Hydrology and Hydraulics Summary

Prepared for:

State of Alaska
Department of Transportation and
Public Facilities

Prepared by:
HDR Alaska, Inc.
2525 C Street, Suite 305
Anchorage, Alaska 99503

March 2006

TABLE OF CONTENTS

1.0 Introduction 1
2.0 Study Purpose 1
3.0 Field Methods 2
4.0 Field Survey Methods 2
5.0 Report Figures 2
6.0 Hydrology 3
6.1 Design Flood Flows 3
6.2 Drainage Basin 4
7.0 Hydraulics 11
7.1 Drainages with Delineated Basins 11
7.2 Drainages with Undelineated Basins 12
8.0 Fish Passage Considerations 13
8.1 Drainage Site D13 (Cooper Creek Alternative) 14
8.2 Drainage Site D25 (Cooper Creek Alternative) 15
8.3 Drainage Site D50 (G South Alternative) and D78 (Juneau Creek Alternative), Tributary to Bean Creek 16
8.4 Drainage Site D56 (G South Alternative) 17
8.5 Drainage Sites D52 and D53 (G South Alternative), Main Stem of Bean Creek 18
8.6 Drainage Site D58 (Cooper Creek - G South alternatives) 19
8.7 Drainage Site D66 (Cooper Creek - G South alternatives) 20
8.8 Drainage Site D67 (Cooper Creek - G South Alternatives) 21
8.9 Drainage Site D94 (Juneau Creek Alternative) 22
8.10 Drainage Site D95 (Juneau Creek Alternative) 23
8.11 Drainage Site D104 (All Alternatives); Fuller Creek 24
9.0 References 26

List of Tables

Table 1: Drainage Properties 5
Table 2: Culvert Flood Flow Capacities 12

List of Figures

Figure 1: Index Map 1
Figure 2: Drainage Basins 2
Figure 3: Detailed Map of Project Area 2
Figure 4: Detailed Map of Project Area 2
Figure 5: Detailed Map of Project Area 2
Figure 6: Detailed Map of Project Area 2
Figure 7: Detailed Map of Project Area 2
Figure 8: Detailed Map of Project Area 2
Figure 9: Detailed Map of Project Area 2
Figure 10: Detailed Map of Project Area 2
Figure 11: Detailed Map of Project Area 2
Figure 12: Drainage site D13, downstream side of Snug Harbor Road crossing. 12
Figure 13: Drainage site D13, upstream side of Snug Harbor Road crossing. 12
Figure 14: Drainage site D25, downstream side of existing road crossing. 15
Figure 15: Drainage site D25, upstream side of existing road crossing. 15
Figure 16: Drainage site D50. 14
Figure 17: Drainage site D78. 16
Figure 18: Drainage site D56. 17
Figure 19: Drainage sites D52 and D53. 18
Figure 20: Drainage site D58 upstream side of existing road crossing. 19
Figure 21: Drainage site D58 downstream side of existing road crossing. 19
Figure 22: Drainage site D66, downstream side of existing road crossing. 20
Figure 23: Drainage site D66, upstream side of existing road crossing. 20
Figure 24: Drainage site D67, downstream side of existing road crossing. 21
Figure 25: Drainage site D67, upstream side of existing road crossing. 21
Figure 26: Drainage site D94. 22
Figure 27: Drainage site D95. 23
Figure 28: Drainage site D104, upstream reach showing gravel deposition. 24
Figure 29: Drainage site D104, downstream side of existing road crossing. 25
Figure 30: Drainage site D104, upstream side of existing road crossing. 25

1.0 INTRODUCTION

The Alaska Department of Transportation and Public Facilities (DOT&PF) is evaluating alternatives to improve the Sterling Highway in the Cooper Landing area. The proposed project is located approximately between Mileposts (MP) 45 and 60 on the Sterling Highway along the Kenai River. DOT&PF contracted HDR Alaska, Inc. (HDR) to provide engineering and environmental support for preparation of a Supplemental Environmental Impact Statement (SEIS).

Kenai River Valley

The three build alternatives under consideration in the SEIS include the Cooper Creek, G South, and Juneau Creek Alternatives, shown on Figure 1. The three build alternatives share the same alignment at both the eastern and western ends of the project. For the purposes of this Hydrology and Hydraulics Summary, these shared areas are referred to as the "all alternatives" area. The Cooper Creek and G South alternatives share a corridor for part of their length along with the Juneau Creek and G South alternatives. Drainages along these shared alignments are grouped together under these titles in Table 1.

2.0 STUDY PURPOSE

This report summarizes the findings of the investigation carried out on all of the identified small streams and drainages intersecting the three build alternative alignments being considered in the SEIS. Investigation of the three larger streams: Kenai River, Cooper Creek, and Juneau Creek were not included in this scope of work. This is a guidance document and the conveyance sizing recommendations should not be construed as final design numbers. Further investigation and analysis of flood flows, conveyance design, and fish passage considerations will be carried out during the design phase. The primary objectives of the study were:

Take field measurements at locations where drainage conveyances will be needed across the alignments.

Provide preliminary guidance on conveyance structures sizing based on projected flood flows, fish passage requirements, and DOT&PF design criteria.

