

Date: March 9, 2017
From: John Wilcockson
To: David Harpley, Canadian Zinc Corp
Subject: **Prairie Creek Mine, all season road habitat loss and offset**

HCP Ref No.: CZN7932

This memo provides information on the Prairie Creek Mine all-season road aquatic habitat balance, providing estimates of both habitat function loss/alteration and gains. The accompanying spreadsheets (Attachment 1) provide area estimates of aquatic and riparian habitat (in m²) that would be lost or altered as a result of the proposed all season road, as well as habitat that could be gained.

For ease of calculations, potential losses/alterations have been divided into individual worksheets based on similar properties. These are:

1. Crossings – aquatic habitat function lost or modified due to installation of embedded culverts and clear-span bridges;
2. Sundog Creek encroachments – aquatic habitat permanently lost where the all-season road will encroach on Sundog Creek;
3. Sundog Creek diversion berm – aquatic habitat lost under the footprint of the diversion berm;
4. Sundog Creek diversion permanent habitat alteration – assumes that the diversion results in a semi-permanent alteration of the original channel;
5. Riparian habitat lost at crossings;
6. Riparian habitat lost at road encroachments;
7. Littoral habitat temporarily lost as a result of water withdrawal for dust suppression;
8. Habitat gained in the form of pools, side channels, and/or the new post-diversion channel; and
9. Summary of habitat lost, altered and gained.

Habitat loss at road crossings occurs in a small number of cases due to encroachment of bridge abutments or backfilling around culverts. For road crossings, the bankfull width was considered to define aquatic habitat, and was generally identified by the absence of mature vegetation.

For Sundog Creek, aquatic habitat was split into the following categories: (A) normally wetted (functional) habitat within the 2 year return, (B) normally dry (non-functional) habitat within the 2 year return; and (C) habitat outside the 2 year return but without established vegetation. The 2 year return line was assumed roughly equal to the ordinary high water mark (HWM), the water level defined by DFO as delineating aquatic habitat¹.

Category-A was defined using orthophotos of Sundog Creek and supported by ground truthing during 2016 field surveys. July is typically a mid-flow month, so it is a reasonable time to identify channels which are normally wetted (and therefore provide greater habitat function than categories B and C below). It should be noted that during the 2016 study period, the area was experiencing moderate to high water levels, and some channels dry in July 2014 were carrying water, thus our assignment of estimates in Category A is conservative (i.e., likely higher than expected). The wetted area will be greater during freshet and major rain events.

Category-B was defined as the area within the modelled 2 year return lines², but without water on the orthophoto. Ground truthing during the July 2016 field survey confirmed the absence of water.

Category-C was defined as the area outside the 2 year return line, but without established vegetation ("established" vegetation was defined as vegetation large enough to be seen in the orthophoto). Ground truthing in this area in July 2016 indicated exposed substrate (generally cobble), with minimal small vegetation. This area estimates the extent of the 20 year inundation. An explanation of how Category-C habitat was identified is provided in Attachment 2.

The orthophotos used to estimate the area of each of these categories affected by road encroachment is provided in Attachment 3. These maps were produced by Allnorth Consulting.

For the purpose of the offsetting table (Attachment 1), the following definitions were used:

- Modification – the change in habitat resulting in equal habitat function. For a modification, there is no loss of habitat function and therefore offset should not be required.
- Loss – the removal of habitat function via complete loss of aquatic habitat. Examples of habitat loss are the areas where the road will be built within the Sundog Creek floodplain and within the 2 year return line.
- Alteration – the removal of habitat function, via the creation of habitat that is less desirable. An example of an alteration is the partial dewatering of the existing channel downstream of the planned diversion.

Habitat loss/alteration was divided into the following categories based on importance to ecological function:

1. Low importance – e.g., loss of fish food function, when the loss is small, short-term, or where there are abundant similar sources of food available;
2. Medium importance – e.g., loss/alteration of abundant or non-critical fish habitat; and
3. High importance – e.g., loss/alteration of limiting or critical fish habitat.

¹ DFO operational statement: Bridge Maintenance Fisheries and Oceans Canada, Nunavut Operational Statement Version3.0 DFO/2007-1329

² This 2-year return maximum water level contour line was created as a result of modelling provided by Tetra Tech, Edmonton.

Sundog Diversion

Between km 35.5 and km 36.95, Sundog Creek water will be diverted from the existing channel into a similar historical channel (within the same alluvial floodplain). The partially dewatered channel (the original channel) is considered to be a residual habitat alteration. An estimation of the habitat altered is provided in Attachment 1, Worksheet 4. The diversion, as proposed, is approximately 1.5 km long. The orthophotos used to estimate the habitat areas altered are provided in Attachment 4.

Culverts and Bridges

Confirmed fish bearing streams will be crossed using clear-span bridges, apart from one small stream. In nearly all cases, the abutments of the bridges will be created outside the channel width (i.e., outside the high water mark (HWM)), therefore will not result in any habitat loss. In the few cases where the abutments of clear-span bridges encroach on the channel width, the impact to aquatic habitat has been accounted for as an aquatic habitat loss.

For the three small streams that may contain fish, 1.4 m diameter will be partially submerged into substrate, thus creating an area of natural substrate in the bottom. Each culvert will be 20 m in length.

Riparian Habitat

Riparian vegetation was identified as established plant growth (as observed on the orthophoto) on either side of streams. Typically, vegetation within 30 m of a stream was considered riparian vegetation; however, for streams <3 m wide and believed to be non-fish bearing, the riparian zone was reduced to 20 m. Conversely, the riparian zone was increased to 50 m for larger streams, including: Prairie Creek, Sundog Creek, Tetcela River, Grainger River, and the Liard River. This approach is consistent with the BC Forests and Range Practices Act. The area of riparian vegetation lost was modified based on the proportion of riparian coverage as observed in the orthophoto.

Similar to aquatic habitat lost or altered, the riparian habitat to be lost was categorized as follows:

- H (High) – riparian vegetation overhangs a fish-bearing creek, and provides cover, food, flow mitigation, and some temperature regulation.
- M (Moderate) – riparian vegetation is set back from a fish-bearing creek (does not overhang), and/or riparian vegetation overhanging a non-fish bearing stream (i.e., providing temperature regulation and food).
- L (Low) – riparian vegetation associated with non-fish bearing streams, where vegetation is set back from the stream, or where the stream runs through a wetland or beaver pond before reaching potential fish-bearing habitat.

Between km 0 and km 17, the all-season road pre-exists and is permitted. However, in this area, it is anticipated that an additional 2.5 m of riparian area may have to be removed on average to make improvements to the existing road prism.

In our opinion, the loss of riparian vegetation will result in negligible loss of ecological function, and therefore result in no serious harm to fish.

Littoral Zones

Lakes used for water withdrawal during the summer months will experience a small drop in water level, and the littoral zone may be temporarily reduced incrementally. The littoral zone is the most productive zone of lakes and therefore loss of this habitat can have an effect on the ecological functioning of lakes.

The table (Attachment 1) used predicted water level reductions for each lake as calculated by Canadian Zinc. The slope of the littoral zone (as inferred from bathymetric maps) was then used to estimate the width of the littoral zone lost. The circumference of the lake was then multiplied by this number to estimate the maximum area of littoral zone lost each summer. In order to put this number into context, it was compared to the total area of littoral zone for each lake, defined as the total area of lake under no more than 2 m of water. In all cases, the proportion of littoral zone dried each summer would be no more than 1.1% of the total littoral zone. Given that this is such a small portion of the existing littoral zone, and given that any effect would be temporary, we do not intend to directly offset these potential losses.

Habitat Mitigated

The road prism will cover a side channel at km 37.5, known to provide habitat to Arctic grayling (*Thymallus arcticus*) and slimy sculpin (*Cottus cognatus*). As a mitigation, this side channel will be re-created adjacent to the road and outside of the road prism.

Habitat Gains

Habitat lost or altered can be offset via three approaches:

- For the Sundog diversion, creation of a new channel by modifying a former channel with similar habitat attributes as the old channel;
- Creation of a deep pool suitable to provide overwintering habitat; and/or
- Creation of a small side channel, providing rearing and possibly spawning habitat.

New channel – a diversion berm would direct water into a pre-existing channel within the Sundog Creek alluvial flood plain. As designed, the new channel would provide the same habitat (primarily migratory) to fish as the existing channel. In addition to creating similar thalweg velocities, CZN would place large boulders along the north shore of the new channel to approximate the same frequency of boulders in the existing channel (Figure 1). It is anticipated that the presence of boulders (>1 m in diameter) in the creek would provide refuge for fish from higher velocities during their migration.

Detailed air photos would be used to approximate the appropriate frequency of boulders in the new channel.

Boulders would also be placed along the channel upstream of the diversion, where road encroachment covers existing boulders.

Figure 1 Sundog Creek, conceptual placement of boulders in new channel to approximate habitat lost in original channel.



Deep Pool – Deep pools suitable for potential overwintering appear to be uncommon in the Sundog Creek watershed. This type of habitat, followed by potential spawning habitat (i.e., lower gradient side channels having smaller gravels), are the least common. For potential offsetting purposes, a deep pool could be created at the downstream extent of the old channel to provide overwintering habitat. This channel would receive less flow once the creek has been diverted, thus mitigating against infilling. The elevation of this pond would be similar to the downstream thalweg, thus providing three-season access to Arctic grayling and avoiding stranding as flows subside after freshet. Figure 2 shows the potential location of an overwintering pool. The presence of four sets of rapids indicates areas of greater elevation loss. Given the lower expected flows in the original channel post diversion, it is anticipated that water may go sub-surface at the top end of higher gradient areas, emerging again near the bottom. In order to assure three-season access for fish to the pool, the pool would need to be constructed near the confluence of the old thalweg and the new thalweg, thus avoiding the areas of greater elevation loss.

Small Side Channel – A third habitat offsetting opportunity is the construction of a low-gradient side-channel off of Sundog Creek either upstream or downstream of the diversion. Ideally, this would be located in a portion of Sundog where the thalweg is on the north side of the channel (i.e., furthest from the road). Two potential locations are km 34.3 and km 39. The side channel would be 20 m long by 3 m wide, for a total of 60 m, which is a relatively small amount of habitat gained. It may also be difficult to build the channel in such a way that would avoid stranding as waters recede after freshet or major precipitation events. For these reasons, the creation of a small side channel is not a preferred offsetting option.

Predicted habitat losses, alterations and gains associated with the preferred habitat offset approaches are provided in Attachment 1.9, and summarized in Table 1 below. The small side channel option was not included in calculations for reasons above.

Table 1 **Habitat balance for Sundog Creek.**

Habitat Value	Area (m ²)			
	High	Medium	Low	Other
Losses	206	1,139	13,125	85,764
Alterations	0	24,526	21,030	22,790
Gains	400	24,526	21,030	22,790

