Hunter Creek Preliminary HDD Feasibility Assessment Report

08C7138-PL-RPT-0004, Rev. 3

08-Jun-2010

Enbridge Northern Gateway Project

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ENBRIDGE NORTHERN GATEWAY PROJECT – HUNTER CREEK PRELIMINARY HDD FEASIBILITY ASSESSMENT REPORT

REV	DESCRIPTION	ORIGINATOR	REVIEWER	WORLEYPARSONS APPROVAL	DATE (dd-Mmm-yyyy)
3	Issued for Implementation	Jim Murphy	Clive MacKay	Louis McIver	08-Jun-2010

EXECUTIVE SUMMARY

This *Hunter Creek Preliminary HDD Feasibility Assessment Report* (this report) was prepared by WorleyParsons Canada Services Ltd. (WorleyParsons) for Northern Gateway Pipelines Inc. (Northern Gateway) in support of a regulatory application for approval to construct and operate the Enbridge Northern Gateway Project (the Project).

This report discusses the feasibility of using a horizontal directional drilling (HDD) construction technique to cross the Hunter Creek. Based on a review of the available geological and / or geotechnical information, site visits, site photos and ground profiles, an HDD technique appears to be a feasible crossing method. This crossing will require a detailed survey and geotechnical investigations during detailed engineering to further assess the feasibility of an HDD and to prepare the detailed designs. The contingency plan is to cross the Hunter Creek using an isolated crossing method during the winter season.

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1. INTRODUCTION

This *Hunter Creek Preliminary HDD Feasibility Assessment Report* (this report) was prepared by WorleyParsons Canada Services Ltd. (WorleyParsons) for Northern Gateway Pipelines Inc. (Northern Gateway) under the Enbridge Northern Gateway Project (the Project).

The pipelines will cross approximately 773 identified watercourses having defined bed and banks. An initial screening process identified 83 of these crossings requiring more detailed review to determine the preferred crossing method. Currently, the horizontal directional drilling (HDD) method is the preferred crossing method for the Hunter Creek.

This report has been prepared to comply with the National Energy Board (NEB) filing requirements regarding proposed HDD crossings, specifically to provide a preliminary feasibility report detailing the assessment that was done to determine that HDD could be successfully completed and a description of the contingency plan to be used if the HDD is not successful.

1.1 Purpose

This report discusses the feasibility of using a HDD trenchless construction technique to cross the Hunter Creek. Based on a review of existing geological and / or geotechnical information where available, site visits, site photos and ground profiles, an HDD technique appears to be a feasible crossing method. This crossing will require a detailed survey and geotechnical investigations to further assess the feasibility of an HDD and to prepare the detailed designs.

The location of the crossing with respect to the pipeline alignment is shown in Table 1.

Table 1: Hunter Creek Crossing Location

Crossing	Site No.	KP (Rev. R)	Province
Hunter Creek	3197	1,098.7	BC

1.2 Project Description

Northern Gateway Pipelines Inc. (Northern Gateway), a subsidiary of Enbridge Pipelines Inc., initiated the regulatory phase of the Enbridge Northern Gateway Project (the Project) to obtain regulatory approvals for the Project. The Project is being developed to provide pipelines and associated facilities for the transportation of approximately 83,400 m^3/d (525,000 bbl/d) of oil from Bruderheim, Alberta to Kitimat, British Columbia and the transportation of approximately 30,700 m^3/d (193,000 bbl/d) of condensate from Kitimat to Bruderheim.

The Project includes the following major components:

- an oil pipeline, 914 mm OD (NPS 36), approximately 1172 km long extending from the outlet of the Bruderheim station to the Kitimat Terminal
- a condensate pipeline, 508 mm OD (NPS 20), approximately 1172 km long, located in the same right-of-way as the oil pipeline, extending from the Kitimat Terminal to the Bruderheim Station
- the Bruderheim Station, consisting of the oil initiating pump station and the condensate receiving facilities
- eight intermediate pump stations located at intervals along the pipelines
- two tunnels, approximately 6.5 km and 6.6 km long, to route the oil and condensate pipelines between the Clore River and Hoult Creek valleys
- the Kitimat Terminal which will comprise the following:
    - a tank terminal including oil tanks, condensate tanks and associated infrastructure
    - a marine terminal including two tanker berths and one utility berth
    - an initiating condensate pump station
    - oil receiving facilities

For an overview map showing the locations of these project facilities, see Figure 1.

