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Feasibility Study -

ELM CREEK REGULATORY RESERVOIR

Elm Creek Watershed -

Dawson & Buffalo Counties NE

JANUARY 10, 2010

OLSSON ASSOCIATES

NRD

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

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1.0 EXECUTIVE SUMMARY

1.1 Study Goals

The primary goal of the Platte River Recovery Implementation Program (PRRIP) is rehabilitation of habitat for three targeted species in Central Platte River. The reach of the Central Platte River generally includes the area from Lexington to Chapman. The three targeted species are the interior least tern (*Sternula antillarum*), piping plover (*Charadrius melodus*) and whooping crane (*Grus Americana*). Habitat rehabilitation consists of many aspects and includes re-timing and improving flows to reduce target flow shortages in the Platte River and release of a short duration high flow (SDHF) event to create vegetation-free sand bars. Olsson Associates was contracted by the Central Platte Natural Resources District (CPNRD), with the assistance of the Platte River Recovery Implementation Program, to evaluate the feasibility of using the proposed Elm Creek Regulatory Reservoir to aid in the reduction of target flow shortages and/or releases to support SDHF events.

The reservoir water supply was based on the concept of capturing of Platte River water during times when there is water in excess to target flows. The Elm Creek Regulatory Reservoir would then store water, for later release to the Platte River to accommodate the PRRIP goals. The information used during this study came from field surveys conducted in the watershed, a geotechnical investigation, public meetings, interviews with stakeholder agencies and readily available data sources such as the Platte River Research Cooperative Reconnaissance Level Water Action Plan, Water Action Plan, Central Nebraska Public Power and Irrigation District, Elm Creek Preliminary Feasibility Study (Olsson, May 2006), the Irrigation District Depletion Mitigation Study, Phase I, and Dawson Canal information provided by Nebraska Public Power District. This information was used to evaluate the reservoir's potential to provide water to support: 1) reduction of target flow shortages, 2) water releases for SDHF events, and 3) determine the impacts to the surrounding region caused by the construction of the Elm Creek Regulatory Reservoir.

1.2 Project History

In 2003, landowners and operators in the Elm Creek and Turkey Creek Watersheds petitioned the Central Platte Natural Resources District (CPNRD) to budget funds for the purpose of developing a plan to reduce flooding in the Elm Creek and Turkey Creek watersheds. In August of 2004, the CPNRD retained Olsson Associates to conduct a conceptual-level study of existing flooding problems and to investigate alternatives to address the flooding. The Preliminary Feasibility Study flood control alternatives included:

- Channel maintenance on Elm Creek and Turkey Creek
- Turkey Creek flood diversion channel to improve Highway 30 conveyance
- Construction of three (3) dry flood control structures and a diversion channel to route flood flows around the Village of Elm Creek
- Construction of a 975-surface-acre multi-purpose flood control and flow augmentation reservoir on Elm Creek one (1) mile upstream of the Village of Elm Creek

The Preliminary Feasibility Study (Olsson, May 2006) found that the downstream flood benefits were not adequate to justify the capital construction cost necessary to protect the area, based on the State of Nebraska Resources Development Fund guidelines.

Additional benefits were explored in the preliminary study to help provide more than just flood reduction benefits. The additional benefits included flow augmentation water for environmental benefits on the Platte River, and recreation benefits. The Preliminary Feasibility Study concluded that further study was needed to evaluate the augmentation benefits to the Platte River, and determine how the Elm Creek Regulatory Reservoir could help in reducing deficits to target flows and/or support SDHF events for the Platte River during the critical times of the year.

1.3 Project Components, Project Alternatives, and Component Options

The Elm Creek Regulatory Reservoir feasibility analysis has three major project components. The project components consist of: 1) reservoir size, 2) water supply and 3) Elm Creek outlet and channel conveyance. The reservoir size component consists of Beneficial Storage Volume Options listed below. Water supply component consists of: 1) Dawson County Canal Options, 2) Kearney Canal Diversion Options and 3) Platter River Well Field Options listed below. The Elm Creek outlet and channel conveyance component consists of outlet and channel capacity options listed below.

Reservoir Size Component

- Reservoir Surface Area and Dam Structure Options
  - Beneficial Storage Volume – 6,800 acre-feet
  - Beneficial Storage Volume – 12,000 acre-feet
  - Beneficial Storage Volume – 19,850 acre-feet

Water Supply Component

- Dawson County Canal Options
  - Winter Operations – Canal capacity 50 cfs
  - Winter Operations – Canal capacity 75 cfs
  - Winter Operations – Canal capacity 125 cfs
  - Non-Winter Operations – Canal capacity 50 cfs
  - Non-Winter Operations – Canal capacity 75 cfs
  - Non-Winter Operations – Canal capacity 125 cfs
  - With Pumps – Canal capacity 50 cfs

- With Pumps – Canal capacity 75 cfs
- With Pumps – Canal capacity 125 cfs

- Kearney Canal Diversion Options
  - Pump Station – 100 cfs capacity
  - Pump Station – 130 cfs capacity
  - Pump Station – 150 cfs capacity
- Platte River Well Field and Pump Station Options
  - Pump Station – 70 cfs capacity
  - Pump Station – 100 cfs capacity
  - Pump Station – 130 cfs capacity

Elm Creek Reservoir Outlet and Channel Conveyance Components

- Reservoir Outlet Options
  - Outlet Capacity – 1,000 cfs
  - Outlet Capacity – 1,500 cfs
  - Outlet Capacity – 2,000 cfs
- Elm and Buffalo Creek Channel Options
  - Channel Capacity – 1,000 cfs
  - Channel Capacity – 1,200 cfs
  - Channel Capacity – 1,400 cfs
  - Channel Capacity – 1,600 cfs
  - Channel Capacity – 2,000 cfs

During the early stages of this feasibility study, the project team determined an increase in the Elm Creek Reservoir Outlet Conveyance capacity did not increase the project benefits significantly to justify the increase in project cost. An increase in the outlet channel capacity would also have additional environmental impacts. Based on these findings, the Elm Creek Reservoir Outlet Conveyance capacity was held at 1,000 cfs for all project alternatives. With the outlet capacity held constant, a project alternative matrix was developed by the combination of the reservoir size components and the water supply components. This project alternatives matrix is shown in Table 1.3.1.

PROJECT ALTERNATIVE MATRIX				
Beneficial Storage Volume Component		19,850	12,000	6,800
Water Supply Component	Capacity			
Dawson County Canal Winter Operation	50	DCC-WO-1	DCC-WO-4	DCC-WO-7
Dawson County Canal Winter Operation	75	DCC-WO-2	DCC-WO-5	DCC-WO-8
Dawson County Canal Winter Operation	125	DCC-WO-3	DCC-WO-6	DCC-WO-9
Dawson County Canal Non-Winter Operation	50	DCC-NW-1	DCC-NW-4	DCC-NW-7
Dawson County Canal Non-Winter Operation	75	DCC-NW-2	DCC-NW-5	DCC-NW-8
Dawson County Canal Non-Winter Operation	125	DCC-NW-3	DCC-NW-6	DCC-NW-9
Dawson County Canal with Pumps	50	DCC-P-1	DCC-P-4	DCC-P-7
Dawson County Canal with Pumps	75	DCC-P-2	DCC-P-5	DCC-P-8
Dawson County Canal with Pumps	125	DCC-P-3	DCC-P-6	DCC-P-9
Kearney Diversion Canal	100	KC-1	NA	NA
Kearney Diversion Canal	130	KC-2	NA	NA
Kearney Diversion Canal	150	KC-3	NA	NA
Platte River Pump Station	70	PRP-1	NA	NA
Platte River Pump Station	100	PRP-2	NA	NA
Platte River Pump Station	130	PRP-3	NA	NA

Table 1.3.1 – Project Alternative Matrix

1.4 Summary of Findings and Recommendations

The Project goals were to evaluate the reservoir's potential to provide water to support: 1) reduction of target flow shortages, 2) water releases for SDHF events, and 3) determine the impacts to the surrounding region caused by the construction of the Elm Creek Regulatory Reservoir.

The reservoir size was used to optimize the water storage and the water delivered to the Platte River. The alternatives were ranked based on life cycle cost and the reservoir impacts.

The study has found that the most feasible project alternatives were driven by 1) the available water supply, and 2) the utilization of the existing Dawson County Canal to deliver water to the Elm Creek Reservoir. If the Dawson County Canal could be operated during the winter months, additional benefits could be obtained.

The water stored in the Elm Creek Regulatory Reservoir is available to support augmentation of short duration high flows (SDHF), and reduce deficits to target flows in the Platte River. The reservoir is located four (4) miles north of the Platte River and eight (8) miles below the Overton Gauge which is near the beginning of the associated habitat of the Platte River.

The study process evaluated the different project alternatives and the recommendations are based on capital costs, water yield, project life cycle cost per acre feet of water release from the reservoir and impacts to the surrounding region. The study process eliminated many of the project alternatives. Project alternative with the lowest life cycle cost per acre-feet included utilization of the Dawson County Canal with a capacity of 125 cfs, vertical groundwater wells pumping rate of 70 cfs and the reservoir size of 19,850 acre-feet of beneficial storage. The life cycle cost did not significantly change by increasing the beneficial storage volume option from 12,000 to 19,850 acre-feet. However, the amount of water released from the reservoir increased. When the storage volume increased, so did the project costs and the project yields. The Project Alternative's life cycle cost of $37 per acre-feet remained relatively constant.

The reservoir has adequate storage volume at both the 12,000 and 19,850 acre-feet reservoir sizes to release the 2,000 cfs of flow for three (3) days. The limitation in providing the 2,000 cfs SDHF is the cost to improve the Elm Creek and Buffalo Creek Channels to convey the 2,000 cfs flow. The costs increased significantly for flows in excess of 1,000 cfs. Study results indicated the most effective use of the Elm Creek Reservoir would be to reduce deficits to target flows and supplement the SDHF with the release rate of 1,000 cfs or less. The optimal delivery would be in the range of 700 cfs to 800 cfs, which would minimize the channel improvements cost and minimize the environmental impacts.

The proposed construction of the Elm Creek Regulatory Reservoir will have an impact on the region around the Village of Elm Creek. The dam and reservoir will impact 1,930 acres of land, at the 100-year flood pool water surface elevation, with a beneficial storage volume of 19,850 acre-feet. The reservoir will impact 29 parcels of land and 24 landowners. Seven and one-quarter (7.25) miles of county roads will be closed and miscellaneous utilities will need to be relocated. Thirteen registered wells will be retired.

The proposed reservoir will create a dome-shaped water "mound" with groundwater rises of over thirteen (13) feet occurring directly underneath the proposed reservoir. The groundwater table will rise at least one (1) foot at a radius of over three (3) miles from the reservoir. At the Village of Elm Creek, the water table elevation will increase by two (2) to four (4) feet from the southeast to the northwest edges of the Village, without mitigation.

To mitigate the high water table near the Village of Elm Creek, and the surrounding agricultural area, five (5) wells pumping at 200-500 gpm are proposed within one (1) to two (2) miles south and southeast of the reservoir.

The proposed project improvements will have impacts to the environment within the project area. The preliminary environmental review identified, with the use of the USFWS NWI Program, 37 water bodies that total approximately 22.6 acres of potential wetlands and deep water habitats. An on-site wetland delineation will be required to more accurately assess wetland impacts on the site. The wetland delineation will likely reveal wetland areas not depicted on the NWI map, and conversely, it will likely reveal some of the wetland areas depicted on the NWI map are smaller or not present at all.

Stream and river resources are present within the study area. The National Hydrograph Database shows seven (7) named streams or canals plus several unnamed streams that total 302,945 linear feet of stream channel within the recommended project area. Due to the potential size and scope of this project, there could be extensive impacts to streams channels and adjacent riparian corridors. The Corps of Engineers' personnel at the agency review meeting, held on June 22, 2010, confirmed that because the Dawson County Canal has a down gradient connection to Elm Creek, it is considered waters of the United States. By minimizing the work required on the Elm Creek Channel, the stream impacts would be minimized.

The project will require a Section 404 Individual Permit from the Corps of Engineers. This will require an on-site delineation of wetland and other waters of the United States to be conducted over the entire project footprint. The project will require a federal action and therefore will require compliance with the National Environmental Policy Act (NEPA). The level of NEPA compliance documentation will depend on the lead federal agency, which will almost certainly be the Corps of Engineers. Depending on the scope and timing of the project, this may require surveys for threatened, endangered and other special status species (including bald eagle and migratory birds) prior to construction. The requirements for these surveys will be determined as a result of coordination between CPNRD, Corps of Engineers, the NGPC and USFWS.

The NeSHPO records indicate ten (10) archaeological sites in the area of the proposed project. NeSHPO recommends that the project area be inspected by a qualified archaeologist to determine if unreported sites will be affected by the project. Compliance with these recommendations will almost certainly be required by the Corps of Engineers.

In summary, the Elm Creek Regulatory Reservoir will provide the Platte River Recovery Implementation Program a feasible project to assist in meeting the goal of habitat rehabilitation. The project is technically sound and is an economically feasible alternative in reducing deficits to target flows and supplementing the SDHF event. The project does not contain any fatal flaw issues, but will require working with local, state and federal agencies to resolve permitting requirements. The maximum yield volume (acre-feet), released by the proposed reservoir, would be achieved with the use of the Dawson County Canal with a canal capacity of 125 cfs (during non-winter operations) and installation of groundwater wells with the capacity of 70 cfs. These wells will be installed along the Dawson County Canal without impacting the Platte River flows. The maximum water yield produced by the project was 38,000 acre-feet. To provide the maximum yield, a reservoir with the beneficial storage volume of 19,850 acre-feet will be required. The life cycle cost for the water stored is $37 per acre-feet. The use of the 12,000 acre-feet beneficial storage volume in the reservoir would lower the total water yield but would maintain the same life cycle cost of $37 per acre-feet of water released from the reservoir.

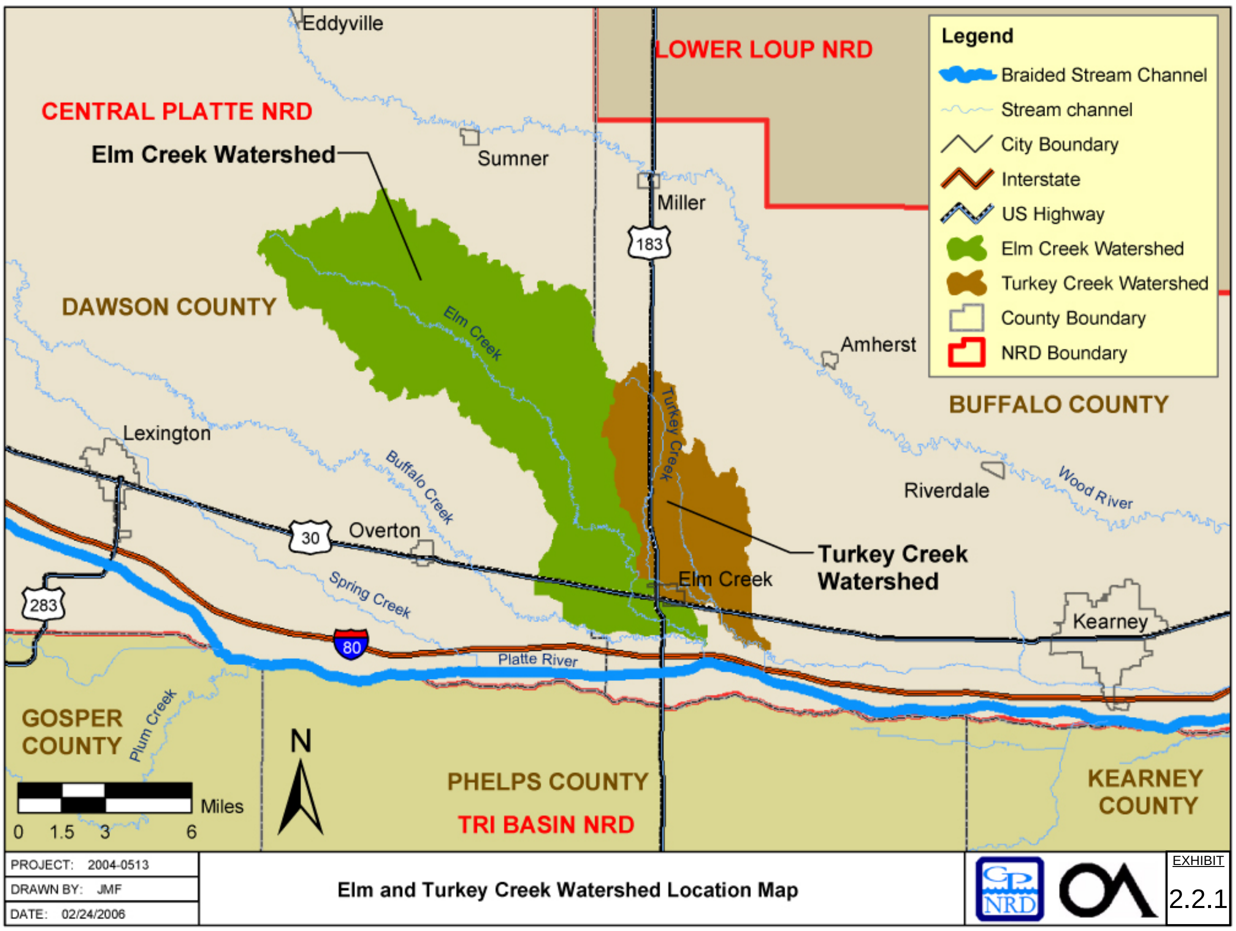
The project provides storage opportunities that have not been explored in this feasibility study. The Elm Creek Regulating Reservoir could be used in conjunction with other WAP Projects, such as to store water obtained through water leasing, in conjunction with groundwater recharge projects, or provide secondary storage for environmental account water released from Lake McConaughy. This study did not quantify water from the Dawson County Canal delivered to the Elm Creek Channel during canal spring start up and operational water, not utilized during the irrigation season. The reservoir will capture these flows which will increase the total project yield benefit.

This project is unique in many ways. The Project is a potential solution to help reduce deficits to target flows on the Platte River and to provide off stream storage opportunities to conserve water along the Platte River. The water loses from the Dawson County Canal and the Elm Creek Regulating Reservoir our manageable, so not to impact the Elm Creek Region. Losses to the groundwater, not captured by the project, will remain in the Platte River Basin. The project will impact the area, but with a project of this size and magnitude, the impacts are manageable and not excessive to the area. The project will provide incidental flood reduction benefits and will provide potential recreational benefits. Meetings will need to take place with the local residents and governing bodies to fully explain the benefits and impacts that will be realized with the successful completion of this project.

2.0 ELM CREEK REGULATORY RESERVOIR

2.1 Project Location

Elm Creek is a north bank tributary to the Platte River located mid-way between the cities of Lexington and Kearney, Nebraska. The proposed reservoir site is located one (1) mile west and two (2) miles north of the Village of Elm Creek. The 81-square-mile watershed outlets onto the Platte River floodplain one (1) mile west of the Village of Elm Creek, and is routed past the Village of Elm Creek through a straightened section of the Elm Creek channel. The Elm Creek channel outlets into the Platte River approximately two (2) miles southeast of the Village of Elm Creek. An Elm Creek and Turkey Creek Watershed Location Map is shown in Exhibit 2.2.1.



