



JULY 2017

OLSSON PROJECT NO. 016-1500

PLATTE REPUBLICAN DIVERSION PROJECT FEASIBILITY REVIEW

PREPARED FOR:

PLATTE REPUBLICAN DIVERSION
LOWER REPUBLICAN
NATURAL RESOURCES DISTRICT
AND TRI-BASIN
NATURAL RESOURCES DISTRICT



LOWER REPUBLICAN NATURAL RESOURCES DISTRICT



Tri-Basin
Natural Resources District

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ASSOCIATES

EXECUTIVE SUMMARY

FINDINGS:

Based on the results of this feasibility study, the Platte Republican Diversion Project would be cost-effective. With minimal improvements to the channel, and the existing bridge and culverts along Turkey Creek, diverting unallocated flows of up to 100 cfs from the Platte River basin could provide substantial benefits to the Republican River basin without negatively impacting Turkey Creek.

The water resources of the Platte and Republican Rivers have been extensively developed in part through the construction of many large reservoirs and canal delivery systems. This development has drastically altered the occurrence of surface water in both timing and location within each basin. The proximity of canals on the south side of the Platte River relative to tributaries to the Republican River now presents a golden opportunity.

While the Platte River basin has had incredible flows the past few years, the water supplies remain relatively low in the Republican River basin. This feasibility study looks at diverting excess flows from the Platte River basin into the Republican River via Turkey Creek.

Olsson used a three-step analysis strategy to develop a benefit cost ratio that would indicate the relative feasibility of this project.

1. The first step involved conducting a geomorphologic field analysis, an environmental assessment, and obtaining survey data to use during the analysis.
2. The second step involved creating a surface water hydraulic model for Turkey Creek. This model was used along with the information developed as part of step one to develop a list of improvements that are needed in order to protect or replace existing structures and mitigate against potential erosion that might occur along Turkey Creek under prolonged periods of higher flows resulting from the diversion project.
3. From the list of improvements, a cost of the project was developed for several different alternatives. A benefit cost ratio for the project was developed using information from the previous costs of providing equivalent benefits to streamflow in the Republican River basin by alternative means.

Given the favorable Benefit Cost Ratios, the Platte Republican Diversion project has great potential to provide needed additional flow into the Republican River basin when excess water is available in the Platte River.

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1.0 INTRODUCTION

This report documents the preliminary results of the feasibility review of the Platte Republican Diversion project in Gosper and Furnas counties, Nebraska. The feasibility review was conducted on behalf of the Lower Republican Natural Resources District (LRNRD) and the Tri-Basin Natural Resources District (TBNRD). The purpose of the proposed Platte Republican Diversion project is to divert unallocated flows from the Platte River to the Republican River via Turkey Creek. The purpose of the feasibility review is to determine impacts of diverting these unallocated flows into Turkey Creek, to develop a benefit-cost analysis for the project, and to provide additional guidance on the feasibility of the project.

Turkey Creek is a tributary to the Republican River and generally runs north to south starting approximately 4 miles east of Elwood, Nebraska. It empties into the Republican River between Edison and Oxford, Nebraska. The upper 4 to 5 miles of Turkey Creek runs through canyon areas and many stretches do not have a fully defined bed and bank. This upper section does have a fairly defined stream centerline, but the overall capacity of the creek in this section is less than the capacity of the creek in the middle and lower sections. The upper section of Turkey Creek also includes several farm ponds that currently retain a portion of the flow along Turkey Creek. The middle and lower portions of Turkey Creek have fully defined beds and banks that carry base flow. The primary land use for the adjacent properties to Turkey Creek are either pastures or farmland.

There are times during the year when the Platte River has potential excess flows that are not allocated or appropriated for downstream uses. Currently, these flows continue on down the Platte River past the proposed diversion point.

Excess flows in the Platte River will be used to help augment flows in the Republican River through Turkey Creek with a direct beneficial use to the state of Nebraska's interstate compact obligations, using publicly owned existing infrastructure. Other beneficial uses include groundwater recharge, and potential recreational benefits at Harlan County Lake.

2.0 REVIEW AND ANALYSIS OF EXISTING CONDITIONS OF TURKEY CREEK

2.1 Existing Characteristics

The uppermost portions of the Turkey Creek watershed lack a defined channel, with runoff occurring through canyons as sheet flow. At approximately 5 miles downstream near Drive 432A, the creek and its tributaries have a fully defined bed and bank with a visible flowline. The eastern branch of Turkey Creek and the main channel of Turkey Creek, the portions of the watershed that will need to transmit the diverted water, can be divided into three distinct flow reaches based on channel capacity. Exhibit A in Appendix A is an overall map of the project reaches.

