Fisheries and Oceans Canada | Pêches et Océans Canada

Suite 301, 5204 50th Avenue
Yellowknife, NT
X1A 1E2

February 11, 2019

Your files Votre référence
W2015L2-0001

Our file Notre référence
98-HCAA-CA6-00021

Ryan Fequet
Executive Director
Wek'eezhii Land and Water Board
1-4905 48th Street
Yellowknife, NT X1A 3S3

Dear Ryan Fequet,

Re: Information Request #6& #15 - Diavik Diamond Mines (2012) Inc. Technical Session (Pk to Mine Workings Amendment Application for W2015L2-0001)

The Fisheries Protection Program of Fisheries and Oceans Canada (DFO-FPP) wishes to thank the Wek'eezhii Land and Water Board (WLWB) for the opportunity to provide further information that may benefit other parties following the technical session noted above which was held on January 16-17, 2019.

The WLWB requested that DFO-FPP provide the following:
IR #6: To provide a copy of the relevant Diavik's Fisheries Act Authorization(s), follow-up correspondence related to any such Authorization(s), and the associated No-Net Loss Plan(s).

As the requested documents are agreements between DDMI and DFO-FPP, our department has requested confirmation from the proponent both at the technical session and in writing that they concur to releasing this information. DDMI has agreed on both occasions. Please find attached to this letter, the WLWB's requested documents and DDMI's letter of support.

IR #15 for All Parties:
To identify what additional information, if any, is necessary to inform the preliminary screening determination of the Amendment Application. If any, please provide rationale for why this information is needed.

DFO-FPP does not require further additional information from DDMI to inform the preliminary screening determination of the Amendment application at this time.

If you or any other parties require further information, please contact Angie McLellan at: 867-669-4924, or angie.mclellan@dfo-mpo.gc.ca

Sincerely,

Angie McLellan
Fisheries Protection Biologist
Fisheries Protection Program, Fisheries and Oceans Canada

cc:
Marek Janowicz, Regulatory Review Manager, DFO
Anneli Jokela, Regulatory Manager, WLWB
Sean Sinclair, Superintendent, Environment, DDMI

Attachments:
TAB 1: DDMI Fisheries Act Authorization SC980001, Section 32
TAB 2: DDMI Fisheries Act Authorization SC980001, Section 35(2)
TAB 3: DDMI Fisheries Act Authorization SC980001, Amended 22/08/2013
TAB 4: DDMI No Net Loss Plan, September 1998
TAB 5: DDMI No Net Loss Plan, April 1999
TAB 6: DDMI Letter of Support

Government of Canada | Gouvernement du Canada
Fisheries and Oceans | Pêches et Océans

August 2, 2000

Your file Votre référence

Our file Notre référence

SC980001

Diavik Diamond Mines Inc.
Post Office Box 2498
Suite 205, 5007-50th Avenue
Yellowknife, Northwest Territories X1A 2P8

Attention: Dr. Stephen F. Prest - President

Dear Dr. Prest:

RE: Authorization for the Destruction of Fish by Any Means Other Than Fishing Pursuant to Section 32 of the *Fisheries Act*

Fish Habitat Management – Western Arctic Area staff have completed their review of your application to use explosives, and destroy fish by means other than fishing in the waters of Lac de Gras and other smaller lakes identified in the attached Authorization. Based on the information you provided, it is our understanding that the explosives will be used for the purposes of mining and there are no practical alternatives other than explosives to achieve this task. Since the use of explosives in and near fish habitat has been shown to cause injury and/or death to fish, sometimes at considerable distance from the point of detonation, an Authorization To Destroy Fish By Means Other Than Fishing is hereby issued in accordance with Section 32 of the *Fisheries Act*. This Authorization shall be conditional upon implementation of mitigation measures specified on the attached document.

The environmental impacts of this undertaking have been reviewed by the Department of Fisheries and Oceans in accordance with the *Canadian Environmental Assessment Act*. This review concluded that the project is not likely to cause significant adverse environmental effects if the mitigation specified are implemented.

Failure to comply with any of the conditions specified on the attached Authorization may result in a contravention of Section 32 of the *Fisheries Act*.

NOTE: None of the foregoing should be taken to imply Authorization of this undertaking in accordance with any Section of the *Fisheries Act* **other** than Section 32. Also note that Authorization under the *Fisheries Act* does not release the proponent from the requirements of any other federal, territorial or municipal legislation.

Please contact me at (867) 669-4902, or Pete Cott at (867) 669-4913 should you have any questions or require additional information.

Pete Cott
for

Ron Allen
A/Area Director – Western Arctic Area

c. Pete Cott, DFO-FHM, A/Area Chief, Habitat
Dennis Wright – DFO-Science, Coordinator, Environmental Affairs
Neil Robinson, DFO-C&P, Supervisor/Fishery Officer
Murray Swyripa - DDMI, Vice-President, Environmental Affairs
Gord Macdonald - DDMI, Environmental Advisor
Heidi Klein - Mackenzie Valley Environmental Review Board, Executive Director

Canada

Fisheries and Oceans / Pêches et Océans

AUTHORIZATION TO DESTROY FISH BY ANY MEANS OTHER THAN FISHING
AUTHORISATION POUR DESTRUCTION DE POISSONS PAR AUTRES MOYENS QUE LA PECHE

DFO File No. SC98001
Authorization No./N° de l'autorisation

Authorization Issued To/Autorisation délivrée à

Name: Dr. Stephen F. Prest - President

Address: Diavik Diamond Mines Inc.
Post Office Box 2498
Suite 205, 5007-50th Avenue
Yellowknife, Northwest Territories X1A 2P8

Telephone: (867) 669-6500

Facsimile: (867) 669-9058

Location of Project/Emplacement du projet

On and adjacent to the East Island located on the eastern side of Lac de Gras, approximately 300 km northeast of Yellowknife in the Northwest Territories. Latitude 64°31' north, Longitude 110°20' west.

Valid Authorization Period/Période de validité

From/De: determined as indicated in section 12.0 **To/ À:** December 31, 2020

Description of Works or Undertakings/Description des ouvrages ou entreprises

Diavik Diamond Mines Inc. (DDMI) proposes to conduct open pit and underground mining of kimberlite pipes at their Lac de Gras mine site (Project). Explosives will be used as the primary method of excavating rock during construction and operation of the open pit mines. Small inland lakes known as e1, e3, e6, e7, e8 and e10 (as indicated in *the Project Plans*) will be draining or manipulated to conduct the Project. It is anticipated that the use of explosives and draining or manipulation of lakes associated with the conduct of this Project could result in death or injury to fish by means other than fishing.

Conditions of Authorization/Conditions de l'autorisation

1.0 Pursuant to s. 32 of the *Fisheries Act*, R.S.C., 1985, c. F. 14, the Minister of Fisheries and Oceans (DFO) authorizes DDMI to destroy fish by means other than fishing under the following conditions. In developing this Authorization, DFO considered its *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* (DFO 1998) (hereafter referred to as the *Guidelines*) and the *Policy for the Management of Fish Habitat* (DFO 1986).

2.0 For the purposes of this Authorization, mine activities are considered to be any activity undertaken with respect to the Project related to construction, operation, closure or post closure.

AUTHORIZATION TO DESTROY FISH BY ANY MEANS OTHER THAN FISHING
AUTHORISATION POUR DESTRUCTION DE POISSONS PAR AUTRES MOYENS QUE LA PECHE

DFO File No. SC98001
Authorization No./N° de l'autorisation

3.0 The approved documents include the works and/or undertakings proposed:

1.1 *Environmental Effects Report* documents, dated September 1998, prepared by DDMI;

1.2 The above documents are hereafter referred to as the *Project Plans*.

4.0 The weight of the explosive charges used shall be calculated based on the proximity of the charge to the limit of the Blast Zone (as identified in the *Project Plans*) such that the post-detonation shock wave produced and measured at the limit of the Blast Zone shall not exceed a maximum Peak Pressure of 100kPa.

5.0 The weight of the explosive charges used shall be calculated based on the proximity of the charge to the limit of the Blast Zone such that the Peak Particle Velocity produced and measured at the limit of the Blast Zone shall not exceed a maximum of 13 mm/s.

6.0 DDMI shall submit a Mitigation Plan to DFO for review and approval within one year following the issuance of this Authorization. This Mitigation Plan should suggest mitigation measures to be implemented in the event that the *Guidelines* are exceeded within the Blast Zone, methods proposed to deter fish (e.g. acoustic deterrents, plastic covering on spawning shoals etc.) from the Blast Zone, and a plan to monitor the success of the mitigation proposed.

7.0 DDMI shall develop and conduct a Blasting Effects Study and shall submit the Study Plan to DFO for review and approval a minimum of 3 months prior to the anticipated start date of blasting activities associated with both the A154 pit, as indicated in the *Project Plans*, that meets the objectives of:

7.1 Verifying the extent of the blasting zone beyond the centerline of the dike, both spatially and temporally;

7.2 Verifying the prediction that the extent of the blasting zone will decrease as the pit deepens;

7.3 Monitoring the areas outside of the dike for the presence of dead or moribund fish and conducting a necropsy on any dead fish to determine the magnitude of trauma to internal organs and structures;

7.4 Determining egg percent mortality and level of effect within the predicted and confirmed blast zone relative to control sites;

7.5 Developing mitigative measures to prevent potential impacts of blasting within and beyond the blast zone into Lac de Gras;

7.6 Providing DFO with adequate information to determine whether similar Blasting Effects Studies for the A418 and A21 pits are required.

8.0 Should the results of the either the Blasting Effects Study conclude that the Peak Pressure or the Peak Particle Velocity exceed the *Guidelines* within the Blast Zone, or should there be an excessive number of dead or moribund fish on the surface following a blast (as determined by DFO), DDMI shall invoke the Mitigation Plan and reconfigure the maximum weight of the explosives used for each charge so as to conform to the *Guidelines*.

AUTHORIZATION TO DESTROY FISH BY ANY MEANS OTHER THAN FISHING
AUTHORISATION POUR DESTRUCTION DE POISSONS PAR AUTRES MOYENS OUE LA PECHE

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Authorization No./N° de l'autorisation

9.0 Conditions for Authorization of the pits A418 and A21 shall be contingent on the results of the Mitigation Plan and the Blasting Effects Study and shall be determined by DFO.

10.0 Fish will be sacrificed during the draining of the small inland lakes known as e1, e3, e6, e7, e8 and e10 (identified in the *Project Plans*), the conditions to be followed are outlined in the Section 35 *Fisheries Act* Authorization issued concurrently with this Authorization.

11.0 A copy of this Authorization shall be at the work site during all work periods.

12.0 This Authorization is deemed to be in force on that day upon which DFO receives a copy thereof dated and signed by DDMI, to signify that DDMI has read and understood its content and undertakes to carry out the company activities accordingly.

The holder of this authorization is hereby authorized under the authority of section 32 of the *Fisheries Act*, R.S.C., 1985, c. F. 14, to carry out the work or undertaking described herein. It does not purport to release the applicant from any obligation to obtain permission from or to comply with the requirements of any other regulatory agencies.

Failure to comply with any condition of this authorization may result in charges being laid under the *Fisheries Act*.

This authorization form should be held on site and work crews should be made familiar with the conditions attached

Le détenteur de la présente est autorisé en vertu du paragraphe 32 de la *Loi sur les pêches*, L.R.C. 1985, ch. F. 14, à exploiter les ouvrages ou entreprises décrits aux présentes. Elle ne dispense pas le requérant de l'obligation d'obtenir la permission d'autres organismes réglementaires concernés ou de se conformer à leurs exigences.

En vertu de la *Loi sur les pêches*, des accusations pourront être portées contre ceux qui ne respectent pas les conditions prévues dans la présente autorisation.

Cette autorisation doit être conservée sur les lieux des travaux, et les équipes de travail devraient en connaître les conditions.

AUTHORIZATION TO DESTROY FISH BY ANY MEANS OTHER THAN FISHING
AUTHORISATION POUR DESTRUCTION DE POISSONS PAR AUTRES MOYENS QUE LA PECHE

DFO File No. SC98001
Authorization No./N° de l'autorisation

Date of Issuance: 2-8-00

Approved by: for Ron Allen
A/ Area Director
Western Arctic Area
Fisheries and Oceans Canada
Central and Arctic Region

Prepared by: Dennis Wright
Coordinator, Environmental Affairs
Science – Winnipeg, Manitoba
Fisheries and Oceans Canada
Central and Arctic Region

Pete Cott
A/Area Chief, Habitat
Western Arctic Area
Fisheries and Oceans Canada
Central and Arctic Region

Dr. Stephen F. Prest – President
Diavik Diamond Mines Inc.

Signature:

Witness:
Diavik Diamond Mines Inc.

Signature:

Copy signed by DDMI received by DFO

Signature:

Date:

AUTHORIZATION FOR WORKS OR UNDERTAKING AFFECTING FISH HABITAT
AUTHORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON

DFO File No. SC98001
Authorization No./N° de l'autorisation

Authorization Issued To/Autorisation délivrée à

Name: Dr. Stephen F. Prest - President

Address: Diavik Diamond Mines Inc.
Post Office Box 2498
Suite 205, 5007-50th Avenue
Yellowknife, Northwest Territories X1A 2P8

Telephone: (867) 669-6500

Facsimile: (867) 669-9058

Location of Project/Emplacement du projet

On and adjacent to the East Island located on the eastern side of Lac de Gras, approximately 300 km northeast of Yellowknife in the Northwest Territories. Latitude 64°31' North, Longitude 110°20' West.

Valid Authorization Period/Période de validité

The valid authorization period for the harmful alteration, disruption or destruction of fish habitat from the activities described in the section below, "Description of HADD Works or Undertakings", is from August 2, 2000, as determined in section 18.0 of this authorization, to December 31, 2025. The valid authorization period for studies, compensation works, monitoring, and other conditions of this authorization are as set out below.

Description of HADD Works or Undertakings/Description des ouvrages ou entreprises

Diavik Diamond Mines Inc. (DDMI) proposes to conduct open pit and underground mining of kimberlite pipes at their Lac de Gras mine site (Project). It is anticipated that activities related to the Project will cause the following harmful alteration, disruption or destruction (HADD) of fish habitat:

(i) In addition to other lakes and ponds within the mine footprint that were determined not to be fish habitat, fish habitat in the following six lakes on the East Island identified in the *Project Plans* will be destroyed due to mine development: e1, e3, e6, e7, e8, and e10,

ii) Fish habitat in streams on the east island will be destroyed due to mine development;

iii) Fish habitat in Lac de Gras will be destroyed due to the placement of rock in the lake to construct approximately 5 kilometers of dikes;

iv) Fish habitat in Lac de Gras (inside of the dikes) will be destroyed due to open pit mining;

v) Fish habitat in the North Inlet of Lac de Gras will be destroyed due to the construction of a dike across the mouth of the inlet, and the use of the inlet as part of DDMI's water management system;

vi) Fish habitat in Lac de Gras will be altered due to the construction of a rock jetty to support a water intake structure and;

AUTHORIZATION FOR WORKS OR UNDERTAKING AFFECTING FISH HABITAT
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vii) Fish habitat in Lac de Gras will be altered due to the deposit of sediment as a result of dredging and dike construction.

The above are collectively referred to as "Project Effects".

Conditions of Authorization/Conditions de l'autorisation

1.0 Pursuant to subsection 35(2) of the *Fisheries Act*, the Minister of Fisheries and Oceans (DFO) authorizes DDMI to cause the Project Effects by the following means or under the following conditions. In developing this Authorization, DFO considered its *Policy for the Management of Fish Habitat* (DFO 1986).

2.0 For the purposes of this Authorization, mine activities are considered to be any activity undertaken with respect to the Project related to construction, operation, closure and post closure.

3.0 DDMI confirms that all plans and specifications for all works and undertakings proposed relating to this Authorization have been duly prepared and reviewed by appropriate professionals working on behalf of DDMI. DDMI acknowledges that it is solely responsible for all design, safety and workmanship aspects of all works associated with this Authorization.

4.0 The approved drawings and documents include those specifying the works and/or undertakings proposed, mitigative measures, compensation and monitoring requirements:

4.1 *No Net Loss Plan Addendum*, (NNL Plan Addendum) dated April 12, 1999, prepared by DDMI;

4.2 *No Net Loss Plan*, (NNL Plan) dated August 1998, prepared by DDMI;

4.3 *Environmental Effects Report* documents, dated September 1998, prepared by DDMI;

4.3.1 *Environmental Effects Report, Fish and Water*, dated September 1998, prepared by DDMI;

4.4 *Project Description Submission*, dated March 1998, prepared by DDMI;

4.5 *Class A Water Licence Application*, dated March 4, 1998 submitted by DDMI

4.6 *"Terms of Reference" - Habitat Utilization Study*, dated June 15, 2000, and signed by Murray Swyripa, DDMI;

4.7 The above drawings and documents are hereafter referred to as the *Project Plans*.

4.8 DDMI shall notify DFO of any proposed changes to the *Project Plans*, activities or methodologies that have the potential to adversely impact fish and/or fish habitat.

5.0 Reporting Requirements and Approvals

Original document August 2, 2000

AUTHORIZATION FOR WORKS OR UNDERTAKING AFFECTING FISH HABITAT AUTHORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON

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5.1 DDMI shall submit all study, compensation, monitoring and other plans required under this Authorization to DFO for review and approval a minimum of 3 months prior to the initiation of the corresponding studies etc., unless otherwise specified within this Authorization or approved by DFO.

5.2 DDMI shall ensure that all study, compensation, monitoring and other plans initiated are completed in a reasonably timely manner and DDMI shall submit all study reports etc., required under this Authorization, to DFO for review and approval a maximum of 6 months after completion of the corresponding studies, unless otherwise specified within this Authorization or approved by DFO.

5.3 Any and all requirements outlined within this Authorization, including habitat compensation, studies, and reporting, shall be done to the satisfaction of DFO.

6.0 Compensation for the HADD of fish habitat

6.1 DDMI shall compensate for the HADD of fish habitat though the following;

Inland Lakes

6.1.1 Compensation for the HADD of at least 4.6 habitat units (HUs, equal to habitat suitability index multiplied by area for the following inland lakes indentified in the *Plan*: e1, e3, e6, e7, e8 and e10) of inland lake habitat on the East Island shall be achieved by the enhancement of existing lakes within the Project area, namely;

6.1.1.1 Creating connections suitable for water movement and fish passage among lakes designated as m1, m2 & m3 on the mainland (as identified in the *NNL Plan Addendum*), to achieve a gain of approximately 3.7 HUs;

6.1.1.2 Enhancing at least one east island lake (lakes e11, e14 or e17, as identified in the *NNL Plan*) with the goal of enhancing limiting habitat types and structures such that the productive capacity of the habitat in the chosen lake (or lakes) is increased for an approximate gain of 3.3 HUs;

6.1.1.3 Ensuring that the total gained HUs:lost HUs ratio for inland lake fish habitat is 1.5 or better.

Streams

6.1.2 Compensation for the HADD of stream habitat on the East Island shall be achieved through the enhancement of a stream denoted as ws1 located on the West Island between lake w1 and Lac de Gras as well as incorporation of habitat features in the connector stream created between lakes m1 and m3 on the mainland, as identified in the *NNL Plan* and *NNL Plan Addendum*;

Original document August 2, 2000

AUTHORIZATION FOR WORKS OR UNDERTAKING AFFECTING FISH HABITAT
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6.1.2.1 The habitat compensation shall be in the form of improving in-stream habitat and improving fish passage, for those fish species identified as using streams in the project area, within the streams as identified in the *NNL Plan* and *NNL Plan Addendum*.

Lac De Gras

6.1.3 Compensation for the HADD of at least 77 HUs of fish habitat within Lac de Gras (accounting for habitat impacted due to the dike footprints, North Inlet development, open pit mining, and the construction of the water intake structure) shall be achieved as follows;

6.1.3.1 By the development of shallow rearing habitat, spawning shoals and shoreline habitat within the diked areas around the open pits in Lac de Gras upon completion of mining in each open pit;

6.1.3.2 By ensuring that habitat features within the diked areas, upon completion of mining in each open pit (including depth, substrate type, size and configuration), are modeled after those features found in other productive areas of the lake, as well as incorporating traditional knowledge where applicable;

6.1.3.3 By the enhancement of the outer edges of the dikes around the open pits for fish spawning by incorporating optimal features used by those fish such as; substrate size, shape, slope, suitable wave exposure and proximity to complementary habitat types and features;

6.1.3.3.1 Dike enhancement on the lake side of the dikes shall not commence until DDMI has satisfactorily demonstrated (in a report submitted to DFO prior to dike enhancement) that water quality due to dike leaching and potential effects due to blasting (as per the section 32 *Fisheries Act* Authorization issued concurrently with this Authorization) will not adversely affect fish targeted in the enhancement efforts.

6.1.3.4 By constructing the water intake support jetty with slopes and materials as specified in the engineering designs submitted for the section 30 *Fisheries Act* Approval issued April 6, 2000.

6.1.3.5 By ensuring that fish habitat compensation efforts in Lac de Gras will achieve a total gained HUs:lost HUs ratio of 1.2 or better.

6.1.4 Fish sa lvage methods shall be developed and implemented for moving fish from behind the dikes into Lac de Gras so as to minimize mortalities and allow complete documentation of species composition, numbers and mortalities.

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6.1.5 DDMI shall report on the fish salvage in side of each dike (in particular the methods employed and results) within 3 months of completing the dewatering of the respective dike pools.

Compensation and Monitoring Plans

6.2 DDMI shall develop implementation plans for compensation of fish habitat, hereafter knows as *Compensation Plans*;

6.2.1 Develop *Compensation Plans* for each of the above mentioned areas of habitat compensation. At a minimum these plans must include a description of the process for consultation with First Nations groups and DFO, scheduling, compensation strategies, engineering design, and construction activities. The following *Compensation Plans* shall be submitted to DFO for review and approval one year following the issuance of this Authorization:

6.2.1.1 A *Compensation Plan* for the enhancement of inland lake and stream habitat;

6.2.1.2 A *Compensation Plan* for the development of habitat within the diked areas of Lac de Gras, and;

6.2.1.3 A *Compensation Plan* for the enhancement of habitat external to the dikes

6.2.2 DDMI shall develop and submit to DFO, within two years of the issuance of this Authorization, the design specifications in the *Compensation* as per the approaches contained within DDMI's *No Net Loss Plan* and *No Net Loss Addendum*, with full consideration of input received through consultation with affected First Nations groups and further consultation with DFO.

6.2.3 Design specifications in the *Compensation Plans* shall be developed with considerations for such things as timing, engineering techniques, and contingencies.

6.3 DDMI shall develop, in consultation with affected First Nations groups *Monitoring Plans* for determining the effectiveness of all habitat enhancement and development efforts and shall submit these *Monitoring Plans* to DFO one year following the issuance of this Authorization:

6.4 DDMI shall develop the *Compensation Plans* and *Monitoring Plans* with specific consideration for the terms denoted in Section 6.1;

6.5 DDMI shall alter or modify the habitat compensation approach or structures, as required by DFO, to obtain the level of lake and stream habitat compensation to the satisfaction of DFO.

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AUTHORIZATION FOR WORKS OR UNDERTAKING AFFECTING FISH HABITAT
AUTHORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON

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6.6 DDMI shall submit estimates of pit water quality for each dike area updated with the results of the water quality monitoring as per Section 11.0, a minimum of three months prior to the anticipated date of commencement of habitat compensation works within each dike area.

6.6.1 DDMI shall demonstrate that water quality will be acceptable to DFO prior to any dike breaching as per Section 11.1.2;

6.6.2 If water quality within the diked area is unacceptable, DDMI shall submit a revised *Compensation Plan* (within six months of the unacceptable water quality results) for habitat compensation within the A21 area of Lac de Gras prior to implementing compensatio n efforts within that dike.

6.6.3 Upon demonstration of acceptable water quality, DDMI shall commence with the *Compensation Plans* for each of the diked areas provided that;

6.6.3.1 The locations and sizes of dike breaches are specified within the *Navigable Waters Protection Act* Permit (issued concurrently with this Authorization).

6.7 DDMI shall submit a report on the habitat compensation efforts (a final calculation of actual habitat losses and habitat gains expressed as HUs for each of the dikes) including and follow-up monitoring within one year of the breaching of each dike;

6.8 DDMI shall maintain all habitat compensation as required, and monitor, verify and report on the effectiveness of the compensation efforts that will be outlined in the *Compensation and Monitoring Plans* as approved by DFO;

6.8.1 Results from A21 monitoring shall be used to modify habitat compensation plans and monitoring plans, as necessary, for the A154 and A418 areas ,

6.9 The conditions detailed in Sections 6.7 shall also apply to the A154 diked area and the A418 diked area.

7.0 Fish-out Studies:

7.1 DDMI shall conduct Fish-out Studies, as per approved study design, on each of the following lakes on the East Island scheduled for dewatering; e3, e7, e8, and e10.

7.2 DDMI shall submit reports on the Fish-out Studies within six months of the initiation of dewatering any of the following lakes: e3, e7, e8, and e10.

7.3 These reports shall include results, data analyses, discussion of the results and recommendations.

8.0 Fish Habitat Utilization Study

Original document August 2, 2000

AUTHORIZATION FOR WORKS OR UNDERTAKING AFFECTING FISH HABITAT
AUTHORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON

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8.1 DDMI shall conduct a Fish Habitat Utilization Study as indicated in the *Project Plan*, that meets the following general objectives;

8.1.1 Two years prior to in-lake dike construction activities, approximately 25 fish are to be tagged, approximately half from an area near the dike and the others from high quality habitat in another part of Lac de Gras. The tagged fish shall be monitored to determine the linkage between these fish and habitat usage (including spawning, feeding, over-wintering habitat).

8.1.2 Link information obtained in the radio-tagging component of the study to existing habitat mapping work that has been conducted for Lac de Gras.

8.1.3 Monitor the fish habitat use in the vicinity of the mine (including shoals) on an annual basis, to determine if use of these habitats has been altered, as indicated in the *Project Plan*.

8.2 DDMI shall submit a report on this study with specific reference to the objectives in section 8.1 following the completion of the study.

9.0 Fish Palatability and Texture Study

9.1 Within two years of the issuance of this Authorization DDMI shall, in cooperation with DFO and affected First Nations groups, develop and conduct a 'Fish Palatability and Texture Study' to ensure that fish palatability and texture is not degraded by mining activities. Once the study methods have been finalized, testing shall be conducted to determine pre-mining conditions. Additional testing at a frequency of once every five years shall be conducted thereafter, unless DFO receives complaints of effects on fish palatability and/or texture in writing. In this case the frequency of testing shall increase as directed by DFO.

9.1.1 Fish tissue metal analysis shall be conducted prior to the fish being utilized for this study.

9.2 Where practical sampling of fish shall be coordinated with the monitoring of fish populations and indices of health as per Section 10.0, with the goal of reducing the number of fish sacrificed.

9.3 DDMI shall submit a report on the results of this study each year after the studies are conducted, unless otherwise agreed to by DFO.

9.3.1 Such reports shall also suggest mitigative measures which will be implemented by DDMI if the results show that palatability and/or texture of fish is being degraded by mining activities.

10.0 Monitoring of fish populations and indices of fish health

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Original document August 2, 2000

AUTHORIZATION FOR WORKS OR UNDERTAKING AFFECTING FISH HABITAT
AUTHORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON

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10.1 Fish populations and indices of fish health in Lac de Gras shall be monitored through;

10.1.1 Obtaining a randomized sample of fish (not to exceed 60 fish, see section 11.1.5.3) every 5 years from the Project area to collect data on length, weight, age at maturity, fecundity, contaminant load and food habits;

10.1.1.1 Such sampling shall be coordinated with other requirements of this Authorization with the goal of reducing the number of fish sacrificed.

10.2 The results of the fish population and indices of fish health monitoring shall be provided following the year being reported on, unless otherwise agreed to by DFO.

11.0 Monitoring of water quality, metals and trace elements

11.1 DDMI shall verify their predictions of impacts on fish and fish habitat as presented in their *Environmental Assessment Report* documents, dated September 1998, by monitoring and reporting results regarding the following:

11.1.1 Water quality of pit inflows to estimate pit water quality prior to flooding each pit;

11.1.2 Undertaking verification sampling prior to dike breaching to ensure water quality parameters within the diked areas acceptable to DFO;

11.1.3 Metal and trace element concentrations in dike interstitial water, verification of metal and trace element leaching rates from the dikes, and verification of predicted spatial and seasonal water column concentrations of such metals and trace elements concentrations at various locations adjacent to the dikes;

11.1.4 Metal concentrations in sediment samples and benthic invertebrate samples obtained from sites radiating from the mine water discharge, at the 60m mixing zone boundary, adjacent to the dikes in Lac de Gras, and at control sites, both prior to mine activities and following the onset of mine activities and every three years thereafter; OK

11.1.4.1 Metal analysis is to be done on total benthic invertebrate biomass in the event that there is not enough biomass of individual taxa to do separate analyses. If an adequate protocol for invertebrate metal analysis cannot be carried out, DFO shall be informed of sampling efforts and a request may be made to amend the requirement for benthic invertebrate metal analysis. OK

11.1.4.2 The results and interpretation of the metal analysis of sediment core samples and benthic invertebrate samples, unless amended as per section 11.1.4.1, along with an analysis of changes in benthic communities, shall be submitted to DFO within 6 months of sampling, unless otherwise agreed to by DFO. OK

Amended May 16, 2001

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11.1.5 Slimy sculpins (*Cottus cognatus*) shall be sampled prior to dredging and dike construction to provide pre-activity baseline data for metallothionein and metals;

11.1.5.1 If, post-activity, chemical analysis of waters and sediments demonstrate elevations in metals and trace elements (based on annual review of water and sediment quality data), annual sampling of slimy sculpin shall be initiated at the end of the open water season from no less than six sites local to the vicinity of the mine site (the same sites to be used annually), to obtain at least twenty fish per site;

11.1.5.2 Visceral contents (stomach, intestine and all other internal abdominal organs) shall be analysed for metals and metallothionein, and the remaining carcass (muscle, skin, and fins, but not the head) shall be analysed for metals.

11.1.5.3 If the interpretation of the results from the slimy sculpin sampling indicate that, relative to pre-activity results, metals and/or trace element bioavailablility has increased and that the fish species metallothionein production has also increased then, lake trout (*Salvelinus namaycush)* as well as round whitefish (*Prosopium cylindraceum*), shall be sampled at no less than three sites to obtain at least twenty fish per site (the same sites to be used annually), per species, at the end of the next open water season, and every three years thereafter.

11.1.5.4 Lake trout and whitefish kidneys and livers shall be analysed for metals and metallothionein, and muscle tissue analysed for metals.

11.1.5.4.1 The results and interpretation of the metal and methallothionein monitoring in Lac de Gras fish shall be provided followinig sampling, unless otherwise agreed to by DFO.

11.1.5.5 If the metals and/or trace element bioavailablility and/or metallothionein production has increased to a level unacceptable to DFO then mitigation shall be initiated.

11.2 Measurements of under ice dissolved oxygen levels shall be periodically taken in the vicinity of the sewage outfall in Lac de Gras to monitor for potential oxygen depletion;

11.2.1 If dissolved oxygen is depressed to a level that may represent adverse impact to fish and/or habitat, then mitigative measures shall be employed.

12.0 Total suspended solids (TSS) in relation to dredging and dike construction

12.1 DDMI shall monitor <u>daily</u> discrete depth total suspended solids (TSS) concentrations during all dredging and dike construction (A154, A418, A21 and North Inlet) and ensure established target

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thresholds for TSS are not exceeded at agreed upon monitoring location located around dredging activities;

12.1.1 Threshold value of 45 mg/L TSS for a 110 day average (final compliance limit) is not to be exceeded beyond the monitoring locations established in 12.1.2, to minimize adverse effects on fish;

12.1.2 For the purposes of TSS monitoring, monitoring locations are to be established as close as is practical to the 200m boundary is measured from the toe of the dike and will be marked by buoys;

12.1.3 The 110 day average shall be based on discrete depth TSS measurements taken at the depth of greatest TSS concentration as determined by daily turbidity profiles.

12.1.3.1 The data used for calculations of the average shall be the day's actual measurements plus the preceding 109 days' measurements. Pre-construction measurements will be deemed average background TSS levels.

12.1.3.2 Missing data (e.g. when weather conditions make sampling unsafe) shall be substituted with a TSS estimate based on turbidity data derived from automated turbidity meters at each fixed station, using a TSS/turbidity relationship.

12.2 DDMI shall monitor daily discrete depth TSS concentrations and turbidity profiles and notify DFO immediately if TSS levels reach 75% of the threshold values established in 12.1.1;

12.3 During dredging and dike construction and throughout the open water season, DDMI shall determine the spatial and temporal extent of the TSS plume in Lac de Gras (defined as TSS concentrations above background). This shall be accomplished through weekly TSS and turbidity surveys at appropriate sampling stations, delineating the plume, as well as expressing the plume area as a percentage of the total fish habitat available in the eastern basin of Lac de Gras.

12.4 DDMI shall determine sediment deposition on shoal habitat adjacent to the dikes and compare these areas and amounts of sedimentation to those predicted by dispersion modeling. DDMI shall verify that the shoals are washed clean one year following the completion of dredging activities. If the shoals are not washed clean as predicted, additional fish habitat compensation may be required.

12.5 DDMI shall conduct a biological survey of the benthic invertebrate community, and an analysis of sediment composition and water chemistry prior to and after sediment deposition due to dredging and dike construction activities, to assess changes in benthic community composition, abundance and distribution. OK

12.5.1 Benthic invertebrate samples shall be obtained at sites adjacent to the dike alignments within the zones of sediment deposition and at control sites. OK

Amended May 16, 2001

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12.6 To mitigate impacts to fish habitat in Lac de Gras beyond the dike dredging and construction activities, a continuous floating silt curtain material shall be deployed.

ok

12.7 The sediment curtain deployed to the south of the A154 dike alignment (in the vicinity of stations referred to as stations 1645-64 and -65 in the NWT Water License N7L2-1645 and amended to 1645-58 and -59) shall be moved further north such that the maximum amount of shoreline is protected from further inundation by suspended and deposited sediments. This adjustment of the sediment curtain shall be done as soon as the dredge anchors have moved beyond this area and will no longer interfere with the sediment curtain anchors.

ok

12.8 TSS measurements and levels/conditions shall be made available to DFO on a weekly basis throughout the dike construction activities unless otherwise required (see section 12.2).

12.9 Dredged material resulting from the construction of dike A154 shall be deposited via pipeline to a land based containment facility on the East Island. Dredged material resulting from the construction of dikes A418 and A21 shall be deposited via pipeline to the North Inlet Facility. All dredged material shall be contained to prevent re-entry into Lac de Gras.

13.0 No Fishing Policy

13.1 DDMI shall develop and enforce a policy that prohibits fishing on Lac de Gras, in the East Island lakes or streams by individuals on the mine site in a capacity as mine employee, contractor or visitor during all phases of mining activities, unless otherwise agreed to by DFO.

13.1.1 This Policy shall be made available and understood by individuals on the mine site in a capacity as mine employee, contractor or visitor during all phases of mining activities.

14.0 Security Deposit:

14.1 DDMI shall provide DFO with a monetary deposit as security for the performance by DDMI with regard to all of its obligations under this Authorization, including the required breaching of dikes, fish habitat compensation, 3 years of post breaching compensation monitoring (per dike), reporting, and additional work determined by DFO if required, according to the following schedule:

a) prior to commencement of dredging and dike construction of the A154 pit an amount of one million five hundred thousand ($ 1,500,000.00) dollars.

b) prior to commencement of dredging and dike construction of the A418 pit an additional nine hundred thousand ($ 900,000.00) dollars.

c) prior to commencement of dredging and dike construction of the A21 pit an additional one million five hundred thousand ($ 1,500,000.00) dollars.

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14.2 The security deposit provided by DDMI must be in a form agreed to by DFO.

14.3 DDMI shall maintain the deposited amounts until all DDMI's obligations under this Authorization are satisfied.

14.4 At the discretion of DFO, the amount of the security deposit may be adjusted annually to account for fish habitat compensation completed or to accomplish additional work that DFO may require to satisfy the objectives of fish habitat compensation.

14.5 DFO shall be able to call on the security deposit unconditionally if DDMI does not meet any of the requirements outlined within this Authorization, as determined solely by DFO.

14.6 To the extent not prohibited by law, DDMI shall have the right to audit, from time to time with reasonable notice to DFO and at DDMI's expense, any expenditure of funds withdrawn by DFO.

14.7 Once DDMI has completed to the satisfaction of DFO all studies, reports and works required by DFO, DFO shall return to DDMI any unused portion of the security deposit.

General Conditions:

15.0 DDMI shall ensure that no adverse impacts to fish and/or fish habitats occur as a result of the Project beyond those impacts that have been identified and compensated for under this agreement, unless authorized by DFO.

16.0 Any deviation from ***the Plan***, the construction schedule or the mitigation and compensation measures stated above that may potentially affect fish or fish habitat, must be discussed and approved in writing by the Department of Fisheries and Oceans - Fish Habitat Management, Western Arctic Area prior to implementation.

17.0 A copy of this Authorization shall be at the work site during all work periods. Work crews shall be made familiar with the conditions of this Authorization prior to implementation of the works or undertakings.

18.0 This Authorization is deemed to be in force on that day upon which DFO receives a copy thereof dated and signed by DDMI, to signify that DDMI has read and understood its content and undertakes to carry out the company activities accordingly.

The holder of this Authorization is hereby authorized under the authority of section 35(2) of the *Fisheries Act*, R.S.C., 1985, c. F. 14, to carry out the work or undertaking described herein. This Authorization is valid only with respect to fish habitat and for no other purposes. It does not purport to release the applicant from any obligation to obtain permission from or to comply with the requirements of any other regulatory agencies.

Failure to comply with any condition of this Authorization may result in charges being laid under the *Fisheries Act*.

Original document August 2, 2000

Fisheries and Oceans   Pêches et Océans

AUTHORIZATION FOR WORKS OR UNDERTAKING AFFECTING FISH HABITAT
AUTHORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON

DFO File No. SC98001
Authorization No./N° de l'autorisation

This Authorization form should be held on site and work crews should be made familiar with the conditions attached.

Le détenteur de la présente est autorisé en vertu du paragraphe 35(2) de la *Loi sur les pêches*, L.R.C. 1985, ch. F. 14, à exploiter les ouvrages ou entreprises décrits aux présentes.
L'autorisation n'est valide qu'en ce qui concerne l'habitat du poisson et pour aucune autre fin. Elle ne dispense pas le requérant de l'obligation d'obtenir la permission d'autres organismes réglementaires concernés ou de se conformer à leurs exigences.

En vertu de la *Loi sur les pêches*, des accusations pourront être porteés contre ceux qui ne respectent pas les conditions prévues dans la présente autorisation.

Cette autorisation doit être conservée sur les lieux des travaux, et les équipes de travail devraient en connaître les conditions.

Date of Issuance:

Approved by:

Ron Allen
A/ Area Director
Western Arctic Area
Fisheries and Oceans Canada
Central and Arctic Region

Prepared by: Julie Dahl
Pete Cott

Fish Habitat Management
Western Arctic Area
Fisheries and Oceans Canada
Central and Arctic Region

Dr. Stephen F. Prest – President
Diavik Diamond Mines Inc.

Signature:

Witness:
Diavik Diamond Mines Inc.

Signature:

Copy signed by DDMI received by DFO

Signature:

Date:

Original document August 2, 2000

Canada

Fisheries and Oceans Canada	Pêches et Océans Canada

#301, 5204-50th Ave.
Yellowknife, NT
X1A 1E2

August 22, 2013

Our file Notre référence
98-HCAA-CA6-00021

Gord Macdonald
Diavik Diamond Mines Inc.
Post Office Box 2498
Suite 205, 5007-50th Avenue
Yellowknife, NWT X1A 2P8

Dear Mr. Macdonald:

Subject: Diavik Diamond Mines Inc. (DDMI) Fisheries Act Authorization SC98001 – amended conditions

As you are aware, I will be leaving Fisheries and Oceans Canada – Fisheries Protection Program (DFO) on August 23, 2013. Kelly Eggers will be the new fish habitat biologist assigned to the Diavik file. Therefore, to assist with the transition I would like to take this opportunity to amend conditions within the Authorization to provide you with the current status of DDMI's obligations.

Condition:

6.0 Compensation for the HADD of fish habitat

Inland Lakes

6.1.1 Compensation for the HADD of at least 4.6 habitat units (HUs, equal to habitat suitability index multiplied by area for the following inland lakes indentified in the Plan: e1, e3, e6, e7, e8 and e10) of inland lake habitat on the East Island shall be achieved by the enhancement of existing lakes within the Project area, namely

6.1.1.1 Creating connections suitable for water movement and fish passage among lakes designated as m1, m2 & m3 on the mainland (as identified in the NNL Plan Addendum), to achieve a gain of approximately 3.7 HUs;

6.1.1.2 Enhancing at least one east island lake (lakes e11, e14 or e17, as identified in the NNL Plan) with the goal of enhancing limiting habitat types and structures such that the productive capacity of the habitat in the chosen lake (or lakes) is increased for an approximate gain of 3.3 HUs.

Streams

6.1.2 Compensation for the HADD of stream habitat on the East Island shall be achieved through the enhancement of a stream denoted as ws1 located on the West Island between lake w1 and Lac de Gras as well as incorporation of habitat features in the connector stream created between lakes m1 and m3 on the mainland, as identified in the NNL Plan and NNL Plan Addendum;

Status:

6.1.1.1
Project plan for the m-lakes has been approved and constructed. Completion of monitoring field work, potential minor adjustments based on monitoring results, reporting and submission of as-built reports are still required.

6.1.1.2
The requirement for enhancement of at least one east island lake has been replaced with the requirement to complete two off-site, community-based projects, one in Lutsel k'e and one in Kugluktuk as agreed upon by DFO.

6.1.2
Project plan for the west island stream (ws1) has been approved and constructed. Completion of monitoring field work, potential minor adjustments based on monitoring results, reporting and submission of as-built reports are still required

Condition:

6.1.3.3 By the enhancement of the outer edges of the dikes around the open pits for fish spawning by incorporating optimal features used by those fish such as; substrate size, shape, slope, suitable wave exposure and proximity to complementary habitat types and features;

6.1.3.3.1 Dike enhancement on the lake side of the dikes shall not commence until DDMI has satisfactorily demonstrated (in a report submitted to DFO prior to dike enhancement) that water quality due to dike leaching and potential effects due to blasting (as per the section 32 Fisheries Act Authorization issued concurrently with this Authorization) will not adversely affect fish targeted in the enhancement efforts.

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Status:

Based on the conclusions reached in *Assessment of the Use of Dikes at Diavik Diamond Mine Lac de Gras for Lake Trout Spawning 2011* (Fitzsimons, 2013), it was determined that there was no compelling reason to attempt to enhance the outer dikes to provide spawning habitat. Additional fish habitat was created as part of the West Island Stream Project; therefore, dike enhancement works are no longer required.

Condition:

6.1.3.4 By constructing the water intake support jetty with slopes and materials as specified in the engineering designs submitted for the section 30 Fisheries Act Approval issued April 6, 2000.

Status:

This work has been completed; therefore, this condition has been met.

Condition:

8.0 Fish Habitat Utilization Study

8.1 DDMI shall conduct a Fish Habitat Utilization Study as indicated in the Project Plan, that meets the following general objectives;

8.1.1 Two years prior to in-lake dike construction activities, approximately 25 fish are to be tagged, approximately half from an area near the dike and the others from high quality habitat in another part of Lac de Gras. The tagged fish shall be monitored to determine the linkage between these fish and habitat usage (including spawning, feeding, over-wintering habitat).

8.1.2 Link information obtained in the radio-tagging component of the study to existing habitat mapping work that has been conducted for Lac de Gras.

8.1.3 Monitor the fish habitat use in the vicinity of the mine (including shoals) on an annual basis, to determine if use of these habitats has been altered, as indicated in the Project Plan.

8.2 DDMI shall submit a report on this study with specific reference to the objectives in section 8.1 following the completion of the study.

Status:

The fish habitat utilization study was deemed complete December 2, 2008; therefore, this condition has been met.

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Condition:

9.0 Fish Palatability and Texture Study

9.1 Within two years of the issuance of this Authorization DDMI shall, in cooperation with DFO and affected First Nations groups, develop and conduct a 'Fish Palatability and Texture Study' to ensure that fish palatability and texture is not degraded by mining activities. Once the study methods have been finalized, testing shall be conducted to determine pre-mining conditions. Additional testing at a frequency of once every five years shall be conducted thereafter, unless DFO receives complaints of effects on fish palatability and/or texture in writing. In this case the frequency of testing shall increase as directed by DFO.

9.1.1 Fish tissue metal analysis shall be conducted prior to the fish being utilized for this study.

9.2 Where practical sampling of fish shall be coordinated with the monitoring of fish populations and indices of health as per Section 10.0, with the goal of reducing the number of fish sacrificed.

9.3 DDMI shall submit a report on the results of this study each year after the studies are conducted, unless otherwise agreed to by DFO.

9.3.1 Such reports shall also suggest mitigative measures which will be implemented by DDMI if the results show that palatability and/or texture of fish is being degraded by mining activities.

Status:

A fish palatability study is now required under the Water Licence. To avoid duplication of regulatory requirements, this condition is no longer required under the *Fisheries Act* Authorization.

Condition:

10.0 Monitoring of fish populations and indices of fish health

10.1 Fish populations and indices of fish health in Lac de Gras shall be monitored through;

10.1.1 Obtaining a randomized sample of fish (not to exceed 60 fish, see section 11.1.5.3) every 5 years from the Project area to collect data on length, weight, age at maturity, fecundity, contaminant load and food habits;

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10.1.1.1 Such sampling shall be coordinated with other requirements of this Authorization with the goal of reducing the number of fish sacrificed.

10.2 The results of the fish population and indices of fish health monitoring shall be provided following the year being reported on, unless otherwise agreed to by DFO.

11.1.5 Slimy sculpins (Cottus cognatus) shall be sampled prior to dredging and dike construction to provide pre-activity baseline data for metallothionein and metals;

11.1.5.1 If, post-activity, chemical analysis of waters and sediments demonstrate elevations in metals and trace elements (based on annual review of water and sediment quality data), annual sampling of slimy sculpin shall be initiated at the end of the open water season from no less than six sites local to the vicinity of the mine site (the same sites to be used annually), to obtain at least twenty fish per site;

11.1.5.2 Visceral contents (stomach, intestine and all other internal abdominal organs) shall be analysed for metals and metallothionein, and the remaining carcass (muscle, skin, and fins, but not the head) shall be analysed for metals.

11.1.5.3 If the interpretation of the results from the slimy sculpin sampling indicate that, relative to pre-activity results, metals and/or trace element bioavailablility has increased and that the fish species metallothionein production has also increased then, lake trout (Salvelinus namaycush) as well as round whitefish (Prosopium cylindraceum), shall be sampled at no less than three sites to obtain at least twenty fish per site (the same sites to be used annually), per species, at the end of the next open water season, and every three years thereafter.

11.1.5.4 Lake trout and whitefish kidneys and livers shall be analysed for metals and metallothionein, and muscle tissue analysed for metals.

11.1.5.4.1 The results and interpretation of the metal and methallothionein monitoring in Lac de Gras fish shall be provided following sampling, unless otherwise agreed to by DFO.

11.1.5.5 If the metals and/or trace element bioavailablility and/or metallothionein production has increased to a level unacceptable to DFO then mitigation shall be initiated.

Status:

Monitoring of fish populations and indices of fish health is now included in the Aquatic Effects Monitoring Program required under the Water Licence. To avoid duplication in regulatory requirements, this condition is no longer required under the *Fisheries Act* Authorization. DFO will provide recommendations and advice to the Wek'eezhii Land and Water Board as required regarding the fish monitoring program. Metallothionein analysis is not included in the AEMP as it was not determined to be necessary for monitoring effects of metals on fish.

Condition:

11.1.3 Metal and trace element concentrations in dike interstitial water, verification of metal and trace element leaching rates from the dikes, and verification of predicted spatial and seasonal water column concentrations of such metals and trace elements concentrations at various locations adjacent to the dikes;

11.1.4 Metal concentrations in sediment samples and benthic invertebrate samples, obtained from sites radiating from the mine water discharge, at the 60m mixing zone boundary, adjacent to the dikes in Lac de Gras, and at control sites, both prior to mine activities and following the onset of mine activities and every three years thereafter;

11.1.4.1 Metal analysis is to be done on total benthic invertebrate biomass in the event that there is not enough biomass of individual taxa to do separate analyses. If an adequate protocol for invertebrate metal analysis cannot be carried out, DFO shall be informed of sampling efforts and a request may be made to amend the requirement for benthic invertebrate metal analysis.

11.1.4.2 The results and interpretation of the metal analysis of sediment core samples and benthic invertebrate samples, unless amended as per section 11.1.4.1, along with an analysis of changes in benthic communities, shall be submitted to DFO within 6 months of sampling, unless otherwise agreed to by DFO.

12.5 DDMI shall conduct a biological survey of the benthic invertebrate community, and an analysis of sediment composition and water chemistry prior to and after sediment deposition due to dredging and dike construction activities, to assess changes in benthic community composition, abundance and distribution.

12.5.1 Benthic invertebrate samples shall be obtained at sites adjacent to the dike alignments within the zones of sediment and deposition and at control sites.

Status:

Based on dike monitoring results to date, these conditions will no longer apply to dike A154. The status of A418 will be determined once an analysis is completed by Zajdlik & Associates and reviewed by DFO. This is expected to occur in September 2013.

These conditions must be met for a post-construction monitoring period if and when dike A21 is constructed, with the exception of condition 11.4.1 which DFO agreed to remove in a letter dated, May 28, 2004 due to insufficient biomass being available at the site to conduct metal analysis on benthic invertebrates. Post-construction monitoring results for dike A21 will dictate if further monitoring is required.

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Condition:

11.2 Measurements of under ice dissolved oxygen levels shall be periodically taken in the vicinity of the sewage outfall in Lac de Gras to monitor for potential oxygen depletion;

11.2.1 If dissolved oxygen is depressed to a level that may represent adverse impact to fish and/or habitat, then mitigative measures shall be employed.

Status:

This monitoring was completed and sewage discharge to Lac de Gras discontinued. Therefore, this condition has been met.

Condition:

12.0 Total suspended solids (TSS) in relation to dredging and dike construction

12.1 DDMI shall monitor of discrete depth total suspended solids (TSS) concentrations during all dredging and dike construction (A154, A418, A21 and North Inlet) and ensure established target thresholds for TSS are not exceeded at agreed upon monitoring location located around dredging activities.

12.1.1 Threshold value of 45 mg/L TSS for a 110 day average (final compliance limit) is not exceeded beyond the monitoring locations established in 12.1.2 to minimize adverse effects on fish;

12.1.2 For the purposes of TSS monitoring, monitoring locations are to be established as close as is practical to the 200m boundary that is measured from the toe of the dike and will be marked by buoys.

12.1.3 The 110 day average shall be based on discrete depth TSS measurements taken at the depth of greatest TSS concentration as determined by daily turbidity profiles.

12.1.3.1 The data used for calculations of the average shall be the day's actual measurements plus the preceding 109 days' measurements. Pre-construction measurements will be deemed average background TSS levels.

12.1.3.2 Missing data (e.g. when weather conditions make sampling unsafe) shall be substituted with a TSS estimate based on turbidity data derived from automated turbidity meters at each fixed station, using a TSS/turbidity relationship.

12.2 DDMI shall monitor daily discrete depth TSS concentrations and turbidity profiles and notify DFO immediately if TSS levels reach 75% of the threshold values established in 12.1.1.

.../8

12.3 During dredging and dike construction and throughout the open water season, DDMI shall determine the spatial and temporal extent of the TSS plume in Lac de Gras (defined as TSS concentrations above background). This shall be accomplished through weekly TSS and turbidity surveys at appropriate sampling stations, delineating the plume, as well as expressing the plume area as a percentage of the total fish habitat available in the eastern basin of Lac de Gras.

12.6 To mitigate impacts to fish habitat in Lac de Gras beyond the dike dredging and construction activities, a continuous floating silt curtain material shall be deployed.

12.7 The sediment curtain deployed to the south of the A154 dike alignment (in the vicinity of stations referred to as stations 1645-64 and -65 in the NWT Water Licence N7L2-1645 and amended to 1645-58 and -59) shall be moved further north such that the maximum amount of shoreline is protected from further inundation by suspended and deposited sediments. This adjustment of the sediment curtain shall be done as soon as the dredge anchors have moved beyond this are and will no longer interfere with the sediment curtain anchors.

12.8 TSS measurements and levels/conditions shall be made available to DFO on a weekly basis throughout the dike construction activities unless otherwise required (see section 12.2).

12.9 Dredged material resulting from the construction of dike A154 shall be deposited via pipeline to a land based containment facility on the East Island. Dredged material resulting from the construction of dikes A418 and A21 shall be deposited via pipeline to the North Inlet Facility. All dredged material shall be contained to prevent re-entry into Lac de Gras.

Status:

TSS monitoring has been completed for dikes A154 and A418. A monitoring program has been approved for dike A21 as per the Construction Environmental Management Plan required under the Water Licence. Therefore, these conditions are no longer required under the *Fisheries Act* Authorization.

Condition:

12.4 DDMI shall determine sediment deposition on shoal habitat adjacent to the dikes and compare these areas and amounts of sedimentation to those predicted by dispersion modeling. DDMI shall verify that the shoals are washed clean one year following the completion of dredging activities. If the shoals are not washed clean as predicted, additional fish habitat compensation may be required.

Status:

Monitoring to verify that shoals adjacent to dikes A154 and A418 were washed clean, was inconclusive. Studies relied on tiles placed in shoal areas prior to dike construction and then surveyed following construction. Currents in the area were sufficient that tiles were dislodged which impacted post construction surveys leading to the conclusion that if the current is sufficient to dislodge weighted tiles then it would also be sufficient to wash any sediment deposited from dike construction. This observation of strong currents associated with shoal habitat was also observed by Fitzsimons (2013) based on dislodging of artificial eggs. Fitzsimons suggests currents around shoals could be in the order of 6 cm/s based on similar observations of dislodging in Lake Champlain.

Based on this information, this condition is no longer required.

All other conditions contained within *Fisheries Act* Authorization SC98001 remain in effect.

If you have any questions, please contact Kelly Eggers at (867) 669-4905, or by email at Kelly.Eggers@dfo-mpo.gc.ca.

Yours sincerely,

Bruce Hanna
Senior Habitat Biologist
DFO Western Arctic Area

Cc:
David Wells - Rio Tinto
Stuart Niven, Kelly Eggers - DFO
Mark Fenwick - EMAB
Ryan Fequet, Kathy Racher - MVLWB

No Net Loss Plan

Back

Disclaimer (1)

Submitted to: Diavik Diamond Mines Inc.
Yellowknife, NT.

August 1998

REPORT SUMMARY

On behalf of the Diavik Diamonds Project, Diavik Diamond Mines Inc. (Diavik) is proposing to develop a diamond mine at Lac de Gras, in the Northwest Territories. The diamond-bearing kimberlite pipes are located near the shoreline of the east island in Lac de Gras. Mining, which would be primarily by open pit, would necessitate the construction of containment dikes in Lac de Gras. Infrastructure construction would result in both permanent and temporary alteration of small lake and stream habitat on the east island. In addition, a long narrow bay on the east island (the north inlet) would be closed by a dike at the entrance, and used as part of the water treatment system. Dike construction and infrastructure development would affect existing fisheries habitat.

The purpose of this document is to present Diavik's proposal to mitigate habitat losses thereby achieving the Department of Fisheries and Oceans' principle of ***no net loss*** of the productive capacity of fish habitat as required under the Federal *Fisheries Act*.

During field work conducted in summer of 1996, an assessment was conducted of the physical characteristics and fisheries habitat potential of: shorelines, shoals, deep-water areas, small lakes and streams. Fish species were also enumerated.

Determination of fisheries habitat value was based on the Habitat Evaluation Procedures (HEP) which include the development of a Habitat Suitability Index (HSI) for each habitat class (spawning, nursery, rearing, foraging, overwintering and migration corridor) for each fish species utilizing water bodies affected by the proposed Project. The HSI value, which is a measure of habitat *quality*, was multiplied by the area of each type of habitat available (i.e., the habitat *quantity*). This yielded a measure, in Habitat Units (HUs), of the relative value of all habitat in the area. The difference in habitat quantity weighted by habitat quality between the existing and future conditions enabled an evaluation of the net effect of the proposed Project on fish habitat.

Mitigation plans were developed with the intent of adhering to the principle of no net loss. Whenever possible, "like for like" habitat replacement was the objective of mitigation efforts.

In Lac de Gras, the majority (45%) of habitat altered by dike construction would be open water (i.e., shallow or deep water). Shoals (24%) and shorelines (31%) would account for the remainder of the major physical attributes of Lac de Gras altered by dike construction. Habitat types most affected would be average or lower quality rearing and foraging habitat. Only a small percentage of the total available spawning and nursery habitat for most fish species would be affected by the proposed Project. Mitigation efforts in Lac de Gras would focus on the creation of high quality shallow-water rearing and foraging habitat for the fish species most likely to be in a position to take advantage of this type of habitat.

Alteration of habitat in Lac de Gras would be mitigated in several ways. Containment dikes would be modified to provide productive habitat for fish. The external edge of the dikes would be constructed in a manner that creates spawning habitat for fish species that prefer exposed coarse substrates. Upon closure of the mine, the dikes would be breached. Prior to breaching, artificial reefs and other habitat features would be built on a shallow shelf between the pits and the inner walls of the dike. This area would provide high quality rearing and foraging habitat for a variety of fish species. The pre-existing shoreline would be returned to its original condition. Dike construction would result in the loss of 2,432 HUs for fish in Lac de Gras. Mitigation activities would fully offset this loss by creating approximately 2,618 HUs. A surplus of approximately 186 HUs would result; the largest gains of habitat would be in the form of rearing habitat which is limiting in Lac de Gras.

Three small fish-bearing lakes located on the east island would be permanently lost due to infrastructure construction. Two other lakes, one fish bearing and one that does not contain fish, would be drained for the duration of the construction/operations phase.

Habitat lost in small lakes due to mine infrastructure would be fully mitigated by modifying four lakes on the east island. Portions of the deep waters of three of these lakes would be filled in with rock to a depth of one metre to provide rearing and foraging habitat. One shallow lake (the non-fish-bearing lake drained during construction/operations) would be excavated to provide a deep water area that would allow fish to successfully overwinter. Fish from nearby lakes would be used to establish fish communities in the modified lakes. The fish-bearing lake that would be drained for the construction/ operations phase would be re-filled without modification and the fish community would be restored to baseline conditions. A surplus of 71 HUs of small lake habitat would result from the completion of the proposed mitigation.

