

GEOTECHNICAL WORK

FACT SHEET



The Northern Gateway Project has engaged pipeline engineering, tunneling and geotechnical experts familiar with the conditions in northern BC to carry out geotechnical (scientific study of the land) evaluations. These geotechnical evaluations in combination with pipeline route selection will be used to understand the measures needed to either avoid or minimize exposure of the pipelines and associated facilities to potential issues.

- These geotechnical evaluations will ensure that:
- The pipeline route avoids, where possible, land subject to geotechnical issues.

Appropriate measures are used to ensure that the pipelines are properly designed to meet pipeline integrity, operational safety and environmental considerations.

Pipeline Route Selection

While selecting the pipeline route engineers attempted to avoid, where possible, land subject to geotechnical issues. For example, the pipeline route runs along the west side of the lower Kitimat River valley and therefore avoids areas on the east side of the valley that have sensitive marine clays beneath them. The route also avoids crossing any active fault lines.

Following the selection of the initial pipeline route, further work and field studies were done, and the route was revised at specific locations to avoid or limit exposure of the pipelines and associated facilities to geotechnical issues such as unstable slopes, rock falls and avalanches. For example:

- The Athabasca River crossing location was revised to avoid a deep-seated landslide on the north valley slope.
- The Simonette River crossing location was revised to avoid unstable valley slopes.
- The Smoky River crossing location was revised to avoid deep-seated landslides on the east valley slopes.
- The Wapiti River crossing location was revised to avoid extensive instability on the east slope of the river valley.
- The Stuart River crossing location was revised to avoid deep-seated landslides on the east and west walls of the river valley.
- The Morice River crossing location was revised to avoid landslides on both sides of the river valley and to remove a crossing of the Thautil River.
- The Coast Mountains segment of the pipeline route was revised to improve constructability and operability of the pipelines, and to avoid or limit exposure of the pipelines to the geotechnical and topographical issues in this region. Specifically, two tunnels, approximately 6.5 km and 6.6 km long, will be installed to route the pipelines through the Coast Mountains.
- The Chist Creek to Iron Mountain segment of the pipeline route was revised to avoid sensitive marine clays in the area.

Geotechnical Considerations and Standard Mitigation Measures

The table on the following pages identifies the primary geotechnical considerations associated with the pipeline route that were addressed during the engineering phase so that the pipelines were properly designed to meet pipeline integrity, operational safety and environmental considerations.

Primary Geotechnical Considerations and Standard Prevention Measures

Primary Geotechnical Considerations	Standard Prevention Measures
Deep seated slides	<ul style="list-style-type: none"> ▪ locate pipelines and facilities to avoid deep seated slides ▪ install ground and surface water control ▪ install berm (level space between two areas) and riprap (rocks used to prevent soil erosion) ▪ site monitoring
Shallow to moderately deep slides	<ul style="list-style-type: none"> ▪ locate pipelines and facilities to avoid slides ▪ install ground and surface water control ▪ design cuts and fills to minimize instability ▪ install anchors, shotcrete (sprayable concrete), or mechanical stabilized earth
Rock falls and rock toppling	<ul style="list-style-type: none"> ▪ locate pipelines and facilities to avoid rock falls ▪ design rock cuts to minimize instability ▪ install stabilization measures, including scaling, anchoring, shotcrete, and mesh ▪ install rock fall protection measures, including berms, catchment areas and ditches ▪ install reinforced concrete slabs over pipelines in selected areas ▪ remove potential problem boulders on slopes
Debris flows	<ul style="list-style-type: none"> ▪ locate pipelines and facilities to avoid debris flows ▪ locate above ground structures away from alluvial fans (fan shaped deposits of water transported sediment) and streams subject to debris flow ▪ install pipelines at a deeper depth in selected areas ▪ install concrete coated pipe in selected areas ▪ install debris flow berms ▪ monitor weather and snow melt conditions during construction in areas subject to debris flows, and remove personnel and equipment if necessary ▪ set temporary bridges to appropriate elevations on debris flow streams during construction

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<p>Avalanches</p>	<ul style="list-style-type: none"> ▪ locate pipelines and facilities to avoid avalanches ▪ consider avalanche issues when locating key facilities such as tunnel portals that will require year round construction ▪ conduct avalanche monitoring and control during construction ▪ conduct avalanche monitoring and control where required during operations ▪ install pipeline at a deeper depth or install a concrete coated pipe in locations prone to avalanche caused avulsion (change in course of a body of water)
<p>Sedimentation and erosion</p>	<ul style="list-style-type: none"> ▪ design cuts and fills to minimize sedimentation and erosion ▪ install ground and surface water control ▪ avoid diversion of surface water flows along the pipeline ▪ install silt fencing and temporary water control, revegetate disturbed areas ▪ install sedimentation ponds, sediment collection berms and filtration berms in selected areas
<p>Karst</p> <p><i>[A feature created on the Earth's surface by the drainage of water into the ground or by its discharge at springs.]</i></p>	<ul style="list-style-type: none"> ▪ locate pipelines and facilities to avoid karst formations
<p>Acid rock drainage (ARD)</p> <p><i>[The outflow of acidic water from areas where the earth has been disturbed.]</i></p>	<ul style="list-style-type: none"> ▪ locate pipelines and facilities to avoid ARD ▪ conduct visual assessment followed by sampling and analysis, when required, during construction ▪ implement prevention measures, including disposal, in designated areas where oxidation will be avoided (capped or under water), mixing with buffer material and shotcreting of bedrock surfaces ▪ ARD prevention protocols will conform with Guidelines for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia

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Seismicity	<ul style="list-style-type: none">▪ locate pipelines and facilities away from areas of potential liquefaction (process by which saturated, unconsolidated sediments are transformed into a substance that acts like a liquid).▪ design pipelines and facilities to current seismic standards
Marine clays	<ul style="list-style-type: none">▪ locate the pipelines and facilities away from areas of potentially sensitive marine clays▪ conduct detailed stability analysis during detailed engineering
Tsunamis	<ul style="list-style-type: none">▪ locate facilities away from areas of high tsunami risk▪ design facilities to limit potential tsunami impacts