FINAL

CNPPID J-2 REREGULATING RESERVOIR FEASIBILITY REPORT

PREPARED FOR

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MAY 1, 2012

OLSSON ASSOCIATES

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

BLACK & VEATCH

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EXECUTIVE SUMMARY

Purpose and Objective

The primary goal of the Platte River Recovery Implementation Program (PRRIP or Program) is to support the recovery of four threatened or endangered species: the interior least tern (*Sternula antillarum*), piping plover (*Charadrius melodus*), whooping crane (*Grus americana*), and pallid sturgeon (*Scaphirhynchus albus*) within the Platte River corridor.

The PRRIP Water Advisory Committee (WAC) compiled previous studies and directed the production of Water Management Study (WMS) Phase I and Phase II reports for the evaluation of augmenting short duration high flows (SDHF) and target flows. Phase I concluded that additional storage is needed near the associated habitat to help achieve SDHF objectives. The WMS Phase II Report screened and evaluated three project concepts: re-operation of the existing Elwood Reservoir, creation of a Plum Creek Reservoir, and creation of reregulating reservoirs.

Olsson Associates analyzed and developed alternatives for the concepts of re-operation of the existing Elwood Reservoir, and/or creation of a J-2 reregulating reservoir for the augmentation of SDHFs and target flows, along with capability to mitigate hydropower flow cycling to the Platte River to the extent that it does not negatively affect the ability to meet the Program SDHF and target flow goals. The study was documented in the report *Elwood and J-2 Alternatives Analysis Project Report* dated February 18, 2010. The study is also referred to as the "pre-feasibility" or "conceptual study" since conceptual design of the alternatives was completed.

One of the criteria on which the alternatives were evaluated was the volume of reservoir releases used to reduce U.S. Fish and Wildlife Service (USFWS) target flow shortages. This volume, referred to as "yield," was modeled for the various alternatives. The recommended alternative, J-2 Alternative 2, Areas 1 and/or 2, was advanced to the feasibility stage of analysis. Alternative 2, Areas 1 and 2, which consisted of excavating storage in two locations south of the Platte River, was selected for advancement. Figure ES-1 shows the locations of Areas 1 and 2. The locations of the storage sites considered under Task 1 of the feasibility study are generally similar to the pre-feasibility study sites and would have similar features as discussed in the pre-feasibility study.

The primary objectives of this feasibility study were to investigate combined reservoir operations, develop and refine alternatives, and to provide feasibility-level design and cost estimates. As part of the project, a wetland delineation and a geotechnical investigation were conducted.

Investigation of Reservoir Combined Operations

Currently, releases to the Platte River from the J-2 hydropower plant operated by Central Nebraska Public Power and Irrigation District (CNPPID) fluctuate from zero to as much as 2,000 cubic feet per second (cfs) within an hour. The duration of flow released to the Platte River is a function of the amount of flow available to CNPPID on each day. A larger volume of water available equates to a longer duration of hydropower generation and a longer duration of releases to the Platte River. While hydrocycle mitigation is not a direct part of the Program, the hourly fluctuations of flow (hydropower cycling) are a concern of the USFWS (FERC, 2007), and CNPPID is interested in the potential for the reregulating reservoirs under consideration to be operated to provide mitigation. Hydrocycle mitigation would reduce or eliminate the large fluctuations in releases to the Platte River.

If it could be accomplished, full mitigation of the hydrocycle surge would result in a uniform release rate to the Platte River. As a reporting and accounting simplification, the hydrocycle mitigation modeling period was considered to be the 24-hour period of a calendar day, which resulted in the need to jump to a different flow at midnight. The volume of flow from day to day changes and, hence, the uniform release rate must likewise change from day to day. Hydrocycle mitigation is depicted in Illustration ES-1. The blue line indicates the flows released from the J-2 hydropower plant. The flows vary throughout the day, depending on whether the hydropower plant is on or off and the total volume of water available to be run through the plant on a particular day. The green line depicts the flows back to the Platte River without hydrocycle mitigation. Like the releases from the J-2 hydropower plant, the flows are variable throughout the day. The red line indicates the flows back to the Platte River with hydrocycle mitigation. Throughout a given day, the release to the river remains constant. Between days, the release rate changes since a different volume of water is available from day to day.

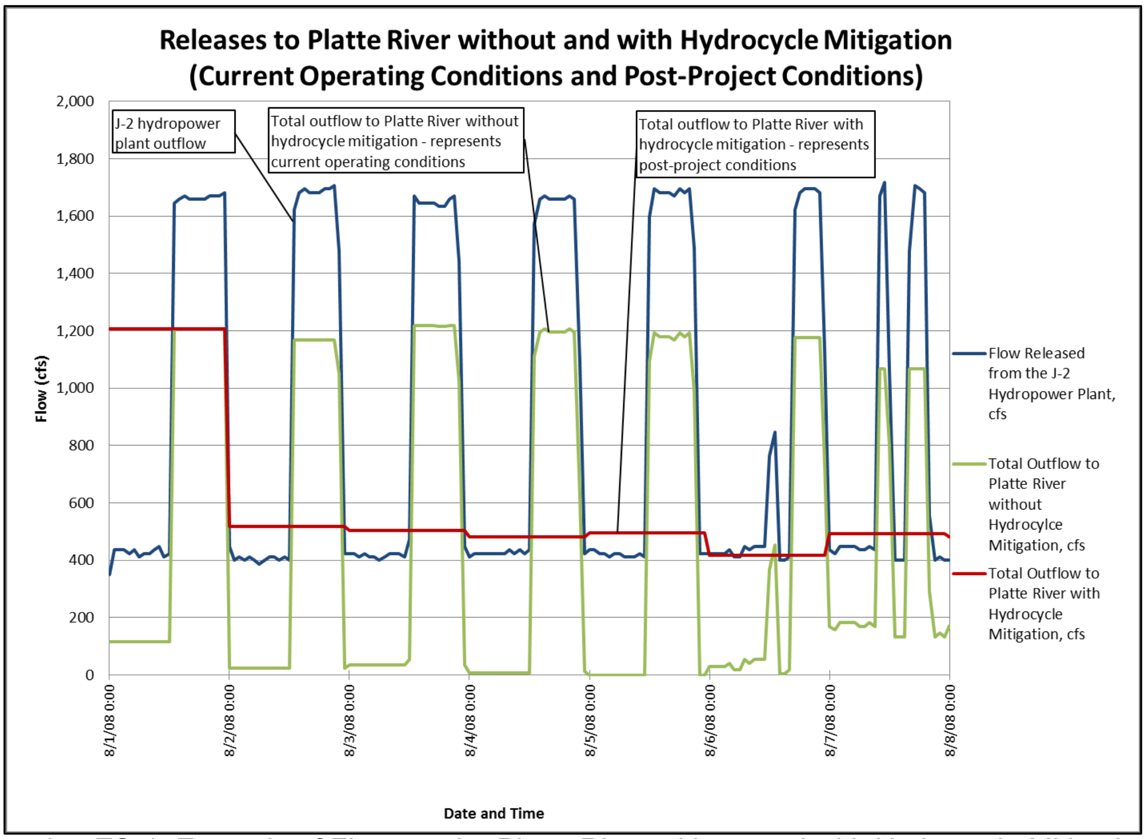


Illustration ES-1. Example of Flows to the Platte River without and with Hydrocycle Mitigation

An investigation of reservoir combined operations was conducted to evaluate whether Program target flow augmentation would be adversely affected by mitigating a hydrocycle surge by use of the proposed Area 1 and Area 2 storage sites identified in the pre-feasibility study.

The modeling for the combined goals of augmentation of target flow shortages and hydrocycle mitigation was done using CNPPID's preferred operation of the J-2 hydropower plant, which is more predictable and more efficient than the current mode of operation. In order to do that, a synthetic data set was developed by CNPPID to reflect preferred operations outside of the non-irrigation season. The modeling indicated that both objectives could be met with little reduction of yield for Program uses. When water is plentiful, both objectives can be fully met. When water availability is low, both objectives cannot be adequately met and special operational procedures must be used.

Use of Area 2 by CNPPID

CNPPID seeks to maximize hydroelectric power production during peak value times of the day during the irrigation season by using Area 2 to regulate flows for irrigation delivery. The desire is to pulse the flows out of the hydropower plant during the peak value times but meanwhile deliver a uniform flow rate in the Phelps Canal downstream of Area 2. The effect of removing Area 2 from Program use during the irrigation season on yield for reducing shortages to target flows was evaluated. The results of this analysis indicated that an average reduction in yield for the Program of 5.9% and 11.8% could result if Area 2 were simply eliminated from use during the irrigation seasons of June 15-August 31 and April 1-August 31, respectively.

Incremental Cost Analysis

After developing alternatives to maximize power production during peak operations and regulate flows for irrigation delivery at Area 2, the next step in the project was to determine how large Areas 1 and 2 should be. The storage volumes of Areas 1 and 2 were modified and evaluated to develop an incremental cost analysis with which to compare the different alternatives. Five options were developed, and four advanced to further evaluation – Options 1, 3, 4, and 5. The options represented different storage area configurations. Option 5 eliminated the pump station that would have increased the storage capacity of Area 2 by allowing water to be stored up to a higher elevation than could be achieved by gravity flow into Area 2. Eliminating the pump station decreased the available storage in Area 2. The results of the incremental cost analysis are shown in Illustration ES-2. Option 5 emerged as the most cost-effective alternative.

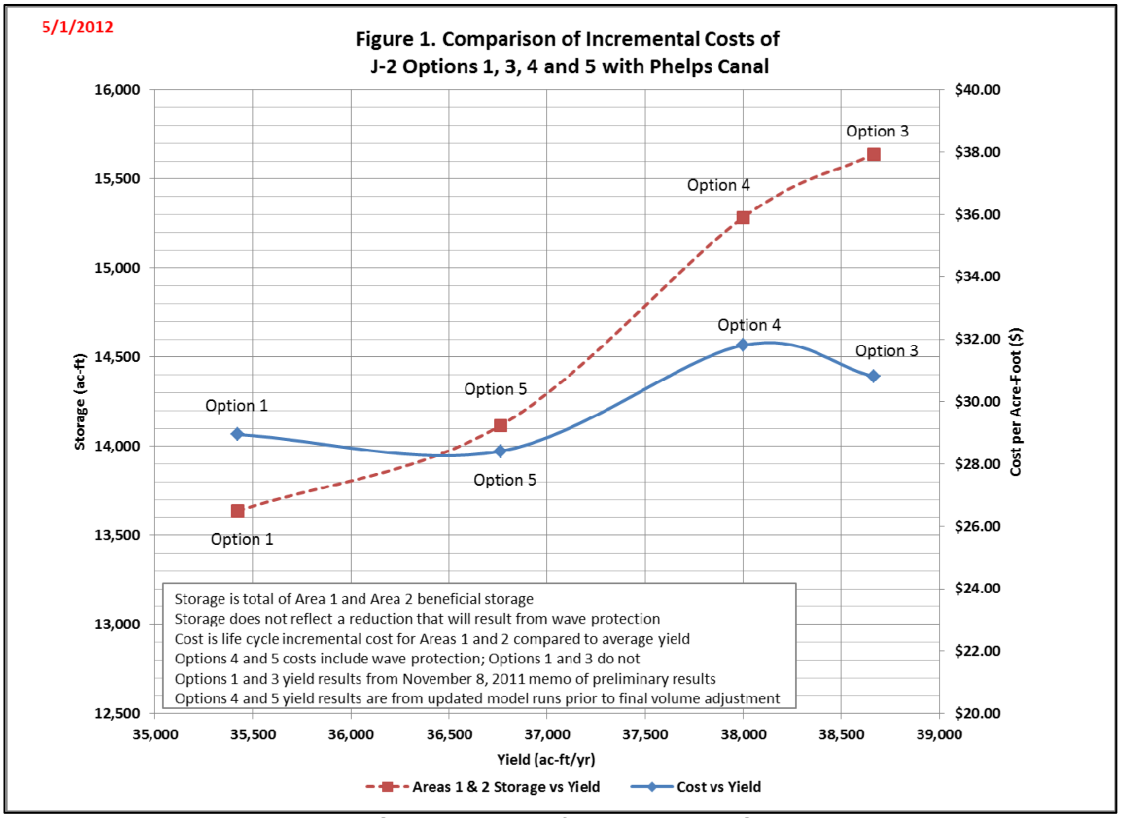


Illustration ES-2. Results of Incremental Cost Analysis

Program Yield

Throughout the process of developing and refining alternatives, continuous simulation modeling was conducted using the synthetic data in order to compare the effects of the various system configurations on yield for the Program. The average estimated Program yield for reducing shortages to target flows for Option 5 was approximately 37,000 acre-feet per year over the entire modeling period.

Phelps Canal Delivery System Upgrade

In order for CNPPID to be able to store and use the water passing through the J-2 hydropower plant while operating near peak efficiency, the Phelps Canal must be upgraded to convey 1,675 cfs. A larger Phelps Canal capacity has been shown to result in higher yield for the Program, providing more water for shortages to target flows. The improvements needed to convey 1,675 cfs with two feet of freeboard and a maximum water surface of 2358.0 at the entrance to Phelps Canal were analyzed. Improvements included the following:

- Raising the berms on either side of the canal in select areas to achieve two feet of freeboard.
- Replacing the existing Parshall flume with a larger one.
- Installing a second siphon pipe under Plum Creek.
- Widening nearly 7,000 linear feet of canal upstream of the siphon under Plum Creek.
- Installing new bridges over the Phelps Canal on Road 749 and on the farm access from Road 749 between Roads 436 and 437.
- Installing riprap bank protection along the outer bends of the canal, which could be prone to erosion with the increased flow.

Storage Areas 1 and 2 Feasibility-Level Design

Areas 1 and 2 were graded to achieve an earthwork balance between excavation of the storage areas and construction of berms around the storage areas so that expensive haul-off of excess material would not be needed. The footprints of Areas 1 and 2 are approximately 718 acres and 345 acres, respectively. Control gates will be needed at the inlets and outlets of Areas 1 and 2. An inline gate is also needed in Phelps Canal to regulate the water surface in the canal. Table ES.1 shows the selected gate sizes.

Table ES.1 Control Gates Size Summary

Location	Gate Type	Number of Gates	Gate Width, ft	Gate Height, ft
Area 1 Inlet	Sluice	3	12	10
Area 1 Outlet	Radial	1	20	28
Area 2 Inlet	Sluice	3	12	12
Area 2 Outlet	Radial	1	10	24
Phelps Canal	Radial	1	30	18

Geotechnical Considerations

A geotechnical investigation was undertaken to support the feasibility-level design of the storage areas and embankments. The key findings and recommendations follow:

- An evaluation of the adequacy of onsite soils revealed that collapsible soils were encountered below the embankments for Areas 1 and 2 in very limited locations. The collapsible material should be overexcavated and recompacted to remove the collapse potential of the soils.
- A stability analysis of the embankment slopes indicated that the embankments were stable under the analyzed conditions of steady seepage and rapid drawdown. A sand toe drain will be needed for both areas. The sand toe drain should be located at the river side edge of the embankment and should extend a minimum lateral distance of 27 feet into the embankment.
- A cutoff trench is recommended along the entire berm centerline for both areas.
- In order to manage the total potential seepage out of the bottom of the storage areas, a 12-inch compacted clay liner is recommended in the bottom of the storage areas.
- In order to prevent desiccation cracking of the clay liner, a dead pool of water is required. The compacted clay liner can either be covered by 12 inches of soil and 12 inches of water or it can be covered by 24 inches of water. Wave protection will be needed on the reservoir sides of the north and east embankments to prevent erosion due to wind.
- Due to uplift concerns outside of storage Area 1 in the northeast corner, alluvial clay soils that are present should be excavated along approximately 2,100 lineal feet of the river side toe. Additional geotechnical analysis will be needed during the preliminary design.

Permitting

The project was assessed for its compatibility with the Platte River Environmental Impact Statement (EIS) and was found to be compatible with the EIS. A wetland delineation was conducted to determine the extent of wetlands and other waters within Areas 1 and 2. Three wetlands and/or waters of the U.S. or state were identified in the project area. A jurisdictional determination needs to be made by the U.S. Army Corps of Engineers (COE) to determine whether the wetlands/waters are jurisdictional and will require a Section 404 permit from the COE. In order to satisfy requirements of the National Historic Preservation Act, an archeological investigation was conducted. Additional needed permits and approvals were identified and include approval from the Nebraska Department of Natural Resources (NDNR) dam safety group, storage and floodplain permits from NDNR, Federal Energy Regulatory Commission (FERC) approval, and construction-related permits.

Project Costs

Option 5, Areas 1 and 2 without a pump station and upgrade of Phelps Canal, is the recommended alternative. Cost estimates that include construction contingency, allowances for engineering design, permitting, legal and administration, construction management, and land acquisition were developed. Table ES.2 shows the estimated cost for Option 5.

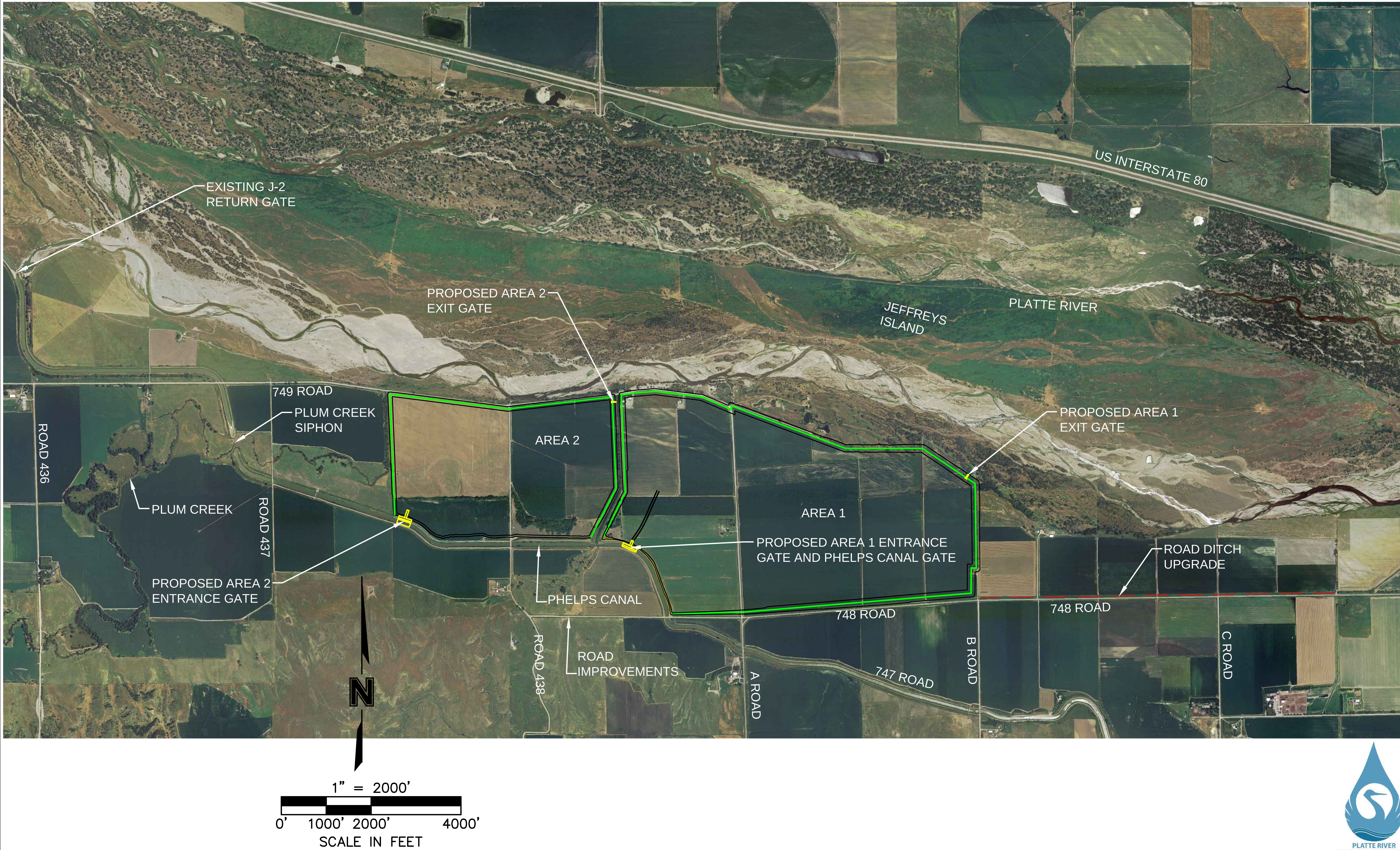
Table ES.2 Cost Summary for Option 5

Project Component	Probable Construction Cost Including 25% Contingency	Allowances	Land Acquisition	Construction Plus Allowances and Land Acquisition
Area 1	$21,113,815	$4,222,763	$3,472,000	$28,808,578
Area 2	$13,667,244	$2,735,449	$1,380,000	$17,792,693
Phelps Canal	$2,589,309	$517,862	$0	$3,107,171
Total	$37,380,367	$7,476,073	$4,852,000	$49,708,441

Conclusions

The following conclusions related to the overall purpose of the J-2 reregulating reservoirs project may be drawn from the analyses to date:

1. The J-2 reregulating reservoirs Areas 1 and 2 can feasibly be used by the Program to provide storage with which to produce a short duration high flow and to provide water for reduction of shortages to target flows.
2. If CNPPID uses Areas 1 and 2 for hydrocycle mitigation, only small reductions to Program yield are predicted to occur, assuming CNPPID implements its preferred operation of the J-2 hydropower plant.
3. If CNPPID uses Area 2 during the irrigation season of June 15-August 31 to regulate flows for irrigation delivery while maximizing hydroelectric power production during peak value times of the day, Program yield will be reduced approximately 5.9%.
4. It is recommended that Option 5, construction of Areas 1 and 2 without the Area 2 pump station plus upgrade of the Phelps Canal be advanced to preliminary and final design.



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PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

PROJECT: 009-1466 DRAWN BY: CRL DATE: 3.19.2012	J-2 REREGULATING RESERVOIR PROJECT LOCATION MAP GOSPER AND PHELPS COUNTIES, NEBRASKA	OLSSON ASSOCIATES BLACK & VEATCH	FIGURE ES-1

1.0 INTRODUCTION AND EFFORT TO DATE

1.1 Purpose and Objective

The primary goal of the Platte River Recovery Implementation Program (PRRIP or Program) is to support the recovery of four threatened or endangered species: the interior least tern (*Sternula antillarum*), piping plover (*Charadrius melodus*), whooping crane (*Grus americana*), and pallid sturgeon (*Scaphirhynchus albus*) within the Platte River corridor.

The PRRIP Water Advisory Committee (WAC) compiled previous studies and directed the production of Water Management Study (WMS) Phase I and Phase II reports for the evaluation of augmenting short duration high flows (SDHF) and target flows. The Phase I report (WMS Phase I, 2008) concluded that additional storage is needed near the associated habitat to help achieve SDHF objectives. The Phase I report also evaluated 13 projects identified in the Water Action Plan (WAP) for their potential contribution to the PRRIP flow targets. Under target flow operations, flows in excess of PRRIP target flows (excess flows) are stored and then released when flows are below the target flows (shortage). The WMS Phase II Report screened and evaluated three project concepts: re-operation of the existing Elwood Reservoir, creation of a Plum Creek Reservoir, and creation of reregulating reservoirs.

Olsson Associates was selected in July of 2009 to analyze the concepts of re-operation of the existing Elwood Reservoir, and/or creation of a J-2 reregulating reservoir for the augmentation of SDHFs and target flows, along with capability to mitigate hydropower flow cycling to the Platte River to the extent that it does not negatively affect the ability to meet the Program SDHF and target flow goals. The goal of the analysis was to develop and evaluate Central Nebraska Public Power and Irrigation District (CNPPID) reregulating reservoir alternatives for the existing Elwood Reservoir and potential new reservoirs in the vicinity of CNPPID's J-2 Return. The study was documented in the report *Elwood and J-2 Alternatives Analysis Project Report* (Alternatives Report) dated February 18, 2010. The study is also referred to as the "pre-feasibility" or "conceptual study" since conceptual design of the alternatives was completed.

In addition to alternatives relating to Elwood Reservoir, three J-2 return reservoir alternatives were evaluated during the pre-feasibility study. Alternative 1 consisted of constructing storage in the south channel of the Platte River; Alternative 2 consisted of excavating storage in one or more of four locations south of the Platte River, termed Area 1 through Area 4; and Alternative 3 involved construction of an embankment across an unnamed creek immediately upstream of the Phelps Canal siphon at canal mile station 9.7. The recommended alternative, J-2 Alternative 2, Areas 1 and/or 2, was advanced to the feasibility stage of analysis. Figure 1-1 in Appendix A shows the locations of Areas 1 and 2. The locations of the storage sites considered under Task 1 of the feasibility study are generally similar to the pre-feasibility study sites and would have similar features as discussed in the pre-feasibility study. One of the criteria on which the alternatives were evaluated was the volume of reservoir releases used to reduce U.S. Fish and Wildlife Service (USFWS) target flow shortages. This volume, referred to as "yield," was modeled for the various alternatives.

The primary objectives of this feasibility study were to investigate combined reservoir operations, develop and refine alternatives, and to provide feasibility-level design and cost estimates. As part of the project, a wetland delineation and a geotechnical investigation were conducted.

1.2 Storage Site Refinement

Refinements have been made since the pre-feasibility study was completed. The footprint for Area 1 was revised to extend west to an existing drainage ditch. Using better topographic data developed from LiDAR spot elevations, the excavation and fill volumes were also adjusted in order to balance the earthwork at the site. The footprint of Area 2 was revised to exclude flow and sediment from Plum Creek. Similar to the alternatives analysis, both Areas 1 and 2 would receive flow from the existing Phelps Canal. Inlet gates from Phelps Canal, as well as release gates to the Platte River will be needed. Area 2 was evaluated both with and without a pump station to fill the top portion of the reservoir storage.

Area 2 will release to the drainage ditch/tributary on the east side of the reservoir. A HEC-RAS model was assembled in September utilizing available LiDAR information to verify that the channel would have capacity. During preliminary design, a detailed survey should be conducted in this area to verify the LiDAR data and bridge information collected to perform a bridge scour analysis. Scour protection consisting of a concrete dissipation basin and transition rip rap at the outlet of the gate is included in the cost estimates.

1.3 Studies and Memoranda since the Pre-Feasibility Study

1.3.1 Investigation of Reservoir Combined Operations

Currently, releases to the Platte River from the J-2 hydropower plant operated by CNPPID fluctuate from zero to as much as 2,000 cubic feet per second (cfs) within an hour. The duration of flow released to the Platte River is a function of the amount of flow available to CNPPID on each day. A larger volume of water available equates to a longer duration of hydropower generation and a longer duration of releases to the Platte River. While hydrocycle mitigation is not a direct part of the Program, the hourly fluctuations of flow (hydropower cycling) are a concern of the U.S. Fish and Wildlife Service (USFWS) (FERC, 2007), and CNPPID is interested in the potential for the reregulating reservoirs under consideration to be operated to provide mitigation. Hydrocycle mitigation would reduce or eliminate the large fluctuations in releases to the Platte River.

During the CNPPID Reregulating Reservoir pre-feasibility study, use of the proposed storage sites was evaluated primarily for SDHF augmentation with a designed release rate of 2,000 cfs for a three-day duration. A subsequent analysis was performed during that study to evaluate whether the sites could be beneficial for target flow augmentation and/or hydrocycle mitigation. The findings indicated the sites would be viable for target flow augmentation, or hydrocycle mitigation, but it was unclear whether the two purposes could be accomplished simultaneously.

An investigation of reservoir combined operations was conducted to evaluate whether target flow augmentation would be adversely affected by mitigating a hydrocycle surge by use of the proposed Area 1 and Area 2 storage sites identified in the pre-feasibility study.

If it could be accomplished, full mitigation of the hydrocycle surge would result in a uniform release rate to the Platte River. As a reporting and accounting simplification, the modeling period was considered to be the 24-hour period of a calendar day. The side effect of a completely uniform release over the course of one day is the need to jump to a different flow at midnight. The volume of flow from day to day changes and, hence, the uniform release rate must likewise change from day to day. The flow jump could be changed to occur at a different time of day but this jump must occur if the volume of flow changes from day to day. It should be noted that the hydrocycle mitigation would take place before the flows reached the Overton gage, which is immediately downstream of the Area 1 release gate.

Hydrocycle mitigation is depicted in Illustration 1-1. The blue line indicates the flows released from the J-2 hydropower plant. The flows vary throughout the day, depending on whether the hydropower plant is on or off and the total volume of water available to be run through the plant on a particular day. The green line depicts the flows back to the Platte River without hydrocycle mitigation. Like the releases from the J-2 hydropower plant, the flows are variable throughout the day. The red line indicates the flows back to the Platte River with hydrocycle mitigation. Throughout a given day, the release to the river remains constant. Between days, the release rate changes since a different volume of water is available from day to day.

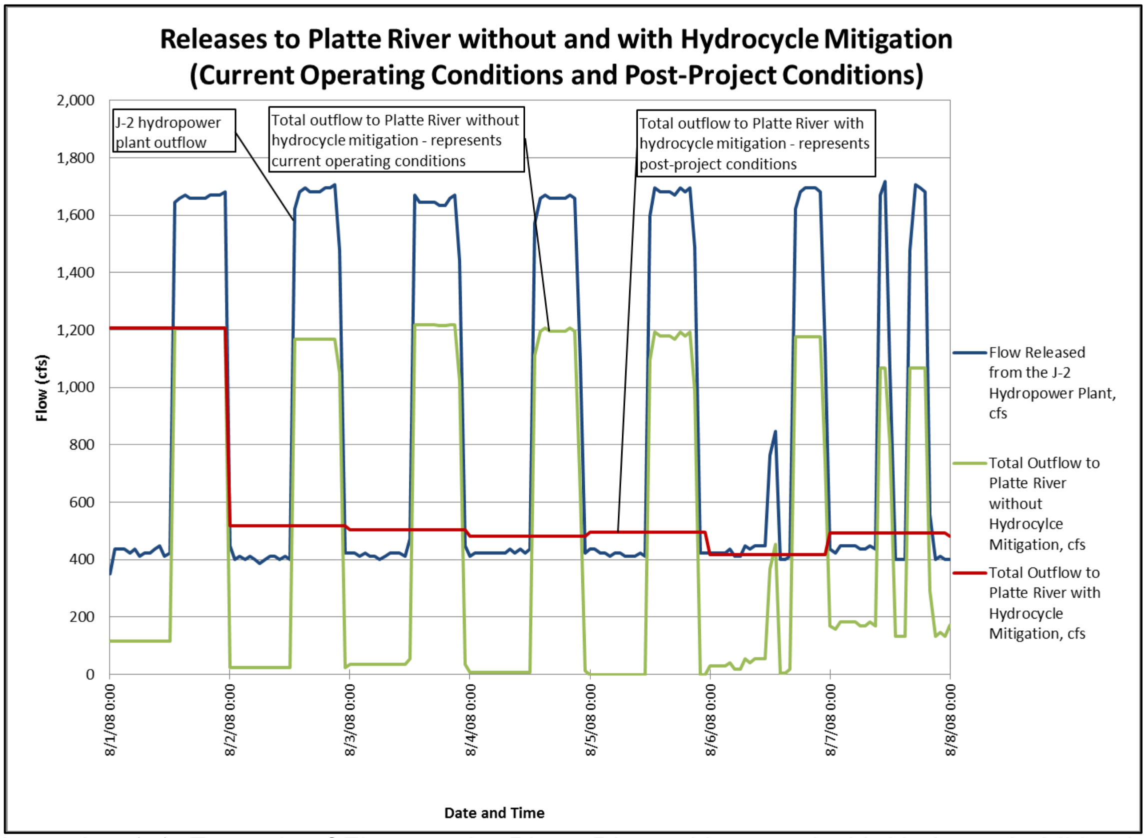

Illustration 1-1. Example of Flows to the Platte River without and with Hydrocycle Mitigation

The modeling for combined goals of augmentation of target flow shortages and hydrocycle mitigation was done using CNPPID's preferred operation of the J-2 hydropower plant, which is more predictable and more efficient than the current mode of operation. In order to do that, a synthetic data set was developed by CNPPID to reflect preferred operations outside of the non-irrigation season. The modeling indicated that both objectives could be met with little reduction of yield for Program uses. When water is plentiful, both objectives can be fully met. When water availability is low, both objectives cannot be adequately met and special operational procedures must be used.

The results of the combined operations investigation were documented in the report *CNPPID J-2 Reregulating Reservoir Task 1 of Feasibility Study: Investigation of Reservoir Combined Operations* dated June 24, 2011. The report is included in Appendix B. The combined operations report contains detailed information on the criteria used for the combined operations modeling, development of the synthetic data set, the modeling process, the results, and recommendations for improving target flows. The information is not repeated in the body of this report.

1.3.2 Task 1.5 of Investigation of Reservoir Combined Operations

After the combined operations report was finalized, questions remained about achieving 100% hydrocycle mitigation. Under Task 1.5 of the Investigation of Reservoir Combined Operations, Olsson was tasked with investigating the four typical circumstances identified in the combined operations report under which hydrocycle mitigation was not achieved. The analysis, results, and recommendations were documented in the memorandum *Results of Task 1.5 of Investigation of Reservoir Combined Operations* dated September 14, 2011 and included in Appendix C. Following are the key conclusions:

- Analysis showed that hydrocycle mitigation was achieved on all of the days targeted, those outside of the irrigation season of April 1-August 31, as a result of hydropower operational changes and the decision to carry a small volume of water over to the next day. A small operating pool was maintained.
- The analysis showed that achieving 100% hydrocycle mitigation will result in some decreases in Program yield.
- On some days, there could be increases in shortages to target flows while achieving 100% hydrocycle mitigation, but the water would be released on subsequent days that have shortages. The decision to allow increases in shortages on a given day has policy implications.
- A dead pool of water was recommended to protect the bottom liners of Areas 1 and 2. The water would also be beneficial for increasing the overall head on the outlet gates from Areas 1 and 2, which would improve Program yield and hydrocycle mitigation.

1.3.3 Task 1.6 of Investigation of Reservoir Combined Operations

The use of Areas 1 and 2 for hydrocycle mitigation in addition to reducing shortages to target flows and the SDHF appeared to be desirable and likely at this point in the project. Under Task 1.6 of the Investigation of Reservoir Combined Operations, Olsson was tasked with developing an initial estimate of how removal of Area 2 from Program use during the irrigation season could affect yield for reducing shortages to target flows. CNPPID seeks to maximize hydroelectric power production during peak value times of the day during the irrigation season by using Area 2 to regulate flows for irrigation delivery. The desire is to pulse the flows out of the hydropower plant during the peak value times but meanwhile deliver a uniform flow rate in the Phelps Canal downstream of Area 2.

The analysis, results, recommendations, and issues that should be addressed as the project progresses were documented in the memorandum *Results of Task 1.6 of Investigation of Reservoir Combined Operations* dated September 21, 2011 and included in Appendix C.

The results of this analysis indicated that an average reduction in yield for the Program of 5.9% and 11.8% could result if Area 2 were simply eliminated from use during the irrigation seasons of June 15-August 31 and April 1-August 31, respectively. Changes could be made to the footprint of Area 2 and/or Area 1 that would reduce the impact on yield. Changing the footprint for Area 1 would be more beneficial than changing the footprint for Area 2. A modest increase in the Area 1 footprint could be used to offset the decrease in yield.

1.3.4 Task 1.7 of Investigation of Reservoir Combined Operations

Under Task 1.7 of the Investigation of Reservoir Combined Operations, the physical layout of a system that would allow CNPPID to use Area 2 to maximize power production during peak operations and regulate flows for irrigation delivery was investigated. Four alternatives for the inlet into Area 2 were evaluated and consisted of:

- Alternative 1: Completely remove the berm between Area 2 and the Phelps Canal
- Alternative 2: Remove a limited width of the berm and install a concrete weir between Area 2 and the Phelps Canal
- Alternative 3: Remove the top portion of the berm along its entire length down to a certain elevation
- Alternative 4: Install a dual flow inlet/outlet sluice gate structure between the Phelps Canal and Area 2.

The results of this analysis indicated that Alternative 4, installing dual flow direction inlet/return sluice gates, would be most economical since an inlet gate is already needed as part of the overall project. In addition, the gates would provide the most control and flexibility for the system. Regardless of which of the alternatives was selected for the inlet structure, an inline gate structure on Phelps Canal will be required downstream of Area 2.

The analysis, conceptual layouts, cost estimates, and recommendations were documented in the memorandum *Results of Task 1.7 of Investigation of Reservoir Combined Operations* dated September 27, 2011 and included in Appendix C.

1.3.5 November 22, 2011 Incremental Cost Analysis

Under Tasks 1.5 through 1.7 of the Investigation of Reservoir Combined Operations and 2.2 through 2.4 of the Alternatives Refinement, Olsson Associates developed alternatives to maximize power production during peak operations and regulate flows for irrigation delivery at Area 2. The next step in the project was to determine how large Areas 1 and 2 should be. The storage volumes of Areas 1 and 2 were modified and evaluated to develop an incremental cost analysis with which to compare the different alternatives. The analysis was documented in the memorandum *Incremental Cost Analysis for Reservoir Combined Operations* dated November 22, 2011, which is included in Appendix D.

In addition to construction cost estimates, 50-year life cycle costs were developed as part of the incremental cost analysis. The life cycle costs included the following:

- Capital construction costs spread out over the 50-year life cycle time period
- Annual operation and maintenance costs, calculated as a percentage of initial construction cost
- Annual cost of electricity to pump water into Area 2

- Replacement of the Area 2 pumps every 25 years spread out over the 50-year life cycle time period

Five options were developed for analysis. Table 1.1, excerpted from the incremental cost memorandum, describes each alternative.

Table 1.1. Descriptions of Alternatives for November 22, 2011 Incremental Cost Analysis

Option	Total Storage, acre-feet	Description
1	13,637	• Area 1 footprint matches the February 2010 pre-feasibility study • Area 2 was limited to the east side of Plum Creek and will require pumps above elevation 2356 • Earthwork was balanced for Areas 1 and 2 • Clay liner protected with a soil/vegetative cover
2	N/A	• Area 1 footprint extended south across County Road 748 • Area 2 was limited to the east side of Plum Creek and will require pumps above elevation 2356 • Earthwork was balanced for Areas 1 and 2 • Clay liner protected with a soil/vegetative cover • Due to the impacts associated with closure and re-routing of County Road 748, Option 2 was dropped from further evaluation
3	15,640	• Area 1 footprint extended west to the east bank of an un-named stream • Area 2 was limited to the east side of Plum Creek and will require pumps above elevation 2356 • Earthwork was balanced for Areas 1 and 2 • Clay liner protected with a dead pool consisting of one foot of water
4	15,283	• Area 1 footprint extended west to the east bank of an un-named stream. It is similar to Option 3 but the southwest corner was not excavated, which reduced the earthwork required to achieve a similar volume as in Option 3. • Area 2 is the same as in Option 3 and will require pumps above elevation 2356 • Earthwork was balanced for Areas 1 and 2 • Clay liner protected with a dead pool consisting of one foot of water
5	13,960	• Area 1 footprint is the same as in Option 4 • Area 2 was limited to the east side of Plum Creek and no pumping will be used. • Earthwork is balanced for Areas 1 and 2. Because the highest water storage elevation is lower than in other options, the berms around Area 2 were reduced and the earthwork re-balanced. • Clay liner protected with a dead pool consisting of one foot of water

Continuous simulation modeling was completed on an hourly basis to determine yield for the Program. Construction and life cycle costs were developed with and without the upgrade of Phelps Canal. During the analysis, conference calls were held with the Executive Director's Office, CNPPID, and the State of Nebraska to discuss results and determine the next steps.

Options 1, 3, and 4 were first analyzed and compared to each other. Refinements were made and Option 5, which eliminated the Area 2 pump station, was added. It became clear that Options 4 and 5 were becoming the most attractive alternatives. Options 4 and 5 were further refined. Table 1.2, excerpted from the incremental cost memorandum, highlights the advantages and disadvantages of Options 4 and 5.

Table 1.2. Comparison of Options 4 and 5 from November 22, 2011 Incremental Cost Analysis

Option	Description	Pros	Cons
4	15,283 acre-feet of storage plus Area 2 pump station	• Greater yield for the Program than Option 5 • More storage volume	• Higher construction cost and life cycle incremental cost than Option 5 (but lower than previously estimated Options 1 or 3) • Maintenance of a pump station required
5	13,960 acre-feet of storage without Area 2 pump station	• Lower construction cost than Option 4 • Lower life cycle incremental cost than Option 4 • No maintenance of a pump station	• Less storage than Option 4 • Less yield for the Program

Illustration 1-2 shows a comparison of the four alternatives on the basis of cost versus Program yield and storage versus Program yield.

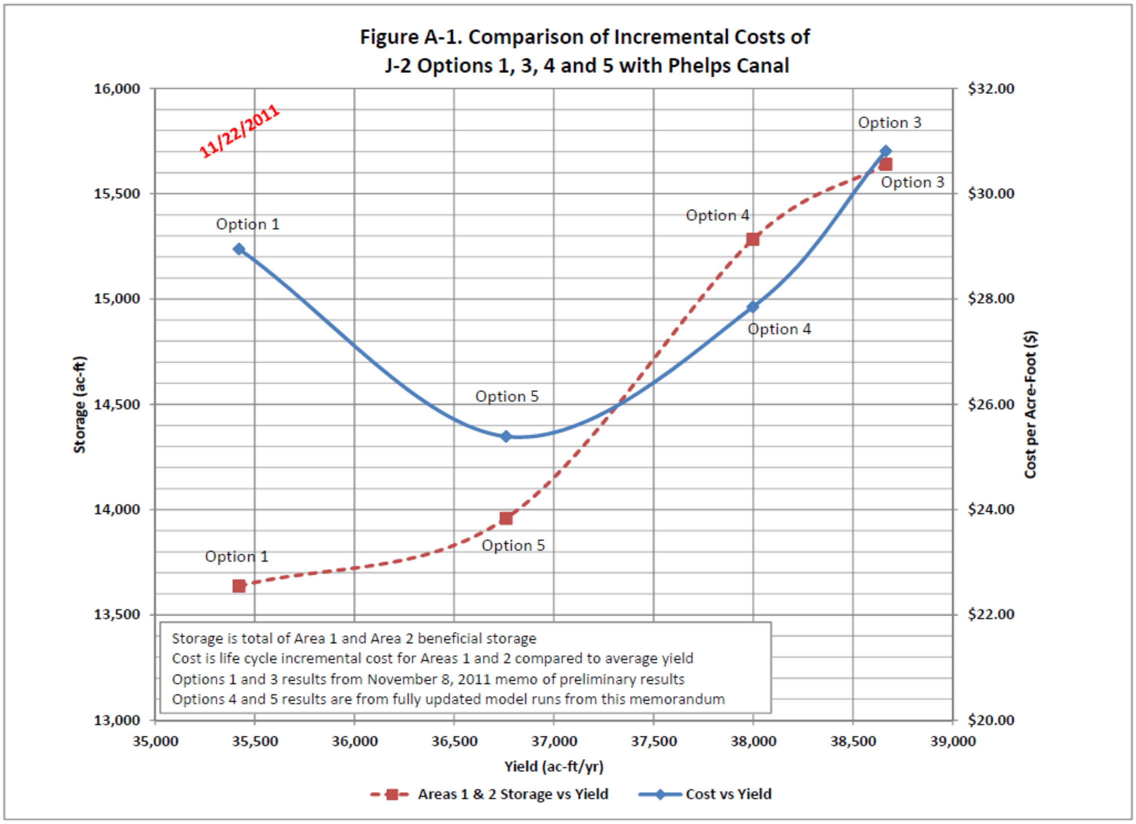

Illustration 1-2. Results of November 22, 2011 Incremental Cost Analysis

1.3.6 January 31, 2012 Incremental Cost Analysis Update

The geotechnical recommendations were reviewed after the options were refined to determine whether the recommendations were still relevant or whether new issues needed to be addressed. At that time, a clarification was made regarding the protective clay liner and/or dead pool of water needed in the bottom of Areas 1 and 2 (see Sections 2.3.4 and 2.3.6). Alternatives for protecting the clay liner were as follows:

1. If a vegetative cover is used (as in Option 1), the 12-inch clay liner must be buried approximately three feet down, or generally below frost line. In the November 2011 incremental cost analysis, only 12 inches of cover were included in the cost. The actual construction cost would be approximately $8 million higher, making Option 1 less feasible than it already is. Due to the high cost, this type of protection was not considered further. Nothing was changed in the incremental cost analysis since Option 1 was not under further consideration.
2. A dead pool of water must be used (Options 3, 4, and 5) to protect the compacted clay liner. The bottom of Areas 1 and 2 would consist of 12 inches of compacted clay liner placed 12 inches below finished grade and covered by 12 inches of soil plus 12 inches of water at all times.
3. In lieu of 12 inches of soil, the compacted clay liner can be covered by 24 inches of water. This option was used in determining the revised grading and cost for Option 5 presented in this report. The storage areas were regraded to maintain roughly the same beneficial storage. The Area 1 beneficial storage increased from 10,473 acre-feet to 10,941 acre-feet. The Area 2 beneficial storage decreased from 3,486 acre-feet to

3,174 acre-feet. The total beneficial storage increased from 13,959 to 14,115 acre-feet. The continuous simulation modeling was not redone with the final Option 5 beneficial storage, but the storage volume was included in the revised tables and charts in the updated incremental cost analysis.

Additional changes were made to the design and cost estimates.

- A small amount of grading was added to achieve two feet of freeboard along the berm between Area 1 and Phelps Canal (see Section 2.1 for a discussion of Phelps Canal). The unit price of structural concrete was also increased. The cost of the Phelps Canal improvements, therefore, increased from the November 22, 2011 incremental cost analysis.
- It was determined that the synthetic liner that had been included for the Phelps Canal could be eliminated and the drain tile expanded.
- The gate sizes were re-evaluated for the Option 5 parameters. The outlet gates were significantly reduced in size. Updated costs were prepared and incorporated into the updated incremental cost analysis. Costs for the gates were not re-evaluated for Option 4. If the gates were re-evaluated for Option 4 and gates similar to those in Option 5 could be used, the cost decrease would be expected to be approximately $1 million. The life cycle cost would decrease by approximately $0.60 per acre-foot per year.
- Due to the refinements made, the construction contingency percentage was reduced from 30% to 25%.

The updated costs, comparison graphs, and figures are included in Appendix D with a brief memorandum dated January 31, 2012 describing the changes. The key tables for Option 5 with Phelps canal are Tables 4, 6, and 7 of the update.

After the January 31, 2012 Incremental Cost Analysis update, wave protection for the reservoir sides of the north and east embankments was added to the conceptual design and cost estimates. The north and east embankments will be most susceptible to wave action due to the predominant wind patterns. These costs were added to the May 1, 2012 version of this report. Beneficial storage volumes were not changed to reflect the anticipated loss in storage that will occur to provide a gravel beaching slope and rock riprap protection, as described in Section 2.3.6.

Figure 1-2 (in Appendix A) shows the plan view and stage-storage relationship for Area 1. The beneficial storage is available for use, while the total storage includes the dead pool. Figure 1-2 also shows the location of the inlet and outlet gates, the Phelps Canal control gate location, area roads and proposed road closures, and the storage area embankments. The Phelps Canal control gate will be located close to the entrance gate to Area 1. Figure 1-3 shows the existing topographic contours in the Area 1 location. Figures 1-4 and 1-5 show cross sections through Area 1. Figures 1-6 through 1-9 depict the same information for Area 2.

The net changes in the 50-year life cycle cost due to the changes between the November 22, 2011 memorandum and January 31, 2012 update were minimal. The cost difference with the added wave protection was more significant. Table 1.3 shows the difference for Options 4 and 5 with the Phelps Canal upgrade. Illustration 1-3 shows the updated results.

Table 1.3. Comparison of Life Cycle Costs for Options 4 and 5

Version	Life Cycle Cost per ac-ft of Water[1]	
	Option 4 with Phelps Canal	Option 5 with Phelps Canal
November 22, 2011	$27.85	$25.39
January 31, 2012	$28.15	$24.66
May 1, 2012	$31.81	$28.41

[1]The Program yield volume of water used in the per acre-foot cost was calculated prior to the final beneficial storage volume determination.

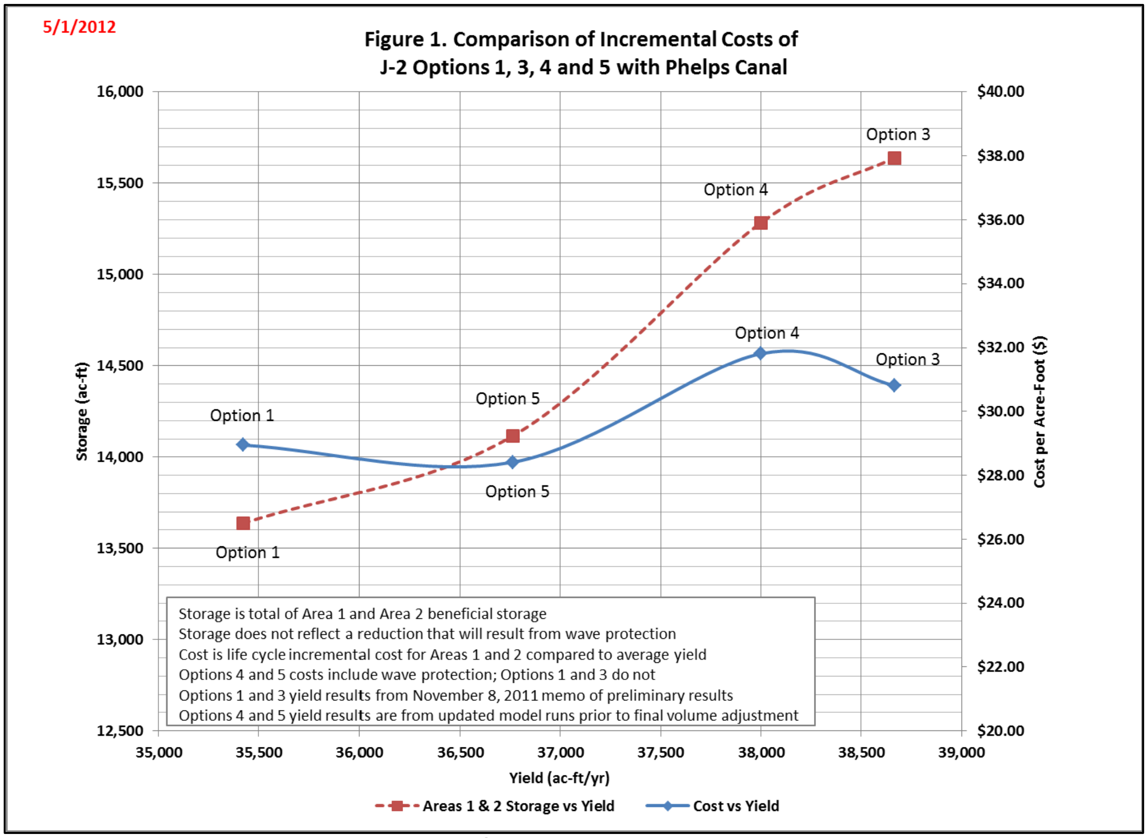

Illustration 1-3. Incremental Cost Analysis Results Updated May 1, 2012

1.3.7 Comparison of Yields for Alternatives

Throughout the process of developing and refining alternatives, continuous simulation modeling was conducted to be able to compare the effects of the various system configurations on yield for the Program. Table 1.4 on the following page was developed by the ED Office to track the comparisons as the project evolved. For each scenario, the column "Document" specifies the memorandum or report that describes that particular scenario in detail. For more information on the scenarios, the associated document should be consulted. In general, the yield showed relatively small changes between scenarios. Yield was not estimated for the beneficial storage volumes that need to be calculated as a result of incorporating wave protection into the reservoir embankments.

Most of the modeling was done with the synthetic data set that reflected CNPPID's preferred operations outside of the irrigation season. Scenario 9 was to involve development of an optimized data set during the irrigation season. During the irrigation season, CNPPID would like to pulse the flows but a dedicated storage area that would allow them to do so was not built into the spreadsheet models. The specific operating characteristics must be developed. Area 2 can be modeled in this manner in future phases of the project. It may be possible to model Area 2 using critical event scenarios rather than continuous simulation modeling

Table 1.4. Comparison of Target Flow Yields for Various Operating Scenarios

Scenario	Hydrology	Operations Mode		Phelps Canal Capacity (cfs)	Area 1 + 2 Storage Capacity (AF)	Normal Year		Model Period Average		Scenario Comparison	Document	Option
		Irrigation Season	Non-Irrigation Season			Target Flow Yield (AF)	Percent Reduction	Target Flow Yield (AF)	Percent Reduction[f]			
1[a]	Representative historical Normal, Wet, and Dry year	Target Flow Ops Only	Target Flow Ops Only	1,000	16,269	47,480		-			Pre-Feasibility Study	
2[b]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Target Flow Ops Only	Target Flow Ops Only	1,000	13,637	41,452		35,258		*Baseline for Scenario 4*	Feasibility Task 1.4	
3[b]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Target Flow Ops Only	Target Flow Ops Only	1,400	13,637	45,657		37,608		*Baseline for Scenario 5*	Feasibility Task 1.4	
4[b]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Target Flow Ops & Hydro Mitigation	Target Flow Ops & Hydro Mitigation	1,000	13,637	41,564	0%	34,838	1%	2 vs 4	Feasibility Task 1.4	
5[b]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Target Flow Ops & Hydro Mitigation	Target Flow Ops & Hydro Mitigation	1,400	13,637	45,272	1%	37,062	1%	3 vs 5	Feasibility Task 1.4	
6[b]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Target Flow Ops & Hydro Mitigation	Target Flow Ops & Hydro Mitigation	1,675	13,637	47,177		37,649		*Baseline for Scenarios 7-12*	Feasibility Task 1.5	
7[c]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Target Flow Ops & Hydro Mitigation	Target Flow Ops w/ 100% Hydro Mitigation	1,675	13,637	44,784	5%	36,899	2%	6 vs 7	Feasibility Task 1.5	
8[d]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Area 2 - CNPPID Use; Area 1 - Target Flow Ops & Hydro Mitigation	Target Flow Ops & Hydro Mitigation	1,675	13,637	46,648	1%	35,421	6%	6 vs 8	Feasibility Task 1.6	Option 1
9	1997-2008: synthetic irrigation and non-irrigation season	Area 2 - CNPPID Use; Area 1 - Target Flow Ops & Hydro Mitigation	Target Flow Ops & Hydro Mitigation	1,675	13,637	Not completed due to need for different operational characteristics						
10[d]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Area 2 - CNPPID Use; Area 1 - Target Flow Ops & Hydro Mitigation	Target Flow Ops & Hydro Mitigation	1,675	15,640	49,499		38,665	-3%	6 vs 10	Incremental Cost Analysis	Option 3
11[d, e]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Area 2 - CNPPID Use; Area 1 - Target Flow Ops & Hydro Mitigation	Target Flow Ops & Hydro Mitigation	1,675	15,283	49,090		37,998	-1%	6 vs 11	Incremental Cost Analysis	Option 4
12[d, e]	1997-2008: historical Apr 1 - Aug 31; synthetic non-irrigation season	Area 2 - CNPPID Use; Area 1 - Target Flow Ops & Hydro Mitigation	Target Flow Ops & Hydro Mitigation	1,675	13,959	47,620		36,761	2%	6 vs 12	Incremental Cost Analysis	Option 5

[a]Pre-Feasibility Study model used for Scenario 1 with higher storage capacity and modeled for one representative normal year (1975); EDO Scoring Case Study resulted in preliminary program score of 40,000 AF using OpStudy hydrology.

[b]Pre-Feasibility Study model was updated for Scenarios 2 and 3 to reflect lower storage capacity and continuous model simulation; hydrocycle mitigation logic was added for Scenarios 4, 5, and 6.

[c]Hydrocycle mitigation logic was manually optimized for Scenario 7.

[d]Area 2 was removed during the irrigation season of June 15-August 31 for Scenarios 8 through 12. If CNPPID uses Area 2 from April 1-August 31, the target flow yield reduction would be 11.8% when comparing Scenario 8 to Scenario 6 (instead of 6%).

[e]The gate sizes used in Olsson's model for Scenarios 11 and 12 were: Area 1 outlet gate width = 36 feet, Area 2 outlet gate width = 20 feet. The gate sizes used for Scenarios 2-10 are: Area 1 outlet gate width = 40 feet, Area 2 outlet gate width = 30 feet. The yield was not sensitive to the gate size, as determined in the Combined Operations Report.

[f]Negative represents an increase in yield, but an increase would not be anticipated during actual operations

2.0 RECOMMENDED ALTERNATIVE PROJECT COMPONENTS

The recommended project alternative consists of several components, including the storage areas, berms surrounding the storage areas, inlet and outlet gates for the storage areas, and upgrades to the Phelps Canal.

2.1 Phelps Canal Delivery System Upgrade

In order for CNPPID to be able to store and use the water passing through the J-2 hydropower plant while operating near peak efficiency, the Phelps Canal must be upgraded to convey 1,675 cfs. A larger Phelps Canal capacity has been shown to result in higher yield for the Program, providing more water for shortages to target flows.

Olsson completed an evaluation of improvements needed to convey 1,420 cfs, the design and master plan flow, and 1,675 cfs. The results are documented in the memorandum *Phelps Canal Evaluation* dated December 14, 2010, which is included in Appendix E. LiDAR and topographic survey data were used to develop a Hydraulic Engineering Center River Analysis System (HEC-RAS) model. The existing conditions of the Phelps Canal were evaluated to determine the existing capacity. Improvements that would allow the Phelps Canal to convey 1,675 cfs with two feet of freeboard were then determined. After the initial evaluation, documented in the December 14, 2010 memorandum, the canal was evaluated with the criteria of limiting the water surface elevation in the canal at the inlet gates (Milepost 0) to 2358.0, which had not previously been considered. The differences were documented in the memorandum *Phelps Canal Evaluation Modifications (Update)* dated January 26, 2012 and included in Appendix E.

The recommended improvements are shown in Figure 1 of the January 26, 2012 memorandum in Appendix E and include the following:

- Raising the berms on either side of the canal to achieve two feet of freeboard. No additional land or easement would be needed to raise the top elevations of the berms. Additional freeboard was also needed between the Phelps Canal and Area 1. It was shown on both sides of the canal, but may only be necessary on the northeast side.
- Installing a new Parshall flume that has a throat width of 50 ft, as compared to the existing throat width of 30 feet.
- Installing a second siphon pipe under Plum Creek. The existing pipe is one 165-in diameter corrugated metal pipe. An additional 144-in pipe is needed to achieve the desired upstream water surface elevation.
- Widening nearly 7,000 linear feet of canal upstream of the siphon under Plum Creek. Widening is necessary to reduce the water surface elevation in the canal enough to meet the criteria. The proposed cross section is a trapezoidal shape with a 60-ft bottom width and 2 horizontal feet to 1 vertical foot (2:1) side slopes. The berms were moved out on the north side of the canal to widen it. A 16-foot top width was maintained for maintenance vehicle access.
- Installing new bridges over the Phelps Canal on Road 749 (for Option 1 as described in Section 1.3.5) and on the farm access from Road 749 between Roads 436 and 437 (for all options). The bridges are necessary due to the widened canal.
- Installing riprap bank protection along the outer bends of the canal, which could be prone to erosion with the increased flow.

The estimated costs of the proposed upgrades to the Phelps Canal are discussed in Section 4.0 and are detailed in Appendix D.

2.2 Storage Area Inlet and Outlet Structures

Areas 1 and 2 were graded to achieve an earthwork balance between excavation of the storage areas and construction of berms around the storage areas so that expensive haul-off of excess material would not be needed. The footprints of Areas 1 and 2 are approximately 720 acres and 340 acres, respectively. Figures 1-2 through 1-9 in Appendix A illustrate the layouts of Areas 1 and 2. Black & Veatch analyzed the physical and operational parameters to determine the needed inlet and outlet gate types and sizes for Areas 1 and 2, as well as the water control gate in Phelps Canal. The inlet, outlet, and Phelps Canal gate types and sizes are discussed in the following subsections and the supporting technical memoranda are included in Appendix F.

2.2.1 Design Data and Operational Characteristics

A summary of the basic hydraulic data and operational characteristics for the reservoirs, inlet structures, and outlet structures is included as Table 2.1. The data provided in the table was used as the basis for the structure descriptions and cost opinions.

Table 2.1. Reservoir and Gate Hydraulic Data

Item	Value	Comments
Phelps Canal		
Flow Range to Inlets	0 – 1,675 cfs	Combined flows
Flow Range Past Area 1	0 – 1,000 cfs	Irrigation flows past gate
<u>At Area 1 Inlet</u>		
Invert El.	2342.0 ft	
Max WS El. @ no flow	2357.0 ft	
Max WS El. @ 1675 cfs	2353.0 ft	
<u>At Area 2 Inlet</u>		
Invert El.	2343.0 ft	
Max WS El. @ no flow	2357.0 ft	
Max WS El. @ 1675 cfs	2355.0 ft	
<u>Canal Control Gate 1 (Downstream of Area 1)</u>		
Water Surface Elevation	2342 – 2357 ft	
Flow Range	0 – 1,000 cfs	
Function	Flow Regulation	

Table 2.1. Reservoir and Gate Hydraulic Data

Item	Value	Comments
Area 1 Reservoir		
Embankment Crest Elevation	2357.25 ft	
Max. Operating WS Elevation	2354.25 ft	
Min. Operating WS Elevation	**2336.25 ft**	
Maximum Reservoir Bottom Elevation	2334.25 ft	
Storage Capacity, Total	12,322 acre-ft	
Storage Capacity, Beneficial	10,941 acre-ft	
<u>Inlet Gate Structure</u>		
Flow Range	0 – 1,675 cfs	Inlet and outlet gate/structure hydraulics are preliminary and will be updated based on the final inlet and outlet configuration.
Gate Sill Elevation	2342.0 ft	
Function	Flow Regulation	
<u>Outlet Gate Structure</u>		
Flow Range, Typical	0 – 1,500 cfs	
Minimum Flow to Size Gate	1,500 cfs with 9.5 ft head	
Flow, Maximum	2,000 cfs	
Gate Sill Elevation	2328.0 ft	
Function	Flow Regulation, SDHF	
Area 2 Reservoir		
Embankment Crest Elevation	2360.0 ft	
Max. Operating WS Elevation	2357.0 ft	Max. Operating WS based on Phelps Canal master plan elevation.
Min. Operating WS Elevation	**2347.0 ft**	
Maximum Reservoir Bottom Elevation	2345.0 ft	
Storage Capacity, Total	3,797 acre-ft	
Storage Capacity, Beneficial	3,174 acre-ft	
<u>Inlet Gate Structure</u>		Inlet and outlet gate/structure hydraulics are preliminary and will be updated based on the final inlet and outlet configuration.
Flow Range	0 – 1,675 cfs	
Gate Sill Elevation	2343.0 ft	
Function	Flow Regulation	
<u>Outlet Gate Structure</u>		
Flow Range, Typical	0 – 500 cfs	
Minimum Flow to Size Gate	1,000 cfs with 11.5 ft head	Inlet gate sill elevation is required to match Phelps Canal invert to provide minimum required flows into and out of Area 2.
Flow, Maximum	2,000 cfs	
Gate Sill Elevation	2338.0 ft	
Function	Flow Regulation, SDHF	

Table 2.1. Reservoir and Gate Hydraulic Data

Item	Value	Comments
Platte River		
WS Elevation Near Area 1 Outlet		
0 cfs	2315.2 ft	Design discharge during
5,000 cfs	2323.1 ft	SDHF
69,660 cfs	2331.9 ft	100-year discharge
WS Elevation Near Area 2 Outlet		
0 cfs	2324.6 ft	Design discharge during
5,000 cfs	2331.8 ft	SDHF
69,660 cfs	2342.2 ft	100-year discharge

A HEC-RAS model of a segment of the Platte River was developed as part of a 1-dimensional sediment transport model that was completed as part of a separate project. The model was used for this project to determine the Platte River tailwater conditions at the outlet gates of Areas 1 and 2. Comments on the model and responses to them were documented in a brief memorandum titled *Platte River HEC-RAS Model,* dated July 23, 2010. The memorandum and supporting Platte River peak flow data are included in Appendix H.

2.2.2 Inlet Structures

The reservoir inlet structures for Area 1 and Area 2 were considered to have a maximum hydraulic capacity of 1,675 cfs, corresponding to the maximum discharge capacity being considered for the Phelps Canal and the maximum rate of flow being considered from the Phelps Canal into storage. The flow duration relationship of discharges into storage over the 10-year modeling period is provided in Appendix F.

The configurations for the inlet structures were based on the installation of a control gate within the Phelps Canal immediately downstream of Area 1 to control the water surface elevation in the canal to provide sufficient head at the inlet structures, and to regulate downstream irrigation flows. A Phelps Canal maximum water surface elevation of 2358.0 was used upstream of the canal control gate at zero flow. It should be noted that this elevation was derived from the master plan for the Phelps Canal (CH2M Hill, undated). Based on the modeling of the Phelps Canal, it may be possible to increase the water surface elevation. This issue should be investigated during preliminary design. At a Phelps Canal flow of 1,675 cfs, a maximum water surface elevation of 2353.0 was used at Area 1 and an elevation of 2355.0 was used at Area 2. Note that water can be stored higher in anticipation of the SDHF.

An inlet structure with downward closing sluice gates was considered for each location. Flows into the reservoirs would be regulated by controlling the Phelps Canal water surface elevation with the Phelps Canal control gate and by modulating the sluice gates to achieve the desired discharge. For the Area 1 inlet structure, the sill elevation would be at 2342.0, corresponding to the Phelps Canal invert elevation. For a maximum Phelps Canal water surface elevation of 2353.0 and an inlet capacity of 1,675 cfs, a total of three 12-foot wide by 10-foot high sluice gates would be required. The sluice gates would be closed when the Area 1 reservoir reached maximum operating level to prevent additional inflow from Phelps Canal, or if it is desired to convey water from Phelps Canal into Area 2 with no discharge into Area 1.

For the Area 2 inlet structure, the sluice gate sill would be at elevation 2343.0, to match the Phelps Canal invert. For a maximum Phelps Canal water elevation of 2355.0 and an inlet capacity of 1,675 cfs, a total of three 12-foot wide by 12-foot tall sluice gates would be required. The sluice gates would be closed as the reservoir water level approached an elevation of 2355.0 to prevent backflow from the reservoir to the canal or if it is desired to convey water from Phelps Canal into Area 1 with no discharge into Area 2. The configuration of the reservoir inlet structures is shown in Figures 2-1 and 2-2.

The Area 1 inlet structure was designed for flow into the reservoir for storage, with no requirement to discharge water back into the Phelps Canal. The Area 2 inlet structure was designed to allow flow into the reservoir for storage, and discharge back into the Phelps Canal to maintain a constant flow rate when the hydropower facility is used for peaking.

During hydropower cycling, the Phelps Canal will be nearly full as it will be at peak capacity (approximately 1,675 cfs). Table 2.2 and the associated graphic Illustration 2-1 show the amount of differential head required to convey 1,675 cfs into the Area 2 reservoir with the inlet gates 100% open (0.3 feet of differential head is required with a Phelps Canal water elevation of 2355.0). The rating curve also illustrates the amount of water that can be pushed into the reservoir as the differential head decreases to zero.

Table 2.2. Filling Area 2 Storage

Phelps Canal Elevation	Area 2 Water Surface Elevation	Flow Rate, cfs
2355	2353.00	1,675
2355	2354.00	1,675
2355	2354.50	1,675
2355	2354.70	1,675
2355	2354.75	1,525
2355	2354.90	950
2355	2354.95	675
2355	2355.00	0

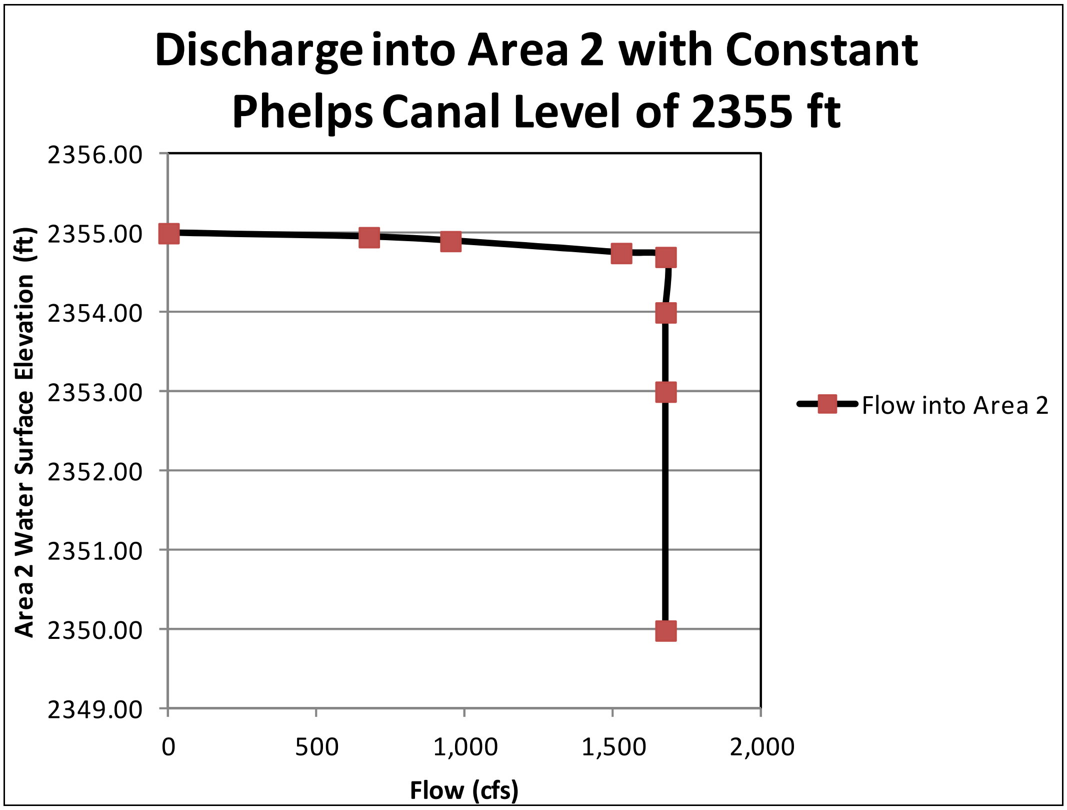

Illustration 2-1. Discharge into Area 2

Once the Area 2 reservoir is full or nearly at the same water elevation as the canal, the hydropower plant will be shut off and the Phelps Canal can be lowered so that Area 2 can discharge at a slower, constant rate back to the Phelps Canal to meet the downstream irrigation demand. The maximum discharge from Area 2 back to the Phelps Canal would typically not exceed 900 cfs, however 1,000 cfs was used for the feasibility analysis. The minimum Phelps Canal water surface elevation to convey 1,000 cfs is 2351.5.

