Fish presence was also assessed in the wetland associated with West Alexander Creek Reach 4 (WAL4) through the deployment of minnow traps.

Benthic Invertebrate Community

A representative area was identified in each wetland for benthic invertebrate sampling collection. Using a kick-net, a crew member would pass the net along the edges of the wetland while moving the net up and down to stir up sediment and disturb vegetation. Contents of the netting were emptied into a sample tray to collect a representative sample of the benthic invertebrate community. Each sample was placed into a 1 L plastic container and preserved with formalin solution.

Aquatic Health

Benthic invertebrate tissue and sediment sampling was conducted within the six lentic sites following the same methods described above for lotic sites. Water quality samples were also collected and analyzed for general chemistry, anions and nutrients, total and dissolved organic carbon, total and dissolved metals, and PAHs.

12.4.2.2 Results

12.4.2.2.1 Alexander and West Alexander Creeks

Alexander Creek is a fish bearing fourth order tributary of Michel Creek located adjacent to the Project footprint. Alexander Creek was delineated into 11 reaches; 7 of these were studied in detail during the baseline programs. Alexander Creek Reaches 7, 8, and 9 are immediately downstream or adjacent to the Project (Figure 12.4-5). Reaches 1 and 2 are also downstream, but further afield, and mark the downstream limit of the Fish and Fish Habitat LSA in the Alexander Creek watershed. Reaches 10 and 11 are upstream of the Project and are not expected to be affected by the Project and, are therefore considered to be reference areas. Alexander Creek reaches 1 to 10 are fish bearing (confirmed by the B.C. Ministry of Environment [2018] and studies completed for the proposed Project). Descriptions of each reach are provided in the Fish and Fish Habitat Baseline Assessment in Appendix 12-B.

West Alexander Creek is a second order stream and a tributary of Alexander Creek that comprises four reaches, all of which occur within the Project footprint. Reaches 1 and 2 (WAL1 and WAL2) are fish bearing, while Reaches 3 and 4 (WAL3 and WAL4) are non-fish bearing. West Alexander Creek has four non-fish bearing tributaries: Unnamed West Alexander 1 (UWA1; first order tributary), Unnamed West Alexander 1b (UWA1b; first order tributary), Unnamed West Alexander 2 (UWA2), and Unnamed West Alexander 3 (UWA3; first order tributary). While fish population studies focussed on the fish bearing portions of the West Alexander Creek valley, a habitat description of the non-fish bearing sections upstream of the fish bearing reaches is provided as they will also be removed by the Project. Since there is a connection between ecological contributions (nutrients and stream maintenance) between non-fish bearing and fish bearing sections of a stream, it is important to include a description of the non-fish bearing habitat in the West Alexander Creek valley.

West Alexander Creek Reach 3 is considered non-fish bearing as it has a gradient of 45% over 200 m (FPCBC, 1998). West Alexander Creek Reach 3 is 0.58 km in length. This reach was also frequently observed to dewater. The dewatered channel essentially exists to convey flow from the headwater wetland habitat of WAL4 to WAL2. There are two small tributaries (UWA2 and UWA3) that enter in WAL3. The gradient

barrier and frequent dewatering of WAL3 prevents fish migration upstream; West Alexander Creek Reach 3 does not provide any fish habitat. West Alexander Reach 4 is a wetland area at the headwaters of the West Alexander watershed. Overland flow leaving the wetland quickly goes underground throughout much of the year. The gradient barrier and frequent dewatering of WAL3 prevents fish migration into WAL4 and no tributaries were observed entering the wetland. The area of the wetland is approximately 4,107 m^2, with depths ranging from 0.5 m near the shore to approximately 2 m in the centre of the wetland when full. The substrate was dominated by fines and organics. The riparian vegetation was dominated by mature coniferous forest.

Unnamed West Alexander Creek 1b (UWA1b) is a first order, unnamed tributary on the east side of West Alexander Creek, which is located approximately 5.57 km northwest from the Alexander Creek/West Alexander Creek confluence. There are two reaches on this stream, UWA1b-1 and UWA1b-2. Unnamed West Alexander Creek 1b Reach 1 is 0.18 km long with an average gradient of 10%. The stream is deeply channelized near the confluence with West Alexander Creek. Unnamed West Alexander Creek 1b Reach 2 is 1.39 km long with an average gradient of 20.0%. Unnamed West Alexander Creek 1b Reach 2 starts at the increase in gradient upstream of UWA1b-1 and ends at the headwaters. The slope increases to >30% for 200 m and this steep gradient is considered a barrier to fish movement. Unnamed West Alexander Creek 1b Reach 2 is classified as a step-pool morphology and is considered non-fish bearing based on gradient (FPCBC, 1998).