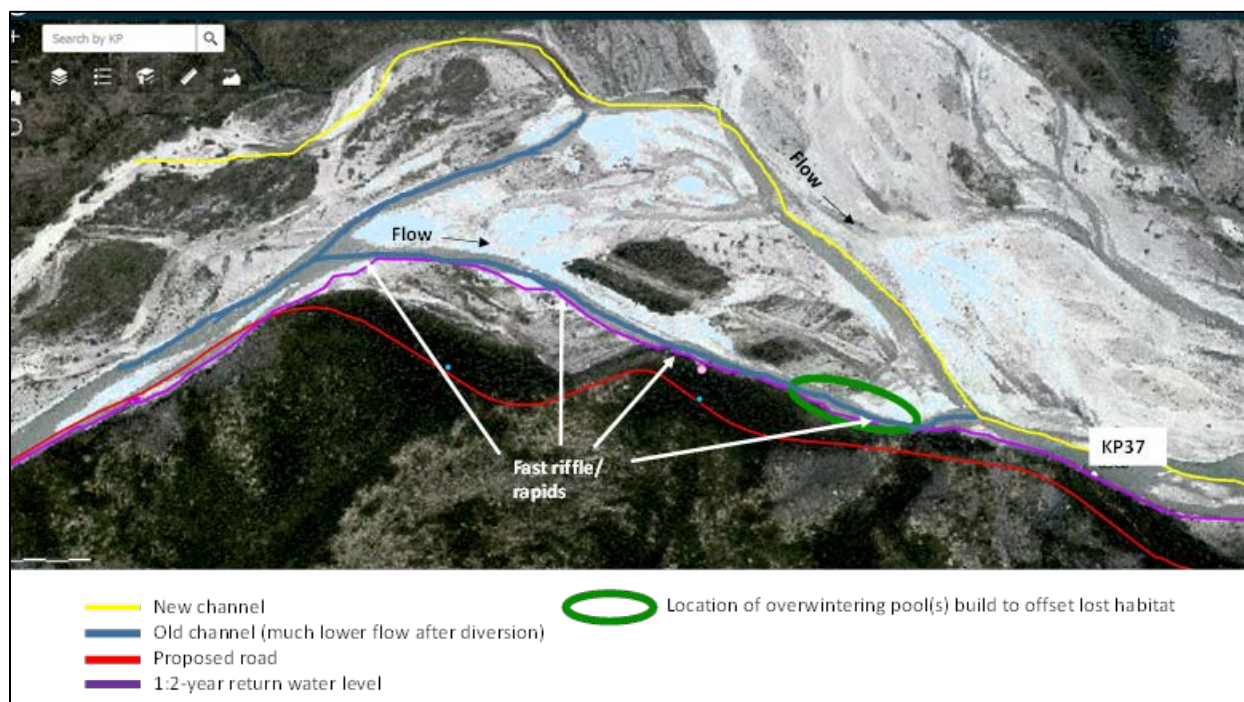
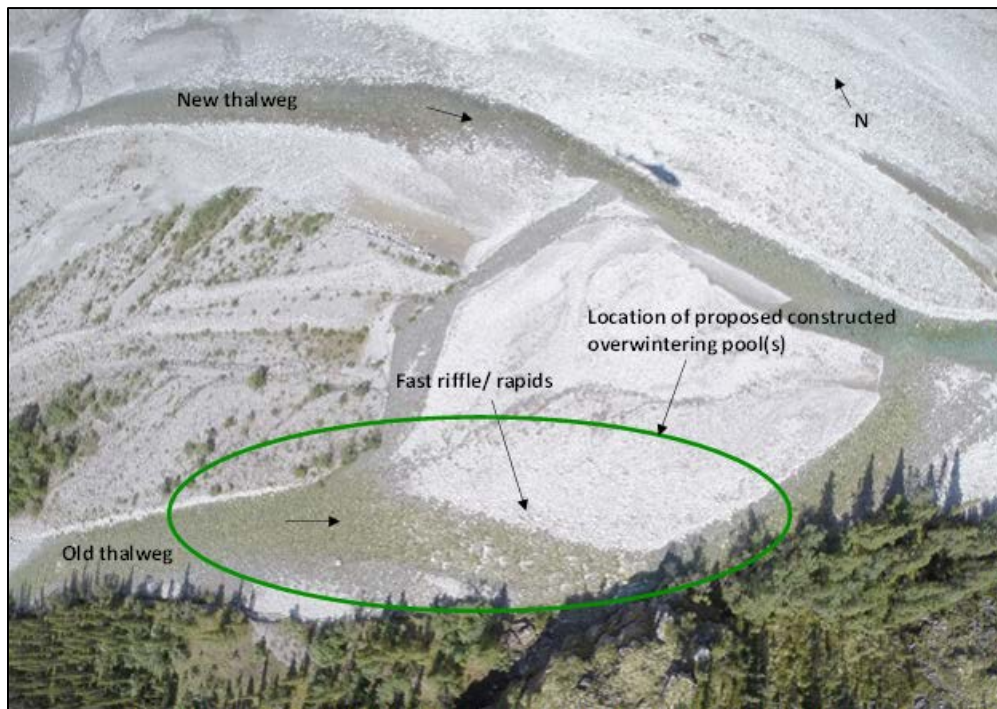
Figure 2 **Sundog Creek, conceptual location of overwintering pool for offsetting purposes (km 36.8 to km 37).**

Figure 3 Sundog Creek, conceptual location of overwintering pool.



Attachment 1

Habitat Offsetting Tables

Table A1.1 Crossings.

No.	Original kp	km on Habitat Data Sheets	Stream Name	Description of Creek	Details of Crossing Type	Fish?	Fish Species and Life-Stage	Fish Habitat at Crossing	Habitat Loss (m ²)	Habitat Modification (m ²)	Details
1	2.9		Prairie Trib.	High gradient, ephemeral	culvert ¹	N	-	-	-	-	
2	3.3		Prairie Trib.	High gradient, ephemeral	culvert ¹	N	-	-	-	-	
3	4.4		Prairie Trib.	Poorly-defined small channel with little flow	culvert ¹	N	-	-	-	-	
4	6.1		Casket Creek	Defined channel above fan, sufficient flow for fish	Open span, already exists	Y	BT: all; slimy sculpin; SS: all	migration, rearing	-	-	Bridge and causeway exist. New armoured footings replace existing gabion baskets.
5	6.15		Casket Trib.	Stream off hillside discharges to alluvium. Poorly-defined channel above and below road.	culvert ¹	N	-	-	-	-	
6	6.6		Prairie Trib.	Very high gradient	culvert ¹	N	-	-	-	-	
7	9.3		Funeral Trib.		culvert ¹	N	-	-	-	-	
8	9.75		Funeral Trib.		culvert ¹	N	-	-	-	-	
9	9.85		Funeral Trib.		culvert ¹	N	-	-	-	-	
10	10.2		Funeral Trib.	High gradient, interrupted by existing road bed.	culvert ¹	N	-	-	-	-	
11	10.7		Funeral Trib.		culvert ¹	N	-	-	-	-	
12	10.95		Funeral Trib.		culvert ¹	N	-	-	-	-	
13	11.05		Funeral Trib.		culvert ¹	N	-	-	-	-	
14	11.7		Funeral Trib.		culvert ¹	N	-	-	-	-	
15	13.3		Funeral Trib.		culvert ¹	N	-	-	-	-	
16	13.4		Funeral Trib.	High gradient downstream.	culvert ¹	N	-	-	-	-	
17	14.85	14.8	Funeral Trib.	Reconnaissance-level back-pack electro-fishing conducted.	culvert ¹	N	-	-	-	-	
18	15.2		Funeral Trib.		culvert ¹	N	-	-	-	-	
19	15.8		Funeral Trib.		culvert ¹	N	-	-	-	-	
20	18.45		Sundog Trib.	Very high gradient. 10 m falls downstream. Reconnaissance-level back-pack electro-fishing conducted.	culvert ¹	N	-	-	-	-	
21	20.5		Sundog Trib.	10 m falls downstream @km 25.5. Reconnaissance-level back-pack electro-fishing conducted.	culvert ¹	N	-	-	-	-	
22	23.4		Sundog Creek	10 m falls @km 25.5. Reconnaissance-level back-pack electro-fishing conducted. Canyon.	Open span bridge	N	-	-	-	-	
23	25.3		Sundog Trib.	Very steep, incised rock chute.	Open span bridge	N	-	-	-	-	
24	26.6		Sundog Trib.	Very high gradient chute.	culvert ¹	N	-	-	-	-	
25	27.3		Sundog Trib.		culvert ¹	N	-	-	-	-	
26	28.6		Sundog Trib.	Assumed to be accessible to fish.	Open span bridge	Y	AG: j, a; SS: all	migration, rearing	-	-	Abutments above normal HWM.

Table A1.1 (Cont'd.)

No.	Original kp	km on Habitat Data Sheets	Stream Name	Description of Creek	Details of Crossing Type	Fish?	Fish Species and Life-Stage	Fish Habitat at Crossing	Habitat Loss (m ²)	Habitat Modification (m ²)	Details
27	29.1		Sundog Trib.	High gradient, crossing rock or talus, usually with a fan of variable size at the toe of the slope.	culvert ¹	N	-	-	-	-	
28	29.9		Sundog Trib.		culvert ¹	N	-	-	-	-	
29	30.2		Sundog Trib.		culvert ¹	N	-	-	-	-	
30	30.5		Sundog Trib.		culvert ¹	N	-	-	-	-	
31	31		Sundog Trib.		culvert ¹	N	-	-	-	-	
32	31.3		Sundog Trib.		culvert ¹	N	-	-	-	-	
33	31.7		Sundog Trib.		culvert ¹	N	-	-	-	-	
34	32.4		Sundog Trib.		culvert ¹	N	-	-	-	-	
35	32.5		Sundog Trib.		culvert ¹	N	-	-	-	-	
36	36.8		Sundog Trib.		culvert ¹	N	-	-	-	-	
37	37.1		Sundog Trib.		culvert ¹	N	-	-	-	-	
38	37.9		Sundog Trib.		culvert ¹	N	-	-	-	-	
39	39.4	39.8	Sundog Trib.	Grayling observed in pools. Studies downstream.	Open span bridge	Y	AG: j, a; SS: all	migration, rearing	15	-	Abutment on western approach may be 1m within bankful width.
40	40.1		Sundog Trib.	Poorly defined channels and habitat at crossings, no defined connections to main stem.	culvert ¹	N	-	-	-	-	
41	40.3		Sundog Trib.		culvert ¹	N	-	-	-	-	
42	43.15	43.5	Sundog Trib.	Long, rock chute downstream. Reconnaissance-level back-pack electro-fishing conducted.	culvert ¹	N	-	-	-	-	
43	45.5		Polje Trib.	Grassy swale. No defined channel.	culvert ¹	N	-	-	-	-	
44	45.8	47	Polje Creek	Fish caught by Beak, 1982.	1 pipe, Ø1.4m, substrate on bottom, 1.2m wide	Y	AG: j, a; SS: all	migration, rearing	-	9.6	19.2m l x 0.5m w, equal habitat function after 1.4m culvert installed, natural substrate >0.5m wide in culvert.
45	46.5		Polje Trib.	Wetland. Small, poorly defined channel.	culvert ¹	N	-	-	-	-	
46	47.2		Polje Trib.	Swale.	culvert ¹	N	-	-	-	-	
47	48.05	49.1	Polje Trib.	Multiple slumps blocking channel.	culvert ¹	N	-	-	-	-	
48	48.6	49.4	Polje Trib.	No channel at all	culvert ¹	N	-	-	-	-	
49	49.6	50.2	Polje Trib.	Small accessible channel, poor habitat.	1 pipe, Ø1.4m, substrate on bottom, 1.2m wide	?	AG: j, a; SS: all	migration, rearing	-	23.0	19.2m l x 1.2m w, equal habitat function after 1.4m culvert installed, natural substrate 1.2m wide in culvert.
50	50.7		Polje Trib.	Wetland. Small, poorly defined channel.	culvert ¹	N	-	-	-	-	
51	50.8		Polje Trib.		culvert ¹	N	-	-	-	-	
52	53.4	54.2	Polje Trib.	Grassy swale. No defined channel.	culvert ¹	N	-	-	-	-	
53	53.5	54.3	Polje Trib.	4-5 feet wide braided channel off main stem.	1 pipe, Ø2m, substrate on bottom, 1.6m wide	Y	AG: j, a; SS: all	migration, rearing	-	30.7	19.2m l x 1.6m w, equal habitat function after 2m culvert installed, natural substrate 1.6m wide in culvert.
54	53.55	54.4	Polje Creek	Fish caught by Beak, 1982. Also, see Bathurst, 2005.	Open span bridge	Y	AG: j, a; SS: all	migration, rearing	-	-	Abutments above normal HWM.

Table A1.1 (Cont'd.)

No.	Original kp	km on Habitat Data Sheets	Stream Name	Description of Creek	Details of Crossing Type	Fish?	Fish Species and Life-Stage	Fish Habitat at Crossing	Habitat Loss (m ²)	Habitat Modification (m ²)	Details
55	56.35		Polje Trib.	Small channel, wetland without defined	culvert ¹	N	-	-	-	-	
56	56.45		Polje Trib.	channel downstream.	culvert ¹	N	-	-	-	-	
57	60.4		Polje Trib.	Drains into Polje system with no	culvert ¹	N	-	-	-	-	
58	61.5		Polje Trib.	channel outlet.	culvert ¹	N	-	-	-	-	
59	63.6	64.6	Polje Trib.	Inlet to Mosquito L., part of Polje system. Wetland, poor habitat.	culvert ¹	N	-	-	-	-	
60	67.1		Tetcela Trib.	Headwater swale, steep incised	culvert ¹	N	-	-	-	-	
61	71.05		Tetcela Trib.	channel d/s.	culvert ¹	N	-	-	-	-	
62	85.45		Tetcela Trib.	Densely vegetated. Steep d/s. Poor habitat.	culvert ¹	N	-	-	-	-	
63	86.9		Tetcela Trib.	No defined channel.	culvert ¹	N	-	-	-	-	
64	87.25	87.7	Tetcela Trib.	Major trib. Multiple fish species d/s, Beak 1982.	Open span bridge	Y	AG, NP, LNS, RWF, SS, LC, LND: all?	migration, rearing, spawning	-	-	Abutments above normal HWM.
65	89.8	90.1	Tetcela Main stem	Multiple fish species, Beak 1982.	Open span bridge	Y	AG, NP, LNS, RWF, SS, LC, LND: j,a?	migration & rearing	-	-	Abutments above normal HWM.
66	91.3		Fishtrap Trib.		culvert ¹	N	-	-	-	-	
67	92.1		Fishtrap Trib.		culvert ¹	N	-	-	-	-	
68	92.4		Fishtrap Trib.		culvert ¹	N	-	-	-	-	
69	93		Fishtrap Trib.		culvert ¹	N	-	-	-	-	
70	93.5		Fishtrap Trib.	Wetland stream, part of large wetland system forming headwaters to Fishtrap	culvert ¹	N	-	-	-	-	
71	93.9		Fishtrap Trib.	Creek. Poor fish habitat, multiple	culvert ¹	N	-	-	-	-	
72	94.2		Fishtrap Trib.	beaver ponds downstream. No fish,	culvert ¹	N	-	-	-	-	
73	94.9	95	Fishtrap Creek	Beak 1982.	culvert ¹	N	-	-	-	-	
74	96.9		Fishtrap Trib.		culvert ¹	N	-	-	-	-	
75	97.5		Fishtrap Trib.		culvert ¹	N	-	-	-	-	
76	98.3		Fishtrap Trib.		culvert ¹	N	-	-	-	-	
77	98.6		Fishtrap Trib.		culvert ¹	N	-	-	-	-	
78	103.4		Un-named Ck Trib.	Drain into a large headwater wetland sytem that flows north. Poor fish habitat. Multiple beaver ponds.	culvert ¹	N	-	-	-	-	

Table A1.1 (Cont'd.)