2.2 Watershed Characteristics

2.2.1 Hydrologic Model Development

The United States Army Corps of Engineers (USACE) Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) was used to develop peak flood flow rates from the Elm and Turkey Creek Watersheds. During model development, the 81-square-mile Elm Creek Watershed was divided into 26 sub-basins and the 28-square-mile Turkey Creek Watershed was divided into 10 sub-basins. All sub-basins were delineated using United States Geological Survey (USGS) data and the calculation of overland flow length, basin slope and stream reach length for each sub-basin was calculated. State Soil Geography (STATSGO) soil data and aerial photography were used to develop weighted NRCS curve numbers. Table 2.2.1 provides the range of physical parameters for model basins and reaches. The hydrology model runoff volumes, peak flow, lag time and diversion routings were calibrated to gage data. See Elm Creek Preliminary Feasibility Report (Olsson, 2006)

Parameter	Units	Value(s)
Sub-Basin Drainage Area	Mi^2	0.05 - 6.5
Curve Number	-	66 - 81
Initial Abstraction	In.	0.5 -1.0
Lag Time	Min.	20 - 760
Reach Length	Ft.	200 – 41,060
Energy Slope	%	0.01 – 0.2
Manning's N	-	0.04

Table 2.2.1 – Elm and Turkey Creek HEC-HMS Hydrologic Parameter Values

Watershed upland soils consist of Loess deposits. STATSGO data identified an outcropping of Wood River clays at the proposed reservoir site and in the Village of Elm Creek. Wood River clays have intermittent deposits of a low permeability soil that meets the hydrologic drainage classification of a type 'D' Soil. This soil deposit slows the infiltration of floodwaters causing extended durations of ponded water.

Table 2.2.2 summarizes the flow rates calculated by HEC-HMS at key points in the watersheds. The flows include the effects of undersized stream crossings and overflows into other areas of the watersheds.

		Peak Flow (cfs) for Storm Event Return Interval (years)						
Stream	Location	1	2	5	10	25	50	100
Elm Creek	70th Road	390	750	2,250	3,570	5,580	7,000	8,440
	Hwy 30	390	600	600	600	600	600	600
Turkey Creek	70th Road	310	540	1,320	1,950	2,780	3,430	4,070
	Hwy 183	310	540	1,320	1,320	1,320	1,320	1,320
	Hwy 30	250	460	1,200	1,560	1,910	2,100	2,300
Elm & Turkey Overflow	NW corner of Hwy 30 & Hwy 183	250	280	1,430	3,290	5,400	6,930	8,500

Table 2.2.2 – Elm and Turkey Creek HEC-HMS Model Flow Rates

2.3 Reservoir Characteristics

LiDAR spot elevation (2009) data for the reservoir site was obtained from the CPNRD. The spot data was processed into one (1) foot contours and used to refine the reservoir stage-storage data from the Preliminary Feasibility Study. The updated stage-storage figure for the Elm Creek reservoir is show in Figure 2.3.1.

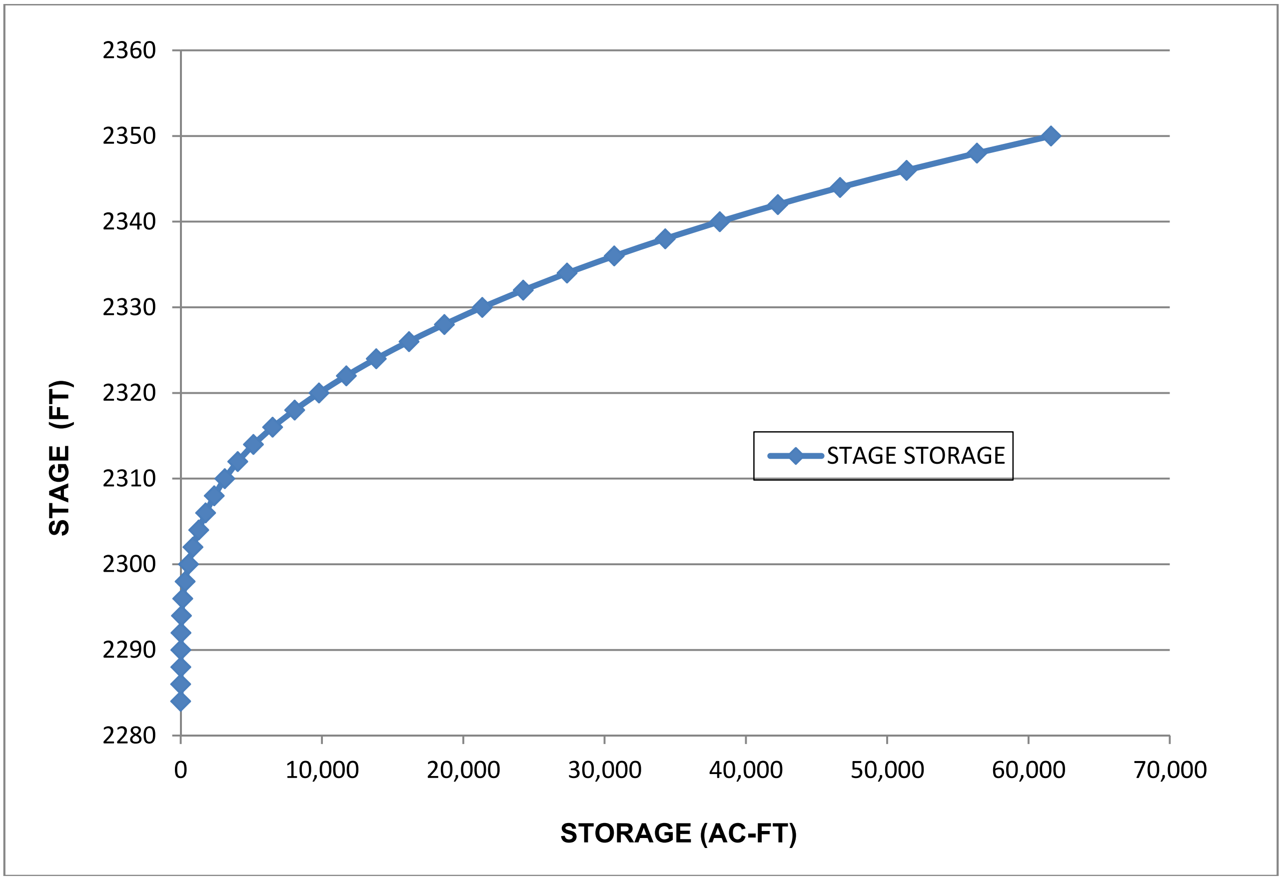


Figure 2.3.1 – Elm Creek Regulatory Reservoir - Stage Storage Curve

A 50-year sediment storage volume for the Elm Creek regulatory reservoir was based on 1.27 watershed inches of sediment being transmitted from the 51,840 acres watershed. The total sediment yield is 5,480 acre-feet. The 50-year sediment pool elevation was based on eighty (80) percent of the total sediment yield to be submerged, and twenty (20) percent aerated. The eighty (80) percent of submerged sediment would fill 4,385 acre-feet of storage to an elevation of 2312.6 ft.

Beneficial water stored for reduction to shortages of target flows and/or short duration high flows (SDHF) will be stored above the sediment pool elevation. Three (3) different beneficial water storage volumes have been analyzed to determine the reservoir size sensitivity. The three (3) beneficial storage volumes include 6,800 acre-feet, 12,000 acre-feet and 19,850 acre-feet. The corresponding beneficial water pool elevations are 2321.4, 2326.2 and 2332.1, respectively; and have surface areas of 986 acres, 1,213 acres and 1,504 acres, respectively.

Flood routing was performed using the NRCS SITES program to determine the auxiliary spillway elevation, top of dam elevation and the 100-year flood pool elevation. Hydraulic structure sizing was in accordance with the Nebraska Dam Safety guidelines for high hazard dams. The results of the flood routings are found in the following section. All flood routings assumed the sediment and beneficial use pools were at the maximum elevations.

2.4 Dam Embankment Structure

2.4.1 Characteristics

The proposed Elm Creek Regulatory Reservoir dam embankment centerline is located upstream of 70th Road, between Arrow Road and Turkey Creek Road. The proposed dam is planned to have homogeneous earth fill with earth fill saddle embankments to contain the reservoir. Plan and profile exhibits for the dam embankment and saddle embankment construction are shown in Appendix 2.1, 2.2.1 and 2.2.2, respectively. The properties of the dam are based on a preliminary geotechnical investigation completed by Olsson in July 2007. The geological borehole locations and boring logs are contained in the Elm Creek Groundwater Study (Olsson, July 2007). The proposed embankment will be approximately sixty (60) feet high with a minimum top width of fourteen (14) feet, 3.5H:1V side slopes upstream and 3H:1V downstream. The proposed dam embankment cross-section for the maximum dam height is shown in Figure 2.4.1. A full slope-stability analysis will be performed in future design phases to verify the integrity of the proposed cross section. Rock rip rap will provide erosion protection on the upstream face of the dam. The Principal Spillway will consist of a concrete inlet riser and concrete box conduit. The conduit will discharge into a hydraulic jump basin that will discharge directly into the Elm Creek Channel. The auxiliary spillway is proposed to be a concrete labyrinth weir crest and chute spillway.

Three storage volumes were evaluated to determine the most desirable reservoir size for the Regulatory Reservoir. The active storage volume used for flow augmentation varied from 6,800 acre-feet, as proposed in the preliminary study, to a maximum size of 19,850 acre-feet. Several flood routings using SITES runs were used to determine the top of dam elevation of the reservoir for beneficial storage volumes of 6,800 acre-feet, 12,000 acre-feet and 19,850 acre-feet.

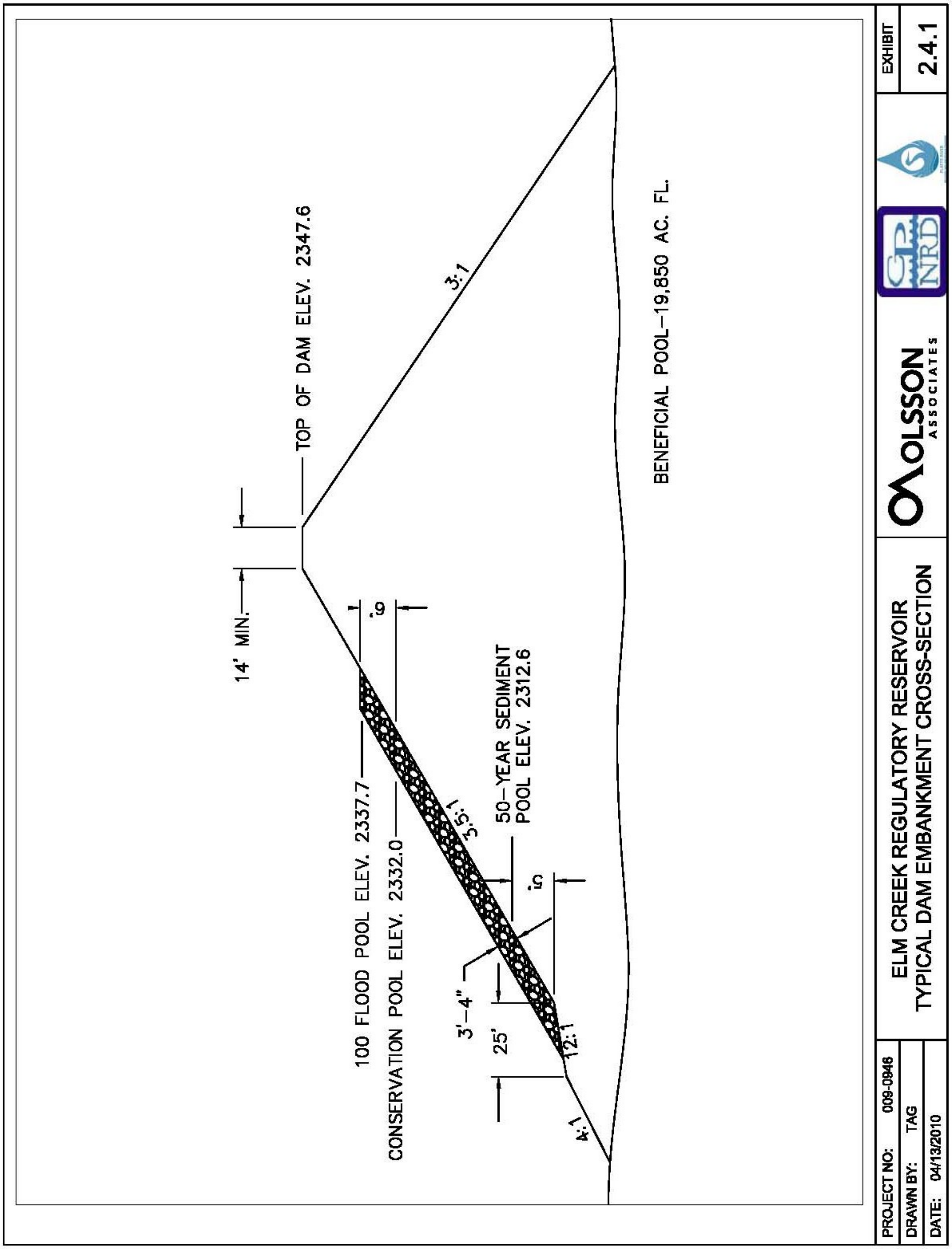


Exhibit 2.4.1 – Elm Creek Regulatory Reservoir Dam Embankment Cross Section

The incremental construction costs of the dam, as compared to the volume of storage decreased as the reservoir was enlarged for additional active beneficial storage for flow augmentation. A detailed cost breakdown is presented in Appendix 7. Opinions of probable cost are shown in Figure 2.4.1.

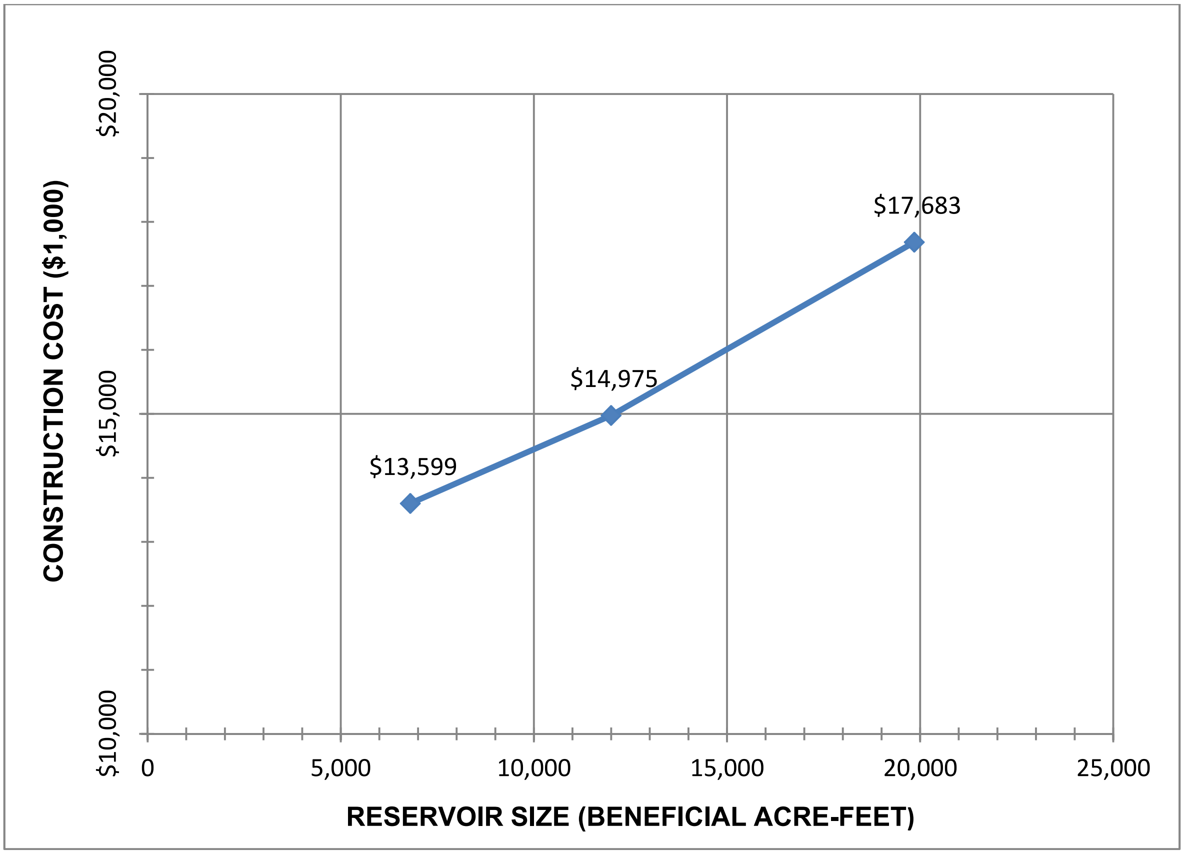


Figure 2.4.1 – Elm Creek Dam Embankment Probable Construction Cost –vs.– Reservoir Size

2.4.2 Embankment Stability

The earthen dam is planned to have a maximum height of approximately sixty (60) feet and a length of approximately 4,000 feet. The maximum top of the dam is planned at elevation 2,347.6 feet.

Based on preliminary field borings completed by Olsson Associates in 2007, the subsurface profile beneath the dam is anticipated to consist of approximately thirty (30) feet of low plasticity clay soil (Peorian Loess) underlain by sands and sandstone at a depth of approximately seventy (70) feet. It is anticipated that clay soil within the lake area will be used to construct the dam embankment.

2.4.2.1 Rapid Drawdown Analysis

For the SDHF release, flow releases from storage of about 2,000 cfs could be sustained over a three day period. This release will quickly lower the reservoir water surface. Excess pore water pressures will develop in the embankment which could result in slope failures.

The shear strength of the material used in the embankment is critical to the performance of the upstream slope of the dam under the rapid drawdown event. Strength testing of the proposed borrow material for the embankment needs to be performed to verify that the materials used to construct the dam exhibit the strength parameters used in our analysis. Testing should include a consolidated undrained triaxial strength testing with pore pressure measurements on each distinct soil type encountered. This material testing was not completed in the preliminary geotechnical investigation.

In performing our analysis, we estimated shear strength parameters based on our experience with loess in Nebraska. These soil parameters are provided in Table 2.4.1.

Material	**Effective Shear Strength Parameters**	
	c' (psf)	**φ'**
Embankment Material	70 psf	27°
Peorian Loess	70 psf	27°
Sands	0	30°

Table 2.4.1: Estimated Shear Strength Parameters

The rapid drawdown analysis was performed on the upstream side of the dam for the following condition:

- Rapid drawdown from the maximum pool elevation of 2332 feet to 2312 feet.

Slope/W was used to calculate the upstream slope stability under a rapid drawdown condition. The estimated water profile through the dam was based on steady state seepage and a maximum pool level. Under the rapid drawdown condition, a 3.5(H):1(V) upstream slope would be needed to obtain a minimum factor of safety of 1.2, which is the minimum acceptable factor of safety for a rapid drawdown condition in Nebraska. The results of the rapid drawdown analysis are in Appendix 2.3.

The critical failure surface for the rapid draw down analysis passes through the embankment of the dam. If a 3H:1V upstream slope is desired for the dam, the soil strength parameters shown in Table 2.4.2 that would be required for the embankment materials to achieve a minimum factor of safety of 1.2 under the rapid drawdown condition.

Material	**Effective Shear Strength Parameters**	
	c' (psf)	**φ'**
Embankment Material	100 psf	27°
Peorian Loess	50 psf	27°
Sands	0	30°

Table 2.4.2 Required Soil Shear Strength Parameters for a 3H:1V Embankment

To use a 3H:1V upstream slope for the upstream embankment under the rapid draw down condition, additional soil shear strength testing of the proposed borrow materials would be needed. Only borrow materials meeting the minimum shear strengths as described in Table 2.4.2 could be allowed in the dam. Based on our experience with the loessial soils in this area, the availability of these materials could be limited, depending on the source of the potential borrow materials. A 3.5H:1V slope requires somewhat lower minimum shear strengths of the soil, potentially allowing a wider range of local soils that could be used in the construction of the dam. Without the recommended additional strength testing, we recommend that a 3.5H:1V upstream be used to provide a minimum factor of safety of 1.2 for the rapid drawdown condition of the slope.

