REGIONAL DISTRICT OF CENTRAL KOOTENAY
BOX 590, 202 Lakeside Drive, NELSON, BC V1L 5R4
ph: 250-352-8165 fax: 250-352-9300
email: plandept@rdck.bc.ca

REFERRAL FORM
FLOODPLAIN EXEMPTION APPLICATION
RDCK Planning File: F2001F
Date: MAY 28 2020

You are requested to comment on the attached FLOODPLAIN EXEMPTION for potential effect on your agency's interests. We would appreciate your response WITHIN 30 DAYS (PRIOR TO JUNE 29 2020). If no response is received within that time, it will be assumed that your agency's interests are unaffected.

LEGAL DESCRIPTION & GENERAL LOCATION:

LOT 1, PLAN NEP5740, DISTRICT LOT 787, KOOTENAY LAND DISTRICT

(PID: 014-401-487)

PRESENT USE AND PURPOSE OF PERMIT REQUESTED:

The property comprises a Single Family Dwelling and attached garage. The property is zoned as Suburban Residential (R1F) in Electoral Areas F, I, J and K Zoning Bylaw No. 1674, 2004, and designated as Suburban Residential (SR) in Electoral Area F Official Community Plan Bylaw No. 2214, 2012.

The application relates to a Site Specific Floodplain Exemption. The existing dwelling is located within the Floodplain Setback, and built below the Flood Construction Level, as prescribed within the Floodplain Management Bylaw No. 2080, 2009. The application seeks to regularize the existing dwelling, as well as enable the re-construction of an attached garage following a fire.

AREA OF PROPERTY AFFECTED	ALR STATUS	ZONING	OCP
0.3 hectares (0.77 acres)	N/A	Suburban Residential (R1F)	Suburban Residential (SR)

APPLICANT: Pennco Engineering (BC) Ltd

OTHER INFORMATION:

As development has taken place within the 30m Floodplain Setback, a report from a Qualified Engineering Professional has been submitted. This report is attached to the referral.

ADVISORY PLANNING COMMISSION PLEASE NOTE:

If your Advisory Planning Commission plans to hold a meeting to discuss this Development Variance Permit application, please note that the applicants must be provided with an opportunity to attend such meeting, in accordance with Section 461, subsection (8) of the *Local Government Act*, which reads as follows:

"If the commission is considering an amendment to a plan or bylaw, or the issue of a permit, the applicant for the amendment or permit is entitled to attend meetings of the commission and be heard."

Please fill out the Response Summary on the back of this form. If your agency's interests are 'Unaffected' no further information is necessary. In all other cases, we would appreciate receiving additional information to substantiate your position and, if necessary, outline any conditions related to your position. Please note any legislation or official government policy which would affect our consideration of this permit.

TAMARA DALE, PLANNER
REGIONAL DISTRICT OF CENTRAL KOOTENAY

TRANSPORTATION ☐ West Kootenay District Office, Nelson ☐ HABITAT BRANCH FRONT COUNTER BC (FLNRORD) ☒ Nelson ☐ Cranbrook ☐ AGRICULTURAL LAND COMMISSION ☐ REGIONAL AGROLOGIST ☐ ENERGY & MINES ☐ MUNICIPAL AFFAIRS & HOUSING INTERIOR HEALTH ☒ HBE Team, Nelson ☐ KOOTENAY LAKES PARTNERSHIP (FORESHORE DEVELOPMENT PERMITS) ☐ SCHOOL DISTRICT NO. ☐ WATER SYSTEM OR IRRIGATION DISTRICT ☐ UTILITIES (FORTIS, BC HYDRO, NELSON HYDRO, COLUMBIA POWER)	REGIONAL DISTRICT OF CENTRAL KOOTENAY DIRECTORS FOR: ☐ A ☐ B ☐ C ☐ D ☐ E ☒ F ☐ G ☐ H ☐ I ☐ J ☐ K ALTERNATIVE DIRECTORS FOR: ☐ A ☐ B ☐ C ☐ D ☐ E ☒ F ☐ G ☐ H ☐ I ☐ J ☐ K ☐ APC AREA ☐ RDCK FIRE SERVICES District Chief Nora Hannon – Kaslo, Balfour, Harrop, North Shore & Ymir District Chief George Hamm – Pass Creek, Ootischenia, Robson, Tarry's & Beasley District Chief Gord Ihlen – Crescent Valley, Passmore, Winlaw, Slocan & Blewett ☒ RDCK EMERGENCY SERVICES ☒ RDCK BUILDING SERVICES ☐ RDCK UTILITY SERVICES ☐ RDCK RESOURCE RECOVERY ☐ RDCK REGIONAL PARKS INSERT COMMENTS ON REVERSE . . .

The personal information on this form is being collected pursuant to *Regional District of Central Kootenay Planning Procedures and Fees Bylaw No. 2457, 2015* for the purpose of determining whether the application will affect the interests of other agencies or adjacent property owners. The collection, use and disclosure of personal information are subject to the provisions of FIPPA. Any submissions made are considered a public record for the purpose hbyhhhhhhhhhh s of this application. Only personal contact information will be removed. If you have any questions about the collection of your personal information, contact the Regional District Privacy Officer at 250.352.6665 (toll free 1.800.268.7325), **info@rdck.bc.ca**, or RDCK Privacy Officer, Box 590, 202 Lakeside Drive, Nelson, BC V1L 5R4.

RESPONSE SUMMARY
FILE: F2001F APPLICANT: PENNCO ENGINEERING (BC) LTD

Name: Date:

Agency : Title:

RETURN TO: TAMARA DALE, PLANNER
DEVELOPMENT SERVICES
REGIONAL DISTRICT OF CENTRAL KOOTENAY
BOX 590, 202 LAKESIDE DRIVE
NELSON, BC V1L 5R4
Ph. 250-352-8175
Email: plandept@rdck.bc.ca

PENNCO ENGINEERING (BC) LTD.
Suite 201–601 Front Street; Nelson, BC V1L 4B6
Phone: (250) 354-0112; Fax: (250) 354-0113; e-mail: bernie@pennco.ca

Wednesday April 22, 2020 Pennco File: 20-1474

The Regional District of Central Kootenay
Box 590, 202 Lakeside Drive
Nelson, BC V1L 5R4

Via e-mail: MWheaton@rdck.bc.ca

Attention: Ms. Mikeala Wheaton, Planning Assistant

Dear Ms. Wheaton,

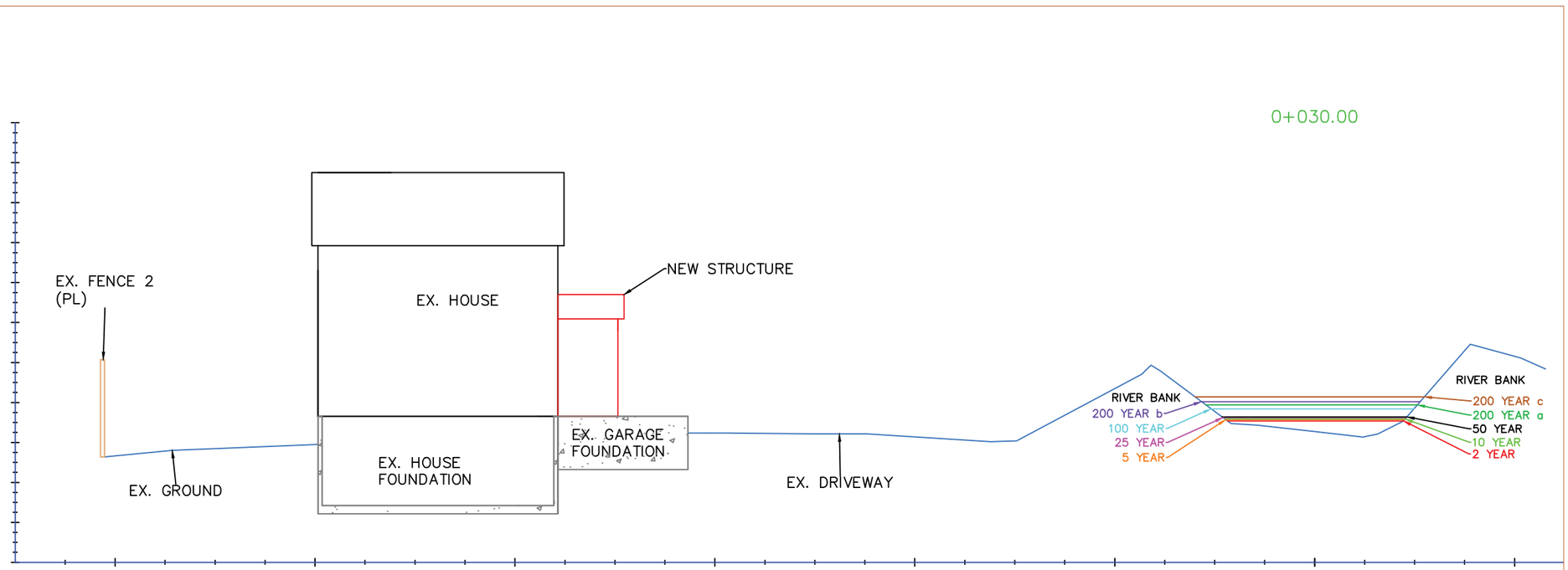
Reference: Floodplain Assessment for Fink Garage, 2737 Lower Six Mile Road, Nelson, BC

1.0 INTRODUCTION

Mr. Greg Fink is the homeowner of 2737 Lower Six Mile Road, located north of Nelson, BC with the legal description of Lot 1, Plan NEP5740, District Lot 787, Land District 26, and PID: 014-401-487. A structure fire occurred on or about June 10, 2019 that was contained to the attached garage of the dwelling that damaged the garage to the point of demolition of all above ground construction. The dwelling was not affected structurally and had been assessed previously by others. The foundation of the original garage is in place and the homeowner would like to rebuild a new structure on the existing concrete, with the knowledge that the foundation will require a structural assessment and possible upgrading to meet the 2018 British Columbia Building Code (BCBC) if deficiencies are identified.

