AMERICAN RIVER –LONG TERM ECONOMIC ANALYSIS

INTRODUCTION

The American River Watershed Project over the last decade has had several reports with a number of features authorized including the Common Features and Folsom Modifications. In this study of the Long Term Project, it is assumed that these features will be completed and be part of the without project condition. The purpose of this analysis is to address economic changes since the 1996 Supplemental Information Report SIR report, define the new without project damages, and estimate benefits of the remaining array of measures and alternatives.

Historical Flooding Problems

In the mid 1800's through the early 1900's, Sacramento was hit by a series of damaging floods from both the American and Sacramento Rivers. After many of these floods, measures were taken to minimize the risk to the community. Early measures included raising the downtown streets by 10 feet, and later building the bypass system and levees (authorized in 1917) to protect the populated areas. The surrounding areas, not protected by these improvements, suffered from several flood events from 1925 to 1950. The most recent flood was in 1950 when over 9,000 acres east of Sacramento were inundated from the American River. Damages from this flood were small (estimated less than $4 million in 1950 prices) due to the fact that the area in 1950 was primarily agricultural. This area is now fully developed and protected by levees and Folsom Dam. The partial construction of Folsom Dam (which was completed in 1956) saved Sacramento from severe damage from the 1955 flood. The system was again tested during the events of 1986 and 1997, with flooding occurring on rivers to the north and south, when the American River faced unprecedented high flows. If levees had failed in the Sacramento area from either of these events, the damage would have been much greater than the reported $150 million in 1997 to less-densely populated Yuba County.

INVENTORY REVISITED

This section will explain the process used to re-evaluate the structural inventory for the American River Watershed. The original inventory was gathered in 1989-1990 for the 1992 Feasibility Report and then later updated for the 1996 Supplemental Information Report (SIR.) This data was then used as the basis for all damage and benefit estimates found in documents from 1996 (SIR) to the 1999 Section 566 report. In accordance with ER 1105-2-100, those elements that could have the biggest impact on damages and corresponding benefits were given the focus of this reevaluation.

Changes Since 1996 and 1990

Since 1996, there have been several studies[1] performed in the area that indicate that the values and number of residential structures originally computed in the 1990 inventory may have been overestimated. New technologies such as digital databases and GIS (Geographical Information

[1] South Sacramento Streams 1998, Post Flood Assessment 1999, SAFCA Assessment 2000.

Systems) were not available in 1989-1990. The residential structure count was based on area averages, developing density (number of units per acre) and using the same relationship throughout the flood plain. Commercial, industrial, and public structures were computed on a structure by structure basis and the count did not seem unreasonable. But based on the inconsistencies of residential counts, a 100 % new inventory for residential structures was developed for this study.

Study Area – Economic Reaches

For this re-evaluation, the inventory was grouped geographically into four economic reaches, the Downtown Area, Rancho Cordova, South Sacramento and North Sacramento (for this analysis Natomas reach was excluded as the project does not provide benefits for that area.) The area is extensive, with about 55,000 acres subject to inundation. The reaches and extent of the flood plain can be seen in figure 1.

The four economic reaches (Downtown Area, Rancho Cordova, South Sacramento and North Sacramento) of the Lower American River were grouped together for the risk-based analysis. A common index point, at river mile 7.75 – index point # 2, was used to evaluate these reaches. As mentioned, one of the reaches from SIR, Natomas was dropped from this analysis as both damages and flood risk would be the same for that area under without project conditions and any of the alternatives considered.

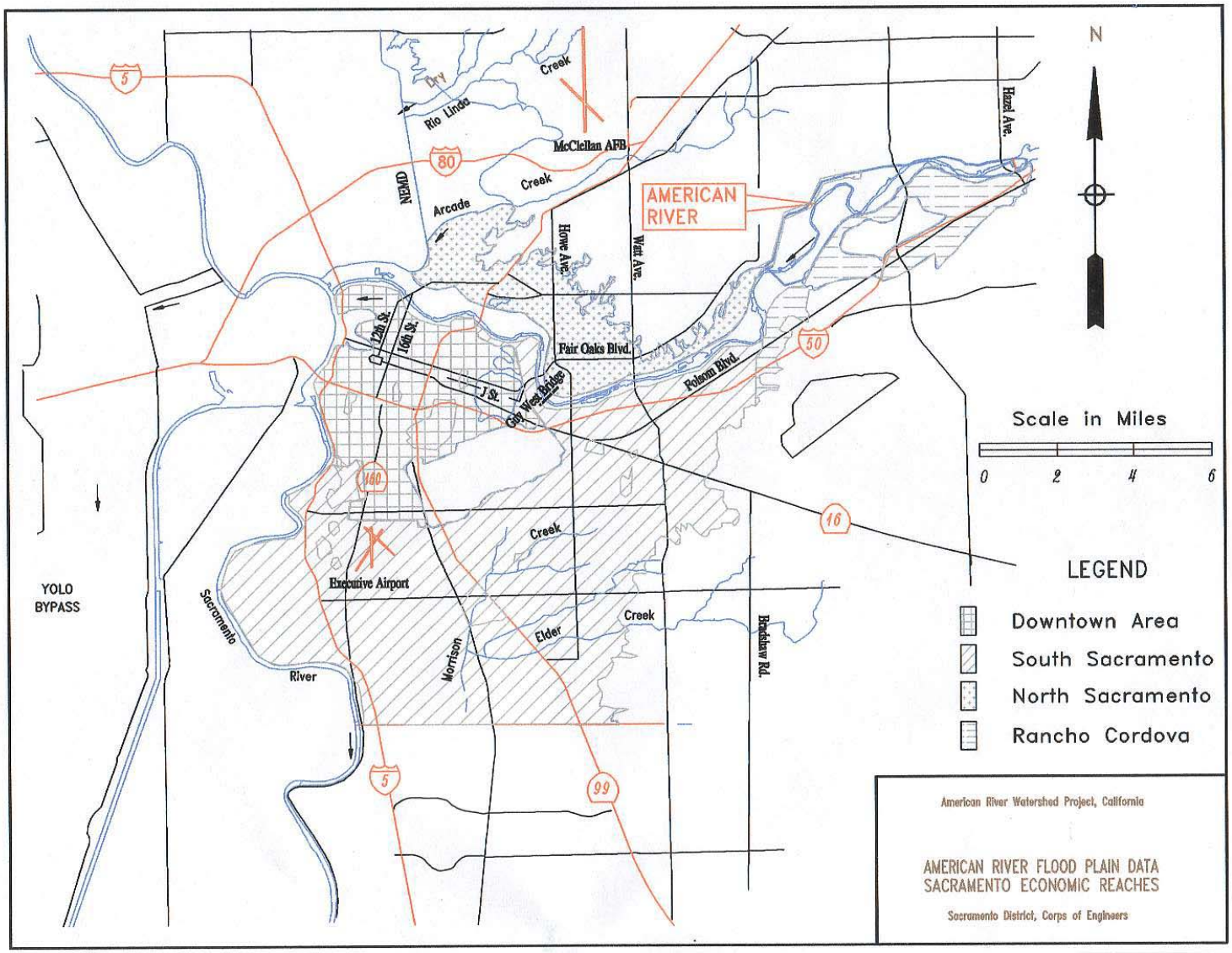
N
Scale in Miles
0 2 4 6
AMERICAN RIVER
Dry Creek
Rio Linda
McClellan AFB
Arcade Creek
NEMD
Hazel Ave.
Howe Ave.
Watt Ave.
12th St.
16th St.
J St.
City West Bridge
Fair Oaks Blvd.
Folsom Blvd.
Executive Airport
Creek
Elder Creek
Morrison Creek
Bradshaw Rd.
YOLO BYPASS
Sacramento River
5
80
50
16
99
LEGEND
Downtown Area
South Sacramento
North Sacramento
Rancho Cordova
American River Watershed Project, California
AMERICAN RIVER FLOOD PLAIN DATA
SACRAMENTO ECONOMIC REACHES
Sacramento District, Corps of Engineers

FIGURE 1

Residential Inventory

The original flood plains for this study included 100-year and 400-year frequency delineations. While these frequencies have changed due to new flow-frequency relationships and completed project elements, the corresponding outflows still would produce similar flooding characteristics (same depths, area extent, duration) but at less likely frequencies. The original flood plains were digitized and used for developing the new inventory utilizing digital parcel data. The new inventory represents all residential structures in the flood plain including new development up to November 1999. Table 1 shows the number of residential units by area. The number of residential structures is about 20 % less than listed in earlier inventories.