The upper section consists of the first 3,000 feet of eastern branch of Turkey Creek. It has a fairly steep slope for the entire length, which will generate higher velocities during flow events, significantly increasing the potential for erosion. It has a fairly defined centerline however lacks a channel bed, banks, and cross-sectional area to contain flows. Any runoff generated by rainfall events flows overland as sheet flow through this area. With no defined channel the flow is not contained and the upper section has an existing capacity of zero (0) cubic feet per second (cfs).



Upper Section of Project Area.



Middle Section of Project Area.

The middle section consists of approximately the next 5 miles of eastern branch of Turkey Creek. It has a defined channel, but has a more limited capacity and is generally steeper relative to the lower section. This middle section has a general top of bank capacity of ranging from 100 cfs at the beginning of the section to 650 cfs just north of Drive 432A. The capacity slowly increases as you progress downstream.

Several farms ponds along Turkey Creek in the upper/middle section affect flow downstream.

Topographic Summary of the Project Area

Turkey Creek can be divided into three distinct flow reaches based on channel capacity and characteristics.

The remainder of Turkey Creek is referred to as the lower section. This section has a well-defined channel with higher channel capacities. There is a steady base flow during the majority of the year, and this section can handle the majority of larger storm events. The general top-of-bank capacity is 885 cfs for this portion of Turkey Creek.

2.2 Hydrology

A hydrologic analysis was completed along the entire project length to determine the typical flows that have historically occurred in Turkey Creek. It is important to establish the baseline

conditions so that these baseline conditions can be considered relative to the conditions that will occur when diverted flows are added to the creek. This will help separate existing erosional conditions from potential new erosion concerns when designing channel improvements.



Lower Section of Project Area.

The project length was separated into different drainage areas to correctly determine typical flows from upstream to downstream along the creek. Exhibit B in the Appendix A shows the drainage areas as they were delineated. Drainage areas 1 and 2 are in the previously defined upper section, drainage areas 3 through 6 are in the middle section, and drainage areas 7 through 25 are in the lower section. The upper section was divided into two areas to more accurately reflect flows in that section. Downstream of the upper section, drainage areas were separated and delineated according to drainage structures or roadway crossings. A separate drainage area was developed for each structure and peak flows were calculated. Below the uppermost drainage area, the peak flows are combined to reflect a total flow in Turkey Creek at that location.

Two different hydrologic methods were utilized to calculate peak flows along Turkey Creek. The method chosen was based on the size of each drainage area being analyzed. The first method, Technical Release 55 (TR-55), is a simplified procedure to calculate storm runoff volume, peak rate of discharge, and hydrographs for small watersheds and was used for drainage areas under 5 square miles. The second method, which involved using selected Regional Regression Equations, was used for the drainage areas greater than 5 square miles.

Because of a flatter slope and larger flow area, the peak flows actually decrease somewhat toward the downstream areas of Turkey Creek. Peak flows for the 2-year, 10-year, 25-year, 50-year, and 100-year events were calculated. Exhibit C in Appendix A shows the peak flows that were calculated for each drainage area and the cumulative flows along Turkey Creek.

2.3 Hydraulics

Next, the hydraulic characteristics of Turkey Creek were modeled using HEC-RAS 4.0. The HEC-RAS program was developed by the Hydrologic Engineering Center and is designed to model one-dimensional

steady flow, one and two-dimensional unsteady flow, sediment transport/mobile bed conditions, and water temperature / water quality conditions. Input data for the HEC-RAS model included the hydrologic information discussed above, LiDAR and survey data to represent the channel shape and the topography, and channel and overbank roughness coefficients. The one-dimensional steady flow model was utilized for this project. The current conditions of Turkey Creek were analyzed to establish the existing water surface elevations along the project length. Each existing drainage structure was also analyzed as part of this modeling effort.

2.4 Geomorphology

A geomorphologic analysis was performed along the entire project length. Soil samples, stream measurements, erosion areas, and other pertinent information were collected during the site visit and used during the analysis. The full geomorphology report is included in Appendix B for reference. The general purpose of the geomorphology study was to determine what would be the potential impact of adding the diverted flows into Turkey Creek for an extended length of time. Flow rates of 40 cfs and 100 cfs were both analyzed for their impacts and length of time that the diverted flows could realistically be diverted into Turkey Creek without causing erosion issues. General findings from this analysis conclude that the upper section would require extensive grading to create a defined channel area or installation of a pipe to handle the new flows. Without a newly created channel, either flow amount would have a highly erosive effect on the existing ground creating large areas of erosion.

The middle and lower sections of Turkey Creek have enough existing capacity to handle 40 cfs of flow during certain times of the year. If the diverted flow of 40 cfs is allowed down Turkey Creek during the months of September through April, the existing creek conditions appear to be sufficient to handle the additional flows. If diverted flows of 100 cfs are introduced into Turkey Creek during the same months, the number of continuous days in a row will need to be monitored. Based off existing conditions and capacity it is recommended that a flow of 100 cfs only be diverted into Turkey Creek for a maximum of 5 continuous days before reducing the diversion of excess flows. Longer periods of the diverted flow of 100 cfs would begin to affect the stability of Turkey Creek and could begin to cause sloughing along the banks and headcutting to the existing flowline. Therefore, it is recommended that the diverted flows be stopped for at least 7 days after the 5 days of continuous 100 cfs of flow. The final recommendation for this will be determined during final design.

