RECLAMATION

Managing Water in the West

Draft
Economics Technical Report

Odessa Subarea Special Study
Columbia Basin Project, Washington

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Acronyms and Abbreviations

AF	acre-feet
BCA	benefit-cost analysis
BCR	benefit-cost ratio
CRP	Conservation Reserve Program
DEIS	draft environmental impact statement
ECBID	East Columbia Basin Irrigation District
EQ	environmental quality
ERS	Economic Research Service
GAC	gross absorption coefficients
GWMA	Columbia Basin Groundwater Management Area
IDC	interest during construction
IMPLAN	IMpact analysis for PLANning
kWh	kilowatthours
NASS	National Agricultural Statistics Service
NED	national economic development
NFI	net farm incomes
O&M	operation and maintenance
OMR&P	operating, maintenance, replacement, and power
OSE	other social effects
P&Gs	*Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*
psi	pounds per square inch
RED	regional economic development
TIO	total industry output

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Draft Economics Technical Report

Odessa Subarea Special Study

The economic analyses developed for the Odessa Subarea Special Study, Columbia Basin Project, Washington (Study) are comprised of a national economic development (NED) benefit-cost analysis (BCA) and a regional economic development (RED) impact analysis. These two analyses comprise two of the "accounts" described in the four account analysis of the Draft Feasibility-Level Special Study Report, Odessa Subarea Special Study, Columbia Basin Project, Washington (Special Study Report)—the other two accounts are the environmental quality (EQ) account and the other social effects (OSE) account. The results of the RED impact analysis are also presented within the socioeconomic section of the Draft Environmental Impact Statement, Odessa Subarea Special Study, Columbia Basin Project, Washington (Odessa DEIS).

The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (U. S. Water Resources Council, 1983), otherwise referred to as the *P&Gs*, represent the main set of guidelines for Federal water management agency economic analyses. The *P&Gs* describe the NED and RED accounts from the perspective of evaluating of the economic effects of proposed alternative plans. According to the *P&Gs*, a primary distinction between an NED benefit-cost analysis and a RED regional economic impact analysis is geographic. The RED analysis focuses on economic impacts to the local region, whereas NED analysis focuses on economic benefits to the entire Nation. The RED evaluation recognizes the NED benefits accruing to the local region plus the transfers of income into the region. However, since the RED analysis focuses purely on the local region, it does not take into account potential offsetting effects occurring outside the region, as does the NED analysis. As a Federal agency, Reclamation must analyze the NED effects so as not to favor one area of the country over another. Reclamation also analyzes the RED effects to the local economy to provide specific information on the primary impact area. However, economic justification is determined for each alternative solely by the benefit-cost analysis and must be demonstrated on the basis of NED benefits exceeding NED costs.

In addition to the geographic differences between the analyses, the RED analysis includes not only the initial or direct impact on the primary affected industries (as does the NED analysis), but also the secondary or indirect effects on those industries providing inputs to the directly affected industries (referred to as the multiplier effect). This multiplier effect is not included in the NED analysis.

Finally, yet another difference between the analyses relates to the distinction between economic impacts and economic benefits. Economic impacts measure total or gross economic activity within a given region using such indicators as output (sales or gross receipts), income, and employment. Gross measures simply show the amount of money changing hands (e.g., sales reflect income to the business, but expenditures to the purchaser). Economic impacts stem from changes in expenditures/revenues within the region. Conversely, benefits measure economic welfare based on a net value concept. For consumers, economic welfare reflects the value of goods and services consumed above what is actually paid for them (willingness-to-pay in excess of cost; also referred to as consumer surplus). For producers or businesses, economic welfare can be estimated by gross revenues minus operating costs (profit). One way to visualize the difference between impacts and benefits is to consider how each reacts to increases in expenditures only. Regional economic impacts increase as in-region expenditures increase, whereas benefits (i.e., consumer surplus or profitability) tend to decrease as costs or expenditures increase.

While benefits and economic impacts often move in unison (since they typically rise or fall with levels of production), there are many situations where changes in benefits and economic impacts diverge. This potential for divergence, combined with the need to consider both national and regional perspectives, and the fact that different user groups are often interested in different economic measures, creates a need for both NED and RED analyses.

In addition to the No Action Alternative (Alternative 1), the Study is evaluating eight proposed or “action” alternatives for moving irrigated agriculture off of groundwater and on to surface water within the Odessa Study Area. Given the ongoing trend of declining groundwater levels within the study area, moving agriculture on to surface water should provide a more stable water source. The partial replacement alternatives (Alternatives 2A, 2B, 2C, and 2D) will move nearly 57,100 acres on to surface water and the full replacement alternatives (Alternatives 3A, 3B, 3C, and 3D) will move approximately 102,600 acres. The main difference between the range of partial and full replacement alternatives is the source of the water supply. Alternatives 2A and 3A have the water supply coming from Banks Lake; Alternative 2B and 3B have the water supply coming from Banks Lake and Lake Roosevelt; Alternatives 2C and 3C have the water supply coming from Banks Lake and the new Rocky Coulee Reservoir; and finally, Alternatives 2D and 3D have the water supply coming from Banks Lake, Lake Roosevelt, and the new Rocky Coulee Reservoir.

1.0 National Economic Development (NED) Benefit-Cost Analysis (BCA)

The purpose of a NED BCA is to compare the benefits of a proposed project to its costs. The total costs of the project are subtracted from the total benefits to measure net benefits. If the net benefits are positive, implying benefits exceed costs, the project could be considered economically justified. Conversely, if net benefits are negative, implying costs exceed benefits, the project would not be economically justified. In studies like this one, where multiple alternatives are being considered, the alternative with the greatest positive net benefit would be preferred from strictly an economics perspective. Another way of displaying this benefit-cost comparison involves dividing total project benefits by total project costs resulting in what is referred to as the benefit-cost ratio (BCR). A BCR greater than one is analogous to a positive net benefit and a BCR less than one is analogous to a negative net benefit.

Before comparisons can be made between costs and benefits, they must be converted to the same dollar year and point in time. Since all the costs and benefits are measured in current dollars, no dollar year adjustment was necessary. However, the costs and benefits will occur at different times. As is standard Reclamation practice, the decision was made to measure all the costs and benefits as of the end of the construction period. As is described under the construction cost section, the canal construction period is divided into a series of phases. The end of the canal construction period is defined as the end of the last canal construction phase (year 2025). Starting from the end of the canal construction period in year 2025, using a 100-year analysis period, the period of analysis runs from 2026 to 2125. Since the same level of benefits or costs incurred in the future are worth less than they are today (because one could put the required funds in a bank and earn interest on the investment), costs and benefits incurred in the future are discounted (present valued) back to the start of the period of analysis (equivalent to the end of the construction period) using the Federal 2009-2010 water project planning rate of 4.375 percent. Since benefits associated with all those phases other than the last canal construction phase would begin at the end of each phase and not the end of the last canal construction phase, some of those benefits would accrue prior to the end of the canal construction period in year 2025. This implies that these benefits would need to be compounded (future valued) to the end of the construction period. These same present and future valuing concepts are applied to the costs incurred during the canal construction period and period of analysis.

1.1 NED BCA Results

Tables NED_BCA1 and NED_BCA2 present the results of the benefit-cost analyses for each alternative. The tables display total benefits (agriculture, municipal, industrial), total costs (canal, reservoir, and drainage system construction costs; interest during construction (IDC); operating, maintenance, replacement, and power (OMR&P) costs; lost hydropower benefits), net benefits, and benefit-cost ratios.

The results in table NED_BCA1 are emphasized given they were generated using the required 2009-2010 federal water project planning rate of 4.375 percent.

Table NED_BCA1.—Results of NED BCA (based on current planning rate: 4.375%) ($ millions)

Alternatives	Partial replacement alternatives				Full replacement alternatives			
	2A	**2B**	**2C**	**2D**	**3A**	**3B**	**3C**	**3D**
1) Total NED benefits	1,170.2	1,170.2	1,170.2	1,170.2	1,820.5	1,820.5	1,820.5	1,820.5
a) Agriculture benefits	1,153.3	1,153.3	1,153.3	1,153.3	1,800.7	1,800.7	1,800.7	1,800.7
b) Other direct benefits – Municipal	5.1	5.1	5.1	5.1	8.1	8.1	8.1	8.1
c) Other direct benefits – Industrial	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8
2) Total NED costs (including lost benefits)	1,276.7	1,276.7	1,726.1	1,726.1	4,148.6	4,148.6	4,597.9	4,597.9
a) Canal and reservoir construction and IDC costs	908.0	908.0	1,326.0	1,326.0	3,255.7	3,255.7	3,673.7	3,673.7
b) Canal and reservoir OMR&P costs	180.7	180.7	212.1	212.1	401.5	401.5	432.8	432.8
c) Drainage system construction and IDC costs	28.5	28.5	28.5	28.5	83.5	83.5	83.5	83.5
d) Drainage system OMR&P costs	3.1	3.1	3.1	3.1	10.4	10.4	10.4	10.4
e) Lost hydropower benefits	156.4	156.4	156.4	156.4	397.6	397.6	397.6	397.6
3) Net benefits (row 1 minus row 2)	-106.5	-106.5	-555.9	-555.9	-2,328.1	-2,328.1	-2,777.4	-2,777.4
4) Benefit-cost ratio (row 1 divided by row 2)	0.917	0.917	0.678	0.678	0.439	0.439	0.396	0.396

Total benefits were estimated at $1,170.2 million for the partial replacement alternatives and $1,820.5 million for the full replacement alternatives. Total costs vary by alternative and range from $1,276.7 million to $1,726.1 million for the partial replacement alternatives and from $4,148.6 million to $4,597.9 million for the full replacement alternatives. Therefore, all of the alternatives result in negative net benefits (-$106.5 to -$555.9 million for partial replacement and -$2,328.1 to -$2,777.4 million for full replacement) and benefit cost ratios less than one (0.917 to 0.678 for partial replacement and 0.439 to 0.396 for full replacement). As a result, none of these alternatives would be considered economically justified.

The results in table NED_BCA2 were generated using the planning rate in place when the Columbia Basin Project was first authorized (3.0 percent) and are presented for informational purposes only. Total benefits were estimated at $1,504.5 million for the partial replacement alternatives and $2,401.9 million for the full replacement alternatives. Total costs vary by alternative and range from $1,328.3 million to $1,736.1 million for the partial replacement alternatives and from $4,185.5 million to $4,593.2 million for the full replacement alternatives. Alternatives 2A/2B result in a positive net benefit of $176.2 million and a BCR of 1.133. All of the other alternatives result in negative net benefits (-$231.5 million for partial replacement alternatives 2C/2D and -$1,783.6 to -$2,191.3 for full replacement alternatives) and benefit-cost ratios of less than one (0.867 for partial replacement alternatives 2C/2D and 0.574 to 0.523 for full replacement alternatives).

Table NED_BCA2.—Results of NED BCA (based on current planning rate: 3.0%) ($ millions)

Alternatives	Partial replacement alternatives				Full replacement alternatives			
	2A	2B	2C	2D	3A	3B	3C	3D
1) Total NED benefits	1,504.5	1,504.5	1,504.5	1,504.5	2,401.9	2,401.9	2,401.9	2,401.9
a) Agriculture benefits	1,478.7	1,478.7	1,478.7	1,478.7	2,371.1	2,371.1	2,371.1	2,371.1
b) Other direct benefits – Municipal	9.3	9.3	9.3	9.3	14.3	14.3	14.3	14.3
c) Other direct benefits – Industrial	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
2) Total NED costs (including lost benefits)	1,328.3	1,328.3	1,736.1	1,736.1	4,185.5	4,185.5	4,593.2	4,593.2
a) Canal and reservoir construction and IDC costs	832.5	832.5	1,200.0	1,200.0	2,981.5	2,981.5	3,348.9	3,348.9
b) Canal and reservoir OMR&P costs	239.9	239.9	280.1	280.1	535.5	535.5	575.7	575.7
c) Drainage system construction and IDC costs	31.4	31.4	31.4	31.4	93.5	93.5	93.5	93.5
d) Drainage system OMR&P costs	5.2	5.2	5.2	5.2	17.7	17.7	17.7	17.7
e) Lost hydropower benefits	219.3	219.3	219.3	219.3	557.3	557.3	557.3	557.3
3) Net benefits (row 1 minus row 2)	+176.2	+176.2	-231.5	-231.5	-1,783.6	-1,783.6	-2,191.3	-2,191.3
4) Benefit-cost ratio (row 1 divided by row 2)	1.133	1.133	.867	.867	.574	.574	.523	.523

1.2 Methodology, Assumptions, and Results

This section describes the methodology, assumptions, and results associated with each benefit and cost component of the BCA.

1.2.1 Benefit Analyses

The primary beneficiary of the proposed project to move agricultural groundwater pumpers off of groundwater and on to surface water is not surprisingly agriculture. Benefits were also estimated for municipal and industrial uses. Municipal and industrial benefits were considered "other direct benefits" since they are "incidental to the purposes for which the water resources plan is being formulated" (U.S. Water Resources Council, 1983).

1.2.1.1 Agricultural Benefits

Methodology and Assumptions – Washington's Adams, Grant, Franklin, and Lincoln Counties make up the analysis area for the irrigated agriculture section. The study area is located within these four counties. This analysis of irrigated agriculture is based on information about the following:

1. Groundwater irrigation in the study area
2. Current crops grown in the study area
3. Projections of changes to the types and amounts of crops that would be grown in the future under the action alternatives

Historical data about the number of acres of cropland, average farm sizes, agricultural land values, and agricultural production were collected for the four-county analysis area. All of this information came from published sources. Some of the general data is published every 5 years in the Census of Agriculture. Other pieces of information, such as average crop yield and average sales prices received for crops, are published annually by the National Agricultural Statistics Service (NASS) for the state of Washington.

A general picture of agricultural production in the four-county area does not provide the depth of information needed to accurately portray the future of farms in the study area; therefore, more detailed information is included to make the agricultural impacts analysis as accurate as possible. In this analysis, the general picture of agricultural production in the four-county area precedes more detailed information. Generally, Census of Agriculture data shows average farm sizes for each of the four counties and land values since 1997. These data record primary crops grown in the four-county area. Additionally, annual data provided by NASS addresses county-average yields and average crop prices.

The Columbia Basin Groundwater Management Area (GWMA) provides the next level of detail for this analysis. The GWMA information is specific to lands within the study area and includes information about crops grown in the study area and irrigation wells. In addition, GWMA offers recommendations about the future of agriculture in the study area.

1.2.1.1.1 Census of Agriculture Data

Census of Agriculture data paints a general picture of agriculture. Very little Census of Agriculture data are used in this analysis, but the data help to understand what is happening in four counties in eastern Washington.

1.2.1.1.1.1 Farms and Farm Size

Census of Agriculture data for Adams, Franklin, Grant, and Lincoln counties in Washington was available for 2007, 2002, and 1997. In 2007, the four-county analysis area had 4,329 farms encompassing 3,885,663 acres of land, for an average farm size of 900 acres. The 2002 Census of Agriculture showed that the four-county analysis area had 4,208 farms with 4,039,405 total acres. Average farm size according to the 2002 Census of Agriculture was 960 acres. The 1997 Census of Agriculture showed 3,882 farms with 4,131,131 total acres and an average farm size of 1,064 acres. The general trend seen from the Census of Agriculture data is that the number of farms is increasing, while farm size is decreasing.

Census of Agriculture information documents the number of farms with irrigated lands. Farms with irrigation range from a low of about 120 farms in Lincoln County to a high of about 1,410 farms in Grant County. The average number of irrigated acres has been decreasing in Adams and Lincoln counties over time. Franklin and Grant counties have seen fairly steady amounts of irrigated land from 1997 to 2007. Overall, the number of irrigated acres per farm averages 333 acres for the four-county analysis area. Over the three Census of Agriculture periods, irrigated lands make up about 22 percent of the total farmland and 62 percent of the total number of farms are irrigated. The number of irrigated acres, according to the Census of Agriculture reports, rose from 863,330 acres in all four counties in 1997, to 900,259 acres in 2002, and then dropped in 2007 to 843,614 acres. Table AgBen1 presents the Census of Agriculture data for number of farms, land in farms, and irrigated farms in the four-county area.

The four-county analysis area encompasses the study area, which only has 102,616 acres of land currently irrigated with groundwater authorized to receive CBP water. Thus, irrigated land in the study area would account for about 12 percent of the irrigated land in the four-county analysis area.

Table AgBen1.—Census of agriculture number of farms data for the four-county analysis area

	Adams	Franklin	Grant	Lincoln	Total
2007 data					
Number of farms	782	891	1,858	798	4,329
Land in farms (acres) average	1,098,487	609,046	1,087,952	1,090,178	3,885,663
Farm size (acres)	1,405	684	586	1,366	898
Irrigated land (number of farms)	304	702	1,403	125	2,534
Irrigated land (acres)	124,515	217,238	469,790	32,071	843,614
Average number of irrigated acres	410	309	335	257	333
2002 data					
Number of farms	717	943	1,801	747	4,208
Land in farms (acres)	1,067,079	664,875	1,074,074	1,233,377	4,039,405
Average farm size (acres)	1,488	705	596	1,651	960
Irrigated land (number of farms)	316	744	1,448	141	2,649
Irrigated land (acres)	120,746	241,063	485,459	52,991	900,259
Average number of irrigated acres	382	324	335	376	340
1997 data					
Number of farms	628	848	1,699	707	3,882
Land in farms (acres)	1,096,447	563,716	1,095,099	1,375,869	4,131,131
Average farm size (acres)	1,746	665	645	1,946	1,064
Irrigated land (number of farms)	294	725	1,409	120	2,548
Irrigated land (acres)	148,018	221,145	446,183	47,984	863,330
Average number of irrigated acres	503	305	317	400	339

Source: 1997, 2002, and 2007 Census of Agriculture.

1.2.1.1.1.2 Agricultural Land Values

The market value of agricultural land averaged $1,024, $2,161, $2,495, and $996 per acre for Adams, Franklin, Grant, and Lincoln counties, respectively, according to the 2007 Census of Agriculture. In general terms, when average land values from the 1997, 2002, and 2007 Census of Agriculture are examined, average land values show a pronounced upward trend. For example, the 1997 Census of Agriculture showed that Adams County average land values were $714/acre. The average land value for Adams County was $745/acre in the 2002 Census of Agriculture, a 4.3 percent increase. In 2007, land values increased to $1,024/acre, a 37.5 percent increase over a 5-year period. This same trend, albeit with differing land values for each county, was seen in all four of the counties in the analysis area. Table AgBen2 presents the Census of Agriculture data relating to average market values for counties in the area.

Table AgBen2.—Average market value of land for the four-county analysis area

	Adams	Franklin	Grant	Lincoln	Average
2007 data					
Market value of land ($)	1,438,309	1,477,309	1,460,726	1,360,226	1,434,143
Average market value ($/acre)	$1,024	$2,161	$2,495	$996	$1,669
2002 data					
Market value of land ($)	1,114,407	982,716	1,115,289	1023866	1,059,070
Average market value ($/acre)	$745	$1,448	$1,923	$606	$1,181
1997 data					
Market value of land ($)	1,307,300	969359	1,001,298	1,078,654	1,089,153
Average market value ($/acre)	$714	$1,469	$1,596	$537	$1,079

Source: 1997, 2002, and 2007 Census of Agriculture.

1.2.1.1.2 National Agricultural Statistics Service Data

NASS gathers and publishes agricultural data specific to the state of Washington every year, including information about the number acres of harvested crops in the analysis area. This source was also used for information about crop yields and prices. A 5-year average was used to determine baseline crop acreage, yield, and price received. Data from NASS are usually the only source of information about acres of harvested crops, yields, and the price received when crops are sold.

Wheat, hay, and potatoes account for almost 91 percent of all crops grown in the four-county analysis area, according to the NASS. Table AgBen3 shows some of the most common crops harvested in the study area from 2004–08. Wheat is by far the most common crop produced in the analysis area, accounting for 63.4 percent of the total acreage harvested. Alfalfa and other hay cover 20.2 percent of total acreage. Potatoes are 7.2 percent. Corn for grain (3.4 percent) and barley (3.4 percent) are the next most commonly produced crops. Corn silage, oats, pinto beans, pink beans, and dry edible beans comprise the remaining 2.5 percent of harvested acres. Harvested acreage over the four-county region totals 1,345,193 acres.

Table AgBen3.—Primary irrigated crop acreages for the four-county analysis area, 2004–08

Crop	2004	2005	2006	2007	2008	Average	Percent
All wheat	914,600	913,200	890,700	833,100	872,000	884,720	63.4%
Corn grain	43,000	47,400	32,700	68,900	45,200	47,440	3.4%
Corn silage	9,700	11,700	10,800	15,500	9,000	11,340	0.8%
Oats	300		400			350	0.0%
All barley	61,400	45,000	41,800	46,900	39,100	46,840	3.4%
Beans – Pinto	2,100	4,300	3,900	4,900	5,000	4,040	0.3%
Beans – Pink	1,800	1,450	1,800			1,683	0.1%
Beans – Sm.- red	1,900	2,500	2,000	2,900	2,100	2,280	0.2%
Beans – Dry-red	15,400	19,300	19,000	10,700	8,900	14,660	1.1%
Alfalfa	259,000	243,000	239,500	230,400	182,500	230,880	16.5%
Hay – Other	40,000	39,500	45,000	67,000	63,000	50,900	3.6%
Potatoes	100,800	95,500	97,500	105,500	101,000	100,060	7.2%
Total	1,450,000	1,422,850	1,385,100	1,385,800	1,327,800	1,395,193	

Source: NASS, 2004–08.

1.2.1.1.2.1 County-Level Crop Yields and Prices

County-average crop yields of representative crops (irrigated and dryland wheat, potatoes, and mixed crops) were obtained from NASS; however, GWMA disagreed with the results finding that the published county-average yield for irrigated wheat, at 101.5 bushels per acre, was too low. This observation was confirmed by the Washington State University Farm Business Management Report EB2029E. Therefore, an average yield of 125 bushels per acre was used for irrigated wheat, based on GWMA's recommendation and substantiated by the published report. All other yields were used in the analysis, as reported in table AgBen4.

Table AgBen4.—Weighted county average yields by crop, 2004–08

Crop	Yield unit	2004	2005	2006	2007	2008	Average
Irrigated wheat	Bushels	91.6	108.3	102.4	103.6	N/A	101.5
Dryland wheat	Bushels	32.9	28.9	43.6	35.6	N/A	35.3
Mixed crops	Pounds	2,753.5	2,261.1	1,615.4	2,433.5	2,355.1	2,247.7
Potatoes	Cwt	590.4	626.2	588.7	624.2	627.6	611.4

Source: NASS, 2004–08.

Prices received for the crops came from the USDA, Economic Research Service (ERS) and NASS. The ERS publishes normalized prices for commodities. The normalized prices are used for evaluating alternative development and management plans for water and related land resources as required by the Water Resources Planning Act of 1965. Normalized prices are only published for basic commodities. When non-basic crops, such as potatoes, are used in an NED benefits analysis, a three-year average of state-average prices are obtained and used. The prices used for this analysis are in table AgBen5.

Table AgBen5.—Normalized prices received by crop, 2009

Crop	Yield unit	Normalized prices used in analysis
Wheat	Bushel	$4.98
Mixed crops	Pounds	$0.2812
Potatoes	Cwt	$6.23

The county-average published statistics were used to determine commonly grown crops in the study area, but a higher level of detail was needed. More detailed information was obtained from GWMA, who provided cropping patterns specific to study area lands irrigated from groundwater sources. NASS county-level yield and state-level price information was incorporated with GWMA acreage data in this analysis.

1.2.1.1.3 GWMA Data

GWMA provided annual data for the types of crops grown in the study area and the number of acres of each crop, as well as expected crop yield and irrigation wells. In this analysis, this specific level of detail was needed, because the study area covers parts of four counties.

1.2.1.1.3.1 Crop Acreages in the Study Area

GWMA supplied data about crops and respective acreages for years 2001 to 2005, but GWMA was unable to exactly reproduce the boundaries of the study area as Reclamation has defined them. Therefore, total harvested acres from the GWMA dataset cover 102,370 acres. Since the 2001 to 2005 GWMA data is specific to the study area, it was more appropriate for this analysis than the 2004 to 2008 county-average data available from the NASS. To compensate for the difference in acreages, once the percentage split by crop was determined from the GWMA data, the percentage split was applied to the Reclamation-specified number of acres in the study area.