Commercial- Industrial-Public Inventory

The updated inventory for the 1996 SIR included the original 1989-1990 inventory plus new development up to the end of 1994. This inventory was complete count (without sampling) and is representative of conditions as of 1994. The current study was focused on identifying new structures developed between 1995 and 1999. These new structures were identified by comparing changes in land use from the 1995 and 1999 digital parcel databases. Parcels that were vacant in 1995 but had improvement values in the new database were verified during field visitation and added to the inventory. Additional structures under current construction were also included. The total number of new structures added: 84 commercial, 3 industrial, and 10 public structures.

TABLE 1
NUMBER OF STRUCTURES
BY LAND USE AND REACH

REACH	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	PUBLIC	TOTAL
DOWNTOWN	21,869	1,610	47	383	23,909
NORTH SACRAMENTO	12,046	1,229	29	303	13,607
RANCHO CORDOVA	6,830	262	20	14	7,126
SOUTH SACRAMENTO	64,154	1,528	77	513	66,272
TOTAL	104,899	4,629	173	1,213	110,914

Value of Damageable Property

Values were revised using several methods. All values are listed in October 2001 price levels. All values represent depreciated replacement values.

Residential Structures

Residential values were determined by comparing cost per square foot method with adjusted improvement values. For all residential parcels, the assessed value list was gathered and adjusted based on year of recording assessment. This gave a relative value for each and every structure within the flood plain. To verify the depreciated replacement values, a sample of 365 individual structures were randomly selected. Characteristics, such as square footage, type, class, age and condition were gathered from database, Marshall & Swift Valuation, and field visitation. Value was determined as a function of dollar per square foot (by class & type) multiplied by square footage multiplied by percent of remaining value (total value minus depreciation.) This depreciated replacement value was compared to the adjusted improvement value of the 365 sample structures to determine standard deviation and to verify the values used. The total depreciated replacement value of the sample was only two percent greater than the total adjusted improvement value and this percentage adjustment was made to the remaining residential structures.

Commercial, Industrial, and Public Structures

In contrast to the residential structures (which in the 1990 inventory were based on average values that were aggregated per acre,) the original inventory had unique values for each individual commercial, industrial and public structure. To reevaluate these structures, a sample consisting of more than two hundred structures from the original inventory were selected. From this sample the values used the 1996 SIR were compared to new values. New values were determined based on square footage, land use, type of activity (retail, office, warehouse, etc.) construction class, and condition. Field visitation was performed and data was gathered for each structure in the sample. Current values were based on cost per square foot method (similar to the method used on the residential but with more class and type distinctions for varying land use activities) and compared to the original values from the 1996 SIR study. Based on the summation of the sample, the new values were 5% less than the old values. As with the residential sample, the data was used in determining standard deviations and the structure values were adjusted to represent the 5% difference in value. New structures were valued at depreciated replacement value and were added to the inventory. The values of these structures are displayed in Table 2

Content Value

Content values were estimated as a percentage of the structure value. The percentages used were the same as used in the original study. For residential structures, a fifty percent content to structure ratio was used. For commercial, industrial, and public the content to structure ratio ranged from 24% to 209% depending the different land uses and activities. For new structures, land use and activity categories were identified and assigned content percentage. The values of contents are displayed in Table 2.

TABLE 2
VALUE OF DAMAGEABLE PROPERTY
VALUES IN MILLIONS, OCTOBER 2001 PRICES

LAND USE	AREA REACH				TOTAL
	DOWNTOWN	NORTH SACRAMENTO	RANCHO CORDOVA	SOUTH SACRAMENTO	
RESIDENTIAL					
STRUCTURE	$ 2,105	$ 1,648	$ 971	$ 5,739	$ 10,463
CONTENT	$ 1,053	$ 824	$ 486	$ 2,870	$ 5,233
COMMERCIAL					
STRUCTURE	$ 1,469	$ 1,245	$ 358	$ 1,775	$ 4,847
CONTENT	$ 1,661	$ 1,407	$ 410	$ 2,020	$ 5,498
INDUSTRIAL					
STRUCTURE	$ 23	$ 14	$ 26	$ 157	$ 220
CONTENT	$ 26	$ 14	$ 28	$ 163	$ 231
PUBLIC					
STRUCTURE	$ 922	$ 291	$ 22	$ 888	$ 2,123
CONTENT	$ 385	$ 123	$ 17	$ 465	$ 990
TOTAL	$ 7,644	$ 5,566	$ 2,318	$ 14,077	$ 29,605

FLOOD INUNDATION DAMAGES

Structural and content damages were estimated based on depth of flooding and depreciated replacement value. Depth damage relationships were used to determine the percent of value damaged at a given depth. Depth damage relationships were the same as used in the original study (based primarily on Federal Emergency Management Agency (FEMA) and Tennessee Valley Authority (TVA) curves and verified by other studies.) Uncertainties in structure and content values, first floor elevation, and percent damaged were used in Monte Carlo simulation. The Monte Carlo simulations were run to estimate three means and standard deviations representing three single events using the current data. Damages were determined based on the flood plain characteristics (depth, duration, extent of flooding) from the original 1992 Feasibility Study for the 80, 100 and 400-year depths of flooding using the 100 and 400-year flood plains. The other damage points used to complete the stage damage curves were interpolated based data

from the original 1992 Feasibility Study. The original study used the non-risk based program HEC-EAD (Hydrologic Engineering Center- Expected Annual Damages) to generate the stage damage relationships. Damages to structure and content represent over 95% of the total damages. The other minor damage categories, such as autos, roads and emergency costs, were updated by price indexing and adjusted based on the change in residential structure counts and occupancy.

Stage-Damage Curves

Damages for each category were determined and grouped by the original frequencies used. Damage estimates were then tied to stage (linked by the original flow-frequency relationship) for entry into the MONTE program. The combined stage frequency curve, with uncertainty, is displayed in Table 3 below. The original stage-damage curves had zero dollar damages below 43 feet. This is based on the condition that the levees would not fail below this stage. Since then, a series of levee improvements have brought the zero dollar damage point up to a series of higher stages. In the MONTE program, the PNP (probable non-failure point) determines the stage where damages first occur. With construction completed from the Common Features project, the PNP equals 49 feet under without project conditions for this study (damages would be zero for all stages below 49 feet.)

