FISHERIES ASSESSMENT OF HABITAT STRUCTURES AT THREE WATERCOURSE CROSSINGS NEAR KUGAARUK, NUNAVUT

Engineering Earth's Development, Preserving Earth's Integrity

Golder Associates

REPORT ON

FISHERIES ASSESSMENT OF HABITAT STRUCTURES AT THREE WATERCOURSE CROSSINGS NEAR KUGAARUK, NUNAVUT

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Quinn Taggart (Senior Administrative Officer)

Guido Tigvareark (Assistant Senior Administrative Officer)

Remi Krikort (Deputy Mayor and Wildlife Officer)

Getan Apsaktaun (Road Project Foreman)

The following staff members of Golder participated in the field assessment and in the preparation of the report:

Jim O'Neil (Senior Biologist, Project Reviewer)

Alison Little (Fisheries Biologist, Project Manager)

Jim Campbell (Fisheries Biologist)

Angie Wight (Administrative Assistant)

TABLE OF CONTENTS

SECTION PAGE

LIST OF TABLES

2.0 STUDY AREA

The study area was located southeast of the Hamlet of Kugaaruk and included a single span bridge crossing of the Alliarusiq River and culvert crossings on two tributaries to the Alliarusiq River. The Alliarusiq River, which is 11 km in length, originates in Barrow Lake. It flows into the Kugajuk River, which enters St. Peters Bay (Gulf of Boothia) near the Hamlet of Kugaaruk. The three watercourse crossings were labeled Km 18 Culvert, Second Bridge, and Km 24 Culvert (Table 1).

Table 1 Crossing designations, structures, and descriptions, 7 August 2002.

Crossing ID	Crossing Structure	UTM Coordinates[1]	Description
Km 18	Culvert	395219E/7599294N	Unnamed tributary to the Alliarusiq River.
Second Bridge	Single span bridge	393032E/7598059N	Upper Alliarusiq River near Barrow Lake outflow.
Km 24	Culvert	392192E/7597702N	Overflow channel to Barrow Lake.

[1]NAD 27, Zone 16W

3.0 METHODS

Two fisheries biologists from Golder Associates Ltd. assessed stream conditions and the effectiveness of habitat enhancement structures at three watercourse crossings near Kugaaruk, NU on 7 August 2002. Water depth and selected water quality parameters (dissolved oxygen, water temperature, conductivity, pH, and turbidity) were measured at each crossing. Also, the habitat enhancement structures were measured to calculate the area of habitat created. Representative photographs were collected at each site.

Discharge was determined at the culvert sites (Km 18 and Km 24); however, due to unsafe wading conditions, discharge was not recorded at the Second Bridge. Discharge at the Km 24 Culvert was calculated according to methods outlined by Buchanan and Somers (1969). Velocity was measured with a direct read-out Swoffer Model 2100 meter. Thirteen readings were taken along a tag line positioned perpendicular to the thalweg. Discharge at Km 18 Culvert was measured using the timed-fill bucket method, since a proper velocity transect could not be completed at this site. The timed-fill bucket method was most practical since the entire stream was flowing through the culvert in a small quantity and could be collected entirely into a bucket. Discharge was calculated from the volume of water flowing from the culvert over a known time.

Dissolved oxygen (±0.01 mg/L) and temperature (±0.1°C) were measured at each site using an Oxyguard Handy Beta dissolved oxygen temperature meter. Water conductivity and pH were measured with an Oakton TDSTestr3 (±1.0 µS/cm) and an Oakton pHTestr2 (±1.0), respectively. Turbidity samples were collected from each site, preserved and measured in the laboratory with an Orbeco-Hellige Model 966 meter (0.01 NTU).

Fisheries information was gathered from local residents, from onsite observations, and from a snorkeling survey conducted at the Second Bridge crossing (i.e., section extending 100 m upstream to 500 m downstream of the bridge).