The worst case volume of temporary storage needed for hydropower cycling in Area 2 is approximately 831 acre-ft, which corresponds to approximately 2.6 feet of water in Area 2 (831 acre-ft / 317 acre-ft per vertical foot). Therefore, the Area 2 water surface elevation after releasing 831 acre-ft would be 2352.1 (2354.7-2.6). With an Area 2 water surface elevation of 2352.1, 1,000 cfs can be conveyed from Area 2 to the Phelps Canal as long as the canal water surface elevation is at or below approximately 2351.84. Since 2351.84 is greater than the minimum of 2351.5, there is adequate temporary storage available in Area 2 and the inlet channel and gates are sized adequately to allow for hydropower cycling. Table 2.3 and the associated graphic Illustration 2-2 show the differential head rating curve for discharges from Area 2 to the Phelps Canal.

Table 2.3. Discharge from Area 2 to Phelps Canal

Area 2 Water Surface Elevation	Phelps Canal Elevation	Flow Rate, cfs
2355	2354.94	1,000
2355	2354.95	800
2355	2354.97	600
2355	2354.99	400
2355	2354.99	200
2355	2355.00	0
2354	2353.91	1,000
2354	2353.94	800
2354	2353.97	600
2354	2353.98	400
2354	2353.99	200
2354	2354.00	0
2353	2352.89	1,000
2353	2352.93	800
2353	2352.95	600
2353	2352.97	400
2353	2352.99	200
2353	2353.00	0
2352	2351.84	1,000
2352	2351.88	800
2352	2351.95	600
2352	2351.98	400
2352	2351.99	200
2352	2352.00	0

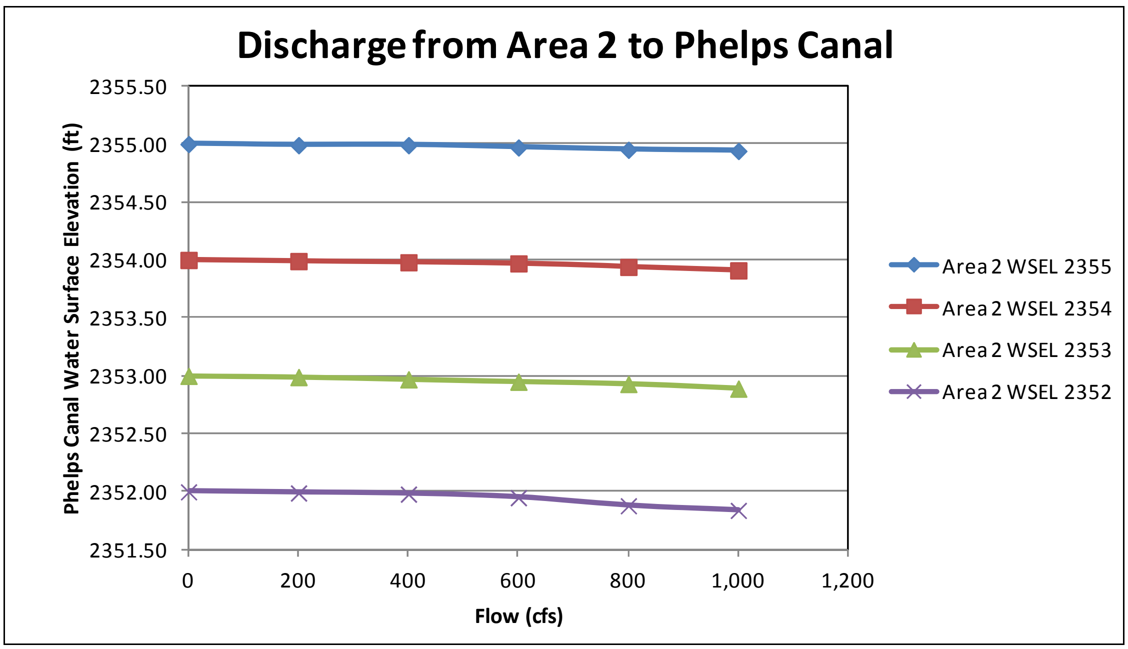

Illustration 2-2. The maximum height fluctuation for the Phelps Canal during hydropower cycling would be approximately 3.16 feet (2355.0-2351.84)

2.2.3 Outlet Structures

The outlet structures for Areas 1 and 2 were similarly arranged. Each outlet structure would release water from storage for the mitigation of hydropower cycling, Platte River target flow augmentation and SDHF discharges.

The outlet gate design for each reservoir was based on the minimum reservoir stage at the end of the three-day SDHF. Since both reservoirs are needed to achieve the full three-day SDHF, it was assumed that a constant release rate would be used from each reservoir. A 2,000 cfs SDHF constant release over three days is equivalent to 11,901 acre-ft of volume. The beneficial storage volume in Area 1 at an elevation of 2354.25, when it is full, is 10,941 acre-ft. The beneficial storage volume in Area 2 at an elevation of 2357, when it is full, is 3,174 acre-ft. The combined storage volume equals 14,115 acre-ft. After 11,901 acre-ft is released for the SDHF, 2,214 acre-ft of water would remain.

Because Area 1 is approximately three times larger than Area 2, the average constant release rate from Area 1 during the SDHF will be three times that of Area 2 (1,500 cfs from Area 1 and 500 cfs from Area 2). Therefore, the Area 1 outlet structure was sized to release 1,500 cfs at the reservoir's minimum stage at the end of the three-day SDHF. The typical release rate from Area 2 is anticipated to be 500 cfs, but the outlet structure gate was designed for a release rate of 1,000 cfs at the minimum stage for greater flexibility in meeting Platte River target flow augmentation.

At the end of the SDHF, the water surface elevation in Area 1 would be 2337.5, resulting in a beneficial storage volume of 673 acre-ft and 9.5 feet of head at the outlet gate. A single radial gate with a width of 20 feet and height of 28 feet will pass 1,500 cfs at 9.5 feet of head. At the end of the SDHF, the water surface elevation in Area 2 would be 2349.5, resulting in a beneficial storage volume of 784 acre-ft and 11.5 feet of head at the outlet gate. A single radial gate with a width of 10 feet and height of 24 feet will pass 1,000 cfs at 11.5 feet of head. Thus, for sizing the outlet gates, the total storage remaining in both reservoirs was 1,457 acre-ft. The normal operating water surface elevation varies 18 feet, from 2336.25 to 2354.25, in Area 1 and 10 feet, from 2347.0 to 2357.0, in Area 2. Because of the range of flow regulation and the maximum water depth for the outlet gates, radial gates were selected for each outlet structure.

When the reservoirs are both full, each one could release more than 2,000 cfs for at least a short time period. A maximum flow of 2,000 cfs was used to size the outlet works energy dissipation and downstream erosion protection. It will be important during operation of the gates not to fully open the gates when the reservoirs are full. The resulting discharge would exceed the outlet works energy dissipation and could result in substantial downstream erosion and scour hole formation.

The flow duration of releases over the 10-year modeling period is provided in Appendix F. From the flow duration relationship, it is noted that total discharge is less than 200 cfs for 80 percent of the time and there is no discharge expected for approximately 50 percent of the time. Due to the low discharges that are periodically required, future consideration should be given to including a smaller service gate at each outlet structure.

The configurations of the outlet structures are shown on Figures 2-3 and 2-4. The outlet gates rating curve are provided in Appendix F.

2.2.4 Phelps Canal Control Gate

A control gate is needed in the Phelps Canal downstream of Area 1 to maintain a sufficient water surface elevation in the canal for storage operations and to regulate downstream irrigation flows. The flow duration relationship of irrigation flows within the Phelps Canal over the 10-year modeling period for the April through August irrigation season is provided in Appendix F. The flow duration relationship illustrates that the maximum irrigation flow is 1,000 cfs, and no irrigation flow is expected for approximately 25 percent of time. Under existing operations, flow in the canal is zero during the non-irrigation season (September through March). However, under future operations, the canal will have flow throughout the year. It is anticipated that water will flow under a layer of ice during winter flows. The Phelps Canal control gate must be able to modulate from fully closed to fully open while maintaining the required downstream irrigation flow and an upstream water elevation based on the desired flow rate from the canal into storage. The gate must also be able to accommodate bottom releases during winter flows. A 30-foot wide by 18-foot high radial type gate was selected for the Phelps Canal control gate. The Phelps Canal would be transitioned from its current trapezoidal cross-section to a concrete lined rectangular cross-section to accommodate the control gate.

2.2.5 Inlet Gates and Phelps Canal Control Gate Summary

Table 2.4 summarizes the gate sizes for Areas 1 and 2 inlets and outlets and the Phelps Canal.

Table 2.4 Control Gates Size Summary

Location	Gate Type	Number of Gates	Gate Width, ft	Gate Height, ft
Area 1 Inlet	Sluice	3	12	10
Area 1 Outlet	Radial	1	20	28
Area 2 Inlet	Sluice	3	12	12
Area 2 Outlet	Radial	1	10	24
Phelps Canal	Radial	1	30	18

Table 2.5 summarizes the operation of the inlet gates and Phelps canal gate. The estimated costs of the control gates and associated construction are discussed in Section 4.0 and are detailed in Appendix D.

Table 2.5 Inlet and Phelps Canal Control Gates Operational Summary

Condition	Component	Position/Function	Comments
1 – Initial Condition with Empty Reservoirs	Phelps Canal Gate	Closed	Gate will modulate to control downstream irrigation flow in Phelps Canal
	Reservoir Inlet Gates	Closed	If no excess flows are available, the water level in Phelps Canal will be controlled from the existing gate located downstream of Area 1
2 – Fill Reservoirs by Gravity	Phelps Canal Gate	Regulation	Gate will modulate to control downstream irrigation flow in Phelps Canal and upstream canal water level and flow rate into storage
	Reservoir Inlet Gates	Raised position	

Note: In all scenarios, the Phelps Canal control gate will modulate so that the upstream water elevation does not exceed 2358.0

2.3 Geotechnical Investigation

A geotechnical investigation and analysis were conducted to address the geotechnical considerations for the project, including embankment stability, seepage conditions, and settlement. A memorandum titled *J-2 Areas 1 and 2 Analysis,* dated February 25, 2011 documents the preliminary assessment and is included in Appendix G. As part of the study, 29 soil test borings were drilled and 38 locations were probed. Laboratory analyses were performed on the soil samples and the results were used in the geotechnical evaluation. The results are detailed in *Report of Geotechnical Exploration: CNPPID Reregulating Reservoir Feasibility Study, J-2 Return Alternatives, Gosper and Phelps County, Nebraska*, dated August 19, 2010. This report is included as an appendix to the geotechnical memorandum and is also included in Appendix G.

2.3.1 Adequacy of Onsite Soil

Collapsible soils were encountered below the embankments for Areas 1 and 2 in very limited locations. The collapsible material should be overexcavated and recompacted to remove the collapse potential of the soils. Excavations necessary to remove the collapsible soils above the ground water table would involve excavations ranging in depth from 5 to 10 feet below the existing ground surface in Area 1 and from 5 to 15 feet below the existing ground surface in Area 2. The volume of soil to remove and recompact is estimated to be 75,200 cubic yards, however, a more refined geotechnical investigation should be performed during the preliminary design to better define the area of concern.

2.3.2 Embankment Slope Stability

Based upon the tested soil properties, the embankments were stable under the analyzed conditions of steady seepage and rapid drawdown. The maximum water height for both conditions was set at 3 feet below the top of the embankment. A toe sand drain will be needed for both areas. The sand toe drain should be located at the river side edge of the embankment. The sand drain should extend a minimum lateral distance of 27 feet into the embankment. The on-site sand that will likely be encountered during grading operations appears to be suitable for construction of the toe sand drains. A cutoff trench is recommended along the entire berm centerline for both areas. The cutoff trench should be excavated to a depth of 5 feet to mitigate excessive seepage through the upper foundation soils which may have greater permeabilities due to processes such as frost and desiccation cracking. Illustration 2-3 depicts the sand toe drain along the embankment profile.

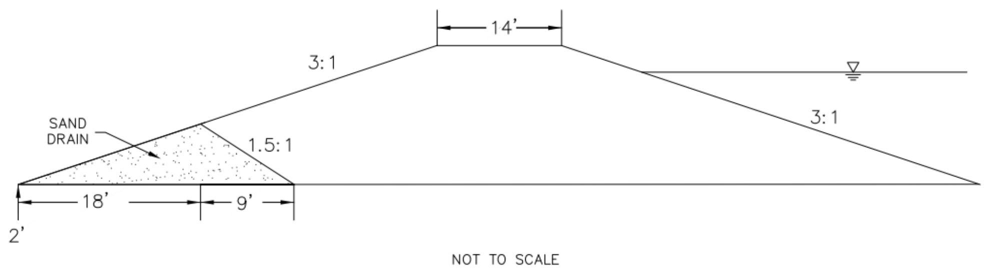

Illustration 2-3. Embankment Profile

To protect the cemetery that is located near the southeast corner of Area 1, a trench drain should be installed along the entire perimeter of the cemetery. The drain should extend at least 6 feet below the existing ground surface and be approximately 2.5 feet wide. The trench drain will need to daylight for gravity drainage. Two options exist to daylight the trench drain. One option is to deepen the ditch on the north side of county road 748. This ditch will need to continue east until it meets existing grade or meets existing ditch grades. The other option would be to utilize the drainage system between Area 1 and Area 2 that drains into the Platte River. The existing drainage system is not deep enough to provide the needed drainage. Deepening the drainage to the Plate River would be required. The cost of this system versus deepening the existing road 748 ditch should be evaluated during preliminary design.

2.3.3 Phelps Canal Slope Stability

Additional analysis will be required to address the need for a pressure relief system due to uplift concerns related to the Phelps Canal when Areas 1 and 2 are empty or when the storage areas are full and Phelps Canal is empty. As part of the feasibility study, a limited evaluation was performed based on limited information and parameters. The analysis indicated that the potential does exist to relieve the uplift pressures by installing a drain tile system between the Phelps Canal and Area 2 and approximately 2,000 ft along Area 1 in order to relieve the uplift pressures. Further analysis will be necessary as additional information is developed as part of the preliminary design for the pressure relief system, including the pipe sizing and spacing.

2.3.4 Areas 1 and 2 Compacted Clay Liner

In order to manage the total potential seepage out of the bottom of the storage areas, a 12-inch compacted clay liner is recommended. It is anticipated that the northern one-third of Areas 1 and 2 will need to be overexcavated and lined with at least 12" of clay because sandy soils were encountered at the existing ground surface or are anticipated to be encountered during excavation operations. Grading operations will also likely encounter sand in the south side of Area 2 in an area around soil test B-7 in Area 1 (see the Area 1 Boring Location Map in Appendix G) and in the southwest corner of Area 2. These areas will also need to be lined with clay. Based on the elevation of the sand that was encountered in the limited number of soil test borings completed for the feasibility assessment, it is anticipated that suitable clay will be encountered at the proposed finished grade throughout the remainder of the storage areas. The existing clays at the proposed finished grade will need to be compacted to improve their water holding capability.

The overall size of Area 1 increased after the soil test boring operations had been completed. Therefore, no soil test borings were completed in the western third of Area 1 and the thickness of existing clay layer and the elevation of the sand must be further evaluated during the preliminary design.

2.3.5 Dead Pool Cover

The clay liner will be vulnerable to desiccation cracking if not properly protected. Two options exist for protecting the liner. One option is to place the clay liner 12 inches below the finished grade and cover with 12 inches of soil and at least 12 inches of water at all times. The other option would be to place the liner at the finished grade and then cover with 24 inches of water at all times. If, under extreme drought conditions, the liner does become desiccated, bentonite might be required to restore the water holding capability. Embankment material placed within four feet of the inner slope should consist of silty clay soils.

2.3.6 Wave Protection

With the recommendation of two feet of dead pool to protect the clay liner, erosion due to wind-driven wave action is a possibility. Further, if the basins were held full during a sustained high wind event, the upper portion of the reservoir embankments could be exposed to a sustained wave attack. A conference call was held with the ED Office and CNPPID on March 21, 2012 to discuss wave protection options. It was discussed that at this level of analysis, the costs for protecting the entire embankment as opposed to only the upper portion and toe of the embankments should be compared. The topic should be further evaluated during the preliminary design process, during which an evaluation will be performed to determine the risk exposure of a sustained high wind event occurring when the pool is at high stage.

A conceptual level wave protection analysis was performed in accordance with Natural Resources Conservation Service's Technical Release 69 (TR-69), *Riprap for Slope Protection against Wave Action*. The highest temporary pool elevations in Areas 1 and 2 were assumed to be present during the high wind event for a conservative approach. The reservoir sides (insides) of the north and east embankments are most susceptible to wave action due to the prevailing summer wind directions that are common in Central Nebraska. An assumed 50 mph sustained wind in the direction of the longest fetch was used for the calculations.

Four alternatives were developed to protect the embankment and clay liner and cost estimates were prepared. The alternatives included rock riprap on the entire inside face of either all of the embankments or only the north and east embankments or a combination of riprap on the top 1/3 of the embankment and a gravel-surfaced beaching slope (12 horizontal feet to one vertical foot) from the toe to approximately 3 feet above the dead pool. The advantage to the beaching slope is that the materials are locally available as opposed to rock riprap, which would need to be hauled in or delivered by rail. The disadvantage is that some volume will be lost. The embankments cannot be moved out any farther. Table 2.6 summarizes the alternatives and their associated construction costs, not including such factors as contingency and allowance.

Table 2.6 Wave Protection Alternatives and Costs

Alt. No.	Alternative	Area 1 Cost	Area 2 Cost	Total Cost
1	Rock riprap on entire face, all sides	$6,474,000	$3,022,500	$9,496,500
2	Rock riprap on top 1/3 and toe, all sides	$4,104,750	$2,548,000	$6,652,750
3	Rock riprap on top 1/3 and gravel beaching slope at bottom, all sides	$4,745,000	$2,691,000	$7,436,000
4	Rock riprap on top 1/3 and gravel beaching slope at bottom, north and east sides only	$2,863,500	$1,432,950	$4,296,450

The recommended planning-level alternative is Alternative 4, a combination of a gravel-surfaced beaching slope at the bottom of the embankment and rock riprap at the top. The Area 1 and Area 2 storage volumes presented in this report have not been adjusted to include the wave protection, nor have the continuous simulation models ben re-run to estimate Program yield. The cost tables, however, have been updated. Figure 2-5 in Appendix A shows a detail of the embankment protection.

2.3.7 Area 1 Uplift Protection

Due to uplift concerns outside of storage Area 1 in the northeast corner, the alluvial clay soils should be excavated along approximately 2,100 lineal feet of the river side toe of the embankment. The excavation should extend a perpendicular distance of 60 feet from the river side toe of the embankment and then be backfilled with sand. Based on the soil test borings, excavations to remove the alluvial clay soils will likely extend approximately 1.5 to 3.5 feet below the existing ground surface.

2.4 Recommendations for Further Geotechnical Analyses

The purpose of the geotechnical analyses to date was to address the feasibility of Areas 1 and 2. A more detailed geotechnical evaluation must be completed during the preliminary and final design phases. The detailed geotechnical evaluation must, at a minimum, include the following items:

- More detailed assessment of the extents of the collapsible soils.
- Additional soil test borings throughout Areas 1 and 2 and in particular the western 1/3 of Area 1 in order to better delineate the elevation of the sand and potential sand outcroppings. A geophysical assessment should also be considered to better assess the layering of the site soil conditions.
- Additional permeability testing must be performed on the on-site soils to verify suitability for use as liner material.

- Complete a geotechnical evaluation of the proposed structures which should include soil test borings and laboratory testing.
- Detailed analysis of the uplift pressure associated with the Phelps County Canal including both storage areas and the necessary pressure relief system.
- A water supply source would be needed to maintain the dead pool. An average monthly water balance should be calculated that includes evaporative and seepage loss for the volume needed.

3.0 PRELIMINARY ENVIRONMENTAL AND PERMITTING DISCUSSION

3.1 Compatibility with Platte River EIS

The PRRIP was established through the Environmental Impact Statement (EIS) that was jointly conducted by the USFWS and the U.S. Bureau of Reclamation. The purpose of the EIS was to establish a program that would be responsible for conducting restoration activities on the central Platte River to improve habitat for interior least tern, piping plover, and whooping crane, while not adversely affecting habitat for pallid sturgeon in the lower Platte River. Three plans were set up: an adaptive management plan to utilize research and monitoring to improve management; a land program to acquire habitat; and a water program to provide flows for habitat. Among the alternatives considered within the water planning process were re-regulating reservoirs to provide flows that could improve habitat. Thus, this project is compatible with the Platte River EIS.

3.2 Waters of the U.S. and Waters of the State

Waters of the U.S. Section 404 permit. Any reservoir project in the vicinity of the Platte River is likely to impact waters of the U.S., either temporarily during construction, or permanently from excavation or fill activities. These activities are regulated by the U.S. Army Corps of Engineers (COE) under Section 404 of the Clean Water Act, and will require a Section 404 permit. Depending on the extent of impacts to wetlands and other waters, the permitting process could be done under a general permit, including Nationwide Permits (NWP), which can be utilized throughout the country for specific purposes, or a Regional General Permit, which would be issued to the Program for the specific purposes of habitat restoration. If the project does not meet the criteria for a General Permit, the Program would need to submit an application for an Individual Permit (IP).

An IP is much more complicated to obtain than a NWP, and would require a detailed discussion of efforts to avoid, minimize, and mitigate impacts in that order (referred to as "sequencing") as well as a discussion of other alternatives considered. In addition, a detailed compensatory mitigation plan that considers functions of the aquatic resources, and an assessment of environmental impacts similar to an Environmental Assessment, would be required. An IP requires a public notification period and can take a minimum of six to nine months, and up to several years, to obtain, whereas a NWP should be issued within three to five months.

Note that all Section 404 permits, including NWPs, must be in compliance with the requirements of the Endangered Species Act (ESA) and the National Historic Preservation Act (NHPA).

Waters of the U.S. Section 401 Water Quality Certification. Furthermore, an IP and some NWPs require coordination with Nebraska Department of Environmental Quality (NDEQ) to obtain an individual Section 401 Water Quality Certification. Like IPs, individual WQCs involve a public notification period. It is recommended that coordination with both COE and NDEQ be done early in the preliminary and final design process to facilitate the permitting of the project.

Waters of the State. Based on the location of wetlands, and determination of whether they have a significant nexus to navigable waters, the COE does not have jurisdiction over some wetlands. Some of these wetlands have been determined to be Waters of the State rather than Waters of the U.S. The State of Nebraska regulates impacts to these wetlands under the anti-degradation clause of Title 117, Surface Water Quality Standards. Although at present there is no permitting process associated with determining whether an action prevents degradation of wetlands, NDEQ will issue a letter of opinion that indicates the project will not degrade wetlands. Generally, mitigation for impacts to wetlands is required to obtain a letter of opinion. In addition, if a project will impact both Waters of the U.S. and Waters of the State, the COE is likely to require compensatory mitigation for all wetland impacts. Note that the COE determines jurisdiction, in other words, whether a wetland is Waters of the U.S. or Waters of the State.

Executive Order 11990, Protection of Wetlands. EO 11990 applies to Federal Government projects. If Federal funds are involved in this design or construction of the reservoir, then EO 11990 will apply. As for Section 404 IPs, this EO would require a consideration of the functions of the aquatic resources and efforts to avoid and minimize impacts to wetlands, including Waters of the State as well as Waters of the U.S.

3.2.1 Wetlands and Other Waters

A wetland delineation was conducted to determine the extent of wetlands and other waters within Areas 1 and 2. The delineation included review of existing databases, as well as an on-site investigation using the COE Wetland Delineation Manual methodology. The delineation was documented in the report *Jurisdictional Evaluation and Wetland Delineation Report: CNPPID Re-Regulating Reservoir Project, Phelps and Gosper Counties, Nebraska*, dated September 2010. Based on the review of existing resources and the field investigation it was determined that three wetlands are located within the project study areas, two in Study Area 1 and one in Study Area 2. In addition, two other waters were identified in Study Area 1 during the site visit. The wetlands and waters are summarized in the following paragraphs. Figures 3-1 and 3-2 in Appendix A are Figures 4A and 4B excerpted from the wetland delineation report and are included to show the specific location of the wetlands.

Wetland/Waters A is located within the northeast portion of Study Area 1 (Figure 3-1 in Appendix A) and is an agricultural re-use pit. The re-use pit is depicted on the NWI map as a Palustrine Unconsolidated Bottom Semipermanently Flooded Excavated (PUBFx) waters. The field investigation found a Palustrine Emergent Temporarily Flooded Excavated (PEMAx) wetland fringe surrounding a PUBFx waters at the site. The wetland fringe was dominated by a sedge species and spreading yellowcress. Because this wetland/waters is an agricultural re-use pit that was constructed in an upland area it is not likely to be jurisdictional. Thus, impacts to Wetland/Waters A are not likely to require a Section 404 permit.

Wetland/Waters B (Figure 3-1 in Appendix A) is located within the roadside ditch north of 748 Road in the southern portion of Study Area 1. This ditch is depicted on the NWI map as a Palustrine Emergent Seasonally Flooded Excavated (PEMCx) wetland. The bottom of this ditch was characterized by flowing water up to 1 foot deep with areas of emergent vegetation and other areas that lacked vegetation. The vegetated areas were dominated by reed canarygrass and cattails and are PEMCx wetlands. The un-vegetated areas are Riverine Intermittent Streambed Mud Excavated (R4SB5x) waters. Because this wetland/waters appears to be a relatively permanent water, and because it appears to be directly connected to the Platte River approximately 2 miles down-gradient of the site, it is likely that Wetland/Waters B is jurisdictional, and thus impacts would require a Section 404 permit.

Wetland C (Figure 3-2 in Appendix A) is located within a wooded area in the southeast portion of Study Area 2. This wooded area is located along a remnant section of Plum Creek. Plum Creek has since been diverted just west of Study Area 2, which effectively conveys all the water in Plum Creek directly north to the Platte River. This diversion has eliminated Plum Creek within the study areas and most of the land that was formerly encompassed by Plum Creek and its adjacent riparian area is now being used for irrigated row crop production. However, one remnant isolated section of Plum Creek is still located within Study Area 2 and this is where Wetland C is located. Portions of this area are depicted on the NWI as Palustrine Forested Temporarily Flooded (PFOA), Palustrine Scrub/Shrub Seasonally Flooded (PSSC), and PEMC wetlands.

The site visit revealed that water likely only flows through this area during large runoff events and that PEMA/C and Palustrine Aquatic Bed Semipermanently Flooded wetlands are located within the old channel, but not in the adjacent wooded area. The PEMA/C portions of the wetland had standing water or saturated soils in the upper 12 inches and were dominated by smartweed species, kidney-leaf buttercup, and reed canarygrass during the site visit. The PABF portion of the wetland was characterized by submergent aquatic vegetation, duckweed, and algae. Because Plum Creek has been diverted up-gradient of the study area, this wetland does not have a surface water connection to Plum Creek. Therefore, this wetland is likely non-jurisdictional and impacts will not require a Section 404 permit.

3.2.2 Regulatory Issues

Wetlands and other waters determined to be jurisdictional are waters of the U.S. under the jurisdiction of the COE. Placement of dredged or fill material into jurisdictional wetlands and other waters of the U.S. requires a Section 404 Permit from the COE. This project may be eligible for a Nationwide Permit (NWP) depending on the amount of impacts to jurisdictional wetlands and other waters of the U.S. Based on current regulation, if wetland impacts are less than 0.5 acres, and impacts to stream beds are less than 300 linear feet, the activity may be eligible for a NWP. If impacts are greater than 0.5 acres and/or remove more than 300 feet of stream bed, an IP may be required, although a waiver may be granted for minimal impacts over 300 feet. In addition, if permanent impacts to jurisdictional wetlands are over 0.1 acre the COE will likely require mitigation. Note that the current NWPs expire in March, 2012, and it is not yet known what the criteria will be for the new NWPs.

As mentioned above, only the COE can determine jurisdiction. If wetlands on the site are determined by the COE to be non-jurisdictional, the State of Nebraska may consider the wetlands waters of the State. Impacts to waters of the State are regulated by the Nebraska Department of Environmental Quality (NDEQ) under Title 117 – Nebraska Surface Water Quality Standards. If the project is to impact waters of the State, coordination with NDEQ and potential mitigation will be required to ensure the project does not violate the Anti-degradation Clause (Chapter 3) of Title 117.

Until plans are more fully developed, it is not possible to determine if this project will require a NWP or an IP, or possibly even no Section 404 permit. For example, if Wetland/Waters B is the only jurisdictional waters, and it is avoided, no 404 permit is required. However, if it is entirely impacted, an IP will be needed.

Impacts to Waters of the U.S. and Waters of the State will both require mitigation. In general, the COE requires a minimum mitigation ratio of 2:1 mitigation acreage: impacted acreage for Waters of the U.S., and NDEQ requires a mitigation ratio of 1.5:1 for Waters of the State. In addition, the COE is developing mitigation guidelines for stream impacts in Nebraska, which are currently available in draft form. Depending on the nature of the design, it may be possible to incorporate design features that make the project self-mitigating, without the need to identify and construct additional mitigation sites.

All statements regarding jurisdiction and permitting requirement (including mitigation) presented in this report are preliminary. Detailed project plans and coordination with the COE and the NDEQ will be required to determine waters of the U.S., waters of the State, and what level of permitting and mitigation is required for the project. If impacts to waters of the U.S. can be reduced below the thresholds for an IP (0.5 acres of wetland and 300 linear feet of stream channel impact), then a NWP may be applicable.

Recommendations: A Jurisdictional Determination should be requested from the Corps to determine which wetlands are Waters of the U.S. In addition, if possible, design plans should make efforts to avoid wetlands and waters.

3.3 Compliance with National Historic Preservation Act

Any Federal action, such as federal funding or issuance of a Section 404 permit by the COE, requires compliance with the National Historic Preservation Act (NHPA), and coordination with the State Historic Preservation Office under Section 106 of the NHPA. In addition, the Platte River EIS committed projects undertaken through the Program to compliance with NHPA. Therefore, a consideration of potential historic or archeological sites is a component of this project.

An archeological investigation was conducted and documented in the report *Archeological Investigation and Assessment: Platte River Recovery Implementation Program, Areas of Potential Effect, Plum Creek Vicinity, Gosper and Phelps Counties, Nebraska* (Cultural Resources Consulting, 2012). The following paragraphs summarize key findings from the report.

The Platte River corridor has been an area used by both Native Americans and by thousands of EuroAmericans for migration along the Oregon and Mormon trails. As a result, it is likely that there could be pre-historic or historic archeological sites anywhere within the river valley or adjacent hills and bluffs. Therefore, in order to comply with the NHPA, an archeological survey of Area 1 and Area 2 was conducted. The survey consisted of a review of existing documented sites, and a pedestrian survey to identify artifacts. The pedestrian survey inspected the surface for artifacts or other evidence of cultural features on the surface. No excavations were done.

Search of the Nebraska State Historic Society (NSHS) archeological site files indicated three historic sites within Area 1 Area of Potential Effect (APE): 25PP1, “Fort Plum Creek;” 64 25PP15, “Freeman’s Second Post;” and 25PP16, “Plum Creek Station” within Area 1 APE. In addition, the historic site 25PP17, “The Thomas Ranch,” is recorded immediately east of Area 1. Files also indicate historic site, 25PP18, Oregon Trail Wagon Ruts, located within the southern portion of Area 2 APE. Additionally, 25PP7, a Central Plains Tradition prehistoric village site, is recorded a short distance east of Area 2.

Communication with local residents, as well as notations contained in the Phelps County and the Dawson County Historical Societies indicated that numerous individual artifacts have been collected within the extent of Areas 1 and 2, as well as from landforms in the immediate vicinity of the APEs.

The on-site investigation at Area 1 indicated that all three previously recorded sites within the APE have been significantly impacted by years of cultivation, and land leveling to allow gravity irrigation. No prehistoric materials or significant historic artifacts were encountered. However, given past evidence of artifacts and historic sites, some potential for intact buried cultural features such as privies and postholes may remain.

The study recommended the following:

> "If construction occurs at these site locations, shallow grading [should] be conducted to remove the plowzone, along with archeological monitoring to determine if intact subsurface features remain that may contain valuable data. Given the significant amount of earthmoving related to land leveling to allow gravity irrigation and filling of the historic Plum Creek channel in the Area 1 APE, and the grading of terraces and filling of the historic Plum Creek channel of Area 2, substantial impact has undoubtedly negatively affected any archeological site that was present at one time. It appears the greatest concern for impacting intact cultural features would be related to encountering burials during excavations. Archives document numerous burials along the Platte River Road, and burial encounters by early settlers to the region, although their precise locations are unknown….If prehistoric artifacts or features are encountered, or if concentrations of historic artifacts or buried historic cultural features outside of the PRRIP Area 1 farmstead Scatter 1 and Scatter 2 as shown in this report (Figure 14) are encountered during any excavations, work should be halted and the NeSHPO contacted for further advice."

Recommendation: It is recommended that coordination with the State Historic Preservation Office (SHPO) and any applicable tribal entities begin early in the preliminary design process to minimize impacts and to provide for mitigation measures, and potentially a Memorandum of Agreement, which may be required in order to obtain a Section 404 permit.

3.4 Platte River Depletions

Due to the cumulative effect of numerous small diversions of surface and ground water within the Platte River basin, the U.S. Fish and Wildlife Service has determined that any additional depletions to river flows have the potential to adversely affect the habitat of threatened and endangered species that use the river, including interior least tern, piping plover, whooping crane, and pallid sturgeon. New impoundments result in increased evaporation, resulting in additional flow depletions. Thus, the State of Nebraska Department of Natural Resources (NDNR) is not permitting projects that impound water within the vicinity of the Platte, without mitigation for the additional flow depletions.

In addition, the COE may require a calculation of flow depletions if a Section 404 permit is required, as the permitting process requires coordination with U.S. Fish and Wildlife Service and possibly the Nebraska Game and Parks Commission through Federal and State Endangered Species Acts (ESA) and the Fish and Wildlife Coordination Act.

Impounding water for hydrocycle mitigation and for a dead pool liner will increase the depletions. However, this project is designed to impound water for short periods and release the water to obtain short duration high flows during the spring and additional releases during times of shortages, which are intended to maintain habitat for these very species. Thus, the overall benefits to the species will increase.

Recommendation: It is recommended that coordination with NDNR (and potentially COE) be done early in the preliminary design process to determine whether flow depletions are a concern, and whether mitigation will be required to allow permitting of the project.

3.5 Other Permits/Required Coordination

Additional permits and approvals must be obtained as part of the final design process and prior to construction. Key approvals and permits are listed below, however, additional permits and approvals may be required.

- Dam Safety approval through NDNR
- Storage Permit through NDNR
- Floodplain Permit through NDNR
- FERC approval, which is being handled by CNPPID
- National Pollutant Discharge Elimination System (NPDES) Permit for Storm Water Discharges from Construction Sites through the Nebraska Department of Environmental Quality

4.0 PROJECT COSTS

Feasibility-level costs were prepared for construction of Areas 1 and 2 and upgrades to the Phelps Canal. The detailed cost estimates are included in the incremental cost analysis update dated January 31, 2012 and included in Appendix D. Tables 4-7 are the key tables relating to Options 4 and 5 with upgrade of the Phelps Canal.

Major cost items for construction of Areas 1 and 2 included the following:

- Earthwork for excavation of storage areas and construction of berms to surround them
- Remediation of collapsible soils
- Toe drains
- Protective clay liner
- Toe drains and drain tile
- Riprap and gravel beaching slope wave protection on reservoir sides of north and east embankments
- Inlet sluice gates for Areas 1 and 2 and associated work items including controls, electrical work, and erosion protection
- Outlet radial gates for Areas 1 and 2 and associated work items
- Inline radial gate in Phelps Canal and associated work items
- Roadway improvements to mitigate for impacted roads
- Pump station for Area 2 (all Options but 5)
- Property acquisition including three houses

Major cost items for construction of the Phelps Canal upgrade included the following:

- Earthwork for raising the berms and widening the canal in select areas
- Enlargement of Parshall flume
- Additional siphon under Plum Creek
- Enlargement of flume over Plum Creek return channel
- Bridge replacement
- Riprap protection of channel bends

A construction contingency was added to the costs due to the uncertainties in the estimate at this stage of design. Allowances were added for engineering, permitting, administrative and legal services, and construction management and administration during project construction. The following percentages were used:

Construction contingency	25%
Design	8%
Permitting	2.5%
Administrative and Legal	2.5%
Construction Management and Administration	7%

Table 4.1 summarizes the total construction costs for Option 5, the recommended alternative.

Table 4.1 Cost Summary for Option 5

Project Component	Probable Construction Cost Including 25% Contingency	Allowances	Land Acquisition	Construction Plus Allowances and Land Acquisition
Area 1	$21, 113, 815	$4,222,763	$3,472,000	$28,808,578
Area 2	$13,667,244	$2,735,449	$1,380,000	$17,792,693
Phelps Canal	$2,589,309	$517,862	$0	$3,107,171
Total	$37,380,367	$7,476,073	$4,852,000	$49,708,441

5.0 CONCLUSIONS

The following conclusions related to the overall purpose of the J-2 reregulating reservoirs project may be drawn from the analyses to date:

1. The J-2 reregulating reservoirs Areas 1 and 2 can feasibly be used by the Program to provide storage with which to produce a short duration high flow and to provide water for reduction of shortages to target flows.
2. If CNPPID uses Areas 1 and 2 for hydrocycle mitigation, only small reductions to Program yield were estimated to occur, assuming CNPPID implements its preferred operation of the J-2 hydropower plant.
3. If CNPPID uses Area 2 during the irrigation season to regulate flows for irrigation delivery while maximizing hydroelectric power production during peak value times of the day, Program yield will be reduced approximately 5.9%.
4. It is recommended that Option 5, construction of Areas 1 and 2 without the Area 2 pump station plus upgrade of the Phelps Canal be advanced to preliminary and final design.

6.0 IMPLEMENTATION TASKS AND SCHEDULE

The following list outlines the major steps to be taken to complete the J-2 reregulation reservoir project. The permitting and approval process should begin as early as possible.

1. Pre-application meetings with the following entities to facilitate permitting and needed approvals. After meetings are held and requirements are determined, the permitting/approval processes can begin.
    - U.S. Army Corps of Engineers
    - Federal Energy Regulatory Commission
    - State of Nebraska Department of Natural Resources
    - U.S. Fish and Wildlife Service
    - Phelps and Gosper Counties concerning road closures and crossings
2. Preliminary Design
3. Land Acquisition
4. Final Design
5. Public Bid Letting
6. Construction Phase

Illustration 6-1 shows a projected schedule for project completion, assuming that the consultant that will be completing the final design is selected, their contract is negotiated, and they receive a notice to proceed around January 15, 2013. The permitting timeline was based on a nationwide permit or similar abbreviated Corps of Engineers permitting process. An individual permit can take much longer. It is anticipated a winter shutdown will occur during construction.

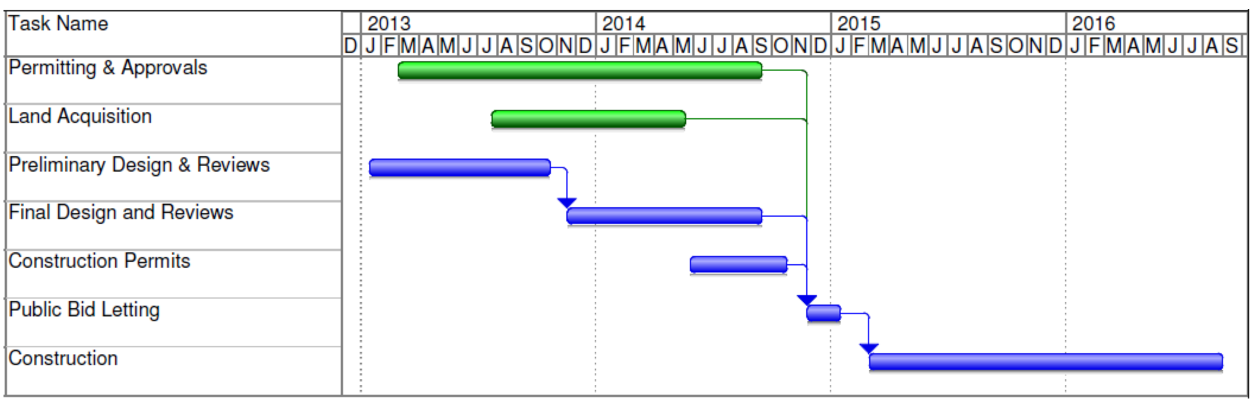

Illustration 6-1. Potential Project Schedule

7.0 REFERENCES

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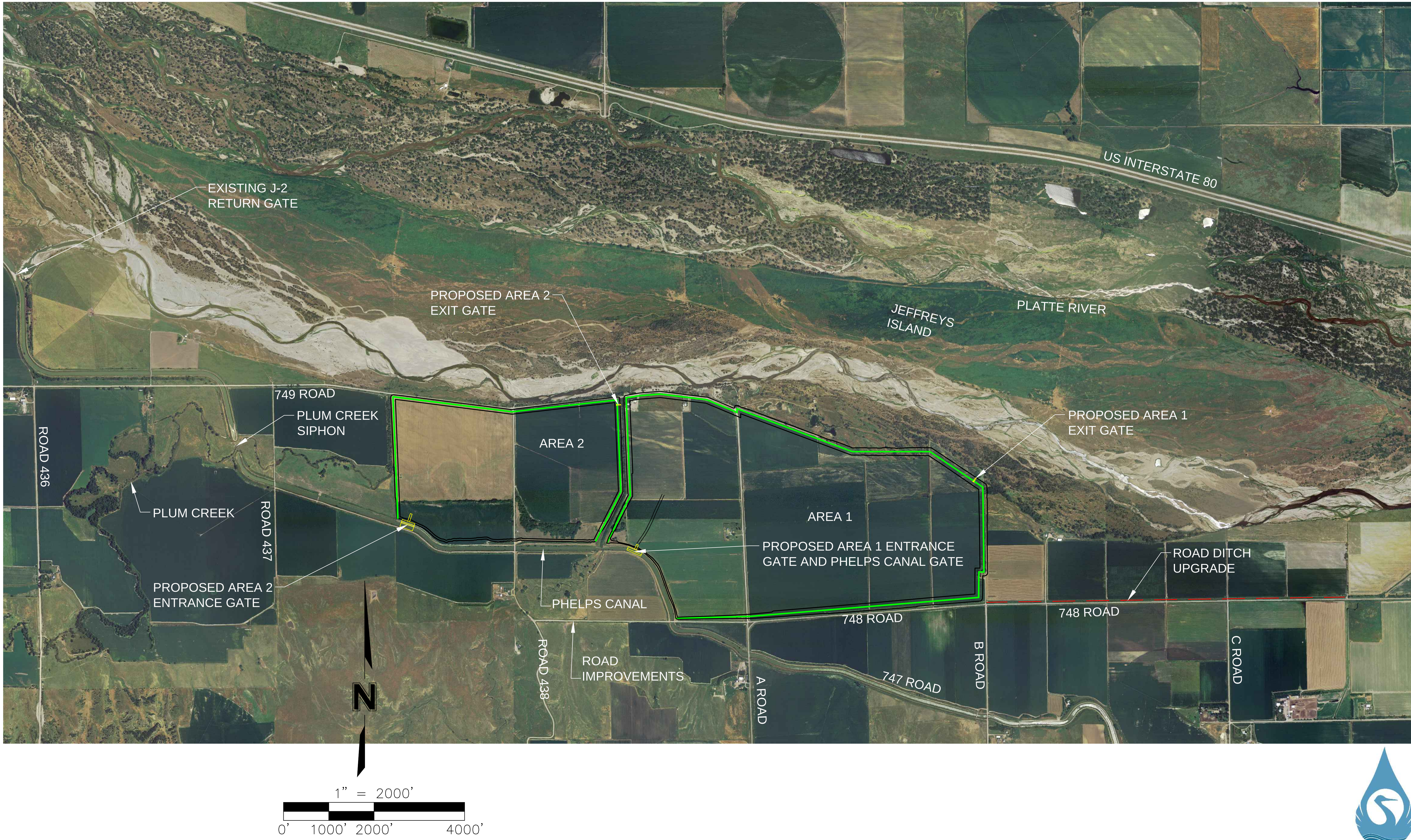
APPENDIX A

FIGURES



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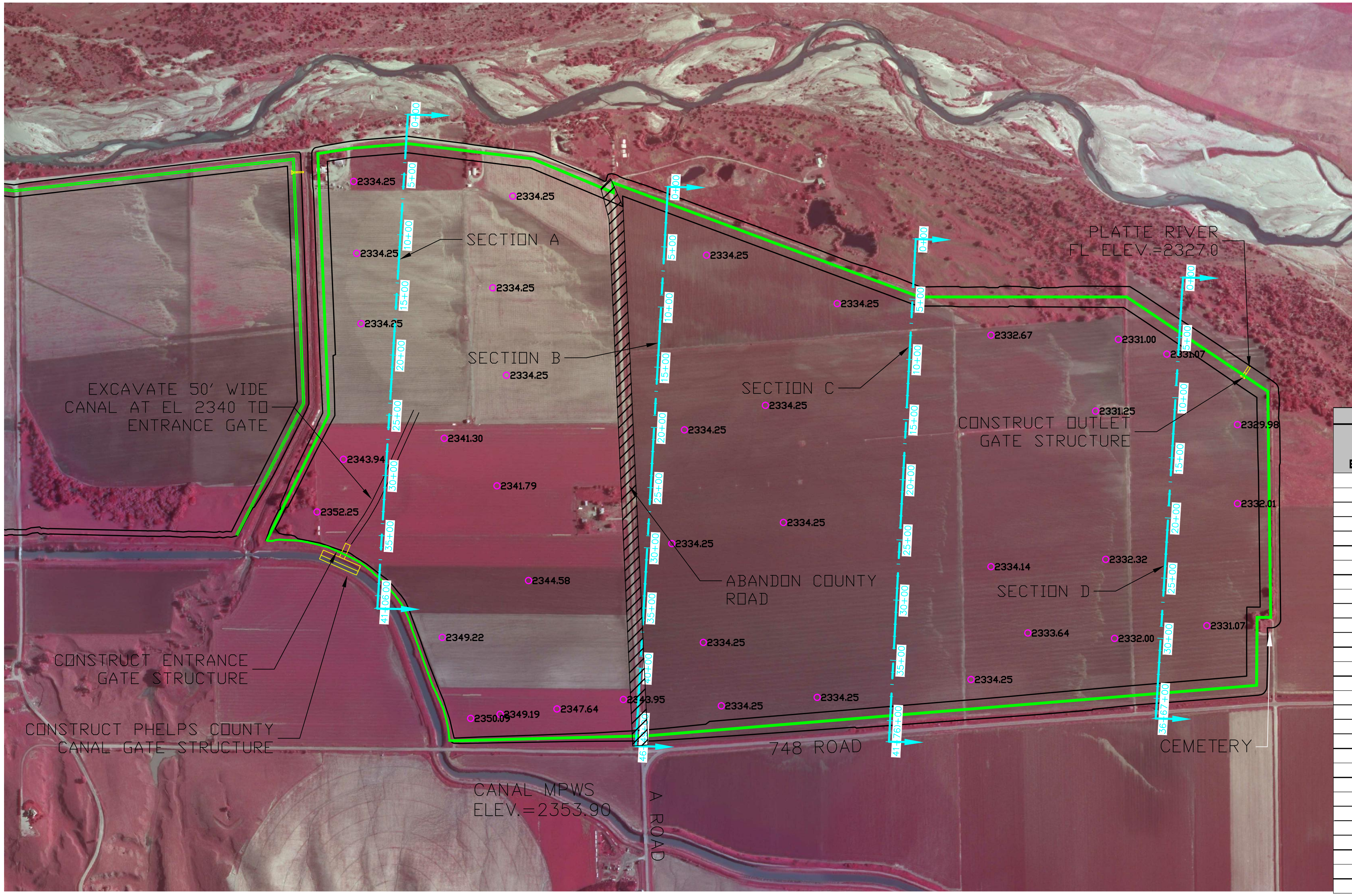
PROJECT: 009-1466	J-2 REREGULATING RESERVOIR PROJECT LOCATION MAP GOSPER AND PHELPS COUNTIES, NEBRASKA
DRAWN BY: CRL	
DATE: 3.19.2012	

OLSSON ASSOCIATES

BLACK & VEATCH

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

FIGURE 1-1



N

1" = 1000'

0' 500' 1000' 2000'

SCALE IN FEET

Option 5, Stage Storage - Area 1					
Elevation	Area (sf)	Area (acre)	Incremental Storage (acre-ft)	Total Storage (acre-ft)	Beneficial Storage (acre-ft)
2329	7,170	0	0	0	0
2330	173,032	4	2	2	0
2331	802,747	18	11	13	0
2332	2,672,435	61	40	53	0
2333	4,799,676	110	86	139	0
2334	6,570,955	151	131	269	0
2334.2	7,741,894	178	33	302	0
2334.3	23,248,250	534	36	338	0
2335	23,298,522	535	374	712	0
2336	23,363,608	536	536	1,247	0
2337	23,446,709	538	537	1,785	403
2338	23,531,918	540	539	2,324	942
2339	23,619,371	542	541	2,865	1,483
2340	23,709,194	544	543	3,409	2,027
2341	23,785,091	546	545	3,954	2,572
2342	24,736,098	568	557	4,511	3,129
2343	25,333,586	582	575	5,085	3,704
2344	26,051,407	598	590	5,675	4,293
2345	26,545,556	609	604	6,279	4,897
2346	27,028,546	620	615	6,894	5,512
2347	27,525,225	632	626	7,520	6,138
2348	27,973,044	642	637	8,157	6,775
2349	28,409,848	652	647	8,804	7,422
2350	28,841,458	662	657	9,461	8,080
2351	29,195,253	670	666	10,128	8,746
2352	29,292,827	672	671	10,799	9,417
2353	29,495,671	677	675	11,474	10,092
2354	29,642,156	680	679	12,153	10,771
2354.25	29,663,235	681	170	12,323	10,941

LEGEND

STORAGE AREA BOUNDARY
EXISTING GRADE
TOE OF EMBANKMENT
TOP OF EMBANKMENT
SPOT GRADE ELEVATION

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PROJECT: 009-1466
DRAWN BY: CRL
DATE: 3.19.2012

J-2 RETURN ALTERNATIVE 2
OPTION 5, AREA 1 STAGE STORAGE

OLSSON ASSOCIATES

BLACK & VEATCH

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

FIGURE 1-2

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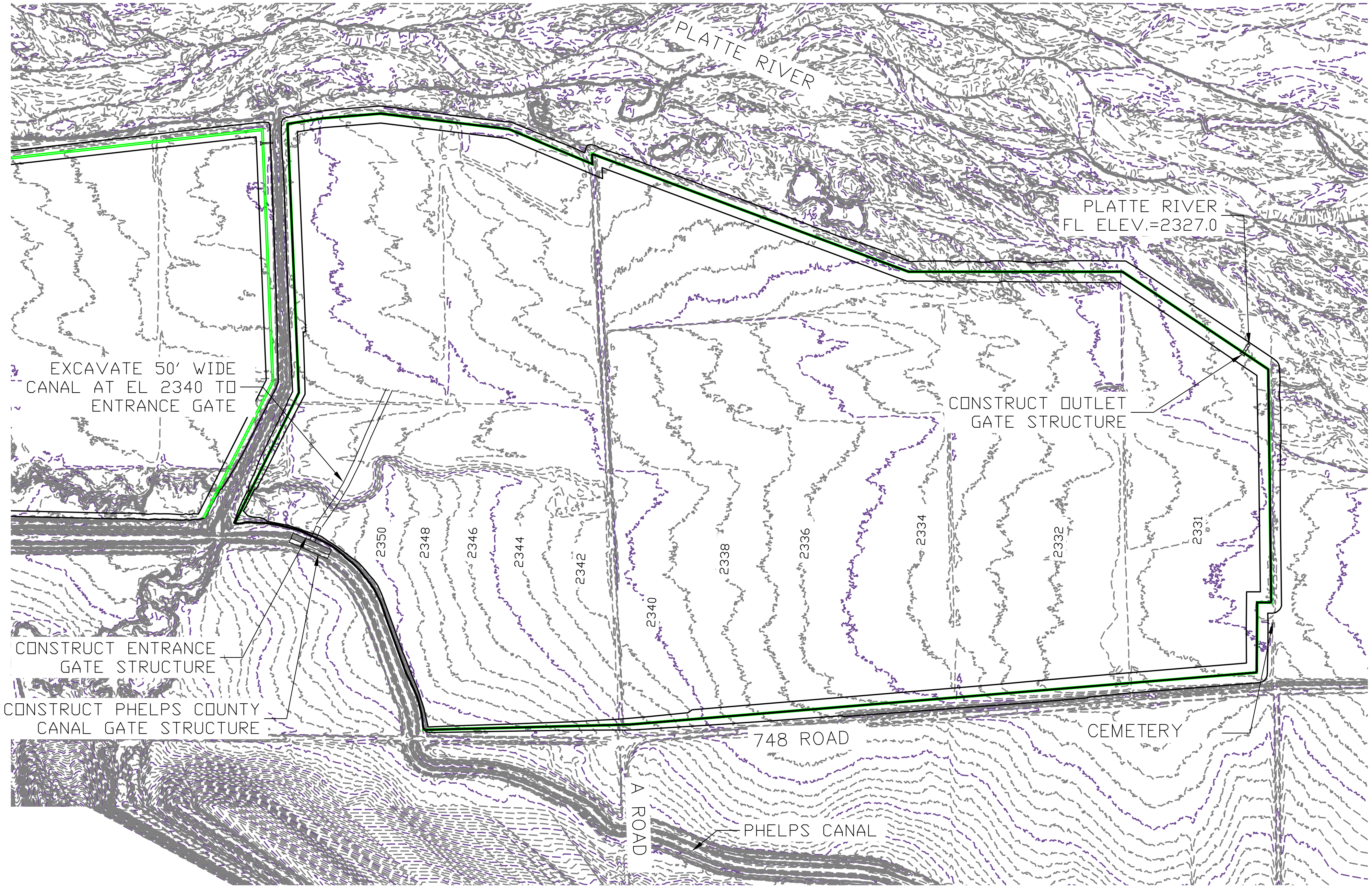
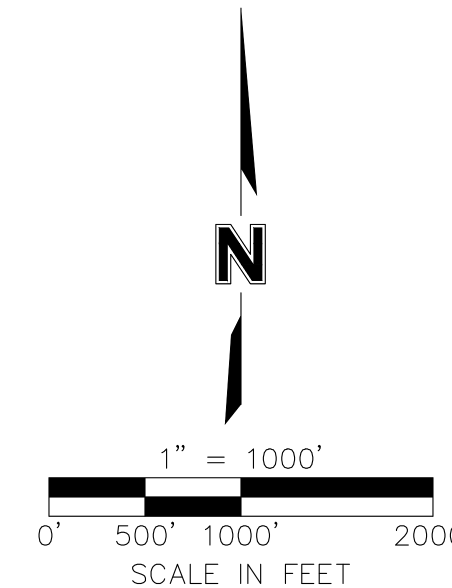




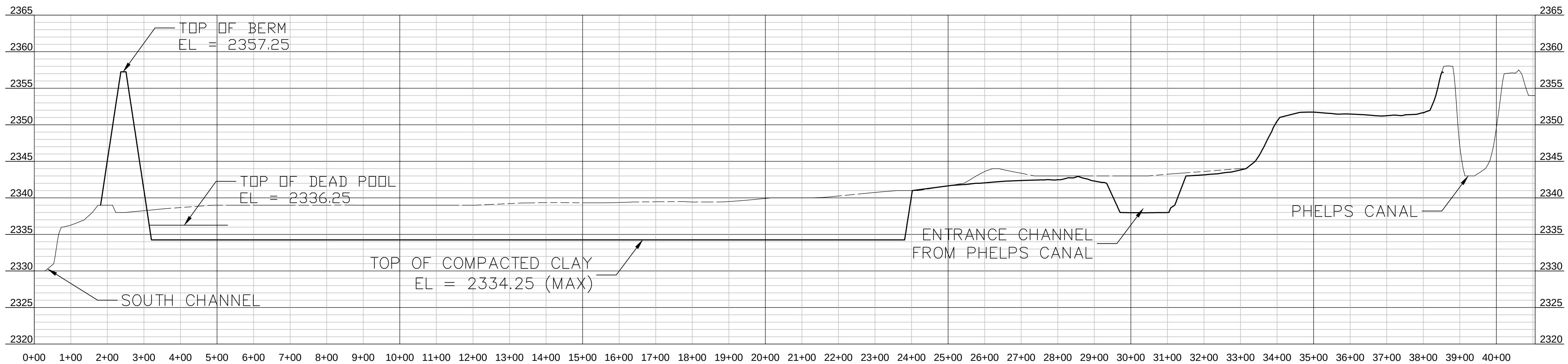
LEGEND

- STORAGE AREA BOUNDARY
- TOE OF EMBANKMENT
- TOP OF EMBANKMENT
- EXISTING MINOR CONTOUR
- EXISTING MAJOR CONTOUR

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

PROJECT: 009-1466	J-2 RETURN ALTERNATIVE 2 OPTION 5, AREA 1 EXISTING CONTOURS	OLSSON ASSOCIATES	BLACK & VEATCH	FIGURE 1-3
DRAWN BY: CRL				
DATE: 3.19.2012				

SECTION A



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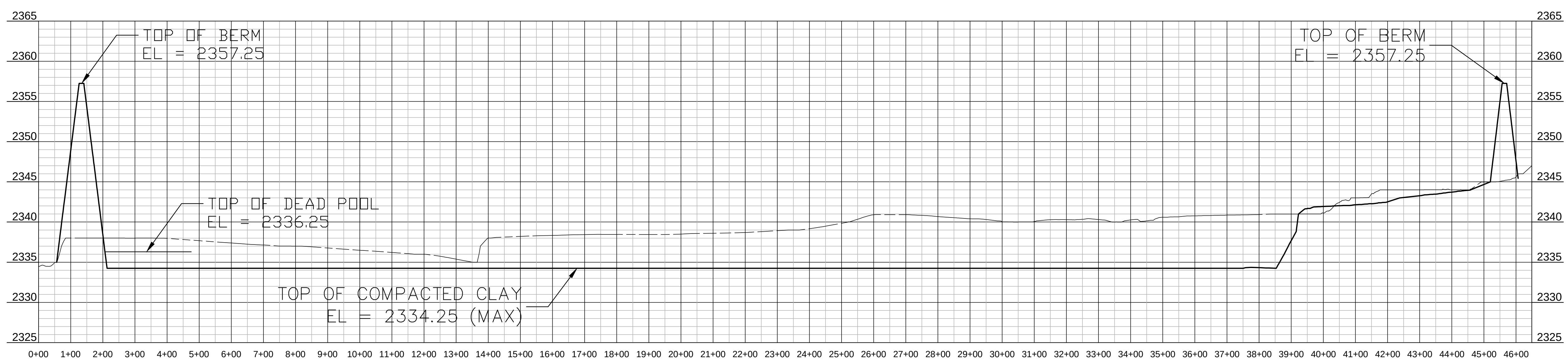

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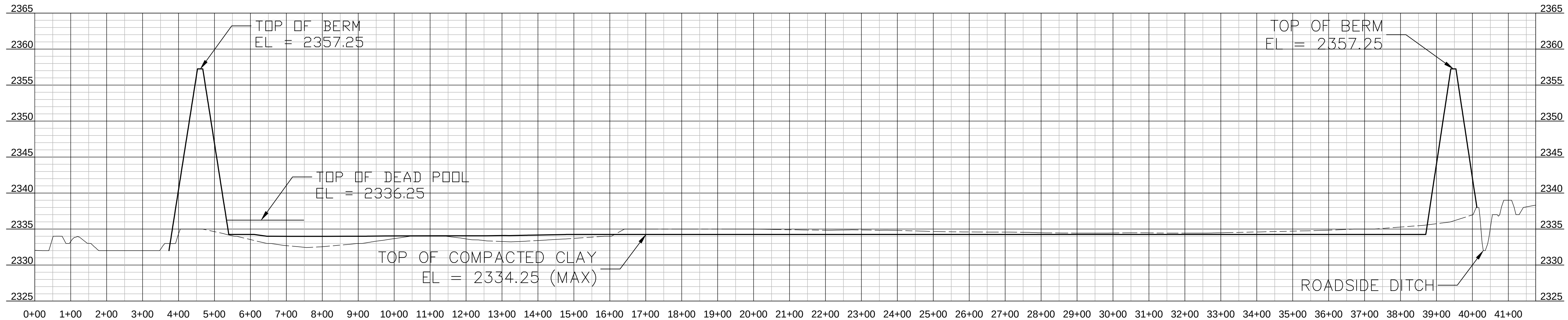
PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

PROJECT: 009-1466 DRAWN BY: CRL DATE: 3.19.2012	J-2 RETURN ALTERNATIVE 2 OPTION 5, AREA 1 CROSS SECTIONS	OLSSON ASSOCIATES BLACK & VEATCH	FIGURE 1-4

SECTION C



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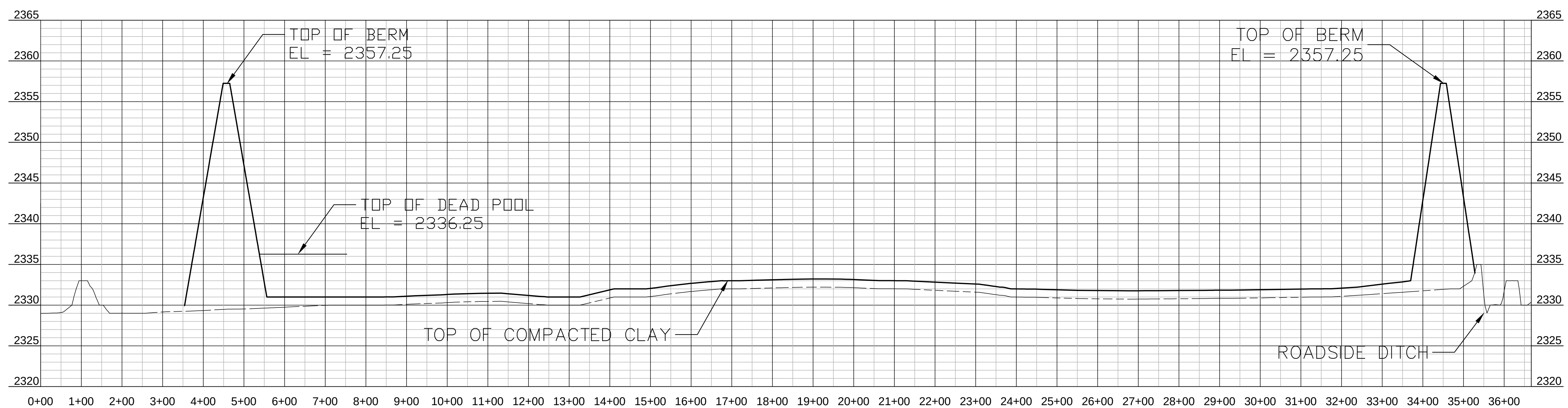

PROJECT: 009-1466
DRAWN BY: CRL
DATE: 3.19.2012

J-2 RETURN ALTERNATIVE 2
OPTION 5, AREA 1 CROSS SECTIONS

FIGURE
1-5

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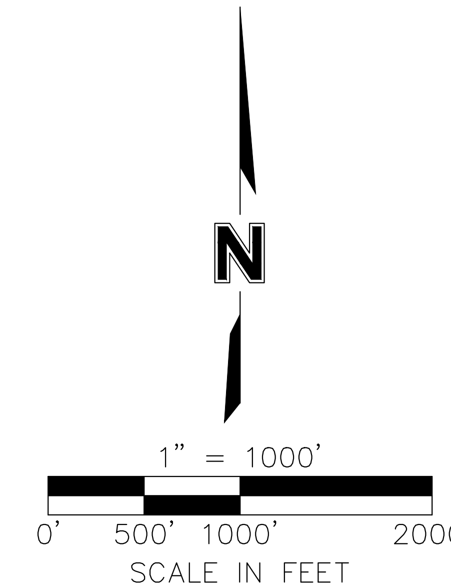

J-2 Return Option 5 Stage Storage - Area 2					
Elevation	Area (sf)	Area (acre)	Incremental Storage (acre-ft)	Total Storage (acre-ft)	Beneficial Storage (acre-ft)
2345	13,508,690	310	0	0	0
2346	13,554,067	311	311	311	0
2347	13,599,514	312	312	622	0
2348	13,645,033	313	313	935	313
2349	13,690,624	314	314	1,249	626
2350	13,736,285	315	315	1,564	941
2351	13,782,016	316	316	1,879	1,257
2352	13,827,816	317	317	2,196	1,574
2353	13,873,687	318	318	2,514	1,892
2354	13,919,628	320	319	2,833	2,211
2355	13,965,640	321	320	3,153	2,531
2356	14,011,721	322	321	3,475	2,852
2357	14,057,872	323	322	3,797	3,174

LEGEND

- STORAGE AREA BOUNDARY
- EXISTING GRADE
- TOE OF EMBANKMENT
- TOP OF EMBANKMENT
- EXISTING MAJOR CONTOUR
- SPOT GRADE ELEVATION

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

PROJECT: 009-1466
DRAWN BY: CRL
DATE: 3.19.2012

J-2 RETURN ALTERNATIVE 2
OPTION 5, AREA 2 STAGE STORAGE

OLSSON ASSOCIATES
BLACK & VEATCH

FIGURE 1-6

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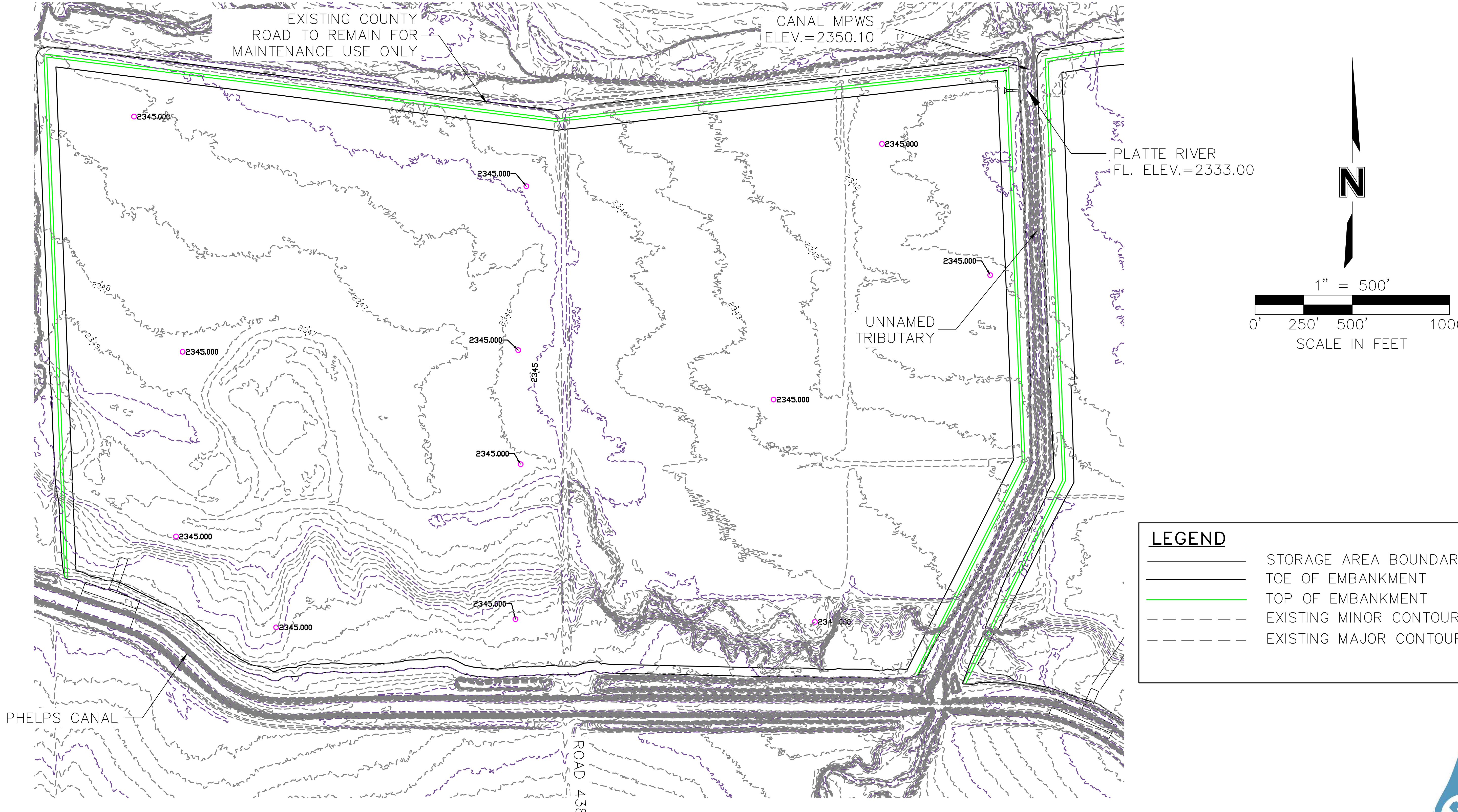

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PROJECT: 009-1466	J-2 RETURN ALTERNATIVE 2 OPTION 5, AREA 2 EXISTING CONTOURS
DRAWN BY: CRL	
DATE: 3.19.2012	

OLSSON ASSOCIATES | BLACK & VEATCH | PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

FIGURE 1-7

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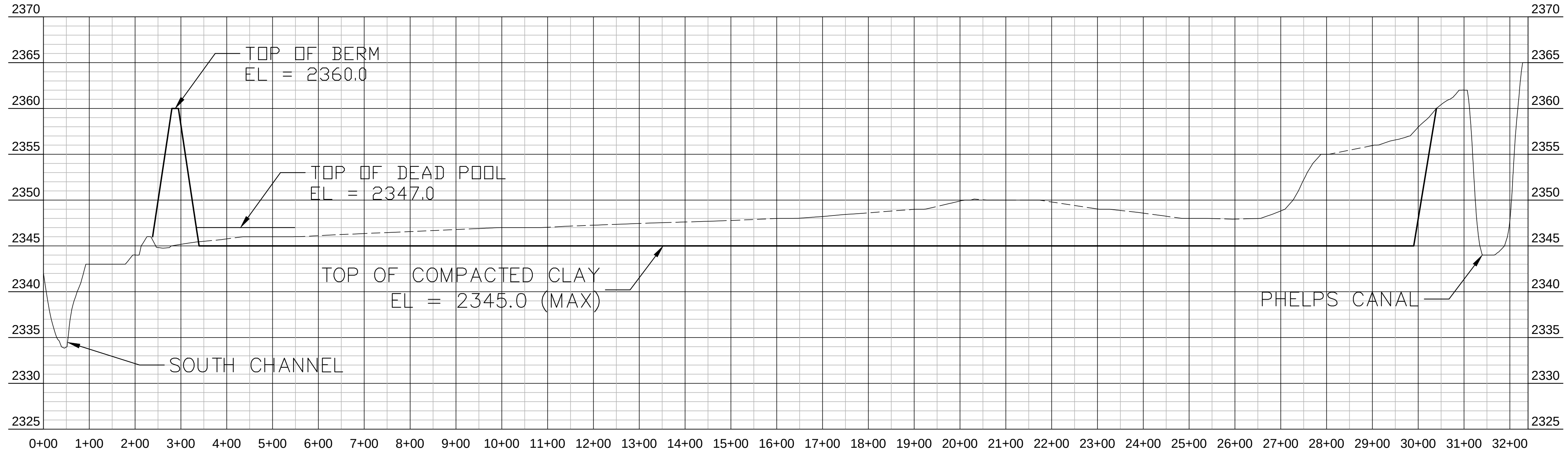
SECTION A



