APPENDIX G: HYDRAULIC CONCEPTUAL DESIGN

Although not used as a direct input to the evaluation matrix presented in Chapter 5, the hydraulic conceptual design described below was used to generate a portion of the conceptual construction costs for each of the alignment alternatives. The intent of this design was to ascertain an approximate construction cost for whatever hydraulic conveyance structures final design of the selected alternative might call for. Structure types and sizes described herein are preliminary and may be refined as the project design progresses. The general methodology for the hydraulic design process was broken down into five steps:

1. Identification of mapped stream and river crossings and delineation of their drainage areas
2. Calculation of design flows for mapped stream crossings
3. Sizing of major bridges for mapped streams and rivers
4. Sizing of culverts and drainage structures for mapped streams
5. Identification of un-mapped minor drainages and inclusion of additional quantities

G.1 Water Crossing Identification and Drainage Area Delineation

Stream and river crossings to be sized for flow were identified from data obtained from the Matanuska-Susitna Borough's GIS Division based on tax parcel maps and orthoimagery. Once crossing locations were identified, their drainage areas were delineated using ESRI's ArcHydro program. After computing flow directions based on a USGS 2 arc-second (30 meter) digital elevation map, a flow accumulation grid was obtained for the project area. The same program was then used to delineate the drainage area of each crossing location based on the flow direction and accumulation patterns. Drainage divides located according to this method can be somewhat unreliable in some of the flat, poorly drained areas without a denser, highly accurate digital elevation model. Therefore, the computer-generated delineations were subsequently checked and refined using USGS digital topographic quadrangle maps. A map illustrating the twenty-nine crossing locations (listed in Table G-1) and drainage area delineations can be seen in Figure G-1, attached at the end of this appendix. The delineations used for this preliminary analysis are the most accurate possible without more extensive survey. The presence of lake inlets and outlets or stream courses located by future field investigations may warrant modification of the boundaries used here.

Table G-1 Drainage Area Properties

Milepost	Total Area (sq mi)	Storage Areas	Storage Area (sq mi)	Storage % Total Area	Annual Precip. (in)	Q-100 (cfs)	Q-100 Flow Sized Structure	Maximum Culvert Flow (cfs)
MW-5.0	4.08	Freshwater Pond Lake	0.03 0.36	9.5%	20	91.1	48-in Culvert	98.7
MW-11.3	0.91	Freshwater Pond Lake	0.02 0.06	9.2%	20	25.8	36-in Culvert	45.0
ME-4.4	1.66	Freshwater Pond Lake	0.02 0.36	23.0%	20	35.1	36-in Culvert	45.0
C1-2.6	5.96	Freshwater Pond Lake	0.03 0.22	4.1%	20	148.7	72-in Culvert	272.5
W-0.6 (Little Susitna River)	295.5	Freshwater Pond Lake	1.53 8.90	3.5%	28	5891.8	Bridge	NA
W-10.0	32.14	Freshwater Pond Lake	0.52 4.23	14.8%	20	474.3	Drainage Structure	NA
W-14.4	0.75	Freshwater Pond Lake	0.00 0.00	0.0%	20	37.8	36-in Culvert	45.0
W-16.7	5.4	Freshwater Pond Lake	0.10 0.70	14.8%	20	104.9	72-in Culvert	272.5
W-20.9	0.86	Freshwater Pond Lake	0.00 0.00	0.2%	20	40.6	36-in Culvert	45.0
W-24.0 (Willow Creek)	255.57	Freshwater Pond Lake	0.92 2.03	1.2%	27	5946.0	Bridge	NA
MP-189.0 (Existing Bridge)	12.54	Freshwater Pond Lake	0.07 0.00	0.6%	24	448.4	Bridge	NA
MP-190.3 (Existing Bridge)	5.43	Freshwater Pond Lake	0.03 0.04	1.3%	25	212.3	Bridge	NA
H-0,8	25.06	Freshwater Pond Lake	0.32 1.64	7.8%	20	440.9	Drainage Structure	NA
H-4.3	2.14	Freshwater Pond Lake	0.03 0.42	21.0%	20	44.4	36-in Culvert	45.0
H-6.3	17.35	Freshwater Pond Lake	0.07 1.69	10.2%	20	305.3	Drainage Structure	NA
H-9.6	2.81	Freshwater Pond Lake	0.01 0.22	8.3%	20	68.4	48-in Culvert	98.7
HN-3.2 (Little Susitna River)	202.54	Freshwater Pond Lake	0.44 2.02	1.2%	32	5787.4	Bridge	NA
HN-5.7	21.44	Freshwater Pond Lake	0.31 1.44	8.2%	20	382.4	Drainage Structure	NA
HS-1.0	0.77	Freshwater Pond Lake	0.00 0.00	0.0%	20	38.6	36-in Culvert	45.0
MP-174.3 (Existing Bridge)	160.41	Freshwater Pond Lake	0.08 0.39	0.3%	35	5798.3	Bridge	NA
B-6.4	13.38	Freshwater Pond Lake	0.09 1.34	10.7%	20	242.6	72-in Culvert	272.5
B-9.0	118.04	Freshwater Pond Lake	1.27 11.15	10.5%	20	1535.5	Drainage Structure	NA

(Table G-1 Cont.)

