TECHNICAL MEMORANDUM

DATE 30 December 2016 **REFERENCE No.** 1114220046-664-TM-Rev0-1150

TO Marina Wright, Fisheries and Oceans Canada
Malissa Smith, Ministry of Forests, Lands and Natural Resources Operations

CC Rob Hajdú, Canadian Environmental Assessment Agency
Derek Holmes, BURNCO

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BURNCO AGGREGATE PROJECT: ADDITIONAL INFORMATION REGARDING WATERCOURSE TWO (WC2), FISH AND FISH HABITAT

1.0 INTRODUCTION

1.1 Setting

BURNCO Rock Products Ltd. (BURNCO) and 0819042 BC Ltd. are proposing to construct and operate a sand and gravel operation, the BURNCO Aggregate Project (Project), on private property in the lower portion of the McNab Creek watershed (BC Watershed Code 900-106300) on the western shore of Howe Sound's Thornbrough Channel.

The proposed sand and gravel pit will be situated on a flat area of the glacial fan-delta that was clear-cut between 2002 and 2004 west of the mouth of McNab Creek. A groundwater-fed channel (WC2) approximately 1,220 m in length was constructed in stages as habitat restoration and compensation projects; the upper section of WC2 is in the area of the planned gravel pit and will result in habitat loss. WC2 was originally built to provide spawning habitat for chum salmon (*Oncorhynchus keta*), with the additional function of providing spawning and rearing habitat for coho salmon (*O. kisutch*). WC2 was constructed in three stages over an 18 year period from 1985 to 2003:

- The first stage is a 230 m long tidal channel running north from the estuary that was constructed in 1985 by Fisheries and Oceans Canada's (DFO's) Resource Restoration Unit.
- The second stage was constructed in 1998. It extended the 1985 channel to the west by approximately 470 m. This work was funded by DFO with in-kind contributions from Canfor Ltd. In the remainder of this report, Stages 1 and 2 of the project will collectively be referred to as the "lower" section of the channel.
- The third stage of the channel above the BC Hydro right-of-way was constructed from 2001 to 2003 by Howe Sound Pulp and Paper Limited Partnership (HSLP), who owned the property at the time. This phase of the Project runs north for approximately 520 m and is referred to as the upper section of the channel.

The purpose of this technical memo is to provide additional fish use information on recent and historic spawning activity within the groundwater-fed channel WC2. Predicted changes in the level of groundwater influx into the lower section of WC2 are provided. An overview of the habitat use of constructed groundwater-fed channels by various salmonids and the potential of the proposed channel extension (Appendix 5.1-B) to offset for loss of the upper section of WC2 is also presented.

1.2 Original Groundwater-fed Channel Objectives

Developing groundwater-fed channels to create spawning habitat for chum salmon was first introduced by DFO in British Columbia during the 1970s. It was known that many chum salmon sought out areas of groundwater upwelling and that excavating channels below the existing water table within a floodplain would allow groundwater to upwell through exposed gravel. The influx of groundwater passing through the gravel provided suitable conditions for chum spawning and incubation (Sheng et. al 1990). While monitoring the early channels DFO observed that if coho were present in the system, juvenile coho salmon would almost invariably use of the constructed groundwater-fed channels for rearing. By the 1990s additional woody structure and deeper pools were being incorporated into groundwater-fed channel construction to support rearing of juvenile coho as rearing and overwintering habitat appeared to be limiting coho in some systems (Lister and Finnigan 1997). Side channels that incorporate a diversity of flowing- and standing-water areas are more likely to provide the variety of habitats (i.e., spawning, summer rearing, and overwintering) required by salmonids to carry out their life cycle in freshwater and increase smolt production (Sheng et al. 1990).

Based on a review of DFO correspondence regarding construction of the groundwater-fed channel (WC2), the first and lowest section was constructed in 1985 and its design was focused specifically on chum salmon spawning. In 1998, the original channel was extended with the goal to triple the length of the channel and create additional chum spawning habitat. Habitat complexing using boulders and large woody debris to improve rearing habitat for coho salmon and coastal cutthroat trout (*O. clarkii clarkii*) was included in the design.

The upper section of the channel above the BC Hydro right-of-way was constructed from 2001 to 2003 as part of a section 35(2) *Fisheries Act* Authorization issued by DFO to HSLP. It was constructed to compensate for habitat losses in the Rainy River watershed located approximately 8 km west of the site. Similar to the second phase, the objective for the upper section was to provide spawning habitat for chum salmon while also providing rearing habitat for coho and cutthroat trout (Hatfield 2009). A six-year effectiveness monitoring program was completed by Hatfield Consultants Ltd. (Hatfield) to determine whether the upper section of channel was functioning as intended. Based on the results of the monitoring program, DFO released the letter of credit and confirmed that the project was providing viable fish habitat.

1.3 Salmonid use of Constructed Groundwater–fed Channels

Various species and life stages of salmonids utilize groundwater-fed channels. The benefits and value of creating additional groundwater-fed off-channel habitat depend on the fish species present in the system and how their life stages are adapted to the conditions provided by the habitat. The most common salmonid species present in WC2 are chum and coho salmon and coastal cutthroat trout. As discussed below each of these species use the habitat provided by groundwater-fed channels in different ways and these species have co-evolved and adapted to a range of positive and negative inter and intra-specific interactions.