The evaluation of the embankment discussed in this study, only addressed the rapid drawdown condition on the upstream face of the dam. The analysis did not consider end-of-construction, steady state seepage or seismic loads on the embankment. We have not evaluated settlement of the dam following construction or seepage beneath the dam.

2.4.3 Auxiliary Spillway System (AS)

Numerous routings were made using the SITES program in an effort to determine if a non-breaching vegetative auxiliary spillway could be attained. The process included a combination of increasing the capacity of the principal spillway system (PS), raising the crest elevation of the auxiliary spillway (AS), and increasing the width of the auxiliary spillway until a non-breach condition was indicated. The starting point for the analysis was a conservation pool at elevation 2332.0, an auxiliary spillway crest at elevation 2338.2 and the top of dam at elevation 2347.6.

The vast majority of the material sampled from the field bore holes classified as either silty clay, CL-ML or clay, CL. Material properties, dry density, void ratio, and unconfined strength, were very similar. The primary difference was in the plasticity index (PI) with higher values in the CL material (Elm Creek Groundwater Study, Olsson, 2007). This data was used to develop the input values for the erosion model portion of the NRCS SITES computer analysis program.

The analysis, summarized in Appendix 2.4, indicated that in order to obtain a non-breaching vegetative type auxiliary spillway, the principal spillway would need to be as large as a twin 10'x10' box conduit, the crest of the auxiliary spillway raised seven (7) feet to elevation 2345.2 and the width increased to 1000 feet. The top of dam would need to be raised one (1) foot to elevation 2348.2. Other variations are possible however based on these results it was concluded that a vegetative spillway was not practical and a structural auxiliary spillway would be needed.

For the structural auxiliary spillway option, a labyrinth type inlet structure was selected in order to maximize discharge with head and keep the structural width as small as possible. The hydraulic-jump type outlet structure was selected as being the most viable for reliable performance and energy dissipation. The width of the inlet and outlet structures needed to be coordinated from a hydraulic design standpoint. A structural chute on a 3H:1V slope will connect the inlet and outlet structures.

A 150 foot structural width was selected with the labyrinth weir crest set at elevation 2339.0 and the floor at elevation 2331.0. The hydraulic proportioning of this system was based on a discharge of 19,800 cfs which is 2/3 of the routed freeboard hydrograph peak discharge of 29,700 cfs however the system has the capacity to pass the full 29,700 cfs with the top of dam not exceeding the original 2347.6 elevation. In addition, one or a combination of orifices can be placed in the labyrinth weir walls so that the 100yr-24hr design storm can be passed with the water surface not exceeding the labyrinth weir crest elevation and with the maximum discharge not exceeding 850 cfs until water flows over the labyrinth crest. This would provide the flood control requested in the original CPNRD project.

A stepped type chute floor was investigated to determine if the energy dissipated within the chute would allow for a significant reduction in the jump-basin requirements. Although some reduction in the basin was indicated, the additional material required to construct the steps (rather than a smooth floor) more than offset the basin reduction and this approach was discarded.

Estimated material quantities and opinion of probable construction costs for this spillway system are shown in Appendix 2.5.

2.4.4 SDHF Release System

Three release rates, 1,000 cfs, 1,500 cfs, and 2,000 cfs, were investigated and associated pipe or box conduit sizes were determined for each SDHF release rate. The computed capacity of each size pipe or box was based entirely on pipe flow control. The gate opening and reservoir level can be coordinated such that the release rates would be held essentially constant for the full 3-day release period. In all cases the assumed reservoir starting level, elevation 2332.0, was more than adequate to provide the head and volume necessary for the release. Appendix 2.6 summarizes all the data from this analysis.

Figure 2.4.2 shows the opinion of probable construction costs for the conduits at the indicated release rates. In all cases the concrete box conduit appears to be the most cost effective. The computations for this chart are contained in Appendix 2.6.

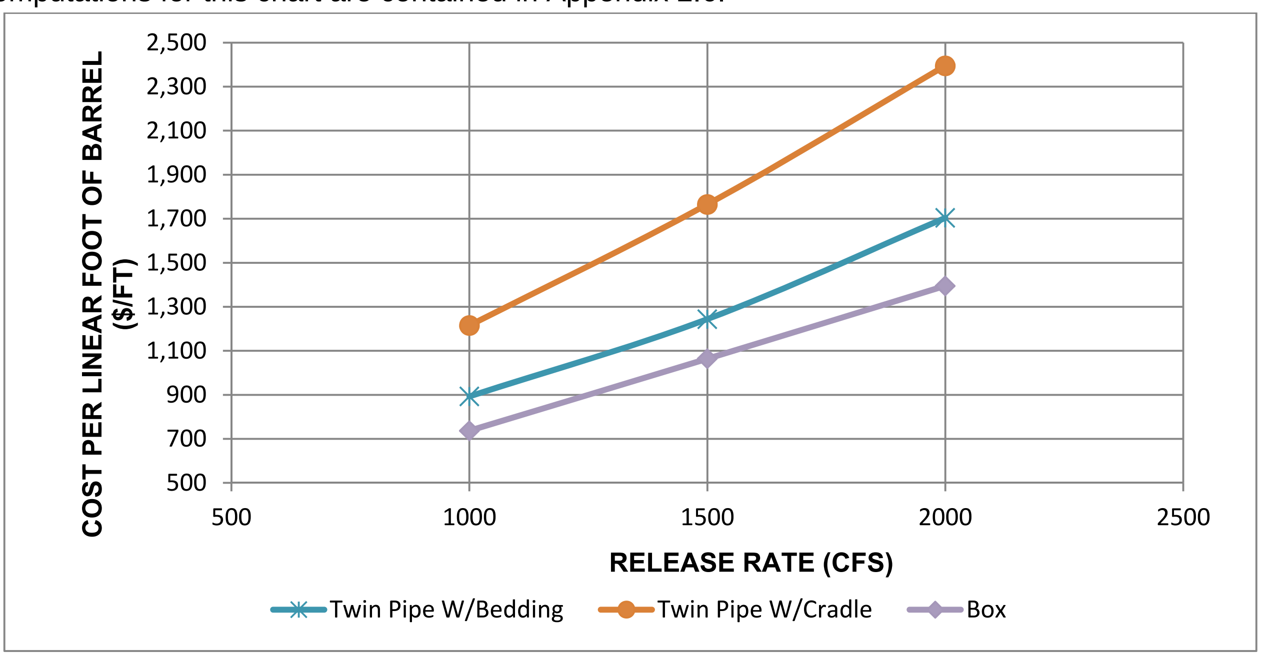


Figure 2.4.2 – SDHF Release System Probable Construction Costs

The high release rates will require energy dissipation before flows can be discharged into the Elm Creek channel. Two structure types were investigated for the energy dissipation needed at the outlet of this system, an impact basin and a hydraulic jump basin. Either type should work well for this application. The associated material quantities are shown in Appendix 2.6.

2.5 Reservoir Impacts

2.5.1 Right of Way Impacts

The proposed Elm Creek Regulatory Reservoir will require approximately 1,930 acres based on the 100-year flood pool elevation for the 19,850 acre-feet beneficial water reservoir. The impacted acres have an existing land use that is rural in nature. Cropland dominates the impacted acres and is approximately 67% of the total impacted acres. Pastureland accounts for 22% of the total impacted acres. Woodland pastureland located along the existing stream banks accounts for 10% of the total impacted acres. Dam embankments make up the remaining one percent. Land use impacts are summarized in Table 2.5.1.

	100-Year Surface Area Impacts		
Land Use Type	**19,850**	**12,000**	**6,800**
Cropland	1,308	1,062	900
Pasture Land	436	322	266
Woodland Pasture Land	186	169	152
Total Surface Area Impacts	**1,930**	**1,553**	**1,318**

Table 2.5.1 – Elm Creek Regulatory Reservoir Land Use Impacts

The proposed Elm Creek Regulatory Reservoir impacted acreages include 29 parcels of land and 24 landowners. Farmsteads relocations are summarized in Table 2.5.1 and shown in Appendix 2.7.

	Approximate LiDAR	Relocation due to 100-Year Flood Pool Elevation		
Property Location	**Surface Elevation**	**19,850**	**12,000**	**6,800**
		100-Year Pool Elevations		
		2339	**2333**	**2328.5**
NE 1/4 SE 1/4 SEC 18 T9N-R18W	2309	Yes	Yes	Yes
* SE 1/4 NE 1/4 SEC 18 T9N-R18W	2303	No	No	No
SW 1/4 NW 1/4 SEC 18 T9N-R18W	2312	Yes	Yes	Yes
** SE 1/4 NW 1/4 SEC 13 T9N-R19W	2337	Yes	No	No
SE 1/4 SE 1/4 SEC 12 T9N-R19W	2350	No	No	No
SE 1/4 SW 1/4 SEC 1 T9N-R19W	2332	Yes	Yes	No
NW 1/4 NW 1/4 SEC 12 T9N-R19W	2348	No	No	No
SE 1/4 NE 1/4 SEC 2 T9N-R19W	2343	No	No	No
SW 1/4 SW 1/4 SEC 36 T10N-R19W	2345	No	No	No
NW 1/4 SE 1/4 SEC 35 T10N-R19W	2346	No	No	No
NE 1/4 SE 1/4 SEC 13 T9N-R19W	2350	No	No	No
	Total Relocations	**4**	**3**	**2**

All Surface Elevation are based on LiDAR data. Finished Floor Elevation will need to be field verified for final design.

* Out Building, Structure does not support living quarters. ** Access Issues

Table 2.5.2 – Elm Creek Regulatory Reservoir Property Owner Impacts

2.5.2 County Road Impacts

The Elm Creek Regulatory Reservoir will impact several county roads within the reservoir. A majority of the county roads will be closed within the reservoir area, while county roads surrounding the reservoir will be improved. Table 2.5.3 and Table 2.5.4 summarize the county road impacts and are shown in Appendix 2.8.

County Road	County Road Closure Locations	County Road Closure Lengths (Miles)		
		19,850	12,000	6,800
DR 449	RD 753 to RD 755	2.0	2.0	2.0
Apache Road	1/4 mile north of 70th Road to DR 754	1.0	1.0	1.0
Arrow Road	70th Road to 85th Road	1.0	1.0	1.0
70th Road	Arrow Road to 3/4 mile east	0.75	0.75	0.75
RD 754	Drive 449 west 1/2 mile	0.5	0.5	0.5
85th Road	Apache Road to Arrow Road	1.0	1.0	1.0
DR 754	DR 449 to Apache Road	0.5	0.5	0.5
RD 755	RD 449 to DR 449	0.5	0.5	0.0
	Total County Road Closures	**7.25**	**7.25**	**6.75**

Table 2.5.3 – Elm Creek Regulatory Reservoir County Road Closures

County Road	County Road Upgrade Locations	County Road Upgrade Lengths (Miles)		
		19,850	12,000	6,800
DR 448	RD 756 to RD 757	1.25	1.25	0.0
RD 449	RD 755 to RD 756	1.0	1.0	0.0
Apache Road	DR 754 to RD 755	0.75	0.75	0.75
Arrow Road	85th Road to 1/4 mile north	0.25	0.25	0.25
85th Road	Arrow Road to 1/4 mile east	0.25	0.25	0.25
RD 755	RD 449 to Apache	0.50	0.50	1.00
100th Road	Apache Road to Arrow Road	1.0	1.0	1.0
RD 756	DR 448 to Apached Road	0.75	0.75	0.00
	Total County Road Upgrades	**5.75**	**5.75**	**3.25**

Table 2.5.4 – Elm Creek Regulatory Reservoir County Road Upgrades

Dawson and Buffalo County highway officials have yet to be contacted regarding the county road improvements. Coordination with the county officials will occur in future project phases.

2.5.3 Miscellaneous Impacts

Power lines and telephone lines run adjacent to the county roads throughout the Elm Creek Regulatory Reservoir area. A majority of the utility lines will be segmented and improvements will be made to re-route the lines around the reservoir. Olsson has estimated the need to relocate three (3) miles of power line and two (2) miles of telephone line. Nineteen (19) registered wells are located in the reservoir area and will be impacted with the construction of the regulatory reservoir. Table 2.5.5 summarizes the well impacts. Retired wells will be taken out of operation. The modified wells can remain in operation, but pivot operation will need to be modified. The wells are shown in Appendix 2.9. Based on the abandonment of the thirteen (13) registered wells, 1,310 acres of crop land will be retired below the 100-year pool elevation for the maximum 19,850 acre-feet reservoir size.

Irrigation Well Impacts	Irrigation Well Impacts		
	19,850	12,000	6,800
Total Retired Wells	13	12	12
Total Modified Wells	6	7	7
Total Well Impacts	**19**	**19**	**19**

Table 2.5.5 – Elm Creek Regulatory Reservoir Registered Well Impacts

2.6 GROUNDWATER MODEL EVALUATION AND RESULTS

2.6.1 Introduction

The following section summarizes the results of a groundwater model study prepared to simulate conditions in the Elm Creek area before and after construction of the proposed Elm Creek Reservoir. The current modeling effort was initiated to support feasibility analysis of several operational scenarios for the Elm Creek regulatory reservoir. The entire groundwater modeling report that includes model design and calibration is included in Appendix 2.10 of this report.

2.6.2 Modeling Objectives

During the Preliminary Feasibility Study, a groundwater modeling evaluation was completed and results were reported in a Groundwater Modeling Evaluation Report prepared for the Elm Creek Watershed Project (Olsson, 2007). The preliminary study groundwater model revealed:

- A groundwater mound will occur in the vicinity of the reservoir.
- No appreciable gains in area streams will occur.
- A water table increase of less than one foot was predicted at the Village of Elm Creek after construction of the reservoir.

Since the 2007 study, the design and operations of the reservoir have changed to maximize the use of the reservoir to provide augmentation flows to the Platte River. The design changes that affect the outcome of the previous groundwater model include an increase in the size of the reservoir and potential for water supply wells installed along the Platte River and/or along Dawson Canal. The previous groundwater model did not include the Platte River nor did it extend far enough to the west to evaluate the feasibility of using extraction wells along the Dawson Canal to provide water to the reservoir during certain months of the year.

A new groundwater model was developed to address current questions about the proposed Elm Creek Reservoir. The current groundwater model developed for the Elm Creek Reservoir Project was prepared to answer the following technical questions and topics:

1. Estimate the increase in the water table elevation surrounding the proposed reservoir at the beneficial pool level of 2,332 feet above mean sea level.

2. Evaluate if an increase in base flows to streams will occur in the study area and if so, how much?
3. Evaluate an optimal configuration of extraction wells to mitigate the water table rise in the Village of Elm Creek and the agricultural fields south of the reservoir.
4. Evaluate an optimal quantity and pumping rate for proposed extraction wells along the Platte River.
5. Evaluate the optimal quantity and pumping rate for proposed extraction wells located along Dawson Canal.

To answer these questions and address a request from Central Platte Natural Resource District to use a different groundwater modeling software program, the current model was:

- Created using the Groundwater Vistas software program by Environmental Simulations, Inc.
- Expanded to include the Platte River and the area west of Elm Creek along Dawson Canal.
- Developed using a steady-state simulation instead of transient conditions to ensure that the water table mound reaches equilibrium and provides insight into the maximum water table rise.

2.6.3 Conceptual Model

The groundwater model developed for this study is a site-specific model that lies within the Eastern Model Unit (EMU) developed by the Platte River Cooperative Hydrology Study (COHYST). The regional aquifer system characteristics were derived from the COHYST Hydrostratigraphic Units and Aquifer Characterization Report (Cannia et al, 2006). Since the COHYST model covers an area of 29,300 square miles, the regional information provided in the COHYST report was augmented by site specific data from the modeled area gathered from the following sources:

- Water level measurements from 1983 to 2007 at ten (10) monitoring wells in the Elm Creek area (Source: CPNRD)
- Irrigation well information from the Department of Natural Resources Groundwater Well databank (http://dnrdata.dnr.ne.gov/wellssql/)
- Site specific subsurface drilling logs and geotechnical analysis from the 2007 Groundwater Model Evaluation Report (Olsson, 2007)

Quaternary age sand and gravel units and the coarser portions of the Ogallala Formation are the primary aquifers in the area. Across the Elm Creek area, groundwater is unconfined (water-table conditions) and flows east to southeast. Area well records indicate the depth to groundwater varies from one (1) to twenty-five (25) feet below ground surfaces (bgs) in the Platte River Valley to 31 to 145 feet bgs in the upland areas north of Elm Creek.

COHYST identified five (5) hydrostratigraphic units (HU) in the Elm Creek area (Cannia, 2006) based on the differences in hydraulic properties of the specific units. Each HU corresponds to individual layers in the groundwater model discussed in this report. Layer 1 (HU-1) represents Quaternary fines ($Q_{l/s}$ loess and dune sand). HU-2 represents Quaternary alluvial/valley fill deposits

(Q_a). The lower three layers (HU-3, HU-4 and HU-5) represent the Miocene silts (primarily in HU-3) and sand and gravel deposits (HU-4 and HU-5) of the Ogallala Group(T_o).

2.6.3.1 Hydraulic Properties

The hydraulic properties of the five hydrostratigraphic units in the Elm Creek model are based on information from the COHYST Hydrostratigraphic Units and Aquifer Characterization Report (Cannia, 2006). Hydraulic properties of the COHYST Hydrostratigraphic Units were used in the current simulations to ensure reproducibility and comparability of the model solutions. One exception to this was the hydraulic property information used to simulate the lake bed of the proposed Elm Creek Reservoir. Falling head permeability tests were performed on samples collected from the materials underlying the proposed reservoir during a 2007 geotechnical field investigation (Olsson 2007). Results of the investigation indicate vertical hydraulic conductivities up to 0.008 feet per day (ft/day) in the underlying loess deposits.

2.6.3.2 Hydraulic Parameters

The hydraulic parameters used for the Elm Creek Model were provided by the Central Platte NRD as defined in the Eastern Model Unit (EMU) for COHYST (Cannia, 2006). The statistics on the horizontal hydraulic conductivity for the five layer model are presented in Table 2.6.1. The hydraulic parameters were not changed during model development or calibration.

COHYST Unit Name	Layer in Model	COHYST Hydrostratigraphic Unit Description	Mean Hydraulic Conductivity (ft/d)	Range Hydraulic Conductivity (ft/d)	Standard Deviation (ft/d)
HU1	Layer 1	Quaternary loess and silt deposits	10	10	0.0
HU2	Layer 2	Quaternary alluvial gravel and sand	137	7.5-240	65.4
HU3	Layer 3	Miocene silts deposits	16.6	5-139	32.0
HU4	Layer 4	Tertiary Ogallala – upper unit	30.7	12-37	10.8
HU5	Layer 5	Tertiary Ogallala – middle unit	18	10-37	12.4

Table 2.6.1 - Hydrostratigraphic Unit Hydraulic Conductivity Parameters

2.6.4 Simulation with Elm Creek Reservoir

Elm Creek Reservoir was simulated with the MODFLOW Lake Package (USGS, 2000). This package, within the MODFLOW-2000 code, provides the capability to represent constructed storage reservoirs or natural lakes and ponds. The Lake Package can account for surface flows to and from the reservoir, as well as inflow from surface runoff and precipitation and outflow from surface evaporation. The package calculates a separate lake water budget and stage using the input/output terms that MODFLOW-2000 uses to calculate the flux and gradient of flow between the reservoir and the aquifer. A full description of the model development is in Appendix 2.10. For the simulation with the Elm Creek regulatory reservoir, a lakebed thickness of forty (40) feet and a vertical hydraulic conductivity of 0.0047 ft/d (geometric mean of values reported in 2007 Olsson geotechnical study) were applied to the Groundwater Vistas interface which automatically calculated a conductance term for each lake cell in the model. These input terms are based on the Olsson geotechnical investigation (Olsson, 2007) that determined the water table depth and permeability of area soils. 1996 hydrologic information (Dawson Canal flows and Elm Creek inflows, evaporation, precipitation) was averaged for input parameters to the lake package to assess the impacts of the proposed Elm Creek regulatory reservoir on the local water table. The overall lake area assigned to the model grid covers an area defined where the shoreline of the beneficial pool stage level (2,332 ft asl) would exist. A stage of 2,332 ft was maintained during all of the assessment simulations described in the following sections.

