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CONCEPTUAL DESIGNS

Submitted to:
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Milk River, Alberta

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Calgary, Alberta

May 2010
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Future components of the project that are required for the selected site and are not part of this study include:

- Aquatic Environmental Assessment;
- Permit/approval applications, advertising and liaison with regulatory agencies;
- Tendering services (tender package preparation, contractor selection, etc.); and,
- Construction services (inspection, materials testing, fish salvage, turbidity monitoring, construction surveys, as-built reporting, etc.).

The three sites identified by the MRWCC are listed below and their locations are shown on Figure 1 and also on the conceptual drawings contained in Appendix A.

- Site 1 – North Fork Milk River – Hilmer Bridge, Cardston County, NE 10-2-21 W4M;
- Site 2 – Milk River – Weir Bridge, County of Warner, SE 8-2-13 W4M; and,
- Site 3 – Milk River – Gold Springs Park, County of Warner, NE 6-2-15 W4M.
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Figure 1

Legend
- Milk River Watershed
- National/Provincial Park
- Rural Municipality
- Water
- Road
- Canal
- Town
- Candidate Streambank Stabilization Site
2.0 SITE DESCRIPTION AND HISTORIC CHANNEL MOVEMENT

A general description of the reach in which the three sites are located is provided in this section. Site specific characteristics and historic channel movement at the three sites are also discussed. Site photographs are included on the drawings contained in Appendix A. Appendix B contains the 1915 survey by Peters which shows pre-diversion conditions such as channel location, width as well as vegetation and soils information.

2.1 General Reach Characteristics

Table 2.1 lists the general reach characteristics for the North Milk River, where the Hilmer Bridge site is located and for the Milk River Gravel Bed Reach, where the Weir Bridge and Gold Springs Park sites are located. In comparison to the North Fork, the Milk River Gravel Bed Reach has a considerably larger channel, flatter gradient and smaller sediment size.

<table>
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<tr>
<th></th>
<th>North Milk River</th>
<th>Milk River Gravel Bed Reach</th>
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<tr>
<td>Depth¹ (m)</td>
<td>2.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Width (m)</td>
<td>26 to 53 mean 33</td>
<td>45 to 85 mean 59</td>
</tr>
<tr>
<td>Slope (m/m)</td>
<td>0.0035</td>
<td>0.0013 to 0.0019</td>
</tr>
<tr>
<td>Q₁:₂ year (m³/s)</td>
<td>24.8</td>
<td>57.6</td>
</tr>
<tr>
<td>Q₁:100 year (m³/s)</td>
<td>100</td>
<td>282</td>
</tr>
<tr>
<td>Median Annual (50% exceedance) Discharge (m³/s)</td>
<td>12.6</td>
<td>15.8</td>
</tr>
<tr>
<td>20% exceedance Discharge² (m³/s)</td>
<td>18.2</td>
<td>20.2</td>
</tr>
<tr>
<td>Surface Gradation D₅₀ (mm)</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>Sub-Surface Gradation D₅₀ (mm)</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>Daily Mean Suspended Sediment³ (mg/L)</td>
<td>49.0</td>
<td>72.5</td>
</tr>
</tbody>
</table>

Notes:
1. Depth is equivalent to maximum channel depth; it is measured from the top-of-bank to the channel thalweg (minimum streambed elevation).
2. The 20% exceedance discharge provides some indication of the higher range of diversion discharges. These discharges are equaled or exceeded 49 days of the year.
3. Daily Mean Suspended Sediment Concentration is based on Water Survey of Canada measurements.

AMEC (February 2008) contains the following description of the North Milk River:

“Prior to the diversion the North Milk River had an irregular, confined meander pattern and displayed alternating pools and riffles. The channel was composed of gravel and sand and the banks were described as predominantly sandy loam (Peters, 1910). Abandoned meander scars on the floodplain indicate that channel shifting and cut-off activity occurred prior to the diversion. Comparison of the early
township surveys with Peters’ maps showed five cut-offs took place, in the 15 years before the diversion started.”

AMEC (February 2008) contains the following description of the Milk River ‘Gravel Bed Reach’:

“The Upper Milk River had a meandering gravel-bed channel with silty or sandy loam banks. The channel was frequently confined by valley walls composed of stony clay or sandstone. The channel was considerably larger than the North Milk branch due to the large drainage area contributed by the South branch.”

2.2 Ice Jams

Ice jam processes in the Milk River system have not been well studied previously and there are many unknowns. The following description of ice jams on the Milk River is contained in AMEC (February, 2008):

“The formation of ice jams along the Milk River is a regular occurrence. The AENV letter dated 29 August 1979 suggests that ‘during the annual spring break-up, ice runs and ice jamming are a regular phenomenon on most rivers which go through a freeze-thaw cycle… [and] the Milk River is no exception’.

Discussions with John Ross revealed that ice jam events occurred periodically along the Milk River. Several events had occurred over years of his recent memory and a significant event occurred adjacent to his property some 10 to 15 years ago. During this significant event water levels rose approximately 10 feet and ice overtopped fences. Damage to cattle fences from ice action has become problematic. Mr. Ross also noted one instance where an ice jam formed a channel cut-off downstream of his property.”

Ice is a significant consideration in the design of the Milk River Streambank Stabilization.