1.3.1 Chum Salmon

Chum salmon normally spawn in the lower reaches of rivers, including groundwater-fed channels and areas under tidal influence (Salo 1991). Chum use freshwater habitat mainly for spawning in the fall and after emergence in the spring, chum fry quickly migrate downstream to the estuary where they rear before making the full transition to saltwater. Chum fry tend to spend less than two weeks in freshwater and do little feeding and are therefore not overly dependent on freshwater habitat for rearing (Salo 1991). The period of residence in estuarine near shore waters is considered to be a more critical phase in the life history of chum salmon (Healey 1982).

Spawning chum generally select areas with head riffles or in upwelling groundwater zones (Scott and Crossman 1973). Chum spawners use substrate with moderately sized gravel with low amounts of fine sediments (Bonnell 1991). Studies indicate that survival of chum salmon embryos and alevins is higher in systems with more stable flow regimes that reduces egg mortality when spawning occurs in areas that are dewatered during lower flows. Rates of survival to fry emergence has been shown to increase when flow control is implemented to reduce variation in baseflows (Connor and Pflug 2004). Chum carcasses, post-spawning activity, are known to be an important source of food and nutrients for invertebrates and other fish species including juvenile coho and coastal cutthroat trout that rear in the channels (Sheng et al. 1990).

1.3.2 Coho Salmon

Coho salmon typically ascend farther upstream in coastal rivers to spawn, but are also known to spawn in large river main stems and offchannel habitat. Like chum, they may also seek out groundwater upwelling zones to spawn (Gribanov 1948). Most coho spawn in substrate with gravel less than 10 cm in diameter (Bjornn and Reiser 1991). Following emergence, coho fry remain in fresh water for one or sometimes two full years before migrating to sea (Bradford et al. 1997). Coho fry typically disperse upstream and downstream after emergence seeking out lower velocity habitat for rearing in the summer (Swales and Levings 1989). Densities of juvenile coho tend to be higher in slower velocity areas and the development of additional off-channel habitat has been shown to increase juvenile coho summer rearing capacity (Beechie et al. 1994). Coho fry exhibit a range of movement patterns following emergence. These movement patterns may be caused by physical displacement due to high streamflow (Tschaplinski 1987) or a behavioural response to density-dependent aggression and territorial spacing (Chapman 1962). In either case it is common for coho fry to colonize available off-channel habitat including areas not accessible to adult coho for spawning (Neave 1949). Some fry may be displaced downstream all the way to the estuary where they move along the shoreline in the freshwater lens before entering a different stream for summer rearing (Otto an McInerney 1970).

A second movement of juvenile coho into deeper off-channel habitats in the fall is also common (Brown and Hartman 1988), as fish redistribute from summer rearing habitat into overwintering habitats. Juvenile coho tend to overwinter in deeper pool habitats (Brown and Hartman 1988; Peterson 1989). Smolt production in some coastal systems appears to be limited by overwinter survival (Hartman et al. 1996), and there is evidence that overwinter survival is determined by the availability of adequately deep pools (Nickelson et al. 1992). No consistent relationship between smolt production and the number of adult spawners has been found in longer productivity studies (Knight 1980; Holtby and Scrivener 1989). Coho smolt production appears to be determined by density-dependent factors related to the availability of suitable juvenile rearing habitat rather than levels of spawning or availability of spawning habitat (Bradford et al. 1997 and Roni et al. 2006).

1.3.3 Cutthroat Trout

Coastal cutthroat trout inhabit a wide variety of diverse freshwater, estuarine and marine habitats. Cutthroat trout spawn in freshwater and tend to use tributaries that are smaller and higher in stream systems than those used by coho salmon. Their use of small tributaries and their affinity for selecting areas with abundant cover means that their spawning behaviour is not well documented (McPhail 2007). Cutthroat trout spawn in the late winter or early spring and their fry emerge in late spring or early summer after the salmon fry have emerged. After emerging cutthroat fry move down into slower pool and off-channel habitats unless they are displaced to shallower riffle habitat by larger and more aggressive coho fry (Rosenfeld et al. 2000). When coho fry are absent cutthroat fry select deeper slower moving areas with abundant cover for summer rearing (Heggenes et al. 1991). Like coho cutthroat move into deeper pools in the fall for overwintering (Bustard and Narver 1975).

The life histories and movements of coastal cutthroat trout populations are also highly diverse (Northcote 1997). This diversity appears to be due to variable movements of individual fish between rearing, overwintering, and spawning areas. The diversity of life history strategies may include populations where the majority of fish are anadromous but some individuals in the population never go to sea while others may utilize estuarine habitat on a seasonal basis and return to fresh water to overwinter (Northcote 1997). Multiple life-history forms often coexist within the same system and even within the same stream reach (Johnston 1982). Individuals may even change strategies during their lifetime (Tomasson 1978). This high level of individual flexibility allows coastal cutthroat trout to shift and exploit habitats that are only seasonally utilized by other salmonids (Johnston 1982). The early movements and habitat selection of their fry may be adapted to avoid competition with juvenile coho (Pearcy et al. 1990) while still allowing seasonal access to habitat and resources. Conversely, older cutthroat trout that are resident or move back into freshwater from the estuary in the fall are able to prey on salmon eggs and juvenile coho on a seasonal basis (Pearcy et al. 1990, Northcote 1997).