Milepost	Total Area (sq mi)	Storage Areas	Storage Area (sq mi)	Storage % Total Area	Mean Annual Precip. (in)	Q-100 (cfs)	Q-100 Flow Sized Structure	Maximum Culvert Flow (cfs)
B-14.3	0.23	Freshwater Pond Lake	0.03 0.00	11.6%	20	7.7	24-in Culvert	14.5
B-14.8	1.09	Freshwater Pond Lake	0.07 0.00	6.1%	20	38.6	36-in Culvert	45.0
B-15.1	0.56	Freshwater Pond Lake	0.00 0.00	0.0%	20	29.5	36-in Culvert	45.0
B-15.2	15.86	Freshwater Pond Lake	0.11 0.60	4.5%	20	334.4	Drainage Structure	NA
B-15.9	46.01	Freshwater Pond Lake	0.38 2.57	6.4%	20	767.6	Drainage Structure	NA
B-16.6	2.12	Freshwater Pond Lake	0.00 0.21	10.1%	20	51.7	48-in Culvert*	98.7
B-17.4	1.75	Freshwater Pond Lake	0.00 0.21	12.3%	20	42.1	36-in Culvert*	45.0

NOTES:

From Mannings Equation the maximum flow (full pipe flow) for the corresponding sizes of corrigated metal pipes (Manning's N=.023) at 1% slope and a head to a depth of 1.5 X the culvert diameter (AREMA Manual for Railway Engineering 2006 Section 4.8.2) (calculated using FHWA's HY-8 culvert design software)
24-inch: 14.5 cfs
36-inch: 45 cfs
48-inch: 98.7 cfs
72-inch: 272.5 cfs

Pipe sizings were designed for the 100 year event (AREMA Manual for Railway Engineering 2006 Section 4.8.2) for each drainage area as calculated by the USGS regression equations published in USGS Water-Resources Investigation Report 03-4188

Total Drainage Areas were calculated using ArcHydro watershed delineation of USGS 2-arc second DEM's as well as USGS quad maps

Areas of lakes and ponds within each drainage area were taken from USFWS NWI quad maps

Drainage Structures will be determined during the final design process and multi-plate culverts; pre-cast arches; and single or multiple short span bridges

Anadromous streams, highlighted in blue, are currently sized for flow; however, sizing for fish passage will also need to be performed for final design.

* - Conveyance structures within 1500' of trail crossings were sized up to drainage structures in Table G-2

G.2 Design Flow Calculation

The design flow used to size hydraulic structures for mapped streams was calculated for the 100-year event, as recommended by the American Railway Engineering and Maintenance-of-Way Association (AREMA Manual for Railway Engineering 2006). For each drainage area, the 100-year flow was calculated by the USGS regression equations published in USGS Water-Resources Investigation Report 03-4188. The regression equations for the project area take into account total drainage area, the percent area of water storage within each drainage area, and the mean annual precipitation. The drainage areas were first computed from the GIS drainage delineations. The areas of lakes, ponds, and rivers within each drainage area were then computed by intersecting each GIS drainage area with digital USFWS NWI quadrangle maps. Finally, the mean annual precipitation for each drainage area was computed using digital annual precipitation data obtained from the USGS Water Resources Department. The input values and results of these calculations for the twenty-nine water crossings analyzed can be seen in Table G-1. Unmapped minor drainages, wetland equalization culverts, and additional culverts listed in subsequent tables have not yet been sized for flow. This will be completed during the final design process once an alignment has been selected.

G.3 Bridge Sizing

Of the crossing locations analyzed, three were designated as major bridge crossings. These included the Willow alignment over Willow Creek (Willow), the Houston North alignment over the Little Susitna River (Little Susitna-Miller), and the Willow alignment over the Little Susitna River (Little Susitna-Berma). Three additional bridges are shown in Table G-1 which will be sized to match existing bridges on the ARRC Mainline. For the new bridge locations, a HEC-RAS 3.1.3 hydraulic model was created in order to calculate the minimum opening, or maximum contraction, that would result in no more than a 1-foot rise in the headwater upstream of the bridge for the 100-year event.

For each of these models, channel and overbank cross-sections were surveyed at the approximate bridge location, as well as at 50-, 100-, and 500-feet upstream and downstream. A typical cross section layout is shown in Figure G-2. The seven cross-sections for each bridge location were then entered into each model according to the schematic diagram below in Figure G-3. The HEC-RAS river stationing increases from downstream to upstream.

