APPENDIX C – OPERATION AND MAINTENACE BACKGROUND DATA

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Date:	July 16, 2012	Job No:	178514

RE: Operations and Maintenance Cost Evaluation for Alternative Stages

1.0 Purpose of Memorandum

There are alternative operational scenarios under consideration for the Fargo-Moorhead Diversion flood control system. The proposed project areas included in this O&M evaluation are a diversion channel, upstream Staging Area, Storage Area #1, and an "in-town", or flood reduction, area (the existing Red River channel, adjacent floodplains, and the levees and floodwalls located in Fargo, ND and Moorhead, MN). The operational scenarios under consideration for the flood control system would result in different water surface elevations (stages) and frequencies of inundation in the diversion channel, upstream Staging Area, storage area, and the in-town area. The variation in operations would be achieved through alterations to gate configurations and operations. This memorandum discusses how operations and maintenance (O & M) costs would change depending on stage and frequency of flooding in the various project areas.

2.0 Background

An evaluation of O&M costs was developed as part of the Final Feasibility Report and Environmental Impact Statement (USACE, July 2011). A Total Project Cost Summary (PTCS) was developed in support of the USACE evaluation. Barr Engineering provided opinions of probable construction cost for project features as part of the TPCS evaluation. USACE used that opinion of probable construction cost as a basis for calculating O&M costs for the project. The O&M calculations by USACE were estimated by calculating O&M as a percentage of initial capital costs, and creating an annual estimated cost. Percentages were applied to all constructed features, and additional costs were added for regular maintenance and inspection activities. The USACE O&M estimate was on the basis of the Locally Preferred Plan project configuration. A copy of the spreadsheet tab with O&M data (USACE O&M) is provided in Appendix A of this memorandum.

HDR reviewed the USACE O&M calculations to identify which costs incorporated into that analysis would change depending on stage and frequency variations. The only items accounted for in the USACE O&M evaluation which were deemed by HDR to be likely to vary based on stage and frequency were embankment repair, topsoil, and revegetation (activities associated with the tie-back levees in the Staging Area).

A meeting was held on April 4, 2012 with representatives of the City of Fargo, City of Moorhead, and Cass County to discuss the intent of this memorandum and to develop an understanding of operations and maintenance activities and costs associated with flooding in their jurisdictions. Subsequent to this meeting, additional conversations were held with April Walker (City of Fargo) and Tom Soucy (Cass County Highway Department).

Based on discussions with project stakeholders and a review of project features and area land uses, HDR identified stage and frequency dependent O&M tasks in addition to those variable items already identified in the USACE O&M evaluation. The variable operations and maintenance costs are defined in sections 2.1 thru 2.3 of this memorandum. Sections 3.0 and 4.0 of this memorandum describe the development of costs associated with those items. Section 5.0 discusses how the variable O&M items discussed in this memorandum are used as a supplement to the USACE O&M evaluation and provides the results of the O&M cost evaluation.

2.1 Evaluation Criteria

This O&M evaluation includes costs that are incurred to public entities as a result of inundation. The public entities included the City of Fargo, ND, the City of Moorhead, MN, and Cass County. Although some public entity costs may be unaccounted for in this evaluation, the results presented in this memorandum should capture the most significant O&M costs associated with the project.

The USACE O&M evaluation included costs for diversion channel repair (embankment repair, topsoil, and revegetation). Review of channel hydraulic modeling indicated that the wetted perimeter of the diversion channel cross section will not change significantly for alternative operational stages in the in-town areas. As such, HDR does not anticipate that these diversion channel O&M items will vary significantly based on the range of operational stages under consideration. Furthermore, it is not anticipated that the frequency of embankment, topsoil, or vegetation repair will vary significantly for varied frequencies of intermittent diversion channel flooding. The velocities anticipated in the diversion channel should not cause significant scour. The proposed vegetation and riprap should be sufficient for maintaining the integrity of the diversion channel side slopes over time.

Although varying flood stages and frequencies of inundation could impact City and regional economies through loss of business access, loss of customers, and interruption of labor or material supplies, HDR deemed these costs to be outside of the context of flood control operations, and these items were not included in this O&M evaluation. Changes to operations would also impact the use and productivity of

agricultural fields in the upstream Staging Area and Storage Area #1. These impacts would result in costs to landowners. These costs were also deemed to be outside of the context of flood control operations costs.

Revenue losses to publicly owned facilities were included in the analysis. These included public golf courses, campgrounds, and athletic facilities in the City of Fargo. Review of inundation mapping indicates that there are golf courses in the upstream Staging Area and in the City of Moorhead that could become inundated depending on operational stage. These courses, however, are privately owned. Any loss of revenue or repair costs to the owners of these privately owned facilities were not included in this evaluation.

2.2 Operations Defined

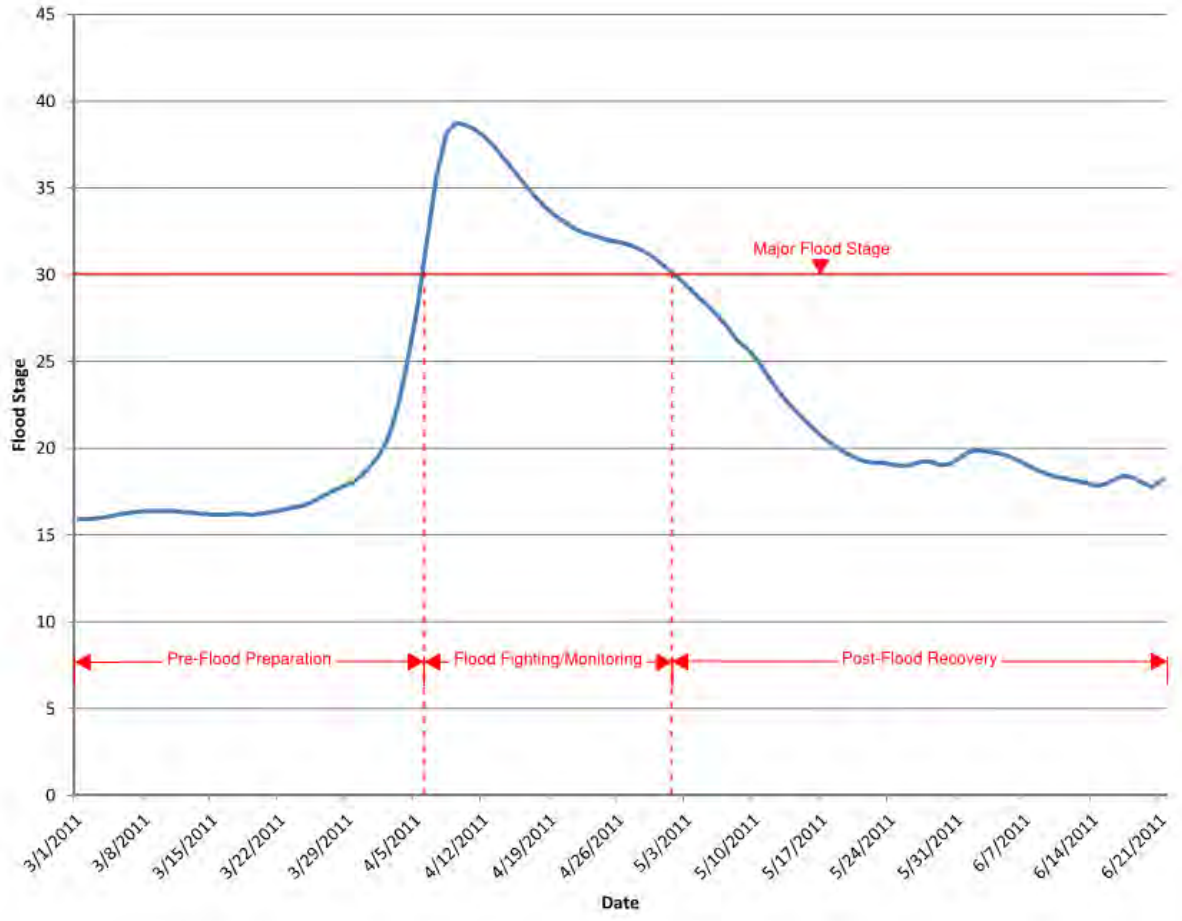
Flood operations are activities that must take place in order to establish and maintain flood control systems which protect the community. The operations activities can be thought of in terms of three modes: pre-flood preparation, monitoring /flood fighting, and post-flood recovery.

The National Weather Service (NWS) provides continual monitoring and predictions for flood stages on the Red River. The monitoring information and predictions provided by the NWS are used by the local community and government agencies as a basis for determining what flood monitoring/fighting activities must take place and determining the timing of these operations. Table 2 provides a description of the activities which would occur during each mode of operations. Figure 1 provides an illustration of the time distribution of these operational stages as they would have occurred during the 2011 flood. The level of effort (and cost) associated with each mode is variable and dependent on factors such as time of year of the flood, anticipated peak elevation, duration of flooding, and weather conditions.

Table 1 – Operations Activities

Operations Mode	Flooding Condition	Activities
Pre-Flood Preparation	Stages lower than 30 feet	Human resources and administrative preparation, flood system inspections, inventory, preparatory maintenance activities, securing backup power supplies, public communications
Monitoring/Flood Fighting	Stages over 30 feet	Staffing of emergency management command center, human resources and administration, emergency levee construction and other flood fighting activities, operation of closures, levee and floodwall patrols, monitoring of pump stations and backup power supplies, public safety and communications, and agency coordination.
Post-Flood Recovery	Stages lower than 30 feet after passing of peak flooding	Human resources and administration, agency coordination, removal of flood fighting measures, post-flooding inspections, and inventory.

Figure 1 – Flood Operations Mode by River Stage (2011)



2.3 Maintenance Defined

Maintenance is defined in this evaluation as regularly scheduled work that is required to maintain flood control systems or on-demand work that is required to maintain flood control systems or city infrastructure as a result of flooding. The types of activities included in maintenance are as follows:

- Clean up of Open Space
- Clean up of Paved Surfaces
- Levee Embankment Maintenance
- Levee Topsoil Maintenance
- Levee Turf Maintenance/Replacement
- Roadway Embankment Repair

- Ditch Cleanout and Debris Removal

Section 4.0 describes the type of work associated with each activity, and the assumptions used in developing costs for these activities.

2.4 Summary of O&M Items Incorporated in Analysis

A summary of the variable cost items incorporated by HDR into the O&M evaluation is provided in Table 2 by project area.

Table 2 – Summary of O&M Items by Area

In-Town Area
Operations:
Flood Monitoring
Flood Fighting
Parks Department Revenue Losses
Maintenance:
Open Area Clean Up
Roadway Clean Up
Roadway Embankment Repair
Ditch Cleanout and Debris Removal
Levee Embankment Maintenance
Levee Topsoil Maintenance
Levee Turf Maintenance/Replacement
Staging Area
Operations:
Flood Monitoring
Flood Fighting
Maintenance:
Roadway Embankment Repair
Ditch Cleanout and Debris Removal
Storage Area #1
Operations:
Flood Monitoring
Flood Fighting
Maintenance:
Roadway Embankment Repair
Ditch Cleanout and Debris Removal

2.5 Accounting for Operational Stages and Associated Exceedence

In the analysis O&M Costs will vary depending on the 100-yr operations stage. In addition, each 100 year event operational stage will alter the associated river stages for the frequency of the 5 to 100-yr return periods (refer to Table 3 below). For example, if the system is operated such that the in town residual flood stage is at an elevation of 30, the effective river stage for the 5 though 100-yr return periods is 30 feet. Alternatively, operating to river stage 34, the river stage is 30 at the 5-yr but increases to 34 at the 8-yr. With the examples above, the O&M costs which may result over the 50 years of operations would be different and would be affected by the likelihood of any given event occurring within the 50 year period. In order to account for this variation in operational stages, HDR converted each of the 100 year event costs to expected annual O&M costs. The expected annual costs are the sum of the potential annual cost for each exceedance probability (2-yr through 100-yr) multiplied by the probability of the exceedance under each of the 100-yr operational stage.

Table 3: In-town stage associated with exceedance and 100 year event operational stage

Exceedance	100 Year Event Operational Stage							
	30	31	32	33	34	35	36	37
5	30	30	30	30	30	30	30	30
6	30	31	32	32	32	32	32	32
7	30	31	32	33	33	33	33	33
8	30	31	32	33	34	34	34	34
10	30	31	32	33	34	35	34	34
25	30	31	32	33	34	35	36	37
50	30	31	32	33	34	35	36	37
100	30	31	32	33	34	35	36	37

The expected annual O&M cost provides a probability weighted estimate of the O&M cost which could result given the frequency of inundation for various in-town stages. The expected annual O&M cost is calculated to estimate the recurring costs which would result over the entire 50 year life of the project. A present value of the stream of payments can then be calculated. To estimate the present value the analysis period was assumed to be 50 years with a discount rate of 4.375 percent used in the USACE feasibility study.

3.0 Operations

The following sections provide a description of the assumptions used in the calculation of variable flood operations costs along with a summary of the findings. The calculations used to estimate the operations costs are presented in Appendix B. In order to estimate the variable costs of operations, cost curves are constructed which deconstruct the cost of flood operations under existing conditions to the cost of flood operations per day, for the stage of flooding, and for the length of levee impacted. Through this process, these curves may be reapplied to with-project conditions to examine how operations costs can be expected to change for lower operations levels. Furthermore, the curves may be adjusted to account for mitigation measures explored in Section 6 which will further reduce the cost of O&M costs.

Operations costs considered here are a function of the labor hours expended prior to flooding, during the flood fighting efforts, and those from cleanup. The costs include both regular and overtime hours for all employees which are billed to flood fighting (emergency, admin, monitoring, etc). Furthermore these costs include employee hours associated with the in town permanent and temporary levees as well as tie-back levees in the in the Staging Area and the containment levees in Storage Area #1.

The costs expended during the pre-flood preparation may be somewhat variable depending on the predicted timing of the flood crest, the anticipated peak flood elevation, weather conditions, and uncertainty associated with predictions. For purposes of this analysis, however, the operations costs associated with pre-flood preparation are considered a non-variable sunk cost. This approach was used because while there may be some variability, many of the pre-flood preparation costs associated with human resources and administrative preparation, flood system inspections, inventory, preparatory maintenance activities, securing backup power supplies, and public communications would be similar regardless of the ultimate flood stage (between 30 and 37) in town. The methodology used to develop the operations costs are discussed in detail below. The methodology provides a summary of the data used to assemble the operations costs curves, the assumptions used, and the data inputs necessary to develop the analysis.

3.1 Methodology

Cost Data

Operations costs for flooding were developed using labor data recorded by City of Fargo during the 2009, 2010, and 2011 flood events. The data included labor hours and costs from regular and overtime hours. The data includes hours and costs (wages) associated with all personnel working on flood fighting activities.

In order to differentiate between pre-flood sunk costs and variable flood fighting operations costs the following assumptions were initially made:

- Any costs incurred up until the river stage equaled 30 (the elevation of major flood event) would be classified as sunk costs.

- Costs incurred beginning at river stage 30 were classified as variable costs and are considered to be costs which result in response to the declaration of reaching major flood stage.

In order to segregate the variable costs which occur above river stage 30 from the pre-flood costs, river stages were identified for each of the labor costs. Costs which were incurred on days where the river stage was below 30 were eliminated from the data set. This refined data set was then deconstructed by days of flooding, foot of flood stage, permanent and temporary measures, and linear feet of levee. This data was then assembled into operations cost curves.

In Town Operations Cost Curves

The first step in assembling the operations costs curves was to deconstruct the daily costs of flood fighting into a usable metric which can then be reapplied to project conditions. To do this the daily cost data was broken into an average cost per day, per foot of flood stage, and per linear feet of levee (permanent or temporary). To begin this process the data was summed to daily totals for regular and overtime hours. The daily totals were then divided by the feet of flood stage to get a daily average cost per foot of flood inundation.

The cost data did not provide a differentiation between activities associated with implementation and monitoring of temporary flood protection and those associated with permanent flood protection measures. In order to do this, it was assumed that 80 percent of flood operations were associated with temporary measures and 20 percent were associated with permanent measures. This cost distribution was based on the assumption that implementation and monitoring requires more time for temporary measures which are at a greater risk of failure. This ratio was applied to the daily average cost per foot of flood inundation to determine a cost for permanent and temporary measures costs.

Next the costs were divided by the linear feet of protection impacted by flooding for a given flood stage resulting in a daily cost of flooding for type of protection, per foot of flood stage, and per linear foot of levee. The average of the daily cost was then taken per equivalent operational flood stage resulting in the average cost per day per foot of flood stage per linear feet of levee of operations at each flood stage.