2.5 Environmental Evaluation

A full wetland delineation was completed along the project reach to determine the extent of existing wetlands. A memo, site map, and wetland map of each drainage structure are included in Appendix C for reference. The location of the existing wetlands will be taken into account during final design. Erosion control measures and proposed grading will be designed to avoid affecting existing wetlands and the creek. If the U.S. Army Corps of Engineers (USACE) requires a Clean Water Act (CWA) Section 404 permit, it is anticipated that a nationwide permit will be obtainable. The Section 404 permit program regulates the construction activities that take place in waters of the U.S. including wetlands.

Existing Condition Information

Generally, the current condition of Turkey Creek is stable and it can handle typical flows that occur each year. However, if a consistent 40 to 100 cfs is going to be introduced into the system, some improvements must be made to allow Turkey Creek to maintain its current integrity.

2.6 Existing Conditions Conclusion

During large storm events in the upper section, the terrain of the large canyon areas allows the water to spread out and continue to flow downstream without causing issues to the surrounding properties. The middle and lower sections of Turkey Creek have enough capacity to handle the 100-year flood event without overtopping the banks. The existing bridges can also handle up to a 100-year storm event without overtopping. In the vicinity of some of the existing drainage structures there is bank erosion. Left unchecked, this erosion could potentially undermine the structures. Table 1, below, lists each of the existing structure and indicates if it is already in need of repairs due to erosion. The recommended actions

are listed with the anticipated size of the erosion repair needed. A large erosion repair size is approximately 150 tons of riprap, medium repair is 75 tons of riprap, and small repair is 25 tons of riprap. The cost associated with these repairs are listed in Table 1 and Table 2 below and are not included as part of the project costs because the erosion at these structures will need to be addressed regardless of whether or not the excess flows are diverted into Turkey Creek. All existing structures require some erosion repair be completed. Generally, the current condition of Turkey Creek is stable and it can handle typical flows that occur each year. However, if a consistent 40 to 100 cfs is going to be introduced into the system, some improvements must be made to allow Turkey Creek to maintain its current integrity.

Table 1. Turkey Creek Structures – Current Conditions

Drainage Area Number	Structure	Existing Size	Recommended Actions	Cost
7	County Road 738	36" Culvert	Small Erosion Repair	\$2,000
8	Private Drive 432a	1 span - 20' wide Bridge	Small Erosion Repair	\$2,000
9	County Road 737	Triple 9' x 10' Box Culverts	Small Erosion Repair	\$2,000
10	County Road 735	120" Culvert	Small Erosion Repair	\$2,000
11	Field Access	96" Culvert	Small Erosion Repair	\$2,000
12	Private Drive 432	72" Culvert	Medium Erosion Repair	\$6,000
13	County Road 731	1 span - 85' wide Bridge	Large Erosion Repair	\$12,000
14	County Road 730	1 span - 55' wide Bridge	Small Erosion Repair	\$2,000
15	County Road 728	3 span – 90' wide Bridge	Medium Erosion Repair	\$6,000

16	County Road 727	1 span – 60' wide Bridge	Small Erosion Repair	\$2,000
17	County Road 726	3 span – 100' wide Bridge	Large Erosion Repair	\$12,000
18	County Road 431/725	3 span – 100' wide Bridge	Medium Erosion Repair	\$6,000
None	County Road 431	1 span – 40' wide Bridge	Large Erosion Repair	\$12,000
19	Highway 6	4 span – 190' wide Bridge	Large Erosion Repair	\$12,000
20	County Road 722	1 span – 45' wide Bridge	Small Erosion Repair	\$2,000
21	County Road 721	3 span – 125' wide Bridge	Large Erosion Repair	\$12,000
22	BNSF Bridge	1 span – 55' wide Bridge	Large Erosion Repair	\$12,000
22	Highway 136	3 span – 105' wide Bridge	Large Erosion Repair	\$12,000
23	County Road 720	3 span – 85' wide Bridge	Medium Erosion Repair	\$6,000
24	Field Access	Twin 60" Culverts	Small Erosion Repair	\$2,000
25	Field Crossing	36" Culvert	Medium Erosion Repair	\$6,000

Table 2 – Turkey Creek Structures - Estimated Costs for Erosion Repair

Construction Item	Quantity	Unit Price	Total Price
Small Erosion Protection	9 Each	\$2,000/Each	\$18,000
Medium Erosion Protection	5 Each	\$6,000/Each	\$30,000
Large Erosion Protection	7 Each	\$12,000/Each	\$84,000
Estimated Total Erosion Repair Costs			\$132,000

3.0 PROPOSED IMPROVEMENTS

3.1 Overview of Improvements

The geomorphologic analysis was used to help determine whether the existing creek would be able to handle the diverted flows or whether improvements will be needed. The potential areas of concerns observed during the geomorphologic field investigation and analysis were reviewed and focused on during the conceptual design.