No spawning or rearing habitat exists in the east island streams due to their ephemeral nature. A low potential exists for migration corridor habitat where a stream only provides a brief connection between Lac de Gras and a small lake. A total of 0.12 HUs, of the existing 0.15 HUs of stream habitat, would be altered during the construction/operations phase. Re-establishment of natural drainage patterns on the east island at closure would restore most of these streams. Mitigation plans for the residual habitat loss calls for stream habitat improvement on the west island.

Mitigation of habitat losses in Lac de Gras would result in a net surplus of 186 HUs. This represents a 0.04% increase in overall available habitat in Lac de Gras. Modification of small lakes would result in complete mitigation of habitat losses due to construction once fish communities are established. A surplus of 71 HUs would be created in small lake habitat. All losses of migration corridor habitat in streams would be mitigated. Mitigation efforts would also produce an additional 0.016 HUs of spawning habitat for Arctic grayling and longnose sucker and 0.14 HUs of migration habitat for all species.

Once mitigation options are in place, monitoring would occur to assess the utility of the new habitats for resident fish species. In the interest of adaptive management, monitoring results would be used to evaluate and refine the new habitats if necessary, to better provide suitable fish habitat.

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1. INTRODUCTION

1.1 PROJECT OVERVIEW

The Diavik Diamonds Project is a joint venture between Diavik Diamond Mines Inc. (Diavik) and Aber Diamond Mines Ltd. Diavik proposes to mine diamond-bearing kimberlite pipes located at Lac de Gras in the Northwest Territories. Lac de Gras is a large lake (637 km²) located approximately 300 km northwest of Yellowknife (Figure 1-1). The kimberlite pipes are located near the shoreline of an island, at the eastern edge of Lac de Gras, referred to as the “east island”. The proposed Project facilities would be sited entirely on the east island, with the mine located just offshore, in Lac de Gras (Figure 1-2).

Dikes would be constructed around the kimberlite pipes to allow for open-pit mining, possibly followed later by underground mining of three pipes (A418, A154S and A154N, Figure 1-2). The dike for pipe A418 would be constructed in the year 2000, followed by the dike for pipes A154S and A154N in 2001. Dike construction for pipe A21 (Figure 1-2) would start later, possibly 7 to 11 years after start-up. Following dike completion, the area within the dike would be dewatered. Lake bed sediments would be collected and disposed of in the processed kimberlite containment structure. The construction and operation phases would overlap; maximum mine development would occur about 2024.

Once mining is completed at a pipe, mined country rock and finer sediment material would be placed along the inside of the dike. Water levels would be equalized gradually between the lake and the interior of the dike, and the dike breached to create fish habitat. The breaches would be sized and located to achieve the desired water circulation. The closure phase would overlap with the operation phase; the end of the closure phase is expected to occur in 2050.

A long narrow bay (the north inlet) extends along an east-west axis on the north side of the east island (Figure 1-2). The mouth of the north inlet would be blocked off with an impermeable dike and the inlet would be drawn down. At closure, water movement would be re-established between the north inlet and Lac de Gras, but no fish passage would occur. Currently, it is thought that the dike would remain in place post-closure and fish habitat would not be restored within the north inlet.

Figure 1-1 Proposed Project Location

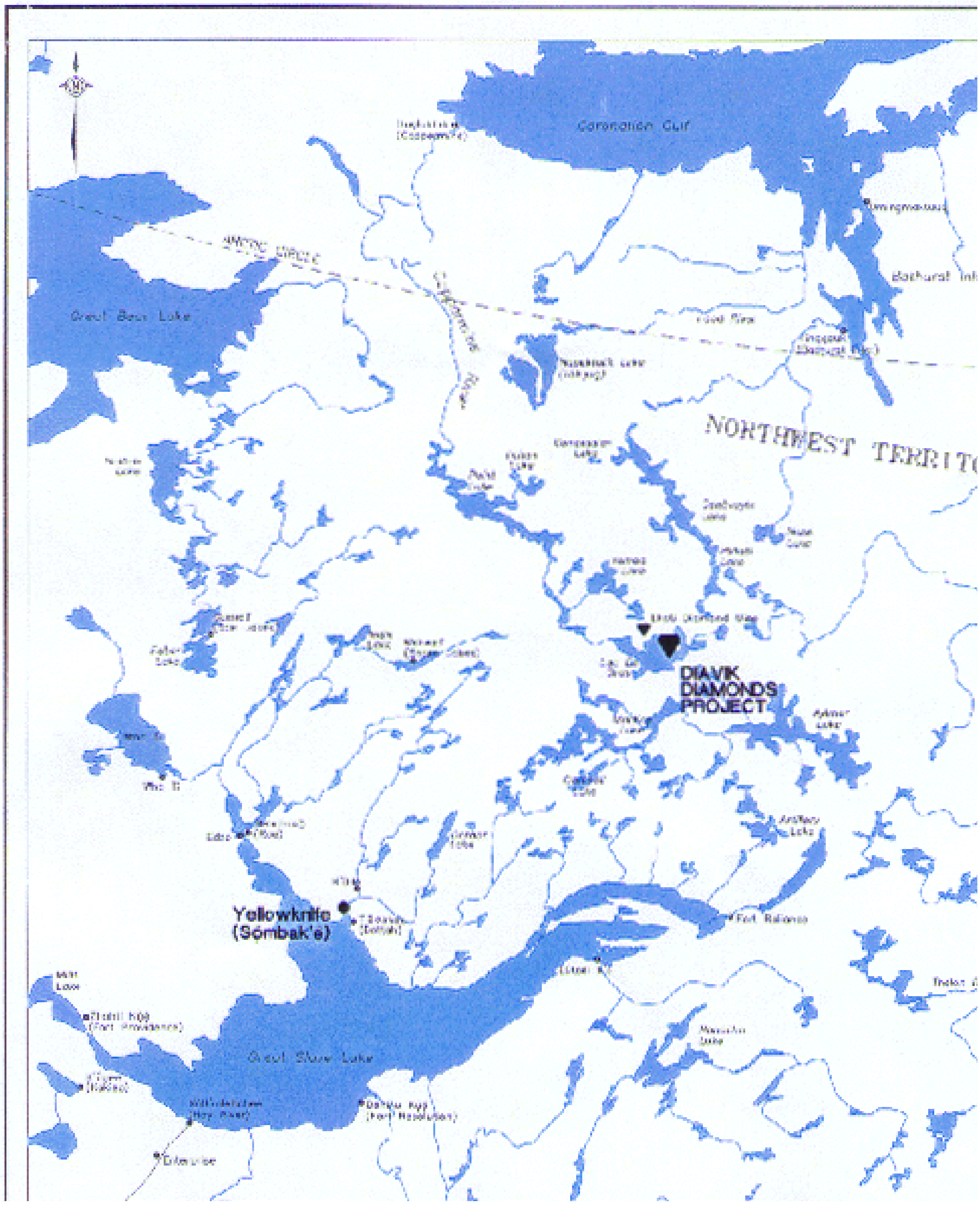
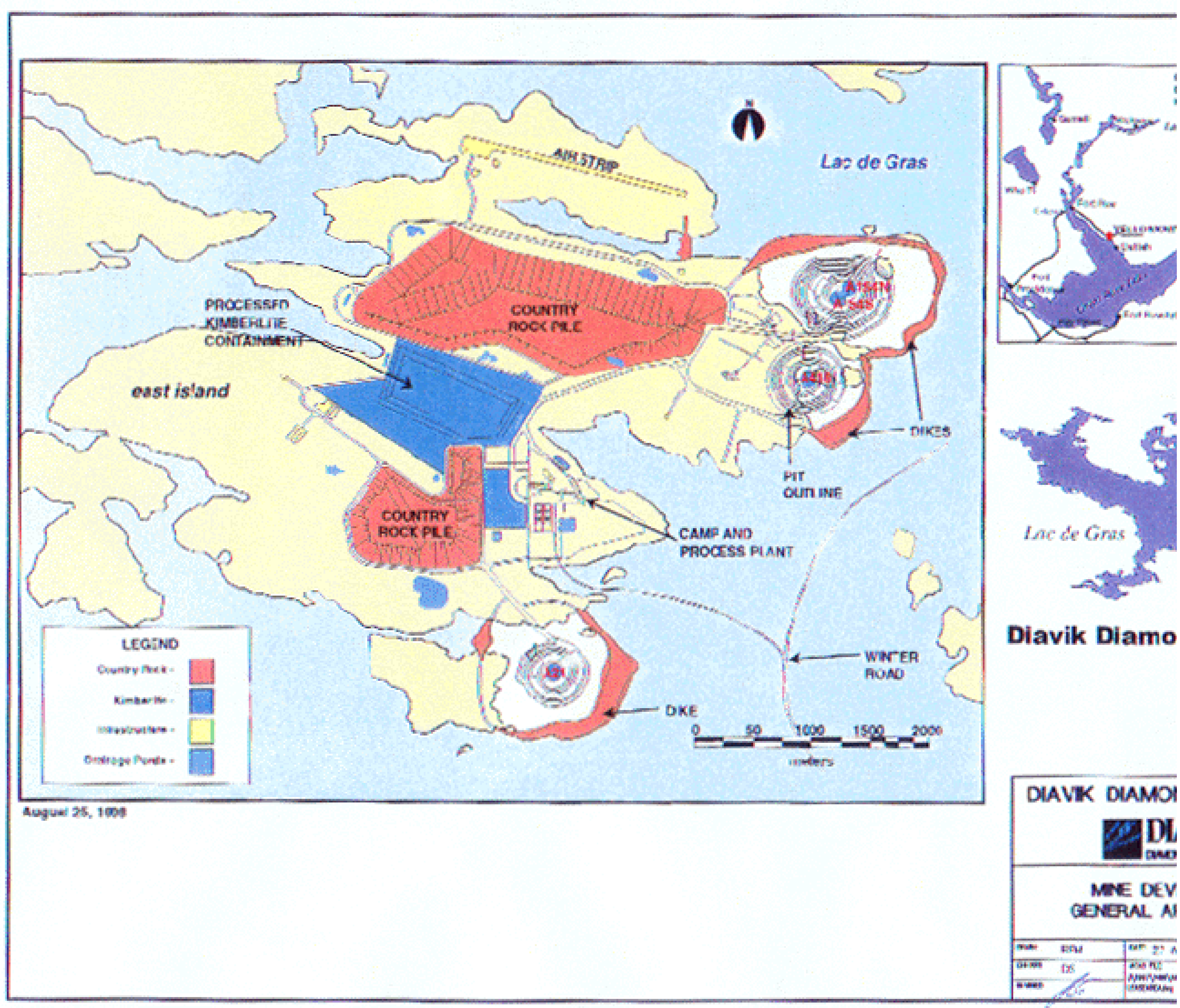

Coronation Gulf
Great Bear Lake
Bathurst Inl
NORTHWEST TERRITO
DIAVIK
DIAMONDS
PROJECT
Yellowknife
(Sombak'e)
Great Slave Lake
Fort Reliance
Enterprise

Figure 1-2 Mine Development General Arrangement



Note: Revised figure is being prepared by Diavik in their Yellowknife Office.

Mine infrastructure on the east island would affect habitat in the small fish-bearing lakes and streams located on the island. A total of three fish-bearing lakes located on the east island would be permanently removed from fish production by the development of the proposed Project. A fourth fish-bearing lake would be drained for the duration of the project and restored upon closure. Based on the proposed Project design specifications, 11 of 21 sub-basins on the east island would have stream habitat altered by construction. Within these 11 sub-basins, 24 streams would be affected.

In summary, fish habitat in Lac de Gras affected by the proposed Project would include the area under the dikes and the area contained within the dikes, including the north inlet. In addition, the mine infrastructure on the east island would affect three fish-bearing small lakes and some ephemeral streams on that island.

1.2 STUDY AREA

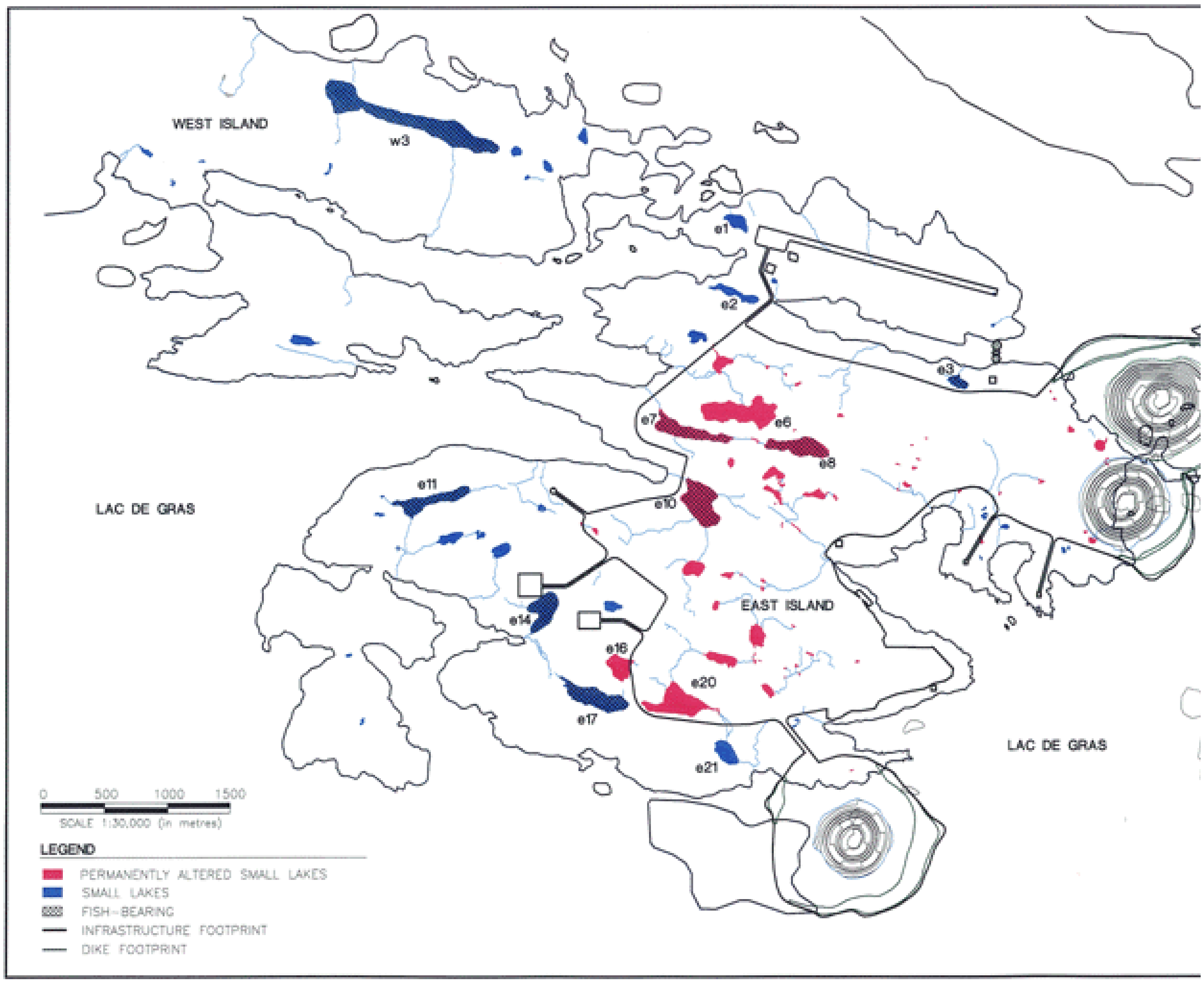
The Regional Study Area (Study Area) consists of Lac de Gras. The fish-bearing lakes and streams located on the east island are shown on Figure 1-3. Within this area, the no-net-loss plan evaluates only the lakes and streams with habitat that would be altered by the proposed Project. The percentage of habitat that may be altered is presented in the context of the Study Area.

Aquatic habitat in Lac de Gras can be classified into four distinct environments: shorelines, shoals, shallow bays and deep water areas. These environments provide varying quality of habitat for different life stages of fish, which can be characterized by the following habitat classes: spawning, nursery, rearing, foraging and overwintering habitat. Overwintering habitat was not considered in Lac de Gras since it is ubiquitous throughout the lake.

The shorelines of Lac de Gras are dominated by boulders (>25 cm in diameter) which descend to a maximum depth of 6 m. Other, less common substrates include cobble, gravel, bedrock and sand, or various combinations of each. The shoreline is rugged, with numerous bays and inlets. Shallow rocky substrates in Lac de Gras usually have little or no attached algae or silt cover.

Shoals are common and can occur either in association with the many islands in Lac de Gras or be completely underwater. The majority of shoals are composed of boulder/cobble substrates down to a depth of 6 m.

Figure 1-3 Location of Small Lakes on the East Island



In shallow and deep open-water areas, lake bottom sediments consist of fine sand, silt and clay. Lac de Gras is a cold, ultra-oligotrophic (unproductive) lake which supports a cold water fish community. The lake does not thermally stratify in summer.

Stream habitats within the Study Area range from ephemeral, snowmelt-driven tributaries to large streams with defined channels that flow through the open-water season. Streams in the vicinity of the proposed Project are all dominated by snowmelt runoff and, therefore, have short duration flows (i.e., less than three weeks).

Streams on the east island typically have no distinct channel. When flowing, stream flow percolates through vegetation and boulders. These features limit fish movement into the small lakes to high flow years. None of the streams on the east island provide spawning or rearing habitat because the duration of flow is too short to provide sufficient time for incubation.

The east island contains seven fish-bearing lakes that range in size from 1.3 to 11.7 hectares (ha). Maximum depth in fish-bearing lakes range from 4.0 to 10.5 m. There is little flow in or out of these lakes. Water quality does not vary significantly between the lakes, and is very similar to the water quality in Lac de Gras. Shorelines of the small lakes are predominantly composed of boulders with a steep gradient to a depth of approximately 2 m. Below this depth, the bottom becomes relatively flat and is composed of a mixture of large boulders and sand. Where deep holes are present, they typically exhibit steep gradients.

1.3 NEED FOR A NO-NET-LOSS PLAN

Despite the implementation of mitigation measures, changes to fish habitat would occur, varying from temporary to permanent habitat alterations. In Lac de Gras, habitats along the shoreline, as well as shoals, shallow-water and deep-water habitats would be permanently altered. Additionally, a number of small lakes and streams on the east island would be altered.

The Federal Department of Fisheries and Oceans (DFO) released a *Policy for the Management of Fish Habitat* (DFO 1986) which recognizes that fish habitats constitute healthy production systems for Canada's fisheries resources and reaffirms the need for their management and protection. The overall objective of the Policy was to obtain a ***net gain*** in the productive capacity of fish habitat in Canada. This overall objective is achieved through three goals:

I. **conservation** of existing habitats;
II. **restoration** of damaged habitats; and
III. **development** of new habitats.

To achieve conservation, DFO strives to ensure that the current productive capacity of existing habitats is maintained by applying the guiding principle of ***no net loss***. Under this principle, existing fish habitats are protected, while unavoidable habitat alterations are balanced by development of new habitat. The legislated authority provided by the *Fisheries Act* is used to achieve ***no net loss***.

An Authorization under Section 35(2) of the *Fisheries Act* is required to comply with the habitat protection provisions of the *Act*. Measures to compensate for the habitat that would be altered become conditions of the Authorization issued to the proponent. In cases where DFO believes that adequate mitigation cannot be achieved or when the alteration of a particular habitat type is unacceptable, DFO may deny the Authorization.

Mitigation measures are developed according to a hierarchy of preferences (DFO 1986):

- Redesign or relocate the project

In keeping with the spirit and intent of the *Policy for the Management of Fish Habitat* (DFO 1986), Diavik has developed a plan to achieve ***no net loss*** of fish habitat. This report describes the fish habitats which would be altered or lost by mine construction and operation, and outlines the measures Diavik would implement to compensate for the effects the mine would have on these habitats.

1.4 OBJECTIVES AND APPROACH

Wherever possible, the objectives of the *Policy for the Management of Fish Habitat* (DFO 1986) were incorporated into the proposed no-net-loss plan. The principal factors which governed the design of mitigation alternatives were as follows:

- Whenever possible, proposed mitigation was "like for like" as detailed in the Policy (DFO 1986). For example, altered lake trout (*Salvelinus namaycush*) spawning habitat was replaced by other lake trout spawning habitat whenever possible.
- Mitigation alternatives were within the immediate vicinity of the altered fish habitat so that no changes in the overall fish productive capacity of the region occurred.
- Mitigation was developed for all fish species present in the immediate vicinity of the mine, which includes Lac de Gras, and the small lakes and streams of the east island. In addition:
  - Measures were developed to maximize the production of the most important fish species in the region. Importance was placed on those species which have the potential to provide a fishery (e.g., lake trout, cisco (*Coregonus artedi*), round whitefish (*Prosopium cylindraceum*), Arctic grayling (*Thymallus arcticus*)) through their commercial and/or subsistence value.
  - Measures focused on those species whose habitats were most likely affected by the project (e.g., lake trout, cisco, round whitefish).

The overall objective of the mine development plan in dealing with potential fish habitat alteration or loss was to ensure that no residual habitat losses would remain by the end of the post-closure phase. This objective would be achieved in two ways:

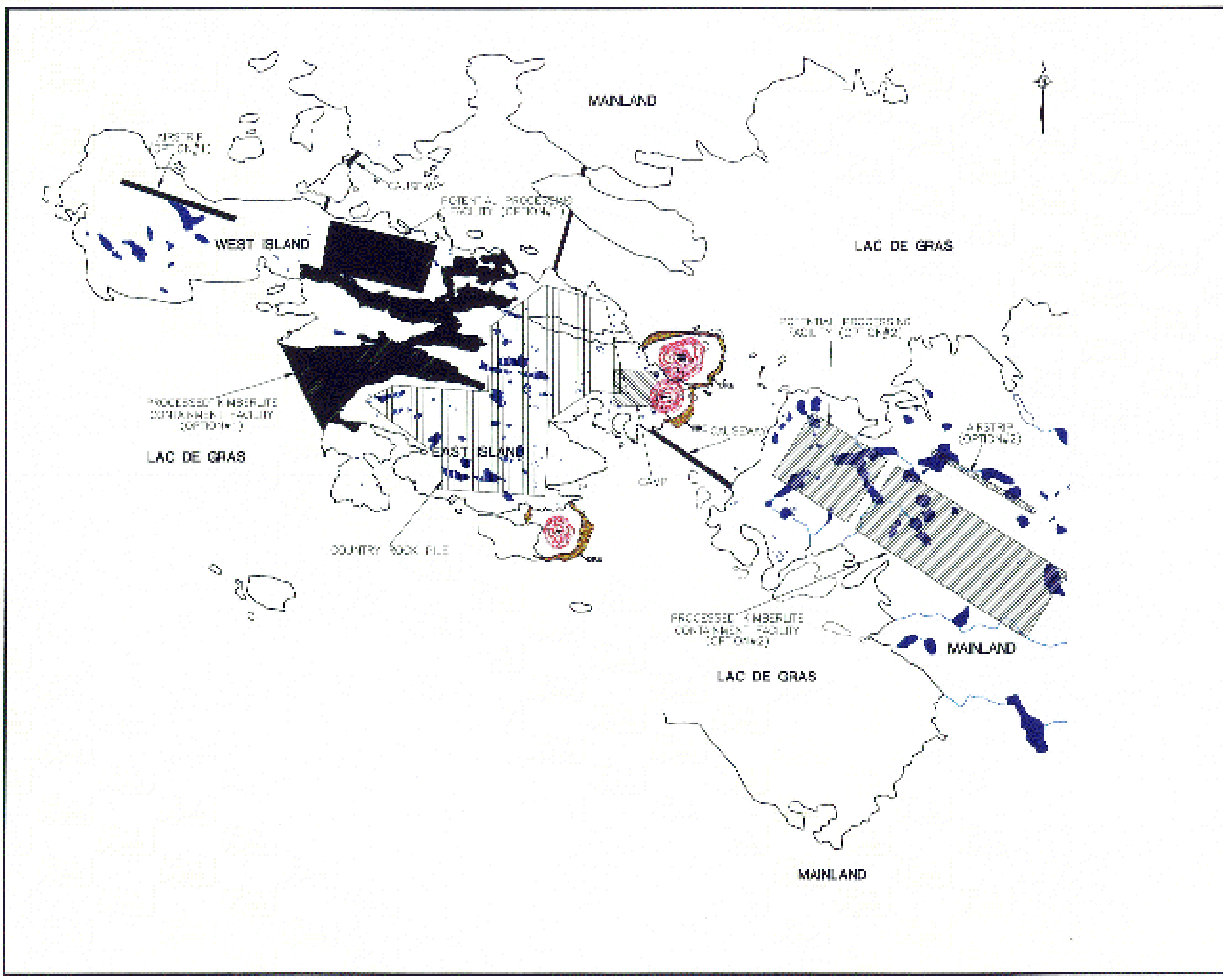
- Avoidance of habitat alteration or losses by reducing the size of the mine footprint; and,
- Incorporation of mitigative measures in the mine development plan so that all fish habitat alterations or losses are dealt with during the life of the mine.

The most effective means of achieving the objectives of the DFO Policy (1986) is to avoid habitat alteration or loss whenever possible. This was a key component in the evolution of the proposed mine development plan. Several alterations to the design of the mine occurred as knowledge was gained on the habitat characteristics of Lac de Gras, mainland lakes, island lakes and streams. Changes to the proposed mine development plan can be summarized as follows:

- The original mine footprint included a portion of the mainland directly east of the east island (Option #2, Figure 1-4). Development on the mainland was subsequently avoided.
- It was originally proposed that processed kimberlite be stored between the east and west islands (Option #1, Figure 1-4). However, these shallow waters were identified as being good quality rearing and foraging habitat for a variety of fish species (Appendix VII). Consequently, this area was removed from further consideration.
- Several fish-bearing lakes were identified on the east and west islands (Golder Associates 1997d). The mine footprint was further reduced so that no development occurred on the west island. Development was reduced on the east island so that two fish-bearing lakes would no longer be affected by mine development.
- The proposed development plan now includes a further reduction in the mine footprint on Lac de Gras. The size of the dikes has been considerably reduced from their original proportions (Figure 1-2).

In spite of these changes, the development of the proposed project would result in some unavoidable alterations or losses of fish habitat. Therefore, additional mitigative measures are identified in this no-net-loss plan (Section 2.0 and appendices).

Figure 1-4 Initial Project Concept (1996)



2. PROPOSED MITIGATIVE MEASURES

2.1 INTRODUCTION

The following sections address the fish habitat which would be affected by the construction and operation of the proposed Project, as well as the proposed mitigative measures.

Mitigative measures for fish habitat in Lac de Gras, as well as the small lakes and streams on the east island will be discussed separately in this section. All mitigation is to take effect by the end of the closure phase.

2.2 LAC DE GRAS

During construction of the open pits, the outsides of the dikes would be configured to maximize their potential value as fish habitat, particularly spawning and rearing habitat. During closure, the insides of the dikes would be contoured to maximize their potential value as fish habitat, particularly shallow foraging and rearing habitat (see Appendix VII).

The quality of the habitat created by the exterior of the dike would vary with depth and substrate size. The region of the dike from 0-2 m would provide good rearing and foraging habitat, but poor spawning habitat for lake trout and other fall spawners (Figure 2-1). The best spawning habitat would be found at depths from 2-6 m (Figure 2-1) (Golder Associates 1997a). Appropriate substrates would be added to this region of the dike to improve spawning and nursery habitats. At depths greater than 6 m, spawning and nursery habitat are expected to be poor for all species except possibly slimy sculpin (Figure 2-1).

Once the mining of the kimberlite pipes is complete, the process of fish habitat creation through re-configuration of the dike interior would begin. The overall objective is to flood the interior of the dikes to provide fish habitat within the dike walls (Figure 2-2). After mitigation, the dike interior would consist of the interior wall of the dike, the open pit shelf and the open pit. The open pit shelf would be a large expanse of flat ground between the dike interior and the edge of the open pit. The open pit would be a large hole with steep walls which would descend to a depth of approximately 250 m (Figure 2-2).

Figure 2-1 Proposed Design of Dike Exterior (Operations and Closure)

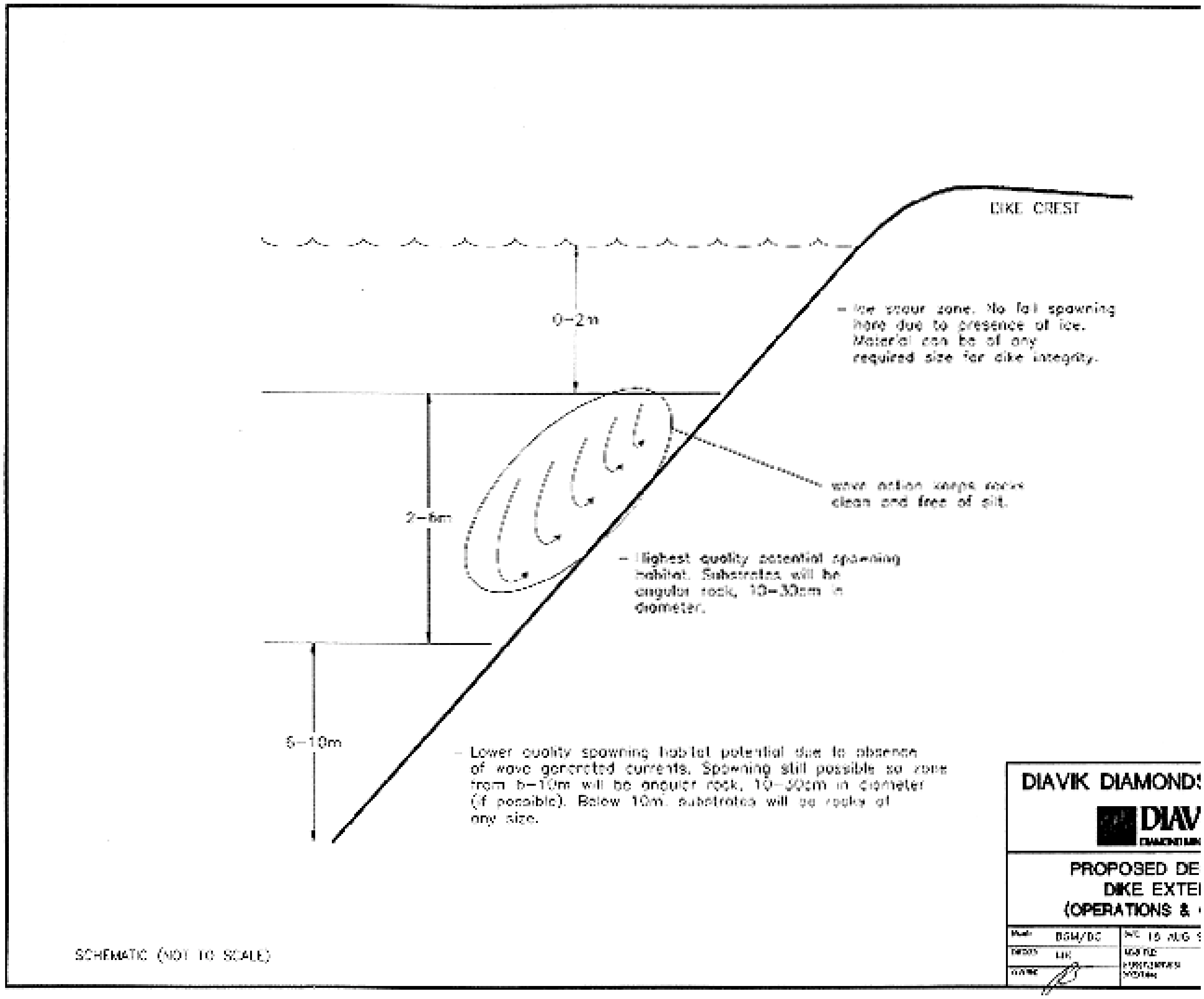
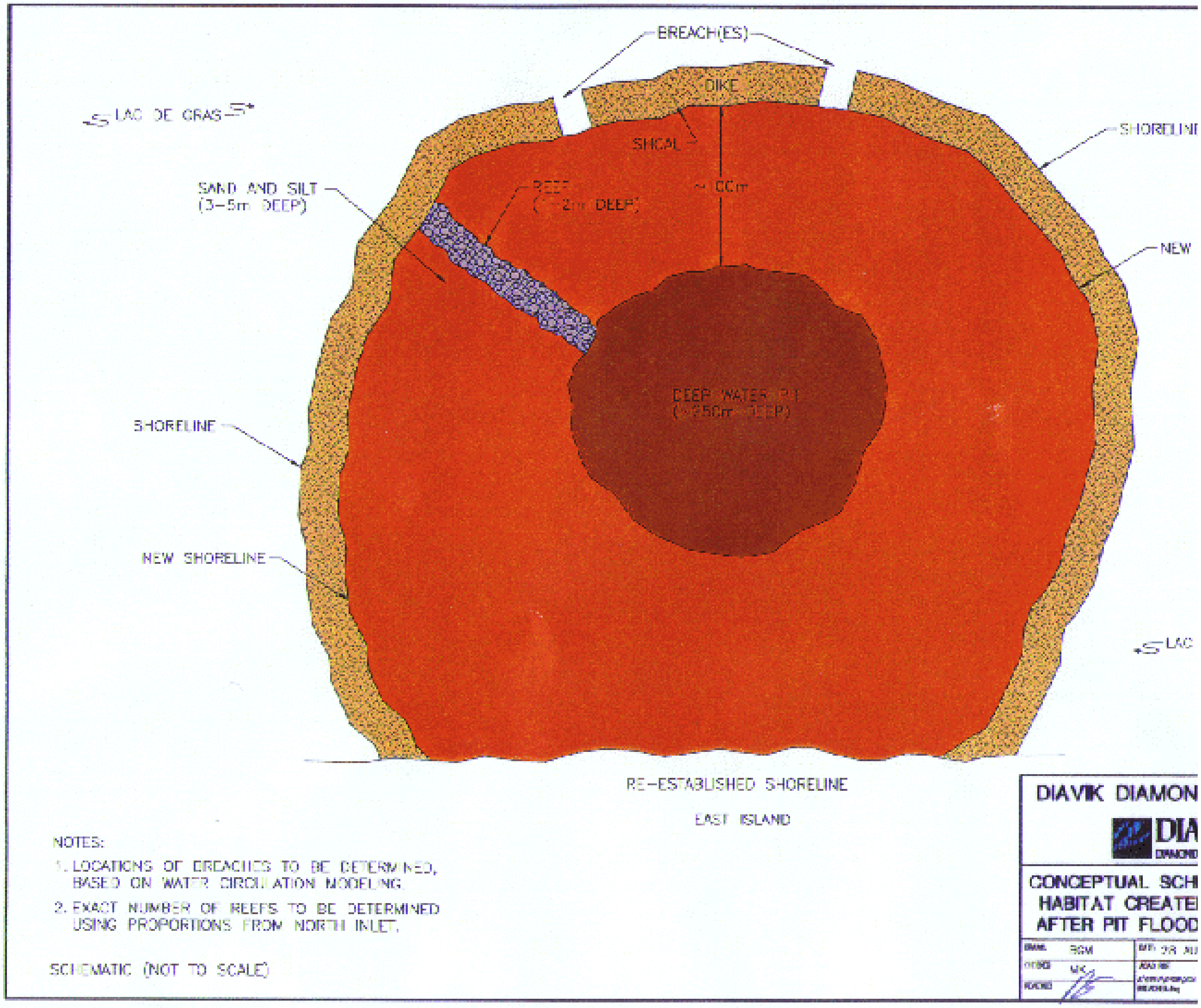


Figure 2-2 Conceptual Schematic of Fish Habitat Created Inside Dikes After Pit Flooding (Closure)



The following steps would be taken during the closure phase to maximize the creation of fish habitat in association with the dikes:

- The pit shelf would be re-contoured so that it would lie approximately 5 m below the water line once the dike walls are breached.
- Once this is complete, long, narrow rocky reefs would be created which would extend from the inside wall of the dike to the edge of the open pit. Reefs would be built in areas with water at least 5 m deep. These reefs would be approximately 10 m wide

and 2 m high. The amount of granular versus soft substrate would be based on the proportion of these substrate types in the north inlet.

- The disturbed portions of shoreline along the east island would be re-configured to pre-development conditions as much as possible. This would entail the placement of boulder substrates to a depth of approximately 2 m to mimic undisturbed shorelines in Lac de Gras.
- Upon completion of these tasks, the diked area would be allowed to fill with water.
- After the interior is flooded, the dike walls would be breached. Three breaches are proposed for the dikes surrounding pipe A418 and pipes A154N and A154S, whereas two breach points are proposed for the dike surrounding pipe A21. The breaches would not be complete, but would create shallow (about one metre) entrances, to deter the movement of larger fish into the nursery and rearing habitat. This design emulates the rearing habitat in the north inlet.

A limited amount of above-average spawning habitat would be created by the dike exterior. Overall, there would be a net reduction in the amount of spawning habitat for fall spawners in Lac de Gras as a result of dike construction. However, spawning habitat was found to be plentiful in this lake. Spawning shoals of equal or better quality to those being altered were observed in several locations outside the zone of dike construction (Golder Associates 1997a). It is unlikely that the replacement of spawning habitat to pre-development conditions would help increase fish production in Lac de Gras since this habitat type does not appear to be limiting the fish populations using them for spawning.

The focus of the re-configuration of the dikes at closure would be to create rearing habitat for a variety of fish species. Rearing habitat is likely the limiting habitat type for almost all fish species in Lac de Gras (Appendix VII). Consequently, emphasis was placed on creating the habitat type which provided the greatest opportunity to improve the productive capacity of the lake. In addition, good rearing habitat would be provided next to spawning habitat. The rationale for the creation of rearing habitat is presented in Appendix VII.

A large proportion of the Habitat Units (HUs) lost in Lac de Gras originate from deep-water habitat. Mitigation for the losses of deep water is impractical due to the nature of this habitat type. The abundance of overwintering habitat in Lac de Gras and the lack of summer stratification reduce the importance of these losses. Mitigation efforts in Lac de Gras were directed towards the creation of shallow water habitats in the interior of the dikes which would provide important rearing and foraging habitat for a variety of fish species. The created habitats are more suited to providing rearing and foraging habitat for larval and juvenile fish than the deep-water habitat that would be lost.

2.3 SMALL LAKES ON THE EAST ISLAND

2.3.1 Habitat to be Replaced

Mitigation is being proposed to replace the small-lake fish habitats that would be altered on the east island. The amount of habitat to be replaced was based on the number of fish species present and the mitigation opportunities available. If four fish species were present in a lake, the amount of habitat to be replaced was multiplied by four, depending on differing habitat requirements for various life stages.

For the purposes of this plan, lakes on the east island were considered fish habitat if one of two conditions were met:

1) The lake supported a permanent fish community or single population.
2) Fish from Lac de Gras could access the lake and use it on a seasonal basis.

No habitat has been assessed and no mitigation is being proposed for the 11 fishless lakes (Golder Associates 1997e) and the unnamed ponds for the following reasons:

- No fish were caught at the time of the summer surveys (Golder Associates 1997b);
- Ice cover is generally about 2 m deep; lakes that are ≤ 3 m depth are not suitable for successful overwintering (Golder Associates 1997d, e); and,
- The streams connecting these lakes to other small, fish bearing lakes or Lac de Gras were too small and/or flowed for too short a period of time to allow fish from other waterbodies to use these lakes on a seasonal basis (Golder Associates 1997f).

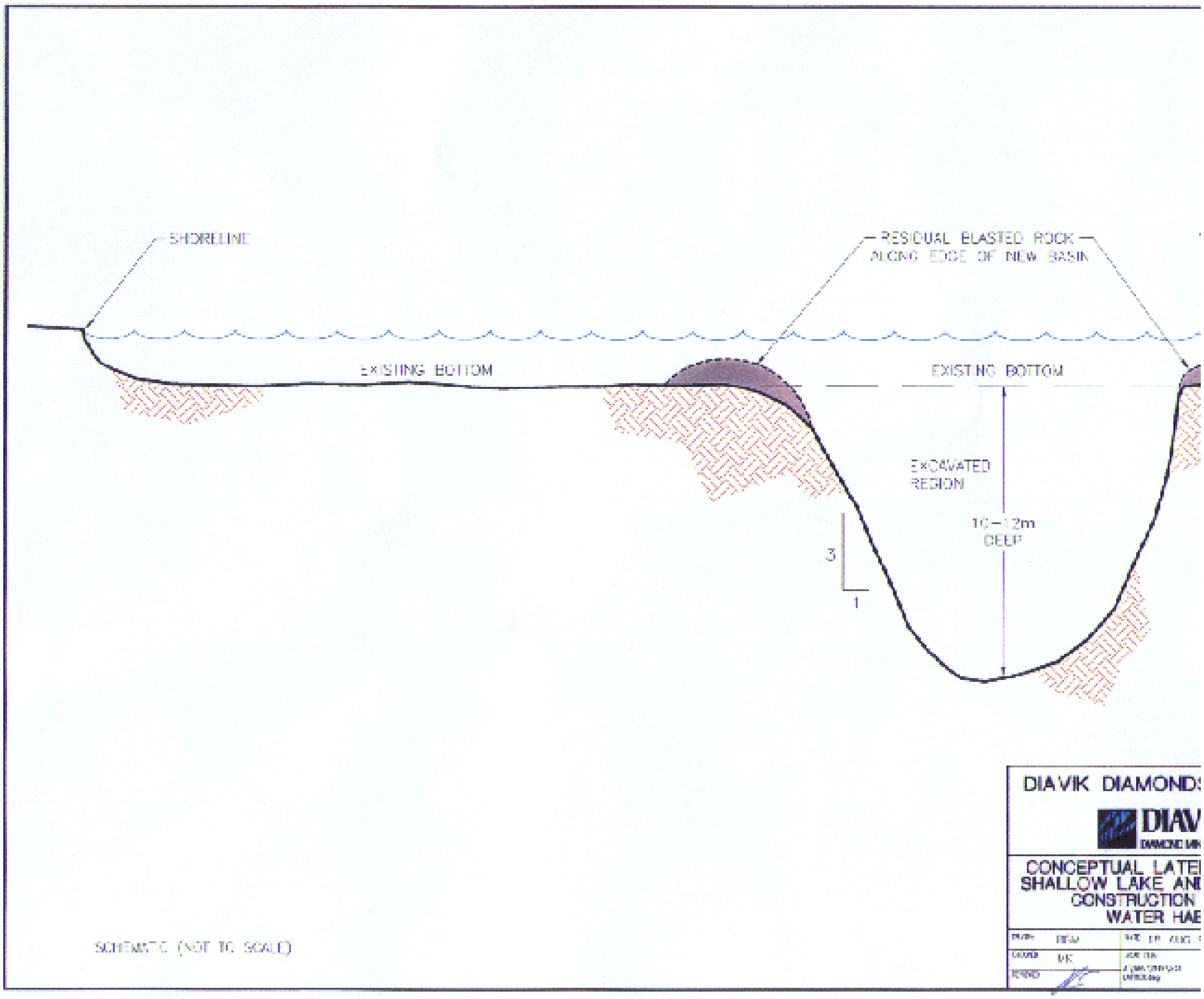
2.3.2 Approach to Habitat Mitigation

The mitigation plan allows for the construction of habitat that best emulates that which would be altered. Plans for the creation of small lake fish habitat were based on the physical characteristics of the habitats and the behaviour of the fish using the habitats for various life stage requirements.

Many small lakes on the east island and the mainland have no resident fish populations because of a lack of overwintering habitat. Generally, lakes with less than 4.0 m of water had no permanent fish populations (Golder Associates 1997d, e). Lakes of this nature may be used by fish on a seasonal basis for rearing and foraging habitat if stream access is possible. It was also observed that fish occasionally become isolated in small lakes and in pools within connecting streams, due to a sudden drop in stream flows after the runoff peak due to snowmelt (Golder Associates 1997f). Fish isolated in stream pools are invariably lost as most streams become dry by early summer.

One alternative to creating new lake habitat is to improve existing shallow lakes which do not have permanent fish populations. This can be done by creating a deep hole in the lake which would serve as overwintering habitat and allow a permanent fish community to be established (Figure 2-3). The most appropriate means of designing new small lake fish habitat, which would mimic the habitat being altered, is to use existing information on the physical characteristics of the small lakes within the project area as a model for construction of new habitats. Using these lakes as a model for construction would provide the best chance of creating fish habitat which can be used on a permanent basis. Appendix VII provides the rationale for the development of small lake construction criteria.

Figure 2-3 Conceptual Lateral View of Shallow Lake and Proposed Construction of Deep Water Habitat



Another means of mitigating habitat losses is to enhance existing fish habitat. Fish bearing lakes having deep-water areas (i.e., > 3 m) that occupy more than 20% of the lake's area can be made more shallow. These dimensions are modelled after lake e10 which has slightly less than 20% of its surface area that is deeper than 3 m. Lake e10, despite having one of the smallest proportional overwintering areas, contained one of the largest fish communities out of all the small lakes surveyed (Golder Associates 1997d). This suggests that 20% overwintering habitat may be a threshold value to sustain a productive fish community. The small lakes on the east island are ultra-oligotrophic. Creating additional shallow waters would enhance primary productivity due to an increase in the amount of rock that is influenced by sunlight and subject to increased algae and plant growth. Selected areas of lakes would be filled in with waste rock to a depth of 1 m. A depth of 1 m was selected to ensure exposure of the rock to maximum sunlight during the summer and to prevent siltation that may occur in deeper areas not affected by wave action.

2.3.3 Proposed Mitigation Measures

A total of three small fish-bearing lakes would be permanently altered by the development of the mine. A fourth fish-bearing lake would be drained for the duration of the construction/operations phase until closure, at which time the baseline fish community would be re-established. The habitat mitigation plan involves the modification of three undisturbed small lakes and the restoration of one other. All losses of small lake fish habitat would be mitigated by the end of the closure phase.

Lake e21 is presently too shallow to provide permanent fish habitat. The mitigation plan calls for the excavation of about 20% of the lake's surface area to a depth of 6-12 m. This would create sufficient overwintering habitat to allow fish to survive on a permanent basis. Lake e21 would be excavated at the end of the closure phase. The modified lake would be stocked with four species of fish taken from surrounding lakes: lake trout, round whitefish, lake whitefish and cisco.

If possible lakes e11, e14 and e17 would be re-configured in 1999 to optimize the fish habitat. Rock would be added to selected deep-water areas to create more shallow-water habitat. All three lakes apparently contain lake trout only. Cisco could be introduced to create a forage base for the lake trout. Round whitefish and lake whitefish could also be introduced to all three lakes. The round whitefish and lake whitefish could take advantage of the increased shallow-water areas for foraging and rearing. The source of these fish would be lake e10, which is scheduled for dewatering in 2000. If this schedule is unattainable, the fish from e10 would be stocked in lakes e11, e14 and e17 prior to enhancement. Details of all mitigation plans for small lakes are presented in Appendix VII.

2.4 STREAMS ON THE EAST ISLAND

Migration corridor habitat is habitat that allows fish to access permanent or seasonal habitats outside of their immediate environment. Migration corridor habitat on east island would be altered by the development of the mine on east island. However, since streams on the east island do not provide spawning or rearing habitat due to the extremely short duration of flows in the streams, the mitigation for this habitat type is proposed for the west island instead.

The outlet stream of lake w1 on the west island was evaluated to be the best opportunity to replace the east island migration corridor habitat. This lake has an outlet stream which drains into Lac de Gras. However, the existing channel configuration prevents fish access to the stream or the lake even during spring run-off. There is a small set of falls between Lac de Gras and the stream which blocks access to the remainder of the stream. Removal of this barrier would allow fish species such as Arctic grayling to use the stream for spawning, foraging and rearing purposes.

It is proposed that this barrier be removed by the creation of step-pools. The stream channel would also be re-configured so that fish may pass into the outlet stream of lake w1. Spawning habitat would be created in the stream channel by the addition of a cobble/gravel substrate. The area under consideration is approximately 60 m by 40 m. Flows of the stream are presently dispersed over and through a variety of barriers such as large boulders and sand. Since the flows of this stream are relatively small, it is proposed that a single channel be constructed. This would increase the amount of time that fish can use the stream.

3. HABITAT EVALUATION

3.1 APPROACH

A modified Habitat Evaluation Procedures (HEP) was used to calculate the quantity and quality of fish habitats being altered, lost or created during all three phases (i.e., construction, operations, closure) of the proposed Project (United States Fish and Wildlife Service 1980). HEP analysis combines habitat quality, defined by the Habitat Suitability Index (HSI), with habitat quantity to calculate Habitat Units (HUs), a measure that accounts for both the quantity and quality of habitat available for the species of interest. Multiplying the HSI value for each species and life stage by the area of each type of habitat provided the number of HUs available for each species and life stage during each Project phase.

Comparing the number of HUs available under baseline conditions to those available during construction/operations and post-closure, allows the quantification of the overall number of HUs altered, lost and created by the proposed Project, including mitigative measures. Thus, the difference in habitat quantity, weighted by habitat quality, between existing and future conditions enables an evaluation of the net effect of the proposed Project on fish habitat.

3.2 HABITAT TYPE AND AREA

Lac de Gras

A bathymetric survey of Lac de Gras was conducted by Challenger Surveys and Services Ltd. Survey data were used to produce digital bathymetric maps displaying contour lines at one metre intervals. These maps clearly depicted the shoal and shoreline habitat present in Lac de Gras, though resolution was much greater within one kilometre of the east island where transects were more closely spaced (Appendix I).

The major physical attributes of Lac de Gras were individually surveyed in the field during the baseline study in the summer of 1996. Major physical attributes of the lake included shorelines (0-6 m), shoals, shallow water (6-10 m) and deep water (>10 m). The physical attributes of all shorelines (e.g., slope, substrate type, vegetation type, etc.) in Lac de Gras were investigated. The shoreline habitat survey (Appendix II) describes standard procedures used by field personnel to assess and map shoreline fish habitat.

Methods used to delineate shoreline habitat were as follows:

- Scanned aerial photos of the Study Area were overlaid with bathymetric information and this composite image was transferred into GIS format.
- Using field records, the maximum depth of the silt-free rocky substrate was determined for each section of shoreline in the Study Area. Beyond this depth, the substratum is almost invariably composed of 100% silt. Where the depth could not be determined from air photos, 6 m was chosen as a conservative estimate.
- Using the maximum depths, GIS was used to calculate the area (ha) of available habitat along each uniform section of shoreline. The total area present for each habitat type (e.g., boulders, cobble, etc.) was then calculated for the shorelines that may be altered by dike construction.

Shoreline habitat types are highly repetitive throughout the lake (Figure 3-1). To facilitate comparison, a coding system was developed that classifies shorelines into five unique habitat types, using substrate as the primary variable (Appendix II).

All shoals within a 1 km radius of the east island were examined to determine their physical characteristics (i.e., depth, slope, aspect, shape and size of material). A sub-sample of the shoals in the remainder of the lake were also examined. The shoal habitat survey (Appendix III) describes standard procedures used by field personnel to assess and map shoals.

Several distinct types of shoal habitat exist for fish in Lac de Gras (Figure 3-2). Shoals were classified into five unique types, using substrate as the primary variable. The size of interstitial spaces, slope, and relative exposure to wind and wave action were among the characteristics used to classify shoals (Appendix III). Once shoals were defined, GIS was used to calculate the area (ha) of each individual shoal.

Shallow and deep water were identified using Lac de Gras bathymetric information (Figure 3-3). The shallow and deep-water habitat survey (Appendix IV) describes in detail the standard procedures used by field personnel to assess and map shallow and deep waters. This type of habitat was split into two categories: the area of habitat between 6 m and 10 m

Figure 3-1 Location of East Island Shoreline Habitat Types

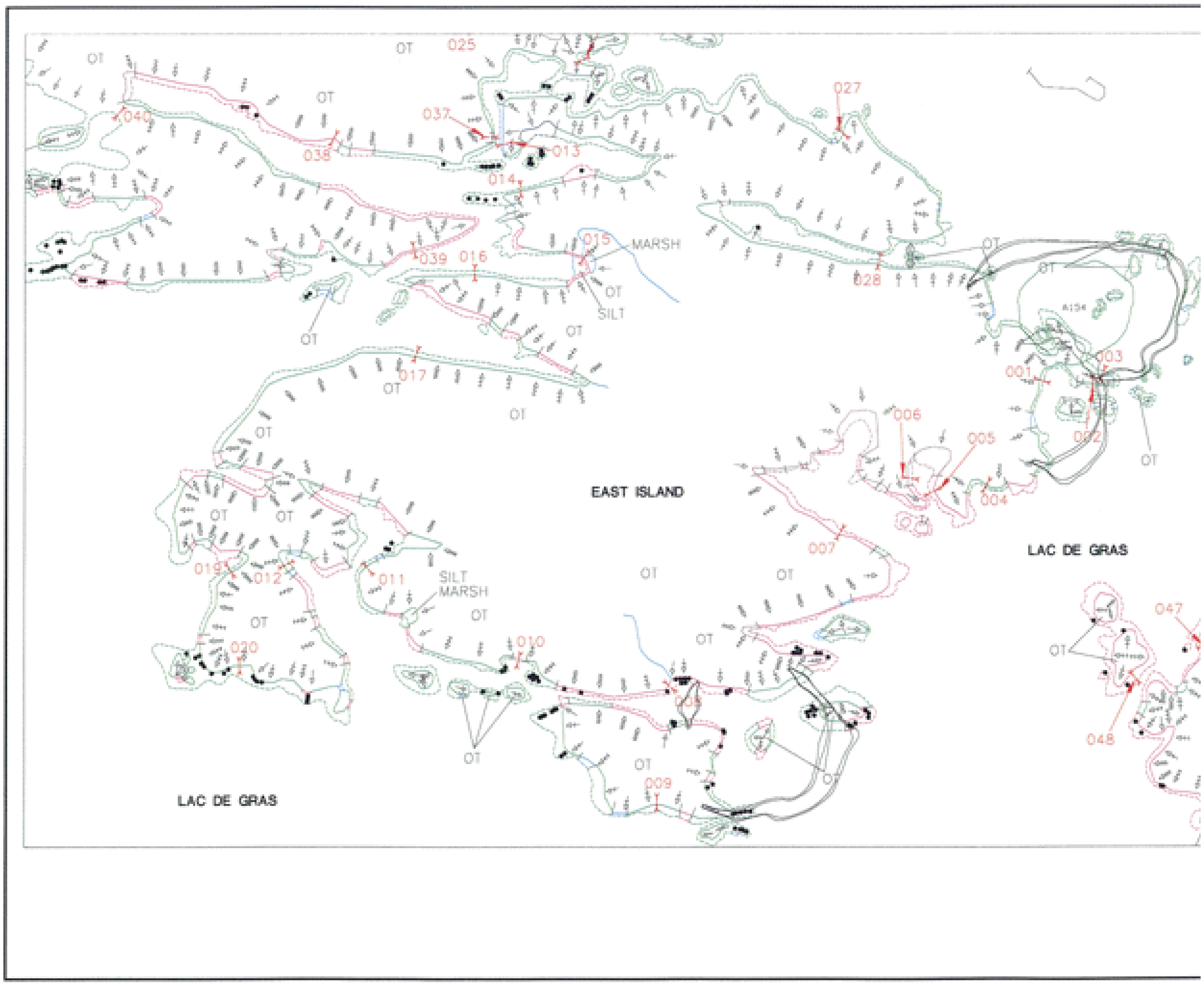


Figure 3-2 Location of Shoal Habitat, Local Study Area

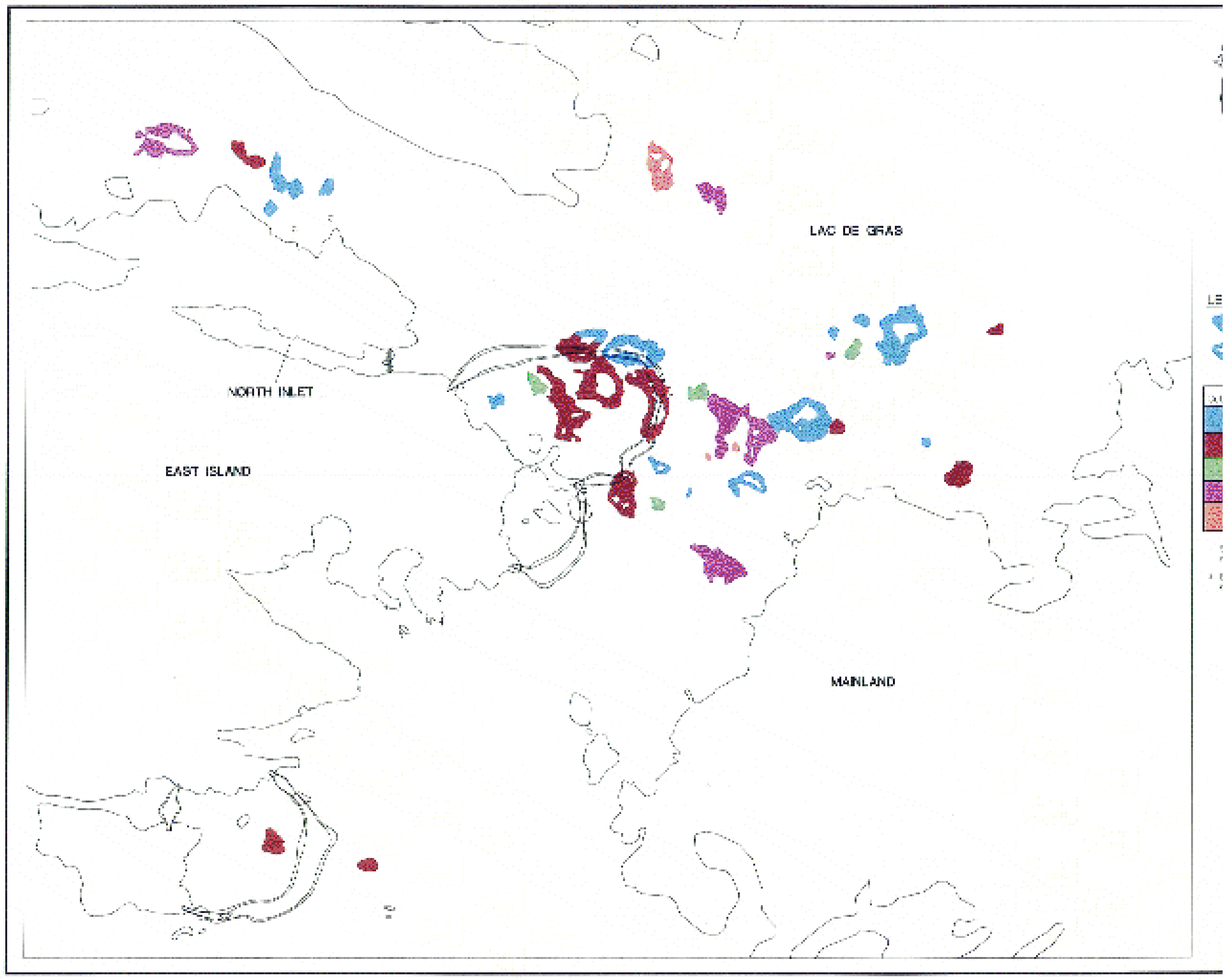
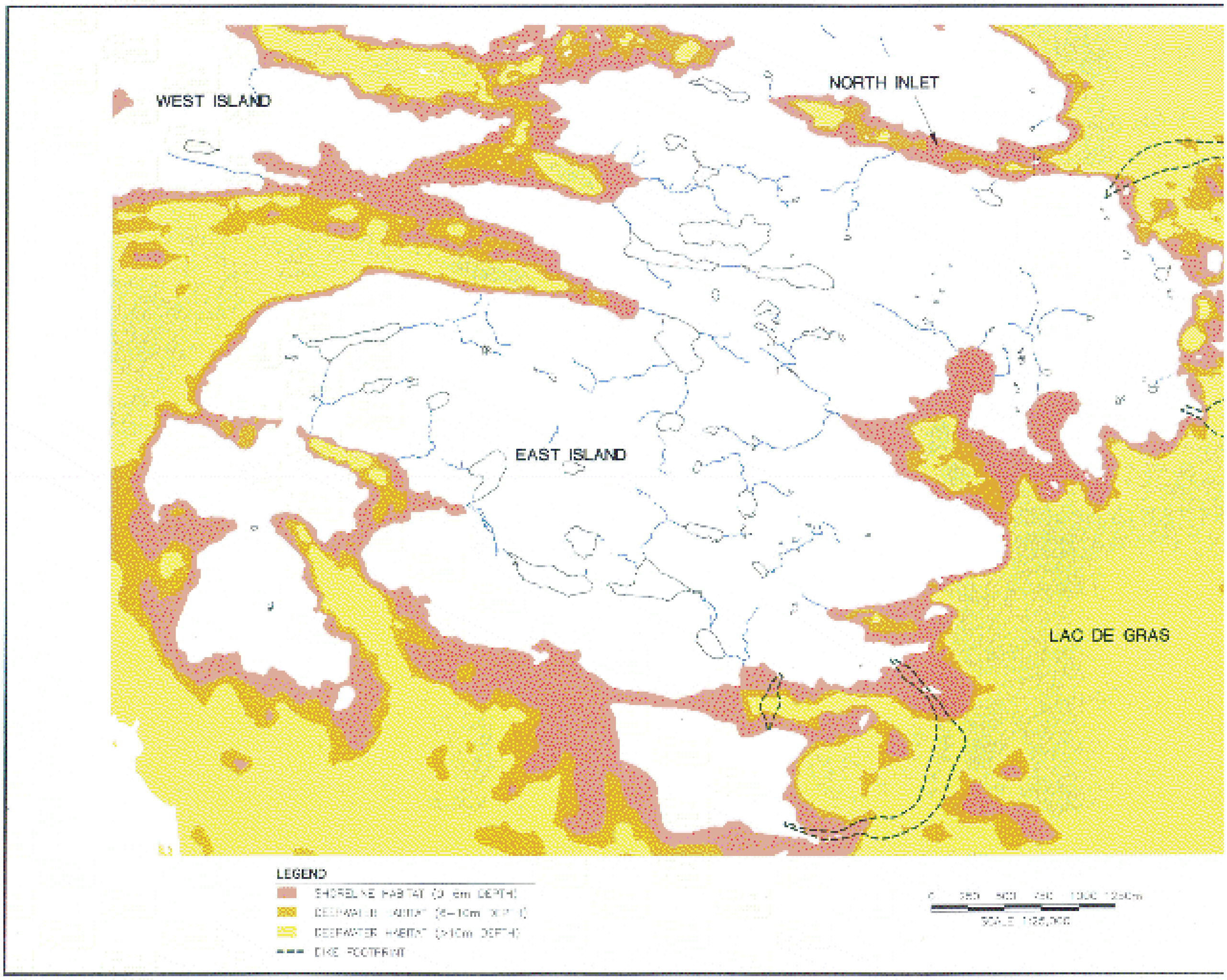


Figure 3-3 Location of Deep-Water Habitat, Local Study Area



deep (shallow water); and, the area greater than 10 m deep (deep water). This division was based on the extent of the photic zone which extended to a depth of 10 m.

