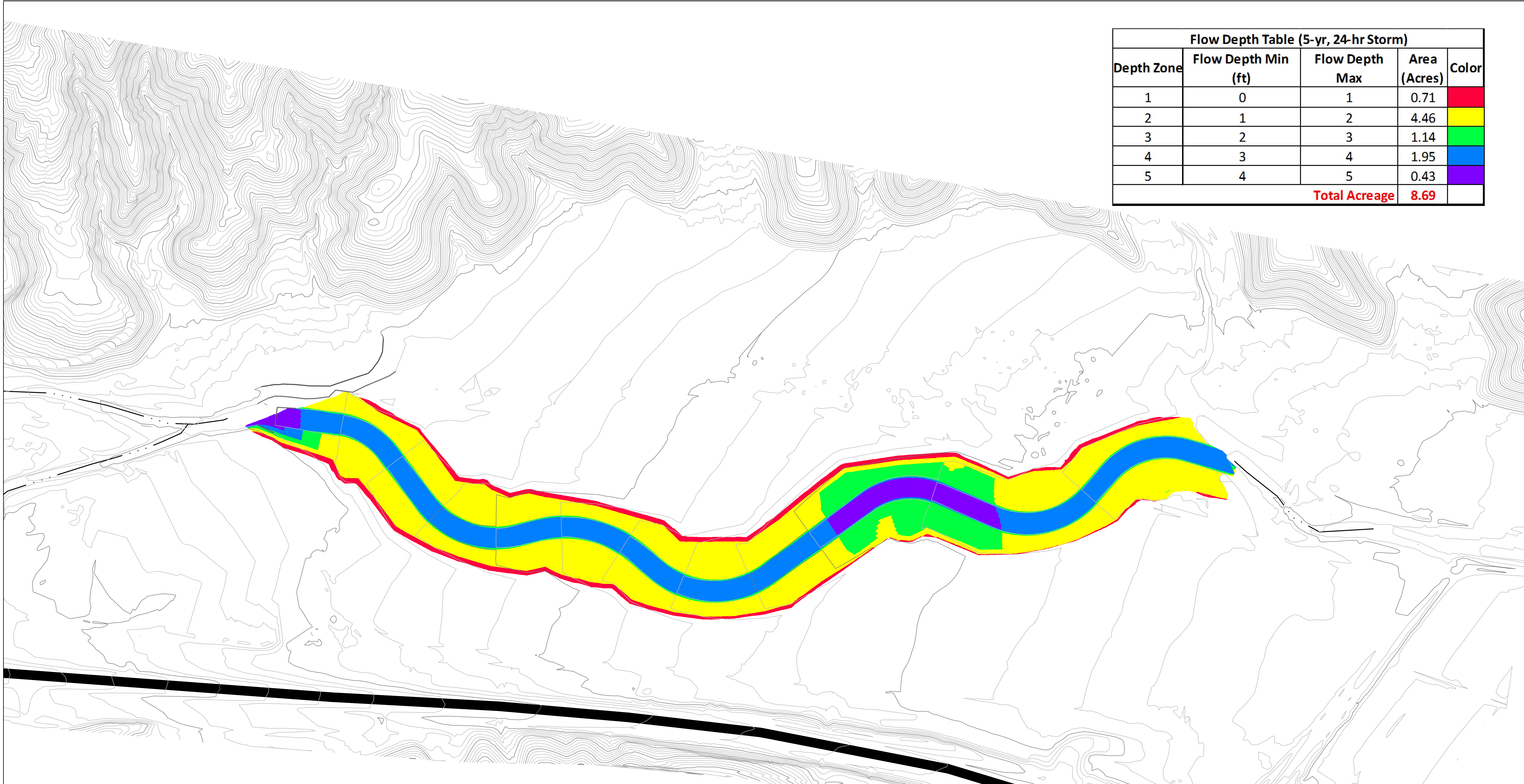
E:\WORK\A626.1-Rosemont-Fill In Sonoita\ACAD\Inundation\2Yr_AreaMap_RailX.dwg

Water & Earth TECHNOLOGIES

NOT FOR CONSTRUCTION

RAIL X
INUNDATION MAPPING
FOR AREA
CALCULATIONS
(2-yr, 24-hr)

EXHIBIT
3



Flow Depth Table (5-yr, 24-hr Storm)				
Depth Zone	Flow Depth Min (ft)	Flow Depth Max	Area (Acres)	Color
1	0	1	0.71	
2	1	2	4.46	
3	2	3	1.14	
4	3	4	1.95	
5	4	5	0.43	
		Total Acreage	8.69	

Note: Inundation surface developed using HEC-RAS modeling; see supporting documentation for discharge information.

Scale

CONTOUR INTERVAL: 2 FEET

0' 200' 400' 600'

Legend

Date

09/08/17

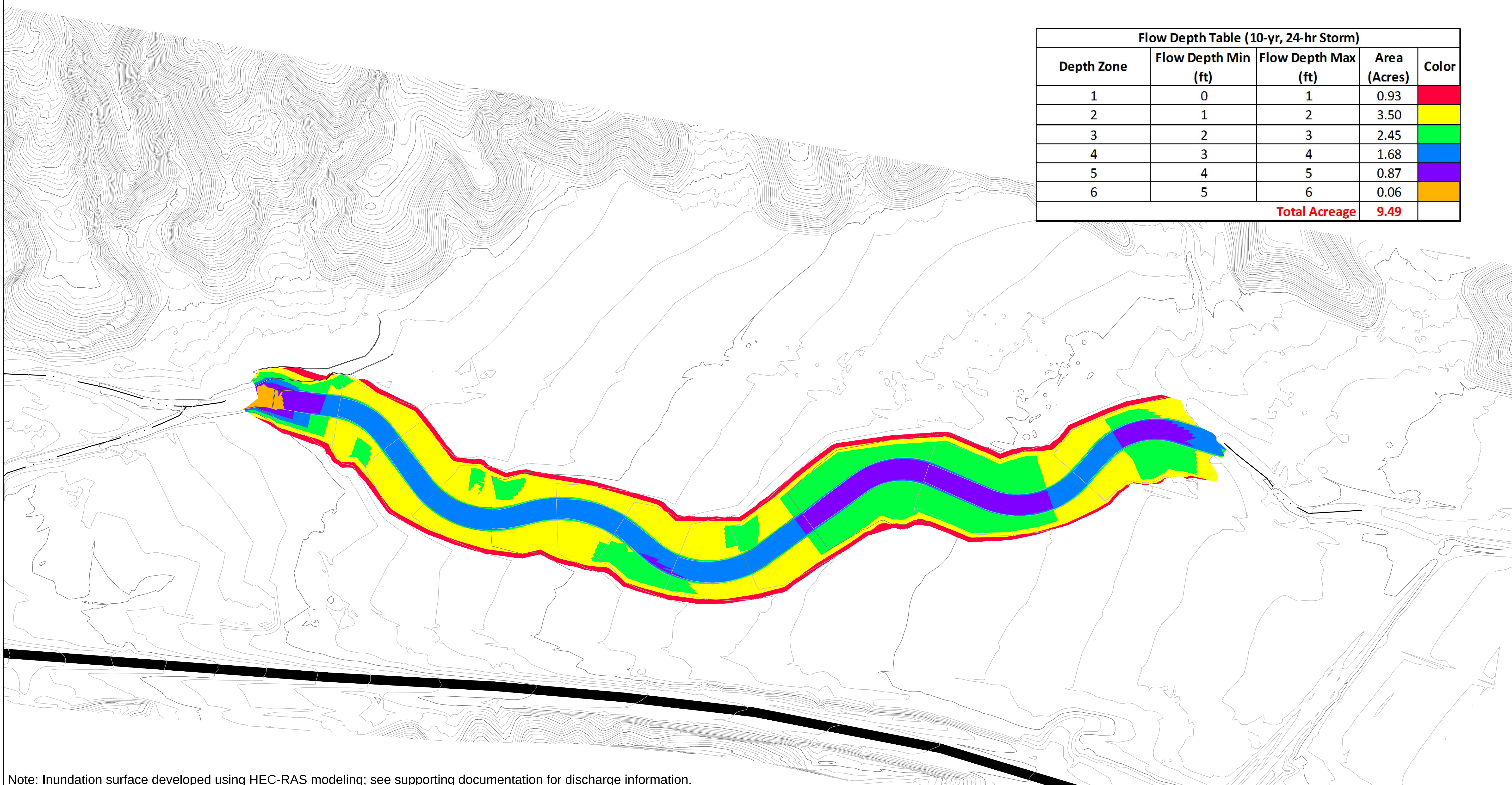
E:\WORK\A626.1-Rosemont-Fill In Sonoita\ACAD\Inundation\5-Yr_AreaMap_RailX.dwg

Water & Earth TECHNOLOGIES

NOT FOR CONSTRUCTION

RAIL X
INUNDATION MAPPING
FOR AREA
CALCULATIONS
(5-yr, 24-hr)

EXHIBIT
4



Flow Depth Table (10-yr, 24-hr Storm)				
Depth Zone	Flow Depth Min (ft)	Flow Depth Max (ft)	Area (Acres)	Color
1	0	1	0.93	
2	1	2	3.50	
3	2	3	2.45	
4	3	4	1.68	
5	4	5	0.87	
6	5	6	0.06	
		Total Acreage	9.49	

Note: Inundation surface developed using HEC-RAS modeling; see supporting documentation for discharge information.

Scale

CONTOUR INTERVAL: 2 FEET

0' 200' 400' 600'

Legend

Date

09/08/17

E:\WORK\A626.1-Rosemont-Fill In Sonoita\ACAD\Inundation\10-Yr_AreaMap_RailX.dwg

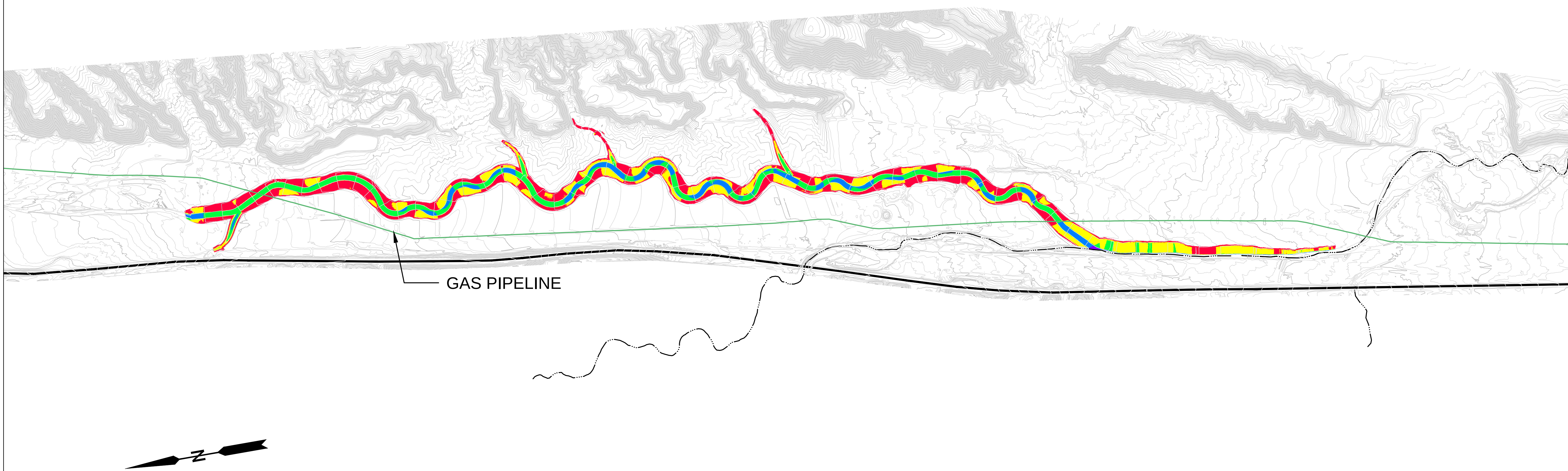
Water & Earth TECHNOLOGIES

NOT FOR CONSTRUCTION

RAIL X
INUNDATION MAPPING
FOR AREA
CALCULATIONS
(10-yr, 24-hr)

EXHIBIT
5

Flow Depth Table (2-yr, 24-hr Storm)				
Depth Zone	Flow Depth Min (ft)	Flow Depth Max	Area (Acres)	Color
1	0	1	20.03	
2	1	2	14.76	
3	2	3	11.14	
4	3	4	4.84	
5	4	5	0.07	
		Total Acreage	50.84	



Note: Inundation surface developed using HEC-RAS modeling; see supporting documentation for discharge information.

Scale

CONTOUR INTERVAL: 2 FEET

0' 1000' 2000' 3000'

Legend

Date

09/08/17

E:\WORK\A626.1-Rosemont-Fill In Sonoita\ACAD\Inundation\2-Yr_AreaMap_NS.dwg

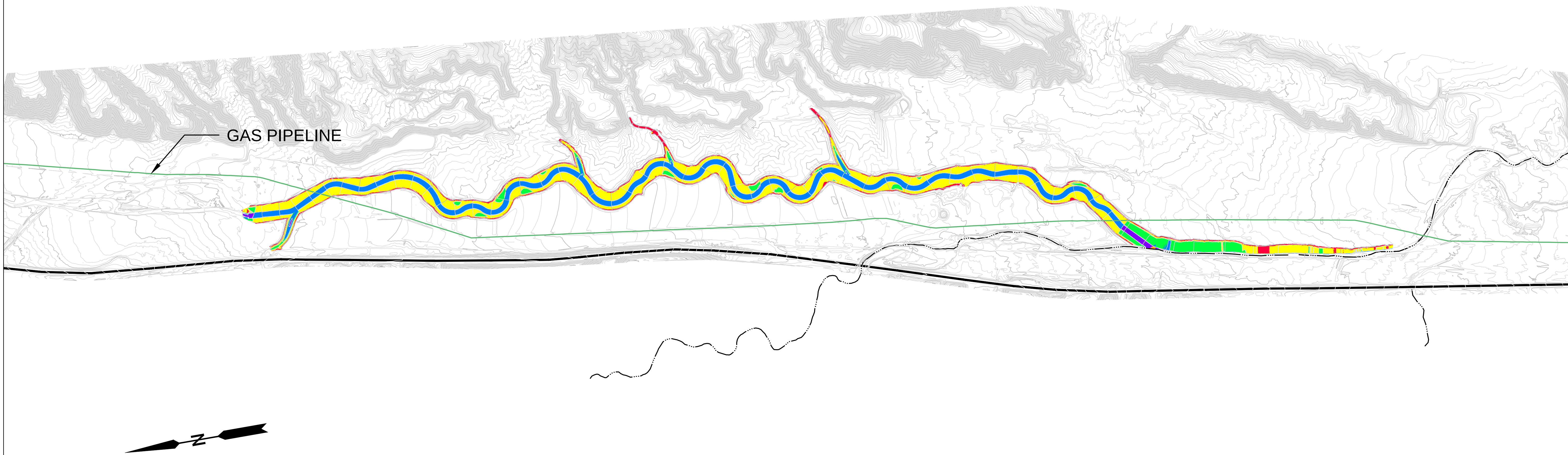
Water & Earth TECHNOLOGIES

NOT FOR CONSTRUCTION

SONOITA CREEK RANCH (SCR) INUNDATION MAPPING FOR AREA CALCULATIONS (2-yr, 24-hr)

EXHIBIT 6

Flow Depth Table (5-yr, 24-hr Storm)				
Depth Zone	Flow Depth Min (ft)	Flow Depth Max	Area (Acres)	Color
1	0	1	6.8	
2	1	2	26.41	
3	2	3	6.46	
4	3	4	14.29	
5	4	5	0.63	
6	5	6	0.03	
		Total Acreage	54.62	



Note: Inundation surface developed using HEC-RAS modeling; see supporting documentation for discharge information.

Scale

CONTOUR INTERVAL: 2 FEET

0' 1000' 2000' 3000'

Legend

Date

09/08/17

E:\WORK\A626.1-Rosemont-Fill In Sonoita\ACAD\Inundation\5-Yr_AreaMap_NS.dwg

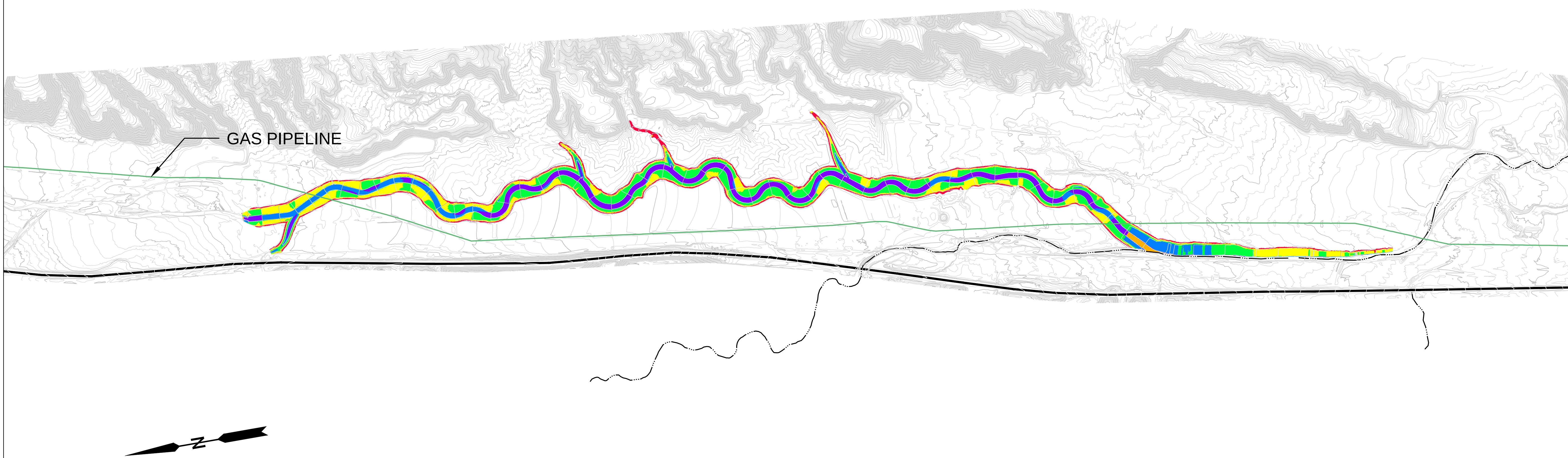
Water & Earth TECHNOLOGIES

NOT FOR CONSTRUCTION

SONOITA CREEK RANCH (SCR) INUNDATION MAPPING FOR AREA CALCULATIONS (5-yr, 24-hr)

EXHIBIT 7

Flow Depth Table (10-yr, 24-hr Storm)				
Depth Zone	Flow Depth Min (ft)	Flow Depth Max (ft)	Area (Acres)	Color
1	0	1	6.29	
2	1	2	14.94	
3	2	3	18.37	
4	3	4	7.57	
5	4	5	9.82	
6	5	6	0.41	
		Total Acreage	57.40	



Note: Inundation surface developed using HEC-RAS modeling; see supporting documentation for discharge information.

Scale

CONTOUR INTERVAL: 2 FEET

0' 1000' 2000' 3000'

Legend

Date

09/08/17

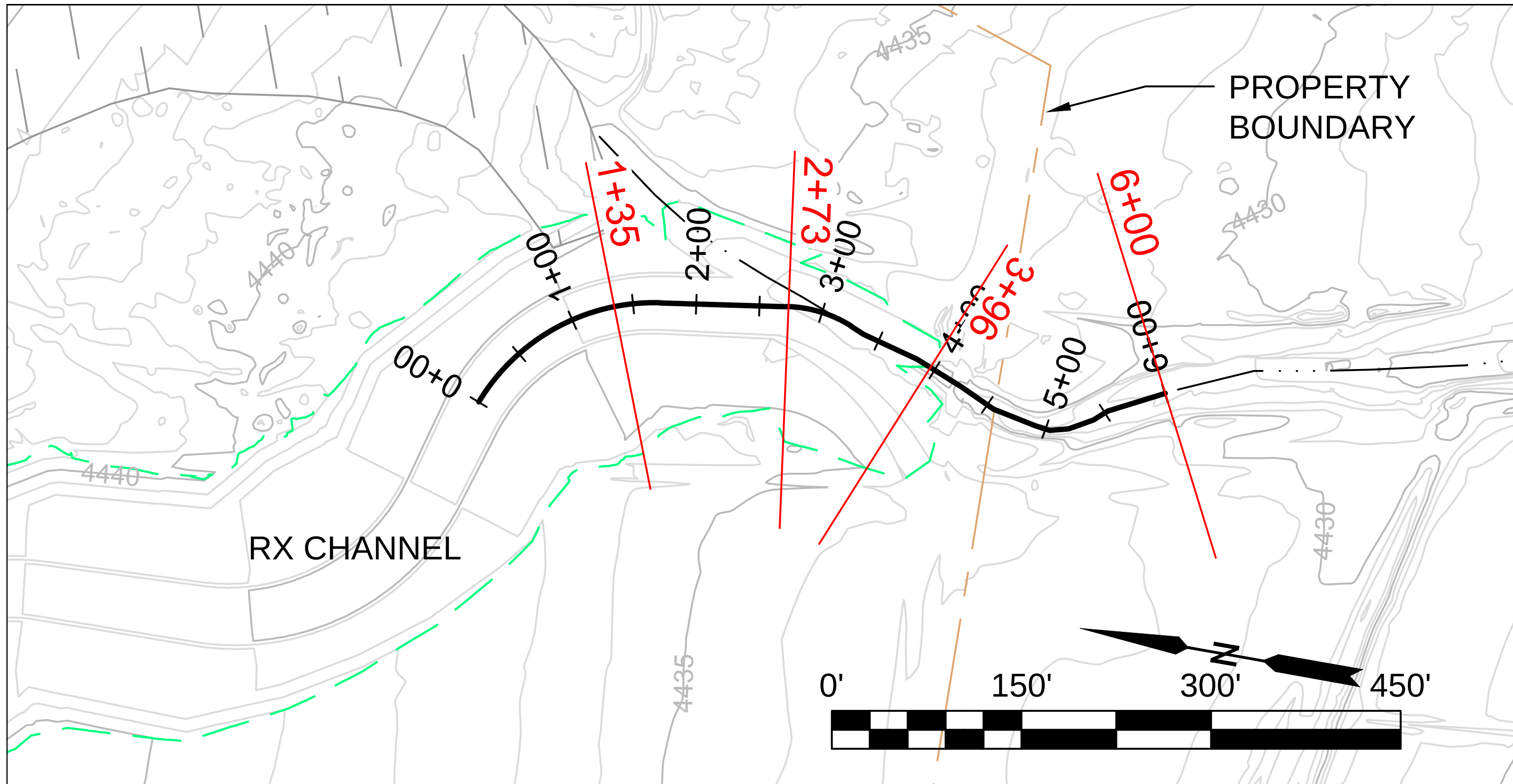
E:\WORK\A626.1-Rosemont-Fill In Sonoita\ACAD\Inundation\10-Yr_AreaMap_NS.dwg

Water & Earth TECHNOLOGIES

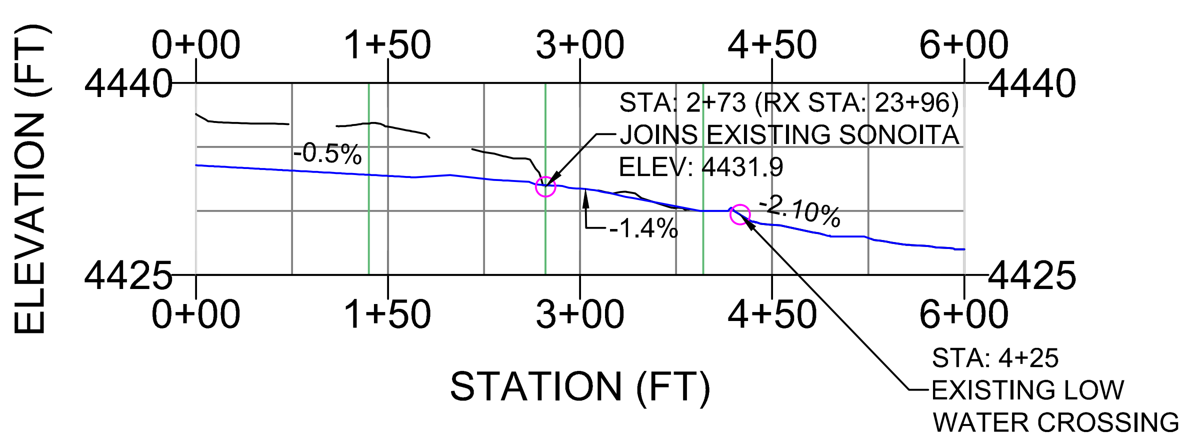
NOT FOR CONSTRUCTION

SONOITA CREEK RANCH (SCR) INUNDATION MAPPING FOR AREA CALCULATIONS (10-yr, 24-hr)

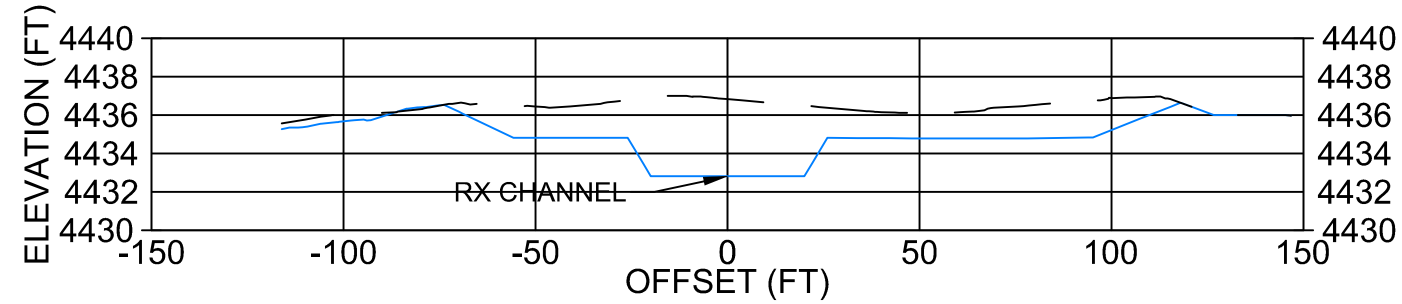
EXHIBIT 8



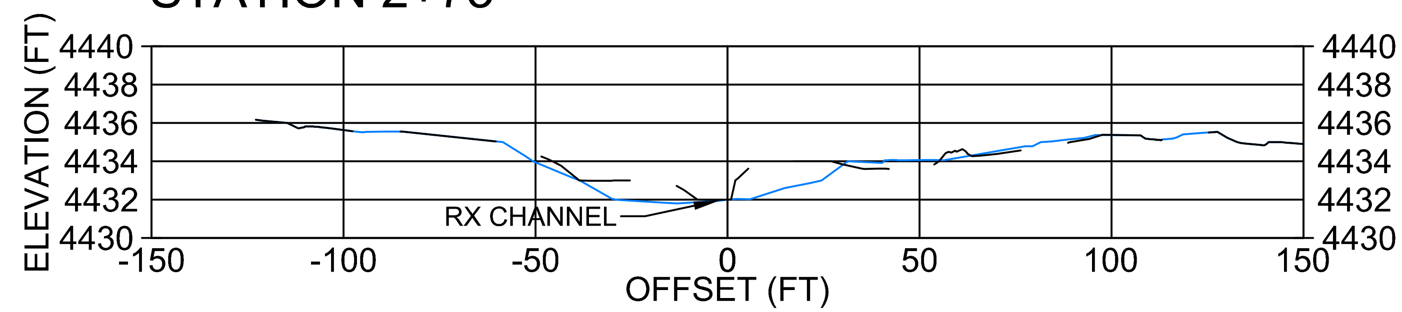
RX TRANSITION TO SONOITA PROFILE



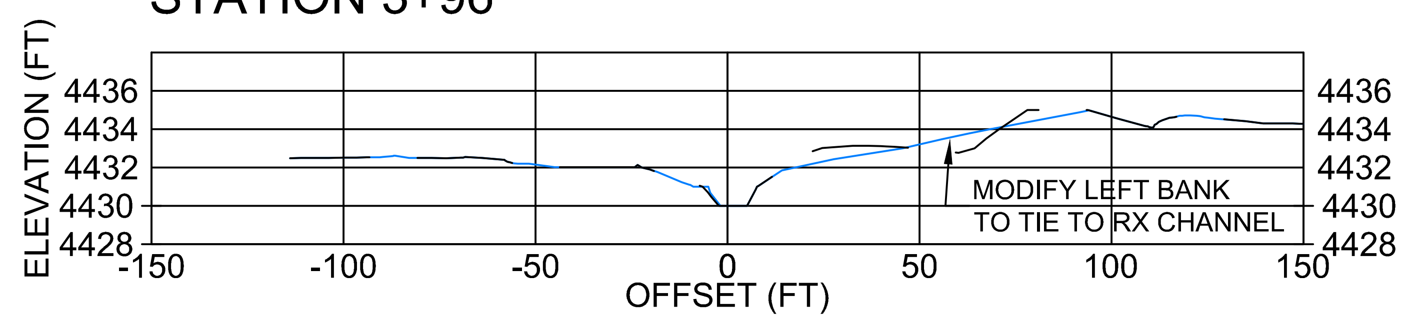
STATION 1+35



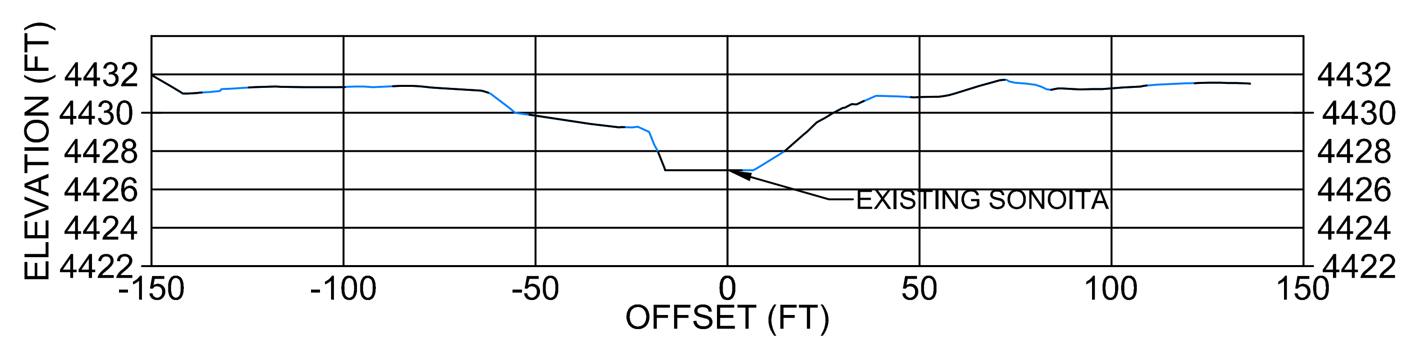
STATION 2+73



STATION 3+96



STATION 6+00



CONTOUR INTERVAL: 1 FOOT

Legend

0+89 CROSS SECTION
TRANSITION ALIGNMENT
EXISTING EPHEMERAL DRAINAGE
EXISTING GRADE PROFILE
PROPOSED FINAL GRADE PROFILE
CHANNEL EXCAVATION LIMIT
FILL IN EXISTING SONOITA

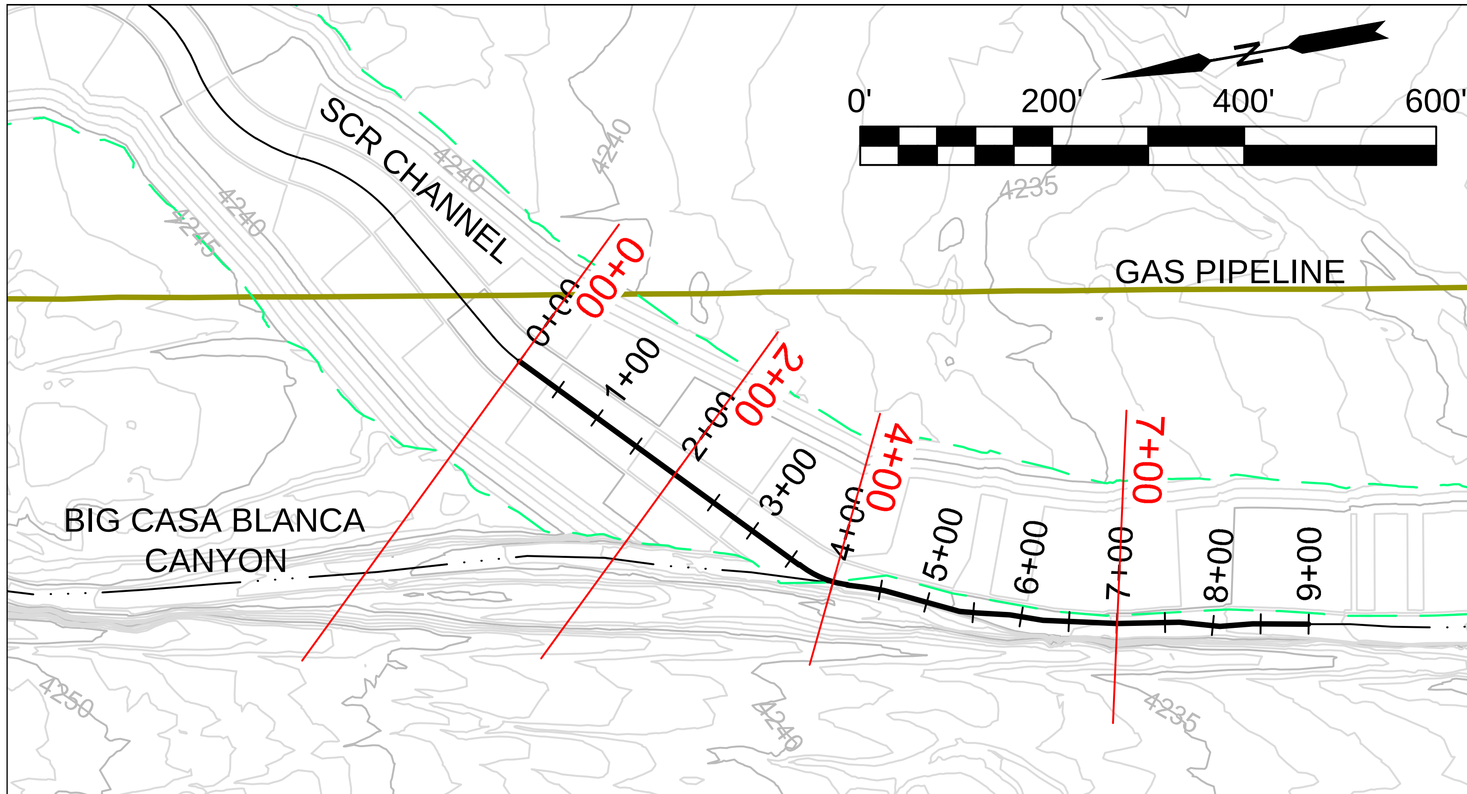
Date
09/08/17

Water & Earth TECHNOLOGIES

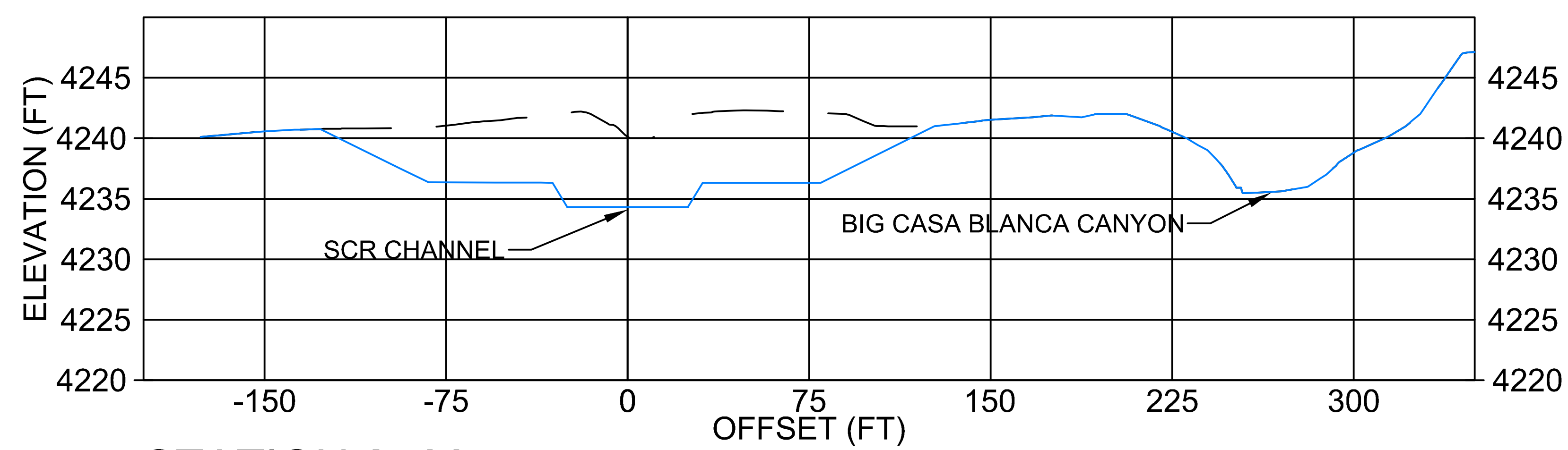
NOT FOR CONSTRUCTION

RX CHANNEL TIE-IN WITH EXISTING SONOITA TRANSITION DETAILS

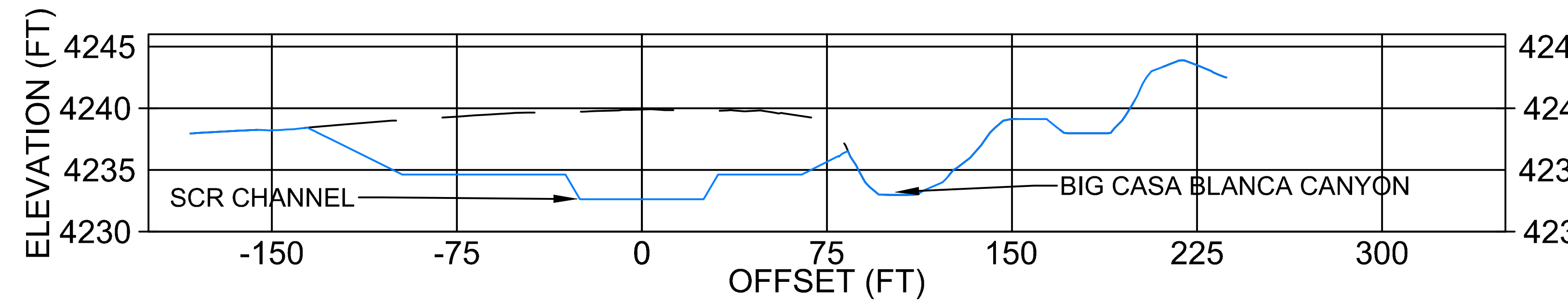
EXHIBIT 9



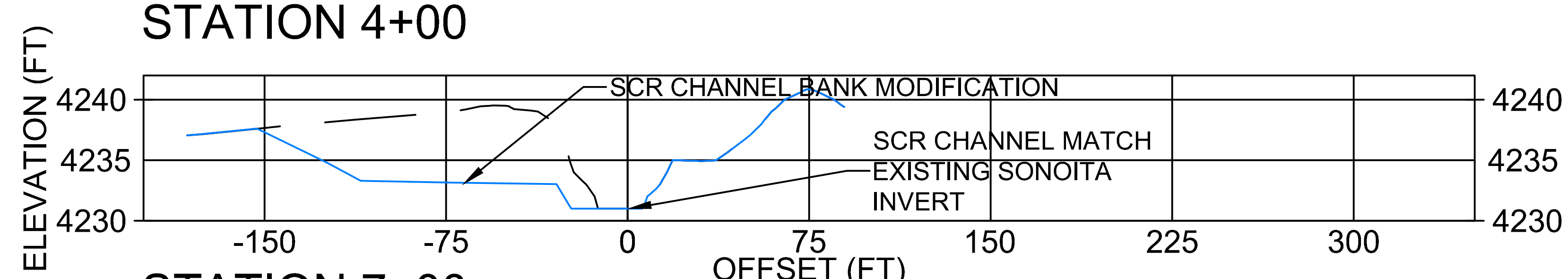
STATION 0+00



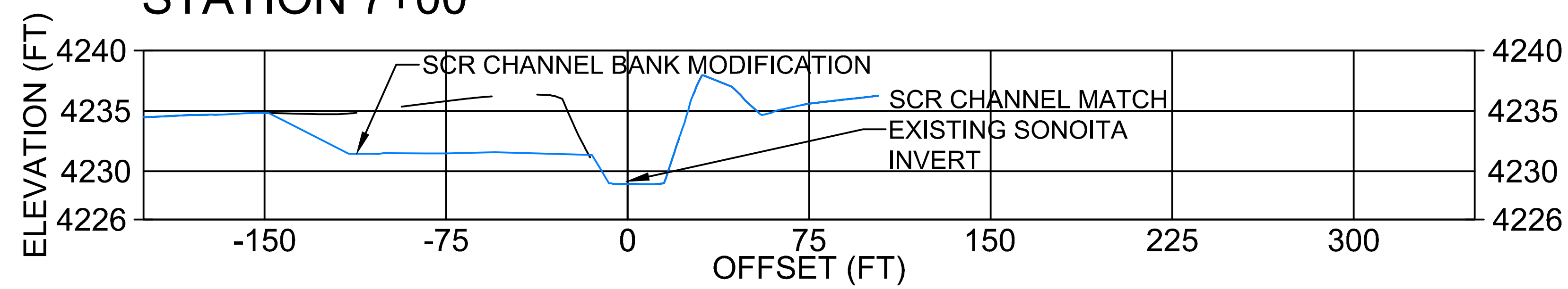
STATION 2+00



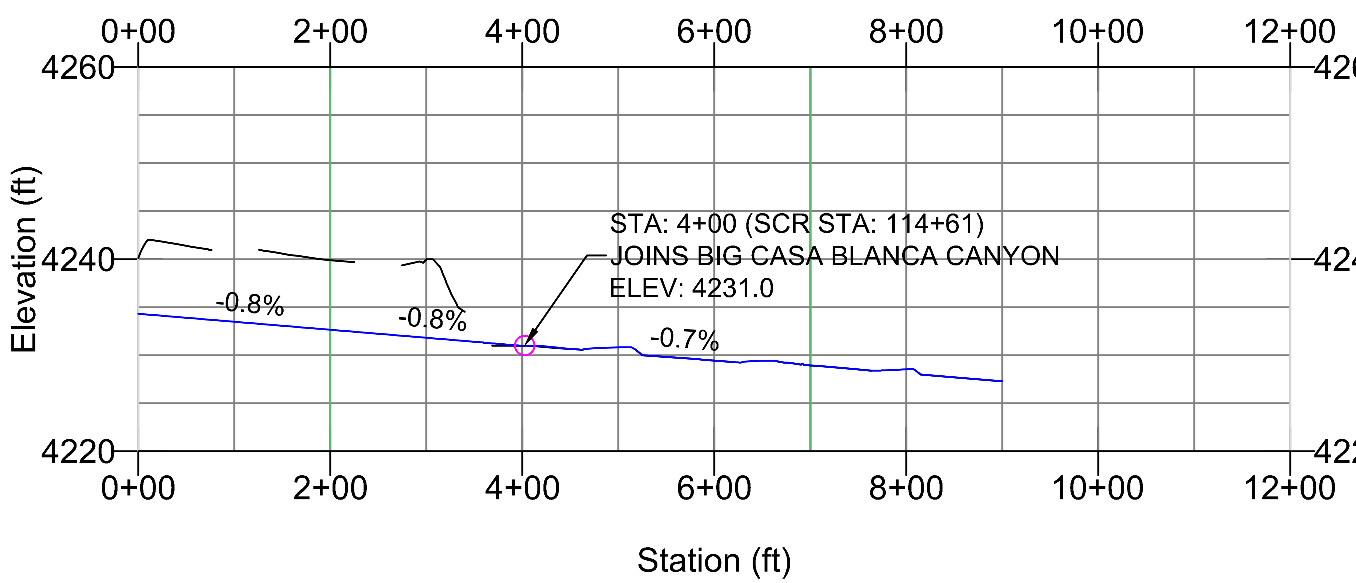
STATION 4+00



STATION 7+00



SCR CONFLUENCE WITH CASA BLANCA CANYON PROFILE



CONTOUR INTERVAL: 1 FOOT

Legend

- 0+89 CROSS SECTION
- TRANSITION ALIGNMENT
- EXISTING EPHEMERAL DRAINAGE
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- CHANNEL EXCAVATION LIMIT

Date

09/08/17

Water & Earth TECHNOLOGIES

NOT FOR CONSTRUCTION

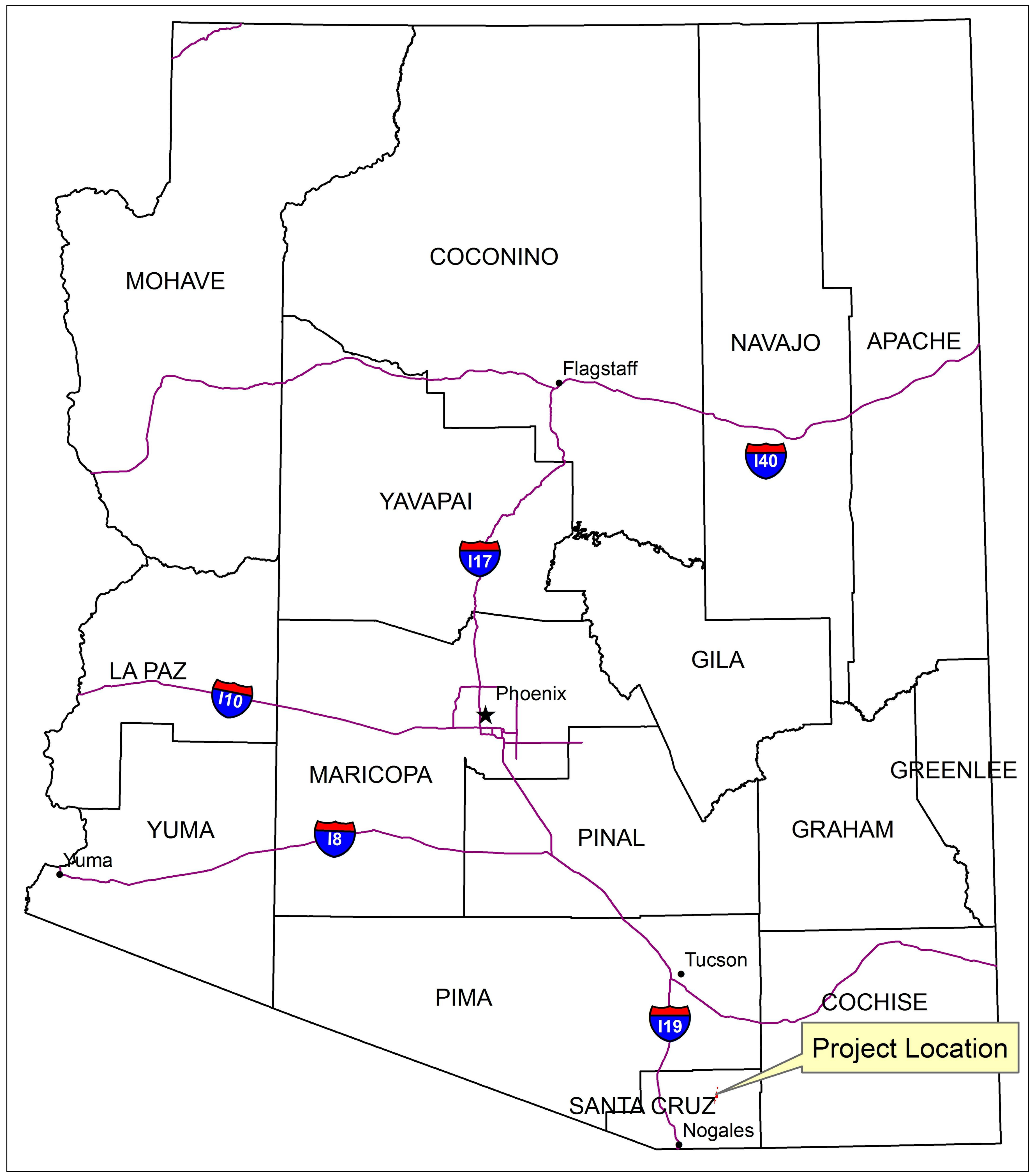
SCR CHANNEL DOWNSTREAM TIE-IN WITH EXISTING BIG CASA BLANCA TRANSITION DETAILS

EXHIBIT 10

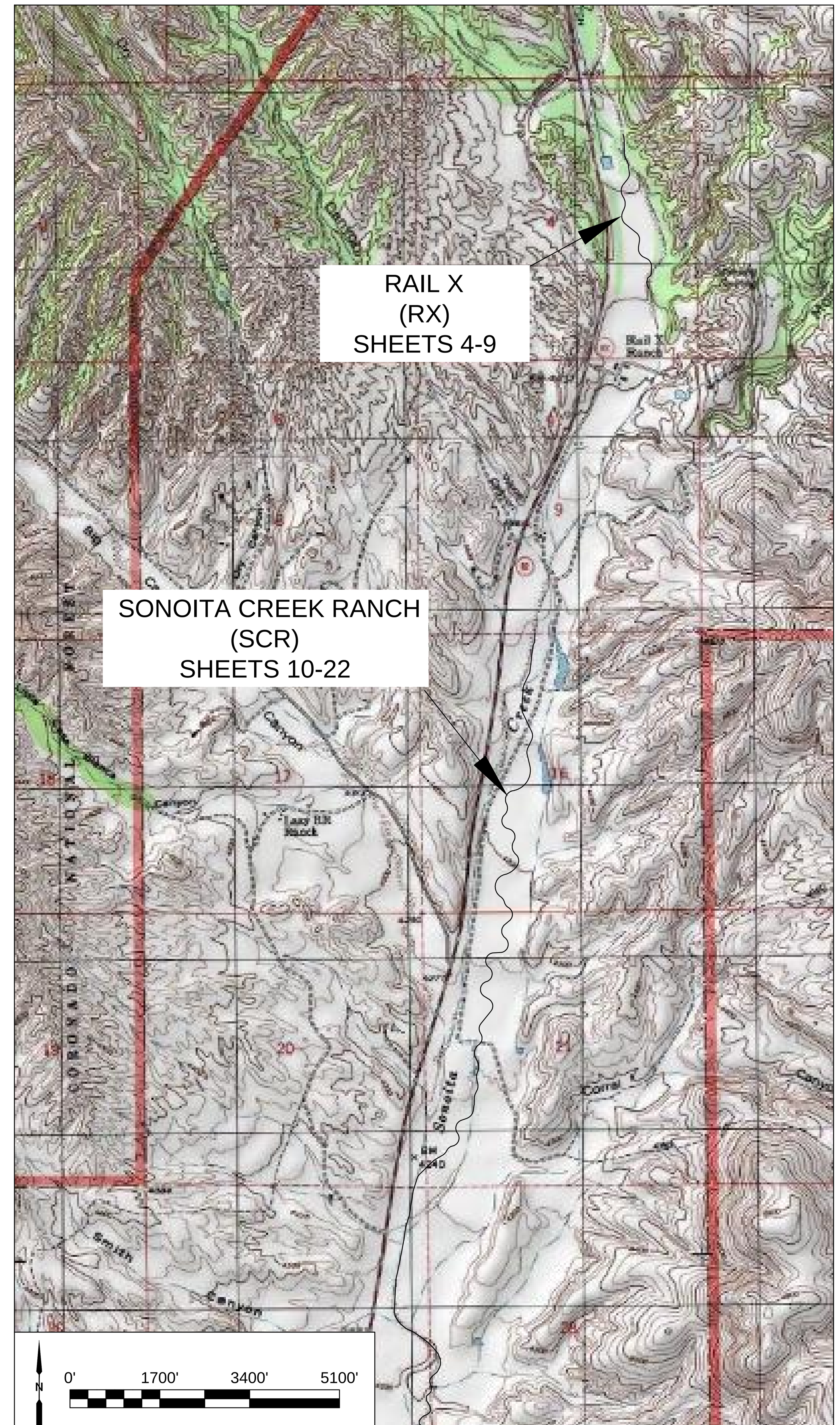
DRAWINGS

SONOITA CREEK MITIGATION PROJECT
SONOITA CREEK, SANTA CRUZ COUNTY, ARIZONA
SEPTEMBER 8, 2017

STATE OF ARIZONA



PROJECT LOCATION



CLIENT:

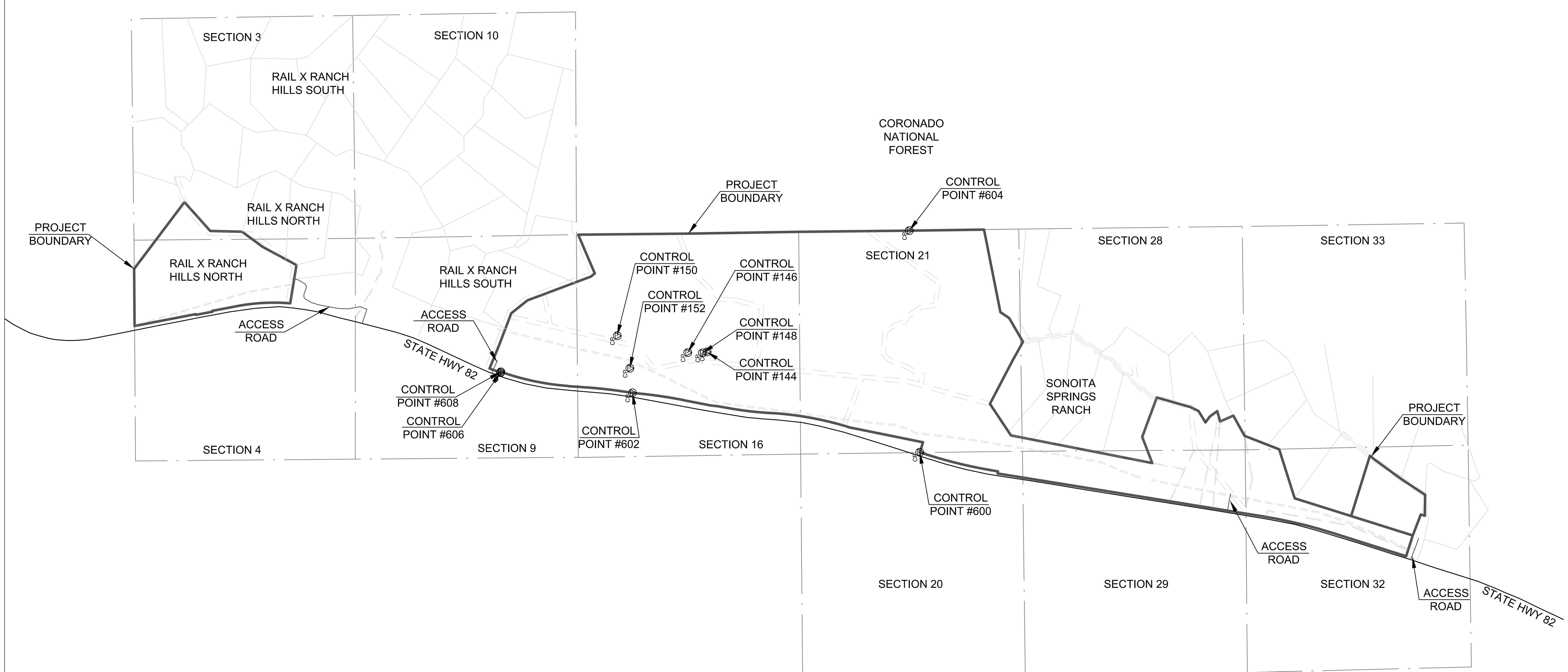
HUDBAY
ROSEMONT PROJECT
ROSEMONT COPPER COMPANY
5255 EAST WILLIAMS CIRCLE, SUITE W1065
TUCSON, ARIZONA, 85711

ENGINEER & PROJECT MANAGER:

WATER & EARTH TECHNOLOGIES, INC.
1225 RED CEDAR CIR, SUITE A
FORT COLLINS, COLORADO 80524

DRAWING INDEX:

NOT FOR CONSTRUCTION



LEGEND

PIPELINE EASEMENT
UTILITY, ROAD AND PEDESTRIAN EASEMENTS
PARCEL BOUNDARIES

SURVEY NOTES

1. THIS IS NOT A BOUNDARY SURVEY.
2. BOUNDARY LINES, PARCEL LINES, FOUND MONUMENTS, RIGHT-OF-WAYS, AND EASEMENTS WERE TAKEN FROM AN UNRECORDED ALTA PREPARED BY STANTEC CONSULTING SERVICES INC., PROJECT #181306001

HORIZONTAL\VERTICAL CONTROL POINTS

NO.	NORTH	EAST	ELEV	DESCRIPTION
144	222917.54	1073447.44	4366.73	SET BRIDGE SPIKE
146	223373.83	1073429.47	4370.55	SET BRIDGE SPIKE
148	223026.71	1073421.29	4331.22	FOUND 1/2" REBAR "RLS14172"
150	225044.96	1073828.60	4410.31	SET BRIDGE SPIKE
152	224743.69	1073058.37	4334.25	SET BRIDGE SPIKE
600	217881.79	1071069.07	4265.17	FOUND 3" BRASS DISC IN CONC "AHD ELV 4262.59, STA 1180+95.10, 1965"W/PUNCH
602	224683.64	1072475.36	4332.40	FOUND 3"BRASS DISC IN CONC "AHD ELV 4329.90, STA 1250+50.10, 1965" W/PUNCH
604	218129.63	1076318.65	4357.48	FOUND 2.5" BRASS DISC "GLO 1/4, S21, 1925"
606	227799.78	1072973.54	4380.09	FOUND 3" BRASS DISC IN CONC "AHD ELV 4377.38, STA 1283+00, 1965" W/PUNCH
608	227806.48	1072954.76	4379.24	FOUND 3" BRASS DISC IN CONC "AHD ELV 4376.46, STA 1283+00, 1965" W/PUNCH

BASIS FOR COORDINATES IS ARIZONA STATE PLANE COORDINATE SYSTEM NAD 83, EAST ZONE. COORDINATES WERE DERIVED FROM MULTIPLE OPUS SOLUTIONS, AND CHECK SHOTS TO THE SANTA CRUZ COUNTY LIDAR MAPPING PROJECT CONTROL. COORDINATES FOR THE LIDAR CONTROL CHECK MEASUREMENTS WERE PROVIDED BY STANTEC ENGINEERING. ALL ELEVATIONS ARE NAVD 88 DATUM PER THE LIDAR MAPPING PROJECT CONTROL.

N

0' 1500' 3000' 4500'

ANSI D

PREPARED BY:

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FORT COLLINS, CO 80524
(970) 225-6080
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SONOITA CREEK MITIGATION PROJECT

REFERENCES		REFERENCES		REVISIONS							REVISIONS						
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION	NO.	BY	CKD	APP.	CLIENT	DATE	DESCRIPTION

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ROSEMONT PROJECT

SURVEY CONTROL

NOT FOR CONSTRUCTION

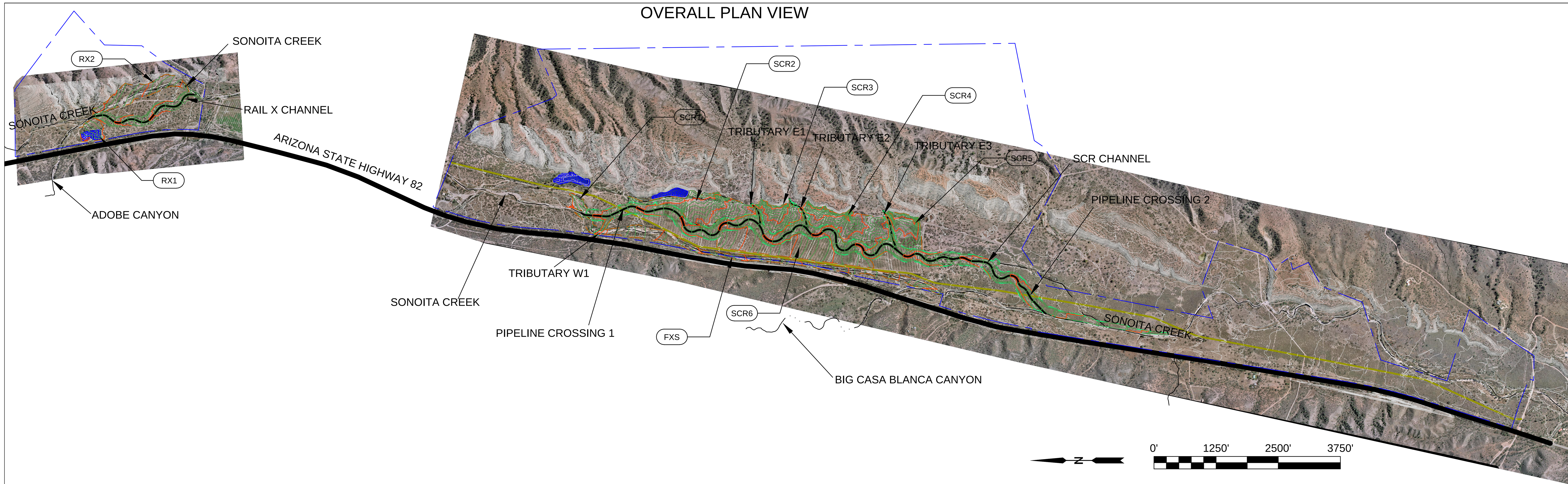
CONTRACTOR DWG. NO. WET 2

DWG. NO.

REVISION

DATE 09/08/17

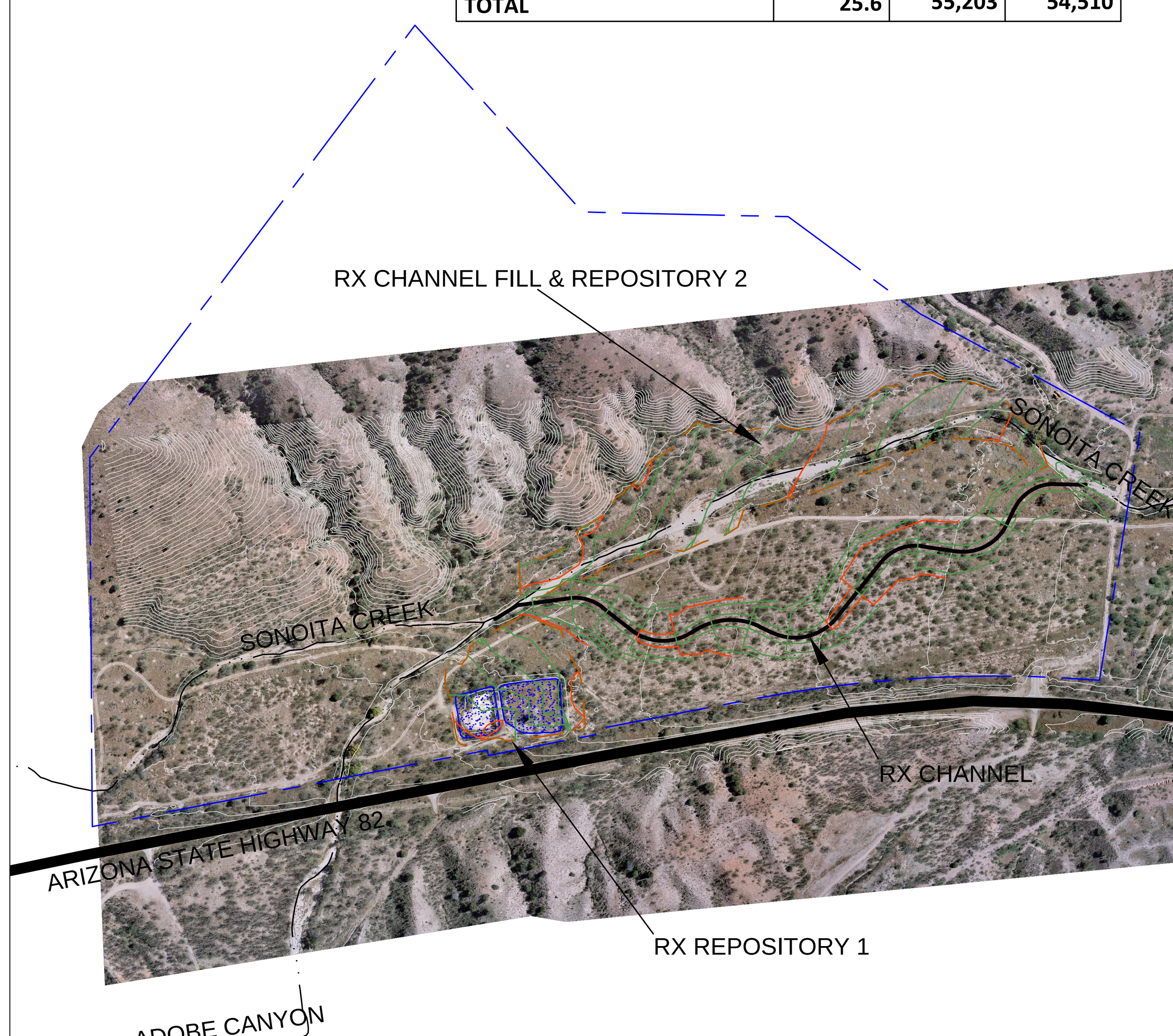
OVERALL PLAN VIEW



- EXISTING INDEX CONTOUR (25-FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (5-FT INTERVAL)
- PROPOSED INDEX CONTOUR (25-FT INTERVAL)
- PROPOSED INTERMEDIATE CONTOUR (5-FT INTERVAL)
- EXISTING EPHEMERAL DRAINAGE
- PROPOSED CHANNEL ALIGNMENT
- GAS PIPELINE ALIGNMENT
- CHANNEL EXCAVATION BOUNDARY
- SOIL REPOSITORY/ROAD BOUNDARY
- ARIZONA STATE HIGHWAY 82
- PROPERTY BOUNDARY
- POND
- SCR 1 SOIL REPOSITORY ID

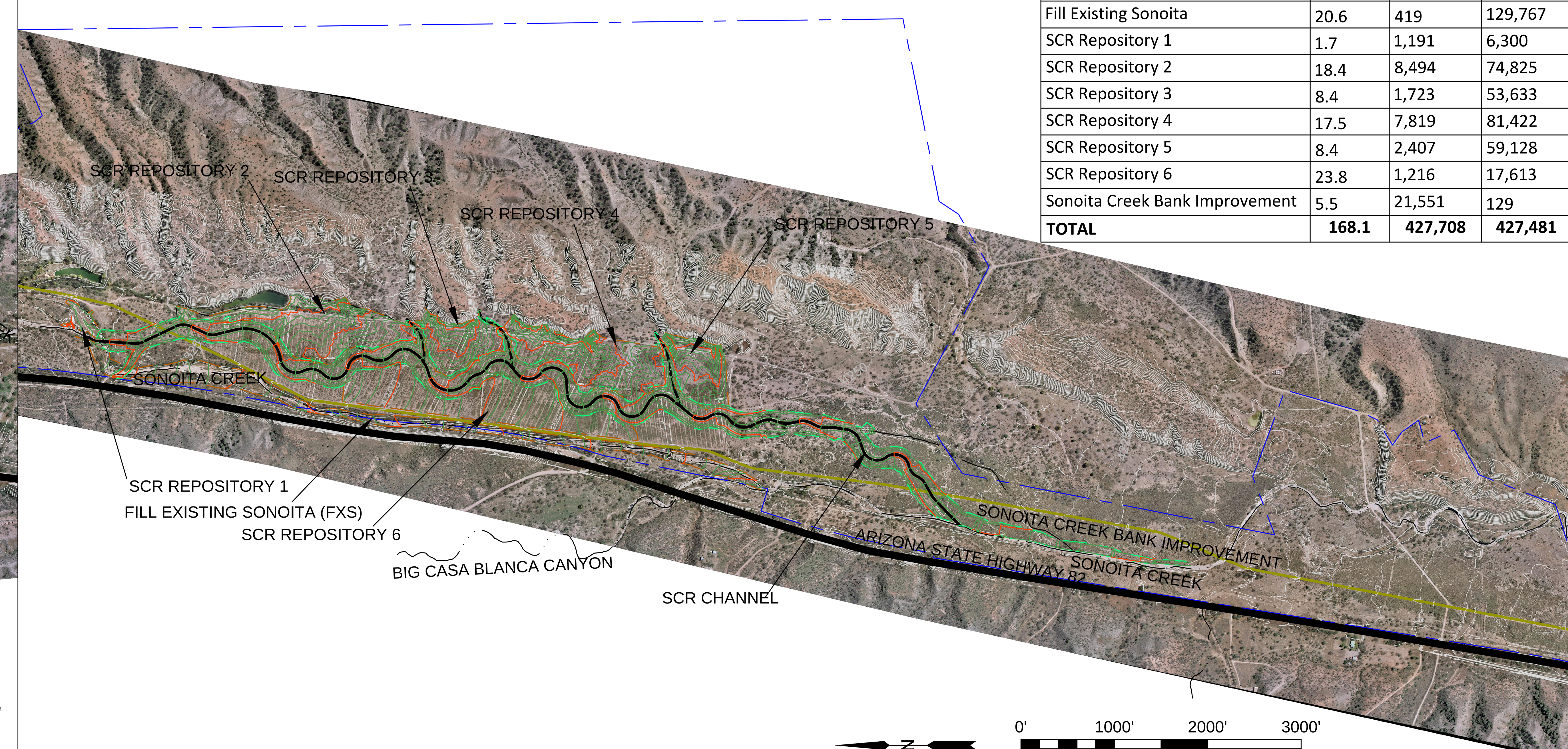
RAIL X CONSTRUCTION VOLUMES & AREAS

Design Feature	Area (ac)	Cut (C.Y.)	Fill (C.Y.)
RX Channel	10.5	52,925	6
RX Repository 1	4.1	2,086	9,359
RX Channel Fill & Repository 2	11.0	192	45,145
TOTAL	**25.6**	**55,203**	**54,510**



SCR CONSTRUCTION VOLUMES & AREAS

Design Feature	Area (ac)	Cut (C.Y.)	Fill (C.Y.)
SCR Channel	59.6	367,885	2,962
Tributary W1	0.9	2,159	1,429
Tributary E1	0.8	3,227	64
Tributary E2	1.0	2,669	208
Tributary E3	1.5	6,948	1
Fill Existing Sonoita	20.6	419	129,767
SCR Repository 1	1.7	1,191	6,300
SCR Repository 2	18.4	8,494	74,825
SCR Repository 3	8.4	1,723	53,633
SCR Repository 4	17.5	7,819	81,422
SCR Repository 5	8.4	2,407	59,128
SCR Repository 6	23.8	1,216	17,613
Sonoita Creek Bank Improvement	5.5	21,551	129
TOTAL	**168.1**	**427,708**	**427,481**



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REFERENCES		REFERENCES		REVISIONS							REVISIONS						
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION	NO.	BY	CKD	APP.	CLIENT	DATE	DESCRIPTION

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ROSEMONT PROJECT

SONOITA CREEK MITIGATION PROJECT

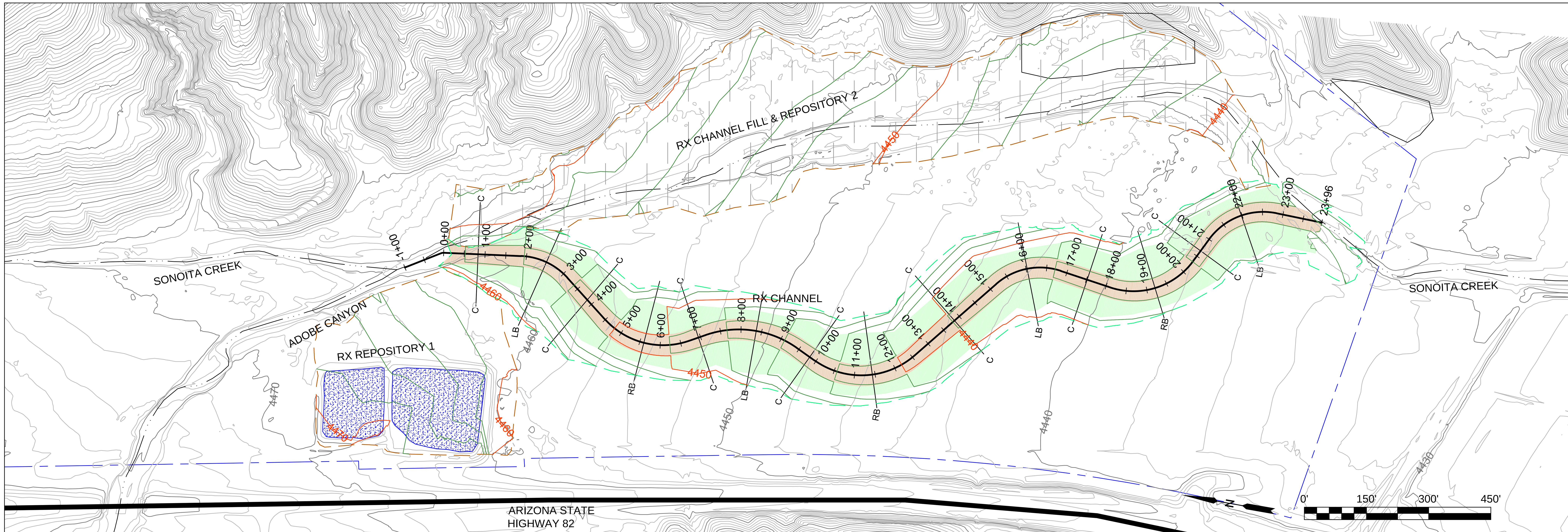
PROJECT OVERVIEW & CONSTRUCTION VOLUMES

NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. WET 3

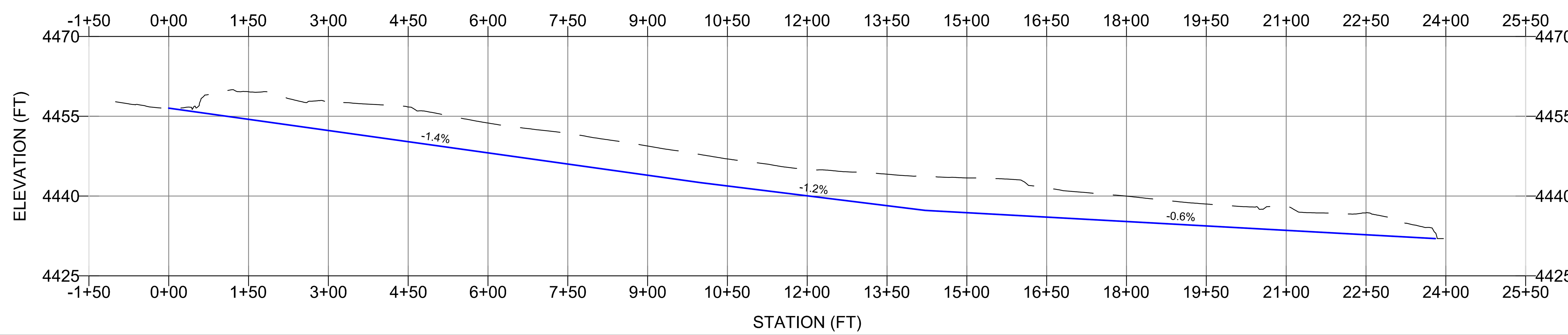
DWG. NO.

REVISION | DATE 09/08/17

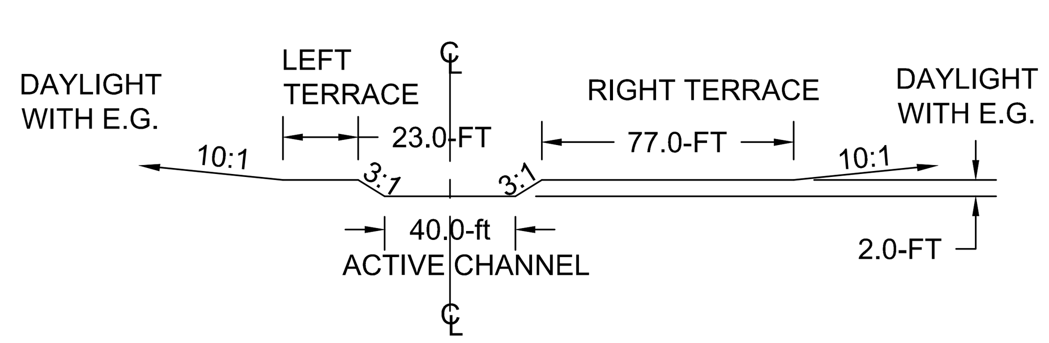


- EXISTING INDEX CONTOUR (10-FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED INDEX CONTOUR (10-FT INTERVAL)
- PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED CHANNEL EXCAVATION LIMIT
- CHANNEL FILL AND REPOSITORY BOUNDARY
- PROPOSED CHANNEL ALIGNMENT WITH STATIONS
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- EXISTING EPHEMERAL DRAINAGE
- AZ STATE HIGHWAY 82
- PROPERTY BOUNDARY
- RB — TYPICAL RIGHT BEND CROSS SECTION
- C — C TYPICAL CENTERED CROSS SECTION
- LB — TYPICAL LEFT BEND CROSS SECTION
- POND
- CHANNEL TERRACE
- ACTIVE CHANNEL
- FILL IN EXISTING SONOITA CREEK

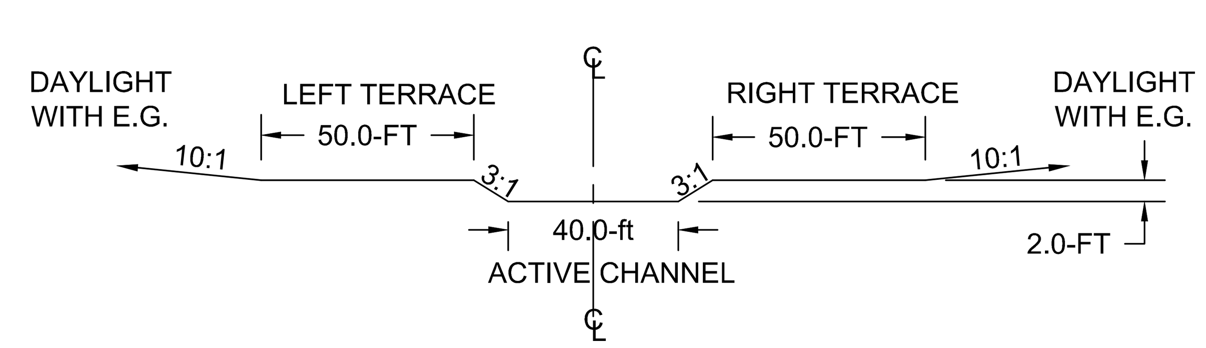
RX CHANNEL PROFILE



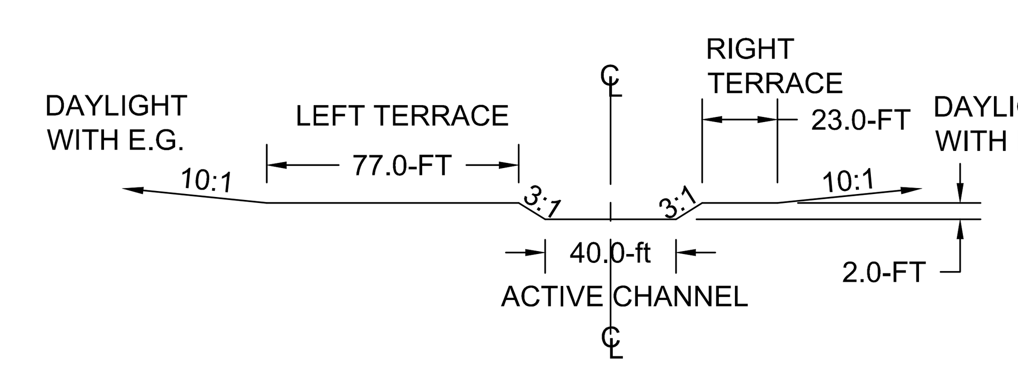
RX CHANNEL
TYPICAL RIGHT BEND (RB) CROSS SECTION
RB



RX CHANNEL
TYPICAL CENTERED (C) CROSS SECTION
C——C



RX CHANNEL
TYPICAL LEFT BEND (LB) SECTION
LB



NOTES

1. PROFILES OF EXISTING GRADE AND FINAL GRADE CORRESPOND TO CHANNEL CENTERLINE ELEVATIONS.
2. FINAL GRADE PROFILE CORRESPONDS TO CHANNEL INVERT ELEVATION.
3. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM.
4. ACTIVE CHANNEL IS ALWAYS CENTERED ON THE CHANNEL ALIGNMENT CENTERLINE.
5. RX CHANNEL LEFT AND RIGHT CHANNEL TERRACE WIDTHS SHALL ALWAYS SUM TO TOTAL TERRACE WIDTH OF 100-FT.
6. RX CHANNEL RIGHT BEND: MINIMUM LEFT TERRACE WIDTH IS 23.0-FT AND MAXIMUM RIGHT TERRACE WIDTH IS 77.0-FT.
7. RX CHANNEL LEFT BEND: MAXIMUM LEFT TERRACE WIDTH IS 77.0-FT AND MINIMUM RIGHT TERRACE WIDTH IS 23.0-FT.
8. ACTIVE CHANNEL GRADUALLY MEANDERS WITHIN THE TOTAL TERRACE WIDTH.

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ROSEMONT PROJECT

SONOITA CREEK MITIGATION PROJECT

RX CHANNEL PLAN & PROFILE WITH TYPICAL CHANNEL CROSS SECTIONS

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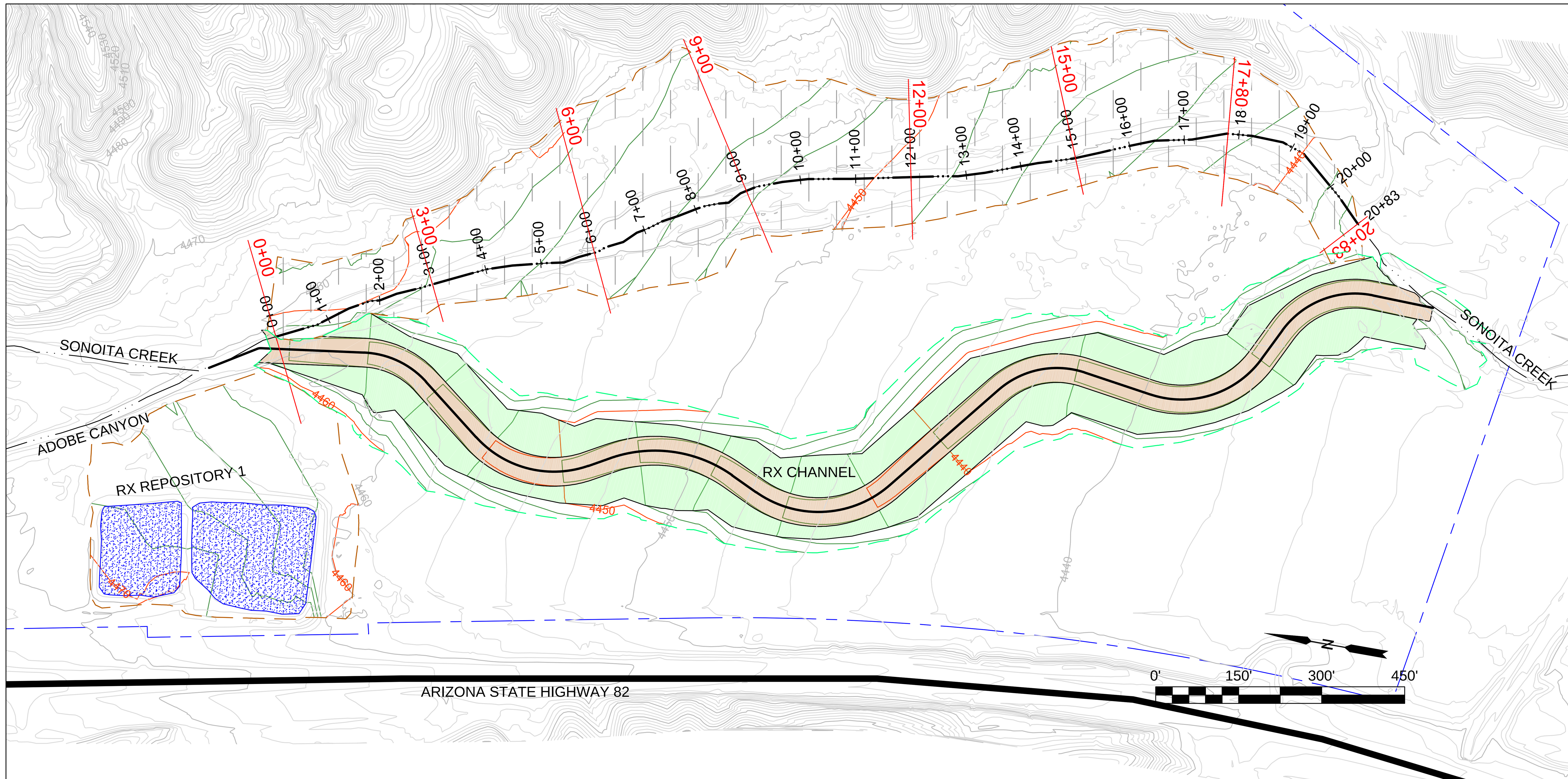
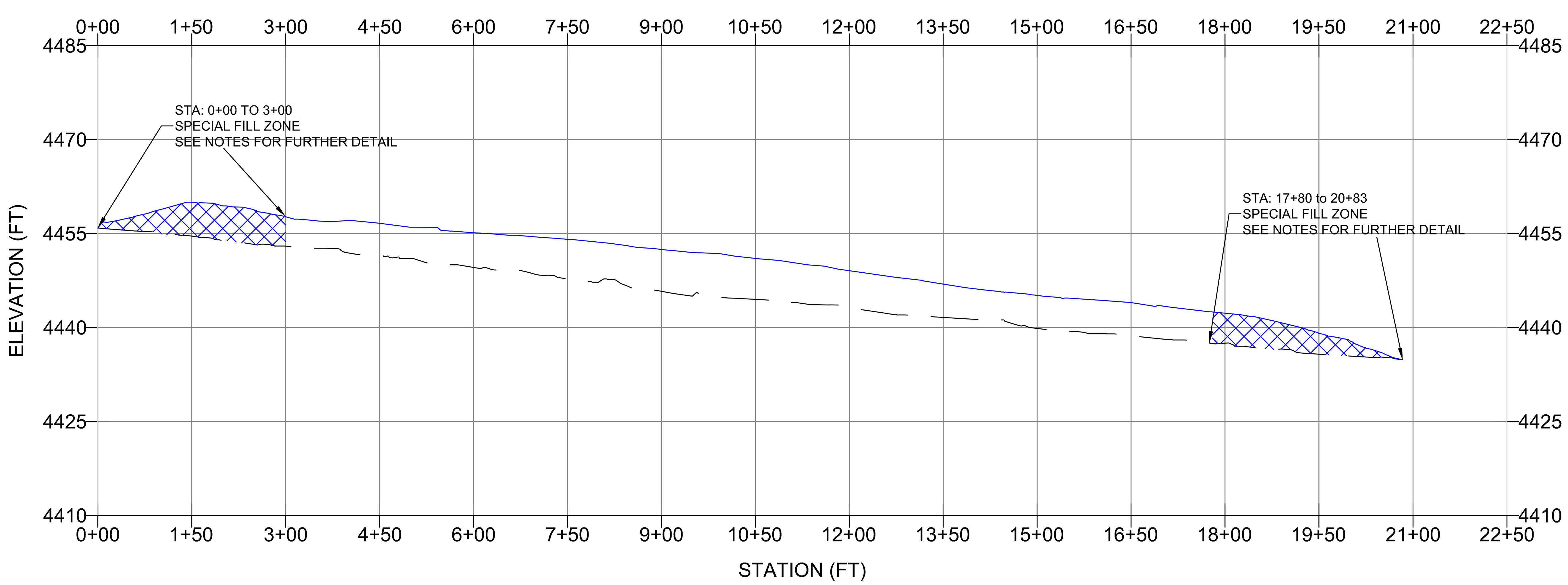
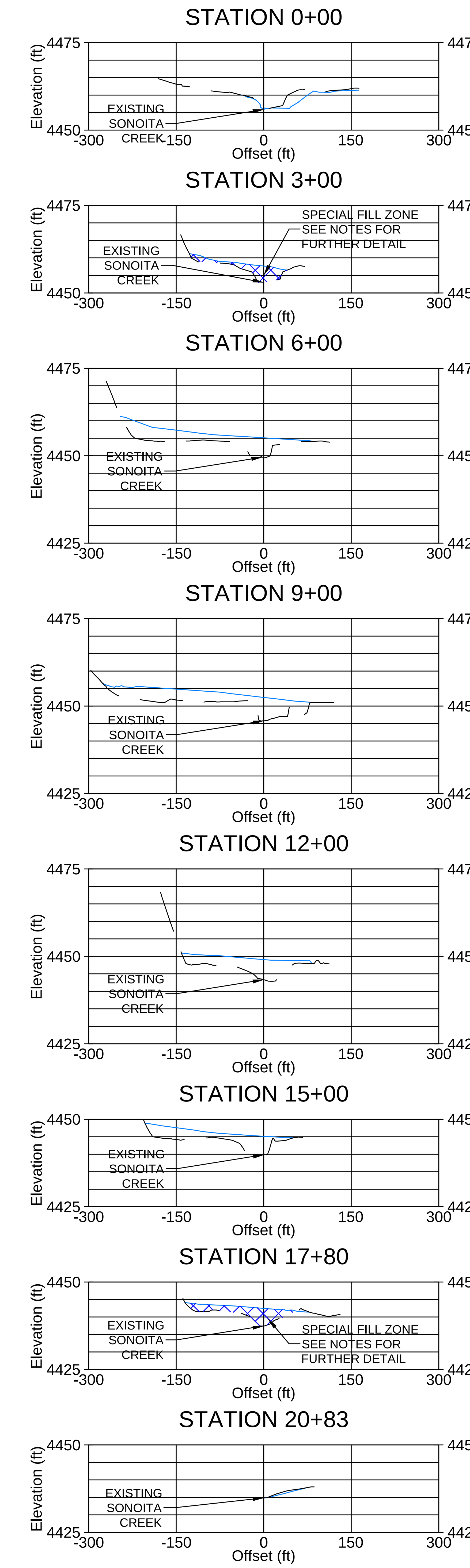
CONTRACTOR DWG. NO. WET 4
DWG. NO.
REVISION
DATE 09/08/17



RX EXISTING SONOITA PROFILE





- EXISTING INDEX CONTOUR (10-FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED INDEX CONTOUR (10-FT INTERVAL)
- PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
- 0+89 CROSS SECTION
- EXISTING EPHEMERAL DRAINAGE
- PROPOSED CHANNEL ALIGNMENT
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- GAS PIPELINE ALIGNMENT
- GEOMORPHIC REPOSITORY BOUNDARY
- PRIMARY RIDGE
- SWALE CENTERLINE
- ARIZONA STATE HIGHWAY 82
- PROPERTY BOUNDARY
- POND
- CHANNEL TERRACE
- ACTIVE CHANNEL
- FILL IN EXISTING SONOITA CREEK
- SPECIAL FILL ZONE

NOTES

1. CHANNEL BACKFILL AND REPOSITORY AREAS DESIGNATED AS A SPECIAL FILL ZONE SHALL BE COMPACTED IN LOOSE LIFTS NOT EXCEEDING 1-FT DEEP AND COMPACTED TO 95% OF A STANDARD PROCTOR (ASTM D698).
2. ALL REMAINING CHANNEL FILL SHALL BE COMPACTED IN LOOSE LIFTS NOT EXCEEDING 18" AND COMPACTED TO MATCH SURROUNDING TERRAIN COMPACTION.