The fieldwork was conducted on May 4, 5, 6, 11, and 12, 2005. Supplemental field work was completed on October 14, 2005 based on new aerial photography and questions generated as a result of preliminary data analysis. The work was completed by HDR staff.

3.0 FIELD METHODS

Alignment areas inaccessible by vehicle were traversed on foot. All observed drainages with flowing water and seeps were surveyed. A total of 47 drainages and 13 seeps were surveyed.

Seeps were defined as areas where there was wet ground with an obvious drainage direction but no continuous overland flow channel. Often the water could be seen running through holes in the vegetation cover and between roots and/or forming boggy areas. Areas where this ground water discharge required a drainage conveyance were logged as seeps.

Areas where the proposed alignments are adjacent to the existing highway were surveyed by car. 47 existing culverts where located and surveyed. 22 culverts are associated with definable drainage basins. Many of these contained active streams but some were dry at the time of the survey. Kenai River, Cooper Creek, and Juneau Creek will require substantial bridge structures and were not surveyed.

4.0 FIELD SURVEY METHODS

At each drainage site the following information was collected:

- Coordinates and elevation from handheld GPS receiver
- Width and depth of flow at the time of survey
- Width and depth at the ordinary high water mark (OHW)
- Channel slope
- Direction of flow
- Stream bottom material
- Photos
- Description and other notes on the drainage

5.0 REPORT FIGURES

All identified drainages, seeps and existing culverts are shown on Figures 1 through 11. Figure 1 shows the alignment alternatives and an index map for Figures 3 through 11. Figure 2 shows the full extent of all delineated drainage basins along the alignments. Basins are identified by drainage number. Figures 3 through 11 show the alternative alignments in detail with the individual drainage crossing sites. The following information is depicted on these figures:

- Alternative alignment centerlines and limits of cut and fill.
- All drainages, seeps and existing culverts as field surveyed. Locations shown are from field-collected GPS waypoints and may not correspond exactly to the centerline of the alignments. The ID numbering is random, starting on the east end of the project area and

following the most southern alternative until it intersects with the next northern alternative.

- Drainage basin boundaries are shown where applicable. The full extent of some basins can only be seen on Figure 2. Basins for the different alternatives overlap where one alternative is downslope from another. In these cases the identifier for the downslope alternative is shown on the additional downslope area and the identifier for the upslope alternative is shown on the more upslope basin area.
- Approximate location of stream and drainage channels. Drainage channel mapping is an approximation taken from USGS mapping, field locates, 5-foot contour mapping, and aerial photo interpretation. The full extent of each drainage was not field checked.
- Fish symbols are used to indicate fish bearing streams. Fish streams were identified from previous fisheries work done as part of this project and from information contained in the Alaska Department of Fish and Game (ADF&G) and Alaska Department of Natural Resources *Atlas and Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes.* The fisheries investigation conducted by HDR personnel is summarized in the November 2004 report titled "Fisheries Evaluation, Sterling Highway Milepost 45 to 60" and in the January 2006 "2005 Addendum to the 2004 Fisheries Evaluation." Two additional fish streams were identified by the H&H crews during the supplemental October field work.
- Landmarks such as roads.

6.0 HYDROLOGY

6.1 *Design Flood Flows*

Flood flows from definable drainage basins are based on regression equations and methodology contained in "Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins of Canada" (U.S. Geological Survey [USGS] Water Resources Investigations Report 03-4188). To calculate flood flows (Q) for the 2, 50, 100, and 500-year return intervals, 45 inches of annual precipitation (from USGS Jones and Fahl mapping) was incorporated into the Area 4 regression equations. Basin storage surface area values, represented by ponds and lakes, were ignored if less than 0.5%.

All but six of the drainage basins are below the size limit for application of the regression equations method. Therefore, the minimum size (1.07 square miles) restriction for application of the regression equations was ignored. Regression analysis was used in the absence of viable alternative methods.

The flood flows determined by regression analysis were compared with flows calculated using the rational method (using a runoff coefficient for undeveloped land [0.2]), on a few select drainages. This limited comparison indicates the regression numbers are the more conservative values. No specific runoff coefficients are available for the mixed forested uplands that dominate many of these drainages, and the regression method was chosen as the more conservative approach in spite of the small size of the drainages. An alternate method of flood flows calculation may be chosen during final design.

6.2 *Drainage Basin*

Drainage basin boundaries were defined using 5-foot contour base mapping generated for the project, supplemented with USGS quadrangle maps and aerial photo overlays. Some basins were considered too small or the topography too vague for delineation. These drainages are designated as "undelineated" in Table 1 and the discussion.

Table 1 lists drainage sites noted through field reconnaissance and through aerial photo interpretation, including basin characteristics, flood flows, and proposed minimum culvert sizes. Fisheries streams are also indicated. Length of the conveyance was measured off the projected cut and fill limits as shown on the Figures 3 through 11.

