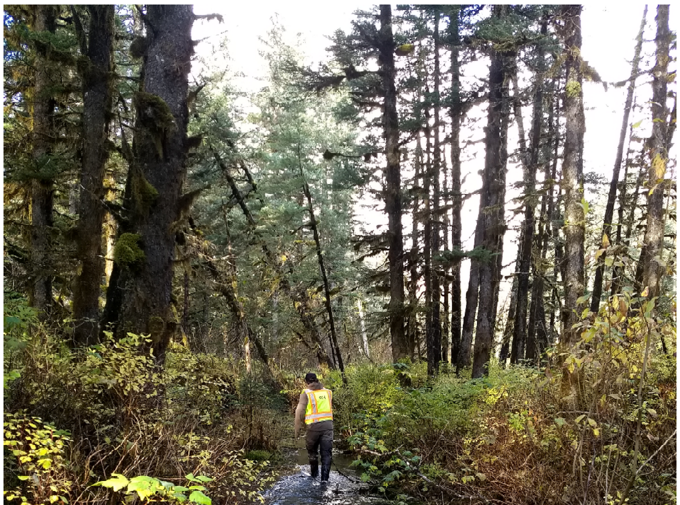


Hydraulic and Hydrologic Report DRAFT

Copper River Watershed Fish Passage Improvement Project

Copper River Highway, Cordova, Alaska

December 21, 2018

Introduction

The Copper River watershed and delta is an expansive system reaching from its mouth in the Gulf of Alaska to the interior north of Paxson, Alaska and stretches from the Nelchina River basin into the Yukon Territory, Canada. The delta area encompasses not only the branches of the Copper River but also numerous significant drainages that head in the coastal mountains. It contains many complex intricate relict channels with equally complex base flows that support salmon and trout fisheries, as well as numerous bird species.