According to the information provided by GWMA, the primary crops grown in the study area from 2001 to 2005 included potatoes, wheat, corn, alfalfa, peas, grass seed, and a catchall category called "other" crops (onions and dry beans). Potatoes accounted for more than 15 percent of these reported acres; wheat acres and grass seed acres 46.7 percent; and "other" crops 17 percent. Cumulatively, these three crop categories form almost 79 percent of groundwater-irrigated acres.

Total wheat acres in the GWMA dataset, both irrigated and dryland, came to 46.7 percent of the total acres. It was decided at the outset that dryland wheat acres in this analysis would be capped at 5 percent of total study area acres (102,616 acres) initially. This assumption came about because the initial number of acres being served by the most undependable wells was set at 5 percent. Capping the number of initial dryland acres therefore simplified the analysis. The remaining 41.7 percent of wheat acres were assumed to be irrigated. Table AgBen6 shows the GWMA cropping pattern information that contributed to this analysis.

Table AgBen6.—GWMA crop acreages for the study area, 2000–05

Crop	2000	2001	2002	2003	2004	2005	Average	Percent of total acres
Alfalfa	4,264	4,918	6,526	8,079	N/A	5,608	5,879	5.7%
CRP[1]	4,254	3,090	3,532	3,090	N/A	0	2,793	2.7%
Corn	4,307	7,908	9,303	5,721	N/A	12,592	7,966	7.8%
Other	24,088	22,756	13,661	12,252	N/A	15,007	17,553	17.1%
Peas	3,364	4,538	3,793	6,647	N/A	6,333	4,935	4.8%
Potatoes	14,711	18,404	14,004	15,215	N/A	14,927	15,452	15.1%
Dryland wheat	4,403	5,088	9,896	6,189	N/A	3,591	5,833	5.7%
Irrigated wheat/ grass seed	42,979	35,668	41,655	45,177	N/A	44,312	41,958	41.0%
Total acres	102,370	102,370	102,370	102,370		102,370	102,370	

[1] Conservation Reserve Program.

1.2.1.1.3.2 Representative Crops Selected

After examining the GWMA cropping pattern for 2001 to 2005, four representative crops were selected to reflect current farming practices in the study area: irrigated potatoes, irrigated wheat, irrigated mixed crops, and dryland wheat/fallow rotation. These representative crops were selected based on communication with and cropping patterns provided by GWMA. It should be noted that grass seed was a prevalent crop during the 2001 to 2005 period; however, the importance of grass seed in the study area has since been reduced, because grass seed can no longer profitably compete with irrigated wheat. Therefore, grass seed was not used in the cropping pattern for current conditions.

The category "mixed crops" was used to represent a diverse set of crops that includes corn, alfalfa, conservation reserve program acres, peas, onions, dry beans, and numerous other crops grown in the study area. Collectively the acres of these crops add up to a substantial amount. To expedite the agricultural impact analysis, the acres associated with these crops were categorized as "mixed crops." Representative costs of production and gross income from "mixed crops" came from a dry beans budget prepared by Washington State University. Table AgBen7 shows the crops reported in table AgBen4 that were combined into the four representative crops.

Table AgBen7.—The four representative crops, the combined GWMA crops for each representative crop, each crop's acreage, and percent of total acres, 2000–05

Representative crop name	Crops included	Acres	Percent of total acres
Potatoes	Potatoes	15,452	15.1%
Mixed crops	Peas, corn, alfalfa, CRP, dry beans, etc.	39,126	38.2%
Irrigated wheat	Irrigated wheat, grass seed	42,688	41.7%
Dryland wheat	Dryland wheat/fallow rotation	5,119	5.0%
Total acres		102,370	100.0%

1.2.1.1.3.3 Groundwater Irrigation in the Study Area

Irrigated acres in the study area are currently served by groundwater. The output and dependability of the wells used by farms in the study area were categorized from the most dependable, high output wells to the least dependable, low output wells by GWMA. Additionally, GWMA provided information on the rate of decline of well dependability.

One of the base assumptions used in the agricultural impact portion of this study was the classification of existing wells into five levels of dependability. Another base assumption for the agricultural impact analysis was related to the decline in well dependability and how that declining dependability affected the crops grown in the study area.

1.2.1.1.3.4 Well Levels

Chapter 2, Section 2.3.1.1, describes the status of groundwater wells in the Odessa Subarea. Regarding irrigated agriculture, level 1 wells (presently serving 5 percent of all study area lands) are suitable for meeting the irrigation requirements of high water use crops such as potatoes for an entire irrigation season. No decline in dependability or output was assumed for level 1 wells; therefore, no future change in the cropping pattern for level 1 wells is expected.

Level 2 wells, currently serving 30 percent of all study area lands, are also suitable for meeting irrigation requirements for high water-use crops. However, level 2 wells are projected to have reduced output and be less dependable in the future. As level 2 wells become less dependable, they will be downgraded to be Level 3 wells and a less water-intensive cropping pattern is assigned to the acres served by those wells. Thus, over time, fewer and fewer acres will be served by level 2 wells.

Level 3 and level 4 wells (currently serving 60 percent of all acres in the study area) may be able to meet irrigation requirements for part of the year, but would not sustain high water use crops for an entire irrigation season. The crops grown on lands served by level 3 and level 4 wells are irrigated wheat and mixed crops, which need less water than crops such as potatoes. Level 3 and level 4 wells are subject to lessened well output and dependability, and 10 percent of lands irrigated with levels 3 and 4 wells will be taken out of the levels 3 and 4 cropping pattern each year. Once these lands have lost their ability to pump irrigation water, only a crop such as dryland wheat can be produced, and the well level category will be downgraded to level 5.

Level 5 wells (5 percent of all wells) are unusable and farmland is assumed to be in a dryland wheat/fallow rotation.

As level 2, level 3, and level 4 wells reduce output, they sink to the next lowest level. Over time, this means fewer acres served by each well level and more and more acres in dryland wheat/fallow rotation. Table AgBen8 shows the present number of acres in the study area served by each well level, percentage split of acres relative to the total number of acres in the study area, and acres affected by reduced well output.

Table AgBen8.—Well levels, acres served by each well level, and rate of decline by well level

Well level	Output and dependability	Acres served	Percent of total acres served	Percent of acres lost from each well level annually
Level 1	Highest	5,131	5%	0%
Level 2	High	30,785	30%	10%
Level 3	Low	30,785	30%	10%
Level 4	Low	30,785	30%	10%
Level 5	None	5,131	5%	
Total		102,616	100%	

1.2.1.1.3.5 Representative Farm Budgets

Reclamation values irrigation benefits by using a farm budget methodology. The farm budget methodology used by Reclamation first defines one or more representative farms for an area and then looks at the costs and returns of producing common crops in the local area. Benefit studies measure the economic consequences to the nation if residual net farm income from irrigation is lost because of a reduction in water supply or a change from one source of irrigation water to another.

In agricultural benefit analyses the P&Gs require the interest rate to be the current fiscal year planning rate on the entire value of assets, as if 100 percent debt exists. The planning rate for 2010 is 4.375 percent.

The benefit analysis also uses a normalized price which is calculated annually by USDA-ERS for farm program commodities. In this study, only wheat and mixed crops are basic crops which are included in the USDA-ERS list. A 3-year average price was used for the irrigated potato acreage in accordance with the P&Gs.

The return to management in a benefit budget is calculated as 6 percent of variable cost on a benefit study.

Negative residual net farm incomes are common when benefit budgets are prepared. This is not a cause for concern in an analysis; a negative residual net farm income value does not mean that a negative benefit has been estimated. An estimate of agricultural benefits is obtained when the difference in residual net farm income between “with” project and “without” project representative farms is calculated. As long as there is a positive difference between the "with" and "without" project residual net farm incomes, there will be a positive agricultural benefit value.

A summary of the farm budgeting assumptions is presented in table AgBen9.

Table AgBen9.—Basic assumptions of agricultural benefits budgets

	Benefit budget
Methodology	Comparison of residual net farm income between two budgets
Interest rate	4.375%
Debt-to-asset ratio*	100%
Return to owner's equity	None
Return to management	6% of variable expenses

For this study, four "without" project and four "with" project multi-crop representative farms were developed to reflect agriculture in the study area. The representative farms reflect the cultural and economic practices of the project. Furthermore, the representative farms reflect the crop mix and farm types for each of five well levels. The costs and returns associated with the representative farm were used to generate the results of this study.

The size of the representative farms was chosen based on guidance received from local farmers and the CCAO. Cultural practices used in the farm budget came from Extension Cost and Return studies published by Washington State University. After determining the farm size, cropping pattern, average yields and expected prices received for the representative farm, gross returns to the farm were calculated.

After estimating the gross farm income, the variable and fixed costs of producing the crops were subtracted from the gross returns to find net farm revenue.

Finally, a residual net farm income was derived by subtracting an allowance for a return to management and a return to labor from net farm revenues. This value was divided by the total number of acres in the representative farm.

The "without" project representative farms were based on expectations of future conditions in the study area if no surface water supply was developed to replace the current groundwater supply. As wells become unusable, irrigated farms will transition into growing only dryland wheat. Table AgBen10 summarizes the "without" project representative farms for well levels 1-4.

Table AgBen10.—Without project representative farms summary for well levels 1-4

WITHOUT PROJECT representative farm well level 1					
Farm size	1470				
Irrigated acres	1400				
Farmstead	70				
Crops	**Acres**	**Yield**	**Price received**	**Gross value/acre**	**Total income**
Irr. potatoes	350	611.4	6.23	$3,809.02	$1,333,157.70
Irr. wheat	1050	101	4.98	$502.98	$528,129.00
			TOTAL INCOME		$1,861,286.70
Variable costs					$1,567,703.50
Fixed costs					$351,783.44
Returns to farmer					$19,671.20
Residual NFI[1]					-$77,871.44
Residual NFI per acre					-$52.97
WITHOUT PROJECT representative farm well level 2					
Farm size	1470				
Irrigated acres	1400				
Farmstead	70				
Crops	**Acres**	**Yield**	**Price received**	**Gross value/acre**	**Total income**
Irr. potatoes	646	611.4	6.23	$3,809.02	$2,460,628.21
Irr. wheat	579	101	4.98	$502.98	$291,225.42
Irr. mixed crops	175	22.48	28.12	$632.14	$110,624.08
			TOTAL INCOME		$2,862,477.71
Variable costs					$2,344,695.75
Fixed costs					$247,118.81
Returns to farmer					$24,956.01
Residual NFI					$245,707.14
Residual NFI per acre					$167.15
WITHOUT PROJECT representative farm well level 3-4					
Farm size	1470				
Irrigated acres	1400				
Farmstead	70				
Crops	**Acres**	**Yield**	**Price received**	**Gross value/acre**	**Total income**
Irr. wheat	700	50	4.98	$249.00	$174,300.00
Irr. mixed crops	700	14.39	28.12	$404.65	$283,252.76
			TOTAL INCOME		$457,552.76
Variable costs					$696,859.13
Fixed costs					$196,801.44
Returns to farmer					$18,245.88
Residual NFI					-$454,353.69
Residual NFI per acre					-$309.08

[1] Net farm incomes.

A representative farm was developed for well level 5; the crop mix consisted of a dryland wheat/fallow rotation. The farm size selected for the well level 5 representative farm was 4,000 acres based on guidance from local farmers. There is no distinction between "with" and "without" project conditions for a representative farm that only has dryland wheat in the crop mix because there would be no difference in residual net farm income. There is no difference in residual net farm income because irrigation water is not taken away. When acres of land transition from a dryland crop mix to an irrigated crop mix, the benefits will be the difference in residual net farm income of the dryland representative farm compared to the residual net farm income of the irrigated crop mix, for example well level 2. The well level 5 is summarized in table AgBen11.

Table AgBen11.—Well level 5 representative farm summary

WITH PROJECT dryland wheat representative farm					
Farm size	4070				
Irrigated acres	4000				
Farmstead	70				
Crops	**Acres**	**Yield**	**Price received**	**Gross value/acre**	**Total income**
Wheat	2000	35	4.98	$174.30	$348,600.00
Fallow	2000	0	0	$0.00	$0.00
			TOTAL INCOME		$348,600.00
Variable costs					$826,120.00
Fixed costs					$320,745.97
Returns to farmer					$22,725.00
Residual NFI[1]					-$820,990.97
NFI per acre					-$205.25

[1] Net farm incomes.

The "with" project representative farms were assumed to receive a full supply of surface irrigation water at the completion of nine construction phases. When a construction phase was completed, acres that had transitioned into a different well level with less, or no, irrigation deliveries from groundwater sources were assumed to start receiving 3 acre-feet of surface water per acre. Acres receiving 3 acre-feet per acre of surface water were assumed to have a crop mix that included irrigated potatoes, mixed crops, and wheat. Table AgBen12 presents the "with" project representative farm summaries.

Table AgBen12.—With project representative farms summary

WITH PROJECT representative farm pumping level 1					
Farm size	1470				
Irrigated acres	1400				
Farmstead	70				
Crops	**Acres**	**Yield**	**Price received**	**Gross value/acre**	**Total income**
Irr. potatoes	350	611.4	6.23	$3,809.02	$1,333,157.70
Irr. wheat	1050	125	4.98	$622.50	$653,625.00
			TOTAL INCOME		$1,986,782.70
Variable costs					$1,335,182.25
Fixed costs					$448,653.53
Returns to farmer					$19,530.39
Residual NFI[1]					$183,416.53
Residual NFI per acre					$124.77
WITH PROJECT representative farm pumping level 2					
Farm size	1470				
Irrigated acres	1400				
Farmstead	70				
Crops	**Acres**	**Yield**	**Price received**	**Gross value/acre**	**Total income**
Irr. potatoes	646	611.4	6.23	$3,809.02	$2,460,628.21
Irr. wheat	579	101	4.98	$622.50	$360,427.50
Irr. mixed crops	175	22.48	28.12	$632.14	$110,624.08
			TOTAL INCOME		$2,931,679.79
Variable costs					$2,013,992.25
Fixed costs					$247,118.81
Returns to farmer					$24,819.22
Residual NFI					$645,749.51
Residual NFI per acre					$439.29
WITH PROJECT representative farm pumping level 3-4					
Farm size	1470				
Irrigated acres	1400				
Farmstead	70				
Crops	**Acres**	**Yield**	**Price received**	**Gross value/acre**	**Total income**
Irr. wheat	700	125	4.98	$622.50	$435,750.00
Irr. mixed crops	700	22.48	28.12	$632.14	$442,496.32
			TOTAL INCOME		$878,246.32
Variable costs					$501,141.22
Fixed costs					$196,801.44
Returns to farmer					$18,245.88
Residual NFI					$162,057.78
Residual NFI per acre					$110.24

[1] Net farm incomes.

The representative farm summaries presented in tables AgBen9-AgBen11 are composed of many types of information from multiple sources. Once the data has been gathered, it is compiled into a farm budget program that takes individual data, aggregates it, and then presents it in a manner that can be easily understood. The collected data for the representative farms includes:

An Estimation of Gross Farm Income—Gross farm income consists of the sale of products produced on the farm and is calculated after finding the appropriate size of the farm, the cropping pattern, yields, and the price that is expected to be received when the crops are sold.

The Representative Farms—This is the information about farm size, crop mix, cultural practices, etc. Both “without” and “with” project farms are depicted.

Crop Yields—Crop yields are based on county-averages for a 5-year period. Crop yields are presented in table AgBen4.

Prices Received—On a benefit budget the USDA normalized price is used. Prices received are presented in table AgBen5.

Farm Expenses—Crop production expenses were taken from Washington State University Extension Farm Budgets, discussions with farmers, and others knowledgeable with agriculture in the area. Some farm expenses are indexed from a previous study or from Extension farm budgets compiled years earlier. These expenses are indexed to 2008, the last year for which indexing and pricing information is available.

Real Estate Investment—Real estate investment is included in the budget to estimate the amount of interest paid on investments and/or loans. Real estate investment includes land, buildings, and improvements. Investment in irrigated land in this study is the market value of land for agricultural purposes. Irrigated land is valued at $1,685 per acre.

Buildings on a full-time farm in the area vary widely in value, size, and numbers per farm. The representative set of farm buildings for this study includes a machine shed valued at $60,000, a storage shed valued at $40,000.

Crop Expenses—Crop expenses include custom work, herbicides, insect control, disease control, fertilizer, seed, and miscellaneous crop expenses. Crop expenses were taken from Extension farm budgets, discussion with local farmers, and from past studies. Most crop expenses were taken from Extension farm budgets and indexed to 2008. An expense for gypsum and liquid sulfur was added to all “without” project budgets; this expense was estimated to occur on 33 percent of the groundwater irrigated acres. Gypsum was applied at a rate of 500 pounds per acre and liquid sulfur was applied at 30 pounds per acre. Custom work includes application of chemicals and fertilizer, and custom combining the wheat.

Fertilizer is used on most irrigated land for maximum production. This consists of potash, phosphate, and gypsum based fertilizers applied during the production years. Nitrogen based fertilizers are also applied.

Chemicals are used on the representative farm to control weeds and insects and include herbicides, insecticides, and other chemicals needed to produce the crops on the representative farms.

Seed costs are for purchase of high quality seed for maximum germination and production.

General Expenses—General expenses include expenses not easily categorized into any of the expense categories listed above.

Labor Distribution—Labor expense is derived from labor required to operate machinery and manual labor for irrigation. Machinery labor is calculated by adding 10 percent to the total power machinery use. Power machinery use for machines, that require a non-power implement, in this case the tractors, is found by adding 10 percent to the total non-power machinery use.

Hired labor is used by the representative farm budgets if the amount of labor hours supplied by the operator and family labor cannot fulfill all the labor requirements.

Wages—Wages are reported by the Bureau of Labor Statistics on a state wide basis. Wages paid in the area are about $7.50 per hour for farm labor. This is the rate used for hired labor and family labor. Skilled labor is figured at $12.50 per hour and is used for operator labor. These rates were obtained from the U.S. Bureau of Labor Statistics.

Social Security and Worker's Compensation—Social Security and Medicare expense, in a farm budget, is calculated only for hired labor. The social security rate is 15.30 percent, which is divided between the employer and employee, thus, the hired labor rate is 7.65 percent. A Worker's Compensation rate of 12 percent is used in this study.

Machinery Costs—Information on cultural practices, machinery needed, time of use, new costs, depreciation, and repair costs were obtained from several sources including discussions with local irrigators, Extension farm budgets, and University of Minnesota Farm Machinery Economic Cost Estimates for 2005. Machinery values are based on all new machinery and are depreciated over a maximum of 25 years using the sinking fund method. The interest rate used for the sinking fund method is 4.375 percent based on the 60-month average yield of monthly U.S. Treasury marketable securities with maturities of 5 years.

Fuel costs are calculated using the American Society of Agricultural Engineers formula for diesel fuel consumption of 0.044 gallons per horsepower per hour. A cost of $2.55 per gallon for diesel fuel was used. This cost was taken from the USDA Agricultural Prices 2006 Summary, dated July 2007, and indexed to 2008 using the Annual average index for diesel fuel published in the USDA Agricultural Prices, January 2008.

All tractors on the farm are represented by new 150-horsepower, 200-horsepower, and 300-horsepower tractors. The number and types of tractors and other self-propelled machines was obtained from Extension Cost and Return Estimates published by Washington State University.

Telephone and Electricity Expenses—The average annual telephone cost for the western United States is $1,047. This is from the U.S. Bureau of Census Statistical Abstract, 2004. This study assumes one-half of the total telephone bills are attributable to the farm operation. The estimated telephone cost is $524 per year. Most farmers now have cell phones for farm use. An allowance of $40 per month or $480 per year for the farm portion of use increases telephone cost to $1,004 per year.

The U.S. Bureau of Census Statistical Abstract publication was also used for electrical costs. The average residential electrical cost for the western U.S. is $969 per year. It is estimated, for this study, that approximately the same amount of electricity is used for the farm as for the residence; therefore, that amount is used as the electrical cost for the farm operation.

Property Taxes—Property tax information was set at 1.248 percent in the representative farm budgets. Buildings are valued at market value for tax purposes. Building values were adjusted 50 percent to allow for depreciation. Vehicles were assumed to have an annual license fee of $108.

Insurance Costs—Fire and wind insurance costs were set at $6.67 per $1,000 of asset worth. Liability insurance was included as an expense in the farm budgets. Insurance costs can vary greatly depending on location, insurance history, age of property, and other demographic factors.

Liability insurance pays for personal injury and property damage that occurs on the property or is caused by the insured while off the property. A farmer in the area is usually insured for $1,000,000, which costs $300 per year.

Vehicle insurance is quoted in dollar amounts and can also vary depending on several factors. The average insurance cost for a new pickup would be about $700.

Return to Farm Family—The farm operator and farm family are entitled to income from the farm as a result of their investment, management, and labor.

Return to Equity—There is no return to equity in a benefit budget since interest is charged on 100 percent of assets.

Return to Management—Return to management is to pay the operator for his ability to manage and operate the unit in an efficient and profitable manner. While this value varies extensively with each operator's ability, 6 percent of variable expenses was used for Benefit budgets.

Return to Labor—The farm operator and his family are also entitled to income for labor they perform on the farm. Return to labor is calculated as wages paid to the farm operator and farm family. In this study operator wages are $12.50 per hour and family wages are $7.50 per hour.

1.2.1.1.3.6 Determining Lost Irrigation Benefits

Irrigation benefits are generally found by taking the change in residual net farm income under a “with” project condition versus a “without” project condition. The “with” project condition in this study was assumed to have a full supply of irrigation water. The “without” project condition was assumed to have a partial supply of irrigation water.

1.2.1.1.3.7 Finding the Change in Irrigated Acres

The annual reduced number of irrigated acres was estimated with a spreadsheet model. The model estimated how many acres of irrigated crops were grown in the study area in 2010. Then, the spreadsheet model, based on assumptions about decreasing well dependability, estimated the reduced number of groundwater irrigated acres annually for the “without” project conditions. As acres transitioned from one well level to another, a change in the crop mix occurred along with a resultant change in residual net farm income. As wells became completely unusable, acres were placed into the well level 5 category and grew only dryland wheat in a wheat/fallow rotation.

The same spreadsheet model, with different assumptions, was used to project the change in the number of irrigated acres and the associated change in residual net farm income for the “with” project conditions. In this version of the spreadsheet model, acres began to receive a full supply of surface water as construction phases were completed. Acres receiving a full supply of surface water began growing the well level 2 crop mix of irrigated potatoes, mixed crops, and wheat. The "with" project version of the spreadsheet model estimated changes in irrigated acres for each of nine construction phases. The alternative being evaluated, Partial-Banks or Full-Banks, dictated how many acres would receive agricultural benefits because of the implementation of the project. For example, when the Partial-Banks Alternative was evaluated, 57,070 acres accrued agricultural benefits and 45,545 acres did not. Under the Full-Banks Alternative, 102,616 acres accrued agricultural benefits.

In both versions of the spreadsheet model, changes in the number of irrigated acres and associated residual net farm income were estimated each year beginning in 2010 and ending in 2126 with construction phases completed in 2019, 2020, 2023, and 2025. Thus, changes in irrigated acres and residual net farm income were projected 100 years into the future after 2025.

1.2.1.1.3.8 Calculating the Change in Net Farm Income

After the spreadsheet models for the No Action, Partial-Banks, and the Full-Banks Alternatives had been completed, it was possible to identify the changes in groundwater irrigated acreage over time.

In this analysis, the primary driver for agricultural benefits comes from a change in pumping costs. Reduced pumping costs lower farm cost, resulting in higher residual net farm incomes. A secondary driver for agricultural benefits comes from an incremental change in crop acres as wells become less dependable and the crop mix is changed. The "with" project condition assumed that groundwater pumping costs were minimized since surface water was delivered for irrigation purposes. The "without" project condition was characterized by full groundwater pumping costs based on a 900-foot lift. The difference between the residual net farm incomes under the "with" and "without" conditions is the benefit to irrigated agriculture.

For example, if the performance of level 2 wells is reduced and those wells become classified as level 3 wells, there will be a change in the crops that can be grown on the acres served by those wells. Thus, a change in crop production will occur (different crops will be grown) along with a resultant change in net farm income.

After incorporating the effects on residual net farm income from reducing pumping costs and the incremental change in crop mix into the representative farm budget, a total benefit accruing to agriculture can be estimated.
Table AgBen13 shows the agricultural benefits attributable to each well pumping level. These values were obtained from the "with" and "without" project net farm incomes (NFI) for each whole farm for each well pumping level.