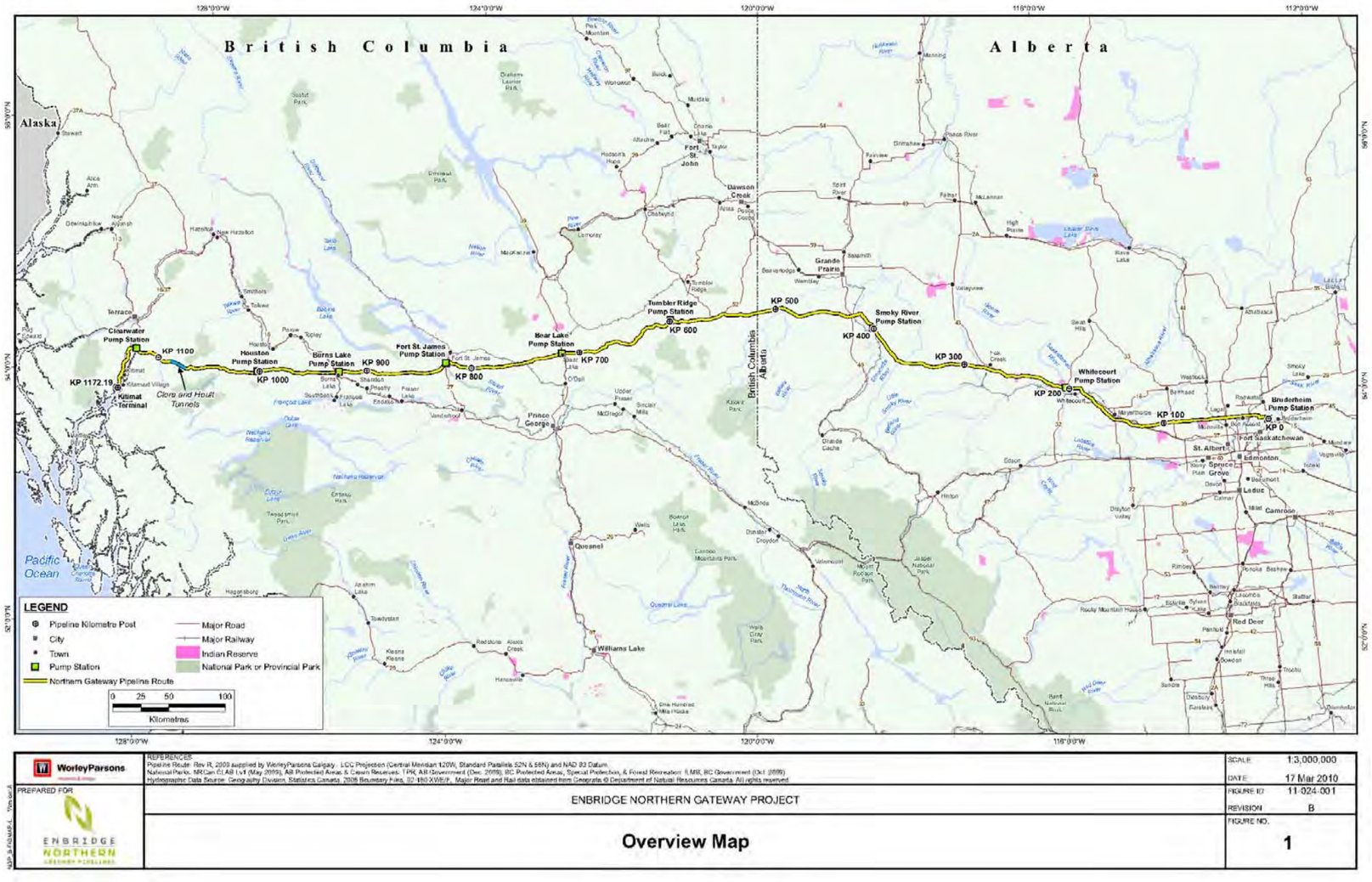


Figure 1: Overview Map Showing the Locations of the Project Facilities

1.3 Terminology

Appendix A lists abbreviations used in this report.

2. HORIZONTAL DIRECTIONAL DRILLING DESIGN

Horizontal Directional Drilling (HDD) is a trenchless crossing technique widely used for the installation of pipelines below watercourses, as well as below other infrastructure such as railways, highways and foreign pipelines. Under appropriate conditions, the HDD technique is practical for installations up to about 2,000 m long for the pipeline diameter ranges under consideration on the Project.