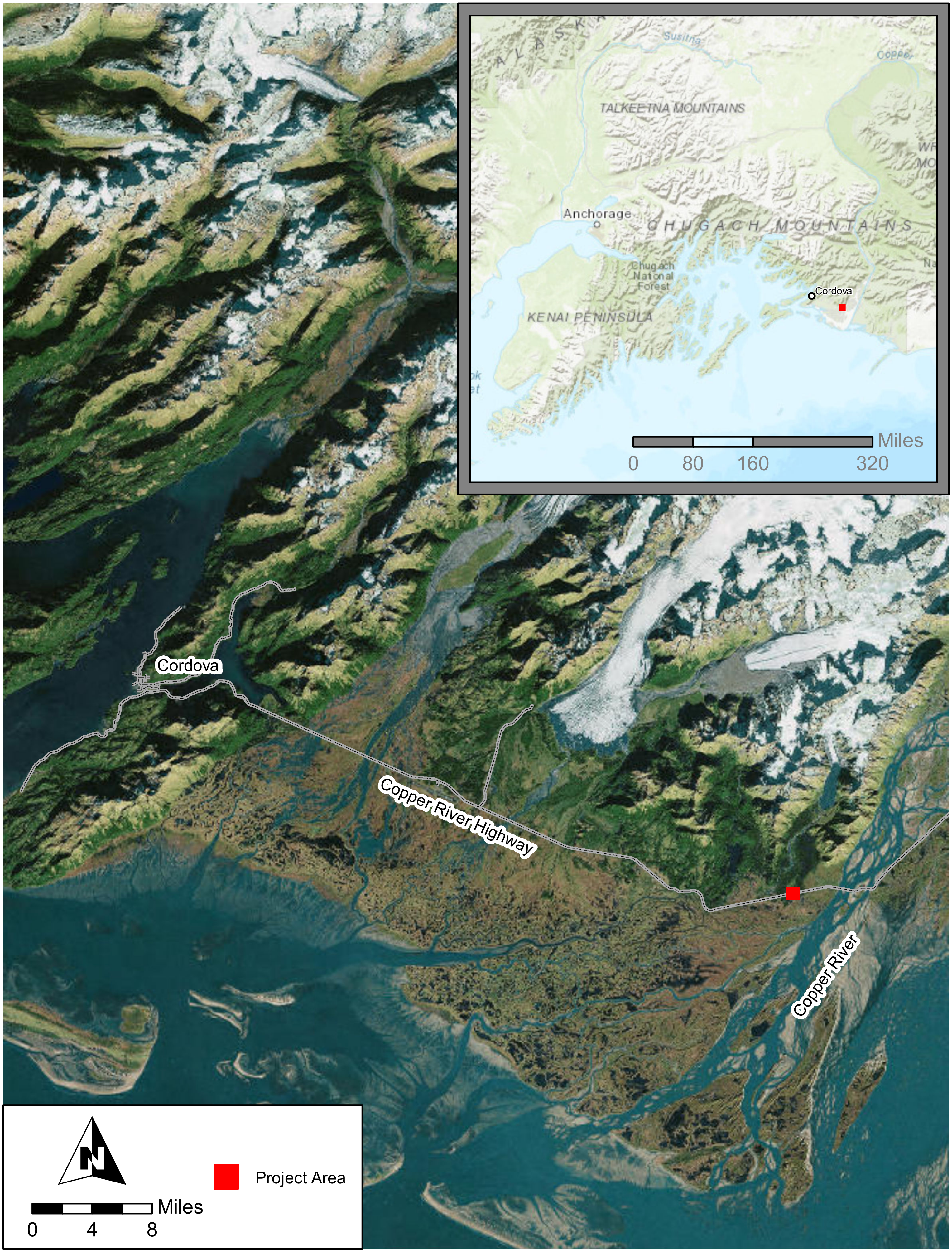
The sites that are the subject of this report are contained within a short stretch of Alaska State Highway 10 between the Mud Hole Smith Airport and the Copper River (See Figure 1). This report provides hydrologic and hydraulic backing for the design of three replacement fish passage culverts along Highway 10. Survey data of the three sites were provided by St. Denny Surveying Inc. as contractors for Bratslavsky Consulting Engineers, Inc. (BCE). Flow gaging data is provided by the USFWS.

This report investigates potential flood flows and fish passage challenges posed by the three crossings and is intended as design guidance for replacement of the culverts. This report will:

- Determine stream slope and profile for long-term channel stability and fish passage.
- Investigate roadway grade, fill height, and width.
- Create and analyze watershed sizes, analyze peak storm flows, discuss flood plain and routing issues, size conveyance to meet hydraulic and fish passage requirements, and provide scour analysis and stream substrate sizing.
- Provide design guidance for the new crossing culvert width, invert elevations, length, structure type, and skew angle.
- Design stream substrate and other grade control structures.

It is anticipated that stream simulation design will be used for the design of these crossing structures and low-flow information provided by the USFWS will be used for low-flow channel design within the crossing structures. The structures will be sized to pass the 100-year flood event at 0.8 times the opening height of the culvert and the low-flow channel will be constructed to simulate the natural creek channel through the crossings. The crossings were modeled using HY-8 to ensure the proposed culvert size will convey the 100-year flood event.

Figure 1 shows the projects location:



Cordova
Copper River Highway
Copper River
Project Area
Miles
0
4
8
Susitna
Copper
TALKEETNA MOUNTAINS
Anchorage
CHUGACH MOUNTAINS
Chugach National Forest
KENAI PENINSULA
Cordova
Miles
0
80
160
320

Site Analysis

To better understand the methodology used in this H&H Study a brief description of the area's history, geomorphology, and their affects is given below.

HISTORY OF THE AREA

Between 1907and 1911 the Kennecott Corporation constructed the Copper River and Northwestern Railway extending up the Copper River to access large copper ore deposits in Chitna River basin. The railway ran for 195 miles from Cordova through Chitina and up the Chitna River to the Kennecott mines. The use of the railway ended in 1938 due to the closure of the Kennecott mines and the ROW was donated to the US government in 1941. At the Cordova end approximately 51 miles of the railway were converted to the Copper River Highway from 1945 to 1973 (USGS, 1997).