2.3 Site 1 – North Fork Milk River – Hilmer Bridge, Cardston County

The erosion site is located on the south (right side looking downstream) bank, immediately upstream of the Hilmer Bridge. The site is located on the outside bank along the downstream section of a meander bend. The bridge guidebanks are located just downstream of the site. The bridge guidebanks result in the channel making a sharp bend downstream of the erosion site. The channel width is in the order of 20 m and the bank height varies from 2 to 3 m. The channel is located within a 300 m wide floodplain. An extremely large pool is present adjacent to the right bank, upstream of the guidebank. The pool may be the result of an eddy formed by the guidebank. The pool may provide valuable over-wintering habitat for fish.

Figure 2 shows comparative air photos of the Hilmer Bridge site. Site characteristics, features annotated on the air photos, and historic channel movement are discussed below.
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Appendix B  Peters 1915 Survey of Sites
1.0 INTRODUCTION
The Milk River Watershed Council Canada (MRWCC) retained AMEC Earth & Environmental (AMEC) to undertake engineering design services for the Milk River Streambank Stabilization Project. This report contains conceptual streambank stabilization designs for three candidate sites that were identified by the MRWCC. The MRWCC will select one of the three sites, based on the engineering evaluation contained herein, and a detailed design will be developed for that site.

The MRWCC intends to construct a demonstration project on the Milk River to show innovative streambank stabilization techniques which may include conventional engineering techniques, bioengineering techniques, or a combination of both. Construction is tentatively scheduled for either the fall of 2010 or spring of 2011.

The streambank stabilization project is required due to widespread erosion occurring on all reaches of the Milk River. Stakeholders are concerned with the damage to infrastructure and loss of land due to streambank erosion. The existing diversion of water from St. Mary’s River to Milk River was completed in 1917 and has resulted in channel widening, increased channel sinuosity, and an increase in cut-off activity. AMEC Earth and Environmental’s February 2008 study, Study of Erosion and Sedimentation on the Milk River, indicates that the channel is still widening, some 90 years after the original diversion was initiated. Although erosion and deposition (i.e., river migration) is a naturally occurring process, the existing diversion has resulted in increased streambank erosion due to the increased magnitude of the channel forming discharge and its duration.

AMEC undertook this study in conjunction with Vince Petherbridge of Enviroscapes, who provided vegetation input for the assessment and designs for the three sites.

1.1 Scope of Work
The scope of work is based on MRWCC’s Request for Proposal and AMEC’s proposal dated December 2009 and is summarized below:

- Assess each of the three candidate sites and provide a conceptual design using the most effective streambank stabilization method that considers costs (construction and operational), appropriateness, ancillary benefits (e.g., aesthetics, fish and wildlife habitat) and ease of implementation. Bank stabilization techniques may include conventional engineering designs, bioengineering techniques, or a combination of methods.
- Provide a recommended maintenance and monitoring/evaluation program for the sites.
- Identify regulatory requirements.
- Prepare an approximate cost estimate for project implementation (e.g., necessary permits, material sources, equipment requirements). For each site, identify quantity and location of materials.
- Develop a detailed design for the selected site.
Future components of the project that are required for the selected site and are not part of this study include:

- Aquatic Environmental Assessment;
- Permit/approval applications, advertising and liaison with regulatory agencies;
- Tendering services (tender package preparation, contractor selection, etc.); and,
- Construction services (inspection, materials testing, fish salvage, turbidity monitoring, construction surveys, as-built reporting, etc.).

The three sites identified by the MRWCC are listed below and their locations are shown on Figure 1 and also on the conceptual drawings contained in Appendix A.

- Site 1 – North Fork Milk River – Hilmer Bridge, Cardston County, NE 10-2-21 W4M;
- Site 2 – Milk River – Weir Bridge, County of Warner, SE 8-2-13 W4M; and,
- Site 3 – Milk River – Gold Springs Park, County of Warner, NE 6-2-15 W4M.
Future components of the project that are required for the selected site and are not part of this study include:

- Aquatic Environmental Assessment;
- Permit/approval applications, advertising and liaison with regulatory agencies;
- Tendering services (tender package preparation, contractor selection, etc.); and,
- Construction services (inspection, materials testing, fish salvage, turbidity monitoring, construction surveys, as-built reporting, etc.).

The three sites identified by the MRWCC are listed below and their locations are shown on Figure 1 and also on the conceptual drawings contained in Appendix A.

- Site 1 – North Fork Milk River – Hilmer Bridge, Cardston County, NE 10-2-21 W4M;
- Site 2 – Milk River – Weir Bridge, County of Warner, SE 8-2-13 W4M; and,
- Site 3 – Milk River – Gold Springs Park, County of Warner, NE 6-2-15 W4M.
2.0 SITE DESCRIPTION AND HISTORIC CHANNEL MOVEMENT

A general description of the reach in which the three sites are located is provided in this section. Site specific characteristics and historic channel movement at the three sites are also discussed. Site photographs are included on the drawings contained in Appendix A. Appendix B contains the 1915 survey by Peters which shows pre-diversion conditions such as channel location, width as well as vegetation and soils information.

2.1 General Reach Characteristics

Table 2.1 lists the general reach characteristics for the North Milk River, where the Hilmer Bridge site is located and for the Milk River Gravel Bed Reach, where the Weir Bridge and Gold Springs Park sites are located. In comparison to the North Fork, the Milk River Gravel Bed Reach has a considerably larger channel, flatter gradient and smaller sediment size.

