KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: November 20, 2015

TO: Mr. Jim Pitre, Boss Creek Development Ltd.

CC: Mr. Nigel Hemingway, Cariboo Geographic Systems

FROM: Andrew Kolper, P.Eng., KWL

RE: **BOSS CREEK DEVELOPMENT, ELECTORAL AREA 'C', VERNON, BC**
Pre-development Site Drainage Conditions
Our File 2329.003-300

1. Purpose and Context

The purpose of this memo is to accompany the recent 2015 stormwater management plan in response to MoTI's PLA conditions and to define the pre-development site drainage conditions at the future Boss Creek development. Given the size and nature of the development, it is critical for proper site design, due diligence and for future reference that the natural pre-development runoff conditions be understood and documented.

This memorandum should be read with reference to the 2007 Stormwater Management Plan, KWL, which describes the broader drainage context and numeration of the individual drainages on the site.

The Boss Creek Development lands are located within Electoral Area 'C' of the Regional District of North Okanagan (RDNO), on the west-facing slope of 'Vernon Hill', about 1.5 km east of the City of Vernon boundary. The site is comprised of 278 ha of land, though it is understood that the extent of land is subject to change.

The subject area for Phase 1 comprises 35.8 ha, with 12 Country Residential fee simple lots of average 1.7 ha, and Common Lot access road of 15.8 ha.

In preparation of this report, KWL was advised by local MoT staff that MoT does not maintain records of local drainage conditions or historical flood conditions for the subject area of Electoral Area 'C'. Accordingly, the pre-development site drainage situation has been developed from topographical models, developer's local knowledge, the author's site investigations and hydrologic modelling. Although this approach describes the pre-development conditions in the broader context, ongoing manipulation of drainage at the public road and private property level downslope of the site may change the flow routing described herein.

2. Pre-Development Drainage Conditions

2.1 Site Topography and Drainage

The site slopes and drains predominantly west. Much of the property is in a natural state, although most of the land has been altered for logging, clearing, various minor development activities and the related access road construction. There are some residential dwellings on the subject site. Terrain at the site is generally steep and vegetative cover is mostly second-growth forest and scrub. Generally, drainage follows the natural topography, draws and gullies. There are, however, several linear features throughout the site which affect the natural drainage routing, including roads cut for historic access and clearing purposes, public roads and ditches (e.g., Galiano Road), and remnants of the Grey Canal (for irrigation, in use early 1900s to mid-1960s). Field observations and geotechnical investigations indicate that surface soils are highly permeable, and it appears that little surface runoff occurs during average rainfall events.

Groundwater and interflow surfaces naturally at several locations across the 2.5 km width of the western base of the property. During significant rainfall events and spring snowmelt, the natural drainage channels become active and runoff from the slope occurs within the site draws and gullies, and to the natural off-site downslope drainage routes. During extreme events (e.g., June 1996 (date to be confirmed)) natural runoff in the channels across the base of the site has exceeded the capacity of the local rural roadside ditches, resulting in flood and erosion damage on public roads and private property. From aerial photographs and observations, it appears that over the years some private property owners have altered the natural drainage gullies and channels downstream (west) of the site.

2.2 Major Overland Flow Paths

As mentioned in Section 2.1, during small to medium storm events, due to the high infiltration rate of the surficial soils, there is expected to be very little runoff and gullies remain relatively dry. During larger storm events, particularly when the ground is frozen, runoff is expected to sheet flow until it is intercepted by natural gullies and existing infrastructure. Three natural gullies convey the majority of runoff from the catchments (refer to Figure 1). A number of catchments have no defined drainage paths and runoff from these catchments is expected to be primarily sheet flow. Canopy interception may also play a role in these areas.

2.2.1 Gulley A

One gulley runs through Catchment 4, with roughly half of this catchment contributing runoff to this gulley. The gulley runs through the location of the future Gate House parking lot at approximately Elev. 596 m. Downstream at approximately Elev. 583 m, the remaining intact portion of the Grey Canal intercepts all of the flows from Gulley A and Catchment 4. This canal slopes gently towards the North until its abrupt end adjacent to a private property. At this point, flows would head west down the hill, flow over a residential driveway, then continue downhill over De Roo Road and pool in the adjacent agricultural lands. Flows may eventually make their way back to the natural stream after crossing East Vernon Road.

2.2.2 Gulley B

A second gulley runs through Catchment 5A, crosses an existing unnamed road at approximately Elev. 576 m, then continues downhill to enter a culvert on Phillips Road. The culvert conveys the water to a field where it flows downslope to enter the ditch on the north side of Welker Road. Just past the intersection of Black Rock Road and East Vernon Road, the flow passes through a second culvert and eventually joins up with the natural stream north of the intersection of Black Rock Road and Francis

Street (see Figure 1). This gulley is expected to convey runoff from Catchments 5A and 5B (approximately 117 ha). There is currently no culvert crossing on the gulley at the existing unnamed road to convey flow downstream, making this area a potential concern for road washout and downstream erosion during larger storm events.

2.2.3 Gulley C

A third gulley begins at the westernmost (downstream) end of the site boundary, where the future site access will be constructed. This gulley conveys runoff from a small portion of Catchment 6A. From its origin, the gulley heads downhill then bends south just before reaching the eastern end of McLeish Road (starting location of future access road). It appears that some of this channel has been filled in by private property owners. The flow path then crosses a residential property before entering a ditch on the east side of Bodwell Road. The ditch system crosses Bodwell Road near the intersection with Pottery Road where flow enters a natural channel.

2.3 Hydrology

Runoff and Snowmelt

In the pre-development condition, the largest design runoff condition occurs when the 100-year event occurs on frozen ground and is also combined with snowmelt. In this scenario there will be no infiltration of runoff and additional runoff will be generated from the melting snow.

Snowmelt rates were calculated using formulae in the U.S. Army Corps of Engineers "Runoff from Snowmelt" Engineering Manual (EM 1110-2-1406, March 31, 1998).

An average daily maximum snowmelt rate of 1.1 mm/hr was calculated based on the annual average wind speed for Vernon (11 km/hr) as well as the average daily maximum temperature during winter (November 1 to March 31) rainfall events (5.4^{o}C, based on data from 1984-2004).

Rainfall intensities were calculated using a formula in the City of Vernon Stormwater Management Policies and Design Manual (2002). The average daily maximum snowmelt rate is combined with rainfall to produce winter runoff depths for conveyance design.

Table 1 shows the 100-year rainfall and snowmelt runoff depths for storms of varying duration.

Table 1: 100-Year Calculated Precipitation Depths for Storms of Varying Duration

Storm Duration	Rainfall Depth (mm)	Snowmelt Depth (mm Water Equivalent)	Rainfall and Snowmelt Depth (mm)
1-hour	18.2	1.1	19.3
2-hour	20.7	2.2	22.9
4-hour	25.3	4.4	29.7
6-hour	25.8	6.6	32.4
12-hour	32.8	13.2	46.0
24-hour	41.8	26.4	68.2

100-Year Modelled Flows

The site drainage was modelled using PCSWMM software for the above 100-year winter rainfall and snowmelt depths. Model details are included in Appendix A. Runoff was analyzed at the four key locations noted in Section 2.2: Gulley A at the future Gate House parking lot, the north end of the intact Grey Canal, Gulley B crossing at the existing unnamed road, and Gulley C crossing at the future access road.

In all three cases, the 6-hour storm was found to be governing duration, producing the highest peak flow. Table 2 summarizes the 100-year peak flows at each point of interest.

Table 2: Estimated Pre-Development 100-Year Peak Flows

Section Reference	Location	Contributing Catchment Area (ha)	Peak Flow (m^3/s)	Unit Peak Flow (L/s/ha)
2.2.1	Gulley A at Future Gate House Parking Lot	16	0.21	13.1
2.2.1	North End of Intact Grey Canal	34	0.44	12.9
2.2.2	Gulley B Crossing at Existing Road	117	1.36	11.6
2.2.3	Gulley C Crossing at Future Access Road	10	0.14	14.0

3. Closing

We trust the above meets the needs of Boss Creek Development and MoTI at this time. If you have any questions or require any further information, please do not hesitate to contact the undersigned at akolper@kwl.ca or by phone at 604-293-3277.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA A. J. KOLPER # 39153 2015-11-20

Andrew Kolper, P.Eng.
Stormwater Project Manager

Reviewed by:

David Zabil, P.Eng.
Technical Reviewer

AJK
Attachments: Figure 1 and Appendix A
2007 Stormwater Management Report

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Revision History

Revision #	Date	Status	Revision Description	Author
0	20 Nov 2015	Final	Original	AJK

OQM | Organizational Quality Management Program

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Appendix A – Hydrologic Modelling

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Appendix A – Hydrologic Modelling

MODELLING PURPOSE & MODEL SIZE SUMMARY				
Purpose:	• *Assess 100-year "frozen ground" pre-development drainage flows.*			
Watershed Outlet(s) & Area(s):	*Gulley B at Access Road Crossing*	*117 ha*	**Hydrologic Model:**	*PCSWMM*
	Gulley A at Gate House Parking Area	*16 ha*	**Hydraulic Model:**	*None*
	North End of Irrigation Canal	*34 ha*	**Urban Catchments:**	*0*
	Gulley C Crossing at Future Access Road	*10 ha*	**Undeveloped Catchments:**	*4*

MODEL BUILD	
Watershed Boundary:	*Reviewed and updated based on CAD 1m contours.*
Model Catchments:	*Undeveloped sub-catchments were manually delineated based on CAD 1m contours, watercourse information, and linear features including roads.*
Slopes:	*Estimated between 25-27% based on contour information.*

LAND USE	
Assumptions	*Existing total impervious area was assumed to be 0% based on the fact that the catchments are almost entirely undeveloped. To simulate the winter frozen ground conditions, the soil hydraulic conductivity was reduced to zero. Pervious depression storage was based on similar undeveloped catchments (20mm).*

Appendix A – Hydrologic Modelling

PRECIPITATION

Table A1: 100-Year Precipitation Totals for Varying Storm Durations

Duration	Precipitation Totals		
	Rainfall Depth (mm)	Snowmelt Depth (mm)[1]	Total Precipitation Depth (mm)
1 Hour	18.2	1.1	19.2
2 Hour	20.7	2.2	23.7
4 Hour	25.3	4.4	30.0
6 Hour	25.8	6.6	34.9
12 Hour	32.8	13.2	46.9
24 Hour	41.8	26.4	68.2

1. *Snowmelt rate of 1.1 mm/hr was calculated using formulae in the U.S. Army Corps of Engineers "Runoff from Snowmelt" Engineering Manual (EM 1110-2-1406, March 31, 1998).*

DESIGN STORMS

Distribution	Description
AES for Interior BC	*100-year return period winter precipitation totals (rainfall plus snowmelt) fitted to distribution. Larger of resulting peak flows (1-, 2-, 4-, 6-, 12-, or 24-Hour) governs.*

MODELLED PEAK FLOW ESTIMATES

Table A2: Summary of Peak Flow Estimates

Location	Contributing Catchment Area (ha)	Peak Flow (m^3/s)	Unit Peak Flow (L/s/ha)
Gulley A at Future Gate House Parking Lot	16	0.21	13.1
North End of Intact Grey Canal	34	0.44	12.9
Gulley B Crossing at Existing Unnamed Road	117	1.36	11.6
Gulley C Crossing at Future Access Road	10	0.14	14.0

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1. INTRODUCTION

1.1 BACKGROUND

Boss Creek Developments has retained Kerr Wood Leidal Associates Ltd. (KWL) to develop a stormwater management concept plan and detailed drainage design for the Vernon Hill Ranch Development near Vernon, British Columbia.

The Vernon Hill Ranch Development is located on the west-facing slope of Vernon Hill, just east of the City of Vernon and comprises approximately 278 hectares (687 acres). The land is currently undeveloped and existing drainage within the site is generally undefined. Field observations indicate that existing soils at the site are highly permeable and it appears that little surface runoff occurs during the majority of storm events. Groundwater and interflow does appear to surface at the base of the site.

1.2 STORMWATER MANAGEMENT PLAN OBJECTIVES

The primary objective of the Stormwater Management Plan is to develop a drainage system that safely conveys stormwater and snowmelt through the site to the receiving waters or drainage collection system. The proposed drainage system must also meet the requirements of North Okanagan Regional District (NORD). NORD does not have any specific stormwater design criteria, therefore, the design criteria and guidelines that will be applied to the site during the development of the stormwater management plan will be obtained from such sources as the City of Vernon, British Columbia Ministry of Water, Land and Air Protection, and Canada Department of Fisheries and Oceans.

This report presents the following information:

- existing site conditions and description of existing off-site drainage infrastructure;
- design criteria for stormwater management and drainage design;
- stormwater management plan and required infrastructure;
- hydrologic and hydraulic model description and results; and
- an indicative cost estimate.

The following issues must be considered in the drainage design for the site:

- The City of Vernon “Subdivision and Development Servicing” Bylaw states that post-development runoff must be maintained at pre-development levels for a 5-year storm event. The pre-development surface runoff from the site for a 5-year storm event is estimated to be close to zero.

- The site naturally drains toward the West both pre- and post-development. Site drainage flows overland or discharges via four mapped, ephemeral drainageways that leave the site and appear to connect to existing drainage paths, ditches and creeks below the site. The capacity of the downstream drainage infrastructure is unknown and is not estimated for this plan.

In order to address these challenges, a stormwater management plan has been developed that requires capturing and infiltrating storms up to the 100-year return period. Discharges greater than the 100-year level are conveyed off the site via the road-side ditches, in accordance with the City of Vernon's "Subdivision and Development Servicing" Bylaw. This approach has the benefit of reducing downstream offsite impacts as much as possible up to the level of the 100-year return period storm. A detailed review of the capacity of off-site infrastructure has not been conducted as part of this study.

At this time, site design and layout is in process. As a consequence, road, pipe and lot boundary locations are currently approximate and are likely subject to change before final design and construction.

1.3 GLOSSARY OF TERMS

Runoff: Stormwater that travels along the surface of the ground.
Interflow: Stormwater that travels in the topsoil layer.
Groundwater: Water that can be found at depths ranging from one metre to tens of metres.

2. SITE DESCRIPTION

2.1 GENERAL DESCRIPTION

The Vernon Hill Ranch is just east of the City of Vernon, on the west-facing slope of Vernon Hill. The area is 278 hectares in size, and is currently undeveloped. Primary access to the property is from Galiano Road. The development will be a Bare Land Strata with approximately 140 lots of various sizes averaging 2.0 ha per lot. Terrain at the site is generally steep and vegetative cover is mostly second-growth forest. A location map and aerial photo of the site are shown in Figure 1.

2.2 SOILS AND INFILTRATION RATES

A preliminary geotechnical investigation program consisting of test pits and percolation tests was conducted by Golder Associates in July and August, 2006 (*Preliminary Soils Investigation, Proposed Vernon Hill Ranch Development, Vernon, BC*. Golder Associates, Kelowna, BC, September 2006)

Soil profiles generally consist of 0.1 m to 0.5 m of topsoil underlain by 1 m to 2 m of dense sandy silt followed by very dense till or bedrock. A few deposits of sandier and clayey materials are scattered throughout the site. An average saturated infiltration rate of 7.0 mm/hr was assumed for the topsoil, based on the test pit log descriptions of the surface soil layer, and an average infiltration rate of 1.5 mm/hr was measured in the silty layer underlying the topsoil.

2.3 HYDROLOGY AND HYDROGEOLOGY

Drainage catchment areas for the existing topography are shown in Figure 2; off-site drainage features are shown in Figure 1. The site slopes and drains predominantly towards the west, toward the City of Vernon boundary. The north-eastern section of the development drains into Bate Creek which runs east to west on that portion of the site. Bate Creek in turn drains toward the northwest and into B.X. Creek.

The main portion of the site is divided into two primary catchment areas. The northern catchment drains to a gully or ephemeral stream which drains west towards the City of Vernon. This does not appear to connect to Grey Canal near the base of the site, which is a former irrigation canal that runs south to north along the western edge of the catchment. Runoff from the northern part of the catchment drains toward the west in earthen ditches before discharging to BX Creek. The southern catchment area drains toward the site boundary on the west and south, mainly via overland and shallow concentrated flow as there are no mapped streams on this portion of the site. There are no perpetual surface watercourses in the catchment area, and drainage appears to occur primarily by interflow and groundwater. Ephemeral streams near the base of the site are thought to pick up some of the shallow groundwater and convey to other streams and eventually to BX Creek.

2.4 ADJACENT LANDOWNER INTERVIEWS

To be completed subsequent to site visit.

2.5 ENVIRONMENT

A Preliminary Environmental Sensitivity Analysis for Vernon Hill Ranch Development was completed by Golder Associates and submitted in a report to Mr. Jim Pitre dated June 13, 2006. This report was included in the Vernon Hill Ranch Development Proposal. Specific conclusions about environmental sensitivity of the Vernon Hill Ranch Development area include:

- The site contains one known watercourse, Bate Creek. Any development within 30 m of Bate Creek requires a development permit and is subject to the Riparian Area Regulation (RAR). Several rock outcrops and talus slopes appear to be located in the north portion of the site. Due to the rarity of the habitat in the Okanagan and the potential for species at risk to utilize these areas, they have been identified as ESA I and should be maintained as much as possible in their natural state.

- The areas that link the ESA I areas of the site and may potentially be used as migration corridors for species at risk have been identified as ESA II.

- The majority of the site is primarily undeveloped forest with a history of selective harvesting and limited residential development, and is located within a wildfire interface development permit area. Due to its disturbed nature, the majority of the site is considered ESA III. However, a detailed site reconnaissance to determine that no environmentally sensitive habitat features are located within this area has not been performed.

2.6 FUTURE LAND USE

The future land use for the site is shown in Figure 3; the future land use consists of single family residential, with park and conservation areas interspersed. The site is intended to have a network of trails as a secondary means of transport that may be used both by residents and neighbors of the site.

The development will incorporate approximately 140 properties of varying sizes while maintaining an average density of 2.0 hectares (5 acres) per lot. It has been specified in the rezoning application that lot coverage shall not be greater than twelve percent (12 %) of the total lot area. Individual lots shall be 0.8 hectares minimum size except for a few cases, where the minimum lot size is 0.4 hectares.

The overall percentage impervious area for the site (including roads, parks and conservation areas) is 19%. Pervious areas are assumed to be essentially undeveloped, in keeping with the overall natural site goals of the development.

2.7 OFF-SITE DRAINAGE INFRASTRUCTURE

As stated in section 1.2, the goal of the stormwater management plan is to detain and infiltrate on-site all storms up to the 100-year return period. This means that there will be no impact on any downstream infrastructure for any storm up to the 100-year storm. Any storm in excess of the 100-year is assumed to be a major flood event, for which downstream infrastructure is not designed. Flood flows from the Vernon Hill Ranch site will be discharged overland from Galliano Road and from retention pond overflows into natural drainage paths.

3. DESIGN CRITERIA

3.1 REFERENCE DOCUMENTS

Design criteria and guidelines for stormwater management and drainage system design are based on the following documents:

- City of Vernon "Subdivision and Development Servicing Bylaw No. 3843, Schedule F, Regulations, Standards and Specifications for the Design and Installation of Drainage Systems", 1992.
- Dayton and Knight Consulting Engineers Ltd. "City of Vernon, Stormwater Management Policies and Design Manual", August 2002.
- British Columbia Ministry of Water, Land and Air Protection "Stormwater Planning: A Guidebook for British Columbia", May 2002.
- Summit Environmental Consultants Ltd., Environmental Assessment Reports (listed above).

3.2 SUMMARY OF DESIGN STORM EVENTS AND DISCHARGE OBJECTIVES

RAINFALL

The City of Vernon "Subdivision and Development Servicing Bylaw" provides rainfall IDF curves for use in the Rational Method of drainage design. Due to the size of the catchment area (greater than 20 hectares), analysis of the Vernon Hill Ranch drainage system needs was performed using a hydrologic and hydraulic computer model. This model requires time-series of rainfall as an input.

Time series of rainfall for summer and winter storm events are provided in the Dayton and Knight Ltd. "City of Vernon, Stormwater Management Policies and Design Manual". The design storm events were developed based on AES curves for Penticton and Interior B.C. Design return periods and durations are as follows:

Return Periods: 5-, 10-, and 100-year
Durations: 30-minutes, 1-, 2-, 3-, 4-, 5-, 6-, 8-, 10-, 12-, 16-, 18-, 20-, and 24 hours

The summer rainfall events are identical in volume and intensity to the winter rainfall events, the only difference being the addition of a constant snowmelt for the winter events as described below.

SNOWMELT

The Dayton and Knight Ltd. "Stormwater Management Policies and Design Manual" recommends a constant snowmelt rate of 3.5 mm/hr for coincident rainfall on snow events. This snowmelt condition appears to be calculated using a temperature of 19.4 degrees Celsius; this temperature is the maximum recorded in Vernon from November to March in 29 years of record keeping. This snowmelt rate is then applied over the 24-hour period. However, the 19.4-degree temperature was the peak hour temperature, and did not occur over the entire day. Furthermore, the combination of a record high temperature occurring at the same time as a 100-year return period or 1-percent probability storm, would have a combined probability of much less than 1-percent.

KWL has conducted a review of snowmelt rates for the climatic conditions in Vernon and has concluded that a lower, more realistic snowmelt rate is appropriate. Snowmelt rates were calculated using formulae in the U.S. Army Corps of Engineers "Runoff from Snowmelt" Engineering Manual (EM 1110-2-1406, March 31, 1998).

An average daily maximum snowmelt rate of 1.1 mm/hr is calculated based on the annual average wind speed for Vernon (11 km/hr) and the average daily maximum temperature during winter (November 1 to March 31) rainfall events (5.4^{o}C, based on data from 1984-2004). An average daily snowmelt rate of 0.6 mm/hr is calculated based on the annual average wind speed and the average daily temperature during winter rainfall events (2.8^{o}C).

The average daily maximum rate is combined with rainfall to produce winter runoff depths for conveyance design; this is due to the fact that the peak discharges are critical for storm sewer design. The average daily rate is used for retention and infiltration facility design and soil depth calculations because volume, not peak flow, is the critical parameter in the design of these items.