This derived operational cost is an average incremental cost which takes into account how operations costs change as flooding stage increases. Review of these costs demonstrate that at stages 30-32 operations costs are high as temporary flood measures are put in place and monitoring is conducted. As flood duration continues and stages increase beyond 33 feet, average incremental costs decrease as operations move to monitoring and as needed repair. These costs were then assembled into the cost curves for permanent and temporary flood measures.

To assemble the curves, the incremental average costs were combined to a total average cost per day per foot of flood stage and per linear foot or levee. This was done by summing the respective costs for flood stages below each effective operational stage. For example, for the operational 100-yr river stage 34, the total cost was derived by summing the incremental costs for river stages 30 to 34. In doing so the cost for each operational stage will reflect the costs accrued as stages increase up to the maximum

operational stage. The curves are shown below in Figure 2 and Figure 3 for permanent and temporary levees.

Figure 2: Total Estimated Annual Operations Costs Curves for In Town Permanent Levees

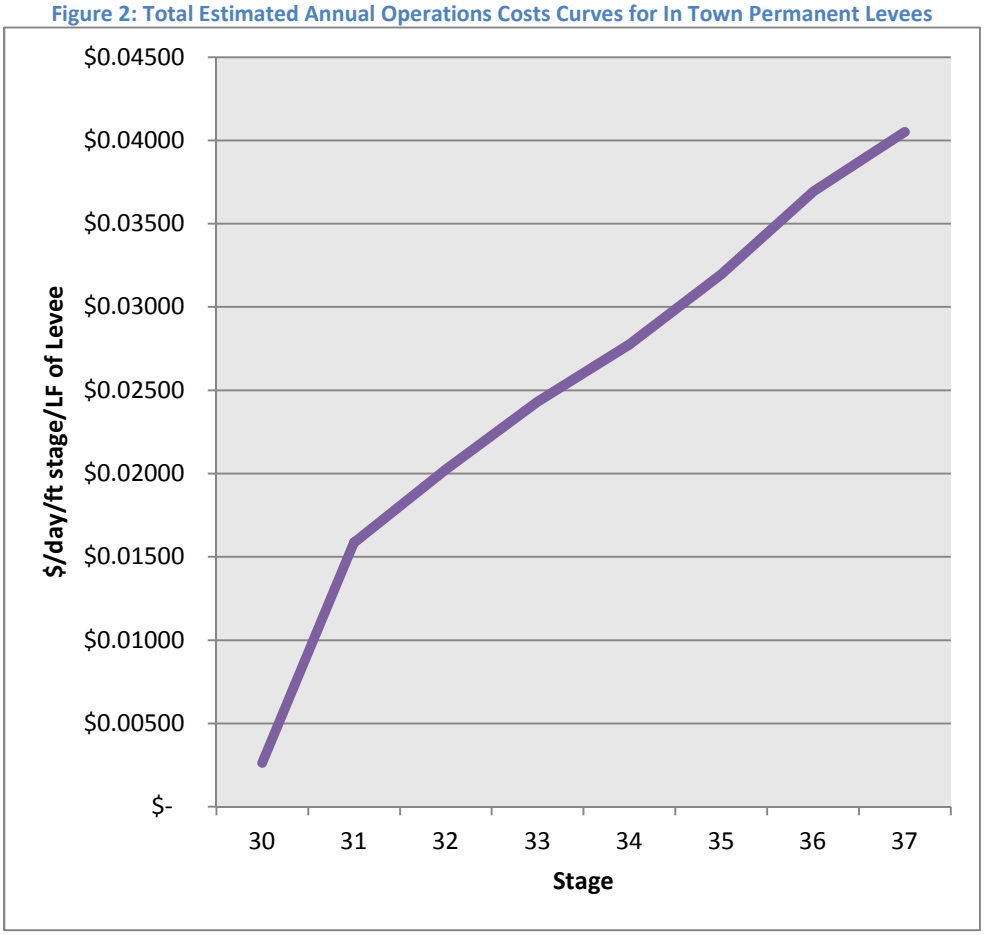
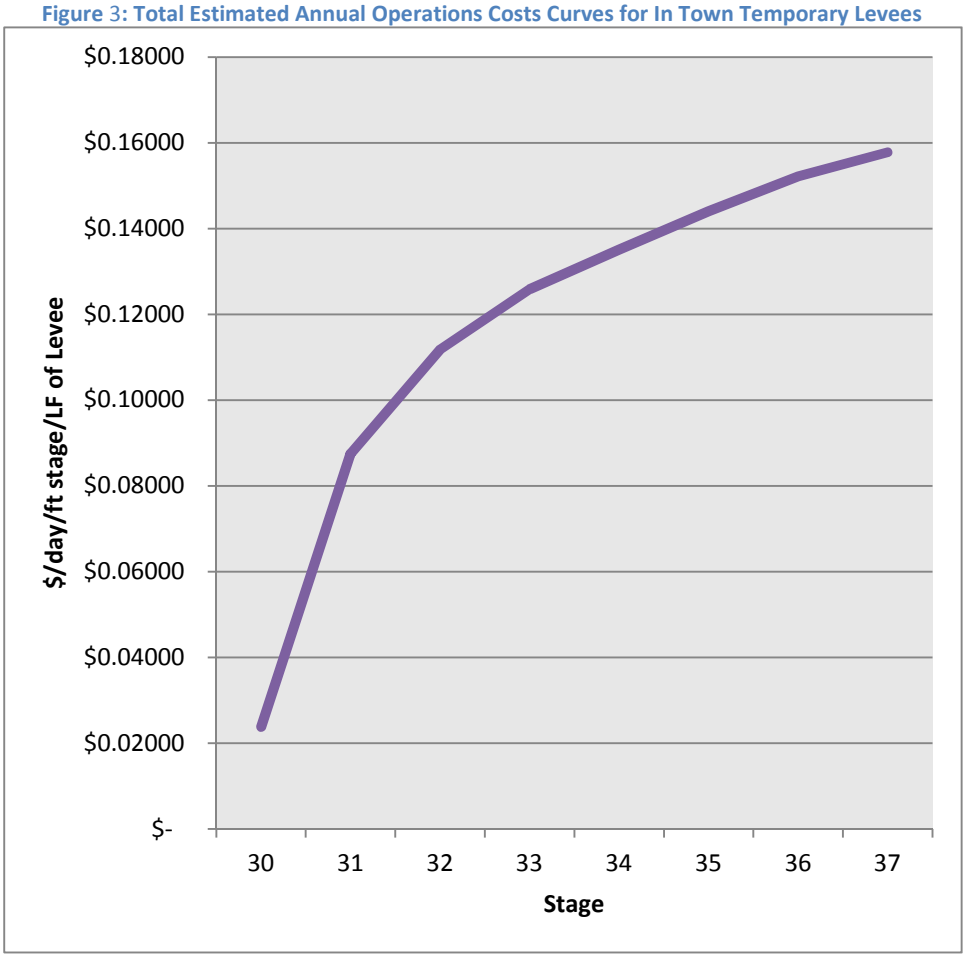


Figure 3: Total Estimated Annual Operations Costs Curves for In Town Temporary Levees



The cost curves described above are based on cost data from historical flood events. During these historical events, the ultimate height and extents of temporary flood protection measures were built according to expected peak river stages (elevations forecast for flood fighting purposes). These expected peaks were at elevations higher than the river stage elevations which occurred at the peak of the flooding. The presence of the diversion channel and the ability to restrict or divert flows under post-project conditions will result in reduced uncertainty associated with post-project river stages. Due to this anticipated reduction in river level uncertainty and the elimination of a need to 'overbuild' temporary measures, the operations costs incurred during these historical events were reduced. These reductions were accomplished through use of a reduction factor to be applied to the cost curves.

An adjustment factor for 'overbuilding' was developed by fitting a linear curve to the historical cost data. The expected peak was used as the dependent variable. The fitted curve was then used to predict a cost for river stages of 30-37. From these cost estimates, a percent difference between the historical cost and the expected cost at RS 30-37 was then calculated. The percent difference was applied to the cost curves. For example: at river stage 30 the overbuild adjustment factor is 76%. This adjustment factor indicates that although still above major flood stage, approximately 25% of the flood fighting

operations which were necessary with expected peaks of 38-40 in the historical data would no longer be necessary.

A reduction factor was also developed to account for the fact that offering higher protection under post-project conditions would lower the variable and sunk costs associated with more frequent flooding at lower river stages. For example, if the in-town system is able to operate at a 100 year river stage of 37 feet, the amount spent on O&M when flooding occurs to a stage of 30 or 31 feet would less than if the in-town system is designed to an elevation of 31 feet. In order to account for this reduction in costs for more frequent events, a set of discount factors were applied to the cost curves. Those discount factors are shown below in **Error! Reference source not found.**.

Table 4: River Stage Cost Curve Discount Factor for Protection below 100-year Design

In Town Flood 100-year Flood Protection Level	River Stage							
	30	31	32	33	34	35	36	37
30	1.0	-	-	-	-	-	-	-
31	1.0	1.0	-	-	-	-	-	-
32	1.0	1.0	1.0	-	-	-	-	-
33	0.8	1.0	1.0	1.0	-	-	-	-
34	0.6	0.8	1.0	1.0	1.0	-	-	-
35	0.4	0.6	0.8	1.0	1.0	1.0	-	-
36	0.2	0.4	0.6	0.8	1.0	1.0	1.0	-
37	0.2	0.2	0.4	0.6	0.8	1.0	1.0	1.0

To illustrate how both the overbuild discount factor and the river stage cost curve discount factor are applied together; consider the difference between RS 30 and RS 37 at the 5 and 100 year events post-project. At river stage 30, the 5 year and 100 year river stage is 30. An overbuild adjustment factor of 76% is applied to the cost curve to account for the reduction in costs associated with lower expected peaks that occur post-project. Also, from table 4, an adjustment factor 1.0 is then applied to RS 30. This indicates no cost savings at lower events because the 5 year through 100 year events RS 30 and would require the same level of preparedness.

If the post-project operational level is RS 37 then RS 30 is also considered because expected annual cost for RS 37 includes RS 30 at the 5 year. The overbuild adjustment factor of 95% is applied to the cost

curve at RS 37 and 76% is applied to the cost curve at RS 30 to account for the reduction in costs associated with lower expected peaks that occur post-project. From table 4, the adjustment factor 1.0 is then applied to RS 37. This indicates no cost savings at the 100 year events RS 37 as it would require a high level of preparedness and flood fighting. However at RS 30 (5 year), the adjustment factor 0.2 is applied to the cost curve. This value accounts for the significant reduction in sunk costs and variable costs which would result because of the protection offered by the project.

Storage Area 1 and Staging Area Cost Curves

The containment levees in Storage Area #1 and the tie-back levees in the Staging Area were considered to be permanent levees for this analysis. During flood operations these structures will require monitoring, as well as any necessary reinforcement. Historical operations cost data is not available to estimate flood operations cost curves for these structures since they are not yet built. It was assumed that the cost curves developed for the in-town permanent levees could be used as a basis for determining the cost curves costs associated with the Staging Area tie-back levees and the Storage Area #1 containment levees. It was assumed, however, that costs for the Staging Area and Storage Area #1 levees would be significantly lower than for the in-town levees because they are not located in populated areas and as a result would require less intensive efforts such as providing security, public communications, monitoring and administrative support. Following this assumption, the costs at each 100-year operational stage were assumed to be 20% of the costs develop through application of the in-town levee operations costs curves. A change in classification of these structures to dams could change periodic inspection and flood monitoring requirements. It is likely, however, that costs would still be significantly lower for a dam-classified structure due to the location of these structures outside of an urban area. The impact to O&M costs were reviewed taking into account the affect of varying the 20% reduction factor. It was found that doubling the reduction factor from 20% to 40% would increase the total O&M costs for the project between +0.2% for a river stage of 30 feet and +1.8% for a river stage of 37 feet.

4.0 Maintenance

The following sections provide information on assumptions used in calculation of variable maintenance costs. Supporting calculations are provided in Appendix B.

4.1 Open Area Clean Up

Publicly owned open areas that become inundated will need to be inspected and cleaned up after flood waters recede (for public safety and sanitation reasons). Clean up would include items such as removal of sediment and debris, washing of surfaces, and other miscellaneous duties. The in-town open areas include undeveloped properties owned by the City of Fargo, City of Moorhead, and the State of Minnesota. It is assumed that open areas on developed publicly owned properties would be cleaned up as part of regular site maintenance and was not accounted for as a variable O&M cost.

As detailed in Appendix B, a clean up crew (consisting of assumed staffing and representative wage rates) was estimated to be able to inspect and clean up areas that become inundated at the rate of 10

acres per day. The total open areas inundated at each stage were determined based on GIS coverage. The assumed staffing and wage rates were estimated based on City of Fargo FEMA claims payroll data. It was assumed that the same crew and wage rates would be applicable to open areas within the City of Moorhead.

Open areas within the upstream Staging Area and Storage Area #1 are primarily agricultural. As such, it was assumed that clean up costs in the upstream Staging Area and Storage Area #1 would be accounted for as part of the project capital cost (addressed as part of landowner negotiations/settlements if applicable).

4.2 Roadway Clean Up

Inundated streets will likely need to be inspected and cleaned as part of post-flood maintenance activities. A cost for street sweeping was used as the basis of cost for this activity. The sweeping cost was assumed to include inspection and any miscellaneous manual labor that would be required.

It was assumed that clean up of roadways would be a more substantive effort for in town areas due to the presence of more paved roads, higher traffic volumes, and NPDES water quality requirements. Although some minor clean up of roadways may be necessary in the upstream staging and storage area, it was assumed this would be a minor expense, and that it would be covered by ordinary maintenance activities.

4.3 Roadway Repair

In discussions with Tom Soucy (Cass County), it was indicated that some roadway embankment repair was required after previous flooding events. This work consisted of excavating sloughed materials out of ditches adjacent to the road and recompaction of that material onto the roadway embankment slope. Increased frequency of flooding and increased staging heights could increase the degree and cost associated with roadway embankment repair.

In order to estimate potential future roadway repair costs, GIS coverage was used to determine the linear feet of roadway inundated at each stage between 30 and 37 feet. It was assumed that 2% of the total length of roadways inundated at any given stage would require repair. An assumed repair cross section was used to estimate the volume of earthwork required to repair the 2% length of roadway. The USACE unit cost of $17.51/CY for “Levee Embankment Maintenance” was used as an earthwork cost for repair of the roadway embankment. This unit cost is conservative if the fill material used for the roadway embankment comes from the adjacent ditches. The conservative rate was selected, however, to cover costs associated with road closure, seeding, erosion control, and other miscellaneous items related to roadway repair but not otherwise accounted for.

It was assumed that roadway embankment repair would only be required on rural roadway sections. The majority of the roadway embankment repair would occur in the upstream Staging Area and Storage Area #1. There are some rural roadway sections, however, in the outer regions of the in-town area. As a result, roadway embankment repair was quantified for the Staging Area, Storage Area #1, and the in-

town area. It was assumed that 20% of the roadways within the in-town areas would have a rural section.

4.4 Levee Embankment Repair

The USACE O&M evaluation included a quantity for repair of tie-back levees in the Staging Area. The topic of levee embankment repair for in-town levees was discussed with April Walker (City of Fargo). Although she indicated that repair of constructed levees has not historically been a large expense, it was agreed that increases to stage and frequency of flooding would likely result in higher embankment repair costs. In order to be consistent with the USACE O&M evaluation, and to account for likely increases to in-town repairs, a cost was calculated for repair of in-town levee embankments, and Staging Area tie-back levees. The HDR evaluation also added costs associated with anticipated repair of Storage Area #1 containment levees.

GIS coverages were used to identify the approximate length of earthen levees that had water against their base at any given stage. It was assumed that 5% of the length of in-town levees detaining water at any given stage would need to be repaired prior to the next flooding event. The costs of such repairs were adjusted based on exceedence intervals in order to develop expected annual costs and a present value cost.

Costs associated with repair of levees in the Staging Area and Storage Area #1 were also based on an assumption of that 5% of the levees detaining water would need to be repaired. The costs for levee repair in the Staging Area and Storage Area #1 also accounted for exceedence intervals for each stage. Calculations for levee repair are provided in Appendix B.

4.4 Levee Topsoil Repair

The USACE O&M evaluation included a quantity for levee topsoil maintenance for the tie-back levees in the Staging Area. To provide consistency between treatment of Staging Area and in-town levees, topsoil repair was included as a variable cost for the in-town levees. The USACE O&M evaluation used a quantity of topsoil repair for the tie-back levees that amounted to 13.2% of the quantity of levee embankment repair. The same percentage was applied to the estimated volume of levee embankment repair for in-town levees and for Storage Area #1 containment levees.