<table>
<thead>
<tr>
<th></th>
<th>North Milk River</th>
<th>Milk River Gravel Bed Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth¹ (m)</td>
<td>2.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Width (m)</td>
<td>26 to 53 mean 33</td>
<td>45 to 85 mean 59</td>
</tr>
<tr>
<td>Slope (m/m)</td>
<td>0.0035</td>
<td>0.0013 to 0.0019</td>
</tr>
<tr>
<td>Q₁:2 year (m³/s)</td>
<td>24.8</td>
<td>57.6</td>
</tr>
<tr>
<td>Q₁:100 year (m³/s)</td>
<td>100</td>
<td>282</td>
</tr>
<tr>
<td>Median Annual (50% exceedance) Discharge (m³/s)</td>
<td>12.6</td>
<td>15.8</td>
</tr>
<tr>
<td>20% exceedance Discharge² (m³/s)</td>
<td>18.2</td>
<td>20.2</td>
</tr>
<tr>
<td>Surface Gradation D₅₀ (mm)</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>Sub-Surface Gradation D₅₀ (mm)</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>Daily Mean Suspended Sediment³ (mg/L)</td>
<td>49.0</td>
<td>72.5</td>
</tr>
</tbody>
</table>

Notes:
1. Depth is equivalent to maximum channel depth; it is measured from the top-of-bank to the channel thalweg (minimum streambed elevation).
2. The 20% exceedance discharge provides some indication of the higher range of diversion discharges. These discharges are equaled or exceeded 49 days of the year.
3. Daily Mean Suspended Sediment Concentration is based on Water Survey of Canada measurements.

AMEC (February 2008) contains the following description of the North Milk River:

“Prior to the diversion the North Milk River had an irregular, confined meander pattern and displayed alternating pools and riffles. The channel was composed of gravel and sand and the banks were described as predominantly sandy loam (Peters, 1910). Abandoned meander scars on the floodplain indicate that channel shifting and cut-off activity occurred prior to the diversion. Comparison of the early
township surveys with Peters’ maps showed five cut-offs took place, in the 15 years before the diversion started.”

AMEC (February 2008) contains the following description of the Milk River ‘Gravel Bed Reach’:

“The Upper Milk River had a meandering gravel-bed channel with silty or sandy loam banks. The channel was frequently confined by valley walls composed of stony clay or sandstone. The channel was considerably larger than the North Milk branch due to the large drainage area contributed by the South branch.”

2.2 Ice Jams

Ice jam processes in the Milk River system have not been well studied previously and there are many unknowns. The following description of ice jams on the Milk River is contained in AMEC (February, 2008):

“The formation of ice jams along the Milk River is a regular occurrence. The AENV letter dated 29 August 1979 suggests that ‘during the annual spring break-up, ice runs and ice jamming are a regular phenomenon on most rivers which go through a freeze-thaw cycle… [and] the Milk River is no exception’.

Discussions with John Ross revealed that ice jam events occurred periodically along the Milk River. Several events had occurred over years of his recent memory and a significant event occurred adjacent to his property some 10 to 15 years ago. During this significant event water levels rose approximately 10 feet and ice overtopped fences. Damage to cattle fences from ice action has become problematic. Mr. Ross also noted one instance where an ice jam formed a channel cut-off downstream of his property.”

Ice is a significant consideration in the design of the Milk River Streambank Stabilization.

2.3 Site 1 – North Fork Milk River – Hilmer Bridge, Cardston County

The erosion site is located on the south (right side looking downstream) bank, immediately upstream of the Hilmer Bridge. The site is located on the outside bank along the downstream section of a meander bend. The bridge guidebanks are located just downstream of the site. The bridge guidebanks result in the channel making a sharp bend downstream of the erosion site. The channel width is in the order of 20 m and the bank height varies from 2 to 3 m. The channel is located within a 300 m wide floodplain. An extremely large pool is present adjacent to the right bank, upstream of the guidebank. The pool may be the result of an eddy formed by the guidebank. The pool may provide valuable over-wintering habitat for fish.

Figure 2 shows comparative air photos of the Hilmer Bridge site. Site characteristics, features annotated on the air photos, and historic channel movement are discussed below.
• The 1922 air photo was taken prior to construction of the road and bridge crossing. The future road alignment was marked on the 1922 air photo for ease of comparison with the other air photos.

• The 1922 air photo was taken not long after the diversion was initiated. Hence, the channel characteristics were still in the process of adjusting to the new channel regime. Feature ‘C1’ denotes multiple meander scars on the floodplain, which indicates the channel was naturally prone to cut-offs prior to diversion.
• The 1922 channel configuration at the future road crossing was significantly different from
existing conditions. The 1922 channel was located on the north side of the valley, in
comparison to its existing location on the south side of the valley. Feature ‘A1’ is the
existing erosion site and feature ‘B1’ is an existing oxbow lake. The 1922 air photo shows
that feature ‘A1’ is far removed from the channel and ‘B1’ is the active channel at that time.

• Based on our air photo review, it is uncertain whether the meander bend cut-off resulting in
the current channel location on the south side of the valley was natural or whether it was
man-made due to the road crossing.

• The 1915 Peter's survey in Appendix B shows a similar channel configuration as shown on
the 1922 air photo. Peter's notes indicate that floodplain soils vary from sandy loam to
heavy clay loam and that vegetation consists of shrubs, grass and weeds in varying
percentages. For example in some locations the vegetation consists of 75% shrubs to 25%
grass and in other locations 25% grass and 75% weeds.

• The 1922 channel alignment is superimposed on the 1986 air photo and the significant
change in channel alignment is evident. The 1986 air photo shows that feature ‘A1’ is
adjacent to the channel and ‘B1’ is an oxbow lake.

• Bridge File drawings obtained from Alberta Transportation indicate a new bridge was
constructed sometime in the late 1980s (i.e., after the 1986 air photo). The 1999 air photo
shows this new bridge with guidebanks, which may result in a narrower bridge opening than
previous. Erosion at ‘A1’ appears to have worsened, possibly due to the downstream
guidebank, causing an impingement at this location.