No.	Original kp	km on Habitat Data Sheets	Stream Name	Description of Creek	Details of Crossing Type	Fish?	Fish Species and Life-Stage	Fish Habitat at Crossing	Habitat Loss (m ²)	Habitat Modification (m ²)	Details
79	103.8		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
80	105.2		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
81	105.3		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
82	105.4		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
83	106.3		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
84	106.7		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
85	109.4		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
86	109.7		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
87	110.7		Un-named Ck Trib.	Drain into a large headwater wetland sytem that flows north. Poor fish habitat. Multiple beaver ponds. Main stem crossing at Km 111.7. Debris flow crossings at Km 112.3, 112.45 and 112.6.	culvert ¹	N	-	-	-	-	
88	111.7		Un-named Creek		culvert ¹	N	-	-	-	-	
89	112		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
90	112.3		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
91	112.45		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
92	112.6		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
93	113		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
94	114		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
95	114.55		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
96	114.9		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
97	115.05		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
98	115.15		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
99	117.05		Un-named Ck Trib.		culvert ¹	N	-	-	-	-	
100	119		Grainger Trib.	Mountain outwash fan just below gorge. Braided at main stem. Likely only flows at high water.	culvert ¹	N	-	-	-	-	
101	119.2		Grainger Trib.	Wetland trib. to outwash fan.	culvert ¹	N	-	-	-	-	
102	124.5	125.1	Grainger River	Grayling observed in pools. Fish caught, Beak 1982.	Open span bridge	Y	AG, SS, RWF, NP	migration, rearing	-	-	Abutments are above HWM therefore no loss or modification. Culverts provided in approaches in the event of possible secondary channels during 1:100 flows.
103	126.2		Grainger Trib.	Wetlands at Grainger main stem confluence. Poorly defined channel and fish habitat.	culvert ¹	N	-	-	-	-	
104	126.7		Grainger Trib.	No channel downstream.	culvert ¹	N	-	-	-	-	
105	130.7	131.3	Grainger Trib.		culvert ¹	N	-	-	-	-	
106	132.7	133.7	Grainger Trib.	Road crosses near headwaters of streams. Small channels. Downstream beaver dams seen from helicopter.	culvert ¹	N	-	-	-	-	
107	134.5	135.6	Grainger Trib.		culvert ¹	N	-	-	-	-	
108	134.8		Grainger Trib.	Unlikely to have fish passable connection to Grainger main stem. Fish presence possible but unlikely.	culvert ¹	N	-	-	-	-	
109	135.5		Grainger Trib.		culvert ¹	N	-	-	-	-	
110	135.95	136.7	Grainger Trib.		culvert ¹	N	-	-	-	-	
111	136.5		Grainger Trib.		culvert ¹	N	-	-	-	-	
112	137.2		Grainger Trib.		culvert ¹	N	-	-	-	-	

Table A1.1 (Cont'd.)

No.	Original kp	km on Habitat Data Sheets	Stream Name	Description of Creek	Details of Crossing Type	Fish?	Fish Species and Life-Stage	Fish Habitat at Crossing	Habitat Loss (m ²)	Habitat Modification (m ²)	Details
113	139.6		Liard Trib.		culvert ¹	N	-	-	-	-	
114	140.1		Liard Trib.	Headwater streams. Small channels	culvert ¹	N	-	-	-	-	
115	140.5		Liard Trib.	with poor habitat. Often include steep	culvert ¹	N	-	-	-	-	
116	141.8		Liard Trib.	cobbly sections downstream. Beaver	culvert ¹	N	-	-	-	-	
117	144	144.7	Liard Trib.	habitat downstream very common e.g.	culvert ¹	N	-	-	-	-	
118	146.3		Liard Trib.	multiple dams downstream of 144.	culvert ¹	N	-	-	-	-	
119	149.3		Liard Trib.	Channel outlets to Liard River also	culvert ¹	N	-	-	-	-	
120	150.3		Liard Trib.	hanging, limiting migration.	culvert ¹	N	-	-	-	-	
121	151.1		Liard Trib.		culvert ¹	N	-	-	-	-	
122	152.2		Liard Trib.	No channel.	culvert ¹	N	-	-	-	-	
123	154.4	154.4	Liard Trib.	As for 139.6-151.1.	culvert ¹	N	-	-	-	-	
124	159.7		Liard River		barge/ice bridge	Y	See below ²	migration & rearing	-	2,379	Laying of gravel only, north ramp 1,268.75m ² , south ramp 1,110m ² both constitute a habitat modification (no anticipated change in habitat function).
125	163.95		Liard Trib.	Hanging wetland channel.	culvert ¹	N	-	-	-	-	
126	165.4		Liard Trib.		culvert ¹	N	-	-	-	-	
127	172		Liard Trib.	Wetland exit of old channel, hanging.	culvert ¹	N	-	-	-	-	
									Totals	0	2,442
										15	
										0	

Fish: N=unlikely based on habitat or downstream barriers; Y= likely based on habitat or documented occurrences; ?=Uncertain

1. Please refer to Allnorth design.

2. Fish of Liard river: Sport fish species include Arctic grayling, chum salmon, bull trout, inconnu, lake whitefish, mountain whitefish, northern pike and burbot. Other non-game fish consist of the long nose sucker, lake chub, flat head chub, slimy sculpin, white sucker, round whitefish and the long nose dace. (taken from BCMOE parks, Liard River Corridor Provincial Park,

Habitat loss was divided based on the following broad categories:

Low importance	e.g., loss of fish food function, when the loss is small, short-term, or where there is abundant similar sources of food available
Medium importance	e.g., loss of common or non-critical function to fish
High importance	e.g., loss of uncommon or critical function to fish

Table A1.2 Sundog Creek road encroachments.

2700

Encroachments of the Road onto Aquatic Habitat				Within 1:2 Year Return Period				Category C - Outside 1:2 Year Return Period, but no established vegetation		
road prism width (m)		10		Category A - Normally Wetted		Category B - Normally Not Wetted				
				Footprint (m²)		Footprint (m²)		Footprint (m²)		
No.	km start	km end	Length of section (m)	Habitat Loss	Habitat Alteration	Habitat Loss	Habitat Alteration	Habitat Loss	Habitat Alteration	Details
1	33.63	33.86	230	-	-	-	-	930	-	Main thalweg and secondary channels located on opposite (west) side of the floodplain. Dry at time of July 2016 field program, plants growing throughout. 50% of area calculated by Allnorth appears to have established vegetation (as per othophoto), therefore not included in area estimation.
2	33.87	33.99	120	-	-	-	-	240	-	
3	34.02	34.14	120	-	-	-	-	360	-	
4	34.86	35.04	180	-	-	1,995	-	495	-	Estimated from Allnorth table
5	35.04	35.31	270	275	-	275	-	1400	-	Appears that 50% of road prism within 1:2 year return may be normally wetted. Some boulders in this area, could be important for rearing and refuge for fish.(planned mitigation, see comment)
6	35.52	35.63	110	-	-	518	-	262	-	Sundog Creek diversion area - road enroachments will be on permanently altered channel (See worksheet 4). Since the old channel will be partially dewatered, road prism inside the 1:2 year return is considered Category B habitat. All remaining habitat inside the 1:100 year return, and within the road prism, does not have established vegetation, therefore is captured as a Category C loss.
7	35.82	36.51	690	-	-	6900	-	2046	-	
8	37.55	37.77	220	810	-	301	-	-	-	Appears that portion of road prism within 1:2 year return will cover a low gradient normally wetted secondary channel. Fish were found in this secondary channel in July 2014, it is likely important for rearing, possibly important for spawning. Uncommon habitat. Planned mitigation here (by recreating channel further from shore). Therefore, the Category A loss has been downgraded to account for this mitigation....number only accounts for residual loss .
9	37.77	38.01	240	824	-	1,545	-	-	-	Appears that portion of road prism within 1:2 year return is 40% on normally wetted thalweg (Category A), 60% on normally dry habitat (Category B). In the Category A portion, deeper pools (max 0.7m deep in July 2014) and bedrock wall act as cover in about 20% of the normally wetted thalweg (shown as a high value loss [red]). The remainder is riffle habitat, a common habitat in Sundog and is shown as a moderate value loss [orange] .
				206	-		-	-		
10	38.01	38.07	60	-	-	56	-	274	-	
Total				1,085		11,590		6,007		
				824		0				
				206		0				

Areas taken from excel spreadsheet "Sundog Footprint analysis.xls" sent to John Wilcockson by Ernest Kragt of Allnorth on August 17, 2016. However, areas have been adjusted to account for fish habitat quality. Allnorth spreadsheet provides 1:2 return overlap with road prism, as well as overlap with other channel types (active, secondary, channel thalweg, and old historic). The latter area minus the 1:2 return overlap area was used to quantify Category C habitat.

Habitat loss was divided based on the following broad categories:

Low importance	e.g., loss of fish food function, when the loss is small, short-term, or where there is abundant similar sources of food available
Medium importance	e.g., loss of common or non-critical function to fish
High importance	e.g., loss of uncommon or critical function to fish

Table A1.3 Sundog Creek diversion berm foot print.

This Worksheet Estimates the area and categorizes aquatic habitat loss as a result of the diversion berm footprint.

Length (m)	Width (m)	Total Area (m ²)	Description Based on Map	Category	Est Length of Berm (m)	Est Area of Habitat Loss (m ²)	Habitat Value Description
130	10	1300	Thalweg	A	15	150	Fish migration and rearing only
			Secondary Channel (x3)	A	15	150	Fish migration and rearing only
			1:2 yr return, but normally dry	B	45	450	Seasonal migration and rearing
			Outside 1:2 yr, no established veg	C	35	350	Minimal fish habitat value
					110		

Total	450
	300
	0

Table A1.4 Sundog Creek Diversion - Alteration of Old Channel.

This Worksheet Estimates the area of aquatic habitat altered in the existing Sundog Creek channel after diversion.

The area estimates provided here were based on a GIS analysis conducted by Teena Major, Allnorth. The tables below were first provided in a Hatfield memo, "Prairie Creek Mine, all season road undertaking 7 IR replies - PCA IRs", dated November 3, 2016.

a) Raw data from maps in Attachment 4.

	Area (m ²) Diversion (as proposed)
Normally wetted main channel	21,312
Normally wetted side channels	3,214
1:2 year flood level	45,556
1:100 year flood level minus areas having established vegetation	68,346
1:100 year flood level	73,097

Areas include sub-areas (e.g., 1:100 year flood area includes 1:2 flood area and wetted channel areas)

b) Areas of habitat classes (as per offsetting tables).

Aquatic habitat classification	Area (m ²) Diversion (as proposed)	
A	24,526	Fish migration and rearing only
B	21,030	Seasonal migration and rearing
C	22,790	Minimal fish habitat value

A = normally wetted channels; B = area within 1:2 but not including normally wetted channels; C = area within 1:100, but not including areas with established vegetation, 1:2 or normally wetted channels.

Habitat loss was divided based on the following broad categories:

Low importance	e.g., loss of fish food function, when the loss is small, short-term, or where there is abundant similar sources of food av
Medium importance	e.g., loss of common or non-critical function to fish
High importance	e.g., loss of uncommon or critical function to fish

Table A1.5 Riparian vegetation lost at crossings.