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SONOITA CREEK MITIGATION PROJECT

REFERENCES		REFERENCES		REVISIONS							REVISIONS						
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ROSEMONT PROJECT

RX EXISTING SONOITA BACKFILL DETAIL SHEET

NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. WET 5

DWG. NO.

REVISION

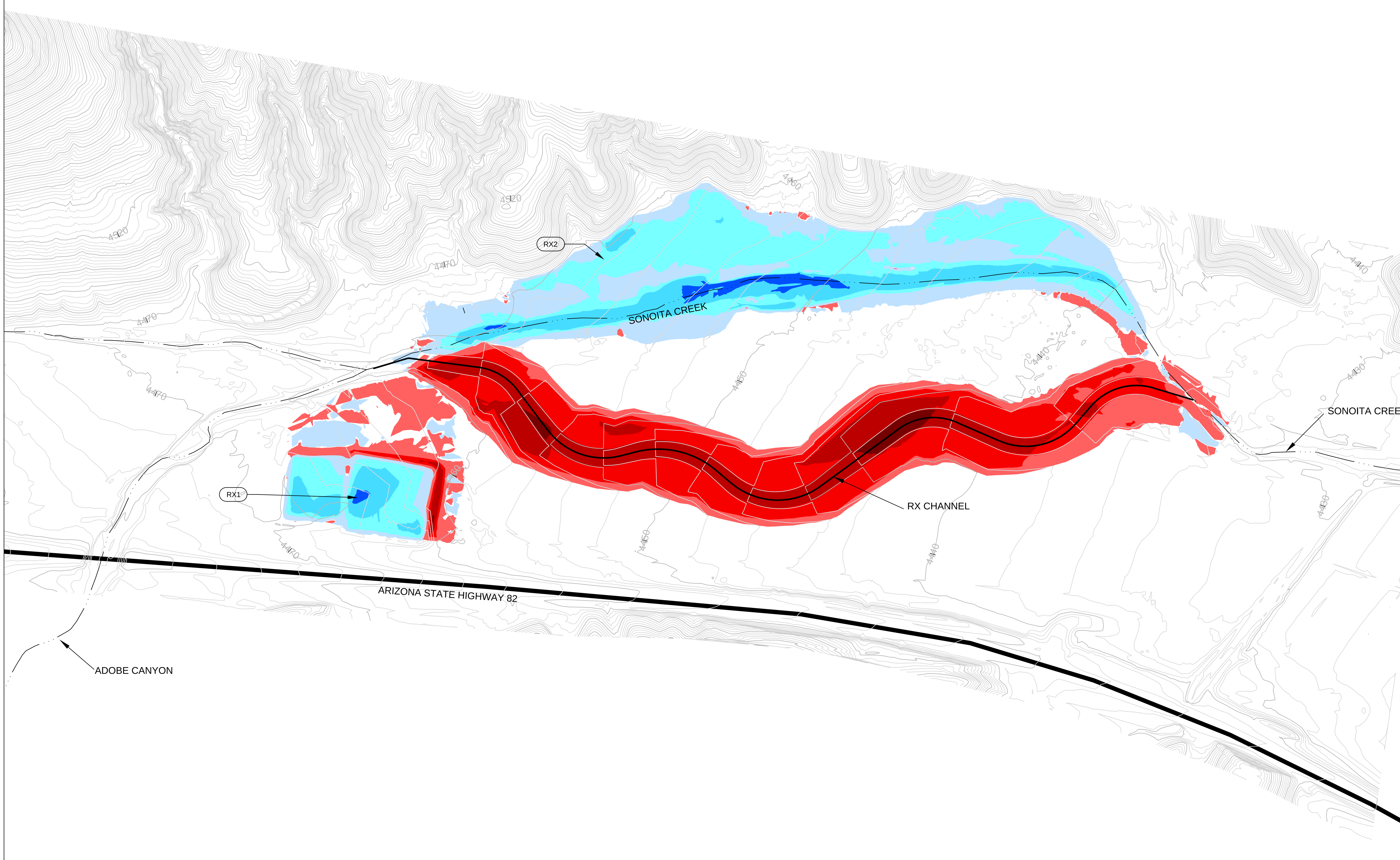
DATE 09/08/17

DESIGN INDEX CONTOUR (10-FT INTERVAL)
DESIGN INTERMEDIATE CONTOUR (2-FT INTERVAL)
EXISTING EPHEMERAL DRAINAGE
PROPOSED CHANNEL ALIGNMENT
GAS PIPELINE ALIGNMENT
ARIZONA STATE HIGHWAY 82
SCR 1 SOIL REPOSITORY ID

CUT\FILL ELEVATIONS TABLE		
MINIMUM ELEVATION	MAXIMUM ELEVATION	
-11	-10	
-10	-9	
-9	-8	
-8	-7	
-7	-6	
-6	-5	
-5	-4	
-4	-3	
-3	-2	
-2	-1	
-1	-0.1	
0.1	1	
1	2	
2	3	
3	4	
4	5	
5	6	
6	7	
7	8	
8	9	
9	10	
10	11	
11	12	
12	13	
13	14	
14	15	
15	16	
16	17	
17	18	
18	19	
19	20	

N

0' 150' 300' 450'



NOTES

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Fort Collins, CO 80524
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SONOITA CREEK MITIGATION PROJECT

REFERENCES		REFERENCES		REVISIONS							REVISIONS						
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RX CUT-FILL SHEET

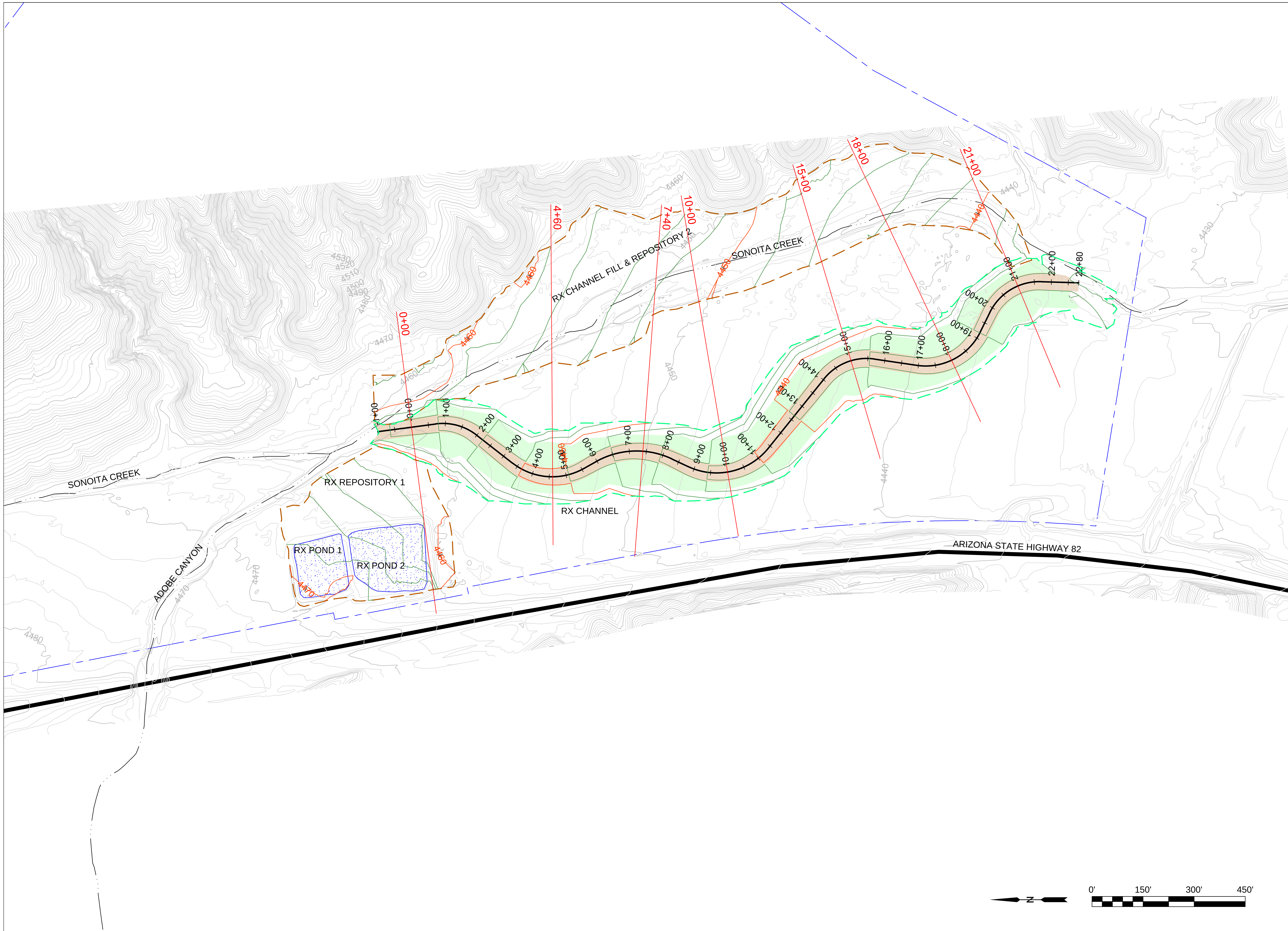
NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. WET 6

DWG. NO.

REVISION

DATE 09/08/17



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EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
PROPOSED INDEX CONTOUR (10-FT INTERVAL)
PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
EXISTING EPHEMERAL DRAINAGE
PROPOSED CHANNEL ALIGNMENT
0+40 CROSS SECTION
CHANNEL EXCAVATION BOUNDARY
SOIL REPOSITORY BOUNDARY
ARIZONA STATE HIGHWAY 82
PROPERTY BOUNDARY
CHANNEL TERRACE
ACTIVE CHANNEL
POND

NOTES:
SEE RX CHANNEL & REPOSITORY CROSS SECTION SHEETS 2 AND 3 FOR PLOTTED CROSS SECTIONS.

PREPARED BY:

Water & Earth TECHNOLOGIES

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FORT COLLINS, CO 80524
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REFERENCES		REFERENCES		REVISIONS							REVISIONS						
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HUDBAY
ROSEMONT PROJECT

SONOITA CREEK MITIGATION PROJECT

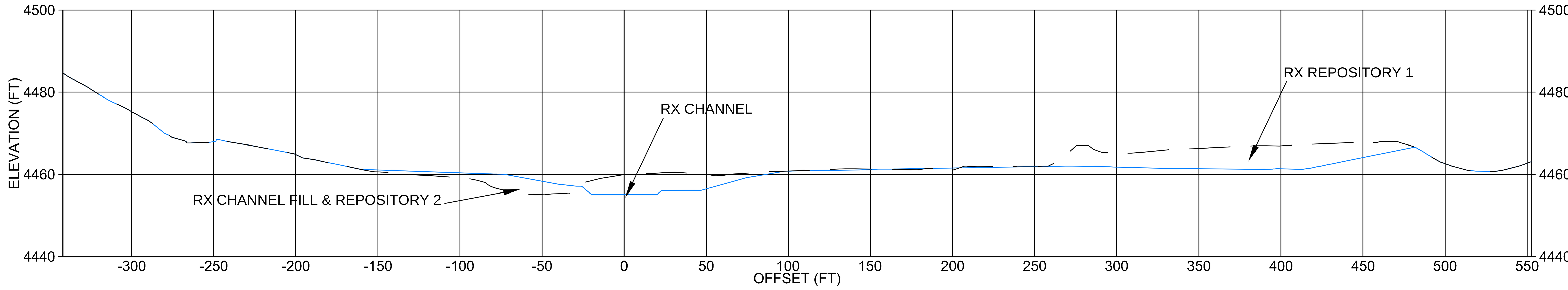
RX CHANNEL & REPOSITORY CROSS SECTION SHEET 1

NOT FOR CONSTRUCTION

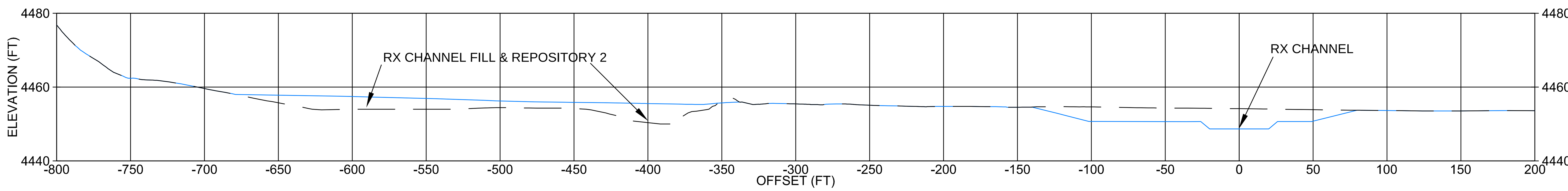
CONTRACTOR DWG. NO.	WET 7
DWG. NO.	
REVISION	DATE 09/08/17

RX VALLEY CROSS SECTIONS

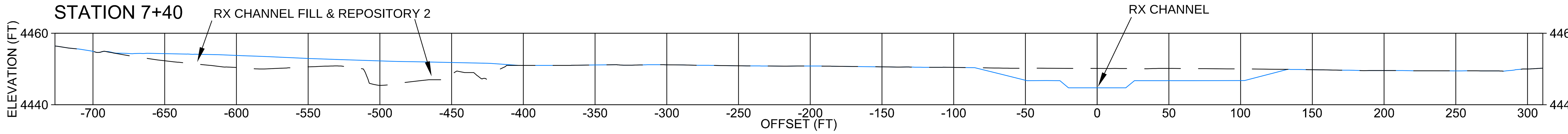
STATION 0+00



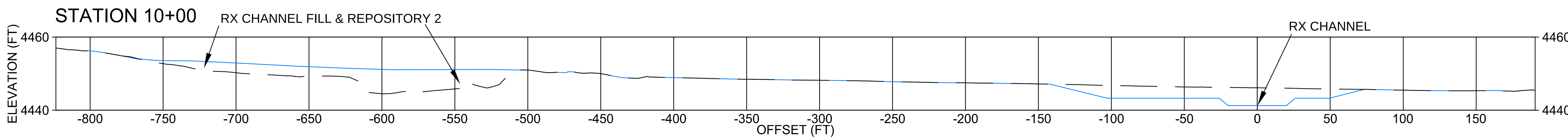
STATION 4+60



STATION 7+40



STATION 10+00



EXISTING GRADE
FINAL GRADE

NOTES

1. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM.
2. OFFSET OF 0.0 FT CORRESPONDS TO RX CHANNEL CENTERLINE.
3. SEE RX CHANNEL & REPOSITORY CROSS-SECTION SHEET 1 FOR CROSS SECTION PLAN VIEW.

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SONOITA CREEK MITIGATION PROJECT

RX CHANNEL & REPOSITORY CROSS SECTION SHEET 2

CONTRACTOR DWG. NO. WET 8

DWG. NO.

REVISION | DATE 09/08/17

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ROSEMONT PROJECT

REFERENCES	
DWG. NO.	TITLE

REFERENCES	
DWG. NO.	TITLE

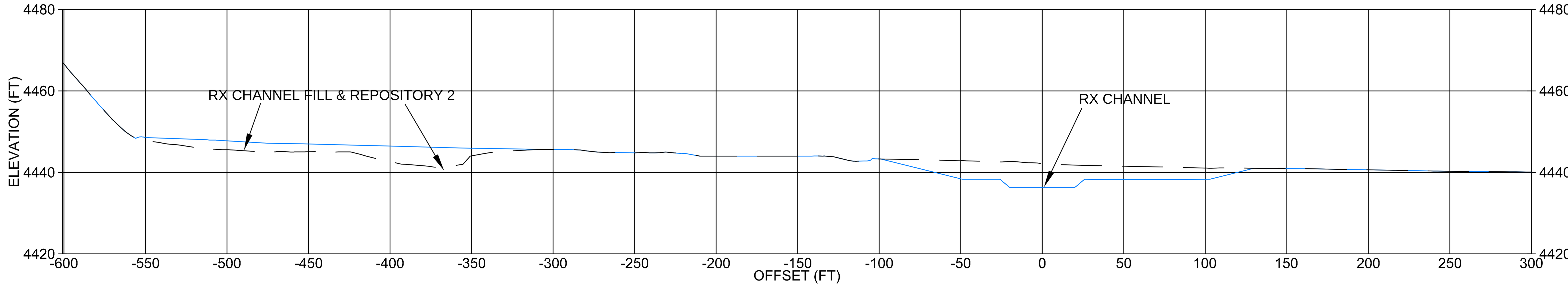
REVISIONS						
NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION

REVISIONS						
NO.	BY	CKD	APP.	CLIENT	DATE	DESCRIPTION

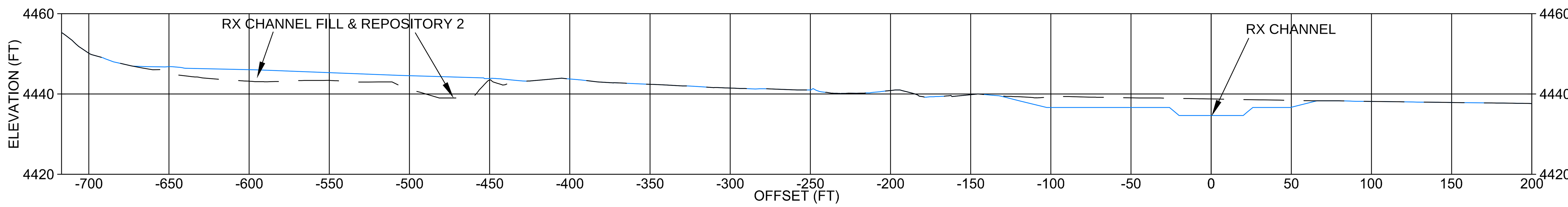
RX VALLEY CROSS SECTIONS

EXISTING GRADE
FINAL GRADE

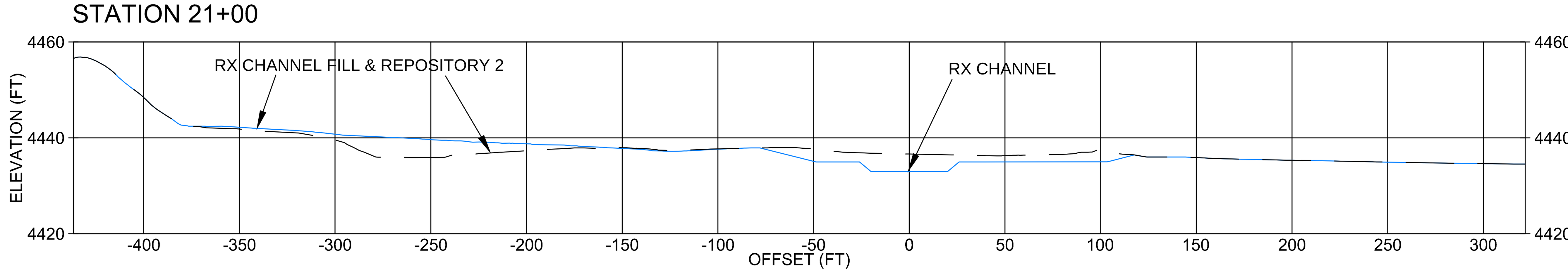
STATION 15+00



STATION 18+00



STATION 21+00



NOTES

1. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM.
2. OFFSET OF 0.0 FT CORRESPONDS TO RX CHANNEL CENTERLINE.
3. SEE RX CHANNEL & REPOSITORY CROSS-SECTION SHEET 1 FOR CROSS SECTION PLAN VIEW.

PREPARED BY:

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ROSEMONT PROJECT

SONOITA CREEK MITIGATION PROJECT

RX CHANNEL
& REPOSITORY CROSS
SECTION SHEET 3

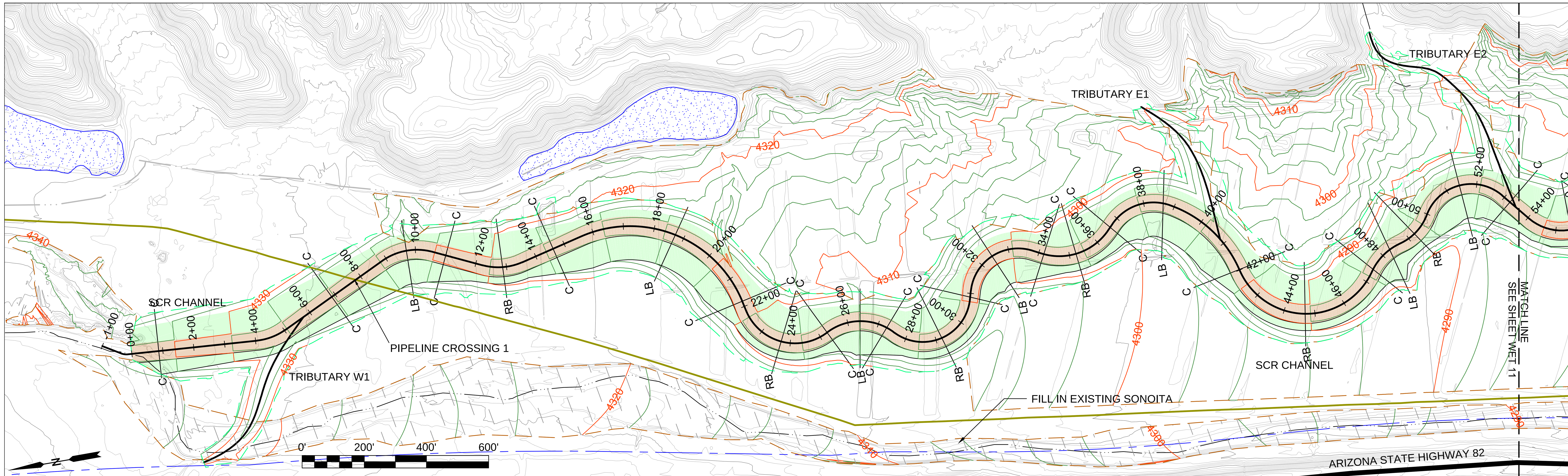
NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. WET 9

DWG. NO.

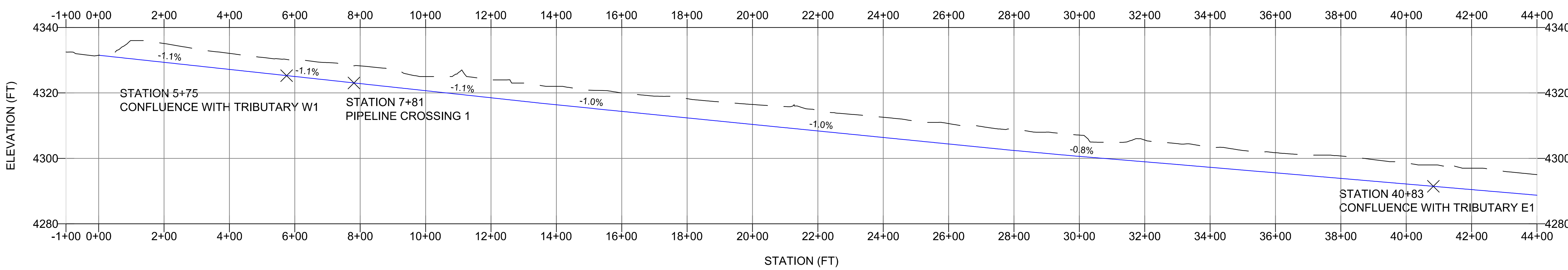
REVISION

DATE 09/08/17



EXISTING INDEX CONTOUR (10-FT INTERVAL)
EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
PROPOSED INDEX CONTOUR (10-FT INTERVAL)
PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
PROPOSED CHANNEL EXCAVATION LIMIT
PROPOSED SOIL REPOSITORY BOUNDARY
PROPOSED CHANNEL ALIGNMENT WITH STATIONS
GAS PIPELINE ALIGNMENT
POND
EXISTING DITCH
EXISTING GRADE PROFILE
PROPOSED FINAL GRADE PROFILE
EXISTING EPHEMERAL DRAINAGE
AZ STATE HIGHWAY 82
PROPERTY BOUNDARY
RB — TYPICAL RIGHT BEND CROSS SECTION
C — C TYPICAL CENTERED CROSS SECTION
LB — TYPICAL LEFT BEND CROSS SECTION
CHANNEL TERRACE
ACTIVE CHANNEL
FILL IN EXISTING SONOITA CREEK

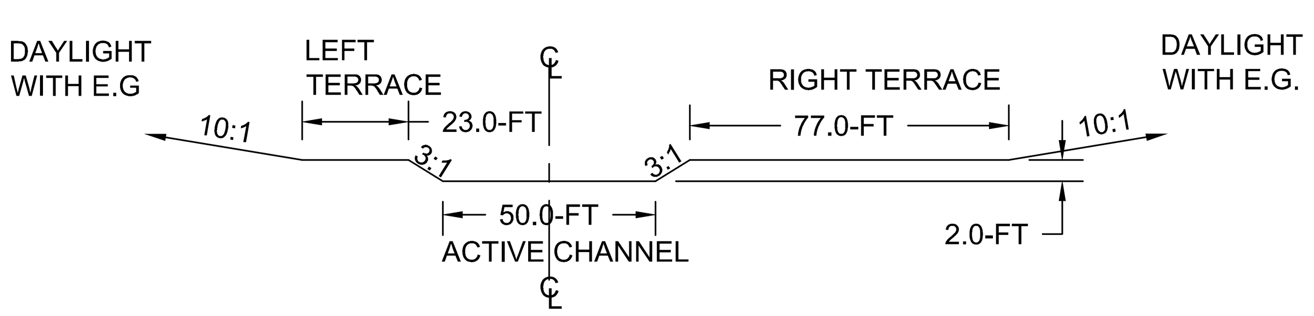
SCR CHANNEL PROFILE



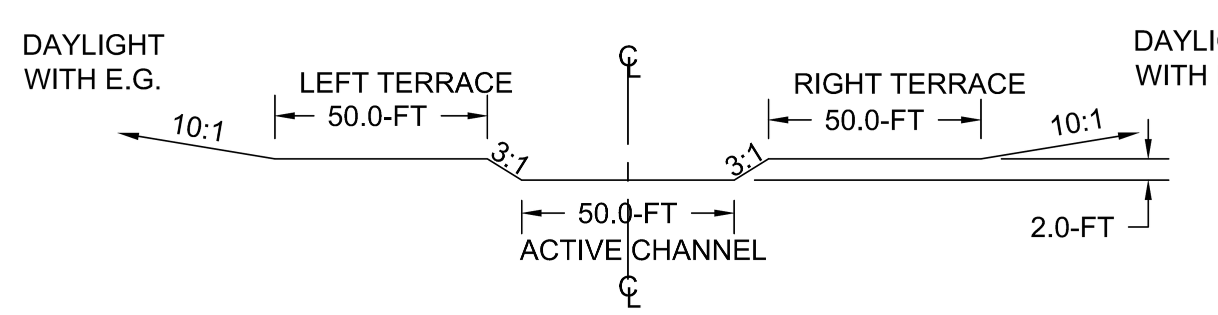
NOTES

1. PROFILES OF EXISTING GRADE AND FINAL GRADE CORRESPOND TO CHANNEL CENTERLINE ELEVATIONS.
2. FINAL GRADE PROFILE CORRESPONDS TO CHANNEL INVERT ELEVATION.
3. CROSS SECTIONS ARE DRAWN FACING DOWNSTREAM.
4. ACTIVE CHANNEL IS ALWAYS CENTERED ON THE CHANNEL ALIGNMENT CENTERLINE.
5. SCR CHANNEL LEFT AND RIGHT CHANNEL TERRACE WIDTHS SHALL ALWAYS SUM TO TOTAL TERRACE WIDTH OF 100-FT.
6. SCR CHANNEL RIGHT BEND: MINIMUM LEFT TERRACE WIDTH IS 23.0-FT AND MAXIMUM RIGHT TERRACE WIDTH IS 77.0-FT.
7. SCR CHANNEL LEFT BEND: MAXIMUM LEFT TERRACE WIDTH IS 77.0-FT AND MINIMUM RIGHT TERRACE WIDTH IS 23.0-FT.
8. ACTIVE CHANNEL GRADUALLY MEANDERS WITHIN THE TOTAL TERRACE WIDTH.
9. TERRACE CONSTRUCTION ALONG THE LEFT BANK OF SONOITA CREEK WITH BEGIN AT THE CONFLUENCE WITH SCR CHANNEL (SEE WET 15).
10. WHERE IT BECOMES NECESSARY TO FILL GREATER THAN 1.5-FT DEEP WITHIN THE CHANNEL EXCAVATION BOUNDARY, THEN FILL SHALL BE COMPACTED IN LOOSE LIFTS NOT EXCEEDING 1-FT DEEP AND COMPACTED TO 95% OF A STANDARD PROCTOR (ASTM D698).

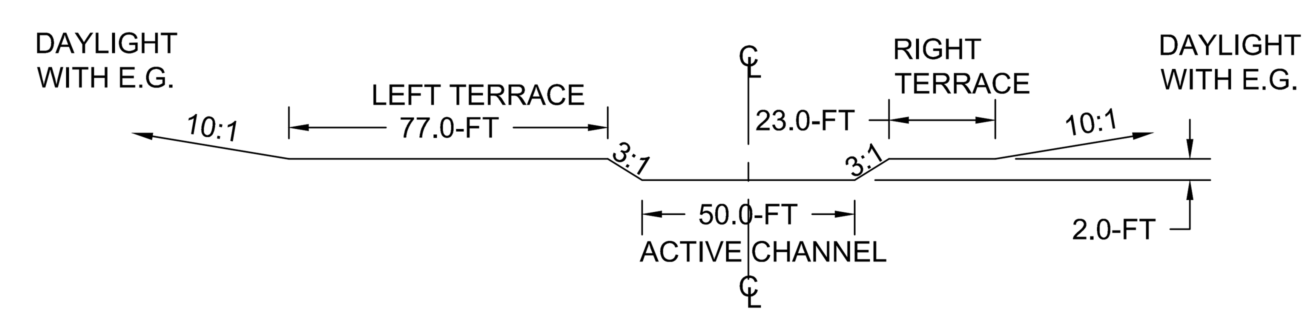
SCR CHANNEL
RIGHT BEND SECTION
STATION 0+00 TO 114+61



SCR CHANNEL
CENTERED SECTION
STATION 0+00 TO 114+61



SCR CHANNEL
LEFT BEND SECTION
STATION 0+00 TO 114+61



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SONOITA CREEK MITIGATION PROJECT

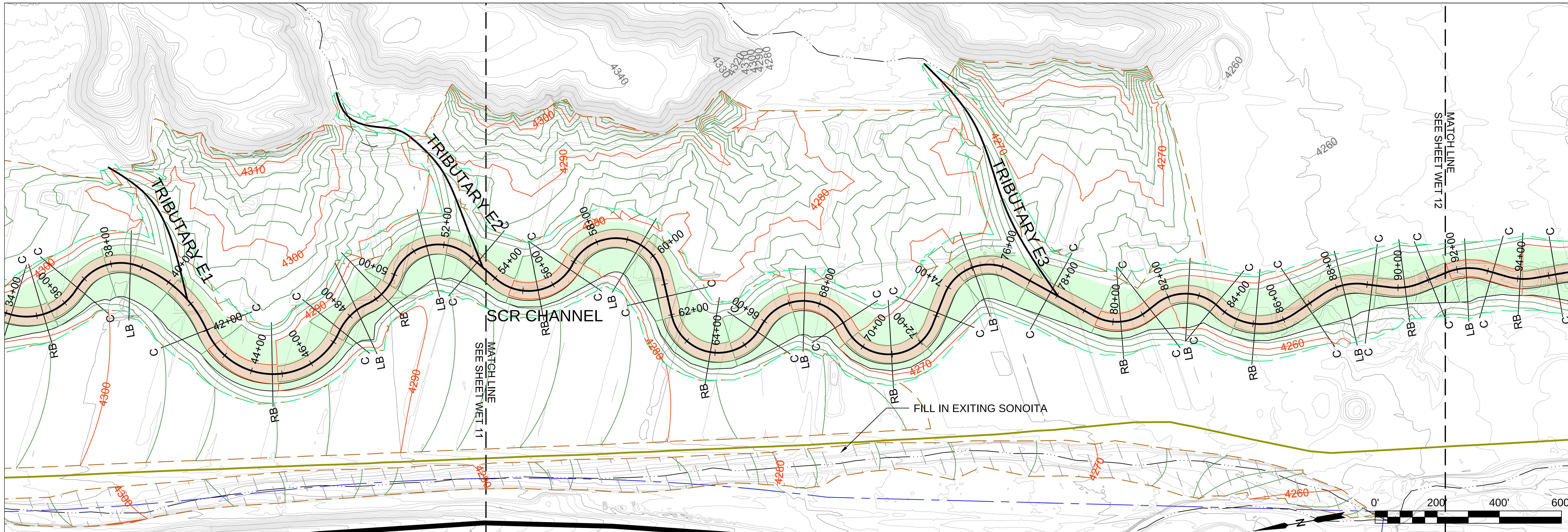
REFERENCES		REFERENCES		REVISIONS							REVISIONS						
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION	NO.	BY	CKD	APP.	CLIENT	DATE	DESCRIPTION

HUDBAY
ROSEMONT PROJECT

SCR CHANNEL
PLAN & PROFILE WITH TYPICAL
CHANNEL CROSS SECTIONS 1

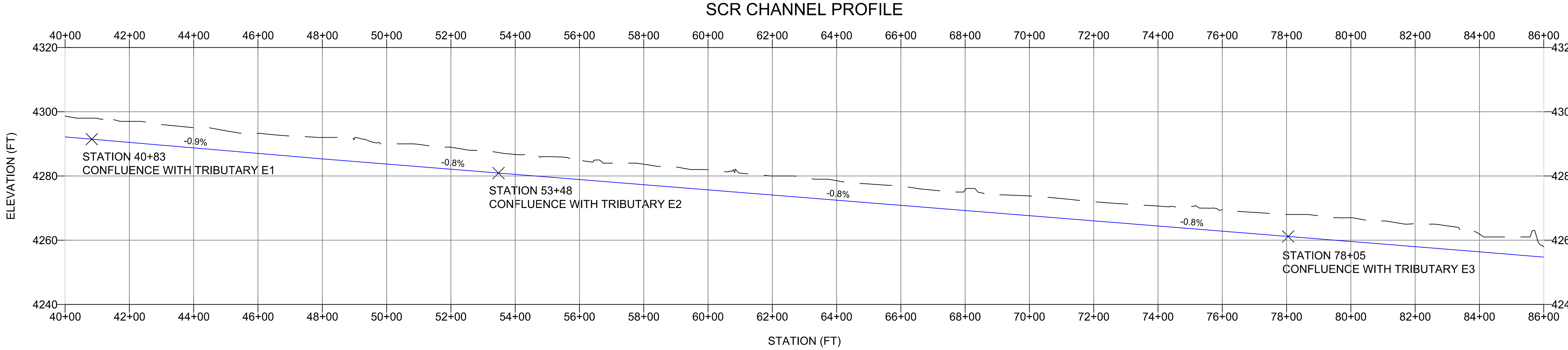
NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. WET 10
DWG. NO.
REVISION
DATE 09/08/17



- EXISTING INDEX CONTOUR (10-FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED INDEX CONTOUR (10-FT INTERVAL)
- PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED CHANNEL EXCAVATION LIMIT
- PROPOSED SOIL REPOSITORY BOUNDARY
- PROPOSED CHANNEL ALIGNMENT WITH STATIONS
- GAS PIPELINE ALIGNMENT
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- EXISTING EPHEMERAL DRAINAGE
- AZ STATE HIGHWAY 82
- PROPERTY BOUNDARY
- RB — TYPICAL RIGHT BEND CROSS SECTION
- C — C TYPICAL CENTERED CROSS SECTION
- LB — TYPICAL LEFT BEND CROSS SECTION
- CHANNEL TERRACE
- ACTIVE CHANNEL
- FILL IN EXISTING SONOITA CREEK

SCR CHANNEL PROFILE



NOTES

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2. FINAL GRADE PROFILE CORRESPONDS TO CHANNEL INVERT ELEVATION.
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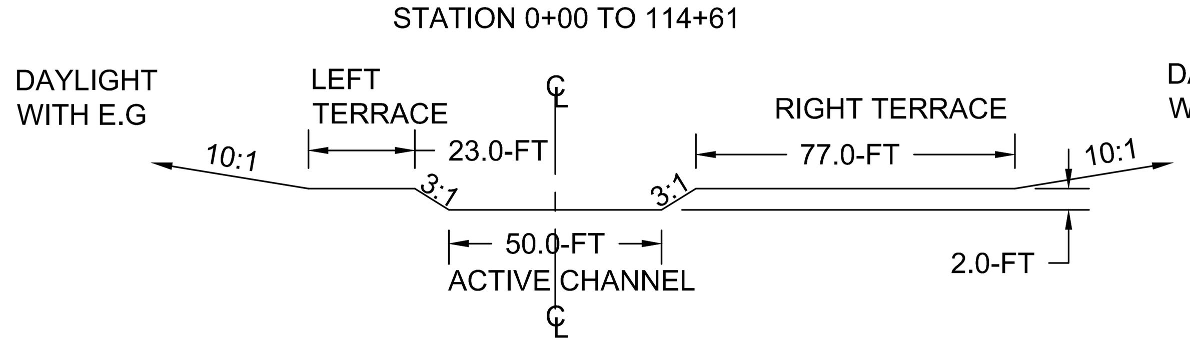
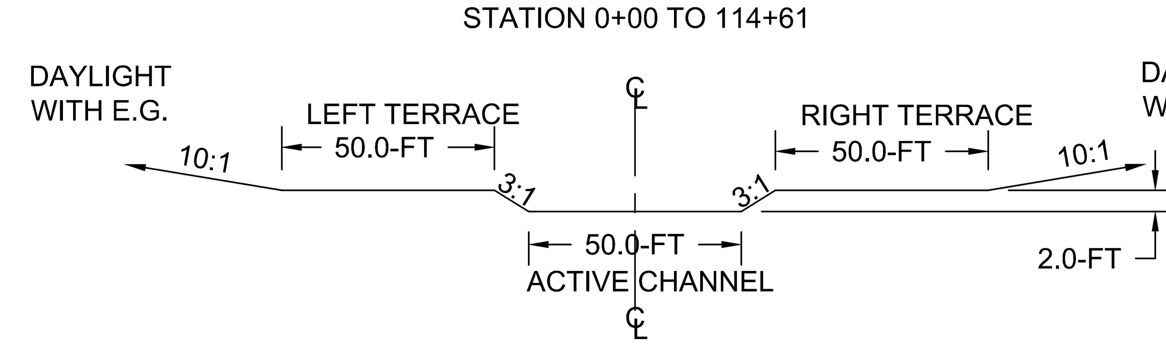
9. TERRACE CONSTRUCTION ALONG THE LEFT BANK OF SONOITA CREEK WITH BEGIN AT THE CONFLUENCE WITH SCR CHANNEL (SEE WET 15).
10. WHERE IT BECOMES NECESSARY TO FILL GREATER THAN 1.5-FT DEEP WITHIN THE CHANNEL EXCAVATION BOUNDARY, THEN FILL SHALL BE COMPACTED IN LOOSE LIFTS NOT EXCEEDING 1-FT DEEP AND COMPACTED TO 95% OF A STANDARD PROCTOR (ASTM D698).

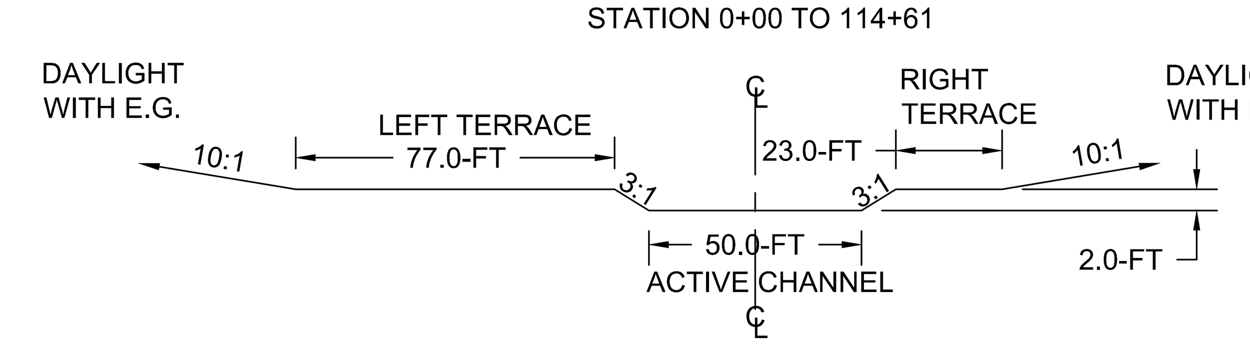
SCR CHANNEL
RIGHT BEND SECTION
STATION 0+00 TO 114+61



SCR CHANNEL
CENTERED SECTION
STATION 0+00 TO 114+61



SCR CHANNEL
LEFT BEND SECTION
STATION 0+00 TO 114+61



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REFERENCES		REFERENCES		REVISIONS							REVISIONS						
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HUDBAY

ROSEMONT PROJECT

SONOITA CREEK MITIGATION PROJECT

SCR CHANNEL
PLAN & PROFILE WITH TYPICAL
CHANNEL CROSS SECTIONS 2

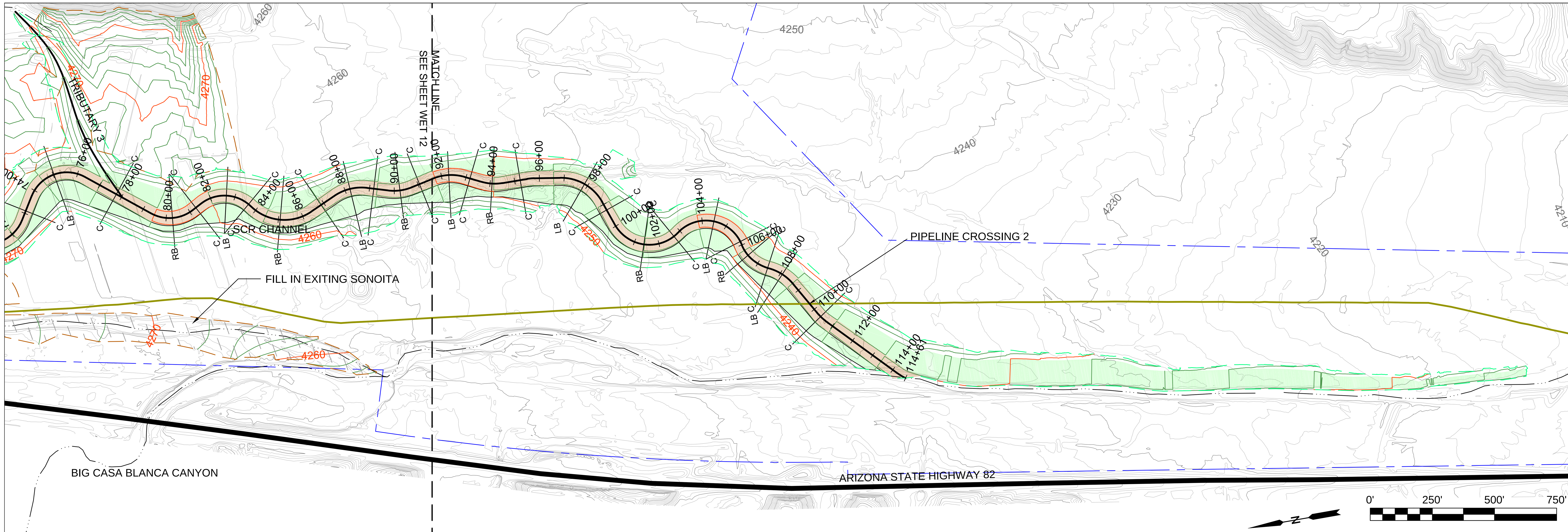
NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. WET 11

DWG. NO.

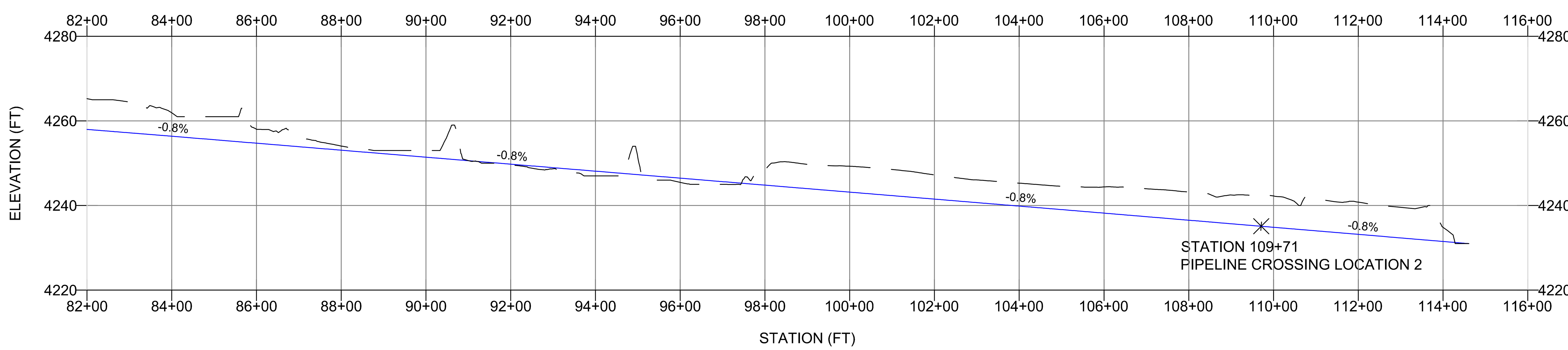
REVISION

DATE 09/08/17



	EXISTING INDEX CONTOUR (10-FT INTERVAL)
	EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
	PROPOSED INDEX CONTOUR (10-FT INTERVAL)
	PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
	PROPOSED CHANNEL EXCAVATION LIMIT
	PROPOSED SOIL REPOSITORY BOUNDARY
	PROPOSED CHANNEL ALIGNMENT WITH STATIONS
	GAS PIPELINE ALIGNMENT
	EXISTING GRADE PROFILE
	PROPOSED FINAL GRADE PROFILE
	EXISTING EPHEMERAL DRAINAGE
	AZ STATE HIGHWAY 82
	PROPERTY BOUNDARY
RB	TYPICAL RIGHT BEND CROSS SECTION
C — C	TYPICAL CENTERED CROSS SECTION
LB	TYPICAL LEFT BEND CROSS SECTION
	CHANNEL TERRACE
	ACTIVE CHANNEL
	FILL IN EXISTING SONOITA CREEK

SCR CHANNEL PROFILE



NOTES

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2. FINAL GRADE PROFILE CORRESPONDS TO CHANNEL INVERT ELEVATION.
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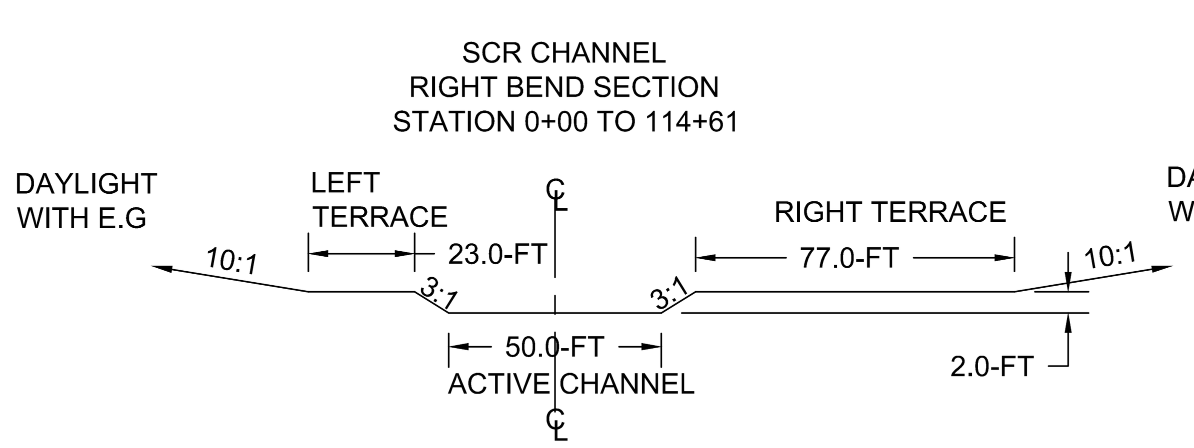
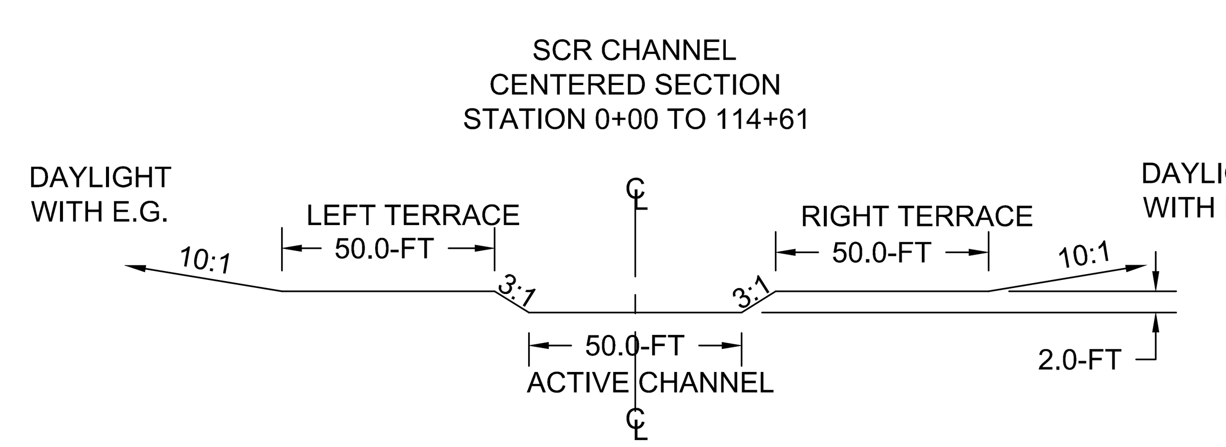
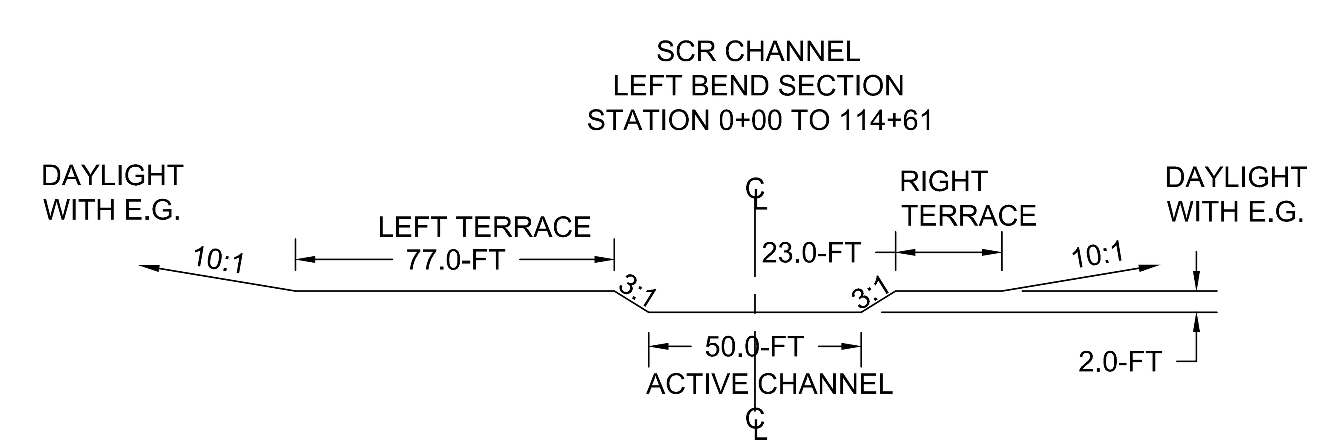
10. WHERE IT BECOMES NECESSARY TO FILL GREATER THAN 1.5-FT DEEP WITHIN THE CHANNEL EXCAVATION BOUNDARY, THEN FILL SHALL BE COMPACTED IN LOOSE LIFTS NOT EXCEEDING 1-FT DEEP AND COMPACTED TO 95% OF A STANDARD PROCTOR (ASTM D698).







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HUDBAY

ROSEMONT PROJECT

SONOITA CREEK MITIGATION PROJECT

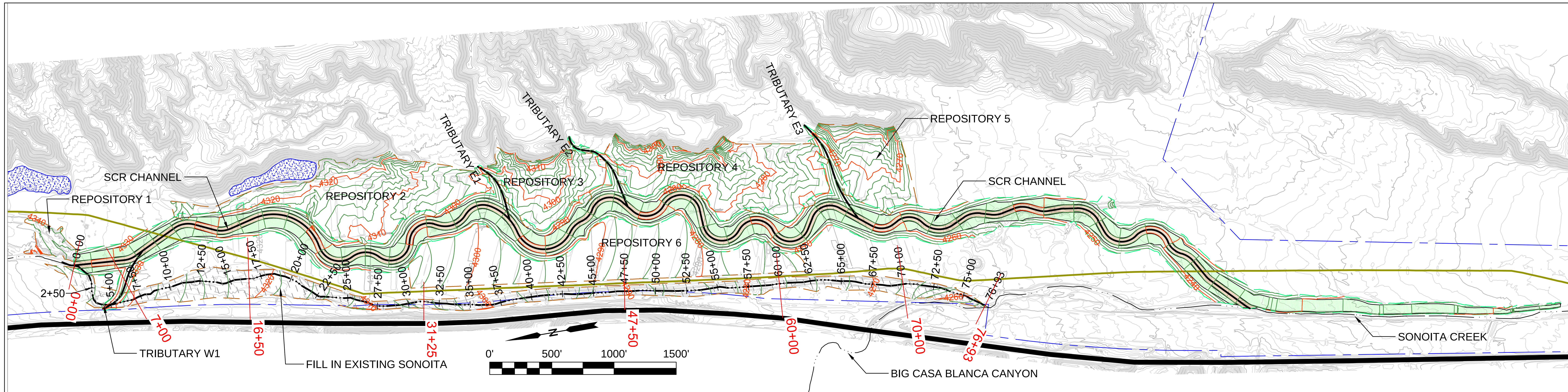
SCR CHANNEL
PLAN & PROFILE WITH TYPICAL CHANNEL CROSS SECTIONS 3

NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. WET 12

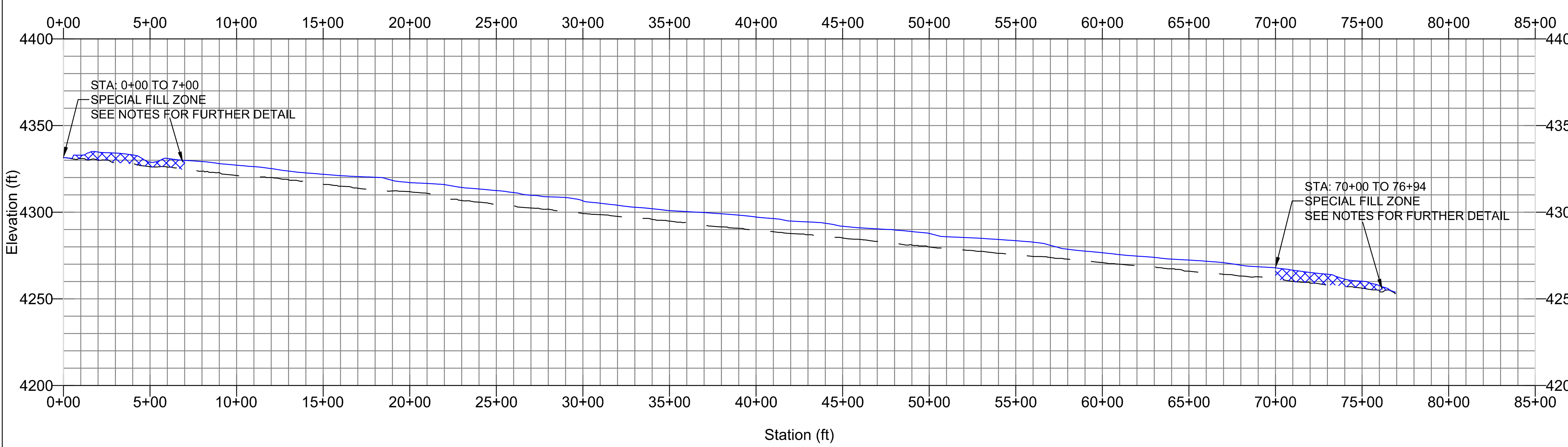
DWG. NO.

REVISION | DATE 09/08/17

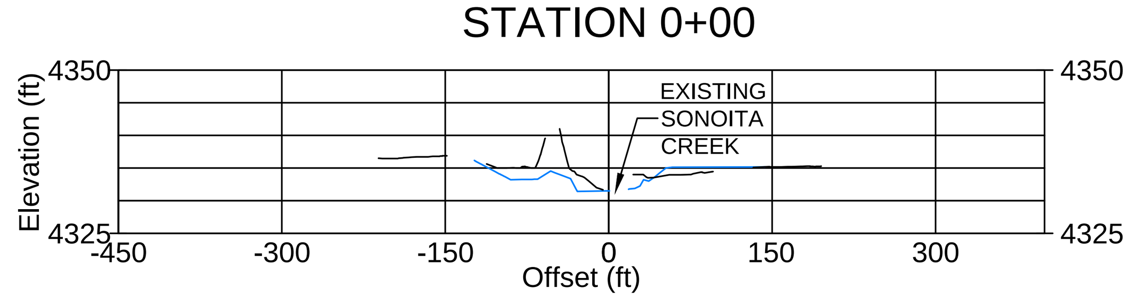


EXISTING INDEX CONTOUR (10-FT INTERVAL)
EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
PROPOSED INDEX CONTOUR (10-FT INTERVAL)
PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
0+89 CROSS SECTION
EXISTING EPHEMERAL DRAINAGE
PROPOSED CHANNEL ALIGNMENT
EXISTING GRADE PROFILE
PROPOSED FINAL GRADE PROFILE
GAS PIPELINE ALIGNMENT
GEOMORPHIC REPOSITORY BOUNDARY
PRIMARY RIDGE
SWALE CENTERLINE
ARIZONA STATE HIGHWAY 82
PROPERTY BOUNDARY
POND
CHANNEL TERRACE
ACTIVE CHANNEL
FILL IN EXISTING SONOITA CREEK
SPECIAL FILL ZONE

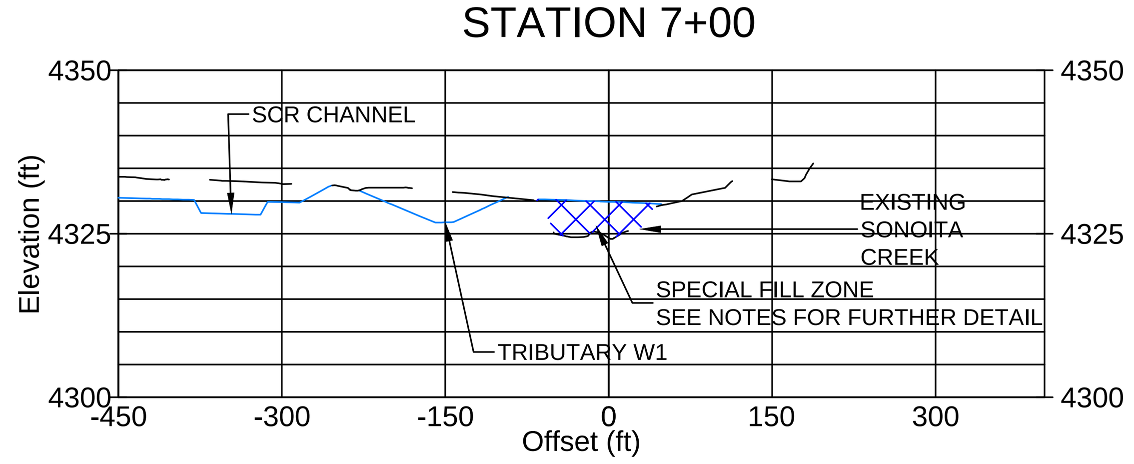
SCR EXISTING SONOITA PROFILE



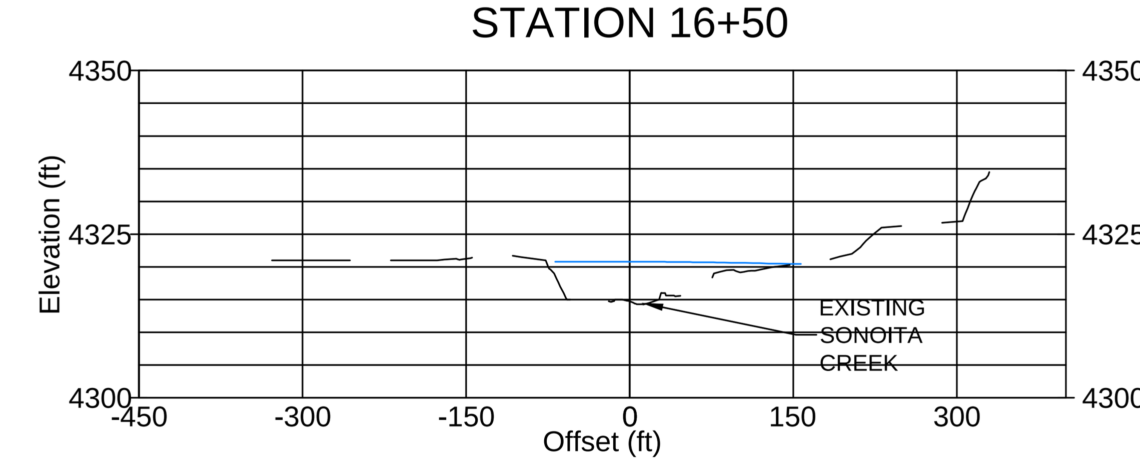
STATION 0+00



STATION 7+00



STATION 16+50



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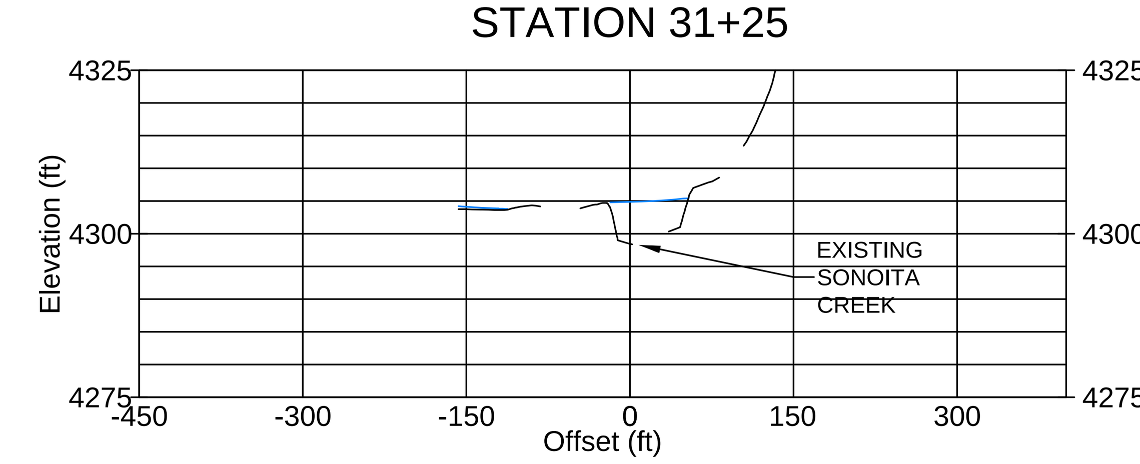

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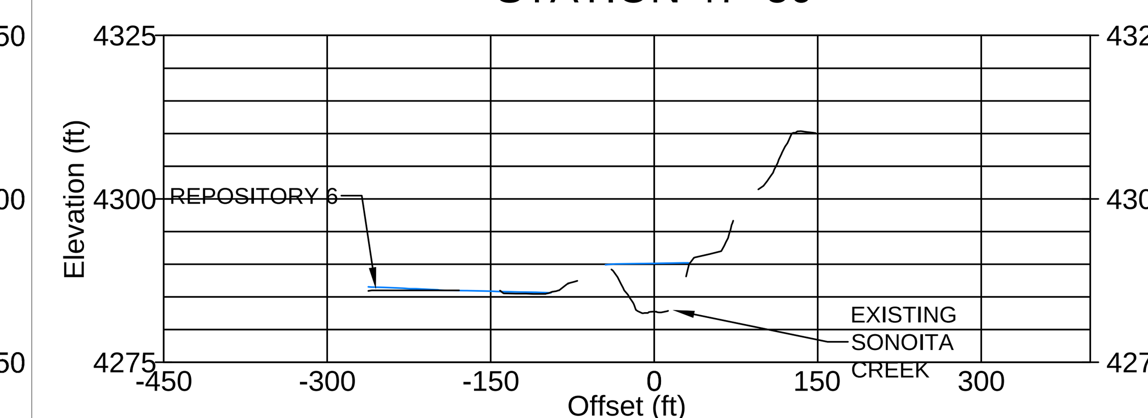
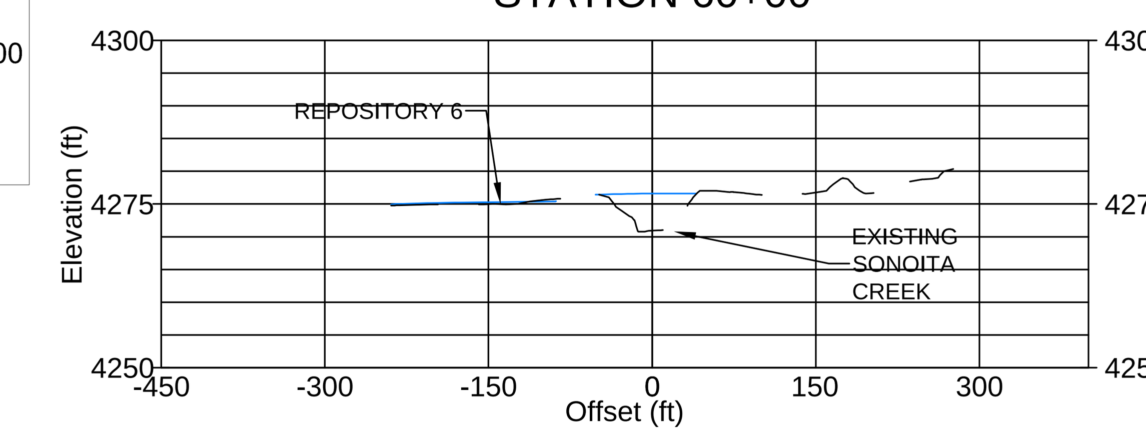
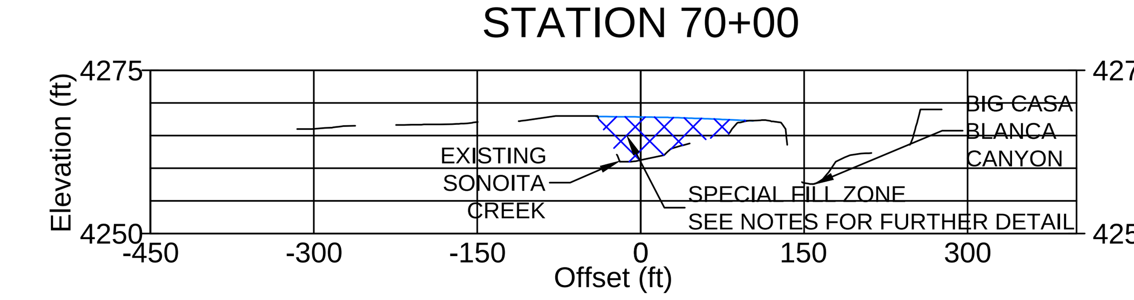


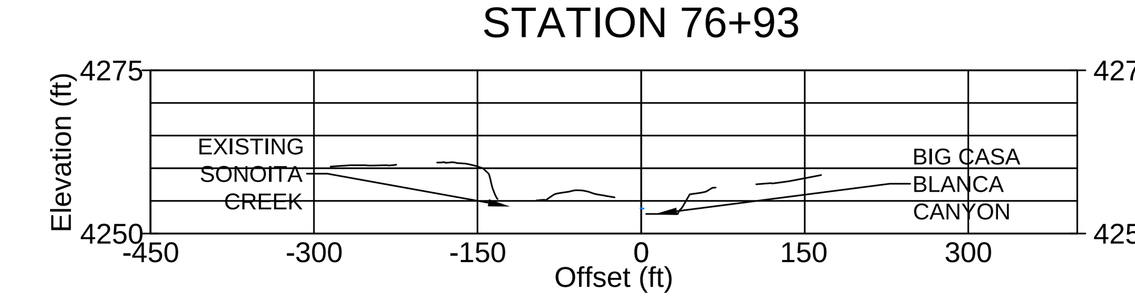
STATION 60+00



STATION 70+00



STATION 76+93



NOTES

1. CHANNEL BACKFILL AND REPOSITORY AREAS DESIGNATED AS A SPECIAL FILL ZONE SHALL BE COMPACTED IN LOOSE LIFTS NOT EXCEEDING 1-FT DEEP AND COMPACTED TO 95% OF A STANDARD PROCTOR (ASTM D698).
2. ALL REMAINING CHANNEL FILL SHALL BE COMPACTED IN LOOSE LIFTS NOT EXCEEDING 18" AND COMPACTED TO MATCH SURROUNDING TERRAIN COMPACTION.

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REFERENCES		REFERENCES		REVISIONS							REVISIONS						
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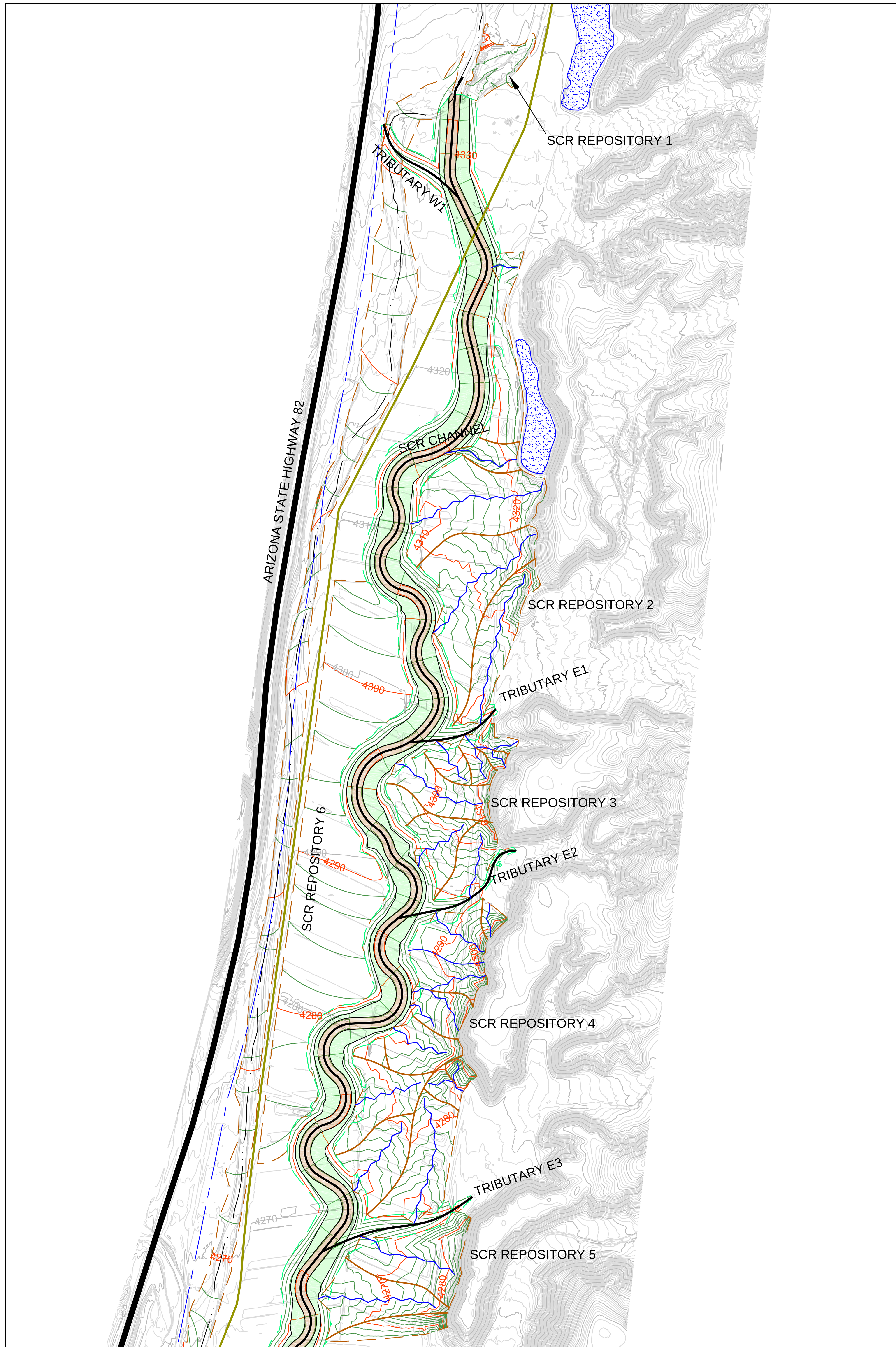
HUDBAY
ROSEMONT PROJECT

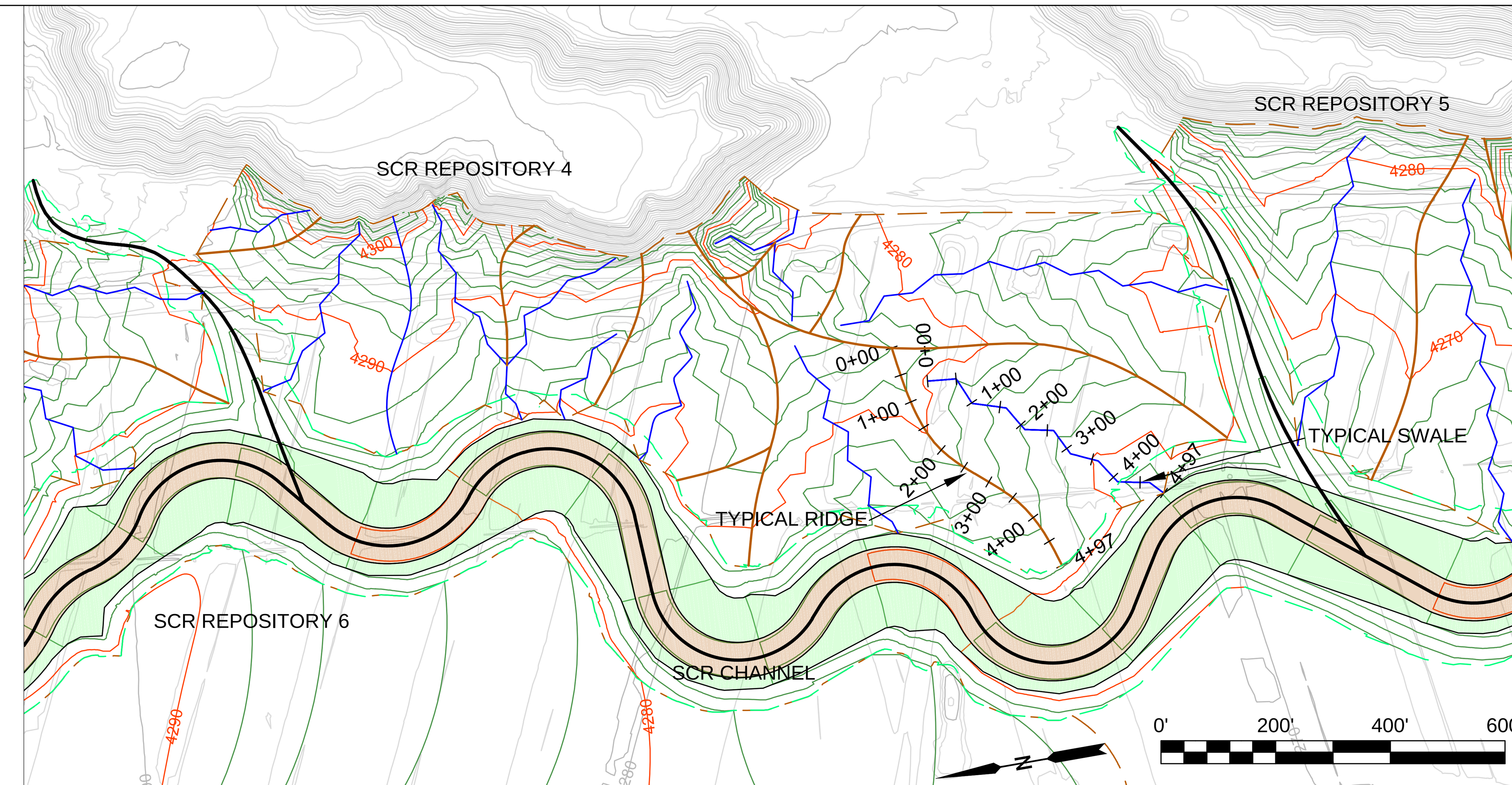
SONOITA CREEK MITIGATION PROJECT

SCR EXISTING SONOITA BACKFILL DETAIL SHEET

NOT FOR CONSTRUCTION

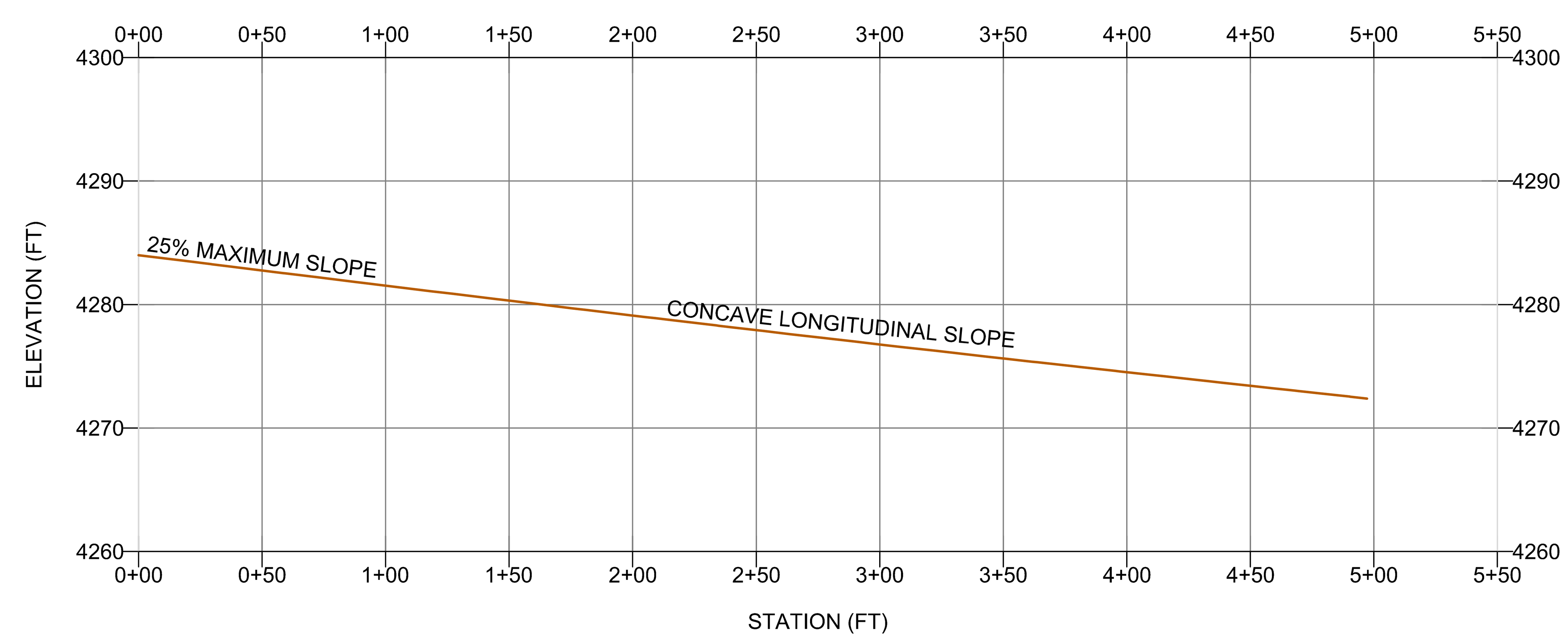
CONTRACTOR DWG. NO. WET 13
DWG. NO.
REVISION
DATE 09/08/17



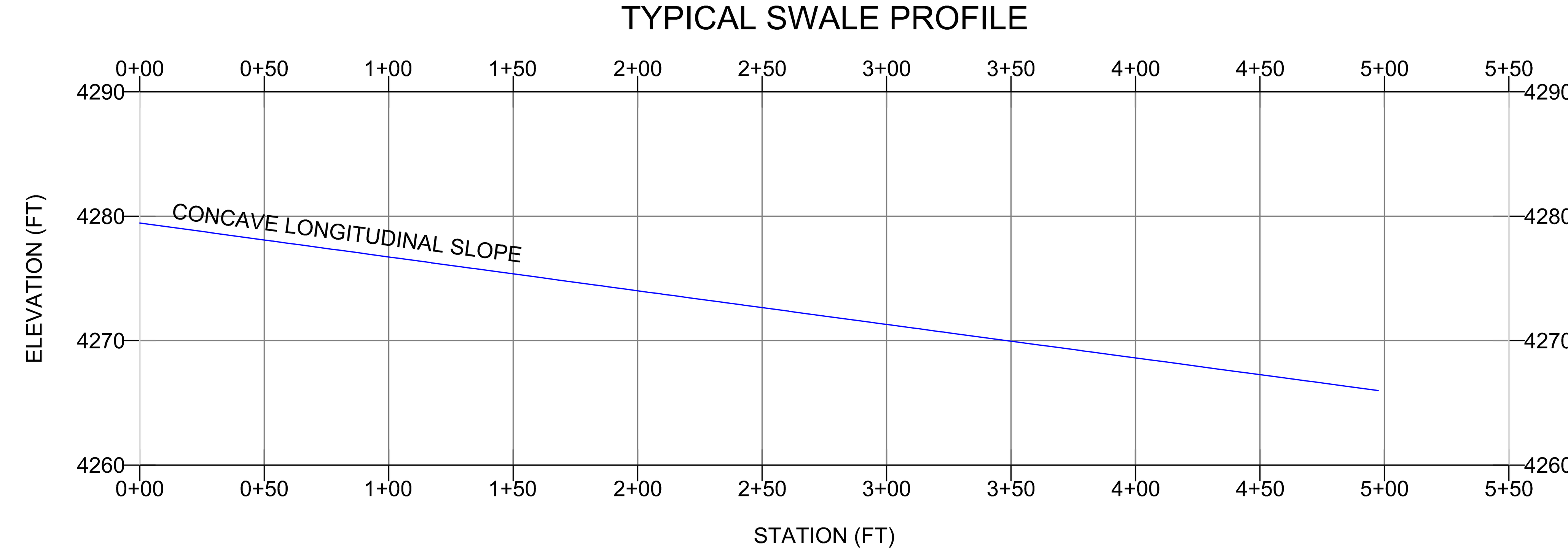


EXISTING INDEX CONTOUR (10-FT INTERVAL)
EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
PROPOSED INDEX CONTOUR (10-FT INTERVAL)
PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
EXISTING EPHEMERAL DRAINAGE
PROPOSED CHANNEL ALIGNMENT
GAS PIPELINE ALIGNMENT
SOIL REPOSITORY BOUNDARY
PRIMARY RIDGE
SWALE CENTERLINE
ARIZONA STATE HIGHWAY 82
PROPERTY BOUNDARY
POND
CHANNEL TERRACE
ACTIVE CHANNEL

TYPICAL RIDGE PROFILE



TYPICAL SWALE PROFILE



NOTES

1. SOIL REPOSITORIES SHALL BE CONSTRUCTED WITH CONCAVE SLOPES THAT CONTINUALLY FLATTEN IN THE DOWNGRADIENT DIRECTION.
2. GRADED SLOPES IN THE SOIL REPOSITORIES SHALL NOT BE STEEPER THAN 4:1.
3. SOIL REPOSITORIES SHALL BE CONSTRUCTED WITH A NO ADDITIONAL COMPACTION EFFORT BEYOND THAT INCIDENTAL TO CONSTRUCTION.
4. SOIL REPOSITORIES SHALL CONSIST OF SUITABLE TOPSOIL FOR AN AVERAGE DEPTH OF 12 INCHES.
5. DECOMPACTION OF THE UPPER 1-FT MAY BE NECESSARY FOLLOWING FINAL FILL PLACEMENT TO ENCOURAGE DEEP ROOT ESTABLISHMENT OF RECLAMATION SEEDLINGS. DISCING AND RIPPING SHALL PROCEED ACROSS THE SLOPE OR ALONG THE CONTOUR.

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SONOITA CREEK MITIGATION PROJECT

REFERENCES		REFERENCES	
DWG. NO.	TITLE	DWG. NO.	TITLE

REVISIONS							REVISIONS						
NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION	NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION

HUDBAY

ROSEMONT PROJECT

SCR SOIL REPOSITORY DETAIL SHEET

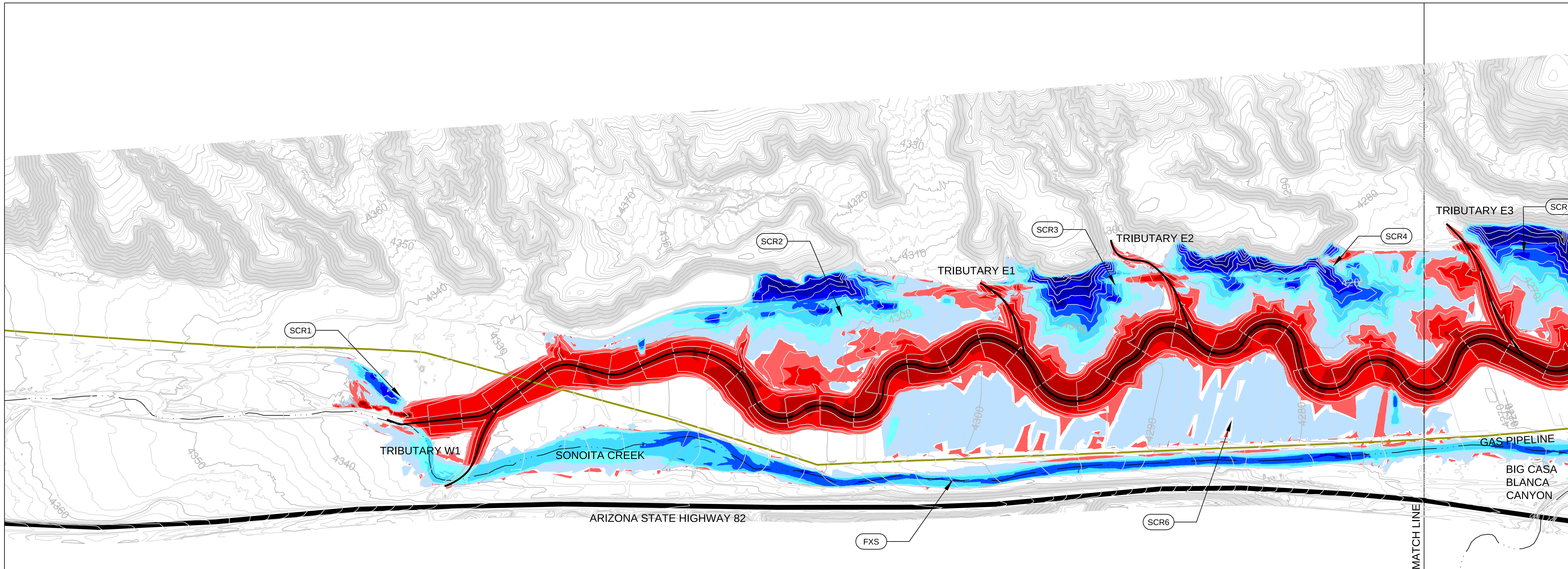
NOT FOR CONSTRUCTION

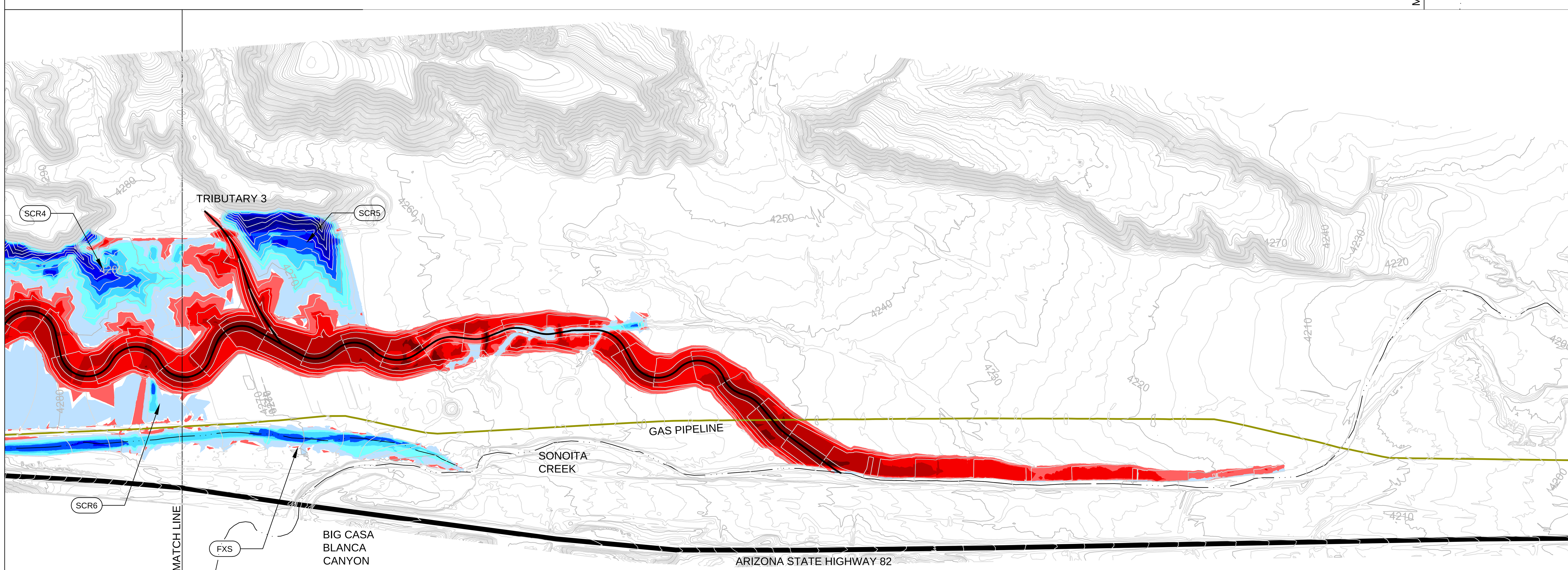
CONTRACTOR DWG. NO. WET 14

DWG. NO.

