Lost River Design Report

Prepared For:

Red Lake Watershed District
Thief River Falls, Minnesota

June 2003

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Lost River Design Report
Red Lake Watershed District
Thief River Falls, MN 56701
June 23, 2003

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a Licensed Professional Engineer under the laws of the State of Minnesota.

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____
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for
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I. INTRODUCTION

The Red Lake Watershed District commissioned Houston Engineering to evaluate alternative erosion control methods for a reach of the Lost River. The District is proposing this project as a demonstration on the use of emerging technology and innovative approaches toward erosion control, stream stabilization, and water quality improvements.

The project goals are to directly reduce erosion and improve water quality in the Lost River through implementation of erosion control measures in an eroding reach, as well as indirectly improve water quality in the region through education and information on the use of innovative and emerging erosion control methods/technologies.

II. LOCATION

The project site is located on the Lost River within Sections 5 and 6 of Gully Township, Polk County. Figure 1 is an aerial photo of the project location.

Figure 1. Lost River at CSAH 28, Sections 5 and 6 Gully Township[1]

The topography of the river basin in this area is typical of a glacial lake-washed plain. Figure 2 and Figure 3 are maps of the project location and the geomorphic regions of the Red Lake Watershed District.

[1] U.S. Geological Survey, Aerial Photo from May 1991, website: http://terraserver.homeadvisor.msn.com

Figure 2. Project Location

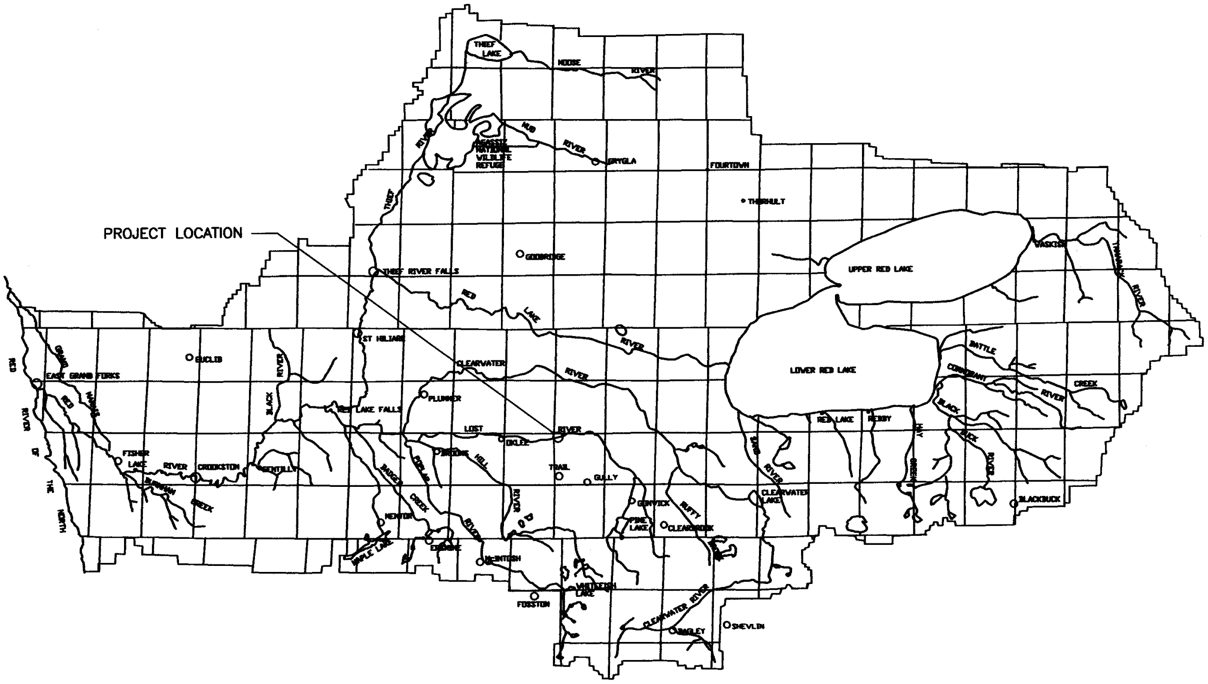
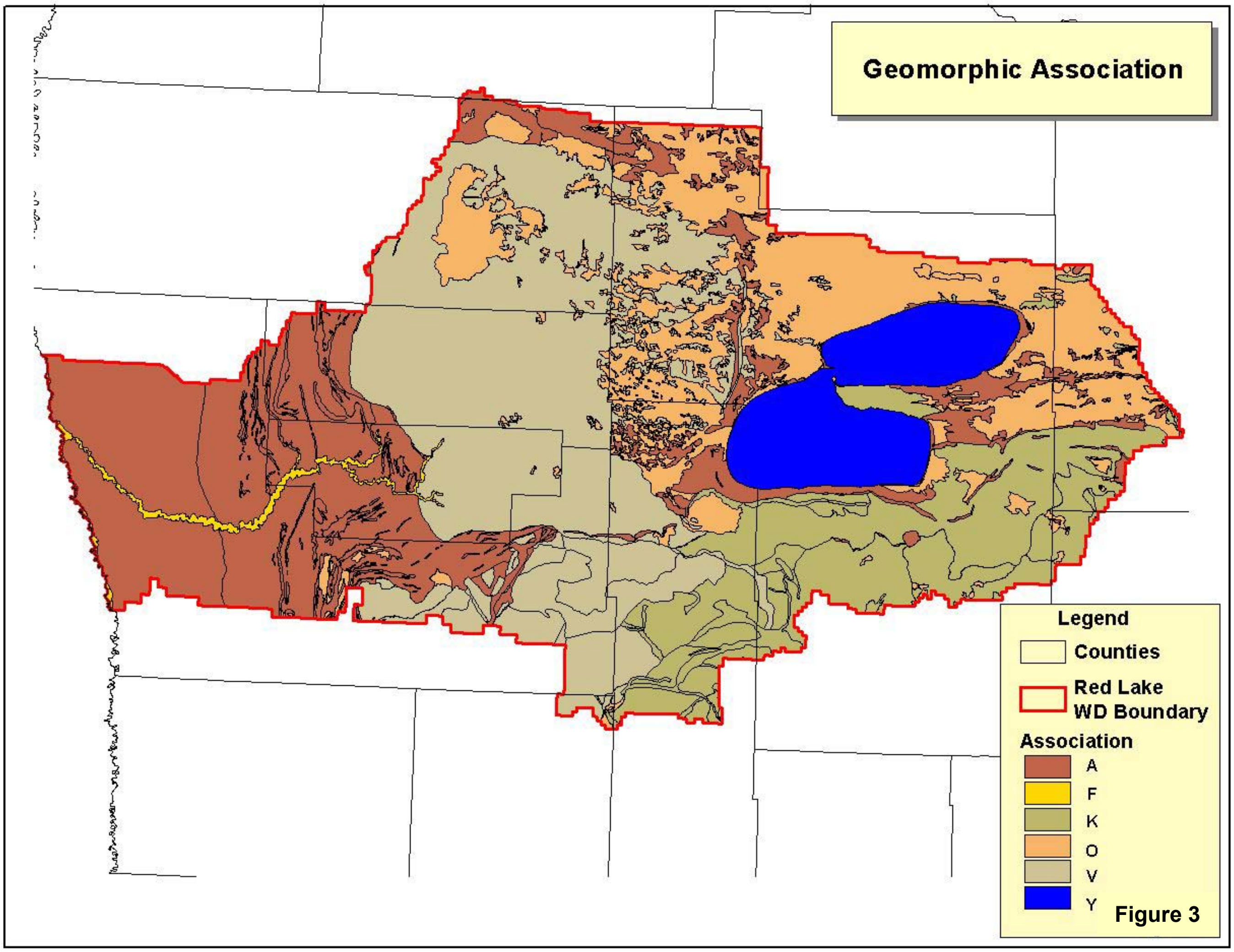