MONTE Program

For all of the American River Watershed Investigation studies since 1994, a software program called MONTE was used for all risk-based analysis. MONTE was developed by the Hydrologic Engineering Center (HEC) in Davis, CA and was the MS-DOS based precursor to the more familiar HEC-FDA program. While it is not as popular as the windows-based FDA, it has been used for numerous studies in several districts in the US Army Corps of Engineers. The program uses the same relationships as FDA in its risk analysis and specifically for the American River: a) Discharge-Frequency, b) Inflow-Outflow to account for reservoir regulation, c) Stage-Discharge, d) Levee Failure Probability defined at probable failure and non-failure points (PFP set at 85% probability and PNP at 15% probability,) and e) Stage-Damage. These relationships include uncertainty parameters with distributions including Normal, Triangular, and Log-Pearson. Team discussions during the study proposed dropping MONTE and migrating all data to FDA. But to preserve consistency to prior American River studies, the team and HEC recommended staying with MONTE.

TABLE 3
STAGE-DAMAGE CURVE
At Index Point # 7 (River Mile 7.75)
Existing Conditions
Damages in $ Millions, October 2001 Prices

Stage in Feet	Frequency (1 in x chance)	Damage Category					Total Damages	Standard Deviation
		Residential	Commercial	Industrial	Public	Other		
43.60	1 in 115	$ 3,475	$ 1,041	$ 14	$ 462	$ 26	**$ 5,019**	**$ 781**
49.33	1 in 149	$ 4,168	$ 1,464	$ 33	$ 597	$ 243	**$ 6,504**	**$ 807**
55.50	1 in 192	$ 4,898	$ 2,672	$ 136	$ 881	$ 355	**$ 8,942**	**$ 974**
63.30	1 in 233	$ 5,674	$ 3,318	$ 161	$ 1,011	$ 457	**$ 10,621**	**$ 1,049**
67.20	1 in 417	$ 6,424	$ 4,374	$ 199	$ 1,229	$ 625	**$ 12,851**	**$ 1,078**
68.00	1 in 500	$ 6,537	$ 4,543	$ 203	$ 1,261	$ 626	**$ 13,170**	**$ 1,109**

Future Economic Conditions

In the 1996 SIR, future growth within the flood plain was projected out to the study base year, which was 2008. Excluding Natomas, new damageable structures were limited to the fringe areas to the south and east. In the 1996 study, damages were projected to increase by less than 1.1 percent per year and only for events beyond the 100-year. To verify the growth, damages from structures built from 1995 to 1999 were compared with the total inventory. Based on these findings, damages would not increase due to new growth by more than 0.8 percent per year. The original growth estimates were incorporated with the new growth data to update stage-damage curves (Table 4) up to year 2010. By this date the area within the flood plain should reach full build out. Damages under future conditions were estimated and evaluated over the period of analysis to determine average annual equivalent damages. Average annual equivalent benefits are listed in Table 13, and are based on a 2011 to 2060 period of analysis, October 2001 prices, and 6 1/8 % discount rate.

TABLE 4
STAGE DAMAGE CURVES
Future Conditions
Damages in $ Millions, October 2001 Prices

Year of Estimated Development	Damages at Indicated Stage (Stage in feet @ Index # 7 - River Mile 7.75)					
	43.60	**49.33**	**55.50**	**63.30**	**67.20**	**68.00**
2000	$ 5,019	$ 6,504	$ 8,941	$ 10,621	$ 12,851	$ 13,170
2001	$ 5,019	$ 6,504	$ 8,986	$ 10,695	$ 12,954	$ 13,275
2002	$ 5,019	$ 6,504	$ 9,017	$ 10,770	$ 13,051	$ 13,375
2003	$ 5,019	$ 6,504	$ 9,049	$ 10,846	$ 13,149	$ 13,475
2004	$ 5,019	$ 6,504	$ 9,080	$ 10,922	$ 13,241	$ 13,570
2005	$ 5,019	$ 6,504	$ 9,112	$ 10,998	$ 13,334	$ 13,665
2006	$ 5,019	$ 6,504	$ 9,144	$ 11,075	$ 13,427	$ 13,760
2007	$ 5,019	$ 6,504	$ 9,167	$ 11,130	$ 13,494	$ 13,829
2008	$ 5,019	$ 6,504	$ 9,190	$ 11,186	$ 13,562	$ 13,898
2009	$ 5,019	$ 6,504	$ 9,213	$ 11,242	$ 13,629	$ 13,968
2010	$ 5,019	$ 6,504	$ 9,236	$ 11,298	$ 13,697	$ 14,037

Pre- Project Conditions – Completion of Folsom Modifications and Common Features

Since the original 1992 Feasibility Report, several project features have been either constructed or authorized. In WRDA 1996 and WRDA 1999, several improvements were authorized to reduce flood damages. These included levee improvements and gages under the Common Features, and changes to the dam outlets under the Folsom Modifications. The without project condition for the Long-Term study includes the completion of these elements. Separate reports were completed to evaluate the benefits for both the Common Features and the Folsom Modification projects. Tables 5 and 6 show the progression of damage reduction for the increments of these prior projects and how they would compare to proposed measures in this report.

TABLE 5
DERIVED FREQUENCY – DAMAGE RELATIONSHIPS
REPRESENTS EXPECTED DAMAGES FROM A SINGLE EVENT
COMPARISON OF PRE-PROJECT CONDITIONS
AND CURENT MEASURES CONSIDERED
(All are without advanced release)
EXISTING ECONOMIC CONDITIONS
Values in $ Millions, October 2001 Prices

CONDITION	PROBABILITY & 1 in X CHANCE PER YEAR					
	1.00% 1 in 100	0.80% 1 in 125	0.67% 1 in 150	0.50% 1 in 200	0.25% 1 in 400	0.10% 1 in 1000
Pre-Common Features	$ 6,877	$ 8,760	$ 9,785	$ 10,936	$ 12,569	$ 13,170
Common Features (96&99)	-	$ 8,461	$ 9,594	$ 10,836	$ 12,563	$ 13,170
Folsom Modifications (No Surcharge Storage)	-	-	$ 7,708	$ 10,000	$ 12,337	$ 13,170
Folsom Modifications (With Surcharge to 474 ft.)	-	-	$ 7,632	$ 10,009	$ 12,388	$ 13,170
Raise Folsom (To 478 ft Pool Elevation)	-	-	-	$ 9,348	$ 12,225	$ 13,170
Raise Folsom (To 482 ft Pool Elevation)	-	-	-	$ 8,271	$ 12,072	$ 13,170
Raise Folsom (To 487 ft Pool Elevation)	-	-	-	$ 6,284	$ 11,874	$ 13,170
Stepped Release (@ 160k cfs.)	-	-	$ 5,616	$ 9,133	$ 12,159	$ 13,170
Stepped Release (@ 160k cfs. + New Outlets)	-	-	-	$ 8,686	$ 12,215	$ 13,170
Stepped Release (@ 180k cfs.)	-	-	-	$ 8,727	$ 12,066	$ 13,170
Combo (Stepped Release@ 160 + Raise Folsom@ 482)	-	-	-	$ 5,710	$ 11,741	$ 13,170
Detention Dam (545k acft. @ Auburn)	-	-	-	-	-	$ 12,658

TABLE 6
EXPECTED ANNUAL DAMAGES
COMPARISON OF PRE-PROJECT CONDITIONS
AND CURENT MEASURES CONSIDERED
(All are without advanced release)
Values in $ Millions, October 2001 Prices