The Hunter Creek crossing, at a horizontal length of 1,022 metres and with pipe diameters of 914 mm OD (NPS 36) and 508 mm OD (NPS 20), falls within current practical length limits. The feasibility of HDD rests primarily upon the geotechnical conditions encountered at a particular site. Other critical factors are suitable topography and availability of temporary workspace for laydown of the makeup section of pipeline.

The HDD design for a 914 mm OD (NPS 36) steel heavy wall pipe requires a preliminary design bend radius of at least 1,100 m. The entry and exit angles range from 12° to 16° and minimum entry and exit tangent lengths are 50 m. This basic limiting geometry, site topography, the no-drill zone (NDZ) established by the geotechnical engineer and other drilling and construction requirements will determine, in most cases, the overall length of the HDD. For this Project, the minimum practical length will be about 500 m (depending on topography and the results of the final geotechnical investigations).

The geotechnical engineer's report typically will specify the extent and shape of a NDZ as a guide for the HDD design engineer. The NDZ includes an assessment of the drill profile required both to prevent release of drilling fluids to the ground surface during drilling and to avoid potential zones of slope instability. An HDD profile will be a minimum of 10 m below a watercourse and could be substantially deeper. The minimum drill depth below surface to prevent release of drilling fluid to the surface is dependent on hydrostatic mud pressures and the permeability and strength of overlying soil and rock. Generally, most HDD crossings are drilled with the entry point on the low elevation side to minimize the fluid pressure in the pilot hole while maximizing fluid return to the drill rig. Drilling fluid, typically made up of bentonite and water, is cleaned of drill cuttings at the drill rig and then reused in the drilling process.

Since full circulation of drilling fluids is not possible in permeable soils such as coarse sand and gravel, steel pipe 'casing' driven through the surficial sand and gravel materials is used to isolate and seal the drill bore profile from these porous materials. Typically, casing is sealed into a lower competent soil or rock.

3. HUNTER CREEK (SITE NO. 3197) PRELIMINARY DESIGN

3.1 Site Location and Access Details

The Hunter Creek crossing, site no. 3197, is located at KP 1,098.7 on the south side of Iron Mountain, (see Attachment 1 in Appendix B). The creek is located within the Coast Mountains physiographic region in western BC. The creek originates 7 km east-northeast of the crossing on the north side of Mount Hoult and is fed by numerous streams originating in alpine bowls at higher elevation. The elevation of the crossing is 280 m.

A Forest Service Road (FSR) exists nearby the crossing and will provide convenient access to the construction site. The alignment of the FSR crosses the proposed HDD route twice. The FSR also has a bridge that crosses Hunter Creek north and east of the crossing location, approximately 100 metres upstream of the crossing. Because access between entry and exit points will be required for construction, this bridge will be a key element in the installation of the HDD.

Terraces of sand and gravel occur on both sides of the lower Hunter Creek Valley. The creek has cut down through these deposits, leaving steep terrace fronts on both sides of the valley. Thin till, glaciofluvial and slope wash deposits overlie bedrock higher up the valley slopes.

3.2 Route Revision R Centreline Alignment

The proposed HDD alignment is shown in Attachment 2 (see Appendix B) and is not coincident with the Route Rev. R centreline. The HDD has a horizontal crossing length of 1,022 m. A route revision is recommended to align with the HDD alignment.

3.3 Design Profile and Parameters

One preliminary HDD design drawing is shown in Attachment 3 (see Appendix B) for both the 914 mm OD (NPS 36) and the 508 mm OD (NPS 20) watercourse crossings. The radius of curvature used on the HDD design drawing for both pipes is the industry's standard for 914 mm OD (NPS 36), which is 1,100 m. The 508 mm OD (NPS 20) pipe can use a smaller design radius. The design of this crossing will be reviewed during detailed engineering when more specific geotechnical and survey information is available. With a smaller design radius, which is expected to be about 600 metres, there is a possibility that the 508 mm OD (NPS 20) pipe crossing can be a shorter drill depending on geological and detailed subsurface conditions.

The two crossings are proposed to be within a common 25 m wide right-of-way (ROW). Within the ROW, the current plan proposes that the HDDs for the two parallel pipelines will have a horizontal separation distance of 15 m. Additional workspace is needed on the entry and exit sides of the drill. The drawings show a 50 m by 60 m combined temporary working rights (TWR) space and ROW area at both the entry and exit sites. This space is required for the rig setup and for the required work at the entry and exit sites. Additional workspace may be required for various construction and topographic considerations.

This HDD assessment is preliminary, pending more detailed site survey and geotechnical information.