• The 2006 air photo is generally indicative of existing channel configuration and conditions.
Sub-channels are evident at ‘C1’, indicating continued channel instability.

• Future erosion can be expected at this site due to the general instability within the reach
reviewed above, the location of the site on the outside of a bend, and local erosion due to
the guidebanks impinging on the flow.

2.4 Site 2 – Milk River – Weir Bridge, County of Warner

Figure 3 shows comparative air photos of the Weir Bridge site. The channel width is in the
order of 20 to 30 m and the bank height varies from 2 to 3 m. The channel is located in a 400 m
wide floodplain. Site characteristics, features annotated on the air photos, and historic channel
movement are discussed below.

• The 1915 Peter’s survey in Appendix B shows the streambank is close to the existing
erosion site although the channel configuration is very different. In 1915, the channel at the
upstream of existing erosion site had a west to east orientation, as compared to the tight
radius meander with the south-north orientation that currently exists. Peter’s notes that
floodplain soils vary from light sandy soils to clay loam. Groves of cottonwood are noted at
several locations, as are willows, grass, and chokecherry bushes.

• Significant channel changes are evident in the 1951, 1986 and 2006 air photos. Feature
‘B2’, the existing erosion site, is located 230 m and 100 m, back from the bank in the 1951
and 1986 air photos, respectively. At ‘A2’, the average rate of bank retrogression was 4 m/year between 1949 and 2006.

- The 2006 air photos shows that the meander neck at ‘B2’ has narrowed considerably and could be a potential meander cut-off location.
- Feature ‘C2’ is a relatively stable meander bend that has not moved significantly, over the period evaluated.
- The 2002 air photo is included as it shows the site during flood conditions. Note the overbank flow at ‘B2’, which is one of the processes that could lead to a cut-off of this meander neck.
- The meander neck ‘B2’ is subject to attack at both the upstream and downstream sides of the meander bend. This attack from both sides narrows the meander bend neck, which eventually results in a cut-off. Armouring the bank at ‘A2’ would increase the attack at the downstream end of ‘B2’, possibly hastening creation of a cut-off channel.
2.5 Site 3 – Milk River – Gold Springs Park

Figure 4 shows comparative air photos of the Gold Springs Park site. The channel width is in the order of 30 to 40 m. The channel is bounded by the 20 m high west valley wall, upstream of the site. Gold Springs Park is located on bench that is 4 to 5 m above the channel bed. The channel bed contains more coarse-grained material such as cobbles and boulders than is typical for the Milk River Gravel Bed Reach. This material is eroded from the high west valley wall and deposited within the channel.

Site characteristics, features annotated on the air photos and historic channel movement are discussed below.

- The 1922 air photo was taken prior to the construction of the road. The future road alignment was marked on the 1922 air photo for ease of comparison with the other air photos.
- The 1922 air photo was taken not long after the diversion was initiated. Hence, the channel characteristics were still in the process of adjusting to the new channel regime.
- The 1915 Peter's survey in Appendix B shows a similar channel configuration as shown on the 1922 air photo. Peter's notes that coarse gravel is located adjacent to the channel at several locations and floodplain soils are generally light sandy loam.
- Between 1922 and 1986 the channel migrated approximately 110 m south towards feature 'A3', which results in a migration rate of 1.7 m/year.
- Between 1986 and 2006 the channel migrated an additional 20 m south towards feature 'A3', which results in a migration rate of 1 m/year.
- Feature 'B3' is an oxbow lake that has been developed as part of Gold Springs Park. This oxbow pre-dates the 1922 air photo.
- Feature 'C3' indicates depositional features on the left side of the channel downstream of the high cliffs on the right bank. Material that is eroded from the high cliffs, which are located on the outside of a bend, is deposited further downstream on the inside of the bend. This deposition directs the flow to the other bank which increases the attack and erosion at 'A3'.

3.0 HYDROLOGY

Design flood discharges for the Milk River at various locations are contained in AMEC (February 2008) and summarized in Table 3.1. The North Milk River discharges are applicable to the Hilmer site, and the Milk River at the Town of Milk River discharges are applicable to the Weir Bridge and Gold Springs sites.

<table>
<thead>
<tr>
<th>Return Period (years)</th>
<th>Exceedance Probability in Any Year (%)</th>
<th>North Milk River near International Boundary (m³/s)</th>
<th>Milk River at Town of Milk River (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1.0</td>
<td>100</td>
<td>282</td>
</tr>
<tr>
<td>50</td>
<td>2.0</td>
<td>86.3</td>
<td>245</td>
</tr>
<tr>
<td>20</td>
<td>5.0</td>
<td>68.2</td>
<td>194</td>
</tr>
<tr>
<td>2</td>
<td>50.0</td>
<td>24.8</td>
<td>57.6</td>
</tr>
</tbody>
</table>

The discharges listed above are based on recorded discharges for the 74-year period from 1928 to 2001. Hence, they are representative of existing diversion flow conditions. As a result of potential increases to the diversion flows from the St. Mary’s River into the Milk River, peak flood discharges could increase by as much as 65% beyond present values for the typical spring flood event on the North Milk River (AMEC, February 2008). The effects on flood frequencies diminish for greater return period events and for locations further downstream. Based on discussions with MRWCC, the values listed in Table 3.1 were used for the design.
4.0 PRELIMINARY HYDRAULIC ANALYSIS

Preliminary hydraulics (water levels, velocities, etc.) were based on a single cross-section and assuming normal depth of flow. Manning’s roughness coefficient “n” was based on the following:

- The “n” values for the Gold Springs Park site were increased to account for the presence of large diameter cobbles and boulders, which are eroded from the high valley walls and deposited in the channel.
- A higher “n” value was used for the Hilmer site to account for the coarser-grained bed material that generally exists in the North Milk River, as compared to the Milk River.