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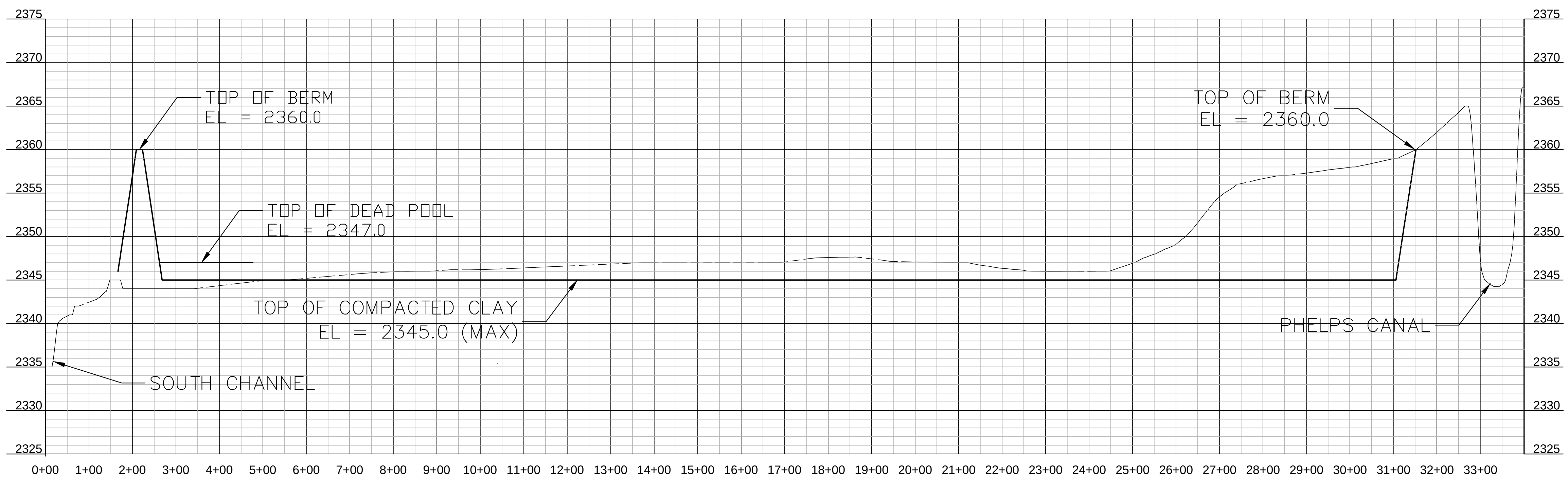

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

PROJECT: 009-1466	J-2 RETURN ALTERNATIVE 2 OPTION 5, AREA 2 CROSS SECTIONS	OLSSON ASSOCIATES	BLACK & VEATCH	FIGURE 1-8
DRAWN BY: CRL				
DATE: 3.19.2012				

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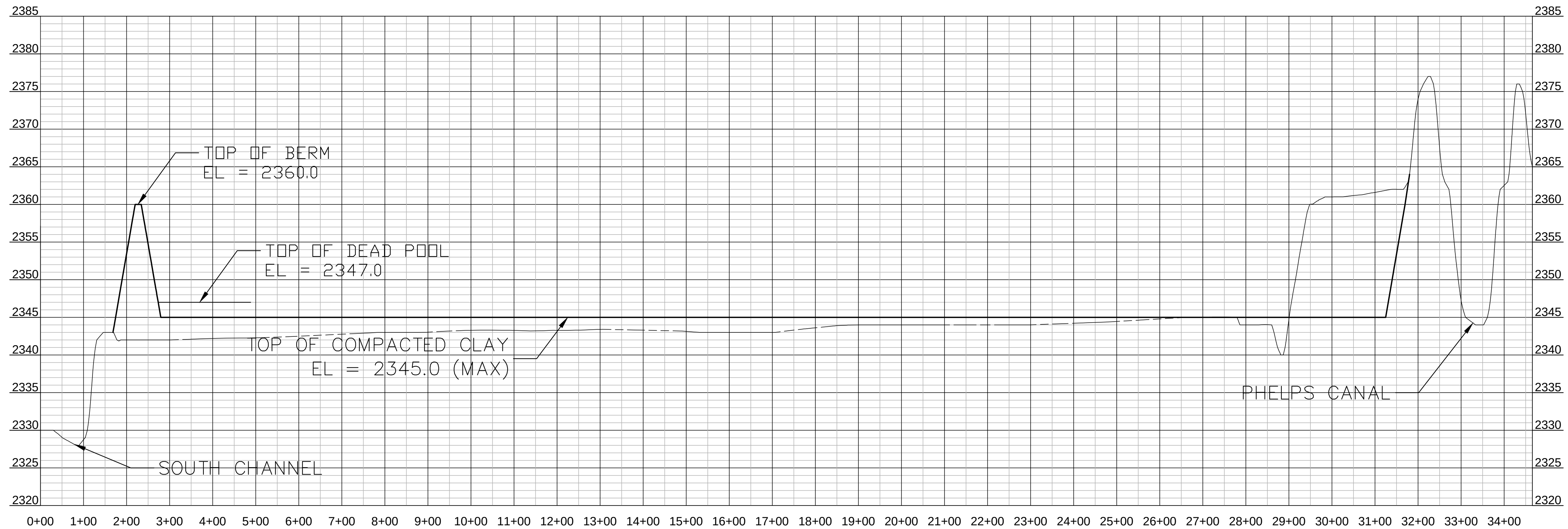
SECTION C



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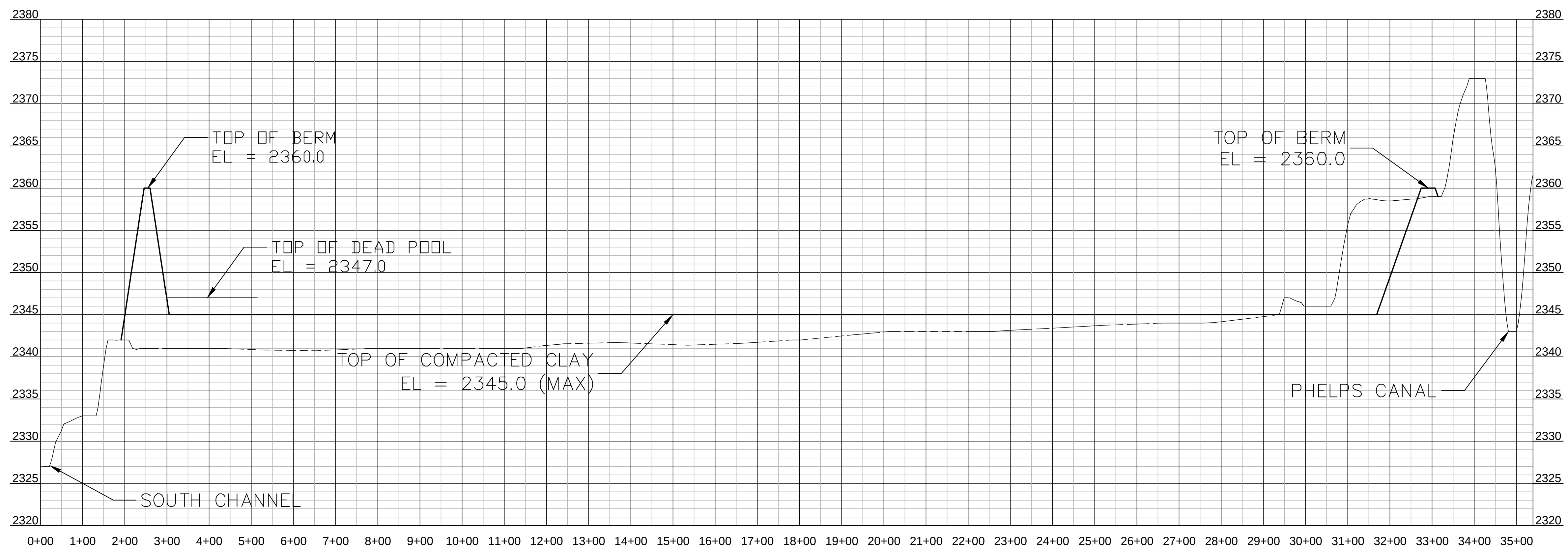
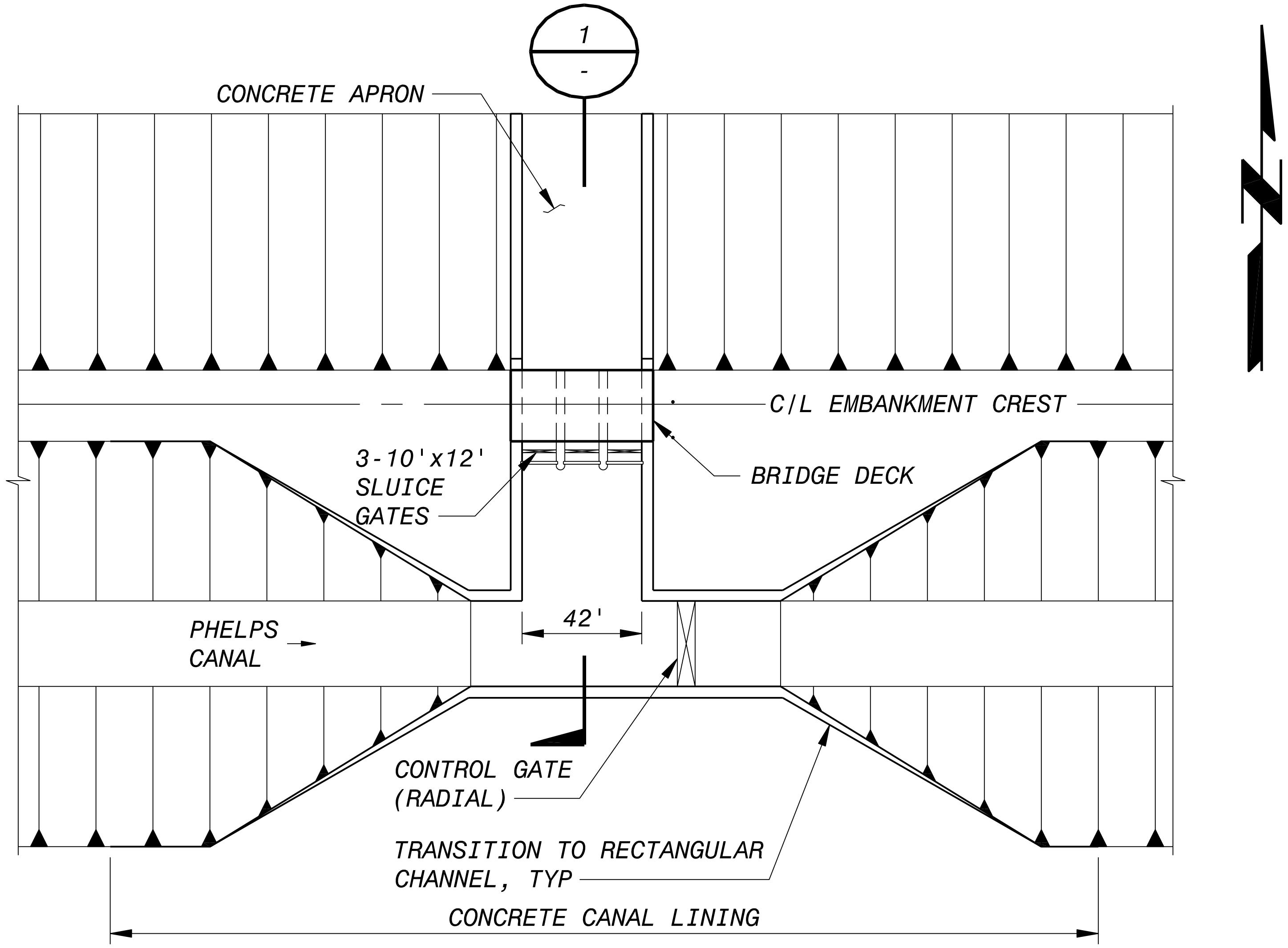


PROJECT: 009-1466
DRAWN BY: CRL
DATE: 3.19.2012

J-2 RETURN ALTERNATIVE 2
OPTION 5, AREA 2 CROSS SECTIONS

OLSSON ASSOCIATES
BLACK & VEATCH

FIGURE
1-9

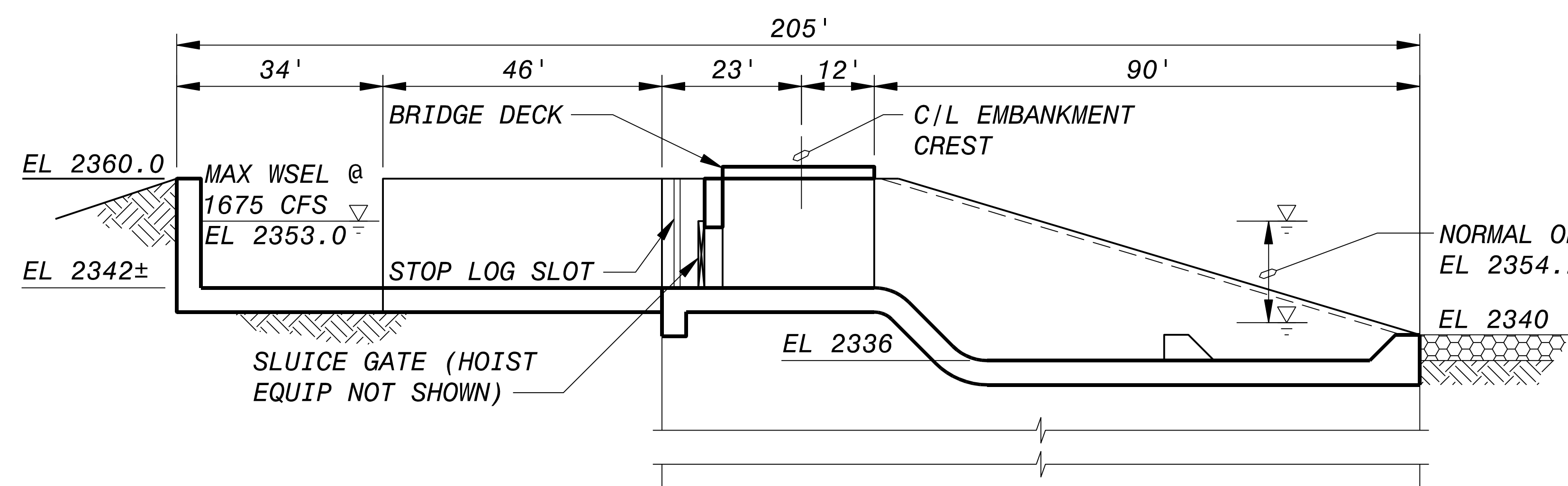


PLAN - AREA 1 INLET STRUCTURE

1" = 60'-0"

NOTES

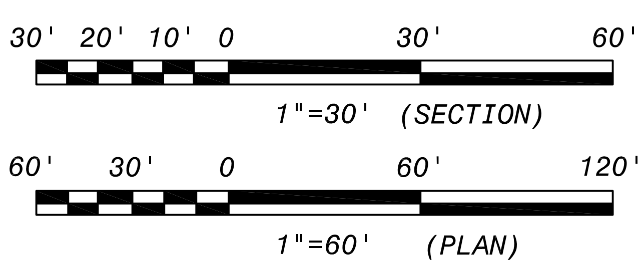
1. ALL DIMENSIONS ARE APPROXIMATE, AND ARE BASED ON CONCEPTUAL LEVEL DESIGN.
2. PHELPS CANAL CONTROL GATE IS A RADIAL GATE 30 FT WIDE BY 18 FT TALL LOCATED IN A RECTANGULAR CONCRETE CHANNEL.



SECTION 1

1" = 30'-0"

PRELIMINARY



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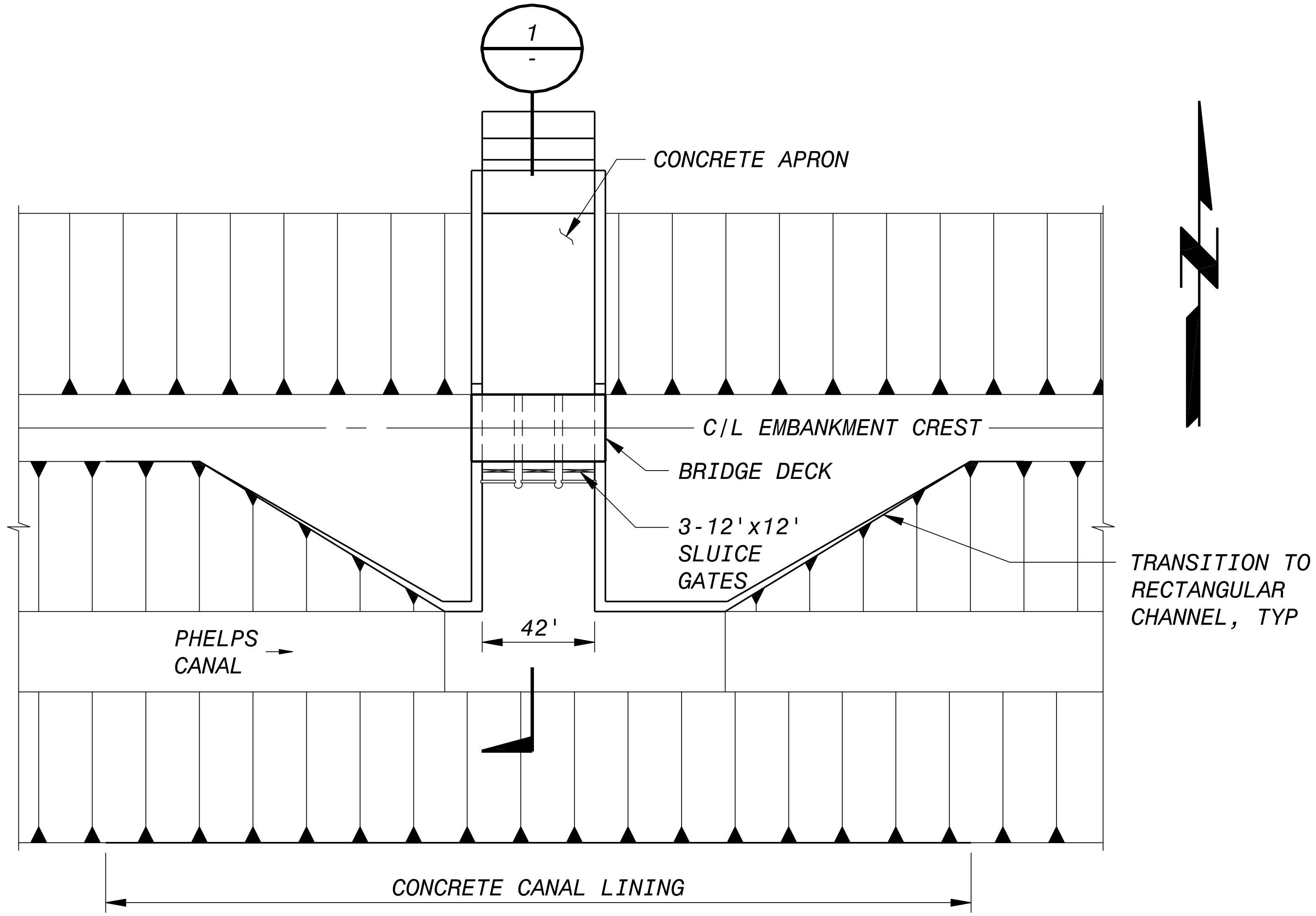
DATE: 02.07.12	

OLSSON ASSOCIATES

BLACK & VEATCH

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

FIGURE 2-1

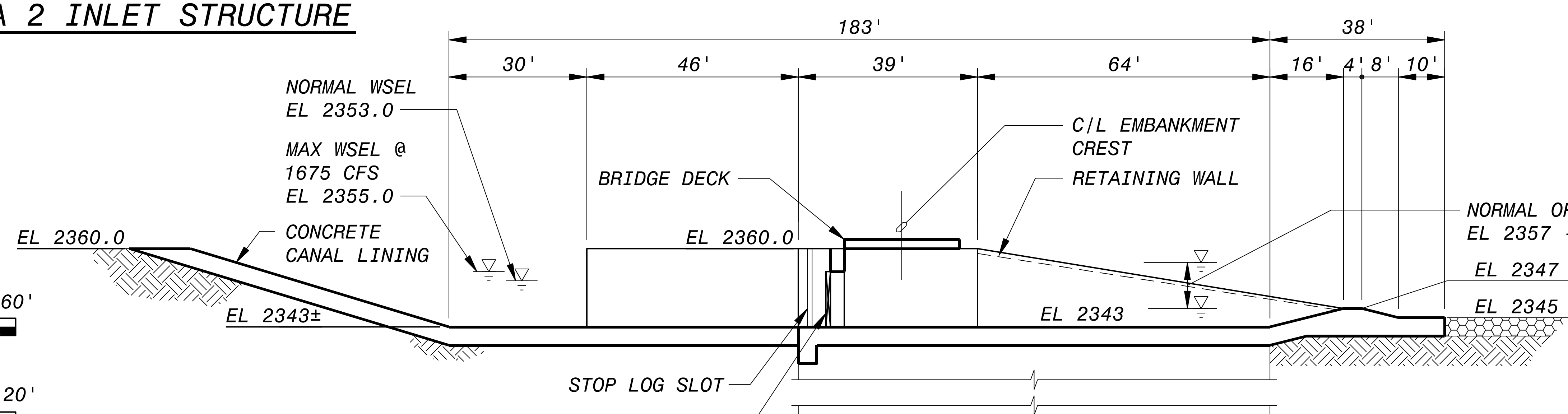


PLAN - AREA 2 INLET STRUCTURE

1" = 60'-0"

NOTES

1. ALL DIMENSIONS ARE APPROXIMATE, AND ARE BASED ON CONCEPTUAL LEVEL DESIGN.



SECTION 1

1" = 30'-0"

PRELIMINARY

30' 20' 10' 0 30' 60'

1"=30' (SECTION)

60' 30' 0 60' 120'

1"=60' (PLAN)

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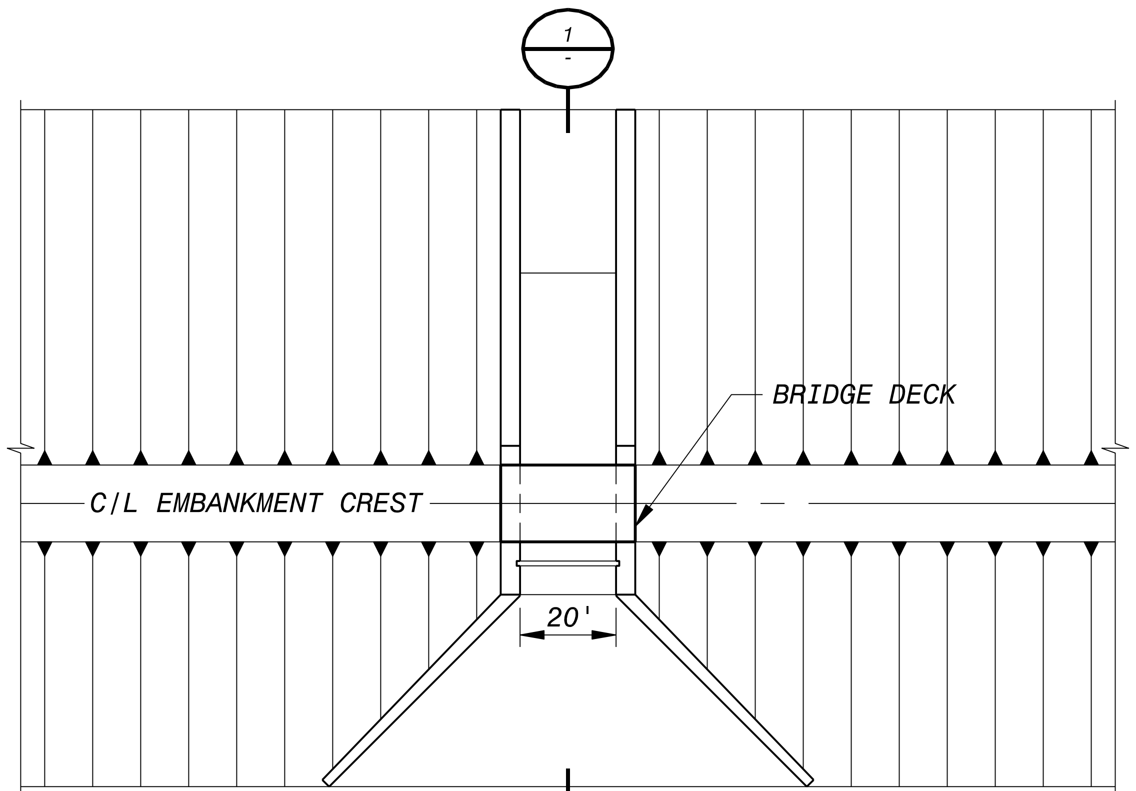
PROJECT: 09-1466	CNPPID J-2 REGULATING RESERVOIR AREA 2 INLET STRUCTURE	OLSSON ASSOCIATES / BLACK & VEATCH	FIGURE
DRAWN BY: B&V			2-2
DATE: 02.07.12			

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

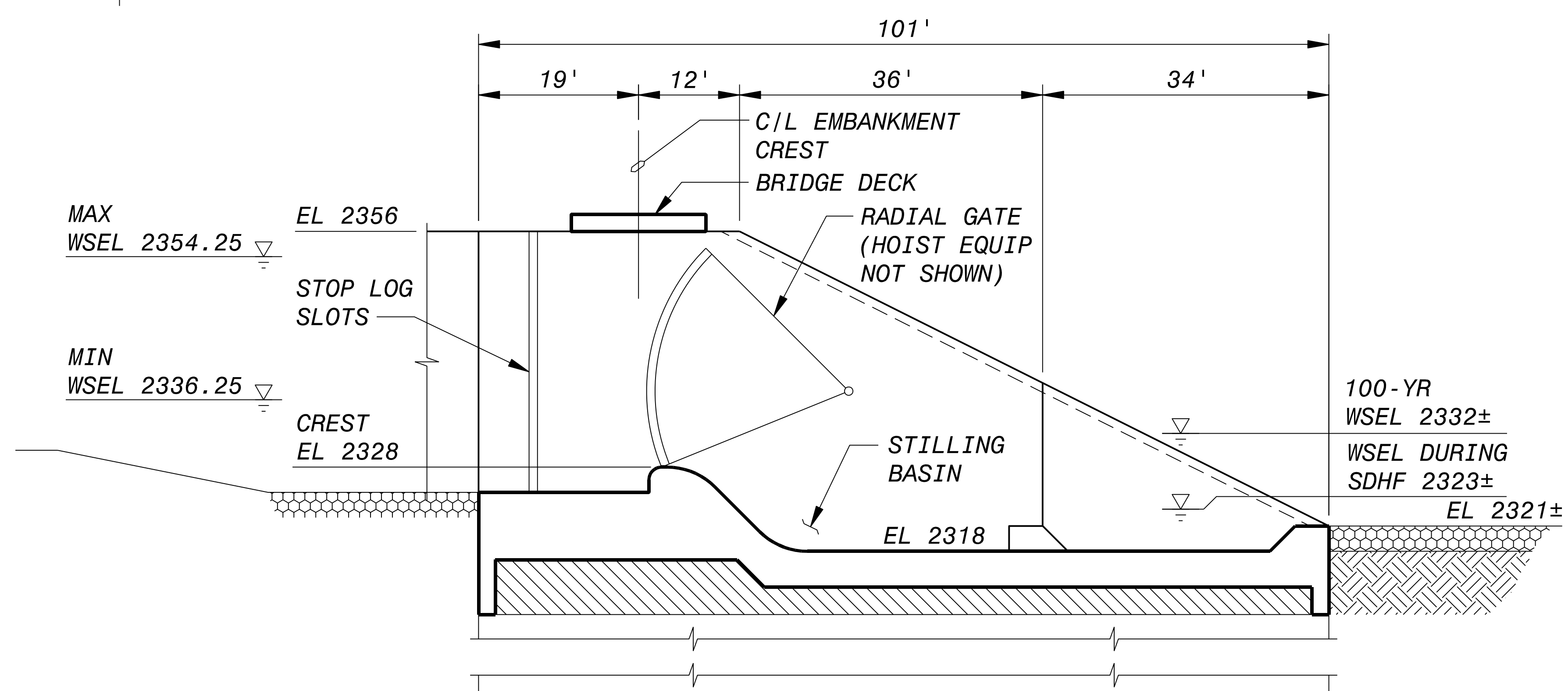
NOTES

1. ALL DIMENSIONS ARE APPROXIMATE, AND ARE BASED ON CONCEPTUAL LEVEL DESIGN.



AREA 1 OUTLET STRUCTURE

1" = 40'-0"



SECTION 1

1" = 20'-0"

PRELIMINARY

20' 10' 0 20' 40'

1"=20' (SECTION)

40' 20' 0 40' 80'

1"=40' (PLAN)

DWG: C:\Cygnet\Cache\168977\Figure 2-3.dwg XREFS:

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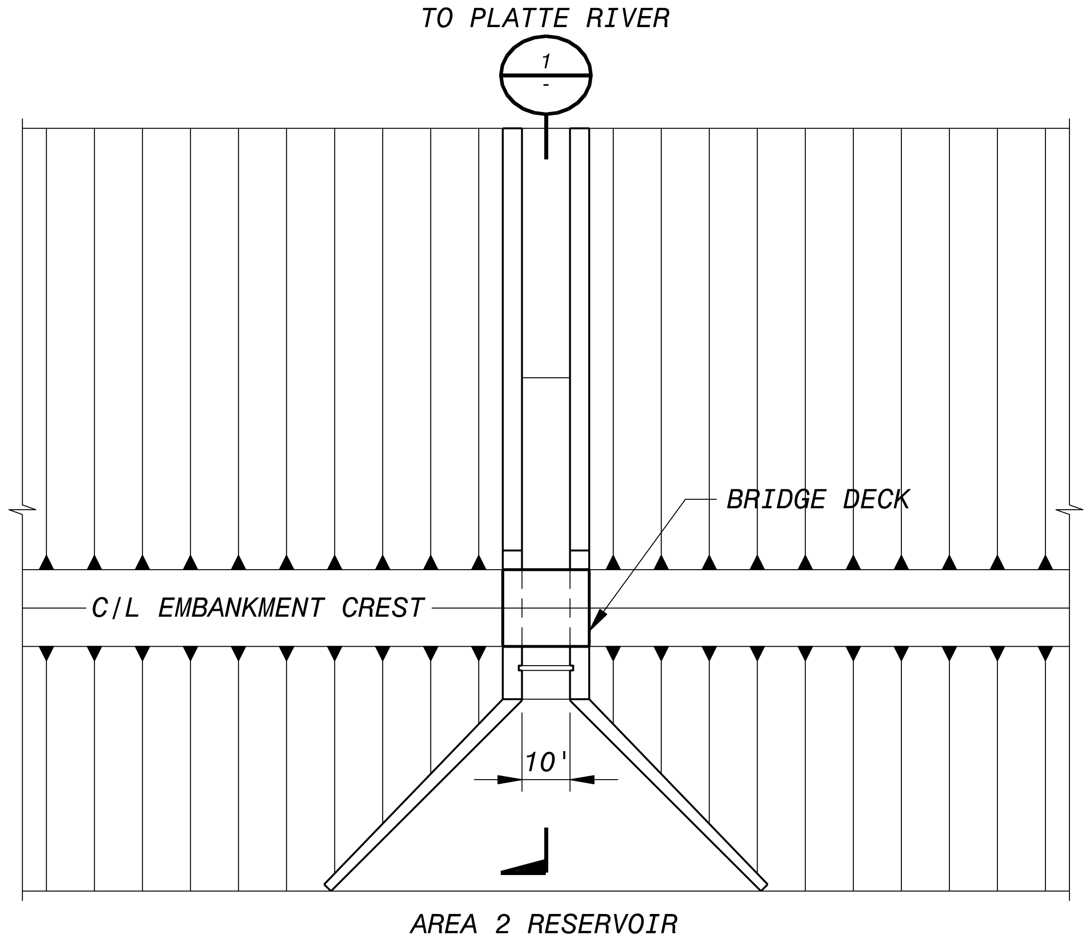
PROJECT: 09-1466	CNPPID J-2 REGULATING RESERVOIR AREA 1 OUTLET STRUCTURE	FIGURE 2-3
DRAWN BY: B&V		
DATE: 02.07.12		

OLSSON ASSOCIATES

BLACK & VEATCH

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

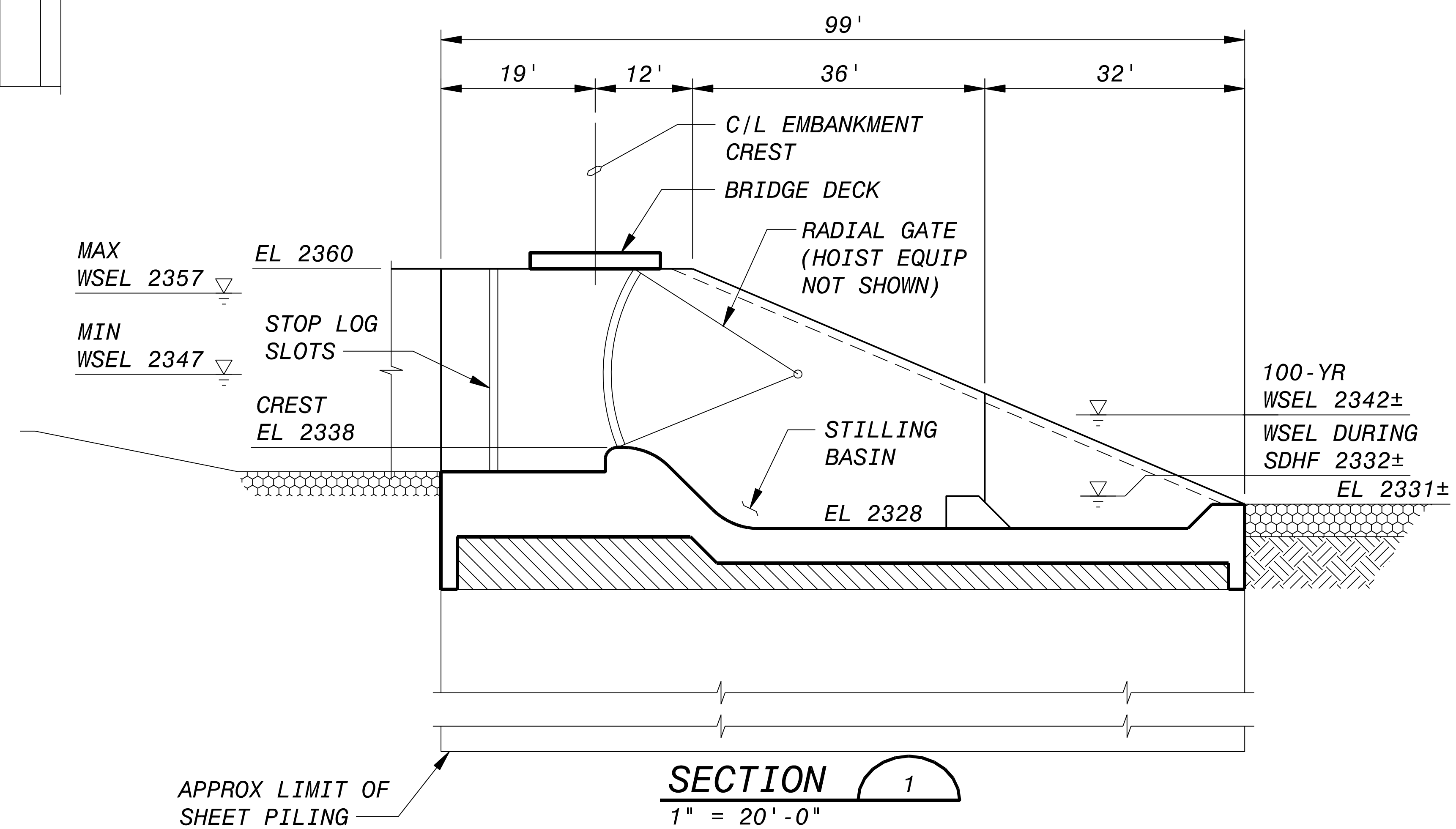


AREA 2 OUTLET STRUCTURE

1" = 40'-0"

NOTES

1. ALL DIMENSIONS ARE APPROXIMATE, AND ARE BASED ON CONCEPTUAL LEVEL DESIGN.



SECTION 1

1" = 20'-0"

PRELIMINARY

20' 10' 0 20' 40'

1"=20' (SECTION)

40' 20' 0 40' 80'

1"=40' (PLAN)

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DRAWN BY: B&V	
DATE: 02.07.12	

OLSSON ASSOCIATES

BLACK & VEATCH

FIGURE 2-4

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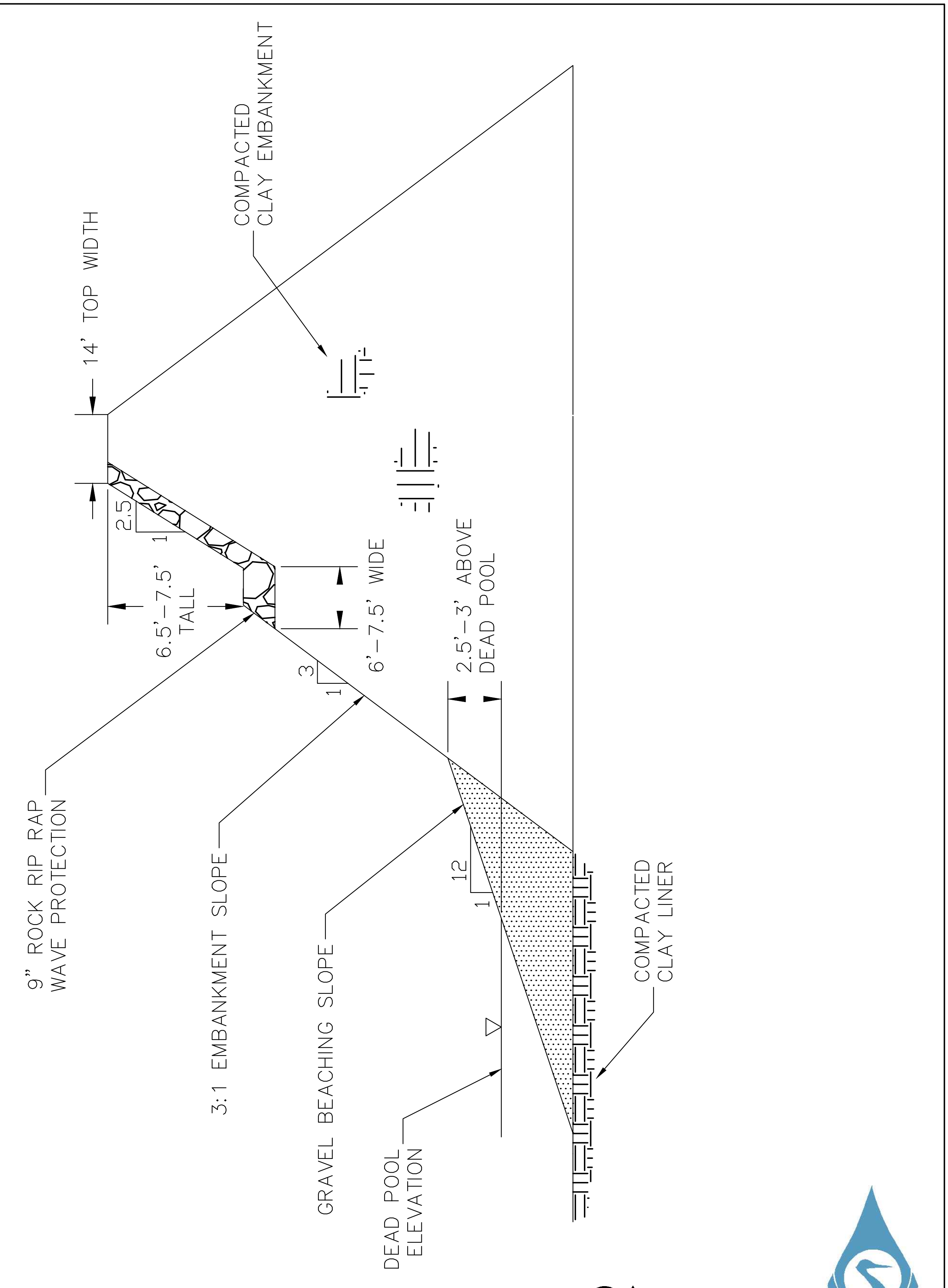
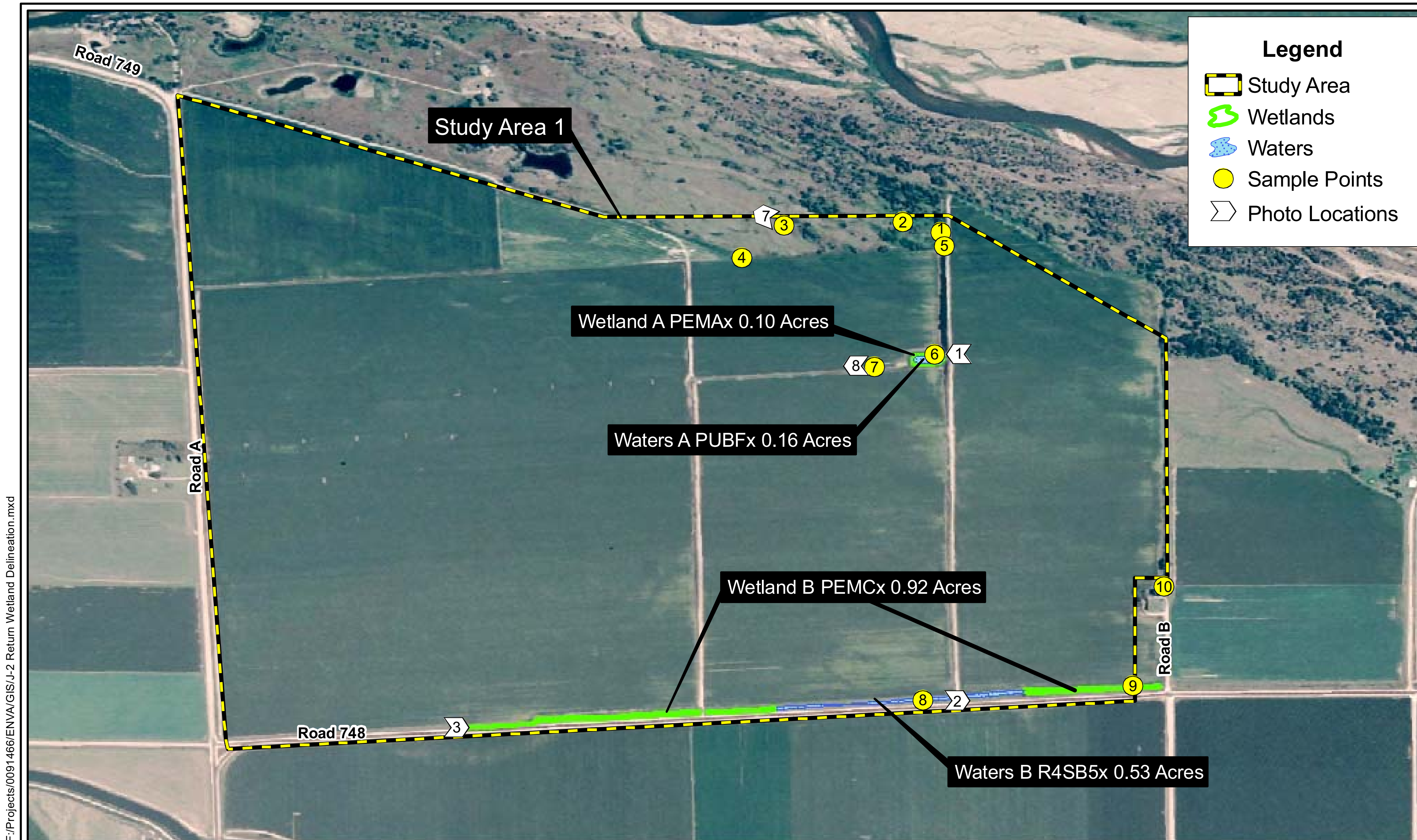


OLSSON ASSOCIATES

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

PROJECT: 009-1466 DRAWN BY: EJS DATE: 3.26.2012	J-2 RETURN ALTERNATIVE 2 WAVE PROTECTION DETAILS	BLACK & VEATCH	FIGURE 2-5



Data Source: 2007 NAIP Aerial Photograph, Gosper & Phelps Counties

OLSSON ASSOCIATES

N

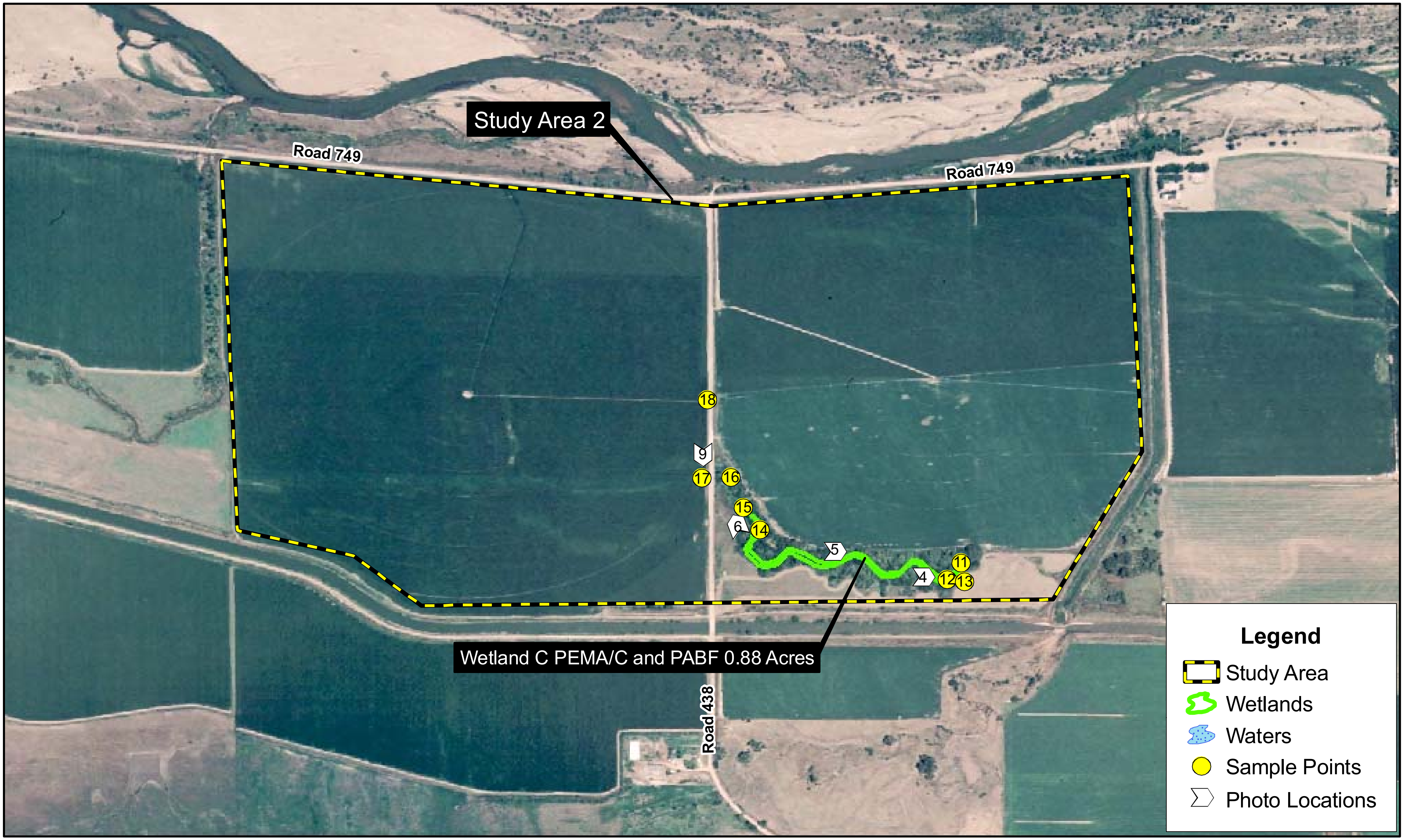
Figure 3-1

0 500 1,000 Feet

1:12,000

CNPPID Re-Regulation Reservoir Project
Platte River Recovery Implementation Program
OLSSON Project No. 009-1466
Gosper and Phelps Counties, Nebraska

Study Area 1 Delineation Map
Figure 4A



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Data Source: 2007 NAIP Aerial Photograph, Gosper & Phelps Counties

Figure 3-2

N

0 500 1,000 Feet

1:12,000

OLSSON ASSOCIATES

CNPPID Re-Regulation Reservoir Project
Platte River Recovery Implementation Program
OLSSON Project No. 009-1466
Gosper and Phelps Counties, Nebraska

Study Area 2 Delineation Map

Figure 4B

APPENDIX B

INVESTIGATION OF RESERVOIR COMBINED OPERATIONS MEMORANDUM

Note: The memorandum states that the draft memorandum was included as an appendix. Due to its size and the fact that it was superseded by the final memorandum, it was not included in this document.

FINAL

CNPPID J-2 REREGULATING RESERVOIR
TASK 1 OF FEASIBILITY STUDY
INVESTIGATION OF RESERVOIR COMBINED OPERATIONS

PREPARED FOR

Executive Director's Office
Platte River Recovery Implementation Program

4111 4th Avenue, Suite 6
Kearney, Nebraska 68845
Phone: (308) 237-5728

PREPARED BY

Olsson Associates
4690 Table Mountain Drive, Suite 200
Golden, Colorado 80403
Phone: (303) 237-2072
Contact: Deb Ohlinger, PE
Olsson Project No. B09-1466

June 24, 2011

OLSSON ASSOCIATES

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

BLACK & VEATCH

EXECUTIVE SUMMARY

Purpose and Objective

Currently, releases to the Platte River from the J-2 hydropower plant operated by Central Nebraska Public Power and Irrigation District (CNPPID) fluctuate from zero release to as much as two thousand cubic feet per second (cfs) within an hour. The hourly fluctuations of flow (hydropower cycling) are a concern of the USFWS (FERC, 2007). Hydrocycle mitigation would reduce or eliminate the large fluctuations in releases to the Platte River.

The Platte River Recovery Implementation Program (PRRIP or Program) retained Olsson Associates to analyze the concept of creation of a J-2 reregulating reservoir for the augmentation of short duration high flows (SDHFs) and target flows, along with potential to mitigate hydropower flow cycling to the Platte River to the extent that it does not significantly reduce the yield for Program purposes. The recommended alternative consisted of construction of two new storage reservoirs, termed Area 1 and Area 2.

During the CNPPID Reregulating Reservoir pre-feasibility study, use of the proposed storage sites was evaluated primarily for SDHF augmentation with a designed release rate of 2,000 cfs for a three-day duration. A subsequent analysis was performed during that study to evaluate whether the sites could be beneficial for target flow augmentation and/or hydrocycle mitigation. The findings indicated the sites would be viable for target flow augmentation, or hydrocycle mitigation, but it was unclear whether the two purposes could be accomplished simultaneously. The goal of this current analysis was to evaluate the extent to which hydrocycling surge can be mitigated without adversely affecting target flow augmentation by use of the proposed Area 1 and Area 2 storage sites identified in the pre-feasibility study. The hydrocycle mitigation would take place before the flows reached the Overton gage, which is immediately downstream of the Area 1 release gate.

Hydrocycle Mitigation Modeling

A hydrocycle mitigation model was developed to predict post-project performance of joint operations based on several improvement alternatives. The model is based on fundamental operation objectives that all excess flows should be stored as they become available. Stored excess flows should then be released to reduce shortages to PRRIP target flows as soon as possible. All excess flow capture and target flow releases should be performed so that they do not increase the fluctuation in hourly flows in the Platte River. It is also based on smoothing hydrocycle releases throughout each 24-hour calendar day but does not manage day-to-day fluctuations. Figure ES-1 shows an illustration of hydrocycle mitigation for an example week.

The data set for the modeling was hourly flow data for the years 1997-2008. Initial modeling was conducted with a data set of only historic data. The historic data, however, did not reflect CNPPID's preferred future operations of the J-2 hydropower plant. CNPPID developed a synthetic data set that does reflect the preferred operations for the non-irrigation season, September through March. A discussion on the method CNPPID used to develop the synthetic data is presented in Appendix B. The resulting data set was a combination of historic data for the irrigation season and the synthetic data developed by CNPPID for the non-irrigation season. The parameters of Phelps Canal capacity, the capacity of the pump required to achieve full storage in Area 2, and the gate widths for Areas 1 and 2 were varied to form nine alternatives.

Modeling Results

The modeling for combined goals of augmentation of target flow shortages and hydrocycle mitigation indicated that both objectives could be met with little reduction of yield for Program uses. When water is plentiful, both objectives can be fully met. When water availability is low, both objectives cannot be adequately met and special operational procedures must be used. The average reduction in yield for adding hydrocycle mitigation to target flow shortage augmentation across all alternatives was 1.1%. The hydrocycle mitigation greatly reduced the fluctuations in hourly flows, as measured by the average of the standard deviations on a daily basis. Flow changes at midnight, necessary due to a flat release rate on a daily basis, still occur. The changes are smaller than those predicted with the all historic data. The Phelps Canal capacity had a significant impact on the yield and hydrocycle mitigation. The Area 2 pump station capacity and Areas 1 and 2 gate widths had essentially no impact on yield or hydrocyling mitigation.

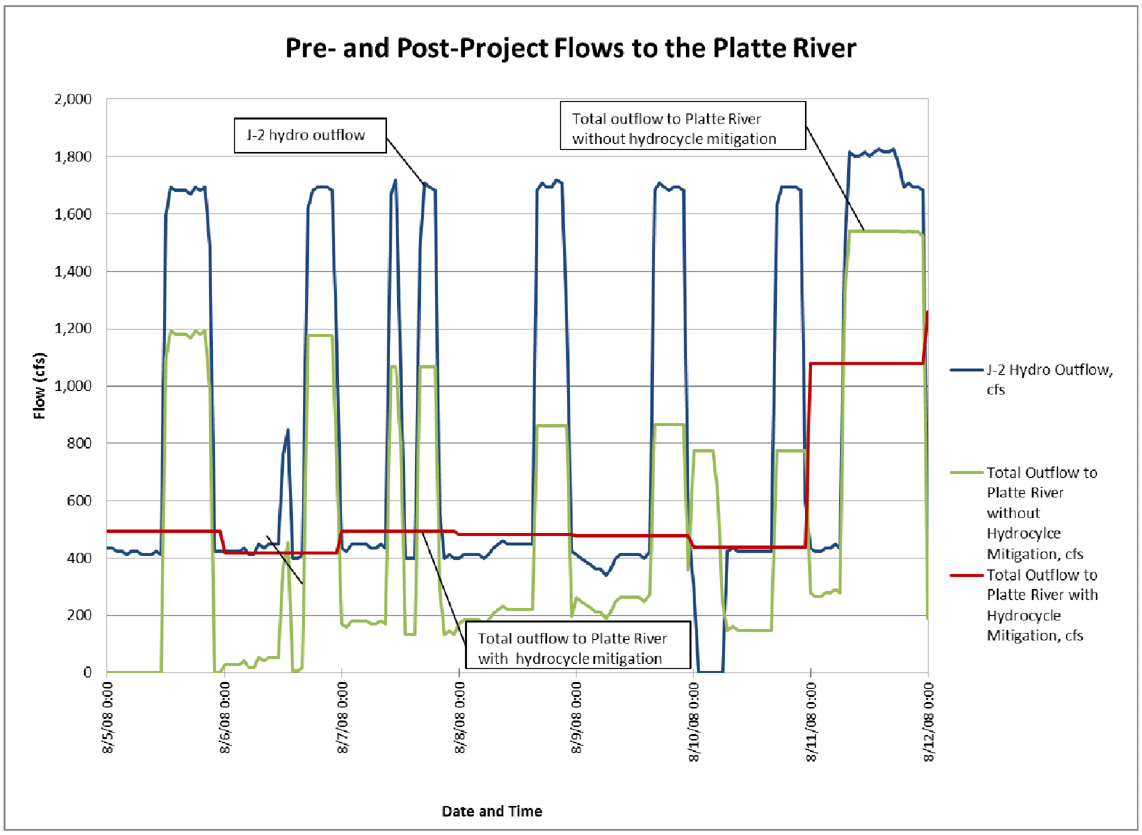

Figure ES-1. Flows to the Platte River without and with Hydrocycle Mitigation

Recommendations and Discussion

- CNPPID operations that are more consistent and predictable will benefit both the Program's objective of augmentation of target flow shortages and hydrocycle mitigation. CNPPID's preferred future operations as modeled in this study would result in improved hydrocycle mitigation and yield for Program projects.
- The Phelps Canal capacity is currently less than the J-2 hydropower plant and results in unavoidable hydropower surges under certain operational scenarios. Modeling of

different canal capacities indicated that increasing the capacity would reduce the hydropower surge, particularly during dry years, and would increase yield.
- Beginning the day with water in storage would allow for water to be drained for hydrocycle mitigation and target flow shortage implementation before the J-2 hydropower plant turns on for the day. This recommendation is an operational one.
- Accounting for target flow shortage augmentation over a period longer than a day would allow for optimized operation of the storage areas.

Throughout the project, the question of would more storage benefit the Program goals has been asked. It seems clear that the more storage that is available, the more beneficial it would be for the Program. At some point, however, the cost becomes prohibitive. The modeling was conducted with one storage option, combined Areas 1 and 2. Under Task 2.1 of Olsson's current contract, up to three storage alternatives will be evaluated. Further, under Task 2.3.1, Olsson will develop an incremental storage versus construction cost relationship.

Area 3, located approximately one mile upstream of Area 2 and adjacent to the J-2 return gate, was evaluated in the pre-feasibility study. Construction of a smaller storage and less expensive Area 3 than that identified in the pre-feasibility study is being considered by CNPPID for the sole purpose of mitigating a hydrocycle surge. Though the revised Area 3 has not been modeled, it is reasonable to expect that it would help hydrocycle mitigation but would not benefit Program yields.

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1.0 INTRODUCTION

1.1 J-2 Reregulation Reservoir Background

The primary goal of the Platte River Recovery Implementation Program (PRRIP or Program) is to support the recovery of four threatened or endangered species: the interior least tern (*Sternula antillarum*), piping plover (*Charadrius melodus*), whooping crane (*Grus americana*), and pallid sturgeon (*Scaphirhynchus albus*) within the Platte River corridor. Several studies and documents have been completed that discuss various methods and options to support the recovery (Water Action Plan (WAP), 2000).

The PRRIP Water Advisory Committee (WAC) compiled previous studies and directed the production of Water Management Study (WMS) Phase I and Phase II reports for the evaluation of augmenting short duration high flows (SDHF) and target flows. The Phase I report (WMS Phase I, 2008) concluded that additional storage is needed near the associated habitat to help achieve SDHF objectives. The Phase I report also evaluated 13 projects identified in the Water Action Plan (WAP) for their potential contribution to the PRRIP flow targets. Under target flow operations, flows in excess of PRRIP target flows (excess flows) are stored and then released when flows are below the target flows (shortage). The WMS Phase II Report screened and evaluated three project concepts, including: re-operation of the existing Elwood Reservoir, creation of a Plum Creek Reservoir, and creation of reregulating reservoirs.

Olsson Associates was selected in July of 2009 to analyze the concepts of a re-operation of the existing Elwood Reservoir, and/or creation of a J-2 reregulating reservoir for the augmentation of SDHFs and target flows, along with capability to mitigate hydropower flow cycling to the Platte River to the extent that it does not negatively affect the ability to meet the Program SDHF and target flow goals. The goal of the analysis was to develop and evaluate Central Nebraska Public Power and Irrigation District (CNPPID) reregulating reservoir alternatives for the existing Elwood Reservoir and potential new reservoirs in the vicinity of CNPPID's J-2 Return. The study was documented in the report Elwood and J-2 Alternatives Analysis Project Report (Alternatives Report) dated February 18, 2010. The study is also referred to as the "pre-feasibility" or "conceptual study" since conceptual design of the alternatives was completed.

1.2 Potential Storage Sites

In addition to alternatives relating to Elwood Reservoir, three J-2 return reservoir alternatives were evaluated during the pre-feasibility study. Alternative 1 consisted of constructing storage in the south channel of the Platte River; Alternative 2 consisted of excavating storage in one or more of four locations south of the Platte River, termed Area 1 through Area 4; and Alternative 3 involved construction of an embankment across an unnamed creek immediately upstream of the Phelps Canal siphon at canal mile station 9.7. The recommendation resulting from the alternatives analysis was to advance J-2 Alternative 2, Areas 1 and/or 2 to the feasibility stage of analysis. Figure A-1 in Appendix A shows the location and general layout of Area 1. Figure A-2 shows a cross section through the storage area and the elevation, area, and storage relationship. Figures A-3 and A-4 show the same information for Area 2. The locations of the storage sites considered under Task 1 of the feasibility study are generally similar to the pre-feasibility study sites and would have similar features as discussed in the pre-feasibility study.

Some refinements have been made since the pre-feasibility study was completed. The footprint for Area 1 was not changed, but based on better topographic data developed from LiDAR spot elevations, the excavation and fill volume were adjusted in order to balance the earthwork at the site. The footprint of Area 2 was revised to exclude flow and sediment from Plum Creek. The embankment height of Area 2 was increased to offset some of the lost storage due to the smaller footprint. Similar to the alternatives analysis, both Areas 1 and 2 would receive flow from the existing Phelps Canal. Inlet gates within Phelps Canal, as well as release gates to the Platte River will be needed. Area 2 would also require a pump station to fill the top portion of the reservoir storage. The total available storage with this revised layout is 13,640 acre-feet (ac-ft), compared to the pre-feasibility study volume of 14,320 ac-ft. Additional storage volume could be obtained by adding a pump station to Area 1, or by increasing the footprint of Area 1. These alternatives may be evaluated during the next phase of this feasibility study. A triangular-shaped area south of Area 1 has been investigated on a conceptual level. The area is located south of County Road 748 and north of the Phelps Canal and could add approximately 2,150 acre-feet of additional storage. The combined operations modeling documented in this report did not include the area south of County Road 748.

1.3 Target flows

For this study, PRRIP target flows were the daily values presented in Appendix A-5 of the Program Document Attachment 5 Water Plan, Section 11 Water Plan Reference Material (PRRIP, 2006), and shown in Table 1.

Table 1. PRRIP Target Flows

Time Period	PRRIP Target Flows, cfs		
	Wet	Normal	Dry
Jan 1 – Jan 31	1,000	1,000	600
Feb 1 – Feb 14	1,800	1,800	1,200
Feb 15 – Mar 15	3,350	3,350	2,250
Mar 16 – Mar 22	1,800	1,800	1,200
Mar 23 – May 10	2,400	2,400	1,700
May 11 – May 19	1,200	1,200	800
May 20 - May 26	4,900	3,400	800
May 27 – June 20	3,400	3,400	800
June 21 – Sept 15	1,200	1,200	800
Sept 16 – Sept 30	1,000	1,000	600
Oct 1 – Nov 15	2,400	1,800	1,300
Nov 16 – Dec 31	1,000	1,000	600

1.4 Hydrocycle Mitigation

Currently, releases to the Platte River from the J-2 hydropower plant operated by CNPPID fluctuate from zero release to as much as two thousand cubic feet per second (cfs) within an hour. The duration of flow release to the Platte River is a function of the amount of flow available to CNPPID on each day. A larger volume of water available equates to a longer duration of hydropower generation and a longer duration of releases to the Platte River. While hydrocycle mitigation is not a direct part of the Program, the hourly fluctuations of flow (hydropower cycling) are a concern of the USFWS (FERC, 2007), and CNPPID is interested in the potential for the reregulating reservoirs under consideration to be operated to provide mitigation. Hydrocycle mitigation would reduce or eliminate the large fluctuations in releases to the Platte River.

1.5 Goal of Combined Operations

During the CNPPID Reregulating Reservoir pre-feasibility study, use of the proposed storage sites was evaluated primarily for SDHF augmentation with a designed release rate of 2,000 cfs for a three-day duration. A subsequent analysis was performed during that study to evaluate whether the sites could be beneficial for target flow augmentation and/or hydrocycle mitigation. The findings indicated the sites would be viable for target flow augmentation, or hydrocycle mitigation, but it was unclear whether the two purposes could be accomplished simultaneously.

The goal of this current analysis was to evaluate whether target flow augmentation would be adversely affected by mitigating a hydrocycle surge by use of the proposed Area 1 and Area 2 storage sites identified in the pre-feasibility study. The work documented in this report was completed under Task 1 of Olsson's contract with the Program, which is to conduct a feasibility study of the CNPPID J-2 reregulation reservoir.

If it could be accomplished, full mitigation of the hydrocycle surge would result in a uniform release rate to the Platte River. As a reporting and accounting simplification, the modeling period was considered to be the 24-hour period of a calendar day. The side effect of a completely uniform release over the course of one day is the need to jump to a different flow at midnight. The volume of flow from day to day changes and, hence, the uniform release rate must likewise change from day to day. The flow jump could be changed to occur at a different time of day but this jump must occur if the volume of flow changes from day to day. It should be noted that the hydrocycle mitigation would take place before the flows reached the Overton gage, which is immediately downstream of the Area 1 release gate.

2.0 SYNTHETIC FLOW DATA DEVELOPMENT

A historic data set was developed to use for the hydrocycle mitigation modeling. After initial modeling was conducted, it was decided during a meeting between the PRRIP Executive Director's Office (ED Office), CNPPID, and Olsson that a partially synthetic data set would be developed to better reflect the preferred future operations of CNPPID. Historic data would be used for the irrigation season, while synthetic data would be used outside of the irrigation season. A discussion of the development of both the historic and synthetic data can be found in the memorandum revised on March 21, 2011, located in Appendix B.

Hydrocycle mitigation modeling using the historic data was conducted as described in later sections. The results of the modeling were documented in a draft memorandum dated September 29, 2010. The draft memorandum is included in Appendix E. Discussion of the results, modeling methodology, and assumptions led to the conclusion that using the historic hourly data to model combined operations under CNPPID operational preferences that were not reflected in the model did not adequately provide answers to the questions being asked. During a conference call on January 11, 2011 between the ED Office, CNPPID, and Olsson, it was decided that a synthetic data set would be developed to better reflect the preferred future operations of CNPPID. In addition, the ED Office and CNPPID agreed that using synthetic data might yield adequate answers at this point in the study. Development of the synthetic data set and comparisons to other data sets, including Program and CNPPID data, was described in a memorandum dated February 19, 2011 and revised February 28, 2011. The memorandum is included in Appendix B. Development of the synthetic data is paraphrased from the memorandum as follows.

It was decided that a data set reflecting CNPPID's preferred operation should be developed for the non-irrigation season, September through the end of March, as canal operations such as maintenance are considered to begin April 1st. The 1996 through 2008 corrected historic data developed during the first modeling effort was to be used for the irrigation season. Cory Steinke of CNPPID was tasked with providing daily volumes and flows that would represent preferred, future operations of the J-2 hydropower plant during non-irrigation season. This data, in the form of average daily flows, along with a written description explaining how the data was developed, was provided to Olsson and the ED office on January 13, 2011. The data set was provided for June 17, 1996 through January 9, 2011. Graphs of daily flows by year provided with the data show the synthetic data flows to be more consistent than the historic flows used for comparison, but variability between days still exists. The description of the CNPPID synthetic data set development is included in Appendix B.

In order to convert the daily data to hourly data, Olsson determined the total volume of water for a given day, based on the average daily flow rate provided by CNPPID. That volume was spread over the maximum number of hours that volume of water could be released at a flow rate of 1,675 cfs, CNPPID's preferred release rate for peak efficiency. Water was released between a start time determined by the number of hours 1,675 cfs could be released and midnight, when the J-2 hydro was turned off if not enough water was available to run all day. CNPPID's preference is to run the hydro in the evening. For example, if enough water was available on a particular day to run the hydro for 5 hours at 1,675 cfs, the hydro would be run between 7:00 pm and midnight on that day. On some days, the flow from the J-2 hydro was greater than 1,675 cfs for the entire day. The flows, however, were never greater than 2,000 cfs.

Because the volume of water available per day was not typically equivalent to a multiple of 1,675 cfs, it was necessary to make an adjustment within that day to account for the volume of water greater than or less than the volume accumulated at the 1,675 cfs flow. For example, if 300 ac-ft of water were available on a given day, the J-2 hydropower plant would be run for two hours at 1,675 cfs, resulting in a total volume of approximately 277 ac-ft. The additional 23 ac-ft that was available on that day must be included in the data. In this case, a one-hour flow equivalent to 23 ac-ft would be 278 cfs, which was accounted for in the hour before the 1,675 flow started. If the total volume was less than an equivalent multiple of 1,675 cfs, the flow was subtracted from 1,675 cfs during the first hour the hydropower plant was running.

Table 2 shows summary characteristics of the synthetic data. The average daily standard deviation column was calculated as the hourly deviation in flow per day and was then averaged for the year. A lower standard deviation indicates a more uniform flow over a day.

Table 2. Synthetic J-2 Hydropower Plant Hourly Flow Data Summary

Year	Year Type	J-2 Plant Generation Volume ac-ft	Maximum Monthly Average cfs	Minimum Monthly Average cfs	Average flow for the Year cfs	Peak Hourly Flow cfs	Minimum Hourly Flow cfs	Hourly Standard Deviation cfs
1997	Wet	1,130,672	Oct 1,899	Jan 1,191	1,562	1,930	0	403
1998	Wet	1,175,840	Feb 1,905	July 1,173	1,624	1,930	0	345
1999	Wet	1,194,287	Oct 1,894	July 1,254	1,650	2,000	0	320

Table 2. Synthetic J-2 Hydropower Plant Hourly Flow Data Summary

2000	Wet	879,902	Feb 1,888	Dec 611	1,212	1,921	0	677
2001	Normal	599,507	July 1,133	Oct 423	828	1,742	0	721
2002	Dry	391,734	July 1,069	Dec 322	541	1,997	0	688
2003	Dry	211,261	Aug 760	Oct 0	292	1,742	0	527
2004	Dry	160,816	Aug 670	Oct 26	222	1,682	0	435
2005	Dry	189,163	Jun 829	Sept 94	261	1,791	0	490
2006	Dry	154,304	July 483	May 12	213	1,718	0	461
2007	Dry	273,167	July 872	Sept 57	377	1,912	0	629
2008	Normal	238,105	July 780	Sept 93	328	2,000	0	600

3.0 HYDROCYCLE MITIGATION MODELING

A hydrocycle mitigation model was developed to predict post-project performance of joint operations based on several improvement alternatives. The overall goal of the modeling, as listed in the scope of work, was to limit negative impacts on yield for reducing shortages to target flows. The model is based on fundamental operational assumptions that all excess flows should be stored as they become available, and subsequently released to reduce shortages to PRRIP target flows as soon as possible. It is also based on smoothing flows throughout each 24-hour calendar day but does not manage day-to-day fluctuations. To graphically depict this operation, Figure 1 shows the post-project outflows for a week with complete daily mitigation of the hydropower cycle. This particular week also demonstrates the flow change that would occur at midnight if releases to the Platte River were managed to be constant during each calendar day.

