TECHNICAL MEMORANDUM

DATE October 12, 2010 **PROJECT No.** 09-1416-0004

TO Derek Holmes
Burnco Rock Products Ltd.

FROM Chris Coles **EMAIL** chris_coles@golder.com

HYDROLOGIC AND HYDRAULIC CHARACTERIZATION
MCNAB VALLEY AGGREGATE PROJECT
HOWE SOUND, BC

1.0 INTRODUCTION

BURNCO Rock Products Ltd. (BURNCO) and 0819042 B.C. Ltd. are proposing to develop a sand and gravel pit, processing facility and marine barge load-out marine facility as a component of the McNab Valley Aggregate Project (the Project). The McNab Creek valley is located on the western shore of Howe Sound immediately north of Gambier Island, and northeast of Gibsons, BC (Figure 1). Additional project details are provided in the McNab Valley Aggregate Project Description (Golder 2010). As requested by BURNCO, Golder Associates Ltd. (Golder) has evaluated the hydrologic and hydraulic conditions at the Project.

This assessment was completed as partial fulfillment of a request for additional information from Fisheries and Oceans Canada in a letter dated December 23, 2009. The purpose of the assessment was to evaluate the flood level risks and the necessity for a dike to prevent flood waters from McNab Creek from impacting the Project site and if necessary, identify the approximate extents of the dike.

It should be noted that the analysis reported herein is focused on clear-flow design flood events. The potential for debris slides, flows and other significant or large-scale geomorphic events were not considered as part of this analysis and are discussed under separate cover.

This technical memorandum should be read in conjunction with the “Important Information and Limitations of this Report” which is appended following the text of the technical memorandum. The reader’s attention is specifically drawn to this information as it is essential that it be followed for the proper use and interpretation of this technical memorandum.

2.0 HYDROLOGIC ASSESSMENT

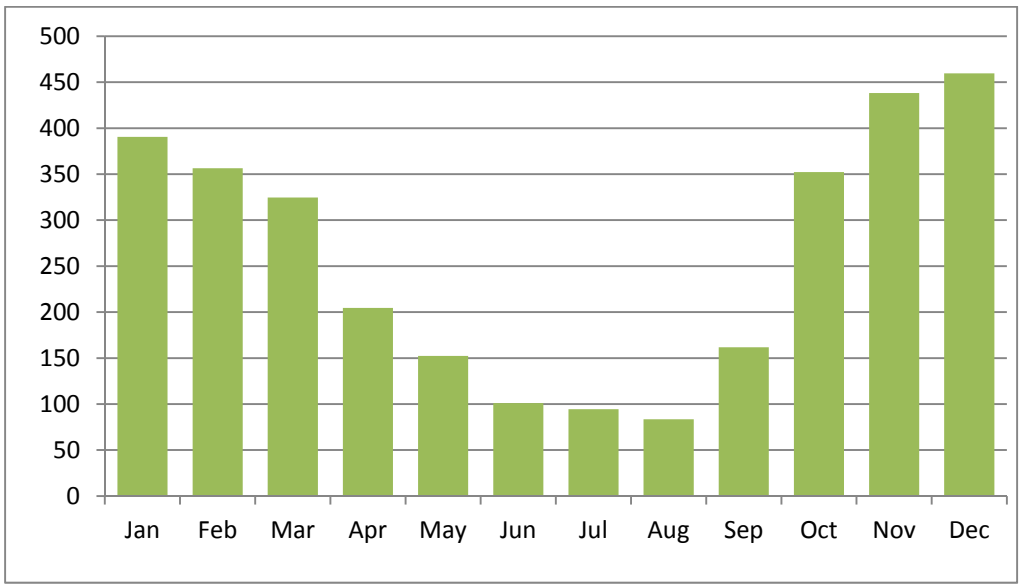
In order to evaluate the necessity for a dike at the project site, the McNab Creek watershed was modelled and an extreme flood discharge in McNab Creek was estimated. The standard design flood for the construction of dikes in British Columbia is a 200 year return period event. Although it is not likely that a dike constructed for the Project will be regulated under the Dike Maintenance Act, this design standard was considered appropriate and was adopted for this assessment.