ELEVATION

As the Vernon Hill Ranch development site is relatively steep the site elevations range from approximately 600 metres on the western edge to approximately 1200 metres on the eastern edge. This is a large difference in elevation and it is possible that orographic effects may induce greater rainfall on the higher elevations of the site. Orographic effects occur when storm clouds move higher and become denser as they encounter a mountain or other tall obstruction.

KWL researched whether such effects have been documented or estimated for sites in the Vernon area. While some stream flow studies indicate that a greater rainfall depth is assumed for "upper watersheds" above a certain elevation level, there was no indication of the magnitude of the effects or the method by which the rainfall increase was developed.

KWL also examined rainfall data from two climate stations near the Vernon Hill Ranch Site. The Vernon CS station is a real-time precipitation and temperature station South of the site at an elevation of 482 m. The Vernon Silver Star station is a daily gauge located at Silver Star Lodge at an elevation of 1572 m. Only daily (24-hour totals) precipitation could be compared between the two stations and there was a poor correlation of rainfall between the sites. The sites are approximately 16.6 km apart, which is too far to assume the same rainfall intensity occurs on both sites from a given storm as 3 km is a standard limit. Therefore no estimate of orographic rainfall effects can be made based upon this data. In the absence of any evidence or studies indicating rainfall increase with elevation there are assumed to be no effects for the purposes of the modeling for this site.

DESIGN STORM EVENTS

Winter storm events with durations ranging from 30 minutes to 24 hours are used for drainage system design. Winter precipitation depths for the 24-hour duration storm event are provided in Table 3-1 below. Mean annual rainfall and pan-evaporation rates are presented in Table 3-2.

Table 3-1: 24-Hour Precipitation Depths from Stormwater Management Policies and Design Manual

Return Period	Summer Rainfall Depth (mm)	Winter Rainfall and Snowmelt Depth (mm)
2-year (MAR)	21.8	48.2
5-year	27.2	53.6
10-year	30.7	57.1
25-year	35.2	61.6
50-year	38.5	64.9
100-year	41.8	68.2

1. Winter depths are calculated by adding 1.1 mm/hr snowmelt to the summer rainfall amounts.

Table 3-2: Mean Annual Rainfall and Pan-Evaporation Rates

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall[1] (mm)	38.1	27.7	23.7	30.2	41.2	46.2	39.7	29.7	36.4	34.2	50.1	47.9	445.2
Evaporation[2] (mm)	0	0	0	0	105	143	137	111	63	40	0	0	600.3

1. Environment Canada Climate Normals for Vernon Bella Vista 1971-2000.
2. Measured evaporation rates for Vernon South from 1951-1980.

ANTECEDENT SOIL MOISTURE CONDITIONS

The following soil moisture conditions are assumed for each of the design storm events:

Frozen: Frozen ground; assumed to be 100% impervious in all areas; and
Un-Frozen: Soil moisture between wilting point and field capacity (assumed at 4% and 31% respectively).

DISCHARGE OBJECTIVES

Design criteria and discharge objectives have been developed to provide flood protection and mitigate downstream erosion as follows:

Table 3-3: Summary of Design Storm Events and Discharge Objectives

Component	Criteria/Guidelines
Hydrotechnical Component (Flood Protection)	▪ Minor Drainage System – 5-year return period design event.[1] ▪ Major Drainage System – 100-year return period design event.[1]
Environment	▪ Provide on-site or off-site detention facilities to restrict the post-development peak runoff to the pre-development grassland condition for all storms up to the 100-year return period design event under non-frozen ground conditions.
1. City of Vernon "Subdivision and Development Servicing Bylaw".	

3.3 DESIGN CRITERIA FOR DESIGN AND SIZING OF FACILITIES

ON-SITE CONVEYANCE

The Vernon Hill Ranch site will use road-side ditches to convey runoff along the road alignments to the retention pond locations. The ditches will be rock-lined for erosion resistance and have a minimum cross-section. Selected criteria for ditch deign are provided for reference as follows:

- the minimum design slope shall be calculated by use of the Manning Formula;
- minimum velocity of channel flow at maximum for the 100-year non-frozen event shall be 1.0 m/s; and
- minimum dimensions shall be a v-shaped channel cross-section 1 m wide and 0.5 m deep.

RETENTION AND INFILTRATION PONDS

Design criteria for detention ponds and infiltration/groundwater recharge facilities are provided in Section 3 of the Dayton and Knight Ltd. "City of Vernon, Stormwater Management Policies and Design Manual". Reference can be made to this document for specific design criteria.

OVERLAND FLOW ROUTES

Section 2.14 of the City of Vernon "Subdivision and Development Servicing Bylaw" provides requirements for design of overland flow routes. Selected criteria from this document are provided for reference as follows:

- All overland flows in excess of 0.05 cms shall have specifically designed flow routes.
- On arterial roads, the 100-year hydraulic grade shall not be higher than the centerline of the pavement with the maximum flow depth not to exceed 300 mm.
- On collector and local roads, the entire roadway may be used as a major flood path with the maximum flow depth not exceeding 300 mm.

4. HYDROLOGIC AND HYDRAULIC MODELLING

4.1 SOFTWARE

The SWMM model (RUNOFF and EXTRAN Blocks) was used for hydrologic and hydraulic analysis of the Turtle Mountain Development. A SWMM model developed by XP-Software Inc. called XP-SWMM (Version 9.51) was chosen for the following reasons:

- industry-standard SWMM analysis engine is well-proven;
- allows fully dynamic backwater analysis (EXTRAN block);
- capability for both event modelling and continuous (multi-event, multi-year) modelling; and
- many of the parameters used in the XP-SWMM model are based on physical quantities which can be measured in the field; thereby minimizing the number of parameters which must be estimated based on engineering tradition or judgement.

The physical basis of XP-SWMM enables the same model and parameters to be used for all antecedent design conditions, and for both frequent and extreme events. This makes the model suitable for continuous (multi-year or typical year) modeling which is a useful tool for the assessment of land use changes and stormwater management strategies.

4.2 PRE-DEVELOPMENT MODEL

A pre-development (existing) conditions model was created in XP-SWMM based on the sub-catchment areas shown in Figure 2. Runoff simulations were then conducted for the design rainfall events and two soil conditions (saturated unfrozen, and frozen) to determine baseline runoff discharges and volumes.

4.3 POST-DEVELOPMENT MODEL

The post-development model is shown in Figure 3. The site is divided into separate sub-catchment areas for un-developed areas, lots and roadways based on slopes and drainage ways, and grades for road-side ditches.

Model simulations were conducted for 5-year and 100-year return period storm events for drainage system design.

The following results were extracted from the model:

- peak discharges and velocities for the worst-case flood flows (frozen conditions) for design of the ditches and overland flow paths; and
- hydrographs at retention/infiltration pond sites to determine retention volume and infiltration area requirements.

A flow chart description of the runoff generation and flows in the developed case SWMM model is shown in Figure 4.

4.4 ANALYSIS RESULTS AND INFRASTRUCTURE REQUIREMENTS

EXISTING LAND USE (PRE-DEVELOPMENT CONDITIONS)

Peak surface runoff and interflow discharges and volumes for each sub-catchment for 100-year storm events with saturated antecedent soil conditions and frozen soil conditions are provided in Figure 2. Surface runoff discharges and volumes are essentially zero for the 100-year event in unfrozen ground conditions due to the high infiltration rates of the existing soils.

POST-DEVELOPMENT LAND USE

Model results for the post-development land-use have been used for design of the drainage infrastructure and development of the stormwater management plan; this is described in detail in the next section.

5. STORMWATER MANAGEMENT PLAN AND PROPOSED INFRASTRUCTURE

5.1 STORMWATER MANAGEMENT PLAN

INTRODUCTION

The discharge objectives listed in Table 3-3 state that surface runoff from the site must be the same as or less than the pre-development level for return periods up to the 100-year event.

The existing land use displays different behaviour for frozen and un-frozen ground conditions. When the ground is not frozen, the high permeability surface soil absorbs almost all of the rainfall and snowmelt, and the stormwater is captured in the soil and/or travels as interflow below the ground surface. If the ground is frozen, virtually all of the rainfall and snowmelt runs off the site as surface runoff. The stormwater management plan for both scenarios is described in the following sections.

STORMWATER MANAGEMENT: UN-FROZEN GROUND CONDITIONS

For un-frozen ground conditions, the proposed drainage system makes use of retention and infiltration to eliminate the majority of surface runoff from the site up to the 100-year return period. For events with a return period greater than 100-years, excess runoff will will be conveyed offsite via overflows and road-side ditch conveyance. A flow chart showing the hydrologic path of rainfall and snowmelt in un-frozen ground conditions is provided in Figure 4; the flow paths are different for undeveloped land, lots and roadways and are described as follows:

Undeveloped Land: Rainfall and snowmelt infiltrates and follows natural hydrologic pathways.

Lots: Rainfall and snowmelt on pervious surfaces infiltrates and is captured in the soil; runoff from roofs and driveways is directed to pervious surfaces. High intensity rainfall that exceeds the infiltration capacity of the soil is collected by roadside ditches and conveyed to retention ponds. The rainfall and snowmelt that is captured in the soil and retention ponds is slowly discharged and travels off-site as interflow.

For storm events with return periods greater than 100-years, runoff and retention pond overflow will occur and is directed to the road-side ditches and natural drainage ways for conveyance offsite.

Roads: Rainfall and snowmelt on roadways is collected by road-side ditches and conveyed local retetention/infiltration facility. For storm events with return periods greater than 100-years, the storm sewers and retention/infiltration facility will be at capacity, and surface flow will occur and will be directed off-site.

STORMWATER MANAGEMENT: FROZEN GROUND CONDITIONS

For frozen ground conditions, runoff will still be directed to the retention/infiltration facilities, but infiltration into the soil will be minimal or not occur as the surface will be frozen. For large storm events, the retention facilities will fill and then overflow. Flood flows will be carried offsite by the road-side ditches and overflow pathways. The volume of water leaving the site will be smaller for the post-development condition than the existing condition because some of the stormwater will be captured and retained in the ponds rather than all of the rainfall running off the site.

5.2 DESCRIPTION OF DRAINAGE INFRASTRUCTURE COMPONENTS

A description of the proposed on-site drainage infrastructure is provided in the following sections.

LOW IMPACT DEVELOPMENT TECHNIQUES

Current practice is to build new developments with low impact development (LID) techniques to meet the criteria in Table 3-3. The LID techniques described below are considered to be appropriate for the Vernon Hill Ranch site**.**

Roof Leader Disconnection: The disconnected roof leaders would typically be located on the downhill side of the lot, and would be directed to splash pads. The runoff would then travel downslope and infiltrate into permeable ground, or runoff to a road-side ditch depending on the soil conditions and rainfall intensity. Under frozen conditions, most rainfall runs off to the roadside ditches.

On-Site Retention/Infiltration Facilities: The on-site retention/infiltration system would consist of several un-lined ponds located near the downslope side of roads in locations where runoff would tend to collect by gravity. These ponds act as retention facilities for containing and holding site runoff from the 100-year, 24-hour storm event. As they are unlined, the ponds are also infiltration facilities, and the retained runoff will slowly infiltrate into the subsurface and/or evaporate over time. The ponds will function as retention facilities under frozen conditions, but will not retain the volume of the 100-year event runoff for that case. Under frozen conditions, runoff will fill and overflow the ponds and be conveyed to the base of the site via the road-side ditches.

ROADSIDE DITCHES AND OVERLAND FLOW ROUTES

The roadside ditches are designed to convey the 100-year storm event runoff for the for Vernon Hill Ranch site, as the ditches will carry road runoff and any intercepted overland flow. The road-side ditches are sized to convey the 100-year discharge under frozen ground conditions for lots and roadways, as the worst case scenario for flood flows to be conveyed off the site. This way the ditches function both as conveyance to the retention ponds and as flood overflow routes for frozen ground conditions.

SWMM model results for the drainage system design runs are provided in Figure 5. The total site discharges and peak flows for the worst-case conditions (100-year storm events, frozen surfaces and rain-on-snow) decreased for each watershed and for the site as a whole as a result of the stormwater management facilities modeled for the developed site. Discharges and capacities of the retention/infiltration ponds and road-side ditches are described in Appendix C.

6. SUMMARY AND CONCLUSIONS

The Vernon Hill Ranch development is located east of the City of Vernon on the west-facing slope of Vernon Hill. The land is currently undeveloped and the majority of the site does not have a discernable drainage outlet. Based on geotechnical investigations of the subsurface soils, the surface layer of silty loam material has a relatively high hydraulic conductivity, estimated at 7 mm/hr, while the underlying till layer has a measured hydraulic conductivity averaging 1.5 mm/hr.

The existing land use displays different behaviour for frozen and un-frozen ground conditions. When the ground is not frozen, the surface soil absorbs almost all of the rainfall and snowmelt, and the stormwater is captured in the soil and/or travels as interflow below the ground surface. When the ground is frozen, all of the rainfall and snowmelt can run off the site as surface flow.

The proposed drainage system makes use of a mixture of retention, infiltration and conveyance to meet the discharge objectives and safely convey stormwater and snowmelt through and off the site under non-frozen and frozen conditions. The retention pond facilities are sized to capture and infiltrate the 100-year storm event runoff in unfrozen ground conditions. The roadside ditches convey runoff flows to the retention ponds, and are sized to convey runoff from the entire site under frozen conditions when infiltration into the soil is minimal. The on-lot drainage infrastructure consists of the following:

- disconnected roof leaders;
- an undisturbed, naturally high field capacity soil layer underlain by a low permeability soil layer, to infiltrate and capture stormwater;
- a maximum lot imperviousness of 12%;

The drainage infrastructure associated with the roadways includes road-side ditches and stormwater retention/infiltration ponds sized to retain and infiltrate stormwater from the roadways.

It is recommended that this report be reviewed by a geotechnical engineer for consideration of slope stability impacts of the retention/infiltration ponds.

Report Submission
Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

____
Laurel Morgan, M.Sc., P.E. (MO, WA).
Project Engineer

Reviewed by:

____
Crystal Campbell, P.Eng.
Stormwater Management Specialist

STATEMENT OF LIMITATIONS

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of Wesbild Holdings Ltd. for the Turtle Mountain Stormwater Management Plan. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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Appendix A: Test Pit Logs

Appendix B: Infiltration Test Results

Appendix C: Drainage System Data

Appendix D: Calculations

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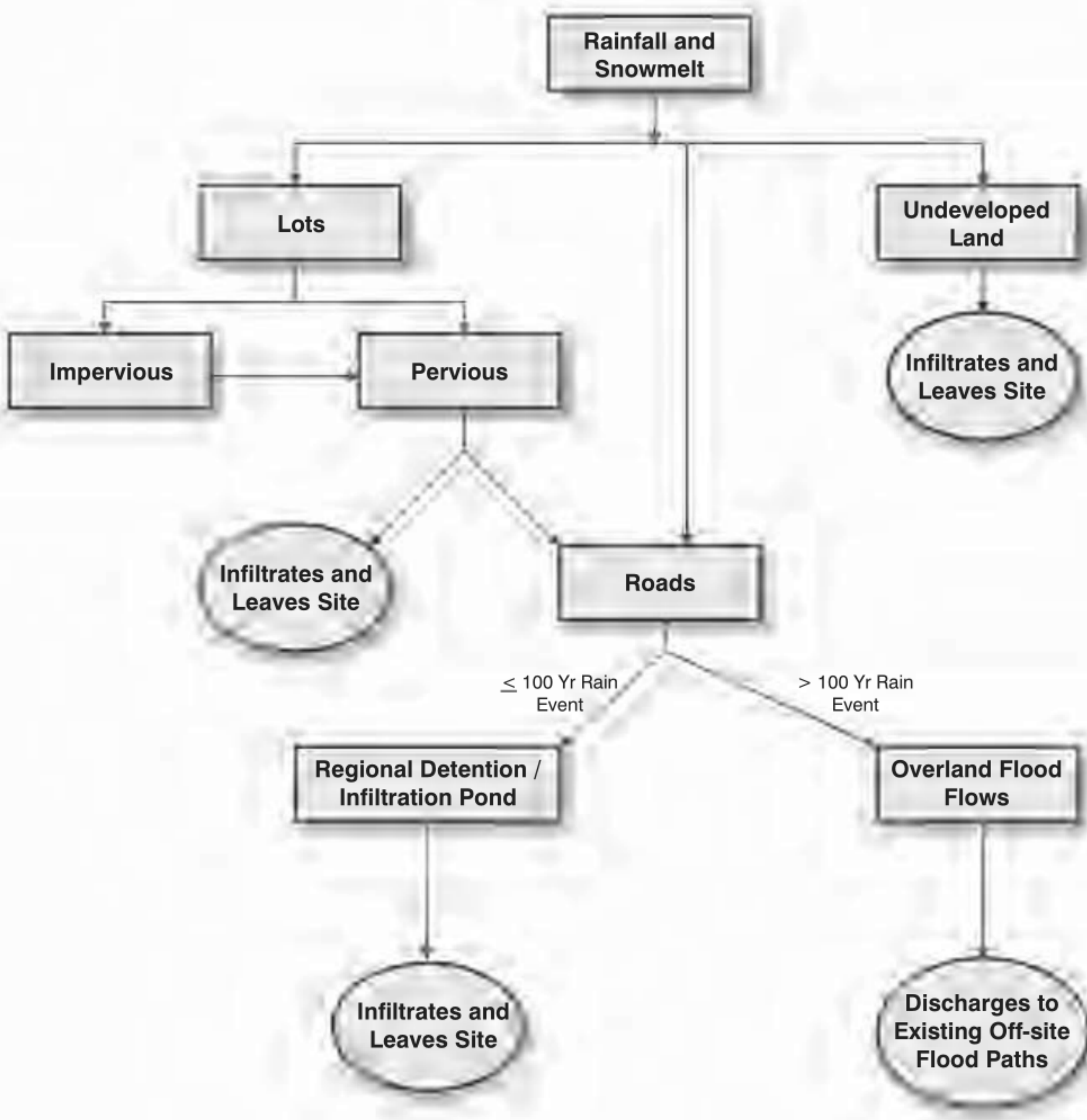

2329-002\500-Drawings\2329002Fig.CDR

Flow Chart for Drainage System Hydrology and Hydraulics (Un-Frozen Soil)

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

Figure 4

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: January 6, 2017

TO: Mr. Jim Pitre, Boss Creek Development
Ms. Desiree Lantenhammer, BSc, Ministry of Transportation and Infrastructure

CC: Mr. Nigel Hemingway, Cariboo Geographic Systems

FROM: Andrew Kolper, P.Eng.

RE: **BOSS CREEK DEVELOPMENT, ELECTORAL AREA 'C', VERNON, BC**
Bannister Property - Road B Extension
MoTI eDAS File No. 2014-0461
Our File 2329.003-300

1. Purpose and Context

The purpose of this memo is to provide the Ministry of Transportation and Infrastructure (MoTI) with culvert sizing and minimum total infiltration swale length for the proposed extension of Road B through the Bannister Property as part of the Boss Creek Development.

The Boss Creek Development lands are located within Electoral Area 'C' of the Regional District of North Okanagan (RDNO), on the west-facing slope of 'Vernon Hill', approximately 1.5 km east of the City of Vernon boundary. The development site is approximately 278 ha.

MoTI has previously voiced concern that the new roads of the proposed development will intercept what is effectively sheet flow, channelize it, and then discharge the concentrated runoff to areas which are not able to handle these flows. This memo will summarize the stormwater management system relating to the Road B extension as well as to provide further information to MoTI regarding how runoff generated by the proposed Road B will be treated. In addition, this memorandum provides information as to the sizing of the two culverts to direct flows from undeveloped portions of the property along their natural flowpaths within Gully B.

This memorandum should be read in conjunction with the *Addendum to the Stormwater Management Plan for Phase 1, KWL, May 2016,* the *Boss Creek Development Stormwater Management Plan, KWL, April 2016* as well as the *Boss Creek Pre-Development Site Drainage Conditions, KWL, November 2015.*

2. Stormwater Management Concept

The stormwater management concept for the Boss Creek Development site is intended to provide for disposal via infiltration for runoff generated from developed areas of the site and safe conveyance through the site for overland flow and snowmelt, discharging from the site in a manner that closely reflects the pre-development conditions.

The drainage system which includes road side ditches and infiltration swales on the upper portion of the development and infiltration galleries along the lower access road (currently an MoTI ROW), was designed to capture and effectively infiltrate storms up to and including the 100-year return period for all built impervious areas. In addition, culverts and defined overland flow paths will safely direct overland flow from undeveloped areas through the development and into the pre-development, natural drainage paths as shown in Figure 1 and further defined in the *Boss Creek Pre-Development Site Drainage Conditions, KWL, November 2015*. This approach has the benefit of mitigating downstream offsite impacts as the runoff is captured and infiltrated, for impervious areas, for all events up to and including the 100-year return period storm.

3. Site Hydrology

As part of the *Preliminary Stormwater Management Plan, KWL, November 2015*, KWL developed a hydrologic and hydraulic model using PCSWMM.

3.1 Runoff and Snowmelt

As in the pre-development condition, the largest design runoff from site post development occurs when the 100-year event happens on frozen ground and is also combined with snowmelt. In this scenario there will be no infiltration of runoff and additional runoff will be generated from the melting snow.

Rainfall intensities were calculated using a formula in the *City of Vernon Stormwater Management Policies and Design Manual (2002).* The average daily maximum snowmelt rate calculated using formulae in the *U.S. Army Corps of Engineers "Runoff from Snowmelt" Engineering Manual (EM 1110-2-1406, March 31, 1998* is combined with rainfall to produce winter runoff depths for conveyance design.

3.2 100-Year Modelled Flows

The site drainage was previously modelled using PCSWMM software for the above 100-year winter rainfall and snowmelt depths. A further model run was undertaken and runoff was analyzed at intersection of Road B and Gully "B" noted on Figure 1. As was the case previously, the 6-hour storm was found to be the governing duration, producing the highest peak flow.

A summary table detailing the required pipe size, expected peak flow, and outlet treatment to be used can be found in Table 2.

4. Stormwater Management

This section summarizes the overall stormwater management concept for the development site and includes how runoff from developed and undeveloped portions of the site will be managed.