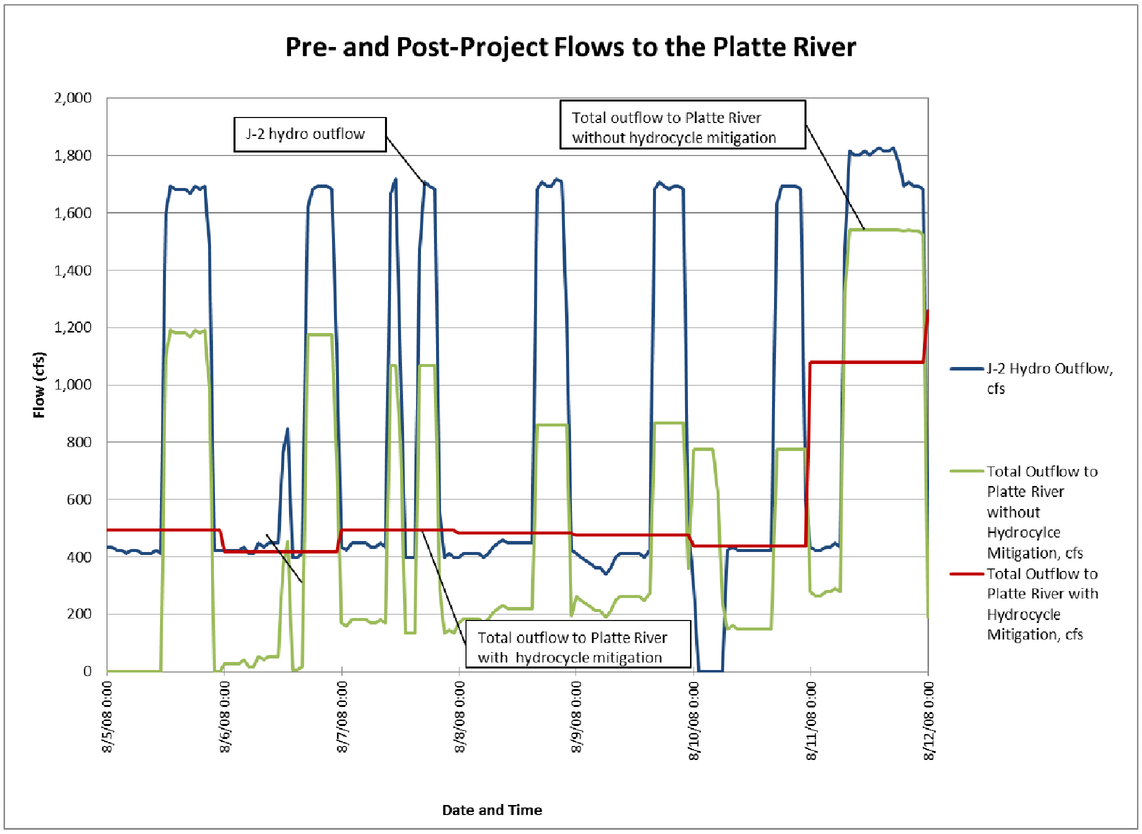

Figure 1. Flows to the Platte River without and with Hydrocycle Mitigation

3.1 Hourly Model Development

The ED office developed a large amount of data (through 2008) in Excel that included a daily time step model for calculation of shortages, excesses and amount of water that could be stored in the proposed sites. A revised Excel model was developed by Olsson and used to evaluate the inflow/outflow data on an hourly time step rather than the previous daily time step model. In addition, a reservoir stage-storage-discharge routing function was added into the model to evaluate the effects of the outlet gate sizes. This revised model was used to model target flow releases on an hourly time step for a post-project condition without attempting to mitigate hydrocycling flow releases to the Platte River.

A second Excel model was developed by adding code to route the hydropower surge that is currently being released from the J-2 Return gate into the proposed storage areas for mitigation of the surge. The initial modeling with the historic data set and preliminary modeling with the synthetic data set indicated that when water was plentiful, hydrocycle mitigation combined with meeting target flows was easily achieved. The objectives of both the Program and hydrocycle mitigation were met. When water was less plentiful and the reservoirs were low, however, meeting the goals of both the Program and hydrocycle mitigation became more challenging, as discussed in Section 3.1.2. The initial modeling with historic data also showed that mitigation hydrocycle mitigation could be challenging when the reservoirs were full since there was no room to store additional water. The issue with the full reservoirs was resolved with operational changes implemented with the updated modeling. Comparison of the two Excel models indicated the reduction in yield to meet target flows when hydrocycle mitigation was done.

Figure 2 on the next page and the following sections summarize the two basic operational modes these facilities could operate in while attempting to mitigate the hydrocycle surge.

3.1.1 Excesses to Target Flows

Under this condition (Figure 2, right side of chart), flows in the Platte River as measured at the Grand Island gage are above targets. Frequently under this condition, CNPPID has adequate volume of water in its system to generate power for 24 hours but the flow rate will vary. The Program's objective is to store excesses, while CNPPID's hydrocycle mitigation objective is to smooth flows. Key operational procedures for the modeling are to capture as much excess water as possible and release as little as possible from the J-2 Return gate. The portion that must be released due to limited storage volume or limited ability to convey it through Phelps Canal should be released at a flow rate that is as uniform as possible.

3.1.2 Shortages to Target Flows

Under a shortage condition (Figure 2, left side of flow chart), flows in the Platte River, as measured at the Grand Island gage, are below targets. Frequently this condition has a limited volume available to CNPPID for hydropower operation, which results in a hydropower surge between when the system is generating or is not generating power at the J-2 plant. Key Program operational objectives are to release stored water to augment Platte River flows. The combined operational objective is to augment the Platte River flows while releasing a uniform rate throughout the day to mitigate surges due to hydropower generation. A portion of the release from the J-2 hydropower plant should be temporarily stored so it could be released to even out the flows after the plant turns off. Under this scenario, all of the daily flow through the J-2 power plant should be routed to the Platte River and water should be released from the proposed storage sites to reduce the target flow shortage. The Program seeks to limit any increase in target flow shortage on a daily basis. The modeling herein identified an opportunity to use the reservoirs to smooth hourly hydropower releases and release previously stored Program water to decrease the shortage on a daily basis.

A conference call was held on February 15, 2011 between Olsson and CNPPID to discuss preferences during low water availability. During times when only low flows are available and the J-2 hydropower plant can only run the low flows, storage in the reservoirs will subsequently be low. Minutes from the call are included in Appendix B. The model could either release all available stored water to meet target flow shortages for the maximum time possible, often just a couple of hours, or could average out the release of the available water at a lower flow until the hydropower plant turns on for the day. Under the first operational scenario mentioned, water would be released until none remained, and then no water would flow in the river since the J-2 hydropower plant release would comprise essentially all the flow in the Platte River. The latter operation was selected, since it was thought better to have at least a low flow in the River until the J-2 hydropower plant turns on than no flow.

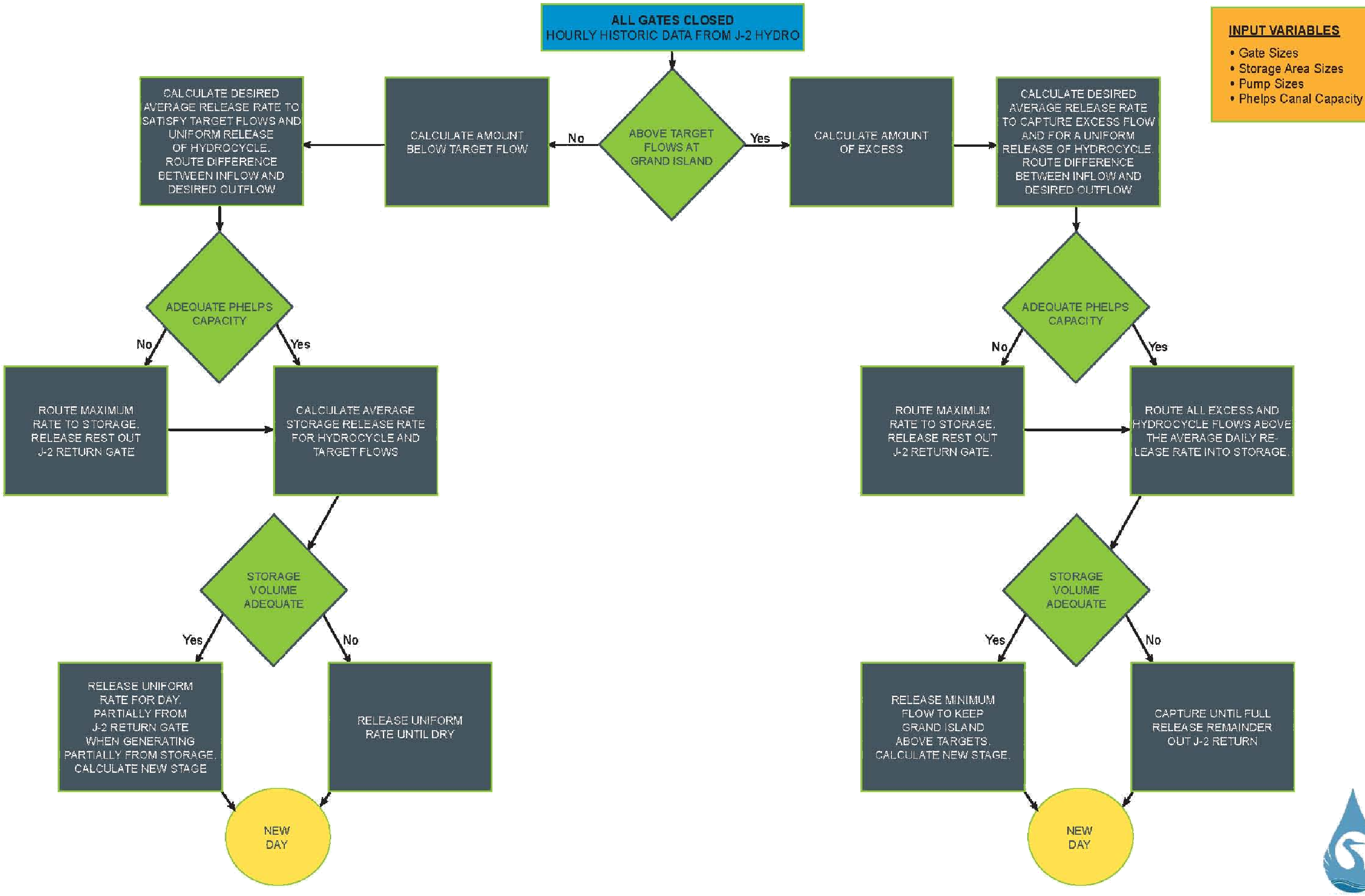

Figure 2. Proposed CNPPID Reservoir Operation Flow Chart

3.2 Modeling Assumptions

Assumptions used for the modeling process included the following:

General Modeling Parameters

- Hydrologic Conditions were applied on a calendar year, as intended by the USFWS.
- No lag time was assumed between reservoirs and Grand Island.
- No transit losses or gains from Overton to Grand Island were estimated when calculating the volume of excess flows that can be stored.
- To be consistent with prefeasibility level analysis, no reservoir evaporation or seepage was applied.
- The J-2 reservoir inlet capacity equals Phelps County Canal capacity (see PRRIP sensitivities analysis).
- Areas 1 and 2 received flow from only Phelps Canal.
- Maximum flow rates into the storage areas were equal to the capacity of Phelps Canal.
- Weir flow equation was used to estimate max discharge from reservoir outlet gate when gate is fully open at low stage. Gates were fully open to calculate maximum discharge.
- No tail water effects from the Platte River were modeled.
- The excesses available in CNPPID's system were calculated by the ED Office and were set as the minimum of excesses at Grand Island (without pulse flows but with EA flows), J-2 return flows (without pulse and EA flows), and Odessa flows (without pulse without EA flows).

CNPPID Operational Parameters

- The operational preference of CNPPID was to run the hydro plant at 1,675 cfs during the evening hours.
- The system was able to be operated in the future such that the variability in flow volumes from day to day can be reduced as presented in the synthetic data.
- No system downtime or equipment failures were included in the synthetic data.
- Operating the hydropower plant above 1,675 cfs is less efficient but if a surplus of water is available, the flow rate will be run up to 2,000 cfs.
- Phelps Canal was limited to 1,000 cfs capacity for irrigation water, a limitation not to be mistaken for overall capacity. [CNPPID noted that they do not foresee running more than 1,000 cfs to meet irrigation demand due to the erosion that could be caused by fluctuating water levels. Historic flows that were higher than 1,000 cfs were limited, with the additional water added to the J-2 Return. As part of the feasibility study, evaluation of a gate on the downstream side of the entrance to Area 1 will be needed. The gate will serve two purposes – maintaining the water level to prevent erosion due to fluctuating levels, and preventing excessive uplift pressures in the canal when the storage areas are full. The latter recommendation was made in the geotechnical memorandum for Areas 1 and 2 prepared by Olsson and dated February 25, 2011.]

Modeling Procedures

- The model considered only the excess flow capture, target flow releases and hydrocycle mitigation operations. The Short Duration High Flow was not modeled, however, the size of the reservoir outlet gates was based on the capability of releasing the SDHF.
- The reporting and accounting simplification was to create a uniform release rate over the course of one 24-hour day, as discussed during the June 24, 2010 conference call.
- The starting water surface elevation in the reservoir had no impact on the reported yields and standard deviation. The model ran from 6/17/1996 to 12/31/1996, before the reporting period began on 1/1/1997. In this time period, the reservoir emptied and refilled

such that the starting water surface had no effect on the results by the time the reporting period began.

- Area 1 and 2 were filled and drained together. For example, when it was 5 feet deep in Area 1, it was also 5 feet deep in Area 2. They were essentially modeled as one reservoir, with the exception of the additional pumping to Area 2. [Area 1 and Area 2 each contains a different storage volume and will require a different gate size in order to release the SDHF. Initial modeling indicated difficulties in releasing all of the water when the level was low due to the low head on the weir. With the addition of a permanent pool, this issue is less of a concern.]
- The gravity fill for Area 2 stopped at an elevation of 2356 feet, after this elevation pumps were used to complete the filling. Area 2 completed fill at the same time as Area 1 completed filling.
- The maximum release rate from any one reservoir did not exceed 2,000 cfs to be consistent with the SDHF modeling performed in the pre-feasibility study.
- Two operational modes were modeled – excesses to target flows and shortages to target flows. Their descriptions and assumptions are included in Sections 3.1.1 and 3.1.2.
- No increases in target flow shortages incurred over a daily time period, but there was flexibility on an hourly basis to the extent that it assisted with hydrocycle mitigation.

3.3 Model Results

In both the without hydrocycle mitigation and with hydrocycle mitigation Excel spreadsheets, the Phelps Canal capacity, the pump station capacity for Area 2 and the outlet gate widths were adjusted to generate nine alternatives for the study period of 1997 to 2008. The impacts of the Phelps Canal capacity, Area 2 pump station capacity, and outlet gate width on yield and relative success in mitigation of the hydrocycle surge were evaluated.

Table 3 summarizes the results of the hourly modeling without and with hydrocycle mitigation. It should be noted that alternatives, #1, #5, and #8 shown in Table 3 are actually the same but were included in the varied parameter group for ease of comparison. The non-hydrocycle mitigation results represent no attempt to mitigate for hydrocycling and operating the reservoirs for excess flow capture and release during shortages to target flows. The hydrocycle mitigation results represent operating the reservoirs for excess flow capture with releases to reduce target flow shortages and to mitigate a daily hydrocycle surge. Program yields were calculated hourly and summarized annually in Table 3. The hourly standard deviation was calculated each day and then averaged for the year. A standard deviation of zero would represent a uniform release over the entire day and full attainment of the hydropower surge mitigation.

3.3.1 Target Flow Augmentation without Hydrocycle Mitigation

Figure 3 shows an example of using the storage areas to reduce shortages in target flows but not to reduce the hydrocycling surge during a time when water availability is low. Total outflows to the Platte River fluctuate significantly as the reservoirs fill and empty to release water to reduce target flow shortages. The fluctuations are due to the J-2 hydropower release. Only enough water was available to release at 1,675 cfs for less than four hours. Water began to be stored when the J-2 hydropower plant started, at which time more flow was available than necessary to meet the target flows. After the J-2 hydropower plant shut off, water was released from the storage areas at a constant rate, slowly draining the storage until the J-2 hydropower plant started the next day. In this example, Phelps Canal capacity was 1,400 cfs, Area 2 pump capacity was 300 cfs, and Areas 1 and 2 gates were 40 and 30 feet wide, respectively.

Yield for the Program ranged from 16,754 ac-ft for a dry year to 62,647 ac-ft for a wet year. As the results in Table 3 indicate, the capacity of Phelps Canal had the greatest impact on yield. Increasing the Phelps Canal capacity from 1,000 cfs to 1,400 cfs was predicted to increase yield by 1,678, 4,205, and 2,432 cfs for a dry, normal, and wet year, respectively. If the Phelps Canal capacity were increased from 1,000 cfs to 2,000 cfs, the yield was predicted to increase by 1,879, 6,376, and 2,747 ac-ft, respectively.

The Area 2 pump station capacity showed no changes to yield. The greatest change in yield for the different gate sizes was -0.1%. For evaluating changes in yield for meeting target flow shortages but not hydrocycle mitigation, these two parameters are not significant. The standard deviations in flow ranged from 82-294 cfs based on evaluation by year type. The standard deviation was highest for normal years and lowest for wet years. Tables C-1 through C-3 in Appendix C summarize the average standard deviations by month and year for the study period.

It was assumed that if the Program released water to the Platte River, it would be done at a uniform rate. That assumption, combined with more consistent CNPPID operations, caused inadvertent mitigation of the hydrocycle surge.

Table 3. Results of Modeling Without and With Hydrocycle Mitigation

							Without Hydrocycle Mitigation			With Hydrocycle Mitigation			
Alterna-tive	Total Storage Available, ac-ft	Phelps Capacity, cfs[1]	Area 2 Pump Station Capacity, cfs[1]	Area 1 Gate Size[1]	Area 2 Gate Size[1]	Year Type	Standard Deviation of Outflow Rate, cfs	Standard Deviation of Outflow Rate, cfs	Average Annual Yield, ac-ft[2]	Standard Deviation of Outflow Rate, cfs	Standard Deviation of Outflow Rate, cfs	Average Annual Yield, ac-ft[2]	Reduction in Yield
1	13,637	1,000	300	40 ft	30 ft	Wet	193	92	59,900	66	13	59,013	-1.5%
						Normal		294	41,452		91	41,564	0.3%
						Dry		227	16,765		92	16,478	-1.7%
2	13,637	1,400	300	40 ft	30 ft	Wet	168	83	62,331	13	5	61,371	-1.5%
						Normal		246	45,657		14	45,272	-0.8%
						Dry		199	18,443		18	18,120	-1.8%
3	13,637	2,000	300	40 ft	30 ft	Wet	163	82	62,647	4	5	61,594	-1.7%
						Normal		237	47,828		3	47,167	-1.4%
						Dry		192	18,644		3	18,370	-1.5%
4	13,637	1,000	250	40 ft	30 ft	Wet	193	92	59,900	66	13	59,013	-1.5%
						Normal		294	41,452		91	41,564	0.3%
						Dry		227	16,765		92	16,478	-1.7%
5	13,637	1,000	300	40 ft	30 ft	Wet	193	92	59,900	66	13	59,013	-1.5%
						Normal		294	41,452		91	41,564	0.3%
						Dry		227	16,765		92	16,478	-1.7%
6	13,637	1,000	350	40 ft	30 ft	Wet	193	92	59,900	66	13	59,013	-1.5%
						Normal		294	41,452		91	41,564	0.3%
						Dry		227	16,765		92	16,478	-1.7%
7	13,637	1,000	300	50 ft	40 ft	Wet	193	92	59,898	66	13	59,026	-1.5%
						Normal		294	41,471		90	41,566	0.2%
						Dry		227	16,760		92	16,482	-1.7%
8	13,637	1,000	300	40 ft	30 ft	Wet	193	92	59,900	66	13	59,013	-1.5%
						Normal		294	41,452		91	41,564	0.3%
						Dry		227	16,765		92	16,478	-1.7%
9	13,637	1,000	300	30 ft	20 ft	Wet	193	92	59,905	66	14	59,077	-1.4%
						Normal		294	41,413		91	41,556	0.3%
						Dry		227	16,754		93	16,474	-1.7%

Notes: [1]Shaded cells show parameter that was varied. Alternatives 1, 5, and 8 are the same but are repeated for easier comparison.
[2]Yield represents reductions to shortages to target flows

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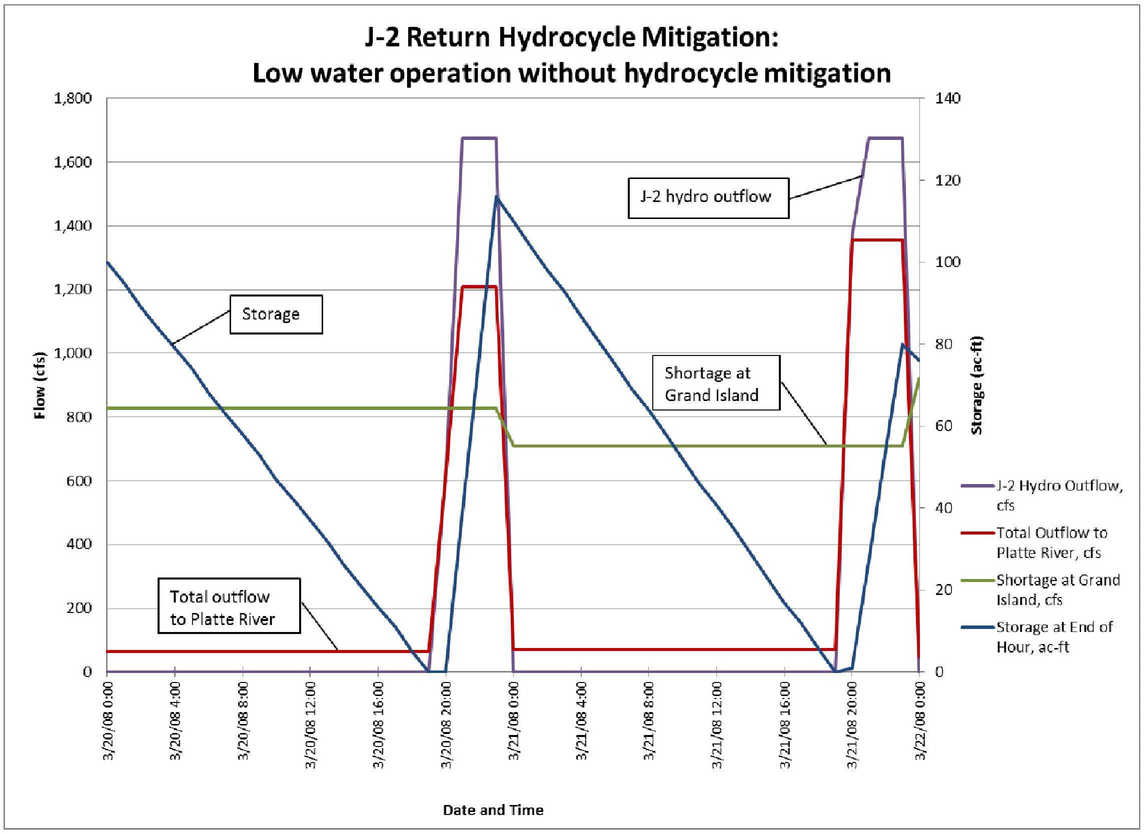

Figure 3. Example of Low Water Operations without Hydrocycle Mitigation

Figures 4-6 show box plots of the daily standard deviations on an annual basis for the pre-project, or without hydrocycle mitigation conditions. The graphs illustrate the impact of the Phelps Canal capacities of 1,000, 1,400, and 2,000 cfs. When compared to Figures 11-13, they also illustrate the differences between the pre- and post-project conditions.

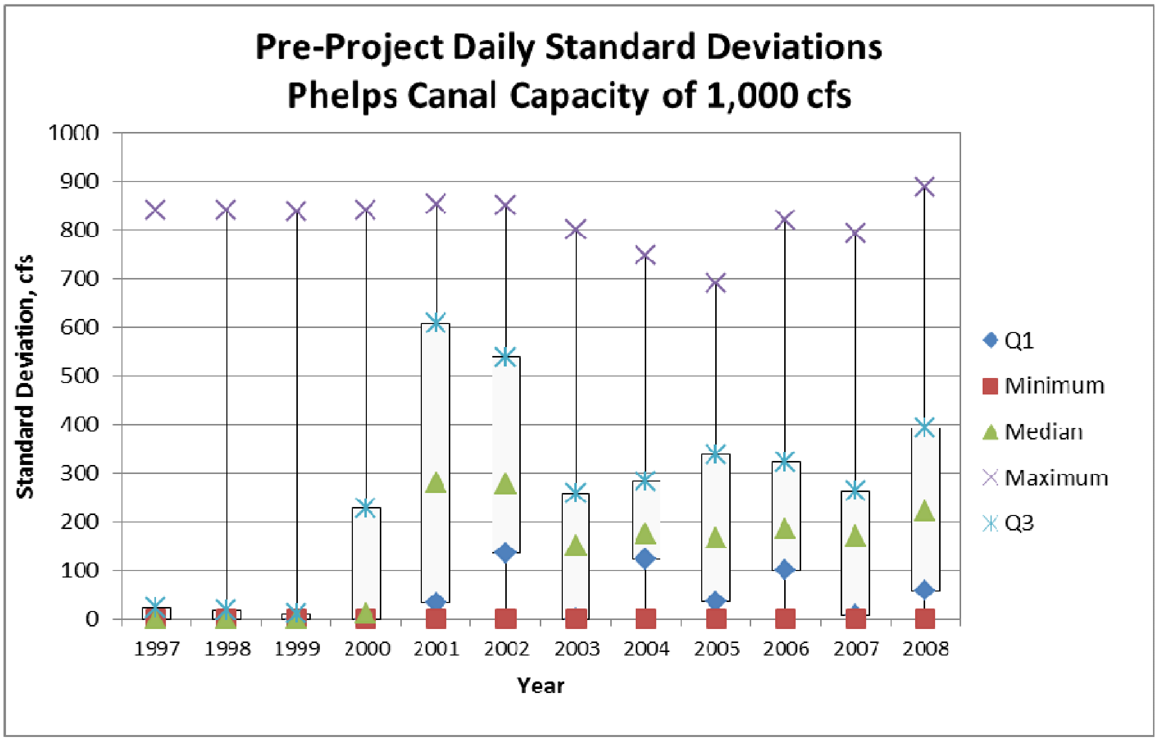

Figure 4. Box Plot of Pre-Project Standard Deviations, Phelps Canal Capacity of 1,000 cfs

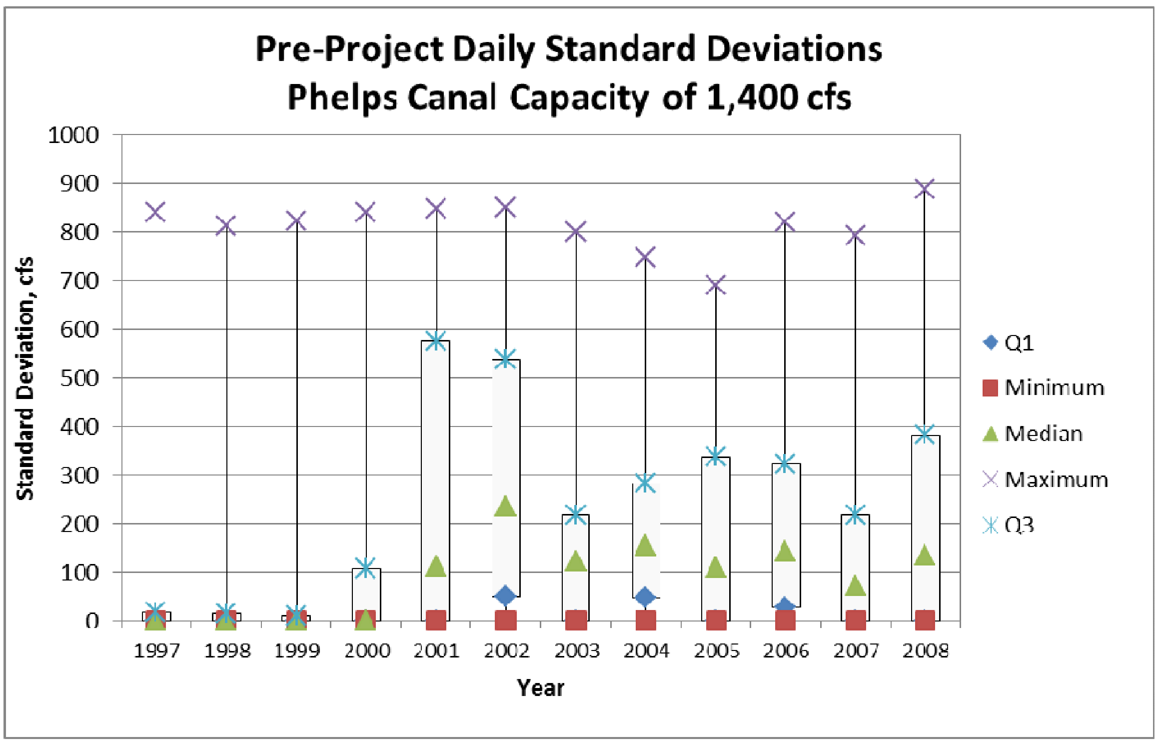

Figure 5. Box Plot of Pre-Project Standard Deviations, Phelps Canal Capacity of 1,400 cfs

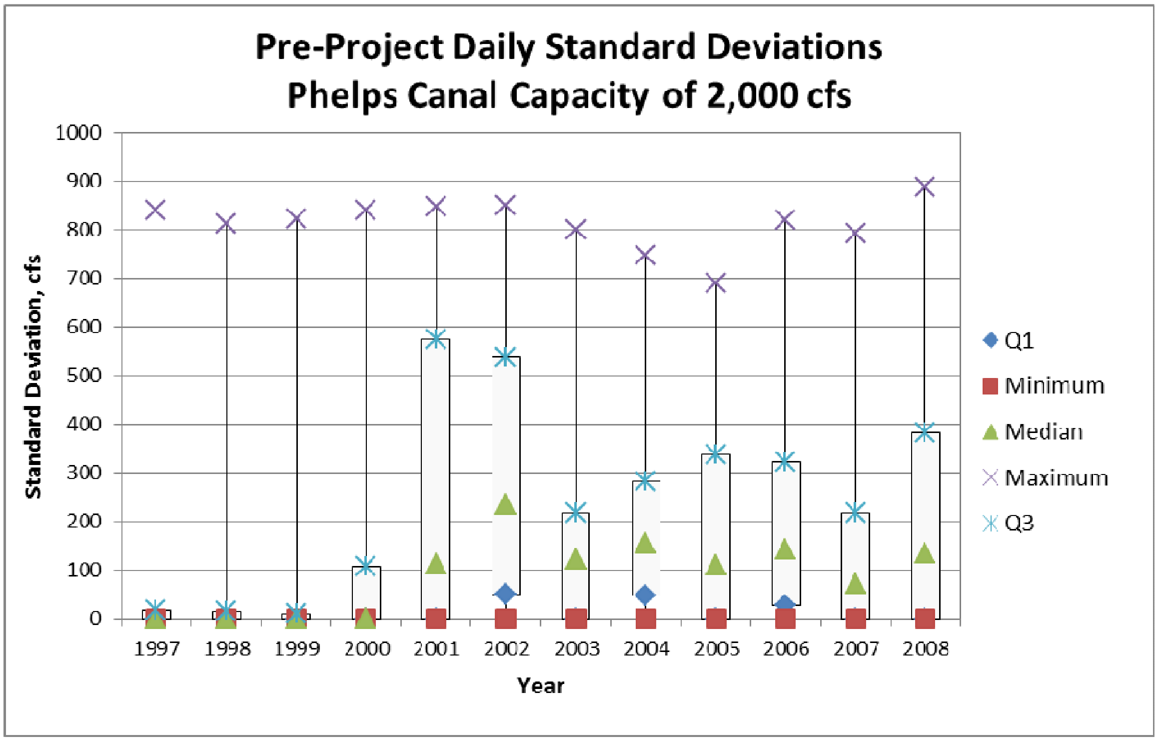

Figure 6. Box Plot of Pre-Project Standard Deviations, Phelps Canal Capacity of 2,000 cfs

3.3.2 Target Flow Augmentation with Hydrocycle Mitigation

Results from the modeling of hydrocycle mitigation along with target flow augmentation are shown in Table 3. Over the whole study period, operating the system to meet both objectives was predicted to reduce yield by an average of 1.1% (407 ac-ft). Reduction in yield was greatest in dry and normal years. For the normal years when the Phelps Canal capacity is 1,000 cfs, the average yield was calculated to be slightly higher, by no more than 150 acre-feet, with hydrocycle mitigation as compared to without hydrocycle mitigation. The difference occurs in 2001. Because the operational rules are different for the with and without hydrocycle mitigation cases, the storage is often slightly different at the start of the day, which leads to a different release rate for the day. The net effect is that higher yield is realized for more hours in the first part of the day and that less yield is realized for fewer hours toward the end of the day. It can essentially be viewed as a retiming of storage and flows. Due to the very low overall difference, it would be appropriate to disregard it.

The success of the hydrocycle mitigation is shown by the standard deviations in Table 3. For all alternatives and year types, the standard deviation decreased during hydrocycle mitigation. Tables C-4 though C-6 in Appendix C show standard deviations with hydrocycle mitigation by month and year. The greatest fluctuations tended to occur outside of the irrigation season and during dry years when the Phelps Canal capacity was 1,000 or 1,400 cfs.

The modeling indicated that the standard deviation of the hydrocycle surge would decrease from 193 cfs to 66 cfs, a 66% reduction, if Phelps Canal were left at the current 1,000 cfs capacity and the Areas 1 and 2 were constructed as indicated in the pre-feasibility study. If Phelps Canal were improved to a 1,400 cfs capacity the decrease in standard deviation would be from 168 cfs to 13 cfs, a 92% decrease. If Phelps Canal were improved to a 2,000 cfs capacity, the decrease in standard deviation would be from 163 cfs to 4 cfs, a 98% decrease.

Table 4 shows the difference in number of days for which the deviation from the average daily flow would have been zero, or no fluctuation. The total number of days in the study period was 4,383. The number of days of zero fluctuation nearly doubled with Phelps Canal at 1,000 cfs and 1,400 cfs capacity and storage Areas 1 and 2 in use and more than doubled for Phelps Canal capacity of 2,000 cfs. The high number of zero standard deviation days in the without hydrocycle mitigation scenario was due to the consistency of the synthetic data. With Phelps Canal capacity of 1,000 cfs, hydrocycle mitigation could be expected to be achieved 55% of the time, as compared to 31% of the time based on more consistent operation by CNPPID or zero flow days.

Table 4. Days of Zero Standard Deviation without and with Hydrocycle Mitigation

Phelps Canal Capacity	Without Hydrocycle Mitigation		With Hydrocycle Mitigation		
	Days with Standard Deviation=0	Percentage of Days with Standard Deviation=0	Days with Standard Deviation=0	Additional Days of Standard Deviation=0	Percentage of Days Hydrocycle Mitigation is Achieved
1,000 cfs	1,378	31%	2,396	1,018	55%
1,400 cfs	1,598	36%	3,177	1,579	72%
2,000 cfs	1,897	43%	4,068	2,171	93%

The days for which full hydrocycle mitigation was not achieved (standard deviation greater than 0) fell into one of four categories:

- The reservoirs were full or almost full and could not take in and store water
- The reservoirs started the day with very little storage so they released at a constant flow until they were nearly empty, at which time the J-2 hydropower plant turned on and the outflow to the Platte River changed.
- The pumps could not keep up with the flow, which resulted in a non-uniform release rate for the day. The number of days this situation happens, though not specifically quantified, are few. In future refinements, additional code can be added to the model to create the uniform release rate.
- Very little water was in storage such that the head available over the weir was low and not enough water could be released. Revisions to add a dead pool as discussed in this report will alleviate this issue.

The synthetic data was used outside of the irrigation season. Table 5 shows a comparison of the number of days outside the irrigation season for which the standard deviation was greater than zero, or for which hydrocycle mitigation was not achieved.

Table 5. Days Outside of Irrigation Season for which Standard Deviation was Greater than Zero

Phelps Canal Capacity	Standard Deviation>0 without Hydrocycle Mitigation	Standard Deviation>0 with Hydrocycle Mitigation
1,000 cfs	1,629	1,335
1,400 cfs	1,489	875
2,000 cfs	1,251	130

Because specialized operational patterns have not been developed for periods of low storage, there is additional potential to optimize joint operations. Previous ED Office analyses showed that the volume of excess flows within CNPPID's system exceed J-2 reregulating reservoir capacities currently being considered.

Revised hydrocycle mitigation goals during times of low storage may be beneficial to endangered species with minimal impact on the PRRIP target flow yields. Due to the excess flows exceeding the proposed storage capacities, electing to occasionally use stored excess flows to mitigate for hydropower cycling may not necessarily decrease yields because the system can be quickly refilled. Further, during times of below target flows, it may be desirable to release flows over several days as opposed to using all of the stored water to meet the target flow requirements for a single day. Such potential flexibility in operational modes should be evaluated to further optimize system capabilities.

3.3.3 Example Day with Target Flow Augmentation and Hydrocycle Mitigation

Figure 7 shows an example of hydrocycle mitigation when the reservoirs are full. In this example, the Phelps Canal capacity was 1,400 cfs, the Area 2 pump station capacity was 300 cfs, and the Areas 1 and 2 gate sizes were 40 and 30 feet, respectively. As seen in the illustration, before the J-2 hydropower plant turned on, the storage areas were drained to release water at a constant rate and to make room for storage water once the J-2 hydro started. The storage volumes at the beginning and the end of the day are the same.

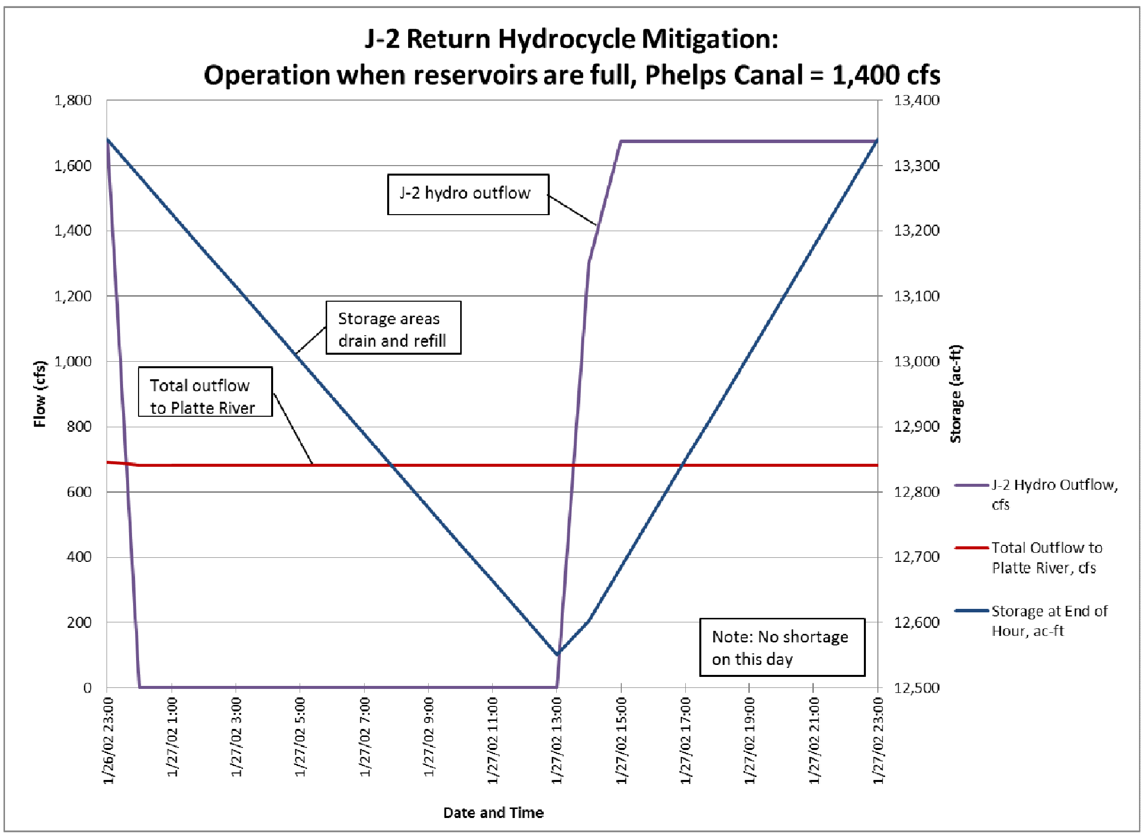

Figure 7. Example of Full Reservoir Operations with Hydrocycle Mitigation and Phelps Canal Capacity of 1,400 cfs

Figure 8 shows the same information as Figure 7, with the exception that the Phelps Canal capacity was reduced to 1,000 cfs. The results are similar, with the exception that the storage was less for Phelps Canal capacity of 1,000 cfs.

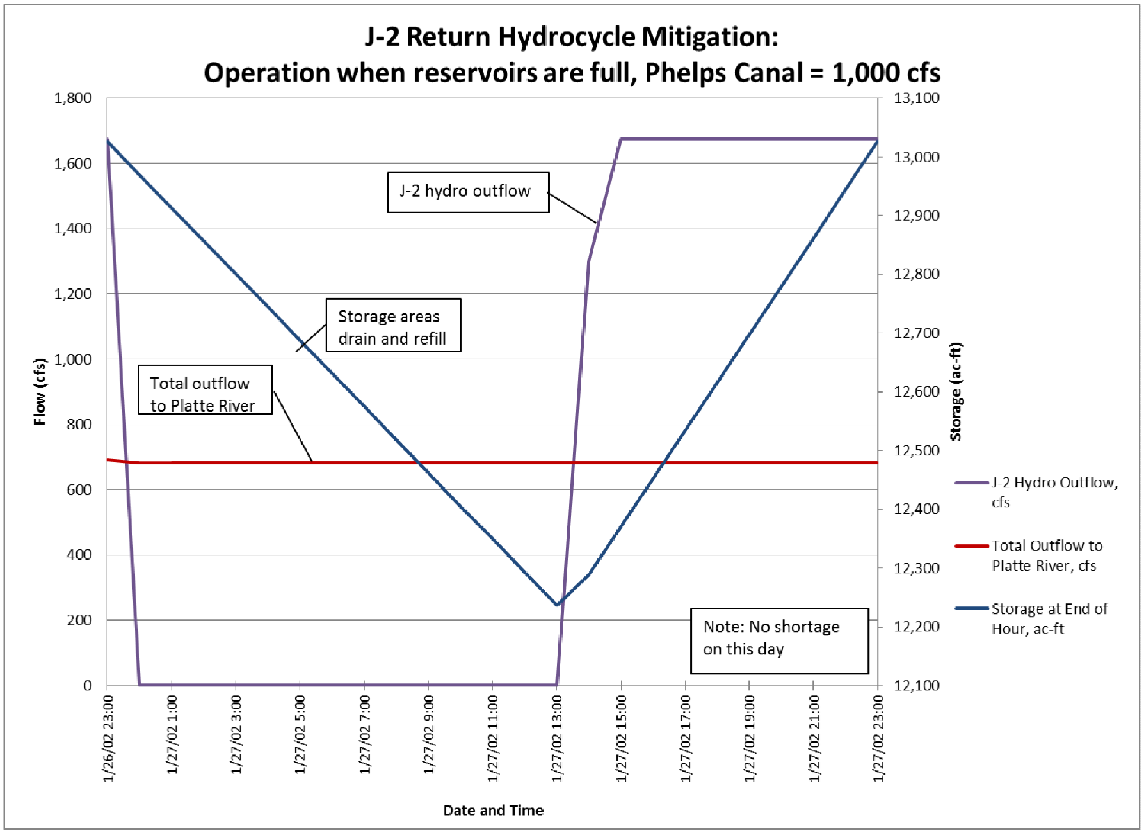

Figure 8. Example of Full Reservoir Operations with Hydrocycle Mitigation and Phelps Canal Capacity of 1,000 cfs

Figure 9 provides an example of a "normal" day of operation, when shortages exist but the reservoirs aren't full but aren't empty. Water in storage was used to meet target flow shortages until the J-2 hydro was started. During that time period, the net volume of water released over the course of the day was included in the project yield and was also used to create a flat flow to the river.

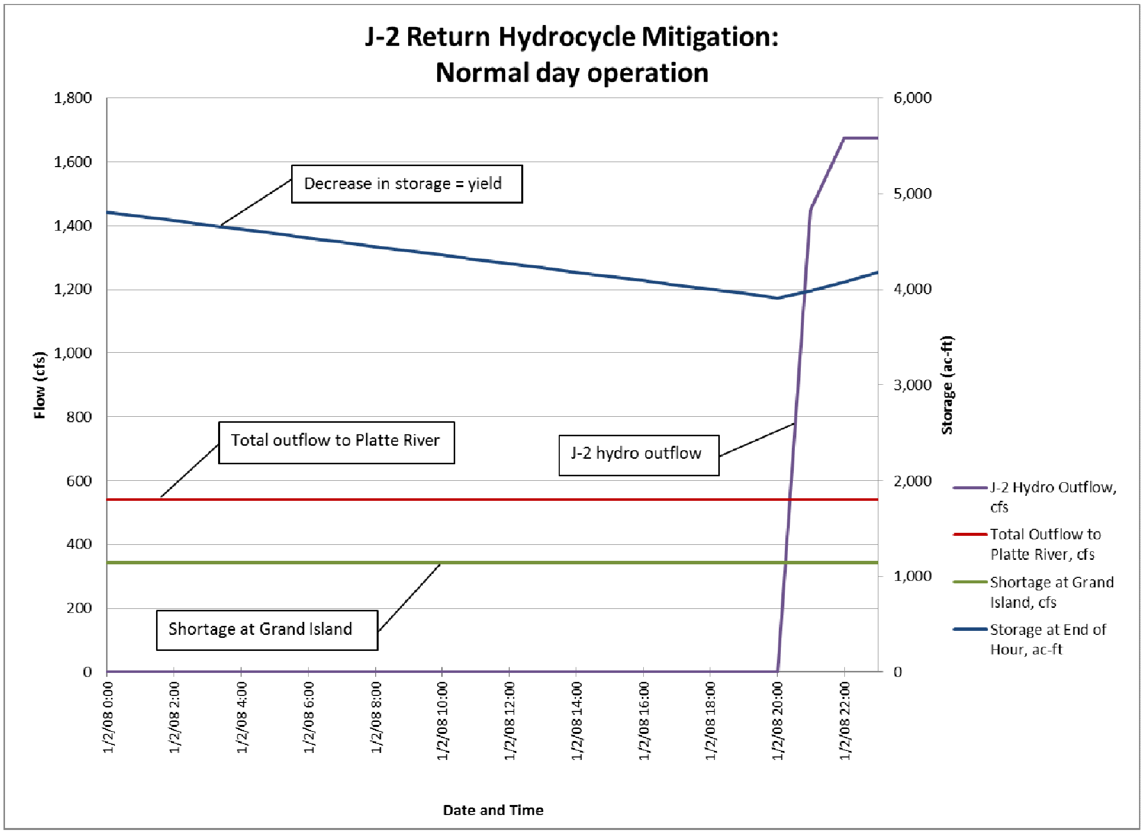

Figure 9. Example of Normal Day Operations with Hydrocycle Mitigation

Figure 10 shows the same day as Figure 3 but with hydrocycle mitigation. The water availability was low and was not enough to meet target shortages. Rather than simply releasing all of the water in storage at the beginning of the day to meet the target flows and then releasing no water until the J-2 hydro started, water was released at an average rate over the day. The average release rate was determined by the volume of water in storage at the beginning of the day. Figure 10 also illustrates the change in flows between days.

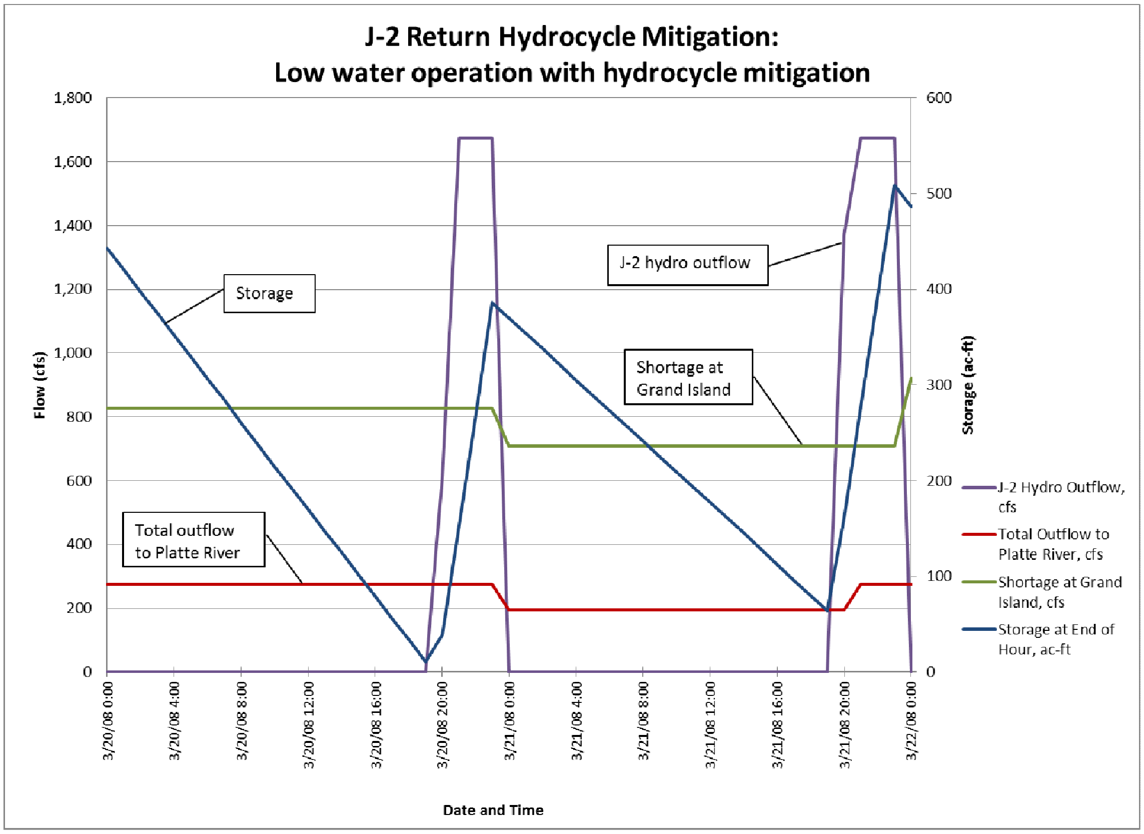

Figure 10. Example of Low Water Operations with Hydrocycle Mitigation

Figures 11-13 show box plots of the daily standard deviations on an annual basis for the post-project, or with hydrocycle mitigation, condition. When compared to figures 4-6, the decrease in daily standard deviations is clear.

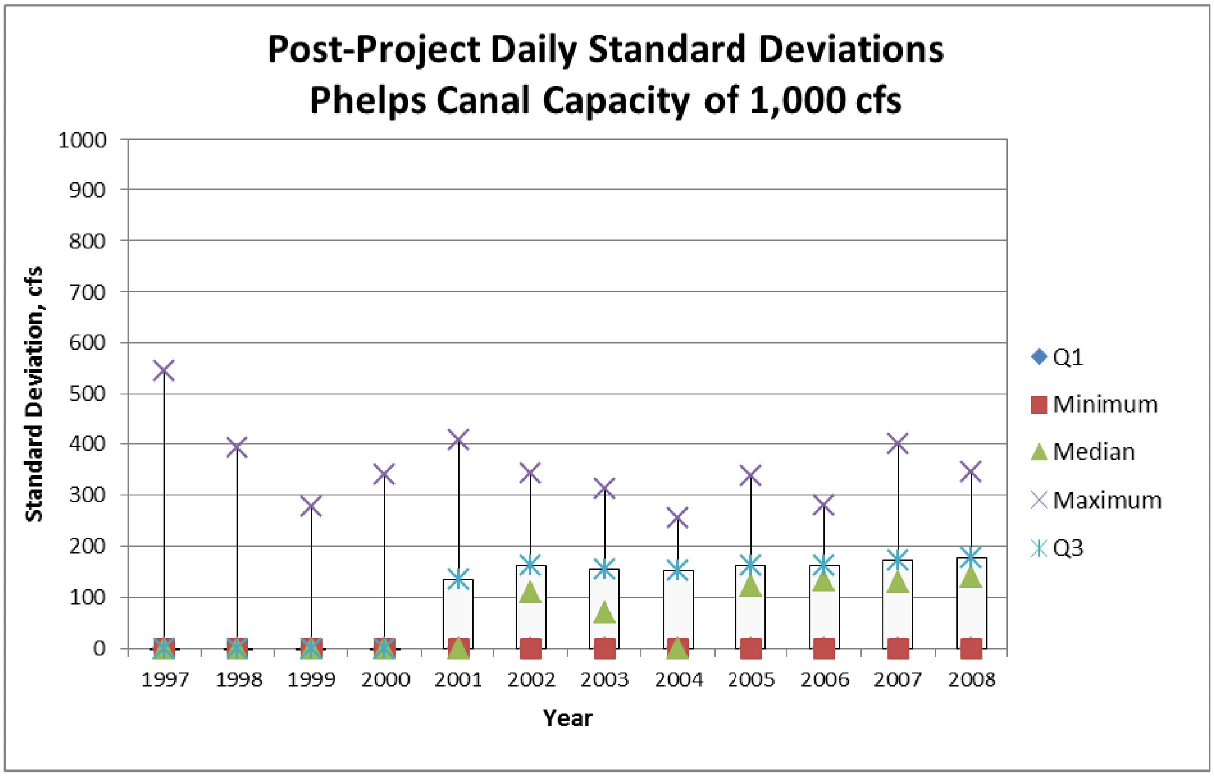

Figure 11. Box Plot of Pre-Project Standard Deviations, Phelps Canal Capacity of 1,000 cfs

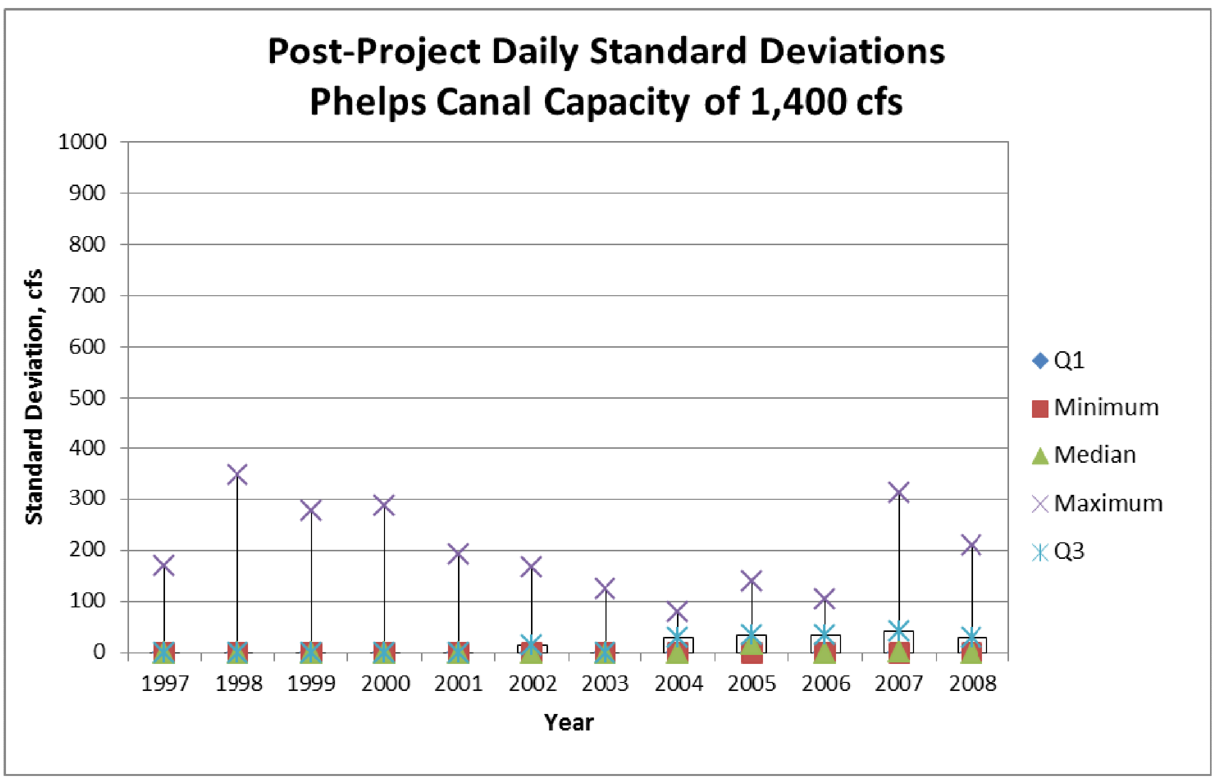

Figure 12. Box Plot of Pre-Project Standard Deviations, Phelps Canal Capacity of 1,400 cfs

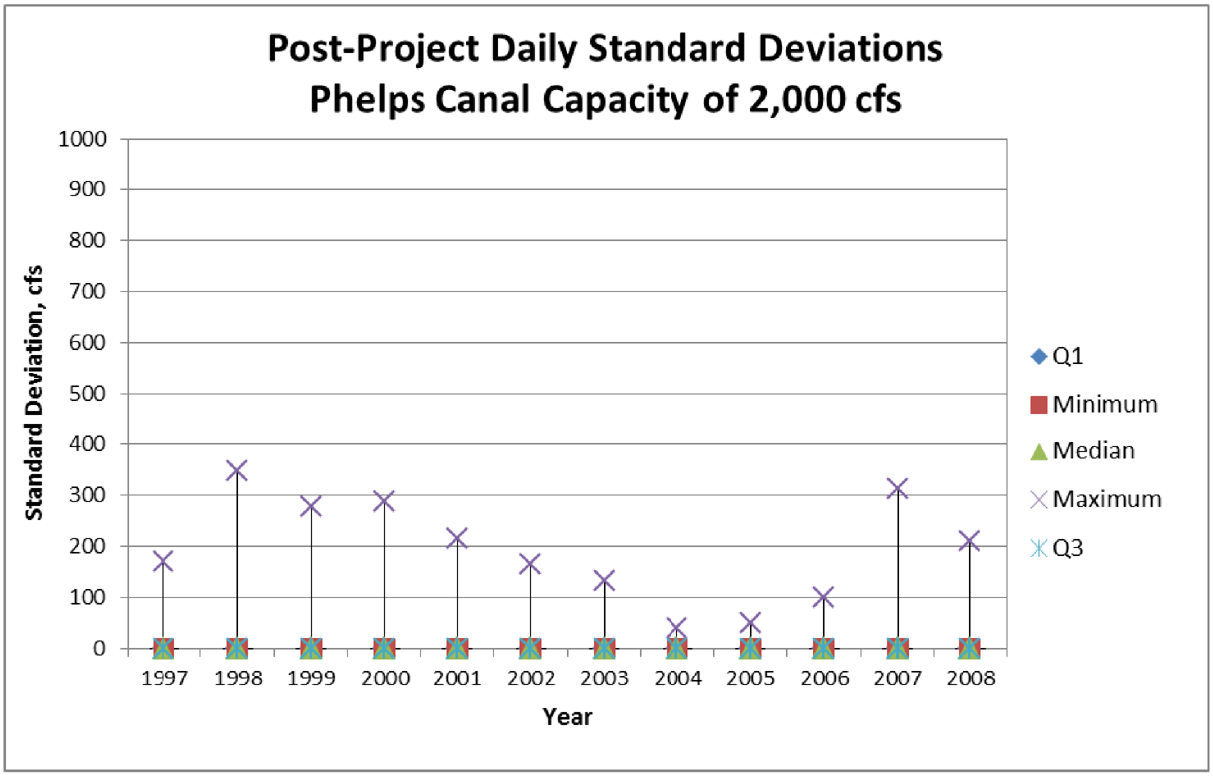

Figure 13. Box Plot of Pre-Project Standard Deviations, Phelps Canal Capacity of 2,000 cfs

3.3.4 Flow Changes at Midnight

The modeling did not attempt to level flows between days, so jumps in flows occur at midnight. Appendix D contains tables showing the average jump by month and year. Using the synthetic data, the jumps were less during the non-irrigation season than when historic data was used in the first modeling effort. The jumps at midnight were slightly less for the irrigation season than for the non-irrigation season when the Phelps Canal capacity was 2,000 cfs, but were significantly less when the Phelps Canal capacity was 1,000 cfs.. The jumps were significantly less than those for the previous modeling with all corrected historic data, due to the more consistent operation of the J-2 hydropower plant. In order to reduce jumps at midnight, multiple days must be evaluated, as discussed in Section 5.0.

3.3.5 Difficult Hydrocycle Mitigation Situations

The situations that proved to be difficult to mitigate hydrocycling included:

A. Routing flows greater than the capacity of Phelps Canal out of the J-2 hydropower plant. During times of excess the desire is to route all water into storage. It is not physically possible to route the flows into storage due to a limited Phelps Canal capacity and a surge resulted when flows varied from hour to hour and remained greater than 1,000 cfs. Also, during brief periods of power generation, a large flow rate would occur for a minimal duration. Ideally, much of this flow would be routed into storage for slow release during the remainder of the 24-hr day. With a limited Phelps Canal conveyance, some water needed to be released from the J-2 return. The higher the flow rate over 1,000 cfs from the J-2 hydropower plant and the shorter the duration of operation, the greater amount of water needed to be released from the J-2 return and the greater the surge. If complete mitigation of the hydropower cycle is required, Phelps Canal will need to be increased in capacity. The surge problem cannot be solved simply by operational changes.

B. When the reservoirs were full, it was difficult to predict an operation pattern such that releases could be made to mitigate for the surge. Releases in the morning followed by subsequent re-filling in the evening would be able to mitigate a hydropower surge even when the reservoir started full in the morning. This scenario, however, requires minimal hydropower operation in the morning followed by increasing flow rates in the evening. When the reservoirs were full in the morning and hydropower releases were high, the subsequent surge rate had to be released to the river due to a lack of available volume to store water in. If the hydropower releases decreased later in the day, the reservoirs remained full for target flow purposes and hence a surge developed. Conceptually, water in storage from a previous day could be released in the morning to offset the projected late afternoon/evening hydropower cycle. While the hydropower plant is running, a portion of the flow could be diverted back into storage such that the net stored amount of water would be unchanged from the beginning of the day. Under such an optimized scenario, the hydropower cycling mitigation could occur without requiring any additional storage volume over what is constructed for target flow augmentation and without requiring increased Phelps Canal capacity.

C. When the reservoirs were empty, or near empty, a surge typically developed. This scenario was the most critical in terms of hydrocycle mitigation. When below target flow conditions occurred for several days, the previously stored excess water was drained. Without water in storage, a slow uniform release rate was no longer possible. Also, many times this condition occurred when the plant was hydrocycling in the evening. The lack of water to release in the morning could not compensate for the surge that occurred in the evening. Under these situations, either no attempt at hydrocycle surge mitigation could be performed to keep as much water in the Platte River hour by hour as possible or conversely, a slow multi-day release could be performed to maintain a higher multi-day average release rate. Hydropower operational changes such as a morning operation followed by a late day operation would also tend to smooth the releases if Phelps had adequate capacity.

D. Large volume of flow fluctuation from day to day proved to be difficult to mitigate especially when there was limited water in storage. A brief evaluation looked at what would be necessary in terms of operations or storage requirements to mitigate for a large increase in flow volume when previous days were fairly uniform. Mitigation would require knowing approximately a week or more in advance the larger volume of water to be produced so that the storage areas could be drained enough to provide volume to store a large peak or to hold enough water back to mitigate a partial day of hydropower operation. This type of advance knowledge is simply not available. It was assumed the large fluctuations in volumes from day to day are due to storm events and it appeared some of this peak release pattern will continue to occur. Figure 14 shows excess flows in 1975, an illustrative normal year from the pre-feasibility study. The spike in flows that occurred in early August, for example, will not be able to be fully mitigated.

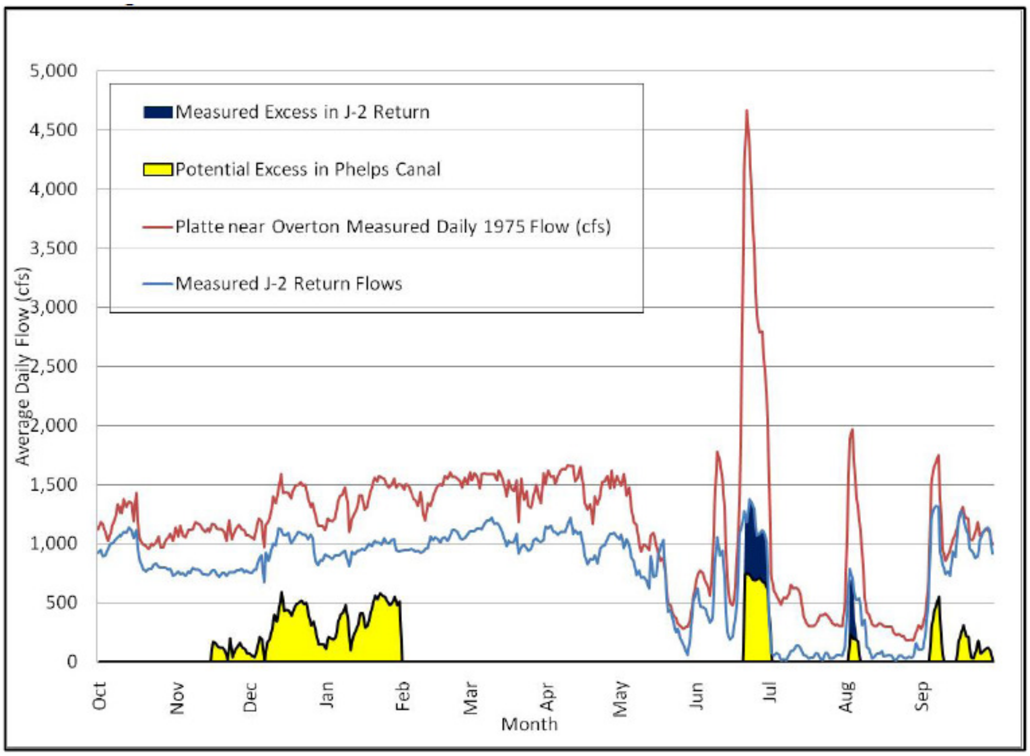

Figure 14. Excerpt of Figure 4.6.2 from the Pre-feasibility Study (Olsson, 2010)

4.0 RECOMMENDATIONS FOR IMPROVEMENTS TO MEET HYDROCYCLE MITIGATION GOALS

The model findings are based on the fundamental assumption that all excess flows should be stored as they become available, and released to reduce shortages to PRRIP target flows as soon as possible. It is also based on an operational objective to smooth flows throughout a calendar day but does not manage day-to-day fluctuations. The following general conclusions can be stated.

4.1 Hydropower Production Schedule Changes

Historic hourly data of the J-2 hydropower plant outflows indicated there was a wide range of J-2 hydropower operational modes, both temporal and rate of flow. If the hydropower plant could be operated under a more predictable schedule, especially during times when the reservoirs are nearly full or empty, hydropower surge mitigation could potentially be accomplished more successfully while minimizing any additional storage volume requirements. The use of synthetic data that represented CNPPID's preferred operations for the non-irrigation season provided more consistent operations and resulted in improved hydrocycle mitigation and yield.

4.2 Phelps Canal Capacity Increase

Phelps Canal capacity is less than the capacity of the J-2 hydropower plant. The potential storage areas are located adjacent to Phelps Canal, and hence more water can be passed through the J-2 plant than can be delivered to the storage areas. The lack of capacity results in an unavoidable hydropower surge under certain operational scenarios, even with the storage areas constructed and available for use. It also results in a limited amount of water that can be delivered to the storage areas during times of excess flow in the Platte River. The sensitivity analysis of improving Phelps Canal capacity showed that increasing the capacity reduced the hydropower surge, particularly during dry years, and slightly increased yield.

4.3 Beginning of Day Minimum Water Storage

Conceptually, water in storage from a previous day could be released in the morning to offset the projected late afternoon/evening hydropower cycle. While the hydropower plant is running, a portion of the flow could be diverted back into storage such that the net stored amount of water would be unchanged from the beginning of the day. Under such an optimized scenario, the hydropower cycling mitigation could occur without requiring any additional storage volume over what is constructed for target flow augmentation. This scenario, however, does require some amount of water in storage at the beginning of the day. The amount of water and length of storage time will depend on the hydrologic conditions and precipitation runoff timing. Water would need to be stored during a time of excess that cannot be more than two days prior to the anticipated surge, or day when hydrocycle mitigation cannot be achieved since CNPPID is not allowed to hold water during times of shortage. It may not be possible for CNPPID to be able to predict the storage needs or the occurrence of an excess event.

4.4 Hydrocyling Mitigation Pool Storage

During periods of frequent shortages to target flows, very little water will be stored in the reservoirs. During such a period of low water storage, frequently there would still be inflow to the reservoirs from partial-day hydropower operation. The outlet gates modeled for the Area 1 and 2 proposed storage sites had difficulty releasing all of the hydropower water from the storage areas by the end of the day due to the low head over the weir. Stored water would eventually all be released to the Platte River, but not always during a single day. This carryover of water into the next day would be reported as a shortage increase over existing conditions for the particular day, but would be released the next day and reported as a reduction in shortage. The long term net effect would be to slightly even out the release over a series of days and tend to minimize the occurrence of zero flow releases to the Platte River. Water stored in the reservoir for the purpose of protection of the reservoir liner, as recommended in the geotechnical report (Olsson, 2011) will help reduce or eliminate this problem. The water will be a dead pool and unavailable for use, but will help increase the head over the weir.

4.5 Additional Storage Discussion

Throughout the project, the question of would more storage benefit the Program goals has been asked. It seems clear that the more storage that is available, the more beneficial it would be for the Program. At some point, however, the cost becomes prohibitive. The modeling was conducted with one storage option, combined Areas 1 and 2. Under Task 2.1 of Olsson's current contract, up to three storage alternatives will be evaluated. Further, under Task 2.3.1, Olsson will develop an incremental storage versus construction cost relationship.

Area 3, located approximately one mile upstream of Area 2 and adjacent to the J-2 return gate, was evaluated in the pre-feasibility study. In the pre-feasibility study, the conceptual design for Area 3 included a storage volume of 1,749 acre-feet based on gravity fill, with pumps to increase the volume to 4,516 acre-feet. As shown, Area 3 was estimated to cost approximately $40 million due to the large volume of excavation required. Construction of a smaller storage and less expensive Area 3 is being considered by CNPPID for the sole purpose of mitigating a hydrocycle surge. In general, the concept is to only excavate enough material to build berms that would match the current J-2 return canal top of berm. An uncontrolled weir would let water flow into the storage area when the water in the J-2 return would get high enough. The water would flow back out the storage area over the same weir when the water in the J-2 canal was low enough. Flows over 1,000 cfs would be stored and released back into the canal to maintain a more uniform flow. When flows are below 1,000 cfs no water would be stored.