During the insurance review and permitting process to rebuild the garage the dwelling was identified as being situated within the floodplain setback of the adjacent Duhamel Creek. According to BC Assessment data, the home is a 3,154 ft^2 (293 m^2) single-story plus basement structure with four bedrooms and two bathrooms that was constructed in 1975. The most western edge of the home is located approximately 24 m from the top of the riverbank of the adjacent creek. The required setback as per the Floodplain Management Bylaw No. 2080 (Floodplain Bylaw) of the Regional District of Central Kootenay (RDCK) for the location is 30 m. A representative of the homeowner's insurance company has retained Pennco Engineering BC Ltd. (Pennco) of Nelson, BC to request a Site-Specific Exemption under the Floodplain Bylaw for the property. This report has been prepared as part of the RDCK's requirements for a flood hazard assessment of the site to be undertaken by a qualified Professional. Figure 1 below shows the subject property and proximity to Duhamel Creek.

The preparation of this report included gathering topographic survey data of the site and creek, as well as reviewing flood mapping and performing hydrologic and hydraulic analysis. The survey was completed by Mr. Linden Jennings, EIT, and Mr. Colton Koehle of Pennco on March 19 and 20, 2020. The property was surveyed to obtain the elevations of the home and garage foundation as well as the property to the east and south. Duhamel Creek was also surveyed approximately 120 m upstream of the Fink property to obtain cross sections of the riverbed surface and adjacent riverbanks. The surveying of the site was followed by hydraulic modelling and mapping of the creek to determine maximum expected flow depths, flow volumes, and the creation of a 3D model with sections through the creek.



General Notes

1.

No.	Revision/Issue	Date

DESIGNED LJ DATE MARCH 2020
CHECKED BHP DATE MARCH 2020
DRAWN CK DATE MARCH 2020

CDG ENTERPRISES Ltd.

DESIGN CONSULTANT
PENNCO ENGINEERING (BC) LTD.
CONSULTING ENGINEERS
Suite 201–601 Front Street
Nelson, B.C. V1L 4B6
Tel: (250) 354–0112
Fax: (250) 354–0113
Email: bernie@pennco.ca

TWIN RIVER ESTATES - PHASE 2

LOT LAYOUT #1
(50 TOTAL)

Project No.	Drawing No.
19–1432	19–1432–01
Scale: 1:200	Sheet: 1 OF 1
Date: MARCH 05, 2020	REV.

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TWIN RIVER ESTATES - PHASE 2

LOT LAYOUT #1
(50 TOTAL)

Project No.	Drawing No.
19–1432	19–1432–01
Scale: 1:250	Sheet: 1 OF 1
Date: MARCH 05, 2020	REV.

General Notes

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Via e-mail: MWheaton@rdck.bc.ca

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Figure 1: Location of Subject Property
(Courtesy of BC Assessment)

2.0 PROPERTY DESCRIPTION

The Fink property is located approximately 10 km north of Nelson and is 0.31 ha (0.77 acres or 3,116 m^2) in area. It is bounded by Lower Six Mile Road on the southern edge, the west channel of Duhamel Creek on the western edge, and adjacent properties to the north and east. The dwelling is located approximately in the center of the property. The property is generally flat with built-up soil mounds on the west side sloping up towards the creek. There is vegetation along the property edge of this bank, with a patch of large coniferous trees in the southwestern corner of the property near the river. Large coniferous trees line the top of this bank heading upstream along adjacent properties.

The west channel of Duhamel Creek flows along the west edge of the Fink property, and discharges into the west arm of Kootenay Lake approximately 175 m south of the property. Duhamel Creek is approximately 11.2 km in total length and originates at Six Mile Lakes. The catchment area was estimated to be approximately 60.5 km^2 and is shown below in Figure 2. At a location approximately 600 m to the north of the Fink property, and beside Duhamel Creek Road the creek separates into two channels, with the western channel flowing west of and adjacent to the subject property. The east channel of Duhamel Creek lies approximately 260 m northeast of the Fink property along Lower Six Mile Road. A flood mapping study of the area completed by RDCK in 2019 is included in Appendix A for reference.

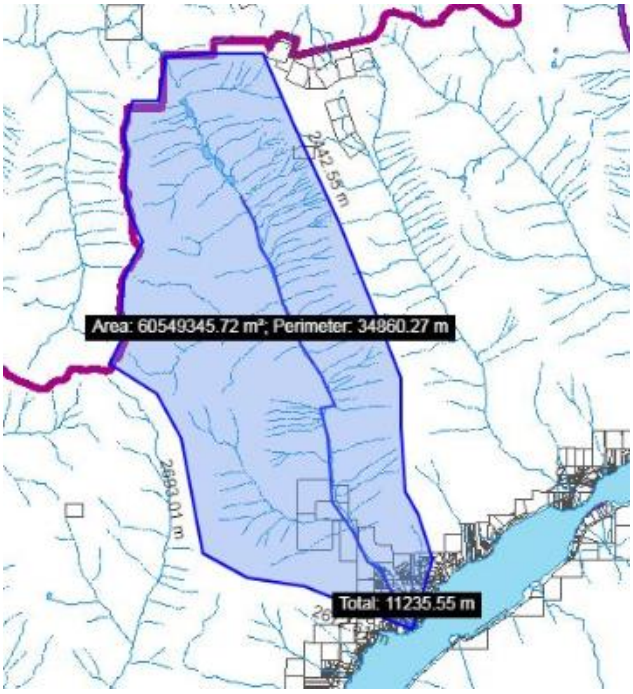


Figure 2: Duhamel Creek Catchment Area
(Courtesy of RDCK)

Reviewing the location using Google Earth, the approximate slope of the creek varied from 20% to 2% grade along the full length, with an average grade of approximately 8%. The portion surveyed included the segment of creek from the intersection with Lower Six Mile Road toward the north 120 m upstream. The slope of the riverbed for this segment was measured to be approximately 3%. The channel width varied from approximately 16 m wide at the north section surveyed to approximately 12 m wide at the southern end, near Lower Six Mile Road. The banks of the creek were lined mainly with small angular rocks, cobbles, and boulders from the creek surface to the top of the bank on both sides (it was assumed that similar bank conditions existed below the water surface). The western bank was gravel lined, benched, and vegetated with grass near the top of the bank while the eastern bank was rock-lined for the full height with coniferous trees running parallel to the creek at the top of the bank. The bed of the creek was mainly lined with smooth cobbles and many small boulders, in the section surveyed. The riverbed was generally a uniform cross section for the portion assessed. The slopes of the banks did vary somewhat and typical bank slopes are shown in Table 1 below for reference. The portion of the creek surveyed was generally straight with no significant bends or changes in direction. The high water level mark was not observed at the time of the survey and there did not appear to be a significant potential for damming or log jamming along this portion of the creek.

Table 1: Summary of Duhamel Creek Bank Slopes

	Maximum Slope (%)	Minimum Slope (%)	Average Slope (%)
West Bank	72.7	7.7	59.2
East Bank	52.9	7.1	23.8

3.0 LOCAL HISTORY REVIEW

A review of local history was completed to determine that Duhamel Creek has a history of flooding prior to the 1980's, with significant flood events occurring in 1956, 1968, and 1972. After the 1972 flood, efforts to improve the watercourse were undertaken by volunteers, including dredging the creek, stabilizing the banks with large rocks and rip rap, and installing cribbing at a creek bifurcation point just above highway 3A. Results of the upgrades undertaken seem to have improved the creek flows, as there have been no significant flood related issues since then. Prior to these efforts and generally during spring freshets, the creek would often overflow its banks and flow overland across the flatter surfaces of the fan until it reached the lake [1]. Landslides have occurred in the Duhamel drainage basin in 1997, 2011, and 2014 [2].

"Past flood problems at Duhamel Creek have been discussed by MoE (1976), Thurber Consultants (1983), and Hardy-BBT (1988). The creek has a long history of channel instability and avulsion suggesting the sediment supply is relatively high. The sedimentation problems on the fan are governed by fluvial processes and not as a result of debris flow impacts.

Previous flooding has most frequently been initiated at road bridges or at the bifurcation near the fan apex. This bifurcation divides the main west channel from the much smaller east channel. After 1968, the original bifurcation structure was replaced by installing a "V dyke", and reconstructing a timber pile wall. Future flooding could still be initiated at this point, particularly as a result of debris and logs being trapped and forcing the flow to make an avulsion." [3]

"Due to the high density of development on the fan and the past history of major channel shifting and avulsion across most of its surface, potential flood damages and hazards are very high on this fan. Furthermore, the risk of avulsion appears to be very uniformly distributed across the fan surface.

A helicopter reconnaisance revealed little evidence of unusual accumulated debris upstream of the fan and the fan does not appear to be debris torrent prone. However, some logging is occurring in the basin and it is vulnerable to log jams." [3]

4.0 ANALYSIS RATIONALE

Environment Canada has a monitoring station (09NJ026) located on Duhamel Creek, above the diversion point of the creek, which measures both the flow rate and depth of water in the creek in real-time as well as provides historical data for the site dating back to 1995 (data can be accessed at wateroffice.ec.gc.ca). The data from this station was reviewed for both the historical annual extremes as well as monthly averages for both flow rates and depth. These values served as a comparison for the calculated anticipated flow rates using the Rational method and available local precipitation data from Table 2.4 of the Subdivision and Servicing Bylaw 3170 (2011) for the City of Nelson. The maximum annual monthly flow rate for the creek using data from Environment Canada's monitoring station was determined to be 8.21 m^3/s that occurred in 2018 with an average flow rate calculated to be 5.45 m^3/s over the time-period of 1995 to 2018. Also using data from Environment Canada's monitoring station, the maximum creek depth in 2018 was 1.18 m with a calculated average depth of 1.10 m from 2011 to 2018.

The hydraulic analysis of the creek was determined by using the Rational Method, a commonly accepted method of computing design discharge from a small watershed, including the expected peak runoff for a catchment area based on the anticipated precipitation for that area. It is also dependent on a number of variables, including the time of concentration (the time required for the most remote location of stormwater inside the catchment area to flow to the outlet), runoff coefficients for the type of soil material and ground cover, and the delineation of the catchment area. The design discharge is calculated for different return periods or frequencies of anticipated storms, generally ranging from two years to 200 years, where the larger the value the smaller the probability of annual exceedance. The expected maximum discharge, Q, can be calculated as follows:

Q = RAIN

where:

- Q = peak runoff (m^3/hr)
- R = runoff coefficient (dimensionless coefficient)
- A = catchment area (ha)
- I = rainfall intensity (mm/hr)
- N = 1/360

The calculations were performed following the procedure outlined in bylaw 3170, and due to the site's proximity to the City of Nelson, it is reasonable to assume that the rainfall data used for Six-Mile is the same as for Nelson. The runoff coefficient for the catchment area R used the value of 0.05 for the 2-50 year return period range and 0.1 for the 100-200 year return period range, which represents the R-values for "Woodlot" designation in Table 2.2 of Bylaw 3170. The catchment area of the site was approximated using the RDCK Interactive Web Map by tracing out the extents of land that would be expected to drain into Duhamel Creek, starting at the upper boundary of Six Mile Lakes and ending at the discharge point into Kootenay Lake. This area measured approximately 6,055 ha.

