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**Re: Geotechnical Memorandum 4 – Embankment Construction For Gully Infill
and Hillside Slopes, Highway 16 Mile 28 Crossing**

1.0 TERMS OF REFERENCE

This memorandum provides geotechnical recommendations for the construction of embankment fills through gullies along hillsides for the proposed Mile 28 CN Rail overpass located on Highway 16, approximately 40 km west of Terrace BC.

Site characterization and description along with initial geotechnical recommendations are outlined in the conceptual geotechnical report issued by the Ministry, and dated September 30, 2015.

2.0 PROPOSED EMBANKMENT CONSTRUCTION

Construction of new highway grade is required as part of the proposed overpass construction and realignment of Highway 16 at the existing CN Rail level crossing (CNR Mile 28). Portions of the new highway will be across steep bedrock hillside above the existing CN Rail and Highway 16 embankment, extending from the western edge of the rock bluff at 1046+20 to the west abutment of the new crossing structure at 1056+46.

Three areas of this alignment will require embankment fill construction on sloping hillside as the proposed route crosses gully features. Hydrotechnical design has not required culvert installation at these locations.

3.0 WEST GULLY (Sta. 1050 to 1051)

Steeply dipping bedrock is present above a topographic depression that forms a seasonal pond along the north edge of the CN Rail embankment. Significant infilling is proposed at this location in order to reach the highway grade.

Access to this area during the investigation and design of this project was not possible, and geotechnical assessment and design was carried out inferred from boreholes drilled along the current highway (MoTI, Sept. 30, 2015). Drilling results indicated that the existing embankment was underlain by compact sand and gravel soils, and that a deep clay stratum was present overlying bedrock.

Stability and settlement analysis carried out for the proposed infill, using conditions encountered at TH 15-05 drilled on the highway embankment indicated suitable factors of safety for static and pseudo-static conditions, with elastic (immediate) settlement under the rail embankment ranging from 40 to 50 mm, with an additional consolidation settlement ranging from 25 to 35 mm at two years and 90 to 175 mm after 70 years.

It is recommended that embankment fill be constructed between the CN Rail embankment and the hillside in a series of 5 m stages, with a waiting period to allow for dissipation of pore water pressures within the clay stratum at depth. Duration of hold times will be contingent on monitoring results for piezometers, as described in Section 3.2, below. For planning purposes, hold periods of 2 months at elevations 20, 25 and 30 m are recommended.

Embankment slopes of 2H:1V are recommended at this location. In addition, the shatter zone should be increased to 900mm thickness below the roadway in order to transition between the cut and fill portions of the embankment.

3.1 Drilling and Instrumentation

Drilling of boreholes and installation of vibrating wire piezometers is required in order to verify the design conditions, and monitor porewater pressures during construction to determine the hold period between stages.

The contractor will be required to construct access for a track mounted drill rig and place up to 2 m of fill in the low-lying area at 1050+40 to create a drill pad in order to drill two mud rotary boreholes. These boreholes should be cased and drilled to bedrock with Standard Penetration Test (SPT) samples obtained at regular intervals. Vibrating wire piezometers should be installed in the clay stratum within both boreholes, and equipped with digital data loggers. Vibrating wire cable should be encased in steel or PVC pipe before backfill, and should be marked and protected from damage during

construction. One vibrating wire piezometer should be installed in the middle of the clay stratum in the northern most borehole location (approximately -11 m elevation), and two piezometers should be installed in the southern most borehole (approximately -6 m and -17m elevation). Piezometers should be grouted in place using a tremmie tube.

Contingencies could be included to install one slope inclinometer into bedrock at 1050+40 on the south (river-side) shoulder of the highway if deep clay soils are encountered in the test holes drilled within the low-lying area to the north of the rail track. Bedrock is anticipated to be at elevation -19 m at this location.

Settlement gauges should be installed at 20 m spacing on original grade at this location, and monitored during construction.

Monitoring of the CN Rail track will be required during and after construction in accordance with spacing and monitoring frequency recommended by CN Rail.

4.0 MIDDLE GULLY (Sta. 1052+40 to 1053+60)

The middle gully is located on an inside curve about the existing CN Rail Mile 27 marker. At this location, an indistinct drainage feature is present leading to an accumulation of water in a topographic depression that drains to the Skeena River through the coarse rock fill that comprises the CN Rail embankment. As proposed, embankment fill will be constructed on a sloping hillside for portions of this alignment.

Stripping of organics and soft or loose surficial materials should be carried out and the approved subgrade should be constructed in accordance with Standards Specifications for Highway Construction SS 201. Should the subgrade consist of steeply dipping and smooth bedrock surface, it is recommended that a series of 2m benches be excavated into bedrock at the discretion of the Ministry Representative and the Geotechnical Engineer. If required, benches can be installed at elevation 30m and 35m, corresponding to hold point elevations described below. Increased shatter zone thickness of 900 mm below the road subgrade is recommended in areas of cut-fill transition.

Slopes of 1.75H:1V are required at this location in order to avoid intersecting the CN Rail embankment. It is recommended that a shear key be constructed along the base of the embankment fill at this location. The shear key should be constructed 5 m wide with a minimum depth of 2 m below the base of the embankment toe using selected Type "A" excavation material. If temporary excavation slopes of 1.5H:1V cannot be achieved for the shear key, construction of the shear key may need to be completed in short (5 m) sections. All excavations shall be offset from top of the rail embankment by

a minimum horizontal distance equal to 1.5 times the vertical height of the rail embankment. Boulders are present at the base of the hillside where the shear key construction is required. In addition, dewatering and surface water control measures may be required depending on the time of year.

Settlement gauges should be installed at 20 m spacing through this area and monitored during construction. Settlement gauges should be placed at the mid-slope of the embankment and along the toe above the shear key.

Hold periods should be placed during embankment construction after the completion of 5 m vertical stages at elevation 20 m, 25 m, 30 m and 35 m. Duration of the hold should be determined based on the results of the settlement gauges monitoring and CN Track settlement monitoring. Deep clay soils were not identified near this location, and it is anticipated that hold times will be in the order of 2 to 4 weeks between stages.

5.0 EAST GULLY (Sta. 1054+40 to 1054+90)

The east gully consists of a partial bench and fill slope located along a steeply dipping portion of hillside. Consideration could be given to either construction of short section of retaining walls to retain the embankment fill, or construction of 2H:1V embankment fill benched in order to achieve a minimum width of 5m. Sliver fills less than 5m are not recommended. Use of smaller compaction equipment may be required due to accessibility constraints at this location.

A shear key 2m deep extending 5 m should be constructed behind the toe of the embankment fill through this area. A shatter zone of 900 mm should be established below the highway subgrade in areas of cut-fill transition.

Monitoring of the CN Rail track will be required during and after construction in accordance with spacing and monitoring frequency recommended by CN Rail.

6.0 CLOSURE

We trust that this provides the information you require at this time. Should you have any further questions, please do not hesitate to contact the undersigned to discuss.

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