The Cost of ESA Compliance in the Platte River Basin and the Net Economic Impact of the Platte River Recovery Implementation Program

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Platte River Recovery Implementation Plan

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Executive Summary

This analysis estimates the economic impact of complying with the Endangered Species Act (ESA) in the Platte River Basin, with and without the existence of the Platte River Recovery Implementation Program (PRRIP or Program). The difference in these impacts can be reasonably attributed to the collaborative process and Adaptive Management strategy characterizing the PRRIP.

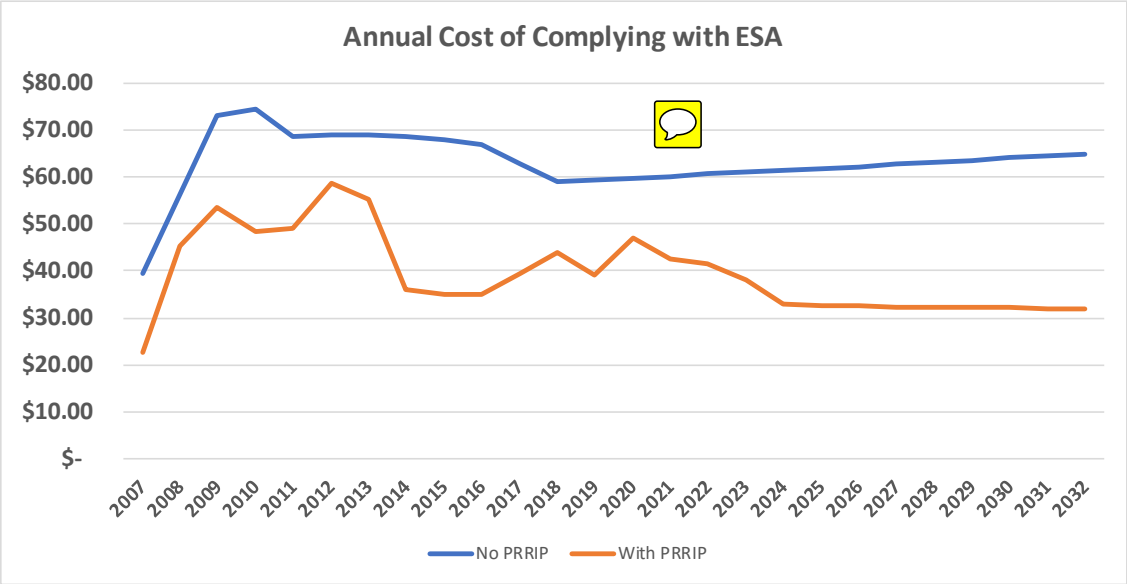
The analysis was developed in several steps:

1. Development of a non-PRRIP scenario that describes the major components of the economic impact of ESA compliance and estimates their magnitude through 2032;
2. Developing a PRRIP scenario that describes and quantifies the economic impact of accomplishing the land and water acquisition goals of the First Increment through 2032;
3. A comparison of the economic impact of (2) v. (1), whose difference represents the net benefit of the PRRIP;
4. Develop conclusions from the economic analysis.

Similar to any study, assumptions influence the results, and there numerous and wide-ranging assumptions used here. Many of these assumptions, were drawn from two previous studies by HDR Engineering, Inc. and the Bureau of Reclamation.[1] The balance of the assumptions used to conduct the analysis were developed here and are discussed in the text below and Appendix A.

Estimated annual expenditures associated with the No-PRRIP and the PRRIP scenarios are shown in Figure 1. These expenditures are expressed in current dollars, without the influence of inflation.

Figure 1. Estimated Expenditures for ESA Compliance With and Without the PRRIP



[1] "*PRRIP: Economic Impacts to the State of Nebraska*", prepared for the CPNRD by HDR Engineering, et al., October 2006;
Platte River Final Programmatic EIS, January, 2006, Agricultural Economics and Hydropower Appendices, USBR.

Table ES-1 summarizes the types of economic impacts considered and their net present value over the period 2007 through 2032, coinciding with the PRRIP's First Increment, with an extension through 2032. It shows that estimated costs of the No-PRRIP scenario to exceed $1.1 billion dollars over this period, while costs associated with the PRRIP and other State activities to be approximately $689 million, or about $0.69 billion. This results in an estimated net benefit of the Program in excess of $400 million over the period 2007 through 2032. Since the No-PRRIP scenario follows a more traditional path of ESA compliance, but the PRRIP is achieving the same or greater species benefit at greatly reduced cost, it would appear that the Adaptive Management framework guiding the PRRIP works well.

Table ES-1
Results of the Impact Analysis, Program-Wide

Net present value, 2007-2032, 3% discount, in millions	Without PRRIP	With PRRIP
Biological Opinion and Section 7 Consultation Cost	$10.96	$5.96
Mitigation costs, water and land	$325.73	
Impacts to North Platte irrigators and region	$385.61	
Potential mitigation costs and operational changes for CNPPID and NPPD hydro-electric production	$60.84	
Impact to Nebraska groundwater irrigators	$338.74	$455.46
Hydro-power production at Federal facilities in the North Platte basin	($11.99)	($15.62)
Tamarack and Pathfinder expenditures, inc, other State contributions		$22.03
Expenditures for Platte River Recovery Implementation Program		$221.32
Additional benefits		*tbd*
Totals	$1,109.90	$689.15

Table ES-2 breaks down these economic impacts to the State and Federal level. It shows that all three States accrue substantial benefits from the PRRIP compared to the No-PRRIP scenario. Although the benefits vary by State, they are all high in dollar amount and relative to their investment. This should provide incentive for the States to continue to participate in the PRRIP.

Although these economic results are not as applicable to the Federal component of the PRRIP, the FWS benefits from the demonstration that collaboration and adaptive management can work to improve habitat conditions and reduce costs while using sound scientific approaches. This should be a valuable case study for the FWS moving forward with this sort of ESA recovery approach.