4.4 Levee Turf Maintenance/Replacement

The USACE O&M evaluation included a quantity for turf maintenance/replacement for the tie-back levees in the Staging Area. To provide consistency in the evaluation turf maintenance was included as a variable cost for the in-town levees and Storage Area #1 containment levees. HDR estimated the area of turf maintenance/replacement by dividing the topsoil repair volume by an assumed topsoil placement depth of 6”.

4.4 Ditch Cleanout and Debris Removal

It was assumed that more frequent inundation of rural roadway sections with adjacent ditches would result in more expenses associated with inspection and maintenance of ditches. It was assumed that time would be spent on inspection, minor grade repair, removal of brush, and clearing culvert inlets.

It was assumed that the length of ditch requiring maintenance would be the same as the length of roadway requiring repair. Cost was calculated using an assumed work crew performing 100 feet of ditch cleanout per day. It was assumed that ditch cleanout and debris removal would only be required on rural roadway sections. The majority of rural roadway sections are in the upstream Staging Area and Storage Area #1. There are some rural roadway sections, however, in the outer regions of the in-town area. As a result, ditch cleanout and debris removal was quantified for the Staging Area, Storage Area #1, and the in-town area. It was assumed that 20% of the roadways within the in-town areas would have a rural section and would require ditch cleanout and debris removal.

5.0 Operations and Maintenance Costs

A summary of categorized O&M costs by project area is provided in Table 5. The costs presented provide the expected annual costs associated for each in-town operational stage. These expected annual costs use the cost of O&M for a single inundation event as a basis, with probability weighting applied to account for the likelihood of a given flood event occurring.

Table 6 provides a summary of total O&M costs by stage. The annual cost indicates the cost that would be incurred as a result of a single 100-year event inundation. The expected annual cost provides a probability weighted annual cost for the total O&M costs. The present value column provides the present worth of the expected annual costs, assuming a 50 year project life and a discount rate of 4.375 percent (as used in the USACE feasibility study). Figure 4 provides a graphical representation of the results provided in Table 6.

Table 5: Summary of Operations and Maintenance Costs Associated with the Occurrence of a 100 Year Event for each Operational Stage (2012 $'s)

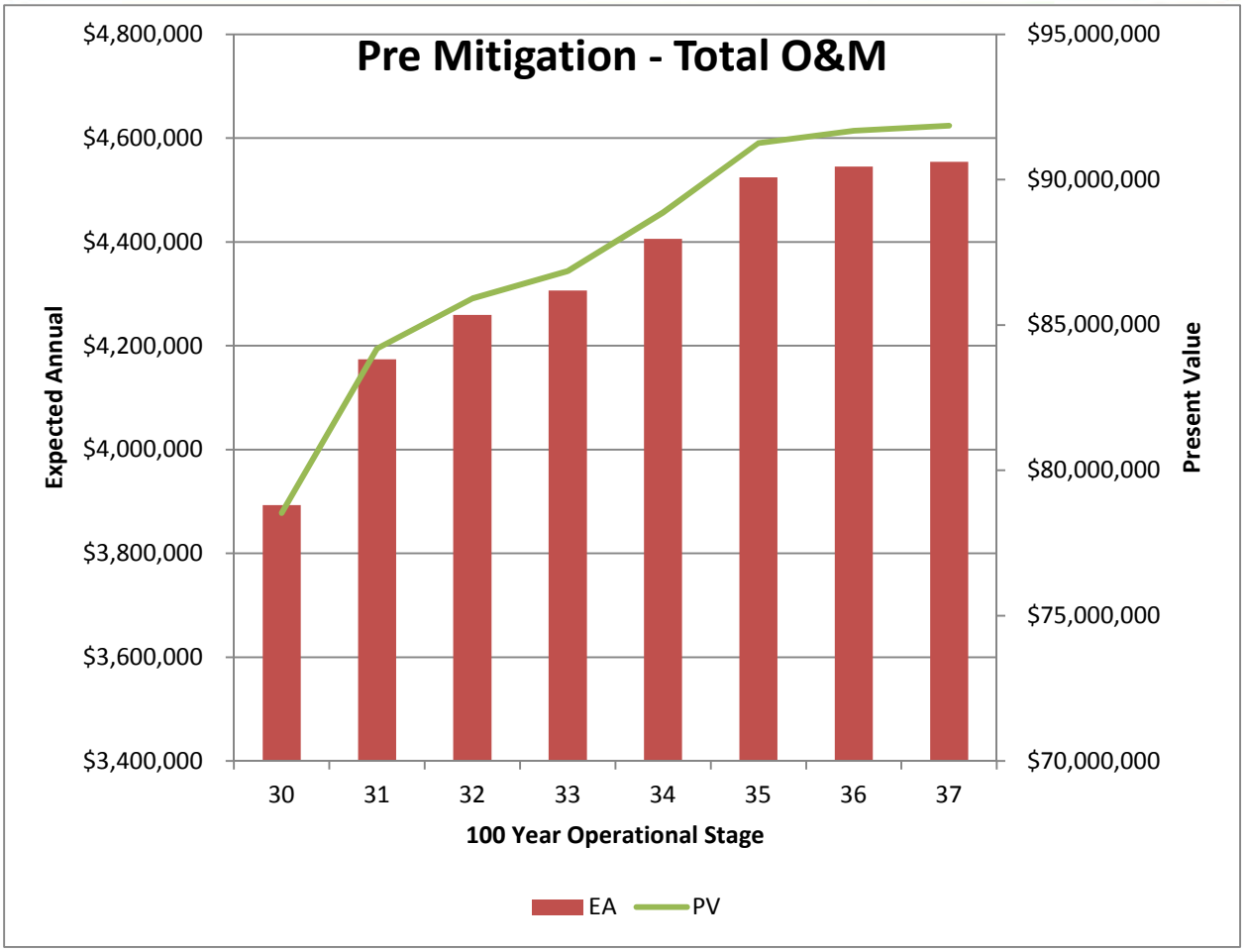
		Operations Costs				Maintenance Costs		
Stage	USACE O&M	In-town Levees (Permanent and Temporary)	Staging Area and Storage Area # 1 Levees	Emergency Levee Construction Costs	Loss of Service (Revenue)	Variable In Town Costs	Variable Staging Area and Storage Area 1 Costs	Total Annual O&M
30	3,559,000	11,000	8,000	-	73,000	70,000	473,000	4,194,000
31	3,559,000	124,000	55,000	-	367,000	84,000	471,000	4,660,000
32	3,559,000	203,000	73,000	41,000	367,000	92,000	467,000	4,802,000
33	3,559,000	405,000	85,000	66,000	367,000	133,000	395,000	5,010,000
34	3,559,000	722,000	93,000	109,000	367,000	173,000	394,000	5,417,000
35	3,559,000	1,359,000	111,000	159,000	367,000	211,000	393,000	6,159,000
36	3,559,000	1,982,000	132,000	216,000	342,000	234,000	393,000	6,858,000
37	3,559,000	2,441,000	138,000	368,000	342,000	257,000	392,000	7,497,000

Table 6: Summary of Total 100 Year Event Costs, Expected Annual, and Present Value Operations and Maintenance Costs by Operational Stage (2012 $'s)

Stage	Total Operations and Maintenance		
	Cost of 100 Year Event	Expected Annual Cost	Present Value*
30	4,194,000	3,893,000	78,525,000
31	4,660,000	4,174,000	84,191,000
32	4,802,000	4,259,000	85,906,000
33	5,010,000	4,306,000	86,854,000
34	5,417,000	4,406,000	88,871,000
35	6,159,000	4,524,000	91,252,000
36	6,858,000	4,545,000	91,677,000
37	7,497,000	4,554,000	91,857,000

* Assumed 50 year project period with discount factor of 4.375%.

Figure 4: Comparison of Expected Annual and Present value Operations and Maintenance Costs for each Operational Stage ($'s 2012)


Pre Mitigation - Total O&M
$4,800,000
$4,600,000
$4,400,000
$4,200,000
$4,000,000
$3,800,000
$3,600,000
$3,400,000
Expected Annual
$95,000,000
$90,000,000
$85,000,000
$80,000,000
$75,000,000
$70,000,000
Present Value
30
31
32
33
34
35
36
37
100 Year Operational Stage
EA
PV

6.0 O&M Cost Reductions Based on Supplemental Project Elements

In addition to providing an evaluation of O&M costs associated with alternate stages for in-town flooding, HDR's O&M evaluation considers the impacts of two flood mitigation options. These flood mitigation options include the following activities:

Option 1

- El Zagal location - construct a levee (to replace an existing earthen levee)
- Mickelson Park - minor grading and construction of a new earthen levee
- 2nd Street - realign street and build a flood wall
- Belmont location - construct an earthen levee
- Isolated Urban Property Mitigation Measures (buyouts) in Moorhead, MN
- Road raises (within in-town area)

Option 2

- El Zagal location – property buyouts (no levee)
- Mickelson Park – no improvements
- 2nd Street - build floodwall (no street realignment)
- Belmont location - property buyouts (no levee)
- Isolated Urban Property Mitigation Measures (buyouts) in Moorhead, MN
- Road raises (within in-town area)

Construction of new levees (to replace temporary flood fighting levees) will lower operations costs due to the fact that costs are lower for monitoring permanent levees than they are for monitoring temporary flood fighting levees. The additional levee length would, however, result in increases to amount of levee embankment repair and associated turf maintenance and topsoil repairs. The buy-out of properties results in additional open areas that must be maintained resulting in increases to maintenance costs. Flood mitigation projects also reduced the costs associated with street cleaning, ditch and culvert cleanout, and debris removal. No buyouts, road raises or other mitigation measures within the Staging Area or Storage Area #1 are incorporated in this O&M evaluation.

The impacts of the changes to O&M as a result of Options 1 and 2 are summarized in Table 7, Table 8, and Table 9.

Table 7: Option 1 - Summary of Reductions in Operations and Maintenance Costs by 100 Year Operational Stage with Mitigation (2012 $'s)

Stage	Variable Operations Costs		Variable Maintenance Costs	Net Reduction in 100 Year Event O&M Costs	Net Reduction in Expected Annual O&M costs	Net Reduction in Present Value O&M Costs
	Operations Costs of In Town Levees	Emergency Levee Construction	In Town Costs			
30	6,000	-	(2,000)	4,000	6,000	121,000
31	64,000	-	(2,000)	62,000	42,000	847,000
32	89,000	41,000	(1,000)	129,000	81,000	1,633,000
33	228,000	66,000	-	294,000	153,000	3,086,000
34	448,000	109,000	-	557,000	229,000	4,619,000
35	902,000	159,000	-	1,061,000	312,000	6,293,000
36	1,390,000	216,000	(1,000)	1,605,000	336,000	6,778,000
37	1,705,000	368,000	-	2,073,000	348,000	7,019,000

Table 8: Option 2 - Summary of Reductions in Operations and Maintenance Costs by 100 Year Operational Stage with Mitigation (2012 $'s)

Stage	Variable Operations Costs		Variable Maintenance Costs	Net Reduction in 100 Year Event O&M Costs	Net Reduction in Expected Annual O&M costs	Net Reduction in Present Value O&M Costs
	Operations Costs of In Town Levees	Emergency Levee Construction	In Town Costs			
30	6,000	-	(2,000)	4,000	6,000	121,000
31	66,000	-	(2,000)	64,000	42,000	847,000
32	93,000	41,000	(1,000)	133,000	81,000	1,633,000
33	232,000	66,000	(1,000)	297,000	153,000	3,086,000
34	452,000	109,000	(1,000)	560,000	229,000	4,619,000
35	906,000	159,000	(1,000)	1,064,000	312,000	6,293,000
36	1,397,000	216,000	(1,000)	1,612,000	336,000	6,778,000
37	1,718,000	368,000	(2,000)	2,084,000	348,000	7,019,000

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Table 9: Comparison of Pre- and Post-Mitigation Annual Operations and Maintenance Costs, (2012 $'s Millions)

Stage	Before Mitigation			With Mitigation Option 1				With Mitigation Option 2			
	Cost of 100 Year Event	EA	PV	Cost of 100 Year Event	EA	PV	% Reduction	Cost of 100 Year Event	EA	PV	% Reduction
30	4.19	3.89	78.53	4.19	3.89	78.40	-0.2%	4.19	3.89	78.40	-0.2%
31	4.66	4.17	84.19	4.60	4.13	83.34	-1.0%	4.60	4.13	83.34	-1.0%
32	4.80	4.26	85.91	4.67	4.18	84.27	-1.9%	4.67	4.18	84.27	-1.9%
33	5.01	4.31	86.85	4.72	4.15	83.77	-3.6%	4.71	4.15	83.77	-3.6%
34	5.42	4.41	88.87	4.86	4.18	84.25	-5.2%	4.86	4.18	84.25	-5.2%
35	6.16	4.52	91.25	5.10	4.21	84.96	-6.9%	5.10	4.21	84.96	-6.9%
36	6.86	4.55	91.68	5.25	4.21	84.90	-7.4%	5.25	4.21	84.90	-7.4%
37	7.50	4.55	91.86	5.42	4.21	84.84	-7.6%	5.41	4.21	84.84	-7.6%

7.0 Additional Considerations

The City of Fargo indicated that they used 176 temporary pumps during the 2009 flood fight. These pumps, in addition to the City of Fargo's existing 72 stormwater lift stations, were used to convey internal stormwater runoff and seepage water back to the Red River. Similar types of permanent and temporary measures were required in the City of Moorhead. The labor costs associated with Fargo and Moorhead City staff mobilizing and monitoring pumping operations are incorporated as part of the operations costs calculated for this study as these costs were included in the City of Fargo cost data for historical floods. Costs to the private sector (such as time spent by residents monitoring pumps) were not included in this study's operations costs.

The higher design river stages through the protected area, will result in increased dependency on existing infrastructure such as stormwater pump stations and stormwater piping. Alternatives which result in higher in-town stages would result in a greater number of pumps being required. Additional consideration should be given to evaluating the reliability and redundancy of the existing system for various river stages. The presence of redundant pumping capacity (extra pumps), the presence of backup power for pump stations, and the ability to provide generator power to pump stations should be evaluated as part of this additional study.

Although design storm hydrographs indicate that higher in-town river stages will not result in longer in-town flooding durations, changes to in-town river stages could result in changes costs to privately owned facilities or businesses due to inundation of different areas or use of alternative mitigation options. Although these private costs were outside of the scope of this study, they could be significant and could warrant further consideration.