CONDITION	Annual Exceedance Probability	1 in X Chance Per Year	Expected Annual Damages		Percent Reduction in EAD from Pre-Common Features
			Existing 2000	Future 2010	
Pre-Common Features	0.0120	1 in 83	$ 120.62	$ 126.67	-
Common Features (96&99)	0.0099	1 in 101	$ 106.61	$ 112.43	12 %
Folsom Modifications (No Surcharge Storage)	0.0075	1 in 133	$ 82.41	$ 87.14	32 %
Folsom Modifications (With Surcharge to 474 ft.)	0.0073	1 in 137	$ 81.35	$ 85.99	33 %
Raise Folsom (To 478 ft Pool Elevation)	0.0065	1 in 154	$ 72.58	$ 76.77	40 %
Raise Folsom (To 482 ft Pool Elevation)	0.0057	1 in 175	$ 64.71	$ 68.46	46 %
Raise Folsom (To 487 ft Pool Elevation)	0.0051	1 in 196	$ 57.86	$ 61.22	52 %
Stepped Release (@ 160k cfs.)	0.0067	1 in 149	$ 73.70	$ 77.79	39 %
Stepped Release (@ 160k cfs. + New Outlets)	0.0063	1 in 159	$ 70.21	$ 74.14	42 %
Stepped Release (@ 180k cfs.)	0.0060	1 in 167	$ 67.39	$ 71.28	44 %
Combo (Stepped Release@ 160 + Raise Folsom@ 482)	0.0051	1 in 196	$ 56.28	$ 59.44	53 %
Detention Dam (545k acft. @ Auburn)	0.0019	1 in 526	$ 24.43	$ 24.43	81 %

Without Project Conditions – Advance Release from Folsom Dam

When the Folsom Modifications Project is completed in 2007, the additional outlet capacity at Folsom will allow for changes in flood management operations. One of these changes involves the ability to make advance releases based on weather forecasts. The affect of advance release is to create additional flood space within Folsom Lake by temporarily encroaching into the water supply space. This space is then replenished as the flood risk diminishes. The without project limit of this advance release is dependent upon the ability to replace this storage thus not causing adverse impacts to water supply, recreation, hydroelectric and related uses. A detailed discussion of the Advance Release operations can be found in Chapters 3 & 5 of the main report.

The level of storage available from this operation is dependent on many factors, with the primary being the duration of the advance releases prior to the peak. The range of storage is varied based on assumptions for both operations and forecasts. For this study, it was determined for economic evaluation purposes that a reasonable range of effective storage could be as low as zero additional acre feet to 190,000, with the most likely available storage around 100,000 acre feet. The without project condition includes, in addition to the completion of the Common Features and Folsom Modification projects, this advanced release scenario which is identified as the Moderate Advanced Release in the main report.

Note: For sensitivity analysis in the main report, conditions were based three possible future outcomes. The most likely without project condition includes the moderate advanced release and was the basis for the economic analysis. Two other possible conditions are no advanced release and a maximum advanced release (100,000-190,000-240,000 range.) Summary results of these other two possible conditions in comparison with the without project condition can be found for each alternative in Chapter 5 of the main report.

Expected Annual Damages

Annual damages were estimated using the MONTE program. The stage-damage curve listed in this appendix was entered along with flow-frequency, inflow-outflow, and stage-flow curves. In addition to these relationships, potential levee failure was estimated based on PNP (probable non-failure points at 15% probability of failure) and PFP (probable failure points at 85% probability of failure) and was incorporated in the program. Project element accomplishments were then simulated by changing either the inflow-outflow curve (for dam improvements) or the PNP/PFP stages (for levee improvements.) Tables 7 & 8 show expected annual damages (EAD) by damage area reach and by damage category. Detailed results from Monte Carlo simulation are described in the next section.

Table 7
Expected Annual Damages by Reach
Existing Without Project Conditions
Values in $ Millions, October 2001 Prices

Damage Area Reach	Expected Annual Damages	Percent of Total Study
Downtown	$17.89	26 %
North Sacramento	$13.76	20 %
Rancho Cordova	$ 4.82	7 %
South Sacramento	$32.34	47 %
Total Study Area	$ 68.81	

Table 8
Expected Annual Damages by Category
Existing Without Project Conditions
Values in $ Millions, October 2001 Prices

Damage Category	Expected Annual Damages	Percent of Total
Residential	$35.68	52 %
Commercial	$22.39	33 %
Industrial	$ 1.03	1 %
Public	$ 6.59	10 %
Other Damages	$ 3.12	4 %
Total Damages	$ 68.81	

BENEFIT ESTIMATION

Alternatives Considered in Benefit Estimation

For the economic analysis, a number of alternatives were considered that provided flood reduction benefits beyond the currently authorized Folsom Modifications and Moderate Advanced Release. These include three Folsom Raise plans, three Stepped Release plans, a Combination Stepped Release with Folsom Raise plan, and one moderate sized Detention Dam near Auburn, California.

The Raise Folsom Dam plans provide additional flood damage reduction by increasing the flood storage pool. The difference between the three Raise Folsom plans can be described by flood pool elevation. The first is a 3.5-foot physical raise that will increase the flood pool to an elevation of 478-feet (listed in the tables as Raise Folsom to 478ft Pool Elevation.) The second is a 7-foot physical raise that will allow the flood pool to be raised to 482-feet (listed in the tables as Raise Folsom to 482ft Pool Elevation.) The final is the largest, a physical raise of 12-feet providing a flood pool of 487-feet (listed in the tables as Raise Folsom to 487ft Pool Elevation.)

The Stepped Release plans are designed to increase the objective release from Folsom Dam in operational steps to provide additional flood damage reduction while minimizing downstream impacts. The difference between the three Stepped Release plans is the final step objective release and timing of the steps. The first is the Stepped Release of 145,000-160,000 cubic feet per second (listed in the tables as Stepped Release @ 160K cfs.) Under this plan Folsom would be operated to step from 115,000 to 145,000 cubic feet per second (cfs,) matching reservoir inflow, and then stepped to a maximum objective release of 160,000 cfs. The second is the Stepped Release of 145,000-180,000 cfs (listed in the tables as Stepped Release @ 180K cfs.) This plan is similar to the first plan but with the maximum objective release of 180,000 cfs. This plan also requires more Lower American levee improvements and bridge raises. The third is the Early Stepped Release of 145,000-160,000 cfs (listed in the table as Step. Release @ 160K + New Outlets.) This plan is similar to the first except the first step would be possible at 145,000 cfs due to the addition of new low level outlets.

Another alternative (listed in the tables as Combo – Stepped Release @ 160 + Raise Folsom @ 482) combines the Stepped Release @ 160,000 cfs with the Folsom Raise @ 482-feet.

These alternative are identified in the main report by the following identifiers:

Alternative 1: No Action (without project)

Alternative 2: 3.5-Foot Dam Raise/478-Foot Flood Pool Elevation

Alternative 3: Seven-Foot Dam Raise/482-Foot Flood Pool Elevation

Alternative 4: Twelve-Foot Dam Raise/487-Foot Flood Pool Elevation

Alternative 5: Stepped Release to 160,000 cfs

Alternative 6: Stepped Release to 160,000 cfs and New Outlet at Folsom Dam

Alternative 7: Stepped Release to 180,000 cfs

Alternative 8: Stepped Release to 160,000 cfs and Seven-Foot Dam Raise/482-Foot Flood Pool Elevation

The final project analyzed in this section (listed in the tables as Detention Dam 545,000 acft. @ Auburn) is a size variation of the originally proposed Detention Dam near Auburn, which was determined to be the NED plan in both the 1992 Feasibility and the 1996 SIR reports. This dam plan, at 545,000 acre-feet of flood storage, is smaller than the 894,000 acre-feet dam selected in the 1996 SIR. While the Detention Dam is not one of the alternatives considered for selection in the main report, its significance in reference to National Economic Development (NED) is discussed in Chapter 10.

With Project Damages

Expected annual damages were estimated based on with and without project conditions. The most likely without project condition includes adding the Moderate Advanced Release once the Folsom Modifications project has been completed. Changes were made to the inflow-outflow relationship or to the PNP and PFP to simulate project conditions for the array of alternatives considered. The difference between the without project and with project damages represent the benefits attributable to the given alternative. These differences can also be represented by damages at various frequencies, expected annual damages and by other performance factors. Results of the Risk-Based analysis of the without project and with project can be found in Tables 9 to 13.