2.1 Hydrologic Setting

The Project area is located along the Howe Sound coastline, near the mouth of McNab Creek. McNab Creek drains mountainous, mostly undeveloped lands with an area of about 63.3 km^2 to Howe Sound. The land elevation ranges from sea level at the mouth of McNab Creek to mountain peak elevations in excess of 1600 m above sea level.

According data collected at the nearby Port Mellon Climate station located about 10km southwest, the region receives an average of 3120 mm of precipitation per year. Typically the heaviest precipitation occurs during the months of October through March with average monthly precipitation ranging between 300-450 mm. For the purposes of this analysis, and in the absence of site specific data, it was assumed that the magnitude and distribution of precipitation at Port Mellon is representative of that in the McNab Creek basin.

Chart 1 Monthly Average Precipitation, Port Mellon EC Station 1046330



2.2 Regional Analysis

Available Environment Canada (EC) hydrometric stations near the site were researched. Long-term stations (i.e., with more than 10 years of data) located near the site on unregulated systems were identified and are listed in Table 1 below.

Table 1: WSC Hydrometric Stations Analyzed

Station No.	Station Name	Period of Record	n	Location	Catchment Area (km^2)	Distance from Site (km)
08GA060	Chapman Creek above Sechelt	1970-1988	18	49°28'56"N, 123°42'39"W	64.5	25
08GB013	Clowhom River near Clowhom Lake	1993-2008	13	49°47'16"N, 123°25'13"W	147	25

Although there are several hydrometric stations available near the project site, only 2 stations (No. 08GA060, and 08GB013) are located in watercourses with natural flows, correspond to catchment areas of similar magnitude to the catchment area of interest, and have appropriate periods of record.

The 1:200 year daily peak flows for Stations No. 08GA060 and No. 08GB013 were estimated by performing a statistical frequency analysis of the available data and resulted in estimates of 183 m^3/s and 597 m^3/s, respectively. Given that the catchment areas for these hydrometric stations are different than the McNab Creek watershed, the estimated peak values were adjusted for the site using an exponential flow-area relationship (refer to Equation 1). A scaling factor of 0.785 was assumed, as suggested by Coulson (1998) for the province of British Columbia.

$$Q_{A_1} = Q_{A_2} \times \left(\frac{A_1}{A_2} \right)^{0.785} \quad \text{[Eq.1]}$$

Where:

Q_{A_1} = Flow at point 1;

Q_{A_2} = Flow at point 2;

A_1 = Catchment area contributing to point 1; and,

A_2 = Catchment area contributing to point 2.

Based on the analysis described above, the 1:200 year daily peak flow at the site was estimated to be 181 m^3/s and 308 m^3/s based on data from station No. 08GA060 and 08GB013, respectively. It is anticipated that the 1:200 year daily peak flow at the site would be within the range of these two predictions however because of the wide variation, a numerical runoff model of the watershed was prepared to refine the estimate.

2.3 HEC-HMS Model

To further refine the expected discharge calculated using the regional analysis of hydrometric stations, a HEC-HMS[1] (version 3.5) model was prepared to estimate the rainfall-runoff response in the McNab Creek watershed. HEC-HMS is a hydrologic modelling system developed by the US Army Corp of Engineers to simulate the precipitation–runoff processes of watershed systems. The HEC-HMS model was configured using the assumptions and parameters listed below:

- The watershed was assumed to have good forest cover;
- Ground conditions were assumed to be saturated (AMC III);
- Curve Number (CN) of 85 was considered representative of these conditions; and
- The watershed was assumed to have an impervious fraction of 8%.