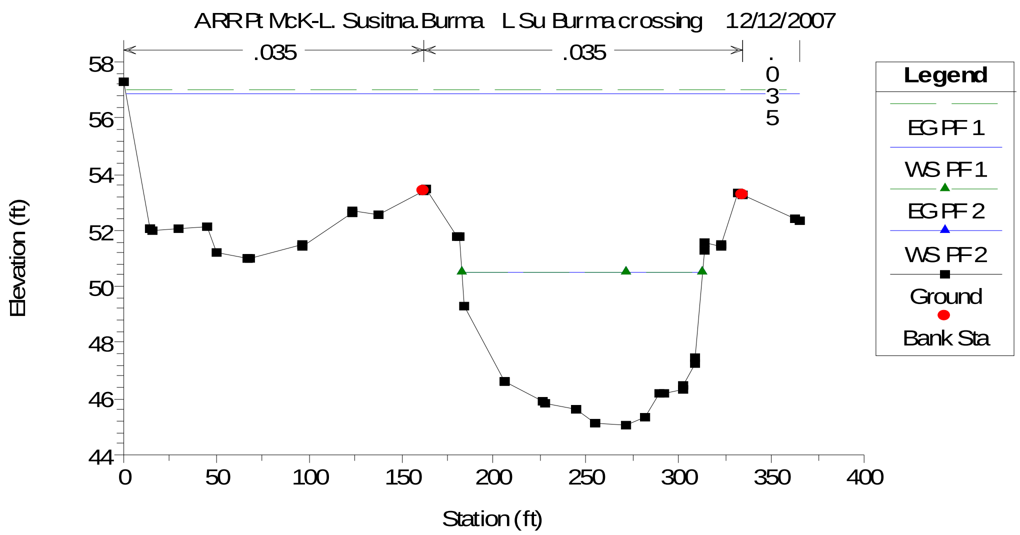

Figure G-2 HEC-RAS Typical Cross-Section

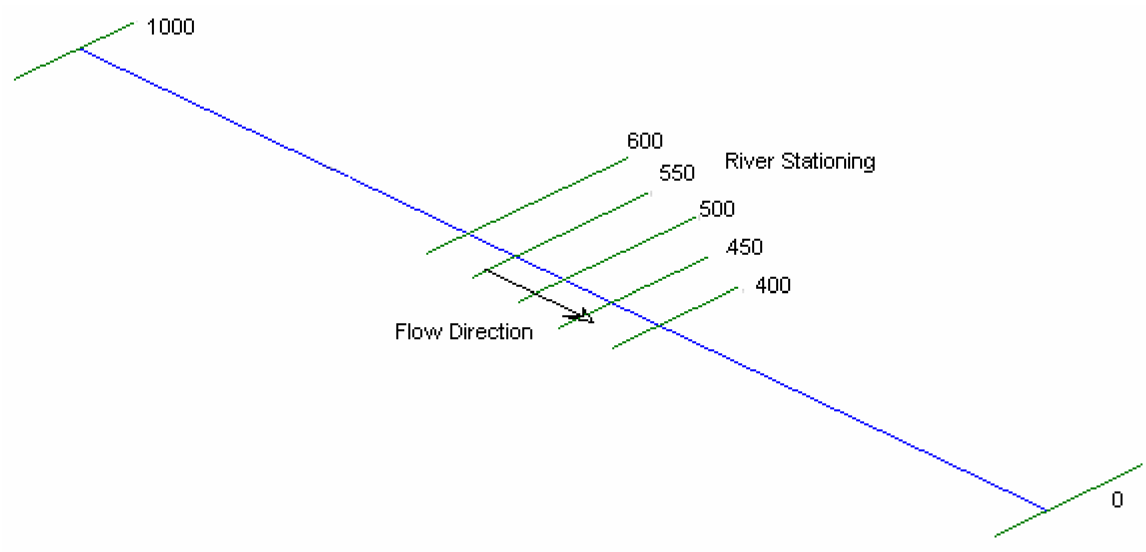

Figure G-3 HEC-RAS Model Schematic

The boundary conditions were specified as normal flow with the energy slopes upstream and downstream of S(Willow) = 0.0015; S(Little Susitna-Miller) = 0.001; and S(Little Susitna-Burma) = 0.00046. The slope values were determined from a linear fit to the channel bottom elevation data. A manning n = .035 was used for the main channel and overbanks for each bridge location. One flow rate (designated by HEC-RAS as a profile or PF on the graphs) was used for each model; the estimated 100-year peak flows of 5976-cfs, 5787-cfs, and 5892-cfs for Willow Little Susitna-Miller, and Little Susitna - Burma respectively. Each crossing site was modeled with two scenarios: without and with the imposed minimum flow opening. The HEC-RAS feature of "ineffective area" was used to provide an approximate estimation of the upstream backwater effect of the restricted opening. The criteria that no more than an approximate 1-foot rise at the upstream section (Station 550) over the no-bridge scenario was used for each bridge location. This was accomplished by using a method that applied sequentially narrower bridge openings until the aforementioned criteria was reached. A sample result for the cross-section used above is shown below in Figure G-4. Note that the HEC-RAS model treats the outer limit points as vertical flows limits for computation purposes. This is an acceptable for conservative minimum opening width results. This analysis was made for each of the three bridge sites. The results are summarized below:

Bridge	**100-Year Flow**	**Minimum Opening Width**
Willow Creek	5946-cfs	86-feet
L. Susitna-Miller	5787-cfs	59-feet
L. Susitna-Burma	5892-cfs	47-feet

It should be noted that the final design for the bridge opening width will likely be significantly wider than the minimum opening widths indicated above, since considerations for fill and piers within the waterway will be negotiated. Additional hydraulic analysis will need to be completed for final design once more information, such as abutment and pier locations, is known. Furthermore, the three bridges cross designated anadromous waterways; therefore, sizing for fish passage will also need to be performed for final design.