2.0 METHODS

Enumeration of salmon spawner returns to WC2 was conducted for nine consecutive years. Hatfield conducted annual spawner surveys each November from 2004 to 2008. Golder conducted multiple surveys of WC2 from 2009 to 2012. The Golder surveys were initiated in late summer and repeated through to winter in order to span the spawning season. During the Golder surveys, teams of two observers walked upstream through designated segments, along watercourse margins and banks and recorded spawning activity and numbers of adult salmon spawners and carcasses. Similar spawner surveys were conducted by Golder on 13 October and 10 November of 2016 to provide information on spawning activity during an exceptional chum salmon return throughout Howe Sound (Jennifer Nener DFO 2016 pers. comm.)

To evaluate changes in the level of groundwater influx into the lower section of WC2 associated with different phases of the proposed Project, the groundwater model described in Section 5.6.4.10 of Groundwater Resources was used to predict the level of groundwater influx during operation and closure.

3.0 RESULTS

The following results are a summary of spawner enumeration data collected between 2004 and 2016 by Hatfield and Golder. A summary of predicted changes in the level of groundwater influx to WC2 below the proposed pit lake is also provided for reference.

3.1 Salmon Spawner Observations

Hatfield conducted adult chum and coho spawner enumeration during WC2 monitoring conducted each November between 2004 and 2008 (Table 1). Spawner numbers were collected during single site visits and foot surveys timed to occur during chum spawning each year. Each visit is an annual snap shot of the entire length of WC2 and does not necessarily reflect peak or average returns.

Table 1: Adult Salmon Spawner Enumeration Data Collected by Hatfield in WC2 between 2004 and 2008

Year	Chum	Coho
25-Nov-2004	73	1
16-Nov-2005	31	1
23-Nov-2006	89	0
13-Nov-2007	0	4
13-Nov-2008	20	0

As described in the Fish and Fish Habitat Baseline (Appendix 5.1-A), in order to span the spawning season Golder conducted surveys of the entire length of WC2 from late summer to early winter from 2009 to 2012 (Table 2). Estimates for adult Coho, Chum and Pink Salmon returns were derived using the Peak Count method which is based on the largest total live and dead salmon counts observed over the survey period.

Table 2: Adult Salmon Spawner Enumeration Data Collected by Golder for WC2 from 2009 to 2012

Year	Chum	Coho	Pink
2009 (5 surveys)	16	1	0
2010 (8 surveys)	0	0	0
2011 (9 surveys)	0	0	38
2012 (7 surveys)	9	1	0

Two surveys of WC2 were conducted during the fall of 2016 to collect adult salmon spawner numbers for the upper and lower section of the channel (Table 3). Only a single chum carcass was observed in the lower section of WC2 during the October survey. During the November survey 202 chum and 6 coho spawners or carcasses were observed (Figure 1). Chum spawning activity was observed throughout the gravel run habitat within the lower section of the channel and in areas with exposed gravel in the upper channel. More than 4 times as many chum spawners were observed in the lower channel as compared to the upper channel.

Table 3: Adult Salmon Spawner Enumeration Data for WC2 October and November 2016

Date	Upper Section		Lower Section	
	Chum	Coho	Chum	Coho
13 Oct 2016	0	0	1	0
10 Nov 2016	38	4	164	2

3.2 Groundwater Influx

The influx of groundwater into the lower section of the channel is predicted to increase with the loss of the upper section of WC2 and the creation of the pit lake. The conceptual groundwater model was used to predict potential changes in the level of groundwater influx to the lower section of WC2 during pit operation and closure. Groundwater influx to WC2 will increase throughout operation and expansion of the pit lake with a predicted 45% increase by year 5 that will increase to 110% over baseline by year 16 and closure (Table 4).

Table 4: Predicted Changes in Groundwater Influx in Lower Section of WC2

Project Date	Pit Lake Elevation	Groundwater influx m3/day	Percent Increase from baseline
Year 0	n/a	9,800	n/a
Year 5	5.5	14,200	45%
Year 10	4.5	17,500	79%
Year 15	4.9	19,900	103%
Year 16	5.0	20,600	110%

4.0 DISCUSSION

A review of the spawner numbers observed between 2004 and 20012 by Hatfield and Golder appear to suggest a decline in spawning activity within the entire groundwater-fed channel between 2004 and 2012. The lack of spawners observed by Golder between 2009 and 2012 are however within the variation found by Hatfield during the earlier years of operation. Just considering the numbers observed, the potential decline may be suspect in nature as salmon spawner returns are known to be influenced by a multitude of variable freshwater and marine factors affecting production and survival. For example a direct barrier to salmon access in the form of a debris jam just below the culvert was observed during the October 2016 survey. Salmon populations have evolved and adapted to these variable factors and are able to exploit freshwater habitat when it is available. However, it has also been observed that chum salmon fry production in groundwater-fed spawning channels often declines over time (Bonnell 1991). The reasons for this decline may include the gradual deterioration of the spawning gravels due to settling of fine particles that limits water exchange through the substrate (Sheng et al. 1990, Lister and Finnigan 1997). In the upper section of the groundwater-fed channel, erosion from the steep un-vegetated banks is a source of sand and fine sediment. The low gradient, coupled with the absence of a freshet flow to provide seasonal scouring appears to have led to the accumulation of a sand and fine sediment layer over the majority of the upper sections potential spawning substrate.