Description of Tables

Table 9 shows the derived frequency damage relationships taken from the MONTE program. These tables show how damages are reduced for the various alternatives at different frequencies. Damage reduction can be seen as full reduction to zero for some frequencies and a reduction in magnitude for other frequencies.

Long-term risk is described in Table 10 as the probability of a one-time exceedance over time. These tables show the probability of having a flood event over a 10-year, 25-year, and 50-year period. This table is useful in determining the chance of damage over the length of a loan or remaining structure life.

Table 11 displays the project performance of each alternative. Sometimes described as reliability, this table gives the probability of non-levee failure (probability of no damages) for events ranging from the 2% to 0.25% chance occurrence.

Table 12 displays the following: Probable Exceedance, Expected Annual Damages (EAD)- under existing and future economic conditions, and Percent Reduction in EAD for each alternative. The probable exceedance is the chance of levee failure or incurring damages in any given year. EAD represents the average damages in any given year and is determined by integrating the derived probability damage function.

Table 13 lists the Average Annual Equivalent Benefits for each alternative. These are determined by discounting future damages for each condition over the period of analysis at the current discount rate of 6 1/8 %. For this study, because all of the future growth is in place by the base year of analysis, the average annual equivalent damages are the same as the future year 2010 damages. Benefits are then just the difference between the without project and the with project average annual equivalent damages.

Summary of Flood Damage Reduction Benefits

Average annual benefits derived from flood damage reduction, vary greatly based on which alternative is eventually selected. The stepped release at 160,000 cfs, would provide the least economic benefit of all the alternatives (about $ 6 million average annual benefits with the

implementation of advanced release.) The detention dam would provide the highest benefits, providing more than $ 48 million in average annual benefits during the period of analysis.

Economic optimization of alternatives is based on efficiency, measured by maximizing net benefits. Discussion of project costs, net benefits and benefit-cost ratios for each alternative can be found in the next section of this appendix and in Chapter 8 of the main report.

TABLE 9
DERIVED FREQUENCY – DAMAGE RELATIONSHIPS
REPRESENTS EXPECTED DAMAGES FROM A SINGLE EVENT
ALL ALTERNATIVES INCLUDE ADVANCED RELEASE
(Min=0, Most Likely=100,000, Max=190,000 acft.)
EXISTING ECONOMIC CONDITIONS
Values in $ Millions, October 2001 Prices

CONDITION	ALTERNATIVE IN MAIN REPORT	PROBABILITY & 1 in X CHANCE PER YEAR					
		1.00% 1 in 100	0.80% 1 in 125	0.67% 1 in 150	0.50% 1 in 200	0.25% 1 in 400	0.10% 1 in 1000
Without Project	Alternative 1	-	-	-	$ 8,410	$ 12,124	$ 13,170
Raise Folsom (To 478 ft Pool Elevation)	Alternative 2	-	-	-	$ 7,253	$ 11,934	$ 13,170
Raise Folsom (To 482 ft Pool Elevation)	Alternative 3	-	-	-	-	$ 11,795	$ 13,170
Raise Folsom (To 487 ft Pool Elevation)	Alternative 4	-	-	-	-	$ 11,033	$ 13,170
Stepped Release (@ 160k cfs.)	Alternative 5	-	-	-	$ 7,660	$ 11,920	$ 13,170
Stepped Release (@ 160k cfs. + New Outlets)	Alternative 6	-	-	-	$ 7,108	$ 11,753	$ 13,170
Stepped Release (@ 180k cfs.)	Alternative 7	-	-	-	$ 6,908	$ 11,880	$ 13,170
Combo (Stepped Release@ 160 + Raise Folsom@ 482)	Alternative 8	-	-	-	-	$ 11,256	$ 13,170
Detention Dam (545k acft. @ Auburn)	Original NED	-	-	-	-	-	$ 12,658

Note: For the Detention Dam, advance release will have little impact on reducing damages.
Residual damages for the Original NED were estimated the same for advanced and non-advanced release options.

TABLE 10
LONG TERM RISK
ALL ALTERNATIVES INCLUDE MODERATE ADVANCED RELEASE
THE PROBABILITY OF ONE OR MORE EXCEEDANCES OVER TIME

CONDITION	ALTERNATIVE IN MAIN REPORT	PROBABILITY OF EXCEEDANCE OVER TIME		
		10 YEARS	25 YEARS	50 YEARS
Without Project	Alternative 1	6 %	14 %	26 %
Raise Folsom (To 478 ft Pool Elevation)	Alternative 2	5 %	12 %	23 %
Raise Folsom (To 482 ft Pool Elevation)	Alternative 3	5 %	11 %	21 %
Raise Folsom (To 487 ft Pool Elevation)	Alternative 4	4 %	10 %	20 %
Stepped Release (@ 160k cfs.)	Alternative 5	6 %	13 %	25 %
Stepped Release (@ 160k cfs. + New Outlets)	Alternative 6	5 %	13 %	24 %
Stepped Release (@ 180k cfs.)	Alternative 7	5 %	12 %	23 %
Combo (Stepped Release@ 160 + Raise Folsom@ 482)	Alternative 8	4 %	11 %	20 %
Detention Dam (545k acft. @ Auburn)	Original NED	2 %	5 %	9 %

Note: Long -term risk is the same for the Detention Dam with or without Advanced Release

TABLE 11
RELIABILITY- PROJECT PERFORMANCE
ALL ALTERNATIVES INCLUDE MODERATE ADVANCED RELEASE
PROBABILITY OF NON-FAILURE FROM SPECIFIC EVENTS

CONDITION	ALTERNATIVE IN MAIN REPORT	CONDITIONAL NON-EXCEEDANCE OF SPECIFIC EVENTS			
		1 in 50 Chance 0.02	1 in 100 Chance 0.01	1 in 200 Chance 0.005	1 in 400 Chance 0.0025
Without Project	Alternative 1	98.9%	85.6%	47.8%	14.4%
Raise Folsom (To 478 ft Pool Elevation)	Alternative 2	99.3%	89.8%	56.5%	20.3%
Raise Folsom (To 482 ft Pool Elevation)	Alternative 3	99.6%	92.4%	63.5%	26.1%
Raise Folsom (To 487 ft Pool Elevation)	Alternative 4	99.7%	94.1%	68.5%	31.1%
Stepped Release (@ 160k cfs.)	Alternative 5	98.7%	87.0%	52.6%	18.0%
Stepped Release (@ 160k cfs. + New Outlets)	Alternative 6	98.9%	88.7%	56.2%	20.6%
Stepped Release (@ 180k cfs.)	Alternative 7	99.2%	90.4%	59.7%	23.4%
Combo (Stepped Release@ 160 + Raise Folsom@ 482)	Alternative 8	99.3%	92.9%	68.0%	31.6%
Detention Dam (545k acft. @ Auburn)	Original NED	100.0%	99.5%	94.5%	76.0%

TABLE 12
EXPECTED ANNUAL DAMAGES
ALL ALTERNATIVES INCLUDE MODERATE ADVANCED RELEASE
All Values in $ Millions, October 2001 Prices