The rainfall intensity was calculated as per Bylaw 3170 using the Intensity-Duration-Frequency equation

$$\mathbf{I = a \times T_c^{\,b}}$$

where:

- I = rainfall intensity (mm/hr)
- a, b are coefficient from Table 2.4 based on return period of storm
- T_c = Time of concentration (hr)

The time of concentration was calculated using three different equations and taking an average of the resulting values. The Airport Method, Bransby-Williams Method, and Hathaway Methods were used. Sample calculations have been included in Appendix B for reference. The slope of the creek was taken to be 5% as an average of the 8% determined from Google Earth and the 3% calculated for the lower surveyed section of the creek.

The required return period for floodplain assessment of creeks in the RDCK is 1-in-200-year as per the Floodplain Management Bylaw No. 2080 (Bylaw 2080). There were no coefficients provided for this return period to determine the associated rainfall intensity. Therefore, the 1-in-200-year flood was approximated in three ways using the data provided for the 1-in-100-year flows. The 200-year flood was modelled as 125% (200a), 150% (220b) and 200% (200c) of the 100-year flood. These three values were selected to approximate the worst-case scenario that could be anticipated.

The flow and depth data provided by the monitoring center is located above the bifurcation point of the creek. Option 1 Flow calculations represent all water in the creek being diverted into the west channel, in the event that the east channel became blocked. The west channel was assumed to take 50% of the total creek flow and the east channel was assumed to take the other 50%. The calculated full-flow values were compared to the monitoring station flow data and the average observed value was approximately equal to the calculated 1 in 5 year return-period value for the site. This comparison provided feedback on the accuracy of the calculations and indicated that the calculated values were appropriate for the model.

5.0 GEOTECHNICAL INFORMATION

Within the Selkirk Mountains lie the Slocan and Nelson ranges, which are primarily underlain by Cretaceous granitic rocks that make up the Duhamel Creek drainage basin. In addition to the granitic rocks are limestone and quartzite members of the Ymir group, and they are noted to be particularly erosion resistant.

"Surficial sediments in the upland portion of the basin consist of basal tills or recent colluvium. The lower portion of the basin cuts through a kame terrace (a flat-topped mound or hill composed of sorted sand and gravel deposited by meltwater in a former glacial lake) deposited along both sides of the West Arm of Kootenay Lake, below elevation 750 m." [3] The glacio-fluvial kame terraces provide an abundant source of coarse sediments that gets transported and relocated further downstream under fast-flowing freshet conditions.

6.0 FLOOD MAPPING

Flood mapping of Duhamel Creek adjacent to the property was undertaken as part of the flood assessment. In accordance with the Provincial "Flood Hazard Area Land Use Management Guidelines" and Bylaw 2080, an Average Recurrence Interval (ARI) of 200 years was used to determine the designated flood, with the value calculated as outlined in Section 4.0 above.

A Hydrologic Engineering Centers River Analysis System (HEC RAS 5.0.7) model was developed for the section of Duhamel Creek adjacent to the Fink property. The model extended 65 m upstream from the intersection with the bridge at Lower Six Mile Road and contained 13 cross sections through the creek spaced at 5 m intervals. The data was imported from the digital terrain model (DTM) that was created from collected field survey data of the site.

The model included nine flow profiles to be assessed and computed for the following return periods:

Table 2: Summary of HEC RAS Flow Data

	Flow Profiles in HEC RAS Model (m^3/s)								
Return Period (yrs)	**2**	**5**	**10**	**25**	**50**	**100**	**200a[(1)]**	**200b[(2)]**	**200c[(3)]**
Full flow	4.05	5.08	5.72	6.59	7.20	15.63	19.54	24.45	31.27
Half Flow	2.02	2.54	2.86	3.29	3.60	7.82	9.77	11.72	15.63

(1) 125% of 100-year flow
(2) 150% of 100-year flow
(3) 200% of 100-year flow

Two scenarios were assessed as follows: - a normal and expected flow situation where the west creek channel takes 50% of the total flows from upstream (half-flow condition) and a worst-case situation modelling the blockage of the east channel, forcing 100% of the water into the west channel adjacent to the Fink house (full-flow condition). While this scenario is not expected to ever occur, the situation was reviewed in order to determine how the property would be impacted by such an event. A third scenario was also assessed in an effort to simulate the annual observed high-water condition using a flow of 8.21 m^3/s, taken as the highest annual monthly flow rate from the monitoring station.

A manning's "n" value (roughness coefficient) of 0.030 was assumed for all surfaces of the creek. This was selected in accordance with Table 3-1, Manning's "n" Values in the HEC RAS River Analysis System Hydraulic Reference Manual, Version 5.0. While various values of "n" are available, the creek was observed to be a combination of the material options presented (Main Channel and Mountain Streams) and 0.030 was determined to most accurately represent the observed conditions. A channel slope of 5% was selected as outlined above in Section 4.0.

The results of the trials were presented in graphical and tabular formats as outputs from HEC RAS. Cross sections showing the water levels in the creek at the different return periods were provided along with the associated depths, in a tabular format. Inundation boundaries for each flow were created showing the height of water surface at the riverbanks and each boundary was imported to RAS-Mapper to view the flow boundaries and depth of water. A screen shot of the plan view model and RAS-Mapper results is included in Appendix C for reference. The inundation boundaries for each flow test were exported to Civil 3D and added to the DTM and survey for the project. The plan view and channel section drawings of the full-flow and half-flow conditions are included in Appendix D.

7.0 RESULTS

All flow results obtained from test calculations using return periods up to 200 years resulted in models of the west channel of Duhamel Creek whereby the creek was contained within its banks, for the approximate 200 m of channel beside the Fink house. The values used for the 200-year return period would also be considered conservative in nature, particularly the 200c option, due to the uncertainty associated with modelling these profiles. The full-flow 200c-year flow is the worst-case condition that

could be expected to occur and in this instance, virtual models showed the channel banks were not overtopped (for the approximate 200 m of channel beside the Fink house). Under this worst-case condition, the water surface level remained 0.80 m below the top of the east side riverbank, adjacent to the Fink property at station 0+0 30.00. The actual flows generated in the creek and the associated water levels are anticipated to be significantly less than the worst case with more freeboard available. Based on this analysis, the authors can reasonably conclude that the length of west channel of Duhamel Creek near the Fink house is able to contain the 200-year flood within its banks.

Table 3 below summarizes the anticipated depths for the worst-case full-flow condition of the 200c-year flood (Q_{max} = 31.24 m^3/s) for the stations near the property and the remaining riverbank freeboard height prior to overtopping.

Table 3: Full-Flow 200c-Year Flow Depths

Station (m)	River Bank Height Elevation (m)	Water Surface Elevation (m)	Remaining Bank Height (Freeboard) (m)
0+005.00	2.58	1.64	0.38
0+010.00	2.43	1.69	0.74
0+015.00	2.18	1.50	0.68
0+020.00	2.01	1.47	0.54
0+025.00	1.83	1.31	0.52
0+030.00	1.94	1.14	0.80
0+035.00	1.77	1.40	0.37
0+040.00	1.52	0.81	0.71
0+045.00	1.19	0.63	0.56
0+050.00	1.17	0.57	0.60
0+055.00	1.02	0.49	0.53
0+060.00	0.95	0.41	0.54
0+065.00	1.08	0.30	0.78

Table 4 below summarizes the anticipated depths for the worst-case half-flow condition of the 200c-year flood (Q_{max} = 15.63 m^3/s) for the stations near the property and the remaining riverbank freeboard height prior to overtopping. At the station closest to the home (0+030.00) the water surface elevation is 1.08m below the top of the riverbank on the east side. This would be the anticipated maximum flow and associated depth that would reasonably be expected under 200 year half-flow conditions.

Table 4: Half-Flow 200c-Year Flow Depths

Station (m)	River Bank Height Elevation (m)	Water Surface Elevation (m)	Remaining Bank Height (Freeboard) (m)
0+005.00	2.58	1.44	1.14
0+010.00	2.43	1.47	0.96
0+015.00	2.18	1.27	0.91
0+020.00	2.01	1.21	0.80
0+025.00	1.83	1.05	0.78
0+030.00	1.94	0.86	1.08
0+035.00	1.77	1.01	0.76
0+040.00	1.52	0.51	1.01
0+045.00	1.19	0.34	0.85
0+050.00	1.17	0.25	0.92
0+055.00	1.02	0.21	0.81
0+060.00	0.95	0.09	0.86
0+065.00	1.08	-0.07	1.15

As a comparison between the calculated maximum flows and depths, the historical maximum observed flow rate was modelled and analyzed. At the same station location of 0+030.00m, the water surface is 1.28m below the top of the riverbank. This is 0.20m lower than the expected maximum 200-year flow condition. Table 5 below summarizes the anticipated depths for the annual monthly maximum flow condition of the data collected at the monitoring station (8.21 m^3/s) for the stations near the property and the remaining riverbank height prior to overtopping. Flow and depth data from the monitoring station is included in Appendix E for reference.

Table 5: Annual Monthly Maximum Flow Depths

Station (m)	River Bank Height Elevation (m)	Water Surface Elevation (m)	Remaining Bank Height (Freeboard) (m)
0+005.00	2.58	1.43	1.15
0+010.00	2.43	1.31	1.12
0+015.00	2.18	1.08	1.10
0+020.00	2.01	1.01	1.00
0+025.00	1.83	0.86	0.97
0+030.00	1.94	0.66	1.28
0+035.00	1.77	0.74	1.03
0+040.00	1.52	0.32	1.20
0+045.00	1.19	0.17	1.02
0+050.00	1.17	0.07	1.00
0+055.00	1.02	0.02	1.00
0+060.00	0.95	-0.14	1.09
0+065.00	1.08	-0.33	1.41

The drawings included in Appendix D also show the inundation boundaries of the water with respect to the riverbanks.