The questions of whether Area 3 is helpful to meeting the goals of the Program or whether constructing Area 3 can be done instead of increasing the Phelps Canal capacity were raised. The revised Area 3 has not been modeled but some reasonable expectations are that it would help hydrocycle mitigation but would not benefit project yields. Area 3 could provide a more uniform supply rate to the storage sites. The more uniform supply rate would help when the Phelps Canal capacity is the limiting factor preventing hydrocycle surge mitigation. Because it would not be able to store water from one day to the next, it would not be able to mitigate the hydrocycle surge on its own. Water needs to be in storage in the morning hours in order to mitigate the flow being produced later in the day. Area 3 would not assist with this aspect of hydrocycle mitigation. Also, since excess flows cannot be stored for a long duration, it is anticipated there will not be any increase in project yields if Area 3 was constructed.

If Phelps Canal were upgraded to 2,000 cfs, Area 3 would not be needed. A cost comparison of Phelps Canal versus Area 3 would require modeling of Area 3 to determine the required volume and associated cost.

5.0 RECOMMENDATION FOR MODEL REFINEMENT

In order to reduce the change in flow at midnight and improve hydrocycle mitigation, modeling of flow ramping within an acceptable range of flows is the next logical step for model refinement. Allowing increases and decreases in flows within a range deemed acceptable by the Federal Energy Regulatory Commission (FERC), as described in their biological opinion document (FERC, 2007), will reduce large fluctuations in releases at midnight. The model would need to look ahead to the volume available the following day or couple of days and determine how to spread the flow over those days while augmenting target flow shortages. During times of low water, it may be desirable to release flows over several days as opposed to using all of the stored water to meet the target flow requirements for a single day. As long as the reductions in shortages are calculated on a longer time scale than a day, ramping operations should not increase shortages. Such potential flexibility in operational modes should be evaluated to further optimize system capabilities. Parameters for modeling such as an acceptable ramping range and not allowing increases in flow at night while the birds are roosting will need to be established prior to modeling.

Modeling multiple days at a flat rate would result in greater storage requirements and decreased yield for Program uses. Areas 1 and 2 do not contain enough storage to be able to mitigate for hydrocycle mitigation for multiple days in a row. At the end of a multiple-day modeling period, the same issue of a jump in flows between modeling (or operational periods) would exist.

6.0 CONCLUSIONS

Modeling to date shows that hydropower cycling mitigation could be successfully integrated with target flow releases without a large decrease in reduction of target flow shortages for the majority of the situations the proposed structures will encounter, if a combination of operational changes and system improvement are made. When the reservoirs are empty, or nearly empty, a specialized operation will need to be adopted that balances the needs between target flow releases and hydropower surge mitigation. The hydrocycle surge was reduced in part due to more consistent operation by CNPPID and the assumption that if the Program released water to that Platte River, it would be done at a uniform rate.

7.0 REFERENCES

Boyle Engineering Corporation, 2008. Water Management Study Phase I Evaluation of Pulse Flows for the Platte River Recovery Implementation Program, Platte River Recovery Implementation Program.

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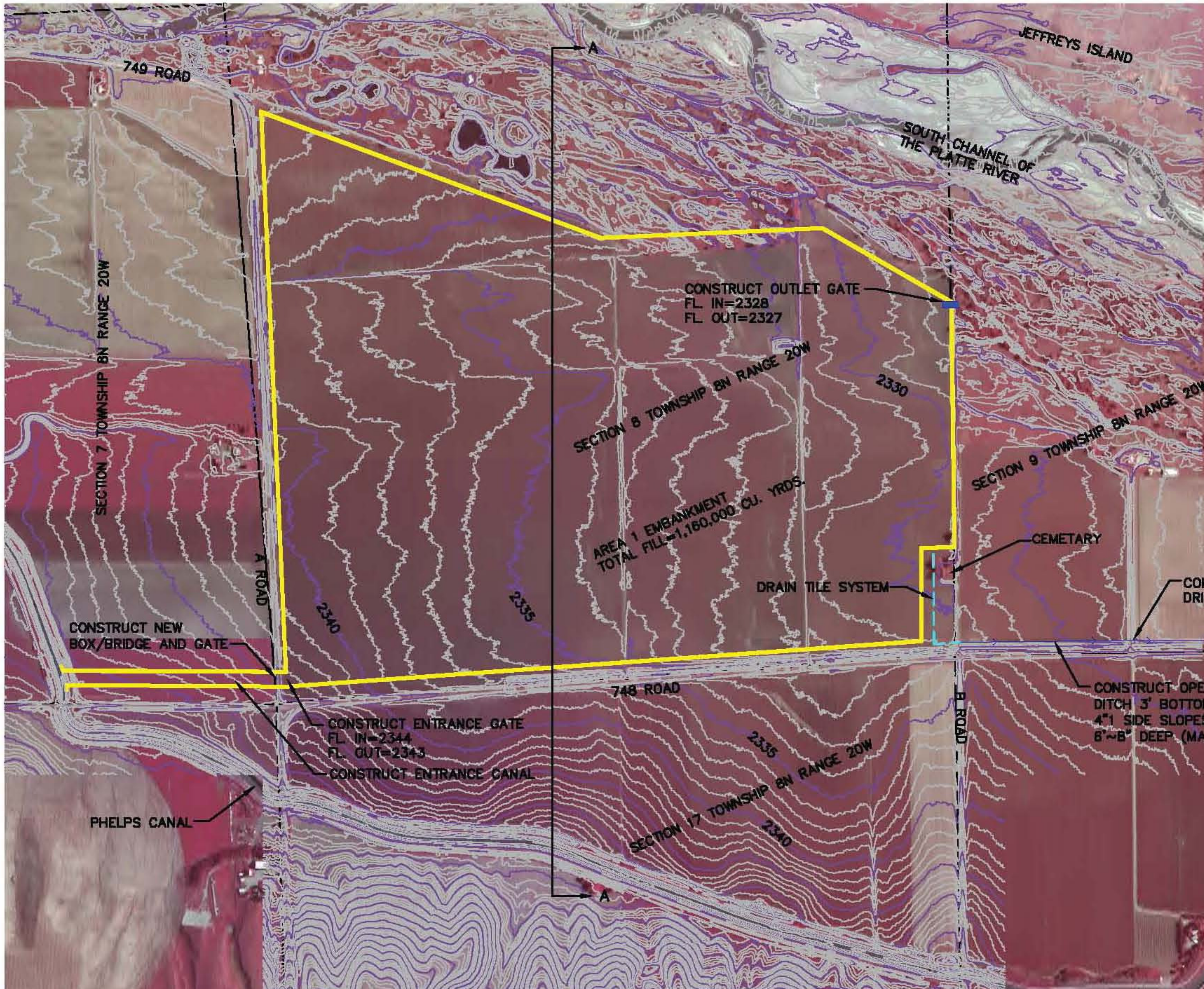
Platte River Recovery Implementation Program. December 7, 2006. *Platte River Recovery Implementation Program (PRRIP) Program Document, Attachment 5, Section 11, Water Plan Reference Materials, Appendix A-5*.

APPENDIX A

AREAS 1 AND 2 FIGURES



NOTES:

1. CONTOURS DEVELOPED FROM LIDAR POINTS.
2. AREA 1 FOOTPRINT IS BASED ON THE CONCEPTUAL STUDY FINDINGS DATED 2-18-2010
3. ASSUMES NO PUMPS WILL BE NEEDED TO FILL OR DRAIN THE STORAGE SITE.
4. EXCEPT FOR THE NEW ENTRANCE CANAL, NO STORAGE OR EMBANKMENTS WILL BE IN THE COUNTY RIGHT-OF-WAY.

N

0' 400' 800'
SCALE IN FEET

LEGEND

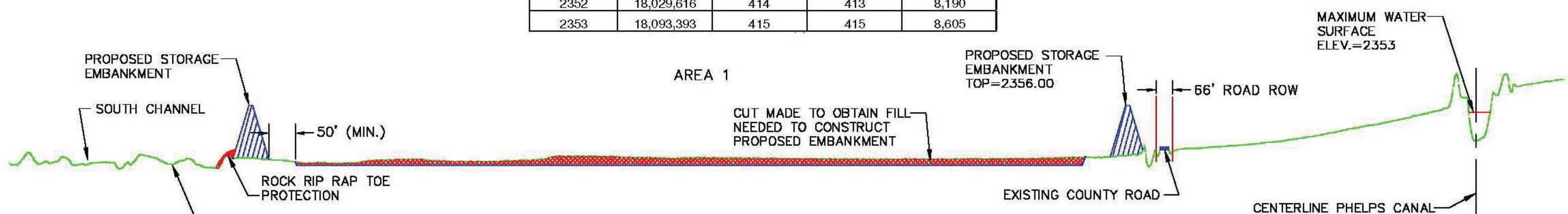
- EXCAVATION AREA BOUNDARY
- EXISTING GRADE
- PROPOSED STORAGE
- TOP OF EMBANKMENT
- EXISTING MAJOR CONTOUR

DWG: F:\Projects\009-1466\B09-1466_WTRS\Design\Lidar Surface Work\Option #1\009-1466_Area1StageStorageExhibit.dwg USER: cluttrell
DATE: Jun 18, 2010 12:45pm XREFS: 009-1466_SectionTownship 009-1466_HighResolutionAerials 091466_xcon TitleBlock

PROJECT: 09-1466 DRAWN BY: CRL DATE: 6.18.2010	**DRAFT SET** CNPPID REREGULATION RESERVOIR FEASIBILITY STUDY PHELPS COUNTY, NEBRASKA **DRAFT SET**	OLSSON ASSOCIATES	AREA 1 STORAGE OPTION #1	FIGURE A-1

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

CNPPID REREGULATION RESERVOIR FEASIBILITY STUDY				
AREA 1 OPTION #1				
Elevation	Area (sf)	Area (acre)	Incremental Storage (acre-ft)	Total Storage (acre-ft)
2328	19,249	0	0	0
2329	233,324	5	3	3
2330	722,672	17	11	14
2331	3,447,501	79	48	62
2332	16,150,266	371	225	287
2333	16,269,259	373	372	659
2334	16,354,378	375	374	1,033
2335	16,493,710	379	377	1,410
2336	16,616,193	381	380	1,790
2337	16,724,981	384	383	2,173
2338	16,844,047	387	385	2,558
2339	17,058,455	392	389	2,948
2340	17,182,452	394	393	3,341
2341	17,272,388	397	395	3,736
2342	17,348,122	398	397	4,133
2343	17,420,077	400	399	4,533
2344	17,476,306	401	401	4,933
2345	17,534,389	403	402	5,335
2346	17,593,615	404	403	5,738
2347	17,653,015	405	405	6,143
2348	17,719,999	407	406	6,549
2349	17,789,572	408	408	6,956
2350	17,877,647	410	409	7,366
2351	17,965,914	412	411	7,777
2352	18,029,616	414	413	8,190
2353	18,093,393	415	415	8,605



CROSS SECTION A–A
NOT TO SCALE

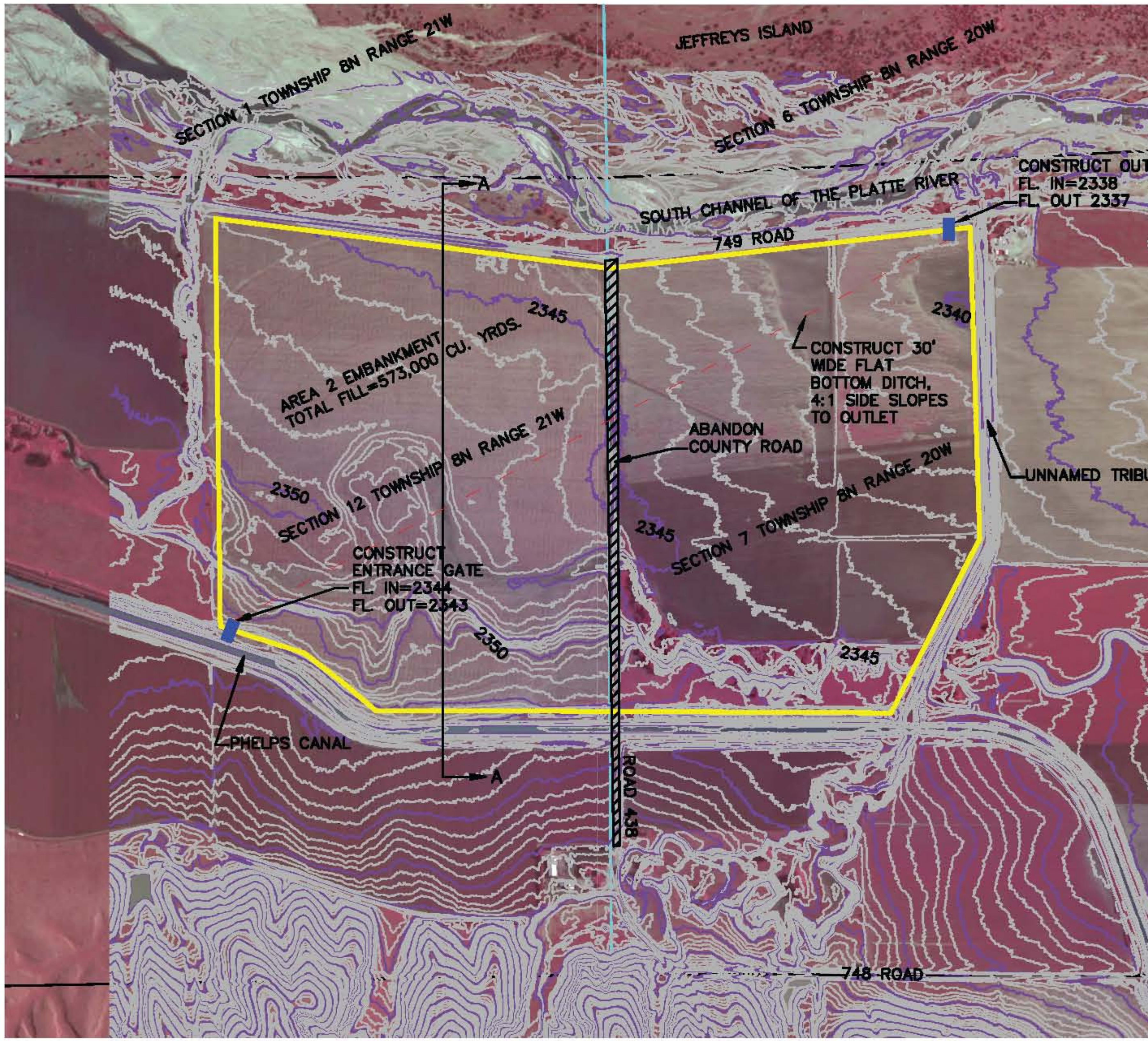
PROJECT: 09-1466
DRAWN BY: CRL
DATE: 6.18.2010

DRAFT SET CNPPID REREGULATION RESERVOIR FEASIBILITY STUDY PHELPS COUNTY, NEBRASKA **DRAFT SET**

OLSSON ASSOCIATES

AREA 1 STORAGE OPTION #1

FIGURE A-2



NOTE:
CONTOURS DEVELOPED FROM LIDAR POINTS.

N

0' 400' 800'
SCALE IN FEET

LEGEND

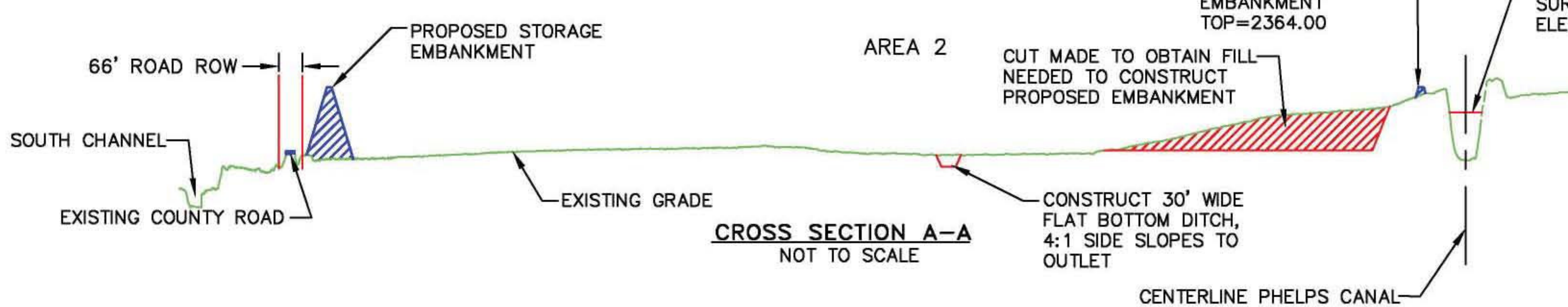
- EXCAVATION AREA BOUNDARY
- PROPOSED STORAGE
- TOP OF EMBANKMENT
- EXISTING MAJOR CONTOUR

PROJECT: 09-1466 DRAWN BY: CRL DATE: 6.18.2010	**DRAFT SET** CNPPID REREGULATION RESERVOIR FEASIBILITY STUDY PHELPS COUNTY, NEBRASKA **DRAFT SET**	OLSSON ASSOCIATES	AREA 2 STORAGE OPTION #1	FIGURE A-3

CNPPID REREGULATION RESERVOIR FEASIBILITY STUDY				
AREA 2 OPTION #1				
Elevation	Area (sf)	Area (acre)	Incremental Storage (acre-ft)	Total Storage (acre-ft)
2339	35,336	1	0	0
2340	79,100	2	1	1
2341	476,576	11	6	8
2342	1,666,108	38	25	32
2343	3,044,059	70	54	86
2344	4,492,224	103	87	173
2345	6,341,362	146	124	297
2346	7,666,467	176	161	458
2347	12,912,674	296	236	694
2348	13,039,824	299	298	992
2349	13,125,002	301	300	1,292
2350	13,267,743	305	303	1,595
2351	13,320,237	306	305	1,901
2352	13,373,027	307	306	2,207
2353	13,427,740	308	308	2,515
2354	13,484,999	310	309	2,824
2355	13,544,789	311	310	3,134
2356	13,596,813	312	312	3,445
2357	13,707,331	315	313	3,759
2358*	13,769,009	316	315	4,074
2359*	13,862,731	318	317	4,391
2360*	13,942,301	320	319	4,710
2361*	14,133,022	324	322	5,033

NOTE:

*STORAGE AREA WILL REQUIRE PUMPS TO FILL BETWEEN ELEVATION 2357 TO ELEVATION 2361.



CROSS SECTION A–A
NOT TO SCALE

PROJECT: 09-1466
DRAWN BY: CRL
DATE: 6.18.2010

DRAFT SET

CNPPID REREGULATION RESERVOIR FEASIBILITY STUDY
PHELPS COUNTY, NEBRASKA

DRAFT SET

OLSSON ASSOCIATES

AREA 2 STORAGE OPTION #1

FIGURE A-4

APPENDIX B

MEETING MINUTES AND MEMORANDA

OLSSON ASSOCIATES

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☐	Other: ___________

TO:	Beorn Courtney, Cory Steinke
RE:	Hydrocycling Meeting Minutes
MEETING DATE:	6/24/10, 2:00 pm Central
PROJECT #:	20091466
PHASE:	1

Conference Call Meeting Notes:

The meeting purpose was to discuss hydrocycling operation and hydrocycling surge mitigation modeling. Nine questions were asked in an email from Eric prior to the meeting to be discussed during this meeting. The questions and answers from the meeting to these questions are presented below. It is intended these questions and answers will be used to help develop the modeling assumptions section of the reports and findings memorandums.

1) Allowable hydrocycling surge? FERC/USFW have indicated up to a 200 cfs surge will not result in a taking of T&E species. Do we use this or something different for the "goal". Maybe no more than a theoretical 50 cfs (+/-) surge is appropriate at this level of analysis?

> Cory said that though we want no (0 cfs) surge, 50 or 100 cfs may be more reasonable. He said a zero surge (uniform release rate over the day) should be the goal as a theoretical approach and should be used at this point. This may need to be re-evaluated if the zero surge goal causes a large construction cost increase compared to a more reasonable allowable surge.

2) J-2 hydropower desirable outflow rate? Do I use 1,675 cfs always or should I look at other flow rates when the volume available is low?

> Cory said that 1,675 cfs is the most efficient outflow rate. In the future, CNPPID might consider 2 starts a day if all equipment is fixed. For now, use 1,675 cfs at a fixed rate for one start per day.

3) Minimum duration of operation? If we have a fixed outflow rate of 1,675 cfs but a limited volume of water, then I can calculate the how many hours of operation. It appears that if less than 400 ac-ft is available the J-2 hydro will not be turned on (zero outflow). Should I use this number or something different? Will this change as part of target flow operation?

> Cory said that the plant will not be run unless it can be run for at least 2 hrs. 2 hrs times 1,675 cfs yields a minimum daily volume of 277 ac-ft.

4) Hours of preferred operation? I am assuming similar to the concept study hydropower operation if not 24 hrs will be evening. Off at midnight and calculate the start based on the volume available that day. Is this still correct?

Yes. Eric said he would have modeling issues if the volume was distributed into the next day (past midnight) as he will have to eventually give daily averages.

5) Phelps Canal capacity? Do I keep 1,000 cfs for all options or do you want me to see what the capacity needs to be to meet the zero surge goal?

Eric said that increases in Phelps Canal capacity make it easier to meet hydrocycling goals. Cory said that maybe it is best to state what needs to be done to meet the goal and then decide if it's feasible. Eric said he would run a sensitivity analysis on the capacity of Phelps by starting with a large Phelps capacity and start backing off until he sees the hydrocycling surge mitigation impact. Eric would tabulate the hydrocycling surge mitigation results for 1,675 cfs down to the current capacity of 1,000 cfs similar to the sensitivity analysis Laura is performing. The construction plans show the system was designed for 1,400 cfs so it is believed siphons/ gates/ bridges would have to be improved if the desired capacity exceeds 1,400 cfs.

Eric mentioned that there are slope stability issues in canals when they are filled and emptied rapidly. He suggested the possibility of a new gate in Phelps might be needed to maintain a certain water level. Gates are currently used in the J-2 Return canal to hold a uniform water level.

6) Area 3, top portion, minimal excavation, remove north side of canal berm. This is related to item 5. If I hold 1,000 cfs as the peak capacity for Phelps AND the daily average discharge is less than 675 cfs, I may not be able to meet the goal. 675 cfs= 1,339 ac-ft/ day. At what point do I look at Area 3?

The group agreed Olsson would only look at Areas 1 and 2 at this point per the contract scope. The decision to look at Area 3 will be joint decision by CNPPID and ED office based on their review of the initial modeling results.

7) Hydrocycle only model? Do I need to develop a model that only address hydrocycling surge and not SDHF or Target flow augmentation? If yes, then do I assume the hydrocycling water is on top (similar to the concept study) or that storage sites are otherwise empty? This goes into the gate sizing and "holding" water in order to increase the head on the gates.

More of this discussion is in question 9. Cory mentioned that typically if there are excesses they are running 24 hrs a day anyway, so there are no hydrocycling impacts. If there are no excesses, they are running only part of the time, so there are hydrocycling impacts to mitigate for. In addition, some water can be released from the J-2 return while some water can be routed for temporary storage. Likewise, potentially some water in temporary storage could be used to mitigate some of the surge. Therefore, the accounting becomes different depending on the operational mode and some of the water could potential be a shared use. The hydrocycling surge is an hourly event where as target flow releases are a daily average. Because of the difference, the hydrocycling surge mitigation may not require additional storage or at least minimal storage.

This modeling will need to be closely linked to an operational decision tree. Beorn suggested the ED office review the operational mode assumptions before the modeling is performed. Eric said that he would provide a graphical decision tree so that the assumptions made in the modeling are transparent and can be agreed upon. This will show the “rules” for operation depending on if excesses are available or not, and if the reservoir is being used for hydrocycling mitigation, target flow operations, or a combination of the two.

8) Hydrocycle model time period? Hydrocycle surge does not show up on daily data so the model will need hourly inputs and evaluation at hourly time steps. This will be a large data set. Should I look at wet/normal/dry year similar to concept study? Should I use last 10 years/ 20/ 30? OPSTUDY time period? OPSTUDY vs Historic flows?

Beorn said that it was preferable to not use the wet-normal-dry years for analysis. Cory said that there were operational changes about 10 yrs ago, and the 90’s were wet while the late 2000’s were dry. Kasi said hourly data is only available so far back in history. Eric said maybe it would be best to start when hourly data is available so that we are not mixing measured data with theoretical hourly data, and Beorn said that might be ok.

9) Target flow augmentation and Hydrocycle surge mitigation joint operation model. Hourly time step. Run one without hydrocycle surge mitigation and then with hydrocycle surge mitigation. Compare peak storage results and if target flow augmentation volume changes. Other parameters to compare? Reasonable approach?

It was decided that the model had to be a joint model with historic hourly data. A hydrocycling-only model is not needed because these impacts will show up in historic calculations. In other words, the historic data has periods when no excess or releases would be able to be made and the only activity in the reservoir would be for hydrocycling surge mitigation. During other periods, there would be a mix of activities for hydrocycling, storing excesses and hydrocycling mitigation. Evaluation and comparison of the historic data will likely show differences between these operations. The group decided to re-visit this topic based on the initial modeling results.

Action items:
Meeting minutes should be sent out by OA
An operation flow chart should be sent from OA, due Monday 6/28/10
The date that hourly historical data became available should be researched and sent out by OA

CC: Eric Dove, Olsson Associates
Beorn Courtney, ED Office
Cory Steinke, CNPPID
File

TO: CNPPID REREGULATING RESERVOIR WORKGROUP

FROM: ED OFFICE

SUBJECT: WORKGROUP MEETING FOLLOW-UP

DATE: SEPTEMBER 17, 2010

Introduction

This memo addresses several questions that were raised at the August 10, 2010 Workgroup meeting. These include:

- Does the use of daily average flows over-estimate the project yield (score) because hourly peak flows may be greater than the Phelps County Canal capacity?;
- Does the Phelps County Canal capacity impact the project yield (score) when analysis is done on an hourly basis?; and
- How does historical hydrology for the post-OPStudy period (1995 – 2008) impact the project yield[1]?

Background on Additional Target Flow Operations Modeling

To address the concerns outlined above, the ED Office used hourly historical data for the J-2 Return and Phelps County Canal provided by Olsson from mid-1996 through 2008 to compare target flow results for daily and hourly operations. Excess flows and shortages at Grand Island were calculated on a daily basis using daily average Grand Island gage data[2]. The same hourly data was used by the ED Office for hourly calculations and to develop the daily average J-2 Return and Phelps Canal historical flows used in the daily analysis. This was done, as compared to using historical daily average J-2 Return and Phelps County Canal data previously provided by CNPPID to ensure that hourly and daily data were consistent. Note that the current Phelps County Canal capacity is 1000 cfs and the design capacity is 1,400 cfs. The J-2 hydro capacity is 2,000 cfs and it runs most efficiently at 1,675 cfs.

Daily and hourly modeling was completed for target flow operations only. No hydrocycling mitigation was included as it is not known if the reservoir will be used for this purpose. Daily modeling was completed similarly to past modeling, storing J-2 Return flows up to the value of excess flows at Grand Island available, constrained by remaining Phelps County Canal capacity and J-2 Reservoir storage capacity. Two hourly calculation methods were used to evaluate potential impacts and also to provide information to help the Workgroup decide which method should be used moving forward. Method A evaluates hourly J-2 Return flows against the daily Grand Island excess flow value, which is constant throughout the day. Method B turns the daily

[1] The GC and Scoring Subcommittee determined that the project will be scored using OPStudy hydrology for the 1947 – 1998 period. However, the project Workgroup was interested in knowing how the recent drought period would impact the yield.

[2] Sufficient hourly data was not available to calculate excess flows at Grand Island on an hourly basis. The ED Office also believes it is appropriate to calculate excesses flows and shortages on a daily basis rather than an hourly basis, as hourly calculations are not referred to in the Program Document's Water Plan Reference Materials which outline options for applying Program target flows.

Grand Island excess flow value into a daily total volume (AF) and then stores up to this volume in the reservoir over the day. Note that Olsson used a method similar to Method B in completing Task 1 of the Feasibility Study. Examples of these two methods are shown in columns F and G in **Table 1**, respectively.

Table 1 includes data from the model for a randomly selected day (12/18/2007). There are 16 hours with no flow in the J-2 Return and 8 hours of hydrocycling. The daily average J-2 Return flow is 988 cfs and the daily average excess flow at Grand Island is 805 cfs. Under Option A, each hour, excess flows at Grand Island are compared to the hourly J-2 Return flow and flow is diverted up to the average daily excess flow value, not exceeding the Phelps County Canal capacity. This results in a total of 129 AF being stored over the day. Under Option B, for the hours when there is flow in the J-2 Return, flow can be diverted each hour up to the total volume of excess flows (not to exceed the Phelps County Canal capacity) at Grand Island for the day. This results in a total of 407 AF being stored over the day, though during hours when the water is being diverted to the reservoir, flows in the river would decrease below the target/instream flow. Note that this illustrates one day only. Previous analyses and later sections of this memo show that there are significantly more excess flows available in CNPPID's system than are stored in the reservoir. Though less water is stored on this illustrative day using Method A, additional excess flows may be stored in subsequent days, ultimately resulting in the same (or similar) volume in storage as determined using Method B.

An example of daily calculations for the same day (12/18/2007) is shown in **Table 2**. Excess flows stored using the hourly Method B and daily calculations are the same, 407 AF.

Table 1: Hourly Target Flow Operations for 12/18/2007, using a 1,000 cfs Phelps Canal Capacity

Time	Target/ Instream Flow	Grand Island Flow (cfs)	Excess Flow at GI (cfs)	J-2 Return Flow (cfs)	Excess Flows Stored in J-2 Reservoir (cfs)*	
					Method A: Store Up to Hourly Excess	Method B: Store Up to Daily Excess
A	B	C	D	E	F	G
0:00	600	805	205	0	0	0
1:00	600	805	205	0	0	0
2:00	600	805	205	0	0	0
3:00	600	805	205	0	0	0
4:00	600	805	205	0	0	0
5:00	600	805	205	0	0	0
6:00	600	805	205	0	0	0
7:00	600	805	205	0	0	0
8:00	600	805	205	0	0	0
9:00	600	805	205	0	0	0
10:00	600	805	205	0	0	0
11:00	600	805	205	0	0	0
12:00	600	805	205	0	0	0
13:00	600	805	205	0	0	0
14:00	600	805	205	1597	205	1000
15:00	600	805	205	1718	205	1000
16:00	600	805	205	1694	205	1000
17:00	600	805	205	1706	205	1000
18:00	600	805	205	1706	205	925
19:00	600	805	205	1694	205	0
20:00	600	805	205	1718	205	0
21:00	600	805	205	121	121	0
22:00	600	805	205	0	0	0
23:00	600	805	205	0	0	0
TOTAL			407 AF	988 AF	**129 AF**	**407 AF**

*Assuming reservoir capacity is available and that the Phelps County Canal capacity is the current 1,000 cfs with no historical canal diversions for this period.

Table 2: Daily Target Flow Operations for 12/18/2007, using a 1,000 cfs Phelps Canal Capacity

Date	Target/ Instream Flow	Grand Island Flow (cfs)	Excess Flow at GI (cfs)	J-2 Return Flow (cfs)	Excess Flows Stored in J-2
12/18/2007	600	805	205	498	205
TOTAL					**407 AF**

Impact of Daily Modeling on J-2 Reservoir Yield

In completing an evaluation of combined target flow operation and hydrocycling mitigation for a J-2 Reservoir (Task 1 of the CNPPID Reregulating Reservoir Feasibility Study), Olsson Associates (Olsson) asked the ED Office if the daily target flow operations scoring model might be overestimating what could actually be routed down the Phelps County Canal and stored in the Reservoir. Their concern was that modeling using daily average values might not capture the fact that actual excess flows might exceed the Phelps County Canal capacity at times during the day, and then drop much lower at other times (perhaps to zero) when hydrocycling wasn't occurring. Daily modeling would show that all excess flows (as captured in the daily average value) could be stored which would over-estimate the score. For example, if actual daily J-2 Return flows (the reservoir's water supply) were 1,675 cfs (the most efficient operating rate for the J-2 Hydro) for 12 hours and then 0.0 cfs for 12 hours, the daily average flow would be 838 cfs. If excess flows at Grand Island were 1,200 cfs, daily calculations would find that 1,667 AF could be stored (838 cfs for the day converted to AF). However, if flows are really 0.0 cfs for 12 hours, only 992 AF (1,000 cfs diverted down the Phelps County Canal for 12 hours) could actually be stored. This would result in daily modeling overestimating the project score.

Daily and hourly modeling (Method A and B) from mid-1996 through 2008 was completed for Phelps County Canal capacities of 1,000 cfs (current capacity), 1,400 cfs (design capacity) and 1,675 cfs (the optimal J-2 hydropower generating rate). **Table 3** shows annual and average excesses in CNPPID's system, excesses limited by remaining Phelps County Canal capacity (canal capacity minus historical diversions), and water stored in the reservoir. The same excess flows and shortages at Grand Island were used for daily and hourly analyses. Excess flows in CNPPID's system we slightly less (4%) for Option A modeling, but still well above what was stored in the reservoir. **Table 4** shows excesses released from the reservoir and reductions to shortages at Grand Island (or "yield").

The reductions to shortages to target flows in **Table 4**, are useful in evaluating if daily calculations over-estimate the target flow yield. For a Phelps County Canal capacity of 1,000 cfs, hourly Method A resulted in an average annual yield 12% lower than the yield using daily calculations. Hourly Method B average annual yield was only 4% lower. For Phelps County Canal capacities of 1,400 cfs and 1,675 cfs, hourly Method A resulted in an average annual yield 10% lower than the yield using daily calculations. Hourly Method B average annual yields were very similar to daily calculations yields for these canal capacities. It is also noticeable that the annual differences between hourly and daily yields appear to be dependent on the year type, with greater differences in dry years. This analysis is heavily weighted towards dry years.

This analysis shows that, daily calculations may or may not be over-estimating target flow operations and that the ability of modeling assumptions to represent actual operational decisions may have an impact on resolving this question. If hourly Method B, or a combination of the hourly methods, is similar to how real time operations may occur, then daily calculations are likely not significantly over-estimating the yield.

The ED Office requests CNPPID and the Workgroup to consider how real-time operations of a J-2 Reservoir would work for target flow operations. Daily average flow data would not yet be available so would the real-time Grand Island flow be compared to the target flow and any flow in CNPPID's system above the real-time Grand Island excess be available to be stored in the reservoir (similar to hourly Method A)? Alternatively, if CNPPID's knows how many hours they will be hydrocycling on a given day then excess flows at Grand Island could be estimated and a daily volume up to this value diverted to the reservoir, similar to hour Method B. Models often assume perfect knowledge with data that would not be available in real time. Calculations have moved from monthly (OPStudy) to daily (for preliminary project scoring) to hourly (for design feasibility). The appropriate level of consideration for different purposes (project scoring versus design and implementation) should be discussed with the Workgroup. The ED Office will update this analysis once input has been received.

Table 3: Excess Flows Stored and Released for Various Phelps County Canal Capacities and Daily and Hourly Calculations (all units are acre-feet unless specified)

Year	Year Type	Excess Flows at Grand Island		Shortages at Grand Island		Excesses in CNPPID's System		Excesses Available to Phelps County Canal						Excesses Stored in J-2 Reservoir								
								1000 cfs capacity		1400 cfs capacity		1675 cfs capacity		1000 cfs capacity			1400 cfs capacity			1675 cfs capacity		
														Hourly Calcs			Hourly Calcs			Hourly Calcs		
		Hourly Calcs	Daily Calcs	Hourly Calcs	Daily Calcs	Hourly Calcs Method A**	Daily Calcs	Hourly Calcs Method A**	Daily Calcs	Hourly Calcs Method A**	Daily Calcs	Hourly Calcs Method A**	Daily Calcs	Method A	Method B	Daily Calcs	Method A	Method B	Daily Calcs	Method A	Method B	Daily Calcs
1996*	Wet	377202	377202	22654	22654	305871	312875	221379	228796	281656	290691	302260	309365	31082	31082	31082	31082	31082	31082	31082	31082	31082
1997	Wet	720110	720110	193697	193697	440031	441848	311063	314261	390161	393250	426339	428691	50007	50251	50895	50590	50895	50895	50590	50895	50895
1998	Wet	666892	666892	130947	130947	524171	525421	356017	357428	468345	470123	509075	510609	69773	69637	69845	72609	72609	72609	72609	72609	72609
1999	Wet	1054131	1054131	93681	93681	618487	619044	395747	398476	528662	531104	596268	597770	39593	39717	39729	39593	39717	39729	39593	39717	39729
2000	Wet	228955	228955	399971	399971	204341	207920	141700	146292	175073	179118	193754	197675	46934	48435	48953	49488	51142	51535	49674	51470	51715
2001	Normal	94474	94474	498003	498003	73935	94000	72434	92498	73935	94000	73935	94000	61614	69786	71112	63115	72084	71976	63115	72062	71976
2002	Dry	57942	57942	433521	433521	31436	55100	31436	55100	31436	55100	31436	55100	14014	12900	13224	14014	13191	13224	14014	13214	13224
2003	Dry	20589	20589	494234	494234	4643	16113	4643	16113	4643	16113	4643	16113	4643	14198	16113	4643	15747	16113	4643	16025	16113
2004	Dry	4915	4915	570539	570539	1157	3771	1157	3771	1157	3771	1157	3771	1157	3771	3771	1157	3771	3771	1157	3771	3771
2005	Dry	56528	56528	475530	475530	15234	20453	13509	19927	14792	20453	15220	20453	13509	18543	19927	14792	19961	20453	15219	20389	20453
2006	Dry	9144	9144	527643	527643	2065	4198	2065	4198	2065	4198	2065	4198	2065	4173	4198	2065	4173	4198	2065	4173	4198
2007	Dry	192314	192314	173592	173592	80452	101300	63609	97365	75152	101300	80116	101300	30497	35184	39632	32995	38629	39632	34260	39632	39632
2008	Normal	192538	192538	547055	547055	28835	35484	23782	35128	26973	35484	28731	35484	23782	27172	35128	26973	32680	35484	28730	35346	35484
AVERAGE		282749	282749	350851	350851	179281	187502	126042	136104	159542	168824	174231	182656	29898	32681	34124	31009	34283	34669	31289	34645	34683
% Difference from Daily		0%		0%		4%		7%		5%		5%		12%	4%		11%	1%		10%	0%	

*Partial year. 1996 data starts on June 17.

** This variable is not applicable for Hourly Calculation Method B and was not used in calculations.

Table 4: Excess Flows Stored and Released for Various Phelps County Canal Capacities and Daily and Hourly Calculations (all units are acre-feet unless specified)

		J-2 Reservoir Releases									J-2 Reservoir Reductions to Shortages to Target Flows								
		1000 cfs capacity			1400 cfs capacity			1675 cfs capacity			1000 cfs capacity			1400 cfs capacity			1675 cfs capacity		
		Hourly Calcs			Hourly Calcs			Hourly Calcs			Hourly Calcs			Hourly Calcs			Hourly Calcs		
Year	**Year Type**	**Method A**	**Method B**	**Daily Calcs**	**Method A**	**Method B**	**Daily Calcs**	**Method A**	**Method B**	**Daily Calcs**	**Method A**	**Method B**	**Daily Calcs**	**Method A**	**Method B**	**Daily Calcs**	**Method A**	**Method B**	**Daily Calcs**
1996*	Wet	16762	16762	16762	16762	16762	16762	16762	16762	16762	15371	15371	15371	15371	15371	15371	15371	15371	15371
1997	Wet	50007	50251	50895	50590	50895	50895	50590	50895	50895	47637	47875	48494	48198	48494	48494	48198	48494	48494
1998	Wet	69773	69637	69845	72609	72609	72609	72609	72609	72609	65596	65466	65666	68324	68324	68324	68324	68324	68324
1999	Wet	39593	39717	39729	39593	39717	39729	39593	39717	39729	37558	37680	37691	37558	37680	37691	37558	37680	37691
2000	Wet	61254	62288	62443	63808	64809	65025	63994	65046	65205	58499	59440	59590	60956	61865	62073	61131	62093	62239
2001	Normal	51744	56270	57959	53244	58755	58823	53244	58823	58823	46348	50548	52085	47771	52845	52905	47771	52905	52905
2002	Dry	23466	25853	26017	23466	25984	26017	23466	26006	26017	21620	23651	23806	21620	23775	23806	21620	23796	23806
2003	Dry	5062	13835	15555	5062	15379	15555	5062	15552	15555	4472	12366	13932	4472	13770	13932	4472	13929	13932
2004	Dry	1157	5163	5519	1157	5328	5519	1157	5434	5519	975	4458	4760	975	4598	4760	975	4688	4760
2005	Dry	12009	15132	16515	13292	16550	17042	13720	16977	17042	7268	9682	10846	8141	10628	11062	8542	11029	11062
2006	Dry	3115	6929	6942	3115	6929	6942	3115	6929	6942	2642	6115	6126	2642	6115	6126	2642	6115	6126
2007	Dry	29445	31241	35693	31944	34680	35693	33208	35682	35693	17170	18736	22957	19540	21997	22957	20739	22948	22957
2008	Normal	25283	31772	39733	28474	37285	40089	30232	39952	40089	22018	27757	34573	24781	32489	34869	26311	34753	34869
AVERAGE		29898	32681	34124	31009	34283	34669	31289	34645	34683	26706	29165	30454	27719	30612	30952	27973	30933	30964
% Difference from Daily		12%	4%		11%	1%		10%	0%		12%	4%		10%	1%		10%	0%	

*Partial Year. 1996 data starts on June 17.

Impact of Phelps County Canal Capacity on Project Yield

Modeling results presented in **Tables 3** and **4** show that the capacity of the Phelps County Canal has a small impact on the project yield. Comparing the reductions to shortages to target flows in **Table 4** using daily calculations shows average annual results were only slightly different for the various canal capacities: 30,454 AF for the 1,000 cfs capacity, 30,952 AF for the 1,400 cfs, and 30,964 AF for the 1,675 cfs capacity. Differences for hourly modeling were also small, ranging from 26,706 AF for the 1,000 cfs capacity canal to 27,973 AF for the 1,675 cfs for Method A and 29,165 AF for the 1,000 cfs capacity to 30,933 AF for the 1,675 cfs capacity for Method B.

The ED Office reviewed the current 1,000 cfs and 1,400 cfs design capacity results in more detail to better understand why the canal capacity didn't have a larger impact. Several things appear to be occurring:

- Frequently total shortages to target flows are less than the volume in storage, as modeled for both the 1,000 cfs and 1,400 cfs Phelps County Canal capacities. Even though there may be more water stored when the canal capacity is 1,400 cfs, both canal capacities result in the same water released from storage and reductions to shortages to target flows;
- Excesses available in CNPPID's system are often below 1,000 cfs so the lower canal capacity isn't a limiting factor during these times (see **Figures 1** and **2**); and
- Also, though the reservoir may fill more quickly with a canal capacity of 1,400 cfs, there are often prolonged periods of excesses when the reservoir fills to the same volume, just more slowly over subsequent days with the 1,000 cfs canal capacity.

Figures 1 and **2** show the percent of days and hours of excess flows, respectively, when excess flows in CNPPID's system were in the stated range. The vast majority of excess flows available were 1,000 cfs of less. **Table 3** shows that that of the excess flows in CNPPID's system, on average less than 19% were stored in the reservoir each year using daily calculations and less than 18% was stored each year using hourly calculations Method A. **This analysis shows that the Phelps County Canal capacity does not have large impact on target flow yields. If the reservoir is also used for hydrocycling mitigation, this may change depending on project configuration and operational assumptions.**

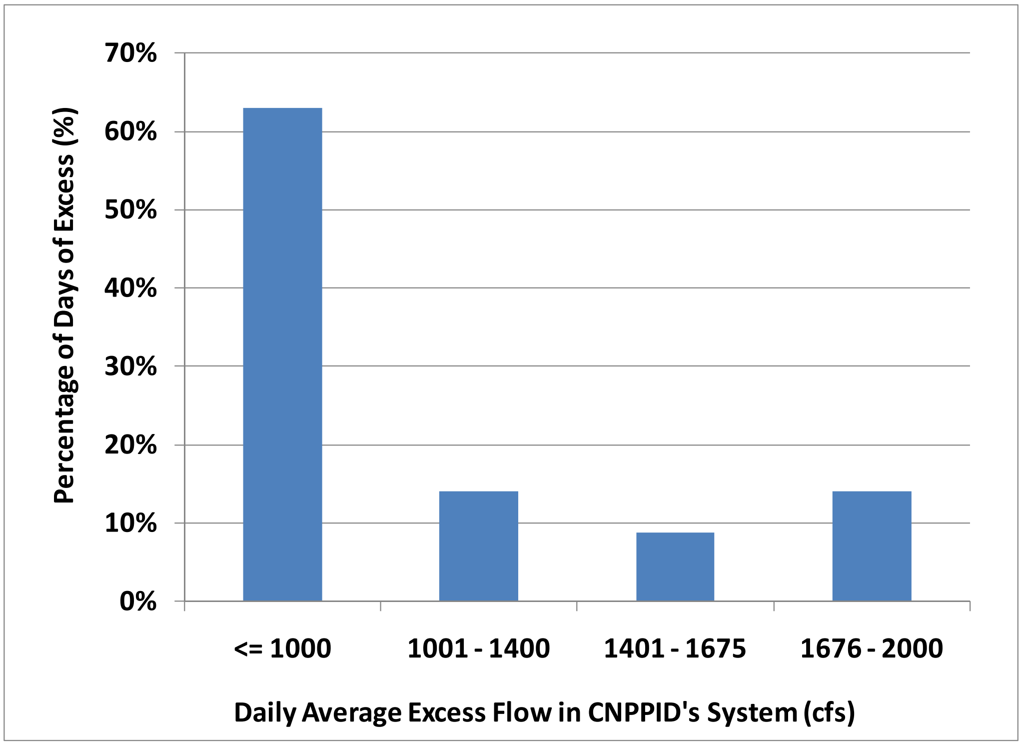


Figure 1: Percentage of Days of Excess when Average Daily Excess Flows in CNPPID's System were in the Stated Range

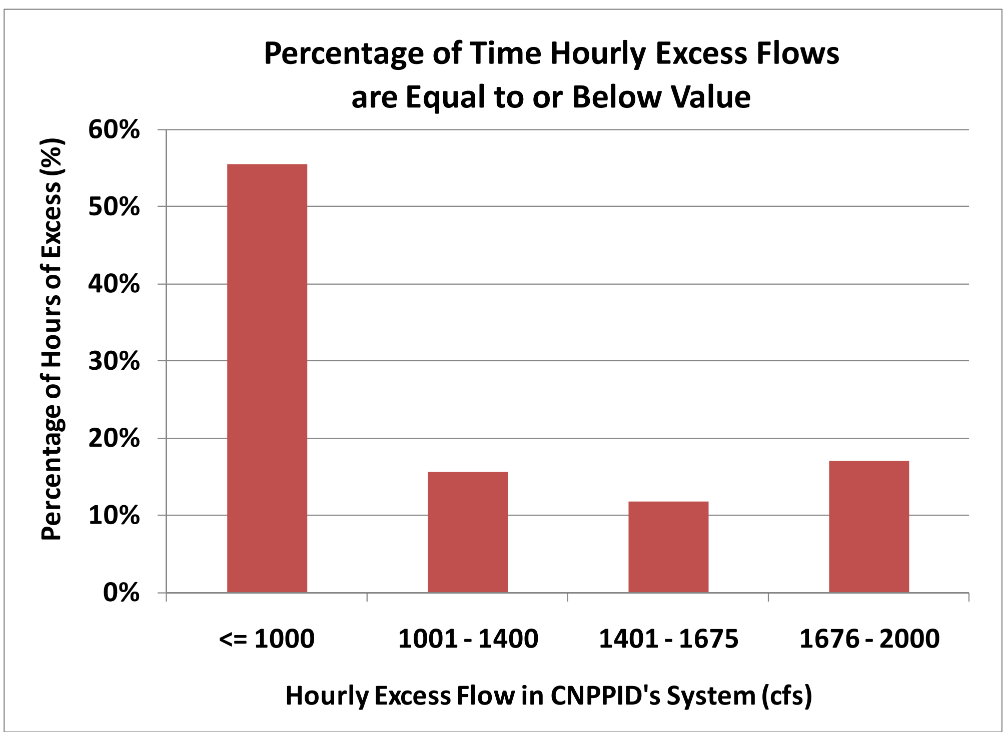


Figure 2: Percentage of Hours of Excess when Hourly Excess Flows in CNPPID's System were in the Stated Range

Impact of Historical 1995 through 2008 Period on Yield

At their June 2010 meeting, the Governance Committee determined that 1947 – 1994 OPStudy hydrology should be used for WAP project scoring. However, members of the WAC have expressed interest in the impact of the recent prolonged dry period (2002 through 2007) on potential project yields. Results were presented at the August 10 workgroup meeting and an additional request made to the ED Office to look at yields for the 1995 – 2008 period, primarily for informational purposes.

Figure 3 shows the average annual target flow yields for the J-2 Reservoir, using OPStudy and historical hydrology with a daily model. Note that this model uses the average daily reported gage flows, rather than the daily average flows calculated from hourly data which was used to develop the results presented earlier in this memo. Historical results are presented for the full period and also are broken down into the OPStudy 1947 – 1994 period and the post-OPStudy 1995 – 2008 period. Only one simulation was run, from 1947 through 2008. Annual data from this run was then averaged for the periods presented.

Using historical data for the 1947 – 2008 resulted in average annual Grand Island shortage reductions of 37,500 AF as compared to shortage reductions of 41,700 AF using OPStudy hydrology. This was a decrease in project yield of 4,200 AF. Looking at historical results for only the 1947 – 1994 period only (the OPStudy period) slightly increased the average historical yields by an additional 800 AF to 38,300 AF as compared to historical yields for the entire 1947 – 2008 period. The average annual yield for the later historical period (1995 – 2008) was lower, at 34,900 AF. These result illustrate the impact of the recent dry period.

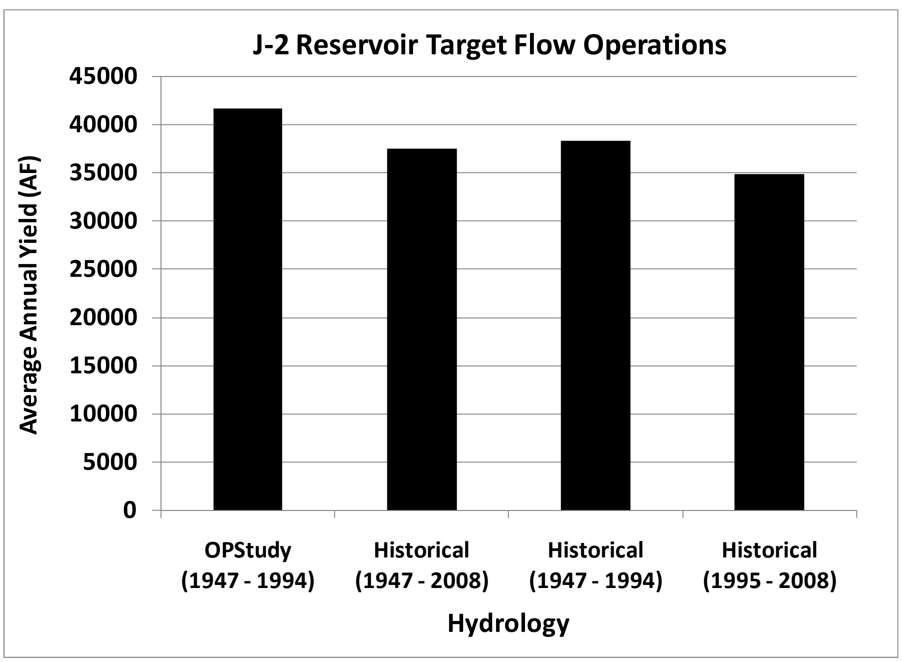


Figure 3: J-2 Reservoir Target Flow Operations Hydrology and Modeling Period Impacts on Project Yield

OLSSON ASSOCIATES

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☒	Other: e-mail_____

TO:	Beorn Courtney
FROM:	Eric Dove
RE:	CNPPID J-2 Reregulation Reservoir J-2 Hydropower Raw Data Corrections
DATE:	9/10/2010
PROJECT #:	B09-1466
PHASE:	Investigation of Reservoir Combined Operations

Raw Data Summary

The J-2 hydropower plant operated by CNPPID adjusts the flow rate and duration of power production based on the volume of water available within their infrastructure system. The adjustments are recorded by CNPPID at hourly time steps. The hourly values are then tallied into a cumulative daily total.

J-2 hydropower plant hourly release data was obtained from CNPPID on 7/14/10 based on the accumulator readings for the entire hourly period of record (6/17/96 thru 7/14/10). The accumulator readings indicate the cumulative acre-feet of water passed through the power plant, and is recorded at an hourly time step.

The provided raw data was screened for outliers and missing data. A substantial amount of both existed within the data set. Many of the outliers were associated with the accumulator being reset to zero. It was assumed the accumulator was reset to zero after the last hour of generation so no flow volume was “lost” during the reset. Periodic erroneous accumulator readings were also present. Missing data was filled in two different manners depending on the duration of the missing values. Missing data for limited numbers of hours were filled in by linear interpolation using the pre and post accumulator readings. Complete missing days were filled by using the reported daily flow volume and a flow rate of 1,675 cfs (see meeting minutes dated 6/24/10), until the daily volume was exhausted. The operation time was set to end at midnight and the start was adjusted based on the reported daily volume available. If the daily volume was greater than 1,675 cfs average flow rate, then the calculated average flow rate was used for the entire day.

An additional screening step was to compare the calculated daily flow volume to the reported volume. For departures greater than 100 cfs, average daily flow was investigated further to determine if the departure was an accumulator reporting error. If no apparent error in the accumulator readings existed then the flow was unchanged. An additional revision was made to accumulator readings to limit the peak hourly flow to 2,000 cfs in accordance with CNPPID recommendations. The adjusted raw data set was provided to PRRIP staff and the filled in data was highlighted in red. The average error between the reported daily values and the calculated daily values from the hourly data set was 9 cfs.

Synthetic J2 Return Data Analysis

Overview

This synthetic data set was constructed for use in O&A models for testing the abilities to mitigate hydrocycling. Historically CNPPID did not operate to smooth out the river. J2 operations and return flows were erratic with no distinct trend or preferred mode of operation. Using historic data to test the mitigation of hydrocycling was difficult. The synthetic data set was developed to show a smoother J2 operation that CNPPID would be able to accomplish if it would assist in mitigating hydrocycling.

Synthetic Data Development

The development of the data started at the diversion dam at North Platte. The patterns of the flows at the diversion will most likely not change from historic operations. The daily diversions were then routed through CNPPID's system removing any irrigation deliveries, losses and returns to the river. A 300 cfs loss was issued to the water as it moves through the system. A two day lag time was given to the diversion dam flows before they were returned at the J2 Return.

Calibrating

In the spreadsheet analysis of the synthetic data, each year actual J2 return flows and the synthetic flows were plotted to determine the accuracy of the synthetic data set. Looking through each year it is evident that losses throughout the system change. For some years it appears that 300 cfs of loss is not enough loss (1998-2000) and in others it is too much loss (winter of 2005). A pattern that seems to match the data sets is to increase the losses during the wet years and lower them during the dry years.

Centrals cycling mode of operations are also visible in the charts in the non-irrigation months compared to the smoother operations of the synthetic data. During the years of the drought the synthetic data shows J2 return flows during the irrigation season. This was not the case as the mode of operation was to not return any water back to the river at J2. CNPPID used regulation space within the system to hold that water for future use.

It appears that in wet year, large flows, the synthetic data is pretty close to the actual J2 data. This makes sense due to the fact that during large flows there is less need to hydrocycle and operations are smoother.

Outages and regulation activities are also visible in the data comparison. For example, during the drought CNPPID would lower Johnson Lake at the end of the irrigation season and refill it in August. These operations are visible in 2004 through 2007. J2 outages can also be seen in the fall of 2002, 2003 and 2007.

Conclusion

The synthetic data looks like a good option for use in the model for the non irrigation season (September 1st through March 31st). Actual J2 data should be used for the irrigation season (April 1 through August 31st). Losses could also be adjusted if desired for the non irrigation months based on diversion amounts at the diversion dam.

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☒	Other: email

TO:	Beorn Courtney, Cory Steinke
CC:	Eric Dove, Mike Yost, File
FROM:	Deb Ohlinger
RE:	Hourly J-2 Synthetic Data Development
DATE:	Original date February 19, 2011. Revised February 28, 2011 with revised synthetic data. Revised March 21, 2011 with discussion of historic data development.
PROJECT #:	B09-1466

J-2 Hydropower Plant Hourly Flow Raw Data

Daily flows, shortages to target flows and excess flow calculations were previously prepared by the ED Office for both historic gage data and OPSTUDY revised gage data. The J-2 hydropower plant operated by CNPPID adjusts the flow rate and duration of power production based on the volume of water available within their infrastructure system. The adjustments are recorded by CNPPID at hourly time steps. The hourly values are then tallied into a cumulative daily total. If the daily cumulative total is divided by 24 hours to develop an average daily flow rate, several errors develop. Average daily data would tend to underestimate the peak flow and overestimate the minimum flow from the hydropower plant. Likewise, average daily data would overestimate the amount of time hydropower generation occurred. For modeling of hydropower mitigation and target flow combined operations, hourly time step data were required. On June 24, 2010, prior to modeling, a conference call was held with CNPPID, ED Office and Olsson. During this call, it was decided to use historic hourly data. Meeting notes from the call are included in Appendix B.

A CNPPID Reregulating Reservoir Workgroup meeting was held on August 10, 2010 to discuss the modeling. Questions regarding the conversion from daily excesses and target flows to the use of hourly data arose from the workgroup meeting and were documented in a memorandum dated September 17, 2010 and issued by the ED Office. The memorandum is included in Appendix B.

Modification of Hourly Flow Raw Data

J-2 hydropower plant hourly release data was obtained from CNPPID on July 14, 2010 based on the accumulator readings for the entire hourly period of record (June 17, 1996 through July 14, 2010). The provided raw data was corrected for outliers and missing data. Following the corrections, the average error between the reported daily values and the calculated daily values from the hourly data set was 9 cfs. A more complete discussion of the raw data corrections are discussed in the September 10, 2010 memorandum in Appendix B.

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Comparison of Historic Data to Preferred Operations

The corrected hourly data set was compared to the hydropower operating preferences that were discussed during the June 24, 2010 conference call. The preferred operation pattern that was discussed would be to operate the hydropower plant at 1,675 cfs whenever power is being generated, except during irrigation season. If adequate water is not available to operate the entire day at 1,675 cfs, the preference is to utilize the available water to operate the plant toward the end of the day at the full 1,675 cfs flow rate for as long as the available water will allow. Following review of the raw data, it was discussed that during irrigation season the hydropower plant would be operated for a full 24-hour period equal to the Phelps Canal irrigation demand if water was not being returned to the Platte River.

The historic data set did not show a clear trend toward a uniform J-2 flow rate of 1,675 cfs with a variable duration. For example, in December of 2009, outside of irrigation season, there were 12 days that the plant operated near 450 cfs for the entire day, after which, the plant operated between 1,100 cfs to 1,040 cfs for the remainder of the month. An example day during the irrigation season, July 11, 1996, showed only 580 cfs for several hours during the early morning, followed by an increase to 1,500 cfs later in the day. A uniform rate was not held even during the irrigation season. The hourly historic data highlighted the variability in the system operations due to multiple constraints such as limited volume of water availability, variability of Platte River flows in response to runoff, equipment limitations, irrigation demand, icing concerns, and system storage upstream of the power plant.

Development of J-2 Synthetic Data

During a conference call held January 11, 2011 between the Executive Director's (ED) office, Central Nebraska Public Power and Irrigation District (CNPPID), and Olsson Associates (Olsson), it was decided that a data set reflecting CNPPID's preferred operation should be developed for the non-irrigation season, September through the end of March, as canal operations such as maintenance are considered to begin April 1st. Historic data during the non-irrigation did not reflect CNPPID's preferred future operations. The 1996 through 2008 historic data will be used for the irrigation season. The historic data was developed during previous modeling efforts. Cory Steinke was tasked with providing daily volumes and flows that would represent preferred, future operations of the J-2 hydropower plant during non-irrigation season. This data, in the form of average daily flows, along with a written description explaining how the data was developed, was provided to Olsson and the ED office on January 13, 2011. The data set was provided for June 17, 1996 through January 9, 2011. Graphs of daily flows by year provided with the data show the synthetic data flows to be more consistent than the actual flows used for comparison, but variability between days still exists.

In order to convert the daily data to hourly data, Olsson determined the total volume of water for a given day, based on the average daily flow rate provided by CNPPID. That volume was spread over the maximum number of hours that volume of water could be released at a flow rate of 1,675 cfs, CNPPID's preferred release rate for peak efficiency. Water was released between a start time determined by the number of hours 1,675 cfs could be released and midnight, when the J-2 hydro was turned off if not enough water was available to run all day. CNPPID's preference is to run the hydro in the evening. For example, if enough water was available on a particular day to run the hydro for 5 hours at 1,675 cfs, the hydro would be run between 7:00 pm and midnight on that day.

Because the volume of water available per day was not typically equivalent to a multiple of 1,675 cfs, it was necessary to make an adjustment within that day to account for the volume of water greater than or less than the volume accumulated at the 1675 cfs flow. For example, if 300 ac-ft of water were available on a given day, the J-2 hydropower plant would be run for two hours at 1,675 cfs, resulting in a total volume of approximately 277 ac-ft. The additional 23 ac-ft that was available on that day must be included in the data. In this case, a one-hour flow equivalent to 23 ac-ft would be 278 cfs, which was accounted for in the hour before the 1,675 cfs flow starts. Conversely, if the total volume was less than an equivalent multiple of 1,675 cfs, the flow was subtracted from 1,675 cfs during the first hour the hydropower plant was running.

In this memorandum, the hourly data developed by Olsson as described above will be termed simply "synthetic data." The CNPPID synthetic data denotes the data developed by CNPPID and submitted to Olsson and the ED Office. Data was developed for both the J-2 hydro and the J-2 return. Comparisons in this memorandum were made for the J-2 hydro data.

Comparison of CNPPID Synthetic Data to Program Historic Data

Comparisons were made between the CNPPID synthetic data and the Program's historic daily data on the basis of daily and monthly average flow rates and monthly volumes for June 17, 1996 through December 31, 2008. These comparisons are shown in Figures 1-3, respectively. It should be noted that the synthetic flows developed for the irrigation season, which frequently show negative values due to the method used to calculate them, were not used. Only synthetic flows during non-irrigation season were utilized in the final modeling. The two data sets appear to compare favorably to each other, when the irrigation season is disregarded.

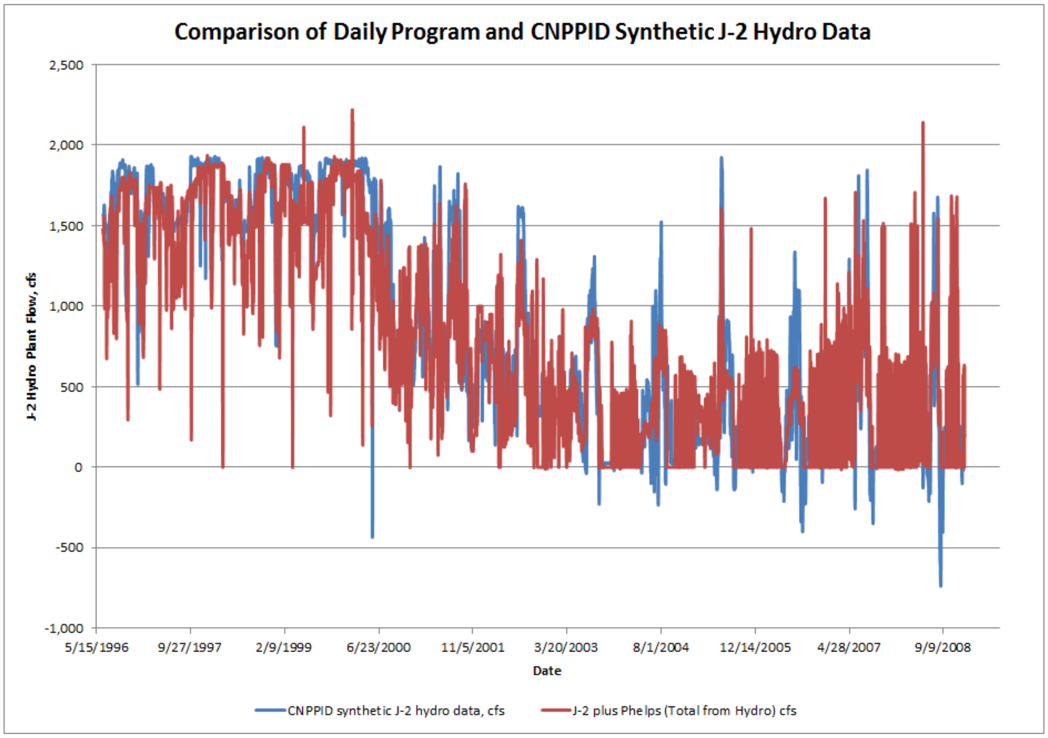

Figure 1. Average Daily Flow Comparison for Program Historic and CNPPID Synthetic J-2 Hydro Data

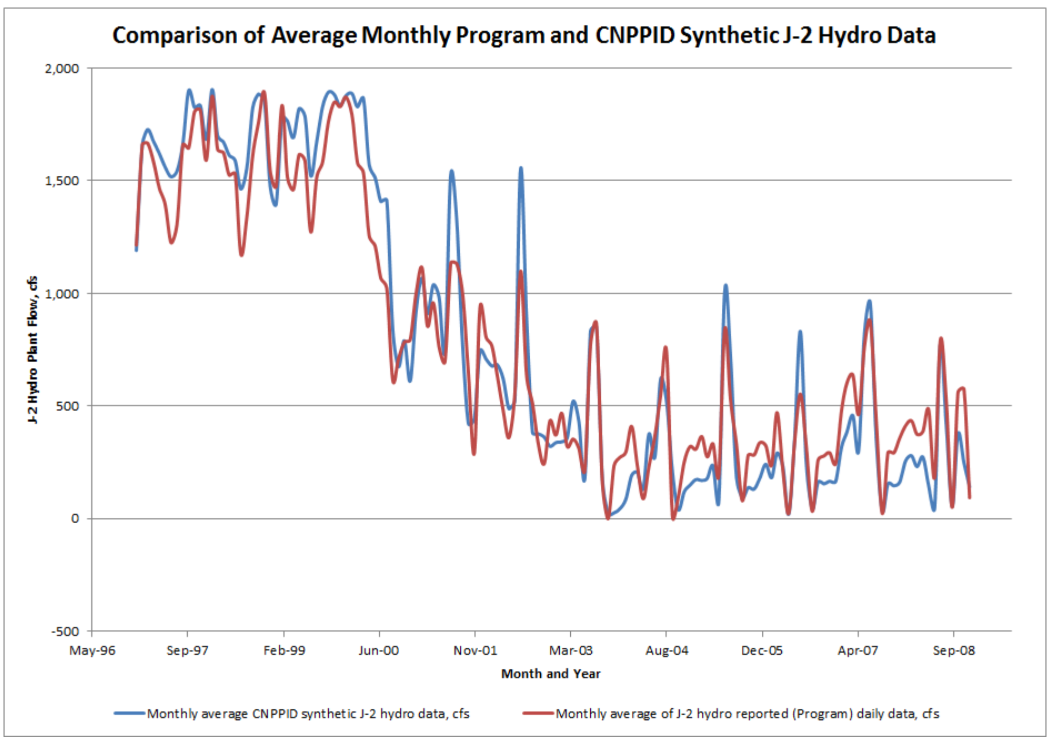

Figure 2. Average Monthly Flow Comparison for Program Historic and CNPPID Synthetic J-2 Hydro Data

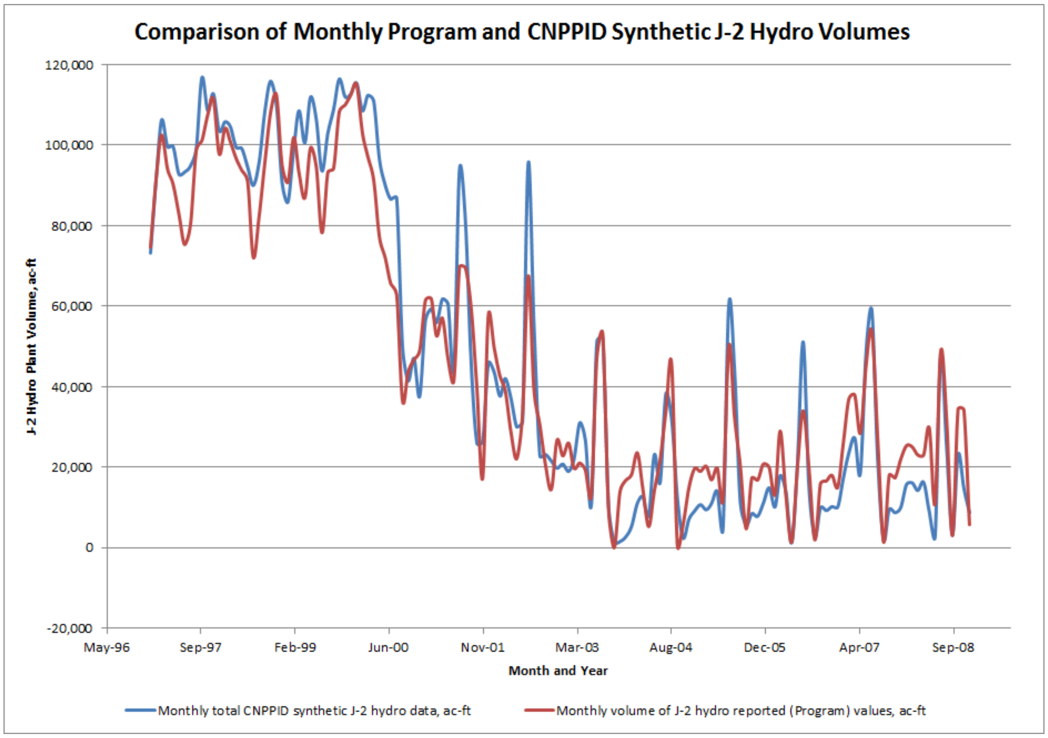

Figure 3. Monthly Volume Comparison for Program Historic and CNPPID Synthetic J-2 Hydro Data

Comparison of CNPPID Synthetic Data to Synthetic Data

Comparisons were made between the CNPPID synthetic data and the data developed by Olsson that consists of a combination of the hourly synthetic J-2 data for the non-irrigation season and the historic data for the irrigation season. The hourly synthetic data development was described above. The hourly flows were averaged to arrive at daily or monthly flows and totaled to arrive at monthly volumes. Comparisons of daily and monthly average flow rates and monthly volumes are shown in Figures 4-6, respectively. The two data sets appear to compare favorably to each other, when the irrigation season is disregarded.