road prism width 10 m

No.	Original kps	Winter Road kps	Stream Name	Description of Creek	Ephemeral / Permanent	Proportion Riparian Coverage	Possible Width of Riparian Zone to be Lost (m)	Fish?	Fish Species	Riparian Value (H, M, L)	Riparian Management Zone (m)	Riparian Area Lost (m ²)	Details
1	2.9		Prairie Trib.	High gradient, ephemeral	Ephemeral	0.8	2.5	N	-	L	20	80	
2	3.3		Prairie Trib.	High gradient, ephemeral	Ephemeral	0.8	2.5	N	-	L	20	80	
3	4.4		Prairie Trib.	Poorly-defined small channel with little flow	Ephemeral	0.5	2.5	N	-	L	20	50	
4	6.1		Casket Creek	Defined channel above fan, sufficient flow for fish	Permanent	0.5	2.5	Y	Bull Trout Slimy Sculpin	M	30	75	
5	6.15		Casket Trib.	Stream off hillside discharges to alluvium. Poorly-defined channel above and below road.	Ephemeral	0.25	2.5	N	-	L	20	25	
6	6.6		Prairie Trib.	Very high gradient	Ephemeral	1	2.5	N	-	L	20	100	
7	9.3		Funeral Trib.		Ephemeral	1	2.5	N	-	L	20	100	
8	9.75		Funeral Trib.		Ephemeral	0.6	2.5	N	-	L	20	60	
9	9.85		Funeral Trib.		Ephemeral	0.6	2.5	N	-	L	20	60	
10	10.2		Funeral Trib.	High gradient, interrupted by existing	Ephemeral	1	2.5	N	-	L	20	100	
11	10.7		Funeral Trib.	road bed.	Ephemeral	1	2.5	N	-	L	20	100	
12	10.95		Funeral Trib.		Ephemeral	0.6	2.5	N	-	L	20	60	
13	11.05		Funeral Trib.		Ephemeral	1	2.5	N	-	L	20	100	
14	11.7		Funeral Trib.		Ephemeral	1	2.5	N	-	L	20	100	
15	13.3		Funeral Trib.		Ephemeral	1	2.5	N	-	L	20	100	
16	13.4		Funeral Trib.	High gradient downstream.	Permanent	1	2.5	N	-	L	20	100	
17	14.85	14.8	Funeral Trib.	Reconnaissance-level back-pack	Ephemeral	0.05	2.5	N	-	L	20	5	
18	15.2		Funeral Trib.	electro-fishing conducted.	Ephemeral	0.05	2.5	N	-	L	20	5	
19	15.8		Funeral Trib.		Ephemeral	0.05	2.5	N	-	L	20	5	
20	18.45		Sundog Trib.	Very high gradient. 10 m falls downstream. Reconnaissance-level back-pack electro-fishing conducted.	Permanent?	0.5	10	N	-	L	30	300	
21	20.5		Sundog Trib.	10 m falls downstream @km 25.5. Reconnaissance-level back-pack electro-fishing conducted.	Permanent	0.6	10	N	-	L	30	360	
22	23.4		Sundog Creek	10 m falls @km 25.5. Reconnaissance-level back-pack electro-fishing conducted.Canyon.	Permanent	0.3	10	N	-	L	30	180	
23	25.3		Sundog Trib.	Very steep, incised rock chute.	Permanet?	0.5	10	N	-	L	30	300	
24	26.6		Sundog Trib.		Ephemeral	0.7	10	N	-	L	20	280	
25	27.3		Sundog Trib.	Very high gradient chute.	Ephemeral	0.7	10	N	-	L	20	280	
26	28.6		Sundog Trib.	Assumed to be accessible to fish.	Permanent?	0.6	10	Y	Arctic grayling, slimy sculpin	M	30	360	
27	29.1		Sundog Trib.		Ephemeral	0.2	10	N	-	L	20	80	
28	29.9		Sundog Trib.		Ephemeral	0.1	10	N	-	L	20	40	
29	30.2		Sundog Trib.		Ephemeral	0.6	10	N	-	L	20	240	
30	30.5		Sundog Trib.		Ephemeral	0.6	10	N	-	L	20	240	
31	31		Sundog Trib.		Ephemeral	0.4	10	N	-	L	20	160	
32	31.3		Sundog Trib.	High gradient, crossing rock or talus,	Ephemeral	0.2	10	N	-	L	20	80	
33	31.7		Sundog Trib.	usually with a fan of variable size at	Ephemeral	0.2	10	N	-	L	20	80	
34	32.4		Sundog Trib.	the toe of the slope.	Ephemeral	1	10	N	-	L	20	400	
35	32.5		Sundog Trib.		Ephemeral	0.6	10	N	-	L	20	240	
36	36.8		Sundog Trib.		Ephemeral	1	10	N	-	L	20	400	
37	37.1		Sundog Trib.		Ephemeral	1	10	N	-	L	20	400	
38	37.9		Sundog Trib.		Ephemeral	0.05	10	N	-	L	20	20	
39	39.4	39.8	Sundog Trib.	Grayling observed in pools. Studies downstream.	Permanent	0.05	10	Y	Arctic grayling, slimy sculpin	L	30	30	very sparse, in floodplain

Table A1.5 (Cont'd.)

No.	Original kps	Winter Road kps	Stream Name	Description of Creek	Ephemeral / Permanent	Proportion Riparian Coverage	Possible Width of Riparian Zone to be Lost (m)	Fish?	Fish Species	Riparian Value (H, M, L)	Riparian Management Zone (m)	Riparian Area Lost (m ²)	Details
40	40.1		Sundog Trib.	Poorly defined channels and habitat at	Ephemeral	1	10	N	-	L	20	400	
41	40.3		Sundog Trib.	crossings, no defined connections to main stem.	Ephemeral	1	10	N	-	L	20	400	
42	43.15	43.5	Sundog Trib.	Long, rock chute downstream. Reconnaissance-level back-pack electro-fishing conducted.	Permanent	1	10	N	-	L	30	600	
43	45.5		Polje Trib.	Grassy swale. No defined channel.	Ephemeral	1	10	N	-	L	20	400	
44	45.8	47	Polje Creek	Fish caught by Beak, 1982.	Permanent	1	10	Y	Arctic grayling, slimy sculpin	M	30	600	
45	46.5		Polje Trib.	Wetland. Small, poorly defined channel.	Ephemeral?	1	10	N	-	L	20	400	
46	47.2		Polje Trib.	Swale.	Ephemeral	1	10	N	-	L	20	400	
47	48.05	49.1	Polje Trib.	Multiple slumps blocking channel.	Ephemeral	1	10	N	-	L	20	400	
48	48.6	49.4	Polje Trib.	No channel at all	Ephemeral	1	10	N	-	L	20	400	
49	49.6	50.2	Polje Trib.	Small accessible channel, poor habitat.	Permanent?	1	10	?		M	20	400	
50	50.7		Polje Trib.	Wetland. Small, poorly defined	Ephemeral?	1	10	N	-	L	20	400	
51	50.8		Polje Trib.	channel.	Ephemeral?	1	10	N	-	L	20	400	
52	53.4	54.2	Polje Trib.	Grassy swale. No defined channel.	Ephemeral	1	10	N	-	L	20	400	
53	53.5	54.3	Polje Trib.	4-5 feet wide braided channel off main stem.	Permanent	1	10	Y	Arctic grayling, slimy sculpin	H	30	600	overhanging vegetation on small tributary
54	53.55	54.4	Polje Creek	Fish caught by Beak, 1982. Also, see Bathurst, 2005.	Permanent	1	10	Y	Arctic grayling, slimy sculpin	M/H	50	1000	small amount of overhanging vegetation
55	56.35		Polje Trib.	Small channel, wetland without	Ephemeral	1	10	N	-	L	20	400	
56	56.45		Polje Trib.	defined channel downstream.	Ephemeral	1	10	N	-	L	20	400	
57	60.4		Polje Trib.	Drains into Polje system with no	Ephemeral?	1	10	N	-	L	20	400	
58	61.5		Polje Trib.	channel outlet.	Ephemeral?	1	10	N	-	L	20	400	
59	63.6	64.6	Polje Trib.	Inlet to Mosquito L., part of Polje system. Wetland, poor habitat.	Permanent	1	10	N	-	L	20	400	
60	67.1		Tetcela Trib.	Headwater swale, steep incised	Ephemeral	1	10	N	-	L	20	400	
61	71.05		Tetcela Trib.	channel d/s.	Ephemeral	1	10	N	-	L	20	400	
62	85.45		Tetcela Trib.	Densely vegetated. Steep d/s. Poor habitat.	Ephemeral?	1	10	N	-	L	20	400	
63	86.9		Tetcela Trib.	No defined channel.	Ephemeral	1	10	N	-	L	20	400	
64	87.25	87.7	Tetcela Trib.	Major trib. Multiple fish species d/s, Beak 1982.	Permanent	1	10	Y	Note 1 below	M	50	1000	
65	89.8	90.1	Tetcela Main stem	Multiple fish species, Beak 1982.	Permanent	1	10	Y	Note 1 below	M	50	1000	
66	91.3		Fishtrap Trib.		Ephemeral?	1	10	N	-	L	20	400	
67	92.1		Fishtrap Trib.		Ephemeral?	1	10	N	-	L	20	400	
68	92.4		Fishtrap Trib.		Ephemeral?	1	10	N	-	L	20	400	
69	93		Fishtrap Trib.		Ephemeral?	1	10	N	-	L	20	400	
70	93.5		Fishtrap Trib.		Ephemeral?	1	10	N	-	L	20	400	
71	93.9		Fishtrap Trib.	Wetland stream, part of large wetland system forming headwaters to	Ephemeral?	1	10	N	-	L	20	400	
72	94.2		Fishtrap Trib.	Fishtrap Creek. Poor fish habitat,	Ephemeral?	1	10	N	-	L	20	400	
73	94.9	95	Fishtrap Creek	multiple beaver ponds downstream.	Permanent	1	10	N	-	L	20	400	
74	96.9		Fishtrap Trib.	No fish, Beak 1982.	Ephemeral?	1	10	N	-	L	20	400	
75	97.5		Fishtrap Trib.		Ephemeral?	1	10	N	-	L	20	400	
76	98.3		Fishtrap Trib.		Ephemeral?	1	10	N	-	L	20	400	
77	98.6		Fishtrap Trib.		Ephemeral?	1	10	N	-	L	20	400	

Table A1.5 (Cont'd.)

No.	Original kps	Winter Road kps	Stream Name	Description of Creek	Ephemeral / Permanent	Proportion Riparian Coverage	Possible Width of Riparian Zone to be Lost (m)	Fish?	Fish Species	Riparian Value (H, M, L)	Riparian Management Zone (m)	Riparian Area Lost (m ²)	Details
78	103.4		Un-named Ck Trib.	Drain into a large headwater wetland sytem that flows north. Poor fish habitat. Multiple beaver ponds.	Permanent	1	10	N	-	L	20	400	
79	103.8		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
80	105.2		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
81	105.3		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
82	105.4		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
83	106.3		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
84	106.7		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
85	109.4		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
86	109.7		Un-named Ck Trib.	Drain into a large headwater wetland sytem that flows north. Poor fish habitat. Multiple beaver ponds. Main stem crossing at Km 111.7. Debris flow crossings at Km 112.3, 112.45 and 112.6.	Ephemeral?	1	10	N	-	L	20	400	
87	110.7		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
88	111.7		Un-named Creek		Permanent	1	10	N	-	L	20	400	
89	112		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
90	112.3		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
91	112.45		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
92	112.6		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
93	113		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
94	114		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
95	114.55		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
96	114.9		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
97	115.05		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
98	115.15		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
99	117.05		Un-named Ck Trib.		Ephemeral?	1	10	N	-	L	20	400	
100	119		Grainger Trib.	Mountain outwash fan just below gorge. Braided at main stem. Likely only flows at high water.	Ephemeral	1	10	N	-	L	20	400	
101	119.2		Grainger Trib.	Wetland trib. to outwash fan.	Ephemeral	1	10	N	-	L	20	400	
102	124.5	125.1	Grainger River	Grayling observed in pools. Fish caught, Beak 1982.	Permanent	1	10	Y	Note 2 below	M	20	400	
103	126.2		Grainger Trib.	Wetlands at Grainger main stem confluence. Poorly defined channel and fish habitat.	Ephemeral	1	10	N		L	20	400	
104	126.7		Grainger Trib.	No channel downstream.	Ephemeral	1	10	N	-	L	20	400	
105	130.7	131.3	Grainger Trib.		Ephemeral	1	10	N	-	L	20	400	
106	132.7	133.7	Grainger Trib.	Road crosses near headwaters of streams. Small channels.	Ephemeral	1	10	N	-	L	20	400	
107	134.5	135.6	Grainger Trib.	Downstream beaver dams observed.	Ephemeral	1	10	N	-	L	20	400	
108	134.8		Grainger Trib.	Unlikely to have fish-passable connection to Grainger main stem.	Ephemeral	1	10	N	-	L	20	400	
109	135.5		Grainger Trib.	Fish presence unlikely.	Ephemeral	1	10	N	-	L	20	400	
110	135.95	136.7	Grainger Trib.		Ephemeral	1	10	N	-	L	20	400	
111	136.5		Grainger Trib.		Ephemeral	1	10	N	-	L	20	400	
112	137.2		Grainger Trib.		Ephemeral	1	10	N	-	L	20	400	
113	139.6		Liard Trib.		Ephemeral	1	10	N	-	L	20	400	
114	140.1		Liard Trib.	Headwater streams. Small channels with poor habitat. Often include steep cobbly sections downstream. Beaver habitat downstream very common e.g. multiple dams downstream of 144.	Ephemeral	1	10	N	-	L	20	400	
115	140.5		Liard Trib.		Ephemeral	1	10	N	-	L	20	400	
116	141.8		Liard Trib.		Ephemeral	1	10	N	-	L	20	400	
117	144	144.7	Liard Trib.		Ephemeral	1	10	N	-	L	20	400	
118	146.3		Liard Trib.		Ephemeral	1	10	N	-	L	20	400	
119	149.3		Liard Trib.	Channel outlets to Liard River also hanging, limiting migration.	Ephemeral	1	10	N	-	L	20	400	
120	150.3		Liard Trib.		Ephemeral	1	10	N	-	L	20	400	
121	151.1		Liard Trib.		Ephemeral	1	10	N	-	L	20	400	
122	152.2		Liard Trib.	No channel.	Ephemeral	1	10	N	-	L	20	400	
123	154.4	154.4	Liard Trib.	As for 139.6-151.1.	Ephemeral	1	10	N	-	L	20	400	

Table A1.5 (Cont'd.)

No.	Original kps	Winter Road kps	Stream Name	Description of Creek	Ephemeral / Permanent	Proportion Riparian Coverage	Possible Width of Riparian Zone to be Lost (m)	Fish?	Fish Species	Riparian Value (H, M, L)	Riparian Management Zone (m)	Riparian Area Lost (m ²)	Details
124	159.7		Liard River		Permanent	1	10	Y		L	20	400	
125	163.95		Liard Trib.	Hanging wetland channel.	Permanent?	1	10	N	-	L	20	400	
126	165.4		Liard Trib.		Permanent?	1	10	N	-	L	20	400	
127	172		Liard Trib.	Wetland exit of old channel, hanging.	Permanent?	1	10	N	-	L	20	400	

Fish: **N**=unlikely based on habitat or downstream barriers; **Y**= likely based on habitat or documented occurrences; **?**=Uncertain
Existing permitted all season road, It has been assumed that the road will need to be widened by 2.5m on average.

