FINAL

Keystone XL Pipeline Montana Stream Crossing Inspections Report

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Prepared by

ENTRIX

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Executive Summary

Prior to making a decision under MFSA and the Montana Water Quality Act (MCA 75-5-318), MDEQ must conduct a review of stream crossings for the applicant's proposed route and make a determination on Keystone's Joint Application 318 Permit for short-term exemption from its turbidity standard. Under MFSA, that decision must be made concurrently with a decision on Keystone's application for a MFSA Certificate of Compliance. ENTRIX, as the third-party environmental contractor for DOS and MDEQ has conducted on-site inspections of selected crossing sites in Montana proposed by Keystone. This report provides information on the proposed crossing methods, the process used to select crossing sites for field inspection, office and field methods used, and the results of analyses for each crossing site assessed. This report also provides potential site-specific protective measures for consideration by MDEQ.

SELECTION OF CROSS SECTIONS

The proposed pipeline would cross a total of 389 waterbodies in Montana, including intermittent, perennial, and ephemeral streams. Of that total, 55 sites met the requirement for review by MDEQ, including 20 perennial and 35 intermittent streams. All perennial crossings were inspected with the exception of Pennel Creek and Buffalo Spring Creek. MDEQ was not able to obtain landowner approval for onsite inspections at these sites and the crossing locations were therefore assessed from nearby public lands (i.e., upstream or downstream bridges or from public land along the creeks).

Initial desktop evaluations of the 35 proposed crossings of intermittent streams were conducted to determine which would require field inspection. This evaluation included consideration of the following criteria:

- Crossing locations that occur within a designated floodplain of the state;
- Crossing locations that include waterbodies with species of concern to the state or which are known to include the habitats of those species; and
- Crossing locations that include streams of special interest to the state.

Application of these criteria identified 16 intermittent crossings where site inspections would be conducted. The remaining 19 intermittent stream crossings were evaluated using the office review procedures described below.

OFFICE ANALYSES

Office analyses of the proposed crossings were conducted to provide context, background, and support for the field investigations. The analyses included a review of available literature and addressed flood flow and geomorphic characterization of the proposed crossing sites. Flood flow frequency analyses were conducted for each proposed crossing site using a regional regression equation (Omang 1992) to calculate the discharge for the 2-, 5-, 10-, 50-, and 100-year storm recurrence intervals. The nearest gauge station was included in the analysis using FEMA's Bulletin 17B method. Checks were conducted on arbitrarily selected stations by using either a second flood flow calculation or an exceedance probability curve from historical annual peak flow data.

The geomorphic assessments were conducted using GIS and several sources of data: aerial photographs from 2005; USGS topographic maps in 1:24,000 scale from 1940 to 1995; geologic maps in 1:100,000 scale from the Montana Bureau of Mines and Geology; and digital surface water data from the USGS National Hydrography Database. Data were obtained for the channels to be crossed and for the surrounding floodplains and valleys. Channel characterization included measurements of the width, form, gradient, and sinuosity of each channel. Valley characteristics examined were width, gradient, geology, and the presence of landslides or floodplain features such as relic channels. Infrastructure in the vicinity of each crossing, including the presence of in-stream structures, was also catalogued.

The literature review consisted of online searches in state and national agency databases for previous channel migration zone studies. It also included review of reports on hydrology, hydraulics, sediment transport, bridge scour, ice jams and turbidity.

FIELD METHODS

Site specific information collected in the field included characterization of stream form and geometry, alluvial substrate, soils, vegetation, evidence of current and previous instability, and natural and artificial disturbance affecting the crossing site. Field maps and valley cross-sections were developed for each proposed crossing site, including topographic, geologic, and soils map for each site, as well as current and historic air photos.

Valley cross-sections along the proposed route were developed using USGS 30-minute digital terrain models. This reach-level information was used to place the proposed crossing location in context with the surrounding topography, geology, soils, and hydrology, and to identify natural or artificial disturbances adjacent to the crossing that may affect the crossing site. The results of the flood frequency analyses were used as a check on field interpretations of the locations of the extents of the bankfull channel and recurrence intervals on identified floodplains.

Evaluations of each of the crossing sites focused on the following considerations:

- Adequacy of the proposed stream crossing method to withstand stream scour, incision, and lateral stream movement over the life of the project;

- Ability of the proposed crossing method to reduce turbidity during construction and operation; and

- Assessment of the proposed crossing method and location relative to potential environmental impacts considering the state of available technology and the nature and economics of the various alternatives.

EXISTING CONDITIONS, POTENTIAL IMPACTS, AND PROTECTIVE MEASURES

At each crossing site assessed in the field with water present in the channel, turbidity was observed to be moderate to high at the time of the assessment.

The analysis determined that several proposed crossing sites have indicators of instability or the presence of features that could lead to future instability. These indicators include nearly vertical banks, actively slumping or undercut banks, side channels on floodplains adjacent to the bankfull channel, and perennial or intermittent in-stream impoundments. For crossing sites studied in the field, the SCIR provides potential preventative or mitigative measures including suggested minimum cover depths over defined linear extents at each site. While site-specific scour depth calculations are beyond the scope of this report, and will not be made until the pipeline crossings locations have been finalized, the minimum depth below the lowest point in the stream channel should be located at the greater of the following:

- Federal regulation CFR 49 parts 192.327;
- Standard design specification in the Construction, Mitigation and Reclamation Plan (CMRP) minimum burial depth of five feet below the lowest point in the stream channel; or
- at least two feet more than the calculated scour depth unless solid rock is encountered.

Keystone is currently analyzing all waterbody crossings for potential scour and lateral migration. This analysis will be used to determine any additional depth and extents over beyond those prescribed in the CMRP.

The SCIR also includes draft potential management plans for monitoring the sites after construction is completed. The SCIR also identifies potential pipeline route adjustments for some crossings to avoid reaches of the channel that are less stable than others.

For crossings where a field assessment was not conducted, potential prevention and mitigation methods were developed that include minimum suggested cover depths over defined linear extents, site reclamation measures, and adaptive management plans that include site monitoring and response measures. The suggested minimum cover presented in the SCIR for some sites is greater than those included in Keystone's Construction Mitigation and Reclamation Plan (CMRP, see Appendix B of the EIS). Increased cover depth over defined linear extents provides both an enhanced buffer to maintain the integrity of the pipeline if the stream were to migrate during operation of the project and construction workspace for implementation of preventative protection measures. The suggested management plan described in the SCIR is intended to be implemented for all crossing sites with indicators of active instability and includes specific monitoring during routine pipeline inspections. If channel migration is detected during monitoring and if it reaches a threshold value, the preventative protection measures identified in the SCIR would be implemented in the adjacent floodplain.

Assuming that the measures presented in the SCIR are implemented by MDEQ and Keystone, there would not be a significant impact on surface waters due to project construction and normal operation at the waterbody crossings assessed in this report.

Summary of Stream Crossing Concerns and Prevention and Mitigation Measures

Stream Crossing	Turbidity Concerns During Inspection	Incision Concerns	Channel Migration Concerns	Consider Route Concerns	Consider Adaptive Management Plan	Consider Alternative Crossing Technique
Corral Coulee	No	Yes	Yes	No	Yes	No
Corral Coulee	No	Yes	Yes	No	Yes	No
Frenchman Creek	No*	Yes	Yes	No	Yes	Yes
Hay Coulee	No	No	No	No	Yes	No

Summary of Stream Crossing Concerns and Prevention and Mitigation Measures

Stream Crossing	Turbidity Concerns During Inspection	Incision Concerns	Channel Migration Concerns	Consider Route Concerns	Consider Adaptive Management Plan	Consider Alternative Crossing Technique
Rock Creek	No*	Yes	Yes	No	Yes	Yes
Willow Creek	No*	Yes	Yes	No	Yes	Yes
Lime Creek	No	Yes	Yes	Yes	Yes	No
Brush Fork	No	Yes	Yes	No	Yes	No
Bear Creek	No	Yes	Yes	No	Yes	No
Unger Coulee	No	Yes	Yes	No	Yes	No
Buggy Creek	No	Yes	Yes	No	Yes	No
Spring Creek	No	Yes	Yes	No	Yes	No
Cherry Creek	No	Yes	Yes	Yes	Yes	No
Spring Coulee	No	Yes	Yes	Yes	Yes	No
East Fork Cherry Creek	No	Yes	Yes	No	Yes	No
Espeil Coulee	No	Yes	Yes	No	Yes	No
Milk River	No	No	No	No	No	No
Missouri River	No	No	No	No	No	No
West Fork Lost Creek	No*	No	No	No	Yes	Yes
Tributary to West Fork Lost Creek	No*	No	No	No	Yes	Yes
East Fork Prairie Elk Creek	No*	Yes	Yes	Yes	Yes	Yes
Redwater River	No*	Yes	Yes	No	Yes	Yes
Buffalo Springs Creek	No*	Yes	Yes	No	Yes	Yes
Berry Creek	No*	Yes	Yes	No	Yes	Yes
Clear Creek	No*	Yes	No	No	Yes	Yes
Side Channel Yellowstone River	No	No	No	No	No	No
Yellowstone River	No	No	No	No	No	No
Cabin Creek**	No*	Yes	Yes	No	Yes	Yes
Cabin Creek***	No*	Yes	Yes	No	Yes	Yes
Dry Fork Creek****	No*	Yes	Yes	No	Yes	Yes
Pennel Creek****	No*	Yes	Yes	No	Yes	Yes
Little Beaver Creek	No*	Yes	Yes	No	Yes	Yes
North Fork Coal Bank Creek	No	No	No	No	Yes	No
South Fork Coal Bank Creek	No	Yes	Yes	Yes	Yes	No
Boxelder Creek	No*	Yes	Yes	No	Yes	Yes

*
** the Cabin Creek (MP 201.4) crossing was replaced by a crossing on Spring Creek, see Cabin Creek (MP 202.0) for reference site to spring Creek
*** the Cabin Creek (MP 202.0) crossing is presented as a reference site for Spring Creek
**** due to landowner access denial, field assessments for this crossing were performed at an alternate location with similar characteristics

SECTION 1

Introduction

1.1 KEYSTONE XL PIPELINE DESCRIPTION

As described in Section 1.0 of the U.S. Department of State (DOS) environmental impact statement (EIS), TransCanada Keystone Pipeline, L.P. (Keystone) has applied to DOS for a Presidential Permit at the border of the United States for the proposed construction, connection, operation, and maintenance of a pipeline and associated facilities for importation of crude oil from Canada. DOS receives and considers applications for Presidential Permits for such oil pipelines pursuant to the authority delegated to it by the President of the United States under Executive Order (EO) 13337 as amended (69 Federal Register [FR] 25299). DOS has determined that issuance of a Presidential Permit would constitute a major federal action that may have a significant impact upon the environment within the context of the National Environmental Policy Act of 1969 (NEPA) and prepared an EIS for the proposed Project. To comply with NEPA, the principal objectives of the EIS are to:

- Identify and assess potential impacts on the natural and human environment that would result from implementation of the proposed Keystone XL Pipeline Project (Project) in the United States;
- Describe and evaluate reasonable alternatives, including no action, to the Project in the United States that would avoid or minimize adverse effects to the environment;
- Identify the DOS preferred alternative in the final EIS;
- Identify specific mitigation measures, as necessary, to minimize environmental impacts; and
- Facilitate public, tribal, and agency involvement in identifying significant environmental impacts.

TransCanada Keystone Pipeline, L.P. (Keystone) has applied to DOS for a Presidential Permit at the border of the United States for the proposed construction, connection, operation, and maintenance of a pipeline and associated facilities for importation of crude oil from Canada.

The proposed Keystone XL Project would transport Western Canadian Sedimentary Basin (WCSB) crude oil from an oil supply hub near Hardisty, Alberta, Canada to destinations in the south central United States, including the Port Arthur and east Houston areas of Texas. In total, the Project would consist of approximately 1,707 miles of new, 36-inch-diameter pipeline, consisting of approximately 327 miles in Canada and 1,380 miles within the U.S. In Canada, the proposed pipeline would be adjacent to an existing pipeline along much of the route, including at the proposed border crossing near Morgan, Montana. The alternatives analyzed in the EIS do not include the portion of the pipeline in Canada.

The Project would initially have a nominal transport capacity of 700,000 barrels per day (bpd) of crude oil from the oil supply hub near Hardisty, Alberta to existing terminals in Texas. The proposed Project would consist of three new pipeline segments plus additional pumping capacity on the previously permitted and currently under construction Cushing Extension Segment of the Keystone Pipeline Project (Keystone Cushing Extension). The three proposed new pipeline segments in the U.S. consist of the following:

- Steele City Segment (from near Morgan, Montana to Steele City, Nebraska) that connects to the northern end of the Keystone Cushing Extension;
- Gulf Coast Segment (from Cushing, Oklahoma to Nederland, Texas) that connects to the southern end of the Keystone Cushing Extension; and
- Houston Lateral (from the Gulf Coast Segment, in Liberty County, Texas to Moore Junction, Liberty County, Texas).

The new pipeline would extend through five states: Montana, South Dakota, Nebraska, Oklahoma, and Texas. It would pass through Montana for 282.5 miles until the border with South Dakota near Mill Iron, Montana (Figure 1.1-1).

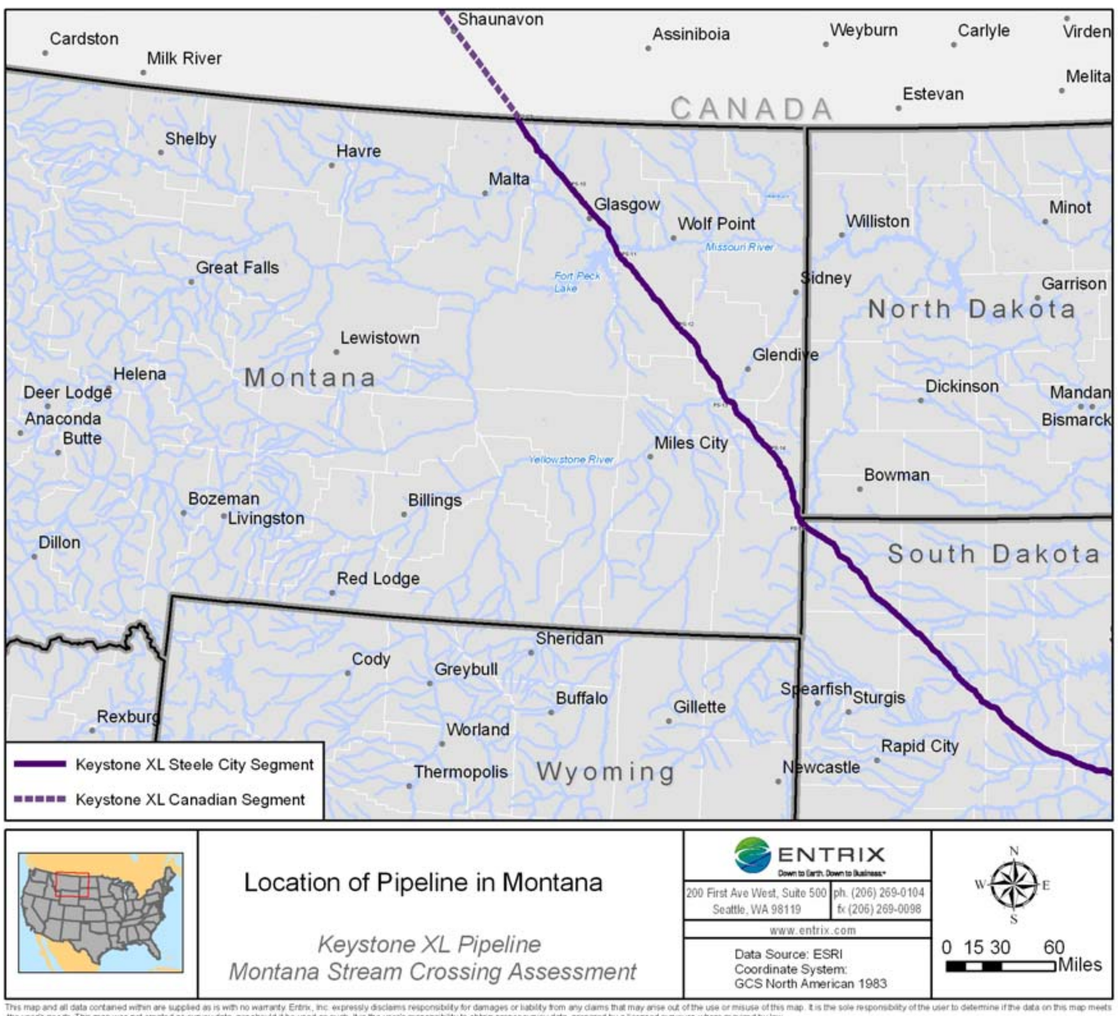

Figure 1.1-1 The Study Location

1.2 MONTANA DEPRTMENT OF ENVIRONMENTAL QUALITY REQUIREMENTS

Because the proposed Project would extend through portions of Montana, Keystone must obtain environmental and other permits from Montana state and local agencies. Keystone would have to obtain a Certificate of Compliance from the Montana Department of Environmental Quality (MDEQ) under Montana's Major Facility Siting Act (MFSA). MDEQ's issuance of the Certificate of Compliance must be based on substantive findings pursuant to Montana Code Annotated (MCA) Section 75-20-301(1) and the application of location criteria listed in Circular MFSA-2. MDEQ is also the lead agency for compliance with the State of Montana Environmental Policy Act (MEPA). Considering issuance of a Certificate of Compliance under MFSA is a state action for which MDEQ is required to prepare an EIS under MEPA.

Prior to making a decision under MFSA and the Montana Water Quality Act (MCA 75-5-318), MDEQ requires a review of stream crossings for the applicant's proposed route. Under MFSA, MDEQ must make a determination on the 318 Authorization concurrent with a decision on the MFSA Certificate of Compliance. ENTRIX, acting as a third-party contractor for DOS and MDEQ, conducted inspections of proposed crossings at all perennial streams and select intermittent streams in Montana.

This Stream Crossing Inspections Report (SCIR) provides information required by MDEQ for the portion of the proposed route in Montana, including the proposed stream crossing methods, selection of crossing sites for field inspection, office and field methods used, results of analyses for each crossing site assessed, and potential site-specific protective measures.

1.3 STREAM CHANNEL MIGRATION AND SCOUR CONCEPTS

Rivers are essentially agents of erosion and transportation, moving the water and sediment supplied to them from the land surface to the oceans. The character and behavior of the fluvial system at any particular location reflects an integrated set of upstream controls, notably climate, geology, land use and basin physiography, which together determine the hydrologic regime and the quantity and type of sediment supplied. Channel migration is the lateral movement of the position of a stream over time; the channel migration zone is the area subject to erosion by the stream (Rapp and Abbe 2003). Channel migration can occur gradually over time (a meander bend moving across the floodplain) or during a single event (channel avulsion). While the channel appears to shift across the floodplain, the overall system of meanders moves downstream. As the channel migrates, the meander belt widens, the curves enlarge, channel width increases and channel profile may change. Scour is the process by which flows wash away sediment from the bed and banks of a stream. General scour, or bed degradation, lowers the elevation of the stream bed. Contraction scour occurs on the bed and banks where flows increase in speed due to narrowing of the channel and local scour takes place around flow obstructions like bridge abutments or piers.

The process of channel migration is a function of stream discharge, sediment supply, and the material characteristics of the channel banks. The rate of migration is controlled to a large degree by bend geometry, especially channel curvature (the ratio of the radius of curvature to channel width). Factors such as bank material erodibility, valley physiography, geology, the presence of vegetation and wood also influence the extent and rate of channel migration. A pipeline could be adversely affected by channel erosion if the burial extent does not accommodate changes in ground surface elevation due to channel migration or scour. Figures 1.3-1 and 1.3-2 illustrate unfavorable and favorable burial conditions where the channel is migrating.

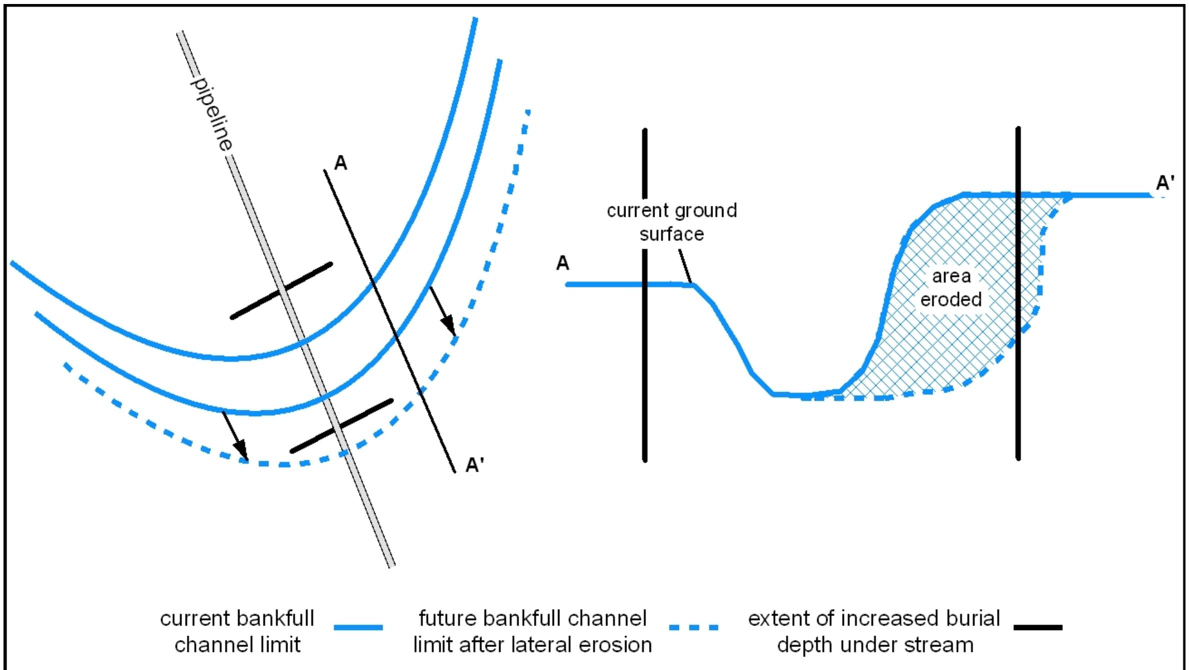

Figure 1.3-1 Undesired Conditions

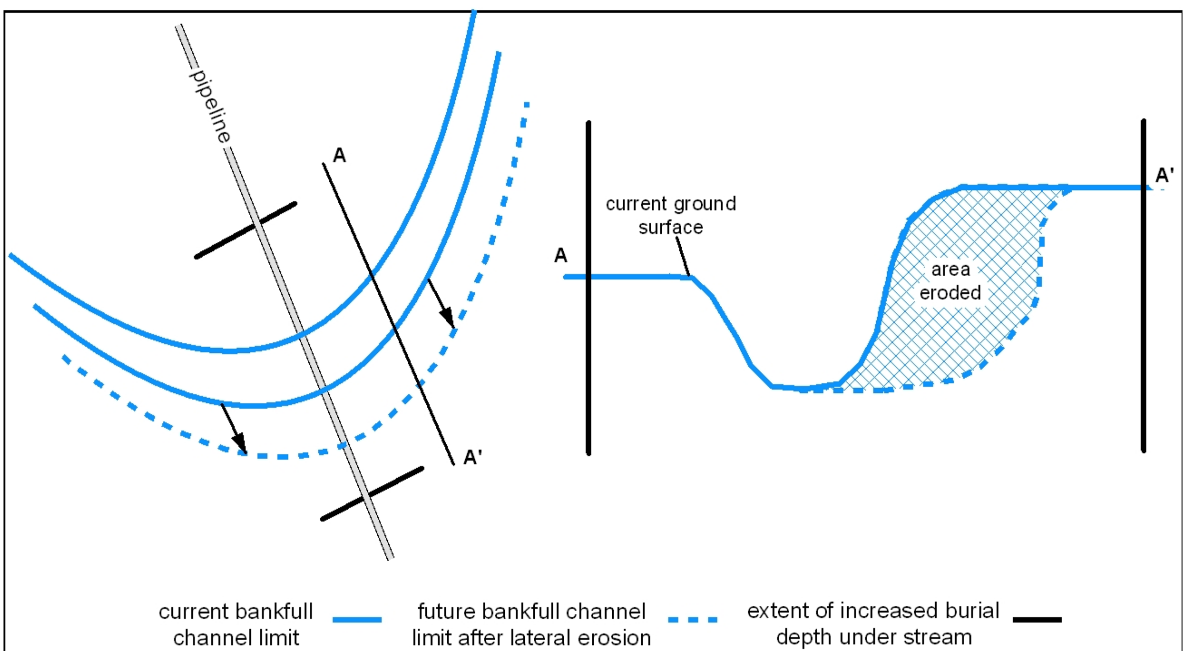

Figure 1.3-2 Desired Conditions

1.4 PROPOSED CROSSING METHODS

Pipeline construction would generally proceed as a moving sequence, including survey and staking of the ROW, clearing and grading, pipe stringing, bending, trenching, welding, lowering-in, backfilling, hydrostatic testing, and cleanup. A number of methods are proposed for the stream crossings in the Construction, Mitigation, and Reclamation Plan (CMRP) (Keystone 2008). The specific method to be used at each stream has not yet been outlined and the plan, once complete, may be changed or amended as conditions at the site dictate. Such conditions include flow depth, rate of flow, subsurface soils, environmental sensitivity of the waterbody and construction duration and timing.

Keystone is currently assessing the potential for vertical scour and lateral migration at each relevant waterbody crossing. A detailed description of the methodology used is provided in Attachment P in MFSA supplemental (blue) filing (09-19-09) (page P-88). Criteria such as soil types, drainage areas, terrain, contours, and water flow velocities that would result from a 100-year event are incorporated into this detailed assessment. The initial evaluation of stream crossings for each vertical-scour potential will include initial basin boundary delineation, delineation basin flood discharge rates, channel cross-section estimate, and other factors to estimate scour depth potential. Each waterbody with a possible scour greater than 5 feet will be considered for field data collection and more in-depth analysis.

The evaluation of the potential for lateral migration will include a review of the vertical scour analysis, a linear discriminant analysis, an analysis based on examining evidence of lateral migration, inspection of current and historic aerial photographs and other pertinent factors. The evaluation procedure will be based on site-specific needs and will use the best available information.

The results from the vertical scour and lateral migration assessments will be incorporated into the engineering and design of the crossings, including the method of crossing, depth of crossing, and extra depth extents of the crossing.

The preferred crossing method is the open-cut crossing method. Major waterbodies (greater than 100 feet wide at the water's edge) and sensitive environments will use horizontal directional drilling (HDD). Dry-ditch methods will be used if construction timing will not protect sensitive waterbodies sufficiently. For waterbodies with important fisheries or special use designation, Keystone will develop crossing plans that occur during construction fish windows in consultation with state agencies and U.S. Fish and Wildlife Service (USFWS) and in agreement with U.S. Army Corps of Engineers (USACE) permits. The CMRP describes certain procedures which will be common to all waterbody crossings regardless of the method used. These procedures are as follows:

- The Contractor will mark clearing boundaries and a minimum 10-foot vegetative buffer will be retained along the edges of the streams, with a sediment barrier upslope of the buffer on both sides.
- Grading of the ROW will be done so that soil is pushed away from the stream and grading and grubbing of banks will be minimized as much as possible. Sediment barriers will be installed across the ROW at any flowing streams and at the edge of the ROW adjacent to all waterbodies. The sediment barriers will be maintained until restoration or permanent erosion control can be established.
- Staging areas will be established a minimum of 10 feet from the waterbody.

- Hazardous material storage, refueling, and equipment repair or washout will not occur within 100 feet of the edge of the waterbody.
- Equipment bridges will be installed perpendicular to the stream and sediment barriers will be installed around access paths.
- All materials and equipment will be made ready before trenching except where the non-flowing open cut method is used or where rock is encountered.

For all crossing methods, except for the non-flowing open cut, the CMRP calls for additional techniques to be applied. These techniques include the following:

- The Contractor will limit equipment use in-channel by working from the banks as much as possible.
- A trench breaker will be installed at the base of the slopes near the waterbody for all major waterbodies and for intermediate waterbodies as required.
- Trench plugs will be installed to prevent water flowing between the trench and the stream.
- Spoils will be stored at least 10 feet from the waterbody with sediment barriers installed to prevent incursion into the stream. No trench spoil will be stored in the channel unless the crossing cannot be realistically completed otherwise.
- Backfill will consist of spoil with no debris. If the stream bed consists of rock, granular material will be used around the pipe for support.
- The backfill will be armored at the top with riprap or some form of bio-stabilization.
- Travel lanes and bridges will be kept in place during testing and clean up.
- The original stream bank contour will be restored and stabilized, and temporary sediment control will be installed within 24 hours after construction if possible. If the banks are steep, unstable or vulnerable to erosion from flow, the banks will be armored with rock, cribs, or bio-stabilization before revegetation. Riprap will be native rock where possible and will extend from the stream bed to the top of the bank. The approach slope will be graded to a slope appropriate to the soil types present and a permanent slope breaker will be constructed.
- Stream banks will be lined with flexible liners and revegetated after grading.
- After clean up, bridges will be removed.

1.4.1 Non-flowing Open Cut Crossing Method

This method will be used for all waterbodies with no visible flow at the time of construction. If there is flow at the time of construction, the CMRP calls for the Flowing Open Cut Crossing Method. Prior to construction, timber matting and riprap will be installed in the entire area to minimize compaction from equipment. Salvage of topsoil is not required if saturated conditions exist. The pipe section will be fabricated adjacent to the stream or in a staging area. The contractor will trench through the stream, lower in the pipe then backfill. After installation, the contractor will remove the timber mats, restore the grade to pre-construction condition and replace the topsoil. Permanent erosion control will be established upon completion.

1.4.2 Flowing Open Cut Crossing Method for Minor, Intermediate or Major Waterbodies

In this method, the trench is dug through flowing water. Backhoes operating from one or both banks would excavate the trench within the streambed. In wider rivers, in-stream operation of equipment may be necessary. The contractor will trench through the stream, lower in a pipe that is weighted for negative buoyancy, then backfill. The CMRP states that for minor waterbodies (less than 10 feet wide at the water's edge), the trenching and backfill of the crossing will occur within 24 hours and for intermediate waterbodies (10 to 100 feet wide) in 48 hours if practicable. Major waterbodies will be crossed with a site-specific plan implemented as quickly as possible. The temporary equipment crossing will have a hay bale gate that will be open only during use of the bridge. After installation, the contractor will restore the grade and replace the topsoil. Permanent erosion control will be established upon completion.

1.4.3 Flowing Stream Crossing – Dry Flume Method

In this method, the stream flow is diverted into a flume pipe. The flume will be installed before trenching and aligned to minimize erosion of the stream banks and bed. The flume capacity will be 1.5 times the flow, provided it will not be in operation for more than 96 hours. The flume will be placed with 10 percent of the diameter below the stream bed if the soil allows, otherwise it will be at the stream grade and slope. Rock will be placed at the outlet to prevent scour. The stream will be diverted to the flume with impervious dams at each end, keyed into the bank if needed. The seal can be made from sand bags or plastic sheeting and the bed may be modified if necessary. The temporary vehicle crossing is constructed over the flume with a stabilized approach and a silt fence gate closed at night and during rainfall. The pipe will be strung and welded before trenching. The contractor will excavate through the plugs and under the flume as quickly as possible, and then install the pipe under flume. Any water from the trench will be discharged into a sediment dewatering structure 50 feet from the waterbody. After backfill, the dam and flume pipe will be removed unless it is part of the equipment bridge. Sediment control structures will remain on the ROW except during excavation. After installation is complete, the contractor will restore stream banks to the original topography, but not steeper than a 2:1 slope. Site-specific permanent erosion control such as rock or flexible channel liner will be installed and the banks will be stabilized with temporary erosion control within 24 hours of completion.

1.4.4 Flowing Stream Crossing – Dry Dam-and-Pump Method

In this method, the stream flow is dammed and pumped around the trench. The dams will be made from steel plates, inflatable plastic barriers, sandbags, clean gravel with a plastic liner, or other materials that keep sediment and pollutants out of the stream. It may be keyed into the bank to make an effective seal. The pump intakes will be screened and the pump outflow will have an energy dissipater to prevent scour. If no natural pool exists at the pump intake, a temporary sump will be constructed upstream of the dam and lined with rockfill. The pumps will be able to maintain 1.5 times the flow in the stream at the time of construction and a back-up pump will be kept on site. Dams and pumps will be monitored; if construction lasts more that 24 hours, the pumps will be monitored over night. The pipe will be strung and welded before trenching. The contractor will excavate through the plugs and stream bed as quickly as possible. Any water from the trench will be discharged into a sediment dewatering structure 50 feet from the waterbody. The spoil containment area will be a minimum of 10 feet away from the stream with both a berm and silt fence sediment barrier. The temporary vehicle crossing is constructed with a stabilized approach and a silt fence gate closed at night and during rainfall. The sediment control structures will remain on the ROW except during excavation. After installation is complete, the contractor will restore stream banks to the original topography, but not steeper than a 2:1 slope. Site-specific permanent erosion control such as erosion control fabric, rock or flexible channel liner will be installed and the banks will be stabilized with temporary erosion control within 24 hours of completion.

1.4.5 Horizontal Directional Drill Crossing

This method will be used for major and sensitive waterbodies where open cutting is not acceptable. It involves drilling a pilot hole under the waterbody and banks, then enlarging the hole progressively until it is large enough to accommodate a prefabricated segment of pipe. Throughout the process, a water-bentonite slurry would be circulated to power and lubricate the drilling tools, remove drill cuttings, and provide stability to the drilled holes. The fluids used during drilling will be non-toxic for aquatic environments. Pipe sections long enough to span the entire crossing would be staged and welded along the construction work area on the opposite side of the waterbody and then pulled through the drilled hole. The drilling equipment will be staged a minimum of 100 feet from the waterbody. Clearing around the drill equipment will be limited to a 10 foot wide swath for monitoring of the drill. Drilling mud tanks or sumps with downslope berms will be placed at entry and exit points to prevent drilling mud release. The drilling area and the waterbody downstream of the crossing will be monitored for the release of drilling fluids. The CMRP requires the contractor to have a plan in case of *frac-out*, the escape of drilling mud onto the surface as a result of a spill, tunnel collapse or rupture. Drill cuttings and mud will be placed in an approved manner, such as spread over the upland right of way or taken to a licensed landfill.

1.4.6 Horizontal Bore Crossing

This method may be used for major and sensitive waterbodies and also does not require direct contact with the stream. Horizontal bore crossings use vertical holes on each side of the stream, which are then bored through to complete the crossing. The bore annulus will be at most one inch greater than the line pipe. It does not require the use of pressurized mud systems as do horizontal directional drill crossings, so there is no risk of sediment release due to *frac-out*. The pipeline marker and test location will be in the ROW if possible. The crossing pipe will extend to ROW line and will have abrasion resistant coating.

1.5 PROPOSED SITE RECLAMATION METHODS

The purpose of reclamation is to return construction areas to a condition approximating the pre-construction state. The CMRP describes the cleanup process as the removal of construction debris, final contouring, and the installation of erosion control features. After pipeline installation, stream banks would be restored to pre-construction contours. Most restored banks will be protected through the use of flexible channel liners. Where flow conditions or the original stream slope will result in instability, the bank will be contoured to a more stable configuration.

Banks are to be temporarily stabilized within 24 hours of completing in-stream construction. Stable banks would be seeded with native grasses and mulched or covered with erosion control fabric. The seed mix will be developed with information from the local Natural Resource Conservation Service and will be certified to limit noxious weeds. The seeds will be applied by drill seeding, broadcast or hydro-seeding. Permanent erosion control measures may be installed for steep banks, including rock riprap, gabion baskets (rock enclosed in wire bins), log walls, vegetated geogrids, willow cuttings, or alternative wood-based structures.

All areas with high erosion potential and slopes greater than 8 percent will be mulched unless otherwise approved by Keystone. In steep terrain, trench breakers would be used to limit the potential for erosion at the base of slopes adjacent to waterbodies and wetlands. Trench breakers can be made of sand bags, sand/cement bags, bentonite bags, or other similar materials. Permanent slope breakers are generally installed immediately downslope of trench breakers. Constructed from soil or sand bags, slope breakers limit erosion on the ROW and divert surface runoff to adjacent vegetated areas or to energy-dissipating structures. Sediment barriers, such as silt fences, straw bales or drivable berms would be maintained across the ROW at approaches to all waterbodies until permanent vegetation is established. The temporary equipment bridges would be removed following construction. Where the ROW was stripped of topsoil, compaction will be reduced through ripping and discing before replacement of topsoil.

SECTION 2

Methodology

2.1 SITE SELECTION

The proposed pipeline would cross a total of 386 waterbodies in the State of Montana. A total of 55 sites of the 386 were selected for additional review by MDEQ. The selection of these sites was made by MDEQ in consultation with ENTRIX and Keystone. Specific requirements for additional consideration included all perennial streams and intermittent sites with a water quality designation. Of the 55 crossings, 20 are perennial streams and 35 are intermittent streams (Figure 2.1-1).

All 20 perennial crossings were inspected at the proposed crossing locations with the exception of three crossings: Dry Fork Creek, Pennel Creek, and Buffalo Springs Creek. Landowner approval was not obtained for onsite inspections at these sites. Therefore, these crossing locations were assessed from nearby public lands (i.e., upstream or downstream bridges or from public land along the creeks). This was done following consultation and approval from MDEQ which was received on July 23, 2009 (personal communication with Tom Ring).

Initial evaluations in the office were conducted for the 35 proposed crossings of intermittent streams to determine which would require field inspection. This evaluation was conducted in consultation with MDEQ and included consideration of the following criteria:

1. Crossing sites are within a designated floodplain of the state;
2. Crossings of waterbodies with fish Species of Concern to the State of Montana or which are known to include the habitats of those fish species; and
3. Streams of special interest to the state.

No sites were identified within a designated floodplain of the State of Montana. However, 14 streams were identified with fish species of concern to the State of Montana. This represents a total of 15 crossings because Corral Coulee is crossed twice. The Montana Department of Fish Wildlife and Parks has prepared a list containing animals in Montana that are currently identified as “Species of Concern” (http://fwp.mt.gov/wildthings/concern/fish.html). Sites were identified for either the northern redbelly finescale dace or the sauger (Table 2.1-1).

Table 2.1-1 Intermittent Streams with MDFW&P Identified Species of Concern

Stream Crossing	Fish Species of Concern
Bear Creek	Northern Redbelly Finescale Dace
Brush Fork	Northern Redbelly Finescale Dace
Buggy Creek	Northern Redbelly Finescale Dace
Cherry Creek	Northern Redbelly Finescale Dace
Corral Coulee (2 crossings)	Northern Redbelly Finescale Dace

East Fork Cherry Creek	Northern Redbelly Finescale Dace
Espeil Coulee	Northern Redbelly Finescale Dace
Hay Coulee	Northern Redbelly Finescale Dace
Lime Creek	Northern Redbelly Finescale Dace
North Fork Coal Bank Creek	Sauger
South Fork Coal Bank Creek	Sauger
Spring Coulee	Northern Redbelly Finescale Dace
Spring Creek	Northern Redbelly Finescale Dace
Unger Coulee	Northern Redbelly Finescale Dace

The northern redbelly x finescale dace hybrid (*Phoxinus eos x P. neogaeus*) is a Montana Fish Species of Special Concern, Class C (Hunter 1997). It was placed on the species of concern list due to its rarity and unusual form of genetic reproduction (Holton and Johnson 1996). Montana appears to be the only state that designates special status for this hybrid fish (AFS website 2003).