4.1 Swales

As described in the *Preliminary Stormwater Management Plan, KWL, November 2015*, road runoff collected will be routed to infiltration swales. The swales will store the runoff generated from the proposed impervious areas up to and including the 100-year design event and allow it to infiltrate into the native soils over time. In addition, the design of these swales provides a volumetric factor of safety of 2.

During a storm event, runoff will flow down the roadside ditches and be directed into the swale using a check dam in the ditch to prevent water from continuing to flow along the road. In events in excess of the 100-year design event, the swale is designed and will be constructed such that it will fill up to the height of the check dam and any additional flow will overflow the check dam and be directed back down the road to the next swale or overland flow route. At no time should the swales overtop anywhere along their length.

The total length and volume of infiltration swale required for Road "B" is summarized in the table below

Table 1: Preliminary Runoff Volumes and Infiltration Swale Sizing

Storage	Catchment Area (m^2)	Runoff Volume (m^3)	Required Swale Length (m)			Description	
			1 m Swale Width	1.5 m Swale Width	2 m Swale Width	Drainage Type	Road
Road B	3,820	260	260	215	170	Ditch	Road B

4.2 Culverts

Both culverts direct flow from natural upstream flow paths, underneath linear infrastructure (roads & roadside ditches) and back towards their respective overland flow routes. Below is a summary of the each of the culverts to be constructed as part of the expansion of Road B.

Table 2: Culvert Summary Table

Culvert	Drawing Ref.	Drainage Area (ha)	Size (mm)	100-Yr Peak (m^3/s)	Outlet Type
1 (Gully B)	Figure 1 & C-502	111	2 x 825 ϕ	1.3	Apron

Culvert No. 1

This twinned 825 ϕ culvert captures flow from within Gully B and discharges it under Road B. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 2

This 600 ϕ culvert captures flow from a minor catchment upstream of Road B and discharges into Gully B. Flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path into Gully B.

4.3 Culvert Outlet Treatment

The outlet from the culvert shall have a treatment to minimize erosion on the downstream end of the culvert. As the culvert is being discharged to an existing gully (Gully B), a riprap apron will be constructed to provide energy dissipation. The riprap apron sizing is summarized in the table below.

Table 3: Riprap Apron Sizing

Culvert	Drawing Ref.	D50 (mm)	MoTI Riprap Class	Apron Length (m)	Apron Depth (m)	Width (apron end) (m)
1	Figure 1 C-101 & C-502	500	250	5	0.6	5

Riprap for the apron will conform to the *Riprap Design and Construction Guide, MOE, 2000*.

5. Summary

In summary, the stormwater management system includes road side ditches, infiltration swales and infiltration galleries to capture and effectively infiltrate storms up to, and including the 100-year return period for all built impervious areas. In addition, the stormwater management system includes culverts, natural draws and gullies as well as constructed diversions to capture and direct flow from undeveloped areas away from impervious areas and back into the natural flow paths to closely mimic the pre-development conditions.

The infiltration swales and galleries have been designed to capture and infiltrate the flows from the 100-year, 24-hour storm event. There has been a factor of safety of two (2) built into the design to allow for sedimentation and a reduction in infiltration rates over time and it is expected that, with engineering oversight during construction and minor periodic maintenance, the system will function as designed for the foreseeable future.

6. Closing

We trust the above meets the needs of Boss Creek Developments and the Ministry of Transportation and Infrastructure at this time. If you have any questions or require any further information, please do not hesitate to contact the undersigned at akolper@kwl.ca or by phone at 604-294-2088.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

PROFESSIONAL · PROVINCE · 2017-01-06 · A. J. KOLPER · # 30153 · BRITISH COLUMBIA · ENGINEER

Andrew Kolper, P.Eng.
Stormwater Engineer

Reviewed by:

Mark Forsyth, P.Eng.
Project Manager

AJK

Attachments:

Figure 1, Drawing C-101 and C-502

Statement of Limitations

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Revision History

Revision #	Date	Status	Revision Description	Author
0	January 6, 2017	Final	Original	AJK

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KERR WOOD LEIDAL
consulting engineers

Okanagan
202 - 3334 30th Avenue
Vernon, BC V1T 2C8
T 250 503 0841
F 250 503 0847

November 23, 2018

Desiree Lantenhammer, Development Approvals Technician
BC Ministry of Transportation and Infrastructure
4791 23rd Street
Vernon, BC V1T 4K9

Dear Ms. Lantenhammer:

RE: BOSS CREEK DEVELOPMENT – PHASE 1
Preliminary Layout Review – Civil Engineering Submittals
MoTI eDAS File # 2014-04061
KWL File 2329.003-170

This letter and attachments provide assurances related to the civil engineering design and construction aspects of the above development. The following points in MoTI's November 2, 2018 Preliminary Layout Review Summary (PLRS) are addressed.

- Item 2. Review and Update of the Stormwater Management Plan. The approach to stormwater management was developed over a period of years and was documented in several KWL Technical Memoranda (refer to PLRS Item 11). A detailed response to Item 2 is being prepared in two parts:
  1. An Operational Stormwater Management Plan for use by the future Boss Creek Road Society as the client. This OSWMP: describes the hydrology of the development site; presents the description, location and function of each component of the stormwater management and drainage systems; and provides monitoring and maintenance procedures and checklists.
  2. A post-construction Technical Memorandum that will consolidate and update the previous pre-construction Memoranda. This document will be completed for the Approving Officer as the client and will address the points listed in the PLRS Item 2. Regarding the questions presented in the PLRS Item 2, we provide the following observations:
     - KWL has had the opportunity to observe the actual drainage conditions on the development site, importantly through the extreme spring runoff conditions of spring 2017. The initial drainage infrastructure design has been revised to reflect the actual site runoff conditions.
     - The drainage system is functioning as intended. Modifications have been included in several areas to achieve two critical objectives: maintain natural conditions within each catchment area, and to minimize surface runoff to downslope properties. To the extent practical, measures have been taken to mitigate the spring runoff problems that have historically existed for some downslope properties.
     - Drainage is maintained within the catchments in which the precipitation fell. Drainage from precipitation on the natural areas of the site is routed via the natural flow paths to the various gulleys then off site. Drainage from paved roadways is routed to road shoulders and ditches for immediate infiltration, and any excess flow is routed to surface swales and buried cells for sub-surface infiltration.
     - Runoff from Road A paved and Road B gravel surfaces is routed to ten ground infiltration swales and three ground infiltration cells distributed throughout the Phase 1 development.

- We are not aware of any potential for landslide or debris flow other than the pre-development natural hazards outlined in the hazard assessments by Golder Associates. These areas are covered by no-build covenants.
- As with any physical modification to a development site, road work completed has altered the on-site pre-development surface flows. Prior to the Boss Creek development, this site had been logged and there was a network of logging, private access and recreational roads and trails throughout the site. To the extent practical, stormwater management works have been designed and constructed to mitigate potential adverse effects of the new roadworks and to maintain natural hydrologic conditions both on-site and off-site.

- Item 7. Common Access Route. The Common Access route through Phase 1 has been designed and constructed in accordance with the Bare Land Strata Access Route Design Criteria, with some variances pre-approved by MoTI (e.g., road base structure). Each lot created has access onto either public road or the constructed Common Lot road. The related Assurance of Construction document as well as the Ministry's Professional Assurance documents are completed and attached.

- Item 8. Common Lot Scope. The Common Lot 1 encompasses all cuts, fills and ditches and most of the drainage retention/detention facilities. All underground water, gas, hydro and tel works are fully contained within the public or Common Lot road areas. The infiltration and drainage facilities are for the most part located within and adjacent to the public and Common Lot roads. Due to the need to follow the natural topography, in some cases parts of the infiltration swales extend beyond the limits of the Common Lot. These are identified in the Operational Stormwater Management Plan as 'access areas' so that they can be protected and maintained, and the Road Society's authority to access the works is secured by a blanket easement over all development lots.

- Item 11. Stormwater Management Reports. The recommendations in the various stormwater management reports have been implemented, in some cases modified to improve runoff mitigation reflecting the actual site runoff conditions. As mentioned in Item 2 above, the noted stormwater management reports are being consolidated and updated to address the concerns with respect to downslope properties.

- Item 12. Detailed Site Plan for each lot. A draft site plan for each lot is attached. These plans show the areas for buildings, on-site wastewater fields, preliminary driveways, slope analysis, hazard and environmental covenant areas, and the lot area and perimeter characteristics of interest to RDNO Planning. Lot plans will be finalized when the survey of built driveways is received.

Further, we note as follows:

- An assurance letter is being submitted to RDNO Greater Vernon Water for waterworks; and
- Incomplete work-in-progress is identified on the attached Overview Completion Status Report. Further assurance of works completed will be by means of an issued update to that report.

Please advise of further information or clarifications required.

Yours truly,

KERR WOOD LEIDAL ASSOCIATES LTD.

Mike Nolan, MEng, PEng
Project Manager

Cc: Mr. Jim Pitre, Boss Creek Developments
Mr. Michael Blackwell, Fulton & Company

Encl.: MoTI Assurance of Construction of Private Access Route for Subdivision
MoTI Form H1251 Assurance of Coordination by Coordinating Professional Engineer
MoTI Form H1253 Assurance of Professional Design Post Construction
MoTI Form H1254 Assurance of Field Reviews and Compliance
Detailed Site Plans for each lot (16 sheets)
KWL Overview Completion Status Report – as at November 23, 2018

Assurance of Construction of Private Access Route for Subdivision

Project Name Boss Creek - Common Access Route

Location Regional District of North Okanagan - Area 'C'

Ministry File Number ________________ Date ________________

Design Drawing Reference Proj. # 2329-003 Boss Creek - Amended Phase 1 Drawing set

This is to advise that I am a Professional Engineer, registered with the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC), and was retained to undertake and coordinate all field reviews required with respect to construction of this project.

I am the engineer of record for this project and I have taken all steps as regulated under the Provincial Statute for my profession and required by good practice and by the definition of "field reviews", in order to issue the following assurance. As used herein, "field reviews" means such reviews of the access route construction at the project site (and/or the fabrication locations, where applicable) considered necessary by, and at the discretion of the Registered Professional Engineer.

I hereby give assurance that all aspects of construction of the access route have been reviewed, either by me or under my direction, and are to my satisfaction.

I assure that all aspects of the access route construction substantially conformed with the design plans and design criteria as previously submitted to and agreed to by the approving officer. In addition, any significant revisions to the accepted design plans have been documented and marked on the plans, and all have been noted in an "as-built" drawing set to be submitted to the approving officer.

Seal and Signature of Registered Professional Engineer.

Name of Professional Engineer (please print) Sven Rylandsholm

Date signed November 23, 2018

Address (please print) #202 - 3334 30th Ave, Vernon, BC V1T 2C8

Phone number: 250-503-5808

BRITISH COLUMBIA | Ministry of Transportation and Infrastructure

ASSURANCE OF COORDINATION BY COORDINATING PROFESSIONAL ENGINEER

PROJECT NO.	STRUCTURE NO.	DISTRICT	REGION
		Okanagan Shuswap	Southern Interior

PROJECT/STRUCTURE NAME
Boss Creek - Common Access Route

LOCATION / DESCRIPTION
Regional District of North Okanagan Area 'C'

To: Ministry of Transportation and Infrastructure
4791 23 Street
Vernon, BC V1T 4K9
Attention: Desiree Lantenhammer

Date: November 23, 2018

I hereby give assurance that:

1. I am a Professional Engineer[1] registered or licensed to practice in British Columbia;
2. I have been retained as the Coordinating Professional Engineer for the above Project/Structure and have coordinated the design work and field reviews[2] required for the Project/Structure;
3. I have relied upon the certifications of the Project/Structure Engineers of Record and Field Reviewers as listed below:
   a. Engineers of Record: Sven Rylandsholm, P.Eng., Civil
   b. Field Reviewers Bruce VanCalsteren, Ron Serne and Sven Rylandsholm - Civil
4. For those aspects of the Project/Structure work not certified by the Engineers of Record and Field Reviewers listed in paragraph 3 above, I am responsible for and have performed the design and field reviews and the coordination thereof and I provide separate assurance form(s)[3] under my signature, as appropriate;
5. I have utilized the standards of care, skill, and diligence that, in accordance with the standards of my profession, are required of experienced Professional Engineers in the Province of British Columbia; and
6. I hereby provide the assurance that:
   a. all parts of the design have been prepared, certified, and sealed by a Professional Engineer;
   b. Field Reviews have been conducted for each part of the design;
   c. Record Drawings ~~have been~~ will be produced, certified, and sealed by a Professional Engineer, once the survey of physical works is completed.
   d. all appropriate assurance forms[3] have been executed and delivered by each Engineer of Record and Field Reviewer; and
   e. the Project/Structure work as a whole substantially conforms to all applicable design and construction codes, guidelines, standards, and Project/Structure specifications.

KERR WOOD LEIDAL
consulting engineers

Okanagan
202 - 3334 30th Avenue
Vernon, BC V1T 2C8
T 250 503 0841
F 250 503 0847

bosscreek

Operational Stormwater Management Plan

Boss Creek Development – Phase 1

Electoral Area C, Vernon, BC

Final Report

January 31, 2019

KWL Project No. 2329.003

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1. Development Overview

This report provides operational information for the stormwater management and drainage system components within Phase 1 of the Boss Creek development ("Boss Creek"). The primary user of this document is intended to be the Boss Creek Road Society [1], which is responsible for the operation, monitoring and maintenance of the roads and drainage works.

Boss Creek is located within Electoral Area 'C' of the Regional District of North Okanagan. The west-facing forested slopes are locally known as 'Vernon Hill' and the lower rural agricultural area locally known as the 'South BX'. Road access to Boss Creek Phase 1 is from the eastern extent of McLeish Road off of East Vernon Road (McLeish Road extension). Secondary access is from Galiano Road.

The development lands comprise 268 hectares, and the Phase 1 subdivision divides the lands as follows:

22 ha	Common Lot 1 road
22 ha	Phase 1 development Lots 2 to 13
5 ha	Pre-existing rural residential homes on Lots 15 to 17
23 ha	Remainder Lot 14, and
195 ha	Remainder Lot 18.

The Phase 1 Subdivision Plan is contained in Appendix A as Figure 1.

Boss Creek Phase 1 road and drainage works are situated on both provincial public road and on the development's Common Lot 1 road. The extent of the public road right-of-way can be seen on the various Figures 1, 3 and 8 in Appendix A as a straight east extension of McLeish Road west of Phillips Road. The Common Lot 1 road veers north starting at 250 m uphill from the McLeish/Phillips intersection.

Significant attention has been paid to stormwater management planning, on-site roads and drainage design at Boss Creek, with the intent to implement best management practices such that post-development runoff from the property closely reflects the natural pre-development conditions. The development proceeded under the subdivision approval authority of the BC Ministry of Transportation and Infrastructure (MoTI) [2].

A series of stormwater management technical reports were prepared as part of the development approval and design process. They are superseded by this Operational Stormwater Management Plan (OSWMP).

The built roads and drainage infrastructure are shown on the Phase 1 Record Drawings [3].

Due to the role of the Boss Creek stormwater management system in mitigating off-site runoff it is important that the Road Society and Maintenance Operators understand the pre-development conditions and the purpose and function of the Boss Creek stormwater management works. The stormwater management works consist of the paved road surface, roadside ditches, culverts, off-road

[1] The Boss Creek Road Society was created for the purposes of managing the upkeep, maintenance and replacement of the Boss Creek roads and drainage systems located within or contiguous to Common Lot 1. Common Lot 1 is owned by the Owners of all lots within the Boss Creek development, with maintenance costs allocated amongst the Owners. The Owners are party to a Maintenance Agreement which sets out the responsibilities and cost allocation.

[2] MoTI eDAS File No. 2014-0461

[3] Boss Creek Development Ltd., Boss Creek (Amended Phase 1) Construction of Roads & Services, Contract No. 2329-003, Record Drawings (KWL, December 19, 2018)

detention and infiltration swales and buried infiltration cells. The components of the drainage system protect the integrity of the road structure and mitigate the changes to the local hydrology due to the development's roads.

Working together, the stormwater management works act to maintain the pre-development runoff conditions to off-site lands. It is the Road Society's responsibility to properly safeguard, monitor, operate and maintain the road and related drainage works such that the pre-development runoff conditions are maintained over the long-term. This report provides the background, asset inventory and operation and maintenance procedures so that the Road Society can achieve these objectives.

2. Hydrologic Context

2.1 Local and South BX Area

The Boss Creek lands are situated within a larger watershed area as shown in Figure 2. The western face of Vernon Hill and the Boss Creek lands are moderately to steeply sloped to the west, generally vegetated with second-growth coniferous forest, and crossed with historic skid roads and recreational trails. The natural runoff flows to downslope rural residential/agricultural lands via a number of draws which accumulate into several natural gullies. The Grey Canal (built circa 1920s) crosses the lower part of the development lands through Phase 1 in a north-south alignment, somewhat interrupting the natural downslope drainage. Remnants of the Grey Canal within Boss Creek now form part of the regional recreational trail network.

Field observations and geotechnical investigations indicate that on-site surface rock and soils are variable and generally permeable. Groundwater and interflow surfaces naturally at several locations across the 2.5 km width of the western base of the Boss Creek property. During significant rainfall events and spring snowmelt, the natural drainage channels become active and runoff from the slope occurs within the draws and gullies, and to the natural off-site downslope drainage routes.

Off-site local drainage infrastructure in the South BX consists of informal ditches located both on private properties and within the public roads. Most of the natural drainage courses and wetlands that were once prevalent in the area have been replaced with land infill, local roads and ditches.

Very little surface runoff occurs during average rainfall and snowmelt events. Occasionally however, roads and properties throughout the South BX at the base of Vernon Hill experience localized flooding during spring and early summer snowmelt periods, particularly after prolonged seasonal wet periods. The most serious recent flooding events were in 1996 and 2017, during which there was significant and prolonged runoff in all of the westerly gulleys of Vernon Hill. The Boss Creek on-site drainage works are not meant to have an influence on these types of natural runoff events.

2.2 Phase 1 Site Drainages

During small to medium storm events there is very little runoff evident and on-site gullies remain dry. During larger storm events, particularly when the ground is frozen, runoff is by sheet flow until it is intercepted by the draws, gullies and drainage infrastructure. Natural gullies convey the majority of runoff from the catchments within Phase 1 of the development as shown by the topography on Figures 1, 2 and 3.

This Operational Stormwater Management Plan refers to three gullies within Phase 1 - Gullies A, B and C. The hydrology of these gullies is described in the earlier reports (KWL, November 20, 2015).

The site drainage was modelled during design for the 100-year winter rainfall and snowmelt scenario. The following table summarizes the 100-year peak flows at several points of interest within Phase 1.

Table 1: Estimated Pre-Development 100-Year Peak Flows

Location	Catchment Area (ha)	Peak Flow (m^3/s)
Gulley A near the Road A Roundabout	16	0.21
North End of Intact Grey Canal	34	0.44
Gulley B Crossing at Road A	117	1.36
Gulley C Crossing at Road A	10	0.14

The Boss Creek on-site stormwater management works are intended to maintain the natural runoff conditions from these gullies. While the flows shown in the table may seem excessive to those unfamiliar with the long-term runoff behaviour of area, the spring freshet of 2017, for example, confirmed that the model predictions are representative of the flows that can be expected.

3. Stormwater Design Criteria

3.1 Conceptual Approach

Given the size of the project site, its west sloping terrain and the extent of its downslope boundary with adjacent lands, it was critical for proper site design, due diligence and for future reference that the natural pre-development runoff conditions be understood and documented. Given the size of this property it is a basic premise of the stormwater management plan that post-development runoff conditions emulate to the extent practical the pre-development runoff conditions. At the outset of development planning, enquiry to the local MoTI office indicated that MoTI does not maintain records of the drainage and runoff conditions from the site to the local roads and private properties.

The approach to developing the design criteria for the site included the following:

- Constructing a record of the pre-development drainage and runoff conditions in the local area. This included collection of anecdotal information from RDNO and MoTI staff and local residents.
- Following the MoTI *Supplement to TAC Geometric Design Guide* for guidance on stormwater management for subdivisions subject to MoTI review. Design elements addressed were storm mains and ditches for a 10- to 25-year return period event, and provision of detention to reduce the post-development peak runoff of the 5-year return period event to pre-development levels. The SWMP requires capturing and infiltrating storms up to the 100-year return period for all built impervious areas. This approach had the benefit of mitigating downstream offsite impacts due to the increased impervious area to the level of the 100-year return period storm.
- Recognizing that the preliminary SWMP would outline conceptual approaches and preliminary infiltration facility sizing based on conservative design criteria. During the detailed road design and construction phases close attention would be paid to location and sizing of the on-site road ditching, cross-culverts, infiltration swales and their overflow locations to reflect the observed natural drainage paths.
- Clearly distinguishing between two types of runoff:

  a) Natural Pre-Development Runoff – runoff that begins as sheet flow over undisturbed natural areas, collecting into the natural gullies, some of which may become ephemeral flows of several weeks or months duration; and

  b) Development-Influenced Runoff – runoff that begins as rainfall onto paved or gravel roads, or melting plowed snow accumulation, that ends up in roadside ditches and designed swales, ponds or infiltration cells.

  While the former runoff is intentionally left undisturbed, the stormwater management system components are designed to capture the development-influenced runoff and detain and/or infiltrate it so that these flows closely resemble the natural flow when leaving the development site.

3.2 Rainfall and Snowmelt

The largest runoff volume occurs when extreme rainfall occurs on frozen ground and is also combined with snowmelt. Snowmelt rates were calculated using formulae in the *U.S. Army Corps of Engineers Runoff from Snowmelt Engineering Manual* (EM 1110-2-1406, March 31, 1998). An average daily maximum snowmelt rate of 1.1 mm/hr was calculated based on the annual average wind speed for Vernon (11 km/hr) as well as the average daily maximum temperature during winter (Nov 1 to Mar 31) rainfall events (5.4°C, based on data from 1984-2004).

The average daily maximum rate is combined with rainfall to produce winter runoff depths for conveyance design. The average daily rate is used for retention and infiltration facility design and soil depth calculations because volume, not peak flow, is the critical parameter in the design of these items.