REVISION

DATE 09/08/17





DESIGN INDEX CONTOUR (10-FT INTERVAL)
DESIGN INTERMEDIATE CONTOUR (2-FT INTERVAL)
EXISTING EPHEMERAL DRAINAGE
PROPOSED CHANNEL ALIGNMENT
GAS PIPELINE ALIGNMENT
ARIZONA STATE HIGHWAY 82
SCR 1 SOIL REPOSITORY ID

CUT\FILL ELEVATIONS TABLE		
MINIMUM ELEVATION	MAXIMUM ELEVATION	
-11	-10	
-10	-9	
-9	-8	
-8	-7	
-7	-6	
-6	-5	
-5	-4	
-4	-3	
-3	-2	
-2	-1	
-1	-0.1	
0.1	1	
1	2	
2	3	
3	4	
4	5	
5	6	
6	7	
7	8	
8	9	
9	10	
10	11	
11	12	
12	13	
13	14	
14	15	
15	16	
16	17	
17	18	
18	19	
19	20	

N

0' 350' 700' 1050'

NOTES

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SONOITA CREEK MITIGATION PROJECT

SCR CUT-FILL SHEET

NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. WET 15

DWG. NO.

REVISION

DATE 09/08/17

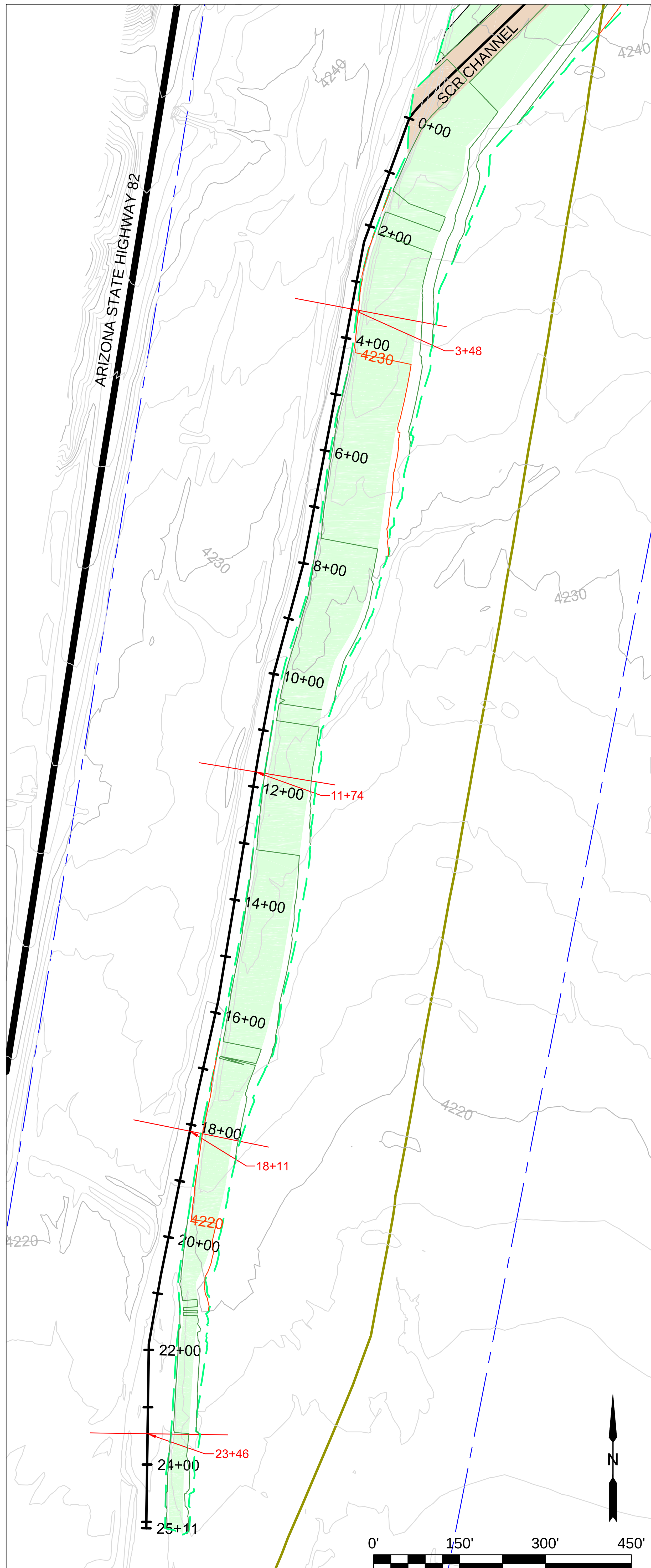
HUDBAY

ROSEMONT PROJECT

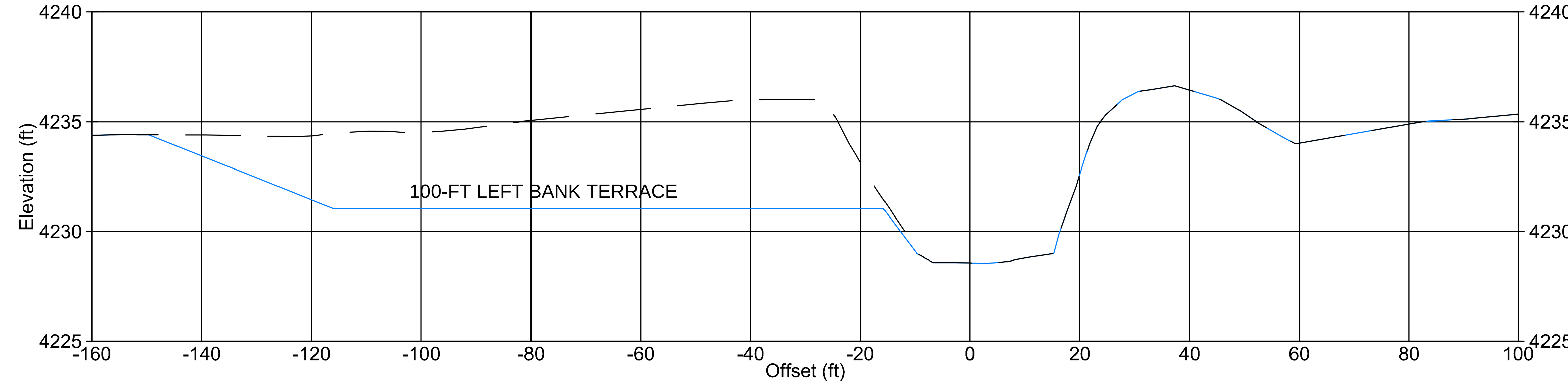
REFERENCES		REFERENCES	
DWG. NO.	TITLE	DWG. NO.	TITLE

REVISIONS						
NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION

REVISIONS						
NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION



STATION 3+48



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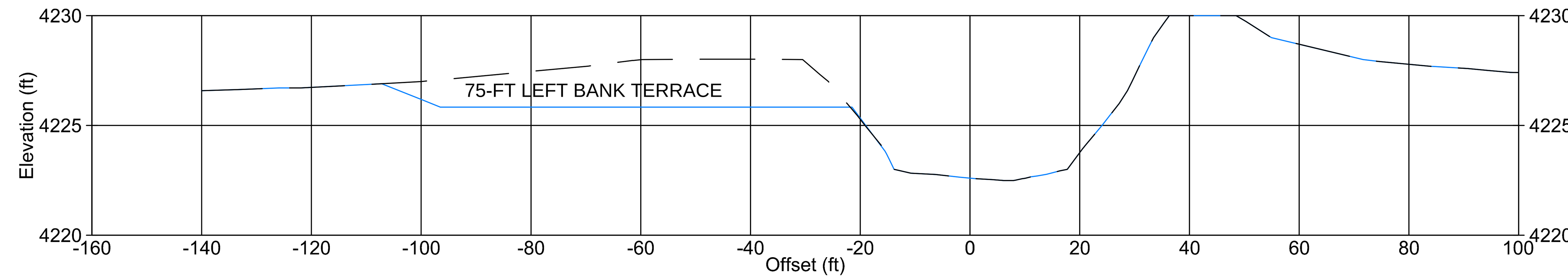
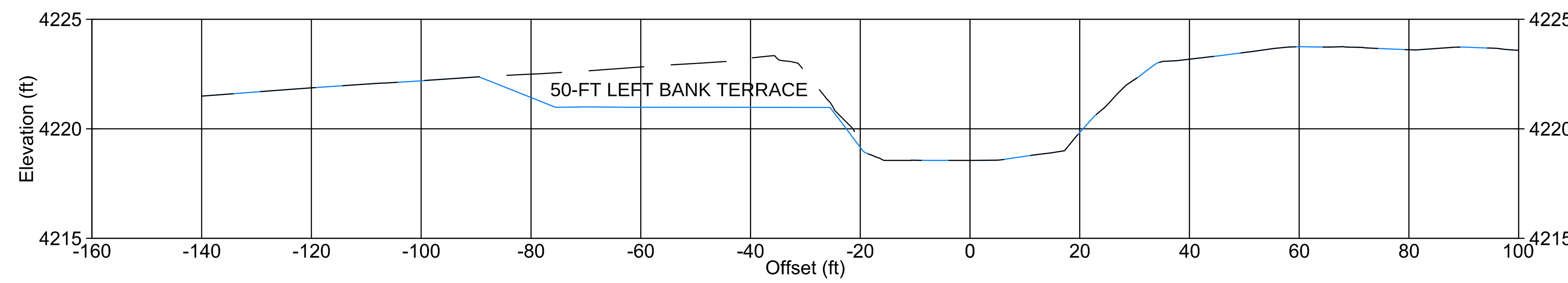
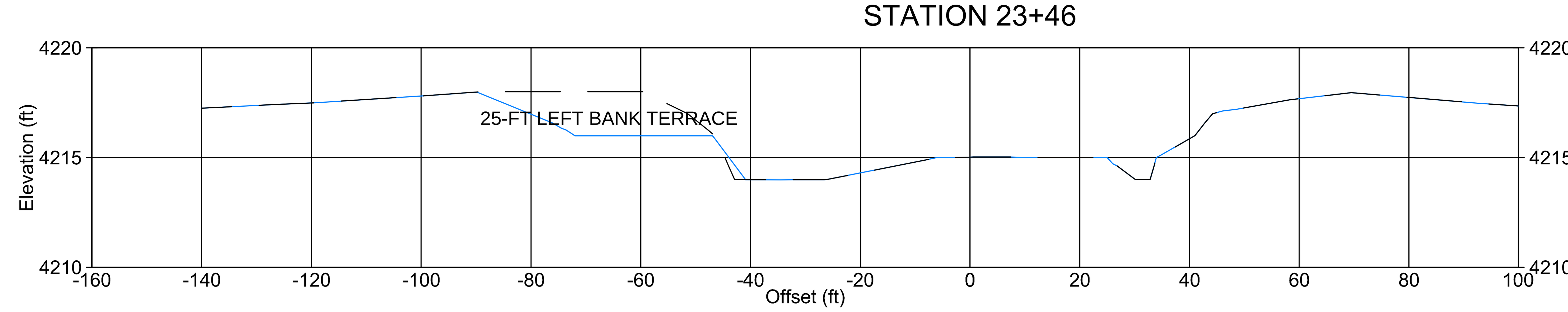


STATION 18+11



STATION 23+46



SONOITA CREEK BANK MODIFICATIONS

Station Range	Treatment
0+00 to 8+45	Construct 100-ft Left Bank Terrace
8+45 to 9+45	Transition from 100-ft Terrace to 75-ft Terrace
9+45 to 16+30	Construct 75-ft Left Bank Terrace
16+30 to 17+50	Transition from 75-ft Terrace to 50-ft Terrace
17+50 to 20+20	Construct 50-ft Left Bank Terrace
20+20 to 20+85	Transition from 50-ft Terrace to 25-ft Terrace
20+85 to 25+11	Construct 25-ft Left Bank Terrace

EXISTING INDEX CONTOUR (10-FT INTERVAL)
EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
PROPOSED INDEX CONTOUR (10-FT INTERVAL)
PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
EXISTING EPHEMERAL DRAINAGE
PROPOSED CHANNEL ALIGNMENT
3+48 CROSS SECTION
CHANNEL EXCAVATION BOUNDARY
SOIL REPOSITORY BOUNDARY
ARIZONA STATE HIGHWAY 82
EXISTING GRADE
FINAL GRADE
PROPERTY BOUNDARY
CHANNEL TERRACE
ACTIVE CHANNEL

NOTES:
1. BEGINNING AT THE CONFLUENCE OF SONOITA CREEK AND THE SCR CHANNEL,A CHANNEL TERRACE FEATURE WILL BE EXCAVATED IN THE LEFT BANK.
2. THE CHANNEL TERRACE WIDTH SHALL BE 100-FT WIDE AT THE UPSTREAM END AND INCREMENTALLY DECREASE TO 25-FT WIDE AT THE DOWNSTREAM END PER THE SONOITA CREEK BANK MODIFICATIONS.
3. TERRACES SHALL BE CUT INTO NATIVE MATERIAL APPROXIMATELY 2 VERTICAL FEET ABOVE THE CHANNEL BOTTOM.
4. THE CHANNEL TERRACE FEATURE WILL DAYLIGHT TO EXISTING GROUND AT A 10:1 SLOPE.
5. THE SONOITA CREEK CHANNEL BOTTOM AND RIGHT BANK WILL NOT BE ALTERED.

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SONOITA CREEK BANK MODIFICATION DETAIL SHEET

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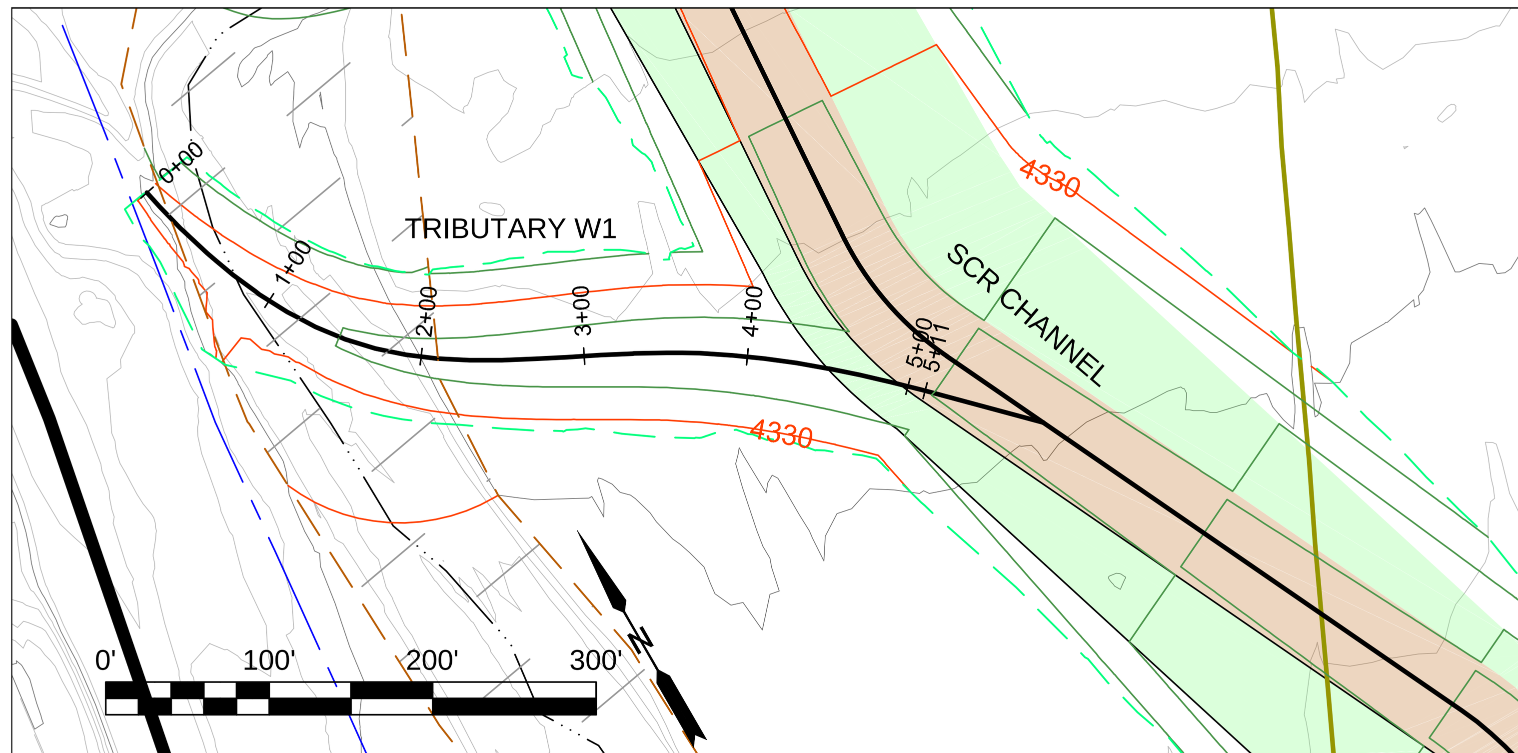

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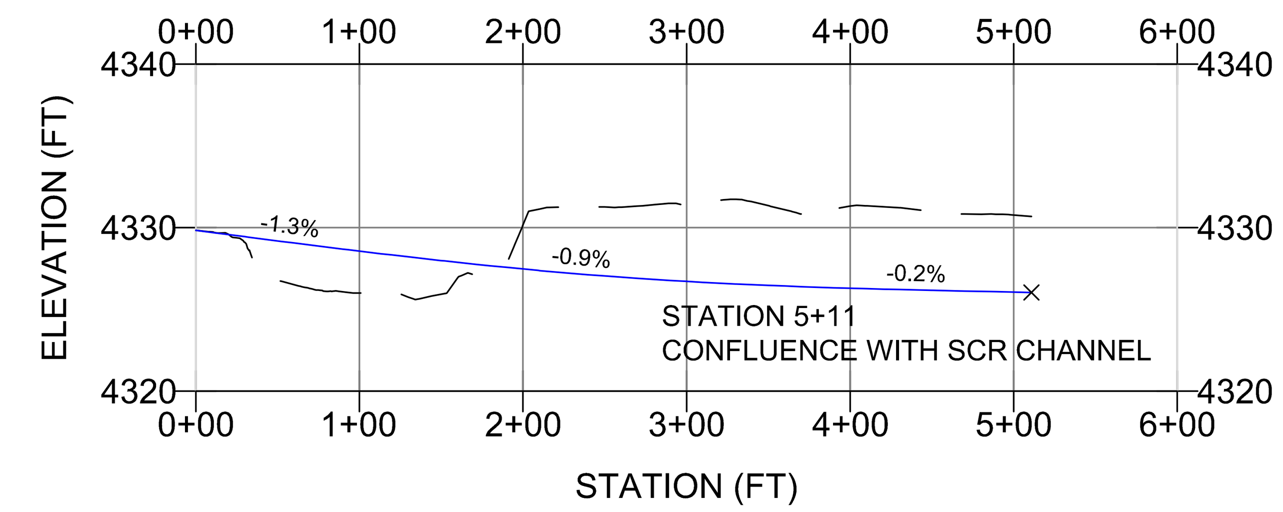
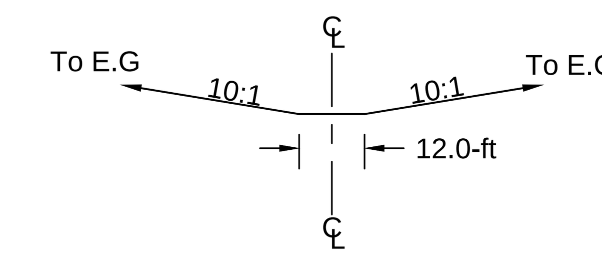
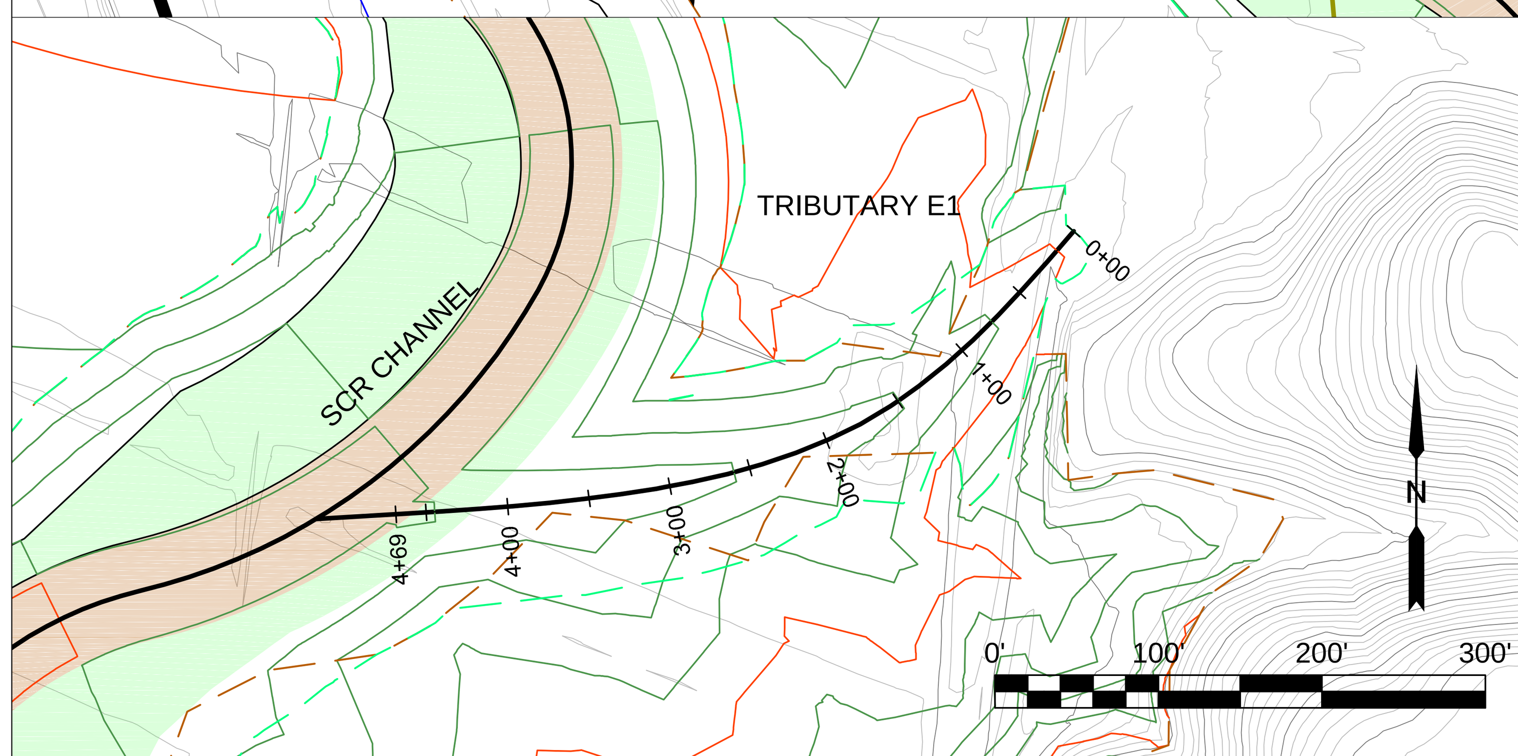


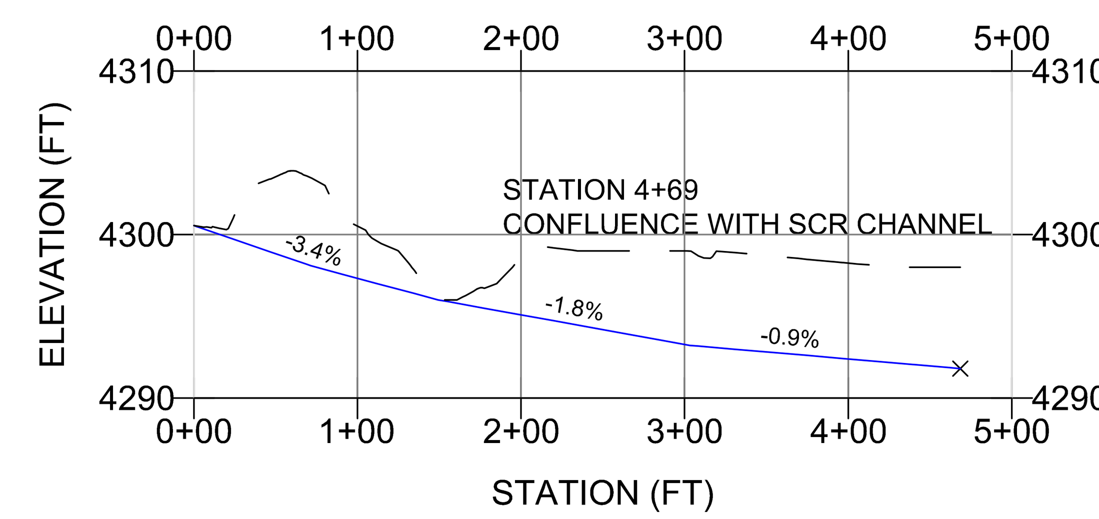
TRIBUTARY TYPICAL SECTION
ALL TRIBUTARIES
(Facing Downstream)

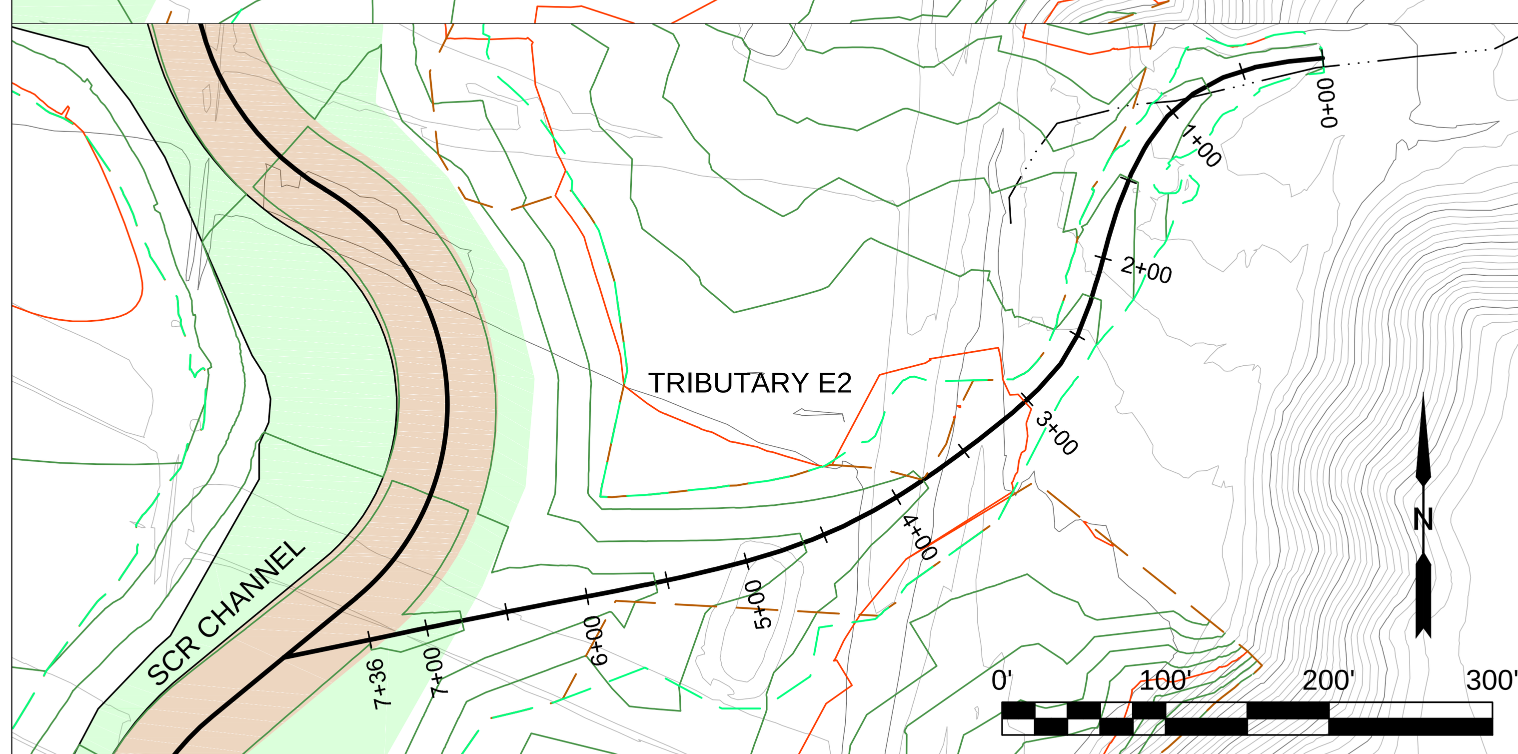


- EXISTING INDEX CONTOUR
- EXISTING INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED CHANNEL EXCAVATION LIMIT
- PROPOSED SOIL REPOSITORY BOUNDARY
- PROPOSED CHANNEL ALIGNMENT WITH STATIONS
- GAS PIPELINE ALIGNMENT
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- CHANNEL TERRACE
- ACTIVE CHANNEL



TRIBUTARY E1 PROFILE





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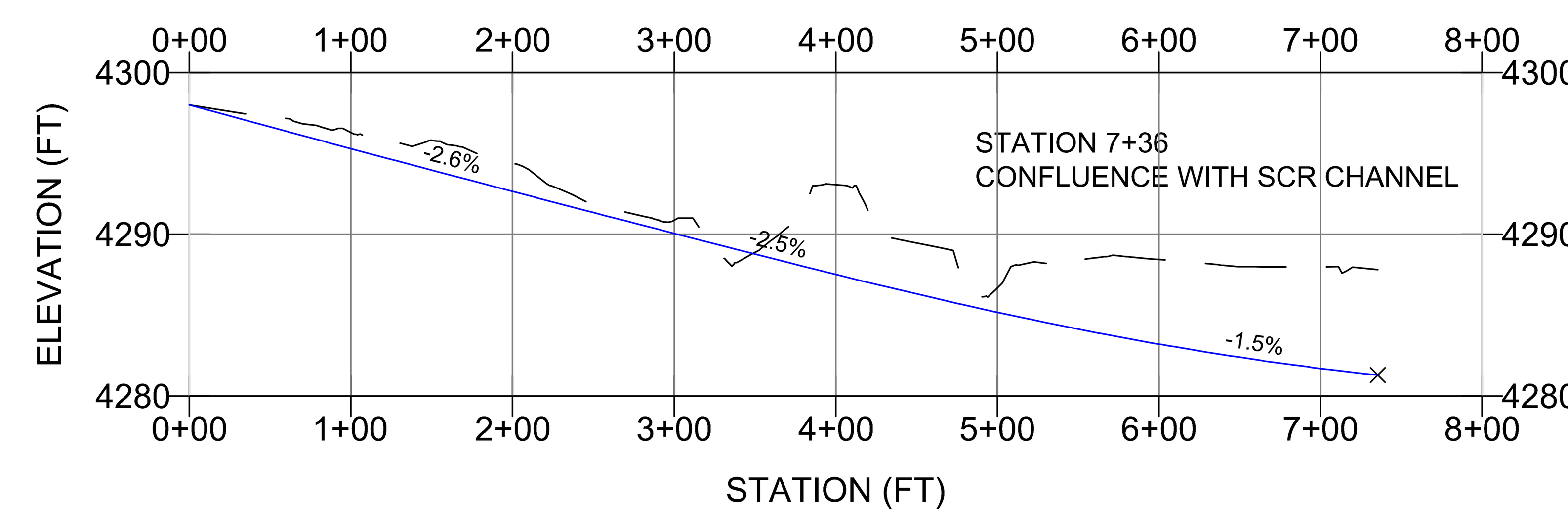

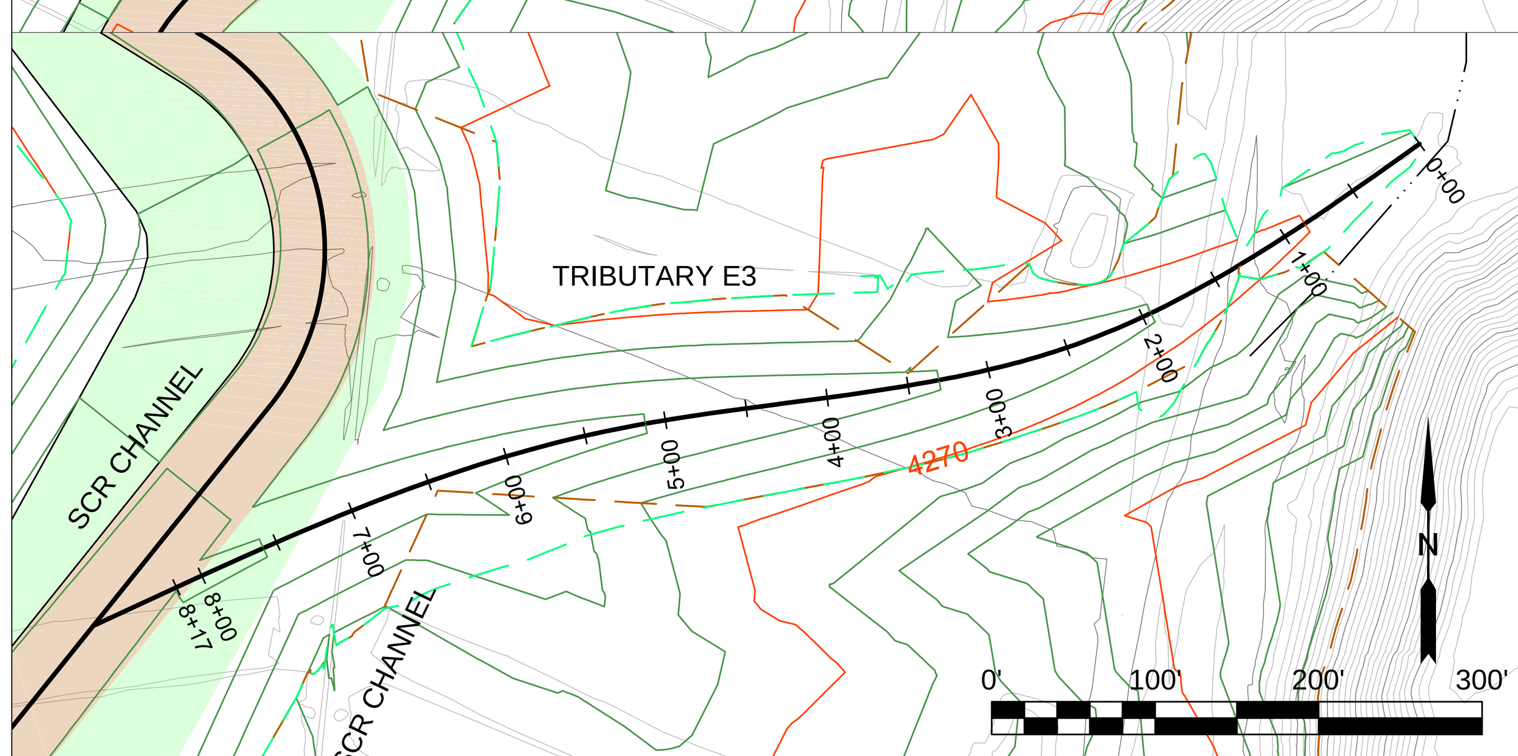

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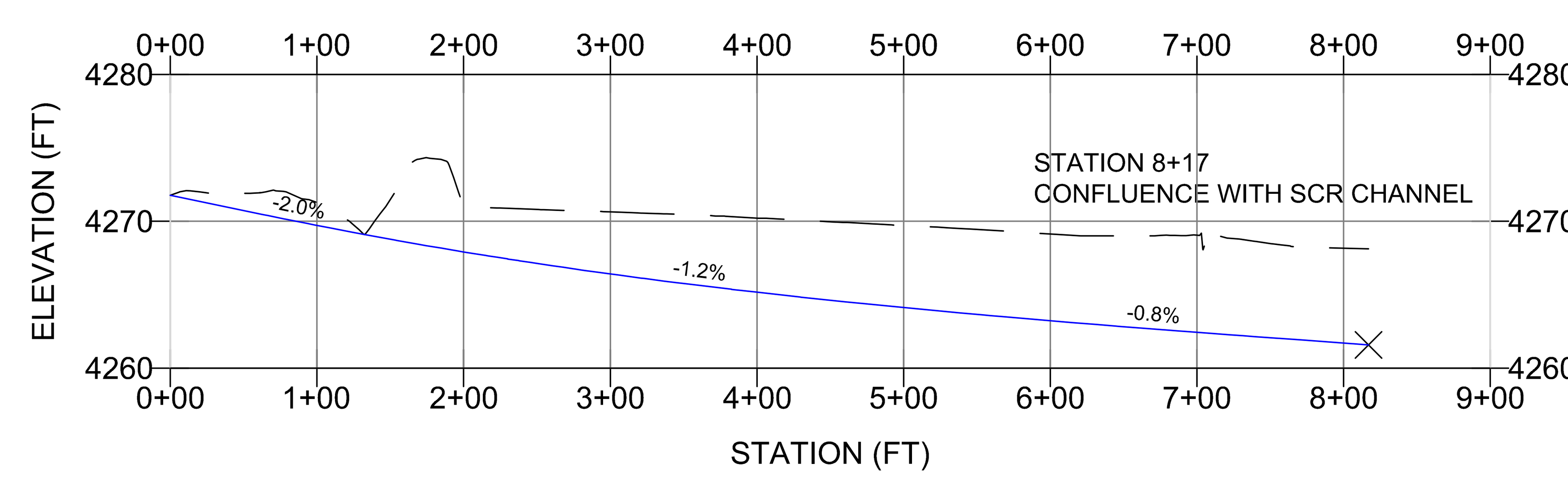

NOTES

1. PROFILES OF EXISTING GRADE AND FINAL GRADE CORRESPOND TO CHANNEL CENTERLINE ELEVATIONS.
2. FINAL GRADE PROFILE CORRESPONDS TO CHANNEL INVERT ELEVATION.
3. TRIBUTARY TYPICAL CHANNEL CROSS SECTION APPLIES TO THE ENTIRE LENGTH OF TRIBUTARY 1, TRIBUTARY 2, AND TRIBUTARY 3.

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TRIBUTARY CHANNEL DETAILS

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DWG. NO.

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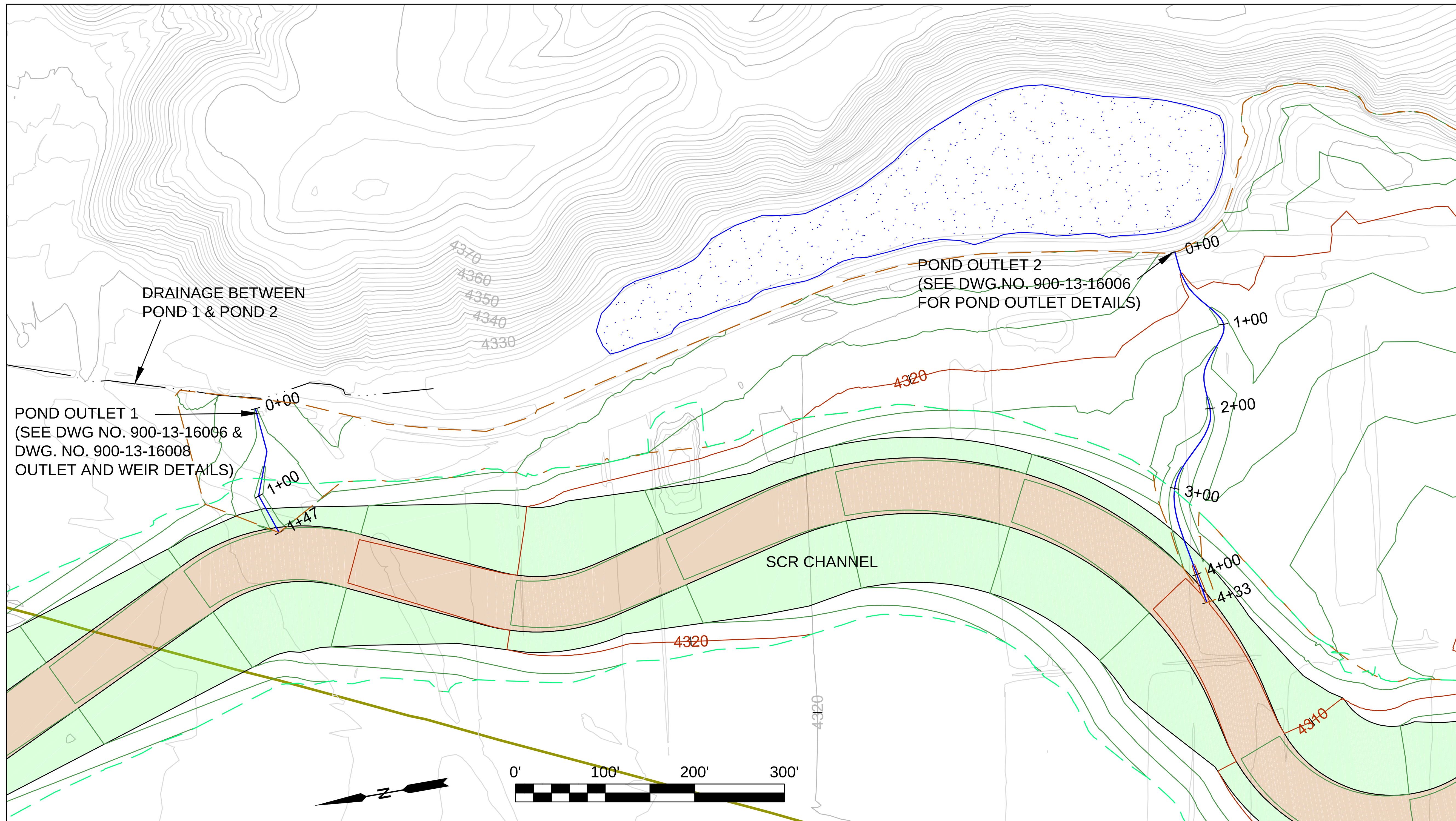
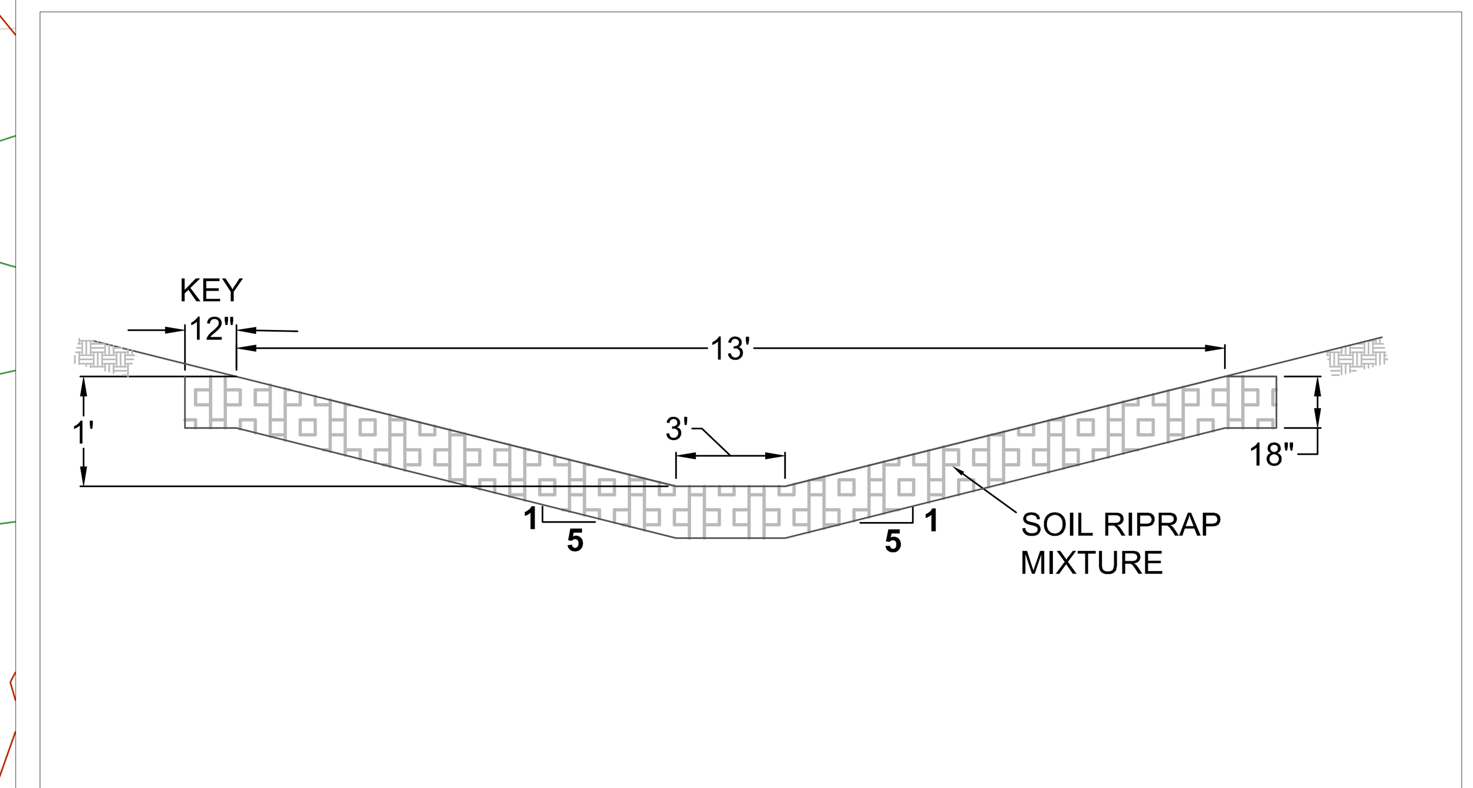


POND OUTLET 1 AND POND OUTLET 2 CROSS SECTION DETAIL

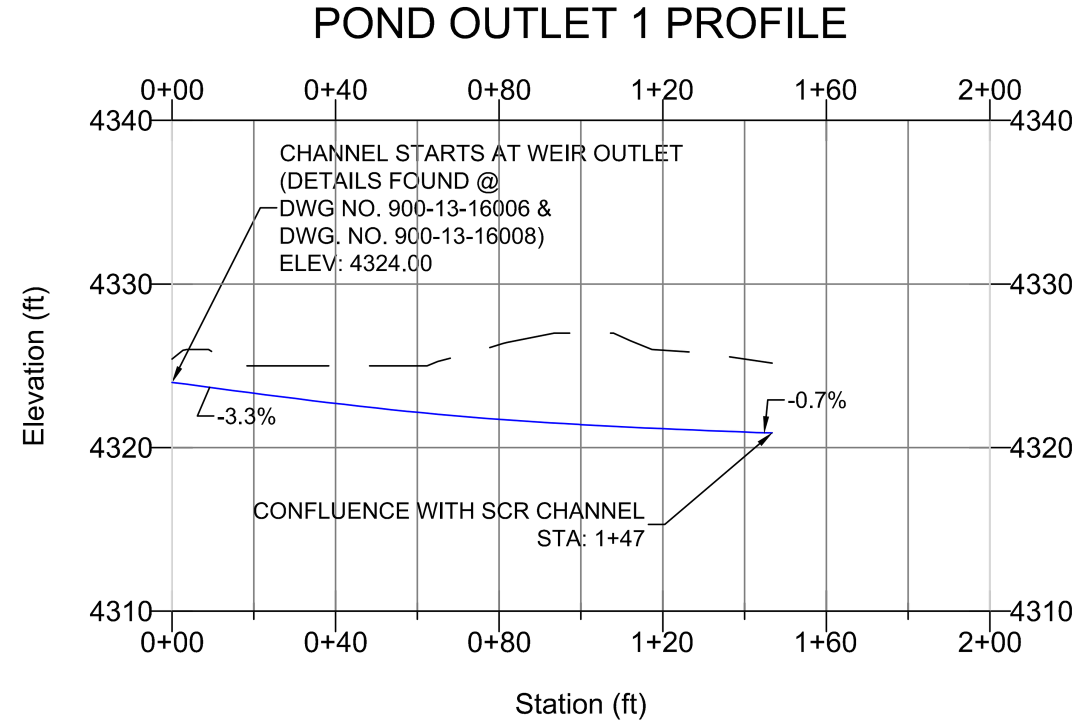


- EXISTING INDEX CONTOUR
- EXISTING INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED CHANNEL EXCAVATION LIMIT
- PROPOSED SOIL REPOSITORY BOUNDARY
- PROPOSED CHANNEL ALIGNMENT WITH STATIONS
- GAS PIPELINE ALIGNMENT
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- CHANNEL TERRACE
- ACTIVE CHANNEL
- POND

NOTES

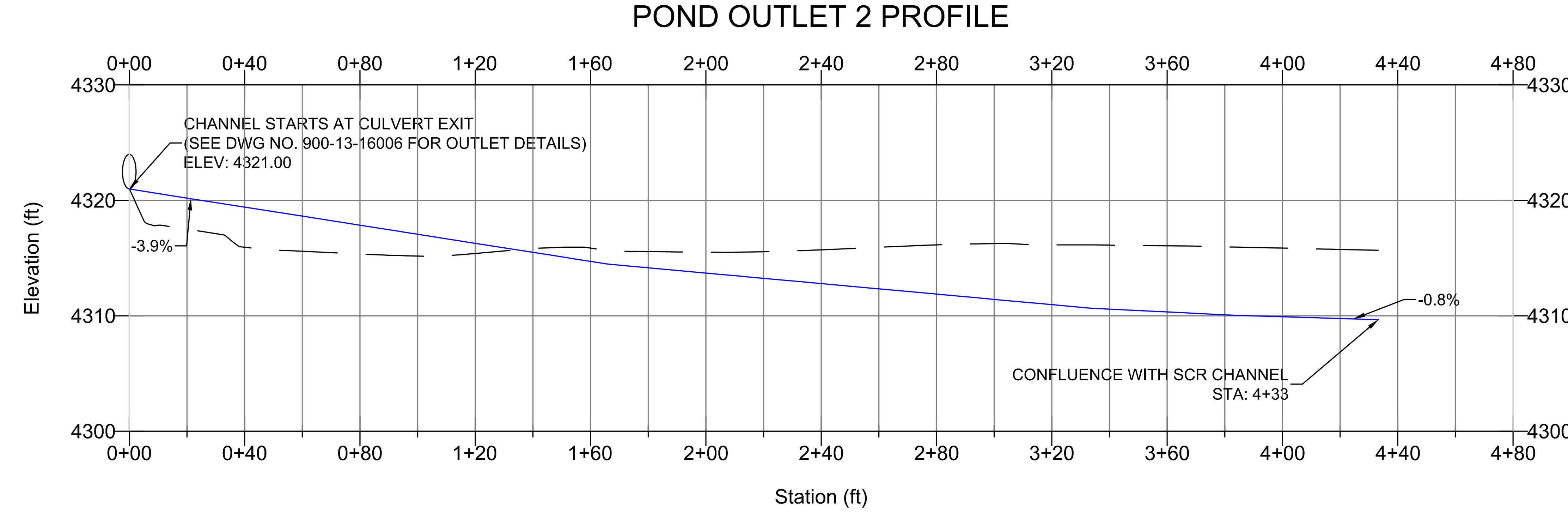
1. THE CHANNEL LINING WILL BE COMPOSED OF A SOIL RIPRAP MATRIX WHICH CONSISTS OF A MIXTURE OF GRADED RIPRAP AND NATIVE SOILS, CALLED SOIL RIPRAP.
2. SOIL RIPRAP SHALL CONSIST OF APPROXIMATELY 65% RIPRAP AND 35% SOIL BY VOLUME.
3. THE RIPRAP SHALL CONSIST OF A WELL-GRADED MIXTURE OF STONE. LARGER STONE SHALL PREDOMINATE, WITH SUFFICIENT SMALLER SIZES TO FILL VOIDS BETWEEN STONES. THE DIAMETER OF THE LARGEST STONE SIZES SHOULD BE NO GREATER THAN 2 TIMES THE D50 SIZE.
4. PRIOR TO MIXING WITH NATIVE MATERIAL, THE RIPRAP SHALL HAVE THE FOLLOWING GRADATION:
   DMIN = 1.5"
   D50 = 3.0"
   DMAX = 6.0"
5. THE RIPRAP SHALL BE HARD, ANGULAR AND HIGHLY WEATHER-RESISTANT. THE RATIO OF LENGTH TO THICKNESS OF ANGULAR STONES SHALL NOT EXCEED 2.
6. RIPRAP AND NATIVE SOIL MATERIAL SHALL BE MIXED PRIOR TO PLACEMENT WITH THE ADDITION.
7. THE SUBGRADE SHALL BE A SMOOTH SURFACE FREE OF DELETERIOUS MATERIAL. SOIL RIPRAP SHALL BE PLACED IN A SINGLE LOOSE LIFT NOT EXCEEDING 12 INCHES AND COMPACTED WITH SUITABLE EQUIPMENT TO ACHIEVE A DENSE MASS OF SOIL RIPRAP THAT IS VIRTUALLY FREE OF VOIDS.
8. MOISTURE CONDITIONING MAY BE USED TO INCREASE COMPACTION IF NATIVE SOILS ARE RELATIVELY DRY. THE SOIL RIPRAP SURFACE MAY BE COVERED WITH FOUR INCHES OF TOPSOIL THAT COMPLETELY COVERS THE RIPRAP MIXTURE. THE SURFACE MAY THEN BE ROUGHENED TO RECEIVE PLANTING OR SEEDING.

POND OUTLET 1 PROFILE



SOIL RIPRAP
STATION 0+00 TO END
D50 = 3"
DMAX= 6"
(SEE NOTES FOR FURTHER DETAIL)

POND OUTLET 2 PROFILE



SCALE: H: 1"=40'
V: 1"=10'

SOIL RIPRAP
STATION 0+00 TO END
D50 = 3"
DMAX= 6"
(SEE NOTES FOR FURTHER DETAIL)

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SOIL RIPRAP DETAIL

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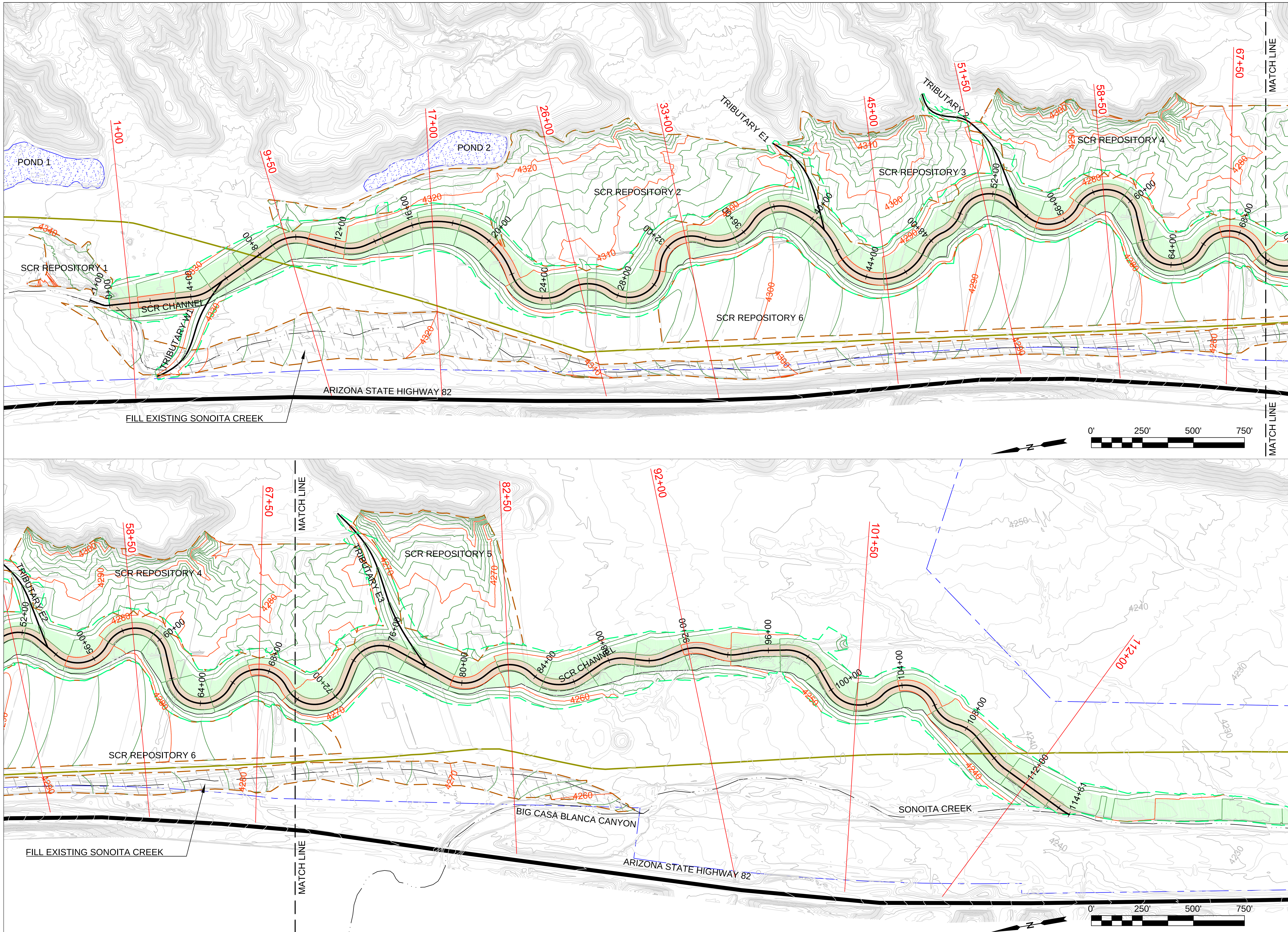

EXISTING INDEX CONTOUR (10-FT INTERVAL)
EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
PROPOSED INDEX CONTOUR (10-FT INTERVAL)
PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
EXISTING EPHEMERAL DRAINAGE
PROPOSED CHANNEL ALIGNMENT
0+89 CROSS SECTION
CHANNEL EXCAVATION BOUNDARY
SOIL REPOSITORY BOUNDARY
ARIZONA STATE HIGHWAY 82
PROPERTY BOUNDARY
CHANNEL TERRACE
ACTIVE CHANNEL
POND
FILL IN EXISTING SONOITA CREEK

NOTES:
SEE SCR CHANNEL CROSS-SECTION SHEETS 2, 3, AND 4 FOR PLOTTED CROSS SECTIONS.

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SONOITA CREEK MITIGATION PROJECT
SCR CHANNEL & REPOSITORY CROSS SECTION SHEET 1
NOT FOR CONSTRUCTION

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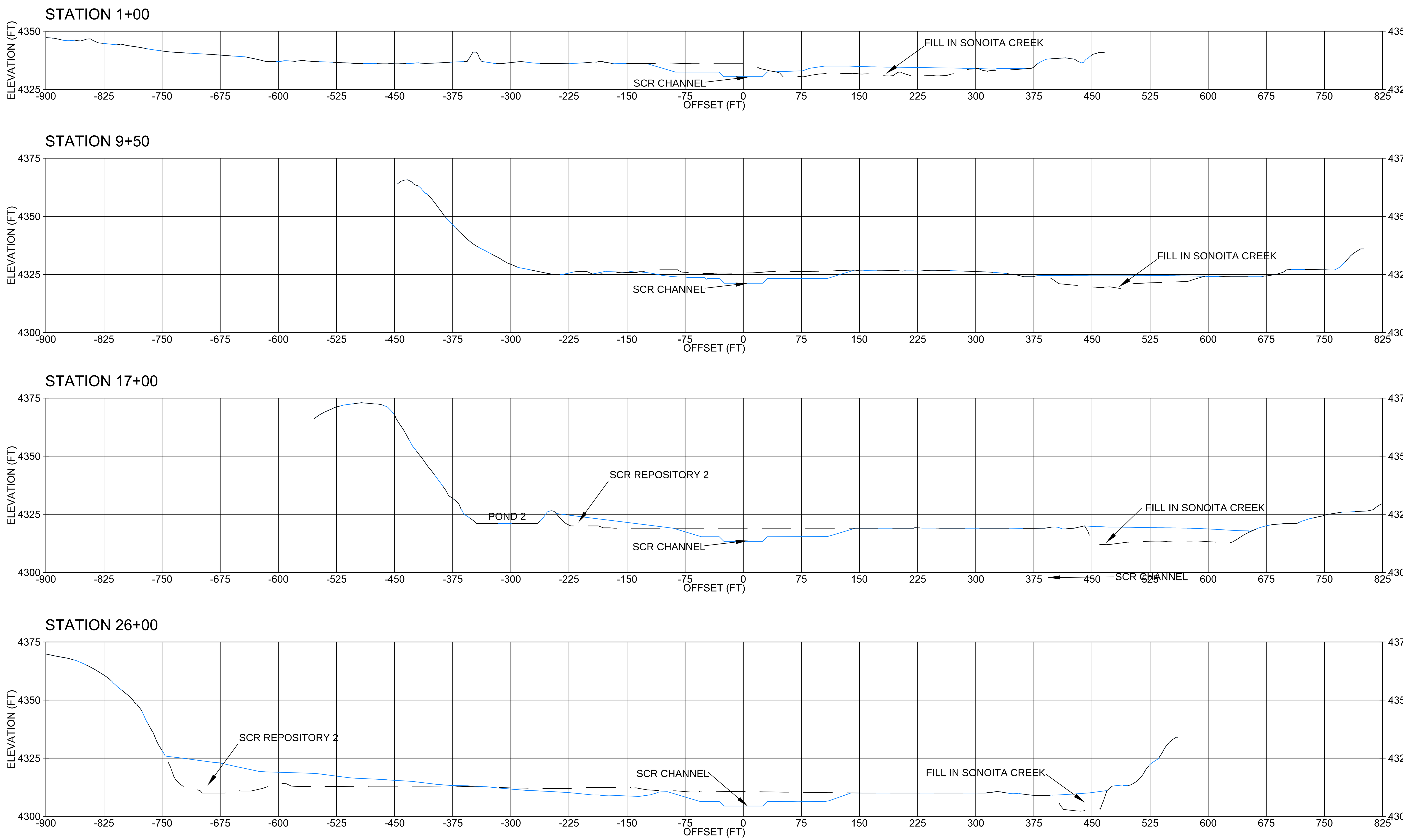
DWG. NO.
REVISION
DATE 09/08/17

SCR VALLEY CROSS SECTIONS



EXISTING GRADE
FINAL GRADE

NOTES

1. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM.
2. OFFSET OF 0.0 FT CORRESPONDS TO SCR CHANNEL CENTERLINE.
3. SEE SCR CHANNEL CROSS-SECTION SHEET 1 FOR CROSS SECTION PLAN VIEW.

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	SCR VALLEY CROSS SECTION SHEET 1		

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SONOITA CREEK MITIGATION PROJECT

SCR CHANNEL & REPOSITORY CROSS SECTION SHEET 2

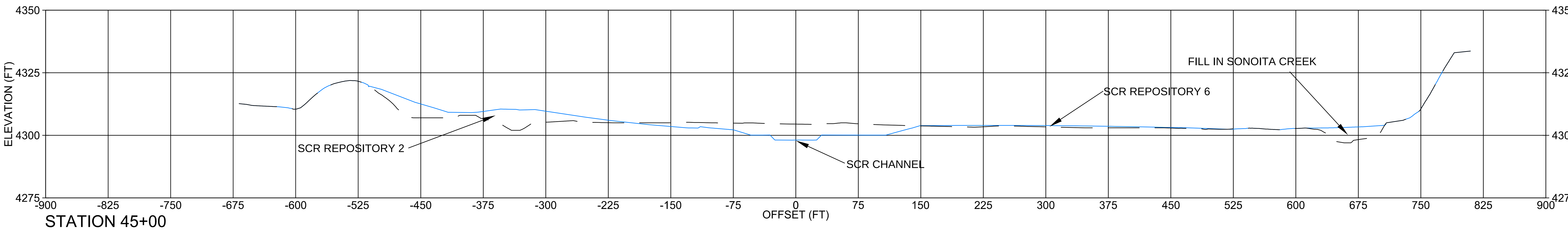
NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO.	WET 20
DWG. NO.	
REVISION	DATE 09/08/17

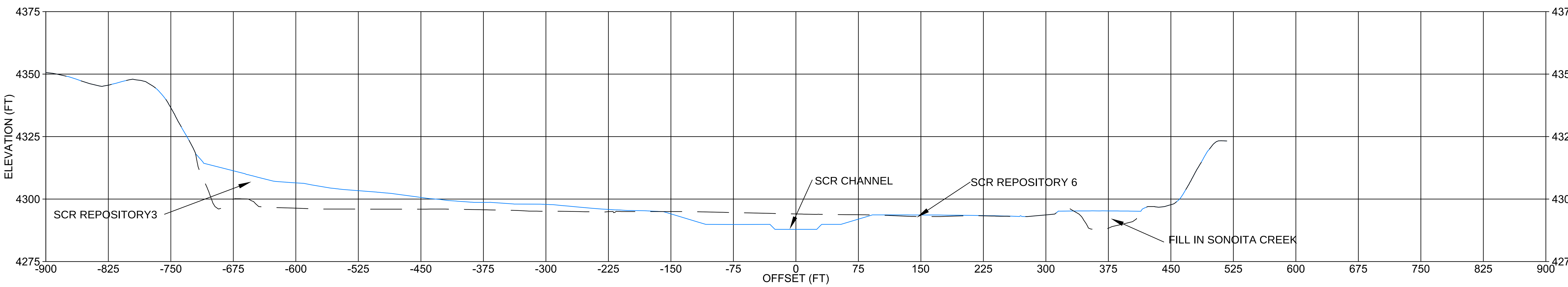
SCR VALLEY CROSS SECTIONS

EXISTING GRADE
FINAL GRADE

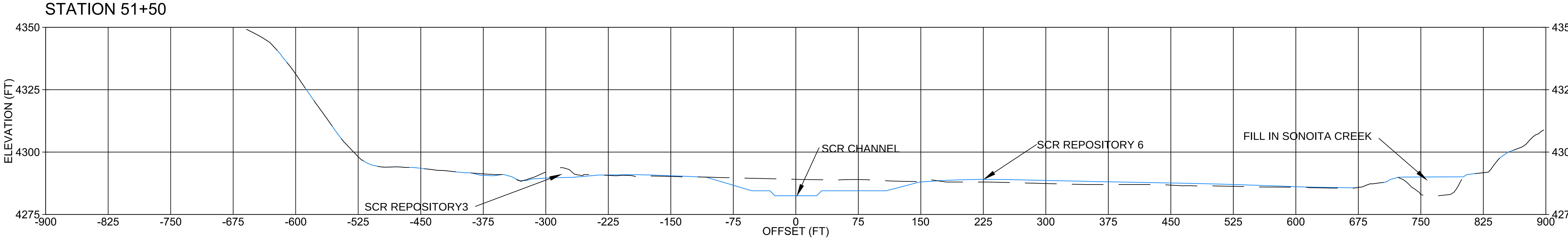
STATION 33+00



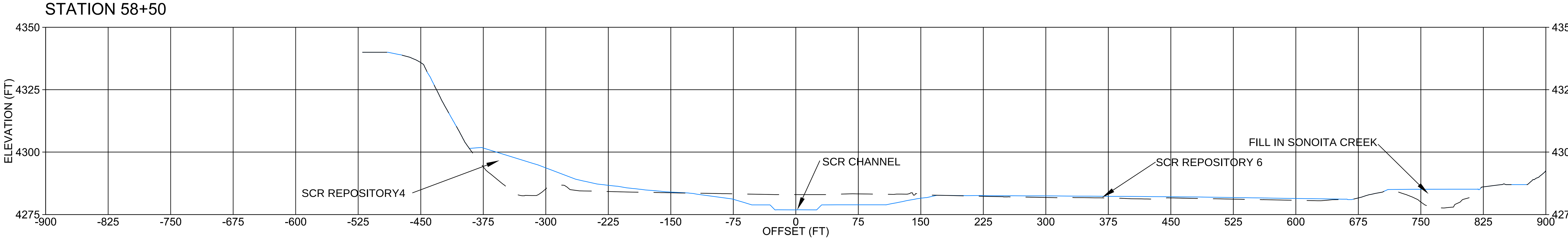
STATION 45+00



STATION 51+50



STATION 58+50



NOTES

1. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM.
2. OFFSET OF 0.0 FT CORRESPONDS TO SCR CHANNEL CENTERLINE.
3. SEE SCR CHANNEL CROSS-SECTION SHEET 1 FOR CROSS SECTION PLAN VIEW.

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SCR CHANNEL & REPOSITORY CROSS SECTION SHEET 3

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DWG. NO.	TITLE

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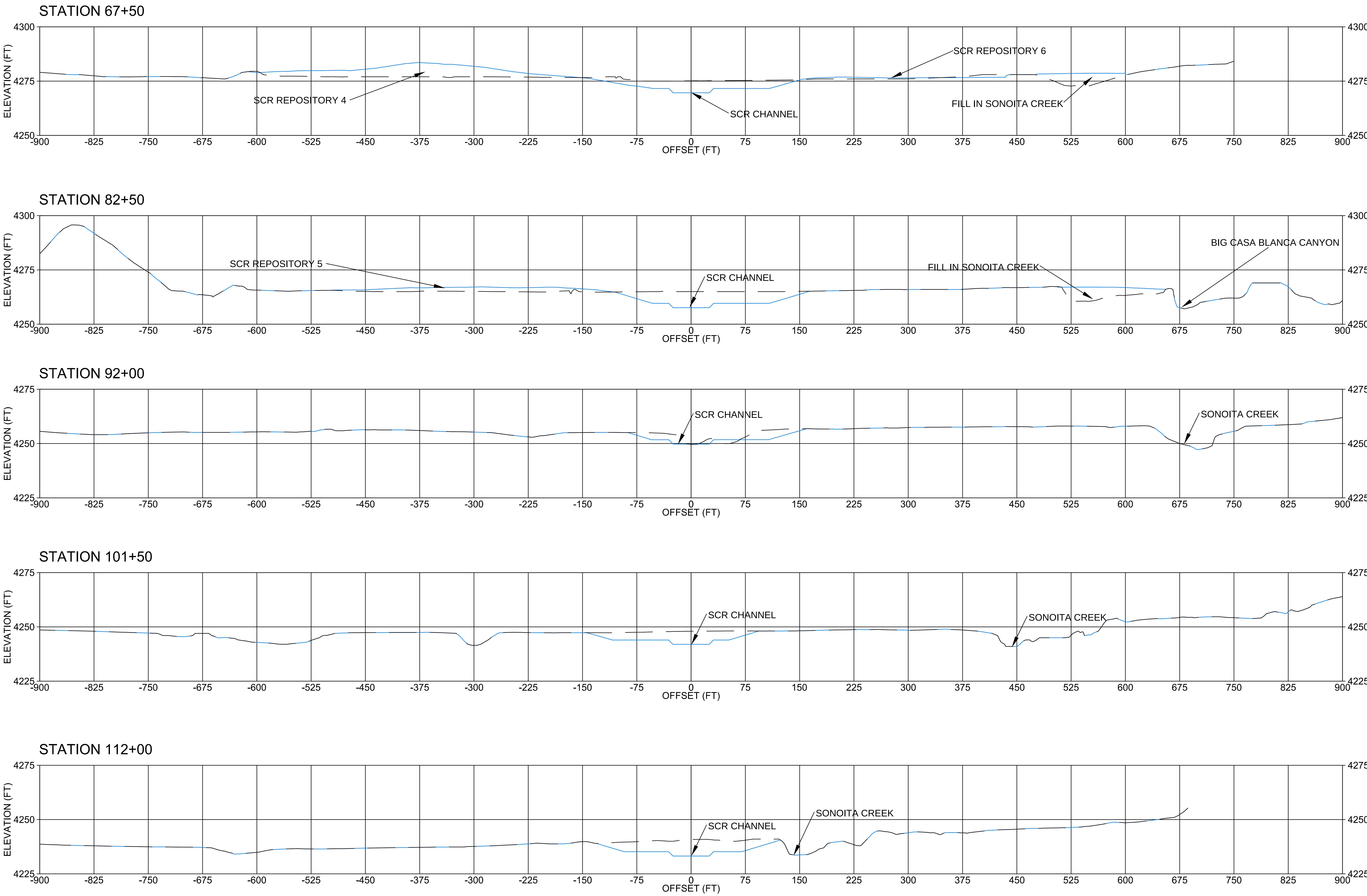
NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION

SCR VALLEY CROSS SECTIONS



EXISTING GRADE
FINAL GRADE

NOTES

1. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM.
2. OFFSET OF 0.0 FT CORRESPONDS TO SCR CHANNEL CENTERLINE.
3. SEE SCR CHANNEL CROSS-SECTION SHEET 1 FOR CROSS SECTION PLAN VIEW.

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SONOITA CREEK MITIGATION PROJECT

SCR CHANNEL & REPOSITORY CROSS SECTION SHEET 4

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DWG. NO.

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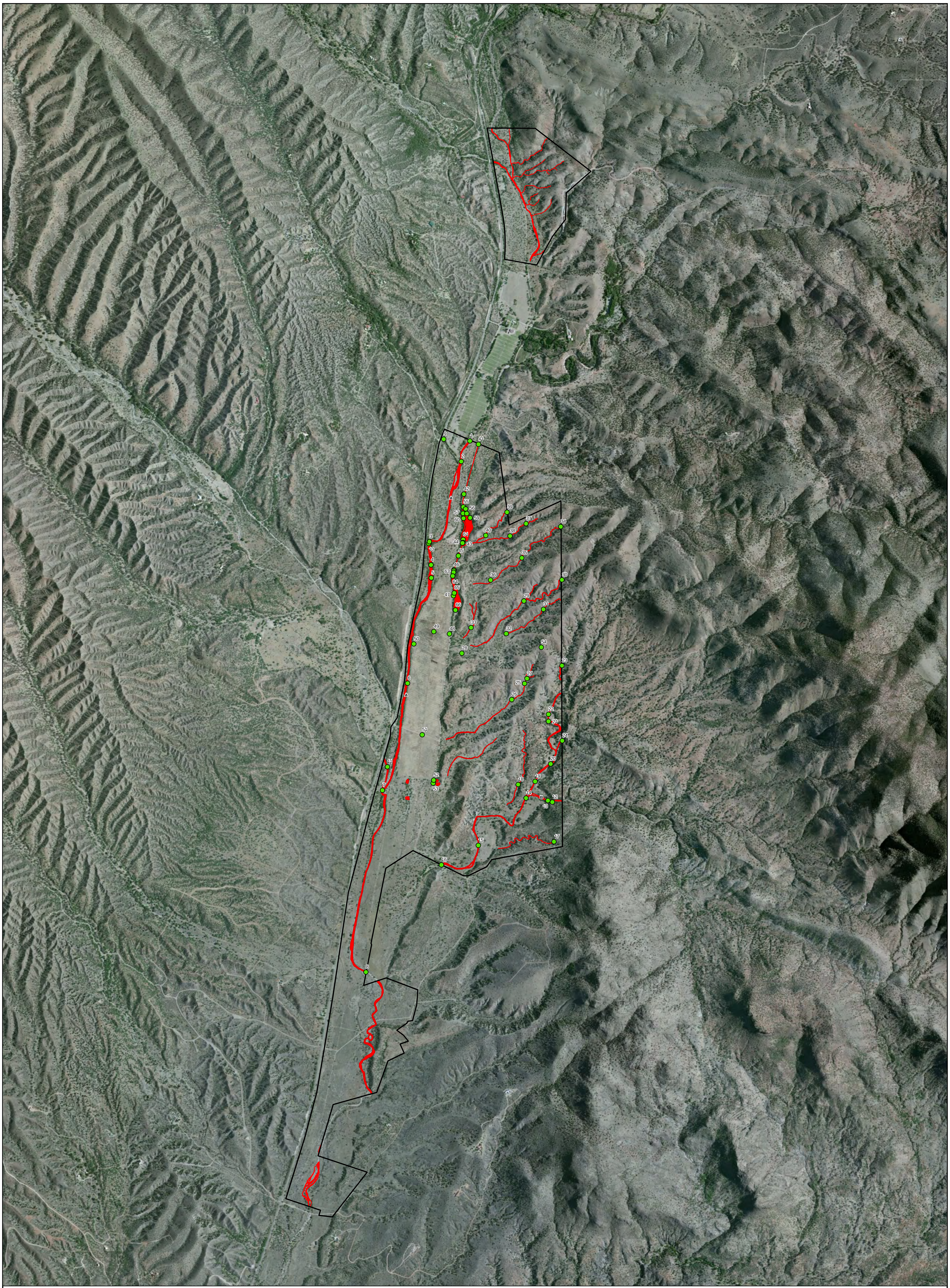
DATE 09/08/17

ATTACHMENT 3

Sonoita
Creek
Ranch
Photopages
(with Map)



T21S, R16E, Portion of Sections 9, 16, 20, 21 & 29
Santa Cruz County, Arizona
Photo Source: ESRI World Imagery,
Microsoft, November 8, 2010

Legend

- Photo Location and Number
- Sonoita Creek Ranch
- Potential Waters of the United States

0 1,200 2,400 Feet
0 300 600 Meters

N

WestLand Resources, Inc.
Engineering and Environmental Consultants

ROSEMONT COPPER COMPANY
Rosemont HMMP

PHOTO LOCATIONS
Attachment

PERMIT NO. SPL-2008-00816-MB

Photo 1
Feature Name: A (Sonoita Creek)

Note: Northern boundary of Sonoita Creek Ranch. Large sycamore (*Platanus* sp.) in background.

Photo 2
Feature Name: A (Sonoita Creek)

Photo 3
Feature Name: A (Sonoita Creek)

Photo 4
Feature Name: A (Sonoita Creek)

Photo 5
Feature Name: A (Sonoita Creek)

Note: Ash (*Fraxinus* sp.) and walnut (*Juglans* sp.) in background.

Photo 6
Feature Name: A (Sonoita Creek)

Note: Armoring of Highway 82 visible in background.

Photo 7
Feature Name: A (Sonoita Creek)

Photo 8
Feature Name: A (Sonoita Creek)

Note: Southern boundary of Sonoita Creek Ranch.

Photo 9
Feature Name: N/A

Note: Looking eastward at upland swale east of Highway 82 at the terminus of Wood Canyon. Little to no evidence of flow was observed in this swale.

Photo 10
Feature Name: A1

Note: Confluence of unnamed wash and Sonoita Creek (HW 82 in background).

Photo 11
Feature Name: A2

Photo 12
Feature Name: B (Corral Canyon)

Note: Near the eastern boundary of Sonoita Creek Ranch. Large oaks (*Quercus* sp.) and sycamores line this stretch of Corral Canyon.

Photo 13
Feature Name: B (Corral Canyon)

Note: Walnut saplings lining Corral Canyon.

Photo 14
Feature Name: B (Corral Canyon)

Photo 15
Feature Name: B (Corral Canyon)

Note: Ash saplings lining lower portion of Corral Canyon.

Photo 16
Feature Name: B (Corral Canyon)

Note: Near the terminus of Corral Canyon drainage where flows spread out and transition into overland flow. Large flats of alkali sacaton (*Sporobolus airoides*) are present in this area (visible in background).

Photo 17
Feature Name: B2

Note: Near the heavily shaded headwaters of Drainage B2.

Photo 18
Feature Name: B4

Photo 19
Feature Name: B5

Photo 20
Feature Name: B5

Note: Mature oaks lining Drainage B5.

Photo 21
Feature Name: B5

Photo 22
Feature Name: B5

Note: Mature oaks lining Drainage B5 in background.

Photo 23
Feature Name: B5

Note: Near the northern boundary of Sonoita Creek Ranch.

Photo 24
Feature Name: B5(a)

Photo 25
Feature Name: C

Photo 26
Feature Name: C

Photo 27
Feature Name: C1

Photo 28
Feature Name: D

Photo 29
Feature Name: D

Photo 30
Feature Name: D

Note: Near the headwaters of Drainage D.

Photo 31
Feature Name: D1

Photo 32
Feature Name: D1

Photo 33
Feature Name: D2

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Engineering and Environmental Consultants

Photo 34
Feature Name: E

Photo 35
Feature Name: E

Photo 36
Feature Name: E

Note: Near terminus of Drainage E.

Photo 37
Feature Name: F

Photo 38
Feature Name: F

Photo 39
Feature Name: F1

Photo 40
Feature Name: F1

Photo 41
Feature Name: G

Note: Near northern boundary of Sonoita Creek Ranch. Looking south along Drainage G, an earthen and concrete-lined canal providing the water to Sonoita Creek Ranch.

Photo 42
Feature Name: G

Photo 43
Feature Name: G

Note: Wetlands fringing Drainage G.

Photo 44
Feature Name: G

Note: Earthen-lined portion of Drainage G fringed by wetland in foreground.

Photo 45
Feature Name: G

Photo 46
Feature Name: G

Note: The concrete pipe pictured diverts water towards the agriculture fields in the background of the photo. Some water is diverted to the left of the concrete pipe which feeds Wetland 2 (off photo to the left).

Photo 47
Feature Name: G

Note: Water in Drainage G is diverted westward across agriculture fields at this location.

Photo 48
Feature Name: N/A

Note: Looking westward across the fallow agriculture fields (HW 83 in background).

Photo 49
Feature Name: N/A

Note: Damaged irrigation infrastructure in the fallow agriculture fields.

Photo 50
Feature Name: N/A

Note: Looking eastward across the fallow agriculture fields (Canelo Hills in far background).

Photo 51
Feature Name: N/A

Note: Panorama of fallow agriculture fields.

Photo 52
Feature Name: Pond 3

Photo 53
Feature Name: Pond 4

Note: Water levels are high and Ponds 2 and 3 are adjoined in this photograph.

Photo 54
Feature Name: N/A

Note: Looking westward at a panorama of Sonoita Creek Ranch. The fallow agriculture fields are visible in background.

Photo 55
Feature Name: Wetland 1

Note: Northern edge of Wetland 1. Remnants of the channel of Drainage G are visible as it merges with Wetland 1.

Photo 56
Feature Name: N/A

Note: Looking southward across Wetland 1, inhabited by a diverse emergent hydrophytic plant community.

Photo 57
Feature Name: Wetland 1

Note: Looking southward across Wetland 1.

Photo 58
Feature Name: Wetland 1

Photo 59
Feature Name: N/A

Note: Ash saplings present in Wetland 1.

Photo 60
Feature Name: Wetland 1

Note: Drainage G leaving Wetland 1 visible by line of hydrophytic vegetation in photograph.

Photo 61
Feature Name: Wetland 1

Note: Looking northward across the deeper water habitat of Wetland 1.

Photo 62
Feature Name: Wetland 2

Note: Looking southward along the western boundary of Wetland 2.

Photo 63
Feature Name: Wetland 2

Photo 64
Feature Name: Wetland 2

Photo 65
Feature Name: Wetland 2

Note: Open water habitat of Wetland 2.

Photo 66
Feature Name: Wetland 2

Note: Looking northward across open water habitat of Wetland 2.

ATTACHMENT 4

Stock Tank Removal Plan

Stock Tank Removal Plan

Prepared for:

Rosemont Copper Company
5255 East Williams Circle
Suite 1065
Tucson, Arizona 85711

Prepared by:

Water & Earth Technologies, Inc.
1225 Red Cedar Circle, Suite A
Fort Collins, CO 80524

September 8, 2017

Table of Contents

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1 Introduction

Rosemont intends to reclaim four stock tanks within the Barrel Canyon watershed to mitigate for impacts to ephemeral streamflow resulting from the Rosemont Mine. Operations, primarily due to waste rock and tailings placement, will result in the permanent loss of some watershed area within the Barrel Canyon Watershed. Direct impacts to Barrel Canyon are mitigated by the Sonoita Creek Ranch Mitigation project, located off-site. Loss of flows from Barrel Canyon will be mitigated by removing four stock tanks, which are located on-site within the Barrel Canyon Watershed. The stock tanks are small earthen embankments that impound stormwater in otherwise relatively undisturbed ephemeral stream reaches. Their removal and associated channel restoration will reconnect approximately 950 acres (ac) of contributing watershed to Barrel Canyon, increasing stormwater flows and re-establishing sediment transport.

The stock tank removals will include redistributing the material that forms each earthen embankment, and as needed, additional material deposited as sediment upstream of the embankment from the impounded water. An unimpeded drainage pattern will be re-established such that up-gradient stormwater runoff and sediment will once again contribute to the normal hydrologic, hydraulic, and geomorphic functions of Barrel Canyon. Since these watersheds are essentially in an undisturbed state, and since the stock tank removal will recreate the original drainage pattern and profile, no hardened engineering designs such as riprap are proposed. The four stock tanks, shown in Figure 1, are identified as: Barrel East, McCleary Canyon, Gunsight Pass, and Rosemont Crest. Contributing watershed area for each of the stock tanks is shown below (Table 1).

Table 1. Rosemont Stock Tank Watershed Characteristics

Stock Tank ID	Watershed Area (ac)
Barrel East	734
McCleary Dam	186
Rosemont Crest	21
Gunsight Pass	5

The McCleary Canyon, Gunsight Pass, and Rosemont Crest stock tanks are located in the McCleary Canyon watershed. McCleary Canyon flows into Barrel Canyon downstream of the tailings and waste rock facility. Barrel Canyon East is located in the Trail Creek watershed, which joins Barrel Canyon just downstream of its confluence with McCleary Canyon. This report, with its appendices and drawings, provides the stock tank removal grading plans and summarizes the hydrologic and hydraulic modeling upon which the grading designs are based, as well as describing the revegetation plans and monitoring requirements for the project.

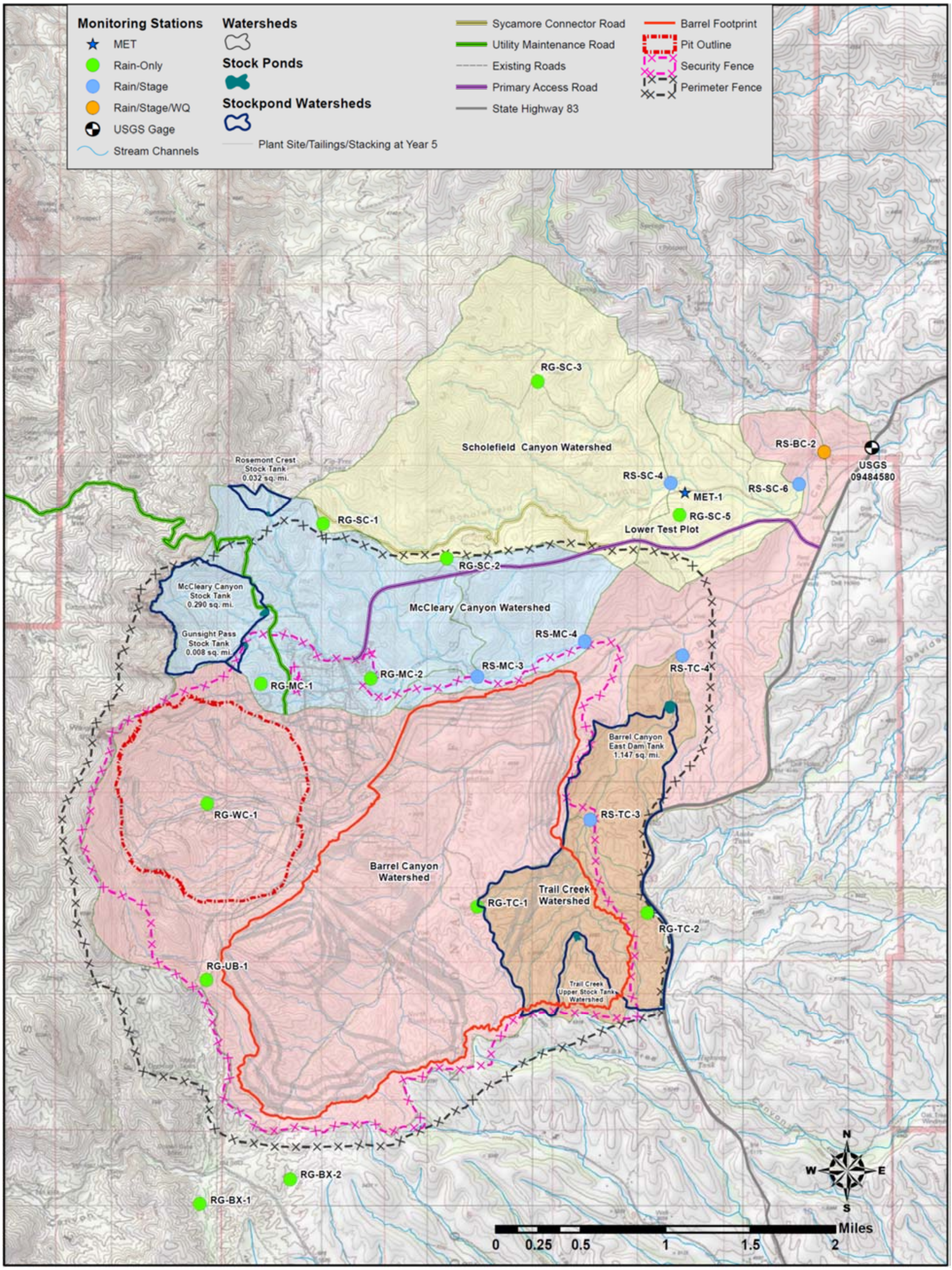


Figure 1. Stock Tank Location Map

2 Hydrology and Hydraulics

Hydrologic analyses that estimate average annual stormwater runoff volumes for the stock tanks have already been completed (Tetra Tech, 2017). The average annual runoff volumes calculated for each stock tank represent the modeled increase in stormwater that will flow into Barrel Canyon. Table 2 displays average annual runoff volumes calculated for the four stock ponds by Tetra Tech using their multi-variable relationship.

Table 2. Estimated Average-Annual Runoff Volumes from July 14, 2017 Tetra Tech Memo.

Stock Tank Name/ID	Contributing Watershed Area (sq. mi.)	Annual Runoff Volume* (ac-ft)
Barrel Canyon East Dam Tank	1.147	132.5
McCleary Canyon Stock Tank	0.290	34.3
Gunsight Pass Tank	0.008	1.0
Rosemont Crest Tank	0.032	4.0

*Annual Runoff Volume reported is from Equation 2 in the Tetra Tech memo.

In addition, SEDCAD was used to estimate peak discharge for storm events expected to produce significant downstream flows; the 5-year, 24-hour storm was modeled to represent such flows. The Arizona Department of Water Resources (ADWR) State Standards Workgroup developed the State Standard for Hydrologic Modeling Guidelines (ADWR, 2007) to support consistency in hydrologic analyses in Arizona. The hydrologic modeling methods used for this project are compliant with these guidelines. The State Standards allow for the use of many different hydrologic models for rainfall-runoff modeling in Arizona, using NOAA Atlas 14 precipitation values.

SEDCAD was used to determine peak discharges expected from statistical precipitation events. SEDCAD shares many similarities with other hydrologic models like HEC-HMS, that use Soil Conservation Service (SCS) curve numbers (CN) for watersheds to quantify the total runoff volume from storm precipitation and the unit hydrograph (UH) method to describe hydrologic response.

The SEDCAD model uses a double triangle dimensionless UH shape, which is parameterized based on the time of concentration. Runoff hydrographs from semi-arid watersheds are often characterized by a sharp rising limb, a fairly narrow peak, and a longer receding limb. The double triangle UH accounts for delayed response due to interflow (water that moves through the unsaturated zone and returns to the surface) by providing a two-segment trailing limb of the hydrograph (Ward et al. 2004). A medium response time double triangle was used, which defines the appropriate double triangle shape for semi-arid land cover, based on SEDCAD users' manual guidance.