CONDITION		Annual Exceedance Probability	1 in X Chance Per Year	Expected Annual Damages		Percent Reduction in EAD from Without Project
				Existing 2000	Future 2010	
Without Project	Alternative 1	0.0061	1 in164	$ 68.81	$ 72.79	-
Raise Folsom (To 478 ft Pool Elevation)	Alternative 2	0.0053	1 in 189	$ 60.26	$ 63.77	12%
Raise Folsom (To 482 ft Pool Elevation)	Alternative 3	0.0047	1 in 213	$ 53.77	$ 56.90	22%
Raise Folsom (To 487 ft Pool Elevation)	Alternative 4	0.0043	1 in 233	$ 49.74	$ 52.65	28%
Stepped Release (@ 160k cfs.)	Alternative 5	0.0058	1 in 172	$ 63.44	$ 66.97	8%
Stepped Release (@ 160k cfs. + New Outlets)	Alternative 6	0.0054	1 in 185	$ 60.57	$ 63.99	12%
Stepped Release (@ 180k cfs.)	Alternative 7	0.0051	1 in 196	$ 58.42	$ 61.82	15%
Combo (Stepped Release@ 160 + Raise Folsom@ 482)	Alternative 8	0.0045	1 in 222	$ 49.68	$ 52.45	28%
Detention Dam (545k acft. @ Auburn)	Original NED	0.0019	1 in 526	$ 23.00	$ 24.43	67%

TABLE 13
AVERAGE ANNUAL EQUIVALENT BENEFITS
ALL ALTERNATIVES INCLUDE MODERATE ADVANCED RELEASE
In $ Millions, October 2001 Prices
6 1/8 % Interest Rate, 2011 to 2060 Period of Analysis

CONDITION		Future – Year 2010		Average Annual Equivalent Damages With Project	Average Annual Equivalent Benefits
		Without Project Damages	With Project Residual Damages		
Without Project	Alternative 1	$ 72.80	$ 72.80	$ 72.80	**0**
Raise Folsom (To 478 ft Pool Elevation)	Alternative 2	$ 72.80	$ 63.80	$ 63.80	**$ 9.00**
Raise Folsom (To 482 ft Pool Elevation)	Alternative 3	$ 72.80	$ 56.90	$ 56.90	**$ 15.90**
Raise Folsom (To 487 ft Pool Elevation)	Alternative 4	$ 72.80	$ 52.70	$ 52.70	**$ 20.10**
Stepped Release (@ 160k cfs.)	Alternative 5	$ 72.80	$ 67.00	$ 67.00	**$ 5.80**
Stepped Release (@ 160k cfs. + New Outlets)	Alternative 6	$ 72.80	$ 64.00	$ 64.00	**$ 8.80**
Stepped Release (@ 180k cfs.)	Alternative 7	$ 72.80	$ 61.80	$ 61.80	**$ 11.00**
Combo (Stepped Release@ 160 + Raise Folsom@ 482)	Alternative 8	$ 72.80	$ 52.50	$ 52.50	**$ 20.30**
Detention Dam (545k acft. @ Auburn)	Original NED	$ 72.80	$ 24.40	$ 24.40	**$ 48.40**

BENEFIT COST SUMMARY

The following section will explain how benefits and costs were allocated for flood damage reduction for the eight alternatives considered in the main report and a version of the detention dam at Auburn (the NED plan in the 1991 and 1996 reports.)

ADDITIONAL BENEFIT CATEGORIES

Several of the proposed alternatives provide additional economic benefits besides those listed in the tables above. These additional benefits are either realized outside the period of analysis or are not directly related to flood damage reduction.

Benefits prior to Base Year

In the 1996 SIR, there were several measures that reduced flood damages prior to the base year (during the construction period.) For this study, only the detention dam will contribute benefits prior to the base year in 2011. These benefits will occur for two reasons. First, during construction as the dam will begin to allow for partial storage capacity. Second, the dam can be completed in a shorter time period. The other alternatives in this study will not be operational until the base year. When these benefits are amortized over the 50-year period of analysis, the detention dam will provide an additional $ 8.4 million in average annual benefits. This will bring the total benefits directly attributable to flood damage reduction to $ 56.8 million.

Advanced Replacement of the Spillway Bridge

With the various alternatives that include dam raises, the spillway bridge will be replaced earlier than under without project conditions. The cost savings of the advanced spillway bridge replacement was estimated at $ 0.2 million. This benefit is attributable to alternatives 2, 3, 4 and 8.

Savings in Folsom Modification Project Costs

The dam raise alternatives also provide a potential savings in costs required to complete the Folsom Modification project. The surcharge storage increment to Folsom Modifications would not be needed to provide this benefit. The reduction in annual costs would translate to a $ 3.1 million benefit for alternatives 2, 3, 4 and 8.

Advanced Bridge Replacement

Two of the projects analyzed in this report provide additional benefits in the form of advanced bridge replacement. Similar to the spillway replacement for the dam raise alternatives, the cost savings of early replacement the Howe Avenue Bridge would provide a $ 1.2 million benefit for alternative 7. The second project providing advanced bridge replacement would be the Detention Dam at Auburn. Based on the updated estimates from the 1996 SIR report, replacing the Highway 49 bridge would contribute $ 2.2 million in benefits to the Detention Dam.

Resource Replacement

Completion of the Detention Dam would allow for reoperation of Folsom Dam back to the original fixed 400,000 acre feet of flood space. This removal of the 400,000 to 600,000 ac. ft. variable space operation provides the opportunity for benefits in the form of water supply and hydro-electric power restored to levels prior to reoperation. Based on local sponsor estimated updates of the 1996 SIR report, these benefits would be around $ 12 million for the Detention Dam.

COST ALLOCATION BY USE

Probable Maximum Flood- Dam Safety as a Project Purpose

Alternatives 2, 3, 4, and 8 require significant changes to the existing dam at Folsom. For these alternatives, the proposed project must satisfy an additional purpose beyond flood damage reduction. Currently Folsom Dam cannot safely pass the probable maximum flood. Projects that significantly alter Folsom are required to address this dam safety issue. Under current without project conditions, the least costly project that would satisfy the dam safety issue would be similar to alternative 2 (Dam Raise to 478 foot pool.) Total annual costs of this project would include the $ 12.1 million required for the single purpose of flood damage reduction plus an additional $ 1.6 million to correct the following: the spillway at L.L. Anderson Dam; extension of the Folsom stilling basin; and to complete the work required to lower the existing spillway at Folsom. A summary of the annual cost computations for the least cost dam safety alternative and the single purpose flood damage reduction component of alternative 2 are shown below in Table 14. Details of individual cost components can be found in Appendix C (Engineering,) Section H (Cost Estimates) and a summary of costs and interest during construction in Attachment 1 of this appendix.

Table 14
Computation of Single Purpose Costs
All Values are in $ Millions,
October 2001 Prices using 6 1/8 % Interest Rate

ITEM	Alternative 2 3.5 foot Dam Raise	Single Purpose- Least Cost Dam Safety Alternative	Single Purpose- Flood Damage Reduction 3.5 foot Dam Raise
First Cost of Alternative 2	176.6	176.6	176.6
- Sunk Costs[1]	-12.9	-12.9	-12.9
- LL Anderson			-8.2
- Stilling Basin Ext.			-6.8
- Folsom Spillway			-7.3
First Cost – Single Purpose (as used in annual cost computation)		163.7	141.4
Interest During Construction	44.8	44.8	42.2
Investment Costs	208.5	208.5	183.6
Interest & Amortization	13.5	13.5	11.9
Operation & Maintenance	0.2	0.2	0.2
Annual Costs	**$ 13.7**	**$ 13.7**	**$ 12.1**

[1] Sunk costs of $ 12.9 million are for prior PED costs, are only attributable to the first costs of flood damage reduction alternatives and are not included in any of the annual cost computations.