Turkey Creek

The proposed improvements that would be required as part of the Platte Republican Diversion project are separated into two main categories. The first type of improvement includes modifications to the existing creek channel so that it will handle the diverted flows without causing additional erosion. The second type of improvements includes modifications to existing structures including bridges, culverts, and farm ponds so that they will not be impacted by the diverted flows.

Two different diverted flow values (40 cfs and 100 cfs) were analyzed in the HEC-RAS model to determine how the existing channel and proposed improvements in the upper section would handle the diverted flows over an extended period of time.

3.2 Channel Improvements

Because of the significantly greater channel slopes, the initial focus with regard to channel improvements was in the upper section - the first 3,000 feet of the east branch of Turkey Creek. The existing creek cross-section and slope are not equipped to handle the diverted flows without causing erosion along the existing flow path. A new, larger and more defined typical section will need to be established for the upper section to increase capacity and minimize the potential for erosion from the diverted flows. It is also important that the channel slope in the upper section be reduced to decrease the velocity and in turn minimize potential erosion. A series of grade control structures will need to be installed in the upper 3000-foot section to create a more stable slope. Exhibit D in Appendix A shows the proposed profile along Turkey Creek for this section. The proposed grade control structures can be constructed out of riprap, sheet pile or lumber. The proposed grade structures would include a 4-foot drop on the downstream side of the structure to allow a 1 percent slope to be established for the first 3,000 feet of Turkey Creek. A 1 percent slope is stable and would minimize the erosion that otherwise might occur during the introduction of diverted flows.

Another improvement option for the upper section would be to install a new underground polyvinyl chloride (PVC) pipe for the entire 3,000-foot length instead of grading a defined creek channel. The new pipe would need to be in the range of 36-inches diameter to 48-inches diameter in size. The actual pipe size would be determined during final design. A smaller pipe could be utilized with a steeper slope while a larger pipe would be needed with a flatter slope.

The middle section of Turkey Creek (approximately the next 5 miles) has an intermittently defined channel with varying capacity. Some grading would need to be completed along this section to increase the capacity to handle up to a 100 cfs without causing headcutting or incising of the existing creek. Total regrading of Turkey Creek would not be necessary, but rather would consist of widening of the existing channel in some areas to allow the diverted flows to stay within the banks.

The rest of Turkey Creek's cross-section downstream of the first 5 miles currently has sufficient capacity to handle the diverted flows along with the current base flow that Turkey Creek carries, which is approximately 12 cfs. No substantial improvements are anticipated along this stretch. There may be some minor grading that occurs along this section to repair large areas of erosion that have occurred over time. Any minor grading will take place above the ordinary high water mark (OHWM) so as to minimize any impacts to the existing stream and allow a Nationwide Section 404 permit to be obtained if needed.

3.3 Improvements to Existing Structures

The second category of proposed improvements deals with the existing structures and erosion control measures that need to be installed at each drainage structure location. As indicated above, many of the existing drainage structures at the upstream face have erosion issues that need to be addressed regardless of whether the diverted flows are introduced into Turkey Creek. If measures are not taken to control erosion in these areas erosion will continue to expand and may eventually compromise bridge abutments or cause failure along roadway embankments. It is proposed that riprap will be installed at the upstream face to provide protection either at bridge abutments or the inlets of culverts. The cost of these improvements are separate from the estimated project costs.

There are additional improvements to these existing structures that would be recommended in order to accommodate the introduction of diverted flows into the creek. Table 3 and 4 below lists the additional improvements anticipated for each drainage structure for both 40 cfs and 100 cfs starting at the upstream end of the project and continuing downstream along Turkey Creek. The erosion protection improvements are listed as large, medium and small. This refers to the anticipated amounts of riprap that may have to be installed at each location. A large amount is approximately 150 tons of riprap, medium is 75 tons of riprap, and small is 25 tons of riprap. This erosion protection is in addition to the riprap that will need to be placed at the structures due to existing erosion issues. Tables 3 and 4 below list the total number of erosion protection improvements and their associated costs. The additional riprap reflects the protection needed due to the diverted flows into Turkey Creek. A few existing drainage structures will overtop during a flow of 40 cfs or 100 cfs. Currently, it is anticipated that four drainage structures will need to be replaced, or upsized or that an additional culvert will need to be added to handle the diverted flows.