The original rail bed cut across the Copper River Delta on its way to Pilot Point. Construction methods may have been to simply lay down a gravel rail bed on whatever boggy soils were encountered and to bridge encountered drainages with wooden trestles on closely spaced piles. Historical aerial imagery circa 1950 show three short railroad trestles in the area of COP 42-46 and a large area of embankment impoundment which remains today. This projects RFP describes:

"This two-lane dirt road persists on a remnant rail-bed of the former Copper River and Northwestern Railway. Due to improper culvert design during construction, this 50-mile stretch of road intersecting the Copper River Delta between Cordova and the Copper River now functions similarly to a dike at many of the 73 culverts originally intended to provide drainage. As such, the presence of this road-bed has unintentionally disrupted the Delta's hydrology and led to reduced ecological function as well as expensive road repair following major high water events."

1964 EARTHQUAKE

According to the 1997 USGS Report, during the 1964 earthquake:

"the Copper River Delta was raised about 6 ft. (Plafker, 1969). In the Cordova area, the tidal regime was significantly altered: large areas of subtidal estuary became intertidal and much of the intertidal wetlands became supertidal."

This may only be significant when viewed in geologic time and realizing that this uplifting action has been a ongoing process. It is likely that the extensive flats surrounding the rail alignment were once tidal with fine marine sediment strata underlying the courser alluvial gravels

GEOMORPHOLOGY OF THE AREA

The project contains three sites which for the purpose of this report are assumed to share a joint drainage basin. Low interconnecting marsh and beaver activity frequently redirect flow between the three sites. This co-drainage basin was delineated using historical aerial imagery, USGS IfSAR data (IfSAR), and field reconnaissance.

The basin is difficult to define precisely due to several factors and may change significantly during flood events. As presented at the time of the field visit the streams were relatively small even during a significant rain event. Flows were mostly from ground water and local sheet runoff in the remnant channels within a half mile of the crossing sites. Following these remnant flood channels upslope eventually led to ground water seeps as surface flows petered out in the flat glacial outwash terrain.

Having noted the lack of sustained channel flows from the headwater basins it is also noted that the streams do occupy remnant flood channels and there is evidence that these channels could and do see larger flood flows as the Saddlebag River overflows its bank into this area.

Looking at the delineated basin as a whole, there are three points of uncertainty or “tipping points” that could change the basin’s size significantly. The Saddlebag River of which these smaller drainages is a subbasin contains a large active glacier, glacial lake, and significant alluvial features. It is these alluvial features that through continued sediment deposition move the basins flows between channels and alter the geometry of the basins feeding the three crossings. Figure 2 shows the larger basin and the tipping points.

Tipping Points

1. Saddlebag River

The first tipping point is an outside bend in the Saddlebag River where high flows jump the banks course out into the timber to join channels that cross back into the site basin. A field reconnaissance of the area confirmed that this is a relatively common occurrence but photo records appear to indicate that at least since 1907 the Saddlebag River has never been completely rerouted at this point. Such an event would have washed out the rail bed and the 3 small trestles seen in the 1950 aerial would have been replaced with a larger river crossing. The Saddlebag River has not always been contained entirely within its current banks and channel. In fact, these images show that in the past the river has had multiple active side channels that run parallel to the existing US Forest Service road that is adjacent to the project area but none of these channels has rerouted the river and it continues to hug the west side of the valley and carry most of the larger drainage to the larger existing bridge west of the culvert sites.

The point at the river bend is still active and showed evidence of overtopping in the past summer but once waters subsided the river has gone back to its main channel. The following photos are of this river bend and the sediment deposits in the adjacent forest. Note that there is no high bank for the flood waters to overcome, almost any high flow event floods out into the forest. Although the forest floor trends downhill toward the east from this point it appears that the gradient of the existing thalweg is steeper than the alternative routing into the forest and the river has historically settled back to the westerly channel after significant flood events.