Small Lakes

The survey of small lakes was designed to assess the quality and quantity of fish habitats available in each lake. Major physical attributes identified in small lakes included shorelines, shallow water and deep water. The majority of lakes on the east and west islands were surveyed, as well as a sample of small lakes on the mainland to the east of the proposed Project (33 lakes in total). The detailed procedures used for the determination of small lake habitats are presented in Appendix V.

Streams

Stream surveys for the purpose of assessing potential fish habitat (i.e., spawning, rearing and migration habitat) were conducted during the spring freshet in June, 1996. The survey included the east and west islands, as well as a sample of the tributary streams of Lac de Gras. Streams throughout the survey area were selected, primarily using helicopter reconnaissance, to include a representative range of sizes. Selection criteria included size, channel characteristics, and flow. Appendix VI contains all the field procedures used to evaluate the stream habitats.

The HEP analysis entailed calculating the habitat area influenced by the Project for:

- Shoals, shorelines, shallow and deep-water areas of Lac de Gras;
- Shorelines and deep-water areas of fish-bearing small lakes on the east island; and,
- Streams on the east island.

3.3 FISH SPECIES SELECTION

Fish were captured by a variety of means (i.e., gill nets, seine nets, hoop nets, angling) in Lac de Gras, the small lakes and small streams to identify species presence and relative abundance, or to confirm habitat use (Golder Associates 1997c). Electrofishing was not a feasible sampling method due to the very low conductivity of Lac de Gras water (~10-20 µS/cm). Trap nets also proved ineffective. The baseline sampling program included an adult fish survey, fall spawning surveys, shoreline fish sampling, stream spring spawning survey and small lake fish sampling. The details on how and where fish were captured are presented in Appendix VIII.

The fish species captured during the baseline field work were selected as the species to be considered for habitat mitigation (Table 3-1). However, not all species were captured in each type of water body. Since there were differences in fish communities among the water bodies affected by the project, separate mitigation plans were developed for Lac de Gras and the small lakes and streams on the east island. Due to the extremely short duration of flows, streams provided potential migration corridors for only Arctic grayling and longnose sucker (see also Appendix VI).

Table 3-1 Fish Species Considered for Habitat Mitigation

Lac de Gras	East Island Lakes	East Island Strear
Lake trout (LKTR) *Salvelinus namaycush* Walbaum	Lake trout	Arctic grayling

Lac de Gras	East Island Lakes	East Island Strear
Arctic grayling (ARGR) *Thymallus arcticus* Linnaeus	Arctic grayling	Longnose sucker
Cisco (CISC) *Coregonus artedi* Lesueur	Cisco	
Round whitefish (RNWH) *Prosopium cylindraceum* Pallas	Round whitefish	
Longnose sucker (LNSC) *Catostomus catostomus* Forster	Lake whitefish	
Lake whitefish (LKWH) *Coregonus clupeaformis* Mitchill	Longnose sucker	
Burbot (BURB) *Lota lota* Linnaeus	Lake chub (LKCH) *Couesius plumbeus* Agassiz	
Slimy sculpin (SLSC) *Cottus cognatus* Richardson		
Northern pike (NRPK) *Esox lucius* Linnaeus		

3.4 DEVELOPMENT OF HABITAT SUITABILITY MODELS

This habitat evaluation included developing habitat suitability indices (HSIs) for each fish species and life stage. HSI values range from 0.0 to 1.0, with a rating of 1.0 being optimal. The same shoal or stretch of shoreline may receive a ranking of ‘Excellent’ (HSI=1.00) for spawning for one species and ‘Average’ (HSI=0.50) for another. As fish have different habitat preferences during different times of their lives, four life stages (spawning, nursery, rearing and foraging) were considered for each species. For example, 36 HSI values (9 fish species x 4 life stages) were assigned for shoal habitat.

The choice of models used to determine HSI values for each species was determined by their availability in the literature. Published HSI models are available for only four of the nine species captured in Lac de Gras: lake trout (Marcus et al. 1984), Arctic grayling (Hubert et al. 1985), longnose sucker (Edwards 1983), and northern pike (Inskip 1982). These models were reviewed as to their applicability to Arctic waters. The lake trout model was deemed unsuitable since the variables deal primarily with oxygen and temperature levels in the hypolimnion during summer months. Since Lac de Gras does not stratify, this model is unsuitable for the purposes of this study. The model for northern pike clearly shows that all life stages of this species are dependent on the presence of aquatic macrophytes. Since limited aquatic macrophytes are present within the study area, a detailed review of this model was not necessary. The existing models for longnose sucker and Arctic grayling were modified to fit Arctic conditions. A detailed description is available for these models since they were modified from existing models (Appendix VI). The same level of detail could not be provided for the models developed for other species. The lack of published models necessitated the development of simple models for lake trout, round whitefish, cisco, burbot, slimy sculpin, lake chub and lake whitefish. These models were developed to fit site-specific habitat conditions.

In order to address both the lack of published HSI models and the need for validation of existing models, information was gathered from the following three sources:

- A literature review;
- A Delphi exercise; and,
- Field observations.

All three sources of information were incorporated into the development of new HSI models for this plan and validation of existing HSI models. It is a requirement of HEP analysis that HSI models be validated for the region where they are to be used.

Delphi Exercise

A process was initiated to solicit opinions on habitat needs for Lac de Gras fish species. A panel of researchers including government scientists and academics with knowledge of Arctic fish species was selected. The panel members were sent a habitat evaluation package (Appendix IX) and asked to provide their opinion on habitat needs for various fish species. A similar package was sent to informed lay-persons, including local fishermen and Aboriginal persons experienced in traditional fish capture. This approach, whereby informed opinion is solicited to develop a consensus, is known as a “Delphi exercise” (Crance 1987).

The Delphi exercise has proven to be an effective alternative for collecting unpublished information on fish habitat needs. However, only 3 of the 15 government and academic panelists polled responded to the questionnaire. The responses that were received confirmed the HSI models developed in this study. A general reply to the questionnaire sent to northern communities was also received. The response, although not species specific, did confirm suspected habitat use patterns by fish in Arctic lakes.

Literature Review

An extensive literature review was conducted on all fish species being considered for mitigation. The information gathered was used to formulate HSI values for each species and life stage of interest. A summary of the information reviewed and all references is presented in Appendix X.

Field Observations

Field observations were used to either refine or validate existing habitat models (e.g., spawning preferences for lake trout). Validation of existing HSI models using field observations was an important component in the development of these models. Where no published information on habitat preferences in Arctic environments could be found (e.g., cisco and round whitefish preferences for rearing habitat), field observations were used to develop new HSI models. These observations were at times the only source of information available on habitat use patterns for a particular life stage of a fish species.

Confidence in the models, or specific components of models, developed for this plan varied between fish species. A high level of confidence was placed on the lake trout and northern pike models due to the large volume of literature available on their habitat requirements. The models for longnose sucker and Arctic grayling were modified from existing HEP models. Confidence is these models is also high. A lower level of confidence was attributed to the models for round whitefish, cisco and burbot due to the relative lack of information available on their habitat requirements in Arctic waters. This was especially true for the rearing habitat requirements of all three species. To compensate for this lack of confidence in the certain models, conservative HSI values were used.

3.5 HSI CATEGORIES

By using all three sources of information, as well as professional judgment, each type of habitat was assigned a numerical ranking of suitability for each species. The range of HSI values used for all habitats are described in Table 3-2.

Table 3-2 Habitat Suitability Index (HSI) Values Used to Rank Fish Habitat

HSI Value	Habitat Description
1.00	Excellent
0.75	Above Average
0.50	Average
0.25	Below Average
0.00	Unsuitable

The information collected was formulated into a series of models (Appendix XI) describing the habitat needs for each of the eight species. The HSI models were applied to habitat types (e.g., shoals, shorelines) in Lac de Gras and the small lakes and streams on the east island for all fish species present in those locations.

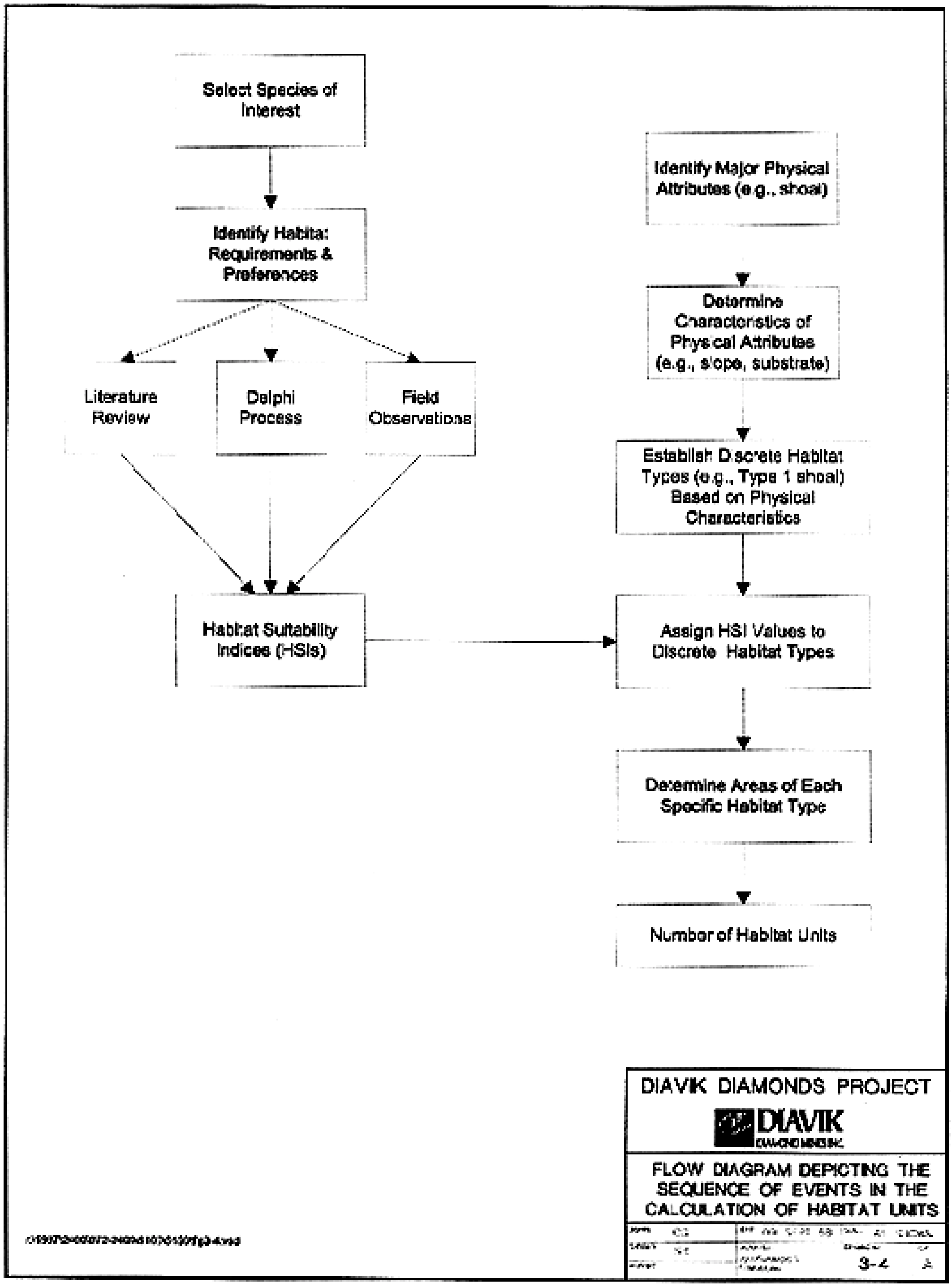
In cases where habitat preferences could be clearly defined (e.g., lake trout spawning habitat), all five HSI categories were developed. However, for certain habitat types and life stages there was insufficient information to properly distinguish the relative habitat preferences between closely related categories such as "excellent" and "above average." The "unsuitable" category was also dropped in some cases, since it could not be determined with certainty that a fish would not use a particular habitat. Consequently, some of the HSI values presented in this document have only three categories (i.e., above average, average and below average) instead of five.

Determination of Habitat Units

Each of the major physical attributes of each waterbody was divided in distinct "types" of habitat based on their physical characteristics (e.g., type 1 shoal). Once habitat types were designated, the HSI models were applied. As a result, an HSI value was assigned to each habitat type for each life stage of all species (Appendices II - VI).

The areas of each habitat type were determined using GIS technology. Once the areas of each habitat type, in hectares, were known, they were multiplied by the appropriate HSI values to obtain HUs. Figure 3-4 summarizes the sequence of events in the calculation of HUs. This formula applies equally to habitats in Lac de Gras and the small lakes and streams.

Figure 3-4 Flow Diagram Depicting the Sequence of Events in the Calculation of Habitat Units


Select Species of Interest
Identify Habitat Requirements & Preferences
Literature Review
Delphi Process
Field Observations
Habitat Suitability Indices (HSIs)
Identify Major Physical Attributes (e.g., shoal)
Determine Characteristics of Physical Attributes (e.g., slope, substrate)
Establish Discrete Habitat Types (e.g., Type 1 shoal) Based on Physical Characteristics
Assign HSI Values to Discrete Habitat Types
Determine Areas of Each Specific Habitat Type
Number of Habitat Units
DIAVIK DIAMONDS PROJECT
DIAVIK
FLOW DIAGRAM DEPICTING THE SEQUENCE OF EVENTS IN THE CALCULATION OF HABITAT UNITS
3-4

4. HABITAT ALTERATION RESULTS

4.1 LAC DE GRAS

The total numbers of habitat units temporarily lost due to the proposed Project are presented in Table 4-1 for each fish species of concern in Lac de Gras. Results were tabulated as the total amount of spawning, nursery, rearing and foraging habitat lost for each fish species. Data from shorelines, shoals, shallow water and deep water have been combined in this summary (Table 4-1). Also, the results for the north inlet and all the mine dikes have been combined to yield a total loss or gain in fish habitat due to the proposed Project.

Details on habitat unit calculations are presented in Appendices II through VI. Habitat lost due to dike construction and closure of the north inlet was calculated based on habitat under the footprint of the dikes, all habitat enclosed by the dikes, and all habitat within the north inlet. Creation of new fish HUs on the outside of the dike was calculated based on the perimeter of the dikes at the water level and assuming a 1.5:1 slope for the dikes. Restoration of habitat on the inside of the dike was calculated based on the footprint of the breached pits (i.e., open pit, pit shelf, and inside edge of the dike) at mine closure.

The potential impacts of habitat alteration in Lac de Gras due to the proposed dike construction are identified and discussed separately from this report. Potential impacts are presented in the "Environmental Effects Report, Fish and Water" (Golder Associates 1998).

Habitat available during pre-development (baseline) conditions and the proportion lost during the construction/operations phase are presented in Table 4-1 for lake trout, cisco, round whitefish, Arctic grayling, lake whitefish, longnose sucker, northern pike, burbot and slimy sculpin. Table 4-1 also presents the amount of habitat created by mitigative measures at the end of the post-closure phase. Percentages refer to percent of habitat lost or gained compared to baseline conditions. Habitat lost and gained is summarized by Table 4-2.

Table 4-1 The Spawning, Rearing, Foraging, and Nursery Habitat Units in the Regional Study Area of Lac de Gras

a) Lake Trout

Habitat	Spawning		Nursery		Rearing		Foraging	
	HUs[1]	%[2]	HUs	%	HUs	%	HUs	%
Baseline	3682		3682		14819		32799	

Construction/Operations	3651		3655		14720		32662	
Habitat Lost	-32	-0.9	-27	-0.7	-99	-0.7	-137	-0.4
Habitat Gained - Mitigation	+6		+5		+191		+101	
Post-Closure	3657		3660		14910		32763	
Net Habitat Lost/Gained[3]	-25	-0.7	-22	-0.6	+91	+0.6	-36	-0.1

b) Cisco

Habitat	**Spawning**		**Nursery**		**Rearing**		**Foraging**	
	HUs[1]	**%[2]**	**HUs**	**%**	**HUs**	**%**	**HUs**	**%**
Baseline	3939		3939		29875		32865	
Construction/Operations	3901		3901		29763		32726	
Habitat Lost	-38	-1.0	-38	-1.0	-112	-0.4	-139	-0.4
Habitat Gained - Mitigation	+5		+5		+190		+163	
Post-Closure	3906		3906		29953		32889	
Net Habitat Lost/Gained[3]	-33	-0.8	-33	-0.8	+78	+0.3	+24	+0.1

c) Round Whitefish

Habitat	**Spawning**		**Nursery**		**Rearing**		**Foraging**	
	HUs[1]	**%[2]**	**HUs**	**%**	**HUs**	**%**	**HUs**	**%**
Baseline	2258		2258		17618		20388	
Construction/Operations	2235		2235		17541		20283	
Habitat Lost	-23	-1.0	-23	-1.0	-76	-0.4	-105	-0.5
Habitat Gained - Mitigation	+35		+35		+128		+101	

Post-Closure	2271		2271		17669		20384	
Net Habitat Lost/Gained[3]	+12	+0.6	+12	+0.6	+52	+0.3	-4	-0.0

d) Arctic Grayling

Habitat	Spawning		Nursery		Rearing		Foraging	
	HUs[1]	%[2]	HUs	%	HUs	%	HUs	%
Baseline	0		0		20550		22035	
Construction/Operations	0		0		20443		21915	
Habitat Lost	0	-	0	-	-107	-0.5	-120	-0.5
Habitat Gained - Mitigation	0		0		97		99	
Post-Closure	0		0		20540		22014	
Net Habitat Lost/Gained[3]	0	-	0	-	-11	-0.1	-21	-0.1

e) Lake Whitefish

Habitat	Spawning		Nursery		Rearing		Foraging	
	HUs[1]	%[2]	HUs	%	HUs	%	HUs	%
Baseline	5039		5039		20816		19483	
Construction/Operations	4993		4993		20716		19383	
Habitat Lost	-46	-0.9	-46	-0.9	-101	-0.5	-101	-0.5
Habitat Gained - Mitigation	+7		+7		+160		+131	
Post-Closure	5000		5000		20875		19514	
Net Habitat Lost/Gained[3]	-39	-0.8	-39	-0.8	+59	+0.3	+31	+0.2

f) Longnose Sucker

Habitat	Spawning		Nursery		Rearing		Foraging	
	HUs[1]	%[2]	HUs	%	HUs	%	HUs	%
Baseline	3790		3790		22685		32529	
Construction/Operations	3766		3766		22580		32395	
Habitat Lost	-24	-0.6	-24	-0.6	-105	-0.5	-134	-0.4
Habitat Gained - Mitigation	+3		+3		+128		+127	
Post-Closure	3769		3769		22708		32522	
Net Habitat Lost/Gained[3]	-21	-0.6	-21	-0.6	+23	+0.1	-7	-0.02

g) Burbot

Habitat	Spawning		Nursery		Rearing		Foraging	
	HUs[1]	%[2]	HUs	%	HUs	%	HUs	%
Baseline	4794		4794		24980		33385	
Construction/Operations	4749		4749		24839		33244	
Habitat Lost	-45	-0.9	-45	-0.9	-141	-0.6	-140	-0.4
Habitat Gained - Mitigation	+3		+3		+129		+99	
Post-Closure	4752		4752		24968		33343	
Net Habitat Lost/Gained[3]	-42	-0.9	-42	-0.9	-12	0.0	-41	-0.1

h) Northern Pike

Habitat	Spawning	Nursery	Rearing	Foraging

	HUs[1]	%[2]	HUs	%	HUs	%	HUs	%
Baseline	0		0		0		0	
Construction/Operations	0		0		0		0	
Habitat Lost	0	-	0	-	0	-	0	-
Habitat Gained - Mitigation	0		0		0		0	
Post-Closure	0		0		0		0	
Net Habitat Lost/Gained[3]	0	-	0	-	0	-	0	-

i) Slimy Sculpin

Habitat	Spawning		Nursery		Rearing		Foraging	
	HUs[1]	%[2]	HUs	%	HUs	%	HUs	%
Baseline	9358		9358		27397		31541	
Construction/Operations	9294		9294		27255		31414	
Habitat Lost	-65	-0.7	-65	-0.7	-142	-0.5	-128	-0.4
Habitat Gained - Mitigation	+165		+165		+166		+162	
Post-Closure	9459		9459		27421		31576	
Net Habitat Lost/Gained[3]	+101	+1.1	+101	+1.1	+24	+0.1	+34	+0.1

1 - Habitat Units (HUs) are in hectares indexed by a measure of quality (HSI value)

2 - Calculated as the amount of HUs available at Baseline minus the amount available in the Post-Closure Phase

3 - Percentage equals the percent of habitat lost or gained relative to the amount available at Baseline

Table 4-2 Habitat Units Lost versus Habitat Units Gained in Lac de Gras Due to Dike Construction

Habitat Type (HUs)	Temporary and Permanent		
	Losses	Gains	Net
Shoreline	-790	+175	-615
Shoal	-362	0	-362
Shallow/deep water	-1,280	+2,443	+1,163
Total	**-2,432**	**+2,618**	**+186**

Note: Habitat Units (HUs) are in hectares indexed by a measure of quality (HSI value)

For all fish species, the greatest losses were in spawning and nursery habitat. These losses ranged from 1% to 2% of the total available spawning and nursery habitat available in Lac de Gras. Spawning habitat was not found to be limiting in Lac de Gras. As such, no special efforts to create shoals, which function primarily as spawning habitat, were made in the mitigation plans. Shoals were observed to be numerous throughout Lac de Gras and the creation of new shoals would only result in a modest increase in spawning habitat. Changes in rearing and foraging habitat were usually smaller than 1%.

The overall total number of created by mitigation is 186 HUs greater than what would be required to achieve ***no net loss***. Though fully mitigated, the losses that did occur were primarily in the deep water portions of Lac de Gras within the boundaries of the dikes. Deep water habitat is not limiting in Lac de Gras. Since it is impractical to re-create deep water habitat (although some is created in the pits), the focus of the mitigation was to build shallow water rearing habitat.

4.2 SMALL LAKES ON THE EAST ISLAND

In the local study area, the habitat in three fish-bearing lakes (e7, e8, and e10) would be permanently lost (shown in Figure 1-3). Lake e3, which is also fish bearing, and lake e21, which is non-fish-bearing, would be drained for the duration of the construction/operation phase, but the loss would be temporary. Lakes e11, e14 and e17 would be enhanced by filling in portions of the deep areas of each lake. Lake e21 would be enhanced by excavation. Lake e3 would be re-filled upon mine closure and the fish community would be re-established to mimic the baseline species composition.

Table 4-3 contains the estimated number of spawning, nursery, rearing, foraging and overwintering HUs for each fish species in lakes on the east island during pre-development (baseline), construction/operations and post-closure phases (after mitigative measures have been implemented). Table 4-4 also indicates the habitat lost or gained at each phase. Only fish-bearing lakes that would be affected to some extent by the proposed Project are included in Table 4-4. There are three fish-bearing lakes on the east island that would not be affected (lake e11, e14, e17). Each of these lakes were included in the mitigation plan since their physical features would be altered to enhance existing habitat.

A surplus of 71 HUs of small lake habitat would result following the completion of the proposed mitigation. The species used in calculating the amount of HUs created were selected based on their distribution on the east island.

Table 4-3 The Spawning, Rearing, Foraging, Nursery and Overwintering Habitat Units in Small Lakes on the East Island

a) Lake Trout

Habitat	**Spawning**		**Nursery**		**Rearing**		**Forag**
	HUs[1]	**%**[2]	**HUs**	**%**	**HUs**	**%**	**HUs**
Baseline[3]	0.141		0.141		8.236		8.386
Construction/Operations[4]	0.141		0.141		8.236		8.386
Habitat Loss	0	-100	0	-100	0	-100	0
Habitat Gained - Mitigation	+2.546		+2.546		+7.866		+9.259
Post-Closure	2.546		2.546		7.866		9.259
Net Habitat Lost/Gained[5]	+2.405	+1703.5	+2.405	+1603.5	-0.370	-4.5	+0.873

b) Cisco

Habitat	Spawning		Nursery		Rearing		Forag
	HUs[1]	%[2]	HUs	%	HUs	%	HUs
Baseline[3]	0.832		0.832		8.145		8.145
Construction/Operations[4]	0.832		0.832		8.145		8.145
Habitat Loss	0	-100	0	-100	0	-100	0
Habitat Gained - Mitigation	+8.172		+8.172		+21.820		+21.820
Post-Closure	8.172		8.172		21.820		21.820
Net Habitat Lost/Gained[5]	+7.339	+881.7	+7.339	+881.7	+13.675	+167.9	+13.675

c) Round Whitefish

Habitat	Spawning		Nursery		Rearing		Forag
	HUs[1]	%[2]	HUs	%	HUs	%	HUs
Baseline[3]	0.448		0.448		8.495		8.089
Construction/Operations[4]	0.448		0.448		8.495		8.089
Habitat Loss	0	-100	0	-100	0	-100	0
Habitat Gained - Mitigation	+6.937		+6.937		+29.843		+27.092
Post-Closure	6.937		6.937		29.843		27.092
Net Habitat Lost/Gained[5]	+6.489	+1448.7	+6.489	+1448.7	+21.348	+251.3	+19.003

d) Lake Whitefish

Habitat	Spawning		Nursery		Rearing		Forag
	HUs[1]	%[2]	HUs	%	HUs	%	HUs
Baseline[3]	0.547		0.547		8.495		8.474
Construction/Operations[4]	0.547		0.547		8.495		8.474
Habitat Loss	0	-100	0	-100	0	-100	0
Habitat Gained - Mitigation	+7.871		+7.871		+30.012		+28.359
Post-Closure	7.871		7.871		30.012		28.359
[2]Net Habitat Lost/Gained[5]	+7.324	+1339.5	+7.324	+1339.5	+21.517	+253.3	+19.885

e) Longnose Sucker

Habitat	Spawning		Nursery		Rearing		Forag
	HUs[1]	%[2]	HUs	%	HUs	%	HUs
Baseline[3]	2.124		2.124		12.819		11.841
Construction/Operations[4]	2.124		2.124		12.819		11.841
Habitat Loss	0	-100	0	-100	0	-100	0
Habitat Gained - Mitigation	+0		+0		+0		+0
Post-Closure	0		0		0		0
Net Habitat Lost/Gained[5]	-2.124	-100	-2.124	-100	-12.819	-100	-11.841

f) Burbot

Habitat	Spawning	Nursery	Rearing	Forag

	HUs[1]	%[2]	HUs	%	HUs	%	HUs
Baseline[3]	1.118		1.118		5.978		5.755
Construction/Operations[4]	1.118		1.118		5.978		5.755
Habitat Loss	0	-100	0	-100	0	-100	0
Habitat Gained - Mitigation	+0		+0		+0		+0
Post-Closure	0		0		0		0
[2]Net Habitat Lost/Gained[5]	-1.118	-100	-1.118	-100	-5.978	-100	-5.755

g) Lake Chub

Habitat	Spawning		Nursery		Rearing		Forag
	HUs[1]	%[2]	HUs	%	HUs	%	HUs
Baseline[3]	0.327		0.327		1.087		1.087
Construction/Operations[4]	0.327		0.327		1.087		1.087
Habitat Loss	0	-100	0	-100	0	-100	0
Habitat Gained - Mitigation	+0.327		+0.327		+1.087		+1.087
Post-Closure	0.327		0.327		1.087		1.087
Net Habitat Lost/Gained[5]	0	0	0	0	0	0	0

1 - Habitat Units (HUs) are in hectares indexed by a measure of quality

2 - Percentage equals the percent of habitat lost or gained relative to the amount available at Baseline

3 - HUs available at baseline in lakes e3, e7, e8 and e10

4 - The amount of habitat available during the Construction/Operation Phase

5 - Calculated as the amount of HUs available at Baseline minus the amount available in the Post-Closure Phase

Table 4-4 Available Habitat by Mining Phase in Small Lakes on the East Island

Lake	Habitat Units (HUs)			
	Baseline	Construction/ Operation	[1]Post-closure	Net Difference at Post-closure
Lake e3	3.11	0	3.11	0
Lake e7	15.55	0	0	-15.55
Lake e8	30.33	0	0	-30.33
Lake e10	77.15	0	0	-77.15
Lake e11	14.19	74.37	74.37	+60.18
Lake e14	12.45	62.32	62.32	+49.87
Lake e17	20.80	76.95	76.95	+56.15
Lake e21	0	0	27.83	+27.83
Net HUs of Small Lake Habitat Available on the east island		213.64	244.58	+71.00

1 - Habitat available at post-closure after subtraction of HUs initially present for lake trout in lakes e11, e14, and e17 under baseline conditions

4.3 STREAMS ON THE EAST ISLAND

To quantify and describe the available habitat under pre-development (baseline) conditions, 30 streams on the east island were surveyed. In addition, small lakes on the east island and on the mainland and west island were evaluated for the potential to provide overwintering habitat (access to overwintering habitat is an essential criterion for the provision of migration habitat by a stream). Separate calculations were performed for three classes of habitat: spawning, rearing and migration habitat. Arctic grayling and longnose sucker were the only species considered for spawning and rearing habitat since they are the only species with the potential to use the streams for these purposes while they flow in the spring.

Of the 24 streams that would be affected by the proposed Project, none presently provide spawning or rearing habitat, but nine streams could potentially provide migration corridor habitat. The total number of HUs for the 24 affected streams on the east island are presented in Table 4-5.

Table 4-5 The Spawning, Rearing and Migration Corridor Habitat Units in Streams

	Arctic grayling and longnose sucker		**Arctic grayling and longnose sucker**		**All Species**	
Habitat	**Spawning**		**Rearing**		**Migration**	
	[1]HUs	**%**	**HUs**	**%**	**HUs**	**%**
Baseline	0		0		0.15	
[2]Construction/Operations	0		0		0.03	
[3]Habitat Lost	0	0	0	0	-0.12	-80
Habitat Gained - Mitigation on west island	+0.016	+100	+0.016	+100	+0.24	
Habitat Gained - Restoration on east island	0		0		+0.02	
Post-Closure	0.016		0.016		0.29	
[4]Net Habitat Lost/Gained	+0.016	+100	+0.016	+100	+0.14	+80

1 - Habitat Units (HUs) are in hectares indexed by a measure of quality

2 - The amount of Habitat Available during the Construction/Operation Phase

3 - Calculated as the amount of Habitat Units available at Baseline minus the amount available in the Post-Closure Phase

4 - Percentage equals the percent of habitat lost or gained relative to the amount available at Baseline

This table also presents the number of HUs created at post-closure to mitigate the potential losses. The restoration of natural drainage patterns on the east island upon closure would result in a gain of 0.02 HUs of migration habitat. The area of migration corridor habitat created by re-configuration of a stream on the west island (i.e., outlet of lake w1) would result in a net gain of 0.24 HUs. The length of stream channel that would receive cobble/gravel substrates would be approximately 40 m. The width of the channel at this point in the stream averages 4 m. The total number of HUs created would be 0.14 for migration habitat and 0.016 for spawning and rearing habitat.

Thus, the mitigation of the outlet stream of lake w1 would result in no net loss of migration corridor habitat for the proposed Project; following closure of the facility on the east island, there would be a net gain of migration habitat. Mitigation plans for the stream draining lake w1 would be implemented early in the construction phase.

A small net gain (0.016 HUs) of spawning and rearing habitat would occur. A small increase (0.14 HUs) in migration corridor habitat is also anticipated following mitigation.

4.4 SUMMARY OF HABITAT ALTERATION RESULTS

Construction activities would result in the loss of fish habitat. Measures outlined above would result in the mitigation of these habitat losses. The purpose of this document is to present conceptual plans to achieve no net loss of fish habitat in accordance with DFO's *Policy for the Management of Fish Habitat* (1986). A summary of the habitat alterations and mitigation options that have been addressed in this document is presented below. The discussion is separated based on the each type of habitat. No net loss of habitat would be achieved in each case.

Lac de Gras

Dike construction around the A154N/S, A418, and A21 pipes would result in the loss of shoreline, shoal, and shallow/deep water fish habitat in Lac de Gras. The blocking of the north inlet from Lac de Gras would result in the loss of shoreline and shallow/deep water habitat. Construction activities would result in the loss of a total of 2,432 HUs. These losses would be fully offset by mitigation measures which are presented in detail in Appendix VII. These measures would result in the creation of 2,618 HUs in Lac de Gras, and a surplus of 186 HUs relative to baseline conditions.

Small Lakes

Construction of infrastructure on the east island would result in the permanent loss of three fish-bearing lakes, namely lake e7, lake e8, and lake e10. Lake e3 would be temporarily drained for the duration of the construction/operations phase and restored upon closure. Fishing results in each lake confirmed the presence of the following fish species: lake e3 supports a population of lake chub; lake e7 was found to have longnose sucker; lake e8 had longnose sucker and burbot; and lake e10 contained lake trout, lake whitefish, round whitefish, and cisco. The alteration of these lakes would result in the permanent loss of 123 habitat units (HUs) and the temporary loss of 3 HUs in lake e3. The permanent loss of 123 HUs would be fully offset by mitigation efforts in lakes e11, e14, e17 and e21 which are presented in detail in Appendix VII. Restoration of lake e3 to baseline conditions would completely offset the HUs lost during the construction/operations phase. Mitigation efforts would result in the creation of 244 HUs, and a surplus of 71 HUs relative to baseline conditions.

Streams

Infrastructure construction on the east island would result in the loss of streams on the east island. The majority of these streams, however, are small, flow only seasonally and for a short duration. Thus, there are no streams on the east island that are suitable for spawning or rearing of fish. Nine streams on the east island may provide migration corridor habitat, during times of very high runoff. Construction on the east island would result in the loss of 0.12 HUs of migration habitat for fish. As east island streams do not provide spawning and rearing habitat for Arctic grayling and longnose sucker, these types of habitats would not be lost in streams due to construction. Restoration of natural drainage patterns on the east island upon mine closure would restore 0.02 HUs of migration habitat for fish. Mitigation efforts in the form of improvements to the stream that drains lake w1 on the west island would result in a further gain of 0.24 HUs of migration habitat and 0.016 HUs of spawning and rearing habitat.

5. MONITORING THE EFFECTIVENESS OF HABITAT COMPENSATION

Four monitoring programs are described below to determine the effectiveness of the habitat compensation and mitigation measures outlined in the “No Net Loss” Plan. The first three programs would begin during the operations period with some components occurring at post-closure. The last monitoring program would take place at post-closure. The four monitoring programs would be conducted to determine:

1. The effectiveness of the creation of fish habitat in small lakes;
2. The effectiveness of the migration corridor habitat constructed to allow fish passage during spring spawning;
3. The effectiveness of the external edges of the dikes in providing fish habitat; and,

4. The effectiveness of the areas behind the breached dikes as rearing and foraging habitat.

5.1 CREATION OF FISH HABITAT IN SMALL LAKES

This monitoring program is identified contingent upon stakeholder/ regulatory direction to focus on re-creating small lake habitat, as opposed to focusing the mitigative effects on Lac de Gras.

The success of the fish habitats enhanced in lakes e11, e14 and e17, and created in lake e21 would be verified to confirm mitigation of the altered small lake habitats on the east island. The monitoring surveys, consisting primarily of non-lethal capture methods, would be conducted on these lakes one and three years after completion of habitat creation and fish transfers. Adult fish would be held in pens prior to being released into the lakes, to ensure good health of the stocked fish. The source of these fish would be small lakes on the east island that would be lost. The long-term viability of the newly created habitats would be tested in two ways:

1. **By verifying survival of the stocked fish in the new habitat.** The first test of the success of the new habitats would be to observe whether or not the stocked adults have survived the winter. Standard gang gill netting would be used to capture the fish one year after stocking. Nets would be checked frequently to minimize fish mortality.
2. **By verifying that reproduction has occurred.** The second test of the success of the new habitats would be to see if the introduced fish were able to reproduce. This would be measured by fishing specifically for young-of-the-year and juvenile fish three years after stocking. Gill and seine netting would be used to search for young-of-the-year and juvenile fish. The presence of these fish would indicate that reproduction has occurred.

Should the small lakes be devoid of the introduced fish species, investigations would be undertaken to determine the cause of the failure of the newly created or enhanced habitat to support fish populations. In any such case, alternative mitigation measures would be identified and evaluated.

The target end-point would be Catch-Per-Unit-Effort values comparable to those realized when sampling lake e10 during baseline data collection. Lake e10 is the lake being emulated during habitat enhancement activities.

5.2 THE EFFECTIVENESS OF THE MIGRATION CORRIDOR HABITAT

The stream from lake w3 on the west island would be improved for fish passage and spawning. Changes to this stream would be implemented during the construction or operations phase. The success of the habitat improvements would be verified during the early operations phase. The measure of success would be the presence of fish in the stream during spring spawning. Spawning activity or evidence of migration to the small lake would indicate that habitat improvements were successful. The species most likely to use this habitat are Arctic grayling and longnose sucker.

The lack of habitat use may not be attributed solely to the suitability of the habitat. Due to such behavioural mechanisms as homing, as well as the relative abundance of the particular habitat type in relation to the number of fish using the habitat (e.g., there are about 200 streams flowing into Lac de Gras), fish may choose not to use this migration corridor/spawning habitat. If habitat use is not detected, the habitat characteristics would be measured (e.g., water depth, water velocity, etc.) and compared to habitat preference criteria. If the enhanced habitat exhibits suitable characteristics for migration corridor use, even in the absence of use by fish, it will be deemed to have achieved the objective of compensating for the loss of migration corridor habitat.

5.3 THE EFFECTIVENESS OF THE EXTERNAL EDGES OF THE DIKES IN PROVIDING FISH HABITAT

Habitat use on the external edges of the dikes would likely commence at the completion of the first dike. The habitat types created on the exterior of the dikes would be spawning, nursery, rearing and foraging. The viability of spawning habitat would be checked by observing fish behaviour during the fall spawning season. This study would occur in the fall for lake trout, round whitefish and cisco. Limited gill netting would be used to confirm that the observed fish were in spawning condition. The protocols for this type of study are the same as those for the fall spawning surveys conducted during the baseline program. Verification that spawning has occurred would also be accomplished by confirming the presence of eggs on the substrates. Air-lift sampling or divers would be used for this purpose. This study would be performed during the operations phase of the project, at locations unaffected by the use of explosives.

Verification of habitat use for the nursery, rearing and foraging life stages would be carried out by direct observation (diver or remotely controlled underwater video camera), and limited gill netting.

This program would be carried out as soon as the first dike is completed, or possibly earlier if there are regions of the dike that are unaffected by dike construction activities. If reasons are apparent that the created habitat does not provide suitable fish habitat, alternative mitigation measures would be investigated and evaluated.

5.4 THE EFFECTIVENESS OF THE FLOODED PITS AS REARING AND FORAGING HABITAT

Verification of fish usage on the interior of the dikes would be carried out on mine pit A21 first, as it would be the first dike that would be breached (about 2017). The evaluation would be conducted three years after breaching (about four years before A154 and A418 are breached). Test netting would be used to verify the presence of juvenile and adult fish inhabiting the flooded area behind the dikes. Habitat features would also be evaluated visually at that time, to ensure these features are providing the desired habitats types. Those features that are apparently preferred by the juvenile and adult life stages would be maximized in the mitigation planning for dikes A154 and A418, while those habitat features that are apparently not suitable, or are less desirable to the target species would be reduced or eliminated from plans for the remaining two pits.

The target end-point would be Catch-Per-Unit-Effort values that are comparable, by species and life stage, to those realized when conducting the baseline surveys of the north inlet, which is the habitat that is largely being replaced.

6. CLOSURE

We trust that this report presents the information that you require. Should any portion of the report require clarification, please contact the undersigned.

Respectfully submitted,

GOLDER ASSOCIATES LTD.

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APPENDIX I - FIELD ACTIVITIES

For the classification of fish habitat in Lac de Gras, the lake was divided into two distinct areas: Extensive and Intensive. The boundary for the Intensive Area was 1 km from the shoreline of the east island, with all other portions of Lac de Gras comprising the Extensive Area. The study areas are defined as follows:

- **Intensive Area** - includes shoal, shoreline, shallow and deep-water habitat in and around the east and west islands, and a stretch of mainland shoreline immediately opposite the proposed Diavik Project Site. This differs from the boundaries of the local study area presented in the "Environmental Effects Report, Fish and Water" since the footprint of the proposed Project was considerably larger when the baseline studies were completed. The proposed Project footprint has since been substantially reduced.

- **Extensive Area** - includes shoal, shoreline, shallow and deep-water habitats in all areas of Lac de Gras not included in the Intensive Area.

More effort was directed towards categorizing habitat in the Intensive Area since all direct effects on fish habitat from the proposed Project would occur in this part of the lake. Habitat survey methods in the larger Extensive Area involved assessment of a sub-sample of all available habitat. For the purpose of determining habitat mitigation, the focus of this document will be on the Intensive Area. However, the descriptions of the methods used in both areas are included.

Bathymetry

A bathymetric survey of Lac de Gras was conducted by Challenger Surveys and Services Ltd. (Challenger). Survey transects were spaced at 25 and 100 m intervals in the Intensive Area. In the Extensive Area, transect spacing was as large as 2000 m. Surveys were completed using boat-based echo sounding equipment and a differentially corrected Global Positioning System (GPS), resulting in survey data of better than one metre accuracy. Survey data were used to produce digital bathymetric maps displaying contour lines at one metre intervals. These maps clearly depicted the shoal and shoreline habitats present in Lac de Gras, although resolution is much greater within one kilometre of the east island where transects were more closely spaced.

Shorelines

Shoreline characteristics were mapped by slowly cruising parallel to the shore in a small boat. Crews maintained a safe distance from shore, usually travelling along the point of sudden drop-off to deep water. Habitat features routinely recorded on maps included:

- Types of substrate (% of each, above and below waterline);
- Shoreline slope (above and below waterline);
- Vegetation type present (aquatic and terrestrial);
- Water level;
- Erosion potential; and,

- Presence of silt or algae on substrates.

In addition to mapping, shoreline habitat transects were established for more detailed assessment of fish habitat. A transect evaluation was conducted whenever a significant change in shoreline habitat was observed or after mapping a 2 km length of unchanging shoreline. Transects were established perpendicular to the shoreline using a measuring tape. Characteristics were noted within a 2 m width on either side of the tape including percentage composition of substrates, depth, coverage of silt and algae, and size and number of interstices between rocks. Fishing (beach seining and hand netting) was conducted at each transect site, where practical.

In the Extensive Area, this transect method was used almost exclusively as a sub-sampling method for assessing shorelines. Due to the large area surveyed, all Extensive Area shorelines were videotaped from a helicopter and shoreline habitat maps were prepared based on the recordings. While preparing the maps, points were identified where the habitat changed dramatically or looked unique. Field crews visited each of these points and a shoreline habitat transect evaluation was conducted. In this manner, the transect results were used to “truth” the habitat maps prepared from the video information. Only 2 of 125 transects required adjustment after comparison with field observations.

Shoals

Shoals designated as potential fish habitat were identified using Lac de Gras bathymetric information. By reading Challenger’s sounder output, shallow-water areas (<10 m but usually <5 m) were identified. All shallow areas (‘shoals’) in the Intensive Area were visited by a field crew. In the Extensive Area, where survey transects were relatively widely spaced, a sub-set of the total number of shoals was identified and surveyed. Therefore, by design, field crews surveyed only a fraction of the available shoal habitat in the Extensive Area.

Universal Transverse Mercator (UTM) coordinates from the survey data were used by the field crews to locate shoals. A camera mounted in a remotely-operated vehicle (ROV) was used to describe the physical characteristics of the shoal. Shoals were recorded on video tape to obtain a permanent record of the habitat observed. The relative size of the material was estimated by placing a quadrat (a 1 × 1 m square divided into a 10 × 10 cm grid) on to the shoal substrate. Each shoal was examined for the following:

- Composition (i.e., size of material);
- Depth;
- Shape of the material (round vs. angular);
- Size of spaces between rocks;
- Slope;

- Aspect;
- Relative proximity to deeper water (> 20 m); and,
- Cleanliness of the material (e.g., silt-covered, epilithic algae).

Further details regarding the shoal survey are available in Technical Memorandum #12 (Golder Associates 1997a).

Shallow and Deep Water

Shallow and deep water areas designated as potential fish habitat were identified using Lac de Gras bathymetric information. By reading Challenger's sounder output, shallow (6 to 10 m) and deep-water (>10 m) areas were identified. Assessment of the substrate was based on distinctive patterns in the bathymetric output, as well as benthic sampling results (Golder Associates 1997b) and observations using an ROV underwater camera. Hard substrates along shorelines were rarely observed beyond six metres deep. After six metres, the lake substrate dramatically changes to a mixture of sand and silt.

Small Lakes

The survey of small lakes within the Diavik Project Site was designed to assess the quality and quantity of fish habitat available in each lake. Lakes were surveyed on the east and west islands and the mainland to the immediate east of the proposed Project (33 lakes in total). Information collected in each survey was presented in Technical Memorandum #13 (Golder Associates 1997c). Each survey consisted of the following steps:

- Preparation of a shoreline habitat map using the standard methods described above for shorelines in the Intensive Area of Lac de Gras;
- Preparation of a bathymetric map from data collected using a chart recording echo sounder;
- Water quality measurements, including depth profiles for pH, temperature, conductivity, dissolved oxygen, and turbidity; and,
- Fish species presence and relative abundance.

Streams

Surveys to assess the fish habitat potential (spawning, rearing and migration habitat) of area streams were conducted during the spring freshet in June, 1996. The Extensive Area included streams on the east island and west island (i.e., those flowing between small lakes), as well as tributary streams that feed Lac de Gras directly. A representative size range of streams throughout the Extensive Area was selected, primarily using helicopter reconnaissance. Selection criteria included factors that influence the ability of fish to enter and migrate upstream, specifically;

- Size (i.e., depth and width);
- Channel characteristics (e.g., presence of pools, boulders, waterfalls); and,
- Water velocity.

Streams throughout the area were largely intermittent, typically flowing for a short duration in the spring (i.e., several days to several weeks). Larger streams, which would flow for several weeks to several months, were present but were found exclusively on the mainland. Habitat survey of the smallest streams, such as those found on the east and west islands, was limited to videography and helicopter reconnaissance because of the lack of distinct channels and the short duration of flow. For these streams, the channel was observed to shift frequently while flowing diffusely through grasses, shrubs, and other vegetation.

Habitat mapping of larger streams, where a defined channel occurred over at least some of the stream length and where flows were maintained for more than a week, was conducted on foot. For each of these streams, channel characteristics were categorized by major habitat type (e.g., riffle, run, pool, etc.). Substrate characteristics, other stream bank and instream features, and discharge measurements were also recorded. Technical protocols describing the mapping methods are appended in the baseline stream habitat technical report (Golder Associates 1997d).

Additional hydrological data (i.e., stream velocity, depth, and flow duration), relevant to assessing the fish habitat potential of several streams on both the islands and mainland, were also collected during 1996 (Vista Engineering 1996).

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APPENDIX II - OFFICE METHODS – SHORELINES

Habitat Delineation

Over most of the Lac de Gras shoreline, rocky substrates begin above the waterline and descend to a depth of approximately 6 m (Golder Associates 1997a,b). The composition of these substrates is homogeneous in most areas. For this reason, shorelines were designated as being the region of the lake from the waterline to a depth of 6 m.

Methods used to delineate shoreline habitat were as follow:

- Scanned aerial photos of the proposed Project Area were overlaid with bathymetric information and this composite image was transferred into Geographic Information System (GIS) format.
- Using field records, the maximum depth of the silt-free rocky substrate was determined for each section of shoreline in the Intensive and Extensive areas. Beyond this depth, the substratum is almost invariably composed of 100% silt. Where the depth could not be distinguished, 6 m was chosen as a conservative estimate.
- Using the maximum depths, GIS was used to calculate the area in hectares of available habitat along each uniform section of shoreline. The total area present for each habitat type was then calculated for the shorelines that may be altered by dike construction.

Several distinct types of shoreline habitat exist for fish in Lac de Gras. Lac de Gras shorelines are composed primarily of boulders (>25 cm in diameter) and cobble (6.5 - 25 cm) with some bedrock. Short (<100 m) stretches of shorelines composed of gravel and sand occur sporadically. Shallow rocky substrates in Lac de Gras usually have little or no attached algae or silt cover.

Shoreline habitat types are highly repetitive throughout the lake. To facilitate comparison, a coding system was developed that classifies shorelines into five unique habitat types, using substrate as the primary variable (Table II-1).

Table II-1 Shoreline Types Used in Lac de Gras for Classification of Habitat

Shoreline Habitat	Description
1	Boulder ledge at shoreline; drop-off composed of boulders leading into sand and boulder patches.

- Using the maximum depths, GIS was used to calculate the area in hectares of available habitat along each uniform section of shoreline. The total area present for each habitat type was then calculated for the shorelines that may be altered by dike construction.

Several distinct types of shoreline habitat exist for fish in Lac de Gras. Lac de Gras shorelines are composed primarily of boulders (>25 cm in diameter) and cobble (6.5 - 25 cm) with some bedrock. Short (<100 m) stretches of shorelines composed of gravel and sand occur sporadically. Shallow rocky substrates in Lac de Gras usually have little or no attached algae or silt cover.

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Table II-1 Shoreline Types Used in Lac de Gras for Classification of Habitat

Shoreline Habitat	Description
1	Boulder ledge at shoreline; drop-off composed of boulders leading into sand and boulder patches.
2	Gravel ledge at shoreline, shifting to cobble, then boulders. Drop-off composed of boulders leading to mixed sand and boulders.
3	Bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand.
4	Mixture of boulder and sand: 4a: Boulder dominant over sand; 4b: Sand dominant over boulders.
5	Mixture of boulder, cobble, and gravel. Elevated gravel mounds alternate through the other substrates in a linear, winding fashion.

By converting the detailed field maps to this coding system, it is possible to compare shoreline fish habitat within the Intensive Area with shorelines elsewhere in Lac de Gras. Once converted, maps depicting shoreline habitat were prepared in digital format (AutoCAD Version 13) with each homogeneous section of shoreline colour-coded to represent the appropriate habitat type.

HSI Value Determination

Habitat Suitability Index (HSI) values were determined for each species and life stage of fish potentially utilizing the habitat. The fish species included Arctic grayling, burbot, cisco, lake trout, lake whitefish, longnose sucker, round whitefish, northern pike, and slimy sculpin. The HSI values for the shoreline habitat classifications in Lac de Gras are based on the HSI values in Table II-2.

Information available from the literature review and from field observations indicated that proximity to deep water was a significant factor in determining habitat use along shorelines. Shoreline and shoal areas are composed primarily of boulder and cobble and, when adjacent to deep water, would be used by species such as lake trout for spawning. Shorelines adjacent to shallow water areas were found to be preferred rearing and foraging areas for species such as slimy sculpin and round whitefish.

No aquatic macrophytes were found growing within the boundaries of any of the affected habitats. Because northern pike require aquatic macrophytes or flooded vegetation for virtually all life stages, the HSIs were evaluated as 0 and are not included in the tables.

Table II-2 Shoreline Habitat Suitability Index Values[1] for Fish Species Present in Lac de Gras

Shoreline Habitat Type	Lake trout				Round whitefish			
	Spawning	Nursery	Rearing	Foraging	Spawning	Nursery	Rearing	Foraging
1	0.50	0.50	0.50	0.50	0.25	0.25	0.25	0.50
2	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.50
3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
4a	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50
4b	0.00	0.00	0.25	0.50	0.00	0.00	0.75	0.25
5	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50

Shoreline Habitat Type	Cisco				Arctic grayling			
	Spawning	Nursery	Rearing	Foraging	Spawning	Nursery	Rearing	Foraging
1	0.50	0.50	0.25	0.50	0.00	0.00	0.25	0.50

2	0.50	0.50	0.50	0.50	0.00	0.00	0.25	0.50
3	0.25	0.25	0.25	0.25	0.00	0.00	0.25	0.25
4a	0.25	0.25	0.50	0.50	0.00	0.00	0.25	0.25
4b	0.25	0.25	0.75	0.50	0.00	0.00	0.25	0.25
5	0.50	0.50	0.50	0.50	0.00	0.00	0.25	0.50

Shoreline Habitat Type	**Longnose sucker**				**Lake whitefish**			
	Spawning	Nursery	Rearing	Foraging	Spawning	Nursery	Rearing	Foraging
1	0.50	0.50	0.50	0.50	0.75	0.75	0.75	0.50
2	0.75	0.75	0.50	0.50	0.50	0.50	0.75	0.50
3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
4a	0.25	0.25	0.75	0.75	0.25	0.25	0.75	0.75
4b	0.25	0.25	0.75	0.75	0.25	0.25	0.75	0.75
5	0.50	0.50	0.75	1.00	0.25	0.25	1.00	0.75

Shoreline Habitat Type	**Burbot**				**Slimy sculpin**			
	Spawning	Nursery	Rearing	Foraging	Spawning	Nursery	Rearing	Foraging
1	0.50	0.50	1.00	0.50	1.00	1.00	1.00	0.50
2	0.50	0.50	0.75	0.50	0.75	0.75	0.75	0.50
3	0.50	0.50	0.25	0.50	0.25	0.25	0.25	0.25
4a	0.50	0.50	0.25	0.50	0.50	0.50	0.50	1.00
4b	0.50	0.50	0.25	0.50	0.25	0.25	0.25	1.00
5	0.50	0.50	1.00	0.50	0.75	0.75	0.75	0.50

1 = The models used to determine HSI values vary in their level of confidence depending on species.

RESULTS

Shorelines

Sections of east island shoreline would be altered by dike construction. The habitat quality varies within each section. Classification of shorelines into similar types led to the calculation of the number of HUs (habitat units) for spawning, nursery, rearing and foraging habitat altered by dike construction for each section of shoreline. HU calculations were done for eight fish species and four life stages (Table II-3). Results are broken down into the amount of HUs contributed by shorelines by HSI category.