Table 3 – Turkey Creek Structures at 40 cfs - Estimated Costs for Erosion Repair

Construction Item	Quantity	Unit Price	Total Price
Small Erosion Protection	2 Each	\$2,000/Each	\$4,000
Medium Erosion Protection	14 Each	\$6,000/Each	\$84,000
Large Erosion Protection	5 Each	\$12,000/Each	\$60,000
Estimated Total Erosion Repair Costs			\$148,000

Table 4 – Turkey Creek Structures at 100 cfs - Estimated Costs for Erosion Repair

Construction Item	Quantity	Unit Price	Total Price
Small Erosion Protection	2 Each	\$2,000/Each	\$4,000
Medium Erosion Protection	14 Each	\$6,000/Each	\$84,000
Large Erosion Protection	5 Each	\$12,000/Each	\$60,000
Estimated Total Erosion Repair Costs			\$148,000

The existing farm ponds will also need some improvements to handle the diverted flows. Either new overflow structures or additional pipes will need to be constructed at each farm pond location to allow the diverted flow to travel downstream instead of creating additional ponding areas and erosion along the farm pond embankment. These improvements could also include some riprap or other method of erosion control to protect the existing embankment.

4.0 BENEFIT-COST ANALYSIS

4.1 Overview

A benefit-cost analysis (BCA) was completed for this project to determine the economic feasibility and potential benefit to the TBNRD, LRNRD and the residents of these two natural resources districts. In this analysis, the cost of designing, constructing, and maintaining the project is compared to the potential benefits or cost savings that it may provide by contrasting these costs with the costs of several previous efforts to reduce consumptive use and/or increase streamflows in the Republican River basin.

4.2 Costs of Diversion Project

Based on the recommended described above and the improvements listed in Tables 3-4, estimated construction costs have been generated for the following improvements to Turkey Creek:

- 1) Additional improvements needed to handle 40 cfs of diverted flows under two options:
 - a. Pipe installation in upper section (Table 5)

- b. Grading improvements in upper section (Table 6)
- 2) Additional improvements need to handle 100 cfs of diverted flows under two options:
 - a. Pipe installation in upper section (Table 7)
 - b. Grading improvements in upper section (Table 8)

The three major costs for this project are the grading along the creek, pipe installation and erosion control measures. The majority of the grading will be completed in the upper section to create a larger and defined, stable channel. An estimated unit price of \$10 per cubic yard (CY) of earthwork was used to develop the cost for grading. If it is determined that the excavated material can be spoiled onsite, then a lower unit price may be realized for this project. Installing a new pipe in the upper section (instead of grading a larger creek section) is also analyzed as part of an estimated project cost. An average cost of \$65 per linear foot was used for the pipe for the 40 cfs option and an average cost of \$90 per linear foot was used for the pipe for the 100 cfs option. Installing erosion control measures at the upstream face of the existing structures will be the other major project cost. It has been estimated that each structure will have a cost in the range of \$2,000 - \$12,000, depending on the magnitude of measures required to accommodate the diverted flows. These erosion control measures are in addition to the erosion repair improvements listed in tables 1-2. The grade control structures needed to create a more stable slope in the upper reach of the project have been estimated at \$10,000 for each structure. The four existing drainage structures that cross the stream cannot handle the diverted flows without overtopping; the cost of dealing with this issue are estimated at \$10,000 per structure for 40 cfs and \$15,000 per structure for 100 cfs. Three well-defined field drives in the upper section will each need a culvert crossing installed along with the proposed channel improvements. Those culvert crossings are estimated to be \$5,000 each for 40 cfs and \$7,500 each for 100 cfs. The last construction cost is associated with the existing farm ponds. The farm pond improvements are estimated to be \$7,500 per pond for 40cfs and \$10,000 per pond for 100 cfs. The anticipated construction cost of the diversion structure from Canal E-65 into Turkey Creek is also included at a cost of \$315,000. All unit prices are based on past construction costs on prior projects and the Nebraska Department of Road's Average Unit Price Summaries.

Table 5 – Estimated Project Costs – Diverting 40 cfs with Pipe Installation in Upper Section

Construction Item	Quantity	Unit Price	Total Price
Mobilization	1 Each	\$50,000/Each	\$50,000
Pipe Installation	3,000 LF	\$65/LF	\$195,000
Small Erosion Protection	2 Each	\$2,000/Each	\$4,000
Medium Erosion Protection	14 Each	\$6,000/Each	\$84,000
Large Erosion Protection	5 Each	\$12,000/Each	\$60,000
Grade Control Structures	9 Each	\$10,000/Each	\$90,000
New Drainage Structures	4 Each	\$10,000/Each	\$40,000
New Culvert Crossings	3 Each	\$5,000/Each	\$15,000
Farm Pond Improvements	7 Each	\$7,500/Each	\$52,500
Contingency (30%)			\$175,000
Estimated Total Construction Cost			\$765,500
Engineering Fees			\$235,000
Construction Observation (10% of Construction Cost)			\$76,550
Diversion Structure	1 Each	\$315,000/Each	\$315,000
Estimated Total Project Cost			\$1,392,050