Using IfSAR data, the upstream drainage basin for the Saddlebag River at the bend of interest is approximately 11.13 square miles, and would produce an additional 3,680 cubic feet per second (cfs) of flood flow during the 100 year event. A flood of this magnitude would likely wash out the highway and significantly alter the drainages in this valley. Rebuilding would require a bridge or very large box culvert. Because of the high degree of uncertainty for this occurrence and the non-critical nature of the transportation connection we have recommended that these flows be ignored until the improbable occurs.

2. Alluvial Drainage Redirection Along the Eastern Boundary

Site reconnaissance, IfSAR, and historical aerial imagery were used to determine an eastern basin border that is believed to fall within the forested area near the mountains to the northeast of the project area. It is believed that surface runoff coming from the eastern wall of the valley flows southeast along the base of the mountains and enters drainages east of the project. At the upper end of this side basin there is an area where upstream flows traverse on alluvial feature with the ability to course into the project basin or alternatively divert into the more eastern drainages. The basin area upstream of this tipping point is approximately 0.73 square miles. We have conservatively included this area in the project basin.

3. Headwaters Diversion

Again, based on IfSAR data and aerial imagery, drainage coming from the extreme headwaters of the basin must traverse an area of uncertain flow paths to enter the project basin. There is a point at the base of the bowl that can be seen from aerial imagery where flows could tip either into the headwater of the Saddlebag River to the north or enter the project basin between the mountain and a low glacial hill mid valley. This area above this point is approximately 0.53 square miles and has again been conservatively include in the watershed.

In summary, for flood flow analysis the delineation of the project basin includes the smaller additions to the basin represented by the 2 latter unknowns but does not include flood flows from the Saddlebag River. Saddlebag River flows are known to occur but their frequency and volume have not been included here.