Table AgBen13.—Irrigation pumping benefits from "with" and "without" project whole-farm budgets

Well level	Without project NFI	With project NFI	Irrigation benefit value per acre
1	-$52.97	$124.77	$177.74
2	$167.15	$439.29	$272.14
3 and 4	-$309.08	$110.24	$419.32
5	-$205.25	-$205.25	$0.00

Results

No Action Alternative

Benefit Analyses

Agricultural Benefits – All agricultural irrigation benefits associated with the action alternatives were measured as changes from the No Action Alternative. to start the agricultural benefits calculation, annual residual net farm income was first calculated for each year under the No Action Alternative by taking the annual change in crop acres for each pumping level and multiplying by the associated "without" project residual net farm income (shown in table AgBen9). This was done for each year of the 100-year period of analysis so that future projections of residual net farm income could be quantified.

Under the No Action Alternative, irrigated agriculture in the study area would be dramatically reduced because groundwater would not be replaced with surface water. As groundwater diminishes, farmers would transition into growing dryland crops in rotation with fallow land. Ultimately, all but level 1 acres would grow dryland crops under the No Action Alternative because no other source of irrigation water would be available to the acres associated with the other well levels.

After forecasting the future number of irrigated and dryland acres, residual net farm income was estimated. There are 102,616 acres in the study area currently irrigated with groundwater. The crops represented by the NED benefits budgets include irrigated potatoes, wheat, mixed crops, and a dryland rotation of wheat and fallow. As stipulated, the farm size was held at a constant 1,400 acres for all farm budgets used in estimating the residual net farm incomes.

Information about crops grown in the study area and the number and status of groundwater wells in the study area was obtained from GWMA (see NED section of the Draft Economics Technical Report). In addition to helping describe current conditions, GWMA also provided guidance and assumptions on the future status of groundwater wells and cropping patterns in the study area under the No Action Alternative.

Groundwater wells in the area were ranked by GWMA according to five status levels (levels 1 to 5) based on output and dependability. Assumptions were made about how long wells would remain in use and what crops would be grown as wells declined in output and dependability. This information was used in a spreadsheet model to predict changes in irrigated acres in the future. Subsequent changes in residual net farm income were estimated by multiplying the number of acres in each well level by the associated residual net farm income for each well level.

The results for the No Action Alternative are presented in two tables. The first table (table AgBen 14) presents the change in groundwater irrigated acres for the years 2019, 2020, 2023, 2025, 2050, 2075, 2100, and 2125. In each year of the analysis, a lagged transition of acres from one well level to the next lowest well level occurred. The lag was introduced into the analysis to show that even though a number of acres would be transitioned into the next lower well level each year that transition would not occur instantaneously. Instead, the transition of acres from one well level to the next would occur at the beginning of the next year. Some of the acres that transitioned from one well level to another were assumed to be in the first year of a fallow rotation. These acres are identified in table AgBen10 as acres not harvested.

The second table presenting No Action Alternative results, table AgBen15, contains information about the estimated residual net farm income generated by each well level and the total residual net farm income for all well levels. The residual net farm income for each well level is estimated by multiplying the "without" project per-acre benefit value for each well level by the number of groundwater irrigated acres in the well level. It can be seen in the table that residual net farm income under "without" project conditions continuously declines through 2025, then rises slightly as the last of the level 3-4 acres transition into level 5 acres.

The crop mix for acres irrigated with level 1 wells had irrigated potatoes and wheat on 5,131 acres (table AgBen 14). Since no level 1 acres were taken out of irrigated production over the 100-year planning horizon, residual net farm income for level 1 acres was a constant -$271,800 (table AgBen 15). The estimate of

Table AgBen14.—No Action Alternative groundwater irrigated acres under the without project condition (by selected years)

	2019	2020	2022	2023	2025	2050	2075	2100	2125
Acres by well level									
Level 1	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131	5,131
Level 2	11,927	10,734	8,695	7,825	6,338	456	33	5	5
Level 3-4	49,179	47,707	44,546	42,893	39,517	9,016	1,344	162	18
Level 5	32,551	35,467	41,132	43,869	49,126	87,998	96,093	97,303	97,447
Acres not harvested	3,828	3,577	3,112	2,898	2,504	69	15	15	15
Total acres	102,616	102,616	102,616	102,616	102,616	102,616	102,616	102,616	102,616

Table AgBen15.—No Action Alternative residual net farm incomes by well level under a without project condition (by selected years)

	2019	2020	2022	2023	2025	2050	2075	2100	2125
Annual residual net farm income without project									
Level 1	-$271,778	-$271,778	-$271,778	-$271,778	-$271,778	-$271,778	-$271,778	-$271,778	-$271,778
Level 2	$1,993,542	$1,794,187	$1,453,292	$1,307,963	$1,059,450	$76,172	$5,468	$788	$788
Level 3-4	-$15,200,269	-$14,745,171	-$13,768,304	-$13,257,383	-$12,213,812	-$2,786,637	-$415,375	-$50,043	-$5,535
Level 5	-$6,681,124	-$7,279,511	-$8,442,286	-$9,004,191	-$10,083,150	-$18,061,503	-$19,723,002	-$19,971,354	-$20,000,910
Total residual net farm income	-$20,159,629	-$20,502,273	-$21,029,076	-$21,225,289	-$21,509,291	-$21,043,746	-$20,404,688	-$20,292,388	-$20,277,436

residual net farm income (-$52.97/acre) under the No Action Alternative came from a representative farm budget for level 1 acres. The total residual net farm income for level 1 acres was derived by multiplying -$52.97/ acre ("without" project residual net farm income) by the 5,131 acres in level 1.

In 2019, acres irrigated by level 2 wells had irrigated potatoes, mixed crops, and wheat on 11,927 acres. Residual Net farm income in 2019 was $1,993,500. By 2125, there were virtually no acres being served by level 2 wells and the residual net farm income had dropped to $800. The level 2 representative farm, with three crops, had a "without" project per-acre residual net farm income of $167.15; multiplying $167.15/acre by the 11,927 acres (in 2019) being served by level 2 wells gives a total residual net farm income of $1,993,500. The per-acre residual net farm income multiplied by the number of acres (5 acres) in 2125 gives $800. The drop in residual net farm income was $1,992,700, a 99.9 percent drop in residual net farm income for this level.

Acres associated with well level 3 and well level 4 had a crop mix of irrigated mixed crops and wheat. In 2019, residual net farm income was -$15,200,300 and by 2125 residual net farm income was -$5,500. There were 49,179 acres served by level 3 and 4 wells in 2019. The representative farm for these two well levels estimated a per-acre residual net farm income of -$309.08. By 2125, the number of acres served by level 3 and 4 wells had dropped to 18 acres and the residual net farm income was -$5,500. There was a 99.9 percent loss of acres served by level 3 and 4 wells.

Level 5 acres were all in a dryland wheat/fallow rotation. As more acres were transitioned into level 5 acres, they were put into the dryland wheat/ fallow rotation. In 2019, 32,551 acres were in level 5; by 2125 level 5 acres numbered 97,447. Residual net farm income went from -$6,681,100 in 2019 to -$20,000,900 in 2125. The per-acre benefit value was -$205.25. The number of acres classified as level 5 was more than 3 times as large in 2125 as it was in 2019.

When the residual net farm incomes from each well level were added together, total residual net farm income remained fairly constant (-$20,159,600 in 2019 compared to -$20,277,400 in 2125) over the planning horizon but large changes in residual net farm income were seen in the different well levels. Specifically, residual net farm income from levels 2, 3, and 4 basically went to zero. The residual net farm income from level 5 kept increasing because more and more acres kept being added to the level 5 category.

Partial Replacement Alternatives – As explained in Chapter 6: Alternatives, the Partial Replacement Alternatives A–D only differ in which reservoir provide the main water supply. All of the partial replacement alternatives would provide CBP surface water to the same approximately 57,000 acres currently using groundwater south of I-90. Thus, the agricultural benefits are the same for each of the partial replacement alternatives.

Agricultural benefits were estimated for the partial replacement alternatives by comparing the residual net farm income under the No Action Alternative to the residual net farm income under the partial replacement alternative.

All of the partial replacement alternatives are based on completing four construction phases, encompassing 57,070 acres, between 2019 and 2025 (the number of acres for each construction phase can be seen in table AgBen16 in the NED Analysis). The 100-year period of analysis for agricultural benefits begins in 2026 and ends in 2125. From 2010 until 2019, when the first construction phase ends, there are no agricultural benefits because there is no difference in residual net farm income between the No Action Alternative and the partial replacement alternative. However, starting in 2019 when construction phase 1 ends, agricultural benefits begin to accrue on the acres served by the construction phase 1 canal(s) and laterals.

Before construction would be completed, there would be a loss of irrigated acreage as wells are taken offline. At the completion of construction, the acres associated with each construction phase are assumed to go back into irrigated production. Table AgBen16 presents the number of acres for each of the four construction phases by well level that would receive surface water deliveries.

Table AgBen16.—Partial replacement alternative: Total number of acres receiving surface water deliveries by construction phase and cropped acreage by well level by construction phases, south of I-90

Construction phase	Acres receiving surface water	Level 1 cropped acres	Level 2 cropped acres	Level 3 and 4 cropped acres	Level 5 cropped acres
South of I-90					
1	18,713	936	5,614	11,227	936
2	22,002	1,100	6,601	13,202	1,100
3	8,932	447	2,679	5,357	447
4	7,423	371	2,227	4,454	371
Subtotal of acres and wells south of I-90	57,070	2,854	17,121	34,240	2,854

When construction phase 1 ends, 18,713 acres will accrue agricultural benefits because those acres will no longer be served by groundwater wells. Additionally, amongst the 18,713 acres, those acres most affected by well performance reductions will gain from the start of surface water deliveries. Each acre previously irrigated with groundwater would receive 3 acre-feet of surface water. Thus, the production losses (from the changes in crops grown) would be gained back.

Under construction phase 2, 22,003 acres will begin to receive surface water deliveries; phase 3, 8,933 acres; and phase 4, 7,423 acres. Thus, the cumulative number of acres receiving agricultural irrigation benefits in 2019, 2022, 2023, and 2025 is 18,713, 40,716, 49,647, and 57,070 acres, respectively. As each construction phase is completed, the acres previously served by groundwater wells will begin to receive 3 acre-feet of surface water per acre.

The results for the partial replacement alternatives are presented in two tables. The first table (table AgBen17) presents the change in irrigated and dryland acres for the years 2019, 2020, 2023, 2025, 2050, 2075, 2100, and 2125. In each year of the analysis, a lagged transition of acres from one well level to the next lowest well level occurred. The lag was introduced into the analysis to show that even though a number of acres would be transitioned into the next lower well level each year that transition would not occur instantaneously. Instead, the transition of acres from one well level to another would occur at the beginning of the next year. Some of the acres that transitioned from one Well level to another were assumed to be in the first year of a fallow rotation. These acres are identified in table AgBen17 as acres not harvested.

The second table presenting the partial replacement alternative results, table AgBen18, contains information about the estimated residual net farm income generated by each well level and the total residual net farm income for all well levels for the years 2019, 2020, 2023, 2025, 2050, 2075, 2100, and 2125. The residual net farm income for the surface water irrigated acres under the "with" project condition for well levels 1 and 2 are multiplied by the with project residual net farm income. Groundwater irrigated acres under the without project condition for well levels 1 thru 5 are multiplied by the without project residual net farm income. The difference in residual net farm income between the No Action Alternative and the partial replacement alternative is the estimate of agricultural benefits arising because of the implementation of any one of the partial replacement alternatives. The difference in residual net farm income between the No Action Alternative and the partial replacement alternative is the estimate of agricultural benefits arising because of the implementation of any one of the partial replacement alternatives. For use in the benefit-cost analysis, the annual agricultural benefits were compounded/discounted to the end of the canal

Table AgBen17.—Partial replacement alternative: Groundwater irrigated acres under a with project condition (by selected years)

	Construction phases ending in each year							
Acres	1	2	3	4	**Selected years after construction ends**			
Surface water irrigated acres (with project condition)	**2019**	**2022**	**2023**	**2025**	**2050**	**2075**	**2100**	**2125**
Level 1	936	2,036	2,482	2,854	2,854	2,854	2,854	2,854
Level 2	17,777	38,680	47,165	54,216	54,216	54,216	54,216	54,216
Subtotal–surface water acres	18,713	40,716	49,647	57,070	57,070	57,070	57,070	57,070
Groundwater irrigated acres (without project condition)								
Level 1	4,195	3,095	2,649	2,277	2,277	2,277	2,277	2,277
Level 2	9,752	5,245	4,039	2,813	202	14	1	1
Level 3-4	40,211	26,871	22,141	17,539	4,002	596	73	8
Dryland acres								
Level 5	26,615	24,811	22,645	21,805	38,923	42,643	43,193	43,261
Acres not harvested	3,130	1,878	1,495	1,112	142	16	2	0
Subtotal–groundwater, dryland, and not harvested acres	83,903	61,900	52,969	45,546	45,546	45,546	45,546	45,546
Total acres	102,616	102,616	102,616	102,616	102,616	102,616	102,616	102,616

Table AgBen18.—Partial replacement alternative: Residual net farm incomes by well level under a with project condition (by selected years)

	Construction phases ending in each year							
Residual net farm income	1	2	3	4	**Selected years after construction ends**			
Surface water irrigated acres (with project condition)	**2019**	**2022**	**2023**	**2025**	**2050**	**2075**	**2100**	**2125**
Level 1	$116,741	$254,007	$309,723	$356,031	$356,031	$356,031	$356,031	$356,031
Level 2	$7,809,412	$16,991,825	$20,718,959	$23,816,766	$23,816,766	$23,816,766	$23,816,766	$23,816,766
Subtotal–surface water acres	$7,926,153	$17,245,832	$21,028,682	$24,172,797	$24,172,797	$24,172,797	$24,172,797	$24,172,797
Groundwater irrigated acres (without project condition)								
Level 3-4	$4,432,839	$2,962,268	$2,440,803	$1,933,547	$441,165	$65,710	$8,046	$859
Dryland acres								
Level 5	-$5,462,757	-$5,092,554	-$4,647,790	-$4,475,395	-$7,988,895	-$8,752,570	-$8,865,424	-$8,879,222
Acres not harvested	$0	$0	$0	$0	$0	$0	$0	$0
Subtotal–groundwater, dryland, and not harvested acres	-$1,029,918	-$2,130,286	-$2,206,987	-$2,541,848	-$7,547,730	-$8,686,860	-$8,857,378	-$8,878,327
Total residual net farm income	$6,896,235	$15,115,546	$18,821,695	$21,630,949	$16,625,067	$15,485,937	$15,315,419	$15,294,470
Difference from no action residual net farm income = annual benefits	$27,055,864	$36,144,622	$40,046,984	$43,140,240	$37,668,813	$35,890,626	$35,607,808	$35,571,871

construction period (year 2025) using the 2009-2010 water project planning rate of 4.375 percent. For all partial replacement alternatives, this compounded/ discounted stream of agricultural benefits equate to $1,153.3 million in year 2025 dollars.

The crop mix for acres irrigated with level 1 wells had irrigated potatoes and wheat on 5,131 acres (table AgBen 14). In 2019, construction phase 1 was completed and 936 acres were transitioned into receiving surface water. Those 936 acres became the "with" project acres and the residual net farm income of $124.77 per acre was multiplied by 936 acres to arrive at a residual net farm income of $116,741. As more construction phases were completed, more level 1 acres began receiving surface water deliveries and the residual net farm income for level 1 acres rose until it reached its maximum amount of $356,031 in 2025 and beyond.

In 2019, acres irrigated by level 2 wells had irrigated potatoes, mixed crops, and wheat on 17,777 acres. Residual Net farm income in 2019 was $7,809,412 under the "with" project condition. Four construction phases had been completed by 2025 and residual net farm income came to $23,816,766 (54,216 acres times $439.29/acre). The level 2 representative farm, with three crops, had a "with" project per-acre residual net farm income of $439.29.

Acres associated with well level 3 and well level 4 had a crop mix of irrigated mixed crops and wheat. In 2019, the residual net farm income was $4,432,839 and by 2125 residual net farm income was $859. There were 49,179 acres served by levels 3 and 4 wells in 2019. The representative farm for these two well levels estimated a per-acre residual net farm income of $110.24. By 2125, the number of acres served by level 3 and 4 wells had dropped to 8 acres and the residual net farm income was $869. There was a 99.9 percent decrease in the number of acres served by level 3 and 4 wells.

Level 5 acres were all in a dryland wheat/fallow rotation. As more acres were transitioned into level 5 acres, they were put into the dryland wheat/fallow rotation. In 2019, 26,615 acres were in level 5; by 2125 level 5 acres numbered 43,261. Residual net farm income went from -$5,462,757 in 2019 to -$8,879,222 in 2125. The per-acre benefit value was -$205.25. Level 5 acres increased by 61.5 percent from 2019 to 2125.

Full Replacement Alternatives – As explained in Chapter 6: Alternatives, the Full Replacement Alternatives A – D only differ in which reservoir provide the main water supply. All of the full replacement alternatives would provide CBP surface water to the same approximately 102,600 acres currently using groundwater in the study area. Thus, the agricultural benefits are the same for each of the full replacement alternatives.

Agricultural benefits were estimated for the full replacement alternatives by comparing the residual net farm income under the No Action Alternative to the residual net farm income under the full replacement alternative.

All of the full replacement alternatives are based on completing nine construction phases, encompassing 102,616 acres, between 2019 and 2025 (the number of acres for each construction phase can be seen in table AgBen11 in the NED Analysis). The 100-year period of analysis for agricultural benefits begins in 2026 and ends in 2125. From 2010 until 2019, when the first construction phase ends, there are no agricultural benefits because there is no difference in residual net farm income between the No Action Alternative and the Full-Banks Alternative. However, starting in 2019 when construction phase 1 ends, agricultural benefits begin to accrue on the acres served by the construction phase 1 canal(s) and laterals.

The replacement irrigation water was assumed to be delivered to 15,495 acres of potatoes, 41,046 acres of irrigated wheat, and 46,075 acres of irrigated mixed crops annually; this crop mix provided the highest gross farm income that could be expected from the 102,616 cropped acres.

Table AgBen19 presents the number of acres for each of the nine construction phases that would receive surface water deliveries, along with the cropped acreage by well level for each construction phase.

The results for the full replacement alternative are presented in two tables. The first table (table AgBen 20) presents the change in groundwater irrigated acres. In each year of the analysis, a lagged transition of acres from one well level to the next lowest well level occurred. The lag was introduced into the analysis as a means of showing that even though a number of acres would be transitioned into the next lower well level each year that transition would not occur instantaneously. Instead, the transition of acres from one well level to another would occur at the beginning of the next year. Some of the acres that transitioned from one Well level to another were assumed to be in the first year of a fallow rotation. These acres are identified in table AgBen20 as acres not harvested.

Table AgBen19.—Full replacement alternative: Total number of acres receiving surface water deliveries by construction phase and cropped acreage by well level by construction phases south of I-90 and north of I-90

Construction phase	Acres receiving surface water	Level 1 cropped acres	Level 2 cropped acres	Level 3 and 4 cropped acres	Level 5 cropped acres
South of I-90					
1	18,713	936	5,614	11,227	936
2	22,002	1,100	6,601	13,202	1,100
3	8,932	447	2,679	5,357	447
4	7,423	371	2,227	4,454	371
Subtotal of acres and wells south of I-90	57,070	2,854	17,121	34,240	2,854
North of I-90					
5	7,085	354	2,126	4,251	354
6	11,671	584	3,501	7,002	584
7	6,147	307	1,844	3,689	307
8	12,756	638	3,827	7,653	638
9	7,887	394	2,366	4,733	394
Subtotal of acres and wells north of I-90	45,546	2,277	13,664	27,328	2,277
Total acres	102,616	5,131	30,785	61,570	5,131

Table AgBen20.—Full replacement alternative: Groundwater irrigated acres under a with project condition (by selected years)

	Construction phases ending in each year								
Acres	1	5	2 and 8	3 and 6	4, 7, and 9	**Selected years after construction ends**			
Surface water irrigated acres (with project condition)	**2019**	**2020**	**2022**	**2023**	**2025**	**2050**	**2075**	**2100**	**2125**
Level 1	936	1,290	3,028	4,058	5,131	5,131	5,131	5,131	5,131
Level 2	17,777	24,508	57,529	77,101	97,485	97,485	97,485	97,485	97,485
Subtotal–surface water acres	18,713	25,798	60,557	81,158	102,616	102,616	102,616	102,616	102,616
Groundwater irrigated acres (without project condition)									
Level 1	4,195	3,841	2,103	1,073	0	0	0	0	0
Level 2	9,752	8,035	3,564	1,473	0	0	0	0	0
Level 3-4	40,211	35,713	18,258	8,969	0	0	0	0	0
Dryland acres									
Level 5	26,615	26,550	16,859	9,173	0	0	0	0	0
Acres not harvested	3,130	2,679	1,275	770	0	0	0	0	0
Subtotal–groundwater, dryland, and not harvested acres	83,903	76,818	42,059	21,458	0	0	0	0	0
Total acres	102,616		102,616	102,616	102,616	102,616	102,616	102,616	102,616

Table AgBen21.—Full replacement alternative: Residual net farm incomes by well level under a with project condition (by selected years)

	Construction phases ending in each year								
Residual net farm income	1	5	2 and 8	3 and 6	4, 7, and 9	**Selected years after construction ends**			
Surface water irrigated acres (with project condition)	**2019**	**2020**	**2022**	**2023**	**2025**	**2050**	**2075**	**2100**	**2125**
Level 1	$116,741	$160,941	$377,785	$506,310	$356,031	$356,031	$356,031	$356,031	$356,031
Level 2	$7,809,412	$10,766,163	$25,271,980	$33,869,720	$42,824,274	$42,824,274	$42,824,274	$42,824,274	$42,824,274
Subtotal “with” project residual net farm income	$7,926,153	$10,927,104	$25,649,765	$34,376,030	$43,180,305	$43,180,305	$43,180,305	$43,180,305	$43,180,305
Groundwater irrigated acres (without project condition)									
Level 3-4	$4,432,839	$3,937,006	$2,012,763	$988,735	$0	$0	$0	$0	$0
Dryland acres									
Level 5	-$5,462,757	-$5,449,418	-$3,460,222	-$1,882,755	$0	$0	$0	$0	$0
Acres not harvested	$0	$0	$0	$0	$0	$0	$0	$0	$0
Subtotal–groundwater, dryland, and not harvested acres	-$1,029,918	-$1,512,412	-$1,447,459	-$894,020	$0	$0	$0	$0	$0
Total “with” project residual net farm income	$6,896,235	$9,414,692	$24,202,306	$33,482,010	$43,180,305	$43,180,305	$43,180,305	$43,180,305	$43,180,305
Difference from no action residual net farm income = annual benefits	$27,055,864	$29,916,965	$45,231,382	$54,704,300	$64,973,734	$64,508,190	$63,869,131	$63,756,831	$63,741,880

When construction phase 1 ended in 2019, 18,713 acres began to accrue agricultural benefits because those acres were no longer served by groundwater wells. Additionally, amongst the 18,713 acres, those acres that had suffered from well performance reductions gained benefits from the start of surface water deliveries because a higher profit crop mix could be planted.

The completion date for construction phase 5 was 2020; 7,085 additional acres of groundwater irrigated acres transitioned into surface water deliveries and a higher profit crop mix.

Construction phases 2 and 8 were completed in 2022; construction phase 2 had 22,003 acres receiving surface water deliveries and construction phase 8 had 12,756 acres receiving surface water deliveries.

Construction phase 3 had 8,931 acres, and construction phase 6 had 11,671 acres; these construction phases were completed in 2023.

Construction phase 4 had 7,423 acres, construction phase 7 had 6,147 acres, and construction phase 9 had 7,887 acres receiving surface water when construction was completed in 2025.

The cumulative number of acres receiving agricultural irrigation benefits in 2019, 2020, 2022, 2023, and 2025 was 18,713, 25,798, 60,557, 81,159 and 102,616 acres, respectively. As each construction phase was completed, the acres previously served by groundwater wells began to receive 3 acre-feet of surface water.

The second table presenting Full-Banks Alternative results, table AgBen21, contains information about the estimated residual net farm income generated by each well level and the total residual net farm income for all well levels. The residual net farm income for the surface water irrigated acres under the "with" project condition for well levels 1 and 2 are multiplied by the with project residual net farm income. Groundwater irrigated acres under the without project condition for well levels 1 thru 5 are multiplied by the without project residual net farm income. The difference in residual net farm income between the No Action Alternative and the partial replacement alternative is the estimate of agricultural benefits arising because of the implementation of any one of the partial replacement alternatives.