Table ES-2
Results of the Impact Analysis by State

Present value of expenditures, 2007-2032 (million)	Colorado		Wyoming		Nebraska		Federal	
	No PRRIP	PRRIP	No PRRIP	PRRIP	No PRRIP	PRRIP	No PRRIP	PRRIP
Biological Opinion and Section 7 Consultation Cost to Applicant	$ 7.67	$4.17	$0.55	$0.30	$0.55	$0.30	$2.19	$1.19
Mitigation costs, water and land	$228.01		$16.29		$16.29		65.14669	
Impacts to North Platte irrigators and region			$52.53		$333.08			
Potential mitigation costs and operational changes for CNPPID and NPPD hydro-electric production					$60.84			
Impact to Nebraska groundwater irrigators					$338.74	$455.46		
Potential impacts to hydro-power production at Federal facilities in the North Platte basin							-11.99027	-15.6204
Tamarack and Pathfinder expenditures, inc, other State contributions		$ 16.60		$5.43				
Expenditures for Platte River Recovery Implementation Program		$28.37		$7.10				185.8452
Additional benefits								
Totals	$ 235.69	$49.14	$69.36	$12.83	$749.50	$455.75	$55.35	$171.42
Net present value of PRRIP	$ 186.55		$ 56.53		$ 293.74		$ (116.07)	

The Cost of ESA Compliance in the Platte River Basin and the Net Economic Impact of the Platte River Recovery Implementation Program

This analysis estimates the economic impact of complying with the Endangered Species Act (ESA) in the Platte River Basin, with and without the existence of the Platte River Recovery Implementation Program (PRRIP or Program). The difference in these impacts can be reasonably attributed to the programmatic, collaborative process and Adaptive Management strategy characterizing the PRRIP.

Historical Perspective

Lead-up Period

In the mid 1990's, the Platte River main stem through Central Nebraska was feeling the cumulative effects of several different forces:

- Upstream dams and irrigation on the North Platte system had reduced base flows, peak flows and sediment movement;
- Irrigation and explosive population growth on the South Platte system also reduced peak and base flows, with little end in sight for the need for future water supply on the Colorado Front Range;
- Modified flow patterns due to hydropower diversions and releases;
- Significant increases in alluvial groundwater irrigation in the River's critical reaches, primarily in Central and Western Nebraska, reducing the River's base flows.

The combination of impacts contributed to the decline in populations that lead to the Threatened and Endangered listing of several species dependent on the Platte River ecosystem in Central Nebraska: the Whooping Crane, the Least Tern, the Piping Plover, and the Pallid Sturgeon.

The U.S. Fish and Wildlife Service (FWS) is responsible for protecting these species and has authority to impose mitigation requirements for water projects or other development projects with a federal nexus that adversely impact the listed species. In this role, with a degree of caution, they imposed a requirement that Colorado Front Range depletions be mitigated, or offset, acre-foot for acre-foot, or 1 for 1, at the Nebraska state line. The requirement was perceived by Colorado water providers as unreasonably burdensome and expensive, and nearly impossible to achieve for smaller entities without adequate financial resources. It also put South Platte River irrigators in the crosshairs of large Colorado municipalities who might use a "buy and dry" approach to fulfilling this mitigation requirement.

However, beyond Colorado, the ESA listings also put North Platte Basin irrigators using Bureau of Reclamation facilities at risk as a potential mitigation target, as well impacting the 1998 relicensing of Central Platte Public Power and Irrigation District (CNPPID) and Nebraska Public Power District (NPPD) hydropower facilities at Lake McConaughy.

In addition, large numbers were being presented as possible water and land goals requirements for restoration of habitat, such as 417,000 acre-feet of additional flow in the River and 29,000 acres of suitable land. How these figures would hold-up to scientific scrutiny was uncertain, but regardless, the thought of their combined impacts provided stakeholders sufficient incentive to talk and stick together.

The Platte River Recovery Implementation Program

The evolution of the PRRIP is well-documented by David Freeman, but has been summarized as "a marriage of stakeholders in which divorce is not possible".[2] The purpose of this collaboration is to use the concept of Adaptive Management work towards recovery of the listed species. This concept might also be called "learning by doing" because it recognizes that knowledge about river systems and wildlife habitat is site specific with many unknowns, so prescriptions for mitigating historical impacts require flexibility and innovation. The PRRIP is led by a Governance Committee representing the affected States, the FWS, USBR, downstream water users, environmental interests, major water providers, and hydropower interests. By design, this diverse group is forced to work with one another on water, land, technological, and financial issues related to habitat restoration on the Platte. This collaboration was made official in 2006 through a Cooperative Agreement, committing them to work together at least through the First Increment of the PRRIP.

The First Increment refers to the land and water acquisition goals established for the PRRIP by the Governance Committee for the period 2007 through 2019. These goals include 10,000 acres of critical habitat acquisition and 130,000 to 150,000 acre-feet of water aimed at reducing shortages to target flows through critical habitat areas at critical times. To date, the land acquisition goals have been met and approximately 90,000 acre-feet have been acquired through measures in Colorado, Wyoming, and Nebraska. Plans are in place to develop the additional water supplies but will require additional time to fully implement. As a result, stakeholders are currently negotiating an extension to the First Increment. At the end of this period, a Second Increment is planned which will gage the previous success in re-establishing critical habitat and take additional measures as necessary to create and maintain additional habitat lands.

The "divorce is not possible" portion of Freeman's observation addresses the potentially dire economic consequences that might have resulted if the PRRIP hadn't evolved or, alternatively, if it breaks-up during the First Increment and the FWS re-imposes pre-PRRIP mitigation requirements for water projects in the Platte River basin. This analysis will quantify these consequences and compare them to actual and estimated future PRRIP expenditures through the First Increment. The difference in these costs can reasonably be attributed to the existence of the PRRIP, which utilizes the scientific concept of adaptive management.

The following sections will develop:

5. A non-PRRIP scenario that describes the major components of the economic impact of ESA compliance and estimates their magnitude through 2032;
6. A PRRIP scenario that describes and quantifies the economic impact of accomplishing the land and water acquisition goals of the First Increment through 2032;
7. A comparison of the economic impact of (2) v. (1), whose difference represents the net benefit of the PRRIP;
8. Conclusions from the economic analysis.

[2] Freeman, David M., "Implementing the Endangered Species Act on the Platte Basin Water Commons". University of Colorado Press. 2010.

Description of a No Platte River Recovery Implementation Program Scenario

A lack of collaboration among the Platte River stakeholders resulting in no PRRIP would have likely continued the historic FWS policies with respect to depletions and resulting mitigation requirements. Those impacted would include those who increase or adversely modify depletions in the Platte River basin covering a wide range of public and private activities. Most notably in the near term, proposed new water projects along the Northern Colorado Front Range and the Denver region, such as Denver Water's Gross Reservoir expansion, Northern Colorado Water Conservancy District's Windy Gap Firming and Northern Integrated Supply Project (NISP) would likely have been faced with uncertain, but substantial, mitigation requirements. However, in addition to these major water providers, a No-PRRIP scenario would have stymied the pace and significantly increased the cost of a wide range of smaller, local projects beyond the Colorado Front Range.