Unnamed West Alexander Creek 2 is a first order, unnamed tributary on the east side of West Alexander Creek. Unnamed West Alexander Creek 2 is 0.77 km long with an average gradient of 23.8% and is located approximately 5.71 km upstream from the Alexander Creek/West Alexander Creek confluence. Unnamed West Alexander Creek 2 is one of the two tributaries that enter WAL3. Unnamed West Alexander Creek 2 is classified as a step-pool morphology and is non-fish bearing. There is a 10 m high waterfall barrier located 15 m from the confluence with WAL3. Unnamed West Alexander Creek 3 is a first order, unnamed tributary on the east side of WAL3. Unnamed West Alexander Creek 3 is 0.87 km long with an average gradient of 14.8% and is located approximately 5.83 km upstream from the Alexander Creek/West Alexander Creek confluence. Unnamed West Alexander Creek 3 is classified as a step-pool morphology and is non-fish bearing. There is a gradient barrier of >60% for 100 m located 5 m from the confluence with West Alexander Creek.

Fish Habitat

Fish Habitat Assessment Procedures

Key habitat characteristics in Alexander Creek, West Alexander Creek, and their unnamed tributaries are summarized in Table 12.4-7, Alexander Creek is characterized by transitions between cascade-pool and cascade-riffle to riffle-pool morphology over the reaches surveyed during the baseline studies. Overall habitat quality was considered to be good in Reach ALE1, with mature riparian vegetation, diverse channel units, and sufficient overhead, but cover was less available in the remainder of the watercourse. ALE11 begins at a long bedrock falls, which was determined to be a barrier to fish migration. ALE11 was therefore not considered fish bearing upstream of the falls. Substrate in Alexander Creek was dominated by cobble and gravel throughout the surveyed reaches.

West Alexander Creek is dominated by cascade-riffle/cascade-glide morphology. There was a moderate amount of cover provided by small and large woody debris and boulders throughout the reaches surveyed. Riparian vegetation primarily consisted of mature coniferous forest, and substrate was dominated by cobble and gravel. WAL3 is considered non-fish bearing as per the *Fish-stream Identification Guidebook* (FPCBC, 1998) because it has a gradient of 45% for over 200m (Table 12.4-7) and frequently dewaters, which prevent fish migration upstream. Consequently, WAL3 does not provide fish habitat. WAL4 is a wetland area at the headwaters of the West Alexander Creek watershed and confirmed to be non-fish bearing through minnow trapping and visual assessment. Overland flow leaving the wetland quickly goes underground throughout much of the year. The gradient barrier and frequent dewatering of WAL3 prevents fish migration into WAL4, and no tributaries were observed entering the wetland. Lentic habitat is further described in Section 12.4.2.2.4.

Table 12.4-7: Habitat Summary and Fish Bearing Status for Alexander Creek and West Alexander Creek Reaches

Site ID	Fish Bearing	Reach Length (m)	Bankfull Width (m)	Bankfull Depth (m)	Wetted Width (m)	Water Depth (m)	% Cascade	% Glide	% Pool	% Riffle	% Other
ALE1	Yes	991.80	8.17	0.13	7.32	0.28	-	-	-	-	-
ALE2	Yes	1,878.4	10.0	0.33	9.72	0.25	-	-	-	-	-
ALE7	Yes	7,734.8	11.56	0.55	8.88	0.28	23.8%	46.2%	5.80%	24.2%	0.00%
ALE8	Yes	1,569.1	11.78	0.42	6.62	0.18	53.4%	10.7%	0.90%	35.1%	0.00%
ALE9	Yes	5,702.4	9.63	0.57	5.51	0.26	64.8%	15.7%	1.70%	17.9%	0.00%
ALE10	Yes	210.9	3.81	0.76	2.34	0.12	51.5%	21.9%	7.10%	19.5%	0.00%
ALE11	No	-	3.55	-	2.71	0.4	-	-	-	-	-
WAL1	Yes	6,751.6	5.89	0.45	3.63	0.15	54.2%	13.1%	2.80%	29.9%	0.00%
WAL2	Yes	261.9	3.82	0.28	3.04	0.12	70.9%	10.3%	8.0%	10.9%	0.00%
WAL3	No	-	2.07	-	1.2	<0.1	-	-	-	-	-
WAL4	No	6,751.6	5.89	0.45	3.63	0.15	54.2%	13.1%	2.8%	29.9%	0.0%
UWA1	No	-	-	-	1.89	-	-	-	-	-	-
UWA1b-1	No	-	2.85	-	1.95	-	-	-	-	-	-
UWA1b-2	No	-	2.80	-	1.89	-	-	-	-	-	-
UWA2	No	-	1.65	-	1.42	<0.1	-	-	-	-	-
UWA3	No	-	2.07	-	1.20	<0.1	-	-	-	-	-

All four unnamed tributaries of West Alexander Creek were also observed to be non-fish bearing due to the presence of waterfall barriers and/or gradients >30%, with the exception of the first 15 m of UWA1. There were trace to moderate amounts of cover provided by small and large woody debris, boulders, and overhanging vegetation. The substrates were dominated by cobbles and gravel, and riparian vegetation consisted of mixed forest.