The crop mix for acres irrigated with level 1 wells had irrigated potatoes and wheat on 5,131 acres (table AgBen 2). In 2019, construction phase 1 was completed and 936 acres were transitioned into receiving surface water. Those 936 acres became the "with" project acres and the residual net farm income of $124.77 per acre was multiplied by 936 acres to arrive at a residual net farm income of $116,741. As more construction phases were completed, more level 1 acres began receiving surface water deliveries and the residual net farm income for level 1 acres rose until it reached its maximum amount of $356,031 in 2025 and beyond.

In 2019, acres irrigated by level 2 wells had irrigated potatoes, mixed crops, and wheat on 17,777 acres. Residual Net farm income in 2019 was $7,809,412 under the “with” project condition. Nine construction phases had been completed by 2025 and residual net farm income came to $42,824,274 (102,616 acres times $439.29/acre). The level 2 representative farm, with three crops, had a “with” project per-acre residual net farm income of $439.29.

Acres associated with well level 3 and well level 4 had a crop mix of irrigated mixed crops and wheat. In 2019, the residual net farm income was $4,432,839 and by 2025 residual net farm income was $0 because all acres had transitioned into receiving surface water. The representative farm for these two well levels estimated a “without” project per-acre residual net farm income of $110.24. The “with” project residual net farm income was $439.29 per acre.

Level 5 acres were all in a dryland wheat/fallow rotation. As more acres were transitioned into level 5 acres, they were put into the dryland wheat/fallow rotation. In 2019, 26,615 acres were in level 5; by 2025 all level 5 acres had been transitioned into receiving surface water and no dryland acres remained. Residual Net farm income went from -$5,462,757 in 2019 to $0 by 2025. The per-acre benefit value was -$205.25.

Table AgBen20 shows the full replacement alternative’s change in irrigated and dryland acres for the years 2019, 2020, 2023, 2025, 2050, 2075, 2100, and 2125. Table AgBen21 presents the change in residual net farm income for the same years. The difference in residual net farm income between the No Action Alternative and the full replacement alternative is the estimate of agricultural benefits arising because of the implementation of any one of the full replacement alternatives. For use in the benefit-cost analysis, the annual agricultural benefits were compounded/discounted to the end of the canal construction period (year 2025) using the 2009-2010 water project planning rate of 4.375 percent. For all full replacement alternatives, this compounded/discounted stream of agricultural benefits equate to $1,800.7 million in year 2025 dollars.

1.2.1.2 Other Direct Benefits – Municipal

Methodology and Assumptions – Municipal benefits related to the proposed alternatives were considered from two perspectives – the amount of agricultural acreage estimated to move off of groundwater and potential pumping cost savings.

1.2.1.2.1 Acreage Moved Off of Groundwater

Municipal water supplies within the Odessa study area are obtained almost exclusively from groundwater sources. Like agricultural wells in the area, municipal wells are also experiencing difficulties as groundwater levels continue to decline. At first glance, it would appear that moving irrigators off of groundwater and on to surface water as proposed by the action alternatives could imply a significant benefit for municipal water users. But the level of benefit to municipal water users depends on what is expected to happen under the No Action Alternative. Under the No Action Alternative, groundwater levels are expected to continue to decline as irrigators continue to pump. However, as described in the agricultural benefits analysis directly above, irrigators will not be able to maintain current levels of groundwater pumping as aquifer levels continue to decline. As can already be seen in the area and as is assumed to expand in the future under the No Action Alternative, irrigators will move to less water intensive crops and ultimately convert to dryland agriculture. The conversion of more and more acres to dryland agriculture over time is equivalent to moving those acres off of groundwater.

The question becomes how quickly would irrigators convert to dryland agriculture under the No Action Alternative versus shifting to surface water under the action alternatives. If the amount of water involved and timing of the conversion to dryland agriculture under the No Action Alternative is similar to the conversion to surface water under the action alternatives, then one would not expect a significant municipal benefit under the action alternatives. Table NED_MUNI1 displays estimates of the number of acres moved off of groundwater pumping and on to either surface water or dryland farming over time.

The table presents acreage estimates starting with the year 2018, the year prior to the end of the first construction phase. For years prior to 2018, the number of acres moved off of groundwater are the same for all alternatives since they are based on the number of acres converted to dryland farming (acres associated with level 5 wells as described in the agricultural section). As each construction phase is completed, acreage within each phase is converted to surface water. Therefore, to estimate the number of acres moved off of groundwater, one needs to add the dryland acreage to the surface water acreage.

By the end of the overall canal construction period in year 2025, it was estimated that over 49,100 acres would be converted to dryland farming under the No Action Alternative. The combination of converted surface water irrigation and dryland farming was estimated at nearly 78,900 acres under the partial replacement alternatives (57,072 acres converted to surface water and 21,805 acres converted to dryland farming). Under the full replacement alternatives, all 102,600 plus acres would be converted to surface water irrigation. By year 2050, the difference between the alternatives tightens considerably with nearly 87,700 acres converted to dryland farming under the No Action Alternative, approximately 96,000 acres converted to surface water or dryland farming under the partial replacement alternatives (57,072 acres converted to surface water and 38,923 acres converted to dryland farming), and the full 102,600 plus acres switched to surface water for the full replacement alternatives.

In addition to the total acreage within the study area converted to either dryland farming or surface water, table NED_MUNI1 also presents information on the converted acreage for those phases/areas located closest to the towns in and around the study area (phases 2-4, 6, and 8). Phase 2 is closest to the town of Warden, phase 3 is closest to Othello, phase 4 is closest to Connell, phase 6 is closest to Moses Lake, and phase 8 is closest to Odessa. All of these construction phases appear to be within 10 miles of each of these communities. By the end of the overall construction period in year 2025, it was estimated that over 30,000 acres within these closest phases would be converted to dryland farming under the No Action Alternative.[1] The combination of converted surface water irrigation and dryland farming was estimated at over 50,000 acres within these closest phases under the partial replacement alternatives (38,359 acres converted to surface water and 11,694 acres converted to dryland farming). Under the full replacement alternatives, all 62,800 plus acres within these closest phases would be converted to surface water irrigation. By year 2050, the difference between the alternatives tightens considerably with nearly 53,700 acres converted to dryland farming under the No Action Alternative, approximately 59,200 acres converted to surface water or dryland farming under the partial replacement alternatives (38,359 acres converted to surface water and 20,875 acres converted to dryland farming), and the full 62,800 plus acres switched to surface water for the full replacement alternatives within these closest phases.

While differences in the amount of acreage converted from groundwater to either dryland farming or surface water exist between the alternatives, initially the assumption was made that the number of acres removed from groundwater pumping by the end of the construction period in year 2025 under the No Action Alternative (nearly 50K in total and 30K for the areas/phases closest to the towns) would be sufficient to significantly reduce the decline in groundwater levels

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[1] While the No Action Alternative doesn't imply any construction, the acreage converted to dryland in these phases/areas was calculated based on the percentage of overall acreage in these phases/areas as compared to the total acreage within the study area.

Table NED_MUNI1.–Total acres removed from groundwater pumping by alternative

	End of construction phase:			1	5		2 and 8	3 and 6		4, 7, 9			
Alternative	Source of irrigated acreage reduction	Year:	2018	2019	2020	2021	2022	2023	2024	2025	2030	2040	2050
No Action	Acreage converted to dryland farming		29,590	32,551	35,466	38,329	41,132	43,869	46,535	49,126	60,844	77,862	87,693
		Acreage %											
Acreage closest to municipalities:	Dryland farming acreage for Phases 2-4, 6, 8	0.612	18,109	19,921	21,705	23,457	25,173	26,848	28,480	30,065	37,236	47,651	53,668
Partial replacement	Switch to Surface Water (Phases 1-4)		0	18,713	18,713	18,713	40,716	49,649	49,649	57,072	57,072	57,072	57,072
	Phase 1 dryland farming acreage		5,396	0	0	0	0	0	0	0	0	0	0
	Phase 2 dryland farming acreage		6,345	6,980	7,605	8,219	0	0	0	0	0	0	0
	Phase 3 dryland farming acreage		2,576	2,834	3,087	3,337	3,581	0	0	0	0	0	0
	Phase 4 dryland farming acreage		2,140	2,355	2,566	2,773	2,975	3,173	3,366	0	0	0	0
Phases 5-9 are not converted to surface water under the partial replacement alternative.	Phase 5 dryland farming acreage		2,043	2,247	2,449	2,646	2,840	3,029	3,213	3,392	4,201	5,376	6,055
	Phase 6 dryland farming acreage		3,365	3,702	4,034	4,359	4,678	4,989	5,293	5,587	6,920	8,856	9,974
	Phase 7 dryland farming acreage		1,773	1,950	2,125	2,296	2,464	2,628	2,788	2,943	3,645	4,664	5,253
	Phase 8 dryland farming acreage		3,678	4,046	4,409	4,765	5,113	5,453	5,785	6,107	7,563	9,679	10,901
	Phase 9 dryland farming acreage		2,274	2,502	2,726	2,946	3,161	3,372	3,577	3,776	4,676	5,984	6,740
		Total:	29,591	45,329	47,713	50,053	65,528	72,294	73,670	78,877	84,077	91,631	95,995
Closest phases to municipalities:	Switch to surface water (Phases 2-4)		0	0	0	0	22,003	30,936	30,936	38,359	38,359	38,359	38,359
	Phase 2 dryland farming acreage (Warden)		6,345	6,980	7,605	8,219	0	0	0	0	0	0	0
	Phase 3 dryland farming acreage (Othello)		2,576	2,834	3,087	3,337	3,581	0	0	0	0	0	0
	Phase 4 dryland farming acreage (Connell)		2,140	2,355	2,566	2,773	2,975	3,173	3,366	0	0	0	0
	Phase 6 dryland farming acreage (Moses Lake)		3,365	3,702	4,034	4,359	4,678	4,989	5,293	5,587	6,920	8,856	9,974
	Phase 8 dryland farming acreage (Odessa)		3,678	4,046	4,409	4,765	5,113	5,453	5,785	6,107	7,563	9,679	10,901
		Total:	18,105	19,917	21,700	23,452	38,350	44,552	45,380	50,053	52,842	56,893	59,234
Full replacement	Switch to surface water (Phases 1-9)		0	18,713	25,798	25,798	60,557	81,161	81,161	102,616	102,616	102,616	102,616
	Phase 1 dryland farming acreage		5,396	0	0	0	0	0	0	0	0	0	0
	Phase 2 dryland farming acreage		6,345	6,980	7,605	8,219	0	0	0	0	0	0	0
	Phase 3 dryland farming acreage		2,576	2,834	3,087	3,337	3,581	0	0	0	0	0	0
	Phase 4 dryland farming acreage		2,140	2,355	2,566	2,773	2,975	3,173	3,366	0	0	0	0
	Phase 5 dryland farming acreage		2,043	2,247	0	0	0	0	0	0	0	0	0
	Phase 6 dryland farming acreage		3,365	3,702	4,034	4,359	4,678	0	0	0	0	0	0
	Phase 7 dryland farming acreage		1,773	1,950	2,125	2,296	2,464	2,628	2,788	0	0	0	0
	Phase 8 dryland farming acreage		3,678	4,046	4,409	4,765	0	0	0	0	0	0	0
	Phase 9 dryland farming acreage		2,274	2,502	2,726	2,946	3,161	3,372	3,577	0	0	0	0
		Total:	29,591	45,329	52,349	54,492	77,416	90,334	90,892	102,616	102,616	102,616	102,616
Closest phases to municipalities:	Switch to surface water (Phases 2-4, 6, 8)		0	0	0	0	34,759	55,363	55,363	62,786	62,786	62,786	62,786
	Phase 2 dryland farming acreage (Warden)		6,345	6,980	7,605	8,219	0	0	0	0	0	0	0
	Phase 3 dryland farming acreage (Othello)		2,576	2,834	3,087	3,337	3,581	0	0	0	0	0	0
	Phase 4 dryland farming acreage (Connell)		2,140	2,355	2,566	2,773	2,975	3,173	3,366	0	0	0	0
	Phase 6 dryland farming acreage (Moses Lake)		3,365	3,702	4,034	4,359	4,678	0	0	0	0	0	0
	Phase 8 dryland farming acreage (Odessa)		3,678	4,046	4,409	4,765	0	0	0	0	0	0	0
		Total:	18,105	19,917	21,700	23,452	45,993	58,536	58,729	62,786	62,786	62,786	62,786

around the municipal wells in the study area. As a result, municipal benefits for the action alternatives over the No Action Alternative were initially assumed to be relatively insignificant.

1.2.1.2.2 Pumping Costs Savings

After further consideration, the decision was made that the differences in agricultural acreage off of groundwater under the various alternatives was significant enough to warrant an evaluation of municipal benefits.

Groundwater levels were estimated by the groundwater team for the No Action Alternative for each canal construction phase area (areas associated with canal phases 1-9). These projections were developed by year through the end of the period of analysis in year 2125 (see table NED_MUNI2). These groundwater level projections were based on recent groundwater level estimates and recent trends in average annual groundwater level declines within each canal construction phase area. These projections would likely be considered pessimistic given they did not take into account the expected movement of agriculture to dryland farming under the No Action Alternative and the associated reduction in agricultural pumping of the deep aquifer.

Table NED_MUNI2.—No Action Alternative groundwater level projection for selected years (2019-2025, 2050, 2075, 2100, and 2125)

Phase	Average annual decline (feet)	2019	2020	2021	2022	2023	2024	2025	2050	2075	2100	2125
1	6.0	539	545	551	557	563	569	575	725	875	1,024	1,174
2	7.1				671	678	685	692	869	1,047	1,224	1,402
3	7.3					750	757	764	947	1,130	1,313	1,497
4	7.5							669	855	1,042	1,228	1,414
5	3.1		490	493	496	499	503	506	583	661	738	816
6	5.6					603	608	614	753	892	1,032	1,171
7	5.5							584	722	859	997	1,134
8	4.5				659	663	668	672	786	900	1,013	1,127
9	6.0							632	782	933	1,083	1,233

Despite the potential problems with the groundwater level projections under the No Action Alternative, if groundwater level estimates could be developed for the proposed action alternatives, then groundwater level differentials could be calculated between alternatives and used to estimate pumping cost differences.

Given the No Action Alternative groundwater level decline estimates may be somewhat overstated, the resulting alternative specific pumping cost saving estimates may also be overstated.

Annual groundwater level estimates were not developed for the proposed action alternatives, but the groundwater section in the Odessa DEIS does suggest that groundwater levels might stabilize within each phase after the irrigators are converted to surface water. If groundwater levels did indeed stabilize, then the assumption could be made that groundwater levels would remain fixed at the stabilization depths from the end of construction of each canal phase to the end of the period of analysis in 2125. Table NED_MUNI3 presents the groundwater stabilization levels associated with each phase.

Table NED_MUNI3.—Groundwater stabilization levels and lower bound pumping depth estimates by phase/town

Phase	Town	Groundwater stabilization level (Feet below surface)	Lower bound pumping depth (Feet below surface)
1	Lind	472	1,950
2	Warden	600	2,000
3	Hatton and Othello	677	2,000
4	Connell	597	2,400
5	None	431	900
6	Moses Lake	536	1,500
7	None	518	1,500
8	Odessa	595	1,500
9	None	563	1,400

An assumption of the pumping cost savings analysis would be that towns associated with each canal construction area would extend their wells or drill new wells to follow the decline of the groundwater under the No Action Alternative. However, it would be unrealistic to assume that towns would continue to extend wells regardless of the groundwater level depth. Therefore, the groundwater team estimated lower bound pumping depths for each phase area based on the deepest wells within each phase (see table NED_MUNI3). If projected groundwater levels reached these lower bound depths under an alternative, then the assumption was made the groundwater pumping would cease. To calculate a groundwater pumping cost differential between alternatives, the analysis would require a pumping cost estimate for each alternative. Therefore, if pumping was eliminated for a particular phase, no pumping cost differential could be estimated for that town in that year. As it turned out, this step proved unnecessary because the lower bound pumping depth estimates were never constraining.

Since only a few of towns are actually located within the study area (Connell, Hatton, Warden), and groundwater level declines are occurring outside the study area, the decision was made to include towns close to the study area as well those within the study area. Wells operated by each town were assumed to experience the same groundwater levels under each alternative as the closest canal phase. Table NED_MUNI3 also displays the towns included in the analysis and their associated phases.

The water level estimates by alternative, phase, and year from the groundwater team were entered into a pumping cost equation used for agriculture. While agricultural wells and pumps may be somewhat larger than municipal pumps, the difference was assumed to be insignificant. Furthermore, as groundwater level depths decline, it is likely that municipalities may need to expand the size of their systems to allow for deeper pumping.

Pumping Cost Equation

Inputs:

1) Pumping pressure: 65 pounds per square inch (psi) (function of pump size)

2) Feet / psi: 2.31 (standard conversion factor)

3) Kilowatthour (kWh) conversion: 1.024 (converts pumping lift to kWh, standard conversion factor)

4) Pumping efficiency: 0.7 (function of pump size)

5) Total efficiency: 0.9 (efficiency of getting water up through the well chamber)

6) Cost per kWh: $0.031 (Mid-Columbia Hub, 2010 average monthly wholesale price, all hours)

7) Acre-feet (AF) pumped annually from deep aquifers by municipality

Step 1: Annual Pumping Head by Alternative

(Pumping pressure * feet per psi) + annual pumping lift by alternative (based on groundwater levels)

Step 2: Annual Kilowatthours to Pump 1 AF by Alternative

(kWh conversion * annual head (step #1)) / (pumping efficiency * total efficiency)

Step 3: Annual Cost to Pump 1 AF by Alternative

Annual kWh per AF (step #2) * cost per kWh

Step 4: Annual Cost by Municipality by Alternative

Annual cost to pump 1 AF (step #3) * # of AF pumped annually from deep aquifer by municipality

Step 5: Aggregate Costs by Year and Alternative

Sum annual costs by alternative across municipalities

Step 6: Aggregate Cost Differential by Year between Alternatives

Subtract annual pumping costs for action alternative from annual pumping costs for the No Action Alternative to estimate annual cost savings

To calculate the annual pumping costs by municipality and alternative, the alternative specific costs of pumping 1 acre-foot (estimated in the model as a function of groundwater level depth) are applied to estimates of annual pumping for each municipality. The groundwater team gathered data on 2010 estimates of annual water use by municipal well and town from local water entities. To focus on pumping from the deep aquifer, the groundwater team recommended removal of wells less than 400 feet deep. As a result, two wells from Moses Lake and both Wilson Creek wells were removed from the analysis. Table NED_MUNI4 presents the total 2010 estimated deep aquifer water use by town.

Since the period of analysis stretches from the end of the first canal construction phase in 2019 until year 2125, deep aquifer water use by town had to be projected across this time period. Water use was projected to grow at the same rate as population. Population projections were not available by town, but were available by county from the Washington Office of Financial Management (see table NED_MUNI4).

Water use for towns located within each county were assumed to grow at the same rate as county population. Since county population projections were only made to year 2030, an approach had to be developed to estimate water use beyond year 2030. Instead of using the average annual rate of growth across the 2010-2030 period, the decision was made to use the rate of growth for the last year (2030) of the projection period across the remaining years of the projection (2031-2125). Applying these annual rates of population growth by county to the 2010 estimates of water use for each associated town provided the required estimates of water use by town over the 2019-2125 period of analysis (table NED_MUNI4 presents water use estimates by town for selected years 2010 , 2019-2025, 2050, 2075,

Table NED_MUNI4.—Population projection growth rate by county and estimated water use by town for selected years

Part I: Medium annual population projection growth rate by county

Source: State of Washington, Office of Financial Management, Washington State County Growth Management Population Projections: 2000 to 2030 (2007 Projection) – Web site: <www.ofm.wa.gov/pop/gma/projections07.asp>

			Medium population projection									
Year	**Period**	**Year #**	**Adams**	**Annual growth %**	**Franklin**	**Annual growth %**	**Grant**	**Annual growth %**	**Lincoln**	**Annual growth %**	**Total**	**Annual growth %**
2010		0	18,376		70,038		88,389		10,393		187,196	
2011		1	18,626	0.013605	72,106	0.029527	89,053	0.007512	10,544	0.014529	190,329	0.016737
2012		2	18,866	0.012885	74,129	0.028056	90,095	0.011701	10,648	0.009863	193,738	0.017911
2013		3	19,103	0.012562	76,172	0.02756	91,050	0.0106	10,756	0.010143	197,081	0.017255
2014	Construction	4	19,337	0.012249	78,250	0.02728	91,931	0.009676	10,872	0.010785	200,390	0.01679
2015	Construction	5	19,568	0.011946	80,348	0.026812	92,719	0.008572	10,994	0.011221	203,629	0.016163
2016	Construction	6	19,814	0.012572	82,311	0.024431	93,264	0.005878	11,199	0.018647	206,588	0.014531
2017	Construction	7	20,052	0.012012	84,379	0.025124	93,889	0.006701	11,370	0.015269	209,690	0.015015
2018	Construction	8	20,290	0.011869	86,460	0.024663	94,493	0.006433	11,546	0.015479	212,789	0.014779
2019	Construction	9	20,526	0.011631	88,553	0.024208	95,071	0.006117	11,725	0.015503	215,875	0.014503
2020	Construction	10	20,761	0.011449	90,654	0.023726	95,623	0.005806	11,907	0.015522	218,945	0.014221
2021	Construction	11	20,998	0.011416	92,585	0.021301	96,222	0.006264	12,085	0.014949	221,890	0.013451
2022	Construction	12	21,230	0.011049	94,614	0.021915	96,771	0.005706	12,264	0.014812	224,879	0.013471
2023	Construction	13	21,458	0.01074	96,637	0.021382	97,301	0.005477	12,441	0.014432	227,837	0.013154
2024	Construction	14	21,683	0.010486	98,656	0.020893	97,811	0.005241	12,616	0.014066	230,766	0.012856
2025	Construction	15	21,905	0.010238	100,666	0.020374	98,303	0.00503	12,790	0.013792	233,664	0.012558
2026	Analysis	16	22,117	0.009678	102,497	0.018189	98,783	0.004883	12,955	0.012901	236,352	0.011504
2027	Analysis	17	22,320	0.009178	104,304	0.01763	99,209	0.004312	13,115	0.01235	238,948	0.010984
2028	Analysis	18	22,525	0.009185	106,149	0.017689	99,644	0.004385	13,279	0.012505	241,597	0.011086
2029	Analysis	19	22,727	0.008968	108,001	0.017447	100,057	0.004145	13,440	0.012124	244,225	0.010878
2030+	Analysis	20	22,926	0.008756	109,861	0.017222	100,449	0.003918	13,601	0.011979	246,837	0.010695
2010-2030		Average annual growth:	0.01112		0.02276		0.0064		0.01354		0.01392	

Part II: Estimated annual water use for selected years (2010, 2019-2025, 2050, 2075, 2100, 2125)

Phase:	1	2	3	3	4	5	6	7	8	9
Town:	Lind	Warden	Hatton	Othello	Connell	Wilson Creek	Moses Lake	None	Odessa	None
County:	Adams	Grant	Adams	Adams	Franklin	Grant	Grant		Lincoln	
Year:										
2010	264	2,762	49	3,682	2,670	0	9,144		338	
2019	295	2,971	55	4,113	3,376	0	9,835		381	
2020	298	2,988	55	4,160	3,456	0	9,892		387	
2021	320	3,007	56	4,207	3,530	0	9,954		393	
2022	305	3,024	57	4,254	3,607	0	10,011		399	
2023	308	3,040	57	4,300	3,684	0	10,066		405	
2024	312	3,056	58	4,345	3,761	0	10,119		410	
2025	315	3,072	58	4,389	3,838	0	10,170		416	
2050	392	3,394	73	5,421	5,893	0	11,237		561	
2075	488	3,743	91	6,800	9,031	0	12,391		756	
2100	606	4,127	113	8,457	13,840	0	13,663		1,018	
2125	754	4,551	140	10,516	21,209	0	15,066		1,371	

2100, and 2125). The annual cost per acre-foot by alternative, phase/town, and year from the pumping cost equation was multiplied by the projected water use in acre feet by town and year to estimate the pumping costs by alternative, town and year. For each town and year, subtracting the pumping costs for the partial and full alternatives from the pumping costs for the No Action Alternative provided an estimate of the pumping cost savings for the partial and full alternatives for that town and year. Aggregating the pumping cost savings across towns/phases provides an estimate of the pumping cost savings by alternative and year. Finally, the pumping cost savings by alternative and year were compounded/ discounted to the end of the canal construction period (year 2025).

This analysis focuses on only the pumping cost savings for the action alternatives as compared to the No Action Alternative. As noted above, this pumping cost savings benefit estimate may be overstated to the extent that No Action Alternative groundwater level estimates may be overly pessimistic. This analysis does not address other potential cost savings such as any differential in well extension costs between alternatives.