Table II-3 Summary of Habitat Units Altered for Shorelines in Lac de Gras Due to Proposed Dike Construction and Use of the North Inlet

a) Lake trout

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	0	0	0
HSI = 0.75	0	0	0	0
HSI = 0.5	23.0	22.6	22.6	23.0
HSI = 0.25	1.0	1.2	1.2	1.0
HSI = 0.0	0	0	0	0
TOTAL	**24.0**	**23.8**	**23.8**	**24.0**

b) Cisco

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	0	0	0
HSI = 0.75	0	0	0	0
HSI = 0.5	23.0	0.4	23.0	23.0

HSI = 0.25	1.0	12.3	1.0	1.0
HSI = 0.0	0	0	0	0
TOTAL	**24.0**	**12.7**	**24.0**	**24.0**

c) Round whitefish

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	0	0	0
HSI = 0.75	0	0	0	0
HSI = 0.5	0.4	0.0	23.0	0.4
HSI = 0.25	12.3	12.5	1.0	12.3
HSI = 0.0	0	0	0	0
TOTAL	**12.7**	**12.5**	**24.0**	**12.7**

d) Arctic grayling

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	0	0	0
HSI = 0.75	0	0	0	0
HSI = 0.5	0	0	23.0	0
HSI = 0.25	0	12.5	1.0	0
HSI = 0.0	0	0	0	0
TOTAL	**0**	**12.5**	**24.0**	**0**

e) Lake whitefish

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	0	0	0

HSI = 0.75	33.9	34.5	0.0	33.9
HSI = 0.5	0.4	0	23.0	0.4
HSI = 0.25	1.0	1.0	1.0	1.0
HSI = 0.0	0	0	0	0
TOTAL	**35.3**	**35.5**	**24.0**	**35.3**

f) Burbot

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	45.2	0	0
HSI = 0.75	0	0.5	0	0
HSI = 0.5	24.9	0	24.9	24.9
HSI = 0.25	0	1.0	0	0
HSI = 0.0	0	0	0	0
TOTAL	**24.9**	**46.8**	**24.9**	**24.9**

g) Longnose sucker

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	0	0	0
HSI = 0.75	0.5	0.0	0	0.5
HSI = 0.5	22.6	23.0	23.0	22.6
HSI = 0.25	1.0	1.0	1.0	1.0
HSI = 0.0	0	0	0	0
TOTAL	**24.1**	**24.0**	**24.0**	**24.1**

h) Slimy sculpin

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	45.2	45.2	0	45.2
HSI = 0.75	0.5	0.5	0	0.5
HSI = 0.5	0.0	0.0	23.0	0.0
HSI = 0.25	1.0	1.0	1.0	1.0
HSI = 0.0	0	0	0	0
TOTAL	**46.8**	**46.8**	**24.0**	**46.8**

Literature Cited

Golder Associates Ltd. 1997a. Technical Memorandum #14: Intensive Shoreline Habitat Survey. Prepared as part of the Diavik Diamond Mines Inc. Environmental Baseline Study.

Golder Associates Ltd. 1997b. Technical Memorandum #15: Extensive Shoreline Habitat Survey. Prepared as part of the Diavik Diamond Mines Inc. Environmental Baseline Study.

APPENDIX III - OFFICE METHODS – SHOALS

Habitat Delineation

The bathymetric maps created by Challenger Surveys & Services Ltd. (Challenger) (for description of the bathymetric survey see Appendix I) were used as base maps upon which shoal locations were marked and labelled alpha-numerically. Using field records, the maximum depth that silt-free (clean) rocky substrates are found was determined for each shoal within the dike construction area. Beyond those depths there is a rapid transition to substrate dominated by silt. Many fish species require silt-free shallow rocky substrates for various activities, particularly spawning, egg incubation, and rearing of fry. Therefore, the bathymetric contour line marking the maximum depth of hard substrates was used to represent the boundary of each shoal. Once shoals were defined, a Geographic Information System (GIS) was used to calculate the area in hectares of each individual shoal.

The outlines of the three proposed dikes (i.e., A154, A418, A21) were superimposed on the habitat/bathymetric base map received from Challenger. This allowed visual determination and subsequent calculation of the total amount of shoal habitat that would be affected by dike construction.

Several distinct types of shoal exist in Lac de Gras (Golder Associates 1997a). Shoals were classified into five unique types, using substrate as the primary variable. The size of interstitial spaces, slope, and relative exposure to wind and wave action were among the characteristics used to classify shoals (Table III-1).

Table III-1 Shoal Habitat Type Classification

Category	Description
1	Clean boulder, near deep water, interstitial spaces of optimum size[1], 45° slope.
2	Clean boulder, not adjacent to deep water, interstitial spaces of optimum size, 45° slope.
3	Gravel, interstitial spaces of inadequate size, clean, 10-20° slope, optimum exposure[2].
4	Gravel, interstitial spaces of inadequate size, slightly sedimented, 10-20° slope, adequate exposure.
5	Sand/gravel, interstitial spaces of inadequate size, 10-20° slope, not adjacent to deep water.

1 - Size of interstitial spaces is related to the size range required to provide necessary conditions for incubating eggs

2 - Exposure is related to the exposure to wind and wave action; optimum exposure allows for complete cleaning of substrate

HSI Value Determination

Shoal habitats in general have a high value to fish species as spawning and nursery habitats, but would be utilized to a lesser extent for rearing primarily because of the risk of predation and the degree of exposure. HSI values developed for shoal habitats were determined for each life stage of fish species present in Lac de Gras since they have potential access to these habitats on a year-round basis throughout their entire lives (Table III-2). As detailed earlier, some HSI categories were excluded (e.g., unsuitable habitat for rearing) since it could not be determined with certainty that a fish would not use a shoal habitat for rearing at some stage in its life.

Because of the requirement for aquatic macrophytes or flooded vegetation for all life stages of northern pike, the HSIs of all available shoal habitat were evaluated as being 0 for this species and are not presented in the tables. The evaluations were based on the literature presented in Appendix IX.

Table III-2 Shoal Habitat Suitability Index Values[1] for Fish Species Present in Lac de Gras

Shoal	Lake trout	Round whitefish

Shoal Habitat Type	Longnose sucker				Lake whitefish			
	Spawning	Nursery	Rearing	Foraging	Spawning	Nursery	Rearing	Foraging
1	0.00	0.00	0.25	0.25	0.50	0.50	0.25	0.50
2	0.00	0.00	0.25	0.25	0.50	0.50	0.25	0.50
3	0.00	0.00	0.50	0.50	0.50	0.50	1.00	0.50
4	0.00	0.00	0.50	0.50	1.00	1.00	1.00	0.50
5	0.00	0.00	0.75	1.75	0.50	0.50	1.00	0.50

Shoal Habitat Type	Burbot				Slimy sculpin			
	Spawning	Nursery	Rearing	Foraging	Spawning	Nursery	Rearing	Foraging
1	1.00	1.00	0.50	0.50	1.00	1.00	1.00	0.50
2	1.00	1.00	1.00	0.50	0.75	0.75	1.00	0.50
3	0.50	0.50	0.50	0.75	0.50	0.50	0.50	1.00
4	0.50	0.50	0.50	0.75	0.50	0.50	0.50	1.00
5	0.50	0.50	0.25	0.75	0.50	0.50	0.50	0.50

1 = The models used to determine HSI values vary in their level of confidence depending on species.

RESULTS

Shoals were delineated as shallow areas, isolated by deeper areas from large land masses (such as the east island), that provided habitat for fish. Both shoals (shallow areas that do not break the surface of the water) and small islands (minus the above-water portion) were included in the total shoal habitat. The total amount of spawning, nursery, rearing and foraging habitat contributed by shoals that would be directly altered due to dike construction in Lac de Gras is presented in Table III-3.

Table III-3 Summary of Habitat Units Altered for Shoal Habitat in Lac de Gras Due to

Proposed Dike Construction

a) Lake trout

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	2.8	16.5	0	2.8
HSI = 0.75	2.0	1.8	0	2.0
HSI = 0.5	1.1	1.0	10.5	1.1
HSI = 0.25	2.0	0	0	2.0
HSI = 0.0	0	0	0	0
[1]TOTAL	**8.0**	**19.3**	**10.5**	**8.0**

b) Cisco

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	0.7	0	0
HSI = 0.75	11.3	0	0	11.3
HSI = 0.5	2.6	1.8	10.5	2.6
HSI = 0.25	0.2	4.2	0	0.2
HSI = 0.0	0	0	0	0
[1]TOTAL	**14.1**	**6.6**	**10.5**	**14.1**

c) Round whitefish

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	0.7	0	0
HSI = 0.75	0.5	0	13.6	0.5
HSI = 0.5	9.6	1.8	0.8	9.6
HSI = 0.25	0.3	4.2	0.3	0.3
HSI = 0.0	0	0	0	0
[1]TOTAL	**10.3**	**6.6**	**14.7**	**10.3**

d) Arctic grayling

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	19.0	20.9	0
HSI = 0.75	0	0	0	0
HSI = 0.5	0	0.7	0	0
HSI = 0.25	0	0	0	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**0.0**	**19.6**	**20.9**	**0.0**

e) Lake whitefish

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0.7	1.3	0	0.7
HSI = 0.75	0	0	0	0
HSI = 0.5	10.1	2.6	10.5	10.1
HSI = 0.25	0	4.2	0	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**10.8**	**8.1**	**10.5**	**10.8**

f) Longnose sucker

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	0	0	0
HSI = 0.75	0	0.5	0.6	0
HSI = 0.5	0	0.3	0.2	0
HSI = 0.25	0	4.9	4.9	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**0.0**	**5.7**	**5.7**	**0.0**

g) Burbot

	Spawning	Rearing	Foraging	Nursery

HSI = 1.0	19.6	16.8	0	19.6
HSI = 0.75	0	0	1.0	0
HSI = 0.5	0.7	1.7	9.8	0.7
HSI = 0.25	0	0.2	0	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**20.2**	**18.7**	**10.8**	**20.2**

h) Slimy sculpin

	Spawning	**Rearing**	**Foraging**	**Nursery**
HSI = 1.0	9.8	19.6	0.7	9.8
HSI = 0.75	7.4	0	0	7.4
HSI = 0.5	0.6	0.6	10.1	0.6
HSI = 0.25	0	0	0	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**17.8**	**20.3**	**10.8**	**17.8**

1 - minor differences in totals are due to rounding

Literature Cited

Golder Associates Ltd. 1997a. Technical Memorandum #12-2: Lac de Gras Shoal Habitat Mapping. Prepared as part of the Diavik Diamond Mines Inc. Environmental Baseline Study.

APPENDIX IV - OFFICE METHODS – SHALLOW AND DEEP WATER

Habitat Delineation

Information on shallow and deep water habitat analysis was gathered using the bathymetric survey data and results of field observations during the shoal survey, sediment sampling survey, and benthic invertebrate survey. Portions of the lake shallower than 6 m were accounted for as shoreline or shoal habitat. Shallow and deep water habitat was delineated as all parts of Lac de Gras deeper than 6 m. This type of habitat was split into two categories; the area of habitat between 6 and 10 m deep (shallow water), and the area greater than 10 m deep (deep water). The reason for this division was based on the extent of the photic zone which descended to a depth of 10 m.

HSI Value Determination

HSI (Habitat Suitability Index) values for shallow and deep water habitat were determined for each species and life stage potentially utilizing the habitat. The fish species included Arctic grayling, burbot, cisco, lake trout, lake whitefish, longnose sucker, round whitefish, northern pike, and slimy sculpin. The HSI values for the shallow and deep water habitat in Lac de Gras were limited to rearing and foraging. Spawning and nursery were not included as none of the species present are pelagic spawners. Overwintering habitat HSI values were not estimated as it was considered a ubiquitous habitat type for all species within Lac de Gras.

The suitability of shallow habitat to fish depends directly on its exposure to high winds. Some species and life stages require shallow water areas that are sheltered from high winds, whereas other species (e.g., lake trout) require exposure to deeper areas as refugia after spawning in shallow areas. As a result, HSI values for shallow water were assigned based on judgment as to whether these areas were exposed or sheltered (Table IV-1). Again, because of the requirement for vegetation for all life stages of northern pike, the HSIs of all available habitats are evaluated as 0 and are not included in the tables.

Table IV-1 Shallow and Deep Water Habitat Suitability Index (HSI) Values[1] for Fish Species Present in Lac de Gras

Lake trout			**Round whitefish**		
Shallow and deep water type	Habitat requirement		Shallow and deep water type	Habitat requirement	
	Rearing	Foraging		Rearing	Foraging
6-10 m (S)	1	0.75	6-10 m (S)	1	1
6-10 m (E)	0.5	1	6-10 m (E)	0.5	0.75
> 10 m (S)	0.5	0.5	> 10 m (S)	0.75	0.5
> 10 m (E)	0.25	0.5	> 10 m (E)	0.25	0.25

Cisco			**Lake whitefish**		
Shallow and deep water type	Habitat requirement		Shallow and deep water type	Habitat requirement	
	Rearing	Foraging		Rearing	Foraging

6-10 m (S)	0.75	1	6-10 m (S)	1	1
6-10 m (E)	0.75	1	6-10 m (E)	0.5	0.75
> 10 m (S)	0.5	0.5	> 10 m (S)	0.75	0.5
> 10 m (E)	0.5	0.5	> 10 m (E)	0.25	0.25

Arctic grayling			**Longnose sucker**		
Shallow and deep water type	Habitat requirement		Shallow and deep water type	Habitat requirement	
	Rearing	Foraging		Rearing	Foraging
6-10 m (S)	1	1	6-10 m (S)	1	1
6-10 m (E)	1	1	6-10 m (E)	1	1
> 10 m (S)	0.25	0.25	> 10 m (S)	0.25	0.5
> 10 m (E)	0.25	0.25	> 10 m (E)	0.25	0.5

Burbot			**Slimy Sculpin**		
Shallow and deep water type	Habitat requirement		Shallow and deep water type	Habitat requirement	
	Rearing	Foraging		Rearing	Foraging
6-10 m (S)	1	1	6-10 m (S)	1	0.75
6-10 m (E)	1	1	6-10 m (E)	1	0.75
> 10 m (S)	0.25	0.5	> 10 m (S)	0.25	0.5
> 10 m (E)	0.25	0.5	> 10 m (E)	0.25	0.5

(E)=Exposed, (S)=Sheltered

[1] = The models used to determine HSI values vary in their level of confidence depending on species

RESULTS

Shallow and Deep Water

Shallow and deep water habitat, which is used by some species for rearing and foraging, was delineated as all areas below 6 m in depth. Shoreline habitat was defined as areas less than 6 m in depth. The area in hectares of shallow and deep water habitat to be altered due to dike construction was calculated based on the assumption that all shallow and deep water is the exposed type. This assumption is based on the proposed perimeter of the dikes which would be built roughly along a line of existing shoals and islands to the immediate east of the proposed Project.

Calculation of HUs (Habitat Units) was accomplished by multiplying the HSI values, for habitat quality, by the area (ha) of the shallow and deep water under the proposed dikes (Table IV-2).

Table IV-2 Summary Table of Habitat Units (HUs) Altered for Shallow and Deep Water Habitat in Lac de Gras Due to Proposed Dike Construction and Use of the North Inlet

a) Lake trout

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	6.5	39.6	0
HSI = 0.75	0	0	4.8	0
HSI = 0.5	0	21.5	58.3	0
HSI = 0.25	0	28.3	0	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**0**	**56.3**	**102.7**	**0**

b) Arctic grayling

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	39.6	46.0	0
HSI = 0.75	0	4.8	0	0
HSI = 0.5	0	1.8	1.8	0
HSI = 0.25	0	28.3	28.3	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**0**	**74.5**	**76.1**	**0**

c) Cisco

	Spawnin g	Rearing	Foraging	Nursery
HSI = 1.0	0	6.5	46.0	0
HSI = 0.75	0	32.3	0	0
HSI = 0.5	0	56.6	58.3	0
HSI = 0.25	0	0	0	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**0**	**95.3**	**104.3**	**0**

d) Round whitefish

	Spawnin g	Rearing	Foraging	Nursery
HSI = 1.0	0	6.5	6.5	0
HSI = 0.75	0	0	29.7	0
HSI = 0.5	0	19.8	0	0
HSI = 0.25	0	29.2	29.2	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**0**	**55.4**	**65.3**	**0**

e) Longnose sucker

	Spawnin g	Rearing	Foraging	Nursery
HSI = 1.0	0	46.0	46.0	0
HSI = 0.75	0	0	0	0
HSI = 0.5	0	0	58.3	0
HSI = 0.25	0	29.2	0	0
HSI = 0.0	0	0	0	0
[1]TOTAL	**0**	**75.2**	**104.3**	**0**

f) Burbot

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	46.0	46.0	0
HSI = 0.75	0	0	0	0
HSI = 0.5	0	0	58.3	0
HSI = 0.25	0	29.2	0	0
HSI = 0.0	0	0	0	0
[1]**TOTAL**	**0**	**75.2**	**104.3**	**0**

g) Lake whitefish

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	6.5	6.5	0
HSI = 0.75	0	2.6	29.7	0
HSI = 0.5	0	19.8	1.8	0
HSI = 0.25	0	28.3	28.3	0
HSI = 0.0	0	0	0	0
[1]**TOTAL**	**0**	**57.2**	**66.2**	**0**

h) Slimy sculpin

	Spawning	Rearing	Foraging	Nursery
HSI = 1.0	0	46.0	0	0
HSI = 0.75	0	0	34.5	0
HSI = 0.5	0	0	58.3	0
HSI = 0.25	0	29.2	0	0
HSI = 0.0	0	0	0	0
[1]**TOTAL**	**0**	**75.2**	**92.8**	**0**

1 - minor differences in totals are due to rounding

APPENDIX V - OFFICE METHODS – SMALL LAKES

Habitat Delineation

Data collected from small lakes within the Intensive Area are presented in Technical Memorandum #13 (Golder Associates 1997a). The location of all lakes on the east island are presented in Figure V-1. Survey information includes the following for each lake surveyed:

- A shoreline habitat map, using a similar coding system as that used to categorize Lac de Gras shorelines (Types 1-5);
- A bathymetric map of each lake (2 m contour intervals); and,
- A table displaying water quality profile results.

The transition point at which rocky substrates along small lake shorelines become 100% silt occurred at a depth of approximately 1 metre. This depth is less than in Lac de Gras (2-6 m). The reduction is likely a result of the lakes being small and frequently sheltered, which limits the effectiveness of wind and wave action in keeping rocky substrates free of silt, as well as reducing the depth of ice scour.

Since factors other than shoreline composition affect habitat use in small lakes, the mapping codes (Types 1-5) were modified to accommodate them. In particular, adjacent deep areas are important to allow larger fish access to unsilted shorelines for feeding. A second category was therefore created for each habitat code (Types 1-5) to represent the shoreline gradient (e.g., Type 3 - deep, Type 3 - shallow). Shoreline vegetation, both emergent and terrestrial, is an important habitat component for juvenile fish of some species (e.g., longnose sucker). Therefore, a third category was created to represent shoreline vegetation (i.e., no vegetation, willows, or other vegetation). The result was to triple the number of habitat codes used for small lake shorelines, relative to shorelines in Lac de Gras (Table V-1).

Figure V-1 Location of Small Lakes Examined During the Summer Small Lakes Survey

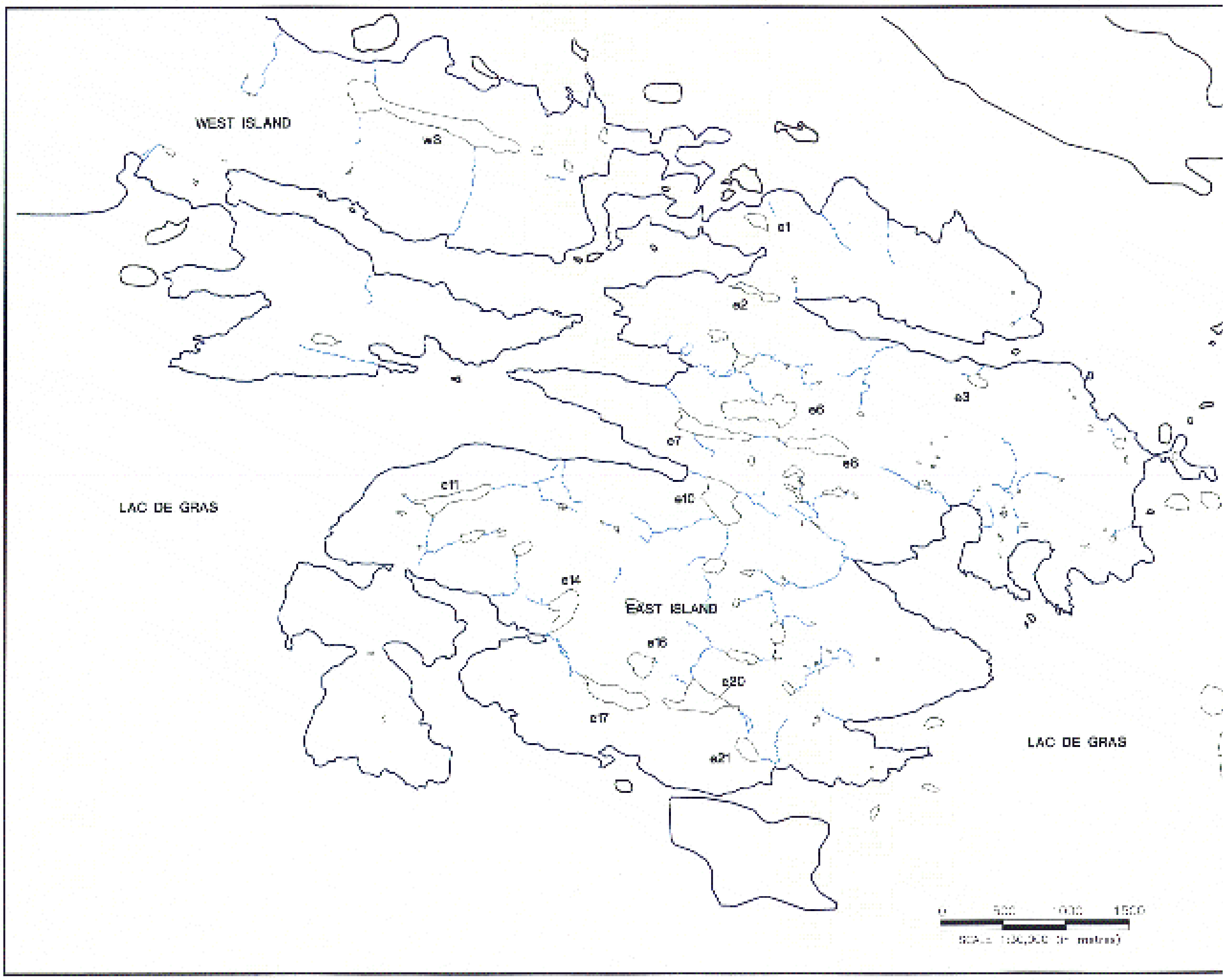


Table V-1 Codes Used to Describe Small Lake Shoreline Habitat

Habitat Criteria	Habitat Type	Description
Substrate	**1**	Boulder ledge at shoreline; drop-off composed of boulders leading into sand and boulder patches.
	2	Gravel ledge at shoreline, shifting to cobble, then boulders. Drop-off composed of boulders leading to mixed sand and boulders.
	3	Bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand.

	4a	Mixture of boulders and sand with boulders dominant over sand.
	4b	Mixture of boulders and sand with sand dominant over boulders.
	5	Mixture of boulder, cobble, and gravel. Elevated gravel mounds alternate through the other substrates in a linear, winding fashion.
	IV	(Inundated Vegetation) Habitat dominated by emergent grasses. Water shallow along shoreline for some distance. Substrate variable but most often boulders mixed with cobble.
	OR	Organic Soil
	-	No vegetation along the shoreline (left as a blank)
Depth	**a**	Shoreline directly adjacent to a low gradient bottom slope (i.e., a change in depth of less than 2 m within 5 m of the shoreline)
	b	Shoreline directly adjacent to a high gradient bottom slope (i.e., a change in depth greater than 2 m within 5 m of the shoreline)
Vegetation	**w**	Willow or shrubs along the shoreline
	v	Terrestrial (land based) vegetation along the shoreline (any kind of vegetation other than willow or shrubs)

The area in hectares of available fish habitat in small lakes was calculated by combining shoreline habitat with bathymetric survey information. The following formula was used to determine the area of each habitat type for each lake;

$$\frac{\text{length}_{la}}{\text{circumference}_l} * \text{area}_l$$

where: $length_{la}$ = the length (m) of shoreline type *a* in lake *l*,

$circumference_l$ = the circumference (m) of lake *l*, and

$area_l$ = the surface area (ha) of lake *l* over water between 0 and 1 m deep.

This formula was used to estimate of the amount of each type of shoreline habitat present in each small lake.

The amount of deep-water habitat is also of interest when assessing fish habitat availability in small lakes. During the summer, deep water areas are used as foraging and rearing areas for many species. During the winter, all species use deep areas for overwintering. To accommodate this seasonal difference, the quantification of deep water areas in small lakes has been done in two ways. First, the area of shallow or deep water in summer was calculated as the surface area (ha) of the lake that is deeper than 1 metre (water that is <1 m being accounted for as shoreline). Shallow waters were those between the depths of 1-3 m. The amount of deep-water habitat available in winter is reduced as most small lakes are covered by approximately 2 m of ice (Golder Associates 1997b). Thus, the amount of deep-water habitat under ice was calculated as the surface area (ha) of the lake deeper than 3 m. The 3 m depth limit was selected because no lakes surveyed that were shallower than 3 m were found to have overwintering fish populations (Golder Associates 1997a).

HSI Value Determination

Based on the habitat delineations for shoreline and deep-water areas, habitat suitabilities were determined for each species and each life stage of fish present in the small lakes on the east island. Fish species included lake trout, round whitefish, lake whitefish, cisco, longnose sucker, burbot, and lake chub. HSIs were defined for the shoreline habitats in relation to spawning, nursery, rearing, and foraging life stages (Table V-2). For the shallow and deep-water habitats, rearing, foraging, and overwintering were considered (Table V-3).

The development of the HSI values for the various habitat types was based on available literature, including published HSI models for any species where they currently exist, and field observations of habitat use from the small lake survey conducted in 1996. The HSIs developed for the shorelines of Lac de Gras also apply to small lake shoreline habitats as most of the same species were considered; however, some slight variations in habitat use were noted. In general, shorelines located next to deep water were found to provide preferred spawning habitat whereas shorelines adjacent to shallow waters provide good rearing and foraging habitat for several species (Appendix X). Shallow-water habitats (< 3 m) were determined to be average or above average rearing and foraging habitat for all species due to their potential for higher benthic invertebrate densities compared to deeper waters. Waters deeper than 3 m were considered excellent overwintering habitat.

Table V-2 Small Lake Shoreline HSI Values[1]

Cisco

Spawning	Shoreline	Depth and Vegetation						Rearing	Shoreline	Dept	
	Substrate	a	b	av	bv	aw	bw		Substrate	a	b
	1	0.75	0.75	0.75	0.75	0.75	0.75		1	0.5	0.5
	2	1	1	1	1	1	1		2	0.5	0.5
	3	0.5	0.5	0.5	0.5	0.5	0.5		3	0.5	0.5

	Shoreline Substrate	a	b	av	bv	aw	bw
	4a	0.75	0.75	0.75	0.75	0.75	0.75
	4b	0.75	0.75	0.75	0.75	0.75	0.75
	5	1	1	1	1	1	1
	IV	0	0	0	0	0	0
	OR	0	0	0	0	0	0
Nursery	**Shoreline**	**Depth and Vegetation**					
	Substrate	**a**	**b**	**av**	**bv**	**aw**	**bw**
	1	0.75	0.75	0.75	0.75	0.75	0.75
	2	1	1	1	1	1	1
	3	0.5	0.5	0.5	0.5	0.5	0.5
	4a	0.75	0.75	0.75	0.75	0.75	0.75
	4b	0.75	0.75	0.75	0.75	0.75	0.75
	5	1	1	1	1	1	1
	IV	0	0	0	0	0	0
	OR	0	0	0	0	0	0

	Shoreline Substrate	a	b	
	4a	0.5	0.5	[illegible]
	4b	0.5	0.5	[illegible]
	5	0.5	0.5	[illegible]
	IV	0	0	
	OR	0	0	
Foraging	**Shoreline**	**Depth**		
	Substrate	**a**	**b**	
	1	0.5	0.5	[illegible]
	2	0.5	0.5	[illegible]
	3	0.5	0.5	[illegible]
	4a	0.5	0.5	[illegible]
	4b	0.5	0.5	[illegible]
	5	0.5	0.5	[illegible]
	IV	0	0	
	OR	0	0	

Lake trout

Spawning	**Shoreline**	**Depth and Vegetation**					
	Substrate	**a**	**b**	**av**	**bv**	**aw**	**bw**
	1	0.5	1	0.5	1	0.5	1
	2	0.25	0.75	0.75	0.75	0.25	0.75
	3	0	0.25	0	0.25	0	0.25
	4a	0	0.25	0	0.25	0	0.25
	4b	0	0.25	0	0.25	0	0.25
	5	0	0.25	0	0.25	0	0.25

Rearing	**Shoreline**	**Depth**		
	Substrate	**a**	**b**	
	1	0.5	0.25	[illegible]
	2	0.5	0.25	[illegible]
	3	0.25	0.25	[illegible]
	4a	1	0.75	
	4b	1	0.75	
	5	1	0.75	

	IV	0	0	0	0	0	0		**IV**	0.25	0.75	0
	OR	0	0	0	0	0	0		**OR**	0.25	0.75	0
Nursery	**Shoreline**	**Depth and Vegetation**						**Foraging**	**Shoreline**	**Depth**		
	Substrate	**a**	**b**	**av**	**bv**	**aw**	**bw**		**Substrate**	**a**	**b**	
	1	0.5	1	0.5	1	0.5	1		**1**	0.75	1	0
	2	0.25	0.75	0.75	0.75	0.25	0.75		**2**	0.75	1	0
	3	0	0.25	0	0.25	0	0.25		**3**	0.5	0.5	[illegible]
	4a	0	0.25	0	0.25	0	0.25		**4a**	0.75	1	0
	4b	0	0.25	0	0.25	0	0.25		**4b**	0.75	1	0
	5	0	0.25	0	0.25	0	0.25		**5**	0.75	1	0
	IV	0	0	0	0	0	0		**IV**	0.25	0.25	0
	OR	0	0	0	0	0	0		**OR**	0	0	

Lake whitefish

Spawning	**Shoreline**	**Depth and Vegetation**						**Rearing**	**Shoreline**	**Depth**		
	Substrate	**a**	**b**	**av**	**bv**	**aw**	**bw**		**Substrate**	**a**	**b**	
	1	0.75	1	0.75	1	0.75	1		**1**	1	1	
	2	0.75	1	0.75	1	0.75	1		**2**	1	1	
	3	0.25	0.5	0.25	0.5	0.25	0.5		**3**	0.5	0.5	[illegible]
	4a	0.75	1	0.75	1	0.75	1		**4a**	0.75	0.75	0
	4b	0.75	1	0.75	1	0.75	1		**4b**	0.75	0.75	0
	5	0.75	1	0.75	1	0.75	1		**5**	1	1	
	IV	0	0	0	0	0	0		**IV**	0.25	0.25	0
	OR	0	0	0	0	0	0		**OR**	0.25	0.25	0
Nursery	**Shoreline**	**Depth and Vegetation**						**Foraging**	**Shoreline**	**Depth**		
	Substrate	**a**	**b**	**av**	**bv**	**aw**	**bw**		**Substrate**	**a**	**b**	

Longnose sucker

Spawning	Shoreline	Depth and Vegetation						Rearing	Shoreline	Deptl	
	Substrate	**a**	**b**	**av**	**bv**	**aw**	**bw**		**Substrate**	**a**	**b**
	1	0.75	1	0.75	1	0.75	1		**1**	0.5	0.25
	2	0.75	1	0.75	1	0.75	1		**2**	0.5	0.25
	3	0.25	0.25	0.25	0.25	0.25	0.25		**3**	0.5	0.25
	4a	0.25	0.25	0.25	0.25	0.25	0.25		**4a**	1	0.75
	4b	0.25	0.25	0.25	0.25	0.25	0.25		**4b**	1	0.75
	5	0.5	0.5	0.5	0.5	0.5	0.5		**5**	0.75	0.75
	IV	0	0	0	0	0	0		**IV**	1	1
	OR	0	0	0	0	0	0		**OR**	0.75	0.75

Nursery	Shoreline	Depth and Vegetation						Foraging	Shoreline	Deptl	
	Substrate	**a**	**b**	**av**	**bv**	**aw**	**bw**		**Substrate**	**a**	**b**
	1	0.75	1	0.75	1	0.75	1		**1**	0.25	0.25
	2	0.75	1	0.75	1	0.75	1		**2**	0.25	0.25
	3	0.25	0.25	0.25	0.25	0.25	0.25		**3**	0.25	0.25
	4a	0.25	0.25	0.25	0.25	0.25	0.25		**4a**	1	0.75
	4b	0.25	0.25	0.25	0.25	0.25	0.25		**4b**	1	0.75
	5	0.5	0.5	0.5	0.5	0.5	0.5		**5**	0.5	0.5
	IV	0	0	0	0	0	0		**IV**	1	1
	OR	0	0	0	0	0	0		**OR**	1	1

Round whitefish

Spawning	Shoreline	Depth and Vegetation						Rearing	Shoreline	Deptl	
	Substrate	**a**	**b**	**av**	**bv**	**aw**	**bw**		**Substrate**	**a**	**b**

Nursery	Shoreline Substrate	Depth and Vegetation a	b	av	bv	aw	bw
	1	0.75	1	0.75	1	0.75	1
	2	0.75	1	0.75	1	0.75	1
	3	0.25	0.25	0.25	0.25	0.25	0.25
	4a	0.25	0.25	0.25	0.25	0.25	0.25
	4b	0.25	0.25	0.25	0.25	0.25	0.25
	5	1	1	1	1	1	1
	IV	0	0	0	0	0	0
	OR	0	0	0	0	0	0

Foraging	Shoreline Substrate	Depth a	b
	1	0.75	0.75
	2	0.75	0.75
	3	0.25	0.25
	4a	0.75	0.75
	4b	0.75	0.75
	5	0.75	0.75
	IV	0.25	0.25
	OR	0.25	0.25

Burbot

Spawning	Shoreline Substrate	Depth and Vegetation a	b	av	bv	aw	bw
	1	0.25	1	0.25	1	0.25	1
	2	0.25	1	0.25	1	0.25	1
	3	0.25	0.25	0.25	0.25	0.25	0.25
	4a	0.25	0.25	0.25	0.25	0.25	0.25
	4b	0.25	0.25	0.25	0.25	0.25	0.25
	5	0.25	0.25	0.25	0.25	0.25	0.25
	IV	0	0	0	0	0	0
	OR	0	0	0	0	0	0
Nursery	**Shoreline Substrate**	**Depth and Vegetation a**	**b**	**av**	**bv**	**aw**	**bw**
	1	0.25	1	0.25	1	0.25	1

Rearing	Shoreline Substrate	Depth a	b
	1	1	1
	2	0.75	0.75
	3	0.25	0.25
	4a	0.25	0.25
	4b	0.25	0.25
	5	0.75	0.75
	IV	0	0
	OR	0	0
Foraging	**Shoreline Substrate**	**Depth a**	**b**
	1	0.5	0.5

2	0.25	1	0.25	1	0.25	1
3	0.25	0.25	0.25	0.25	0.25	0.25
4a	0.25	0.25	0.25	0.25	0.25	0.25
4b	0.25	0.25	0.25	0.25	0.25	0.25
5	0.25	0.25	0.25	0.25	0.25	0.25
IV	0	0	0	0	0	0
OR	0	0	0	0	0	0

2	0.5	0.5
3	0.25	0.25
4a	0.5	0.5
4b	0.5	0.5
5	0.5	0.5
IV	0	0
OR	0	0

1 = The models used to determine HSI values vary in their level of confidence depending on species. See summary section of the main text of this document for details.

Table V-3 Small Lake Shallow and Deep-Water HSI Values[1]

		Burbot			**Cisco**		
Season	**Depth**	Rearing	Foraging	Overwintering	Rearing	Foraging	Overwintering
Summer	Less than or equal to 1 m	0.5	0.5		0.5	0.5	
	Greater than 1 m	0.5	0.5		1	1	
Winter	Less than or equal to 3 m			0			0
	Greater than 3 m			1			1

		Lake trout			**Lake whitefish**		
Season	**Depth**	Rearing	Foraging	Overwintering	Rearing	Foraging	Overwintering
Summer	Less than or equal to 1 m	1	1		1	1	
	Greater than 1 m	0.5	0.5		0.5	0.5	

Winter	Less than or equal to 3 m			0			0
	Greater than 3 m			1			1

		Longnose Sucker			Round Whitefish		
Season	**Depth**	Rearing	Foraging	Overwintering	Rearing	Foraging	Overwintering
Summer	Less than or equal to 1 m	1	1		1	1	
	Greater than 1 m	0.5	0.5		0.5	0.5	
Winter	Less than or equal to 3 m			0			0
	Greater than 3 m			1			1

[1] = The models used to determine HSI values vary in their level of confidence depending on species. See summary section of the main text of this document for details.

RESULTS

Based on the data collected, seven of the lakes located on the east island were found to have fish present. Three of these lakes would be permanently altered by the Project and one other would be temporarily altered (Table V-4). The total number of habitat units altered for each species was determined based on the amount of shoreline, shallow and deep water-habitat available and the HSI values of the habitat for each of the life stages assessed. The calculation of altered Habitat Units (HUs), and consequently the proposed mitigation, was completed only for the species captured in each individual lake, but was completed for all life stages of that species. The fish presence results are assumed to be accurate representations of the species assemblage present in each lake. This is based on utilizing the same fishing effort, (which captured four species in lake e10 but only one species in lake e7) in all the small lakes.

Table V-4 East Island Lakes with Fish Present Which Would be Altered by Infrastructure Construction

Lake	Lake Trout	Round Whitefish	Cisco	Lake Whitefish	Burbot	Longnose Sucker	Lake Chub

Available Habitat

A range of shoreline types was observed in the three small lakes requiring habitat mitigation. Lake e7 was found to have the highest diversity of shoreline types (eight). Lake e10 was found to have the largest amount of shoreline habitat with 43.8 ha available. Lake e10 had the both largest surface area of the three lakes at 95.2 ha, as well as the largest amount of overwintering deep-water habitat available with 1.7 ha (Table V-5).

Table V-5 East Island Lakes Baseline Deep-Water Habitat

Small Lake	Total Lake Surface Area (ha)	Area of substrate ≥ 1 m deep (summer deep water) (ha)	Area of substrate ≥ 3 m deep (winter deep water) (ha)
Lake e3	0.90	0.37	0.29
Lake e7	6.35	3.160	0.90
Lake e8	6.13	2.70	1.05
Lake e10	9.52	5.14	1.69
Lake e11	7.10	4.54	3.09
Lake e14	5.68	3.56	2.41
Lake e17	7.82	4.12	2.44

Habitat Units Altered

Based on the amounts of available habitat listed in Table V-5 and the HSI values determined for each species and life stage, the total number of HUs which would be altered as a result of construction were calculated for each lake (Table V-6). In lake e7, for example, which was inhabited by longnose sucker, a total of 30.9 HUs for this species would be altered (Table V-6). An overall total, for all species combined, of 126.1 HUs would be altered through infrastructure construction. The majority of the HUs altered are associated with longnose sucker and lake trout habitats.

Table V-6 Summary Table of Habitat Units Altered for Shoreline and Deep Water Habitat in Small Lakes on the East Island Due to Proposed Infrastructure Construction[1]

a) Burbot

c) Lake trout

	Spawning	Nursery	Rearing	Foraging	Overwintering
HSI = 1.0	0.0	0.0	4.4	4.4	1.7
HSI = 0.75	0	0	0.3	0.1	0
HSI = 0.5	0.0	0.0	2.6	3.3	0
HSI = 0.25	0.1	0.1	1.0	0.6	0
HSI = 0.0	0	0	0	0	0
TOTAL	**0.1**	**0.1**	**8.2**	**8.4**	**1.7**

d) Lake Whitefish

	Spawning	Nursery	Rearing	Foraging	Overwintering
HSI = 1.0	0	0	4.5	4.4	1.7
HSI = 0.75	0.1	0.1	0.0	0.1	0
HSI = 0.5	0.2	0.2	3.3	3.3	0
HSI = 0.25	0.3	0.3	0.7	0.7	0
HSI = 0.0	0	0	0	0	0
TOTAL	**0.5**	**0.5**	**8.5**	**8.5**	**1.7**

e) Longnose Sucker

f) Lake chub

	Spawning	Nursery	Rearing	Foraging	Overwintering
HSI = 1.0	0.1	0.1	0.5	0.5	0.3
HSI = 0.75	0	0	0.3	0.3	0
HSI = 0.5	0.2	0.2	0.2	0.2	0
HSI = 0.25	0	0	0	0	0
HSI = 0.0	0	0	0	0	0
TOTAL	**0.3**	**0.3**	**1.1**	**1.1**	**0.3**

g) Round whitefish

	Spawning	Nursery	Rearing	Foraging	Overwintering
HSI=1.0	0	0	4.5	4.4	1.7
HSI=0.75	0.1	0.1	0	0.1	0
HSI=0.5	0	0	3.3	2.6	0
HSI=0.25	0.4	0.4	0.7	1.1	0
HSI=0	0	0	0	0	0
TOTAL	**0.4**	**0.4**	**8.5**	**8.1**	**1.7**

[1] Data presented includes Habitat Units permanently lost in lakes e7, e8 and e10, and temporarily lost in lake e3.

REFERENCES

Golder Associates Ltd. 1997a. Technical Memorandum #13. Inland Lake Survey Report, Environmental Baseline Program. Prepared for Diavik Diamonds Project.

Golder Associates Ltd. 1997b. Technical Memorandum #01. Winter Small Lake Survey Report, Environmental Baseline Program. Prepared for Diavik Diamonds Project.

APPENDIX VI - OFFICE METHODS – STREAMS

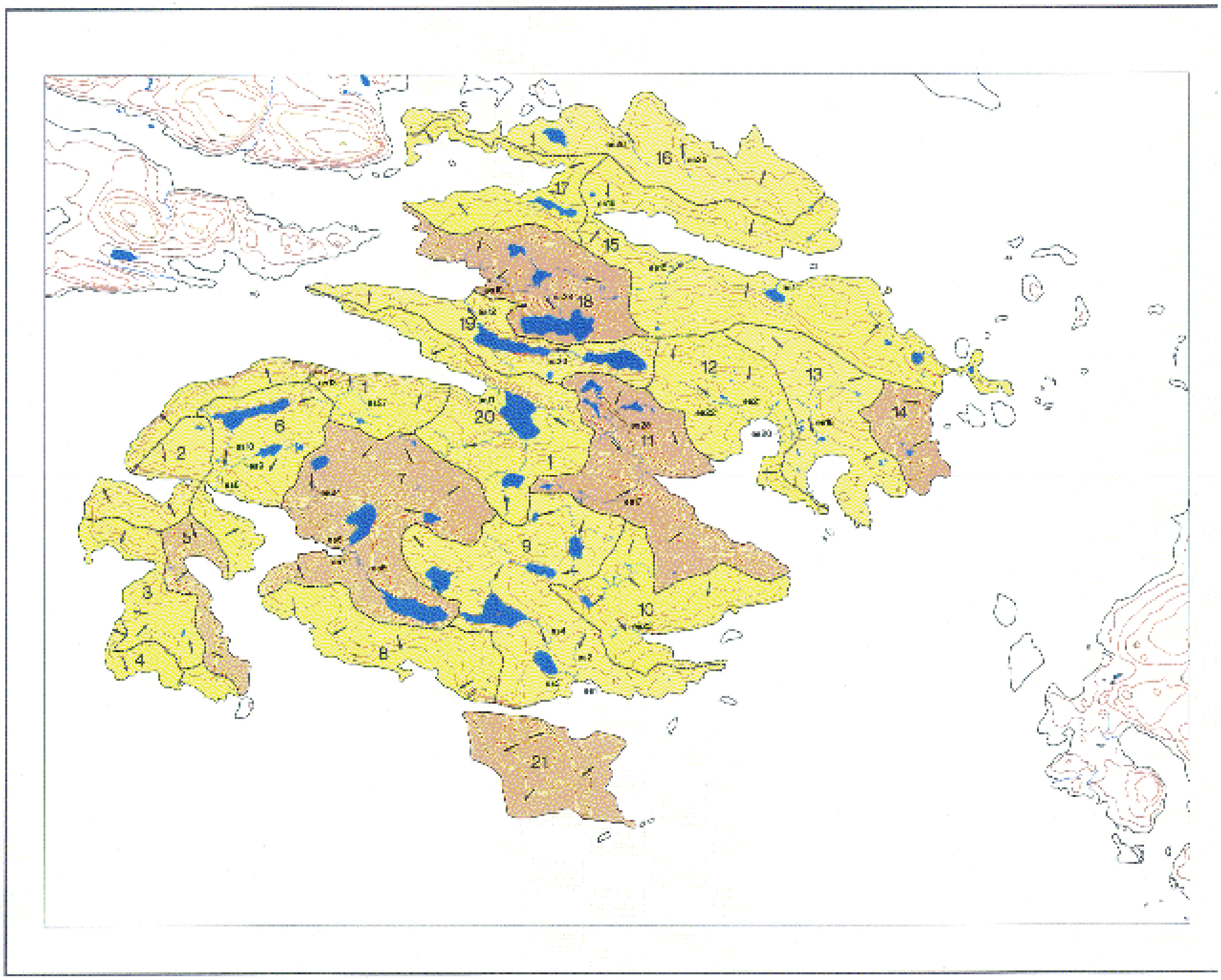
Published HSI models were available for Arctic grayling and longnose sucker in stream habitats. Consequently, a greater level of detail is presented with respect to how the variables from these models were integrated with additional literature and study area observations to establish HSI variables and values applicable to the tributary streams of Lac de Gras.

Habitat Delineation

Thirty streams, located within 21 sub-basins, were evaluated on the east island for fish habitat potential and the effect of the proposed Project on their productive capacity (Figure VI-1). Three aspects or functions of stream habitat (i.e., spawning, rearing, and migration corridor habitat) were assessed for both Arctic grayling and longnose sucker. Both of these spring-spawning species utilize tributaries as spawning and rearing habitat in the region of the proposed development. Migration corridor habitat describes the extent to which a stream provides fish access to small lake habitat which can be used on a seasonal basis or year-round if the lakes are capable of supporting fish populations through the winter. Both of these species are known to migrate, often long distances, and will inhabit both river and lake areas if overwintering habitat is available (Appendix X). Foraging habitat was not considered due to the extremely short duration of flows in these streams.

In order to assess the quantity of habitat available within the study area, several determinations of stream size were required. These included stream length, stream width, and hydrological sub-basin size (because of its influence on stream flow potential). Stream length was measured from digital contour maps of the island. Sub-basin size was determined as part of the hydrological baseline investigation (Golder Associates 1997). Due to the short duration of meltwater flows (< 1 week) for small streams and the need to collect fish for the Arctic grayling spawning survey, streams were selected from a helicopter for detailed habitat assessment, based on their size and ability to allow fish migration. The widths of all streams were not individually measured by field crews because the majority of streams were too narrow and shallow to support fish. Estimates of stream width, therefore, were based on data available from the other streams of similar size on the mainland where average width was measured. The length and average width of the streams were used to calculate the quantity of habitat available in each.

Figure VI-1 East Island Natural Drainage BasinsHSI Value Determination



HSI Value Determination

The purpose of applying an HSI approach to the stream habitat assessment in the project area is to identify the relative suitability of each stream to the Arctic grayling and longnose sucker populations in Lac de Gras and the longnose sucker populations in various small lakes on the east island (no Arctic grayling were captured in any small lakes on the east island).

Currently published U.S. Fish and Wildlife HSI models are available for both Arctic grayling and longnose sucker (Hubert et al. 1985; Edwards 1983). For Arctic grayling, the U.S. Fish and Wildlife model (Hubert et al. 1985) is primarily applicable to riverine habitats where the intent is to assess their suitability to support all life stages of an Arctic grayling population throughout the year. As such, the model groups spawning and embryonic development as one component and migration and overwintering as a second component. The Lac de Gras Arctic grayling population has a great deal of stream habitat, both on the mainland and on the large islands, as well as lake habitat available to support all the life stage requirements. However, as many of the tributary streams are small and flow only during spring run-off or the open-water season, individually they may only support one or two life history phases (i.e., only spawning, only migration, or only spawning and rearing). Although these streams are likely to make an important contribution to Lac de Gras Arctic grayling production, they are not accounted for by the HSI model developed by Hubert et al. (1985). The habitat suitability of these streams for each life stage must be known to develop habitat mitigation strategies for the proposed Project. Consequently, the model was refocused, some variables removed, and additional variables included to allow the relative contribution of individual streams for each of the spawning, rearing, and migration habitat functions, to be assessed.

The longnose sucker model had the same structure as the Arctic grayling model (Edwards 1983). As with the Arctic grayling model, this model was restructured because of the stream characteristics in the study area and the requirement of assessing individual streams for the purposes of determining habitat compensation in the proposed Project area.

Spawning Habitat

Arctic Grayling

Variables used in the spawning habitat assessments for Arctic grayling included several from the existing Arctic grayling HSI model (Hubert et al. 1985), as well as variables identified as important to Arctic grayling for spawning habitat in the type of system (lake and tributary streams) present in the study area. These additional variables were based on 1996 field observations and on available literature. A summary of the information available in the literature regarding habitat requirements for Arctic grayling is provided in Appendix X.

The variables identified for the combined spawning, embryo, and fry development habitat component in Hubert et al. (1985) include:

- Average maximum water temperature during the warmest period of the year in spawning streams;
- Average minimum dissolved oxygen during the late summer, low-flow period in spawning streams;
- Percentage of substrate in spawning areas composed predominantly of gravel and

cobble (1.0 to 25.0 cm diameter);

- Percentage fines (<3 mm) in spawning areas and downstream riffle areas during the spawning and embryo development period;
- Average velocity over spawning areas during the spawning and embryo development period; and,
- Availability of habitat downstream of the spawning areas in the form of backwaters and side channels with a current velocity less than 0.15 m/s.

From these, the variables selected for use in evaluating spawning habitat in streams included:

1. Percentage of substrate in spawning areas composed predominantly of gravel and cobble (1.0 to 25.0 cm diameter);
2. Percentage fines (<3 mm) in spawning areas and downstream riffle areas during the spawning and embryo development period; and,
3. Average velocity over spawning areas during the spawning and embryo development period.

Water temperature and dissolved oxygen (DO) conditions were considered to be similar for all streams within the proposed Project area. Overall, neither of these parameters (temperature and DO) were considered to be biologically limiting factors to fish present in the study area.

Two additional variables were identified as important in evaluating spawning habitat based on the literature and field observations. These were:

4. Stream longevity or the duration of flows adequate to allow egg incubation and emergence of fry, as well as allow fry to access suitable rearing habitat (i.e., would the eggs be capable of hatching and the fry capable of moving out of the stream before flows dropped to levels where the fry could not navigate the stream); and,
5. The percentage of pools within the streams which were available for adult staging activity.

Application of the Variables

Substrates composed of gravel and cobble (1 - 25 cm) have been identified by several sources as an important spawning habitat characteristic (Appendix X). Eggs have been found to be most abundant in these types of substrates, and associated with riffles or the transition area between riffles and pools. The observations of spawning habitat noted during the 1996 field investigations also indicated that gravel and cobble substrates were preferred by fish. The percent coarse substrate variable used in the HSI model (Hubert et al. 1985) rates any percentage over 20% as excellent habitat (Table VI-1). Below 20% coarse substrate, the suitability ranges from unsuitable at 0% through to good at 15%. This approach offers the most conservative estimate of habitat suitability. In the evaluation of the study area streams, the percentage of coarse substrates was assessed for known spawning locations and likely locations observed within each stream. The rating of these locations becomes the overall rating for the stream and is independent of the number of locations or total amount of spawning habitat available (i.e., a stream with one excellent location is rated the same as a stream with more than one excellent location).

The percentage of fine materials (clay, silt, sand <3 mm) in spawning areas and downstream riffle areas has been noted to be important in embryo survival as fine materials can fill interstitial spaces (see Appendix X for references). Based on the existing model (Hubert et al. 1985) less than 10% fines is considered optimal and is rated as excellent (Table VI-1). Above 10% fines, the suitability ranges from unsuitable at >50% to good at 20%. This variable was assessed for both known spawning locations and likely locations observed within each stream. As with percent coarse substrate, the rating for each location becomes the overall rating for the whole stream. This rating is independent of the number of locations or total amount of spawning habitat available (i.e., a stream with one excellent location is rated the same as a stream with more than one excellent location).

Table VI-1 Arctic Grayling Spawning Habitat Variables and Suitability Ratings

	Spawning (Stream Spawner)				
Physical habitat	**Excellent**	**Above Avg.**	**Average**	**Below Avg.**	**Unsuitable**
	1.0	0.75	0.5	0.25	0
Percent coarse substrate material (G and C)	>20%	15%	10%	5%	0%
Percent fine substrate material (S and CS)	<10%	20%	30%	40%	>50%
Average velocity over spawning areas (m/s)	0.25 - 0.5	-	0.1 - 0.2 or 0.6 - 0.8	-	<0.05 or >1.0
Stream longevity	>3 weeks	-	-	-	< 3 weeks
Percent pools	>30%	-	10 - 20%	-	0%

a - Bo = boulder (> 25 cm), C = cobble (> 6.5 cm),

G = gravel (> 0.2 cm), S = sand (> 0.06 mm) and

CS = clay/silt (<0.06 mm).

Velocity over potential spawning areas during the spawning and embryo development period is important for two main reasons. First, enough current is required to prevent fine materials from settling among the embryos, provide DO, and carry away metabolic waste products. Second, velocities which are too high can flush embryos from the substrates (see Appendix X for references). The existing model (Hubert et al. 1985) rates an average velocity of between 0.25 and 0.50 m/s (measured at 0.6 depth) as excellent (Table VI-1). Average velocities less than 0.05 or greater than 1.0 m/s are considered unsuitable. This modelling variable was used for only a few of the streams on the mainland where velocity data were available at locations considered to be potential spawning habitat. In all other streams it was conservatively estimated to be optimal for the spawning period, provided that the stream flow duration was long enough to support egg incubation, emergence, and fry movement to suitable rearing habitat.

Stream longevity, or the duration of flows, was selected as an important variable for identifying potential spawning streams based on the nature of the streams in the study area and the biological requirements for successful spawning by Arctic grayling. Streams in the study area have three main types of flow conditions: (1) those flowing for very brief time periods during snowmelt run-off, some for only a few days and others less than three weeks; (2) those flowing into the summer and lasting for one month and occasionally two months; and, (3) those flowing during the entire open-water season. As a result, some streams had flow periods in 1996 too short to allow incubation, some existed long enough for incubation and sub-gravel stages only, and some existed long enough to provide rearing habitat (discussed further under rearing) during the summer. The amount of runoff is directly related to both the snowpack present prior to spring melting and the nature of the rise in air temperatures.

Based on the biology of Arctic grayling, successful spawning requires enough time to complete the spawning and incubation phases as well as a post-hatch, sub-gravel larval phase. The literature indicates a range of 8 to 32 days for egg incubation depending on water temperature (averages of 15°C for eight days and 5°C for 32 day incubation period). Sixteen to 18 days for incubation were reported at water temperatures of 9°C. In addition to the time required for incubation, several days prior to spawning are often required for staging and an additional three to four days are required to complete the post-hatch, sub-gravel stage before the fry emerge. Water temperature observations in the proposed Project area ranged between a low of 4°C and high of 17°C in June with most recordings being between 8°C and 10°C. At these temperatures a minimum of three weeks was conservatively estimated as the requirement in most years for a combined spawning, incubation, and sub-gravel period (i.e., in some years more than three weeks and in others less than three weeks may be required).

Stream longevity was assessed in four ways: (1) from hydrological metering station data where they existed (Golder Associates 1997); (2) using the regional snowmelt flood peak discharge equation to compare streams with known flow duration to those with unknown duration by comparing catchment area; (3) where a stream flow duration is not known and catchment not determined (several mainland streams), a relative comparison of stream size between the unknown stream and the metered streams;

and, (4) helicopter reconnaissance of the area during the first 3 weeks of June.

The rating system for the stream longevity variable evaluated those streams with at least three weeks of flow as excellent and capable of supporting spawning, incubation, and emergence (Table VI-1). Those streams with less than three weeks of flow were rated as unsuitable. No range of ratings between excellent and unsuitable are given as any longer duration beyond three weeks does not necessarily improve spawning success and is more relevant to the capability of an area to provide rearing habitat.

The percentage of pools within streams is considered important in Arctic grayling rearing habitat, but was also observed to be important to staging adults during the 1996 field studies in the proposed Project area (fewer adult fish were observed in streams with very little pool habitat, even when suitable substrate and depth were available). Staging in pools was also reported in the literature (see Appendix X for references). This variable was identified in the existing HSI model as important for rearing habitat (Hubert et al. 1985). For this reason, the same criteria and ratings were used in evaluating it as a spawning habitat requirement. Streams with 30% or greater pool habitat were rated as excellent (Table VI-1). Streams with 0% pools were rated as unsuitable, while below average to above average habitat ratings were given to streams with between 10% and 25% pools.

The formula for weighting of variables in the existing Arctic grayling model indicated all are equally important for spawning habitat. Based on this, the lowest value for any of the five variables evaluated is taken as the overall HSI value.

The model equation for calculating spawning habitat HSI score for individual streams is:

HSI = Lowest value of variables 1, 2, 3, 4, or 5

Longnose Sucker

Variables used in the spawning habitat assessments for longnose sucker included several from the existing longnose sucker HSI model (Edwards 1983), as well as variables identified as important to longnose sucker for spawning habitat in the type of system lake and tributary streams present in the study area. Any additional variables were based on the 1996 field observations and on available literature. A summary of the information available in the literature regarding habitat requirements for longnose sucker is provided in Appendix X.

The variables identified for the spawning and embryo development habitat component in Edwards (1983) include:

- Depth of riffle area for spawning;
- Current velocity within spawning habitat;
- Mean water temperature during spawning and incubation;
- Percent riffles in spawning streams; and,

- Substrate type in spawning areas.