The channel geometry was not based on any surveyed cross-sections at the sites. Rather it was an idealized section based on a number of sources that included previous surveys within this reach, Alberta Transportation Bridge File drawings, and site observations.

Results of the preliminary hydraulic analysis are summarized in the table below. This hydraulic analysis will be updated for the final design of the selected site based on channel surveys.

**TABLE 4.1**

<table>
<thead>
<tr>
<th>Flood Frequency Return Period (Years)</th>
<th>North Milk River at Hilmer</th>
<th>Milk River at Weir Bridge</th>
<th>Milk River at Gold Springs Park</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water Depth (m)</td>
<td>Mean Channel Velocity (m/s)</td>
<td>Water Depth (m)</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>1:2</td>
<td>1.0</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>1:100</td>
<td>1.8</td>
<td>3.2</td>
<td>2.8</td>
</tr>
</tbody>
</table>
5.0 CONCEPTUAL DESIGNS

Conceptual design drawings for the three sites are attached in Appendix A and the designs are discussed in Table 5.1. Preliminary level cost estimates are shown in Table 5.1 and a more detailed breakdown is provided on the drawings. The costs are based on the following:

- Construction costs are based on a combination of Alberta Transportation unit price averages and Enviroscape estimate for the vegetation cuttings.
- The engineering, environmental services and permitting were estimated as a proportion of the construction costs and includes the following:
  - The aquatic assessment, which is typically required for the environmental permits.
  - Environmental permitting, including application and liaison. The MRWCC may be able to undertake some portion of this task, in which case the costs can be reduced.
  - Part-time construction inspection.
- Equipment and equipment operators required for construction are based on hiring private contractors. Costs would be reduced if these items are donated by the Counties.
- Granular material costs are based on the purchase of the material from local private sources. It is assumed that hauling will be undertaken by private contractors and paid for at standard government rates.
- Vegetation harvesting, handling and construction will be undertaken by a private contractor. The MRWCC may be able to use volunteers for some portion of this task, in which case the costs can be slightly reduced.

5.1 Description of Techniques

Drawing typicals showing the techniques recommended are shown in Drawing 4. A brief description of some of the techniques is contained below.

5.1.1 Vanes

Vanes are re-directive structures constructed from rockfill that project into a channel from the bank to alter flow direction, induce deposition and reduce flow velocity along the bank. Vanes are typically low-profile structures that have a sloped crest. Vanes are typically angled upstream 20 to 30 degrees (measured tangent to the bank). The applicability of re-directive structures depends greatly on the stream type and configuration. Re-directive structures should be quite effective on all reaches of the Milk River due to their ability to induce near-bank deposition of the considerable bed-load conveyed by this system.

Advantages of vanes include the development of a deep pool adjacent to the tip of the vane, which is beneficial to fish habitat. Vanes also result in the thalweg (deepest part of the channel) being shifted away from the stream bank towards the middle of the channel. In comparison, the thalweg becomes entrenched against a conventionally armoured bank, subjecting it to continual attack.
Sediment deposition adjacent to the vanes will result in the ice cover developing further out into the channel, which should help protect both the vanes and the stream bank from ice damage. However, at this stage, the impact of ice on vanes within the Milk River is uncertain and requires further investigation. The MRWCC indicates that vanes have been constructed on the Milk River in Montana and further information on ice impacts should be obtained from the agencies responsible. It would be beneficial to construct vanes and monitor their performance, given the demonstration nature of the MRWCC’s Milk River Stabilization Project.

5.1.2 Longitudinal Peak Stone Toe Protection (LPSTP)

The LPSTP is a free-standing structure (i.e., not keyed into the bed or bank) that has a triangular shape (the apex of the triangle is the peaked top). The triangular shape of the LPSTP allows plantings to be more easily incorporated behind the structure. The LPSTP is designed to launch with scour, hence it does not require a key-in to the streambed or an apron.

The LPSTP treatment has the following advantages as compared to a conventional riprap armouring:

1. LPSTP reduces channel encroachment since it can be constructed at a 1H:1V side-slope and it does not require an apron or key-in at the toe. Conventional riprap requires a 2H:1V side-slope and an apron or key-in at the toe.

2. LPSTP can be constructed in the ‘wet’ in an environmentally sensitive manner. Because the LPSTP structure is free-standing, the large riprap sized material (that is relatively free of fines) can be placed in the ‘wet’, prior to the placement of the finer-grained material that constitutes the fill between the LPSTP and the bank. The conventional riprap treatment requires the finer-grained material to be placed first, which may require a more elaborate isolation technique to prevent silt from entering the watercourse.

LPSTP should perform well under ice conditions as long as the rock is adequately sized to resist ice forces. The top of LPSTP corresponds to bankfull level, which typically is normal ice level.

5.1.3 Brush Layer

‘Brush Layering’ is a thick layer of live willow cuttings that is placed behind rock riprap or on a slope. The above-ground portion of the brush layer should be at or above bankfull/normal ice level.