Results:

No Action Alternative: The municipal benefits were estimated based on the change in pumping costs as compared to the No Action Alternative. As shown in table NED_MUNI5, No Action Alternative pumping costs from 2019-2125 across all seven towns were estimated at $215.8 million. Compounding and discounting to year 2025 reduced this pumping cost estimate to $33.2 million.

Table NED_MUNI5.—No Action and partial replacement alternative pumping costs for years 2019-2025, 2050, 2075, 2100, and 2125

	No Action Alternative		Partial replacement alternative			
Year	Undiscounted	Compounded/ discounted to year 2025	Undiscounted	Compounded/ discounted to year 2025	Undiscounted change from No Action	Compounded/ discounted change from No Action
2019	10,283	13,295	9,277	11,995	1,006	**1,301**
2020	10,490	12,994	9,383	11,623	1,107	**1,371**
2021	10,703	12,703	9,491	11,264	1,212	**1,438**
2022	152,749	173,687	140,605	159,879	12,144	**13,809**
2023	736,512	802,367	707,119	770,345	29,393	**32,021**
2024	747,372	780,070	714,908	746,185	32,464	**33,884**
2025	917,133	917,133	867,589	867,589	49,544	**49,544**
2050	1,339,216	459,133	1,135,275	389,214	203,941	**69,919**
2075	1,935,455	227,488	1,479,981	173,953	455,474	**53,535**
2100	2,797,936	112,746	1,933,327	77,906	864,609	**34,840**
2125	4,067,715	56,196	2,538,301	35,067	1,529,414	**21,129**
Totals	215,846,359	33,231,061	158,634,434	28,115,618	57,211,925	**5,115,444**

Partial Replacement Alternatives: As shown in table NED_MUNI5, partial replacement alternative pumping costs from 2019-2125 across all seven towns was estimated at $158.6 million. This reflects a decrease of $57.2 million as compared to the No Action Alternative. Compounding and discounting this $57.2 million pumping cost savings to year 2025 results in a pumping cost benefit of $5.1 million.

Full Replacement Alternatives: As shown in table NED_MUNI6, full replacement alternative pumping costs from 2019-2125 across all seven towns was estimated at $133.3 million. This reflects a decrease of $82.6 million as compared to the No Action Alternative. Compounding and discounting this $82.6 million pumping cost savings to year 2025 results in a pumping cost benefit of $8.1 million.

Table NED_MUNI6.—No Action and full replacement alternative pumping costs for years 2019-2025, 2050, 2075, 2100, and 2125

Year	No Action Alternative		Full replacement alternative			
	Undiscounted	Compounded/ discounted to year 2025	Undiscounted	Compounded/ discounted to year 2025	Undiscounted change from No Action	Compounded/ discounted change from No Action
2019	10,283	13,295	9,277	11,995	1,006	**1,301**
2020	10,490	12,994	9,383	11,623	1,107	**1,371**
2021	10,703	12,703	9,491	11,264	1,212	**1,438**
2022	152,749	173,687	139,321	158,419	13,428	**15,269**
2023	736,512	802,367	671,802	731,871	64,710	**70,496**
2024	747,372	780,070	676,465	706,060	70,907	**74,009**
2025	917,133	917,133	825,996	825,996	91,377	**91,377**
2050	1,339,216	459,133	1,006,584	345,094	321,071	**114,891**
2075	1,935,455	227,488	1,245,182	146,355	690,273	**81,133**
2100	2,797,936	112,746	1,569,395	63,241	1,228,541	**49,505**
2125	4,067,715	56,196	2,017,805	27,876	2,049,910	**28,320**
Totals	215,846,359	33,231,061	133,260,191	25,164,578	82,586,168	**8,066,483**

1.2.1.3 Other Direct Benefits – Industrial

Methodology and Assumptions – Other direct benefits for industrial water have been identified for the Study. These benefits are associated with increased flexibility in the operation of water supply conveyance facilities under the action alternatives compared to the No Action alternative.

There are several agricultural processing plants in the study area, including those utilizing potatoes grown within the study area. The nutrient content of agricultural processing water is too high to be disposed of or used for other purposes without dilution. Under the direction of the processing plants, the processing water is diluted with clean water from other sources to meet discharge requirements then applied to irrigated crops. Several processors have interruptible contracts with Reclamation totaling 4,700 acre-feet for industrial water to dilute their process water. The water is delivered through East Columbia Basin Irrigation District (ECBID) facilities. However, under the No Action Alternative, the without project condition, the industrial deliveries are interrupted because even though adequate water supplies are available, there is not sufficient capacity within the canal for delivery to all users along the canal during the summer months. Under the partial and full alternatives, sufficient capacity would be provided to allow uninterrupted delivery of the 4,700 acre-feet of industrial water. Information based on discussions with local experts.

Since the 4,700 acre-feet of industrial water is diluted and applied to irrigated crops, the benefit for industrial water was based on the agricultural benefit per acre-foot of water less the cost of industrial water.

Results

No Action Alternative – No industrial benefits.

Partial Replacement Alternatives – The benefit for industrial water was based on the agricultural benefit per acre-foot of water less the cost of industrial water. This yields a benefit of $111 per acre-foot for industrial water or an annual benefit of $521,700. For use in the benefit-cost analysis, the annual industrial benefit was discounted to the end of the canal construction period (year 2025) using the 2009-2010 water project planning rate of 4.375 percent. For all partial replacement alternatives, this discounted stream of industrial benefits equates to $11.8 million in year 2025 dollars.

Full Replacement Alternatives – The benefit for industrial water was based on the agricultural benefit per acre-foot of water less the cost of industrial water. This yields a benefit of $111 per acre-foot for industrial water or an annual benefit of $521,700. For use in the benefit-cost analysis, the annual industrial benefit was discounted to the end of the canal construction period (year 2025) using the 2009-2010 water project planning rate of 4.375 percent. For all full replacement alternatives, this discounted stream of industrial benefits equates to $11.8 million in year 2025 dollars.

1.2.2 Cost Analyses

Project costs are composed not only of construction, IDC, and annual OMR&P costs, but also lost project benefits related to hydropower.

1.2.2.1 Construction Costs, Interest During Construction (IDC), and Annual Operating, Maintenance, Replacement, and Power (OMR&P) Costs

Methodology and Assumptions **–** Canal and reservoir construction costs were estimated by Reclamation cost engineers and include field costs of construction contracts and non-contract costs (lands purchases, construction facilities, studies/investigations/design data collection, engineering design, construction management and contract administration, etc.).

Since the majority of construction activities are associated with different canal segments, the construction period was broken down into a number of phases. Partial replacement Alternatives 2A and 2B were broken down into four canal construction phases and partial replacement Alternatives 2C and 2D were broken down into five phases (canal phases 1-4 and the Rocky Coulee Reservoir). The full replacement Alternatives 3A and 3B were broken down into nine canal construction phases and full replacement Alternatives 3C and 3D were broken down into ten phases (canal phases 1-9 and the Rocky Coulee Reservoir). The canal and reservoir construction period runs from 2014 to 2025 across all phases.

IDC is charged on both field costs and non-contract costs, but only during the construction period. A significant portion of the non-contract costs are incurred prior to the start of the construction period. As a result, non-contract costs incurred prior to the start of the construction period for each phase were aggregated into the first year of the construction period for that phase before calculating IDC.

IDC was calculated on the canal and reservoir construction and non-contract costs incurred annually within each construction phase. Total IDC by phase was added to the total construction and non-contract costs by phase to estimate costs at the end of each phase. These phase specific construction/non-contract and IDC costs were then compounded/future valued to the end of the overall canal construction period in year 2025 (except for those phases which were already at the end of the construction period – phases 4, 7, 9).

In addition to canal and reservoir construction, costs of constructing drainage systems were also estimated by Reclamation cost engineers for each canal phase. Drainage system construction was assumed to start five years after the end of each canal construction phase and last for 15 years. As a result, the drainage system construction period runs from 2024 to 2044 across all phases. As with canal and reservoir construction, IDC was calculated for each drainage system. Total IDC by phase was added to the drainage construction costs by phase to estimate total drainage costs at the end of each phase. These phase-specific construction and IDC drainage costs were then discounted back to the end of the canal construction period in year 2025 (present value). Since canal/reservoir construction and drainage systems construction occur at different times, they were considered as separate construction periods for the IDC calculation.

Average annual OMR&P costs were also estimated by Reclamation cost engineers. Since the construction phases would be completed at different times and OMR&P costs were assumed to begin immediately after completion of each construction phase, the OMR&P costs were estimated separately for each construction phase.

Annual OMR&P costs were included for each year from the end of construction on each phase until year 2125 (end of the 100 year period of analysis). The canal and reservoir OMR&P costs incurred prior to the end of the canal construction period (year 2025) were compounded to the end of the canal construction period. The canal and reservoir OMR&P costs incurred during the period of analysis (2026-2125) were discounted back to the end of the canal construction period. OMR&P costs were also estimated for the drainage systems. OMR&P costs associated with each drainage system would begin well into the future (starting in year 2039 through 2045 depending on the phase) and are therefore discounted back to the end of the canal construction period in year 2025.

Results

No Action Alternative – There are no construction or IDC costs associated with the No Action Alternative. However, OMR&P costs are currently incurred on the existing system. Since all construction, IDC, and OMR&P costs associated with the action alternatives were measured as changes from the No Action Alternative, it is not necessary to estimate construction, IDC, and OMR&P costs for the No Action Alternative.

Partial Replacement Alternatives – Combined canal, reservoir, and drainage system construction and noncontract costs, IDC, and annual OMR&P costs for the partial replacement alternatives are summarized in table NED_COST1.

Construction, IDC, and OMR&P Costs – Tables NED_COST2 and NED_COST3 present the construction and noncontract costs, IDC, and annual OMR&P costs for the four partial replacement alternatives. Note that the costs for these components are the same for Alternatives 2A/2B and 2C/2D.

Table NED_COST1.—Total costs for partial replacement alternatives
(Measured in $ millions at the end of the canal construction period [2025])

Cost components	2A	2B	2C	2D
Canal and reservoir construction, noncontract, and IDC	908.0	908.0	1,326.0	1,326.0
Canal and reservoir OMR&P	180.7	180.7	212.1	212.1
Drainage system construction, noncontract, and IDC	28.5	28.5	28.5	28.5
Drainage system OMR&P	3.1	3.1	3.1	3.1
Total	1,120.3	1,120.3	1,569.7	1,569.7

As shown in table NED_COST2 for partial replacement Alternatives 2A and 2B, canal construction and noncontract costs were estimated by Reclamation engineers at $688.7 million. IDC, in the amount of $98.1 million, was calculated on the annual construction and noncontract costs, added to annual construction and noncontract costs totals, and then compounded to the end of the canal construction period to obtain a canal cost estimate of $908.0 million. Annual canal OMR&P costs were assumed to start at the end of each canal construction phase and continue through the end of the period of analysis in year 2125. Compounding and discounting these costs to the end of the canal construction period resulted in an estimate of $180.7 million. Drainage system construction costs were estimated by Reclamation engineers at $39.6 million. Calculating IDC, in the amount of 15.2 million, adding it to the construction cost totals, and discounting the result to the end of the canal construction period resulted in a drainage cost estimate of $28.5 million. Annual drainage system OMR&P costs were assumed to start at the end of each drainage system construction phase and continue through the period of analysis in year 2125. Discounting these costs back to the end of the canal construction period resulted in an estimate of $3.1 million. These canal and drainage system construction, noncontract, IDC, and OMR&P costs, measured as of the end of the canal construction period in year 2025, sum to a total of $1,120.3 million.

As shown in table NED_COST3 for partial replacement Alternatives 2C and 2D, canal and reservoir construction and noncontract costs were estimated by Reclamation engineers at $964.9 million. IDC, in the amount of $145.2 million, was calculated on the annual construction and noncontract costs, added to annual construction and noncontract costs totals, and then compounded to the end of the canal and reservoir construction period to obtain a canal and reservoir cost estimate of $1,326.0 million. Annual canal and reservoir OMR&P costs were assumed to start at the end of each construction phase and continue through the end of the period of analysis in year 2125. Compounding and discounting these costs to the end of the canal and reservoir construction period resulted in an

Table NED_COST2.—Partial replacement alternative costs (construction, IDC, and OMR&P only)

Water supply scenarios:	2A and 2B		Years to end of canal and reservoir construction period:	11	10	9	8	7	6	5	4	3	2	1	0	
			Year #:	1	2	3	4	5	6	7	8	9	10	11	12	
				Canal and reservoir construction period (w/o drainage system)												
		Discount rate: 0.04375	Year:	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
	Phase #	Future and present value totals	Undiscounted totals													
A.1: Construction costs w/o drainage system:	1		194,308,931		42,626,034	48,057,718	46,055,635	46,055,635	11,513,909							
	2		288,946,464				55,883,955	57,110,051	54,139,218	54,139,218	54,139,218	13,534,804				
	3		107,977,830						23,796,484	26,670,991	25,560,158	25,560,158	6,390,039			
	4		97,469,947								21,995,301	23,911,526	22,916,942	22,916,942	5,729,236	
		Total by year:	688,703,172	0	42,626,034	48,057,718	101,939,590	103,165,686	89,449,611	80,810,209	101,694,676	63,006,488	29,306,982	22,916,942	5,729,236	
A.2: IDC w/o drainage system:	1		25,387,006		932,444	2,956,946	5,145,042	7,385,072	8,967,502							
	2		45,808,153				1,222,462	3,747,688	6,345,227	8,991,422	11,753,387	13,747,967				
(Reflects future value)	3		14,119,071						520,548	1,647,298	2,861,924	4,105,390	4,983,911			
	4		12,799,136								481,147	1,506,409	2,596,687	3,712,909	4,501,984	
			98,113,366													
A.3: Construction and IDC costs w/o drainage system:	1		219,695,937						219,695,937							
	2		334,754,617									334,754,617				
	3		122,096,901										122,096,901			
	4		110,269,083												110,269,083	
			786,816,538	0	0	0	0	0	219,695,937	0	0	334,754,617	122,096,901	0	110,269,083	
Compounded to year 2025:		907,978,612		0	0	0	0	0	284,054,031	0	0	380,641,416	133,014,081	0	110,269,083	
A.4: OMR&P costs w/o drainage system:	1		210,515,117						1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	
	2		269,504,456									2,591,389	2,591,389	2,591,389	2,591,389	
	3		122,316,826										1,187,542	1,187,542	1,187,542	
	4		88,871,415												879,915	
			691,207,814	0	0	0	0	0	1,967,431	1,967,431	1,967,431	4,558,820	5,746,362	5,746,362	6,626,277	…
Compounded and discounted:		180,749,218		0	0	0	0	0	2,543,774	2,437,148	2,334,992	5,183,724	6,260,168	5,997,765	6,626,277	…

				Construction period for drainage system																						
				2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	
B.1: Construction costs for drainage system:	1		16,000,000	320,000	640,000	800,000	1,120,000	1,120,000	1,280,000	1,440,000	1,600,000	1,600,000	1,440,000	1,440,000	1,120,000	960,000	800,000	320,000								
	2		12,000,000				240,000	480,000	600,000	840,000	840,000	960,000	1,080,000	1,200,000	1,200,000	1,080,000	1,080,000	840,000	720,000	600,000	240,000					
	3		6,000,000					120,000	240,000	300,000	420,000	420,000	480,000	540,000	600,000	600,000	540,000	540,000	420,000	360,000	300,000	120,000				
	4		5,600,000							112,000	224,000	280,000	392,000	392,000	448,000	504,000	560,000	560,000	504,000	504,000	392,000	336,000	280,000	112,000		
		Total by year:	39,600,000	320,000	640,000	800,000	1,360,000	1,720,000	2,120,000	2,692,000	3,084,000	3,260,000	3,392,000	3,572,000	3,368,000	3,144,000	2,980,000	2,260,000	1,644,000	1,464,000	932,000	456,000	280,000	112,000		
B.2: IDC for drainage system:	1		6,128,208	7,000	28,306	61,045	105,715	159,340	218,812	287,885	366,979	453,035	539,355	625,952	709,337	785,871	858,753	920,823								
	2		4,596,156				5,250	21,230	45,783	79,287	119,505	164,109	215,913	275,235	339,776	404,516	469,464	532,003	589,403	644,064	690,617					
(Reflects future value)	3		2,298,078					2,625	10,615	22,892	39,643	59,753	82,054	107,957	137,617	169,888	202,258	234,732	266,001	294,702	322,032	345,309				
	4		2,144,873							2,450	9,907	21,366	37,000	55,769	76,584	100,760	128,443	158,562	188,774	219,083	248,268	275,055	300,563	322,288		
			15,167,315																							
B.3: Construction and IDC costs for drainage system:	1		22,128,208															22,128,208								
	2		16,596,156																		16,596,156					
	3		8,298,078																			8,298,078				
	4		7,744,873																					7,744,873		
			54,767,315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,128,208	0	0	16,596,156	8,298,078	0	7,744,873		
Discounted to year 2025:		28,487,299		0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,682,121	0	0	8,364,957	4,007,165	0	3,433,057		
B.4: OMR&P costs for drainage system:																										
	1		7,449,462																85,626	85,626	85,626	85,626	85,626	85,626	85,626	
	2		8,000,328																			95,242	95,242	95,242	95,242	
	3		3,837,256																				46,232	46,232	46,232	
	4		3,615,030																						44,630	
			22,902,076	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85,626	85,626	85,626	180,868	227,100	227,100	271,730	…
Discounted to year 2025:		3,095,622														0	3,095,622	3,095,622	47,017	45,046	43,158	87,342	105,070	100,666	115,401	…
Total cost – Alternatives 2A and 2B:		1,120,310,751																								

Table NED_COST3.—Partial replacement alternative costs (construction, IDC, and OMR&P only)

Water supply scenarios:	2C and 2D		Years to end of canal and reservoir construction period:	11	10	9	8	7	6	5	4	3	2	1	0	
			Year #:	1	2	3	4	5	6	7	8	9	10	11	12	
				Canal and reservoir construction period (w/o drainage system)												
		Discount rate: 0.04375	Year:	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
	Phase #	Future and present value totals	Undiscounted totals													
A.1: Construction costs w/o drainage system:	1		194,308,931	0	42,626,034	48,057,718	46,055,635	46,055,635	11,513,909	0	0	0	0	0	0	
	2		288,946,464	0	0	0	55,883,955	57,110,051	54,139,218	54,139,218	54,139,218	13,534,804	0	0	0	
	3		107,977,830	0	0	0	0	0	23,796,484	26,670,991	25,560,158	25,560,158	6,390,039	0	0	
	4		97,469,947	0	0	0	0	0	0	0	21,995,301	23,911,526	22,916,942	22,916,942	5,729,236	
	Rocky Coulee		276,186,850	78,671,388	48,169,324	45,952,658	45,952,658	45,952,658	11,488,164	0						
		Total by year:	964,890,022	78,671,388	90,795,358	94,010,376	147,892,248	149,118,344	100,937,775	80,810,209	101,694,676	63,006,488	29,306,982	22,916,942	5,729,236	
A.2: IDC w/o drainage system:	1		25,387,006	0	932,444	2,956,946	5,145,042	7,385,072	8,967,502	0	0	0	0	0	0	
	2		45,808,153	0	0	0	1,222,462	3,747,688	6,345,227	8,991,422	11,753,387	13,747,967	0	0	0	
(Reflects future value)	3		14,119,071	0	0	0	0	0	520,548	1,647,298	2,861,924	4,105,390	4,983,911	0	0	
	4		12,799,136	0	0	0	0	0	0	0	481,147	1,506,409	2,596,687	3,712,909	4,501,984	
	Rocky Coulee		47,120,863	1,720,937	4,570,868	6,829,762	9,138,993	11,549,253	13,311,050	0						
			145,234,229													
A.3: Construction and IDC costs w/o drainage system:	1		219,695,937						219,695,937							
	2		334,754,617									334,754,617				
	3		122,096,901										122,096,901			
	4		110,269,083												110,269,083	
	Rocky Coulee		323,307,713						323,307,713							
			1,110,124,251	0	0	0	0	0	543,003,650	0	0	334,754,617	122,096,901	0	110,269,083	
Compounded to year 2025:		1,325,996,624		0	0	0	0	0	702,072,044	0	0	380,641,416	133,014,081	0	110,269,083	
A.4: OMR&P costs w/o drainage system:																
	1		210,515,117	0	0	0	0	0	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	
	2		269,504,456	0	0	0	0	0	0	0	0	2,591,389	2,591,389	2,591,389	2,591,389	
	3		122,316,826	0	0	0	0	0	0	0	0	0	1,187,542	1,187,542	1,187,542	
	4		88,871,415	0	0	0	0	0	0	0	0	0	0	0	879,915	
	Rocky Coulee		109,789,704						1,026,072	1,026,072	1,026,072	1,026,072	1,026,072	1,026,072	1,026,072	
			800,997,518	0	0	0	0	0	2,993,503	2,993,503	2,993,503	5,584,892	6,772,434	6,772,434	7,652,349	…
Compounded and discounted:		212,075,322		0	0	0	0	0	3,870,425	3,708,191	3,552,758	6,350,446	7,377,985	7,068,728	7,652,349	…

				Construction period for drainage system																						
				2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	
B.1: Construction costs for drainage system:	1		16,000,000	320,000	640,000	800,000	1,120,000	1,120,000	1,280,000	1,440,000	1,600,000	1,600,000	1,440,000	1,440,000	1,120,000	960,000	800,000	320,000	0	0	0	0	0	0		
	2		12,000,000	0	0	0	240,000	480,000	600,000	840,000	840,000	960,000	1,080,000	1,200,000	1,200,000	1,080,000	1,080,000	840,000	720,000	600,000	240,000	0	0	0		
	3		6,000,000	0	0	0	0	120,000	240,000	300,000	420,000	420,000	480,000	540,000	600,000	600,000	540,000	540,000	420,000	360,000	300,000	120,000	0	0		
	4		5,600,000	0	0	0	0	0	0	112,000	224,000	280,000	392,000	392,000	448,000	504,000	560,000	560,000	504,000	504,000	392,000	336,000	280,000	112,000		
	Rocky Coulee		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Total by year:	39,600,000	320,000	640,000	800,000	1,360,000	1,720,000	2,120,000	2,692,000	3,084,000	3,260,000	3,392,000	3,572,000	3,368,000	3,144,000	2,980,000	2,260,000	1,644,000	1,464,000	932,000	456,000	280,000	112,000		
B.2: IDC for drainage system:	1		6,128,208	7,000	28,306	61,045	105,715	159,340	218,812	287,885	366,979	453,035	539,355	625,952	709,337	785,871	858,753	920,823	0	0	0	0	0	0		
	2		4,596,156	0	0	0	5,250	21,230	45,783	79,287	119,505	164,109	215,913	275,235	339,776	404,516	469,464	532,003	589,403	644,064	690,617	0	0	0		
(Reflects future value)	3		2,298,078	0	0	0	0	2,625	10,615	22,892	39,643	59,753	82,054	107,957	137,617	169,888	202,258	234,732	266,001	294,702	322,032	345,309	0	0		
	4		2,144,873	0	0	0	0	0	0	2,450	9,907	21,366	37,000	55,769	76,584	100,760	128,443	158,562	188,774	219,083	248,268	275,055	300,563	322,288		
	Rocky Coulee		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			15,167,315																							
B.3: Construction and IDC costs for drainages system:	1		22,128,208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,128,208	0	0	0	0	0	0		
	2		16,596,156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16,596,156	0	0	0		
	3		8,298,078	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,298,078	0	0		
	4		7,744,873	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,744,873		
	Rocky Coulee		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			54,767,315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,128,208	0	0	16,596,156	8,298,078	0	7,744,873		
Discounted to year 2025:		28,487,299		0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,682,121	0	0	8,364,957	4,007,165	0	3,433,057		
B.4: OMR&P costs for drainage system:																										
	1		7,449,462	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85,626	85,626	85,626	85,626	85,626	85,626	85,626	
	2		8,000,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95,242	95,242	95,242	95,242	
	3		3,837,256	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46,232	46,232	46,232	
	4		3,615,030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44,630	
	Rocky Coulee		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			22,902,076	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85,626	85,626	85,626	180,868	227,100	227,100	271,730	…
Discounted to year 2025:		3,095,622		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47,017	45,046	43,158	87,342	105,070	100,666	115,401	…
Total cost – Alternatives 2C and 2D:		1,569,654,868																								

estimate of $212.1 million. Drainage system construction costs were estimated by Reclamation engineers at $39.6 million. Calculating IDC, in the amount of $15.2 million, adding it to the construction cost totals, and discounting the result to the end of the canal construction period resulted in a drainage cost estimate of $28.5 million. Annual drainage system OMR&P costs were assumed to start at the end of each drainage system construction phase and continue through the period of analysis in year 2125. Discounting these costs back to the end of the canal construction period resulted in an estimate of $3.1 million. These canal, reservoir, and drainage system construction, noncontract, IDC, and OMR&P costs, measured as of the end of the canal construction period in year 2025, sum to a total of $1,569.7 million.