4.0 RESULTS

4.1 Km 18 Culvert

At the time of the assessment, the deflecting dyke was situated outside the wetted channel. However, the resting pool below the culvert remained functional (Plates 1 and 2); a juvenile lake trout was observed in the pool. Due to the very low flows (Plate 1), it is very unlikely that this fish would have been able to migrate to suitable overwintering habitat upstream or downstream of the crossing before freeze-up. Because of the low flows, the natural sections of the stream channel between the small headwater lake (Plates 3 and 4) and the Alliarusiq River, would have been largely impassable to fish even if the culvert was not present. Fish (unknown size) were observed rising in the headwater lake, indicating that either these fish overwintered there or had migrated at higher flows during the spring. However, there is some uncertainty regarding fish passage through the culvert during high flow periods, particularly for small fish (<150 mm). Based on the swimming capabilities of fish with a subcarangiform shape, which includes char (Katopodis and Gervais 1991; Appendix A), a fish less than 150 mm in length could not maintain a prolonged swimming speed of 0.55 m/s over a distance of 15 m; a velocity of 0.55 m/s is possible during high flows. Based on Manning's uniform flow equation, velocities up to 1.2 m/s could be developed in the culvert (i.e., 50% flow capacity, slope of 0.3% and a diameter of 1.2 m) (equation cited in Newbury and Gaboury 1993; Appendix B). Given this, it is evident that this culvert could represent a movement barrier to small fish (<150 mm) at moderate velocities (e.g., 0.55 m/s) and possibly to larger fish (400 mm) at higher velocities (e.g., 1.2 m/s).

At high flows the deflective dyke was effective in creating a resting pool (Plates 5-7). It also aids in preventing water from dispersing over the tundra as it exits the culvert (particularly on the left downstream bank area). At high flow, the area of the resting pool would be 22 m^2, and during the present survey the wetted area was 20 m^2. Maximum water depth in the pool was 0.54 m.

To ensure that the culvert does not begin to "hang" and prevent fish passage, this culvert should be inspected each year following the spring meltwater period. Also, water velocities in the culvert should be determined during the high flow period to address fish passage issues.

Dissolved oxygen was 8.8 mg/L and water temperature was 10.6ºC (at 9:15). Water conductivity and pH were 300 µS/cm and 7.6, respectively. Mean turbidity was low (2.04 NTU). Discharge was very low (0.00028 m^3/s or 0.28 litres/sec).

4.2 Second Bridge (Km 23)

At the time of the survey (7 August), most of the spur dyke was located outside the wetted channel (Plates 8 and 9). Although this structure appeared to provide useable fish habitat at high flows (Plate 10), the effective period may be restricted to a two to three week window each year (end of June to beginning of July). During the August survey, there was evidence that a backwater habitat was present at higher flows (i.e., based on the deposition of fines observed at the upstream end of the spur). This backwater habitat was also evident in photos taken during late June of this year (Plate 10).

The spur dyke was 43.3 m in length (parallel to the river) and 20.5 m in width (portion of the structure protruding into the channel). Based on these values, at high water the dyke would encompass approximately 888 m^2 of the channel. On 7 August, approximately 333 m^2 (38%) of the riverbed was dry (i.e., area adjacent to the spur). The calculation of the dry area was based on an average of six equally spaced measurements extending from the spur to the wetted river edge (i.e., average of 7.7 m of dry shoreline). The wetted river edge was approximately 11 m from the spur at the upstream end and 4 m at the downstream end (Plate 11). A spur dyke and rip-rap were also installed on the upstream side of the bridge. Similar to the downstream spur dyke, this dyke was located outside the wetted channel (Plate 12). However, unlike the downstream spur dyke, this dyke likely does not provide fish habitat, even during high flow. At high flow, when the water could reach the spur dyke, a backwater holding area would not be formed due to the angle of the spur and the high water velocities that likely approach this dyke. However, this spur dyke would aid in protecting the road slope from erosion.

Rip-rap armouring on the bridge abutment on the left downstream bank was approximately 58.5 m^2 (58.5 m in linear length with 1 m width of useable habitat), of which 35.4 m^2 was wetted during the August survey. Rip-rap armouring on the bridge abutment on the right downstream bank was approximately 29.5 m^2 (29.5 m in linear length with a 1 m wide band of useable habitat). Of this total, 16.5 m^2 was wetted during the August survey. Additional site photos are presented in Plates 13 and 14.

Young-of-the-year (y-o-y) char were observed to be abundant along the river edge throughout the entire riffle-boulder garden at the bridge, and downstream for approximately 500 m. These individuals were predominantly lake trout; one Arctic char y-o-y was observed. During a snorkelling survey (Plate 15), one adult lake trout (approximately 300 mm in length) was observed approximately 100 m downstream of the bridge. The section at and downstream of the bridge provided good quality rearing and feeding habitat for char species (i.e., lake trout and Arctic char). The resting/backwater habitat (formed by the spur dyke) has increased the habitat diversity in the area, even though it is present only for a short period of time. During periods when the structure is active, adult lake trout may move from the lake to feed in the river and utilize the associated habitat. Adult Arctic char may also use these structures for short term resting and feeding as they migrate from the lake to the ocean.