So in addition to flood damage reduction, alternatives 2, 3, 4, 8 and the detention dam at Auburn all satisfy a second purpose of dam safety. For the economic benefit-cost analysis, the Separable-Costs-Remaining-Benefit (SCRB) method was used to allocate costs for multiple purposes. For these alternatives, the least cost single purpose dam safety alternative costs ($13.7 million annual cost) shown in Table 14 were used. The single purpose flood damage reduction costs for alternatives 3,4, and 8 were determined as the full project cost minus the $ 0.6 million (annual costs) for L.L. Anderson Dam. For the Detention Dam at Auburn, the single purpose flood damage reduction costs are equal to the total project costs as no additional components were needed to satisfy dam safety. Separable costs were determined based on those additional costs components needed with the other use removed. For the smallest dam raise, this separable cost included both work at L.L. Anderson and at the Folsom Spillway, and combined provided an annual cost of $ 1.6 million. For the other alternatives, L.L. Anderson work of $0.6 million annual cost was the only dam safety separable cost. For alternatives 3,4,8 and the Detention Dam at Auburn, the separable flood damage reduction costs were the total project cost minus the single purpose dam safety alternative. The SCRB for all five are shown in Tables 15 to 19.

Table 15
Separable Costs – Remaining Benefits
Alternative 2
3.5-Foot Dam Raise/478-Foot Flood Pool Elevation
All Values in $ Millions, October 2001 Prices

ITEM	Flood Damage Reduction	Dam Safety[1]	Total Project
Allocation of Annual Costs by Use			
a.) Average Annual Benefits (by use)	9.0	13.7	
b.) Alternative Costs (single purpose)	12.1	13.7	
c.) Limited Benefits	9.0	13.7	
d.) Separable Costs	0.0	1.6	
e.)Remaining Benefits			
(1) Amount	9.0	12.1	
(2) Percent of Total	42.7 %	57.3 %	
f.) Allocated Joint Costs	5.2	6.9	
g.) Total Allocated Costs (by use)	**$ 5.2**	**$ 8.5**	**$ 13.7**

[1]Actual benefits to dam safety are not measured in terms of monetary benefit. To perform the SCRB, it was assumed that the annual benefits of dam safety would be equal or greater in value to the cost of dam safety (similar to the practice of non-monetary ecosystem restoration benefits.) For this SCRB, the limited benefits were set equal to dam safety costs. These should not be considered the actual dam safety benefits.

Table 16
Separable Costs – Remaining Benefits
Alternative 3
Seven-Foot Dam Raise/482-Foot Flood Pool Elevation
All Values in $ Millions, October 2001 Prices

ITEM	Flood Damage Reduction	Dam Safety[1]	Total Project
Allocation of Annual Costs by Use			
a.) Average Annual Benefits (by use)	15.9	13.7	
b.) Alternative Costs (single purpose)	14.5	13.7	
c.) Limited Benefits	14.5	13.7	
d.) Separable Costs	0.8	0.6	
e.)Remaining Benefits			
(1) Amount	13.7	13.1	
(2) Percent of Total	51.1 %	48.9 %	
f.) Allocated Joint Costs	7.0	6.7	
g.) Total Allocated Costs (by use)	**$ 7.8**	**$ 7.3**	**$ 15.1**

[1]Actual benefits to dam safety are not measured in terms of monetary benefit. To perform the SCRB, it was assumed that the annual benefits of dam safety would be equal or greater in value to the cost of dam safety (similar to the practice of non-monetary ecosystem restoration benefits.) For this SCRB, the limited benefits were set equal to dam safety costs. These should not be considered the actual dam safety benefits.

Table 17
Separable Costs – Remaining Benefits
Alternative 4
Twelve-Foot Dam Raise/487-Foot Flood Pool Elevation
All Values in $ Millions, October 2001 Prices

ITEM	Flood Damage Reduction	Dam Safety[1]	Total Project
Allocation of Annual Costs by Use			
a.) Average Annual Benefits (by use)	20.1	13.7	
b.) Alternative Costs (single purpose)	26.1	13.7	
c.) Limited Benefits	20.1	13.7	
d.) Separable Costs	12.4	0.6	
e.)Remaining Benefits			
(1) Amount	7.7	13.1	
(2) Percent of Total	37.0 %	63.0 %	
f.) Allocated Joint Costs	5.1	8.6	
g.) Total Allocated Costs (by use)	**$ 17.5**	**$ 9.2**	**$ 26.7**

[1]Actual benefits to dam safety are not measured in terms of monetary benefit. To perform the SCRB, it was assumed that the annual benefits of dam safety would be equal or greater in value to the cost of dam safety (similar to the practice of non-monetary ecosystem restoration benefits.) For this SCRB, the limited benefits were set equal to dam safety costs. These should not be considered the actual dam safety benefits.

Table 18
Separable Costs – Remaining Benefits
Alternative 8
Stepped Release to 160,000 cfs and Seven-Foot Dam Raise/482-Foot Flood
All Values in $ Millions, October 2001 Prices

ITEM	Flood Damage Reduction	Dam Safety[1]	Total Project
Allocation of Annual Costs by Use			
a.) Average Annual Benefits (by use)	20.3	13.7	
b.) Alternative Costs (single purpose)	29.1	13.7	
c.) Limited Benefits	20.3	13.7	
d.) Separable Costs	15.4	0.6	
e.)Remaining Benefits			
(1) Amount	4.9	13.1	
(2) Percent of Total	27.2 %	72.8 %	
f.) Allocated Joint Costs	3.7	10.0	
g.) Total Allocated Costs (by use)	**$ 19.1**	**$ 10.6**	**$ 29.7**

[1]Actual benefits to dam safety are not measured in terms of monetary benefit. To perform the SCRB, it was assumed that the annual benefits of dam safety would be equal or greater in value to the cost of dam safety (similar to the practice of non-monetary ecosystem restoration benefits.) For this SCRB, the limited benefits were set equal to dam safety costs. These should not be considered the actual dam safety benefits.

Table 19
Separable Costs – Remaining Benefits
545,000 ac ft Detention Dam at Auburn
All Values in $ Millions, October 2001 Prices

ITEM	Flood Damage Reduction	Dam Safety[1]	Total Project
Allocation of Annual Costs by Use			
a.) Average Annual Benefits (by use)	56.8	13.7	
b.) Alternative Costs (single purpose)	64.1	13.7	
c.) Limited Benefits	56.8	13.7	
d.) Separable Costs	50.4	0.6	
e.) Remaining Benefits			
(1) Amount	6.4	13.1	
(2) Percent of Total	32.8 %	67.2 %	
f.) Allocated Joint Costs	4.3	8.8	
g.) Total Allocated Costs (by use)	**$ 54.7**	**$ 9.4**	**$ 64.1**

[1] Actual benefits to dam safety are not measured in terms of monetary benefit. To perform the SCRB, it was assumed that the annual benefits of dam safety would be equal or greater in value to the cost of dam safety (similar to the practice of non-monetary ecosystem restoration benefits.) For this SCRB, the limited benefits were set equal to dam safety costs. These should not be considered the actual dam safety benefits.

Benefit Cost Analysis

For each of the alternatives considered, net benefits were estimated for the sole purpose of flood damage reduction and for the project in total. Note that non-monetary benefits such as those inherent in dam safety and ecosystem restoration were not included in the economic benefit calculations. Net benefits are measured as the difference between annual benefits and annual costs. Maximizing net benefits determines the optimal plan. This measure of economic efficiency is used to establish the National Economic Development or NED plan. Both costs and benefits are expressed in annual equivalents at October 2001 price levels, using a 6 1/8 % interest rate, over a 50-year period of economic analysis. The summary of benefits and cost can be seen in Table 20 below. Flood damage reduction net benefits are greatest for Alternative # 3, Seven-Foot Dam Raise/482-Foot Flood Pool Elevation while total net benefits are greatest for the Detention Dam.