Figure 3. Geomorphic Associations of Red Lake Watershed District

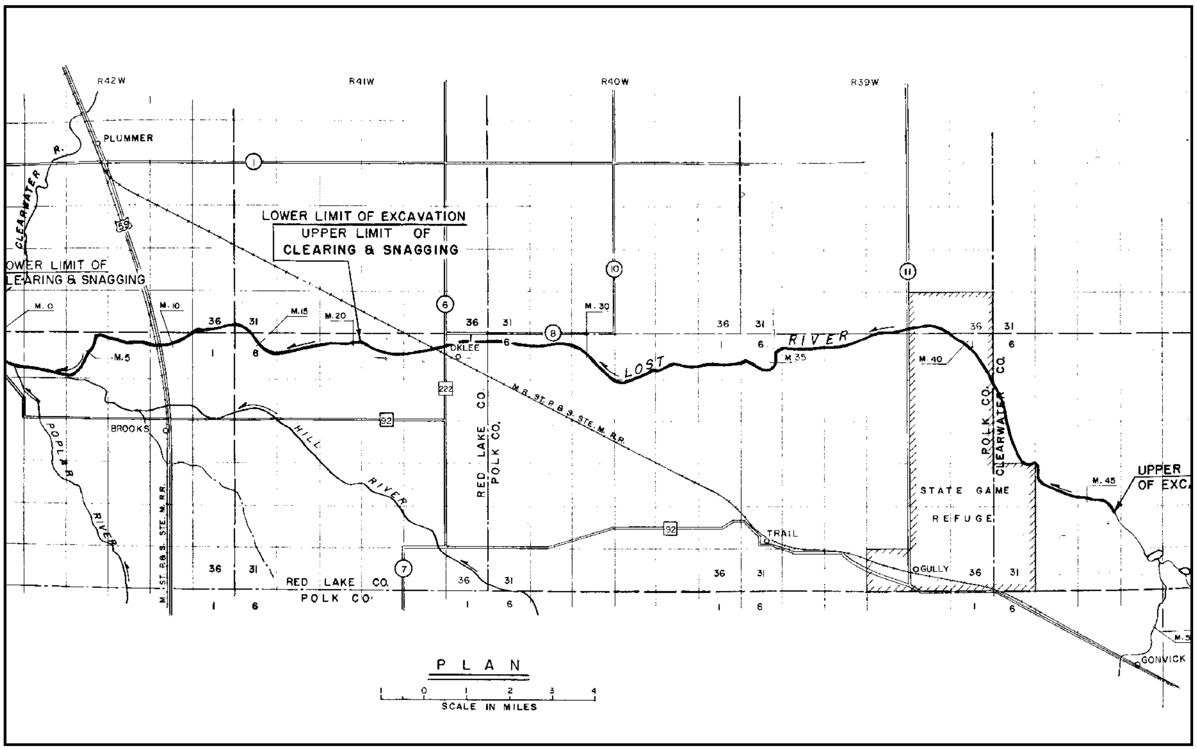


A. Corps Channel Project

In 1965 the U.S. Army Corps of Engineers completed a channel improvement project on the Lost River. The Red Lake Watershed District was the local sponsor. The channel project has the status of a Minnesota Public Drainage System. A benefited area was established as part of the project to allow for construction and maintenance costs to be assessed to benefiting lands. A portion of the original project costs were assessed to the benefited area, and ditch maintenance costs that are incurred are also levied over the benefited area.

The Corps project included clearing and snagging on the lower 20 miles of the Lost River as well as channel work in a reach of approximately 23 miles. The whole project extends from the confluence with the Clearwater River near Brooks to Section 28 of Winsor Township near Gonvick. The clearing and snagging project extended from the river mouth to the west edge of section 3, T150N, R41W Red Lake County. Channel excavation began at this point, river mile 20.25, about two miles west of Oklee. The channel excavation extended 23 miles upstream to river mile 43.3 in the Northeast ¼ of Section 28, T150N, R38W, Clearwater County. Figure 4 is a location map of the Corps project showing the clearing and excavation limits.

Figure 4. Location Map of Corps Flood Control Project on Lost River



The channel design section varied in size along the project reach. A trapezoidal channel was constructed having a bottom width varying from 10 feet to 45 feet, 3:1 sideslopes, and a 20 foot wide berm separating the channel slope from the spoil banks placed along both sides of the channel[2].

The project site is located near the midpoint of the reach of channel excavation at River Mile 32.5, within Sections 5 and 6 of Gully Township, T150N, R39W, Polk County. The site is about 4 ½ miles north of Trail. Table 1 lists the permanent right of way established for the Corps project.

Table 1

Corps Stationing	RLWD 2001 Stationing	Right of way centered on channel
639+90	2+00	
		250 feet
653+20	15+00	
		300 feet
698+00	30+00	

[2] Flood Control Channel Improvement; Local Flood Protection Project, Lost River, Minnesota; U.S. Army Engineer District, St. Paul; Corps of Engineers, July 1963.

III. SURVEY

The Lost River channel in the project area was surveyed in November 2001 by the Red Lake Watershed District survey crew. The channel alignment, bottom profile and cross-sections were measured within a reach of approximately 3000 feet. Figure 5 is an aerial photo of the site showing the approximate survey extents. Appendix A includes the plotted cross-sections and channel profile.

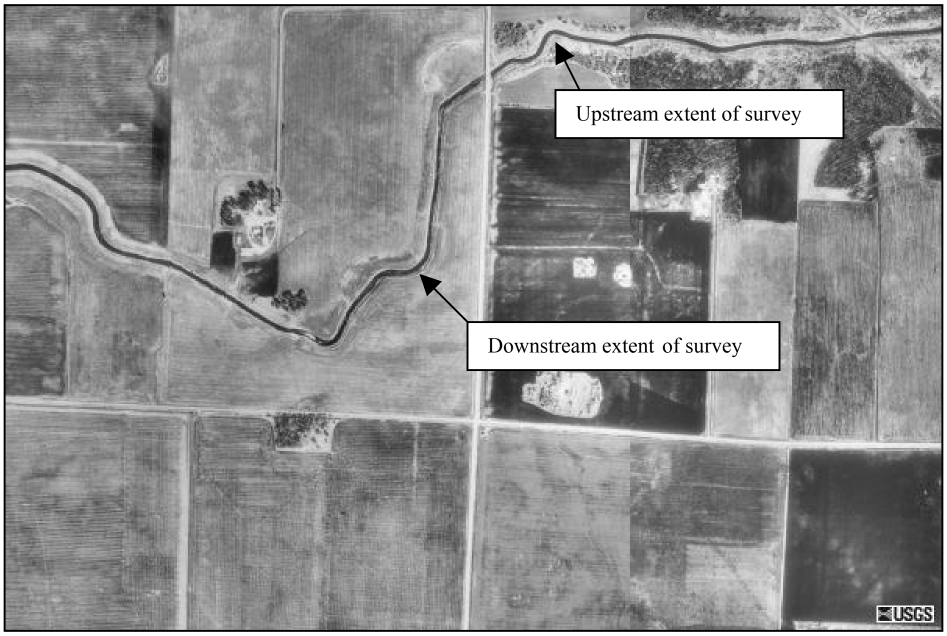
Survey Benchmark: The survey was based on a benchmark described as:

> *Chiseled "X" on top of concrete curb, S.E. corner of C.S.A.H. 28 bridge over Lost River, Elevation = 1156.05, Datum of 1929.*

We compared bridge and channel elevations to those shown on the Corps' Local Flood Protection Project plans dated July 1963, as well as the Polk County Highway Department plans for the bridge on CSAH 28. Both the Corps project and the Bridge plans are in mean sea level datum of 1912. The conversion to RLWD Datum is:

$$\text{RLWD}_{\textit{in 1929 Datum}} = \text{Corps}_{\textit{in 1912 Datum}} - 5 \text{ feet.}$$

Figure 5. Lost River at CSAH 28, Sections 5 and 6 Gully Township



IV. HYDROLOGY

The drainage area of the Lost River is approximately 159 square miles at the project site. A drainage area transfer method was used to determine flow versus frequency relations at the project site, based upon the published flow data from the USGS gauging station on the Lost River at Oklee. Table 2 provides the flow-frequency data published for the Oklee gauging station and calculated for the project site.

Table 2

Recurrence Interval	Lost River at Oklee: Peak Flow[3]	Lost River at Section 6 Gully Township: Peak Flow (by drainage area transfer method)
1.05-yr	318	233
1.11-yr	437	320
1.25-yr	632	463
2-yr	1200	879
5-yr	2130	1552
10-yr	2800	2038
25-yr	3660	2665
50-yr	4310	3143
100-yr	4950	3614
Drainage Area (sq. mi.)	254	159.4

A. Hydraulics

The Army Corps of Engineers' River Analysis System (HEC-RAS) step-backwater computer program[4] was used to complete the channel and bridge hydraulic analyses. This program uses the channel geometry, channel roughness coefficients, and bridge information, to determine the water surface elevations corresponding to the flow rates of interest. The model was started with input tail water levels determined for normal depth with an energy slope of .00033.

[3] High-Streamflow Statistics of Selected Streams in the Red River of the North Basin, ND, MN, SD, and Manitoba; U.S. Geological Survey Open File Report 00-344
[4] U.S. Army Corps of Engineers HEC-RAS River Analysis System Hydrologic Engineering Center Davis CA Version 2, April 1997.

Channel and overbank Manning friction factors were assumed to be .03 and .05, respectively.

The model was checked by comparing the computed water surface profile to that observed during the survey of the channel in November of 2001. The flow at the project site was estimated in relation to the flow recorded at the USGS gauging station at Oklee (by drainage area transfer method). Figure 6 is a hydrograph showing flows recorded at the Oklee gauging station in late fall 2001, and showing flows estimated at the project site. The simulated water surface profile closely matched the water surface recorded by the RLWD survey crew. Figure 7 is a profile drawing showing the channel bottom within the study reach as well as the observed water surface elevations and the computed water surface profile. Figure 8 is a profile drawing showing the computed water surface profiles for a range of floods from the 1.25-year to the 100-year events.

Figure 6. Flows during RLWD Survey

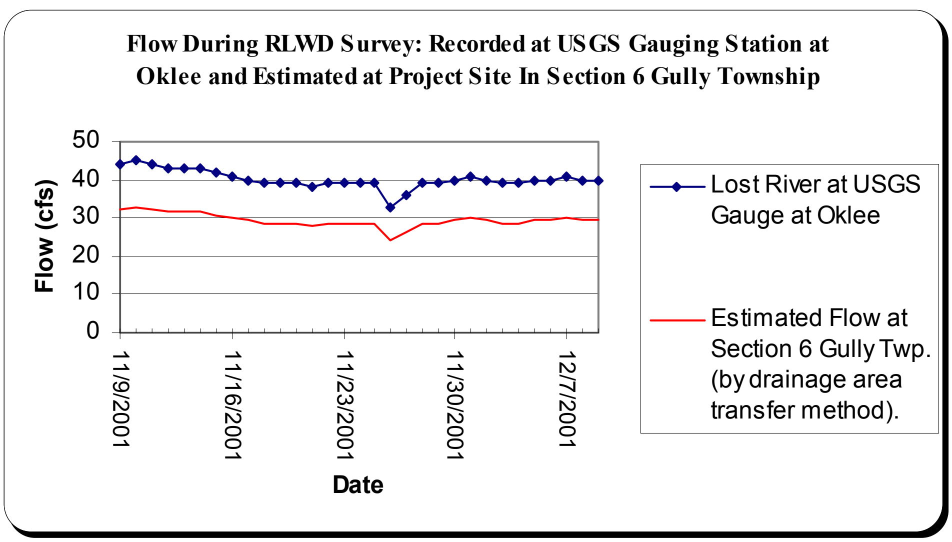


Figure 7. Hydraulic Model Verification

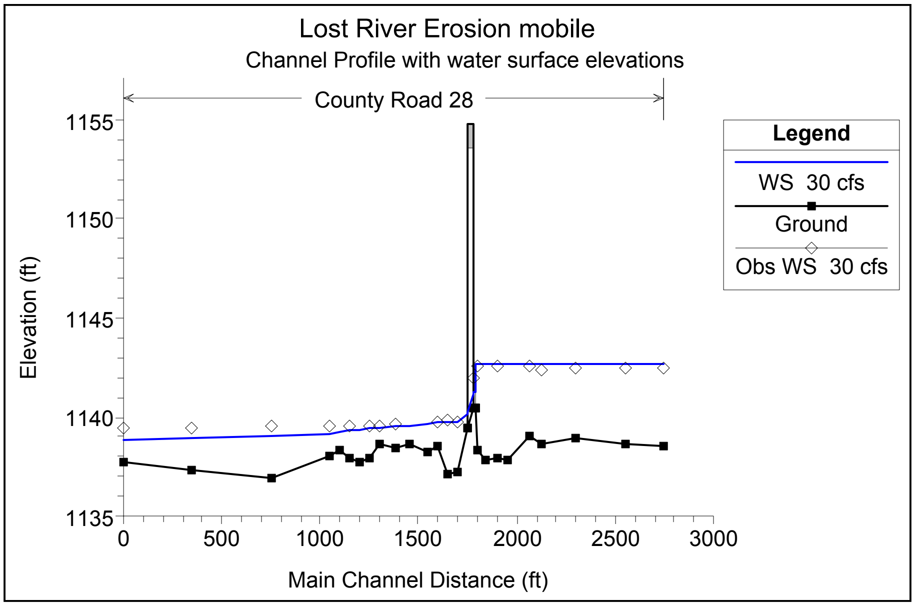
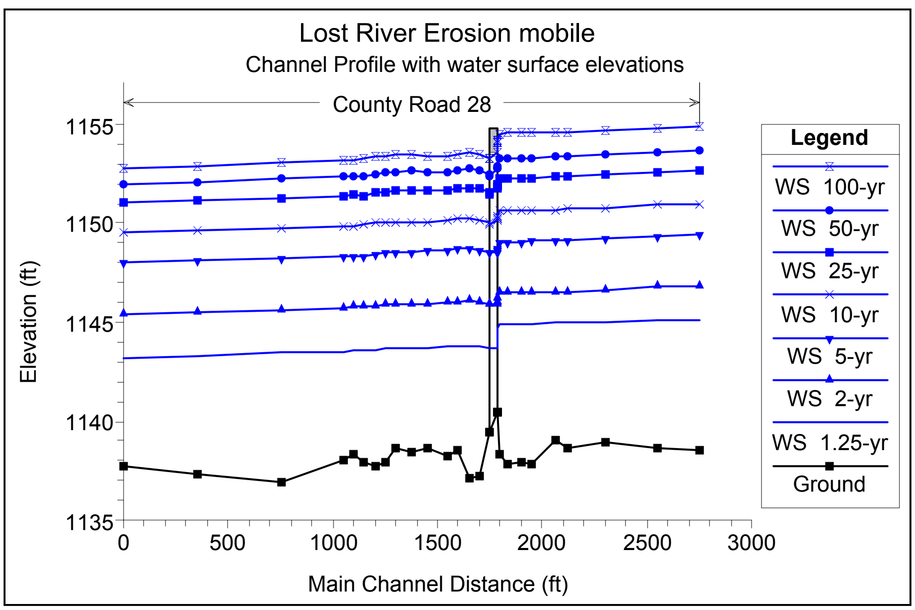