3.3 On-Lot Stormwater Management

The Phase 1 development lots are, on average, just about 2 hectares. Runoff from on-lot impervious surfaces will be managed within the individual lots. Impervious surfaces should be disconnected, and runoff should be dispersed and infiltrated on each lot, thereby reflecting the natural conditions.

It is anticipated that there will be minimal on-lot irrigation, likely limited to small lawn and garden areas near each house. As periods of on-lot irrigation would not likely coincide with the design rainfall or runoff periods of concern, it is not anticipated that on-lot irrigation will materially affect the drainage concepts or Common Lot 1 drainage facility sizing.

Requirements for on-lot management of runoff is incorporated in the *Boss Creek Property Design, Construction and Use Guidelines*. The requirement for private property owners to follow these drainage practices is through the development guidelines registered against the properties.

3.4 Natural Pre-Development Overland Flow Management

Natural overland flow from undeveloped areas is left undisturbed to the extent possible. Natural flow enters the development site from above and/or originates within the development site. This overland flow gathers in local gulleys and routed undisturbed directly through the development site in its natural channel or gulley.

Some of the on-site overland flow is captured in the upslope roadside ditches and directed to the local channels and gulleys or to the stormwater detention / infiltration works.

The stormwater management works are designed such that to the extent practical the post-development off-site flows closely match the pre-development conditions.

3.5 Development-Influenced Runoff Management

Road design and drainage best practices follow the *Bare Land Strata Access Route Design Criteria* issued by the Approving Officer, Okanagan Shuswap Highways District. In general, the Boss Creek on-site stormwater disposal systems are designed to retain and infiltrate the volume of water generated by road runoff from a 100-year 24-hour rainfall event. Runoff from lands above roads that is captured in ditches is returned to the natural channels via culverts at frequent intervals.

Road runoff is handled in two ways. Where the road is centre-crowned runoff from the downslope side of the road flows to the gravel shoulder providing energy dissipation and infiltration before sheet flowing over land to further infiltration into the surficial soils. Runoff from the upslope half of the road is collected in roadside drainage ditches. Where corner superelevation occurs there are upslope ditches and runoff from the impervious pavement width is captured in the roadside ditches. The runoff collected in the ditches is routed to locations where infiltration swales will store and infiltrate the volume of runoff from the roads to closely reflect pre-development conditions.

The roadside swales are flat-bottomed, usually formed from a partial cut into the slope and a berm on the downslope side of the swale. The swales store the runoff generated from the impervious areas during precipitation events and allow it to infiltrate into the native soils over time. The swale locations generally follow the land contour. The swale locations attempt to avoid bedrock near the surface, and to be away from building sites and on-site wastewater fields. Where possible, swales are located within the Common Lot 1, although due to topographical or geotechnical conditions some swales in Phase 1 are located all or in part on the Lots. In such cases there will be legal tenure to provide authority for the Road Society to enter and operate/maintain the facilities.

The road allowance is narrow in the lower portion of the road from the McLeish/Phillips Road intersection through the first northward curve, and about 200 m of this section is within a cut into the native till and rock. Underground infiltration cells / galleries are used in this area to retain and infiltrate runoff to minimize direct runoff to Gulley C and McLeish Road.

As with other areas on the site, this road cut intersects an upslope drainage area of about 2 ha. Runoff from the upslope tributary areas is diverted around the road to its natural pre-existing drainage path.

3.6 Infiltration

A preliminary geotechnical investigation program consisting of test pits and percolation tests was conducted by Golder Associates in July and August [4]. Soil profiles generally consist of 0.1 m to 0.5 m of topsoil underlain by 1 m to 2 m of dense sandy silt followed by very dense till or bedrock. A few deposits of sandier and clayey materials are scattered throughout the site. Estimated hydraulic conductivity for the surficial soils ranged from 46 mm/hr to 108 mm/hr.

In 2015, Fletcher Paine Associates Ltd. conducted a percolation test in a 3.4 m deep test pit at the site of the Trailhead Parking Lot within Phase 1. Based on this test, an average saturated hydraulic conductivity of 9 mm/hr was assumed for the soils at the parking area and within the deeper cuts at the site entrance along McLeish Road. This assumption is considered to be conservative, but appropriate given the variability of the site soils and the long-term role of the infiltration facilities. A hydraulic conductivity of 1.8 mm/hr was used for all infiltration calculations, as generally accepted standard practise to allow for a factor of safety of 5 when infiltrating major storm events.

The storage volumes for swales and infiltration components are sized to capture the 100-year 24-hour rain event with a snowmelt component for a runoff depth of 68 mm. The freeboard in the swales provide a volumetric factor of safety of 2 while the infiltration galleries at the Trailhead Parking Lot and along the lower road have a volumetric factor of safety of 1.5 to address the potential for multiple storm events.

[4] Preliminary Soils Investigation, Proposed Vernon Hill Ranch Development, Vernon, BC (Golder, September 2006)

4. Drainage Works

4.1 Asset Inventory and Purposes

A comprehensive inventory of the Phase 1 stormwater management components is contained in Appendix B. The Tables in Appendix B explain the location and purpose of each asset, as well as the related maintenance activities.

4.2 Asset Code System

A 'Descriptor-Phase-Item' code system is used to identify each drainage component on the drawings and in the tables:

Descriptor	Asset Type
DITCH	Roadside Ditch
CULV	Culvert
SWAL	Surface Infiltration Swale / Pond
MHCB	Manhole – Side-Inlet Catch Basin Style
MHSU	Manhole – Sump Style
DIVN	Gulley B Diversion Structure
CELL	Buried Stormwater Infiltration Cell
WORK	Work (Access) Area

Phase — '1' for all infrastructure in Phase 1

Item — 'A' then sequential

Example: The culvert under the McLeish Road extension at Gulley C is coded as 'CULV 1A'.

4.3 Engineering Drawings

Additional detail regarding the Boss Creek roads and utility services is shown on the project Record Drawings.

5. Operation and Maintenance

5.1 Operational Notes

This section explains the operation of the drainage infrastructure. For the most part, routine drainage works such as ditches and culverts do not require 'operation'. Maintenance requirements for all drainage assets are described in Appendix B.

The stormwater system components are briefly described below. For all components also refer to Section 5.2 and Appendix B for maintenance requirements.

Roads

As mentioned in Section 1, the access and internal roads and drainage works for the Boss Creek development are situated on both Provincial public and Common Lot 1 private lands:

- the Provincial McLeish Road extension: from the intersection of McLeish and Phillips Roads east approximately 250 m; and
- the Boss Creek Common Lot 1: from the Provincial road through the development lands.

Operation and maintenance of the Common Lot 1 roads and drainage works throughout, as well as those situated on McLeish Road, is the responsibility of Boss Creek Road Society.

The Road Society is also responsible for operation and maintenance of the drainage works located on the Provincial road (McLeish Road extension) east of Phillips Road. The Province and Road Society will establish an agreement regarding maintenance of the road works within the Provincial road section (e.g., snow plowing, sanding, asphalt repairs and shoulder maintenance).

Ditches

No specific 'operation' requirements.

Culverts

No specific 'operation' requirements.

Note that Figure 8 shows three Private Culverts, all located outside of the MoTI road right-of-way.

Infiltration Swales and Ponds

Figure 4 – Operation of Swales – indicates the typical features of the swales / ponds. In all cases at Boss Creek the swales act to store and detain a specific volume of water captured from road runoff, and to infiltrate the water slowly over time. The volumes are calculated to simulate the pre-development runoff rates.

Sump Manholes

No specific 'operation' requirements.

Gulley B Diversion Structure

Figure 5 – Operation of Gulley B Diversion Structure – indicates the features of this structure and related culverts and diversion piping. The only operational component is the 200 mm PVC diversion piping that acts to divert water to the detention / infiltration swales SWAL 1C.

The invert of the diversion pipe is set just below the concrete weir elevation, so that the 'first flow' is directed to the infiltration ponds. Setting the diversion flow is accomplished by adjusting the invert of the diversion pipe (turning the 90-degree elbow) and limiting the amount of flow being diverted (cap with hole on the elbow). Some adjustment will be required under actual conditions to determine the proper setting. Operation of this piped diversion should be such that:

- Under rainfall events when flow is entering CULVs 1L,M,N *only* from the roadside ditch: divert flow to the infiltration ponds only to the extent that they overflow back to Gulley B, with the excess (a small part of the flow) routing direct to Gulley B via the overflow weir; and
- Under runoff conditions when some or all of the flow entering CULVs 1L,M,N is originating from Gulley B: divert flow to the infiltration ponds and limit it only to the extent that the ponds overflow to Gulley B. In this case a large amount of water may be flowing direct to Gulley B via the overflow weir. Although this may be objectionable to downslope landowners, this is the natural pre-development flow condition.

Buried Infiltration Cells

Figures 6 and 7 – Operation of Buried Infiltration Cells illustrate the operational concepts for these works.

Again, while there are no specific 'operation' requirements, it is important to understand that the function of these works is to detain and infiltrate road runoff to closely match pre-development conditions. Long-term maintenance of these works is important to mitigate flows leaving the development site. In particular, this means taking all steps to prevent sediment from entering the buried infiltration cells.

5.2 Maintenance Requirements

Regular drainage system and stormwater component maintenance is required to effectively convey design flows, minimize flooding and erosion, and mitigate the impacts of development.

The Tables in Appendix B provide specific monitoring and preventative maintenance procedures and schedules.

In general:

- The drainage components should be inspected annually during low flow conditions, ideally in the spring so that identified problems can be addressed during the dry summer months. The primary purpose of the inspections is to assess the condition of the conveyance facilities for proper condition and operation, erosion, sediment accumulation and vegetation growth.
- An overall drainage system inspection should also be completed after major storm events, and during extended high flow spring runoff conditions.
- Conveyance ditches should be maintained to prevent the growth of weeds, small trees and brush. This needs to be done to maintain the hydraulic conveyance capacities of the ditches and to protect the road base from saturation.

- Remove sediment from sump manholes, detention swales and ponds.
- Remove debris from blocking hydraulic structures as this can cause re-routing of the surface flows and cause flooding problems.
- Inspect swales and ponds periodically during wet weather to observe function, clean sediment as required or when 10 to 15% of pool volume is lost. Inspect the structural and hydraulic components such as the culverts, berms, overflow weirs and slopes.

The tables in Appendix B outline the recommended maintenance activities, as well as checklists for maintenance records.

6. Summary

6.1 Long-Term Observation and Improvements

The drainage facilities for the Boss Creek Phase 1 development were designed and constructed based on accepted design guidelines and observations of actual rainfall, snowmelt and runoff patterns over several seasons. Even so, drainage facilities are subject to re-vegetation, erosion and sedimentation, and must be well maintained if they are to function as designed over a long period of time.

It is expected that Maintenance Operators will implement improvements and adjustments, especially during the first few operating seasons.

6.2 Key Points

The following items particular to the Boss Creek development site are noted to assist in the long-term operation and maintenance of the stormwater management facilities:

1. The site geotechnical conditions are quite variable, with some of the site soils being sensitive to sloughing and erosion once exposed, particularly to rain and/or heavy runoff. Exposed soil areas should be monitored and revegetated or otherwise made stable to prevent erosion and transfer of sediments to the infiltration facilities.
2. The ditches, infiltration swales, sump manholes and buried infiltration cells will accumulate sediment over time. It is critical that sediment accumulation be monitored, and sediment removed on a routine preventative maintenance basis, and when sediment is noted to accumulate.
3. It is particularly important that sediment accumulation be monitored and removed often from the sump manholes associated with the buried infiltration cells. Failure to do so will prematurely clog the cells resulting in ineffective detention and infiltration, and expensive rehabilitation.
4. The roadside drainage works should be clearly marked to prevent damage from snow removal equipment.
5. The drainage facilities located off the roads should be well-marked and cleared of vegetation several times per year. As some of these facilities are located on private property, the Road Society must be sure that the lot Owners either purposefully or inadvertently do not modify the drainage facilities.
6. Until such time as revegetation occurs, exposed soils along the road cuts and fill slopes may be subject to erosion. Further, upland parts of the site will be developed, and roads built in the later development phases. Accordingly, it is to be expected that the Phase 1 drainage works may experience change in their catchment hydrology and/or sedimentation due to soil erosion. All stormwater management facilities should be monitored for proper operation and hydrologic changes as later phases of the development take place.

7. Report Submission

Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

PROFESSIONAL ENGINEER
M. A. NOLAN
BRITISH COLUMBIA
2019.2.5

Mike Nolan, MEng, PEng
Project Manager

Reviewed by:

Mark Forsyth, PEng
Technical Reviewer

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Revision History

Revision #	Date	Status	Revision	Author
0	December 5, 2018	Draft	Issued for Phase 1 subdivision approval.	MN/MF
1	January 31, 2019	Final	Issued with Record Drawings	MN/MF

OQM CERTIFIED

Appendix A
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Figures

This Appendix contains the following Figures:

Figure	Name
1	Phase 1 Subdivision Plan
2	Watershed Overview
3	Phase 1 Stormwater Management Works
4	Operation of Infiltration Swales
5	Operation of Gulley B Diversion Structure
6	Operation of Buried Infiltration Cells (Lower)
7	Operation of Buried Infiltration Cells (Upper)
8	Drainage Assets – Road A (Sheet 1)
9	Drainage Assets – Road A (Sheet 2)
10	Drainage Assets – Road A (Sheet 3)

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Appendix B
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Inventory of Drainage Assets
and
Maintenance Requirements

This Appendix contains an inventory of drainage infrastructure assets and maintenance requirements for each asset type. Drainage Asset Types include:

Table	Descriptor	Asset Type
1	DITCH	Roadside Ditch
2	CULV	Culverts
3	SWAL	Surface Infiltration Swale / Pond
4	MHCB MHSU	Manhole – Side-Inlet Catch Basin Style Manhole – Sump Style
5	DIVN	Gulley B Diversion Structure
6	CELL	Buried Infiltration Cell
7	WORK	Work (Access) Area

Table 1: Ditches - Maintenance

Asset Number	Drawing Reference	Description	Maintenance Completed (date)
DITCH 1A	Fig. 8-11	Drainage at Boss Creek is by roadside ditches. Effective functioning of ditches is critical to protecting the road structure and overall stormwater management.	

Maintenance Activity	Frequency
a) Road Surfaces – The stormwater management plan is based on infiltrating road runoff in swales and buried cells. Always consider how to minimize sediment entering ditches (e.g.: accumulation of winter road sand should be captured by a sweeper truck rather than flushed into the ditches; vegetate erodible slopes).	
b) Fall Inspection - Mark sensitive items along ditch to prevent damage by snowplows. - Undertake work to prevent sediment entering manholes. - Repair erosion areas. - Remove accumulated debris or sloughing. - Ensure gravel support around electrical junction boxes. - Remove vegetation growth.	Every Fall following leaf fall and prior to snow and freezing temperatures.
c) Spring Inspection - Ensure ditches and culverts are clear of obstructions. - Undertake work to prevent sediment entering manholes. - Repair snowplow damage. - Repair erosion areas. - Remove accumulated debris or sloughing. - Ensure gravel support around electrical junction boxes.	Every Spring during snowmelt.
d) Heavy Rainstorm Inspection - Monitor and repair erosion. - Undertake work to prevent sediment entering manholes. - Monitor and take action to reduce flows leaving the Boss Creek site.	During and following major rainfall events.
e) Vegetation control - Remove vegetation growth through the growing season as required. - More frequent vegetation removal will prevent formation of root structures in the soil.	Routinely through the growing season.

Table 2: Culverts - Maintenance

Asset Number	Drawing Ref.	Description (field-confirm all prior to final report)	Maintenance Completed (date)
CULV 1A	Fig. 8	600 mm dia CSP – Gulley C natural drainage	
CULV 1B	Fig. 8	confirm	
CULV 1C	Fig. 8	300 mm Poly – minor, private property low point	
CULV 1D	Fig. 8	600 mm CSP – Gulley C natural drainage	
CULV 1E	Fig. 8	450 mm CSP – roadside ditch	
CULV 1F	Fig. 8	600 mm Poly – minor ditch diversion around vaults	
CULV 1G	Fig. 8	600 mm CSP – ditch MHCB 1G to SWAL 1C.	
CULV 1H	Fig. 8	300 m CSP – overflow from Lot 2 storm pond	
CULV 1I,J	Fig. 8	2 x 900 m CSP – Gulley B natural drainage. See note d) in Maintenance Activity table below.	
CULV 1K	Fig. 8	200 mm PVC – controlled diversion to SWAL 1C	
CULV 1L,M,N	Fig. 8	3 x 600 mm CSP – Gulley B natural drainage and roadside ditch runoff. See note d) in Maintenance Activity table below.	
CULV 1O	Fig. 9	600 mm CSP – Gulley A natural drainage	
CULV 1P	Fig. 9	600 mm CSP - MHCB 1H to SWAL 1D	
CULV 1Q	Fig. 9	600 mm CSP – upper ditch crossing to SWAL 1E	
CULV 1R	Fig. 9	450 mm CSP – roadside ditch crossing driveway	
CULV 1S	Fig. 9	600 mm CSP - roadside ditch crossing Road A	
CULV 1T	Fig. 9	450 mm CSP - roadside ditch crossing driveway	
CULV 1U	Fig. 9	600 mm CSP – ditch crossing Road A to SWAL 1D	
CULV 1V	Fig. 10	450 mm CSP - roadside ditch crossing driveway	
CULV 1W	Fig. 11	600 mm CSP – roadside ditch to SWAL 1I	
CULV 1X	Fig. 11	450 mm CSP - roadside ditch crossing driveway	
CULV 1Y	Fig. 11	1050 mm CSP – Gulley B natural drainage. See note d) in Maintenance Activity table below.	
CULV 1Z	Fig. 11	600 mm CSP - ditch crossing Road B to SWAL 1J	
CULV 1AA	Fig. 11	600 mm CSP - ditch crossing Road B to SWAL 1K	
Count	27 of		

Table 2: Culverts – Maintenance, continued

Maintenance Activity	Frequency
a) Fall Inspection - Mark culverts to prevent damage by snowplows. - Repair and armour erosion at inlets and outlets. - Remove accumulated debris and vegetation.	Every Fall following leaf fall and prior to snow and freezing temperatures.
b) Spring Inspection - Ensure unobstructed flow. - Repair snowplow damage. - Repair and armour erosion at inlets and outlets. - Remove accumulated debris and vegetation.	Every Spring during snowmelt.
c) Heavy Rainstorm Inspection - Ensure unobstructed flow. - Repair any erosion areas.	During and following major rainfall events.
d) Note: Although the culverts on Gulley B may appear to be oversized, 2017 runoff conditions proved the needed capacity of these culverts. Maintenance Operators and neighbouring landowners should be made aware of the potential high natural runoff flows in Gulley B. Pay particular attention to erosion at the outlets of culverts on Gulley B during and after large flow events.	
e) Note: Figure 8 indicates three “Private Culverts” where culverts are located on private property and serve only the needs of those properties’ driveways.	

Table 3: Surface Infiltration Swales / Ponds - Maintenance

Asset Number	Drawing Reference	Description	Maintenance Completed (date)
SWAL 1A	Fig. 8	Long cutoff / diversion swale intercepting hillside surface runoff away from the Road A cut slope, diverting back to the natural creek channel via CULV 1D. The N-S part is located on private property and the steep E-W part is on road r/w.	
SWAL 1B	Fig. 8	Detention / infiltration swale to capture runoff from the gravel Trailhead Parking Lot. Overflow to detention / stepped ditch to Road A ditch.	
SWAL 1C	Figs. 5, 8	A 2-pond detention / infiltration swale to capture road ditch runoff from above CULV 1LMN and CULV 1G. Controlled diversion from Gulley B to 1st detention pond. Return overflow from 2nd detention pond to Gulley B. Same components are on private property.	
SWAL 1D	Fig. 9	Large detention / infiltration swale located along old Grey Canal alignment below the Road A Roundabout. Captures road runoff from above Roundabout. Overflow to Grey Canal / trail.	
SWAL 1E	Fig. 9	Stepped detention / infiltration swale capturing upslope natural and roadside runoff. Overflow to Road A ditch.	
SWAL 1F	Fig. 9	Roadside stepped detention / infiltration swale capturing upslope runoff. Overflow to Road A ditch.	
SWAL 1G	Fig. 9	Stepped detention / infiltration swale capturing road runoff from CULV 1U. Overflow to Road A ditch	
SWAL 1H	Fig. 10	Roadside detention / infiltration swale capturing ditch and natural upslope runoff. Partly situated on private property by blanket easement in favour of Road Society.	
SWAL 1I	Fig. 11	Stepped detention / infiltration swale located at CULV 1W below Road A-B intersection. Captures natural upland and ditch. Overflow to natural gulley on Lot 8.	
SWAL 1J	Figs. 4, 11	Detention / infiltration swale at CULV 1Z. Captures natural upland and ditch flows. Overflow to Lot 14 to Gulley B. Partly situated on private property by blanket easement in favour of Road Society.	
SWAL 1K	Fig. 11	Detention / infiltration swale at CULV 1AA. Captures natural upland and ditch flows. Overflow to Lot 14. Partly situated on private property by blanket easement in favour of Road Society.	
Count	11 of		

Table 3: Surface Infiltration Swales / Ponds – Maintenance, continued

Maintenance Activity	Frequency
a) Note: swales and ponds must be maintained to prevent the growth of weeds, bushes and small trees. This is important in order to maintain the hydraulic conveyance, storage and infiltration capacities of these facilities. Inspect routinely, especially after large rainfall /runoff events.	Routinely, as needed.
b) Maintain the swale infiltration areas in a stable vegetated condition (low grasses). Remove any larger vegetation, shrubs and trees within the limits of the swales, ponds and WORK areas. More frequent vegetation removal will prevent formation of root structures in the soil.	Routinely through the growing season as required to limit growth of larger vegetation, shrubs and trees.
c) Remove sediment accumulated in the swales and ponds.	Annually.
d) Ensure that neighbouring property owners, utility crews and others working in the area are aware of the presence and purpose of the swales. Preferably, maintain signage indicating the areas of the swales.	Monitor.