To assess the impacts of the proposed Elm Creek reservoir on the area water table within the study area, the calibrated model described in Appendix 2.10 was simulated with the Lake package configured with the input terms described. The steady-state simulation results are shown in Exhibit 2.6.1.

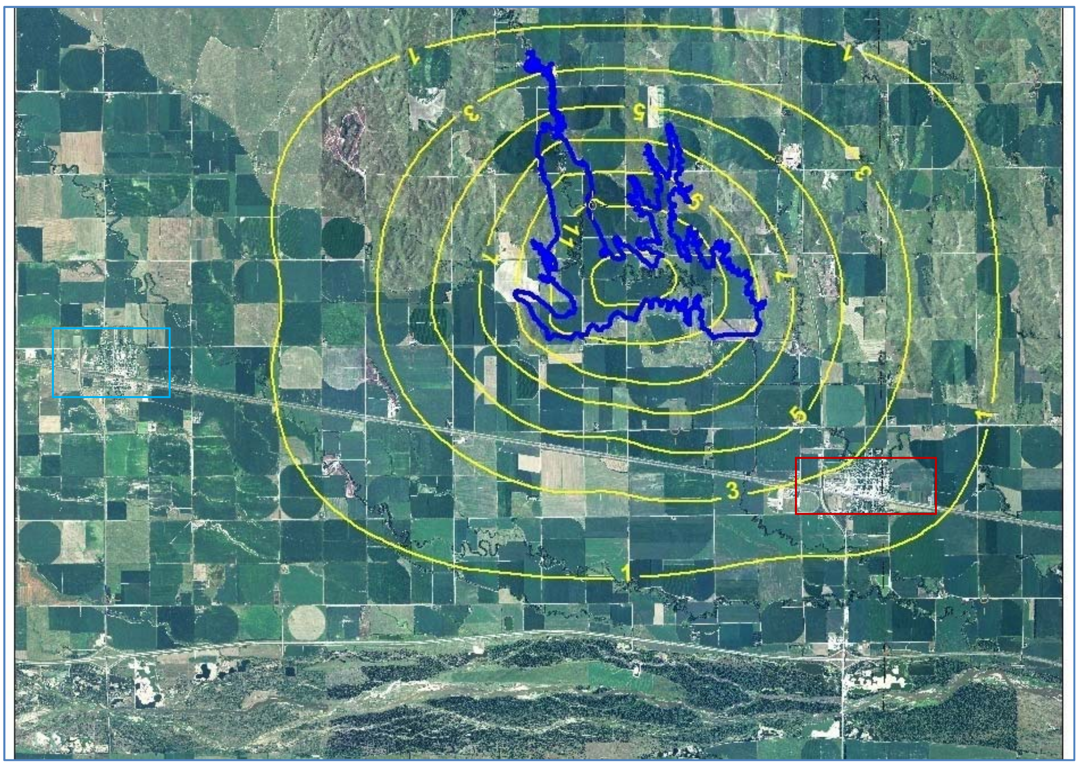


Exhibit 2.6.1 - Simulated increase in water table elevations post-lake construction and filling. Contour intervals are set at 2 ft. The Village of Elm Creek is shown in the red box.

2.6.4.1 Potential Impacts to Water Levels at the Village of Elm Creek and Surrounding Areas

Exhibit 2.6.1 shows contours of the water table rise or "mound" created by seepage from the proposed reservoir at a point when the system reaches steady state. The water table mound created by lake seepage ranges from eleven (11) to thirteen (13) feet at the reservoir to one (1) foot at a radius of approximately three (3) miles from the reservoir. Of particular interest to this investigation is the rise in water levels south and southeast of the reservoir where a relatively shallow water table exists beneath the Village of Elm Creek and agricultural fields south of the reservoir. At the Village of Elm Creek (area inside red box on Exhibit 2.6.1), the rise in the water table ranges from approximately four (4) feet on the northwest side of town to slightly over a foot southeast of town. In this area, the water table is typically about ten (10) feet below the land surface, so potential exists that the water table could approach five (5) feet below the land surface on the northwest edge of Elm Creek without mitigation.

Directly south of the proposed reservoir, the water table rise ranges from three (3) feet directly west of town, to ten (10) feet within a half mile of the south side of the reservoir. As with the mounding levels near the Village of Elm Creek, the water table can potentially come within five (5) feet of the land surface in the agricultural fields south of the reservoir without mitigation measures.

2.6.4.2 Mitigation of Water Table Mounding

As demonstrated by Exhibit 2.6.1, water table mounding from the proposed Elm Creek reservoir could range from two (2) to four (4) feet at the Village of Elm Creek, and three (3) to ten (10) feet in the agricultural areas directly south of the reservoir. Olsson explored options of mitigating the water table mound in these areas, Olsson tested model scenarios with extraction wells placed west and northwest of the Village of Elm Creek. The objective was to find the optimal number and placement of wells with rates that would reduce the mound levels to pre-reservoir conditions. Exhibit 2.6.2 shows the final configuration of a well field comprised of five (5) wells with pumping rates ranging from 200 to 500 gallons per minute (GPM). The three (3) wells directly south of the reservoir were each simulated with a pumping rate of 500 GPM, and the two wells north and northwest of the Village of Elm Creek were assigned pumping rates of 200 and 300 GPM. The contours show that the decline in the water table in the Elm Creek/agricultural area approach twenty (20) feet near the wells and exceed the level of mounding in this area. Exhibit 2.6.3 shows the decrease in the water table below the pre-lake water table. The amount of decline below pre-lake levels indicates that a well field configured with five (5) wells pumping at rates of 200-500 GPM is a conservative design that has the potential to reduce the mounded water table well below pre-lake conditions. Well field layout is shown in Appendix 2.11.

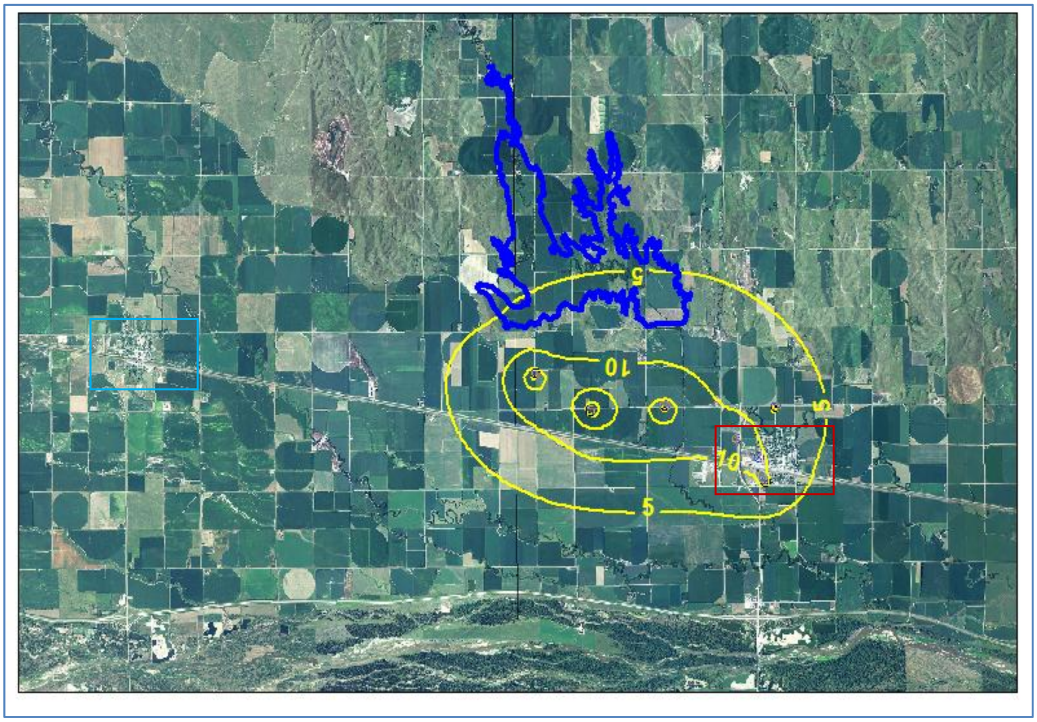


Exhibit 2.6.2 - Simulated decrease in the mounded water table from 5 extraction wells pumping 200 to 500 GPM. Contour intervals are 5 ft.

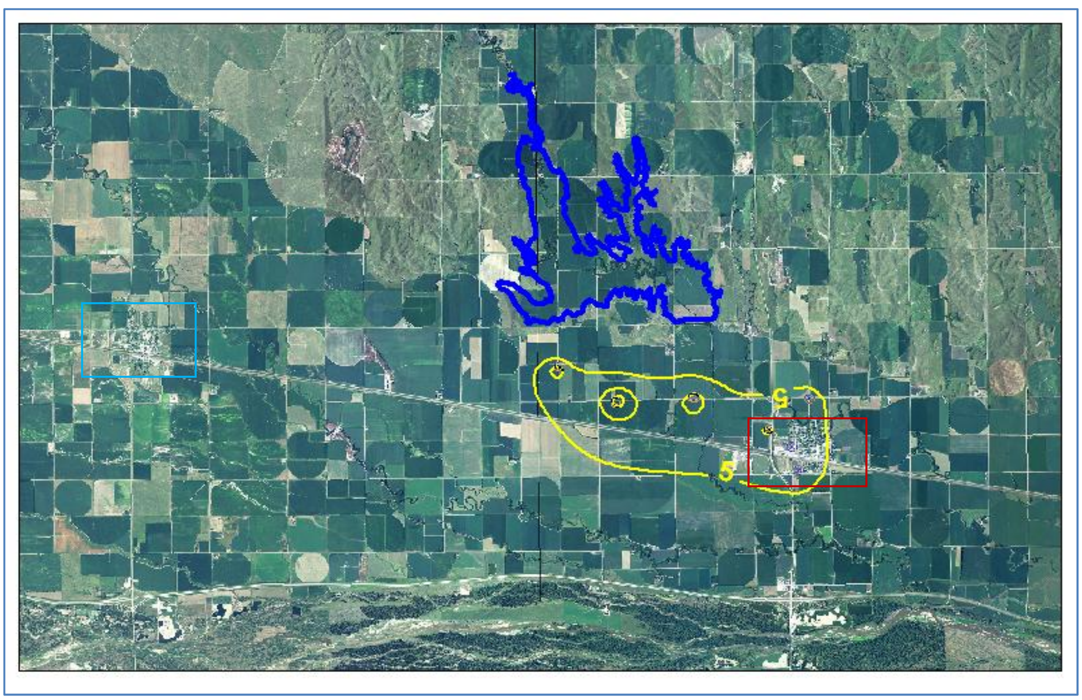


Exhibit 2.6.3 - Simulated decrease in the water table below pre-reservoir conditions from 5 extraction wells pumping 200 to 500 GPM. Contour intervals are 5 ft.

2.7 Water Budget

The Elm Creek Regulatory Reservoir has several water budget components to evaluate when considering the project water budget. The water budget consists of reservoir seepage, pre- and post- project consumptive use, watershed yield, Platte River excess flows methodology and groundwater supply. The reservoir surface area and storage volume are also contributing factors when considering the water budget. A detailed discussion of the water budget and project yield is presented in Section 6.0.

2.8 Reservoir Project Benefits

2.8.1 Platte River Flow Augmentation Benefits

The Elm Creek Regulatory Reservoir provides storage capacity for the retiming of Platte River excess flows. Reservoir storage can also be used for water obtained through water leasing, in conjunction with ground water recharge projects, or secondary storage for environmental account water from Lake McConaughy. The augmentation of the Platte River flows has become the primary benefit of the Elm Creek Regulatory Reservoir Project. The goal of the project is to reduce shortages to the target flows in the Platte River and/or to supplement a short duration high flow (SDHF) event in the Platte River. Target flows and excess flows are summarized in Section 6.1.4.

2.8.2 Flood Control Benefits

The Elm Creek Project was first proposed to reduce flooding downstream of the proposed regulatory reservoir and to provide flood protection to the Village of Elm Creek. The State of Nebraska Dam Safety Requirements classifies the proposed regulatory reservoir as a “High Hazard” structure. The dam will be required to control runoff from a 100-year flood event, and pass the PMP storm event through the auxiliary spillway without overtopping the embankment. A breach routing of the dam has not been completed in this study. The “High Hazard” design criteria were used to preliminary size the dam structure. The high hazard dam design requirements will provide flood reduction downstream of the reservoir. Therefore the project will continue to meet one of the original goals of the CPNRD, but benefits from the flood reduction have not been analyzed in this report.

2.8.3 Recreational Benefits

A potential benefit of the project will be recreation related to the reservoir. This site is suitable for public recreation with a large deep pool and fairly large water surface. Water-based projects of this size could support public activities ranging from RV and tent camping, to hiking, biking, and horseback riding. Recent projects around the state have featured a wide range of recreation amenity designs, generally related to the size of the proposed reservoir. This was identified in the Preliminary Feasibility Report (Olsson, May 2006). This Feasibility Study did not analyze the potential for recreational benefits.

3.0 WATER SUPPLY

3.1 Dawson County Canal System

3.1.1 Introduction

The Dawson County Canal is a potential water supply conveyance system for the regulatory reservoir. Dawson County Canal is an existing irrigation canal currently operated by Nebraska Public Power District (NPPD). The Platte River diversion location for the Dawson County Canal is located near the Cozad Interstate 80 (I-80) Interchange. The Dawson County Canal is approximately 42 miles long and terminates into the Elm Creek Channel near the proposed regulatory reservoir. An overview map of Dawson County Canal is located in Appendix 3.1. Elm Creek Regulatory Reservoir is situated to capture the water from the Dawson County Canal that is not used for irrigation.

The existing Dawson County Canal has a diversion capacity of 450 cfs at the Cozad I-80 Interchange. The lower reach of the Dawson County Canal was evaluated for hydraulic capacity. The study reach is from the French Creek Siphon to the canal termination which runs approximately 26 miles. The French Creek Siphon is located approximately six (6) miles north and one (1) mile west of Lexington, Nebraska. The French Creek Siphon has an existing capacity of 365 cfs. The lower reach of Dawson County Canal has an existing capacity of approximately twenty (20) cfs, based on existing culvert restrictions. The existing canal cross section within this reach of the canal has a bottom width of five (5) to ten (10) feet, side slopes of 1:1 to 3:1 and a depth of flow of five (5) to eight (8) feet. This cross section has the ability to handle 80 cfs to 400 cfs without the culvert restrictions. The main constrictions in the canal are the siphons and the road culverts. Three (3) siphons are located downstream of the French Creek Siphon. The Hack Siphon is located 8.6 mile upstream of the canal termination point and has an existing capacity of 125 cfs. The Bye Siphon is located 6.6 miles upstream of the canal termination point and has an existing capacity of 120 cfs. The East Siphon is located 2.7 miles upstream of the termination point and has an existing capacity of 55 cfs.

3.1.2 Capacity Analysis

The options evaluated in the study, include upgrades of the lower reach of the canal to a capacity of 50 cfs, 75 cfs, 100 cfs and 125 cfs. The East Siphon will need to be reconstructed to accommodate the flow capacities of 75 cfs, 100 cfs, and 125 cfs. The Hack Siphon and the Bye Siphon will carry flows of 125 cfs and 120 cfs, respectively, which are considered to have adequate capacity for this study.

An increase in flow at the structures will produce an increase in the headwater elevation, thus, an increase in the depth of flow. Table 3.1.1 indicates the length of canal improvements necessary to contain the backwater, and the estimated increase in levee height required. The levee improvements contain the increased flow and maintain one (1) foot of freeboard. Table 3.1.1 improvements reflect no siphon or culvert improvements.

	Levee Improvements	Increase Levee Height (1' FB)
CFS	Miles	Feet
20	0	0.0'
50	3.2	1.2'
75	8.5	1.5'
100	13.4	1.8'
125	16.1	2.3'

Table 3.1.1 – Dawson County Canal – No Culvert Replacements

Culvert improvements were included in the HEC-RAS model and Table 3.1.2 indicates the length of canal improvements necessary to contain the backwater impacts and estimates the increases in levee heights. The levee improvements contain the flows in Dawson County Canal and maintain one (1) foot of freeboard. Culvert restrictions caused by backwater were identified by hydraulic jumps in the water surface profile across the culverts. These culverts were identified to be removed and replaced with a larger culvert to accommodate the higher flows. The proposed culvert improvements include four (4) 48" CMP, ten (10) 60" CMP, one (1) 60" CMP arch and three (3) 72" CMP. The location of the culvert improvements are shown on the plan and profile exhibits in Appendix 3.1.

	Levee Improvements	Increase Levee Height (1' FB)
CFS	Miles	Feet
20	0	0.0'
50	0.9	0.8'
75	4.8	1.0'
100	10.5	1.3'
125	14.7	1.5'

Table 3.1.2 – Dawson County Canal – Culvert Improvements

Dawson County Canal levee improvements will require additional embankment material to increase the levee elevations. The levee improvements will require additional ROW easements. A detailed analysis of the ROW impacts was not performed for this study. However, the ROW impacts have been quantified for the purpose of cost estimating. Water velocities were evaluated to determine if the canal levees will remain stable. Water velocities under four (4) feet per second were considered to be stable. Based on the HEC-RAS analysis shown in Appendix 3.2, 95 percent of the canal has water velocities under four (4) feet per second for the different flow regimes. When the velocities are high, minor canal armoring is anticipated and has been quantified for the purpose of cost estimating. The increase in water surface elevations in Dawson County Canal will have an impact on existing check structures and farm field turnouts that deliver water for irrigation. A detailed inventory of structures was not available for this analysis. Based on past experience with irrigation canals, Olsson has assumed replacement of five (5) farm field turn outs and one (1) check structures per mile for this study. Dawson County Canal outlet will be re-graded and diverted into the proposed reservoir. The existing canal downstream of the diversion will remain to serve irrigation along the existing canal. The Dawson County Canal diversion is shown in Appendix 3.3. Coordination with NPPD will be required to determine what impact the proposed improvements will have on the water delivery structures.

Opinion of probable construction cost estimates have been generated for Dawson County Canal improvements for 50 cfs, 75 cfs, 100 cfs and 125 cfs. Detail cost estimates are included in Appendix 7. The results of the cost analysis are shown in Figure 3.1.1.