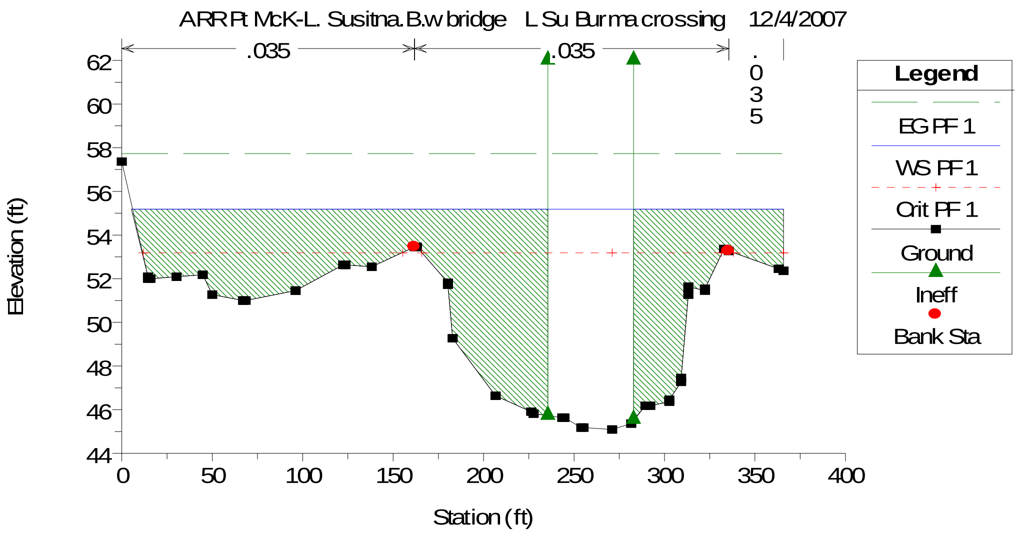

Figure G-4 HEC-RAS Typical Result

G.4 Culvert Sizing

Culverts were sized to convey the 100-year flow event with a head to a depth of 1.5 times the culvert diameter (AREMA Manual for Railway Engineering 2006 Section 4.8.2). The maximum flow (full pipe flow) was calculated using Manning's equation as computed by FHWA's HY-8 culvert design software for 24-, 36-, 48-, and 72-inch diameter, corrugated metal pipes (Manning's N = 0.023) at 1% slope, with an assumed length of 80 feet. The flow-based culvert sizings are shown in Table G-1. For the purposed of obtaining a cost estimate, several assumptions were made:

- Those drainage areas that had 100-year flow rates greater than the calculated maximum flow for a 72-inch culvert have been designated as "Drainage Structures." The selection and sizing of these structures will be determined during the final design process. Possible structures could include, but are not limited to, multi-plate circular and arch culverts; pre-cast arches; and single or multiple short span bridges.

- Anadromous streams are currently sized for flow; however, sizing for fish passage will be negotiated with jurisdictional agencies and included in the final design.
- Conveyance structures within 1,500' of trail crossings were sized up to "Drainage Structures" with the intention of routing the trail underneath the track.

The 100-year flows calculated for each of the analyzed drainage areas and the maximum flows for each of the four culvert diameters are shown in Table G-1.

G.5 Minor Drainages and Additional Quantities

As described in Section G.1, a flow accumulation grid was computed using ArcHydro GIS software to define the pattern of drainage from the digital elevation model. To further define the drainage lines, a stream network was created using the same software. While the additional drainage lines located using this method were not sized for flow (due to limitations in the digital elevation data and the current lack of survey data for the project), culverts will likely be installed at these approximate locations. Therefore, to improve the accuracy of the cost estimate, 80-foot long, 48-inch diameter culverts were specified at locations where the stream network crossed the alignment, but no 100-year flow rates are shown. Several of these drainages occurred in close proximity to existing trail crossings. In order to avoid construction of additional crossing structures, conveyance structures within 1500-feet of trail crossings were sized up to "Drainage Structures" as described previously. These culverts, along with flow sized culverts, bridges, other drainage structures, and extensions for existing culverts, are shown in the attached Table G-2, attached at the end of this appendix.

To account for unknown drainages along each alignment, an additional 36", 80' long culvert was added for every 1 mile of track in each segment. These quantities are listed in Table G-2, attached at the end of this appendix, as "Additional" Segments and show an unspecified stationing. Maintenance and preservation of hydraulic connectivity of wetlands is of special concern; therefore, an additional 24", 60' long equalization culvert was added for every 1000' of track through wetlands in each segment. These quantities are listed in Table G-2, attached at the end of this appendix, as "Equalization" Segments and also show an unspecified stationing.

G.6 Hydraulic Conceptual Design Summary

It is important to note that the hydraulic conceptual design described herein was intended to ascertain an approximate construction cost for whatever hydraulic conveyance structures are eventually designed for the selected alignment. The structure types and sizes specified above and quantified below are preliminary and may be refined as the project design progresses. A summary of the quantities of major bridges, minor bridges, and the lengths of each of the four sizes of culverts included in each segment and alignment alternative are shown in Tables G-3 and G-4, respectively.