8.0 DISCUSSION

The existing floodplain construction levels (FCL) for Duhamel Creek as identified by the RDCK are as follows:

- 3.0m vertically above the natural boundary of the creek
- 30.0m horizontally from the natural boundary of the creek

The natural boundary of the creek is defined by the RDCK to be the visible high water mark of the watercourse. This location was not evident during the survey. Water elevations were calculated by HEC RAS using the average annual maximum flow of 5.45 m^3/s to determine the anticipated average water elevation that would be commonly experienced year-to-year. At station 0+030.00 m nearest to the Fink house, this elevation was determined to be 0.66m and gave a horizontal distance of 27.3m from the edge of the garage foundation to the water surface. The horizontal distance from the edge of the garage foundation to the top of the east riverbank at this location was measured to be 23.7m.

The existing house on the property has a basement with an estimated habitable floor elevation of -2.66m in the local coordinate system. The main floor is accessed via stairs from grade. At station 0+030.00, the bottom of the riverbed is located at 0.09 m and the estimated high water mark is located at 0.66 m. Therefore, the existing structure is below the existing observed water levels and significantly below the required 3.0m elevation requirement.

Presently, the house and garage do not meet the requirements of the floodplain bylaw in either the vertical or horizontal directions. However, due to the presence of high riverbanks adjacent to the property, the anticipated 1-in-200-year flood model is contained within its banks, for the approximate 200 m of channel near the Fink house. Future flooding could still occur at the original bifurcation point due to debris and logs being trapped at the "V dyke" area, thereby causing the creek to make an avulsion. Inspection of the creek at regular times during a freshet would indicate potential debris build-up location(s) with appropriate maintenance measures taken. Previous reconnaissance done upstream indicated little evidence of accumulated debris in or near the creek channel upstream of the fan and the fan does not appear to be debris torrent prone. [3]

The house was constructed in 1975 and throughout its history has never been flooded, or experienced flood related issues from Duhamel Creek. Additionally, Section 3.2.3 of BC Flood Hazard Area Land Use Management Guidelines (2004 amended 2018) states that:

"The requirements for small streams may be reduced where the following conditions exist:

- *Sufficient discharge records are available to establish the designated flood and/or the designated flood can be otherwise estimated to be less than 80 m^3/s; and*
- *The watercourse has no significant history of flooding and/or bank erosion; and/or*
- *The watercourse is not located on an alluvial fan or colluvial fan; and/or*
- *It is deemed appropriate by an approving officer.*

Setback
The setback requirement may be reduced to 15m from the natural boundary of the watercourse provided the floodway is not obstructed.

FCL
The elevation of areas used for habitation, business, or storage of good damageable by floodwaters should be established within any building at an elevation greater than 1.5m above the natural boundary of the watercourse."

In the event that a Site-Specific Floodplain Exemption is deemed inappropriate, it is suggested that this clause be considered for the property. "The designated flood flow volume has been estimated to be significantly less than 80 m^3/s and there is sufficient flow history available to show the expected discharges in the creek are within the accepted range." There has been no flood history in Duhamel Creek since this home was constructed and there is no concern of bank erosion as the banks are protected with boulders and rip rap. The horizontal setback requirement is met in this case. Subject to approval by an approving officer, the vertical elevation may be considered appropriate given the fact that the riverbanks protect the home from the anticipated designated 1-in-200-year flood event.

9.0 RECOMMENDATIONS

After completing floodplain analysis and mapping for the property, Pennco recommends the following tasks be undertaken:

- Grant an exemption of the property from the floodplain bylaw;
- Assess the condition of the east riverbank and determine any locations that may require additional scour protection (benefits all adjacent and downstream properties – not solely the Fink residence);
- Rebuild the garage in the original location, following an assessment of the existing foundation by a Professional Engineer to ensure that the concrete is adequate for reuse and implementing the required modifications to meet the 2018 BCBC; and
- Ensure the property owner is aware that the existing structure is within the floodplain boundary of Duhamel Creek and that future flooding is an unlikely but potential risk.

10.0 CONCLUSIONS

Impacts to the property are not anticipated by flood events up to and including a 200-year event that were considered in the analysis and HEC RAS modelling of Duhamel Creek. The home has been in place since 1975 and has not experienced issues related to flooding in its 45-year history. The property and home can continue to be used safely as intended and the garage rebuilt in its original location. Representative cross sections of the creek were created from field survey data obtained in and around the property, and the height of the creek banks are adequate to contain all flood events modelled. Additionally, the creek banks are currently lined with small boulders that are generally resistant to erosion and do provide scour protection for the adjacent property.

11.0 CLOSURE

This report has been prepared for use by Sedgwick Canada Inc. and includes distribution or reproduction as may be required for their purposes. The development requirements and assessment procedures contained herein have been carried out in accordance with generally accepted engineering practice. Engineering judgment based on similar experience has been applied in creating Recommendations and Conclusions contained herein. No other warranty is made, either expressed or implied.

Pennco Engineering Ltd. trusts that the information presented above meets your current requirements. If you have any questions or require further information, please contact the undersigned.

Respectfully submitted,
Pennco Engineering Ltd.

Bernie H Penner, for
Linden Jennings, EIT
Junior Engineer

Reviewed By:

Bernie H Penner
B. H. PENNER
Bernie H Penner, P.Eng.
Senior Engineer

REFERENCES

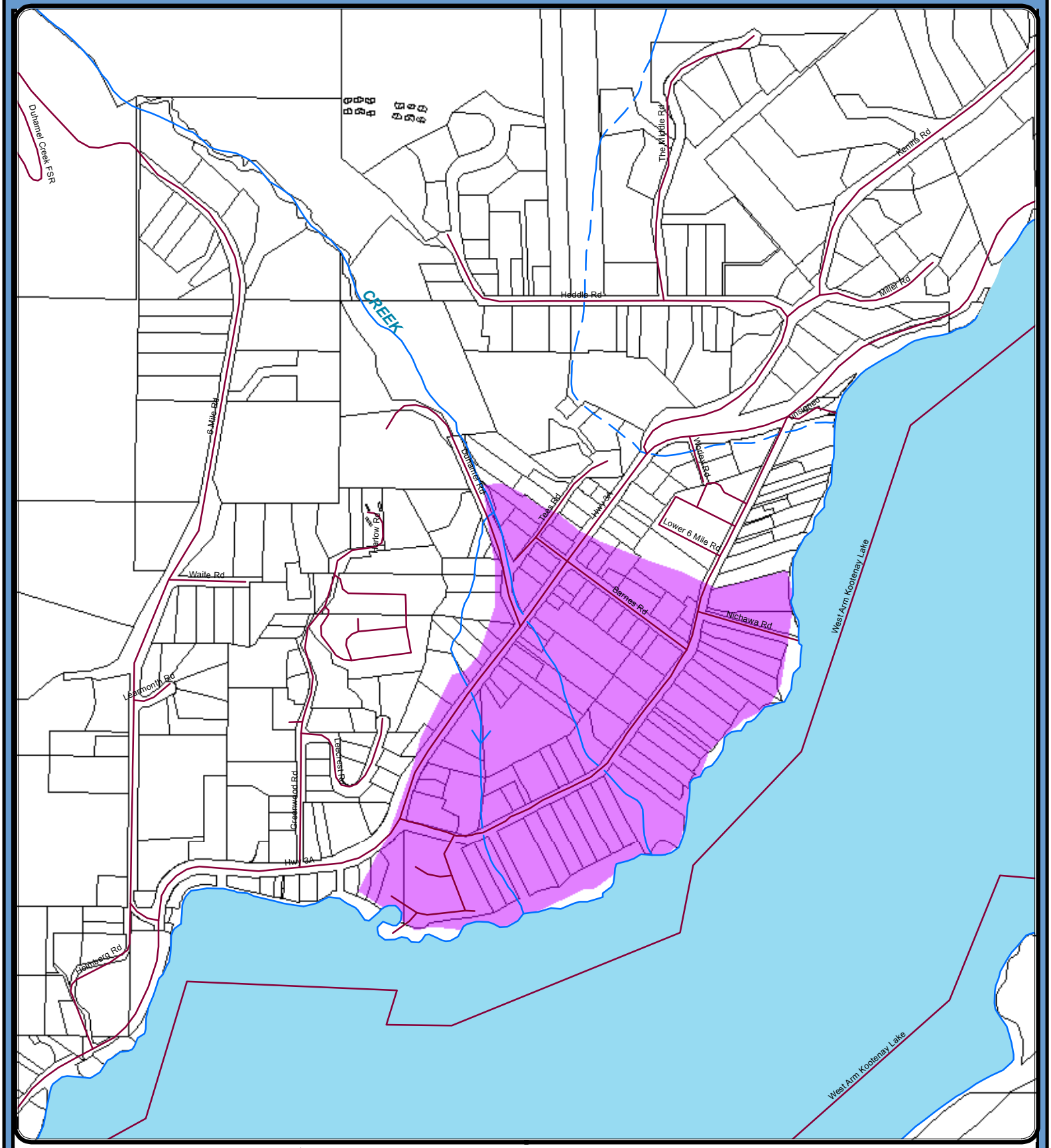
[1] "Duhamel Watershed Society" (2014, September 23). Retrieved March 27, 2020, from https://upthelakehistory.wordpress.com/home/community/community-activism/duhamel-watershed-society/

[2] "Floods on Duhamel Creek" (2014, September 25). Retrieved March 27, 2020 from https://upthelakehistory.wordpress.com/home/history/floods-on-duhamel-creek/

[3] "Alluvial Fan Hazard Assessment" (1990). Final Report Prepared for the Regional District of Central Kootenay by Northwest Hydraulic Consultants Ltd. and Thurber Consultants Ltd.

Appendices:

A. RDCK flood map;
B. Sample Calculations;
C. HECRAS Output Map
D. Plan and Section View Drawings for Worst Flow Case; and
E. Stream Flow Data for Monthly Maximum & Extremes.



Duhamel Creek

- Roads
- Streams
- Lakes and Rivers
- Steep Creek Study Areas
- Lot Lines

Map Scale

250 metres

Map Projection: UTM Zone 11 Map Datum: NAD83

Date Plotted: Friday, June 14, 2019

Data Sources

The following sources of data are updated as changes occur:
Cadastral Lot - Surveyed lots/parcels of land;
Sources: Crown Land Registry Services and RDCK
District Lot; Source: Crown Land Registry
Services, Integrated Cadastral Initiative (ICI) and RDCK
TRIM Data - Planimetry, Unsurveyed Roads, Contours; Source: Ministry of Water,
Roads - Digital Road Atlas, Province of BC
Steep Creek and & Clear Water Flood Study Areas: BGC Engineering (2019).