5.1.4 Live Pallisades

Live palisades are described as follows by Polster (December 2003):

“Live palisades are large cottonwood posts installed in trenches adjacent to the eroding stream where natural riparian vegetation has been lost due to clearing or erosion. Large cottonwood posts (15 to 20 cm diameter by 3 to 4 m long) are inserted into a trench dug by an excavator a few metres away from the actively eroding bank. The cottonwood post is expected to root along its entire below-ground length and
thus produce a dense cylinder of roots that will protect the bank from erosion as stream encroaches on the palisade. Additional cuttings (willow and red-osier dogwood) can be used to provide site diversity. The key is to get the base of the live cuttings and cottonwood posts down into the water table so they will grow even during dry weather.”

Ice is typically not a concern for Live Pallisades since they are setback from the top of the bank.

5.2 Maintenance/Monitoring/Evaluation

Monitoring and maintenance is an important consideration for works constructed at any of three sites. Future flood flows, debris, or gradual changing conditions might result in damage to works requiring repairs.

The works should be inspected before and after high-flow periods, and if possible, during high flow events. The inspections should include the works themselves as well as conditions upstream and downstream. The riprap should be examined for holes, protrusions, settlement and also for scour at the toe of the bank.

Additional maintenance, monitoring and evaluation requirements include the following:
- Vegetation planted at the sites will likely require beaver protection and watering in the first year to promote vegetation growth.
- A benchmark to measure channel changes.
- Exclusion fencing to reduce traffic (both human and live stock).
### TABLE 5.1
Discussion of Recommended Conceptual Streambank Stabilization Designs

<table>
<thead>
<tr>
<th>Site</th>
<th>Recommended Design and Preliminary Cost Estimate</th>
<th>Appropriateness / Design Considerations</th>
<th>Ancillary Benefits (Aesthetics / Fish and Wildlife / Other)</th>
<th>Constructability / Ease of Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>Hilmer Bridge – North Milk River</td>
<td><strong>Longitudinal Peak Stone Toe Protection (LPSTP)</strong> incorporating two rows of brush layering. Wattle fencing in upstream portion where the attack is not as severe. Pallisade to restore riparian buffer zone. Fencing is required to prevent grazing. Live shrub (containerized and plugs) planting in the swale parallel to the road approach from the south. The preliminary cost estimate is $148,000. Near-shore works such as LPSTP are appropriate since they preserve the existing pool and work well with the eddy at this location. Vanes are not considered appropriate due to an existing large pool, which should not be infilled due to fisheries considerations. The erosion site is in the lee side of the valley and subject to snow deposition up to the top of the bank. The vegetation has to be at a high enough level that it does not get suffocated by the snow.</td>
<td>The valley is sparsely vegetated due to grazing. Re-vegetation of the riparian zone and fencing will benefit streambank stability, aesthetics, and fish and wildlife.</td>
<td>Good access for construction equipment due to close proximity to the highway.</td>
</tr>
</tbody>
</table>

| Site 2 | Weir Bridge – Milk River | **Phase 1 (Year 1)** consists of: (1) a series of vanes to induce sediment deposition adjacent to the eroding bank; (2) plantings extending a few metres upstream and downstream of the vane key-in location. Depending on availability of large-sized material, use a combination of live willow and cottonwood cuttings and posts (large diameter cuttings); and, (3) palisades and fencing to restore the riparian zone. Phase 2 (Year 2 or later) consists of live staking and/or brush layering of the bank between the vanes as well as the near-shore area where sediment deposition occurred during Year 1. Phase 2 construction would be mostly by hand, thereby reducing impacts to the bank and vegetation. The preliminary cost estimate for Phase 1 is $243,000. Riprap toe protection between the vanes was not utilized in order to reduce costs and due to the near-shore sediment deposition that is anticipated to occur. There is a short-term risk of bank erosion between the vanes if sufficient sediment deposition does not occur between the vanes. Some local bank erosion repair may be required as part of Phase 2. Given the significant recreational river use (i.e. canoes, rafts and tubes) and the river access point (take-out) just downstream of the site, the issue of impact on the vanes on navigability (in particular recreational user safety) will have to be evaluated further as well as issues of liability (the County would likely be the owner of the structures). It should be possible to resolve these issues as deposition will occur adjacent to the vanes and push the thalweg out to the centre of the channel. However, these issues do require further evaluation and discussion with stakeholders. | The County is considering enhancing the existing river access point downstream of the site for recreational users. A grove of large mature cottonwood trees is present at this site. Re-vegetation of the riparian zone and fencing will protect the existing grove and future succession. Existing trees and new plantings should be protected from beaver damage. | Generally good access due to proximity of highway. However, there is a considerable amount of existing riparian vegetation, especially at the downstream end of the site. Select removal of existing vegetation is required to allow construction. |

| Site 3 | Gold Springs Park – Milk River | A series of vanes are required at the upstream end of the site adjacent to the 20 m high west valley wall. To allow access to the upstream end of the site and also to stabilize the downstream portion, a bench will be constructed at the bottom of the steep river bank slope. The outer (channel) face of the bench will be armoured with riprap and the bench will be vegetated with sedges and rushes. This mimics the existing stabilized bench section at the downstream end of the project area. In addition to the hydrophyte plantings, woody vegetation (live staking) will also be installed at the bench. Stabilization of the steep slope gully, which is closest to the road will be addressed using Modified Brush Layers (MBL). The vegetated component of the MBL will incorporate live native shrub plug plantings (Wolf Willow, Buffalo Berry and Snowberry) on the bench rather than willow stakes since moisture is a limiting factor for successful establishment of willows at this location. The slope will also be seeded to a native grass mix for additional soil stabilization. At the upstream end of the site, vanes are preferred to the armoured bench that is utilized for the remainder of the site. Vanes offer the advantage of re-directing the thalweg to the middle of the channel and inducing deposition adjacent to the toe of the high valley wall. This will enhance the long-term stability of the existing site. The vanes are not expected to adversely affect the opposite bank or adjacent areas at this location. The vanes will result in the thalweg shifting more towards the middle of the channel and eroding the mid-channel bar/island. The preliminary cost estimate is $512,000. | There is a high risk of loss of the access road within a 10- to 20-year timeframe, unless channel stabilization works are constructed. | Very poor access to the upstream end of the site (adjacent to the high west valley wall). Access to the site will likely have to be via a road constructed from the downstream end. A geotechnical assessment of the high slope may be required to review the safety of working at the toe of the high valley wall. |
6.0 PRELIMINARY FISHERIES ASSESSMENT