The majority of projects affecting depletions and requiring Section 7 consultations, Biological Opinions (BO), and possible mitigation are small projects involving federal agencies or containing a federal nexus. These projects might include mining and energy development, dust abatement for roadway projects, livestock watering systems, changing the location of a diversion, and many other possible actions temporary or permanent in nature. The cost of environmental compliance as measured in time needed for approval and the cost of mitigation would be significantly higher.

Beyond the immediate needs of municipal providers, impacts to other water users arise over time. Federal Energy Regulatory Commission (FERC) mitigation requirements for re-licensing hydro-power contracts with CNPPID and NPPD facilities would likely be more conservative with respect to maintaining critical habitats. Federal power production at hydro-facilities in the North Platte basin would likely be altered to increase water available for maintaining downstream flows. Also, as water service contracts expire, Wyoming and Western Nebraska irrigators using Bureau of Reclamation North Platte projects would likely see reductions in irrigated acreage as a portion of their historic supply is reallocated towards habitat in Central Nebraska.

In addition to the above impacts, Nebraska irrigators are required to comply with LB 962 under either a No-PRRIP scenario or with the PRRIP. LB 962 established a process through the Nebraska Department of Natural Resources to declare a river basin fully- or over-appropriated and to work with the local Natural Resource Districts to prepare integrated groundwater/surface water management plans. A major component of these plans involve retirement of currently irrigated lands in proximity of the Platte River. Although LB 962 is implemented with or without the PRRIP, the PRRIP should accelerate the pace of irrigated land retirement and move these potentially adverse impacts into the nearer term.

Description of Potential Impacts and Assumptions

Impacts of the No-PRRIP scenario will accrue to different types of water users and by geographic regions. Geographic regions include the states of Colorado, Nebraska, and Wyoming. The federal government will also experience impacts that would be distributed on a National basis.

Table 1 identifies the types of impacts that would have likely occurred in absence of the PRRIP, major assumptions used to analyze their impacts, and the geographic area experiencing the impact. More detailed descriptions of the major assumptions are contained in Appendix A.

Table 1. Components of ESA Compliance in the Platte River Corridor Without the PRRIP		
Type of impact	**Major analytical assumptions (see Appendix A)**	**Geographic area impacted**
Longer, more expensive Biological Opinions and Section 7 Consultations relative to PRRIP's Tiered Process	Longer consultations without the PRRIP, 50% longer as measured in months; larger projects even greater time and cost relative to No-PRRIP scenario	All States and some federal agencies, but primarily high growth areas, such as Northern Colorado Front Range.
Mitigation associated with BO's and Consultations; water and land requirements	A wide range was considered: on the high end, 417,000 acre-feet of water supply and 29,000 acres of habitat land were assumed; on the low end, 130,000 acre-feet and 10,000 acres of habitat land.	Same as above.
Potential reductions in irrigated acreage for North Platte Project irrigators	Approximately 56,000 acres of surface water irrigated lands in the Nebraska Panhandle and southeastern Wyoming are either converted to dryland production or fallowed. Direct and indirect impacts are considered, as well as local property tax impacts.	Nebraska fallows 48,000 acres in the Panhandle, Wyoming fallows approximately 8,000 acres.
Potential modification of FERC licenses at Nebraska CNPPID and NPPD facilities, requiring additional mitigation and operational changes	A collective impact of $35 million is initially assumed, consisting of the NEPA process, mitigation, and other costs. Annual O&M for mitigation is assumed to be $2 million	Nebraska
Potential changes in hydropower production at North Platte facilities in Wyoming	Hydropower impacts for USBR North Platte facilities relative to 2006 conditions, were updated from the PRRIP EIS ("Full Water Leasing" alternative). Impacts for CNPPID and NPPD facilities are considered above.	Federal, Bureau of Reclamation
Reductions in Nebraska groundwater irrigation due to LB 962	Approximately 72,000 acres of groundwater irrigated lands in hydrologically connected areas are assumed converted to dryland production over a 10-year period. Direct and indirect impacts are considered, as well as local property tax impacts.	Nebraska

Description of the PRRIP Scenario

The PRRIP Scenario's impacts focus upon:

- Use of tiered, or streamlined, Section 7 consultations, as allowed by the FWS due to the existence of the PRRIP.
- PRRIP's expenditures to date and planned expenditures through the First Increment

- States' expenditures on the Tamarack Project, Pathfinder Dam modification, and Environmental Account as components of meeting First Increment goals.
- Hydropower impacts in the North Platte basin.
- An acceleration of the LB 962 impacts in Nebraska.

The major characteristic PRRIP is that it provides evidence of collaboration between the ESA stakeholders along the Platte River system and a financial commitment to achieving habitat goals through an incremental adaptive management approach. With this commitment, the FWS has eased their initial mitigation requirements of 417,000 acre-feet of additional water and 29,000 acres of habitat land to 130,000 to 150,000 acre-feet and 10,000 acres. It allows for orderly depletions for each State with mitigation costs included in each State's annual PRRIP cost share. As importantly, it allows for a tiered Section 7 consultation process through the use of a programmatic Environmental Impact Statement and project-specific components to streamline the Section 7 consultation process, saving time and money. In Colorado, entities participating in South Platte Water Related Activities Program, Inc. (SPWRAP) benefit from this streamlined process.

The PRRIP expenditures are financed through cost sharing of cash contributions between the States and federal government as follows:

- Colorado, 12.82%
- Wyoming, 3.21%
- Federal government, through the Bureau of Reclamation, 83.97%

Nebraska's share does not include cash and is paid in-kind through the land and water impacts to the State.

Table 2 summarizes the impacts considered, the major assumptions behind them, and the geographic area experiencing the impact.

Table 2. Components of ESA Compliance in the Platte River Corridor With the PRRIP

Type of impact	Major analytical assumptions (see Appendix A)	Geographic area impacted
Tiered, accelerated Biological Opinions and Section 7 Consultations	Shorter time frames for BO and consultations	All States and some federal agencies, but primarily high growth areas, such as Northern Colorado Front Range.
Adaptive Management through the PRRIP	These costs are assumed to be the actual PRRIP expenditures 2007-2016, with future expenditures through 2032 as estimated by the PRRIP ED Office.	Cost obligation is based on shares: 12.82% paid by Colorado 3.21% paid by Wyoming 83.97% paid by Federal government; Nebraska's payment is in the form of land and water.
Reductions in Nebraska groundwater irrigation due to LB 962	Approximately 72,000 acres of groundwater irrigated lands in hydrologically connected areas are assumed converted to dryland production over a 10-year period.	Nebraska
Potential changes in hydropower production	Hydropower impacts for USBR North Platte facilities and Nebraska facilities, relative to 2006	Federal

at facilities in Wyoming and Nebraska	conditions, were updated from the PRRIP EIS ("Governance Committee" alternative).	