The FHAP results from the baseline assessment are presented in Figure 12.4-7, Figure 12.4-8, Figure 12.4-9, Figure 12.4-10, Figure 12.4-11, and Figure 12.4-12. These maps include information on geomorphological classification of each reach (pool, riffle, cascade, etc.) and barriers for fish movement.

Barriers to Fish Passage

Bedrock falls were observed to be a barrier to fish passage within ALE10. These falls have resulted in a gradient greater than 20% for 20 m, limiting fish access into ALE11 as per the *Fish-stream Identification Guidebook* (FPCBC, 1998). No other fish passage barriers were noted throughout Alexander Creek. The gradient barrier and frequent dewatering of WAL3 was noted to prevent fish migration into WAL4 within West Alexander Creek, which was also confirmed to be fish bearing. All of the unnamed tributaries to West Alexander Creek (considered non-fish bearing) were noted to contain either gradients that are not conducive to fish passage, or waterfalls.

Calcite Assessment

Low amounts of calcite was observed in ALE7, ALE8, and ALE9, and no calcite was observed at the remainder of the sample sites (Table 12.4-8).

Table 12.4-8: Calcite Assessment Summary

Reach	Mean Concretion Score (0-2)	Mean Calcite Presence Score (0-1)	Mean Calcite Index Score
ALE1	0	0.11	0.11
ALE2	0	0.15	0.15
ALE7	0	0.26	0.26
ALE8	0	0.20	0.20
ALE9	0	0.21	0.21
ALE10	0	0	0.00
ALE11	0	0	0.00
WAL1	0	0	0.00

Fish Community

Population Study 2020-2021

Angling resulted in the capture of 79 fish, comprised of 67 Westslope Cutthroat Trout, 6 Bull Trout, 4 Mountain Whitefish, 1 Rainbow Trout, and 1 Cutbow (*Oncorhynchus clarkii* × *mykiss*). In total, 30 Westslope Cutthroat Trout were surgically implanted with radio tags. The length and weight, and capture/release locations of these radio-tagged fish, are provided in Table 12.4-9.