Table 1: Drainage Properties for Each Build Alternative

ID	Fish Stream	OHW Width (ft)	OHW Depth (ft)	Slope (%)	Basin Area (sq miles)	Q_2 (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Q_{500} (cfs)	Existing Culvert Size (in)	Proposed Culvert length (ft)	Proposed Culvert Size (in)	Q_{100} Flood evaluation for culverts with equivalent size greater than 48"	Field Notes
Cooper Creek Alternative														
D1-D9 (see All alternatives)														
D10		5.0	2.0	10%	0.77	19	79	95	137	60	140	48	Proposed culvert will pass Q_{100} flow at HW/D = 1.5	High water mark at culvert's perched outlet at 2 ft. Culvert appears oversized perhaps for icing considerations.
D11		3.0	1.0	3%	0.23	6	28	34	51	36	125	36		Small stream; waterfall on north (upstream) side of road. Channel dimensions are of south (downstream) side.
D12		3.0	1.0	1%	0.78	19	80	96	139	24	125	48	Proposed culvert will pass Q_{100} flow at HW/D = 1.5 and has 5 + times the capacity of the existing culvert.	Small creek just east of Wildman's Store. Seems undersized; slope could be steeper.
D13	yes	3.0	1.0	1%	0.60	15	64	77	112	30	180	60 w/fill	Equivalent capacity without fill is less than the 48 inches requiring Q_{100} analysis.	Follows ditch along south side of Sterling Highway. Existing culvert is under the Snug Harbor Road.
D14		0.2	0.05	9%	0.10	3	14	17	26		185	36		Very small groundwater-fed ditch drainage.
D15		3.0	1.5	15%	0.41	11	46	56	82			0		Small permanent stream on alluvial fan with cobble bottom. Combined with D16.
D16		1.0	1.0	20%	0.41	11	46	56	82		170	36		Small stream; same alluvial fan as D15.
D17		2.0	1.0	20%	0.41	11	46	56	82			0		Small stream; same alluvial fan as D15 and D16. Combined with D16.
D18		1.0	0.3	9%	0.01	0	1	2	3		170	36		Small stream fed by spring 100 ft above alignment. Muck bottom.
D19		8.0	1.5	12%	0.60	15	64	77	112		175	42		Mid-sized stream with D50 of 8 inches.
D20		1.5	0.8	10%	0.06	2	9	11	17		175	36		Small stream with organic bottom. (no ribbon hung)
D21		3.0	1.0	17%	0.08	2	12	14	22		155	36		Mid-sized stream in ravine (100 ft wide by 20 ft deep). D50 is 2 inches.
D22		1.5	1.5	10%	0.11	3	15	18	27		160	36		Steep, narrow channel with gravel bottom (D50=1 in).
D23		3.0	1.0	25%	0.69	17	72	87	126		220	42		Small, steep drainage in V-gully (100 ft wide and 20 ft deep)
D24		NA	NA	0%	undelineated						160	36		Local drainage.
D25	yes	4.0	1.0	1%	0.18	5	22	27	40		125	48 w/fill	Equivalent capacity without fill is less than the 48 inches requiring Q_{100} analysis.	Small low gradient stream that parallels south side of road for approximately 400 ft. Perhaps fish.

ID	Fish Stream	OHW Width (ft)	OHW Depth (ft)	Slope (%)	Basin Area (sq miles)	Q_2 (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Q_{500} (cfs)	Existing Culvert Size (in)	Proposed Culvert length (ft)	Proposed Culvert Size (in)	Q_{100} Flood evaluation for culverts with equivalent size greater than 48"	Field Notes
Cooper Creek Alternative (continued)														
D57-D77 (see Cooper Creek and G South alternatives)														
D96-D106 (see All alternatives)														
G South Alternative														
D1-D9 (see All alternatives)														
D26-D49 (see Juneau Creek and G South alternatives)														
D50	yes	2.5	1.0	5%	0.52	13	56	68	99		430	54 w/fill	Equivalent capacity without fill is less than the 48 inches requiring Q_{100} analysis.	Same stream as D78 with cobble bottom. Culvert at road crossing downstream is 36" in diameter.
D51		1.0	0.2	1%	0.53	13	58	69	101		170	42		Small drainage; likely intermittent. Actual slope is < 1%.
D52	yes	4.0	2.0	1%	0.69	17	72	87	125			0		Low bank in marshy area. Possibly a fish stream. Parallels alignment.
D53	yes	4.0	2.0	1%	0.69	17	72	87	125		150	60 w/fill	Equivalent capacity without fill is less than the 48 inches requiring Q_{100} analysis.	Stream parallels the alignment between D52 and D53.
D54		2.0	1.5	8%	0.37	10	42	51	75		205	36		Dry stream bed with gravel bottom in large alluvial fan.
D55		2.0	0.1	1%	undelineated						240	36		Small spring fed stream; as much spring fed marsh as stream. Actual slope < 1%.
D56	yes	2.0	0.6	1%	0.19	5	24	29	43		225	36		Small stream through marsh with sandy bottom. Possibly fish habitat. Actual slope < 1%.
D57-D77 (see Cooper Creek and G South alternatives)														
D96-D106 (see All alternatives)														
Juneau Creek Alternative														
D1-D9 (see All alternatives)														
D26-D49 (see Juneau Creek and G South alternatives)														
D78	yes	5.0	1.2	18%	0.52	13	56	68	99		540	54 w/fill	Equivalent capacity without fill is less than the 48 inches requiring Q_{100} analysis.	Branch of Bean Creek. Cobble bottom (D50=6 in).
D79		1.0	1.5	1%	0.12	3	16	20	30		230	36		Small stream that drains wetland.
D80		2.0	1.5	2%	0.30	8	35	43	63		230	36		Small, E channel; velocity 1.5 ft/s.
D81		1.5	3.0	1%	0.48	12	53	63	92		175	36		Bean Creek; small, E channel, velocity approximately 1 ft/s. Actual slope < 0.01.