Total 43,375

1. Fish of Tetcela River: Arctic grayling, pike, lake chub, longnose dace, burbot, slimy sculpin and longnose sucker

2. Fish of Granger River: Arctic grayling, pike, lake chub, longnose dace and slimy sculpin.

3. Fish of Liard river: Sport fish species include Arctic grayling, chum salmon, bull trout, inconnu, lake whitefish, mountain whitefish, northern pike and burbot. Other non-game fish consist of the long nose sucker, lake chub, flat head chub, slimy sculpin, white sucker, round whitefish and the long nose dace. (taken from BCMOE parks, Liard River Corridor Provincial Park, http://www.env.gov.bc.ca/bcparks/explore/parkpgs/liard_rv_corr/nat_cul.html)

Table A1.6 Riparian vegetation lost (within 50m of HWM) where roads parallel streams.

Only Sundog, Funeral, Fast and Prairie Creeks assessed, creeks further to the east do not encroach on streams.

Does not include roads on existing winter road

road prism width				10	m		FOOTPRINT (square m)						
No.	kp start	kp end	Length of section (m)	Stream Name	Fish?	Fish Species and Life-Stage	Fish Habitat within encroachment	Proportion riparian coverage	Proportion of road lens covering riparian	Riparian Value (H, M, L)	Permanent Habitat Loss	Temporary Habitat Loss	Details
	1	6.8	5800	Prairie	Y	BT:all; SS:all; RWF:all	migration/rearing for AG; all for SS & RWF.	0.3	0.25	L (no instream benefits, possible minor fish food value only)	2,175		
	6.8	6.95	150	Fast	Y	BT:all; SS:all	migration/rearing for AG, all for SS.	0.3	0.25	L (no instream benefits, possible minor fish food value only)	113		
	7.2	7.4	200	Fast	Y	BT:all; SS:all	migration/rearing for AG, all for SS.	0.3	0.25	L (no instream benefits, possible minor fish food value only)	150		
	7.4	12.6	5200	Funeral	Y	BT:all	rearing for BT, possible spawning	0.5	0.25	M (no instream benefits, likely important for fish food and water retention)	6,500		
1	23.3	23.4	100	Sundog	N	-	-	0.5	1	L (no instream benefits, possible minor fish food value only)	500		
2	28.1	28.47	370	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.4	1	L (no instream benefits, possible minor fish food value only)	1,480		
3	28.8	29	200	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.2	1	L (no instream benefits, possible minor fish food value only)	400		
4	29.84	29.87	30	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.3	1	L (no instream benefits, possible minor fish food value only)	90		
5	30	30.3	300	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.4	1	L (no instream benefits, possible minor fish food value only)	1,200		
6	30.95	31.05	100	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.6	1	L (no instream benefits, possible minor fish food value only)	600		
7	33	33.6	600	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.5	1	L (no instream benefits, possible minor fish food value only)	3,000		
8	33.6	33.95	350	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.1	1	L (no instream benefits, possible minor fish food value only)	350		main stream channel is located on opposite (west) side of the floodplain.
9	33.95	34.05	100	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.05	1	L (no instream benefits, possible minor fish food value only)	50		
10	34.05	34.8	750	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.8	1	L (no instream benefits, possible minor fish food value only)	6,000		
11	34.8	34.92	120	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.05	1	L (no instream benefits, possible minor fish food value only)	60		
12	34.92	35.01	90	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.25	1	L (no instream benefits, possible minor fish food value only)	225		
13	35.01	35.19	180	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.5	1	L (no instream benefits, possible minor fish food value only)	900		
14	35.19	35.3	110	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.05	1	L (no instream benefits, possible minor fish food value only)	55		
15	35.3	35.5	200	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	1	1	L (no instream benefits, possible minor fish food value only)	2,000		
16	35.5	35.6	100	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.05	1	L (no instream benefits, possible minor fish food value only)	50		
17	35.6	35.8	200	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	1	1	L (no instream benefits, possible minor fish food value only)	2,000		
18	35.8	36.12	320	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.05	1	L (no instream benefits, possible minor fish food value only)	160		
19	36.12	36.45	330	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.05	1	L (no instream benefits, possible minor fish food value only)	165		
21	36.45	37.1	650	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.8	1	L (no instream benefits, possible minor fish food value only)	5,200		
22	37.1	37.5	400	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	1	1	L (no instream benefits, possible minor fish food value only)	4,000		
23	37.5	38.05	550	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.05	1	L (no instream benefits, possible minor fish food value only)	275		
24	38.05	38.8	750	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.4	1	L (no instream benefits, possible minor fish food value only)	3,000		
25	38.8	39.8	1000	Sundog	Y	AG and SS: all	migration/rearing for AG, all for SS.	0.3	1	L (no instream benefits, possible minor fish food value only)	3,000		
Total											34,760		

Table A1.7 Littoral habitat lost as a result of water withdrawal.

Lake ID	Predicted Drop (mm)	Predicted Drop (m)	Slope of Near-shore Based on Bathymetry Map		Width Lost (m)	Circumference (m)	Maximum Littoral Habitat Lost (m2)	Total Lake Area (m2)	Estimated Littoral Area % of Lake	Estimated Littoral Area (m2)	% Littoral Lost
			rise (m)	run (m)							
Mosquito	2.4	0.0024	1	22	0.05	6,240	324	450,500	0.15	67,575	0.5%
km 70	5.7	0.0057	2	30	0.09	2,880	246	217,700	0.1	21,770	1.1%
km 115	2	0.002	1	30	0.06	1,520	91	95,720	0.25	23,930	0.4%
km 121	1.2	0.0012	1	20	0.02	3,500	84	252,400	0.8	201,920	0.0%
km 139	0.9	0.0009	1	50	0.05	5,040	227	393,900	0.7	275,730	0.1%
km 141	2.6	0.0026	1	40	0.10	2,880	300	186,200	0.3	55,860	0.5%
Sum							1,272				

Table A1.8 Habitat Gains.

1) Constructed habitat foot prints

Enhancement Option 1 - Deep Pool at downstream end of Sundog Creek diversion (kp 36.8)

Length	Width	Area	Value
40	10	400	High

Enhancement Option 2 - Constructed low-gradient blind side channel on Sundog Creek (kp 34.3 or kp 39).

Length	Width	Area	Value
20	3	60	High

Sum	460	High
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2) New channel created as a result of the diversion (assumes same habitat attributes as old channel)

Area	Value
24,526	Medium
21,030	Low

Table A1.9 Summary of losses, alterations and gains.

Losses	Area (m ²)			
	High	Medium	Low	Other
1. Fish habitat - Crossings	0	15	0	0
2. Fish habitat -Sundog encroachments	-	-	-	-
Category A	206	824	1,085	0
Category B	0	0	11,590	0
Category C	0	0	0	6,007
3. Fish habitat -Sundog diversion berm footprint	0	300	450	350
5. Riparian vegetation -Cossings	0	0	0	43,375
6. Riparian vegetation - Encroachments	0	0	0	34,760
7. Littoral habitat lost (maximum, temporary)	0	0	0	1,272
Total Losses	206	1,139	13,125	85,764

Alterations	Area (m ²)			
	High	Medium	Low	Other
4.Fish habitat - Sundog diversion alteration of old channel	-	-	-	-
Category A	0	24,526	0	0
Category B	0	0	21,030	0
Category C	0	0	0	22,790
Total Alterations	0	24,526	21,030	22,790

Gains	Area (m ²)			
	High	Medium	Low	Other
Enhancement 1 - Deep Pool at downstream end of Sundog Creek diversion (kp36.8)	400	-	-	-
New channel created as a result of the diversion	0	24,526	21,030	22,790
Total	400	24,526	21,030	22,790

Notes:

Low value habitat generally consists of normally dry channel or lost habitat that is mitigated using habitat enhancement approaches. Therefore we feel that this category of loss does not need to be offset.

Other habitat generally consists of temporary loss or loss of riparian vegetation having little value to adjacent aquatic habitat. Therefore we feel that this category of loss does not need to be offset.

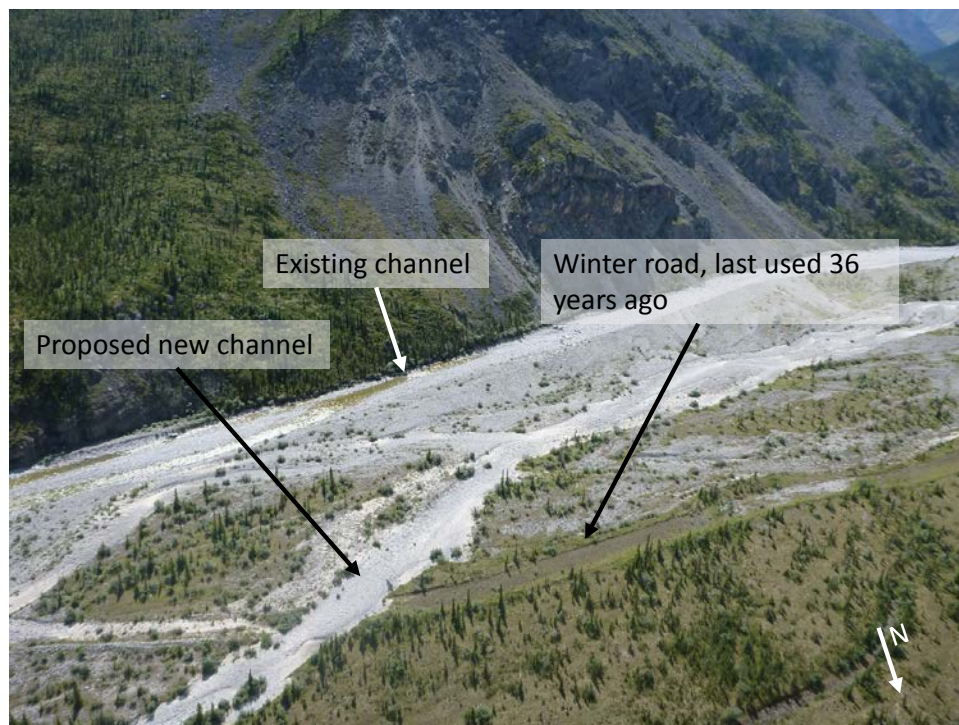
Attachment 2

Examples of Habitat Categories

Attachment 2: Habitat Category “C” Estimation

The photos in this attachment provide examples of how the extent of habitat identified as Category-C in the offsetting calculations was estimated. Hydrological modelling identified both the extent of the Q2 and Q100. The Q20 was estimated using the Q100, but areas containing vegetation were removed since vegetation appears to take more than 20 years to become established. Photograph 1 shows a portion of the former winter road in the alluvial floodplain of Sundog Creek, and illustrates how slowly vegetation recovers in these higher elevation, alpine areas. Despite last being used in 1980 (37 years ago), the former winter road shows minimal plant growth.

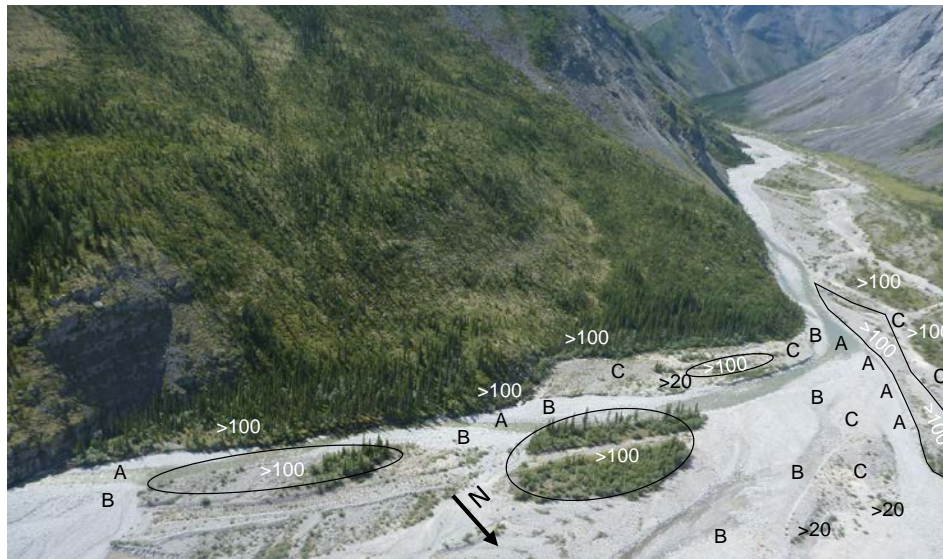
Photograph 1 Sundog Creek at km 36.3 looking upstream. Old winter road shown with no mature vegetation despite not being used for 37 years.



Established vegetation was generally identified on orthophotos as areas having a dark grey colour. Site photos and ground truthing were used to verify the classification. Photographs 2, 3 and 4, show the same section of Sundog Creek (~km 36.5 to 37) and demonstrate how habitat was characterized. The Q100 (or areas last inundated “>100” years ago) was based only on the hydrological model results.