The sauger (*Stizostedion canadenseis*) is native to Montana east of the Continental Divide. It inhabits both large rivers and reservoirs, but is mainly a river fish. Sauger are a highly prized sport fish and in some areas outside Montana are also commercially fished.

In addition, one site was identified as a stream of special interest to the State of Montana following a flyover by MDEQ in the Spring of 2009.

Therefore, these criteria identified a total of 16 intermittent crossings where site inspections would be conducted. The remaining 19 intermittent stream crossing did not meet any of these criteria and were therefore evaluated using the office review procedures only.

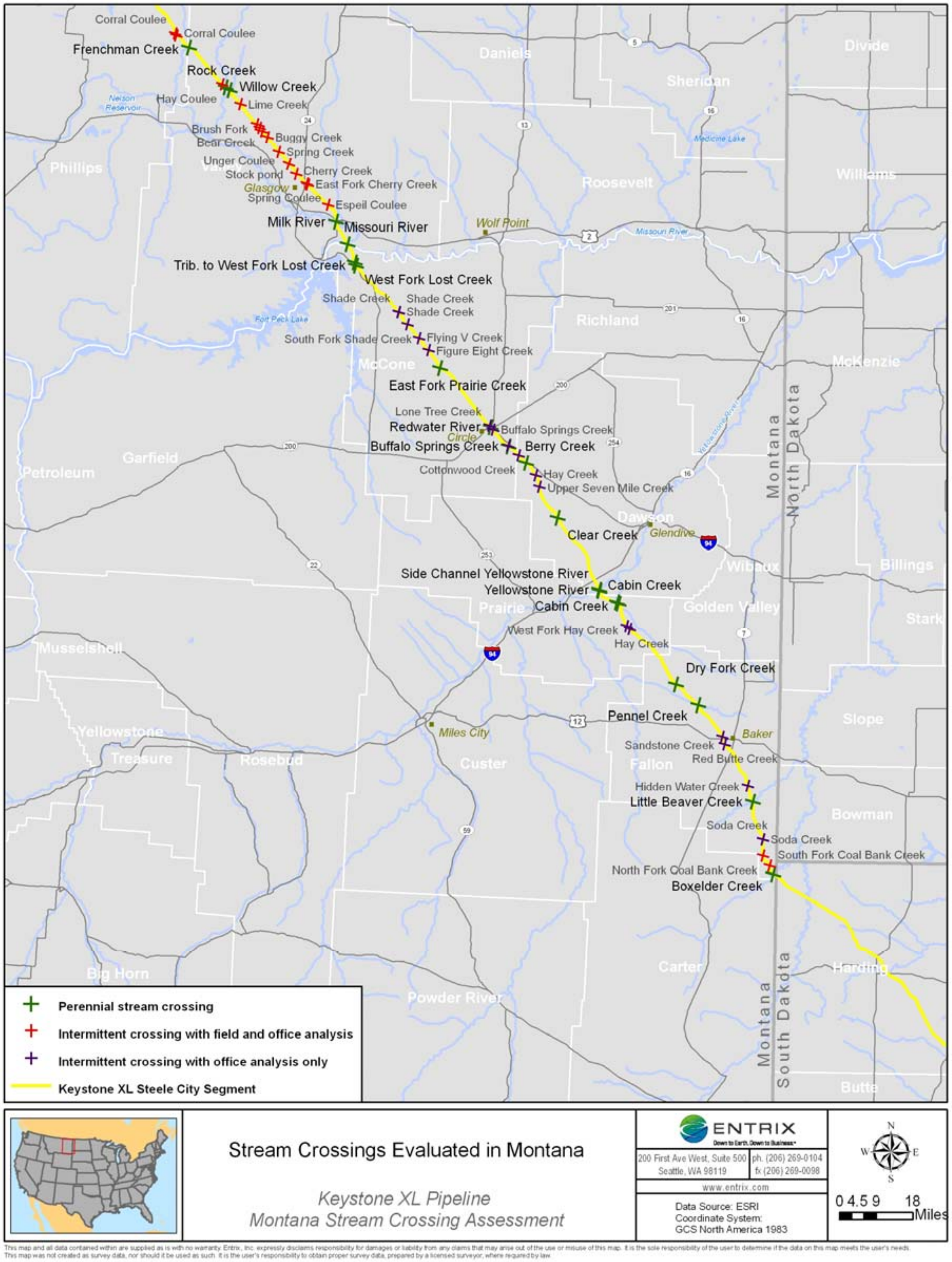

Figure 2.1-1 The Location of Stream Crossings Evaluated in Montana

2.2 OFFICE ANALYSIS

The purpose of the office analysis is to provide context, background and support for the field investigations. It was comprised of examinations of three aspects of the proposed crossings: flood flow, geomorphic characterization, and review of available literature. Flood flow frequency analyses were performed at the proposed crossing locations. Flood flow discharge for Montana streams can be calculated using regression equations developed for the physiographic regions of the state (Omang 1992). These regional regression equations can only be applied to locations in which the drainage basin size is between 0.4 and 2,500 square miles (Omang 1992). The area of the basin draining to the crossing was delineated and its mean elevation derived from a U.S. Geological Survey (USGS) 30-meter digital elevation model (DEM). Entering these variables into the appropriate regression equation allowed the discharge for the 2, 5, 10, 50 and 100-year flow to be calculated.

The nearest flow gauge on the stream was included in the analysis if the hydrological elements at the gauge were similar to those at the crossing (e.g., drainage basin area). The Federal Emergency Management Agency (FEMA)'s Bulletin 17B method calculates flood flows using the arithmetic mean, standard deviation and a weighted coefficient of skewness (FEMA 1981). The weighted coefficient of skewness is influenced by the skew of the gauge station data (station skew) and the location of the gauge station (location skew). Stations were arbitrarily selected for an additional flood flow calculation as a check to assess the influence of location skew on the results by using only the station skew (USACE 2009). Some stations were arbitrarily selected for a second method as a check using an exceedance probability curve. The historical annual peak flow data was ranked and an exceedance probability was calculated to determine the flood flow discharge for each return period.

The geomorphic assessment was conducted using ArcGIS, a geographic information system, and several sources of data acquired from the Montana Natural Resource Information System:

- Aerial photographs from July to August of 2005 taken by the U.S. Farm Services Agency National Agricultural Imagery Program (NAIP) (orthorectified, 1-meter resolution);
- 1:24,000-scale topographic maps in from the USGS Digital Raster Graphics of original maps developed between 1940 and 1995
- 1:100,000-scale geological maps from the Montana Bureau of Mines and Geology
- Geological unit descriptions (Vuke et al. 2007)
- Digital surface water data from the USGS National Hydrography Database

Parameters were qualified for the channel to be crossed as well as the surrounding floodplain and valley. Channel characterization was based on aerial photographs of the reach extending 3 meander wavelengths upstream and downstream of the crossing. The width of the channel and valley was measured at the crossing and at additional locations upstream and downstream. The meander wavelength and amplitude were measured and the radius of curvature for the meander bends in the study reach were calculated. The sinuosity of the stream was calculated; a sinuosity of less than 1.2 is considered relatively straight, sinuosity of about 1.2 to 1.5 is considered moderate and high sinuosity is greater than about 1.5. The channel was visually assessed for form: single channel, anabranching or braided stream. An anabranching channel has distributaries that branch off and rejoin, separated by bedrock or stable alluvium islands; a braided channel consists of multiple channels in a complex interlacing network. The gradient for the channel and the valley bottom was determined using the topographic maps and DEM. A slope of less than 2 percent is considered low, 2 percent to 4 percent is moderate and greater than 4 percent is classified as high gradient.

The geology present in the valley and upstream was determined using the digital maps and the width of valley bottom alluvium was measured if present. The aerial photographs were examined for evidence of floodplain features such as scroll bars, oxbow lakes, relic channels, and cut-offs. Landslide indicators were also noted (e.g., scars on the landscape, disturbed vegetation, drainage anomalies, or lobed run-outs). Infrastructure in the vicinity of the crossing was catalogued on aerial photographs and topographic maps. The proximity of floodplain features, landslide indicators and infrastructure to the crossing was measured as a straight-line distance up or down the valley. Locations were also described as being on river right or left; these indicate the direction as one looks downstream. The literature review looked for any previous channel migration zone studies as well as reports on hydrology, hydraulics, sediment transport, bridge scour, ice jams and turbidity.

2.3 FIELD ANALYSIS

All 20 perennial stream crossings and 16 of 35 intermittent stream crossings were evaluated in the field to collect site specific information for each crossing. MDEQ identified the following major criteria for the evaluation of the crossings:

- Evaluation of the adequacy of the proposed stream crossing methods to withstand stream scour, incision, and lateral stream movement over the life of the project;
- Assessment of the proposed crossing techniques to reduce turbidity during construction and operations;
- Assessment of the location of the proposed crossing relative to MDEQ's required finding under the MFSA that the project minimize adverse environmental impact, considering the state of available technology and the nature and economics of the various alternatives; and
- Identification of appropriate stream bank protection and reclamation measures.

Field data forms were developed using these criteria and with support from stakeholders. Site specific information collected included characterization of the stream form and geometry, alluvial substrate, soils, vegetation, evidence of current and previous instability, and natural and artificial disturbance impacting the crossing site. Information was recorded on the field data forms as quantitative and qualitative metrics, photos, and sketches (planview and cross-section).

Field engineers and a land agent from Trow and Universal ENSCO (Keystone pipeline engineering and land acquisition sub-contractors) accompanied ENTRIX geomorphologists at each proposed crossing site. Land agents coordinated with landowners prior to each site visit to ensure permission to access private property was granted and so landowners could be present during the field assessment, provide their input, and have any questions answered. Field engineers were present to answer technical questions pertaining to the proposed crossing methods (site specific limitations and feasibility) and the proposed pipeline route.

Information from the office evaluation was used during the field assessments. This reach-level information was used to place the proposed crossing location in context with the surrounding topography, geology, soils, hydrology, and note any natural or artificial disturbances adjacent to the crossing that may impact the site. Field maps and valley cross-sections were developed for each proposed crossing site, which included a series of maps: topography, geology, current and historic air photos, and soils. Valley cross-sections along the proposed route were developed using USGS 30m DEMs. More detailed channel and floodplain cross-sections were sketched in the field to capture site specific landforms lacking in the resolution of the DEMs. The flood frequency analysis results were used to confirm field interpretations of the limits of the bankfull channels and the inundation frequency of a given floodplain.

During each field assessment general site characteristics were documented including the channel and valley form, confinement, flow conditions, and any additional parameters that directly influence the four MDEQ criteria. Shallow (less than 2-foot) pits were excavated to characterize alluvial substrate in the channel bed, banks, floodplains, and bars (if present). Banks on both sides of the stream were characterized by their height (above the channel thalweg for dry streams and above the water line for flowing streams), slope, vegetation cover and rooting depth, and any evidence of instability. Floodplains were characterized by soil maturity, vegetation cover, and the presence of levees (natural and artificial), side channels, or crevasse splays and channels. The bankfull channel width, depth, and indicators of its extent were recorded. Dimensions of channel bars, islands, and pools were measured and any evidence of channel incision or aggradation was documented. Adjacent infrastructure and channel disturbances such as bridges, roads, instream structures, woody debris, landslides, and beaver dams were recorded. All channel and floodplain characteristics documented and measured in the field were photographed. Planview and cross-section sketches were drawn to graphically depict the site and the relative locations of features within the crossing area. Turbidity was qualitatively described where water was present at the proposed crossing and any potential impacts expected during in-stream construction. At sites where the HDD crossing technique is proposed there is no expected turbidity impact.

SECTION 3

Site Descriptions

For each proposed perennial stream crossing, and some intermittent stream crossings a detailed site description follows. Intermittent stream crossings with a detailed site description include those where indicators of instability were recorded during the field assessment, and as a result where additional protective measures could be provided to enhance longer term crossing stability, or where an adjustment in the crossing location may provide enhanced geomorphologic stability and should be considered if feasible in light of all other relevant parameters (e.g., land ownership, land use, project economics, etc.). The results of the office analysis for all perennial and intermittent streams are provided in Appendix A. At crossings where a field assessment was conducted, field forms are provided in Appendix B.

Moderate to high background turbidity was observed at all field sites with water present. Potential sources of turbidity observed include: erosive fine-grained soils along channel banks, cattle grazing disturbing channel banks, unconsolidated channel bottom, and irrigation runoff. Background turbidity should be measured prior to crossing to compare with monitoring during construction activities in the stream.

3.1 PERENNIAL STREAMS

3.1.1 Frenchman Creek (MP 25.8)

3.1.1.1 Site Characteristics

Frenchman Creek is a perennial stream with a drainage area of approximately 366.8 square miles at the proposed crossing. This is an estimate because evaluation of topographic maps indicates that roughly 55 percent of the watershed is located in Canada, for which data was not available. The portion of the watershed located within United States is 163 square miles in area. Tributaries to the creek include unnamed streams upstream of the proposed crossing at 0.1, 0.4 and 0.6 mile. Downstream of the crossing, tributaries join the creek at 0.5, 0.6, 0.8 and 0.9 mile from the crossing. The geology of the valley on both sides of the creek consists of the Judith River Formation: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. Upstream of the crossing on both sides is the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. Indicators for landslides are visible in 2005 aerial photographs 1.6 miles upstream of the crossing. In addition, this creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). Aerial photographs also show scroll bars 0.6 mile upstream and relic channels 1.3, 1.8, and 2 miles upstream of the proposed crossing. An oxbow lake also appears on the aerial photographs, apparently enhanced for use in the surrounding agricultural fields. The floodplain is mapped as modern alluvium 3,151 feet wide at the proposed crossing and the gradient is low. Sinuosity is high and the meanders directly upstream of the crossing are especially tortuous. Channel widths range from 34 to 61 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-1). No stream gauge data were available for this creek.

Table 3.1-1 Regional Regression Analysis for Frenchman Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	366.8*	2,656	619	1,787	2,924	4,735	6,472	8,337

*163mi² of watershed is located in US. An evaluation of the relief map showed more than half of the watershed in within Canada

Frenchman Creek at the 25.8 Mile Post (MP) crossing is a single thread meandering stream confined within a 2,000 to 3,000-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg. At some locations in the center of the valley there is a high elevation floodplain that is adjacent to the low elevation floodplain. Fill material has been placed on the high elevation floodplain at some locations, increasing elevation by tens of feet.

The bankfull channel at the MP 25.8 crossing is approximately 60 feet wide and is 6 to 8 feet deep. The unvegetated thalweg width is approximately 50 feet. The silty clay surficial alluvium of the channel thalweg is unarmored. The limit of the bankfull channel is well defined by a 2 to 2.5-foot bank on either side. At the crossing the 2.5-foot-high, 45 to 90-degree left bank (the outside meander bend) is comprised of silty clay and is undercut at several locations of slumping. The slope of the 2-foot-high right bank (the inside of meander bend) is 45 degrees and is comprised of silty clay. Both the left and right banks are densely vegetated with willow shrubs with rooting depths of over 2.5 feet.

Floodplains exist on either side of the bankfull channel at the crossing site. There is both a high and low elevation floodplain on the right side of Frenchman Creek. The low elevation floodplain sits 2 feet above and adjacent to the unvegetated channel and is approximately 180 feet wide. The alluvium on the low elevation floodplain is silty clay with a moderately developed organic surface. Vegetation is dominated by annual grasses and dense stands of willow shrubs. An additional 1,400-foot low elevation floodplain exists adjacent to the right valley margin along the proposed pipeline route that is interpreted to be a relic channel location. This section of the right floodplain is hydrologically connected to the contemporary stream channel but at a meander bend upstream of the crossing. The high elevation right floodplain sits 5 feet above and adjacent to the low elevation floodplain and is approximately 470 feet wide with annual grasses and scattered sagebrush. The floodplain on the left side of Frenchman Creek is a low elevation floodplain that is 2.5 feet above and adjacent to the unvegetated channel and is approximately 750 feet wide. The alluvium is silty clay with a moderately developed organic surface. Vegetation is dominated by annual grasses and dense stands of willow shrubs.

3.1.1.1.1 Disturbance

Infrastructure in the area includes a parallel road 0.85 mile from the left bank and a concrete dam 2.6 miles downstream of the proposed crossing. The dam forms Frenchman Reservoir which is 1.5 miles long and 0.75 mile wide. A road crosses over this dam and runs along the right bank of the reservoir beside a group of buildings.

3.1.1.2 Alternative Approach

3.1.1.2.1 Crossing Technique

The proposed crossing method for Frenchman Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.1.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that Frenchman Creek at MP 25.8 has migrated laterally throughout the alluvial valley bottom. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) at the proposed crossing site the right low floodplain is a relic oxbow feature that the channel once occupied. The presence of Frenchman Reservoir immediately downstream of the proposed pipeline route has significantly altered the hydraulics at the site. The reservoir acts as grade control reducing the potential for scour and incision, and has likely greatly reduced flood velocities and associated shear stresses on the channel bed and banks, making lateral migration unlikely over the lifespan of the project. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 40 feet beyond both the left and right banks (approximately 140 feet in length) (Figure 3.1-1). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Frenchman Creek (MP 25.8) this plan would include placing field stakes 40 feet and 10 feet from the right and left channel banks where the pipeline crosses the stream. Additional monitoring stakes should be placed along the primitive road between the river upstream and the low right floodplain. During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the channel banks or beyond the primitive road on the right floodplain (Figure 3.1-1), preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

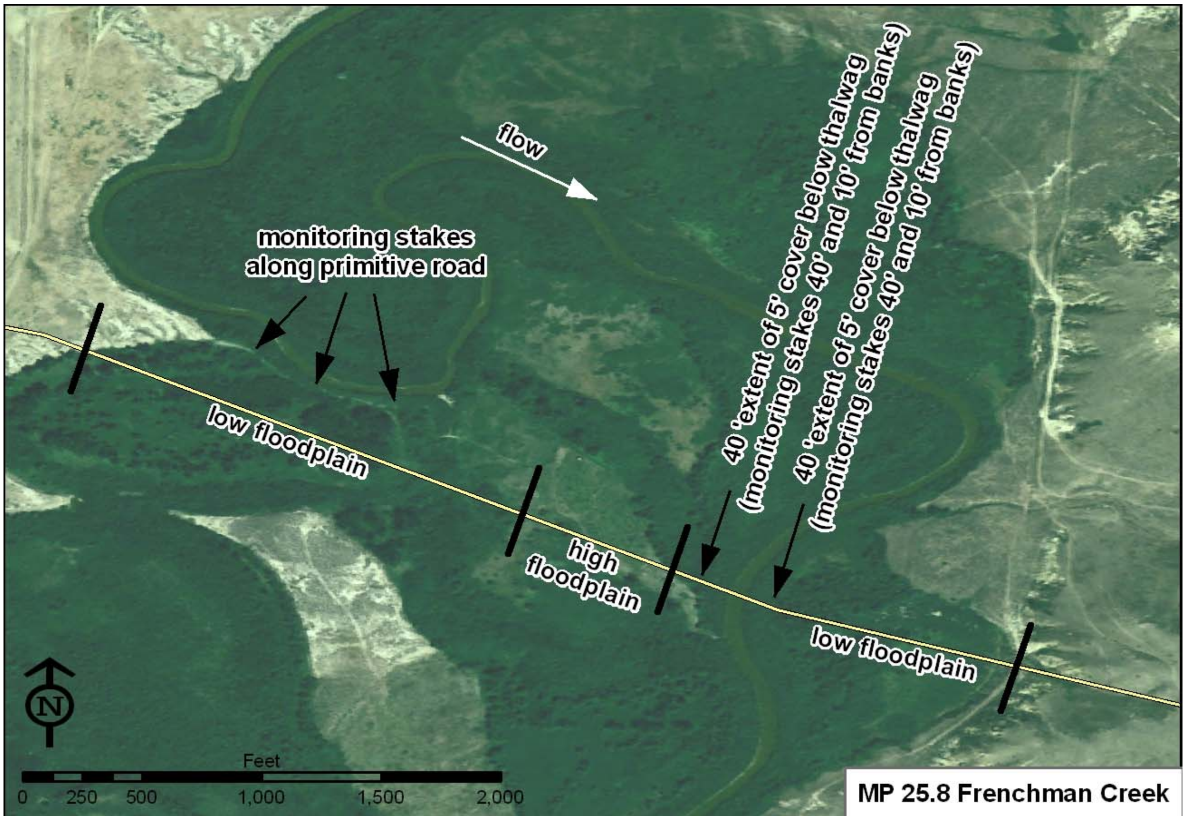

Figure 3.1-1 Burial Depth and Extent for Frenchman Creek

The presence of Frenchman Reservoir dam downstream of the proposed crossing poses a potential risk to the pipeline. Failure of the downstream structure would result in a rapid decrease in the channel bed elevation that would quickly migrate upstream and could potentially expose and damage the pipeline. An investigation into the structural integrity and maintenance requirements of the downstream structure to assess the stability of the structure and its potential to fail during the lifetime of the project was beyond the scope of this analysis.

3.1.1.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.2 Rock Creek (MP 39.2)

3.1.2.1 Site Characteristics

Rock Creek is a perennial stream with a drainage area of approximately 293.8 square miles at the proposed crossing. This is an estimate because evaluation of topographic maps indicates that roughly 30 percent of the watershed is located in Canada, for which data was not available. The portion of the watershed located within the United States is 226 square miles in area. Tributaries to the creek include unnamed streams upstream of the proposed crossing at 0.1, 0.5, 0.77, 0.81, and 1.5 miles. Downstream of the crossing, tributaries join the creek at 0.1, 0.3, and 1.2 miles from the crossing. The geology of the valley on both sides of the creek consists of the Judith River Formation: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. The left bank of the valley also is mapped with Claggett Shale: shale with thin sandstone laminae and beds in the upper or middle part and calcareous concretions in the lower part. Quaternary landslide deposits border the valley on the right bank in a continuous strip that is 560 feet wide at the crossing. In addition, this creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The floodplain is mapped as Quaternary sand and gravel deposits 638 feet wide at the proposed crossing and modern alluvium 701 feet wide at the crossing. The gradient is low, sinuosity is moderate to high and channel widths range from 26 to 60 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-2). No stream gauge data were available for this creek.

Table 3.1-2 Regional Regression Analysis for Rock Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	293.8*	2,603	535	1,570	2,587	4,221	5,791	7,491

*226 mi^2 of watershed area is located in USA and an additional 30 percent of the watershed area is within Canada.

Rock Creek at the 39.2 MP crossing is a single thread meandering pool-riffle stream confined within a 900 to 1,200-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Both in-stream and lateral bars are present adjacent to and within the unvegetated channel. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present they are deeply incised into the surrounding valley alluvium and adjacent to the channel thalweg. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the low elevation floodplain.

The bankfull channel at the MP 39.2 crossing is approximately 100 feet wide and is 3 to 4 feet deep. The unvegetated thalweg width is approximately 45 feet. The gravel-pebble surficial alluvium of the channel thalweg is unarmored. The thalweg channel is well defined by a 2 to 3-foot bank on either side. At the crossing the 3-foot-high, 15-degree left bank is comprised of fine to very fine sand. The slope of the 2-foot-high right bank is 25 degrees and is comprised of fine to very fine sand. Both the left and right banks have no woody vegetation and are dominated by annual grasses and herbs with 0.5-foot rooting depths. The limit of the bankfull channel is well defined by a 15 to 20-foot bank on either side. At the crossing the 15 to 20-foot-high, 50-degree left bank is comprised of fine to very fine sand. The slope of the 15 to 20-foot-high right bank is 70 to 90 degrees and is comprised of fine to very fine sand. The high right bank has numerous locations with documented slumping. Both the high left and right banks have no woody vegetation and are dominated by annual grasses and herbs with 0.5-foot rooting depths. Approximately 50 feet downstream of the crossing is an instream sandy gravel bar with 60 percent to 70 percent wetland herbaceous plants cover.

A bankfull floodplain exists on right side of the unvegetated channel at the crossing site. There is no well defined floodplain on the left of the unvegetated channel at the crossing site. The low elevation floodplain sits 2 feet above and adjacent to the unvegetated channel and is approximately 25 feet wide. The alluvium on the low elevation floodplain is fine to very fine sand with a poorly developed organic surface. Vegetation is dominated by wetland herbaceous plants. Approximately 15 to 20 feet above the low elevation floodplain is a high terrace floodplain that represents a 50 to 100 year floodplain. The terrace floodplain has no evidence of recent overland flow and supports an upland sagebrush community with very widely scattered mature cottonwood trees.

At both the upstream and downstream meander bends from the proposed crossing the channel is located at the margin of the alluvial valley bottom. The channel is actively eroding the valley margins creating high, nearly vertical cliffs composed of unconsolidated alluvium. Evidence of recent failure is present. A large failure of any of these high cliffs could potentially fill the channel at its base, causing widespread flooding and channel re-location.

3.1.2.1.1 Disturbance

Infrastructure in the vicinity includes a number of small roads running parallel to the creek on both sides and a group of buildings 0.9 mile downstream of the proposed crossing.

3.1.2.2 Preventative Measures

3.1.2.2.1 Crossing Technique

The proposed crossing method for Rock Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.2.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that Rock Creek at MP 39.2 has migrated laterally throughout the alluvial valley bottom. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) at the proposed crossing site the high right bank has numerous locations with documented slumping. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 40 feet beyond both the left and right high (bankfull) banks (approximately 195 feet in length) (Figure 3.1-2). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Rock Creek (MP 39.2) this plan would include placing field stakes 40 feet and 10 feet from the right and left banks defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-2). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

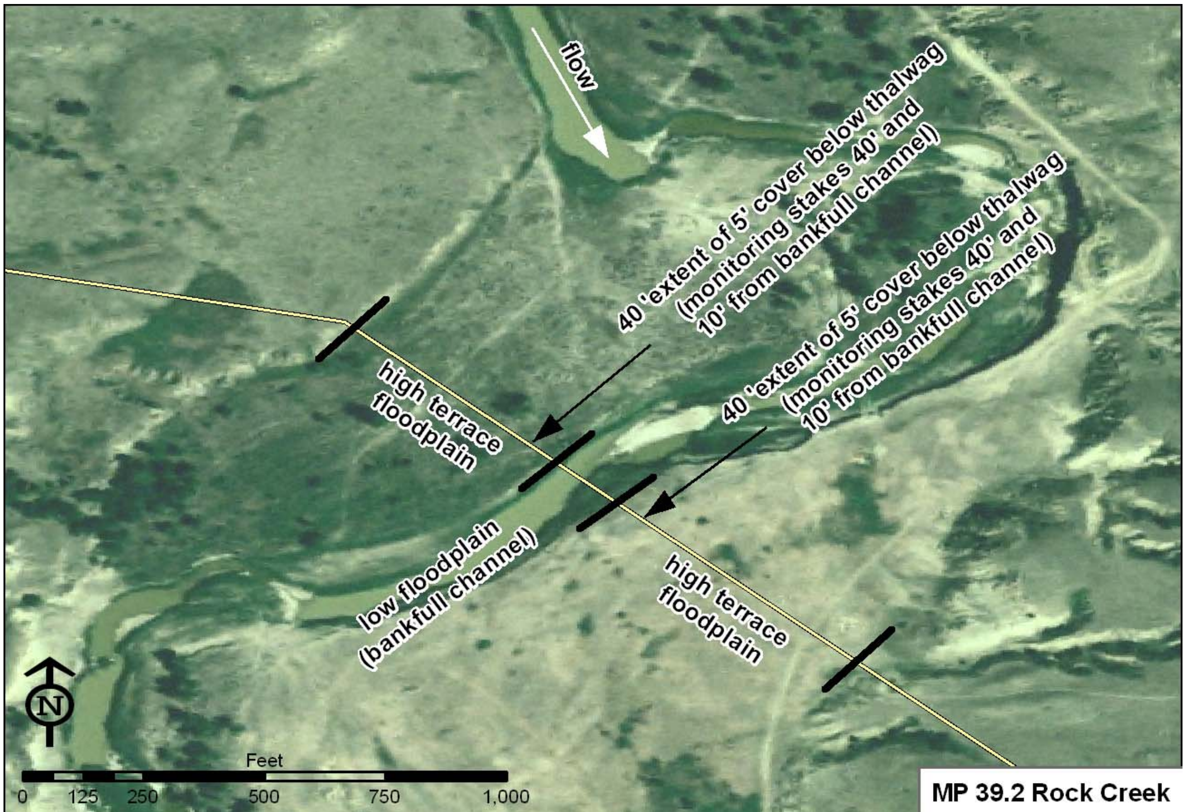

Figure 3.1-2 Burial Depth and Extent for Rock Creek

3.1.2.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.3 Willow Creek (MP 40.4)

3.1.3.1 Site Characteristics

Willow Creek is a perennial stream with a drainage area of 273.2 square miles at the proposed crossing. Eagle's Nest Coulee joins Willow Creek at 0.86 mile upstream of the crossing and a number of unnamed tributaries are present upstream and downstream. Willow Creek flows into Rock Creek 1.5 miles downstream of the crossing. The geology of the valley on both sides of the creek consists of the Judith River Formation: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. Just upstream and downstream of the crossing, the Claggett Formation outcrops along the bottom of the valley walls on both sides: shale with thin (gray) sandstone laminae and beds in upper or middle part and calcareous concretions in lower part. Quaternary landslide deposits border the valley on the right bank downstream of the crossing and indicators for landslides are visible on 2005 aerial photos 0.4 mile upstream of the crossing. In addition, this creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). Relic channels are visible in the aerial photos at locations 0.4 mile upstream and 0.3, 0.6, 1 and 1.4 miles downstream of the proposed crossing. Scroll bars can be seen 1.6 miles downstream of the crossing and on Eagle's Nest Coulee at its confluence with Willow Creek. The floodplain is mapped as Quaternary sand and gravel deposits 2,558 feet wide at the proposed crossing and the gradient is low. Sinuosity is high and channel widths range from 27 to 49 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals. The data from the USGS stream gauge on the creek is not sufficient for a peak flow flood frequency analysis, so the regional regression equation was used for the gauge data as a comparison. The results of these analyses are summarized in Table 3.1-3.

Table 3.1-3 Regional Regression and Peak Flow Analysis for Willow Creek

Regional Regression										
Source	Drainage Area (mi²)		Average Elevation (ft)		Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
Omang (1992)	273.2		2,658		505	1,475	2,428	3,953	5,419	6,999
Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi²)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06170200 Willow Creek near Hinsdale MT (Regional regression)	283.0	DS	1.45	8 (1965-1973)	517	1,509	2,482	4,039	5,535	7,146

Willow Creek at the 40.4 MP crossing is a single thread meandering pool-riffle stream confined within a 2,000 to 2,700-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. In-stream bars are present within the unvegetated channel. Floodplain widths vary according to the relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. The channel thalweg is deeply incised into the adjacent floodplain and conveys all flows less than the bankfull discharge. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the floodplain.

The bankfull channel at the MP 40.4 crossing is approximately 54 feet wide and is 10 to 12 feet deep. The unvegetated thalweg width is approximately 42 feet. The gravel-pebble surficial alluvium of the channel thalweg is unarmored. Gravel-pebble bars are present adjacent to the unvegetated channel, alternating from the left to right bank. The bankfull channel is well defined by a 10 to 12-foot bank on either side. At the crossing the 12 feet high, 70 to 90-degree left bank is comprised of very fine sand. The slope of the 10 to 12-foot-high right bank is 50 to 90 degrees and is comprised very fine sand. Both the left and right banks have dense stands of willows covering 25 percent to 60 percent of the bank with greater than 1-foot rooting depths.

The bankfull discharge is completely conveyed within the channel at the Willow Creek crossing. There is a high floodplain approximately 10 to 12 feet above the unvegetated channel on either side of the channel at the crossing. The floodplain is 50 feet wide on the right side (outside meander bend) and 340 feet wide on the left side (inside meander bend) of the channel. The right floodplain is composed of very fine sand and is vegetated with young woody shrubs and upland herbaceous plants. The left floodplain is composed of very fine sand and has an upland sagebrush community with scattered stands of mature cottonwood trees. Topographic depressions are found throughout the left floodplain and a several foot high bank defines the outer margin of the floodplain. Above the left floodplain is a terrace with no indicators of recent overland flow.

3.1.3.1.1 Disturbance

Infrastructure in the vicinity includes a parallel road that crosses the creek with a bridge 0.84 mile downstream of the proposed crossing.

3.1.3.2 Preventative Measures

3.1.3.2.1 Crossing Technique

The proposed crossing method for Willow Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.3.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that Willow Creek at MP 40.4 has migrated laterally throughout the alluvial valley bottom. These lines of evidence include 1) the channel meanders across the entire valley bottom both upstream and downstream, 2) historic aerial photo analysis indicated channel migration downstream of the crossing site. To provide protective measures the pipe could be buried a minimum of 5 feet below the channel thalweg, and maintained at that elevation 40 feet beyond both the left and right bankfull banks (approximately 135 feet in length) (Figure 3.1-3). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Willow Creek (MP 40.4) this plan would include placing field stakes 40 feet and 10 feet from the right and left banks defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-3). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

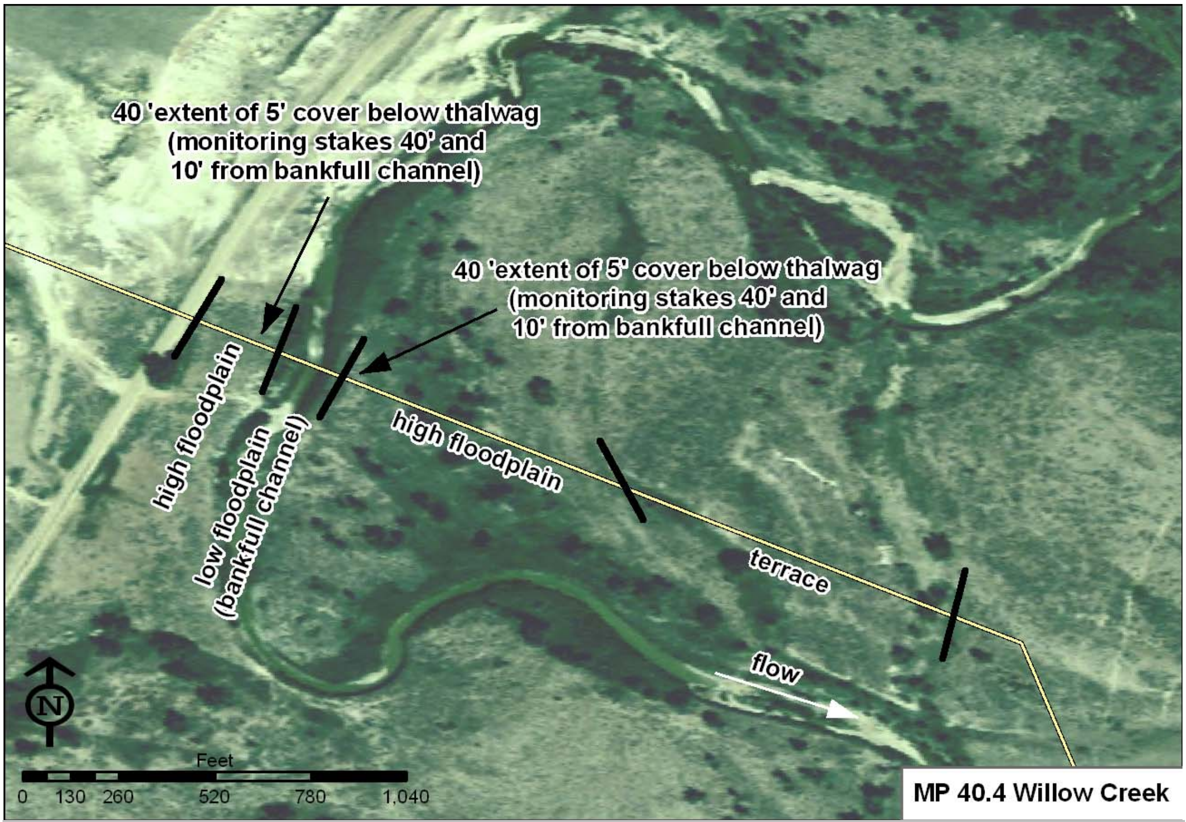

Figure 3.1-3 Burial Depth and Extent for Willow Creek

3.1.3.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.4 Milk River (MP 82.7)

3.1.4.1 Site Characteristics

The Milk River has a drainage area of 22,324 square miles at the proposed crossing. Tributaries to the creek include an unnamed stream 2.3 miles upstream of the proposed crossing and numerous irrigation canals. Porcupine Creek joins the river 2.6 miles downstream and the Milk flows into the Missouri River 6.1 miles downstream of the proposed crossing. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. Quaternary undivided glacial deposits are mapped on the river right beyond the Bearpaw shales. These deposits reflect the glacial origins of the Milk River valley, which is an oversized pre-glacial channel of the Missouri River. Aerial photographs from 2005 indicate landslide activity 0.34 mile upstream of the crossing and this river is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). Relic channels are visible in the 2005 aerials at locations 1.1, 1.9, and 2.45 miles upstream and 0.5 mile downstream of the proposed crossing. Scroll bars can be seen 1.1 and 1.9 miles upstream and 2.4 miles downstream of the crossing. The floodplain is mapped as modern alluvium 8,683 feet wide at the proposed crossing. Alluvium-colluvium deposits occur on the right bank downstream of the crossing. The gradient is low, sinuosity is high and channel widths range from 84 to 104 feet. A regional regression analysis could not be conducted to estimate stream discharge. The regression equations were developed by Omang (1992) for watersheds up to 2,500 square miles in size and this river exceeds that. The stream gauge data available for this river was sufficient for both types of flood frequencies analyses: USGS Bulletin 17B and the exceedence probability. The results of both flood frequency analyses are summarized in Table 3.1-4.

Table 3.1-4 Regional Regression and Peak Flow Analysis for Milk River

Regional Regression										
Source	Drainage Area (mi²)		Average Elevation (ft)		Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
Omang (1992)	22,324*		3,120		--	--	--	--	--	--
Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi²)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06174500 Milk River at Nashua MT (Exceedence Probability)	22,332	DS	2.49	70 (1939-2009)	5,750	12,200	17,200	23,700	28,600	33,400
06174500 Milk River at Nashua MT (Bulletin 17B)	22,332	DS	2.49	70 (1939-2009)	5,452	11,118	15,392	19,673	25,313	29,540

*The regional regression equations apply to watersheds between 0.04 mi² and 2,250 mi².

The Milk River at the 82.7 MP crossing is a single thread meandering pool-riffle stream confined within a 9,000-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. A number of oxbow lakes are present throughout the alluvial valley bottom and represent relic channel locations. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the river and narrow to no floodplains on the outside bends of the stream. The channel is deeply incised into the adjacent floodplain and conveys all flows less than the bankfull discharge. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the floodplain.

The bankfull channel at the MP 82.7 crossing is approximately 120 feet wide and is 3 to 4 feet deep. The unvegetated thalweg width is approximately 40 feet. The very fine sandy clay surficial alluvium of the channel thalweg is unarmored. The bankfull channel is well defined by a 3 to 4-foot bank on either side. At the crossing the 3-foot-high, 90-degree right bank is comprised of very fine sandy silt. The slope of the 4-foot-high left bank is approximately 70 degrees and is comprised very fine sandy silt. Both the left and right banks have very widely scattered willows covering 5 percent of the bank with greater than 3-foot rooting depths.

The bankfull discharge is completely conveyed within the channel at the Milk River crossing. There is a high floodplain approximately 12 to 15 feet above the unvegetated channel on the left side of the channel at the crossing. The floodplain is 1,150 feet wide on the left side (inside meander bend) of the channel. A mature cottonwood forest covers the entire left floodplain. Topographic depressions are found throughout the left floodplain.