Figure 8. Water Surface Profile



B. Channel Capacity

The Corps project design capacity within Section 6 of Gully Township transitioned from 610 cfs upstream of CSAH 28 to 830 cfs downstream from CSAH 28.[5] The design water surface elevation of 1152.7 feet (1912 datum) at the highway bridge is equivalent to 1147.7 feet (1929 datum). The design flow of 830 cfs is approximately a two-year peak flow rate according to the recent hydrologic analysis. The two-year peak water surface elevation at the highway bridge is 1146.0 (1929 datum). The 5-year flow of 1552 cfs would result in a channel water surface elevation of approximately 1148.7. The Corps design water surface elevation of 1147.7 feet has a present day capacity of 1300 cfs and a recurrence interval of approximately 3.3 years.

C. Channel Profile Changes Over Time

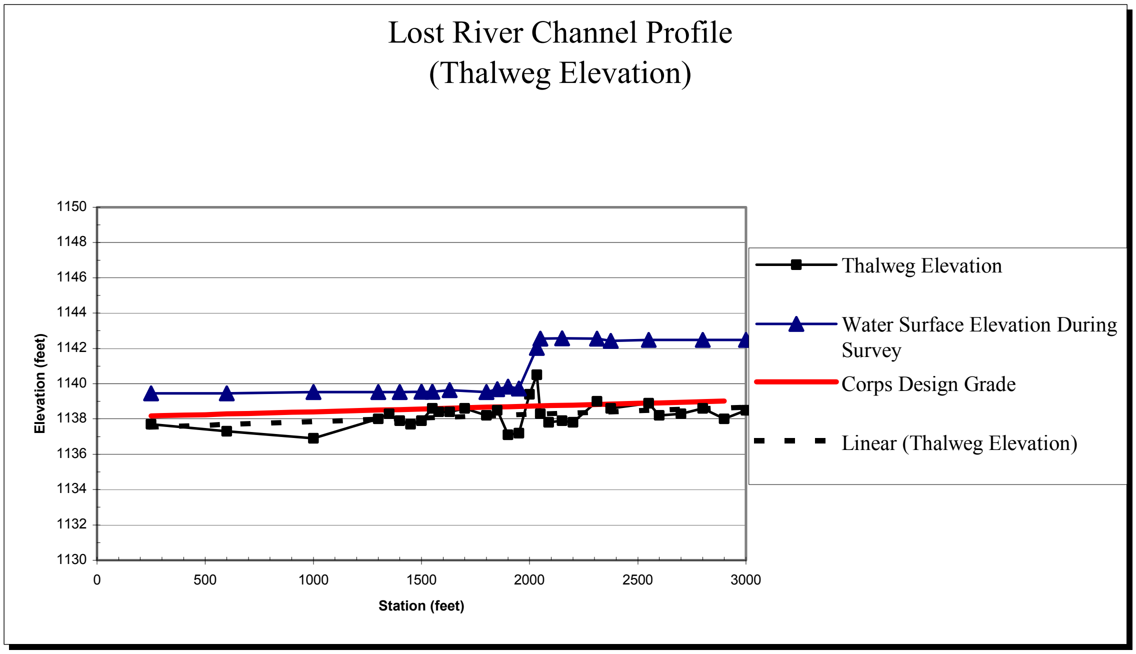
The Corps channel work lowered the bottom profile of the Lost River by approximately 4 feet in the project area. The difference in river bottom profile (pre- and post- construction) varied from about 3 feet to 5 feet. We determined the datum adjustment necessary to convert the Corps plans to current datum. The following equation is appropriate for converting between the various datums:

$$\text{RLWD}_{\textit{in 1929 Datum}} = \text{Corps}_{\textit{in 1912 Datum}} - 5 \text{ feet.}$$

The Corps used a design grade of .033% through the reach including Section 6 of Gully Township. The recent survey shows that the channel bottom profile fluctuates, but generally follows a slope of .039%. Figure 9 is a channel profile drawing showing the existing channel profile, the Corps design profile and the water surface profile observed during the 2001 survey. The existing channel bottom is very near to the design grade line set by the Corps.

[5] General Design Memorandum, Flood Control and Major Drainage; Lost River, Minnesota; U.S. Army Engineer District, St. Paul; Corps of Engineers, March 1960

Figure 9. Lost River Profile Drawing



D. Channel Cross-Section Changes Over Time

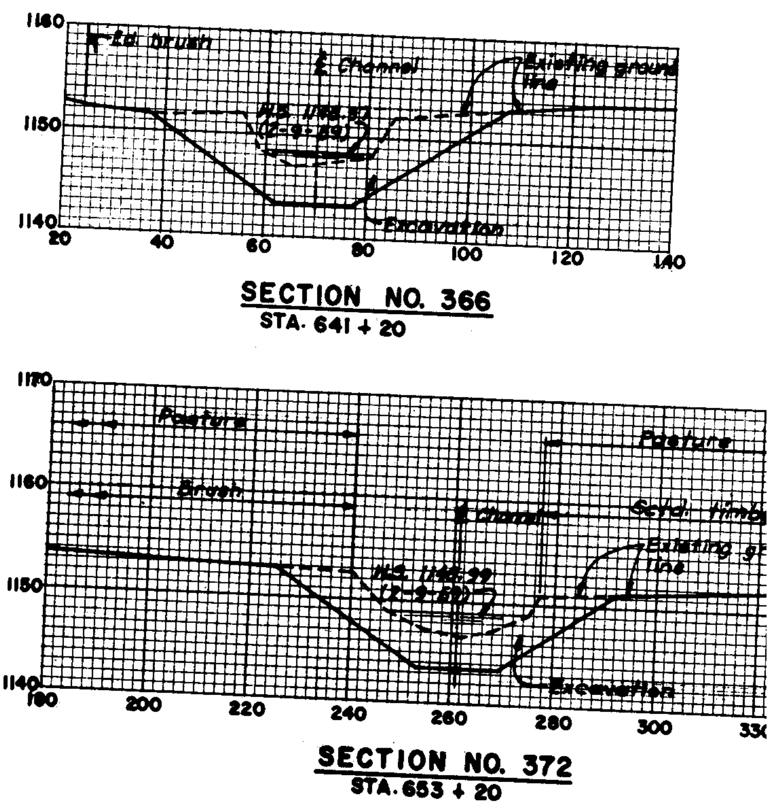
Figure 10 and 11 show the Corps design cross section overlaid upon the 1959 Lost River channel cross section. Figure 12 shows the Lost River channel section in 1959, the Corps Design Channel section and Lost River cross-sections in 2001.