Table G-3 Quantity Summary by Segment										
	Willow	**Conn1**	**Conn2**	**Conn3**	**Houston**	**Houston North**	**Houston South**	**Big Lake**	**Mac East**	**Mac West**
River Bridges	2	0	0	0	0	1	1	0	0	0
Minor Bridges	5	2	0	0	2	1	0	6	0	0
24-Inch Culvert (ft)	1140	420	240	120	1320	1380	240	1160	600	1200
36-Inch Culvert (ft)	2540	400	320	400	880	880	720	1760	1120	1120
48-Inch Culvert (ft)	750	400	320	80	480	310	270	400	320	960
72-Inch Culvert (ft)	80	0	0	0	80	30	0	60	0	0

Table G-4 Quantity Summary by Alignment Alternative								
	Mac West, Conn 1, Willow	**Mac West, Conn 1, Houston, Houston North**	**Mac West, Conn 1, Houston, Houston South**	**Mac West, Conn 2, Big Lake**	**Mac East, Conn 3, Willow**	**Mac East, Conn 3, Houston, Houston North**	**Mac East, Conn 3, Houston, Houston South**	**Mac East, Big Lake**
River Bridges	2	1	1	0	2	1	1	0
Minor Bridges	7	5	4	6	5	3	2	6
24-Inch Culvert (ft)	2760	4320	3180	2600	1860	3420	2280	1760
36-Inch Culvert (ft)	4060	3280	3120	3200	4060	3280	3120	2880
48-Inch Culvert (ft)	2110	2150	2110	1680	1150	1190	1150	720
72-Inch Culvert (ft)	80	110	80	60	80	110	80	60

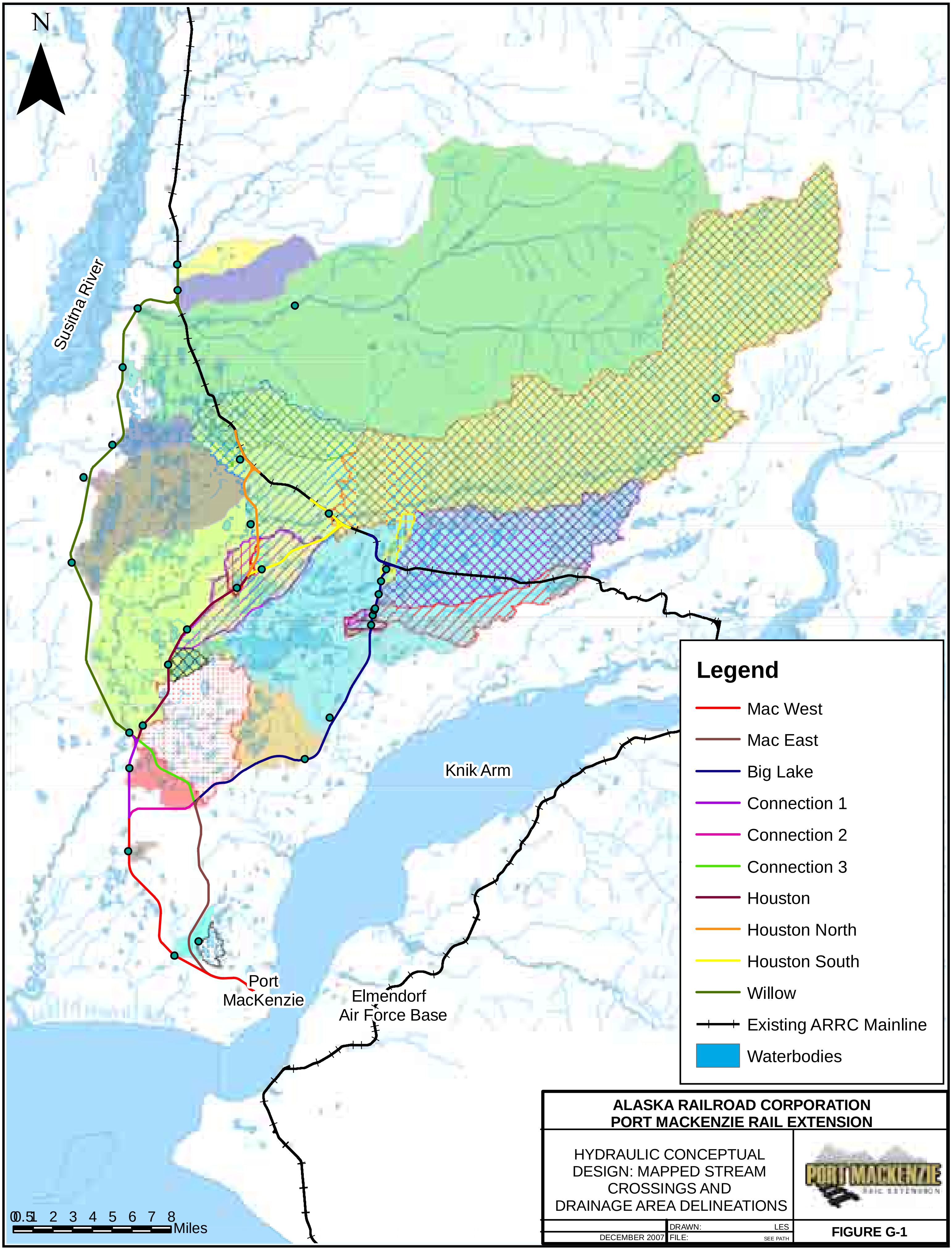
N
Susitna River
Knik Arm
Port MacKenzie
Elmendorf Air Force Base
0 0.5 1 2 3 4 5 6 7 8 Miles
Legend
Mac West
Mac East
Big Lake
Connection 1
Connection 2
Connection 3
Houston
Houston North
Houston South
Willow
Existing ARRC Mainline
Waterbodies
ALASKA RAILROAD CORPORATION
PORT MACKENZIE RAIL EXTENSION
HYDRAULIC CONCEPTUAL DESIGN: MAPPED STREAM CROSSINGS AND DRAINAGE AREA DELINEATIONS
DRAWN: LES
DECEMBER 2007
FILE: SEE PATH
FIGURE G-1