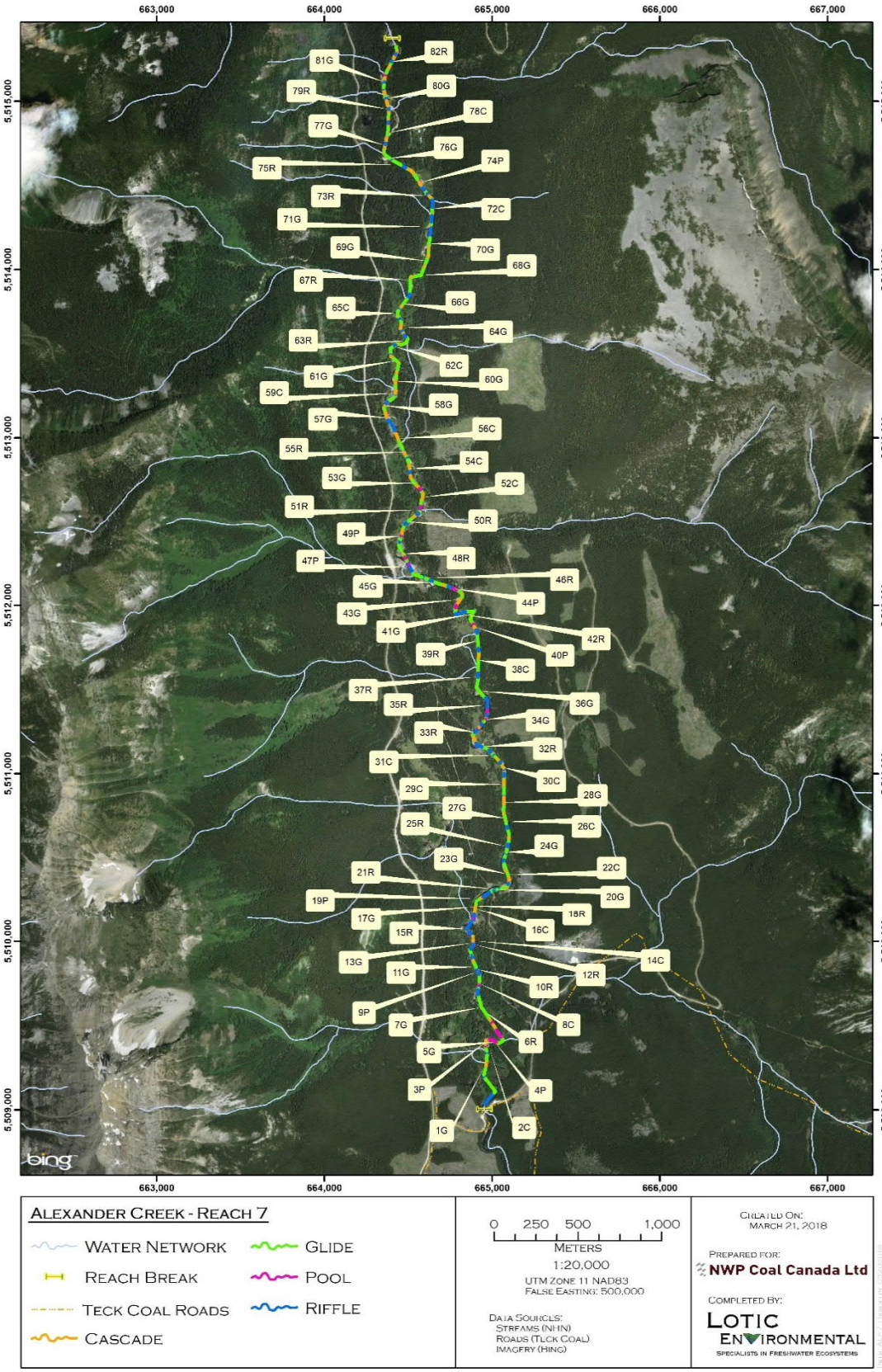

Figure 12.4-7: FHAP Results for ALE7

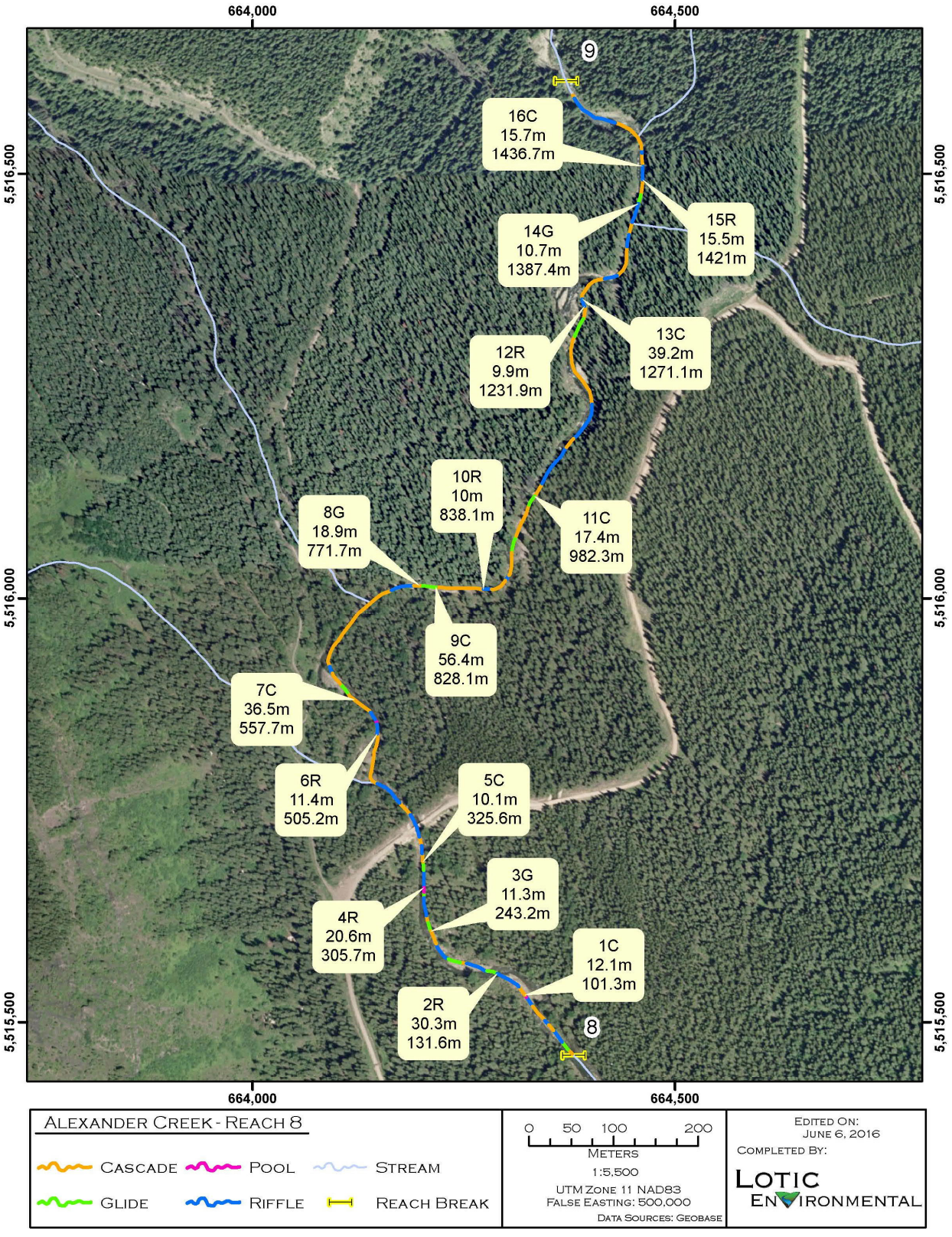

Figure 12.4-8: FHAP Results for ALE8

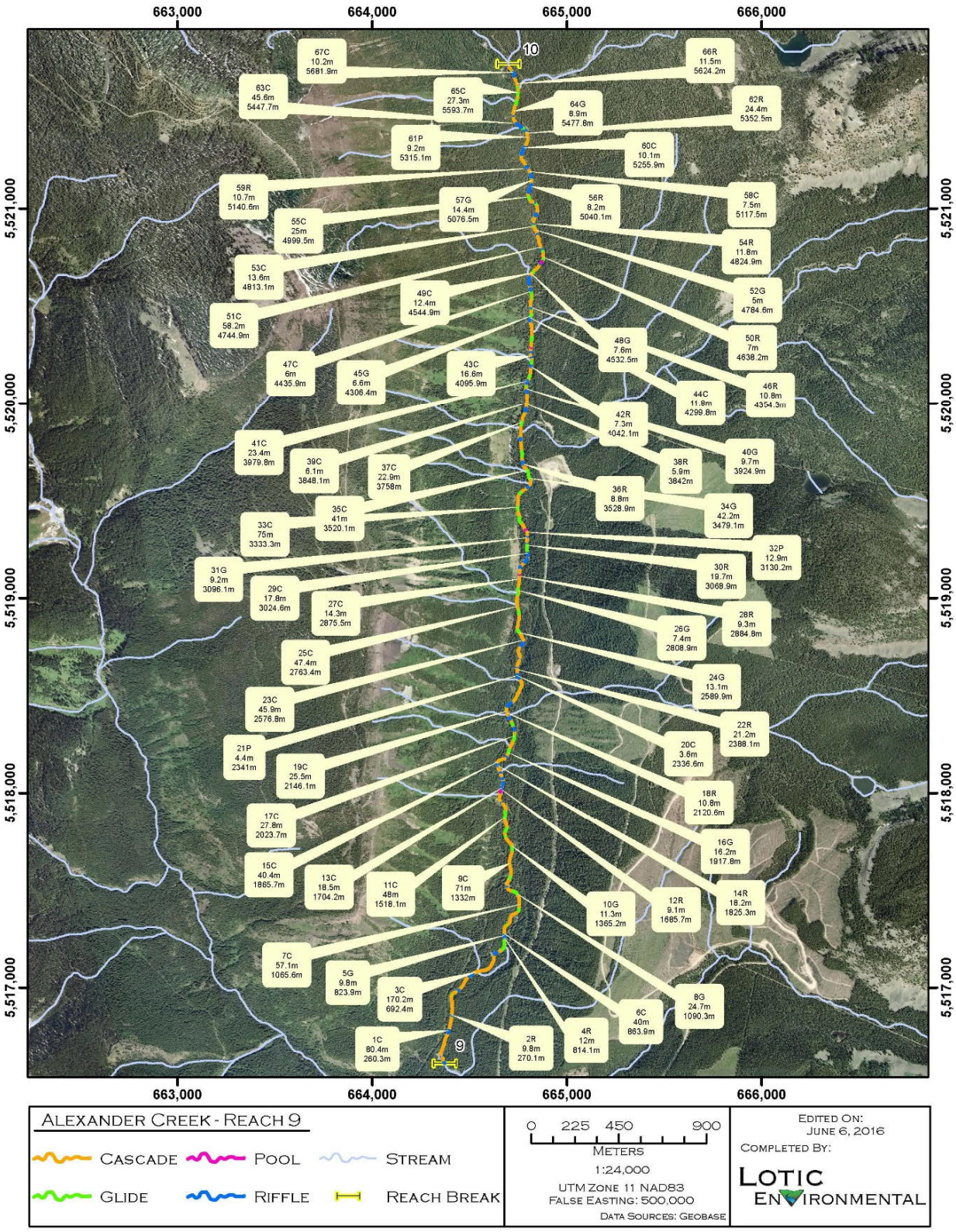

Figure 12.4-9: FHAP Results for ALE9

Figure 12.4-10: FHAP Results for ALE10

Figure 12.4-11: FHAP Results for WAL1

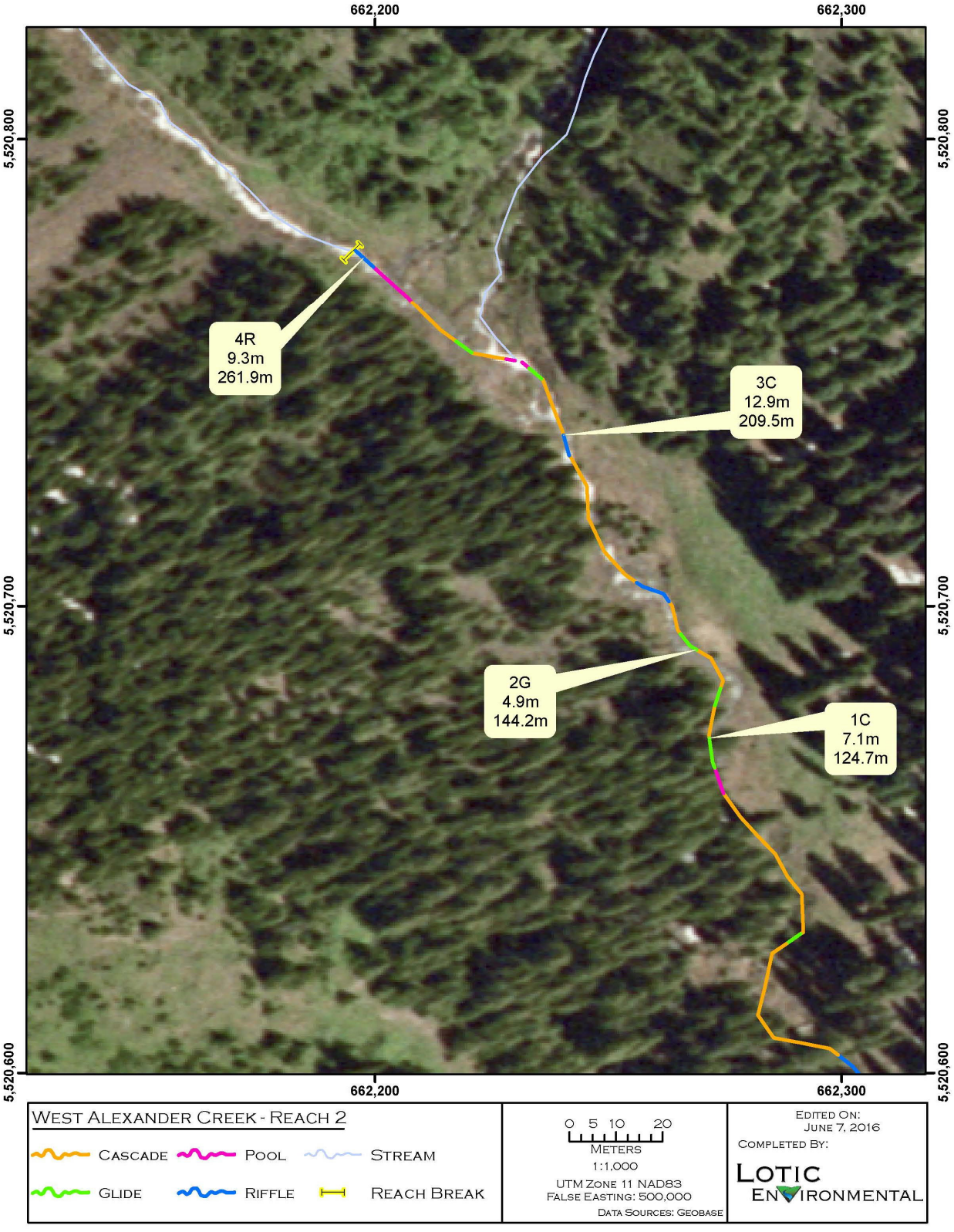

Figure 12.4-12: FHAP Results for WAL2

Table 12.4-9: Summary of Tagged Fish during the Population Study (2020-2021)

Area/ Frequency	*n*	Mean FL (mm)	Min FL (mm)	Max FL (mm)	Mean Wt (g)	Min Wt (g)	Max Wt (g)
West Alex.	7	220	200	248	132	100	183
Upper Alex.	6	246	204	299	216	111	379
Middle Alex.	5	321	268	467	449	227	1,162
Lower Alex.	12	416	365	478	905	594	1,262
West/Upper	13	232	200	299	171	100	379
Middle/Lower	17	388	268	478	771	227	1,262
150.600 MHz	10	218	200	248	131	100	183
150.340 MHz	20	372	254	478	701	227	1,262

Legend: FL = fork length; Wt = weight; Min = minimum; Max = maximum

The 30 Westslope Cutthroat Trout that were implanted with radio tags were split into groups by capture/release area for initial analysis. Of these fish, 7 were captured and released in West Alexander Creek, 6 in Upper Alexander Creek, 5 in Middle Alexander Creek, and 12 in Lower Alexander Creek.