For modeling, watershed areas above the stock tanks were delineated using USGS topographic mapping. The composite curve number for the watersheds was determined using NRCS soil mapping coupled with vegetative cover estimates from aerial photography. Curve numbers based upon NRCS soil type analysis for the stock tank removal locations are provided in Appendix A.

The longest flowpath used to determine time of concentration was measured from the USGS topographic mapping. Peak flows for the modeled watersheds were calculated using 24-hour NRCS Type II storms, with the major portion of the 24-hour event occurring over a 1-hour period. The rainfall amounts used in the SEDCAD models came directly from the NOAA Atlas 14 point-precipitation database for the Project area. Peak discharge for the 5-year, 24-hour design storm is reported in Table 3. Detailed modeling output is provided in Appendix B. The stock tank removals result in a channel with a longitudinal gradient that smoothly transitions between the natural drainage above and below the stock tank, such that major nick points are avoided. The channel cross-sectional geometry is designed to mimic the upstream and downstream natural drainages without creating a significant contraction or expansion through the stock tank removal zone.

Table 3. Stock Tank Hydrologic Summary

Site	5-Year, 24-Hour Point Precipitation (in)	CN	Area (ac)	5-Year, 24-Hour Peak Discharge (cfs)
Barrel Canyon East	2.79	72	734	216.2
McCleary Canyon	2.81	80	186	227.4
Gunsight Pass	2.81	80	5	6.3
Rosemont Crest	2.81	80	21	25.1

3 Stock Tank Grading Plans

To the extent practical, each earthen embankment will be removed so that the original drainage pattern is re-established through the stock tank area and reconnected with the downstream receiving drainage. In addition, some of the sediment that accumulated in the stock tank will be excavated to create a consistent longitudinal gradient through the stock tank that transition smoothly between the upstream and downstream natural channel (Figure 2). Historically, these drainage features have evolved for thousands of years to handle the larger peak flows that occurred prior to the stock tank installations (which capture upstream flow). The stock tanks have only been in place for the last 15 – 20 years, therefore, removal of the stock tanks and reintroducing the up-gradient stormflow is not expected to trigger downstream instability.

Soil excavated from the earthen dam will be backfilled on site and revegetated. The areas receiving backfill will be brushed and grubbed, and recoverable topsoil will be salvaged prior to backfill placement. After final grading is complete, disturbed upland areas will be revegetated with native species per the Revegetation and Growth Media Monitoring Plan (RGMMP), presented in Appendix C. Vegetation monitoring will be conducted in accordance with the RGMMP.

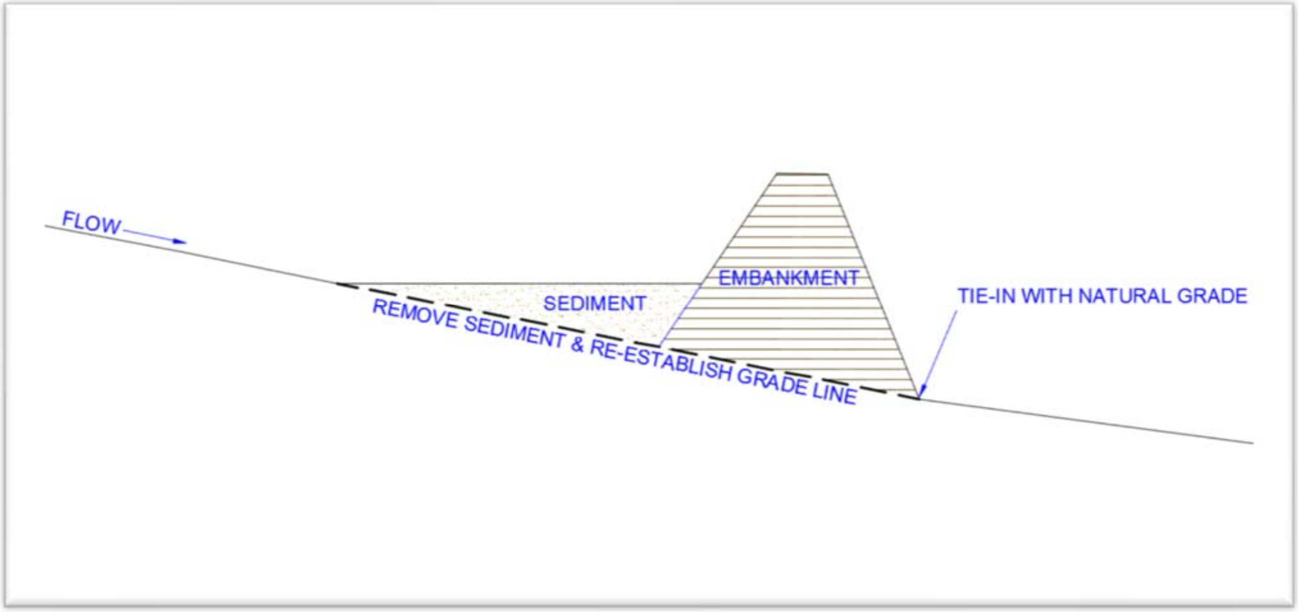


Figure 2. Stock Tank Removal Schematic

3.1 Barrel East Stock Tank Removal

The Barrel East Stock Tank has the largest contributing area of the four stock tanks, with an upgradient watershed of 734 ac. This stock tank is located at a natural base level change in Trail Creek which creates a significant change in channel geometry for the reach upstream of the stock tank compared to the reach below. Above the stock tank the existing drainage is fairly wide (50 feet wide or greater), while the channel downstream is much narrower (20 to 30 feet wide). There is an old concrete dam with historical significance downstream of the earthen embankment that impounds the stock tank. Due to its historical significance, the old concrete dam will remain in place. Historical aerial photographs of the Barrel East Stock Tank area that precedes construction of the stock tank were available and were used to guide the channel design for the stock tank removal (Appendix D).

The excavation through the stock tank will provide a zone to transition from the relatively wider natural channel above the stock tank to the narrower channel downstream of the stock tank. The channel reconstructed in place of the earthen embankment will be 30-feet wide (see Drawing S.Tank 1). Material excavated from the stock tank will be placed adjacent to the material placed from the earthen embankment and reclaimed according to the RGMMP (see Appendix C).

3.2 McCleary Canyon Stock Tank Removal

The 186-acre watershed tributary to the McCleary Canyon Stock Tank is the second largest of the four stock tanks' contributing watersheds. Available historical aerial photography of the channel reach precedes construction of the stock tank, and was used to guide the channel design resulting from the stock tank removal (Appendix D). The earthen embankment will be removed and a 20-foot wide channel reconstructed in its place as depicted in Drawing S.Tank 2.

3.3 Gunsight Pass Stock Tank Removal

Of the four stock tanks, Gunsight Pass Stock Tank has the smallest contributing watershed area of 5 ac. This stock tank is different from the other three in that its earthen embankment is located on a hillslope rather than constructed across a drainage. Storm water from an ephemeral drainage, and overland sheet flow is captured with a diversion ditch and directed into the stock tank. Historical aerial photography of the area precedes construction of the stock tank, and was used as a guide for the stock tank removal (Appendix D). The earthen embankment and diversion ditch will be reclaimed to restore the natural sheet flow condition at this site (see Drawing S.Tank 3).

3.4 Rosemont Crest Stock Tank Removal

The Rosemont Crest Stock Tank has a contributing watershed area of 21 ac. Historical aerial photography of the area precedes construction of the Rosemont Crest stock tank, and was used to guide the channel design proposed for stock tank removal (Appendix D). The earthen embankment will be removed and a 5-foot wide channel reconstructed in its place as depicted in Drawing S.Tank 4.

4 Monitoring and Performance Standards

Monitoring of the stock tank removals and the re-established channels for function and performance will occur throughout the 15-year monitoring period described in the RGMMP. Hydrologic monitoring that consists of a network of automated rainfall and streamflow gages is already in place throughout the project area. Channel geomorphology will be assessed both quantitatively and qualitatively. Field observations will be made in addition to comparing channel topography to the as-built topography to quantify incremental changes through time. Measurement of precipitation will occur at fixed locations, while observations of channel conditions will be made throughout the system. Vegetation monitoring for reclamation of disturbed areas at these sites is provided in Appendix C Revegetation and Growth Media Monitoring.

During the 15-year monitoring period, Rosemont may propose changes to the procedures and timing of inspection surveys described below for Corps approval. Restoration of these ephemeral channels will result in a dynamic system that may need an equally dynamic monitoring regime to ensure that the adaptive management process is effective and that pertinent information is collected. This could include a determination that the system is fully functioning and revegetated, or that changes to the restored channel are required to ensure long-term functionality with minimal maintenance. It is anticipated that the Corps will provide guidance regarding concerns or successes.

4.1 Stock Tank Removal Inspection Surveys

A field inspection of each stock tank removal site will be conducted annually. The field visit will be scheduled relatively soon after the annual monsoon season dissipates so that evidence of flow, erosion features and aggradation features are still relatively fresh and obvious to experienced field personnel. The purpose of these annual inspections is to observe and record changes to the restored drainage reach.

The re-established channel reaches, and the natural channel reaches upstream and downstream of each stock tank removal, will be traversed on foot so that channel conditions can be observed and documented. Documentation will include: observations of channel bed and bank stability, channel bed composition, evidence of erosion and aggradation such as cut-bank and bar formation and any development of channel braiding.

4.2 Stock Tank Topographic Surveys

As-built topography at the stock tank removal sites will be surveyed at the end of construction; this survey will be used as a benchmark of comparison for the 15-year monitoring period. Future topographic surveys will be completed every five years during the monitoring period, and each survey will be compared against the as-built survey and previous 5-year surveys. Changes in channel geomorphology will be quantified from the comparative results of the topographic surveys. A summary report quantifying changes to the channel profile and horizontal alignment will be prepared every 5th year following the initial topographic survey.

The topographic surveys will have a spatial extent large enough to completely encompass the stock tank removal site and extend at least 500-feet upstream and downstream of the tie-ins with the existing natural channel. The stock tank removal sites will be surveyed with enough precision to produce topographic mapping with a 1-foot contour interval. The topographic surveys will be completed with aerial or ground based LiDAR, aerial drone surveys, survey grade GPS units, or other means that may become available with new technology provided that they are capable of producing topographic mapping of at least a 1-foot contour interval.

4.3 Performance Standards

The performance standards established below will ensure that project goals are met. The desired project goals include reconnecting upgradient watershed areas to the ephemeral Barrel Canyon channel so that stormwater and sediment can contribute to downstream channel functionality in Barrel Canyon. The first performance standard will be met once positive drainage has been established and maintained through the stock tank footprint.

The second performance standard is to ensure that sediment transport is re-established in the restored stock tank reaches. If excessive erosion results in deep channel incision (more than 3-5 feet deep) at any stock tank removal site and persists longitudinally for a reach length at least 10 times the re-constructed channel bottom width for two annual inspections, then stabilization measures will be implemented to mitigate the erosion.

In addition to the first two performance standards, all of the vegetative performance standards from the RGGMP will apply to these sites (Appendix C).

4.4 Adaptive Management

Adaptive management allows the managers to respond to channel evolution based on the channel behavior that is observed and measured. Additionally, the state of the practice in stream restoration will also evolve during the next 15 years, with new research and best management practices (BMPs) identified. Thus, management of the stock tank removal sites may change not only in response to channel behavior, but also in response to new technology and practices in land or system management. The monitoring program allows managers to detect and quantify changes to the system. Should the re-established channel reaches fail to meet performance standards, then corrective actions will be implemented after discussion with, and approval from, the Corps.

A possible repair if excessive erosion is observed could consist of an earthwork-only repair that re-aligns the restored channel with a reduced channel gradient. Other options might include vegetative bioengineering controls along the streambank to arrest migration or armoring the streambank with riprap (e.g., buried riprap).

Using the monitoring plan coupled with adaptive management will allow changes to be made during the 15-year monitoring period based upon observed conditions at the restored reaches. For instance, after the first monsoon season, it may become apparent that changes to monitoring requirements and/or frequencies are necessary to adequately evaluate changes to the restored channels. Management of the stock tank removal sites may be more intensive during the first few years following construction, when each site will be responding to the construction disturbance, and before vegetation communities are fully matured. Subsequently, during the 15-year monitoring period, monitoring and management may become more passive as the channel will have had time for adjustment and some maturation will have occurred within the vegetative communities. The Corps will be an integral partner in determining appropriate adaptive management and monitoring requirements during the post-construction period.

5 Summary

Four stock tanks will be reclaimed, with restored ephemeral channels modeled on historic aerial photos of each area, reconnecting existing upstream natural drainages with the downstream drainage. The resulting drainage network will allow stormwater (which is currently intercepted and retained in the stock tanks) to flow downstream for the benefit of Barrel Canyon. Removal of these four stock tanks will reconnect upgradient watershed areas to Barrel Canyon. The watershed area gained by removing these four stock tanks will increase downstream flows to Barrel Canyon and improve sediment continuity. Reduction of flows resulting from mining operations are offset by removing these four stock tanks which increases downstream flows to Barrel Canyon.

6 References

Arizona Department of Water Resources (ADWR) Flood Mitigation Section, 2007, State Standard for Hydrologic Modeling Guidelines. August 2007.

Civil Software Design, 1998, SEDCAD for Windows Design Manual and User's Guide, Warner, R.C., Schwab, P.J. and D.J. Marshall. August 1998. SEDCAD Build date 2010.12.16.

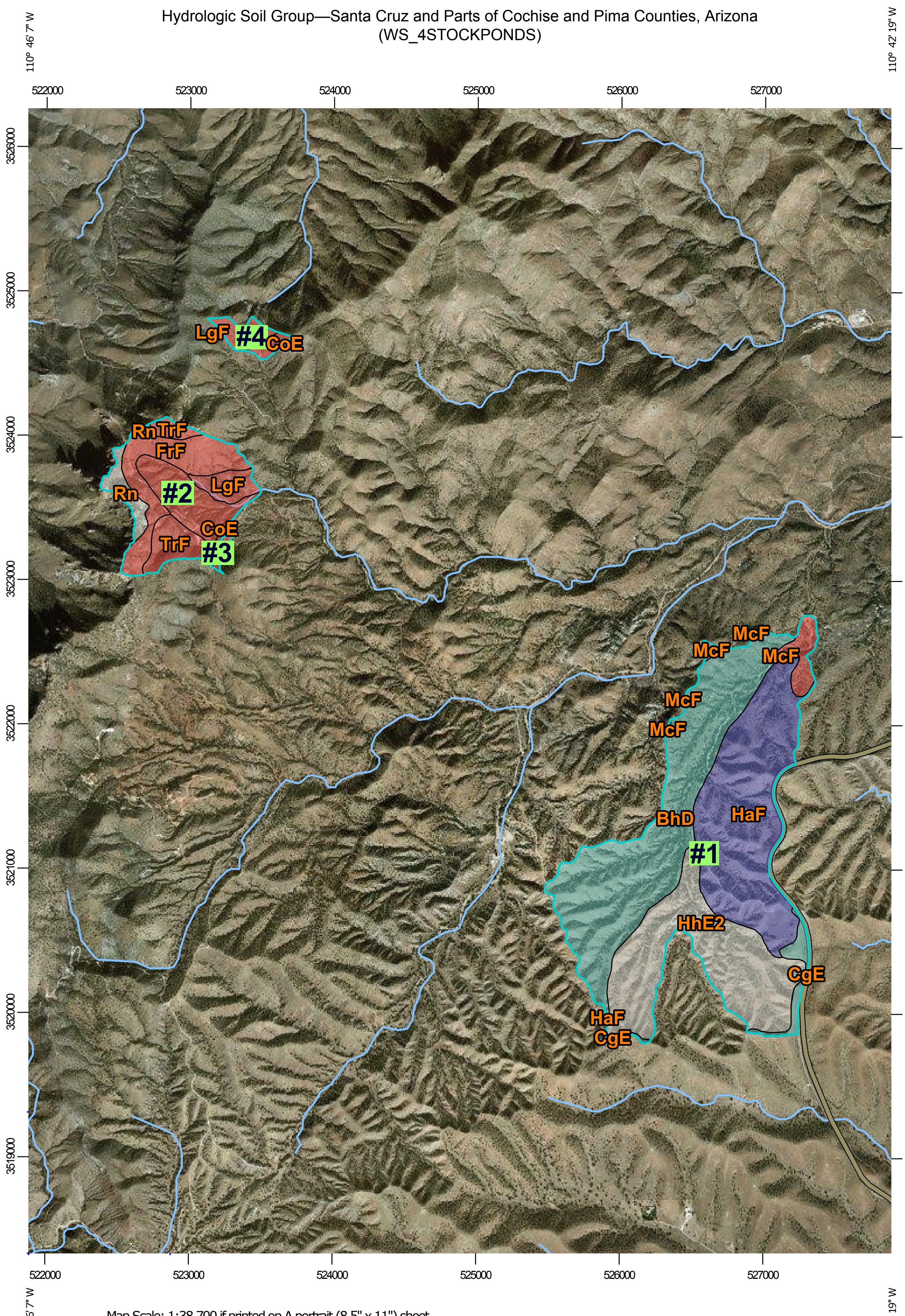
Tetra Tech (2017). Rosemont Stock Ponds – Preliminary Potential Runoff Volumes Calculation. Technical Memorandum dated July 14, 2017.

Ward, A. D. and S. W. Trimble, 2004, Environmental Hydrology, Second Edition, CRC Press.

Appendix A

CN Soil Analysis Map

Hydrologic Soil Group—Santa Cruz and Parts of Cochise and Pima Counties, Arizona
(WS_4STOCKPONDS)



Map Scale: 1:38,700 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 1500, 3000, 6000, 9000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Santa Cruz and Parts of Cochise and Pima Counties, Arizona
Survey Area Data: Version 8, Sep 14, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 2, 2013—Mar 10, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — #1, Santa Cruz and Parts of Cochise and Pima Counties, Arizona (AZ667)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BhD	Bernardino-Hathaway association, rolling	C	274.2	29.0%
CgE	Caralampi gravelly sandy loam, 10 to 40 percent slopes	C	17.3	1.8%
HaF	Hathaway gravelly sandy loam, 20 to 50 percent slopes	B	229.8	24.3%
HhE2	Hathaway soils, 1 to 40 percent slopes, eroded		190.7	20.2%
McF	Mabray-Chiricahua-Rock outcrop association, steep	D	22.4	2.4%
WgE	White House gravelly loam, 10 to 35 percent slopes	C	0.0	0.0%
Subtotals for #1			**734.5**	**77.6%**
Totals for Area of Interest			**945.9**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — #2, Santa Cruz and Parts of Cochise and Pima Counties, Arizona (AZ667)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
CoE	Chiricahua cobbly sandy loam, 10 to 45 percent slopes	D	0.8	0.1%
FrF	Faraway-rock outcrop complex, 30 to 60 percent slopes	D	65.4	6.9%
LgF	Lampshire-Graham-Rock outcrop association, steep	D	18.5	2.0%
McF	Mabray-Chiricahua-Rock outcrop association, steep	D	48.9	5.2%
Rn	Rock outcrop-Lithic Haplustolls association		17.6	1.9%
TrF	Tortugas-Rock outcrop complex, 25 to 60 percent slopes	D	34.2	3.6%
Subtotals for #2			**185.5**	**19.6%**
Totals for Area of Interest			**945.9**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — #3, Santa Cruz and Parts of Cochise and Pima Counties, Arizona (AZ667)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
CoE	Chiricahua cobbly sandy loam, 10 to 45 percent slopes	D	3.5	0.4%
TrF	Tortugas-Rock outcrop complex, 25 to 60 percent slopes	D	1.6	0.2%
Subtotals for #3			**5.1**	**0.5%**
Totals for Area of Interest			**945.9**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — #4, Santa Cruz and Parts of Cochise and Pima Counties, Arizona (AZ667)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
CoE	Chiricahua cobbly sandy loam, 10 to 45 percent slopes	D	9.9	1.0%
LgF	Lampshire-Graham-Rock outcrop association, steep	D	10.9	1.2%
Subtotals for #4			**20.8**	**2.2%**
Totals for Area of Interest			**945.9**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Appendix B

SEDCAD Modeling

1. Stock Tank Removal Barrel East. 5-yr, 24-hr Design Storm
2. Stock Tank Removal McCleary Canyon. 5-yr, 24-hr Design Storm
3. Stock Tank Removal Gunsight. 5-yr, 24-hr Design Storm
4. Stock Tank Removal Rosemont Crest. 5-yr, 24-hr Design Storm

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Stock Tank Removal Barrel East

5-yr, 24-hr

Brennan/Wade

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	5 yr - 24 hr
Rainfall Depth:	2.790 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	At Dam Removal Site

#1
Null

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	734.080	734.080	216.23	33.45

Structure Detail:

Structure #1 (Null)

At Dam Removal Site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	734.080	0.536	0.000	0.000	72.000	M	216.23	33.453
	Σ	**734.080**						**216.23**	**33.453**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	4.23	505.00	11,927.00	6.170	0.536
#1	**1**	**Time of Concentration:**					**0.536**

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Stock Tank Removal McCleary Canyon

5-yr, 24-hr

Brennan/Wade

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	5 yr - 24 hr
Rainfall Depth:	2.810 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	At Dam Removal Site

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	185.600	185.600	227.43	17.14

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Structure Detail:

Structure #1 (Null)

At Dam Removal Site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	185.600	0.097	0.000	0.000	80.000	M	227.43	17.139
	Σ	**185.600**						**227.43**	**17.139**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	12.25	450.00	3,673.00	10.500	0.097
#1	**1**	**Time of Concentration:**					**0.097**

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Stock Tank Removal Gunsight

5-yr, 24-hr

Brennan/Wade

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	5 yr - 24 hr
Rainfall Depth:	2.810 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	At Dam Removal Site

#1
Null

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	5.120	5.120	6.27	0.47

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Structure Detail:

Structure #1 (Null)

At Dam Removal Site

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	5.120	0.010	0.000	0.000	80.000	M	6.27	0.473
	Σ	**5.120**						**6.27**	**0.473**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	12.25	450.00	3,673.00	10.500	0.097
#1	**1**	**Time of Concentration:**					**0.010**

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Stock Tank Removal Rosemont Crest

5-yr, 24-hr

Brennan/Wade

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General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	5 yr - 24 hr
Rainfall Depth:	2.810 inches

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	At Dam Removal Site

#1
Null

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	20.480	20.480	25.10	1.89

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Structure Detail:

Structure #1 (Null)

At Dam Removal Site

Copyright 1998 -2010 Pamela J. Schwab

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	20.480	0.010	0.000	0.000	80.000	M	25.10	1.891
	Σ	**20.480**						**25.10**	**1.891**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	12.25	450.00	3,673.00	10.500	0.097
#1	**1**	**Time of Concentration:**					**0.010**

Appendix C

Revegetation and Growth Media Monitoring Plan

Revegetation and Growth Media Monitoring Plan

As Required By: Mitigation Measure FS-SR-01 and Mitigation Measure FS-SR-02

June 2017

Prepared by:

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HUDBAY

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Monitoring and Reporting Schedule

Task Schedule	*Purpose/Description/ Timing*	*Pre-Mining Period (Pre-Construction & Construction)*					*Active Mining Phase/ Operations Phase*					*Closure Phase/ Post-Closure Period*[1]				
		AN	*W*	*Q*	*A*	*O*	*AN*	*W*	*Q*	*A*	*O*	*AN*	*W*	*Q*	*A*	*O*
FS-SR-01																
During growth media salvage and storage activities	Conduct visual inspections, record area of soil placement (parent material), soil texture, particle size, and chemistry		X					X					X			
During growth media placement activities	Record location of growth media (Reclamation Management Area [RMA] unit), parent material, depth, texture, chemistry, and particle size		X					X					X			
During growth media placement activities	Record geographic information system (GIS) data of soil placement locations			X					X					X		
During growth media placement activities	Inspect soil stockpiles to ensure that they are convex in shape, have slopes no steeper than 3:1, revegetated with native species no later than the first growing season, and check that sediment control structures are installed and other best management practices are implemented			X					X					X		

Task Schedule	*Purpose/Description/ Timing*	*Pre-Mining Period (Pre-Construction & Construction)*					*Active Mining Phase/ Operations Phase*					*Closure Phase/ Post-Closure Period*[1]				
		AN	*W*	*Q*	*A*	*O*	*AN*	*W*	*Q*	*A*	*O*	*AN*	*W*	*Q*	*A*	*O*
Test plots and reference area monitoring	Monitor test plots, reference areas every 2 to 3 years (monitor macroplots / woody plants every 5 years) Vegetation measurements (as detailed in FS-SR-02) would be collected annually at the peak of the warm growing season. Photographs will also be captured to track revegetation efforts. Soil stability measurements (detailed in FS-SR-01) may be collected during any time of year.					X					X					X
Reclamation Management Area (RMA) monitoring	RMA vegetation and soil stability measurements would be collected at the peak of the warm growing season. Qualitative measurements are to be collected the first 1-5 years, depending on conditions, followed by quantitative measurements every 2-3 years.					X					X					X

Task Schedule	*Purpose/Description/ Timing*	*Pre-Mining Period (Pre-Construction & Construction)*					*Active Mining Phase/ Operations Phase*					*Closure Phase/ Post-Closure Period*[1]				
		AN	***W***	***Q***	***A***	***O***	***AN***	***W***	***Q***	***A***	***O***	***AN***	***W***	***Q***	***A***	***O***
Conduct soil stability inspections following significant rainfall events	Conduct visual inspections of recently reclaimed areas after significant rainfall event, 0.5 inch or greater precipitation within 24-hour period	X					X					X				
Conduct soil stability inspections following significant rainfall events	Inspect stormwater channels for sediment build-up	X					X					X				
Collect site measurements	Collect one-time measurement of slope aspect, elevation, topographic location of RMAs. If maintenance changes any of these properties, site characteristics will be updated as needed (FS-SR-01 and FS-SR-02).					X					X					X
FS-SR-02																
Invasive Species Monitoring	Conduct surveys for invasive species twice a year following winter and summer rains on disturbed and revegetated areas. These locations would be mapped and actions taken to prevent, eliminate, or control invasive plants should they occur					X					X					X

Task Schedule	***Purpose/Description/ Timing***	***Pre-Mining Period (Pre-Construction & Construction)***					***Active Mining Phase/ Operations Phase***					***Closure Phase/ Post-Closure Period[1]***				
		AN	***W***	***Q***	***A***	***O***	***AN***	***W***	***Q***	***A***	***O***	***AN***	***W***	***Q***	***A***	***O***
Revegetation efforts	Record approximate areas revegetated, acreage of initial seeding, seed/plant mixtures, seed/plant application rates, transplanting rates and success				X					X					X	
Collect attributes that influence seeding and vegetation	Measurements include precipitation, temperature, and other environmental measurements					X					X					X
FS-CR-09																
Use of culturally important species in revegetation efforts	Seed and transplant culturally important species in revegetation efforts	X					X					X				
Coordinate plant removal with consulting tribes	Consulting tribes will be provided an opportunity to collect plants for removal to their reservations. Some plants would be transplanted to a designated area and access provided to collect plants used for medicinal, ceremonial, and craft purposes.	X					X					X				
FS-VR-02																

Task Schedule	Purpose/Description/ Timing	Pre-Mining Period (Pre-Construction & Construction)					Active Mining Phase/ Operations Phase					Closure Phase/ Post-Closure Period[1]				
		AN	W	Q	A	O	AN	W	Q	A	O	AN	W	Q	A	O
Monitoring of revegetated and disturbed areas in select areas during final reclamation and closure	Revegetation will be measured for density, vegetation type, location, and invasive species following removal of facilities, including plant site, some roads, perimeter and security fence, and the utility corridor.													X		

Reporting												
Task Schedule	***Purpose/Description/ Timing***	***Pre-Mining Period (Pre-Construction & Construction)***			***Active Mining Phase/ Operations Phase***				***Closure Phase/ Post-Closure Period [1]***			
		AN	***Q***	***A***	***AN***	***Q***	***A***	***O***	***AN***	***Q***	***A***	***O***
FS-SR-01 & FS-SR-02												
Soil (growth media) salvage and storage	Report results from weekly visual inspections of growth media salvage and storage activities, including GIS data, and soil characteristics as described in monitoring section (FS-SR-01).		X			X				X		
Vegetation and soil stability results	Report vegetation and soil stability measurement results from test plots, reference areas, and revegetated area monitoring. Report woody vegetation cover, and invasive species, including GIS data. Determine if success criteria has been met. Propose adaptive management strategies (FS-SR-01 and FS-SR-02).			X			X				X	

Reporting												
Task Schedule	***Purpose/Description/ Timing***	***Pre-Mining Period (Pre-Construction & Construction)***			***Active Mining Phase/ Operations Phase***				***Closure Phase/ Post-Closure Period [1]***			
		AN	***Q***	***A***	***AN***	***Q***	***A***	***O***	***AN***	***Q***	***A***	***O***
Determination of success	Report success criteria of revegetated areas as statistically analyzed/ compared to reference areas, test plots, previously revegetated RMAs, and Ecological Site Descriptions. Aspect, elevation, and topographic location would be considered when making comparisons. Success will be based on quantitative and qualitative results (FS-SR-01 and FS-SR-02).				X				X			
Revegetation locations and treatments	Revegetation efforts, including maps, of approximate areas revegetated and acreage of initial seeding, seed/plant mixture, seeding/ planting application rate, propagation, and transplanting would be reported on an annual basis (FS-SR-02).						X				X	
FS-CR-09	Use of culturally important species in seed mixtures. Successful plant transplantation and propagation as reported in the annual reclamation reporting.			X			X				X	

Reporting													
Task Schedule	***Purpose/Description/ Timing***	***Pre-Mining Period (Pre-Construction & Construction)***			***Active Mining Phase/ Operations Phase***				***Closure Phase/ Post-Closure Period [1]***				
		AN	***Q***	***A***	***AN***	***Q***	***A***	***O***	***AN***	***Q***	***A***	***O***	
FS-VR-02	Quarterly report that includes mapping general areas of vegetation type, density, and locations. Report to include invasive species locations and treatments, should they occur.									X			

W = Weekly; Q = Quarterly; A = Annually; O = Other, [1] = Monitoring in post-closure phase to be determined

Revision Log

Revision Number	*Revision Lead*	*Purpose of Revision*	*Revision Date*

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1.0 PLAN OBJECTIVES AND DESCRIPTION

This *Revegetation and Growth Media Monitoring Plan* (Plan) was developed as a mitigation and monitoring measure (Mitigation Measure) requirement of the U.S. Forest Service's (USFS, Forest Service) Coronado National Forest (Coronado) Final Environmental Impact Statement (FEIS; USFS, 2013) for the Rosemont Copper Project (Project). The Mitigation Measure requirement for revegetation is specified as "FS-SR-02: Revegetate disturbed areas with native species" on pages B-11 through B-14 in Appendix B of the FEIS. The Mitigation Measure requirement for growth media is specified as "FS-SR-01: Growth media salvage and application" on pages B-8 through B-11 in Appendix B (FEIS; USFS, 2013).

Monitoring associated with Mitigation Measure FS-SR-01 would begin when growth media (soil) salvage is initiated (in the Pre-Mining Period) and would continue until the Forest Service determines that that no further revegetation efforts (seeding, planting, site stabilization, etc.) are necessary to meet final closure objectives.

Except for current work on the Revegetation Test Plots and Reference Areas, monitoring associated with Mitigation Measure FS-SR-02 would also begin when growth media salvage is initiated (Pre-Mining Period) and would continue until no further revegetation efforts are necessary to meet revegetation objectives (Post-Closure Period).

As noted for both Mitigation Measures, activities near known lesser long-nosed bat roosts would not occur when bats are present, typically during the period from November 1st to July 1st of each year.

1.1 PLAN OBJECTIVES

The objectives of Mitigation Measures FS-SR-01 and FS-SR-02 are to:

- Provide substrate for improving success of revegetation efforts (FS-SR-01);
- Promote revegetation and reduce impacts to surface water quality from potential erosion (FS-SR-01 and FS-SR-02);
- Enhance soil function and stability (FS-SR-01 and FS-SR-02);
- Reduce impacts to visual resources (FS-SR-01 and FS-SR-02);
- Provide potential wildlife habitat (including habitat for jaguar, ocelot, and lesser long-nosed bat) and suitable livestock grazing conditions. This includes woody vegetation goals (FS-SR-02);
- Establish culturally important plant species, such as agave (FS-SR-02);
- Provide for future recreational use (FS-SR-02); and
- Reduce establishment and spread of invasive species (FS-SR-02).

In addition to the requirements listed in Mitigation Measures FS-SR-01 and FS-SR-02, this Plan, in whole or in part, is based on the following documentation previously submitted to the Forest Service:

- *Revegetation Performance Measures* (memorandum by CDM Smith dated July 23, 2013; CDM Smith, 2013a);
- *Rosemont Reference & Reclaimed Area Sampling Protocol* (memorandum by CDM Smith dated July 23, 2013; CDM Smith, 2013b); and
- *Preliminary Soil Salvage Management Plan* (report by CDM Smith dated July 2012; CDM Smith, 2012).

For reference, CDM Smith (2013a) and CDM Smith (2013b) are provided in Appendices A and B of this Plan, respectively. With respect to these CDM Smith documents, Rosemont Copper Company (Rosemont) has set up, and has been monitoring, Reference Areas in support of this Plan. These Reference Areas are located outside of the anticipated Project disturbance area and will be used to assess future reclamation success. Monitoring performed in 2013, 2014, and 2015 is detailed in the *Reference Area Monitoring Report – Site Selection and Results for 2013, 2014, and 2015* (MPO Volume IV-o).

Revegetation plans presented herein were also partially developed using the results of the multiple-year research work being carried out by the University of Arizona (UofA), which includes two (2) revegetation test plot locations (upper and lower plots). Research associated with these studies incorporated information from the Natural Resource Conservation Service (NRCS) Ecological Site Descriptions (ESDs), native sites in the Rosemont Project area, and knowledge of land reclamation scientists and studies to prepare revegetation specifications. Results from the research studies can be found in the following documents:

- Report for Augusta Resource Corporation: Final Report for Phase 1 (report dated July 6, 2007; Jeffry S Fehmi, University of Arizona, 2007)
- Phase II – Project Report – Final (report dated December 17, 2008; Jeffry S Fehmi, Taryn M Kong, and Leslie Wood, University of Arizona, 2008)
- Grassland Revegetation for Mine Reclamation in Southeast Arizona (Lawson, 2011)
- Effects of soil type, rainfall, straw mulch, and fertilizer on semi-arid vegetation establishment, growth and diversity (Fehmi and Kong; Ecological Engineering, 2012)

Other Forest Service mitigation measures and/or other permits/requirements/certifications associated with revegetation and/or reclamation activities associated with Project activities include:

- FS-SR-03: Concurrent placement of perimeter buttress. This mitigation measure requires the construction of a buttress formed from waste rock to encapsulate the dry stack tailings. The slopes would be configured to support successful revegetation (see *Reclamation and Closure Plan* [MPO Volume III-a] and pages B-14 and B-15 of the FEIS);
- FS-BR-04: Salvage, growing, planting, and monitoring of Palmer's agave. This mitigation measure requires the planting and monitoring of Palmer's agaves on the Landform, utility corridor, plant site, and the abandoned segment of the Arizona National Scenic Trail. The Landform consists of a consolidated and reclaimed Waste Rock Storage Area (WRSA) and Dry Stack Tailings Facility (DSTF). Agave seed will be used in the Rosemont seed mixture if commercially available. Details regarding Palmer's agave can be found in the *Agave Management Plan* (MPO Volume II-b). Additional revegetation reporting in FS-BR-04 includes shrub/tree density objectives and monitoring similar to that in FS-SR-02 (see pages B-30 and B-31 in Appendix B of the FEIS);
- FS-CR-09: Transplanting of critical plant resources and inclusion of species within revegetation mixture. This mitigation measure specifically involves culturally important plants (see pages B-73 and B-74 in Appendix B of the FEIS and *Cultural Resources Management Plan* [MPO Volume II-i]);
- FS-VR-02: Removal of unneeded facilities during closure. This mitigation measure requires monitoring of revegetation progress and success quarterly during final reclamation and closure. This includes the plant site, perimeter and security fences, unneeded roads, and the

utility corridor (see pages B-60 and B-61 of the FEIS and *Visual Resources Monitoring Plan* [MPO Volume II-cc]); and

- FS-VR-03: Measures to reduce color contrasts from cuts, fills, and concrete structures associated with the Project. This mitigation measure requires the diversion channels fill slopes to be covered with soil (growth media) and revegetated to reduce visual impacts (see pages B-61 and B-62 of the FEIS and *Visual Resources Monitoring Plan* [MPO Volume II-cc]).

The following plans related to site reclamation and revegetation have been developed by Rosemont.

- Rosemont's *Agave Management Plan* (MPO Volume II-b) includes requirements for mitigation measures FS-BR-04 and FS-BR-17. Palmer's agaves would be grown and planted, or transplanted to reclaimed areas to provide a food source for the federally endangered lesser long-nosed bat. Seeding and transplanting protocols are defined in this Plan. Additionally, details regarding an agave survey are provided to determine the number of agaves within the security fence area. An agave study is also outlined, which will be used to determine if excluding cattle grazing is an effective method to increase the number of successful agave flowering stalks. Details regarding the agave survey and study can also be found in the *Biological Monitoring Plan* (MPO Volume II-f).

- Rosemont's *Biological Monitoring Plan* (MPO Volume II-f) describes monitoring requirements regarding biological resources within the FEIS and revised Biological Opinion (USFWS, 2016). The Plan describes methods for surveys, location, timing, frequency, and reporting associated with special-status species, including Forest Service sensitive species and federally threatened and endangered species.

- Rosemont's *Vegetation Clearing and Area Clearance Plan* (MPO Volume II-aa) defines the process and methodology related to clearing vegetation and the criteria required for area clearance. Selected species, like the Palmer's Agave and culturally important species, will be salvaged and re-used, as practicable, for revegetation efforts or set aside for tribal use. The Area Clearance Checklist (within the *Vegetation Clearing and Area Clearance Plan*) itemizes conditions that must be met prior to ground disturbance. These conditions include biological as well as cultural items. Biological items include both plant and animal clearance surveys.

- Rosemont's *Invasive Species Monitoring Plan* (MPO Volume II-o) provides control methods of both invasive plant (noxious weeds) and non-plant (American bullfrogs, northern crayfish, tiger salamanders) species. The *Invasive Species Monitoring Plan* speaks of ways to prevent the introduction and spread of invasive species, as well as the treatment, and monitoring of invasive species (Mitigation Measure FS-SR-02). The Plan covers mitigation measures that pertain to revegetation and aquatic invasive species that may impact the federally threatened Chiricahua leopard frog (CLF). Adaptive management is a key component of the *Invasive Species Monitoring Plan*, as it will allow change in methodology for effective treatments.

- Rosemont's *Reclamation and Closure Plan* (MPO Volume III-a) focuses on reclamation issues, including laws and regulations, design, and bonding considerations. In the main Project area, concurrent reclamation will allow revegetation of the Landform to progress during operations. Growth media (soil) will be salvaged from the footprint of the facilities and replaced on the Landform and other areas requiring reclamation. Reclamation areas will be revegetated according to methods found in this *Revegetation and Growth Media Monitoring Plan*.

- Rosemont's *Utility Corridor Reclamation Plan* (MPO Volume III-b) summarizes the reclamation and revegetation components associated with the power and water line utility corridor. The *Utility Corridor Reclamation Plan* is part of the larger *Reclamation and Closure Plan* (MPO Volume III-a).

As noted, the *Cultural Resources Management Plan* (MPO Volume II-i) and *Visual Resources Monitoring Plan* (MPO Volume II-cc) also contain revegetation related components.

1.2 PLAN DESCRIPTION

The remainder of this Plan is divided into the following sections:

- Section 2: Regulatory Requirements
- Section 3: Post-Mining Land Uses
- Section 4: Soils and Vegetation Baseline
- Section 5: Vegetation Objectives and Approach
- Section 6: Reclamation Implementation
- Section 7: Performance Evaluations
- Section 8: Monitoring and Reporting
- Section 9: Closure and Bond Release
- Section 10: Adaptive Management Process
- Section 11: Data Management
- Section 12: References

Revegetation includes establishing productive, diverse, and self-sustainable, self-repairable native plant communities capable of stabilizing the soil against excessive wind and water erosion, and providing wildlife habitat, recreational use, and grazing land. Objectives will be accomplished by using carefully selected native plant species, designing the Landform and other reclamation areas with slope angles that can support vegetation growth, and salvaging soil that can sustain vegetation. These objectives are consistent with statutory requirements and long-term land use goals. A Monitoring Group, consisting of Rosemont, the Forest Service, and possibly the NRCS, will be established to make decisions regarding revegetation issues. As noted, the Landform is the consolidated and reclaimed Waste Rock Storage Area (WRSA) and Dry Stack Tailings Facility (DSTF).

Revegetation practices are site-specific and are influenced by local climate, soil properties, disturbances, and other factors. Rosemont will revegetate disturbed areas, including the Rosemont Landform, the Utility Corridor, decommissioned roads, closed portions of the Arizona Trail, and the Plant Site once operations cease. Areas to be revegetated will be contoured, graded, prepared, and seeded and/or planted in accordance to the *Reclamation and Closure Plan* (MPO Volume III-a) and the *Utility Corridor Reclamation Plan* (MPO Volume III-b).

Revegetation using native species will occur throughout the life of the Project and as needed into the Post-Closure Period. Concurrent reclamation will allow the outer slopes of the Landform to be revegetated commencing in the early years of the operation. At the end of operations, a large portion of the Landform will have been revegetated. Once revegetated, these areas will be compared with undisturbed areas (reference areas) to determine when revegetation has been successful as detailed in Section 7.4. Natural Resource Conservation Service Ecological Site Descriptions were used to identify the anticipated comparable reference areas in the vicinity of the Rosemont Project site. Adaptive management will allow practices to be modified according to new research, technology and monitoring results, which will result in optimal revegetation practices.

Multi-year monitoring continues to take place on two test plots, put in place cooperatively by the University of Arizona and Rosemont to test plant species and seedbed preparation techniques and determine applicability to reclamation (Lawson, 2011). This monitoring will ensure that the native seed mixture is robust, resistant to invasive species, self-sustaining, and will support post-mining land uses. The seed mixture may be adjusted according to the test plot monitoring results, ESDs, and the reference area data. Test plot data indicates that many of the plant species present on the site can volunteer from seed and underground plant parts found within salvaged soil. Therefore, it is anticipated that local plant species will become an integral component of the reclaimed areas when soils from the upper portion of the soil profile are salvaged and directly hauled and placed. Additional seeds may blow-in from surrounding areas and contribute to the local genetic stock. The use of well-adapted and commercially available seed will further enhance the revegetation effort by ensuring the establishment of robust plant communities that are common to the area.

The entire revegetation effort, including species selection, soil selection, seedbed preparation, sowing technique, and weed control, has been designed to maximize revegetation success and meet the targeted post-reclamation land uses and other regulatory requirements.

One of the Project goals has been to identify, and then ultimately salvage and utilize, area growth media (soils) during the reclamation and revegetation process. Soils will be identified to meet physical and chemical characteristics needed for reclamation efforts. Salvage quantities will be managed so there is optimal operational efficiency and protection of the soils during handling and storage. The intent is to minimize stockpiling of the soil resources to preserve its biological integrity. For this reason, material will be directly hauled from disturbed areas whenever feasible. Anticipated growth media (soil) stockpiles are addressed in the *Reclamation and Closure Plan* (MPO Volume III-a). Soil stockpiles will be revegetated to maintain health, and monitored for erosion. Soil characteristics, type, and placement will be reported.

Rosemont will monitor and evaluate data in conjunction with approved performance standards to determine when reclamation (site stability and revegetation) has been successful. Monitoring will begin when seeding is initiated and will continue into the Post-Closure Period when the Forest Service determines that reclamation has been successful and final objectives have been met. To manage reclamation, the Landform will be divided up into Reclamation Management Areas (RMAs). An RMA will be dependent upon the position on the Landform, including slope aspect (north-, east-, south-, west-facing slopes, flat areas, or rocky slopes), soil type (based on parent material), and the year in which seeding occurs.

Adaptive management can be used to modify specifications and protocols as necessary in order to meet the defined reclamation and revegetation objectives of soil stabilization and creating a self-sustainable ecosystem on the Landform and other reclamation areas. This process is based on standard guidance such as that developed for the U.S. Department of the Interior (DOI) (Williams et al. 2009). Key elements of adaptive management for land reclamation are the identification of, the comparison of data from revegetated areas to those outcomes, and the adjustment of specifications or procedures (i.e., data feedback) when the desired outcomes are not being met.

Monitoring of growth media, soil stability, and site characteristics on reference areas, test plots, and previously revegetated areas will provide quantifiable results and set up a data feedback loop to continually adjust techniques and objectives by the Monitoring Group and to determine whether changes are needed in growth media texture, site preparation, soil amendments, soil mycorrhizal inoculation, or other characteristics. Revegetated area results would be statistically compared with reference area results to determine whether objectives are being met. Revegetation success criteria would be based on a percent similarity of Ecological Site Descriptions, reference areas, test plots, and ongoing site monitoring of previously reclaimed areas.

2.0 REGULATORY REQUIREMENTS

The state of Arizona and federal agencies that manage public land in Arizona provide broad overarching reclamation guidance for land disturbed by mining. Land management agencies use various guidance documents to develop specific reclamation standards, including methodologies used to assess reclaimed areas and to determine compliance. A key requirement stated in several regulatory statutes is to return the mined lands to the designated post-mining land uses.

The Arizona Mined Land Reclamation Act (Act) is administered by the Arizona State Mine Inspector (ASMI). The Act covers private lands and requires that 1) mined land be reclaimed to a safe and stable condition for the specified post-mining land uses and that 2) the operator re-establish the type, density, and diversity of vegetation that is appropriate and technically and economically practicable given site-specific characteristics. Plant species chosen must support the post-reclamation land use. Under Arizona Statutes, reclaimed areas must be compatible with fish and wildlife habitat on adjacent lands. With respect to post-mining revegetation requirements, a reclamation plan is required that describes the techniques, methods, controls, and/or success measures to be used in revegetation. A *Mined Land Plan Reclamation Plan* (MLRP; Tetra Tech, 2008) was submitted to ASMI and approved (ASMI, 2009). The MLRP will be updated following approval of the Mine Plan of Operations (MPO) for the Project and will follow the Reclamation and Closure Plan (MPO Volume III-a).

The Coronado manages some of the property at the Rosemont Project site. Chapter 2841 of Forest Service Manual (FSM) 2800 identifies environmental components for reclamation Plans of Operations (MPOs) that include the following aspects of revegetation:

- Revegetation of disturbed areas, including timing, kind, and amount;
- Soil management, soil salvaging, and reapplication;
- Watershed management, including runoff and erosion control, and riparian and wetland protection;
- Visual resource management during and after operations; and
- Fish and wildlife habitat reclamation or mitigation.

Chapter 2842 of FSM 2800 also specifies that a MPO include measurable performance standards for all requirements, including revegetation. The success standards that address both the ASMI and Forest requirements are incorporated in this *Revegetation and Growth Media Monitoring Plan*.

Chapter 2070.11 of the FSM identifies laws that govern the management and use of non-native plant materials of National Forest System lands under Forest administration. The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, as amended by the National Forest Management Act (NFMA) of 1976, section 6 codified at 16 U.S.C. §§ 1600 (g) provides that the Secretary shall "promulgate regulations . . . (3) specifying guidelines for land management plans ... which ... (B) provides for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives, and within the multiple-use objectives of a land management plan ... provide, where appropriate, to the degree practicable, steps to be taken to preserve the diversity of tree species similar to that existing in the region controlled by the plan".

In terms of viewshed, Forest Service Manual 2380.15 (FSM 2300 Recreation, Wilderness, and Related Resource Management, Chapter 2380 Landscape Management) requires that mineral operations be harmonized with scenic values to the extent practicable. Additionally, Title 36 Code of Federal Regulations (Part 228, Subpart A, Locatable Minerals [36 CFR part 228, subpart A]), includes requirements for harmonizing mineral operations with scenic values.

There are specific reclamation/revegetation requirements for the Rosemont Project stated within the FEIS (USFS, 2013) and the amended Biological Opinion (BO; USFWS, 2016). These requirements are meant to avoid, minimize, reduce, rectify, or compensate for impacts.

3.0 POST-MINING LAND USES

Post-mining objectives for the Project area are consistent with the rural values embodied in the use concepts associated with western open space, such as dispersed recreation, wildlife habitat, and ranching. Current and probable post-mining recreational activities include horseback riding, hunting, prospecting, hiking, bird watching, ranching, and other non-motorized activities (see *Reclamation and Closure Plan* [MPO Volume III-a]).

The Project area is part of an existing ranching operation with approximately 30,000 acres of grazing leases. Much of the reclaimed landscape will be suitable for grazing once vegetation is established. Details regarding grazing will be specified in an Allotment Management Plan, which is due within one (1) year of issuance of the Record of Decision (ROD). The post-mining landscape will include a landform (Landform) created by development of the Waste Rock Storage Area (WRSA) and the Dry Stack Tailings Facility (DSTF).

The establishment of wildlife habitat and use are expected to start early in the life of the Project due to the concurrent reclamation of the Landform. Rosemont's reclamation and revegetation process also includes consideration of the visual, or scenic aspects, of the Project. Scenic quality is a reclamation objective addressed through the shaping of the Landform and other reclaimed areas, the use of diverse seed mixtures, and the anticipated volunteer plants within the soil, which will create a natural distribution of plant communities consisting of herbaceous and woody species.

4.0 SOILS AND VEGETATION BASELINE

4.1 SOIL SURVEY RESULTS

Soil (growth media) management begins with soil salvage. As practicable, soil salvage will be conducted over the entirety of the defined Project disturbance area, with the depth of salvage dependent on the suitability of the soil for reclamation efforts. Soil salvage areas include the pit area, the footprint of the WRSA and DSTF, and other disturbance areas such as the Plant Site.

In 2007 and 2010, Tetra Tech (2007, 2010) conducted detailed soil resource evaluations at the Rosemont site, which was used to plan the harvesting of soil materials. This assessment was conducted to describe the soil profiles or pedons, document soil characteristics including any vegetation growth-limiting characteristics, sample and analyze the physical and chemical properties of representative pedons, prepare a description of the mapping units and components, evaluate the soil suitability for reclamation, and propose suitable salvage depths (Tetra Tech, 2007). Soil classification methods used were consistent with the NRCS soil surveys and detailed laboratory analyses were conducted. The 2007 Tetra Tech report was updated (Tetra Tech, 2010) to reflect additional potential areas of impact (soil study areas) based on the various alternatives analyzed during development of the Environmental Impact Statement (EIS). Tetra Tech's reports indicated that sufficient soil (growth media) material was available for revegetation for each alternative. These reports also describe the soil type, depth, site characteristics and other soil characteristics, including salvage-limiting factors.

The NRCS provides soil data and linked information through the Web Soil Survey produced by the National Cooperative Soil Survey. This data includes soil maps, soil classification and properties, ecological site assessments, and other technical information. NRCS soil maps (see CDM Smith [2013a] memorandum in Appendix A) were produced for the Project site in order to obtain linked vegetation information contained in the ESDs. Although vegetation can be adapted to multiple soil types, each soil type is identified to a specific plant community. There is a direct relationship between vegetation and soil types as discussed in Section 4.2 below. Table 1 provides soil map unit codes, names, and the approximate number of acres they encompass within the Barrel Alternative footprint.

4.2 ECOLOGICAL SITES ADJACENT TO THE PROJECT

NRCS ecological sites were used to help characterize vegetation at the Rosemont site. An ecological site is defined by the NRCS as "a distinctive kind of land with specific characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation". ESDs include a narrative of site characteristics (physical features, climate, soil, and water features), plant communities, site interpretations, and other supporting information related to these ecological sites. Appendix A (Figure 2) shows the extent of the mapped NRCS ecological sites at the Rosemont Project. The ecological sites selected to represent the Rosemont site include:

- Limy Slopes 12-16 inches annual precipitation zones
- Granitic Hills 12-16 inches annual precipitation zones

Geologic maps of the area display two (2) dominant soil parent materials: Arkose (or Willow Canyon Formation) and Gila Conglomerate. These two (2) units are generally grouped with the Granitic Hills and Limy Slopes ESDs, respectively. It is anticipated that the soils placed on the reclaimed surfaces of the Landform, and in other areas requiring reclamation, will generally match the soil types associated with one of these two (2) ecological sites. Additional information regarding ecological sites, State-Transition Models, and plant communities can be found in the CDM Smith (2013a) memorandum provided in Appendix A).

4.3 SELECTION OF REFERENCE AREAS

Reference areas are undisturbed sites that will be used to compare ecological structure and function to reclamation sites as a measure of success. As such, reference areas may be used as targets or models for reclamation projects, as well as a yardstick for measuring the progress or success. Reference areas were located using NRCS soils and ESDs (USFS, 2013: FS-SR-01). Reference areas with the most similar site characteristics to the planned Landform, such as slope gradient, aspect, soils, elevation, (USFS, 2013: FS-SR-02) and plant community, will provide the most direct and appropriate comparisons. As a note, the most prevalent physical characteristics influencing the composition of undisturbed sites and the establishment of vegetation on the constructed Landform are slope aspect and slope angle.

Reference areas were established at the Rosemont Site in 2013 outside of the Project footprint. The location of the reference areas can be found in the *Reference Area Monitoring Report – Site Selection and Results for 2013, 2014, and 2015* (MPO Volume IV-o). Using the same methods, vegetation and soil stability measurements will be monitored on the revegetated areas and compared with the reclamation test plots and the reference areas. The reference area data will be used, in conjunction with the research data collected from the reclamation test plots, to determine when reclaimed areas meet revegetation success criteria (Chambers and Brown 1983) (see Section 7.4 of this *Revegetation and Growth Media Monitoring Plan*).

Appendix B provides a memorandum titled *Reference & Reclaimed Area Sampling Protocol* (CDM Smith, 2013b) that outlines an approach to selecting and sampling reference areas. This memorandum explains the use of vegetation measurements, including transects and macroplots, in order to quantify and track plant community characteristics. Results from the 2013 through 2015 monitoring can be found in the *Reference Area Monitoring Report – Site Selection and Results for 2013, 2014, and 2015* (MPO Volume IV-o). The memorandum (CDM Smith, 2013b) also discusses methods to monitor revegetated RMAs to be established on the Landform. Reference area data will be used to calculate native species' occurrence, density, and cover to set revegetation success criteria (USFS, 2013: FS-SR-02).

5.0 VEGETATION OBJECTIVES AND APPROACH

The revegetation objectives are to establish productive, diverse, and self-sustainable native plant communities capable of stabilizing the soil against excessive wind and water erosion, and providing wildlife habitat and grazing land. The revegetation objectives will be accomplished by using carefully selected native plant species, designing the Landform (and other areas, including soil stockpiles) with slope angles that can support vegetation growth, and salvaging soil that can sustain vegetation. These objectives are consistent with statutory requirements and long-term land use goals. A Monitoring Group, consisting of Rosemont, the Forest Service, and possibly the NRCS, will be established to make decisions regarding revegetation issues.

Plant communities and vegetation patterns in the Rosemont area were evaluated to determine the revegetation approach on the Landform. As discussed above in Section 4.2, NRCS Ecological Sites were used to characterize existing vegetation. Additionally, there are vegetation patterns that can be observed across the Rosemont site. The north-facing slopes have increased amounts and cover of woody species, while south-facing slopes have more arid-adapted species. Reference areas, as described above in Section 4.3, will help assess and quantify vegetation patterns and trends. Additional details regarding the definition of plant communities can be found in the *Revegetation Performance Measures* memorandum (CDM Smith, 2013a; Appendix A). Revegetation of the Landform is planned to mimic natural patterns, including seasonal characteristics, plant communities, and slope effects of the Rosemont area, which will allow the Landform to be more visually similar to surrounding areas.

Based on the NRCS definition of an ecological site, the Landform will be divided according to physical conditions (slope aspects), which represent different anticipated plant communities. Soil type will determine species within a seed mixture, but the anticipated plant community will remain the same. Ecological sites anticipated on the reclaimed Landform include:

- Semi-desert Grassland on East-facing Slopes (Grassland)
- Semi-desert Grassland on Level Ground (Savanna)
- Semi-desert Grassland on North-facing Slopes (Dispersed Woodlands)
- Semi-desert Grassland with Increased Rock Cover (Steep, Rocky Slopes)
- Semi-desert Grassland on South-facing Slopes (Grassland with Succulents Added)
- Semi-desert Grassland on West-facing Slopes (Grassland)

Figure 20 of the *Reclamation and Closure Plan* (MPO Volume III-a) shows the general anticipated layout of the plant communities, accounting for slope aspect and gradient. This layout will help to determine the seed mixture, amount of woody species plantings, and to determine RMAs. Sequencing of revegetation is also anticipated to follow that shown on Figure 19 of the *Reclamation and Closure Plan* (MPO Volume III-a). The revegetation process will follow details found below in Section 6.0.

6.0 RECLAMATION IMPLEMENTATION

6.1 THE REVEGETATION PROCESS

The revegetation process is outlined in Illustration 1.

6.2 VEGETATION CLEARING AND MANAGEMENT

Vegetation salvage, clearing, and other concerns are addressed in the *Vegetation Clearing and Area Clearance Plan* (MPO Volume II-aa). Cultural and biological resource clearances will be obtained before any plant salvage or soil disturbance occurs. Conservation measures to protect the lesser long-nosed bat (LLNB) will be followed. Activities near known LLNB roosts would occur when LLNB are not present, typically from November 1 to July 1 of each year (USFS 2013: FS-SR-01). Prior to clearing existing vegetation, species of special interest, such as the Palmer's agave and selected culturally significant plants, will be removed, transplanted directly onto the reclaimed Landform (or other reclamation areas) or transported to a storage area for later planting. As needed, Rosemont will also coordinate plant removal with consulting tribes (USFS 2013: FS-CR-09). There may also be opportunities for organizations and nurseries to salvage plants from the site; however, the number of desirable and manageable specimens is predicted to be relatively low. Vegetation removed from the Project site would be in accordance with the Arizona Department of Agriculture land-clearing permit in accordance to the Arizona Native Plant Law for private and State lands (see page 57 of the FEIS, USFS 2013b).

Existing vegetation in the Project area consists of native plant communities of grasses, forbs, shrubs, succulents, and trees. Clearing will remove trees and other vegetation, and grubbing will remove large underground plant material, such as stumps, roots, and buried logs (as needed). Soil stripping follows clearing and grubbing activities. Areas that are not under immediate construction will not be disturbed until needed in order to preserve site stability. It is anticipated that areas will be cleared between six (6) to 12 months prior to use.

Some of the woody material, trees and shrubs, will be shredded or chipped and used as an amendment (thin surface mulch) for seedling germination during revegetation efforts and to enhance soil stability. Large pieces of cleared and grubbed material will be scattered onto the reclaimed Landform or other reclamation areas following seeding to improve slope stability, add organic matter, enhance microhabitats for invertebrate and small vertebrate species, and to enhance seed germination (USFS 2013: FS-SR-01). Density of woody debris will meet guidelines that are portrayed in the draft Coronado forest plan as stated in the FEIS (USFS, 2013: FS-SR-01). Woody debris will not be stored on Forest Service land for more than one year.

Large pieces of cleared material may be scattered on the Landform at a rate from 10 to 30 tons per acre while material is available. This rate may be adjusted as determined by the Monitoring Group. Large shrubs and trees that were cleared may also be cut to manageable sizes and used in gullies and in other areas for erosion control. Burying cleared and grubbed material is not being considered.

Grasses, forbs, cacti, and small shrubs will be removed with the soil. This plant material will contribute to the reestablishment of the local genetic stock as some seeds will remain in the soil (seed bank) or attached to the plants, and rhizomes and other underground reproductive material will increase the ability of these plants to tiller (sprout) and become re-established on the Landform, etc. Plant material that dies during the soil salvage process will be a source of organic matter for soil microbes.

6.3 SOIL SALVAGE

Soil (growth media) salvage, including where and how soil will be stored, and how and where it will be applied on disturbed areas in order to facilitate revegetation, is required under Mitigation Measure FS-SR-01 (USFS, 2013).

Suitable soils will either be directly placed onto the Landform during operations or into soil stockpiles (see *Reclamation and Closure Plan*; MPO Volume III-a). The stockpiles will be managed, to the extent practicable, to preserve properties of the soil to support revegetation.

As discussed in Section 4.1, soil surveys were performed and soils classified with physical and chemical properties to determine which soils will support vegetation. Prior to soil salvage, soils (growth media) will be evaluated to classify the area as an Arkosic soil, Gila Conglomerate, or other soil type. Soil pits may be excavated to determine the depth of the soil to be removed. If the growth media contains characteristics that are not suitable for revegetation, they will be further evaluated to determine if amendments may be used to improve their physical or chemical characteristics. Additional materials may be excavated and amended to provide additional growth media, as needed, in order to provide sufficient cover for all disturbed areas to be reclaimed (USFS, 2013: FS-SR-01). The *Preliminary Soil Management Plan* (CDM Smith, 2012) describes some of the growth media characteristics that may be investigated, as well as amendments that may be used to improve the growth media.

The strategy for salvaging and using soil is geared towards preserving the biological component within the soil to the extent practicable. This will help promote the natural reestablishment of plant species native to the Project area. This strategy includes selectively stripping the upper soil layers and either directly placing that material on the reclaimed Landform (or other reclamation areas) or storing that material in as shallow a stockpile as possible for as short of a time as possible. Soil texture, surface particle size, and soil stability measurements would meet interim and final reclamation and revegetation objectives (USFS, 2013: FS-SR-02). As practicable, soils with the same parent material will be applied to a similar physical area of the Landform for best management, which will allow for better classification of RMAs. For example, a RMA may consist of an east-facing slope with growth media with the same parent materials and seeded in the same year.

6.4 SOIL STOCKPILES

Soil (growth media) stockpiling will occur throughout the life of the Project. Direct placement of the salvaged growth media onto reclaimed areas, such as the Landform, is not possible throughout the life of the Project due to the rate of expansion of the disturbed footprint versus available reclamation areas.

Similar to soil salvage and use, soil stockpile goals are directed at preserving the biotic community, nutrients, and other components of good soil health. In order to achieve these goals, soils would be handled minimally, stored for as short of a duration as possible, and the stockpiles would be protected from erosion. Sediment control would be installed and other best management practices implemented as needed to protect growth media from loss (wind or rain runoff) (USFS, 2013: FS-SR-01). Additionally, stockpiles would be wide and shallow, to the extent practicable, and convex in shape and with slopes no steeper than 3:1 (USFS, 2013: FS-SR-01). The stockpiles would be revegetated with native species no later than the first growing season following the Pre-Mining Period (USFS, 2013: FS-SR-01).

Soil stockpile locations would be located as close to the final placement as possible. Relocation of the stockpiles is anticipated in the later years of the Project. Anticipated stockpile locations are indicated on Figures 04 through 11 in the *Reclamation and Closure Plan* (MPO Volume III-a). As noted, stockpiled soils, would be segregated according to their parent materials to the extent practicable.

6.5 SOIL PLACEMENT

Placement of growth media and revegetation would be implemented concurrently with reclamation efforts (USFS, 2013: FS-SR-01, FS-SR-02). Salvaged soils from the Project area will be placed on the slopes of the Landform and used as a plant-growth media (USFS, 2013: FS-SR-01). Soil surface particle size, chemistry and texture would be determined when growth media is placed; texture of growth media would be defined using the U.S. Department of Agriculture soil classification system (USFS, 2013: FS-SR-01). Should soil texture, surface particle size, or soil stability measurements not meet revegetation objectives, appropriate site-specific measures would be developed in cooperation with the Monitoring Group. Measures may include: additional soil placement, soil amendments, soil stability measures, and/or other amendments/prescribed treatments. Erosion control would comply with any requirements of the stormwater permit and associated *Stormwater Pollution Prevention Plan* (SWPPP) (MPO Volume IV-q, r) as indicated in the FEIS (USFS, 2013: FS-SR-01).

6.6 SITE PREPARATION

Site preparation will begin with grading areas to stable, permanent slopes as specified in the *Reclamation and Closure Plan* (MPO Volume III-a). Grading is intended to restore more natural slopes with effective drainage and minimize scour and erosion. Salvaged soils from the footprint of the Landform and other facility areas will be placed on the slopes as a growth media. Where needed, the ground surface will be ripped to decompact the soil. Additional surface soil manipulation may be used to create a seedbed that has microniches, or safe sites, for optimum seed germination and plant establishment. Ripping and other surface soil manipulation techniques will be conducted along contours to create furrows that decrease soil erosion, increase the infiltration rate, and generally repair hydrological functions. Following ripping/furrowing, a screen, chain, or other dragging implement may be used to knock down furrowing ridges to create a smoother surface. Additional treatments to stabilize soils, including the addition of soil amendments and/or soil mycorrhizal inoculations, may be considered pending monitoring results. Monitoring results would be used to determine whether additional mitigation measures are needed to enhance plant success on growth media types or to improve soil stability (USFS, 2013: FS-SR-01).

6.7 SEEDING, MULCH AND WEED MANAGEMENT

To direct the reconstructed ecosystem on the Landform, Rosemont will establish native grasses, forbs, shrubs, and trees in similar functional group, or plant type, composition and seasonal variety as undisturbed lands (USFS, 2013b: FS-SR-02). The native seed mixture (see Table 2) contains grasses, forbs, and shrubs that will be broadcast onto reclamation soil surfaces during the period determined optimal for seedling establishment, which is anticipated to be just prior to monsoon moisture and secondly, prior to winter moisture. Species that are found in multiple ecological sites are commonly seen on the Project site and are adapted to a variety of conditions (see CDM Smith [2013a] in Appendix A of this Plan). Species selected for the seed mixture are expected to be self-sustainable, provide soil stability, achieve desired conditions, including wildlife habitat, and include species that are culturally important to tribes (USFS, 2013: FS-SR-02). Functional groups and the species contained in each group will be proportioned according to the ESDs to represent a semi-desert grassland plant community. For example, if a semi-desert grassland is composed of 50% perennial grasses, perennial grasses will make up 50% of the seeds in the seed mixture.

The reclamation test plots verified that the species in the seed mixture established well at the Rosemont site. Alternative or additional species (Table 3) may be used to enhance the Rosemont seed mixture (Table 2) on all slope aspects. These species may be used: 1) when seed is not commercially available, 2) or to increase species diversity when the seedbank is expected to be small or absent. Species in the seed mixtures will be determined by the NRCS ESDs, reference areas, reclamation test plots, and (in the future) RMA monitoring results (USFS, 2013b: FS-SR-02). Native species would be approved by the Forest Service in advance (USFS 2013: FS-SR-02). The Monitoring Group will review monitoring results to determine if seed mixture modifications are necessary. Additional species including trees, shrubs, and/or agave will be seeded in selected areas (see Sections 6.8 and 6.9).

Seed will be sown at an overall density of approximately 50 to 100 pure live seeds (PLS) per square foot. The seeding rate will be in the range of 5 to 12 pounds of PLS per acre, depending on the species composition and desired number of seeds per square foot. The seeding rate may be modified downward if a substantial seed bank is present in the growth media. This may be evaluated through an adaptive management process prior to changing the specification.

Seed will be obtained from commercial seeders. This seed is well adapted to a variety of environments and has proved to establish well at the Rosemont site. NRCS has also helped to develop commercial seed using seed collected from Southern Arizona. When possible, commercial seeders using NRCS-developed stock will be utilized. If that seed is not available, the seed will be obtained from commercial seeding sites most similar to the Rosemont site. Seed and other organic material will be tested by an independent lab for noxious and invasive species prior to use (USFS, 2013: FS-SR-02).

Certified weed-free wheat straw mulch with a tackifier will be applied at a rate of approximately one (1) ton per acre, or shredded mulch from on-site woody materials may be applied at the rate of approximately a one (1) centimeter depth. Certified weed-free sources of plant and erosion control materials are required under FS-SR-02 (USFS, 2013). Seeding will occur prior to mulching when applied to the soil surface to ensure good soil-to-seed contact. In areas that are prone to windy conditions and contain soils that contain an acceptable amount of coarse fragments, certified weed-free straw mulch would be tilled, or mixed, into the soil at a rate of up to two (2) tons per acre so that the mulch is secured in place. Seeding will occur following mulch incorporation (when mulch would be tilled into the soil) for best seed placement.

The *Invasive Species Management Plan* (MPO Volume II-o) contains information on how to prevent, detect, treat, and monitor invasive species. Undesirable plant species will be managed in accordance with federal and state regulations in order to help eradicate weeds within the Project site. Revegetation would be protected by early detection and treatment of invasive weed species (USFS, 2013: FS-SR-02). Early detection focuses on high-traffic areas such as roads and parking areas that serve as invasive seed transport corridors. All other disturbed areas would be monitored twice a year following the rainy seasons. Infestations of invasive species would be treated as soon as they are identified or as soon as conditions are appropriate for treatment (USFS, 2013: FS-SR-02). Methods to manage noxious weeds include:

- Prevent the introduction of invasive species;
- Early detection of invasive species and initiate rapid responses to prevent their spread within and near the Rosemont site;
- Treatment and control to eradicate small populations and manage large populations of invasive species;
- Monitoring of invasive species to determine trends and treatment effectiveness in accordance with land management goals; and
- Communication with agencies and organizations to determine best available science for invasive species management.

6.8 TREES, SHRUBS AND ADDITIONAL SPECIES

Trees and shrubs (woody species) have been identified to provide wildlife habitat, ecological functions, and maintain visual quality in the Project area. Mitigation requires that 3 to 40% of woody plant cover (>1 to 50% as averaged over the reclamation area, excluding the pit per the amended Biological Opinion [USFWS, 2016]) will be established for jaguar and ocelot habitat (USFS, 2013: FS-SR-02) and will be achieved by meeting the cover and density success criteria listed in Table 4. Additional tree and shrub cover may be required in order to meet success criteria in relation to reference areas (USFS, 2013: FS-SR-02). If these criteria are not met, adaptive management will be used by the Monitoring Group to determine desirable conditions and modifications to revegetation techniques. The NRCS will be consulted to provide expertise on seeding rates and revegetation techniques to produce favorable results. Table 5 shows the approach to tree and shrub establishment on the slope aspects of the Landform.

Woody species are naturally the most prevalent on north-facing slopes, which creates a visual pattern across the landscape as shown in Appendix A of this *Revegetation and Growth Media*

Monitoring Plan (see Figure 3 in CDM Smith, 2013a). Revegetation of woody species will generally follow these natural landscape patterns on the final Landform (USFS, 2013: FS-SR-01, FS-SR-02). In comparison, the top of the Landform may have a lower density of trees and shrubs, as visually shown in photographs provided in Appendix A. Woody species will generally be widely scattered on east- and west-facing slopes. South-facing slopes may be limited to very widely scattered small shrubs and trees. Additional details on enhancing vegetation patterns and mitigating visual impacts, such as the viewshed from State Route 83, are highlighted in Table 5. The concurrent placement of the perimeter buttress with mining operations will also reduce visual impacts (USFS, 2013: FS-SR-03).

Trees and shrubs will be established by volunteering (from the seed bank), seeding, or planting. One species of shrub, fairy duster (*Calliandra eriophylla*), is included in the core Rosemont seed mixture (Table 2) and therefore will be seeded across all revegetation areas. As observed on the reclamation test plots, woody species readily volunteer from the seed bank and are likely to readily establish and provide structural diversity in the plant communities. When soil is not directly replaced, woody plant species may be added to the seed mixture according to slope aspect to create a desirable density or cover of trees or shrubs. Each RMA must contain a similar amount of woody species (Table 4) compared to the reference areas in order to meet the success criteria. If a desirable amount of woody plant cover does not establish from the seed bank or through seeding, tree plantings may be used. If woody plants establish in undesirable patterns and densities, adaptive management will allow the Monitoring Group to determine the appropriate actions.

Seeding woody species will occur prior to the monsoon season or cool season. Woody species will be drill seeded prior to broadcast seeding of the core Rosemont seed mixture (Table 2) or they may be mixed into and broadcasted with the Rosemont seed mixture, depending upon the species selected and their optimal seeding depth. Plantings would use nursery-grown trees or shrubs to create “tree or shrub islands”. Island plantings would typically consist of about 20 – 30 individuals of mixed species (Table 5) within about an acre. This will produce a higher cover of woody species for wildlife habitat within relatively small areas and help to diversify the plant age structure. Tree/shrub islands will be randomly placed within the reclamation areas or as determined by the Monitoring Group. The number of plants and tree/shrub islands would also be adjusted according to specific locations on the Landform or slope aspect. About 10 – 15 islands are anticipated on the north-facing slopes. This equates to about one (1) tree or shrub island per 30 acres based on about 370 acres on north-facing slopes based on the Landform closure concept (see *Reclamation and Closure Plan* [MPO Volume III-a]). The planting of about 5 to 10 tree islands are anticipated on top of the Landform for enhanced wildlife habitat. The number of woody plants and islands may be adjusted according to project goals and as determined by the Monitoring Group.

The placement of trees and shrubs (or islands/plantings) on the east-facing slopes of the Landform is also important to help enhance the viewshed quality from State Route 83. Revegetated shrub and tree plantings will be scattered across the landscape in a random/patchy distribution to mimic natural vegetation patterns on adjacent undisturbed areas (USFS 2013: FS-SR-01). In addition to random plantings, woody islands are anticipated to help blend features such as the stormwater benches into the Landform. Species selection and planting techniques will also be adjusted for the rockier soil cover that is anticipated on the longer east-facing slopes. Broadcast seeding will allow seeds to reach the soil in between the rocks. However, fewer seeds expected to reach their optimal seeding depth and an increased seeding rate may compensate for the difference. Adaptive management (Section 10.0) will be used to assess the effectiveness of the species and placement to ensure vegetation growth as compared to visual quality objectives.

Transplanting trees from the footprint of the Project facilities was considered, but is not likely to be successful. Rocky soils and slopes will prevent the use of specialized equipment like tree spades. Woody species will most likely be grown from seed to a specified size at a nursery and then planted on the Landform; this technique has been shown to produce higher establishment rates than transplanting. Additional reclamation techniques, like water harvesting or artificial irrigation gels, may be initially required to assist some plants to establish on the site. Reclamation techniques may be evaluated on the reclamation test plots prior to application on a larger scale. Adaptive management will also be used to adjust techniques in order to produce the most successful woody plant establishment.

Compared to herbaceous species, woody plants require more time to grow to sizes comparable to the undisturbed sites. Woody species generally invest in their root structure prior to their canopy; therefore, woody species may not be visible from a distance for 5 to 10 years. This concept is demonstrated in Table 6. Trees and shrubs established by seed will take longer to become visible as compared to plantings. If site conditions are not favorable for tree or shrub growth, height and production may be affected. Some species, like oaks, grow slowly and are likely to remain a relatively smaller size for a longer period of time. Woody species that may be appropriate for seeding or for tree/shrub plantings are shown in Table 7. Although mesquite, acacia, mimosa, and one-seed juniper are common in the Rosemont area, they will not be actively planted. It is expected that these species will readily colonize the reclaimed areas opportunistically without seeding or planting through seeds and plant materials within the soil, mulching, and erosion control.

Except for Palmer's agave, which will be planted on all slopes (USFS, 2013: FS-BR-04), culturally significant shrub species in Table 8 will generally only be applicable to south-facing slopes. Other culturally significant species that will be found on the Landform are described in Section 6.10. NRCS ESDs, on-site observations, culturally significant species, and commercially available seed were considered in the development of Table 8. These species will support post-mining land uses described earlier in Section 3.0. It is anticipated that testing transplanting techniques on select species will be conducted (on reclamation test plots or selected RMAs) prior to implementation on a large-scale to ensure their suitability for the site conditions (i.e., soil type/slope aspect) on the reclaimed Landform and other reclaimed areas.

6.9 REESTABLISHMENT OF PALMER'S AGAVE

Palmer's agave (*Agave palmeri*) salvage, growth, and planting will follow protocol defined in the *Agave Management Plan* (MPO Volume II-b). The agave is a critical food source for the federally endangered lesser long-nosed (LLN) bat (*Leptonycteris yerbabuenae*). The agave is also a culturally significant plant for Native Americans.

Mitigation requires Rosemont to plant Palmer's agaves at ecologically appropriate densities on the Landform for the LLNB. Once re-established, the agave population is expected to be self-sustainable, while providing a food source for the bat. Transplanting and propagation, as well as possible seeding, will be used to provide a varying population age structure.

The *Agave Management Plan* discusses harvesting techniques, storage and care techniques, propagation, post-planting watering strategies, and other key technical components for a successful program. As needed, salvaged agaves will be placed into a nursery until they are placed on the Landform or other reclamation areas (USFS, 2013: FS-BR-04). Agave seed may be used if it becomes commercially available. Each year, a portion of the agave population is expected to flower and provide forage for the LLNB. Monitoring and adaptive management will allow for adjustments to ensure appropriate agave densities and age structure will persist on the Landform.

Tribes will be offered an opportunity to collect plants, including Palmer's agaves, prior to ground disturbance as discussed in the *Cultural Resources Management Plan* (MPO Volume II-i) and in the *Vegetation Clearing and Area Clearance Plan* (MPO Volume II-aa). Other plants, including agaves, may also be transplanted in a designated area and access provided to members of consulting tribes (USFS, 2013: FS-CR-09).

6.10 PLANTS OF TRADITIONAL IMPORTANCE

Tribal consultation regarding plants of traditional importance has been implemented pursuant to Section 106 of the National Historic Preservation Act. As appropriate, Rosemont will incorporate culturally significant plant species into revegetation efforts on the Landform (Griset 2011; USFS, 2013: FS-SR-02. FS-CR-09). Specific plants were traditionally harvested for food, shelter, ceremonial, medicinal, or other purposes. A number of trees, shrubs, cacti, succulents, forbs, and grasses have been identified as culturally significant by the Tribal Council, which includes the Tohono O'odham and Apache tribes.

Many of the species previously identified by SWCA, the Forest Service's consultant, were seeded as part of the research conducted by the UofA and are included in the Rosemont seed mixture (USFS, 2013: FS-SR-02). Species are also anticipated to establish voluntarily as observed on the reclamation test plots. Traditionally important species known in the proposed Project area are identified in Table 8. Additional culturally significant shrub species that will be used in the woody species mixture are described in Section 6.8 and Table 7.

6.11 RECLAMATION MANAGEMENT AREAS

Reclamation Management Areas (RMAs) will be defined according to the variables that affect revegetation. These variables include the slope aspect, soil type, and the year in which they were seeded. Additional factors, including soil condition and timing of seeding (during the warm season from May to October, or during the cool season from November to April), may also be used to define an RMA for management purposes.

In order to more efficiently manage soil, soil (growth media) will be characterized before it is salvaged. As practicable, similar soil types will be placed together on the Landform, (for example, within a defined elevation range and slope aspect), which will help to define RMAs. Additionally, soil that is located within the top portion of the soil profile will be prioritized for direct placement. Managing this soil will help to preserve the seed bank (seeds within the soil), which will promote species diversity. Soils that contain a seed bank will utilize the Rosemont seed mixture (Table 2) while other soils will be seeded with the Rosemont seed mixture plus additional species (Table 3) within the seed mixture to promote species diversity.

Table 9 provides an example of RMAs that were defined based on the slope aspect (north-, west-, south-, east-facing slope, rocky slopes or flat slopes), soil type, and number of acres reclaimed each year. An RMA consists of a maximum of 100 acres. Since the soil type to be placed in a RMA has not yet been determined (Gila, Arkose, or Other), a range of RMAs were provided in the total number of per general time period.

To confirm the soil type, a soil pit will be dug in each RMA. Soil depth, effervescence, soil texture, coarse fragments, and other characteristics will be collected at these locations per Mitigation measure FS-SR-01 (USFS, 2013). Once the soil type is confirmed, the proper soil amendments, seedbed preparation, seeding amendments (such as mulching), seed mixture, and plantings can be applied within the RMA.

Initially, qualified personnel will assess seed germination and establishment qualitatively. Qualitative measurements will include the 17 Indicators of Rangeland Health (Pellant et al, 2005), as described in the *Rosemont Reference & Reclaimed Area Sampling Protocol Memorandum* (CDM Smith, 2013b) provided in Appendix B of this Plan. Additional monitoring, including SWPPP inspections, will be conducted as needed to determine stability and maintenance needs. Since seeding will rely on precipitation and is subject to extreme conditions, like freezing and drought, it may take multiple years for vegetation to establish successfully. It is anticipated that qualitative measurements will be conducted from 1 to 5 years, depending on conditions observed. If the plant community is composed of small, immature plants (not yet reproducing), qualitative monitoring will continue. In the event that seeds do not establish for 2 to 5 years, the RMA may be re-seeded and additional amendments may be applied as necessary. A soil sample may also be collected at this time for lab analysis to inform adaptive management decisions. The Monitoring Group will help to determine an adaptive management approach in order to successfully revegetate and stabilize the RMA.

If revegetation within an RMA provides favorable qualitative results (i.e., well-established, mature plants), quantitative measurements will commence. These measures are discussed in the *Revegetation Performance Measures Memorandum* (CDM Smith, 2013a) as provided in Appendix A of this Plan and summarized in Section 7.0 (below). A total of three (3) sampling unit replications will be conducted within an RMA, including macroplots, transects, and quadrat measurements as detailed in *Rosemont Reference & Reclaimed Area Sampling Protocol* (CDM Smith, 2013b; see Appendix B of this *Revegetation and Growth Media Monitoring Plan*). Sampling locations may be chosen using stratified random sampling. Sampling locations will be chosen at random using coordinates (X = Easting, Y = Northing) using geographic information system (GIS), according to maximum and minimum coordinates of the stratified area within the RMA.

Additional RMAs may be defined according to monitoring results by splitting a RMA into smaller areas. If quantitative results are not satisfactory, additional treatments, seeding, plantings, or other amendments may be applied as determined by the Monitoring Group. If major treatments are applied (for example, seedbed disturbance, re-seeding), the RMA may be subject again to qualitative measurements until determined ready for additional quantitative measurements (plants have been established for at least 2 years). If the quantitative vegetation and site stability measurements are satisfactory in a specific RMA, (as stated in the *Revegetation Performance Measures Memorandum* by CDM Smith (2013a, see Appendix A of this Plan), Rosemont may apply for the associated bond release (see Section 7.4).

7.0 PERFORMANCE EVALUATIONS

7.1 OVERVIEW

Revegetated areas at the site will be monitored to determine: 1) if the seeded species have become established (or if reseeding is required); 2) maintenance requirements; and, 3) whether revegetated areas are compliant with the reclamation success criteria so that bonding can be released for a particular area (an RMA). Newly seeded areas will be monitored to decide if the seeded species have germinated and have become established. Often in arid environments, weather-related factors prevent germination of some seed during the first year. If after two or more growing seasons perennial plant establishment is poor and the long-term development of the plant community is questionable, the Monitoring Group will develop an adaptive management plan (Section 6.11). The plan may include soil testing, over-seeding, tilling and reseeding, applying soil amendments, or adjusting other revegetation methods. This on-going evaluation and adjustment process is part of an adaptive management approach that would allow flexibility in adjusting to unanticipated conditions. Adaptive management would also be used to set and refine techniques for revegetation and site stability (USFS, 2013: FS-SR-01). Site assessments for success determination/bond release purposes will be conducted separately as described in the sections below.

Qualified personnel will conduct site assessments. These personnel will have knowledge, site-specific training, and experience evaluating ecological conditions within the Rosemont area and will therefore be familiar with reclamation techniques, vegetation community dynamics, and landscape stability on undisturbed reference areas as well as the reclaimed sites. They will also understand how sampling methodologies affect plant attribute data and will also be knowledgeable about the objectives and reclamation process specific to the Project.

7.2 MONITORING

Revegetation monitoring will begin during the Active Mining Phase on the RMAs following initial seeding or planting and will continue until the Forest Service determines that objectives for revegetation and site stability have been met. Monitoring and the determination of success on RMAs will continue until the Final Reclamation and Closure Phase (Closure Phase) or Post-Closure Period (USFS, 2013: FS-SR-02). Monitoring will be performed using: 1) the 17 attributes of rangeland health described in *Interpreting Indicators of Rangeland Health* (Pellant et al., 2005), and 2) quantitative vegetation measurements as described in the *Reference & Reclaimed Area Sampling Protocol* memorandum (CDM Smith, 2013b; Appendix B of this Plan). The 17 attributes are an efficient way to determine general vegetation and soil conditions on a site while the rangeland health assessment addresses the ecosystem components of soil/site stability, hydrologic function, and vegetation (biotic integrity). This is a standard technical approach used by the Bureau of Land Management (BLM) and other agencies. The vegetation and soil attributes to be assessed are listed on the field forms in Appendix B of this *Revegetation and Growth Media Monitoring Plan* and are described below.

Vegetation monitoring will be performed at the time of peak plant growth. RMAs will be defined based on slope aspect, soil type, and the year in which the seeding occurred. RMAs may be refined based on soil type, soil conditions, or other conditions that are common to an area. Monitoring RMAs will begin by mapping the boundaries of the area and then conducting a walk-over evaluation to understand the variation in vegetation cover and soil stability throughout the area. The walk-over also allows the evaluator to create a species list to document the presence of uncommon species and to ensure that small infestations of noxious and other undesirable plant species are identified so they can be eradicated or treated. Once the vegetation and erosion conditions are understood, the evaluator will randomly establish transects and collect quantitative plant cover and density measurements. The measurements will be used to calculate perennial plant density and cover by plant type, species diversity, and plant type composition, as well as other plant community attributes.

Soil stability monitoring may occur within an RMA. Monitoring may include measurements of soil surface particle size, litter and basal plant cover, rills, water flow patterns, pedestals/terracettes, gullies, wind-scoured areas, soil surface loss or degradation, plant community distribution relative to infiltration and runoff, soil surface aggregate stability, and soil compaction (Pellant et al., 2005; USFS, 2013: FS-SR-02). Additional measurements across the reclaimed sites may be required to detect the presence of rills and gullies and to quantify soil movement (USFS, 2013: FS-SR-01). Maintenance may be conducted as a result of soil stability monitoring. Erosion control would be implemented according to the stormwater permit and SWPPP (USFS, 2013: FS-SR-01).

Standard field methods will be used to collect soil/site stability and vegetation data during the monitoring event and for the purpose of determining success. These methods are described in the following manuals:

- Evaluating rangeland health indicators (soil/site stability, hydrologic function, vegetation) using the 17 attributes identified in *Interpreting Indicators of Rangeland Health* (Pellant et al., 2005) (see Appendix B of this Plan).

- Using line-point intercept to determine vegetation cover, bare ground cover, community richness, and other attributes as defined in *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems* (Herrick et al. 2005) and *Sampling Vegetation Attributes* (Coulloudon et al., 1999).

- Determining plant density using quadrats as described in *Measuring and Monitoring Plant Populations* (Elzinga et al. 2001) and using macroplots to determine tree density as described in *Sampling Vegetation Attributes* (Coulloudon et al., 1999).

- Determining the presence and absence of special and invasive/weedy plant species (Herrick et al., 2005).

- Determining rock and litter cover sizes as described in *Field Book for Describing and Sampling Soils* (Schoeneberger, et al., 2012).

- Permanent photographic points will be established for each RMA to show landscape views and close-ups of the ground cover in order to track trends as the plant community develops. Opportunistic photographs will also be taken to record significant issues.

Monitoring data and information will be provided to the Monitoring Group. This will include maps delineating the RMA evaluated, completed field forms, summarized vegetation and soil data, and photographs. Upon request, Rosemont will meet with the Monitoring Group to discuss issues or concerns. Rosemont will implement contingency measures for issues that are predicted to hamper an area’s ability to meet the success criteria.

7.3 REPORTING

Quantitative monitoring and reporting of revegetation and soil stability will be submitted to the Forest Service. Revegetation efforts, including maps of approximate areas revegetated and acreage of initial seeding, seed/plant mixture, seeding/planting application rate, propagation, and transplanting will be reported (USFS, 2013: FS-SR-02). Reporting will include species richness, canopy cover, basal cover, density/frequency, and plant community structure. Invasive species found during revegetation monitoring and invasive species surveys will be reported as detailed in the *Invasive Species Management Plan* (MPO Volume II-o).

Adaptive management adjustments would be proposed with supporting monitoring data and results from the RMAs, test plots, and reference areas, and documented in the evaluation report (USFS, 2013: FS-SR-01). RMA results will be statistically compared with reference area results to determine whether objectives are being met (USFS, 2013: FS-SR-01, FS-SR-02). Monitoring results of RMAs would be in the same or better class of soil movement as compared to reference areas, ESDs, reclamation test plots, or previously revegetated RMAs (see Section 7.4). Growth media and site stability would be sufficient to meet revegetation objectives, including successful seeding and planting of desired plant species and communities in location zones specified in the *Reclamation and Closure Plan* (MPO Volume III-a; see USFS, 2013: FS-SR-02). The Forest Service will evaluate the monitoring results to determine and document compliance with the National Environmental Policy Act (NEPA) decision and effectiveness of mitigation (USFS, 2013: FS-SR-01, FS-SR-02).

The Forest Service is responsible for spot-checking revegetation success and soil stability on National Forest Service (NFS) lands throughout the year. It is anticipated that the Forest Service will conduct annual (at a minimum) site inspections to review monitoring results in cooperation with Rosemont to: 1) determine whether success criteria have been met and the cause for better or worse results than predicted; 2) if data (from reference areas, reclamation test plots, and RMAs) indicate the need for adjustments to growth media or soil amendments, seed/plant mixture, seed/plant application rates, or site preparation, determine whether acceptable soil stability has been achieved; and 3) determine the need for additional mitigation measures for more successful revegetation and increased soil stability (USFS, 2013: FS-SR-01, FS-SR-02).

7.4 DETERMINATION OF RECLAMATION SUCCESS

Approach

A specific (i.e., map-delineated) RMA will be assessed for compliance with the success criteria when the monitoring data suggests that revegetation has been successful. The Forest Service will be notified prior to this assessment and afforded the opportunity to oversee the data collection effort.

As with the data gathered from monitoring, quantitative data used for success determination will be collected during the peak of the primary growth season using a set of transects. Based on the understanding of vegetation and site stability gained through multiple years of monitoring, transects and quadrats will be randomly located within the delineated RMA in order characterize the site in an unbiased manner. RMAs and reference areas will be sampled with the same techniques in order to obtain a direct comparison for determining success. A description of the sampling approach can be found in the *Reference & Reclaimed Area Sampling Protocol* memorandum by CDM Smith (2013b) provided in Appendix B of this Plan.

Adaptive management will be used as necessary to modify these approaches and to ensure that the Forest Service is in agreement that the data is representative of actual conditions with the evaluated RMA.

Success Standards

The proposed soil/site stability and vegetation attributes, field methods (with references), and success metrics for the Project are identified in Table 4. Success criteria would be based on quantitative monitoring results and statistical analyses/comparisons of results from reference areas, test plots, and ongoing site monitoring of previously reclaimed areas (USFS, 2013: FS-SR-01). Mitigation measure FS-SR-02 (USFS, 2013) also states that EDSs would be used to set success criteria. Although a variety of measurements and data will be collected in the field to track vegetation and site stability trends (including the frequency of species), the recommended performance parameters used to determine reclamation success for the Project are the soil/site stability component of the BLM rangeland health assessment, perennial plant cover, and density using the identified methods. Vegetation species (by functional group) and density would be similar to reference areas as determined by the adaptive management feedback loop by the Forest Service (USFS, 2013: FS-SR-02).