3.1.4.1.1 Disturbance

Infrastructure in the vicinity of the proposed crossing includes the town of Nashua 1.4 miles downstream and scattered residences in the valley. A road and railway run parallel to and 0.26 mile from the left bank. Another road crosses the river with a bridge 0.6 mile downstream and sewage disposal ponds can be seen 1.6 miles downstream of the crossing.

3.1.4.2 Preventative Measures

3.1.4.2.1 Crossing Technique

The proposed crossing method for the Milk River is a horizontal directional drill (HDD). Due to the nature of an HDD crossing, there is no expected impact to turbidity during construction of the crossing.

3.1.4.2.2 Pipeline Burial Depth and Extent

Burial depths and extents are provided in the preliminary plan-set. The pipeline would be buried approximately 30 feet below the channel thalweg, and would extend below the entire length of the left floodplain (Appendix C, Milk River HDD plan). The HDD would end approximately 400 feet from the channel on the right terrace.

3.1.4.2.3 Site Reclamation

Due to the nature of HDD crossings there is no expected impact to the form, grade, banks, floodplains, or channel of the river system. Therefore, no site reclamation is anticipated.

3.1.5 Missouri River (MP 89)

3.1.5.1 Site Characteristics

The Missouri River has a drainage area of 57,565 square miles at the proposed crossing. Tributaries to the creek include the Milk River at 0.2 mile downstream of the proposed crossing and numerous irrigation canals and small tributaries. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. The right side of the valley also consists of the Hell Creek Formation: bentonitic claystone that alternates with gray to brown sandstone interbedded with carbonaceous shale, and the Fox Hills Formation: fine- to medium-grained, non-calcareous sandstone in the upper part, and interbedded sandstone, siltstone, and shale with calcareous concretion zone in the lower part. Both sides have locations of Quaternary undivided glacial deposits. While no landslides were visible in aerial photographs from 2005, landslide deposits and alluvium-colluvium are mapped on both sides of the valley. In addition, this river is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). Scroll bars can be seen in the 2005 aerials 0.5, 1, 1.8, and 3.95 miles upstream and 0.5 mile (at the Milk River confluence) and 1.7 miles downstream of the crossing. An oxbow lake occurs adjacent to the crossing off the right bank and relic channels may occur in a number of downstream locations, but are obscured by agricultural fields throughout the valley bottom. The floodplain is mapped as modern alluvium 12,651 feet wide at the proposed crossing and the gradient is low. Sinuosity is moderate and channel widths range from 656 to 987 feet. A regional regression analysis could not be conducted to estimate stream discharge. The regression equations developed by Omang (1992) apply to watersheds up to 2,500 square miles in size and this river far exceeds that. Peak flow flood frequency analysis used the FEMA Bulletin 17B method with both station skew and regional skew for comparison. The results of both flood frequency analyses are summarized in Table 3.1-5.

Table 3.1-5 Regional Regression and Peak Flow Analysis for Missouri River

Regional Regression*										
Source	Drainage Area (mi^2)	Average Elevation (ft)			Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
Omang (1992)	57,565	--			--	--	--	--	--	--
Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi^2)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06132000 Missouri River below Fort Peck Dam MT: Bulletin 17B-regional skew	57,556	US	1.81	74 (1934-2008)	16,900	23,900	28,700	34,800	39,500	44,300
06132000 Missouri River below Fort Peck Dam MT: Bulletin 17B-station skew	57,556	US	1.81	74 (1934-2008)	16,127	23,332	28,554	33,985	41,321	47,229

*The regional regression equations apply to watersheds between 0.04 mi^2 and 2,250 mi^2.

The Missouri River at the 89 MP crossing is a single thread meandering stream within an 11,000 to 13,000-foot alluvial valley bottom. The channel meanders approximately half the width of the alluvial valley bottom in the vicinity of the crossing. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the river and narrow to no floodplains on the outside bends of the stream. The channel is deeply incised into the adjacent floodplain and conveys all flows less than the bankfull discharge. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the floodplain.

The bankfull channel at the MP 89 crossing is approximately 1100 feet wide and is 12 to 15 feet deep. The unvegetated thalweg width is approximately 1000 feet. The fine sand surficial alluvium of the channel thalweg is unarmored. The bankfull channel is well defined by a 12 to 25-foot bank on either side. At the crossing the 12-foot-high, 70-degree right bank is comprised of very fine sandy silt. The slope of the 25-foot-high left bank is approximately 75 degrees and is comprised very fine sandy silt. The right bank has dense stands of willows covering 75 percent of the bank with greater than 3-foot rooting depths. There is no woody cover on the left bank.

The bankfull discharge is completely conveyed within the channel at the Missouri River crossing. There is a high floodplain approximately 12 feet above the unvegetated channel on the right side of the channel at the crossing. The floodplain is 1,200 feet wide and supports a mature cottonwood forest that covers the entire left floodplain. Topographic depressions are found throughout the left floodplain, which has an 8-foot-high bank at its margin with a 3,100 to 3,500-foot-wide terrace above.

3.1.5.1.1 Disturbance

Infrastructure in the vicinity includes the Fort Peck Dam and spillway 5.5 miles and 0.9 mile upstream respectively. The town of Fort Peck lies adjacent to the dam, just downstream of Fort Peck Lake. A high voltage transmission line crosses the river 0.05 mile upstream. A railway and road run parallel to the left bank 0.4 mile and 0.6 mile away respectively. There are two reservoirs 3.9 miles upstream of the crossing and numerous stock ponds off the right bank of the river.

3.1.5.2 Preventative Measures

3.1.5.2.1 Crossing Technique

The proposed crossing method for the Missouri River is a horizontal directional drill (HDD). Due to the nature of an HDD crossing, there is no expected impact to turbidity during construction of the crossing.

3.1.5.2.2 Pipeline Burial Depth and Extent

Burial depths and extents are provided in the preliminary plan-set. The pipeline would be buried approximately 30 feet below the channel thalweg, and would extend below the entire length of the left floodplain (Appendix C, Missouri River HDD plan). The HDD would end approximately 400 feet from the channel on the right terrace.

3.1.5.2.3 Site Reclamation

Due to the nature of HDD crossings there is no expected impact to the form, grade, banks, floodplains, or channel of the river system. Therefore, no site reclamation is anticipated.

3.1.6 West Fork Lost Creek (MP 93.8)

3.1.6.1 Site Characteristics Disturbance

The West Fork Lost Creek is a perennial stream with a drainage area of 0.39 square mile at the proposed crossing. There are 2 small tributaries to the creek 0.3 and 0.4 mile downstream of the crossing. The geology of the valley on both sides of the creek consists the Hell Creek Formation: bentonitic claystone that alternates with (gray to brown) sandstone interbedded with carbonaceous shale, and the Fox Hills Formation: fine- to medium-grained, non-calcareous sandstone in the upper part, and interbedded sandstone, siltstone, and shale with calcareous concretion zone in the lower part. While no landslides were visible in aerial photographs from 2005, substantial landslide deposits are mapped 1.25 miles to the west along Fort Peck Lake. In addition, this river is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The valley floor gradient is moderate to high and channel widths range from 24 to 42 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-6). No stream gauge data were available for this creek.

Table 3.1-6 Regional Regression Analysis for West Fork Lost Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	0.39	2585	14	50	94	176	259	306

West Fork Lost Creek at the 93.8 MP crossing is a single thread plane-bed stream confined within a 75 to 200-foot alluvial valley bottom. The channel is completely confined within the valley bottom and occupies its entire width. There are no floodplains adjacent to the channel at the crossing site.

The grass lined bankfull channel at the MP 93.8 crossing is 10 to 15 feet wide and is 2 feet deep. The gravelly silty clay surficial alluvium of the channel is unarmored. The bankfull channel is well defined by a 2-foot bank on either side. At the crossing the 2-foot-high, 90-degree right and left banks are comprised of silty clay. The banks have moderate woody vegetation cover dominated by mixed aged willow. The confining valley margins are greater than 30 feet high and slope toward the channel at 20 to 30 degrees. Along the base of the valley margins adjacent to the creek are stands dominated by willow of mixed age.

3.1.6.1.1 Disturbance

Infrastructure near the proposed crossing includes a parallel road 0.1 mile from the left bank and a powerline that crosses the creek 0.5 mile upstream. An earthen dam with a pond is visible in aerial photographs 0.2 mile downstream of the crossing.

3.1.6.2 Preventative Measures

3.1.6.2.1 Crossing Technique

The proposed crossing method for West Fork Lost Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction of the crossing.

3.1.6.2.2 Pipeline Burial Depth and Extent

There is no evidence suggesting that West Fork Lost Creek has significantly migrated laterally. The entire stream system is confined within its valley and there is little available space to migrate. Much of the stability of the stream is from the riparian buffer along the banks and floodplain. Removal of this buffer during construction may potentially lead to accelerated bank erosion. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond both banks (approximately 45 feet in length) (Figure 3.1-4). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At West Fork Lost Creek (MP 93.8) this plan would include placing field stakes at and 15 feet from the right and left banks defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-4). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed at the bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

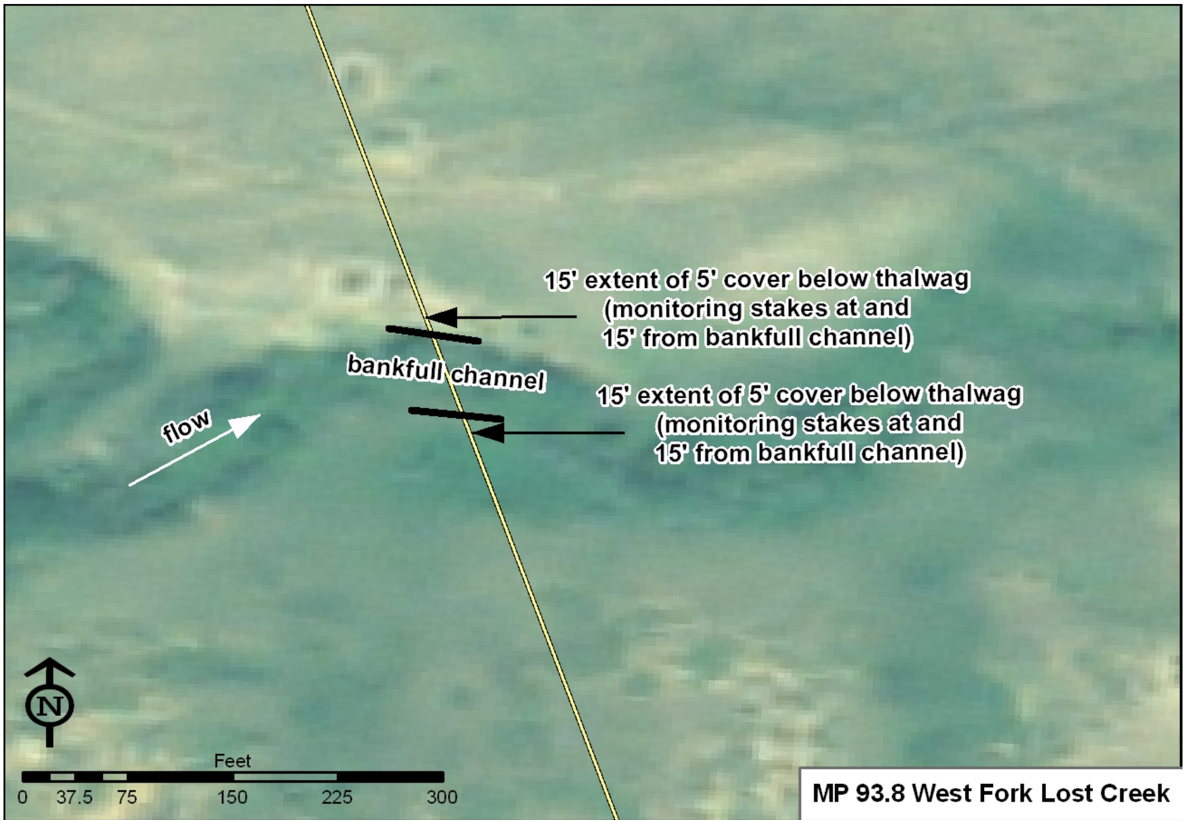

Figure 3.1-4 Burial Depth and Extent for West Fork Lost Creek

3.1.6.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.7 Tributary to West Fork Lost Creek (MP 94.6)

3.1.7.1 Site Characteristics

The Tributary to West Fork Lost Creek is a perennial stream with a drainage area of 0.39 square mile at the proposed crossing. There is a small tributary at the location of the proposed crossing. The geology of the valley on both sides of the creek consists the Hell Creek Formation: bentonitic claystone that alternates with (gray to brown) sandstone interbedded with carbonaceous shale, and the Fox Hills Formation: fine- to medium-grained, non-calcareous sandstone in the upper part, and interbedded sandstone, siltstone, and shale with calcareous concretion zone in the lower part. Upstream the Bearpaw Formation (shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds) is also found in the valley. While no landslides were visible in aerial photographs from 2005, substantial landslide deposits are mapped 2 miles to the west along Fort Peck Lake. In addition, this river is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The valley floor gradient is moderate to high and channel widths range from 34 to 47 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-7). No stream gauge data were available for this creek.

Table 3.1-7 Regional Regression Analysis Tributary to West Fork Lost Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	0.39	2588	14	50	93	176	258	305

The Tributary to West Fork Lost Creek at the 94.6 MP crossing is a single thread plane-bed stream confined within a 75 to 100-foot alluvial valley bottom. The channel is completely confined within the valley bottom and occupies its entire width. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream.

The bankfull channel at the MP 94.6 crossing is approximately 25 feet wide and is 1 to 2 feet deep. The grass lined thalweg width is approximately 10 feet. The gravelly silty clay surficial alluvium of the channel is unarmored. The channel thalweg is well defined by a 1 to 3-foot bank on either side. At the crossing the 3-foot-high, 70-degree right thalweg bank is comprised of silty clay. The right thalweg bank has moderate woody vegetation cover dominated by mixed aged willow. The left thalweg bank is 1 foot high and is composed of silty clay. The bank has no woody vegetation and is completely covered with herbaceous plants and grasses.

The bankfull channel is well defined by a 3-foot-high bank on the right and the valley wall on the left. Above the 3-foot bank on the right is a sloped floodplain that is approximately 50 feet wide. The floodplain supports a wide willow riparian buffer and is composed of silty clay. The confining valley margins are greater than 50 feet high and slope toward the channel at 40 to 70 degrees. Along the base of the valley margins adjacent to the creek are stands dominated by willow of mixed age.

3.1.7.1.1 Disturbance

Infrastructure near the proposed crossing includes a powerline that crosses the creek 0.25 mile upstream and Highway 24, which crosses the creek 0.6 mile upstream from the crossing with a culvert.

3.1.7.2 Preventative Measures

3.1.7.2.1 Crossing Technique

The proposed crossing method for the Tributary to West Fork Lost Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction of the crossing.

3.1.7.2.2 Pipeline Burial Depth and Extent

There is no evidence suggesting that the Tributary to West Fork Lost Creek has significantly migrated laterally. The entire stream system is confined within its valley and there is little available space to migrate. Much of the stability of the stream is from the riparian buffer along the banks and floodplain. Removal of this buffer during construction may potentially lead to accelerated lateral migration into the right floodplain. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond left bank and 40 feet beyond the right bank (approximately 95 feet in length) (Figure 3.1-5). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At the Tributary to West Fork Lost Creek (MP 94.6) this plan would include placing a field stake at and 15 feet from the left bank defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-5). Additional field stakes would be placed 40 feet and 10 feet from the bankfull boundary on the right (Figure 3.1-5). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the right bankfull boundary or at the left bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

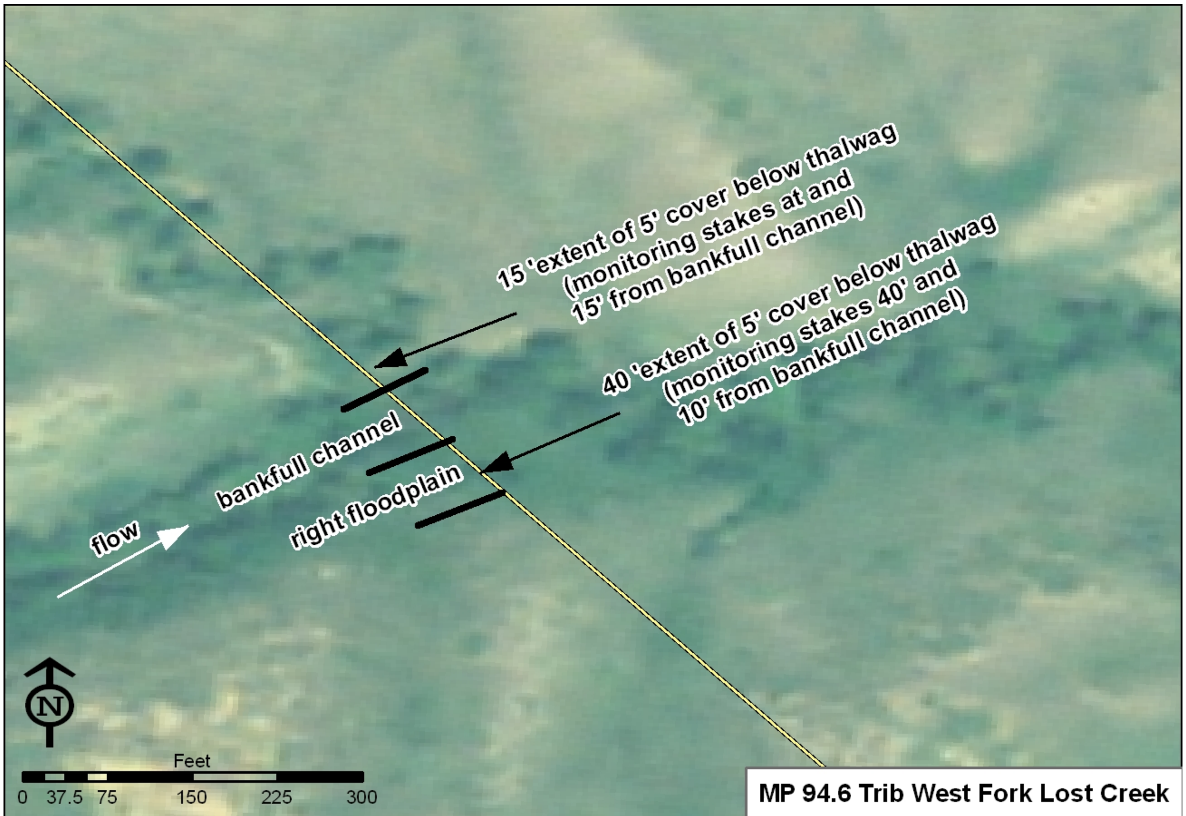

Figure 3.1-5 Burial Depth and Extent for Tributary to West Fork Lost Creek

3.1.7.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.8 East Fork Prairie Elk Creek (MP127.6)

3.1.8.1 Site Characteristics

East Fork Prairie Elk Creek is a perennial stream with a drainage area of 20.39 square miles at the proposed crossing. An unnamed tributary joins the creek 125 feet upstream of the crossing. This tributary appears to be dammed 0.2 mile from the confluence (in 2005 aerial photographs). Another unnamed creek joins East Fork Prairie Elk 0.3 mile upstream of the proposed crossing, with its source at the pond behind the same dam. The geology of the valley on both sides of the creek just upstream through downstream of the proposed crossing consists of the Tullock Member of the Fort Union Formation: sandstone interbedded with subordinate shale and thin beds of coal. Further upstream both sides of the valley are also mapped as the Fort Union

Formation: the Lebo Member (carbonaceous shale, bentonitic claystone, sandstone, and coal) and the Tongue River Member (sandstone, sandy and silty carbonaceous shale, and coal). Quaternary alluvium-colluvium deposits are found on both sides of the creek upstream. Additionally, small amounts of mass movement appear to be present in 2005 aerial photographs 0.3 mile upstream of the proposed crossing. The floodplain is mapped as modern alluvium 505 feet wide at the crossing and the gradient is low. Sinuosity is high and channel widths range from 12 to 60 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals. The results of this analysis and of the flood frequency analysis of the USGS gauge on the creek are summarized in Table 3.1-8.

Table 3.1-8 Regional Regression and Peak Flow Analysis for East Fork Prairie Elk Creek

Regional Regression										
Source	Drainage Area (mi^2)	Average Elevation (ft)			Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
Omang (1992)	20.39	2,581			125	407	734	1,278	1,801	2,130
Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi^2)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06175540 Prairie Elk Creek near Oswego MT	352.0	DS	39.2	10 (1975-1985)	5,563	18,034	30,150	44,504	56,098	58,943

East Fork Prairie Elk Creek at the 127.6 MP crossing is a single thread meandering pool-riffle stream confined within a 500 to 800-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the floodplain.

The proposed route crossing of East Fork Prairie Elk Creek crossed the river at an oblique angle. This resulted in a long section of the proposed route through the CMZ, and very near the river upstream on the opposite side of the valley from the crossing (Figure 3.1-6). In order to reduce the length of the route within the CMZ and away from the river upstream, a potential route variation was recommended by Entrix. The potential route variation places the route approximately 300 feet downstream (north) from the proposed route (Figure 3.1-6). The field assessment for East Fork Prairie Elk Creek was performed at the potential route variation location.

The bankfull channel at the proposed adjusted crossing location is approximately 64 feet wide and is 5 feet deep. The channel thalweg is densely vegetated with herbaceous wetland plants and is approximately 45 feet wide. The silty clay surficial alluvium of the channel thalweg is unarmored. The limit of the bankfull channel is well defined by a 5-foot right bank and a transition to upland vegetation at the base of a low slope on the left bank. At the crossing the 5-foot-high, 40 to 90-degree right bank (outside meander bend) is comprised of very fine sand with several noted locations of slumping. The slope of the 2-foot-high left thalweg bank (inside of meander bend) is 30 degrees and is comprised of silty clay. An approximately 3-foot-high, 20-degree left bankfull bank is composed of silty clay. Both the left banks are densely vegetated with herbaceous wetland plants with rooting depths over 1 foot. The 5-foot right bank is unvegetated.

Floodplains exist on either side of the bankfull channel at the proposed adjusted crossing location. There is both a high and low elevation floodplain on the left side of East Fork Prairie Elk Creek. The low elevation floodplain sits 2 feet above and adjacent to the channel thalweg and is approximately 26 feet wide. The alluvium on the low elevation floodplain is sandy silt with a no organic surface. Vegetation is dominated by wetland grasses and herbs. A sloped high floodplain approximately 120 feet wide is present approximately 3 feet above the low floodplain and supports an upland sagebrush community. Right of the 5-foot-high right bank is a gently sloping high floodplain composed of very fine sand with upland grasses. There is no significant woody vegetation on either bank or floodplain.

3.1.8.1.1 Disturbance

Infrastructure in the vicinity includes a residence 0.8 mile upstream on river left and a road crossing with no bridge or culvert 0.5 mile upstream of the proposed crossing.

3.1.8.2 Preventative Measures

3.1.8.2.1 Crossing Technique

The proposed crossing method for East Fork Prairie Elk Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction of the crossing.

3.1.8.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that East Fork Prairie Elk Creek at the proposed adjusted crossing location has the potential to migrate laterally across the alluvial valley bottom. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) at the proposed crossing site the 5-foot-high unvegetated right bank is composed of highly erodible material and has documented slump features. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 40 feet beyond both the left and right high (bankfull) banks (approximately 170 feet in length) (Figure 3.1-6). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At East Fork Prairie Elk Creek this plan would include placing field stakes 40 feet and 10 feet from the right and left banks defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-6). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

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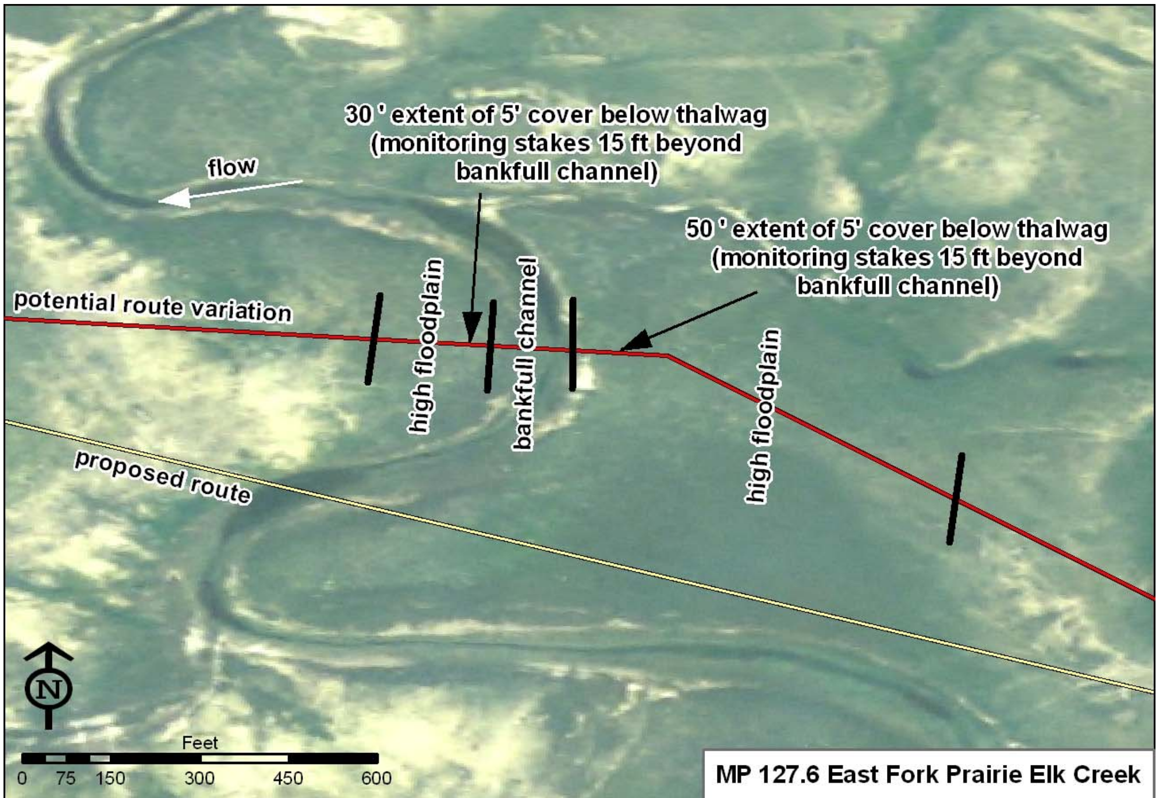

Figure 3.1-6 Burial Depth and Extent for East Fork Prairie Elk Creek

3.1.8.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.9 Redwater River (MP146.6)

3.1.9.1 Site Characteristics

The Redwater River is a perennial stream with a drainage area of 548.8 square miles at the proposed crossing. A number of tributaries feed into the river. The confluence with Buffalo Springs Creek is 665 feet upstream of the proposed crossing and Lone Tree Creek is 0.2 mile upstream. Unnamed creeks join the river at 0.3 mile, 0.7 mile, and 0.8 mile upstream and 0.1 mile downstream of the crossing. The geology of the valley on both sides of the creek consists of the Tongue River Member of the Fort Union Formation: sandstone, sandy and silty carbonaceous shale, and coal. In 2005 aerial photographs, there are relic channels adjacent to the proposed crossing and 0.25 mile upstream. In addition, the photographs show scroll bars on Buffalo Springs Creek 0.1 mile upstream of the crossing on river right. Quaternary alluvial terrace deposits occur in places upstream of the proposed crossing on the left bank and downstream on the right bank. The floodplain is mapped as modern alluvium 2,202 feet wide at the crossing and the gradient is low. Channel widths range from 21 to 98 feet. The USGS stream gauge is very close to the proposed crossing with only nominal addition of flow from Buffalo Springs Creek downstream of the gauge. Thus, it is preferable to use the flood frequency analysis of actual gauge data rather than the regression equations developed for the region by Omang (1992). The regional regression analysis was conducted as a comparison. The results of these analyses are summarized in Table 3.1-9.

Table 3.1-9 Regional Regression and Peak Flow Analysis for Redwater River

Regional Regression*										
Source	Drainage Area (mi^2)		Average Elevation (ft)		Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
Omang (1992)	668.3		2,765		746	2,269	3,964	6,468	8,846	10,539
Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi^2)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06177500 Redwater River at Circle MT (Bulletin 17B)	547.0	US	3.9	85 (1929-2004)	427	2,253	4,752	8,290	14,575	20,505

Redwater River at the 146.6 MP crossing is a single thread meandering pool-riffle stream confined within a 1,700 to 2,300-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the floodplain.

The bankfull channel at the 146.6 MP crossing is approximately 85 feet wide and is 4 feet deep. The unvegetated channel width is approximately 75 feet wide. The gravelly sand surficial alluvium of the channel thalweg is unarmored. The limit of the bankfull channel is well defined by a 2 to 3-foot left bank and 14-foot right bank. At the crossing the 2 to 3-foot-high, 90-degree left bank (inside meander bend) is comprised of very fine sandy silt with several noted locations of slumping. The left bank is completely vegetated with herbaceous wetland plants with rooting depths over 2 feet. The slope of the 14-foot-high right bank (outside of meander bend) is 90 degrees at the toe (bottom 2 feet) and 30 degrees above and is comprised of cobble gravel at the toe (bottom 2 feet) and very fine sandy silt above. Several locations of bank slumping were noted in the field along the right bank. The right bank has approximately 75 percent herbaceous cover with over 2-foot rooting depths.

There is both a high and low elevation floodplain to the left of the bankfull channel along the route. The low elevation floodplain sits 2 to 3 feet above and adjacent to the bankfull channel and is approximately 55 feet wide. The alluvium on the low elevation floodplain is very fine sandy silt with little to no organic surface. Vegetation is dominated by wetland grasses and herbs. A 3-foot-high, 30-degree bank defines the limit of the low floodplain and transition to the high floodplain. The high floodplain is approximately 1000-foot wide with hummocky terrain and supports a sagebrush community. The high floodplain likely represents a > 10 year floodplain surface. Along the outer margin of the left high floodplain is a high bank, above which are terrace deposits. To the right of the bankfull channel above the 14-foot-high bank is a terrace deposit that is above and outside of the 100 yr floodplain. There is no significant woody vegetation on either banks or floodplains.

3.1.9.1.1 Disturbance

Infrastructure in the vicinity includes two roads parallel to the river on either side which cross all the tributaries listed above. There are road and railway crossings with bridges 1.2 miles upstream of the proposed crossing. The city of Circle is located 2.2 miles upstream of the crossing with nearby sewage disposal ponds 1.5 miles from crossing and a local airport 1.1 miles away from the crossing. A power line runs parallel to the river 0.3 mile upstream on river left.

3.1.9.2 Preventative Measures

3.1.9.2.1 Crossing Technique

The proposed crossing method for the Redwater River would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.9.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that the Redwater River at MP 146.6 has the potential to migrate laterally across the alluvial valley bottom. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) at the proposed crossing site the 2-foot-high left bank has documented slump features. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the left low floodplain and 15 feet beyond the top of the 14-foot-high right bank (approximately 175 feet in length) (Figure 3.1-7). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At the Redwater River (MP 146.6) this plan would include placing a field stake at and 15 feet from the right high bank defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-7). Additional field stakes would be placed 15 feet to the left and right of the left low/high floodplain boundary (Figure 3.1-7). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed on the right of the bankfull boundary or 15 feet to the right of the left low/high floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

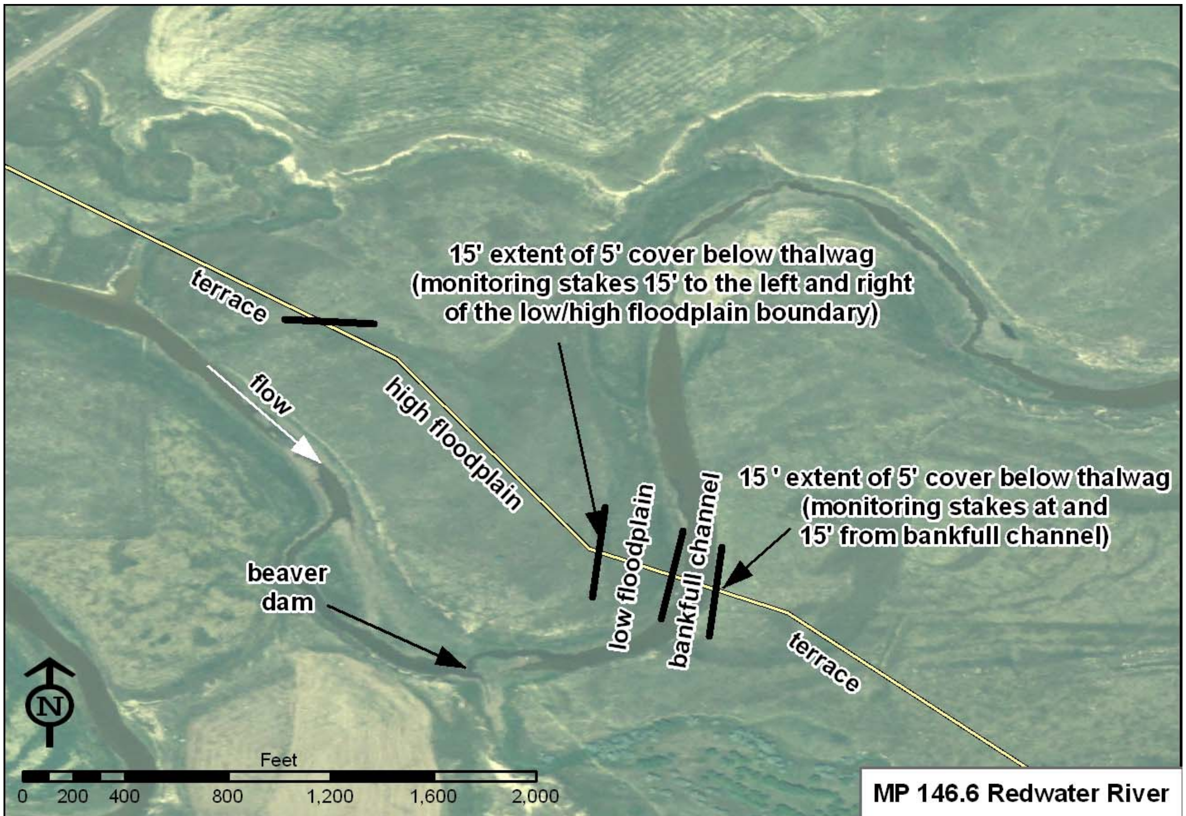

Figure 3.1-7 Burial Depth and Extent for Redwater River

3.1.9.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.10 Buffalo Springs Creek (MP 150)

3.1.10.1 Site Characteristics

Buffalo Springs Creek is a perennial stream with a drainage area of 152.4 square miles at the proposed crossing. West Fork Buffalo Springs Creek and an unnamed tributary join the creek 1.8 and 0.17 mile upstream of the proposed crossing, respectively. Buffalo Springs Creek flows into the Redwater River 3.2 miles from the crossing. The geology of the valley on both sides of the creek consists of the Tongue River Member of the Fort Union Formation: sandstone, sandy and silty carbonaceous shale, and coal. A relic channel can be seen on the 2005 aerial photos 0.3 mile downstream of the crossing. Evidence of a landslide is visible 0.2 mile downstream of the crossing on the right valley wall. The floodplain is comprised of modern alluvium 650 feet wide at the crossing and the gradient is low. Sinuosity is moderate to high and channel widths range from 12 to 21 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-10). No stream gauge data were available for this creek.

Table 3.1-10 Regional Regression Analysis for Buffalo Springs Creek

Source	Drainage Area (mi²)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	152.4	2805	119	335	555	937	1,65	1,715

The original proposed crossing of Buffalo Springs Creek at the 153.3 MP crossing was adjusted by Trow (personal communication with John Buchanan and R.E. Butch Wallace) prior to the ENTRIX field assessment due to landowner issues. The proposed adjusted route crosses Buffalo Springs Creek approximately 3.3 miles downstream from the proposed route. The field assessment for Buffalo Springs Creek was performed at the proposed route adjustment location. Buffalo Springs Creek at MP 150 is a plane bed trapezoidal engineered stream channel. The stream is diverted into the engineered channel approximately 400 feet upstream of the proposed crossing. The channel was cut into the left bank floodplain and terrace and appears to have been constructed to move the channel away from the erodible right bank that supports a railroad track and Highway 200.

The bankfull channel at the proposed adjusted crossing location is approximately 50 feet wide, 6 to 8 feet deep, and is densely vegetated with herbaceous plants. The gravel-pebble surficial alluvium of the bankfull channel is unarmored. The limit of the bankfull channel is well defined by 4 to 8-foot banks on either side. At the proposed crossing the 6 to 8 feet high, 55-degree left bank is comprised of very fine to fine sand. The slope of the 4 to 6-foot-high right bank is 35 degrees and is comprised of very fine to fine sand. Both the left and right banks are densely vegetated with herbaceous plants with rooting depths approximately 1 foot.

Floodplains exist on either side of the bankfull channel at the crossing site. There is both a high and low elevation floodplain on the right side of Buffalo Springs Creek. The right low elevation floodplain (pre-diversion channel location) is separated from the bankfull channel by a high elevation floodplain (Figure 3.1-8). The elevation of the low floodplain is 1 to 2 feet above the channel thalweg and is approximately 70 feet wide. The alluvium on the low elevation floodplain is very fine to medium sand with no organic surface. Vegetation is dominated by a mix of grasses and herbs with a few widely scattered willow trees. The high floodplain separating the bankfull channel and low floodplain is approximately 120 feet wide, is sloped toward the low elevation floodplain, and supports upland grasses. The left high elevation floodplain is at a similar elevation to the right high floodplain and is approximately 125 feet wide. The texture is silty fine sand and it supports an upland grass community.

3.1.10.1.1 Disturbance

Highway 200 and a railway cross with bridges 0.1 mile downstream of the proposed crossing. The road and railway then run parallel to the creek. A power line runs parallel to the right bank as well.