ID	Fish Stream	OHW Width (ft)	OHW Depth (ft)	Slope (%)	Basin Area (sq miles)	Q_2 (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Q_{500} (cfs)	Existing Culvert Size (in)	Proposed Culvert length (ft)	Proposed Culvert Size (in)	Q_{100} Flood evaluation for culverts with equivalent size greater than 48"	Field Notes
Juneau Creek Alternative (continued)														
D82		6.0	2.0	1%	1.50	36	140	167	238		150	54	No private land or structures upstream. Flood hazard minimal. Food waters will backwater to height of fill.	Small to moderately sized stream with gravel bottom (D50=1 in).
D83		12.0	1.5	2%	3.26	75	273	322	451		170	72	Drainage Basin not clearly defined. Will require further study. No private land or structures upstream. Flood hazard minimal. Food waters will backwater to height of fill.	Moderate sized stream with gravel bottom (D50=2 in). Velocity is approximately 5 ft/s.
D84		5.0	0.5	1%	0.42	11	47	57	83		130	36		Small to moderately sized undisturbed stream with sand bottom. Approximately 1 ft/s flow.
D85		3.0	0.5	2%	0.04	1	6	7	11		250	36	Drainage Basin not clearly defined. Will require further study.	Same stream as D86. Road alignment parallels stream; could move centerline uphill 100 ft?
D86		3.0	0.5	7%	0.04	1	6	7	11			0	Drainage Basin not clearly defined. Will require further study.	Small stream in broad ravine. Logging has disturbed stream bed (width and depth are questionable). Same stream as D85, keep stream on south side of ROW.
D87		NA	NA	0%	undelineated						130	36		Seep.
D88		3.0	0.5	17%	0.33	8	38	46	67		265	36		Narrow ravine with bedrock walls.
D89		2.0	1.0	38%	0.03	1	5	6	9		180	36		Small stream; diverted from original stream bed by logging road. Original stream bed 2 ft wide by 1 ft deep (bank full).
D90		NA	NA	18%	0.07	2	10	12	19		140	36		Dry stream bed; has not had flow for several years.
D91		3.0	1.0	35%	0.34	9	39	47	70		170	36		Small steep stream. A channel with large cobble bottom and broad ravine.
D92		4.0	0.2	6%	0.13	4	18	22	32		165	36		Small stream w/ surface & subsurface flow. 18" CMP culvert in old road insufficient; high water has overtopped. House pits on both sides of stream.
D93		2.0	0.2	1%	undelineated					18	300	36		Small local drainage. 18 in CMP culvert under road.

Juneau Creek Alternative (continued)														
D94	yes	2.5	1.5	1%	0.43	11	48	58	85		110	54 w/fill	Equivalent capacity without fill is less than the 48 inches requiring Q_{100} analysis. Design may choose to keep this stream north of the road in w	Low gradient stream with sandy bottom (actual slope < 1%). Possible fish habitat. Stream just touches ROW then turns back to the NW.
D95	yes	20.0	3.0	0.0%	0.52	13	57	68	99		Bridge	Bridge		Stream/pond/wetland complex.
D96-D106 (see All Alternatives)														
Cooper Creek and G South Alternatives														
D57		NA	NA	1%	0.38	10	43	52	76	24	145	36		Small low gradient stream. Actual slope < 1%.
D58	yes	NA	NA	2%	1.17	28	113	135	193	36	110	66 w/fill	Pond-wetland complex upstream, no structures. Flood hazard from backwater minimal.	Two small streams flow into pond above culvert.
D59		NA	NA		undelineated					24	150	36		Local drainage; may not be necessary.
D60		NA	NA		undelineated					24	145	36		Local drainage; drains to north.
D61		NA	NA		undelineated						180	36		Now flow present. Culvert may not be necessary.
D62		NA	NA		undelineated					24	140	36		No stream; local.
D63		NA	NA		undelineated					24	115	36		No stream; local.
D64		6.0	0.0		1.71	41	157	186	265	36	115	60	Will pass Q_{100} flood at WH/D = 1.5. Some potential for flooding of private property upstream. Proposed culvert is 3 times the capacity of the existing structure.	Small stream.
D65		NA	NA		undelineated					24	105	36		Local drainage.
D66	yes	10.0	1.5	4%	3.78	86	310	365	510	24/36	105	114 w/fill	Proposed culvert will pass Q_{500} flood at WH/D = 1.5	Culvert is undersized (overflow 24" CMP installed off to side). Moderate stream with cobble bottom (D50=6 in). Possible fish passage issues: high velocity & pinched downstream opening. Designed for HW/D=1, Private property in floodplain upstream.
D67	yes	5.5	1.0	2%	0.13	3	17	20	31	24	110	60	Drainage Basin not clearly defined. Will require further study.	Small stream.
D68		NA	NA		undelineated					24	125	36		Ditch drainage and seep.
D69		NA	NA		undelineated					24	125	36		Ditch drainage.
D70		NA	NA		undelineated					24	125	36		Ditch drainage and seep.
D71		NA	NA	5%	0.51	13	55	66	97	24	120	42		Small steep stream.