Box 590, 202 Lakeside Drive, Nelson, BC V1L 5R4
Phone: (250) 352-6665 Toll-Free 1-800-268-7325 (BC)
Fax: (250) 352-9300 Internet: www.rdck.bc.ca

Project Name	Fink Garage Rebuild	Prepared By: L. Jennings, EIT
Project No.	20-1474	Date: March 2020
Subject	Time of Concentration and Flow Calculations- Half-Flow Condition	

Historical Data:

Max. peak value, Qmax=	14.2	m3/s	-2012
Max. peak value, Qmax=	20.2	m3/s	(instantaneous- 2008)
Average max annual flow, Qav=	8.98	m3/s	
Min. flow, Qmin=	0.167	m3/s	-2008
Monthly max discharge Qmmax=	8.21	m3/s	
Monthly average discharge, Qmav=	5.454167	m3/s	
C5- Runoff Coefficient =	0.05		
C100- Runoff Coefficient =	0.1		
r (timberland) =	0.7		
L- Basin Length =	11235	m	
Sw- Slope=	0.05	m/m	
Sw- Slope=	5	%	
A- Basin Area	6054.935	Ha	

Airport Method- C < 0.40

	Tc (min)	Tc (hrs)
$Tc = \frac{3.26*(1.1-C)*L^{0.5}}{Sw^{0.33}}$	213.3209	3.555348

Bransby Williams- C > 0.40

$Tc = \frac{0.057*L}{Sw^{0.2}*A^{0.1}}$	194.2867	3.238111

Hathaway Method

$Tc = \frac{(r*L)^{0.467}}{1.65*S^{0.234}}$	192.0378	3.20063
Note: L in km Average:	199.8818 min	3.331363 hr

Return Period- average Tc

	2	5	10	25	50	100	200a	200b	200c
coefficient a	10.4	13.4	15.3	17.8	19.6	21.4			
coefficient b	-0.64	-0.662	-0.673	-0.682	-0.688	-0.693			
intensity, a*Tc^b mm/hr	4.814545	6.041281	6.807174083	7.834149	8.564306	9.29473			
Flow, Q=CiA/360 (m3/2)	2.024428	2.540248	2.862291431	3.294116	3.601133	7.816526	9.770656886	11.72478826	15.63305102
							projected as 1.25*Q100	projected as 1.5*Q100	projected as 2.0*Q100

Return Period- Bransby-Williams Tc

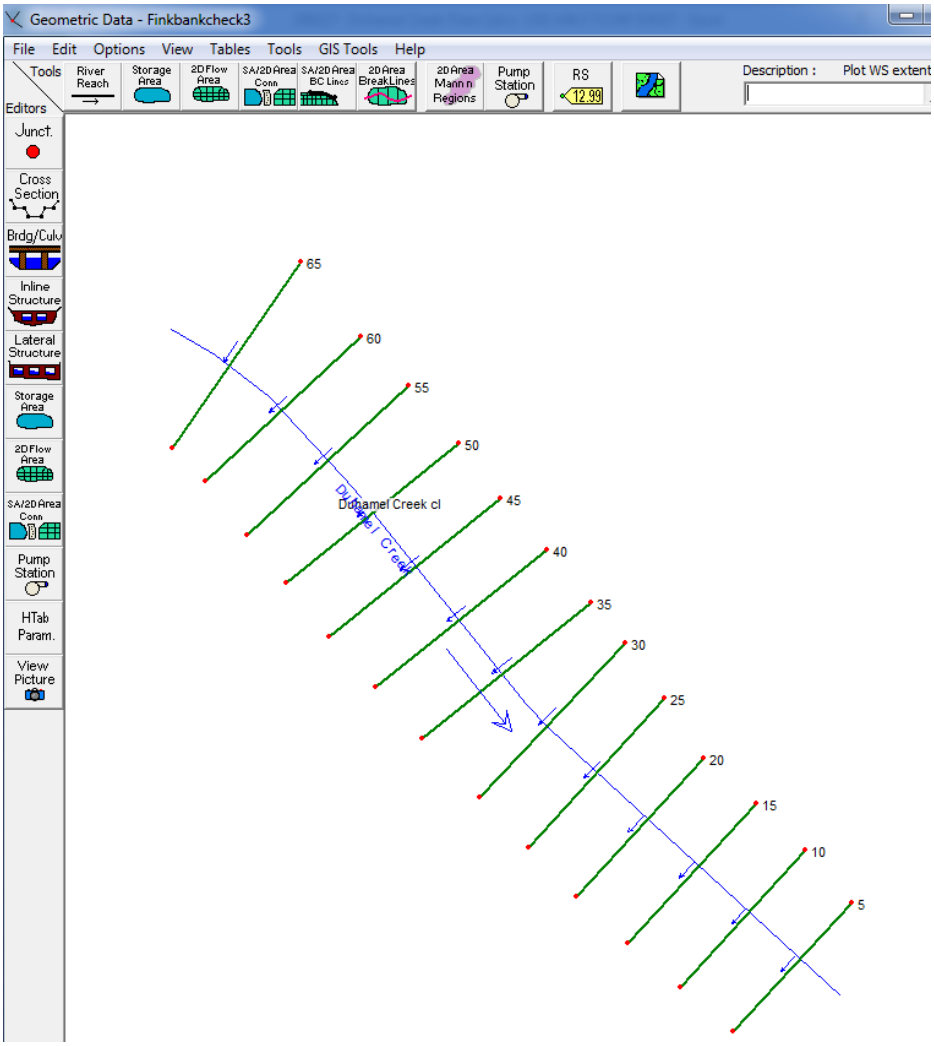
	2	5	10	25	50	100	200a	200b	200c
coefficient a	10.4	13.4	15.3	17.8	19.6	21.4			
coefficient b	-0.64	-0.662	-0.673	-0.682	-0.688	-0.693			
intensity, a*Tc^b mm/hr	4.902828	6.155902	6.938492046	7.987319	8.733239	9.479416			
Flow, Q=CiA/360 (m3/2)	2.061549	2.588443	2.917508218	3.358521	3.672166	7.97184	9.964800413	11.9577605	15.94368066
							projected as 1.25*Q100	projected as 1.5*Q100	projected as 2.0*Q100

Return Period- Hathaway Tc

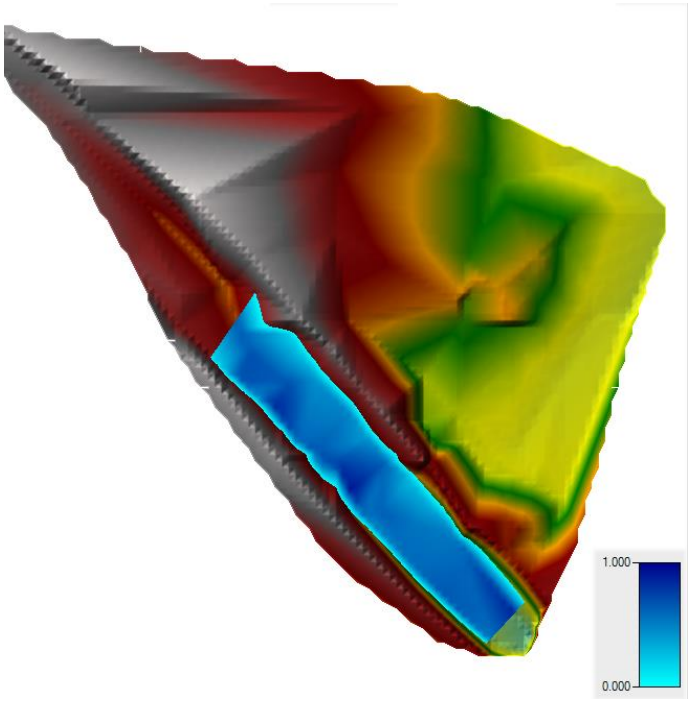
	2	5	10	25	50	100	200a	200b	200c
coefficient a	10.4	13.4	15.3	17.8	19.6	21.4			
coefficient b	-0.64	-0.662	-0.673	-0.682	-0.688	-0.693			
intensity, a*Tc^b mm/hr	4.939496	6.20353	6.993071176	8.050992	8.803473	9.556208			
Flow, Q=CiA/360 (m3/2)	2.076967	2.60847	2.940457738	3.385294	3.701699	8.036419	10.04552371	12.05462846	16.07283794
							projected as 1.25*Q100	projected as 1.5*Q100	projected as 2.0*Q100

Return Period- Airport Tc

	2	5	10	25	50	100	200a	200b	200c	
coefficient a	10.4	13.4	15.3	17.8	19.6	21.4				
coefficient b	-0.64	-0.662	-0.673	-0.682	-0.688	-0.693				
intensity, a*Tc^b mm/hr	4.618158	5.786565	6.51550057	7.494082	8.189346	8.884899				
Flow, Q=CiA/360 (m3/2)	1.941851	2.433144	2.739648087	3.151123	3.443469	7.471873	9.339841149	11.20780938	14.94374584	11.83046546
							projected as 1.25*Q100	projected as 1.5*Q100	projected as 2.0*Q100	projected as average of proposed Q200s



HEC RAS Model for Duhamel Creek



RAS-MAPPER Output for 200c-yr Return Period Flow

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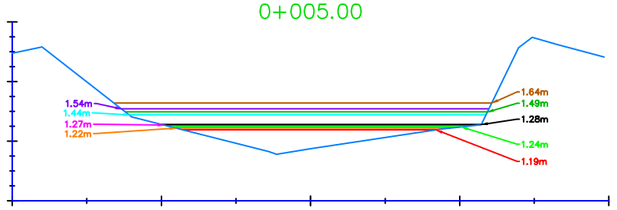

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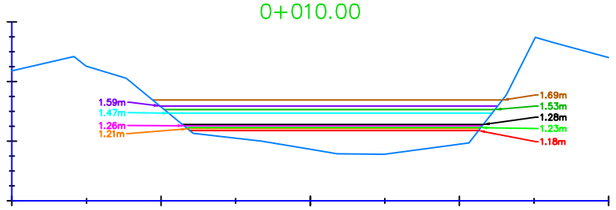