From these, the variables selected for use in evaluating longnose sucker spawning habitat in the proposed Project area streams included:

1. Depth of riffle area for spawning;
2. Current velocity within spawning habitat;
3. Percent riffles in spawning streams; and,
4. Substrate type in spawning areas.

Mean water temperature during spawning and incubation was considered similar for all streams within the project area. Temperature was not a limiting factor as this species is known to utilize streams in the study area for spawning.

One additional variable was identified as important in evaluating spawning habitat based on the literature and field observations. This was:

5. Stream longevity or the duration of flows adequate to allow egg incubation and emergence of fry as well as allow fry to access suitable rearing habitat (i.e., would the eggs be capable of hatching and the fry capable of at least moving out of the stream before flows dropped too low).

Application of the Variables

The depth of riffles in spawning areas was identified as important to longnose sucker spawning success as eggs are broadcast over the substrate at a certain depth so they drift only far enough to lodge in the riffle and do not wash downstream (Appendix X). The existing model (Edwards 1983) rates riffle depths between 9 and 21 cm as excellent spawning habitat (Table VI-2). Riffle depths of 0 cm were rated as unsuitable. Depths of 60 cm were evaluated as average.

Table VI-2 Longnose Sucker Spawning Habitat Variables and Suitability Ratings

	Spawning (Stream Spawner)		
Physical Habitat	**Excellent**	**Average**	**Unsuitable**
	1.0	0.5	0
Depth of riffle area for spawning (cm)	9 - 21	3 - 6 or 54 - 60	0
Current velocity within spawning habitat (m/s)	0.3 - 1	2	0

Percent riffles in spawning streams	25 - 75%	10 - 15% or 100%	0%
Substrate type in spawning areas	clean gravel and rubble	gravel, sand, boulder mixture	mud, silt, detritus, or bedrock
Stream longevity	>3 weeks	-	< 3 weeks

a - Bo = boulder (> 25 cm), C = cobble (> 6.5 cm),

G = gravel (> 0.2 cm), S = sand (> 0.06 mm), and

CS = clay/silt (<0.06 mm).

Velocity over potential spawning areas during the spawning and embryo development period has been found to be important for the same types of reasons as identified for Arctic grayling. Enough current is required to prevent fine materials from settling among the embryos, provide DO, and carry away metabolic waste products. In addition, although not specifically mentioned in the literature for longnose suckers, velocities which are too high can flush embryos from the substrates (see Appendix X). The existing model (Edwards 1983) rates an average velocity of between 0.3 and 1 m/s (measured at 0.6 depth) as excellent (Table VI-2). Average velocities of 0 m/s are considered unsuitable, while velocities of 2.0 m/s were still evaluated as having average suitability. This modelling variable was used for only a few of the streams on the mainland where velocity data were available at locations considered to be potential spawning habitat. In all other streams it was conservatively estimated to be optimal for the spawning period, provided that the stream flow duration was long enough to support egg incubation, emergence, and fry movement to suitable rearing habitat.

The percentage of a potential spawning stream that is comprised of riffles is included in Edwards' (1983) model since, in riverine habitat, this species will only spawn in riffle areas. Therefore any potential spawning streams require riffle habitat. Streams with between 25% and 75% riffles are considered excellent for spawning (Table VI-2). Streams with 0% riffle are considered unsuitable while streams with 100% riffle are rated as average.

Longnose suckers require clean (free of silt) gravel and cobble substrates (1 to 25 cm) for spawning (see Appendix X). The evaluation of substrate suitability for longnose sucker spawning habitat in the existing model incorporates both coarse material and fine material in the same suitability index (Edwards 1983). Based on this, areas with clean gravel and rubble substrate are rated as excellent habitat, areas with a mixture of gravel, sand and boulders are rated as average habitat, and those areas dominated by mud, silt, detritus, or bedrock are considered unsuitable (Table VI-2).

As with Arctic grayling, stream longevity, or the duration of flows, was selected as an important variable for identifying potential spawning streams based on the nature of the streams in the study area and the biological requirements for successful spawning by longnose suckers. Based on the biology of longnose suckers, successful spawning requires enough time to complete the spawning and incubation phases as well as a post-hatch, sub-gravel larval phase. The literature indicates a range of 8 to 14 days for egg incubation depending on water temperature (temperature averages of 15°C for eight day and 12°C for 14 day incubation periods) (see Appendix X). In addition to the time required for incubation, several days prior to spawning are often required for staging and an additional one to two weeks are reported for completing a post-hatch, sub-gravel stage before the fry emerge. Peak fry migration out of spawning areas was reported to occur approximately one month after spawning. Water temperature observations in the Diavik Project Area ranged between a low of 4°C and high of 17°C in June with most recordings being between 8°C and 10°C. At these temperatures a minimum of three weeks was conservatively estimated as the requirement in most years for a combined spawning, incubation, and sub-gravel period (i.e., in some years more than three weeks and in others less than three weeks may be required).

The evaluation of stream longevity for longnose sucker spawning habitat suitability was assessed using the same stream flow data and following the same criteria applied to the evaluation of Arctic grayling spawning habitat. Those streams with at least three weeks of flow were rated as excellent and capable of supporting spawning, incubation, and emergence (Table VI-2). Those streams with less than three weeks of flow were rated as unsuitable. No range of ratings between excellent and unsuitable are given as any longer duration beyond three weeks does not necessarily improve spawning success and is more relevant to the capability of an area to provide rearing habitat.

In the existing longnose sucker HSI model, two approaches to calculating an overall HSI value are given. The first approach essentially takes the average suitability index values for each variable and for each life stage, and combines them to reach an overall HSI value for an area. The second approach identified follows the calculation procedure used for the Arctic grayling assessment. In this calculation, the lowest suitability index value for a set of variables is used as the overall HSI value. The reasoning for the second approach is that all variables are all equally important for spawning habitat. For the assessment of longnose sucker habitat HSI values in the proposed Project area streams, the second approach was applied to better reflect the value of individual streams and individual life stages.

The model equation for calculating spawning habitat HSI score for individual streams is:

HSI = Lowest value of variables 1, 2, 3, 4, or 5

Rearing Habitat

Arctic Grayling

Variables used in the rearing habitat assessments for Arctic grayling included several from the existing Arctic grayling HSI model (Hubert et al. 1985), as well as variables identified as important to Arctic grayling rearing in the type of system (lake and tributary streams) present in the study area. Any additional variables were based on the 1996 field observations and on available literature. A summary of the information available in the literature regarding habitat requirements for Arctic grayling is provided in Appendix X.

The variables identified for the combined spawning, embryo, and fry development habitat component in Hubert et al. (1985) include:

- Average maximum water temperature during the warmest period of the year in spawning streams;
- Average minimum dissolved oxygen during the late summer, low-flow period in spawning streams;
- Percentage of substrate in spawning areas composed predominantly of gravel and cobble (1.0 to 25.0 cm diameter);
- Percentage fines (<3 mm) in spawning areas and downstream riffle areas during the spawning and embryo development period;
- Average velocity over spawning areas during the spawning and embryo development period; and,
- Availability of habitat downstream of the spawning areas in the form of backwaters and side channels with a current velocity less than 0.15 m/s.

From these, the variables selected for use in evaluating rearing habitat in the proposed Project study areas streams included:

1. Average maximum water temperature during the warmest period of the year in spawning streams; and,
2. Percentage of the spawning and nursery area downstream from the spawning areas as backwater and side channel areas with a current velocity less than 0.15 m/s which was considered to be percent pools within a stream.

Of the existing model variables, DO during the late summer is the only other variable relevant to rearing habitat requirements. This variable was considered to be similar for all streams within the proposed Project area, provided suitable water depth and velocity was present during the rearing period and was not considered to be a limiting factor within the study area.

One additional variable was identified as important in evaluating Arctic grayling rearing habitat based on the literature and field observations. This was:

3. Stream longevity or the duration of flows adequate to allow some period of rearing following fry emergence as well as allow movement out of the stream before the water became too shallow.

Application of the Variables

Water temperature has an large influence on embryo growth and survival. In particular, maximum daily temperatures have been found to be more important than minimum temperatures (see Appendix X). Based on the literature, Arctic grayling fry have a medium tolerance limit of 24.5°C. Stream temperatures during the summer period are not available for all streams within the study area. However, temperatures are available for those streams on the mainland with hydrological metering stations. Very similar maximum temperatures occurred in all the metered streams (Vista Engineering 1996). This suggests a similar value would be applicable to streams throughout the area (based on similar climatic conditions in the summer). The habitat suitability rating for stream considers temperatures between 8°C and 16°C to be excellent (Table VI-3) (Hubert et al. 1985). Stream temperatures below 5°C or above 25°C are considered to be unsuitable. Average suitability ratings apply to temperatures of 6 to 7°C and 19 to 22°C.

The percentage of pools within the streams is considered important for Arctic grayling rearing habitat and was identified in the published HSI model (Hubert et al. 1985). These low current velocity areas provide high quality refuge and foraging habitats for young and are considered critical to 0 age fish. Streams with 30% or greater pool habitat were rated as excellent (Table VI-3). Streams with 0% pools were rated as unsuitable while below average to above average habitat ratings were given to streams with between 10% and 25% pools.

Table VI-3 Arctic Grayling Rearing Habitat Variables and Suitability Ratings

	Rearing Habitat (Streams)		
Physical Habitat	**Excellent**	**Average**	**Unsuitable**
	1.0	0.5	0
Average maximum water temperature - mid summer (°C)	7-16	5 or 18	<4 or >20
Percent pools	>30%	10 - 20%	0%
Stream longevity	>8 weeks	>4 weeks	<4 weeks

The evaluation of stream longevity for Arctic grayling rearing habitat suitability was assessed using the same streamflow data and following similar criteria applied to the evaluation of spawning habitat. However, in order to provide a minimal amount of rearing habitat it was assumed that at least four weeks of suitable streamflow conditions would be required. Streams with at least eight weeks of flow were rated as excellent and capable of supporting an extended rearing period (Table VI-3). Those streams that flow for less than four weeks were rated as unsuitable.

The formula for weighting of variables in the existing Arctic grayling model indicated all are equally important for rearing habitat. Based on this, the lowest value for any of the three variables evaluated is taken as the overall HSI value.

The model equation for calculating rearing habitat HSI score for individual streams is:

HSI = Lowest value of variables 1, 2, or 3

Longnose Sucker

Variables used in the rearing habitat assessments for longnose sucker included those from the existing longnose sucker HSI model (Edwards 1983), as well as variables identified as important to longnose rearing in the type of system (lake and tributary streams) present in the study area. Any additional variables were based on the 1996 field observations and on available literature. A summary of the information available in the literature regarding habitat requirements for longnose sucker is provided in Appendix X.

Longnose sucker are known to utilize both lacustrine and riverine habitats for rearing (Edwards 1983). Once the fry have emerged from the gravel they begin a downstream drift and seek refuge habitat in shallow, quiet waters with cover (see Appendix X). Within the proposed Diavik Project Area lake and tributary stream system, it is likely that if low velocity, quiet water habitat (pools) with cover is available in a stream it would be utilized by fry. However, if it were not available, the fry would likely continue their downstream drift and locate suitable rearing habitat in the littoral areas of any downstream lakes.

The variables identified for the rearing habitat component in Edwards (1983) include:

a) Percent cover in the form of vegetation, boulders, or rubble in shallow edge or shoreline areas (May to July); and,
b) Fluctuation in water level in mid-summer (in reservoirs).

From these, the variable selected for use in evaluating rearing habitat in the proposed Project study areas streams was limited to:

1. Percent cover in the form of vegetation, boulders, or cobble in shallow edge or shoreline areas (May to July).

Of the existing model variables, fluctuations in water levels is not applicable to the study area. This variable is intended to be used in the evaluation of shoreline areas of reservoirs.

One additional variables was identified as important in evaluating longnose sucker rearing habitat based on the literature and field observations. This was:

2. Stream longevity or the duration of flows adequate to allow some period of rearing following fry emergence as well as allow movement out of the stream before the stream became too shallow.

Application of the Variables

Percent cover in the form of vegetation, boulders, or cobble in shallow edge or shoreline areas during the rearing period was identified as important for providing refuge and foraging habitat (see Appendix X). In the existing HSI model, available cover between 25% and 75% is considered to provide excellent rearing habitat (Table VI-4) (Edwards 1983). Average habitat is rated as that providing 10% to 20% or greater than 85% cover. Streams with 0% cover were rated as unsuitable. For the application of these rating to the study area streams, percent cover in pools was assessed as these areas would also provide quieter, lower velocity habitats.

Table VI-4 Longnose Sucker Rearing Habitat Variables and Suitability Ratings

	Rearing Habitat (Streams)		
Physical Habitat	**Excellent**	**Average**	**Unsuitable**
	1.0	0.5	0
Percent cover	25 - 75%	10 - 20% or >85%	0%
Stream longevity	>8 weeks	>4 weeks	<4 weeks

The evaluation of stream longevity for longnose sucker rearing habitat suitability was assessed using the same streamflow data and following similar criteria applied to the evaluation of rearing habitat for Arctic grayling habitat. Although stream rearing habitat is not considered to be critical to longnose sucker fry, the streams may be supplying some quantity of rearing habitat. In order to do this, flow duration would have to be adequate for the fry to remain in the stream during some component of their early feeding and growth. In order to provide a minimal amount of rearing habitat it was assumed that at least four weeks of flow would be required. Streams with at least eight weeks of flow were rated as excellent and capable of supporting an extended rearing period (Table VI-4). Those streams with less than four weeks of flow were rated as unsuitable.

For the assessment of rearing HSI values for the proposed Project Area streams, the same approach as was applied to longnose sucker spawning was used. In this approach, the lowest suitability index value for the variables assessed is taken as the overall HSI value for each individual stream.

The model equation for calculating rearing habitat HSI score for individual streams is:

HSI = Lowest value of variables 1 or 2

Migration Corridor Habitat

Arctic Grayling and Longnose Sucker

Migration corridor habitat describes the ability of a stream to provide access to small lake habitat which can be used on a seasonal basis or year-round if the lakes are capable of supporting fish populations through the winter. The use of small streams as migration corridors to other habitats is not considered in the existing HSI models for Arctic grayling or longnose sucker species (Hubert et al. 1985; Edwards 1983). However, both of these species are known to migrate, often long distances, and will inhabit both river and lake areas if overwintering habitat is available.

To conduct a habitat suitability assessment of the streams in the proposed Project area, three variables were selected. These variables determine the capability of a stream to supply migration corridor habitat. They are:

1. Stream velocity and depth;
2. Barriers to migration; and,
3. Presence of small lake habitat.

Both longnose sucker and Arctic grayling were considered to have the same requirements with regard to these variables. Because of this, the same suitability criteria are applied to both.

Application of the Variables

To provide a migration corridor a stream would require sufficient depth and velocity to allow fish movement. Within the Study Area, three general types of streamflow were observed. Larger, more permanent streams were found to have flow within defined channels as well as diffuse flow alongside the main channel through shrubs, other vegetation, and fractured bedrock during the peak run-off period. For the smaller streams flow was generally overland through grasses, shrubs, and other vegetation in a diffuse and dynamic pattern. Based on this, three levels of suitability were defined. Excellent habitat would be provided by streams with annual flow in defined channels sufficient to allow fish movement (Table IV-5). Average habitat would be provided by streams where, although no permanent channel is present, water depth and velocity during some high run-off years in temporary channels would be sufficient to allow fish passage. Unsuitable habitat was evaluated as those streams serving only as run-off drainage, where no channel would form and the stream would have insufficient depth in any year to allow fish movement.

In addition to insufficient depth, barriers like large boulder gardens with sub-surface flow, water falls, and some cascades would prevent fish movement to upstream areas (Table VI-5). Streams with no barriers observed were rated as providing excellent migration habitat. Average habitat would be provided by streams where impassable barriers would occur under low flow conditions, but would be passable under most conditions. Migration habitat would only need to be supplied once to allow a fish population to become established in a suitable small lake. Because of this, there is the possibility that barriers would be present on a stream which would be passable rarely and under extreme conditions. A ranking of rarely suitable was established as part of the habitat evaluation to account for these extreme circumstances.

Table VI-5 Arctic Grayling and Longnose Sucker Migration Corridor Habitat Variables and Suitability Ratings

	Migration Corridor			
Physical Habitat	**Excellent**	**Average**	**Rarely Suitable**	**Unsuitable**
	1.0	**0.5**	**0.1**	**0**
Stream flows	flow present annually in a defined channel and sufficient to allow fish movement	flow present in some years and sufficient to allow fish movement during high run-off conditions	-	insufficient flow to allow fish passage
Presence of barriers	no barriers to fish migration	barriers present during low flow years limiting access	barriers present which may be passed rarely and only under extremely high water conditions	no possibility of fish passage occurring
Inland lake habitat	suitable habitat available upstream capable of supporting year-round fish populations - or suitable summer habitat present and access to overwintering habitat maintained by continued stream flows	-	-	no suitable habitat available upstream - or access will not exist to overwintering habitat

In order for migration corridor habitat to be valuable, suitable small lake habitat or access to overwintering habitat must also be available. This is particularly relevant to small ephemeral streams, with a limited duration of flow, where a fish may be able to move upstream in the spring, locate summer foraging habitat, but have no route back to overwintering areas. Streams which would provide access to year-round small lake habitat, or suitable summer habitat and access to overwintering areas, were rated as excellent migration corridor habitat (Table VI-5). Streams which would not provide this were rated as unsuitable.

For the calculation of the overall HSI value, all variables were considered to be equally important. As a result, the lowest suitability index value for the set of variables was used as the HSI value.

The model equation for calculating migration corridor habitat HSI score for individual streams is:

HSI = Lowest value of variables 1, 2, or 3

RESULTS

Streams

Stream Longevity Determination

Stream longevity was assessed as an important variable in determining the potential habitat limitations of streams within the study area. To determine the duration of flows for the east island streams, an empirical regional snowmelt peak discharge equation was used to compare streams with known flow duration on the mainland to those with unknown duration on the east island (Golder Associates 1997). This was done by comparing catchment area between metered and unmetered streams. All east island streams were estimated to have stream longevity duration of less than two weeks based on these calculations (Table VI-6).

The mainland streams which were used for comparison to east island streams were those with regularly monitored hydrological metering stations (Vista Engineering 1996). For these stations, data were available on snowmelt duration and the date when flow was no longer measurable. East island streams were visually assessed by helicopter during the snowmelt period and were generally observed to last from several days to one week. In addition, the 1996 snowmelt runoff was estimated to be approximately 10% above the long-term average for the region (Golder Associates 1997). This indicates that the stream flows observed were representative of higher than average conditions and allow a conservative estimate of the habitat capability of the streams.

Streams Affected by the Proposed Project

Based on the proposed Project design specifications, 11 of the 21 sub-basins on the east island would have stream habitat altered by construction. Within these sub-basins, 24 of 30 streams assessed for habitat potential would be affected (Table VI-7; see Figure 1-2).

Table VI-6 Maximum Discharge Calculations

Basin Location	Stream Basin	Basin Area (ha)	Snowmelt Peak Flood Discharge (m^3/s)	Snowmelt Duration

Mainland	P1/2	221	2.45	7-13 DAYS
	P3	20	0.67	6-11 DAYS
	W3	123	1.79	6 DAYS
	T1	845	5.03	13-29 DAYS
	T2	339	3.08	15-31 DAYS
	T3	302	2.90	17-33 DAYS
	A	3 746	11.20	27-41 DAYS
	E	21 466	28.59	22 TO 43 DAYS
East Island	SB1	79	1.41	< 2 weeks*
	SB2	47	1.07	< 2 weeks*
	SB3	55	1.16	< 2 weeks*
	SB4	25	0.76	< 2 weeks*
	SB5	36	0.92	< 2 weeks*
	SB6	98	1.58	< 2 weeks*
	SB7	79	2.19	< 2 weeks*
	SB8	76	1.38	< 2 weeks*
	SB9	190	2.26	< 2 weeks*
	SB10	97	1.57	< 2 weeks*
	SB11	142	1.93	< 2 weeks*
	SB12	89	1.50	< 2 weeks*
	SB13	99	1.59	< 2 weeks*
	SB14	38	0.95	< 2 weeks*
	SB15	221	2.45	< 2 weeks*
	SB16	129	1.83	< 2 weeks*
	SB17	63	1.25	< 2 weeks*
	SB18	110	1.68	< 2 weeks*
	SB19	82	1.44	< 2 weeks*

	SB20	118	1.75	< 2 weeks*
	SB21	81	1.43	< 2 weeks*

Note: SB denotes the sub-basins of the east island

* estimated duration

Table VI-7 East Island Sub-basins and Streams affected by the Project Design

Sub-basin	Streams
SB7	es5, es6, es7, es24
SB9	es1, es2, es3, es4
SB10	es23
SB11	es17, es28
SB12	es20, es21, es22
SB13	es18
SB15	es14, es15
SB16	es25, es26
SB18	es19, es29
SB19	es12, es30
SB20	es11

Note: es denotes east island stream

Spawning Habitat

Overall, streams on the east island were found to provide no suitable spawning habitat for Arctic grayling or longnose sucker. The limiting factor is the short duration of spring flows (Table VI-6). Based on the sub-basin sizes and field observations none of the streams would flow for the three week minimum required for successful spawning, incubation, and emergence phases. No habitat units for spawning would be altered as a result of the proposed construction activity on the east island (Tables VI-8 & VI-9). There was no spawning habitat found for either longnose sucker or Arctic grayling on the east island. Consequently, there were no HUs altered for this habitat type.

Table VI-8 HSI Evaluation for Arctic Grayling Spawning Habitat in Streams Affected by the Proposed Project Design

Stream ID	[1]Stream Length (m)	Stream Area (10^4 ha)	%Coarse	%Fines	Average Velocity	Stream Longevity	%Pools	Other Relevant Data	Overall HSI Value
es1	63	57	n/a	n/a	n/a	0	n/a	*see below for description	0
es2	464	418	n/a	n/a	n/a	0	n/a	*	0
es3	143	129	n/a	n/a	n/a	0	n/a	*	0
es4	155	140	n/a	n/a	n/a	0	n/a	*	0
es5	49	44	n/a	n/a	n/a	0	n/a	*	0
es6	172	155	n/a	n/a	n/a	0	n/a	*	0
es7	36	32	n/a	n/a	n/a	0	n/a	*	0
es11	167	150	n/a	n/a	n/a	0	n/a	*	0
es12	250	225	n/a	n/a	n/a	0	n/a	*	0
es14	81	73	n/a	n/a	n/a	0	n/a	*	0
es15	541	487	n/a	n/a	n/a	0	n/a	*	0
es16	162	146	n/a	n/a	n/a	0	n/a	*	0
es17	650	585	n/a	n/a	n/a	0	n/a	*	0
es18	542	488	n/a	n/a	n/a	0	n/a	*	0
es19	476	428	n/a	n/a	n/a	0	n/a	*	0
es20	345	311	n/a	n/a	n/a	0	n/a	*	0
es21	154	139	n/a	n/a	n/a	0	n/a	*	0
es22	763	687	n/a	n/a	n/a	0	n/a	*	0
es23	254	229	n/a	n/a	n/a	0	n/a	*	0
es24	635	572	n/a	n/a	n/a	0	n/a	*	0

Stream ID	[1]Stream Length (m)	Stream Area (10^4 ha)	%Coarse	%Fines	Average Velocity	Stream Longevity	%Pools	Other Relevant Data	Overall HSI Value
es25	391	352	n/a	n/a	n/a	0	n/a	*	0
es26	431	388	n/a	n/a	n/a	0	n/a	*	0
es28	927	834	n/a	n/a	n/a	0	n/a	*	0
es29	416	374	n/a	n/a	n/a	0	n/a	*	0
es30	209	188	n/a	n/a	n/a	0	n/a	*	0

Note: * - Stream Habitat: Primarily dispersed flow through sedges and boulders. Distinct channels rare, streams ephemeral. Entrance to Lac de Gras almost always impassable to fish due to dispersed flows beneath extensive boulder gardens.

n/a = not available

1 - stream lengths are as shown. Stream width was estimated as 0.9 m for all east island streams based on baseline data reported for width of Stream P3 during spring snowmelt period (Vista Engineering 1996). Stream P3, located on the mainland southeast of the proposed Project, is the smallest stream for which detailed hydrological data exists.

Table VI-9 HSI Evaluation for Longnose Sucker Spawning Habitat in Streams Affected by the Proposed Project Design

Stream ID	[1]Stream Length (m)	Stream Area (10^4 ha)	Riffle Depth (cm)	Current Velocity (m/s)	%Riffles	Substrate Type	Stream Longevity	Other Relevant Data	Overall HSI Value
es1	63	57	n/a	n/a	n/a	n/a	0	*see below for description	0
es2	464	418	n/a	n/a	n/a	n/a	0	*	0
es3	143	129	n/a	n/a	n/a	n/a	0	*	0
es4	155	140	n/a	n/a	n/a	n/a	0	*	0
es5	49	44	n/a	n/a	n/a	n/a	0	*	0

es6	172	155	n/a	n/a	n/a	n/a	0	*	0
es7	36	32	n/a	n/a	n/a	n/a	0	*	0
es11	167	150	n/a	n/a	n/a	n/a	0	*	0
es12	250	225	n/a	n/a	n/a	n/a	0	*	0
es14	81	73	n/a	n/a	n/a	n/a	0	*	0
es15	541	487	n/a	n/a	n/a	n/a	0	*	0
es16	162	146	n/a	n/a	n/a	n/a	0	*	0
es17	650	585	n/a	n/a	n/a	n/a	0	*	0
es18	542	488	n/a	n/a	n/a	n/a	0	*	0
es19	476	428	n/a	n/a	n/a	n/a	0	*	0
es20	345	311	n/a	n/a	n/a	n/a	0	*	0
es21	154	139	n/a	n/a	n/a	n/a	0	*	0
es22	763	687	n/a	n/a	n/a	n/a	0	*	0
es23	254	229	n/a	n/a	n/a	n/a	0	*	0
es24	635	572	n/a	n/a	n/a	n/a	0	*	0
es25	391	352	n/a	n/a	n/a	n/a	0	*	0
es26	431	388	n/a	n/a	n/a	n/a	0	*	0
es28	927	834	n/a	n/a	n/a	n/a	0	*	0
es29	416	374	n/a	n/a	n/a	n/a	0	*	0
es30	209	188	n/a	n/a	n/a	n/a	0	*	0

Note: * - Stream Habitat: Primarily dispersed flow through sedges and boulders. Distinct channels rare, streams ephemeral. Entrance to Lac de Gras almost always impassable to fish due to dispersed flows beneath extensive boulder gardens.

n/a = not available

1 - stream lengths are as shown. Stream width was estimated as 0.9 m for all east island streams based on

baseline data reported for width of Stream P3 during spring snowmelt period (Vista Engineering 1996). Stream P3, located on the mainland southeast of the proposed Project, is the smallest stream for which detailed hydrological data exists.

Rearing Habitat

Streams on the east island were found to provide no suitable rearing habitat for Arctic grayling or longnose sucker. The primary reason for this was again the limited duration of spring flows (Table VI-6). Based on the sub-basin sizes and field observations, none of the streams would flow for the four week minimum required to provide rearing habitat. No habitat units for rearing would be altered as a result of the proposed construction (Tables VI-10 & VI-11).

Table VI-10 HSI Evaluation for Arctic Grayling Rearing Habitat in Streams Affected by the Proposed Project Design

Stream ID	[1]Stream Length (m)	Stream Area (10^4 ha)	Average Max. Temp.	%Pools	Stream Longevity	Other Relevant Data	Overall HSI Value
es1	63	57	n/a	n/a	0	*see below for description	0
es2	464	418	n/a	n/a	0	*	0
es3	143	129	n/a	n/a	0	*	0
es4	155	140	n/a	n/a	0	*	0
es5	49	44	n/a	n/a	0	*	0
es6	172	155	n/a	n/a	0	*	0
es7	36	32	n/a	n/a	0	*	0
es11	167	150	n/a	n/a	0	*	0
es12	250	225	n/a	n/a	0	*	0
es14	81	73	n/a	n/a	0	*	0
es15	541	487	n/a	n/a	0	*	0
es16	162	146	n/a	n/a	0	*	0

es17	650	585	n/a	n/a	0	*	0
es18	542	488	n/a	n/a	0	*	0
es19	476	428	n/a	n/a	0	*	0
es20	345	311	n/a	n/a	0	*	0
es21	154	139	n/a	n/a	0	*	0
es22	763	687	n/a	n/a	0	*	0
es23	254	229	n/a	n/a	0	*	0
es24	635	572	n/a	n/a	0	*	0
es25	391	352	n/a	n/a	0	*	0
es26	431	388	n/a	n/a	0	*	0
es28	927	834	n/a	n/a	0	*	0
es29	416	374	n/a	n/a	0	*	0
es30	209	188	n/a	n/a	0	*	0

Note: * - Stream Habitat: Primarily dispersed flow through sedges and boulders. Distinct channels rare, streams ephemeral. Entrance to Lac de Gras almost always impassable to fish due to dispersed flows beneath extensive boulder gardens.

n/a = not available

1 - stream lengths are as shown. Stream width was estimated as 0.9 m for all east island streams based on baseline data reported for width of Stream P3 during spring snowmelt period (Vista Engineering 1996). Stream P3, located on the mainland southeast of the proposed Project, is the smallest stream for which detailed hydrological data exists.

Table VI-11 HSI Evaluation for Longnose Sucker Rearing Habitat in Streams Affected by the Proposed Project Design

Stream ID	[1]Stream Length (m)	Stream Area (10^4 ha)	%Cover	Stream Longevity	Other Relevant Data	Overall HSI Value

es1	63	57	n/a	0	*see below for description	0
es2	464	418	n/a	0	*	0
es3	143	129	n/a	0	*	0
es4	155	140	n/a	0	*	0
es5	49	44	n/a	0	*	0
es6	172	155	n/a	0	*	0
es7	36	32	n/a	0	*	0
es11	167	150	n/a	0	*	0
es12	250	225	n/a	0	*	0
es14	81	73	n/a	0	*	0
es15	541	487	n/a	0	*	0
es16	162	146	n/a	0	*	0
es17	650	585	n/a	0	*	0
es18	542	488	n/a	0	*	0
es19	476	428	n/a	0	*	0
es20	345	311	n/a	0	*	0
es21	154	139	n/a	0	*	0
es22	763	687	n/a	0	*	0
es23	254	229	n/a	0	*	0
es24	635	572	n/a	0	*	0
es25	391	352	n/a	0	*	0
es26	431	388	n/a	0	*	0
es28	927	834	n/a	0	*	0
es29	416	374	n/a	0	*	0
es30	209	188	n/a	0	*	0

Note: * - Stream Habitat: Primarily dispersed flow through sedges and boulders. Distinct channels rare, streams ephemeral. Entrance to Lac de Gras almost always impassable to fish due to dispersed flows beneath extensive boulder gardens.

n/a = not available

1 - stream lengths are as shown. Stream width was estimated as 0.9 m for all east island streams based on baseline data reported for width of Stream P3 during spring snowmelt period (Vista Engineering 1996).

Stream P3, located on the mainland southeast of the proposed Project, is the smallest stream for which detailed hydrological data exists.

Migration Corridor Habitat

The potential to provide migration corridor habitat was identified for 10 streams on the east island. However, barriers, evaluated as passable only under rare circumstances during very high flow conditions, were observed at all the streams assessed (Table VI-6). As a result, 0.0167 migration HUs would be altered from the proposed construction activity on the east island (Table VI-12). This migration corridor habitat alteration is applicable to Arctic grayling, longnose sucker and other species including lake trout, lake whitefish, round whitefish, cisco, and burbot which may also migrate into small lakes on the east island. Because of the number of species which may utilize the streams as migration habitat, the overall total HUs requiring compensation would be 0.1169 (Table VI-13).

Table VI-12 HSI Evaluation for All Species for Migration Corridor Habitat in Streams Affected by the Proposed Project Design

Stream ID	[1]Stream Length (m)	Stream Area (10^4 ha)	Presence of Flow	Presence of Barriers	Inland Lake Habitat	Overall HSI Value	HUs
es1	63	57	0.5	0.1	0	0	0
es2	464	418	0.5	0.1	0	0	0
es3	143	129	0.5	0.1	0	0	0
es4	155	140	0.5	0.1	0	0	0
es5	49	44	0.5	0.1	1	0.1	0.0004
es6	172	155	0.5	0.1	1	0.1	0.0016
es7	36	32	0.5	0.1	1	0.1	0.0003
es11	167	150	0.5	0.1	1	0.1	0.0015
es12	250	225	0.5	0.1	1	0.1	0.0023
es14	81	73	0.5	0.1	1	0.1	0.0007
es15	541	487	0.5	0.1	0	0	0
es17	650	585	0.5	0.1	0	0	0
es18	542	488	0.5	0.1	0	0	0

es19	476	428	0.5	0.1	1	0.1	0.0043
es20	345	311	0.5	0.1	0	0	0
es21	154	139	0.5	0.1	0	0	0
es22	763	687	0.5	0.1	0	0	0
es23	254	229	0.5	0.1	0	0	0
es24	635	572	0.5	0.1	0	0	0
es25	391	352	0.5	0.1	0	0	0
es26	431	388	0.5	0.1	0	0	0
es28	927	834	0.5	0.1	0	0	0
es29	416	374	0.5	0.1	1	0.1	0.0037
es30	209	188	0.5	0.1	1	0.1	0.0019

1 - stream lengths are as shown. Stream width was estimated as 0.9 m for all east island streams based on baseline data reported for width of Stream P3 during spring snowmelt period (Vista Engineering 1996). Stream P3, located on the mainland southeast of the proposed Project, is the smallest stream for which detailed hydrological data exists.

Table VI-13 Calculation of Habitat Units For Migration Habitat

Species	Available Stream Habitat (ha)	Overall HSI Value	Habitat Units Altered
Arctic Grayling	0.1669	0.1	0.0167
Longnose Sucker	0.1669	0.1	0.0167
Lake Trout	0.1669	0.1	0.0167
Lake Whitefish	0.1669	0.1	0.0167
Round Whitefish	0.1669	0.1	0.0167
Cisco	0.1669	0.1	0.0167

Burbot	0.1669	0.1	0.0167
Total	1.168	0.1	0.1169

Note: Habitat Units are based on those streams that had an HSI Value in Table VI-12.

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APPENDIX VII - PROPOSED HABITAT MITIGATIVE MEASURES

INTRODUCTION

Appendices II through VI present the quantity and quality of fish habitat which would be affected in Lac de Gras and the small lakes and streams on the east island. Habitat losses would occur during the construction/operations phase. In this section, mitigation measures are presented which would replace the habitat altered by the proposed Project. Although the fish habitat created during each phase of the Project would vary, this section summarizes the total amount of fish habitat that would be created after the post-closure phase. A rationale is presented for the various types of fish habitat being created. An explanation of why certain habitat types were preferred over others is also presented.

FISH HABITATS CREATED BY DIKES

General Habitat Features to be Altered by Dike Construction

The shoals and shorelines located within the proposed dike perimeters were described in Technical Memoranda #12, #14, and #15 (Golder Associates 1997a, b, c). Generally, shorelines along the east island where the dikes would be located are classified as Type 1 (primarily boulder substrates) and are located in exposed areas. None of these shorelines are located near deep water. The majority of shoals inside the proposed dike perimeters are composed of boulder substrates. Some of these shoals are located next to deep water, and provide excellent spawning habitat for species such as lake trout. Those shoals surrounded by shallow waters are less suitable for spawning, and were given lower HSIs for spawning. Most of the deep water was observed to be 6 to 10 m deep. The deep-water areas located in more than 6 m of water all had sand/silt substrates. This type of deep water provided foraging habitat for fish feeding on insect larvae such as chironomids. It is unlikely that juvenile fish frequent these areas due to the high risk of predation by larger fish (MacDonald et al. 1992).

Appendix XI presents the information used to develop the models that were then used to determine the HSI values for each life stage and fish species of interest in Lac de Gras. Whenever possible, these same criteria were used to evaluate the suitability of fish habitats created by the exterior and interior of the dikes. However, the dikes would create some unique habitat types previously not found in Lac de Gras (e.g., clean rocky substrates along shorelines at depths greater than 6 m, at least in the short term). A summary of the HSI values assigned to various components of the dike are given in Table VII-1. The HSI values differ for various components of the dike, depending on their physical characteristics, location and ability to provide habitat for various fish species. The rationale for these HSI values is presented in the following sections.

Suitability of Fish Habitats Created by Dike Exteriors

Details of the dike design are presented in the project description (Diavik 1998). The dike exterior would have a slope of 1.5:1 from its apex 3 m above the water line to the bottom of the lake. Depth next to the dike and aspect of the dike would vary depending on location. The water depth along the dike exterior wall would vary from a few metres to over 40 m in some locations. These are important considerations when determining the quality of spawning habitat, especially for lake trout (see Appendix X).

The dike exterior was considered shoreline habitat and evaluated with the same criteria that were used to describe the native shorelines that would be altered by dike construction. The dike would become a permanent physical feature of Lac de Gras and consequently the fish habitats created must be evaluated on their ability to provide habitat on a long-term basis. Important parameters that were considered when the habitats created by the dike exterior were evaluated included wave-generated currents for maintaining silt-free substrates, ice cover, light intensity, temperature, depth, substrate size, proximity to deep water, slope and aspect. The HSI models used to evaluate the suitability of each habitat for each species of interest are presented in Appendix XI.

The suitability of various sections of the dike exterior as fish habitat would depend on two principle factors: depth and substrate size. Substrate size is the only aspect of the dike design which can be manipulated to maximize fish habitat creation. Other dike characteristics, such as slope, aspect and depth, cannot be manipulated for the purposes of fish habitat creation due to design requirements. Figure VII-1 illustrates how the dike exterior was divided into three depth zones (0-2 m, 2-6 m and >6 m) when habitat suitability was evaluated. The HSIs attributed to the habitats in each depth zone were determined based on the life stage requirements of various fish species. The following is a description of each depth strata and the quality of the habitats that each would create (Figure VII-1).

Table VII-1 HSI Values Assigned to Various Habitats Created for All Fish Species of Interest in Lac de Gras

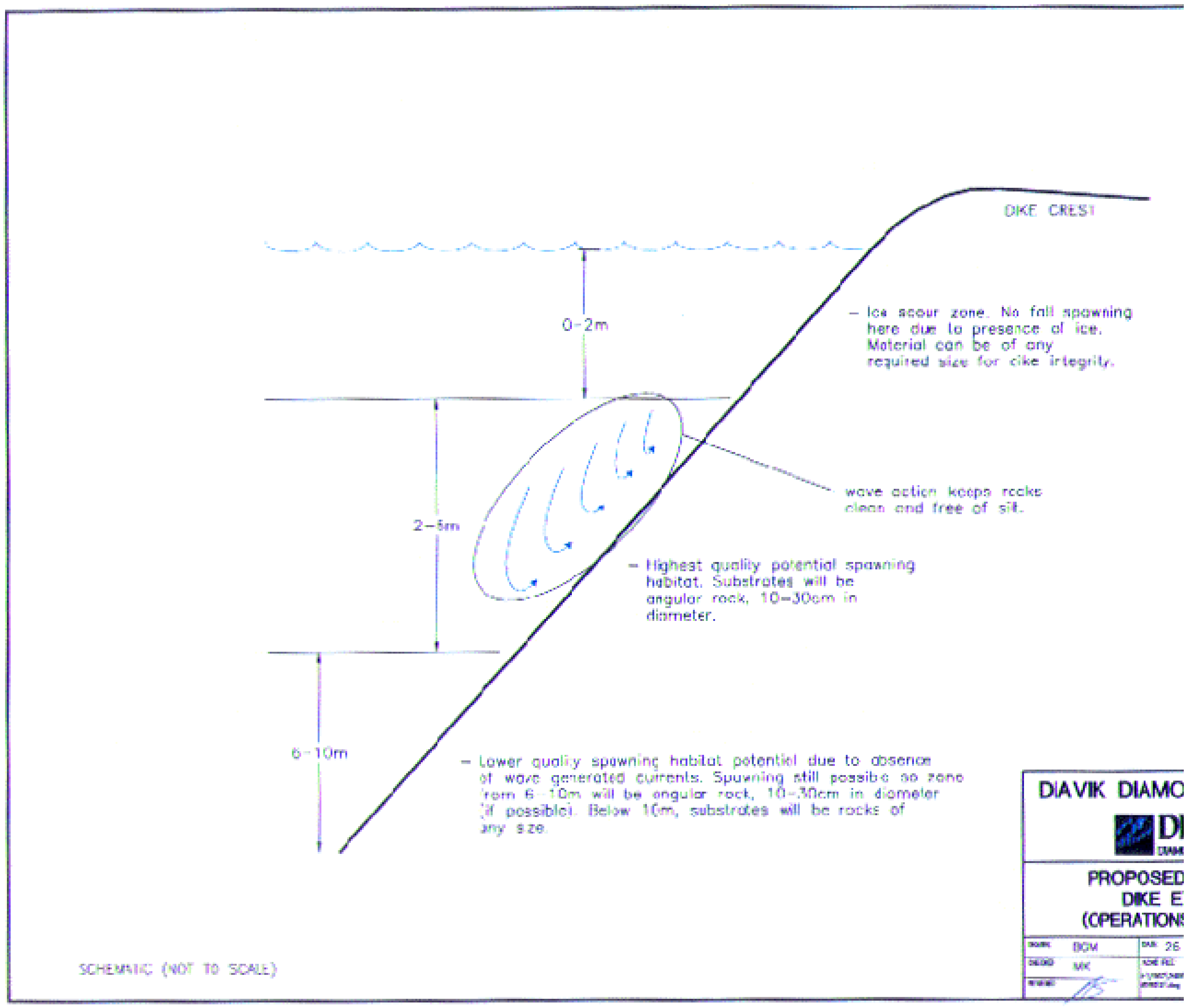
Habitat	Lake trout				Arctic grayling			
Descriptions	Spwn.	Rear.	Frge.	Nurs.	Spwn.	Rear.	Frge.	Nurs.
External Edge of Dike								
0-2 m	0	0.25	0.75	0	0.25	0.25	0.5	0
2-6 m	1.0	0.25	0.75	1.0	0	0.25	0.5	0
>6 m	0.25	0.25	0.5	0.25	0	0	0.25	0
Internal Edge of Dike	0.25	0.75	0.5	0.25	0	0.5	0.5	0
Pit Shelf Area	0	1	0.5	0	0		0.5	0
Deep water >10 m (pit)	0	0.25	0.25	0	0	0.25	0.25	0
	Longnose sucker				**Burbot**			
	Spwn.	Rear.	Frge.	Nurs.	Spwn.	Rear.	Frge.	Nurs.
External Edge of Dike								
0-2 m	0.5	0.25	0.25	0.5	0	0.25	0.5	0
2-6 m	0.25	0.25	0.25	0.25	0.25	0.25	0.5	0.25
>6 m	0	0.25	0.25	0	0.25	0	0.5	0.25
Internal Edge of Dike	0.25	0.5	0.25	0.25	0.25	0.5	0.5	0.25
Pit Shelf Area	0	0.75	0.75	0	0	0.75	0.5	0
Deep water >10 m (pit)	0	0.25	0.25	0	0	0.25	0.25	0
	Round whitefish				**Cisco**			
	Spwn.	Rear.	Frge.	Nurs.	Spwn.	Rear.	Frge.	Nurs.
External Edge of Dike								
0-2 m	0	0.25	0.75	0	0	0.25	0.75	0

2-6 m	1.0	0.25	0.75	1.0	1.0	0.25	0.75	1.0
>6 m	0.25	0	0.25	0.25	0.25	0	0.25	0.25
Internal Edge of Dike	0.25	0.75	0.5	0.25	0.25	0.75	0.5	0.25
Pit Shelf Area	0	1	0.75	0	0	1	0.75	0
Deep water >10 m (pit)	0	0.25	0.25	0	0	0.5	0.5	0

	Lake whitefish				**Northern pike**			
	Spwn.	Rear.	Frge.	Nurs.	Spwn.	Rear.	Frge.	Nurs.
External Edge of Dike								
0-2 m	0	0.25	0.75	0	0	0	0	0
2-6 m	1.0	0.25	0.75	1.0	0	0	0	0
>6 m	0.25	0	0.25	0.25	0	0	0	0
Internal Edge of Dike	0.25	0.75	0.5	0.25	0	0	0	0
Pit Shelf Area	0	1	0.75	0	0	0	0	0
Deep water >10 m (pit)	0	0.25	0.25	0	0	0	0	0

	Slimy sculpin			
	Spwn.	Rear.	Frge.	Nurs.
External Edge of Dike				
0-2 m	0.75	1.0	0.5	0.75
2-6 m	1.0	1.0	0.5	1.0
>6 m	0.5	0.5	0.5	0.5
Internal Edge of Dike	1.0	1.0	1.0	1.0
Pit Shelf Area	0.25	0.25	0.25	0.25
Deep water >10 m (pit)	0.25	0.25	0.25	0.25

Figure VII-1 Proposed Design of Dike Exterior (Operations and Closure)



Dike exterior - Depth 0-2 m: Due to the potential for ice scouring, the exterior of the dike from the surface to a depth of 2 m would have to be composed of very large boulders. Normal ice thickness is usually in the range of 2 m for Lac de Gras. Since ice would occupy the 0-2 m zone of the dike exterior during the winter period, this section of the dike was not considered suitable spawning habitat for fall spawners such as lake trout or round whitefish. Spring spawners, such as longnose sucker or Arctic grayling, could use this habitat for spawning since egg incubation does not extend into the winter period. However, due to the large substrate size, this area of the dike was assigned a below average HSI (0.25) for spring spawners. Both longnose sucker and Arctic grayling are known to prefer smaller substrates (cobble/gravel) and moving water for spawning (Edwards 1983; Hubert et al. 1985).

During the open-water period, the 0 to 2 m zone of the dike would provide nursery, rearing and foraging habitat for all fish species present in Lac de Gras, with the exception of northern pike. The crevices between boulders would provide refuge from predators for small fish. This zone would have the highest light intensity and the warmest temperatures during the open-water season due to its shallow depth. Consequently, primary and secondary productivity rates should be higher in this zone than in the deeper zones. The HSI values attributed to this zone for each fish species are presented in Table VII-1.

Dike exterior - Depth 2-6 m: The results of the shoal survey (Appendix III) revealed that hard substrates in either shoals or shorelines rarely exceeds 6 m in depth. The fall lake trout spawning survey revealed that this species uses clean boulder/cobble shoals and shorelines with steep gradients next to deep water for spawning. Shoals with these characteristics were observed to be the preferred lake trout spawning habitat (see HSI models). In order to optimize the suitability of the dike exterior as spawning habitat, the depth zone from 2-6 m would be covered with several layers of boulder (75%) and cobble (25%). Since the dike exterior would be exposed to wave action, the substrates would remain clean as they do along shoals and shorelines in Lac de Gras in similar locations. The slope, aspect, substrate size, cleanliness and proximity to deep water of this section of the dike would provide above average spawning and nursery habitat for a variety of fish species including lake trout, cisco and round whitefish. This area could also serve as spawning habitat for spring spawners such as Arctic grayling and longnose sucker; although they have been known to spawn on rocky substrate in lakes, it is more likely that they would migrate to tributary streams to spawn. Spawning in streams is supported by observations made in the spring of 1996 (Golder Associates 1997d).

Dike exterior - Depth >6 m: The portions of the dike found at a depth below 6 m are not expected to be kept free of silt by wave action. Gradual accumulations of silt are expected on the rocky exterior of the dike over time. Due to the potential presence of silt, this area of the dike was categorized as being unsuitable for all fish species in Lac de Gras.

The largest loss of habitat for lake trout is spawning habitat (0.9%; relative to the total amount available in Lac de Gras) (see Table 4-1 of the main section of this document). Of the 32 HUs of spawning habitat being lost in Lac de Gras, 4.8 HUs would be above average or excellent quality. The total amount of lake trout spawning habitat available in Lac de Gras is 3682 HUs. The loss of spawning habitat can be put into context when the results of the fall lake trout spawning survey are considered (Golder Associates 1997e). Lake trout were observed spawning only on habitat (primarily shoals) of excellent or above average quality (Golder Associates 1997e). Spawning fish were observed throughout the lake wherever this quality of habitat occurred, indicating that there was no preference for any one site. Lake trout spawning habitat was the only spawning habitat for which the HSI values could be verified using field observations. No other spawning studies for fall lake spawning fish species were conducted due to inclement weather or seasonal limitations (e.g., burbot spawning in winter).

Intermittent spawning, where male and female lake trout do not produce mature gonads every year, has been observed in northern latitudes (Johnson 1972). In Lac de Gras, resting females accounted for 33%

of all females sampled whereas resting males accounted for only 8% of the individuals sampled from Lac de Gras (Golder Associates 1997e). Consequently, it can be estimated that only 66% of the population would require spawning habitat in any one spawning season.

McAughey and Gunn (1995) showed that in lakes where spawning habitat is not limiting, lake trout would readily select alternate spawning sites if historical sites become unavailable. In Lac de Gras, numerous alternate spawning sites of excellent and above average quality are available (Golder Associates 1997e). In addition, 6 HUs of above average quality spawning habitat would be created by the dike exteriors in the immediate vicinity of the original habitat that would be lost. At post-closure the overall loss of spawning habitat for lake trout would be 25 HUs. It is anticipated that lake trout that are presently using this habitat would select alternate sites for spawning in Lac de Gras.

Fish Habitats Created by the Area Behind Dikes

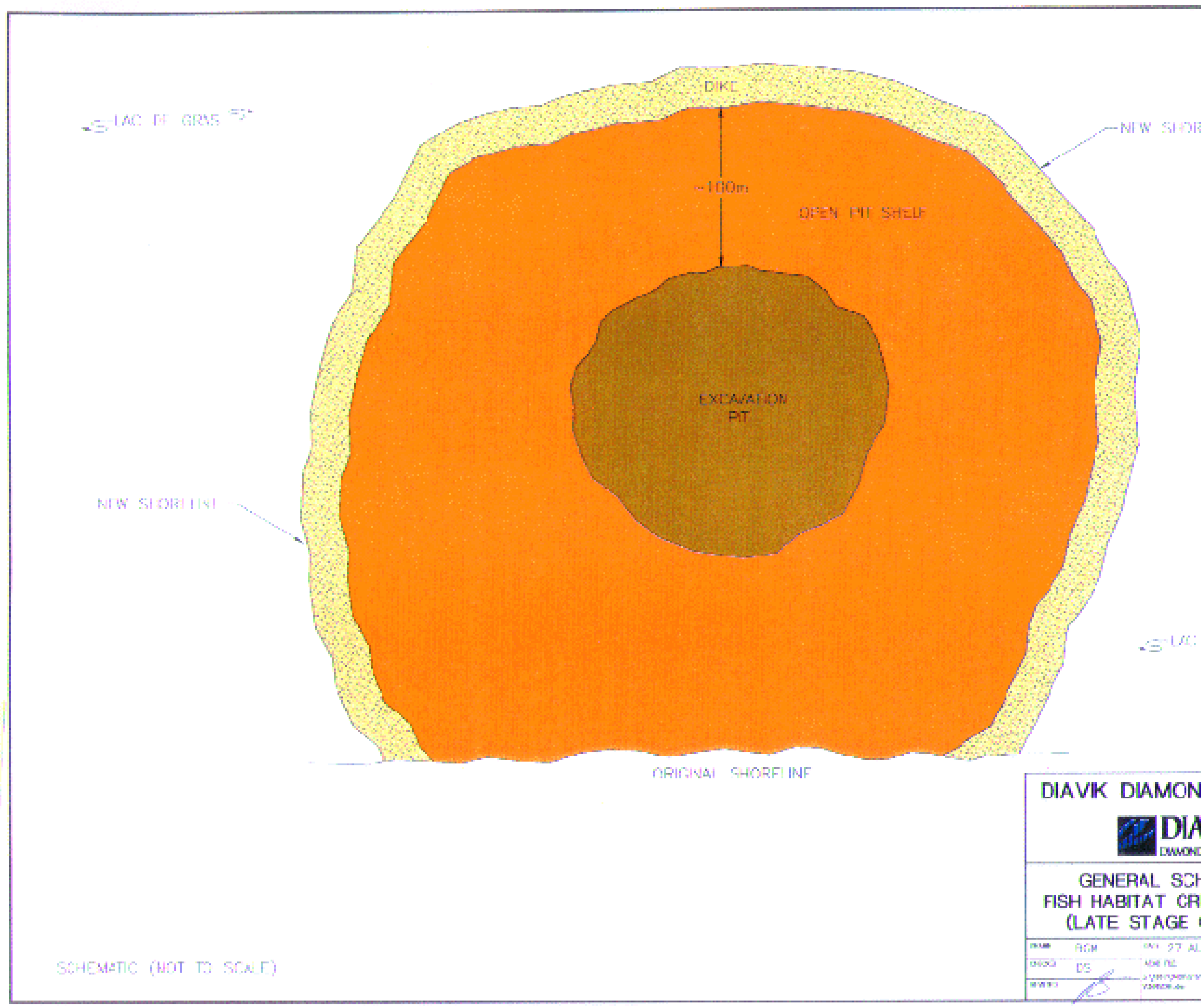
Once the mining of the kimberlite pipes is complete, the process of fish habitat creation through re-configuration of the dike interior would begin. The overall objective is to flood the interior of the dikes to provide fish habitat within the dike walls. Figure VII-2 shows how a dike would appear during the operations phase. The dike interior at this stage would consist of the interior wall of the dike, the open pit shelf and the open pit. The pit shelf would be a large expanse of flat ground between the dike interior and the edge of the open pit. The open pit would be a large hole with steep walls which would descend to a depth of approximately 250 m.

The following steps would be taken during the closure phase to maximize the creation of fish habitat within the dikes:

- The pit shelf would be re-contoured so that it would lie approximately 5 m below the water surface once the dike walls are breached.

Once re-contouring is complete, long, narrow rocky reefs would be created which would extend from the inside wall of the dike to the edge of the open pit. Shoals would be built in areas with water at least five metres deep. These shoals would be approximately ten metres wide and two metres high. Maximum ice depth in Lac de Gras is approximately two metres. Care would be taken to ensure that new reefs are well below the ice cover thereby limiting potential scouring of the habitat by ice. The exact number of reefs will be determined from information gathered from the north inlet. This inlet is known to be excellent rearing habitat and the proportion of hard and soft substrates will be determined and used as a model for construction within the dike walls. The area between the reefs would not be covered with hard substrates. Soft substrates, such as sand and silt, would be necessary to enhance the productivity of benthic invertebrates such as chironomids, a primary food source for many fish species. Benthic invertebrate surveys in Lac de Gras have shown that the majority of benthic organisms in Lac de Gras originate from the soft substrates (Golder Associates 1997f). The proportion of soft/hard substrates would be the same as that documented for the north inlet.

Figure VII-2 General Schematic of Fish Habitat Created by Dike (Late Stage Operations)



- The disturbed portions of shoreline along the east island would be re-configured to pre-development conditions as much as possible. This would entail the placement of boulder substrates to a depth of approximately two metres to mimic undisturbed shorelines in Lac de Gras.
- Upon completion of these tasks, the dike would be allowed to fill with water. The dike walls would not be breached until the interior of the dike is filled with water.

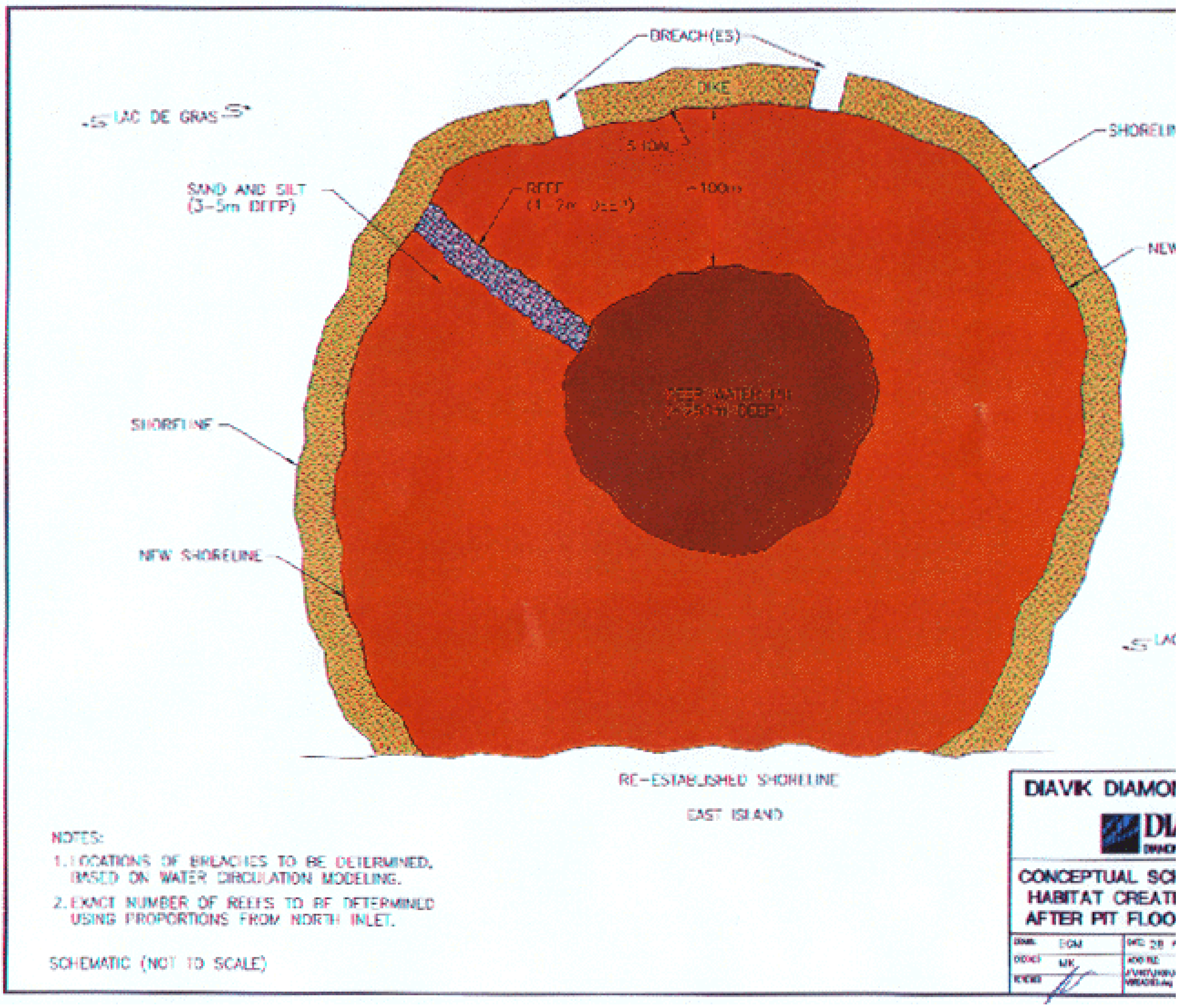
- Once flooded, the dike walls would be breached. Three breaches are proposed for the A418 and A154N/S dikes whereas two breach points are proposed for the A21 dike (Figure VII-3). The number of breaches would allow for water to circulate within the dike walls. Modelling of the circulation patterns in Lac de Gras (Golder Associates 1997k) has shown that velocities in the shallow, sheltered regions of Lac de Gras where juvenile fish were caught (e.g., between the east and west islands) were at or near 0. Since the objective is to create rearing habitat similar to that which exists in the lake, breaches would be made in the dike walls to allow slow water movement within the dikes. The breaches would be shallow (about one metre deep) to deter the movements of larger fish into this nursery/rearing habitat. This would emulate existing conditions in the north inlet.