Cooper Creek and G South Alternatives (continued)														
D72		NA	NA		undelineated					24	110	36		Ditch and seep drainage. Inlet of culvert is buried.
D73		NA	NA		undelineated					24	110	36		Sportsman's Landing; drains to the north.
D74		NA	NA		undelineated					24	110	36		Ditch drainage.
D75		NA	NA		0.35	9	40	49	71	24	130	36		Small stream approximately 60 ft west of culvert drains along ditch to culvert.
D76		NA	NA		undelineated					24	120	36		Ditch drainage. Culvert inlet is partially buried.
D77		NA	NA		0.14	4	19	23	34	30	105	36		Small stream; steep exit slope at outlet.
Juneau Creek and G South Alternatives														
D26		5.0	1.0	20%	0.77	19	79	95	137		230	48	Proposed culvert will pass Q_{100} flood at WH/D = 1.5.	Small canyon approximately 100 ft wide and 20 ft deep. (no flagging hung)
D27		1.0	1.0	14%	0.19	5	24	29	42		225	36		Small valley approximately 50 ft wide and 6 ft deep. (no flagging hung)
D28		2.0	1.0	20%	0.22	6	27	32	48		300	36		V-canyon 200 ft wide and 50 ft deep. Sand and gravel bottom. (no flagging hung)
D29		4.0	1.0	30%	0.74	18	76	91	132		145	48	Proposed culvert will pass Q_{100} flood at WH/D = 1.5. Steep narrow canyon, no backwater flood hazard to structures or private lands	Steep A channel; bedrock or large cobbles. Downstream culvert 24”.
D30		NA	NA	14%	undelineated						145	36		Stream runs surface and subsurface along drainage.
D31		NA	NA	20%	undelineated						160	36		Stream subsurface; large cottonwoods; photo 1829 shows drainage basin.
D32		NA	NA		undelineated						165	36		Seep
D33		NA	NA		undelineated						175	36		Seep
D34		NA	NA		undelineated						200	36		Seep
D35		NA	NA	17%	undelineated						165	36		Small stream
D36		NA	NA		undelineated						185	36		Seep
D37		NA	NA		undelineated						185	36		Seep
D38		NA	NA		undelineated						190	36		Seep
D39		NA	NA		undelineated						190	36		Seep
D40		NA	NA	16%	undelineated						155	36		Defined drainage; surface and subsurface flow.
D41		NA	NA	17%	undelineated						140	36		Same as D40
D42		NA	NA	0%	undelineated						160	36		Seep
D43		NA	NA	13%	undelineated						145	36		Same as D40
D44		NA	NA		undelineated						165	36		Seep
D45		NA	NA		undelineated						160	36		Seep
D46		NA	NA	20%	undelineated						190	36		Same as D40
D47		NA	NA		undelineated						200	36		Seep

Juneau Creek and G South Alternatives (continued)														
D48		1.0	0.6	3%	undelineated						200	36		Small drainage with mud bottom.
D49		2.0	1.2	5%	undelineated						200	36		E channel (small) with subsurface to surface flow. Mud bottom.
All Alternatives														
D1		NA	NA		undelineated					24	155	36		Ditch drainage.
D2		NA	NA		undelineated					24	135	36		Ditch drainage.
D3		4.0	1.3	13%	0.34	9	40	48	70	36	170	36		Small stream; perched 2 ft at outlet.
D4		NA	NA		undelineated					24	260	36		No flow for years. Exits at top of steep slope?
D5		2.0	1.0	7%	0.25	7	30	37	54	36	185	36		Small stream.
D6		NA	NA	10%	0.28	7	33	40	59	24	180	36		Small stream located 50 ft east of CMP. Outlet is perched. New culvert should be placed diagonally across road.
D7		NA	NA		undelineated					12	145	36		Ditch drainage.
D8		NA	NA		undelineated					24	160	36		Ditch drainage.
D9		NA	NA		undelineated					36	135	36		Local drainage with no flow (none for years).
D96		NA	NA		undelineated					24	175	36		Ditch drainage.
D97		3.0	1.0	3%	0.43	11	48	58	85		185	36		Small steep stream 50 ft north of road with sand bottom.
D98		NA	NA		undelineated					24	150	36		Ditch drainage.
D99		NA	NA		undelineated					24	150	36		Drainage ditch.
D100		NA	NA	10%	0.67	13	53	64	92	24	130	42		Moderate sized stream with second stream located 100 ft west. Culvert undersized; overflows to east. Perched at outlet and waterfall on north side.
D101		NA	NA		0.22	6	27	33	48	24	145	36		Ditch drainage and small creek.
D102		6.0	1.2	2%	0.43	11	48	58	84	36	130	36		Small creek with falls on north (upstream) side of road. Width and depth measurements are for downstream portion of creek.
D103		NA	NA		undelineated					24	125	36		Ditch drainage.
D104	yes	16.0	1.0	3%	3.22	68	242	285	399	36	150	Bridge	No private land or structures in upstream back water area.	Fuller Creek, Moderate stream parallels road for 200 ft from east. Culvert undersized, with high-water mark 4 ft above top, of culvert, flooding top of road. Stream parallels road on south for 200 feet west. Large sediment transport
D105		NA	NA		0.28	7	33	40	60	24	150	36		Culvert drains marshy area. Culvert invert plugged and above level of marsh
D106		NA	NA		undelineated					24	175	36		Culvert in dry area. Downstream end shows flow.