[1] The Hydrologic Engineering Center's Hydrologic Modelling System

The rainfall intensities for various duration storm events were obtained from the Intensity-Duration-Frequency (IDF) curves from the Port Mellon meteorological station. Storms of several durations ranging from 1 to 24 hours were analyzed. The watershed lag time was estimated to be 83 minutes based on the watershed area and the maximum flow path length.

A 6-hour duration 200-year return period average rainfall intensity of approximately 17.8 mm/hr was found to yield the highest estimated peak discharge (262 m^3/s). A sensitivity analysis was performed by varying the lag time between 20 and 120 minutes; however, the modelled peak flow result was found to be relatively insensitive to the lag time estimate.

Based on the HEC-HMS model results and the above-noted assumptions, a design flow event of 262 m^3/s (clear-flow) was adopted for the McNab Creek watershed. This result is corroborated by the Regional Analysis which indicated an expected peak design flow in the range of 181 to 308 m^3/s.

3.0 HYDRAULIC ANALYSIS

HEC-RAS[2] version 4.0.0, a 1-D hydraulic model developed by the US Army Corps of Engineers, was used to model the flood profile at the site during the design event.

The HEC-RAS model simulated flow in an approximately 2,500 m long reach of McNab Creek. The model was developed using the survey data recently collected by Peter M. Gordon Land Surveying Inc. combined with LiDAR mapping provided by McElhaney Land Surveys Ltd.

The HEC-RAS model was configured considering the assumptions listed below:

- Manning's roughness coefficients of 0.050 and 0.100 were assumed for the creek's channel and overbank areas, respectively;
- The upstream boundary condition for the modelled reach was assumed to be equal to the normal flow depth for a design flow of 262 m^3/s (clear-flow), with a channel slope of 1.8% (average channel slope of McNab Creek between the two upstream-most cross sections); and
- The downstream boundary condition for the modelled reach was assumed to be the estimated high-high tide level at the Project area of approximately 1.93 m geodetic.

The results of the HEC-RAS model indicate that, in the absence of a dike or other flood control measures, the estimated design flood would result in overland flow within the Project area. Specifically, the model results indicate that the design flood would overtop the right bank of McNab Creek on the north side of the Project area over a length of approximately 50 m near station 2+160 (Figure 2). The modelled cross-sectional average flow velocity in McNab Creek along the northern side of the project area was in the range of 3.3 m/s and the maximum depth was predicted to be 3.3 m above the bed of the channel.

The model results suggest that the flood profile would not reach the elevation of the ground surface in the Project area along the east side of the Project area.

[2] The Hydrologic Engineering Center's River Analysis System

4.0 DIKE DESIGN

The dike design details presented in this technical Memorandum should be considered conceptual, further investigation and analysis would be required to prepare a detailed design.

Construction of a setback dike is recommended along the northern side of the Project area as illustrated in Figure 2. The crest of the proposed dike would be approximately 4 m wide with 3H:1V sideslopes and would be approximately 750 m long. As shown in Figure 2, the proposed dike would be set back from McNab Creek by approximately 35 m and built in an area that was previously impacted by logging operations including the existing logging road. As such, it is not anticipated that the construction of the proposed setback dike would include any in-stream works or involve the removal of riparian vegetation.

As described above, the model results indicate that the design flood would overtop the bank on over a relatively short section of the reach along the north side of the Project area. However, flood waters are largely prevented from flowing across the project area by a levee formed by an existing logging road. The proposed dike would be of similar elevation and largely occupy the same footprint as this existing roadway. While the available survey data and the model results indicate that the elevation of the roadway is generally higher than the flood profile plus a freeboard of 0.6 m, further investigation would be required to verify the characteristics of the roadway fill materials and the underlying soils. It is likely that modification or possibly replacement of the existing road fill materials may be required to provide a flood protection dike.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our assessment, the following conclusions and recommendations are made:

- A design event with a recurrence interval of 200 years was considered to be an appropriate design standard;
- The design clear-flow flood event was estimated to be 262 m^3/s;
- The model results indicated that the design flood event would result in overland flow on the Project area;
- A setback dike is recommended to prevent flood water from impacting the Project area;
- The proposed dike would largely occupy the same footprint as an existing roadway on site; however, further analysis would be required to verify the suitability of the roadway fill materials and underlying soils as flood protection dike materials; and,
- It is not anticipated that the construction of the proposed setback dike would include any in-stream works or involve the removal of riparian vegetation.