3.1.10.2 Preventative Measures

3.1.10.2.1 Crossing Technique

The proposed crossing method for Buffalo Springs Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.1.10.2.2 Pipeline Burial Depth and Extent

The proposed crossing of Buffalo Springs Creek will likely be a more engineered solution than is provided in the discussion to follow, given the proposed route crosses a railroad and major highway adjacent to the stream crossing. The suggestions provided here account for the stream crossing only, and do not consider limitations to construction imposed from the adjacent railroad and highway crossings. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the left bankfull boundary and 15 feet beyond the right limit of the right low floodplain (approximately 270 feet in length) (Figure 3.1-8). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At the Buffalo Springs Creek (MP 150) this plan would include placing a field stake at and 15 feet from the left high bank defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-8). Additional field stakes would be placed on and 15 feet to the right of the right low floodplain boundary (Figure 3.1-8). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed on the left bankfull boundary or on the right low floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

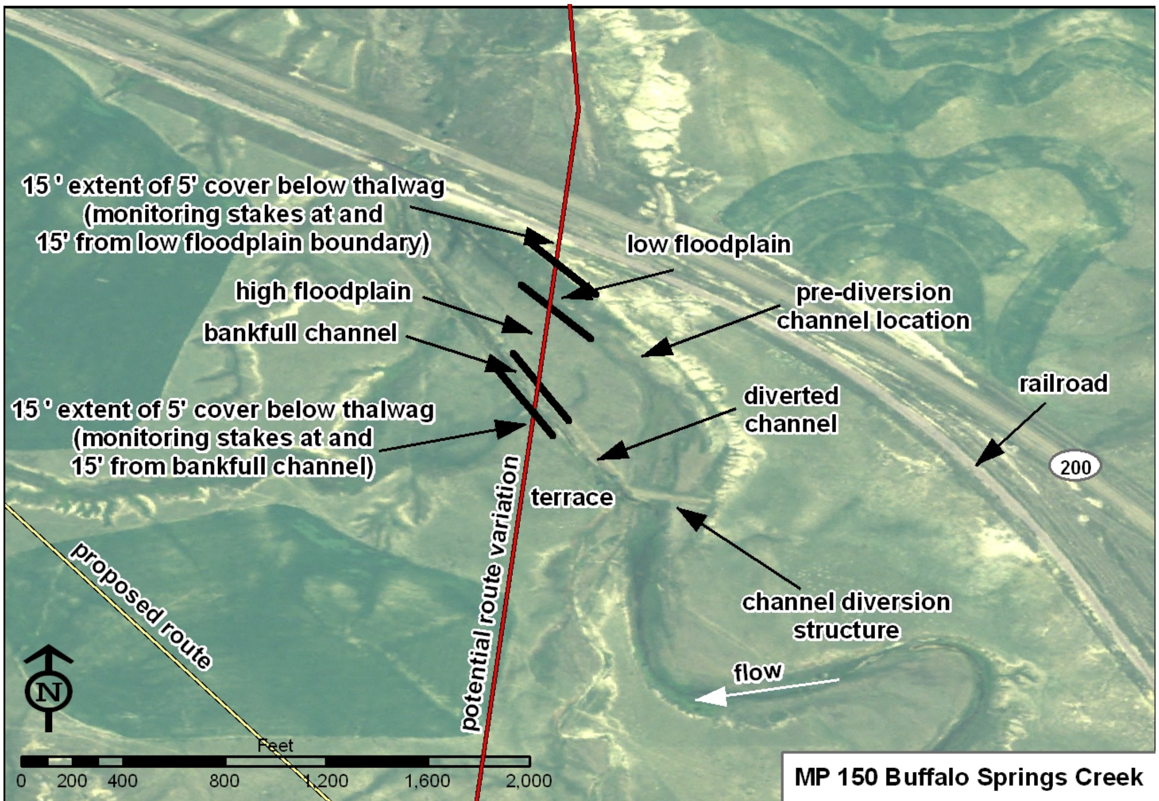

Figure 3.1-8 **Burial Depth and Extent for Buffalo Springs Creek**

The presence of the diversion structure upstream of the proposed crossing poses a potential risk to the pipeline. Failure of the structure during flood would likely result in a highly erosive floodwave with the potential to expose and damage the pipeline. An investigation into the structural integrity and maintenance requirements of the diversion structure to assess the stability of the structure and its potential to fail during the lifetime of the project is beyond the scope of this assessment.

3.1.10.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.11 Berry Creek (MP 159.2)

3.1.11.1 Site Characteristics

Berry Creek is a perennial stream with a drainage area of 2.47 square miles at the proposed crossing. It joins Cottonwood Creek 0.25 mile downstream of the proposed crossing. The pipeline crosses Cottonwood Creek 0.28 mile northwest. The geology of the valley and floodplain on both sides of the creek consists of the Tongue River Member of the Fort Union Formation: sandstone, sandy and silty carbonaceous shale, and coal. The valley gradient is moderate and the sinuosity is high. Channel widths range from 33 to 134 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-11). No stream gauge data were available for this creek.

Table 3.1-11 Regional Regression Analysis for Berry Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	2.47	2996	29	100	185	341	496	595

The Berry Creek at the 159.2 MP crossing is a single thread entrenched meandering channel deeply incised into the surrounding terrain. A low flow thalweg meanders across the valley bottom, with a low floodplain adjacent to it of varying width. Wider floodplains occur on the inside bends of meanders and very narrow to no floodplain exists on the outside bends of meanders. At the time of the assessment there was vary shallow standing water in the channel thalweg, and soils on the floodplain were saturated. Depth to groundwater is likely very shallow year-round given the abundance of wetland plants and hydric soils across the entire valley bottom.

The bankfull channel at MP 159.2 is approximately 20 feet wide and is 1.5 feet deep. The bankfull channel is densely vegetated with herbaceous wetland plants. The organic silty surficial alluvium of the bankfull channel is unarmored. The limit of the bankfull channel is well defined by a 1.5-foot right bank and the margin of the valley wall on the left. At the proposed crossing the 12-foot-high, 30-degree left bank is composed of medium sand. Mature trees and shrubs cover 35% of the left bank with rooting depths up to 4 feet. The slope of the 1.5-foot-high bankfull right bank is 20 degrees and is comprised of organic silt. Dense herbaceous wetland plants cover the entire right bankfull bank with rooting depths over 1 foot. The right valley wall is 12-foot-high with a slope of 45 degrees and is composed of silty fine sand. Mature trees and shrubs cover 75% of the right valley wall with rooting depths up to 4 feet.

A low floodplain exists on the right side of the bankfull channel at the crossing site. The floodplain is 1.5 to 2 feet higher than the bankfull channel and approximately 60 feet wide at the proposed crossing. The alluvium on the floodplain is silty very fine sand with scattered organics. The hummocky floodplain is entirely covered with wetland grasses and a few scattered young trees.

3.1.11.1.1 Disturbance

Infrastructure in the vicinity includes a road crossing at 0.3 mile downstream, probably with a culvert. A spur road runs parallel 630 feet from the right bank. Another road crosses 0.7 mile upstream of the proposed crossing.

3.1.11.2 Preventative Measures

3.1.11.2.1 Crossing Technique

The proposed crossing method for Berry Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction of the crossing.

3.1.11.2.2 Pipeline Burial Depth and Extent

Given the incised nature of Berry Creek, flood flows do not have room to spread laterally during high water. This condition leads to deeper and faster flood flows with more erosive potential than a stream of similar drainage area that is not incised. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the left and right valley walls (approximately 110 feet in length) (Figure 3.1-9). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At the Berry Creek (MP 159.2) this plan would include placing a field stake at and 15 feet from the right high bank defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-9). Additional field stakes would be placed at and15 feet to the right of the right low floodplain boundary (Figure 3.1-9). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed at the bankfull boundary or at the right low floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

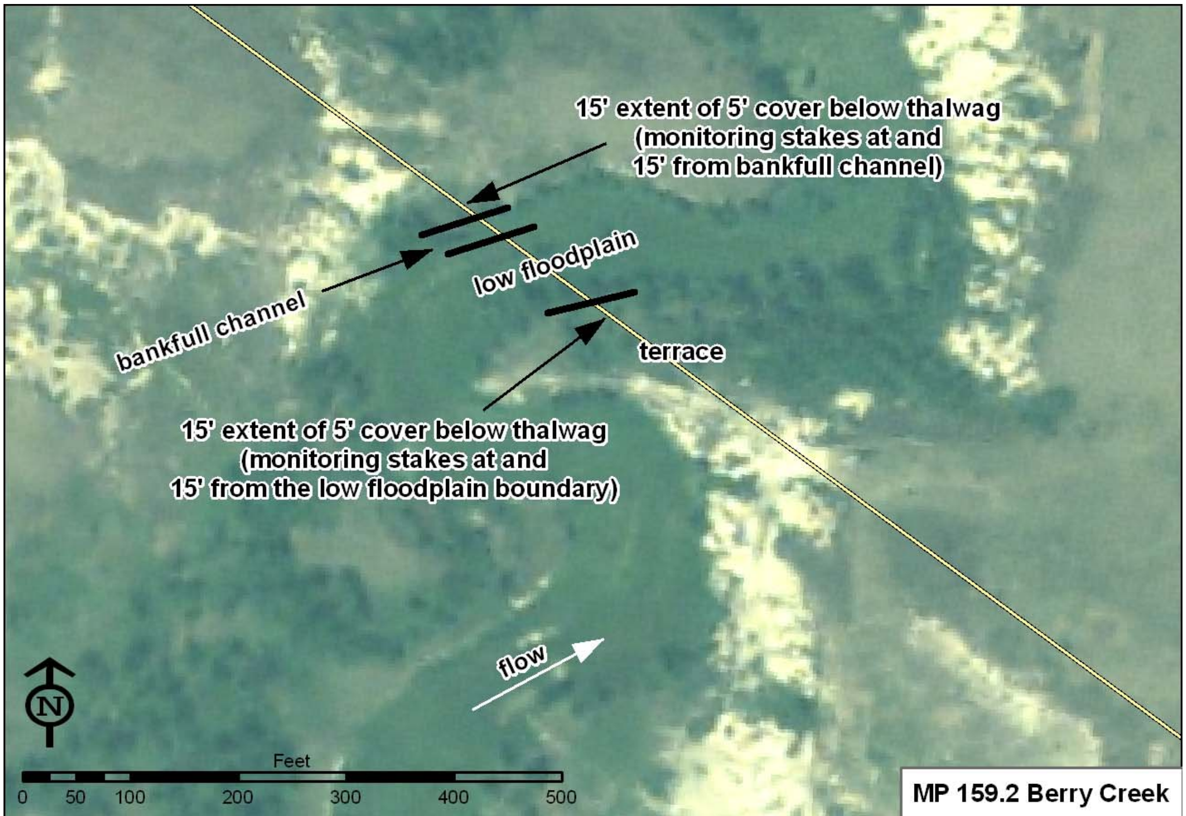

Figure 3.1-9 Burial Depth and Extent for Berry Creek

3.1.11.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.12 Clear Creek (MP 175.2)

3.1.12.1 Site Characteristics

Clear Creek is a perennial stream with a drainage area of 73.10 square miles at the proposed crossing. Tributaries include South Fork Clear Creek at 0.2 mile upstream, an unnamed creek 0.8 mile downstream and Cigar Creek at 1.4 miles downstream of the crossing. An irrigation ditch joins Clear Creek 0.6 mile upstream and connects to Cigar Creek. The geology of the valley and floodplain on both sides of the creek consists of the Tongue River Member of the Fort Union Formation: sandstone, sandy and silty shale, and coal. Quaternary alluvial terrace deposits have also been mapped upstream of the crossing. Aerial photographs from 2005 indicate the presence of relic channels 0.6 mile upstream and 0.2 mile downstream of the proposed crossing. The valley bottom gradient is low, sinuosity is high and channel widths range from 22 to 72 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals. The results are summarized in Table 3.1-12 along with the flood frequency analysis for the nearest stream gauge.

Table 3.1-12 Regional Regression and Peak Analysis for Clear Creek

Regional Regression								
Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	73.10	3018	187	594	1,064	1,829	2,573	3,093

Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi^2)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06326952 Clear Creek near Lindsay MT: regional regression	101.0	DS	9.50	6 (1982-1988)	2,194	7,253	12,343	18,899	24,342	25,911

Clear Creek at the 175.2 MP crossing is a single thread meandering pool-riffle stream confined within a 2,500 to 3,000-foot alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the floodplain. Pools found on the meander bends were dry at most locations at the time of the assessment; however the meander bend where the proposed crossing is located was ponded. Discussions with the landowner confirmed that the meander bend where the crossing is proposed is periodically dredged down to a natural spring to provide livestock drinking water. Evidence of this dredging is apparent as high spoil piles are present along the left bank adjacent to the meander bend.

The bankfull channel at the MP 175.2 crossing is approximately 80 feet wide and is 5 feet deep. The unvegetated thalweg width is approximately 45 feet. The silty surficial alluvium of the channel thalweg is unarmored. The bankfull channel is well defined by a 3.5 to 6-foot bank on either side. At the crossing the 3.5-foot-high, 17-degree left bank is comprised of silt. The slope of the 6-foot-high right bank is 20 degrees at its base and 90 degrees at the upper 1.5 feet and is comprised silt. Numerous locations of slumping were noted during the assessment along the left bank. Both the left and right banks have dense herbaceous cover with greater than 1-foot rooting depths.

There is a 700-foot-wide floodplain approximately 3.5 feet above the unvegetated channel on the right side (inside meander bend) of the channel at the crossing. The floodplain is composed of silt and is completely vegetated with grasses. To the left of the dredge spoil is a high terrace with no indicators of recent overland flow and is likely above the 100 yr floodplain.

3.1.12.1.1 Disturbance

Infrastructure in the area include a road that crosses the creek with a bridge 1.3 miles upstream, small parallel roads on both sides of the creek, and small road crossings 0.4 mile upstream and 0.4 mile downstream of the crossing. Additionally, there is a group of buildings 1.1 miles downstream on the crossing.

3.1.12.2 Preventative Measures

3.1.12.2.1 Crossing Technique

The proposed crossing method for Clear Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.12.2.2 Pipeline Burial Depth and Extent

There is no documented evidence of recent lateral migration of Clear Creek at the MP 175.2 crossing and little to no evidence suggesting lateral migration is likely during the expected lifespan of the project. The only evidence suggesting lateral migration is the documented slumping along the left bank, however this slumping is likely due to oversteepening during dredging of the channel and not from erosion during flooding. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond both the left and right bankfull banks (approximately 110 feet in length) (Figure 3.1-10). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Clear Creek (MP 175.2) this plan would include placing field stakes at and 15 feet from the right and left banks defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-10). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed at the bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of alternative preventative protection measures are provided in Section 4. Continued excavation of the channel poses a risk of damage to the pipeline. If excavations were to continue after installation of the pipeline, then the pipe should be buried to a depth that would maintain a minimum of 5 feet of cover over the pipe from the maximum depth of excavation.

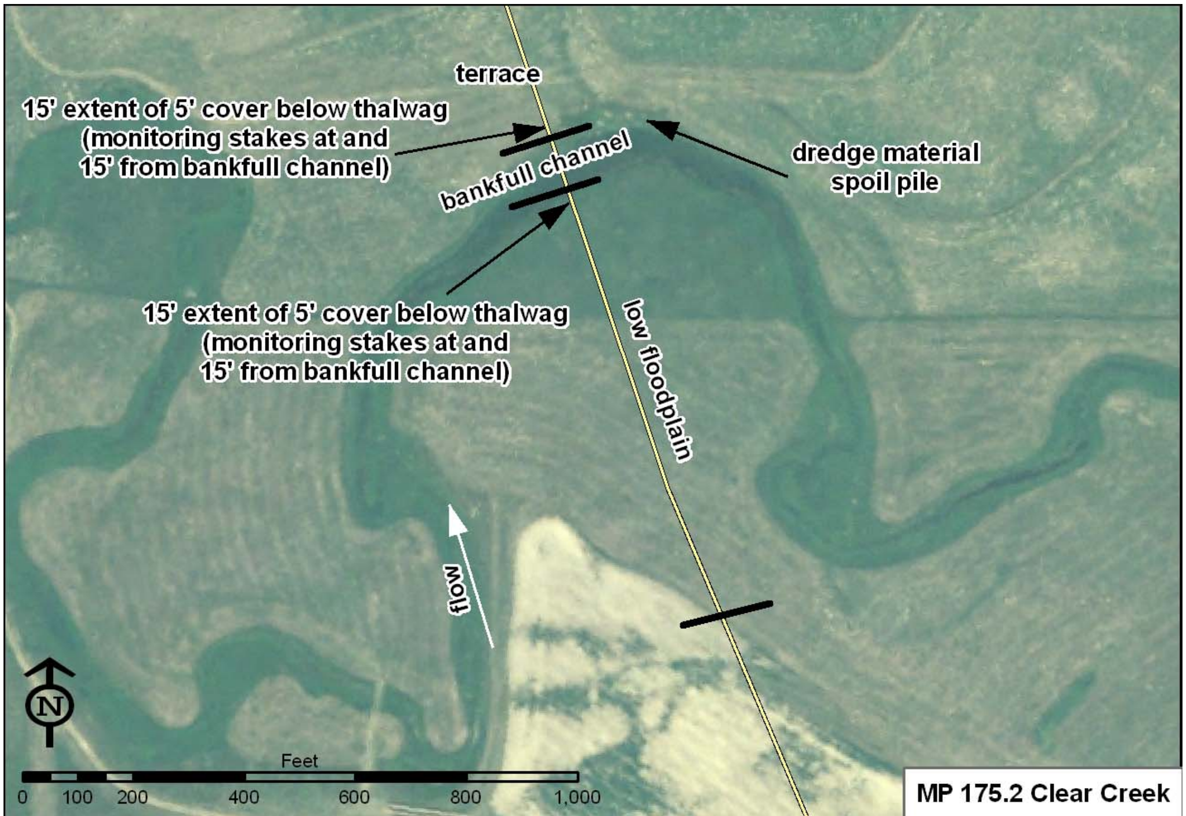

Figure 3.1-10 Burial Depth and Extent for Clear Creek

3.1.12.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.13 Side Channel of the Yellowstone River (MP 195.7)

3.1.13.1 Site Characteristics

The Side Channel of the Yellowstone River has a drainage area of 50,246 square miles at the proposed crossing. The geology of the valley on both sides of the creek consists of the Fort Union Formation: Tongue River Member and Ludlow Member. The Tongue River Member consists of sandstone, sandy and silty shale, and coal. The Ludlow Member is comprised of shale, siltstone, silty or bentonitic claystone, sandstone, and coal. The Lebo Member of the Fort Union Formation is present on river right side of the valley and consists of carbonaceous shale, bentonitic claystone, sandstone, and coal. Quaternary alluvial terrace deposits and alluvium/colluvium have also been mapped on both sides of the valley. Landslide scars on the right valley wall are visible in aerial photographs 5 miles upstream and directly downstream of the crossing. Aerial photographs indicate the presence of scroll bars adjacent to the crossing and 0.5 mile downstream of the proposed crossing. The valley bottom gradient is low and consists of modern alluvium 2,203 feet wide at the proposed crossing. Sinuosity is low to moderate and channel widths range from 31 to 66 feet. The regional regression analysis could not be conducted to estimate stream discharge at the proposed crossing because the equations developed for the region by Omang (1992) apply only to watersheds between 0.4 and 2,250 square miles in extent. Flood frequency analyses for the nearest stream gauges on the river are summarized in Table 3.1-13.

Table 3.1-13 Regional Regression and Peak Flow Analysis for the Side Channel of the Yellowstone River

Regional Regression*								
Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	50,246	--	--	--	--	--	--	--

Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi^2)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06309000 Yellowstone River at Miles City MT (Bulletin 17B)	48,253	US	55.3	87 (1922-2009)	49,918	64,660	73,305	80,910	89,945	96,232
06327500 Yellowstone River at Glendive MT (Bulletin 17B)	66,739	DS	20.3	112 (1897-2009)	60,923	81,241	94,015	105,828	120,616	131,420

*The regional regression equations apply to watersheds between 0.04 mi^2 and 2,250 mi^2.

The Side Channel to the Yellowstone River at the 195.7 MP crossing is a perennial low-flow single thread channel that is entrenched into the surrounding floodplain. The side channel is separated from the main stem of the Yellowstone River by a large instream island with both a high floodplain and terrace. The channel is deeply incised into the adjacent floodplain and conveys all flows less than the bankfull discharge. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the floodplain.

The bankfull channel at the MP 195.7 crossing is 141 feet wide and is 20 feet deep. The unvegetated thalweg width is approximately 40 feet. The cobbly fine sand surficial alluvium of the channel thalweg is unarmored. At depth the channel alluvium is less sandy and more coarse than the surficial alluvium. The bankfull channel is well defined by a 15 to 25-foot bank on either side. At the crossing the 15-foot-high, 10 to 15-degree right bank is comprised of very fine sand. The slope of the 25-foot-high left bank is 90 degrees at the base and 45 degrees above. The lower 5 feet is composed of silty fine sand and the remaining 20 feet above is exposed cobble and poorly indurated bedrock. Both the left and right banks are completely vegetated with herbaceous plants and grasses with greater than 1-foot rooting depths.

The bankfull discharge is completely conveyed within the channel at the Side Channel to Yellowstone River crossing. There is a high floodplain approximately 15 feet above the unvegetated channel on the right side of the channel at the crossing. This floodplain is 350 feet wide and is dominated by grasses and a mature cottonwood forest along the right margin.

Topographic depressions are found throughout the right floodplain. A high terrace sits several feet above the right floodplain and is a sagebrush-cottonwood community with hummocky terrain. A high terrace lied above the 35-foot-high bank on the left side of the unvegetated channel. This terrace is currently irrigated farm land.

3.1.13.1.1 Disturbance

Infrastructure in the vicinity of the side channel includes a road parallel to and 0.25 mile away from the left bank. Groups of buildings are visible 0.4 mile upstream and 0.5 mile downstream of the proposed crossing. Most of the valley bottom of river left is covered in agricultural fields bordered by small farm roads.

3.1.13.2 Preventative Measures

3.1.13.2.1 Crossing Technique

The proposed crossing method for the Side Channel to the Yellowstone River is a horizontal directional drill (HDD). No Alternative approach is proposed. Due to the nature of an HDD crossing, there is no expected impact to turbidity during construction of the crossing.

3.1.13.2.2 Pipeline Burial Depth and Extent

Burial depths and extents are provided in the preliminary plan-set. The pipeline would be buried approximately 30 feet below the channel thalweg, and would extend below the entire length of the left floodplain (Appendix C, Yellowstone River HDD plan). The HDD would end approximately 250 feet from the top of the high bank on the left terrace.

3.1.13.2.3 Site Reclamation

Due to the nature of HDD crossings there is no expected impact to the form, grade, banks, floodplains, or channel of the river system. Therefore, no site reclamation is anticipated.

3.1.14 <u>Yellowstone River (MP 196)</u>

3.1.14.1 Site Characteristics

Yellowstone River has a drainage area of 50,246 square miles at the proposed crossing. Numerous small tributaries feed into the river, including Bad Route Creek 1.4 miles upstream of the crossing and Cabin Creek 5.5 miles downstream. The geology of the valley on both sides of the creek consists of the Fort Union Formation: Tongue River Member and Ludlow Member. The Tongue River Member consists of sandstone, sandy and silty shale, and coal and the Ludlow Member is shale, siltstone, silty or bentonitic claystone, sandstone, and coal. The Lebo Member of the Fort Union Formation is present on river right side of the valley and consists of carbonaceous shale, bentonitic claystone, sandstone, and coal. Quaternary alluvial terrace deposits and alluvium/colluvium have also been mapped on both sides of the valley. Landslide scars on the right valley wall are visible in aerial photographs from 2005 5 miles upstream and directly downstream of the crossing. Aerial photographs indicate the presence of scroll bars 1 mile, 2.5 miles and 5.8 miles upstream and 3.8 and 5 miles downstream of the proposed crossing. The valley bottom gradient is low and is mapped as of modern alluvium 2,203 feet wide at the proposed crossing. Sinuosity is low and channel widths range from 376 to 583 feet. The regional regression analysis could not be conducted to estimate stream discharge at the proposed crossing because the equations developed for the region by Omang (1992) apply only to water sheds between 0.4 and 2,250 square miles in extent. Flood frequency analyses for the nearest stream gauges on the river are summarized in Table 3.1-14.

Table 3.1-14 Regional Regression and Peak Flow Analysis for the Yellowstone River

Regional Regression*										
Source	Drainage Area (mi²)		Average Elevation (ft)		Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
Omang (1992)	50,246		--		--	--	--	--	--	--
Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi²)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06309000 Yellowstone River at Miles City MT (Bulletin 17B)	48,253	US	55.3	87 (1922-2009)	49,918	64,660	73,305	80,910	89,945	96,232
06327500 Yellowstone River at Glendive MT (Bulletin 17B)	66,739	DS	20.3	112 (1897-2009)	60,923	81,241	94,015	105,828	120,616	131,420

*The regional regression equations apply to watersheds between 0.04 mi² and 2,250 mi².

The Yellowstone River at the 196 MP crossing is a multi-thread channel with numerous lateral bars that is up against the left valley margin. A large instream island with both a high floodplain and terrace separates the main stem and a side channel (MP 195.7 crossing). Lateral bars exist on the right side of the unvegetated channel at the crossing. The channel meanders the entire width of the alluvial valley in the vicinity of the crossing, and is up against the left valley margin at the crossing site. The left valley wall is very steep, tall, and with numerous deeply incised channels.

The bankfull channel at the MP 196 crossing is 750 feet wide and is 6 feet deep. The unvegetated thalweg width is approximately 650 feet. The cobble pebble surficial alluvium of the channel thalweg is armored, with a pebble-gravel subsurface. The bankfull channel is well defined by a 5-foot bank on the left and the valley margin on the right. At the crossing the 5-foot-high, 30-degree left bankfull bank is comprised of coarse sand and is completely vegetated with herbaceous plants. Within the bankfull channel is a 40-foot-wide gravel bar adjacent to the wetted channel. Above the gravel bar is a 50-foot-wide silt bench with scattered woody debris that extends to the toe of the bankfull bank.

There is a low floodplain approximately 5 feet above the bankfull channel on the left side of the channel at the crossing. This floodplain is 40 to 50 feet wide and is dominated by herbaceous plants with a few widely scattered willow trees. Topographic depressions are found throughout the low left floodplain. A high terrace sits 7 feet above the left floodplain and is a sagebrush - cottonwood community with hummocky terrain. There is no significant floodplain or terrace along the right margin of the Yellowstone River at the crossing.

3.1.14.1.1 Disturbance

Infrastructure in the area of the proposed crossing includes Interstate 94, which runs parallel 2.5 miles from the left bank and then crosses the river with 2 bridges 7.2 miles upstream. Another road also crosses the river here with a bridge. The town of Fallon is near the bridges and power lines cross the river 6.6 miles upstream of the crossing. A railway runs along the right bank and there are roads parallel to both banks, as near as 80 feet to the right bank and 150 feet to the left bank. Most of the valley bottom of river left is covered in agricultural fields bordered by numerous small farm roads.

3.1.14.2 Preventative Measures

3.1.14.2.1 Crossing Technique

The proposed crossing method for the Yellowstone River is a horizontal directional drill (HDD). No alternative approach is proposed. Due to the nature of an HDD crossing, there is no expected impact to turbidity during construction of the crossing.

3.1.14.2.2 Pipeline Burial Depth and Extent

Burial depths and extents are provided in the preliminary plan-set. The pipeline would be buried approximately 30 feet below the channel thalweg, and would extend below the entire length of the left floodplain (Appendix C, Yellowstone River HDD plan). The HDD would end approximately 800 feet from the toe of the right valley margin.

3.1.14.2.3 Site Reclamation

Due to the nature of HDD crossings there is no expected impact to the form, grade, banks, floodplains, or channel of the river system. Therefore, no site reclamation is anticipated.

3.1.15 Cabin Creek (MP 201.4)

3.1.15.1 Site Characteristics

The landowner has suggested a potential route variation which would eliminate both crossings of Cabin Creek (MP 201.4 and 202) (Figure 3.1-11). Keystone has taken this potential route variation under advisement and study but has not changed the proposed route at this time. The potential route adjustment crosses Spring Creek approximately 0.5 mile west from the proposed MP 202 crossing of Cabin Creek. A field assessment was not conducted at the potential route variation crossing of Spring Creek, however given the proximity and similar valley and channel characteristics to Cabin Creek, the same approach for the Cabin Creek crossing (MP 202) should be applied to the Spring Creek crossing.

3.1.16 Cabin Creek (MP 202)

3.1.16.1 Site Characteristics

Field assessments for both proposed crossings of Cabin Creek (MP 201.4 and 202) were performed prior to a landowner suggested route adjustment that was authorized by Trow (personal communication with John Buchanan and R.E. Butch Wallace) to instead cross Spring Creek at one location (Figure 3.1-11). This route adjustment crosses Spring Creek approximately 0.5 mile west from the proposed MP 202 crossing of Cabin Creek. A field assessment was not conducted at the proposed crossing of Spring Creek, however given the proximity and similar valley and channel characteristics to Cabin Creek, the same approach for the Cabin Creek crossing (MP 202) should be applied to the Spring Creek crossing.

Cabin Creek is a perennial stream with a drainage area of 235.1 square miles at the proposed crossing. Spring Creek joins Cabin Creek just downstream and 400 feet across the valley from the proposed crossing; there is ponding on Spring Creek behind a channel-spanning structure 0.65 mile upstream of the confluence. The geology of the valley and floodplain on both sides of the creek consists of the Fort Union Formation. The members of that formation mapped here are the Tongue River Member: sandstone, sandy and silty shale, and coal and the Ludlow Member: shale, siltstone, silty or bentonitic claystone, sandstone, and coal. Alluvial terrace deposits are mapped between the left bank and the Yellowstone River to the northwest. Aerial photographs from 2005 indicate the presence of relic channels 0.95 mile upstream, 0.6 mile downstream and directly adjacent to the proposed crossing. Scroll bars are visible 0.1 mile and 0.5 mile upstream and 0.9 mile downstream of the crossing. Possible landslide scars appear on the aerials 1.4 miles upstream and 1.1 miles downstream on the right valley wall. The valley bottom is mapped as modern alluvium 1,871 feet wide at crossing and the gradient is low. Sinuosity is high and channel widths range from 5 to 25 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-15). No stream gauge data were available for this creek.

Table 3.1-15 Regional Regression Analysis for Cabin Creek MP 202

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	235.1	2,592	677	1,778	2,838	4,627	6,041	8,218

Cabin Creek at the 202 MP crossing is a single thread meandering stream deeply incised into a 2,000 to 2,300-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a high elevation floodplain adjacent to the channel thalweg. The valley alluvium forms a high terrace that is adjacent to the low elevation floodplain along the valley margins.

The bankfull channel at the 202 MP crossing is approximately 19 feet wide and is 5 feet deep. The unvegetated channel width is 13 feet wide. The pebble gravel surficial alluvium of the channel thalweg is unarmored. Several unvegetated lateral bars are present with gravel pebble textures. The limit of the bankfull channel is well defined by a 3.5 to 4-foot bank on either side of the unvegetated channel. At the crossing the 3.5-foot-high, 40 to 90-degree left bank is comprised of sandy silt. The left bank is completely vegetated with grasses and herbs with rooting depths 2 to 3 feet. At several locations along the left bank, slumping and slight undercutting (less than 1 foot) was noted. The slope of the 4-foot-high right bank is 90 degrees and is composed of sandy silt. The right bank is completely vegetated with grasses and herbs with rooting depths 2 to 3 feet. Slumping was noted at several locations along the left bank.

There is a high elevation floodplain approximately 10 feet above the bankfull channel on either side.

Both high floodplains have poorly developed sandy silt soils. The right floodplain is currently a field with a 2-foot-high berm along the margins. The left floodplain is unmanaged grassland with a few widely scattered mature cottonwood trees. There is microtopography present on the left high floodplain that is likely a relic feature formed prior to incision of the current channel.

3.1.16.1.1 Disturbance

There is a group of buildings just downstream of the crossing between Cabin Creek and Spring Creek. A number of small roads cross the valley, including one that crosses the creek 0.2 mile downstream of the crossing.

3.1.16.2 Preventative Measures

3.1.16.2.1 Crossing Technique

The proposed crossing method for the Cabin Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.16.2.2 Pipeline Burial Depth and Extent

The documented bank slumping and undercutting does not appear to be a result of gradual channel migration, but rather as a result of a highly incised channel with steep high banks. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 40 feet beyond the top of the 10-foot-high banks on either side of the channel (approximately 150 feet in length) (Figure 3.1-11). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Cabin Creek (MP 202) this plan would include placing field stakes 40 feet and 10 feet from the right and left banks defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-11). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

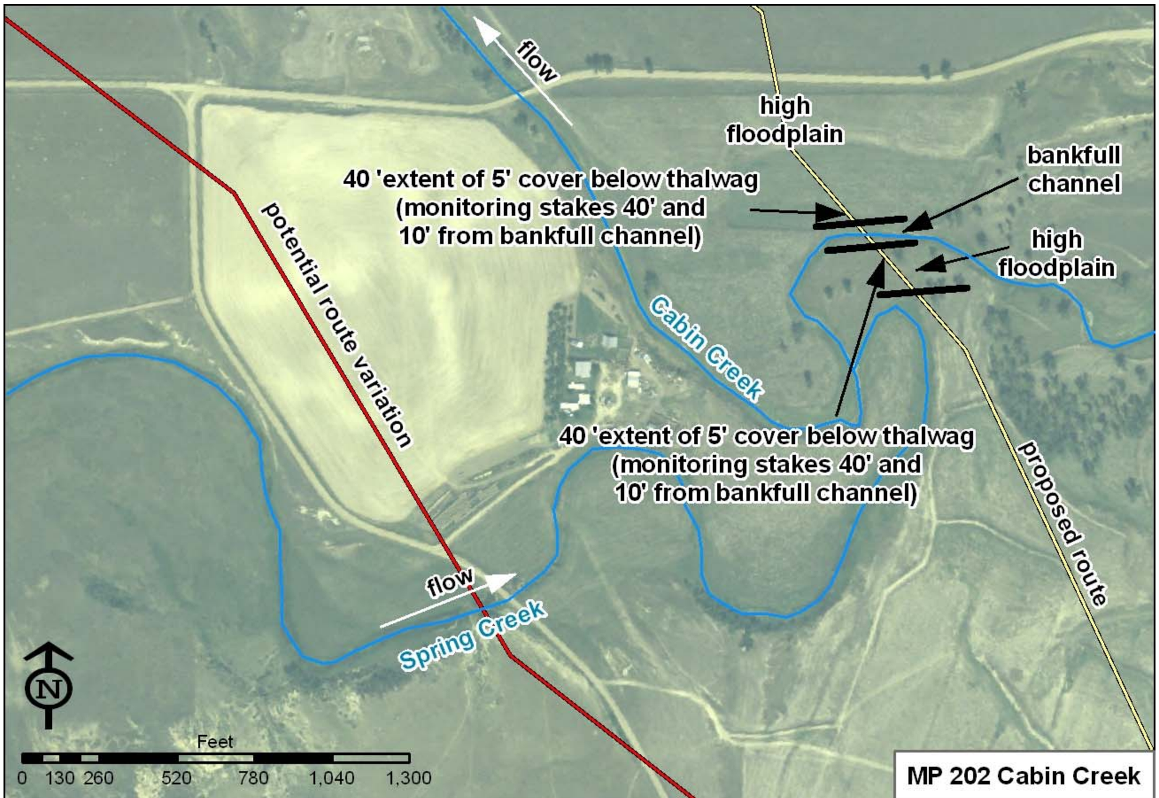

Figure 3.1-11 Burial Depth and Extent for Cabin Creek

3.1.16.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.17 Dry Fork Creek (MP 226.9)

3.1.17.1 Site Characteristics

Dry Fork Creek is a perennial stream with a drainage area of 28.16 square miles at the proposed crossing. Lawrence Creek joins Dry Fork 0.2 mile upstream of the proposed crossing and an unnamed creek joins 200 feet downstream. Additionally there appears to be an irrigation canal 0.26 mile downstream of the crossing. The geology of the valley and floodplain on both sides of the creek consists of the Tongue River Member of the Fort Union Formation: sandstone, sandy and silty shale, and coal. Aerial photographs from 2005 indicate the presence of relic channels 0.5 mile upstream and 0.4 mile and 0.55 mile downstream of the proposed crossing. Downstream 0.18 mile of the crossing is a channel cutoff. The valley bottom gradient is low. The channel form is highly sinuous and channel widths range from 21 to 80 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-16). No stream gauge data were available for this creek.

Table 3.1-16 Regional Regression Analysis for Dry Fork Creek

Source	Drainage Area (mi²)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	28.16	2,888	120	390	704	1,228	1,739	2,081

The denial of landowner permission to access the exact location of the proposed pipeline crossing of Dry Fork Creek prompted assessment at an alternate location. The alternate location is approximately 0.7 mile upstream of the proposed crossing. At the alternate assessment location, Dry Fork Creek is a single thread meandering pool-riffle stream confined within a 200 to 450-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to the relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where present, the low elevation floodplain is adjacent to the channel thalweg. At some locations along the margins of the valley, there is a high elevation floodplain that is adjacent to the low elevation floodplain.

The bankfull channel at the alternate assessment location is approximately 150 feet wide and is 2 feet deep. The unvegetated thalweg width ranges from 0 to 4 feet. The silty-clay surficial alluvium of the channel thalweg is unarmored. The limit of the bankfull channel is defined by a 0.5 to 1.5-foot bank on either side. At the alternate assessment location the 1.5-foot-high, 20-degree left bank is comprised of very fine sandy clay. Vegetation is a mix of herbaceous wetland plants with rooting depths ranging from 1 to 1.5 feet. The slope of the 0.5-foot-high right bank is 10 degrees and is comprised of silty-clay with herbaceous wetland plant cover.

Floodplains exist on either side of the channel thalweg at the crossing site. There is a high elevation floodplain on the left side of Dry Fork Creek. The high elevation floodplain sits 1.5 to 2 feet above and adjacent to the channel thalweg and is approximately 40 feet wide. The alluvium on the high elevation floodplain is very fine sandy clay with a 4 in dark surface. Vegetation is dominated by annual grasses and a few scattered young trees. The floodplain slopes toward the channel thalweg at approximately 10 degrees. The floodplain on the right side of Dry Fork Creek is a low elevation floodplain within the bankfull channel that is 0.5 feet above and adjacent to the channel thalweg and is approximately 140 feet wide. The alluvium is very fine sandy clay with no dark surface. Vegetation is dominated by herbaceous wetland plants and willow shrubs along the outer margin. A very shallow side channel is located with the hummocky floodplain that conveys low flow discharges.

3.1.17.1.1 Disturbance

Two fences cross the river and a utility line at the alternate assessment location. Immediately upstream of the alternate assessment location is a fenced corral that is partially located within the bankfull channel. At the proposed crossing site there are two earthen dams 0.3 mile downstream and 0.3 mile upstream of the crossing. A road runs 0.2 mile downstream of the crossing to the left of the river.

3.1.17.2 Preventative Measures

3.1.17.2.1 Crossing Technique

The proposed crossing method for Dry Fork Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.17.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that Dry Fork Creek at MP 226.9 has the potential to migrate laterally throughout the alluvial valley bottom during the lifetime of the project. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) the presence of a high flow channel within the left bank floodplain that conveys low flow discharges and has the potential to both locally scour and serve as an avulsion channel. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond both the left and right low floodplains (approximately 350 feet in length) where present (Figure 3.1-12). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Dry Fork Creek (MP 226.9) this plan would include placing field stakes 15 feet beyond the right and left banks defining the low floodplain where the pipeline crosses the stream (Figure 3.1-12). Additional field stakes would be placed 15 feet within the right and left banks defining the low floodplain where the pipeline crosses the stream (Figure 3.1-12). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 15 feet within the right or left low floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

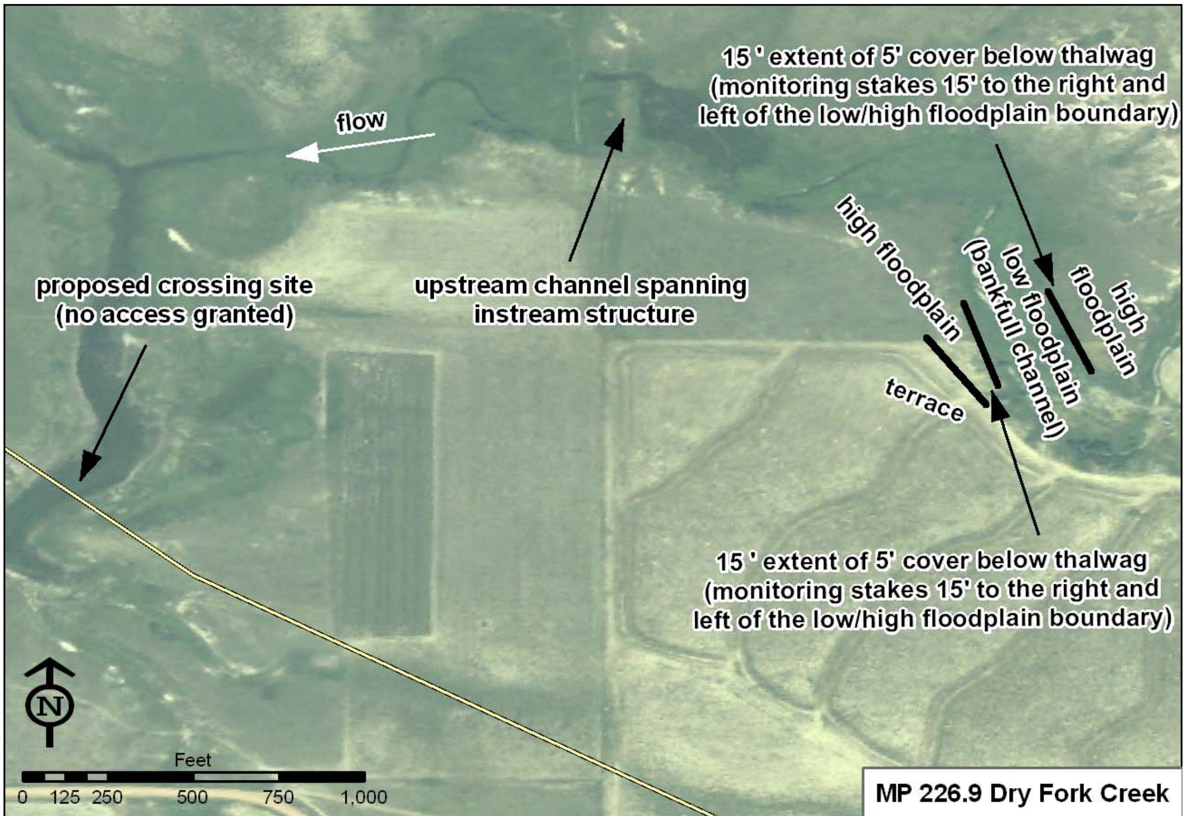

Figure 3.1-12 Burial Depth and Extent for Dry Fork Creek

The presence of channel spanning instream structures both upstream and downstream of the proposed crossing pose a potential risk to the pipeline. Failure of the upstream structure could result in a flood wave with high scour potential that could expose and damage the pipe. Failure of the downstream structure would result in a rapid decrease in the channel bed elevation that would quickly migrate upstream and could potentially expose and damage the pipeline. An investigation into the structural integrity and maintenance requirements of both the upstream and downstream structures to assess the stability of these structures and their potential to fail during the lifetime of the project is beyond the scope of this assessment.