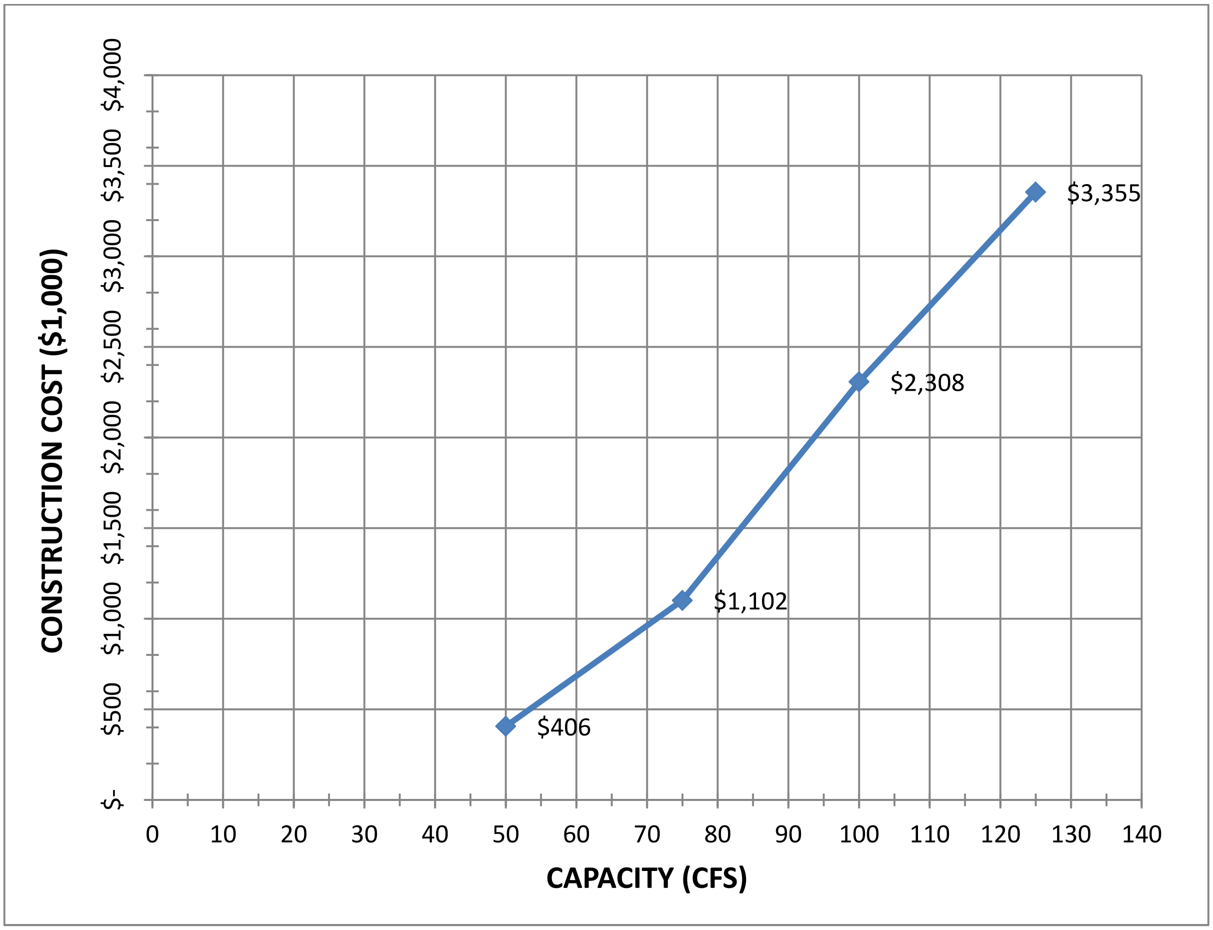


Figure 3.1.1 - Dawson County Canal Non-Winter Operations Improvement Cost

3.1.3 Winter Operations

Dawson County Canal infrastructure has not been evaluated for potential winter operations for the 42 miles of canal. Canal winter operations may require additional freeboard in the canal and at the structures to allow design capacity to flow under an ice cover. At subfreezing temperatures an ice cover readily forms when velocities are less than 2.2 feet per second (Design of Small Canal Structures, US Department of the Interior, Bureau of Reclamation, 1978). Excess Platte River flows are readily available over the winter months. Yield results were generated for the Dawson County Canal winter operation and are discussed in Section 6.3. Opinion of probable construction costs were not generated for the Dawson County Canal winter operation alternatives.

Dawson County Canal groundwater pump alternatives do include winter operation of the lower reach of the canal. Improvements to the lower reach of the canal for winter operation include an increase in freeboard to maintain flows under ice conditions and additional wasteways to relieve a rise in tail water due to ice jams at the structures. These improvements have been quantified and included in the opinion of probable construction cost estimates for the Dawson County Canal groundwater pump alternatives.

Nebraska Public Power District, with the aid of the Platte River Recovery Implementation Program, has hired a consulting firm to study the potential use of the Dawson County Canal under winter operations. Capital costs for the winterization of Dawson County Canal may be generated by the NPPD study. These costs could then be combined with the yield estimates calculated during this study to determine life cycle cost. The feasibility of canal winter operations can then be compared to the results of this study.

3.1.4 Seepage Analysis

A Dawson County Canal seepage loss study was performed (Aqua, 2008) and found a weighted average system loss of 0.5 cfs per mile. Individual segments of the Canal ranged from a gaining portion to a 33% loss section. For the range of flows being considered, and given the loss study findings, a 40% transmission seepage loss rate was applied to the flows entering the head gates. A portion of the seepage losses will return to the Platte River.

A 50-year percent depletion/accretion map along the Platte River valley was developed by the Central Platte Natural Resources District with use of the Platte River Cooperative Hydrology Study's (COHYST) eastern regional groundwater model. This figure is shown in Appendix 3.4. The original COHYST eastern regional groundwater model was used to determine the depletion/accretion percentages and was constructed with five (5) model layers that simulated aquifer conditions over the 1950-1997 time periods. The model simulated 50 years with 1997 climatic and land use conditions held constant for the duration of each model run. Depletion/accretion to the Platte River was calculated with the model for each quarter-square mile model cell using a special application program that cycled a well pumping one (1) cfs for 50 years in each model cell. The 50-year map shows depletion or accretion percentages by legal sections that represent averaged depletion/accretion values over four (4) model cells. To exemplify what each individual value indicates on the map, a section with twelve (12) percent depletion/accretion indicates that within the square mile section, the Platte River would be depleted by a volume of water equal to twelve (12) percent of the volume pumped from a well over 50 years. The same principle can be applied to delineate accretion percentages to the Platte River from seepage or injection occurring within each section in the study area.

Based on the 50-year percent depletion/accretion map, an average return rate for Dawson County Canal Seepage Return Flow of 32% was used. Basically, 32% of the volume of water lost to seepage in the Dawson County Canal, returns to the Platte River in 50 years. This seepage return flow is an increase to Platte River flows and is calculated as a credit in the Platte River Accretion/Depletion Equation (shown in Section 6.1.4.2.1).

3.1.5 Pump Alternatives

Olsson evaluated installing extraction wells along the south side of Dawson County Canal in the northwest part of the study area to capture the seepage losses from the canal. Three (3) configurations were tested: seven (7) wells pumping thirty (30) cfs cumulatively, eleven (11) wells pumping fifty (50) cfs cumulatively, and a seventeen (17) well design pumping a cumulative rate of 75 cfs. Well spacing ranged from nearly a half mile for the thirty (30) cfs design to approximately 1,000 feet for the 75 cfs configuration. Drawdowns from the post-reservoir mounded water table for the three (3) designs are shown in Exhibits 3.1.1 – 3.1.3. Each simulation included the mound mitigation wells described in Appendix 2.10 since it is likely that wells near the Village of Elm Creek would also be installed to prevent excessive rises in the water table south and southeast of the reservoir even with the presence of a well field west of the reservoir along Dawson County Canal.

Based on the 50-year percent depletion/accretion map, a Dawson County Canal pump depletion rate of 10% was used. Ten percent of the water volume pumped, for the Dawson County Canal Pump alternatives, is calculated as a Platte River depletion. The project yields for the Dawson County Canal alternatives reflect the depletion percentage and are included in the project yield summary. See section 6.1.4.2.1 for additional information on project yield calculations.

3.1.5.1 Groundwater Impacts

The increase in the number of wells and associated cumulative pumping rates resulted in a larger zone of influence areas and depths of drawdown of the post-reservoir mounded water levels. With seven (7) wells pumping thirty (30) cfs, the maximum drawdown exceeded twenty (20) feet around the pumping wells at the three (3) eastern wells along the canal shown in Exhibit 3.1.1. With the extraction rate increased to fifty (50) cfs with eleven (11) wells shown in Exhibit 3.1.2, the maximum drawdown of the mounded water table exceeded thirty (30) feet at the easternmost well along the canal. The 75 cfs simulation with seventeen (17) wells showed that a maximum drawdown of post-reservoir mounded water levels would surpass forty (40) feet on the eastern side of the canal well field displayed in Exhibit 3.1.3. With increasing extraction rates/number of wells, the zone of influence of pumping encroaches further south. With seven (7) wells pumping thirty (30) cfs, declines in the mounded water table do not exceed five (5) feet at the eastern limits of the city of Overton (blue box on Exhibits 3.3.1 – 3.3.3), but with an extraction rate of 75 cfs, declines in the mounded water table exceed five (5) feet under the northeastern half of Overton. Increasing extraction rates from the Dawson County Canal well field also influence the amount of decline in the post-reservoir mounded water table south of the reservoir where mitigation wells were a part of the simulation. Declines in the post-reservoir mound near the mitigation wells exceed twenty (20) feet with the canal well field pumping 75 cfs as well as a larger area of influence, as compared to a thirty (30) cfs extraction rate from seven (7) wells along the Dawson County Canal. The drawdowns, indicated in all of these model simulations, are run until a steady state condition exists. Based on the estimated amount of pumping allowed, the steady state condition will not be realized and the pumping levels shown will not represent actual operations conditions.

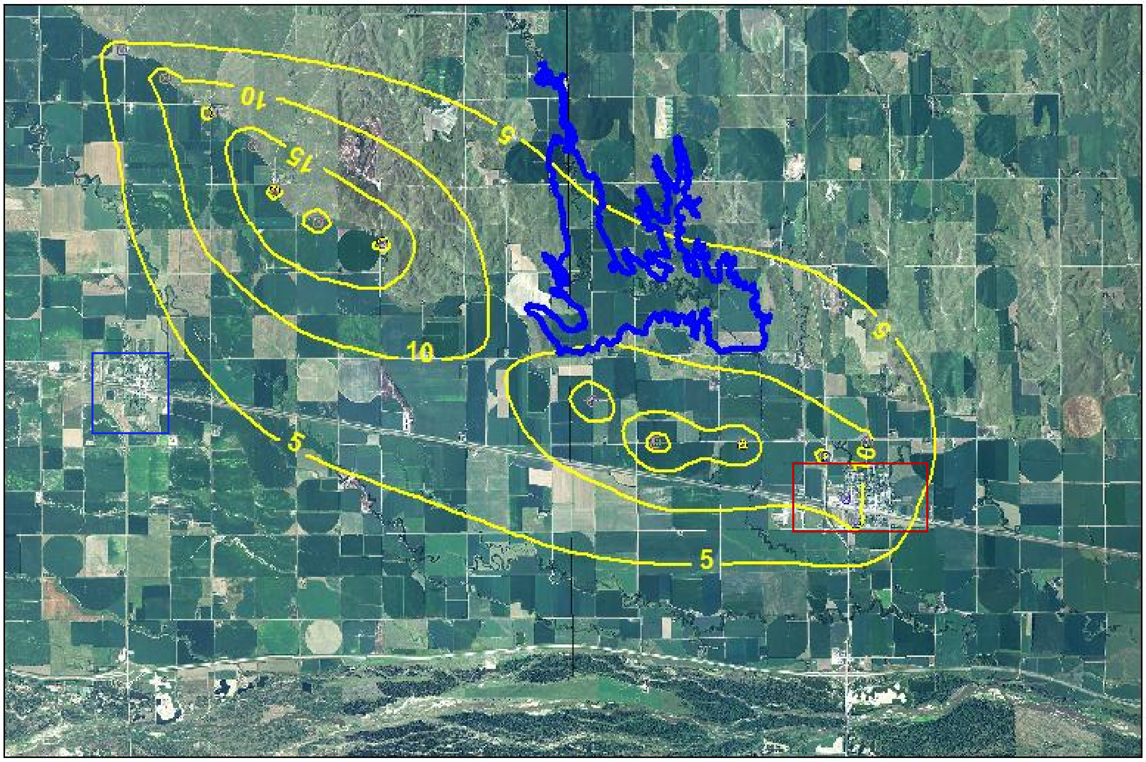


Exhibit 3.1.1 – Groundwater Declines – Pump Rate at 30 cfs. Contour intervals are 5 ft.

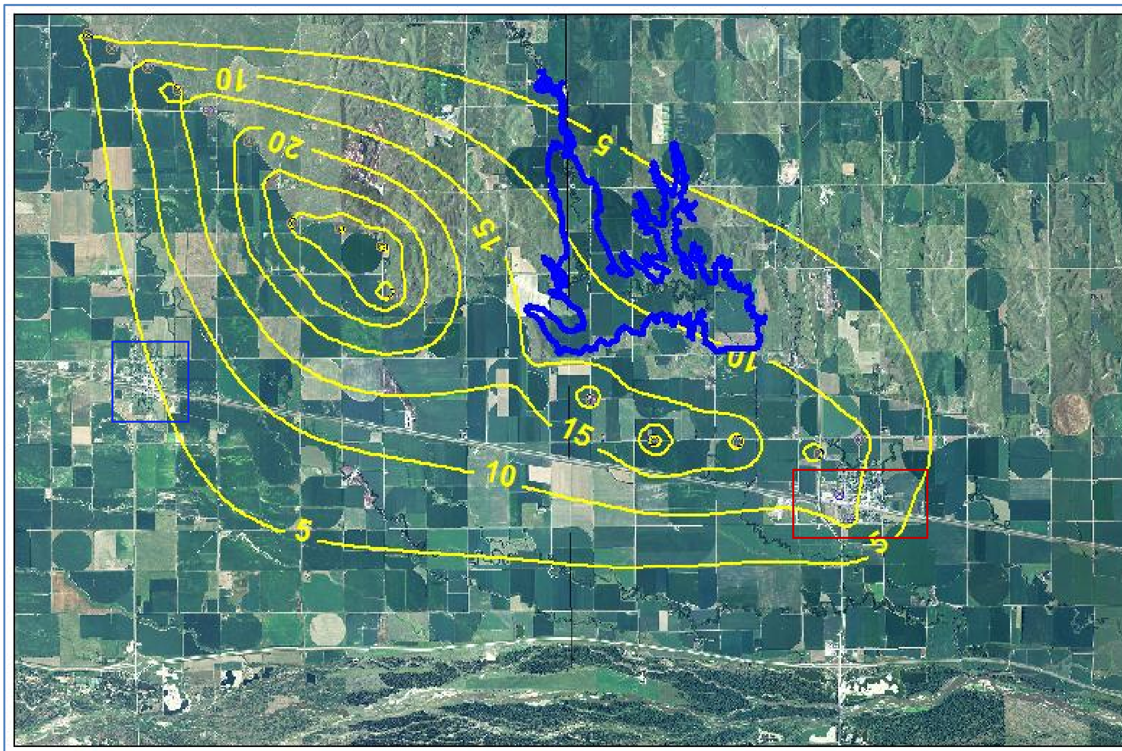


Exhibit 3.1.2 – Groundwater Declines - Pump Rate at 50 cfs. Contour intervals are 5 feet.

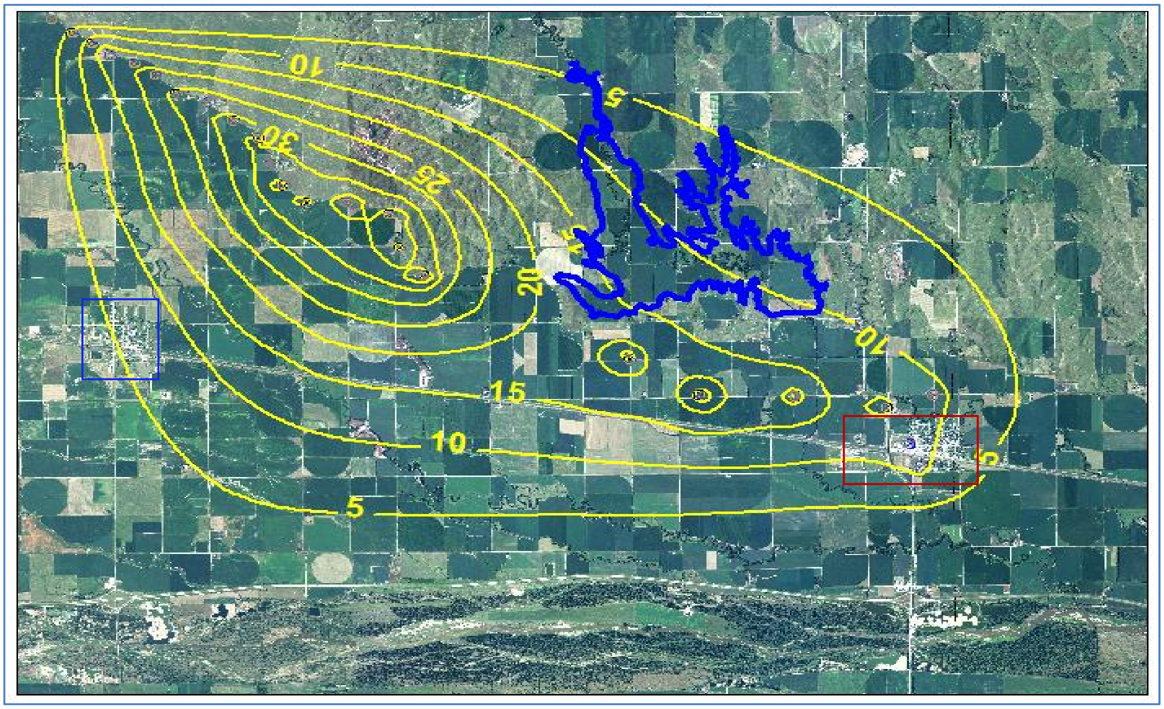


Exhibit 3.1.3 – Groundwater Declines - Pump Rate at of 75 cfs. Contour intervals are 5 feet.

3.2 Platte River Well Field Pump Station

3.2.1 Introduction

A Platte River well field and pump station was another alternative for conveyance of Platte River excess flows to the proposed Elm Creek Regulatory Reservoir. The well field would run parallel to the Platte River South of Interstate 80, and be located adjacent to the river. This alternative would be comprised of vertical extraction wells, collector pipe system, pump station, transmission pipeline and reservoir intake structure. A conceptual layout of the Platte River Well field Pump Station is included in Appendix 3.5. The vertical extraction wells have a spacing of 800 feet and a pumping rate of 1,100 GPM each. The yield methodology for the Platte River Well field Pump Station is discussed in Section 6.1.4.

The Platte River Well field Pump Station alternative was evaluated at three (3) pump supply rates -, included 70 cfs, 100 cfs and 130 cfs. The three (3) pumping rates would deliver water volumes of 138 acre-feet/day, 198 acre-feet/day and 256 acre-feet/day, respectively. A water volume equal to the maximum beneficial storage volume can be delivered to the reservoir in 78 days at the 130 cfs pumping rate, but will take 100 days at 100 cfs pumping rate and 144 days at the 70 cfs pumping rate.

The pump system design is contingent on the elevation head, flow rate, hydraulic pipe friction losses, transmission pipeline diameter, length of transmission pipeline and the maximum design water velocity in the pipeline. Elevation in the Platte River is 2237 feet and the maximum reservoir pool elevation is 2332 feet, for an elevation head of 95 feet. The hydraulic pipe friction head is a function of the pipeline diameter and water velocity in the pipeline. Pipeline diameters of 42-inch, 54-inch and 60-inch, respectively, were used for the three (3) different pumping rates. Design water velocity in the pipeline was maintained at 6.5 feet per second. A hydraulic friction head of 65 feet was used for a total dynamic head of approximately 160 feet for all pumping rates. The transmission pipeline runs approximately four (4) miles north to the proposed reservoir.

The study determined that, for the flow rates and hydraulic head conditions described above, the following pump and pipeline combinations would be used as the basis for developing preliminary cost opinions for the alternative of conveying water to Elm Creek Regulatory Reservoir from the Platte River Well Field Pump Station:

- Flow Rate – 70 cfs, pump station includes three 800 horsepower pumps, delivering water through a 42-inch diameter pipeline four (4) miles long.
- Flow Rate – 100 cfs, pump station includes three 800 horsepower pumps, delivering water through a 54-inch diameter pipeline four (4) miles long.
- Flow Rate – 130 cfs, pump station includes four 800 horsepower pumps, delivering water through a 60-inch diameter pipeline four (4) miles long.