Table 4: Sump Manholes - Maintenance

Asset Number	Drawing Reference	Description	Maintenance Completed (date)
MHCB 1A	Figs. 6, 8	Side-Inlet Sump Manhole. Inflow from Road A curb. Overflows when CELL 1A is full. Provides sediment capture.	
MHCB 1B	Figs. 6, 8	Side-Inlet Sump Manhole. Inflow from Road A curb to the westerly cell of CELL 1B. Overflows when CELL 1B is full. Provides sediment capture.	
MHCB 1C	Figs. 6, 8	Side-Inlet Sump Manhole. Inflow from Road A curb. Provides sediment capture.	
MHCB 1D	Figs. 7, 8	Side-Inlet Sump Manhole Inflow from Road A curb. Overflows to creek when CELL 1C is full. Provides sediment capture.	
MHSU 1E	Figs. 7, 8	Sump Manhole, purpose to provide additional sediment capture from Road A ditch along inside of corner. Inflow from Road A curb.	
MHCB 1F	Fig. 8	Side-Inlet Sump Manhole Inflow from Road A ditch along inside of corner cut. Provides important sediment capture from long inside corner ditch.	
MHCB 1G	Fig. 8	Side-Inlet Sump Manhole. Inflow from Road A ditch. Provides sediment capture.	
MHCB 1H	Fig. 9	Side-Inlet Sump Manhole. Inflow from Road A ditch. Provides sediment capture.	
Count	8 of		

Maintenance Activity	Frequency
a) Note: It is critical for long-term service life of the buried infiltration cells that sediment is routinely removed from the sump manholes MHCB 1A-D, F and MHSU 1E. Sediment should never be allowed to accumulate closer than 200 mm from bottom of the piping. Hire a vacuum truck service to clean sediment from all sump manholes connected to the buried infiltration cells (CELL 1A, B & C (total of 6 sump manholes).	At least twice per year: - Once late fall prior to applying road sand. - Once each spring to remove accumulated road sand. Between these times, monitor sediment accumulation and remove as needed.
b) Cleaned sediment from the other sump manholes MHCB 1G and 1H).	Annually.

Table 5: Gulley B Diversion Structure – Maintenance

Asset Number	Drawing Reference	Description	Maintenance Completed (date)
DIVN 1A	Figs. 5, 8	Reinforced concrete diversion structure located at outlet of CULVs 1LMN. Provides the following functions: - Energy dissipation and erosion protection at CULV 1LMN outlets; - Controlled flow diversion via CULV 1K to detention / infiltration SWAL 1C; - Sediment capture; and - Controlled direction of flow to CULVs 1IJ. See note a) in table below.	

Maintenance Activity	Frequency
a) Note: Although these series of culverts may appear to be oversized, 2017 runoff conditions proved the needed capacity of these culverts. Maintenance Operators and neighbouring landowners should be made aware of the potential high natural runoff flows in Gulley B.	
b) Note: Ensure protection of 200 mm dia pvc diversion pipe from vandalism and unwanted tampering. Note that diversion of flow from Gulley B to SWAL 1C must be monitored to ensure that excess water in not overflowing from SWAL 1C to Gulley B.	
c) Remove accumulated sediment from the diversion structure as needed.	Annually
d) Inspect around the concrete structure for erosion, particularly at the concrete overflow weir, and repair/armour erosion as needed.	Annually During and after major runoff events.

Table 6: Buried Stormwater Infiltration Cells - Maintenance

Asset Number	Drawing Reference	Description (confirm details for Final Report)	Maintenance Completed (date)
CELL 1A	Figs. 6, 8	Buried Infiltration Cell (1 cell) – Cell detention volume is approx 30 m^3 of water.	
CELL 1B	Figs. 6, 8	Buried Infiltration Cell (consists of a series of 3 cells, connected by inlet and outlet piping) - Cell detention volume is approx 155 m^3 of water.	
CELL 1C	Fig7. 7, 8	Buried Infiltration (consists of a series of 3 cells, connected by inlet and outlet piping) - Cell detention volume is approx 250 m^3 of water.	
Count	3 of		

Maintenance Activity	Frequency
a) See Note a) in Table 4.	
b) Maintain the areas over the infiltration cells in a stable, vegetated state, free of large shrubs or trees.	As needed.
c) Ensure that neighbouring property owners, utility crews and others working in the area are aware of the presence of the infiltration cells. Preferably, maintain signage indicating the areas of the cells.	Monitor.

Table 7: Work (Access) Areas - Maintenance

Asset Number	Drawing Reference	Description (confirm areas and tenure prior to Final Report)	Maintenance Completed (date)
Note: The Figures show WORK areas or ACCESS areas around all of the stormwater works located at roadside and on private property. These areas are necessary to ensure long term personnel and equipment access to the stormwater works. The tenure for these works (authority for the works and personnel access on private property) is by means of blanket easements in favour of the Road Society.			
WORK 1A	Fig. 8	Area around SWAL 1A. Partly located on private property.	
WORK 1B, C	Figs. 5, 8	Areas around DIVN 1A, CULV H, I, J, K and SWAL 1C.	
WORK 1D	Fig. 9	Area around SWAL 1E and CULV 1Q. Partly located on private property.	
WORK 1E	Fig. 9	Area around SWAL 1F. Partly located on private property.	
WORK 1F	Fig. 9	Area around SWAL 1G. Partly located on private property.	
WORK G	Fig. 10	Area around SWAL 1H. Partly located on private property.	
WORK 1H	Fig. 11	Area around SWAL 1J. Partly located on private property.	
WORK 1I	Fig. 11	Area around SWAL 1K. Partly located on private property.	
Count	9 of		

Maintenance Activity	Frequency
e) Maintain the WORK and ACCESS areas in a neat, tidy and stable vegetated condition (low grasses). Remove any larger vegetation, shrubs and trees. More frequent vegetation removal will prevent formation of root structures in the soil.	Routinely through the growing season.
a) Preferably, install and maintain signage to indicate limits of these areas.	As needed.

NOTES SHEET

Date: ____________________________

Recorded by: ___________________

/end

KERR WOOD LEIDAL
consulting engineers

Okanagan
202 - 3334 30th Avenue
Vernon, BC V1T 2C8
T 250 503 0841
F 250 503 0847

Memorandum

DATE: November 2, 2015

TO: Mr. Jim Pitre, Boss Creek Development Ltd.

COPY: Mr. Nigel Hemingway, Cariboo Geographic Systems

FROM: Andrew Kolper, P.Eng., KWL

RE: **BOSS CREEK DEVELOPMENT, ELECTORAL AREA 'C', VERNON, BC**
Preliminary Stormwater Management Plan for Phase 1
MoTI eDAS File No. 2014-0461
KWL File 2329.003-300

1. Purpose and Context

The purpose of this *Preliminary* Stormwater Management Plan (SMP) is to present the stormwater management approach and best practices proposed for the subject development. The approach presented has been developed through a series of discussions with Ministry of Transportation and Infrastructure (MoTI) staff over several years. Given the large scale and hillside nature of the development site, it has been agreed prudent by MOTI local development approval staff that a preliminary SMP and concepts should be presented ahead of the ultimate detailed design addressing the requirements outlined in the October 7, 2015 PLA. The PLA stormwater management conditions, and how they are addressed in the preliminary and final SMPs, are presented in the table appended to this memorandum. It is understood that the preliminary SMP presented herein satisfies best practices and the full intent of the PLA. Accordingly, we understand that the Applicant may request MOTI approval to proceed with rough road construction based on this preliminary plan and supporting geotechnical investigations.

In terms of context, the subject Boss Creek Development lands are located within Electoral Area 'C' of the Regional District of North Okanagan (RDNO), on the west-facing slope of 'Vernon Hill', about 1.5 km east of the City of Vernon boundary. The total site comprises about 278 ha, and it is understood that the final extent of land is subject to change. The site slopes and drains predominantly west. The northeast part of the property drains to Bate Creek, which in turn drains to BX Creek (See Figure 4).

Much of the property is in a natural state, although most of the land has been altered for logging, clearing, various development activities and the related road construction. There are some residential dwellings on the properties. Terrain at the site is generally steep and vegetative cover is mostly second-growth forest. Generally, drainage follows the natural topography, draws and gullies. There are, however, several linear features throughout the site which affect the natural drainage routing, including roads cut for historic access and clearing purposes, public roads and ditches (e.g., Galiano Road), and remnants of the Grey Canal (irrigation, in use early 1900s to mid-1960s). Field observations and geotechnical investigations indicate that soils are highly permeable, and it appears that little surface runoff occurs during average rainfall events.

Groundwater and interflow surfaces naturally at several locations across the 2.5 km width of the western base of the property. During significant rainfall events and spring snowmelt, the natural drainage channels become active and runoff from the slope occurs within the site draws and gullies, and to the natural off-site downslope drainages. During extreme events (e.g., June 1996 (date to be confirmed)) natural runoff in the channels across the base of the site has exceeded the capacity of the local rural roads and ditches, resulting in flood and erosion damage on public roads and private property. From aerial photographs and observations, it appears that over the years some private property owners have altered the natural drainage gullies and channels downstream west of the site.

The subject application for Phase 1 comprises 35.8 ha, with 12 Country Residential fee simple lots of average 1.7 ha, and Common Lot access road of 15.8 ha.

It is the intent of this SMP to implement best management practices such that post-development runoff from the property closely reflects the natural pre-development conditions. Given the extent of the rural area downslope to the west, it is beyond the scope of this SMP to address any existing off-site drainage limitations that may exist

2. Stormwater Management Concept

2.1 General Approach

The concepts and recommended approach herein is based on KWL project staff's familiarity with the site itself, as well as familiarity with the general drainage conditions prevalent in the North Okanagan.

Stormwater management planning for the Boss Creek Development site is intended to provide for safe conveyance of stormwater and snowmelt through the site and discharge it from the site in a manner that closely reflects the pre-development conditions. The proposed drainage system shall meet the requirements of MOTI as the approving authority for the subdivision.

The following issues are considered in the drainage design for the site:

- Given the size of the project site, its west sloping terrain and the extent of its downslope boundary with adjacent lands, it is critical for proper site design, due diligence and for future reference that the natural pre-development runoff conditions be understood and documented. Given the size of this property it is a basic premise of the stormwater management plan that post-development runoff conditions emulate to the extent practical the pre-development runoff conditions. Preliminary enquiry to the local MOTI staff indicates that MOTI does not maintain specific records of the drainage and runoff conditions from the site to the local roads and private properties. It is recommended that the applicant's due diligence includes constructing a record of the pre-development drainage and runoff conditions, and that such is provided to MOTI for review with the final SMP. Much of this documentation will likely come from anecdotal interviews with current and past MOTI and RDNO staff and private property owners.
- The MOTI *Supplement to TAC Geometric Design Guide,* Section 1000, includes guidance for stormwater management for subdivisions subject to MOTI review. Key elements to be addressed include design of storm sewers and ditches for a 10- to 25-year return period event, and provision of detention to reduce the post-development peak runoff of the 5-year return period event to pre-development levels. The SMP requires capturing and infiltrating storms up to the 100-year return period for all built impervious areas. This approach has the benefit of mitigating downstream offsite impacts due to the increased impervious area to the level of the 100-year return period storm.

- The site naturally drains toward the west for both pre- and post-development. Site drainage flows overland or discharges via ephemeral drainages from the site connect to existing drainage channels, gullies, ditches and creeks downstream and west of the site. Determining and evaluating the capacity of the off-site downstream drainage infrastructure is beyond the scope of this plan. The development SMP is focused on maintaining the current natural state.
- This preliminary SMP outlines conceptual approaches and preliminary infiltration facility sizing based on conservative design criteria. During the detailed road design stage it will be critical in emulating the pre-development conditions that close attention be paid to the on-site road ditching, and to the location of cross-culverts, infiltration swales and their overflow locations to the natural drainage ways.
- We have reviewed the PLA and created a table that outlines how we are planning on responding to each of MoTI's requirements as shown in Appendix A.

Except as mentioned in the Section 1 above, due to the high infiltration rate of the topsoil on the site there is generally no significant runoff from the land in its natural condition during small to medium storm events. The focus of the SMP therefore is runoff from the built impervious surfaces. The SMP requires capturing and infiltrating storms up to the 100-year return period for all built impervious areas. This approach has the benefit of mitigating downstream offsite impacts of the proposed impervious areas to the level of the 100-year return period storm.

At the time of preparation of this report the final road design and lot layout is in progress. Consequently, road, channel, pipe and lot boundary locations may change before final design and construction. In addition, further location-specific geotechnical investigations will be conducted to set the design criteria for and allow optimization of proposed infiltration works.

2.2 On-Lot Runoff Management

The proposed lots are, on average, just under 2 ha, and hence the runoff from on-lot impervious development is expected to be managed on the individual lots. Impervious surfaces will be disconnected and runoff will be dispersed and infiltrated on each lot, reflecting the natural conditions.

It is anticipated that there will be minimal on-lot irrigation, likely limited to small lawn and garden areas near each house. As periods of on-lot irrigation would not likely coincide with the design rainfall or runoff periods of concern, it is not anticipated that on-lot irrigation will materially affect the drainage concepts or facility sizing discussed in this SMP.

Requirements for on-lot management of runoff is incorporated in the *Boss Creek Property Design, Construction and Use Guidelines*. It is understood that the requirement for private property owners to follow these Guidelines will be via development guidelines and/or otherwise registered against the properties.

2.3 Road Runoff Management

It is understood that the roads within the Boss Creek Development will be owned jointly by the development's landowners, and maintained by a landowner society. A roads and drainage maintenance manual will be prepared to provide the society with direction on operation and maintenance. Road design and drainage best practices follow the *Bare Land Strata Access Route Design Criteria* issued by the Approving Officer, Okanagan Shuswap Highways District.

In general, the onsite stormwater disposal systems will be designed to retain and infiltrate the volume of water generated by road runoff from a 100-year 24-hour rainfall event. Runoff from lands above roads that is captured in ditches will be returned to the natural channels via culverts at frequent intervals

Post-development and road runoff will be handled in two ways. In the upper portion of the site where the road is crowned, runoff from the downslope side of the road will flow across a gravel shoulder providing some energy dissipation before sheet flowing over land to allow for infiltration into the surficial soils.

Runoff from the upslope half of the road will be collected in drainage ditches along the edge of the road on the upslope side. Where the corner superelevation occurs, there will be upslope ditches and the impervious pavement width will be captured in downslope roadside ditches. The runoff collected in the ditches will be routed to locations where infiltration swales will store and infiltrate the volume of runoff from the roads in order to closely reflect pre-development conditions. The swales will be flat-bottomed, formed from a partial cut into the slope and a berm on the downslope side of the swale. The swales will store the runoff generated from the proposed impervious areas during the design event and allow it to infiltrate into the native soils over time. The swale locations will follow the contour and will be located approximately as shown in Figure 1. The swale locations shown have been selected to avoid known bedrock near the surface, and be clear of building sites and on-site wastewater field sites. Final selection of the swale sites and their detailed design will also address the overflow condition and routing of overflow to the natural channels. Infiltration swales will generally be located on private property, and will be protected by restrictive covenant and/or easements in favour of the road maintenance society.

In the lower portion of the site, between the gate and trailhead parking area (Figures 1 and 2), drainage ditches will direct runoff towards an infiltration swale as well as an infiltration gallery in the parking area.

The area below the trailhead parking area to just above the intersection of McLeish and Phillips Roads is unique in that the road right-of-way is narrow, and about 200 m of this 450 m section will be within cut into underlying till and rock. Infiltration galleries will be used to retain and infiltrate runoff to minimize direct runoff to McLeish Road as presently occurs. As with other areas on the site, the road cut intersects an upslope drainage area, in this case estimated to be about 2.1 ha based on the high level site topographical work available to date (Figure 2). Runoff generated from the road will be collected in ditches, and through a combination of diversion of upslope runoff and capture of road runoff in infiltration. Runoff from the upslope tributary areas will be, if practicable, diverted around the road and into natural, pre-existing drainage paths.

3. Hydrology

3.1 Rainfall and Snowmelt

The largest runoff volume will occur when the 100-year event occurs on frozen ground and is also combined with snowmelt. In this scenario there will be no infiltration of runoff within the infiltration swales and additional runoff will be generated from the melting snow, while post construction impervious runoff is mitigated, runoff from undeveloped areas will continue to flow along the pre-existing drainage paths.

Snowmelt rates were calculated using formulae in the U.S. Army Corps of Engineers "Runoff from Snowmelt" Engineering Manual (EM 1110-2-1406, March 31, 1998).

An average daily maximum snowmelt rate of 1.1 mm/hr was calculated based on the annual average wind speed for Vernon (11 km/hr) as well as the average daily maximum temperature during winter (November 1 to March 31) rainfall events (5.4°C, based on data from 1984-2004).

The average daily maximum rate is combined with rainfall to produce winter runoff depths for conveyance design; this is due to the fact that the peak discharges are critical for storm sewer design. The average daily rate is used for retention and infiltration facility design and soil depth calculations because volume, not peak flow, is the critical parameter in the design of these items.

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Table 1 shows the rainfall and snowmelt runoff depths for different return period storm events.

Table 1: 24-Hour Precipitation Depths from *City of Vernon Stormwater Management Policies and Design Manual, 2002*

Return Period	Summer Rainfall Depth (mm)	Winter Rainfall and Snowmelt Depth (mm)
2-year (MAR)	21.8	48.2
5-year	27.2	53.6
10-year	30.7	57.1
25-year	35.2	61.6
50-year	38.5	64.9
100-year	41.8	68.2

1. Winter depths are calculated by adding 1.1 mm/hr snowmelt to the summer rainfall amounts.

3.2 Infiltration

A preliminary geotechnical investigation program consisting of test pits and percolation tests was conducted by Golder Associates in July and August, 2006 (*Preliminary Soils Investigation, Proposed Vernon Hill Ranch Development, Vernon, BC*. Golder Associates, Kelowna, BC, September 2006). Soil profiles generally consist of 0.1 m to 0.5 m of topsoil underlain by 1 m to 2 m of dense sandy silt followed by very dense till or bedrock. A few deposits of sandier and clayey materials are scattered throughout the site. Estimated hydraulic conductivity for the surficial soils ranged from 46 mm/hr to 108 mm/hr.

In 2015, Fletcher Paine Associates Ltd. conducted a percolation test in a 3.4 m deep test pit at the site of the proposed trailhead parking area within Phase 1. Based on this test, an average saturated hydraulic conductivity of 9 mm/hr was assumed for the soils at the parking area and within the deeper cuts at the site entrance along McLeish Road. This assumption is considered to be conservative, but appropriate at this preliminary stage given the level of uncertainty for the infiltration rate any given location on the site. A hydraulic conductivity of 1.8 mm/hr used for all infiltration calculations, as it is generally accepted standard practise to allow for a Factor of Safety of 5 when infiltrating major storm events.

As mentioned above, additional in-situ geotechnical exploration and testing will be undertaken to provide actual infiltration design criteria once the concepts herein are confirmed by MoTI, and the specific location of infiltration areas is better defined. Sizing of the infiltration galleries may change if the in-situ geotechnical test results differ from the average saturated hydraulic conductivity of 9 mm/hr as mentioned above. In addition, downslope migration of water from the infiltration galleries and swales will be addressed upon acceptance of the SMP.

4. Stormwater Disposal

The proposed stormwater management system has been sized to provide sufficient storage including freeboard, in both the infiltration swales and galleries, to capture the runoff from the roads which will discharge into the roadside ditches. The storage volumes are sized to capture the 100-year 24-hour rain event with a snowmelt component for a runoff depth of 68 mm. The freeboard in the swales provide a volumetric factor of safety of 2 while the infiltration galleries at the Trailhead Parking area and along the lower access road have a volumetric factor of safety of 1.5 to address the potential for multiple storm events. A factor of safety of 5 for hydraulic conductivity has been used to determine retention times within the infiltration galleries. Post-development catchment areas for the storage calculations were delineated using AutoCAD to provide the volumes of runoff for storage and infiltration

4.1 Infiltration Swales

The roads within the site have a rural cross section and drain to roadside ditches. The required size of infiltration swales to provide storage for each delineated catchment is summarized in Table 2. The infiltration swales will have a design water depth of 0.5 m with 2H:1V interior side slopes and 0.3 m of freeboard, providing a volumetric factor of safety of 2. The infiltration swales will extend off of the roadside ditches, following contours in order to have a flat base. Infiltration swales will be distributed throughout the development to ensure they are of a reasonable size and that runoff is retained close to where it is occurs to reflect pre-development conditions.

Table 2: Preliminary Runoff Volumes and Infiltration Swale Sizing

Storage	Catchment Area (m^2)	Runoff Volume (m^3)	Required Swale Length (m)			Description	
			1 m Swale Width	1.5 m Swale Width	2 m Swale Width	Drainage Type	Road
Parking Lot Storage	3,339	230	230	190	150	Ditch	Road A/ Parking Lot
Lower Access Road*	3,364	230 + upslope runoff	N/A Infiltration achieved via infiltration galleries below the road			Ditch	Road A
Swale 01	303	20.7	20.7	16.5	13.8	Ditch	Road D
Swale 02	842	57.5	57.5	46.0	38.3	Ditch	Road D
Swale 03	1,662	113.4	113.4	90.7	75.6	Ditch	Road A/D
Swale 04	1,267	86.4	86.4	69.1	57.6	Ditch	Road A
Swale 05	510	34.8	34.8	27.8	23.2	Ditch	Road A
Swale 06	356	24.3	24.3	19.4	16.2	Ditch	Road A
Swale 07	609	41.5	41.5	33.2	27.7	Ditch	Road A/B
Swale 08	2,163	147.5	147.5	118.0	98.4	Ditch	Road A
Swale 09	631	43.0	43.0	34.4	28.7	Ditch	Road A
Swale 10	953	65.0	65.0	52.0	43.3	Ditch	Road A
Swale 11	932	63.6	63.6	50.8	42.4	Ditch	Road A
Swale 12	617	42.1	42.1	33.7	28.1	Ditch	Road B

* Note that the catchment areas and hence runoff volumes shown for these sites include the surface water runoff from the upslope area. Although shown in this preliminary SMP to be captured and infiltrated within the roadway, this is not seen as the preferred approach for the final design. Alternative approaches to address drainage in this area should be investigated concurrent with review of this preliminary SMP.