Suitability of Fish Habitats Created by Dike Interiors

Figure VII-3 illustrates the conceptual layout within the dike after breaching. The overall effect of the design of the dike interior would be to create sheltered shallow-water habitat. The Extensive and Intensive shoreline surveys revealed that sheltered, shallow-water habitats occurred infrequently in Lac de Gras (Golder Associates 1997b, c). The total area of Lac de Gras is 637.4 km^2 or 63,740 hectares. The total area of shoreline habitat (shallow waters associated with shorelines) is 14% of the lake area. The vast majority of the lake is characterized by shorelines with steep gradients that descend quickly into deep water. Shallow, sheltered waters are often restricted to bays or the shallow connections between islands. Habitat of this kind is relatively rare in Lac de Gras.

A total of 0.7% of the rearing habitat for lake trout in Lac de Gras would be lost due to the proposed Project during the construction/operations phase. Mitigation measures would be directed towards the creation of this habitat type at post-closure. Evans et al. (1991) concluded that the availability of rearing habitat appears to control natural recruitment in lake trout populations. These authors stated that "the entire natural lake trout production of a lake is dependent on the quantity and quality of the rearing habitat." For lakes where thermal stratification occurs, critical nursery habitat is the deep portion of lakes that vertically segregate juvenile fish from the adults (Evans et al. 1991). Cannibalism of juvenile lake trout by adults is a very significant mortality factor if this vertical segregation does not occur. In Lac de Gras, there is no thermal stratification to segregate juvenile and adult lake trout. Therefore, juvenile lake trout in deep waters are most likely vulnerable to predation due to the lack of thermal boundaries and cover.

Figure VII-3 Conceptual Schematic of Fish Habitat Created by Dikes after Pit Flooding (Closure)



Sheltered, shallow-water habitats are important to the overall productive capacity of Arctic lakes. Johnson (1972) observed a bimodal distribution of age classes for unexploited lake trout populations in the Canadian Arctic. The theory presented to explain this observation was that large lake trout were forcing juvenile lake trout into the shallow waters to avoid predation. McDonald et al. (1992) suggested that there is an energy trade-off for juvenile lake trout between better zooplankton feeding in deep waters which comes at a price of higher risks of predation, and poorer zooplankton feeding opportunities in shallow waters where predation rates are lower. However, juvenile lake trout kept in pens in inshore and offshore areas of Toolik Lake, NWT, both showed no significant changes in weight (McDonald et al. 1992). Lake trout in offshore pens in one experimental lake did show weight gains although this lake was previously fishless and had an unexploited zooplankton community. The authors suggested that deep water areas were sub-optimal for young-of-the-year (YOY) lake trout growth due to low densities of suitable zooplankton prey. To be successful, McDonald et al. (1992) suggested that YOY lake trout needed to exploit the interface between the near shore rocky areas and the deeper soft sediments. This habitat interface provides cover from predation in the rocky substrates and greater prey abundance, such as chironomids, in the soft substrates. In Lac de Gras, this interface occurs most commonly at a depth of 6 m. Ford et al. (1995) also concluded that the preferred habitat for juvenile lake trout was the shallow inshore areas of large lakes. From this body of evidence, the criteria for high quality rearing habitat appear to be sufficient forage opportunities and refuge from predation.

McDonald and Hershey (1992) found weight increases in slimy sculpins caught at the interface between hard and soft substrates in shallow waters of Arctic lakes. The interface between hard and soft substrates appears to be an important habitat component in the survival of YOY and juvenile fish in Arctic lakes. The rocky habitats provide cover and limited benthic invertebrate production. The soft sand/silt sediments are the major source of food for these fish since this is where the chironomids and other soft sediment invertebrates reside. Areas where these habitats types are in close proximity to each other appear to be the most productive (in terms of growth and survival) for rearing and foraging habitat of young fish.

The majority of juvenile lake trout (15 cm in length or less) captured in the summer of 1996 were found in shallow, sheltered bays (Golder Associates 1997g). This supports the observations and conclusions of the researchers reviewed above. Based on the literature and field observations, sheltered, shallow-water rearing habitats appear to be the most important habitat class for lake trout in Lac de Gras (and also the most productive). However, overall lake trout productivity is likely restricted by the ultra-oligotrophic nature (i.e., extremely low productivity) of Lac de Gras rather than habitat availability.

The vast majority of shorelines and shallow waters in the lake are exposed to high winds or closely associated with deep waters where adults reside. Shallow, sheltered waters are often restricted to bays or inlets and constitute a small percentage of the total shoreline area occupied by shallow waters. Since the quantity and quality of rearing habitat appears to influence lake trout production in Arctic lakes such as Lac de Gras, any loss of this habitat type has to be considered an important effect. Similarly, any gains in this habitat class would have to be regarded as having the highest potential of increasing lake trout productivity in comparison to other habitat classes (e.g., spawning).

The most significant loss of lake trout rearing habitat would occur as a result of blocking off the north inlet since high quality rearing habitat would be lost. However, mitigation in the post-closure phase (e.g., breaching the dikes around the kimberlite pipes to allow fish access) would result in a 190.8 HU gain in lake trout rearing habitat in Lac de Gras at post-closure (Table VII-2).

Major Habitat Types Created by the Inside of the Dike

The dike interior can be divided into three major habitat types: the inside wall of the dike, the pit shelf and the open pit. Each of these features would provide different qualities and quantities of habitat. The general habitats types provided by each major habitat is presented below:

Table VII-2 Summary Table of Habitat Units Gained at Post-closure by Mitigation Efforts in Lac de Gras

a) Lake trout

	Spawning	Rearing	Foraging	Nursery
External edge of dikes	4.58	1.72	5.15	3.43
Internal edge of dikes	0.73	2.19	1.46	0.73
Original shoreline	0.97	0.97	0.97	0.97
Pit Shelf	0	122.71	61.35	0
Open Pit	0	63.22	31.61	0
TOTAL	**6.3**	**190.8**	**100.5**	**5.1**

b) Cisco

	Spawning	Rearing	Foraging	Nursery
External edge of dikes	3.43	1.72	5.15	3.43
Internal edge of dikes	0.73	2.19	1.46	0.73
Original shoreline	0.97	0.49	0.97	0.97
Pit Shelf	0	122.71	92.03	0
Open Pit	0	63.22	63.22	0
TOTAL	**5.1**	**190.3**	**162.8**	**5.1**

c) Round whitefish

	Spawning	Rearing	Foraging	Nursery

External edge of dikes	3.43	1.72	5.15	3.43
Internal edge of dikes	0.73	2.19	1.46	0.73
Original shoreline	0.49	0.49	0.97	0.49
Pit Shelf	30.68	92.03	61.35	30.68
Open Pit	0	31.61	31.61	0
TOTAL	**35.3**	**128.0**	**100.5**	**35.3**

d) Arctic grayling

	Spawning	Rearing	Foraging	Nursery
External edge of dikes	0	1.72	3.43	0
Internal edge of dikes	0	1.46	1.46	0
Original shoreline	0	0.49	0.97	0
Pit Shelf	0	61.35	61.35	0
Open Pit	0	31.61	31.61	0
TOTAL	**0.0**	**96.6**	**98.8**	**0.0**

e) Lake whitefish

	Spawning	Rearing	Foraging	Nursery
External edge of dikes	3.43	1.72	5.15	3.43
Internal edge of dikes	2.19	2.19	1.46	2.19
Original shoreline	1.46	1.46	0.97	1.46
Pit Shelf	0	122.71	92.03	0

Open Pit	0	31.61	31.61	0
TOTAL	**7.1**	**159.7**	**131.2**	**7.1**

f) Burbot

	Spawning	Rearing	Foraging	Nursery
External edge of dikes	1.14	1.72	3.43	1.14
Internal edge of dikes	0.73	1.46	1.46	0.73
Original shoreline	0.97	1.95	0.97	0.97
Pit Shelf	0	92.03	61.35	0
Open Pit	0	31.61	31.61	0
TOTAL	**2.9**	**128.8**	**98.8**	**2.9**

g) Longnose sucker

	Spawning	Rearing	Foraging	Nursery
External edge of dikes	2.29	1.72	1.72	2.29
Internal edge of dikes	0.73	1.46	0.73	0.73
Original shoreline	0	0.97	0.97	0
Pit Shelf	0	92.03	92.03	0
Open Pit	0	31.61	31.61	0
TOTAL	**3.0**	**127.8**	**127.1**	**3.0**

h) Northern pike

	Spawning	Rearing	Foraging	Nursery
External edge of dikes	0	0	0	0
Internal edge of dikes	0	0	0	0
Original shoreline	0	0	0	0
Pit Shelf	0	0	0	0
Open Pit	0	0	0	0
TOTAL	**0**	**0**	**0**	**0**

i) Slimy sculpin

	Spawning	Rearing	Foraging	Nursery
External edge of dikes	6.29	6.87	3.43	6.29
Internal edge of dikes	2.92	2.92	2.92	2.92
Original shoreline	1.95	1.95	0.97	1.95
Pit Shelf	122.71	122.71	122.71	122.71
Open Pit	31.61	31.61	31.61	31.61
TOTAL	**165.48**	**166.05**	**161.65**	**165.48**

Inside Wall of the Dike: The inside wall of the dike would be composed of large rock and it would border the shallow pit shelf. Due to the lack of full wind exposure and proximity to deep water, this area is not expected to provide excellent, above average or average spawning habitat for fall spawners such as lake trout. Consequently, an HSI of 0.25 was assigned to this area for fall spawners. Spring spawners such as slimy sculpin, Arctic grayling and longnose sucker could make use of this habitat. However, due to the large substrate size, a lower HSI values was assigned. The inside wall of the dike would border soft substrates, in between the rock shoals. This would provide excellent, above average or average rearing and foraging habitat for a variety of fish species.

Pit Shelf: The shoals in the pit shelf would provide below average spawning habitat for fall spawners due to the reduced exposure to wind and wave and deep-water areas of Lac de Gras. Spring species, especially slimy sculpin, could use this habitat for spawning. The primary habitat feature the pit shelf would provide is above average and excellent rearing habitat, as a result of the multiple rock and soft sediment interfaces created by the reefs interspersed with soft sediment areas.

Open Pit: The open pit would be a steeply sided large hole which would descend to a depth of approximately 250 m. For the purposes of this habitat assessment, it is being considered as deep-water habitat. Pelagic feeders such as cisco and YOY lake trout may benefit from this zone of deep water. These waters would provide deep-water zooplankton communities to feed upon and may provide reduced predation pressure from larger fish since this deep water area is located within the walls of a dike.

Fish Habitats Created by Dike Breaching

The combined number of habitat units created by the re-contoured shoreline, the dike interior, the dike exterior, the open pits and the pit shelves are presented in Table VII-2. The table presents the amount of each habitat type created for each HSI category for fish species of interest.

Verification of Habitat Creation Success

The success of the mitigation efforts in creating productive habitat within Lac de Gras would be verified in two ways. The focus would be on habitat utilization by fish in the dikes. Verification of fish usage of the dike exterior would be done as soon as possible so any necessary changes in design may be made before all dikes are constructed. Verification of fish usage on the interior of the dikes would be conducted three years after the first dike is breached (A21) and mining is completed. Verification would be done by gill netting to determine the presence of juvenile and adult fish inhabiting the flooded area behind the dikes. If these habitat improvement measures do not result in usage of the habitat by fish, other mitigation measures would be considered. A more detailed description of the monitoring plans are presented in Section 5 of the main body of this report.

Summary and Conclusions

A limited amount of above average spawning habitat would be created by the dike exterior. Overall, there would be a net reduction in the amount of spawning habitat for fall spawners in Lac de Gras as a result of dike construction. However, spawning habitat was found to be plentiful in this lake. Spawning shoals of equal or better quality to those being altered were observed in several locations outside the zone of dike construction (Golder Associates 1997e). It is unlikely that the replacement of spawning habitat to pre-development conditions would help increase fish production in Lac de Gras since this habitat type does not appear to be limiting the growth of fish populations using them for spawning.

The focus of the re-configuration of the dikes at closure would be to create rearing habitat for a variety of fish species. Rearing habitat is likely the most limiting habitat feature for most fish species in Lac de

Gras. Consequently, emphasis was placed on creating the habitat type which had the best chance of improving the productive capacity of the lake. In addition, good rearing habitat would be provided next to spawning habitat. This would likely result in a more than additive effect on production.

Table VII-3 shows the overall balance sheet for the habitat altered and gained by the dikes. A net surplus of 186 HUs would result from mitigation efforts in Lac de Gras. The majority of the habitat gained would be in the form of rearing habitat for juvenile fish. This increase in rearing habitat for most species (91 HUs for lake trout, 52 HUs for round whitefish, 78 HUs for cisco, 59 HUs for lake whitefish, 23 HUs for longnose sucker, and 24 HUs for slimy sculpin) is estimated to have a net beneficial effect on the overall fish community of Lac de Gras.

Except for slimy sculpin, the fish species of Lac de Gras can easily migrate in and out of the proposed Project area. Consequently, the habitat losses in the immediate vicinity of the proposed dikes and north inlet may affect slimy sculpin to a greater extent than other species which can easily use habitats in other regions of the lake. The dikes would produce 659 HUs of slimy sculpin habitat, the largest amount of any species.

Table VII-3 Summary of Habitat Altered and Gained due to Dike Construction in Lac de Gras

Habitat Type	Habitat Units
Shoreline HUs Altered	613
Shoal HUs Altered	362
Deep Water HUs Altered	1,156
North Inlet HUs Altered (shoreline and deep water)	301
Total HUs Altered - Lac de Gras	**2,432**
Dike Exterior HUs Gained	99
Dike Interior HUs Gained	46
Flooded Pit Shelf HUs Gained	1,779
Flooded Open Pit HUs Gained	664
Reclaimed Shoreline HUs Gained	30
Total HUs Gained - Lac de Gras	**2,618**
Net HUs (Altered - Gained)	**+186**

* - Net does not include Habitat Units (HUs) altered in small lakes or streams which are addressed separately.

SMALL LAKES

A total of three fish-bearing lakes (e7, e8, e10) would be permanently removed from fish production by the proposed mine development (Figure VII-4). Another fish-bearing lake (lake e3) would be temporarily altered for use as part of the water management system. Development of the proposed Project would entail covering lakes e7, e8 and e10 with waste rock (country rock piles) or processed kimberlite. Thus, these fish habitats would be permanently removed from the east island. Lake e21 would be drained for the duration of the construction/operations phase. It is not a fish-bearing lake but would be included in the habitat mitigation plan. Consequently, mitigation is being proposed to replace the small lake fish habitats altered on the east island.

The amount of habitat to be replaced was based on the number of fish species present in each lake.

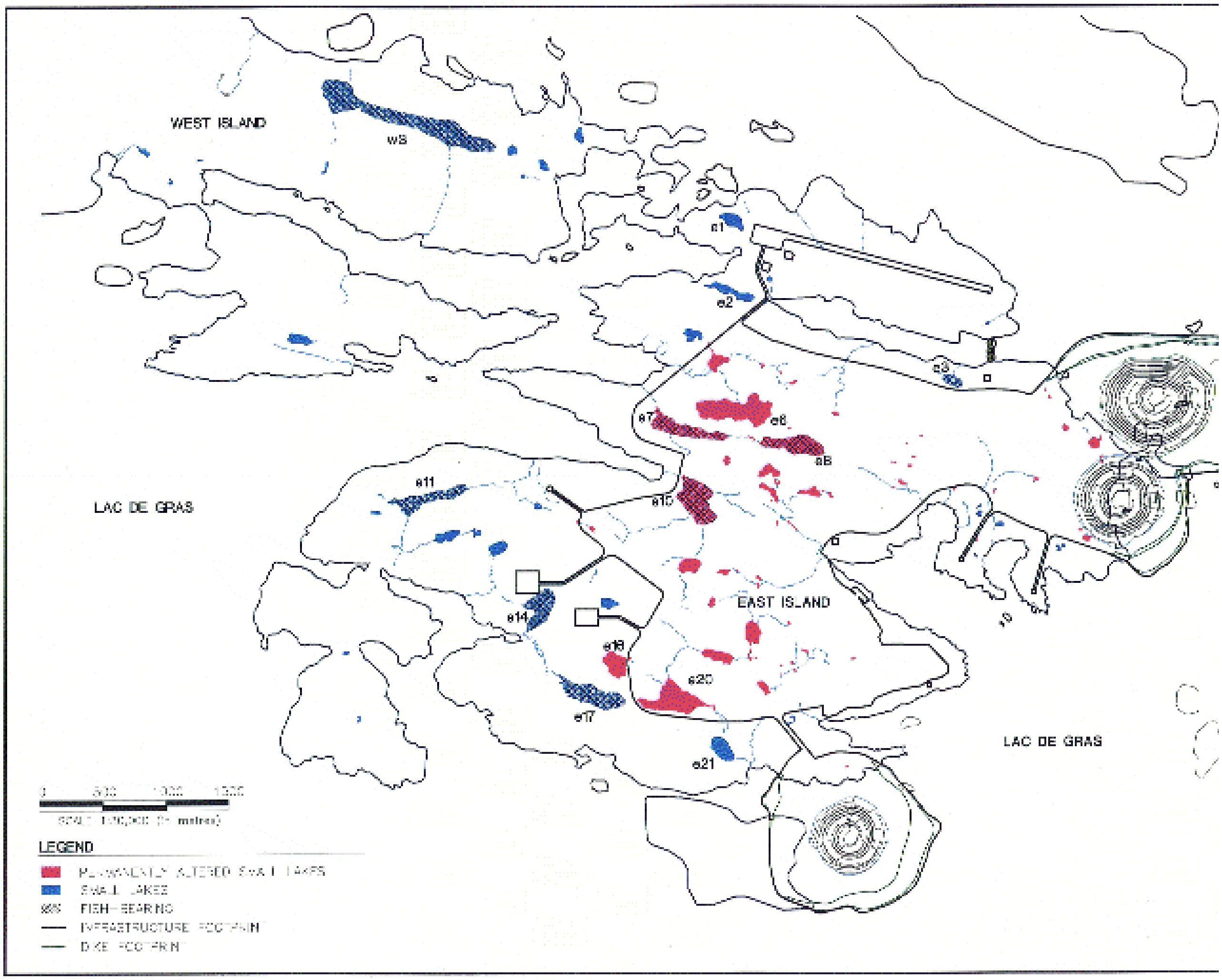
For the purposes of this plan, lakes on the east island were considered fish habitat if one of two conditions were met:

1) The lake supported a permanent fish population.
2) Fish from Lac de Gras could access the lake and use it on a seasonal basis.

No mitigation is being proposed for the 11 fishless lakes (Golder Associates 1997j) and the unnamed ponds for the following reasons:

- No fish were caught at the time of the summer surveys (Golder Associates 1997i);
- Ice cover is generally about 2 m deep; lakes that are ≤ 3 m depth are not suitable for fish to successfully overwinter (Golder Associates 1997i, j); and,
- The streams connecting these lakes to other small lakes bearing fish, or Lac de Gras, were too small and/or flowed for too short a period of time to allow fish from other waterbodies to use these lakes on a seasonal basis (Golder Associates 1997d).

Figure VII-4 Maximum Mine Extent Showing Small Lakes to be Lost and Used in Habitat Compensation



DFO has yet to establish a protocol for dealing with the alteration of entire lakes (Dr. C.K. Minns, pers. comm.). For this mitigation plan, alternative approaches had to be developed which would allow for the construction of habitat that best emulates that which would be altered. Two alternatives for the creation of small lake fish habitat were identified based on the physical characteristics of the habitats and the behaviour of the fish using the habitats for various life stage requirements.

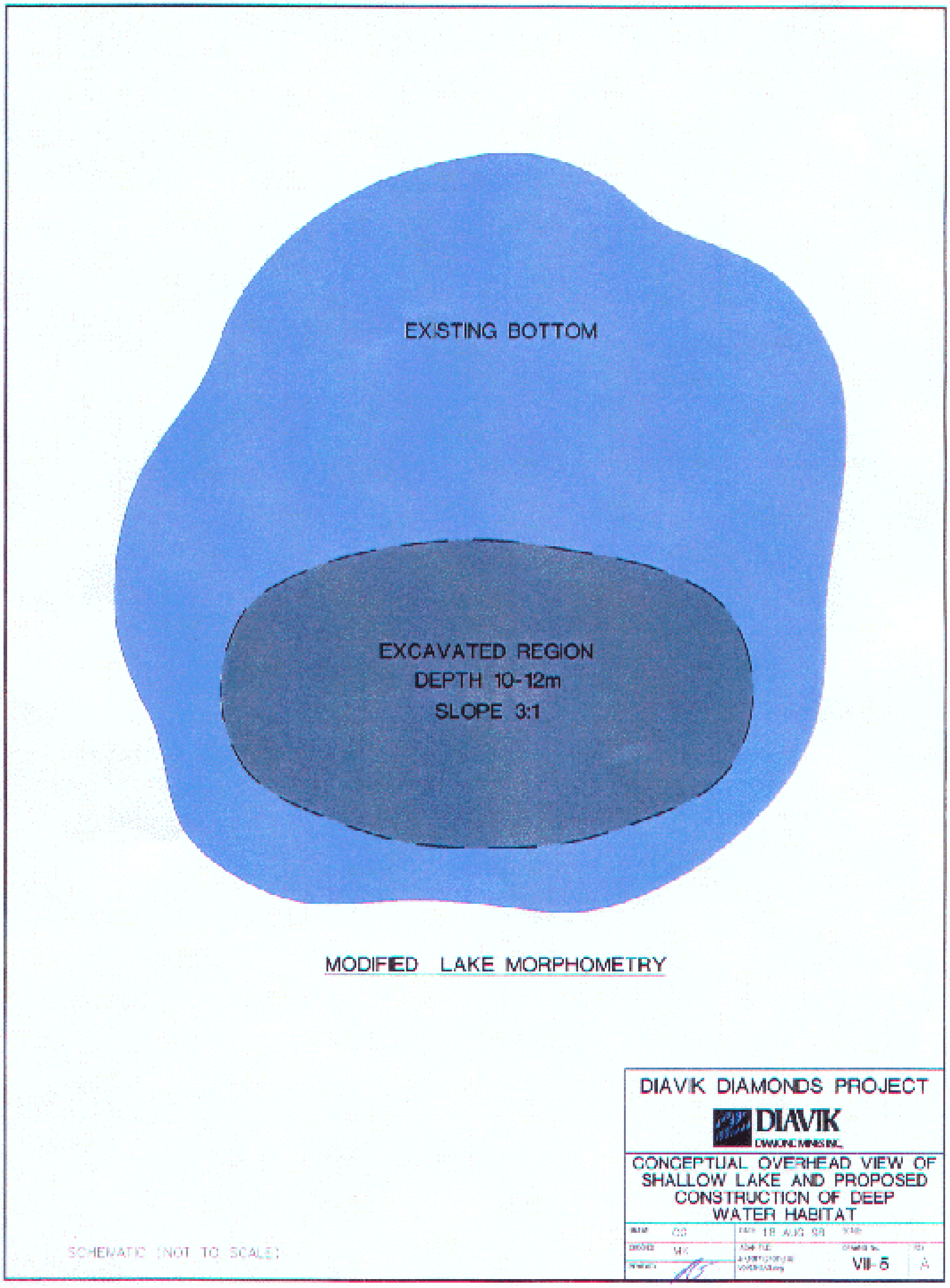
1) Creation of new small lakes by excavating existing shallow fishless lakes

Many small lakes on the east island and the mainland have no resident fish populations because of a lack of overwintering habitat. Generally, lakes with less than 4.0 m of water had no permanent fish populations. Lakes of this nature may be used by fish on a seasonal basis for rearing and foraging habitat if access through a tributary stream was possible. It was also observed that fish occasionally become isolated in small lakes and in pools within connecting streams, due to a sudden drop in streamflows after the peak in the snow melt. Fish isolated in stream pools are invariably lost as most streams become dry by early summer (Golder Associates 1997h).

One alternative to creating new small fish habitat is to improve existing shallow lakes which do not have fish populations. This can be done by creating a deep hole in the lake which would serve as overwintering habitat and allow a permanent fish community to be established (Figure VII-5). Care would have to be taken in the selection of candidate lakes for habitat improvement to prevent damaging a habitat that is used on a seasonal basis. An example of such a situation is lake m9 where several YOY and juvenile Arctic grayling were observed in the spring of 1996 (Golder Associates 1997d). No adult fish are thought to exist in this lake due to its shallow nature (<3 m) and the high probability that the lake freezes to the bottom in winter. This lake has an outlet stream (P1) which connects it to Lac de Gras. This shallow lake already provides good rearing habitat for Arctic grayling and consequently was not considered a candidate for habitat improvement. In order to prevent the destruction of existing fish habitat, the following criteria were used in the selection of candidate lakes for habitat improvement:

- The lake had to have no permanent fish population due to insufficient depth for overwintering;
- The lake had to have a poor connection or no connection to a lake with a permanent fish population to minimize the potential for seasonal habitat use; and,
- The lake had to be of sufficient size to sustain a fish population once habitat improvement was complete.

Figure VII-5 Conceptual View of Shallow Lake and Proposed Construction of Deep-water Habitat


EXISTING BOTTOM
EXCAVATED REGION
DEPTH 10-12m
SLOPE 3:1
MODIFIED LAKE MORPHOMETRY
SCHEMATIC (NOT TO SCALE)
DIAVIK DIAMONDS PROJECT
DIAVIK
CONCEPTUAL OVERHEAD VIEW OF SHALLOW LAKE AND PROPOSED CONSTRUCTION OF DEEP WATER HABITAT
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The most appropriate means of designing new small lake fish habitat which would mimic the habitat being altered is to use existing information on the physical characteristics of the small lakes within the project area as a model for construction of new habitats. By using these lakes as a model, it would provide the best chance of creating fish habitat which can be used on a permanent basis.

In choosing a lake to use as a model, the biological and physical characteristics of the lakes on the east island were considered. Table VII-4 summarizes the fish species present in lakes on the east island.

Table VII-4 Number of Fish Captured in the Small Lakes on the East Island

	Fish Species						
Lake	**Lake Trout**	**Round Whitefish**	**Cisco**	**Lake Whitefish**	**Burbot**	**Longnose Sucker**	**Lake Chub**
e3							**41**
e7						**7**	
e8					**1**[1]	**3 + 5**[1]	
e10	**2**	**22**	**25**	**12**			
e14	**1**						
e17[2]	**1**						
e11[2]	**1**						

1 = fish catch record from Acres and Bryant (1996)

2 = lakes on east island not affected by mine development

Lake e10 had the greatest diversity of fish species present (4) and the highest total number of non-cyprinid fish caught by gill netting (61). The 41 lake chub in lake e3 were caught primarily by seining with some of the larger specimens being caught by gill nets. The large number and size of the lake chub caught in lake e3 suggests that this population is not subjected to predation by piscivorous fish from Lac de Gras.

The number of fish species present in lake e10 and their numbers is indicative of the quality of the overall habitats this lake provides. Based on the fisheries sampling results and the fact that this lake is one of the lakes that would be altered due to mine development, lake e10 was chosen as the template for the construction of new small lake habitats. The physical dimensions of lake e10 are presented in Table VII-5.

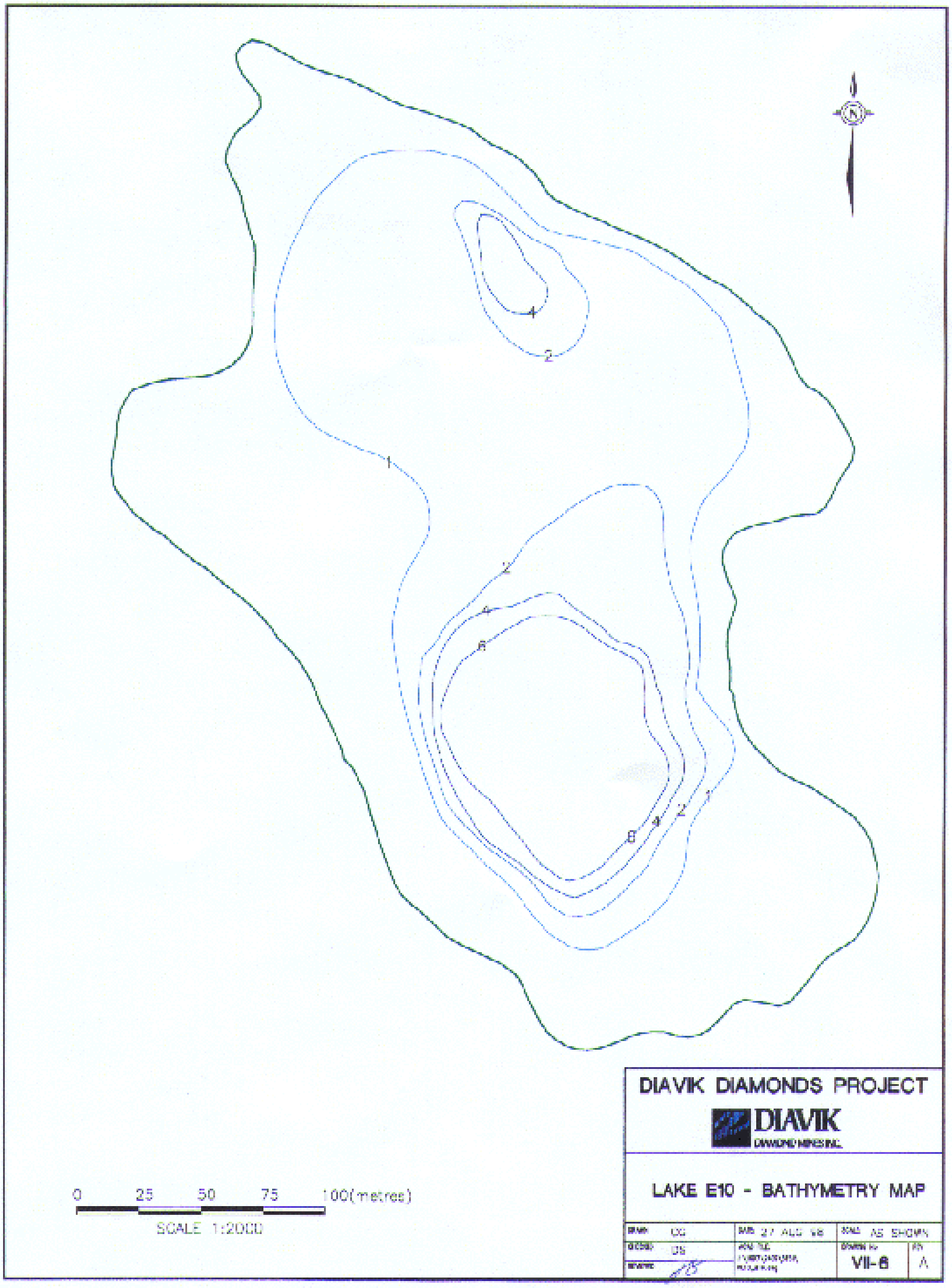
The majority of this lake's volume is found at depths above 6 m (83%) with only 17% of its volume at depths of 6 m or greater. The dimensions of lake e10 show that only a small portion of a lake need be at depths greater than 4 m to provide adequate overwintering habitat for a large number of fish. The shallow portions of the lake most likely provide the foraging, spawning, nursery and rearing habitats needed by the various life stages of each fish species.

Table VII- 5 Physical Characteristics of Lake e10

Depth Contour (m)	Surface Area (m^2)	Percentage of Lake Surface Area (%)	Volume (m^3)	Percentage of Lake Volume (%)
1	43 800	46	73 000	42
2	30 440	32	36 000	21
4	8 280	9	34 000	20
6	3 840	4	21 000	12
7.8 (maximum depth)	8 880	9	8 000	5

The shallow, fishless lake selected for habitat improvement (lake e21) would be dewatered and excavated to approximately the same dimensions as lake e10 (Figure VII-6). The deep portion of the lake would be made deeper than 8 m to allow for settling of materials from the edges of the hole. After dewatering, excavation would be performed by blasting. Residual rock is expected to line the new deep-water habitat, and it could serve as spawning habitat for hard substrate spawners (Figure VII-7). Existing shallow regions of the lake would be left intact as much as possible to preserve benthic invertebrate habitat. The fish communities from one of the lakes within the proposed Project area would be transferred to the new lake.

Figure VII-6 Bathymetric Map of Lake e10


1
2
4
6
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25
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75
100(metres)
SCALE 1:2000
DIAVIK DIAMONDS PROJECT
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LAKE E10 - BATHYMETRY MAP
CG
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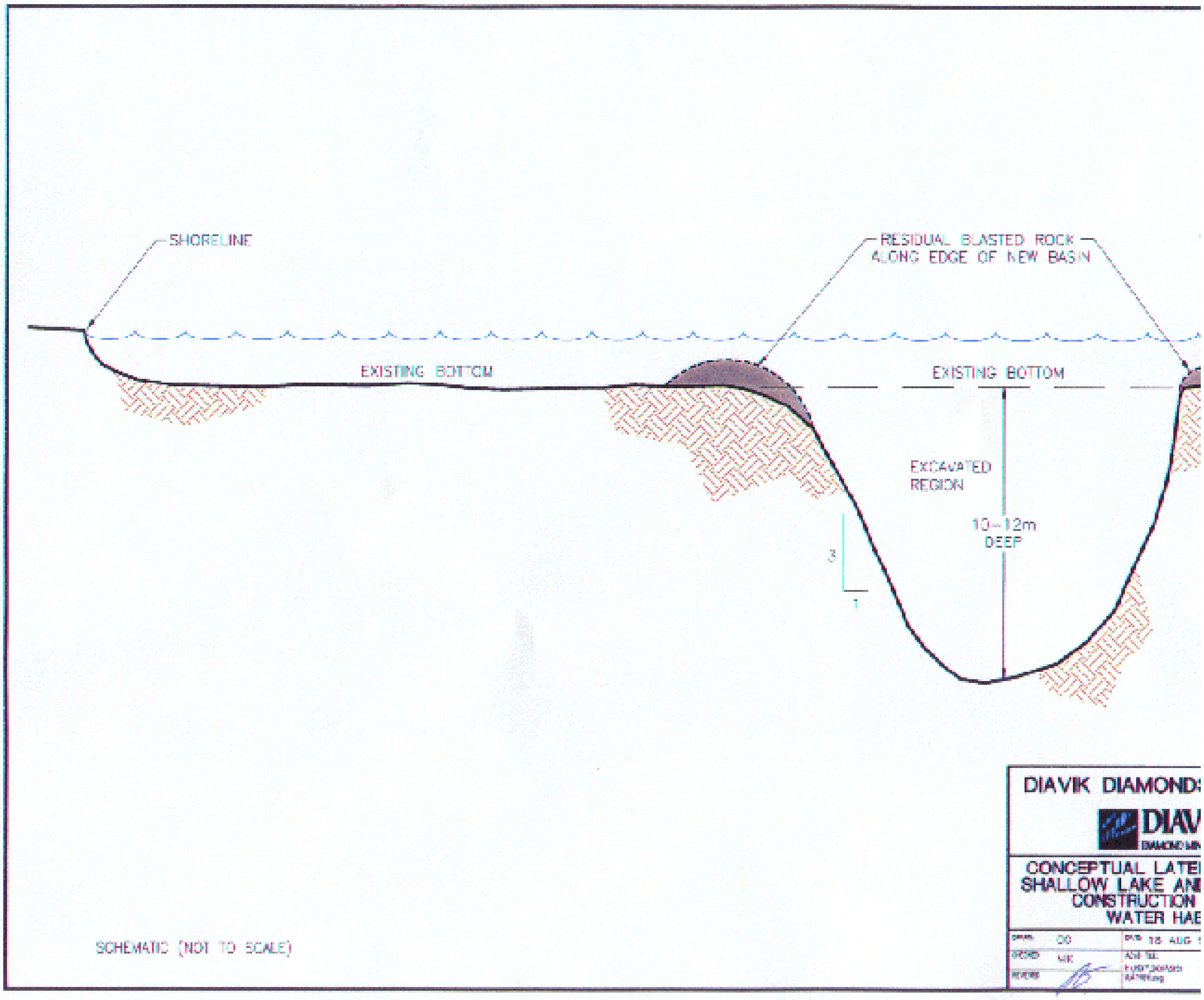
Figure VII-7 Conceptual Lateral View of Shallow Lake and Proposed Construction of Deep-water Habitat



2) Lake re-configuration to optimize habitat potential

Many of the small lakes on the mainland or east island have small or non-existent fish populations despite having sufficient depth for winter survival (Golder Associates 1997i, j). The lack of fish or a low number of small fish is most likely due to the low productivity rates of these small lakes. Productivity rates are likely the lowest in lakes composed principally of deep waters with a small littoral area.

The proportion of deep and shallow waters in a lake often dictates the quality and quantity of various habitats it can provide for native fish species. By altering these proportions, it is possible to maximize the habitat potential of a small lake. Using the dimensions of lake e10 as a template, it is proposed that fish-bearing lakes be re-configured to the dimensions of lake e10 during operations. The objective would be a deep hole occupying approximately 20% of the lake's surface area with the remaining 80% being shallow waters, less than 3 m deep. Material can be added as needed by heavy machinery and/or blasting to obtain the desired distribution of shallow and deep water.

The replacement of deep-water habitat with shallow-water habitat should have a net benefit to the productivity of the lake. The loss of deep waters should not affect the lake's overwintering capacity as long as at least 20% of the lake surface area remains after enhancement. The lakes proposed for enhancement (e11, e14 and e17) would all have a minimum of 20% of their surface area being greater than 3 m deep (lake e11-24%; lake e14-29%; lake e17-20%), once the mitigation is complete. The objective of the enhancement is to create shallow-water rearing and foraging habitat at the expense of deep-water habitat. Catches of fish were poor in these lakes (one lake trout in each lake) compared to lake e10 (see Table VII-4) where 61 fish were captured using comparable fishing efforts. It is expected that the productivity of the lakes scheduled for enhancement would increase to levels comparable to lake e10.

Proposed Mitigation Measure #1 - Excavation of Lake e21

Lake e21 on the east island is a small lake which would be drained for the duration of the operations phase (Figure VII-8). The majority of the lake is shallow, with 88% of the surface area being 2 m or less in depth. It has a small basin that reaches 3.8 m in depth but this area accounts for only 12% of the surface area. No fish were either observed or captured during the baseline inventory of lake e21 (Golder Associates 1997i). It is proposed that the deep-water basin of this lake be excavated to a depth of 6 m. This basin excavation would occur within the boundaries of the existing 1 m contour line (Figure VII-8). This would create the overwintering habitat needed for a fish populations to survive the winter. A deeper basin is not being proposed due to the lake's small size.

Since lake e21 has a poor connection to Lac de Gras, the chances of a fish population establishing itself after construction are poor. It is proposed that a fish community similar to that of lake e10 be established in lake e21 once the modifications are complete. Introduced species, therefore, would include lake trout, round whitefish, lake whitefish, and cisco.

The shallow-water areas of the lake would provide good foraging and rearing habitat. There would be more deep-water habitat, of better quality, in lake e21 than currently exists. The HSIs used to calculate the new habitat created were the same as those used to calculate quantity and quality of the altered habitat in other lakes on the east island. The total number of habitat units is 27.83.

Proposed Mitigation Measure #2 - Enhancement of Lake e11

Lake e11 would not be affected by the proposed Project. The proportions of deep-water and shallow-water habitat would be adjusted to mimic those of lake e10 (i.e., 20% deep and 80% shallow). Lake e11 presently has two large deep holes (10 and 12 m in depth) that are separated by an area of the lake that is 6-8 m in depth. The deep waters occupy well over 20% (43%) of its surface area (Figure VII-9). The existing lake volume would be reduced in size by the addition of rock to the deep water area between the two holes (Figure VII-9). This would created a larger area of shallow water which would have an average depth of 1 m in the enhanced portion. Round whitefish, cisco, and lake whitefish from lake e10 would be introduced to the lake to provide a forage base for the existing lake trout population. The total HUs of rearing and foraging habitat created would be 26.6 and 25.6 respectively. The creation of deep-water habitat HUs would be 3.6. The re-configuration should maximize the fish production potential of lake e11.

Proposed Mitigation Measure #3 - Enhancement of Lake e14

Similar to lake e11, lake e14 would not be affected by the proposed Project. Lake e14 presently has a large deep basin which occupies well over 20% of its area (Figure VII-10). The proportions of deep-water and shallow-water habitat would be adjusted to mimic the dimensions of lake e10 (i.e., 20% deep and 80% shallow). The deep waters currently occupy approximately 42% of the surface area of the lake. The existing lake volume would be reduced in size by the addition of rock to a portion of the deep water area (Figure VII-10). This would created a larger area of shallow water which would have an average depth of 1 m in the enhanced portion. Round whitefish, lake whitefish and cisco would be introduced to the lake to provide a forage base for the existing lake trout population. These fish would be taken from lake e10. The total HUs of rearing and foraging habitat created would be 20.8 and 21.7, respectively. The creation of deep-water habitat HUs would be 4.2. The re-configuration should maximize the fish production potential of lake e14.

Figure VII-8 Lake e21 Bathymetric Map Showing Enhanced Area

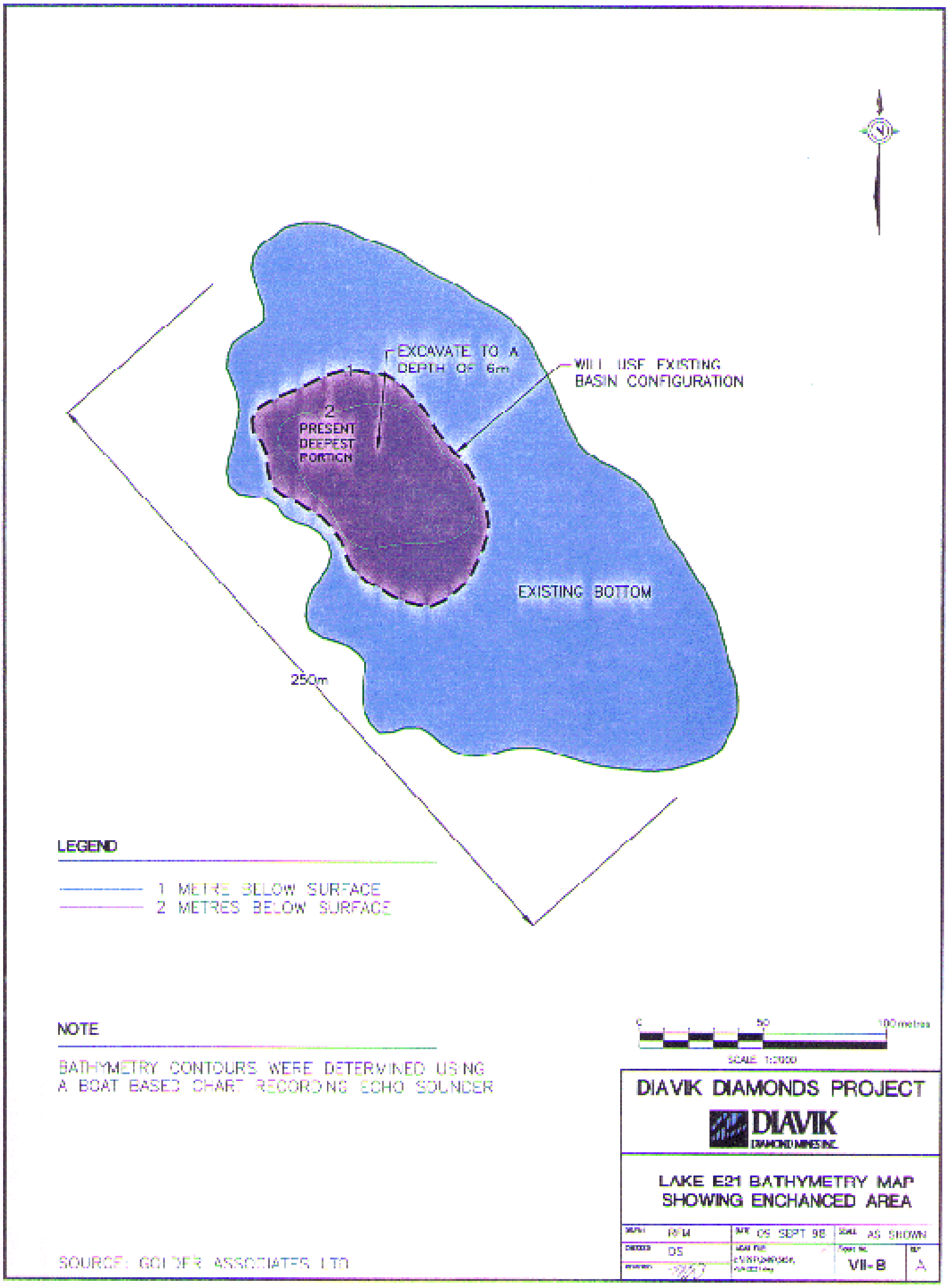

EXCAVATE TO A DEPTH OF 6m
WILL USE EXISTING BASIN CONFIGURATION
PRESENT DEEPEST PORTION
EXISTING BOTTOM
250m
LEGEND
1 METRE BELOW SURFACE
2 METRES BELOW SURFACE
NOTE
BATHYMETRY CONTOURS WERE DETERMINED USING A BOAT BASED CHART RECORDING ECHO SOUNDER
SOURCE: GOLDER ASSOCIATES LTD
SCALE 1:2000
DIAVIK DIAMONDS PROJECT
DIAVIK DIAMOND MINES INC.
LAKE E21 BATHYMETRY MAP SHOWING ENCHANCED AREA
09 SEPT 98
AS SHOWN
VII-B

Figure VII-9 Conceptual Enhanced Bathymetric Map of Lake e11

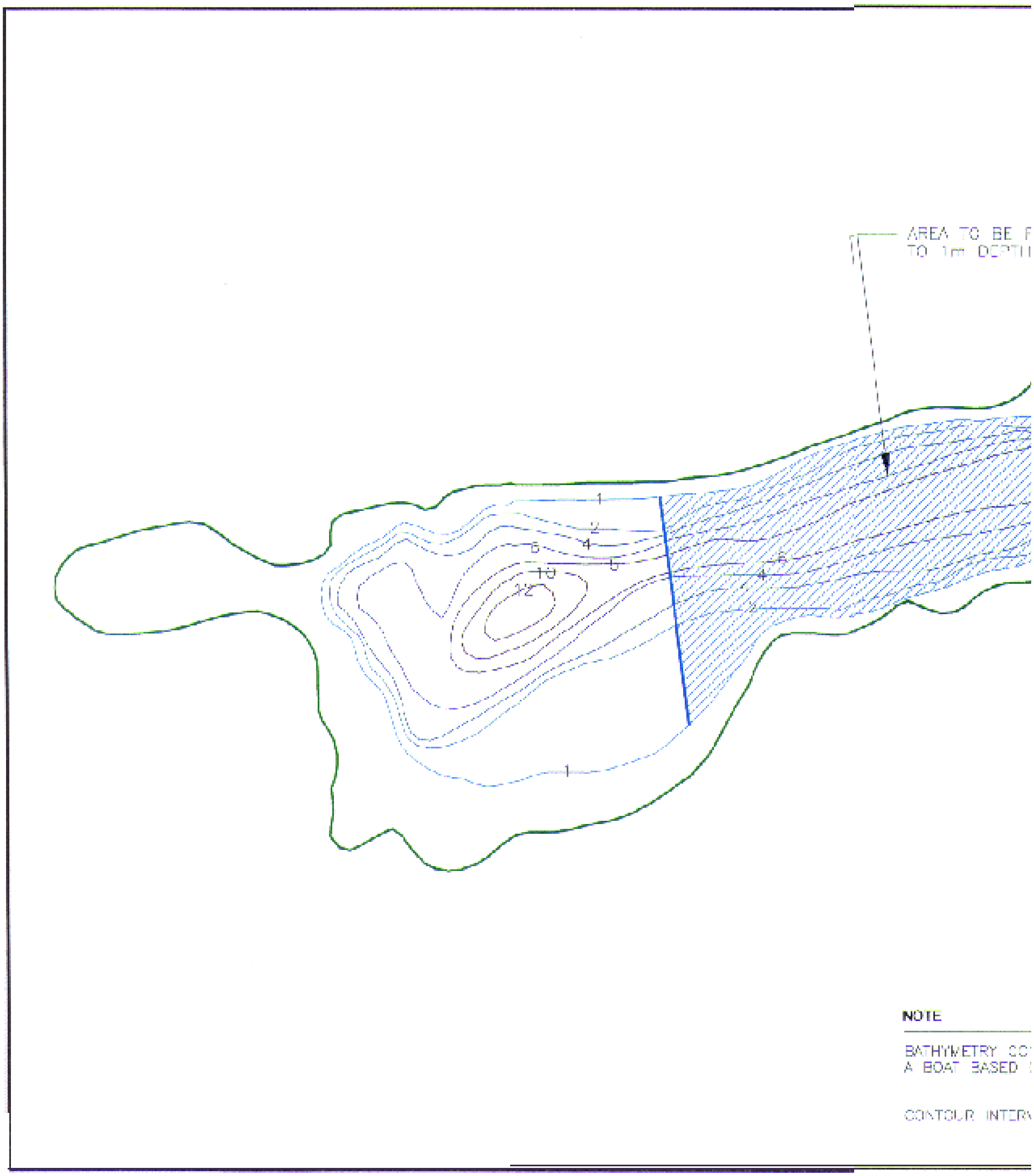

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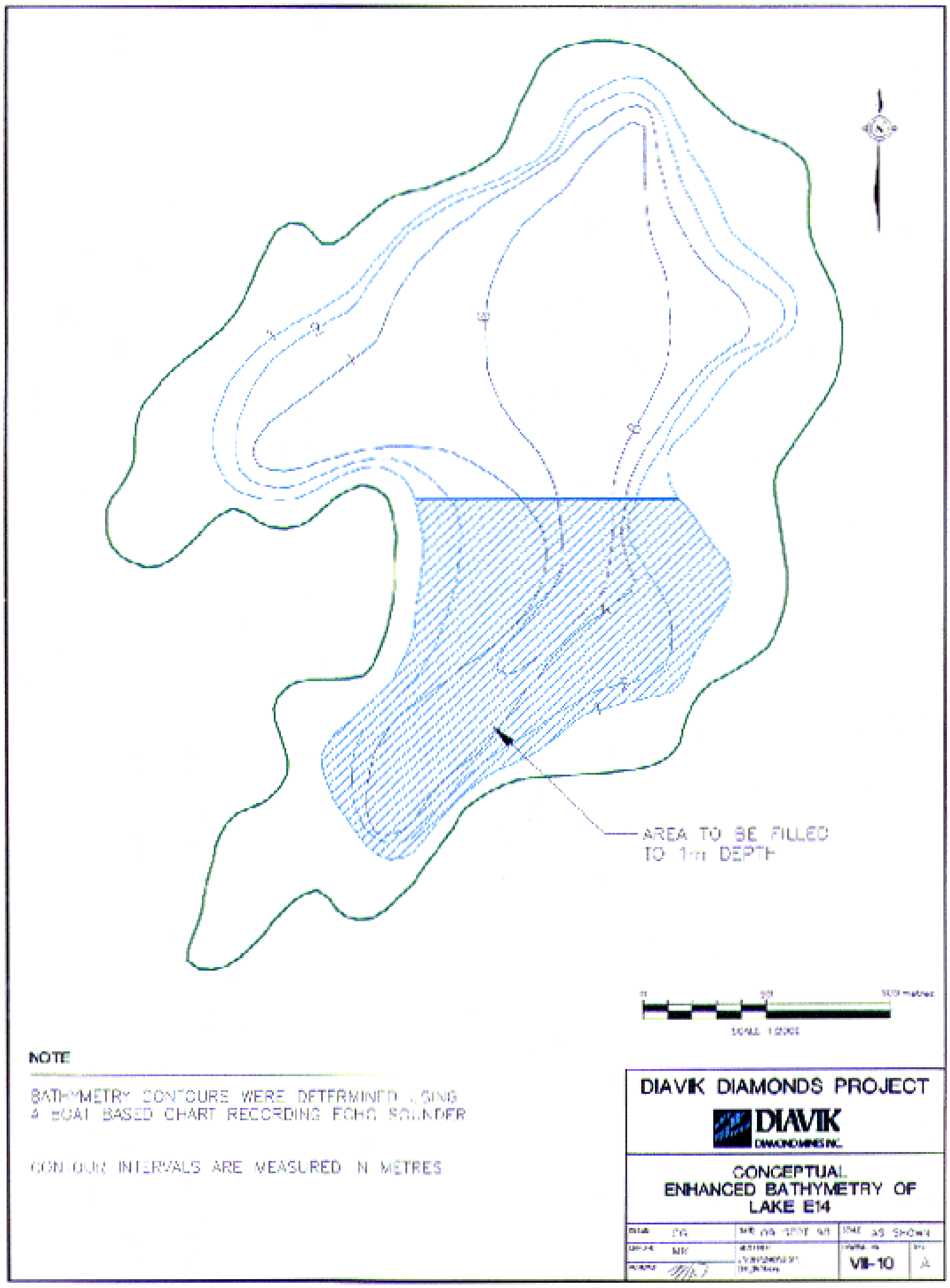
Figure VII-10 Conceptual Enhanced Bathymetric Map of Lake e14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A BOAT BASED CHART RECORDING ECHO SOUNDER
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DIAVIK DIAMONDS PROJECT
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CONCEPTUAL
ENHANCED BATHYMETRY OF
LAKE E14
AS SHOWN
VII-10
A

Proposed Mitigation Measure #3 - Enhancement of Lake e17

As with the other two lakes proposed for enhancement, the proposed Project would not affect lake e17. This lake presently has a large single hole which occupies well over 20% of its area (Figure VII-11). The proportions of deep-water and shallow-water habitat would be adjusted to mimic the dimensions of lake e10 (i.e., 20% deep and 80% shallow). The deep water section of the lake currently occupies approximately 31% of the surface area of the lake. The existing lake volume would be reduced in size by the addition of rock to a portion of the deep water area in the northwest corner of the lake (Figure VII-11). This would create a larger area of shallow water which would have an average depth of 1 m in the enhanced portion. Round whitefish, lake whitefish, and cisco would be introduced to the lake to provide a forage base for the existing lake trout population. Lake whitefish would be introduced to this lake to re-establish their presence on the east island. These fish would be taken from lake e10. Lake e17 was chosen since it is the largest lake of the three proposed for enhancement. The total HUs of rearing and foraging habitat created would be 28.6 and 27.7, respectively. The creation of deep-water habitat HUs would be 3.8. The re-configuration should maximize the fish production potential of lake e17.

Table VII-6 summarizes the surface areas of various depth contours for each lake proposed for enhancement during baseline conditions and after mitigation efforts have taken place. Table VII-7 shows the overall change in the proportion of deep water to shallow water for each lake once enhancement has taken place.

Verification of Habitat Creation Success

The success of the habitats created in lakes e11, e14, and e17 in producing fish would be verified to ensure that the small lake habitats altered on the east island have been mitigated. Monitoring surveys, consisting of non-lethal capture methods, are proposed for these lakes one and three years after completion of the habitat creation and fish transfers. More detailed description of monitoring plans are presented in Section 5 of the main body of this report.

Figure VII-11 Conceptual Enhanced Bathymetric Map of Lake e17

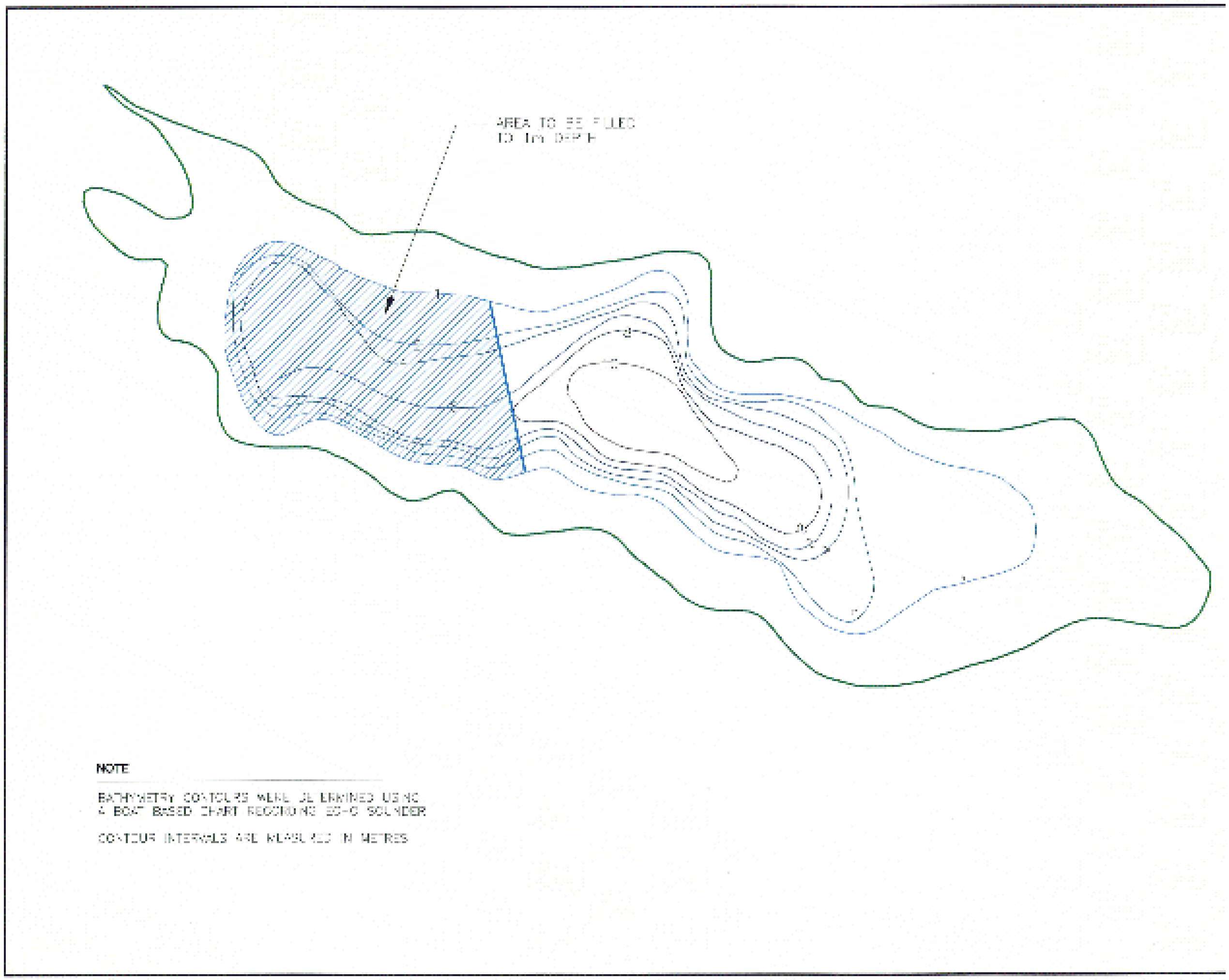

Table VII-6 Surface Areas of Bathymetric Contours for Lakes Proposed for Habitat Enhancement; Baseline and Enhanced Conditions

	Lake e10	Lake e11		Lake e14		Lake e17		
Contour Line	Area (m^2)	Baseline	Modified	Baseline	Modified (m^2)	Baseline	Modified	B

1 - modified bathymetry of lake e21 would depend on desired slope angles. Dimensions would be as shown (surface area <3 m deep = 19 704 m^2; surface area >3 m deep = 7 176 m^2).