3.4 Design Considerations for the 914 mm (NPS 36) and 508 mm (NPS 20) Pipe

The crossing location has been visited on a number of occasions for route selection purposes by WorleyParsons and AMEC field personnel. Geotechnical information for the Hunter Creek crossing is contained in the report *Preliminary Geotechnical HDD Feasibility Assessment Hunter Creek (#3197)* which reports on the results of three boreholes (HU06-1,2 & 3) that were drilled in the vicinity of the crossing location. The boreholes identified conditions potentially favourable to an HDD. In general, the boreholes encountered sand and gravel alluvial deposits up to 10-m deep overlying bedrock. Consideration of the soil and rock conditions encountered, and the site topography has lead to the design of a NDZ by AMEC. The NDZ is shown on the design drawing.

The site topography and the specified NDZ demonstrate a need at this site for a low-to-high drill with the exit being about 30 m higher than the entry. Certain risks are created with the exit at a much higher elevation. The primary risk will be the potential for encountering permeable conditions that result in groundwater flow into the bore of the drill. Future geotechnical investigations will need to be completed to determine if this potential exists. This eventuality would not necessarily mean a failed drill, however, there would be a requirement to handle and treat an increased volume of diluted fluid on site. The topography of the exit area may necessitate a large excavation to provide a level area to exit the directional drill. Detailed engineering will include a review of the area to determine if there is a better location to exit the drill.

Based on the centreline Route Rev. R alignment and the geotechnical recommendations, including the proposed no-drill zone a preliminary crossing design has been prepared. Three preliminary drawings have been prepared for the crossing:

- Preliminary Proposed HDD Crossing Watercourse Location D-5.8-HDD-3197 (see Attachment 2 in Appendix B)
- Preliminary Proposed HDD Watercourse Crossing D-5.8-HDD-3197R (see Attachment 3 in Appendix B)
- Hydrofracture Analysis D-5.8-HDD-3197R-HYD (see Attachment 4 in Appendix B)

As shown on the proposed HDD crossing drawing, the preliminary proposed drill path will be about 1,040 m long. The total heavy wall pipe length will be 1,073 m, including an additional 33 m to allow for the tie-ins. The pipe will cross Hunter Creek at a depth of about 101 m below the higher ground surface elevation on the northwest side of the crossing. The deepest point below the riverbed will be 54 m. The pipe will enter the ground at an angle of 12° and exit at an angle of 16°. The entry and exit locations are setback from the centre of the river by approximately 573 m and 449 m respectively. The southeast side has been selected as the entry side as it is approximately 30 m lower in elevation than the northwest side. The makeup section will be strung out on the entry side, or southeast side. This may necessitate moving the rig to the exit side for the pull through. Additional TWR will be required to lay out the makeup section in a relatively straight line at entry side. Because the HDD alignment is not coincident with the Route Rev. R centreline at the entry side and it will not be possible to place the makeup area along the existing Route Rev. R alignment. Existing road right of ways and clear-cuts will be used where possible.

The hydrofracture calculation curve is shown on the drawing in Attachment 4 (see Appendix B). This drawing demonstrates that the drill profile provides sufficient depth to minimize the risk of fluid release

to the surface based on the preliminary parameters chosen for the design. It is typical for this drawing to be used by the drilling contractor in conjunction with a required annular pressure monitoring tool to control the potential for drilling fluid release and loss of drill fluid circulation.

Casing may be planned for the entry side. The requirement for casing on the exit side will be reviewed during detailed design when subsurface information is available. If casing is required on both sides of the crossing to penetrate sand and gravel, then a drill intersect will most likely be required. Casing size is anticipated to be a minimum of 1372 mm (NPS 54) in diameter with a minimum of 19 mm wall thickness for the NPS 36 pipeline. If telescoping of the casing is required, then the initial casing size may be 1524 mm (NPS 60) or greater with a wall thickness of about 25.4 mm. Casing will be suitably sized for the NPS 20 pipeline.

3.5 Drilling Schedule

Construction of the 914 mm OD (NPS 36) crossing may require a schedule of four and half months of drilling excluding time to install casing. The 508 mm OD (NPS 20) pipe may require a drilling schedule of up to three and half months. A total time of approximately eight months will be required to complete back-to-back drills. Consideration may be given to drilling the two crossings simultaneously, within the time frame required for the larger drill. HDD construction activities will include clearing, grading, mobilization, casing installation, pilot hole drilling, reaming, product pipe pull, demobilization and site restoration.