6.1 Introduction

An overview of aquatic habitat and historical fisheries resources in the vicinity of Hilmer Bridge (NE 10-2-21-W4M), Gold Springs Park (NE 6-2-15-W4M) and Weir Bridge (SE 8-2-13-W4M) is contained in this section. The three sites are located on two distinct sections of the Milk River. The Hilmer Bridge site is located on the North Milk River Reach and both the Gold Springs Park and Weir Bridge sites are located in the Milk River Gravel Bed Reach. The reaches are described below.

6.2 Aquatic Habitat

**North Milk River Reach**

The North Milk River Reach is distinguished by dominant boulder and cobble substrate. The reach is approximately 80 km long, has a moderate to steep stream gradient (RL&L 1987) and begins at the western international boundary and ends at the confluence to the south stem of the Milk River.

The banks of the North Milk River are mainly composed of unconsolidated alluvial material except for those areas where the channel abuts the valley wall (sandstone). The North Milk River Reach has high stream flow energy resulting in the deposition of coarser channel substrate material such as boulders and gravel. These materials create good cover and riffle habitat for fish species. As well, the North Milk River is characterized as having low turbidity and increased turbidity in a downstream direction (RL&L 1987). RL&L (1987) found that the North Milk River Reach was characterized by predominantly run, riffle and pool habitats with low velocity areas (stream margins and pools) receiving a large amount of sediment accumulation.

Aquatic macrophytes are sparse but are found in the upstream portion of the North Milk River in the mouths of tributaries, flooded areas and shallow, low velocity pools. The higher turbidity found further downstream in the North Milk River is thought to limit the distribution of aquatic macrophytes (RL&L 1987). Typically this reach receives more rainfall than the other downstream reaches (ASRD 2004) and is glacier fed from the St. Mary River thus maintaining lower temperatures than the other downstream reaches. This characteristic makes habitat more suitable for coldwater species (i.e., salmonids) in comparison to other reaches.

**Milk River Gravel Bed Reach**

This reach begins at the confluence of the North Milk River and the south stem of the Milk River and ends in the vicinity of Writing-on-Stone Provincial Park. This reach is highly erosional and is dominated by gravel and cobble substrate.

RL&L (1987) found this reach was mainly dominated by good quality run habitats, depositional pools and few flat habitats. Slight changes in stream gradient along this reach determine the distribution of different habitat types. High quality holding areas are more frequent in the mid and to a lesser extent, in the upper sections of this reach. Shallow habitat types are most
common in the lower section of the reach. RL&L (1987) concluded this reach had the most habitat diversity compared to the other two reaches.

6.3 Historical Fisheries Resources

Background information was compiled within 5 m upstream and downstream of the three sites using provincial Fisheries and Wildlife Management Information System (FWMIS) database (ASRD 2010). Table 6.1 summarizes fish species captured within a 5 km radius of each site. Information was obtained from the FMIS database (ASRD 2010).

<table>
<thead>
<tr>
<th>Fish Species</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Hilmer Bridge</th>
<th>Gold Springs Park</th>
<th>Weir Bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>burbot</td>
<td>Lota lota</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>fathead minnow</td>
<td>Pimephales promelas</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>flathead chub</td>
<td>Platygobio gracilis</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>lake chub</td>
<td>Couesius plumbeus</td>
<td></td>
<td>●</td>
<td>-</td>
<td>●</td>
</tr>
<tr>
<td>longnose dace</td>
<td>Rhinichthys cataractae</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>longnose sucker</td>
<td>Catostomus catostomus</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>mountain sucker</td>
<td>Catostomus platyrhynchus</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>mountain whitefish</td>
<td>Prosopium williamsoni</td>
<td></td>
<td>●</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>northern pike</td>
<td>Exos lucius</td>
<td></td>
<td>-</td>
<td>-</td>
<td>●</td>
</tr>
<tr>
<td>northern redbelly dace</td>
<td>Phoxinus eos</td>
<td></td>
<td>●</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rocky Mountain sculpin (St. Mary shorthead sculpin)</td>
<td>Cottus bairdi punctuatus</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>sauger</td>
<td>Sander canadensis</td>
<td></td>
<td>-</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>stonecat</td>
<td>Noturus flavus</td>
<td></td>
<td>-</td>
<td>●</td>
<td>-</td>
</tr>
<tr>
<td>trout-perch</td>
<td>Percopsis omiscomaycus</td>
<td></td>
<td>●</td>
<td>●</td>
<td>-</td>
</tr>
<tr>
<td>western silvery minnow</td>
<td>Hybognathus argyritis</td>
<td></td>
<td>-</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>white sucker</td>
<td>Catostomus commersoni</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