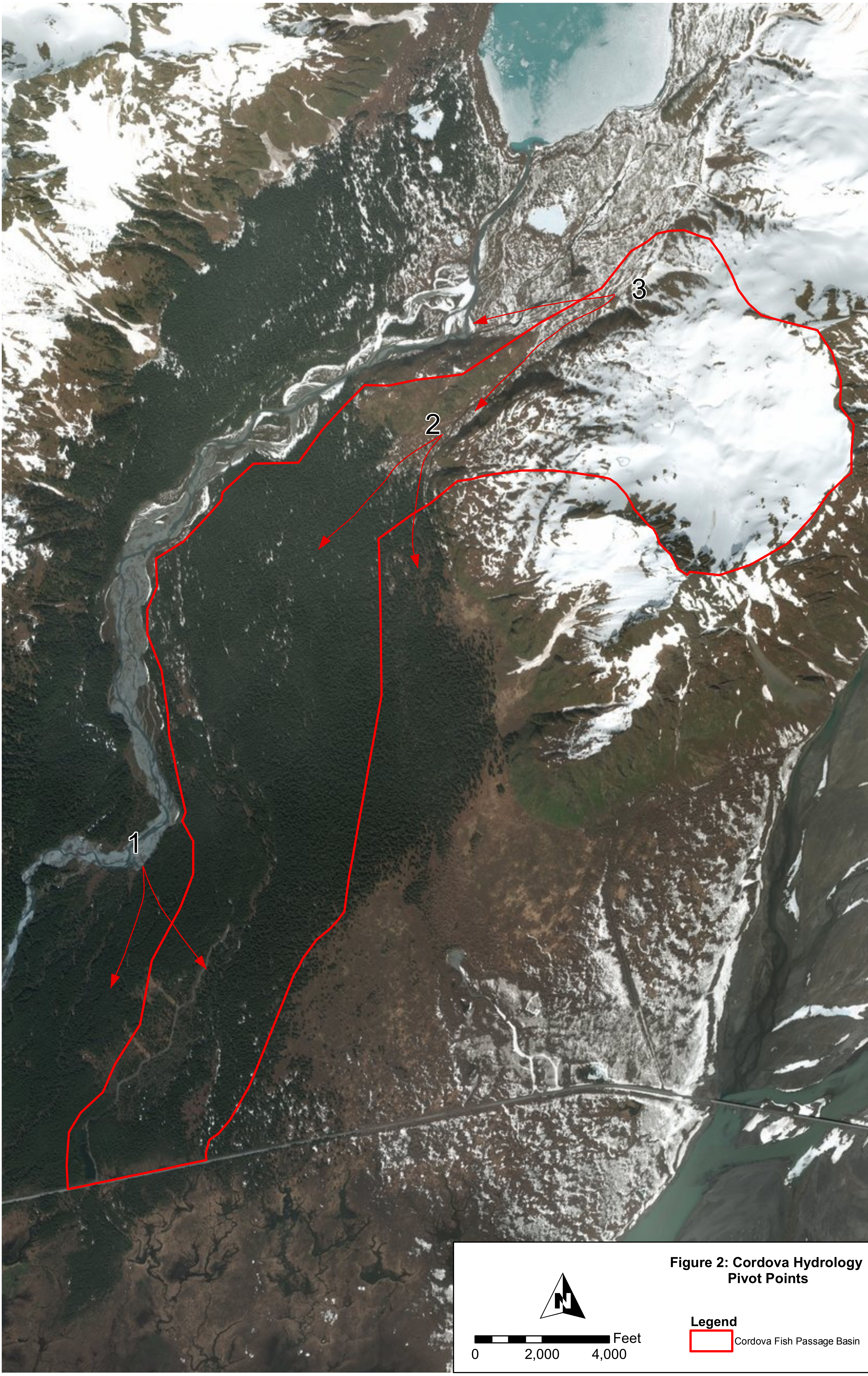


Figure 2: Cordova Hydrology Pivot Points

Other Affecting Factors

Embankment Impoundment

Due to the previously alluded to poor construction of multiple existing culverts along this roadway and the backwaters created by beaver dams, water is currently impounded behind the roadway beginning from COP 42 and continuing east to COP 45. This creates a man and beaver maintained wetland area spanning the length of the upstream project area. This area contains numerous small side channels and may provide significant fish and wildlife habitat. With improvements to the culverts the project should set crossing elevations and maintain this wetland area.

Beaver Activity

There is an active and robust beaver population in the project area's streams that do not show any signs of leaving. There is a small pond that flows into COP 42 (a crossing structure in the USFS road west of the project area) and then continues into COP 43. This small pond's elevation is currently determined by a beaver dam at the south end of the pond and a beaver dam built within a culvert on the Forest Service road connecting COP 42 to COP 43. Also, at COP 44 and COP 45 the tail water elevation is controlled by existing beaver dams downstream of the crossing.

Evidence suggests that beavers are attracted to the sound of water spilling across threshold features and that larger structures with quiescent flows are less likely targets of dam building activity. This characteristic should be a design goal of the replacement structures and considered when setting invert elevations and sizing openings.

Flood Flow Analysis

Drainage basin area (square miles): 1.72 sq. miles

PRISM Annual Precipitation (inches/year): 126 in/yr

2-Year Event	208 cfs
10-Year Event	317 cfs
50-Year Event	589 cfs
100-Year Event	679 cfs

Much of the area surrounding the three culvert locations is relatively flat and delineation can be difficult from aerial photography and available topography, therefore, the basin has been developed using a conservative approach and have included areas of uncertainty described in the Site Analysis. The resultant flood flows calculated using the 2016 USGS regression equations (USGS, 2016) seem large when compared to the size of the stream channels and the observed flows recorded by USFWS. This apparent mismatch is likely due to the conservative inclusion of larger areas of the headwater basins.