Dissolved oxygen was 12.5 mg/L and water temperature was 5.6ºC (at 12:05). Water conductivity and pH were 30 µS/cm and 7.1, respectively. Water clarity was very high (i.e., mean turbidity of 0.04 NTU).

4.3 Km 24 Culvert at the overflow channel

One culvert was in place at this site, although a second culvert is expected to arrive on the barge in September 2002 (pers. comm. Quinn Taggart, Senior Administrative Officer). At the time of the survey, the culvert appeared to be passable by fish (Plates 16 and 17); the culvert would likely to also be passable at high flows (Plate 18). The second culvert should be installed before the next spring melt to prevent water flowing over the road and introducing sediment into the stream. At high flows (30 June 2002, Plate 18) the culvert was almost entirely filled with water, and during August there was still water ponding on the upstream end of the culvert (Plates 19 and 20).

The deflective dyke appeared to assist in the development of the resting pool below the culvert (Plates 16 and 17). At the time of the survey (low flow), the area of the resting pool was 87 m^2. During higher flow periods (e.g., July), this pool could cover at least twice this area (i.e., 174 m^2). Numerous y-o-y char (predominantly lake trout) were observed along the wetted perimeter of the resting pool, indicating that the structure was providing good quality rearing habitat at these flows. Placement of a few more large rocks (boulder/cobble) could be considered to provide additional cover in the middle of the pool. Good quality rearing habitat was also noted below the deflective dyke. This area was a dispersed boulder garden (25 m across the channel; Plate 17) and provided habitat for numerous y-o-y and a juvenile char.

Dissolved oxygen was 10.8 mg/L and water temperature was 10.7ºC (at 10:15). Water conductivity and pH were 30 µS/cm and 6.8, respectively. Water clarity was exceptionally high (i.e., mean turbidity was 0.96 NTU). Discharge was very low (0.042 m^3/s).

5.0 SUMMARY

Overall, the habitat enhancement structures appear to have been effective, but primarily during the snow melt period (2 to 3 week window from the end of June to beginning of July). At higher flows, the structures will increase the habitat diversity in the project area.

It should be noted that the habitat associated with the various structures may increase in area and quality over time due to the ongoing channel processes (scour, deposition, etc.). However, there is a concern is that high scour velocities could result in the formation of hanging culverts, which could become a barrier to upstream fish movement. Consideration should be given to re-assessing these structures after 2 to 3 years to determine the long term effectiveness in an Arctic setting.

6.0 CLOSURE

This report was prepared by Golder Associates Ltd. (Golder) for the account of Jivko Engineering Ltd. The material in it reflects Golder's best judgment in light of information available to it at the time of preparation. Any use which a third party makes of this report or any reliance on or decisions to be made based on it, are the responsibility of such third party. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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We trust the information contained in this report is sufficient for your present needs. Should you have any questions regarding the project, please do not hesitate to contact the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

Alison Little, M.Sc., P. Biol.
Fisheries Biologist

Reviewed by:

Jim O'Neil, B.Sc., P. Biol.
Senior Fisheries Biologist

AL/aw

7.0 BIBLIOGRAPHY

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Newbury, R.W. and M.N. Gaboury. 1993. Stream analysis and fish habitat design: a field manual. Co-published by Newbury Hydraulics Ltd., British Columbia and Manitoba Habitat Heritage Corporation, Manitoba Natural Resources.

Katopodis C. and R. Gervais. 1991. Ichthyomechanics. Working paper, Canada Department of Fisheries and Oceans.

7.2 Personal Communication

Quinn Taggart, Senior Administrative Officer, Kugaaruk, Nunavut, 6 August 2002.

Plate 1 Km 18 Culvert, *7 August 2002.* Resting pool on downstream end of culvert. Note: the deflecting dyke situated outside of wetted channel and very little flow through the culvert and in downstream channel.

Plate 2 Km 18 Culvert, *7 August 2002.* Resting pool and deflecting dyke below culvert. Note: juvenile lake trout observed within the pool.