Full Replacement Alternatives – Combined canal, reservoir, and drainage system construction and noncontract costs, IDC, and annual OMR&P costs for the full replacement alternatives are summarized in table NED_COST4.

Table NED_COST4.—Total costs for full replacement alternatives
(Measured in $ millions at the end of the construction period [2025])

Cost components	3A	3B	3C	3D
Canal and reservoir construction, noncontract, and IDC	3,255.7	3,255.7	3,673.7	3,673.3
Canal and reservoir OMR&P	401.5	401.5	432.8	432.8
Drainage system construction, noncontract, and IDC	83.5	83.5	83.5	83.5
Drainage system OMR&P	10.4	10.4	10.4	10.4
Total	3,751.0	3,751.0	4,200.3	4,200.3

Construction, IDC, and OMR&P Costs: Tables NED_COST5 and NED_COST6 present the construction and noncontract costs, IDC, and annual OMR&P costs for the four full replacement alternatives. Note that the costs for these components are the same for Alternatives 3A/3B and 3C/3D.

As shown in table NED_COST5 for full replacement Alternatives 3A and 3B, canal construction and noncontract costs were estimated by Reclamation engineers at $2,460.8 million. IDC, in the amount of $362.1 million, was calculated on the annual construction and noncontract costs, added to annual construction and noncontract costs totals, and then compounded to the end of the canal construction period to obtain a canal cost estimate of $3,255.7 million. Annual canal OMR&P costs were assumed to start at the end of each canal construction phase and continue through the end of the period of analysis in year 2125. Compounding and discounting these costs to the end of the canal construction period resulted in an estimate of $401.5 million. Drainage system construction costs were estimated by Reclamation engineers at $121.6 million. Calculating IDC, in the amount of $46.6 million, adding it to the construction cost totals, and discounting the result to the end of the canal construction period resulted in a drainage cost estimate of $83.5 million. Annual drainage system OMR&P costs were assumed to start at the end of each drainage system construction phase and continue through the period of analysis in year 2125. Discounting these costs back to the end of the canal construction period resulted in an estimate of $10.4 million. These canal and drainage system construction, noncontract, IDC, and OMR&P costs, measured as of the end of the canal construction period in year 2025, sum to a total of $3,751.0 million.

As shown in table NED_COST6 for full replacement Alternatives 3C and 3D, canal and reservoir construction and noncontract costs were estimated by Reclamation engineers at $2,737.0 million. IDC, in the amount of $409.2 million, was calculated on the annual construction and noncontract costs, added to annual construction and noncontract costs totals, and then compounded to the end of the canal and reservoir construction period to obtain a canal and reservoir cost estimate of $3,673.7 million. Annual canal and reservoir OMR&P costs were assumed to start at the end of each construction phase and continue through the end of the period of analysis in year 2125. Future valuing and discounting these costs to the end of the canal and reservoir construction period resulted in an estimate of $432.8 million. Drainage system construction costs were estimated by Reclamation engineers at $121.6 million. Calculating IDC, in the amount of $46.6 million, adding it to the construction cost totals, and discounting the result to the end of the canal construction period resulted in a drainage cost estimate of $83.5 million. Annual drainage system OMR&P costs were assumed to start at the end of each drainage system construction phase and continue through the period of analysis in year 2125. Discounting these costs back to the end of the canal construction period resulted in an estimate of $10.4 million. These canal, reservoir, and drainage system construction, noncontract, IDC, and OMR&P costs, measured as of the end of the canal construction period in year 2025, sum to a total of $4,200.3 million.

1.2.2.2 Annual Lost Benefits

Losses in average annual benefits for hydropower were estimated for each alternative based on alternative specific hydrology. These benefit losses were assumed to begin after the end of the canal construction period. Since a lost benefit can be thought of as a project cost, to allow for comparison with project benefits, the lost hydropower benefits had to be discounted back to the end of the canal construction period. Note that lost benefits are also presented for recreation, but given that recreation losses were assumed to be mitigated, they were not included in the BCA.

Table NED_COST5.—Partial replacement alternative costs (construction, IDC, and OMR&P only)

Water supply scenarios:	3A and 3B		Years to end of canal and reservoir construction period:	11	10	9	8	7	6	5	4	3	2	1	0
			Year #:	1	2	3	4	5	6	7	8	9	10	11	12
				Canal and reservoir construction period (w/o drainage system)											
		Discount rate: 0.04375	Year:	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	Phase #	Future and present value totals	Undiscounted totals												
A.1: Construction costs w/o drainage system:	1		194,308,931	0	42,626,034	48,057,718	46,055,635	46,055,635	11,513,909	0	0	0	0	0	0
	2		288,946,464	0	0	0	55,883,955	57,110,051	54,139,218	54,139,218	54,139,218	13,534,804	0	0	0
	3		107,977,830	0	0	0	0	0	23,796,484	26,670,991	25,560,158	25,560,158	6,390,039	0	0
	4		97,469,947	0	0	0	0	0	0	0	21,995,301	23,911,526	22,916,942	22,916,942	5,729,236
	5		857,012,318		165,808,436	169,373,716	160,563,128	160,563,128	160,563,128	40,140,782					
	6		303,124,355						67,966,856	74,502,308	71,402,308	71,402,308	17,850,577		
	7		220,342,776								48,962,868	54,297,183	52,036,767	52,036,767	13,009,192
	8		276,482,296				53,539,690	54,630,123	51,788,456	51,788,456	51,788,456	12,947,114			
	9		115,143,664								30,846,390	26,697,719	25,599,802	25,599,802	6,399,951
		Total by year:	2,460,808,581	0	208,434,469	217,431,434	316,042,409	318,358,937	369,768,051	247,241,754	304,694,699	228,350,811	124,794,127	100,553,511	25,138,378
A.2: IDC w/o drainage system:	1		25,387,006	0	932,444	2,956,946	5,145,042	7,385,072	8,967,502	0	0	0	0	0	0
	2		45,808,153	0	0	0	1,222,462	3,747,688	6,345,227	8,991,422	11,753,387	13,747,967	0	0	0
(Reflects future value)	3		14,119,071	0	0	0	0	0	520,548	1,647,298	2,861,924	4,105,390	4,983,911	0	0
	4		12,799,136	0	0	0	0	0	0	0	481,147	1,506,409	2,596,687	3,712,909	4,501,984
	5		135,874,118		3,627,060	11,117,853	18,821,627	26,669,711	34,861,147	40,776,720					
	6		39,758,465						1,486,775	4,668,334	8,064,237	11,540,899	13,998,220		
	7		28,854,145								1,071,063	3,376,735	5,850,523	8,383,092	10,172,732
	8		43,840,962				1,171,181	3,588,635	6,073,544	8,605,006	11,247,220	13,155,377			
	9		15,630,858								674,765	1,963,063	3,192,955	4,452,639	5,347,436
			362,071,914												
A.3: Construction and IDC costs w/o drainage system:	1		219,695,937						219,695,937						
	2		334,754,617									334,754,617			
	3		122,096,901										122,096,901		
	4		110,269,083												110,269,083
	5		992,886,436							992,886,436					
	6		342,882,820										342,882,820		
	7		249,196,921												249,196,921
	8		320,323,258									320,323,258			
	9		130,774,522												130,774,522
			2,822,880,495	0	0	0	0	0	219,695,937	992,886,436	0	655,077,875	464,979,721	0	490,240,526
Compounded to year 2025:		3,255,657,890		0	0	0	0	0	284,054,031	1,229,934,603	0	744,873,282	506,555,447	0	490,240,526

A.4: OMR&P costs w/o drainage system:																
	1		210,515,117	0	0	0	0	0	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	
	2		269,504,456	0	0	0	0	0	0	0	0	2,591,389	2,591,389	2,591,389	2,591,389	
	3		122,316,826	0	0	0	0	0	0	0	0	0	1,187,542	1,187,542	1,187,542	
	4		88,871,415	0	0	0	0	0	0	0	0	0	0	0	879,915	
	5		235,100,580							2,217,930	2,217,930	2,217,930	2,217,930	2,217,930	2,217,930	
	6		188,882,842										1,833,814	1,833,814	1,833,814	
	7		118,983,959												1,178,059	
	8		237,406,416									2,282,754	2,282,754	2,282,754	2,282,754	
	9		85,134,718												842,918	
			1,556,716,329	0	0	0	0	0	1,967,431	4,185,361	4,185,361	9,059,504	12,080,860	12,080,860	14,981,752	…
Compounded and discounted:		401,458,443		0	0	0	0	0	2,543,774	5,184,601	4,967,283	10,301,344	13,161,059	12,609,398	14,981,752	…

				Construction period for drainage system																					
				2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
B.1: Construction costs for drainage system:	1		16,000,000	320,000	640,000	800,000	1,120,000	1,120,000	1,280,000	1,440,000	1,600,000	1,600,000	1,440,000	1,440,000	1,120,000	960,000	800,000	320,000	0	0	0	0	0	0	
	2		12,000,000	0	0	0	240,000	480,000	600,000	840,000	840,000	960,000	1,080,000	1,200,000	1,200,000	1,080,000	1,080,000	840,000	720,000	600,000	240,000	0	0	0	
	3		6,000,000	0	0	0	0	120,000	240,000	300,000	420,000	420,000	480,000	540,000	600,000	600,000	540,000	540,000	420,000	360,000	300,000	120,000	0	0	
	4		5,600,000	0	0	0	0	0	0	112,000	224,000	280,000	392,000	392,000	448,000	504,000	560,000	560,000	504,000	504,000	392,000	336,000	280,000	112,000	
	5		17,500,000		350,000	700,000	875,000	1,225,000	1,225,000	1,400,000	1,575,000	1,750,000	1,750,000	1,575,000	1,575,000	1,225,000	1,050,000	875,000	350,000						
	6		22,000,000					440,000	880,000	1,100,000	1,540,000	1,540,000	1,760,000	1,980,000	2,200,000	2,200,000	1,980,000	1,980,000	1,540,000	1,320,000	1,100,000	440,000			
	7		20,000,000							400,000	800,000	1,000,000	1,400,000	1,400,000	1,600,000	1,800,000	2,000,000	2,000,000	1,800,000	1,800,000	1,400,000	1,200,000	1,000,000	400,000	
	8		12,000,000				240,000	480,000	600,000	840,000	840,000	960,000	1,080,000	1,200,000	1,200,000	1,080,000	1,080,000	840,000	720,000	600,000	240,000				
	9		10,500,000							210,000	420,000	525,000	735,000	735,000	840,000	945,000	1,050,000	1,050,000	945,000	945,000	735,000	630,000	525,000	210,000	
		Total by year:	121,600,000	320,000	990,000	1,500,000	2,475,000	3,865,000	4,825,000	6,642,000	8,259,000	9,035,000	10,117,000	10,462,000	10,783,000	10,394,000	10,140,000	9,005,000	6,999,000	6,129,000	4,407,000	2,726,000	1,805,000	722,000	
B.2: IDC for drainage system:	1		6,128,208	7,000	28,306	61,045	105,715	159,340	218,812	287,885	366,979	453,035	539,355	625,952	709,337	785,871	858,753	920,823	0	0	0	0	0	0	
	2		4,596,156	0	0	0	5,250	21,230	45,783	79,287	119,505	164,109	215,913	275,235	339,776	404,516	469,464	532,003	589,403	644,064	690,617	0	0	0	
(Reflects future value)	3		2,298,078	0	0	0	0	2,625	10,615	22,892	39,643	59,753	82,054	107,957	137,617	169,888	202,258	234,732	266,001	294,702	322,032	345,309	0	0	
	4		2,144,873	0	0	0	0	0	0	2,450	9,907	21,366	37,000	55,769	76,584	100,760	128,443	158,562	188,774	219,083	248,268	275,055	300,563	322,288	
	5		6,702,727		7,656	30,960	66,768	115,626	174,279	239,325	314,874	401,384	495,507	589,920	684,635	775,838	859,546	939,261	1,007,150						
	6		8,426,286					9,625	38,921	83,936	145,359	219,093	300,866	395,841	504,597	622,923	741,613	860,684	975,339	1,080,572	1,180,785	1,266,132			
	7		7,660,260							8,750	35,383	76,306	132,144	199,175	273,514	359,856	458,724	566,294	674,194	782,440	886,672	982,339	1,073,441	1,151,029	
	8		4,596,156				5,250	21,230	45,783	79,287	119,505	164,109	215,913	275,235	339,776	404,516	469,464	532,003	589,403	644,064	690,617				
	9		4,021,636							4,594	18,576	40,061	69,376	104,567	143,595	188,924	240,830	297,304	353,952	410,781	465,503	515,728	563,556	604,290	
			46,574,381																						

B.3: Construction and IDC costs for drainage system:	1		22,128,208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,128,208	0	0	0	0	0	0		
	2		16,596,156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16,596,156	0	0	0		
	3		8,298,078	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,298,078	0	0		
	4		7,744,873	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,744,873		
	5		24,202,727																24,202,727							
	6		30,426,286																			30,426,286				
	7		27,660,260																					27,660,260		
	8		16,596,156																		16,596,156					
	9		14,521,636																					14,521,636		
			168,174,381	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,128,208	24,202,727	0	33,192,312	38,724,364	0	49,926,769		
Discounted to year 2025:		83,532,741		0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,682,121	13,289,648	0	16,729,913	18,700,103	0	22,130,956		
B.4: OMR&P costs for drainage system:																										
	1		7,449,462	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85,626	85,626	85,626	85,626	85,626	85,626	85,626	
	2		8,000,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95,242	95,242	95,242	95,242	
	3		3,837,256	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46,232	46,232	46,232	
	4		3,615,030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44,630	
	5		8,534,640																	99,240	99,240	99,240	99,240	99,240	99,240	
	6		16,008,708																				192,876	192,876	192,876	
	7		11,568,906																						142,826	
	8		12,379,416																			147,374	147,374	147,374	147,374	
	9		7,609,626																						93,946	
			79,003,372	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85,626	184,866	184,866	427,482	666,590	666,590	947,992	…
Discounted to year 2025:		10,353,327		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47,017	97,255	93,178	206,432	308,405	295,478	402,601	…
Total cost – Alternatives 3A and 3B:		3,751,002,401																								

Table NED_COST6.—Partial replacement alternative costs (construction, IDC, and OMR&P only)

Water supply scenarios:	3C and 3D		Years to end of canal and reservoir construction period:	11	10	9	8	7	6	5	4	3	2	1	0
			Year #:	1	2	3	4	5	6	7	8	9	10	11	12
				Canal and reservoir construction period (w/o drainage system)											
		Discount rate: 0.04375	Year:	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	Phase #	Future and present value totals	Undiscounted totals												
A.1: Construction costs w/o drainage system:	1		194,308,931	0	42,626,034	48,057,718	46,055,635	46,055,635	11,513,909	0	0	0	0	0	0
	2		288,946,464	0	0	0	55,883,955	57,110,051	54,139,218	54,139,218	54,139,218	13,534,804	0	0	0
	3		107,977,830	0	0	0	0	0	23,796,484	26,670,991	25,560,158	25,560,158	6,390,039	0	0
	4		97,469,947	0	0	0	0	0	0	0	21,995,301	23,911,526	22,916,942	22,916,942	5,729,236
	5		857,012,318	0	165,808,436	169,373,716	160,563,128	160,563,128	160,563,128	40,140,782	0	0	0	0	0
	6		303,124,355	0	0	0	0	0	67,966,856	74,502,308	71,402,308	71,402,308	17,850,577	0	0
	7		220,342,776	0	0	0	0	0	0	0	48,962,868	54,297,183	52,036,767	52,036,767	13,009,192
	8		276,482,296	0	0	0	53,539,690	54,630,123	51,788,456	51,788,456	51,788,456	12,947,114	0	0	0
	9		115,143,664	0	0	0	0	0	0	0	30,846,390	26,697,719	25,599,802	25,599,802	6,399,951
	Rocky Coulee		276,186,850	78,671,388	48,169,324	45,952,658	45,952,658	45,952,658	11,488,164	0	0	0	0	0	0
		Total by year:	2,736,995,431	78,671,388	256,603,794	263,384,092	361,995,067	364,311,595	381,256,215	247,241,754	304,694,699	228,350,811	124,794,127	100,553,511	25,138,378
A.2: IDC w/o drainage system:	1		25,387,006	0	932,444	2,956,946	5,145,042	7,385,072	8,967,502	0	0	0	0	0	0
	2		45,808,153	0	0	0	1,222,462	3,747,688	6,345,227	8,991,422	11,753,387	13,747,967	0	0	0
(Reflects future value)	3		14,119,071	0	0	0	0	0	520,548	1,647,298	2,861,924	4,105,390	4,983,911	0	0
	4		12,799,136	0	0	0	0	0	0	0	481,147	1,506,409	2,596,687	3,712,909	4,501,984
	5		135,874,118	0	3,627,060	11,117,853	18,821,627	26,669,711	34,861,147	40,776,720	0	0	0	0	0
	6		39,758,465	0	0	0	0	0	1,486,775	4,668,334	8,064,237	11,540,899	13,998,220	0	0
	7		28,854,145	0	0	0	0	0	0	0	1,071,063	3,376,735	5,850,523	8,383,092	10,172,732
	8		43,840,962	0	0	0	1,171,181	3,588,635	6,073,544	8,605,006	11,247,220	13,155,377	0	0	0
	9		15,630,858	0	0	0	0	0	0	0	674,765	1,963,063	3,192,955	4,452,639	5,347,436
	Rocky Coulee		47,120,863	1,720,937	4,570,868	6,829,762	9,138,993	11,549,253	13,311,050	0	0	0	0	0	0
			409,192,777												

A.3: Construction and IDC costs w/o drainage system:	1		219,695,937						219,695,937																
	2		334,754,617									334,754,617													
	3		122,096,901										122,096,901												
	4		110,269,083												110,269,083										
	5		992,886,436							992,886,436															
	6		342,882,820										342,882,820												
	7		249,196,921												249,196,921										
	8		320,323,258									320,323,258													
	9		130,774,522												130,774,522										
	Rocky Coulee		323,307,713						323,307,713																
			3,146,188,208	0	0	0	0	0	543,003,650	992,886,436	0	655,077,875	464,979,721	0	490,240,526										
Compounded to year 2025:		3,673,675,902		0	0	0	0	0	702,072,044	1,229,934,603	0	744,873,282	506,555,447	0	490,240,526										
A.4: OMR&P costs w/o drainage system:																									
	1		210,515,117	0	0	0	0	0	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431	1,967,431										
	2		269,504,456	0	0	0	0	0	0	0	0	2,591,389	2,591,389	2,591,389	2,591,389										
	3		122,316,826	0	0	0	0	0	0	0	0	0	1,187,542	1,187,542	1,187,542										
	4		88,871,415	0	0	0	0	0	0	0	0	0	0	0	879,915										
	5		235,100,580							2,217,930	2,217,930	2,217,930	2,217,930	2,217,930	2,217,930										
	6		188,882,842										1,833,814	1,833,814	1,833,814										
	7		118,983,959												1,178,059										
	8		237,406,416									2,282,754	2,282,754	2,282,754	2,282,754										
	9		85,134,718												842,918										
	Rocky Coulee		109,789,704	0	0	0	0	0	1,026,072	1,026,072	1,026,072	1,026,072	1,026,072	1,026,072	1,026,072										
			1,666,506,033	0	0	0	0	0	2,993,503	5,211,433	5,211,433	10,085,576	13,106,932	13,106,932	16,007,824	…									
Compounded and discounted:		432,784,547		0	0	0	0	0	3,870,425	6,455,644	6,185,049	11,468,066	14,278,876	13,680,360	16,007,824	…									
				Construction period for drainage system																					
				2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
B.1: Construction costs for drainage system:	1		16,000,000	320,000	640,000	800,000	1,120,000	1,120,000	1,280,000	1,440,000	1,600,000	1,600,000	1,440,000	1,440,000	1,120,000	960,000	800,000	320,000	0	0	0	0	0	0	
	2		12,000,000	0	0	0	240,000	480,000	600,000	840,000	840,000	960,000	1,080,000	1,200,000	1,200,000	1,080,000	1,080,000	840,000	720,000	600,000	240,000	0	0	0	
	3		6,000,000	0	0	0	0	120,000	240,000	300,000	420,000	420,000	480,000	540,000	600,000	600,000	540,000	540,000	420,000	360,000	300,000	120,000	0	0	
	4		5,600,000	0	0	0	0	0	0	112,000	224,000	280,000	392,000	392,000	448,000	504,000	560,000	560,000	504,000	504,000	392,000	336,000	280,000	112,000	
	5		17,500,000	0	350,000	700,000	875,000	1,225,000	1,225,000	1,400,000	1,575,000	1,750,000	1,750,000	1,575,000	1,575,000	1,225,000	1,050,000	875,000	350,000	0	0	0	0	0	
	6		22,000,000	0	0	0	0	440,000	880,000	1,100,000	1,540,000	1,540,000	1,760,000	1,980,000	2,200,000	2,200,000	1,980,000	1,980,000	1,540,000	1,320,000	1,100,000	440,000	0	0	
	7		20,000,000	0	0	0	0	0	0	400,000	800,000	1,000,000	1,400,000	1,400,000	1,600,000	1,800,000	2,000,000	2,000,000	1,800,000	1,800,000	1,400,000	1,200,000	1,000,000	400,000	
	8		12,000,000	0	0	0	240,000	480,000	600,000	840,000	840,000	960,000	1,080,000	1,200,000	1,200,000	1,080,000	1,080,000	840,000	720,000	600,000	240,000	0	0	0	
	9		10,500,000	0	0	0	0	0	0	210,000	420,000	525,000	735,000	735,000	840,000	945,000	1,050,000	1,050,000	945,000	945,000	735,000	630,000	525,000	210,000	
	Rocky Coulee		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Total by year:	121,600,000	320,000	990,000	1,500,000	2,475,000	3,865,000	4,825,000	6,642,000	8,259,000	9,035,000	10,117,000	10,462,000	10,783,000	10,394,000	10,140,000	9,005,000	6,999,000	6,129,000	4,407,000	2,726,000	1,805,000	722,000	

B.2: IDC for drainage system:	1		6,128,208	7,000	28,306	61,045	105,715	159,340	218,812	287,885	366,979	453,035	539,355	625,952	709,337	785,871	858,753	920,823	0	0	0	0	0	0		
	2		4,596,156	0	0	0	5,250	21,230	45,783	79,287	119,505	164,109	215,913	275,235	339,776	404,516	469,464	532,003	589,403	644,064	690,617	0	0	0		
(Reflects future value)	3		2,298,078	0	0	0	0	2,625	10,615	22,892	39,643	59,753	82,054	107,957	137,617	169,888	202,258	234,732	266,001	294,702	322,032	345,309	0	0		
	4		2,144,873	0	0	0	0	0	0	2,450	9,907	21,366	37,000	55,769	76,584	100,760	128,443	158,562	188,774	219,083	248,268	275,055	300,563	322,288		
	5		6,702,727	0	7,656	30,960	66,768	115,626	174,279	239,325	314,874	401,384	495,507	589,920	684,635	775,838	859,546	939,261	1,007,150	0	0	0	0	0		
	6		8,426,286	0	0	0	0	9,625	38,921	83,936	145,359	219,093	300,866	395,841	504,597	622,923	741,613	860,684	975,339	1,080,572	1,180,785	1,266,132	0	0		
	7		7,660,260	0	0	0	0	0	0	8,750	35,383	76,306	132,144	199,175	273,514	359,856	458,724	566,294	674,194	782,440	886,672	982,339	1,073,441	1,151,029		
	8		4,596,156	0	0	0	5,250	21,230	45,783	79,287	119,505	164,109	215,913	275,235	339,776	404,516	469,464	532,003	589,403	644,064	690,617	0	0	0		
	9		4,021,636	0	0	0	0	0	0	4,594	18,576	40,061	69,376	104,567	143,595	188,924	240,830	297,304	353,952	410,781	465,503	515,728	563,556	604,290		
	Rocky Coulee		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			46,574,381																							
B.3: Construction and IDC costs for drainage system:	1		22,128,208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,128,208	0	0	0	0	0	0		
	2		16,596,156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16,596,156	0	0	0		
	3		8,298,078	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,298,078	0	0		
	4		7,744,873	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,744,873		
	5		24,202,727	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24,202,727	0	0	0	0	0		
	6		30,426,286	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30,426,286	0	0		
	7		27,660,260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27,660,260		
	8		16,596,156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16,596,156	0	0	0		
	9		14,521,636	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14,521,636		
	Rocky Coulee		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			168,174,381	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,128,208	24,202,727	0	33,192,312	38,724,364	0	49,926,769		
Discounted to year 2025:		83,532,741		0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,682,121	13,289,648	0	16,729,913	18,700,103	0	22,130,956		
B.4: OMR&P costs for drainage system:																										
	1		7,449,462	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85,626	85,626	85,626	85,626	85,626	85,626	85,626	
	2		8,000,328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95,242	95,242	95,242	95,242	
	3		3,837,256	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46,232	46,232	46,232	
	4		3,615,030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44,630	
	5		8,534,640	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99,240	99,240	99,240	99,240	99,240	99,240	
	6		16,008,708	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	192,876	192,876	192,876	
	7		11,568,906	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	142,826	
	8		12,379,416	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	147,374	147,374	147,374	147,374	
	9		7,609,626	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93,946	
	Rocky Coulee		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			79,003,372	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85,626	184,866	184,866	427,482	666,590	666,590	947,992	…
Discounted to year 2025:		10,353,327		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47,017	97,255	93,178	206,432	308,405	295,478	402,601	…
Total cost – Alternatives 3C and 3D:		4,200,346,518																								

1.2.2.2.1 Lost Hydropower Benefits

Methodology and Assumptions – Losses in Columbia River system hydropower benefits were anticipated due to the increased pumping from the Columbia River to provide surface water supplies for agriculture. Bonneville Power Administration (BPA) ran their Columbia River System hydropower model based on operational changes (as compared to the No Action Alternative) associated with each action alternative. Note that since each partial (2A-D) replacement alternative would imply the same level of additional pumping out of the Columbia River, there is no difference in terms of the downstream hydropower effects across the partial replacement alternatives. The same holds true for the full replacement alternatives. However, the partial and full replacement alternatives differ (i.e., Alternatives 2A-D are the same and Alternatives 3A-D are the same, but Alternatives 2A-2D are different from Alternatives 3A-3D). BPA multiplied the changes in average monthly hydropower generation by Aurora Model based average monthly power values to estimate losses in average annual hydropower benefits. In addition, the costs of pumping the additional water up into Banks Lake were included in the BPA analysis and not the OMR&P costs.