Development of the Analysis

This analysis considers a time frame from 2007 through 2032, corresponding to the PRRIP's First Increment of 2019, with an extension to 2032. Annual expenditures for ESA compliance are tracked over these years for a No-PRRIP scenario and for a PRRIP scenario, with their present values are compared from a 2007 viewpoint. Consistent with established water project evaluation guidelines, inflation is assumed to be zero and expenditures are discounted at a real, inflation-free rate. For this analysis, the discount rate is assumed to be 3%. It should be noted that activities associated with ESA compliance, with or without PRRIP, will continue past 2032, and some activities associated with the First Increment may take longer to complete.

Results of the Analysis

The results of the analysis are initially presented at a Program-wide level to assess its overall net benefit. Impacts by State are presented after the Program-wide impacts.

System-Wide Results

Year by year results for each category of impact are shown in Appendix B, Table B-1. These estimates form the basis for the present values shown below. Their totals are shown graphically in Figure 1, which shows that No-PRRIP expenditures would exceed PRRIP expenditures in every year of the analysis. Costs incurred under the No-PRRIP scenario would primarily borne by entities within each state, ultimately being paid by water providers, water users through rates and fees, and by local taxpayers. Expenditures with the PRRIP in place are primarily borne by the federal taxpayers, with the states contributing funds as per their cost shares and through specific projects benefitting the river system.

Figure 1. Estimated Expenditures for ESA Compliance With and Without the PRRIP

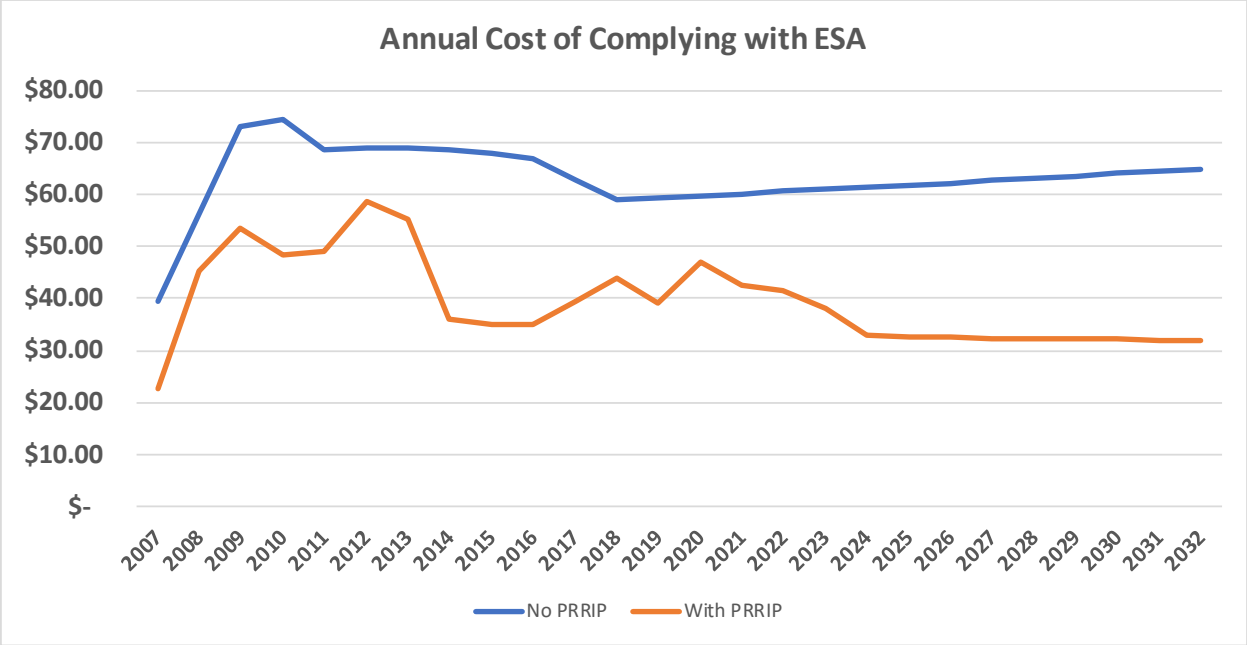


Table 3 indicates these estimates translate to a present value of about $1.1 billion under the No-PRRIP scenario and about $690 million with the PRRIP. This results in a net benefit of about $400 million over the period 2007 through 2032.

Table 3
Results of the Impact Analysis, Program-Wide

Net present value, 2007-2032, 3% discount, in millions	Without PRRIP	With PRRIP
Biological Opinion and Section 7 Consultation Cost	$10.96	$5.96
Mitigation costs, water and land	$325.73	
Impacts to North Platte irrigators and region	$385.61	
Potential mitigation costs and operational changes for CNPPID and NPPD hydro-electric production	$60.84	
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Expenditures for Platte River Recovery Implementation Program		$221.32
Additional benefits		*tbd*
Totals	$1,109.90	$689.15

Table 4 summarizes impacts for the States and for the Federal component (*table will be in landscape in distributed draft*). It shows that estimates of net benefits of to each state are substantial in dollar amount and in relation to the costs of the No-Program Scenario. The Federal component, however, does not experience this net benefit.

Table 4
Results of the Impact Analysis by State

Present value of expenditures, 2007-2032 (million)	Colorado		Wyoming		Nebraska		Federal	
	No PRRIP	PRRIP	No PRRIP	PRRIP	No PRRIP	PRRIP	No PRRIP	PRRIP
Biological Opinion and Section 7 Consultation Cost to Applicant	$ 7.67	$4.17	$0.55	$0.30	$0.55	$0.30	$2.19	$1.19
Mitigation costs, water and land	$228.01		$16.29		$16.29		65.14669	
Impacts to North Platte irrigators and region			$52.53		$333.08			
Potential mitigation costs and operational changes for CNPPID and NPPD hydro-electric production					$60.84			
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Tamarack and Pathfinder expenditures, inc, other State contributions		$ 16.60		$5.43				
Expenditures for Platte River Recovery Implementation Program		$28.37		$7.10				185.8452
Additional benefits								
Totals	$ 235.69	$49.14	$69.36	$12.83	$749.50	$455.75	$55.35	$171.42
Net present value of PRRIP	$ 186.55		$ 56.53		$ 293.74		$ (116.07)	

Uncertainty and Sensitivity of the Results

The results presented above are products of assumptions developed in the analysis and those borrowed from previous studies. With the exception of actual PRRIP expenditures to date, all of the assumptions are highly uncertain because of the unique nature of the Platte River issues, uncertain future mitigation requirements, uncertain agricultural crop prices, and the resulting lack of historical data trends to rely upon. As a result, many of the assumptions were bracketed by ranges, presented in Appendix A, in order to see if there are combinations of uncertainties that might result in the No-PRRIP Scenario being preferred to the PRRIP Scenario. The brief answer is no, there is very low probability that the No-PRRIP would ever be preferred. A Monte Carlo simulation analysis of these uncertainties indicated that this probability was less than 5%. The use of Monte Carlo simulation to test the sensitivity of the results is described in Appendix C.