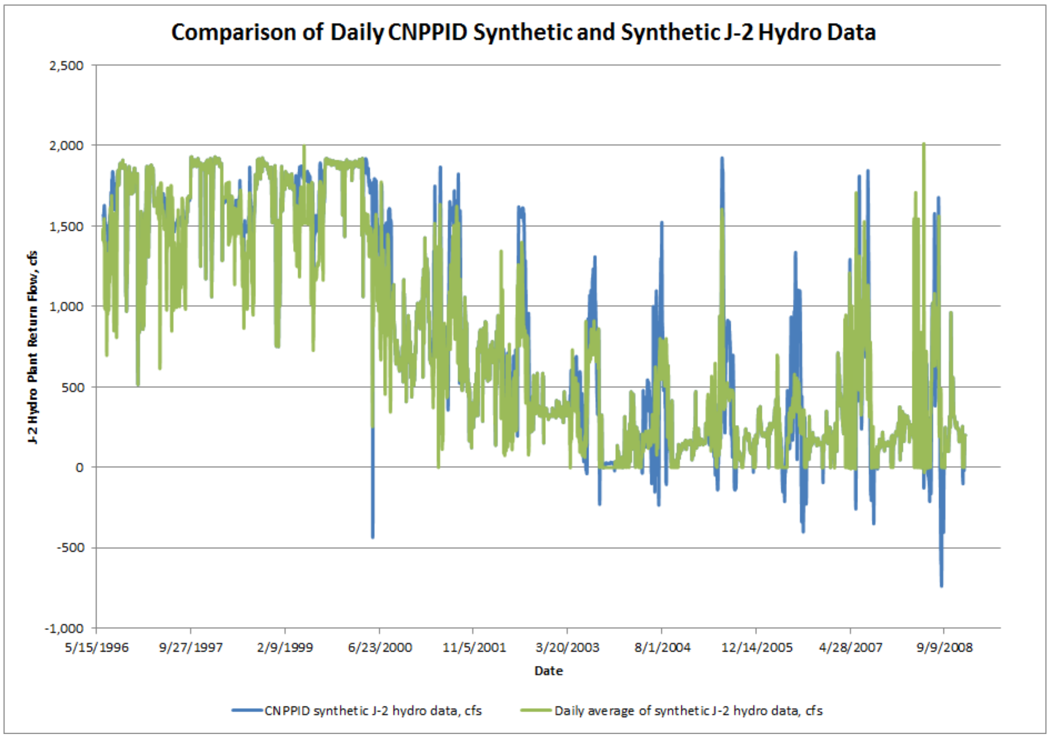

Figure 4. Average Daily Flow Comparison for CNPPID Synthetic and Synthetic J-2 Hydro Data

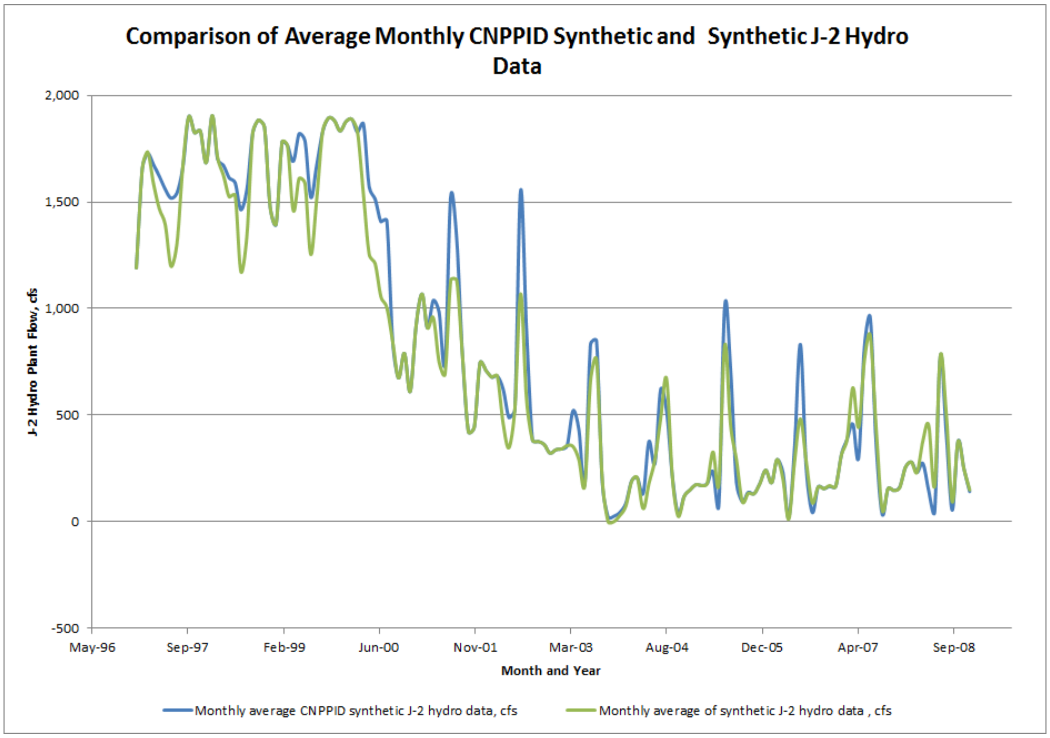

Figure 5. Average Monthly Flow Comparison for CNPPID Synthetic and Synthetic J-2 Hydro Data

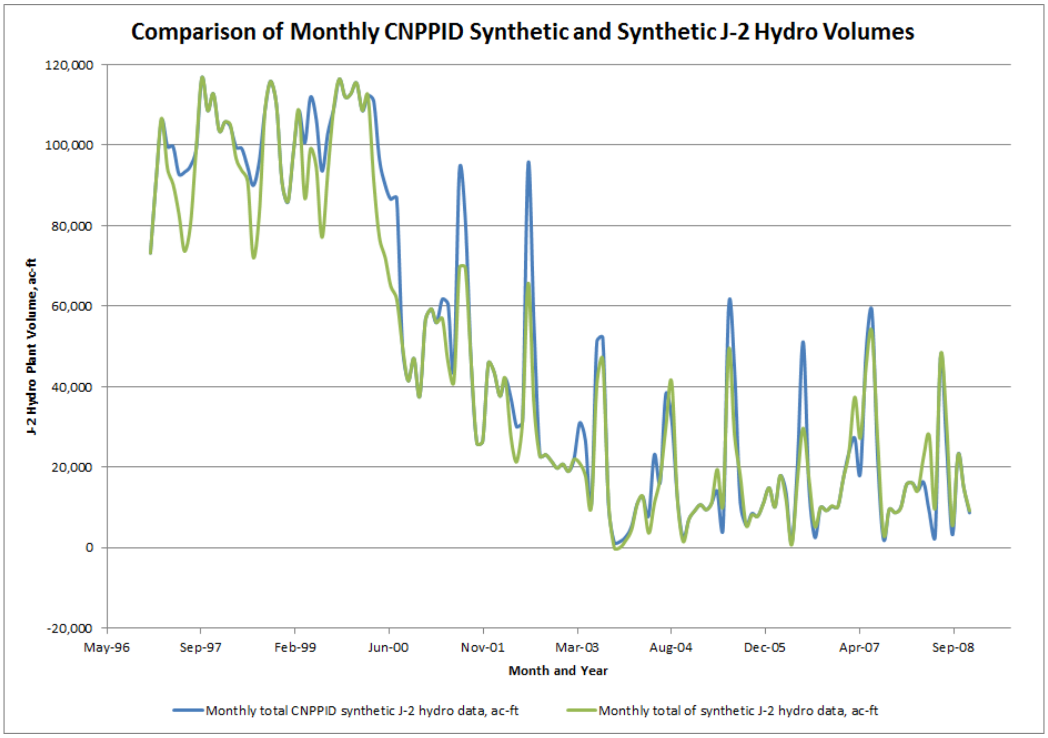

Figure 6. Monthly Volume Comparison for CNPPID Synthetic and Synthetic J-2 Hydro Data

Figure 7 shows a comparison of the annual volumes for the CNPPID synthetic and synthetic data described in this memorandum modeling. The synthetic data is typically lower than the CNPPID synthetic data. The total volume for the synthetic data over the study period is 6.1% lower than the total volume for the CNPPID synthetic data.

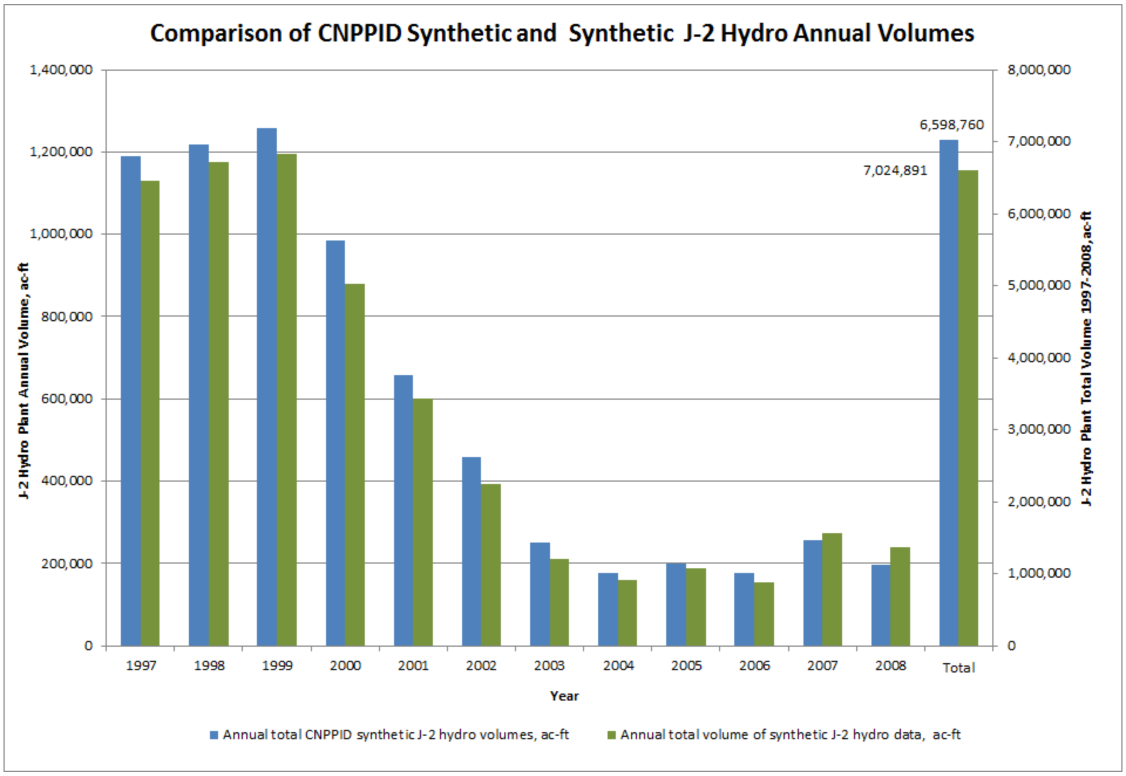

Figure 7. Comparison of Annual Volume and Total Volume for 1997-2008 for the CNPPID Synthetic and Synthetic J-2 Hydro Data Sets

Comparison of Synthetic Data to Program Historic Data

Comparisons were made between the synthetic data developed as described in this memorandum to the Program's historic daily data. The hourly flows were averaged to arrive at daily or monthly flows and totaled to arrive at monthly volumes. Comparisons of daily and monthly average flow rates and monthly volumes are shown in Figures 8-10, respectively. The two data sets appear to compare more favorably during the wet years and less favorably during the dry years.

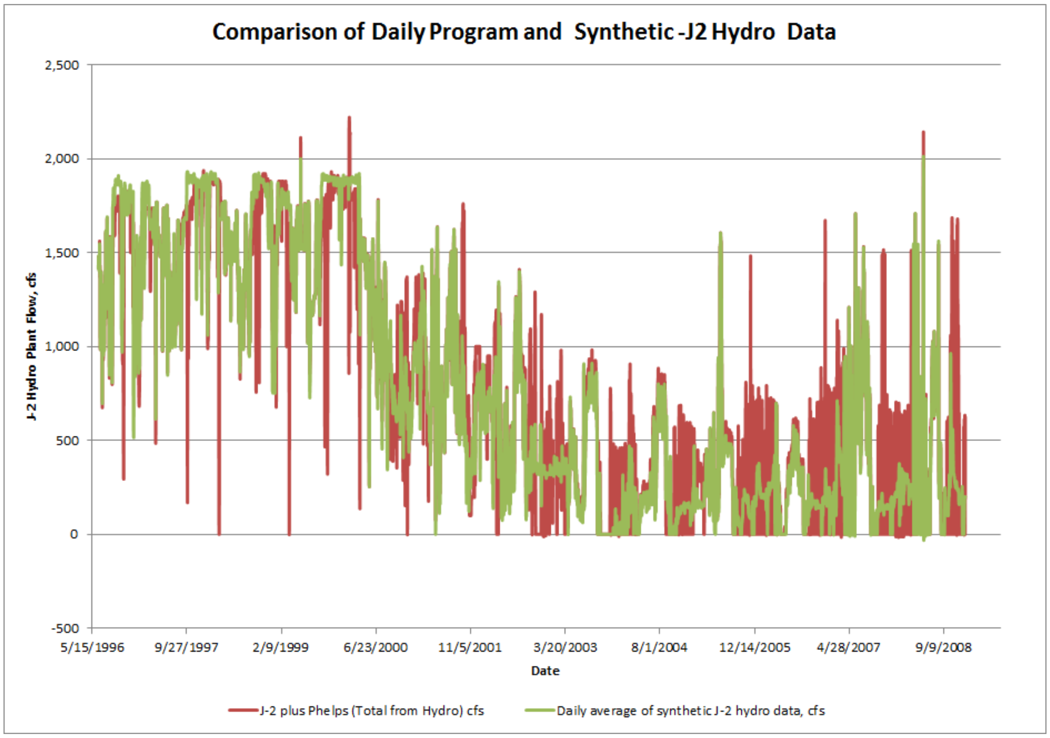

Figure 8. Average Daily Flow Comparison for Synthetic and Program Historic J-2 Hydro Data

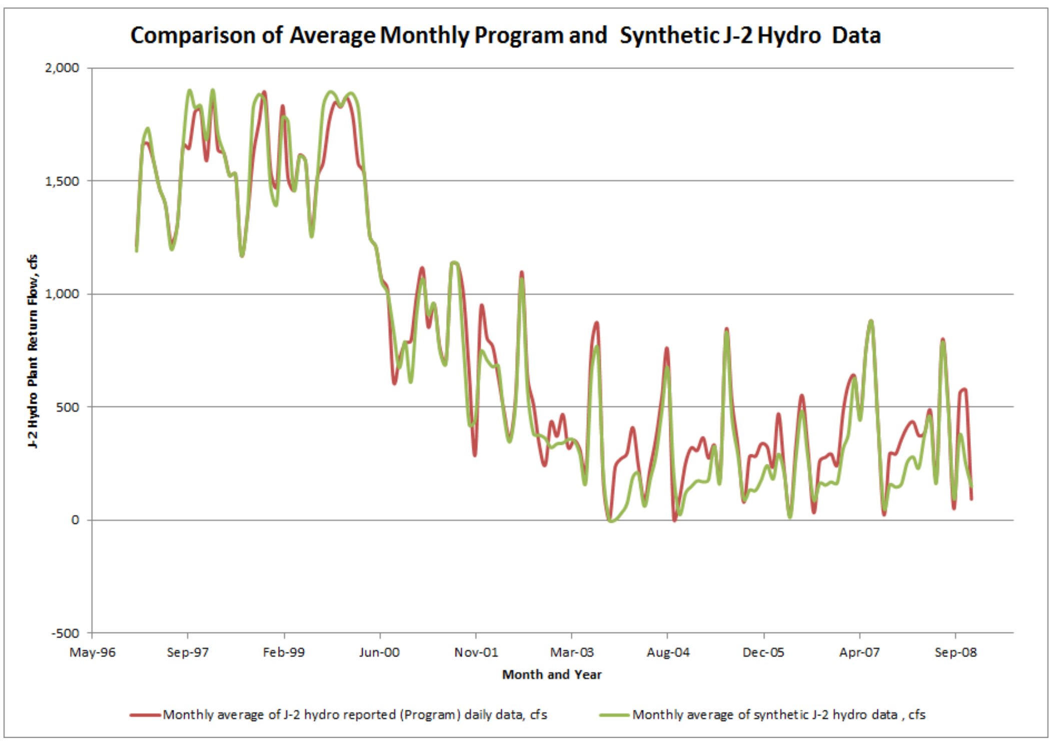

Figure 9. Average Monthly Flow Comparison for Synthetic and Program Historic J-2 Hydro Data

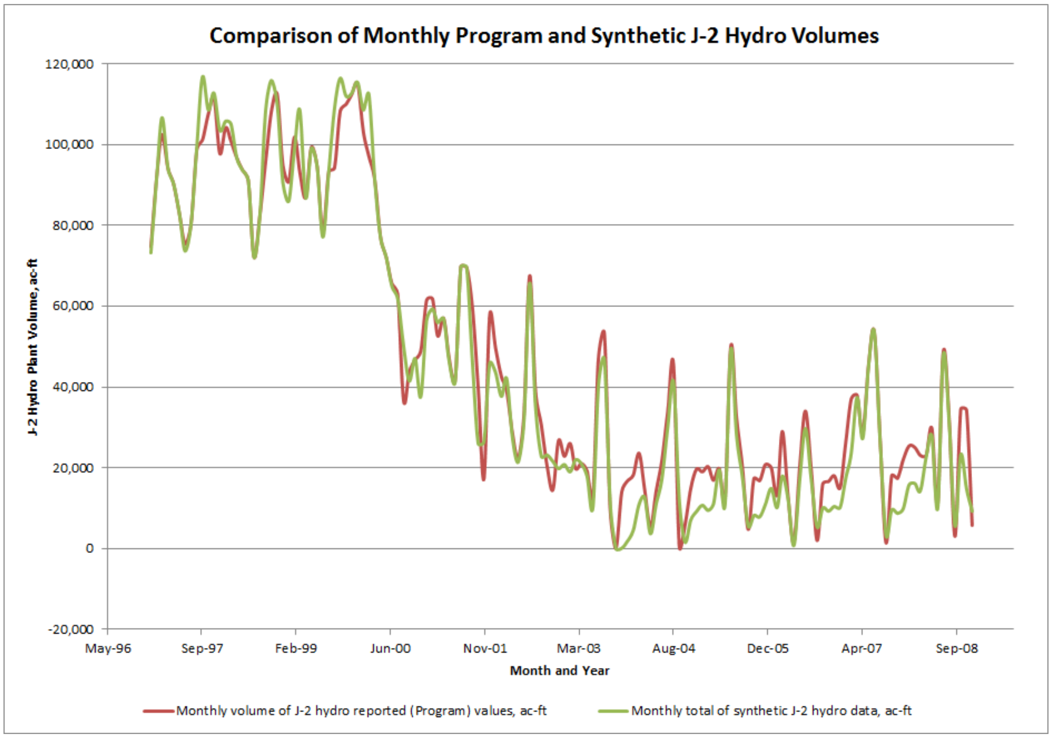

Figure 10. Monthly Volume Comparison for Synthetic and Program Historic J-2 Hydro Data

Figure 11 shows a comparison of annual volumes for the synthetic data and the Program historic J-2 data. The synthetic data annual volumes range from being 2.7% higher than the Program volumes in 1999 to 26.2% lower in 2004. The total volume of the synthetic data for the years 1997-2008 is 4.3% lower than the total volume of the Program data.

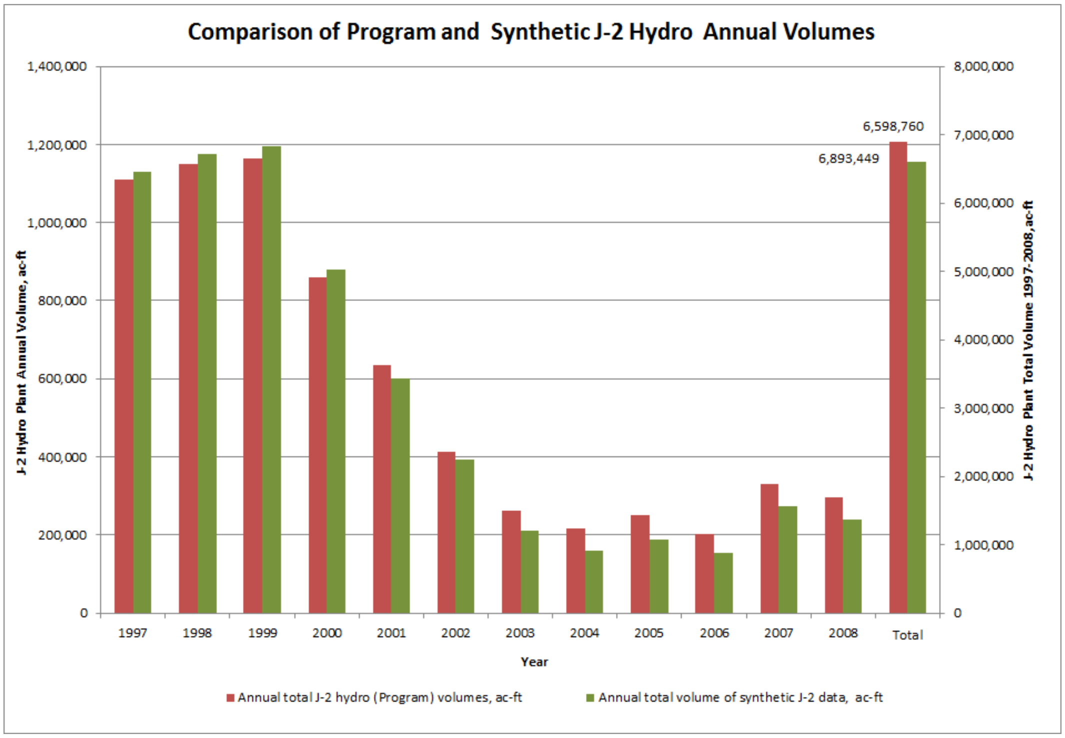

Figure 11. Comparison of Annual Volume and Total Volume for 1997-2008 for the Synthetic and Program Historic J-2 Hydro Data Sets

Comparison of Synthetic Data to Previous Historic Data

Comparisons were made between the synthetic data developed as described in this memorandum to the historic data set used for previous combined operations modeling. The hourly flows were averaged to arrive at daily or monthly flows and totaled to arrive at monthly volumes. Comparisons of daily and monthly average flow rates and monthly volumes are shown in Figures 12-14, respectively. Although it is not easily discernable in Figures 12-14, the average daily and monthly flows and volumes are the same during the irrigation season. The two data sets appear to compare particularly well during the wet years and less well during the dry years.

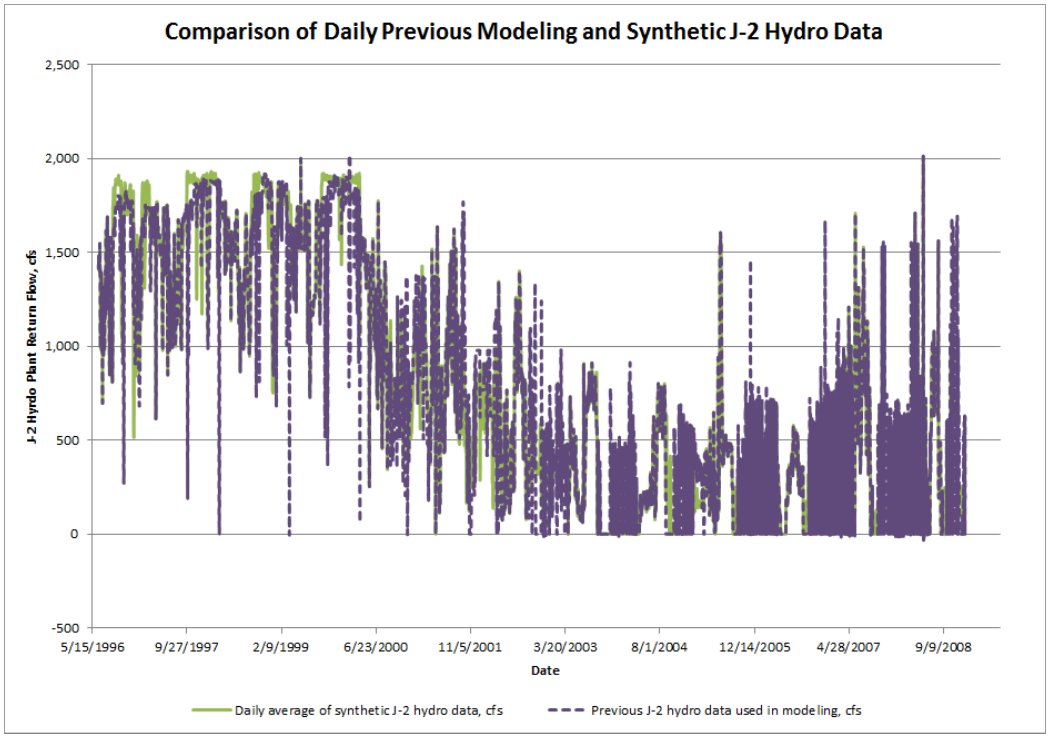

Figure 12. Average Daily Flow Comparison for Synthetic and Previous Historic J-2 Hydro Data

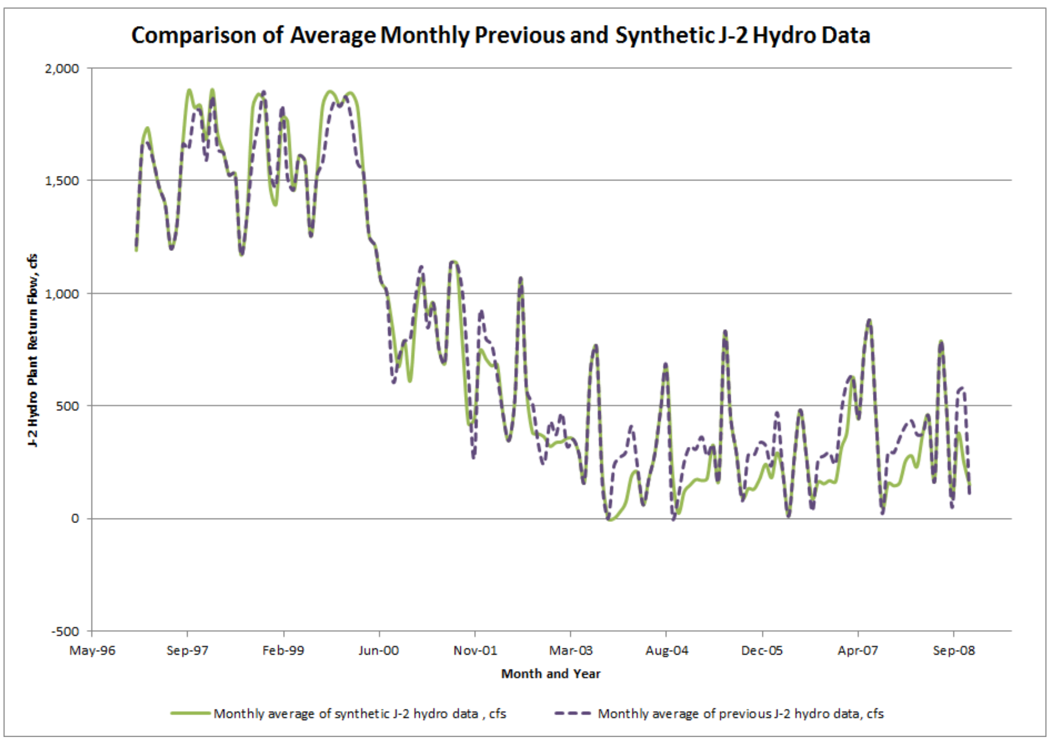

Figure 13. Average Monthly Flow Comparison for Synthetic and Previous Historic J-2 Hydro Data

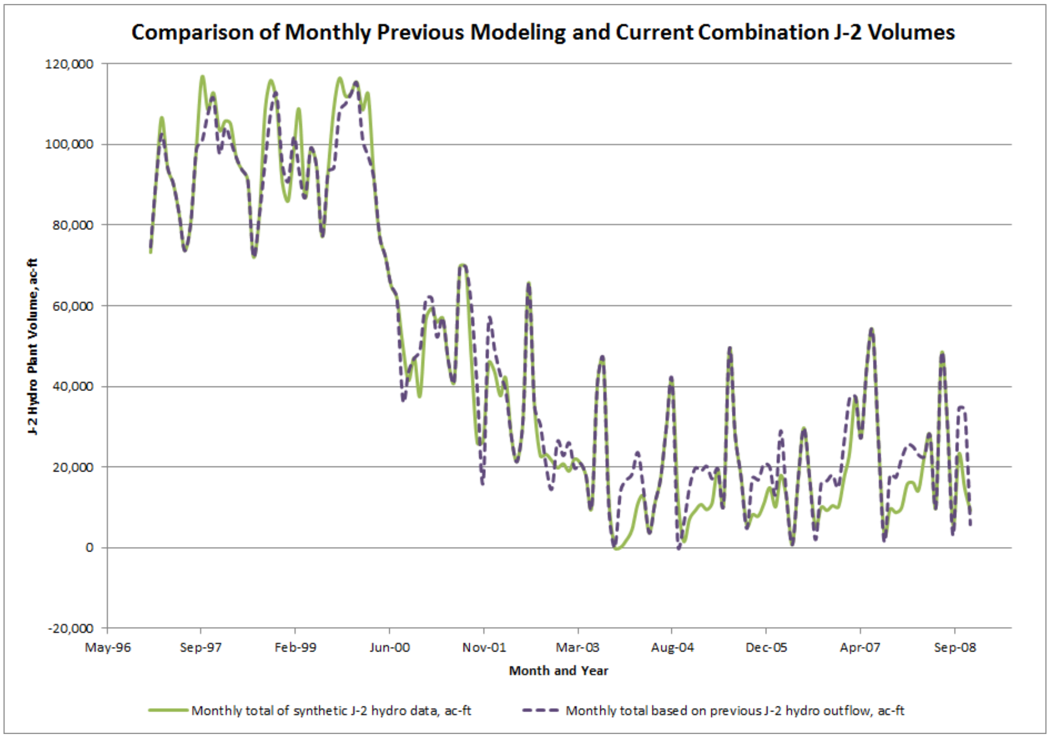

Figure 15. Monthly Volume Comparison for Synthetic and Previous Historic J-2 Hydro Data

Figure 15 shows a comparison of the annual volumes for the synthetic data described in this memorandum and the historic data used in the previous modeling. The synthetic data shows a higher annual volume for the wet years and a lower annual volume for the dry years. The total volume for the synthetic data over the study period is 3.1% lower than the total volume for the previously modeled historic data.

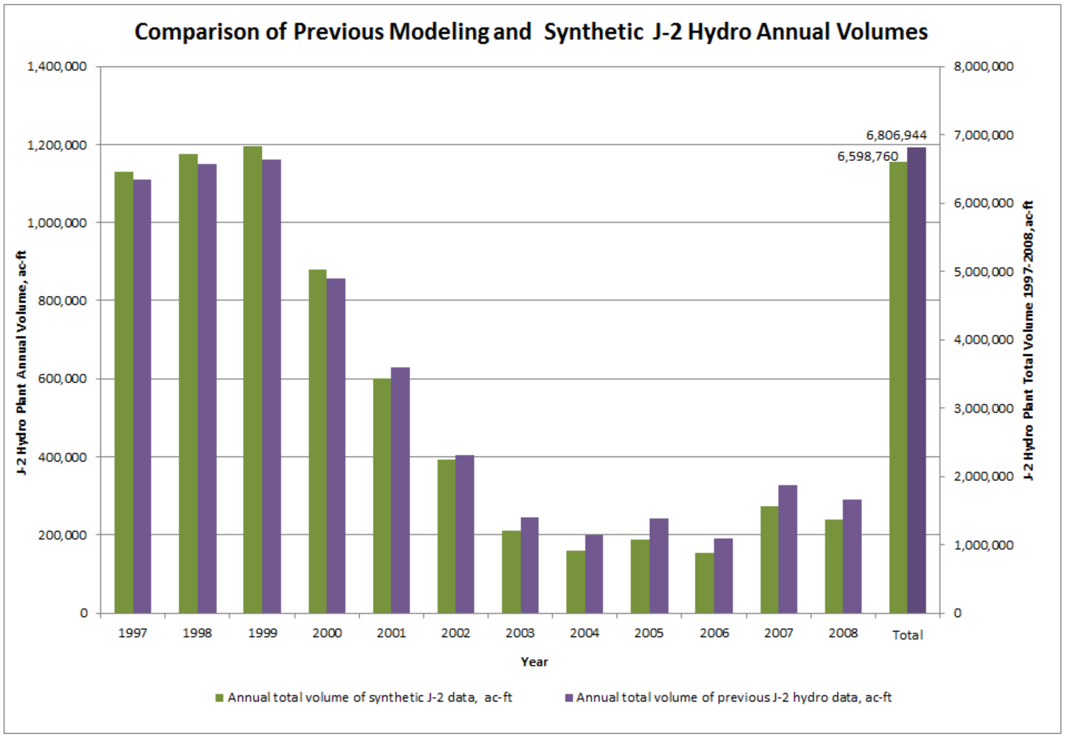

Figure 15. Comparison of Annual Volume and Total Volume for 1997-2008 for the Synthetic and Previous Historic J-2 Hydro Data Sets

Volume Comparison of Multiple Data Sets

The annual volume of water and total volume of water for the years 1997-2008 were compared for several data sets, as shown in Figure 16. Volumes derived from the accumulator at the J-2 hydropower plant minus the Phelps Canal flows were compared to the other data sets since the accumulator should represent the best data set for volumes/flows through the J-2 hydropower plant. In a given year, the data showed differences of varying magnitudes. The overall total for the study period 1997-2008 showed that the greatest difference between data sets is 8%.

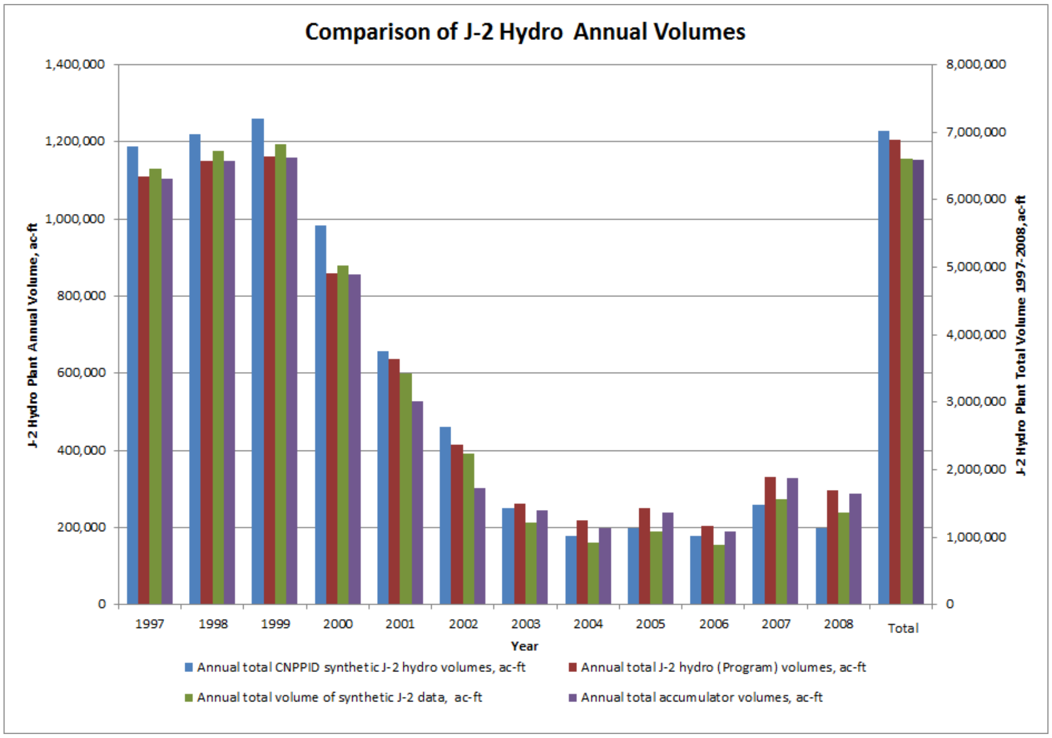

Figure 16. Comparisons of Annual Volume and Total Volume for 1997-2008 for J-2 hydro Data Sets

Conclusion

The synthetic data comprised of a combination of historic irrigation season data and synthetic J-2 data outside of the irrigation season appears to be reasonable for use in modeling CNPPID's preferred operation of the J-2 hydropower plant. Yield may be slightly overestimated in wet years and slightly underestimated in normal and dry years, as compared to the Program historic flow data.

Platte River Recovery Implementation Program
J-2 Return Reservoir Feasibility Analysis
Combined Operations for Hydrocycling Mitigation and Program Use

Conference Call Meeting Minutes
February 15, 2011, 3:00PM MST

Attendees:
Cory Steinke, CNPPID
Eric Dove, Olsson Associates
Deb Ohlinger, Olsson Associates
Kasi Rogers, Olsson Associates
Mike Yost, Olsson Associates

While this summary is not intended to represent a comprehensive account of the meeting, it is intended to reflect the key points raised and issues for further consideration and to identify the action items resulting from the discussions.

Meeting Goals:
The goal of the meeting was to obtain guidance on how CNPPID would prefer to operate on an hourly basis when water is limited. This situation happens frequently during low water years and sometimes during normal water years.

Meeting Discussion Items:

1. An example day provided prior to the call consisted of a day during which the hydro ran for twelve hours, the second half of the day. At the beginning of the day, there was not enough water stored to release at the rate needed to meet shortages for the first twelve hours. When not enough storage is available in the reservoir at the beginning of the day to meet hourly shortages before the hydro plant starts on a given day, water can:

   a. be released at the rate needed to meet the shortage for a limited time until the total volume is released, which could be only an hour or two,
   b. be released evenly at an average rate until the hydro is turned on based on the volume of water stored, or
   c. be stored without release.

   This question was not directly answered. It was decided that water must be stored to be available for release. CNPPID will be able to predict a day or two in advance the volume of water that will be available for release and can plan accordingly to store enough water to meet shortages. For example, if it is known that 300 acre-feet will be needed on Tuesday, that volume can be left in the reservoir by the end of the day Monday. Thus, the situation of not having enough water in storage at the beginning of the day should not occur.

2. On the same example day as in #1 above, during the second half of the day, after the hydro plant starts, is it better to release the full amount available, typically 1,675 cfs, or release only the amount needed to meet the shortage and store the rest? CNPPID's preference is to release only the needed amount and to store the rest.

3. In the opposite case of #1, when the reservoir is full of water to be used to meet hourly shortages and the hydro plant has not started, the reservoir is too full to store water for hydrocycling mitigation. When this situation occurs, the operation will be to release water to mitigate for hydrocycling, and then fill to the exact starting place, so that the daily change in volume is 0, and the amount of water held is 0.

4. The base model, which assumes operation to reduce the shortages and no hydrocycling, is complete. The base model only considers Program needs. The model now being completed addresses hydrocycling mitigation at times when water supply is low since hydrocycling mitigation is not an issue when water is plentiful. To determine the impact on yield, results from the two models will be compared.

5. Cory noted that addressing the day to day step in flows will need to occur at some point. It is an issue that is important to both CNPPID and the Program. Cory and Eric agreed that multi-day flow leveling modeling needs to be completed but that it is not within the current project scope.

6. Eric noted that a quick ramp up of flows and slow drain down would mimic natural hydrology. Cory did not think that would be acceptable to the regulators. CNPPID is allowed to ramp up slowly and then turn off quickly.

7. Cory would like answers to big picture questions such as:

    a. Is more storage needed most of the time?
    b. Does Phelps need 1,400 cfs capacity?
    c. Is there a certain volume of water that should remain in the reservoirs?

Action Items:
Olsson:

- Finish the low water hydrocycling model with the direction provided by Cory

Minutes prepared by: Deb Ohlinger
cc: Attendees, Beorn Courtney, Jerry Kenny, File

APPENDIX C

PRE-PROJECT AND POST-PROJECT STANDARD DEVIATIONS OF RELEASES BY MONTH AND YEAR

Table C-1. Pre-Project Average Standard Deviation by Month and Year for 1,000 cfs Phelps Canal Capacity

	Average Standard Deviation (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	519	14	0	15	32	65	46	38	54	0	67	52	75
1998	200	0	73	65	47	32	52	29	6	0	0	256	63
1999	363	1	0	24	15	41	26	25	27	0	0	46	47
2000	0	0	37	4	33	34	41	67	583	811	431	104	179
2001	530	332	572	389	195	347	48	63	390	322	453	393	336
2002	768	252	493	374	341	302	51	124	284	472	397	170	336
2003	220	387	579	336	199	170	148	143	197	0	0	36	201
2004	78	345	409	67	259	268	167	135	254	84	214	160	203
2005	169	313	386	447	204	67	10	18	156	302	228	167	206
2006	181	336	469	331	18	297	113	88	124	328	217	157	222
2007	141	230	247	334	142	533	23	83	60	237	202	162	199
2008	148	518	518	115	243	67	290	228	171	395	204	132	252
Average	276	227	315	208	144	185	84	87	192	246	201	153	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table C-2. Pre-Project Average Standard Deviation by Month and Year for 1,400 cfs Phelps Canal Capacity

	Average Standard Deviation (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	461	14	0	0	31	47	46	33	30	0	67	52	65
1998	189	0	74	64	47	22	39	29	6	0	0	188	55
1999	349	1	0	23	22	41	26	23	21	0	0	46	46
2000	0	0	33	4	31	23	41	67	583	811	379	15	166
2001	343	320	537	389	158	347	48	60	317	292	427	104	278
2002	730	226	409	371	338	302	51	124	258	470	349	50	307
2003	51	381	579	336	145	155	148	143	197	0	0	14	179
2004	25	344	409	67	259	268	167	135	254	84	162	49	185
2005	57	297	385	447	181	50	10	18	155	302	196	67	180
2006	36	330	469	331	18	297	113	88	121	328	157	50	195
2007	40	163	177	301	122	503	0	69	44	223	138	51	153
2008	98	518	518	115	188	34	208	225	171	345	117	58	216
Average	198	216	299	204	128	174	75	85	180	238	166	62	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table C-3. Pre-Project Average Standard Deviation by Month and Year for 2,000 cfs Phelps Canal Capacity

	Average Standard Deviation (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	458	14	0	0	31	33	46	30	30	0	67	52	63
1998	189	0	74	64	47	16	40	29	6	0	0	176	53
1999	336	1	0	23	21	41	26	23	19	0	0	46	45
2000	0	0	33	4	31	23	37	67	583	811	379	3	164
2001	294	320	536	389	155	347	48	60	303	294	427	97	272
2002	710	226	394	371	338	302	51	124	257	470	345	42	302
2003	0	379	579	336	135	153	148	143	197	0	0	3	173
2004	2	343	409	67	259	268	167	135	254	84	149	27	180
2005	38	298	385	447	167	49	10	18	155	302	191	23	174
2006	2	334	469	331	18	297	113	88	121	328	144	17	188
2007	18	129	162	280	133	492	0	63	44	223	114	0	138
2008	98	518	518	115	167	31	175	207	171	322	65	51	203
Average	179	214	297	202	125	171	72	82	178	236	157	45	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table C-4. Post-Project Average Standard Deviation by Month and Year for 1,000 cfs Phelps Canal Capacity

	Average Standard Deviation (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	18	0	0	15	0	46	23	28	13	0	0	0	12
1998	0	0	3	35	22	16	18	22	6	0	0	0	10
1999	0	0	0	0	13	20	17	22	0	0	0	0	6
2000	0	0	3	2	12	11	6	6	60	23	78	104	25
2001	83	8	53	13	44	0	5	3	161	109	148	153	65
2002	28	52	138	101	98	65	12	5	162	149	151	169	94
2003	220	123	159	76	148	93	46	51	97	0	0	34	87
2004	76	126	154	0	0	4	13	6	120	28	134	159	68
2005	167	144	165	121	31	18	0	0	95	116	136	164	97
2006	182	130	166	79	11	44	4	0	93	158	159	153	98
2007	138	194	135	113	125	42	19	25	56	158	165	162	111
2008	140	168	166	10	96	31	148	68	91	182	172	116	116
Average	88	79	95	47	50	32	26	20	80	77	95	101	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table C-5. Post-Project Average Standard Deviation by Month and Year for 1,400 cfs Phelps Canal Capacity

	Average Standard Deviation (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	0	0	0	0	1	27	13	19	2	0	0	0	5
1998	0	0	4	34	22	5	1	13	6	0	0	0	7
1999	0	0	0	0	10	20	19	20	0	0	0	0	6
2000	0	0	0	2	9	0	2	0	16	0	2	15	4
2001	15	0	3	0	10	0	1	0	33	1	18	3	7
2002	1	0	24	21	13	8	0	0	45	13	14	39	15
2003	51	8	0	3	18	20	0	0	10	0	0	11	10
2004	24	18	21	0	0	1	1	0	13	9	36	40	14
2005	43	29	31	5	12	1	0	0	22	21	34	53	21
2006	36	14	9	11	4	8	0	0	21	35	37	40	18
2007	32	50	33	59	36	14	0	9	14	36	44	51	32
2008	25	6	15	1	21	12	34	3	20	42	48	20	20
Average	19	10	12	11	13	10	6	5	17	13	19	23	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table C-6. Post-Project Average Standard Deviation by Month and Year for 2,000 cfs Phelps Canal Capacity

	Average Standard Deviation (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	0	0	0	0	1	12	13	16	2	0	0	0	4
1998	0	0	4	34	22	0	0	13	6	0	0	0	6
1999	0	0	0	0	8	19	19	19	0	0	0	0	5
2000	0	0	0	2	9	0	0	0	6	0	13	3	3
2001	14	0	0	0	8	0	0	0	19	0	4	1	4
2002	1	0	0	7	5	0	0	0	41	10	7	28	8
2003	0	5	0	0	4	0	0	0	0	0	0	0	1
2004	0	0	0	0	0	0	0	0	0	0	1	5	1
2005	4	0	0	0	0	0	0	0	0	0	2	2	1
2006	2	0	3	0	0	0	0	0	0	0	5	3	1
2007	6	7	24	32	21	14	0	0	0	0	0	0	9
2008	8	0	0	0	0	7	0	0	0	9	1	6	2
Average	3	1	3	6	7	4	3	4	6	2	3	4	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

APPENDIX D

POST-PROJECT AVERAGE AND MAXIMUM FLOW CHANGE AT MIDNIGHT

Table D-1. Post-Project Average Flow Change at Midnight by Month and Year for 1,000 cfs Phelps Canal Capacity

	Average Flow Change at Midnight (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	20	9	9	1	20	23	0	54	36	1	1	1	15
1998	3	19	22	43	33	20	20	3	69	41	9	12	24
1999	17	1	11	13	25	61	3	32	28	0	0	1	16
2000	0	12	1	36	23	39	12	9	81	29	186	190	52
2001	145	29	123	10	14	11	12	13	300	286	349	308	133
2002	28	128	293	54	8	1	20	8	384	373	383	453	178
2003	535	332	400	0	87	19	3	6	279	0	0	160	152
2004	272	424	504	2	1	1	2	9	376	128	579	573	239
2005	570	517	550	27	5	42	30	2	397	417	581	535	306
2006	507	451	462	1	1	5	2	1	385	560	567	514	288
2007	459	533	311	75	15	39	19	1	258	567	594	544	284
2008	404	467	481	32	33	1	20	58	355	484	517	417	272
Average	247	243	264	25	22	22	12	16	246	240	314	309	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table D-2. Post-Project Average Flow Change at Midnight by Month and Year for 1,400 cfs Phelps Canal Capacity

	Average Flow Change at Midnight (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	22	9	9	8	14	9	14	55	4	1	1	1	12
1998	3	19	23	44	33	12	50	30	69	41	9	12	29
1999	17	1	11	13	41	74	7	35	28	0	0	1	19
2000	0	12	8	36	25	34	1	5	22	29	23	18	18
2001	10	15	24	32	23	10	8	12	50	16	32	5	20
2002	18	21	48	16	3	8	7	2	91	25	41	102	32
2003	104	34	6	6	13	4	1	3	32	0	0	52	21
2004	60	85	83	2	1	1	1	1	49	37	155	142	52
2005	142	117	106	2	5	26	30	0	97	74	156	166	77
2006	82	81	30	0	4	2	2	1	90	122	131	136	57
2007	93	144	47	51	59	16	17	4	71	131	163	162	80
2008	73	18	27	9	28	2	7	24	81	105	145	74	49
Average	52	46	35	18	21	16	12	14	57	48	71	73	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table D-3. Post-Project Average Flow Change at Midnight by Month and Year for 2,000 cfs Phelps Canal Capacity

	Average Flow Change at Midnight (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	22	9	9	8	14	6	14	58	4	1	1	1	12
1998	3	19	23	44	33	6	51	30	69	41	9	12	28
1999	17	1	11	13	45	77	7	36	28	0	0	1	20
2000	0	12	8	36	25	34	1	5	10	16	36	6	16
2001	7	15	17	32	18	10	11	12	17	17	3	1	13
2002	18	21	5	10	3	3	7	2	81	18	23	75	22
2003	25	25	6	10	19	1	1	3	1	0	0	1	8
2004	30	28	5	2	1	1	1	0	2	2	2	12	7
2005	1	14	8	4	5	26	30	0	0	6	14	2	9
2006	15	28	14	0	4	4	2	1	3	1	16	12	8
2007	4	42	29	27	50	16	13	0	5	1	6	17	17
2008	25	0	20	25	5	2	37	38	3	17	1	12	16
Average	14	18	13	18	18	15	14	16	19	10	9	13	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table D-4. Post-Project Maximum Flow Change at Midnight by Month and Year for 1,000 cfs Phelps Canal Capacity

	Maximum Flow Change at Midnight (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	181	961	598	1,164	3,557	694	196	564	165	997	36	73	765
1998	24	120	806	24	2,566	481	254	589	1,339	877	231	24	611
1999	24	863	1,027	427	777	108	206	216	290	419	39	36	369
2000	24	489	958	163	3,986	551	1,072	234	121	12	676	629	743
2001	276	1,649	809	408	2,047	46	525	363	760	331	414	28	638
2002	187	723	727	1,153	221	300	83	538	799	427	815	505	540
2003	602	558	11	59	200	740	422	322	495	0	589	414	368
2004	292	652	0	0	0	684	640	347	0	99	559	581	321
2005	637	124	139	0	572	545	81	5	93	0	872	643	309
2006	1,050	0	201	0	0	380	330	482	0	0	848	807	341
2007	1,148	0	1,167	942	927	290	304	256	122	24	612	698	541
2008	637	0	12	12	1,535	700	238	676	0	964	779	715	522
Average	424	511	538	363	1,366	460	363	383	349	346	539	429	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table D-5. Post-Project Maximum Flow Change at Midnight by Month and Year for 1,400 cfs Phelps Canal Capacity

	Maximum Flow Change at Midnight (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	380	453	628	1,452	3,793	586	1,083	1,077	399	360	250	460	910
1998	130	120	1,032	288	2,194	1,155	1,114	1,176	1,240	176	529	235	782
1999	227	892	685	448	982	697	909	717	195	25	26	247	504
2000	76	480	1,010	644	4,040	580	1,495	279	995	527	856	314	941
2001	596	1,738	751	1,514	1,555	136	1,628	831	367	530	559	384	882
2002	412	969	730	1,077	507	354	215	118	449	292	314	192	469
2003	499	256	86	420	236	678	54	100	192	0	3	216	228
2004	687	127	158	53	97	104	156	86	129	55	45	46	145
2005	301	87	2	247	606	634	38	79	123	30	75	91	193
2006	612	101	251	654	151	160	72	98	53	73	88	92	200
2007	356	128	716	1,416	1,145	468	600	649	120	54	90	261	500
2008	217	23	640	1,408	1,197	700	672	643	56	698	354	504	593
Average	374	448	557	802	1,375	521	670	488	360	235	266	254	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

Table D-6. Post-Project Maximum Flow Change at Midnight by Month and Year for 2,000 cfs Phelps Canal Capacity

	Maximum Flow Change at Midnight (cfs)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1997	380	453	628	1,452	3,793	1,259	1,083	1,004	399	360	250	460	960
1998	130	120	737	288	2,194	1,155	1,114	1,176	1,240	176	529	235	758
1999	227	892	685	448	1,278	1,056	909	683	195	25	26	247	556
2000	76	480	1,010	644	4,040	580	1,495	279	955	527	1,295	314	975
2001	495	1,738	751	1,514	1,555	136	1,706	831	513	538	514	379	889
2002	407	969	730	1,119	766	302	215	118	488	357	313	346	511
2003	696	336	83	425	229	653	54	100	447	0	3	216	270
2004	743	172	129	44	97	102	156	86	196	70	74	239	176
2005	576	87	207	265	606	634	39	72	122	75	137	194	251
2006	612	101	266	653	146	117	73	98	114	33	59	146	202
2007	543	266	482	1,413	911	468	600	648	247	62	117	327	507
2008	270	67	718	1,116	1,197	700	609	642	114	691	366	504	583
Average	430	473	536	782	1,401	597	671	478	419	243	307	301	

Additional parameters: Area 2 pump station = 300 cfs capacity, Area 1 gate = 40 feet wide, Area 2 gate = 30 feet wide

APPENDIX C

TASK 1 MEMORANDA

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☒	Other: email

TO:	Beorn Courtney
CC:	Eric Dove, File
FROM:	Deb Ohlinger
RE:	Results of Task 1.5 of Investigation of Reservoir Combined Operations
DATE:	September 14, 2011
PROJECT #:	B09-1466

Under Task 1.5 of the Investigation of Reservoir Combined Operations, Olsson was tasked with investigating the four circumstances identified in the report titled "CNPPID J-2 Reregulating Reservoir Task 1 of Feasibility Study Investigation of Reservoir Combined Operations," by Olsson Associates and dated June 24, 2011 under which hydrocycle mitigation was not achieved.

The four scenarios were as follows:

1. The reservoirs were full or almost full, could not take in and store water, and the hydropower plant operated in a non-ideal pattern.
2. The reservoirs started the day with very little storage so they released at a constant flow until they were nearly empty, at which time the J-2 hydropower plant turned on and the outflow to the Platte River changed.
3. The pumps could not keep up with the flow, which resulted in a non-uniform release rate for the day. The number of days this situation happens, though not specifically quantified, are few.
4. Very little water was in storage such that the head available over the weir was low and not enough water could be released within the calendar day.

Achieving 100% hydrocycle mitigation for these four scenarios was investigated. One of the original spreadsheet models was revised for Phelps Canal capacity of 1,675 cfs. The original models investigated Phelps Canal capacities of 2,000, 1,400, and 1,000 cfs. Since the likely required capacity moving forward at this point in time is 1,675 cfs, that change was made. The original modeling focused on hydrocycle mitigation outside of the irrigation season, considered to be April 1-August 31. Achieving 100% hydrocycle mitigation outside of these dates was the focus of this analysis.

Table 1 shows a comparison of the number of days during which hydrocycle mitigation was not achieved, represented by a standard deviation greater than zero, for the two modeling scenarios.

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Table 1. Comparison of Standard Deviations

Data Set	Days of Standard Deviation>0 Outside of the Irrigation Season
Spreadsheet model in Combined Operations Report revised for Phelps Canal capacity of 1,675 cfs	127
Spreadsheet revised for 100% mitigation outside the irrigation season April 1-August 31	0

Table 2 compares the yield for the two scenarios. A reduction in yield was generally seen. For some of the years, a negative reduction, or an increase in yield, was seen. Comparing the two models, the operational regime for a day as determined by factors such as the volume of storage available at the beginning of a day and the target release was different for some of the days. Because the model is a continuous simulation model, a change in one day has the potential to change all of the days after the modified day. Over time, these differences led to what appeared to be a slight increase in yield, however, once actual operations are modeled, increases in yield are not anticipated.

Table 2. Comparison of Target Flow Augmentation for Combined Reservoir Operations with Phelps Canal Capacity of 1,675 cfs for Initial Modeling versus Achieving 100% Hydrocycle Mitigation Outside of the Irrigation Season

Year	Year Type	Yield for Phelps Canal Capacity = 1,675 cfs (ac-ft)[1]	Yield for Phelps Canal Capacity = 1,675 cfs and 100% mitigation outside of the irrigation season (April 1 - August 31) (ac-ft)[1]	Reduction in Yield (ac-ft)[2]	Reduction in Yield (%)[2]
1997	Wet	54,239	54,239	0	0.0%
1998	Wet	78,260	78,412	-152	-0.2%
1999	Wet	49,159	49,159	0	0.0%
2000	Wet	64,870	65,218	-347	-0.5%
2001	Normal	56,529	51,653	4,876	8.6%
2002	Dry	23,610	21,610	1,999	8.5%
2003	Dry	13,138	13,153	-15	-0.1%
2004	Dry	2,765	2,658	107	3.9%
2005	Dry	15,101	15,170	-69	-0.5%
2006	Dry	9,713	9,421	292	3.0%
2007	Dry	46,584	44,182	2,402	5.2%
2008	Normal	37,824	37,915	-91	-0.2%
	Average All:	37,649	36,899	750	2.0%
	Average Wet:	61,632	61,757	-125	-0.2%
	Average Normal:	47,177	44,784	2,393	5.1%
	Average Dry:	18,485	17,699	786	4.3%

Notes: [1]Area 2 pump capacity = 300 cfs
[2]Negative reduction in yield, or an increase in yield, is due to differences in operational regimes within the modeling. Increases in yield are not anticipated with actual operation.

As seen in Table 2, some years exhibited a far greater impact on yield than others. For example, 2001 resulted in a reduction in yield of nearly 4,900 acre-feet. Due to the cumulative effects of the continuous simulation modeling, changes to a given day carried down through all days after that day. A significant amount of impact occurs on a relatively small number of days. Table 3 shows the number of days for which there was a decrease in yield. In the case of 2001, October 11th and 12th each resulted in a reduction of yield of approximately 1,700 acre-feet, for a total of approximately 3,400 acre-feet. The cumulative effects of the continuous simulation modeling reduced the storage available at the start of the day on October 11th. Significantly more water was available to be released from storage with the non-100% hydrocycle mitigation case. It is anticipated operational changes on these limited number of days would greatly reduce the loss in yield. For instance, to provide more water at the beginning of the day to reduce shortages to target flows, the J-2 hydropower plant could be run at the beginning of the day or have two starts during these infrequent times.

Table 3. Number of Days by Year with a Decrease in Yield (ac-ft)

	Decrease in Yield (ac-ft)					
Year	**0 to 500**	**500 to 1000**	**1,000 to 1,500**	**1,500 to 2,000**	**>2,000**	**Total Yield Reduction**
1997						0
1998	4					-152
1999						0
2000	7	4	1			-347
2001	12	4		2		4,876
2002	37	3				1,999
2003	2	1				-15
2004	6					107
2005	9					-69
2006	12					292
2007	15	1			1	2,402
2008	8	1	1			-91
Total Days	112	14	2	2	1	

Each of the four cases of not achieving hydrocycle mitigation in the original model was investigated as described in the following sections.

Case 1: Full or almost full reservoirs

This case did not occur outside of the irrigation season. CNPPID provided a synthetic data set that they felt best represented future operations. With this revised data set, operational changes were made such that this problem was eliminated outside of irrigation season. If it were to occur, additional slight changes in hydropower generation operations would eliminate the situation.

Case 2: Low storage prior to start of J-2

The overwhelming majority of the days for which hydrocycle mitigation was not achieved fell into the Case 2 scenario. At the beginning of the day, not enough storage was available to meet the release rate desired. Under the original scenario, until the J-2 hydropower plant started, the water in storage was released at a constant rate until storage was depleted. After the J-2 hydropower plant started, all water was released to the Platte River at a higher rate so that shortages would not be increased. Most of the days occurred when there were shortages. The preference during the modeling thus far has been to provide as much water for shortages to target flows. Operating in this manner would maximize the volume of water released to the Platte River during times of shortages but the water was released in a non-uniform manner, resulting in large fluctuations in flow to the river. The large fluctuations have been identified by the U.S. Fish and Wildlife Service as undesirable.

To achieve hydrocycle mitigation, in an ideal mitigation scenario, all water in storage was drained prior to the start of the J-2 hydropower plant, but the release rate would be kept constant after the J-2 hydro turns on, as shown by the dashed line in Figure 1. The solid line in Figure 1 illustrates the previous operational mode that resulted in a hydropower surge but did not result in an increase in shortages. Under the 100% hydrocycle mitigation approach, the water that previously would have been released would be directed into storage for use on the following day or subsequent days. On this day, however, shortages would be increased and yield would be decreased.

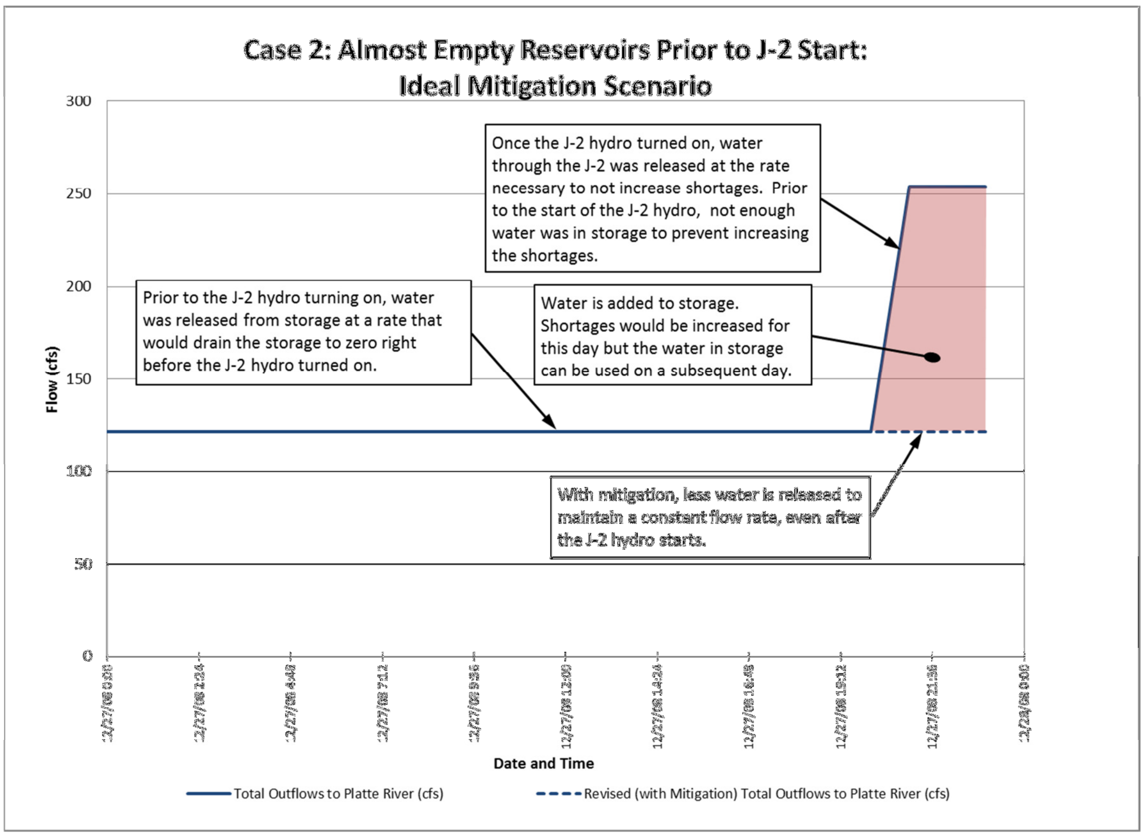

Figure 1 – Hydrocycle Mitigation for Case 2: Ideal Mitigation Scenario

As combined operations modeling progressed, it became clear that when the reservoirs were fully drained, operations on the following day and/or subsequent days were very challenging. A mode of operation that could be considered as providing an operating pool by saving water for a subsequent day was adopted. In this mode, less water was released each hour of the day so that there would still be a small volume of water in the reservoirs by the time the J-2 hydro started. The rationale is that it would be better to have a small flow being released to the Platte River in subsequent days than no flow. The operating pool mode illustrated in Figure 2 is what was included in the modeling for low water days. Shortages would be increased and yield would be decreased on this particular day, but the additional water directed to storage could be used on the following day or subsequent days.

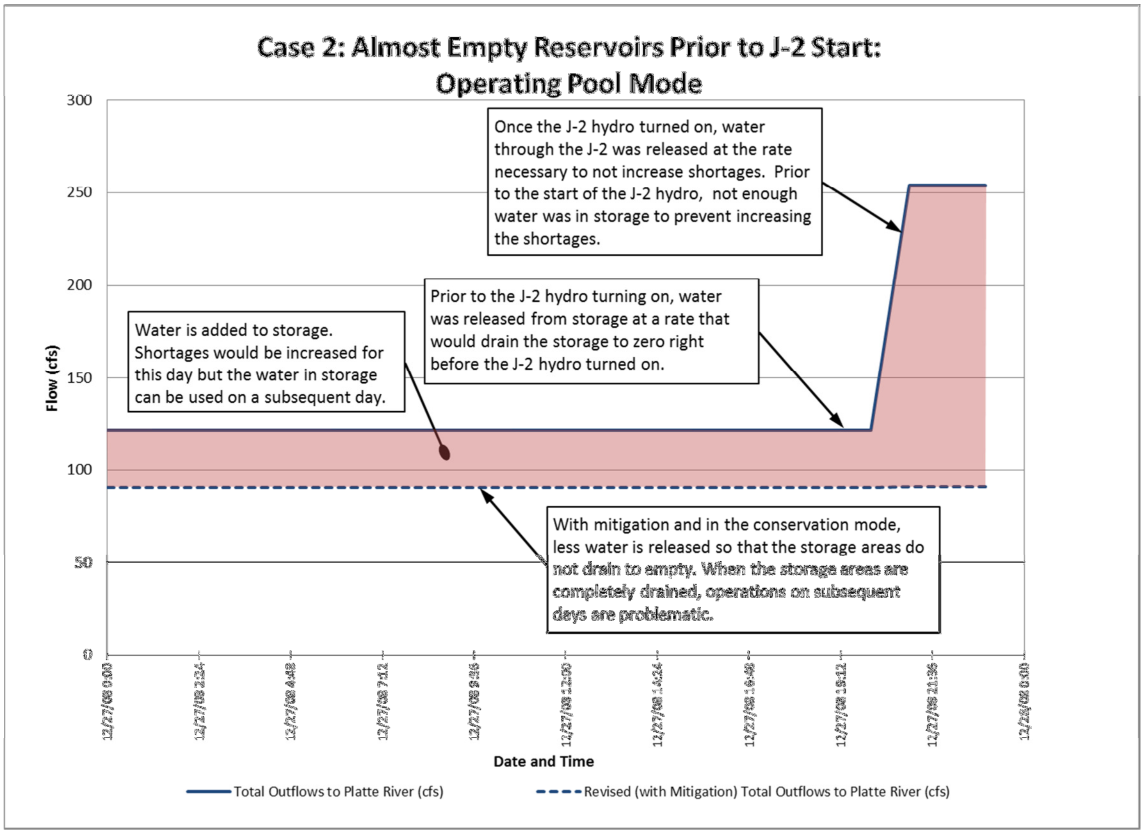

Figure 2 – Hydrocycle Mitigation for Case 2: Operating Pool Mode

Case 3: Area 2 pumps unable to keep up with incoming flow on days of high storage

The capacity of the Area 2 pumps ranged from 250 to 350 cfs during the initial modeling. For most of the modeling, the pumps were set at 300 cfs. The exact pump capacity will be determined under later tasks of the project. There were days when Area 2 was full enough that the pumps were needed to add water into Area 2 and conveying the entire 1,675 cfs from the J-2 hydropower plant could not be accommodated. Therefore, additional water had to be released at the J-2 return. To achieve hydrocycle mitigation, the higher release rate is used for the entire day, as illustrated in Figure 3. Storage changed slightly since more was released in the first few hours of the day.

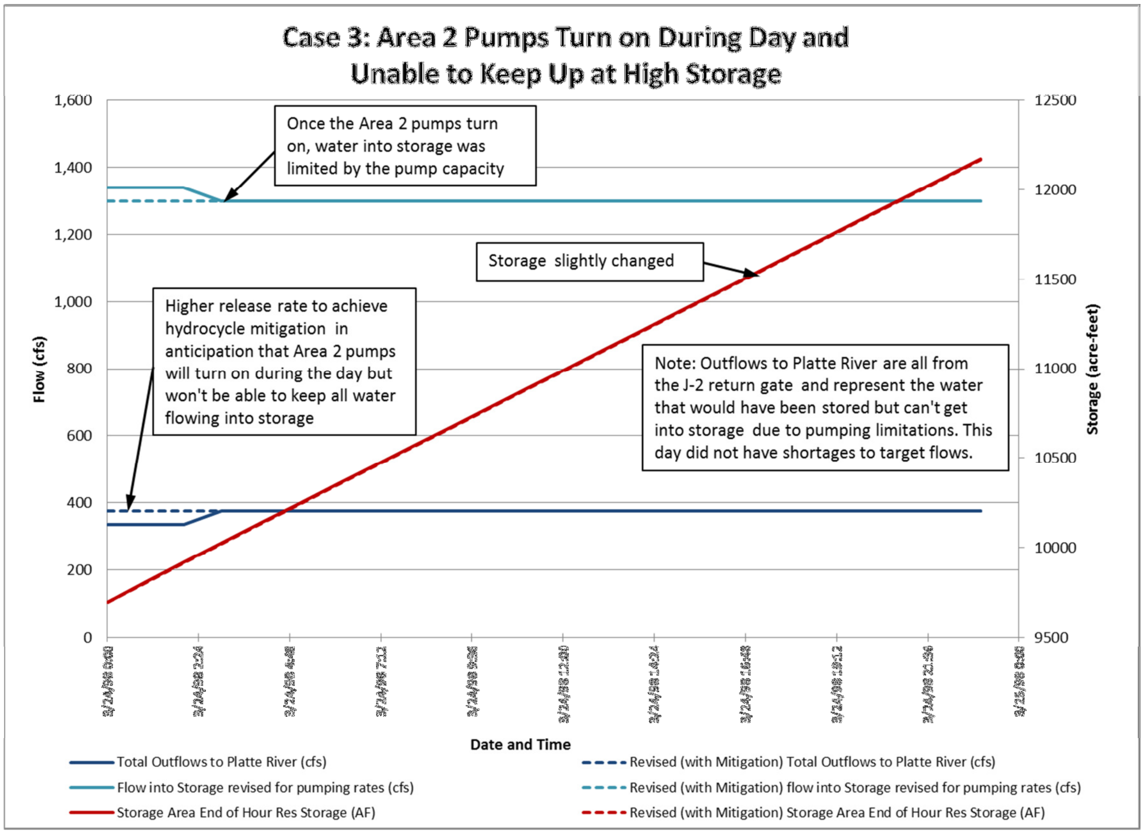

Figure 3 – Hydrocycle Mitigation for Case 3

Case 4: Low storage resulting in low head over the storage area outlet weirs

In a small number of cases, the desired release rate could not be met because the storage volume and resulting water elevation were low enough that water could not be conveyed over the weirs of the outlets to the storage areas. Because a dead pool will be part of the design moving forward, this situation would be unlikely to occur.