It is recommended that a RMA be considered successfully stabilized when the soil/site stability component is in the same or a higher class when compared to the applicable reference area. The individual soil/stability attributes evaluated using the guidance (Pellant et al., 2005) are: rills, water flow patterns, pedestals and terracettes, bare ground, gullies, wind-scoured, blowouts or deposition areas, litter movement, surface soil resistance to water erosion, surface soil loss or degradation, and soil compaction layer (see field form in Appendix B of this Plan). Success criteria for vegetation will be: total perennial plant cover that is at least 70% that of the reference area; total perennial plant density that is at least 70% that of the reference area; and woody plant density that is at least 70% that of the reference area (USFS 2013b: FS-SR-01). Aspect, elevation, and topographic location would be considered when quantifying comparisons between reference areas and RMAs (USFS, 2013: FS-SR-02).

Compliance Determination and Bond Release

When an RMA has met the soil/site stability and vegetation success criteria or as determined by the Forest Service, that area will have met the land use, plant community characteristics, and site stability goals established for the Project. At that point, the revegetation requirements will have been met and the reclamation bond can be released for that area. Reclaimed areas can also be judged successfully reclaimed even if not all of the numeric success criteria are met. For example, the Forest Service can make a determination of success if a reclaimed area has lower cover or woody plant density than the standard but is stable and has an appropriate species composition. This determination could be made using an adaptive management process to adjust the cover criteria or by providing the rationale for declaring the area successfully revegetated. The most important factors will be whether the revegetated area is physically stable, if it has a variety of native, indigenous plant species capable of providing a permanent cover, and if it is meeting the identified land use goals.

8.0 MONITORING AND REPORTING

Monitoring and reporting components for Mitigation Measures FS-SR-01 and FS-SR-02 are listed below.

8.1 MONITORING

The following monitoring will be conducted as part of growth media salvage and site revegetation:

Mitigation Measure FS-SR-01

Monitoring of soil (growth media) will begin when soil salvage begins. Monitoring will continue through stockpiling activities and placement of growth media to ensure that it is stable, placed in accordance with the *Reclamation and Closure Plan* (MPO Volume III-a), and that soil stockpiles do not erode excessively and do not contribute large quantities of dust during wind events (USFS, 2013: FS-SR-01). Monitoring would continue until the Forest Service determines that no further reclamation efforts (seeding, planting, site stabilization, etc.) are necessary to meet final objectives to be determined by the Forest Service.

Location

As practicable, soil (growth media) salvage will occur within all disturbed areas. Growth media will be applied to reclamation areas such as the Landform.

Weekly Monitoring

- During growth media salvage and storage activities, visual inspections will be conducted to ensure compliance with specifications and the following would be recorded:
    - Area of soil placement (note the parent material of growth media)
    - Soil texture
    - Soil surface particle size, and
    - Chemistry.
- During growth media placement activities, when growth media is placed for reclamation, record its location (RMA unit), parent material, depth (a minimum of 12-inches), texture, chemistry, and particle size. Texture of growth media would be defined using the U.S. Department of Agriculture soil classification system. Each RMA unit will be monitored for these properties.

Quarterly Monitoring

- Geographic information system (GIS) information would be collected to record the approximate areas where growth media was placed.
- Inspect soil stockpiles to ensure that they are convex in shape, have slopes no steeper than 3:1, revegetated with native species no later than the first growing season following the Pre-Mining Period, and check that sediment control structures are installed and other best management practices implemented as needed to protect growth media from loss (wind or rain runoff).

Biennial to Triennial Monitoring

Biennial (every other year) to triennial (every 3 years) monitoring would be conducted on the reference areas, test plots, and RMAs. Monitoring every 2 to 3 years would be consistent with NRCS monitoring intervals for grasslands. Macroplots, however, would be monitored for woody plants every 5 years. Once RMAs have been established (following qualitative measurements), quantitative measurements may be collected every 2 to 3 years. Soil stability measurements include, but are not limited to, the 17 rangeland health indicators (per Pellant et al., 2005) and 2 additional measurements listed in FS-SR-01 (USFS, 2013).

- Rills
- Water flow patterns
- Pedestals/terracettes
- Amount of bare ground (percent)
- Gullies
- Wind-scoured areas
- Litter movement
- Soil surface resistance to erosion (Soil surface aggregate stability (FS-SR-01)) Soil surface loss or degradation
- Soil surface loss or degradation
- Plant community distribution (relative to infiltration and runoff)
- Compaction layer
- Functional/structural groups
- Plant mortality or decadence
- Litter amount
- Annual production
- Invasive plants
- Reproductive capability of perennial plants
- Soil surface particle size (FS-SR-01)
- Litter and basal plant cover (FS-SR-01)

As Needed Monitoring

- Visual inspections of recently reclaimed areas after a significant rainfall event (0.5 inch or greater precipitation within 24-hour period):

- Inspect for signs of accelerated erosion (record)
- Inspect areas in need of stabilization (record and develop/implement an action plan to stabilize)

- Inspect stormwater channels for sediment build-up. Remove sediment as needed to maintain flow capacity. Record channel segments maintained and approximate amount of sediment removed, including disposition of sediments (see *Site Water Management Plan* [MPO Volume IV-w]). Erosion control would be implemented in accordance with the stormwater permit and *Stormwater Pollution Prevention Plan* (SWPPP; MPO Volume IV-q).

- Measurements across the RMAs to detect the presence of rills and gullies and to quantify soil movement.

- Monitoring of soil (growth media) properties, including nutrients, salinity, organic matter, biotic community, or other properties may be analyzed to determine if amendments are necessary.

- Record site characteristics of reference areas, test plots, and RMAs. Characteristics include slope aspect, slope gradient, elevation, soil type, soil chemistry, soil texture, and soil depth. This should be a one-time measurement, as it will not change over time. If maintenance to RMAs changes any of these properties, site characteristics will be updated as needed.

Mitigation Measure FS-SR-02

Revegetation monitoring will begin with initial seeding or planting during the Active Mining Phase and would continue until the Forest Service determines that final reclamation objectives for revegetation and site stability have been met during the Closure Phase or Post-Closure Period (USFS, 2013: FS-SR-02). Revegetation would be protected by detection and treatment of invasive weed species (as detailed in the *Invasive Species Management Plan* (MPO Volume II-o).

Species that are important to Native American cultural uses would be considered for inclusion in the revegetation efforts (Mitigation Measure FS-CR-09; USFS, 2013). Woody vegetation cover would be established for jaguar habitat. Species would be self-sustainable, provide soil stability, and provide wildlife habitat.

Location

Native grasses, forbs, shrubs, and trees would be established on areas disturbed by the Project, except for the pit area.

Bi-annual Monitoring

Disturbed and revegetated areas would be surveyed for invasive species twice a year following winter and summer rains. These locations would be mapped and actions taken to prevent, eliminate, or control invasive plants should they occur, as detailed in the *Invasive Species Management Plan* (MPO Volume II-o).

Annual Monitoring

Revegetation efforts would be monitored annually. Revegetation and soil stability will also be spot checked on Coronado lands throughout the year by the Forest Service. Revegetation will begin when seeding is initiated until post-closure when the Forest Service determines that reclamation has been successful and final objectives have been met (Mitigation Measures FS-SR-01, FS-SR-02; USFS, 2013). Revegetation effort monitoring includes:

- Approximate areas revegetated,

- Acreage of initial seeding,
- Seed/Plant mixture, (noting culturally important species),
- Seeding/Planting application rate,
- Transplanting rates and success, and
- Agave transplanting, propagation, and planting monitoring and reporting are detailed in the *Agave Management Plan* (MPO Volume II-b).

Additional attributes that influence seeding and vegetation success, including precipitation, temperature, and other environmental measures will be collected over the year.

<u>Biennial to Triennial Monitoring</u>

Vegetation and soil stability measurements would be collected at the peak of the warm growing season, typically in September to October. Monitoring will begin when seeding is initiated or when (agave or woody vegetation) species are planted until post-closure when the Forest Service determines that reclamation has been successful and final objectives have been met (Mitigation Measures FS-SR-01, FS-SR-02; USFS, 2013).

- Vegetation measurements include:
- Species occurrence,
- Species richness,
- Canopy cover,
- Basal cover,
- Density/frequency,
- Plant community structure (grasses, forbs, shrubs, trees),
- Woody vegetation cover in macroplots [every 5 years in reference areas] (Mitigation Measure FS-SR-02), and
- Soil stability measurements, as detailed in FS-SR-01.

Photographs will be captured in selected locations (i.e. at the end of a transect) to document and track revegetation efforts and trends over time.

<u>As Needed Monitoring</u>

As detailed in FS-SR-01, site characteristics (slope aspect, elevation, topographic location) should be a one-time measurement, as it will not change over time. If maintenance to the Reclamation Management Areas (RMAs) changes any of these properties, site characteristics will be updated as needed.

<u>Mitigation Measure FS-CR-09</u>

This Mitigation Measure involves using culturally important species in revegetation efforts. Some plants will be salvaged and transplanted to private property where Tribes will be allowed to collect plants used for medicinal, ceremonial, and craft purposes. Consulting tribes will be provided access to collect plants for removal to their reservations (see *Cultural Resources Management Plan* [MPO Volume II-i]).

Mitigation Measure FS-VR-02

Monitoring of revegetated areas quarterly during final reclamation and closure would include density, vegetation type, and locations. Revegetation would occur following the removal of facilities that are not needed for future management of the land. The facilities to be removed from Forest Service lands include buildings, the plant site, some roads, the perimeter and security fence, and the utility corridor. These areas would be revegetated with native grasses, trees, and/or shrubs (see *Visual Resources Monitoring Plan* [MPO Volume II-cc]).

Monitor disturbed and revegetated areas for noxious and invasive weeds quarterly during Final Reclamation and Closure (FS-VR-02); map such locations and take action to prevent, eliminate, or control weeds should they occur (as detailed in the *Invasive Species Management Plan* [MPO Volume II-o]).

8.2 REPORTING

The following reporting will be conducted as part of growth media salvage and site revegetation:

Mitigation Measure FS-SR-01

Quarterly Reporting

- Report results from weekly visual inspections of soil (growth media) salvage and storage activities

- GIS information on the approximate areas where growth media was placed

- Soil texture, surface particle size, and chemistry of the growth media in the areas where growth media was placed

Annual Reporting

- Vegetation and soil stability monitoring results from the RMAs, reference areas, and test plots. Determine if revegetation objectives have been met and determine if success criteria has been met.

- Propose adaptive management adjustments to be assessed by the Monitoring Group to ensure compliance with the current NEPA. These adjustments must be supported by monitoring data results and documented in the annual report.

As Needed Reporting

- Determination of success (FS-SR-01 and FS-SR-02). If monitoring results show that success has been met, success criteria would be expressed as a percent similarity of revegetated areas as compared with reference areas. Revegetation success criteria would be based on quantitative monitoring results and statistical analyses/comparisons of results from reference areas, test plots, and previously revegetated RMAs. Soil stability success measures would be based on qualitative measurements. Mitigation measure FS-SR-02 states that percent similarity would also be established based on ESDs.

- As stated in Section 7.4, success criteria for vegetation will be: total perennial plant cover that is at least 70% that of the reference area; total perennial plant density that is at least 70% that of the reference area; and woody plant density that is at least 70% that of the reference area (USFS 2013b: FS-SR-01).

Mitigation Measure FS-SR-02

Annual Reporting

- Revegetation efforts, including maps of approximate areas revegetated and acreage of initial seeding, seed/plant mixtures, seeding/planting application rate, propagation, and transplanting will be reported on an annual basis.

- Revegetated RMA results would be compared with reference area results to determine whether objectives are being met. Aspect, elevation, and topographic location would be considered when quantifying comparisons between reference areas and RMAs (USFS, 2013: FS-SR-02).

- GIS data for treatment areas of invasive species, description of species treated, and the type and amount of herbicides used would be reported to the Forest Service annually as described in the *Invasive Species Management Plan* (MPO Volume II-o).

Reporting to the Forest Service on revegetation would occur annually during the Active Mining Phase and continue through the Closure Phase or into Post-Closure Period. The report will include a summary of measurements collected from the reference areas, test plots, and revegetated RMAs. Adaptive management strategies will be proposed when determined necessary. Revegetation success criteria would be based on a percent similarity of reference areas, test plots, and ongoing site monitoring of previously reclaimed areas (Mitigation Measure FS-SR-01).

Mitigation Measure FS-CR-09

Culturally important species that have been successfully transplanted onto private property will be reported annually. Use of culturally important species in seed mixtures used for revegetation will also be reported annually.

Mitigation Measure FS-VR-02

Reporting to the Forest Service on revegetation would occur quarterly during the Closure Phase and will include the following information:

- vegetation type (functional group),

- density, and locations.

9.0 CLOSURE AND BOND RELEASE

This section addresses closure activities associated with this Plan as well as the approach for funding of those activities and bond release of those funds. If bonding is set for one year or less (i.e., simply completing test work or finalizing reporting) no bond release is proposed. For longer periods, the bonding terms and application for bond release, as well as the mechanism for that release, are included.

9.1 INTERIM CLOSURE

Interim closure activities associated with this Plan include the maintenance of previously revegetated areas. The costs for this work are included in the *Reclamation and Closure Plan* (MPO Volume III-a).

9.2 FINAL CLOSURE

Closure activities associated with revegetation will occur in the Closure Phase and 5-years into the Post-Closure Period and include monitoring and revegetation of reclamation areas. The costs for this work are included in the *Reclamation and Closure Plan* (MPO Volume III-a).

9.3 BOND RELEASE

Bond release for revegetation related activities will occur 5-years into the Post-Closure Period.

10.0 ADAPTIVE MANAGEMENT PROCESS

Rosemont will incorporate the adaptive management process into Mitigation Measures FS-SR-01 and FS-SR-02. This process will ensure that the intent of this Plan is being met and that pertinent data is being collected and analyzed correctly, as well as ensuring effective implementation of growth media salvage and revegetation practices in the field. The three key components of adaptive management are:

- Testing assumptions – collecting and using monitoring data to determine if current assumptions are valid;

- Adaptation – making changes to assumptions and monitoring program to respond to new or different information obtained through the monitoring data and project experience; and

- Learning – documenting the planning and implementation processes and its successes and failures for internal learning.

Specific to this Plan, growth media salvage and site revegetation would be conducted following an adaptive management process outlined by the USFS (2004) and would ensure compliance with the FEIS (USFS, 2013), the ROD (USFS, 2017), and the amended Biological Opinion (USFWS, 2016). Adaptive management can be used to modify specifications and protocols as necessary to meet the defined objectives. This process is based on standard guidance that was developed for the U.S. Department of the Interior (DOI) (Williams et al., 2009). Key elements include 1) assessing the objectives and issues, 2) design and develop plans, 3) implement plans according to specifications, 4) monitor according to protocols, 5) evaluate the monitoring data, and 6) adjust the plans according to monitoring results.

Adaptive management adjustments to be assessed by the Monitoring Group will ensure compliance with the NEPA. Key elements of adaptive management for land reclamation are the identification of, the comparison of data from revegetated areas to those outcomes, and the adjustment of specifications or procedures (i.e., data feedback) when the desired outcomes are not being met. Monitoring of vegetation, growth media, soil stability, and site characteristics on reference areas, test plots, and previously revegetated areas (RMAs) would provide quantifiable results to the Monitoring Group. This data feedback loop would be used, as needed, to adjust techniques, success criteria, and objectives and to determine whether changes were needed in growth media texture, site preparation, soil amendments, soil mycorrhizal inoculation, species to be used in the seed mixture/planting, or other characteristics (USFS, 2013: FS-SR-01, FS-SR-02).

Revegetated area (RMA) results would be statistically compared with reference area results to determine whether objectives are being met. Revegetation success criteria would be based on a percent similarity of reference areas, test plots, and ongoing site monitoring of previously reclaimed areas (RMAs) (USFS, 2013: FS-SR-01).

Elements that may be modified as part of the adaptive management process for this Plan include, but are not limited to, the following:

- Revegetation specifications;

- Monitoring schedules;

- Growth media stockpiling;

- RMA selection criteria;

- Reclamation procedures/methods/protocols;

- Performance standards and success criteria; and
- Reporting.

11.0 DATA MANAGEMENT

Rosemont currently maintains data in various formats including logbooks, electronic logbooks, spreadsheets, hardcopy and database formats. It is Rosemont's intent that ultimately a robust database will be used to house all data collected for the various monitoring programs. Numeric data ultimately will be stored in a database and spatial data will be maintained in an ESRI database.

Depending upon the type of data to be reported, Rosemont will develop custom reports displaying required information in table or figure format. Electronic submittals will be provided in pdf format to provide a permanent record of the submittal and "raw" data will be maintained on-site for review by the Forest Service. If the Forest Service requests numeric data, it may include information such as cumulative results documenting the monitoring history and include baseline data for the resource.

Electronic submittals will be made within the reporting period specified. Reports will be submitted in hard copy form with a duplicate electronic pdf. Delivery of the electronic files will depend upon the size of the file and will either be made via email, via a CD/DVD or thumb drive, or via a website set up and maintained for delivery of files to the Forest Service. Details regarding access will need to be worked out so transmittals can take place seamlessly.

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TABLES

Table 1 – Soil Types (NRCS)

NRCS Code	NRCS Soil Name	Acres
BhD	Bernadino-Hathaway association, rolling	710.5
FrF	Faraway-rock outcrop complex, 30-60% slopes	59.2
McF	Mabray-Chiricahua rock outcrop association, steep	550.1
CtB	Comoro soils, 0-5% slopes	11.3
WgE	White House gravelly loam, 10-35% slopes	195.5
Rn	Rock outcrop Lithic Haplustolls association	35.7
CmE	Casto very gravelly sandy loam, 10-45% slopes	94.2
CoE	Chiricahua cobbly sandy loam, 10-45% slopes	182.4
TrF	Tortuga-Rock outcrop complex, 25-60% slopes	103.8
LgF	Lampshire-Graham rock outcrop association, steep	38.6
HaF	Hathaway gravelly sandy loam, 20-50% slopes	778.8
HhE2	Hathaway soils, 1-40% slopes, eroded	185.0

Table 2 – Rosemont Seed Mixture

Common Name	Scientific Name	Season	Functional Group
Arizona cottontop	*Digitaria californica*	Warm	Perennial Grass
Blue grama	*Bouteloua gracilis*	Warm	Perennial Grass
Curly mesquite	*Hilaria belangeri*	Warm	Perennial Grass
Green sprangletop	*Leptochloa dubia*	Warm	Perennial Grass
Plains Lovegrass	*Eragrostis intermedia*	Warm	Perennial Grass
Sideoats grama	*Bouteloua curtipendula*	Warm	Perennial Grass
Bottlebrush squirreltail	*Elymus elymoides*	Cool	Perennial Grass
Mexican gold poppy	*Eschscholzia californica ssp. Mexicana*	Cool	Annual Forb
Desert Marigold	*Baileya multiradiata*	Warm	Perennial Forb
Fairy Duster	*Calliandra eriophylla*	Warm	Shrub

Table 3 - Seed Mixture Enhancement Species

Potential Species	Scientific Name	Functional Group
Cane Beardgrass	*Bothriochloa barbinodis*	Perennial Grass
Hairy Grama	*Bouteloua hirsuta*	Perennial Grass
Sprucetop Grama	*Bouteloua chondrosioides*	Perennial Grass
Slender Grama	*Bouteloua repens*	Perennial Grass
Tanglehead	*Heteropogon contortus*	Perennial Grass
Wolftail	*Lycurus pheloides*	Perennial Grass
Sand dropseed	*Sporobolus cryptandrus*	Perennial Grass
Dalea	*Dalea* sp.	Shrub
Buckwheat	*Eriogonum* sp.	Shrub
Range ratany	*Krameria* sp.	Shrub
Winterfat	*Krascheninnikovia* sp.	Shrub
Menodora	*Menodora* sp.	Shrub
Mariola	*Parthenium incanum*	Shrub
Zinnia	*Zinnia* sp.	Shrub
Lippia	*Lippia* sp.	Shrub
Desert Senna	*Senna covesii*	Shrub

Table 4 – Recommended Reclamation Success Criteria

Attribute	Method	Reference	Success Metric
Site Stability / Soil Erosion			
Soil/site stability component of the Rangeland Health Assessment guidance.	Visual Indicator Assessment	Pellant, M., P. Shaver, D.A. Pyke, and J.E. Herrick. 2005. Interpreting Indicators of Rangeland Health, version 4. Technical Reference 1734-6. U.S. Department of the Interior, Bureau of Land Management, National Science and Technology Center, Denver, CO. BLM/WO/ST-00/001+1734/REV05.	Rating for the soil/site stability component must be in the same class or a higher class compared to the reference area* information.
Vegetation			
Species foliar cover Plant type composition Species richness Bare ground	Line-point intercept	Herrick et al. 2005. Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems. USDA – ARS Jornada Experimental Range, Las Cruces, NM. Coulloudon et al. 1999. Sampling Vegetation Attributes. BLM Technical Reference BLM/RS/ST-96/002+1730.	Total perennial plant cover $\geq$70% that of the reference site with a 90% level of confidence
Perennial plant density Species and plant type frequency	Quadrat (40x40 cm) Or Macroplots (100 x 100 ft)	Elzinga et al. 2001. Measuring and Monitoring Plant Populations. BLM Technical Reference 1730-1. BLM/RS/ST-98/005+1730-1. Coulloudon et al. 1999. Sampling Vegetation Attributes. BLM Technical Reference BLM/RS/ST-96/002+1730.	Total Perennial plant density $\geq$70% that of the reference area. Total woody plant density $\geq$70% that of the reference area.
Presence/Absence of Special, Invasive and Weedy Species	Visual survey (in addition to line-point and quadrat data)	Herrick et al. 2005.	Information used for plant species tracking and management. Weedy species actively managed per state regulations

*Reference areas to be identified for the various slope aspect- and gradient-defined plant associations

Table 5 – Tree and Shrub Establishment Approach

Slope Aspect	Technique
East-Facing Slope (Semi-desert Grasslands)	-Rosemont seed mixture* -Scattered tree/shrub plantings or islands -Agave plantings
North-Facing Slope (Dispersed Woodlands)	-Rosemont seed mixture* -Tree/shrub islands -Agave plantings -Drill or broadcast seeding of selected species in Table 7 prior to, or with broadcasting Rosemont seed mixture in selected areas
South-Facing Slope (Semi-desert Grasslands with additional succulents)	-Rosemont seed mixture* -Addition of culturally significant species in Table 7 will be seeded/planted in clumped distributions - Increased amounts of agave plantings
West-Facing Slope (Semi-desert Grasslands)	-Rosemont seed mixture* -Agave plantings
Slopes with Increased Rock Cover	-Rosemont seed mixture* -Broadcast tree/shrub seeds
Level Ground / Gently Rolling Slopes (Savanna)	-Rosemont seed mixture* -Tree/shrub islands -Drill or broadcast seeding of selected species in Table 7 prior to, or with broadcasting Rosemont seed mixture

*See Table 2

Table 6 - Anticipated Vegetation Condition Following Planting of the Reclaimed Rosemont Landform

Ecological Site	Year 5	Year 10	Year 15	Landform Closure Concept
Semi Desert Grasslands on East-facing Slopes	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-5% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-5% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-15% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-15% cover
Semi Desert Grasslands on North-facing Slopes (Dispersed Woodland)	5-10 species of grasses, 10-30% cover 3-7 species of shrubs, 3-10% cover 1-2 species of trees, 0-3% cover	5-10 species of grasses, 10-30% cover 3-7 species of shrubs, 3-10% cover 1-2 species of trees, 1-5% cover;	5-10 species of grasses, 15-45% cover 3-10 species of shrubs, 5-10% cover 1-2 species of trees, 1-5% cover	5-10 species of grasses, 15-45% cover 3-10 species of shrubs, 5-15% cover 1-2 species of trees, 2-5% cover
Semi Desert Grassland on South facing-Slopes (Grassland with additional Succulents)	5-10 species of grasses, 5-15% cover 1-3 species of shrubs, 1-5% cover 1-3 species of succulents, 1-3% cover	5-10 species of grasses, 10-20% cover 1-3 species of shrubs, 1-5% cover 1-3 species of succulents, 1-5% cover	5-10 species of grasses, 10-20% cover 1-3 species of shrubs, 1-5% cover 1-3 species of succulents, 1-5% cover	5-10 species of grasses, 10-30% cover 1-3 species of shrubs, 1-5% cover 1-3 species of succulents, 1-5% cover
Semi Desert Grasslands on West-facing Slopes	5-10 species of grasses, 10-20% cover 3-5 species of shrubs, 1-5% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-5% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-15% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-15% cover
Semi Desert Grassland with increased Rock Cover (Steep, Rocky slopes)	3-7 species of grasses, 5-20% cover 1-3 species of shrubs, 0-5% cover	3-7 species of grasses, 10-20% cover 1-3 species of shrubs, 1-5% cover	3-7 species of grasses, 10-20% cover 1-3 species of shrubs, 3-5% cover	3-7 species of grasses, 10-20% cover 1-3 species of shrubs, 3-5% cover
Semi Desert Grasslands on Level Ground (Savanna)	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-5% cover 1-2 species of trees, 0-3% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-10% cover 1-2 species of trees, 0-3% cover	5-10 species of grasses, 15-40% cover 3-5 species of shrubs, 1-10% cover 1-2 species of trees, 1-3% cover	5-10 species of grasses, 15-40% cover 3-5 species of shrubs, 1-10% cover 1-2 species of trees, 1-3% cover
***Agaves do not offer significant cover and cover values do not change greatly over time; however, the density would likely increase.**				

Table 7 - Additional Tree and Shrub Species List

Potential Species	Scientific Name	Functional Group
<u>Woody Species</u>		
Emory Oak	*Quercus emoryi*	Tree
Arizona White Oak	*Quercus arizonica*	Tree
Mexican Blue Oak	*Quercus oblongifolia*	Tree
Alligator Juniper	*Juniperus deppeana*	Tree
Evergreen Sumac	*Rhus coriophylla*	Shrub
Skunkbush Sumac	*Rhus trilobata*	Shrub
Mountain Mahogany	*Cercocarpus breviflorus*	Shrub
Four-wing Saltbush	*Atriplex canescens*	Shrub
Wright's Silktassel	*Garrya wrightii*	Shrub
Desert Hackberry	*Celtis pallida*	Shrub or Tree
<u>Culturally Significant Shrub Species</u>		
Sacahuista (Beargrass)	*Nolina microcarpa*	Shrub
Sotol	*Dasylirion wheeleri*	Shrub
Palmer’s Agave	*Agave palmeri*	Shrub (Succulent)
Ocotillo	*Fouquieria splendens*	Shrub
Soaptree Yucca	*Yucca elata*	Shrub
Schott’s Yucca	*Yucca schottii*	Shrub

Table 8 - Plants of Traditional Importance within the Rosemont Project Area

Plant	Apache[1]	Tohono O'odham[2]	Establishment
Trees/Shrubs			
Velvet mesquite (*Prosopis velutina*)	X	X	Volunteer Species
One seed juniper (*Juniperus monosperma*)	X		Volunteer Species
Alligator juniper (*Juniperus deppeana*)	X		Additional Tree and Shrub Species List
Emory oak (*Quercus emoryi*)	X		Additional Tree and Shrub Species List
Coral bean (*Erythrina flabelliformis*)	X		
Fairy duster (*Calliandra eriophylla*)			Rosemont Seed Mixture
Saltbush (*Atriplex* sp.)		X	Volunteer Species
Hackberry (*Celtis pallida, C. reticulata*)		X	Additional Tree and Shrub Species List
Acacia (*Acacia greggii, Acacia constricta*)		X	Volunteer Species
Succulents and Cacti			
Palmer agave (*Agave palmeri*)	X		Salvage, Grow, Plant, Possible Seeding
Beargrass (*Nolina microcarpa*)	X	X	Additional Tree and Shrub Species List
Sotol (*Dasylirion wheeleri*)	X		Additional Tree and Shrub Species List
Prickly pear (*Opuntia* sp.)	X	X	Volunteer Species
Cholla (*Cylindropuntia* sp.)		X	Volunteer Species
Forbs			
Desert marigold (*Baileya multiradiata*)		X	Rosemont Seed Mixture
Penstemon (*Penstemon* sp.)		X	Volunteer Species
Globemallow (Sphaeralcea ambigua)		X	Volunteer Species
Mexican gold poppy (*Eschscholzia californica* ssp. *Mexicana*)		X	Rosemont Seed Mixture
Prickly poppy (*Argemone* sp.)			Volunteer Species
Lupine (*Lupinus* sp.)		X	Volunteer Species
Grasses			
Blue grama (*Bouteloua gracilis*)	X		Rosemont Seed Mixture
Sideoats grama (*Bouteloua curtipendula*)	X		Rosemont Seed Mixture
Arizona cottontop (*Digitaria californica*)			Rosemont Seed Mixture
Curly mesquite (*Hilaria belangeri*)			Rosemont Seed Mixture
Green sprangletop (*Leptochloa dubia*)			Rosemont Seed Mixture
Plains lovegrass (*Eragrostis intermedia*)			Rosemont Seed Mixture
Bottlebrush squirreltail (*Elymus elymoides*)			Rosemont Seed Mixture

[1]Information supplied by the Mescalero Apache Tribal Historic Preservation Office
[2]Information from Sonoran plant list compiled by Tohono O'odham for ASARCO mine reclamation; supplemented by comments by O'odham representatives during onsite tours
Note: Volunteer species are expected to establish from the seed bank or other seed sources, but will not be actively seeded or planted.

Table 9 – Reclamation Management Areas (RMAs) (example)

Slope Aspect	Soil Type	Year 1 Reclamation (acres)	RMAs Year 1	Year 3 Reclamation (acres)	RMAs Year 3	Year 5 Reclamation (acres)	RMAs Year 5	Year 10 Reclamation (acres)	RMAs Year 10	Year 15 Reclamation (acres)	RMAs Year 15	Reclamation at Closure (acres)	RMAs during Closure
North	Gila Conglomerate	50	Up to 1	30	Up to 1	70	Up to 1	30	Up to 1	30	Up to 1	150	Up to 2
	Arkose		Up to 1		Up to 1		Up to 1		Up to 1		Up to 1		Up to 2
	Other		Up to 1		Up to 1		Up to 1		Up to 1		Up to 1		Up to 2
East	Gila Conglomerate	60	Up to 1	50	Up to 1	90	Up to 1	40	Up to 1	40	Up to 1	140	Up to 2
	Arkose		Up to 1		Up to 1		Up to 1		Up to 1		Up to 1		Up to 2
	Other		Up to 1		Up to 1		Up to 1		Up to 1		Up to 1		Up to 2
South	Gila Conglomerate	-	-	120	Up to 2	1	Up to 1	90	Up to 1	80	Up to 1	490	Up to 5
	Arkose		-		Up to 2		Up to 1		Up to 1		Up to 1		Up to 5
	Other		-		Up to 2		Up to 1		Up to 1		Up to 1		Up to 5
West	Gila Conglomerate	-	-	1	Up to 1	10	Up to 1	10	Up to 1	20	Up to 1	140	Up to 2
	Arkose		-		Up to 1		Up to 1		Up to 1		Up to 1		Up to 2
	Other		-		Up to 1		Up to 1		Up to 1		Up to 1		Up to 2
Flat	Gila Conglomerate	-	-	-	-	-	-	-	-	-	-	710	Up to 8
	Arkose		-		-		-		-		-		Up to 8
	Other		-		-		-		-		-		Up to 8
Rocky, Steep	Gila Conglomerate	-	-	-	-	-	-	-	-	-	-	120	Up to 2
	Arkose		-		-		-		-		-		Up to 2
	Other		-		-		-		-		-		Up to 2
Total Area Reclaimed (acres)*		**110**		**201**		**171**		**170**		**170**		**1750**	
Range of Total RMAs**			**2 - 6**		**5 - 15**		**4 - 12**		**4 - 12**		**4 - 12**		**21 - 63*****

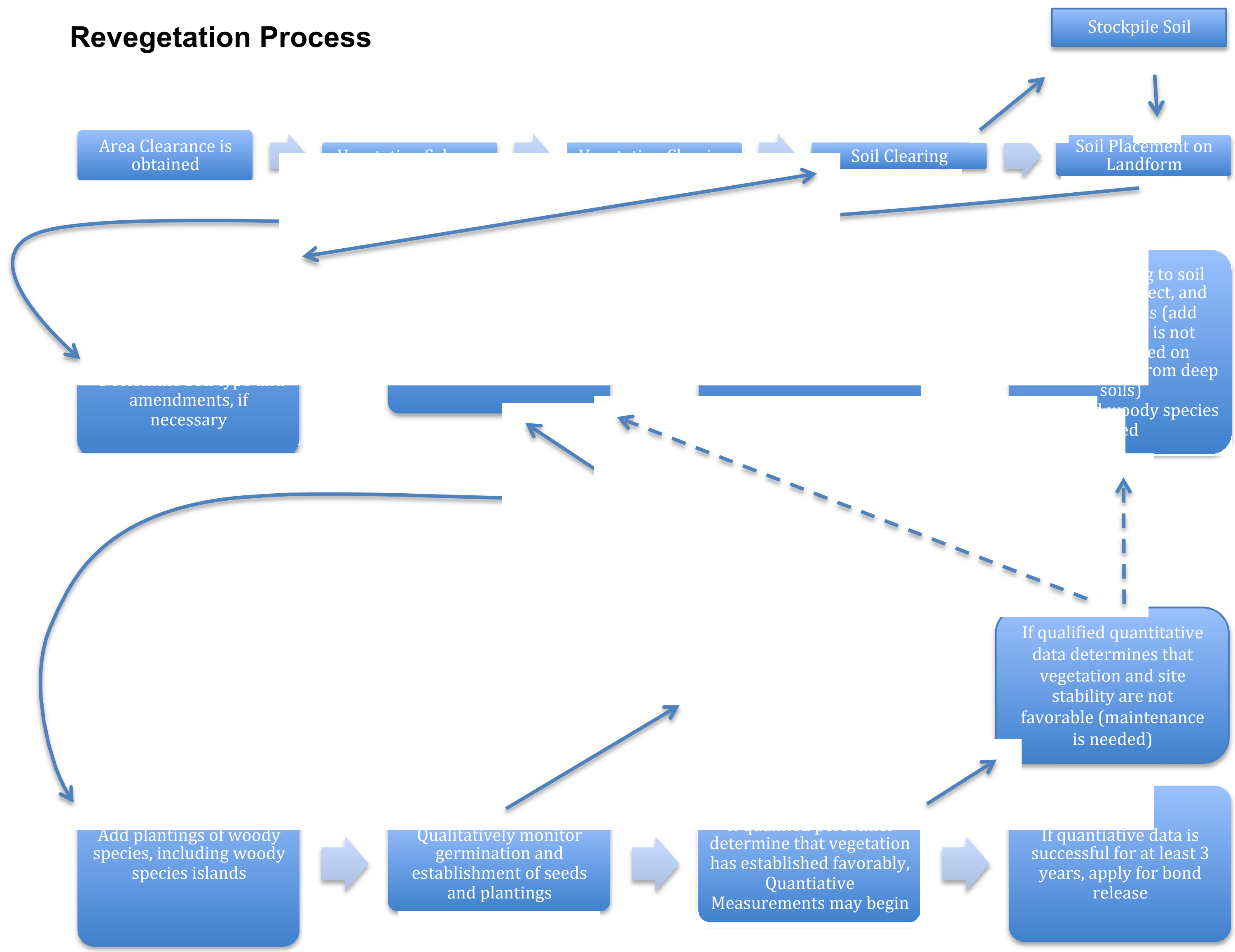
*Areas are approximate.

**A Reclamation Management Area (RMA) is based on the slope aspect, soil type, and year seeded. It can be a maximum of 100 acres. Since soil type is not yet determined, a range of 1-3 soil types may be selected.

***RMAs may be grouped if they have the same site characteristics (slope aspect and soil type) and similar vegetation characteristics.

ILLUSTRATION

Illustration 1 - Revegetation Process.



APPENDIX A

Revegetation Performance Measures
(memorandum by CDM Smith dated July 23, 2013)

Memorandum

To: *Kathy Arnold, Vice President, Rosemont Copper Company*

From: *Bob Rennick, CDM Smith*
Brian Antonioli, CDM Smith

Date: *July 23, 2013*

Subject: *Revegetation Performance Measures*

After reviewing the Preliminary Reclamation and Closure Plan (July 2012), the U.S. Forest Service (Forest) requested clarification regarding the revegetation approach, evaluation protocol, and performance measures to be used at the Rosemont Copper Project (Project).

This memorandum addresses current and future vegetation issues for the Rosemont Copper Project (Project). Regulatory requirements and designated post-mining land uses are driving factors for revegetation efforts. Salvaging and replacing suitable soils will assist in establishing vegetation on the reclaimed Rosemont Landform (Landform) that is created from the Waste Rock and Dry Stack Tailings Facility. Ecological sites were defined using soil surveys to define reference areas. Reference areas will be used to determine when revegetated areas have been successfully reclaimed. Success criteria are also addressed.

1.0 Regulatory Requirements

The state of Arizona and federal agencies that manage public land in Arizona provide broad overarching reclamation guidance for land disturbed by mining. Land management agencies use various guidance documents to develop specific reclamation standards, including methodologies used to assess reclaimed areas and to determine compliance.

The Arizona Mined Land Reclamation Act (Act), which is administered by the Arizona State Mine Inspector, requires that 1) mined land be reclaimed to a safe and stable condition for the specified post-mining land uses and that 2) the operator reestablish the type, density, and diversity of vegetation that is appropriate and technically and economically practicable given site-specific characteristics. Plant species chosen must support the post-reclamation land use. Under Arizona Statutes, reclaimed areas must be compatible with fish and wildlife habitat on adjacent lands. With respect to post-mining revegetation requirements, the reclamation plan must describe the revegetation to be used as well as the techniques, methods, controls, or measures to be used.

Some of the property at the Rosemont Project site is managed by the Forest. Chapter 2841 of Forest Service Manual (FSM) 2800 identifies administrative and environmental components for reclamation Plans of Operations that include:

- Topsoil management, soil salvaging, and reapplication;
- Revegetation of disturbed areas, including timing, kind, and amount;
- Watershed management, including runoff and erosion control, and riparian and wetland protection; and
- Fish and wildlife habitat reclamation or mitigation.

FSM 2841 also specifies that a Plan of Operations include measurable revegetation performance standards. The success standards to be used at the Project address both the Arizona and Forest requirements and are described later in this memorandum.

Chapter 2070.11 of the FSM identifies laws that govern the management and use of non-native plant materials of National Forest System lands under Forest administration. The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, as amended by the National Forest Management Act (NFMA) of 1976, section 6 codified at 16 U.S.C. §§ 1600 (g) provides that the Secretary shall "promulgate regulations . . . (3) specifying guidelines for land management plans ... which ... (B) provides for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives, and within the multiple-use objectives of a land management plan ... provide, where appropriate, to the degree practicable, steps to be taken to preserve the diversity of tree species similar to that existing in the region controlled by the plan".

In terms of viewshed, Forest Service Manual 2380.15 (FSM 2300 Recreation, Wilderness, and Related Resource Management, Chapter 2380 Landscape Management) requires that mineral operations be harmonized with scenic values to the extent practicable. Additionally, Title 36 Code of Federal Regulations (Part 228, Subpart A, Locatable Minerals (36 CFR part 228, subpart A), includes requirements for harmonizing mineral operations with scenic values.

A key requirement stated in several regulatory statutes is that the reclamation and revegetation of mined lands return those lands to the designated post-mining land uses.

2.0 Post-Mining Land Uses

Post-mining reclamation objectives for the Project are consistent with the rural values embodied in the use concepts associated with western open space, such as dispersed recreation, wildlife habitat, and ranching. Current and probable post-mining recreational activities include horseback riding, hunting, prospecting, hiking, bird watching, ranching, and other non-motorized activities. The Project area is part of an existing ranching operation with approximately 30,000 acres of grazing leases. Much of the reclaimed landscape will be suitable for grazing once vegetation is established. The post-mining landscape will include a landform (Landform) created by development of the Waste Rock Storage Area and the Dry Stack Tailings Facility.

The establishment of wildlife habitat and use are expected to start early in the life of the Project since reclamation activities will be conducted concurrently with operations. By year 10 of operations, large portions of the Landform will have been reclaimed and revegetated.

Rosemont's reclamation and revegetation process includes consideration of the visual, or scenic aspects, of the Project. This is sometimes referred to as viewshed and can be a concern to the public. For the Project, this is especially important for the areas closest to State Highway 83. Although not a revegetation compliance criteria, scenic quality is a reclamation objective addressed through the shaping of the Landform, the use of diverse seed mixtures, and the anticipated volunteer plants within the topsoil, which will create a natural distribution of plant communities consisting of herbaceous and woody species. Revegetation of the Landform is designed to mimic natural vegetation patterns, which will allow the Landform to maintain scenic quality.

3.0 Soil Reclamation and Revegetation

3.1 Soil Survey Results

One of the Project goals has been to identify and then ultimately salvage and utilize soils during the reclamation and revegetation process. The intent is to minimize stockpiling of the soil resources (or growth media) to preserve its biological integrity. For this reason, material will be directly hauled from disturbed areas and placed as the final cover when feasible. It is recognized though, that the footprint of the Waste Rock Storage Area and Dry Stack Tailings Facility will expand faster than the Landform can be built and movement of soil during Project development activities will necessitate stockpiling. Rosemont is currently working with the University of Arizona (UofA) to determine methods that will best support revegetation efforts. Details on soil stockpiling management will be provided in a reclamation plan to be submitted with the final MPO.

In March 2007, a detailed soil resource evaluation was conducted at the Rosemont site and used in planning the harvesting of soil or growth media materials. This assessment was conducted to describe the soil profiles or pedons, document soil characteristics including any limiting characteristics, sample and analyze the physical and chemical properties of representative pedons, prepare a description of the mapping units and components, evaluate the soil suitability for reclamation, and propose suitable salvage depths (Tetra Tech 2007). Soil classification methods used by soil scientists were consistent with the Natural Resources Conservation Service (NRCS) soil surveys and detailed laboratory analyses were conducted. The 2007 Tetra Tech report was updated (Tetra Tech 2010) to reflect additional potential areas of impact (soil study area) based on the various alternatives analyzed in the Draft Environmental Impact Statement (DEIS). Tetra Tech's report indicated that sufficient soil type material was available for revegetation of each alternative.

Results from the Tetra Tech (2010) soil study are summarized below and show that there were six (6) soil pedon units and eight (8) borrow depths identified. A soil pedon includes all horizons or layers of the soil used for classification. Sites were divided according to slope aspect. The two (2) most common soil types in the Project area, as defined by their geologic parent materials, are Gila

Conglomerate and Arkose soils.

North aspect soils located in the southern portion of the soil survey area are formed from colluvium and slope wash-alluvium. The geologic parent material in this area is the Gila Conglomerate, which consists of quartz sandstone, carbonates, argillite, hornfels, granitic rock and quartz –feldspar. The average depth of suitable borrow soil is approximately twelve (12) inches. The soils available for salvage are sandy loams with 15 to 20% gravel, 0 to 5% cobbles and between 45 and 65% surface coarse fragments. Slopes range from 20 to 45 degrees. These soils generally have moderate vegetative cover including trees, shrubs, and grasses.

South aspect soils located in the southern portion of the soil survey area are formed from colluvium and slope wash-alluvium. The geology of this area is also the Gila Conglomerate. These soils have approximately six (6) inches of suitable soil for salvage with occasional deeper deposits in concave physiographic positions. The texture of these soils are sandy loam to coarse sandy loam with coarse fragment content on the surface ranges from 50 to 75% and coarse fragment content in the soil ranges 20 to 40% gravel and 0 to 5% cobbles. Slopes occurring in these areas range from 20 to 40 degrees. Vegetation cover is primarily forbs, cactus, and grasses on these slopes.

Alluvial washes are located in drainage bottoms throughout the soil survey area. These soils are deep with depths ranging from 24 to 45 inches and with textures of loamy sand to sandy loams. Coarse fragment content ranges from 15 to 45%, consisting primarily of small gravels. The active flood plain portions of the wash generally have insufficient fines within the profile to support vegetation. Vegetation cover varies widely depending on the orientation/position of the sampling location.

Alluvial terraces are fairly limited and located in the western portion of the soil survey area. These soils are derived from Late Pleistocene alluvial terrace material at the toe of the upper slopes of the Santa Rita Mountains. They are deep gravelly to very gravelly loams over weakly cemented very reactive, extremely gravelly alluvium. The salvageable borrow ranges from 12 to 18 inches with gravel and cobble generally being the restrictive feature. Vegetative production is good and is primarily comprised of grasses.

Map units located in the northwestern portion of the Project area are Arkosic soils are derived from very weathered residuum of the Willow Canyon Formation. These soils are moderately deep; however, borrow depths are generally limited to one (1) foot due to coarse fragment content and heavy clay soils. Surface coarse fragment content ranges from 30 to 50%. Near surface textures are generally clay loams, grading to clays with slopes varying greatly from 5 to 40% depending on the location. Vegetative cover varies from moderate to good.

A shallow bedrock unit is located in the center and northern portions of the soil survey area. The major geologic formations include: the Willow Canyon, an Arkosic to tuffaceous siltstone, sandstone, and conglomerate; the Apache Canyon, a shale and laminated siltstone; and the Mount

Fagan Rhyolite, an ash flow tuff. Soil depths range from very shallow (five (5) inches on slopes), to deep (24 inches in drainages). The soils in this area range from coarse sandy loams to clay loams. Coarse fragments within the soil are between 25 and 45% gravels and surface fragments range from 40 to 60% and higher. Some isolated pockets of borrow soil may be available on a site-specific basis in this area. The limiting factor for suitable borrow soil are the bedrock outcrops and the shallow depth to bedrock throughout the majority of this area. This material is the initial pedogenesis zone and was generally not considered during soil salvage determinations. However, since the current vegetation cover primarily includes forbs, cactus, and grasses, this indicates that the shallow bedrock unit is actively serving as a growth media.

The estimated soil salvage areas and volumes located within the footprint of the Dry Stack Tailings Facility, Waste Rock Storage Area, and operations areas (Plant Site) of the Rosemont Project are based on the suitable soil pedons identified above. The total estimated volume of salvage soil for the Barrel Alternative, for example, was approximately 2.8 million bank cubic yards. Additionally, underlying the salvageable soil throughout the site, and specifically underlying the above operational areas, is a substantial amount of unconsolidated and weathered bedrock. The volume of these materials was estimated using a minimum depth of four (4) feet. Based on Tetra Tech's analysis, the estimated volume of unconsolidated and weathered bedrock is over 17 million bank cubic yards.

The Natural Resource Conservation Service (NRCS) provides soil data and linked information through the Web Soil Survey produced by the National Cooperative Soil Survey. This data includes soil maps, soil classification and properties, ecological site assessments, and other technical information. NRCS soil maps (Figure 1 – figures are provided after the text) were produced for the Project site in order to obtain linked vegetation information contained in the ecological site descriptions (ESDs). Each soil type is identified to a plant community, though vegetation can be adapted to multiple soil types. There is a direct relationship between vegetation and soil types as discussed in the section below. Table 1 provides soil map unit codes, names, and the number of acres they encompass, using the Barrel Alternative as an example.

Table 1. Soils classified by NRCS.

Rosemont Soils

NRCS Code	NRCS Soil Name	Acres
BhD	Bernadino-Hathaway association, rolling	710.5
FrF	Faraway-rock outcrop complex, 30-60% slopes	59.2
McF	Mabray-Chiricahua-Rock outcrop association, steep	550.1
CtB	Comoro soils, 0-5% slopes	11.3
WgE	White House gravelly loam, 10-35% slopes	195.5
Rn	Rock outcrop-Lithic Haplustolls association	35.7
CmE	Casto very gravelly sandy loam, 10-45% slopes	94.2
CoE	Chiricahua cobbly sandy loam, 10-45% slopes	182.4
TrF	Tortuga-Rock outcrop complex, 25-60% slopes	103.8
LgF	Lampshire-Graham-Rock outcrop association, steep	38.6
HaF	Hathaway gravelly sandy loam, 20-50% slopes	778.8
HhE2	Hathaway soils, 1-40% slopes, eroded	185

3.2 Ecological Sites Adjacent to the Project

Several NRCS ecological sites are present at the Rosemont site. An ecological site is defined by the NRCS as "a distinctive kind of land with specific characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation". Ecological site descriptions (ESDs) include a narrative of site characteristics (physical features, climate, soil, and water features), plant communities, site interpretations, and other supporting information related to these ecological sites. Figure 2 (provided after the text) shows the extent of these mapped NRCS ecological sites at the Rosemont Project. Also shown for reference are the footprints of the Open Pit and the Barrel Alternative Landform. Based on soil survey reports, vegetation reconnaissance work, and the NRCS maps, the most common ecological sites found at the Rosemont site include:

- Limestone Hills 12-16 inches annual precipitation zone (p.z.)
- Limy Slopes 12-16 & 16-20 inches annual p.z.
- Granitic Hills 12-16 & 16-20 inch annual p.z.
- Clay Loam Upland 12-16 inches annual p.z.
- Loamy Slopes 12-16 & 16-20 inches annual p.z.
- Sandy Wash 12-16 inches annual p.z.

Annual precipitation at the Rosemont site is between 14- and 18-inches, which falls in between the designated NRCS precipitation zones. Although the various ecological sites within the Project area are distinguished by different rainfall amounts, there will be a very limited number of reclaimed acres that fall in the 16-20" precipitation zone. In the field, no clear vegetation patterns have been observed across the two precipitation zones. Additionally, the growth medium will be xeric when placed on the Landform. For these reasons, ecological site information for the 12-16" precipitation zones are considered appropriate to use for the Project. In consideration of this and based on Figure 2, the following three (3) ecological sites were selected to represent the majority of the planned disturbance area:

- Limy Slopes
- Granitic Hills
- Clay Loam Upland

Geologic maps of the area display two (2) dominant soil parent material: Arkose (or Willow Canyon Formation) and Gila Conglomerate. These two (2) units are generally grouped with the Granitic Hills and Limy Slopes ESDs, respectively. It is anticipated that the soils placed on the reclaimed surfaces of the Landform, and in other areas requiring reclamation, will generally match the soil types associated with one of these two (2) ecological sites.

The Clay Loam Upland ecological site occurs in the center of the Landform. This ecological site, like the Limy Slopes, is defined geologically as tertiary gravels and they appear to be a transition between the Arkose and the Gila Conglomerate. However, a review of the 2010 Tetra Tech soil sample data indicates that only a portion of the soil samples collected from the Clay Loam Upland area actually classify as clay loam. Most of the soils in this area classify as loam, silt loam, sandy loam, and sandy clay loam and are therefore more characteristic of soils described in the Granitic Hills and Limy Slopes ESDs. Since the NRCS soil surveys and ecological sites are intended for general, large-scale use, the soil characterizations performed by Tetra Tech are considered a more accurate representation of the Project site. It is noted that soils that are high in clay may be eliminated as salvageable soil, or may be used if they are currently supporting vegetation. Also, clay Loam Upland ecological sites share many vegetation characteristics with that of the Granitic Hills and Limy Slopes ecological sites.

A comparison of five (5) of the six (6) ecological sites listed above are provided in the crosswalk table in Attachment A. The Sandy Wash ESD was not chosen for vegetation characterization of the site since the Landform will not contain similar physical characteristics. Each ESD states that the plant communities "*are naturally variable. Composition and production will vary with yearly conditions, location, aspect, and the natural variability of the soils. The historical climax plant community represents the natural potential plant communities found on relict or relatively undisturbed sites."* The ESDs and the crosswalk table (Attachment A) also describe other plant communities that are known to occur when these sites are disturbed by factors such as fire, grazing, or drought. It is noted that the ecological site descriptions are general classifications of the Rosemont area.

Surface soils on these five (5) ecological sites generally range from loam to sandy loam to clay loam and have a significant component of coarse fragments. Descriptors such as gravelly, very gravelly, and cobbly accompany the texture classification. The cover of large (>3 inch) surface rock fragments ranges from a low of 5% to a high of 50% cover.

The ecological sites were used to develop the Rosemont seed mixture (see Section 3.5) and other species that will be used in revegetation. Warm season perennial grasses dominate each of the plant communities present on these ecological sites. Species common to these sites include sideoats grama and black grama. Short grasses and threeawns are common and strong components of bush muhly, cane beardgrass, and plains lovegrass often occur. Perennial forbs and shrubs are well represented on some sites (e.g., Limestone Hills), but play minor roles on other sites (Loamy Slopes). Palmer's agave and sacahuista are the prominent succulents on the Loamy Slopes, while a mixture of agave (Schott, Palmer), sotol, sacahuista, pricklypear, and Schott yucca are notable components of the Limestone Hills ecological site. Trees, when present, represent a minor component of these communities; canopy cover is generally less than 5%. Arizona white oak, Mexican blue oak, and Emory oak are species found sometimes on the Limy Slopes and Loamy Slopes ecological sites. On the Granitic Hills site, One seed juniper, rosewood, and velvet mesquite can be present.

Natural fire was an important factor in the historic development of plant communities at these ecological sites. In the absence of wildfire and/or with overgrazing, shrubs and trees generally increase and may come to dominate these sites. Once the canopy cover of shrubs and trees, particularly One seed juniper and velvet or honey mesquite, gets above approximately 25%, soil erosion increases and the sites become unstable (Fehmi, 2007). Well-developed gravel and cobble covers can protect the soil from erosion and protect forage species from heavy use. Fire frequencies for these sites naturally ranged from about 10 to 20 years and this frequency can help maintain a balance between grasses, forbs, and shrubs. With good management, which includes grazing or some burning, native perennial grasses can regain their dominance in plant communities historically subjected to continuous heavy grazing or fire suppression.

3.3 Anticipated Vegetation Types on the Reclaimed Landform

The NRCS ESDs are being used to help select reference areas that will be used to determine revegetation success on the Landform and other areas requiring reclamation (see description of reference area selection and use in Section 3.6). Based on the NRCS definition of an ecological site, revegetation areas were divided according to physical conditions (slope aspects) and anticipated plant communities. Ecological sites anticipated on the reclaimed Landform include:

- Semi-desert Grassland on Level Ground (Savanna)
- Semi-desert Grassland on North-facing Slopes (Dispersed Woodlands)
- Semi-desert Grassland on East-facing Slopes
- Semi-desert Grassland on West-facing Slopes
- Semi-desert Grassland on South-facing Slopes (Succulents Added)
- Semi-desert Grassland with Increased Rock Cover (Steep, Rocky Slopes)

Vegetation types describe "a plant community with distinguishable characteristics" (Chambers and Brown 1983). The terms 'savanna' and 'dispersed woodlands' are used here based on definitions provided by Dr. Steven Archer, professor of grasslands, savannas, and shrubland ecology at the University of Arizona who has worked on projects throughout the world.

By definition, savannas are composed primarily of grass and herbaceous cover with scattered shrubs or low trees. Woodlands have cover of small trees or shrubs (<5 meters) whose crowns do not mesh and have grass present between the canopy cover. Grasslands are primarily composed of grass and herbaceous cover, and may contain subshrubs; trees and shrubs may be absent or compose a minor component of the ecosystem. More detailed vegetation types with respect to ecological sites are described below.

Rosemont's revegetation efforts will target the same plant communities, display the same seasonal characteristics and vegetation patterns, and support the same land uses that exist under undisturbed conditions. Species chosen for revegetation represent a semi-desert grassland, are native and common to the Project area, and will support post-mining land uses of ranching, recreation, and wildlife habitat.

There is a strong slope effect in Southern Arizona that influences soil and vegetation type. This can be seen in the photograph in Figure 3 and in Figure 4 (provided after the text), which shows an aerial photograph of the Rosemont area. This photograph is located just south of FR 4064 and east of Barrel Canyon wash, within the Barrel Alternative footprint.

North-facing slopes receive less sunlight and experience less evaporation, thereby making more soil moisture available than other slope aspects. With more available soil moisture, shrubs and trees favor north-facing slopes (dark dots in Figure 4). In contrast, the south-facing slopes receive more sunlight and have less available soil moisture. Shallower soils with fewer nutrients contribute to additional cacti and succulents observed on south-facing slopes and grasslands occur on east- and west-facing slopes as well as drier convex slopes (open, or non-dotted, areas in Figure 4).

Revegetation plans will divide the areas requiring reclamation by primary slope aspect and slope gradient (especially on the Landform). Like undisturbed sites, the most soil moisture will be retained on the north-facing slopes and the least on south-facing slopes. The majority of the Landform will be sloped to a 3H:1V (18-degree angle), but the top of the Landform will consist of gently rolling hills graded for proper drainage. One would expect that higher soil moistures would be associated with flatter areas as compared to angled slopes, which would allow for more tree and shrub establishment. However, since slope aspect is expected to have a greater influence on soil moisture than slope gradient, north-facing slopes are still anticipated to have a higher potential for trees and shrubs than the top of the Landform. Elevation also influences plant communities. The Barrel Landform will primarily fall between 4,600 to 5,500-feet above mean sea level (amsl) with relatively small areas that are located between 5,500 to 5,700-feet amsl (overall a 1,100-foot total elevation difference). Areas with steeper slope gradients (i.e., limited areas on the west side of the Landform) and areas with longer slope runs (i.e., areas on the east side of the Landform), will require additional erosion control such as increased rock cover.

Similar to the ecological sites present in the Project area, the areas to be reclaimed will be comprised of semi-desert grasslands dominated by warm season perennial grasses. In the early years of reclamation immediately following seeding, areas will be dominated by grasses and other herbaceous species. Compositional variations between the reclaimed areas will therefore initially be small. Depending on slope aspect and gradient, the composition (relative amounts) of grasses, forbs, succulents, shrubs, and trees will vary as plant community succession occurs. Ultimately, slopes that are cooler and have more plant-available soil moisture will tend to have a greater component of woody vegetation. This is expected to be especially evident on the north-facing as compared to the south-facing aspects. Photographs from NRCS ESDs and Project area photographs (Attachment B) demonstrate what the revegetation areas are anticipated to look like after they have been well established and woody plants have grown to comparable sizes.

The following are descriptions of the plant communities that are anticipated to become established following revegetation of the Landform on the various aspects.

- Semi-Desert Grasslands on east-facing slopes
  - Vegetation will be composed primarily of warm season perennial grasses, some forbs, and small shrubs. Small shrubs or sub-shrubs may be present, but will not be clearly visible from a distance. Trees may be present, but will be very widely distributed and

make up a small amount of the plant community. Long slope runs may require additional rock cover for soil stabilization. The predominance by grasses will turn the slope green during the monsoon season and will be a light tan color the remainder of the year.

- Semi-Desert Grasslands on level ground (savanna)
  - Vegetation will be composed primarily of warm season perennial grasses, mixed forbs, an increased amount of small shrubs as compared to east- and west-facing slopes and widely dispersed trees. Shrubs and trees will be give a savanna-like appearance and will be visible from a distance once the plant community matures, which will take a number of years to grow large enough to be visible from a distance. The grasses will turn the slope green during the monsoon season and will be a light tan color the remainder of the year, eventually broken up by green shrub and tree canopies.

- Semi-Desert Grasslands on north-facing slopes (dispersed woodlands)
  - Vegetation will be composed of warm season perennial grasses and forbs, mixed with shrubs and dispersed trees. A higher density of shrubs and trees will establish on these slopes as compared to savannas, or level ground grasslands. It will take a number of years for shrubs and trees to grow large enough to be visible from a distance. The grasses will turn the slope green during the monsoon season and will be a light tan color the remainder of the year, but the slopes will appear green from shrub and tree canopies year-round. Some species of trees may be deciduous, losing their leaves during the winter.

- Semi-Desert Grasslands with increased rock cover (steep, rocky slopes)
  - Vegetation will be composed primarily of warm season perennial grasses, mixed forbs, and a minor component of small shrubs as compared to east- and west-facing slopes. Due to the steepness of these slopes, increased rock cover will be placed over the soil cap for erosion protection and increased stability. Species that favor rocky soils will be utilized. These areas are expected to be stable, even with relatively low amounts of vegetation cover and will primarily be on the western side of the Landform – not visible from State Highway 83.

- Semi-Desert Grasslands on south-facing slopes (succulents added)
  - Vegetation will be composed primarily of warm season perennial grasses, some forbs, and small shrubs. Small shrubs or sub-shrubs may be present, but not clearly visible from a distance. Trees may be present, but will be very widely distributed and will make up a small component of the plant community. Palmer agaves may be transplanted in clumps, to mimic how they appear on undisturbed sites. Other culturally significant plants, such as sotol (*Dasylirion wheeleri*) and sacahuista (*Nolina microcarpa*), may also be planted in clumped distributions on these portions of the Landform. The grasses will turn the slope green during the monsoon season and will be a light tan color the remainder of the year, broken up by clumps of agaves and other plantings and volunteer plants. The greater amount of surface rock and less grass cover in these areas (compared to other vegetation types) will be clearly visible.

- Semi-Desert Grasslands on west-facing slopes
  - Vegetation will be composed primarily of warm season perennial grasses, some forbs, and small shrubs. Small shrubs or sub-shrubs may be present, but not clearly visible from a distance. Trees may be present, but will be very widely distributed and will make up a minor component of the plant community. West-facing aspects will look similar to east-facing aspects, but may be composed of different species within the same functional groups. The predominance of grasses will turn the slope green during the monsoon season and will be a light tan color the remainder of the year.

Based on the plant canopy and basal cover percentages listed in the NRCS ESDs, Table 2 lists the anticipated percent cover for the key plant types on the reclaimed Rosemont Landform. The table estimates the range of cover for the post-seeding intervals of 5, 10, 15, and 20 years. Although vegetation data can be found in the ESDs, it is only intended for general use. Reference areas will be selected based on the selected ecological sites in undisturbed locations outside of the Project footprint. These locations will be used to collect soil and vegetation data (see Section 6.0 that discusses the reference and reclaimed area sampling protocol) to eventually assess revegetation success on reclaimed sites (see Section 6.3 and Table 9 on success criteria).

Table 2. Anticipated Vegetation Condition Following Planting of the Reclaimed Rosemont Landform

Ecological Site	Year 5	Year 10	Year 15	Year 20
Semi Desert Grasslands on east-facing slopes	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-5% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-5% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-15% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-15% cover
Semi Desert Grasslands on level ground (savanna)	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-5% cover 1-2 species of trees, 0-3% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-10% cover 1-2 species of trees, 0-3% cover	5-10 species of grasses, 15-40% cover 3-5 species of shrubs, 1-10% cover 1-2 species of trees, 1-3% cover	5-10 species of grasses, 15-40% cover 3-5 species of shrubs, 1-10% cover 1-2 species of trees, 1-3% cover
Semi Desert Grasslands on north-facing slopes (dispersed woodland)	5-10 species of grasses, 10-30% cover 3-7 species of shrubs, 3-10% cover 1-2 species of trees, 0-3% cover	5-10 species of grasses, 10-30% cover 3-7 species of shrubs, 3-10% cover 1-2 species of trees, 1-5% cover;	5-10 species of grasses, 15-45% cover 3-10 species of shrubs, 5-10% cover 1-2 species of trees, 1-5% cover	5-10 species of grasses, 15-45% cover 3-10 species of shrubs, 5-15% cover 1-2 species of trees, 2-5% cover
Semi Desert Grassland with increased rock cover (steep, rocky slopes)	3-7 species of grasses, 5-20% cover 1-3 species of shrubs, 0-5% cover	3-7 species of grasses, 10-20% cover 1-3 species of shrubs, 1-5% cover	3-7 species of grasses, 10-20% cover 1-3 species of shrubs, 3-5% cover	3-7 species of grasses, 10-20% cover 1-3 species of shrubs, 3-5% cover
Semi Desert Grassland on south facing-slopes (succulents added)	5-10 species of grasses, 5-15% cover 1-3 species of shrubs, 1-5% cover 1-3 species of succulents, 1-3% cover	5-10 species of grasses, 10-20% cover 1-3 species of shrubs, 1-5% cover 1-3 species of succulents, 1-5% cover	5-10 species of grasses, 10-20% cover 1-3 species of shrubs, 1-5% cover 1-3 species of succulents, 1-5% cover	5-10 species of grasses, 10-30% cover 1-3 species of shrubs, 1-5% cover 1-3 species of succulents, 1-5% cover
Semi Desert Grasslands on west-facing slopes	5-10 species of grasses, 10-20% cover 3-5 species of shrubs, 1-5% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-5% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-15% cover	5-10 species of grasses, 10-30% cover 3-5 species of shrubs, 1-15% cover

0= less than 1

*Agaves do not offer significant cover and cover values do not change greatly over time; however, the density would likely increase.

3.4 Sequence of Vegetation Establishment on the Landform

To mimic natural vegetation patterns, varying plant compositions will occur on different slope aspects. The Barrel Alternative Landform has been chosen to demonstrate revegetation patterns. These vegetation types are consistent with the vegetation types listed in Section 3.3. The vegetation staging sheets (VSS-1-6) show the vegetation types that will be present on the Landform at years 1, 3, 5, 10 and 22 during the life of the mine (Attachment C). The sheets provide a conceptual-level representation of vegetation types to be established on the different aspects on the sloped areas of the Landform as well as on the more level areas at the top of the Waste Rock Storage Area and Dry Stack Tailings Facility. Each sheet provides the estimated number of new acres reclaimed since the previous interval, plus the total number of acres reclaimed at that point in time. Area calculations are further divided for each vegetation type.

In selecting plant species for the multi-phase reclamation research project, the University of Arizona (UofA) reviewed the ESDs for the vegetation/habitat types anticipated to be present on the reclaimed Landform. In addition, Rosemont staff conducted vegetation surveys at several native sites in the Project area to confirm the presence and relative abundance of the plant species identified in the ESDs.

3.5 University of Arizona Testing Program

Rosemont has sponsored reclamation research conducted by the U of A since 2007. The research was performed to gather the necessary data and other information to ensure that reclamation efforts will be successful and achieve desired post-mining land uses. For this reason, the research plots were implemented using the same techniques and materials (e.g., soil types, mulch) that are anticipated to be available during the actual reclamation and revegetation processes. With respect to simulating actual reclamation, the following key attributes were addressed in the greenhouse and field test plot work:

- Soil material with appropriate texture and coarse fragment content;
- Application of soil to the test plot area in the same manner and to the same depth;
- Reviewing plant species composition in the NRCS ESDs and evaluating plant species in adjacent reference/comparison areas;
- Performing seedbed preparation with full-size equipment in a manner similar to the reclamation design specification;
- Selecting native, adaptive, and available plant species; and
- Broadcast seeding the test plots.

Using this approach, the test plots were expected to be, and have demonstrated that they are, vegetatively similar to the native ecological sites and similar to the anticipated vegetation on the reclaimed Landform. The reclamation research was conducted in several phases. Initially, an assessment was conducted using the NRCS ESDs to develop the seed mixture. Over 500 species were considered. Criteria for species seed selection were: 1) species had to be native, 2) common to the area, and 3) commercially available. During the second phase of the study, four (4) seed mixtures and amendments were identified for greenhouse evaluation. The most suitable seed mixture was used on the reclamation test plots during the third phase of the U of A revegetation study. The seed mixture (Table 3) represents semi-desert grassland with similar proportions of functional groups. The study has been summarized in the University of Arizona Final Report for Phase 1 (Fehmi 2007), the University of Arizona Phase II – Final Project Report (Fehmi et al. 2008), and Grassland Revegetation for Mine Reclamation in Southeast Arizona (Lawson 2011).

Table 3. Rosemont Seed Mixture

Common Name	Scientific Name	Season	Functional Group
Arizona cottontop	*Digitaria californica*	Warm	Perennial Grass
Blue grama	*Bouteloua gracilis*	Warm	Perennial Grass
Curly mesquite	*Hilaria belangeri*	Warm	Perennial Grass
Green sprangletop	*Leptochloa dubia*	Warm	Perennial Grass
Plains Lovegrass	*Eragrostis intermedia*	Warm	Perennial Grass
Sideoats grama	*Bouteloua curtipendula*	Warm	Perennial Grass
Bottlebrush squirreltail	*Elymus elymoides*	Cool	Perennial Grass
Mexican gold poppy	*Eschscholzia californica ssp. Mexicana*	Cool	Annual Forb
Desert Marigold	*Baileya multiradiata*	Warm	Perennial Forb
Fairy Duster	*Calliandra eriophylla*	Warm	Shrub

The test plots were designed to simulate reclamation efforts in a field setting and to validate greenhouse testing. This included selecting soils that are similar to the ecological sites and the soil data collected by Tetra Tech (2010). Surface soils used in reclamation will generally range from loam to sandy loam and have a significant component of coarse fragments. Descriptors such as gravelly, very gravelly, and cobbly accompany the texture classification of these soils. The Rosemont seed mixture is adapted to the anticipated range of soil textures on the Landform and is therefore expected to perform well and meet success criteria for all reclaimed areas. During actual reclamation, minor compositional adjustments may be made to the mixture to ensure revegetation success.

Two (2) seedbed preparation techniques (rough surface, smooth surface) and three (3) straw mulch treatments (surface mulch, incorporated mulch, bare soil) were tested for their potential to establish vegetation and prevent erosion. Two (2) soil types (Arkose- and Gila Conglomerate-derived) were placed on east-facing, 3H:1V (i.e., 3 horizontal units to 1 vertical unit, or 18-degree) slopes located at two (2) elevations (4,600 to 5,400-feet amsl). The test plots were constructed in late 2009 by removing the soil, ripping and grading to the correct slope, and then placing the soil. The seedbed treatments were randomly applied and constructed in rows, then the mulch treatments were randomly applied and seeding was accomplished in December 2009.

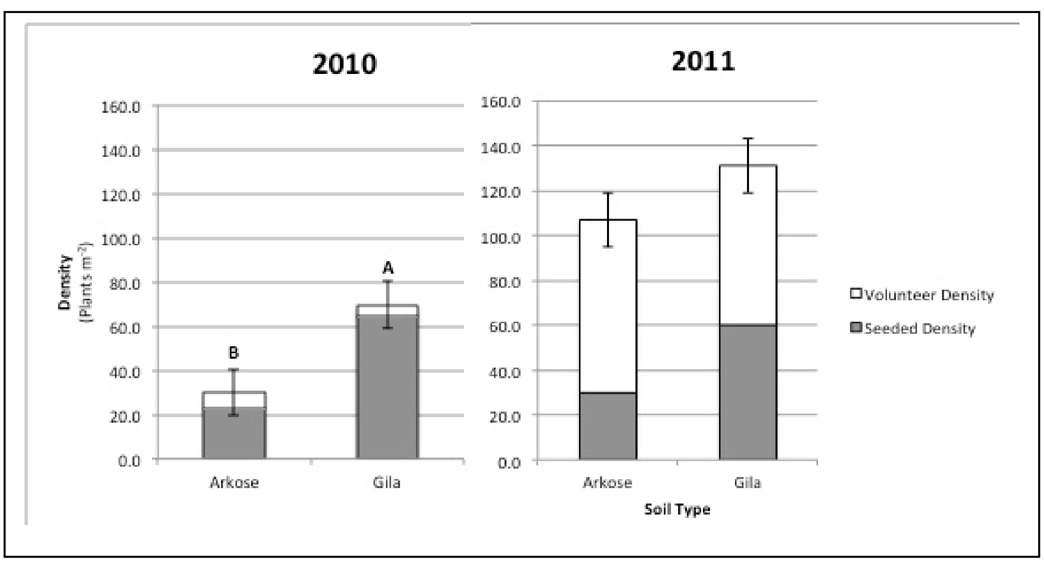
Test plot comparison areas were established as a way of evaluating vegetation trends over time. The comparison areas were in close proximity to each test plot on east-facing slopes with a similar slope gradient on two (2) soil types (native Arkose-derived soil and Mabray-Chiricahua soil).

Evaluation of the resulting plant cover, diversity, and density indicate that robust plant communities can be established within two (2) growing seasons on both the Arkose-derived (sandy loam) and Gila-derived (sandy loam) soils. Table 4 provides general plant cover results during the peak of the warm season using ocular estimates within 40x40 cm quadrats and Illustration 1 5 provides general plant density results by year and treatment. The 2012 data for the test plots are currently being analyzed. In 2011, richness ranged from 2.7 to 11.3 plant species per square meter depending on soil type and elevation (Table 4). It is noteworthy that more than 100 volunteer species were observed on the test plots as a result of seeds from within the soil (Illustration 1). For this reason, Rosemont will directly haul soil from the source and place it onto the Landform as much as practicable. The goal of this practice is to preserve the soil microbial community, and the genetic variation of the volunteer seeds within the soil.

Table 4. Species Richness and Canopy Cover by Year and Treatment

Elevation	Soil Type	Species Richness (Species m^{-2})		Canopy Cover (Percent)	
		2010	**2011**	**2010**	**2011**
Lower	Arkose	5.9	8.9	27.8	50.3
	Gila	5.2	4.9	11.9	35.7
Upper	Arkose	3.6	2.7	10.3	15.9
	Gila	9.5	11.3	20.8	51.1
Lower Control	Mabray-Chiricahua	11.9	15.6	73.7	62.9
Upper Control	Natural Arkose	15	14	63.9	34.3

Illustration 1. Plant Density Results by Year and Treatment



Data from the comparison areas used during the test plot work show the natural variability of species diversity and canopy cover over short periods of time. Similarly, the test plots showed variable species diversity from 2010 to 2011. During the first year of establishment, canopy cover on the comparison areas exceeded the test plot cover. During the second year of growth, canopy cover on the test plots increased and approached or exceeded canopy cover of the comparison areas (Table 4).

Both the Arkose- and Gila Conglomerate-derived soils are capable of producing a productive, diverse plant community. After only two (2) growing seasons, the test plots have demonstrated that revegetation efforts can provide grass production similar to natural areas and suggests it could support cattle grazing, a determined post-mining land use. Seedbed and straw mulch treatments will support revegetation efforts with the correct applications. The seedbed preparation methods that appeared to promote the best vegetation germination, establishment, and site stability were those with a relatively smooth surface and surface mulch. Incorporating mulch also aided vegetation establishment and is recommended for sites that are prone to windy conditions since the mulch is anchored into the ground. The ability to incorporate mulch into the ground, however, is limited by the amount of rocky material. Although a mulching rate of one (1) ton per acre provided good seed germination and establishment, this rate may need adjustment depending on slope aspect and the potential for erosion. It should be noted that soil with coarse fragments or increasing rock cover may be used for increased site soil stability.

The Rosemont test plot seed mixture (Table 3) proved successful and will be used for the core reclamation seed mixture. Data from the comparison areas used during the research work indicate that revegetated areas will need additional time to grow to produce more canopy cover. Long-term monitoring of the test plots will allow Rosemont to observe self-sustainability, identify trends, and predict future reclamation outcomes. During actual reclamation, the seed mixture may be adjusted based on slope aspect, gradient, elevation, and soil characteristics as needed to ensure that the success criteria will be met. Species within the core seed mixture are adapted to a wide range of environments and performed well on the test plots, but some species may need to be replaced according to the actual reclamation conditions and availability. Certain species of seed may not be available to purchase due to competition for seed; commercial growers are subject to climate and pest problems that may hinder the amount and quality of seed available for purchase. The number of species within the seed mixture may also be adjusted to meet diversity success criteria. Modifications to the seed mixture to ensure revegetation success would be part of an adaptive management process (see Section 7.0). This process would allow Rosemont staff to bring technological advances into the reclamation design and to adjust to unforeseeable conditions to successfully vegetate the Landform and other disturbed areas. The ability to adjust the seed mixture would also be available to Rosemont as necessary to respond to requests for the addition of plants used for cultural (i.e., tribal) purposes or other potential species requested by the Forest.

It should be noted that the test plots were built as a research tool to carefully control and understand the experimental variables. It is expected that the success achieved on the test plots (e.g., vegetation growth rate) may be different than actual reclamation areas due to the above-average precipitation received following test plot seeding. Nonetheless, the data from these plots, together with data from reference areas, can be used to help understand what constitutes reclamation success.

3.6 Selection of Reference Areas

NRCS soils, ESDs, and native comparison areas were used during the University of Arizona's research to assist in selecting plant species for testing. Potential reference areas will be selected using ESDs and will be sampled by Rosemont and the Forest to ensure that appropriate sites are identified and can be used, in conjunction with the research data collected from the field test plots, to determine when reclaimed areas meet revegetation success criteria (Chambers and Brown 1983). Reference areas are undisturbed sites that are comparable in structure and function to reclamation sites before they were disturbed. As such, reference areas may be used as models for reclamation projects, as well as a yardstick for measuring the progress or success. The goal of the reference area identification process for the Rosemont Project is to select undisturbed sites adjacent to the Project area that are similar to the NRCS ecological sites covered by the footprint. In addition to selecting reference areas in undisturbed areas, possible sites may also include select portions of the revegetation test plots.

Attachment D provides a memorandum titled Rosemont Reference & Reclaimed Area Sampling Protocol that outlines an approach to selecting and sampling potential reference areas. This memorandum explains the use of transects and macroplots in order to quantify and track plant community characteristics. The memorandum also discusses reference areas to be established on the Landform. These reference areas, along with the area they represent, are termed Reclaimed Management Areas.

The most important physical characteristics influencing the composition of undisturbed sites and the establishment of vegetation on the constructed Landform are aspect and slope angle. The harshest conditions for plants are generally on sloped areas located on south and southwest aspects. The north aspects have the coolest temperatures and more plant-available soil moisture, while conditions on the east and west aspects are intermediate to those on the north and south aspects. The less critical site characteristics on the Landform will be the range of precipitation across the area, elevation, and soil texture. Precipitation varies at the Rosemont site but is generally in the 14- to 18-inch range annually. The elevation will vary by approximately 1,100 feet on the constructed Barrel Landform, for example. Based on the soil texture and coarse fragment content information provided in the ESDs, the Tetra Tech soil investigation report (Tetra Tech 2010), and the data from the Rosemont test plots, soil salvaged from the site during mining will be coarse-textured and have a significant component of coarse material (i.e., rock >3 inches). Although soils high in lime and clay content have been identified in the Project area, the majority of salvaged soil used during reclamation will be similar to a gravely sandy loam. Details will be provided in the reclamation plan to be provided with the Final MPO.

4.0 Revegetation Objectives and Approach

The revegetation objectives are to establish diverse and productive native plant communities capable of stabilizing the soil against wind and water erosion, and providing wildlife habitat and grazing land. This will be accomplished using carefully selected plant species within the NRCS ESDs and a Landform with slopes and soil placement similar to the selected reference sites. These objectives are consistent with statuary requirements and long-term land use goals. A Monitoring Group, consisting of Rosemont, the Forest Service, and likely other groups such as the NRCS, will be established to make decisions regarding revegetation issues.

Upland plant communities in the prospective Project area are not currently at their highest potential. The most visible evidence of a degraded plant community is the substantial cover of One seed juniper and velvet or honey mesquite. These trees, while being native species, encroach upon sites that have had a lower than normal fire frequency combined with historical overgrazing by cattle. Once the canopy cover of these species gets above about 25%, soil erosion and soil loss often becomes a serious issue and the overall site becomes unstable. The Rosemont seed mixture is designed to improve the current range condition.

Native seed mixtures are in the final stages of field-testing for the site. Results from the test plots will be used to formulate a well-adapted mixture for the targeted ecological sites. Test plot data indicates that many of the plant species present on the site can volunteer from seed and underground plant parts. Therefore, it is anticipated that plant species having the local genetic make-up will become an integral component of the reclaimed areas. Additional seeds may blow-in from surrounding areas and contribute to the local genetic stock. The use of well-adapted and commercially available seed will further enhance the revegetation effort by ensuring the establishment of robust plant communities common to the area.

The entire revegetation effort, including species selection, soil selection, seedbed preparation, sowing technique, and weed control, has been designed to maximize revegetation success and meet the targeted post-reclamation land uses and other regulatory requirements.

5.0 Reclamation Implementation

5.1 Site Preparation

Salvaged soils from the Project area will be placed on the slopes of the Landform to a depth of 12 inches as a soil plant-growth medium. As will be described more thoroughly in the reclamation plan to be provided with the Final MPO, the strategy for salvaging and using soil is geared to preserving the biological component within the soil to the extent practicable. This will help promote the natural reestablishment of plant species native to the Project area. This strategy includes selectively stripping the upper soil layers and either directly placing that material on the reclaimed Landform or storing that material in shallow stockpiles for as short a time as possible. This approach will be implemented when and where possible during operations.

Site preparation will begin with grading areas to stable, permanent slopes as specified in the post-construction grading plan (to be provided in the reclamation plan). Grading is intended to restore more natural slopes with effective drainage and minimize scour and erosion. Where necessary, the ground surface will be ripped to decompact the soil. Additional surface soil manipulation may be used to create a seedbed that has microniches, or safe sites, for optimum seed germination and plant establishment. Ripping and other surface soil manipulation techniques will be conducted along contours within safety parameters to create furrows that minimize soil erosion, increase the infiltration rate and root zone soil moisture levels, and generally repair hydrological functions. Salvaged soils from the footprint of the Landform and other facility areas will then be placed on the slopes as a topsoil growth medium.

5.2 Seeding, Mulching, and Weed Management

The native seed mixture (see Table 3) containing grasses, forbs, and shrubs will be broadcasted onto the soil surface during the period determined optimal for seedling establishment, which is anticipated to be just prior to monsoon moisture. To develop the seed mix, the University of Arizona (UofA) identified five (5) NRCS ESDs in the Project area and the most common species of each plant type (functional group). Species that are found in multiple ecological sites are commonly seen on the Project site across multiple ESDs (Attachment A). These plant types were proportioned according to the ESDs to represent a semi-desert grassland plant community. Twenty-nine (29) species were tested in four (4) seed mixes in UofA greenhouses with prescribed rainfall and reclamation method treatments (Fehmi 2007). Species were evaluated and the most suitable were chosen for field testing. The reclamation test plots verified that the species in the seed mix established well at the Rosemont site. Alternative or additional species (Table 5) may be used to enhance the Rosemont seed mixture (Table 2) on all slope aspects when seed for particular species are not commercially available or to increase species diversity. Species will be approved by the Monitoring Group prior to use. Additional species including trees, shrubs, and agave will be used in selected areas (see Section 5.3).

Table 5. Seed Mix Enhancement Species Under Consideration.

Potential Species	Scientific Name	Functional Group
Cane Beardgrass	*Bothriochloa barbinodis*	Perennial Grass
Hairy Grama	*Bouteloua hirsuta*	Perennial Grass
Sprucetop Grama	*Bouteloua chondrosioides*	Perennial Grass
Slender Grama	*Bouteloua repens*	Perennial Grass
Tanglehead	*Heteropogon contortus*	Perennial Grass
Wolftail	*Lycurus* sp.	Perennial Grass
Sand dropseed	*Sporobolus cryptandrus*	Perennial Grass
Feather Delea	*Dalea* sp.	Shrub
Buckwheat	*Eriogonum* sp.	Shrub
Range ratany	*Krameria* sp.	Shrub
Winterfat	*Krascheninnikovia* sp.	Shrub
Menodora	*Menodora* sp.	Shrub
Mariola	*Parthenium incanum*	Shrub
Zinnia	*Zinnia* sp.	Shrub
Lippia	*Lippia* sp.	Shrub
Desert Senna	*Senna covesii*	Shrub

Seed will be sown at an overall density of approximately 50 to 100 pure live seeds (PLS) per square foot. The seeding rate will be in the range of 5 to 12 pounds of PLS per acre, depending on the species composition and desired number of seeds per square foot. The seeding rate may be modified downward if a substantial seed bank is present in the growth medium. This would be evaluated, if necessary, through an adaptive management process prior to changing the specification. Seed for the seed mix will be obtained from commercial seeders. This seed is well adapted to a variety of environments and has proved to establish well at the Rosemont site. NRCS has helped to develop commercial seed using seed collected from Southern Arizona. When possible, commercial seeders using NRCS-developed stock will be utilized. If that seed is not available, the seed will be obtained from commercial seeding sites most similar to the Rosemont site.

Certified weed-free straw mulch with a tackifier will then be applied at a rate of approximately one (1) ton per acre. Seeding will occur prior to mulching when applied to the soil surface to ensure good soil-to-seed contact. In areas that are prone to windy conditions and contain soils that contain an acceptable amount of coarse fragments, certified weed-free straw mulch will be mixed into the soil at a rate of up to two (2) tons per acre so that the mulch is secured in place. Seeding will occur following mulch incorporation for best seed placement.

A Preliminary Invasive Species Management Plan (Rosemont 2012) was developed that contains detailed information on how to detect, treat, and monitor invasive species. An updated invasive species plan will be established in conjunction with the reclamation plan. Undesirable plant species will be managed in accordance with federal and state regulations in order to eradicate weeds within the Project site. Methods to manage noxious weeds could include:

- Establish perennial plant communities on reclaimed areas and the sides of roadways to compete with the weeds;
- Regular monitoring of revegetated areas and soil stockpiles to determine the presence of noxious weeds as soon as possible and to establish treatment options based on species' biology;
- Treatment options include mechanical, cultural, chemical, or biological controls; and
- Careful application of herbicide to reduce the number of invasive species and to protect native perennial vegetation growing adjacent to reclaimed areas.

5.3 Trees, Shrubs, and Additional Species

Trees and shrubs (woody species) have been identified to provide wildlife habitat, ecological functions, and maintain visual quality in the Project area. For mitigation purposes, 3 – 40% woody plant cover is required and will be achieved by meeting the cover and density success criteria listed in Table 9. If these criteria are not met, adaptive management will be used by the Monitoring Group to determine desirable conditions and modifications to revegetation techniques. The NRCS will be consulted to provide expertise on seeding rates and revegetation techniques to produce favorable results. Table 6 shows the approach to tree and shrub establishment on the slope aspects of the Landform.

Woody species are naturally the most prevalent on north-facing slopes, which creates a visual pattern across the landscape as shown on Figure 3. Revegetation of woody species will generally follow these natural landscape patterns on the final Landform. In comparison, the top of the Landform may have a lower density of trees and shrubs, as visually shown in photographs in Attachment B. Woody species will generally be widely scattered on east- and west-facing slopes. South-facing slopes may be limited to very widely scattered small shrubs and trees. Additional details on enhancing vegetation patterns and mitigating visual impacts, such as the viewshed from State Route 83, are highlighted below.

Table 6. Tree & Shrub Establishment Approach

Slope Aspect	Technique
East-Facing Slope	-Rosemont seed mixture -Scattered tree/shrub plantings or islands
West-Facing Slope	-Rosemont seed mixture
South-Facing Slope	-Rosemont seed mixture -Culturally significant species in Table 7 will be seeded/planted in clumped distributions
North-Facing Slope	-Rosemont seed mixture -Tree/shrub islands -Drill or broadcast seeding of selected species in Table 7 prior to, or with broadcasting Rosemont seed mixture in selected areas
Relatively Flat (Gently Rolling)	-Rosemont seed mixture -Tree/shrub islands -Drill or broadcast seeding of selected species in Table 7 prior to, or with broadcasting Rosemont seed mixture

Trees and shrubs will be established by volunteering, seeding, or planting. One species of shrub, fairy duster (*Calliandra eriophylla*), is included in the core Rosemont seed mixture and therefore will be seeded across all revegetation areas. As observed on the reclamation test plots, woody species readily volunteer from the soil and are likely to thrive and provide structural diversity in the plant communities. When soil is not directly replaced, woody plant species may be added to the seed mixture according to slope aspect to create a desirable density or cover of trees or shrubs. If a desirable amount of woody plant cover does not establish from the seed bank or through seeding, tree plantings may be used. If woody plants establish in undesirable patterns and densities, adaptive management will allow the Monitoring Group to determine the appropriate actions.

Seeding woody species will occur prior to the monsoon season. Woody species will be drill seeded prior to broadcast seeding of the core Rosemont seed mixture (Table 2) or they may be broadcasted with the Rosemont seed mixture, depending upon the species selected and their optimal seeding depth. Plantings would use nursery grown trees or shrubs to create “tree or shrub islands”. Island plantings would consist of about 20 – 30 individuals of mixed species (Table 7) within about an acre. This will produce a higher cover of woody species for wildlife habitat within relatively small areas. Tree/shrub islands will be randomly placed within the reclaimed areas or as determined by the Monitoring Group. The number of plants and tree/shrub islands would also be adjusted according to specific locations on the Landform or slope aspect. About 15 – 20 islands are anticipated on the north-facing slopes. This equates to about one (1) tree or shrub island per 30 acres based on about 600 acres on north-facing slopes at Year 22 (see Attachment C: VSS 6). About 5 – 10 tree islands are anticipated to be placed on top of the Landform for enhanced wildlife habitat. The number of woody plants and islands may be adjusted according to project goals and as determined by the Monitoring Group

The placement of trees and shrubs (or islands/plantings) on the east facing slopes of the Landform is also important to help enhance the viewshed quality from State Route 83. In addition to random plantings, woody islands are anticipated to help blend features such as the stormwater benches into the Landform. Species selection and planting technique will also consider the rockier soil cover anticipated on the longer east-facing slopes. Adaptive management (Section 7.0) will be used to assess the effectiveness of the species and placement to ensure that vegetation growth enhances rather than from visual quality objectives.

Transplanting trees from the footprint of the Project facilities is not likely to be successful. High costs and rocky soils will prevent the use of specialized equipment like tree spades. Woody species will therefore be grown from seed to a specified size at a nursery and then planted on the Landform; this technique has been shown to produce higher establishment rates than transplanting. Additional reclamation techniques, like water harvesting or artificial irrigation gels, may be initially required to assist some plants to establish on the site. Reclamation techniques may be evaluated on the UofA test plots prior to application on a larger scale. Adaptive management will also be used to adjust techniques in order to produce the most successful woody plant establishment.

Compared to herbaceous species, woody plants require more time to grow to sizes comparable to the undisturbed sites. Woody species generally invest in their root structure prior to their canopy; therefore, woody species may not be visible from a distance for 5 or 10 years. This concept is demonstrated in Table 2. Trees and shrubs established by seed will take longer to become visible as compared to plantings. If site conditions are not favorable for tree or shrub growth, height and production may be affected. Some species, like oaks, grow slowly and are likely to remain a relatively smaller size for a longer period of time.

Woody species that may be appropriate for inclusion in the seed mixture or for tree/shrub plantings are shown in Table 7. Culturally significant species in Table 7 will generally only be applicable to south-facing slopes, expect for Parmer's agave which will be planted on all slopes (see Section 5.4). NRCS ecological site descriptions, on-site observations, culturally significant species, and commercially available seed were considered in the development of Table 7. These species must, and will, support post-mining land uses of wildlife habitat, grazing, and recreation and promote site stability. It is anticipated that testing will be performed for most of these species (on test plots or reclaimed areas) prior to implementation to ensure their suitability for the site conditions (i.e., soil type/slope aspect) on the reclaimed Landform. Rosemont is currently consulting with NRCS staff to develop protocol for agave, sotol, and beargrass seeding and the introduction of woody species onto the reclaimed areas.