3.1.17.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.18 Pennel Creek (MP 234.5)

3.1.18.1 Site Characteristics

Pennel Creek is a perennial stream with a drainage area of 67.7 square miles at the proposed crossing. Unnamed tributaries join the creek at 1.65 miles and 1.8 miles upstream of the proposed crossing and 0.1 mile, 0.5 mile, and 1.1 miles downstream of the crossing. Numerous stock ponds have been built on tributaries in the valley, including three on the closest tributary that are 0.5 mile, 0.66 mile and 1 mile from the confluence with Pennel Creek. The geology of the valley on both sides of the creek consists of a number of units. Two members of the Fort Union Formation have been mapped: the Ludlow Member (shale, siltstone, silty or bentonitic claystone, sandstone, and coal) and the Tongue River Member (sandstone, sandy and silty carbonaceous shale, and coal). Also present is the Hell Creek Formation: bentonitic claystone that alternates with sandstone interbedded with carbonaceous shale and the Pierre Formation: partly silty shale with abundant bentonite beds and zones of calcareous concretions. The Fox Hills Formation has been mapped as well: the Timber Lake Member: fine- to medium grained, noncalcareous, hummocky-bedded sandstone, and the Trail City Member: wavy-bedded siltstone and black shale with a calcareous concretion zone. Relic channels can be seen on the 2005 aerial photographs 0.1, 0.55, 0.65 and 0.72 mile downstream and 0.6, 0.78, 0.95, 1 and 1.4 miles upstream of the proposed crossing. The floodplain is mapped as modern alluvium, 590 feet wide at the crossing and the gradient is low. The sinuosity is high and channel widths range from 10 to 17 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-17). No stream gauge data were available for this creek.

Table 3.1-17 Regional Regression Analysis for Pennel Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	67.7	3034	178	564	1,102	1,743	2,456	2,953

Landowner access denial to the exact location of the proposed pipeline crossing of Pennel Creek prompted assessment at an alternate location. The alternate assessment location is approximately 2.4 miles downstream of the proposed crossing and was limited to visual observations that could be made from Plevna Road. At the alternate assessment location, Pennel Creek is a single thread meandering pool-riffle stream with floodplains incised into the 2,100-foot alluvial valley bottom. The channel occupies the southern side of the asymmetric alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg and a high elevation floodplain above. Along the margins of the valley there is a high terrace that is adjacent to the high elevation floodplain.

The bankfull channel at the alternate assessment location is approximately 90 feet wide and is 8 feet deep. The unvegetated thalweg width ranges from 0.5 to 3 feet. The limit of the bankfull channel is well defined by a 6-foot bank on either side. At the alternate assessment location the 6-foot-high, 55-degree bankfull banks are completely vegetated with grasses and have minimal woody cover. Minor bank slumping was observed along the channel thalweg immediately upstream of the Plevna Road bridge.

Two floodplains exist on either side of the channel thalweg at the alternate assessment location. There is a low elevation floodplain on either side of the thalweg. The low elevation floodplain sits approximately 3 feet above and adjacent to the channel thalweg and is approximately 5 feet wide on the left side and 85 feet wide on the right. Vegetation is dominated by grasses. The floodplain slopes toward the channel thalweg at approximately 5 degrees and represents the extent of the bankfull channel. Above the 6-foot-high bankfull banks is a high floodplain that is 90 to 120 feet wide on either side of the bankfull channel. Vegetation is dominated by grasses with a few scattered sagebrush and mature cottonwood trees. The outer extent of the high floodplain is well defined by a 4-foot-high bank, above which lies a sagebrush terrace.

3.1.18.1.1 Disturbance

Infrastructure nearby includes a road which crosses the creek with a bridge or culvert 0.28 mile downstream and a residence 0.30 mile downstream of the proposed crossing. Another road and a group of buildings can be seen on aerial photos 1.54 miles upstream.

3.1.18.2 Preventative Measures

3.1.18.2.1 Crossing Technique

The proposed crossing method for Dry Fork Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.18.2.2 Pipeline Burial Depth and Extent

Given the channel geometry similarity between the alternate assessment location and the proposed crossing, site-specific suggestions are provided for the proposed crossing location. Two lines of documented evidence suggest that the thalweg of Pennel Creek has the potential to migrate laterally throughout the bankfull channel during the lifetime of the project. These lines of evidence include 1) the thalweg meanders across the entire bankfull channel upstream and downstream, 2) active bank slumping was observed along the thalweg channel. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 40 feet beyond both the top of the left and right bankfull banks (approximately 180 feet in length) (Figure 3.1-13). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Pennel Creek (MP 234.5) this plan would include placing field stakes 40 feet and 10 feet from the right and left banks defining the bankfull channel where the pipeline crosses the stream (Figure 3.1-13). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

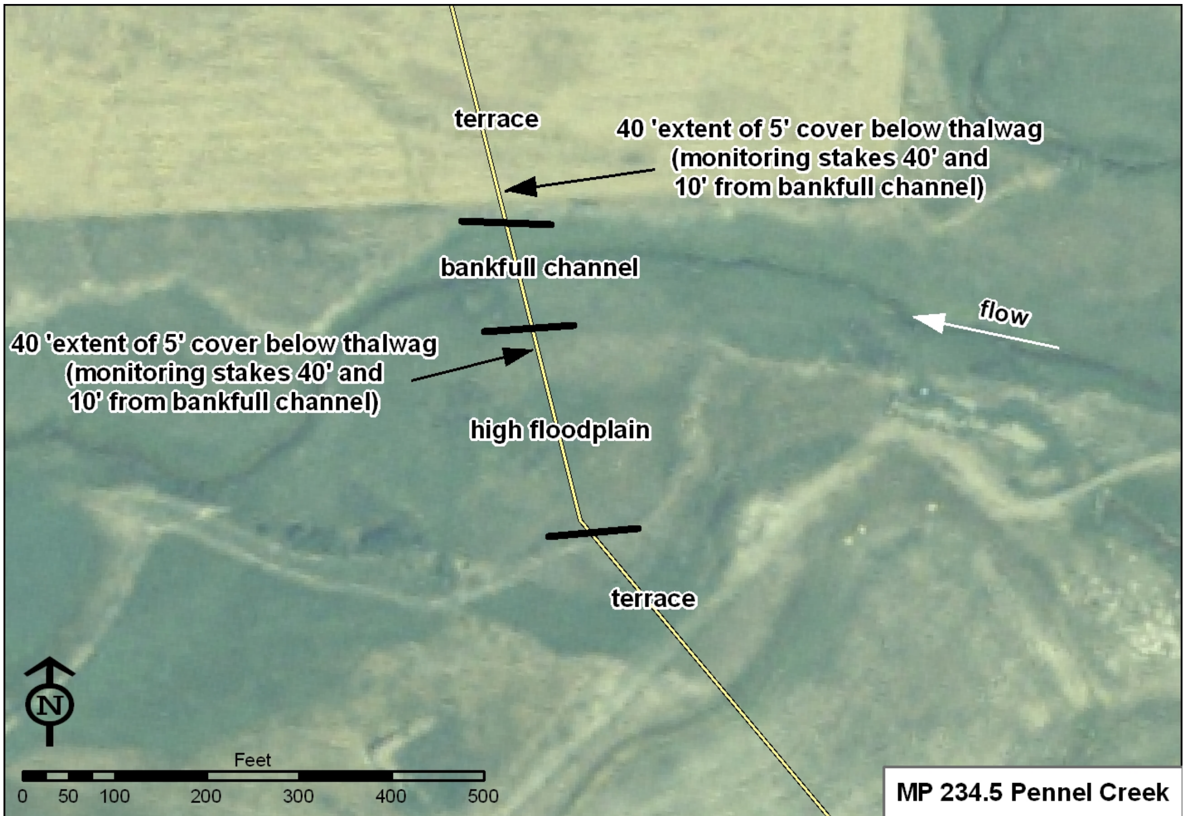

Figure 3.1-13 Burial Depth and Extent for Pennel Creek

3.1.18.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.19 Little Beaver Creek (MP 262.4)

3.1.19.1 Site Characteristics

Little Beaver Creek is a perennial stream with a drainage area of 391.9 square miles at the proposed crossing. Unnamed tributaries join the creek 0.4, 0.7, and 0.9 mile upstream of the proposed crossing and at 0.2, 1, and 1.2 miles downstream of the crossing. The geology of the valley on both sides of the creek consists of the Pierre Formation downstream of the crossing: partly silty shale with abundant bentonite beds and zones of calcareous concretions. Adjacent to and upstream of the crossing on both sides is the Hell Creek Formation: bentonitic claystone that alternates with sandstone interbedded with carbonaceous shale. Further upstream is the Ludlow Member of the Fort Union Formation: shale, siltstone, silty or bentonitic claystone, sandstone, and coal. Relic channels can be seen on the 2005 aerial photographs 0.5 and 0.7 mile downstream and 1.2 miles upstream of the proposed crossing. Scroll bars are visible 0.8 mile downstream of the crossing. The floodplain is comprised of modern alluvium 1,604 feet wide at the crossing and the gradient is low. Sinuosity is high and channel widths range from 18 to 44 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.1-18). No stream gauge data were available for this creek.

Table 3.1-18 Regional Regression Analysis for Little Beaver Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	391.9	3,385	412	1,118	1,828	3,3038	4,032	5,427

Little Beaver Creek at the 262.4 MP crossing is a single thread meandering pool-riffle stream confined within a 1,300 to 2,000-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg. Along the margins of the valley the alluvium forms a high terrace that is adjacent to the floodplain.

The bankfull channel at the 262.4 MP crossing is approximately 30 feet wide and is 4 feet deep. The unvegetated channel width is 12 to 20 feet wide. The gravelly very fine sand surficial alluvium of the channel thalweg is unarmored. The limit of the bankfull channel is well defined by a 3-foot left bank and 4.5-foot right bank. At the crossing the 3-foot-high, 20 to 90-degree left bank (outside meander bend) is comprised of silty sand with several noted locations of slumping. The left bank is completely vegetated with herbaceous wetland plants with rooting depths greater than 1 foot. The slope of the 4.5-foot-high right bank (inside of meander bend) is 15 to 20 degrees is composed of silty sand. The right bank completely vegetated with herbaceous cover with greater than 1-foot rooting depths.

Low alternating silt benches occur adjacent to the thalweg channel and are vegetated with wetland sedges. There is both a high and low elevation floodplain to the right of the bankfull channel along the route. The low elevation floodplain sits 4.5 feet above and adjacent to the bankfull channel and is approximately 30 feet wide. The alluvium on the low elevation floodplain is fine sand with no organic surface. Vegetation is dominated by grasses and herbs. An approximately 3-foot-high bank defines the limit of the low floodplain and transition to the high floodplain. The high floodplain is approximately 10 feet wide and supports a sagebrush community. The high floodplain likely represents a greater than 10 year floodplain surface. Along the outer margin of the left high floodplain is a high bank, above which are terrace deposits. To the left of the bankfull channel above the 3-foot-high bank is a hummocky low floodplain with grasses and herbs. There is no significant woody vegetation on either banks or floodplains.

3.1.19.1.1 Disturbance

Infrastructure in the vicinity includes a group of buildings with a small road 0.5 mile upstream of the proposed crossing on river left. Additional small roads, one of which crosses the creek, can be seen in aerial photographs 1.3 miles downstream of the crossing.

3.1.19.2 Preventative Measures

3.1.19.2.1 Crossing Technique

The proposed crossing method for the Little Beaver Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.19.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that Little Beaver Creek at MP 262.4 has the potential to migrate laterally. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) at the proposed crossing site the 3-foot-high left bank has documented slump features. The pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the top of the 35-foot bank defining the extent of the left floodplain and 15 feet beyond the top of the bank defining the limit of the right low floodplain (approximately 245 feet in length) (Figure 3.1-14). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Little Beaver Creek (MP 262.4) this plan would include placing field stakes 15 feet beyond the right and left banks defining the low floodplain where the pipeline crosses the stream (Figure 3.1-14). Additional field stakes would be placed 15 feet within the right and left banks defining the low floodplain where the pipeline crosses the stream (Figure 3.1-14). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 15 feet within the right or left low floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

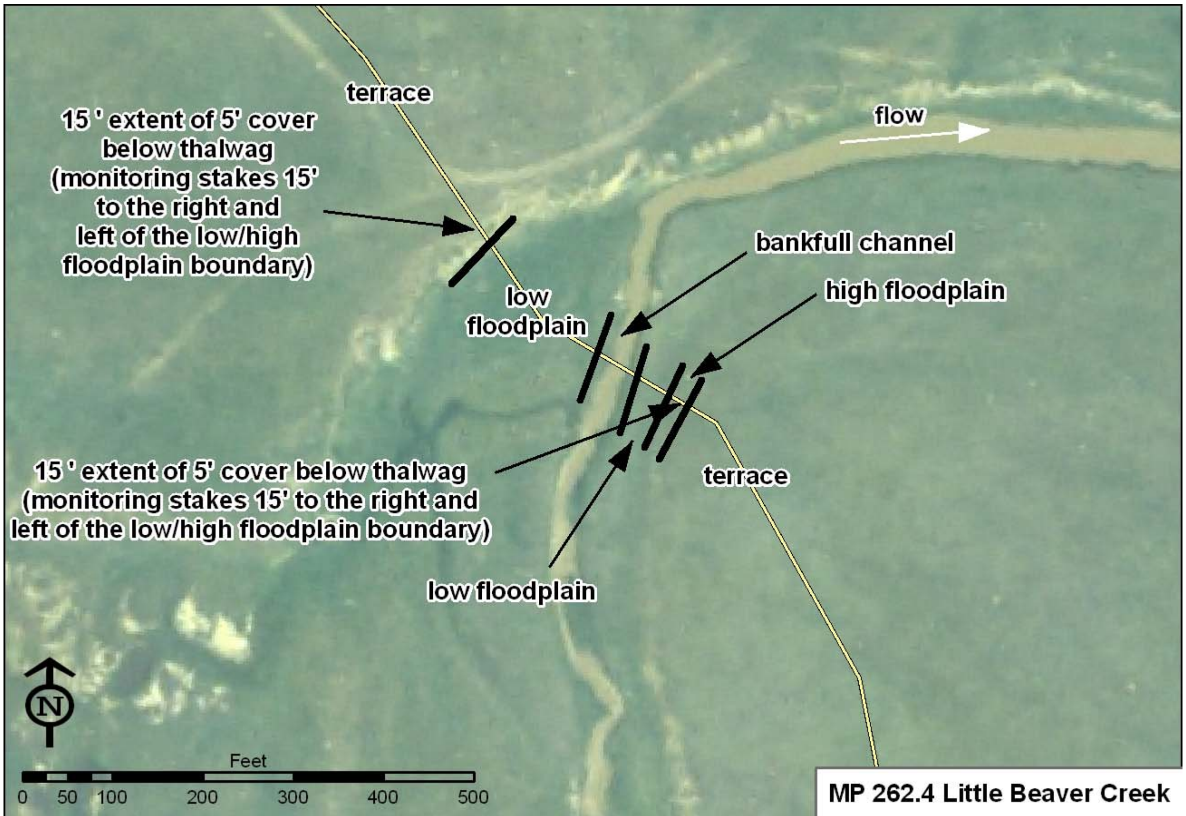

Figure 3.1-14 Burial Depth and Extent for Little Beaver Creek

3.1.19.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.1.20 Boxelder Creek (MP 281.4)

3.1.20.1 Site Characteristics

Boxelder Creek is a perennial stream with a drainage area of 1,088.9 square miles at the proposed crossing. Horse Creek flows into Boxelder Creek 0.5 mile upstream of the proposed crossing and Coal Bank Creek at 1.8 miles downstream. Unnamed tributaries join the creek 0.85 mile and 1.6 miles upstream of the proposed crossing and at 0.2 mile and 0.4 mile downstream of the crossing. The geology of the valley on both sides of the creek consists of the Ludlow Member of the Fort Union Formation: shale, siltstone, silty or bentonitic claystone, sandstone, and coal. In addition the Hell Creek Formation is present on the right wall of the valley: bentonitic claystone that alternates with sandstone interbedded with carbonaceous shale. On the left wall, the Ekalaka

Member of the Fort Union Formation is present: fine- to medium-grained sandstone interbedded with mudstone and thin shale and coal beds. Scroll bars are evident on the 2005 aerial photographs 1 and 2 miles upstream and 0.4 mile downstream of the proposed crossing. A relic channel is visible 0.6 mile downstream of the crossing. The floodplain is comprised of modern alluvium 4,609 feet wide at the crossing and landslide deposits have been mapped 3.9 miles upstream of the crossing. The valley bottom gradient is low and sinuosity is high; the meanders roughly 2 miles downstream of the crossing are particularly tortuous. Channel widths range from 38 to 69 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals. These results and data from the nearest USGS stream gauge are summarized in Table 3.1-19.

Table 3.1-19 Regional Regression and Peak Flow Analysis for Boxelder Creek

Regional Regression									
Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)						
			2	5	10	25	50	100
Omang (1992)	1088.9	3,408	709	1,885	3,055	5,028	6,608	8,890

Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi^2)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06334630 Boxelder Creek at Webster MT (Bulletin 17B)	1092.0	DS	1.82	13 (1960-1973)	1,936	5,223	9,001	14,300	24,432	35,223

Boxelder Creek at the 281.4 MP crossing is a single thread meandering pool-riffle stream confined within an 1100-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg. Along the margins of the valley the alluvium forms a high terrace that is adjacent to the floodplain.

The bankfull channel at the 281.4 MP crossing is approximately 150 feet wide and is 6 feet deep. The unvegetated channel width is 35 feet wide. The pebble gravel surficial alluvium of the channel thalweg is unarmored. Several lateral and instream bars are present with gravel pebble textures. Vegetation cover on bars ranges form 25 to 90 percent and is wetland grasses and herb. The limit of the bankfull channel is well defined by a 2.5-foot left bank and 15 to 20-foot right bank. At the crossing the 2.5-foot-high, 75-degree left bank is comprised of pebble gravel. The left bank is completely vegetated with grasses and herbs with rooting depths greater than 1 foot. The slope of the 15 to 20-foot-high right bank is 50 to 90 degrees and is composed of coarse sand. The right bank largely unvegetated with several locations of active slumping and collapsed banks.

There is both a high and low elevation floodplain to the left of the bankfull channel along the route. The low elevation floodplain sits 3 to 4 feet above and adjacent to the bankfull channel and is approximately 100 feet wide. The alluvium on the low elevation floodplain is coarse sand with no organic surface. Vegetation is dominated by grasses and herbs with a few scattered cottonwood trees along the margin. An approximately 3-foot-high bank defines the limit of the low floodplain and transition to the high floodplain. The high floodplain is approximately 160 feet wide and is composed of very fine sand with grasses and a few scattered mature cottonwood trees. The high floodplain likely represents a greater than 10 year floodplain surface. Along the outer margin of the left high floodplain is a high bank, above which are terrace deposits. To the right of the bankfull channel above the 15 to 20-foot-high bank is a grassy flat terrace that likely represents a greater than 50 year floodplain.

3.1.20.1.1 Disturbance

The infrastructure in the area includes groups of building with small roads at 1.1 and 1.8 miles upstream of the proposed crossing. Two dams are visible 2.2 miles upstream of the crossing on a tributary that does not appear to flow directly into the channel, but rather into the floodplain 650 feet from the left bank.

3.1.20.2 Preventative Measures

3.1.20.2.1 Crossing Technique

The proposed crossing method for Boxelder would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry or at seasonal low-flow to reduce the potential for turbid water release during construction of the crossing.

3.1.20.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that Boxelder Creek at MP 281.4 has the potential to migrate laterally. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) at the proposed crossing site the 15 to 20-foot-high right bank has several locations of documented failure. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 40 feet beyond the top of the 15 to 20-foot right bank and 40 feet beyond the top of the left bank defining the limit of the low floodplain, (approximately 290 feet in length) (Figure 3.1-15). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Boxelder Creek (MP 281.4) this plan would include placing field stakes 40 feet and 10 feet from the right bankfull channel where the pipeline crosses the stream (Figure 3.1-15). Additional field stakes would be placed 40 feet and 10 feet to the left of the left low/high floodplain boundary (Figure 3.1-15). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the bankfull boundary or 10 feet from the low/high floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

Figure 3.1-15 Burial Depth and Extent for Boxelder Creek

3.1.20.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2 INTERMITTENT STREAMS

3.2.1 Corral Coulee (MP 20.8)

3.2.1.1 Site Characteristics

Corral Coulee is an intermittent stream with a drainage area of 8.91 square miles at the proposed crossing. Unnamed tributaries visible in aerial photographs from 2005 join the creek at the crossing and upstream 1.22 miles. The confluence with Frenchman Creek is 4.5 miles downstream of the crossing. Another proposed crossing on Corral Coulee is located 0.6 mile downstream. The geology of the valley on both sides of the creek consists of the Bearpaw

Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. Downstream of the crossing the Judith River Formation is mapped: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. Relic channels can be seen on aerial photographs 0.16 mile upstream and 0.38 mile downstream of the crossing. While no landslide indicators were visible on the aerial photographs, this coulee is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The floodplain is mapped as modern alluvium 364 feet wide at the proposed crossing. The floodplain gradient is low and the channel is moderately sinuous. The channel widths range from 15 to 37 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-1). No stream gauge data were available for this creek.

Table 3.2-1 Regional Regression Analysis for Corral Coulee (MP 20.8)

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	8.91	2,768	47	155	272	470	665	885

Corral Coulee at the 20.8 MP crossing is a single thread meandering pool-riffle stream confined within a 120 to 150-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg. At some locations along the margins of the valley there is a high elevation floodplain that is adjacent to the low elevation floodplain.

The bankfull channel at the MP 20.8 crossing is approximately 40 feet wide and is 3 feet deep. The unvegetated thalweg width ranges from 0 to 3 feet. The cobble-gravel surficial alluvium of the channel thalweg is unarmored. The limit of the bankfull channel is well defined by a 2 to 3-foot bank on either side. At the crossing the 3-foot-high vertical left bank (outside meander bend) is comprised of gravelly sand and is undercut with several noted locations of bank collapse. Vegetation is a mix of annual and woody plants with rooting depths ranging from 0.5 to 2.5 feet. The slope of the 2-foot-high right bank (inside of meander bend) is 30 degrees and is comprised of gravelly sand.

Floodplains exist on either side of the bankfull channel at the crossing site. There is both a high and low elevation floodplain on the left side of Corral Coulee. The low elevation floodplain sits 3.5 feet above and adjacent to the channel thalweg and is approximately 50 feet wide. The alluvium on the low elevation floodplain is silty fine sand with a poorly developed one inch dark surface. Vegetation is dominated by annual grasses and a few scattered woody shrubs. An ephemeral tributary joins Corral Coulee immediately downstream of the proposed crossing location and flows through the low elevation floodplain. The high elevation floodplain sits 2 feet above and adjacent to the low elevation floodplain and is approximately 40 feet wide with annual grasses and scattered sagebrush. The floodplain on the right side of Corral Coulee is a low elevation floodplain that is 2 feet above and adjacent to the channel thalweg and is approximately 60 feet wide. The alluvium is silty fine sand with a poorly developed one inch dark surface. Vegetation is dominated by annual grasses and a few widely scattered shrubs. A 1 to 1.5-foot-deep side channel is located at the outer margin of the floodplain adjacent to the valley wall that conveys water during bankfull discharges.

3.2.1.1.1 Disturbance

The only documented nearby existing infrastructure is a small stock pond approximately 2,800 feet up the tributary that joins Corral Coulee immediately downstream of the proposed crossing.

3.2.1.2 Preventative Measures

3.2.1.2.1 Crossing Technique

The proposed crossing method for Corral Coulee would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.1.2.2 Pipeline Burial Depth and Extent

Three lines of documented evidence suggest that Corral Coulee at MP 20.8 has the potential to migrate laterally throughout the alluvial valley bottom during the lifetime of the project. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) at the proposed crossing site the left bank is actively migrating into the left low elevation floodplain, and 3) the presence of a high flow channel along the margin of the valley bottom on the right low floodplain conveys flows during moderate to high flows and has the potential to both locally scour and serve as an avulsion channel. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the left low floodplains and 40 feet beyond the right low floodplain (approximately 205 feet in length) (Figure 3.2-1). In addition, given the documented lateral erosion at the crossing site, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Corral Coulee (MP 20.8) this plan would include placing field stakes at and 15 feet beyond the boundary of the left low floodplain where the pipeline crosses the stream (Figure 3.2-1). Additional field stakes would be placed 40 feet and 10 feet beyond the right low floodplain boundary (Figure 3.2-1). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10’ from the right low floodplain or at the left low floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

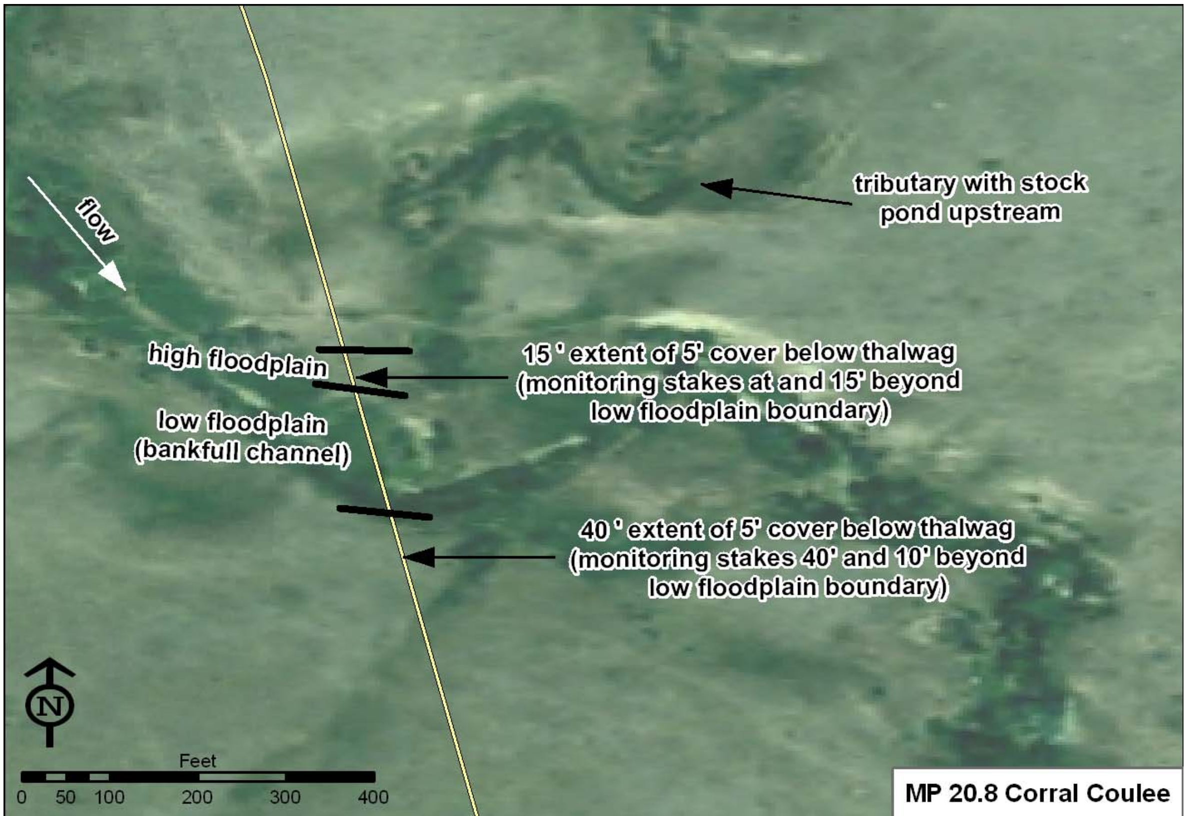

Figure 3.2-1 Burial Depth and Extent for Corral Coulee (MP 20.8)

The presence of channel spanning instream structures on the tributary that joins Corral Coulee immediately downstream of the proposed crossing poses a potential risk to the pipeline. Failure of the structure could result in a flood wave with high scour potential that could expose and damage the pipe. An investigation into the structural integrity and maintenance requirements of both the upstream and downstream structures to assess the stability of these structures and their potential to fail during the lifetime of the project is beyond the scope of this assessment.

3.2.1.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.2 Corral Coulee (MP 21.5)

3.2.2.1 Site Characteristics

Corral Coulee is an intermittent stream with a drainage area of 9.79 square miles at the proposed crossing. Unnamed tributaries visible in aerial photographs from 2005 join the creek 0.1 mile upstream of the proposed crossing. The confluence with Frenchman Creek is 3.8 miles downstream of the crossing. Another proposed crossing on Corral Coulee is located 0.6 mile upstream. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. Downstream of the crossing the Judith River Formation is mapped: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. Relic channels can be seen on aerial photographs 0.24 mile upstream and 0.04 mile downstream of the crossing. While no landslide indicators were visible on the aerial photographs, this coulee is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The floodplain consists of modern alluvium 350 feet wide at the proposed crossing. The floodplain gradient is low and the sinuosity is moderate to high. The channel widths range from 11 to 20 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-2). No stream gauge data were available for this creek.

Table 3.2-2 Regional Regression Analysis for Corral Coulee (MP 21.5)

Source	Drainage Area (mi²)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	9.79	2,768	50	165	289	501	707	941

Corral Coulee at the 21.5 MP crossing is a single thread meandering pool-riffle stream confined within a 70 to 140-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg. At most locations along the margins of the valley there is a terrace that is adjacent to the floodplain.

The bankfull channel at the MP 21.5 crossing is approximately 40 feet wide and is 3 feet deep. The unvegetated thalweg width ranges from 0 to 5 feet. The pebble-gravel surficial alluvium of the channel thalweg is unarmored. The limit of the bankfull channel is well defined by a 1.5 to 2-foot bank on either side. At the crossing the 1.5-foot-high, 10-degree left bank (outside meander bend) is comprised of very fine sand. Vegetation is a mix of grasses and small shrubs with rooting depths ranging from 1 to 1.5 feet. The slope of the 2-foot-high right bank (inside of meander bend) is 33 degrees and is comprised of medium sand and has documented locations of undercutting. Vegetation is a mix of grasses and a few young trees.

Floodplains exist on either side of the bankfull channel at the crossing site. There is both a high and low elevation floodplain on the right side of Corral Coulee at the MP 21.5 crossing. The low elevation floodplain sits 2 feet above and adjacent to the channel thalweg and is approximately 25 feet wide. The alluvium on the low elevation floodplain is cobble pebble with no developed soil. The coarse texture indicates a relic channel location. Vegetation is dominated by annual grasses and a few scattered woody shrubs. A high elevation floodplain site 2 feet above and adjacent to the low elevation floodplain and is approximately 40 feet wide at the crossing. Vegetation is dominated by grasses and a few widely scattered trees. The high elevation floodplain sits 2 feet above and adjacent to the low elevation floodplain and is approximately 40 feet wide with annual grasses and scattered sagebrush. The low elevation floodplain on the left side of Corral Coulee is 1.5 feet above and adjacent to the channel thalweg and is approximately 40 feet wide. The alluvium is silty fine sand with a poorly developed soil. Vegetation is dominated by annual grasses and a few scattered woody shrubs. The outer extent of the left floodplain is defined by an unconsolidated near vertical 60-foot-high wall.

3.2.2.1.1 Disturbance

The only documented nearby existing infrastructure is a small stock pond approximately 2,800 feet up the tributary that joins Corral Coulee immediately upstream of the proposed crossing.

3.2.2.2 Preventative Measures

3.2.2.2.1 Crossing Technique

The proposed crossing method for Corral Coulee would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.2.2.2 Pipeline Burial Depth and Extent

Three lines of documented evidence suggest that Corral Coulee at MP 20.8 has the potential to migrate laterally during the lifetime of the project. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) at the proposed crossing site the lower left floodplain is a channel lag deposit, and 3) the potential exists for mass failure of the 60-foot left valley margin, which would fill the channel completely and push it into the right floodplain. To provide protective measures the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the top of the bank defining the extent of the high right floodplain, and 40 feet beyond the left valley wall (approximately 200 feet in length) (Figure 3.2-2). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Corral Coulee (MP 21.5) this plan would include placing field stakes 40 feet and 10 feet beyond the boundary of the final grade left valley wall where the pipeline crosses the stream. Additional field stakes would be placed 15 feet to the left and right of the right high floodplain/terrace boundary (Figure 3.2-2). During routine field inspections the location of the channel relative to the stake should be documented. If the channel were to migrate beyond either the 10-foot stake from the left valley margin or the stake placed 15 feet within the right high floodplain/terrace boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

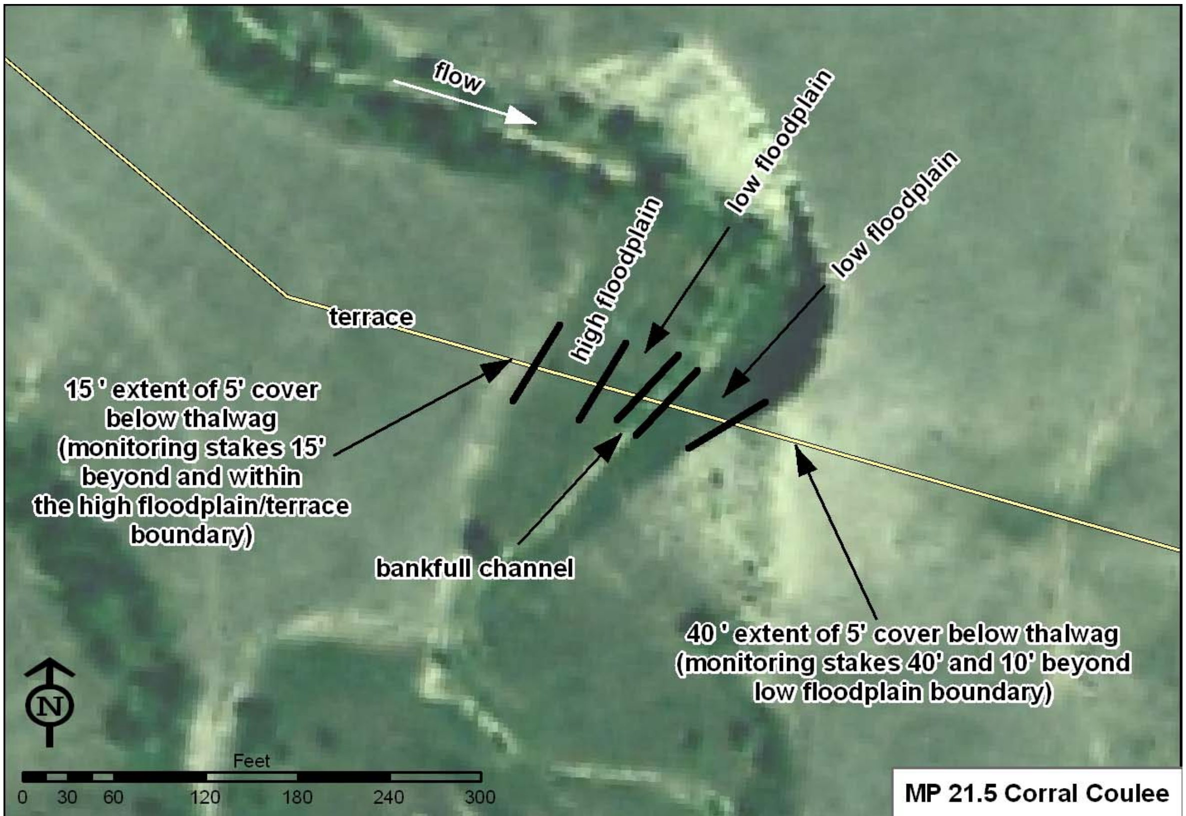

Figure 3.2-2 Burial Depth and Extent for Corral Coulee (MP 21.5)

3.2.2.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.3 Lime Creek (MP 44.9)

3.2.3.1 Site Characteristics

Lime Creek is an intermittent stream with a drainage area of 8.89 square miles at the proposed crossing. An unnamed tributary joins the creek 1.4 miles downstream of the proposed crossing. The geology of the valley on both sides of the creek consists of the Judith River Formation is mapped: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. The Bearpaw Formation is also present on both sides of the creek: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. Relic channels can be seen on aerial photographs 0.23 and 0.68 mile upstream and 0.11 and 0.38 mile downstream of the crossing. Landslide indicators were visible on the aerial photographs 100 feet upstream of the crossing and landslide deposits are mapped in the geology layer 3.5 miles west on Rock Creek. In addition, this creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The floodplain consists of Quaternary sand and gravel 705 feet wide at the proposed crossing. The floodplain gradient is low and sinuosity is high. The channel widths range from 9 to 15 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-3). No stream gauge data were available for this creek.

Table 3.2-3 Regional Regression Analysis for Lime Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	8.89	2627	48	161	283	495	703	941

Lime Creek at the 44.9 MP crossing is a single thread meandering stream confined within a narrow 480 to 550-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Both lateral bars are present, adjacent to the channel thalweg. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present they are incised into the surrounding valley alluvium and adjacent to the channel thalweg. Along the margins of the valley the alluvium forms a high terrace that is adjacent to the low elevation floodplain.

The proposed route crossing of Lime Creek crosses the river at a narrow meander neck (Figure 3.2-3). In order to avoid this site of potential channel cut-off after construction is complete; a minor change in the crossing location is recommended by Entrix and will be taken under consideration by Keystone. The minor change in the crossing location places the route approximately 125 feet upstream (east) from the proposed route (Figure 3.2-3). The field assessment for Lime Creek was performed at the recommended crossing location.