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Table G-2 Drainage Crossing List

Alignment Segment	Station	Mile-post	Water Body Type	Conveyance Type	Culvert Diameter (inches)	Quantity	Culvert Length (feet)	Extention Length (feet)	Fisheries	Navigation	Size-Controlling Factor
Mac East	45+73.32	T-0.9	UMD	Culvert	48	1	80	-		None	
Mac East	65+37.63	T-1.2	Wetland	Culvert	48	1	80	-		None	
Mac East	130+46.23	ME-2.5	UMD	Culvert	48	1	80	-		None	
Mac East	changed	ME-4.5	Stream	Culvert	36	1	80	-	Possible	Possible	Flow
Mac East	389+68.43	ME-7.4	UMD	Culvert	48	1	80	-		None	
Mac East Additional	Unspecified	NA	UMD	Culvert	36	13	80	-	NA	NA	
Mac East Equilization	Unspecified	NA	Wetland	Culvert	24	10	60	-	NA	NA	
Mac West	195+84.69	MW-3.7	UMD	Culvert	48	1	80	-		None	
Mac West	265+06.52	MW-5.0	Stream	Culvert	48	1	80	-	Possible	Possible	Flow
Mac West	276+19.99	MW-5.2	UMD	Culvert	48	1	80	-		None	
Mac West	330+98.80	MW-6.3	UMD	Culvert	48	1	80	-		None	
Mac West	358+53.21	MW-6.8	UMD	Culvert	48	1	80	-		None	
Mac West	382+42.08	MW-7.2	UMD	Culvert	48	1	80	-		None	
Mac West	511+40.33	MW-9.7	UMD	Culvert	48	1	80	-		None	
Mac West	439+14.28	MW-8.3	UMD	Culvert	48	1	80	-		None	
Mac West	461+74.48	MW-8.8	UMD	Culvert	48	1	80	-		None	
Mac West	491+06.15	MW-9.3	UMD	Culvert	48	1	80	-		None	
Mac West	534+03.07	MW-10.1	UMD	Culvert	48	1	80	-		None	
Mac West	597+09.07	MW-11.3	Stream	Culvert	36	1	80	-	Possible	Possible	Flow
Mac West	634+88.01	MW-12.0	UMD	Culvert	48	1	80	-		None	
Mac West Additional	Unspecified	NA	UMD	Culvert	36	13	80	-	NA	NA	
Mac West Equilization	Unspecified	NA	Wetland	Culvert	24	20	60	-	NA	NA	
Conn 1	11+20.07	C1-0.2	Wetland	Culvert	48	1	80	-		None	
Conn 1	35+29.20	C1-0.7	Wetland	Culvert	48	1	80	-		None	
Conn 1	47+47.04	C1-0.9	Wetland	Culvert	48	1	80	-		None	
Conn 1	58+29.20	C1-1.1	Wetland	Culvert	48	1	80	-		None	
Conn 1	118+68.21	C1-2.3	UMD	Drainage Structure	NA	1	80	-		None	Trail
Conn 1	137+13.20	C1-2.6	Stream	Culvert	NA	1	80	-	Anadromous	Possible	Flow
Conn 1	157+84.70	C1-3.0	Wetland	Culvert	48	1	80	-		None	
Conn 2	10+21.66	C2-0.2	Wetland	Culvert	48	1	80	-		None	
Conn 2	90+19.38	C2-1.7	UMD	Culvert	48	1	80	-		None	
Conn 2	98+20.86	C2-1.9	UMD	Culvert	48	1	80	-		None	
Conn 2	118+98.84	C2-2.3	UMD	Culvert	48	1	80	-		None	
Conn 3		C3-1.5	UMD	Culvert	36	1	80	-		None	
Conn 3		C3-2.2	Wetland	Culvert	24	1	80	-		None	
Conn 3	157+36.22	C3-3.0	Wetland	Culvert	48	1	80	-		None	
Conn 3		C3-3.6	UMD	Culvert	36	1	80	-		None	
Conn1 Additional	Unspecified	NA	UMD	Culvert	36	5	80	-	NA	NA	
Conn1 Equalization	Unspecified	NA	Wetland	Culvert	24	7	60	-	NA	NA	
Conn2 Additional	Unspecified	NA	UMD	Culvert	36	4	80	-	NA	NA	
Conn2 Equalization	Unspecified	NA	Wetland	Culvert	24	4	60	-	NA	NA	
Conn3 Additional	Unspecified	NA	UMD	Culvert	36	3	80	-	NA	NA	
Conn3 Equalization	Unspecified	NA	Wetland	Culvert	24	1	60	-	NA	NA	
Willow	28+99.68	W-0.6	Willow	Bridge	NA	1	-	-	Anadromous	Navigable	Flow
Willow	128+90.21	W-2.4	UMD	Culvert	48	1	80	-		None	
Willow	128+90.21	W-8.6	UMD	Culvert	36	1	80	-		None	
Willow	529+01.04	W-10.0	Stream	Drainage Structure	NA	1	-	-	Anadromous	Possible	Flow
Willow	727+48.56	W-13.8	UMD	Culvert	48	1	80	-		None	
Willow	761+24.87	W-14.4	Stream	Culvert	36	1	80	-	Possible	Possible	Flow
Willow	836+23.01	W-15.8	UMD	Culvert	48	1	80	-		None	
Willow	867+76.52	W-16.4	UMD	Culvert	48	1	80	-		None	
Willow	883+09.84	W-16.7	Stream	Culvert	72	1	80	-	Possible	Possible	Flow
Willow	1032+99.57	W-19.6	Wetland	Drainage Structure	NA	1	80	-		None	Trail
Willow	1100+73.35	W-20.9	Stream	Culvert	36	1	80	-	Possible	Possible	Flow