It is interesting to note, however, that the channel has adjusted to form a shape similar to that in 1959--despite the construction work to create a trapezoidal channel with 15-foot bottom width and 3:1 side slopes. The channel bottom width has widened beyond the design 15-foot width, and the side slopes have become steeper than the constructed slopes of 3:1 (horizontal to vertical).

The old channel (pre-Corps) appeared to have a bank-full width of approximately 30 feet and a bank full depth of approximately 5 feet. The old channel also had an extensive flood plain. Once the flow depth exceeded the old bank-full depth, flow could spread out over the relatively flat floodplain along the channel.

Many of the current cross-sections have similar geometric dimensions to the pre-Corps channel, at least in the region below the floodplain bench. The floodplain bench that is forming currently is narrow and flood flows are essentially confined within the channel. While this may be good from a flood control perspective, it generally results in higher shear stresses and velocities than would develop if floods were spread over a wider floodplain rather than contained within an entrenched channel.

Figure 10. Corps Design Cross-Section Overlaid upon the 1959 Lost River Channel Cross-Section



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Flood Control Channel Improvement; Local Flood Protection Project, Lost River, Minnesota; U.S. Army Engineer District, St. Paul; Corps of Engineers, July 1963

Figure 11. Corps Design Cross-Section Overlaid upon the 1959 Lost River Channel Cross-Section.

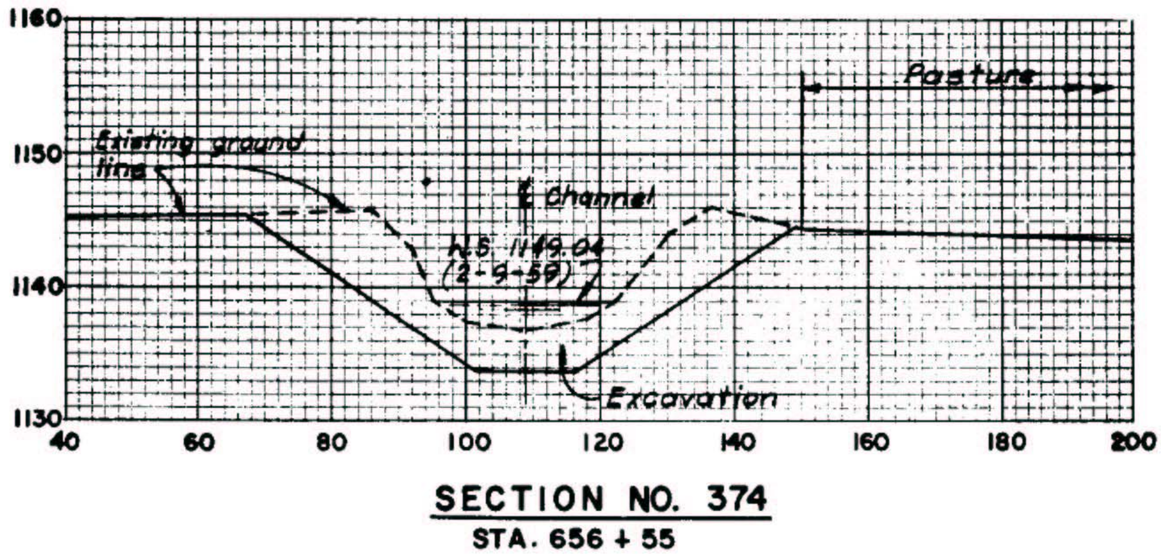
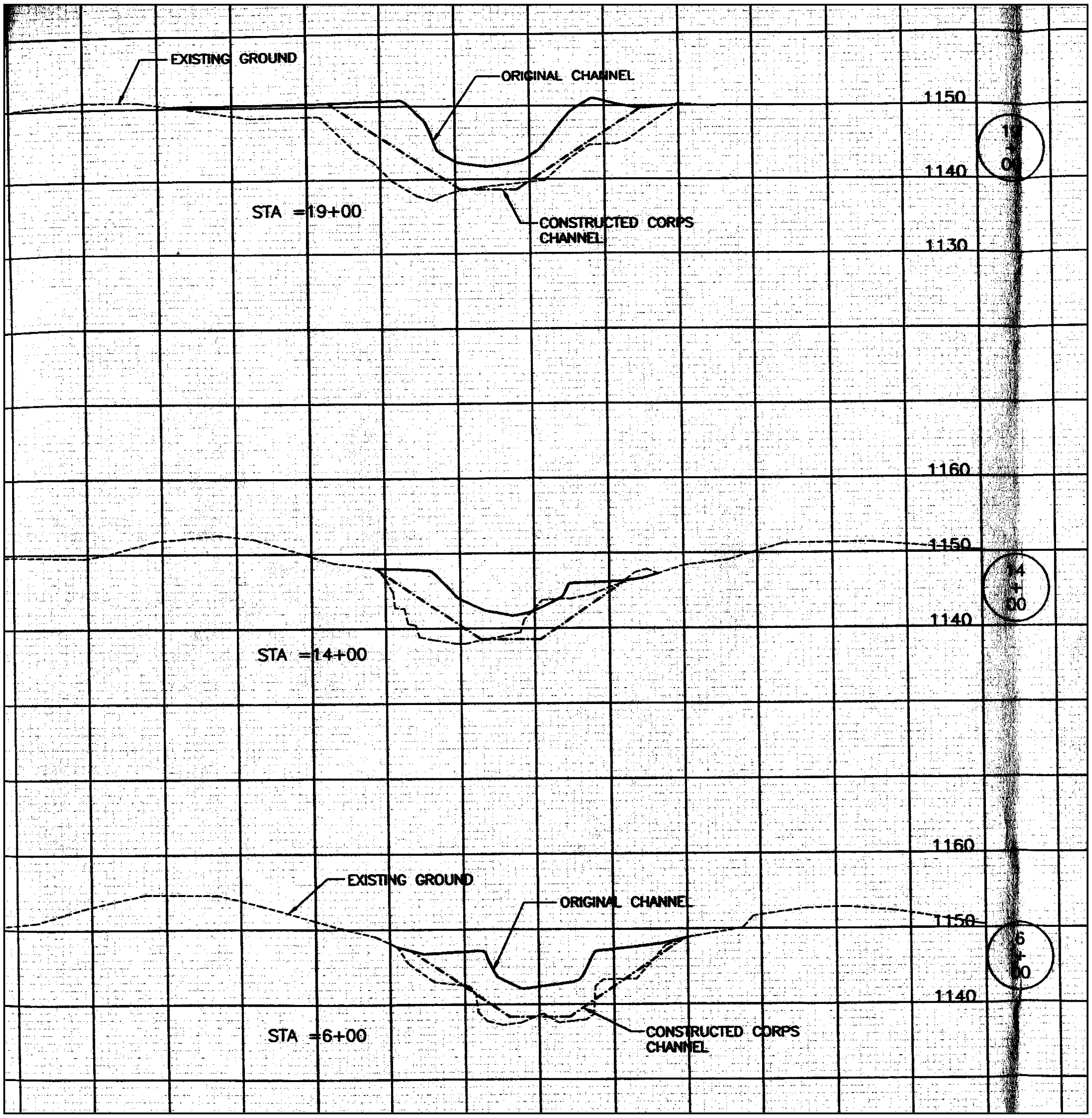