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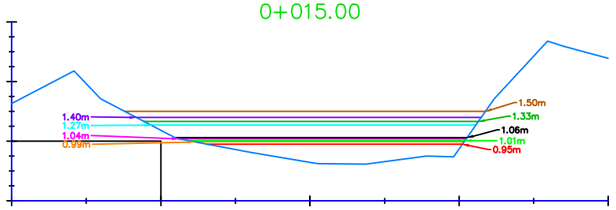

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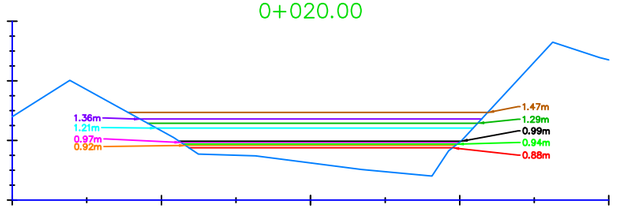

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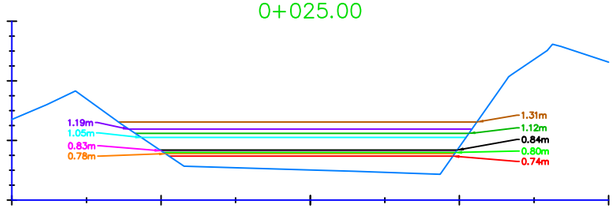

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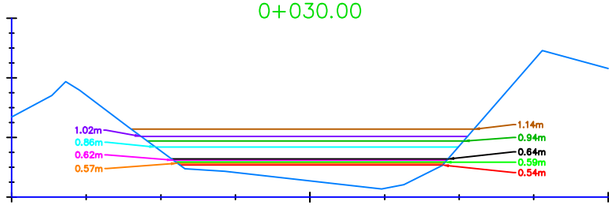

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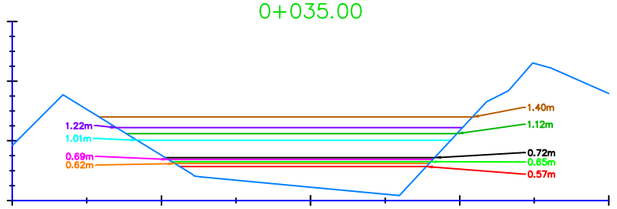

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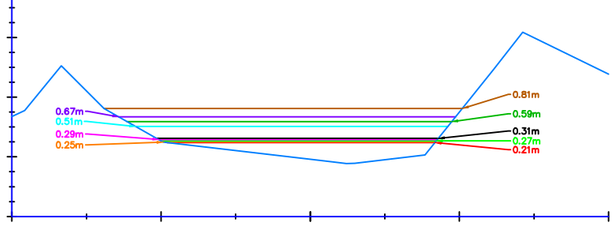

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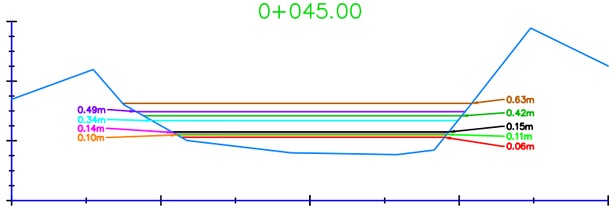

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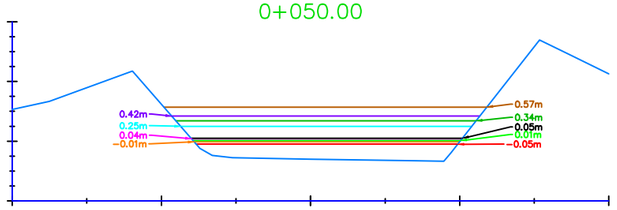

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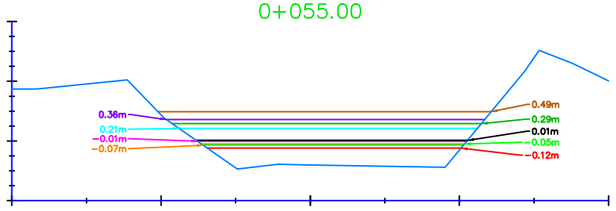

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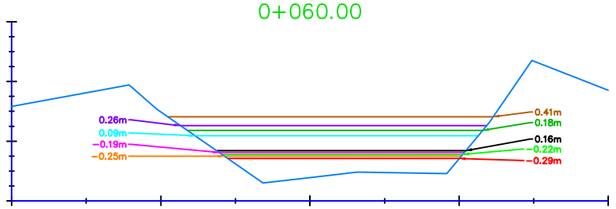

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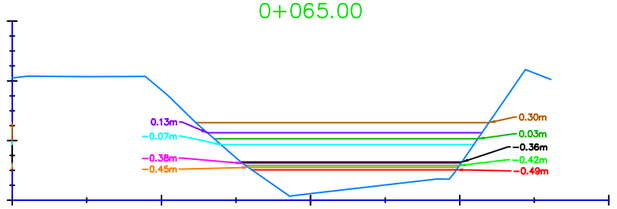

Legend
WS 200YRc
WS 200YRb
WS 200YRa
WS 100YR
WS 50YR
WS 25YR
WS 10YR
WS 5YR
WS 2YR
Ground

General Notes

1.

No.	Revision/Issue	Date

DESIGNED LJ DATE MARCH 2020
CHECKED BHP DATE MARCH 2020
DRAWN CK DATE MARCH 2020

CDG ENTERPRISES Ltd.

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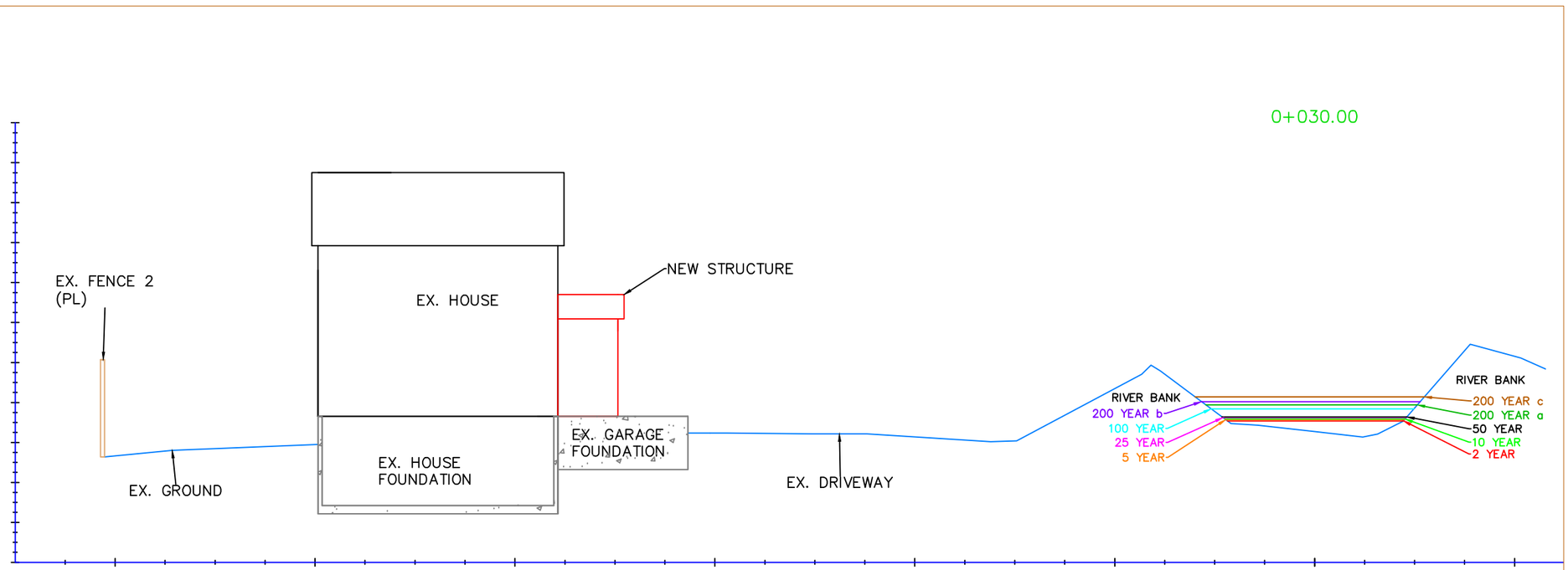
TWIN RIVER ESTATES - PHASE 2

LOT LAYOUT #1
(50 TOTAL)

Project No.	Drawing No.
19–1432	19–1432–01
Scale: 1:200	Sheet: 1 OF 1
Date: MARCH 05, 2020	REV.