The calculations in Attachment 5 (see Appendix B) show that the pull loads are estimated to be 638,000 lb. (excluding buoyancy control). The pull force for the 914 mm OD (NPS 36) pipe with buoyancy water reduces to about 301,000 lb. Assuming the same drill length the pull force calculated for the 508 mm OD (NPS 20) pipe is 261,000 lb. without buoyancy control and 147,000 lb. with buoyancy control. Buoyancy should be considered for the two drills to minimizing the pull loads and drill rig size requirements.

The location of the proposed HDD crossing should allow for drilling to occur in either winter or summer. Year round access is preferable and would eliminate the need to drill the 508 mm OD (NPS 20) and 914 mm OD (NPS 36) simultaneously, although this could be an option for the HDD contractor. If drilling is only possible in a single season then the crossings would need to be drilled simultaneously. Detailed design will include a review of the temporary working rights at entry to ensure that sufficient room is available for two drill rigs to be working on site simultaneously. The elevation difference between entry and exit dictates the two HDDs need to be drilled from the same side. However, it is anticipated that the 508 mm OD (NPS 20) drill path can be designed to allow the entry points to be staggered. Additional workspace will be required for a simultaneous drill.

3.6 Contingency Plans

If, during detailed engineering, the HDD crossing method is determined to be not feasible, or if the attempted HDD installation fails, the contingency method of pipeline installation at Hunter Creek is an isolated crossing method during the winter season.

4. CONCLUSIONS

Based on the available data and information, the preliminary assessment indicates that an HDD crossing of Hunter Creek is feasible at this location for both the 508 mm OD (NPS 20) and 914 mm OD (NPS 36) pipelines. A separation of pipeline crossings of 15 metres is considered acceptable; however, this will need to be reviewed once more detailed geotechnical information is obtained. Additional survey and geotechnical investigation and laboratory testing will be required to confirm the feasibility of an HDD to prepare the detailed designs. Final design will consider profiles for both the 508 mm OD (NPS 20) and 914 mm OD (NPS 36) pipeline crossings.

The contingency plan is to cross Hunter Creek using an isolated crossing method during the winter season.

REFERENCES

AMEC Earth & Environmental. *Preliminary Geotechnical HDD Feasibility Assessment Hunter Creek (Crossing #3197)*

APPENDIX A: ABBREVIATIONS

This appendix lists abbreviations used in this report.