OHW - Ordinary High Water.
HW/D - Depth of backwater (above invert)/diameter of culvert.
NA - Drainages with low or no flow and/or indefinite drainage channel.

Q_2 - Flood discharge with 50% yearly recurrence probability.
Q_{50} - Flood discharge with 2% yearly recurrence probability.
Q_{100} - Flood discharge with 1% yearly recurrence probability.
Q_{500} - Flood discharge with 0.2% yearly recurrence probability.

7.0 HYDRAULICS

7.1 *Drainages with Delineated Basins*

Preliminary culverts sizes were selected to convey the 50-year flood (Q_{50}) flow across the roadway in accordance with the DOT&PF Highway Preconstruction Manual Section 1120.4, January 1998, for drainages with delineated drainage basins. Conveyances with an equivalent diameter exceeding 48 inches were also evaluated for Q_{100} flood conveyance. The Q_{100} evaluation is included as a separate column in Table 1. All pipe sizes are listed for guidance only. Final flood flows, fish passage requirements, and size and type of the conveyance structures, as well as the appurtenant features such as headwalls and erosion control will be determined during the final design.

The proposed culverts were sized using the Federal Highway Administration Hydraulic Design Series No. 5, Hydraulic Design of Highway Culverts (dated 1985). The following assumptions were used in these calculations:

- Culvert is operating under inlet control. This assumption may not hold for long culverts on a flat slope whose size is determined by the Q_{50} or Q_{100} events. This assumption must be checked during the design.
- Culvert entrance type is mitered to conform to the upstream road embankment.
- Headwater condition is equal to 1.5 times the height of the culvert (HW/D = 1.5). HW/D was reduced to 1.0 in two drainages, one to prevent buildup of sediment upstream of the conveyance in an actively eroding stream channel, and the second to prevent flooding of private property. These drainages are noted in Table 1.

All sizing guidance on fish stream conveyances were designed to meet the ADF&G/DOT&PF Memorandum of Agreement (MOA) Tier 1 requirements dated August 29, 2001. These sizes should be considered approximate as final design may elect to meet the requirements of other tiers under this memorandum.

The recommended capacity of equivalent fish passage culverts was evaluated using the same assumptions. The hydraulic capacity of partially filled round culverts was estimated using the flow capacities of dimensionally equivalent pipe-arch culverts. Table 2 gives the estimated capacities of culverts. This table was used to select culverts for the Q_{50} flood flows. Pipe-arch culverts were not used in the preliminary sizing guidance. Culvert use in specific locations will be dictated by cover requirements and fill depths of the final design.

Table 2: Culvert Flood Flow Capacities

Non Fish Passage Culverts		Fish Passage Culverts		
Round Culvert (inches)	**Calculated Capacity (cfs)**	**Round w/ 40% Fill (inches)**	**Approximate Equivalent Pipe-arch (inches)**	**Estimated Capacity w/fill (cfs)**
24	19	36	36x22	25
30	32	42	43x27	40
36	52	54	50x31	57
42	75	60	58x36	83
48	105	66	65x40	110
54	140	72	72x44	140
60	180	78	73x55	200
72	290	84	84x61	265
78	350	96	98x69	370
84	425	114	114x77	510

7.2 *Drainages with Undelineated Basins*

Culverts for undelineated basins were sized using minimum DOT&PF-specified culvert sizes. These sizes are 24 inches for culverts less than 100 feet in length and 36 inches for culverts greater than 100 feet in length. All conveyance structures were determined to be longer than 100 feet. The 50-year flood flow capacity of the 36-inch culvert equates to a drainage basin of approximately ½-square mile, this exceeds the size of all the undelineated basins. Many basins are no more than a few acres. With one exception (D10) all drainages that cross the existing roadway were sized to meet or exceed the size of the existing conveyance. The existing culvert at D10 may be oversized to alleviate winter ice build up. The recommended pipe size for this drainage is based on projected flood flows only.

8.0 FISH PASSAGE CONSIDERATIONS

Fish-bearing streams were delineated as described in section 5.0. Nine fish-bearing streams are identified along the three build alternatives. One of these streams (Cooper Creek) will be spanned by a bridge for the project. A second stream (Fuller Creek) is also a recommended bridge site although this may change during design analysis. Culverts for the remaining crossings were sized to meet the ADF&G/DOT&PF MOA Tier 1 requirements for fish passage. To meet Tier 1 requirements, the culvert width shall be 90 percent of the stream channel width at ordinary high water with channel slopes greater than 1%. Culverts may be installed at slopes less than 0.5% with culvert widths equal or greater than 75% of the ordinary high water width, in streams with slopes less than 1%. Round culverts should be embedded below the stream substrate to 40 percent of their depth and pipe-arch culverts shall be buried at least 20% of the rise. At some crossings this width requirement dictates the culvert size while on others the Q_{50} flood flow capacity dictates the culvert size. A different approach to culvert sizing may be proposed subject to provisions of Title 41 and consultation with state and federal agencies during the actual permit application and review process.