For an additional data point, gage data from a nearby stream was downloaded (USGS 15215900 GLACIER R TRIB). This stream has a similar basin size to the project basin and was analyzed with Log Pearson Type III Distribution (LP3) to compare the results with its 2016 regression flows. While the regression equations underestimated the 2-Year event by 30 percent, it overestimated the 100-Year event by 59 percent. It should be noted that this streams' basin is predominantly mountainous terrain compared to the flatter nature of the project basin, and that there was only 6 years of recorded data which is relatively short for a representative LP3 analysis.

Climate Change Affects:

University of Alaska Fairbanks' (UAF) Scenarios Network for Alaska + Arctic Planning (SNAP) has predicted an overall increase in annual precipitation of approximately 10.2 percent for the years 2090-2099. This results in an annual precipitation increase from 126 in/yr to 138 in/yr. and applying this to the 2016 regression equations increases the 100-Year event flow approximately 7.7 percent from 679 to 731 cfs.

Considering this additional data, we believe that using the 2016 regression equations without applying any additional factors is already sufficiently conservative and in line with the risk and infrastructure impacts associated with the subsequent design recommendations.

Culvert Analysis

EXISTING SITE CHARACTERISTICS

The current culverts at the project location consist of; COP 43, a 36 inch round Corrugated Metal Pipe (CMP) that had debris in its inlet during the site visit, but is otherwise in good condition. COP 44, a 48 inch by 36 inch pipe arch with a partially plugged inlet and rebar beaver debris bars. And COP 45, also a 48 inch by 36 inch pipe arch with a partially plugged inlet and a damaged outlet. COP 43 and COP 44 are connected directly by a roadway impounded pond, and COP 45 is connected to this pond via a roadside ditch.

Grade control downstream of COP 43, is small woody debris and grass choked channels (aquatic sedges), banks are lined with willows and alders. The streambed is predominantly mud/silt, no pebble count was performed.

Downstream reaches of COP 44 and COP 45 are slow moving, backwatered channels (beaver ponds) consisting of deep pools with floating grass mats and beaver dams. Substrate is predominantly gravel and mud.

Due to the complexity of the system, uncertainty of the basin delineation, and the decision to use one basin for all three culverts (described in the Flood Flow Analysis section) the existing culverts were grouped and modeled as one crossing using HY-8. The objective of this is to find what approximate total flow values will overtop the existing roadway at its lowest point and the magnitude of flows crossing the roadway during the 100 year flood. The capacity of each existing culvert and the flows to overtop the roadway at each individual site were not determined due to the connectivity of the system and the elevation of the existing roadway surface adjacent-to and between the culverts.

Table 1 and Table 2 provide an overview of the existing conditions and results from HY-8 analysis of the existing culverts. All measurements are taken from stream and topographic surveys. See Appendix C for more details.

Table 1: Existing Culvert and Channel Characteristics

Culvert ID	COP 43	COP 44	COP 45
Length:	40'	39.9'	38.5'
Shape and Dimensions:	36" Round CMP	48" x 36" Pipe Arch	48" x 46" Pipe Arch
Culvert Slope:	1.83%	2.08%	1.83%
Channel Slope:	1.2%	1.6%	1.2%
Bankfull Width:	18'	19'	25'

Ordinary High Water Width:	14’	16’	20’

Table 2: Existing Headwater Elevation and Discharge

Culvert ID	Event (Q Yr)	Flow (CFS)	Headwater Elevation	Culvert Discharge (CFS)	Roadway Discharge (CFS)
COP 43		94.73	48.80’	23.49	Overtopping
COP 43	2	208	48.89’	24.75	107.42
COP 43	10	317	48.94’	25.47	213.78
COP 43	100	679	49.06’	27.25	568.91
COP 44		94.73	48.80’	33.23	Overtopping
COP 44	2	208	48.89’	34.97	107.42
COP 44	10	317	48.94’	35.96	213.78
COP 44	100	679	49.06’	38.34	568.91
COP 45		94.73	48.80’	38.02	Overtopping
COP 45	2	208	48.89’	39.68	107.42
COP 45	10	317	48.94’	40.61	213.78
COP 45	100	679	49.06’	42.85	568.91
The roadway is overtopped at 94.73 CFS.					