The bankfull channel at the proposed adjusted crossing location is approximately 30 feet wide and is 4 to 5 feet deep. The gravel-pebble surficial alluvium of the channel thalweg is unarmored. The bankfull channel is well defined by a 4 to 5-foot bank on either side. At the crossing the 4 to 5-foot-high, 40 to 90-degree left bank is comprised of fine to medium sand. The slope of the 4 to 5-foot-high right bank is 40 to 50 degrees and is comprised of fine to medium sand. Both the left and right banks have sparse woody vegetation and are dominated by annual grasses and herbs with 2-foot rooting depths.

A narrow floodplain is adjacent to the bankfull channel on the left that is 15 feet wide and sits 5 feet above the channel thalweg. The silty sand floodplain has poorly developed soils and is covered in grasses and herbs. At the outer extent of the floodplain is a 2.5-foot-high bank that defines the boundary with the floodplain and the adjacent terrace. Beyond the right bankfull channel is a terrace supporting a sagebrush community.

3.2.3.1.1 Disturbance

Infrastructure visible in the aerials includes several parallel dirt roads and a building 0.5 mile downstream from the crossing. Numerous stock ponds are present in the channel, especially upstream of the proposed crossing.

3.2.3.2 Preventative Measures

3.2.3.2.1 Crossing Technique

The proposed crossing method for Lime Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.3.2.2 Pipeline Burial Depth and Extent

There is no evidence of previous movement of the channel laterally or vertically at the Lime Creek proposed adjusted crossing location. Therefore, to provide protective measures, the pipe could be buried to a minimum 5 feet below the channel thalweg and maintained at that elevation for 15 feet beyond the top of the bankfull banks on either side of the creek (approximately 60 feet in length) (Figure 3.2.-3). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Lime Creek proposed adjusted crossing location this plan would include placing field stakes at and 15 feet from the right and left banks defining the bankfull channel where the pipeline crosses the stream (Figure 3.2-3). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed at the bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

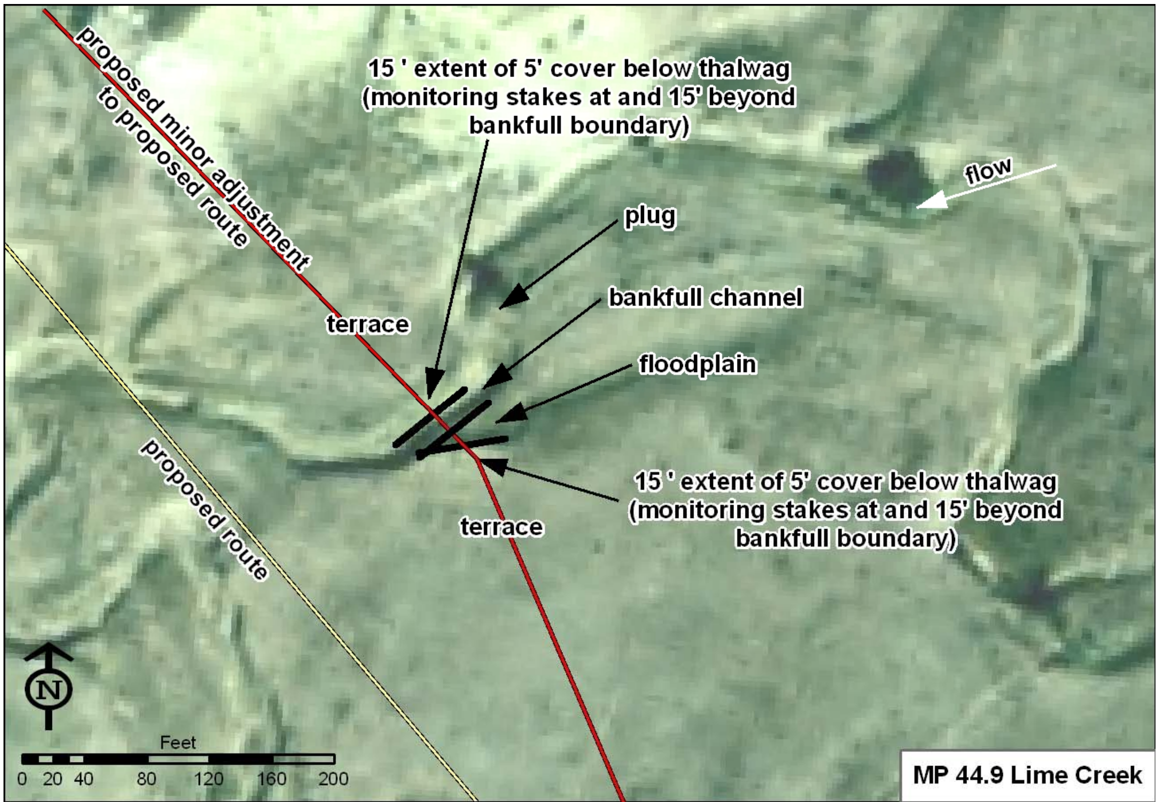

Figure 3.2-3 Burial Depth and Extent for Lime Creek

The presence of a channel plug on Lime Creek upstream of the proposed crossing poses a potential risk to the pipeline. Failure of the structure could result in a flood wave with high scour potential that could expose and damage the pipe. Removal of the plug after construction of the crossing is complete may be advisable. An analysis of the stability of this feature over the life of the pipeline is beyond the scope of this report.

3.2.3.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.4 Brush Fork (MP 51.1)

3.2.4.1 Site Characteristics

Brush Fork is an intermittent stream with a drainage area of 7.13 square miles at the proposed crossing. Brush Fork joins Bear Creek 1.4 miles downstream of the proposed crossing. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. The Judith River Formation is mapped downstream of the crossing on both sides: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. Upstream of the crossing on both sides, the Flaxville Formation is present: gravel, sand, and silt with marl and volcanic ash locally. A channel cut-off can be seen on aerial photographs 0.08 mile upstream of the crossing and a relic channel is visible 1.4 miles downstream near the confluence with Bear Creek. While landslide indicators were not apparent on the aerial photographs, this creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The floodplain consists of modern alluvium 627 feet wide at the proposed crossing and the gradient is low. Sinuosity is high and the channel widths range from 8 to 16 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-4). No stream gauge data were available for this creek.

Table 3.2-4 Regional Regression Analysis for Brush Fork

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	7.13	2,726	40	136	239	417	592	790

Brush Fork at the 51.1 MP crossing is a single thread meandering pool-riffle stream incised into a 400 to 600-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present they are incised into the surrounding valley alluvium and adjacent to the channel thalweg. Along the margins of the valley the alluvium forms a high terrace that is adjacent to the low elevation floodplain.

The bankfull channel at the proposed crossing is approximately 20 feet wide and is 2 feet deep. The gravel-pebble surficial alluvium of the channel thalweg is unarmored. Transitions in the thalweg elevation from pool to riffle sections range from 4 to 6 feet. The bankfull channel is well defined by a 1.5 to 2-foot bank on either side. At the crossing the 1.5-foot-high, 35-degree left bank is comprised of fine sand. The slope of the 2-foot-high right bank is 70 degrees and is comprised of fine to medium sand. Both the left and right banks have no woody vegetation and are dominated by grasses and herbs with 1-foot rooting depths.

Both high and low elevation floodplains are present on either side of the bankfull channel at the proposed crossing. The low elevation floodplains on either side of the bankfull channel are 18 to 20 feet wide with poorly developed fine sandy soils and are completely covered in grasses and herbs. At the outer extent of both low floodplains is a 2.5 to 3-foot-high bank that defines the boundary with the high floodplain. The 40-foot-wide right bank high floodplain supports an upland sagebrush community and is bounded by the valley wall at its outer margin. The 60-foot-wide left high floodplain supports an upland sagebrush community and is bounded by a 3-foot-high bank with an alluvial terrace above.

3.2.4.1.1 Disturbance

Infrastructure visible in the aerials includes a road that crosses the stream 0.34 mile downstream of the proposed crossing. Numerous small stock ponds are present in the channel downstream of the crossing and larger stock ponds are visible in the channel 5.5 miles upstream and 4.5 upstream on a tributary.

3.2.4.2 Preventative Measures

3.2.4.2.1 Crossing Technique

The proposed crossing method for Brush Fork would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.4.2.2 Pipeline Burial Depth and Extent

Immediately upstream of the proposed crossing of Brush Fork is a meander bend in the creek with a deep pool and a near vertical bank on the left outer bank. The meander bend is less than 30 feet from the proposed route. Given the proximity of the meander bend relative to the proposed route, to provide protective measures, the pipe could be buried to a minimum of 5 feet below the pool of the upstream meander bend and maintained at that elevation for 15 feet beyond the left high floodplain and 15 feet beyond the top of the bank defining the right high and low floodplain boundary (approximately 130 feet in length) (Figure 3.2-4). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At the Brush Fork (MP 51.1) this plan would include placing a field stake at and 15 feet beyond the bank defining the right high/low floodplain boundary where the pipeline crosses the stream (Figure 3.2-4). Additional field stakes would be placed at and 15 feet beyond the left high floodplain/terrace boundary (Figure 3.2-4). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed at the right high/low floodplain boundary or at the left high floodplain/terrace boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

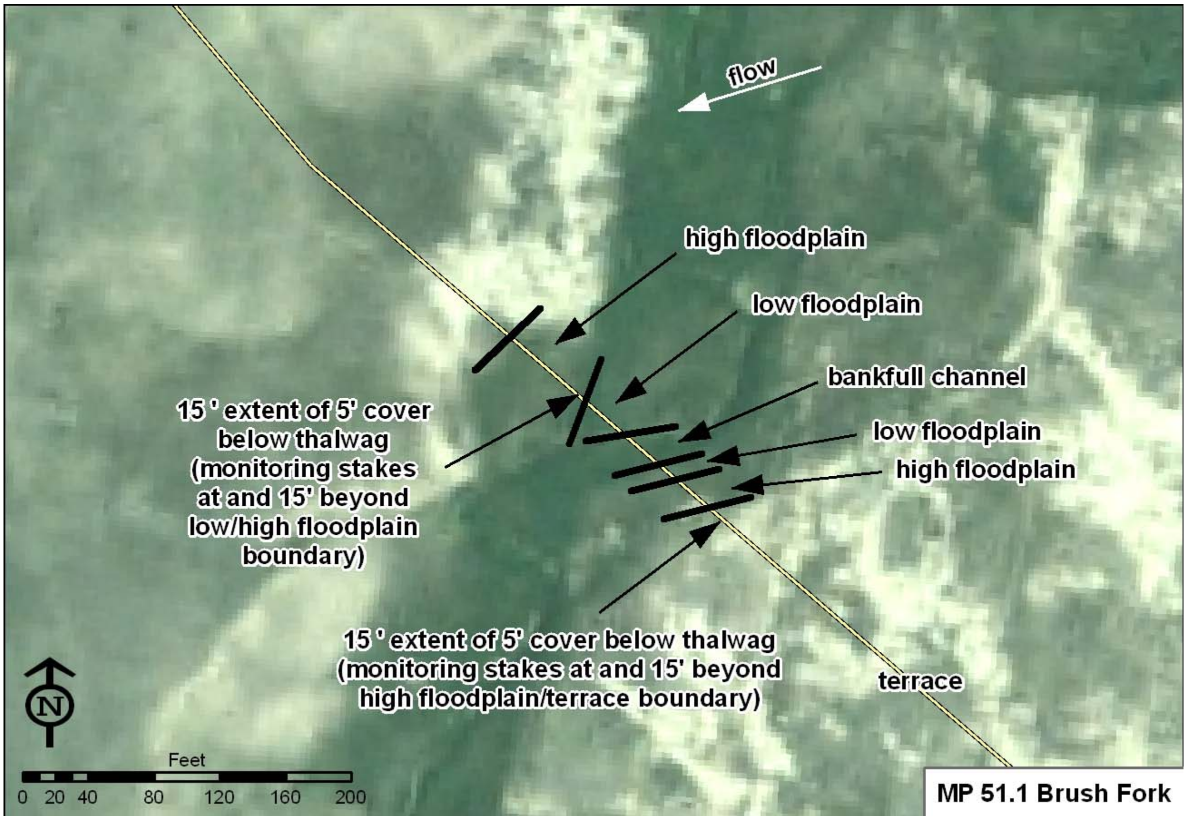

Figure 3.2-4 Burial Depth and Extent for Brush Fork

3.2.4.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.5 Bear Creek (MP 52.3)

3.2.5.1 Site Characteristics

Bear Creek is an intermittent stream with a drainage area of 4.49 square miles at the proposed crossing. Brush Fork joins Bear Creek 0.79 mile downstream of the proposed crossing and an unnamed tributary 0.89 mile downstream. Bear Creek flows into the Milk River 6.8 miles downstream. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. The Judith River Formation is mapped downstream on the river right of the crossing: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. Upstream of the crossing on both sides the

Flaxville Formation is present: gravel, sand, and silt with marl and volcanic ash locally. A relic channel is visible 0.8 mile downstream near the confluence with Brush Fork. While landslide indicators were not apparent on the aerial photographs, this creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The floodplain consists of modern alluvium 906 feet wide at the proposed crossing and the gradient is low. The sinuosity is high and the channel widths range from 9 to 18 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-5). No stream gauge data were available for this creek.

Table 3.2-5 Regional Regression Analysis for Bear Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	4.49	2,768	29	99	176	310	441	591

Bear Creek at the 52.3 MP crossing is a single thread meandering pool-riffle stream incised into a 180 to 200-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present they are incised into the surrounding valley alluvium and adjacent to the channel thalweg. Along the margins of the valley the alluvium forms a high terrace that is adjacent to the low elevation floodplain.

The bankfull channel at the proposed crossing is approximately 25 feet wide and is 2.5 to 3 feet deep. The surficial alluvium of the channel thalweg ranges from cobble gravel in pools and very fine sand in riffles. The elevation of the thalweg varies 3 feet from pool to riffle sections. The bankfull channel is well defined by a 2 to 3-foot bank on either side. At the crossing the 2-foot-high, 15-degree left bank is comprised of fine to very fine sand. The slope of the 3-foot-high right bank is 35 degrees and is comprised of medium sand with several locations of slumping noted. Both the left and right banks have no woody vegetation and are dominated by grasses and herbs with 1.5-foot rooting depths.

A low elevation floodplain is present on the left side of the bankfull channel at the proposed crossing. The low elevation floodplains is approximately 50 feet wide with poorly developed fine sandy soils and is completely covered in grasses and herbs. The entire low floodplain is hummocky with abundant swales present throughout. Approximately 20 feet downstream of the proposed crossing is an actively advancing headcutting side channel. The headcut is 4 feet deep and appears to be hydrologically connected to swale features on the floodplain immediately upstream. At the outer extent of the low floodplains is a 3-foot-high bank that defines the boundary with the high floodplain. The 35-foot-wide left high floodplain supports an upland sagebrush community and is bounded by a 4-foot-high bank with a terrace above. An 80-foot-wide high elevation floodplain is present to the right of the bankfull channel. The high floodplain is composed of very fine to fine sand and supports an upland sagebrush community and is bounded by the valley wall.

3.2.5.1.1 Disturbance

Infrastructure visible in the aerials includes a parallel road off the left bank and a stock pond 0.77 mile downstream on a tributary.

3.2.5.2 Preventative Measures

3.2.5.2.1 Crossing Technique

The proposed crossing method for Bear Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.5.2.2 Pipeline Burial Depth and Extent

Immediately downstream of the proposed crossing of Bear Creek is an actively advancing headcutting side channel that is approximately 1 foot deeper than the current channel thalweg. The headcut is only 20 feet downstream from the proposed route and would pose an immediate threat to the pipe after construction. Given the observed instability within the low floodplain, to provide protective measures, the pipe could be buried to a minimum of 5 feet below the pool at the base of the downstream headcut and maintained at that elevation for 40 feet beyond the top of the bank defining the left low-high floodplain boundary, and 40 beyond the top of the right bankfull channel (approximately 200 feet in length) (Figure 3.2-5). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At the Bear Creek (MP 52.3) this plan would include placing a field stake 40 feet and 10 feet beyond the right high bank defining the bankfull channel where the pipeline crosses the stream (Figure 3.2-5). Additional field stakes would be placed 40 feet and 10 feet to the left of the left low/high floodplain boundary (Figure 3.2-5). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the right bankfull boundary or 10 feet to the left of the left low/high floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

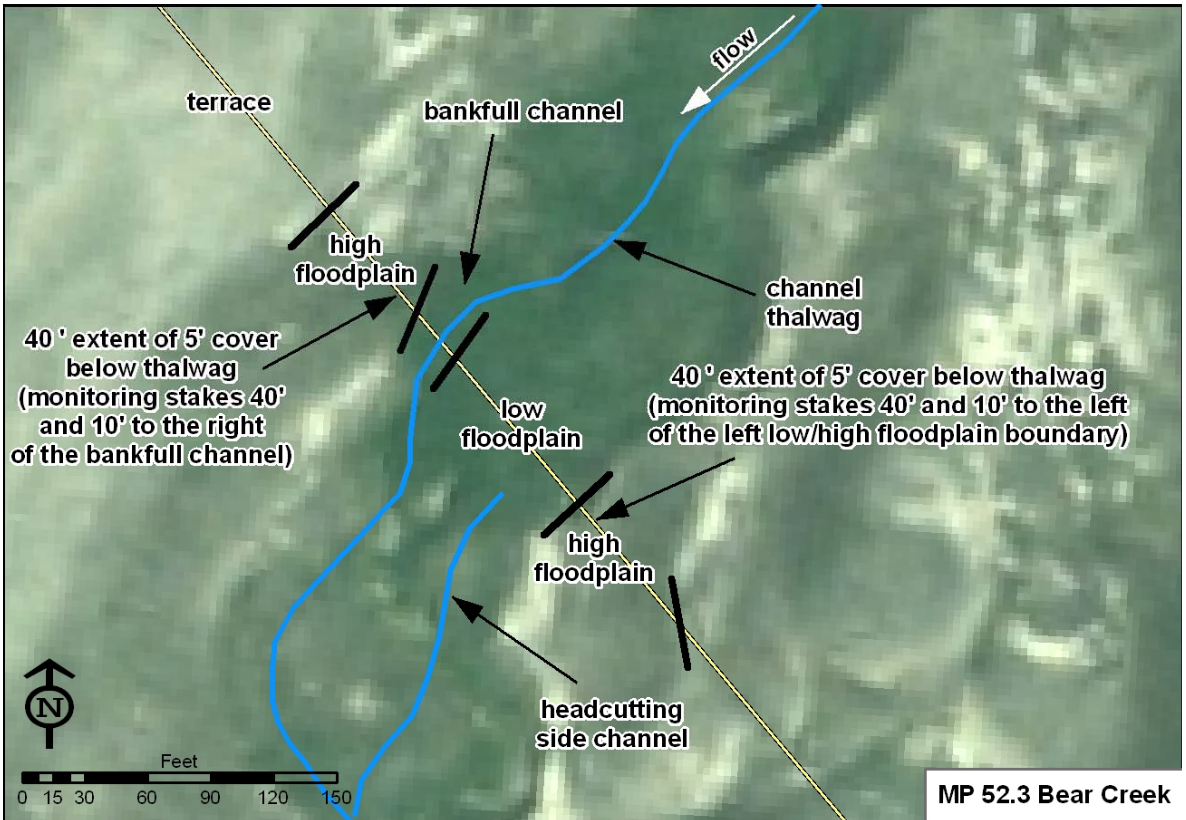

Figure 3.2-5 Burial Depth and Extent for Bear Creek

3.2.5.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.6 Unger Coulee (MP 53.3)

3.2.6.1 Site Characteristics

Unger Coulee is an intermittent stream with a drainage area of 4.45 square miles at the proposed crossing. It joins Buggy Creek 6.4 miles downstream of the proposed crossing. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. The Judith River Formation is mapped downstream of the crossing on both sides: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. Upstream of the crossing on both sides the Flaxville Formation is present: gravel, sand, and silt with marl and volcanic ash locally. Relic channels are visible 0.8 mile upstream and 0.05 mile downstream of the crossing. While landslide indicators were not apparent on the aerial photographs, this creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The floodplain consists of modern alluvium 552 feet wide at the proposed crossing and the gradient is low. Sinuosity is high and the channel widths range from 7 to 13 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-6). No stream gauge data were available for this creek.

Table 3.2-6 Regional Regression Analysis for Unger Coulee

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	4.45	2,686	29	101	180	317	453	609

Unger Coulee at the 53.3 MP crossing is a single thread meandering pool-riffle stream incised into a 600-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present they are incised into the surrounding valley alluvium and adjacent to the channel thalweg. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the low elevation floodplain.

The bankfull channel at the proposed crossing is approximately 7 feet wide and is 2.5 feet deep. The surficial alluvium of the channel thalweg ranges from silty sand pools to gravelly riffles. The elevation of the thalweg varies 2 to 5 feet from pool to riffle sections. The unvegetated channel thalweg is 2 to 5 feet wide. The bankfull channel is well defined by a 2 to 6-foot bank on either side. Typically 2-foot banks occur on the inside of meander bends and 4 to 6-foot banks are opposite on the outside of meander bends. At the crossing the 2-foot-high, 10 to 90-degree left bank is comprised of silty clay and is undercut 0.5 feet at the base. The slope of the 2-foot-high right bank is 10 to 90 degrees and is comprised of medium sand with several locations of slumping noted. Both the left and right banks have very widely scattered shrubs and are dominated by grasses and herbs with 1-foot rooting depths.

A low floodplain is present on either side of the bankfull channel at the proposed crossing. The left low floodplain is 19 feet wide with poorly developed very fine sandy soils. A 1-foot bank defines the limit of the left floodplain with a sagebrush terrace above. The right low floodplain is 7 feet wide, sloping 10 degrees toward the bankfull channel, and is composed of poorly developed silty clay soils. The right floodplain gently slopes up to a sagebrush terrace. Both floodplains are dominated by grass with a few widely scattered shrubs.

3.2.6.1.1 Disturbance

Infrastructure visible in the aerials include a road which crosses the creek with a bridge or culvert 4.5 miles downstream and stock ponds upstream 0.1 mile and 0.3 mile and downstream 0.06 mile and 0.2 mile in the channel.

3.2.6.2 Preventative Measures

3.2.6.2.1 Crossing Technique

The proposed crossing method for Unger would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.6.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that Unger Coulee at MP 53.3 has the potential to migrate laterally during the lifetime of the project. These lines of evidence include 1) the channel meanders across the entire valley bottom upstream and downstream, 2) at the proposed crossing site both banks are undercut with active slumping. In addition, immediately upstream of the crossing is a meander bend with evidence of migration potential that is only 15 to 20 feet away from the proposed route on the right terrace. For protection, the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the top of the bank defining the extent of the floodplain on the left side of the bankfull channel, and 55 feet beyond the top of the bank defining the extent of the floodplain on the right side of the bankfull channel (approximately 130 feet in length) (Figure 3.2-6). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Unger Coulee (MP 53.3) this plan would include placing a field stake at and 15 feet beyond the left high bank defining the low floodplain/terrace boundary where the pipeline crosses the stream (Figure 3.2-6). Additional field stakes would be placed 55 feet and 25 feet to the right of the right low floodplain/terrace boundary (Figure 3.2-6). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed at the left low floodplain/terrace boundary or 25 feet to the right of the right low floodplain/terrace boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

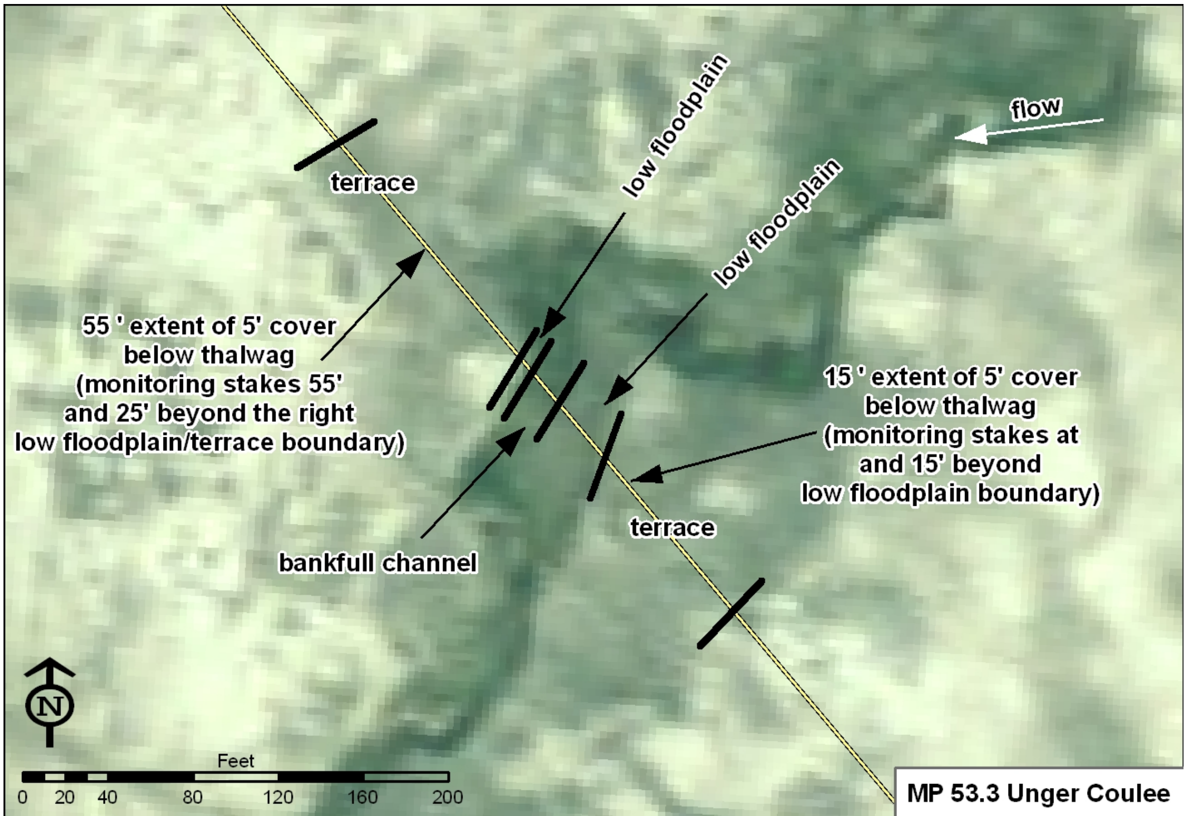

Figure 3.2-6 Burial Depth and Extent for Unger Coulee

3.2.6.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.7 Buggy Creek (MP 55.3)

3.2.7.1 Site Characteristics

Buggy Creek is an intermittent stream with a drainage area of 92.1 square miles at the proposed crossing. Tributaries upstream of the crossing include Crooked Creek at 0.47 miles and Canyon Creek 1.08 miles and downstream Spring Creek 3.8 miles and Unger Coulee 5.2 miles. Buggy Creek joins the Milk River 7.5 miles downstream. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. The Judith River Formation is mapped downstream of the crossing on both sides: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. Upstream of the crossing on both sides, the Flaxville Formation is present: gravel, sand, and silt with marl and volcanic ash locally. Relic channels are visible 0.18 mile and 0.75 mile upstream of the crossing and 0.4 and 1.8 miles downstream of the crossing. While landslide indicators were not apparent on the aerial photographs, this creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). The floodplain consists of modern alluvium 1,735 feet wide at the proposed crossing and the gradient is low. The sinuosity is moderate to high; the section directly adjacent to the crossing for 0.4 mile is less sinuous than the rest of the study reach. The channel widths range from 9 to 14 feet. A regional regression analysis and stream gauge data were used to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-7).

Table 3.2-7 Regional Regression and Peak Flow Analysis for Buggy Creek

Regional Regression										
Source	Drainage Area (mi²)		Average Elevation (ft)		Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
Omang (1992)	92.1		2,798		237	702	1,172	1,934	2,667	3,467
Peak Flood Flow										
Gauge Name and Number	Drainage Area (mi²)	Up or Down-stream	Distance to Crossing (mi)	Range of Data (years)	Recurrence Interval (yrs / cfs)					
					2	5	10	25	50	100
06172200 Buggy Creek near Tampico MT	105	DS	5.41	10 (1957-1967)	607	2,886	5,248	7,792	11,069	13,326

Buggy Creek at the 55.3 MP crossing is a high energy, single thread plane bed stream deeply incised into a 1,600 to 2,000-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom upstream and downstream, but is on the right valley margin at the proposed crossing. The entire channel and floodplain system is deeply incised into the surrounding valley alluvium. Incised floodplains widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Along the margins of the valley the alluvium forms a high terrace that is adjacent to incised floodplain. Approximately 1,500 feet upstream from the proposed crossing the channel is actively migrating at two meander bends.

The bankfull channel at the MP 55.3 crossing is approximately 75 feet wide and is 5 feet deep. The unvegetated thalweg width is 40 feet. The cobble-pebble surficial alluvium of the channel thalweg is unarmored. Lateral cobble-gravel bars are present within the bankfull channel, which are partially vegetated with cottonwood saplings. The bankfull channel is well defined by a 2 to 4-foot bank on either side. At the crossing the 4-foot-high, 35 to 40-degree right bank is comprised of very fine sandy silt with documented slumping. The slope of the 2-foot-high left bank is 35 degrees and is comprised of fine sand. Both the left and right banks have little woody vegetation and are dominated by herbs and grasses with 2-foot rooting depths.

Multiple floodplains are present on either side of the bankfull channel at the proposed 55.3 MP crossing. The 55-foot-wide right bank low floodplain has a medium to fine sandy texture with cobble inclusions and is covered with herbaceous plants and young cottonwood trees. A side channel is present along the toe of the 3-foot-high bank defining the boundary between the low and high right floodplain. The right high floodplain is composed of a cobble-gravel deposit of similar texture to the contemporary channel thalweg. Air photos from 1976 confirm that the channel thalweg once occupied the location of the right high floodplain. The high floodplain supports an upland sagebrush community with a few widely scattered young cottonwood trees. A 20-foot-wide gravelly high flow side channel is present along the outer margin of the high right floodplain that is 1.5 to 2 feet below the high floodplain. The side channel is covered in grasses and herbs with several young cottonwood trees. A 6 to 10-foot-high, 30 to 40-degree bank defines the limit of the right floodplain with the right terrace. The hummocky 40-foot-wide left bank low floodplain has a very fine sandy texture and is covered with herbaceous plants and a mature cottonwood tree. A side channel is present along the toe of the 4 to 5-foot-high bank defining the boundary between the low and high left floodplain. The left high floodplain is composed of very fine sand and has dense stands of mature cottonwood trees. A 6-foot-high, 30-degree bank defines the limit of the left floodplain with the left terrace

3.2.7.1.1 Disturbance

Infrastructure visible in the aerials includes a road which crosses the creek 0.5 mile downstream and a stock pond on an unnamed tributary 0.9 mile downstream of the crossing.

3.2.7.2 Preventative Measures

3.2.7.2.1 Crossing Technique

The proposed crossing method for Buggy Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.7.2.2 Pipeline Burial Depth and Extent

Several lines of documented evidence verify Buggy Creek is an actively migrating high energy stream with high potential for both lateral and vertical movement over the expected lifespan of the project. These lines of evidence include 1) the channel meanders the entire width of the alluvial valley bottom, 2) comparison of air photos from 1976 and 2005 show significant channel migration at the proposed crossing site and 1,500 feet upstream, 3) at the proposed crossing channel lag deposits were identified in the field where the channel was located in the 1976 air photo, confirming migration has occurred, 4) the channel lag deposit is approximately 4 feet above the contemporary channel thalweg, indicating a significant down-cutting trend, 5) numerous side channels are present on all identified floodplains that have the potential laterally and vertically erode the surrounding floodplain, and 6) multiple age stands of cottonwood trees are present that indicate areas of the channel and floodplain that have remained relatively stable over time (mature trees) and areas that have experienced significant recent disturbance (young trees). At the proposed Buggy Creek crossing, to provide protective measures, the pipe could be buried to a minimum 9 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the top of the bank defining the boundary between the high floodplain and terrace on either side (approximately 365 feet in length) (Figure 3.2-7). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Buggy Creek (MP 55.3) this plan would include placing field stakes at and 15 feet from the right and left banks defining the high floodplain/terrace boundary where the pipeline crosses the stream (Figure 3.2-

7). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed on the high floodplain/terrace boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

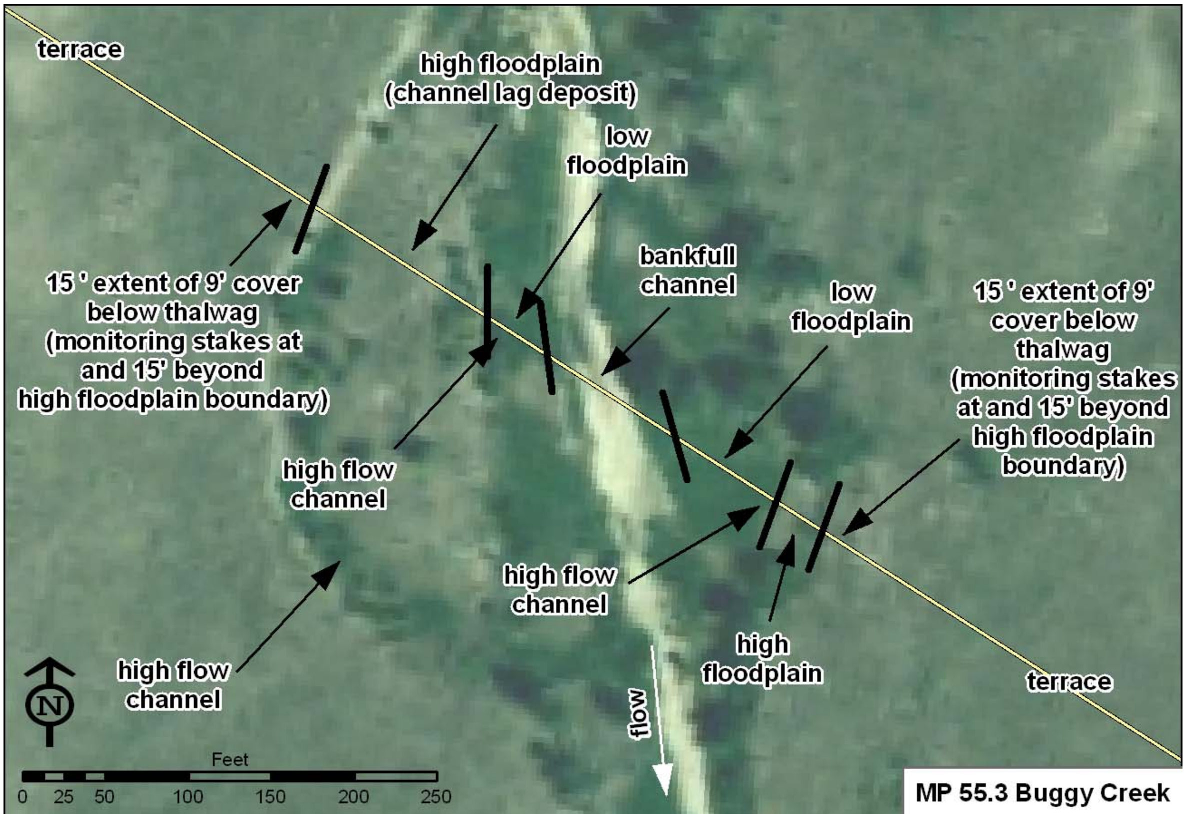

Figure 3.2-7 Burial Depth and Extent for Buggy Creek

3.2.7.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.8 Spring Creek (MP 59.8)

3.2.8.1 Site Characteristics

Spring Creek is an intermittent stream with a drainage area of 10.7 square miles at the proposed crossing. Tributaries downstream of the crossing include Wire Grass Coulee at 0.64 mile, Alkali Coulee at 1.7 miles, Buggy Creek at 3.3 miles and Unger Coulee 4.4 miles. Spring Creek joins Buggy Creek 3.3 miles downstream. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. The Judith River Formation is mapped downstream of the crossing on both sides: fine- to coarse-grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal. Upstream of the crossing on both sides the Flaxville Formation is present: gravel, sand, and silt with marl and volcanic ash locally. Relic channels are visible 0.18 mile and 0.75 mile upstream of the crossing and 0.4 and 1.8 miles downstream of the crossing. A landslide was visible on the aerial photograph 0.76 mile upstream of the crossing. In addition, this creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). A relic channel is visible adjacent and directly upstream of the proposed crossing. The floodplain consists of modern alluvium 561 feet wide at the proposed crossing and the gradient is low. Sinuosity is moderate to high and the channel widths range from 8 to 12 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-8). No stream gauge data were available for this creek.

Table 3.2-8 Regional Regression Analysis for Spring Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	10.7	2,699	54	178	311	539	763	1,016

Spring Creek at the 59.8 MP crossing is a single thread meandering pool-riffle stream incised into a 1,400-foot alluvial valley bottom. Relic channels are evident in the alluvial valley bottom at many locations; however they are well above the current channel and floodplains. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg. At most locations along the margins of the valley there is a terrace that is adjacent to the floodplain.

The bankfull channel at the MP 59.8 crossing is approximately 18 feet wide and is 3 to 4 feet deep. The unvegetated thalweg width ranges from 0 to 15 feet. The surficial alluvium of the channel thalweg ranges from cobble gravel in pools to medium sand in riffles. The elevation of the thalweg varies 2 to 3 feet from pool to riffle sections. The limit of the bankfull channel is well defined by a 3-foot bank on either side. At the crossing the 3-foot-high, 20-degree left bank is comprised of sandy clay with minor undercutting present at the toe. The slope of the 3-foot-high right bank is 30 degrees and is comprised of silty very fine sand with minor undercutting present at the toe. Both banks are grass covered with rooting depths of 1.5 feet.

Floodplains exist on either side of the bankfull channel at the crossing site. There is a low elevation floodplain on the right side of Spring Creek at the MP 59.8 crossing. The low elevation floodplain sits 3 feet above and adjacent to the channel thalweg and is approximately 15 feet wide. The alluvium on the low elevation floodplain is silty very fine sand with no developed soil. Vegetation is dominated by annual grasses and scattered sagebrush. A side channel is present along the outer margin of the right floodplain that connects to the current channel approximately 75 feet upstream from the proposed crossing. To the right of the side channel is a terrace. The low elevation floodplain adjacent to the left bankfull channel is 110 feet wide and gently slopes away from the bankfull channel. The floodplain has a poorly developed gravel-sand soil with grasses and sagebrush. Along the outer margin of the left floodplain is a high flow side channel. A 4-foot-high bank defines the limit of the left floodplain, above which is a terrace.

3.2.8.1.1 Disturbance

Infrastructure visible in the aerials includes a small road which crosses the creek 0.9 mile upstream, a road parallel to the left bank and a group of buildings 0.9 mile downstream of the crossing. Stock ponds can be seen upstream 80 feet, 0.34 mile, 0.5 mile and 0.76 mile from the crossing. A dam on Wire Grass Coulee 0.77 mile from the confluence forms Cornwall Reservoir, which is empty in the photograph. A stock pond on Wire Grass is visible 0.5 mile from confluence and there may be an irrigation ditch between Wire Grass Coulee and Spring Creek 0.08 mile downstream of the crossing.