The following sections address each fish-bearing stream and the flood flow and fish passage parameters governing culvert design. Drainages are listed in numerical order.

8.1 *Drainage Site D13 (Cooper Creek Alternative)*

Shown on Map Figure 4

This stream currently runs in a ditch alongside the Sterling Highway, crosses under the Snug Harbor Road and empties into Kenai Lake upstream of the Cooper Landing Bridge. Final design should address the possibility of rerouting this stream directly to the Kenai River across Kenai Borough lands. The current configuration causes continual maintenance and icing problem.

- Base flow channel width = 30 inches
- Slope = 1%
- Width at ordinary high water = 36 inches
- Drainage basin area = 0.60 square miles
- Q_{50} = 64 cfs
- Culvert width to meet State MOA Tier 1 fish passage requirement = 36 inches
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 60 inches
- Estimated culvert length= 180 feet
- Flood flow capacity controls the size of this conveyance design

Figure 12: Drainage site D13, downstream side of Snug Harbor Road crossing.

Figure 13: Drainage site D13, upstream side of Snug Harbor Road crossing.

8.2 *Drainage Site D25 (Cooper Creek Alternative)*

Shown on Map Figure 8

- Base flow channel width = 36 inches
- Slope = 1%
- Width at ordinary high water = 48 inches
- Drainage basin area = 0.19 square miles
- Q_{50} = 24 cfs
- Culvert width to meet MOA Tier 1 fish passage requirement = 48 inches
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 36 inches
- Estimated culvert length= 125 feet
- Fish passage width controls the size of this conveyance design

Figure 14: Drainage site D25, downstream side of existing road crossing.

Figure 15: Drainage site D25, upstream side of existing road crossing.

8.3 *Drainage Site D50 (G South Alternative) and D78 (Juneau Creek Alternative), Tributary to Bean Creek*

Shown on Map Figure 5

- D50 is on the G South Alternative just upstream of D78, crossing site features are similar
- Base flow channel width = 48 inches
- Slope = 4%
- D_{50} = 6 inches
- Width at ordinary high water = 60 inches
- Drainage basin area = 0.52 square miles
- Estimated culvert length D50, 540 feet and D78, 430 feet
- Q_{50} = 56 cfs
- Culvert width to meet MOA Tier 1 fish passage requirement = 54 inches
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 54 inches
- Flood flow capacity and fish passage width both control the size of this conveyance design

Figure 16: Drainage site D50.

Figure 17: Drainage site D78.

8.4 *Drainage Site D56 (G South Alternative)*

Shown on Map Figure 8

- Base flow channel width = 24 inches
- Slope = 1%
- D_{50} = Sand
- Width at ordinary high water = 24 inches
- Drainage basin area = 0.19 square miles
- Q_{50} = 24 cfs
- Culvert width to meet MOA Tier 1 fish passage requirement = 24 inches
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 36 inches
- Estimated culvert length= 225 feet
- Flood flow capacity controls the size of this conveyance design

Figure 18: Drainage site D56.

8.5 *Drainage Sites D52 and D53 (G South Alternative), Main Stem of Bean Creek*

Shown on Map Figures 5 and 7

The stream parallels the alignment and touches the alignment at two locations. Only one conveyance should be required. Fisheries survey did not find fish at this crossing but this stream is listed as an anadromous stream in the ADF&G 2004 Anadromous Streams Catalog.

- Base flow channel width = 36 inches
- D_{50} = 1 inch
- Width at ordinary high water = 48 inches
- Drainage basin area = 0.69 square miles
- Q_{50} = 72 cfs
- Culvert width to meet MOA Tier 1 fish passage requirement = 48 inches
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 60 inches
- Flood flow capacity controls the size of this conveyance design

Figure 19: Drainage sites D52 and D53.

8.6 *Drainage Site D58 (Cooper Creek - G South alternatives)*

Shown on Map Figure 8

This stream drains a small stream/pond complex on the outside of a low speed corner next to the Kenai River. It was the site of a petroleum tanker truck spill 3 years ago but has gotten clean closure from the state Department of Environmental Conservation.

- Base flow channel width = Small pond (n/a)
- Slope = 0%
- Width at ordinary high water = Small pond (n/a)
- Drainage basin area = 1.17 square miles
- Q_{50} = 113 cfs
- Culvert width to meet MOA Tier 1 fish passage requirement = Stream width not applicable. Tier II design should be considered for this conveyance.
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 66 inches
- Estimated culvert length= 110 feet
- Flood flow capacity control the size of this conveyance design

Figure 20: Drainage site D58 upstream side of existing road crossing.

Figure 21: Drainage site D58 downstream side of existing road crossing.