Results

No Action Alternative – All lost hydropower benefits associated with the action alternatives were measured as changes from the No Action Alternative. While there are hydropower benefits associated with the No Action Alternative, those benefits would not change over time with declining groundwater levels as would the agricultural benefits. As a result, it is not necessary to estimate hydropower benefits for the No Action Alternative.

Partial Replacement Alternatives – The average annual loss in hydropower benefits was estimated by BPA at $6.939 million for all four partial replacement alternatives. Discounting the 100-year stream of average annual lost hydropower benefits to the end of the construction period results in a total hydropower loss estimate of $156.4 million for all partial replacement alternatives.

Full Replacement Alternatives – The same average annual loss in hydropower benefits, $17.638 million, was estimated by BPA at for all four full replacement alternatives. Discounting the 100-year stream of average annual lost hydropower benefits to the end of the construction period results in a total hydropower loss estimate of $397.6 million for all full replacement alternatives.

1.2.2.2.2 Lost Recreation Benefits

Methodology and Assumptions – The analysis presented in section 4.14 Recreation Resources of the Odessa DEIS indicates boat ramps at Banks Lake will become unavailable more frequently under the action alternatives as compared to the No Action Alternative. This would likely lead to reductions in recreation visitation and adverse recreation economic effects for these alternatives. To address this potential adverse effect, Reclamation and Ecology have committed to necessary mitigation measures as described in section 4.29.10 Recreation Resources of the Odessa DEIS. This mitigation assumption results in the elimination of the majority of the anticipated adverse recreation economic effects. Prior to this decision being made, a recreation analysis was conducted to estimate losses in recreation visitation and value for each action alternative. The results of this recreation economic analysis is presented in this technical report, but the losses in recreation value are not carried forward into the benefit-cost analysis.

Possible losses in recreation activity and benefits were anticipated at Banks Lake and Lake Roosevelt due to additional reservoir drawdowns required to meet the agricultural surface water demands of the action alternatives. Based on historical hydrology and alternative specific operations, Reclamation hydrologists estimated average end of month water levels at both reservoirs for each alternative including the No Action Alternative (see table NED_REC1). At Banks Lake, the most significant reductions in water levels as compared to the No Action Alternative are expected to occur in the July thru September months. At Lake Roosevelt, the most significant reductions occur in August, although generally speaking, the reductions were fairly minor.

These end-of-month water level estimates by alternative were compared to low end usability thresholds gathered for boat ramps at the two reservoirs to evaluate changes (reductions) in facility availability as compared to the No Action Alternative.[2] The comparison of facility availability at Lake Roosevelt indicated no change in boat ramp availability as compared to the No Action Alternative under average conditions. As a result, since boat ramp availability was used for measuring changes in recreation visitation, no changes in recreation visitation and benefits were estimated for Lake Roosevelt.

For the 12 boat ramps found at Banks Lake, table NED_REC2 shows the low end usability thresholds for each ramp (thresholds range from 1560 to 1565). The table also presents estimates of the percent of boat launching capacity associated with each boat ramp (as obtained from study team recreation planners). Five of these ramps (Coulee Playland and Sunbanks Resort to the north, SRSP Rest Area

[2] The boat ramp availability results presented here in the recreation economic analysis differs somewhat from that described under the recreation section of the Odessa DEIS due to the time step. In the Odessa DEIS recreation section, end of month water levels estimated by Reclamation hydrologists were assumed to change between months using a constant filling/drawdown rate. This allows for estimation of the number of weeks a ramp would be unusable, including weeks on "both sides" of the end of month elevation. Since the historical recreation visitation data used in the recreation economic analysis presented in this section was available on a monthly basis, the decision was made to measure changes in facility availability and visitation on a monthly basis. It is unlikely that the difference in the weekly versus monthly time steps between these two analyses would significantly affect the visitation estimates by alternative.

Table NED_REC1.—Average reservoir water levels by month by alternative

Alternative	No Action	2A	Decrease from No Action	2B	Decrease from No Action	2C	Decrease from No Action	2D	Decrease from No Action	3A	Decrease from No Action	3B	Decrease from No Action	3C	Decrease from No Action	3D	Decrease from No Action
Banks Lake average conditions																	
January	1570	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0	1568.3	1.7	1570	0
February	1570	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0
March	1570	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0
April	1570	1569.8	0.2	1569.6	0.4	1570	0	1570	0	1569.9	0.1	1569.9	0.1	1570	0	1570	0
May	1570	1570	0	1568.9	1.1	1570	0	1569.5	0.5	1570	0	1568.8	1.2	1570	0	1569.3	0.7
June	1570	1569	1	1567.9	2.1	1570	0	1569.5	0.5	1567.4	2.6	1567	3	1569	1	1568.3	1.7
July	1570	1567.8	2.2	1567	3	1570	0	1569.5	0.5	1564.3	5.7	1567	3	1567.6	2.4	1567	3
August	1565	1561.6	3.4	1562	3	1564.9	0.1	1562	3	1556.5	8.5	1562	3	1560	5	1562	3
September	1570	1568.4	1.6	1567	3	1569.6	0.4	1565	5	1563.9	6.1	1567	3	1564.8	5.2	1565	5
October	1570	1570	0	1570	0	1570	0	1570	0	1568.7	1.3	1569.8	0.2	1567.2	2.8	1567.4	2.6
November	1570	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0
December	1570	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0	1570	0

Alternative	No Action			2B	Decrease from No Action			2D	Decrease from No Action			3B	Decrease from No Action			3D	Decrease from No Action
Lake Roosevelt average conditions																	
January	1260.1			1260.1	0			1260.1	0			1260.1	0			1260.1	0
February	1250			1250	0			1250	0			1250	0			1250	0
March	1246.2			1246.2	0			1246.2	0			1246.2	0			1246.2	0
April	1219.9			1219.9	0			1219.9	0			1219.9	0			1219.9	0
May	1232.5			1232.5	0			1232.5	0			1232.5	0			1232.5	0
June	1289.7			1289.7	0			1289.7	0			1289.4	0.3			1289.7	0
July	1289.4			1289.3	0.1			1289.4	0			1288.2	1.2			1289.4	0
August	1279.2			1278.7	0.5			1279.2	0			1277	2.2			1278.4	0.8
September	1284.9			1284.9	0			1284.9	0			1283.5	1.4			1284.6	0.3
October	1287.9			1287.9	0			1287.9	0			1287.9	0			1287.9	0
November	1290			1290	0			1290	0			1290	0			1290	0
December	1290			1290	0			1290	0			1290	0			1290	0

Table NED_REC2.—Banks Lake boat ramp information

Reservoir sector	Boat ramp	Low-end usability threshold	Percent of boat launch capacity
North	Coulee Playland	1560	.15
	Sunbanks Resort	1562	.1
	Osborn Bay SW	1565	.05
	Osborn Bay SE	1565	.025
Middle	SRSP Rest Area	1560	.1
	SRSP Day Use Area	1562	.2
	Barker Flat	1565	.025
	Million Dollar Mile North	1565	.05
	Million Dollar Mile South	1565	.05
South	Coulee City Park	1562	.15
	Dry Falls Campground	1565	.05
	Dry Falls	1565	.05

and SRSP Day Use Area in the middle reach, and Coulee City Park to the south) were deemed high use ramps since they reflect about 70 percent of the boat launch capacity at Banks Lake. These percentages were assumed to adequately reflect the percent of total boat based visitation associated with each boat ramp. While the relationship between capacity and usage is not always perfect, generally speaking, higher capacity ramps typically get the most use and the lower capacity ramps typically get the least use. Therefore, capacity percentages often closely mirror usage percentages.

Table NED_REC3 presents estimates of historical visitation by month at Banks Lake as obtained from Washington State Parks and Recreation Commission. Current average monthly visitation was estimated based on the most recent five years of monthly data (2004-2008). As also indicated by study team recreation planners, it should be noted that virtually all visitation at Banks Lake is water oriented. The most popular recreation activities are power boating, fishing, and camping. The vast majority of fishing activity is pursued by boat. While most of the campsites can be accessed by car, many have water dependent boat launches. Therefore, while no data exists as to the percentage of visitation by recreation activity and specifically the percentage of visitation stemming directly from the boat ramps, the assumption was made that the majority of recreation activity at Banks Lake directly utilizes the ramps. In addition, fluctuation in the availability of the boat ramps may also reflect a reasonable proxy for reservoir drawdown by providing an indicator of the presence of mud flats. The presence of mud flats would adversely affect the amount of non-boat ramp based recreation activity

Table NED_REC3.—Banks Lake visitation
Source: Washington State Parks and Recreation Commission

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1999	8,116	7,417	24,420	50,111	52,932	78,338	137,015	124,669	94,861	37,733	11,398	15,779	642,789
2000	5,016	7,881	690	43,641	41,788	104,895	109,763	75,779	75,779	32,203	7,183	12,436	517,054
2001	4,528	4,421	6,307	43,794	96,132	93,820	193,283	149,316	85,177	31,496	12,056	17,870	738,200
2002	6,759	10,298	14,118	45,124	87,798	83,662	118,279	182,868	85,202	29,596	12,758	12,674	689,136
2003	3,643	10,020	17,474	54,146	45,907	64,721	86,808	83,406	42,423	26,547	13,741	10,885	459,721
2004	10,885	10,023	18,158	30,695	53,729	66,437	94,746	81,184	39,923	20,216	31,475	9,366	466,837
2005	11,694	10,955	18,112	29,820	69,600	65,078	117,758	80,992	41,255	18,011	30,574	9,181	503,030
2006	8,264	10,702	17,135	33,565	58,152	65,349	102,326	116,240	40,771	18,354	30,975	9,704	511,537
2007	11,301	7,336	16,702	38,931	68,842	63,173	106,347	116,069	42,136	18,318	29,655	9,367	528,177
2008	11,329	6,889	16,203	17,722	53,031	51,677	100,565	101,473	39,957	19,174	23,457	7,611	449,088
10-year avg.	8,154	8,594	14,932	38,755	62,791	73,715	116,689	111,200	58,748	25,165	20,327	11,487	550,557
Percent	1.5	1.6	2.7	7.0	11.4	13.4	21.2	20.2	10.7	4.6	3.7	2.1	100.0
				Apr-Sept	Apr-Oct	May-Sept	May-Oct	Apr-Nov					
			# Months:	6	7	5	6	8					
			Percent:	83.9	88.5	76.9	81.4	92.2					
5-year avg.	**10,695**	**9,181**	**17,262**	**30,147**	**60,671**	**62,343**	**104,348**	**99,192**	**40,808**	**18,815**	**29,227**	**9,046**	**491,734**
Percent	2.2	1.9	3.5	6.1	12.3	12.7	21.2	20.2	8.3	3.8	5.9	1.8	100.0
				Apr-Sept	Apr-Oct	May-Sept	May-Oct	Apr-Nov					
			# Months:	6	7	5	6	8					
			Percent:	80.8	84.7	74.7	78.5	90.6					

Note: In 2003, Washington State Parks began charging a $5 day use fee at Steamboat Rock State Park. As a result, visitation dropped significantly and has stayed low since. Therefore, it seems reasonable to estimate current visitation based on the most recent 5-year average (2004-08).

around the lake (e.g., swimming, sightseeing). Bottomline, the percentages of visitation associated with each boat ramp were applied to the total visitation estimates for each month. This approach may somewhat overstate the degree of recreation loss by essentially assuming all visitation is affected by boat ramp availability, but given that boat ramp availability may also reflect an indicator of reservoir drawdown in the general vicinity of each lost boat ramp, the degree of overestimation was deemed to be relatively minor.

Applying the percentage of boating visitation associated with each lost boat ramp for a particular alternative to the total visitation for the affected month provides an estimate of the visitation loss associated with that month and boat ramp. Aggregating visitation losses across months and ramps provides an estimate of the total visitation loss for that alternative without taking into account potential boat ramp substitution. If a boat ramp becomes unusable due to declining reservoir water levels and another ramp in the general vicinity remains usable, it is likely that a portion, perhaps a significant portion of the visitation associated with the lost ramp might switch to the nearby still available ramp.

In attempting to address boat ramp substitution, two perspectives were considered—locals versus nonlocals. Locals were defined as residents living within 100 miles of Banks Lake and therefore nonlocals reflect those visitors residing outside the Banks Lake 100 mile radius. Locals were assumed to be taking mainly day trips to Bank Lake whereas nonlocals would be taking primarily overnight trips. From a boat ramp substitution perspective, locals taking day trips would likely have less time to spend traveling to access Banks Lake and therefore would be less inclined to substitute to boat ramps further away from their preferred access point. Conversely, nonlocals on multiple day trips staying overnight either on-site or in close proximity to Banks Lake would likely be more apt to travel further to access the lake since they may be less time constrained. In other words, nonlocals may be more willing to substitute to further away boat ramps than locals. Before getting into the details and assumptions of the boat ramp substitution analysis, estimates must first be developed as to the percentage of local versus nonlocal visitation.

The visitation data from 2004-2008 obtained from Washington State Parks and Recreation Commission indicated that approximately 87 percent of the visitation was day use and 13 percent overnight campers. A review of 2008 camping data by zip code indicated that 27 percent of the overnight campers at Steamboat Rock State Park (SRSP) were locals from within 100 miles and 73 percent were nonlocals from outside the 100-mile area. Given that day users could reflect both locals and nonlocals (i.e., nonlocals could stay in motels close to Banks Lake and take day trips), an estimate had to be developed as to the percentage of day use visitation attributable to locals versus nonlocals. Based on numerous discussions with Tom Poplawski (manager at SRSP), it was estimated that 75 percent of day use visits were made by locals. Multiplying the overall day use percentage (0.87) by the local portion of day use visits (0.75) and combining that with the overall overnight use percentage (0.13) times the local portion of overnight use visits (0.27) provides the overall portion of local visitation (0.688). This 68.8 percent estimate for locals was rounded up to 70 percent implying that nonlocals reflect about 30 percent of the overall visitation estimate. This 70/30 split for locals versus nonlocals was used to separate visitation before considering local/nonlocal boat ramp substitution.

As noted above, locals were assumed to be less apt to travel as far as nonlocals to access an available boat ramp. Study team recreation planners divided the reservoir into four areas or sectors: south, middle, Steamboat Rock/Barker Flats, and north. To provide high use ramps in each area, for the "local" ramp substitution analysis, the middle and Steamboat Rock/Barker Flats sectors were combined into one area referred to as the middle sector thereby resulting in three sectors – south, middle, and north. It was assumed that local visitation within each of these sectors would only substitute to other available ramps in that sector. For the north sector, Coulee Playland has the deepest ramp at elevation 1560. It was assumed that if Coulee Playland was available, it would absorb the lost local recreator visitation at the other ramps in the north sector. For the middle sector, SRSP Rest Area has the lowest ramp at elevation 1560. It was assumed that if SRSP Rest Area was available, it would absorb the lost local recreator visitation at the other ramps in the middle sector. For the south sector, Coulee City Park has the deepest ramp at elevation 1562. It was assumed that if Coulee City Park was available, it would absorb the lost local recreator visitation at the other ramps in the south sector. Therefore, if Coulee Playland, SRSP Rest Area, or Coulee City Park ramps were unavailable, no ramp substitution would be made by locals in those sectors. Since nonlocal recreators are likely to be less time constrained, they were assumed to be willing to travel to any available boat ramp at Banks Lake. The only restriction placed on nonlocal recreator substitution was that visitation to high use ramps would need to substitute to another available high use ramp to avoid possible issue of inadequate carrying capacity. The result of including boat ramp substitution in the recreation visitation analysis was to significantly reduce the level of visitation losses as compared to the without substitution analysis.

The visitation losses for each alternative are represented by the sum of the visitation losses by both locals and nonlocals. To estimate the economic benefits associated with these losses in visitation, the visitation losses were multiplied by an average value per visit. The average value visit was obtained from a 2005 meta analysis study of recreation benefit values (Loomis, 2005). This study gathered benefit estimates per recreation day across a range of different recreation activities and geographic areas. Values per day were averaged across motorboating, fishing, and camping activities for the Pacific Coast Region (WA, OR, CA) and indexed to 2009 dollars using the western region consumer price index to obtain a value per visit of $66.38. This value per visit was then applied to the visitation losses to provide estimates of the average annual loss in recreation value by alternative. These average annual losses in recreation value were assumed to begin at the end of the construction period (end of the final construction phase) and accrue across the entire 100 year period of analysis (2026-2125). The changes in facility availability and associated changes in recreation visitation and benefits are based on unmitigated effects.

Results

No Action Alternative – All lost recreation benefits associated with the action alternatives were measured as changes from the No Action Alternative. While there are recreation benefits associated with the No Action Alternative, those benefits would not change over time with declining groundwater levels as would the agricultural benefits. As a result, it is not necessary to estimate recreation benefits for the No Action Alternative.

Partial Replacement Alternatives – The approach for estimating losses in recreation visitation and value based on facility availability is described above under the methodology section. Note that while recreation losses were estimated and presented in this technical report for informational purposes, they were not included in the benefit-cost analysis due to the assumption that boat ramp extensions would fully mitigate any potential loss.

Table NED_REC4 shows the results of the unmitigated facility availability analysis for the partial replacement alternatives. The table displays the average monthly water levels for the high use recreation months from April thru October by alternative as well as the low end usability thresholds for each boat ramp. Note that the analysis was actually conducted across all months, but given there was no variation in boat ramp availability outside of the high use months, those months are not presented in the table. Comparing the low end usability threshold for each boat ramp to the average monthly water level estimate determines the boat ramp availability by alternative. A "YES" result indicates that on average (i.e., based on average EOM hydrology) the boat ramp is expected to be available that month. A "NO" result indicates that on average the boat ramp is not expected to be available that month.

Since all 12 of the boat ramps were expected to be available on average across the entire high use season under the No Action Alternative, any months which show up as a "NO" for the partial replacement alternatives reflect a reduction in boat ramp availability as compared to the No Action Alternative. All of the partial replacement alternatives showed reductions in boat ramp availability based on average hydrologic conditions as compared to the No Action Alternative. As would be expected, the Banks Lake only alternative (2A) results in the largest loss in ramps of the partial replacement alternatives with 10 ramps out (3 high use) on average in the month of August. The other partial replacement alternatives (2B, 2C, 2D) would result in a loss of 7 boat ramps (zero high use) on average in the month of August.

Table NED_REC5 presents estimates of the losses in recreation visitation associated with each boat ramp for the four partial replacement alternatives. For each alternative, visitation loss estimates are presented both with and without boat ramp substitution. Summing the visitation losses measured for local area residents and nonlocal area residents provides the total with substitution estimate. The without substitution estimate is provided to show how much visitation loss was reduced by pursuing the substitution analysis. The with substitution analysis results are considered most appropriate.

The Banks Lake only alternative (2A) results in the largest reduction in recreation visitation (17,359 visits) of the partial replacement alternatives. Applying the recreation value per visit of $66.38 to the visitation loss estimate results in a $1.15 million average annual loss in recreation value under this alternative (this is considerably less than the $4.9 million average annual loss estimate for the without substitution analysis). Discounting the 100-year stream of annual lost recreation benefits to the end of the construction period results in a total recreation loss estimate of $26.0 million for Alternative 2A.

The other partial replacement alternatives (2B, 2C, and 2D) resulted in zero losses in recreation visitation and value under the with substitution analysis.

Full Replacement Alternatives – The approach for estimating losses in recreation visitation and value as compared to the No Action Alternative based on facility availability is described above under the methodology section. Note that while recreation losses were estimated and presented in this technical report for informational purposes, they were not included in the benefit-cost analysis due to the assumption that boat ramp extensions would fully mitigate any potential loss.

Table NED_REC6 shows the results of the unmitigated facility availability analysis for the full replacement alternatives. The table displays the average monthly water levels for the high use recreation months from April thru October by alternative as well as the low end usability thresholds for each boat ramp. Note that the analysis was actually conducted across all months, but given there was no variation in boat ramp availability outside of the high use months, those months are not presented in the table. Comparing the low end usability threshold for each boat ramp to the average monthly water level estimate determines the boat ramp availability by alternative. A “YES” result indicates that on average (i.e., based on average EOM hydrology) the boat ramp is expected to be available that month. A “NO” result indicates that on average the boat ramp is not expected to be available that month.