Table 7. Additional Species Under Consideration

Potential Species	Scientific Name	Functional Group
	Woody Species	
Emory Oak	*Quercus emoryi*	Tree
Arizona White Oak	*Quercus arizonica*	Tree
Mexican Blue Oak	*Quercus oblongifolia*	Tree
Alligator Juniper	*Juniperus deppeana*	Tree
Evergreen Sumac	*Rhus coriophylla*	Shrub
Skunkbush Sumac	*Rhus trilobata*	Shrub
Mountain Mahogany	*Cercocarpus montanus*	Shrub
Four-wing Saltbush	*Atriplex canescens*	Shrub
Wright's Silktassel	*Garrya wrightii*	Shrub
Desert Hackberry	*Celtis pallida*	Shrub or Tree
	Culturally Significant Species	
Sacahuista (Beargrass)	*Nolina microcarpa*	Shrub
Sotol	*Dasylirion wheeleri*	Shrub
Palmer's Agave	*Agave palmeri*	Shrub (Succulent)
Ocotillo	*Fouquieria splendens*	Shrub
Soaptree Yucca	*Yucca elata*	Shrub
Schott's Yucca	*Yucca schottii*	Shrub

5.4 Reestablishment of Palmer's Agave

Prior to the clearing and grubbing of existing vegetation, species of special interest, such as the Palmer's agave, will be transplanted from the area directly onto the reclaimed Landform, or removed and transported to a storage area for later planting. There may also be opportunities for organizations, including Native Americans and nurseries, to salvage plants from the site, but the number of desirable and manageable specimens is predicted to be relatively low.

Palmer's agave (*Agave palmeri*) is a critical food source for the federally listed endangered lesser long-nosed (LLN) bat (*Leptonycteris yerbabuenae*). The abundance of Palmer's agave and the presence of the LLN bat within the Rosemont impact area were assessed during 2008 surveys (WestLand 2009a and b). The agave is also a culturally significant plant for Native Americans.

Based on planned mitigation, Rosemont will plant at least 35,850 Palmer's agaves on the Landform. Once reestablished, the agave population is expected to be self-sustainable, while providing a source of food of the LLN bat. Since Palmer's agave die after flowering once, it is necessary to maintain an age-varying population to ensure forage for the LLN bat during its migration to and from Mexico. Therefore, transplanting and propagation, as well as possible seeding, will be used to provide population age structure. Results from the University of Arizona study (Pavliscak 2010) conducted at the Rosemont site are being used to develop a detailed agave reestablishment plan. That plan discusses harvesting techniques for various plant sizes, storage and care techniques, post-planting watering strategies, and other key technical components for a successful program. To maintain a self-sustaining agave population, both transplanting and seeding methods have been tested by the University of Arizona in order to define the best management practices (BMPs) for use at the Rosemont site.

Agaves will be placed on the Landform according to the reclamation plan schedule. Transplanting will ideally occur prior to monsoon rains or during the cool season when agaves are not actively growing. The agave seedlings will then rely on natural rainfall and will not be irrigated, although surface mulch will be applied to provide shade for the seedlings and protection against environmental extremes. The agave's architecture will direct rainfall to the shallow roots, which is a natural adaptation that will assist successful plantings. When the agaves are transplanted onto the Landform, initial watering, the use of gel packs, or other amendments may be used to enhance moisture to the plants to reduce stress and increase success rates.

Based on mitigation measures, Agave seed may be used if it becomes commercially available. If seeding occurs prior to it being commercially available, Palmer's agave seeds will be hand collected. It should be noted that seeding agave is expected to have poor results due to low germination and establishment rates in natural settings. Another limiting factor to a large-scale agave seeding program may be the amount of seed available to harvest, which depends on annual precipitation and other environmental factors.

In lieu of seeding or transplanting, agave seeds may be grown in greenhouses or nurseries where seedlings can be irrigated and other environmental factors controlled. When nursery-grown seedlings are well established they can be transplanted onto the Landform.

Once the Landform has been reclaimed, the agave population is expected to be self-sustainable. While some agaves will immediately flower following transplanting efforts, other agaves will be producing pups (reproducing vegetatively). The agave population is expected to stabilize and become self-sustainable. Each year, a portion of the agave population is expected to flower and provide forage for the LLN bat. Monitoring and adaptive management will allow for adjustments to ensure appropriate agave densities and age structure will persist on the Landform.

5.5 Plants of Traditional Importance

Tribal consultation regarding plants of traditional importance has been implemented pursuant to Section 106 of the National Historic Preservation Act. Rosemont will continue to work with the Forest Service and local tribes to develop a plan to reestablish culturally significant plant species on the Landform (Griset 2011). Specific plants were traditionally harvested for food, shelter, ceremonial, medicinal, or other purposes. A number of trees, shrubs, cacti, succulents, forbs, and grasses have been identified as culturally significant by the Tribal Council, which includes the Tohono O'odham and Apache tribes. Many of the species previously identified by SWCA, the Forest Service's consultant, were tested during the University of Arizona research for their establishment ability and are included in the Rosemont reclamation seed mixture. Others have been observed as volunteer species on the Rosemont test plots or are expected to voluntarily establish without seeding. Traditionally important species known in the proposed Project area are identified in Table 8.

Table 8. Plants of Traditional Importance within the Rosemont Project Area

Plant	Apache[1]	Tohono O'odham[2]	Establishment
Trees/Shrubs			
Velvet mesquite (*Prosopis velutina)*	**X**	**X**	**Volunteer Species**
One seed juniper (*Juniperus monosperma)*	**X**		**Volunteer Species**
Alligator juniper (*Juniperus deppeana)*	**X**		**Volunteer Species**
Emory oak *(Quercus emoryi)*	**X**		**Identified to Test**
Coral bean (*Erythrina flabelliformis)*	**X**		
Fairy duster (*Calliandra eriophylla)*			**Rosemont Seed Mix**
Saltbush (*Atriplex* species not specified)		**X**	**Volunteer Species**
Hackberry *(Celtis pallida, C. reticulata)*		**X**	**Identified to Test**
Acacia (*Acacia greggii, Acacia constricta*)		**X**	**Volunteer Species**
Succulents and Cacti			
Palmer agave (*Agave palmeri*)	**X**		**Identified to seed and transplant**
Beargrass (*Nolina microcarpa)*	**X**	**X**	**Identified to Test**
Sotol (*Dasylirion wheeleri)*	**X**		**Identified to Test**
Prickly pear (*Opuntia phaeacantha)*	**X**	**X**	**Volunteer Species**
Cholla (species not specified)		**X**	**Volunteer Species**
Forbs			
Desert marigold *(Baileya multiradiata)*		**X**	**Rosemont Seed Mix**
Penstemon *(Penstemon* sp.)		**X**	**Volunteer Species**
Globemallow *(Sphaeralcea ambigua)*		**X**	**Volunteer Species**
Mexican gold poppy (*Eschscholzia californica ssp. Mexicana)*		**X**	**Rosemont Seed Mix**
Prickly poppy (*Argemone* sp.)			**Volunteer Species**
Lupine (*Lupinus* sp.)		**X**	**Volunteer Species**
Grasses			
Blue grama (*Bouteloua gracilis)*	**X**		**Rosemont Seed Mix**
Side oats grama (*Bouteloua curtipendula)*	**X**		**Rosemont Seed Mix**
Arizona cottontop *(Digitaria californica)*			**Rosemont Seed Mix**
Curly mesquite *(Hilaria belangeri)*			**Rosemont Seed Mix**
Green sprangletop *(Leptochloa dubia)*			**Rosemont Seed Mix**
Plains lovegrass *(Eragrostis intermedia)*			**Rosemont Seed Mix**
Bottlebrush squirreltail *(Elymus elymoides)*			**Rosemont Seed Mix**

[1]Information supplied by the Mescalero Apache Tribal Historic Preservation Office
[2]Information from Sonoran plant list compiled by Tohono O'odham for ASARCO mine reclamation; supplemented by comments by O'odham representatives during onsite tours

5.6 Use of Cleared and Grubbed Vegetation

Existing vegetation in the Project area consists of native plant communities of grasses, forbs, shrubs, succulents, and trees. The initial stage of mining will require areas to be cleared and grubbed. Clearing will remove trees and other vegetation and grubbing will remove large underground plant material, such as stumps, roots, and buried logs. Soil is then stripped following the clearing and grubbing activities. Areas that are not under construction will not be disturbed until it is necessary in order to preserve site stability.

Much of the cleared and grubbed material will be scattered onto the reclaimed Landform following seeding and mulching to improve slope stability, add organic matter, and enhance microhabitats for invertebrate and small vertebrate species. Cleared material may be scattered on the Landform at a rate from 10 to 30 tons per acre while material is available. This rate may be adjusted as determined by the Monitoring Group. Burying cleared and grubbed material in the Landform is not currently being considered. Large shrubs and trees removed during the clearing step will be cut to manageable sizes and used in gullies and in other areas for erosion control. Some material will be chipped and also used to enhance soil stability where appropriate. Grasses, forbs, cacti, and small shrubs will be removed with the soil. This plant material will contribute to the reestablishment of the local genetic stock as some seeds will remain in the soil (seed bank) or attached to the plants, and rhizomes and other underground reproductive material will increase the ability of these plants to tiller (sprout) and become re-established on the Landform. Plant material that dies during the soil salvage process will be a source of organic matter for soil microbes. Additional details will be provided in the reclamation plan.

6.0 Performance Evaluations

6.1 Overview

Revegetated areas at the site will be monitored to determine: 1) if the seeded species have become established (or if reseeding is required); 2) maintenance requirements; and, 3) whether revegetated areas are compliant with the established success criteria so that the reclamation bond can be released for a particular area. Newly seeded areas will be monitored to decide if the seeded species have germinated and become established. Often in arid environments, weather-related factors prevent germination of some seed during the first year. However, if after two or more growing seasons perennial plant establishment is poor and the long-term development of the plant community is questionable, a contingency plan will be developed and implemented. That plan may include soil testing, over-seeding, tilling and reseeding, or applying soil amendments. This on-going evaluation and adjustment process is part of an adaptive management approach that could allow flexibility in the revegetation approach to adjust for unanticipated conditions and set the reclaimed areas on a trajectory to meet the success criteria.

Annual monitoring will be conducted for management purposes to track trends in plant community development, to identify areas requiring maintenance, and to determine when a reclaimed area is ready for a reclamation success determination. Annual monitoring and site assessments for success determination/bond release purposes will be conducted separately as described below.

Site assessment work will be conducted by qualified personnel. These personnel will have knowledge, site-specific training, and experience evaluating ecological conditions within the Rosemont area and will therefore be familiar with reclamation techniques, vegetation community dynamics, and landscape stability on undisturbed reference areas as well as the reclaimed sites. They will also understand how sampling methodologies affect plant attribute data and will also be knowledgeable concerning the objectives and reclamation process specific for the Project.

6.2 Annual Monitoring

It is recommended that annual monitoring will be performed using 1) the 17 attributes of rangeland health described in *Interpreting Indicators of Rangeland Health* (Pellant et al. 2005) and 2) quantitative vegetation measurements as described in the Rosemont Reference & Reclaimed Area Sampling Protocol memo (Attachment D). The 17 attributes are an efficient way to determine general vegetation and soil conditions on a site while the rangeland health assessment, which addresses the ecosystem components of soil/site stability, hydrologic function, and vegetation, is a standard technical approach used by the BLM and other agencies. The vegetation and soil attributes to be assessed are listed on the field forms in Attachment D and as described below.

Monitoring will be performed annually at the time of peak plant growth. Monitoring of Reclaimed Management Areas will begin by mapping the boundaries of the area and then conducting a walk-over to understand the variation in vegetation cover and soil stability throughout the area. The walk-over also allows the evaluator to create a species list to document the presence of uncommon species and to ensure that small infestations of noxious and other undesirable plant species are identified so they can be eradicated. Once the vegetation and erosion conditions are well understood, the evaluator will randomly establish transects and collect quantitative plant cover and density measurements. The density and cover measurements will be used to calculate perennial plant density and cover by plant type, species diversity, and plant type composition, as well as other plant community attributes. Details of the annual monitoring (including field forms) can be found in the Rosemont Reference & Reclaimed Area Sampling Protocol memo (Attachment D) and will be provided in the reclamation plan.

Standard field methods will be used to collect soil/site stability and vegetation data during the annual monitoring and for the purpose of determining success. These methods are described in the following manuals:

- Evaluating rangeland health indicators (soil/site stability, hydrologic function, vegetation) using the 17 attributes identified in *Interpreting Indicators of Rangeland Health* (Pellant et al. 2005) (see Attachment D).
- Using line-point intercept to determine vegetation cover, bare ground cover, community richness, and other attributes as defined in *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems* (Herrick et al. 2005) and *Sampling Vegetation Attributes* (Coulloudon et al 1999).

- Determining plant density using quadrats as described in *Measuring and Monitoring Plant Populations*. (Elzinga et al. 2001) and using macroplots to determine tree density as described in *Sampling Vegetation Attributes* (Coulloudon et al 1999).
- Determining the presence and absence of special and invasive/weedy plant species (Herrick et al. 2005).
- Determining rock and litter cover sizes as described in *Field Book for Describing and Sampling Soils* (NRCS 2012).

Permanent photographic points will be established on each reclaimed area to show landscape views and close-ups of the ground cover in order to track trends as the plant community develops. Opportunistic photographs will also be taken to record significant issues.

Annual monitoring data and information will be provided to the Monitoring Group. This will include maps delineating the reclaimed area evaluated, completed field forms, summarized vegetation and soil data, and photographs. Upon request, Rosemont will meet with the Monitoring Group to discuss issues or concerns. Rosemont will implement contingency measures for issues that are predicted to hamper an area's ability to meet the success criteria.

6.3 Determination of Reclamation Success

Approach

A specific (i.e., map-delineated) reclaimed area (Reclaimed Management Area) will be assessed for compliance with the success criteria when the annual monitoring data suggests that it has been reclaimed. The Forest will be notified prior to this assessment and afforded the opportunity to oversee the data collection effort.

As with the annual monitoring, quantitative data used for success determination will be collected during the peak of the primary growth season using a set of transects. Based on the understanding of vegetation and site stability gained through multiple years of monitoring, transects and quadrats will be randomly located within the delineated reclaimed area in order characterize the site in an unbiased manner. Reclaimed and reference sites will be sampled with the same techniques in order to obtain a direction comparison for determining success. A description of the sampling approach can be found in the Rosemont Reference & Reclaimed Area Sampling Protocol memorandum provided in Attachment D.

Adaptive management will be used as necessary to modify these approaches and ensure that the Monitoring Group is in agreement that the data are representative of actual conditions with the evaluated reclamation area.

Success Standards

The proposed soil/site stability and vegetation attributes, field methods (with references), and success metrics for the Project are identified in Table 9. Although a variety of data will be collected in the field to track vegetation and site stability trends, including the frequency of species, the recommended performance parameters used to determine reclamation success for the Project are the soil/site stability component of the BLM rangeland health assessment, and perennial plant cover and density using the identified methods.

It is recommended that a reclaimed area be considered successfully stabilized when the soil/site stability component is in the same or a higher class when compared to the reference area. The individual soil/stability attributes evaluated using the guidance (Pellant et al. 2005) are: rills, water flow patterns, pedestals and terracettes, bare ground, gullies, wind-scoured, blowouts or deposition areas, litter movement, surface soil resistance to water erosion, surface soil loss or degradation, and soil compaction layer (see field form in Attachment D). Success criteria for vegetation will be: total perennial plant cover that is at least 70% that of the reference area (with a 90% level of confidence); total perennial plant density that is at least 70% that of the reference site; and woody plant density that is at least 70% that of the reference area.

Table 9. Recommended Reclamation Success Criteria

Attribute	Method	Reference	Success Metric
Site Stability / Soil Erosion			
Soil/site stability component of the Rangeland Health Assessment guidance.	Visual Indicator Assessment	Pellant, M., P. Shaver, D.A. Pyke, and J.E. Herrick. 2005. *Interpreting Indicators of Rangeland Health*, version 4. Technical Reference 1734-6. U.S. Department of the Interior, Bureau of Land Management, National Science and Technology Center, Denver, CO. BLM/WO/ST-00/001+1734/REV05.	Rating for the soil/site stability component must be in the same class or a higher class compared to the reference area* information.
Vegetation			
Species foliar cover Plant type composition Species richness Bare ground	Line-point intercept	Herrick et al. 2005. *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems*. USDA – ARS Jornada Experimental Range, Las Cruces, NM. Coulloudon et al. 1999. *Sampling Vegetation Attributes*. BLM Technical Reference BLM/RS/ST-96/002+1730.	Total perennial plant cover ≥70% that of the reference site with a 90% level of confidence
Perennial plant density Species and plant type frequency	Quadrat (40x40 cm) Or Macroplots (100 x 100 ft)	Elzinga et al. 2001. *Measuring and Monitoring Plant Populations*. BLM Technical Reference 1730-1. BLM/RS/ST-98/005+1730-1. Coulloudon et al. 1999. *Sampling Vegetation Attributes*. BLM Technical Reference BLM/RS/ST-96/002+1730.	Total Perennial plant density ≥70% that of the reference area. Total woody plant density ≥70% that of the reference area.
Presence/Absence of Special, Invasive and Weedy Species	Visual survey (in addition to line-point and quadrat data)	Herrick et al. 2005.	Information used for plant species tracking and management. Weedy species actively managed per state regulations

*Reference areas to be identified for the various slope-, aspect- and elevation-defined plant associations.

Compliance Determination and Bond Release

When a reclaimed area has met the soil/site stability and vegetation success criteria for a minimum of two (2) consecutive years, or as determined by the Monitoring Group, that area will have met the land use, plant community characteristics, and site stability goals established for the Project. At that point, the revegetation requirements will have been met and the reclamation bond can be released. Reclaimed areas can also be judged successfully reclaimed even if not all of the numeric success criteria are met. For example, the Monitoring Group can make a determination of success if a reclaimed area has lower cover or woody plant density than the standard but is stable and has an appropriate species composition. This could be done using an adaptive management process to adjust the cover criteria or by providing the rationale for declaring the area successfully revegetated. The most important factors will be whether the revegetated area is physically stable, if it has a variety of native, indigenous plant species capable of providing a permanent cover, and if it is meeting the identified land use goals.

7.0 Adaptive Management Process

Adaptive management can be used to modify specifications and protocols as necessary to meet the defined reclamation and revegetation objectives of soil stabilization and plant community attributes on the reclaimed Landform. This process is summarized below and is based on standard guidance such as that developed for the U.S. Department of the Interior (DOI) (Williams et al. 2009). Key elements of adaptive management for land reclamation are the identification of outcomes (in this case reclamation objectives), the comparison of data from revegetated areas to those outcomes, and the adjustment of specifications or procedures (i.e., data feedback) when the desired outcomes are not being met.

A key component of a Rosemont-specific adaptive management process involves stakeholders. For this reason, it will be important that the Forest remain engaged throughout the Rosemont reclamation process. Consistent with guidance, there are six (6) basic steps to adaptive management.

1. <u>Assess objectives and issues.</u> Reclamation and revegetation objectives, which have been identified in the Preliminary Reclamation and Closure Plan (CDM 2012), and in this Revegetation Performance Measures memorandum, are consistent with regulatory requirements and responsible land stewardship. A reclamation plan will also be prepared and provided with the Final MPO.

2. <u>Design.</u> Revegetation plans are being developed using the results of the multiple-year, test plot research work being carried out at the Project site by the University of Arizona. Research associated with the test plots incorporated information from the NRCS ESDs and native sites in the Rosemont area, and knowledge of land reclamation scientists to prepare revegetation specifications. Rosemont is currently expanding on the previously prepared documents and developing a reclamation plan to be provided with the Final MPO.

3. <u>Implement.</u> Rosemont will implement reclamation and revegetation concurrently with operations according to the specifications.

4. Monitor. Rosemont has identified the monitoring methods in Section 6 of this Revegetation Performance Measures memorandum. Reference sites and revegetated areas will be monitored using the defined protocol. Details of the protocol are provided in the Rosemont Reference & Reclaimed Area Sampling Protocol memorandum provided in Attachment D.

5. Evaluate. Rosemont will use the monitoring data in conjunction with approved performance standards identified in Section 6 of this Revegetation Performance Measures memorandum to determine if reclamation (site stability and revegetation) has been successful.

6. Adjust. Data from all sources will be evaluated by the Monitoring Group, which includes personnel from Rosemont, the Forest Service and other agencies such as the NRCS, to determine if identified outcomes are being met, and if not, to identify and implement changes to revegetation implementation, evaluation protocol, or success criteria.

The reclamation plan will include a detailed description of an adaptive management process specific to Rosemont. A key aspect would be the data-driven feedback loop, which includes the evaluation of monitoring data and results submitted to the Monitoring Group as soon as they are available. Discussions between the Monitoring Group can then occur about reclamation and revegetation progress and if changes are warranted. If procedural changes or changes to specifications are necessary to meet the success criteria, Rosemont would implement them as soon as practicable.

8.0 References

Chambers, J.C. and R.W. Brown. 1983. Methods for Vegetation Sampling and Analysis on Revegetated Mined Lands. USDA – Forest Service. General Technical Report INT – 151. October 1983.

Coulloudon et al. 1999. *Sampling Vegetation Attributes*. BLM Technical Reference BLM/RS/ST-96/002+1730.

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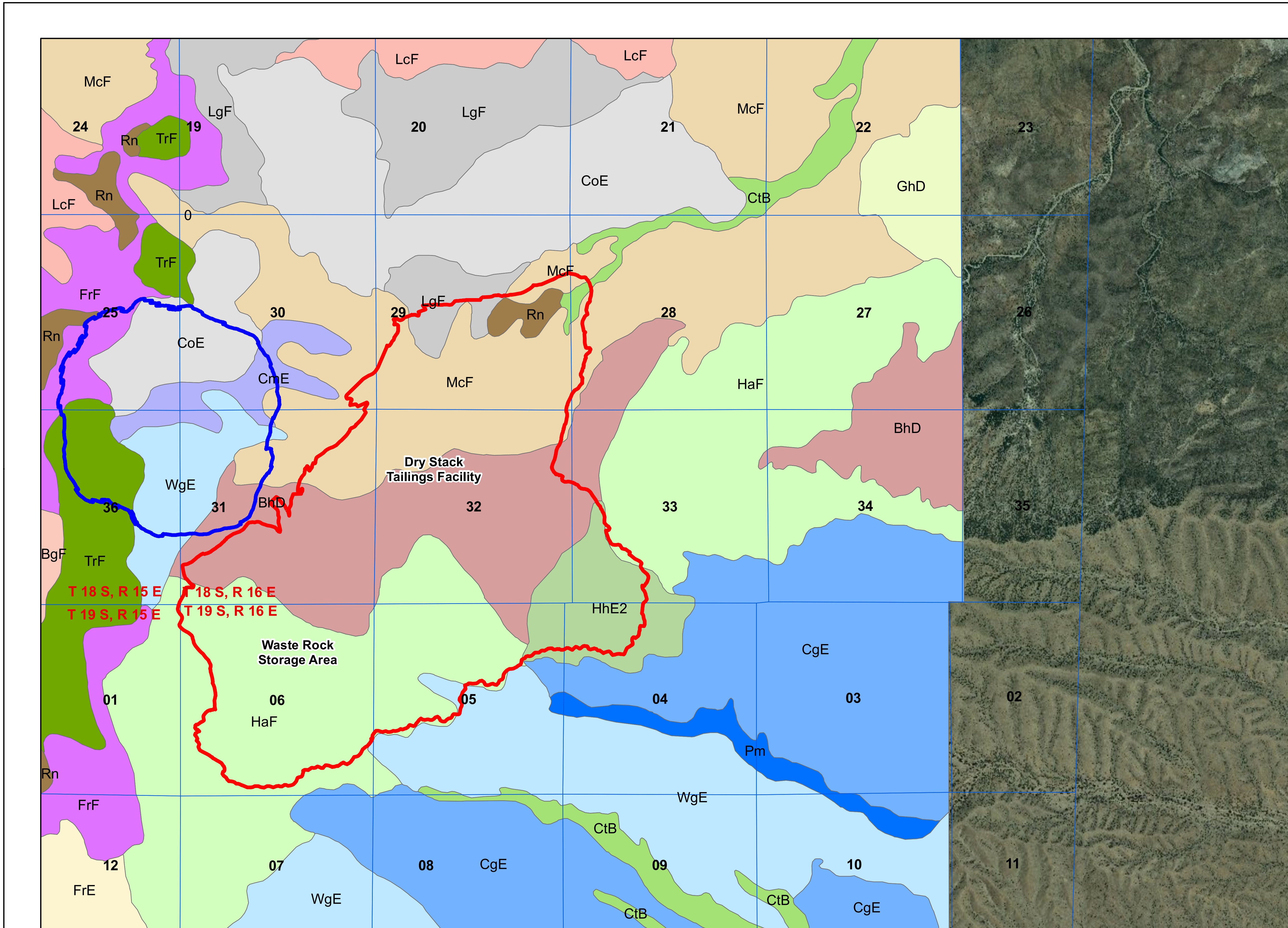
Williams, B.K., R. C. Szano, and C. D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide, Adaptive Management Working Group, Washington, D.C.

Figures



Legend

- Pit Outline
- Final Landform Toe Outline
- Sections

Soil Type

Rosemont Soils

- BhD
- FrF
- McF
- CtB
- WgE
- Rn
- CmE
- CoE
- TrF
- LgF
- HaF
- HhE2

1:30,000

1,700 850 0 1,700

Feet

Project: Rosemont Revegetation Plan

Source: ArcGIS Map Service Server - ESRI_Imagery

County: Pima | State: Arizona

PRJ: NAD83 UTM 12 Meters | Date: 6/28/2013

Figure 1. NRCS Soil Classification.

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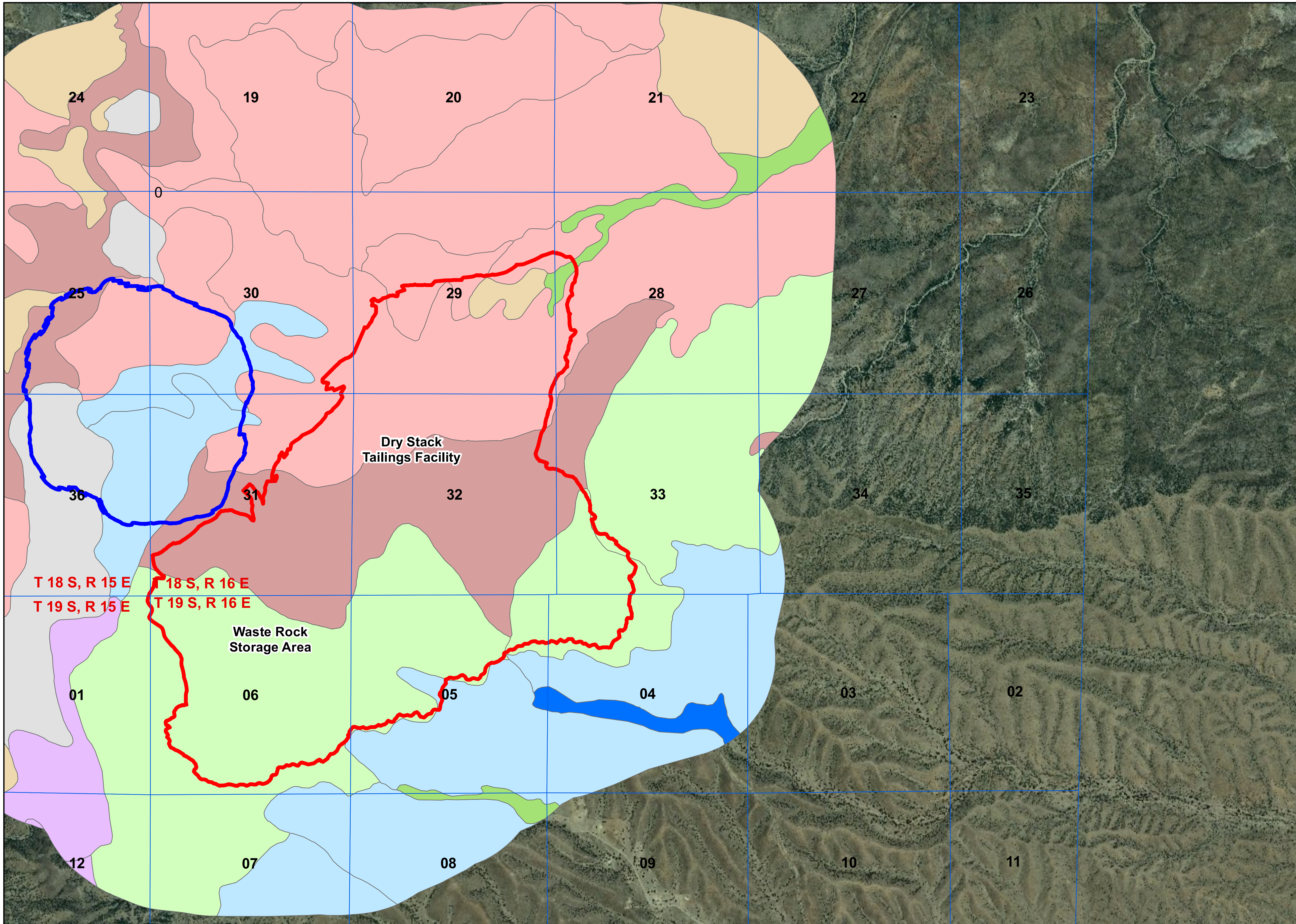

Legend

Sections

Pit Outline

Final Landform Toe Outline

NRCS ESDs

Ecological Sites

Clay Loam Upland 12-16" p.z.

Granitic Hills 12-16" p.z.

Granitic Hills 16-20" p.z.

Limestone Hills 16-20" p.z.

Limy Slopes 12-16" p.z.

Limy Slopes 16-20" p.z.

Loamy Bottom 12-16" p.z.

Loamy Slopes 12-16" p.z.

Loamy Slopes 16-20" p.z.

Oak-Juniper F041XA120AZ

Rock Outcrop

Sandy Wash 12-16" p.z.

1:30,000

1,700 850 0 1,700

Feet

Project: Rosemont Revegetation Plan

Source: ArcGIS Map Service Server - ESRI_Imagery

County:	Pima	State:	Arizona
PRJ:	NAD83 UTM 12 Meters	Date:	7/3/2013

Figure 2. Ecological Sites.

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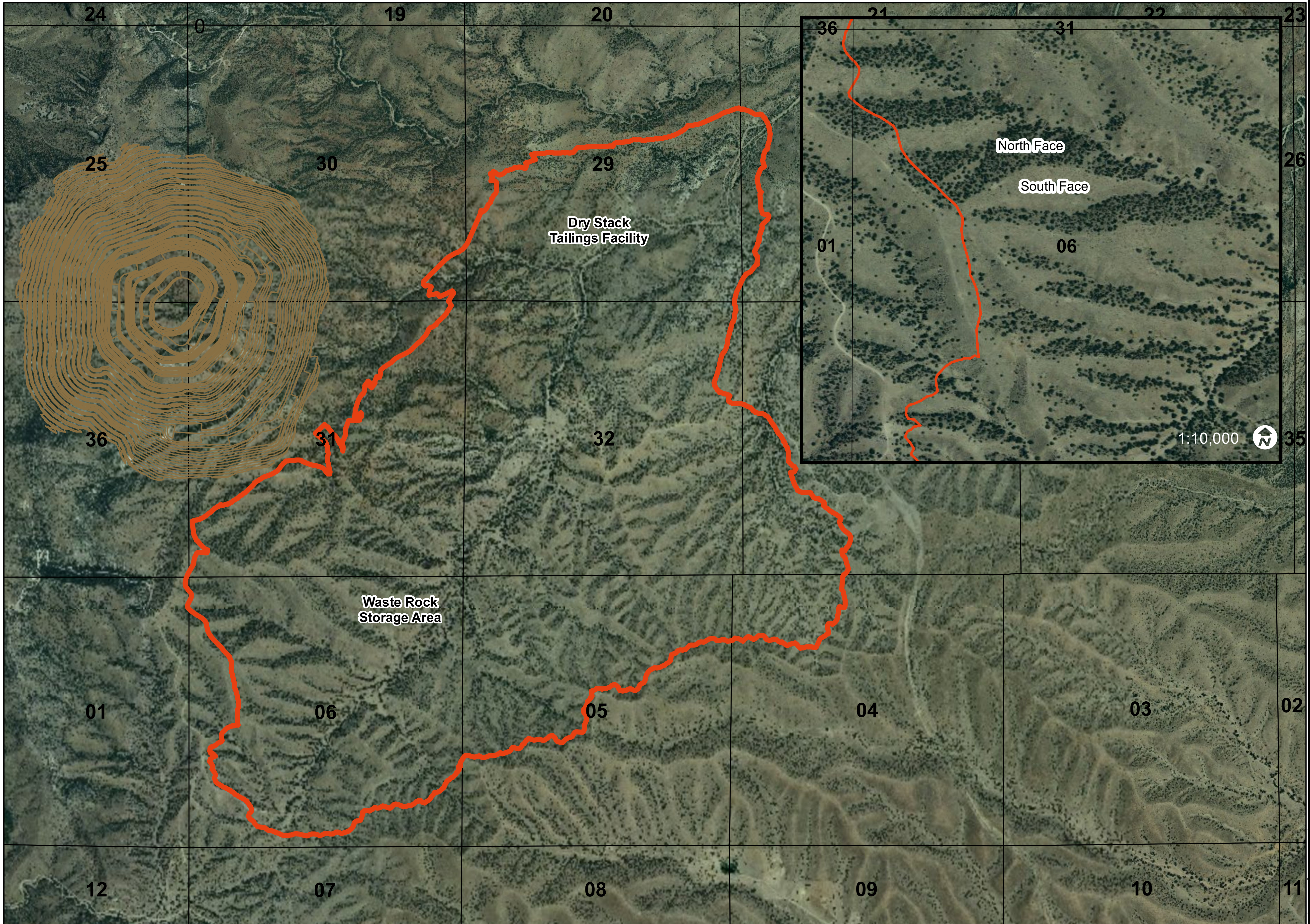
Figure 3. Slope effects within the Project area.



Legend

Year 22 Pit

Final Landform Toe Outline

Sections

1:22,000

1,250 625 0 1,250

Feet

Project: Rosemont Revegetation Plan	
Source: ArcGIS Map Service Server - ESRI_Imagery	
County: Pima	**State:** Arizona
PRJ: NAD83 UTM 12 Meters	**Date:** 5/21/2013

Figure 4. Vegetation Patterns

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Attachment A

Description of Ecological Sites Near the Rosemont Project Area

Comparison of Ecological Sites near Rosemont Site

Ecological Site and Soil Types	NRCS Over / Under Story	Dominants in most common historic, climax plant community type	Site Description and Ecological Dynamics	Cover
Limestone Hills 12-16" Precipitation Zone (PZ) 3500-5500' Soil types: Very gravely sandy loam; Cobbly sandy loam; Very gravely loam	Feather plume - ocotillo / sideoats grama - New Mexico feather grass	Dominated by warm season grasses: black grama, bush muhly and sideoats grama with a component of New Mexico feathergrass (cool season). Shorgrasses and threeawns are common. Succulents and other shrubs are common, especially on south-facing slopes and include fairy duster, feather dalea, and rough menodora. Prominent succulents are agave (Schott, Palmer), sotol, sacahuista, pricklypear, and banana yucca. Trees may or may not be present; can include one seed juniper, rosewood, and mesquite.	Several species of shrubs are well represented on the site. Shrubs can be in concentrations at the edges of rock outcrops and in canyon bottoms. Most of the grass and shrub species are well dispersed throughout the plant community, but a few species (black grama, New Mexico feathergrass, amole, sandpaper bush and mariola) grow in patches that vary in size and are not well dispersed over larger areas of the site. Natural fire was a factor in the development of the potential plant community. In the absence of wildfire and/or with overgrazing, shrubs increase to dominate the plant community. Well-developed gravel and cobble covers protect the soil from erosion and help protect forage species from heavy utilization. The frequency of natural fire on this site was about once every ten years. The large amount of rock outcrop on the site tends to magnify water received by adjacent soil areas. South-facing slopes often exhibit low grass cover, even when adjacent north-facing slope are grass-covered. Limestone hills sites often exhibit less shrub cover and more grass cover than adjacent hills sites, indicating the favorable properties of rocky, limestone-derived soils for grasses.	Basal: Grass 2-5 Forb 0-1 Shrubs 2-5 Trees 0 Canopy: Grass 10-20 Forb 1-5 Shrubs 5-15 Trees 0-5 Litter: 10-25 Large Fragments: 25-50 Small Fragments: 0-8 Bedrock: 0-15 Bare ground: 5-60

Comparison of Ecological Sites Near Rosemont Site

Ecological Site and Soil Types	NRCS Over / Under Story	Dominants in most common historic, climax plant community type	Site Description and Ecological Dynamics	Cover
Limy Slopes 16-20” 4700-5500’ Soil types: Very cobbly sandy loam; Gravely loam	littleleaf ratany - featherplume / black grama - New Mexico feathergrass	Dominated by sideoats grama, black grama, wooly bunchgrass, crinkleawn, and New Mexico feathergrass. Threeawn and other short grasses are common. Soapweed yucca and sacahuista are the dominant yucca-type plants; other succulents are not major components on this ecological site. Trees may or may not be present; these include Mexican blue oak, Arizona white oak, and Emory oak.	The potential plant community on this site is dominated by warm season perennial grasses with a fair component of cool season perennial grasses and half shrubs. Cool season grasses tend to be clumped on the site and not evenly dispersed in the community. Several species of shrubs, cacti, other succulents and forbs are represented in the plant community. The aspect is open grassland to savannah. With continuous heavy grazing, cool season grasses and warm season mid-grasses are removed from the plant community and replaced by unpalatable species like red and blue threeawn. With severe deterioration, shrubby species like wait-a-bit mimosa, one seed juniper and sotol can increase to dominate the site. Mesquite, whitethorn acacia and Lehmann lovegrass can invade the community and increase to dominate. Naturally occurring fires in June-August are an important factor in shaping this plant community. Fire-free intervals range from 10-20 years. Without periodic disturbance, like grazing or fire, perennial mid-grasses can become decadent and forbs like herbaceous sage and cudweed can increase to dominate the plant community. This site is one of the principle habitats for beargrass. Periodic drought can occur and cause significant grass mortality. Droughts in the early 1930s, mid-1950s, 1975-76, 1988-89, 95-96 and 2002 resulted in the loss of much of the grass cover on this site. The site recovers rapidly, however, due to covers of gravel and cobble and the good prevailing climate.	Basal: Grass 8-20 Forb 0-1 Shrubs 1-5 Trees 0 Canopy: Grass 15-30 Forb 1-5 Shrubs 1-5 Trees 0-2 Litter: 30-60 Large Fragments: 10-45 Small Fragments: 0-5 Bedrock: 0 Bare ground: 5-20

Comparison of Ecological Sites near Rosemont Site

Ecological Site and Soil Types	NRCS Over / Under Story	Dominants in most common historic, climax plant community type	Site Description and Ecological Dynamics	Cover
Granitic Hills 12-16" 3500-5500' Soil types: Sandy loam to Clay loam.	Bastardsage - Fairyduster / Sideoats grama - White sagebrush	Dominated by warm season grasses: black grama and sideoats grama with a strong component of cane beardgrass and plains lovegrass. Arizona cottontop and taglehead are also generally present as well as New Mexico feathergrass (cool season). Short grasses and threeawns are common. Increaser shrubs include turpentine bush and broom snakeweed. Common succulents are Palmer agave, Schott agave, and Englemann pricklypear. Trees are not dominant but include one seed juniper, velvet mesquite, and Arizona rosewood can be present.	The potential plant community on this site is dominated by warm season perennial grasses. Several species of low shrubs are well represented on the site, but the aspect is grassland dotted with shrubs and cacti. Larger species of shrubs are concentrated at the edges of rock outcrop areas and in canyon bottoms. Most of the grass and low shrub species are well dispersed throughout the plant community. In the absence of wildfire and/or with overgrazing, shrubs increase to dominate the plant community. Well-developed gravel and cobble covers protect the soil from erosion and protect forage species from heavy use. Natural fire was an important factor in development of the potential plant community; having frequencies of about once every ten years. Fires helped maintain a balance between grasses, forbs and shrubs. With continuous heavy grazing palatable forage species diminish in the plant community and can be replaced by shrubs and succulents. Areas of rock outcrop are little grazed and hold remnant perennial forage species to help reseed the slopes below once grazing is managed. Lehmann lovegrass can occur due to a seed source associated with roads and off-road trails running though the site. The invasion is slow until the area burns; then Lehmann lovegrass can rapidly assume dominance of the plant community. There will always be some diversity of native species left on the site due to diverse habitats in areas of rock outcrop and canyon bottoms. Shrubs and mimosa can increase where wait-a-bit mimosa, velvet pod mimosa and other shrubs like mesquite, ocotillo and succulents like prickly pear have increased to dominate the site. All three species are vigorous sprouters after fire and quickly re-assume dominance after burning. Climatic warming seems to be driving the increases of the mimosa species. Periodic fire will not return this state to a grassy condition once shrubs are well established.	Basal: Grass 3-7 Forb 0-1 Shrubs 2-4 Trees 0 Canopy: Grass 10-20 Forb 1-10 Shrubs 5-10 Trees 0-2 Litter: 25-45 Large Fragments: 25-50 Small Fragments: 0-10 Bedrock: 0-10 Bare ground: 5-40

Comparison of Ecological Sites near Rosemont Site

Ecological Site and Soil Types	NRCS Over / Under Story	Dominants in most common historic, climax plant community type	Site Description and Ecological Dynamics	Cover
Clay loam Uplands 12 – 16” 3200-5000’ Soil types: Very gravely clay loam; clay loam; Gravely sandy loam.	Bastardsage - Fairyduster / Sideoats grama - White sagebrush	Dominated by sideoats grama, Tobosa, cane beardgrass, and sometimes a strong component of plains lovegrass. Grama and threeawn grasses can be prevalent, as can annual grasses. Shrubs may or may not be present in appreciable numbers. Trees are generally not a major component in this ecological site.	The potential plant community on the site is dominated by warm season perennial grasses. Most of the major perennial grass species on the site are well dispersed throughout their plant community. However, tobosa, vine mesquite, and curly mesquite tend to occur in patches on this site. These patches appear to be well dispersed and are variable in size. Perennial forbs are well represented on the site, as well as a few species of low shrubs. The aspect is open grassland. With continuous grazing, palatable perennial grasses like plains lovegrass, blue, black and sideoats grama decrease and species like tobosa and curly mesquite increase. Severe drought can reduce short grasses to very low levels. Drought - fire combinations can reduce perennial grass cover and allow annual herbs to become dominant for a short time (2-4 years) until grasses can recover. Due to heavy surface soil textures, this site can be an inefficient user of intense summer rainfall when the perennial grass cover has been removed or greatly reduced. Mesquite, when present on the site, tends to be shrubby due to the presence of clay horizons at shallow depths. Natural fire was important in the development of the potential plant community.	Basal: Grass 6-25 Forb 0-1 Shrubs 1-2 Trees 0 Canopy: Grass 10-20 Forb 0-2 Shrubs 1-5 Trees 0-1 Litter: 10-60 Large Fragments: 5-45 Small Fragments: 0-5 Bedrock: 0-0 Bare ground: 15-25

Comparison of Ecological Sites near Rosemont Site

Ecological Site and Soil Types	NRCS Over / Under Story	Dominants in most common historic, climax plant community type	Site Description and Ecological Dynamics	Cover
Loamy Slopes 16-20" 4500-5500' Soil types: Cobbly sandy loam; Very gravely loam; Gravely loam	Palmer's agave - sacahuista / Sideoats grama - Plains lovegrass	Dominant species in climax are very productive and consist of mid-grasses: sideoats grama, plains lovegrass, and green sprangletop. Other prominent grasses may include cane beardgrass, taglehead, and gramas. Shrubs are generally not abundant; can include fairy duster. Palmer agave and sacahuista are the prominent succulents. Trees may or not be present depending on microclimate; can include Mexican blue oak, Arizona white oak, and Emory oak.	The potential plant community on this site is dominated by warm season perennial mid-grasses. The major grass species are well dispersed throughout the plant community. Stands of Palmer agave occur in dense patches and are not well dispersed through areas of the site and several species of low shrubs, cacti and other succulents, and forbs are well represented. The aspect is open grassland to savannah. North slopes will often have an open canopy of oaks and / or juniper. South slopes will be agave dotted grassland. With continuous, heavy grazing, mid-grasses are removed from the plant community and replaced by short grasses such as curly mesquite, slender grama and sprucetop grama. With severe deterioration, shrubby species such as wait-a-bit mimosa, one seed and alligator juniper, and mesquite can increase to dominate the site. With good management, native mid-grasses will be able to regain their dominance in the plant community, unless soil erosion is severe enough to strip away the surface horizon. Mesquite and Lehmann lovegrass are at the upper limits of their elevation range, but can increase on the site, especially below 5000 feet elevation and on southern exposures. Climatic warming may allow these two species to push higher in elevation as time goes by. Naturally occurring fires in June-August were an important factor in shaping this plant community. Fire-free intervals range from 10-20 years. Without disturbance like grazing or fire, perennial mid-grasses can become decadent and forbs like annual goldeneye, cudweed and camphorweed can increase to dominate the plant community. This site is the principal habitat for the Agave palmeri in southeastern Arizona, an important food source for the endangered lesser long-nosed bat in June, July, and August. Nectar production in these stands ranges from 6-10 gallons per acre. Periodic drought can occur and cause significant grass mortality. Droughts in the early 1930s, mid 50s, 1975-1976, 88-89, 95-96 and 2002 resulted in the loss of much of the grass cover on this site. The site recovers rapidly, however, due to excellent covers of stone, cobbles and gravel and the favorable climate that prevails in this common resource area.	Basal: Grass 8-15 Forb 0-1 Shrubs 1-2 Trees 0-1 Canopy: Grass 15-30 Forb 1-20 Shrubs 1-10 Trees 0-5 Litter: 20-50 Large Fragments: 15-45 Small Fragments: 0-5 Bedrock: 0-0 Bare ground: 15-40

Attachment B

Photographs of NRCS Ecological Sites and Project Area Photographs

Targeted Vegetation Types (NRCS Ecological Site Description Photos)

1) Semi-Desert Grasslands on east-facing slopes

2) Semi-Desert Grasslands on level ground (savanna)

3) Semi-Desert Grasslands on north-facing slopes (dispersed woodlands)

4) **Semi-Desert Grasslands with increased rock cover**

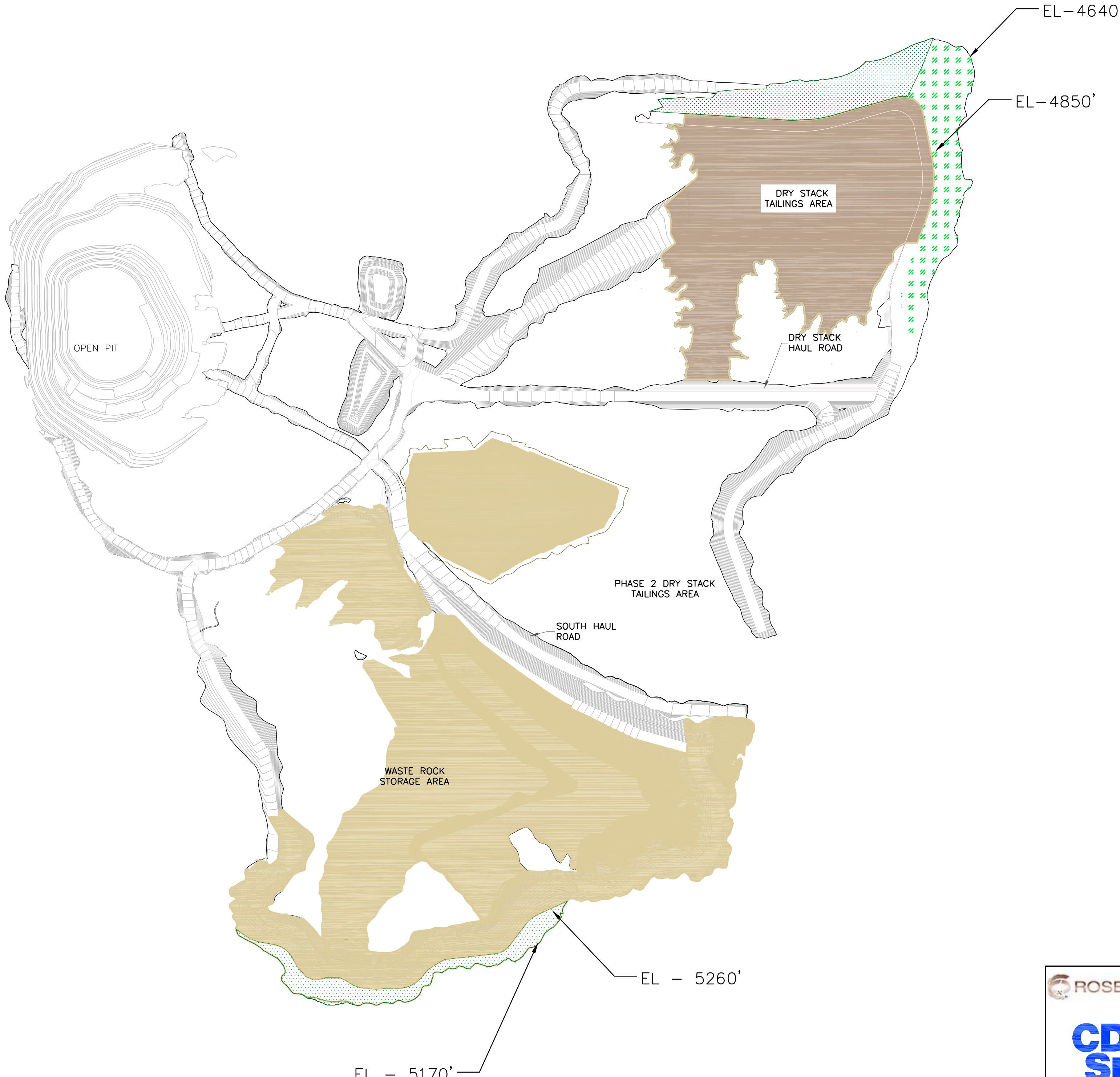
5) Semi-Desert Grasslands on south-facing slopes (the succulents)

6) Semi-Desert Grasslands on west-facing slopes

Targeted Vegetation Types (Rosemont Project area).		
 **1) Semi-Desert Grasslands on east-facing slopes**	 **2) Semi-Desert Grasslands on level ground (savanna)**	 **3) Semi-Desert Grasslands on north-facing slopes (dispersed woodlands)**
 4) **Semi-Desert Grasslands with increased rock cover**	 **5) Semi-Desert Grasslands on south-facing slopes (succulents added)**	 **6) Semi-Desert Grasslands on west-facing slopes in foreground**

Attachment C

Sequence of Vegetation Establishment on the Landform



SEMI-DESERT GRASSLAND ON LEVEL GROUND (SAVANNA)
SEMI-DESERT GRASSLAND ON NORTH-FACING SLOPES (DISPERSED WOODLAND)
SEMI-DESERT GRASSLAND ON EAST-FACING SLOPES
SEMI-DESERT GRASSLAND ON WEST-FACING SLOPES
SEMI-DESERT GRASSLAND ON SOUTH-FACING SLOPES (SUCCULENTS ADDED)
SEMI-DESERT GRASSLAND WITH INCREASED ROCK COVER (STEEP, ROCKY SLOPES)

*NOTE: THE INFORMATION PROVIDED ON THIS FIGURE IS A CONCEPTUAL-LEVEL REPRESENTATION OF THE AREAL EXTENT OF THE VEGETATION TYPES EXPECTED ON THE RECLAIMED LANDFORM. THE AREAL EXTENT AND ELEVATION LIMITS FOR THESE AREAS WILL CHANGE BASED ON ACTUAL CONSTRUCTION AND RECLAMATION ACTIVITIES.

YEAR ONE REVEGETATION TYPES

VEGETATION TYPE	TOTAL (ACRES)
SEMI-DESERT GRASSLAND ON NORTH-FACING SLOPES (DISPERSED WOODLAND)	41
SEMI-DESERT GRASSLAND ON EAST-FACING SLOPES	48
SEMI-DESERT GRASSLAND ON SOUTH-FACING SLOPES (SUCCULENTS ADDED)	26

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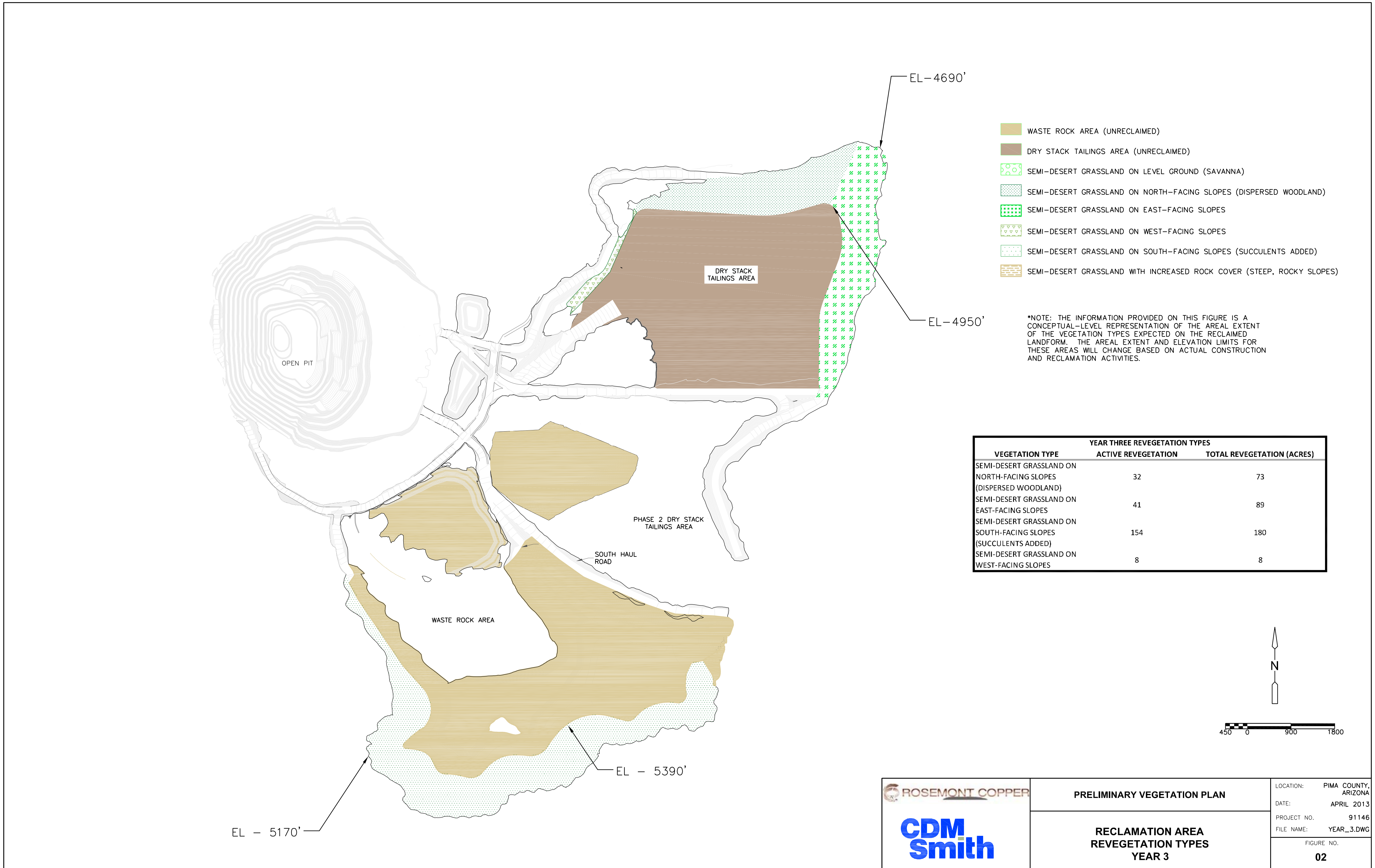
CDM Smith

PRELIMINARY VEGETATION PLAN

RECLAMATION AREA REVEGETATION TYPES YEAR 1

LOCATION: PIMA COUNTY, ARIZONA
DATE: APRIL 2013
PROJECT NO. 91146
FILE NAME: YEAR_1.DWG
FIGURE NO. 01

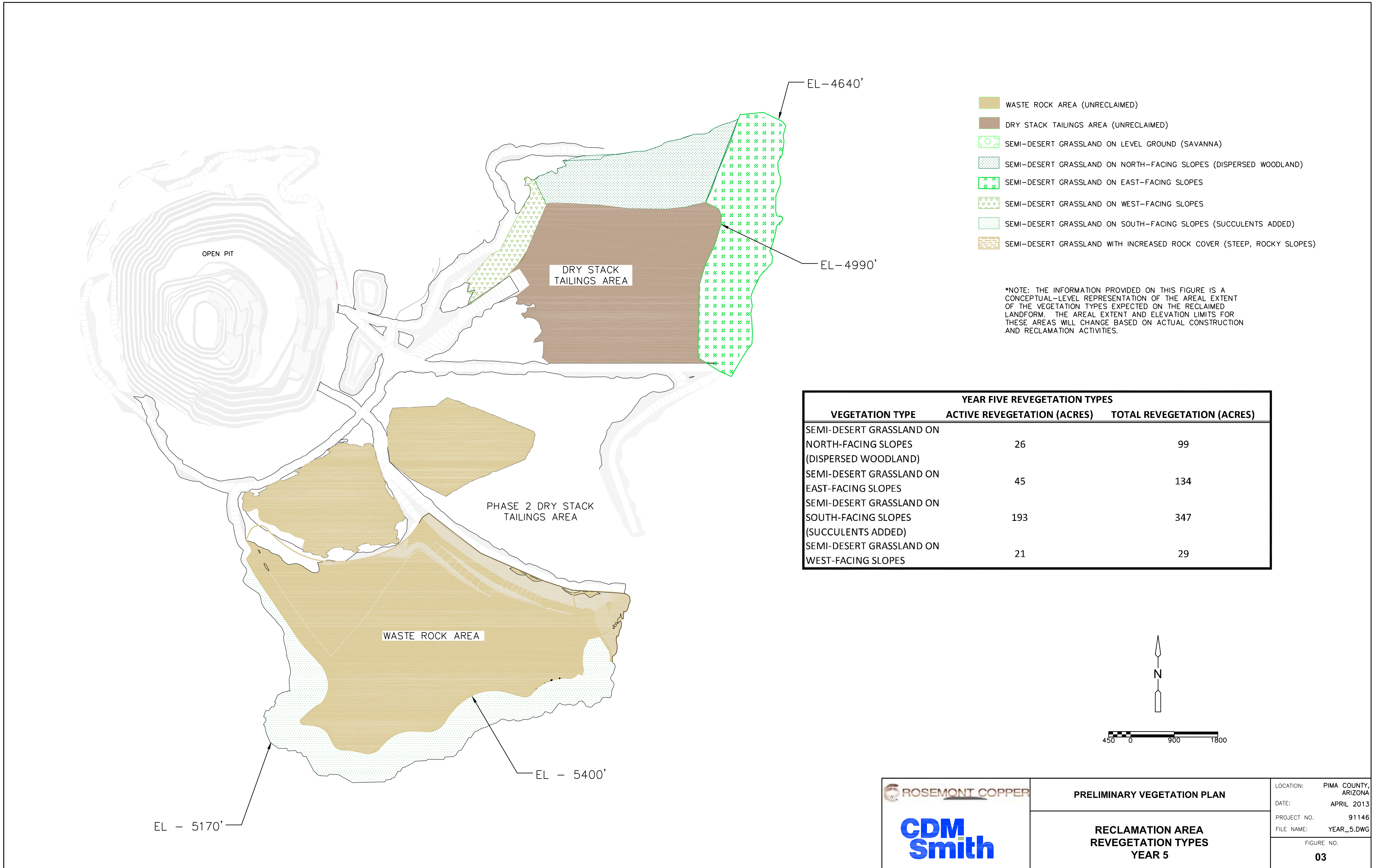
VSS 1. Revegetation areas at Year 1 of Operations.



YEAR THREE REVEGETATION TYPES

VEGETATION TYPE	ACTIVE REVEGETATION	TOTAL REVEGETATION (ACRES)
SEMI-DESERT GRASSLAND ON NORTH-FACING SLOPES (DISPERSED WOODLAND)	32	73
SEMI-DESERT GRASSLAND ON EAST-FACING SLOPES	41	89
SEMI-DESERT GRASSLAND ON SOUTH-FACING SLOPES (SUCCULENTS ADDED)	154	180
SEMI-DESERT GRASSLAND ON WEST-FACING SLOPES	8	8

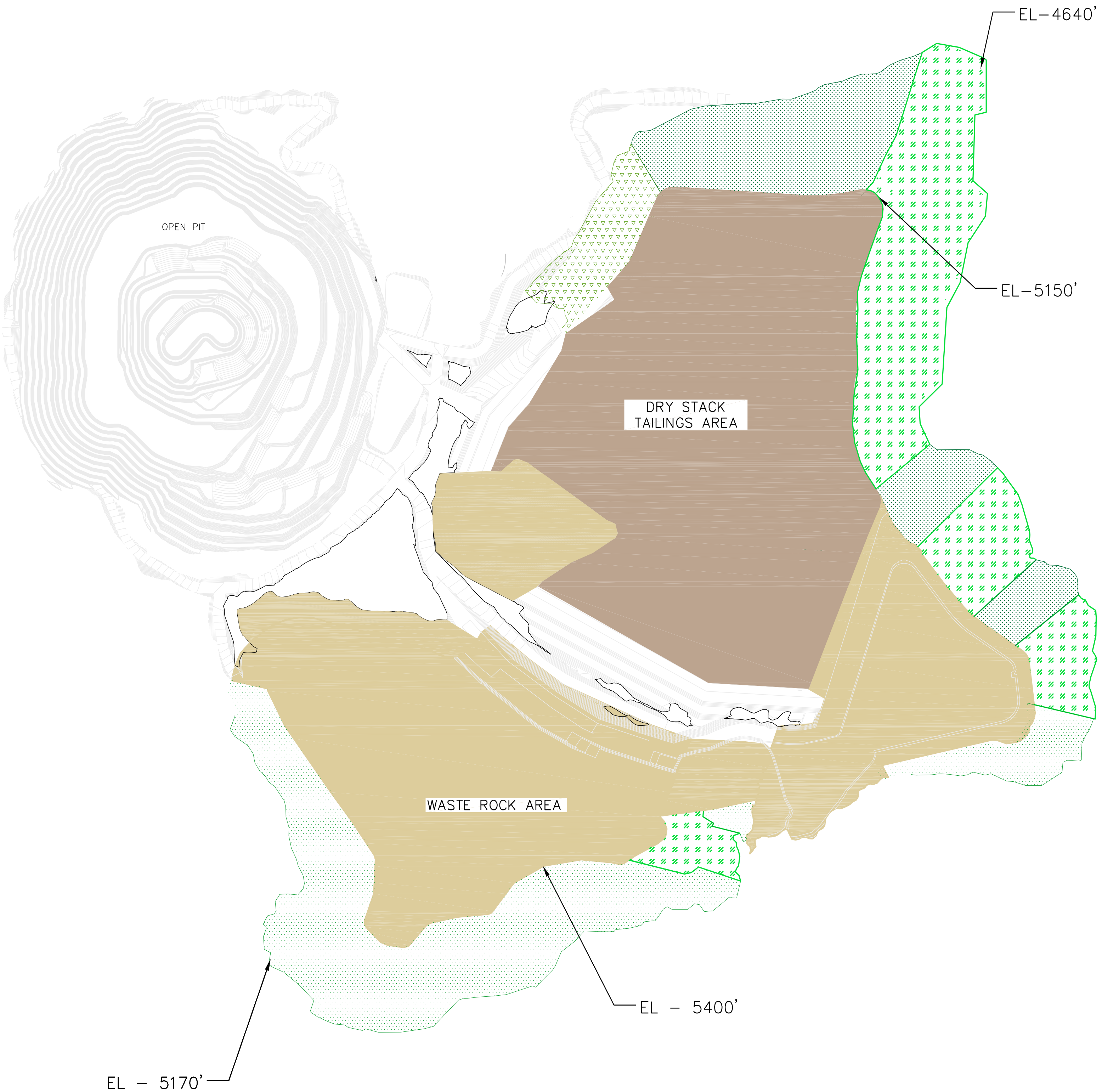
VSS 2. Revegetation areas at Year 3 of Operations.



YEAR FIVE REVEGETATION TYPES

VEGETATION TYPE	ACTIVE REVEGETATION (ACRES)	TOTAL REVEGETATION (ACRES)
SEMI-DESERT GRASSLAND ON NORTH-FACING SLOPES (DISPERSED WOODLAND)	26	99
SEMI-DESERT GRASSLAND ON EAST-FACING SLOPES	45	134
SEMI-DESERT GRASSLAND ON SOUTH-FACING SLOPES (SUCCULENTS ADDED)	193	347
SEMI-DESERT GRASSLAND ON WEST-FACING SLOPES	21	29

VSS 3. Revegetation areas at Year 5 of Operations.



WASTE ROCK AREA (UNRECLAIMED)
DRY STACK TAILINGS AREA (UNRECLAIMED)
SEMI-DESERT GRASSLAND ON LEVEL GROUND (SAVANNA)
SEMI-DESERT GRASSLAND ON NORTH-FACING SLOPES (DISPERSED WOODLAND)
SEMI-DESERT GRASSLAND ON EAST-FACING SLOPES
SEMI-DESERT GRASSLAND ON WEST-FACING SLOPES
SEMI-DESERT GRASSLAND ON SOUTH-FACING SLOPES (SUCCULENTS ADDED)
SEMI-DESERT GRASSLAND WITH INCREASED ROCK COVER (STEEP, ROCKY SLOPES)

*NOTE: THE INFORMATION PROVIDED ON THIS FIGURE IS A CONCEPTUAL-LEVEL REPRESENTATION OF THE AREAL EXTENT OF THE VEGETATION TYPES EXPECTED ON THE RECLAIMED LANDFORM. THE AREAL EXTENT AND ELEVATION LIMITS FOR THESE AREAS WILL CHANGE BASED ON ACTUAL CONSTRUCTION AND RECLAMATION ACTIVITIES.

YEAR TEN REVEGETATION TYPES		
VEGETATION TYPE	**ACTIVE REVEGETATION (ACRES)**	**TOTAL REVEGETATION (ACRES)**
SEMI-DESERT GRASSLAND ON NORTH-FACING SLOPES (DISPERSED WOODLAND)	70	169
SEMI-DESERT GRASSLAND ON EAST-FACING SLOPES	136	270
SEMI-DESERT GRASSLAND ON SOUTH-FACING SLOPES (SUCCULENTS ADDED)	39	386
SEMI-DESERT GRASSLAND ON WEST-FACING SLOPES	26	47

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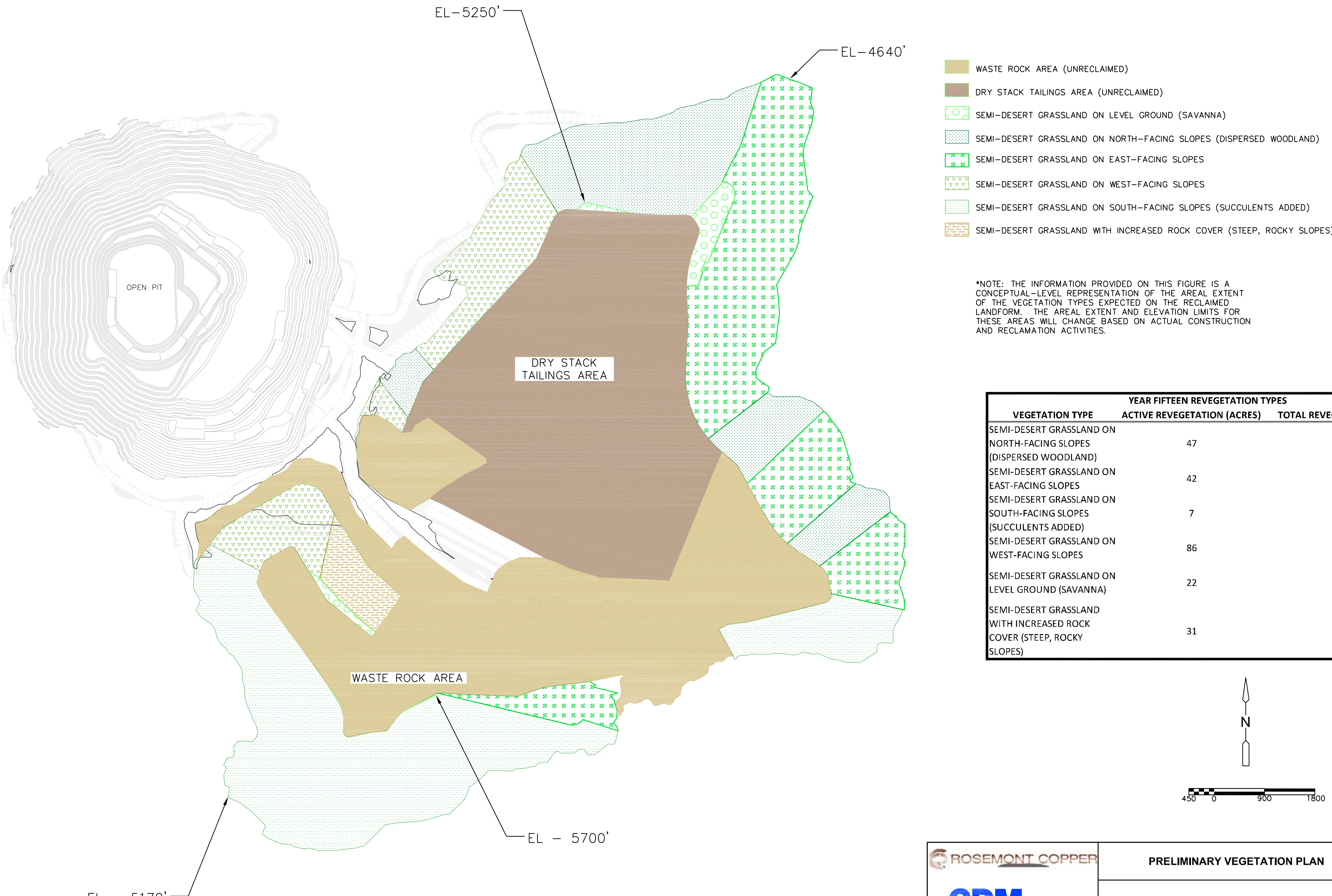
PRELIMINARY VEGETATION PLAN

RECLAMATION AREA REVEGETATION TYPES YEAR 10

LOCATION: PIMA COUNTY, ARIZONA
DATE: APRIL 2013
PROJECT NO. 91146
FILE NAME: YEAR_10.DWG
FIGURE NO. **04**

VSS 4. Revegetation areas at Year 10 of Operations.



*NOTE: THE INFORMATION PROVIDED ON THIS FIGURE IS A CONCEPTUAL-LEVEL REPRESENTATION OF THE AREAL EXTENT OF THE VEGETATION TYPES EXPECTED ON THE RECLAIMED LANDFORM. THE AREAL EXTENT AND ELEVATION LIMITS FOR THESE AREAS WILL CHANGE BASED ON ACTUAL CONSTRUCTION AND RECLAMATION ACTIVITIES.

YEAR FIFTEEN REVEGETATION TYPES

VEGETATION TYPE	ACTIVE REVEGETATION (ACRES)	TOTAL REVEGETATION (ACRES)
SEMI-DESERT GRASSLAND ON NORTH-FACING SLOPES (DISPERSED WOODLAND)	47	216
SEMI-DESERT GRASSLAND ON EAST-FACING SLOPES	42	312
SEMI-DESERT GRASSLAND ON SOUTH-FACING SLOPES (SUCCULENTS ADDED)	7	393
SEMI-DESERT GRASSLAND ON WEST-FACING SLOPES	86	133
SEMI-DESERT GRASSLAND ON LEVEL GROUND (SAVANNA)	22	22
SEMI-DESERT GRASSLAND WITH INCREASED ROCK COVER (STEEP, ROCKY SLOPES)	31	31

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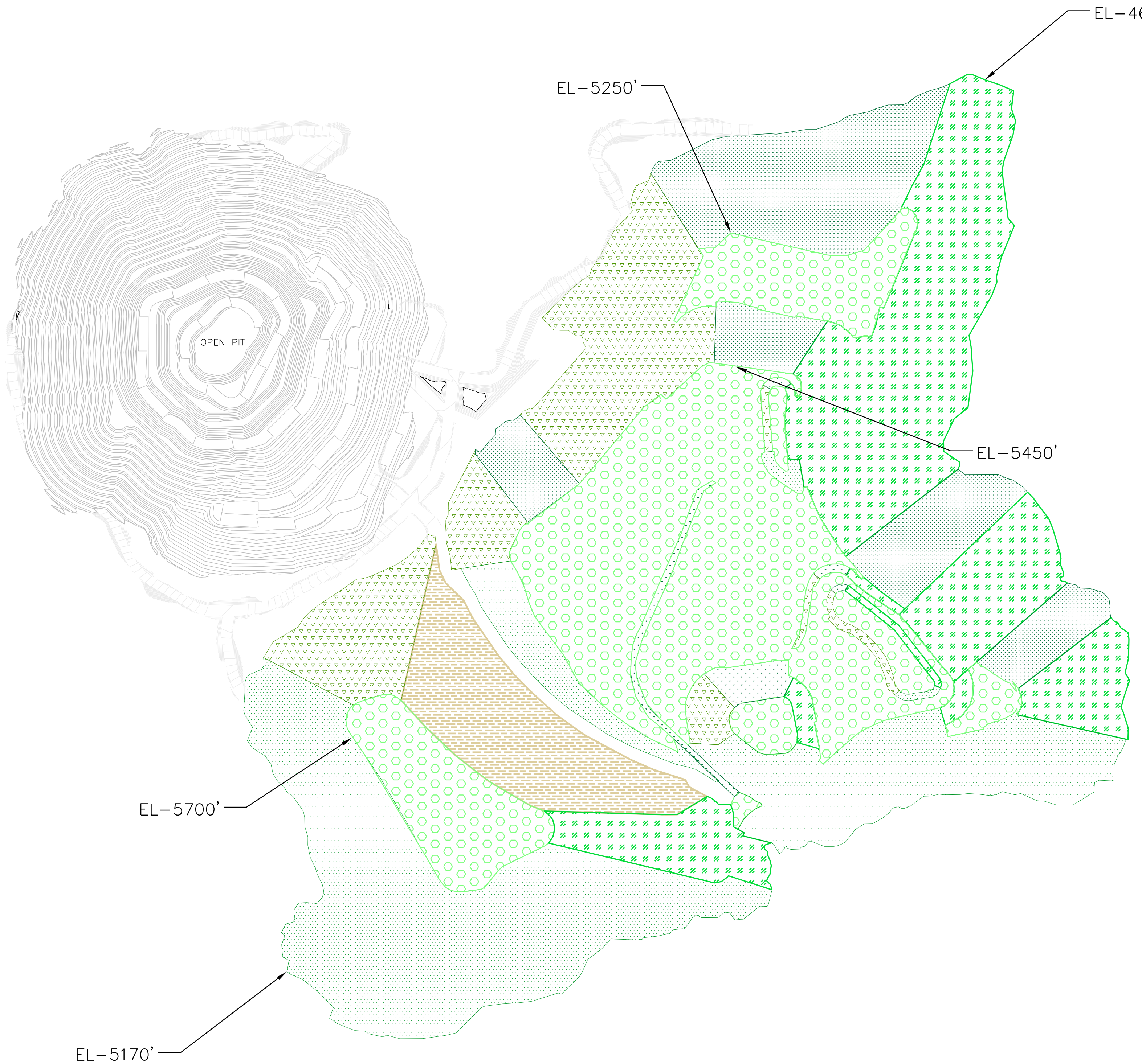
PRELIMINARY VEGETATION PLAN

RECLAMATION AREA REVEGETATION TYPES YEAR 15

LOCATION: PIMA COUNTY, ARIZONA
DATE: APRIL 2013
PROJECT NO. 91146
FILE NAME: YEAR_15.DWG
FIGURE NO. **05**

VSS 5. Revegetation areas at Year 15 of Operations.



YEAR TWENTY TWO REVEGETATION TYPES

VEGETATION TYPE	ACTIVE REVEGETATION (ACRES)	TOTAL REVEGETATION (ACRES)
SEMI-DESERT GRASSLAND ON NORTH-FACING SLOPES (DISPERSED WOODLAND)	87	303
SEMI-DESERT GRASSLAND ON EAST-FACING SLOPES	122	434
SEMI-DESERT GRASSLAND ON SOUTH-FACING SLOPES (SUCCULENTS ADDED)	149	542
SEMI-DESERT GRASSLAND ON WEST-FACING SLOPES	117	250
SEMI-DESERT GRASSLAND ON LEVEL GROUND (SAVANNA)	581	603
SEMI-DESERT GRASSLAND WITH INCREASED ROCK COVER (STEEP, ROCKY SLOPES)	101	132

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PRELIMINARY VEGETATION PLAN

REVEGETATION TYPES
YEAR 22

LOCATION: PIMA COUNTY, ARIZONA
DATE: APRIL 2013
PROJECT NO. 91146
FILE NAME: YEAR_22.DWG
FIGURE NO. 06

VSS 6. Revegetation areas at Year 22 of Operations

APPENDIX B

Rosemont Reference & Reclaimed Area Sampling Protocol
(memorandum by CDM Smith dated July 23, 2013)

Memorandum

To: *Kathy Arnold, Vice President, Rosemont Copper Company*

From: *Bob Rennick, CDM Smith*
Brian Antonioli, CDM Smith

Date: *July 23, 2013*

Subject: *Rosemont Reference & Reclaimed Area Sampling Protocol*

Introduction

This memorandum describes the protocol that Rosemont Copper Company (Rosemont) will use to select and sample reference areas in undisturbed locations adjacent to the Rosemont Copper Project (Project). These reference areas will ideally be used throughout the life of the Project to help determine reclamation success on areas such as the landform (Landform) created by development of the Waste Rock Storage Area and the Dry Stack Tailings Facility. This memorandum also describes the sampling protocol that will be used to monitor revegetated areas on the reclaimed Landform. Although there are several alternatives being evaluated in the environmental impact statement (EIS), the discussions herein are focused on the Barrel Alternative as an example.

Soils salvaged from within the footprint of the Project facilities will be used to reclaim the Landform and other disturbed areas that result from Project activities. Based on the Natural Resources Conservation Service (NRCS) data, soil surveys were used to derive six (6) distinct ecological sites present in the Project area. Ecological sites are defined by soil type, physical features of the site, and resulting vegetation conditions (plant class structure, cover, and production) and are described in the NRCS ecological site descriptions (ESDs). Figure 1 shows the Rosemont Project site with mapped NRCS ecological sites. There is a direct relationship between the NRCS soils and the NRCS ESDs. That is, the NRCS used the mapped soil types to define the boundaries of the ecological sites. Since the soil survey boundaries are only approximate, vegetation characteristics within these areas (as defined in the ecological sites) are considered general. Outlines of the Barrel Alternative Landform and associated Open Pit are also shown.

Ongoing reclamation test plot work by the University of Arizona (U of A), and geological surveys, have classified the two (2) dominant soil types that will be used in reclamation as Arkose (or Willow Canyon Formation) and Gila Conglomerate. These classifications are based on the rock material from which the soils were derived. The Arkose soil is associated with the Granitic Hills ESD (Granitic Hills ecological site with 12-16" annual precipitation) while Gila Conglomerate is associated with the Limy Slopes ESD (Limy Slopes ecological site with 16-20" annual precipitation).

It is anticipated that the soils placed on the reclaimed surfaces of the Landform, and in other areas requiring reclamation, will generally match the soil types associated with one of these two (2) ecological sites.

As seen in Figure 1, the Clay Loam Upland ecological site also occurs in the center of the Landform. A review of the Tetra Tech soil sample data indicates that only a portion of the soil samples collected from this area actually classify as clay loam. Most of the soils in this area classify as loam, silt loam, sandy loam, and sandy clay loam and are therefore more characteristic of soils in the Granitic Hills and Limy Slopes ESDs.

As areas of the Landform are reclaimed, soil classification will be initially determined to verify consistencies with the soil types (texture and coarse fragment content) associated with either the Granitic Hills or Limy Slopes ESDs. Should large areas be covered with soils not matching either the Granitic Hills or Limy Slopes ESDs, soils may be grouped with the ESD most closely resembling that soil, or additional reference areas on undisturbed ground may need to be established that match the placed soil type. This could potentially be the case with soil having a mixture of Granitic Hills or Limy Slopes soil characteristics.

Slope aspect has a large influence on soils and vegetation in Southern Arizona. North-facing slopes receive less sunlight and experience less evaporation, thereby making more soil moisture available than other slope aspects. With more available soil moisture, shrubs and trees favor north-facing slopes. In contrast, the south-facing slopes receive more sunlight and have less available soil moisture. Shallower soils with fewer nutrients contribute to additional cacti and succulents observed on south-facing slopes and grasslands occur on east- and west-facing slopes as well as drier convex slopes. Overall, soil characteristics and slope aspect are expected to have the strongest influence on vegetation. Sampling will be divided according to soil type (which can be connected to an ecological site) and slope aspect for the most comparable results of the reference areas to the revegetated areas on the Landform.

Reference Area Selection Criteria

Potential reference areas in their respective ecological sites will be selected through a collaborative effort consisting of representatives from Rosemont and the Forest Service (Forest), or other groups as needed such as the NRCS (collectively referred herein as the Monitoring Group). Reference areas with the most similar site characteristics to the planned Landform, such as slope gradient, aspect, soils, and plant community, will provide the most direct and appropriate comparisons.

Reference areas will be selected to encompass various slope aspects, such as north- and south-facing slopes, of similar steepness to the Landform (3H:1V slopes) to account for the different aspects and gradients anticipated on the Landform. Based on the Tetra Tech soil data and vegetation characteristics within the ecological sites, as well as discussions with the Forest Service, reference areas will be located within the Granitic Hills and Limy Slopes ecological sites to compare soils and vegetation characteristics to that on the Landform. Reference areas in additional ecological sites may be located at a later date if deemed necessary by the Monitoring Group.

For each selected ecological site, a minimum of three (3) replicates of undisturbed reference areas will be selected to describe the baseline vegetation conditions that will eventually be used to determine reclamation success on the respective areas of the Landform. Each of the selected reference areas will encompass about 100 acres. Within each reference area, four (4) slope aspects will be selected to represent the reclaimed Landform (north-, south-, and east-, and west facing slopes). If present, a relatively flat area will also be delineated within the reference area to compare with the gentle slopes planned for the top of the Landform. Each slope aspect will encompass approximately three (3) acres. Approximately one (1) acre areas will be sufficient for a flatter slope aspect. Each slope aspect will be stratified, or divided, into sub-areas, which is the sampling unit where the data will be collected (Illustration 1). An example of a reference area in the Granitic Hills and in the Limy Slopes ecological sites can be seen in Figure 1. As noted in Figure 1, the location indicated for a Limy Slopes reference area has topography supporting all five (5) aspects while the potential Granitic Hills reference area has topography that supports only four (4) of the five (5) aspects.

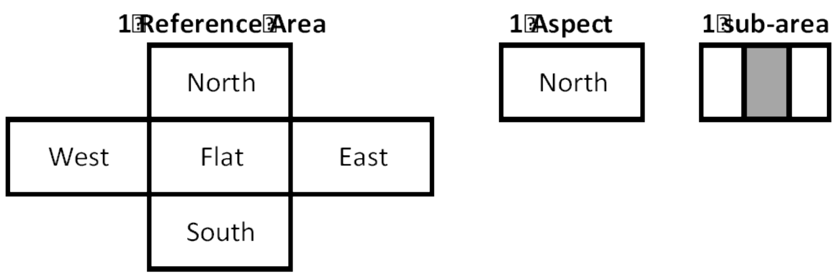
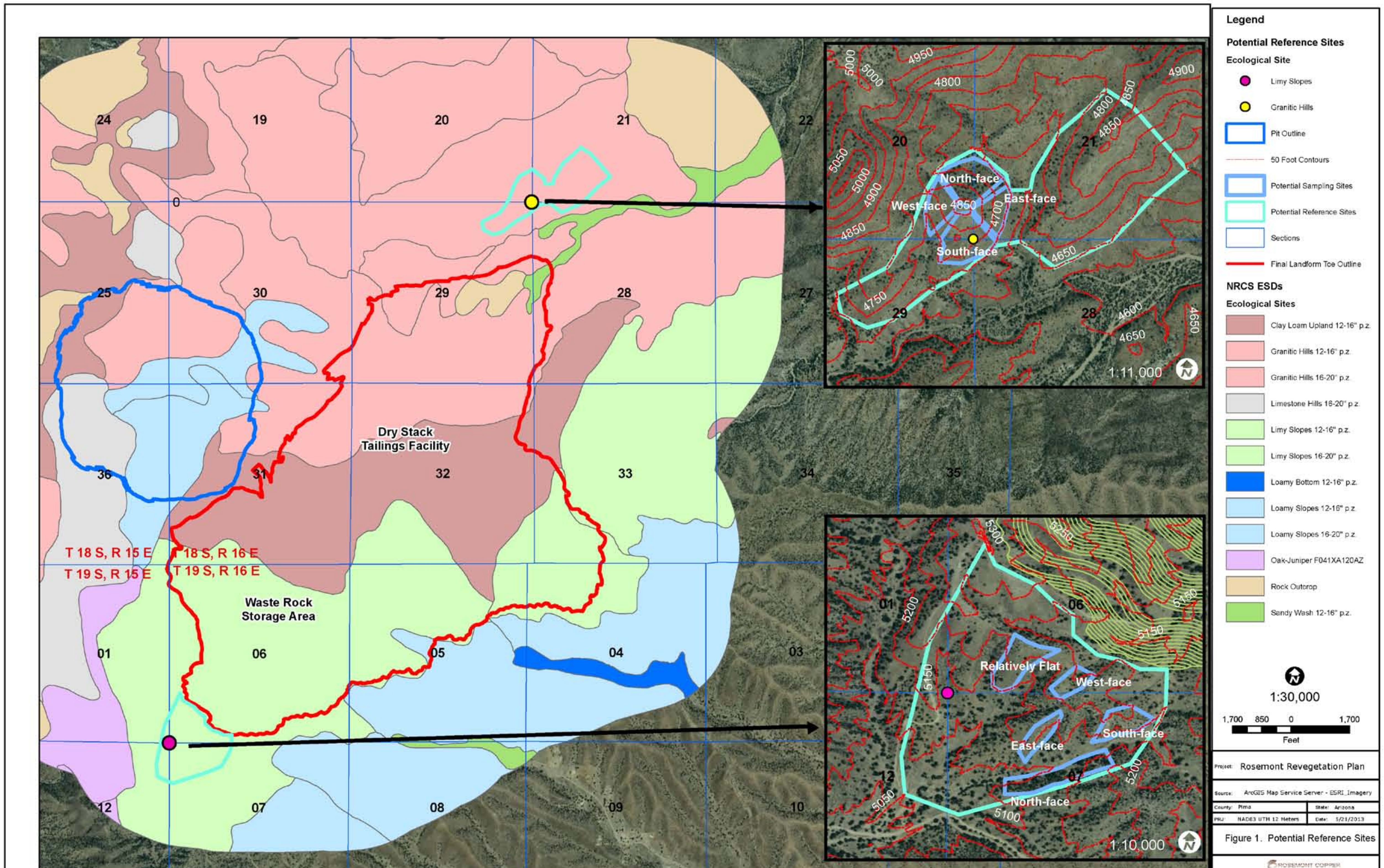


Illustration 1. Sampling Locations.

Multiple sampling units, or sub-areas, within each slope aspect will be selected to address variability in vegetation and site stability. A minimum of three (3) reference areas per ecological site and three (3) transects per slope aspect will be used to decrease the standard error and to increase the confidence interval. Statistics will be calculated to determine the variability between transects, replicates, and sub-areas. Results will provide a range of possible outcomes when applying the reclamation success criteria to the reclaimed site.

Figure 1. Potential Reference Areas & Ecological Sites within the Rosemont area.



Site Characterization and Condition

Once potential reference areas are selected (outside of the footprint of the Project facilities), sampling will be conducted to confirm that the selected locations match the targeted NRCS ESDs using soil characterization (Attachment 1) and physical features of the site. The rangeland health assessment methodology described in the inter-agency document *Interpreting Indicators of Rangeland Health* (Pellant et al. 2005) will be used to evaluate soil and site stability in each of the slope aspects. This assessment will be used to determine similarity in site stability relative to the NRCS Reference Sheet (Attachment 2). The major steps in the evaluation process are:

Step 1 – Determine the soil type (Attachment 1) using the NRCS soil key (NRCS 2010) and the ecological site of the sampling area;

Step 2 – Obtain or develop a Reference Sheet (Attachment 2);

Step 3 – Use the Evaluation Sheet (Attachment 3) to collect supplementary information that may affect site conditions, including grazing or fire; and

Step 4 – Rate the 17 indicators on the Evaluation Sheet (Attachment 3) to determine differences between the sampling site and the determined NRCS ecological site and justify the ratings with written comments. The Evaluation Matrix (Attachment 4) may be used to help compare indicator differences.

Shallow soil pits will be dug throughout the reference areas to characterize the soils. An example of a soil classification data sheet is provided in Attachment 1. Soils will be described and analyzed using *Keys to Soil Taxonomy* (NRCS 2010) and the *Field Book for Describing and Sampling Soils* (NRCS 2012). Evaluated soil characteristics in the field will consist of:

- Soil texture (Approximate Clay, Silt, Sand content)
- Coarse fragment content
- Soil depth of horizons
- Calcium carbonate presence
- Other characteristics identified in the field

Soil data by laboratory analysis will not be needed as the previously collected Tetra Tech (2010) soil data, along with the vegetation response on the U of A test plots, has demonstrated that there are no plant growth limiting factors in the soils found at the Project site. Along with the field soil tests listed above, the NRCS Reference Sheets (provided in Attachment 2) will be used to compare the NRCS-sampled ecological sites to sampling performed on the various slope aspects. Each ecological site has a unique Reference Sheet developed by interagency personnel. If a Reference Sheet is not available, it will be created to cover the information found in Attachment 2. The key to evaluating the soil type will be soil classification, including a determination of texture and coarse fragment content. These sheets also cover other characteristics related to assessing rangeland health, including soil erosion, hydrological, and biological indicators.

Following soil characterization, the potential reference areas will be defined by the NRCS *Soil-Based Key to Ecological Sites*. An initial assessment of a potential site will be made using the Evaluation Sheet (Attachment 3) along with the ESD Reference Sheet (Attachment 2) to determine "Departure from Expected" conditions. This will set the baseline to determine the variability of the potential reference area from the defined ESD. Factors that will be assessed include:

- Soil and Site Stability (presence of water flow patterns, rills, gullies)
- Hydrologic Functions (infiltration, soil surface resistance to erosion)
- Biotic Integrity (invasive species, production, health)

Other factors that may affect site conditions, such as grazing or fire, will also be observed and recorded to better understand the selected reference area. Additional quantitative site stability measurements, including rock cover and bare soil, will be recorded using transects described in the next section.