6.0 CLOSURE

We trust that this information is sufficient for your immediate requirements.

Yours very truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Christopher T. Coles, M.A.Sc., P.Eng.
Senior Water Resource Engineer

ORIGINAL SIGNED

Daniel R. Walker, Ph.D., P.Eng.
Associate and Senior Water Resource Engineer

CC/DRW/MJ/FS/asd

Attachments: Figures 1 and 2

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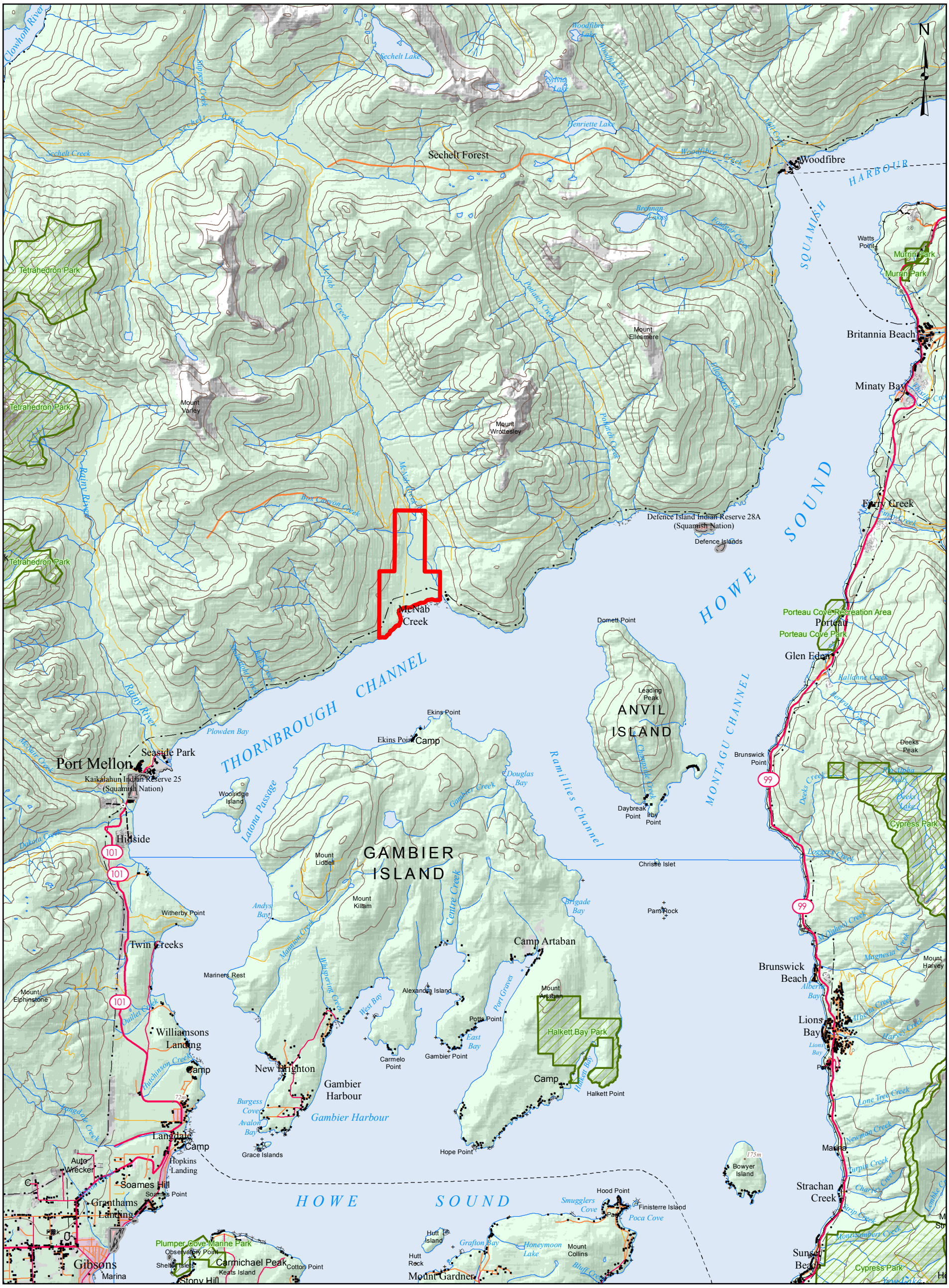
7.0 REFERENCES