Table NED_REC4.—Boat ramp availability for partial replacement alternative

Reservoir			Low-end threshold:	1560	1562	1565	1565	1560	1562	1565	1565	1565	1562	1565	1565
BANKS LAKE			Percent of capacity:	0.15	0.1	0.05	0.025	0.1	0.2	0.025	0.05	0.05	0.15	0.05	0.05
				North sector				**Middle sector**					**South sector**		
Alternative	**Month**	**Water levels**	**5-year average visits by month**	**Coluee Playland**	**Sunbanks Resort**	**Osborn Bay SW**	**Osborn Bay SE**	**SRSP Rest Area**	**SRSP Day Use Area**	**Barker Flat**	**Million Dollar Mile North**	**Million Dollar Mile South**	**Coulee City Park**	**Dry Falls Campground**	**Dry Falls**
2A	Apr	1569.8	30,147	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
High-use season: (Apr-Oct)	May	1570	60,671	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jun	1569	62,343	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jul	1567.8	104,348	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Aug	1561.6	99,192	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO
	Sep	1568.4	40,808	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Oct	1570	18,815	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
2B	Apr	1569.6	30,147	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
High-use season: (Apr-Oct)	May	1568.9	60,671	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jun	1567.9	62,343	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jul	1567	104,348	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Aug	1562	99,192	YES	YES	NO	NO	YES	YES	NO	NO	NO	YES	NO	NO
	Sep	1567	40,808	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Oct	1570	18,815	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
2C	Apr	1570	30,147	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
High-use season: (Apr-Oct)	May	1570	60,671	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jun	1570	62,343	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jul	1570	104,348	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Aug	1564.9	99,192	YES	YES	NO	NO	YES	YES	NO	NO	NO	YES	NO	NO
	Sep	1569.6	40,808	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Oct	1570	18,815	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
2D	Apr	1570	30,147	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
High-use season: (Apr-Oct)	May	1569.5	60,671	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jun	1569.5	62,343	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jul	1569.5	104,348	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Aug	1562	99,192	YES	YES	NO	NO	YES	YES	NO	NO	NO	YES	NO	NO
	Sep	1565	40,808	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Oct	1570	18,815	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Nov	1570	29,227	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Dec	1570	9,046	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table NED_REC5.—Partial replacement alternative – Average annual losses in recreation visitation and value

					Loss in visitation and value with and without substitution													
					North sector				**Middle sector**					**South sector**				
					Coulee Playland	**Sunbanks Resort**	**Osborn Bay SW**	**Osborn Bay SE**	**SRSP Rest Area**	**SRSP Day Use Area**	**Barker Flat**	**Million Dollar Mile North**	**Million Dollar Mile South**	**Coulee City Park**	**Dry Falls Campground**	**Dry Falls**	**Average annual visit loss**	**Average annual value loss ($) ($/visit)**
				Low-end threshold:	1560	1562	1565	1565	1560	1562	1565	1565	1565	1562	1565	1565		66.38
Alternative	**Month**	**Water level**	**Total visits**															
2A	August	1561.6	99,192	Local with substitution	0	0	0	0	0	0	0	0	0	10,415	3,472	3,472	17,359	1,152,321
	August			Nonlocal with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total with substitution	0	0	0	0	0	0	0	0	0	10,415	3,472	3,472	17,359	1,152,321
	August			Total w/o substitution	0	9,919	4,960	2,480	0	19,838	2,480	4,960	4,960	14,879	4,960	4,960	74,394	4,938,519
2B	August	1562.0	99,192	Local with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Nonlocal with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total w/o substitution	0	0	4,960	2,480	0	0	2,480	4,960	4,960	0	4,960	4,960	29,757	1,975,408
2C	August	1564.9	99,192	Local with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Nonlocal with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total w/o substitution	0	0	4,960	2,480	0	0	2,480	4,960	4,960	0	4,960	4,960	29,757	1,975,408
2D	August	1562.0	99,192	Local with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Nonlocal with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total w/o substitution	0	0	4,960	2,480	0	0	2,480	4,960	4,960	0	4,960	4,960	29,757	1,975,408

Table NED_REC6.—Boat ramp availability for full replacement alternative

Reservoir			Low-end threshold:	1560	1562	1565	1565	1560	1562	1565	1565	1565	1562	1565	1565
BANKS LAKE			Percent of capacity:	0.15	0.1	0.05	0.025	0.1	0.2	0.025	0.05	0.05	0.15	0.05	0.05
				North sector				**Middle sector**					**South sector**		
Alternative	**Month**	**Water levels**	**5-year average visits by month**	**Coluee Playland**	**Sunbanks Resort**	**Osborn Bay SW**	**Osborn Bay SE**	**SRSP Rest Area**	**SRSP Day Use Area**	**Barker Flat**	**Million Dollar Mile North**	**Million Dollar Mile South**	**Coulee City Park**	**Dry Falls Campground**	**Dry Falls**
3A	Apr	1569.9	30,147	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
High-use season: (Apr-Oct)	May	1570	60,671	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jun	1567.4	62,343	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jul	1564.3	104,348	YES	YES	NO	NO	YES	YES	NO	NO	NO	YES	NO	NO
	Aug	1556.5	99,192	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Sep	1563.9	40,808	YES	YES	NO	NO	YES	YES	NO	NO	NO	YES	NO	NO
	Oct	1568.7	18,815	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
3B	Apr	1569.9	30,147	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
High-use season: (Apr-Oct)	May	1568.8	60,671	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jun	1567	62,343	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jul	1567	104,348	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Aug	1562	99,192	YES	YES	NO	NO	YES	YES	NO	NO	NO	YES	NO	NO
	Sep	1567	40,808	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Oct	1569.8	18,815	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
3C	Apr	1570	30,147	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
High-use season: (Apr-Oct)	May	1570	60,671	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jun	1569	62,343	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jul	1567.6	104,348	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Aug	1560	99,192	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO
	Sep	1564.8	40,808	YES	YES	NO	NO	YES	YES	NO	NO	NO	YES	NO	NO
	Oct	1567.2	18,815	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
3D	Apr	1570	30,147	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
High-use season: (Apr-Oct)	May	1569.3	60,671	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jun	1568.3	62,343	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Jul	1567	104,348	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Aug	1562	99,192	YES	YES	NO	NO	YES	YES	NO	NO	NO	YES	NO	NO
	Sep	1565	40,808	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
	Oct	1567.4	18,815	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Since all 12 of the boat ramps were expected to be available on average across the entire high use season under the No Action Alternative, any months which show up as a "NO" for the full replacement alternatives reflect a reduction in boat ramp availability as compared to the No Action Alternative. All of the full replacement alternatives showed reductions in boat ramp availability based on average hydrologic conditions as compared to the No Action Alternative. As would be expected, the Banks Lake only alternative (3A) results in the largest loss in ramps of the full replacement alternatives with all 12 ramps out in the month of August and 7 ramps (zero high use ramps) lost in July and September on average. The Banks Lake and Rocky Coulee alternative (3C) results in 10 ramps out (3 high use) on average in the month of August. The other full replacement alternatives (3B, 3D) would result in a loss of 7 boat ramps (zero high use) on average in the month of August.

Table NED_REC7 presents estimates of the losses in recreation visitation associated with each boat ramp for the four full replacement alternatives. For each alternative, visitation loss estimates are provided both with and without boat ramp substitution. Summing the visitation losses measured for local area residents and nonlocal area residents provides the total with substitution estimate. The without substitution estimate is also provided to show how much visitation loss was reduced by pursuing the substitution analysis. The with substitution analysis results are considered most appropriate.

The Banks Lake only alternative (3A) results in the largest reduction in recreation visitation (99,192 visits) of the full replacement alternatives. Applying the recreation value per visit of $66.38 to the visitation loss estimate results in a $6.58 million average annual loss in recreation value under this alternative (this is considerably less than the $9.5 million average annual loss estimate for the without substitution analysis). Discounting the 100-year stream of annual lost recreation benefits to the end of the construction period results in a total recreation loss estimate of $148.4 million for Alternative 3A.

The Banks Lake and Rocky Coulee alternative (3C) results in an estimated 17,359 average annual loss in visitation as compared to the No Action Alternative. Applying the recreation value per visit of $66.38 to the visitation loss estimate results in a $1.15 million average annual loss in recreation value under this scenario (this is considerably less than the $5.8 million average annual loss estimate for the without substitution analysis). Discounting the 100-year stream of annual lost recreation benefits to the end of the construction period results in a total recreation loss estimate of $26.0 million for Alternative 3C. The other full replacement alternatives (3B and 3D) resulted in zero losses in recreation visitation and value under the with substitution analysis.

2.0 Regional Economic Development (RED) Impact Analysis

This section briefly describes the methodology used to estimate the regional economic impacts presented in the RED account as found in the Study. The modeling package used to assess the regional economic effects stemming from construction expenditures, operation and maintenance (O&M) expenditures, agricultural gross value of production and the associated potato processing for each alternative is IMPLAN (IMpact analysis for PLANning). IMPLAN is an economic input-output modeling system that estimates the effects of economic changes in a defined analysis area.

IMPLAN is a static model that estimates impacts for a snapshot in time when the impacts are expected to occur, based on the makeup of the economy at the time of the underlying IMPLAN data. Therefore it's difficult to address dynamic impacts such as a decline in gross farm income due to wells going out of production as a function of time using IMPLAN. As wells become less productive, farmers adapt perhaps by using new technology or new crop varieties. As the economy adapts to changing farm practices, labor and capital inputs employed in the analysis area would move to alternative uses. IMPLAN measures the initial impact to the economy but does not consider long term adjustments as labor and capital move into alternative uses.

The common measures of regional economic impacts include employment, regional income, and regional output (sales). Input output models measure commodity flows from producers to intermediate and final consumers. Purchases for final use (final demand) drive the model. Industries produce goods and services for final demand and purchase goods and services from other producers. These other producers, in turn, purchase goods and services. This buying of goods and services (indirect purchases) continues until leakages from the analysis area (imports and value added) stop the cycle. These indirect and induced effects (the effects of household spending) can be mathematically derived using a set of multipliers. The multipliers describe the change in output for each regional industry caused by a one dollar change in final demand.

IMPLAN data files are compiled from a variety of sources for the analysis area including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor, and the U.S. Census Bureau. This analysis uses 2008 IMPLAN data for the four counties within the analysis area (Adams, Grant, Franklin, and Lincoln Counties of Washington State).

Table NED_REC7.—Full replacement alternative – Average annual losses in recreation visitation and value

					Total loss in visitation and value with and without substitution: Full replacement alternative													
					North sector				**Middle sector**					**South sector**				
					Coulee Playland	**Sunbanks Resort**	**Osborn Bay SW**	**Osborn Bay SE**	**SRSP Rest Area**	**SRSP Day Use Area**	**Barker Flat**	**Million Dollar Mile North**	**Million Dollar Mile South**	**Coulee City Park**	**Dry Falls Campground**	**Dry Falls**	**Average annual visit loss**	**Average annual value loss ($) ($/visit)**
				Low-end threshold:	1560	1562	1565	1565	1560	1562	1565	1565	1565	1562	1565	1565		66.38
Alternative	**Month**	**Water level**	**Total visits**															
3A	August	1561.5	99,192	Local with substitution	10,415	6,943	3,472	1,736	6,943	13,887	1,736	3,472	3,472	10,415	3,472	3,472	69,434	4,609,284
	August			Nonlocal with substitution	4,464	2,976	1,488	744	2,976	5,951	744	1,488	1,488	4,464	1,488	1,488	29,757	1,975,408
	August			Total with substitution	14,879	9,919	4,960	2,480	9,919	19,838	2,480	4,960	4,960	14,879	4,960	4,960	99,192	6,584,692
	July-Sep		244,348	Total w/o substitution	14,879	9,919	12,217	6,109	9,919	19,838	6,109	12,217	12,217	14,879	12,217	12,21 7	142,739	9,475,500
3B	August	1562	99,192	Local with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Nonlocal with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total w/o substitution	0	0	4,960	2,480	0	0	2,480	4,960	4,960	0	4,960	4,960	29,757	1,975,408
3C	August	1560	99,192	Local with substitution	0	0	0	0	0	0	0	0	0	10,415	3,472	3,472	17,359	1,152,321
	August			Nonlocal with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total with substitution	0	0	0	0	0	0	0	0	0	10,415	3,472	3,472	17,359	1,152,321
	Aug-Sep		140,000	Total w/o substitution	0	9,919	7,000	3,500	0	19,838	3,500	7,000	7,000	14,879	7,000	7,000	86,636	5,751,221
3D	August	1562	99,192	Local with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Nonlocal with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total with substitution	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	August			Total w/o substitution	0	0	4,960	2,480	0	0	2,480	4,960	4,960	0	4,960	4,960	29,757	1,975,408

2.1 Construction Costs

The construction costs associated with each alternative were divided into the phases described in chapter 2. The construction related expenditures for each phase were divided into expenditures that would be made inside the analysis area. The construction expenditures inside the analysis area were used in IMPLAN to estimate employment, labor income, and regional sales stemming from construction related activities for each phase. Construction expenditures made outside the analysis area were considered "leakages" and would have no impact on the local economy.

Reclamation's construction cost engineers allocated the costs associated with major construction activities to within-region expenditures as shown in table RED_TA1, and table RED_TA2 shows the regional construction expenditures by phase which were used in the IMPLAN analysis.

Table RED_TA1.—Allocations by construction activity within the analysis area

Construction activity	In region expenditures (%)
Canal enlargement and linings	75
Water service contracts	75
Pump station modifications	75
Wasteways	30
Siphons	60
Laterals	45
Drains subsurface	50
Pumping plants	35
Switchyards and transmission lines	25
Maintenance buildings	40
SCADA systems	20
Mobilization and preparatory work	60

The analysis assumes that the onsite construction workforce would be hired from within the analysis area or commute to the area from nearby communities. It is also assumed that the majority of the construction expenditures would be funded from sources outside the analysis area. Money from outside the analysis area that

Table RED_TA2.—In region IMPLAN construction expenses by phase

Construction phase	In region expenses ($)
Phase 1	67,386,354
Phase 2	103,895,821
Phase 3	36,710,452
Phase 4	36,710,452
Phase 5	404,190,357
Phase 6	125,286,196
Phase 7	92,230,234
Phase 8	101,130,955
Phase 9	39,243,631
Rocky Coulee	1,270,644,211

is spent on goods and services within the analysis area contributes to regional economic impacts, while money that originates from within the analysis area is much less likely to generate regional economic impacts. Spending from sources within the analysis area represents a redistribution of income and output rather than an increase in economic activity.

The impacts by phase would be spread over the length of the construction period and would vary year-by-year proportionate to actual expenditures. The regional impacts associated with each phase cannot be summed across years into a total construction impact for the particular alternative to avoid double counting.

2.2 O&M Costs

Expenditures that are made inside the study region related to O&M will also generate a positive economic output to the regional economy. Annual O&M for each alternative is summarized in table RED_TA3. For the purpose of this analysis, it's assumed that 80 percent of these O&M expenditures are made inside the four-county area. As construction phases are completed, annual O&M expenditures begin to accrue, however this analysis measures annual O&M impacts after all the construction phases are implemented. The analysis does not quantify the positive impacts resulting from replacement costs given they are spread out over the entire study period. Like the construction-related

Table RED_TA3.—Annual operation and maintenance costs by phase and alternative (in $)

	Partial A and B	Partial C and D	Full A and B	Full C and D
Phase 1	977,481	977,481	977,481	977,481
Phase 2	1,210,641	1,210,641	1,210,641	1,210,641
Phase 3	586,957	586,957	586,957	586,957
Phase 4	570,206	570,206	570,206	570,206
Phase 5			385,114	385,114
Phase 6			842,018	842,018
Phase 7			593,720	593,720
Phase 8			676,902	676,902
Phase 9			410,293	410,293
Rocky Coulee		200,000		200,000
Total	3,345,285	3,545,285	6,253,332	6,453,332

expenditures, O&M expenditures made inside the study area associated with each alternative were placed into categories related to the each sector of the economy and run through IMPLAN to estimate impacts to the regional economy.

2.3 Agriculture

Gross farm income estimates are used in IMPLAN to measure changes in regional impacts related to agricultural crop production. The analysis also measures regional economic impacts stemming from potato processing activities associated with potato production in the study area. The following describes the procedure used to estimate the regional impacts stemming from irrigated agricultural production and the associated potato processing.

Impacts were measured for year 2010 and year 2025 when all construction phases are completed for each alternative including the No Action Alternative. Regional impacts were not estimated beyond the end of the construction phases, because of the uncertainties related to the re-employment of labor and capital.

2.3.1 Gross Farm Income

A spreadsheet model was used to forecast the future number of irrigated and dryland acres and the resulting gross farm income for each alternative. The spreadsheet model is described in the NED section. Gross farm income was calculated by multiplying the number of acres of each crop by yield per acre and the price received for each unit of yield. The data used to derive the gross farm income is described in the NED section. However the price received to generate the gross farm income used in the RED analysis differ from the prices used in the NED analysis. The difference is because the P&Gs require the use of USDA normalized prices for benefit analyses. The prices used in the RED analysis are presented below in table RED_TA4.

RED_TA4.— Prices received by crop, 2004–08

Crop	Yield unit	State average prices ($)					
		2004	2005	2006	2007	2008	Average
Wheat	Bushel	3.58	3.21	4.35	7.51	6.25	4.98
Mixed crops	Pounds	0.245	0.218	0.229	0.406	0.308	0.2812
Potatoes	Cwt	4.90	5.60	6.00	6.70	7.95	6.23

Source: USDA 2010.

The average gross farm income generated on the approximately 102,600 acres in the study area is shown, for each alternative, in table RED_TA5.

Because farmers sometimes get some of their inputs from other farmers it is necessary to adjust the gross farm income or farm gate output for final demand. An example of this may be potato farmers buying seed potatoes from other operators. Change in final demand is calculated using the equation below.

$$\text{Final demand factor} * \text{gross farm income} = \text{final demand}$$

$$\text{Final demand factor} = 1/\text{intersect value}$$

The intersect value is found in IMPLAN under “Explore Multipliers” and selecting the Detail Multipliers tab. In the “Detail Multipliers” section the intersect is the Type SAM multiplier for the particular processor industry. If the intersect value is small it indicates that there is very little inter-industry demand is embodied in the multipliers so no double counting occurs, in this case this step can be ignored. The intersect value for IMPLAN industry vegetables and melon farming (sector 3) equals 1.26562 and the intersect value for IMPLAN industry grain farming (sector 2) equals 1.185123.

Table RED_TA5.—Gross farm income by crop and alternative for years 2010 and 2025

Gross farm income by crop	Year 2010	Year 2025
No Action Alternative gross farm income		
Potato	$59,020,857	$11,592,038
Wheat	$19,901,973	$18,195,488
Mixed crops	$27,503,791	$12,951,198
Total	$106,426,621	$42,738,724
Alternative 2A-D : Partial—banks gross farm income		
Potato	$59,020,857	$37,969,627
Wheat	$19,901,973	$21,416,085
Mixed crops	$27,503,791	$19,862,922
Total	$106,426,621	$79,248,634
Alternative 3A-D: Full—banks gross farm income		
Potato	$59,020,857	$59,020,857
Wheat	$19,901,973	$26,322,075
Mixed crops	$27,503,791	$23,124,445
Total	$106,426,621	$108,467,377

Table RED_TA6 shows the final demand numbers which are the used in IMPLAN to calculate the regional impacts stemming from agricultural production for each alternative.

2.3.2 Potato Processors (Forward Linked Activity)

Irrigated potatoes grown in the study area are desirable to local processors due to their high quality and storage characteristics. Local processors use all of the potatoes grown in the study area. Potatoes grown in other areas of the Columbia Basin have a shorter storage life and are used first by the local processors. The potatoes grown in the study area have a long storage life and allow the local

Table RED_TA6.—Gross value of production and final demand by IMPLAN sector for each alternative

	Gross value of production		
	Farm gate value	Intersect	Final demand
No Action year 2010			
Potatoes (IMPLAN sector 3)	$59,020,857	1.26562	$46,633,948
Mixed crops (IMPLAN sector 2)	$27,503,791	1.185123	$23,207,541
Wheat (IMPLAN sector 2)	$19,901,973	1.185123	$16,793,171
No Action year 2025			
Potatoes (IMPLAN sector 3)	$11,592,038	1.26562	$9,159,177
Mixed crops (IMPLAN sector 2)	$12,951,198	1.185123	$10,928,147
Wheat (IMPLAN sector 2)	$18,195,488	1.185123	$15,353,249
Partial Alternative year 2025			
Potatoes (IMPLAN sector 3)	$37,969,627	1.26562	$30,000,811
Mixed crops (IMPLAN sector 2)	$19,862,922	1.185123	$16,760,220
Wheat (IMPLAN sector 2)	$21,416,085	1.185123	$18,070,770
Full Alternative year 2025			
Potatoes (IMPLAN sector 3)	$59,020,857	1.26562	$46,633,948
Mixed crops (IMPLAN sector 2)	$23,124,445	1.185123	$19,512,274
Wheat (IMPLAN sector 2)	$26,322,075	1.185123	$22,210,416

processors to operate on a year round basis. For these reasons local area experts assert that losing potatoes grown in the study area cannot be replaced by production in any other area.

This analysis assumes that the loss of potato production in the study area cannot be replaced by production other areas resulting in a high end estimate of regional impacts. It's likely in the long run that potato growers and processors will adjust leading to potatoes grown in other areas or adjustments in the processing processes. This may be necessary independent of ground water conditions as new ground is also necessary to break disease cycles. Gross value of potato production was estimated using a spreadsheet model, discussed in the NED section, these results are shown in table RED_TA7.

Table RED_TA7.—Gross farm incomes for potatoes for each alternative

Gross farm income by crop	Year 2010	Year 2025
No Action Alternative gross farm income	$59,020,857	$11,592,038
Alternative 3A: Partial gross farm income	Same as No Action	$37,969,627
Alternative 3A: Full gross farm income	Same as No Action	$59,020,857

According to the Washington Potato Commission 10 percent of potatoes grown in study area are sold to the fresh market. Seventy five percent of the study area potatoes are sold to processors for frozen food products. Ten percent are sold for dehydrated potato products. The remaining 5 percent are marketed for chipping potatoes. Because the IMPLAN dataset for the 4 county area indicated that no chipping potatoes exist in the area, the 5 percent assumed to be chipping potatoes was added to the dehydrated category. Table RED_TA8 summarizes the percentages of potatoes sold to each marketing category.

Table RED_TA8.—Percentage of potatoes sold by market category

Fresh market	10
Frozen food products	75
Dehydrated food products	15

Source: Personal communication with WA Potato Commission.

Using these percentages the gross farm income associated with growing potatoes in the study area is divided into the market categories for the purpose of this analysis. It's likely this overstates the value of the product sold to the processors sectors because the inability to estimate the prices of each market category. The monetary values are shown in table RED_TA9.

2.3.2.1 Gross Absorption Coefficient Approach

Input-output models like IMPLAN rely on monetary inputs in terms of producer prices. The gross absorption coefficients (GAC) provided by IMPLAN are used to convert the monetary values in table RED3 to producer prices, referred to as the Gross Absorption Coefficient Approach.

Table RED_TA9.—Value of potatoes by market category for each alternative for years 2010 and 2025

Year 2010	Frozen food products	Dehydrated food products
No Action Alternative	$44,265,643	$8,853,129
Alternative 3A: Partial	Same as No Action	Same as No Action
Alternative 3A: Full	Same as No Action	Same as No Action
Year 2025	**Frozen food products**	**Dehydrated food products**
No Action Alternative	$8,694,028	$1,738,805
Alternative 3A: Partial	$28,477,970	$5,695,594
Alternative 3A: Full	$44,265,642	$8,853,128

The approach uses the averaged industry production functions provided by IMPLAN for the potato processing sectors. The GACs display how much money an industry spends on inputs for every dollar of total industry output. For example, the GAC for Frozen Food Products (IMPLAN sector 53) as an input to potato production is a ratio of input value (potatoes farm gate) to output value. Because we know the farm gate prices of potatoes, the total industry output (TIO) for the frozen food sector is estimated using the following equation.

$$\text{Frozen food TIO} = \text{total revenue (potatoes)} * (1 + \text{GAC})$$

The GAC equals 6.11% for frozen food products (IMPLAN industry 54) and the GAC for dehydrated food products (IMPLAN industry 55) equals 5.23%.

The purpose of this calculation is to account for markups like transportation and marketing costs. These results are shown in table RED_TA10.

Table RED_TA10.—Total industry output

Year 2010	Frozen food products	Dehydrated food products
No Action Alternative	$46,971,601	$9,316,147
Alternative 3A: Partial	Same as No Action	Same as No Action
Alternative 3A: Full	Same as No Action	Same as No Action
Year 2025	**Frozen food products**	**Dehydrated food products**
No Action Alternative	$9,225,494	$1,829,745
Alternative 3A: Partial	$30,218,829	$5,993,474
Alternative 3A: Full	$46,971,601	$9,316,147

Because potato processors sometimes get some of their potatoes from other potato processors it is necessary to adjust the gross farm income (farm gate values) for final demand. Change in final demand is calculated using the equation below.

Final demand factor * TIO = final demand

Final demand factor = 1/intersect value

The intersect value is found in IMPLAN under "Explore Multipliers" and selecting the Detail Multipliers tab. In the "Detail Multipliers" section the intersect is the Type SAM multiplier for the particular processor industry. If the intersect value is small it indicates that there is very little inter-industry demand is embodied in the multipliers so no double counting occurs, in this case this step can be ignored. The intersect value for IMPLAN industry 53 (frozen food products) equals 1.05191 and the intersect value for IMPLAN industry 55 (dehydrated food products) equals 1.021437.

Table RED_TA11 shows the final demand numbers which are the used in IMPLAN to calculate the regional impacts stemming from potatoes grown in the Study area by alternative.

RED_TA11.—Final demand by alternative for years 2010 and 2025

Year 2010	Frozen food products	Dehydrated food products
Year 2010		
No Action Alternative	$46,729,031	$9,120,628
Alternative 3A: Partial	Same as No Action	Same as No Action
Alternative 3A: Full	Same as No Action	Same as No Action
Year 2025	**Frozen food products**	**Dehydrated food products**
No Action Alternative	$9,177,852	$1,791,344
Alternative 3A: Partial	$30,062,773	$5,867,688
Alternative 3A: Full	$46,729,031	$9,120,628

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