During the November 2016 survey much higher numbers of returning chum were observed in WC2. This is not surprising as the chum salmon return along the southern coast of BC was exceptional in 2016 and chum spawners were observed in a range of locations where they are not normally observed throughout the region. It is important to note that during the November 2016 survey more chum spawners were observed in the lower section of the channel and the amount of available spawning habitat in the upper channel was not increased above what was documented in the baseline (Appendix 5.1-A) and the estimate of less than 200 m^2 of suitable spawning habitat was observed above the culvert during the November survey.

It is not surprising that the lower section of WC2 was observed to support chum spawning activity, as it was originally designed to provide spawning habitat for chum salmon. The existing lower section of WC2 meets the factors and criteria that are generally accepted for the construction of a functional groundwater-fed spawning channel (Table 5).

Table 5: Factors and Criteria for Assessing Groundwater-fed Spawning Channel Projects

Factor	Criteria
Gradient	0.002 to 0.005 center line of channel
Substrate	Clear gravel low % fines
Water Source	Aquifer with high percolation rate
Water Table	Close to ground surface with little fluctuation
Dissolved Oxygen	Minimum of 5 mg/L
Siltation	Low potential for siltation
Velocity	Low velocity 5 – 15 cm/sec
Temp	8-13oC summer / 3-7oC winter
Depth	Minimum 25 cm preferred for adult salmon
Banks	Less than 3 m high with 2 to 1 slope

(Bonnell 1991, Lister & Finnigan 1997 and Sheng et al. 1990)

The proposed Project will lead to the loss of approximately 200 m^2 of spawning habitat in the upper section of WC2 however, this loss is addressed by the Fish Habitat Offset Plan (Appendix 5.1-B). The offset plan proposes to extend the length of the existing lower section of WC2 by approximately 790 m (Figures 2 and 3). The proposed design for the channel extension uses the existing lower channel as a template and it will meet the factors and criteria outlined in Table 5 above and should provide conditions similar to the existing run habitat in the lower section of WC2 that was designed as chum spawning habitat by DFO and where spawning activity was observed during the November 2016 survey.

The creation of the pit lake is predicted to cause a doubling of groundwater influx into the lower section of WC2 (Table 4). The increase in ground water influx will lead to additional groundwater upwelling and the increased upwelling is expected to provide increased levels of intergravel flow that will be suitable for eggs and alevins. The average depth in the proposed offset habitat extension and the remaining section of WC2 is predicted to be above 0.3 m making it suitable for salmon spawning. As described in the Aquatic Health assessment provided in Surface Water Resources (Section 5.5.7.2) of the application, the water quality and temperature of ground and surface water entering the offset habitat and existing lower section of WC2 will be suitable for salmonids to complete all stages of their life history including spawning.

In response to comments from the Working Group the design of the habitat offset plan was revised to allow approximately 20 m of pool habitat upstream of the culvert and approximately 20 m of gravel bed run habitat downstream of the culvert to be retained (Figures 2 and 3) which will avoid approximately 232 m^2 of habitat loss. Table 6 provides updated habitat losses and gains associated with the revised design. The design of the channel extension incorporates run and pool habitat in approximately a 1 : 1 ratio, based on this design and the use of run habitat for spawning in the existing lower channel it is expected that more than 2, 000 m^2 of the offset channel habitat will provide conditions suitable for salmonid spawning.

The elevation of the pit lake will be maintained to be relatively constant this will mean that groundwater influx and baseflows of the channels below the pit lake will be subject to less fluctuation. A more consistent baseflow is expected to result in higher chum productivity as spawning will be less likely to occur in areas that will dewater during lower flows. The design of the overflow structure out of the pit lake also incorporates a low level release valve designed to allow the release of flushing flows that will be adequate to flush fine sediments that may accumulate in the offset channel. The monitoring program of the offset habitat will include evaluation of substrate embeddedness and identification of a threshold that will be used to determine the need for a flushing flow that could be released during a least risk window. This design feature increases the potential long-term viability of the offset habitat that is not currently available for the existing gravel habitat in WC2.

Table 6: Habitat losses and gains associated with Project effects and Fish Habitat Offset Plan.