Golder 2010. McNab Creek Valley Aggregate Project, Howe Sound, BC, Project Description. October 6, 2010. Submitted to BC Environmental Assessment Office, Victoria, BC. 17p. Appendices A, B and C.



LEGEND

Project Area (Approximate)	Other Infrastructure	Limited Use Road	Waterbody
Building	Contour - Index (500 ft)	Ferry Route	Built-up Area
Elevation Point	Dam	Tunnel	Vegetation
Hazard to Navigation	Cable	Watercourse	Aboriginal Title Area
Historic Site	Transmission Line	Conduit	Park/Protected Area
Navigation Aid	Railway	Wharf	
Picnic Area	Bridge	Facility	
Tank	Highway	Rocky Ledge	
Communication Tower	Major Road	Mining Area	
	Local Road	Sand	

REFERENCE

Parks, and protected areas provided by B.C. LRDW. Aboriginal Areas provided by Geobase. Base features from geogratis.ca NTDB data.
For map symbology not included in legend, see http://cartes.rncan-nrcan.gc.ca/cartospecs/mainindex50_e.php.
Projection: UTM Zone 10 Datum: NAD 83

2,500 0 2,500
SCALE 1:100,000 METRES

PROJECT
BURNCO ROCK PRODUCTS LTD.
MCNAB VALLEY AGGREGATE PROJECT
HOWE SOUND, B.C.

TITLE
KEYPLAN

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 09-1416-0004			PHASE No. 6000		
DESIGN	MJ	06OCT10	SCALE AS SHOWN	REV. 0	
GIS	KG	11OCT10	**FIGURE 1**		
CHECK	CC	12OCT10			
REVIEW	DW	12OCT10			

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LEGEND

- Proposed Dike (Approximate)
- Cross Section
- Contour - Index
- Contour - Index - Depression
- Contour - Intermediate
- Contour - Intermediate - Depression
- Canal
- Creek - Indefinite
- Ditch
- River Shore
- Bridge
- Gravel Road
- Rough Road
- BURNCO Property Boundary
- Proposed Aggregate Pit Area

200 0 200

SCALE 1:7,500 METRES

PROJECT

BURNCO ROCK PRODUCTS LTD.
MCNAB VALLEY AGGREGATE PROJECT
HOWE SOUND, B.C.

TITLE

HYDRAULIC MODEL CROSS SECTIONS AND PROPOSED DIKE LOCATION

REFERENCE

Areas of Interest provided by Golder Associates. Orthophoto and LIDAR data provided by McElhanney.
Projection: UTM Zone 10 Datum: NAD 83

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 09-1416-0004			PHASE No. 6100	
DESIGN	CC	08OCT10	SCALE AS SHOWN	REV. 0
GIS	KG	11OCT10		
CHECK	CC	12OCT10		
REVIEW	DW	12OCT10		

FIGURE 2

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