Sampling Methods and Approach

Vegetation sampling on the reference areas is intended to identify vegetation characteristics that are representative of a stable, undisturbed site that will support the same land uses as the reclaimed Landform, including grazing, recreation, and wildlife habitat. As described above, sampling and information collection on the reference areas will occur within defined sub-areas and the reference areas will be selected for use in comparing vegetation on the reclaimed Landform to determine when an area has been successfully reclaimed. Because vegetation growth is greatly affected by weather conditions, such as precipitation and temperature, these factors will be used to help correlate patterns between the reclaimed sites (Landform) and the undisturbed reference sites. Simple rain gauges will be placed at each of the undisturbed reference sites and at select locations on the reclaimed Landform to collect precipitation data. Other factors may also be considered when determining vegetation success. Some factors may include assessments of:

- Soil and site stability using indicators of rangeland health
- Bare ground
- Plant type (Functional groups) foliar cover
- Species richness
- Perennial plant (including woody species) density and frequency
- Plant type composition

Slope aspects will be delineated using the best professional judgment of the Monitoring Group. The boundaries of these slope aspects will be surveyed using global positioning system (GPS) technology. The slope aspects will then be walked to observe the biological and physical characteristics in order to become familiar with the plant species, soils, surface coarse fragment content, and the variability of these characteristics throughout the slope. A species list of the area will be created to help determine if the areas sampled are representative of the slope aspect and to characterize species diversity. The locations of any observed noxious or invasive weeds will be recorded.

Stratified random sampling will divide each slope aspect into three (3) sub-areas prior to sampling. An example of stratified random sampling can be seen in Illustration 2. One (1), 100-foot transect will be located within the boundaries of each sub-area. Within each slope aspect, three (3) transects will be established (generally running up and down the slope as appropriate). The starting location of each transect will be randomly located within the each sub-area. Each transect end will be permanently marked using metal posts and their locations recorded using GPS.

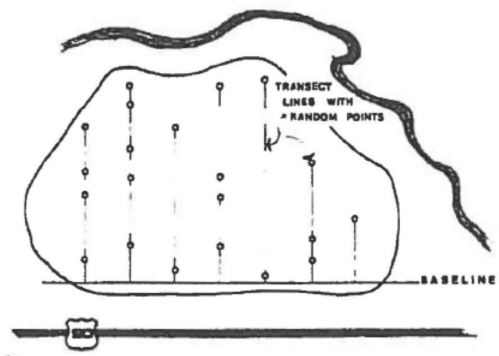


Illustration 2. Stratified Random Sampling (Chambers & Brown 1983).

The collection of data from a minimum of three (3) separate transects in each sub-area will allow the data set to be stratified in order to better assess the variation throughout each slope aspect. Adjustments to the number of transects sampled may be made as determined by the Monitoring Group.

Along each transect, 50 intervals (locations) will be used to collect line-point data and 25 intervals will be used to locate 40-by-40 centimeter quadrats to collect plant density data. The transect sampling points will be spaced two (2) feet apart and the quadrat intervals will be spaced four (4) feet apart. Line-point cover data will include rock, bare ground, plant litter, basal and canopy cover. Line-point cover data will be recorded by vegetation canopy layer along with attributes at the soil surface. The cover form in Attachment 5 shows that line-points will be used to record plant species or types in order of height to capture the top and lower canopy layers. The form also shows that attributes such as rock fragments, bedrock, moss, lichen, bare soil, and litter will be recorded for the soil surface.

Sampling on each transect will begin at the lowest elevation of the transect (i.e., the bottom end on slopes). The side of the transect that is sampled (using the quadrat) will be recorded for future reference.

Macroplots will be used to estimate the density and sizes of woody plant species. One (1) distinct 100-by-100 foot macroplot will be associated with each transect. Trees and shrubs of importance within each macroplot will be counted in categories according to their characteristics. For example, trees will be recorded into the following categories: 0-1 foot in height, 1-5 feet, 5-10 feet, and more than 10 feet high. Other species will be recorded according to their specific characteristics, as determined by the Monitoring Group. As an example, some species, such as Agave, are better characterized by diameter rather than height. Counting of select species within a macroplot will be discontinued when over 50 plants are counted. The sampling frequency of the macroplots will occur once every three (3) to five (5) years or as determined by the Monitoring Group. Subshrubs will also be counted within the macroplots if the density data from the quadrat sampling is inadequate to characterize this plant class. The Monitoring Group will decide which specific species of trees, shrubs, and subshrubs are to be considered in the macroplots (i.e. juniper, mesquites, oaks, and agaves).

The layout of the sampling sites (with replication) can be seen in Illustration 3 (below). The upper part of the illustration indicates the various slope aspects associated with each reference area. The lower part of the illustration shows one slope aspect with three (3) sub-areas, each containing one (1) transect and one (1) macroplot.

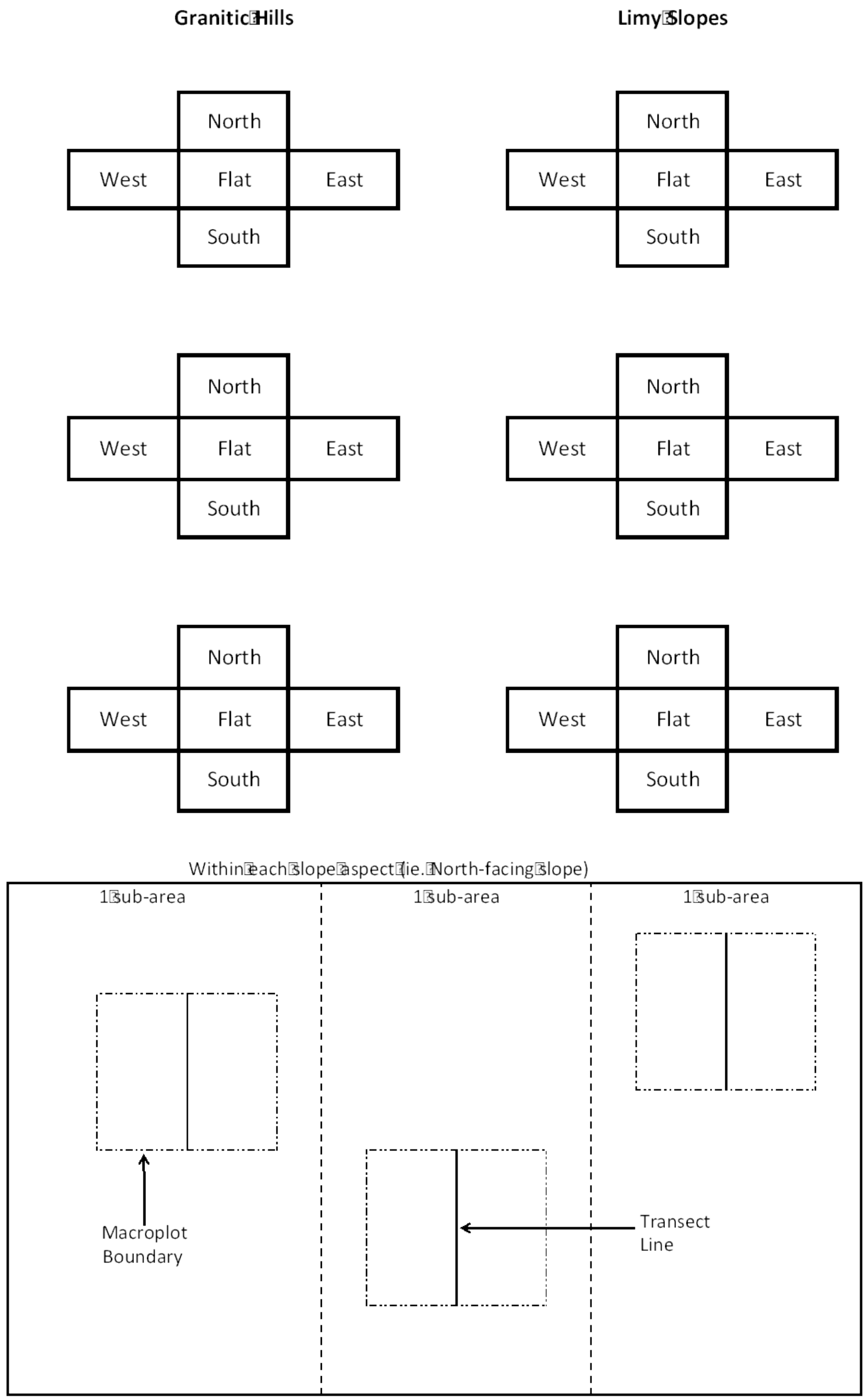


Illustration 3. Sub-Area and Transect Sampling Design Sample Layout.

Assuming that three (3) suitable reference areas can be found that match the Granitic Hills ESD and the Limy Slopes ESD, and that that each site has suitable topography to evaluate the four (4) slope aspects, at least 72 total transects (3 minimum of 3 within each slope aspect) would be evaluated. The following shows a factorial representation of the transect numbers:

2 Ecological Sites X 3 reference areas X 4 aspects X 3 sub-areas X 1 transect (within each sub-area) = 72 transects

In addition to the four (4) slope aspects, one (1) additional evaluation will be made (aspect) that matches the relatively flat (gently rolling) areas of the reclaimed Landform (see Figure 1 for example site). A relatively flat area will be selected within each reference area, if available. This would add at least 18 additional transects.

2 Ecological Sites X 3 reference areas X 1 flat slope aspect X 3 sub-areas X 1 transect (within each sub-area) = 18 transects

Based on this sampling scheme, reference area monitoring would include at least 90 transects. Since there will be a macroplot for each transect, at least 90 macroplots would also be evaluated during applicable years.

Monitoring reference area transects, quadrats, and site stability are anticipated yearly for the first three (3) years. Monitoring thereafter may be adjusted by the Monitoring Group such as every second year or every fifth year, etc., depending on the needs of the Project. Macroplot monitoring is anticipated to occur every fifth year following the same initial schedule.

Once formed, the Monitoring Group will adhere to the appropriate sampling protocol from the guidance list below.

- *Methods for Vegetation Sampling and Analysis on Revegetated Mine Lands. (*Chambers and Brown 1983). USFS - General Technical Report INT – 151, for use of stratified random sampling;
- *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems.* Herrick et al. 2005. USDA – ARS Jornada Experimental Range, Las Cruces, NM, for use in collecting line-point intercept data;
- *Field Book for Describing and Sampling Soils*. NRCS 2012, for use in determining rock and litter cover sizes;
- *Measuring and Monitoring Plant Populations.* (Elzinga et al. 2001). BLM Technical Reference 1730-1. BLM/RS/ST-98/005+1730-1, for the collection of plant density data; and/or
- *Sampling Vegetation Attributes.* (Coulloudon et al 2005). BLM Technical Reference BLM/RS/ST-96/002+1730, for the collection of macroplot data.

Reclaimed Site Sampling

Operations at the Rosemont Project are anticipated to last 22 years. During this time the outer slopes of the Landform will be reclaimed in a staged manner that will be concurrent with operations. Revegetated sites on the reclaimed slopes, and eventually on the top surface, will be selected to monitor revegetation performance and to verify reclamation success. The selection of these Reclaimed Management Areas will be ongoing throughout the duration of the Project and will be selected by Rosemont with input from the Monitoring Group. These Reclaimed Management Areas will be selected to account for each of the various aspects and different soil types.

Monitoring locations will be conducted at discrete locations throughout each of the Reclaimed Management Areas. At each discrete location, an assessment of the site will include the 17 indicators of rangeland health (Pellant et al 2005), including detailed and overview site photographs. The locations of any observed noxious or invasive weeds will be recorded according to an invasive species management plan being prepared by Rosemont.

It is anticipated that a minimum of three (3) transects will be located at each of the selected Reclaimed Management Areas and sampled in the same manner as described for the undisturbed reference sites. During the first and possibly second year following seeding, some plants will be recorded only by plant type due to difficulties in determining species as seedlings. The Monitoring Group will decide where and when (i.e., time after seeding) placement and monitoring of the transects will begin for a given Reclaimed Management Area. When analysis of the data shows that the sites are stable and year-to-year variability is low, the Monitoring Group may determine that the sampling frequency can be reduced. The Monitoring Group will have the ability to combine (consolidate) Reclaimed Management Areas where vegetation and site stability are similar, thus increasing sampling efficiency.

In addition to soil classification, transects, quadrats (quantitative measures), and qualitative measurements, woody species (trees, shrubs, subshrubs) are also anticipated to be measured with macroplots on these reclaimed areas (per acre counts) in a similar manner as conducted for the reference sites. Simple rain gauges will be installed within the Reclaimed Management Areas for comparison to data collected at the undisturbed reference areas.

Bond release for a given Reclamation Management Area would be initiated when revegetation success criteria are met (i.e., when compared to an undisturbed reference area with similar aspect and soil type).

General Sampling Schedule

Reference area and reclaimed site monitoring will occur during the standard time frame for rangeland monitoring in Southern Arizona. Soil characterization may occur during any time of the year. The primary vegetation growth season occurs from July to September, extending into October during some years. This growth season may be referred to as the warm season. Since weather does not conform to calendar dates, it will be necessary to monitor the monsoon rains to determine when to begin to monitor. Generally, vegetation monitoring begins in early September and ends in early- to mid-October.

Data reduction would generally occur immediately following collection to determine if additional data are necessary. If more samples were needed, that information would be collected as soon as possible in order to capture the peak vegetation growth.

References

Chambers, J.C. and R.W. Brown. 1983. Methods for Vegetation Sampling and Analysis on Revegetated Mined Lands. USDA – Forest Service. General Technical Report INT – 151. October 1983.

Coulloudon et al. 1999. Sampling Vegetation Attributes. BLM Technical Reference BLM/RS/ST-96/002+1730.

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Herrick et al. 2005. Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems. USDA – ARS Jornada Experimental Range, Las Cruces, NM.

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Pellant, M., P. Shaver, D.A. Pyke, and J.E. Herrick. 2005. Interpreting Indicators of Rangeland Health, version 4. Technical Reference 1734-6. U.S. Department of the Interior, Bureau of Land Management, National Science and Technology Center, Denver, CO. BLM/WO/ST-00/001+1734/REV05.

Tetra Tech 2010. Survey of Salvage Topsoil Resources for the Rosemont Mining Area – Revision 1. November 2010.

Attachment 1

Field Soil Characterization Data Sheet

Field Sheet to Record Soil Characteristics

Soil Series ____________ Classification ____________
Location ____________ Quad ____________
Landform ____________ Elevation ____________ Aspect ____________ Erosion ____________
Parent material ____________ MAP ____________ MAAT ____________ MAST ____________
Native vegetation ____________ STR ____________ SMR ____________
Present use ____________
Diagnostic features ____________

Horizon	Depth	Bdry	Color		Texture	Clay	Rock Frags	Structure	Consistence			pH	Clay Films	Roots	Pores	CO_3	Other
			Dry	Moist					D	M	W						

Groundwater ____________ Permeability ____________
Remarks ____________

Attachment 2

Reference Sheets (Pellant et al 2005)

Reference Sheet

Author(s)/participant(s): ______________________________

Contact for lead author: ______________________________

Date:________ **MLRA:**_________ **Sub-MLRA:**________ **Ecological Site:**__________ This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community *cannot* be used to identify the ecological site.

Composition (Indicators 10 and 12) based on: __Annual Production, __Foliar Cover, __Biomass

Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years and natural disturbance regimes for **each** community within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

1. Number and extent of rills:

2. Presence of water flow patterns:

3. Number and height of erosional pedestals or terracettes:

4. Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are **not** bare ground):

5. Number of gullies and erosion associated with gullies:

6. Extent of wind scoured, blowouts and/or depositional areas:

7. Amount of litter movement (describe size and distance expected to travel):

8. Soil surface (top few mm) resistance to erosion (stability values are averages – most sites will show a range of values):

9. Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):

10. Effect of plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:

11. Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):

12. Functional/Structural Groups (list in order of descending dominance by above-ground production or live foliar cover (specify) using symbols: >>, >, = to indicate much greater than, greater than, and equal to; place dominants, subdominants and "others" on separate lines):
    Dominants:
    Sub-dominants:
    Other:

13. Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):

14. Average percent litter cover (______%) and depth (_____ inches).

15. Expected annual production (this is TOTAL above-ground production, not just forage production):
_________ - _________ lbs./acre or kg/ha (choose one)

16. Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site.:

17. Perennial plant reproductive capability:

Reference Sheet

Author(s)/participant(s): Dave Womack, Dan Robinett, Tom Reis, Emilio Carrillo

Contact for lead author: NRCS Tucson Area Office

Date: 2/17/2005 **MLRA:** 041X **Ecological Site:** Granitic Hills 16-20" p.z. R041XA102AZ This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community cannot be used to identify the ecological site.

Composition (indicators 10 and 12) based on: X Annual Production, Foliar Cover, Biomass

---

Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community and natural disturbance regimes within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

---

1. **Number and extent of rills:** None

2. **Presence of water flow patterns:** Water flow patterns occupy less than 5%of area, mostly 1 footin length, discontinuous.

3. **Number and height of erosional pedestals or terracettes:** Pedestals are uncommon. Terracettes are comon, 3-8 feet id and every 2-5 feet up and down slope.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, standing dead, lichen, moss, plant canopy are not bare ground):** Less than 5%. Less than 1% on north slope with high oak leaf litter.

5. **Number of gullies and erosion associated with gullies:** None

6. **Extent of wind scoured, blowouts and/or depositional areas:** None

7. **Amount of litter movement (describe size and distance expected to travel):** Most litter size classes are staying in place, herbaceous litter moves < 1 fot in water flow paths.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Highly resistant due to high canopy and gravel cover. No slake test done. Expect values of 4-6 across site.

9. **Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** Moderate angular to subangular blocky on south aspect. 10YR5/4 dry, 10YR3/4 moist; 1-6 inches thick. Weak granular to subangular blocky 10YR4/2 dry, 10YR2/2 moist, 1-6 inches thick.

10. **Effect on plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Canopy 75%; basal 15-20%, rock 25%, gravel 50%; 35-40% perennial grasses, 40-45% trees and shrubs, 5-10% succulents and 2-3% perennial forbs. Cover is well dispersed throughout site.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None

12. **Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to) with dominants and sub-dominants and "others" on separate lines:**
    Dominant: perennial grass > trees & shrubs > annual forbs & grasses > succulents > perennial forbs
    Sub-dominant:
    Other:
    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** approximately 10% basal area of perennial grass lost, no visible canopy of trees and shrubs lost.

14. **Average percent litter cover (5 %) and depth (0.25 inches):** Plant interspaces ominated by rock & gravel, and oak leaf litter on north slopes

15. **Expected annual production (this is TOTAL above-ground production, not just forage production):** 1000 lbs/ac unfavorable precipitation; 2000 lbs/ac normal precipitation; 3000 lbs/ac favorable precipitation

16. **Potential invasive (including noxious) species (native and non-native). List Species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicator, we are describing what is NOT expected in the reference state for the ecological site:** Velvet pod mimosa, wait-a-bit mimosa, prickly pear

17. **Perennial plant reproductive capability:** Not affected even following several years of prolonged drought period for region.

Attachment 3

Evaluation Sheet (Pellant et al 2005)

Evaluation Sheet (Front)

Aerial Photo:____

Management Unit:____________ State:________ Office:_____________ Range/Ecol. Site Code:______________
(Allotment or pasture)

Ecological Site Name:______________________ Soil Map Unit/Component Name:_______________________

Observers:____ Date:____________________

Location (description):____

T. ____ R. _____ or ___________N. Lat. Or UTM E______________m Position by GPS? Y / N
UTM Zone___, Datum___

Sec. _____, ______ ___________W. Long. N______________m Photos taken? Y / N

Size of evaluation area:____

Composition (Indicators 10 and 12) based on:__Annual Production, __Cover Produced During Current Year or __Biomass

---

Soil/site verification:

Range/Ecol. Site Descr., Soil Surv., and/or Ecol. Ref. Area:
Surface texture ______________________________
Depth: very shallow __, shallow __, moderate __, deep __
Type and depth of diagnostic horizons:
1. _________________ 3. _________________
2. _________________ 4. _________________
Surf. Efferv.: none __, v. slight __, slight __, strong __, violent __

Parent material ______ Slope ____% Elevation _____ft.

Average annual precipitation ____inches

Evaluation Area:
Surface texture ______________________________
Depth: very shallow __, shallow __, moderate __, deep __
Type and depth of diagnostic horizons:
1. ________________ 3. ________________
2. ________________ 4. ________________
Surf. Efferv.: none __, v. slight __, slight __, strong __, violent __

Topographic position _______________ Aspect ______

Seasonal distribution ____________________________

Recent weather (last 2 years) (1) drought _____, (2) normal _____, or (3) wet _____.

Wildlife use, livestock use (intensity and season of allotted use), and recent disturbances:

Off-site influences on evaluation area:

Criteria used to select this particular evaluation area as REPRESENTATIVE (specific info. and factors considered; degree of "representativeness")

Other remarks (continue on back if necessary)

Reference: (1) Reference Sheet:__________________; Author:___________________________; Creation Date:_______
or (2) Other (e.g., name and date of ecological site description; locations of ecological reference area(s))________________

Evaluation Sheet (Back)

Departure from Expected	Code	Instructions for Evaluation Sheet, Page 2
None to Slight	N-S	(1) Assign 17 indicator ratings. If indicator not present, rate None to Slight.
Slight to Moderate	S-M	(2) In the three grids below, write the indicator number in the appropriate column for each indicator that is applicable to the attribute.
Moderate	M	(3) Assign overall rating for each attribute based on preponderance of evidence.
Moderate to Extreme	M-E	(4) Justify each attribute rating in writing.
Extreme to Total	E-T	

Indicator	Rating			Comments
1. Rills	S	H		
2. Water-flow Patterns	S	H		
3. Pedestals and/or terracettes	S	H		
4. Bare ground _______%	S	H		
5. Gullies	S	H		
6. Wind-scoured, blowouts, and/or deposition areas	S			
7. Litter movement	S			
8. Soil surface resistance to erosion	S	H	B	
9. Soil surface loss or degradation	S	H	B	
10. Plant community composition and distribution relative to infiltration		H		
11. Compaction layer	S	H	B	
12. Functional/structional groups			B	
13. Plant mortality/decadence			B	
14. Litter amount		H	B	
15. Annual production			B	
16. Invasive plants			B	
17. Reproductive capability of perennial plants			B	

E-T	M-E	M	S-M	N-S

Attribute Rating Justification
Soil & Site Stability:

S (10 indicators):
Soil & Site Stability
Rating:________________

E-T	M-E	M	S-M	N-S

Attribute Rating Justification
Hydrologic Function:

H (10 indicators):
Hydrologic Function
Rating:________________

E-T	M-E	M	S-M	N-S

Attribute Rating Justification
Biotic Integrity:

B (9 indicators):
Biotic Integrity
Rating:________________

Attachment 4

Evaluation Matrix (Pellant et al 2005)

Evaluation Matrix

State ______ **Office** ______ **Ecological Site** ______ **Site ID** ______

Authors ______ **Revision Date** ______

Indicator*	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
	Departure from Reference Sheet				
1. Rills ______					Reference Sheet: ______
Generic Descriptor	Rill formation is severe and well defined throughout most of the site.	Rill formation is moderately active and well defined throughout most of the site.	Active rill formation is slight at infrequent intervals; mostly in exposed areas.	No recent formation of rills; old rills have blunted or muted features.	Current or past formation of rills as expected for the site.
2. Water Flow Patterns ______					Reference Sheet: ______
Generic Descriptor	Water flow patterns extensive and numerous; unstable with active erosion; usually connected.	Water flow patterns more numerous and extensive than expected; deposition and cut areas common; occasionally connected.	Number and length of water flow patterns nearly match what is expected for the site; erosion is minor with some instability and deposition.	Number and length of water flow patterns match what is expected for the site; some evidence of minor erosion. Flow patterns are stable and short.	Matches what is expected for the site; minimal evidence of past or current soil deposition or erosion.
3. Pedestals and/or Terracettes ______					Reference Sheet: ______
Generic Descriptor	Abundant active pedestalling and numerous terracettes. Many rocks and plants are pedestaled; exposed plant roots are common.	Moderate active pedestalling; terracettes common. Some rocks and plants are pedestaled with occasional exposed roots.	Slight active pedestalling; most pedestals are in flow paths and interspaces and/or on exposed slopes. Occasional terracettes present.	Active pedestalling or terracette formation is rare; some evidence of past pedestal formation, especially in water flow patterns on exposed slopes.	Current or past evidence of pedestaled plants or rocks as expected for the site. Terracettes absent or uncommon.

* Descriptions for each indicator should be more specific than those listed in the Generic Descriptors, if possible, and refer to the criteria included in the None to Slight description, which is based on the Reference Sheet (Appendix 1).

Indicator*	Departure from Reference Sheet: Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
4. Bare Ground					Reference Sheet:
Generic Descriptor	Much higher than expected for the site. Bare areas are large and generally connected.	Moderate to much higher than expected for the site. Bare areas are large and occasionally connected.	Moderately higher than expected for the site. Bare areas are of moderate size and sporadically connected.	Slightly to moderately higher than expected for the site. Bare areas are small and rarely connected.	Amount and size of bare areas match that expected for the site.
5. Gullies					Reference Sheet:
Generic Descriptor	Common with indications of active erosion and downcutting; vegetation is infrequent on slopes and/or bed. Nickpoints and headcuts are numerous and active.	Moderate in number to common with indications of active erosion; vegetation is intermittent on slopes and/or bed. Headcuts are active; down-cutting is not apparent.	Moderate in number with indications of active erosion; vegetation is intermittent on slopes and/or bed. Occasional headcuts may be present.	Uncommon, vegetation is stabilizing the bed and slopes; no signs of active headcuts, nickpoints, or bed erosion.	Match what is expected for the site; drainages are represented as natural stable channels; vegetation common and no signs of erosion.
6. Wind Scoured, Blowout, and/or Depositional Areas					Reference Sheet:
Generic Descriptor	Extensive.	Common.	Occasionally present.	Infrequent and few.	Match what is expected for the site.

* Descriptions for each indicator should be more specific than those listed in the Generic Descriptors, if possible, and refer to the criteria included in the None to Slight description, which is based on the Reference Sheet (Appendix 1).

Departure fromReference Sheet

Indicator*	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
7. Litter Movement (wind or water)					Reference Sheet:
Generic Descriptor	Extreme; concentrated around obstructions. Most size classes of litter have been displaced.	Moderate to extreme; loosely concentrated near obstructions. Moderate to small size classes of litter have been displaced.	Moderate movement of smaller size classes in scattered concentrations around obstructions and in depressions.	Slightly to moderately more than expected for the site with only small size classes of litter being displaced.	Matches that expected for the site with a fairly uniform distribution of litter.
8. Soil Surface Resistance to Erosion					Reference Sheet:
Generic Descriptor	Extremely reduced throughout the site. Biological stabilization agents including organic matter and biological crusts virtually absent.	Significantly reduced in most plant canopy interspaces and moderately reduced beneath plant canopies. Stabilizing agents present only in isolated patches.	Significantly reduced in at least half of the plant canopy interspaces, or moderately reduced throughout the site.	Some reduction in soil surface stability in plant interspaces or slight reduction throughout the site. Stabilizing agents reduced below expected.	Matches that expected for the site. Surface soil is stabilized by organic matter decomposition products and/or a biological crust.
9. Soil Surface Loss or Degradation					Reference Sheet:
Generic Descriptor	Soil surface horizon absent. Soil structure near surface is similar to, or more degraded, than that in subsurface horizons. No distinguishable difference in subsurface organic matter content.	Soil loss or degradation severe throughout site. Minimal differences in soil organic matter content and structure of surface and subsurface layers.	Moderate soil loss or degradation in plant interspaces with some degradation beneath plant canopies. Soil structure is degraded and soil organic matter content is significantly reduced.	Some soil loss has occurred and/or soil structure shows signs of degradation, especially in plant interspaces.	Soil surface horizon intact. Soil structure and organic matter content match that expected for site.

* Descriptions for each indicator should be more specific than those listed in the Generic Descriptors, if possible, and refer to the criteria included in the None to Slight description, which is based on the Reference Sheet (Appendix 1).

Departure from Reference Sheet

Indicator*	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
10. Plant Community Composition and Distribution Relative to Infiltration and Runoff					Reference Sheet:
Generic Descriptor	Infiltration is severely decreased due to adverse changes in plant community composition and/or distribution. Adverse plant cover changes have occurred.	Infiltration is greatly decreased due to adverse changes in plant community composition and/or distribution. Detrimental plant cover changes have occurred.	Infiltration is moderately reduced due to adverse changes in plant community composition and/or distribution. Plant cover changes negatively affect infiltration.	Infiltration is slightly to moderately affected by minor changes in plant community composition and/or distribution. Plant cover changes have only a minor effect on infiltration.	Infiltration and runoff are not affected by any changes in plant community composition and distribution. Any changes in infiltration and runoff can be attributed to other factors (e.g. compaction).
11. Compaction Layer (below soil surface)					Reference Sheet:
Generic Descriptor	Extensive; severely restricts water movement and root penetration.	Widespread; greatly restricts water movement and root penetration.	Moderately widespread, moderately restricts water movement and root penetration.	Rarely present or is thin and weakly restrictive to water movement and root penetration.	Matches that expected for the site; none to minimal, not restrictive to water movement and root penetration.

* Descriptions for each indicator should be more specific than those listed in the Generic Descriptors, if possible, and refer to the criteria included in the None to Slight description, which is based on the Reference Sheet (Appendix 1).

Departure from Reference Sheet

Indicator*	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
12. Functional/ Structural Groups (F/S Groups) See Functional/ Structural Groups Worksheet					Reference Sheet:
Generic Descriptor	Number of F/S groups greatly reduced **and/or** Relative dominance of F/S groups has been dramatically altered **and/or** Number of species within F/S groups dramatically reduced.	Number of F/S groups reduced **and/or** One dominant group and/or one or more sub-dominate group replaced by F/S groups not expected for the site **and/or** Number of species within F/S groups significantly reduced.	Number of F/S groups moderately reduced **and/or** One or more sub-dominant F/S groups replaced by F/S groups not expected for the site **and/or** Number of species within F/S groups moderately reduced.	Number of F/S groups slightly reduced **and/or** Relative dominance of F/S groups has been modified from that expected for the site **and/or** number of species within F/S slightly reduced.	F/S groups and number of species in each group closely match that expected for the site.
13. Plant Mortality/ Decadence					Reference Sheet:
Generic Descriptor	Dead and/or decadent plants are common.	Dead plants and/or decadent plants are somewhat common.	Some dead and/or decadent plants are present.	Slight plant mortality and/or decadence.	Plant mortality and decadence match that expected for the site.
14. Litter Amount					Reference Sheet:
Generic Descriptor	Largely absent or dominant relative to site potential and weather.	Greatly reduced or increased relative to site potential and weather.	Moderately more or less relative to site potential and weather.	Slightly more or less relative to site potential and weather.	Amount is what is expected for the site potential and weather.

* Descriptions for each indicator should be more specific than those listed in the Generic Descriptors, if possible, and refer to the criteria included in the None to Slight description, which is based on the Reference Sheet (Appendix 1).

Indicator*	Departure from Reference Sheet: Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
15. Annual Production ______					Reference Sheet:____
Generic Descriptor	Less than 20% of potential production for the site based on recent weather.	20-40% of potential production for the site based on recent weather.	40-60% of potential production for the site based on recent weather.	60-80% of potential production for the site based on recent weather.	Exceeds 80% of potential production for the site based on recent weather.
16. Invasive Plants					Reference Sheet:____
Generic Descriptor	Dominate the site.	Common throughout the site.	Scattered throughout the site.	Present primarily in disturbed areas within the site.	If present, composition of invasive species, matches that expected for the site.
17.Reproductive Capability of Perennial Plants (native or seeded)					Reference Sheet: ____
Generic Descriptor	Capability to produce seed or vegetative tillers is severely reduced relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is greatly reduced relative to recent climatic conditions	Capability to produce seed or vegetative tillers is moderately reduced relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is slightly reduced relative to recent climatic conditions.	Capability to produce seed or vegetative tillers is not reduced relative to recent climatic conditions.

* Descriptions for each indicator should be more specific than those listed in the Generic Descriptors, if possible, and refer to the criteria included in the None to Slight description, which is based on the Reference Sheet (Appendix 1).

Attachment 5

Line-Point Intercept data sheet example (Herrick et al 2005).

Line-point Intercept with Height Data Form

Page ____ of ____

Shaded cells for calculations

Plot: ______________ Line No.: __________ Observer: __________________ Recorder: __________________

Direction: _________ Date: ______________ Intercept (point) spacing interval = _____ cm (_____ in)

Pt.	Top canopy	Ht.	Lower canopy layers			Soil surface	Pt.	Top canopy	Ht.	Lower canopy layers			Soil surface
			Code 1	Code 2	Code 3					Code 1	Code 2	Code 3	
1							26						
2							27						
3							28						
4							29						
5							30						
6							31						
7							32						
8							33						
9							34						
10							35						
11							36						
12							37						
13							38						
14							39						
15							40						
16							41						
17							42						
18							43						
19							44						
20							45						
21							46						
22							47						
23							48						
24							49						
25							50						

% canopy (foliar) cover = ____ canopy pts (1st col) x 2 = ____%

% bare ground* = ____ pts (w/ NONE over S) x 2 = ____%

% basal cover = ____ plant base pts (last col) x 2 = ____%

Top canopy codes: Species code, common name, or NONE (no canopy)

Lower canopy layers: Species code, common name, L (herbaceous litter), W (woody litter, >5mm [1/4 in] diameter)

Unknown species codes:

AF# = annual forb
PF# = perennial forb
AG# = annual grass
PG# = perennial grass
SH# = shrub
TR# = tree

Soil surface codes (do not use litter):

Species code (for basal intercept)
R = rock fragment (>5mm [1/4 in] diameter)
BR = bedrock
M = moss
LC = visible lichen crust on soil
S = soil, without any other soil surface code
EL = embedded litter
D = duff

*Bare ground occurs ONLY when Top canopy = NONE, Lower layers are empty (no L), and Soil surface = S

Appendix D

Historical Aerial Photography

Stock tank aerial images and conditions throughout time. Imagery from Google Earth.

Figure 1. Barrel Canyon East Stock Tank. 1996 Aerial Photo Prior to Stock Tank Construction

Figure 2. Barrel Canyon East Stock Tank. Present Day Aerial Photo Showing Stock Tank.

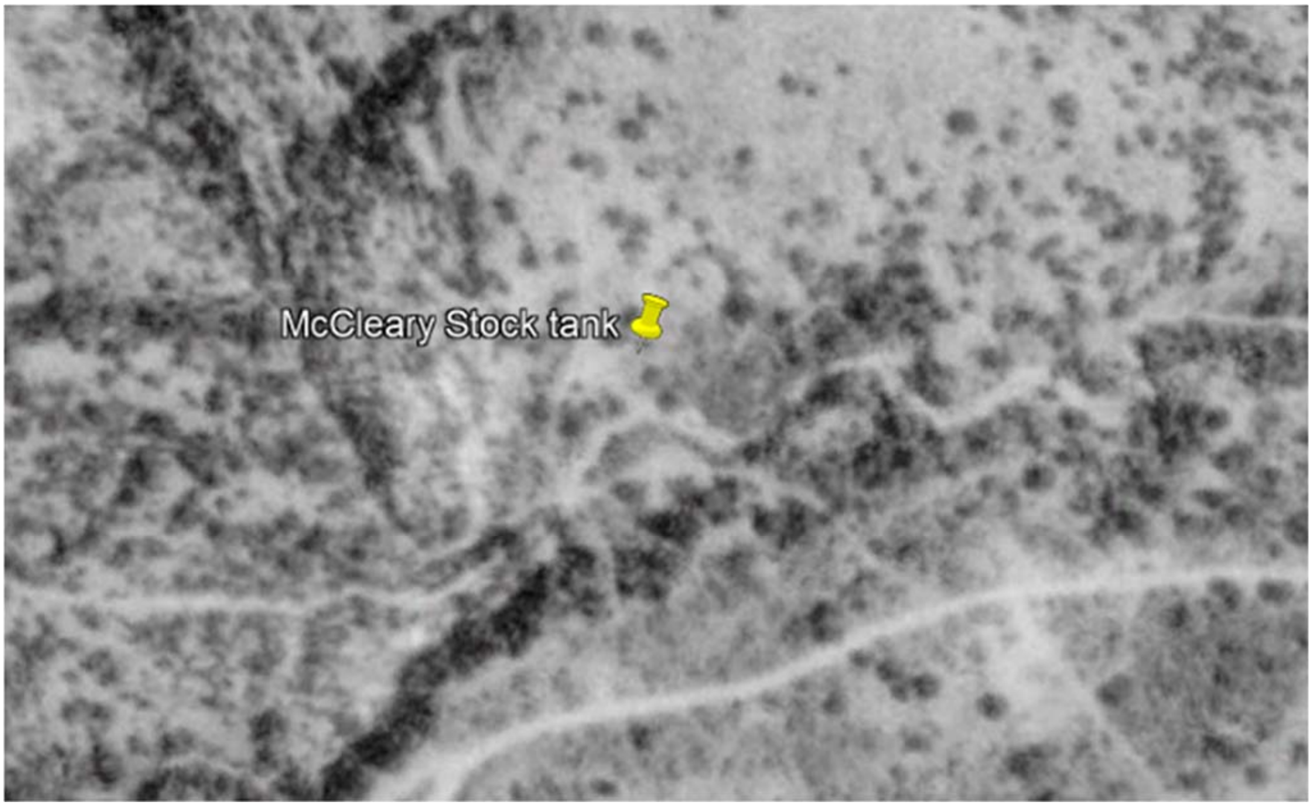


Figure 3. McCleary Stock Tank. 1992 Aerial Photo Prior to Stock Tank Construction

Figure 4. McCleary Stock Tank. 2016 Aerial Photo Showing Stock Tank

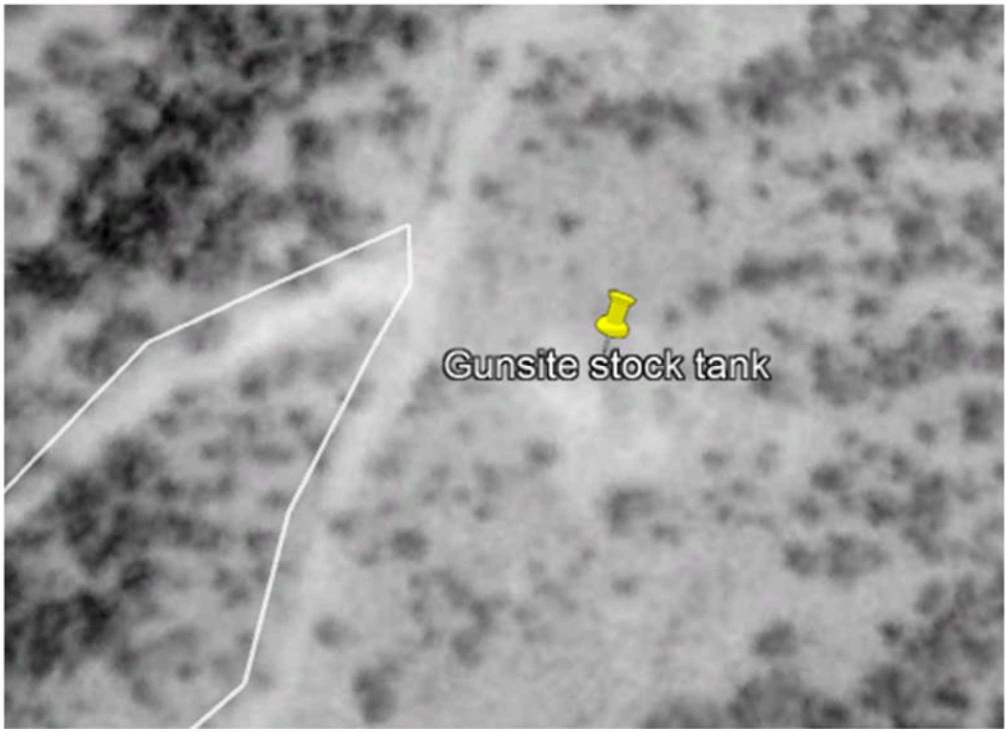


Figure 5. Gunsite Stock Tank. 1992 Aerial Photo Prior to Stock Tank Construction

Figure 6. Gunsite Stock Tank. 2007 Aerial Photo Showing Stock Tank

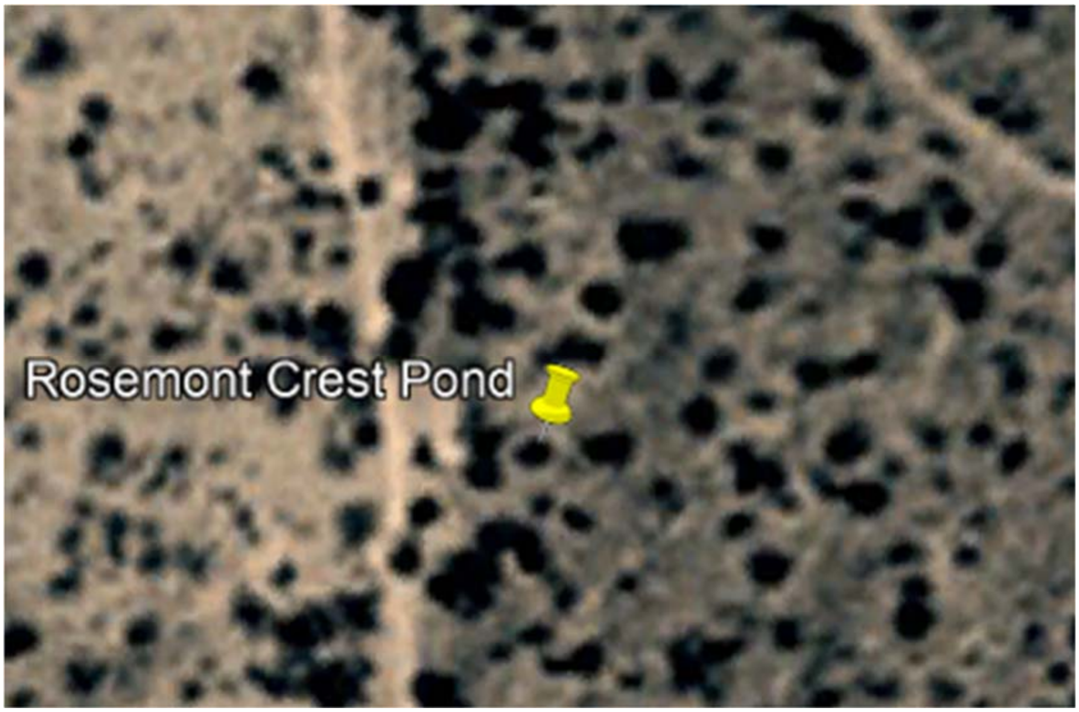
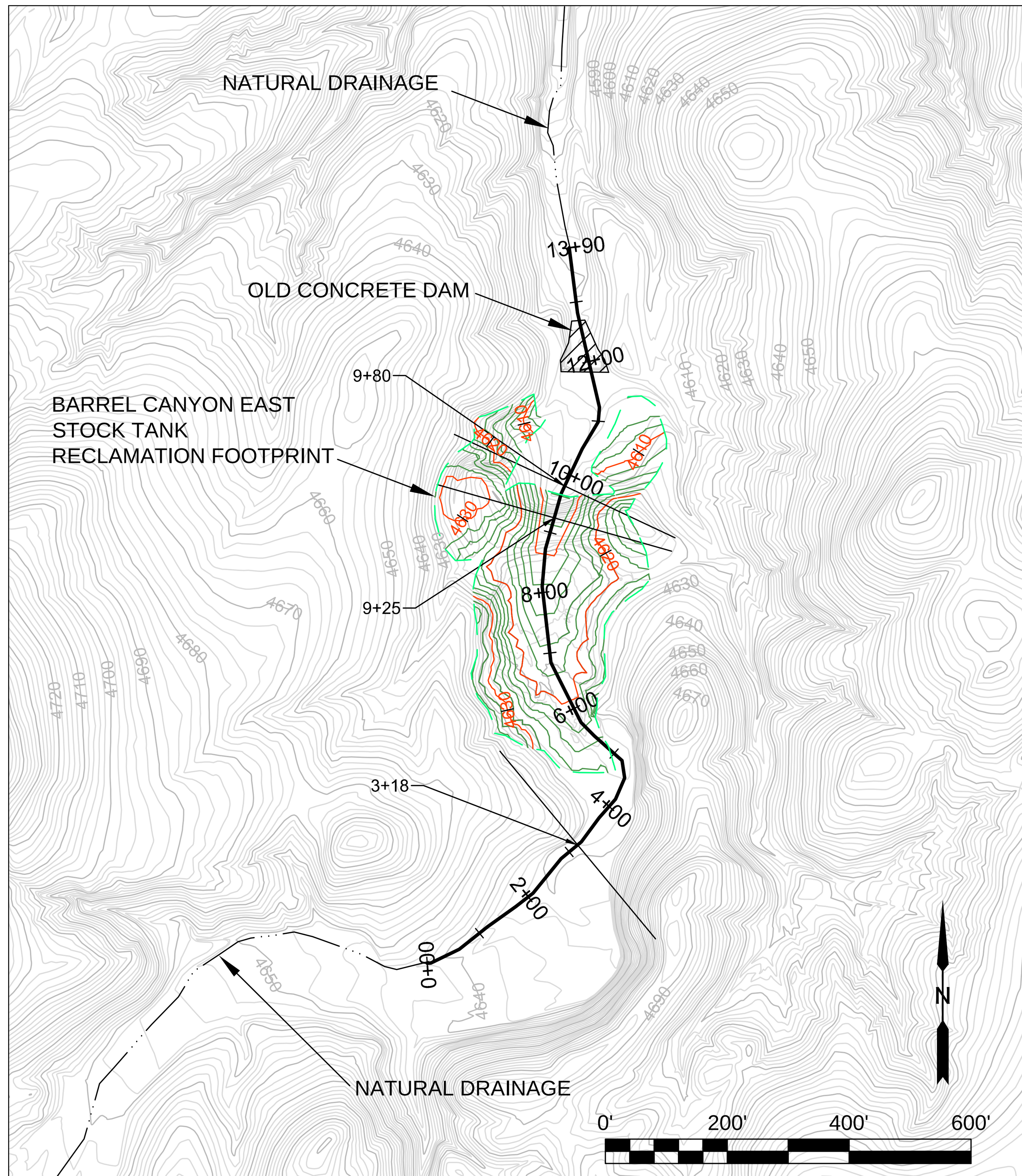
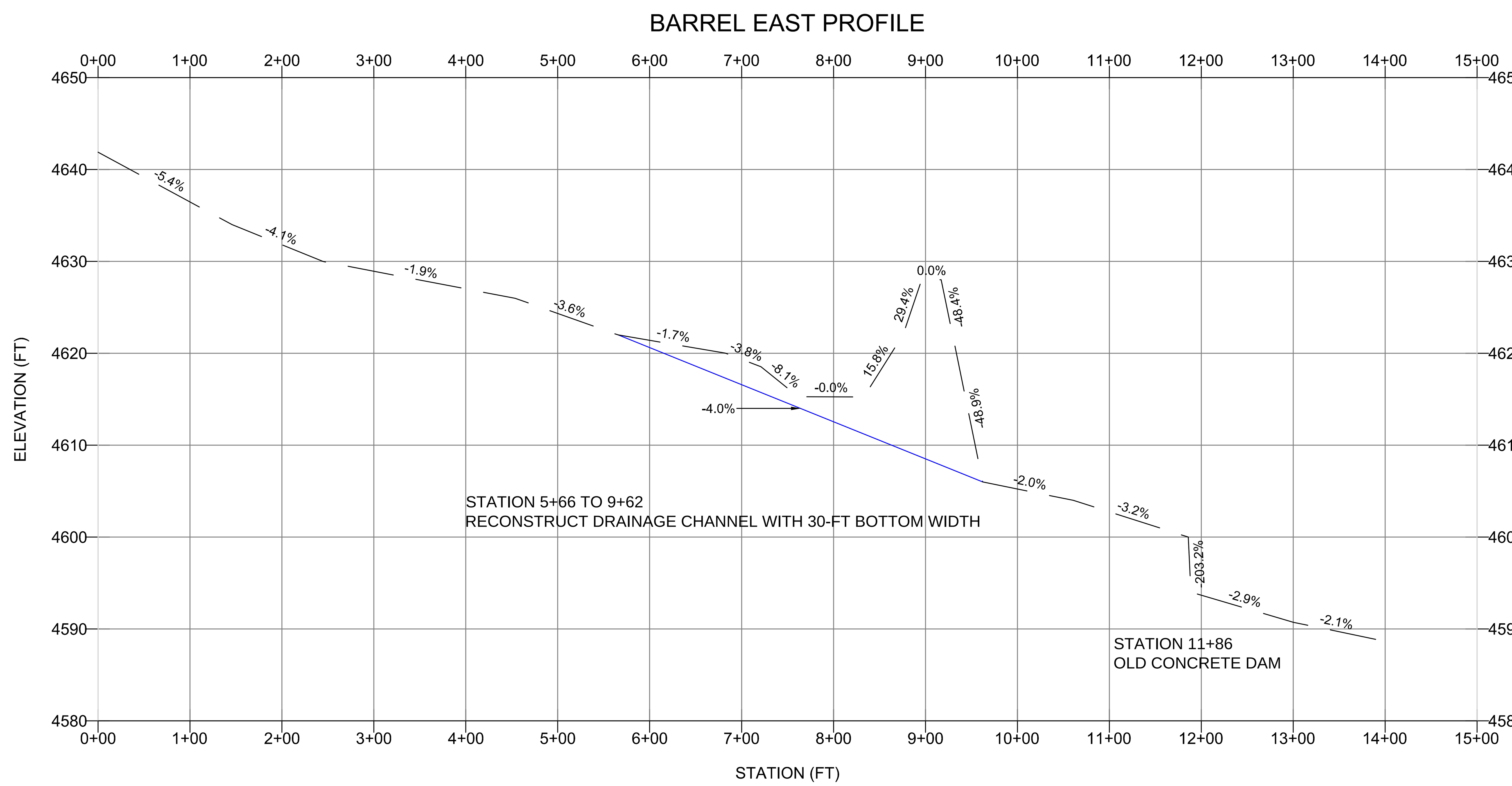
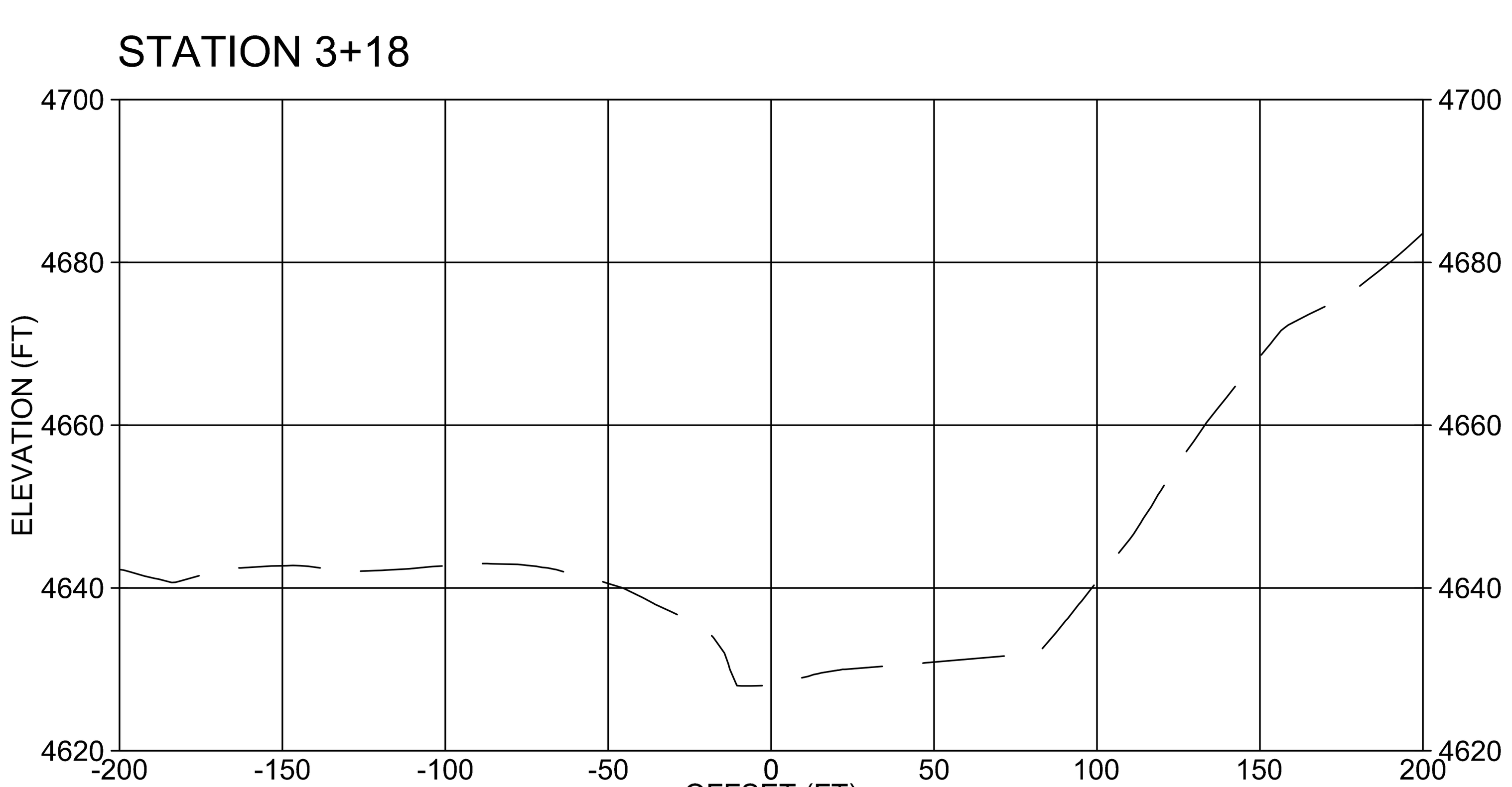


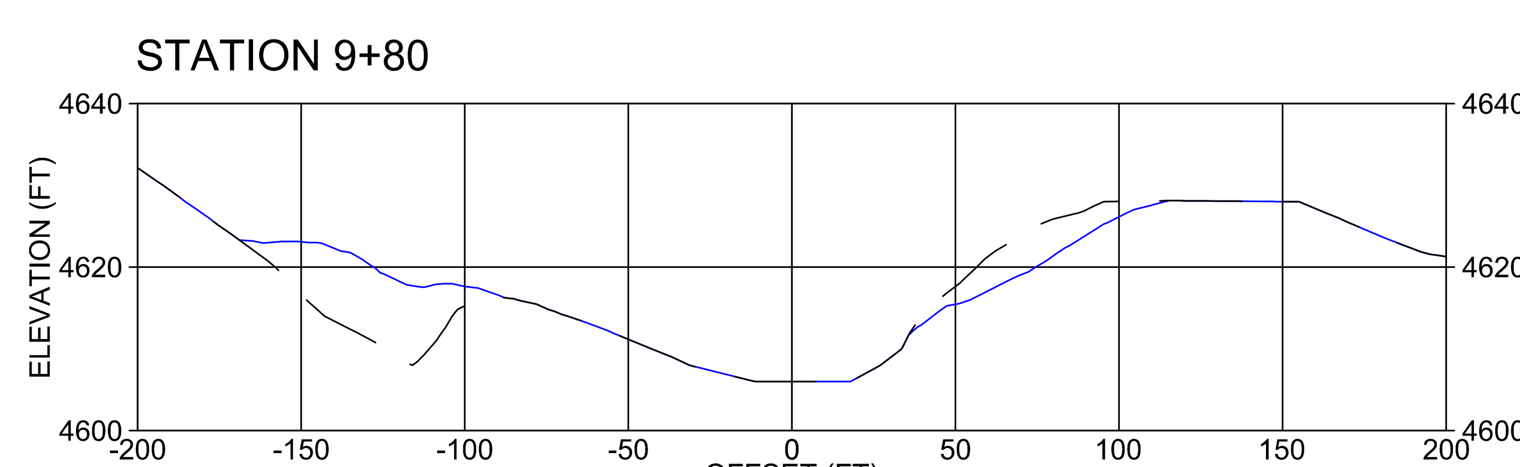
Figure 7. Rosemont Crest Stock Tank. 1996 Aerial Photo Prior to Stock Tank Construction

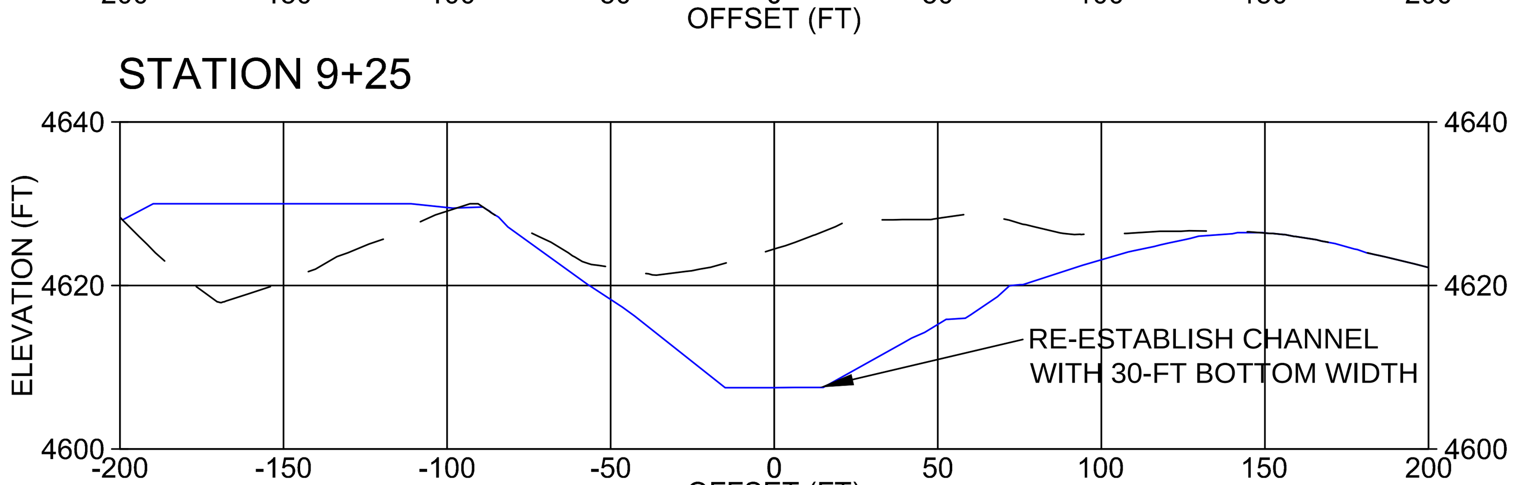
Figure 8. Rosemont Crest Stock Tank. 2017 Aerial Photo Showing Stock Tank











LEGEND

- EXISTING INDEX CONTOUR (10-FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED INDEX CONTOUR (10-FT INTERVAL)
- PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED CHANNEL EXCAVATION LIMIT
- CHANNEL ALIGNMENT WITH STATIONS
- CROSS SECTION
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- EXISTING EPHEMERAL DRAINAGE

NOTES

1. PROFILES OF EXISTING GRADE AND FINAL GRADE CORRESPOND TO CHANNEL CENTERLINE ELEVATIONS.
2. FINAL GRADE PROFILE CORRESPONDS TO CHANNEL INVERT ELEVATION.
3. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM.
4. RECONSTRUCTED DRAINAGE CHANNEL SHALL BLEND IN WITH THE NATURAL DRAINAGE AT THE UPSTREAM AND DOWNSTREAM EXCAVATION LIMITS.
5. CONSTRUCTION SHALL NOT DISTURB THE OLD CONCRETE DAM.
6. FOLLOWING CONSTRUCTION THE DISTURBED AREA WILL BE REVEGETATED PER THE "REVEGETATION AND GROWTH MEDIA MONITORING PLAN".

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SEAL

STOCK TANK REMOVAL

REFERENCES		REFERENCES		REVISIONS							REVISIONS						
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION	NO.	BY	CKD	APP.	CLIENT	DATE	DESCRIPTION

HUDBAY

ROSEMONT PROJECT

BARREL CANYON EAST STOCK TANK REMOVAL PLAN

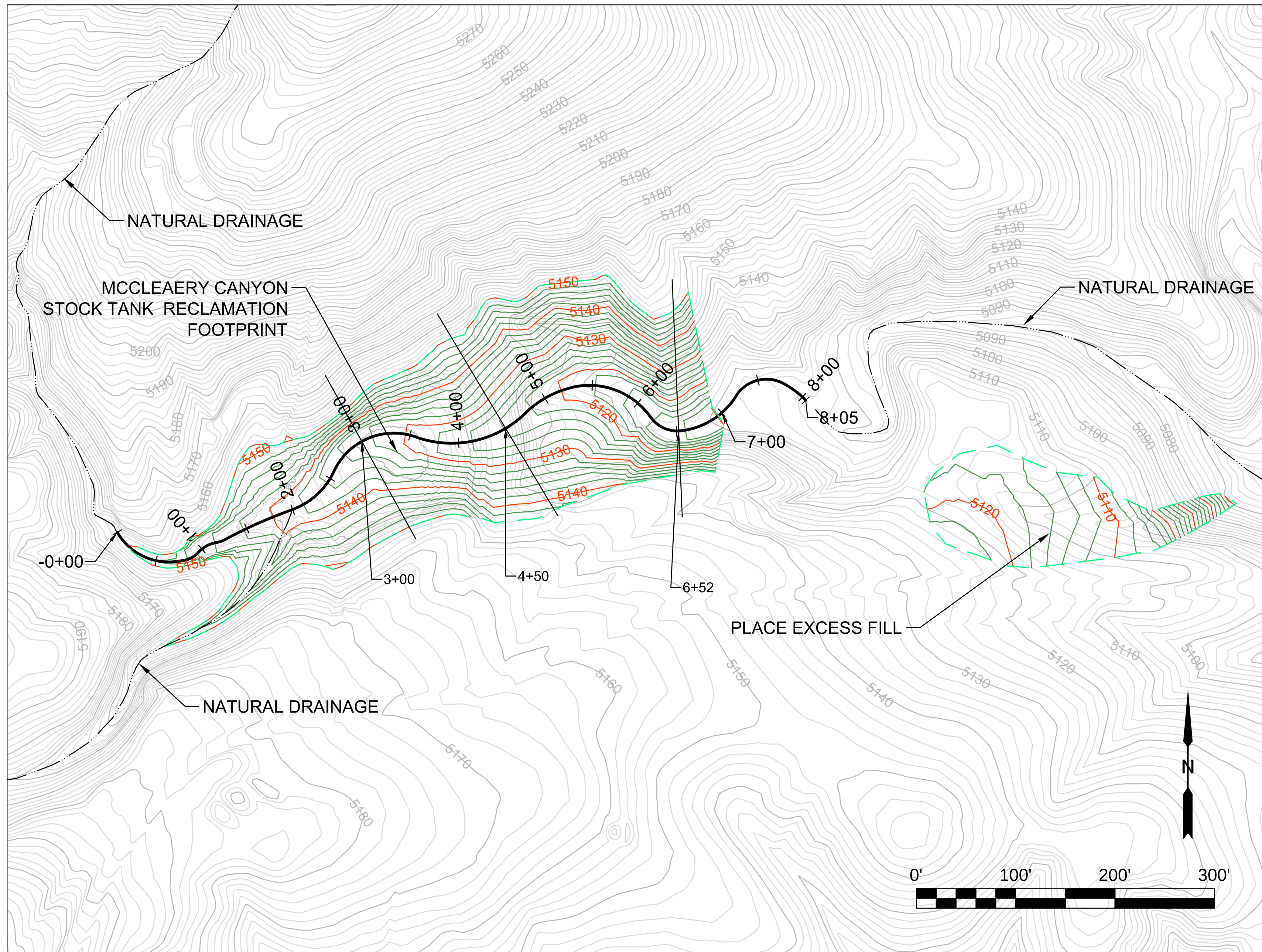
NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. S.TANK 1

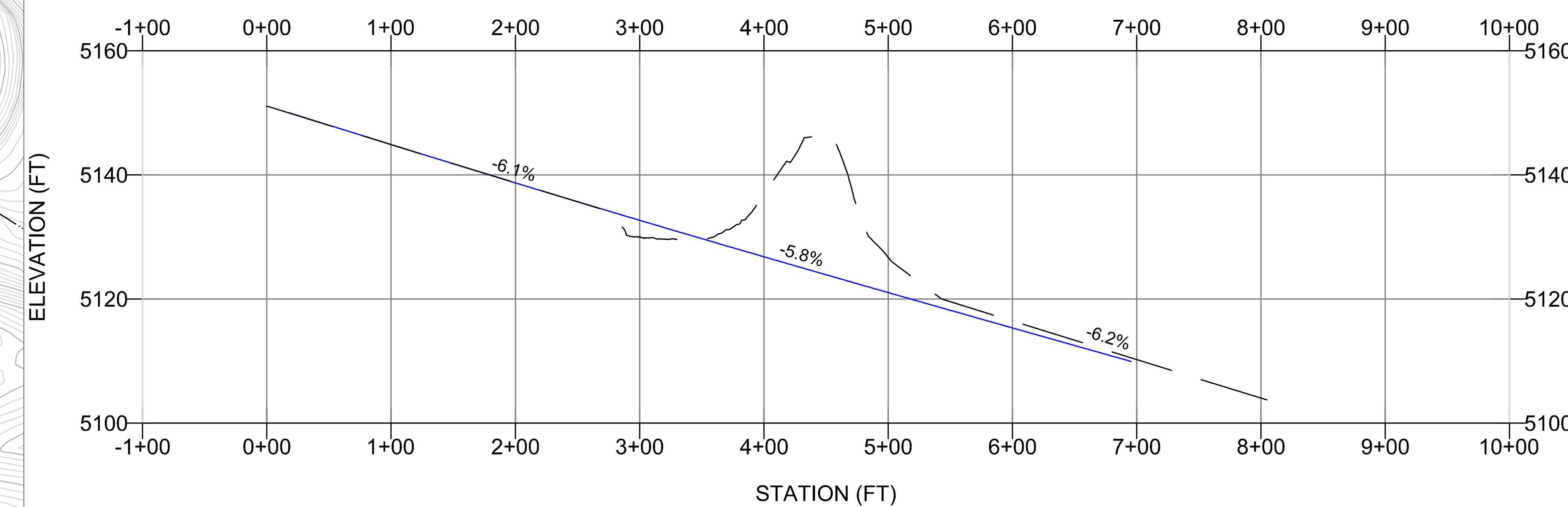
DWG. NO.

REVISION

DATE 09/08/2017



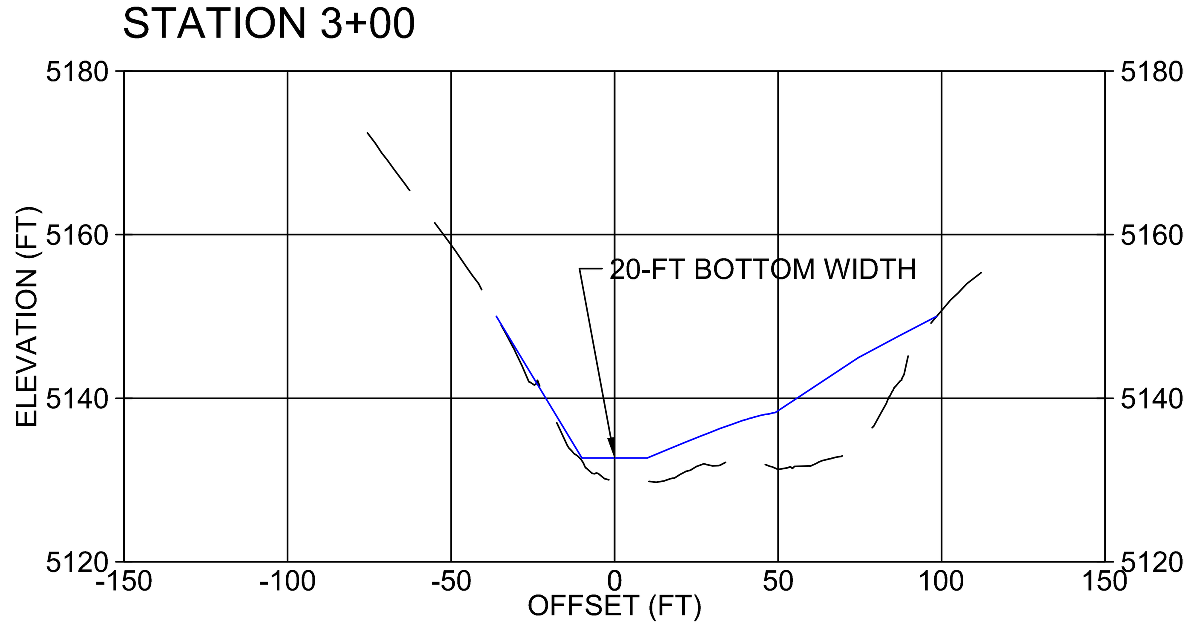
MCLEARY CANYON PROFILE



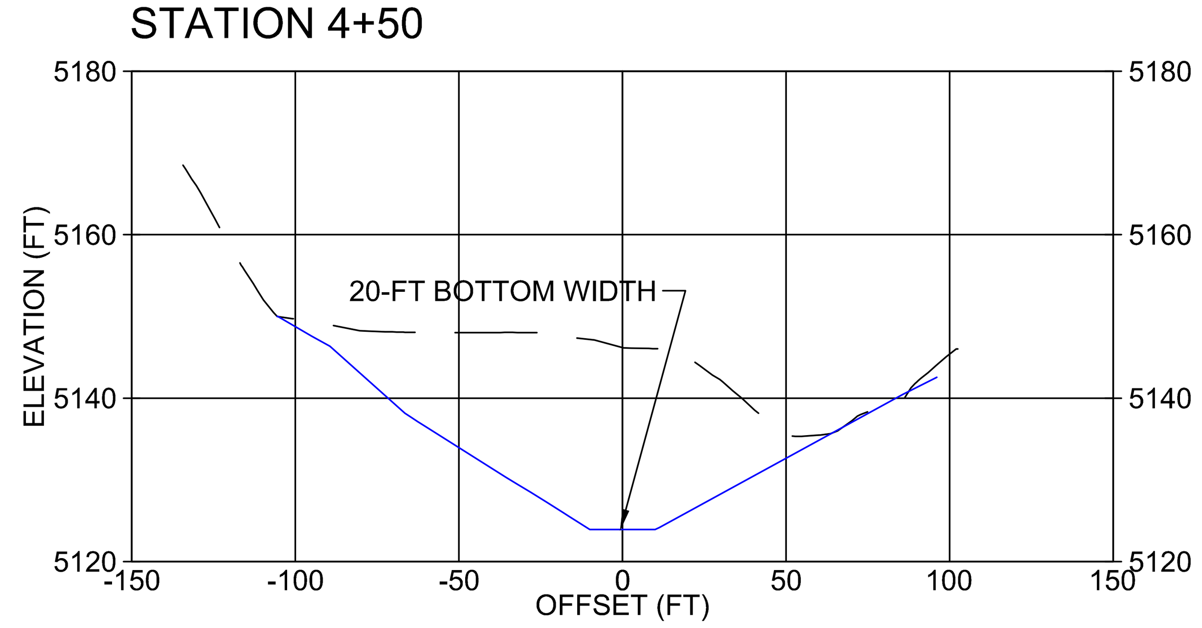
LEGEND

- EXISTING INDEX CONTOUR (10-FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED INDEX CONTOUR (10-FT INTERVAL)
- PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED CHANNEL EXCAVATION LIMIT
- CHANNEL ALIGNMENT WITH STATIONS
- CROSS SECTION
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- EXISTING EPHEMERAL DRAINAGE

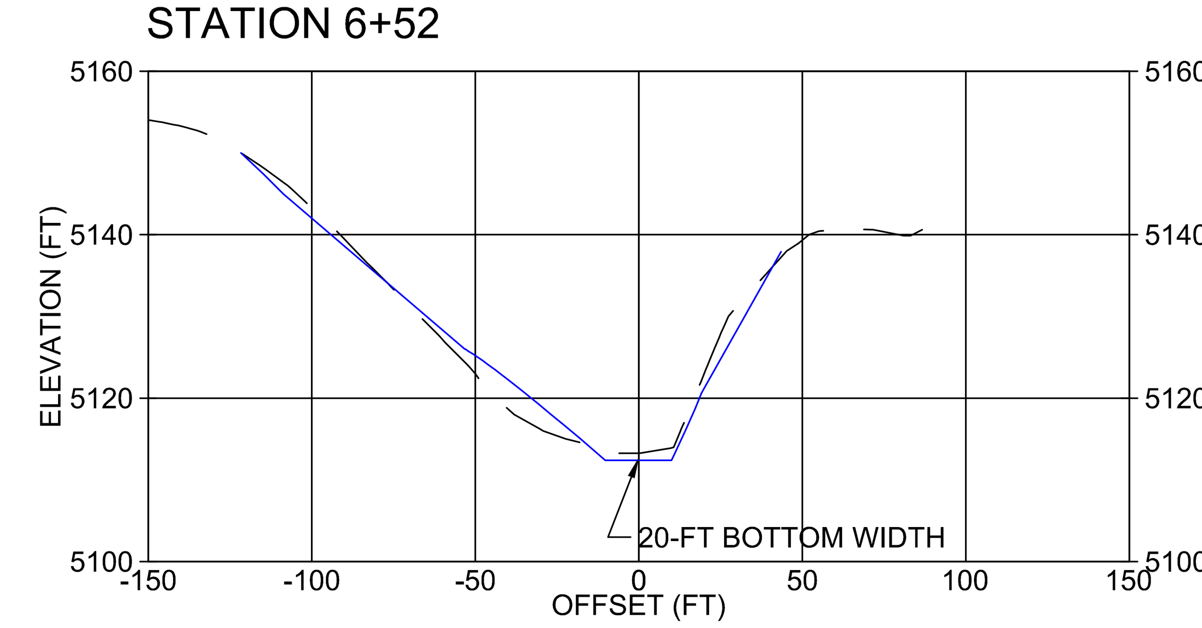
STATION 3+00



STATION 4+50



STATION 6+52



NOTES

1. PROFILES OF EXISTING GRADE AND FINAL GRADE CORRESPOND TO CHANNEL CENTERLINE ELEVATIONS.,
2. FINAL GRADE PROFILE CORRESPONDS TO CHANNEL INVERT ELEVATION.
3. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM
4. RECONSTRUCTED CHANNEL SHALL BLEND IN WITH THE NATURAL DRAINAGE AT THE UPSTREAM AND DOWNSTREAM EXCAVATION LIMITS.
5. FOLLOWING CONSTRUCTION THE DISTURBED AREA WILL BE REVEGETATED PER THE "REVEGETATION AND GROWTH MEDIA MONITORING PLAN".

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REFERENCES		REFERENCES		REVISIONS							REVISIONS						
DWG. NO.	TITLE	DWG. NO.	TITLE	NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION	NO.	BY	CKD	APP.	CLIENT	DATE	DESCRIPTION

HUDBAY

ROSEMONT PROJECT

STOCK TANK REMOVAL

MCCLEARY CANYON
STOCK TANK REMOVAL PLAN

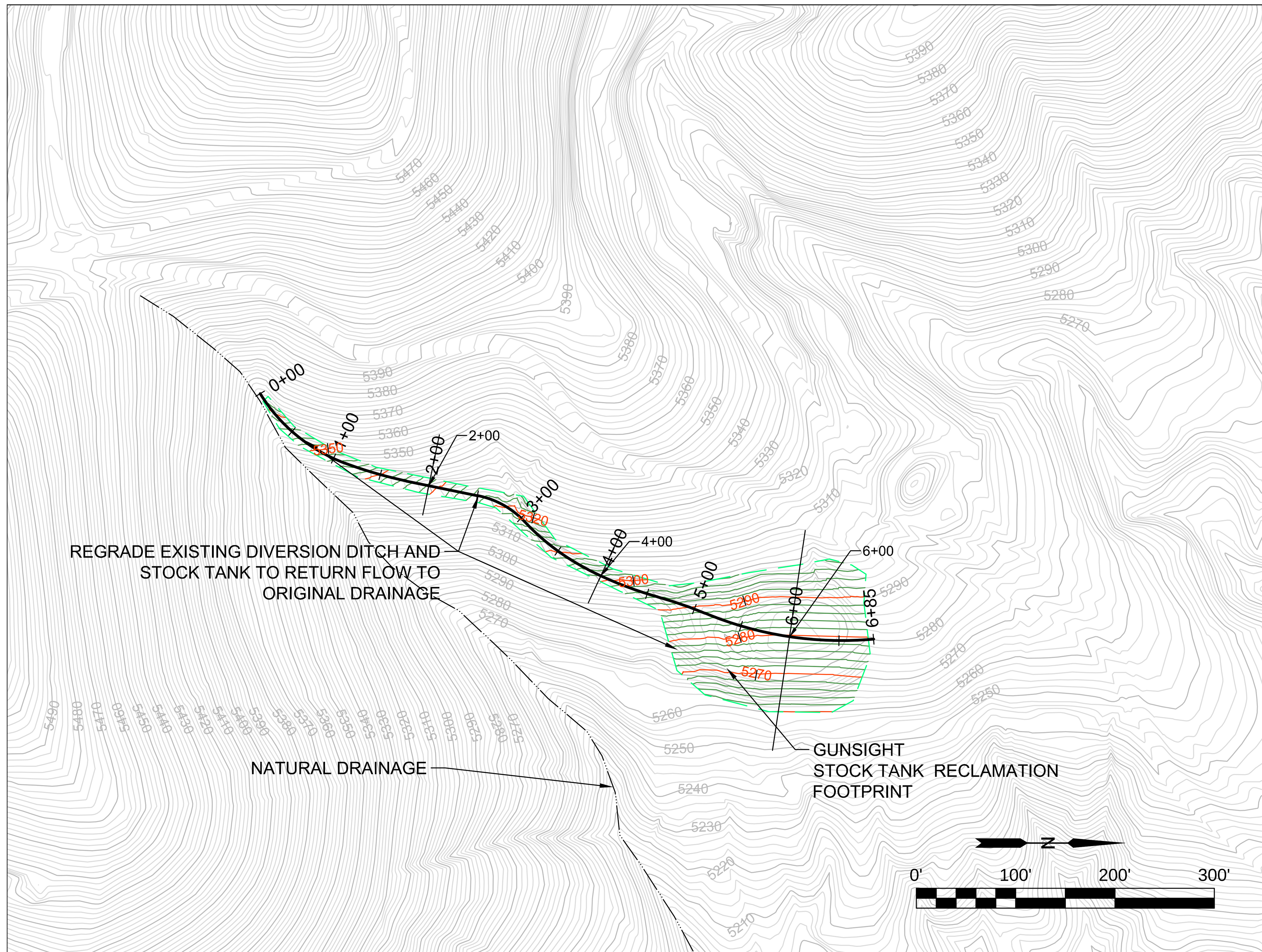
NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. S.TANK 2

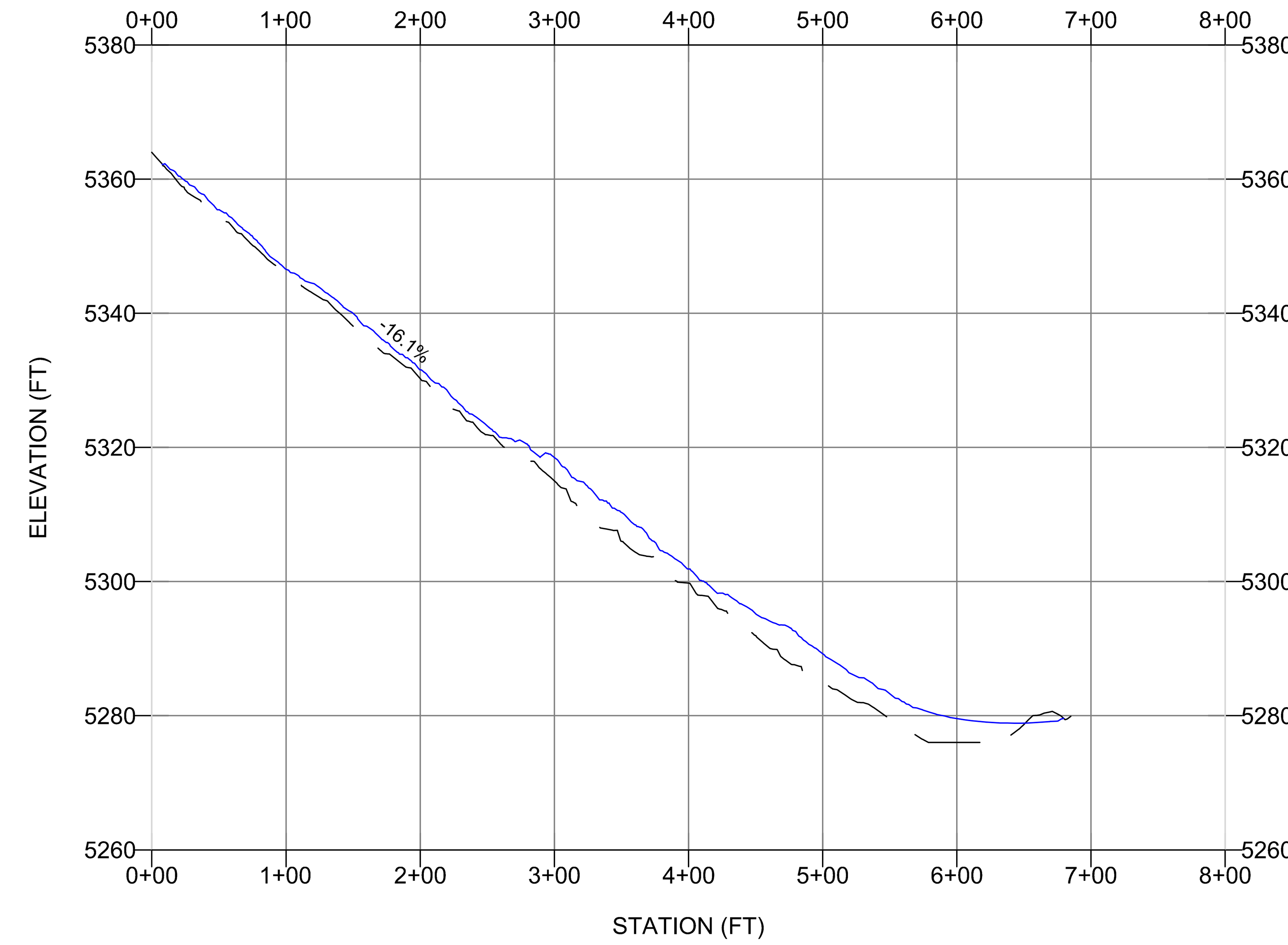
DWG. NO.

REVISION

DATE 09/08/17



GUNSIGHT PROFILE



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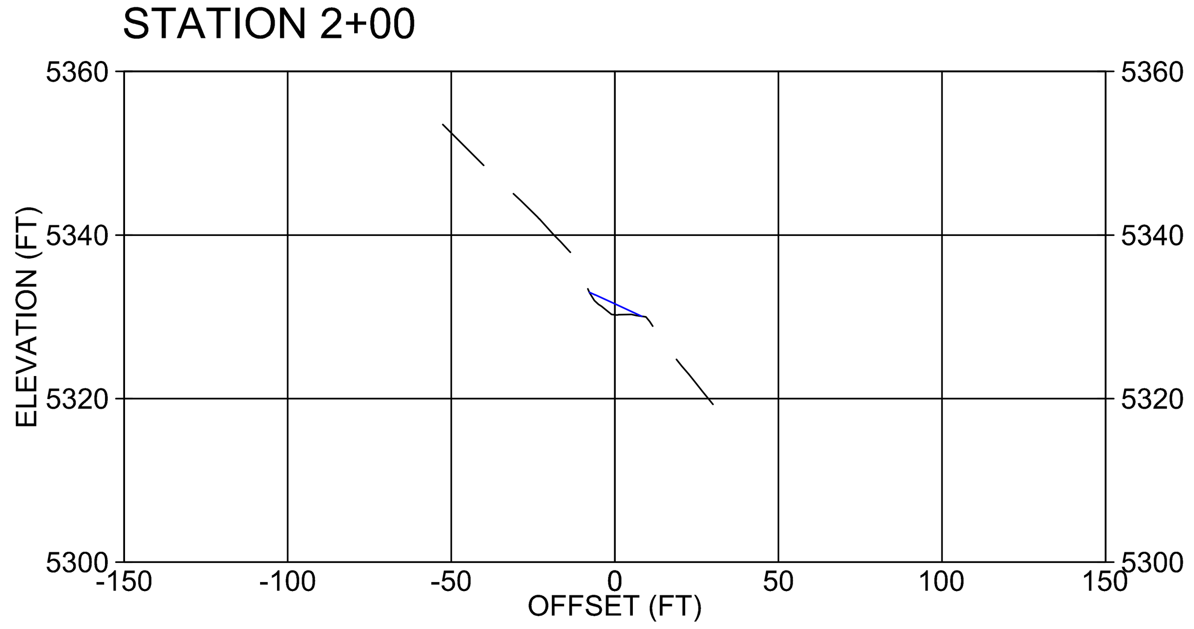

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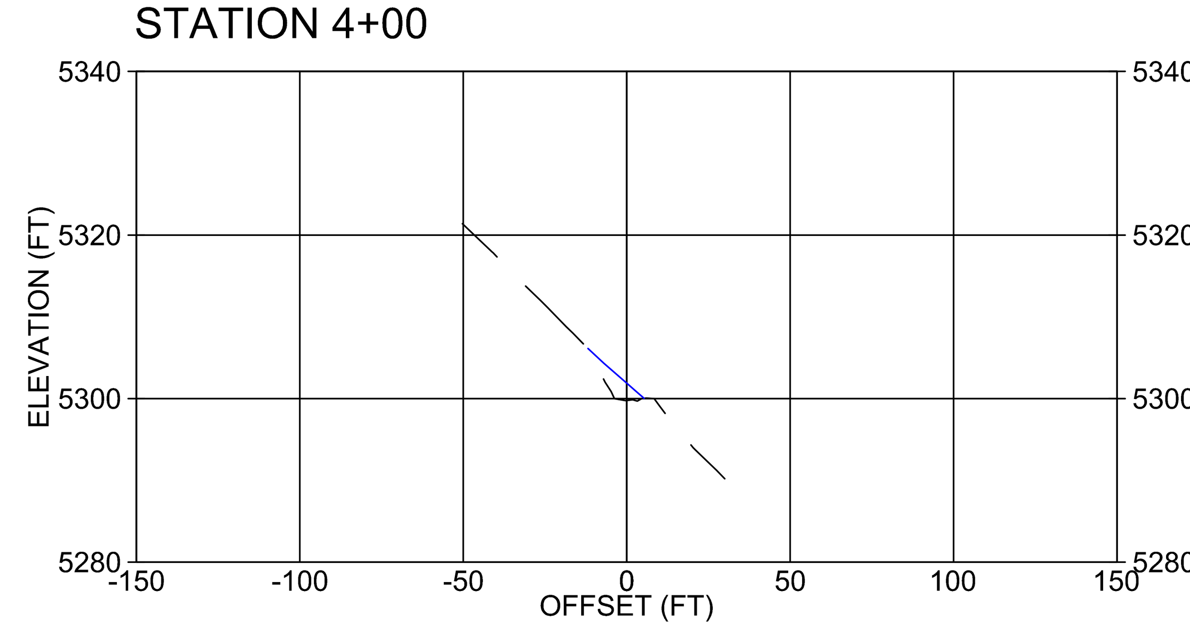

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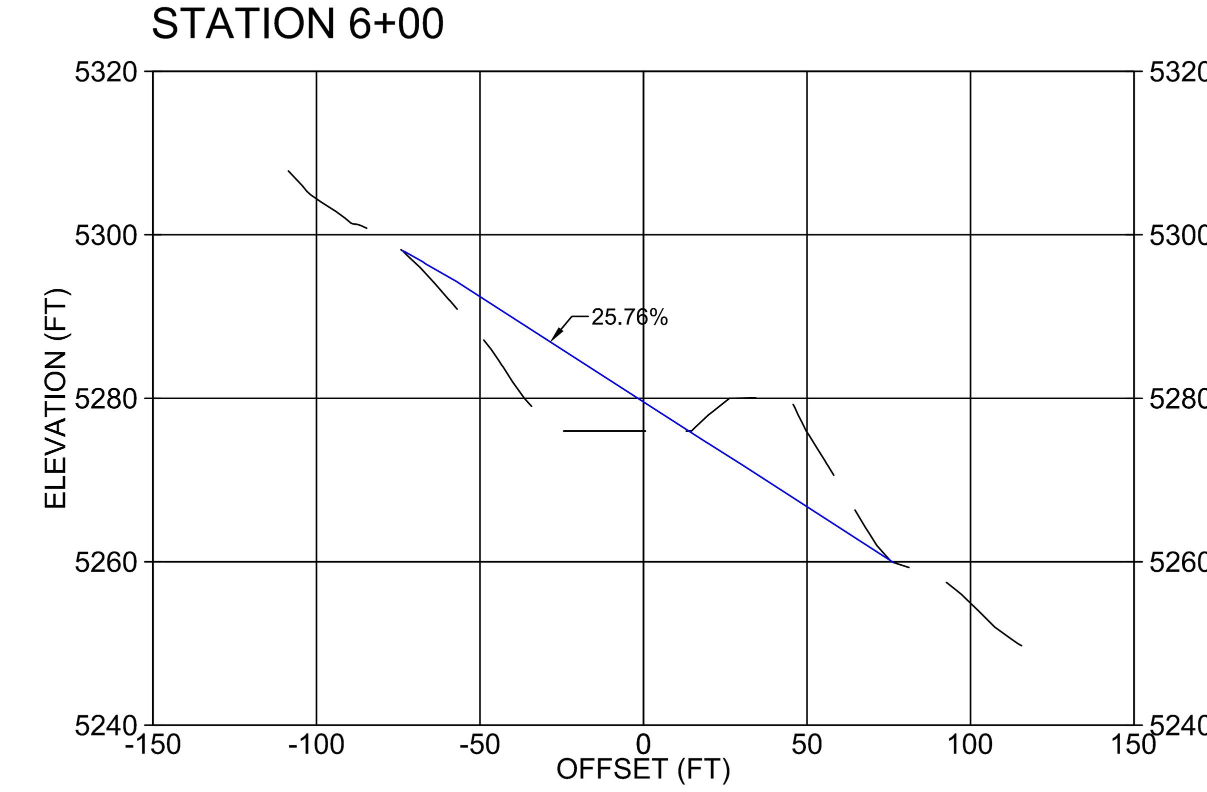

LEGEND

- EXISTING INDEX CONTOUR (10-FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED INDEX CONTOUR (10-FT INTERVAL)
- PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED CHANNEL EXCAVATION LIMIT
- CHANNEL ALIGNMENT WITH STATIONS
- CROSS SECTION
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- EXISTING EPHEMERAL DRAINAGE

NOTES

1. PROFILES OF EXISTING GRADE AND FINAL GRADE CORRESPOND TO ALIGNMENT CENTERLINE ELEVATIONS.,
2. FINAL GRADE PROFILE CORRESPONDS TO ALIGNMENT INVERT ELEVATION.
3. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM
4. RECONSTRUCTED SLOPE SHALL BLEND IN WITH THE NATURAL SLOPE
5. FOLLOWING CONSTRUCTION THE DISTURBED AREA WILL BE REVEGETATED PER THE "REVEGETATION AND GROWTH MEDIA MONITORING PLAN".