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Scale: 1:200	Sheet: 1 OF 1
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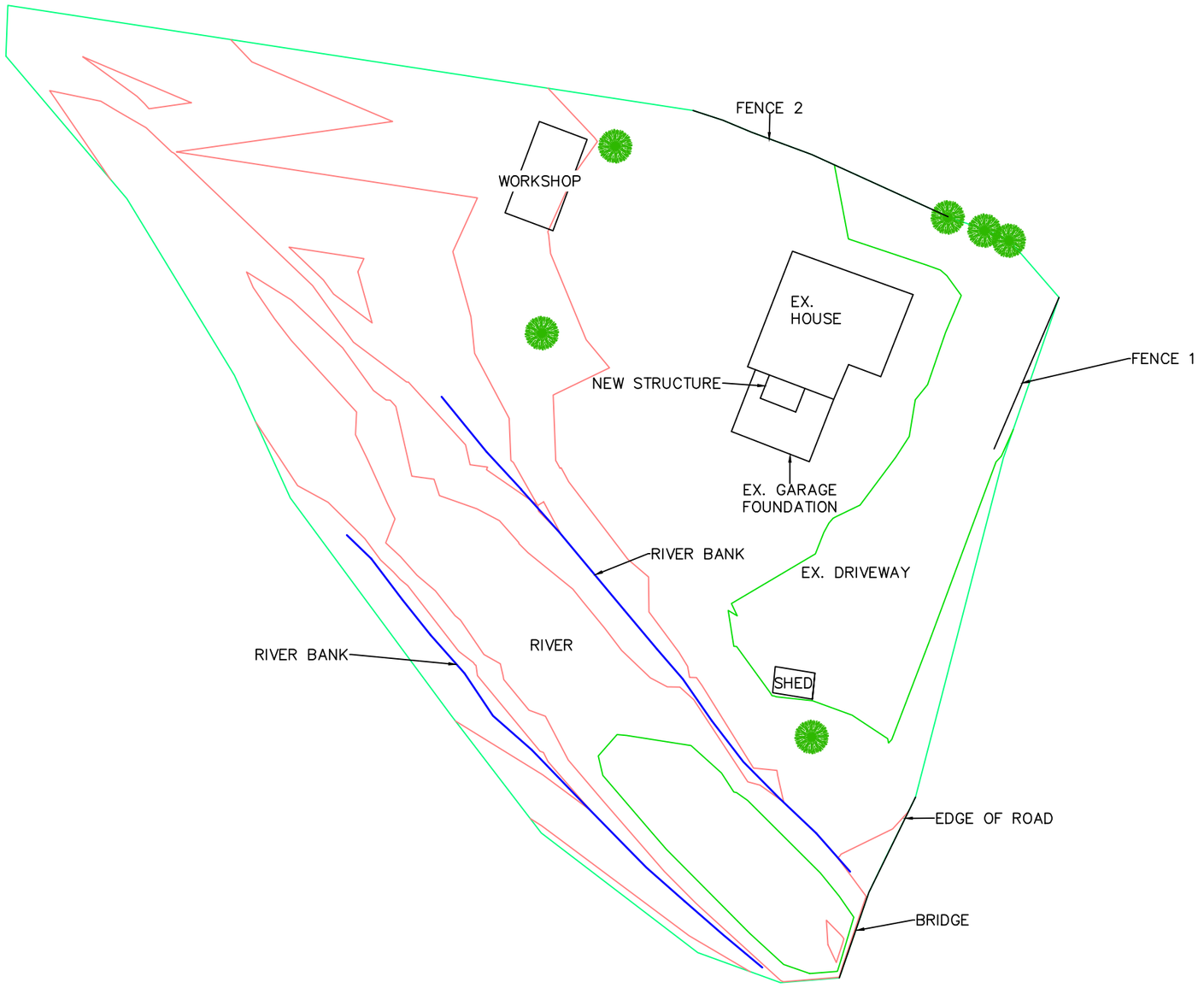

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LOT LAYOUT #1
(50 TOTAL)

Project No.	Drawing No.
19–1432	19–1432–01
Scale: 1:200	Sheet: 1 OF 1
Date: MARCH 05, 2020	REV.

General Notes

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TWIN RIVER ESTATES - PHASE 2

LOT LAYOUT #1
(50 TOTAL)

Project No.	Drawing No.
19–1432	19–1432–01
Scale: 1:250	Sheet: 1 OF 1
Date: MARCH 05, 2020	REV.

General Notes

1.

No.	Revision/Issue	Date

DESIGNED LJ DATE MARCH 2020
CHECKED BHP DATE MARCH 2020
DRAWN CK DATE MARCH 2020

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TWIN RIVER ESTATES - PHASE 2

LOT LAYOUT #1
(50 TOTAL)

Project No. 19–1432	Drawing No. 19–1432–01
Scale 1:250	Sheet 1 OF 1
Date MARCH 05, 2020	REV.

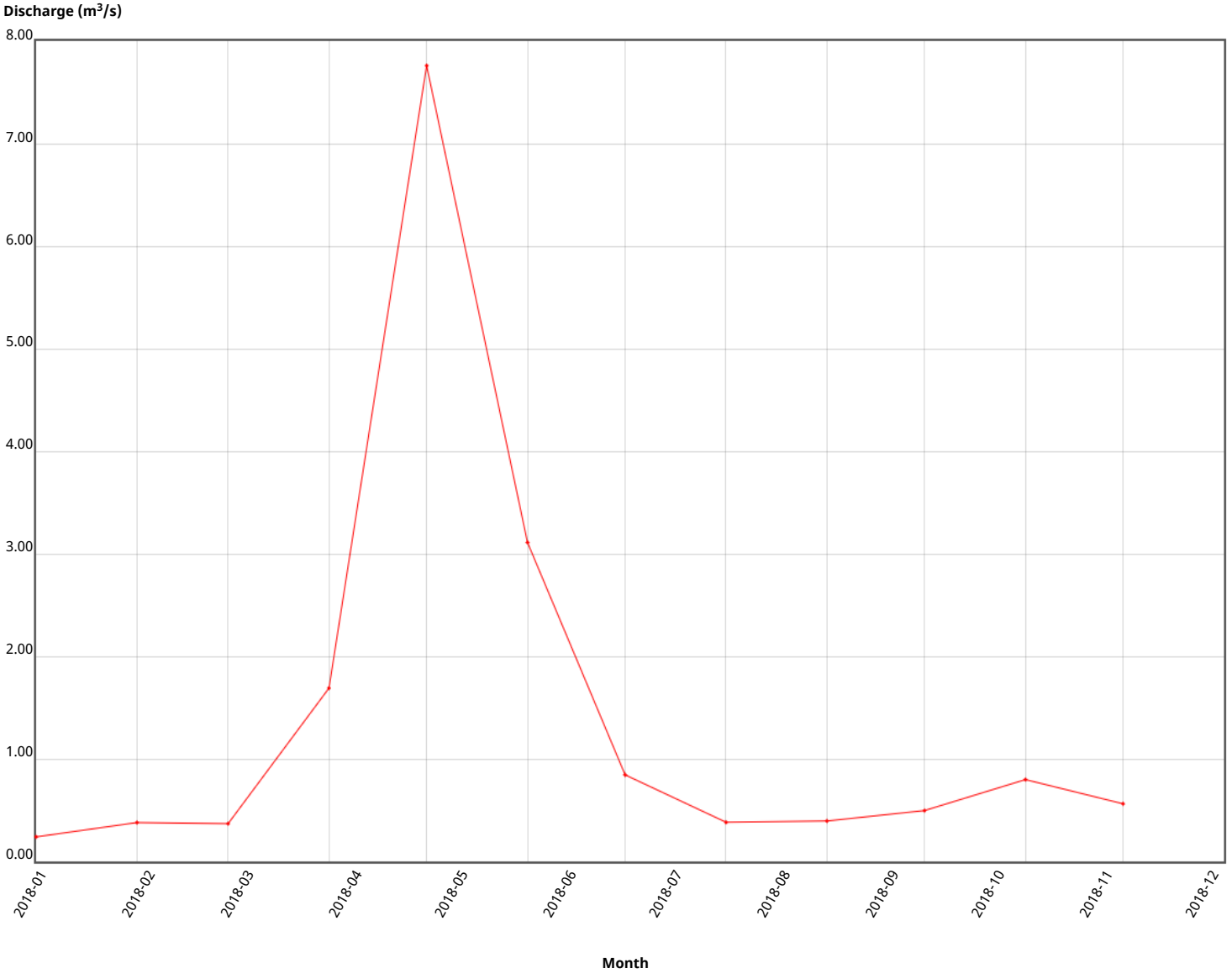
Government of Canada / Gouvernement du Canada

Monthly Discharge Graph for DUHAMEL CREEK ABOVE DIVERSIONS (08NJ026) [BC]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

▼ Legend

2018 Data



Statistics corresponding to 26 years of data recorded from 1922 and 2018.*

*Note: If n<10, percentiles are not calculated.

Station Information

Active or discontinued:	Active	**Province / Territory:**	British Columbia
Latitude:	49° 35' 25'' N	**Longitude:**	117° 14' 32'' W
Gross drainage area:	52.9 km²	**Effective drainage area:**	N/A
Record length:	32 Years	**Period of record:**	1911 - 2020
Regulation type:	Natural	**Regulation length:**	N/A
Real-time data available:	Yes	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	VANCOUVER	**Current Operation Schedule:**	Continuous
Data contributed by:	N/A	**Operation Period:**	JAN - DEC
Datum of published data:	ASSUMED DATUM		

Data Collection History

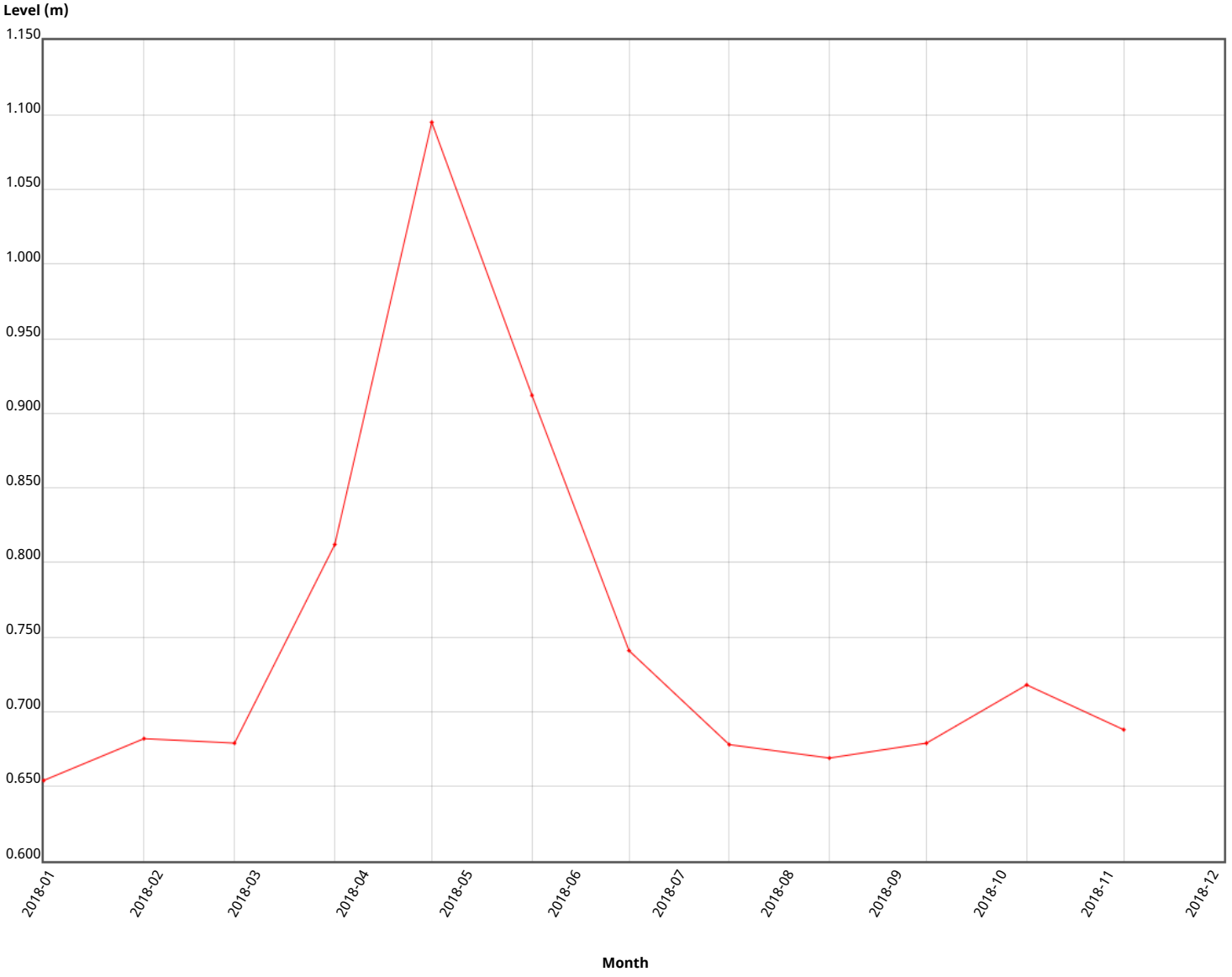
Government of Canada / Gouvernement du Canada

Monthly Water Level Graph for DUHAMEL CREEK ABOVE DIVERSIONS (08NJ026) [BC]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

▼ Legend

2018 Data



Statistics corresponding to 8 years of data recorded from 2011 and 2018.*

*Note: If n<10, percentiles are not calculated.