PROPOSED SITE CHARACTERISTICS

The following assumptions were made when designing and modelling the proposed culverts:

- As in the Existing Site Characteristics section, due the decision to use one set of flow numbers for all of the culverts the existing culverts were modeled as one crossing. The objective of this is to find at what approximate total flow value the roadway will overtop at its lowest point.
- It is assumed that the low point of the roadway will remain at the same elevation and location as the existing roadway (near intersection of the Copper River Highway and the USFS road) at approximately 48.80’.
- All of the proposed culverts were sized with beaver activity and stream simulation design as the primary considerations.
- All culverts will have a minimum of 2’ of cover.

The proposed design specifies replacing the existing culverts with two 12-foot 5-inch span aluminum box culverts for COP 43 and COP 45 respectively, and a 15-foot 6-inch span aluminum box culvert for COP 44. The culverts are to be embedded to depths determined by stream simulation design (see Table 3). Survey data was used to draw VAP lines and the vertical location of the new structures are based on a best-fit for the stream channel survey.

An HY-8 analysis of the proposed design indicates that during a large flood event the three crossing structures can convey flows of 446 CFS before flows will begin to overtop the road where the project ties in with the existing roadway. Outlet flow velocities range from 6.50 to 8.23 feet per second during the 100-year event with outlet depths ranging from 1.54 to 2.04 feet. Table 4 provides a summary of HY-8 analysis of the proposed culverts and the conveyance for the 2-year, 10-year, and 100-year, and roadway overtopping flood events. For more details, see Appendix D.

Table 3: Proposed Culvert and Channel Characteristics

Culvert ID	COP 43	COP 44	COP 45
Length:	58.5’	58.5’	58.5’
Shape and Dimensions:	12’5” x 7’4” Aluminum Box	15’6” x 7’3” Aluminum Box	12’5” x 7’4” Aluminum Box
Culvert Slope:	0.10%	0.60%	0.36%
Channel Slope:	1.2%	1.6%	1.2%
Bankfull Width:	18’	19’	25’
Ordinary High Water Width:	14’	16’	20’

Table 4: Proposed Headwater Elevation and Discharge

Culvert ID	Event	Flow (CFS)	Headwater Elevation	Culvert Discharge (CFS)	Roadway Discharge (CFS)
COP 43	2	208	47.52’	93.17	0
	10	317	48.13’	129.05	0
		446	48.80’	171.59	Overtopping
	100	679	48.93’	180.43	207.82
COP 44	2	208	47.52’	66.45	0
	10	317	48.13’	111.64	0
		446	48.80’	160.85	Overtopping
	100	679	48.93’	170.70	207.82
COP 45	2	208	47.52’	48.30	0
	10	317	48.13’	76.27	0
		446	48.80’	111.49	Overtopping
	100	679	48.93’	119.07	207.82
The roadway is overtopped at 446 CFS.					

At the proposed velocity and depth, the substrate should have D100 sizes ranging from XXX inches to XXX inches. To be filled in at a later deliverable.

References

USGS, 1997, Geomorpholgy of the Lower Copper River, Alaska, U.S. Geological Survey Professional Paper 1581.

USGS 2003. Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada, Water-Resources Investigations Report 03-4188

USGS 2016. Estimating Flood Magnitude and Frequency at Gaged and Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada, Based on Data through Water Year 2012, Scientific Investigations Report 2016-5024

Appendix A: Field Notes

Appendix B: Flood Flow Analysis

Appendix C: HY-8 Report for Existing Structures

Appendix D: HY-8 Report for Proposed Structures

Appendix E: Substrate Calculations