Figure 12. Lost River Channel Section in 1959, the Corps Design Channel Section and Lost River Cross-Sections in 2001

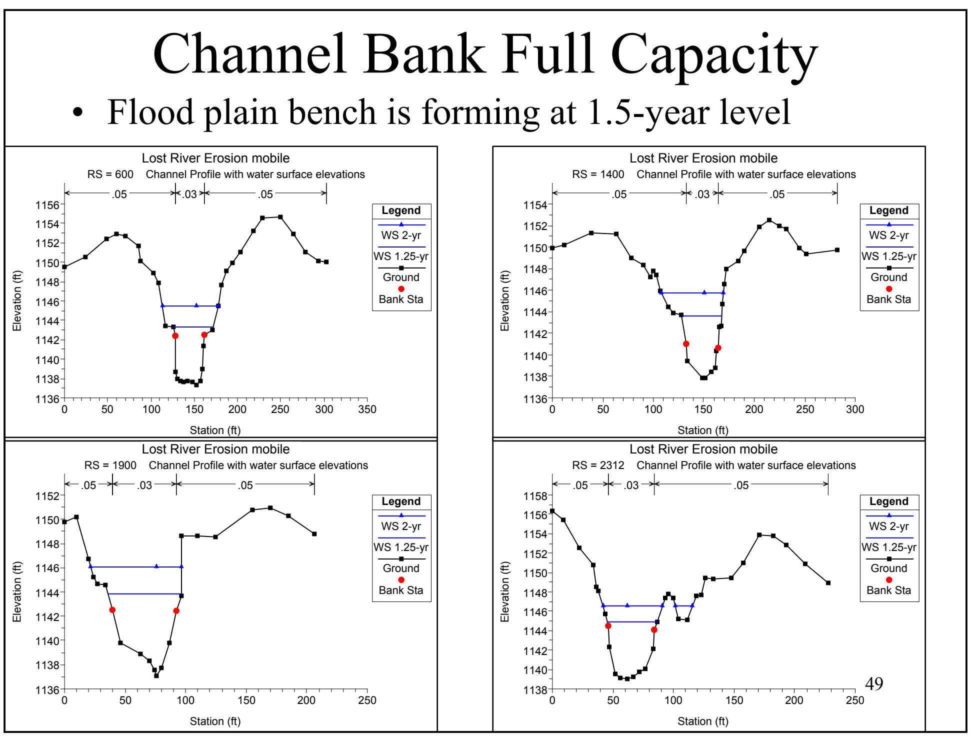


E. Channel Bank - Full Capacity

River and stream channels form with capacity to transport the flow and sediment from their watersheds. The bank-full capacity is defined as the channel forming or channel maintaining flow. For most rivers and streams the recurrence interval of the bank-full flow is 1.5 years[6]. Figure 13 shows channel cross sections with water surface profiles for the 1.25-year and 2-year recurrence peak flows. Inspection of the cross sections indicates that channel erosion and sediment deposition is forming a floodplain bench at the approximate elevation of the 1.5-year peak flow.

The two-year recurrence interval peak flow is estimated to be 880 cfs. The 1.5 to 2 year recurrence interval flows are generally considered to be the channel forming flows. Natural stream channels evolve to carry flows of this general magnitude within their banks, while higher flows are carried by both the channel and adjacent floodplain.

Figure 13. Channel Cross-Sections



[6] Water, Rivers and Creeks, Luna B. Leopold, 1997 p. 84

V. STREAM CLASSIFICATION

Rivers and streams can be classified using measurements and descriptions of the stream cross-section, meander pattern, bottom profile, and bed materials. "The fundamental components of river morphology are its dimension, pattern, and profile. These components represent the integrated response of a river that enables it to be in balance with the prevailing energy gradients, sediment supply and sediment transport characteristics[7]."

Table 3 presents a summary of channel characteristics using the Rosgen stream classification method.

Table 3

	2001 Channel Station 23+75	2001 Channel Station 18+50
Bankfull Elevation	1147.2 by field observation *(1145 to 1146.6 by Hydraulics)*	1143 by field observation *(1143.8 to 1146.1 by Hydraulics)*
Bankfull Width	52	61
Bankfull Mean Depth	7.15	3.6
Floodplain Width	193	80
Entrenchment Ratio (Floodplain/Bankfull)	3.7	1.3
Width/Depth Ratio	7.3	17
Sinuosity (stream length/ valley length)		
Slope	.0004	.0004
Bed material	Inorganic clay (sandy)	Inorganic clay (sandy)
Rosgen Classification	E6	F6

[7] D. Rosgen, Applied River Morphology, 1996

VI. PROBLEM DESCRIPTION

The Lost River in the project reach is actively eroding.

- A scour hole has formed immediately downstream from the CSAH 28 Bridge. A rock pile and beaver dam in the bridge opening raise the water level upstream. A scour hole has formed where the flow exits the bridge opening.
- Additional problems immediately downstream of the bridge are severe bank erosion on the right descending bank and formation of a point bar on the left bank. The flow direction appears to shift at the bridge so that the river is directed into the right bank—causing a lot of bank erosion immediately downstream from the bridge.
- The channel banks are eroding around the outside of most of the meanders within the project reach. Point bars and floodplain deposits are noticeable along much of the reach on the side opposite to the eroding bends.
- The channel banks are slumping in some areas where erosion of the toe of the slope appears to have lead to slope stability problems.

Head cutting does not appear to be a problem, since the existing channel bottom profile appears to be similar to the Corps design channel.

A. Allowable Velocity and Tractive Force

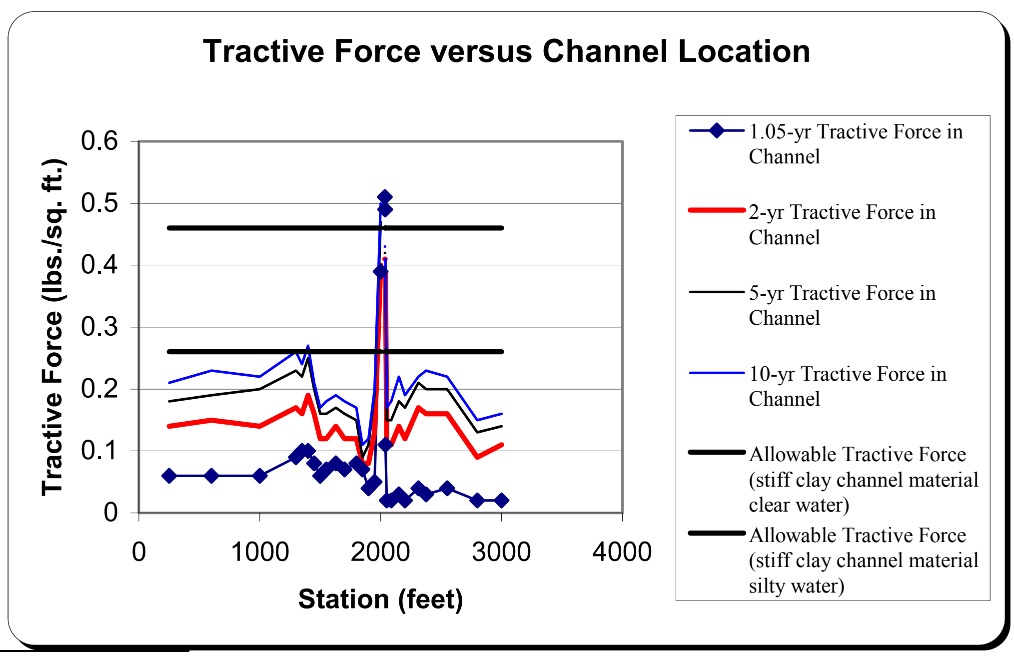
Table 4 lists allowable tractive forces and velocities for a number of channel materials. For a given soil material, flow in the channel that exceeds the allowable velocity or tractive forces will be erosive. Figures 14 and 15 are graphs showing the channel velocity and tractive force versus location for flood magnitudes ranging from 1.05-year to 10-year recurrence intervals. A range of allowable velocities and tractive forces have been shown in each figure for a channel in clay material. Most of the project reach will have flows within the allowable velocity and tractive force ranges—except within the bridge section.