Conclusions

Despite the significant uncertainties surrounding the economic impacts estimated in this analysis, it appears conclusive that the PRRIP and its adaptive management framework is a far less expensive approach for providing habitat for Threatened and Endangered species than less flexible mitigation policies in the Platte River basin. On a region-wide basis, its benefit is estimated to be over $400 million over the period 2007 through 2032. The benefit may be higher or lower, but it is nearly always greater than a No-PRRIP approach.

For the three States participating in the PRRIP, the benefits are qualitatively similar as for the region. All States experience high levels of net benefit, both in dollar terms and in proportion to the funds they spend. There is tremendous economic incentive for them to participate in the PRRIP and maintain the Program.

Although these economic results are not applicable to the Federal component of the PRRIP, the FWS benefits from the demonstration that collaboration and adaptive management can work to improve habitat conditions and reduce costs while using sound scientific approaches. This should be a valuable case study for the FWS moving forward with this sort of ESA recovery approach.

Additional Benefits

Although the above analysis attempts to “hit the high points” with respect to identifying benefits and costs ESA compliance in the Platte River basin, there are a wide range of indirect impacts, both adverse and positive. Impacts to rural communities due to removal of irrigated land from production, or from conversion to dryland production, has been accounted for the analysis through multiplier effects and through analysis of local property tax impacts. However, indirect impacts due to incrementally higher household costs in the three states, such as higher monthly water charges due to a No-PRRIP scenario, or taxes for urban consumers, have not been considered.

However, there are several areas in which the PRRIP has provided indirect benefits that have not yet been incorporated into this analysis:

- Benefits from increased recreation and tourism due to improved river conditions. Recreation is a major industry along the Platte River in Nebraska and the well-known annual Sandhill Crane and Whooping Crane migration attracts thousands of birdwatchers to the critical habitat areas. A recent study estimated that the annual Crane migration contributes about $14.3 million

annually to the Central Nebraska economy and supports about 182 jobs[3]. These types of benefits predate the PRRIP, but it's certain that the PRRIP's contributions to improving the river channel and riparian conditions has increased the dollar estimate significantly compared to a No-PRRIP scenario.

- As mentioned above, the PRRIP has made significant contributions improving the river channel controlling invasive plant species in the river, such as Phragmites. The PRRIP continues these efforts despite diminishing State and local contributions, providing indirect benefits to local irrigators through and other local water users.
- The PRRIP's contribution to the scientific community through the use Adaptive Management should not be minimized. The PRRIP has demonstrated that the concept can work without fears of exorbitant costs and within a finite time frame. It has been demonstrated that this concept can, in fact, reduce costs of ESA compliance.

Conclusions in the Context of the Likely Status of the Species in 2032

Economics aside, a logical question is whether the T&E species are better off with the PRRIP than without it? Possibly the No-PRRIP mitigation measures would have been as successful as the PRRIP's adaptive management approach, but a far higher price. Overall, one can state that with certainty that the species are no worse off with the PRRIP than without it and it's highly likely that the species are much better off.

Tern and plover habitat improvements have been because of PRRIP management on sandpits, although verifying that improvements in Whooping Crane numbers are exclusively due to the PRRIP would be difficult. The main difference is management related – under the No-PRRIP, the FWS would have likely force much more water down the river with an uncertain result, and without the benefit of the PRRIP's adaptive management framework to see if the management action was effective. The most important message is more expensive water would have been used for the target species without the PRRIP, and without the breadcrumb trail between management actions and species responses that is the focus of science and adaptive management with the PRRIP.

[3] Dority, et al. "The Economic Impacts of the Annual Crane Migration on Central Nebraska - 2017". Prepared for the Iain Nicolson Audubon Center at Rowe Sanctuary, 2017.
http://files.constantcontact.com/e7ef339c001/920da855-ab6f-44b6-b393-64a51aedff6c.pdf

Appendix A Analytical Assumptions Used in the Analysis

Longer, More Expensive Biological Opinions Relative to a PRRIP Scenario

The FWS has conducted approximately 157 "Tiered Consultation Biological Opinions" since the creation of the PRRIP in 2007, averaging about 15 to 16 per year. Of these, a high percentage were, or are, for relatively small projects located in Colorado interspersed with a few large projects. Projects for federal facilities were the next largest category of BO's, with Nebraska and Colorado conducting much fewer. Table A-1 summarizes the assumed breakdown of past and future BO's. The proportions in Table A-1 were generally based on existing data, but may not precisely match because they are intended to be representative of longer-term proportions. It is assumed that there 15 new projects per year seeking a BO and Section 7 consultation through the period of analysis.

Table A-1
Biological Opinions Since 2007 in the Platte River Basin

Region or type of project	Proportion of Biological Opinions
Colorado, small projects	65%
Colorado, large projects	5%
Nebraska, all projects	5%
Wyoming, all projects	5%
Federal facilities	20%

Table A-2 and Table A-3 summarize the assumed cost for BO's and consultations for small and large projects, with and without the PRRIP, and also presents a plausible range they may lie within.

Table A-2
Assumed Biological Opinion and Section 7 Consultation Cost for Small Projects, With and Without the PRRIP

Without the PRRIP				
Component	**Expected value**	***Low range of estimate***	***Expected value of estimate***	***High Range of estimate***
Consultation time for typical project (months)	3	2	3	12
Cost per month	$10,000	$5,000	$10,000	$20,000
With the PRRIP				
Component	**Expected value**	***Low range of estimate***	***Expected value of estimate***	***High Range of estimate***
Consultation time for typical project (months)	2	1	2	3
Cost per month	$10,000	$5,000	$10,000	$20,000

Table A-3
Assumed Biological Opinion and Section 7 Consultation Cost for Large Projects, With and Without the PRRIP

Without the PRRIP				
Component	**Expected value**	***Low range of estimate***	***Expected value of estimate***	***High Range of estimate***
Consultation time for typical project (months)	12	3	12	24
Cost per month	$20,000	$10,000	$20,000	$25,000
With the PRRIP				
Component	**Expected value**	***Low range of estimate***	***Expected value of estimate***	***High Range of estimate***
Consultation time for typical project (months)	4	3	4	6
Cost per month	$15,000	$10,000	$15,000	$30,000