Habitat Component	**Instream Habitat Loss (m^2)**	**Riparian Habitat**
Serious Harm		
Loss of Upper segment of the Channel	3,307	1,560
20 m pool section above culvert retained, loss reduced by $120m^2$	- 120	
20 m gravel bed section below culvert retained, loss reduced by 112 m^2	- 112	NA
Lower segment of the Channel (surface area loss due to reduced flows)	116	NA
Total Loss	3,423	1,560
Habitat Offset		
Wetted area of instream habitat in the channel extension	5,341	32,907
Net Gain	1,918	31,347

The design of the proposed offset channel includes gravel bed run habitat similar to the existing run habitat in the lower section and, as outlined in Table 5, meets the criteria for groundwater-fed channels designed to be suitable for chum spawning. The offset channel design also includes habitat complexing with boulders and large woody debris for juvenile coho summer rearing and deeper in-channel and off-channel pools for coho overwintering.

The highly plastic nature of the habitat utilization and life history pattern of coastal cutthroat trout suggests that the creation of additional groundwater-fed channel habitat with sufficient woody cover and complexity will be used by both adult and juvenile cutthroat within the McNab Creek system. The creation of additional groundwater-fed habitat is expected to benefit the overall population of cutthroat trout in the McNab Creek system. The upper section of WC2 did not exist before 2003 when construction was completed. This suggests that cutthroat trout currently using this portion of the channel have only recently accessed the area from other areas within the McNab Creek system. It is reasonable to assume similar colonization of the proposed channel extension will also occur. The additional habitat area and food supply provided by the construction of more available habitat for chum spawning and juvenile coho rearing is expected to benefit the coastal cutthroat trout population in the McNab Creek system.

5.0 CLOSURE

We trust that the information above addresses your needs. If you have any questions, please do not hesitate to contact the undersigned at 604-296-4200.

GOLDER ASSOCIATES LTD.

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Attachments: Figures 1 to 3

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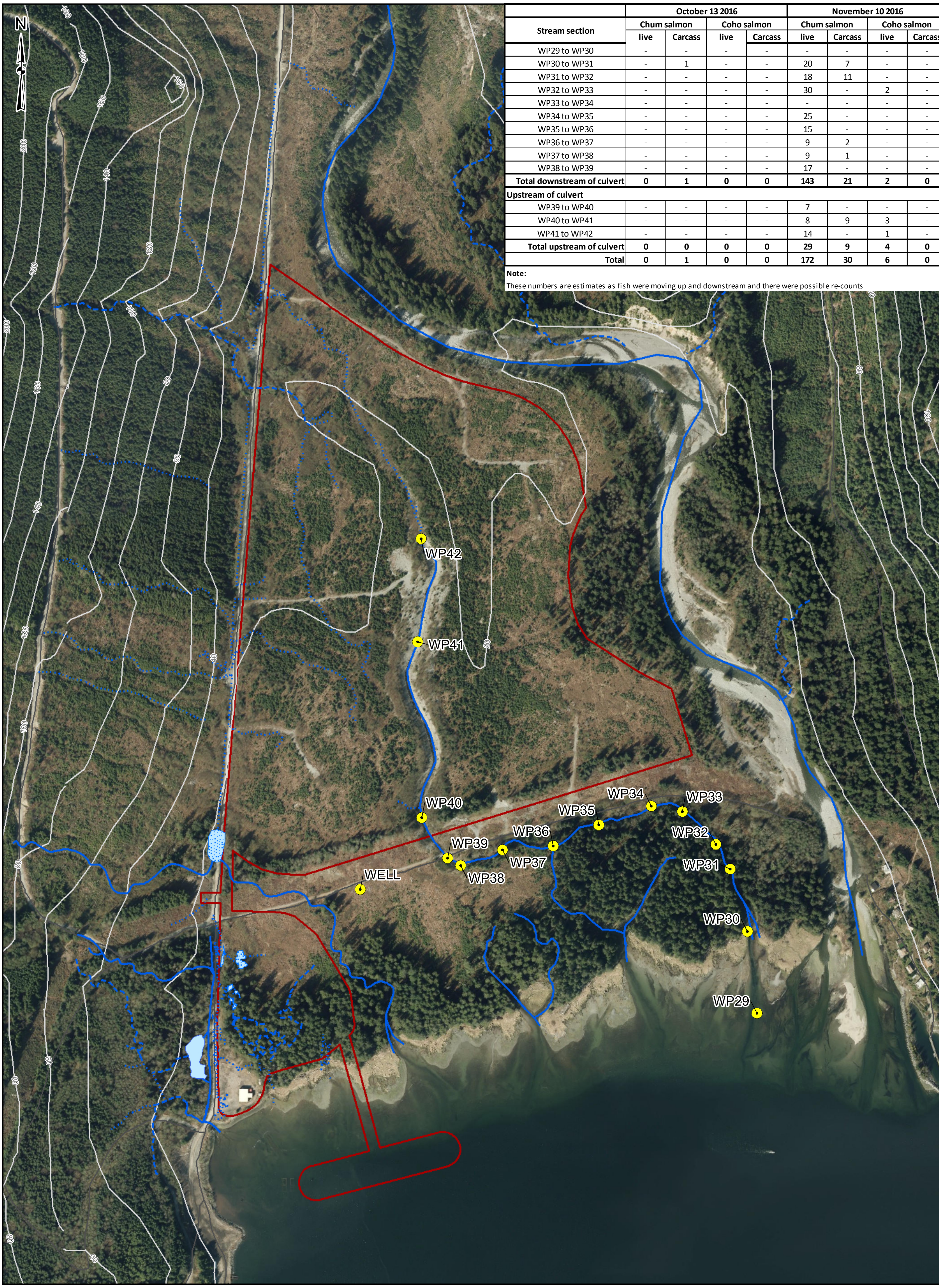