Geotechnical considerations for the proposed swales were evaluated by Fletcher Paine Associates (October 7, 2015). In order for the swales to be stable they will be:

- Located where the ground slope is 2.75:1 or flatter for a minimum of 10 m downslope of the berm;
- Have cut slope above the swale of not steeper than 2.5:1 slope in soil; and
- Be limited to 0.8 m maximum depth, with design depth of 0.5 m water.

4.2 Trailhead Parking Area

The preliminary volume of runoff from the road and parking area combined to be stored and infiltrated using a combination of infiltration swale and infiltration/detention gallery at the trailhead parking area is 230 m^3.

Approximately 100 m^3 of the required 230 m^3 will be stored and infiltrated in an infiltration swale upslope of the parking area. An overflow will direct the remainder of the runoff to an infiltration gallery beneath the trailhead parking area.

Preliminary design is for a 650 m^2 infiltration area of the trailhead parking lot to be excavated to a depth of 2.5 m. This depth allows for a 1 m-thick storage layer of rock and a 1.5 m-depth of cover for frost protection. The storage layer will be constructed of clean, uniform-size crushed rock with an assumed porosity of 0.35. The total storage volume within the swale as well as the infiltration gallery will be 350 m^3 which is the total expected runoff volume produced during a 100-year 24-hour rainfall event plus a volumetric factor of safety of 1.5.

In addition, assuming no infiltration within the swale due to frozen ground conditions and an infiltration rate of 1.8 mm/hr as previously noted in Section 3.2 above, the 650 m^2 of surface area within the infiltration gallery should allow for approximately 30 m^3 of runoff to percolate into the soils over a 24 hour period, and the runoff volume should be able to infiltrate into the subsurface within 11 days.

4.3 Lower Access Road

The runoff generated on the lower access road (McLeish and Phillips to just below the trailhead parking area) as well as any runoff intercepted from the upslope catchment is proposed to be retained and infiltrated within a number of infiltration galleries located along the Lower Access Road. It should be noted that it is intended to intercept and divert any runoff from the undeveloped upslope catchment around the road cut and into the pre-existing natural drainage paths.

The volume of road runoff is 230 m^3 with an additional 850 m^3 required to be retained and infiltrated *if* the upslope catchment area is intercepted by the road cut (Figure 2). The actual tributary area here must be confirmed by local survey. Alternative means to intercept, retain and infiltrate this upslope area specific catchment should be investigated given the extent of the in-road infiltration approach discussed here.

Runoff generated by the 100-year 24-hour rainfall will be directed via roadside ditch to catch basins, where it will discharge into one of a number of infiltration galleries strategically located along the length of the road. A conceptual sketch of the stormwater system is shown on Figure 3.

The table in Figure 2 provides infiltration gallery sizing and potential locations based estimated runoff volumes and available space on site.

Based on the preliminary assumptions outlined, the total storage to be provided by the infiltration galleries is 1200 m^3 (850 m^3 from the upslope catchment and 350 m^3 for the runoff generated by the road). The infiltration galleries are estimated to provide infiltration of 110 m^3 during a 24-hour period, thus providing for full infiltration of the runoff volume generated by the road within 3.5 days.

5. Next Steps

As introduced in the opening section, this SMP is preliminary for the purposes of presenting the approach and obtaining review comments and concept approval from MoTI. In general the approach is considered to be well-aligned with MoTI design criteria and best practice, and design parameters are considered to be conservative at this stage.

We foresee the following next steps:

- MoTI review of this memorandum, and provision of concept approval and review comments.
- Boss Creek proceeding with documentation of the historic pre-development runoff conditions where drainage departs the site along its west boundary, and providing this to MoTI for review.
- Investigate alternative means to address capture and diversion of drainage from the 2.1 ha catchment above the road cut south of the trailhead parking lot.
- Location-specific geotechnical evaluation of stormwater infiltration rates will be completed to confirm infiltration rates required to optimize design of infiltration areas prior to detailed design.
- Final stormwater management plan and detailed design submissions.

6. Closing

We trust the above meets the needs of MOTI at this time. If you have any questions or require any further information, please do not hesitate to contact the undersigned at akolper@kwl.ca or by phone at 604-293-3277.

Yours truly,

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

PROFESSIONAL
PROVINCE OF
A. J. KOLPER
#39153
BRITISH COLUMBIA
ENGINEER

Andrew Kolper, P.Eng.
Stormwater Engineer

Reviewed by:

Craig Kipkie, M.Eng, P.Eng.
Technical Reviewer

Attachments: Appendix A – MoTI PLA Stormwater Management Plan Requirements
Appendix B - Figures 1 to 4

Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of Boss Creek Development Ltd., Vernon, BC. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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Revision History

Revision #	Date	Status	Revision Description	Author
0	November 2, 2015	Final	Final to client.	AJK

BOSS CREEK DEVELOPMENT, VERNON, BC
Preliminary Stormwater Management Plan for Phase 1
November 2, 2015

Appendix A – MoTI PLA Stormwater Management Plan Requirements[1]

MoTI PLA Stormwater Management Plan, Condition #10	How addressed in Preliminary SMP, Final SMP, Predesign Geotechnical Testing and Design Drawings
a) Sketch plan showing location of channels, cross-sections surveyed, erosion control features, test pits, permanent bench marks and cadastral information.	• Natural draws and gulleys, and preliminary locations of road ditches and location/sizing of infiltration swales shown. • Erosion control will follow standard ditch and infiltration basin design standards; details to be provided with detailed design submission. • Preliminary test pit and geotechnical assessment provided (Golder, 2006). • Survey plans provided, by others.
b) How surface and subsurface drainage from each lot will reach the nearest major drainage route.	• Preliminary plans attached to SMP.
c) How natural and future drainage from upstream lands draining into the proposed subdivision will be accommodated. The drainage system is to be designed to accommodate a 1:10 yr. storm (minor system) and a 1:100 yr. storm for overland flows (major system).	• Preliminary plan showing natural and future drainage from upslope of and throughout the site attached to SMP. • Preliminary SMP follows the noted drainage system design criteria.
d) Cross section details of the existing and proposed channels and all proposed erosion control features.	• Road and ditch cross section design follows MoTI *Bare Land Strata Access Route Design Criteria, Okanagan Shuswap District*.
e) A thalweg profile of the existing and proposed channels.	• Natural drainage channels will not be altered. Profiles of roads and ditches will be provided with detailed design. Preliminary road design is available on request.
f) Documentation of the characteristics of the native soils which exist along the proposed routes.	• Provided in attached preliminary site geotechnical report (Golder, 2006).
g) Explanation of design flow depths and velocity used in the design.	• Provided in preliminary SMP.
h) Documentation of proposed methods of erosion control.	• Per a) and d) above.
i) An assessment of the anticipated maintenance requirements for the channels and structures.	• Maintenance requirements for site roads, ditches, culverts and infiltration works will be contained in a maintenance manual written for the roads maintenance society.

[1] Ref, MoTI PLA, eDAS File # 2014-04061, dated Oct. 7, 2015, condition 10.

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Appendix B

Figures 1 - 4

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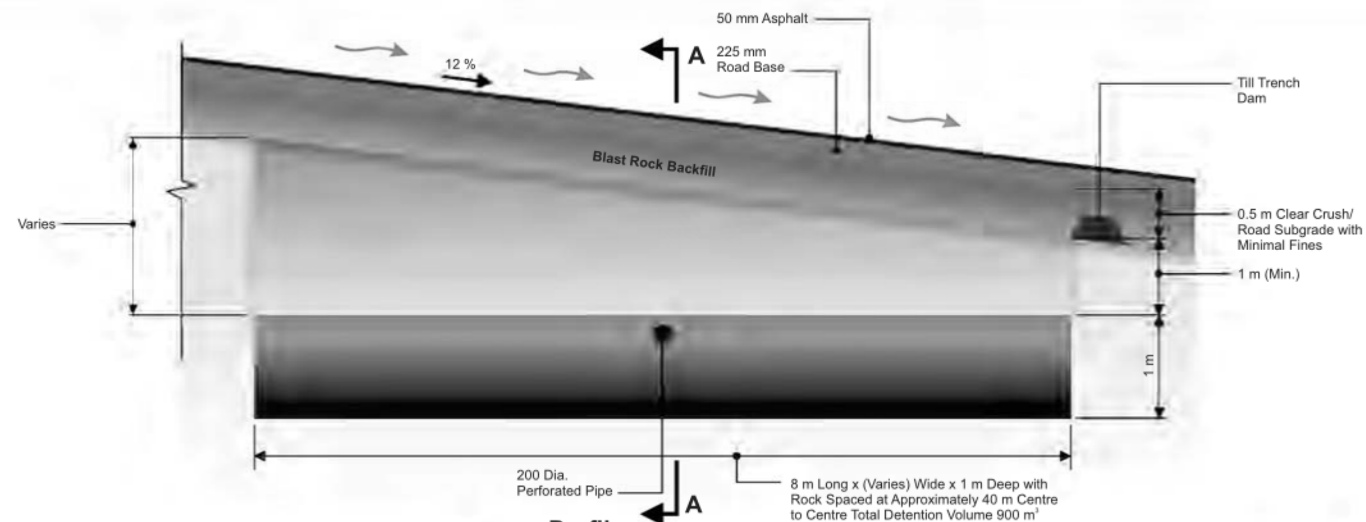

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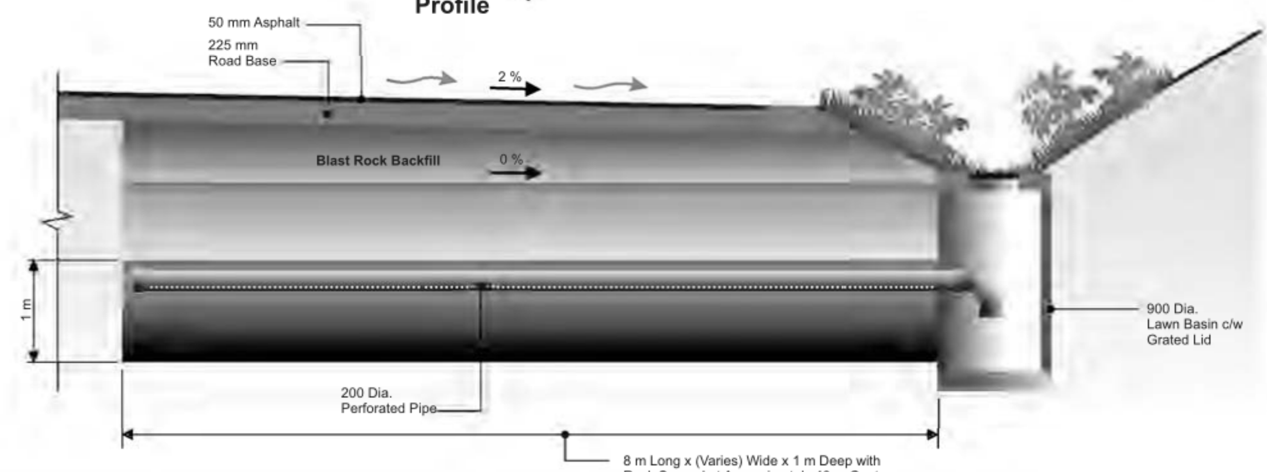

Section A-A

Project No. 2329-005
Date October 2015
Not to Scale

Lower Access Road Stormwater Management System

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Figure 3

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Okanagan
202 - 3334 30th Avenue
Vernon, BC V1T 2C8
T 250 503 0841
F 250 503 0847

Memorandum

DATE: April 6, 2016

TO: Mr. Jim Pitre, Boss Creek Development Ltd.

FROM: Andrew Kolper, P.Eng., KWL

RE: **BOSS CREEK DEVELOPMENT, ELECTORAL AREA 'C', VERNON, BC**
Stormwater Management Plan for Phase 1
MoTI eDAS File No. 2014-0461
KWL File 2329.003-300

1. Purpose and Context

The purpose of this Stormwater Management Plan (SMP) is to present the stormwater management approach and best practices proposed for the subject development. The approach presented has been developed through a series of discussions with Ministry of Transportation and Infrastructure (MoTI) staff over several years. Given the large scale and hillside nature of the development site, it has been agreed prudent by MOTI local development approval staff that a SMP and concepts should be presented ahead of the ultimate detailed design addressing the requirements outlined in the October 7, 2015 PLA. The PLA stormwater management conditions, and how they are addressed in the preliminary and final SMPs, are presented in the table appended to this memorandum. It is understood that the SMP presented herein satisfies best practices and the full intent of the PLA. Accordingly, we understand that the Applicant may request MOTI approval to proceed with rough road construction based on this plan and supporting geotechnical investigations.

In terms of context, the subject Boss Creek Development lands are located within Electoral Area 'C' of the Regional District of North Okanagan (RDNO), on the west-facing slope of 'Vernon Hill', about 1.5 km east of the City of Vernon boundary. The total site comprises about 278 ha, and it is understood that the final extent of land is subject to change. The site slopes and drains predominantly west. The northeast part of the property drains to Bate Creek, which in turn drains to BX Creek (See Pre-development Site Drainage Conditions Memo dated November 20, 2015).

Much of the property is in a natural state, although most of the land has been altered for logging, clearing, various development activities and the related road construction. There are some residential dwellings on the properties. Terrain at the site is generally steep and vegetative cover is mostly second-growth forest. Generally, drainage follows the natural topography, draws and gullies. There are, however, several linear features throughout the site which affect the natural drainage routing, including roads cut for historic access and clearing purposes, public roads and ditches (e.g., Galiano Road), and remnants of the Grey Canal (irrigation, in use early 1900s to mid-1960s). Field observations and geotechnical investigations indicate that soils are highly permeable, and it appears that little surface runoff occurs during average rainfall events.

Groundwater and interflow surfaces naturally at several locations across the 2.5 km width of the western base of the property. During significant rainfall events and spring snowmelt, the natural drainage channels become active and runoff from the slope occurs within the site draws and gullies, and to the natural off-site downslope drainages. During extreme events (e.g., June 1996 (date to be confirmed)) natural runoff in the channels across the base of the site has exceeded the capacity of the local rural roads and ditches, resulting in flood and erosion damage on public roads and private property. From aerial photographs and observations, it appears that over the years some private property owners have altered the natural drainage gullies and channels downstream west of the site.

The subject application for Phase 1 comprises 35.8 ha, with 12 Country Residential fee simple lots of average 1.7 ha, and Common Lot access road of 15.8 ha.

It is the intent of this SMP to implement best management practices such that post-development runoff from the property closely reflects the natural pre-development conditions. Given the extent of the rural area downslope to the west, it is beyond the scope of this SMP to address any existing off-site drainage limitations that may exist

2. Stormwater Management Concept

2.1 General Approach

The concepts and recommended approach herein is based on KWL project staff's familiarity with the site itself, as well as familiarity with the general drainage conditions prevalent in the North Okanagan.

Stormwater management planning for the Boss Creek Development site is intended to provide for safe conveyance of stormwater and snowmelt through the site and discharge it from the site in a manner that closely reflects the pre-development conditions. The proposed drainage system shall meet the requirements of MOTI as the approving authority for the subdivision. All construction of stormwater structures are to be within the road ROW and should not impact private property.

The following issues are considered in the drainage design for the site:

- Given the size of the project site, its west sloping terrain and the extent of its downslope boundary with adjacent lands, it is critical for proper site design, due diligence and for future reference that the natural pre-development runoff conditions be understood and documented. Given the size of this property it is a basic premise of the stormwater management plan that post-development runoff conditions emulate to the extent practical the pre-development runoff conditions. Enquiry to the local MOTI staff indicates that MOTI does not maintain specific records of the drainage and runoff conditions from the site to the local roads and private properties. It is recommended that the applicant's due diligence includes constructing a record of the pre-development drainage and runoff conditions, and that such is provided to MOTI for review with the final SMP. Much of this documentation will likely come from anecdotal interviews with current and past MOTI and RDNO staff and private property owners.
- The MOTI *Supplement to TAC Geometric Design Guide,* Section 1000, includes guidance for stormwater management for subdivisions subject to MOTI review. Key elements to be addressed include design of storm sewers and ditches for a 10- to 25-year return period event, and provision of detention to reduce the post-development peak runoff of the 5-year return period event to pre-development levels. The SMP requires capturing and infiltrating storms up to the 100-year return period for all built impervious areas. This approach has the benefit of mitigating downstream offsite impacts due to the increased impervious area to the level of the 100-year return period storm.

- The site naturally drains toward the west for both pre- and post-development. Site drainage flows overland or discharges via ephemeral drainages from the site connect to existing drainage channels, gullies, ditches and creeks downstream and west of the site. Determining and evaluating the capacity of the off-site downstream drainage infrastructure is beyond the scope of this plan. The development SMP is focused on maintaining the current natural state.
- This preliminary SMP outlines conceptual approaches and preliminary infiltration facility sizing based on conservative design criteria. During the detailed road design stage it will be critical in emulating the pre-development conditions that close attention be paid to the on-site road ditching, and to the location of cross-culverts, infiltration swales and their overflow locations to the natural drainage ways.
- We have reviewed the PLA and created a table that outlines how we are planning on responding to each of MoTI's requirements as shown in Appendix A.

Except as mentioned in the Section 1 above, due to the high infiltration rate of the topsoil on the site there is generally no significant runoff from the land in its natural condition during small to medium storm events. The focus of the SMP therefore is runoff from the built impervious surfaces. The SMP requires capturing and infiltrating storms up to the 100-year return period for all built impervious areas. This approach has the benefit of mitigating downstream offsite impacts of the proposed impervious areas to the level of the 100-year return period storm.

At the time of preparation of this report the final road design and lot layout is in progress. Consequently, road, channel, pipe and lot boundary locations may change before final design and construction. In addition, further location-specific geotechnical investigations will be conducted to set the design criteria for and allow optimization of proposed infiltration works.

2.2 On-Lot Runoff Management

The proposed lots are, on average, just under 2 ha, and hence the runoff from on-lot impervious development is expected to be managed on the individual lots. Impervious surfaces will be disconnected and runoff will be dispersed and infiltrated on each lot, reflecting the natural conditions.

It is anticipated that there will be minimal on-lot irrigation, likely limited to small lawn and garden areas near each house. As periods of on-lot irrigation would not likely coincide with the design rainfall or runoff periods of concern, it is not anticipated that on-lot irrigation will materially affect the drainage concepts or facility sizing discussed in this SMP.

Requirements for on-lot management of runoff is incorporated in the *Boss Creek Property Design, Construction and Use Guidelines*. It is understood that the requirement for private property owners to follow these Guidelines will be via development guidelines and/or otherwise registered against the properties.

2.3 Road Runoff Management

The roads within the Boss Creek Development will be owned jointly by the development's landowners, and maintained by a landowner society. A roads and drainage maintenance manual will be prepared to provide the society with direction on operation and maintenance. Road design and drainage best practices follow the *Bare Land Strata Access Route Design Criteria* issued by the Approving Officer, Okanagan Shuswap Highways District.

In general, the onsite stormwater disposal systems will be designed to retain and infiltrate the volume of water generated by road runoff from a 100-year 24-hour rainfall event. Runoff from lands above roads that is captured in ditches will be returned to the natural channels via culverts at frequent intervals

Post-development and road runoff will be handled in two ways. In the upper portion of the site where the road is crowned, runoff from the downslope side of the road will flow across a gravel shoulder providing some energy dissipation before sheet flowing over land to allow for infiltration into the surficial soils.

Runoff from the upslope half of the road will be collected in drainage ditches along the edge of the road on the upslope side. Where the corner superelevation occurs, there will be upslope ditches and the impervious pavement width will be captured in downslope roadside ditches. The runoff collected in the ditches will be routed to locations where infiltration swales will store and infiltrate the volume of runoff from the roads in order to closely reflect pre-development conditions. The swales will be flat-bottomed, formed from a partial cut into the slope and a berm on the downslope side of the swale. The swales will store the runoff generated from the proposed impervious areas during the design event and allow it to infiltrate into the native soils over time. The swale locations will follow the contour and will be located approximately as shown in Figure 1. The swale locations shown have been selected to avoid known bedrock near the surface, and be clear of building sites and on-site wastewater field sites. Final selection of the swale sites and their detailed design will also address the overflow condition and routing of overflow to the natural channels. Infiltration swales will generally be located on private property, and will be protected by restrictive covenant and/or easements in favour of the road maintenance society.

The area below the trailhead parking area to just above the intersection of McLeish and Phillips Roads is unique in that the road right-of-way is narrow, and about 200 m of this 450 m section will be within cut into underlying till and rock. Infiltration galleries will be used to retain and infiltrate runoff to minimize direct runoff to McLeish Road as presently occurs. As with other areas on the site, the road cut intersects an upslope drainage area, in this case estimated to be about 2.1 ha. Runoff generated from the road will be collected in ditches, and through a combination of diversion of upslope runoff and capture of road runoff in infiltration. Runoff from the upslope tributary areas will be, if practicable, diverted around the road and into natural, pre-existing drainage paths.

3. Hydrology

3.1 Rainfall and Snowmelt

The largest runoff volume will occur when the 100-year event occurs on frozen ground and is also combined with snowmelt. In this scenario there will be no infiltration of runoff within the infiltration swales and additional runoff will be generated from the melting snow, while post construction impervious runoff is mitigated, runoff from undeveloped areas will continue to flow along the pre-existing drainage paths.

Snowmelt rates were calculated using formulae in the U.S. Army Corps of Engineers “Runoff from Snowmelt” Engineering Manual (EM 1110-2-1406, March 31, 1998).

An average daily maximum snowmelt rate of 1.1 mm/hr was calculated based on the annual average wind speed for Vernon (11 km/hr) as well as the average daily maximum temperature during winter (November 1 to March 31) rainfall events (5.4°C, based on data from 1984-2004).

The average daily maximum rate is combined with rainfall to produce winter runoff depths for conveyance design; this is due to the fact that the peak discharges are critical for storm sewer design. The average daily rate is used for retention and infiltration facility design and soil depth calculations because volume, not peak flow, is the critical parameter in the design of these items.

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Table 1 shows the rainfall and snowmelt runoff depths for different return period storm events.