Table VII-7 Overall Change in Surface Area of Deep and Shallow Water due to Lake Enhancement

	Lake e11		Lake e14		Lake e17		Lake e
Contour Line (m)	**Baseline (m^2)**	**Modified (m^2)**	**Baseline (m^2)**	**Modified (m^2)**	**Baseline (m^2)**	**Modified (m^2)**	**Baseline (m^2)**
Shallow Water (< 3 m deep)	40 080	54 305	32 680	40 388	53 840	62 718	25 360
Deep Water (> 3 m deep; overwintering habitat)	30 880	16 655	24 120	16 412	24 360	15 482	1 520
% of Total Surface Area > 3 m deep	44	24	43	29	31	20	6
Total Surface Area	70 960	70 960	56 800	56 800	78 200	78 200	26 880

If the small lakes are found to be devoid of fish, investigations would be undertaken to determine the cause of the failure. Alternative habitat mitigation measures would need to be identified and evaluated should this occur.

Summary

A total of four fish-bearing small lakes would be altered by the development of the mine (lakes e3, e7, e8 and e10). This habitat mitigation plan proposes the construction or enhancement of four small lake habitats, either through the re-configuration of previously unproductive lakes or the enhancement of shallow fishless lakes. The largest amount of habitat would be created by the re-configuration of lake e17, and would provide habitat for a diverse fish community. Lake e3 would be refilled at closure without enhancement and the baseline population of lake chub would be re-established. The amount of spawning, nursery, rearing and foraging habitats being gained through the habitat mitigation measures is presented in Table VII-8.

The mitigation efforts proposed in this document (i.e., restoration of lake e3, excavation of lake e21 and enhancement of lakes e11, e14 and e17) would result in creation of 197 HUs of habitat on the east island. This exceeds the total number of HUs altered (126 HUs) in lakes e3, e7, e8 and e10. The net change in habitat, therefore, would be a surplus of 71 HUs.

Table VII-8 Number of Habitat Units Created for Each Life Stage for All Fish and Life Stages in Small Lakes e3, e11, e14, e17 and e21[1]

a) Cisco

	Spawning	Nursery	Rearing	Foraging	Overwintering
HSI = 1.0	0	0	8.0	8.0	5.6
HSI = 0.75	6.0	6.0	0	0	0
HSI = 0.5	2.2	2.2	13.8	13.8	0
HSI = 0.25	0	0	0	0	0
HSI = 0.0	0	0	0	0	0
[2]**TOTAL**	**8.2**	**8.2**	**21.8**	**21.8**	**5.6**

b) Lake chub

	Spawning	Nursery	Rearing	Foraging	Overwintering
HSI = 1.0	0.1	0.1	0.5	0.5	0.3
HSI = 0.75	0	0	0.3	0.3	0
HSI = 0.5	0.2	0.2	0.2	0.2	0
HSI = 0.25	0	0	0	0	0
HSI = 0.0	0	0	0	0	0
[2]**TOTAL**	**0.3**	**0.3**	**1.1**	**1.1**	**0.3**

c) Lake trout

	Spawning	Nursery	Rearing	Foraging	Overwintering
HSI = 1.0	0	0	7.5	8.5	-2.4
HSI = 0.75	0	0	0	2.9	0
HSI = 0.5	2.5	2.5	0.4	-2.1	0

HSI = 0.25	0	0	0	0	0
HSI = 0.0	0	0	0	0	0
[2]**TOTAL**	**2.5**	**2.5**	**7.9**	**9.3**	**-2.4**

d) Lake whitefish

	Spawning	Nursery	Rearing	Foraging	Overwintering
HSI = 1.0	1.1	1.1	22.6	16.0	5.6
HSI = 0.75	5.1	5.1	0.5	5.5	0
HSI = 0.5	1.0	1.0	6.2	6.2	0
HSI = 0.25	0.6	0.6	0.7	0.7	0
HSI = 0.0	0	0	0	0	0
[2]**TOTAL**	**7.9**	**7.9**	**30.0**	**28.4**	**5.6**

e) Round whitefish

	Spawning	Nursery	Rearing	Foraging	Overwintering
HSI = 1.0	0.8	0.8	22.6	15.3	5.6
HSI = 0.75	4.9	4.9	0	6.0	0
HSI = 0.5	0	0	6.5	4.0	0
HSI = 0.25	1.3	1.3	0.7	1.8	0
HSI = 0.0	0	0	0	0	0
[2]**TOTAL**	**6.9**	**6.9**	**29.8**	**27.1**	**5.6**

1 **-** For HUs gained for lake trout in lakes e11, e14 and e17, HUs present in these lakes under baseline conditions were subtracted from the amount gained through mitigation to arrive at the values presented in the table

2 **-** HUs are in hectares indexed by quality

STREAMS

Migration corridor habitat is habitat that allows fish to access permanent or seasonal habitats outside of their immediate environment. A total of 0.12 HUs of migration corridor habitat would be altered by development of the mine. Thus, an equivalent amount of migration corridor habitat should be developed elsewhere. However, since streams on the east island do not provide spawning or rearing habitat due to the extremely short duration of flows in the streams, and no habitat of these kinds were lost, no mitigation measures are proposed. However, mitigation of migration corridor habitat losses would occur on the west island. This would also result in the creation of spawning and rearing habitat.

The outlet stream of lake w1 on the west island was evaluated to be the best opportunity to replace the east island migration corridor habitat. This lake has an outlet stream which drains into Lac de Gras. There is a small set of falls at the confluence between Lac de Gras and the stream which blocks access to the remainder of the stream. Removal of this barrier would allow fish species such as Arctic grayling to use the stream for spawning, foraging and rearing purposes.

It is proposed that this barrier be removed by the creation of step-pools. The stream channel would also be re-configured so that fish may pass into the outlet stream of lake w1. Spawning habitat would be created in the stream channel by the addition of cobble/gravel substrates. The area in question is approximately 60 m by 40 m. Streamflow is presently dispersed over and through large boulders and sand. Since the flow of this stream is relatively small, it is proposed that a single channel be constructed.

The area of migration corridor habitat created would be 0.24 ha. An HSI of 1.0 for the migration corridor habitat was applied to this area since the habitat fulfills the requirements of this habitat. This resulted in the creation of 0.24 HUs of migration corridor habitat. An additional 0.02 HUs of migration habitat would be gained through the re-establishment of streams on the east island at mine closure. The length of the stream channel that would receive cobble/gravel substrates would be approximately 40 m. The width of the channel at this point in the stream averages 4 m. An HSI of 1.0 was applied to this for use as spawning habitat. The net gain of HUs created would be 0.016 for spawning and rearing habitat. The net HUs gained for migration corridor habitat would be 0.14.

Thus, the remediation of the outlet stream of lake w1 would result in no net loss of migration corridor habitat; following mine closure on the east island, there would be a net gain of migration habitat for the Project overall. This plan would be implemented early in the construction phase.

Verification of Habitat Creation Success

The success of enhancing stream w1 from Lac de Gras to small lake w1 would be verified as to its effectiveness in creating spawning and migration corridor habitat. Habitat modifications would be implemented early in the operations phase. A spring monitoring survey, consisting of non-lethal capture of migrating fish, is proposed one year and three years after completion of the habitat modification. If the stream improvements do not result in migration of spawning fish into the stream draining lake w1, alternate mitigation measures may need to be investigated.

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APPENDIX VIII - FISH CAPTURE TECHNIQUES

In 1994 and 1995, fish were captured as part of the preliminary fish sampling program (Acres and Bryant 1996). The objective of this program was to obtain information on the fish communities of Lac de Gras, a sub-sample of the small lakes on the east island, and to collect flesh samples from these fish for trace metal analyses. In 1996, fish were captured in Lac de Gras, tributary streams, and small lakes as part of the environmental baseline sampling program (Golder Associates 1997a-e). The baseline studies included an adult fish survey, fall spawning surveys, shoreline fish sampling, stream spring spawning survey, and an small lake fish sampling survey. The objectives of each survey included:

- The identification of fish species present in the study area; and,
- The confirmation of habitat utilization and preferences.

Summer Adult Fish Survey

The 1995 summer fish collection program was conducted to obtain information on species presence and relative abundance of fish in Lac de Gras near the proposed Project site. Fish were primarily collected using gill nets composed of four 15.2-m panels with stretched mesh sizes ranging from 25 mm to 114 mm. Nets were usually left to fish for 12 to 24 hours. Trap nets were also set in numerous locations around the east and west islands. This gear proved ineffective in capturing fish from Lac de Gras.

The underlying purpose of collecting fish in Lac de Gras in 1996 was to identify habitat use by various fish species and life stages. Fish were also collected from Lac du Sauvage in 1996, an upstream lake that may potentially be used as a reference lake for monitoring purposes in the operation phase of the proposed Project (Diavik 1998). The fish collected from Lac de Gras were caught primarily within a 10 km radius of the proposed mine site. Fish were collected exclusively through the use of 1/4 standard gang gill nets (74.8-m long, consisting of five 14.9-m panels: 3.75-cm, 5-cm, 7.5-cm, 10-cm, and 12.5-cm mesh sizes). To minimize mortality of juvenile fish, the 3.75-cm mesh was removed from nets early in the survey. Electrofishing was not a viable sampling method for this study due to the very low conductivity of Lac de Gras water (about 10-20 µS/cm).

Nets were set in all available habitat types to determine habitat use by fish. Emphasis was placed on assessment of all habitat suitable for the fish species and life stages present in Lac de Gras. Typical habitat types include bare rock shorelines, shallow channels (e.g., between the east and west islands), deep water silt bottom areas, along small islands and shoals adjacent to deep water, and in long shallow inlets.

The variability of fishing results reflected the wide ranges of uses of the available habitats in Lac de Gras by the range of species present. Adult lake trout were frequently captured along rocky shorelines and small islands. Though typically a deep, cold-water fish, lake trout are not confined solely to deep areas in summer as Lac de Gras does not stratify thermally. Adult round whitefish and Arctic grayling, which are opportunistic feeders, were also caught along rocky shorelines. Juvenile cisco, round whitefish, and lake trout were often caught in shallow inlets; this suggests that these areas serve as rearing habitat in Lac de Gras. Longnose suckers were periodically captured in inshore bays with silt substrates. Deep-water areas (>10 m deep) probably serve a number of functions, including cover and foraging habitat for lake trout, foraging habitat for cisco, migration corridors for all species and overwintering habitat for all resident species. However, sampling in deep-water areas was generally unsuccessful. Information on deep-water areas is limited.

Fall Spawning Surveys

A preliminary fall spawning survey was conducted in September of 1995 (Acres and Bryant 1996). Capture techniques were the same as those used in the summer. Information on the sex ratios of fall spawning species such as lake trout and cisco was obtained although most of the lake trout spawning was missed due to inclement weather. Fish were also captured in the fall of 1994 using gill nets exclusively, for the purposes of obtaining flesh and liver samples for trace metal analyses (Acres and Bryant 1996).

Fall fish spawning surveys were conducted to identify the location of spawning habitat for three species: lake trout, round whitefish and cisco. However, unfavourable field conditions (high winds and low temperatures in late September) prevented confirmation of round whitefish and cisco spawning habitat. Utilization of spawning habitats could only be confirmed for lake trout as these fish spawn in Lac de Gras in the early part of September (Golder Associates 1997b).

Lake trout were collected from September 1-13, 1996 to establish the location and confirm usage of habitat by spawning fish. Spawning habitats in both the Intensive and Extensive Areas were surveyed by two field crews simultaneously. After arriving at each suspected spawning site, the area was visually checked to detect congregations of adult lake trout, and sounding transects were conducted. Field crews travelled the length of the shoal or shoreline while counting fish observed on a fish finder. The number of fish observed in a given time period was recorded for each shoal (fish observed/min.). If lake trout were present, the density of spawning fish was assessed by angling. Results were compared based on ease of fish capture, measured in terms of the catch-per-unit-effort (CPUE). CPUE was measured as the number of fish caught per angler per hour of effort. Gill netting was also conducted, though it was minimized to avoid unnecessary mortalities. All fish were returned to Lac de Gras after determining fish weight, length, sex (if possible), assessment of spawning condition, and collection of a non-lethal aging structure. Prior to release, all fish were tagged with a numbered floy tag. The detailed results of the survey are presented in Technical Memorandum #17 (Golder Associates 1997b). Preferred spawning habitat was found to be clean boulder shoals near deep water between depths of 2 and 6 m and fully exposed to wind and wave action.

Shoreline Fish Sampling

A small number of fish were collected in conjunction with the mapping of shorelines in Lac de Gras. Fish were collected by beach seine netting (9.4-m long, 2-m deep, 0.63-cm mesh) as part of the habitat transect assessments of shorelines. Of the 177 transects conducted, seining was possible at only 67 sites due to dangerous conditions for walking. The vast majority of fish caught under this component of the baseline fisheries program (total = 135) were caught at one site at which 126 juvenile round whitefish were captured in a single netting attempt in a shallow (<0.5 m deep), sheltered bay. Sampling results from the shoreline habitat mapping survey are presented in Technical Memoranda #14 and #15 (Golder Associates 1997c,d).

Small Lakes

Gill nets were used for the collection of fish in small lakes. Net sizes (37.4-m or 74.8-m lengths), duration of sets (between 2-4 hours), and the number of nets set per lake (1-3) varied with the size of the lake. All panels (including the 3.75-cm mesh) were always deployed in an effort to determine the presence of juvenile and forage fish. When available, nets were set at a variety of depths and habitat types. Beach seining was conducted when feasible; however, many shorelines are composed entirely of boulders making walking unsafe. All fish captured were measured for length and weight, examined for external health, and an appropriate aging structure was taken. With few exceptions, all fish captured were returned to the lake unharmed.

The type of fish captured in the small lakes on the east island was dependent on the location and habitat type. The majority of small lakes within the proposed Project site have one centrally located deep hole. Mid-lake shoals were absent except for several lakes where multiple deep areas were separated by a shallow area. Substrates below the influence of ice and wave action rapidly changed to silt. Shorelines were typically steeply sloping and composed of a mixture of boulders and bedrock outcrops. Shoreline substrates in some lakes had a thin covering of algae and silt. Fishing results in these habitats frequently yielded longnose sucker. In the overall Extensive Area, lake trout were less often caught in small lakes due possibly to the lack of habitat diversity and, being piscivorous, the sparse forage base in many lakes. Round whitefish and Arctic grayling were more frequently captured due possibly to food availability, such as algae and benthic invertebrates, on exposed rocks along shorelines. Arctic grayling were not captured in any of the lakes on the east or west islands.

Streams

Fish collection in streams was conducted in June of 1996 during the snowmelt and consequent high-water period for east island streams. Fishing was accomplished primarily with the use of gill and fyke (hoop) nets which were set in pool and riffle areas of streams flowing into Lac de Gras. In some cases, nets were stretched across the entire stream width. Captured fish were measured for weight and length, assessed for spawning condition, and released. In addition, kick sampling for Arctic grayling eggs was conducted during the habitat mapping of all streams to determine habitat use by spawning fish.

Since few data had been gathered on Arctic grayling from the Lac de Gras area in previous years, a fish health survey was performed on individuals of this species from both Lac de Gras and Lac du Sauvage. The detailed protocols for the dissections are presented in Technical Memorandum #7 (Golder Associates 1997e). The results of the stream surveys indicated that Arctic grayling used streams for spawning and rearing and for migration corridors to small lakes.

Literature Cited

Acres and Bryant Environmental Consultants Ltd. 1996. Environmental Baseline Program for Diavik Diamonds Project, Lac de Gras, NWT. 1995 Year End Report. Fisheries and Aquatic Resources. January 1996. Prepared for Diavik Diamonds Project.

Diavik. 1998. *Aquatic Effects Monitoring Program*. Prepared for Diavik Diamonds Project

Golder Associates Ltd. 1997a. Technical Memorandum #20: Spring/Summer Fish Populations and Fish Health Study, Environmental Baseline Program. Prepared for Diavik Diamonds Project.

Golder Associates Ltd. 1997b. Technical Memorandum #17: Fall Spawning Survey, Environmental Baseline Program. Prepared for Diavik Diamonds Project.

Golder Associates Ltd. 1997c. Technical Memorandum #14: Intensive Shoreline Habitat Survey, Environmental Baseline Program. Prepared for Diavik Diamonds Project.

Golder Associates Ltd. 1997d. Technical Memorandum #15: Intensive Shoreline Habitat Survey, Environmental Baseline Program. Prepared for Diavik Diamonds Project.

Golder Associates Ltd. 1997e. Technical Memorandum #07: Spring Stream Habitat and Arctic Grayling Spawning Survey, Environmental Baseline Program. Prepared for Diavik Diamonds Project.

Golder Associates Ltd. 1997f. Technical Memorandum #13: Inland Lake Survey Report, Environmental Baseline Program. Prepared for Diavik Diamonds Project.

APPENDIX IX - DELPHI QUESTIONNAIRES

Panel Members

- Mr. Ian Birtwell - DFO, Salmon Habitat Section
- Mr. Drew Bodaly - Fisheries and Oceans, Central and Arctic Region Mr. Bill Bond - Fisheries and Oceans, Central and Arctic Region
- Mr. Ken Chang-Kue - Fisheries and Oceans, Central and Arctic Region Mr. Doug Chipperzack - Fisheries and Oceans, Inuvik Ms. Maria Healy - Fisheries and Oceans, Yellowknife Dr. Jackie LaPerriere - Alaska Cooperative Fishery Unit - University of Alaska - Fairbanks Dr. Charles K. Minns - Fisheries and Oceans, Burlington Mr. Thomas G. Northcote - Elderstrand - Surnmerland, BC Mr. Jim Reist - Fisheries and Oceans, Central and Arctic Region
- Dr. Jim Reynolds - U.S. Fish and Wildlife Service - Alaska Cooperative Fishery Research Unit

Mr. Jeff Stein- Fisheries and Oceans, Central and Arctic Region Ms. Tasha Stephenson - Fisheries and Oceans, Yellowknife

Mr. Buster Welsh - Fisheries and Oceans, Central and Arctic Region

The Delphi Technique for Development of Habitat Suitability Index Curves

Introduction

This document will provide you with information on the origins and objectives of the Delphi technique for developing Suitability Index (SI) curves, a list of instruction on how to complete the questionnaires and general information on the type of habitats we will be applying the Sl curves to when completed. These Sl curves are required for defining the quality of habitat altered in relation to a mining development in the NWT. A thorough review of the literature revealed that insufficient information was available on the habitat requirements of various life stages of lake trout (Salvelinus namaycush), Arctic grayling (Thymallus arcticus), round whitefish (Prosopium cylindraceum) and cisco (Coregonus artedi) to properly assess the value of habitats types such as shoals. Through this process, in addition to the results of extensive field investigations, we wish to develop Sl curves which will allow us to define the importance of various habitat types to these four species of fish.

Information on Delphi Technique

The Delphi technique for the development of Sl curves was proposed by Crance (1987) of the U.S. Fish and Wildlife Service. This approach is suggested as an option when no or very little field data are available to support assumptions concerning the habitat requirements of a particular fish species. The SI curves developed under this scenario are termed Category I since they are based on professional judgment, with little or no empirical data. The advantage of this technique is that it allows a number of researchers, with varied experience, to participate in the development of the SI curves. Another advantage of this technique is that it allows for the incorporation of Arctic and sub-Arctic research results into the SI curves. Almost all the curves in existence were developed for fish species in southern waters, and many of the habitat criteria developed for these models simply are not relevant to an Arctic situation.

The Delphi technique is a method for systematically developing a consensus among experts. By developing a consensus, the Delphi technique precludes the necessity to choose between estimates, since the "best" estimate is arrived at by the Delphi process. The concept is based on the reasonable premises that: 1) the opinions of the experts are justified inputs to decision-making in inexact areas (i.e., where absolute answers are unknown or impossible), and 2) a consensus of experts will provide a more accurate response to a question than a single expert.

The primary characteristics of Delphi are anonymity of the experts, controlled feedback, and an estimator of group opinion. The anonymity feature is important because it helps to eliminate bias. It is an interactive process, during which at each iteration, there is an assessment of group judgment and controlled feedback to all participants in succeeding rounds.

Panelists, such as yourself, are then polled individually, by questionnaire. The panelists are queried on the habitat requirements of a life stage of a particular species, using a standard blank template. Accompanying the table is an information package that includes a summary of the general habitat features of the lake to which the Sl curves will be applied. A parallel Delphi exercise is being conducted with residents of the north who have northern experience with fish habitat use. This information will be combined with the results of this survey. A copy of the forms submitted to the local fisherman has been provided in this package for your benefit.

Once the panelists have completed the first round of SI value assessment, the results are tabulated and re-submitted to the panelists for discussion and refinement. Either the mean, median or range of values can be submitted to the panelists in the second round. The panelists are asked to answer the questions again, in light of the new information generated by the aggregate responses. If a response is outside the range from the previous round, this respondent must provide a brief explanation in support of this estimate. These explanations are then provided to all respondents in the next round. This process continues until a consensus can be reached on the Sl curves for each species. A traditional Delphi technique usually takes four to five rounds to complete. The end result of this process will be SI curves for the various species of concern that all interest groups will be able to accept.

Methods

The following are the instructions for the completion of the inquiry forms attached to this document. There are two forms to complete for each of the four fish species in question for a total of eight (Forms 1-8). Responses should be in the form of a number between 0.0 and 1.0 which best describes the relationship between large Arctic lake habitat features (if possible) and the fish species in question at each life stage.

Step 1 For each life stage or activity (i.e. spawning, incubation, larval, juvenile and adult), consider the relationship between the habitat variable and the life stage or activity component. Review the forms for each species and the two major habitat variables given (i.e. substrate and depth). Please remember that the substrate issue for this development is primarily related to open water shoals and extended shoreline areas.

Step 2 Complete the forms to the best of your ability. If there is a species with which you are unfamiliar or have not completed research on, simply place an "n/a" symbol in the box. The information provided will be used to develop the preliminary SI curves. This information will be collated and re-submitted to the panelists for review and comment. The basis of the information you provide on the forms can be from any source such as the literature (please list) or from your own personal experience. It is our experience that much of the information provided on the forms will be from the personal knowledge of the panelists gathered in the field.

Step 3 Should you feel any information is missing on the forms or that an important habitat variable or life stage has been omitted, please place your comments in the space provided below each table.

Step 4 Place the forms in the self-addressed, postage-prepaid envelop within 10 days, if possible. If you have any questions, please feel free to call me at 1-306-665-7989 or FAX a message at 1-306-665-3342. My e-mail address is rschryer@golder.com.

Summary of General Habitat Characteristics for the Proposed Project Site

The proposed Project will be located at Lac de Gras, approximately 300 km northeast of Yellowknife, Northwest Territories (NWT) (640 31' North, I 10' 20' West). The community of Kugluktuk lies about 425 km to the northwest, Bathurst Inlet is about 275 km to the northeast, and the Lupin Mine site is about 125 km to the north. BHP Diamonds Incorporated is currently establishing a diamond mine approximately 25 km north of the proposed Project site.

Lac de Gras is about 100 km north of the treeline in the central barren ground tundra of the Northwest Territories, at the headwaters of the Coppermine River. This river, which flows north to the Arctic Ocean east of Kugluktuk, is 520 km long and has a drainage area of 50,800 km^2.

The Lac de Gras area is characteristic of the northwestern Canadian Shield physiographic region, with rolling hills and relief limited to approximately 50 m. The landscape consists of relatively diffuse watersheds with numerous lakes interspersed among boulder fields, eskers and bedrock outcrops. Lac de Gras is within the continuous permafrost zone. Harsh physiographic conditions have resulted in little soil development and relatively little vegetation.

The climate is characterized by long, cold winters and short, cool summers. In the northwest, the mean annual temperature is -11^oC. Mean summer temperatures range from 4^oC to 6^oC, producing a short growing season which is enhanced by long periods of daylight. The mean winter temperature is -28^oC and the mean annual precipitation is less than 400 mm. The average wind speed at Lac de Gras is estimated to be approximately 18 km/hr. Winds from the west occur most frequently compared with the other directions, although the strongest winds are from the northwest.

Lac de Gras has numerous islands of varying size and a large number of shoals. The shoals are primarily composed of boulder with some cobble and can be located in open water or attached to shore. The depth of hard substrates rarely exceeds 6 m. Below 6 m, bottom substrates are most often a mixture of fine sand and silt. It is within a shoal/island complex where the impact of development may occur. The pertinent physical characteristics of Lac de Gras are summarized in Table 1.

Table 1 Summary of the Physical Characteristics of Lac de Gras

Lac de Gras	Surface Area		
		drainage basin	3559 km^2
		lake	637.4 km^2
	Shoreline Length		
		lake per meter	470 km
		all islands	267 km
		total	737 km
	Lake Length (see attached map)		60.5 km
	Lake Width (see attached map)		16.5 km
	Volume (approximate)		6.7 billion m^3
	Average lake depth		12 m
	Maximum lake depth		56 m
	Water Temperature		
		winter (range)	0 to 4°C
		summer (range)	4 to 18°C
		summer (average)	12°C
	Timing of Ice (approximate)		
		formation	early October
		break-up	mid July
	Elevation of the lake (above sea level)		415 m

Literature Cited

Crance, J. H. 1987. Guidelines for using the Delphi technique to develop habitat suitability index curves. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.134). 21 pp.

Round 1	Date:		Panelist		
Complete this table by filling in each column with the appropriate SI (0.0-1.0) value for each substrate type used by **round whitefish**					
Form 1	Suitability Index (0.0-1.0)				
Substrate type[1]	**Spawning**	**Incubation**	**Larvae**	**Juvenile**	**Adult**
organic matter					
mud/soft clay					
silt					
sand					
gravel					
cobble					
boulder					
bedrock					

1. Hard substrates are assumed to be clean and free of silt, algae or other materials.

Should you wish to add information concerning the habitat requirements of this species for any or all life stages, please do so in the space provided below:

Round 1	Date:		Panelist:		
Complete this table by filling in each column with the appropriate SI (0.0-1.0) value for each substrate type used by **cisco**					
Form 2	Suitability Index (0.0-1.0)				
Substrate type[1]	**Spawning**	**Incubation**	**Larvae**	**Juvenile**	**Adult**
organic matter					
mud/soft clay					
silt					
sand					
gravel					
cobble					
boulder					
bedrock					

1. Hard substrates are assumed to be clean and free of silt, algae or other materials.

Should you wish to add information concerning the habitat requirements of this species for any or all life stages, please do so in the space provided below:

Round 1	Date:		Panelist:		
Complete this table by filling in each column with the appropriate SI (0.0-1.0) value for each substrate type used by **lake trout**					
Form 3	Suitability Index (0.0-1.0)				
Substrate type[1]	**Spawning**	**Incubation**	**Larvae**	**Juvenile**	**Adult**
organic matter					
mud/soft clay					
silt					
sand					
gravel					
cobble					
boulder					
bedrock					

1. Hard substrates are assumed to be clean and free of silt, algae or other materials.

Should you wish to add information concerning the habitat requirements of this species for any or all life stages, please do so in the space provided below:

Round 1	Date:		Panelist:		
Complete this table by filling in each column with the appropriate SI (0.0-1.0) value for each substrate type used by **Arctic grayling**					
Form 4	Suitability Index (0.0-1.0)				
Substrate type[1]	**Spawning**	**Incubation**	**Larvae**	**Juvenile**	**Adult**
organic matter					
mud/soft clay					
silt					
sand					
gravel					
cobble					
boulder					
bedrock					

1. Hard substrates are assumed to be clean and free of silt, algae or other materials.

Should you wish to add information concerning the habitat requirements of this species for any or all life stages, please do so in the space provided below:

Round 1	Date:		Panelist:		
Complete this table by filling in each column with the appropriate HSI (0.0-1.0) value for each water depth used by **round whitefish**					
Form 5	Suitability Index (0.0-1.0)				
Water depth[1]	**Foraging**	**Incubation**	**Larvae**	**Juvenile**	**Adult (other than foraging)**
open water <10 m					
open water >10 m					
sheltered bay <10 m					
sheltered bay >10 m					

1. The depth of 10 m was chosen based on average water transparency measurements.

Should you wish to add information concerning the habitat requirements of this species for any or all life stages, please do so in the space provided below:

Round 1	Date:		Panelist:		
Complete this table by filling in each column with the appropriate HSI (0.0-1.0) value for each water depth used by **cisco**					
Form 6	Suitability Index (0.0-1.0)				
Water depth[1]	**Foraging**	**Incubation**	**Larvae**	**Juvenile**	**Adult (other than foraging)**
open water <10 m					
open water >10 m					
sheltered bay <10 m					
sheltered bay >10 m					

1. The depth of 10 m was chosen based on average water transparency measurements.

Should you wish to add information concerning the habitat requirements of this species for any or all life stages, please do so in the space provided below:

Round 1	Date:		Panelist:		
Complete this table by filling in each column with the appropriate HSI (0.0-1.0) value for each water depth used by **lake trout**					
Form 7	Suitability Index (0.0-1.0)				
Water depth[1]	**Foraging**	**Incubation**	**Larvae**	**Juvenile**	**Adult (other than foraging)**
open water <10 m					
open water >10 m					
sheltered bay <10 m					
sheltered bay >10 m					

1. The depth of 10 m was chosen based on average water transparency measurements.

Should you wish to add information concerning the habitat requirements of this species for any or all life stages, please do so in the space provided below:

Round 1	Date:		Panelist:		
Complete this table by filling in each column with the appropriate HSI (0.0-1.0) value for each water depth used by **Arctic grayling**					
Form 8	Suitability Index (0.0-1.0)				
Water depth[1]	**Foraging**	**Incubation**	**Larvae**	**Juvenile**	**Adult (other than foraging)**
open water <10 m					
open water >10 m					
sheltered bay <10 m					
sheltered bay >10 m					

1. The depth of 10 m was chosen based on average water transparency measurements.

Should you wish to add information concerning the habitat requirements of this species for any or all life stages, please do so in the space provided below:

DIAVIK DELPHI PROCESS: NORTHERN FISHERIES KNOWLEDGE QUESTIONNAIRES (APPENDIX IX)

Introduction

One of the traditional activities of NWT residents has always been fishing, either for subsistence, recreation or commercial reasons. As a result, a wealth of knowledge concerning the behaviour of various fish species in the north has been obtained over the years. We are seeking to incorporate fishermen's experience into the Environmental Impact Assessment (ETA) being conducted for Diavik Diamond Mines Inc. Specifically, we wish to gather infon-nation about seasonal habitat use and behaviour of four kinds of fish common to the north. The information is required to define the quality of habitat altered in relation to the development of the Diavik Diamonds Project in the NWT. The results of this exercise will be combined with results of a literature review and field studies to describe the habitat requirements of various life stages of lake trout, Arctic grayling, round whitefish and cisco, to properly assess the value of habitats types such as shoals.

You have been selected as a panelist for this questionnaire. Please read the material provided and check-off the box with the most appropriate answer. You may select more than one response for a habitat variable (e.g. substrate type). If you feel that more than one habitat type is used by fish but to different degrees, you may weight your response by grading one over the other. An example of this would be for round whitefish spawning habitat where you have observed them spawning over boulder, cobble and gravel but they seem to prefer the cobble. In this event, you may grade the importance of each habitat on a scale from 1 to 10. The habitat variable with the most importance should always receive a ranking of 10, meaning it is most important.

If you wish to provide some additional information, you are invited to write it in the space provided under each table. Should you have any questions, they can be addressed to myself or your contact at Diavik Diamond Mines Inc. Thank you for participating in this exercise. Your input will be an integral component of the fish habitat portion of the ETA process. This infon-nation will serve to provide a better understanding of the habitat requirements and behaviour of fish species in northern waters.

Glossary of Terms

In order to insure the habitat description terms being used in this questionnaire are interpreted the same by everyone, a glossary has been prepared. If you are still unclear about which kind of habitat we want information on, please feel free to contact us at any time.

Rivers

Pool: A deep hole in the river with swirling or quiet waters.

Riffle: A shallow portion of a river where the waters flows quickly over stones with a "ripple" effect. Different from rapids in that rapids are deeper and have more water passing through them.

Rapids: Fast moving waters usually over large stones. Water is often "white" due to the breaking waves.

Deep/shallow calm areas: Areas of the river that have uniform depth and flows parallel to the shore.

Lakes

Shoal: A submerged island in open water. Usually made of rocks but can be made of other materials such as sand.

Open water: Deep waters away from the shore or a shoal.

Protected bay: A quiet bay usually with a narrow opening to the rest of the lake.

A. Questions about Spawning Areas

1. Where have you seen each of these kinds of fish spawning?

Kind of fish	Lakes	Rivers
Round whitefish (frost fish, round fish)		
Cisco (tullibee, lake herring)		
Lake trout (namaycush, touladi)		
Arctic grayling (arctic trout, tittimeg)		

2. For those fish you saw spawning in rivers, what type of area were they in?

Species	Rapids	Shallow riffles	Deep calm areas	Shallow calm areas	Pools	Some other type of area
Round whitefish						
Cisco						
Lake trout						
Arctic grayling						

Can you gives us any more information about where you have seen these fish spawning in rivers?

3. For those fish you saw spawning in lakes, what type of area were they in?

Species	Along the shoreline in windy or wavy areas	Along the shoreline out of the wind and waves	Near a shoal or small island in open water	In a protected bay	In some other area
Round whitefish					
Cisco					
Lake trout					
Arctic grayling					

Can you give us any more information about where you have seen these fish spawning in lakes?

4. For any spawning you have seen, what type of river or lake bottom were the fish spawning over?

Species	Boulder (rock larger than a person's head)	Cobble (rock larger than a person's fist)	Gravel (rock larger than a person's finger tip)	Sand	Mud or muck	Some other type of bottom
Round whitefish						
Cisco						
Lake trout						
Arctic grayling						

Can you gives us any more information about the types of river or lake bottom where you have seen these fish spawning?

5. How deep was the water where the fish were spawning?

Species	Less than 30 feet (10 m)	More than 30 feet (10 m)
Round whitefish		
Cisco		
Lake trout		
Arctic grayling		

Can you gives us any more information about the water depth where you have seen these fish spawning?

B. Questions Regarding Young and Juveniles

1. Where have you see young (newly hatched) fish during the summer?

Species	Lakes	Rivers	Streams
Round whitefish			
Cisco			
Lake trout			
Arctic grayling			

Where have you seen juveniles (one or two year old fish)?

Species	Lakes	Rivers	Streams
Round whitefish			
Cisco			
Lake trout			
Arctic grayling			

2. In streams or rivers, what were the areas like where you saw the young fish?

Species	Rapids	Shallow riffles	Deep calm areas	Shallow calm areas	Pools	Some other type of area
Round whitefish						
Cisco						
Lake Trout						
Arctic grayling						

Can you gives us any more information about where you have seen these young fish in streams and rivers?

In streams or rivers, what were the areas like where you saw the juvenile fish?

Species	Rapids	Shallow riffles	Deep calm areas	Shallow calm areas	Pools	Some other type of area
Round whitefish						
Cisco						
Lake trout						
Arctic grayling						

Can you gives some more information about where you have seen juvenile fish in streams and rivers?

3. **In lakes, what were the areas like where you saw young fish?**

Species	Along the shoreline in windy or wavy areas	Along the shoreline out of the wind and waves	Near a shoal or small island in open water	In a protected bay	In some other type of area
Round whitefish					
Cisco					
Lake trout					
Arctic grayling					

Can you gives us any more information about where you have seen these young fish in lakes?

What were the areas like where you saw juvenile fish?

Species	Along the shoreline in windy or wavy areas	Along the shoreline out of the wind and waves	Near a shoal or small island in open water	In a protected bay	In some other type of area
Rounc whitefish					
Cisco					
Lake trout					
Arctic grayling					

Can you gives us any more information about where you have seen these juvenile fish in lakes?

4. **What type of river or lake bottom were the young fish found over?**

Species	Boulder (rock larger than a person's head)	Cobble (rock larger than a person's fist)	Gravel (rock larger than a person's finger tip)	Sand	Mud or muck	Some other type of bottom
Round whitefish						
Cisco						
Lake trout						
Arctic grayling						

Can you gives us any more information about the types of river or lake bottom where you have seen these young fish?

What type of river or lake bottom were the juvenile fish found over?

Species	Boulder (rock larger than a person's head)	Cobble (rock larger than a person's fist)	Gravel (rock larger than a person's finger tip)	Sand	Mud or muck	Some other type of bottom
Round whitefish						
Cisco						
Lake trout						
Arctic grayling						

Can you gives us any more information about the types of river or lake bottom where you have seen these juvenile fish?

5. **How deep was the water where the young fish were found?**

Species	Less than 3 feet (1 m)	Between 3 feet and 10 feet (1 m to about 3 m)	More than 10 feet (about 3 m)
Round whitefish			
Cisco			
Lake trout			
Arctic grayling			

Can you gives us any more information about the water depth where you have seen these young fish?

How deep was the water where the juvenile fish were found?

Species	Less than 3 feet (1 m)	Between 3 feet and 10 feet (1 m to about 3 m)	More than 10 feet (about 3 m)
Round whitefish			
Cisco			
Lake trout			
Arctic grayling			

Can you gives us any more information about the water depth where you have seen these juvenile fish?

C. Questions Regarding Adults During the Spring and Summer

1. Where have you see adults of each fish species feeding during the spring?

Species	Lakes	Rivers	Streams
Round whitefish			
Cisco			
Lake trout			
Arctic grayling			

Where have you seen adults feeding during the summer?

Species	Lakes	Rivers	Streams
Round whitefish			
Cisco			
Lake trout			
Arctic grayling			

2. In streams or rivers, what were the areas like where you saw the adults feeding during the spring?

Species	Rapids	Shallow riffles	Deep calm areas	Shallow calm areas	Pools	Some other type of area
Round whitefish						
Cisco						
Lake trout						
Arctic grayling						

Can you gives us any more information about where you have seen these adult fish feeding in streams and rivers during the spring?

In streams or rivers, what were the areas like where you saw the adults feeding during the summer?

Species	Rapids	Shallow riffles	Deep calm areas	Shallow calm areas	Pools	Some other type of area
Round whitefish						
Cisco						
Lake trout						
Arctic grayling						

Can you gives us any more information about where you have seen these adult fish feeding in streams and rivers during the summer?

3. **In lakes, what were the areas like where you saw adults feeding during the spring?**

Species	Along the shoreline in windy or wavy areas	Along the shoreline out of the wind and waves	Near a shoal or small island in open water	In a protected bay	In some other type of area
Round whitefish					
Cisco					
Lake trout					
Arctic grayling					

Can you give us any more information about where you have seen these adult fish feeding
during the Spring in lakes?

What were the areas like where you saw adults feeding during the summer?

Species	Along the shoreline in windy or wavy areas	Along the shoreline out of the wind and waves	Near a shoal or small island in open water	In a protected bay	In some other type of area
Round whitefish					
Cisco					
Lake trout					
Arctic grayling					

Can you gives us any more information about where you have seen these adult fish feeding during the summer in lakes?

4. **What type of river or lake bottom were the adults feeding over during the spring?**

Species	Boulder (rock larger than a person's head)	Cobble (rock larger than a person's fist)	Gravel (rock larger than a person's finger tip)	Sand	Mud or muck	Some other type of bottom
Round whitefish						
Cisco						
Lake trout						
Arctic grayling						

Can you gives us any more information about the types of river or lake bottom where you have seen these adult fish feeding during the spring?

What type of river or lake bottom were adults feeding over during the summer?

Species	Boulder (rock larger than a person's head)	Cobble (rock larger than a person's fist)	Gravel (rock larger than a person's finger tip)	Sand	Mud or muck	Some other type of bottom
Round whitefish						
Cisco						
Lake trout						
Arctic grayling						

Can you gives us any more information about the types of river or lake bottom where you have seen these adult fish feeding during the summer?

5. **How deep was the water where the adults were found during the spring?**

Species	Less than 3 feet (1 m)	Between 3 feet and 10 feet (1 m to about 3 m)	More than 10 feet (about 3 m)
Round whitefish			
Cisco			
Lake trout			
Arctic grayling			

Can you gives us any more information about the water depth where you have seen these adult fish feeding during the spring?

How deep was the water where the adults were found during the summer?

Species	Less than 3 feet (1 m)	Between 3 feet and 10 feet (1 m to about 3 m)	More than 10 feet (about 3 m)
Round whitefish			
Cisco			
Lake trout			
Arctic grayling			

Can you gives us any more information about the water depth where you have seen these adult fish feeding during the summer?

APPENDIX X - LITERATURE REVIEW

HABITAT REQUIREMENTS
Arctic Grayling
Thymallus arcticus

Last Modified 28-Nov-97

Life Stage		Arctic	
Spawning **(Spring)**	depth & flow	- stream that only flows in summer served as spawning area (Craig and Poulin, 1975) - spawn in depths of 15 to 91 cm (Warner 1955, Tack 1971) - spawn at depths of 10 to 40 cm and flows of 0.5 to 1.0 m/s (Stewart *et al*., 1982) - current velocities range from 0.3 to 1.5 m/s at Alaskan spawning sites (Krueger 1981) - females remain in deep pools and only enter shallows where male territories are located, for short periods, to spawn (Northcote, 1995) - average water depth over territories was 30 cm (range 18 to 73 cm) and average velocity was 0.79 m/s (range 0.34 to 1.46 m/s) (Tack, 1971)	- distribution of s stream level; w occupancy occu flow; avoided c (Beauchamp, 1 - after cruising sp females and sub 1990)

Life Stage		Arctic	
	substrate	- mostly in riffle areas of "pea-sized" gravel (Warner, 1955) - over gravel between 0.075 and 38.1 mm in diameter (Tack 1973) - vegetated silt to large rubble in Alaskan lakes; among sedges over an organic bottom (Armstrong 1986) - mud-bottomed vegetated pools below rapids (Scott and Crossman, 1973) - also spawn on lake shores (rarely) (Foothills Pipe Lines (South Yukon) Ltd., 1979) - generally spawn over rocks or gravel, but will spawn over a variety of substrates (Hatfield *et al*., 1972)	- eggs never fou[r] riffles compose - shoreline grave 1977) - spawn on stabl also observed s fines, gravel, a - important featu stability of the to the range of (Beauchamp, 1
	temperature	- spring spawners; usually move into spawning areas shortly after ice-out (temp's near 4°C) (Northcote, 1995) - spawning occurred during spring breakup of ice on rivers; migration from lakes and large rivers into small tributaries for spawning at water temperatures of 8 to 10°C (Hatfield *et al*., 1972) - spawning in Weir Creek at maximum temps of 3.9 to 16.7°C (Craig and Poulin, 1975) water temperature of 4 °C triggers spawning in Alaskan streams (Armstrong 1986)	- spawning occu during day, not - occurred betwe
Spawning	misc.	- males are territorial; no actual nest or redd is prepared, migrant spawners (Scott and Crossman, 1973) - annual stream spawners (spring) (Hubert *et al*., 1985) - most Yukon and NWT populations spawn between mid-May and mid-June; lake populations usually spawn in tributaries, but lake spawning has been recorded; outlet spawning may occur in some Alaskan lakes; reproductive homing may be involved in spawning (Northcote, 1995) - males and females appear to spawn every year after reaching maturity (de Bruyn and McCart, 1974)	- lack of refuge a driven off spaw Gustafson, 195 - proximity of re spawning grou isolation and in (Beauchamp, 1

Life Stage		Arctic	
Adults	depth & flow	- prefer <10m depth; current velocities 0.2 to 0.8 m/s (Ford *et al.*, 1995) - velocities used by adults is a function of fish size, season (summer *vs.* winter) and activity (feeding *vs.* resting) (Zakharchenko 1973) - summer discharges of 1 to 6 m^3/s; grayling entering creek as discharge dropped from spring flood of 17 m^3/s (Craig and Poulin, 1975) - in Great Slave Lake only caught to a depth of 3.05 m (Scott and Crossman, 1973)	- found in flows
	substrate	- tend to concentrate near rocky shores and around mouths of streams (Rawson, 1951) - gravel, rocks, boulders (Ford *et al.*, 1995) - no evidence to suggest substrate is important to adults (Hubert *et al.*, 1985)	- tends to be ass streams; stream sediment substı
	temperature	- can tolerate 1 to 20°C; optimal 10°C (Ford *et al.*, 1995) - stressed at 16.5 to 17.2 °C and avoided 20 °C water (Hubert *et al.*, 1985) - in Weir Creek at temps of 3.9°C to 16.7°C (Craig and Poulin, 1975)	
	feeding	- feeding behaviour quite plastic; stream debris has negative effect on feeding (O'Brien and Showalter, 1993) - visually orienting predators (Schmidt and O'Brien 1982) - streams with prolonged exposure to high turbidity became devoid of grayling populations (Northcote, 1995) - during summer, fed on a 24 hr basis and ceased feeding only during darkness later in year (Armstrong 1986)	

Life Stage		Arctic	
Adults (con't)	feeding cont'd	- aquatic and terrestrial insects including bees, wasps, grasshoppers, ants, beetles (Scott and Crossman, 1973) - may also feed more on the bottom in lakes than in streams (Armstrong 1986) - grayling are opportunistic feeders; diet is variable and includes: bottom fauna, drift, terrestrial insects, fish, fish eggs, shrews and plant material (de Bruyn and McCart, 1974) - other smaller grayling and cisco, fish eggs, lemmings, and zooplankton (Scott and Crossman, 1973) - main foods are terrestrial insects (beetles, ants, true flies), aquatic insects (caddisflies) and amphipods (*Gammarus*, *Pontoporeia*); also eat small fish, *Mysis*, snails, cladocerans (Great Slave Lake) (Rawson, 1951)	- prefer to feed i 1995)
	turbidity	- reduced feeding with increased turbidity; avoid water above 30 NTU's (Lloyd *et al.*, 1 - may move through brackish water (West *et al.*, 1992) - avoid turbid parts of Mackenzie River, but enter milky, glacial streams (Scott and Cro	
	misc.	- adults may live in lakes and migrate to inlet/outlet streams for spawning and rearing C headwaters/smaller tributaries for spawning and rearing (Ford *et al.*, 1995) - deep pools, spring fed areas in fluvial systems, and lakes are key overwintering habita aquatic habitat and severely limits fish distribution in winter (Hubert *et al.* 1985, Wes - lower lethal oxygen concentration 2.0 mg/L (Ford *et al.*, 1995)	
Juveniles	depth & flow	- prefer <50 cm depth; <0.5 m/s velocity (Ford *et al.*, 1995) - mean water column current velocity in two Alaskan streams was 0.18 and 0.21 m/s (Hubert *et al.* 1985)	

		- juvenile fish usually found in deeper water than fry (de Bruyn and McCart, 1974) - moved into spawning streams 2 to 3 wks after adult spawners had departed (Craig and Poulin 1975) - velocities used by juveniles is a function of fish size, season (summer *vs.* winter) and activity (feeding *vs.* resting) (Zakharchenko 1973)	
	substrate	- gravel, cobble, sand; boulders and adequate cover (Ford *et al*., 1995) - logs, boulders, interstices, and turbulence used for instream cover; no evidence to suggest substrate is important to juveniles (Hubert *et al*., 1985)	
	temperature	- can tolerate 2 to 24.5°C; optimal 10 to 12°C (Ford *et al*., 1995)	
Juveniles (con't)	feeding	- similar to adults, opportunistic feeders, depend heavily on benthic and terrestrial insects in the drift (Hubert *et al*., 1985)	
	turbidity	- reduced feeding with increased turbidity, 100 to 1000 mg/L (Lloyd *et al.*, 1987) - increased susceptibility to toxicants at 300 mg/L; increase plasma glucose at 50 mg/L; displacement and change in body colour at 300, 1000 mg/L (Lloyd, 1987)	
	misc.	- considerable regional variation in age of maturity, much related to differences in growth rate (Northcote 1995) - in Alaskan interior systems most grayling have matured by age 4 to 6, but not until ages 6 to 9 in North Slope watersheds (Armstrong 1986) - among age 5 fish from an interior river most fish 290 mm (FL) or longer were mature (Tack 1974) - on the North Slope, all mature grayling exceeded 295 mm, growing 40 mm/y until age 7 (Craig and Poulin 1975)	- onset of sexual Montana popul under overpopu

Fry	depth & flow	- stream that only flows in summer served as nursery area (Craig and Poulin, 1975) - fry generally occupy shallow, calm waters along stream edges, in backwaters, and side channels (de Bruyn and McCart, 1974) - depth of 30 to 50 cm and velocities <80 cm/s (Ford *et al*., 1995) - early Y-O-Y occupied a mean current velocity of 7 cm/s, while larger Y-O-Y inhabited 16 cm/s (Hubert *et al*., 1985)	- vulnerable to h ability (Northco - prefer shallow and Gould 199
	substrate	- fry emerge from gravel and remain in spawning streams throughout summer; in quiet backwaters and protected areas (Craig and Poulin 1975, Hubert *et al*., 1985) - interstitial spaces among cobble and in lee of boulders is critical to age 0 fish (Hubert *et al*., 1985)	- majority of Y-C predominantly
	temperature	- fry stage least sensitive to high temperatures (Hubert *et al*., 1985) - summer temperatures of 16.7°C in Alaskan waters where fry occur (Craig and Poulin 1975)	
Fry (con't)	feeding	- consume primarily small immature aquatic insects; mayfly and caddisfly larvae, and dipteran larvae and pupae (Hubert *et al*., 1985) - presence of interspecific competition (e.g. sticklebacks) may change food selection (*i.e*., from zooplankton with no competition to insects and benthic organisms in addition to zooplankton with competition) (Havens, 1986) - terrestrial insects become more important source of food as fry become older (Northcote, 1995) - consume mayfly nymphs, dipteran larvae and cladocerans (Hatfield *et al*., 1972)	- begin feeding a small benthic ii 1995)

	turbidity	- reduced feeding with increased turbidity (Lloyd *et al.*, 1987) or sediment levels (Reynolds *et al.*, 1989) - 6 wk exposure to sediment concentrations > 100 mg/L impaired feeding activity, reduced growth rates, caused downstream displacement, and decreased resistance to a reference toxicant (McLeay *et al.*, 1987) - survived long term (6 wk) exposure to inorganic sediment concentrations (≤ 1.0 g/L) and short term (4 day) exposure to high inorganic (≤ 250 g/L) or organic (≤ 50 g/L) sediment concentrations under otherwise optimal water quality conditions (McLeay *et al.*, 1987)	
	misc.	- presence of sticklebacks decreased fingerling survival (Havens, 1986) - increased growth rates after addition of fertilizer to an oligotrophic Alaskan tundra river (Deegan and Peterson, 1992) - reduced winter habitat can force young into areas inhabited by adults and other competitors/predators (DeCicco *et al.*, 1997) - fry tend to congregate in small, dense schools during first several weeks of life; later they become more solitary and hide between rocks in the stream bed (de Bruyn and McCart, 1974)	- back channel u older fry; sumn backwater slou (Northcote, 19
Embryo	depth & flow	- in gravel, eggs are buried to a depth of 2 to 3 cm as posterior portion of female's body forced into substrate (Armstrong 1986) - many eggs washed downstream because of this shallow depth of burial (Warner 1955) - HSI model predicts optimum current flow for embryo development as 25 to 50 cm/s, oxygenating eggs and removing metabolic waste products without dislodging eggs (Hubert *et al.*, 1985)	

	substrate	- optimal is gravel, < 20% sand (Ford *et al*., 1995) - as for other salmonids, fines pose the threat of infiltrating interstitial spaces and smothering eggs (Hubert *et al*., 1985)	- eggs most abun transition betw - 3 to 5 d post-ha develop physic and Smith 197
	temperature	- eggs hatch in 8 to 27 d at water temperatures of 2.0 to 16.1°C (Hubert *et al*., 1985) - 16 to 18 d at 9.0 °C (Northcote 1995) - can tolerate 2 to 16°C; optimal 6 to 10°C (Ford *et al*., 1995)	- require 186.24 and 175.76 deg Smith 1977)
	feeding	- emergent grayling feed principally on zooplankton, switching to larval insects (caddisflies, mayflies, dipterans) as they increase in size (McLeay et al. 1987)	- fry began feedi
	turbidity	- larvae more vulnerable to mining effluent than fry as 400 mg/L caused 50 % mortality, perhaps through abrasion and suffocation (Reynolds et al. (1989)	
	misc.	- larvae difficult to identify, described as “two eyeballs on a thread”; until ~20 mm in length when longer dorsal fin with 17 to 25 rays develops (Armstrong 1986)	

General:

- Arctic grayling are a holarctic species inhabiting waters of Siberia, and Bering Sea and Arctic Ocean drainages from Alaska to the west coast of Hudson Bay; also in headwater of Missouri River (Montana) (Hatfield *et al*., 1972)
- abundant in lakes and streams throughout the mainland NWT, absent from the Boothia Peninsula and the Arctic Islands (McCart and Beste, 1979)
- inhabits clear water streams, rivers and lakes; dependent on water that is not completely frozen in winter for overwinter survival (Hubert *et al*., 1985)
- grayling may return to same overwintering, spawning and feeding areas every year (West *et al*., 1992)
- northern Yukon Territory populations (particularly unexploited ones) are characterized by a much older age composition; some fish surviving up to 22 years

(Northcote, 1995)

- grayling in north tend to grow slower, live longer, and reach smaller maximum sizes than southern populations (Craig and Poulin, 1975)
- many northern populations have to leave their summer feeding habitats because these may freeze solid, dry up or be subject to severe frazil ice formation; suitable winter habitat is reached by refuge migrations of distances varying from a few kilometres up to 160 km (Northcote, 1995)
- the number of different habitats (e.g. spawning habitat, underyearling feeding habitat, juvenile and sub-adult to adult wintering habitats, adult and sub-adult feeding habitats) indicates the critical role that suitable space must have in controlling population size at several key periods; stock specific habitat means that good local information is essential for management or enhancement (Northcote, 1995)
- loss of spring and summer habitat due to mining considered to have a more severe effect on grayling than the direct effects of mining (Northcote, 1995)
- recruitment could be limited through density-independent events such as high river discharge during critical times of fry emergence and rearing (DeCicco *et al*. 1997)
- in northern populations, overwintering habitat may be limiting; winter stream habitat available to fish may be reduced by 95% from that found during the ice-free season (Hemming, 1997)
- Arctic grayling is a popular sports fish, but is not actively sought in commercial or subsistence fisheries (Foothills Pipe Lines (South Yukon) Ltd., 1979)

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HABITAT REQUIREMENTS
Cisco/Lake Herring
Coregonus artedii

Last Modified: 17-Jun-97

Life Stage		**Arctic**	
Spawning	depth		- commonly on i 50 m, Lk. Onta Bay, Wis. (Smi
(Fall)	substrate		- spawning subst vegetation, mos Scott and Cross
	temperature		- trigger after suc Mendota, Wis. temperature de

Life Stage		Arctic	
	turbidity		
	misc.	- major fall spawning migrations in the lower Mackenzie River; form a pattern of migration pulses, migrate after lake and broad whitefish; known pre-spawning aggregation sites (Jessop and Chang-Kue, 1993)	- spawns a week initial stages of Crossman 1973
Adults	depth	- frequently found in shallow water (Rawson 1951) - during fall migration greatest densities at 3-6 m in lower Mackenzie River (Jessop and Chang-Kue, 1993)	- forage in deepe found in large r Crossman 1973 - moving into de hypolimnion be - may be pelagic
	substrate		- inhabits primar
	temperature	- may not move to deep areas in summer in Lac de Gras due to lack of thermal stratification.	- move from shal and Crossman 1
	turbidity		
	feeding	- plankton feeders, incl. copepods, *Mysis* shrimp, and chironomids (Rawson 1951)	- mayfly nymphs water; *Mysis*, *P* & other spp. eg - benthic organis 1971b) - feeds heavily o
Juveniles	depth	- yearlings observed in schools along shorelines of shallow bays of Lac de Gras 1996.	- pelagic feeders
	substrate	- observed along boulder/cobble shorelines - Lac de Gras 1996	
	temperature	- seen in shallows during peak summer water temperatures (~10-12 °C) - Lac de Gras	
	turbidity		

Life Stage		**Arctic**	
Embryo & Fry	depth		- found in assoc. shorelines, Lk. (Faber 1970); l (Anderson & S
	substrate		- present in insho sand beyond ex similar to shore
	temperature	- optimum incubation temperature was 5.6 °C, requiring 92 degree days; 236 days at 0.5 °C (Colby and Brooke 1970)	- found along sh (Faber 1970)
	feeding		- begin to feed b unable to captu (John and Hass - algae, copepod - exclusively on
	turbidity		- no change in su of suspended s (Swenson & M