Stream section	October 13 2016				November 10 2016			
	Chum salmon		Coho salmon		Chum salmon		Coho salmon	
	live	Carcass	live	Carcass	live	Carcass	live	Carcass
WP29 to WP30	-	-	-	-	-	-	-	-
WP30 to WP31	-	1	-	-	20	7	-	-
WP31 to WP32	-	-	-	-	18	11	-	-
WP32 to WP33	-	-	-	-	30	-	2	-
WP33 to WP34	-	-	-	-	-	-	-	-
WP34 to WP35	-	-	-	-	25	-	-	-
WP35 to WP36	-	-	-	-	15	-	-	-
WP36 to WP37	-	-	-	-	9	2	-	-
WP37 to WP38	-	-	-	-	9	1	-	-
WP38 to WP39	-	-	-	-	17	-	-	-
Total downstream of culvert	**0**	**1**	**0**	**0**	**143**	**21**	**2**	**0**
Upstream of culvert								
WP39 to WP40	-	-	-	-	7	-	-	-
WP40 to WP41	-	-	-	-	8	9	3	-
WP41 to WP42	-	-	-	-	14	-	1	-
Total upstream of culvert	**0**	**0**	**0**	**0**	**29**	**9**	**4**	**0**
Total	**0**	**1**	**0**	**0**	**172**	**30**	**6**	**0**

Note:
These numbers are estimates as fish were moving up and downstream and there were possible re-counts

LEGEND

- Project Area
- Watercourse Waypoint
- Low Lying Wetted Area
- Beaver Impounded Wetted Area
- Road (Existing)
- Contour (20m)
- Permanent / Perennial Watercourse
- Intermittent Watercourse
- Ephemeral Watercourse

200 0 200

SCALE 1:6,500 METRES

DRAFT

REFERENCE

Base data from the Province of British Columbia. Contours from TRIM positional data. Watercourses from the Province of British Columbia and field data. Imagery Copyright © 20140115 Esri and its licensors. Source: Sunshine Coast Regional District. Used under license, all rights reserved.
Projection: UTM Zone 10 Datum: NAD 83

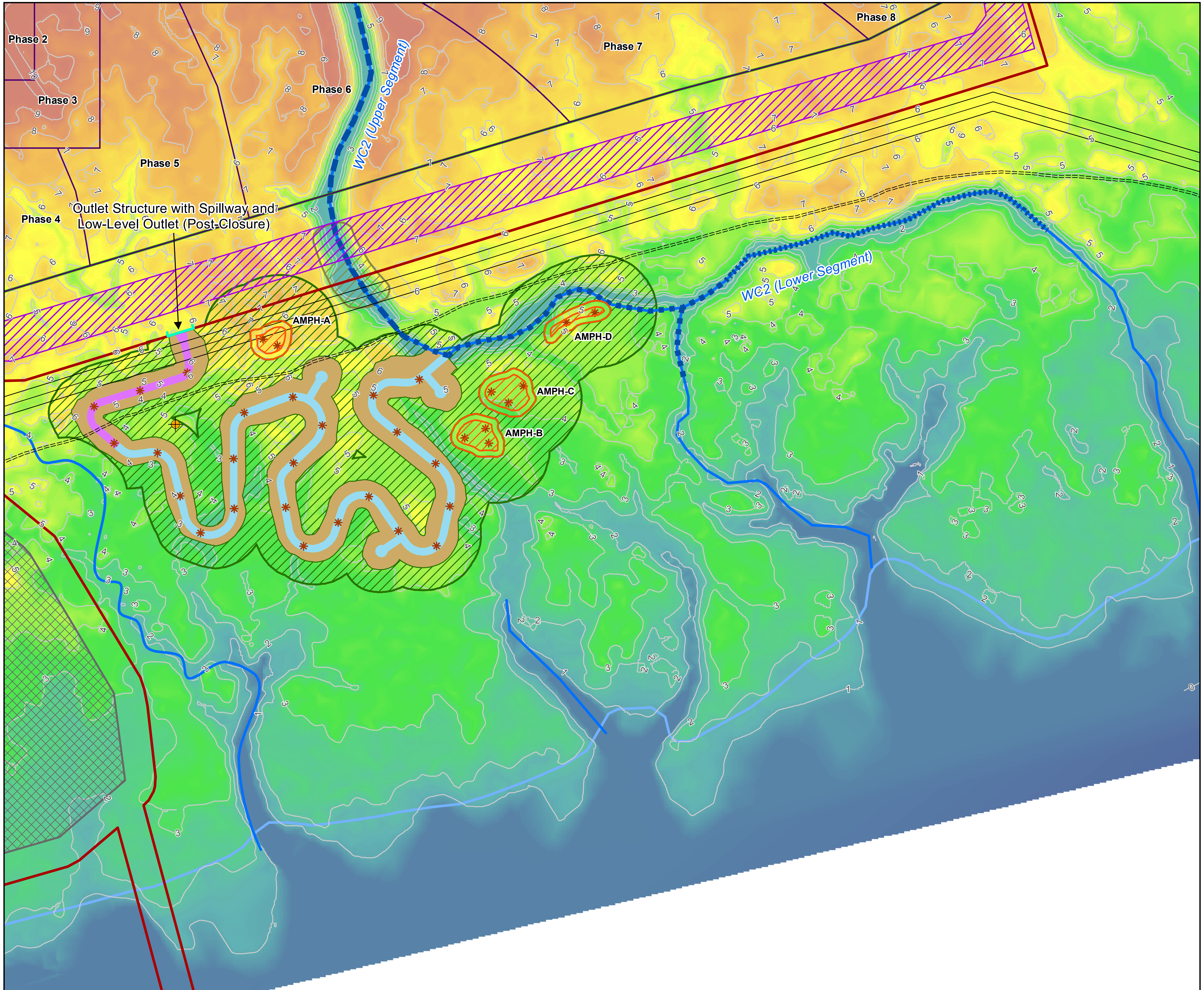
PROJECT
BURNCO ROCK PRODUCTS LTD.
BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.