Plate 3 Km 18 Culvert, *7 August 2002.* Outlet of headwater lake upstream of the culvert (upstream view). Note: very little water flowing through channel.

Plate 4 Km 18 Culvert, *7 August 2002.* Stream channel at upstream end of culvert. Note: rip-rap placement to protect the road slope.

Plate 5 **Km 18 Culvert,** *30 June 2002*. Resting pool on downstream end of culvert during high flow. Note: flowing water allowing fish passage to and from the Alliarusiq River.

Plate 6 **Km 18 Culvert,** *30 June 2002*. Resting pool on downstream end of culvert during high flow.

Plate 7 **Km 18 Culvert,** *30 June 2002*. Resting pool downstream of culvert. Note: water up to edge of deflecting dyke.

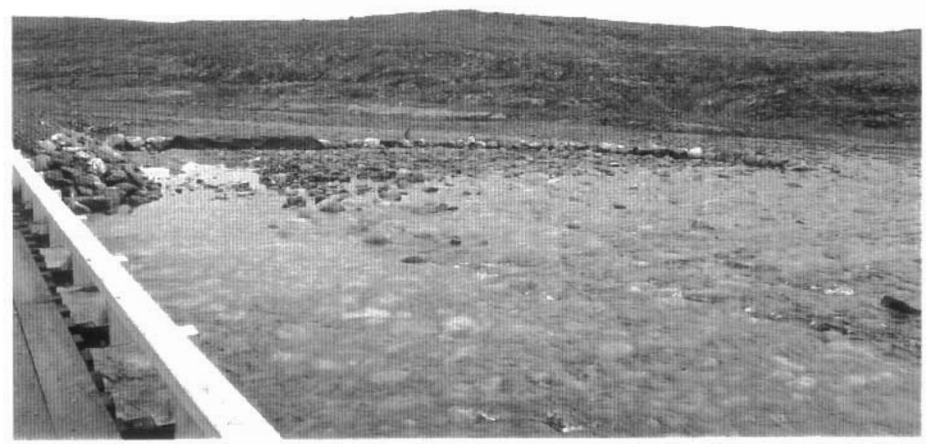


Plate 8 **Second Bridge (Alliarusiq River),** *7 August 2002*. Spur dyke on left downstream bank below the bridge.

Plate 9 **Second Bridge (Alliarusiq River),** *7 August 2002.* Spur dyke on left downstream bank below the bridge. Note: numerous young-of-year (y-o-y) char observed along the shoreline amongst boulders.

Plate 10 **Second Bridge (Alliarusiq River),** *30 June 2002.* Spur dyke below bridge during high flow. Note: spur dyke is effective during this time period and has created a backwater holding area (bottom left).

Plate 11 **Second Bridge (Alliarusiq River),** *7 August 2002.* Upstream view of area of spur dyke which is dry. Note: boulder garden habitat along shoreline providing cover for y-o-y and juvenile fish in shallow water.

Plate 12 **Second Bridge (Alliarusiq River),** *7 August 2002.* Spur dyke on left downstream bank above bridge. Note: during high flow, this structure may aid in preventing erosion to road bank, but likely does not provide fish habitat.