Appendix A *USACE Feasibility Report, O&M Tabulation*

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OPERATION, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION

Life Cycle 50 Years | Date Prepared: 10-Apr-2011
Rate of Return 4.375%

FARGO MOORHEAD METRO FEASIBILITY FLOOD CONTROL STUDY
CHANNEL DIVERSION - LLP ND Phase 4

FARGO MOORHEAD METRO DRAFT FEASIBILITY STUDY

CODE	ITEM DESCRIPTION	ESTIMATED O&M CYCLE	QUANTITY FACTOR	PROJECT QUANTITY	O&M and MAJOR REPLACEMENT COSTS: O&M QUANTITY	UNIT	UNIT PRICE	AMOUNT	EQUIVALENT AVERAGE ANNUAL O&M / MAJOR REPLACEMENT VALUE: PRESENT VALUE	ANNUAL COST	COMMENTS
									$73,241,069	$3,631,084	Percentage of Construction 0.31%
00	**PERIODIC INSPECTIONS**										
	Periodic Inspections										
	1st 5 years	1 Year	1.00	1	1	JOB	$50,000	$50,000	220,266	10,920	
	Year 7, 9 and 11	2 Years	1.00	1	1	JOB	$40,000	$40,000	81,823	4,057	Cost of periodics decreases after the 1st 5 years.
	Every 5 years beginning year 15	5 Years	1.00	1	1	JOB	$30,000	$30,000	67,119	3,328	
	Routine Annual Inspections	1 Year	1.00	1	1	JOB	$10,000	$10,000	201,706	10,000	
	Total Inspections								570,913	28,304	
02	**RELOCATIONS**										
	ROADS										
	County Hwy 81 (South)	10 Years	0.10	1.0	0.10	LS	$3,670,000.00	$367,000	605,927	30,040	
	Interstate 29 (NB-South)	10 Years	0.10	1.0	0.10	LS	$3,660,000.00	$366,000	604,276	29,958	
	Interstate 29 (SB-South)	10 Years	0.10	1.0	0.10	LS	$3,650,000.00	$365,000	602,625	29,876	
	48th Street SE	10 Years	0.10	1.0	0.10	LS	$2,500,000.00	$250,000	412,757	20,463	
	170th Avenue SE	10 Years	0.10	1.0	0.10	LS	$2,750,000.00	$275,000	454,033	22,510	
	46th Street SE	10 Years	0.10	1.0	0.10	LS	$3,280,000.00	$328,000	541,537	26,848	
	44th Street SE	10 Years	0.10	1.0	0.10	LS	$3,010,000.00	$301,000	496,959	24,638	
	41st Street SE	10 Years	0.10	1.0	0.10	LS	$3,530,000.00	$353,000	582,813	28,894	
	Interstate 94 (EB)	10 Years	0.10	1.0	0.10	LS	$3,690,000.00	$369,000	609,229	30,204	
	Interstate 94 (WB)	10 Years	0.10	1.0	0.10	LS	$3,690,000.00	$369,000	609,229	30,204	
	36th Street SE	10 Years	0.10	1.0	0.10	LS	$3,310,000.00	$331,000	546,490	27,093	
	33rd Street SE	10 Years	0.10	1.0	0.10	LS	$3,560,000.00	$356,000	587,766	29,140	
	31st Street SE	10 Years	0.10	1.0	0.10	LS	$2,890,000.00	$289,000	477,147	23,656	
	28th Street SE	10 Years	0.10	1.0	0.10	LS	$2,840,000.00	$284,000	468,892	23,246	
	Interstate 29 (SB-North)	10 Years	0.10	1.0	0.10	LS	$3,720,000.00	$372,000	614,182	30,449	
	Interstate 29 (NB-North)	10 Years	0.10	1.0	0.10	LS	$3,730,000.00	$373,000	615,833	30,531	
	County Hwy 81 (North)	10 Years	0.10	1.0	0.10	LS	$3,360,000.00	$336,000	554,745	27,503	
	25th Street SE	10 Years	0.10	1.0	0.10	LS	$2,900,000.00	$290,000	478,798	23,737	
	173rd Avenue SE	10 Years	0.10	1.0	0.10	LS	$2,880,000.00	$288,000	475,496	23,574	
06	**FISH AND WILDLIFE FACILITIES**										
	Aquatic Footprint Maintenance	10 Years	0.01	1.0	0.01	MI	$2,518,200.00	$25,182	41,576	2,061	
	Fish PassageOperation	10 Years	0.01	1.0	0.01	LS	$25,350,000.00	$253,500	418,536	20,750	
	Wetlands Footprint Maintenance	10 Years	0.01	998.0	9.98	ACRE	$13,750.00	$137,225	226,562	11,232	
	Riparian Forest Footprint Maintenance	10 Years	0.01	199.0	1.99	ACRE	$11,550.00	$22,985	37,948	1,881	
	Adaptive Management	10 Years	1.00	1.0	1.00	LS	$6,440,000.00	$6,440,000	10,632,620	527,135	
08	**RAILROAD BRIDGES**										
	RR Bridge 1 BSNF Hillsboro Subdivision	10 Years	0.10	1.0	0.10	LS	$3,463,100.00	$346,310	571,767	28,347	
	RR Bridge 2 BNSF Prosper Subdivision	10 Years	0.10	1.0	0.10	LS	$3,728,200.00	$372,820	615,536	30,517	
	RR Bridge 3 BNSF KO Subdivision	10 Years	0.10	1.0	0.10	LS	$6,607,700.00	$660,770	1,090,950	54,086	
	RR Bridge 4 RRVW 4th Subdivision	10 Years	0.10	1.0	0.10	LS	$3,987,300.00	$398,730	658,314	32,637	
09	**CHANNELS & CANALS**										
	CHANNELS										
	DIVERSION CHANNEL EXCAVATION & SPOIL BERMS										
	REACH 1										
	Channel Slope Maintenance - Type 1	10 Years	0.05	34,231.0	1,712.0	CY	$3.40	$5,821	9,610	476	
	Excavate Sediment from Channel - Type 2	10 Years	0.10	68,334.0	6,833.0	CY	$3.83	$26,170	43,208	2,142	
	Repair Riprap Channel Bank Protection	10 Years	0.05	815.0	41.0	CY	$119.90	$4,916	8,116	402	
	Repair Low Flow Channel Riprap Protection	5 Years	0.05	38.0	2.0	CY	$104.42	$209	772	38	
	Channel Topsoil Maintenance	10 Years	0.10	2,702.0	270.0	CY	$1.86	$502	829	41	
	Spoil Berm Topsoil Maintenance	25 Years	0.05	18,620.0	931.0	CY	$1.78	$1,657	763	38	
	Turf Maintenance / Replacement	10 Years	0.05	13.0	1.0	ACRE	$4,156.00	$4,156	6,862	340	
	Mowing	1 Year	2.00	13.0	26.00	ACRE	$20.00	$520	10,489	520	2 mowings per year @ $20 / acre
	REACH 2										
	Channel Slope Maintenance - Type 1	10 Years	0.05	161,848.0	8,092.0	CY	$3.40	$27,513	45,424	2,252	
	Channel Slope Maintenance - Type 2	10 Years	0.05	192,083.0	9,604.0	CY	$3.83	$36,783	60,730	3,011	
	Excavate Sediment from Channel - Type 3	10 Years	0.10	204,197.0	20,420.0	CY	$5.03	$102,713	169,581	8,407	
	Repair Riprap Channel Bank Protection	10 Years	0.05	3,096.0	155.0	CY	$119.91	$18,586	30,686	1,521	
	Repair Low Flow Channel Riprap Protection	5 Years	0.05	145.0	7.0	CY	$104.47	$731	2,703	134	
	Channel Topsoil Maintenance	10 Years	0.10	12,824.0	1,282.0	CY	$1.86	$2,385	3,937	195	
	Spoil Berm Topsoil Maintenance	25 Years	0.05	80,881.0	4,044.0	CY	$1.78	$7,198	3,314	164	
	Turf Maintenance / Replacement	10 Years	0.05	58.0	3.0	ACRE	$4,156.00	$12,468	20,585	1,021	
	Mowing	1 Year	2.00	58.0	116.00	ACRE	$20.00	$2,320	46,796	2,320	2 mowings per year @ $20 / acre
	REACH 3										
	Channel Slope Maintenance - Type 1	10 Years	0.05	1,042,050.0	52,103.0	CY	$3.40	$177,150	292,480	14,500	
	Channel Slope Maintenance - Type 2	10 Years	0.05	1,638,021.0	81,901.0	CY	$3.83	$313,681	517,896	25,676	
	Channel Slope Maintenance - Type 3	10 Years	0.05	1,473,360.0	73,668.0	CY	$5.03	$370,550	611,788	30,331	
	Excavate Sediment from Channel - Type 4	10 Years	0.10	27,490.0	2,749.0	CY	$6.47	$17,786	29,365	1,456	
	Repair Riprap Channel Bank Protection	10 Years	0.05	21,511.0	1,076.0	CY	$119.91	$129,023	213,021	10,561	
	Repair Low Flow Channel Riprap Protection	5 Years	0.05	1,009.0	50.0	CY	$104.46	$5,223	19,305	957	
	Channel Topsoil Maintenance	10 Years	0.10	89,967.0	8,997.0	CY	$1.86	$16,734	27,629	1,370	
	Spoil Berm Topsoil Maintenance	25 Years	0.05	664,769.0	33,238.0	CY	$1.78	$59,164	27,237	1,350	
	Turf Maintenance / Replacement	10 Years	0.05	467.0	23.0	ACRE	$4,156.00	$95,588	157,818	7,824	
	Mowing	1 Year	2.00	467.0	934.00	ACRE	$20.00	$18,680	376,786	18,680	2 mowings per year @ $20 / acre
	REACH 4										
	Channel Slope Maintenance - Type 1	10 Years	0.05	3,111,316.0	155,566.0	CY	$3.40	$528,924	873,269	43,294	
	Channel Slope Maintenance - Type 2	10 Years	0.05	3,898,771.0	194,939.0	CY	$3.83	$746,616	1,232,685	61,113	
	Channel Slope Maintenance - Type 3	10 Years	0.05	5,622,796.0	281,140.0	CY	$5.03	$1,414,134	2,334,775	115,752	
	Excavate Sediment from Channel - Type 4	10 Years	0.10	278,668.0	27,867.0	CY	$6.47	$180,299	297,680	14,758	
	Repair Riprap Channel Bank Protection	10 Years	0.05	83,111.0	4,156.0	CY	$119.91	$498,346	822,783	40,791	
	Repair Low Flow Channel Riprap Protection	5 Years	0.05	3,899.0	195.0	CY	$104.46	$20,370	75,291	3,733	
	Channel Topsoil Maintenance	10 Years	0.10	311,941.0	31,194.0	CY	$1.86	$58,021	95,794	4,749	
	Spoil Berm Topsoil Maintenance	25 Years	0.05	2,680,432.0	134,022.0	CY	$1.78	$238,559	109,827	5,445	
	Turf Maintenance / Replacement	10 Years	0.05	1,855.0	93.0	ACRE	$4,156.00	$386,508	638,136	31,637	
	Mowing	1 Year	2.00	1,855.0	3,710.00	ACRE	$20.00	$74,200	1,496,657	74,200	2 mowings per year @ $20 / acre
09	**REACH 5**										
	Channel Slope Maintenance - Type 1	10 Years	0.05	881,257.0	44,063.0	CY	$3.40	$149,814	247,347	12,263	
	Channel Slope Maintenance - Type 2	10 Years	0.05	1,406,889.0	70,344.0	CY	$3.83	$269,418	444,816	22,053	
	Excavate Sediment from Channel - Type 3	10 Years	0.10	575,447.0	57,545.0	CY	$5.03	$289,451	477,892	23,693	
	Repair Riprap Channel Bank Protection	10 Years	0.05	22,978.0	1,149.0	CY	$119.91	$137,777	227,473	11,277	
	Repair Low Flow Channel Riprap Protection	5 Years	0.05	1,078.0	54.0	CY	$104.46	$5,641	20,850	1,034	
	Channel Topsoil Maintenance	10 Years	0.10	75,899.0	7,590.0	CY	$1.86	$14,117	23,308	1,156	
	Spoil Berm Topsoil Maintenance	25 Years	0.05	759,026.0	37,951.0	CY	$1.78	$67,553	31,100	1,542	
	Turf Maintenance / Replacement	10 Years	0.05	517.0	26.0	ACRE	$4,156.00	$108,056	178,403	8,845	
	Mowing	1 Year	2.00	517.0	1,034.00	ACRE	$20.00	$20,680	417,128	20,680	2 mowings per year @ $20 / acre
	REACH 6										
	Channel Slope Maintenance - Type 1	10 Years	0.05	5,204,698.0	260,235.0	CY	$3.40	$884,799	1,460,828	72,424	
	Channel Slope Maintenance - Type 2	10 Years	0.05	5,405,183.0	270,259.0	CY	$3.83	$1,035,092	1,708,966	84,726	
	Channel Slope Maintenance - Type 3	10 Years	0.05	9,514,452.0	475,723.0	CY	$5.03	$2,392,887	3,950,723	195,866	
	Excavate Sediment from Channel - Type 4	10 Years	0.10	3,521,106.0	352,111.0	CY	$6.47	$2,278,158	3,761,303	186,475	
	Repair Riprap Channel Bank Protection	10 Years	0.05	110,081.0	5,504.0	CY	$119.91	$659,985	1,089,653	54,022	
	Repair Low Flow Channel Riprap Protection	5 Years	0.05	5,164.0	258.0	CY	$104.46	$26,951	99,616	4,939	
	Channel Topsoil Maintenance	10 Years	0.10	486,703.0	48,670.0	CY	$1.86	$90,526	149,461	7,410	
	Spoil Berm Topsoil Maintenance	25 Years	0.05	3,461,308.0	173,065.0	CY	$1.78	$308,056	141,821	7,031	
	Turf Maintenance / Replacement	10 Years	0.05	2,468.0	123.0	ACRE	$4,156.00	$511,188	843,986	41,842	
	Mowing	1 Year	2.00	2,468.0	4,936.00	ACRE	$20.00	$98,720	1,991,239	98,720	2 mowings per year @ $20 / acre
	REACH 7										
	Channel Slope Maintenance - Type 1	10 Years	0.05	538,568.0	26,928.0	CY	$3.40	$91,555	151,160	7,494	
	Channel Slope Maintenance - Type 2	10 Years	0.05	256,705.0	12,835.0	CY	$3.83	$49,158	81,161	4,024	
	Excavate Sediment from Channel - Type 3	10 Years	0.10	290,406.0	29,041.0	CY	$5.03	$146,076	241,176	11,957	
	Repair Riprap Channel Bank Protection	10 Years	0.05	23,874.0	1,194.0	CY	$119.91	$143,173	236,382	11,719	
	Repair Low Flow Channel Riprap Protection	5 Years	0.05	1,120.0	56.0	CY	$104.46	$5,850	21,622	1,072	
	Channel Topsoil Maintenance	10 Years	0.10	52,244.0	5,224.0	CY	$1.86	$9,717	16,042	795	
	Spoil Berm Topsoil Maintenance	25 Years	0.05	58,838.0	2,942.0	CY	$1.78	$5,237	2,411	120	
	Turf Maintenance / Replacement	10 Years	0.05	128.0	6.0	ACRE	$4,156.00	$24,936	41,170	2,041	
	Mowing	1 Year	2.00	128.0	256.00	ACRE	$20.00	$5,120	103,273	5,120	2 mowings per year @ $20 / acre
	REACH 8										
	Slope Maintenance - Type 1	10 Years	0.05	100,000.0	5,000.0	CY	$3.40	$17,000	28,067	1,392	
	Slope Maintenance - Type 2	10 Years	0.05	30,884.0	1,544.0	CY	$3.83	$5,914	9,763	484	
	Excavate Sediment from Channel - Type 3	10 Years	0.10	135,516.0	13,552.0	CY	$5.03	$68,167	112,545	5,580	
	Repair Riprap Channel Bank Protection	10 Years	0.05	13,363.0	668.0	CY	$119.91	$80,100	132,247	6,556	
	Repair Low Flow Channel Riprap Protection	5 Years	0.05	627.0	31.0	CY	$104.46	$3,238	11,969	593	
	Channel Topsoil Maintenance	10 Years	0.10	33,493.0	3,349.0	CY	$1.86	$6,229	10,284	510	
	Spoil Berm Topsoil Maintenance	25 Years	0.05	220,624.0	11,031.0	CY	$1.78	$19,635	9,040	448	
	Turf Maintenance / Replacement	10 Years	0.05	157.0	8.0	ACRE	$4,156.00	$33,248	54,893	2,721	
	Mowing	1 Year	2.00	157.0	314.00	ACRE	$20.00	$6,280	126,671	6,280	2 mowings per year @ $20 / acre
09	**RED RIVER INLET CONTROL STRUCTURE**										
	RRN GATED CONTROL STRUCTURE										