TITLE
SPAWNER SURVEY
OCTOBER 13 2016 AND NOVEMBER 10 2016

Golder Associates

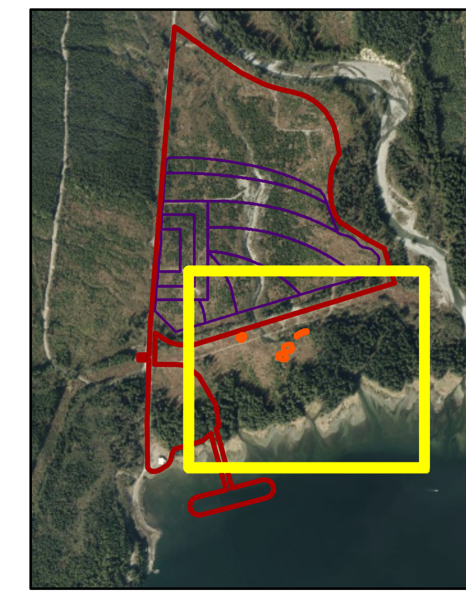
PROJECT NO. 11-1422-0046			PHASE No.	
DESIGN	DC	30 Nov. 2016	SCALE AS SHOWN	REV. 0
GIS	JP	30 Nov. 2016		
CHECK			**FIGURE 1**	
REVIEW				

Path: Y:\Vancouver\Spatial Data\Project Data\BC\McNab\Figures\MXD\Fish\2016\BURNCO_FISH_Figure_01_Spawner_Survey_2016.mxd



LEGEND

- Project Area
- **Proposed WC2 Extension (~770 m)**
- Proposed Channel Extension: Year 1 Channel Construction
- Proposed Channel Extension: Project Closure Channel Construction
- Top of Bank
- Riparian
- Channel Infill, Riprap and Filter Zone
- Proposed Amphibian Pond (Combined Area ~1250 m^2)
- Outlet Structure with Spillway and Low-Level Outlet
- **Constructed Watercourse**
- Phase 1 (1985)
- Phase 2 (1998)
- Phase 3 (2001 - 2003)
- Wood Debris
- Installed Well - Coordinates: 10U 0471586 E 5490127 N +/- 3m
  Depth to bottom of well from top of casing: 5.33 mbtoc
  Stick-up above ground surface: 0.85 m
  Depth to water from top of casing: 2.945 mbtoc (~2.1 mbgs)
- Processing Area
- Final Pit Lake Outline
- Proposed Aggregate Pit Phase
- Pit Lake Containment Berm
- Transmission Line
- Road (Existing)
- **Elevation (m)**
  High : 10.0
  Low : -0.5



DRAFT

REFERENCE

Installed well, wood debris, WC2 Extension and outlet structure from Golder Associates Ltd. Base data from the Province of British Columbia. Contours from TRIM positional data. Watercourses from the Province of British Columbia and field data. Additional detailed site features provided by McElhanney.
Projection: UTM Zone 10 Datum: NAD 83