Of the species known to occur within the vicinity of the three sites, five species are listed provincially, federally or both. The western silvery minnow (*Hybognathus argyritis*) and Rocky Mountain sculpin (*Cottus bairdi punctuatus*) are listed as “Threatened” federally (COSEWIC 2009) and “At Risk” provincially (ASRD 2007). The stonecat (*Noturus flavus*) is listed as “At Risk” provincially (ASRD 2007), and both sauger (*Sander Canadensis*) and northern redbelly dace (*Phoxinus eos*) are listed as “Sensitive” provincially (ASRD 2007).
6.4 Construction Schedule

Based on the Alberta Environment Code of Practice – Lethbridge Management Area Map (AENV 2006), the North Milk River at the Hilmer Bridge site, is a Class C waterbody with a restricted activity period between 16 September to 15 April. The St. Mary’s diversion is in operation from 1 April to 30 September causing water levels at the site to be high and potentially creating problems during construction that would further impact fish habitat. Living cuttings will also be incorporated into the reclamation and habitat enhancement phase of the project. Living cuttings have a better survival rate when planted in early spring or the fall. Therefore, it would be preferred to construct the bank stabilization works during the restricted activity period (early March or October/November) to minimize potential impacts to fish habitat and bolster the survival planted vegetation. ASRD was contacted regarding conducting construction during the restricted activity period. Since stonecat and western silvery minnow are not likely to be found in the vicinity of the Hilmer Bridge and Rocky Mountain sculpin do not spawn until May, the restricted activity period in the early spring (February/March) was waived (pers. comm., T. Clayton). No instream construction can occur during the restricted activity period in the fall (October/November) to protect spawning mountain whitefish in the vicinity of the Hilmer Bridge. The Gold Springs Park and Weir Bridge sites are located on a Class C portion of the Milk River that is subject to a 1 April to 30 June restricted activity period. Construction will occur outside of the restricted activity period.
7.0 REGULATORY AND CONSTRUCTION CONSIDERATIONS

7.1 Regulatory Requirements

Bank stabilization works require the following approval/permits:

- Approval under the provincial Water Act from Alberta Environment (AENV).
- Authorization from Fisheries & Oceans Canada (DFO) under the Fisheries Act. This typically requires a fisheries assessment to be conducted and an application to be submitted to DFO. The fisheries Restricted Activity Period (RAP) also has a bearing on construction timing. The RAP for the North Fork Milk River (Hilmer Bridge Site) is September 16 to April 15, while the RAP for the Milk River (Weir Bridge and Gold Springs Park) is April 1 to June 30.
- Works within a navigable water body must also be reviewed by Transport Canada – Navigable Water Protection, in order to determine if works will have an impact on navigation.
- In addition, any works conducted in the bed and banks must receive approval from Alberta Sustainable Resource Development – Lands Division.

A preliminary meeting with Alberta Environment and Fisheries & Oceans Canada would be beneficial in order to present the various approaches contained in this report and determine collectively between the permitting bodies which approach is most desirable from their viewpoints.

7.2 Schedule

The Restricted Activity Period (RAP) for the Hilmer Bridge site is problematic since the allowable instream construction window (April 16 to September 15) coincides with the period of high diversion flows. Subject to the findings of Aquatic Environmental Assessment, it may be possible to construct within the RAP.

For intrusive structures such as the vanes proposed at the Weir Bridge and Gold Springs Park sites, the Navigable Waters Protection Act (NWPA) approval would likely take in the order of 6 months to obtain. Table 7.1 contains potential construction schedules for Spring 2011. It would likely not be possible to undertake Fall 2010 construction at the Weir Bridge and Gold Springs Park sites, given the lengthy NWPA approval process. At the Hilmer site, Spring 2011 construction is preferred over Fall 2010 construction, given the fisheries considerations discussed in the previous section.
### TABLE 7.1
Preliminary Project Schedule for Subsequent Project Phases

<table>
<thead>
<tr>
<th>Task</th>
<th>Spring 2011 Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start Date</td>
</tr>
<tr>
<td>Aquatic Environmental Assessment at Selected Site</td>
<td>1 July 2010</td>
</tr>
<tr>
<td>Permit Applications – Preparation and Submission</td>
<td>16 August</td>
</tr>
<tr>
<td>Approvals/Permits Regulatory Review and Issuance</td>
<td>1 September</td>
</tr>
<tr>
<td>Construction</td>
<td>1 March 2011</td>
</tr>
</tbody>
</table>
8.0 CLOSURE

This report has been prepared for the exclusive use of the Milk River Watershed Council Canada for specific application to the area within this report. This report is based on and limited by the interpretation of data, circumstances, and conditions available at the time of completion of the work as referenced throughout the report. AMEC Earth & Environmental has performed its services in a manner consistent with the standard of care and skill ordinarily exercised by members of the profession practicing under similar conditions in the geographic vicinity and at the time the services were performed. AMEC Earth & Environmental believes that this information is accurate but cannot guarantee or warrant its accuracy or completeness including information provided by third parties.

Recommendations presented herein are based on an evaluation of the findings of the office and field investigations noted. If conditions other than those reported are noted during subsequent phases of the project, AMEC should be notified and be given the opportunity to review and revise the current recommendations, if necessary.

Please contact the undersigned if you have any questions.

Yours truly,

AMEC Earth & Environmental

Reviewed by

Senior Associate

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Water Resources Engineer

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9.0 REFERENCES

AMEC Earth and Environmental, February 2008, Study of Erosion and Sedimentation on the Milk River, prepared for Milk River Watershed Council Canada


Polster Environmental Services, Alternatives For Bank Stabilization – Literature Review, December 2003, prepared for Fisheries & Oceans Canada):