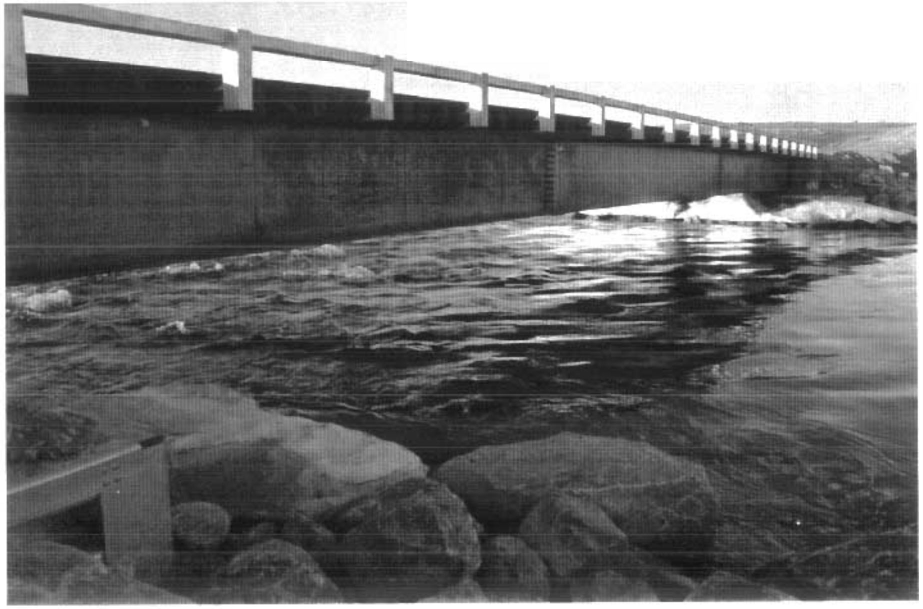


Plate 13 **Second Bridge (Alliarusiq River),** *30 June 2002.* Photo indicating water level below the bridge during high flow.

Plate 14 **Second Bridge (Alliarusiq River),** *7 August 2002.* Photo indicating water level below the bridge during base summer flow.

Plate 15 **Second Bridge (Alliarusiq River),** *7 August 2002.* Snorkelling survey of the Alliarusiq River. Note: one adult lake trout (approx. 300 mm in length) was observed 100 m downstream of bridge.

Plate 16 **Km 24 Culvert,** *7 August 2002.* Overflow channel between tributary to the Alliarusiq River and Barrow Lake. Photo of resting pool at downstream end of culvert. Note: placement of boulder (foreground) in a semi-circle formation which aids in holding water in the pool.

Plate 17 **Km 24 Culvert,** *7 August 2002.* Resting pool below culvert. Note: numerous y-o-y char were observed inside and outside of resting pool area. Most fish observed were located along the edge of the pool.

Plate 18 **Km 24 Culvert,** *30 June 2002.* Ponding of water on upstream side of culvert. Note: additional culverts are needed to maintain flow between the river and the lake. Fish passage possible through the culvert.