Table 1: 24-Hour Precipitation Depths from *City of Vernon Stormwater Management Policies and Design Manual, 2002*

Return Period	Summer Rainfall Depth (mm)	Winter Rainfall and Snowmelt Depth (mm)
2-year (MAR)	21.8	48.2
5-year	27.2	53.6
10-year	30.7	57.1
25-year	35.2	61.6
50-year	38.5	64.9
100-year	41.8	68.2

1. Winter depths are calculated by adding 1.1 mm/hr snowmelt to the summer rainfall amounts.

3.2 Infiltration

A preliminary geotechnical investigation program consisting of test pits and percolation tests was conducted by Golder Associates in July and August, 2006 (*Preliminary Soils Investigation, Proposed Vernon Hill Ranch Development, Vernon, BC*. Golder Associates, Kelowna, BC, September 2006). Soil profiles generally consist of 0.1 m to 0.5 m of topsoil underlain by 1 m to 2 m of dense sandy silt followed by very dense till or bedrock. A few deposits of sandier and clayey materials are scattered throughout the site. Estimated hydraulic conductivity for the surficial soils ranged from 46 mm/hr to 108 mm/hr.

In 2015, Fletcher Paine Associates Ltd. conducted a percolation test in a 3.4 m deep test pit at the site of the proposed trailhead parking area within Phase 1. Based on this test, an average saturated hydraulic conductivity of 9 mm/hr was assumed for the soils at the parking area and within the deeper cuts at the site entrance along McLeish Road. This assumption is considered to be conservative, but appropriate at this preliminary stage given the level of uncertainty for the infiltration rate any given location on the site. A hydraulic conductivity of 1.8 mm/hr used for all infiltration calculations, as it is generally accepted standard practise to allow for a Factor of Safety of 5 when infiltrating major storm events.

As mentioned above, additional in-situ geotechnical exploration and testing will be undertaken to provide actual infiltration design criteria once the concepts herein are confirmed by MoTI, and the specific location of infiltration areas is better defined. Sizing of the infiltration galleries may change if the in-situ geotechnical test results differ from the average saturated hydraulic conductivity of 9 mm/hr as mentioned above. In addition, downslope migration of water from the infiltration galleries and swales will be addressed upon acceptance of the SMP.

4. Stormwater Disposal

The proposed stormwater management system has been sized to provide sufficient storage including freeboard, in both the infiltration swales and galleries, to capture the runoff from the roads which will discharge into the roadside ditches. The storage volumes are sized to capture the 100-year 24-hour rain event with a snowmelt component for a runoff depth of 68 mm. The freeboard in the swales provide a volumetric factor of safety of 2 while the infiltration galleries at the Trailhead Parking area and along the lower access road have a volumetric factor of safety of 1.5 to address the potential for multiple storm events. A factor of safety of 5 for hydraulic conductivity has been used to determine retention times within the infiltration galleries. Post-development catchment areas for the storage calculations were delineated using AutoCAD to provide the volumes of runoff for storage and infiltration

4.1 Infiltration Swales

The roads within the site have a rural cross section and drain to roadside ditches. The required size of infiltration swales to provide storage for each delineated catchment is summarized in Table 2. The infiltration swales will have a design water depth of 0.5 m with 2H:1V interior side slopes and 0.3 m of freeboard, providing a volumetric factor of safety of 2. The infiltration swales will extend off of the roadside ditches, following contours in order to have a flat base. Infiltration swales will be distributed throughout the development to ensure they are of a reasonable size and that runoff is retained close to where it is occurs to reflect pre-development conditions.

Table 2: Preliminary Runoff Volumes and Infiltration Swale Sizing

Storage	Catchment Area (m^2)	Runoff Volume (m^3)	Required Swale Length (m)			Description	
			1 m Swale Width	1.5 m Swale Width	2 m Swale Width	Drainage Type	Road
Parking Lot Storage	3,339	230	230	190	150	Ditch	Road A/ Parking Lot
Lower Access Road*	3,364	230 + upslope runoff	N/A Infiltration achieved via infiltration galleries below the road			Ditch	Road A
Swale 01	303	20.7	20.7	16.5	13.8	Ditch	Road D
Swale 02	842	57.5	57.5	46.0	38.3	Ditch	Road D
Swale 03	1,662	113.4	113.4	90.7	75.6	Ditch	Road A/D
Swale 04	1,267	86.4	86.4	69.1	57.6	Ditch	Road A
Swale 05	510	34.8	34.8	27.8	23.2	Ditch	Road A
Swale 06	356	24.3	24.3	19.4	16.2	Ditch	Road A
Swale 07	609	41.5	41.5	33.2	27.7	Ditch	Road A/B
Swale 08	2,163	147.5	147.5	118.0	98.4	Ditch	Road A
Swale 09	631	43.0	43.0	34.4	28.7	Ditch	Road A
Swale 10	953	65.0	65.0	52.0	43.3	Ditch	Road A
Swale 11	932	63.6	63.6	50.8	42.4	Ditch	Road A
Swale 12**	617	42.1	42.1	33.7	28.1	Ditch	Road B

* Note that the catchment areas and hence runoff volumes shown for these sites include the surface water runoff from the upslope area. Although shown in this preliminary SMP to be captured and infiltrated within the roadway, this is not seen as the preferred approach for the final design. Alternative approaches to address drainage in this area should be investigated concurrent with review of this preliminary SMP.
** Road B will not be constructed as part of Phase 1

Geotechnical considerations for the proposed swales were evaluated by Fletcher Paine Associates (October 7, 2015). In order for the swales to be stable they will be:

- Located where the ground slope is 2.75:1 or flatter for a minimum of 10 m downslope of the berm;
- Have cut slope above the swale of not steeper than 2.5:1 slope in soil; and
- Be limited to 0.8 m maximum depth, with design depth of 0.5 m water.

4.2 Trailhead Parking Area

The preliminary volume of runoff from the road and parking area combined to be stored and infiltrated using a combination of infiltration swale and infiltration/detention gallery at the trailhead parking area is 230 m^3.

Approximately 100 m^3 of the required 230 m^3 will be stored and infiltrated in an infiltration swale upslope of the parking area. An overflow will direct the remainder of the runoff to an infiltration gallery beneath the trailhead parking area.

Preliminary design is for a 650 m^2 infiltration area of the trailhead parking lot to be excavated to a depth of 2.5 m. This depth allows for a 1 m-thick storage layer of rock and a 1.5 m-depth of cover for frost protection. The storage layer will be constructed of clean, uniform-size crushed rock with an assumed porosity of 0.35. The total storage volume within the swale as well as the infiltration gallery will be 350 m^3 which is the total expected runoff volume produced during a 100-year 24-hour rainfall event plus a volumetric factor of safety of 1.5.

In addition, assuming no infiltration within the swale due to frozen ground conditions and an infiltration rate of 1.8 mm/hr as previously noted in Section 3.2 above, the 650 m^2 of surface area within the infiltration gallery should allow for approximately 30 m^3 of runoff to percolate into the soils over a 24 hour period, and the runoff volume should be able to infiltrate into the subsurface within 11 days.

During construction we will be exploring the possibility to store all of the water at the trailhead parking area in an open infiltration swale as opposed to the storage area under the parking lot.

4.3 Lower Access Road

The runoff generated on the lower access road (McLeish and Phillips to just below the trailhead parking area) as well as any runoff intercepted from the upslope catchment is proposed to be retained and infiltrated within a number of infiltration galleries located along the Lower Access Road. It should be noted that it is intended to intercept and divert any runoff from the undeveloped upslope catchment around the road cut and into the pre-existing natural drainage paths.

The volume of road runoff is 230 m^3. We intend to intercept the water that would naturally be caught by the road between the parking lot and the McLeish ROW. This is illustrated on drawing C-107 of the Approvals Set. This intercepted water will be routed through the site and directed down the natural channel as if the road had not been constructed.

Runoff generated by the 100-year 24-hour rainfall will be directed via roadside ditch to catch basins, where it will discharge into one of a number of infiltration galleries strategically located along the ROW. This is illustrated on drawings C-102 and C-503.

Based on the preliminary assumptions outlined, the total storage to be provided by the infiltration galleries is 320 m^3. The infiltration galleries are estimated to provide infiltration of 110 m^3 during a 24-hour period, thus providing for full infiltration of the runoff volume generated by the road within 3.5 days. We consider the infiltration rates to be conservative based on materials that have been viewed on site but not tested.

The infiltration galleries proposed are expected to have a life span of at least 25-30 years. Maintenance will be required annually and after each event exceeding a two-year return period. Maintenance should consist of checking and cleaning of the catch basins.

The infiltration gallery design has been reviewed by a geotechnical professional with Tetratech. Tetratech had no concerns with the proposed design. Water that is infiltrated next to the road should not affect the durability or load carrying capacity of the road structure.

We do not expect groundwater to be an issue for the infiltration galleries as there has been no indication of a high groundwater table in the area that we propose the galleries. If the ground becomes saturated during a significant storm event the galleries will also fill up. Since the galleries are designed to contain the 100 year storm event, anything larger would be expected to bypass the galleries and continue down the natural drainage path.

5. Closing

We trust the above meets the needs of MOTI at this time. If you have any questions or require any further information, please do not hesitate to contact the undersigned at akolper@kwl.ca or by phone at 604-293-3277.

Yours truly,

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

For

Andrew Kolper, P.Eng.
Stormwater Engineer

Reviewed by:

Craig Kipkie, M.Eng, P.Eng.
Technical Reviewer

Attachments: Appendix A – MoTI PLA Stormwater Management Plan Requirements
Appendix B - Figure 1

Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of Boss Creek Development Ltd., Vernon, BC. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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Revision History

Revision #	Date	Status	Revision Description	Author
0	November 2, 2015	Final	Final to client.	AJK
1	April 6, 2016	Final	Final to client.	AJK

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c) How natural and future drainage from upstream lands draining into the proposed subdivision will be accommodated. The drainage system is to be designed to accommodate a 1:10 yr. storm (minor system) and a 1:100 yr. storm for overland flows (major system).	• Preliminary plan showing natural and future drainage from upslope of and throughout the site attached to SMP. • Preliminary SMP follows the noted drainage system design criteria.
d) Cross section details of the existing and proposed channels and all proposed erosion control features.	• Road and ditch cross section design follows MoTI *Bare Land Strata Access Route Design Criteria, Okanagan Shuswap District*.
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f) Documentation of the characteristics of the native soils which exist along the proposed routes.	• Provided in attached preliminary site geotechnical report (Golder, 2006).
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h) Documentation of proposed methods of erosion control.	• Per a) and d) above.
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KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: April 19, 2016

TO: Mr. Jim Pitre, Boss Creek Development

CC: Mr. Nigel Hemingway, Cariboo Geographic Systems

FROM: Andrew Kolper, P.Eng.

RE: **BOSS CREEK DEVELOPMENT, ELECTORAL AREA 'C', VERNON, BC**
Addendum to the Stormwater Management Plan for Phase 1
MoTI eDAS File No. 2014-0461
Our File 2329.003-300

1. Purpose and Context

MoTI has voiced concern that the new roads of the proposed development will intercept what is effectively sheet flow, channelize it, and then discharge the concentrated runoff to areas, which are not able to handle these flows. The purpose of this memo is to provide further information to MoTI regarding how runoff generated from the undeveloped areas will be directed through the culverts and what treatments will be used to minimize the impact of the flow concentration on the receiving environment.

This memo should be read in conjunction with the *Boss Creek Development Stormwater Management Plan, KWL, April 2016* as well as the *Boss Creek Pre-Development Site Drainage Conditions, KWL, November, 2015.*

2. Hydrology

As part of the *Preliminary Stormwater Management Plan, KWL, November 2015*, KWL developed a hydrologic and hydraulic model using PCSWMM.

Runoff and Snowmelt

As in the pre-development condition, the largest design runoff from site post development occurs when the 100-year event happens on frozen ground and is also combined with snowmelt. In this scenario there will be no infiltration of runoff and additional runoff will be generated from the melting snow.

Rainfall intensities were calculated using a formula in the City of Vernon Stormwater Management Policies and Design Manual (2002). The average daily maximum snowmelt rate calculated using formulae in the *U.S. Army Corps of Engineers "Runoff from Snowmelt" Engineering Manual (EM 1110-2-1406, March 31, 1998* is combined with rainfall to produce winter runoff depths for conveyance design.

100-Year Modelled Flows

The site drainage was modelled using PCSWMM software for the above 100-year winter rainfall and snowmelt depths. Runoff was analyzed at the eleven culvert locations noted on Figure 1 and in all cases, the 6-hour storm was found to be governing duration, producing the highest peak flow.

A summary table detailing the required pipe size, expected peak flows and outlet treatments to be used for each culvert can be found in Table 1.

3. Culverts

Six of the 11 culverts (Culverts 1, 2, 3, 5, 6, and 10) shown on Figure 1 will direct surface flows already contained within Gullies A, B or C underneath the road to be discharged back into their respective gullies. The remaining 5 gullies direct runoff intercepted by linear infrastructure (roads, cut-off ditches) towards their respective overland flow routes. In all cases, runoff from the site is directed toward the natural overland flow routes.

Below is a summary of the each of the culverts to be constructed as part of Phase 1 of the development.

Culvert No. 1

This 600 ϕ culvert captures flow from within Gully C and discharges it under the driveway of 491 McLeish. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 2

This 600 ϕ culvert captures flow from within Gully C and discharges it under McLeish Rd towards Culvert No. 1. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path

Culvert No. 3

This 600 ϕ culvert captures flow intercepted by the interception ditch above the road cut (Refer Drawing C-102, C-103) and directs it via a constructed channel to its natural flow path in Gully C.

Culvert No. 4

This 600 ϕ culvert captures intercepted flow from above the trailhead parking area and discharges that runoff via a constructed channel to its natural flow path in Gully B.

Culvert No. 5

These twin 900 ϕ culverts captures flow within Gully B and discharges it across the road. The culverts will be installed at the low point of the gully above the road and will discharge into the continuation of the gully on the low side of the road.

Culvert No. 6

This 600 ϕ culvert captures flow within Gully A and discharges it across the road into the Grey Canal. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation.

Culvert No. 7

This 600 ϕ culvert captures overland flow from Proposed Lot No. 6 and the gully which flows through Proposed Lot No. 4 and Culvert 10 before discharging back into the gully. The gully, in turn, discharges to the disused Grey Canal. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 8

This 600 ϕ culvert captures flow discharged from Culvert No. 9 and discharges it via a 600 ϕ culvert to a minor gully which in turn discharges to the disused Grey Canal. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 9

This 600 ϕ culvert captures intercepted flow from above the road and discharges that runoff to a roadside ditch. This ditch then conveys the flow to Culvert No. 8.

Culvert No. 10

This 600 ϕ culvert captures intercepted flow from above a small gully in Proposed Lot No. 4 and discharges it back into the same gully on the opposite side of the road in Proposed Lot No. 6. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 11

This 600 ϕ culvert collects flow intercepted by the road and discharges it to the roadside ditch, which in turn is directed to Culvert No. 9 & 8 respectively.

A summary of the flows for each of the above culverts is shown in Table 1 below.

Table 1: Culvert Summary Table

Culvert	Drawing Ref.	Drainage Area (ha)	Size (mm)	100-Yr Peak Flow (m3/s)	Outlet Type	Channel Slope
1 (Gully C)	C-102	5.2	600 φ	0.077	Apron	
2 (Gully C)	C-102	3.5	600 φ	0.051	Apron	
3 (Gully C)	C-102	1.8	600 φ	0.026	Channel	0.12
4 (Gully B)	C-103	7.7	600 φ	0.106	Channel	0.40
5 (Gully B)	C-103	118.6	2x 900 φ	1.385	Apron	0.40
6 (Gully A)	C-104	18.3	600 φ	0.241	Apron	
7	C-104	1.4	600 φ	0.021	Apron	
8	C-104	9.2	600 φ	0.126	Apron	
9	C-105	9.1	600 φ	0.124	Ditch	0.12
10	C-105	1.1	600 φ	0.016	Apron	
11	C-105	6.5	600 φ	0.089	Ditch	0.10
Note: Culvert capacity assessment based on PCSWMM modelled flows.						

4. Culvert Outlet Treatment

The outlets from each culvert shall have a treatment to minimize erosion on the downstream end of the culvert. If the culverts are being discharged to an existing channel or gully, a riprap apron will be constructed to provide energy dissipation. Where no gully exists or where there is a higher risk of erosion due to the design flows, a constructed channel will direct the runoff into the

Table 2: Riprap Apron Sizing

Culvert	Drawing Ref.	D50 (mm)	Riprap Class	Apron Length (m)	Apron Depth (m)	Width (apron end) (m)
1	C-102	125	1	2.4	0.4	3.4
2	C-102	125	1	2.4	0.4	3.4
6	C-104	250	3	3.0	0.5	3.8
7	C-104	125	1	2.4	0.4	3.4
8	C-104	250	3	2.4	0.5	3.4
10	C-105	125	1	2.4	0.4	3.4

Table 3: Riprap Sizing for Channels/Ditches

Culvert	Drawing Ref.	D50 (mm)	Riprap Class	Channel Slope	Side Slopes (xH:1V)	Bottom Width (m)	Minimum Channel Depth (m)
3	C-102	125	1	12%	1.5	1	0.35
4	C-103	250	3	40%	1.5	1	0.4
5	C-103	500	5	40%	1.5	2.5	0.45
9	C-105	250	3	12%	1.5	0.3	0.5
11	C-105	250	3	10%	1.5	0.3	0.5

Riprap for both the channels and aprons will conform to the Riprap Design and Construction Guide, MOE, 2000. In addition, the channels will conform to the *Supplement to TAC Geometric Design Guide, 1030 Open Channel Design, MoTI 2007*.

5. Closing

We trust the above meets the needs of Boss Creek Developments at this time. If you have any questions or require any further information, please do not hesitate to contact the undersigned at akolper@kwl.ca or by phone at 604-293-3277.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

2016-04-19
A. J. KOLPER
39153

Andrew Kolper, P.Eng.
Stormwater Project Manager

AJK
Attachments: Figure 1

Statement of Limitations

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This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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Revision History

Revision #	Date	Status	Revision Description	Author
0	19 April 2016	Final	Original	AJK

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KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: May 10, 2016

TO: Mr. Jim Pitre, Boss Creek Development
Ms. Desiree Lantenhammer, BSc, Ministry of Transportation and Infrastructure

CC: Mr. Nigel Hemingway, Cariboo Geographic Systems

FROM: Andrew Kolper, P.Eng.

RE: **BOSS CREEK DEVELOPMENT, ELECTORAL AREA 'C', VERNON, BC**
Addendum to the Stormwater Management Plan for Phase 1
MoTI eDAS File No. 2014-0461
Our File 2329.003-300

1. Purpose and Context

MoTI has voiced concern that the new roads of the proposed development will intercept what is effectively sheet flow, channelize it, and then discharge the concentrated runoff to areas which are not able to handle these flows. The purpose of this memo is to summarize the stormwater management system in its entirety as well as to provide further information to MoTI regarding how runoff generated from the undeveloped areas will be directed through the culverts and what treatments will be used to minimize the impact of the flow concentration on the receiving environment.

This memo should be read in conjunction with the *Boss Creek Development Stormwater Management Plan, KWL, April 2016* as well as the *Boss Creek Pre-Development Site Drainage Conditions, KWL, November 2015.*

2. Stormwater Management Concept

The stormwater management concept for the Boss Creek Development site is intended to provide for disposal via infiltration for runoff generated from developed areas of the site and safe conveyance through the site for overland flow and snowmelt, discharging from the site in a manner that closely reflects the pre-development conditions.

The drainage system which includes road side ditches and infiltration swales on the upper portion of the development and infiltration galleries along the lower access road (currently an MoTI ROW), has been designed to capture and effectively infiltrate storms up to, and including the 100-year return period for all built impervious areas. In addition, culverts and defined overland flow paths will safely direct overland flow from undeveloped areas through the development and into the pre-development, natural drainage paths as shown in Figure 1 and further defined in the *Boss Creek Pre-Development Site Drainage Conditions, KWL, November 2015*.

This approach has the benefit of mitigating downstream offsite impacts as the runoff is captured and infiltrated, for impervious areas, for all events up to and including the 100-year return period storm.

3. Site Hydrology

As part of the *Preliminary Stormwater Management Plan, KWL, November 2015*, KWL developed a hydrologic and hydraulic model using PCSWMM.

Runoff and Snowmelt

As in the pre-development condition, the largest design runoff from site post development occurs when the 100-year event happens on frozen ground and is also combined with snowmelt. In this scenario there will be no infiltration of runoff and additional runoff will be generated from the melting snow.

Rainfall intensities were calculated using a formula in the *City of Vernon Stormwater Management Policies and Design Manual (2002)*. The average daily maximum snowmelt rate calculated using formulae in the *U.S. Army Corps of Engineers "Runoff from Snowmelt" Engineering Manual (EM 1110-2-1406, March 31, 1998* is combined with rainfall to produce winter runoff depths for conveyance design.

100-Year Modelled Flows

The site drainage was modelled using PCSWMM software for the above 100-year winter rainfall and snowmelt depths. Runoff was analyzed at the eleven culvert locations noted on Figure 1 and in all cases, the 6-hour storm was found to be the governing duration, producing the highest peak flow.

A summary table detailing the required pipe size, expected peak flows, and outlet treatments to be used for each culvert can be found in Table 1.

Table 1: Culvert Summary Table

Culvert	Drawing Ref.	Drainage Area (ha)	Size (mm)	100-Yr Peak (m^3/s)	Outlet Type	Channel Slope
1 (Gully C)	C-102	5.2	600 φ	0.077	Apron	
2 (Gully C)	C-102	3.5	600 φ	0.051	Apron	
3 (Gully C)	C-102	1.8	600 φ	0.026	Channel	0.12
4 (Gully B)	C-103	7.7	600 φ	0.106	Channel	0.40
5 (Gully B)	C-103	118.6	2x 900 φ	1.385	Apron	0.40
6 (Gully A)	C-104	18.3	600 φ	0.241	Apron	
7	C-104	1.4	600 φ	0.021	Apron	
8	C-104	9.2	600 φ	0.126	Apron	
9	C-105	9.1	600 φ	0.124	Ditch	0.12

10	C-105	1.1	600 φ	0.016	Apron	
11	C-105	6.5	600 φ	0.089	Ditch	0.10
Note: Culvert capacity assessment based on PCSWMM modelled flows.						