The final design and selection of pipeline and pump sizes for the requirements of this specific project requires detailed engineering analysis and balancing of several design parameters including: hydraulic efficiency, cost, and system-component parameters to develop and construct facilities that will be efficient over the life of the project. Smaller-size pipes are generally less costly, but can substantially increase the hydraulic friction head and corresponding pump-equipment-size/energy costs necessary to "push" the required flow to its delivery point.

Opinions of probable construction cost are shown in Figure 3.2.1 for the three (3) pumping rates. The Platte River Well Field Pump Station alternative to supply Platte River water to the Elm Creek Regulatory Reservoir is a higher cost alternative, due to the substantial capital cost of constructing the four (4) mile long transmission pipeline from the river into the reservoir.

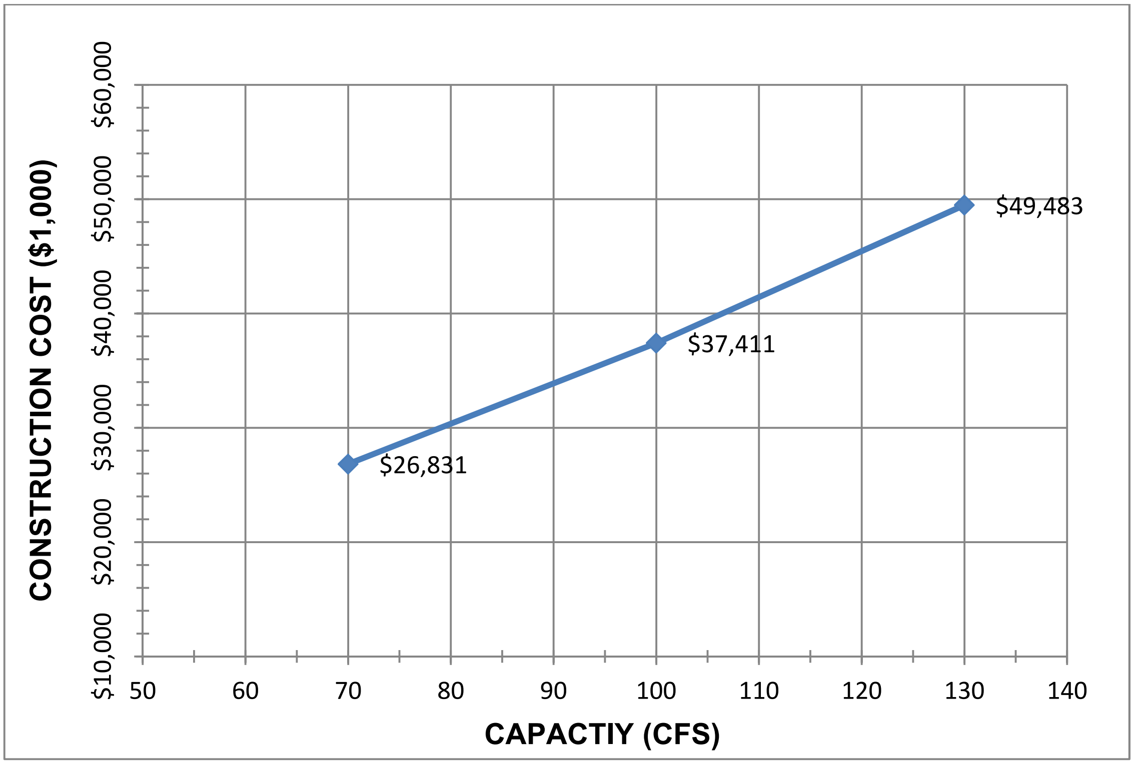


Figure 3.2.1 – Platte River Well Field Pump Station with Pipeline - Opinion of Construction Costs

3.2.2 Potential Impacts of Extraction Wells near the Platte River

Exhibit 3.2.1 shows the decline in the post-reservoir water table at steady state (worst case) conditions resulting from an extraction rate of 75 cfs. The decrease in the mounded water table approaches forty (40) feet near the center of the well field and exceeds ten (10) feet under much of the Village of Elm Creek. It is apparent that in comparison with the increase in water levels from lake seepage in Exhibit 2.6.1, a well field along the Platte River would reduce the post-reservoir mounded water table by six to eight feet below pre-reservoir levels near the Village of Elm Creek and ten to fifteen feet below pre-reservoir levels in the agricultural lands west of the village. The wells would be operated at times of excess flows in the Platte River and the steady state (worst case) conditions will not occur.

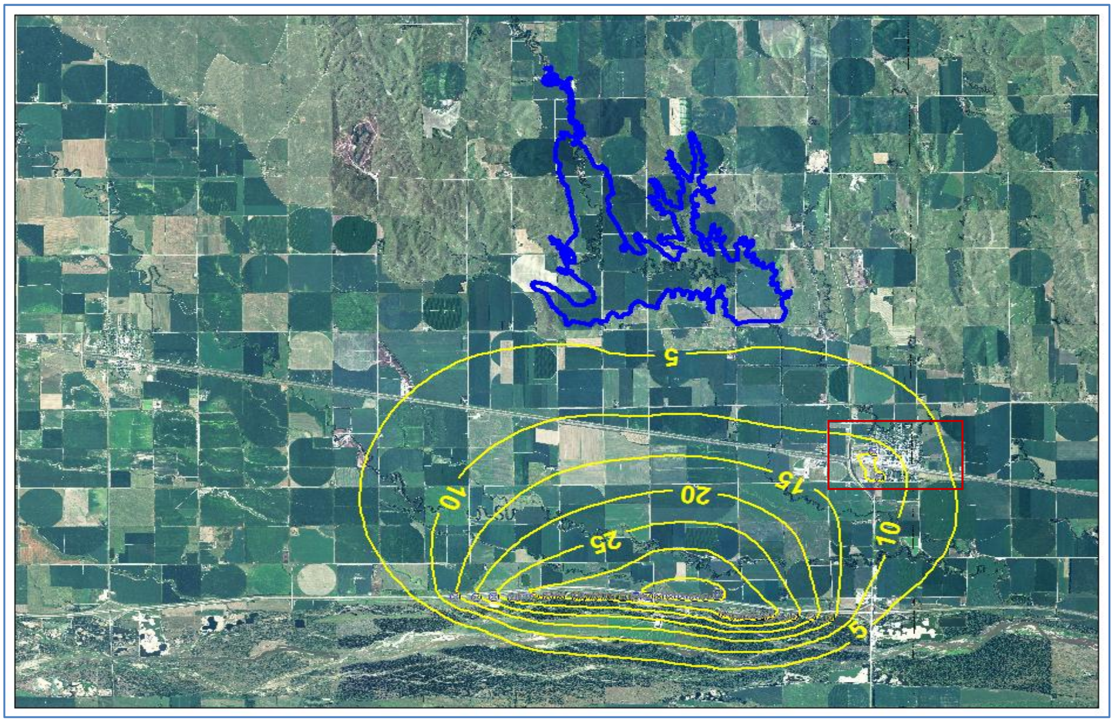


Exhibit 3.2.1 – Water table decrease – Groundwater pumping at 75 cfs. Contour intervals are 5 ft.

3.3 Kearney Canal Diversion Pump Station

3.3.1 Introduction

The Kearney Canal Diversion Dam and the Kearney Canal was a third alternative for conveyance of Platte River excess flows to the to the proposed Elm Creek Regulatory Reservoir. A pump station along the Kearney Canal would be constructed downstream of the Kearney Canal diversion dam. Nebraska Public Power District currently owns and operates the Kearney Canal for surface water irrigation and hydro-power. The diversion is located one (1) mile east and two (2) miles south of the Village of Elm Creek. This alternative would be comprised of a diversion structure on Kearney Canal, pump station, transmission pipeline and reservoir intake structure. A conceptual layout of the Kearney Canal Diversion Pump Station is shown in Appendix 3.6. The yield methodology for the Kearney Canal Diversion Pump Station is discussed in Section 6.1.4.

The Kearney Canal Diversion Pump Station alternative was evaluated at three (3) pumping rates, which include 100 cfs, 130 cfs, and 150 cfs. The three pumping rates could deliver water volumes of 198 acre-feet/day, 256 acre-feet/day and 298 acre-feet/day, respectively. A water volume equal to the maximum beneficial volume can be delivered to the reservoir in 67 days at the 150 cfs pumping rate, but it would take 78 days of pumping at 130 cfs, or 100 days at 100 cfs.

The pump system design is contingent on the elevation head, hydraulic pipe friction head, transmission pipeline diameter, length of transmission pipeline and design water velocity in the pipeline. The elevation head is the difference in elevation between the Kearney Canal and the reservoir. Elevation in the Kearney Canal is 2237 feet and the maximum reservoir pool elevation is 2332 feet, for an elevation head of 95 feet. The hydraulic pipe friction head is a function of the pipeline diameter and water velocity in the pipeline. Pipeline diameters of 54-inch, 60-inch and 66-inch, respectively, were used for the three (3) different pumping rates. Design water velocity in the pipeline was maintained at 6.5 feet per second. The hydraulic friction head is approximately 65 feet and was added to the elevation head for a total dynamic head of 160 feet. The transmission pipeline runs approximately seven (7) miles north to the proposed reservoir.

The study determined that, for the flow rates and hydraulic head conditions described above, the following pump and pipeline combinations would be used as the basis for developing preliminary cost opinions for the alternative of conveying water to Elm Creek Regulatory Reservoir from the Kearney Canal:

- Flow Rate – 100 cfs, pump station includes three 800 horsepower pumps, delivering water through a 54-inch diameter pipeline seven (7) miles long.
- Flow Rate – 130 cfs, pump station includes four 800 horsepower pumps, delivering water through a 60-inch diameter pipeline seven (7) miles long.
- Flow Rate – 150 cfs, pump station includes five 800 horsepower pumps, delivering water through a 66-inch diameter pipeline seven (7) miles long.

The final design and selection of pipeline and pump sizes for the requirements of this specific project requires detailed engineering analysis and balancing of several design parameters including: hydraulic efficiency, cost, and system-component parameters to develop and construct facilities that will be efficient over the life of the project. Smaller-size pipes are generally less costly, but can substantially increase the hydraulic friction head and corresponding pump-equipment-size/energy costs necessary to “push” the required flow to its delivery point.

Opinions of probable construction cost are shown in Figure 3.3.1 for the three (3) pumping rates. Kearney Canal Diversion Pump Station conveyance alternative to supply Platte River water to the Elm Creek Regulatory Reservoir has a higher cost than other alternatives due to the substantial capital cost of constructing the seven (7) mile long transmission pipeline from the river into the reservoir.

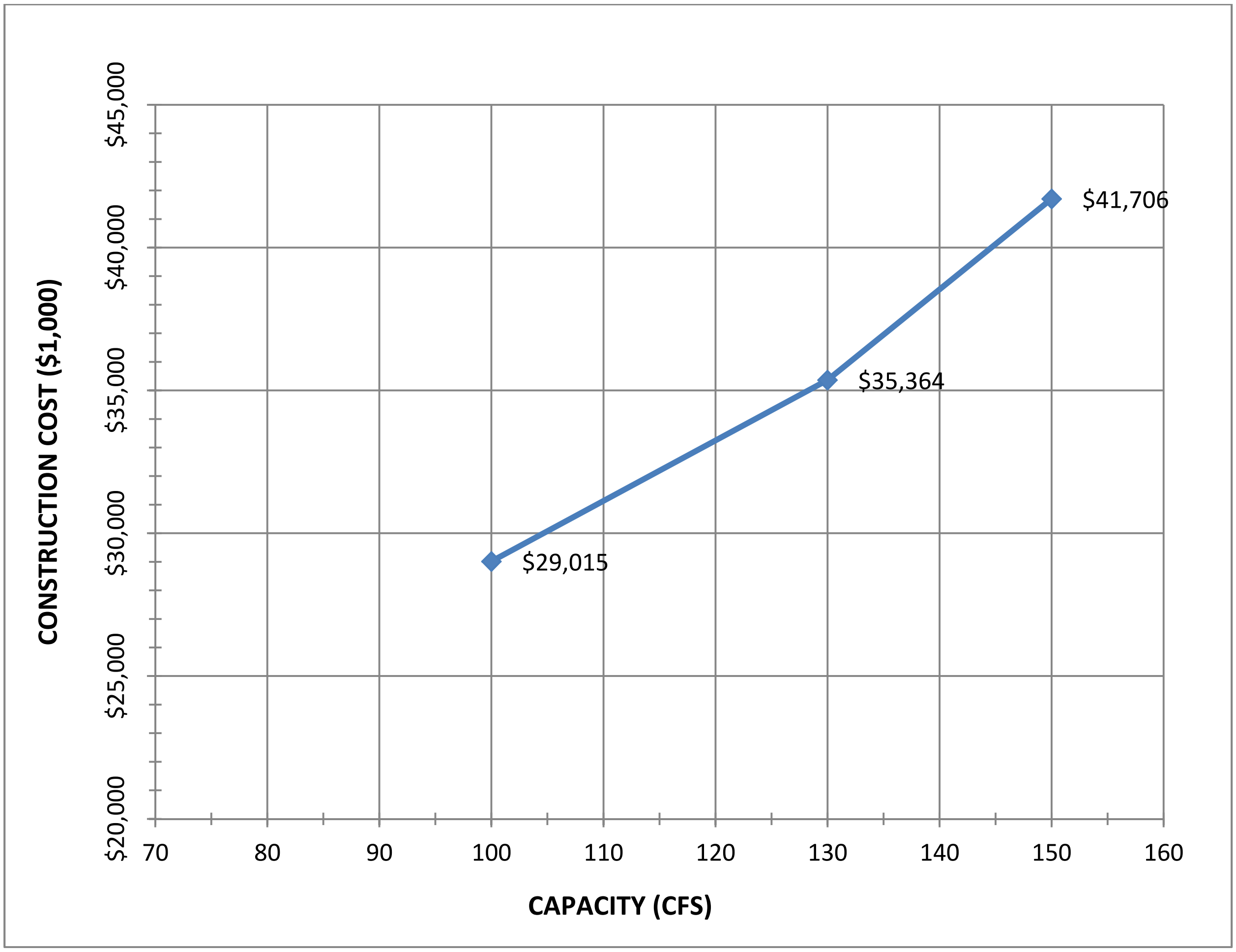


Figure 3.3.1 – Kearney Canal Diversion Pump Station Cost

4.0 CONVEYANCE TO THE PLATTE RIVER

4.1 Introduction

Elm Creek Regulatory Reservoir outlet conveyance alternatives have been evaluated to meet the needs of this study. Those needs include the release of captured excess Platte River flows during times of shortages and the release of the SDHF event. The outlet conveyance alternatives evaluated release rates ranging from 1,000 cfs to 2,000 cfs and include capacity analysis of Elm Creek, Buffalo Creek and an Elm Creek diversion channel to Buffalo Creek. Appendix 4.1 shows the outlet conveyance options.

The evaluation of the outlet conveyance commences at the dam structure near 70th Road between Turkey Creek Road and Arrow Road. The Elm Creek flows approximately 1.5 miles south where it crosses under U.S. Highway 30. The creek continues south past Highway 30 approximately 0.5 miles then meanders east-southeast approximately one (1) mile eastward where it crosses U.S. Highway 183. Continuing east-southeast the creek crosses Bison Road and 24th Road between Barley Road and Box Wood Road. Approximately 3,000 ft downstream of 24th Road, Buffalo Creek joins Elm Creek at their confluence. Approximately 2,000 ft below the confluence, Elm Creek and Buffalo Creek flows are conveyed underneath Interstate Highway 80, via a large, single span bridge, and into the Platte River. The length of the channel reach referenced in this section is approximately 6.7 miles. The Buffalo Creek capacity analysis was conducted from approximately one half (1/2) mile upstream of Turkey Creek Road to 2.5 miles east (approximately four (4) stream miles), to the confluence with Elm Creek.

4.2 Outlet Conveyance Analysis

The Elm Creek existing conditions capacity analysis was conducted and summarized in the Elm Creek Pre-Feasibility Study (Olsson, 2006). Since the 2006 study was completed, detailed survey data has been gathered for the Elm Creek and Buffalo Creek channels and bridge structures at roadway crossings. In addition, LIDAR topography is now available for the area. The new data was used to create an updated HEC-RAS model of Elm Creek and Buffalo Creek. The updated model was used to perform a new capacity analysis for existing conditions, refining and updating the results of the 2006 analysis. The results of the new capacity analysis were similar, but not identical, to those provided in the 2006 study, and are shown in Table 4.2.1.

In Table 4.2.1, channel capacity is an estimate of the flow rate that will cause floodwaters to break out of banks upstream from the bridge. Bridge capacity is an estimate of the flow rate that will cause the bridge to be submerged. In order to provide a conservative estimate, both the channel capacity and bridge capacity estimates include approximately six (6) inches of freeboard. Along certain segments of the stream, the banks of the Elm Creek channel are elevated, indicating channel straightening or improvements were performed in the past and the spoil material was placed in berms along the channel banks. These berms are not continuous and cannot be counted on to contain flows within the Elm Creek channel. The bridges and channel along Buffalo Creek have adequate capacity to convey diverted flows from Elm Creek. There are some locations upstream of Turkey Creek Road along Buffalo Creek where diverted flows may rise out of banks and cause minor flooding in farm fields. From Turkey Creek Road downstream to the confluence with Elm Creek, diverted flows within Buffalo Creek channel appear to be contained within the riparian corridor.

Stream	Location	Channel/Bridge Capacity (cfs)	Corresponding Storm Event	Capacity Limiting Element
Elm	70th Road	2,250/2,250	~ 5 yr/~ 5 yr	Channel/Bridge Size
Elm	Elm Creek Canal	800	~ 2 yr	Channel Size
Elm	56th Road	800/800	~ 2 yr/~ 2 yr	Channel/Bridge Size
Elm	Hwy 30	500/1,600	< 2 yr/< 5 yr	Channel Size
Elm	BNSF RR	500/1,200	< 2 yr/> 2 yr	Channel Size
Elm	39th Road	500/800	< 2 yr/~ 2 yr	Channel Size
Elm	Turkey Creek	600/600	< 2 yr/< 2 yr	Channel/Bridge Size
Elm	Highway 183	500/2,000	< 2yr/< 5 yr	Channel Size
Elm	Bison Road	600/1,000	< 2 yr/> 2 yr	Channel Size
Elm	24th Road	600/3,000	< 2 yr/> 5 yr	Channel Size
Elm	Interstate Highway	800/> 4,000	~ 2 yr/> 100 yr	Channel Size

Table 4.2.1 – Elm Creek Existing Capacity

The Elm Creek channel flow line has a fairly consistent grade throughout the modeled reach, with a nearly uniform slope of approximately 0.0012 ft/ft. The channel has a total of 44 vertical feet of elevation change in the study area. The Elm Creek channel shape throughout the reach varies from parabolic to a classic eight point cross section with a low-flow channel and high flow benches on either side of the channel. In some areas, the channel has been straightened and the shape is trapezoidal.

A HEC-RAS hydraulic model of Elm Creek was created. Flood profiles for a range of flows were computed to determine the flow capacity of the creek downstream from the proposed Elm Creek Regulatory Reservoir. The flow capacity of the channel, independent of the bridges, appears to be approximately 1,500 cfs, but velocities vary from 3 to 7 feet per second depending on location. At higher velocities, channel scouring and erosion become a concern. Without channel stabilization to combat higher velocities, flow conditions that limit velocities to a maximum value of 3 feet per second should be evaluated. Simple channel and bank stabilization measures should be adequate to prevent channel scour in locations where channel velocities exceed the scouring velocities of channel bank and bed materials. A detailed investigation of scour protection and channel stabilization measures was not included in this report.