Photograph 2

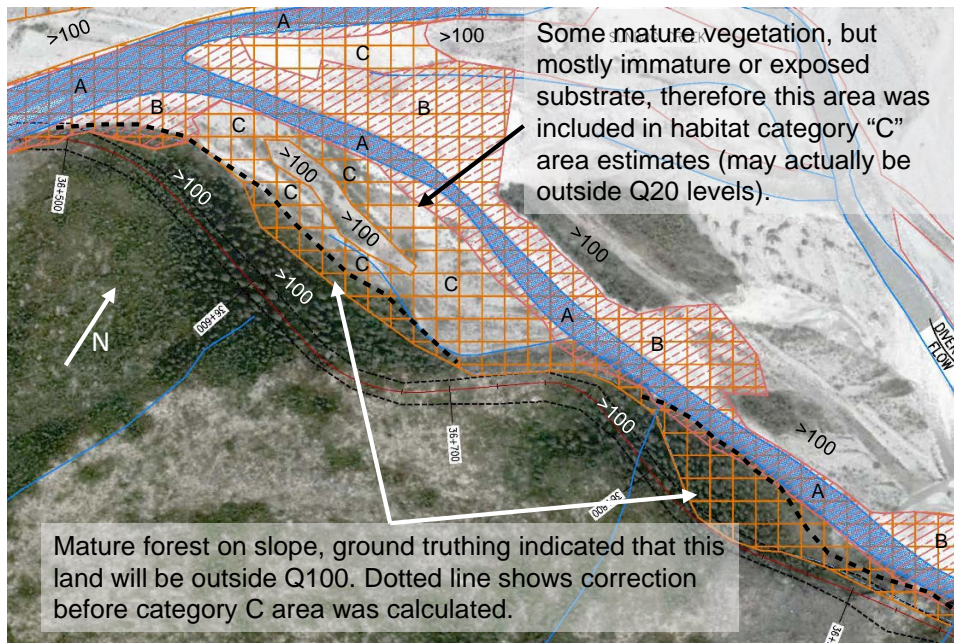
Sundog Creek at km 36.75 looking upstream. Letters indicate how habitat was categorized.



A = Category A habitat, B = Category B habitat, C = Category C habitat, >20 indicates habitat that is outside the Q20, but inside the Q100 (inferred by size of vegetation), and >100 indicates habitat that is outside the Q100 (based on modeling).

Photograph 3

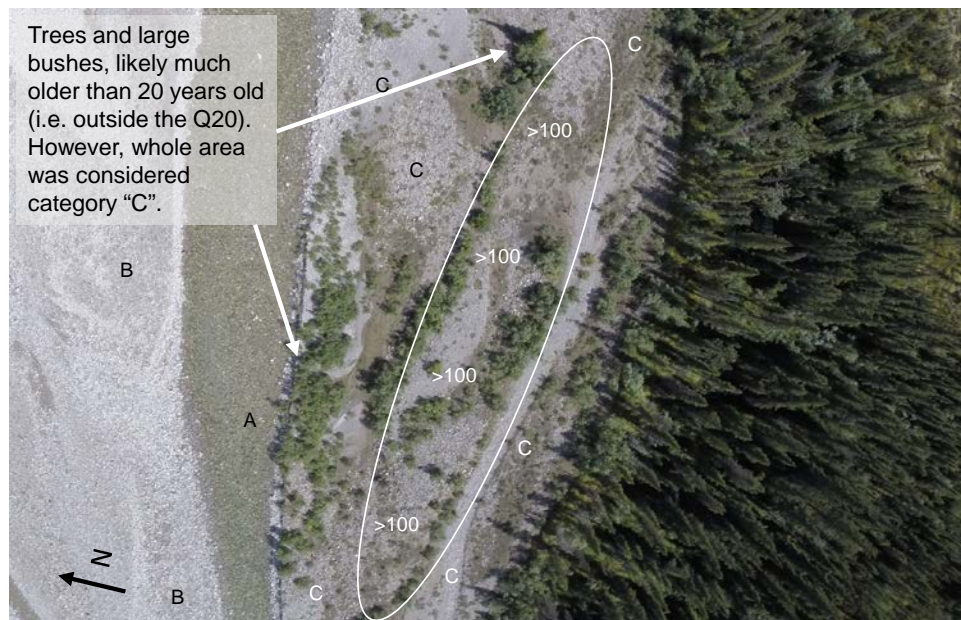
Orthophoto of km 36.6, showing modeled Q2 and Q100 zones, and habitat categories, as provided in Photograph 2.



Orange grid represents modeled area within Q100, orange diagonal cross hatch represents modeled area within Q2. A, B and C categories are also provided. The dark black dotted line indicates area where modeled Q100 was corrected.

Photograph 4

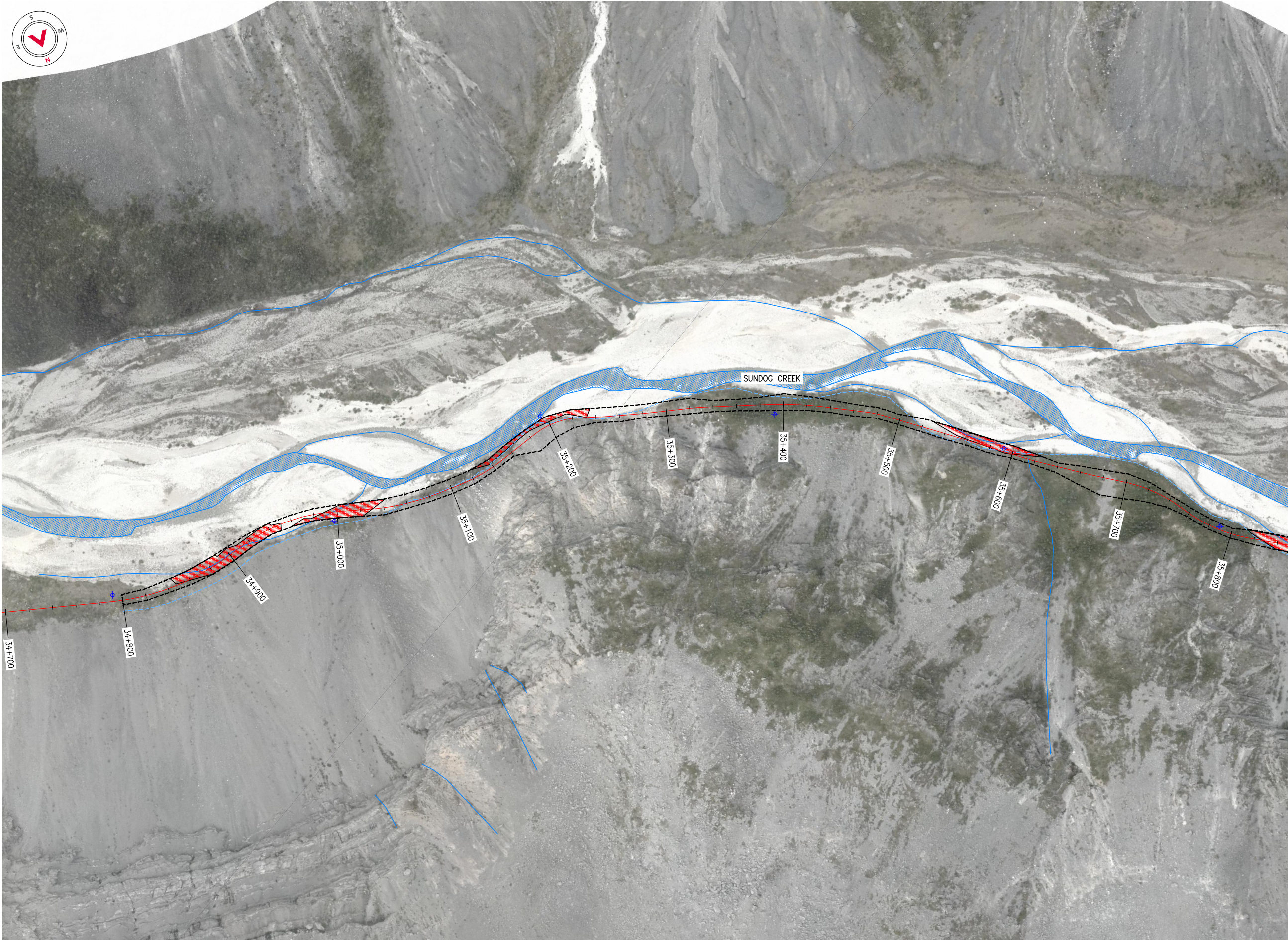
Photo of km 36.6 taken from a helicopter, July 2016.



The white oval represents the approximate area identified by the hydrological model to be outside Q100 (see Photograph 3).

Attachment 3

Sundog Creek Map Used to Estimate Road Prism Encroachment



KEY PLAN

AREA OF DESIGN

LEGEND

PROPOSED DESIGN CL

PROPOSED CUT/FILL LINES

WATERCOURSES

SUNDOG Q2 HEC-RAS

Q2 FOOTPRINT ROAD PRISM OVERLAP

OLD HISTORIC FLOODPLAIN Q100 (HWM)

ACTIVE FLOODPLAIN Q100 (HWM)

CHANNEL THACWEG Q100 (HWM)

SECONDARY FLOODPLAIN Q100 (HWM)

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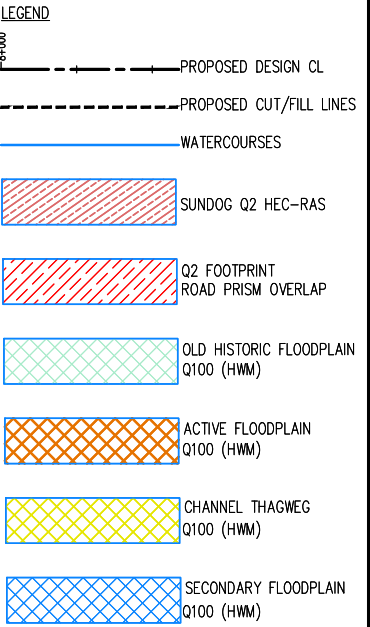
PROJECT:

SUNDOG CREEK
FLOODPLAIN / ROAD PRISM
ANALYSIS

TITLE:

PLAN VIEW
km 34+800 to km 35+800

DWG NO:	16GP0041-325-1920-005	REV:	4
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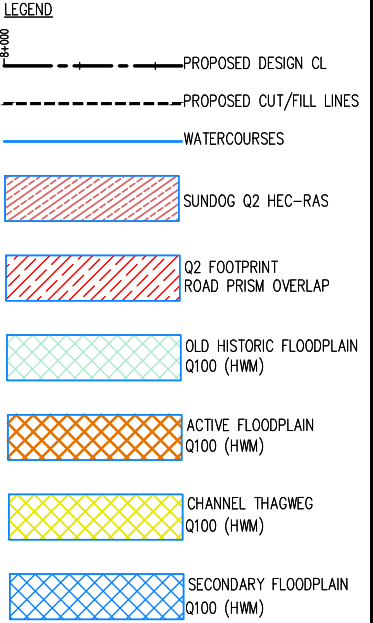
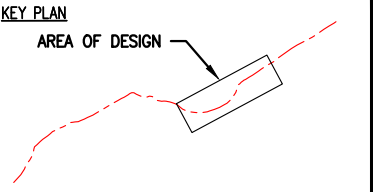
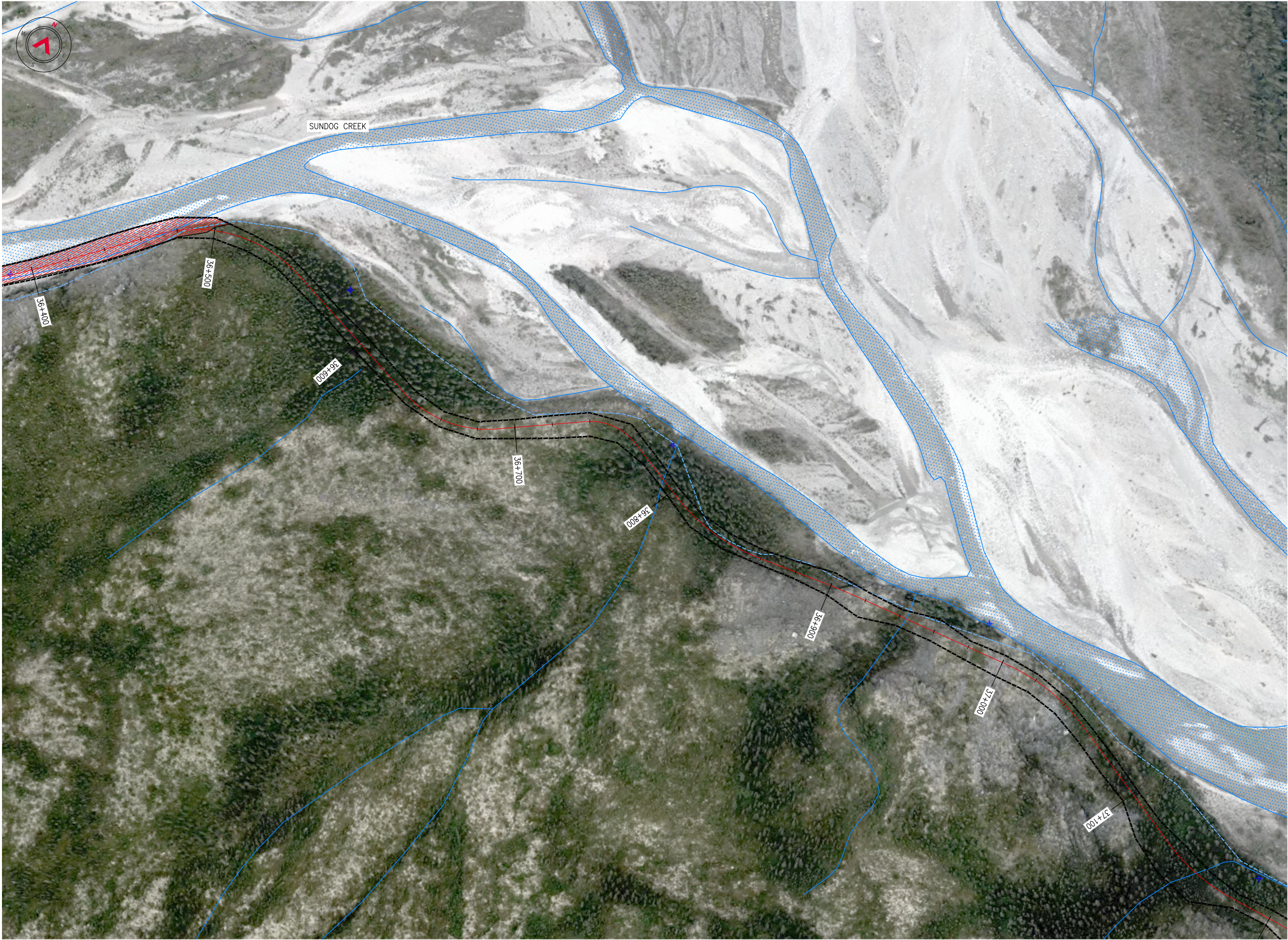
PROJECT:

**SUNDOG CREEK
FLOODPLAIN / ROAD PRISM
ANALYSIS**

TITLE:

**PLAN VIEW
km 35+800 to km 36+400**

DWG NO:	REV:
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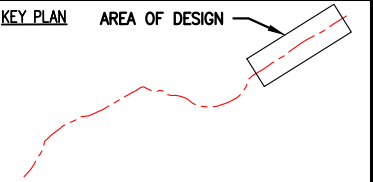
PROJECT:

**SUNDOG CREEK
FLOODPLAIN / ROAD PRISM
ANALYSIS**

TITLE:

**PLAN VIEW
km 36+400 to km 37+100**

DWG NO:	16GP0041-325-1920-007	REV:	4
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LEGEND

	PROPOSED DESIGN CL
	PROPOSED CUT/FILL LINES
	WATERCOURSES
	SUNDOG Q2 HEC-RAS
	Q2 FOOTPRINT ROAD PRISM OVERLAP
	OLD HISTORIC FLOODPLAIN Q100 (HWM)
	ACTIVE FLOODPLAIN Q100 (HWM)
	CHANNEL THAGWEG Q100 (HWM)
	SECONDARY FLOODPLAIN Q100 (HWM)

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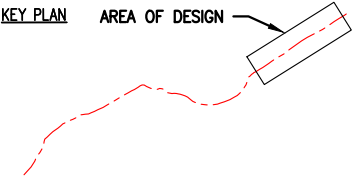
PROJECT:

**SUNDOG CREEK
FLOODPLAIN / ROAD PRISM
ANALYSIS**

TITLE:

**PLAN VIEW
km 37+100 to km 37+800**

DWG NO:	REV:
16GP0041-325-1920-008	4



- LEGEND
- PROPOSED DESIGN CL
 - PROPOSED CUT/FILL LINES
 - WATERCOURSES
 - SUNDOG Q2 HEC-RAS
 - Q2 FOOTPRINT ROAD PRISM OVERLAP
 - OLD HISTORIC FLOODPLAIN Q100 (HWM)
 - ACTIVE FLOODPLAIN Q100 (HWM)
 - CHANNEL THAGWEG Q100 (HWM)
 - SECONDARY FLOODPLAIN Q100 (HWM)

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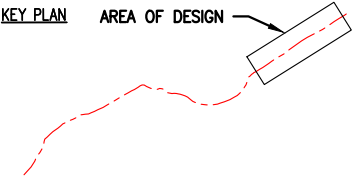
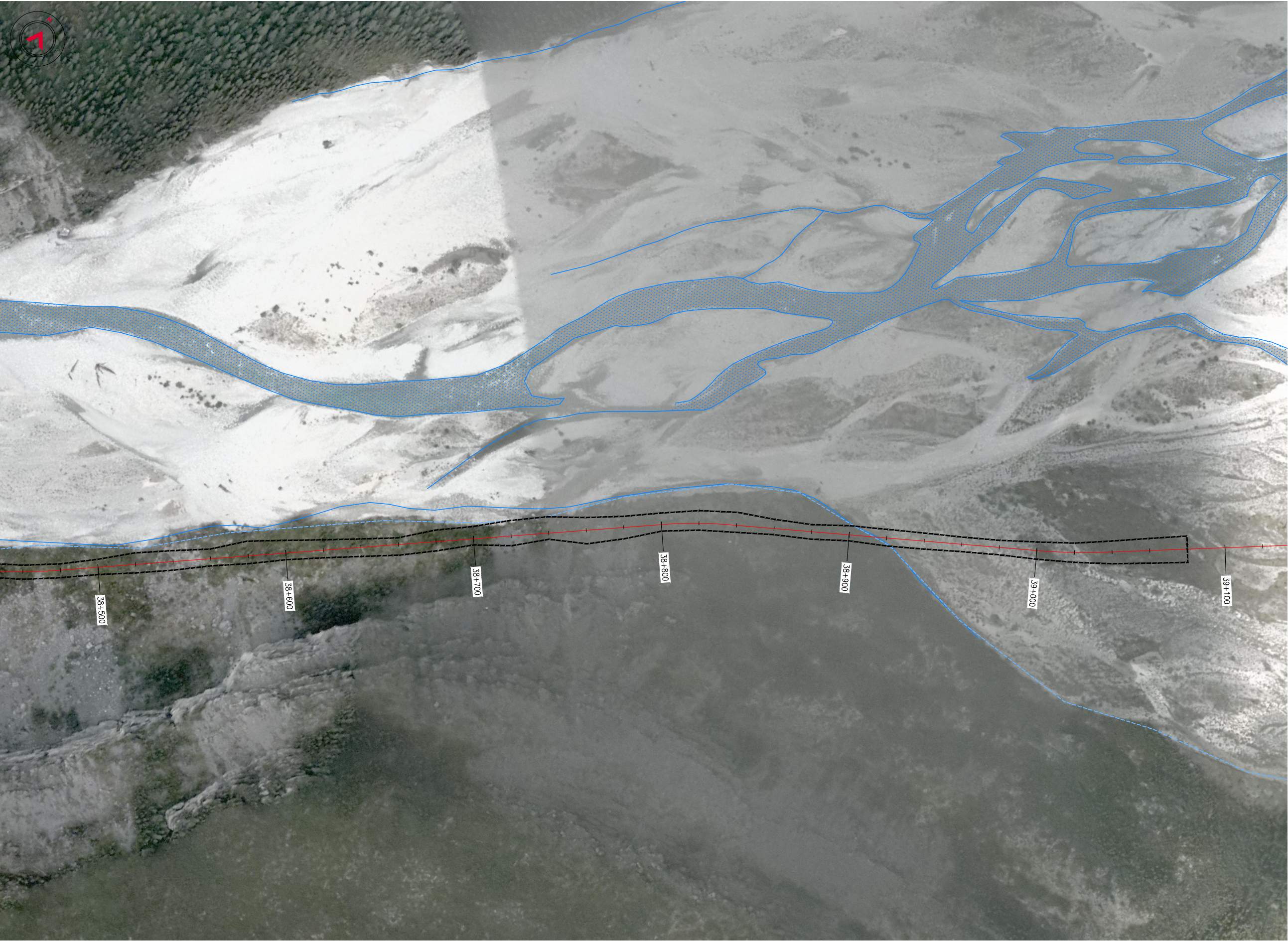
PROJECT:

**SUNDOG CREEK
FLOODPLAIN / ROAD PRISM
ANALYSIS**

TITLE:

**PLAN VIEW
km 37+800 to km 38+500**

DWG NO:	REV:
16GP0041-325-1920-009	4



LEGEND

8+000

	PROPOSED DESIGN CL
	PROPOSED CUT/FILL LINES
	WATERCOURSES
	SUNDOG Q2 HEC-RAS
	Q2 FOOTPRINT ROAD PRISM OVERLAP
	OLD HISTORIC FLOODPLAIN Q100 (HWM)
	ACTIVE FLOODPLAIN Q100 (HWM)
	CHANNEL THAGWEG Q100 (HWM)
	SECONDARY FLOODPLAIN Q100 (HWM)

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DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: 16/02/25
SCALE:	H = 1:2000	APVD: WBM	DATE: 16/02/25

PROJECT:

**SUNDOG CREEK
FLOODPLAIN / ROAD PRISM
ANALYSIS**

TITLE:

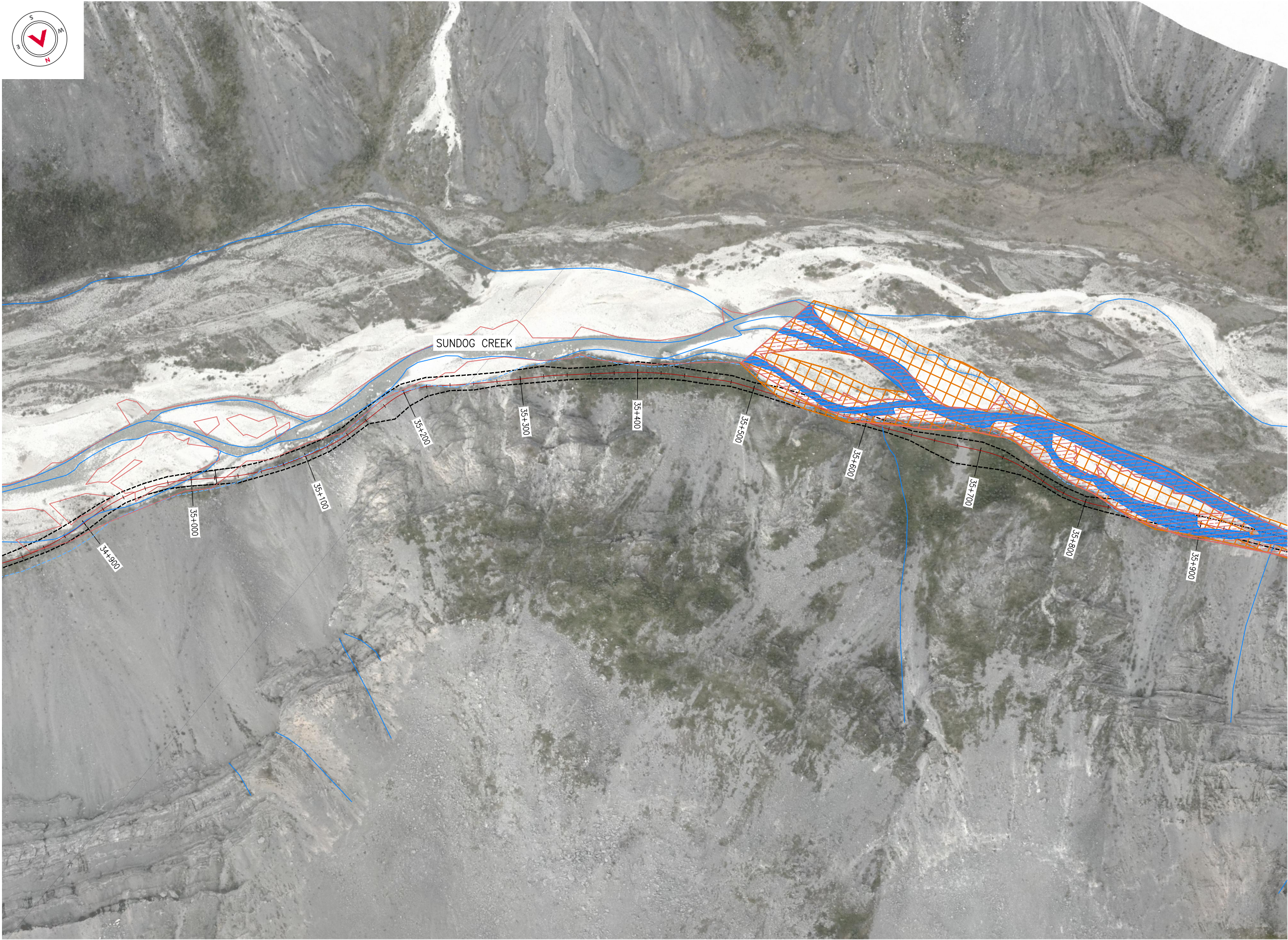
**PLAN VIEW
km 38+500 to km 39+000**

DWG NO:	REV:
16GP0041-325-1920-010	4

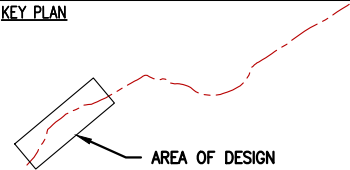
Attachment 4

Sundog Creek Map Used to Estimate Area of Habitat Permanently Altered as a Result of the Diversion

Date: 2016/11/03 | User: Terna Major | File: P:\GP\2016\000\16GP0041 Canadian Zinc-LowSundog\alignments\1000-Drawings\1011-Cut\01-Production\16GP0041-325-1920-35-500b36-500-PLANVIEW-WettedChannel-Option#1_101101 | Layout: 16GP0041-325-1920-005 | Paper Size: 558.8mm x 431.8mm