OPERATION, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION

Life Cycle 50 Years | Date Prepared: 10-Apr-2011
Rate of Return 4.375%

FARGO MOORHEAD METRO FEASIBILITY FLOOD CONTROL STUDY
CHANNEL DIVERSION - LLP ND Phase 4

FARGO MOORHEAD METRO DRAFT FEASIBILITY STUDY

CODE	ITEM DESCRIPTION	ESTIMATED O&M CYCLE	QUANTITY FACTOR	PROJECT QUANTITY	O&M QUANTITY	UNIT	UNIT PRICE	AMOUNT	EQUIVALENT AVERAGE ANNUAL O&M / MAJOR REPLACEMENT VALUE: PRESENT VALUE	EQUIVALENT AVERAGE ANNUAL O&M / MAJOR REPLACEMENT VALUE: ANNUAL COST	COMMENTS
		O&M and MAJOR REPLACEMENT COSTS							$73,241,069	$3,631,084	Percentage of Construction 0.31%
	Gated Structure										
	Concrete - Major Rehab	50 Years	0.50	1.0	0.50	LS	$3,619,300.00	$1,809,650	212,701	10,545	
	Gates and Bulkheads - Major Rehab	50 Years	0.50	1.0	0.50	LS	$5,931,200.00	$2,965,600	348,569	17,281	
	Gates and Bulkheads - Annual O & M	1 Year	1.00	1.0	1.0	LS	$30,000	$30,000	605,117	30,000	
	Wingwalls - Concrete - Major Rehab	50 Years	0.50	1.0	0.50	LS	$5,633,000.00	$2,816,500	331,044	16,412	
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$3,398,700.00	$169,935	280,567	13,910	
	Fish Passage System Miantenance	10 Years	0.05	1.0	0.05	LS	$5,950,300.00	$297,515	491,206	24,353	
	Mech, Elect, SCADA, Ice Control & Misc. Items	1 Year	0.02	1.0	0.02	LS	$1,024,600.00	$20,492	413,335	20,492	Annual O&M costs = 2.0% of construction
	WOLVERTON CREEK CLOSURE/DRAINAGE STRUCTURE										
	WOLVERTON CREEK STRUCTURE										
	Gated Structure										
	Concrete - Major Rehab	50 Years	0.50	1.0	0.50	LS	$1,627,400.00	$813,700	95,640	4,742	
	Gates and Bulkheads - Major Rehab	50 Years	0.50	1.0	0.50	LS	$637,300.00	$318,650	37,453	1,857	
	Gates and Bulkheads - Annual O & M	1 Year	1.00	1.0	1.0	LS	$30,000	$30,000	605,117	30,000	
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$57,200.00	$2,860	4,722	234	
	Mech, Elect, SCADA, Ice Control & Misc. Items	1 Year	0.02	1.0	0.02	LS	$256,200.00	$5,124	103,354	5,124	Annual O&M costs = 2.0% of construction
	WILD RICE RIVER CONTROL STRUCTURES										
	WWR GATED CONSTROL STRUCTURE										
	Gated Structure										
	Concrete - Major Rehab	50 Years	0.50	1.0	0.50	LS	$1,505,600.00	$752,800	88,482	4,387	
	Gates and Bulkheads - Major Rehab	50 Years	0.50	1.0	0.50	LS	$1,753,900.00	$876,950	103,074	5,110	
	Gates and Bulkheads - Annual O & M	1 Year	1.00	1.0	1.0	LS	$30,000	$30,000	605,117	30,000	
	Wingwalls - Concrete - Major Rehab	50 Years	0.50	1.0	0.50	LS	$2,545,400.00	$1,272,700	149,590	7,416	
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$1,632,000.00	$81,600	134,724	6,679	
	Fish Passage System Miantenance	10 Years	0.05	1.0	0.05	LS	$4,550,300.00	$227,515	375,634	18,623	
	Mech, Elect, SCADA, Ice Control & Misc. Items	1 Year	0.02	1.0	0.02	LS	$3,962,000.00	$79,240	1,598,317	79,240	Annual O&M costs = 2.0% of construction
	EAST WEIR (at Connecting Channel)										
	EAST WEIR STRUCTURE										
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$47,600.00	$2,380	3,929	195	
	SCADA	1 Year	0.02	1.0	0.02	LS	$75,100.00	$1,502	30,296	1,502	Annual O&M costs = 2.0% of construction
	INLET WEIR TO DIVERSION STRUCTURE										
	INLET WEIR STRUCTURE										
	Concrete Rollway Structure	50 Years	0.50	1.0	0.50	LS	$956,800.00	$478,400	56,230	2,788	
	Structure Walls	50 Years	0.50	1.0	0.50	LS	$2,118,100.00	$1,059,050	124,478	6,171	
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$171,300.00	$8,565	14,141	701	
	Mech, Electrical, SCADA & Misc. Features	1 Year	0.02	1.0	0.02	LS	$2,322,700.00	$46,454	937,004	46,454	Annual O&M costs = 2.0% of construction
09	**SHEYENNE RIVER AQUEDUCT STRUCTURES**										
	SHEYENNE RIVER AQUEDUCT STRUCTURE										
	Gated Aqueduct Structure & Wingwalls										
	Concrete - Major Rehab	50 Years	0.50	1.0	0.50	LS	$13,193,300.00	$6,596,650	775,352	38,440	
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$1,569,900.00	$78,495	129,597	6,425	
	Mech, Elect, SCADA, Ice Control & Misc. Items	1 Year	0.02	1.0	0.02	LS	$2,722,000.00	$54,440	1,098,086	54,440	Annual O&M costs = 2.0% of construction
	SHEYENNE RIVER SPILLWAY WEIR TO DIVERSION CHANNEL										
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$2,727,500.00	$136,375	225,159	11,163	
	Concrete Wall & Steel Reinforcement Rehab	50 Years	0.50	1.0	0.50	LS	$394,700.00	$197,350	23,196	1,150	
	MAPLE RIVER CONTROL STRUCTURE										
	MAPLE RIVER GATED CONTROL STRUCTURE										
	Gated Aqueduct Structure & Wingwalls										
	Concrete - Major Rehab	50 Years	0.50	1.0	0.50	LS	$13,036,200.00	$6,518,100	766,120	37,982	
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$1,411,300.00	$70,565	116,505	5,776	
	Mech, Elect, SCADA, Ice Control & Misc. Items	1 Year	0.02	1.0	0.02	LS	$2,621,300.00	$52,426	1,057,463	52,426	Annual O&M costs = 2.0% of construction
	MAPLE RIVER SPILLWAY WEIR TO DIVERSION CHANNEL										
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$2,362,800.00	$118,140	195,052	9,670	
	Concrete Wall & Steel Reinforcement Rehab	50 Years	0.50	1.0	0.50	LS	$153,200.00	$76,600	9,003	446	
	DRAIN 14 - LARGE DRAIN STRUCTURE										
	DRAIN 14 STRUCTURE										
	Drop Structure & Walls - Concrete Major Rehab	50 Years	0.50	1.0	0.50	LS	$2,915,900.00	$1,457,950	171,363	8,496	
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$164,100.00	$8,205	13,547	672	
	SCADA, & Misc. Safety Items	1 Year	0.02	1.0	0.02	LS	$35,200.00	$704	14,200	704	Annual O&M costs = 2.0% of construction
	LOWER RUSH RIVER DROP STRUCTURE										
	Drop Structure & Walls - Concrete Major Rehab	50 Years	0.50	1.0	0.50	LS	$3,005,900.00	$1,502,950	176,653	8,758	
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$428,200.00	$21,410	35,349	1,752	
	Fish Passage System Miantenance	10 Years	0.05	1.0	0.05	LS	$1,826,800.00	$91,340	150,805	7,476	
	Mech, Elect, SCADA, & Misc. Items	1 Year	0.02	1.0	0.02	LS	$477,200.00	$9,544	192,508	9,544	Annual O&M costs = 2.0% of construction
	RUSH RIVER DROP STRUCTURE										
	Drop Structure & Walls - Concrete Major Rehab	50 Years	0.50	1.0	0.50	LS	$3,436,300.00	$1,718,150	201,947	10,012	
	Repair Riprap Erosion Protection	10 Years	0.05	1.0	0.05	LS	$475,300.00	$23,765	39,237	1,945	
	Fish Passage System Miantenance	10 Years	0.05	1.0	0.05	LS	$1,247,200.00	$62,360	102,958	5,104	
	Mech, Elect, SCADA, & Misc. Items	1 Year	0.00	1.0	0.00	LS	$447,100.00	$0	0	0	
	LARGE DRAIN	10 Years	0.05	1.0	0.05	EA	$447,400.00	$22,370	36,933	1,831	
	SMALL DRAINS	10 Years	0.05	2.0	0.10	EA	$127,200.00	$12,720	21,001	1,041	
	SIDE CHANNEL INLET MANHOLES - 72-INCH	10 Years	0.05	19.0	0.95	EA	$444,900.00	$422,655	697,815	34,596	
	SIDE CHANNEL INLET MH - TWIN 72-INCH	10 Years	0.05	7.0	0.35	EA	$808,900.00	$283,115	467,431	23,174	
	RED RIVER OUTLET CONTROL STRUCTURE										
	Riprap Erosion Protection	10 Years	0.05	1.0	0.05	CY	$1,260,300.00	$63,015	104,040	5,158	
	DIVERSION LANDSCAPE PLANTINGS	10 Years	0.01	36.6	0.37	MI	$30,000.00	$10,980	18,128	899	
11	**LEVEES & FLOODWALLS**										
	LEVEES										
	TIE-BACK LEVEES										
	Levee Embankment Maintenance	10 Years	0.05	835,320.0	41,766.00	CY	$17.51	$731,323	1,207,434	59,861	
	Levee Topsoil Maintenance	10 Years	0.05	110,024.0	5501.20	CY	$1.81	$9,957	16,440	815	
	Levee Turf Maintenance / Replacement	10 Years	0.05	1.0	0.05	ACRE	$2,750,700.00	$137,535	227,074	11,258	
	Mowing	1 Year	4.00	1.0	4.00	ACRE	$20.00	$80	1,614	80	4 mowings per year @ $20 / acre
	Fertilizing & Weed Control	1 Year	1.00	1.0	1.00	ACRE	$250.00	$250	5,043	250	
14	**RECREATIONAL FACILITIES**										
	Multi-Purpose Trails	10 Years	0.05	19.0	0.95	MI	310,600.00	$295,070	487,169	24,152	
	Soft Trails	10 Years	0.05	25.0	1.25	MI	106,400.00	$133,000	219,587	10,886	
	Trail River Crossing	10 Years	0.05	3.0	0.15	EA	2,850,000.00	$427,500	705,814	34,992	
	Trailhead Facilities	5 Years	0.05	3.0	0.15	EA	166,600.00	$24,990	92,369	4,579	
	Restroom Facilities Maintenance	1 Years	1.00	3.0	1.00	LS	42,500.00	$42,500	857,250	42,500	Maint person = 1 FT @ 60K/yr + 1 PT @ 25K/yr for 6 mo
	Restroom Facilities Operating Utilitites	1 Years	1.00	3.0	3.00	EA	1,200.00	$3,600	72,614	3,600	Utilities each site @ $200 per month for 6 months
	Parking Facilities										
	Car Parking Lots	10 Years	0.10	4.0	0.40	EA	45,900.00	$18,360	30,313	1,503	
	Car/Trailer Park Lots	10 Years	0.10	2.0	0.20	EA	146,800.00	$29,360	48,474	2,403	
	Wildlife Viewing Overlooks	10 Years	0.10	2.0	0.20	EA	7,900.00	$1,580	2,609	129	
	Interpretive Siganage	10 Years	0.10	30.0	3.00	LS	1,100.00	$3,300	5,448	270	
	Fishing Sites	10 Years	0.10	4.0	0.40	EA	32,000.00	$12,800	21,133	1,048	
	Landscaping Maintenance	10 Years	0.01	150.0	1.50	ACRE	31,300.00	$46,950	77,516	3,843	
	Total O&M								**$73,241,069**	**$3,559,151**	

Appendix B *HDR O&M Cost Spreadsheet Tabulations*

925 10th Ave E • West Fargo • ND • 58078 | (701) 282-4692

OPERATION and MAINTENANCE SUMMARY

Life Cycle 50 Years

Rate of Return 4.375%

	Pre Mitigation		Design Conditions Stages 30	31	32	33	34	35	36	37
	Total Annual O&M = A+B+C+D+E+F+G+H+I	**100 yr Event Cost**	**$ 4,194,000**	**$ 4,660,000**	**$ 4,802,000**	**$ 5,010,000**	**$ 5,417,000**	**$ 6,159,000**	**$ 6,858,000**	**$ 7,497,000**
		EA	**$ 3,893,000**	**$ 4,174,000**	**$ 4,259,000**	**$ 4,306,000**	**$ 4,406,000**	**$ 4,524,000**	**$ 4,545,000**	**$ 4,554,000**
		PV	**$ 78,525,000**	**$ 84,191,000**	**$ 85,906,000**	**$ 86,854,000**	**$ 88,871,000**	**$ 91,252,000**	**$ 91,677,000**	**$ 91,857,000**
A	Non-variable O&M Components from USACE TPCS Worksheets	**100 yr Event Cost**	$ 3,559,000	$ 3,559,000	$ 3,559,000	$ 3,559,000	$ 3,559,000	$ 3,559,000	$ 3,559,000	$ 3,559,000
		PV	$ 71,787,000	$ 71,787,000	$ 71,787,000	$ 71,787,000	$ 71,787,000	$ 71,787,000	$ 71,787,000	$ 71,787,000
B	Operations Costs of Intown Levees (Permanent and Temporary)	**100 yr Event Cost**	$ 11,000	$ 124,000	$ 203,000	$ 405,000	$ 722,000	$ 1,359,000	$ 1,982,000	$ 2,441,000
		EA	**$ 9,000**	**$ 77,000**	**$ 125,000**	**$ 213,000**	**$ 306,000**	**$ 407,000**	**$ 432,000**	**$ 428,000**
		PV	$ 182,000	$ 1,553,000	$ 2,521,000	$ 4,296,000	$ 6,172,000	$ 8,209,000	$ 8,714,000	$ 8,633,000
C	Operations Costs of Staging Area and Storage Area 1 Levees	**100 yr Event Cost**	$ 8,000	$ 55,000	$ 73,000	$ 85,000	$ 93,000	$ 111,000	$ 132,000	$ 138,000
		EA	**$ 6,000**	**$ 35,000**	**$ 46,000**	**$ 51,000**	**$ 53,000**	**$ 56,000**	**$ 56,000**	**$ 56,000**
		PV	$ 121,000	$ 706,000	$ 928,000	$ 1,029,000	$ 1,069,000	$ 1,130,000	$ 1,130,000	$ 1,130,000
E	Emergency Levee Construction Costs	**100 yr Event Cost**	$ -	$ -	$ 41,000	$ 66,000	$ 109,000	$ 159,000	$ 216,000	$ 368,000
		EA	**$ -**	**$ -**	**$ 25,000**	**$ 36,000**	**$ 48,000**	**$ 57,000**	**$ 56,000**	**$ 67,000**
		PV	$ -	$ -	$ 504,000	$ 726,000	$ 968,000	$ 1,150,000	$ 1,130,000	$ 1,351,000
F	Total Variable In Town Costs	**100 yr Event Cost**	$ 70,000	$ 84,000	$ 92,000	$ 133,000	$ 173,000	$ 211,000	$ 234,000	$ 257,000
		EA	$ 57,000	$ 65,000	$ 70,000	$ 88,000	$ 100,000	$ 106,000	$ 103,000	$ 106,000
		PV	$ 1,150,000	$ 1,311,000	$ 1,412,000	$ 1,775,000	$ 2,017,000	$ 2,138,000	$ 2,078,000	$ 2,138,000
i	Clean up of Open Space	**100 yr Event Cost**	$ 20,000	$ 21,000	$ 21,000	$ 44,000	$ 57,000	$ 60,000	$ 74,000	$ 76,000
		EA	**$ 16,000**	**$ 17,000**	**$ 17,000**	**$ 27,000**	**$ 31,000**	**$ 31,000**	**$ 32,000**	**$ 32,000**
ii	Roadway Cleaning Costs	**100 yr Event Cost**	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000
		EA	**$ 2,000**	**$ 2,000**	**$ 2,000**	**$ 2,000**	**$ 2,000**	**$ 2,000**	**$ 2,000**	**$ 2,000**
iii	In-Town Levees Embankment Repair	**100 yr Event Cost**	$ 16,000	$ 26,000	$ 33,000	$ 46,000	$ 66,000	$ 94,000	$ 100,000	$ 114,000
		EA	**$ 13,000**	**$ 19,000**	**$ 23,000**	**$ 29,000**	**$ 35,000**	**$ 40,000**	**$ 37,000**	**$ 38,000**
iv	In-Town Levee Topsoil Maintenance	**100 yr Event Cost**	$ -	$ -	$ -	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 2,000
		EA	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 1,000**
v	In-Town Levee Turf Maintenance/Replacement	**100 yr Event Cost**	$ 4,000	$ 6,000	$ 7,000	$ 10,000	$ 15,000	$ 21,000	$ 22,000	$ 25,000
		EA	**$ 3,000**	**$ 4,000**	**$ 5,000**	**$ 6,000**	**$ 8,000**	**$ 9,000**	**$ 8,000**	**$ 9,000**
vi	Roadway Embankment Repair	**100 yr Event Cost**	$ 23,000	$ 24,000	$ 24,000	$ 25,000	$ 26,000	$ 27,000	$ 29,000	$ 31,000
		EA	**$ 19,000**	**$ 19,000**	**$ 19,000**	**$ 20,000**	**$ 20,000**	**$ 20,000**	**$ 20,000**	**$ 20,000**
vii	Ditch and Culvert Cleanout, Debris Removal	**100 yr Event Cost**	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 6,000	$ 6,000	$ 6,000	$ 7,000
		EA	**$ 4,000**	**$ 4,000**	**$ 4,000**	**$ 4,000**	**$ 4,000**	**$ 4,000**	**$ 4,000**	**$ 4,000**
G	Variable Staging Area and Storage Area 1 Costs	**100 yr Event Cost**	$ 157,000	$ 155,000	$ 151,000	$ 79,000	$ 78,000	$ 77,000	$ 77,000	$ 76,000
		EA	$ 127,000	$ 126,000	$ 122,000	$ 92,000	$ 92,000	$ 91,000	$ 92,000	$ 91,000
		PV	$ 2,562,000	$ 2,541,000	$ 2,461,000	$ 1,856,000	$ 1,856,000	$ 1,836,000	$ 1,856,000	$ 1,836,000
i	Flood Monitoring and Road Closures	**100 yr Event Cost**	$ 28,000	$ 27,000	$ 26,000	$ 25,000	$ 24,000	$ 23,000	$ 23,000	$ 22,000
		EA	**$ 23,000**	**$ 22,000**	**$ 21,000**	**$ 21,000**	**$ 21,000**	**$ 20,000**	**$ 21,000**	**$ 20,000**
ii	Ditch and Culvert Cleanout, Debris Removal	**100 yr Event Cost**	$ 23,000	$ 23,000	$ 22,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000
		EA	**$ 19,000**	**$ 19,000**	**$ 18,000**	**$ 13,000**	**$ 13,000**	**$ 13,000**	**$ 13,000**	**$ 13,000**
iii	Roadway Embankment Repair	**100 yr Event Cost**	$ 106,000	$ 105,000	$ 103,000	$ 44,000	$ 44,000	$ 44,000	$ 44,000	$ 44,000
		EA	**$ 85,000**	**$ 85,000**	**$ 83,000**	**$ 58,000**	**$ 58,000**	**$ 58,000**	**$ 58,000**	**$ 58,000**
H	Variable Staging Area and Storage Area 1 Levee Embankment*	**100 yr Event Cost**	$ 316,000	$ 316,000	$ 316,000	$ 316,000	$ 316,000	$ 316,000	$ 316,000	$ 316,000
		EA	$ 76,000	$ 76,000	$ 76,000	$ 31,000	$ 12,000	$ 12,000	$ 12,000	$ 12,000
		PV	$ 1,533,000	$ 1,533,000	$ 1,533,000	$ 625,000	$ 242,000	$ 242,000	$ 242,000	$ 242,000
i	Tie-back Levee Embankment Maintenance	**100 yr Event Cost**	$ 256,000	$ 256,000	$ 256,000	$ 256,000	$ 256,000	$ 256,000	$ 256,000	$ 256,000
		EA	**$ 60,000**	**$ 60,000**	**$ 60,000**	**$ 24,000**	**$ 9,000**	**$ 9,000**	**$ 9,000**	**$ 9,000**
ii	Tie-back Levee Topsoil Maintenance	**100 yr Event Cost**	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000
		EA	**$ 3,000**	**$ 3,000**	**$ 3,000**	**$ 2,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**
iii	Tie-back Levee Turf Maintenance/Replacement	**100 yr Event Cost**	$ 57,000	$ 57,000	$ 57,000	$ 57,000	$ 57,000	$ 57,000	$ 57,000	$ 57,000
		EA	**$ 13,000**	**$ 13,000**	**$ 13,000**	**$ 5,000**	**$ 2,000**	**$ 2,000**	**$ 2,000**	**$ 2,000**
I	Loss of Service	**100 yr Event Cost**	$ 73,000	$ 367,000	$ 367,000	$ 367,000	$ 367,000	$ 367,000	$ 342,000	$ 342,000
		EA	**$ 59,000**	**$ 236,000**	**$ 236,000**	**$ 236,000**	**$ 236,000**	**$ 236,000**	**$ 235,000**	**$ 235,000**
		PV	$ 1,190,000	$ 4,760,000	$ 4,760,000	$ 4,760,000	$ 4,760,000	$ 4,760,000	$ 4,740,000	$ 4,740,000