Mitigation Costs

- Without the PRRIP, mitigation costs are generally based on pre-PRRIP mitigation requirements, including acquisition of 29,000 acres of riparian habitat lands and 417,000 acre-feet of additional water during to augment flows. For purposes of this analysis, the following assumptions are implemented:
- The FWS would have reduced the 417,000 acre-feet estimate as more information is acquired regarding flows and habitat, regardless of the PRRIP. It is assumed they would have required about 150,000 of acre-feet of additional water for augmenting flows. This figure may range from 120,000 acre-feet, what is currently the proposed requirement for the PRRIP, to the original target of 417,000 acre-feet. Despite the assumed reduction in the No-PRRIP mitigation requirement, there would not likely be collaboration among the range of stakeholders in developing these supplies. Also, the First Increment projects, including Pathfinder Dam modification, the Tamarack recharge project, and the Environmental Account in Lake McConaughy, would not likely exist without the PRRIP.
- The effective cost of mitigation water is assumed to be $3,000 per acre-foot, reflecting its value for irrigation. This price may be as low as $2,500 per acre-foot to $3,500 per acre-foot. This assumption is conservative on the low side given recent transactions of C-BT shares and other Front Range irrigation supplies converting to M&I usage. The real cost of water, aside from inflation, is assumed to increase at a rate of 2% per year, reflecting its relative scarcity over time.
- FWS mitigation requirements for habitat land is assumed to be 29,000 acres, the same as before the PRRIP. The cost of land is assumed to be $3,500 per acre, based on dryland cropland values.

- Annual O&M for water mitigation projects is assumed to be $10 per acre-foot per year. For habitat lands, O&M is assumed to be 2% of the land's cost.

Reduced Irrigated Acreage in the North Platte Basin

It is assumed that some proportion of federal water under Bureau of Reclamation water service contracts would be reallocated for instream purposes. There are estimated to be about 335,000 acres irrigated with under either full service contracts (226,000 acres), with the balance under supplemental service contracts. About 280,000 of these acres are delivered by three irrigation districts in Nebraska and the balance is delivered to Wyoming irrigators.

- Based on the HDR analysis of potential Platte River impacts to Nebraska, it was assumed that 48,000 acres of surface water irrigated lands in Western Nebraska and about 8,000 acres of irrigated lands in Wyoming would be fallowed without the PRRIP.[4]
- Enterprise farm budget analysis estimates that the foregone profits due to this reduction in water availability may range from $135 to $350 per acre depending on crop prices considered. Based on a 10-year average of crop prices, 2005 through 2015, the farm-level impact is about $196 per acre for converting an irrigated acre to dryland in this region. Considering foregone regional economic impacts and property tax impacts, the short term estimated impact is near $650 per acre, decreasing to a longer-term impact of near $2409 per acre as local economies adjust.

LB 962 Impacts

Impacts of LB 962 to Nebraska irrigators are qualitatively similar to those described above for the North Platte irrigators. Rather than surface water, retirement of groundwater irrigated acreage is assumed and the acres revert to dryland production rather than go fallow.

- Based on the HDR analysis of potential Platte River impacts to Nebraska, it was assumed that 72,000 acres of groundwater irrigated lands in Central Nebraska would be retired with or without the PRRIP.
- Enterprise farm budget analysis estimates that the foregone profits due to this reduction in water availability may range from $110 to $270 per acre depending on crop prices and dryland yields considered. Based on a 10-year average of crop prices, 2005 through 2015, the farm-level impact is about $194 per acre for converting an irrigated acre to dryland in this region. Considering foregone regional economic impacts and property tax impacts, the short term estimated impact is near $500 per acre, decreasing to a longer-term impact of near $2409 per acre as local economies adjust.

Modification of FERC Licenses for CNPPID and NPPD Facilities

Collective mitigation costs for Nebraska power providers is assumed to be $35 million, which includes the NEPA process, mitigation costs, and the present value of possible foregone production. This is based on results of the 2006 HDR study, updated for inflation. These costs are highly uncertain and could range from $13 million to $90 million. Annual O&M for mitigation is assumed to be $2 million.

[4] HDR Engineering. *PRRIP: Economic Impacts to the State of Nebraska*. Prepared for the Central Platte NRD. October, 2006. Estimated reduction in irrigated land in Wyoming is assumed proportional to that in Nebraska in terms of fallowed acreage to total irrigated acreage.

Hydropower Impacts at Bureau of Reclamation Facilities in the North Platte Basin

These estimated impacts are assumed to be the same as described in the PRRIP's Environmental Impact Statement, Hydropower Appendix, updated for inflation.[5] The Hydropower Appendix estimated that value of North Platte hydropower would increase by approximately $466,000 per year with the PRRIP relative to a No-PRRIP condition.

[5] Hydro-Power Appendix, USBR EIS for the PRRIP. (Need better citation)

Appendix B Annual Impact Estimates for the No-PRRIP and PRRIP Scenarios

Appendix C Assessing the Impact of Uncertainties Using Monte Carlo Simulation

An initial assessment of the high uncertainty associated with many of the assumptions in economic impact estimates resulted in an additional task of conducting a risk assessment of the results. Its purpose was to see to what degree these risks might affect results and conclusions about the relative impacts of the No-PRRIP and PRRIP scenarios. However, a preliminary Monte Carlo-based risk analysis of the major uncertain variables revealed that although there was significant uncertainty, there was very little probability, less than 1%, that these uncertainties would lead to erroneous conclusions. As a result, less emphasis has been put on this risk analysis than initially anticipated and it has been relegated to an appendix of this report.

Despite the reduced role of the risk assessment, this appendix presents assumptions and results in the assessment to demonstrate the degree of confidence the analysis has in its results. Given this reduced role, there is little discussion of the use and benefits of Monte Carlo simulation beyond discussion in the the following section. Following this

Monte Carlo Simulation

Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values—a probability distribution—for any factor that has inherent uncertainty. It then calculates results over and over, each time using a different set of random values from the probability functions. Depending upon the number of uncertainties and the ranges specified for them, a Monte Carlo simulation could involve thousands or tens of thousands of recalculations before it is complete. For this analysis, 10,000 recalculations were specified. Monte Carlo simulation produces distributions of possible outcome values.

By using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a much more realistic way of describing uncertainty in variables of a risk analysis. Common probability distributions might include:

- The normal, bell-shaped distribution that is the basis for parametric statistics.
- Triangular distributions for which low, most likely, and high bounds are specified. These distributions can approximately about any shape, albeit imprecisely.
- Log-normal and other classes of non-normal distributions. These distributions may cover a wide range of shapes more precisely than a triangular distribution but require increasingly more calculation capacity as the mathematics become more complex.