4. Stormwater Management

This section summarizes the overall stormwater management concept for the development site and includes how runoff from developed and undeveloped portions of the site will be managed.

4.1 Swales

As described in the *Preliminary Stormwater Management Plan, KWL, November 2015*, road runoff collected in the ditches will be routed to infiltration swales. The swales will store the runoff generated from the proposed impervious areas up to and including the 100-year design event and allow it to infiltrate into the native soils over time. In addition, the design of these swales provides a volumetric factor of safety of 2.

During a storm event, runoff will flow down the roadside ditches and be directed into the swale using a check dam in the ditch to prevent water from continuing to flow along the road. In events in excess of the 100-year design event, the swale is designed and will be constructed such that it will fill up to the height of the check dam and any additional flow will overflow the check dam and be directed back down the road to the next swale or overland flow route. At no time should the swales overtop anywhere along their length.

4.2 Infiltration Galleries

As described in the *Preliminary Stormwater Management Plan, KWL, November 2015*, runoff generated on the lower access road (McLeish and Phillips to just below the trailhead parking area) is to be retained and infiltrated within a number of infiltration galleries located along the Lower Access Road (refer to drawing C-102 & C-503).

Runoff generated by the 100-year 24-hour rainfall will be directed via roadside ditch to catch basins, where it will be collected and discharged into one of a number of infiltration galleries. Overflow from upstream galleries will be directed to the adjacent gallery until such time as the galleries are at capacity. Overflow sumps will allow for excess water to escape and become overland flow thus preventing heave due to excess water not being able to escape.

Based on the hydrology of the area and expected runoff volume, the infiltration galleries have been designed to capture the 230 m^3 of runoff generated by the road with a factor of safety of 1.5 for a total volume of 350 m^3 of storage. Based on preliminary infiltration testing, the infiltration galleries will provide infiltration of the entire 100-year 24-hour storm event within a 24-hour period.

4.3 Culverts

Six of the 11 culverts (Culverts 1, 2, 3, 5, 6, and 10) shown on Figure 1 will direct surface flows already contained within Gullies A, B or C underneath the road to be discharged back into their respective gullies. The remaining 5 gullies direct runoff intercepted by linear infrastructure (roads, cut-off ditches) towards their respective overland flow routes. In all cases, runoff from the site is directed toward the natural overland flow routes.

Below is a summary of the each of the culverts to be constructed as part of Phase 1 of the development.

Culvert No. 1

This 600 ϕ culvert captures flow from within Gully C and discharges it under the driveway of 491 McLeish. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 2

This 600 ϕ culvert captures flow from within Gully C and discharges it under McLeish Rd towards Culvert No. 1. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 3

This 600 ϕ culvert captures flow intercepted by the interception ditch above the road cut (Refer Drawing C-102, C-103) and directs it via a constructed channel to its natural flow path in Gully C.

Culvert No. 4

This 600 ϕ culvert captures intercepted flow from above the trailhead parking area and discharges that runoff via a constructed channel to its natural flow path in Gully B.

Culvert No. 5

These twin 900 ϕ culverts capture flow within Gully B and discharge it across the road. The culverts will be installed at the low point of the gully above the road and will discharge into the continuation of the gully on the low side of the road.

Culvert No. 6

This 600 ϕ culvert captures flow within Gully A and discharges it across the road into the Grey Canal. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation.

Culvert No. 7

This 600 ϕ culvert captures overland flow from Proposed Lot No. 6 and the gully which flows through Proposed Lot No. 4 and Culvert 10 before discharging back into the gully. The gully, in turn, discharges to the disused Grey Canal. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 8

This 600 ϕ culvert captures flow discharged from Culvert No. 9 and discharges it via a 600 ϕ culvert to a minor gully which in turn discharges to the disused Grey Canal. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 9

This 600 ϕ culvert captures flow from the road side ditch and some intercepted flow from above the road and discharges that runoff to a roadside ditch. This ditch then conveys the flow to Culvert No. 8.

Culvert No. 10

This 600 ϕ culvert captures intercepted flow from above a small gully in Proposed Lot No. 4 and discharges it back into the same gully on the opposite side of the road in Proposed Lot No. 6. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path towards Culvert No. 7.

Culvert No. 11

This 600 ϕ culvert collects flow intercepted by the road and discharges it to the roadside ditch, which in turn is directed to Culvert No. 9 & 8 respectively.

Culvert Outlet Treatment

The outlets from each culvert shall have a treatment to minimize erosion on the downstream end of the culvert. If the culverts are being discharged to an existing channel or gully, a riprap apron will be constructed to provide energy dissipation. Where no gully exists or where there is a higher risk of erosion due to the design flows, a constructed channel will direct the runoff into the appropriate gully or natural flow path.

Table 2: Riprap Apron Sizing

Culvert	Drawing Ref.	D50 (mm)	MoTI Riprap Class	Apron Length (m)	Apron Depth (m)	Width (apron end) (m)
1	C-102	125	10	2.4	0.4	3.4
2	C-102	125	10	2.4	0.4	3.4
6	C-104	250	25	3.0	0.5	3.8
7	C-104	125	10	2.4	0.4	3.4
8	C-104	250	25	2.4	0.5	3.4
10	C-105	125	10	2.4	0.4	3.4

Table 3: Riprap Sizing for Channels/Ditches

Culvert	Drawing Ref.	D50 (mm)	MoTI Riprap Class	Channel Slope	Side Slopes (xH:1V)	Bottom Width (m)	Minimum Channel Depth (m)
3	C-102	125	10	12%	1.5	1	0.35
4	C-103	250	25	40%	1.5	1	0.4
5	C-103	500	250	40%	1.5	2.5	0.45
9	C-105	250	25	12%	1.5	0.3	0.5
11	C-105	250	25	10%	1.5	0.3	0.5

Riprap for both the channels and aprons will conform to the *Riprap Design and Construction Guide, MOE, 2000*. In addition, the channels will conform to the *Supplement to TAC Geometric Design Guide, 1030 Open Channel Design, MoTI 2007*.

5. Summary

In summary, the stormwater management system includes road side ditches, infiltration swales and infiltration galleries to capture and effectively infiltrate storms up to, and including the 100-year return period for all built impervious areas. In addition, the stormwater management system includes culverts, natural draws and gullies as well as constructed diversions to capture and direct flow from undeveloped areas away from impervious areas and back into the natural flow paths to closely mimic the pre-development conditions.

The infiltration swales and galleries have been designed to capture and infiltrate the flows from the 100-year, 24-hour storm event. There has been a factor of safety built into the design (2 for swales and 1.5 for infiltration galleries) to allow for sedimentation and a reduction in infiltration rates over time and it is expected that, with engineering oversight during construction and minor periodic maintenance, the system will function as designed for the foreseeable future.

6. Closing

We trust the above meets the needs of Boss Creek Developments and the Ministry of Transportation and Infrastructure at this time. If you have any questions or require any further information, please do not hesitate to contact the undersigned at akolper@kwl.ca or by phone at 604-293-3277.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

PROFESSIONAL
PROVINCE OF
2016-05-10
A. J. KOLPER
39153
BRITISH COLUMBIA
ENGINEER

Andrew Kolper, P.Eng.
Stormwater Project Manager

Reviewed by:

Mark Forsyth, P.Eng.
Project Manager

AJK
Attachments: Figure 1

Statement of Limitations

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This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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Revision History

Revision #	Date	Status	Revision Description	Author
3	10 May 2016	Revised	Summary of overall plan and an Engineer's opinion as to the functionality of the design as requested by MoTI	AJK/mhf
2	4 May 2016	Revised Final	Addition of Figure 2 and swale function description	AJK
1	28 April 2016	Final	MoTI riprap class added & culvert descriptions clarified	AJK
0	19 April 2016	Final	Original	AJK

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KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: May 4, 2016

TO: Mr. Jim Pitre, Boss Creek Development

CC: Mr. Nigel Hemingway, Cariboo Geographic Systems

FROM: Andrew Kolper, P.Eng.

RE: **BOSS CREEK DEVELOPMENT, ELECTORAL AREA 'C', VERNON, BC**
Addendum to the Stormwater Management Plan for Phase 1
MoTI eDAS File No. 2014-0461
Our File 2329.003-300

1. Purpose and Context

MoTI has voiced concern that the new roads of the proposed development will intercept what is effectively sheet flow, channelize it, and then discharge the concentrated runoff to areas, which are not able to handle these flows. The purpose of this memo is to provide further information to MoTI regarding how runoff generated from the undeveloped areas will be directed through the culverts and what treatments will be used to minimize the impact of the flow concentration on the receiving environment.

This memo should be read in conjunction with the *Boss Creek Development Stormwater Management Plan, KWL, April 2016* as well as the *Boss Creek Pre-Development Site Drainage Conditions, KWL, November, 2015.*

2. Hydrology

As part of the *Preliminary Stormwater Management Plan, KWL, November 2015*, KWL developed a hydrologic and hydraulic model using PCSWMM.

Runoff and Snowmelt

As in the pre-development condition, the largest design runoff from site post development occurs when the 100-year event happens on frozen ground and is also combined with snowmelt. In this scenario there will be no infiltration of runoff and additional runoff will be generated from the melting snow.

Rainfall intensities were calculated using a formula in the City of Vernon Stormwater Management Policies and Design Manual (2002). The average daily maximum snowmelt rate calculated using formulae in the *U.S. Army Corps of Engineers "Runoff from Snowmelt" Engineering Manual (EM 1110-2-1406, March 31, 1998* is combined with rainfall to produce winter runoff depths for conveyance design.

100-Year Modelled Flows

The site drainage was modelled using PCSWMM software for the above 100-year winter rainfall and snowmelt depths. Runoff was analyzed at the eleven culvert locations noted on Figure 1 and in all cases, the 6-hour storm was found to be governing duration, producing the highest peak flow.

A summary table detailing the required pipe size, expected peak flows and outlet treatments to be used for each culvert can be found in Table 1.

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2 (Gully C)	C-102	3.5	600 φ	0.051	Apron	
3 (Gully C)	C-102	1.8	600 φ	0.026	Channel	0.12
4 (Gully B)	C-103	7.7	600 φ	0.106	Channel	0.40
5 (Gully B)	C-103	118.6	2x 900 φ	1.385	Apron	0.40
6 (Gully A)	C-104	18.3	600 φ	0.241	Apron	
7	C-104	1.4	600 φ	0.021	Apron	
8	C-104	9.2	600 φ	0.126	Apron	
9	C-105	9.1	600 φ	0.124	Ditch	0.12
10	C-105	1.1	600 φ	0.016	Apron	
11	C-105	6.5	600 φ	0.089	Ditch	0.10

Note: Culvert capacity assessment based on PCSWMM modelled flows.

3. Swales

As described in the *Preliminary Stormwater Management Plan, KWL, November 2, 2015*, road runoff collected in the ditches will be routed to infiltration swales. The swales will store the runoff generated from the proposed impervious areas up to an including the 100-year design event and allow it to infiltrate into the native soils over time. In addition, the design of these swales provides a volumetric factor of safety of 2.

During a storm event, runoff will flow down the roadside ditches and be directed into the swale using a check dam in the ditch to prevent water from continuing to flow along the road. In events in excess of the 100-year design event, the swale is designed and will be constructed such that it will fill up to the height of the check dam and any additional flow will overflow the check dam and be directed back down the road to the next swale or overland flow route. At no time should the swales overtop anywhere along its length.

4. Culverts

Six of the 11 culverts (Culverts 1, 2, 3, 5, 6, and 10) shown on Figure 1 will direct surface flows already contained within Gullies A, B or C underneath the road to be discharged back into their respective gullies. The remaining 5 gullies direct runoff intercepted by linear infrastructure (roads, cut-off ditches) towards their respective overland flow routes. In all cases, runoff from the site is directed toward the natural overland flow routes.

Below is a summary of the each of the culverts to be constructed as part of Phase 1 of the development.

Culvert No. 1

This 600 ϕ culvert captures flow from within Gully C and discharges it under the driveway of 491 McLeish. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 2

This 600 ϕ culvert captures flow from within Gully C and discharges it under McLeish Rd towards Culvert No. 1. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path

Culvert No. 3

This 600 ϕ culvert captures flow intercepted by the interception ditch above the road cut (Refer Drawing C-102, C-103) and directs it via a constructed channel to its natural flow path in Gully C.

Culvert No. 4

This 600 ϕ culvert captures intercepted flow from above the trailhead parking area and discharges that runoff via a constructed channel to its natural flow path in Gully B.

Culvert No. 5

These twin 900 ϕ culverts captures flow within Gully B and discharges it across the road. The culverts will be installed at the low point of the gully above the road and will discharge into the continuation of the gully on the low side of the road.

Culvert No. 6

This 600 ϕ culvert captures flow within Gully A and discharges it across the road into the Grey Canal. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation.

Culvert No. 7

This 600 ϕ culvert captures overland flow from Proposed Lot No. 6 and the gully which flows through Proposed Lot No. 4 and Culvert 10 before discharging back into the gully. The gully, in turn, discharges to the disused Grey Canal. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 8

This 600 ϕ culvert captures flow discharged from Culvert No. 9 and discharges it via a 600 ϕ culvert to a minor gully which in turn discharges to the disused Grey Canal. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path.

Culvert No. 9

This 600 ϕ culvert captures flow from the road side ditch and some intercepted flow from above the road and discharges that runoff to a roadside ditch. This ditch then conveys the flow to Culvert No. 8.

Culvert No. 10

This 600 ϕ culvert captures intercepted flow from above a small gully in Proposed Lot No. 4 and discharges it back into the same gully on the opposite side of the road in Proposed Lot No. 6. The flow will be directed across a riprap apron at the culvert outlet for energy dissipation before continuing along its natural overland flow path towards Culvert No. 7.

Culvert No. 11

This 600 ϕ culvert collects flow intercepted by the road and discharges it to the roadside ditch, which in turn is directed to Culvert No. 9 & 8 respectively.

5. Culvert Outlet Treatment

The outlets from each culvert shall have a treatment to minimize erosion on the downstream end of the culvert. If the culverts are being discharged to an existing channel or gully, a riprap apron will be constructed to provide energy dissipation. Where no gully exists or where there is a higher risk of erosion due to the design flows, a constructed channel will direct the runoff into the

Table 2: Riprap Apron Sizing

Culvert	Drawing Ref.	D50 (mm)	MoTI Riprap Class	Apron Length (m)	Apron Depth (m)	Width (apron end) (m)
1	C-102	125	10	2.4	0.4	3.4
2	C-102	125	10	2.4	0.4	3.4
6	C-104	250	25	3.0	0.5	3.8
7	C-104	125	10	2.4	0.4	3.4
8	C-104	250	25	2.4	0.5	3.4
10	C-105	125	10	2.4	0.4	3.4

Table 3: Riprap Sizing for Channels/Ditches

Culvert	Drawing Ref.	D50 (mm)	MoTI Riprap Class	Channel Slope	Side Slopes (xH:1V)	Bottom Width (m)	Minimum Channel Depth (m)
3	C-102	125	10	12%	1.5	1	0.35
4	C-103	250	25	40%	1.5	1	0.4
5	C-103	500	250	40%	1.5	2.5	0.45
9	C-105	250	25	12%	1.5	0.3	0.5
11	C-105	250	25	10%	1.5	0.3	0.5

Riprap for both the channels and aprons will conform to the Riprap Design and Construction Guide, MOE, 2000. In addition, the channels will conform to the *Supplement to TAC Geometric Design Guide, 1030 Open Channel Design, MoTI 2007.*

6. Closing

We trust the above meets the needs of Boss Creek Developments at this time. If you have any questions or require any further information, please do not hesitate to contact the undersigned at akolper@kwl.ca or by phone at 604-293-3277.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, A. J. KOLPER # 39153, 2016-05-04

Andrew Kolper, P.Eng.
Stormwater Project Manager

Reviewed by:

Mark Forsyth, P.Eng.
Project Manager

AJK
Attachments: Figure 1

Statement of Limitations

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Revision History

Revision #	Date	Status	Revision Description	Author
2	4 May 2016	Revised Final	Addition of Figure 2 and swale function description	AJK
1	28 April 2016	Final	MoTI riprap class added & culvert descriptions clarified	AJK
0	19 April 2016	Final	Original	AJK

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KERR WOOD LEIDAL
consulting engineers

Okanagan
202 - 3334 30th Avenue
Vernon, BC V1T 2C8
T 250 503 0841
F 250 503 0847

February 22, 2019

Bill Sparkes, PAO
BC Ministry of Transportation and Infrastructure
Via email to bill.sparkes@gov.bc.ca

Dear Mr. Sparkes:

RE: BOSS CREEK DEVELOPMENT
Drainage Planning Documentation and Assurance
MoTI eDAS File No. 2014-0461; KWL File 2329.003-200

This follows our February 20th meeting wherein you mentioned that you wish to consider the overall drainage approach and related due diligence and regulatory compliance. As the project drainage-related documents are extensive, we provide a list of related reports that should prove useful. We also summarize KWL's professional assurances discussed today.

Drainage-related Documents

Table 1 provides a list of the professional environmental and engineering stormwater management reports prepared by KWL and other consultants that are related to drainage (not exhaustive). As far as we are aware all of these reports were previously submitted to MoTI. KWL's reports have been prepared by professional engineers qualified in hydrology, stormwater management, B.C. regulations and best practices, and per EGBC OQM[1] requirements the reports have received independent technical review.

Drainage Assurances

KWL has provided MoTI with a number of sealed professional assurance documents. In addition, specifically pertaining to stormwater and drainage planning, design and built infrastructure we provide the following:

a) The stormwater management approach and best practices meet or exceed the requirements agreed with MoTI and as contained in the PLA and documented in the SWM Plans. Boss Creek and KWL have further committed to a spring 2019 review of the stormwater system *performance and function* to address the points raised in the MoTI PLR Summary letter of November 2, 2018, item 2, and to address deficiencies identified.

b) A specific RAR review (Lakeshore Environmental, 2013) concluded that "a RAR assessment is not required for watercourses in the proposed development area". Various environmental assessments were conducted between 2006 and 2008.[2] These identified only Bate Creek at the north extent of the property as an ephemeral stream not considered to be fish-bearing. The Boss Creek Phase 1 roads and drainage works are not proximate to Bate Creek. The environmental reports did not identify the need for permits, notifications or approvals for the roads and drainage works in Phase 1.

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[1] Engineers and Geoscientists of B.C., Organizational Quality Management Program

[2] Environmental assessments were completed between 2006 and 2013. Although we are not providing an interpretation of regulations here, for reference: the *Water Sustainability Act* became effective in 2016; the development stormwater management plans were completed in 2010-2015; design completed and submitted to MoTI in 2015; and construction began in spring 2016.

c) To the extent practical with brownfield land development and stormwater management applications, the built drainage infrastructure will meet the drainage performance objectives and criteria. In short, runoff from the development site will not exceed pre-development conditions, and drainage works have been implemented to mitigate impacts on downslope properties.

d) We confirm that any drainage works situated on private property Part Lot 2 Plan EPP24440 (M & B Andretta) are not material to the function and performance of the stormwater management plan, and their existence will not materially increase runoff flows on this or other downslope properties.

Please advise if we can provide further information.

Yours truly,

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:	Reviewed by:	
Mike Nolan, M.Eng., P.Eng. Project Manager	Sven Rylandsholm, P.Eng. Engineer of Record	Andrew Kolper, P.Eng. Sr. Stormwater Engineer

Cc: Michael Blackwell
Jim Pitre

Encl. Table 1 - Reports Related to Boss Creek Environmental Assessments and Stormwater Management Planning

Table 1: Reports Related to Boss Creek Environmental Assessments and Stormwater Management Planning

Report	Purpose
Environmental Assessments	
Preliminary Environmental Sensitivity Analysis for Vernon Hill Ranch Development, Vernon, BC (Golder Assoc., June 13, 2006, 56pp)	Desktop regulatory review, research and site analysis to identify and characterize environmentally sensitive habitat features.
Preliminary Soils Investigation, Proposed Vernon Hill Ranch Development, Vernon, BC (Golder Assoc., Sept 22, 2006, 24pp)	Investigate geological conditions and assess suitability of site soils for in-ground effluent disposal and stormwater infiltration.
Vernon Hill Ranch – Environmental Assessment (Summit Environmental Consultants Ltd., January18, 2008, 57pp)	Describe the baseline ecological resources for the development property and identify environmentally sensitive areas ESAs.
Riparian Areas Regulation Assessment Investigation – Vernon Hill Ranch, Lakeshore Environmental Ltd., June 14, 2013, 2pp	Ascertains whether any watercourses on the site require RAR assessments.
Stormwater Management Planning Reports	
Vernon Hill Ranch Site Servicing, Stormwater Management Summary (Letter to Mr. B. Sparkes PAO, KWL, May 11, 2010, 3pp)	Describes SWMP criteria, approach and concepts to MoTI for preliminary feedback.
Preliminary Stormwater Management Plan for Phase 1, Boss Creek Development, Electoral Area 'C', Vernon, BC (KWL, November 2, 2015, 15pp)	Presents the stormwater management approach and best practices to be used to meet the objectives contained in the PLA.
Pre-Development Site Drainage Conditions, Boss Creek Development (KWL, November 20, 2015, 40pp)	Documents the pre-development on- and off-site drainage conditions. For future reference and to provide baseline flows for design purposes.
Addendum to the Stormwater Management Plan for Phase 1, Boss Creek Development (KWL, May 10, 2016, 7pp)	Provides specific information to MoTI regarding site hydrology and how the drainage infrastructure meets the development approval objectives.
Bannister Property – Road B Extension, Boss Creek Development (KWL, January 6, 2017, 6pp)	Provides culvert sizing and infiltration swale
Operational Stormwater Management Plan, Boss Creek Development (KWL, January 31, 2019, 40pp).	Provide background to objectives and critical aspects of the SWM built system, list all drainage infrastructure, purpose and o&m requirements.
Record Drawings	
Boss Creek (Amended Phase 1) Construction of Roads & Services, Contract No. 2329-003, Record Drawings (KWL, Dec 2018, 35pp)	Provides a record of 'as-built conditions' reflecting all design incorporated changes during construction.