Table 6 – Estimated Project Costs – Diverting 40 cfs with Grading in Upper Section

Construction Item	Quantity	Unit Price	Total Price
Mobilization	1 Each	\$80,000/Each	\$80,000
Earthwork	45,000 CY	\$10/CY	\$450,000
Small Erosion Protection	2 Each	\$2,000/Each	\$4,000
Medium Erosion Protection	14 Each	\$6,000/Each	\$84,000
Large Erosion Protection	5 Each	\$12,000/Each	\$60,000
Grade Control Structures	9 Each	\$10,000/Each	\$90,000
New Drainage Structures	4 Each	\$10,000/Each	\$40,000
New Culvert Crossings	3 Each	\$5,000/Each	\$15,000
Farm Pond Improvements	7 Each	\$7,500/Each	\$52,500
Contingency (30%)			\$260,000
Estimated Total Construction Cost			\$1,135,500
Engineering Fees			\$235,000
Construction Observation (10% of Construction Cost)			\$115,000
Diversion Structure	1 Each	\$315,000/Each	\$315,000
Estimated Total Project Cost			\$1,800,500

Table 7 – Estimated Project Costs – Diverting 100 cfs with Pipe Installation in Upper Section

Construction Item	Quantity	Unit Price	Total Price
Mobilization	1 Each	\$65,000/Each	\$65,000
Pipe Installation	3,000 LF	\$90/LF	\$270,000
Small Erosion Protection	2 Each	\$2,000/Each	\$4,000
Medium Erosion Protection	14 Each	\$6,000/Each	\$84,000
Large Erosion Protection	5 Each	\$12,000/Each	\$60,000
Grade Control Structures	9 Each	\$10,000/Each	\$90,000
New Drainage Structures	4 Each	\$15,000/Each	\$60,000
New Culvert Crossings	3 Each	\$7,500/Each	\$22,500
Farm Pond Improvements	7 Each	\$10,000/Each	\$70,000
Contingency (30%)			\$220,000
Estimated Total Construction Cost			\$945,500
Engineering Fees			\$235,000
Construction Observation (10% of Construction Cost)			\$95,000
Diversion Structure	1 Each	\$315,000/Each	\$315,000
Estimated Total Project Cost			\$1,590,500

Table 8 – Estimated Project Costs – Diverting 100 cfs with Grading in Upper Section

Construction Item	Quantity	Unit Price	Total Price
Mobilization	1 Each	\$85,000/Each	\$85,000
Earthwork	45,000 CY	\$10/CY	\$450,000
Small Erosion Protection	2 Each	\$2,000/Each	\$4,000
Medium Erosion Protection	14 Each	\$6,000/Each	\$84,000
Large Erosion Protection	5 Each	\$12,000/Each	\$60,000
Grade Control Structures	9 Each	\$10,000/Each	\$90,000
New Drainage Structures	4 Each	\$15,000/Each	\$60,000
New Culvert Crossings	3 Each	\$7,500/Each	\$22,500
Farm Pond Improvements	7 Each	\$10,000/Each	\$70,000
Contingency (30%)			\$275,000
Estimated Total Construction Cost			\$1,200,500
Engineering Fees			\$235,000
Construction Observation (10% of Construction Cost)			\$120,000
Diversion Structure	1 Each	\$315,000/Each	\$315,000
Estimated Total Project Cost			\$1,870,500

The estimated total construction costs are listed below in Table 9 and are based on the preliminary analysis and design. Two costs are given for the 40 cfs option, and two costs are given for the 100 cfs option. All the construction costs currently have a 30 percent contingency fee included in the total and the estimated costs would be refined during final design. Table 9 also lists estimated total project costs when incorporating the estimated cost for final design and construction observation. Project land rights acquisition costs have not been estimated as part of project development costs. The sponsors anticipate acquiring easements from landowners without compensation.

Table 9 – Estimated Project Costs

Project Option	Estimated Construction Cost	Estimated Total Project Cost
40 cfs with Pipe Option	\$756,500	\$1,392,050
40 cfs with Grading Option	\$1,135,500	\$1,800,500
100 cfs with Pipe Option	\$945,500	\$1,590,500
100 cfs with Grading Option	\$1,200,500	\$1,870,500

4.3 Benefits

The benefits of the project are generally related to improving water supply conditions in the Republican River. Water use is limited in the Republican River basin (Basin) due to the Republican River Compact (Compact). Nebraska is allocated a certain percentage of the Basins water supply, which varies from year to year based on climatic conditions. During many previous dry years, Nebraska has used more than its allocation of water. Excess flows from the Platte River would be used to offset any potential overuse in the future, reducing or eliminating the cost of other management actions that might be needed.