Notes: * levee embankment repair costs for the Staging Area and Storage Areat 1 were tabulated specifically for each exceedance and provided in the summary only as expected annual

OPERATION and MAINTENANCE SUMMARY

Life Cycle 50 Years

Rate of Return 4.375%

		$ 481,000	$ 526,000	$ 540,000	$ 480,000	$ 487,000	$ 504,000	$ 525,000	$ 530,000
		$ 209,000	$ 237,000	$ 244,000	$ 174,000	$ 157,000	$ 159,000	$ 160,000	$ 159,000
					Design Conditions Stages				
Post Mitigation Option 1 - Net Change		30	31	32	33	34	35	36	37
Total Annual O&M = A+B+C+D+E+F+G+H+I	**100 yr Event Cost**	$ (8,000)	$ (66,000)	$ (131,000)	$ (294,000)	$ (557,000)	$ (1,061,000)	$ (1,607,000)	$ (2,073,000)
	EA	$ (6,000)	$ (42,000)	$ (81,000)	$ (153,000)	$ (229,000)	$ (312,000)	$ (336,000)	$ (348,000)
	PV	$ (121,000)	$ (847,000)	$ (1,633,000)	$ (3,086,000)	$ (4,619,000)	$ (6,293,000)	$ (6,778,000)	$ (7,019,000)
B Change in Operations Costs of Intown Levees (Permanent and Temporary)	**100 yr Event Cost**	$ (6,000)	$ (64,000)	$ (89,000)	$ (228,000)	$ (448,000)	$ (902,000)	$ (1,390,000)	$ (1,705,000)
	EA	**$ (4,000)**	**$ (40,000)**	**$ (55,000)**	**$ (116,000)**	**$ (180,000)**	**$ (254,000)**	**$ (279,000)**	**$ (280,000)**
	PV	$ (81,000)	$ (807,000)	$ (1,109,000)	$ (2,340,000)	$ (3,631,000)	$ (5,123,000)	$ (5,628,000)	$ (5,648,000)
E Emergency Levee Construction Costs	**100 yr Event Cost**	$ -	$ -	$ (41,000)	$ (66,000)	$ (109,000)	$ (159,000)	$ (216,000)	$ (368,000)
	EA	**$ -**	**$ -**	**$ (25,000)**	**$ (36,000)**	**$ (48,000)**	**$ (57,000)**	**$ (56,000)**	**$ (67,000)**
	PV	$ -	$ -	$ (504,000)	$ (726,000)	$ (968,000)	$ (1,150,000)	$ (1,130,000)	$ (1,351,000)
F Change in Variable In Town Costs	**100 yr Event Cost**	$ (2,000)	$ (2,000)	$ (1,000)	$ -	$ -	$ -	$ (1,000)	$ -
	EA	$ (2,000)	$ (2,000)	$ (1,000)	$ (1,000)	$ (1,000)	$ (1,000)	$ (1,000)	$ (1,000)
	PV	$ (40,000)	$ (40,000)	$ (20,000)	$ (20,000)	$ (20,000)	$ (20,000)	$ (20,000)	$ (20,000)
i Clean up of Open Space	**100 yr Event Cost**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	EA	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
ii Roadway Cleaning Costs	**100 yr Event Cost**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	EA	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
iii In-Town Levees Embankment Repair	**100 yr Event Cost**	$ -	$ -	$ 1,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 3,000
	EA	**$ -**	**$ -**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**
iv In-Town Levee Topsoil Maintenance	**100 yr Event Cost**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	EA	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
v In-Town Levee Turf Maintenance/Replacement	**100 yr Event Cost**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,000
	EA	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
vi Roadway Embankment Repair	**100 yr Event Cost**	$ (2,000)	$ (2,000)	$ (2,000)	$ (2,000)	$ (2,000)	$ (2,000)	$ (3,000)	$ (4,000)
	EA	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**

					Design Conditions Stages				
Post Mitigation Option 2 - Net Change		30	31	32	33	34	35	36	37
Change in Annual O&M	**100 yr Event Cost**	$ (8,000)	$ (68,000)	$ (135,000)	$ (299,000)	$ (562,000)	$ (1,066,000)	$ (1,614,000)	$ (2,088,000)
	EA	$ (6,000)	$ (42,000)	$ (81,000)	$ (153,000)	$ (229,000)	$ (312,000)	$ (336,000)	$ (348,000)
	PV	$ (121,000)	$ (847,000)	$ (1,633,000)	$ (3,086,000)	$ (4,619,000)	$ (6,293,000)	$ (6,778,000)	$ (7,019,000)
B Change in Operations Costs of Intown Levees (Permanent and Temporary)	**100 yr Event Cost**	$ (6,000)	$ (66,000)	$ (93,000)	$ (232,000)	$ (452,000)	$ (906,000)	$ (1,397,000)	$ (1,718,000)
	EA	**$ (4,000)**	**$ (40,000)**	**$ (55,000)**	**$ (116,000)**	**$ (180,000)**	**$ (254,000)**	**$ (279,000)**	**$ (280,000)**
	PV	$ (81,000)	$ (807,000)	$ (1,109,000)	$ (2,340,000)	$ (3,631,000)	$ (5,123,000)	$ (5,628,000)	$ (5,648,000)
E Emergency Levee Construction Costs	**100 yr Event Cost**	$ -	$ -	$ (41,000)	$ (66,000)	$ (109,000)	$ (159,000)	$ (216,000)	$ (368,000)
	EA	**$ -**	**$ -**	**$ (25,000)**	**$ (36,000)**	**$ (48,000)**	**$ (57,000)**	**$ (56,000)**	**$ (67,000)**
	PV	$ -	$ -	$ (504,000)	$ (726,000)	$ (968,000)	$ (1,150,000)	$ (1,130,000)	$ (1,351,000)
F Change in Variable In Town Costs	**100 yr Event Cost**	$ (2,000)	$ (2,000)	$ (1,000)	$ (1,000)	$ (1,000)	$ (1,000)	$ (1,000)	$ (2,000)
	EA	$ (2,000)	$ (2,000)	$ (1,000)	$ (1,000)	$ (1,000)	$ (1,000)	$ (1,000)	$ (1,000)
	PV	$ (40,000)	$ (40,000)	$ (20,000)	$ (20,000)	$ (20,000)	$ (20,000)	$ (20,000)	$ (20,000)
i Clean up of Open Space	**100 yr Event Cost**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	EA	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
ii Roadway Cleaning Costs	**100 yr Event Cost**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	EA	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
iii In-Town Levees Embankment Repair	**100 yr Event Cost**	$ -	$ -	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 2,000	$ 2,000
	EA	**$ -**	**$ -**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**	**$ 1,000**
iv In-Town Levee Topsoil Maintenance	**100 yr Event Cost**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	EA	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
v In-Town Levee Turf Maintenance/Replacement	**100 yr Event Cost**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	EA	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
vi Roadway Embankment Repair	**100 yr Event Cost**	$ (2,000)	$ (2,000)	$ (2,000)	$ (2,000)	$ (2,000)	$ (2,000)	$ (3,000)	$ (4,000)
	EA	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**	**$ (2,000)**

Notes: * levee embankment repair costs for the Staging Area and Storage Areat 1 were tabulated specifically for each exceedance and provided in the summary only as expected annual

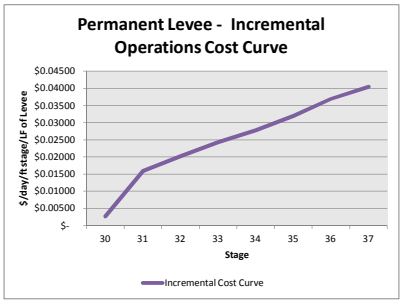
OPERATION and MAINTENANCE SUMMARY

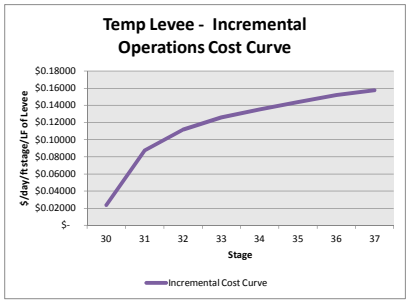
Life Cycle 50 Years

Rate of Return 4.375%

Comparison of Option 1 & Option 2		Design Conditions Stages 30	31	32	33	34	35	36	37
O&M Pre-Mitigation	**100 yr Event Cost**	$ 4,194,000	$ 4,660,000	$ 4,802,000	$ 5,010,000	$ 5,417,000	$ 6,159,000	$ 6,858,000	$ 7,497,000
	EA	$ 3,893,000	$ 4,174,000	$ 4,259,000	$ 4,306,000	$ 4,406,000	$ 4,524,000	$ 4,545,000	$ 4,554,000
	PV	$ 78,525,000	$ 84,191,000	$ 85,906,000	$ 86,854,000	$ 88,871,000	$ 91,252,000	$ 91,677,000	$ 91,857,000
O&M Post-Mitigation Option 1	**100 yr Event Cost**	$ 4,186,000	$ 4,594,000	$ 4,671,000	$ 4,716,000	$ 4,860,000	$ 5,098,000	$ 5,251,000	$ 5,424,000
	EA	$ 3,887,000	$ 4,132,000	$ 4,178,000	$ 4,153,000	$ 4,177,000	$ 4,212,000	$ 4,209,000	$ 4,206,000
	PV	$ 78,404,000	$ 83,344,000	$ 84,273,000	$ 83,768,000	$ 84,252,000	$ 84,959,000	$ 84,899,000	$ 84,838,000
% Increase from Baseline		**-0.15%**	**-1.01%**	**-1.90%**	**-3.55%**	**-5.20%**	**-6.90%**	**-7.39%**	**-7.64%**
O&M Post-Mitigation Option 2	**100 yr Event Cost**	$ 4,186,000	$ 4,592,000	$ 4,667,000	$ 4,711,000	$ 4,855,000	$ 5,093,000	$ 5,244,000	$ 5,409,000
	EA	$ 3,887,000	$ 4,132,000	$ 4,178,000	$ 4,153,000	$ 4,177,000	$ 4,212,000	$ 4,209,000	$ 4,206,000
	PV	$ 78,404,000	$ 83,344,000	$ 84,273,000	$ 83,768,000	$ 84,252,000	$ 84,959,000	$ 84,899,000	$ 84,838,000
% Increase from Baseline		**-0.15%**	**-1.01%**	**-1.90%**	**-3.55%**	**-5.20%**	**-6.90%**	**-7.39%**	**-7.64%**

	Permanent Levee $/day/ft stage/lf perm levee				*Temporary Levee* $/day/lf temp levee			
stage (rounded)	Regular Hours	Overtime Hours	Aggregated Cost Curve	Incremental Cost Curve	Regular Hours	Overtime Hours	Aggregated Cost Curve	Incremental Cost Curve
30	$ 0.00176	$ 0.00088	**$ 0.00264**	**$ 0.00264**	$ 0.01586	$ 0.00794	**$ 0.02380**	**$ 0.02380**
31	$ 0.00883	$ 0.00441	**$ 0.01323**	**$ 0.01587**	$ 0.04247	$ 0.02121	**$ 0.06368**	**$ 0.08748**
32	$ 0.00217	$ 0.00220	**$ 0.00437**	**$ 0.02024**	$ 0.01207	$ 0.01226	**$ 0.02433**	**$ 0.11181**
33	$ 0.00298	$ 0.00110	**$ 0.00408**	**$ 0.02432**	$ 0.01025	$ 0.00380	**$ 0.01404**	**$ 0.12585**
34	$ 0.00118	$ 0.00226	**$ 0.00344**	**$ 0.02776**	$ 0.00317	$ 0.00608	**$ 0.00925**	**$ 0.13510**
35	$ 0.00196	$ 0.00223	**$ 0.00419**	**$ 0.03195**	$ 0.00418	$ 0.00476	**$ 0.00894**	**$ 0.14404**
36	$ 0.00136	$ 0.00360	**$ 0.00496**	**$ 0.03691**	$ 0.00223	$ 0.00588	**$ 0.00811**	**$ 0.15215**
37	$ 0.00145	$ 0.00214	**$ 0.00359**	**$ 0.04050**	$ 0.00227	$ 0.00333	**$ 0.00560**	**$ 0.15775**