West Alexander Creek

All of the seven fish implanted with radio tags in West Alexander Creek remained there for the life of the tags. These fish were smaller than WCT captured in Middle and Lower Alexander Creek, and were only detected in West Alexander Creek, including for the overwintering and spawning periods. These fish are suspected to have overwintered in interstitial spaces, likely with groundwater influence, a behaviour that has been observed in other areas and sub-populations (Cope et al., 2016). A potential overwintering pool was observed in Reach 1 during the spawning survey on July 9, 2021, indicating that some of these fish may overwinter in such areas. These fish were all detected periodically until June 2021, when the tags began reaching end of transmitting capability.

Spawning surveys were conducted in West Alexander Creek on June 26 and July 9, 2021. On June 26, a WCT was observed holding over a potential redd, but was spooked by the observer's approach and did not return to the area while the surveyors remained. On July 9, 2021, 7 redds were observed within West Alexander Reach 1.

Upper Alexander Creek

Of the 6 radio-tagged WCT from this area, 5 fish remained upstream of the confluence with West Alexander Creek for the life of the tags. The remaining fish moved downstream into Middle Alexander Creek where it was detected until June. Five of these fish were last detected in June 2021, and one in February 2021.

These fish were present in Upper Alexander Creek (or the upstream portion of Middle Alexander Creek) during the overwintering and spawning periods. Spawning surveys were not conducted in this portion of Alexander Creek (or other downstream portions) due to time constraints.

Middle Alexander Creek

Of the 5 radio-tagged fish in this area, 3 fish moved out of Alexander Creek into the Elk River during September/October 2021, one was last detected in Lower Alexander Creek in October, and one remained in Middle Alexander Creek until last detected in June 2021. Therefore, three of these fish overwintered in the Elk River and one in Middle Alexander Creek (it is unknown where the remaining fish overwintered). Of the three fish that moved into the Elk River, one moved back into Lower Alexander Creek in May 2021 and Middle Alexander Creek in June 2021, one was last detected in Michel Creek downstream of Alexander Creek in June 2021 (presumably migrating back into Alexander Creek), and one (ID 45) was last detected in the Elk River upstream of Sparwood in June 2021.

The fish with ID 45 may have been caught by an angler or bird prior to June 18, 2021. This fish was detected on June 18 and June 25, 2021 during helicopter surveys, but the temperatures indicated by the sensor tag were 25ºC and 26ºC, respectively, substantially higher temperatures than water temperatures at that time of year.

Lower Alexander Creek

Of the 12 Westslope Cutthroat Trout implanted with radio tags in this area, 10 fish moved into the Elk River in the fall 2020, one remained in Lower Alexander Creek (exhibited little movement, but was observed alive during snorkel surveys), and one was never detected after release. Of the 10 fish that moved into the Elk River and overwintered there, 8 fish returned to Lower Alexander Creek in June 2021, one was last detected in Michel Creek upstream of the mouth of Alexander Creek at the mouth of Leach Creek in June 2021, and one was last detected in the Elk River in February 2021. More results and details on the Population Study is presented in Appendix 12-C.

Key Observations and Findings of the Population Study

There appears to be two populations or sub-populations of Westslope Cutthroat Trout in Alexander Creek:

- Smaller bodied “fluvial resident” fish that hold, feed, overwinter, and spawn in Upper Alexander Creek and West Alexander Creek. Note that movement of these fish between Upper Alexander and West Alexander was not recorded. A portion of these fish are believed to overwinter in interstitial spaces fed by groundwater, but additional data are needed to confirm/strengthen this observation; and
- Larger bodied “fluvial migratory” fish that leave Alexander Creek in the fall (September/October) to overwinter in the Elk River and return to Alexander Creek in the spring (May/June), likely to spawn.

Spawning occurs in Reach 1 of West Alexander Creek:

- Spawning may occur in other reaches, but continued assessment would be required to confirm this;
- The fluvial migratory Westslope Cutthroat Trout likely spawn in Alexander Creek. Additional studies are required to confirm this observation; and
- Fluvial resident fish likely spawn in Upper Alexander Creek. Additional studies are required to confirm.