Station Information

Active or discontinued:	Active	**Province / Territory:**	British Columbia
Latitude:	49° 35' 25'' N	**Longitude:**	117° 14' 32'' W
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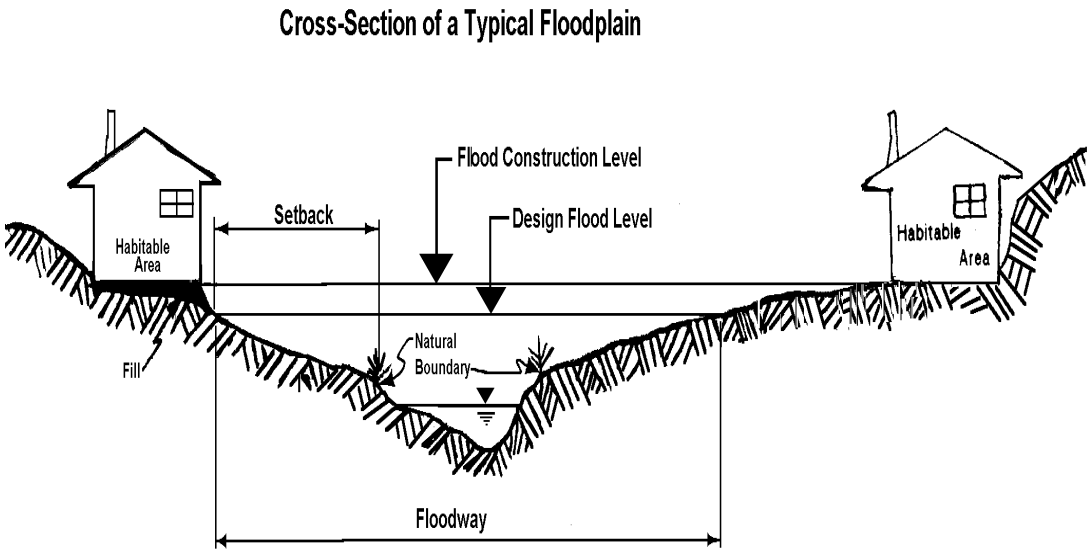
Type of water body:	River	**RHBN:**	No
EC Regional Office:	VANCOUVER	**Current Operation Schedule:**	Continuous
Data contributed by:	N/A	**Operation Period:**	JAN - DEC
Datum of published data:	ASSUMED DATUM		

Data Collection History

Diagram 1



Note: *This diagram is provided for illustrative purposes only (source: British Columbia Ministry of Environment)*

6.0 FLOODPLAIN DESIGNATION

6.1 The following are designated as Floodplain:

a. Land shown as Floodplain in Schedule "B" – Floodplain Map

b. Land within the Non-Standard Flooding and Erosion Area boundaries as delineated in Schedule "C" – Non-Standard Flooding and Erosion Areas Map

c. Lands within the designated Floodplain Setback as specified in Section 7.2 of this Bylaw.

7.0 FLOODPLAIN SPECIFICATIONS

7.1 Flood Construction Levels

The following elevations are specified as Flood Construction Levels, except where more than one Flood Construction Level is applicable, the higher elevation shall be the specified Flood Construction Level:

a. Where Floodplain Mapping is available, the Flood Construction Level (F.C.L.) for a specific property shall be determined by interpolation from the "200 year frequency Flood Level" as identified in Schedule "B" of this Bylaw

b. Where Floodplain Mapping is not available, the following elevations are specified as Flood Construction Levels:

a. 652.3 G.S.C. Datum on Whatshan Lake;

b. 581.2 G.S.C. Datum on Duncan Lake;

c. 539.2 G.S.C. Datum on Slocan Lake;

d. 536.5 G.S.C. Datum on Kootenay Lake;

e. 443.5 G.S.C. Datum on the Arrow Reservoir;

f. 3.0 metres above natural boundary for the Duncan, Goat, Halfway (Arrow Reservoir), Kaslo, Kootenay (Brilliant Dam to Columbia River), Kootenay (Corra Lynn Dam to South Slocan Dam), Lardeau, Little Slocan, Moyie, Pend D'orelle, Salmo, Slocan, South Salmo, Westfall and Whatshan Rivers;

g. 3.0 metres above natural boundary for Barnes, Burton, Caribou, Carpenter, Cooper, Corn, Crawford, Cultus, Dog (Arrow Lake north of Castlegar), Duhamel, Eagle (Arrow Reservoir), East, Erie, Fosthall, Fry, Hall, Hamill, Hawkins, Howser, Keen, Koch, Kokanee, Kuskanax, Lemon, Midge, Mosquito, Pingston, Poplar, Stagleap, Summit and Wilson (Slocan Lake) Creeks;

h. 1.5 metres above natural boundary for Wilson Creek (Kootenay Lake drainage and South Salmo River Drainage); and

i. 1.5 metres above natural boundary for all other small lakes, ponds, marshes and small watercourses.

7.2 Floodplain Setbacks

The following distances are specified as Floodplain Setbacks, except where more than one Floodplain Setback is applicable, the greater distance shall be applied:

a. Floodplain Setbacks for the Arrow Reservoir shall be above the safe line for properties with a covenant and reference plan. For properties without a covenant or reference plan, the Floodplain Setback shall be 30 metres from the 440.7 metre contour interval;

b. Floodplain Setbacks for the Kootenay River between the South Slocan Dam and Brilliant Dam shall be the safe line for properties with a covenant and reference plan. For properties without a covenant and reference plan the Floodplain Setback shall be 15.0 metres from the natural boundary;

c. Floodplain Setbacks for the Duncan River shall be the setback as defined for properties with a covenant. For properties without a covenant the Floodplain Setback shall be as determined by Schedule B or 30.0 metres from the natural boundary.

d. 90.0 metres from Bernard Creek;

e. 50.0 metres from the natural boundary of the west bank of Preacher Creek and 20.0 metres from the natural boundary of the east bank of Preacher Creek;

f. 45.0 metres from the natural boundary of the east bank of Grohman Creek and 30.0 metres from the natural boundary for the west bank of Grohman Creek;

g. 30.0 metres from the natural boundary of the Columbia, Goat, Halfway (Arrow Reservoir), Kaslo, Kootenay (excluding that portion from the South Slocan Dam to Brilliant Dam), Lardeau, Little Slocan, Moyie, Pend D'orelle, Salmo, Slocan, South Salmo, Westfall and Whatshan Rivers;

h. 30.0 metres from the natural boundary for Barnes, Burton, Caribou, Carpenter, Cooper, Corn, Crawford, Cultus, Dog (Arrow Lake north of Castlegar), Duhamel, Eagle (Arrow Reservoir), East, Erie, Forty-nine, Fosthall, Fry, Hall, Hamill,

Hawkins, Howser, Inonoaklin, Keen, Koch, Kokanee, Kuskanax, Lemon, Midge, Mosquito, Pingston, Poplar, Stagleap, Summit and Wilson Creek (Slocan Lake Drainage);

i. 30.0 metres from the natural boundary of Duncan Lake;

j. 15.0 metres from the natural boundary of Wilson Creek (Kootenay Lake and South Salmo River Drainages);

k. 15.0 metres from the natural boundary for all other lakes and small watercourses; and

l. 7.5 metres from the natural boundary for all small lakes, ponds and marshes.

A 7.5 metre setback is required for any standard dike or structure used for flood protection or any easement or right of way for a standard dike or structure used for flood protection.

8.0 FLOODPLAIN REGULATIONS

8.1 No building, manufactured home or unit, modular home or structure or any part thereof shall be constructed, reconstructed, moved, extended or located with the underside of a wooden floor system or top of concrete slab of any area used for habitation, business, or storage of goods damageable by floodwaters, or in the case of a manufactured home or unit the ground level or top of pad on which it is located, lower than the Flood Construction Level specified in Section 7.1 of this Bylaw.

8.2 No landfill or structural support required to support a floor system or pad, shall be constructed, reconstructed, moved, extended or located within any Floodplain Setback specified in Section 7.2 of this Bylaw.

8.3 Unless specifically provided for elsewhere in this Bylaw, no area below the Flood Construction Level shall be used for the installation of furnaces, major electrical switchgear, or other fixed equipment susceptible to damage by floodwater.

8.4 Structural support or compacted fill or a combination of both may be used to elevate the underside of the floor system or the top of the pad above the Flood Construction Level. The structural support and/or fill

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Legend

- Non Standard Flooding Erosion Area
- Flood Construction Levels
- Official Community Plan

Zoning Class

- Commercial
- Industrial
- Institutional
- Open Space
- Residential 1
- Residential 5
- Electoral Areas
- Cadastre
- Civic Address

Map Scale:

1:4,514

Date: May 28, 2020

The mapping information shown are approximate representations and should only be used for reference purposes. The Regional District of Central Kootenay is not responsible for any errors or ommissions on this map.