3.2.8.2 Preventative Measures

3.2.8.2.1 Crossing Technique

The proposed crossing method for Spring Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.8.2.2 Pipeline Burial Depth and Extent

Two lines of documented evidence suggest that Spring Creek at MP 59.8 has the potential to migrate laterally during the lifetime of the project. These lines of evidence include 1) the presence of side channel on either floodplain, and 2) both of the bankfull banks are undercut. To provide protective measures the pipe cold be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 40 feet beyond the top of the bank defining the extent of the low floodplain on either side of the channel (approximately 220 feet in length) (Figure 3.2-8). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Spring Creek (MP 59.8) this plan would include placing field stakes 40 feet and 10 feet from the right and left banks defining the low floodplain/terrace boundary where the pipeline crosses the stream (Figure 3.2-8). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 10 feet from the low floodplain/terrace boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

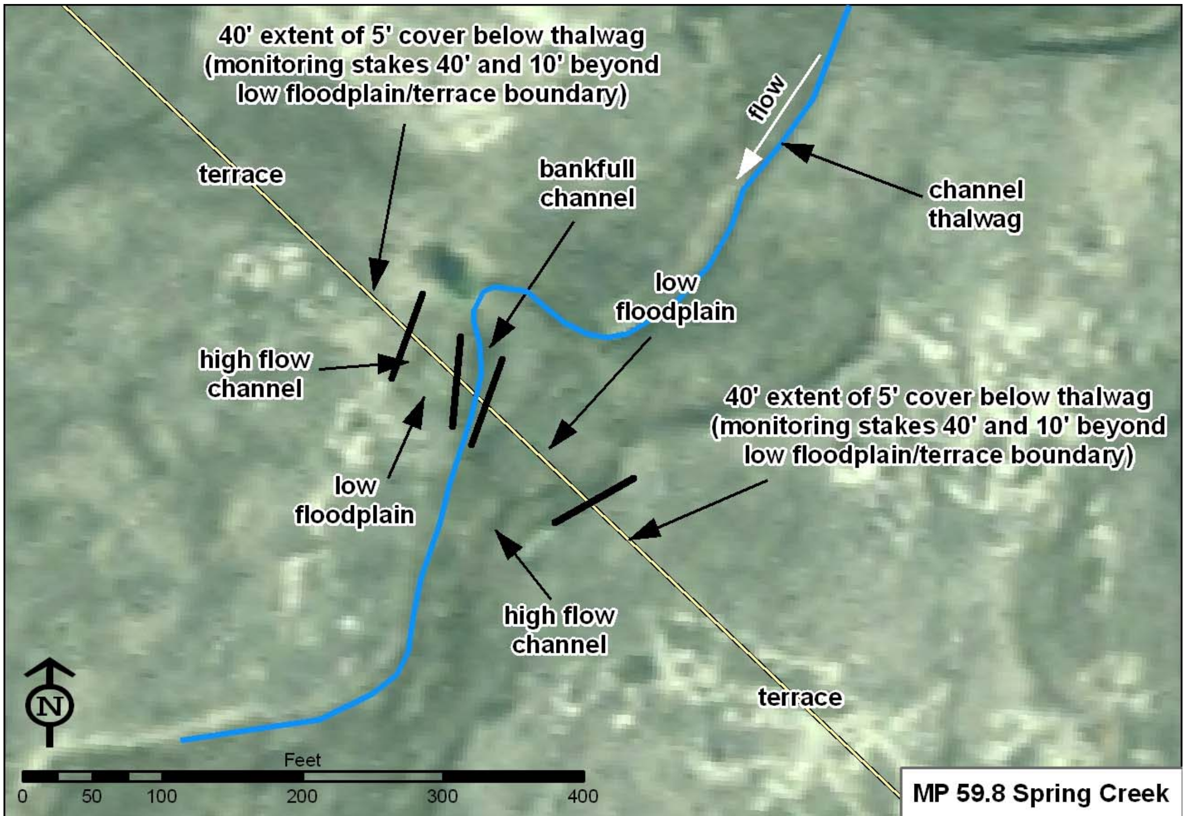

Figure 3.2-8 Burial Depth and Extent for Spring Creek

3.2.8.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.9 Cherry Creek (MP 66.9)

3.2.9.1 Site Characteristics

Cherry Creek is an intermittent stream with a drainage area of 54.2 square miles at the proposed crossing. Tributaries upstream of the crossing include an unnamed stream at 0.2 mile, School Section Coulee at 1.3 miles and West Fork Cherry Creek at 6 miles. Downstream the creek is joined by East Fork Cherry at 2.2 miles and Martin Coulee at 3.7 miles. Cherry Creek joins the Milk River 7.7 miles from the crossing. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. Upstream of the crossing on both sides the Flaxville Formation is mapped: gravel, sand, and silt with marl and volcanic ash locally. The creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). Relic channels are visible adjacent to the crossing, upstream 0.14 mile and 0.5 mile from the crossing and downstream 0.25 mile from the crossing. The floodplain consists of modern alluvium 1,465 feet wide at the proposed crossing. Quaternary alluvium/colluvium deposits are mapped along School Section Coulee and near the confluence with the Milk River. The floodplain gradient is low and the channel is highly sinuous. The meanders downstream of the crossing are particularly tortuous, while the channel near the crossing is less sinuous than the rest of the study reach. The channel widths range from 10 to 16 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-9). No stream gauge data were available for this creek.

Table 3.2-9 Regional Regression Analysis for Cherry Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	54.2	2,657	165	516	877	1,474	2,054	2,697

Cherry Creek at the 66.9 MP crossing is a single thread meandering pool-riffle stream confined within a 1,400 to 1,500-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Along the margins of the valley the alluvium forms a high terrace that is adjacent to the low elevation floodplain.

The proposed route crossing of Cherry Creek at the 66.9 MP crossing was inspected approximately 950 feet downstream (south) from the proposed route per Trow's request.

The bankfull channel at the inspected crossing location is approximately 45 to 55 feet wide and is 3 to 5 feet deep. The channel thalweg is armored with a cobble-pebble surface overlying a gravel-pebble subsurface. The bankfull channel is well defined by a 3 to 5-foot bank on either side. At the crossing the 3 to 5-foot-high, 20 to 90-degree left bank is comprised of silty clay. The slope of the 3 to 5-foot-high right bank is 20 to 50 degrees and is comprised of silty clay. Both the left and right banks have 20 percent woody vegetation cover and are dominated by annual grasses and herbs with 2-foot rooting depths.

Floodplains adjacent to the bankfull channel are present on either side at the proposed adjusted crossing location. The floodplain to the left of the bankfull channel is approximately 1,300 feet wide and is hummocky with discontinuous swales supporting seasonal wetlands. The floodplain surface is composed of silty clay with grasses and a few mature trees adjacent to the seasonal depressions. The right floodplain is approximately 174 feet wide and has isolated depressions. The floodplain surface is silty clay with grasses and a few scattered mature trees adjacent to depressions.

3.2.9.1.1 Disturbance

Infrastructure visible in the aerials includes road crossings 0.16 mile and 0.3 mile upstream and a parallel road 0.3 mile from the left bank. Downstream roads cross at 1.1 miles with a bridge and at 1.65 miles. Groups of buildings can be seen upstream 0.40 miles and downstream 0.4 mile, 1.1 miles and 1.5 miles from the crossing.

3.2.9.2 Preventative Measures

3.2.9.2.1 Crossing Technique

The proposed crossing method for Cherry Creek would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.9.2.2 Pipeline Burial Depth and Extent

The isolated depressions on both floodplains are remnant channels that retain and convey floodwater and rainfall. These features are well above the contemporary channel and do not pose a risk of lateral migration or incision. Therefore, to provide protective measures, the pipe could be buried to a minimum 5 feet below the channel thalweg and maintained at that elevation for 15 feet beyond the top of the bankfull banks on either side of the creek (approximately 80 feet in length) (Figure 3.2-9). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Cherry Creek (MP 66.9) this plan would include placing field stakes at and 15 feet beyond the right and left banks defining the bankfull channel where the pipeline crosses the stream (Figure 3.2-9). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed at the bankfull boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

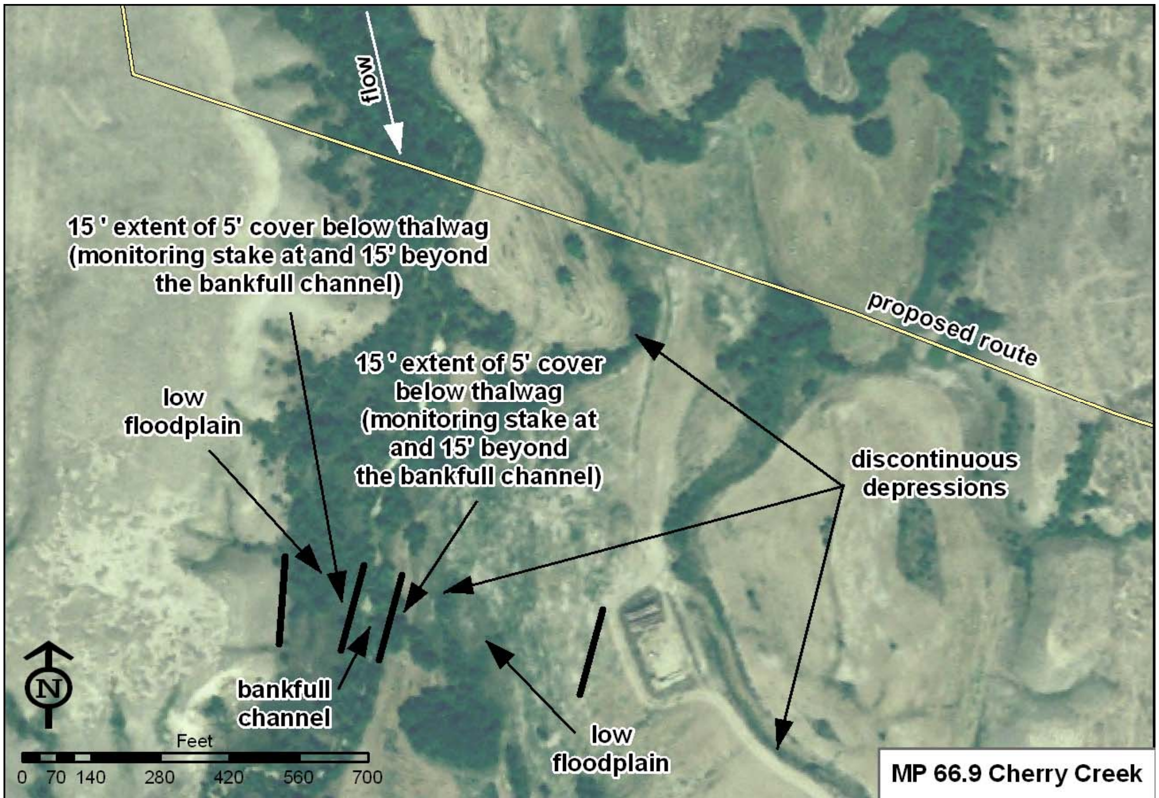

Figure 3.2-9 Burial Depth and Extent for Cherry Creek

3.2.9.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.10 Spring Coulee (MP 70.4)

3.2.10.1 Site Characteristics

Spring Coulee is an intermittent stream with a drainage area of 18.2 square miles at the proposed crossing. An unnamed tributary joins at 4.4 miles upstream and Spring Coulee flows into East Fork Cherry Creek 0.6 miles downstream of the crossing. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. Upstream of the crossing on both sides the Flaxville Formation is mapped: gravel, sand, and silt with marl and volcanic ash locally. While no landslide evidence was visible on aerial photographs, the creek is within the area mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System

(2007). A relic channel is visible 1 mile upstream of the crossing. The floodplain consists of Quaternary alluvium/colluvium deposits 597 feet wide at the proposed crossing and the gradient is low. Sinuosity is moderate and the channel widths range from 10 to 15 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-10). No stream gauge data were available for this creek.

Table 3.2-10 Regional Regression Analysis for Spring Coulee

Source	Drainage Area (mi²)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	18.2	2,624	78	256	446	767	1,081	1,438

Spring Coulee at the 70.4 MP crossing is a single thread meandering stream confined within a 550 to 1,200-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present they are incised into the surrounding valley alluvium and adjacent to the channel thalweg. Along the margins of the valley the alluvium forms a high terrace that is adjacent to the low elevation floodplain. Depth to groundwater is shallow across the floodplains at the proposed crossing site, with several springs present in the vicinity.

The proposed route crossing of Spring Coulee at the 70.4 MP crossing was inspected approximately 1400 feet upstream (north) from the proposed route (Figure 3.2-10) per Trow's request.

The bankfull channel at the inspected crossing location is approximately 58 feet wide and is 2 to 3 feet deep. The organic silty clay surficial alluvium of the channel thalweg is unarmored, with inclusions of gravel and cobble at depth. The entire bankfull channel is densely vegetated with wetland grasses and sedges with rooting depths greater than 1 foot, and is well defined by a 2 to 3-foot bank on either side. At the proposed adjusted crossing location the 1.5-foot-high, 15 to 25-degree left bank is comprised of organic silty clay. The slope of the 2-foot-high right bank is 20 to 35 degrees and is comprised of silty clay. Both the left and right banks have no woody vegetation and are dominated by wetland grasses and sedges with greater than1-foot rooting depths.

Both floodplains on either side of the bankfull channel are densely vegetated with grasses and a few wetland plants with very widely scattered willow trees. There is a well developed silty clay soil with a one inch organic surficial horizon on both floodplains. The outer extent of the 90-foot-wide left floodplain is defined by a 3.5-foot bank, with a sagebrush terrace above. The outer extent of the 203-foot-wide right floodplain is defined by the valley margin.

3.2.10.1.1 Disturbance

A large gravel pit 0.5 mile upstream of the crossing appears to cut through the channel. A road crosses the stream with a bridge or culvert 1.1 miles upstream and additional small road crossings occur 0.5 mile and 0.6 mile downstream. A parallel road runs 0.5 mile form the right bank and a railway 1 mile from the right bank. Buildings are scattered in the valley.

3.2.10.2 Preventative Measures

3.2.10.2.1 Crossing Technique

The proposed crossing method for Spring Coulee would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction.

3.2.10.2.2 Pipeline Burial Depth and Extent

There is no evidence of previous movement of the channel laterally or vertically at the Spring Coulee proposed adjusted crossing location. Therefore, to provide protective measures, the pipe could be buried to a minimum 5 feet below the channel thalweg and maintained at that elevation for 15 feet beyond the top of the floodplain banks on either side of the channel (approximately 380 feet in length) (Figure 3.2-10). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At Spring Coulee (MP 70.4) this plan would include placing field stakes at and 15 feet from the right and left banks defining the limits of the low floodplain where the pipeline crosses the stream (Figure 3.2-10). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed on the outer boundary of the low floodplain, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

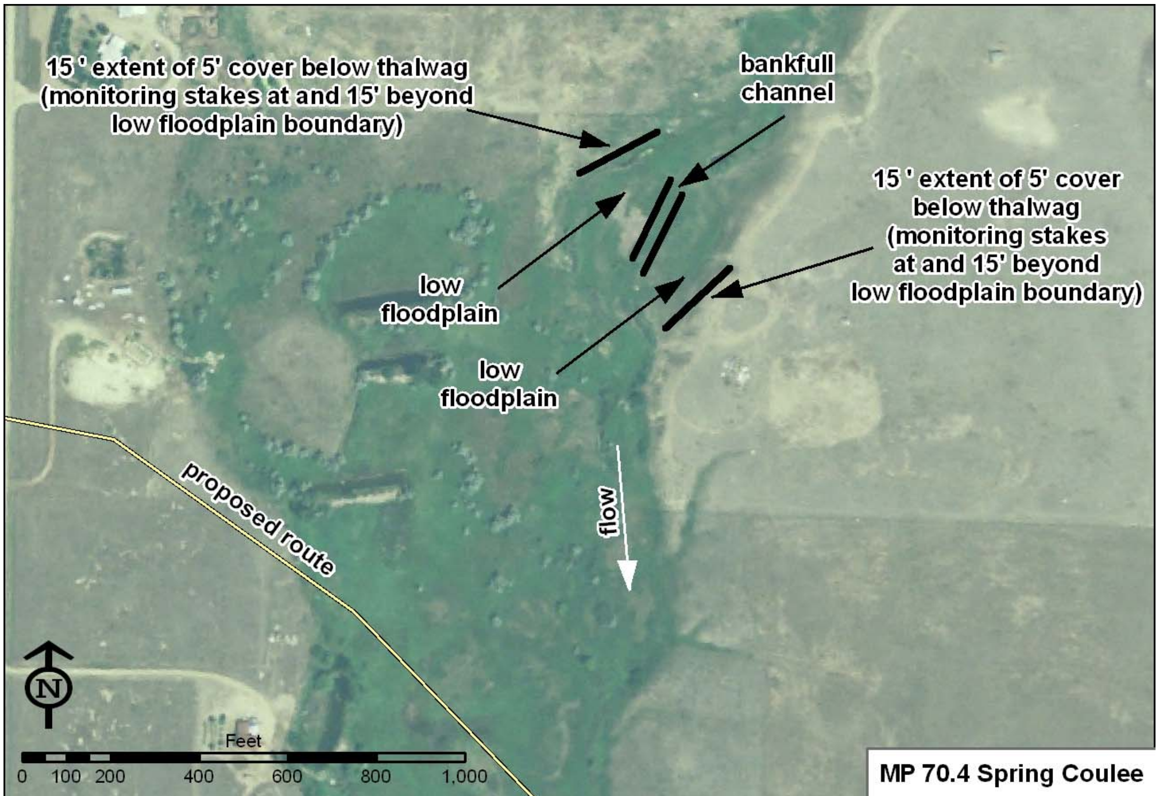

Figure 3.2-10 Burial Depth and Extent for Spring Coulee

3.2.10.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.11 East Fork Cherry Creek (MP 70.9)

3.2.11.1 Site Characteristics

East Fork Cherry Creek is an intermittent stream with a drainage area of 27.7 square miles at the proposed crossing. Tributaries include an unnamed stream 2.9 miles and Hawk Coulee 80 feet upstream of the crossing and Spring Coulee 0.7 mile and Foss Coulee 2.2 miles downstream of the proposed crossing. The creek joins Cherry Creek 3.1 miles from the crossing. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. Upstream of the crossing on both sides the Flaxville Formation is mapped: gravel, sand, and silt with marl and volcanic ash locally. While no landslide evidence was visible on aerial photographs, the creek is within the area mapped for high landslide hazard by the

Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System (2007). A relic channels is visible 1 mile upstream of the crossing. The floodplain consists of modern alluvium 1,138 feet wide at the proposed crossing. Quaternary alluvium/colluvium deposits are mapped along Hawk Coulee and near its confluence with East Fork Cherry Creek. The floodplain gradient is low and sinuosity is moderate. The channel widths range from 7 to 14 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-11). No stream gauge data were available for this creek.

Table 3.2-11 Regional Regression Analysis for East Fork Cherry Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	27.7*	2,496	107	348	605	1,042	1,470	1,955

*The crossing is assumed to occur downstream of the confluence of the two tributaries

East Fork Cherry Creek at the 70.9 MP crossing is a single thread meandering stream confined within an 800 to 900-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present they are incised into the surrounding valley alluvium and adjacent to the channel thalweg. Along the margins of the valley, the alluvium forms a high terrace that is adjacent to the low elevation floodplain. The proposed crossing is immediately upstream with the confluence with Hawk Coulee.

The landowner has suggested a minor change in the crossing location from the proposed route at East Fork Cherry Creek (70.9 MP) . Keystone has taken this suggested minor change in the crossing location under advisement and study but has not changed the proposed route at this time. The minor change in the crossing location crosses East Fork Cherry Creek approximately 75 feet upstream (north) from the proposed route. The field assessment for East Fork Cherry Creek was performed at the landowner suggested crossing location.

The bankfull channel at the inspected crossing location is approximately 15 to 20 feet wide and is 3 feet deep. The gravel pebble surficial alluvium of the channel thalweg is unarmored. The bankfull channel is well defined by a 2.5 to 3-foot bank on either side and is characterized by 2 to 5-foot-deep pools transitioning into grassy swales. Flowing water in the channel would spread laterally in the swale sections of the channel where multiple flowpaths were identified. At the proposed adjusted crossing location the 2.5-foot-high, 20 to 90-degree left bank is composed of gravelly sand. The slope of the 2.5-foot-high right bank is 20 to 90 degrees and is composed of silty sand. Both the left and right banks are slightly undercut and have < 5% woody vegetation dominated by mature cottonwood trees.

Both floodplains on either side of the bankfull channel have scattered mature cottonwood stands adjacent to the bankfull channel. The floodplains have poorly developed silty soils with numerous intermittent side channel swales. The outer extent of the 530-foot-wide left floodplain is defined by a high bank, with a sagebrush terrace above. The outer extent of the 375 feet wide right floodplain is defined by the valley margin.

3.2.11.1.1 Disturbance

Three large gravel pits are in evidence 1.74 miles, 2.2 miles and 2.8 miles from the crossing. A road crosses with a bridge 1 mile downstream of the crossing and a number of small roads and buildings are visible in the vicinity of the Spring Coulee confluence 0.7 mile downstream. A small parallel road and buildings have been built 0.1 mile downstream of the crossing. Upstream a small road crosses 0.8 mile from the crossing and a group of buildings can be seen 1.3 miles from the crossing. Power lines run parallel 0.15 mile from the left bank.

3.2.11.2 Preventative Measures

3.2.11.2.1 Crossing Technique

The proposed crossing method for Spring Coulee would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction of the crossing.

3.2.11.2.2 Pipeline Burial Depth and Extent

The pool-swale nature of both the East Fork Cherry Creek and Hawk Coulee channels presents ample opportunity for either channel to avulse into a new location throughout the entire floodplain. Overbank flow would occur during even moderate flows in swale sections of the channels. This overbank flow has the potential to scour locally and form a new channel. Because the entire floodplain has side channels present that have the potential to capture the channel, to provide protective measures, the pipe could be buried to a minimum of 5 feet below the channel thalweg and maintained at that elevation for 15 feet beyond the top of the floodplain on either side of the channel (approximately 995 feet in length) (Figure 3.2-11). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At East Fork Cherry Creek (MP 70.9) this plan would include placing field stakes at and 15 feet from the right and left banks defining the limits of the low floodplain where the pipeline crosses the stream (Figure 3.2-11). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed on the outer boundary of the low floodplain, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

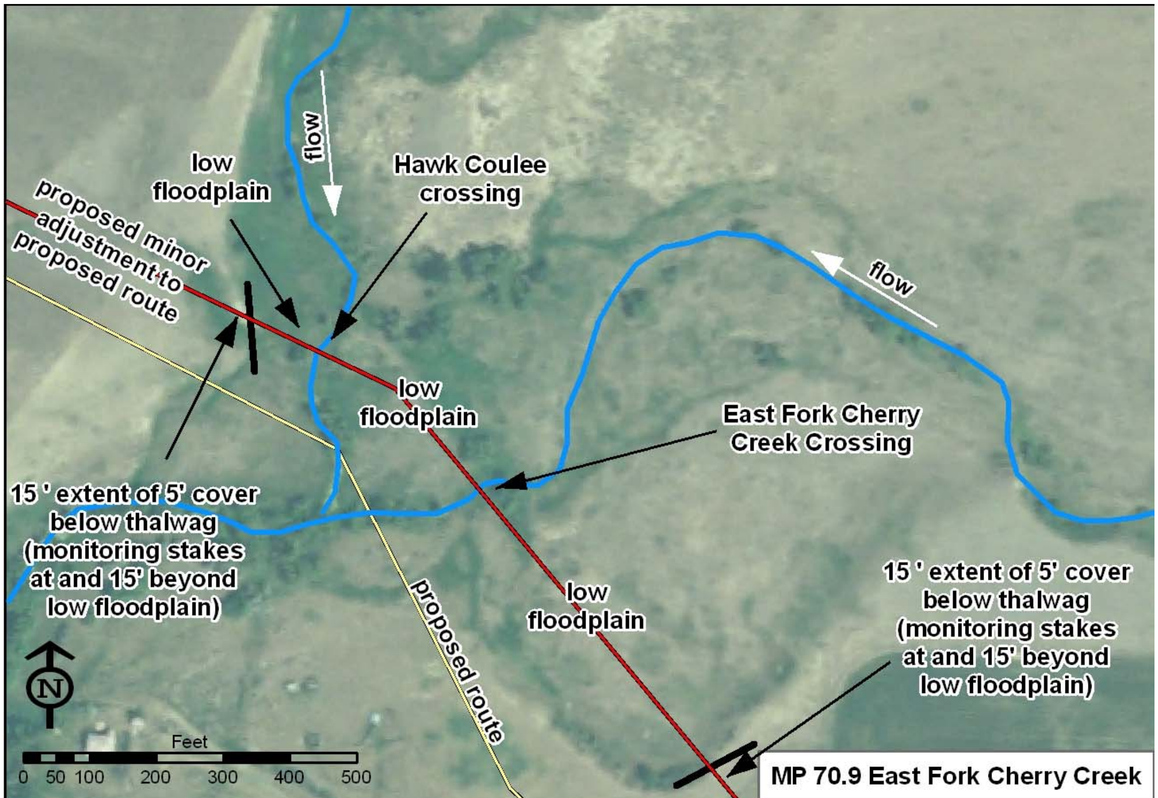

Figure 3.2.11 Burial Depth and Extent for East Fork Cherry Creek

3.2.11.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.12 Espeil Coulee (MP 77.9)

3.2.12.1 Site Characteristics

Espeil Coulee is an intermittent stream with a drainage area of 5.86 square miles at the proposed crossing. Tributaries near the crossing include unnamed creeks 0.1 and 0.8 mile upstream and 0.3 mile downstream from the crossing. Espiel Creel flows into the Milk River 2.3 miles from the crossing. The geology of the valley on both sides of the creek consists of the Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds. A relic channel was observed on aerial photographs from 2005 0.5 mile upstream of the proposed crossing. The floodplain consists of alluvium and colluvium approximately 375 feet wide at the proposed crossing and the gradient is low. The channel is highly sinuous and channel widths range from 15 to 37 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-12). No stream gauge data were available for this creek.

Table 3.2-12 Regional Regression Analysis for Espeil Coulee

Source	Drainage Area (mi²)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	5.86	2,368	37	132	238	426	613	833

Espeil Coulee at the 77.9 MP crossing is a single thread meandering pool-riffle stream confined within a 150 to 270-foot alluvial valley bottom. Pools found primarily at meander bends have ponded water with dense wetland vegetation. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present there is a low elevation floodplain adjacent to the channel thalweg. At most locations along the margins of the valley there is a high floodplain that is adjacent to the low floodplain.

The bankfull channel at the MP 77.9 crossing is approximately 40 feet wide and is 3 to 3.5 feet deep. The organic silty clay surficial alluvium of the channel thalweg is unarmored. The entire bankfull channel is densely vegetated with wetland grasses and sedges with rooting depths over 1 foot, and is well defined by a 2 to 3-foot bank on either side. At the proposed crossing the 3-foot-high, 25-degree left bank is comprised of very fine sandy silt. The slope of the 1.5 to 2-foot-high right bank is 20 degrees and is comprised of silty clay. Vegetation on both banks is dominated by wetland grasses with rooting depths of 2 feet. A single willow tree is present on the right bank.

Little to no floodplain exists on the left side of the bankfull channel as it is up against the left valley margin. There is both a low and high elevation floodplain on the right side of Espeil Coulee at the MP 77.9 crossing. The low elevation floodplain sits 2 feet above and adjacent to the bankfull channel and is approximately 80 feet wide. The alluvium on the low elevation floodplain is silty clay with a well developed 2 to 3 in organic horizon. The hummocky low floodplain is dominated by wetland grasses. A 60-foot-wide high floodplain sits 1.5 feet above the low floodplain at the base of the valley margin and is covered by grasses and sagebrush.

3.2.12.1.1 Disturbance

Infrastructure in the vicinity includes a perpendicular road 0.3 mile upstream of the crossing with a group of buildings. The unnamed tributary 0.8 miles upstream of the proposed crossing has a dam 340 feet from the confluence with Espeil Coulee.

3.2.12.2 Preventative Measures

3.2.12.2.1 Crossing Technique

The proposed crossing method for Espeil Coulee would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction of the crossing.

3.2.12.2.2 Pipeline Burial Depth and Extent

Little evidence suggests the potential for lateral migration at Espeil Coulee at the 77.9 MP crossing. The presence of deep scour pools and the hummocky right low floodplain does however suggest the potential for local scour during high flow events. To provide protective measures, the pipe be could buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the top of the right bankfull channel, and 15 feet beyond the top of the bank defining the boundary of the right low and high floodplain (approximately 150 feet in length) (Figure 3.2-12). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At the Espeil Coulee (MP 77.9) this plan would include placing a field stake at and 15 feet from the left high bank defining the bankfull channel where the pipeline crosses the stream (Figure 3.2-12). Additional field stakes would be placed 15 feet to the left and right of the right low/high floodplain boundary (Figure 3.2-12). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed at the left bankfull boundary or 15 feet to the left of the right low/high floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

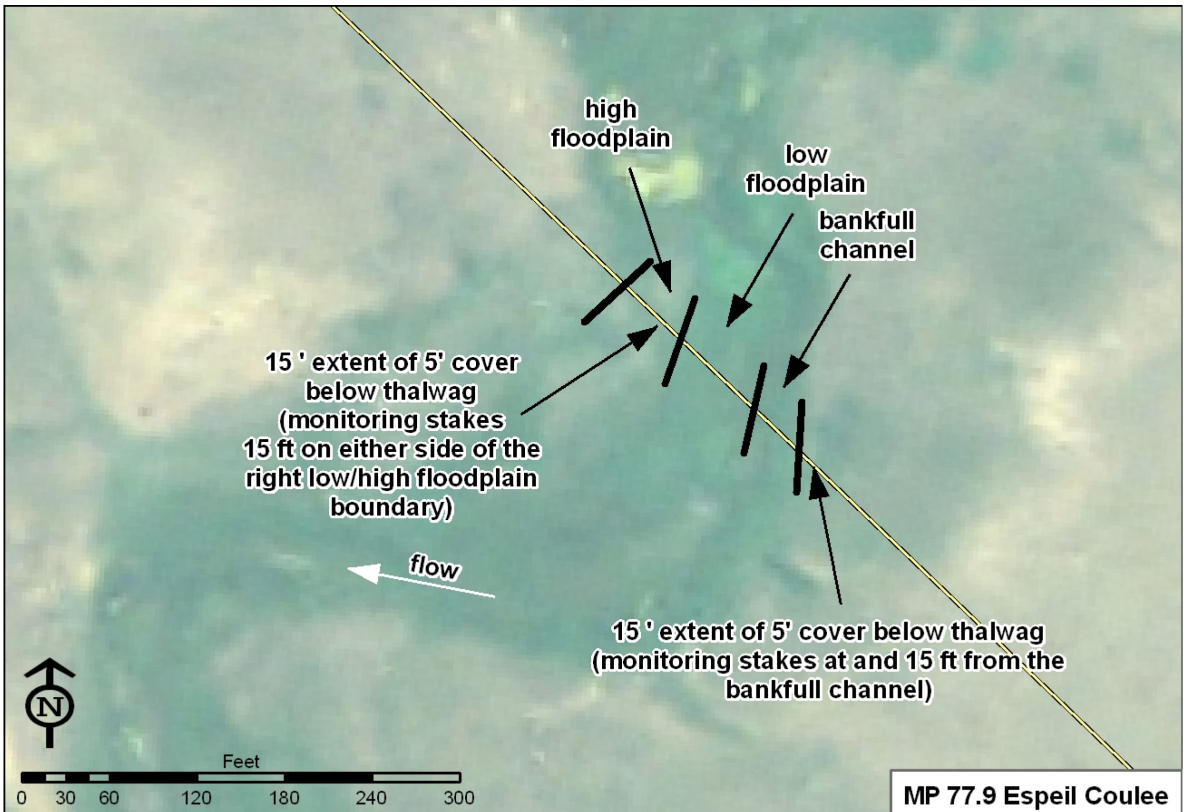

Figure 3.2-12 Burial Depth and Extent for Espeil Coulee

3.2.12.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.13 South Fork Coal Bank Creek (MP 279.2)

3.2.13.1 Site Characteristics

South Fork Coal Bank Creek is an intermittent stream with a drainage area of 13.80 square miles at the proposed crossing. It joins North Fork Coal Bank Creek 0.72 miles downstream of the crossing to form Coal Bank Creek. Tributaries near the crossing include an unnamed creek 4.1 miles upstream of the proposed crossing. The geology of the valley on both sides of the creek consists of the Ludlow member of the Fort Union Formation: shale, siltstone, silty or bentonitic claystone, sandstone and coal. Some outcrops occur upstream of the Ekalaka Member of the Fort Union Formation: fine- to medium-grained sandstone interbedded with mudstone and thin shale and coal beds. Relic channels are evident on aerial photographs 0.3 mile upstream and 0.2 mile downstream of the crossing. The floodplain consists of modern alluvium 643 feet wide at the proposed crossing and the gradient is low. The channel is highly sinuous and channel widths range from 10 to 39 feet. A regional regression analysis was conducted to estimate stream discharge at the proposed crossing for selected recurrence intervals (Table 3.2-13). No stream gauge data were available for this creek.

Table 3.2-13 Regional Regression Analysis for South Fork Coal Bank Creek

Source	Drainage Area (mi^2)	Average Elevation (ft)	Recurrence Interval (yrs / cfs)					
			2	5	10	25	50	100
Omang (1992)	13.80	3,191	78	223	375	641	875	1,181

South Fork Coal Bank Creek at the 279.2 MP crossing is a single thread meandering stream incised within a 350 to 500-foot alluvial valley bottom. The channel thalweg meanders the entire width of the alluvial valley bottom. Floodplain widths vary according to their relationship with the channel thalweg, with wider floodplains occurring on the inside bends of the stream and narrow to no floodplains on the outside bends of the stream. Where floodplains are present they are incised into the surrounding valley alluvium and adjacent to the channel thalweg. The valley alluvium forms a high terrace that is adjacent to the low elevation floodplain along the valley margins.

The proposed route crossing of South Fork Coal Bank Creek crossed the river at a location where a tributary joins the stream and a high, unstable left valley wall (Figure 3.2-13). In order to avoid crossing the tributary and the unstable, high wall; a potential route variation was recommended by Entrix. The potential route variation places the route approximately 1300 feet downstream (east) from the proposed route (Figure 3.2-13). The field assessment for South Fork Coal Bank Creek was performed at the potential route variation location.

The bankfull channel at the proposed adjusted crossing location is approximately 15 feet wide and is 2.5 feet deep. The fine to coarse sandy surficial alluvium of the channel thalweg is unarmored. The unvegetated channel width is 13 feet with well defined 1.5 to 2-foot banks on either side. At the proposed adjusted crossing location the 1.5-foot-high, 70 to 90-degree left bank is comprised of very fine sand with minor slumping. The slope of the 1.5 to 2-foot-high right bank is 60 to 90 degrees and is composed of very fine sand with minor slumping. Both banks are completely vegetated with grasses with rooting depths of 1 to 2 feet.

The low floodplains on either side of the bankfull channel are densely vegetated with grasses and a few scattered sagebrush. There is a poorly developed very fine sandy soil on both low floodplains. The low floodplain on the left of the bankfull channel is 15 to 30 feet wide and the right low floodplain is 50 feet wide. A high floodplain sits 10 to 12 feet above the low floodplain on either side of the channel at the proposed adjusted crossing location. The high floodplains support a grassy sagebrush upland community with few indicators of overbank flow.

3.2.13.1.1 Disturbance

Infrastructure in the vicinity includes dams upstream at 1.5 miles and 1.9 miles. The latter is associated with a group of buildings and a 480 foot wide pond. A road crosses the creek with a culver 0.57 mile upstream of the proposed crossing. A small road crosses upstream of the crossing at 0.4 mile.

3.2.13.2 Preventative Measures

3.2.13.2.1 Crossing Technique

The proposed crossing method for South Fork Coal Bank would be an open cut. The crossing method will be determined at the time of construction based on site-specific conditions to ensure a successful crossing. To the extent possible the crossing should be constructed while the stream is dry to reduce the potential for turbid water release during construction of the crossing.

3.2.13.2.2 Pipeline Burial Depth and Extent

The presence of bank slumping on both banks along the bankfull margin does suggest the potential for local scour during high flow. To provide protective measures, the pipe could be buried to a minimum 5 feet below the channel thalweg, and maintained at that elevation 15 feet beyond the top of the bank defining the boundary of the low and high floodplain on either side of the channel (approximately 140 feet in length) (Figure 3.2-13). In addition, an adaptive management plan could be used to monitor changes in the channel and implement preventative protective measures if erosion were to occur after construction is complete. At South Fork Coal Bank Creek (MP 279.2) this plan would include placing field stakes 15 feet on either side of the right and left low/high floodplain boundary where the pipeline crosses the stream (Figure 3.2-13). During routine field inspections the location of the channel relative to the stakes should be documented. If the channel were to migrate beyond either stake placed 15 feet within the low/high floodplain boundary, preventative protection measures would be put in place to prevent further lateral migration. A list and descriptions of preventative protection measures are provided in Section 4.

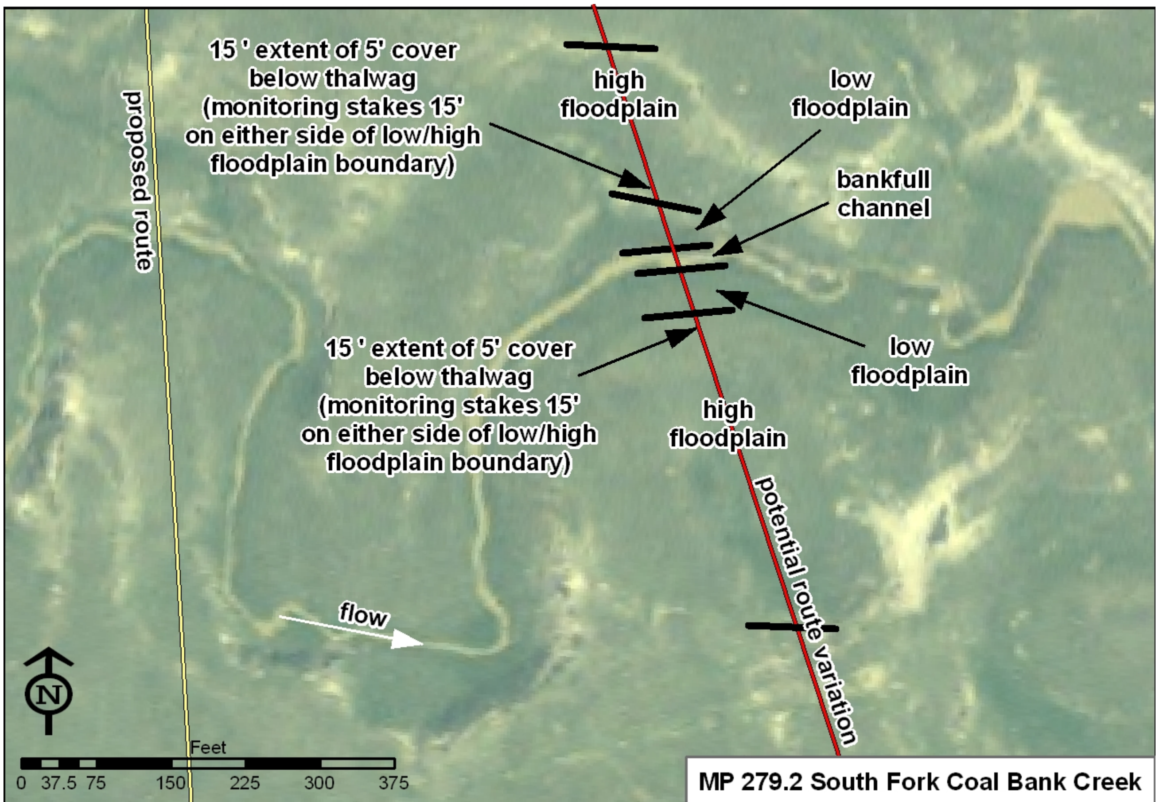

Figure 3.2-13 Burial Depth and Extent for South Fork Coal Bank Creek

3.2.13.2.3 Site Reclamation

Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded and/or planted with native vegetation. Native vegetation present prior to and removed during construction should be re-established. If stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

3.2.14 Additional Intermittent Streams

Office analyses were also conducted for the 19 intermittent streams that did not receive field inspections. These evaluations are based on the 2005 aerial photographs, geological maps and topographic maps. Since they were not verified in the field, they are subject to more interpretation, particularly where the resolution of the photos and maps does not support clear views of small features. A summary of these analyses and of those intermittent creeks that did not show erosion potential is presented in Table 3.2.14.