The standard step model includes backwater effects from bridges or constricted segments of the channel. The following structures were used in the model: 40’ steel bridge at 70th Road, 44’ steel bridge at 56th Road, 78’ bridge at Highway 30, 84’ bridge at BNSF Railroad, twin 12' by 8' box culverts at 39th Road (replaced a 24' steel bridge), 32’ bridge at Turkey Creek Road, 93’ concrete bridge at Highway 183, 29’ concrete bridge at Bison Road and a 37’ concrete bridge at 24th Road

Several of the bridges create slight restrictions to flow along the channel, including the Turkey Creek Road Bridge and the 39th Road Bridge. In general, the bridges have conveyance capacities similar to the upstream and downstream channel sections. The limiting bridge capacity appears to be approximately 600 cfs. Residential or farm structures were noted near the channel banks upstream from several bridges including the Highway 30 Bridge, the 39th Road Bridge, and the 24th Road Bridge. The exact elevations of these structures are unknown. Care should be taken to avoid flooding these structures with pulse flow releases from the proposed reservoir.

4.3 Conveyance Improvements and Flood Control Measures

Outlet conveyance improvements and flood protection measures for the 1,000 cfs reservoir release rate include: flood control berms from ½ mile upstream of 56th Road to 70th Road, capacity improvements to the channel from Highway 30 to ¼ mile upstream from 56th Road, flood control berms from 39th Road to the BNSF railroad structure, a new structure at 39th Road, a new Turkey Creek Road bridge and flood control berms from downstream of 39th Road to downstream of 24th Road. For the 1,000 cfs discharge, no Elm Creek diversion channel is required.

Outlet conveyance improvements for the 1,400 cfs reservoir release rate include: flood control berms from ½ mile upstream of 56th Road to 70th Road, capacity improvements to the channel from Highway 30 to ¼ mile upstream from 56th Road, flood control berms from 39th Road to the railroad structure, a new diversion structure at 39th Road, and an Elm Creek diversion channel that conveys flows south to Buffalo Creek. The top of berm elevations and extents of the proposed flood control berms along Elm Creek for the 1,400 cfs discharge rate are larger than those for the 1,000 cfs discharge.

The proposed diversion canal from Elm Creek to Buffalo Creek consists of twin 8' x 4' concrete box culverts underneath 39th Road. From there, discharges are conveyed to Buffalo Creek by a 5,000 foot long, eight (8) foot deep channel with a ten (10) foot bottom width, a 0.0014 foot/foot longitudinal slope and 3H:1V vegetated side slopes. The diversion channel alignment is illustrated in Appendix 4.1. The alignment chosen is centered along property boundaries and was chosen to avoid dividing land parcels (where possible) and maintain the contiguity of the farm fields and access to those farm fields. Between the downstream end of the diversion channel, where it drains into Buffalo Creek, and the Turkey Creek Road crossing of Buffalo Creek, flood control berms may need to be constructed to keep Buffalo Creek within the channel.

Outlet conveyance improvements for the 2,000 cfs reservoir release rate include: flood control berms from ½ mile upstream of 56th Road to 70th Road, capacity improvement to the channel from Highway 30 to ¼ mile upstream from 56th Road, flood control berms from 39th Road to the rail road structure, new 56th Road bridge, improved UPRR bridge opening, new diversion structure at 39th Road, new Turkey Creek Road bridge and new Bison Road Bridge. No improvements will be required on Buffalo Creek. The top of berm elevations and extents of the proposed flood control berms for the 2,000 cfs discharge rate are larger than those required for the 1,400 cfs discharge.

Elm Creek Outlet Conveyance alternatives are summarized in Figure 4.3.1.

The opinions of cost provided above are based on the available LIDAR topographic data, surveyed channel cross sections and bridge openings, and structure location information from aerial photographs. A more detailed investigation of the proposed flood control and conveyance improvement measures is required before preliminary design of the proposed measures can be completed. At that stage, construction measures, materials, quantities, and extents can be selected and refined and more accurate opinions of cost can be developed.

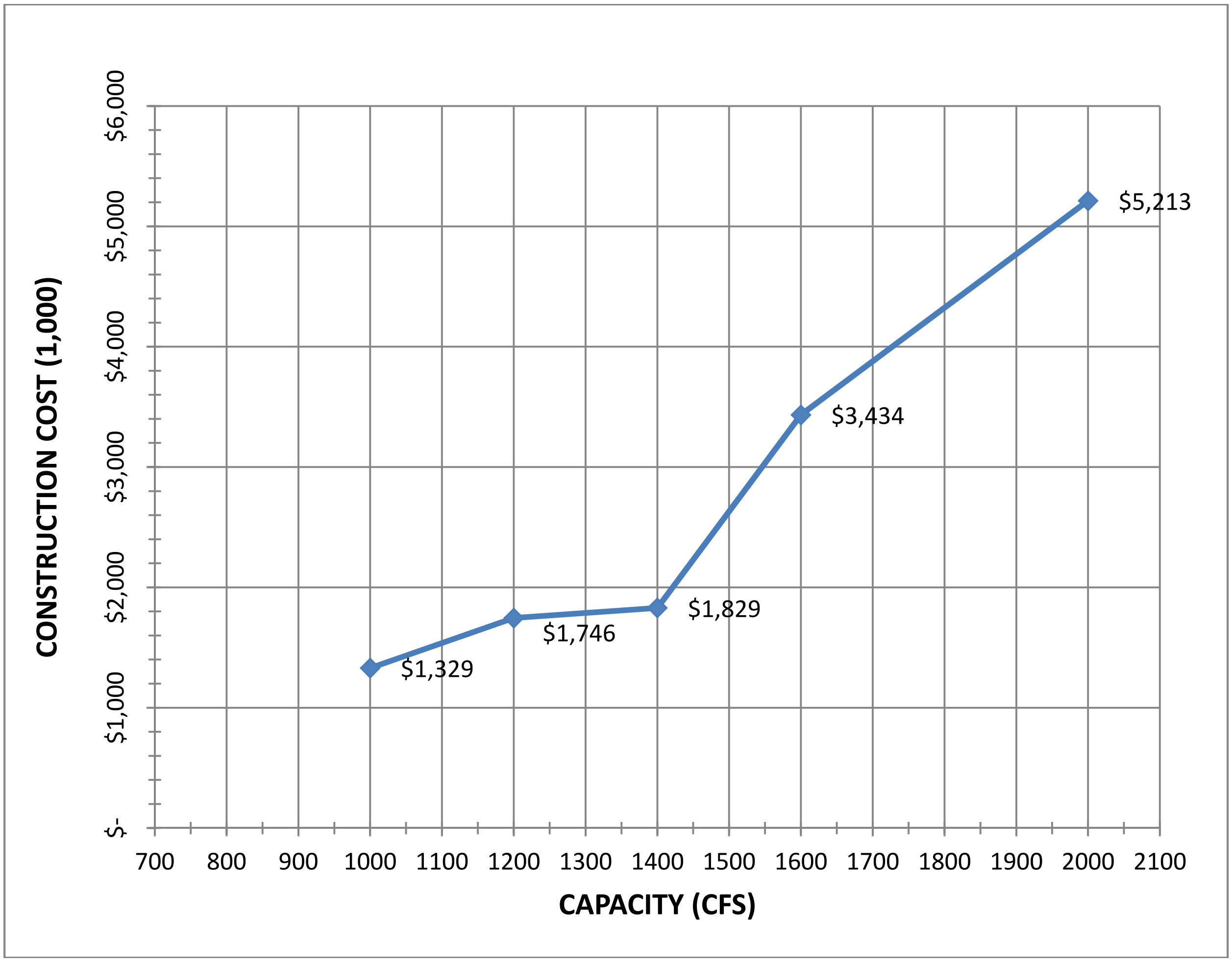


Figure 4.3.1 – Elm Creek Outlet Conveyance Cost

5.0 PRELIMINARY ENVIRONMENTAL REVIEW

Olsson staff conducted a review of existing data including: USGS topographical maps, National Wetland Inventory (NWI) maps, National Hydrograph Dataset (NHD), U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) soil data, Nebraska Game and Parks Commission (NGPC) threatened and endangered species data, and aerial photography to assess resources at the site. Olsson visited the site on June 5, 2010 to conduct a preliminary windshield survey of the study areas via public access roads. During the on-site survey, photos and field notes were taken. Based on a review of existing resources and the field investigation, Olsson determined that waters of the U.S. are present on the site in the form of streams, rivers, canals, and wetlands and portions of the study areas provide potential habitat for threatened and endangered and special status species.

As part of the environmental review, Olsson contacted federal and state agencies for information regarding threatened and endangered species, historical, cultural and archaeological resources, and requested any other comments as pertained to the study areas. In addition, an interagency meeting was conducted on June 22, 2010 during which the agencies were able to visit the site and offer additional comments and concerns regarding the project. Much of the discussion during this meeting focuses on permitting requirements if the project were to move forward.

5.1 Study Area

The study area is located in a predominately rural portion of central Nebraska. Land use is primarily agriculture production. Irrigated crops (corn, beans, and alfalfa) are most common in the Platte River valley with the loess hills north of the valley consisting of a mixture of irrigated and dryland crops and grasslands. The Village of Elm Creek is located within the Conveyance study area. Acreages and farmsteads are located throughout the study areas. See Appendix 5 for study limits and land used within the study area. The study area was broken into three (3) areas for study, 1) the Elm Creek Regulatory Reservoir, 2) Elm Creek Channel and 3) Dawson County Canal.

The USGS 7.5 minute topographic maps were used to identify topographical characteristics and the National Wetland Inventory (NWI) and National Hydrograph Data Set (NHD) was used to review of existing resources within the study area.

5.2 Agency Consultation

Olsson submitted letters to state and federal agencies describing the project and requesting preliminary agency consultation for the proposed project considering the following scenarios – 1) the project proceeds as a flood control project only and 2) the project proceeds as a flood control water storage project with the PRRIP partnered with the CPNRD to provide flow augmentation to the Platte River.

The agencies that were contacted included:

U.S. Army Corps of Engineers – Nebraska Regulatory State Office
U.S. Fish and Wildlife Service – Nebraska Field Office
U.S. Environmental Protection Agency – Region 7 Office
Nebraska Game and Parks Commission
Nebraska Department of Environmental Quality
Nebraska State Historical Preservation Office

Hardcopies of the response letters or comments received to date from the agencies and any communication records with Olsson are included in Appendix 5.5. A summary of the responses received to date from the agencies is included below.

5.2.1 Nebraska State Historic Preservation Office (NeSHPO)

On May 20, 2010 Olsson submitted a letter to NeSHPO regarding historical, cultural, and archaeological resources located within the study area, and they provided comment in a letter dated June 2, 2010. Their response indicated that there are ten (10) known archaeological sites in the area of the proposed project study areas. It was their recommendation that the project area be inspected by a qualified archaeologist to determine if unreported sites will be affected (see Appendix 5.5.1).

5.2.2 U.S. Environmental Protection Agency (EPA)

On June 8, 2010, Olsson submitted a letter requesting any comments they may have regarding the proposed project. The only response received to date was in the form of an email dated June 29, 2010 from Eliodora Chamberlain. In the email the EPA suggests the CPNRD follow the Section 404 pre-application process that has been used by Papio-Missouri NRD. The email included a flow chart that outlined the basic pre-application process (see Appendix 5.5.2). All other written agency responses are pending.

5.2.3 Agency Meeting

On June 22, 2010 an on-site agency meeting was conducted by Olsson as part of the agency coordination process. The meeting was attended by representatives of the USFWS, Corps, NGPC, Nebraska Department of Environmental Quality (NDEQ), PRRIP, CPNRD, and Olsson Associates. The site visit included stops at several proposed project areas including the dam location on Elm Creek, potential diversion areas along the Dawson County Canal, potential Elm Creek diversion channel location, and the Kearney Canal diversion on the Platte River. A copy of the meeting minutes is included in Appendix 5.5.3.

In general, the agencies stressed the importance and challenge of developing the purpose and need for a project such as this. They mentioned the importance of early agency involvement, especially as it relates to making sure the project complies with the National Environmental Policy Act (NEPA) and Section 404 permitting processes. The USFWS and NGPC stressed keeping impacts to all species and habitats (such as riparian habitat) in mind during project planning and that it will be important to not only consider the project's impact on threatened and endangered species but on other wildlife as well.

5.3 FIELD INVESTIGATION

Site visits were conducted on June 5 and June 22, 2010 as part of the preliminary environmental investigation of the site. The site visits included driving the project site and making general observations about wetland and stream resources and habitat characteristics of the site, including potential habitat for threatened and endangered and other special status species. It is anticipated that if the project moves forward and is more defined, more detailed field investigations will be required.

5.4 SUMMARY OF FINDINGS AND CONCLUSION

The proposed project includes the Elm Creek Regulatory Reservoir, Improvements to the Dawson County Canal with wells along the canal and the improvements on Elm Creek channel from the proposed dam location to its confluence with Buffalo Creek to accommodate releases from the reservoir, and the installation of five dewatering wells and piping to pump high groundwater near the Village of Elm Creek into the reservoir.

The NWI map within the proposed project area depicts 37 water bodies that total approximately 22.6 acres. Four of the features within the recommended project area are listed as Palustrine forested or scrub/shrub wetlands, seven are listed as Palustrine emergent wetlands, two are listed as Riverine unconsolidated shore water bodies (likely non-wetland), twenty-four are listed as a Palustrine unconsolidated bottom, unconsolidated shore, or aquatic bed water bodies (ponds that are likely non-wetland). An on-site wetland delineation will be required to more accurately assess wetland impacts on the site. The wetland delineation will likely reveal wetland areas not depicted on the NWI map and conversely it will likely reveal some of the wetland areas not depicted on the NWI map are smaller or not present at all.

The National Hydrograph Database flow line data was the primary tool used to assess stream and river resources within the study area. The NHD database shows seven named streams or canals plus several unnamed streams that total 302,945 linear feet of stream channel within the recommended project area. Due to the potential size and scope of this project, there could be extensive impacts to streams channels and adjacent riparian corridors. The Corps personnel at the agency review meeting, held on June 22, 2010, confirmed that because the Dawson County Canal has a down gradient connection to Elm Creek, the canal is waters of the United States.

5.5 REGULATORY REQUIREMENTS

The project will require a Section 404 Individual Permit from the U.S. Army Corps of Engineers. This will require an on-site delineation of wetland and other waters of the U.S. to be conducted over most, if not all, of the project footprint. The project will require a federal action and therefore will require compliance with the National Environmental Policy Act (NEPA). The level of NEPA compliance documentation will depend on the lead federal agency, most likely the U.S. Army Corps of Engineers. Depending on the scope and timing of the project this may require surveys for threatened and endangered and other special status species (including bald eagle and migratory birds) prior to construction. The requirements for these surveys will be as a result of coordination between Central Platte Natural Resource District, U.S. Army Corps of Engineers, Nebraska Game and Parks and U.S. Fish and Wildlife.

The NeSHPO records indicate ten (10) archaeological sites in the area of the proposed project. NeSHPO recommends that the project area be inspected by a qualified archaeologist to determine if unreported sites will be affected by the project. Compliance with these recommendations will be required by the lead federal agency.

6.0 WATER BUDGET/WATER YIELD

The Elm Creek Regulatory Reservoir has several components to evaluate when considering the project water budget. The water budget was developed using reservoir seepage losses, pre- and post- project consumptive use, watershed yield, Platte River excess flow methodology and groundwater supply. The reservoir surface area and storage volume are also contributing factors when considering the water budget.

6.1 Water Budget Components

6.1.1 Reservoir Seepage

The groundwater model results are discussed in Appendix 2.10. With the proposed dewatering wells in place, much of the reservoir seepage losses will be pumped back to the reservoir in order to limit groundwater rise within the Village of Elm Creek. The volume of seepage water returned to the reservoir has been estimated at 3,665 acre-feet per year. Because of this recirculation of seepage water, reservoir seepage losses were not included in the project yield calculations.

6.1.2 Consumptive Use

Evapotranspiration and evaporation have been evaluated to determine the Elm Creek Regulatory Reservoir project's pre- and post- consumptive use. The project's pre- and post- results were produced from the Consumptive Use Calculator – Evapo-Transpiration Calculations for Cover Types in a Non-Stressed Environment created by Nebraska Natural Resources Conservation Service and United State Department of Agriculture found on Nebraska Department of Natural Resource's web site. The methodology used in the creation of the calculator follow the NRCS National Engineering Handbook Part 623 – Chapter 2.

Evapotranspiration was calculated for the existing land use below the beneficial pool elevation. The results of the pre-project conditions were compared to the post project conditions, which include reservoir evaporation and evapotranspiration of the new land use above the water level and below the beneficial use pool. The calculator runs from March 1 through November 31 and assumes no water use the in the months of January and December. The results are shown in Table 6.1.1.

RESERVOIR SIZE	PRE-PROJECT	POST PROJECT	PLATTE RIVER ACCRETION
AC-FT	AC-FT/YEAR	AC-FT/YEAR	AC-FT/YEAR
6,800	2,907	2,708	199
12,000	3,421	3,187	234
19,850	3,995	3,748	247

TABLE 6.1.1 – Consumptive Use Calculation Results

The Consumptive Use results show that the pre-conditions and the post conditions are close in value and actual show a slight accretion to the Platte River system.

The Consumptive Use results were viewed as negligible and not included in the project yield results for the Kearney Canal Diversion and the Platte River Well Field alternatives. Platte River depletions/accretions for the Dawson County Canal alternatives are discussed further in Section 6.1.4.2.1.

6.1.3 Watershed Yield

The watershed yield was computed using historic data and current stream discharge data from the Elm Creek gage combined with other longer period of record stream gage data in the area. The Elm Creek gage shows no perennial base flow and that flash floods from summer rain events characterize the stream runoff. The regional gage analysis indicate approximately one watershed inch is the average yield per year for a watershed of this size and soil type. The average annual yield from the watershed is determined to be 1,980 acre-feet (Olsson 2006). Watershed yield (rainfall runoff) would be periodic and may not occur during times of excess. If the runoff occurs during times of shortages to target flows, it is assumed all entering runoff would need to be released to the Platte River. If the runoff occurs during times of excess to target flows, the runoff could be stored until shortages to target flows occur. A conservative approach has been used and no watershed yield is used in the project yield calculations.

6.1.4 Platte River Excess Flows

6.1.4.1 Calculation Methodology

The general concept of the Platte River Excess Flow Methodology is to fill the reservoir with water diverted from the Platte River during times of excess flow. When Platte River flows drop below target flows, stored water can be released to the Platte River to reduce shortages. Target flows are the minimum daily flow values presented in Appendix A-5 of the Program Document Attachment 5 Water Plan Section 11 Water Plan Reference Material (PRRIP, 2006). Excess flows are calculated as those flows in excess of the maximum of Program Daily Target Flows, the Nebraska Game and Parks Commission (NGPC) flows and Central Platte NRD in- stream flows as measured at the Platte River Grand Island stream gage. Target flows and excess flows are summarized in the following Tables 6.1.2 and 6.1.3. Project yield, for the purpose of this study, is the amount of water released from the proposed reservoir during times of shortages. Water released from the proposed reservoir increase the Platte River flows to the values listed in Table 6.1.2.

The PRRIP Executive Director's Office (ED Office) has completed preliminary project yield sensitivity analysis which document the approach, assumptions and calculation of daily excess and shortages to target flows (PRRIP, 5/4/2010). The analysis utilized an Excel spreadsheet for rapid calculation of multiple project alternatives. Olsson utilized this Excel spreadsheet with minor revisions to develop feasibility level project excess capture, groundwater pumping volumes and reductions to shortages for several alternatives. The project yields (shown in Table 6.3.1) are the volume of water released from the proposed Elm Creek Reservoir when the flow in the Platte River is below target flows.

The Platte River Excess Flow Methodology was calculated using historic Platte River daily flows from 1947-2005 provided to Olsson by the ED Office. For consistency with other PRRIP projects, the WAP score utilizing 1947-1994 OPSTUDY flow data will be calculated by the ED Office based in part on the findings within this report. Based on past ED Office calculations, OPSTUDY flow data will show an increase in yield during years classified as dry when compared to the analysis performed with historic gage flow data.