Fish Inventory and Distribution

Surveyed reaches considered to be fish bearing included ALE1 to ALE10, WAL1, and WAL2. The fish species captured included WCT, Bull Trout, Mountain Whitefish, and Eastern Brook Trout (Table 12.4-10). Fish bearing status was either confirmed directly by fish capture, inferred if connected to a fish bearing reach in absence of a fish barrier, or confirmed by the provincial database (B.C. Ministry of Environment, 2018). Fish were captured in all fish bearing reaches except ALE8 and ALE10. Both of these reaches defaulted to fish bearing based on unimpeded connection to downstream fish bearing reaches.

Table 12.4-10: Fish Inventory Sampling Summary for Fish Bearing Reaches in the Alexander Creek Watershed

Reach	Sample Date	Electrofishing Effort (s)	Species	Total Number Captured	Min Fork Length (mm)	Max Fork Length (mm)
ALE7	July 12, 2017	1,848	BT	1	172	172
	August 2, 2017	3,856	WCT	2	186	190
			EB	2	170	240
			BT	1	250	250
	August 4, 2017	1,550	BT	4	160	191
			EB	1	175	175
ALE8	August 1, 2014	415	-	-	-	-
ALE9	July 10, 2014	396	WCT	2	150	160
	July 12, 2017	1,691	WCT	2	159	169
	August 3, 2017	2,301	WCT	6	159	225
			BT	2	150	160
ALE10	July 10, 2014	202	-	-	-	-
WAL1	July 30, 2014	385	WCT	1	45	45
	July 12, 2017	3,005	WCT	3	148	198
			BT	2	186	240
	August 3, 2017	1,490	WCT	6	149	229
			BT	2	100	200
WAL2	July 28, 2014	169	WCT	3	180	202

Legend: Min = minimum; Max = maximum; WCT = Westslope Cutthroat Trout; BT = Bull Trout; EB = Eastern Brook Trout; - = no fish captured

Rearing

Summer rearing fish use was assessed via fish community surveys in ALE7 to ALE10 and WAL1 in 2017, and in ALE1 and ALE2 in 2019. Fish community sampling was completed to provide a more detailed and quantifiable assessment of fish density in fish bearing reaches. Fish community results, including species captured, total number of species capture, minimum/maximum fork length (mm), and pooled fish density (fish/100 m^2) are provided in Table 12.4-11. WCT were abundant throughout the Alexander Creek watershed and were found to have the highest site-specific density of all species present, with the exception of ALE1, which was dominated by Eastern Brook Trout. Bull Trout were the second most widely distributed species. Fish densities ranged from <1 to 14 fish/100 m^2 with the downstream reach of West

Alexander Creek having the highest density of fish observed. The species with the highest density at ALE1 was Eastern Brown Trout (7.12 fish/100 m^2). ALE7, ALE8, and ALE9 all had low densities of fish (<1 fish/100 m^2). No fish were captured at ALE10.

Results suggest that all reaches surveyed are primarily used by juvenile age-classes. WAL1 was unique in that it was the only reach with WCT fry present. Mountain Whitefish were not captured within the upper portions of the Alexander Creek watershed. However, Mountain Whitefish fry were captured in ALE1 and ALE2, which are located closer to the Michel Creek mainstem (Figure 12.4-13).

Table 12.4-11: Fish Community Assessment Data for Fish Bearing Reaches in the Alexander Creek Watershed

Reach	Sample Date	Species	Total Number Captured	Min Fork Length (mm)	Max Fork Length (mm)	Density (fish/100 $m^{2)}$
ALE1	September 12, 2019	EB	12	20	44	7.12
		MW	3	68	74	1.12
		BT	1	68	68	0.75
		WCT	1	121	121	0.37
ALE2	September 13, 2019	WCT	14	72	152	4.66
		BT	5	128	139	2.33
		MW	1	82	82	0.29
ALE7	September 14, 2017	WCT	4	127	199	<1
		EB	2	195	199	<1
ALE8	September 14, 2017	BT	7	121	200	1
ALE9	September 19, 2017	WCT	5	80	186	1
		BT	1	146	146	<1
ALE10	September 18, 2017	-	-	-	-	-
WAL1 d/s	August 22, 2017	WCT	11	55	151	4
WAL1 u/s	August 22, 2017	WCT	23	48	182	14

Legend: Min = minimum; Max = maximum; WCT = Westslope Cutthroat Trout; BT = Bull Trout; MW = Mountain Whitefish; EB = Eastern Brook Trout; - = no fish captured during sampling.

Spawning

Based on spring and fall spawning surveys, Alexander Creek provides variable spawning suitability (Table 12.4-12). Out of the reaches classified as fish bearing, ALE1, ALE2, ALE7, and WAL1 provided the best potential habitats for spawning use, with WAL1 corroborated by high WCT fry density. Many of the other reaches had moderate to poor spawning potential based on high channel gradient, low water depth, or large substrate size.