The proposed crossing method for these streams is the non-flowing open cut crossing. Constructing the crossing during dry conditions is preferable; however, if water is present at the time of construction, an alternative approach to this could be use of the dry flume method. Since there is no evidence of previous movement of the channel laterally or vertically at these crossings, it would be protective to bury the pipe to a minimum 5 feet below the channel thalweg and maintained at that elevation for 15 feet beyond the top of the bankfull banks on either side of the stream. Restoration of the stream bed, banks, and adjacent floodplains should include re-establishment of the pre-construction contours. Surficial alluvium should be separated during trenching as needed to assist in re-establishment of textural differences between the stream bed, banks, and floodplain. Immediately following re-contouring the crossing should be seeded with native vegetation. Where stream banks are excessively steep and unstable, bio-stabilization measures should be implemented.

Some of these creeks appear to have channel spanning instream structures upstream of the proposed crossings. Such structures would pose a potential risk to the pipeline. Failure of such a structure could result in a flood wave with high scour potential that could expose and damage the pipe. An investigation into the structural integrity and maintenance requirements of both upstream and downstream structures present on the stream to assess the stability and potential failure during the lifetime of the project is beyond the scope of this analysis.

Table 3.2-14 Additional Intermittent Stream Crossings

Site Name	MP	Drainage Area (mi^2)	Valley Width (ft)	Channel Width (ft)	Channel Form	Instream Structures and Distance From Crossing	Landslides
Hay Coulee	38	1.68	331	17	Single	Bud Reservoir 0.34 mi upstream; stock ponds 0.97 mi upstream and 0.45 mi downstream. Small road crosses 0.86 mi downstream.	None. Listed as high risk by PHMSA NPMS Landslide Hazard Map.
Stock Pond	69.2	0.93	363	17	Single	The earthen dam that forms pond is 800 ft downstream from crossing.	None
Shade Creek	110.4	8.99	668	8	Single	Goose Island Reservoir 0.1 mi up tributary that is 1 mi upstream; Teds Reservoir 0.5 mi up tributary that is 1.7 mi upstream; stock pond 0.2 mi up tributary that joins 0.3 mi downstream.	Landslide deposits mapped in hills 1 mi from right bank (0.4 mi from pipeline).
Shade Creek	110.5	8.99	668	8	Single	Goose Island Reservoir 0.1 mi up tributary that is 1 mi upstream; Teds Reservoir 0.5 mi up tributary that is 1.7 mi upstream; stock pond 0.2 mi up tributary that joins 0.3 mi downstream.	Landslide deposits mapped in hills 1 mi from right bank (0.4 mi from pipeline).
Shade Creek	110.5	8.99	668	8	Single	Goose Island Reservoir 0.1 mi up tributary that is 1 mi upstream; Teds Reservoir 0.5 mi up tributary that is 1.7 mi upstream; stock pond 0.2 mi up tributary that joins 0.3 mi downstream.	Landslide deposits mapped in hills 1 mi from right bank (0.4 mi from pipeline).
South Fork Shade Creek	114.2	4.66	581	11	Single	Stock ponds 0.1 mi and 1 mi up tributary that joins 0.1 mi downstream; stock pond 0.1 mi up tributary that joins 0.95 mi downstream. Small road crosses 0.38 mi upstream.	Upstream 0.2 and 0.4 mi on right, downstream 1.1 mi on left, several landslide deposits mapped 2 to 3 mi to the west.
Flying V Creek	118.6	7.21	864	14	Single	Stock ponds upstream at 0.2 mi, 1.4 mi, 2.3 mi, 2.8 mi and downstream at 2.3 mi. Stock ponds 0.35 mi up tributary that joins at 0.2 mi upstream and 1.8 mi up tributary that joins at 0.7 mi upstream. Small roads cross at 0.8 mi upstream and 1.7 mi downstream.	None
Figure Eight Creek	122.3	19.63	476	10	Single	Stock pond 0.2 mi downstream. Stock ponds 0.8 mi up tributary that joins 0.4 mi upstream, 0.3 mi up tributary that joins 1.7 mi upstream. Stock ponds 1.2 mi and 0.33 mi up tributary that joins 0.14 mi downstream. Road with bridge or culvert crosses at 0.3 mi downstream and small road crosses 1.5 mi upstream.	1.9 mi upstream on river right.
Lone Tree Creek	146.2	8.51	731	20	Single	Stock pond 0.9 mi upstream; stock ponds 0.3 mi and 0.75 mi up tributary that joins at 1.85 mi upstream. Road crossings with culvert at 700 ft and 2.7 mi upstream; small road crossing at 1.79 mi upstream.	None
Buffalo Springs Creek	147.5	18.82	285	10	Single	Roads cross at 0.58 mi downstream with culvert and 1.65 mi upstream.*	None
Buffalo Springs Creek	153.2	0.01	457	8	Single	Small road crosses 420 ft.*	None
Cottonwood Creek	156.7	5.02	349	9	Single	Stock pond 0.1 mi up tributary that joins at 0.4 mi upstream. Road crossings at 0.8 mi upstream and 0.2 mi downstream with a culvert.	1.5 mi upstream on river left.
Hay Creek	163.1	4.04	326	11	Single	Stock pond 725 ft up a tributary that joins 0.4 mi downstream.	None

Upper Seven Mile Creek	166.2	6.16	248	9	Single	Stock pond 0.15 mi up a tributary that joins at 0.48 mi downstream. Roads cross at 0.4 mi and 1.46 mi upstream.	0.79 mi downstream on river right.
West Fork Hay Creek	208	8.62	546	10	Single	Road crossing 1.2 mi downstream.	None
Hay Creek	209.1	6.57	486	9	Single	Buckley Dam 1.22 mi upstream.	None
Sandstone Creek	244.3	53.3	695	14	Single	Stock pond on floodplain 0.77 mi upstream, 3 sewage disposal ponds 1.3 mi upstream, Lake Baker and town of Baker 2.75 mi upstream. Stock pond 0.1 mi up tributary that joins 1 mi downstream and 0.36 up tributary 0.36 mi downstream. Railroad and road cross with bridge 2.27 mi upstream.	None
Red Butte Creek	246.2	16.06	858	11	Single	Red Butte Dam 1.1 mi downstream. Stock pond 0.5 mi up tributary at 0.3 mi upstream. Road crosses with bridge 0.96 mi upstream.	None
Hidden Water Creek	258.4	25.25	446	16	Single	Stock ponds 0.24 mi up tributary that joins at 1.37 mi upstream and 0.67 mi up tributary at 0.6 mi downstream. Road crossing 1 mi downstream, small road crosses 0.97 mi upstream.	1.1 mi upstream on river left.
Soda Creek	272.1	1.16	167	9	Single	Stock ponds 1.5 mi upstream and on tributaries that join at 0.63 and 1.15 mi upstream. Stock ponds 0.45 and 0.55 mi up tributary that joins 100 ft downstream (Soda Creek MP 272.2 crossing is on this branch).	None
Soda Creek	272.2	1.76	174	10	Single	Stock ponds at 0.45 and 0.55 mi upstream. Stock ponds 1.5 mi up main branch Soda Creek and on other tributaries upstream.	None
North Fork Coal Bank Creek	276.1	8.97	1005	11	Single	Stock ponds on tributaries that join at 0.17 mi, 1 mi and 2.1 mi upstream and 0.34 mi downstream. Road crosses with culvert 2.7 mi upstream and small road crosses 235 ft downstream.	None

* A field assessment was conducted downstream at the perennial crossing of Buffalo Springs Creek at MP

SECTION 4

Summary Considerations

The following is a list of considerations related to the construction and reclamation procedures associated with waterbody crossings. Table 4.0-1 provides a summary of ENTRIX suggestions for the waterbody crossings that received a field site assessment. Specific suggestions are provided for stream crossings where a field assessment was conducted in Sections 3.1 and 3.2 of this report. The following summary considerations apply to waterbody crossings where a field assessment was not conducted. Extension of the minimum cover and extents, and implementation of an adaptive management plan reflect the importance of protecting the integrity of the pipeline from exposure as a result of stream scour and/or lateral migration during the expected lifespan of the project. Additional site reclamation suggestions are directly tied to both minimizing the environmental impact of constructing the crossing as well as minimizing channel instability post-construction.

4.1 MINIMUM COVER AND EXTENTS

As stated in the Keystone XL CMRP (Keystone 2008) "The pipeline shall be installed so that the top of the pipe and coating is a minimum depth of 5 feet below the bottom of waterbodies including rivers, creeks, streams, ditches, and drains. This depth shall normally be maintained over a distance of 15 feet on each side of the waterbody measured from the top of the defined stream channel" (Figure 4.1-1). Observations during the field assessments provide sufficient evidence that these measures are generally sufficient at stable channel crossings. However at crossings with indicators of instability, changes in both cover depth and the length of pipeline requiring additional cover depth may be necessary.

The location within the channel that is used to determine bottom of the waterbody should reflect the local minimum. The local minimum channel elevation should be taken at the deepest part of the channel within one-half meander wavelength, or 20 channel widths, from the proposed crossing. These minimums would likely occur at the bottom of scour pools located at bends in the river or adjacent to structures or debris in the channel (Figure 4.1-2). The local minimum channel elevation should be used as the elevation to which a minimum of 5 feet of cover is maintained over the top of the pipe at the crossing.

Table 4.0-1 Summary of Proposed Crossing Specifications and ENTRIX Suggestions for Field Assessment Crossings

Waterbody	Approx. mile post	Intermittent / Perennial	Keystone proposed crossing method	crossing method	Route adjustment suggested	Keystone proposed minimum cover and length of minimum cover		minimum cover and length of minimum cover	
						Minimum cover below thalweg	Total length of minimum cover	Minimum cover below thalweg	Total length of minimum cover
Corral Coulee	20.8	Intermittent	non-flowing open cut	non-flowing open cut	No	5	70	5	205
Corral Coulee	21.5	Intermittent	non-flowing open cut	non-flowing open cut	No	5	70	5	200
Frenchman Creek	25.8	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	90	5	140
Hay Coulee	38.0	Intermittent	non-flowing open cut	non-flowing open cut	No	5	72	5	72
Rock Creek	39.2	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	145	5	195
Willow Creek	40.4	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	85	5	135
Lime Creek	44.9	Intermittent	non-flowing open cut	non-flowing open cut	Yes	5	60	5	60
Brush Fork	51.1	Intermittent	non-flowing open cut	non-flowing open cut	No	5	50	5	130
Bear Creek	52.3	Intermittent	non-flowing open cut	non-flowing open cut	No	5	55	6	200
Unger Coulee	53.3	Intermittent	non-flowing open cut	non-flowing open cut	No	5	37	5	130

Buggy Creek	55.3	Intermittent	non-flowing open cut	non-flowing open cut	No	5	105	9	365
Spring Creek	59.8	Intermittent	non-flowing open cut	non-flowing open cut	No	5	48	5	220
Cherry Creek	66.9	Intermittent	non-flowing open cut	non-flowing open cut	Yes	5	80	5	80
Spring Coulee	70.4	Intermittent	non-flowing open cut	non-flowing open cut	Yes	5	90	5	380
East Fork Cherry Creek	70.9	Intermittent	non-flowing open cut	non-flowing open cut	No (route adjusted prior to field assessment)	5	50	5	995
Espeil Coulee	77.9	Intermittent	non-flowing open cut	non-flowing open cut	No	5	70	5	150
Milk River	82.7	Perennial	HDD	HDD	No	30	400	30	400
Missouri River	89.0	Perennial	HDD	HDD	No	30	400	30	400
West Fork Lost Creek	93.8	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	45	5	45
Tributary to West Fork Lost Creek	94.6	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	70	5	95
East Fork Prairie Elk Creek	127.6	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	Yes	5	120	5	170
Redwater River	146.6	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	115	5	175

Buffalo Springs Creek	150	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No (route adjusted prior to field assessment)	5	80	5	270
Berry Creek	159.2	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	50	5	110
Clear Creek	175.2	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	110	5*	110
Side Channel Yellowstone River	195.7	Perennial	HDD	HDD	No	30	250	30	250
Yellowstone River	196	Perennial	HDD	HDD	No	30	800	30	800
Cabin Creek**	201.4	Perennial	NA	NA	No (route adjusted prior to field assessment)	NA	NA	NA	NA
Cabin Creek***	202.0	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No (route adjusted prior to field assessment)	5	49	5	150
Dry Fork Creek****	226.9	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	180	5	350
Pennel Creek****	234.5	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	120	5	180

Little Beaver Creek	262.4	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	60	5	245
North Fork Coal Bank Creek	276.1	Intermittent	non-flowing open cut	non-flowing open cut	No	5	75	5	75
South Fork Coal Bank Creek	279.2	Intermittent	non-flowing open cut	non-flowing open cut	Yes	5	45	5	140
Boxelder Creek	281.4	Perennial	Flowing – open cut Dry Flume Dam & Pump	Dry Flume Dam & Pump	No	5	180	5	290

* At Clear Creek (MP 175.2) the minimum depth of cover under the thalweg should be increased significantly if channel dredging continues after construction of the pipeline.
** The Cabin Creek (MP 201.4) crossing was replaced by a crossing on Spring Creek, see Cabin Creek (MP 202.0) for reference site to spring Creek
*** The Cabin Creek (MP 202.0) crossing is presented as a reference site for Spring Creek
**** Due to landowner access denial, field assessments for this crossing were performed at an alternate location with similar characteristics

At crossings where side channels are not present, to provide protective measures, the pipe should be buried to a minimum of 5 feet below the elevation of the local minimum and maintained at that elevation over a distance of 40 feet from either side of the bankfull channel (Figure 4.1-1B). This measure increases the distance over which the pipe would have additional cover, and provides room for the river or stream to migrate over time without threatening the integrity of the pipeline. In addition, the 40-foot buffer from the bankfull channel is needed to provide ample workspace for preventative protection measures to be constructed in the dry and out of the channel. If the channel were to migrate laterally during the expected lifetime of the project the channel bottom would remain at its current elevation or lower. Maintenance of 5ft of cover from the surface of the floodplain adjacent to the bankfull channel is likely to be insufficient if the channel were to migrate laterally.

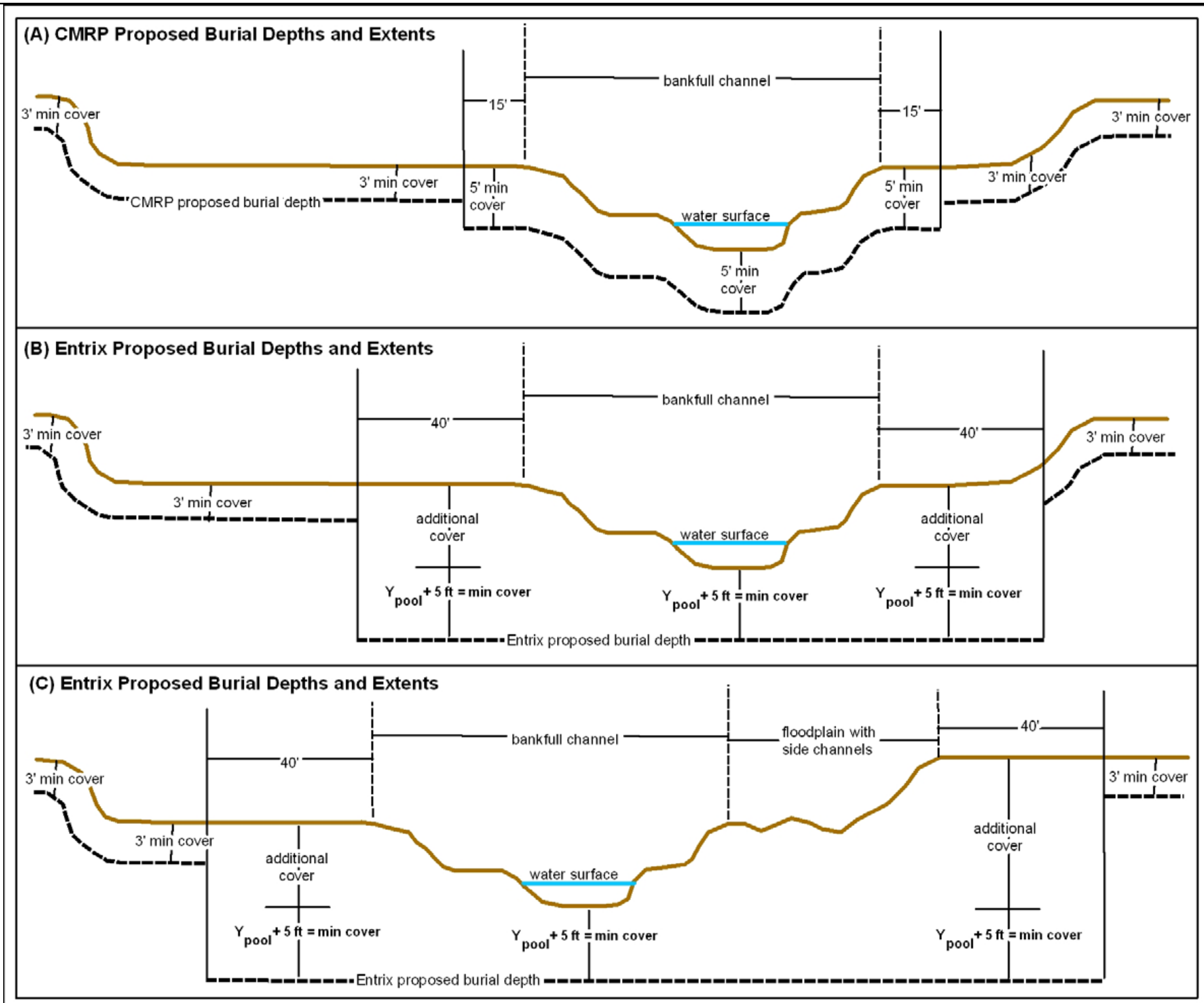

Figure 4.1-1 Comparison between CMRP (A) and ENTRIX Proposed Minimum Burial Depths and Extents (B and C)

At several locations where a field assessment was conducted side channels were observed within the floodplains adjacent to the bankfull channel. The presence of side channels in a floodplain indicates channelization of floodwater over the floodplain, which can lead to incision and/or avulsion of the main channel. Side channels are typically less stable than the main channel during floods and have the potential to scour, migrate, and propagate. To provide protective measures the pipe should be buried to a minimum of 5 feet below the elevation of the local minimum and maintained at that elevation over the entire distance of any floodplain where side channels are present (Figure 4.1-1C).

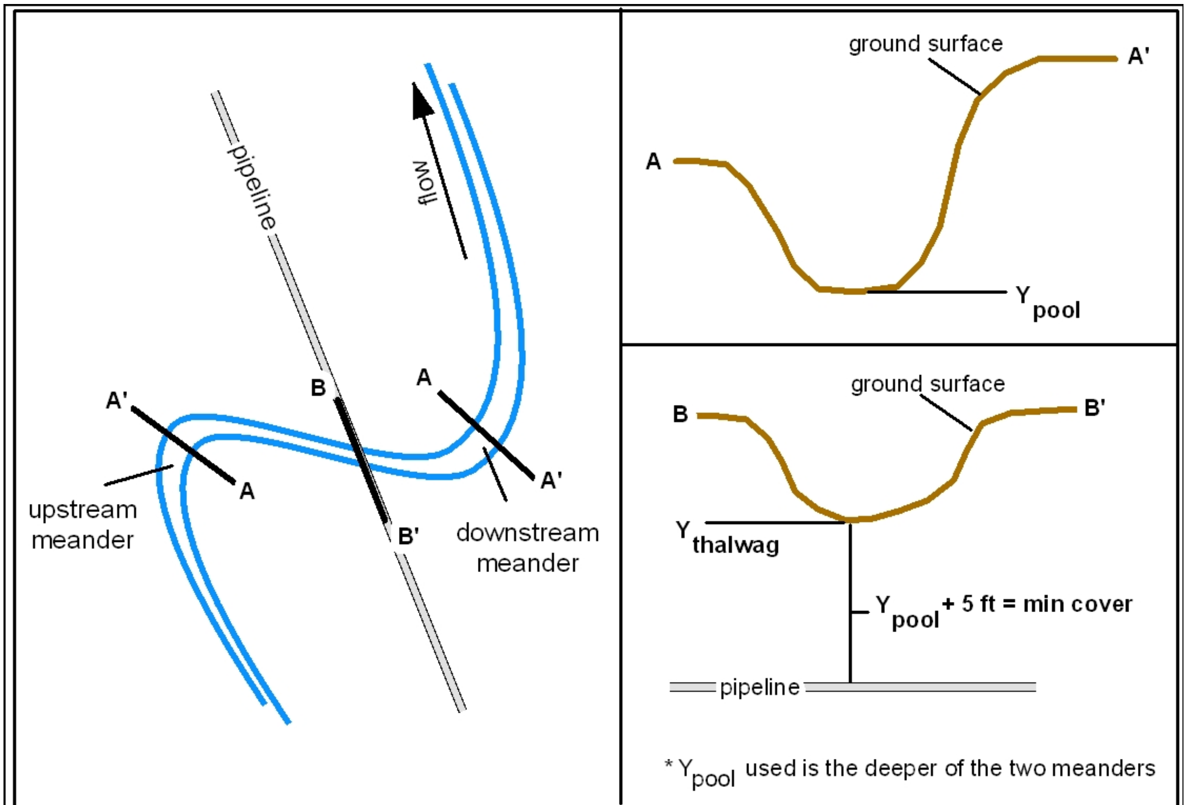

Figure 4.1-2 Location of the Local Minimum Depth Relative to the Crossing

A flow diagram depicting how preventative measures are chosen for each waterbody crossing and inclusion into the adaptive management plan is provided in Figure 4.1-3.

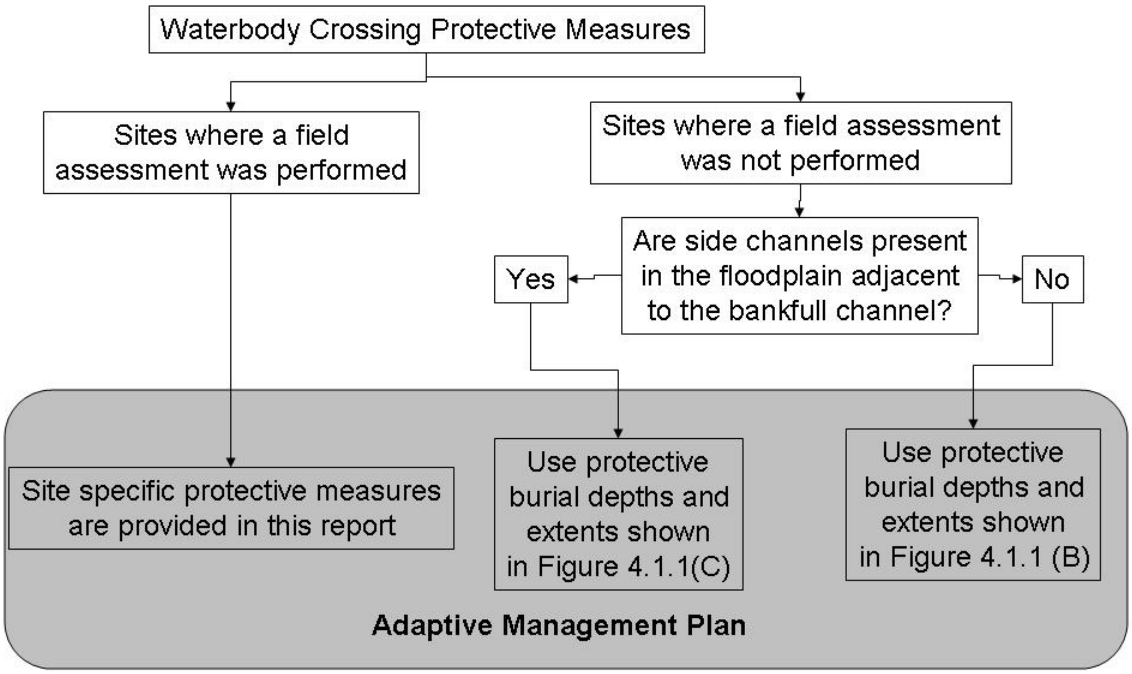

Figure 4.1-3 Decision Flow Chart Depicting Selection of ENTRIX PREVENTATIVE MEASURES

The presence of channel spanning instream structures either up or downstream of any proposed crossing pose a potential risk to the pipeline. Failure of the upstream structure could result in a flood wave with high scour potential that could expose and damage the pipe. Failure of the downstream structure could result in a rapid decrease in the channel bed elevation that would quickly migrate upstream and could potentially expose and damage the pipeline. An investigation into the structural integrity and maintenance requirements of existing instream structures that could affect pipeline stability may be advisable.

4.2 SITE RECLAMATION

An overview of the proposed site reclamation measures outlined in the CMRP are provided in Section 1.4 of this report. The following BMPs would provide additional measures to reduce turbidity during construction and channel instability following construction:

- Install temporary erosion and sediment control BMPs prior to initial disturbance;
- Install temporary erosion and sediment control BMPs at all crossings;
- Spoil removed from the streambed should be placed in separate piles, one pile with channel spoil and one pile with floodplain spoil;
- Channel spoil should be used to backfill the channel and floodplain spoil used to backfill the floodplain to the extent possible. The top of backfill in the stream and floodplains should be

the same material as was present prior to trenching. If not possible, the top of backfill should be imported to match the existing condition of the stream and floodplain prior to trenching.

- The use of rock riprap should be avoided; and
- Streambank stabilization should be performed using bio-stabilization measures.

4.3 ADAPTIVE MANAGEMENT PLAN

Stream crossing locations with indicators of instability and the potential for lateral migration or avulsion are of particular concern to maintaining the integrity of the pipe over the life span of the project. Indicators of instability include actively eroding banks which typically exhibit slumping, vertical to near vertical slopes, and/or undercutting. These indicators of instability highlight the potential for lateral migration that could pose an exposure risk to the pipe. High and low-flow side channels found on floodplains adjacent to the bankfull channel have the potential to locally scour and migrate as well as the potential to capture the flow of the main channel, leading to a relocation (avulsion) of the main channel. An avulsion of the main channel into a location where the minimum depth of cover was not sufficient to maintain cover over the pipeline would pose an immediate risk to the integrity of the pipe.

The minimum burial depths and extents proposed herein are intended to provide room for the stream or river channel to migrate and/or scour without threatening the pipeline, and to ensure sufficient workspace for placement of preventative protection measures to mitigate further migration and/or scour. Recognizing that the threat to the pipeline from rivers and streams does not end after construction of a crossing is complete, implementation of an adaptive management plan at all stream crossings would provide an additional protective measure. The plan provides a systematic method of monitoring the stability of stream crossings during operations to ensure streams are not threatening the integrity of the pipe over the lifespan of the project. Additionally, the adaptive management plan ensures preventative protection measures are implemented before an immediate risk to the pipeline is encountered. In order to monitor waterbody crossings, permanent monitoring stakes should be placed on either side of the channel at the outer extent of maximum burial depth under the waterbody. An additional permanent monitoring stake should be placed 40 feet inside the outer monitoring stakes on either side of the channel (Figure 4.3-1).

The adaptive management plan includes routine monitoring of each stream crossing. During routine monitoring, a brief assessment of the stability of each crossing would be conducted. This brief assessment would include observing the channel bed and banks for indicators of instability, features such as scour pools, slumping, vertical to near vertical slopes, and/or undercutting. Additional documentation of the presence of side channels on the floodplain adjacent to the bankfull channel should be included in the assessment. If none of these features are present at the time of the assessment, the channel is currently stable and no further action is required. If indicators of instability or side channels are present during the assessment, the distance between the two monitoring stakes on the left side of the channel, and the distance between the two monitoring stakes on the right side of the channel should be recorded (Figure 4.3-1). If the distance between the monitoring stakes is greater than or equal to 30 feet no further action is required. If the distance between the monitoring stakes is less than 30 feet, preventative protection measures need to be implemented to mitigate further migration. Additionally, the elevation difference between the inside left and right monitoring stakes relative to the thalweg of the channel should be recorded to monitor scour. If the elevation difference reaches greater than 1 foot from the post-construction difference, preventative protection measures should be implemented to mitigate further incision. At some crossings where a field site assessment was conducted the recommended maximum burial depth under the waterbody is less than 30 feet. If the distance between the monitoring stakes on either side of the channel decreases at all preventative protection measures should be implemented immediately.

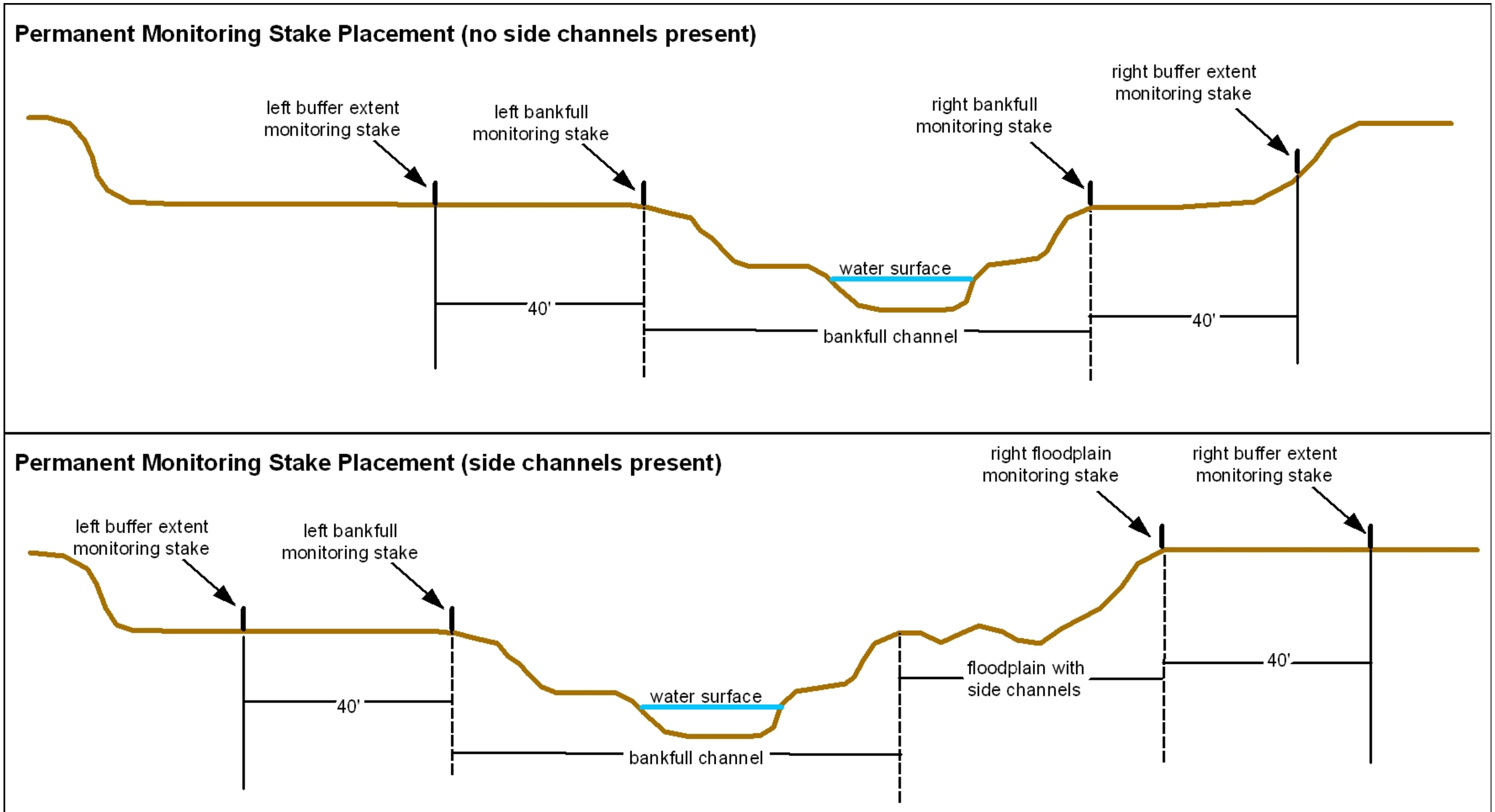

Figure 4.3-1 Locations of Monitoring Stakes Relative to the Channel Features

4.3.1 Preventative Protection Measures

If during routine inspections the distance of the channel relative to established monitoring stakes decreases to less than or equal to 30 feet, then preventative protection measures should be implemented. Likewise, if the channel thalweg is observed to have scoured more than 1 foot, preventative protection measures should be implemented. Implementation of preventative protection measures includes a detailed site-specific assessment of the mechanisms driving channel instability at the crossing, design of protective measures to prevent or mitigate further instability of the channel at the crossing, and installation of protective measures.

Selection of preventative protection measures should be driven by the site-specific assessment of the mechanisms contributing to channel instability. Given the mechanism of instability, preventative protection measures may need to be located either on the pipeline route or up or downstream. If sufficient workspace is available between the channel margin and the outer extent of the maximum burial depth under the waterbody, preventative protection measures should be constructed in the floodplain adjacent to the channel (Figure 4.3-2). As the channel continues to migrate it would engage the structure and be prevented from further migration. Construction in the floodplain and out of the channel helps to streamline permitting requirements. Additionally, installation of structures into the floodplain and allowing the channel to engage them prevents the need for emergency actions later. Example preventative protection measures suitable for this type of application would include, but are not limited to spur dikes, engineered wood structures,[1] longitudinal stone toe, longitudinal stone toe with spurs, trench fill revetment, vegetated gabion basket, or soil and grass covered riprap (ISPG 2003, NCHRP 2005) (Table 4.3.1). If insufficient workspace is available for placement of preventative protection measures in the floodplain, instream applications to mitigate channel migration or scour are needed (Figure 4.3.1). Example preventative protection measures suitable for instream application would include but not limited to spur dikes, vanes, bendway weirs, engineered wood structures,[1] longitudinal stone toe, longitudinal stone toe with spurs, vegetated gabion basket, live cribwalls, or soil and grass covered riprap (ISPG 2003, NCHRP 2005) (Table 4.3-1). Special consideration should be taken to emulate native conditions adventitious to fish and wildlife; this will streamline project permitting and minimize the need for mitigation.

[1] dependent on wood material longevity and local riparian conditions

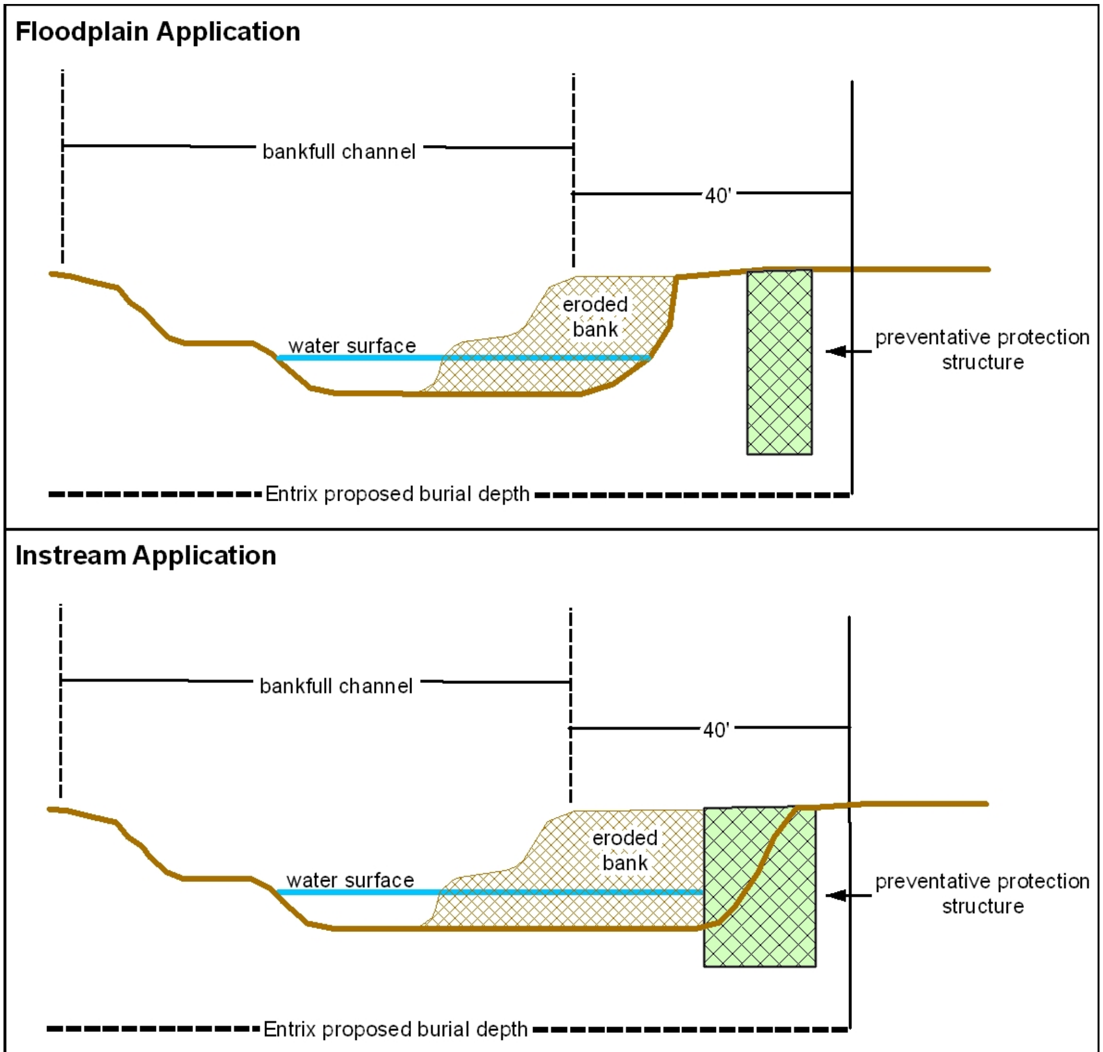

Figure 4.3-2 Application of Preventative Protection Measures

Table 4.3-1 Example of Preventative Protection Measures

Structure	Floodplain application	Instream application
Spur dikes	X	X
Engineered wood structures[1]	X	X
Longitudinal stone toe	X	X
Longitudinal stone toe with spurs	X	X
Trench fill revetment	X	
Vegetated gabion basket	X	X
Soil and grass covered riprap	X	X
Vanes		X
Bendway weirs		X
Live cribwalls		X

4.4 ALTERNATE CROSSING METHODS

To identify alternative stream crossing methods not listed in TransCanada's CMRP, a literature review was completed drawing from several different published sources. This review included any alternative: stream crossing methods, pipeline route strategies and additional construction methodology needed to reduce the risk of pipeline rupture and negative effects on aquatic habitat. The literature review search included several engineering, water resources and environmental databases with the best available science of pipeline stream crossing methods, including Compendex, Web of Science, and Water Resources abstracts. State and federal manuals were also reviewed to identify any protective stream crossing methods. No additional crossing techniques beyond those described in the CMRP were found.

SECTION 5

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APPENDIX A

Field Data Forms

APPENDIX B

Office Data Forms

APPENDIX C

Horizontal Directional Drill Plan Sets