Conclusions

- The majority of days for which 100% hydrocycle mitigation was not achieved with the previous modeling occurred with Case 2, when storage in the reservoirs was very low and shortages to target flows were occurring.
- Hydrocycle mitigation was achieved on all of the days targeted, those outside of the irrigation season of April 1-August 31, as a result of hydropower operational changes and the decision to carry a small volume of water over to the next day. A small operating pool was maintained.
- The analysis showed that achieving 100% hydrocycle mitigation will result in some decreases in Program yield, as shown in Table 2.
- On some days, there could be increases in shortages to target flows while achieving 100% hydrocycle mitigation, but the water would be released on subsequent days that have shortages. The decision to allow increases in shortages on a given day has policy implications that will need review and/or input from the Program.

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☒	Other: email

TO:	Beorn Courtney
CC:	Eric Dove, File
FROM:	Deb Ohlinger
RE:	Results of Task 1.6 of Investigation of Reservoir Combined Operations
DATE:	September 21, 2011
PROJECT #:	B09-1466

Under Task 1.6 of the Investigation of Reservoir Combined Operations, Olsson was tasked with developing an initial estimate of how removal of Area 2 from Program use during the irrigation season could affect yield for reducing shortages to target flows. CNPPID seeks to maximize hydroelectric power production during peak value times of the day during the irrigation season by regulating flows for irrigation delivery using Area 2. The desire is to pulse the flows out of the hydropower plant during the peak value times but meanwhile deliver a uniform flow rate in the Phelps Canal downstream of Area 2.

For this investigation, the irrigation season was first considered to be April 1-August 31 and then considered to be June 15-August 31. The evaluation was completed by modifying spreadsheet models that were developed to evaluate reservoir combined operations. The report titled "CNPPID J-2 Reregulating Reservoir Task 1 of Feasibility Study Investigation of Reservoir Combined Operations," by Olsson Associates and dated June 24, 2011 presents detail on the layouts of Areas 1 and 2, analysis methodology, assumptions, and a sensitivity analysis.

As part of the current effort, Olsson developed two Excel spreadsheets by modifying the previously developed spreadsheets for the reservoir combined operations investigation (the June 24, 2011 report). These spreadsheets used the synthetic data provided by CNPPID outside of the irrigation season and historic data during the irrigation season. It should be noted that the historic irrigation data was used for April 1-August 31. The following steps were completed as part of the investigation:

1. The Excel spreadsheet with a Phelps Canal capacity of 2,000 cfs was modified for a Phelps Canal capacity of 1,675 cfs, which was not previously modeled. This was the same base spreadsheet as the starting point in Task 1.5.
2. The Excel spreadsheet in Item 1 was modified to make storage available in only Area 1 between April 1 and August 31. Outside of these dates, both Areas 1 and 2 were available for use. For each year, the storage in Area 2 at the end of the day on March 31 was subtracted from the total available storage on April 1 since it will not be available to the Program. At the beginning of the day on September 1, the same volume of water was

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added back to the total storage. CNPPID would essentially replace the water at the end of the irrigation season so that it is available for Program use.

3. A third Excel spreadsheet was developed similar to the one described in item 2, with the exception that Area 2 was available outside of the irrigation season of June 15-August 31. The storage volume in Area 2 at the end of the day on June 14 was subtracted from the available storage on June 15. It was added back to the available volume on September 1.

The spreadsheet models essentially consider the storage to be one “bucket.” To determine the volume in Area 2 at the end of the day on either March 31 or June 14, the combined storage in Areas 1 and 2 that is in the Excel spreadsheet was used to determine the storage in Area 2. Stage-storage-discharge relationships are included in each spreadsheet. They identify this relationship for Area 1, Area 2, and the two areas combined. The combined storage is based on the volumes of storage in Area 1 and Area 2 at a given elevation. For example, at elevation 2340, Area 1 has 3,340 acre-feet of storage, Area 2 has 1,596 acre-feet of storage, and the combined storage is 4,936 acre-feet. On each March 31 or June 14, the combined storage determined in the Excel spreadsheet model was compared to the storage in Area 2 and that volume was subtracted from the combined storage volume at the beginning of the day on April 1 or June 15. That same volume was added back in to the combined storage volume on September 1 of each year.

Table 1 (see page 4) presents a comparison of the differences in yield with and without Area 2 available. It should be noted that the purpose of the task was to provide a simple and quick estimate of how the yield might be impacted by not having Area 2 available. Several issues not considered in this analysis may need to be addressed in subsequent project tasks:

1. In previous efforts, the size of Area 2 was reduced to avoid Plum Creek. Moving forward, in Task 2, the Area 1 volume and/or the Area 2 footprint, and consequently volume, would need to be increased to compensate for the loss of Area 2 volume to maintain the desired Program yield, since loss of Area 2 during the irrigation season results in a reduction in Program yield.
2. In this analysis, the Area 2 pumps were still used as needed outside of the irrigation season, assuming the concept would physically allow for use of the pumps. As the design is refined as part of Task 2, the benefit to Program yield of keeping the pumps will be evaluated versus the cost effectiveness of using them.
3. How CNPPID would use Area 2 and the downstream influence on Phelps Canal during the irrigation season was not specifically modeled. As the design progresses, discussions with CNPPID will continue to determine whether their desired operation of Area 2 would affect the design of the system and/or the use of it for Program purposes.

On a daily basis, each model determined whether enough storage was available to meet the desired demand (flow needed for hydrocycle mitigation and/or reduction in shortages to target flows) for the day. If enough storage was available, the water was released to meet this demand. If it was not, it was released at a slower rate that did not meet the goal for reduction to shortages. The nature of the continuous simulation modeling resulted in different amounts of storage available at the beginning of a given day for the two different models. For the same day, the two different release patterns just described might have occurred in the two different models. When Program yield was compared on that day for the two models, there were differences in the Program yield. The overall yield might have increased or decreased on that day when comparing the two scenarios – with and without Area 2 available – but generally tended to result in an overall reduction in yield for the without Area 2 scenario.

Conclusion

The results of this analysis indicate that an average reduction in yield for the Program of 5.9% and 11.8% could result if Area 2 were simply eliminated from use during the irrigation seasons of June 15-August 31 and April 1-August 31, respectively. Changes could be made to the footprint of Area 2 and/or Area 1 that would reduce the impact. Changing the footprint for Area 1 would be more beneficial than changing the footprint for Area 2. A modest increase in the Area 1 footprint could be used to offset the decrease in yield. This topic is being further investigated in subsequent tasks of the feasibility study.

Table 1. Comparison of Target Flow Augmentation for Combined Reservoir Operations with and without Area 2

		Area 2 Available All Year	**Area 2 Available Outside of Irrigation Season: June 15-August 31**			**Area 2 Available Outside of Irrigation Season: April 1-August 31**		
Year	Year Type	Yield (ac-ft)	Yield (ac-ft)	Reduction in Yield (ac-ft)	Reduction in Yield (%)	Yield (ac-ft)	Reduction in Yield (ac-ft) [1]	Reduction in Yield (%)[1]
1997	Wet	54,239	49,017	5,222	9.6%	46,300	7,939	14.6%
1998	Wet	78,260	69,222	9,039	11.5%	63,225	15,035	19.2%
1999	Wet	49,159	44,021	5,138	10.5%	38,430	10,728	21.8%
2000	Wet	64,870	62,846	2,024	3.1%	62,681	2,189	3.4%
2001	Normal	56,529	56,529	0	0.0%	51,423	5,106	9.0%
2002	Dry	23,610	23,610	0	0.0%	23,713	-104	-0.4%
2003	Dry	13,138	13,138	0	0.0%	13,138	0	0.0%
2004	Dry	2,765	2,765	0	0.0%	2,765	0	0.0%
2005	Dry	15,101	15,101	0	0.0%	15,579	-477	-3.2%
2006	Dry	9,713	9,713	0	0.0%	9,713	0	0.0%
2007	Dry	46,584	42,325	4,259	9.1%	37,228	9,356	20.1%
2008	Normal	37,824	36,768	1,057	2.8%	34,492	3,333	8.8%
	Average All:	37,649	35,421	2,228	5.9%	33,224	4,426	11.8%
	Average Wet:	61,632	56,277	5,356	8.7%	52,659	8,973	14.6%
	Average Normal:	47,177	46,648	528	1.1%	42,957	4,219	8.9%
	Average Dry:	18,485	17,775	710	3.8%	17,023	1,463	7.9%

Notes: Hydrocycle mitigation is included, Phelps Canal capacity = 1,675 cfs, Area 2 pump capacity = 300 cfs
[1]Negative reduction in yield, or an increase in yield, is due to differences in gate effects of one versus two storage areas and in operational regimes within the modeling. Increases in yield are not anticipated with actual operation.

OLSSON ASSOCIATES

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☒	Other: email

TO:	Beorn Courtney
CC:	Eric Dove, File
FROM:	Deb Ohlinger
RE:	Results of Task 1.7 of Investigation of Reservoir Combined Operations
DATE:	September 27, 2011
PROJECT #:	B09-1466

Introduction

Under Tasks 1.7 of the Investigation of Reservoir Combined Operations, Olsson was tasked with developing alternatives to maximize power production during peak operations and regulate flows for irrigation delivery at Area 2. The report titled "CNPPID J-2 Reregulating Reservoir Task 1 of Feasibility Study Investigation of Reservoir Combined Operations," by Olsson Associates and dated June 24, 2011 presents detail on the layouts of Areas 1 and 2, analysis methodology, assumptions, and a sensitivity analysis. The four alternatives that were evaluated under Task 1.7 for the inlet into Area 2, shown on Figure 1, consisted of:

- Alternative 1: Completely remove the berm between Area 2 and the Phelps Canal
- Alternative 2: Remove a limited width of the berm and install a concrete weir between Area 2 and the Phelps Canal
- Alternative 3: Remove the top portion of the berm along its entire length down to a certain elevation
- Alternative 4: Install a dual flow inlet/outlet sluice gate structure between the Phelps Canal and Area 2.

Regardless of which of the alternatives is selected for the inlet structure, an inline gate structure on Phelps Canal will be required downstream of Area 2. The next downstream existing gate on Phelps Canal is near milepost seven, which is likely too far downstream to provide the control needed. The new inline gate on Phelps Canal will assist in backing water into Area 2 and would also be used to regulate the flow to the downstream irrigation customers. The new inline Phelps Canal gate structure may be located either downstream of Area 2, or potentially downstream of the Area 1 inlet. Potentially, one new gate on Phelps would benefit both storage areas and would give greater flexibility to the operations. This new inline gate on Phelps Canal has not yet been sized and will be part of future tasks.

An important distinction among the alternatives is that Alternative 1 combines the storage area with Phelps Canal, which means that irrigation flows could not bypass the storage area. Further, the water surface elevation on Area 2 would be limited to the height of Phelps Canal levees. Currently, pumps are anticipated on Area 2 to increase storage and store water to a higher elevation. Phelps Canal could be used independently to some extent with Alternatives 2 and 3, and could be run separately with Alternative 4. As a result, yield would be impacted throughout the year with Alternatives 1-3 but only during the irrigation season with Alternative 4.

Alternative Analyses

Olsson evaluated the Phelps Canal capacity and documented the results in a memorandum dated December 14, 2010. The evaluation showed that although the canal can convey 1,675 cfs, it cannot convey this flow with adequate freeboard. Recommendations to improve the capacity focused on increasing the height of the berms, which would increase freeboard. The water surface elevations determined as part of the evaluations would be similar for existing and proposed conditions. If Phelps Canal were improved, the elevations in the area of the Area 2 inlet would be similar to existing. The water surface elevation in Phelps Canal on the downstream side of Area 2 is 2353.77 at 1,675 cubic feet per second (cfs) under existing conditions. The corresponding volume in Area 2 at an elevation of 2353.77 is 2,753 acre-feet.

CNPPID indicated that the peak irrigation demand to downstream users is 900 cfs. If the J-2 hydropower plant were not running, the total volume of water needed to be stored for a 900 cfs release for a 24-hour period would be 1,785 acre-feet. An inflow to Area 2 of 1,675 cfs for 13 hours would yield 1,800 acre-feet of water, slightly more than the required 1,785 acre-feet. However, water would continually be leaving Area 2 or being conveyed by the Phelps Canal, so it is not necessary to store that entire amount of irrigation water. Using a simple routing procedure that takes into account 1,675 cfs entering Area 2 and 900 cfs leaving Area 2, 826 acre-feet of storage would be needed. For simplicity, the maximum required irrigation storage volume was considered to be 833 acre-feet, which occurs after 13 hours of J-2 operation. Subtracting 833 acre-feet of storage from 2,753 acre-feet available at elevation 2353.77 leaves 1,920 acre-feet of volume below a corresponding elevation of 2351.05. The weir crest in Alterative 2 and the elevation of the top of berm in Alternative 3 were initially set at an elevation of 2351.05 as a starting point for analysis. The volume below the weir crest would essentially be a static pool that would remain in Area 2 during the irrigation season but be available for Program use following the irrigation season.

The conceptual level sizing of the weir in Alternative 2 and the dual flow inlet/return gate in Alternative 4 were determined using the 2009 Bentley FlowMaster V8i computer program. Weir calculations were used for the weir and orifice equations were used for the gate. The headwater elevation was set to 2353.77. Starting with the initial weir crest elevation of 2351.05, the weir crest elevation, weir length, and tailwater elevations were iterated to determine the shortest weir length that can convey 1,675 cfs. The resulting weir crest elevation was 2350.60, with a weir length of 99 feet (rounded to 100 feet), weir breadth of 90 feet, and static pool storage below the crest of 1783.3 acre-feet. The resulting tailwater elevation during the 13th hour of water entering Area 2 would be 2353.32, which would be the highest and, therefore, limiting tailwater elevation. For Alternative 3, lowering the entire length to an elevation of 2351.0 was sufficient. The key factor for determining the crest elevation for Alternative 3 was to be able to access the “bottom” of the active storage rather than the weir hydraulics. The Alternative 4 dual flow inlet/return gate was determined to be two 15-foot wide by 12-foot high sluice gates. The proposed twin 15-foot wide by 12-foot high dual flow inlet/return sluice gates would be used for both entrance flow and returning flow back into Phelps Canal.

Cost Estimates

Conceptual level costs were determined for the alternatives and are include as Exhibit 1. Only the excavation, topsoil, and seed/mulch quantities that would be additional to the Area 2 quantities already presented in the February 2010 Pre-Feasibility Report were included in the cost estimate. This memorandum compares the costs associated with only the construction between the Phelps Canal and Area 2. Items identified in the Pre-Feasibility Report such as the proposed berm along the perimeter, which would be lower than shown in the Pre-Feasibility Report, must be removed or adjusted from cost estimates after an alternative is selected.

It was assumed that Area 2 would be graded down at a 3 horizontal feet to 1 vertical foot (3:1) slope from the top of the existing berm. The upstream reach of the Phelps Canal does not have a defined berm; therefore a top width of 50 feet, typical of the existing berm downstream, was used to begin the 3:1 slope into Area 2. This area, shown with a blue hatch pattern in the Figure 1 cross sections, was used to determine the excavation, topsoil, and seed/mulch quantities. It was assumed that the ultimate Area 2 design would be modified for Alternatives 1 through 3 to balance earthwork quantities. Soil removed from the existing Phelps Canal berm can be used to construct the proposed Area 2 perimeter berm.

As mentioned previously, for each of the four alternatives, an inline gate on Phelps Canal would be needed downstream of Area 2 or farther downstream at Area 1. The Phelps Canal inline gate would be part of the overall project cost and not an additional cost for this scenario. In addition, a gate would be required between the Phelps Canal and Area 2 for Program uses, regardless of whether hydrocycle mitigation or the use of Area 2 by CNPPID are implemented. The sluice gates included in the Pre-Feasibility Study, for Program use only, were 2-15' wide by 13.5' high gates. The sluice gates identified for this effort, for combined operations, were 2-15' wide by 12' high gates. The cost for Alternative 4 would equate to the difference in cost for the gates. As part of Task 2, the needed gate sizes are being evaluated and cost estimates are being refined.

Summary and Conclusion

Table 1 summarizes the pros and cons of each alternative evaluated.

Table 1. Area 2 Inlet/Outlet Alternatives Summary

Alt. No.	Description	Cost	Pros	Cons
1	Remove berm	$2,880,000	• Increased footprint of Area 2 and capacity compared to other alternatives • Easier maintenance access	• High cost • Cannot use Phelps Canal if storage area is unavailable due to maintenance • Area 2 pumps and associated additional storage would be eliminated
2	Concrete weir	$240,000	• Low cost • Can continue to use Phelps Canal to some extent if storage area is unavailable due to maintenance	• Difficult weir maintenance access • Area 2 pumps and associated additional storage would be eliminated
3	Remove top of berm along entire length	$1,360,000	• Can continue to use Phelps Canal to some extent if storage area is unavailable due to maintenance	• High cost • Area 2 pumps and associated additional storage would be eliminated
4	Install inlet gates	To be determined	• Can control flow rate into Area 2 • Can continue to use Phelps Canal if storage area is unavailable due to maintenance • Pumps into Area 2 can still be used to maintain entire volume	• Sluice gate costs are higher than other types of gates

The results of this analysis indicate that Alternative 4, installing dual flow direction inlet/return sluice gates, would be most economical since an inlet gate is already needed as part of the overall project. In addition, the gates would provide the most control and flexibility for the system.

For Alternatives 1 and 3, vertical storage volume in Area 2 would be lost due to removing or lowering the berm with these configurations. If pumps were eliminated at Area 2, an additional four vertical feet of storage would be lost, for a total of over half the storage volume. For all alternatives, a loss of storage volume for the Program will occur during the irrigation season. To compensate for lost volume in Area 2, it is anticipated that Area 1 will need to increase in size.

References

Olsson Associates. June 24, 2011. CNPPID J-2 Reregulating Reservoir Task 1 of Feasibility Study Investigation of Reservoir Combined Operations.

Olsson Associates. December 14, 2010. Memorandum: Phelps Canal Evaluation.

Olsson Associates. February 18, 2010. Elwood and J-2 Alternatives Analysis Project Report. (Pre-Feasibility Report).

EXHIBIT 1
PRELIMINARY STATEMENT OF PROBABLE CONSTRUCTION COSTS
September 8, 2011

J-2 - Alternative 1, Remove Entire Berm

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 46,392.00	$ 46,392.00
2	Excavation	427,150	CY	$ 4.00	$ 1,708,600.00
3	Salvaging and Spreading Topsoil, 12" Thick	32,270	CY	$ 4.00	$ 129,080.00
4	Seeding and Mulching	20	AC	$ 900.00	$ 18,000.00
				Subtotal =	**$ 1,902,072**
				20% Mapping Uncertainty =	**$ 380,414**
				20% Construction Contingency =	**$ 380,414**
				Probable Construction Costs =	**$ 2,662,901**
				Permitting and Design (8%) =	**$ 213,032**
				Total Estimated Project Cost =	**$ 2,875,933**

J-2 - Alternative 2, Remove Part of Berm and Install Concrete Weir

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 477.00	$ 477.00
2	Excavation	4,770	CY	$ 4.00	$ 19,080.00
3	Structural Concrete for Weir	280	CY	$ 500.00	$ 140,000.00
				Subtotal =	**$ 159,557**
				20% Mapping Uncertainty =	**$ 31,911**
				20% Construction Contingency =	**$ 31,911**
				Probable Construction Costs =	**$ 223,380**
				Permitting and Design (8%) =	**$ 17,870**
				Total Estimated Project Cost =	**$ 241,250**

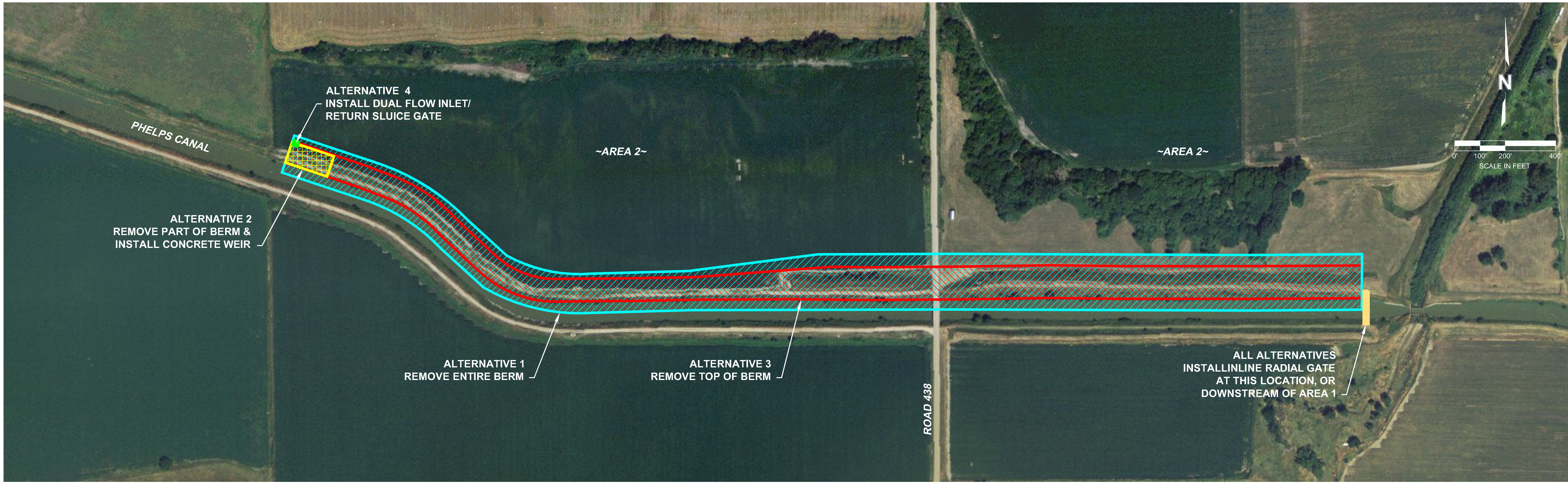
J-2 - Alternative 3, Remove Top of Berm

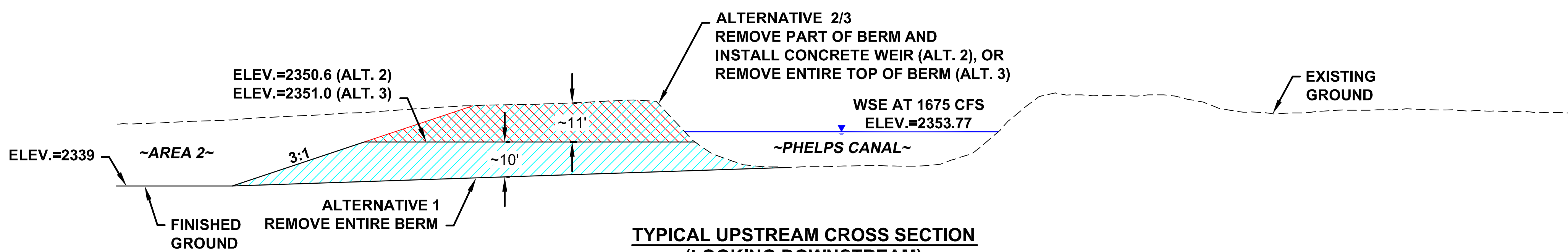
Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 22,001.00	$ 22,001.00
2	Excavation	201,630	CY	$ 4.00	$ 806,520.00
3	Salvaging and Spreading Topsoil, 12" Thick	16,130	CY	$ 4.00	$ 64,520.00
4	Seeding and Mulching	10	AC	$ 900.00	$ 9,000.00
				Subtotal =	**$ 902,041**
				20% Mapping Uncertainty =	**$ 180,408**
				20% Construction Contingency =	**$ 180,408**
				Probable Construction Costs =	**$ 1,262,857**
				Permitting and Design (8%) =	**$ 101,029**
				Total Estimated Project Cost =	**$ 1,363,886**

J-2 - Alternative 4, Inlet/Return Gate Between Phelps Canal and Area 2

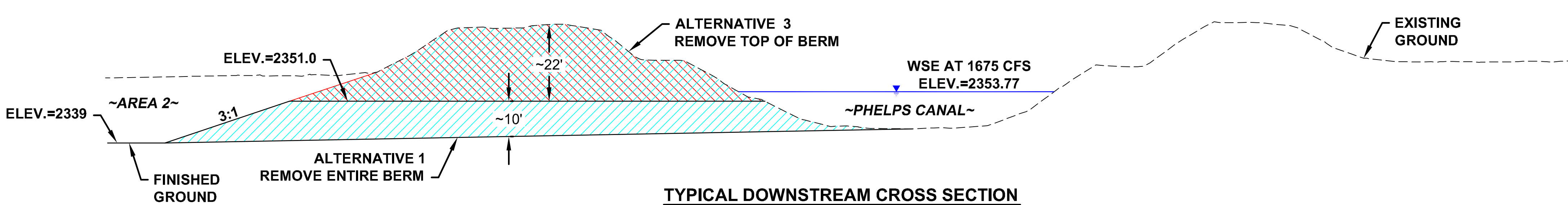
A gate at the inlet of the storage areas would be required for the Program's overall project. For the combined operations scenario and Alternative 4, it is anticipated that a gate with higher capacity would be required than that for Program use only. The cost for Alternative 4 would be the difference between the smaller capacity Program-only gate and the larger capacity combined operations gate. Gate sizes will be determined under Task 2 and an estimate of the difference in cost can then be made.

Notes: Phelps Canal inline radial gate is needed for all aternatives and for the overall Program project so was not included in the cost.
Rock riprap required at the gates would be required for the overall project and was not included in these costs.





TYPICAL UPSTREAM CROSS SECTION
(LOOKING DOWNSTREAM)
NOT TO SCALE



TYPICAL DOWNSTREAM CROSS SECTION
(LOOKING DOWNSTREAM)
NOT TO SCALE

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

PROJECT: 09-1466	PHELPS CANAL AREA 2 INLET/OUTLET ALTERNATIVES	OLSSON ASSOCIATES	FIGURE 1
DRAWN BY: AG			
DATE: 09/2011			

APPENDIX D

INCREMENTAL COST ANALYSIS MEMORANDA

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☐	Other: email

TO:	Beorn Courtney
CC:	Eric Dove, File
FROM:	Deb Ohlinger
RE:	Incremental Cost Analysis for Reservoir Combined Operations (Update)
DATE:	May 1, 2012
PROJECT #:	B09-1466

Introduction

Olsson Associates (Olsson) completed an incremental cost analysis to compare alternatives consisting of different Area 1 and Area 2 configurations. The analysis was documented in a memorandum dated November 22, 2011 and updated January 31, 2012. Further refinements have been made since the memorandum was issued.

Changes since January 31, 2012 Incremental Cost Analysis Update

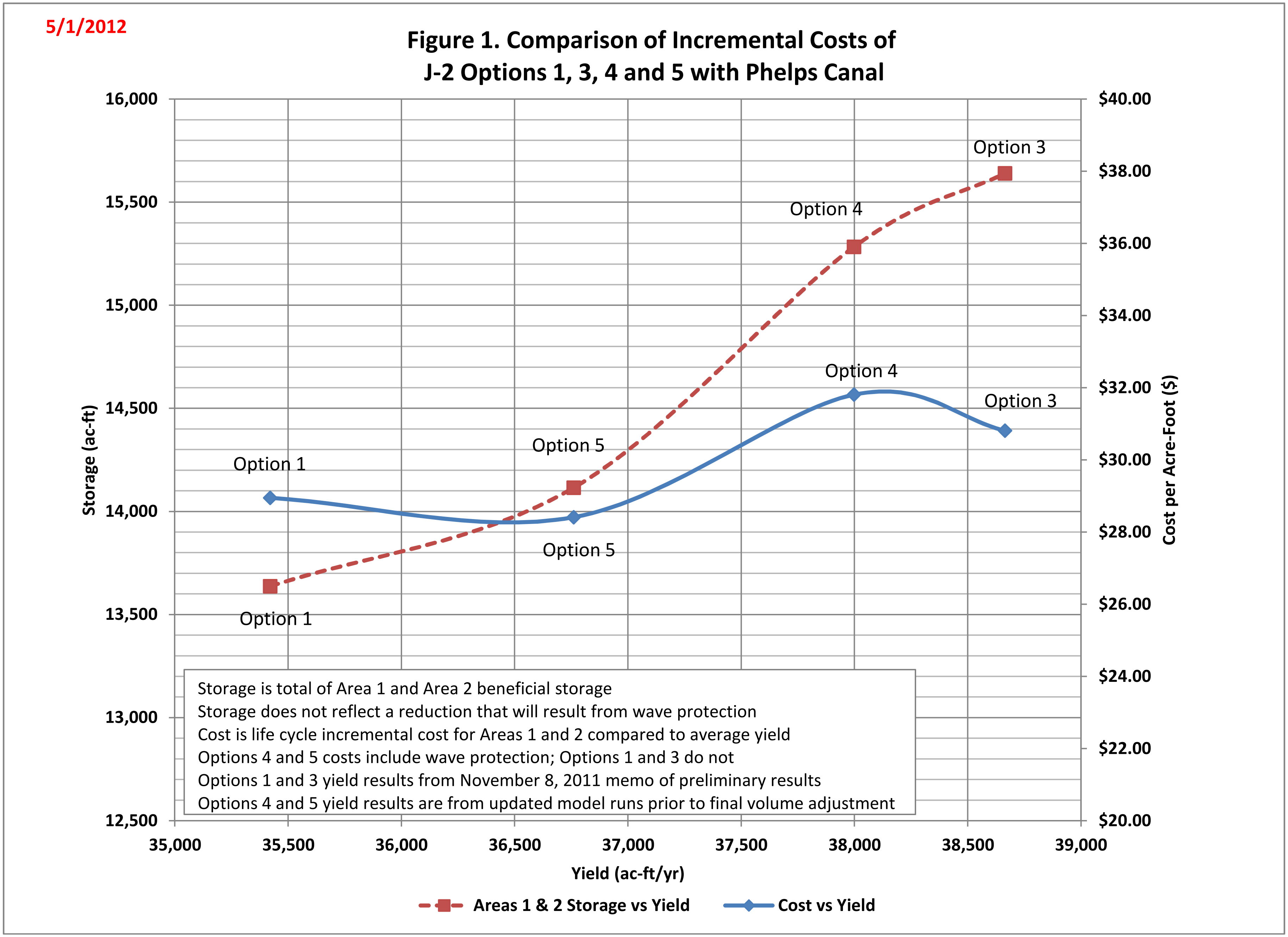
Protection of the Area 1 and Area 2 embankments against erosion from wave action was incorporated into the design. The recommended alternative entailed protection of the north and east embankments, those most susceptible to wave action due to the prevailing summer wind directions that are common in Central Nebraska. Rock riprap would be placed on the top 1/3 of the embankments and a gravel-surfaced beaching slope (12 horizontal feet to one vertical foot) would be constructed from the toe to approximately 3 feet above the dead pool.

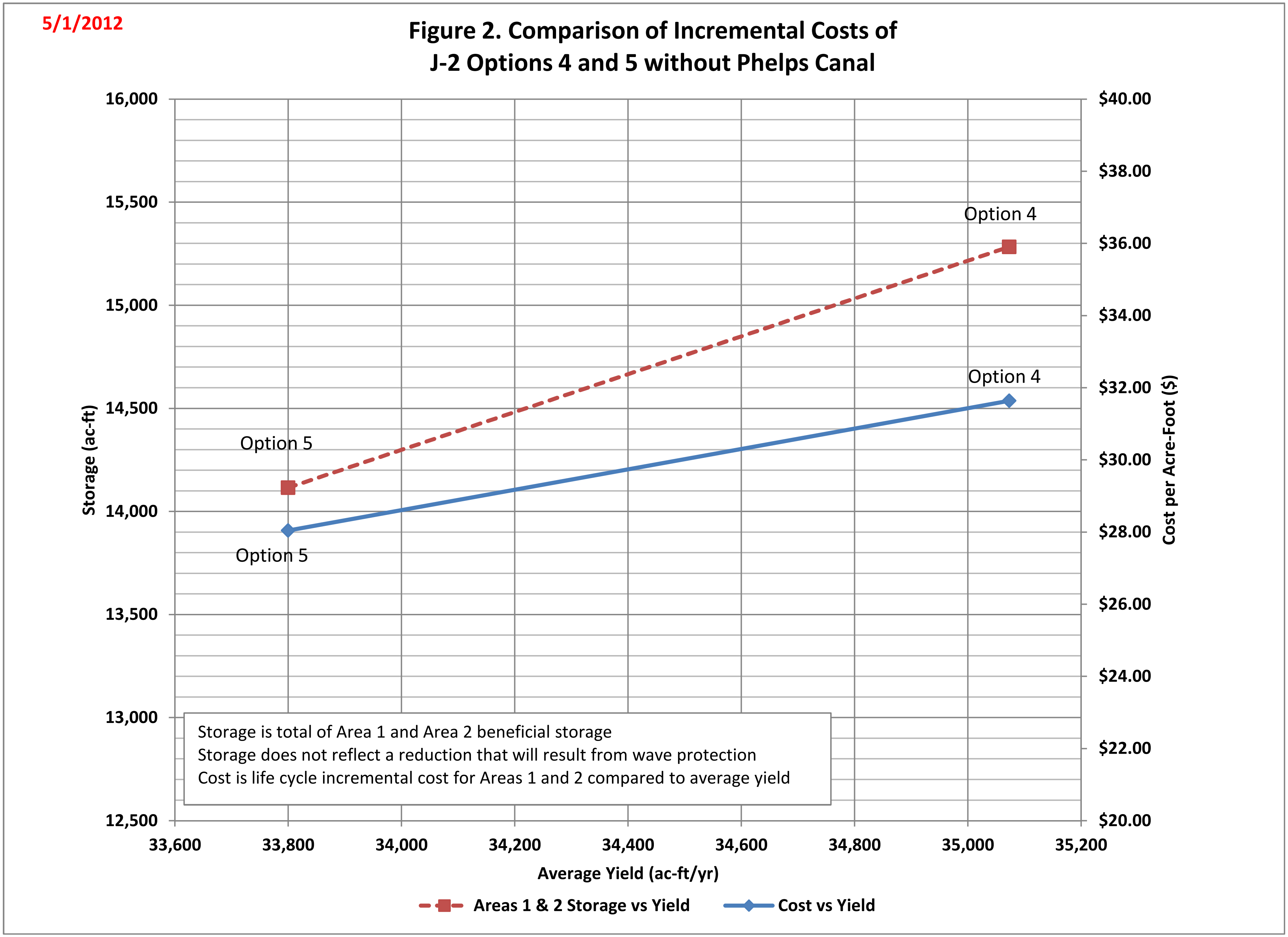
The net changes in the 50-year life cycle costs due to the changes are shown in the following table for Options 4 and 5 with the Phelps Canal upgrade.

	Life Cycle Cost per ac-ft of Water[1]	
Version	Option 4 with Phelps Canal	Option 5 with Phelps Canal
November 22, 2011	$27.85	$25.39
January 31, 2012	$28.15	$24.66
May 1, 2012	$31.81	$28.41

[1]The Program yield volume of water used in the per acre-foot cost was calculated prior to the final beneficial storage volume determination and wave protection.

Updated graphs, tables, and costs are included with this memorandum.


5/1/2012
Figure 1. Comparison of Incremental Costs of
J-2 Options 1, 3, 4 and 5 with Phelps Canal
16,000
15,500
15,000
14,500
14,000
13,500
13,000
12,500
Storage (ac-ft)
$40.00
$38.00
$36.00
$34.00
$32.00
$30.00
$28.00
$26.00
$24.00
$22.00
$20.00
Cost per Acre-Foot ($)
Option 3
Option 4
Option 4
Option 3
Option 5
Option 1
Option 5
Option 1
Storage is total of Area 1 and Area 2 beneficial storage
Storage does not reflect a reduction that will result from wave protection
Cost is life cycle incremental cost for Areas 1 and 2 compared to average yield
Options 4 and 5 costs include wave protection; Options 1 and 3 do not
Options 1 and 3 yield results from November 8, 2011 memo of preliminary results
Options 4 and 5 yield results are from updated model runs prior to final volume adjustment
35,000
35,500
36,000
36,500
37,000
37,500
38,000
38,500
39,000
Yield (ac-ft/yr)
Areas 1 & 2 Storage vs Yield
Cost vs Yield



5/1/2012
Figure 2. Comparison of Incremental Costs of
J-2 Options 4 and 5 without Phelps Canal
Storage (ac-ft)
16,000
15,500
15,000
14,500
14,000
13,500
13,000
12,500
Cost per Acre-Foot ($)
$40.00
$38.00
$36.00
$34.00
$32.00
$30.00
$28.00
$26.00
$24.00
$22.00
$20.00
Option 4
Option 4
Option 5
Option 5
Storage is total of Area 1 and Area 2 beneficial storage
Storage does not reflect a reduction that will result from wave protection
Cost is life cycle incremental cost for Areas 1 and 2 compared to average yield
33,600
33,800
34,000
34,200
34,400
34,600
34,800
35,000
35,200
Average Yield (ac-ft/yr)
Areas 1 & 2 Storage vs Yield
Cost vs Yield

Table 1. J-2 Alternatives Operation and Maintenance Costs without Phelps Canal

5/1/2012

Alternative	Beneficial Storage, acre-feet	Capital Costs ($000)	Operation Cost Rate	Pumped acre-feet	Pumping Costs @ $1.60/ac-ft ($000)	Pump Replacement ($000)	Annual Operating Cost ($000)	Equivalent Annual Cost ($000)	SDHF Augmentation, cfs	SDHF Augmentation, ac-ft/yr	Reductions to Shortages to Target Flows, Average Year ac-ft/yr	Delivered total ac-ft/yr	Life Cycle Cost per ac-ft
J -2 Option 4	15,283	$52,939	0.75%	5,300	8.48	10	$427.19	$1,486.17	2,000	11,901	35,073	46,974	$31.64
J -2 Option 5	14,115	$46,601	0.75%	0	0	0	$349.51	$1,281.53	2,000	11,901	33,800	45,701	$28.04

Assumptions

1. Option 4 includes hydrocycle mitigation, Area 2 pump capacity = 300 cfs, Area 1 outlet gate width = 36 feet, Area 2 outlet gate width = 20 feet, Area 2 available outside of irrigation season of June 15-August 31, Phelps Canal capacity = 1,000 cfs
2. Option 5 includes hydrocycle mitigation, no pumping into Area 2, Area 1 outlet gate width = 36 feet, Area 2 outlet gate width = 20 feet, Area 2 available outside of irrigation season of June 15-August 31, Phelps Canal capacity = 1,000 cfs
3. Options 4 and 5 storage areas included a dead pool of water over a clay liner. The dead pool volume was subtracted from the overall storage volume to determine the beneficial storage volume.
4. Life Cycle is 50 years.
5. Interest is not included in cost calculation.
6. Annual operations and maintenance cost of reservoirs is 0.75% of initial construction cost plus an additional 0.5% for the pump station.
7. Pumps will need to be replaced every 25 years.
8. Cost of pumping is $1.60 per acre-foot.
9. SDHF Augmentation is based on 3 days at 2000 cfs. Though the units are ac-ft per year, the values presented are the total volume of SDHF augmentation flows provided by the alernative over three days.
10. Water to reduce shortages to target flows is excess flows in CNPPID's system that could be stored during times of excess, and released during periods of shortage.

Table 2. Option 4 without Phelps Canal Upgrade

Option 4

J-2 - Alternative 2, Area 1, 5/1/2012

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 442,876.88	$ 442,876.88
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	49,200	CY	$ 5.00	$ 246,000.00
4	Core Trench	140,500	CY	$ 3.00	$ 421,500.00
5	Earth Fill, Class A Compaction	1,600,000	CY	$ 4.00	$ 6,400,000.00
6	Toe Drains	25,200	CY	$ 20.00	$ 504,000.00
7	Salvaging Topsoil, 6" Thick	56,000	CY	$ 4.00	$ 224,000.00
8	Compact existing Clay, 12" thick	867,000	CY	$ 2.00	$ 1,734,000.00
9	30' w x 12' h Sluice Gate Inlet (3@10'w x 12'h) with Controls, Elec. & Assoc. Work	3	EA	$ 648,000.00	$ 1,944,000.00
10	36' w x 28' h Radial Gate Outlet (2@18'w x 28'h) with Controls, Elec. & Assoc. Work	2	EA	$ 1,236,000.00	$ 2,472,000.00
11	18' w x 30' h Radial Phelps County Gate with Controls, Elec. & Assoc. Work	1	EA	$ 575,000.00	$ 575,000.00
12	Gravel Surfacing	4,700	CY	$ 15.00	$ 70,500.00
13	Seeding and Mulching	70	AC	$ 900.00	$ 63,000.00
14	Road Improvements	0.5	MI	$ 45,000.00	$ 22,500.00
15	Drain Tile	3,000	LF	$ 30.00	$ 90,000.00
16	Drain Tile Sand and Gravel, on site source	1,700	CY	$ 5.00	$ 8,500.00
17	Rip Rap Wave Protection	16,400	CY	$ 65.00	$ 1,066,000.00
18	Gravel Beaching Slope	71,900	CY	$ 25.00	$ 1,797,500.00
19	Ditch Grading	13000	CY	$ 5.00	$ 65,000.00
20	18" CMP, Galvanized 14 gauge	75	LF	$ 21.00	$ 1,575.00

Subtotal =	**$ 18,157,952**
25% Construction Contingency =	**$ 4,539,488**
Probable Construction Costs =	**$ 22,697,440**
Design (8%) =	**$ 1,815,795**
Permitting (2.5%) =	**$ 567,436**
Administrative and Legal (2.5%) =	**$ 567,436**
Construction Management and Administration (7%) =	**$ 1,588,821**
Land Acquisition Costs (718 ac @ $4,000 per ac plus three structures) =	**$ 3,472,000**
Total Estimated Project Cost =	**$ 30,708,928**

Option 4

J-2 - Alternative 2, Area 2, 5/1/2012

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 339,028.25	$ 339,028.25
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	25,000	CY	$ 5.00	$ 125,000.00
4	Earth Fill, Class A Compaction	962,802	CY	$ 4.00	$ 3,851,208.00
5	Core Trench	110,500	CY	$ 3.00	$ 331,500.00
6	Toe Drains	15,129	CY	$ 20.00	$ 302,580.00
7	Salvaging Topsoil, 6" Thick	32,000	CY	$ 4.00	$ 128,000.00
8	Compact existing clay, 12" thick	500,321	CY	$ 2.00	$ 1,000,642.00
9	21' w x 12' h Sluice Gate Inlet (3@7'w x 12'h) with Controls, Elec. & Assoc. Work	3	EA	$ 589,000.00	$ 1,767,000.00
10	20' w x 24' h Radial Gate Outlet (1@20'w x 24'h) with Controls, Elec. & Assoc. Work	1	EA	$ 1,479,000.00	$ 1,479,000.00
11	Pump Station - 4 pumps <150 hp, with Controls, Structure and Elec.	1	EA	$ 2,333,000.00	$ 2,333,000.00
12	Box Culvert under 748 road, 30' wide by 10' high	100	LF	$ 1,500.00	$ 150,000.00
13	Gravel Surfacing	5,640	CY	$ 15.00	$ 84,600.00
14	Seeding and Mulching	40	AC	$ 900.00	$ 36,000.00
15	Drain Tile	8,000	LF	$ 30.00	$ 240,000.00
16	Drain Tile Sand and Gravel, on site source	4,800	CY	$ 5.00	$ 24,000.00
17	Road Improvements	4.20	MI	$ 45,000.00	$ 189,000.00
18	Rip Rap Wave Protection	11,430	CY	$ 65.00	$ 742,950.00
19	Gravel Beaching Slope	27,600	CY	$ 25.00	$ 690,000.00
20	18" CMP, Galvanized 14 gauge	50	LF	$ 21.00	$ 1,050.00
21	Double 12' x 7' Box Culvert	1	LS	$ 75,600.00	$ 75,600.00

Subtotal =	**$ 13,900,158**
25% Construction Contingency =	**$ 3,475,040**
Probable Construction Costs =	**$ 17,375,198**
Design (8%) =	**$ 1,390,016**
Permitting (2.5%) =	**$ 434,380**
Administrative and Legal (2.5%) =	**$ 434,380**
Construction Management and Administration (7%) =	**$ 1,216,264**
Land Acquisition Costs (345 ac @ $4,000 per ac) =	**$ 1,380,000**
Total Estimated Project Cost =	**$ 22,230,237**
Total Area 1 and 2	**$ 52,939,165**

Table 3. Option 5 without Phelps Canal Upgrade

Option 5

J-2 - Alternative 2, Area 1, 5/1/2012

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 411,976.88	$ 411,976.88
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	49,200	CY	$ 5.00	$ 246,000.00
4	Core Trench	140,500	CY	$ 3.00	$ 421,500.00
5	Earth Fill, Class A Compaction	1,600,000	CY	$ 4.00	$ 6,400,000.00
6	Toe Drains	25,200	CY	$ 20.00	$ 504,000.00
7	Salvaging Topsoil, 6" Thick	56,000	CY	$ 4.00	$ 224,000.00
8	Compact existing Clay, 12" thick	867,000	CY	$ 2.00	$ 1,734,000.00
9	36' w x 10' h Sluice Gate Inlet (3@12'w x 10'h) with Controls, Elec. & Assoc. Work	3	EA	$ 648,000.00	$ 1,944,000.00
10	20' w x 28' h Radial Gate Outlet (1@20'w x 28'h) with Controls, Elec. & Assoc. Work	1	EA	$ 1,236,000.00	$ 1,236,000.00
11	30' w x 18' h Radial Phelps County Gate with Controls, Elec. & Assoc. Work	1	EA	$ 575,000.00	$ 575,000.00
12	Gravel Surfacing	4,700	CY	$ 15.00	$ 70,500.00
13	Seeding and Mulching	70	AC	$ 900.00	$ 63,000.00
14	Road Improvements	0.5	MI	$ 45,000.00	$ 22,500.00
15	Drain Tile	3,000	LF	$ 30.00	$ 90,000.00
16	Drain Tile Sand and Gravel, on site source	1,700	CY	$ 5.00	$ 8,500.00
17	Rip Rap Wave Protection	16,400	CY	$ 65.00	$ 1,066,000.00
18	Gravel Beaching Slope	71,900	CY	$ 25.00	$ 1,797,500.00
19	Ditch Grading	13000	CY	$ 5.00	$ 65,000.00
20	18" CMP, Galvanized 14 gauge	75	LF	$ 21.00	$ 1,575.00

Subtotal =	**$ 16,891,052**
25% Construction Contingency =	**$ 4,222,763**
Probable Construction Costs =	**$ 21,113,815**
Design (8%) =	**$ 1,689,105**
Permitting (2.5%) =	**$ 527,845**
Administrative and Legal (2.5%) =	**$ 527,845**
Construction Management and Administration (7%) =	**$ 1,477,967**
Land Acquisition Costs (718 ac @ $4,000 per ac plus three structures) =	**$ 3,472,000**
Total Estimated Project Cost =	**$ 28,808,578**

J-2 - Alternative 2, Area 2, 5/1/2012

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 266,873.05	$ 266,873.05
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	25,000	CY	$ 5.00	$ 125,000.00
4	Earth Fill, Class A Compaction	842,000	CY	$ 4.00	$ 3,368,000.00
5	Core Trench	110,500	CY	$ 3.00	$ 331,500.00
6	Toe Drains	15,129	CY	$ 20.00	$ 302,580.00
7	Salvaging Topsoil, 6" Thick	32,000	CY	$ 4.00	$ 128,000.00
8	Compact existing clay, 12" thick	500,321	CY	$ 2.00	$ 1,000,642.00
9	36' w x 12' h Sluice Gate Inlet (3@12'w x 12'h) with Controls, Elec. & Assoc. Work	3	EA	$ 638,000.00	$ 1,914,000.00
10	10' w x 24' h Radial Gate Outlet (1@10'w x 24'h) with Controls, Elec. & Assoc. Work	1	EA	$ 1,262,000.00	$ 1,262,000.00
11	Box Culvert under 748 road, 30' wide by 10' high	100	LF	$ 1,500.00	$ 150,000.00
12	Gravel Surfacing	5,640	CY	$ 15.00	$ 84,600.00
13	Seeding and Mulching	40	AC	$ 900.00	$ 36,000.00
14	Drain Tile	8,000	LF	$ 30.00	$ 240,000.00
15	Drain Tile Sand and Gravel, on site source	4,800	CY	$ 5.00	$ 24,000.00
16	Road Improvements	4.20	MI	$ 45,000.00	$ 189,000.00
17	Rip Rap Wave Protection	11,430	CY	$ 65.00	$ 742,950.00
18	Gravel Beaching Slope	27,600	CY	$ 25.00	$ 690,000.00
19	18" CMP, Galvanized 14 gauge	50	LF	$ 21.00	$ 1,050.00
20	Double 12' x 7' Box Culvert	1	LS	$ 75,600.00	$ 75,600.00

Subtotal =	**$ 10,941,795**
25% Construction Contingency =	**$ 2,735,449**
Probable Construction Costs =	**$ 13,677,244**
Design (8%) =	**$ 1,094,180**
Permitting (2.5%) =	**$ 341,931**
Administrative and Legal (2.5%) =	**$ 341,931**
Construction Management and Administration (7%) =	**$ 957,407**
Land Acquisition Costs (345 ac @ $4,000 per ac) =	**$ 1,380,000**
Total Estimated Project Cost =	**$ 17,792,693**
Total Area 1 and 2	**$ 46,601,270**

5/1/2012

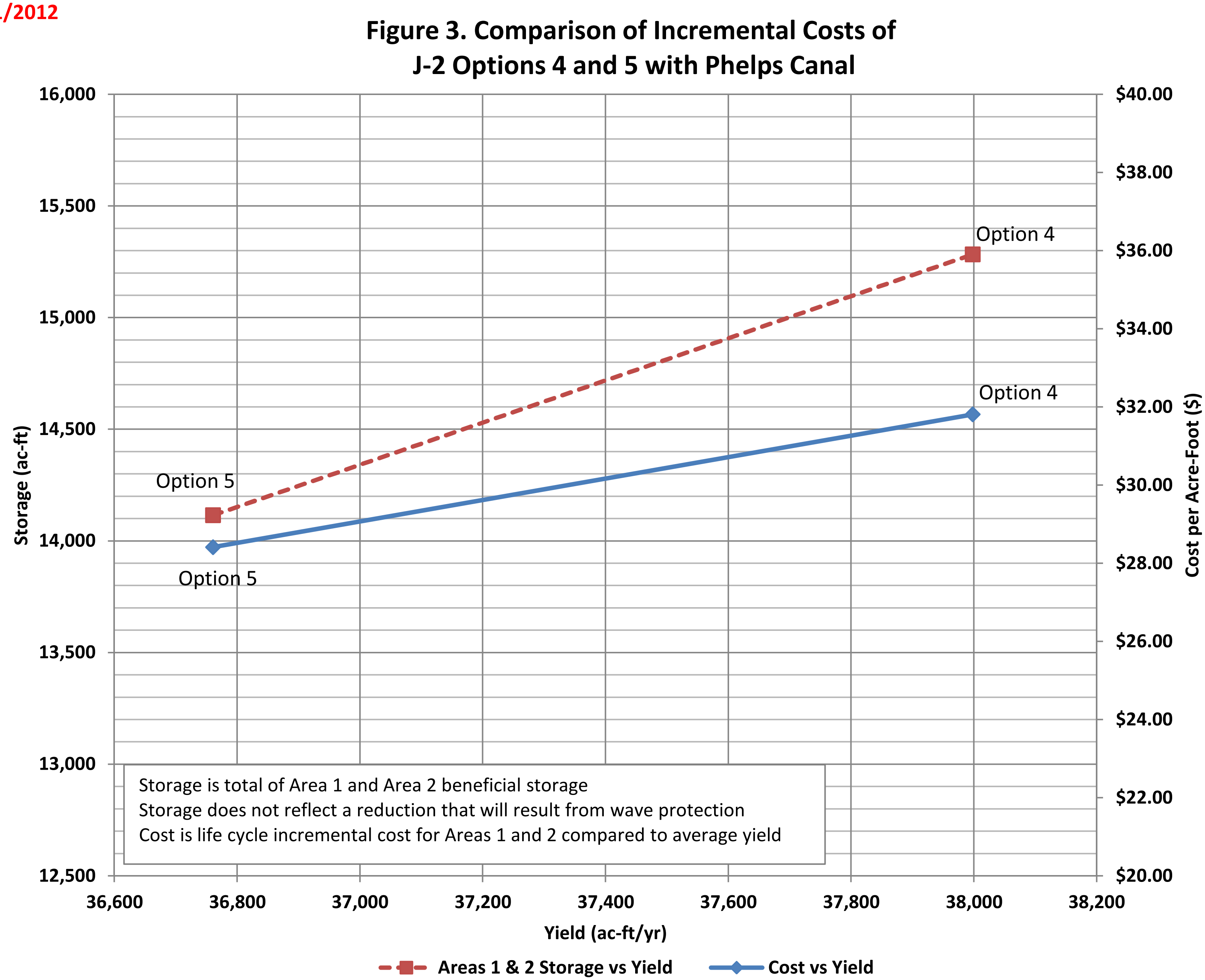


Figure 3. Comparison of Incremental Costs of
J-2 Options 4 and 5 with Phelps Canal
16,000
15,500
15,000
14,500
14,000
13,500
13,000
12,500
Storage (ac-ft)
$40.00
$38.00
$36.00
$34.00
$32.00
$30.00
$28.00
$26.00
$24.00
$22.00
$20.00
Cost per Acre-Foot ($)
Option 4
Option 4
Option 5
Option 5
Storage is total of Area 1 and Area 2 beneficial storage
Storage does not reflect a reduction that will result from wave protection
Cost is life cycle incremental cost for Areas 1 and 2 compared to average yield
36,600
36,800
37,000
37,200
37,400
37,600
37,800
38,000
38,200
Yield (ac-ft/yr)
Areas 1 & 2 Storage vs Yield
Cost vs Yield

Table 4. J-2 Alternatives Operation and Maintenance Costs with Phelps Canal

5/1/2012

Alternative	Beneficial Storage, acre-feet	Capital Costs ($000)	Operation Cost Rate	Pumped acre-feet	Pumping Costs @ $1.60/ac-ft ($000)	Pump Replacement ($000)	Annual Operating Cost ($000)	Equivalent Annual Cost ($000)	SDHF Augmentation, cfs	SDHF Augmentation, ac-ft/yr	Reductions to Shortages to Target Flows, Average Year ac-ft/yr	Delivered total ac-ft/yr	Life Cycle Cost per ac-ft
J -2 Option 4 with Phelps Canal	15,283	$56,046	0.75% 1.25%	5,300	8.48	10	$466.03	$1,587.16	2,000	11,901	37,998	49,899	$31.81
J -2 Option 5 with Phelps Canal	14,115	$49,708	0.75% 1.25%	0	0	0	$388.35	$1,382.52	2,000	11,901	36,761	48,662	$28.41

Assumptions

1. Option 4 includes hydrocycle mitigation, Area 2 pump capacity = 300 cfs, Area 1 outlet gate width = 36 feet, Area 2 outlet gate width = 20 feet, Area 2 available outside of irrigation season of June 15-August 31, Phelps Canal capacity = 1,675 cfs
2. Option 5 includes hydrocycle mitigation, no pumping into Area 2, Area 1 outlet gate width = 36 feet, Area 2 outlet gate width = 20 feet, Area 2 available outside of irrigation season of June 15-August 31, Phelps Canal capacity = 1,675 cfs
3. Options 4 and 5 storage areas included a dead pool of water over a clay liner. The dead pool volume was subtracted from the overall storage volume to determine the beneficial storage volume.
4. Life Cycle is 50 years.
5. Interest is not included in cost calculation.
6. Annual operations and maintenance cost of reservoirs is 0.75% of initial construction cost plus an additional 0.5% for the pump station.
7. Annual operations and maintenance cost of Phelps Canal is 1.25% of initial construction cost.
8. Pumps will need to be replaced every 25 years.
8. Cost of pumping is $1.60 per acre-foot.
9. SDHF Augmentation is based on 3 days at 2000 cfs. Though the units are ac-ft per year, the values presented are the total volume of SDHF augmentation flows provided by the alernative over three days.
10. Water to reduce shortages to target flows is excess flows in CNPPID's system that could be stored during times of excess, and released during periods of shortage.

Table 5. Option 4 with Phelps Canal Upgrade

Option 4

J-2 - Alternative 2, Area 1, 5/1/2012

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 442,876.88	$ 442,876.88
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	49,200	CY	$ 5.00	$ 246,000.00
4	Core Trench	140,500	CY	$ 3.00	$ 421,500.00
5	Earth Fill, Class A Compaction	1,600,000	CY	$ 4.00	$ 6,400,000.00
6	Toe Drains	25,200	CY	$ 20.00	$ 504,000.00
7	Salvaging Topsoil, 6" Thick	56,000	CY	$ 4.00	$ 224,000.00
8	Compact existing Clay, 12" thick	867,000	CY	$ 2.00	$ 1,734,000.00
9	30' w x 12' h Sluice Gate Inlet (3@10'w x 12'h) with Controls, Elec. & Assoc. Work	3	EA	$ 648,000.00	$ 1,944,000.00
10	36' w x 28' h Radial Gate Outlet (2@18'w x 28'h) with Controls, Elec. & Assoc. Work	2	EA	$ 1,236,000.00	$ 2,472,000.00
11	18' w x 30' h Radial Phelps County Gate with Controls, Elec. & Assoc. Work	1	EA	$ 575,000.00	$ 575,000.00
12	Gravel Surfacing	4,700	CY	$ 15.00	$ 70,500.00
13	Seeding and Mulching	70	AC	$ 900.00	$ 63,000.00
14	Road Improvements	0.5	MI	$ 45,000.00	$ 22,500.00
15	Drain Tile	3,000	LF	$ 30.00	$ 90,000.00
16	Drain Tile Sand and Gravel, on site source	1,700	CY	$ 5.00	$ 8,500.00
17	Rip Rap Wave Protection	16,400	CY	$ 65.00	$ 1,066,000.00
18	Gravel Beaching Slope	71,900	CY	$ 25.00	$ 1,797,500.00
19	Ditch Grading	13000	CY	$ 5.00	$ 65,000.00
20	18” CMP, Galvanized 14 gauge	75	LF	$ 21.00	$ 1,575.00

Subtotal =	**$ 18,157,952**
25% Construction Contingency =	**$ 4,539,488**
Probable Construction Costs =	**$ 22,697,440**
Design (8%) =	**$ 1,815,795**
Permitting (2.5%) =	**$ 567,436**
Administrative and Legal (2.5%) =	**$ 567,436**
Construction Management and Administration (7%) =	**$ 1,588,821**
Land Acquisition Costs (718 ac @ $4,000 per ac plus three structures) =	**$ 3,472,000**
Total Estimated Project Cost =	**$ 30,708,928**

Option 4

J-2 - Alternative 2, Area 2, 5/1/2012

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 339,028.25	$ 339,028.25
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	25,000	CY	$ 5.00	$ 125,000.00
4	Earth Fill, Class A Compaction	962,802	CY	$ 4.00	$ 3,851,208.00
5	Core Trench	110,500	CY	$ 3.00	$ 331,500.00
6	Toe Drains	15,129	CY	$ 20.00	$ 302,580.00
7	Salvaging Topsoil, 6" Thick	32,000	CY	$ 4.00	$ 128,000.00
8	Compact existing clay, 12" thick	500,321	CY	$ 2.00	$ 1,000,642.00
9	36' w x 7' h Sluice Gate Inlet (3@12'w x 7'h) with Controls, Elec. & Assoc. Work	3	EA	$ 589,000.00	$ 1,767,000.00
10	20' w x 24' h Radial Gate Outlet (1@20'w x 24'h) with Controls, Elec. & Assoc. Work	1	EA	$ 1,479,000.00	$ 1,479,000.00
11	Pump Station - 4 pumps <150 hp, with Controls, Structure and Elec.	1	EA	$ 2,333,000.00	$ 2,333,000.00
12	Box Culvert under 748 road, 30' wide by 10' high	100	LF	$ 1,500.00	$ 150,000.00
13	Gravel Surfacing	5,640	CY	$ 15.00	$ 84,600.00
14	Seeding and Mulching	40	AC	$ 900.00	$ 36,000.00
15	Drain Tile	8,000	LF	$ 30.00	$ 240,000.00
16	Drain Tile Sand and Gravel, on site source	4,800	CY	$ 5.00	$ 24,000.00
17	Road Improvements	4.20	MI	$ 45,000.00	$ 189,000.00
18	Rip Rap Wave Protection	11,430	CY	$ 65.00	$ 742,950.00
19	Gravel Beaching Slope	27,600	CY	$ 25.00	$ 690,000.00
20	18” CMP, Galvanized 14 gauge	50	LF	$ 21.00	$ 1,050.00
21	Double 12' x 7' Box Culvert	1	LS	$ 75,600.00	$ 75,600.00
22	Phelps Canal	1	LS	$ 2,071,447.00	$ 2,071,447.00

Subtotal =	**$ 15,971,605**
25% Construction Contingency =	**$ 3,992,901**
Probable Construction Costs =	**$ 19,964,507**
Design (8%) =	**$ 1,597,161**
Permitting (2.5%) =	**$ 499,113**
Administrative and Legal (2.5%) =	**$ 499,113**
Construction Management and Administration (7%) =	**$ 1,397,515**
Land Acquisition Costs (345 ac @ $4,000 per ac) =	**$ 1,380,000**
Total Estimated Project Cost =	**$ 25,337,408**
Total Areas 1 and 2	**$ 56,046,336**

Table 6. Option 5 with Phelps Canal Upgrade

Option 5

J-2 - Alternative 2, Area 1, 5/1/2012

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 411,976.88	$ 411,976.88
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	49,200	CY	$ 5.00	$ 246,000.00
4	Core Trench	140,500	CY	$ 3.00	$ 421,500.00
5	Earth Fill, Class A Compaction	1,600,000	CY	$ 4.00	$ 6,400,000.00
6	Toe Drains	25,200	CY	$ 20.00	$ 504,000.00
7	Salvaging Topsoil, 6" Thick	56,000	CY	$ 4.00	$ 224,000.00
8	Compact existing Clay, 12" thick	867,000	CY	$ 2.00	$ 1,734,000.00
9	36' w x 10' h Sluice Gate Inlet (3@12'w x 10'h) with Controls, Elec. & Assoc. Work	3	EA	$ 648,000.00	$ 1,944,000.00
10	20' w x 28' h Radial Gate Outlet (1@20'w x 28'h) with Controls, Elec. & Assoc. Work	1	EA	$ 1,236,000.00	$ 1,236,000.00
11	30' w x 18' h Radial Phelps County Gate with Controls, Elec. & Assoc. Work	1	EA	$ 575,000.00	$ 575,000.00
12	Gravel Surfacing	4,700	CY	$ 15.00	$ 70,500.00
13	Seeding and Mulching	70	AC	$ 900.00	$ 63,000.00
14	Road Improvements	0.5	MI	$ 45,000.00	$ 22,500.00
15	Drain Tile	3,000	LF	$ 30.00	$ 90,000.00
16	Drain Tile Sand and Gravel	1,700	CY	$ 5.00	$ 8,500.00
17	Rip Rap Wave Protection	16,400	CY	$ 65.00	$ 1,066,000.00
18	Gravel Beaching Slope	71,900	CY	$ 25.00	$ 1,797,500.00
19	Ditch Grading	13000	CY	$ 5.00	$ 65,000.00
20	18” CMP, Galvanized 14 gauge	75	LF	$ 21.00	$ 1,575.00

Subtotal =	**$ 16,891,052**
25% Construction Contingency =	**$ 4,222,763**
Probable Construction Costs =	**$ 21,113,815**
Design (8%) =	**$ 1,689,105**
Permitting (2.5%) =	**$ 527,845**
Administrative and Legal (2.5%) =	**$ 527,845**
Construction Management and Administration (7%) =	**$ 1,477,967**
Land Acquisition Costs (718 ac @ $4,000 per ac plus three structures) =	**$ 3,472,000**
Total Estimated Project Cost =	**$ 28,808,578**

Option 5

J-2 - Alternative 2, Area 2, 5/1/2012

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 266,873.05	$ 266,873.05
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	25,000	CY	$ 5.00	$ 125,000.00
4	Earth Fill, Class A Compaction	842,000	CY	$ 4.00	$ 3,368,000.00
5	Core Trench	110,500	CY	$ 3.00	$ 331,500.00
6	Toe Drains	15,129	CY	$ 20.00	$ 302,580.00
7	Salvaging Topsoil, 6" Thick	32,000	CY	$ 4.00	$ 128,000.00
8	Compact existing clay, 12" thick	500,321	CY	$ 2.00	$ 1,000,642.00
9	36' w x 12' h Sluice Gate Inlet (3@12'w x 12'h) with Controls, Elec. & Assoc. Work	3	EA	$ 638,000.00	$ 1,914,000.00
10	10' w x 24' h Radial Gate Outlet (1@10'w x 24'h) with Controls, Elec. & Assoc. Work	1	EA	$ 1,262,000.00	$ 1,262,000.00
11	Box Culvert under 748 road, 30' wide by 10' high	100	LF	$ 1,500.00	$ 150,000.00
12	Gravel Surfacing	5,640	CY	$ 15.00	$ 84,600.00
13	Seeding and Mulching	40	AC	$ 900.00	$ 36,000.00
14	Drain Tile	8,000	LF	$ 30.00	$ 240,000.00
15	Drain Tile Sand and Gravel, on site source	4,800	CY	$ 5.00	$ 24,000.00
16	Road Improvements	4.20	MI	$ 45,000.00	$ 189,000.00
17	Rip Rap Wave Protection	11,430	CY	$ 65.00	$ 742,950.00
18	Gravel Beaching Slope	27,600	CY	$ 25.00	$ 690,000.00
19	18” CMP, Galvanized 14 gauge	50	LF	$ 21.00	$ 1,050.00
20	Double 12' x 7' Box Culvert	1	LS	$ 75,600.00	$ 75,600.00
21	Phelps Canal	1	LS	$ 2,071,447.00	$ 2,071,447.00

Subtotal =	**$ 13,013,242**
25% Construction Contingency =	**$ 3,253,311**
Probable Construction Costs =	**$ 16,266,553**
Design (8%) =	**$ 1,301,324**
Permitting (2.5%) =	**$ 406,664**
Administrative and Legal (2.5%) =	**$ 406,664**
Construction Management and Administration (7%) =	**$ 1,138,659**
Land Acquisition Costs (345 ac @ $4,000 per ac) =	**$ 1,380,000**
Total Estimated Project Cost =	**$ 20,899,863**
Total Area 1 and 2	**$ 49,708,441**

Upgrade Phelps Canal

Gosper County, Nebraka

OLSSON PROJECT NO. 009-1466

Table 7. OPTIONS 4 & 5
PRELIMINARY STATEMENT OF PROBABLE CONSTRUCTION COSTS
IMPROVEMENTS TO CONVEY 1,675 CFS WITH 2 FEET OF FREEBOARD
WITH MAXIMUM HEADWATER ELEVATION AT MP 0 OF 2358.0
January 26, 2012

Item Number	Description	Appr. Quantity	Unit	Unit Price		Amount
1	Mobilization/Demobilization	1.0	LS	$ 105,000.00		$ 105,000.00
2	Construction Surveying	1.0	LS	$ 40,000.00		$ 40,000.00
3	Erosion Control	1.0	LS	$ 85,000.00		$ 85,000.00
4	Water Control	1.0	LS	$ 100,000.00		$ 100,000.00
5	Clearing and Grubbing	1.1	AC	$ 1,000.00		$ 1,100.00
6	Excavation, Haul Off-Site	30,196	CY	$ 3.00		$ 90,588.00
7	Excavation, Fill On-Site, Class A Compaction	10,593	CY	$ 4.00		$ 42,372.00
8	Salvaging and Spreading Topsoil	5,022	SY	$ 1.00		$ 5,022.00
9	Seeding and Mulching	1.1	AC	$ 1,100.00		$ 1,210.00
10	Rock Riprap Armoring, Class B	9,849	CY	$ 55.00		$ 541,695.00
11	Granular Filter Fabric	1,642	CY	$ 30.00		$ 49,260.00
12	Flume Modifications					$ 68,400.00
13	Reinforced Concrete	12	CY	$ 700.00	$ 8,400.00	---
14	Remove and Replace Beams	6	EA	$ 10,000.00	$ 60,000.00	---
15	Remove Parshall Flume	1	EA	$ 30,000.00		$ 30,000.00
16	New Parshall Flume	1	EA	$ 360,000.00		$ 360,000.00
17	12-Foot Corrugated Metal Pipe	300	LF	$ 400.00		$ 120,000.00
18	Plum Creek Siphon Inlet Modifications					$ 204,400.00
19	Concrete Demo	1	LS	$ 25,000.00	$ 25,000.00	---
20	Beams	1	LS	$ 50,000.00	$ 50,000.00	---
21	Buttresses	1	LS	$ 30,000.00	$ 30,000.00	---
22	Reinforced Concrete	142	CY	$ 700.00	$ 99,400.00	---
23	Plum Creek Siphon Outlet Modifications					$ 105,000.00
24	Concrete Demo	1	LS	$ 25,000.00	$ 25,000.00	---
25	Beams	1	LS	$ 50,000.00	$ 50,000.00	---
26	Buttresses	1	LS	$ 30,000.00	$ 30,000.00	---
25	Reinforced Concrete	226	CY	$ 700.00	$ 158,200.00	---
26	102'x16' Bridge Farm Access	1,632	SF	$ 75.00		$ 122,400.00
					Subtotal =	**$ 2,071,447.00**
					25% Construction Contingency =	**$ 517,861.75**
					Probable Construction Costs =	**$ 2,589,308.75**
					Design (8%) =	**$ 207,145**
					Permitting (2.5%) =	**$ 64,733**
					Administrative and Legal (2.5%) =	**$ 64,733**
					Construction Management and Administration (7%) =	**$ 181,252**
					Total Estimated Project Cost =	**$ 3,107,170.50**

Assumptions:

1. Improvements consist of widening the canal upstream of the Parshall flume and siphon, replacing the Parshall flume, modifying the Plum Creek siphon and flume at Mile 3.15 and replacement of one bridge.
2. Land acquisition for additional right of way is not included.
3. Temporary construction easements not included.

OLSSON ASSOCIATES

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☒	Other: email

TO:	Beorn Courtney
CC:	Eric Dove, File
FROM:	Deb Ohlinger
RE:	Incremental Cost Analysis for Reservoir Combined Operations (Update)
DATE:	January 31, 2012
PROJECT #:	B09-1466

Introduction

Olsson Associates (Olsson) completed an incremental cost analysis to compare alternatives consisting of different Area 1 and Area 2 configurations. The analysis was documented in a memorandum dated November 22, 2011. Further refinements have been made since the memorandum was issued.