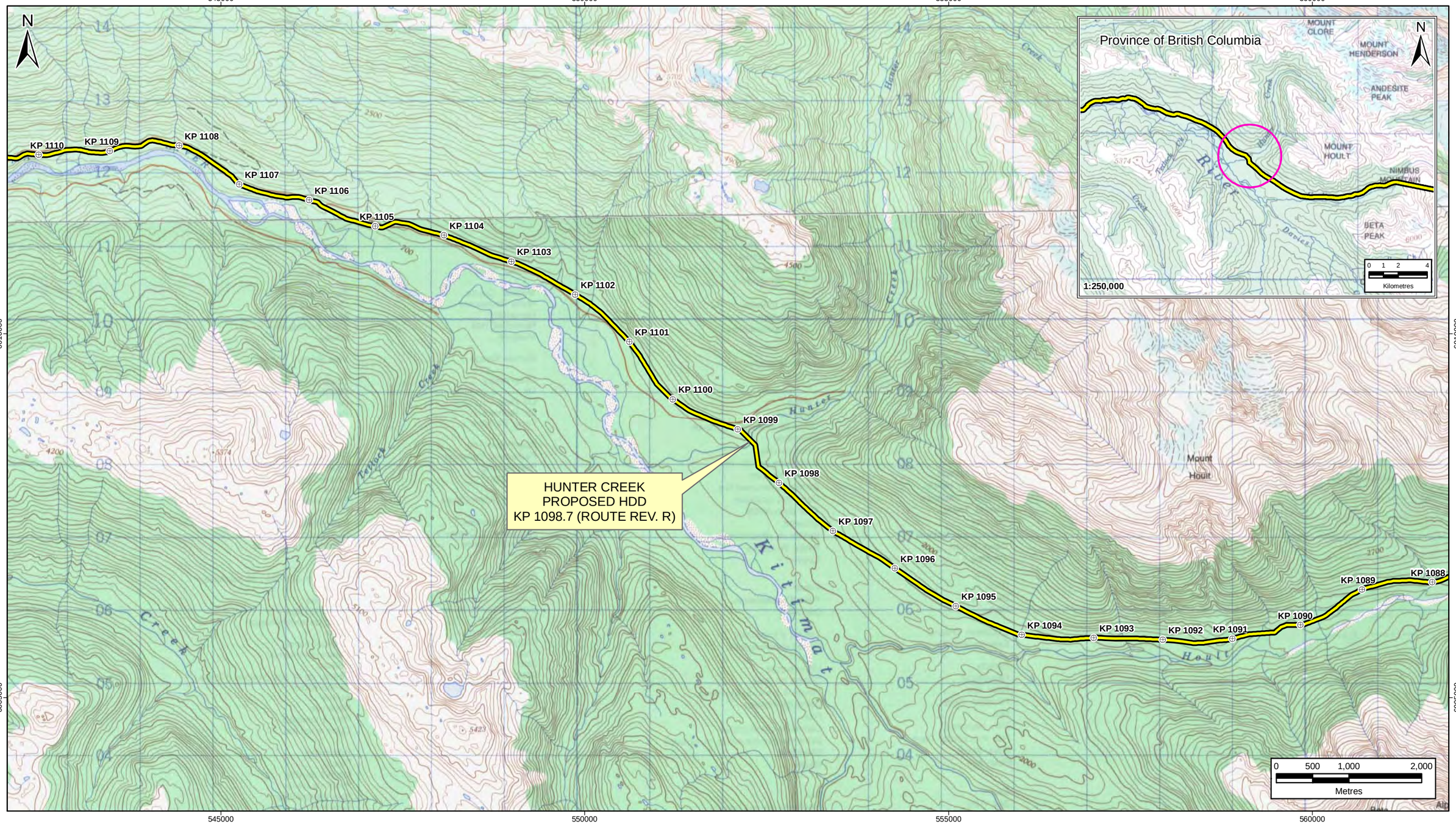
Term	Spelled Out
°	degree(s)
BC	British Columbia
bbl/d	barrels per day
FSR	Forest Service Road
HDD	horizontal directional drilling
km	kilometre(s)
KP	kilometre post
m	metre(s)
m^3/d	cubic metres per day
mm	millimetre(s)
NDZ	no-drill zone
Northern Gateway	Northern Gateway Pipelines Inc.
NPS	nominal pipe size
OD	outside diameter
ROW	right-of-way
the Project	the Enbridge Northern Gateway Project
this report	this *Hunter Creek Preliminary HDD Feasibility Assessment Report*
TWR	temporary work right
WorleyParsons	WorleyParsons Canada Services Ltd.

APPENDIX B: LIST OF ATTACHMENTS

This appendix lists attachments to this report.

No.	Description	Filename
1	Proposed Watercourse Crossing Hunter Creek Location Map	03-332-010_REVA.pdf
2.	Preliminary Proposed HDD Crossing Location D-5.8-HDD-3197	D-5.8-HDD-3197.pdf
3.	Preliminary Proposed HDD Crossing D-5.8-HDD-3197R	D-5.8-HDD-3197R.pdf
4	Hydrofracture Analysis D-5.8-HDD 3197R HYD	D-5.8-HDD-0-3197R-HYD.pdf
5	Horizontal Directional Drilling Pipe Stress Analysis Summaries	Hunter Creek-Stress Analysis.pdf

ATTACHMENT 1: PROPOSED WATERCOURSE CROSSING HUNTER CREEK LOCATION MAP



LEGEND

- ⊕ Proposed Gateway Pipeline KP (Jul. 29, 2009)
- Proposed Gateway Pipeline Route (Jul. 29, 2009)

ENBRIDGE NORTHERN GATEWAY PIPELINES

NORTHERN GATEWAY

NOTES:
- Centreline updated July 29, 2009 (REV R). Kilometre posts correspond to July 29, 2009 (REV R) slack alignment.
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DRAWN	CHECK	DESIGN	APPR.
CS	JK	CS	CM

ENBRIDGE NORTHERN GATEWAY PROJECT
PROPOSED WATERCOURSE CROSSING
HUNTER CREEK LOCATION MAP

PROJECTION	DATUM	CONTRACTOR NAME	MAP NUMBER	REV.
UTM 9N	NAD83	WORLEYPARSONS CALGARY	03-332-010	0

SCALE	DATE	PROJECT NUMBER	ORIG.PAGE SIZE
1:50,000	7 Jun 2010	08C7138	11X17

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ATTACHMENT 2: PRELIMINARY PROPOSED HDD WATERCOURSE CROSSING LOCATION D-5.8-HDD-3197