Time Period	PRRIP Target Flows		
	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

Table 6.1.2 - Daily PRRIP Target Flows from PRRIP Program Document (PRRIP, 2006), Appendix A-5. Flow in the Platte River at the Grand Island gage below these amounts are considered a shortage to Target Flow.

Time Period	PRRIP Target Flows		
	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 – May 31	3,400	3,400	800
June 1 – June 20	3,400	3,400	1,000
June 21 - July 31	1,200	1,200	1,000
Aug 1 – Sept 15	1,200	1,200	800
Sept 16 – Sept 30	1,000	1,000	600
Oct 1 – Oct 11	2,400	1,800	1,350
Oct 12 - Nov 10	2,400	1,800	1,500
Nov 11 – Nov 15	2,400	1,800	1,300
Nov 16 - Dec 31	1,000	1,000	600

Table 6.1.3 - Maximum of PRRIP and NGPC/CPNRD Target/In stream flows. Flows in the Platte River at the Grand Island gage greater than these values are considered Excess Flows.

6.1.4.2 Water Supply Alternatives

Potential surface water conveyance alternatives to fill the reservoir consisted of flows diverted into Dawson County Canal, Kearney Canal and new shallow wells placed adjacent to the Platte River. At this level of analysis, it was assumed the shallow wells adjacent to the Platte River would be under the direct influence of the surface water flows and hence operated similar to other surface water sources. Platte River surface water diversions were allowed to occur only during times of excess flows. Potential groundwater alternatives were developed with the use of vertical wells placed along the Dawson County Canal. The wells were pumped to off-set seepage losses from Dawson County Canal, so no net depletions to the Platte River occur.

6.1.4.2.1 Dawson County Canal

Dawson County Canal system is one option to divert water from the Platte River to the proposed reservoir site. The volume of flow to be diverted to the reservoir was limited to the volume of excess flow available at the head gate. The existing irrigation demand form Dawson County Canal was also a limiting factor on the canal's ability to handle excess flows. Due to seepage transmission losses, a minimum diversion of seventeen (17) cfs was utilized. The capacity of Dawson County Canal decreases in the downstream direction. A maximum capacity of 450 cfs is present at the canal head gate and a minimum capacity of twenty (20) cfs is present at the proposed reservoir location. HEC-RAS modeling discussed in Section 3.1.2 documents the existing capacity and the necessary improvements to achieve a proposed flow rate of 125 cfs.

Groundwater wells installed along the lower section of Dawson County Canal were also considered as a source of water. This operational option was discussed in Section 3.1.5.1. For this operational option, Dawson County Canal would divert Platte River excess flows from March 1 through November 15. This option is also limited by excess flows in the Platte River, the existing irrigation demand and transmission seepage losses in the canal system. The vertical wells were allowed to run through the winter months in the lower section of the canal but were not operated during typical irrigation season (May 1 - September 1). The Dawson County Canal pumping options maximized the volume of water extracted from the groundwater, based on the Platte River accretion/depletion equation. This equation set the accretions/depletions equal to zero, and then determined the volume of water available for pumping operations. Groundwater pumping rates were then based on the volume of available water. The groundwater pumping rates varied with the different alternatives.

Groundwater wells around the perimeter of the reservoir were also discussed and considered, but not examined, as part of this feasibility study.

Platte River accretions/depletions for the Dawson County Canal supply conveyance options include the pre-project consumptive use, post-project consumptive use and Dawson County Canal seepage return flow. For the Dawson County Canal pump options, groundwater pumping volumes are included in the equation. Below is a summary of the components contained in the river flow water balance.

Pre-Project Consumptive Use	+	Dawson County Canal Seepage Return Flows	-	Post Project Consumptive Use	-	Dawson County Canal Groundwater Pump Depletions (if used)	=	Platte River Depletion/Accretion

Platte River Accretion/Depletion Equation

Consumptive use for the pre- and post- project conditions was discussed in Section 6.1.2. A 40% transmission seepage loss rate was applied to the flows entering the head gates. As stated in Section 3.1.4, an average return rate for Dawson County Canal Seepage Return Flow of 32% was used. A Dawson County Canal pump depletion rate of ten (10) percent was used. The project yields for the Dawson County Canal alternatives reflect the accretion/depletion percentages stated above and are included in the project yield summary.

Dawson County Canal Non-Winter operations divert Platte River excess flows from March 1 through November 15. This alternative is also limited by excess flows in the Platte River, the existing irrigation demand and transmission seepage losses in the canal system.

Dawson County Canal Winter operations divert Platte River excess flow year round. This alternative is also limited by excess flows in the Platte River, the existing irrigation demand and transmission seepage losses in the canal system. Dawson County Canal winter operation was discussed in Section 3.1.3. This alternative shows the potential yield from year round operations with the Dawson County Canal.

6.1.4.2.2 Kearney Canal Diversion

A second water supply option to deliver excess river flows to the reservoir includes the existing Kearney Canal. The existing head gate for Kearney Canal could be utilized to divert water from the Platte River to a new pump station. The potential Kearney Canal pump station and pipeline is discussed in more detail in Section 3.3. The Kearney Canal head gates have an existing capacity of 360 cfs. For the purpose of this study, it is assumed that Kearney Canal can be utilized year round. A pump station and pipeline capacities were evaluated up to 150 cfs. The volume of diverted flow at the head gate was limited to the volume of excess flow available and the historic irrigation demand.

6.1.4.2.3 Platte River Well Field

A third water supply option to deliver excess river flows to the reservoir includes a Platte River Well field. The well field would include a series of wells installed in or adjacent to the Platte River. As documented in previous studies (Chen, 2005), the Platte River in this area has very high stream bed hydraulic conductivities. In addition, the Platte River is a gaining stream in this general area as shown on the regional groundwater isopleths shown in Appendix 2.10. Shallow groundwater wells installed in or adjacent to the Platte River would likely derive the majority of the flow from surface water in the Platte River. The surface water flow response in the Platte River would be nearly immediate. The hydraulic performance and aquifer properties are discussed in more detail in

Appendix 2.10. As a result of the surface water interaction and the quick response to river flows, the yield from this option is being treated as surface water element. Platte River withdrawals will only be allowed during times of excess flows in the Platte River. If this option is carried forward, a more detailed evaluation of these assumptions will need to be performed as well as discussions held with regulatory agencies.

6.2 Reservoir Volume

Based on the anticipated sediment yield, a 50-year sediment storage pool has been calculated and is considered not available for PRRIP use. Above the sediment storage pool, beneficial use pool volumes of 6,800 acre-feet, 12,000 acre-feet and 19,850 acre-feet have been evaluated for PRRIP use. Beneficial storage volume has a direct relationship with the amount of yield generated. A larger storage volume generates a large project yield. Three (3) storage volumes were considered to determine the sensitivity of the reservoir size.

6.3 Yield Results

Thirty-three project alternatives utilizing various reservoir sizes and supply rates have been calculated. A summary of the project alternative yields are shown in Table 6.3.1. The yield summary Excel spreadsheet tables are shown in Appendix 6.1.

Overall, options that only used Dawson County Canal during non-winter months produced the lowest yields. Using Dawson County Canal year round to deliver water to reservoir resulted in approximately a 200% increase in yield over not using it during the winter months. Options that used Dawson County Canal also needed to overcome the seepage losses with in the canal system that accounted for 40% of all of the water diverted. The seepage loss resulted in a reduction of volume reaching the reservoir but the seepage losses also resulted in groundwater recharge.

Options that utilized wells resulted in nearly a three (3) fold project yield increase over just using Dawson County Canal during non-winter months. Wells had the primary advantage of being able to operate during the winter months. The options using wells tended to easily fill the reservoir and the reservoir size then became the limitation. Based on these findings, it will be important to evaluate options that are capable of supplying water during the winter months in order to maximize the potential yield.

The highest yields involved options that incorporated groundwater wells installed along Dawson County Canal. The wells along the canal resulted in approximately 150% increase in yield over the options involving Platte River wells or Kearney Canal pump station. The Platte River Wells and Kearney Canal pump station only operated during times of Excess flows. These options were only able to capture a small amount of the excess due to a limited pumping rate. Often the excess flow rate exceeded the pumping rate and excess flows were not able to be fully captured. If either the pumping rate is increased or the pumps could be operated during non-excess flows, the yield would be much larger.

	Component Options					Modeling Results	
A	B	C	D	E	F	G	H
Project Alternatives	Reservoir PRRIP Beneficial Use Pool	Dawson County Canal Minimum Capacity	Dawson County Canal Well Field Capacity	Kearney Canal Diversion Pump Station	Platte River Well Field Capacity	Average Amount in Storage	Average Annual Yield From Reservoir
	Ac-Ft	CFS	CFS	CFS	CFS	Ac-Ft	Ac-Ft
DCC-W-1	19,850	50	0	0	0	5,790	11,941
DCC-W-2	19,850	75	0	0	0	6,461	16,541
DCC-W-3	19,850	125	0	0	0	7,530	23,591
DCC-W-4	12,000	50	0	0	0	5,655	11,226
DCC-W-5	12,000	75	0	0	0	6,145	15,358
DCC-W-6	12,000	125	0	0	0	6,816	20,696
DCC-W-7	6,800	50	0	0	0	5,425	10,263
DCC-W-8	6,800	75	0	0	0	5,733	13,264
DCC-W-9	6,800	125	0	0	0	6,060	16,705
DCC-P-1	19,850	50	35	0	0	5,583	19,599
DCC-P-2	19,850	75	50	0	0	6,167	27,264
DCC-P-3	19,850	125	70	0	0	6,949	38,023
DCC-P-4	12,000	50	35	0	0	5,502	19,082
DCC-P-5	12,000	75	45	0	0	5,851	24,712
DCC-P-6	12,000	125	60	0	0	6,338	33,123
DCC-P-7	6,800	50	30	0	0	5,247	16,445
DCC-P-8	6,800	75	40	0	0	5,490	21,742
DCC-P-9	6,800	125	50	0	0	5,761	27,567
DCC-NW-1	19,850	50	0	0	0	5,099	5,870
DCC-NW-2	19,850	75	0	0	0	5,479	8,332
DCC-NW-3	19,850	125	0	0	0	6,082	12,024
DCC-NW-4	12,000	50	0	0	0	5,080	5,699
DCC-NW-5	12,000	75	0	0	0	5,377	7,784
DCC-NW-6	12,000	125	0	0	0	5,685	10,524
DCC-NW-7	6,800	50	0	0	0	4,977	5,204
DCC-NW-8	6,800	75	0	0	0	5,126	6,769
DCC-NW-9	6,800	125	0	0	0	5,284	8,930
KC-1	19,850	0	0	100	0	6,990	20,879
KC-2	19,850	0	0	130	0	7,574	24,775
KC-3	19,850	0	0	150	0	7,892	26,914
PRP-1	19,850	0	0	0	70	6,411	16,436
PRP-2	19,850	0	0	0	100	7,182	21,864
PRP-3	19,850	0	0	0	130	7,847	26,482

Table 6.3.1 – Elm Creek Regulatory Reservoir Yield Results

DCC-W	Dawson County Canal with Winter Operation Alternatives
DCC-P	Dawson County Canal Pump Alternatives
DCC-NW	Dawson County Canal with Non-Winter Operation Alternatives
KC	Kearney Canal Diversion Pump Station Alternatives
PRP	Platte River Well field Pump Station Alternative

The ability to potentially operate the Dawson County Canal wells independent of Excess Flow daily timing allowed this option to generate the highest yields. Based on these findings, the potential for groundwater wells to operate independent of Excess Flow timing is a critical consideration. If the seepage losses in Dawson Canal were used to balance the groundwater pumping rate along the canal, then it might be feasible to evaluate groundwater well pumping volume on an annual basis as opposed to a daily excess flow basis. Operation of Dawson County Canal head gate to only divert surface water during Excess Flows would still need to be evaluated daily. The seepage losses to groundwater, however would have a lag time and potentially, could be evaluated as a yearly water balance. This balanced groundwater use option is discussed more fully in Section 6.1.4.2.1.

7.0 SCREENING PROJECT ALTERNATIVES

Several project alternatives were analyzed to determine the lowest life cycle cost per acre-foot of water released from the reservoir. Table 7.1.1 lists the project alternatives with the following information:

- Construction Cost – Cost to build improvements
- Capital Cost – Construction Cost, Engineer Design, Environmental Permitting and Land Rights Acquisition
- Annual Operations and Maintenance (O&M) Cost – Composite NRCS O&M Cost, Pumping Cost (if utilized), and Pump Replacement Cost (if utilized)
- Life Cycle Operations and Maintenance (O&M) Cost – Annual O&M Cost projected over 50 years
- Total Project Life Cycle Cost – Capital Cost and Life Cycle O&M Cost
- Annual Yield – Volume of water release from the Elm Creek Regulatory Reservoir per year
- Life Cycle Yield – Annual Yield projected over 50 years
- Life Cycle Cost per Acre-Feet – Total Project Life Cycle Cost per Life Cycle Yield

NRCS suggested O&M rates for average annual cost are shown in Table 7.1.1. High use commercial rate of $0.03/Killowatt-Hour was used to determine electrical costs for the pumping options. Detailed opinions of probable costs of all the design features are shown in Appendix 7.1 – 7.7. Appendix 7.8 contains a detailed summary of the project life cycle cost per acre-feet.

Operational and Maintenance Costs	
NRCS Suggested Rate for Average Annual Cost	
Project Feature	O&M Rate
Dam Embankment	0.75%
Dewatering System	2.00%
Reservoir Outlet Conveyance	1.25%
Dawson Count Canal	1.25%
Dawson County Canal Pumps	2.00%
Kearney Diversion Pump Station	2.50%
Platte River Well Field	2.50%

Table 7.1.1 – Operational and Maintenance Cost Rates

The project results show the use of Dawson County Canal is the only viable water supply component for the Elm Creek Regulatory Reservoir. Based on the Dawson County Canal operational analysis, utilization of the canal and vertical pumping wells provided the lowest life cycle cost per acre-feet, as opposed to other Dawson County Canal operations. Based on the Dawson County Canal capacity analysis, utilization of the canal at a capacity of 125 cfs provided the lowest life cycle cost per acre-feet. Dawson County Canal utilizing the vertical pumping wells operations and a canal capacity of 125 cfs provide a lowest life cycle cost per acre-foot of $37 per acre-foot. The reservoir size has little impact on the life cycle cost per acre-foot. As the storage volume increases, project costs and the project yields increase, but the life cycle cost per acre-feet remains nearly constant.

Project yields are shown for the use of the Dawson County Canal under winter operations, but no costs were calculated due to the NPPD study results were not available. Future analysis of the Dawson County Canal under winter operations may be quantified as the results from the NPPD study become available.

The Dawson County Canal Non-Winter operation alternatives did not produce the yield required for an economically feasible project. While the Dawson County Canal is the most economical alternative to deliver water to the reservoir, the canal must be run in the winter and/or supplemental groundwater pumping is required for a cost effective project.

Based on the life cycle cost per acre-feet the Kearney Canal Pump Station and Platte River Well field Pump Station alternatives were eliminated from consideration. Costs, associated with the pump stations and the pipe installation, were tremendous and lead to the elimination of these alternatives. These alternatives were not evaluated for the 6,800 acre-feet and 12,000 acre-feet reservoir sizes.

The Elm Creek Regulatory Reservoir, based on life cycle cost per acre-feet, is a feasible project. This project could be used in conjunction with other WAP Projects. Water stored through obtained water leasing, conjunctive groundwater recharge projects, or providing secondary storage for environmental account water released from Lake McConaughy are all feasible uses for the Elm Creek Regulatory Reservoir not address in this report. The project will provide incidental flood reduction benefits and will provide potential recreational benefits. It should be noted that this study was not able to quantify unused Dawson County Canal irrigation water during spring start-up and waste water during the irrigation season. The Reservoir will capture these flows which will increase the total project yield.

	COMPONENT OPTIONS					PROJECT COST					PROJECT YIELD		RESULTS
A	B	C	D	E	F	G	H	I	J	K	L	M	N
Project Alternatives	Reservoir PRRIP Beneficial Use Pool	Dawson County Canal Minimum Capacity	Dawson County Canal Well Field Capacity	Kearney Canal Diversion Pump Station	Platte River Well Field Capacity	Construction Cost	Capital Cost	Annual Operational Cost	Life Cycle Operational Cost (I * 50 Years)	Total Life Cycle Cost (H + J)	Annual Yield	Life Cycle Yield (L * 50 Years)	Life Cycle Cost Per Acre-Feet (K/M)
	AC-FT	CFS	CFS	CFS	CFS	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)	AC-Ft	AC-FT	$/AC-FT
DCC-P-1	19,850	50	35	0	0	$26,216	$33,568	$373	$18,641	$52,209	19,599	979,950	$53
DCC-P-2	19,850	75	50	0	0	$28,400	$35,943	$448	$22,413	$58,356	27,264	1,363,200	$43
DCC-P-3	19,850	125	70	0	0	$32,831	$40,809	$579	$28,954	$69,763	38,023	1,901,150	$37
DCC-P-4	12,000	50	35	0	0	$23,120	$28,970	$340	$17,010	$45,980	19,082	954,100	$48
DCC-P-5	12,000	75	45	0	0	$25,304	$31,345	$406	$20,291	$51,636	24,712	1,235,600	$42
DCC-P-6	12,000	125	60	0	0	$29,121	$35,546	$516	$25,784	$61,330	33,123	1,656,150	$37
DCC-P-7	6,800	50	30	0	0	$21,659	$26,950	$318	$15,884	$42,834	16,445	822,250	$52
DCC-P-8	6,800	75	40	0	0	$23,549	$29,006	$377	$18,865	$47,871	21,742	1,087,100	$45
DCC-P-9	6,800	125	50	0	0	$26,765	$32,557	$463	$23,169	$55,726	27,567	1,378,350	$40
DCC-NW-1	19,850	50	0	0	0	$22,579	$29,628	$217	$10,868	$40,496	5,870	293,500	$138
DCC-NW-2	19,850	75	0	0	0	$23,275	$30,390	$226	$11,303	$41,693	8,332	416,600	$100
DCC-NW-3	19,850	125	0	0	0	$25,528	$32,898	$254	$12,711	$45,609	12,024	601,200	$76
DCC-NW-4	12,000	50	0	0	0	$20,069	$25,665	$199	$9,927	$35,592	5,699	284,950	$125
DCC-NW-5	12,000	75	0	0	0	$20,765	$26,427	$207	$10,362	$36,789	7,784	389,200	$95
DCC-NW-6	12,000	125	0	0	0	$23,018	$28,935	$235	$11,770	$40,705	10,524	526,200	$77
DCC-NW-7	6,800	50	0	0	0	$18,608	$23,645	$188	$9,379	$33,024	5,204	260,200	$127
DCC-NW-8	6,800	75	0	0	0	$19,304	$24,407	$196	$9,814	$34,221	6,769	338,450	$101
DCC-NW-9	6,800	125	0	0	0	$21,557	$26,915	$224	$11,222	$38,137	8,930	446,500	$85
KC-1	19,850	0	0	100	0	$51,188	$60,633	$1,140	$57,016	$117,649	20,879	1,043,950	$113
KC-2	19,850	0	0	130	0	$57,537	$67,490	$1,341	$67,039	$134,529	24,775	1,238,750	$109
KC-3	19,850	0	0	150	0	$63,879	$74,339	$1,528	$76,388	$150,727	26,914	1,345,700	$112
PRP-1	19,850	0	0	0	70	$49,004	$58,294	$1,151	$57,531	$115,825	16,436	821,800	$141
PRP-2	19,850	0	0	0	100	$59,584	$69,743	$1,493	$74,663	$144,406	21,864	1,093,200	$132
PRP-3	19,850	0	0	0	130	$69,402	$80,374	$1,816	$90,799	$171,173	26,482	1,324,100	$129

Table 7.1.1 – Elm Creek Regulatory Reservoir Cost Analysis Summary

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