The Nebraska Department of Natural Resources (NeDNR) has studied the potential amounts of water that may be available from the Platte River for this project. This evaluation involved a comparison of the historic Platte River streamflows against all currently existing demands to this water to compute flows in excess of current demands. Other agencies, including the Platte River Recovery Implementation Program (PRRIP) are evaluating projects that could affect the future occurrence and availability of excess flows in the Platte River. The water that may be available for this project would be water diverted into the Tri-County Supply Canal for use in generating hydropower and which would otherwise be returned to the Platte River at the J2 return. When there are excess flows downstream of the J2 return (as measured at the Overton gage), some of this water can be retained in the canals and delivered for other purposes, such as to supply water to this diversion project. Data from the NeDNR study from the Overton gage for the years 2000 to 2008 were used to estimate the excess flows that may be available to divert into Turkey Creek during a given year and to calculate the actual water the project could provide based on several assumed capacity limitations. These years were chosen because it was a dry period in which Nebraska could have potentially benefited from the diversion of water into the basin by assisting the state with Compact compliance.

Exhibit E in Appendix A is a spreadsheet that shows the total monthly excess flows available in the Platte River basin during 2000 to 2007. It also contains the amount of water that would be able to be diverted into Turkey Creek based on a project capacity of either 40 cfs or 100 cfs. However, this analysis does not take into account future needs of these excess flows for projects in the Platte River Basin designed to meet the PRRIP goals as well as goals and objectives of the Platte Basin integrated management plans. With assistance from the Executive Directors Office of the PRRIP (J. Farnsworth, personal communication,

June 6, 2017), this evaluation was revised and updated through 2016 to take into account future needs in the Platte Basin and additional potential benefits that could have been realized during more recent years. The estimate for future needs in the Platte is up to 1,000 cfs of additional diversions. Table 10 below shows the average annual amount of water that would be available to divert from the Platte River basin during these years with and without an assumed increased use of 1,000 cfs, for a project capacity of 40 cfs and 100 cfs.

Table 10 – Potential Acre-Feet Available to Divert

YEAR	Without additional 1,000 cfs		With additional 1,000 cfs	
	40 cfs	100 cfs	40 cfs	100 cfs
2000	9340	21721	3722	8989
2001	8102	19117	772	1742
2002	7419	16782	0	0
2003	2408	4877	0	0
2004	2752	5651	0	0
2005	2994	7277	0	0
2006	2487	5120	79	198
2007	3665	8366	79	198
2008	4346	9973	713	1782
2009	5227	12474	356	752
2010	16889	41818	8217	20176
2011	25859	64469	20176	49559
2012	7827	19261	2732	6712
2013	9249	21950	2119	5207
2014	8732	21115	2812	6811
2015	19206	47401	12474	30730
2016	20117	49124	13266	32076

One additional factor needs to be taken into account, which is the extent to which water was actually needed in the Republican River Basin during these years. During 2013-2016, the Republican River Basin NRDs pumped approximately 132,000 acre-feet of groundwater into Republican River tributaries from the Rock Creek and Nebraska Cooperative Platte Republican Enhancement Projects in order to ensure that Nebraska complied with the Republican River Compact during those years.

Table 11 presents the total available excess flow that could have been diverted from the Platte Basin into the Republican Basin during 2013-2016. As it is unclear when the Platte Basin will have the infrastructure in place to create an additional 1,000 cfs of diversions in the Platte Basin, the potential benefits of the project when similar years recur in the future is estimated to be between approximately 30,000 and 130,000 acre-feet (139,590 capped at the approximate need for water during 2013-2016) depending on the capacity of the final diversion project.

Table 11 – Potential Acre-Feet Available to Divert during September through April

Design Option	Without Additional 1,000 cfs	With Additional 1,000 cfs
40 cfs	57,303 acre-feet	30,670 acre-feet
100 cfs	139,590 acre-feet	74,824 acre-feet

4.4 Alternative Costs

There are several metrics available to assess the cost to Nebraska to offset any water use in excess of its allocation that may occur in the future. While Nebraska was ordered by the U.S. Supreme Court to pay Kansas \$5.5 million for its over use of approximately 70,000 acre-feet of water during 2005-2006, the Court made it clear that the cost of a future violation would likely be significantly greater, so using this value as a metric would likely undervalue the benefits of a transfer of water into the Basin from the Platte River.

Another available metric would be the costs of previous actions taken by the state and the natural resources districts (NRDs) to reduce consumptive uses of water in an effort to maintain compliance with the Compact. From 2006 to 2008, surface water was leased from irrigation districts in the basin to assist with compliance with the Republican River Compact (Compact). The state and the local NRDs paid \$18,722,500, which resulted in a reduction of consumptive use of 51,614 acre-feet, which equates to \$362 per acre-feet of water. This value will be used to assign a benefit to the potential volumes of water that could be delivered from this project during future dry years.