8.7 *Drainage Site D66 (Cooper Creek - G South alternatives)*

Shown on Map Figure 9

- Base flow channel width = 98 inches
- Slope = 4%
- D_{50} = 8 inches
- Width at ordinary high water = 120 inches
- Drainage basin area = 3.77 square miles
- Q_{50} = 309 cfs
- Culvert width to meet MOA Tier 1 fish passage requirement = 108 inches
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 114 inches
- Estimated culvert length= 105 feet
- Flood flow capacity controls the size of this conveyance design

Figure 22: Drainage site D66, downstream side of existing road crossing.

Figure 23: Drainage site D66, upstream side of existing road crossing.

8.8 *Drainage Site D67 (Cooper Creek - G South Alternatives)*

Shown on Map Figure 9

- Base flow channel width = 48 inches
- Slope = 2%
- D_{50} = 3 inches
- Width at ordinary high water = 66 inches
- Drainage basin area = 0.13 square miles
- Q_{50} = 17 cfs
- Culvert width to meet MOA Tier 1 fish passage requirement = 60 inches
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 36 inches
- Estimated culvert length= 110 feet
- Fish passage width controls the size of this conveyance design

Figure 24: Drainage site D67, downstream side of existing road crossing.

Figure 25: Drainage site D67, upstream side of existing road crossing.

8.9 *Drainage Site D94 (Juneau Creek Alternative)*

Shown on Map Figure 10

This stream was not surveyed as part of the HDR fisheries evaluation. It is included here as a fisheries stream crossing but should be sampled to determine its status. This stream flows into the stream/pond complex that becomes D95. Final design may keep this stream north of the road in which case no conveyance will be needed.

- Base flow channel width = 30 inches
- Slope = 1%
- Width at ordinary high water = 30 inches
- Drainage basin area = 0.43 square miles
- Q_{50} = 48 cfs
- Culvert width to meet MOA Tier 1 fish passage requirement = 30 inches
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 54 inches
- Estimated culvert length= 110 feet
- Flood flow capacity controls the size of this conveyance design

Figure 26: Drainage site D94.

8.10 *Drainage Site D95 (Juneau Creek Alternative)*

Shown on Map Figure 10

This stream/pond was not surveyed as part of the HDR fisheries investigation. It is included here as a fisheries stream crossing because of apparent fisheries habitat and fish observed during the H&H field investigation. This site will fall at a major intersection of highways. Its final configuration and recommended conveyance will ultimately depend on the layout of this intersection, how much the road fill encroaches into the stream/pond complex, and other factors as yet unknown. The drainage basin and flood flows are small compared to the width of the existing channel; channel grade is near 0%. Tier II analysis could reduce the requirement of this site to a single pipe-arch structure of modest size.

- Base flow channel width = 20 feet
- Slope = 0%
- Width at ordinary high water = 20-25 feet
- Drainage basin area = 0.52 square miles
- Q_{50} = 57 cfs
- Width to meet MOA Tier 1 fish passage requirement = 15 feet. Tier II criteria should be considered for final design.
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 54 inches
- Estimated length= NA
- Fish passage width may control the size of this conveyance design

Figure 27: Drainage site D95.

8.11 *Drainage Site D104 (All Alternatives); Fuller Creek*

Shown on Map Figure 11

Because of the ongoing sediment transport issues surrounding this structure a bridge should be considered for this site. Fuller creek has moved west to the extreme edge of its alluvial fan perhaps by previous road work. The stream is incising into the old alluvial fan 200 yards above the road and depositing the sediments as it slows just above the road crossing. Any structure that reduces velocity in this area is will continue this problem. A more detailed analysis should be done during final design.

- Base flow channel width = 72 inches
- Slope = 3%
- Width at ordinary high water = 192 inches
- Drainage basin area = 3.22 square miles
- Q_{50} = 242 cfs
- Width to meet MOA Tier 1 fish passage requirement = 180 inches
- Round culvert size to meet Q_{50} capacity with 40 percent fill = 84 inches
- Estimated length= 150 feet
- Fish passage width controls the size of this conveyance design

Figure 28: Drainage site D104, upstream reach showing gravel deposition.

Figure 29: Drainage site D104, downstream side of existing road crossing.

Figure 30: Drainage site D104, upstream side of existing road crossing.

9.0 REFERENCES

Alaska Department of Fish and Game (ADF&G) and Alaska Department of Natural Resources. 2004. Atlas and Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes.

ADF&G and Alaska Department of Transportation and Public Facilities (ADOT&PF). 2001. Memorandum of Agreement (MOA) between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design, Permitting and Construction of Culverts for Fish Passage, dated August 29, 2001.

ADOT&PF. 1995. Alaska Highway Drainage Manual, 1st Edition June 1995.

ADOT&PF. 1998. ADOT Highway Preconstruction Manual.

Federal Highway Administration. 1985 Hydraulic Design Series No. 5, Hydraulic Design of Highway Culverts.

HDR Alaska, Inc. 2004. Sterling Highway Milepost 45 to 60 draft Fisheries Evaluation, November 2004.

United States Department of Commerce. 1963. Probable Maximum Precipitation and Rainfall Frequency Data for Alaska, Technical Paper No. 47.

United States Geological Survey (USGS). Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada, USGS Water-Resources Investigation Report 03-4188.