Table 20
Benefit – Costs Analysis for Each Alternative
Values are in $ Millions, October 2001 Prices, Discount Rate of 6 1/8 %

Item	Alt. # 2	Alt. # 3	Alt. # 4	Alt # 5	Alt # 6	Alt. # 7	Alt. # 8	545k Dam
Flood Damage Reduction								
Period of Analysis	9.0	15.9	20.1	5.8	8.8	11.0	20.3	48.4
Prior to Base Year	0	0	0	0	0	0	0	8.4
Total Flood Damage Reduction	$ 9.0	$ 15.9	$ 20.1	$ 5.8	$ 8.8	$ 11.0	$ 20.3	$ 56.8
Replacement Spillway Bridge	0.2	0.2	0.2	0	0	0	0.2	0
Savings- Folsom Mods Costs	3.1	3.1	3.1	0	0	0	3.1	0
Adv. Bridge Replacement	0	0	0	0	0	1.2	0	2.2
Resource Replacement	0	0	0	0	0	0	0	12.0
Total Monetary Benefits	$ 12.3	$ 19.2	$ 23.4	$ 5.8	$ 8.8	$ 12.2	$ 23.6	$ 71.0
Benefit Cost Analysis – Flood Damage Reduction								
Annual Costs – FDR Allocation	$ 5.2	$ 7.8	$ 17.5	$ 14.7	$ 16.8	$ 16.2	$ 19.1	$ 54.7
Net Benefits – Flood Damage Reduction	$ 3.8	$ 8.1	$ 2.6	-8.9	-8.0	-5.2	$ 1.2	$ 2.1
B/C Ratio - FDR	1.73	2.04	1.15	0.39	0.52	0.68	1.06	1.04
Benefit Cost Analysis –Total Project								
Annual Costs – Total Project	$ 13.7	$ 15.1	$ 26.7	$ 14.7	$ 16.8	$ 16.2	$ 29.7	$ 64.1
Net Benefits – Total Project	-1.4	$ 4.1	-3.3	-8.9	-8.0	-4.0	-6.1	$ 6.9
B/C Ratio – Total Project	0.90	1.27	0.88	0.39	0.52	0.75	0.79	1.11

Note: Table does not include any non-monetary benefits such as dam safety or ecosystem restoration.

Attachment # 1
Interest During Construction Computations
And Derivation of Annual Costs

Annual costs for the alternatives described in this report came from the MCACES and the detailed cost estimates in Appendix C- Engineering, Section H- Cost Estimates. A summary, explaining how these estimates were used in the economic analysis and how interest during construction was computed will be displayed in this attachment.

Interest During Construction

In accordance with ER 1105-2-100, cost incurred during the construction period should be increased by adding compound interest at the project discount rate of 6 1/8% from the date the expenditures are incurred to the beginning of the period of analysis (base year = 2011.) Interest during construction or IDC is calculated to insure that costs and benefits are evaluated on an equivalent time basis.

Detailed examples of the IDC computations are shown in Attachment Table 1 below for Alternative # 3 (the selected plan.) Interest is computed based on the mid-point of a given period. Interest is computed from the construction start date to the base year. Each cost item, in the table, is divided into the calendar year of that portion expended. That yearly expenditure is then discounted based on the number of years (from the mid-point of the year) from expenditure to base year. IDC is computed as the expenditure amount multiplied by the interest or discount factor. This factor is determined by the following formula:

Base Year – Start Year – 0.5 (for midpoint of the period) = Periods of Interest
2011 - 2004 - 0.5 = 6.5

Interest Factor = ((1 + Discount Rate) "raised" to the Periods of Interest) - 1
$0.472 = (1.06125)^{6.5} - 1$

Additional IDC computations for the other alternatives can be found in Appendix C- Engineering, Section H- Cost Estimates.

Attachment Table 1
Interest During Construction Computation
Alternative 3 – 7 foot Raise of Folsom Dam
Values are in $ Millions, October 2001 Prices
Period of Analysis: October 2011 to 2060
Discount Rate: 6.125%

Description of Cost Item	Expenditure Amount (by year listed)	Year of Expenditure	Base Year	Periods of Interest (in years)	Interest Factor	**Interest During Construction**
Lands & Damages	$6.5	2003	2011	7.5	0.562	$3.7
Relocations	$1.2	2004	2011	6.5	0.472	$0.6
	$1.2	2005	2011	5.5	0.387	$0.5
Dams	$12.7	2004	2011	6.5	0.472	$6.0
	$25.4	2005	2011	5.5	0.387	$9.8
	$25.4	2006	2011	4.5	0.307	$7.8
	$19.0	2007	2011	3.5	0.231	$4.4
	$19.0	2008	2011	2.5	0.160	$3.0
	$19.0	2009	2011	1.5	0.093	$1.8
	$6.3	2010	2011	0.5	0.030	$0.2
Fish & Wildlife	$2.0	2009	2011	1.5	0.093	$0.2
	$2.0	2010	2011	0.5	0.030	$0.1
Cultural Resources (subj to IDC)	$0.1	2004	2011	6.5	0.472	$0.0
Planning, Engineering & Design	$4.3	2001	2011	9.5	0.759	$3.3
	$4.3	2002	2011	8.5	0.658	$2.8
	$4.7	2003	2011	7.5	0.562	$2.6
Construction Management	$3.5	2004	2011	6.5	0.472	$1.7
	$3.5	2005	2011	5.5	0.387	$1.4
	$3.4	2006	2011	4.5	0.307	$1.0
	$3.4	2007	2011	3.5	0.231	$0.8
	$3.4	2008	2011	2.5	0.160	$0.5
	$3.4	2009	2011	1.5	0.093	$0.3
	$3.4	2010	2011	0.5	0.030	$0.1
Sunk PED Costs	$12.9	Items Not Subject to IDC				
Cult. Res.	$1.3					
Totals	**$191.6**					**$52.6**

Annual Costs

For the benefit cost analysis, all alternative were evaluated using annual costs. Annual costs are a function of investment costs amortized over the period of analysis using the discount rate, plus any annual operation and maintenance costs (above those under the without project condition.) Investment costs represent project first costs, plus IDC, minus sunk costs and cultural resources recovery (limited to 1% of federal expenditure.) Attachment Table 2 shows the annual cost for each of the alternatives.

Attachment Table 2
Annual Costs Computations
For each Alternative
All Values are in $ millions, October 2001 Prices
Using 6.125% Discount Rate, 50 Year Period of Analysis

	Alt # 2	Alt # 3	Alt # 4	Alt # 5	Alt # 6	Alt # 7	Alt # 8	545k Dam
First Cost	176.6	191.6	321.1	176.7	203.9	194.6	355.4	777.0
- Sunk Costs	-12.9	-12.9	-12.9	-12.9	-12.9	-12.9	-12.9	0.0
- Cult. Res.	0.0	-1.3	-1.4	-1.1	-1.1	-1.1	-2.4	-4.9
IDC	44.8	52.6	86.0	35.5	39.4	39.1	88.1	199.4
Investment Costs	208.5	230.0	392.8	198.2	229.3	219.7	428.2	971.5
Interest and Amortization	13.5	14.9	25.4	12.8	14.8	14.2	27.6	62.7
Operation and Maintenance	0.2	0.2	1.3	1.9	2.0	2.0	2.1	1.4
Annual Costs	**13.7**	**15.1**	**26.7**	**14.7**	**16.8**	**16.2**	**29.7**	**64.1**