Both velocity and tractive force will be in the erosive range within the bridge section. Since the channel is armored with riprap within the bridge, erosion will probably not occur at the bridge location, but will likely occur immediately downstream. The scour hole that has developed downstream from the bridge has likely resulted from erosive forces and velocities generated due to the rock pile/beaver dam and the channel constriction at the bridge.

Table 4
Allowable Tractive Force And Velocity[8]

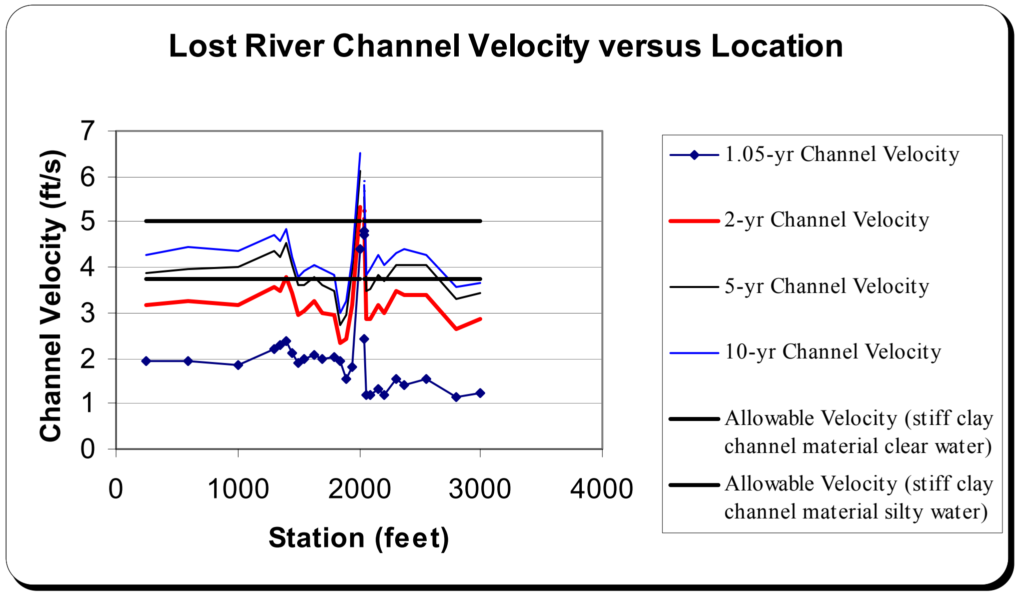
Channel Material	Allowable Tractive Force (lbs./sq.ft. clear water)	Allowable Tractive Force (lbs./sq.ft. silty water)	Allowable Velocity (ft./s. clear water)	Allowable Velocity (ft./s. silty water)
Sandy loam non-colloidal	0.037	0.075	1.75	2.50
Ordinary firm loam	0.075	0.150	2.50	3.50
Fine gravel	0.075	0.320	2.50	5.00
Stiff Clay	**0.260**	**0.460**	**3.75**	**5.00**
Shale and hardpan	0.670	0.670	6.00	6.00
Graded silts to cobbles colloidal	0.430	0.800	4.00	5.50

Figure 14. Channel Velocity and Tractive Force Versus Location for Flood Magnitudes



[8] Open Channel Hydraulics, Chow, Table 7-3, 1959

Figure 15. Channel Velocity and Tractive Force Versus Location for Flood Magnitudes



B. <u>Alternatives</u>

The District is proposing this project as a demonstration on the use of emerging technology and innovative approaches toward erosion control, stream stabilization, and water quality improvements. The project goals are to directly reduce erosion and improve water quality in the Lost River through implementation of erosion control measures in an eroding reach, as well as indirectly improve water quality in the region through education and information on the use of innovative and emerging erosion control methods/technologies.

Three broad options are available for consideration. These options include structural and non-structural solutions as well as the option to do nothing.

- Do Nothing. Let nature take its course.
  - •See what happens and fix problems later if/when they develop.
  - •Do Nothing Period!
- Non-structural
  - •Reduce runoff volume in basin
  - •Reduce runoff rate in basin

- Structural
    - •Remove rock and beaver dam from bridge
    - •Remove sand bars
    - •Ditch maintenance…remove sediment deposits, re-straighten channel
    - •Direct flow away from eroding banks
    - •Armour the channel banks
        - –Concrete liner
        - –Rock, gabions or cable-concrete etc
        - –Composite channel liners, rock and vegetation for example
        - –Vegetative lining.
    - •Construct and/or enlarge the floodplain bench to accelerate the natural process that is underway
    - •Build stable channel, predict ultimate equilibrium state and build it now. Increase channel length, reduce grade, and increase cross sectional area of floodplain bench.
    - •Adjust (raise) the channel bottom elevation

1. Do Nothing

The "No Build" alternative should always be considered. Doing nothing is a reasonable alternative in some cases. Doing nothing has no up front project costs, but doesn't reduce the risk of future problems. If the Lost River is not stabilized in the project area, the potential for continuing erosion remains.

The existing channel in the project reach is an "F6." This channel has a generally flat bottom, nearly vertical side slopes, and banks that are eroding and slumping. The probable future conditions, with the no build option, are continuing erosion in the project reach. The channel will likely continue eroding the outside bends—particularly where the flow is directed into the bank just downstream of the bridge. The width of the high flow channel may increase as the river continues to create a floodplain bench, and the width of low flow channel may decrease as sediment deposition builds point bars and floodplain benches and continues to narrow the low flow section. The elevation of the channel bottom has not changed much since the Corps project and may remain at similar depth and profile.

The "do nothing" alternative does not improve water quality nor demonstrate erosion control technologies, so it does not satisfy the project goals.

2. Non-structural Techniques to Reduce the Rate or Volume of Runoff

Non-structural techniques to reduce the rate of runoff generally include land use changes that slow the flow of water from the watershed. These changes include actions such as changes in tillage practice, changes from row crops to hay or pasture, and restorations of channelized waterways. Techniques to reduce the volume of runoff include many similar tillage and land use changes—actions that promote infiltration and/or evapotranspiration and reduce the volume of storm runoff. Since large-scale land use changes are outside of the scope of this project, techniques to reduce runoff rate or volume are not feasible alternatives for solving the project goals.

3. Structural Alternatives

A number of structural alternatives can be considered for stabilizing the Lost River within the project reach. The following list provides a general description of the desired result and a list of alternatives that may be considered for use.

The goals of the structural alternatives are to stabilize the banks, reduce lateral erosion, and maintain the channel profile (avoiding downcutting or aggradation). Techniques to achieve these goals could be applied separately or in combination.