Another available metric would be to utilize the cost associated with the Nebraska Cooperative Republican Platte Enhancement (N-CORPE) project for the LRNRD. The N-CORPE project provides construction costs and delivery costs for water which can be related to this project to develop potential benefit. These costs are summarized in Table 12. Based on these costs, and an assumed average annual delivery of 3,750 acre-feet, the annual delivery cost for water from N-CORPE is \$272.59 per acre-foot, or \$195,000 per year. The annual delivery cost for the surface water option and the N-CORPE option will be used to calculate a range of benefit-cost ratios below.

Table 12 – Computation of Average Annual Delivery Cost for LRNRD for water from N-CORPE

Cost Items	Cost to LRNRD
Capitol Cost (including interest)	\$41,360,511.00
Cost per year - 50 years	\$827,210.22
Average Annual Capacity	3,750
Annual Cost per AF – capacity	\$220.59
Water Delivery Cost	\$52.00
Cost per AF	\$272.59

Based on this per acre-foot cost of water, the Diversion project would have provided benefits in the range of \$15 to \$36 million dollars during 2013-2016 and would provide benefits in the range of \$8 million to \$20 million during similar years in the future, even after the additional 1,000 cfs of diversion in the Platte River Basin has begun occurring.

4.5 Range of Cost for the Projects and Associated Benefits

The average cost per acre-foot for the alternative sources of water evaluated above are next used to calculate a range of benefit-cost ratios for the Platte Republican Diversion project. Table 13 and Table 14 compute the total delivery costs for the project based on the construction costs presented above and an assumed value of \$44.35 acre-foot for the water delivery.

Table 13 – Potential Annual Cost – 40 cfs

Cost Items	PRD Project – Pipe Option	PRD Project – Grading Option
Capitol Cost	\$1,392,050.00	\$1,800,500.00
Cost per year - 50 years	\$27,841.00	\$36,010.00
Average Annual Supply*	977 acre-feet	977 acre-feet
Annual Capital Cost per AF	\$28.50	\$36.86
Water Delivery Cost	\$44.35	\$44.35
Total Cost per AF	\$72.85	\$81.21

*20% of 4,885 acre-feet from Table 11 to adjust for benefits in 2 out of 10 years

Table 14 – Potential Annual Cost – 100 cfs

Cost Items	PRD Project – Pipe Option	PRD Project – Grading Option
Capitol Cost	\$1,590,500.00	\$1,870,500.00
Cost per year - 50 years	\$31,810.00	\$37,410.00
Average Annual Supply*	1,969 acre-feet	1,969 acre-feet
Annual Cost per AF – capacity	\$16.16	\$19.00
Water Delivery Cost	\$44.35	\$44.35
Total Cost per AF	\$60.51	\$63.35

*20% of 9,846 acre-feet from Table 11 to adjust for benefits in 2 out of 10 years

So the annual cost per acre-foot of water delivered by the Platte Diversion Project would range from \$60 to \$82, depending on the construction option and the ultimate capacity of the project. Table 15 presents the total cost of the water that would have been available during 2013-2016 if the project had been in place and had purchased the total available supply given the capacity limitations. The difference between the two columns represent the significantly greater amount of water that would have been purchased based on actual availability in 2013-2016 and what could be purchased during similar years in the future after the 1,000 cfs of Platte Basin diversions is factored in..

Table 15 – Cost of Water Volumes available During 2013-2016 in Comparison to Project Alternative

Design Alternative	Without additional 1,000 cfs	With additional 1,000 cfs
40 cfs – pipe	\$4,200,000	\$2,240,000
40 cfs – grading	\$4,600,000	\$2,500,00
100 cfs – pipe*	\$8,400,000	\$4,500,000
100 cfs – grading*	\$8,900,000	\$4,800,000

*Benefit-Cost Analysis for 100 cfs option is slightly inflated. In reality the 100 cfs flows can only be diverted into Turkey Creek for 5 days at a time and not for the entire length of time it is available.

Given the potential benefits noted above, and regardless of whether the Platte River Basin had been using an additional 1,000 cfs during 2013-2016, if the project had been in place at the beginning and 2013 and had accessed all available water, it would have paid for itself three to four times over by the end of 2016.

5.0 SUMMARY AND CONCLUSIONS

Based on the preliminary feasibility analysis completed for the Platte Republican Diversion project, the benefit-cost analysis clearly shows the project would provide a significant benefit over the lifetime of the project given the assumptions made for availability of excess flows from the Platte River. With creek improvements in the upper section and erosion control measures at each drainage structure and farm ponds, Turkey Creek will be able to handle diverted flows up to 100 cfs for the designated periods of time without negatively affecting the surrounding land or causing any significant erosion to the existing creek system.

APPENDIX A – EXHIBITS

- Exhibit A – Turkey Creek Map
- Exhibit B – East Branch Turkey Creek Drainage Area Map
- Exhibit C – Turkey Creek Regression
- Exhibit D – Upper Reach Channel Profile of Turkey Creek
- Exhibit E – Available Flows

APPENDIX B – GEOMORPHOLOGY REPORT

APPENDIX C – ENVIRONMENTAL REPORTS