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SEAL

REFERENCES		REFERENCES	
DWG. NO.	TITLE	DWG. NO.	TITLE

REVISIONS						
NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION

REVISIONS						
NO.	BY	CKD	APP.	CLIENT	DATE	DESCRIPTION

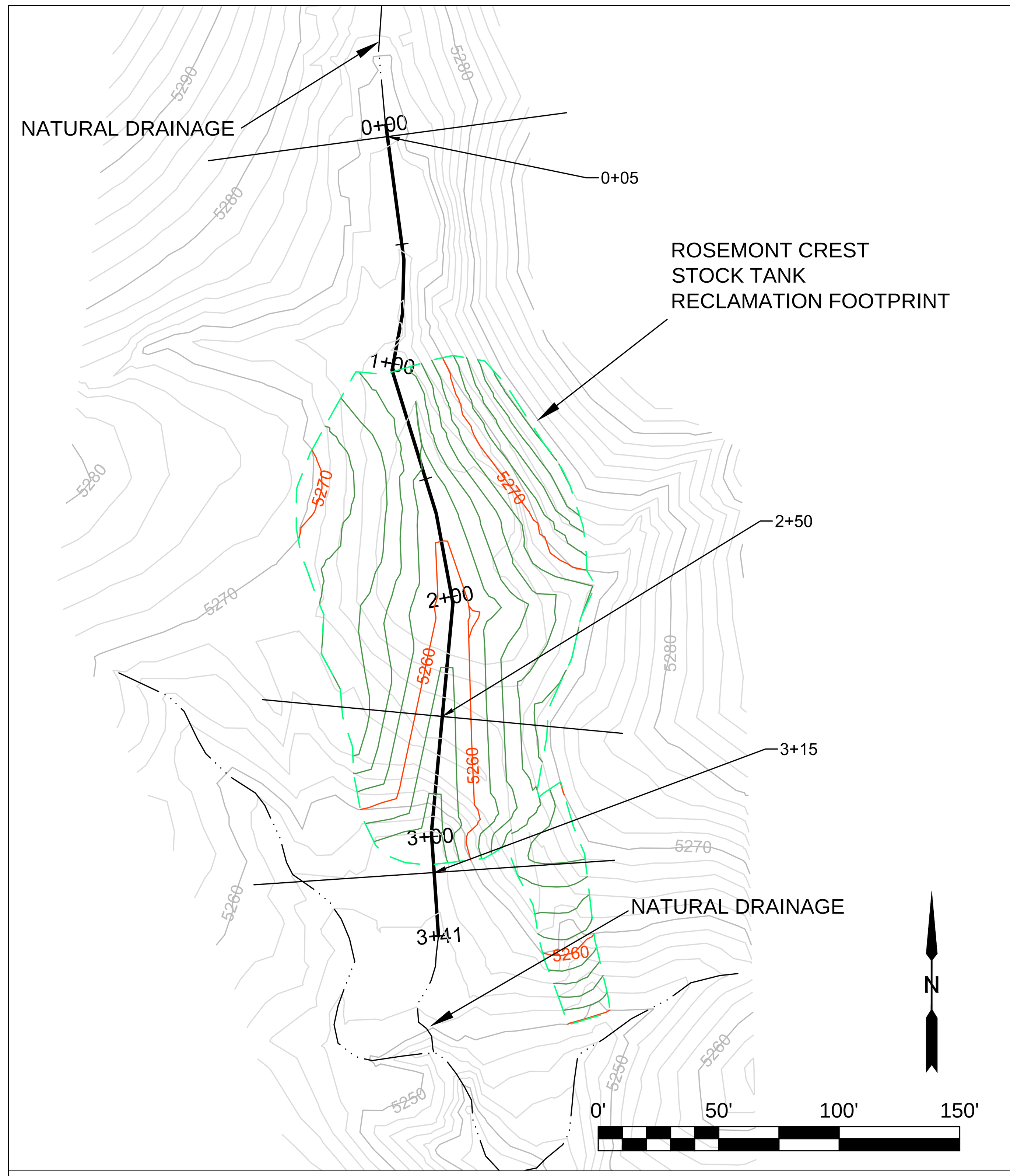
HUDBAY
ROSEMONT PROJECT

STOCK TANK REMOVAL

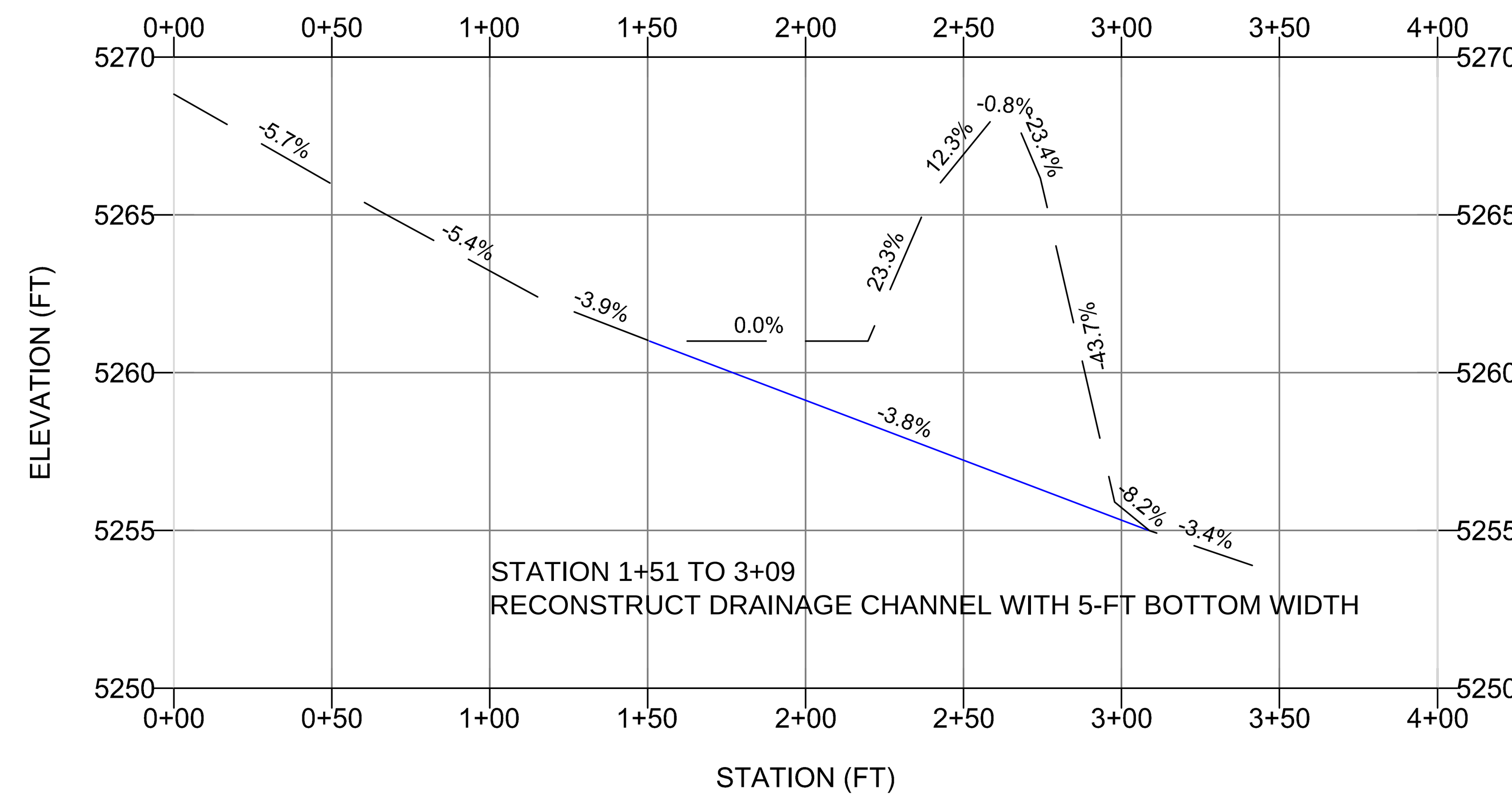
GUNSIGHT
STOCK TANK REMOVAL PLAN

NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. S.TANK 3
DWG. NO.
REVISION
DATE 09/08/17



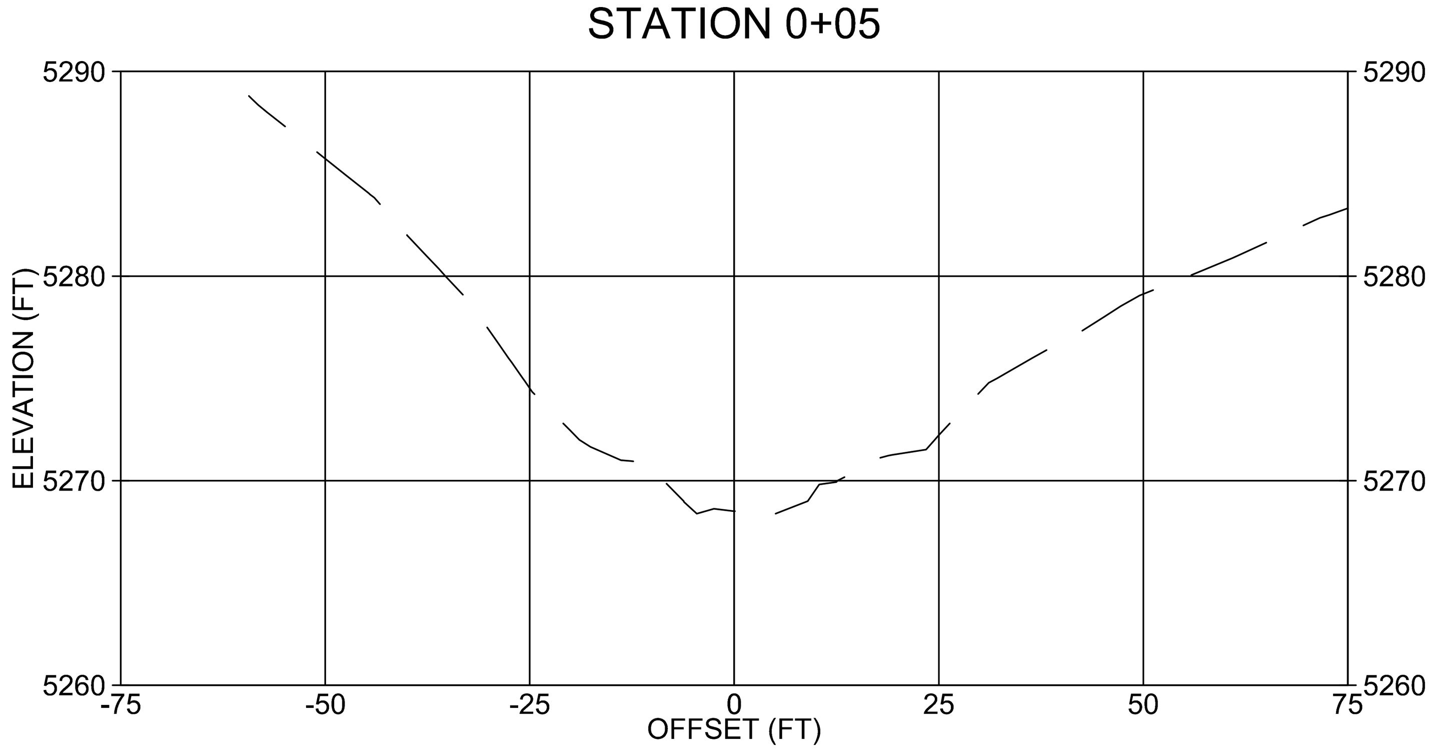
ROSEMONT CREST PROFILE



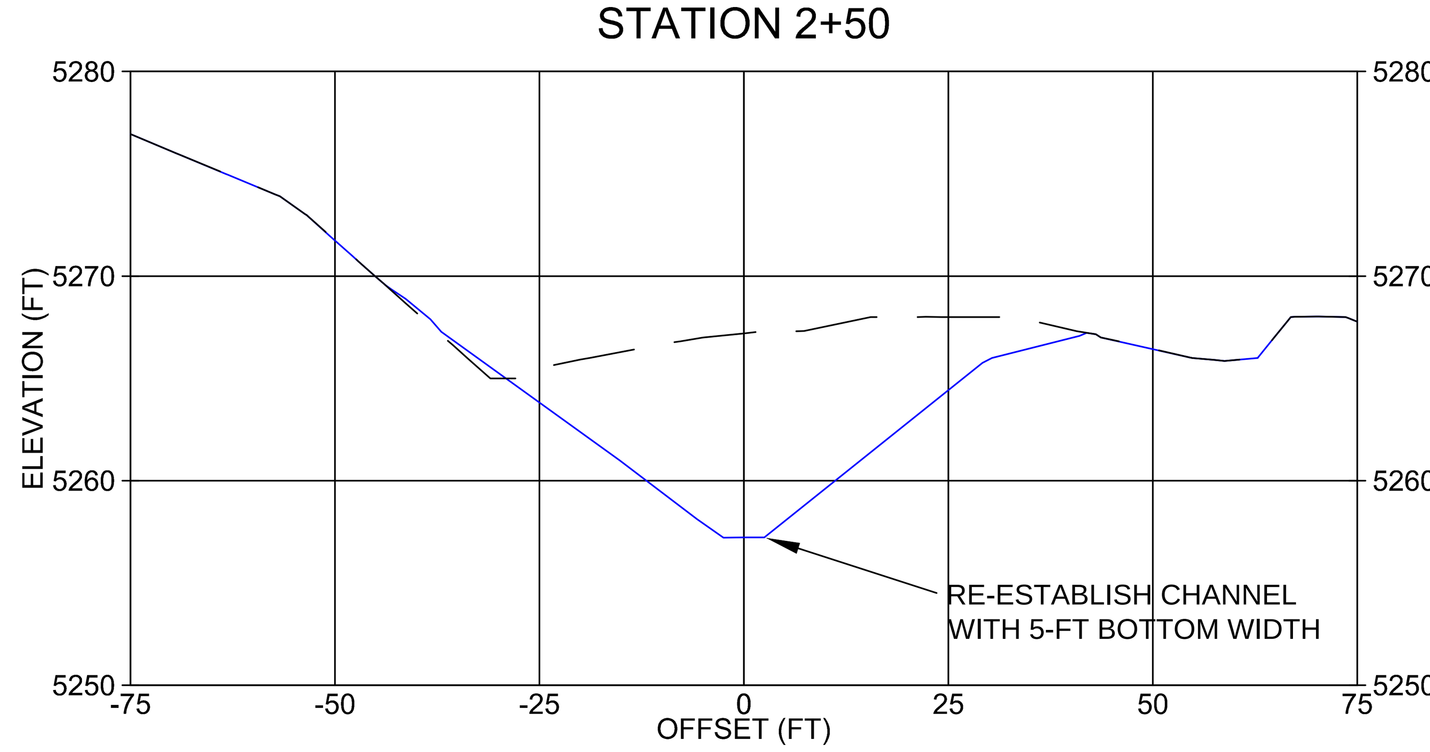
LEGEND

- EXISTING INDEX CONTOUR (10-FT INTERVAL)
- EXISTING INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED INDEX CONTOUR (10-FT INTERVAL)
- PROPOSED INTERMEDIATE CONTOUR (2-FT INTERVAL)
- PROPOSED CHANNEL EXCAVATION LIMIT
- CHANNEL ALIGNMENT WITH STATIONS
- CROSS SECTION
- EXISTING GRADE PROFILE
- PROPOSED FINAL GRADE PROFILE
- EXISTING EPHEMERAL DRAINAGE

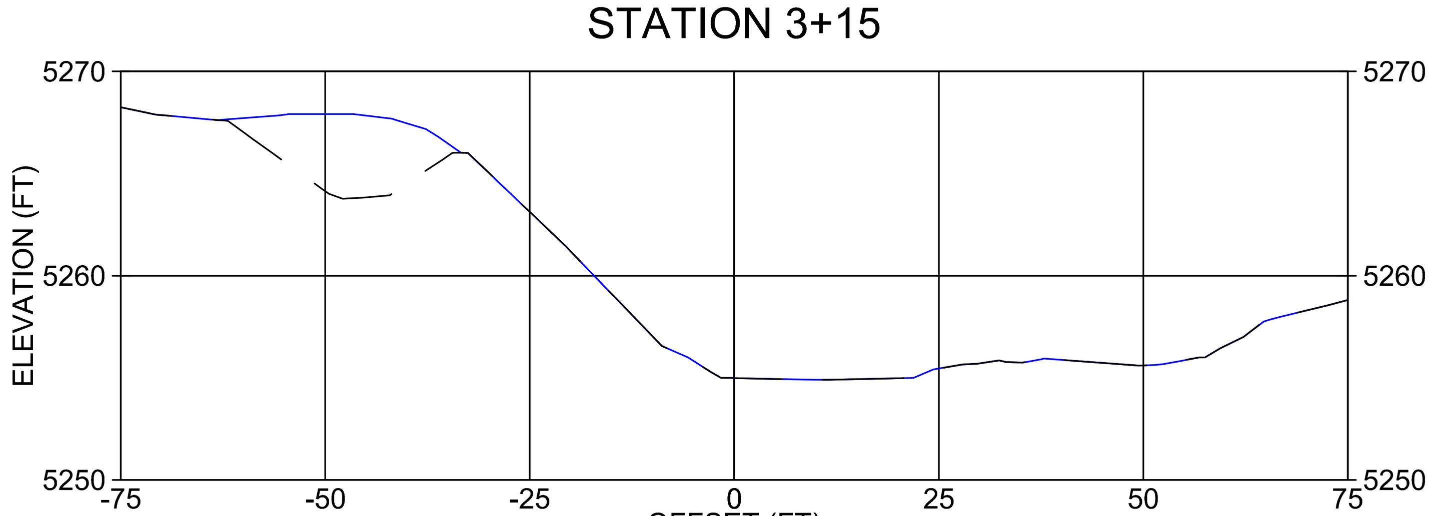
STATION 0+05



STATION 2+50



STATION 3+15



NOTES

1. PROFILES OF EXISTING GRADE AND FINAL GRADE CORRESPOND TO CHANNEL CENTERLINE ELEVATIONS.
2. FINAL GRADE PROFILE CORRESPONDS TO CHANNEL INVERT ELEVATION.
3. CROSS SECTIONS ARE DISPLAYED FACING DOWNSTREAM.
4. RECONSTRUCTED DRAINAGE CHANNEL SHALL BLEND IN WITH THE NATURAL DRAINAGE AT THE UPSTREAM AND DOWNSTREAM EXCAVATION LIMITS.
6. FOLLOWING CONSTRUCTION THE DISTURBED AREA WILL BE REVEGETATED PER THE "REVEGETATION AND GROWTH MEDIA MONITORING PLAN".

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SEAL

REFERENCES	
DWG. NO.	TITLE

REFERENCES	
DWG. NO.	TITLE

REVISIONS						
NO.	BY	CKD	APP	CLIENT	DATE	DESCRIPTION

REVISIONS						
NO.	BY	CKD	APP.	CLIENT	DATE	DESCRIPTION

HUDBAY
ROSEMONT PROJECT

STOCK TANK REMOVAL

ROSEMONT CREST STOCK TANK REMOVAL PLAN

NOT FOR CONSTRUCTION

CONTRACTOR DWG. NO. S.TANK 4
DWG. NO.
REVISION
DATE 09/08/2017

ATTACHMENT 5

MRSC
Worksheets

Attachment 12501.6 - SPD Mitigation Ratio Setting Checklist (See 12501-SPD for Revisions Sheet)

1	Date: July 31, 2017	Corps File No.:	SPL-2005-00816-MB	Project Manager:	Deanna Cummings		
	Impact Site Name:	Rosemont Copper Project - Barrel/Wasp Drainages	ORM Resource Type:	River/Stream		Hydrology:	Ephemeral
	Impact Cowardin or HGM type:	Riverine	Impact area :	19.2	acres	Impact distance:	linear feet
		Column A		**Column B**		**Column C**	
		Mitigation Site Name:	SCR reestablished floodplain channels	Mitigation Site Name:		Mitigation Site Name:	
		Mitigation Type:	Re-establishment	Mitigation Type:		Mitigation Type:	
		ORM Resource Type:	River/Stream	ORM Resource Type:		ORM Resource Type:	
		Cowardin/HGM type:	Riverine	Cowardin/HGM type:		Cowardin/HGM type:	
		Hydrology:	Ephemeral	Hydrology:		Hydrology:	
2	**Qualitative impact-mitigation comparison**:	Starting ratio:	**1.0 : 1.0**	Starting ratio:	**1.0 : 1.0**	Starting ratio:	**1.0 : 1.0**
		Ratio adjustment:	**-1.0**	Ratio adjustment:	**0.0**	Ratio adjustment:	**0.0**
		Baseline ratio:	**1.00 : 2.00**	Baseline ratio:	**1.00 : 1.00**	Baseline ratio:	**1.00 : 1.00**
		PM justification: See qualitative sheet for adjustment		PM justification: See qualitative sheet for adjustment		PM justification: See qualitative sheet for adjustment	
3	**Quantitative impact-mitigation comparison**:	Ratio adjustment from BAMI procedure (attached):	#REF! : #REF!	Ratio adjustment from BAMI procedure (attached):	#REF! : #REF!	Ratio adjustment from BAMI procedure (attached):	#REF! : #REF!
4	**Mitigation site location**:	Ratio adjustment:	**1**	Ratio adjustment:	**0**	Ratio adjustment:	**0**
		PM justification: outside watershed		PM justification:		PM justification:	
5	**Net loss of aquatic resource surface area**:	Ratio adjustment:	**0**	Ratio adjustment:	**0**	Ratio adjustment:	**0**
		PM justification: reestablishment		PM justification:		PM justification:	
6	**Type conversion:**	Ratio adjustment:	**-0.5**	Ratio adjustment:	**0**	Ratio adjustment:	**0**
		PM justification: Like-for-like, but addition of Monkey Spring flows to SCR.		PM justification:		PM justification:	
7	**Risk and uncertainty**:	Ratio adjustment:	**0.5**	Ratio adjustment:	**0**	Ratio adjustment:	**0**
		PM justification: +0.1 PRM; +0.3 complex stream relocation project with robust modeling; +0.1 difficult to replace resources.		PM justification:		PM justification:	
8	**Temporal loss**:	Ratio adjustment:	**3**	Ratio adjustment:	**0**	Ratio adjustment:	**0**
		PM justification: Mesquite trees. No schedule loss.		PM justification:		PM justification:	
9	**Final mitigation ratio(s):**	Baseline ratio from 2 or 3:	1.00 : 2.00	Baseline ratio from 2 or 3:	1.00 : 1.00	Baseline ratio from 2 or 3:	1.00 : 1.00
		Total adjustments (4-8):	4	Total adjustments (4-8):	0	Total adjustments (4-8):	0
		Final ratio:	**5.00 : 2.00**	Final ratio:	**1.00 : 1.00**	Final ratio:	**1.00 : 1.00**
		Proposed impact (total):	19.2 acres	Remaining impact:	-9.40 acres	Remaining impact (acres):	acres
			0 linear feet		0 linear feet	Remaining impact (linear feet):	#VALUE! linear feet
		to Resource type:	River/Stream	to Resource type:	River/Stream	to Resource type:	River/Stream
		Cowardin or HGM:	Riverine	Cowardin or HGM:	Riverine	Cowardin or HGM:	Riverine
		Hydrology:	Ephemera	Hydrology:	Ephemeral	Hydrology:	Ephemeral
		Required Mitigation*:	48.00 acres	Required Mitigation*:	-9.40 acres	Required Mitigation:	#VALUE! acres
			0 linear feet		0.0 linear feet		#VALUE! linear feet
		of Resource type:	River/Stream	of Resource type:	0	of Resource type:	0
		Cowardin or HGM:	Riverine	Cowardin or HGM:	0	Cowardin or HGM:	0
		Hydrology:	Ephemeral	Hydrology:	0	Hydrology:	0
		Proposed Mitigation**:	57.40 acres	Proposed Mitigation**:	acres	Proposed Mitigation**:	acres
			linear feet		linear feet		linear feet
		Impact Unmitigated:	-20 %	Impact Unmitigated:	%	Impact Unmitigated:	%
			-9.40 acres		acres		acres
		Additional PM comments:		Additional PM comments:		Additional PM comments:	
10	**requirements:**						

*At PM's discretion, if applicant's proposed mitigation is less than checklist requirement and additional mitigation type(s) proposed, complete additional columns as needed.
**Only enter proposed mitigation into spreadsheet if accepting applicant's lower (than required ratio) proposal.

Step 2: Qualitative comparison of functions (functional loss vs. gain)

Functions (Column A)	Reconstructed channel	Barrel/Wasp main drainages	Adjustment[1]
Surface Water Storage	++	-	+
Subsurface Flow	+++	--	+
Energy Dissipation	+++	--	+
Groundwater Recharge	+++	-	++
Sediment Transport	+++	--	+
Biogeochemical	+	-	0
Organic Carbon Export	+	-	0
Habitat Connectivity/Structure	+++	--	+
			7

Adjustment: -1

PM Justification: Extensive re-established channel system on floodplain Depth of alluvium and shallow gradient provide for increased flood attenuation and groundwater recharge. Includes contribution from Monkey Spring (600 ac-ft/yr). Barrel and Wasp are older systems that don't contribute as much sediment as the younger Scholefield Canyon.

Instructions:
1. Describe amount of functional loss (impact) and gain (mitigation) in each respective column. Gain and loss can be described in text (for example,
2. Note: alternate lists of functions may be used.
3. Note: a single adjustment should be used to account for all functions combined (see example 7 in attachment 12501.3)

Notes:
1. Total adjustment is scaled to nearest integer between -2 and 4.

Attachment 12501.6 - SPD Mitigation Ratio Setting Checklist (See 12501-SPD for Revisions Sheet)

1	Date: July 31, 2017	Corps File No.:	SPL-2005-00816-MB		Project Manager:	Deanna Cummings				
	Impact Site Name:	Rosemont Copper Project - Sonoita Creek fill	ORM Resource Type:		River/Stream			Hydrology:	Ephemeral	
	Impact Cowardin or HGM type:	Riverine	Impact area :		8.9	acres		Impact distance:		linear feet
		Column A			**Column B**			**Column C**		
		Mitigation Site Name:	SCR reestablished floodplain channels		Mitigation Site Name:	SCR reestablished floodplain channel buffer		Mitigation Site Name:		
		Mitigation Type:	Reestablishment		Mitigation Type:	Reestablishment		Mitigation Type:		
		ORM Resource Type:	River/Stream		ORM Resource Type:	River/Stream		ORM Resource Type:		
		Cowardin/HGM type:	Riverine		Cowardin/HGM type:	Riverine		Cowardin/HGM type:		
		Hydrology:	Ephemeral		Hydrology:	Ephemeral		Hydrology:		
2	**Qualitative impact-mitigation comparison**:	Starting ratio:	**1.0 : 1.0**		Starting ratio:	**1.0 : 1.0**		Starting ratio:	**1.0 : 1.0**	
		Ratio adjustment:	**-1.0**		Ratio adjustment:	**0.0**		Ratio adjustment:	**0.0**	
		Baseline ratio:	**1.00 : 2.00**		Baseline ratio:	**1.00 : 1.00**		Baseline ratio:	**1.00 : 1.00**	
		PM justification: See qualitative sheet for adjustment			PM justification: See qualitative sheet for adjustment			PM justification: See qualitative sheet for adjustment		
3	**Quantitative impact-mitigation comparison**:	Ratio adjustment from BAMI procedure (attached):	#REF! : #REF!		Ratio adjustment from BAMI procedure (attached):	#REF! : #REF!		Ratio adjustment from BAMI procedure (attached):	#REF! : #REF!	
4	**Mitigation site location**:	Ratio adjustment:	**0**		Ratio adjustment:	**0**		Ratio adjustment:	**0**	
		PM justification: same watershed			PM justification: same watershed			PM justification:		
5	**Net loss of aquatic resource surface area**:	Ratio adjustment:	**0**		Ratio adjustment:	**0**		Ratio adjustment:	**0**	
		PM justification: reestablishment			PM justification: reestablishment			PM justification:		
6	**Type conversion:**	Ratio adjustment:	**-0.5**		Ratio adjustment:	**1**		Ratio adjustment:	**0**	
		PM justification: Like-for-like, but addition of Monkey Spring flows to SCR.			PM justification: buffer (non-waters)			PM justification:		
7	**Risk and uncertainty**:	Ratio adjustment:	**0.4**		Ratio adjustment:	**0.4**		Ratio adjustment:	**0**	
		PM justification: +0.1 PRM; +0.3 complex stream relocation project with robust modeling			PM justification: +0.1 PRM; +0.3 complex stream relocation project with robust modeling			PM justification:		
8	**Temporal loss**:	Ratio adjustment:	**3**		Ratio adjustment:	**3**		Ratio adjustment:	**0**	
		PM justification: Mesquite trees. No schedule loss.			PM justification: Mesquite trees. No schedule loss.			PM justification:		
9	**Final mitigation ratio(s):**	Baseline ratio from 2 or 3:	1.00 :	2.00	Baseline ratio from 2 or 3:	1.00 :	1.00	Baseline ratio from 2 or 3:	1.00 :	1.00
		Total adjustments (4-8):	2.9		Total adjustments (4-8):	4.4		Total adjustments (4-8):	0	
		Final ratio:	**3.90 : 2.00**		Final ratio:	**5.40 : 1.00**		Final ratio:	**1.00 : 1.00**	
		Proposed impact (total):	8.9	acres	Remaining impact:	4.08	acres	Remaining impact (acres):	-12.55	acres
			0	linear feet		0	linear feet	Remaining impact (linear feet):	0	linear feet
		to Resource type:	River/Stream		to Resource type:	River/Stream		to Resource type:	River/Stream	
		Cowardin or HGM:	Riverine		Cowardin or HGM:	Riverine		Cowardin or HGM:	Riverine	
		Hydrology:	Ephemera		Hydrology:	Ephemeral		Hydrology:	Ephemeral	
		Required Mitigation*:	17.36	acres	Required Mitigation*:	22.03	acres	Required Mitigation:	-12.55	acres
			0	linear feet		0.0	linear feet		0.0	linear feet
		of Resource type:	River/Stream		of Resource type:	River/Stream		of Resource type:	0	
		Cowardin or HGM:	Riverine		Cowardin or HGM:	Riverine		Cowardin or HGM:	0	
		Hydrology:	Ephemeral		Hydrology:	Ephemeral		Hydrology:	0	
		Proposed Mitigation**:	9.40	acres	Proposed Mitigation**:	34.58	acres	Proposed Mitigation**:	0.00	acres
				linear feet			linear feet			linear feet
		Impact Unmitigated:	46	%	Impact Unmitigated:	-57	%	Impact Unmitigated:		%
			4.08	acres		-12.55	acres			acres
		Additional PM comments:			Additional PM comments:			Additional PM comments:		
10	**requirements:**									

*At PM's discretion, if applicant's proposed mitigation is less than checklist requirement and additional mitigation type(s) proposed, complete additional columns as needed.

**Only enter proposed mitigation into spreadsheet if accepting applicant's lower (than required ratio) proposal.

Step 2: Qualitative comparison of functions (functional loss vs. gain)

Functions (Column A)	Reconstructed channel	SCR Fill	Adjustment[1]
Surface Water Storage	++	-	+
Subsurface Flow	+++	-	++
Energy Dissipation	+++	0	+++
Groundwater Recharge	+++	-	++
Sediment Transport	+++	-	++
Biogeochemical	+	-	0
Organic Carbon Export	+	-	0
Habitat Connectivity/Structure	+++	-	++
			12

Adjustment: -1

PM Justification: Compared to existing, highly constrained Sonoita Creek channel, the mitigation provides extensive reestablished channel system on floodplain. Access to adjacent floodplain provides for increased flood attenuation, energy dissipation, and groundwater recharge. Includes contribution from Monkey Spring (600 ac-ft/yr).

Function (Column B)	Reconstructed Channel Buffer	SCR Fill	Adjustment
Surface Water Storage	+	-	0
Subsurface Flow	+	-	0
Energy Dissipation	+++	0	++
Groundwater Recharge	+	-	0
Sediment Transport	0	-	-
Biogeochemical	+	-	0
Organic Carbon Export	+	-	0
Habitat Connectivity/Structure	+++	-	++
			3

Adjustment: 0

PM Justification: Compared to existing, highly constrained Sonoita Creek channel, reestablished channel buffer will provide significant benefits to energy dissipation, flood attenuation, and habitat connectivity.

Function (Column C)			Adjustment
Surface Water Storage			
Subsurface Flow			
Energy Dissipation			
Groundwater Recharge			
Sediment Transport			
Biogeochemical			
Organic Carbon Export			
Habitat Connectivity/Structure			

Adjustment: 0

PM Justification:

Instructions:
1. Describe amount of functional loss (impact) and gain (mitigation) in each respective column. Gain and loss can be described in text (for
2. Note: alternate lists of functions may be used.
3. Note: a single adjustment should be used to account for all functions combined (see example 7 in attachment 12501.3)

Notes:
1. Total adjustment is scaled to nearest integer between -2 and 4.

Attachment 12501.6 - SPD Mitigation Ratio Setting Checklist (See 12501-SPD for Revisions Sheet)

1	Date: July 31, 2017	Corps File No.:	SPL-2005-00816-MB	Project Manager:	Deanna Cummings
	Impact Site Name:	Rosemont Copper Project - Headwater washes	ORM Resource Type:	River/Stream	Hydrology: Ephemeral
	Impact Cowardin or HGM type:	Riverine	Impact area :	21.2 acres	Impact distance: linear feet

No.	Item	Column A	Column B	Column C	Column D	Column E	Column F	Column G
		Mitigation Site Name: SCR reestablished floodplain channel buffer Mitigation Type: Reestablishment ORM Resource Type: River/Stream Cowardin/HGM type: Riverine Hydrology: Ephemeral	Mitigation Site Name: SCR rehabilitated channel and buffer Mitigation Type: Rehabilitation ORM Resource Type: River/Stream Cowardin/HGM type: Riverine Hydrology: Ephemeral	Mitigation Site Name: SCR enhanced ephemeral washes Mitigation Type: Enhancement ORM Resource Type: River/Stream Cowardin/HGM type: Riverine Hydrology: Ephemeral	Mitigation Site Name: SCR enhanced ephemeral wash buffers Mitigation Type: Enhancement ORM Resource Type: River/Stream Cowardin/HGM type: Riverine Hydrology: Ephemeral	Mitigation Site Name: Enhanced ponds Mitigation Type: Enhancement ORM Resource Type: Cowardin/HGM type: Hydrology: Perennial	Mitigation Site Name: SCR rehabilitated floodplain uplands Mitigation Type: Rehabilitation ORM Resource Type: River/Stream Cowardin/HGM type: Riverine Hydrology: Ephemeral	Mitigation Site Name: LSPWA ILF Project Mitigation Type: Rehabilitation ORM Resource Type: River/Stream Cowardin/HGM type: Riverine Hydrology: Perennial
2	**Qualitative impact-mitigation comparison:**	Starting ratio: **1.0 : 1.0** Ratio adjustment: **0.0** Baseline ratio: **1.00 : 1.00** PM justification: See qualitative sheet for adjustment	Starting ratio: **1.0 : 1.0** Ratio adjustment: **0.0** Baseline ratio: **1.00 : 1.00** PM justification: See qualitative sheet for adjustment	Starting ratio: **1.0 : 1.0** Ratio adjustment: **1.0** Baseline ratio: **2.00 : 1.00** PM justification: See qualitative sheet for adjustment	Starting ratio: **1.0 : 1.0** Ratio adjustment: **1.0** Baseline ratio: **2.00 : 1.00** PM justification: See qualitative sheet for adjustment	Starting ratio: **1.0 : 1.0** Ratio adjustment: **1.0** Baseline ratio: **2.00 : 1.00** PM justification: See qualitative sheet for adjustment	Starting ratio: **1.0 : 1.0** Ratio adjustment: **0.0** Baseline ratio: **1.00 : 1.00** PM justification: See qualitative sheet for adjustment	Starting ratio: **1.0 : 1.0** Ratio adjustment: **0.0** Baseline ratio: **1.00 : 1.00** PM justification: See qualitative sheet for adjustment
3	**Quantitative impact-mitigation comparison:**	Ratio adjustment from BAMI procedure (attached): **#REF! : #REF!**	Ratio adjustment from BAMI procedure (attached): **#REF! : #REF!**	Ratio adjustment from BAMI procedure (attached): **#REF! : #REF!**	Ratio adjustment from BAMI procedure (attached): **#REF! : #REF!**	Ratio adjustment from BAMI procedure (attached): **#REF! : #REF!**	Ratio adjustment from BAMI procedure (attached): **#REF! : #REF!**	Ratio adjustment from BAMI procedure (attached): **#REF! : #REF!**
4	**Mitigation site location:**	Ratio adjustment: **1** PM justification: outside watershed	Ratio adjustment: **1** PM justification: outside watershed	Ratio adjustment: **1** PM justification: outside watershed	Ratio adjustment: **1** PM justification: outside watershed	Ratio adjustment: **1** PM justification: outside watershed	Ratio adjustment: **1** PM justification: outside watershed	Ratio adjustment: **1** PM justification: outside watershed
5	**Net loss of aquatic resource surface area:**	Ratio adjustment: **0** PM justification: reestablishment	Ratio adjustment: **1** PM justification: rehabilitation	Ratio adjustment: **1** PM justification: enhancement	Ratio adjustment: **1** PM justification: enhancement	Ratio adjustment: **1** PM justification: enhancement	Ratio adjustment: **1** PM justification: rehabilitation	Ratio adjustment: **1** PM justification: rehabilitation
6	**Type conversion:**	Ratio adjustment: **1** PM justification: buffer (non-waters)	Ratio adjustment: **0** PM justification: ephemeral washes	Ratio adjustment: **0** PM justification: smaller ephemeral washes and some floodplain washes	Ratio adjustment: **3** PM justification: buffer (non-waters)	Ratio adjustment: **-0.5** PM justification: out of kind but valuable resources	Ratio adjustment: **3** PM justification: buffer (non-waters)	Ratio adjustment: **0** PM justification: buffer (non-waters), but highly valuable landscape scale resource
7	**Risk and uncertainty:**	Ratio adjustment: **0.4** PM justification: +0.1 PRM; +0.3 complex stream relocation project with robust modeling	Ratio adjustment: **0.2** PM justification: +0.1 PRM; +0.1 difficult to replace resources	Ratio adjustment: **0.2** PM justification: +0.1 PRM; +0.1 difficult to replace resources	Ratio adjustment: **0.2** PM justification: +0.1 PRM; +0.1 difficult to replace resources	Ratio adjustment: **0.2** PM justification: +0.1 PRM; +0.1 difficult to replace resources	Ratio adjustment: **0.2** PM justification: +0.1 PRM; +0.1 difficult to replace resources	Ratio adjustment: **0** PM justification: ILF Project
8	**Temporal loss:**	Ratio adjustment: **3** PM justification: Mesquite trees. No schedule loss.	Ratio adjustment: **3** PM justification: Mesquite trees. No schedule loss.	Ratio adjustment: **0** PM justification: No schedule loss.	Ratio adjustment: **0** PM justification: No schedule loss.	Ratio adjustment: **0** PM justification: No schedule loss.	Ratio adjustment: **3** PM justification: Mesquite trees. No schedule loss.	Ratio adjustment: **1.8** PM justification: 3-year phase-in for ILF project (0.05*36 months)
9	**Final mitigation ratio(s):**	Baseline ratio from 2 or 3: 1.00 : 1.00 Total adjustments (4-8): 5.4 **Final ratio: 6.40 : 1.00** Proposed impact (total): 21.2 acres 0 linear feet to Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Required Mitigation*: 135.68 acres 0 linear feet of Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Proposed Mitigation**: 12.55 acres linear feet Impact Unmitigated: 91 % 19.24 acres Additional PM comments:	Baseline ratio from 2 or 3: 1.00 : 1.00 Total adjustments (4-8): 5.2 Final ratio: **6.20 : 1.00** Remaining impact: 19.24 acres 0 linear feet to Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Required Mitigation*: 119.28 acres 0.0 linear feet of Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Proposed Mitigation**: 11.18 acres linear feet Impact Unmitigated: 91 % 17.44 acres Additional PM comments:	Baseline ratio from 2 or 3: 2.00 : 1.00 Total adjustments (4-8): 2.2 Final ratio: **4.20 : 1.00** Remaining impact (acres): 17.44 acres Remaining impact (linear feet): 0 linear feet to Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Required Mitigation: 73.23 acres 0.0 linear feet of Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Proposed Mitigation**: 21.92 acres linear feet Impact Unmitigated: 70 % 12.22 acres Additional PM comments:	Baseline ratio from 2 or 3: 2.00 : 1.00 Total adjustments (4-8): 5.2 Final ratio: **7.20 : 1.00** Remaining impact (acres): 12.22 acres Remaining impact (linear feet): 0 linear feet to Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Required Mitigation: 87.96 acres 0.0 linear feet of Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Proposed Mitigation**: 66.30 acres linear feet Impact Unmitigated: 25 % 3.01 acres Additional PM comments:	Baseline ratio from 2 or 3: 2.00 : 1.00 Total adjustments (4-8): 1.7 Final ratio: **3.70 : 1.00** Remaining impact (acres): 3.01 acres Remaining impact (linear feet): 0 linear feet to Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Required Mitigation: 11.13 acres 0.0 linear feet of Resource type: 0 Cowardin or HGM: 0 Hydrology: Perennial Proposed Mitigation**: 6.00 acres linear feet Impact Unmitigated: 46 % 1.39 acres Additional PM comments:	Baseline ratio from 2 or 3: 1.00 : 1.00 Total adjustments (4-8): 8.2 Final ratio: **9.20 : 1.00** Remaining impact (acres): 1.39 acres Remaining impact (linear feet): 0 linear feet to Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Required Mitigation: 12.76 acres 0.0 linear feet of Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Proposed Mitigation**: 117.77 acres linear feet Impact Unmitigated: -823 % -105.01 acres Additional PM comments:	Baseline ratio from 2 or 3: 1.00 : 1.00 Total adjustments (4-8): 3.8 Final ratio: **4.80 : 1.00** Remaining impact (acres): 3.01 acres Remaining impact (linear feet): 0 linear feet to Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Ephemeral Required Mitigation: 14.44 acres 0.0 linear feet of Resource type: River/Stream Cowardin or HGM: Riverine Hydrology: Perennial Proposed Mitigation**: 0.00 acres linear feet Impact Unmitigated: % acres Additional PM comments:
10	**requirements:**							

*At PM's discretion, if applicant's proposed mitigation is less than checklist requirement and additional mitigation type(s) proposed, complete additional columns as needed.

**Only enter proposed mitigation into spreadsheet if accepting applicant's lower (than required ratio) proposal.

Step 2: Qualitative comparison of functions (functional loss vs. gain)

Functions (Column A)	Reconstructed Channel Buffer	Rosemont headwaters	Adjustment[1]
Surface Water Storage	+	0	+
Subsurface Flow	+	0	+
Energy Dissipation	+++	-	++
Groundwater Recharge	+	-	0
Sediment Transport	0	--	--
Biogeochemical	+	0	+
Organic Carbon Export	+	-	0
Habitat Connectivity/Structure	+++	-	++
			5

Adjustment: 0

PM Justification: Reestablished Sonoita Creek channel buffer provides extensive flood attenuation, energy dissipation, and habitat connectivity functions, particularly compared to small, high gradient Rosemont headwater washes.

Functions (Column B)	SCR Rehabilitated Channel and Buffer	Rosemont headwaters	Adjustment
Surface Water Storage	+	0	+
Subsurface Flow	+	0	+
Energy Dissipation	++	-	+
Groundwater Recharge	++	-	+
Sediment Transport	+	--	-
Biogeochemical	+	0	+
Organic Carbon Export	+	-	0
Habitat Connectivity/Structure	+	-	0
			4

Adjustment: 0

PM Justification: The rehabilitated reach of Sonoita Creek will transition the constructed channel back to the main channel, improving all functions but particularly the energy dissipation and flood attenuation through this reach.

Functions (Column C)	SCR enhanced ephemeral washes	Rosemont headwaters	Adjustment
Surface Water Storage	0	0	0
Subsurface Flow	0	0	0
Energy Dissipation	0	-	-
Groundwater Recharge	0	-	-
Sediment Transport	0	--	--
Biogeochemical	0	0	0
Organic Carbon Export	0	-	-
Habitat Connectivity/Structure	+	-	0
			-5

Adjustment: 1

PM Justification: Enhancement of ephemeral washes resulting from wildlife friendly fencing and grazing exclusion will support habitat connecivity function.

Step 2: Qualitative comparison of functions (functional loss vs. gain)

Functions (Column D)	SCR enhanced ephemeral wash buffers	Rosemont headwaters	Adjustment
Surface Water Storage	0	0	0
Subsurface Flow	0	0	0
Energy Dissipation	0	-	-
Groundwater Recharge	0	-	-
Sediment Transport	0	--	--
Biogeochemical	0	0	0
Organic Carbon Export	0	-	-
Habitat Connectivity/Structure	+	-	0
			-5

Adjustment: 1

PM Justification: Enhancement of ephemeral wash buffers resulting from wildlife friendly fencing and grazing exclusion will support habitat connecivity function.

Functions (Column E)	Enhanced ponds	Rosemont headwaters	Adjustment
Surface Water Storage	0	0	0
Subsurface Flow	0	0	0
Energy Dissipation	0	-	-
Groundwater Recharge	0	-	-
Sediment Transport	0	--	--
Biogeochemical	0	0	0
Organic Carbon Export	+	-	0
Habitat Connectivity/Structure	+	-	0
			-4

Adjustment: 1

PM Justification: Enhancement of ponds includes exotic species control and flow through design bringing spring flows back into the system.

Functions (Column F)	SCR rehabilitated floodplain uplands	Rosemont headwaters	Adjustment
Surface Water Storage	0	0	0
Subsurface Flow	0	0	0
Energy Dissipation	+	-	0
Groundwater Recharge	0	-	-
Sediment Transport	+	--	-
Biogeochemical	0	0	0
Organic Carbon Export	0	-	-
Habitat Connectivity/Structure	++	-	+
			-2

Adjustment: 0

PM Justification: Rehabilitation of the Sonoita Creek floodplain will complement the reestablished channel and riparian buffer that are the cornerstone of the mitigation project. Replacing the exotic grasses in the ag fields with native species will improve wildlife connectivity, as well as energy dissipation and sediment transport.

Step 2: Qualitative comparison of functions (functional loss vs. gain)

Functions (Column G)	LSPRWA ILF Project	Rosemont headwaters	Adjustment
Surface Water Storage	+	0	+
Subsurface Flow	+	0	+
Energy Dissipation	+	-	0
Groundwater Recharge	++	-	+
Sediment Transport	+	--	-
Biogeochemical	+	0	+
Organic Carbon Export	+	-	0
Habitat Connectivity/Structure	++	-	+
			4

Adjustment: 0

PM Justification: ILF project includes rehabilitation of buffer through exotics control and native tree planting. Also, establishment of wetlands and reestablishment of mesquite bosque in a fallow ag field.

Instructions:

1. Describe amount of functional loss (impact) and gain (mitigation) in each respective column. Gain and loss can be described in text (for
2. Note: alternate lists of functions may be used.
3. Note: a single adjustment should be used to account for all functions combined (see example 7 in attachment 12501.3)

Notes:

1. Total adjustment is scaled to nearest integer between -2 and 4.

ATTACHMENT 6

Restrictive Covenant

RECORDING REQUESTED BY AND
WHEN RECORDED RETURN TO:

[insert address]

(Space Above Line for Recorder's Use)

DECLARATION OF RESTRICTIVE COVENANTS

This DECLARATION OF RESTRICTIVE COVENANTS ("**Restrictive Covenant**") is made this ____ day of __________, 20__ by ________________, a _____________corporation (hereinafter "**Declarant**").

RECITALS

A. Declarant is the sole owner in fee simple of certain real property containing ___ acres, located in the City of ____________, County of ___________, State of Arizona, found on Assessor's Parcel Number ____________ (the "**Parcel**"). The Parcel is legally described on **Exhibit "A"** attached hereto and incorporated by this reference. The Declarant desires to grant a restrictive covenant over a ___-acre portion of the Parcel (the "**Restricted Property**"). The Restricted Property is legally described and depicted on **Exhibit "B"** attached hereto and incorporated by this reference.

B. The Restricted Property provides, among other things, compensatory mitigation for certain impacts from development of the ____________________ Project ("**Project**") by Declarant pursuant to requirements of (1) the United States Army Corps of Engineers' ("**ACOE**") Clean Water Act (CWA) Section 404 Permit No. ________________ and any amendments thereto (**"Section 404 Permit**"); and the Arizona Department of Environmental Quality's ("**ADEQ**") CWA Section 401 Certification No. __________ and any amendments thereto (**"Section 401 Certification**"), and the United States Fish and Wildlife Service's ("**USFWS**") biological opinion No. ________ and any amendments thereto ("**BO**"). The foregoing documents are collectively referred to herein as the "**Approval Documents**."

C. This Restrictive Covenant is designed to satisfy and is granted in satisfaction of the Approval Documents.

D. Consistent with the terms and conditions of this Restrictive Covenant, the Restricted Property is and will remain in a Natural Condition as defined herein and is intended to be preserved in its natural, scenic, open condition to maintain its ecological, historical, visual and educational values (collectively, "**Conservation Values**"). The Conservation Values are of importance to the people of the County of _______ and the people of the United States.

E. The ACOE is the federal agency charged with the primary responsibility for regulating activities in waters of the United States, including wetlands, with regulatory authority over discharges of dredged and fill material into such waters pursuant to Section 404 of the Clean Water Act, and is a third party beneficiary of this Restrictive Covenant.

F. [delete if not applicable or revise if fee title to be conveyed to HOA] Following recordation and subject to Section 11 below, Declarant intends to convey all of the Restricted Property to a conservation organization. Should Declarant transfer its interest in the Restricted Property prior to the time that Compensatory Mitigation (defined below) is fulfilled, the conservation organization will assume the roles and responsibilities of Declarant, including long-term maintenance, under this Restrictive Covenant, except that Declarant, as the developer of the Project, will remain responsible for the Compensatory Mitigation until it has been successfully implemented and completed per the success criteria set forth in the Mitigation Plan.

COVENANTS, TERMS, CONDITIONS AND RESTRICTIONS

In consideration of the above recitals and the covenants, terms, conditions, and restrictions contained herein, and pursuant to the laws of the United States and state of Arizona, including Arizona Revised Statutes 33-271, *et seq.*, Declarant hereby declares the Restricted Property shall be held, transferred, conveyed, leased, occupied or otherwise disposed of, and used subject to the following restrictive covenants (and incorporating the above recitals herein by this reference), which shall run with the land, and be binding on Declarant's heirs, successors in interest, administrators, assigns, lessees, or other occupiers and users of the Restricted Property, or any portion of it.

1. Purpose.

(a) The purposes of this Restrictive Covenant are to (1) ensure the Restricted Property will be preserved in a Natural Condition, as defined herein, in perpetuity and (2) prevent any use of the Restricted Property that will impair or interfere with the Conservation Values of the Restricted Property (the "**Purpose**"). Declarant intends that this Restrictive Covenant will confine the use of the Restricted Property to such activities that are consistent with this Purpose, including without limitation, those involving the preservation, restoration, and enhancement of native species and their habitats.

(b) The term "**Natural Condition**," as referenced in the preceding paragraph and other portions of this Restrictive Covenant, shall mean the condition of the Restricted Property as it exists at the time this Restrictive Covenant is executed, as well as future enhancements or changes to the Restricted Property that occur directly as a result of the following activities:

(1) Compensatory mitigation measures (**"Compensatory Mitigation**"), including implementation, maintenance and monitoring activities, required by the Approval Documents and as described in the "[insert name of mitigation plan]," prepared by ________________, dated ______________ (the "**Mitigation Plan**"). The cover page and introduction are attached as **Exhibit "C"**;

(2) In-perpetuity maintenance obligations ("**Long-Term Maintenance**") that occur on the Restricted Property as described in Section 14 herein.

(3) Activities described in Section 3 and Section 5 herein.

(c) Declarant represents and warrants that there are no structures or other man-made improvements existing on the Restricted Property [**OR,** the only structures or other man-made improvements existing on the Restricted Property consist of (describe)]. Declarant further represents and warrants there are no previously granted easements existing on the Restricted Property that interfere or conflict with the Purpose of this Restrictive Covenant as evidenced by the Preliminary Title Report dated __________, attached hereto as **Exhibit "D**." The present Natural Condition is evidenced in part by the depiction of the Restricted Property attached on **Exhibit "E,"** showing all relevant and plottable property lines, easements, dedications, improvements, structures, boundaries, and major, distinct natural features such as waters of the United States. Declarant has delivered further evidence of the present Natural Condition to ACOE consisting of (1) a color aerial photograph of the Restricted Property at an appropriate scale taken __________; (2) an overlay of the Restricted Property boundaries on that aerial photograph; and (3) on-site color photographs showing all improvements, structures, and natural features of the Restricted Property.

(d) If a controversy arises with respect to the present Natural Condition of the Restricted Property, Declarant and/or ACOE shall not be foreclosed from utilizing any and all other relevant documents, surveys, photographs or other evidence or information to assist in the resolution of the controversy.

(e) The term "**Biological Monitor**" shall mean either an employee of the Declarant or an independent third-party consultant with knowledge of riparian resources in the _____ County area and expertise in the field of biology or a related field.

2. ACOE's rights. To accomplish the Purpose of this Restrictive Covenant, Declarant hereby grants and conveys the following rights to ACOE (but without obligation of the ACOE):

(a) A non-exclusive easement on and over the Restricted Property to preserve and protect the Conservation Values of the Restricted Property; and

(b) A non-exclusive easement on and over the Parcel and Restricted Property to enter upon the Restricted Property to monitor Declarant's compliance with and to otherwise enforce the terms of this Restrictive Covenant; and

(c) A non-exclusive easement on and over the Restricted Property to prevent any activity on or use of the Restricted Property that is inconsistent with the Purpose of this Restrictive Covenant and to require the restoration of such areas or features of the Restricted Property that may be damaged by any act, failure to act, or any use that is inconsistent with the Purpose of this Restrictive Covenant; and

(d) All present and future development rights allocated, implied, reserved or inherent in the Property; such rights are hereby terminated and extinguished, and may not be used on or transferred to any portion of the Property, nor any other property adjacent or otherwise; and

(e) The right to enforce by any means, including, without limitation, injunctive relief, the terms and conditions of this Restrictive Covenant.

3. Declarant's Duties. [Declarant's Name] shall undertake construction, maintenance and monitoring of mitigated areas pursuant to the Mitigation Plan until receipt of final approval of

the success of the mitigation from ACOE and ADEQ ("**Final Approval**"). This duty is non-transferrable. Declarant, its successors and assigns shall:

(a) Undertake all reasonable actions to prevent the unlawful entry and trespass by persons whose activities would be inconsistent with the Conservation Values and would violate the permitted uses of the Restricted Property set forth in this Restrictive Covenant; and

(b) Cooperate with ACOE in the protection of the Conservation Values; and

(c) Repair and restore damage to the Restrictive Property directly or indirectly caused by Declarant, Declarant's guests, representatives or agents and third parties within Declarant's control; provided, however, Declarant, its successors or assigns shall not engage in any repair or restoration work in the Restricted Property without first consulting with ACOE; and

(d) Obtain any applicable governmental permits and approvals for any activity or use permitted by this Restrictive Covenant, and any activity or use shall be undertaken in accordance with all applicable federal, state, local and administrative agency statutes, ordinances, rules, regulations, orders or requirements; and

(e) Upon receipt of Final Approval, perform in-perpetuity Long-Term Maintenance on the Restricted Property set forth in Section 14 below; and

(f) Within 60 days of recordation of this Restrictive Covenant, install signs and other notification features saying "Natural Area Open Space," "Protected Natural Area," or similar descriptions that inform persons of the nature and restrictions on the Restricted Property. Prior to erection of such signage, Declarant shall submit detailed plans showing the location and language of such signs to ACOE for review and approval. The erection and maintenance of informative signage shall not be in direct or potential conflict with the preservation of the Natural Condition of the Restricted Property or the Purpose of this Restrictive Covenant and shall be performed in compliance with all applicable statutes, regulations, and permitting requirements; and

(g) Perform an annual compliance inspection of the Restricted Property, prepare an inspection report, and shall make reports available to ACOE upon request.

4. Prohibited Uses. Any activity on or use of the Restricted Property inconsistent with the Purpose of this Restrictive Covenant is prohibited. Without limiting the generality of the foregoing, the following uses by Declarant, and its respective guests, agents, assigns, employees, representatives, successors and third parties within Declarant's control, are expressly prohibited:

(a) Supplemental or unseasonable watering except as specifically provided for in the Mitigation Plan;

(b) Use of herbicides, pesticides, rodenticides, biocides, fertilizers, or other agricultural chemicals or weed abatement activities, except weed abatement activities necessary to control or remove invasive, exotic plant species;

(c) Incompatible fire protection activities, except the fire prevention activities set forth in Subsection 5(f);

(d) Use of off-road vehicles and use of any other motorized vehicles except on existing roadways and as necessary to restore native plant communities consistent with Section 5;

(e) Grazing or other agricultural activity of any kind;

(f) Recreational activities, including, but not limited to, horseback riding, biking, hunting or fishing;

(g) Residential, commercial, retail, institutional, or industrial uses;

(h) Any legal or de facto division, subdivision or partitioning of the Restricted Property;

(i) Construction, reconstruction or placement of any building, road, wireless communication cell towers, or other improvement, or any billboard, fence, boundary marker or sign, except signs permitted in Subsection 3(f);

(j) Depositing, dumping or accumulating soil, trash, ashes, refuse, waste, bio-solids or any other material;

(k) Planting, introduction or dispersal of non-native or exotic plant or animal species;

(l) Filling, dumping, excavating, draining, dredging, mining, drilling, removing or exploring for or extraction of minerals, loam, gravel, soil, rock, sand or other material on or below the surface of the Restricted Property;

(m) Altering the general topography of the Restricted Property, including but not limited to building of roads and trails, and flood control work;

(n) Removing, destroying, or cutting of trees, shrubs or other vegetation, except as necessary for (1) emergency fire protection as required by fire safety officials as set forth in Subsection 5(f), (2) controlling invasive, exotic plants which threaten the integrity of the habitat, (3) preventing or treating disease, (4) conducting activities permitted by the Mitigation Plan, or (5) activities described in Section 3, Section 5 and Section 14. In the event that activity in the Restricted Property is necessary to prevent or treat disease as listed in item (3) herein, the first priority for action shall be chemical and biological methods. No invasive or non-native species shall be introduced to prevent or treat disease, unless chemical or biological methods have failed to resolve the problem and the County of ______ Department of Environmental Health, or other agency with authority, determines that no other methods will address the problem. Removal of vegetation to prevent or treat disease shall only be allowed if chemical or biological methods have failed to resolve the problem or upon a showing that removal of vegetation is required on an emergency basis;

(o) Manipulating or altering any natural watercourse, body of water or water circulation on the Restricted Property other than as described in the Mitigation Plan, and activities or uses detrimental to water quality, including but not limited to degradation or pollution of any surface or sub-surface waters;

(p) Creating, enhancing, or maintaining fuel modification zones (defined as a strip of mowed land or the planting of vegetation possessing low combustibility for purposes of fire suppression), or other activities that could constitute fuel modification zones;

(q) Without the prior written consent of ACOE, which ACOE may withhold, transferring, encumbering, selling, leasing, or otherwise separating the mineral, air or water rights from the Restricted Property; changing the place or purpose of use of the water rights on the Restricted Property; abandoning or allowing the abandonment of, by action or inaction, any water or water rights, ditch or ditch rights, spring rights, reservoir or storage rights, wells, round water rights, or other rights in and to the use of water historically used on or otherwise appurtenant to the Restricted Property, including but not limited to: (1) riparian water rights; (2) appropriative water rights; (3) rights to waters which are secured under contract with any irrigation or water district, to the extent such waters are customarily applied to the Restricted Property; and (4) any water from wells that are in existence or may be constructed in the future on the Restricted Property;

(r) Engaging in any use or activity that may violate, or may fail to comply with, relevant federal, state, or local laws, regulations, or policies applicable to Declarant, the Restricted Property, or the use or activity in question;

(s) No use shall be made of the Restricted Property, and no activity thereon shall be permitted, that is or is likely to become inconsistent with the Purpose of this Restrictive Covenant. Declarant acknowledges that, in view of the perpetual nature of this Restrictive Covenant, it is unable to foresee all potential future land uses, future technologies, and future evolution of the land and other natural resources, and other future occurrences affecting the Purpose of this Restrictive Covenant. ACOE may determine whether (1) proposed uses or proposed improvements not contemplated by or addressed in this Restrictive Covenant or (2) alterations in existing uses or structures, are consistent with the Purpose of this Restrictive Covenant; and

(t) Creation of any encumbrance superior to this Restrictive Covenant, other than those encumbrances set forth in **Exhibit "D"** hereto, or the recording of any involuntary lien (which is not released within thirty calendar days), or the granting of any lease, license or similar possessory interest in the Restricted Property which will affect the Conservation Values of the Restricted Property.

5. Reserved Rights. Declarant reserves to itself, and to its personal representatives, heirs, successors, and assigns, all rights accruing from its ownership of the Restricted Property, including the right to engage in or to permit or invite others to engage in all uses of the Restricted Property that are not expressly prohibited or limited by, and are consistent with, the Purpose of this Restrictive Covenant, including, but not limited to, the following uses:

(a) Access. Reasonable access through the Restricted Property to adjacent land or to perform obligations or other activities permitted by this Restrictive Covenant or that are required under the Approval Documents. In addition, police and other public safety organizations and their personnel may enter the Restricted Property to address any legitimate public health or safety matter. When and if [Name of Present Declarant] assigns its rights and duties under this

Restrictive Covenant to a conservation organization, [Name of Present Declarant] may not assign to the conservation organization the duty to undertake construction, maintenance and monitoring of mitigated areas pursuant to the Mitigation Plan, i.e., [Name of Present Declarant] will remain responsible for the Compensatory Mitigation obligations of the Approval Documents until Final Approval is obtained. In the event [Name of Present Declarant] conveys its interest in the Restricted Property prior to completion of Compensatory Mitigation requirements, [Name of Present Declarant] expressly reserves the right for it or its agents to enter the Restricted Property to perform such work thereon as is required to meet the Compensatory Mitigation obligations of the Approval Documents.

(b) Habitat Enhancement Activities. Enhancement of native plant communities, including the right to plant trees and shrubs of the same type as currently existing on the Restricted Property, so long as such activities do not harm the habitat types identified in the Approval Documents or Mitigation Plan. For purposes of preventing erosion and reestablishing native vegetation, the Declarant shall have the right to revegetate areas that may be damaged by the permitted activities under this Section 5, naturally occurring events or by the acts of persons wrongfully damaging the Natural Condition of the Restricted Property. Prior to any habitat enhancement activities, Declarant shall have a Biological Monitor submit detailed plans to ACOE, ADEQ, and USFWS for review and approval. Habitat enhancement activities shall not be in direct or potential conflict with the preservation of the Natural Condition of the Restricted Property or the Purpose of this Restrictive Covenant and shall be performed in compliance with all applicable laws, regulations, and permitting requirements.

(c) Vegetation, Debris, and Exotic Species Removal. Removal or trimming of vegetation downed or damaged due to natural disaster, removal of man-made debris, removal of parasitic vegetation (as it relates to the health of the host plant) and removal of non-native or exotic plant or animal species. Vegetation, debris, and exotic plant species removal shall not be in direct or potential conflict with the preservation of the Natural Condition of the Restricted Property or the Purpose of this Restrictive Covenant and shall be performed in compliance with all applicable laws, regulations, and permitting requirements.

(d) Erection and Maintenance of Informative Signage. Erection and maintenance of signage and other notification features saying “No Trespass” or similar descriptions that inform persons of the nature and restrictions on the Restricted Property.

(e) No Interference with Development of Adjoining Property. Notwithstanding anything set forth herein to the contrary, nothing in this Restrictive Covenant is intended nor shall be applied to in any way limit Declarant or any of Declarant’s successors and assigns from (1) constructing, placing, installing, and/or erecting any improvements upon the portions of the Parcel not constituting the Restricted Property, and /or (2) developing adjoining property for any purposes, except as limited by any local, state or federal permit requirements for such development and provided that for all of the above clauses, (1) and (2), neither such activity nor any effect resulting from such activity amounts to a use of the Restricted Property, or has an impact upon the Restricted Property, that is prohibited by Section 4 above.

(f) Fire Protection. The right, in an emergency situation only, to maintain firebreaks (defined as a strip of plowed or cleared land made to check the spread of a fire), trim or remove brush, otherwise perform preventative measures required by the fire department to protect structures and other improvements from encroaching fire. All other brush management activities, activities prohibited by Subsection 4(p), or other fire prevention measures suggested by the fire department, shall be limited to areas outside the Restricted Property.

(g) Mitigation Plan. Notwithstanding anything herein to the contrary, [Name of Present Declarant] may take any action required by the Mitigation Plan. Such actions may include, but are not limited to the following: (1) [Name of Present Declarant] shall have the right to maintain, repair and or replace from time to time any or all of the vegetation planted as part of the Mitigation Plan and (2) [Name of Present Declarant] may take actions consistent with the Mitigation Plan.

6. Enforcement.

(a) Right to Enforce. Declarant, its successors and assigns, grant to ACOE, U.S. Department of Justice, and the State Attorney General a discretionary right to enforce these restrictive covenants in a judicial or administrative action against any person(s) or other entity (ies) violating or attempting to violate these restrictive covenants; provided, however, that no violation of these restrictive covenants shall result in a forfeiture or reversion of title. The U.S. Department of Justice and the State Attorney General shall have the same rights, remedies and limitations as ACOE under this Section 6. The rights under this Section are in addition to, and do not limit rights conferred in Section 2 above, the rights of enforcement against Declarant, its successor or assigns under the Section 404 Permit, or any rights of the various documents created thereunder or referred to therein.

(b) Notice.

(1) If ACOE determines Declarant is in violation of the terms of this Restrictive Covenant or that a violation is threatened, ACOE may demand the cure of such violation. In such a case, ACOE shall issue a written notice to Declarant (hereinafter "**Notice of Violation**") informing Declarant of the violation and demanding cure of such violation.

(2) Declarant shall cure the noticed violation within thirty (30) days of receipt of said written notice from ACOE. If said cure reasonably requires more than thirty (30) days, Declarant shall, within the thirty (30) day period submit to ACOE for review and approval a plan and time schedule to diligently complete a cure. Declarant shall complete such cure in accordance with the approved plan. If Declarant disputes the Notice of Violation, it shall issue a written notice of such dispute (hereinafter "**Notice of Dispute**") to the ACOE within thirty (30) days of receipt of written Notice of Violation.

(3) If Declarant fails to cure the noticed violation(s) within the time period(s) described in Subsection 6(b)(2) above, or Subsection 6(c) below, ACOE may bring an action at law or in equity in a court of competent jurisdiction to enforce compliance by Declarant with the terms of this Restrictive Covenant. In such action, the ACOE may (i) recover any damages to which they may be entitled for violation by Declarant of the terms of this Restrictive Covenant, (ii) enjoin the violation, *ex parte* if necessary, by temporary or permanent injunction without the necessity of proving either actual damages or the inadequacy of otherwise available legal

remedies, or (iii) pursue other equitable relief, including, but not limited to, the restoration of the Restricted Property to the condition in which it existed prior to any such violation or injury. ACOE may apply any damages recovered to the cost of undertaking any corrective action on the Restricted Property.

(4) If Declarant provides ACOE with a Notice of Dispute, as provided herein, ACOE shall meet and confer with Declarant at a mutually agreeable place and time, not to exceed thirty (30) days from the date that ACOE receives the Notice of Dispute. ACOE shall consider all relevant information concerning the disputed violation provided by Declarant and shall determine whether a violation has in fact occurred and, if so, whether the Notice of Violation and demand for cure issued by ACOE is appropriate in light of the violation.

(5) If, after reviewing Declarant's Notice of Dispute, conferring with Declarant, and considering all relevant information related to the violation, ACOE determines that a violation has occurred, ACOE shall give Declarant notice of such determination in writing. Upon receipt of such determination, Declarant shall have thirty (30) days to cure the violation. If said cure reasonably requires more than thirty (30) days, Declarant shall, within the thirty (30) day period submit to ACOE for review and approval a plan and time schedule to diligently complete a cure. Declarant shall complete such cure in accordance with the approved plan.

(c) Immediate Action. If ACOE determines that circumstances require immediate action to prevent or mitigate significant damage to the Conservation Values of the Restricted Property, ACOE may immediately pursue all available remedies, including injunctive relief, available pursuant to both this Restrictive Covenant and state and federal law after giving Declarant at least twenty four (24) hours' written notice before pursuing such remedies. So long as such twenty four (24) hours' notice is given, ACOE may immediately pursue all available remedies without waiting for the expiration of the time periods provided for cure or Notice of Dispute as described in Subsection 6(b)(2). The written notice pursuant to this paragraph may be transmitted to Declarant by facsimile. The rights of ACOE under this paragraph apply equally to actual or threatened violations of the terms of this Restrictive Covenant. Declarant agrees that the remedies at law for ACOE for any violation of the terms of this Restrictive Covenant are inadequate and that ACOE shall be entitled to the injunctive relief described in this section, both prohibitive and mandatory, in addition to such other relief to which ACOE may be entitled, including specific performance of the terms of this Restrictive Covenant, without the necessity of proving either actual damages or the inadequacy of otherwise available legal remedies. The remedies described in this Subsection 6(c) shall be cumulative and shall be in addition to all remedies now or hereafter existing at law or in equity.

(d) Costs of Enforcement. Any costs incurred by ACOE, as the prevailing party, in enforcing the terms of this Restrictive Covenant against Declarant including, but not limited to, costs of suit and attorneys' fees, and any costs of restoration necessitated by Declarant's negligence or breach of this Restrictive Covenant shall be borne by Declarant.

(e) Enforcement Discretion. Enforcement of the terms of this Restrictive Covenant shall be at the discretion of ACOE. Any forbearance by ACOE to exercise rights under this Restrictive Covenant in the event of any breach of any term of this Restrictive Covenant by Declarant shall not be deemed or construed to be a waiver by ACOE of such term or of any subsequent breach of the same or any other term of this Restrictive Covenant or of any of the rights of ACOE under this Restrictive Covenant. No delay or omission by ACOE in the exercise of any right or remedy upon any breach by Declarant shall impair such right or remedy or be construed as a waiver. Further, nothing in this Restrictive Covenant creates a non-discretionary duty upon ACOE to enforce its provisions, nor shall deviation from the terms and procedures or failures to enforce its provisions give rise to a private right of action against ACOE by any third party.

(f) Acts Beyond Declarant's Control. Nothing contained in this Restrictive Covenant shall be construed to entitle ACOE to bring any action against Declarant for any injury to or change in the Restricted Property resulting from:

(1) Any natural cause beyond Declarant's control, including without limitation, fire not caused by Declarant, flood, storm, and earth movement; or

(2) Any prudent action taken by Declarant under emergency conditions to prevent, abate, or mitigate significant injury to persons and/or the Restricted Property resulting from such causes, provided that once the emergency has abated, Declarant, its successors or assigns promptly take all reasonable and necessary actions required to restore any damage caused by Declarant's actions to the Restricted Property to the condition it was in immediately prior to the emergency; or

(3) Acts of third parties (including any governmental agencies) that are beyond Declarant's control.

Notwithstanding the foregoing, Declarant must obtain any applicable governmental permits and approvals for any emergency activity or use permitted by this Restrictive Covenant and undertake any activity or use in accordance with all applicable federal, state, local and administrative agency statutes, ordinances, rules, regulations, orders or requirements.

7. Access. This Restrictive Covenant does not convey a general right of access to the public.

8. Costs and Liabilities.

(a) Declarant, or its successor or assign retains all responsibilities and shall bear all costs and liabilities of any kind related to the ownership, operation, upkeep and maintenance of the Restricted Property. Declarant agrees ACOE shall not have any duty or responsibility for the operation, upkeep, or maintenance of the Restricted Property, the monitoring of hazardous conditions thereon, or the protection of Declarant, the public or any third parties from risks relating to conditions on the Restricted Property. Declarant, its successor or assign remains solely responsible for obtaining any applicable governmental permits and approvals for any activity or use permitted by this Restrictive Covenant, and any activity or use shall be undertaken in accordance with all applicable federal, state, local and administrative agency statutes ordinances, rules, regulations, orders and requirements.

(b) Declarant, or its successors and assigns shall hold harmless, protect and indemnify ACOE and its respective directors, officers, employees, agents, contractors, and representatives and the heirs, personal representatives, successors and assigns of each of them (each a "**Third-Party Beneficiary Indemnified Party**" and collectively, "**Third-Party Beneficiary Indemnified Parties**") from and against any and all liabilities, penalties, costs, losses, damages, expenses (including, without limitation reasonable attorneys' fees and experts' fees), causes of action, claims, demands, orders, liens or judgments (each a "**Claim**" and, collectively, "**Claims**"), arising from or in any way connected with injury to or the death of any person, or physical damage to any property, regardless of cause.

9. <u>Taxes; No Liens.</u> If applicable, Declarant, its successor or assign shall pay before delinquency all taxes, assessments, fees, and charges of whatever description levied on or assessed against the Parcel by competent authority, including any taxes imposed upon, or incurred as a result of, this Restrictive Covenant, and agrees to furnish ACOE with satisfactory evidence of payment upon request. Declarant shall keep the Restricted Property free from any liens, including those arising out of any obligations incurred by Declarant or any labor or materials furnished or alleged to have been furnished to or for Declarant at or for use on the Restricted Property.

10. <u>Condemnation.</u> The Purpose of this Restricted Covenant for conservation purposes are presumed to be the best and most necessary public use as defined in Arizona Revised Statutes Section 12-1122 except that Declarant reserves the right to seek fair market value for any condemnation action. Nevertheless, if all or any part of the Restricted Property is taken by exercise of the power of eminent domain, Declarant shall use the net proceeds from the condemnation of the Restricted Property for the purchase of property that replaces the natural resource characteristics the original mitigation was intended to protect, or as near as reasonably feasible. The endowment shall be held for the long-term stewardship of the replacement property. The location of the replacement property and replacement restrictive covenant is subject to prior approval by the ACOE.

11. <u>Assignment and Subsequent Transfers.</u>

(a) Declarant agrees to incorporate the terms of this Restrictive Covenant in any deed or other legal instrument by which Declarant divests itself of any interest in all or a portion of the Restricted Property. Declarant, its successor or assign agrees to (i) incorporate by reference to the title of and the recording information for this Restrictive Covenant in any deed or other legal instrument by which each divests itself of any interest in all or a portion of the Restricted Property, including, without limitation, a leasehold interest and (ii) give actual notice to any such transferee or lessee of the existence of this Restrictive Covenant. Declarant, its successor or assign agrees to give written notice to ACOE of the intent to transfer any interest at least sixty (60) days prior to the date of such transfer. Any subsequent transferee shall be deemed to have assumed the obligations of this Restrictive Covenant and to have accepted the restrictions contained herein. The failure of Declarant, its successor or assign to perform any act provided in this Section shall not impair the validity of this Restrictive Covenant or limit its enforceability in any way.

(b) From and after the date of any transfer of all or any portion of the Restricted Property by Declarant and each transfer thereafter, (i) the transferee shall be deemed to have assumed all of the obligations of Declarant as to the portion transferred, as set forth in this Restrictive Covenant, (ii) the transferee shall be deemed to have accepted the restrictions contained herein as to the portion transferred, (iii) the transferor, as applicable, shall have no further obligations hereunder, except for the obligations set forth above in Section 3 related to Compensatory Mitigation and Subsection 17(f), and (iv) all references to Declarant in this Restrictive Covenant shall thereafter be deemed to refer to such transferee.

12. Notices. Any notice, demand, request, consent, approval, or communication that either party desires or is required to give to the other shall be in writing and be served personally or sent by first class mail, postage prepaid, addressed as follows:

To Declarant:

With a copy to:

To ACOE: District Counsel
U.S. Army Corps of Engineers
915 Wilshire Blvd, Room 1535
Los Angeles, CA 90017-3401

or to such other address as either party shall designate by written notice to the other. Notice shall be deemed effective upon delivery in the case of personal delivery or, in the case of delivery by first class mail, five (5) days after deposit into the United States mail.

The parties agree to accept facsimile signed documents and agree to rely upon such documents as if they bore original signatures. Each party agrees to provide to the other parties, within seventy-two (72) hours after transmission of such a facsimile, the original documents that bear the original signatures.

If the Restrictive Covenant is assigned, the assignment document shall update the Notices provisions.

When the underlying fee for the Restricted Property is conveyed, the successor shall record a document entitled Restrictive Covenant/Change of Notices Provisions.

13. Amendment. Declarant may amend this Restrictive Covenant only after written concurrence by ACOE. Any such amendment shall be consistent with the Purpose of this Restrictive Covenant and shall not affect its perpetual duration. Declarant shall record any amendments to this Restrictive Covenant approved by ACOE in the official records of _____ County, Arizona, and shall provide a copy of the recorded document to ACOE.

14. Long-Term Maintenance.

(a) Upon Final Approval, Declarant shall be responsible for in-perpetuity, ongoing, long-term maintenance of the Restricted Property. Such long-term maintenance shall include but shall not be limited to the following activities: (1) no less than annually, removal of trash or manmade debris, preferably by hand or the least impactive method reasonably feasible, (2) annual maintenance of signage and other notification features or similar descriptions, as applicable, installed pursuant to Subsection 3(f).

(b) Declarant shall be responsible for annual restoration of the Restricted Property damaged by any activities prohibited by Subsection 4 (a) - (t) herein.

(c) Declarant shall prepare a monitoring and maintenance report documenting activities performed under Subsection 14(a) above, and shall make reports available to ACOE upon request.

(d) When activities are performed pursuant to Subsection 14(b) above, Declarant shall retain a qualified Biological Monitor to prepare a Restoration Plan and to oversee/monitor such restoration activities. Declarant shall have its Biological Monitor submit a draft Restoration Plan to ACOE for review and approval prior to its implementation. Upon completion of restoration as specified in the approved Restoration Plan, Declarant shall have its Biological Monitor prepare a detailed monitoring report, and Declarant shall make the report available to ACOE within thirty (30) days of completion of restoration activities. Declarant and the Biological Monitor shall sign the monitoring report. The report shall document the Biological Monitor's name and affiliation, dates Biological Monitor was present on site, activities observed and their location, Biological Monitor's observations regarding the adequacy of restoration performance by the Declarant, or its contractor in accordance with the approved Restoration Plan, and the corrections recommended and implemented.

15. Recordation. Declarant, its successor or assign shall promptly record this instrument in the official records of ______ County, Arizona, and provide a copy of the recorded document to ACOE.

16. Estoppel Certificate. Upon request, ACOE shall within fifteen (15) days execute and deliver to Declarant, its successor or assign a letter confirming that (a) this Restrictive Covenant is in full force and effect, and has not been altered, amended, or otherwise modified (except as specifically noted in the letter), (b) there are no pending or threatened enforcement actions against Declarant except as disclosed in the letter, (c) to the knowledge of the ACOE, there are no uncured violations under the Restrictive Covenant, and no facts or circumstances exist that, with the passage of time, could constitute a violation under the Restrictive Covenant, except as disclosed in the letter.

17. General Provisions.

(a) Controlling Law. The laws of the United States and the State of Arizona, disregarding any conflicts of law principles of such state, shall govern the interpretation and performance of this Restrictive Covenant.

(b) Liberal Construction. Any general rule of construction to the contrary notwithstanding, this Restrictive Covenant shall be liberally construed in favor of the deed to effect the Purpose of this Restrictive Covenant. If any provision in this instrument is found to be ambiguous, an interpretation consistent with the Purpose of this Restrictive Covenant that would render the provision valid shall be favored over any interpretation that would render it invalid.

(c) Severability. If a court of competent jurisdiction voids or invalidates on its face any provision of this Restrictive Covenant, such action shall not affect the remainder of this Restrictive Covenant. If a court of competent jurisdiction voids or invalidates the application of any provision of this Restrictive Covenant to a person or circumstance, such action shall not affect the application of the provision to other persons or circumstances.

(d) No Forfeiture. Nothing contained herein will result in a forfeiture or reversion of Declarant's title in any respect.

(e) Successors and Assigns. The covenants, terms, conditions, and restrictions of this Restrictive Covenant shall be binding upon, and inure to the benefit of, the parties hereto and their respective personal representatives, heirs, successors, and assigns and shall continue as a servitude running in perpetuity with the Restricted Property. The covenants hereunder also benefit ACOE, as a third party beneficiary of this Restrictive Covenant.

(f) Termination of Rights and Obligations. Except as otherwise expressly set forth in this Restrictive Covenant and provided the transfer was consistent with the terms of this Restrictive Covenant, a party's rights and obligations under this Restrictive Covenant shall terminate upon transfer of the party's interest in the Restrictive Covenant or Restricted Property (respectively), except that liability for acts or omissions occurring prior to transfer shall survive transfer. However, in those provisions where the term "[Name of Present Declarant]" is used in this Restrictive Covenant, and not the term "Declarant," those provisions shall be called **"Specific Obligations"** and shall apply exclusively to the [Name of Present Declarant] and shall not be transferred to the conservation organization upon conveyance of the [Name of Present Declarant] interest in the Restrictive Covenant or Restricted Property. If the [Name of Present Declarant] conveys its interest in the Project to a bona fide purchaser, the Specific Obligations are assumed by such bona fide purchaser by virtue of this Restrictive Covenant.

(g) Captions. The captions in this instrument have been inserted solely for convenience of reference and are not a part of this instrument and shall have no effect upon construction or interpretation.

(h) No Hazardous Materials Liability.

(1) Declarant represents and warrants that to Declarant's actual knowledge there has been no release or threatened release of Hazardous Materials (defined below) or underground storage tanks existing, generated, treated, stored, used, released, disposed of, deposited or abandoned in, on, under, or from the Restricted Property, or transported to or from or affecting the Restricted Property. Without limiting the obligations of Declarant under Subsection 8(b) herein, Declarant hereby releases and agrees to indemnify, protect and hold harmless the Third Party Beneficiary Indemnified Parties (defined in Subsection 8(b)) against any and all Claims (defined in Subsection 8(b)) arising from or connected with any Hazardous Materials present, or otherwise alleged to be present, on the Restricted Property at any time, except that this release and indemnification shall be inapplicable to the Third Party Beneficiary

Indemnified Parties with respect to any Hazardous Materials placed, disposed or released by third party beneficiaries, their employees or agents. This release and indemnification includes, without limitation, Claims for (i) injury to or death of any person or physical damage to any property; and (ii) the violation or alleged violation of, or other failure to comply with, any Environmental Laws (defined below).

(2) Despite any contrary provision of this Restrictive Covenant, the parties do not intend this Restrictive Covenant to be, and this Restrictive Covenant shall not be, construed such that it creates in or gives ACOE any of the following:

(i) The obligations or liabilities of an "owner" or "operator," as those terms are defined and used in Environmental Laws (defined below), including, without limitation, the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (42 U.S.C. Section 9601 et seq.; hereinafter, "**CERCLA**"); or

(ii) The obligations or liabilities of a person described in 42 U.S.C. Section 9607(a)(3) or (4); or

(iii) The obligations of a responsible person under any applicable Environmental Laws; or

(iv) The right to investigate and remediate any Hazardous Materials associated with the Restricted Property; or

(v) Any control over Declarant's ability to investigate, remove, remediate or otherwise clean up any Hazardous Materials associated with the Restricted Property.

(3) The term "**Hazardous Materials**" includes, without limitation, (i) material that is flammable, explosive or radioactive; (ii) petroleum products, including by-products and fractions thereof; and (iii) hazardous materials, hazardous wastes, hazardous or toxic substances, or related materials defined in CERCLA, the Resource Conservation and Recovery Act (42 U.S.C. Section 6901 et seq.); the Hazardous Materials Transportation Act (49 U.S.C. Section 5101 et seq.); Title 49 of Arizona Revised Statutes, and in the regulations adopted and publications promulgated pursuant to them, or any other applicable federal, state or local laws, ordinances, rules, regulations or orders now in effect or enacted after the date of this Restrictive Covenant.

(4) The term "**Environmental Laws**" includes, without limitation, any federal, state, local or administrative agency statute, ordinance, rule, regulation, order or requirement relating to pollution, protection of human health or safety, the environment or Hazardous Materials. Declarant represents, warrants and covenants to ACOE that activities upon and use of the Restricted Property by Declarant, its agents, employees, invitees and contractors will comply with all Environmental Laws.

(i) Additional Interests. Declarant shall not grant any additional easements, rights of way or other interests in the surface or subsurface of the Restricted Property (other than a security interest that is subordinate to this Restrictive Covenant), or grant or otherwise abandon or relinquish any water rights relating to the Restricted Property, without first obtaining the written consent of ACOE. ACOE may withhold such consent if it determines that the proposed interest or transfer is inconsistent with the Purpose of this Restrictive Covenant or will impair or interfere with the Conservation Values of the Restricted Property. This Section shall not prohibit transfer of a fee or leasehold interest in the Restricted Property that is subject to this Restrictive Covenant and complies with Section 11. Declarant, its successors and assigns shall record any additional easements or other interests in the Restricted Property approved by the ACOE in the official records of ______ County, Arizona, and provide a copy of the recorded document to the ACOE.

(j) ACOE Benefited Party. Except for Subsection 17(e), the terms of this Restrictive Covenant are for the benefit of the ACOE only and are not for the benefit of any other party.

(k) Extinguishment. If circumstances arise in the future that render the Purpose of the Restrictive Covenant impossible to accomplish, the Restrictive Covenant can only be terminated or extinguished, in whole or in part, by judicial proceedings in a court of competent jurisdiction.

(l) Warranty. Declarant represents and warrants that there are no outstanding mortgages, liens, encumbrances or other interests in the Restricted Property (including, without limitation, mineral interests) which have not been expressly subordinated to this Restrictive Covenant, and that the Restricted Property is not subject to any other Conservation Easement.

(m) Change of Conditions. If one or more of the Purpose of this Restrictive Covenant may no longer be accomplished, such failure of purpose shall not be deemed sufficient cause to terminate the entire Restrictive Covenant as long as any other purpose of the Restrictive Covenant may be accomplished. In addition, the inability to carry on any or all of the permitted uses, or the unprofitability of doing so, shall not impair the validity of this Restrictive Covenant or be considered grounds for its termination or extinguishment. Declarant agrees that global warming and climate change-caused effects shall not be a basis for termination of this Restrictive Covenant.

(n) Funding. Before the execution and recordation of this Restrictive Covenant, the [Name of Present Declarant] shall pay ________________ DOLLARS AND NO/100's DOLLARS ($________________) to [Name of Endowment Holder] to endow the long-term management obligations of the Restrictive Covenant. ACOE shall have the right to review and approve the terms of the endowment management agreement, which shall be executed concurrently with this Restrictive Covenant.

* * * Signatures on following page. * * *

IN WITNESS WHEREOF Declarant has executed this Restrictive Covenant the day and year first above written and agrees to be bound by the terms and provisions hereof.

"**Declarant**"

NAME**,**
A _________ corporation

By: ____________________________
[name and title]

[ATTACH NOTARY ACKNOWLEDGEMENT]

EXHIBIT A

EXHIBIT B

EXHIBIT C

EXHIBIT D

EXHIBIT E

ATTACHMENT 7

Performance Standards

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Attachment 7. Worksheet for SPD Uniform Performance Standards for Compensatory Mitigation Requirements (12505.2)

1	Date: July 2017 DA no.: SPL-2008-00816-MB Project manager: Deanna Cummings	Mitigation site name: Sonoita Creek Ranch Cowardin/HGM type: palustrine Habitat type: semidesert grassland, xeroriparian Site coordinates: Center/1st endpoint: Lat: 31.60021 Lon: -110.7173 2nd endpoint (if linear) Lat: Lon:	Reference site name: Site coordinates: Center/1st endpoint: Lat: Lon: 2nd endpoint (if linear) Lat: Lon:
2	Mitigation objective(s) to improve: [X] habitat conservation/biodiversity; [ ] water storage/flow attenuation; [ ] water quality; [ ] target population of special status biota; [ ] specific aquatic resource function(s); [X] other:		
3	Mitigation type (select one): [X] re-establishment; [ ] establishment; [ ] rehabilitation; [ ] enhancement		
	If enhancement, indicate function(s) to be increased: function 1: function 2 (if applicable): function 3 (if applicable):		
4	Primary type(s) of site treatment: [X] introduction of plant materials; [X] invasive species control; [X] hydrological manipulation; [X] topographic/substrate manipulation		
5	Aquatic resource type (select one): [X] riverine; [ ] depressional wetland; [ ] tidal wetland; [ ] slope wetland; [ ] other:		
6	Performance standard categories (select all that apply): [X] physical; [X] hydrologic; [ ] fauna; [X] flora; [ ] water quality (ecological)		
7	Using selections from 2-6 above, insert applicable performance standards and targets from .12505.1-SPD Table of Uniform Performance Standards for Compensatory Mitigation Requirements into worksheet rows below. Add or remove rows for any category, as needed.		

Number/Categories: Performance Standards: Targets ("R" indicates reference):

		Year 5:	Year 10:	Year 15:
Physical-1	The permittee shall ensure the mitigation expresses channel complexity. Specifically, reestablished channels shall demonstrate or more of the following: • Bar formation and/or bar destruction, cut-bank development, channel cutoff-chutes, general topographic variation to the active channel and floodplain benches, and variability of channel width.			
Physical-2	The permittee shall ensure the mitigation retains or increases stream stability and does not cause site, upstream, or downstream excessive erosion or aggradation. Specifically: • Lateral migration of the reestablished channels shall not extend beyond the established channel migration limits.			
Physical-3	The permittee shall ensure the mitigation retains or increases stream stability and does not cause site, upstream, or downstream excessive erosion or aggradation. Specifically: • Vertical incision shall not impair flows within the reestablished channels from reaching the adjoining floodplain benches in the 10-year, 24-hour stormflow.			

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Hydrologic -1	The permittee shall ensure the main channel geometry (width to depth ratio, sinuosity, etc.) is reestablished such that overbank flooding occurs or water can access high-flow channel(s) in the active floodplain during the 10-year, 24-hour storm event.			
Hydrologic -2				
Fauna-1				
Flora-1	Dominance of natives: the permittee shall ensure target percent relative cover of native species are met by year 15.	≥50%	≥60%	≥75%
Flora -2	Dominance of exotics: Dominance of exotics: the permittee shall ensure target percent absolute cover (for combined tree, shrub, and herb strata) are met for exotic species by year 15.	≤10%	≤10%	≤10%
Flora -3	Dominance of native species: the permittee shall ensure target percent absolute cover of native species (annual and perennial species) is achieved by year 15.	≥10%	≥10%	≥15%
Flora -4	Dominance of native woody species: the permittee shall ensure target density/frequency of mesquite and other native woody tree and shrub species is achieved by year 15. • Channel cut area • Repository area	250/acre 10% frequency	250/acre 10% frequency	250/acre 10% frequency
Flora -5	Dominance of native grasses: the permittee shall ensure target survival of transplanted big sacaton (*Sporobolus wrightii*), including recruits, is achieved by year 15.	≥50%	≥50%	≥50%
Flora -6	Species diversity: the permittee shall ensure that the restoration project reflects adequate flora species diversity, as anticipated for a disturbance community, and that target is achieved by year 15.	3 native species ≥3% of relative cover each	4 native species ≥3% of relative cover each	5 native species ≥3% of relative cover each
WQ-1				
WQ -2				