Willow	1131+74.79	W-21.4	UMD	Culvert	48	1	80	-		None	
Willow	1198+07.28	W-22.7	UMD	Culvert	48	1	80	-		None	
Willow	1219+09.17	W-23.1	Wetland	Drainage Structure	NA	1	80	-		None	Trail
Willow	1269+20.88	W-24.0	Little	Bridge	NA	1	-	-	Anadromous	Navigable	Flow
Willow	1310+43.59	W-24.8	UMD	Culvert	48	1	80	-		None	
Willow	1343+94.53	W-25.5	UMD	Culvert	48	1	80	-		None	
Willow	1353+27.20	W-25.6	UMD	Culvert	48	1	80	-		None	
Willow Additional	Unspecified	NA	UMD	Culvert	36	28	80	-	NA	NA	
Willow Equalization	Unspecified	NA	Wetland	Culvert	24	19	60	-	NA	NA	
Houston	39+60.05	H-0.8	Stream	Drainage Structure	NA	1	-	-	Anadromous	Possible	Flow
Houston	98+04.98	H-1.2	Wetland	Culvert	24	1	80	-		None	
Houston	98+04.98	H-1.9	Wetland	Culvert	48	1	80	-		None	
Houston	145+12.99	H-2.8	UMD	Culvert	48	1	80	-		None	
Houston	226+06.18	H-4.3	Stream	Culvert	72	1	80	-	Anadromous	Possible	Flow
Houston	98+04.98	H-5.8	Wetland	Culvert	36	1	80	-		None	
Houston	333+88.41	H-6.3	Stream	Drainage Structure	NA	1	-	-	Anadromous	Possible	Flow
Houston	374+92.74	H-7.1	UMD	Culvert	48	1	80	-		None	
Houston	438+54.94	H-8.3	UMD	Culvert	48	1	80	-		None	
Houston	497+45.95	H-9.4	UMD	Culvert	48	1	80	-		None	
Houston	505+48.22	H-9.6	Stream	Culvert	48	1	80	-	Possible	Possible	Flow
Houston Additional	Unspecified	NA	UMD	Culvert	36	11	80	-	NA	NA	
Houston Equalization	Unspecified	NA	Wetland	Culvert	24	20	60	-	NA	NA	
Houston North	63+81.81	HN-1.2	UMD	Culvert	48	1	80	-		None	
Houston North	142+75.61	HN-2.7	Wetland	Culvert	48	1	80	-		None	
Houston North	170+19.53	HN-3.2	River	Bridge	NA	1	-	-	Anadromous	Possible	Flow
Houston North	299+32.72	HN-5.7	Stream	Drainage Structure	NA	1	-	-	Anadromous	None	Flow
Houston North Additional	Unspecified	NA	UMD	Culvert	36	8	80	-	NA	NA	
Houston North Equalization	Unspecified	NA	Wetland	Culvert	24	23	60	-	NA	NA	
Houston South	40+24.41	HS-0.8	UMD	Culvert	48	1	80	-		None	
Houston South	50+54.34	HS-1.0	Stream	Culvert	36	1	80	-	Possible	Possible	Flow
Houston South	72+67.94	HS-1.4	UMD	Culvert	48	1	80	-		None	
Houston South	98+43.90	HS-1.9	UMD	Culvert	48	1	80	-		None	
Houston South Additional	Unspecified	NA	UMD	Culvert	36	8	80	-	NA	NA	
Houston South Equalization	Unspecified	NA	Wetland	Culvert	24	4	60	-	NA	NA	
Big Lake	218+17.48	B-4.1	UMD	Culvert	48	1	80	-		None	
Big Lake	671+88.45	B-5.9	Wetland	Culvert	24	1	80	-		None	
Big Lake	337+24.99	B-6.4	Stream	Drainage Structure	NA	1	80	-	Anadromous	Possible	Fish
Big Lake	671+88.45	B-7.2	UMD	Culvert	36	1	80	-		None	
Big Lake	671+88.45	B-8.4	Wetland	Culvert	24	1	80	-		None	
Big Lake	473+59.63	B-9.0	Stream	Drainage Structure	NA	1	-	-	Anadromous	Possible	Flow
Big Lake	671+88.45	B-9.9	Wetland	Culvert	24	1	80	-		None	
Big Lake	671+88.45	B-11.9	Wetland	Culvert	24	1	80	-		None	
Big Lake	671+88.45	B-12.7	Wetland	Culvert	48	1	80	-		None	
Big Lake	710+49.73	B-13.5	Wetland	Culvert	48	1	80	-		None	
Big Lake	753+65.36	B-14.3	Stream	Culvert	24	1	80	-	Possible	Possible	Flow
Big Lake	763+90.56	B-14.5	UMD	Culvert	48	1	80	-		None	
Big Lake	779+75.27	B-14.8	Stream	Culvert	36	1	80	-	Possible	Possible	Flow
Big Lake	795+15.78	B-15.1	Stream	Culvert	36	1	80	-	Possible	Possible	Flow
Big Lake	801+39.38	B-15.2	Stream	Drainage Structure	NA	1	-	-	Anadromous	Possible	Flow
Big Lake	834+37.26	B-15.8	UMD	Culvert	48	1	80	-		None	
Big Lake	839+73.28	B-15.9	Stream	Drainage Structure	NA	1	-	-	Anadromous	Possible	Flow
Big Lake	874+84.99	B-16.6	Stream	Drainage Structure	NA	1	80	-	Anadromous	Possible	Trail
Big Lake	919+57.06	B-17.4	Stream	Drainage Structure	NA	1	80	-	Anadromous	Possible	Trail