In Town Levees Pre Mitigation - Operations

Description	River Stage							
	30	31	32	33	34	35	36	37
Pre-Mitigation								
Time Above 892	8	9	9	8	8	8	8	7
Permanent Levee Length	11,411	17,531	22,646	29,885	41,795	58,129	61,360	70,226
Perm Operations Cost ($/day/ft stage/LF levee)	0.0026	0.0159	0.0202	0.0243	0.0278	0.0320	0.0369	0.0405
Adjustment Factor for Overbuild	0.76	0.79	0.82	0.84	0.87	0.89	0.92	0.95
Permanent Levee Operations Costs	$ 5,513	$ 57,880	$ 101,700	$ 161,586	$ 256,916	$ 436,240	$ 563,221	$ 697,882
Temporary Levee Length	1,265	3,643	4,065	8,688	15,537	27,264	37,506	45,031
Temp Operations Cost ($/day/ft stage/LF levee)	$ 0.0238	$ 0.0875	$ 0.1118	$ 0.1258	$ 0.1351	$ 0.1440	$ 0.1521	$ 0.1577
Adjustment Factor for Overbuild	0.7632	0.7895	0.8158	0.8421	0.8684	0.8947	0.9211	0.9474
Temporary Levee Operations Costs	$ 5,513	$ 66,297	$ 100,856	$ 243,074	$ 464,822	$ 922,341	$ 1,419,132	$ 1,742,997
Total Levee Operations Costs	$ 11,026	$ 124,177	$ 202,556	$ 404,660	$ 721,738	$ 1,358,581	$ 1,982,353	$ 2,440,879
Post-Mitigation Option 1								
Time Above 892	8	9	9	8	8	8	8	7
Permanent Levee Length	-	650	2,080	2,340	2,430	2,440	2,955	3,605
Perm Operations Cost ($/day/ft stage/LF levee)	0	0	0	0	0	0	0	0
Permanent Levee Operations Costs	$ -	$ 2,718	$ 11,450	$ 15,024	$ 17,200	$ 20,466	$ 29,449	$ 37,816
Temporary Levee Length	(1,265)	(3,643)	(4,065)	(8,688)	(15,537)	(27,264)	(37,506)	(45,031)
Temp Operations Cost ($/day/ft stage/LF levee)	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Temporary Levee Operations Costs	$ (5,513)	$ (66,297)	$ (100,856)	$ (243,074)	$ (464,822)	$ (922,341)	$ (1,419,132)	$ (1,742,997)
Total Levee Operations Costs	$ (5,513)	$ (63,579)	$ (89,406)	$ (228,050)	$ (447,622)	$ (901,875)	$ (1,389,683)	$ (1,705,181)
Post-Mitigation Option 2								
Time Above 892	8	9	9	8	8	8	8	7
Permanent Levee Length	-	-	1,475	1,750	1,750	1,920	2,210	2,385
Perm Operations Cost ($/day/ft stage/LF levee)	0	0	0	0	0	0	0	0
Permanent Levee Operations Costs	$ -	$ -	$ 8,120	$ 11,236	$ 12,387	$ 16,104	$ 22,024	$ 25,018
Temporary Levee Length	(1,265)	(3,643)	(4,065)	(8,688)	(15,537)	(27,264)	(37,506)	(45,031)
Temp Operations Cost ($/day/ft stage/LF levee)	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Temporary Levee Operations Costs	$ (5,513)	$ (66,297)	$ (100,856)	$ (243,074)	$ (464,822)	$ (922,341)	$ (1,419,132)	$ (1,742,997)
Total Levee Operations Costs	$ (5,513)	$ (66,297)	$ (92,736)	$ (231,838)	$ (452,435)	$ (906,237)	$ (1,397,107)	$ (1,717,979)

Storage Area Levees Operations

Adjustment Factor for with project Storage Area Levees 20%

Storage Area Levees

Description	River Stage							
	30	31	32	33	34	35	36	37
Perm Operations Cost ($/day/ft stage/LF levee)	0.002637884	0.015871459	0.020238353	0.02432071	0.027758367	0.031952575	0.036910308	0.040500933
Permanent Levee Operations Costs	$ 8,357	$ 55,204	$ 72,664	$ 84,753	$ 93,435	$ 110,716	$ 131,548	$ 138,465

River Stage Cost Discounting for Protection Below 100-Year Design

Description	River Stage							
In-Town Flood Protection Level	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**
30	1.0							
31	1.0	1.0						
32	1.0	1.0	1.0					
33	0.8	1.0	1.0	1.0				
34	0.6	0.8	1.0	1.0	1.0			
35	0.4	0.6	0.8	1.0	1.0	1.0		
36	0.2	0.4	0.6	0.8	1.0	1.0	1.0	
37	0.2	0.2	0.4	0.6	0.8	1.0	1.0	1.0

Cost of Protection with Discounting

Description	River Stage							
30	11,026							
31	11,026	124,177						
32	11,026	124,177	202,556					
33	8,821	124,177	202,556	404,660				
34	6,616	99,342	202,556	404,660	721,738			
35	4,410	74,506	162,045	404,660	721,738	1,358,581		
36	2,205	49,671	121,533	323,728	721,738	1,358,581	1,982,353	
37	2,205	24,835	81,022	242,796	577,391	1,358,581	1,982,353	2,440,879
Expected Annual Cost	**8,871**	**77,273**	**124,655**	**212,707**	**305,804**	**406,874**	**431,784**	**427,523**

Reduction in Cost of Protection with Discounting For Alternatives 1 and 2

Description	River Stage							
30	(5,513)	-	-	-	-	-	-	-
31	(5,513)	(63,579)	-	-	-	-	-	-
32	(5,513)	(63,579)	(89,406)	-	-	-	-	-
33	(4,410)	(63,579)	(89,406)	(228,050)	-	-	-	-
34	(3,308)	(50,863)	(89,406)	(228,050)	(447,622)	-	-	-
35	(2,205)	(38,147)	(71,525)	(228,050)	(447,622)	(901,875)	-	-
36	(1,103)	(25,431)	(53,644)	(182,440)	(447,622)	(901,875)	(1,389,683)	-
37	(1,103)	(12,716)	(35,762)	(136,830)	(358,097)	(901,875)	(1,389,683)	(1,705,181)
Expected Annual Cost	**(4,435)**	**(39,537)**	**(55,151)**	**(115,636)**	**(180,189)**	**(254,212)**	**(278,642)**	**(280,040)**

In-Town Emergency Levee Construction Costs by Stage

Embankment placement and removal	20	cy
Sandbag Cost	4	bag
Sandbag size 14"x26"x2"	0.015641647	cy
Sandbags per CY	64	
Sandbag Levee Cost per cubic yard	255.73	

RS 32

Description	Type	Length	Estimated Ave Height	Replaced by Permanent?	Cost Per foot	Total Cost	Approx. RS32	Ground Elev	Free Board
2nd Street North	Clay	1090	2.35	Yes	$25.59	$27,891.89	893.35	893	2
2nd Street South	Clay	450	2.6	Yes	$29.27	$13,173.33	893.6	893	2
Total		1,540.00				$41,065.22			

RS 33

Description	Type	Length	Estimated Ave Height	Replaced by Permanent?	Cost Per foot	Total Cost	Approx. RS33	Ground Elev	Free Board
2nd Street North	Clay	1240	3.3	Yes	$40.58	$50,316.44	894.3	893	2
2nd Street South	Clay	580	2.5	Yes	$27.78	$16,111.11	894.5	894	2
		1,820.00				$66,427.56			

RS 34

Description	Type	Length	Estimated Ave Height	Replaced by Permanent?	Cost Per foot	Total Cost	Approx. RS34	Ground Elev	Free Board
2nd Street North	Clay	1400	4.18	Yes	$56.85	$79,587.20	895.18	893	2
2nd Street South	Clay	660	3.5	Yes	$44.07	$29,088.89	895.5	894	2
		2,060.00				$108,676.09			

RS 35

Description	Type	Length	Estimated Ave Height	Replaced by Permanent?	Cost Per foot	Total Cost	Approx. RS35	Ground Elev	Free Board
2nd Street North	Clay	1500	5.2	Yes	$78.58	$117,866.67	896.2	893	2
2nd Street South	Clay	700	4.25	Yes	$58.24	$40,768.52	897.75	895.5	2
		2,200.00				$158,635.19			

RS 36

Description	Type	Length	Estimated Ave Height	Replaced by Permanent?	Cost Per foot	Total Cost	Approx. RS36	Ground Elev	Free Board
2nd Street North	Clay	1650	6.17	Yes	$102.10	$168,468.42	897.17	893	2
2nd Street South	Clay	820	4.25	Yes	$58.24	$47,757.41	897.75	895.5	2
		2,470.00				$216,225.83			

RS 37

Description	Type	Length	Estimated Ave Height	Replaced by Permanent?	Cost Per foot	Total Cost	Approx. RS37	Ground Elev	Free Board
2nd Street North	Clay	2070	7	Yes	$124.44	$257,600.00	898	893	2
2nd Street South	Clay	1170	5.2	Yes	$78.58	$91,936.00	898.7	895.5	2
South River Road South	Other	535	2.95	Yes	$34.74	$18,588.28	899.95	899	2
		1,705.00				$368,124.28			

Summary of Emergency Levee Costs	River Stage							
	30	31	32	33	34	35	36	37
Pre - Mitigation Cost	**$ -**	**$ -**	**$ 41,065**	**$ 66,428**	**$ 108,676**	**$ 158,635**	**$ 216,226**	**$ 368,124**
Post Mitigation Cost Option 1 and 2	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**

In-Town Area O&M Costs by Stage

Operations

see separate calculations for operations costs

Maintenance

Open Area Clean Up

Staff Assigned	Rate Per Staff	Number of Staff
Crew Supervisor	$ 30.00	1
Arborist 1	$ 22.00	0.5
Arborist Supervisor	$ 30.00	0.25
Equipment Operator II	$ 23.00	1
Laborer	$ 15.00	5

Hourly rate for crew	$ 116.50	
Hours worked per day	8	hrs
Work rate	10	ac/day
Cost per Acre	$ 93.20	

Description	River Stage							
	30	31	32	33	34	35	36	37
Pre-Mitigation								
Area of Innundation (acres)	2,162	2,235	2,306	2,377	2,448	2,561	2,646	2,708
Percent weighting*	10%	10%	10%	20%	25%	25%	30%	30%
Areas requiring maintenance (acres)	216	224	231	475	612	640	794	812
Cost	**$ 20,150**	**$ 20,831**	**$ 21,492**	**$ 44,314**	**$ 57,032**	**$ 59,665**	**$ 73,990**	**$ 75,706**
Post-Mitigation Option 1								
Area of Innundation (acres) - post mitigation	-	-	9	10	10	10	10	14
Percent weighting*	10%	10%	10%	20%	25%	25%	30%	30%
Areas requiring maintenance (acres)	-	-	1	2	2	2	3	4
Cost	**$ -**	**$ -**	**$ 83**	**$ 180**	**$ 225**	**$ 225**	**$ 269**	**$ 380**
Post-Mitigation Option 2								
Area of Innundation (acres) - post mitigation	-	4	9	9	9	9	10	14
Percent weighting*	10%	10%	10%	20%	25%	25%	30%	30%
Areas requiring maintenance (acres)	-	0	1	2	2	2	3	4
Cost	**$ -**	**$ 38**	**$ 82**	**$ 165**	**$ 206**	**$ 219**	**$ 266**	**$ 391**

* Percent weighting accounts for an assumption that more intensive maintenance efforts would be required for higher elevations
It is assumed that higher elevation land will be developed and used differently since these areas would be flooded less frequently.
It is assumed that the land uses for higher elevations would warrant a higher (but less frequent) maintenance standard

Roadway Clean Up

Street Cleaning Cost 13.05 $/MSF per Means 2009

Assumed % of innundated county roadway requiring repair 2%
Volume of repair per foot of roadway 3 ft deep x 18 ft foreslope length x 1 ft

Assumed percentage of innundated roadway that is of urban section: 80%
(paved, and with either storm sewers or assumed no ditch cleaning due to private residences and businesses nearby performing the work voluntarily

Description	River Stage							
	30	31	32	33	34	35	36	37
Pre-Mitigation								
Length of In-Town Roadways Innundated	132,298	135,336	139,317	142,942	148,415	154,914	164,530	177,511
Cost	**$ 1,726**	**$ 1,766**	**$ 1,818**	**$ 1,865**	**$ 1,937**	**$ 2,022**	**$ 2,147**	**$ 2,317**
Post-Mitigation Option 1								
Length of In-Town Roadways Innundated	(11,134)	(11,168)	(11,891)	(12,269)	(12,469)	(13,541)	(15,517)	(22,878)
Cost	**$ (145)**	**$ (146)**	**$ (155)**	**$ (160)**	**$ (163)**	**$ (177)**	**$ (202)**	**$ (299)**
Post-Mitigation Option 2								
Length of In-Town Roadways Innundated	(11,134)	(11,168)	(11,891)	(12,269)	(12,469)	(13,541)	(15,517)	(22,878)
Cost	**$ (145)**	**$ (146)**	**$ (155)**	**$ (160)**	**$ (163)**	**$ (177)**	**$ (202)**	**$ (299)**

Roadway Embankment Repair

Embankment Repair Cost 17.51 $/CY per USACE Feasibility Study O&M Estimate

Assumed % of innundated rural roadway sections requiring repair 2%

Volume of repair per foot of roadway 3 ft deep x 18 ft foreslope length x 1 ft = 54 CF
2.0 CY

Description	River Stage							
	30	31	32	33	34	35	36	37
Pre-Mitigation								
Length of "In-Town" Area Roadways Innundated	33,075	33,834	34,829	35,736	37,104	38,729	41,133	44,378
(with rural section)								
Linear Feet of Roadway Requiring Repair	661	677	697	715	742	775	823	888
Volume of Embankment Repair	1,323	1,353	1,393	1,429	1,484	1,549	1,645	1,775
Cost	**$ 23,165**	**$ 23,697**	**$ 24,394**	**$ 25,029**	**$ 25,987**	**$ 27,125**	**$ 28,809**	**$ 31,082**
Post-Mitigation Option 1								
Length of "In-Town" Area Roadways Innundated	(2,784)	(2,792)	(2,973)	(3,067)	(3,117)	(3,385)	(3,879)	(5,720)
(with rural section)								
Linear Feet of Roadway Requiring Repair	(56)	(56)	(59)	(61)	(62)	(68)	(78)	(114)
Volume of Embankment Repair	(111)	(112)	(119)	(123)	(125)	(135)	(155)	(229)
Cost	**$ (1,950)**	**$ (1,955)**	**$ (2,082)**	**$ (2,148)**	**$ (2,183)**	**$ (2,371)**	**$ (2,717)**	**$ (4,006)**
Post-Mitigation Option 2								
Length of "In-Town" Area Roadways Innundated	(2,784)	(2,792)	(2,973)	(3,067)	(3,117)	(3,385)	(3,879)	(5,720)
(with rural section)								
Linear Feet of Roadway Requiring Repair	(56)	(56)	(59)	(61)	(62)	(68)	(78)	(114)
Volume of Embankment Repair	(111)	(112)	(119)	(123)	(125)	(135)	(155)	(229)
Cost	**$ (1,950)**	**$ (1,955)**	**$ (2,082)**	**$ (2,148)**	**$ (2,183)**	**$ (2,371)**	**$ (2,717)**	**$ (4,006)**

Ditch and Culvert Cleanout, Debris Removal

Staff Assigned	Rate
Highway Department Engineer	$ 50.00
Temporary Worker	$ 15.00
Hourly rate for crew of 1 engineer and 3 temporary workers	$ 95.00

Assumed work rate: 100 ft/day

Description	River Stage							
	30	31	32	33	34	35	36	37
Pre-Mitigation								
Length of In-Town Area Roadways Innundated	33,075	33,834	34,829	35,736	37,104	38,729	41,133	44,378
(with rural section)								
Linear Feet of Ditch Requiring Cleanout*	661	677	697	715	742	775	823	888
Days of Labor	7	7	7	7	7	8	8	9
Cost	**$ 5,027**	**$ 5,143**	**$ 5,294**	**$ 5,432**	**$ 5,640**	**$ 5,887**	**$ 6,252**	**$ 6,745**
Post-Mitigation Option 1								
Length of In-Town Area Roadways Innundated	(2,784)	(2,792)	(2,973)	(3,067)	(3,117)	(3,385)	(3,879)	(5,720)
(with rural section)								
Linear Feet of Ditch Requiring Cleanout*	(56)	(56)	(59)	(61)	(62)	(68)	(78)	(114)
Days of Labor	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Cost	**$ (423)**	**$ (424)**	**$ (452)**	**$ (466)**	**$ (474)**	**$ (515)**	**$ (590)**	**$ (869)**
Post-Mitigation Option 2								
Length of In-Town Area Roadways Innundated	(2,784)	(2,792)	(2,973)	(3,067)	(3,117)	(3,385)	(3,879)	(5,720)
(with rural section)								
Linear Feet of Ditch Requiring Cleanout*	(56)	(56)	(59)	(61)	(62)	(68)	(78)	(114)
Days of Labor	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Cost	**$ (423)**	**$ (424)**	**$ (452)**	**$ (466)**	**$ (474)**	**$ (515)**	**$ (590)**	**$ (869)**

Levee Embankment Maintenance

Assumed levee repair section

Levee height	6	FT
Levee slope	3	
Repair thickness	3	FT
Length of repaired slope	18	FT
Cross sectional area of repair	54	SF