The preliminary analysis conducted here assumed triangular distributions for the random, or uncertain, variables in the analysis.

Identification of Uncertain Variables

Table C-1 identifies the variables assumed to be random, or uncertain in the analysis.

- The Expected values identified in Table C-1 represent the current best estimate of the variable's value.
- Low, most likely, and high values identify the parameters of the assumed triangular distributions
- For this analysis, it was assumed that the expected value was equal to the most likely value, or the peak, of the triangular range. This simply means there is no reason believe that the expected value would not be the most probable.

Table C-1
Uncertain Variables and their Assumed Ranges

Variable description	Units	Expected value	Possible range Low	Most likely	High
Acre-feet of water required for ESA mitigation, No-PRRIP	acres	150,000	120,000	150,000	417,000
Cost of water	$/acre-foot	$ 3,000	$ 2,500	$ 3,000	$ 3,500
Acreage reduction due to LB 962, groundwater irrigators in Central NE	acres	72,000	48,000	72,000	96,000
Direct impacts to irrigators	$/acre	$ 194.00	$ 126.00	$ 194.00	$ 350.00
Acreage reduction for NE Panhandle irrigators	acres	48,000	24,000	48,000	72,000
Direct impact to irrigators	$/acre	$ 196.00	$ 126.00	$ 196.00	$ 350.00
FERC relicensing for CNPPID and NPPD, NEPA cost	$	$ 10,000,000	$ 2,000,000	$ 10,000,000	$ 30,000,000
FERC relicensing for CNPPID and NPPD, mitigation cost	$	$ 20,000,000	$ 10,000,000	$ 20,000,000	$ 50,000,000
Other relicensing costs	$	$ 5,000,000	$ 1,000,000	$ 5,000,000	$ 10,000,000
Mitigation O&M	$	$ 2,000,000	$ 1,000,000	$ 2,000,000	$ 5,000,000
Section 7 consultation cost for typical project, No-PRRIP	$/month	$ 10,000	$ 5,000	$ 10,000	$ 20,000
Section 7 consultation time for typical projects, No-PRRIP	months	3	2	3	12
Section 7 consultation cost for large projects, No-PRRIP	$/month	$ 20,000	$ 10,000	$ 20,000	$ 25,000
Section 7 consultation time for large projects, No-PRRIP	months	12	3	12	24
Section 7 consultation cost for typical project, PRRIP	$/month	$ 10,000	$ 5,000	$ 10,000	$ 20,000
Section 7 consultation time for typical projects, PRRIP	months	2	1	2	3
Section 7 consultation cost for large projects, PRRIP	$/month	$ 15,000	$ 10,000	$ 15,000	$ 30,000
Section 7 consultation time for large projects, PRRIP	months	4	3	4	6

Correlation

Although the variables identified in Table C-1 are defined as random, they are not necessarily independent of one another other.

- It was assumed that direct impacts to surface water irrigators in the North Platte region would be positively correlated to direct impacts to groundwater irrigators in the Central Platte region. This implies that if impacts to one type of irrigators is high, either due to high crop prices or high yields, it's likely high for all other irrigators; if impacts are low for one, they are likely low for all.
- Costs related to FERC relicensing are also assumed to be positively correlated. If NEPA costs are high, mitigation costs are likely to be high.
- Section 7 consultation costs are assumed to be randomly independent and not correlated to other costs.

- Mitigation acreage and the cost of mitigation water are also assumed to be randomly independent.

Results of Monte Carlo Simulation

The economic impact model examined 10,000 probability-weighted combinations of the uncertain variables in order to compare the results of a No-PRRIP scenario and the PRRIP. The results of the analysis are shown in the form of a frequency analysis of the two scenarios (Figure C-1). Figure C-1 shows that cost of ESA compliance with the PRRIP is distributed somewhat narrowly around its expected value of around $689 million. The cost for this scenario may vary, but not as much the variability around the approximately $1.1 billion estimated cost of the no-PRRIP scenario. As can be seen the figure, it appears probable that the actual cost of the no-PRRIP scenario will be higher than $1.1 billion, most likely in the range of $1.2 to $1.3 billion.

The two distributions in Figure C-1 only overlap in a very small area near the $900 million value, indicating there is very low probability the No-PRRIP scenario has fewer economic impacts. This probability is less than 1%.