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Alignment Segment	Station	Mile-post	Water Body Type	Conveyance Type	Culvert Diameter (inches)	Quantity	Culvert Length (feet)	Extention Length (feet)	Fisheries	Navigation	Size-Controlling Factor
Big Lake Equalization	Unspecified	NA	Wetland	Culvert	24	14	60	-	NA	NA	
Big Lake Additional	Unspecified	NA	UMD	Culvert	36	19	80	-	NA	NA	
Big Lake Existing Mainline	MP170.55	MP-170.0	UMD	Culvert	60	1	70	30		None	Match Existing
Big Lake Existing Mainline	MP169.96	MP-170.5	UMD	Culvert	60	1	96	30	NA	NA	Match Existing
Houston South Existing Mainline	MP173.25	MP-173.3	UMD	Culvert	48	1	82	30		None	Match Existing
Houston South Existing Mainline	MP174.3	MP-174.3	River	Bridge	NA	1	-	-	Anadromous	Navigable	Match Existing
Houston North Existing Mainline	MP178.5	MP-178.5		Culvert	48	1	42	30		None	Match Existing
Houston North Existing Mainline	MP178.85	MP-178.9		Culvert	36	1	54	30	NA	NA	Match Existing
Houston North Existing Mainline	MP178.97	MP-179.0		Culvert	36	1	53	30	NA	NA	Match Existing
Houston North Existing Mainline	MP179.1	MP-179.1		Culvert	48	1	42	30	NA	NA	Match Existing
Houston North Existing Mainline	MP179.4	MP-179.4	UMD	Culvert	60	1	60	30		None	Match Existing
Houston North Existing Mainline	MP179.5	MP-179.5	UMD	Culvert	48	1	50	30		None	Match Existing
Houston North Existing Mainline	MP179.6	MP-179.6		Culvert	36	1	22	30	NA	NA	Match Existing
Houston North Existing Mainline	MP179.67	MP-179.7		Culvert	36	1	22	30	NA	NA	Match Existing
Houston North Existing Mainline	MP179.8	MP-179.8		Culvert	48	1	47	30	NA	NA	Match Existing
Houston North Existing Mainline	MP179.94	MP-179.9		Culvert	48	1	43	30	NA	NA	Match Existing
Houston North Existing Mainline	MP180.34	MP-180.3	UMD	Culvert	36	1	48	30		None	Match Existing
Houston North Existing Mainline	MP180.43	MP-180.4		Culvert	36	1	53	30	NA	NA	Match Existing
Houston North Existing Mainline	MP180.52	MP-180.5		Culvert	36	1	43	30	NA	NA	Match Existing
Houston North Existing Mainline	MP180.6	MP-180.6	UMD	Culvert	36	1	14	30		None	Match Existing
Willow Existing Mainline	MP188.16	MP-188.2	Wetland	Culvert	48	1	53	30		None	Match Existing
Willow Existing Mainline	MP189.0	MP-189.0	Stream	Bridge	NA	1	-	-	Anadromous	Boat	Match Existing
Willow Existing Mainline	MP189.32	MP-189.3	Wetland	Culvert	36	1	36	30	NA	NA	Match Existing
Willow Existing Mainline	MP189.58	MP-189.6	Wetland	Culvert	36	1	40	30	NA	NA	Match Existing
Willow Existing Mainline	MP190.3	MP-190.3	Stream	Bridge	NA	1	-	-	Anadromous	None	Match Existing

NOTES:

Stream - Designates drainage channels mapped by Matanuska-Susitna Borough's GIS Division compiled based on tax parcel maps and orthoimagery

UMD - Designates an "Un-Mapped Drainage" identified by analysis of digital elevation data

Drainage Structures will be determined during the final design process and multi-plate culverts; pre-cast arches; and single or multiple short

Anadromous streams are currently sized for flow; however, sizing for fish passage will also need to be performed for final

Conveyance structures within 1500' of trail crossings were sized up to drainage structures

An additional 36", 80' long culvert was added for every 1 mile of track in each segment

An additional 24", 60' long equalization culverts were added for every 1000' of track through wetland in each segment

Structures highlighted in yellow are not shown on plan and profile sheets

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