Incremental increase for each 1 foot of stage = 0.00%

Description	River Stage							
	30	31	32	33	34	35	36	37
Pre-Mitigation								
Earthen Embankment (FT)	9,356	14,722	19,114	26,353	37,569	53,607	56,837	65,287
% of embankment requiring repair after each flood occurrence	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Length of levee requiring repair (FT)	468	736	956	1,318	1,878	2,680	2,842	3,264
Volume of levee embankment repair (CY)	936	1,472	1,911	2,635	3,757	5,361	5,684	6,529
Dollars/ft of levee in place	$ 1.75	$ 1.75	$ 1.75	$ 1.75	$ 1.75	$ 1.75	$ 1.75	$ 1.75
Cost	**$ 16,382**	**$ 25,778**	**$ 33,469**	**$ 46,144**	**$ 65,783**	**$ 93,866**	**$ 99,522**	**$ 114,318**
Post-Mitigation Option 1								
Earthen Embankment (FT)	-	650	2,080	2,340	2,430	2,440	2,955	3,605
% of embankment requiring repair after each flood occurrence	1.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Length of levee requiring repair (FT)	-	13	42	47	49	49	59	72
Volume of levee embankment repair (CY)	-	26	83	94	97	98	118	144
Dollars/ft of levee in place		$ 0.70	$ 0.70	$ 0.70	$ 0.70	$ 0.70	$ 0.70	$ 0.70
Cost	**$ -**	**$ 455**	**$ 1,457**	**$ 1,639**	**$ 1,702**	**$ 1,709**	**$ 2,070**	**$ 2,525**
Post-Mitigation Option 2								
Earthen Embankment (FT)	-	-	1,475	1,750	1,750	1,920	2,210	2,385
% of embankment requiring repair after each flood occurrence	1.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Length of levee requiring repair (FT)	-	-	30	35	35	38	44	48
Volume of levee embankment repair (CY)	-	-	59	70	70	77	88	95
Dollars/ft of levee in place			$ 0.70	$ 0.70	$ 0.70	$ 0.70	$ 0.70	$ 0.70
Cost	**$ -**	**$ -**	**$ 1,033**	**$ 1,226**	**$ 1,226**	**$ 1,345**	**$ 1,548**	**$ 1,670**

Levee Topsoil Maintenance

Qty of Levee Embankment: 835320 CY per USACE Final Feasibility Report
Qty of Levee Topsoil Maintenance: 110024 CY per USACE Final Feasibility Report

Levee Topsoil Maintenance Cost 1.81 $/CY per USACE O&M estimate

Topsoil maintenance as a % of total levee embankment needing repair: 13.17%

Description	River Stage							
	30	31	32	33	34	35	36	37
Pre-Mitigation								
Volume of topsoil repair (CY)	123	194	252	347	495	706	749	860
Cost	**$ 223**	**$ 351**	**$ 456**	**$ 628**	**$ 896**	**$ 1,278**	**$ 1,355**	**$ 1,556**
Post-Mitigation Option 1								
Volume of topsoil repair (CY)	-	3	11	12	13	13	16	19
Cost	**$ -**	**$ 6**	**$ 20**	**$ 22**	**$ 23**	**$ 23**	**$ 28**	**$ 34**
Post-Mitigation Option 2								
Volume of topsoil repair (CY)	-	-	8	9	9	10	12	13
Cost	**$ -**	**$ -**	**$ 14**	**$ 17**	**$ 17**	**$ 18**	**$ 21**	**$ 23**

Levee Turf Maintenance/Replacement

Assumed average depth of placement 0.17 YD (assumed 6" depth)

repair price estimated from Means 2009:

Section	Line Number	Description	Unit Cost	Units	Page Number
32 91 19.13		Topsoil placement and grading			
	800	Furnish and place, truck dumped, screened, 6" deep	4.94	SY	365

Estimate area to repair based on an assumed average depth of embankment placement:

Description	River Stage							
	30	31	32	33	34	35	36	37
Pre-Mitigation								
Area to Repair (SY)	739	1,163	1,511	2,083	2,969	4,237	4,492	5,160
Cost	**$ 3,653**	**$ 5,748**	**$ 7,462**	**$ 10,288**	**$ 14,667**	**$ 20,928**	**$ 22,189**	**$ 25,488**
Post-Mitigation								
Area to Repair (SY)	-	21	66	74	77	77	93	114
Cost	**$ -**	**$ 102**	**$ 325**	**$ 365**	**$ 379**	**$ 381**	**$ 461**	**$ 563**
Post-Mitigation								
Area to Repair (SY)	-	-	46.63	55.32	55.32	60.69	69.86	75.39
Cost	**$ -**	**$ -**	**$ 230**	**$ 273**	**$ 273**	**$ 300**	**$ 345**	**$ 372**

Staging Area/Storage Area #1 O&M Costs by Stage

Operations

Flood Monitoring and Road Closures

Assume 2 Engineers for duration of innundation above stage 30 feet + 3 days

Assumed hours per day		12	hrs/day	
Assumed wage rate (Engineer)	$	50.00	$/hr	
Assumed wage rate (Administrative support)	$	20.00	$/hr	assume support for 20% of the hours attributed to engineering time
Composite hourly wage rate	$	104.00	$/hr	(=$50 x 2 + 0.2 x $20)

Description	River Stage							
	30	31	32	33	34	35	36	37
Duration of Innundation above Elevation 910 (days)	19.5	18.5	17.5	17	16	15.5	15.5	15
Total hours of monitoring and road closures (hrs)	270	258	246	240	228	222	222	216
(assumes 3-12 hr days in addition to innundation period)								
Cost	**$ 28,080**	**$ 26,832**	**$ 25,584**	**$ 24,960**	**$ 23,712**	**$ 23,088**	**$ 23,088**	**$ 22,464**

Maintenance

Tie-back Levee Embankment Maintenance

Total Volume of Embankment: 835,320 CY per USACE Final Feasibility Report

Calculation of quantity of embankment to repair for each operational stage:

Assumed levee repair section

Levee height	6	FT
Levee slope	3	
Repair thickness	3	FT
Length of repaired slope	18	FT
Cross sectional area of repair	54	SF

Incremental increase for each 1 foot of stage = 0.00%

Description	River Stage							
	30	31	32	33	34	35	36	37
% of embankment length requiring repair after each flood occurrence	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%

Length of Levee Impacted by 100-year Operational Stage and Exceedance

exceedance	30	31	32	33	34	35	36	37
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	36,576	36,576	36,576	10,801	-	-	-	-
8	73,153	73,153	73,153	21,601	-	-	-	-
10	109,729	109,729	109,729	31,471	-	-	-	-
25	121,960	121,960	121,960	69,788	48,808	48,808	48,808	48,808
50	134,192	134,192	134,192	108,106	97,615	97,615	97,615	97,615
100	146,423	146,423	146,423	146,423	146,423	146,423	146,423	146,423

Volume of Levee Repair by 100-year Operational Stage and Exceedance

exceedance	30	31	32	33	34	35	36	37
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	3,658	3,658	3,658	1,080	-	-	-	-
8	7,315	7,315	7,315	2,160	-	-	-	-
10	10,973	10,973	10,973	3,147	-	-	-	-
25	12,196	12,196	12,196	6,979	4,881	4,881	4,881	4,881
50	13,419	13,419	13,419	10,811	9,762	9,762	9,762	9,762
100	14,642	14,642	14,642	14,642	14,642	14,642	14,642	14,642
100- year Annual Cost	256,387	256,387	256,387	256,387	256,387	256,387	256,387	256,387

Expected Annual Cost of Levee Embankment Maintenance

	exceedance	30	31	32	33	34	35	36	37
0.200	**5**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0.167	**6**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0.143	**7**	$ 9,149	$ 9,149	$ 9,149	$ 2,702	$ -	$ -	$ -	$ -
0.125	**8**	$ 16,011	$ 16,011	$ 16,011	$ 4,728	$ -	$ -	$ -	$ -
0.100	**10**	$ 19,214	$ 19,214	$ 19,214	$ 5,511	$ -	$ -	$ -	$ -
0.040	**25**	$ 8,542	$ 8,542	$ 8,542	$ 4,888	$ 3,418	$ 3,418	$ 3,418	$ 3,418
0.020	**50**	$ 4,699	$ 4,699	$ 4,699	$ 3,786	$ 3,418	$ 3,418	$ 3,418	$ 3,418
0.010	**100**	$ 2,564	$ 2,564	$ 2,564	$ 2,564	$ 2,564	$ 2,564	$ 2,564	$ 2,564
Total Expected Annual		$ 60,180	$ 60,180	$ 60,180	$ 24,178	$ 9,401	$ 9,401	$ 9,401	$ 9,401

Tie-back Levee Topsoil Maintenance

Qty of Levee Embankment: 835320 CY per USACE Final Feasibility Report

Qty of Levee Topsoil Maintenance: 110024 CY per USACE Final Feasibility Report

Levee Topsoil Maintenance Cost 1.81 $/CY per USACE O&M estimate

Topsoil maintenance as a % of total levee embankment needing repair: 13.17%

Volume of topsoil repair (CY) by 100-year Operational Stage and Exceedance

exceedance	30	31	32	33	34	35	36	37
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	482	482	482	142	-	-	-	-
8	964	964	964	285	-	-	-	-
10	1,445	1,445	1,445	415	-	-	-	-
25	1,606	1,606	1,606	919	643	643	643	643
50	1,768	1,768	1,768	1,424	1,286	1,286	1,286	1,286
100	1,929	1,929	1,929	1,929	1,929	1,929	1,929	1,929

100- year Annual Cost	$ 3,491	$ 3,491	$ 3,491	$ 3,491	$ 3,491	$ 3,491	$ 3,491	$ 3,491

Expected Annual Cost of Levee Top Soil Repair

	exceedance	30	31	32	33	34	35	36	37
0.200	5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0.167	6	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0.143	7	$ 174	$ 174	$ 174	$ 51	$ -	$ -	$ -	$ -
0.125	8	$ 349	$ 349	$ 349	$ 103	$ -	$ -	$ -	$ -
0.100	10	$ 523	$ 523	$ 523	$ 150	$ -	$ -	$ -	$ -
0.040	25	$ 582	$ 582	$ 582	$ 333	$ 233	$ 233	$ 233	$ 233
0.020	50	$ 640	$ 640	$ 640	$ 515	$ 465	$ 465	$ 465	$ 465
0.010	100	$ 698	$ 698	$ 698	$ 698	$ 698	$ 698	$ 698	$ 698
Total Expected Annual		$ 2,966	$ 2,966	$ 2,966	$ 1,851	$ 1,396	$ 1,396	$ 1,396	$ 1,396

Tie-back Levee Turf Maintenance/Replacement

Assumed average depth of placement 0.17 YD (assumed 6" depth)

repair price estimated from Means 2009:

Section	Line Number	Description	Unit Cost	Units	Page Number
32 91 19.13		Topsoil placement and grading			
	800	Furnish and place, truck dumped, screened, 6" deep	4.94	SY	365

Estimate area to repair based on an assumed average depth of embankment placement:

Volume of topsoil repair (CY) by 100-year Operational Stage and Exceedance

exceedance	30	31	32	33	34	35	36	37
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	2,891	2,891	2,891	854	-	-	-	-
8	5,781	5,781	5,781	1,707	-	-	-	-
10	8,672	8,672	8,672	2,487	-	-	-	-
25	9,638	9,638	9,638	5,515	3,857	3,857	3,857	3,857
50	10,605	10,605	10,605	8,543	7,714	7,714	7,714	7,714
100	11,572	11,572	11,572	11,572	11,572	11,572	11,572	11,572

100- year Annual Cost	$ 57,164	$ 57,164	$ 57,164	$ 57,164	$ 57,164	$ 57,164	$ 57,164	$ 57,164

Expected Annual Cost of Levee Top Soil Repair

	exceedance	30	31	32	33	34	35	36	37
0.200	5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0.167	6	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
0.143	7	$ 2,040	$ 2,040	$ 2,040	$ 602	$ -	$ -	$ -	$ -
0.125	8	$ 3,570	$ 3,570	$ 3,570	$ 1,054	$ -	$ -	$ -	$ -
0.100	10	$ 4,284	$ 4,284	$ 4,284	$ 1,229	$ -	$ -	$ -	$ -
0.040	25	$ 1,905	$ 1,905	$ 1,905	$ 1,090	$ 762	$ 762	$ 762	$ 762
0.020	50	$ 1,048	$ 1,048	$ 1,048	$ 844	$ 762	$ 762	$ 762	$ 762
0.010	100	$ 572	$ 572	$ 572	$ 572	$ 572	$ 572	$ 572	$ 572
Total Expected Annual		$ 13,418	$ 13,418	$ 13,418	$ 5,391	$ 2,096	$ 2,096	$ 2,096	$ 2,096

Embankment Repair Cost 17.51 $/CY per USACE Feasibility Study O&M Estimate

Assumed % of innundated county roadway requiring repair 2%

Volume of repair per foot of roadway 3 FT deep x 18 ft foreslope length x 1 ft = 54

2.0

Roadway Embankment Repair

Description	River Stage (FT)							
	30	31	32	33	34	35	36	37
Length of Staging and Storage Area Roadways Innundated (FT)	151053	149741	147023	62884	62884	62884	62884	62884
Length Roadway Requiring Repair (FT)	3021	2995	2940	1258	1258	1258	1258	1258
Volume of Embankment Repair (CY)	6042	5990	5881	2515	2515	2515	2515	2515
Cost	**$ 105,797**	**$ 104,878**	**$ 102,975**	**$ 44,044**	**$ 44,044**	**$ 44,044**	**$ 44,044**	**$ 44,044**

Ditch and Culvert Cleanout, Debris Removal

Staff Assigned		Rate
Highway Department Engineer	$	50.00
Temporary Worker	$	15.00
Hourly rate for crew of 1 engineer and 3 temporary workers	$	95.00

Assumed work rate: 100 ft/day

Description	River Stage							
	30	31	32	33	34	35	36	37
Length of Storage Area Roadways Innundated	151053	149741	147023	62884	62884	62884	62884	62884
Linear Feet of Roadway Requiring Repair*	3021	2995	2940	1258	1258	1258	1258	1258
Days of Labor	30	30	29	13	13	13	13	13
Cost	**$ 22,960**	**$ 22,761**	**$ 22,348**	**$ 9,558**	**$ 9,558**	**$ 9,558**	**$ 9,558**	**$ 9,558**

* Assumed that the same linear feet of roadway ditching would require maintenance/culvert cleanouts

City of Fargo, Parks Department Revenues

Data Provided from City of Fargo, Parks Department:

Flood Event	Date of Flood Peak	Peak Flood Stage	Duration of Flood above elevation 30	Revenue Losses					
				Golf Course*		Campground**		Athletic Facility***	
				Total Loss	$/day	Total Loss	$/day	Total Loss	$/day
2006	4/5/2006	37.13	9	$ 145,000.00	$ 16,111.11	$ 1,700.00	$ 188.89	$ 15,000.00	$ 1,666.67
2007	6/9/2007	30.88	2	$ 250,000.00	$ 125,000.00	$ 10,000.00	$ 5,000.00	$ 18,000.00	$ 9,000.00
2010	3/21/2010	36.99	14	$ 632,000.00	**$ 45,142.86**	$ -	$ -	$ 26,000.00	$ 1,857.14

* Assumed losses based on historical losses as provided from City of Fargo, Parks Department

** Assumed flood occurs during peak camping season
$10,000/7.5 days = $ 1,333.00 $/day

*** assume
$18,000/7.5 days = $ 2,400.00 $/day

Design Hydrograph Data		Revenue Losses			
Stage	Days Above 910	Golf Course	Campground	Athletic Facility	Total Cost
30	1.5	$ 67,714.29	$ 1,999.50	$ 3,600.00	$ 73,313.79
31	7.5	$ 338,571.43	$ 9,997.50	$ 18,000.00	$ 366,568.93
32	7.5	$ 338,571.43	$ 9,997.50	$ 18,000.00	$ 366,568.93
33	7.5	$ 338,571.43	$ 9,997.50	$ 18,000.00	$ 366,568.93
34	7.5	$ 338,571.43	$ 9,997.50	$ 18,000.00	$ 366,568.93
35	7.5	$ 338,571.43	$ 9,997.50	$ 18,000.00	$ 366,568.93
36	7.0	$ 316,000.00	$ 9,331.00	$ 16,800.00	$ 342,131.00
37	7.0	$ 316,000.00	$ 9,331.00	$ 16,800.00	$ 342,131.00

	exceedance	30	31	32	33	34	35	36	37
0.200	**5**	30	30	30	30	30	30	30	30
0.167	**6**	30	31	32	32	32	32	32	32
0.143	**7**	30	31	32	33	33	33	33	33
0.125	**8**	30	31	32	33	34	34	34	34
0.100	**10**	30	31	32	33	34	35	34	34
0.040	**25**	30	31	32	33	34	35	36	37
0.020	**50**	30	31	32	33	34	35	36	37
0.010	**100**	30	31	32	33	34	35	36	37