Figure C-1. Comparison of the Economic Impacts, With and Without the PRRIP

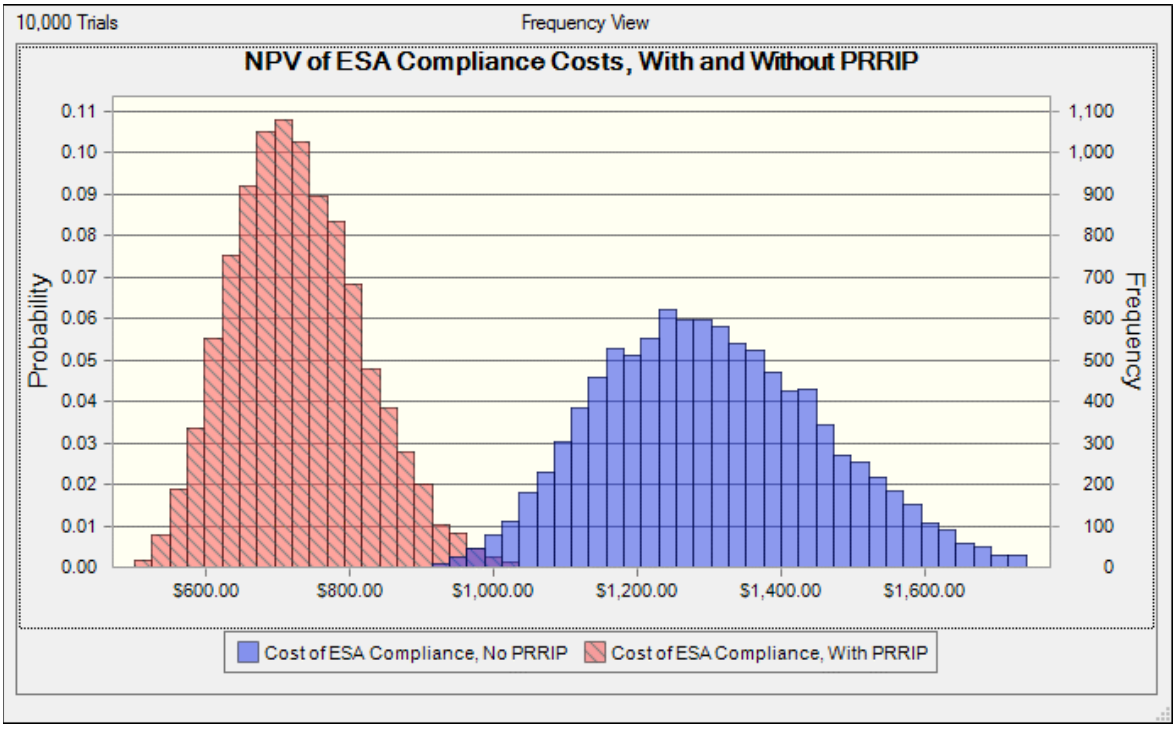
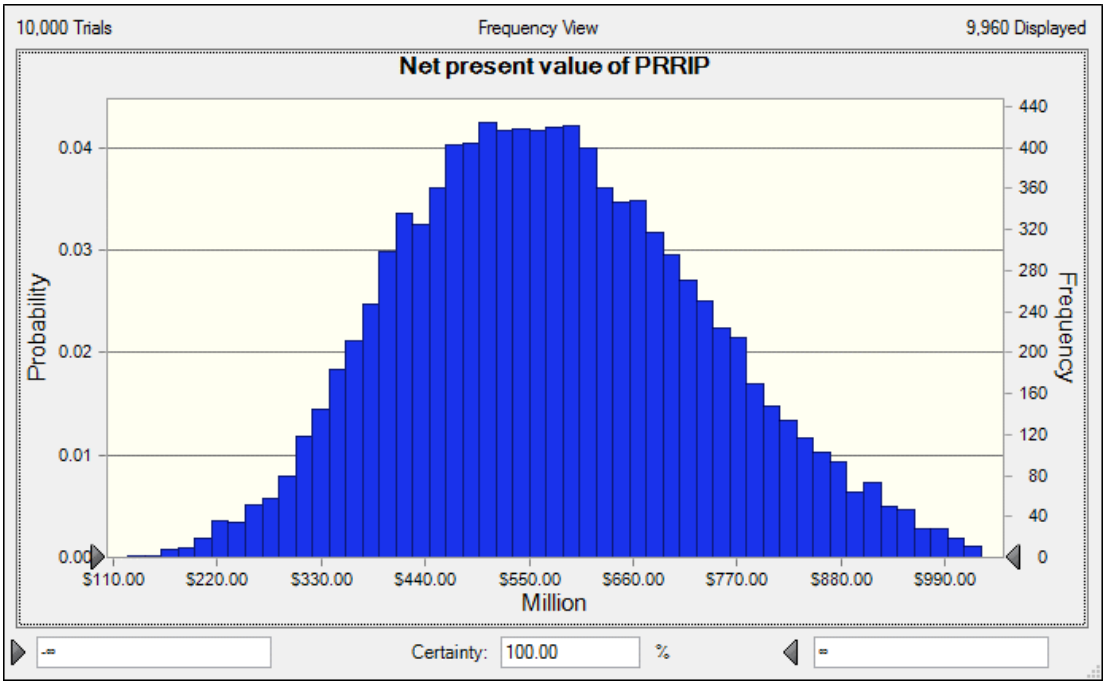


Figure C-2 shows the distribution of the net benefit of the PRRIP, the difference between the No-PRRIP scenario and the PRRIP. The expected value of this difference was approximately $400 million, but as can be seen from Figure C-2, $400 million is on the lower end of this frequency distribution. This means that it is much more probable that net benefits will be higher than $400 million than below it.

If all assumptions were normally distributed, the results would be normally distributed and there would be about a 50-50 chance that the actual benefit would be higher or lower than the expected value, $400 million. However, some of the triangular distributions assumed for the analysis, whose parameters are summarized in Table C-2, are skewed. That is, they are not symmetric around the most likely value. A good example of this is acre-feet needed for mitigation under the No-PRRIP scenario. The low and most likely values are assumed to be 120,000 acre-feet and 150,000 acre-feet, respectively. The high value is assumed to be 417,000 acre-feet, skewing the distribution to towards higher acre-feet values. Assumptions with these characteristics combine to skew the overall results in a similar direction.

Figure C-2. Frequency Distribution Around PRRIP's Net Benefit



Uncertainties around the acre-feet needed for mitigation and the acreage retired from irrigation in the Nebraska Panhandle tend to drive the overall variability of the No-PRRIP impact estimates. This is shown in a contribution to variance summary shown in Figure 3.

There is much less uncertainty with the PRRIP scenario. The main contributors towards uncertainty with the PRRIP are focused upon the LB 962 impacts in Nebraska, specifically the amount of acreage reduced and the profitability of those acres (Figure C-4).

Figure C-3. Contribution to Variance, No-PRRIP Scenario

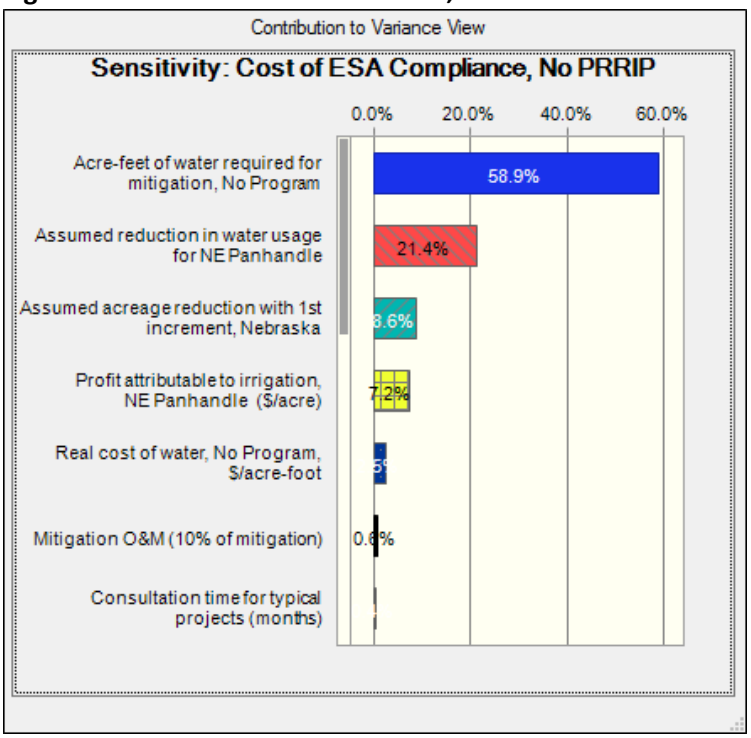


Figure C-4. Contribution to Variance, PRRIP Scenario