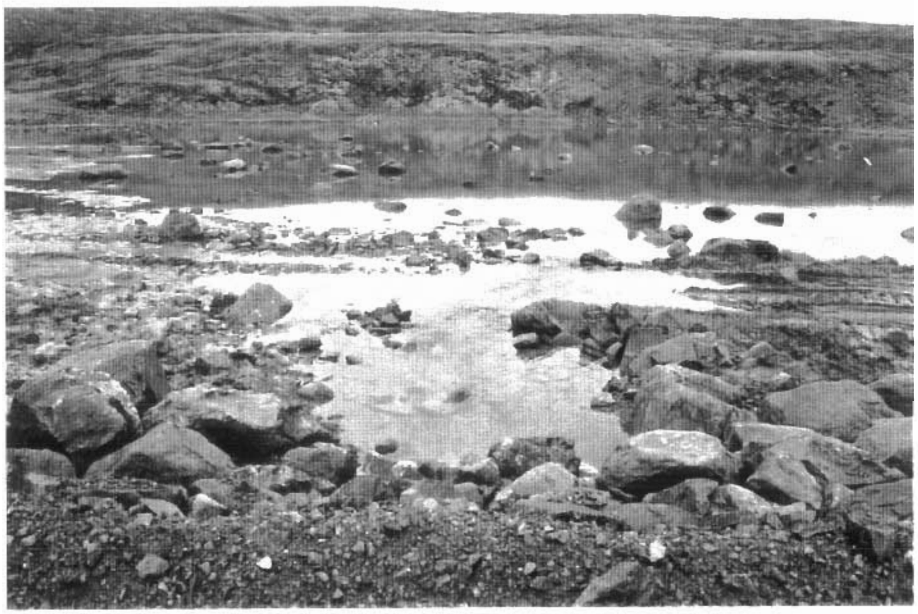
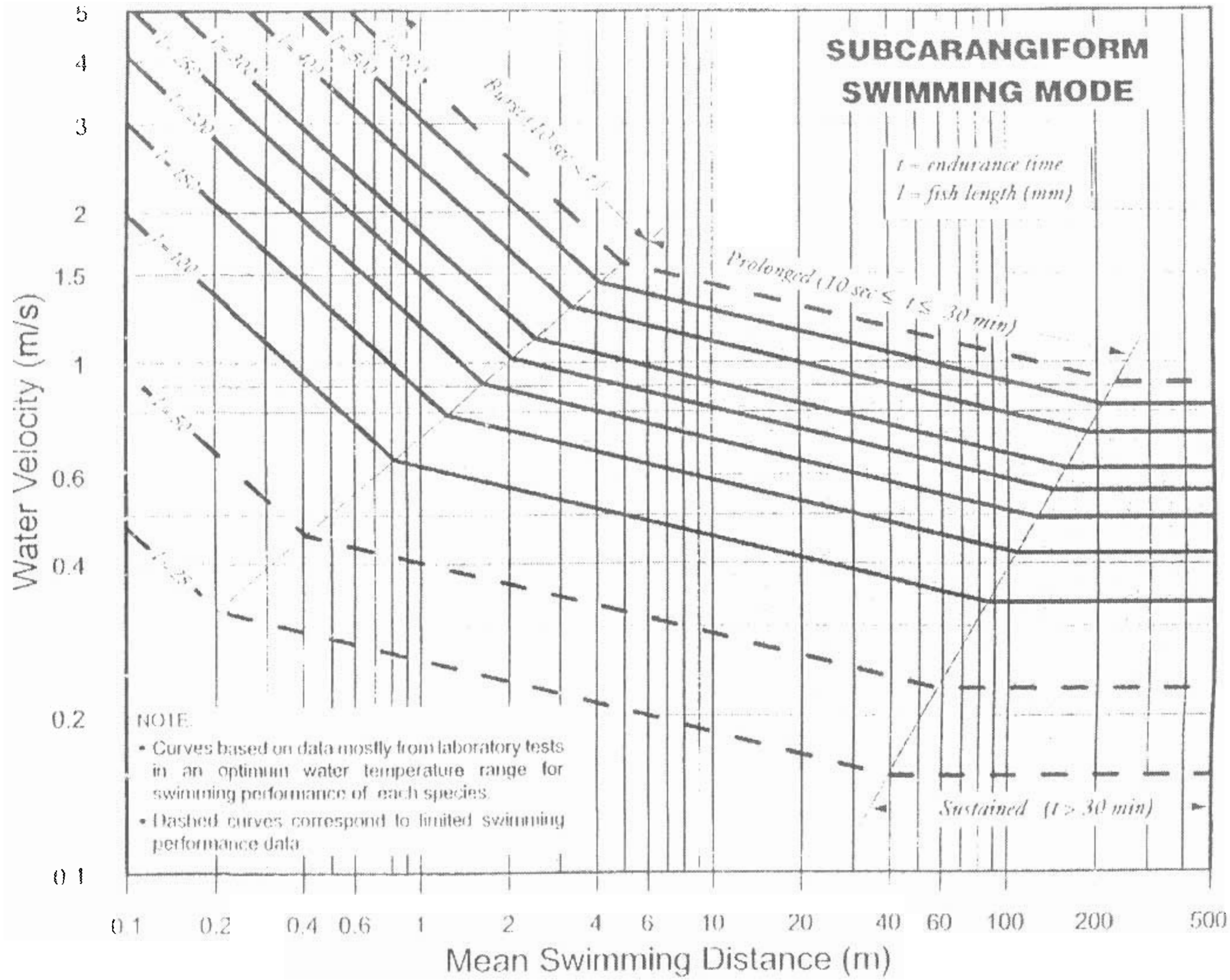


Plate 19 **Km 24 Culvert,** *7 August 2002.* Upstream end of culvert. The river in the background is in a lowland area and has very little flow.

Plate 20 **Km 24 Culvert,** *7 August 2002.* Overview photo of culvert crossing at the overflow channel to Barrow Lake. The resting pool is located on the right side of the road.

APPENDIX A



Swimming Performance Assessment – Subcarangiform Mode (Katopodis and Gervais 1991)

APPENDIX B

Manning's Uniform Flow Equation

Cited in: Newbury, R.W. and M.N. Gaboury. 1993. Stream analysis and fish habitat design: a field manual. Co-published by Newbury Hydraulics Ltd., British Columbia and Manitoba Habitat Heritage Corporation, Manitoba Natural Resources.

$$v = \frac{R^{2/3} \times s^{1/2}}{n}$$

where v = mean velocity (m/s)
R = hydraulic radius of flow (m)
s = average reach slope
n = Manning's roughness factor ($m^{1/6}$) =0.02
A = cross-sectional area of flow (m^2)
p = wetted perimeter of flow (m)