KEY PLAN



LEGEND

- PROPOSED DESIGN CL
- PROPOSED CUT/FILL LINES
- WATERCOURSES
- SUNDOG Q2 HEC-RAS
- SUNDOG Q100 OPTION #1
- SUNDOG Q100 OPTION #2
- WETTED CHANNELS

MAIN CHANNEL AREA
OPTION#1 = 21312.26m2

SIDE CHANNEL AREAS
OPTION#1 = 3213.68m2

SUNDOG Q2 HED-RAS AREA
OPTION#1 = 45555.82m2

SUNDOG Q100 AREA
OPTION#1 = 73096.56m2

ISSUED FOR REVIEW
NOT FOR
CONSTRUCTION

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REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
2	2016/11/03	GENERAL REVISIONS	TMM	WBM
1	2016/11/02	GENERAL REVISIONS	TMM	WBM
0	2016/11/01	ISSUED FOR REVIEW	TMM	WBM

CLIENT:



CLIENT NO:		DRWN:	TMM	DATE:	16/02
PROJECT NO:	14-GP-0128	DSGN:	TMM	DATE:	16/02
DRAWING SIZE:	ANSI "B"	CHKD:	EK	DATE:	
SCALE:	H = 1:2000	APVD:	WBM	DATE:	

PROJECT:

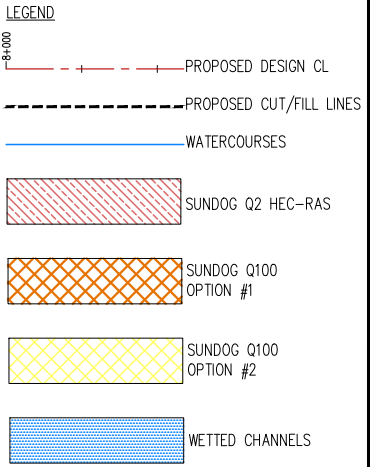
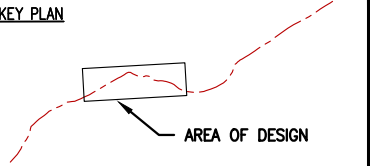
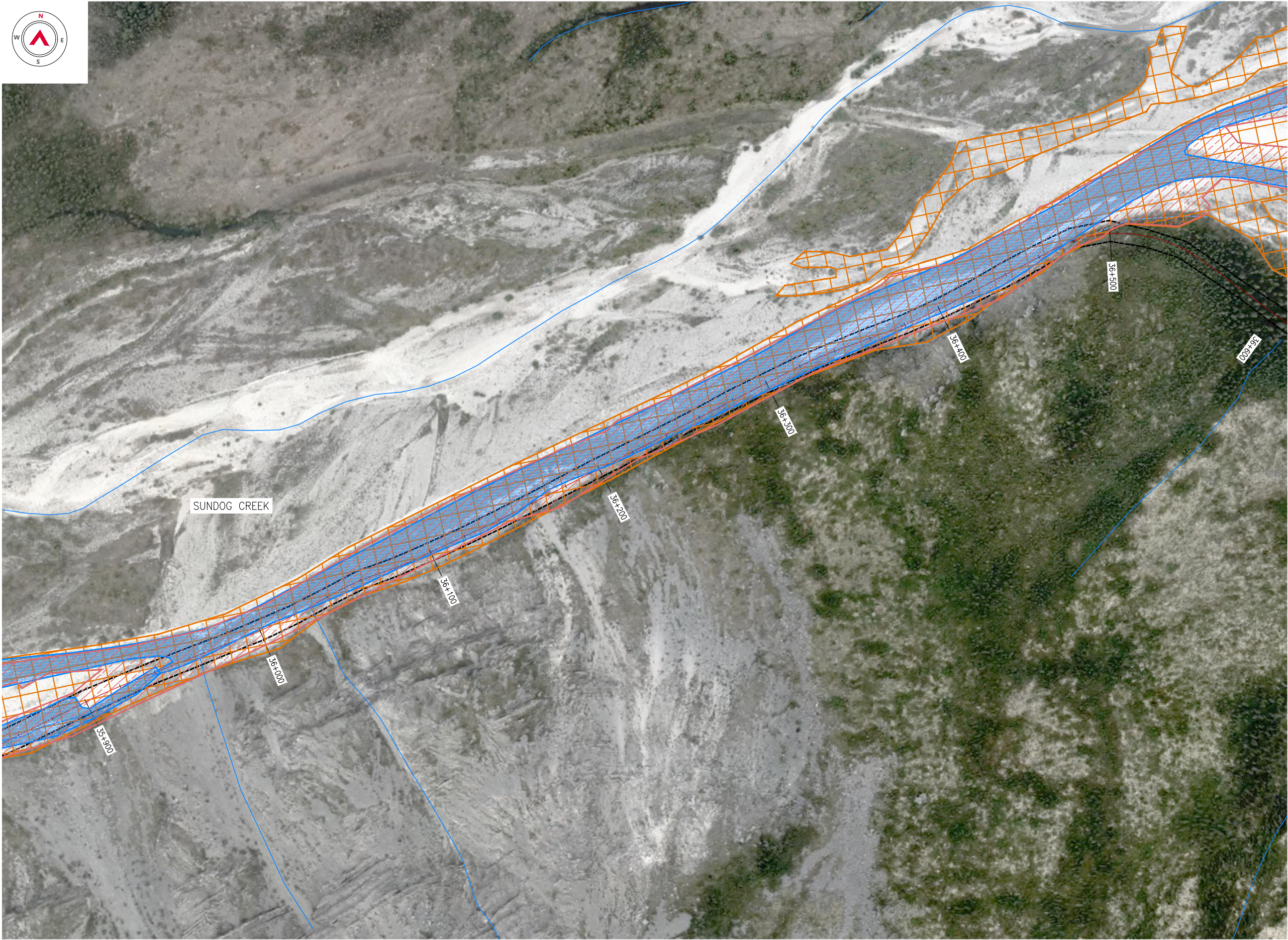
**SUNDOG CREEK
FLOODPLAIN ANALYSIS
OPTION #1**

TITLE:

**PLAN VIEW WITH
AREA CALCULATIONS
km 34+800 to km 35+800**

DWG NO:	16GP0041-325-1920-005	REV:	2
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Date: 2016/11/03 | User: Terna Major | File: P:\GP\2016\000\16GP0041_Canadian Zinc-LowSundogRealignmet\1000-Drawings\1011-Civil\01-Production\16GP0041_325-1920-35+500bs-36+500bs-PLANVIEW-WettedChannel-Option#1_161101 | Layout: 14GP0128-325-1920-006 | Paper Size: 558.8mm x 431.8mm



MAIN CHANNEL AREA
OPTION#1 = 21312.26m²

SIDE CHANNEL AREAS
OPTION#1 = 3213.68m²

SUNDQG Q2 HED-RAS AREA
OPTION#1 = 45555.82m²

SUNDQG Q100 AREA
OPTION#1 = 73096.56m²

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0	2016/11/01	ISSUED FOR REVIEW	TMM	WBM



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PROJECT NO:	14-GP-0128	DSGN: TMM	DATE: 16/02/25
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PROJECT:			

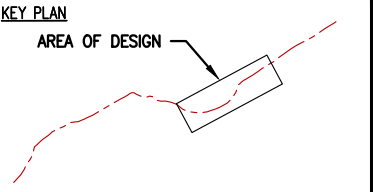
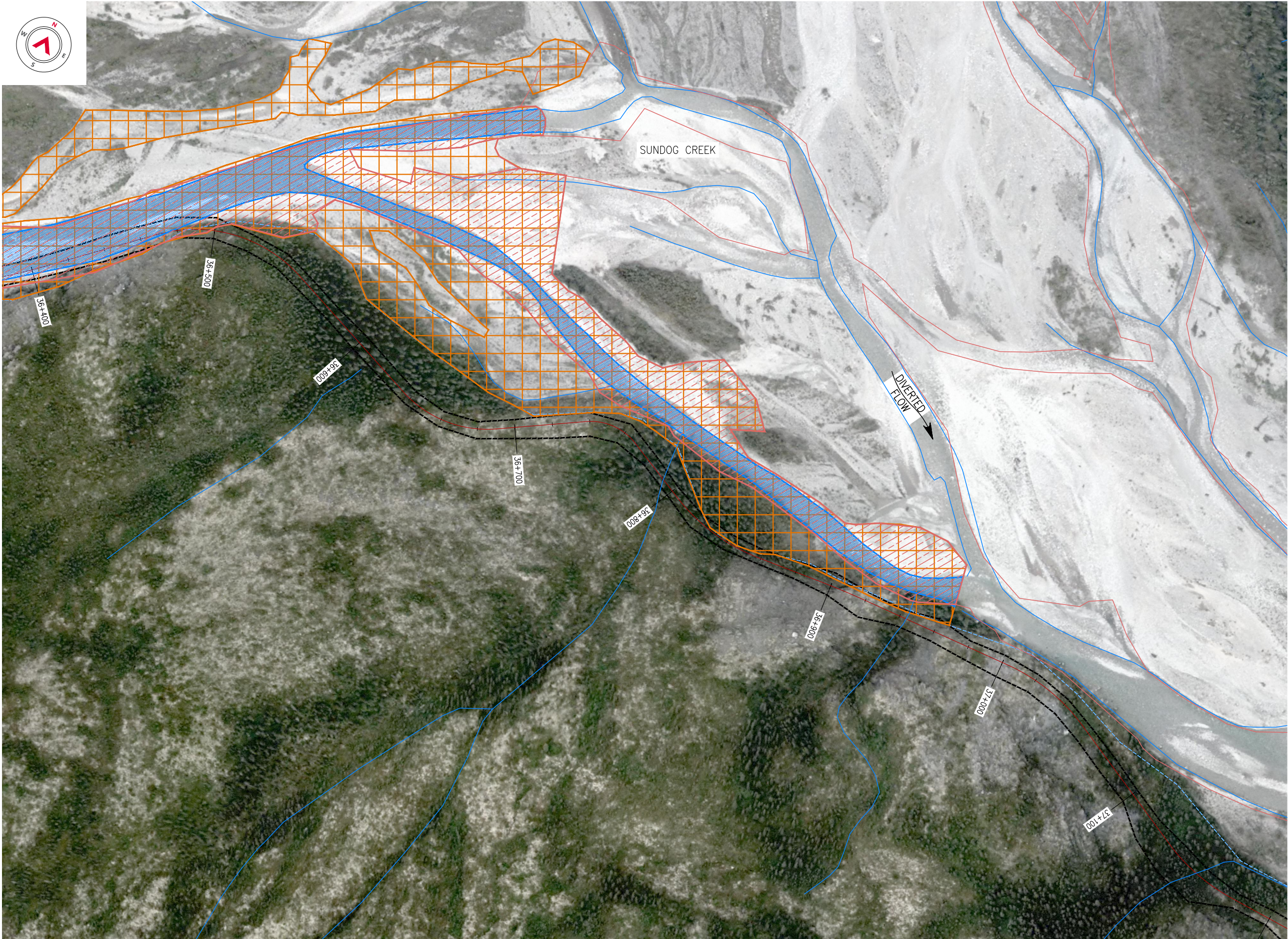
**SUNDOG CREEK
FLOODPLAIN ANALYSIS
OPTION #1**

TITLE:

**PLAN VIEW WITH
AREA CALCULATIONS
km 35+800 to km 36+400**

DWG NO:	14GP0128-325-1920-006	REV:	2
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Date: 2016/11/03 | User: Terna Major | File: P:\GP\2016\000\16GP0041_Canadian Zinc-LowerSundog\Realignments\1000-Drawings\1011-Cali\01-Production\16GP0041-325-1920-35-500b-36-500b-36-500b-PLANVIEW-WettedChannel-Option#1_161101 | Layout: 14GP0128-325-1920-007 | Paper Size: 558.8mm x 431.8mm



- LEGEND**
- PROPOSED DESIGN CL
 - PROPOSED CUT/FILL LINES
 - WATERCOURSES
 - SUNDOG Q2 HEC-RAS
 - SUNDOG Q100 OPTION #1
 - SUNDOG Q100 OPTION #2
 - WETTED CHANNELS

MAIN CHANNEL AREA
OPTION#1 = 21312.26m²

SIDE CHANNEL AREAS
OPTION#1 = 3213.68m²

SUNDOG Q2 HED-RAS AREA
OPTION#1 = 45555.82m²

SUNDOG Q100 AREA
OPTION#1 = 73096.56m²

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1	2016/11/02	GENERAL REVISIONS	TMM	WBM
0	2016/11/01	ISSUED FOR REVIEW	TMM	WBM

CLIENT:

CANADIAN ZINC CORPORATION



CLIENT NO:		DRWN:	TMM	DATE:	16/11/01
PROJECT NO:	14-GP-0128	DSGN:	TMM	DATE:	16/08/15
DRAWING SIZE:	ANSI "B"	CHKD:	EK	DATE:	-
SCALE:	H = 1:2000	APVD:	WBM	DATE:	-
PROJECT:					

PROJECT:

**SUNDOG CREEK
FLOODPLAIN ANALYSIS
OPTION #1**

TITLE:

**PLAN VIEW WITH
CALCULATED AREAS
km 36+400 to km 37+100**

DWG NO:	REV:
16GP0041-325-1920-007	2