Reducing bank stress is desired to prevent further erosion of the channel banks—particularly on the outside banks of meanders. The channel is entrenched, so that flood flows are contained within a relatively small channel. Left unaddressed, the riverbanks will continue to erode in response to high bank stresses.

The reduction of lateral movement is desired to prevent excessive erosion of the channel banks—particularly on the right bank just downstream from the bridge. Bank erosion and lateral migration is a natural channel process. Our desire is to prevent excessive or accelerated erosion and migration, restoring a general balance to the river.

Grade control methods can be used to either maintain the existing channel profile, or restore the stream channel at a higher elevation and milder grade. Restoring the stream at a higher elevation may have additional stabilizing benefits by reducing the entrenchment of the channel and restoring the previously formed floodplain.

Reduce Bank Stresses:

- Restore flow to old floodplain by raising channel flowline
- Create new floodplain at a level consistent with the current channel flowline
- Widen stream…increasing flow area while reducing depth, velocity and tractive force
- Lengthen meanders to reduce the slope, velocity and tractive forces and evenly dissipate the river's energy throughout the reach..

Typical Methods To Improve Slope Stability:

- Re-excavate slopes to flatten them out. Excavation removes existing vegetation, so vegetation needs to be restored as well.
- Protect the toe of the slope from erosion, so slope failures and slumping are reduced
- Reduce soil pore water pressures by installing a seepage collection system (tile or gravel filter)

Typical Methods To Redirect Streamflow

- Direct flow away from eroding banks using excavation, deflectors, vanes and/or weirs.

Remove Beaver Dam and Rock Pile below Bridge:

- The flow depth is increased upstream of the bridge by the rock pile and beaver dam. Erosion is caused downstream of the bridge as the built-up energy is dissipated. Removing the rock and beaver dam will reduce the erosive energy of the flow below the bridge. Removing the beaver dam may have negative effects upstream, since the impounded water may be beneficial in reducing erosion, upstream of the dam, by reducing flow velocity and adding support to the channel banks. The impounded water may also provide stream habitat.

Typical Methods To Reduce Lateral Erosion:

- Shape Banks
  - Cut steep banks to improve stability (may not reduce channel erosion)
  - Fill banks above toe protection measures such as root wads, trees and rocks
- Armor Banks
  - Rock riprap
  - Concrete, sheet piling
  - Trees, logs, root wads
  - Vegetation
  - Wattles, fascines, brush mats, etc

Typical Grade Control Methods:

- Hard points (e.g. constructed rock riffles)
- Drop Structures or dams
- Rock vanes or weir

4. Recommended Alternatives

The problems, project goals and potential solutions were discussed during a meeting with the Red Lake Watershed District Board and staff on September 26, 2002. The following actions were recommended by the engineer and affirmed by the Board.

- Remove point bars at 20+25 R, 19+00 L and 14+50 L
- Install rock riffle/cross vane weir at 19+00 to direct flow away from bank
- Install rock vanes at 14+50 to direct flow away from bank
- Retain rocks under bridge, and beaver dam
- Retain vegetation on outside meander banks rather than reshaping.

5. Recommended Alternatives Meet Project Goals

The recommended alternatives will reduce erosion in the project reach. Using vanes and weirs to redirect the flow of the river is an emerging technology. Vanes work with the river to reduce bank erosion with less rock than would be required to armor the banks and also provide better habitat and a more natural appearance than a riprap armoring project.

6. Plans and Specifications

Houston Engineering has prepared plans and specifications for construction of the erosion control measures, and will assist the RLWD in construction observation efforts. The construction plans and specifications are attached to this report as Appendix A. The plans include drawings of the channel profile and cross sections as well as excavation areas and typical sections of the proposed vanes.

VII. OPINION OF PROBABLE COST

Table 5 is the Opinion of Probable Cost for the construction work shown on the plans and specifications.

Table 5

ENGINEER'S OPINION OF PROBABLE COST						
Lost River Erosion Control Project						
Base Quote						
Item No.	Spec. No.	Description	Unit	Qty	Unit Price	Total
1	2563.601	Traffic Control	l.s.	1	$1,000.00	$1,000.00
2	2021.501	Mobilization	l.s.	1	1,000.00	1,000.00
3	2123.509	Dozer	hour	4	90.00	360.00
4	2123.610	2.5 C.Y. Backhoe	hour	10	125.00	1,250.00
5	2511.501	Random Riprap, Class IV	cu.yd.	335	50.00	16,750.00
6	2573.502	Silt Fence, Type Preassembled	lin. ft.	100	3.00	300.00
7	2573.505	Floating Silt Curtain, Type Moving Water, 3'	lin. ft.	80	18.00	1,440.00
8	2575.501	Seeding	acre	0.5	200.00	100.00
9	2575.502	Seed, Mixture 1	lb.	24	3.00	75.00
10	2575.523	Erosion Control Blanket, Category 4	sq. yd.	163	3.00	489.00
		Total Quote Base Bid				**$22,764.00**
Bendway Weir Option						
11	2123.509	Dozer	hour	2	$90.00	$180.00
12	2123.610	2.5 C.Y. Backhoe	hour	5	125.00	625.00
13	2511.501	Random Riprap, Class IV	cu.yd.	162	50.00	8,100.00
14	2573.502	Silt Fence, Type Preassembled	lin. ft.	50	3.00	150.00
15	2575.523	Erosion Control Blanket, Category 4	sq. yd.	107	3.00	321.00
		Subtotal Quote Option				**$9,376.00**
		Total Quote Base Bid Plus Bendway Weir Option				**$32,140.00**

A. Funding Sources

Project funding sources include an EPA 319 Grant (50%) and local matching funds (50%). The local matching funds will be supplied by the Red Lake

Watershed District Clearwater Nonpoint Funds (Administrative Construction account). Ditch funds will not be used, and no special assessments are planned. No other local or state funds are slated for this project.

B. Permits and Approvals

The following agencies may have project review and permit authority.

- US Army Corps of Engineers, Section 404
- DNR Protected Waters
- Minnesota Wetlands Conservation Act
- MPCA NPDES Construction Permit and Erosion Control Plan
- Red Lake Watershed District and Army Corps: Lost River Flood Control Project
- Polk County Highway Department: C.S.A.H. 28 right of way

Appendix B includes copies of the joint notification permit form i.e. the Minnesota Local/State/Federal Application Form for Water/Wetland Projects. This form will be submitted by the RLWD to the Corps of Engineers, the Minnesota DNR and the East Polk County SWCD.

The area disturbed by this project will be less than 1 acre, so neither a Phase I nor Phase II Storm Water Permit for construction activity is required.

Richard Sanders, Polk County Engineer, stated that work within the river banks does not require a right-of-way permit from Polk County.

VIII. MONITORING PLAN

A monitoring program will be implemented to assess the success of the work at the Lost River erosion site. Monitoring will include a combination of assessments. Physical assessments will include measuring channel profiles and cross sections over time from established monuments and benchmarks. Photo records will also be collected, at each successive inspection, using established photo reference points. Biologic assessments will include measuring the type and abundance of vegetation along established transects. Short-term monitoring activities are planned to continue for five years to document the success (or failure) of the project measures. Reference points and benchmarks will remain into the indefinite future allowing continuing monitoring opportunities. A description of the monitoring plan procedures is included in Appendix C. Baseline data and photographs are also included in the Appendix.