SCALE

100 0 100

SCALE 1:2,500 METRES

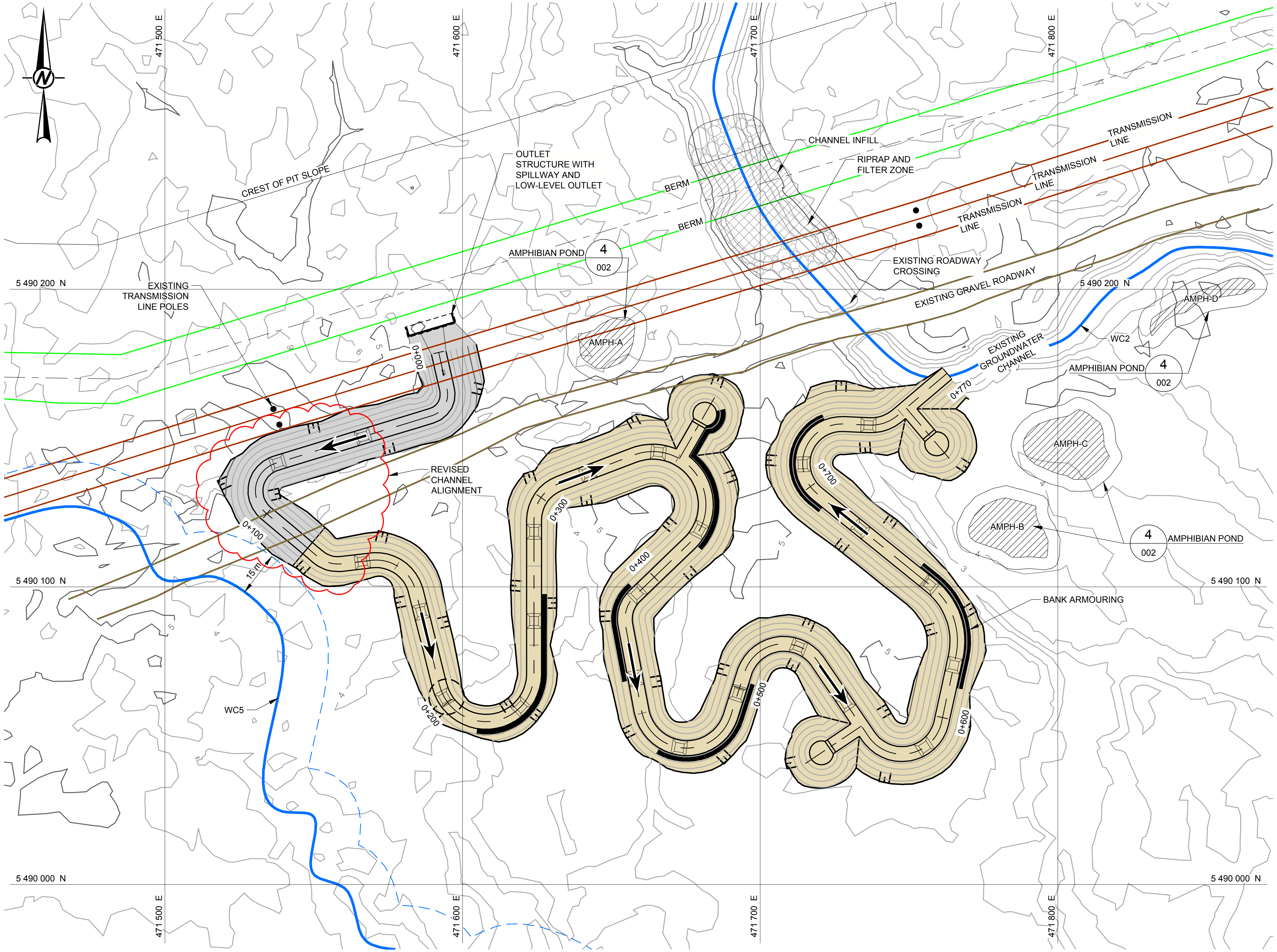
PROJECT

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

TITLE

PROPOSED AMPHIBIAN BREEDING PONDS

Golder Associates	PROJECT NO. 11-1422-0046			PHASE No.
	DESIGN	BD	9 Nov. 2016	SCALE AS SHOWN REV. 0
	GIS	JP	5 Dec. 2016	
	CHECK			FIGURE 2
	REVIEW			



PLAN - PROPOSED AMPHIBIAN BREEDING PONDS

SCALE 1:1,500 m

LEGEND

- EXISTING GROUND CONTOURS
- PROPOSED CHANNEL EXCAVATION CREST
- PROPOSED CHANNEL EXCAVATION TOE
- PROPOSED BERM
- PRE YEAR-1 CHANNEL CONSTRUCTION
- POST CLOSURE CHANNEL CONSTRUCTION
- BANK ARMOURING
- AMPHIBIAN PONDS
- EXISTING WATERCOURSE (APPROXIMATE LOCATIONS)

REFERENCES

1. WATERCOURSES FROM LRDW AND FIELD DATA.
2. CONTOURS FROM TRIM DATA. ADDITIONAL DETAILED SITE FEATURES PROVIDED BY MCELHANNEY. BASE DATA FROM THE PROVINCE OF BRITISH COLUMBIA.
3. PROJECTION: UTM ZONE 10 DATUM: NAD 83

FOR DISCUSSION PURPOSES ONLY

DRAFT

0 25 50

1:1,500 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2016-11-09	ISSUED FOR DISCUSSION	SH	TAK	-	-

CLIENT
BURNCO ROCK PRODUCTS LTD.

CONSULTANT

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CANADA
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www.golder.com

PROJECT
BURNCO AGGREGATE PROJECT
ENVIRONMENTAL PROTECTION PLAN

TITLE
AMPHIBIAN BREEDING PONDS CONCEPTUAL DESIGN OVERVIEW

PROJECT NO.	PHASE	REV.	of	FIGURE
11-1422-0046	10001	A		003