Changes since November 22, 2011 Incremental Cost Analysis

The geotechnical recommendations were reviewed after the options were refined to determine whether the recommendations were still relevant or whether new issues needed to be addressed. At that time, a clarification was made regarding the protective clay liner and/or dead pool of water needed in the bottom of Areas 1 and 2. Alternatives for protecting the clay liner were as follows:

1. If a vegetative cover is used (as in Option 1), the 12-inch clay liner must be buried approximately three feet down, or generally below frost line. In the November 2011 incremental cost analysis, only 12 inches of cover were included in the cost. The actual construction cost would be approximately $8 million higher, making Option 1 less feasible than it already is. Due to the high cost, this type of protection was not considered further. Nothing was changed in the incremental cost analysis since Option 1 was not under further consideration.
2. A dead pool of water must be used (Options 3, 4, and 5). The bottom of Areas 1 and 2 would consist of 12 inches of compacted clay liner placed 12 inches below finished grade and covered by 12 inches of soil plus 12 inches of water at all times.
3. In lieu of 12 inches of soil, the compacted clay liner can be covered by 24 inches of water. This option was used in determining the revised grading and cost for Option 5 presented in this report. The storage areas were regraded to maintain the same beneficial storage. The Area 1 beneficial storage increased from 10,473 acre-feet to 10,941 acre-feet. The Area 2 beneficial storage decreased from 3,486 acre-feet to 3,174 acre-feet. The total beneficial storage increased from 13,959 to 14,115 acre-feet. The continuous simulation modeling was not redone with the final Option 5 beneficial storage, but the storage volume was included in the revised tables and charts in the updated incremental cost analysis.

Additional changes were made to the design and cost estimates.

- A small amount of grading was added to achieve two feet of freeboard along the berm between Area 1 and Phelps Canal (see Section 2.1 for a discussion of Phelps Canal). The unit price of structural concrete was also increased. The cost of the Phelps Canal improvements, therefore, increased from the November 22, 2011 incremental cost analysis.
- It was determined that a synthetic liner that had been included for the Phelps Canal could be eliminated and drain tile expanded.
- Due to the refinements made, the construction contingency percentage was reduced from 30% to 25%.
- The gate sizes were re-evaluated for the Option 5 parameters. The outlet gates were significantly reduced in size. Updated costs were prepared and incorporated into the updated incremental cost analysis. Costs for the gates were not re-evaluated for Option 4. If the gates were re-evaluated for Option 4 and gates similar to those in Option 5 could be used, the cost decrease would be expected to be approximately $1 million. The life cycle cost would decrease by approximately $0.60.

The net changes in the 50-year life cycle costs due to the changes were minimal. The following table shows the difference for Options 4 and 5 with the Phelps Canal upgrade.

	Life Cycle Cost per ac-ft of Water[1]	
Version	Option 4 with Phelps Canal	Option 5 with Phelps Canal
November 22, 2011	$27.85	$25.39
January 31, 2012	$28.15	$24.66

[1]The Program yield volume of water used in the per acre-foot cost was calculated prior to the final beneficial storage volume determination.

Updated graphs, tables, and costs are included with this memorandum.

Figure 1. Comparison of Incremental Costs of J-2 Options 1, 3, 4 and 5 with Phelps Canal

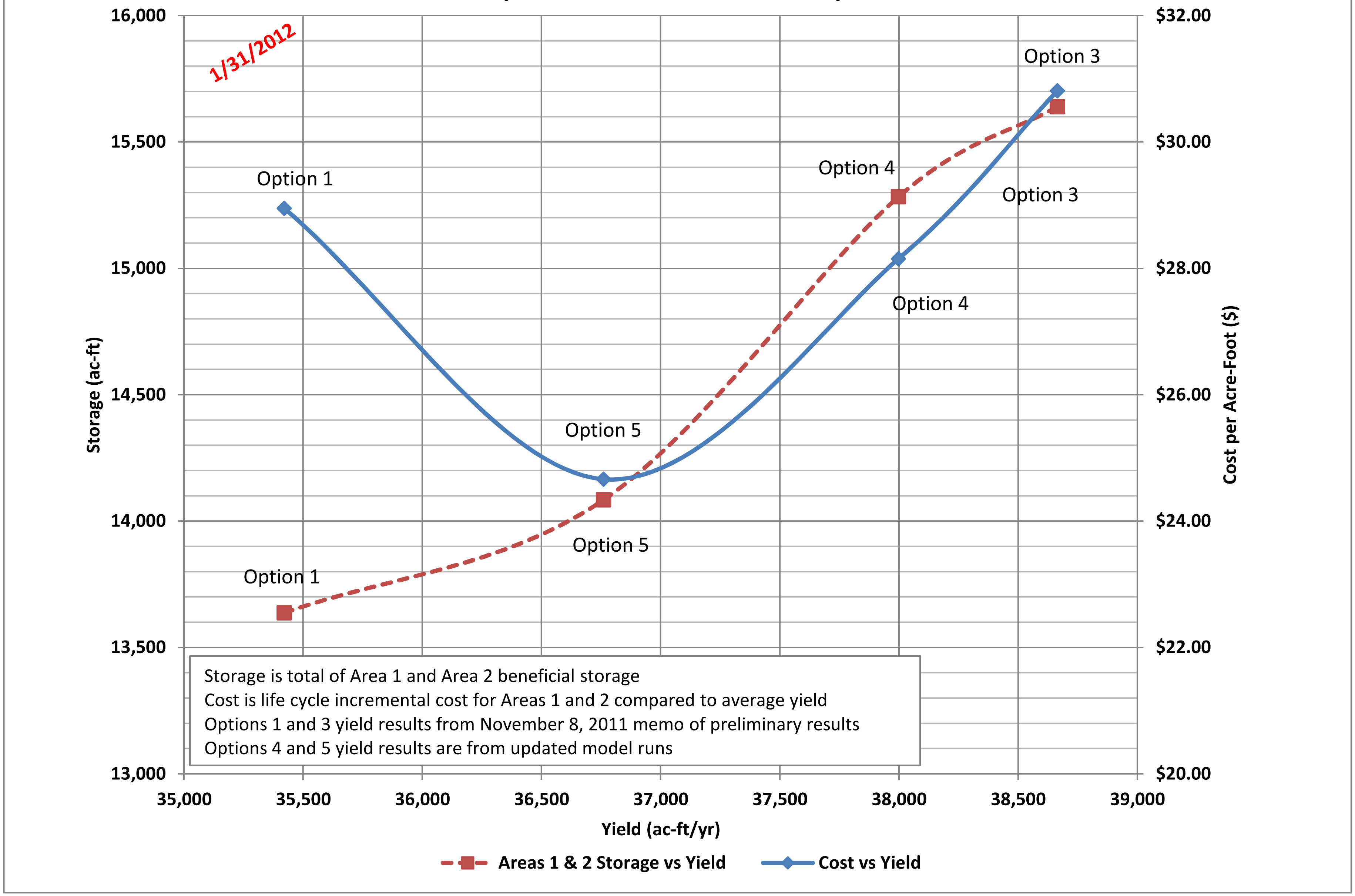


Figure 2. Comparison of Incremental Costs of J-2 Options 4 and 5 without Phelps Canal

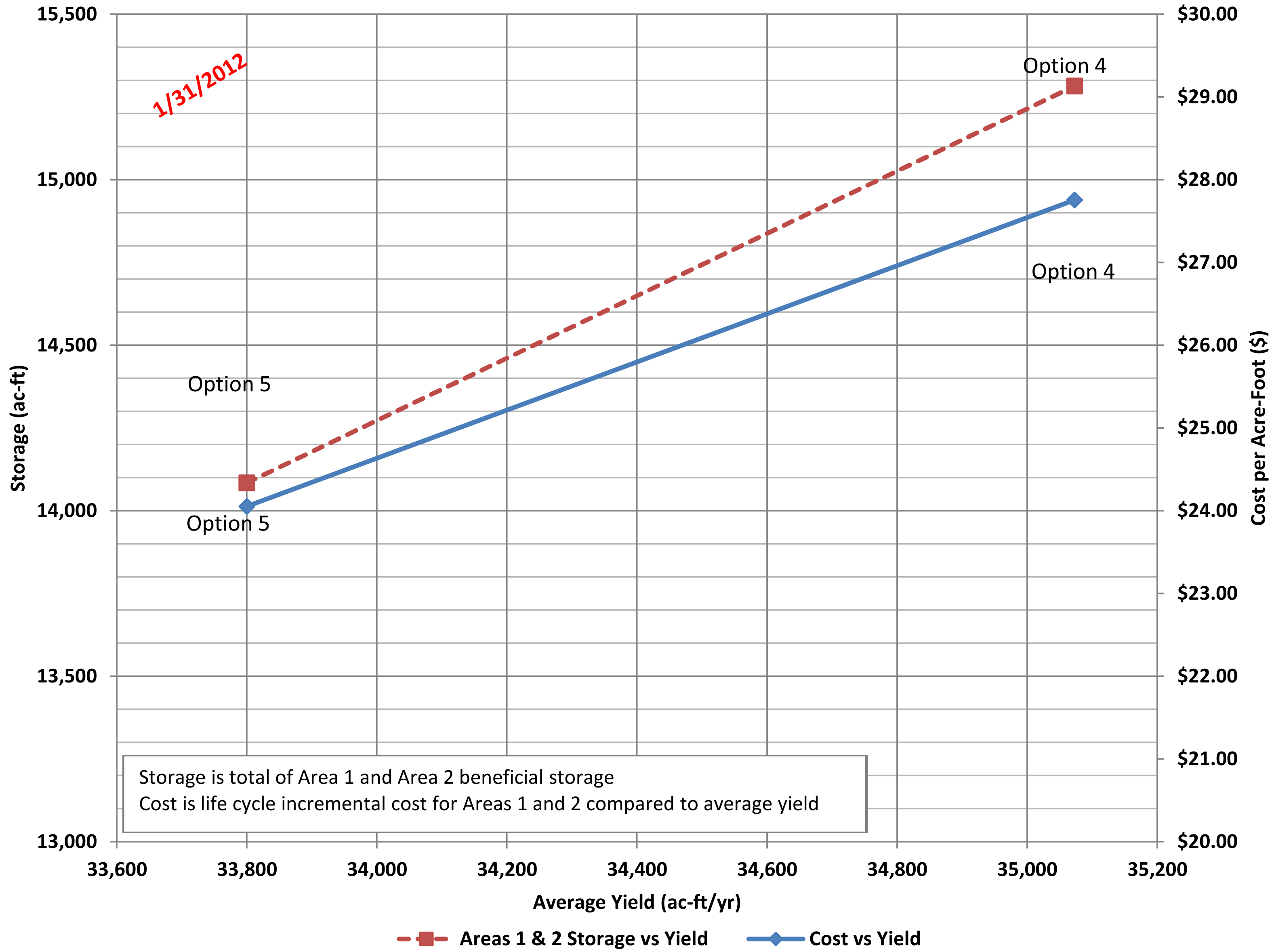


Table 1. J-2 Alternatives Operation and Maintenance Costs without Phelps Canal

1/31/2012

Alternative	Beneficial Storage, acre-feet	Capital Costs ($000)	Operation Cost Rate	Pumped acre-feet	Pumping Costs @ $1.60/ac-ft ($000)	Pump Replacement ($000)	Annual Operating Cost ($000)	Equivalent Annual Cost ($000)	SDHF Augmentation, cfs	SDHF Augmentation, ac-ft/yr	Reductions to Shortages to Target Flows, Average Year ac-ft/yr	Delivered total ac-ft/yr	Life Cycle Cost per ac-ft
J -2 Option 4	15,283	$46,306	0.75%	5,300	8.48	10	$377.44	$1,303.77	2,000	11,901	35,073	46,974	$27.76
J -2 Option 5	14,084	$39,969	0.75%	0	0	0	$299.76	$1,099.14	2,000	11,901	33,800	45,701	$24.05

Assumptions

1. Option 4 includes hydrocycle mitigation, Area 2 pump capacity = 300 cfs, Area 1 outlet gate width = 36 feet, Area 2 outlet gate width = 20 feet, Area 2 available outside of irrigation season of June 15-August 31, Phelps Canal capacity = 1,000 cfs
2. Option 5 includes hydrocycle mitigation, no pumping into Area 2, Area 1 outlet gate width = 36 feet, Area 2 outlet gate width = 20 feet, Area 2 available outside of irrigation season of June 15-August 31, Phelps Canal capacity = 1,000 cfs
3. Options 4 and 5 storage areas included a dead pool of water over a clay liner. The dead pool volume was subtracted from the overall storage volume to determine the beneficial storage volume.
4. Life Cycle is 50 years.
5. Interest is not included in cost calculation.
6. Annual operations and maintenance cost of reservoirs is 0.75% of initial construction cost plus an additional 0.5% for the pump station.
7. Pumps will need to be replaced every 25 years.
8. Cost of pumping is $1.60 per acre-foot.
9. SDHF Augmentation is based on 3 days at 2000 cfs. Though the units are ac-ft per year, the values presented are the total volume of SDHF augmentation flows provided by the alernative over three days.
10. Water to reduce shortages to target flows is excess flows in CNPPID's system that could be stored during times of excess, and released during periods of shortage.

Table 2. Option 4 without Phelps Canal Upgrade

Option 4

J-2 - Alternative 2, Area 1 Updated 1-31-12

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 366,600.00	$ 366,600.00
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	49,200	CY	$ 5.00	$ 246,000.00
4	Core Trench	140,500	CY	$ 3.00	$ 421,500.00
5	Earth Fill, Class A Compaction	1,600,000	CY	$ 4.00	$ 6,400,000.00
6	Toe Drains	25,200	CY	$ 20.00	$ 504,000.00
7	Salvaging Topsoil, 6" Thick	56,000	CY	$ 4.00	$ 224,000.00
8	Compact existing Clay, 12" thick	867,000	CY	$ 2.00	$ 1,734,000.00
9	30' w x 12' h Sluice Gate Inlet (3@10'w x 12'h) with Controls, Elec. & Assoc. W	3	EA	$ 648,000.00	$ 1,944,000.00
10	36' w x 28' h Radial Gate Outlet (2@18'w x 28'h) with Controls, Elec. & Assoc	2	EA	$ 1,236,000.00	$ 2,472,000.00
11	18' w x 30' h Radial Phelps County Gate with Controls, Elec. & Assoc. Work	1	EA	$ 575,000.00	$ 575,000.00
12	Gravel Surfacing	4,700	CY	$ 15.00	$ 70,500.00
13	Seeding and Mulching	70	AC	$ 900.00	$ 63,000.00
14	Road Improvements	0.5	MI	$ 45,000.00	$ 22,500.00
15	Drain Tile	3,000	LF	$ 30.00	$ 90,000.00
16	Drain Tile Sand and Gravel, on site source	1,700	CY	$ 5.00	$ 8,500.00
17	Ditch Grading	13000	CY	$ 5.00	$ 65,000.00
18	18" CMP, Galvanized 14 gauge	75	LF	$ 21.00	$ 1,575.00

Subtotal =	**$**	**15,218,175**
25% Construction Contingency =	**$**	**3,804,544**
Probable Construction Costs =	**$**	**19,022,719**
Design (8%) =	**$**	**1,521,818**
Permitting (2.5%) =	**$**	**475,568**
Administrative and Legal (2.5%) =	**$**	**475,568**
Construction Management and Administration (7%) =	**$**	**1,331,590**
Land Acquisition Costs (718 ac @ $4,000 per ac plus three structures) =	**$**	**3,472,000**
Total Estimated Project Cost =	**$**	**26,299,263**

Option 4

J-2 - Alternative 2, Area 2 Updated 1-31-12

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 289,963.25	$ 289,963.25
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	25,000	CY	$ 5.00	$ 125,000.00
4	Earth Fill, Class A Compaction	962,802	CY	$ 4.00	$ 3,851,208.00
5	Core Trench	110,500	CY	$ 3.00	$ 331,500.00
6	Toe Drains	15,129	CY	$ 20.00	$ 302,580.00
7	Salvaging Topsoil, 6" Thick	32,000	CY	$ 4.00	$ 128,000.00
8	Compact existing clay, 12" thick	500,321	CY	$ 2.00	$ 1,000,642.00
9	21' w x 12' h Sluice Gate Inlet (3@7'w x 12'h) with Controls, Elec. & Assoc. W	3	EA	$ 589,000.00	$ 1,767,000.00
10	20' w x 24' h Radial Gate Outlet (1@20'w x 24'h) with Controls, Elec. & Assoc	1	EA	$ 1,479,000.00	$ 1,479,000.00
11	Pump Station - 4 pumps <150 hp, with Controls, Structure and Elec.	1	EA	$ 2,333,000.00	$ 2,333,000.00
12	Box Culvert under 748 road, 30' wide by 10' high	100	LF	$ 1,500.00	$ 150,000.00
13	Gravel Surfacing	5,640	CY	$ 15.00	$ 84,600.00
14	Seeding and Mulching	40	AC	$ 900.00	$ 36,000.00
15	Drain Tile	8,000	LF	$ 30.00	$ 240,000.00
16	Drain Tile Sand and Gravel, on site source	4,800	CY	$ 5.00	$ 24,000.00
17	Road Improvements	4.20	MI	$ 45,000.00	$ 189,000.00
18	18" CMP, Galvanized 14 gauge	50	LF	$ 21.00	$ 1,050.00
19	Double 12' x 7' Box Culvert	1	LS	$ 75,600.00	$ 75,600.00

Subtotal =	**$**	**12,418,143**
25% Construction Contingency =	**$**	**3,104,536**
Probable Construction Costs =	**$**	**15,522,679**
Design (8%) =	**$**	**1,241,814**
Permitting (2.5%) =	**$**	**388,067**
Administrative and Legal (2.5%) =	**$**	**388,067**
Construction Management and Administration (7%) =	**$**	**1,086,588**
Land Acquisition Costs (345 ac @ $4,000 per ac) =	**$**	**1,380,000**
Total Estimated Project Cost =	**$**	**20,007,215**
Total Area 1 and 2	**$**	**46,306,477**

Table 3. Option 5 without Phelps Canal Upgrade

Option 5

J-2 - Alternative 2, Area 1 Updated 1-31-12

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 335,700.00	$ 335,700.00
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	49,200	CY	$ 5.00	$ 246,000.00
4	Core Trench	140,500	CY	$ 3.00	$ 421,500.00
5	Earth Fill, Class A Compaction	1,600,000	CY	$ 4.00	$ 6,400,000.00
6	Toe Drains	25,200	CY	$ 20.00	$ 504,000.00
7	Salvaging Topsoil, 6" Thick	56,000	CY	$ 4.00	$ 224,000.00
8	Compact existing Clay, 12" thick	867,000	CY	$ 2.00	$ 1,734,000.00
9	36' w x 10' h Sluice Gate Inlet (3@12'w x 10'h) with Controls, Elec. & A	3	EA	$ 648,000.00	$ 1,944,000.00
10	20' w x 28' h Radial Gate Outlet (1@20'w x 28'h) with Controls, Elec. &	1	EA	$ 1,236,000.00	$ 1,236,000.00
11	30' w x 18' h Radial Phelps County Gate with Controls, Elec. & Assoc. V	1	EA	$ 575,000.00	$ 575,000.00
12	Gravel Surfacing	4,700	CY	$ 15.00	$ 70,500.00
13	Seeding and Mulching	70	AC	$ 900.00	$ 63,000.00
14	Road Improvements	0.5	MI	$ 45,000.00	$ 22,500.00
15	Drain Tile	3,000	LF	$ 30.00	$ 90,000.00
16	Drain Tile Sand and Gravel, on site source	1,700	CY	$ 5.00	$ 8,500.00
17	Ditch Grading	13000	CY	$ 5.00	$ 65,000.00
18	18" CMP, Galvanized 14 gauge	75	LF	$ 21.00	$ 1,575.00

Subtotal =	$	**13,951,275**
25% Construction Contingency =	$	**3,487,819**
Probable Construction Costs =	$	**17,439,094**
Design (8%) =	$	**1,395,128**
Permitting (2.5%) =	$	**435,977**
Administrative and Legal (2.5%) =	$	**435,977**
Construction Management and Administration (7%) =	$	**1,220,737**
Land Acquisition Costs (718 ac @ $4,000 per ac plus three structures) =	$	**3,472,000**
Total Estimated Project Cost =	$	**24,398,913**

J-2 - Alternative 2, Area 2 Updated 1-31-12

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 217,808.05	$ 217,808.05
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	25,000	CY	$ 5.00	$ 125,000.00
4	Earth Fill, Class A Compaction	842,000	CY	$ 4.00	$ 3,368,000.00
5	Core Trench	110,500	CY	$ 3.00	$ 331,500.00
6	Toe Drains	15,129	CY	$ 20.00	$ 302,580.00
7	Salvaging Topsoil, 6" Thick	32,000	CY	$ 4.00	$ 128,000.00
8	Compact existing clay, 12" thick	500,321	CY	$ 2.00	$ 1,000,642.00
9	36' w x 12' h Sluice Gate Inlet (3@12'w x 12'h) with Controls, Elec. & A	3	EA	$ 638,000.00	$ 1,914,000.00
10	10' w x 24' h Radial Gate Outlet (1@10'w x 24'h) with Controls, Elec. &	1	EA	$ 1,262,000.00	$ 1,262,000.00
11	Box Culvert under 748 road, 30' wide by 10' high	100	LF	$ 1,500.00	$ 150,000.00
12	Gravel Surfacing	5,640	CY	$ 15.00	$ 84,600.00
13	Seeding and Mulching	40	AC	$ 900.00	$ 36,000.00
14	Drain Tile	8,000	LF	$ 30.00	$ 240,000.00
15	Drain Tile Sand and Gravel, on site source	4,800	CY	$ 5.00	$ 24,000.00
16	Road Improvements	4.20	MI	$ 45,000.00	$ 189,000.00
17	18" CMP, Galvanized 14 gauge	50	LF	$ 21.00	$ 1,050.00
18	Double 12' x 7' Box Culvert	1	LS	$ 75,600.00	$ 75,600.00

Subtotal =	$	**9,459,780**
25% Construction Contingency =	$	**2,364,945**
Probable Construction Costs =	$	**11,824,725**
Design (8%) =	$	**945,978**
Permitting (2.5%) =	$	**295,618**
Administrative and Legal (2.5%) =	$	**295,618**
Construction Management and Administration (7%) =	$	**827,731**
Land Acquisition Costs (345 ac @ $4,000 per ac) =	$	**1,380,000**
Total Estimated Project Cost =	$	**15,569,670**
Total Area 1 and 2	$	**39,968,583**

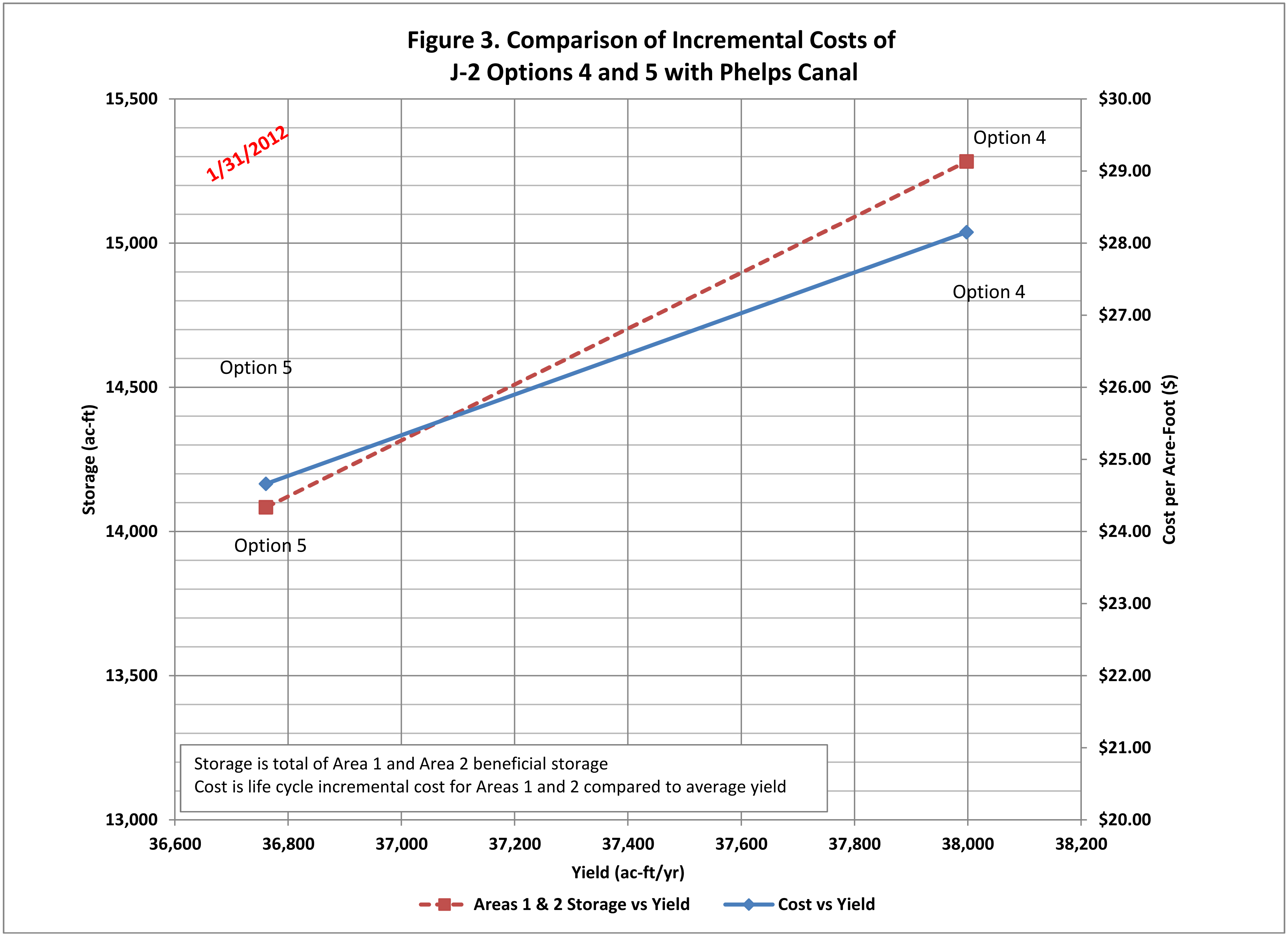


Figure 3. Comparison of Incremental Costs of
J-2 Options 4 and 5 with Phelps Canal
1/31/2012
15,500
15,000
14,500
14,000
13,500
13,000
Storage (ac-ft)
$30.00
$29.00
$28.00
$27.00
$26.00
$25.00
$24.00
$23.00
$22.00
$21.00
$20.00
Cost per Acre-Foot ($)
Option 4
Option 4
Option 5
Option 5
Storage is total of Area 1 and Area 2 beneficial storage
Cost is life cycle incremental cost for Areas 1 and 2 compared to average yield
36,600
36,800
37,000
37,200
37,400
37,600
37,800
38,000
38,200
Yield (ac-ft/yr)
Areas 1 & 2 Storage vs Yield
Cost vs Yield

Table 4. J-2 Alternatives Operation and Maintenance Costs with Phelps Canal

1/31/2012

Alternative	Beneficial Storage, acre-feet	Capital Costs ($000)	Operation Cost Rate	Pumped acre-feet	Pumping Costs @ $1.60/ac-ft ($000)	Pump Replacement ($000)	Annual Operating Cost ($000)	Equivalent Annual Cost ($000)	SDHF Augmentation, cfs	SDHF Augmentation, ac-ft/yr	Reductions to Shortages to Target Flows, Average Year ac-ft/yr	Delivered total ac-ft/yr	Life Cycle Cost per ac-ft
J -2 Option 4 with Phelps Canal	15,283	$49,414	0.75% 1.25%	5,300	8.48	10	$416.28	$1,404.76	2,000	11,901	37,998	49,899	$28.15
J -2 Option 5 with Phelps Canal	14,084	$43,076	0.75% 1.25%	0	0	0	$338.60	$1,200.12	2,000	11,901	36,761	48,662	$24.66

Assumptions

1. Option 4 includes hydrocycle mitigation, Area 2 pump capacity = 300 cfs, Area 1 outlet gate width = 36 feet, Area 2 outlet gate width = 20 feet, Area 2 available outside of irrigation season of June 15-August 31, Phelps Canal capacity = 1,675 cfs
2. Option 5 includes hydrocycle mitigation, no pumping into Area 2, Area 1 outlet gate width = 36 feet, Area 2 outlet gate width = 20 feet, Area 2 available outside of irrigation season of June 15-August 31, Phelps Canal capacity = 1,675 cfs
3. Options 4 and 5 storage areas included a dead pool of water over a clay liner. The dead pool volume was subtracted from the overall storage volume to determine the beneficial storage volume.
4. Life Cycle is 50 years.
5. Interest is not included in cost calculation.
6. Annual operations and maintenance cost of reservoirs is 0.75% of initial construction cost plus an additional 0.5% for the pump station.
7. Annual operations and maintenance cost of Phelps Canal is 1.25% of initial construction cost.
8. Pumps will need to be replaced every 25 years.
8. Cost of pumping is $1.60 per acre-foot.
9. SDHF Augmentation is based on 3 days at 2000 cfs. Though the units are ac-ft per year, the values presented are the total volume of SDHF augmentation flows provided by the alernative over three days.
10. Water to reduce shortages to target flows is excess flows in CNPPID's system that could be stored during times of excess, and released during periods of shortage.

Table 5. Option 4 with Phelps Canal Upgrade

Option 4

J-2 - Alternative 2, Area 1 Updated 1-31-12

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 366,600.00	$ 366,600.00
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	49,200	CY	$ 5.00	$ 246,000.00
4	Core Trench	140,500	CY	$ 3.00	$ 421,500.00
5	Earth Fill, Class A Compaction	1,600,000	CY	$ 4.00	$ 6,400,000.00
6	Toe Drains	25,200	CY	$ 20.00	$ 504,000.00
7	Salvaging Topsoil, 6" Thick	56,000	CY	$ 4.00	$ 224,000.00
8	Compact existing Clay, 12" thick	867,000	CY	$ 2.00	$ 1,734,000.00
9	30' w x 12' h Sluice Gate Inlet (3@10'w x 12'h) with Controls, Elec. & Assoc. Work	3	EA	$ 648,000.00	$ 1,944,000.00
10	36' w x 28' h Radial Gate Outlet (2@18'w x 28'h) with Controls, Elec. & Assoc. Work	2	EA	$ 1,236,000.00	$ 2,472,000.00
11	18' w x 30' h Radial Phelps County Gate with Controls, Elec. & Assoc. Work	1	EA	$ 575,000.00	$ 575,000.00
12	Gravel Surfacing	4,700	CY	$ 15.00	$ 70,500.00
13	Seeding and Mulching	70	AC	$ 900.00	$ 63,000.00
14	Road Improvements	0.5	MI	$ 45,000.00	$ 22,500.00
15	Drain Tile	3,000	LF	$ 30.00	$ 90,000.00
16	Drain Tile Sand and Gravel, on site source	1,700	CY	$ 5.00	$ 8,500.00
17	Ditch Grading	13000	CY	$ 5.00	$ 65,000.00
18	18” CMP, Galvanized 14 gauge	75	LF	$ 21.00	$ 1,575.00

Subtotal =	**$ 15,218,175**
25% Construction Contingency =	**$ 3,804,544**
Probable Construction Costs =	**$ 19,022,719**
Design (8%) =	**$ 1,521,818**
Permitting (2.5%) =	**$ 475,568**
Administrative and Legal (2.5%) =	**$ 475,568**
Construction Management and Administration (7%) =	**$ 1,331,590**
Land Acquisition Costs (718 ac @ $4,000 per ac plus three structures) =	**$ 3,472,000**
Total Estimated Project Cost =	**$ 26,299,263**

Option 4

J-2 - Alternative 2, Area 2 Updated 1-31-12

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 289,963.25	$ 289,963.25
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	25,000	CY	$ 5.00	$ 125,000.00
4	Earth Fill, Class A Compaction	962,802	CY	$ 4.00	$ 3,851,208.00
5	Core Trench	110,500	CY	$ 3.00	$ 331,500.00
6	Toe Drains	15,129	CY	$ 20.00	$ 302,580.00
7	Salvaging Topsoil, 6" Thick	32,000	CY	$ 4.00	$ 128,000.00
8	Compact existing clay, 12" thick	500,321	CY	$ 2.00	$ 1,000,642.00
9	36' w x 7' h Sluice Gate Inlet (3@12'w x 7'h) with Controls, Elec. & Assoc. Work	3	EA	$ 589,000.00	$ 1,767,000.00
10	20' w x 24' h Radial Gate Outlet (1@20'w x 24'h) with Controls, Elec. & Assoc. Work	1	EA	$ 1,479,000.00	$ 1,479,000.00
11	Pump Station - 4 pumps <150 hp, with Controls, Structure and Elec.	1	EA	$ 2,333,000.00	$ 2,333,000.00
12	Box Culvert under 748 road, 30' wide by 10' high	100	LF	$ 1,500.00	$ 150,000.00
13	Gravel Surfacing	5,640	CY	$ 15.00	$ 84,600.00
14	Seeding and Mulching	40	AC	$ 900.00	$ 36,000.00
15	Drain Tile	8,000	LF	$ 30.00	$ 240,000.00
16	Drain Tile Sand and Gravel, on site source	4,800	CY	$ 5.00	$ 24,000.00
17	Road Improvements	4.20	MI	$ 45,000.00	$ 189,000.00
18	18” CMP, Galvanized 14 gauge	50	LF	$ 21.00	$ 1,050.00
19	Double 12' x 7' Box Culvert	1	LS	$ 75,600.00	$ 75,600.00
20	Phelps Canal	1	LS	$ 2,071,447.00	$ 2,071,447.00

Subtotal =	**$ 14,489,590**
25% Construction Contingency =	**$ 3,622,398**
Probable Construction Costs =	**$ 18,111,988**
Design (8%) =	**$ 1,448,959**
Permitting (2.5%) =	**$ 452,800**
Administrative and Legal (2.5%) =	**$ 452,800**
Construction Management and Administration (7%) =	**$ 1,267,839**
Land Acquisition Costs (345 ac @ $4,000 per ac) =	**$ 1,380,000**
Total Estimated Project Cost =	**$ 23,114,385**
Total Areas 1 and 2	**$ 49,413,648**

Table 6. Option 5 with Phelps Canal Upgrade

Option 5

J-2 - Alternative 2, Area 1 Updated 1-31-12

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 335,700.00	$ 335,700.00
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	49,200	CY	$ 5.00	$ 246,000.00
4	Core Trench	140,500	CY	$ 3.00	$ 421,500.00
5	Earth Fill, Class A Compaction	1,600,000	CY	$ 4.00	$ 6,400,000.00
6	Toe Drains	25,200	CY	$ 20.00	$ 504,000.00
7	Salvaging Topsoil, 6" Thick	56,000	CY	$ 4.00	$ 224,000.00
8	Compact existing Clay, 12" thick	867,000	CY	$ 2.00	$ 1,734,000.00
9	36' w x 10' h Sluice Gate Inlet (3@12'w x 10'h) with Controls, Elec. & Assoc. W	3	EA	$ 648,000.00	$ 1,944,000.00
10	20' w x 28' h Radial Gate Outlet (1@20'w x 28'h) with Controls, Elec. & Assoc.	1	EA	$ 1,236,000.00	$ 1,236,000.00
11	30' w x 18' h Radial Phelps County Gate with Controls, Elec. & Assoc. Work	1	EA	$ 575,000.00	$ 575,000.00
12	Gravel Surfacing	4,700	CY	$ 15.00	$ 70,500.00
13	Seeding and Mulching	70	AC	$ 900.00	$ 63,000.00
14	Road Improvements	0.5	MI	$ 45,000.00	$ 22,500.00
15	Drain Tile	3,000	LF	$ 30.00	$ 90,000.00
16	Drain Tile Sand and Gravel	1,700	CY	$ 5.00	$ 8,500.00
17	Ditch Grading	13000	CY	$ 5.00	$ 65,000.00
18	18” CMP, Galvanized 14 gauge	75	LF	$ 21.00	$ 1,575.00

Subtotal =	**$ 13,951,275**
25% Construction Contingency =	**$ 3,487,819**
Probable Construction Costs =	**$ 17,439,094**
Design (8%) =	**$ 1,395,128**
Permitting (2.5%) =	**$ 435,977**
Administrative and Legal (2.5%) =	**$ 435,977**
Construction Management and Administration (7%) =	**$ 1,220,737**
Land Acquisition Costs (718 ac @ $4,000 per ac plus three structures) =	**$ 3,472,000**
Total Estimated Project Cost =	**$ 24,398,913**

Option 5

J-2 - Alternative 2, Area 2 Updated 1-31-12

Item Number	Description	Appr. Quantity	Unit	Unit Price	Amount
1	Mobilization / Demobilization	1	LS	$ 217,808.05	$ 217,808.05
2	Clearing and Grubbing	10	AC	$ 1,000.00	$ 10,000.00
3	Remediation of Collapsible Soils	25,000	CY	$ 5.00	$ 125,000.00
4	Earth Fill, Class A Compaction	842,000	CY	$ 4.00	$ 3,368,000.00
5	Core Trench	110,500	CY	$ 3.00	$ 331,500.00
6	Toe Drains	15,129	CY	$ 20.00	$ 302,580.00
7	Salvaging Topsoil, 6" Thick	32,000	CY	$ 4.00	$ 128,000.00
8	Compact existing clay, 12" thick	500,321	CY	$ 2.00	$ 1,000,642.00
9	36' w x 12' h Sluice Gate Inlet (3@12'w x 12'h) with Controls, Elec. & Assoc. W	3	EA	$ 638,000.00	$ 1,914,000.00
10	10' w x 24' h Radial Gate Outlet (1@10'w x 24'h) with Controls, Elec. & Assoc.	1	EA	$ 1,262,000.00	$ 1,262,000.00
11	Box Culvert under 748 road, 30' wide by 10' high	100	LF	$ 1,500.00	$ 150,000.00
12	Gravel Surfacing	5,640	CY	$ 15.00	$ 84,600.00
13	Seeding and Mulching	40	AC	$ 900.00	$ 36,000.00
14	Drain Tile	8,000	LF	$ 30.00	$ 240,000.00
15	Drain Tile Sand and Gravel, on site source	4,800	CY	$ 5.00	$ 24,000.00
16	Road Improvements	4.20	MI	$ 45,000.00	$ 189,000.00
17	18” CMP, Galvanized 14 gauge	50	LF	$ 21.00	$ 1,050.00
18	Double 12' x 7' Box Culvert	1	LS	$ 75,600.00	$ 75,600.00
19	Phelps Canal	1	LS	$ 2,071,447.00	$ 2,071,447.00

Subtotal =	**$ 11,531,227**
25% Construction Contingency =	**$ 2,882,807**
Probable Construction Costs =	**$ 14,414,034**
Design (8%) =	**$ 1,153,123**
Permitting (2.5%) =	**$ 360,351**
Administrative and Legal (2.5%) =	**$ 360,351**
Construction Management and Administration (7%) =	**$ 1,008,982**
Land Acquisition Costs (345 ac @ $4,000 per ac) =	**$ 1,380,000**
Total Estimated Project Cost =	**$ 18,676,841**
Total Area 1 and 2	**$ 43,075,753**

Upgrade Phelps Canal

Gosper County, Nebraka

OLSSON PROJECT NO. 009-1466

Table 7. OPTIONS 4 & 5
PRELIMINARY STATEMENT OF PROBABLE CONSTRUCTION COSTS
IMPROVEMENTS TO CONVEY 1,675 CFS WITH 2 FEET OF FREEBOARD
WITH MAXIMUM HEADWATER ELEVATION AT MP 0 OF 2358.0
January 26, 2012

Item Number	Description	Appr. Quantity	Unit	Unit Price		Amount
1	Mobilization/Demobilization	1.0	LS	$ 105,000.00		$ 105,000.00
2	Construction Surveying	1.0	LS	$ 40,000.00		$ 40,000.00
3	Erosion Control	1.0	LS	$ 85,000.00		$ 85,000.00
4	Water Control	1.0	LS	$ 100,000.00		$ 100,000.00
5	Clearing and Grubbing	1.1	AC	$ 1,000.00		$ 1,100.00
6	Excavation, Haul Off-Site	30,196	CY	$ 3.00		$ 90,588.00
7	Excavation, Fill On-Site, Class A Compaction	10,593	CY	$ 4.00		$ 42,372.00
8	Salvaging and Spreading Topsoil	5,022	SY	$ 1.00		$ 5,022.00
9	Seeding and Mulching	1.1	AC	$ 1,100.00		$ 1,210.00
10	Rock Riprap Armoring, Class B	9,849	CY	$ 55.00		$ 541,695.00
11	Granular Filter Fabric	1,642	CY	$ 30.00		$ 49,260.00
12	Flume Modifications					$ 68,400.00
13	Reinforced Concrete	12	CY	$ 700.00	$ 8,400.00	---
14	Remove and Replace Beams	6	EA	$ 10,000.00	$ 60,000.00	---
15	Remove Parshall Flume	1	EA	$ 30,000.00		$ 30,000.00
16	New Parshall Flume	1	EA	$ 360,000.00		$ 360,000.00
17	12-Foot Corrugated Metal Pipe	300	LF	$ 400.00		$ 120,000.00
18	Plum Creek Siphon Inlet Modifications					$ 204,400.00
19	Concrete Demo	1	LS	$ 25,000.00	$ 25,000.00	---
20	Beams	1	LS	$ 50,000.00	$ 50,000.00	---
21	Buttresses	1	LS	$ 30,000.00	$ 30,000.00	---
22	Reinforced Concrete	142	CY	$ 700.00	$ 99,400.00	---
23	Plum Creek Siphon Outlet Modifications					$ 105,000.00
24	Concrete Demo	1	LS	$ 25,000.00	$ 25,000.00	---
25	Beams	1	LS	$ 50,000.00	$ 50,000.00	---
26	Buttresses	1	LS	$ 30,000.00	$ 30,000.00	---
25	Reinforced Concrete	226	CY	$ 700.00	$ 158,200.00	---
26	102'x16' Bridge Farm Access	1,632	SF	$ 75.00		$ 122,400.00
					Subtotal =	**$ 2,071,447.00**
					25% Construction Contingency =	**$ 517,861.75**
					Probable Construction Costs =	**$ 2,589,308.75**
					Design (8%) =	**$ 207,145**
					Permitting (2.5%) =	**$ 64,733**
					Administrative and Legal (2.5%) =	**$ 64,733**
					Construction Management and Administration (7%) =	**$ 181,252**
					Total Estimated Project Cost =	**$ 3,107,170.50**

Assumptions:

1. Improvements consist of widening the canal upstream of the Parshall flume and siphon, replacing the Parshall flume, modifying the Plum Creek siphon and flume at Mile 3.15 and replacement of two bridges.
2. Land acquisition for additional right of way is not included.
3. Temporary construction easements not included.

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☒	Other: email

TO:	Beorn Courtney
CC:	Eric Dove, File
FROM:	Deb Ohlinger
RE:	Incremental Cost Analysis for Reservoir Combined Operations
DATE:	November 22, 2011
PROJECT #:	B09-1466

Introduction

Under Tasks 1.5 through 1.7 of the Investigation of Reservoir Combined Operations and 2.2 through 2.4 of the Alternatives Refinement, Olsson Associates developed alternatives to maximize power production during peak operations and regulate flows for irrigation delivery at Area 2. Tasks 1.5, 1.6, and 1.7 were documented in memoranda issued by Olsson. The next step in the project was to determine how large Areas 1 and 2 should be. Figure 1 is a location map showing the locations of Areas 1 and 2. The storage volumes of Areas 1 and 2 were modified and evaluated to develop an incremental cost analysis with which to compare the different alternatives. Options 1 through 5 were developed and analyzed. Table 1 describes each alternative.

Table 1. Descriptions of Alternatives

Option	Total Storage, acre-feet	Description
1	13,637	▪ Area 1 footprint matches the February 2010 pre-feasibility study ▪ Area 2 was limited to the east side of Plum Creek and will require pumps above elevation 2356 ▪ Earthwork was balanced for Areas 1 and 2 ▪ Clay liner protected with a soil/vegetative cover
2	N/A	▪ Area 1 footprint extended south across County Road 748 ▪ Area 2 was limited to the east side of Plum Creek and will require pumps above elevation 2356 ▪ Earthwork was balanced for Areas 1 and 2 ▪ Clay liner protected with a soil/vegetative cover ▪ Due to the impacts associated with closure and re-routing of County Road 748, Option 2 was dropped from further evaluation.
3	15,640	▪ Area 1 footprint extended west to the east bank of an un-named stream ▪ Area 2 was limited to the east side of Plum Creek and will require pumps above elevation 2356 ▪ Earthwork was balanced for Areas 1 and 2 ▪ Clay liner protected with a dead pool consisting of one foot of water
4	15,283	▪ Area 1 footprint extended west to the east bank of an un-named

		stream. It is similar to Option 3 but the southwest corner was not excavated, which reduced the earthwork required to achieve a similar volume as in Option 3. ▪ Area 2 is the same as in Option 3 and will require pumps above elevation 2356 ▪ Earthwork was balanced for Areas 1 and 2 ▪ Clay liner protected with a dead pool consisting of one foot of water
5	13,960	▪ Area 1 footprint is the same as in Option 4 ▪ Area 2 was limited to the east side of Plum Creek and no pumping will be used. ▪ Earthwork is balanced for Areas 1 and 2. Because the highest water storage elevation is lower than in other options, the berms around Area 2 were reduced and the earthwork re-balanced. ▪ Clay liner protected with a dead pool consisting of one foot of water

Preliminary Analysis

Options 1, 3, and 4 were first analyzed and compared to each other. Continuous simulation modeling was conducted to determine the effects of the different options on reductions to shortages to target flows. The modeling included hydrocycle mitigation and the use of Area 2 by CNPPID during the irrigation season of June 15 to August 31 each year. Options 1, 3 and 4 included cost comparisons with and without upgrading Phelps Canal to 1,675 cfs. Black & Veatch analyzed the inlet and outlet gate sizes required for the system and provided cost estimates for the gates and associated construction items such as electrical work and erosion protection. Capital costs and life cycle costs were determined for the three options. Preliminary submittals of the results graphs and tables generated during the analysis were made on October 17, 2011 and November 7, 2011. The “final” preliminary submittal is included in Appendix B of this memorandum.

After each submittal, a conference call was held with the ED Office, CNPPID, State of Nebraska Department of Natural Resources, Olsson, and Black & Veatch to discuss the results and the next steps of the analysis. After the first call, held on October 27, 2011, Olsson was directed to evaluate the cost of Option 5, which consisted of eliminating the pumps at Area 2. Olsson was not directed to complete continuous simulation modeling to determine the impact on Program yield.

The following list summarizes the changes made to the analysis after the first submittal and conference call:

- For Option 5, the pump station was eliminated. Because, as directed, the yield was not modeled without the pumping station, the average volume of water pumped in a year, as determined from previous modeling, was subtracted from the yield for Option 4. The reduction in Program yield due to no pumping and less storage might have been overestimated by subtracting the entire pumped volume.
- In the first submittal, the gate sizes had been determined based on their ability to release 1,000 cfs from each storage area at a minimum water level. As directed during the call, the gate sizes were modified for all options to be able to deliver the short duration high flow when the reservoirs were above their minimum elevation. In other words, they were not almost empty. The size change was reflected in the costs but not the continuous simulation modeling.

- The Phelps Canal gate at Area 2 was eliminated. Areas 1 and 2 will be controlled with one gate at Area 1.
- In the initial submittal, both Olsson and Black & Veatch had included structural concrete at the gates. After it was determined duplication of concrete costs existed, it was removed.
- The analysis of the Phelps Canal (documented in a memorandum dated December 14, 2010) Duplication of bridge costs was removed.

During the November 11, 2011 conference call, held after the second preliminary submittal, several key points and directives were made:

- While the stage-discharge relationship for the new gates was used for Options 4 and 5, it was not used for Option 1. Similarly, the spreadsheet models have two cells, one for each of the Area 1 and Area 2 outlet gate widths. These cells had not been changed. However, as demonstrated in the continuous simulation modeling documented in the June 2011 Combined Operations Report, the results are not very sensitive to the gate widths listed in the two cells. The models did not represent a fully updated analysis.
- While costs were determined for the improvements with and without inclusion of upgrading Phelps Canal from a capacity of 1,000 cfs to 1,675 cfs, the continuous simulation modeling only included a Phelps Canal Capacity of 1,675 cfs.
- Discussion amongst the conference call participants led to the conclusion that Options 4 and 5 were clearly the most feasible alternatives and warranted further investigation.
- Olsson was directed to develop continuous simulation models that were fully updated to reflect the gate sizes. Same as the previous versions, these models would continue to include hydrocycle mitigation and the use of Area 2 by CNPPID during the irrigation season of June 15 to August 31. In addition, in order to develop a true comparison of the unit costs per acre-foot of yield with and without the Phelps Canal capacity upgrade, it was necessary to develop runs for Options 4 and 5 that included a Phelps Canal capacity of 1,000 cfs.

Refined Options 4 and 5

Continuous simulation modeling was done for Option 4 and 5 for Phelps Canal capacities of 1,000 cfs and 1,675 cfs. The outlet gate widths determined by Black & Veatch, along with their stage-discharge relationships were used. For all cases, hydrocycle mitigation and use of Area 2 by CNPPID during the irrigation season of June 15 to August 31 were included. It should be noted that if the Phelps Canal capacity is not upgraded, CNPPID might not use Area 2 during the irrigation season since they will not be able to operate the J-2 hydropower plant at its most efficient flow. Discussion with CNPPID confirmed that analysis with CNPPID's use of Area 2 was acceptable for this effort. Table A-1 in Appendix A presents the results from the modeling.

Incremental cost curves, yields, construction costs, lifecycle costs, and detailed cost estimates are included in Appendix A. Table A-1 shows a summary of the Options 4 and 5 modeling results. Chart A-1 shows a comparison of Options 1, 3, 4, and 5, in which Options 1 and 3 results are from the preliminary information presented in the November 7, 2011 memorandum and Options 4 and 5 results are the fully updated results presented in this memorandum. After Chart A-1, the first set of documents are for the without Phelps Canal capacity improvements scenario, and the second set is with the Phelps Canal improvements. Charts A-1 and A-2 show cost and storage curves for the without and with Phelps scenarios. Table 2 presents advantages and disadvantages of Options 4 and 5. Both alternatives will require a similar footprint and land acquisition.

Figure 2 shows Area 1 for both Options 4 and 5. Figure 3 shows Area 2 for Option 4. Figure 4 shows Area 2 for Option 5.

Table 2. Comparison of Options 4 and 5

Option	Description	Pros	Cons
4	15,283 acre-feet of storage plus Area 2 pump station	• Greater yield for the Program than Option 5 • More storage volume	• Higher construction cost and life cycle incremental cost than Option 5 (but lower than previously estimated Options 1 or 3) • Maintenance of a pump station required
5	13,960 acre-feet of storage without Area 2 pump station	• Lower construction cost than Option 4 • Lower life cycle incremental cost than Option 4 • No maintenance of a pump station	• Less storage than Option 4 • Less yield for the Program

References

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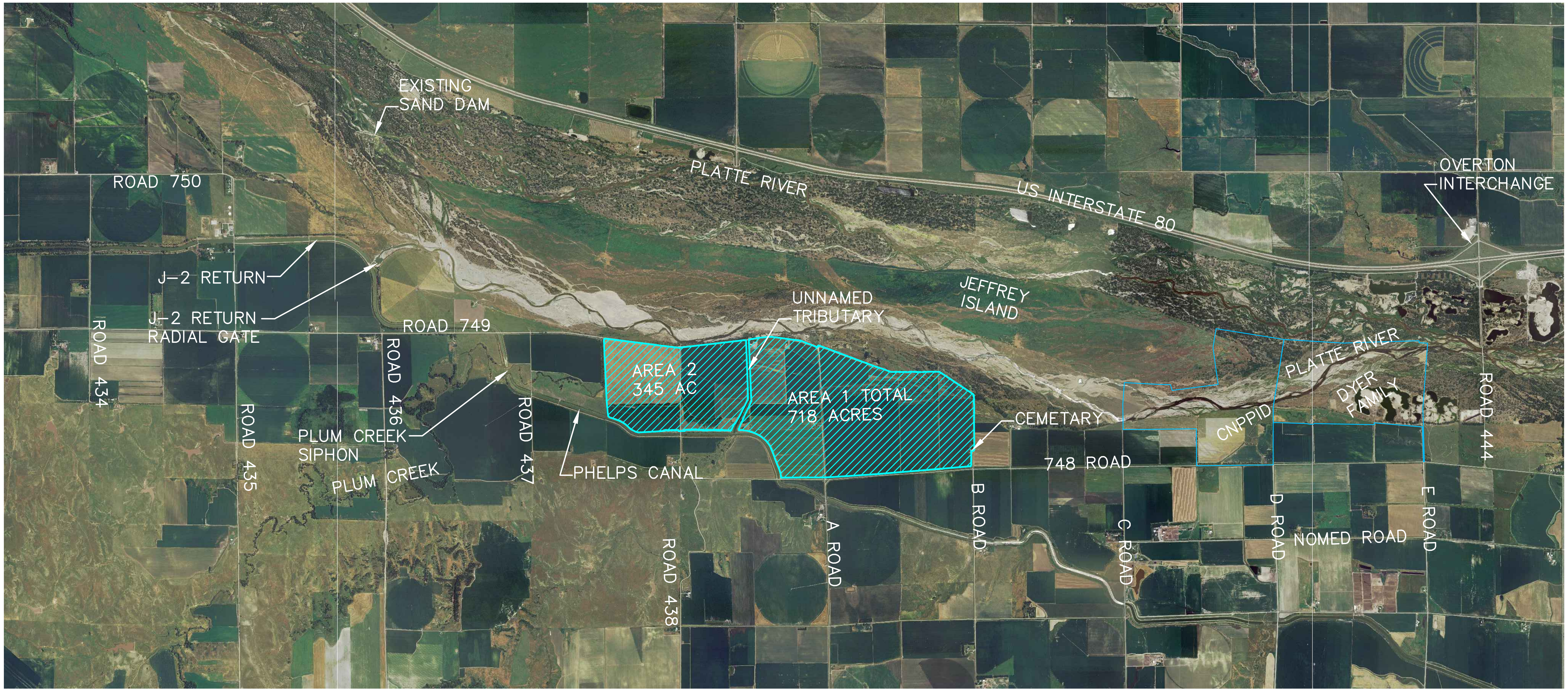

N

0' 2000' 4000'
SCALE IN FEET

LEGEND

PROGRAM LAND BOUNDARY
EXCAVATION AREA BOUNDARY

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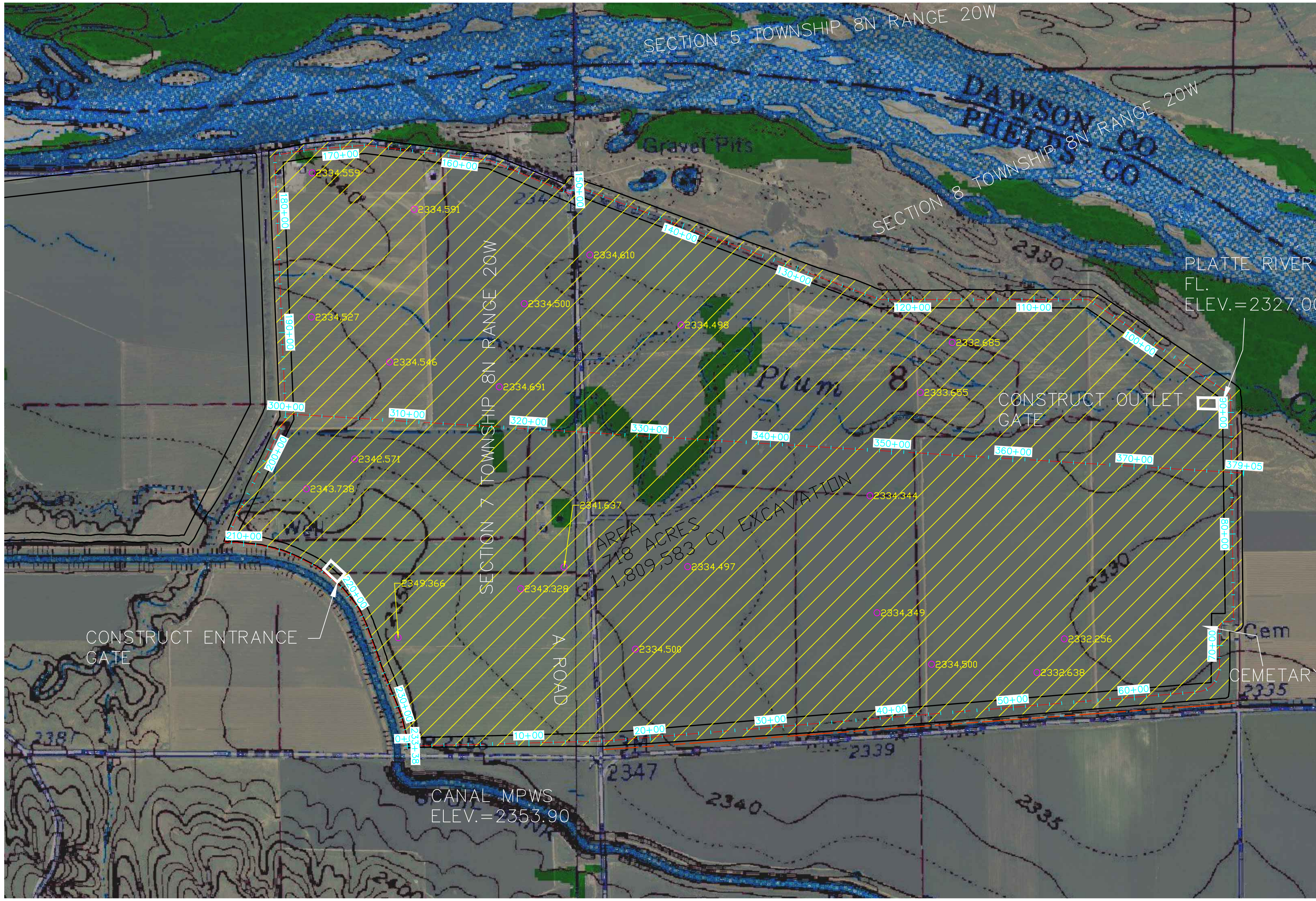
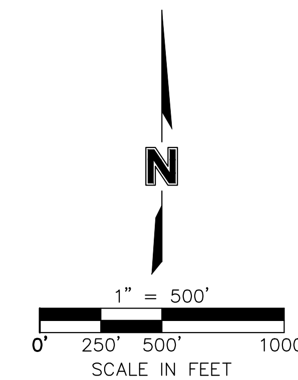
PROJECT: 009-1466 DRAWN BY: EJS DATE: 11.01.11	J-2 RETURN OPTION 3, 4, AND 5 PROJECT LOCATION MAP GOSPER AND PHELPS COUNTY, NEBRASKA	OLSSON ASSOCIATES	FIGURE 1





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Option 4 and 5, Stage Storage - Area 1					
Elevation	Area (sf)	Area (acre)	Incremental Storage (acre-ft)	Total Storage (acre-ft)	Beneficial Storage (acre-ft)
2329	7,170	0	0	0	0
2330	173,032	4	2	2	0
2331	802,747	18	11	13	0
2332	2,672,435	61	40	53	0
2333	4,799,676	110	86	139	0
2334	6,570,955	151	131	269	0
2334.5	7,741,894	178	82	352	0
2334.5	23,218,630	533	0	352	0
2335	23,251,277	534	267	618	0
2336	23,316,608	535	535	1,153	268
2337	23,382,002	537	536	1,689	804
2338	23,447,698	538	538	2,226	1,341
2339	23,513,245	540	539	2,765	1,880
2340	23,579,632	541	541	3,306	2,421
2341	23,646,935	543	542	3,848	2,963
2342	24,674,843	566	555	4,403	3,518
2343	25,308,983	581	574	4,976	4,091
2344	26,008,652	597	589	5,565	4,680
2345	26,509,633	609	603	6,168	5,283
2346	26,996,965	620	614	6,782	5,897
2347	27,494,087	631	625	7,408	6,523
2348	27,968,046	642	637	8,045	7,160
2349	28,382,065	652	647	8,691	7,806
2350	28,816,948	662	657	9,348	8,463
2351	29,139,715	669	665	10,013	9,128
2352	29,296,845	673	671	10,684	9,799
2353	29444618.2	676	674	11,358	10,473

LEGEND

- STORAGE AREA BOUNDARY
- EXISTING GRADE
- TOE OF EMBANKMENT
- TOP OF EMBANKMENT
- SPOT GRADE ELEVATION

NOTE:

CONTOURS DEVELOPED FROM THE COMBINATION OF LIDAR POINTS WITHIN THE PLATTE RIVER AND NED POINTS SOUTH OF THE PLATTE RIVER

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J-2 RETURN ALTERNATIVE 2
OPTIONS 4 AND 5, AREA 1 STAGE STORAGE

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FIGURE 2

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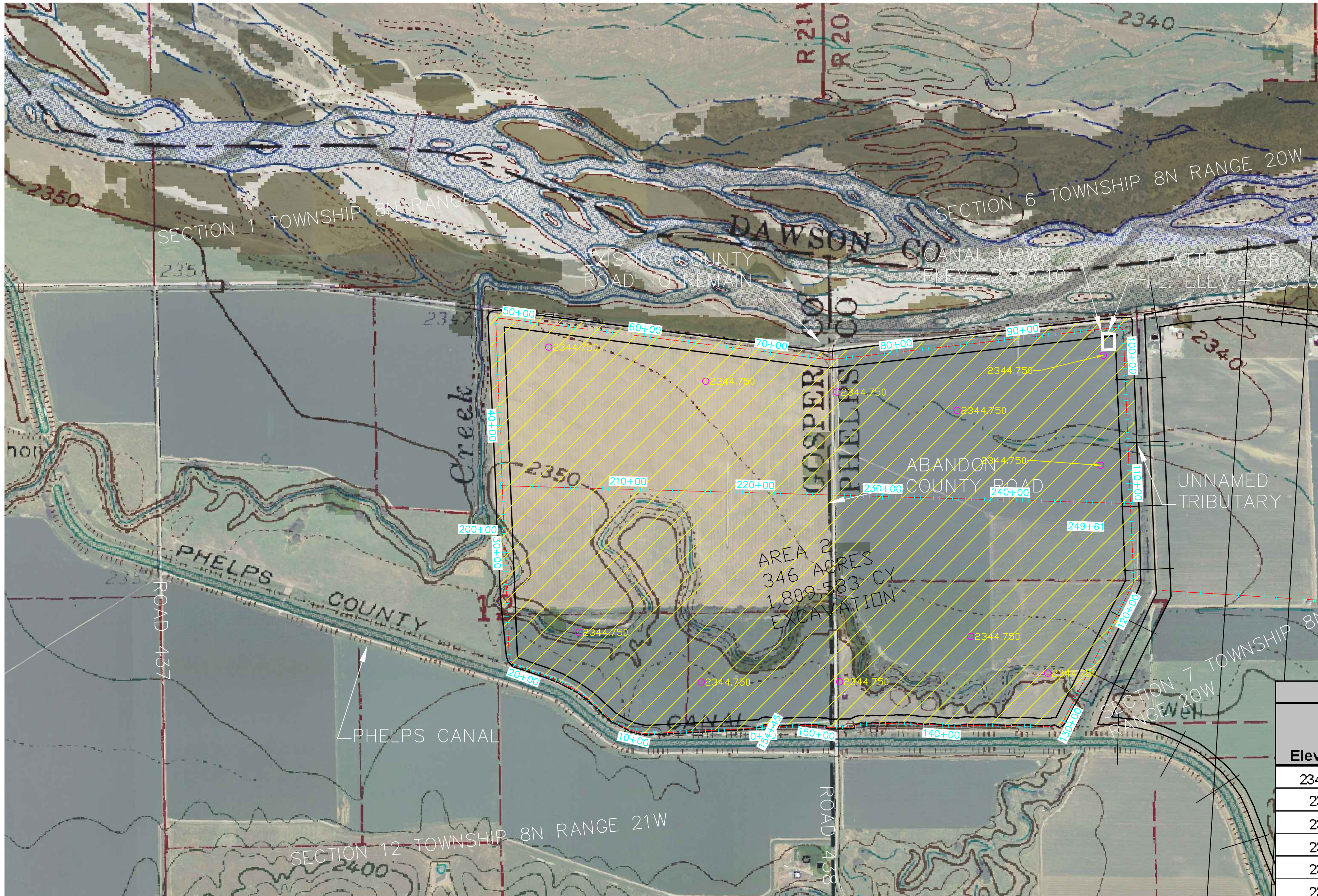

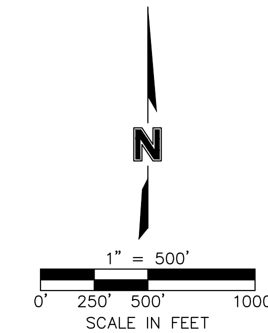

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J-2 Return Alternative 2 Stage Storage - Area 2					
Elevation	Area (sf)	Area (acre)	Incremental Storage (acre-ft)	Total Storage (acre-ft)	Beneficial Storage (acre-ft)
2344.75	13,348,708	306	0	0	0
2345	13,359,933	307	77	77	0
2346	13,404,877	308	307	384	77
2347	13,449,892	309	308	692	385
2348	13,494,977	310	309	1,001	694
2349	13,540,135	311	310	1,312	1,005
2350	13,585,364	312	311	1,623	1,316
2351	13,630,666	313	312	1,935	1,628
2352	13,696,039	314	314	2,249	1,942
2353	13,721,484	315	315	2,564	2,257
2354	13,767,003	316	316	2,879	2,572
2355	13,812,595	317	317	3,196	2,889
2356	13,858,260	318	318	3,514	3,207
2357	13,903,999	319	319	3,832	3,525
2358	13,949,813	320	320	4,152	3,845
2359	13,995,701	321	321	4,473	4,166
2360	14,041,663	322	322	4,795	4,488
2361	14,087,699	323	323	5,117	4,810

LEGEND

- STORAGE AREA BOUNDARY
- EXISTING GRADE
- TOE OF EMBANKMENT
- TOP OF EMBANKMENT
- EXISTING MAJOR CONTOUR
- SPOT GRADE ELEVATION

NOTE:

*STORAGE AREA WILL REQUIRE PUMPS TO FILL BETWEEN ELEVATION 2357 TO ELEVATION 2361.

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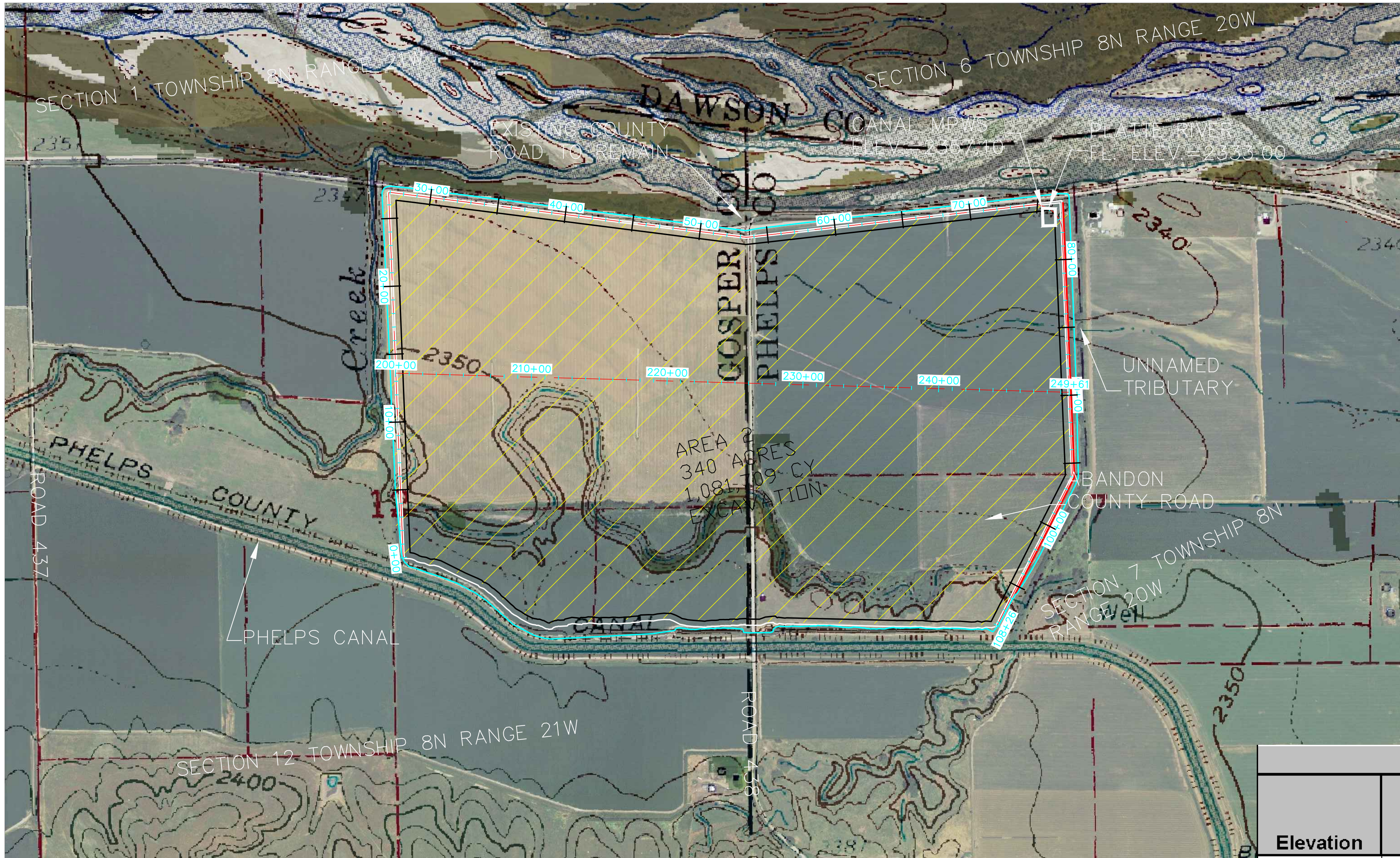
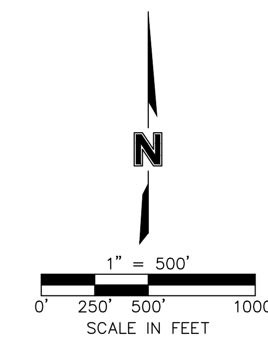
J-2 RETURN ALTERNATIVE 2
OPTION 4, AREA 2 STAGE STORAGE

OLSSON ASSOCIATES

FIGURE 3





PROGRESS PRINT
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LEGEND

- STORAGE AREA BOUNDARY
- EXISTING GRADE
- TOE OF EMBANKMENT
- TOP OF EMBANKMENT
- EXISTING MAJOR CONTOUR
- SPOT GRADE ELEVATION

J-2 Return Option 5 Stage Storage - Area 2

Elevation	Area (sf)	Area (acre)	Incremental Storage (acre-ft)	Total Storage (acre-ft)	Beneficial Storage (acre-ft)
2345	13,508,690	310	0	0	0
2346	13,554,067	311	311	311	0
2347	13,599,514	312	312	622	312
2348	13,645,033	313	313	935	624
2349	13,690,624	314	314	1,249	938
2350	13,736,285	315	315	1,564	1,253
2351	13,782,016	316	316	1,879	1,569
2352	13,827,816	317	317	2,196	1,886
2353	13,873,687	318	318	2,514	2,204
2354	13,919,628	320	319	2,833	2,523
2355	13,965,640	321	320	3,153	2,843
2356	14,011,721	322	321	3,475	3,164
2357	14,057,872	323	322	3,797	3,486

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J-2 RETURN ALTERNATIVE 2
OPTION 5, AREA 2 STAGE STORAGE

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FIGURE 4

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