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HABITAT REQUIREMENTS
Lake Chub
Couesius plumbeus

Last Modified 09-Dec-97

Life Stage		**Arctic**	

Life Stage		**Arctic**	
Spawning **(Spring)**	depth & substrate	- if large lakes are not available in northern part of range, can successfully live in large rivers such as the Mackenzie and Yukon (Scott and Crossman 1973)	- shallow rocky (out of main cur rocks (Brown 1 - fish passed thro evidence of spa grounds (Brow - lake spawning s and rocky shore - chub also found vegetation thou
	temperature	- tuberculated, ripe males and females caught as late as August in NWT barrengrounds (Scott and Crossman 1973)	- close associatio (Ahsan 1966) - first lake chub c May; with spaw at end of May w - river spawning population; spa 1969)
	misc.		- no nest built, br Saskatchewan (
Adults	depth		- shallow water a off-shore into d between 1.8 an nets set along tl - congregate clos deepwater botto Lindsey 1970) - most commonly 1992)

Life Stage		**Arctic**	
	substrate		- LAKE -congre vegetation, not emergent veget disappearing ar - CREEK -roten bottomed rapid 1969)
Adults	temperature		
(con't)	turbidity		- caught in shallo Saskatchewan (
	feeding		- adult forms of a fry, observed su surface(Brown
	misc.		- spawning migra shoreline in 1 n - migration out o movement at da - lake chub tolera widespread nor (McPhail and L
Juveniles	depth		
	substrate		
	temperature		
	feeding		- aquatic and ter

Life Stage		Arctic	
Embryo & Fry	depth & substrate		- newly hatched area where spa water with littl fry downstrear - June 24, first fr mm) remained feeding in low - August 10, ave perch and shin vegetation; lak
	temperature		- hatching occur temperatures fl revealed natura variation simil
	feeding		- within a week at 18 mm stom *Bosmina and C*

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HABITAT REQUIREMENTS
Lake Trout
Salvelinus namaycush

Last Modified: 19-Jun-97

Life Stage		Arctic	
Spawning **(Fall)**	depth	- 2 to 5 m deep on sloping substrate, ~45° in Lac de Gras (1996)	- reports of spaw et al. 1984) - occurs largely l Ford et al. 199
	substrate	- in Lac de Gras (1996) over shoals and some extended shorelines on a mixture of large boulder and cobble; free of silt with many interstitial spaces	- observed to sel larger (Marcus - areas near steep (Marshall 1996 - clean rubble, 2. between 0.1 an 1980) - observed clean 1984)
	temperature		- preferred temp.
	turbidity		
	misc.	- intermittent spawners at high latitudes, Gt. Bear Lk. (Martin & Olver 1980), Walker Lk., Alaska (Adams 1997) - many resting adult fish captured in Lac de Gras, September 1996	- as lake trout ha very important
Adults	depth	- in shallows early in summer, deeper areas later (Wong and Willans 1973) - Lac de Gras (1996) caught along shorelines in <10 m of water - lack of summer thermocline in Lac de Gras allows utilization of shallows	- tend to remain al. 1984)

Life Stage		Arctic	
	substrate	- caught along rocky shores in early summer (Wong and Willans 1973)	- no specific sub
	temperature	- vertical distribution is random in unstratified lakes (Ford et al. 1995)	- optimal temp. = range of 8-15 °
	turbidity		- optimal when T 1995) - found to avoid in Newcombe &
Adults con't	feeding	- fish made up 90% of food items found in Gt. Slave Lk. lake trout caught in main areas of the lake (Rawson 1951); insects and benthic organisms prevalent in Gt. Bear Lk., only 44% fish (Miller & Kennedy 1947) - top predator feeding predominantly on fish; lake whitefish, lake cisco, and slimy sculpin (Johnson 1976)	- primarily pisciv food availabilit - cisco (*Coregon* 1973)
Juveniles	depth	- may remain in inshore areas for some months, even years, Gt. Bear Lk. (Scott and Crossman 1973) - 80% of trout under 500 mm taken in deeper water (Johnson 1972) - deeper, off-shore areas with soft sediments have more benthic invertebrates (chironomids), relative to nearshore rocky areas (Wong and Willans 1993)	- tend to remain
	substrate	- soft sediments as juvenile lake trout shift to larger prey items (chironomids) in their diet (McDonald *et al*. 1992)	- cobble/rubble (
	temperature		- optimal temp. = 1995)
	turbidity		- recommended r
	feeding	- YOY lake trout may be coupled to benthic food supply by the end of their first summer of life (McDonald *et al*. 1992); shifting to fish as they get larger (Martin and Olver 1980)	- primarily zoopl Olver 1980; M

Life Stage		Arctic	
Embryo & Fry	depth	- YOY lake trout utilize shallow inshore habitat to avoid predation; ice cover in winter (depth of 2 m in Toolik lake) substantially reduces the availability of nearshore refugia (McDonald *et al*. 1992)	- shallow inshore - left spawning g areas (Martin a
	substrate	- found under rocks and stones along shorelines of Gt. Bear Lk. (Miller 1947) - rocky inshore areas to avoid predation (McDonald *et al*. 1992)	- cobble/rubble (
	temperature	- August surface temperature in inshore and offshore areas used for experimental rearing was 13 °C (McDonald *et al*. 1992)	- hatching takes 2°C (Ford et al - optimal temper 1979)
	turbidity		- recommended r
	feeding	- almost exclusively invertebrate feeders, typically zooplankton and aquatic insects (Martin and Olver 1980) - availability of zooplankton to YOY lake trout, may be pivotal to their initial growth and recruitment success; primary diet item of inshore YOY was *Diaptomis probilofensis* while offshore was chironomids which, while less abundant in stomachs, are much larger in size (McDonald *et al*. 1992)	- primarily zoopl 1984)

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HABITAT REQUIREMENTS
Lake Whitefish
Coregonus clupeaformis

Last Modified: 18-Jun-97

Life Stage		**Arctic**	
Spawning	depth	- inshore areas of lakes, 1-3 m depth (Morrow 1980)	- depths 0.3-30 r
(Fall)	substrate	- spawn over rocky or gravelly bottoms (Kennedy 1953; Morrow 1980)	- in lakes over bo & Crossman 19 and rocky ledge bottoms (Ford (
	temperature		- spawn when wa Crossman 1973 1995)
	turbidity		
	misc.	- may be an intermittent spawner (Scott & Crossman 1973); high fecundity relative to other species (der Graaf & Machniak 1977)	
Adults	depth	- caught in deeper pelagic areas (Wong & Willans 1973); summer 1996 - caught in Lac du Sauvage and East Island lake 'e10'. Not captured in Lac de Gras, though may be due to netting locations.	- considered a co summer (Ayles defined schools
	substrate		- no established p

Life Stage		**Arctic**	
	temperature	- movement to hypolimnion may not be necessary in arctic lakes due to lack of stratification in summer (Scott and Crossman 1973)	- cool water hyp optimum tempe
	turbidity		- optimum turbic exposure for 1 Scherer 1974)
	feeding	- amphipods are main food in Gt. Slave Lk. (Ayles 1976); food mainly benthic, Hottah Lk., NWT (Wong & Willans 1973)	- benthic feeders (Scott & Cross
Juveniles	depth	- yearlings taken in seine net hauls along shore, Gt. Slave Lk. (Rawson 1951); found in shallow protected areas (Wong & Willans 1973)	- depth preferenc
	substrate		- gravel/cobble/b
	temperature		- optimum tempe
	turbidity		- optimum turbic
	feeding		- copepods, clad to deeper water
Embryo & Fry	depth		- eggs hatch in s & Crossman 19 ice-out in sprin
	substrate		- larvae congrega Crossman 1973 plants (Reckah
	temperature		- leave metalimn summer temp. (
	turbidity		- optimum turbic
			- plankton and b moving to deep

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HABITAT REQUIREMENTS
Longnose Sucker
Catostomus catostomus

Last Modified: 18-Jun-97

Life Stage		Arctic	
Spawning **(Spring)**	depth	- depths of 15-30 cm; velocity of 0.3-1.0 m/s or wave-swept shorelines (Edwards, 1983 - depths of 6-11 inches (152-279 mm); current of 30-45 cm/s (Scott and Crossman, 197 - usually takes place in tributary streams or in shallow parts of lakes (Hatfield *et al*., 19	
	substrate	- eggs broadcast over clean (silt-free) gravel and rocks (Edwards, 1983) - prefer gravel or rocky bottom (Hatfield *et al*., 1972) - gravel of 50-100 mm in diameter (Scott and Crossman, 1973)	
	temperature	- at 5-9°C movement starts; spawning at 10-15°C; movement related to temperature anc - enter spawning streams as soon as stream temperature reaches 5°C (Scott and Crossm - spawn from ice cover breakup in May to June 15 at water temperatures <15°C (Great Slave Lake) (Hatfield *et al*., 1972)	- spawning relate Graham, 1953)
	turbidity		
	misc.	- migrant spawners, spawn in tributaries or shallow areas of large waterbodies starting i - no nest (Edwards, 1983) - move upstream between noon and midnight; greatest numbers move in evening hours; and Crossman, 1973)	
Adults	depth	- most common at depths up to 30 m; will move inshore at night to feed or spawn; have - found in depths from 4 to 80 feet (1-24 metres) (Great Slave Lake) (Hatfield *et al*., 1972)	- reported as dee 1973)

	temperature	- prefer 10-15°C; recorded in lakes ranging from 3°C to 18.5°C (Edwards, 1983) - upper lethal temperature is 26.5°C when acclimated at 14°C or 27°C when acclimated	
	turbidity	- appears to have a high tolerance of turbidity (Hatfield *et al*., 1972)	
Adults (con't)	feeding	- usually omnivorous, consuming amphipods, benthic insects, and other invertebrates (c algae, and detritus; more 'pelagic' feeders than other suckers (Edwards, 1983) - food varies with site, season, and by size; consumption of vertebrates has not been rep (Scott and Crossman, 1973) - predominant foods include plecopterans, corixids, trichopterans, coleopterans and hymenopterans; also ate vegetation (Mackenzie River); amphipods, chironomid larvae, aquatic insects and sphaeriids (Great Slave Lake) (Hatfield *et al*., 1972) - amphipods, chironomid larvae, caddisfly larvae (and other aquatic insects), aphaeriids; also gastropods, mayfly and damselfly nymphs (Great Slave Lake) (Rawson, 1951)	- in tributary stre and Graham, 1! - amphipods, sna higher aquatic
Juveniles	depth	- frequent shallow, weedy areas; remain in subsurface; like some current (Edwards, 198	
	substrate		
	temperature		
	turbidity		
	feeding	- have not been observed feeding on bottom; start with zooplankton, shifting to larger b	- zooplankton an
Embryo & Fry	depth	- fry seek food and shelter in quite, shallow water; fry congregate in top 150 mm of wat - fry remain in gravel for 1 to 2 wks (Scott and Crossman 1973) - fry most abundant in the mouths of fast-flowing, clear, rocky streams; also in shallow pools within rapids of these streams (Mackenzie River) (Hatfield *et al*., 1972)	- cover is import vegetation (Brc - fry migration d (Hatfield *et al*.,
	substrate	- gravel, near the tail of a riffle; fry drift downstream after emerging from gravel (fry sp	

	temperature	- incubation takes 8 days at 15°C and 14 days at 12.2°C; fry assumed to tolerate fluctua (Edwards, 1983)	
	turbidity		
	feeding	- fry feed on zooplankton and diatoms (Edwards, 1983)	- feed on zoopla
	misc.	- increase in fry abundance in fall-most likely due to downstream movements prior to freeze-up (Hatfield *et al*., 1972)	- downstream mi usually at night

General:

- Longnose suckers occur in Siberia and in North America from Alaska to Labrador, south to Pennsylvania, Maryland, and the northern margin of the Mississippi River; frequents both large and small lakes and streams; tolerant of a wide range of turbidity (Hatfield *et al*., 1972)
- individuals in north are significantly smaller than those in south (Edwards, 1983)
- food supply is an important limit to growth (Edwards, 1983)
- most abundant in cold, oligotrophic lakes (34-40 m deep) (Ford *et al*., 1995)
- the longnose sucker is the most successful and widespread cypriniform in the north occurring almost everywhere in clear, cold water in moderately large numbers (Scott and Crossman, 1973)

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HABITAT REQUIREMENTS
Northern Pike
Esox lucius

Last Modified: 3-DEC-97

Life Stage		**Arctic**	
Spawning **(Spring)**	depth	- 0.05 to 70 cm (Machniak, 1975) - high spring water levels can create spawning habitat if terrestrial and wetland vegetation is flooded; depends on shoreline topography and amount of adjacent vegetation (Inskip 1982)	- < 0.25 m (Bryn - -both shallow (off of St. Lawr - greatest density (McCarraher ar - <0.5 m, observ 1950)
	substrate	- vegetation mat should provide abundant surface area for eggs to adhere to, yet allow circulation of water to remove metabolic waste and supply oxygen (Inskip 1982) - bottom is typically soft, organic and silty with decaying vegetation (Machniak 1975) but eggs falling to this type of bottom are unlikely to survive because of anoxic conditions and hydrogen sulphide (Ford *et al.* 1995) - thinly scattered vegetation would provide little, if any, shelter for eggs (Inskip 1982)	- optimal substra wind sheltered - flooded prairie flooded natural 1972) - scatter eggs ov *Potamogeton*, 1996) - eggs on vegeta *Nitell*a (Frost a

Life Stage		**Arctic**	
	temperature	- spawning migrations initiated when sufficient clearance exists between inshore ice and bottom to provide access to spawning grounds (Franklin and Smith 1963; Machniak 1975)	- entered spawni - spawn after ice 1982) - spawn at 4.4 to
	turbidity		- silt deposition (caused 97% mo survival (Hassl
	misc.	- availability of suitable spawning habitat is the factor most limiting occurrence and population size in waterbodies (Inskip 1982)	
Adults	depth	- 90% of pike captured in gill net survey of Great Slave Lake were caught within 400 m of shore and very few taken at depths > 10m (Rawson 1951)	- lakes containin which are 60 to 1977) - remain in areas in water shallov *al*. 1977) - large pike use a pike (typically
Adults (con't)	substrate	- mud and silt (coincident with vegetation) (Ford *et al*. 1995) - ambush style of feeding requires cover, typically in the form of aquatic vegetation but flooded terrestrial vegetation, shoals, drop-offs and boulders (K. Sobey pers. obs.)	
	temperature	- average max. temp. in limnetic zone of Great Bear Lake is 5 to 7 °C (Johnson 1966) and can reach 16°C in protected bays where most pike occur (Miller 1947)	- summer habitat combination of concentrations - can tolerate 0 t
	turbidity		- lakes containin TDS between 5 - significant relat water clarity in and Babaluk 19

	feeding	- omnivorous carnivore, eating any available vertebrate it can engulf; estimated that each pound increase in body weight of northern pike requires 5-6 pounds of food (Scott and Crossman 1973) - cannibalism more prevalent in waters with few fish species than where fish community is diverse (Inskip 1982)	- consumption ra and summer (m - voracious, visu primarily on fis waterfowl and s 1980)
Juveniles	depth		- may move off-s remain along sh and Crossman 1 - <2.0 m (Ford *e* - minimum size c 1979)
	substrate		- mud and silt (c - submerged veg predation and c
	temperature	- growth and survival rates depend on temperature with poor survival < 5.8°C (Inskip 1982)	- growth rate inc about 4% of the - can tolerate 5.8 - peak feeding be
	turbidity		
	feeding		- opportunistic, p suitable sized fo
	misc.		- survival to adul consecutive sur
Embryo & Fry	depth & substrate	- spawning habitat is also fry habitat (Franklin and Smith 1963) - invertebrate fauna associated with dense vegetation in the shallows is a key componen vegetation provides refuge from predators including other pike (Inskip 1982) - after hatching yolk sac fry have papillae on the top of their heads which they can attac sediments, while the yolk sac is being absorbed (Frost and Kipling 1967)	

	temperature		- tolerate 3.0 to 2 6.4°C (Ford *et* - incubation time 10°C, 9 d at 12 *al*. 1973)
	feeding		- exogenous feed and Smith 1963 - initial diet cons insect larvae an cannibalistic as 1954) - food habits of Y dominated in te (Stephanson an

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HABITAT REQUIREMENTS
Round Whitefish
Prosopium cylindraceum

Last Modified: 11-Jun-97

Life Stage		**Arctic**	

Life Stage		Arctic	
Spawning	depth		- 0.15 - 14 m (N 1984); Great L
(Fall)	substrate	- rocky areas in rivers (Harper 1948); eggs collected over diverse substrates/flow regimes, densest in gravel high current areas (Bryan & Kato 1975); eggs settle into rocks and gravel (Morrow 1980).	- gravel/rubble s exposed to pre re: spawning su - gravel and rock
	temperature		- less than 3 °C (- 4.5 °C (Scott a
	turbidity	- "moderately clear" (Harper 1948).	
	location	- inshore areas of lakes, Alaska (Morrow 1980) - rivers (Harper 1948; Alt and Kogl 1973; Bryan and Kato 1975)	- lakes (Norman along shoreline intermittent, no
Adults	depth	- infrequently captured in inshore areas, Gt. Bear Lk. (Kennedy 1949)	- captured in 8-1 Lk. Huron (Re 1975)
	substrate		- found over san
	temperature		- found mid-July
	turbidity	-	
	feeding	- opportunistic benthic feeder: larval Diptera and Trichoptera, lake trout eggs (Morrow 1980; Scott & Crossman 1973); trichopterans., chironomids, gastropods (Rawson 1951).	- opportunistic b et al. 1977); ta (Scott and Cros
Juveniles	depth	- found schooling in shallow inshore bays in Lac de Gras 1995-96.	
	substrate		
	temperature		
	turbidity		

Life Stage		Arctic	
Embryo	depth		- not seen in shal
& Fry	substrate	- stay in spawning areas 2-3 wks. post-hatch (Morrow 1980).	- remain on botto (Normandeau 1 substrates in lo Kolenosky 198
	temperature	- hatch at approx. 2 °C water temp. in spring (140 d) (Normandeau 1969).	

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HABITAT REQUIREMENTS
Slimy Sculpin
Cottus cognatus

Last Modified: 18-Jun-97

Life Stage		**Arctic**	
Spawning **(spring)**	depth	- in shallows 0-5+ m deep (Lane et al. , 1996a) - usually in shallow water (Scott and Crossman, 1973)	
		- in low to medium water column velocities (0-122 cm/s) (Ford *et al.*, 1995)	
	substrate	- shallow rocky shorelines or shoals (Scott and Crossman, 1973) - high affinity for boulder, cobble, rubble and gravel; low affinity for sand and silt (Lan	
	temperature	- surface temperatures of water during spawning usually 5-10°C (Scott and Crossman, 1	- prefer a range c

	turbidity		
	misc.	- nest builders that spawn under large rocks or logs (Scott and Crossman, 1973)	
Adults	depth	- as deep as 128 m in Lake Michigan (Scott and Crossman, 1973) - prefer deep lakes or cool rivers (Scott and Crossman, 1973) - species caught at a great range of depths (5.5-108 m) in Lake Superior (Scott and Cro -	- 0-10+ m in Gre
	substrate	- associated strongly with rubble, gravel or sand substrates (Lane et al. , 1996c) - lower affinity for boulder, cobble or silt (Lane et al. , 1996c)	- uses rocks or lo
	temperature	- considered a cool water species (Lane et al. , 1996c)	
	turbidity		
	feeding	- insect larvae (mayflies, caddisflies, dipterous larvae, stoneflies and dragonflies), crust Crossman, 1973) - preferred food items are the insect larvae making up to 85% of the diet (Scott and Cro -	
	misc.		
Juveniles	depth	- wide range of depths observed; 0-5+(Lane et al. , 1996b)	
	substrate	- use rocks or logs for cover (Lane et al. , 1996b) - preferred substrates include boulder and cobble; less affinity for gravel and sand (Lan	

	temperature	
	turbidity	
	feeding	- presumed to be same as adult diet
Larvae	depth	- eggs deposited in nest by females and then guarded by male (Scott and Crossman, 197 - guarding can last until commencement of exogenous feeding (Scott and Crossman, 19
	substrate	- nests associated with boulder/cobble substrates (Scott and Crossman, 1973, Lane et al
	temperature	- optimal temperature for egg development observed to be 8°C (Scott and Crossman, 19
	turbidity	
Larvae *(con't)*	feeding	
	misc.	

General

- usually resident in deep lakes although will occupy a wide range of depth (Scott and Crossman, 1973);
- in northern Canada also inhabit large, cool rivers (Scott and Crossman, 1973)

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APPENDIX XI - HSI MODELS

Table 1 Habitat Suitability Models Developed to Describe Arctic Grayling Habitat in Lac de Gras

	Spawning						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**	**Unsuit-able**	**Excelle nt**	**Ab A**
HSI Value	1.0	0.75	0.5	0.25	0	1.0	0
Substratum type	-	-	-	-	-	-	
Substratum size	-	-	-	-	-	-	
Min. depth	-	-	-	-	-	-	
Max. depth	-	-	-	-	-	-	
Slope of rock substratum	-	-	-	-	-	-	
Substratum shape	-	-	-	-	-	-	
Substratum cleanliness	-	-	-	-	-	-	
Depth of interstitial spaces	-	-	-	-	-	-	
Exposure to predom. wind and wave action	-	-	-	-	-	-	
Proximity to deep water areas	-	-	-	-	-	-	

Physical habitat	Excellent	Above Ave.	Average	Below Ave.		Excellent	Al A
HSI Value	1.0	0.75	0.5	0.25	-	1.0	0
Substratum type	large Bo/Co	-	sparse Bo/Co	sand/silt	-	Variable	
Substratum size	>25 cm	-	6.5-25 cm	<0.06 mm	-	n/a	
Min. depth	50 cm	-		<50 cm	-	0 m	
Max. depth	>50 cm	-		<50 cm	-	5 m	
Slope of rock substratum	n/a	-	n/a	n/a	-	n/a	
Substratum shape	angular/ round	-	angular only	fines	-	n/a	
Substratum cleanliness	Clean	-	Mod. clean	heavily silted	-	Clean	
Depth of interstitial spaces	n/a	-	n/a	n/a	-	n/a	
Exposure to predom. wind and wave action	n/a	-	n/a	n/a	-	n/a	
Proximity to deep water areas	Directly adjacent	-		Not Adjacent	-	Dir. Adjacent	

a- Be = bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm)

Table 2 Habitat Suitability Models Developed to Describe Burbot Habitat in Lac de Gras

	Spawning						
Physical habitat	Excellent	Above Ave.	Average	Below Ave.	Unsuit-able	Excellent	
HSI Value	1.0	0.75	0.5	0.25	0	1.0	
Substratum type	Bo/Co	-	G/S	-	Be/CS	Bo/Co	

Substratum size	6.5-25 cm	-	>0.2 cm	-	n/a	6.5-25 cm
Min. depth	2 m	-	5 m	-	>20 m	2 m
Max. depth	10 m	-	20 m	-	>20 m	10 m
Slope of rock substratum	10-20°	-	5-10°	-	0-5°	10-20°
Substratum shape	Angular or round	-	Angular/ round	-		Angular/ round
Substratum cleanliness	Clean	-	Mod. clean	-		Clean
Depth of interstitial spaces	1-2 mm	-	>2.0 mm	-	0.06-1 mm	1-2 mm
Exposure to predom. wind and wave action	Full exposure	-	Part. exposure	-	Sheltered	Full exposure
Proximity to deep water areas	Directly adjacent	-		-	Not adjacent	Directly adjacent
	Rearing					
Physical habitat	Excellent	Above Ave.	Average	Below Ave.		Excellent
HSI Value	1.0	0.75	0.5	0	-	1.0
Substratum type	Bo/C	-	C/G	sand/silt	-	Variable
Substratum size	6.5-25 cm	-	0.2-6.5 cm	0.06 mm-0.2 cm	-	n/a
Min. depth	0.25 m	-	1 m	>6 m	-	0 m
Max. depth	3 m	-	6 m	>6 m	-	10 m
Slope of rock substratum	0-10°	-	10-20 °	>20°	-	n/a
Substratum shape	Angular or round	-	Angular/round	Round	-	n/a

Substratum cleanliness	**Clean**	**-**	**Mod. clean**	**Silt/algae**	**-**	**n/a**
Depth of interstitial spaces	**>2 mm**	**-**	**1-2 mm**	**<1 mm**	**-**	**n/a**
Exposure to predom. wind and wave action	**Part. sheltr.**	**-**	**Part. sheltr.**	**Open**	**-**	**n/a**
Proximity to deep water areas	**Directly adjacent**	**-**		**Not adjacent**	**-**	**n/a**

a- Be = bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm)

Table 3 Habitat Suitability Models Developed to Describe Habitat for Cisco in Lac de Gras

	Spawning						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**	**Unsuit-able**	**Excellent**	
HSI Value	**1.0**	**0.75**	**0.5**	**0.25**	**0**	**1.0**	
Substratum type	**G or C or Bo**	**G or C or Bo**	**G or C or Bo**	**Bo or S**	**Be or CS**	**G or C or Bo**	**G**
Substratum size	**1 - 30 cm**	**1-30 cm**	**1-30 cm**	**>1 mm**	**<1 mm**	**1-30 cm**	**1**
Min. depth	**1.5 m**	**<3 m**	**<3 m**	**<3 m**	**<3 m**	**1.5 m**	
Max. depth	**>3 m**	**>3 m**	**1.5-3 m**	**1.5-3 m**	**1.5-3 m**	**>3 m**	
Slope of rock substratum	**20-40°**	**10-20°**	**5-10°**	**0-5°**	**0-5°**	**20-40°**	
Substratum shape	**Angular/ round**	**Angular/ round**	**Angular/ round**	**Angular/ round**	**n/a**	**Angular/ round**	**A**
Substratum cleanliness	**Clean**	**Clean**	**Some silt/algae**	**Silt/algae cover**	**n/a**	**Clean**	
Depth of interstitial spaces	**>10 cm**	**5-10 cm**	**5-10 cm**	**>1 mm**	**n/a**	**>10 cm**	**5**
Exposure to predom. wind and wave action	**Full exposure**	**Full exposure**	**>180° exposure**	**>180° exposure**	**n/a**	**Full exposure**	**e**

Proximity to deep water areas	**Directly adjacent**				**Not adjacent**	**Directly adjacent**	
	Rearing						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**		**Excellent**	
HSI Value	**1.0**	**0.75**	**0.5**	**0**	**-**	**1.0**	
Substratum type	**G/C/S**	**C/S/CS**	**C/G/S/SC**	**Bo/Co**	**-**	**n/a**	
Substratum size	**0.2 cm**	**0.2 cm**	**6.5 cm**	**<25 cm**	**-**	**n/a (pelagic)**	
Min. depth	**0.5 m**	**0.5 m**	**1 m**	**>1 m**	**-**	**1 m**	
Max. depth	**5 m**	**10 m**	**>10 m**	**>10 m**	**-**	**~10 m**	
Slope of rock substratum	**n/a**	**n/a**	**n/a**	**n/a**	**-**	**n/a**	
Substratum shape	**n/a**	**n/a**	**n/a**	**n/a**	**-**	**n/a**	
Substratum cleanliness	**n/a**	**n/a**	**n/a**	**n/a**	**-**	**n/a**	
Depth of interstitial spaces	**n/a**	**n/a**	**n/a**	**n/a**	**-**	**n/a**	
Exposure to predom. wind and wave action	**Sheltered**	**Sheltered**	**Part. sheltr.**	**Open**	**-**	**n/a**	
Proximity to deep water areas	**Directly Adjacent**			**Not Adjacent**	**-**	**n/a**	

a- Be = bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm)

Table 4 Habitat Suitability Models Developed to Describe Lake Trout Habitat in Lac de Gras

	Spawning						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**	**Unsuit-able**	**Excellent**	
HSI Value	**1.0**	**0.75**	**0.5**	**0.25**	**0**	**1.0**	

Substratum type	Bo dominant	Bo or C	Bo or C	Bo/C with G	Be or CS	Bo dominant
Substratum size	25-50 cm	6.5-25 cm	6.5-25 cm	1-30 cm	<1 cm	25-50 cm
Min. depth	2 m	2 m	1.5 m	2-3 m	2-3 m	2 m
Max. depth	>4 m	3-4 m	1.5-3 m	1.5-3 m	1.5-3 m	>4 m
Slope of rock substratum	30-50°	30-50°	15-30°	0-30°	0-30°	30/50°
Substratum shape	Angular/ fractured	Angular	Angular/ round	Angular/ round	n/a	Angular/ fractured
Substratum cleanliness	Clean	Clean	Some silt	Silt/algae covered	n/a	Clean
Depth of interstitial spaces	>30 cm	20-30 cm	10-20 cm	3-10 cm	n/a	>30 cm
Exposure to predom. wind and wave action	Full exposure	Full exposure	>180° exposure	<180° exposure	n/a	Full exposure
Proximity to deep water areas	Directly adjacent				Not adjacent	Directly adjacent
	Rearing					
Physical habitat	Excellent	Above Ave.	Average	Below Ave.		Excellent
HSI Value	1.0	0.75	0.5	0	-	1.0
Substratum type	Bo/C	C		S/CS	-	Bo/C
Substratum size	>6.5 cm	>6.5 cm	<6.5 cm	0	-	6.5-25 cm
Min. depth	n/a	n/a	Variable	Variable	-	1 m
Max. depth	<10m	<10 m	Variable	Variable	-	10 m
Slope of rock substratum	n/a	n/a	25°	0°	-	n/a
Substratum shape	Angular/ round	Angular/ round	Round	100% fines	-	Angular/ round
Substratum cleanliness	n/a	n/a	n/a	Variable	-	n/a

Depth of interstitial spaces	**n/a**	**n/a**	**n/a**	**Variable**	**-**	**n/a**
Exposure to predom. wind and wave action	**Sheltered**	**Sheltered**	**Part. Sheltr.**	**Open**	**-**	**n/a**
Proximity to deep water areas	**Directly adjacent**			**Not adjacent**	**-**	**n/a**

a- Be = bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm)

Table 5 Habitat Suitability Models Developed to Describe Lake Whitefish Habitat in Lac de Gras

	Spawning						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**	**Unsuit-able**	**Excellent**	**Ab A**
HSI Value	**1.0**	**0.75**	**0.5**	**0.25**	**0**	**1.0**	**0**
Substratum type	**C and G**	**C or G**	**Bo/C/G**	**sand/silt/ Be**	**Be/ detritus**	**C and G**	**C**
Substratum size	**0.2-6.5 cm**	**0.2-6.5 cm**	**6.5-25 cm**	**<0.2 cm**	**n/a**	**0.2-6.5 cm**	**0.2 c**
Min. depth	**1.5 m**	**1.5m**	**2 m**	**6 m**	**6 m**	**1.5 m**	**1.**
Max. depth	**5 m**	**5 m**	**6 m**	**>6**	**>6 m**	**5 m**	**5**
Slope of rock substratum	**10-40°**	**5-10°**	**5-10°**	**>0-5°**	**0°**	**10-40°**	**5-**
Substratum shape	**Angular/ round**	**Angular/ round**	**Angular/ round**	**n/a**	**n/a**	**Angular/ round**	**An ro**
Substratum cleanliness	**Clean**	**Clean**	**Mod. clean**	**algae/ heavy silt**	**n/a**	**Clean**	**C**
Depth of interstitial spaces	**2-4 cm**	**1-2 cm**	**1-2 cm**	**nil**	**nil**	**2-4 cm**	**1-2**
Exposure to predom. wind and wave action	**Full exposure**	**Full exposure**	**Partial exposure**	**Sheltered**	**Sheltered**	**Full exposure**	**F exp**

Proximity to deep water areas	**Directly adjacent**				**Not adjacent**	**Directly adjacent**	
	Rearing						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**		**Excellent**	**Al A**
HSI Value	**1.0**	**0.75**	**0.5**	**0**	**-**	**1.0**	**(**
Substratum type	**G/S/CS**	**-**	**Co/G/S/ CS**	**Bo/ Variable**	**-**	**No k**	
Substratum size	**<0.2 cm**	**-**	**0.06 mm-6.5 cm**	**0.2-25 cm**	**-**	**n/a**	
Min. depth	**<5 m**	**-**	**<5 m**	**5-10 m**	**-**	**0 m**	
Max. depth	**<10 m**	**-**	**<10 m**	**>10 m**	**-**	**10 m**	
Slope of rock substratum	**n/a**	**-**	**n/a**	**n/a**	**-**	**n/a**	
Substratum shape	**Variable**	**-**	**Variable**	**Variable**	**-**	**n/a**	
Substratum cleanliness	**n/a**	**-**	**n/a**	**n/a**	**-**	**Clean**	
Depth of interstitial spaces	**n/a**	**-**	**n/a**	**n/a**	**-**	**n/a**	
Exposure to predom. wind and wave action	**Sheltered**	**-**	**Part. sheltr.**	**Open**	**-**	**n/a**	
Proximity to deep water areas	**Directly adjacent**	**-**		**Not adjacent**	**-**	**n/a**	

a- Be = bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm)

Table 6 Habitat Suitability Models Developed to Describe Longnose Sucker Habitat in Lac de Gras

	Spawning						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**	**Unsuit-a ble**	**Excellent**	**A**

HSI Value	**1.0**	**0.75**	**0.5**	**0.25**	**0**	**1.0**	
Substratum type	-	-	-	-	-	-	
Substratum size	-	-	-	-	-	-	
Min. depth	-	-	-	-	-	-	
Max. depth	-	-	-	-	-	-	
Slope of rock substratum	-	-	-	-	-	-	
Substratum shape	-	-	-	-	-	-	
Substratum cleanliness	-	-	-	-	-	-	
Depth of interstitial spaces	-	-	-	-	-	-	
Exposure to predom. wind and wave action	-	-	-	-	-	-	
Proximity to deep water areas	-	-	-	-	-	-	
	Rearing						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**		**Excellent**	**A**
HSI Value	**1.0**	**0.75**	**0.5**	**0**	**-**	**1.0**	
Substratum type	**silt/sand/ veg**	**G/S**	**G/C**	**Be/Bo**	**-**	**silt/sand**	
Substratum size	**0.06 cm**	**0.06-0.2 cm**	**0.2-6.5 cm**	**Variable**	**-**	**0.06 mm-0.2 cm**	
Min. depth	**0.5 m**	**2.5 m**	**3 m**	**5 m**	**-**	**1 m**	
Max. depth	**0-3 m**	**3-5 m**	**5-10 m**	**>10 m**	**-**	**0-10 m**	
Slope of rock substratum	**0-10°**	**10-20°**	**Angular/ round**	**Angular/ round**	**-**	**mod. slope**	

Substratum shape	**n/a**	**n/a**	**n/a**	**n/a**	**-**	**n/a**	
Substratum cleanliness	**n/a**	**n/a**	**n/a**	**n/a**	**-**	**n/a**	
Depth of interstitial spaces	**n/a**	**n/a**	**n/a**	**n/a**	**-**	**n/a**	
Exposure to predom. wind and wave action	**n/a**	**Part. shelter**	**Part. shelter**	**Open**	**-**	**n/a**	
Proximity to deep water areas	**Not adjacent**			**Directly adjacent**	**-**	**n/a**	

a- Be = bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm)

Table 7 Habitat Suitability Models Developed to Describe Habitat for Round Whitefish in Lac de Gras

	Spawning						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**	**Unsuit-able**	**Excellent**	
HSI Value	**1.0**	**0.75**	**0.5**	**0.25**	**0**	**1.0**	
Substratum type	**G and C**	**G and C**	**Bo or C/G**	**Bo/S**	**Be or CS**	**G and C**	
Substratum size	**0.2-6.5 cm**	**0.2-6.5 cm**	**0.2-25 cm**	**0.06 mm-25 cm**	**<0.06 mm**	**0.2-6.5 cm**	
Min. depth	**4 m**	**<4 m**	**<4 m**	**<4 m**	**<4 m**	**4 m**	
Max. depth	**20 m**	**>20 m**	**>20 m**	**>20m**	**> 20 m**	**20 m**	
Slope of rock substratum	**10-25°**	**25-40°**	**<10°**	**<10°**	**<10°**	**10-25°**	
Substratum shape	**Angular/ round**	**Angular/ round**	**Angular/ round**	**Angular/ round**	**n/a**	**Angular/ round**	
Substratum cleanliness	**Clean**	**Some silt**	**Some silt**	**Silt/algae cover**	**n/a**	**Clean**	
Depth of interstitial spaces	**>5 cm**	**>5 cm**	**5 cm**	**1-5 mm**	**n/a**	**>5 cm**	

Exposure to predom. wind and wave action	**Full exposure**	**Full exposure**	**>180° exposure**	**<180° exposure**	**n/a**	**Full exposure**
Proximity to deep water areas	**Directly adjacent**				**Not adjacent**	**Directly adjacent**
	Rearing					
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**		**Excellent**
HSI Value	**1.0**	**0.75**	**0.5**	**0**	**-**	**1.0**
Substratum type	**G/S/SC**	**-**	**C/G/S/SC**	**Bo/Co**	**-**	**B/C**
Substratum size	**<0.2**	**-**	**0.2-6.5 cm**	**6.5-25 m**	**-**	**6.5-25 cm**
Min. depth	**<1 m**	**-**	**1-5 m**	**>10 m**	**-**	**0 m**
Max. depth	**3 m**	**-**	**3-10 m**	**>10 m**	**-**	**6 m**
Slope of rock substratum	**n/a**	**-**	**n/a**	**n/a**	**-**	**n/a**
Substratum shape	**n/a**	**-**	**n/a**	**n/a**	**-**	**Angular/ round**
Substratum cleanliness	**n/a**	**-**	**n/a**	**n/a**	**-**	**Clean**
Depth of interstitial spaces	**n/a**	**-**	**n/a**	**n/a**	**-**	**n/a**
Exposure to predom. wind and wave action	**Sheltered**	**-**	**Part. Sheltr.**	**Open**	**-**	**n/a**
Proximity to deep water areas	**Directly adjacent**	**-**		**Not adjacent**	**-**	**n/a**

a- Be = bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm)

Table 8 Habitat Suitability Models Developed to Describe Habitat for Slimy Sculpin in Lac de Gras

	Spawning	

	Rearing						
Physical habitat	**Excellent**	**Above Ave.**	**Average**	**Below Ave.**		**Excellent**	**A**
HSI Value	**1.0**	**0.75**	**0.5**	**0**	**-**	**1.0**	
Substratum type	**Bo/Co**	**-**	**G**	**S/silt/Be**	**-**	**G/S**	
Substratum size	**-**	**-**	**-**	**-**	**-**	**-**	
Min. depth	**0 m**	**-**	**0 m**	**>6 m**	**-**	**6 m**	
Max. depth	**6 m**	**-**	**6 m**	**>6**	**-**	**60 m**	
Slope of rock substratum	**n/a**	**-**	**n/a**	**n/a**	**-**	**n/a**	
Substratum shape	**n/a**	**-**	**n/a**	**n/a**	**-**	**n/a**	
Substratum cleanliness	**Clean**	**-**	**Some silt**	**Embedd-ed**	**-**	**n/a**	
Depth of interstitial spaces	**n/a**	**-**	**n/a**	**n/a**	**-**	**n/a**	
Exposure to predom. wind and wave action	**n/a**	**-**	**n/a**	**n/a**	**-**	**n/a**	
Proximity to deep water areas	**n/a**	**-**	**n/a**	**n/a**	**-**	**n/a**	

a- Be = bedrock, Bo = boulder (>25 cm), C = cobble (>6.5 cm), G = gravel (>0.2 cm), S = sand (>0.06 mm) and CS = clay/silt (<0.06 mm)

Endnotes

1 (Popup - Disclaimer A)

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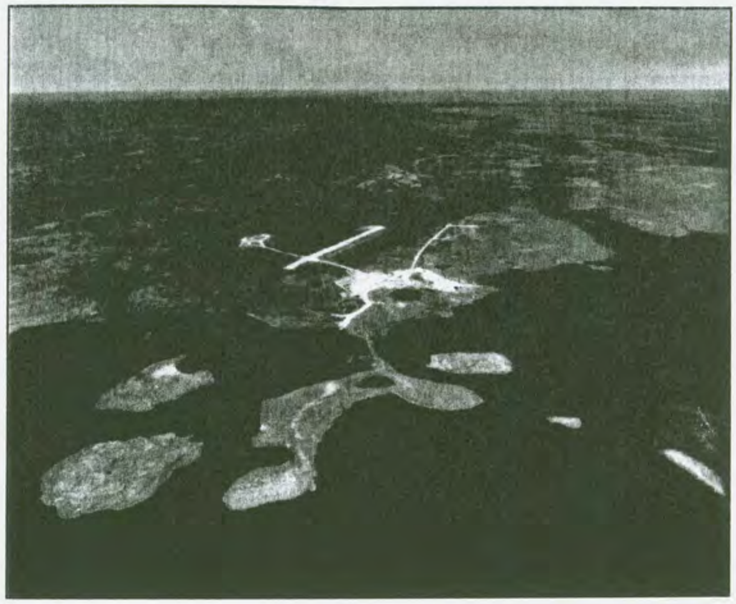
4.2.2



ADDENDUM TO THE DIAVIK DIAMOND MINES "NO NET LOSS" PLAN

Diavik Diamonds Project

DIAVIK
DIAMOND MINES INC.

April, 1999

DFO RCVD APRIL 12/99.

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In September, 1998 Diavik Diamond Mines Inc. (Diavik) submitted a Plan for achieving the Department of Fisheries and Oceans' (DFO) principle of "No Net Loss" of the productive capacity of fish habitat while developing the Diavik Diamonds Project at Lac de Gras (Diavik 1998). Subsequently, the Plan was adapted to conform with DFO's Defensible Methods approach, in consultation with DFO. Defensible Methods is a technique that is under development by DFO to assist in calculating the net change of productivity of fish habitats (Minns 1995).

This report is an addendum to the "No Net Loss" Plan of August, 1998 that reformats the original calculations presented in the Plan to follow the Defensible Methods approach. Also included in this addendum are responses to specific questions raised by DFO in their reviews of the Plan.

1. ASSUMPTIONS FOR NET CHANGE, LAC DE GRAS AND INLAND LAKES

Initially, adaptation of the Plan to follow the Defensible Methods approach was carried out for information from Lac de Gras. This procedure, that was developed in consultation with DFO, is summarized below. DFO has subsequently requested information on how the Defensible Methods approach would be applied to the inland lakes. Following is a review of the procedure used for Lac de Gras, and the procedure to be used for the inland lakes.

Approach for Lac de Gras

The protocol that was followed in the development of species weightings for Lac de Gras included consideration of the relative importance of the fauna in terms of fish exploitation activities in the Northwest Territories. Domestic/commercial species were given a weighting of exploitation importance of 0.4 as a group, sport species were given a weighting of 0.4 as a group and forage species were given a weighting of 0.2 as a group. Six domestic/commercial species are present in Lac de Gras, which results in an individual weighting of 0.07 for each such species. Five species are considered to be sport species, which results in a weighting of 0.08 for each of these species. The two forage species in Lac de Gras were each given a weighting of 0.1. The weights that were assigned on the basis of exploitation importance are shown in Table 1.1.

The species codes, common and scientific names of fish species discussed in this report are presented in Table 1.2.

Table 1.1 Summary of Abundance, Exploitation and Mean Weightings Used for Species in Lac de Gras

Species	Exploitation Weightings	Abundance Weightings	Mean Weightings
LKTR	0.15	0.44	0.29
BURB	0.07	0.004	0.04
NRPK	0.15	0.0	0.07
CISC	0.15	0.42	0.28
RNWH	0.07	0.1	0.09
LKWF	0.15	0.0	0.07
ARGR	0.08	0.004	0.04
LNSC	0.1	0.035	0.07
SLSC	0.1	0.0	0.05

Table 1.2 Species Codes, Common Names and Scientific Names of Fishes Discussed in this Report

Species	Common Name	Scientific Name
LKTR	lake trout	*Salvelinus namaycush*
BURB	burbot	*Lota lota*
NRPK	northern pike	Esox lucius
CISC	cisco	*Coregonus artedi*
RNWH	round whitefish	*Prosopium cylindraceum*
LKWF	lake whitefish	*Coregonus clupeaformis*
ARGR	Arctic grayling	*Thymallus arcticus*
LNSC	longnose sucker	*Catostomus catostomus*
SLSC	slimy sculpin	*Cottus cognatus*
LKCH	lake chub	*Couesius plumbeus*

As weightings on the basis of exploitation alone do not account for ecological relationships, weightings were also developed to reflect the relative abundance of fishes in Lac de Gras. The catch-per-unit-effort results from sampling in 1996 were normalized and used to incorporate abundance information in the weighting scheme. This resulted in the species weightings presented in Table 1.1.

The final weightings developed for the fauna of Lac de Gras, that were developed in consultation with DFO (K. Minns, per. comm.), were the mean of the exploitation and abundance weightings. The final weightings for fish in Lac de Gras are presented in Table 1.1.

In the Defensible Methods approach, weightings are also given to the various life stages present. It is generally accepted that rearing is the most limiting habitat type in Lac de Gras. In the development of life stage weightings, spawning, nursery and foraging were each given a weighting of 0.2, while rearing was given a weighting of 0.4. The results of applying these weightings to the habitat in Lac de Gras that would be affected by the Diavik Diamonds Project are summarized in tabular format in Section 5 of this addendum.

Approach for Inland Lakes

The weightings developed for the fish populations of Lac de Gras are not directly transferable to the inland lakes. While the exploitation information would be applicable, the relative abundance information would not, as the kinds and relative abundance of fish populations in the inland lakes are variable. Additionally, the sampling effort expended on the inland lakes was not as comprehensive as the effort expended on Lac de Gras. Therefore, the approach used to develop weightings for the inland lakes was to calculate the mean of the exploitation weighting and the relative abundance weighting from the combined results from the 1996 baseline surveys. This results in the following weightings for species found in the inland lakes (Table 1.3).

Table 1.3 Summary of Abundance, Exploitation and Mean Weighting Used for Species in the Inland Lakes

Species	Average CPUE	Abundance Weightings	Exploitation Weightings	Mean Weightings	Normalized Weightings
LKCH	0.03	0.01	0.1	0.06	0.06
BURB	0.03	0.01	0.07	0.04	0.05
CISC	0.68	0.29	0.15	0.22	0.25
LKTR	0.25	0.11	0.15	0.13	0.14
LKWH	0.33	0.14	0.15	0.15	0.16
LNSC	0.41	0.18	0.1	0.14	0.15
RNWH	0.60	0.26	0.07	0.16	0.18

The bathymetry of each inland lake was examined to determine appropriate life stage weightings. In addition to the four life stages considered in Lac de Gras (spawning, nursery, rearing and foraging), overwintering was also considered for the inland lakes. Whereas overwintering habitat is abundant in Lac de Gras, overwintering habitat is one of the most limiting habitat types in the inland lakes. Lake e10 was used as a template for overwintering habitat against which other lakes were compared. The amount of overwintering habitat in lake e10 was approximately 20% of the lake's surface area. The life stage weighting protocol for each of the inland lakes included in this analysis is presented in Table 1.4.

Table 1.4 Life Stage Weightings for the Inland Lakes Either Directly Altered by Mine Development or Used for Habitat Mitigation Efforts

Lake	Species	Spawning	Nursery	Foraging	Rearing	Overwintering
E3	LKCH	0.2	0.2	0.2	0.2	0.2
E7	LNSC	0.2	0.2	0.2	0.2	0.2
E8	LNSC	0.24	0.19	0.19	0.19	0.19
	BURB	0.24	0.19	0.19	0.19	0.19
E10	CISC	0.2	0.2	0.2	0.2	0.2
	LKWH	0.2	0.2	0.2	0.2	0.2
	RNWH	0.2	0.2	0.2	0.2	0.2
	LKTR	0.2	0.2	0.2	0.2	0.2
E11	LKTR	0.19	0.19	0.19	0.24	0.19
E14	LKTR	0.19	0.19	0.19	0.24	0.19
E17	LKTR	0.19	0.19	0.19	0.24	0.19

2. SUMMARY OVERVIEW OF WEIGHTED SUITABLE AREAS AND HABITAT UNITS, INLAND LAKES

Predicted habitat losses and gains in the inland lakes on the east island have be recalculated using the weighting factors presented in Section 1. Habitat units based on weighted suitable areas (WSAs) were calculated for all fish species found in the east island lakes during the environmental baseline study. All life stages were accounted for, including spawning, nursery, foraging, rearing and overwintering. The tables used to complete the WSA/HU calculations are presented below (Tables 2.1-2.11). A separate table is presented describing the weighted habitat units for each lake on the east island that will be lost, as well as lakes that will be used for mitigation. A summary of the overall results for all lakes is presented in Table 2.10.

Table 2.11 is an additional summary table that removes the habitat gained in lakes e3 and e21 as a result of mitigation efforts. During the analysis of potential impacts resulting from the proposed project, it was estimated that at reclamation the potential could exist for surface runoff to lakes e3 and e21 to have metal and phosphorous concentrations that are greater than the surface water quality thresholds for the protection of the aquatic life (see Section 10). Surface runoff to lakes e3 and e21 would be monitored, and not reclaimed as fish habitat if this prediction is validated. However, it is apparent from Table 2.11 that no net loss of inland lake habitat would still be achieved if these lakes were not reclaimed as fish habitat in the post-closure phase of the project.

This group of tables (Tables 2.1-2.11) showing weighted suitable area calculations for the inland lakes replaces Table 4-4 in the August (1998) No Net Loss Plan.

Table 2.1 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake E3

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted*	No Weighting	Weighted*	Weighted
Spawning 0.2	LKCH	0.06	0.33	0.00	0.33	0.00	0.00
Rearing 0.2	LKCH	0.06	1.09	0.01	1.09	0.01	0.00
Foraging 0.2	LKCH	0.06	1.09	0.01	1.09	0.01	0.00
Nursery 0.2	LKCH	0.06	0.33	0.00	0.33	0.00	0.00
Overwintering 0.2	LKCH	0.06	0.29	0.00	0.29	0.00	0.00
Total			3.11	0.04	3.11	0.04	0.00
Total by life stage	Spawning		0.33	0.00	0.33	0.00	0.00
	Rearing		1.09	0.01	1.09	0.01	0.00
	Foraging		1.09	0.01	1.09	0.01	0.00
	Nursery		0.33	0.00	0.33	0.00	0.00
	Overwintering		0.29	0.00	0.29	0.00	0.00
Total by species	LKCH		3.11	0.04	3.11	0.04	0.00

Note: minor errors that may be present in the table are due to rounding of numbers

* - numbers shown in these columns have been checked and are correct. The apparent difference between the table values and the total is a result of all table values being rounded downwards.

Table 2.2 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake E7

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning 0.2	LNSC	0.15	0.96	0.03	0.00	0.00	-0.03
Rearing 0.2	LNSC	0.15	6.54	0.20	0.00	0.00	-0.20
Foraging 0.2	LNSC	0.15	6.20	0.19	0.00	0.00	-0.19
Nursery 0.2	LNSC	0.15	0.96	0.03	0.00	0.00	-0.03
Overwintering 0.2	LNSC	0.15	0.90	0.03	0.00	0.00	-0.03
Total			15.55	0.48	0.00	0.00	-0.48
Total by life stage	Spawning		0.96	0.03	0.00	0.00	-0.03
	Rearing		6.54	0.20	0.00	0.00	-0.20
	Foraging		6.20	0.19	0.00	0.00	-0.19
	Nursery		0.96	0.03	0.00	0.00	-0.03
	Overwintering		0.90	0.03	0.00	0.00	-0.03
Total by species	LNSC		15.55	0.48	0.00	0.00	-0.48

Note: minor errors that may be present in the table are due to rounding of numbers

Table 2.3 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake E8

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	LNSC	0.15	1.17	0.04	0.00	0.00	-0.04
0.24	BURB	0.05	1.12	0.01	0.00	0.00	-0.01
Rearing	LNSC	0.15	6.28	0.18	0.00	0.00	-0.18
0.19	BURB	0.05	5.98	0.05	0.00	0.00	-0.05
Foraging	LNSC	0.15	5.64	0.17	0.00	0.00	-0.17
0.19	BURB	0.05	5.75	0.05	0.00	0.00	-0.05
Nursery	LNSC	0.15	1.17	0.03	0.00	0.00	-0.03
0.19	BURB	0.05	1.12	0.01	0.00	0.00	-0.01
Overwintering	LNSC	0.15	1.05	0.03	0.00	0.00	-0.03
0.19	BURB	0.05	1.05	0.01	0.00	0.00	-0.01
Total			30.33	0.59	0.00	0.00	-0.59
Total by life stage	Spawning		2.29	0.06	0.00	0.00	-0.06
	Rearing		12.26	0.24	0.00	0.00	-0.24
	Foraging		11.40	0.22	0.00	0.00	-0.22
	Nursery		2.29	0.04	0.00	0.00	-0.04
	Overwintering		2.10	0.04	0.00	0.00	-0.04
Total by species	LNSC		15.31	0.46	0.00	0.00	-0.46
	BURB		15.02	0.13	0.00	0.00	-0.13

Note: minor errors that may be present in the table are due to rounding of numbers

Table 2.4 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake E10

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	LKTR	0.14	0.14	0.004	0.00	0.00	-0.004
0.2	CISC	0.25	0.83	0.041	0.00	0.00	-0.04
	RNWH	0.18	0.45	0.016	0.00	0.00	-0.02
	LKWH	0.16	0.55	0.018	0.00	0.00	-0.02
Rearing	LKTR	0.14	8.24	0.235	0.00	0.00	-0.24
0.2	CISC	0.25	8.15	0.404	0.00	0.00	-0.40
	RNWH	0.18	8.49	0.312	0.00	0.00	-0.31
	LKWH	0.16	8.49	0.276	0.00	0.00	-0.28
Foraging	LKTR	0.14	8.39	0.240	0.00	0.00	-0.24
0.2	CISC	0.25	8.15	0.404	0.00	0.00	-0.40
	RNWH	0.18	8.09	0.297	0.00	0.00	-0.30
	LKWH	0.16	8.47	0.276	0.00	0.00	-0.28
Nursery	LKTR	0.14	0.14	0.004	0.00	0.00	0.00
0.2	CISC	0.25	0.83	0.041	0.00	0.00	-0.04
	RNWH	0.18	0.45	0.016	0.00	0.00	-0.02
	LKWH	0.16	0.55	0.018	0.00	0.00	-0.02
Overwintering	LKTR	0.14	1.69	0.048	0.00	0.00	-0.05
0.2	CISC	0.25	1.69	0.084	0.00	0.00	-0.08
	RNWH	0.18	1.69	0.062	0.00	0.00	-0.06
	LKWH	0.16	1.69	0.055	0.00	0.00	-0.05
Total			77.15	2.85	0.00	0.00	-2.85
Total by life stage	Spawning		1.97	0.08	0.00	0.00	-0.08
	Rearing		33.37	1.23	0.00	0.00	-1.23
	Foraging		33.09	1.22	0.00	0.00	-1.22
	Nursery		1.97	0.08	0.00	0.00	-0.08
	Overwintering		6.74	0.25	0.00	0.00	-0.25
Total by species	LKTR		18.59	0.53	0.00	0.00	-0.53
	CISC		19.64	0.97	0.00	0.00	-0.97
	RNWH		19.17	0.70	0.00	0.00	-0.70
	LKWH		19.75	0.64	0.00	0.00	-0.64

Note: minor errors that may be present in the table are due to rounding of numbers

Table 2.5 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake E11

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	LKTR	0.14	0.47	0.013	1.51	0.041	0.028
0.19	CISC	0.25	0.00	0.000	2.69	0.127	0.127
	RNWH	0.18	0.00	0.000	2.21	0.077	0.077
	LKWH	0.16	0.00	0.000	2.58	0.080	0.080
Rearing	LKTR	0.14	5.53	0.190	7.61	0.261	0.071
0.24	CISC	0.25	0.00	0.000	6.88	0.410	0.410
	RNWH	0.18	0.00	0.000	9.21	0.406	0.406
	LKWH	0.16	0.00	0.000	9.23	0.360	0.360
Foraging	LKTR	0.14	6.09	0.165	8.69	0.236	0.071
0.19	CISC	0.25	0.00	0.000	6.88	0.324	0.324
	RNWH	0.18	0.00	0.000	8.20	0.286	0.286
	LKWH	0.16	0.00	0.000	8.68	0.268	0.268
Nursery	LKTR	0.14	0.47	0.013	1.51	0.041	0.028
0.19	CISC	0.25	0.00	0.000	2.69	0.127	0.127
	RNWH	0.18	0.00	0.000	2.21	0.077	0.077
	LKWH	0.16	0.00	0.000	2.58	0.080	0.080
Overwintering	LKTR	0.14	3.09	0.084	1.67	0.045	-0.039
0.19	CISC	0.25	0.00	0.000	1.67	0.079	0.079
	RNWH	0.18	0.00	0.000	1.67	0.058	0.058
	LKWH	0.16	0.00	0.000	1.67	0.051	0.051
Total			15.65	0.46	90.02	3.43	2.97
Total by life stage	Spawning		0.47	0.01	8.99	0.32	0.31
	Rearing		5.53	0.19	32.93	1.44	1.25
	Foraging		6.09	0.17	32.45	1.11	0.95
	Nursery		0.47	0.01	8.99	0.32	0.31
	Overwintering		3.09	0.08	6.66	0.23	0.15
Total by species	LKTR		15.65	0.46	20.99	0.62	0.16
	CISC		0.00	0.00	20.81	1.07	1.07
	RNWH		0.00	0.00	23.48	0.90	0.90
	LKWH		0.00	0.00	24.74	0.84	0.84

Note: minor errors that may be present in the table are due to rounding of numbers

Table 2.6 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake E14

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning 0.19	LKTR	0.14	0.64	0.017	1.38	0.037	0.020
	CISC	0.25	0.00	0.000	2.30	0.109	0.109
	RNWH	0.18	0.00	0.000	2.12	0.074	0.074
	LKWH	0.16	0.00	0.000	2.19	0.068	0.068
Rearing 0.24	LKTR	0.14	4.71	0.162	6.18	0.212	0.050
	CISC	0.25	0.00	0.000	5.56	0.331	0.331
	RNWH	0.18	0.00	0.000	7.63	0.336	0.336
	LKWH	0.16	0.00	0.000	7.63	0.298	0.298
Foraging 0.19	LKTR	0.14	5.19	0.141	7.02	0.191	0.050
	CISC	0.25	0.00	0.000	5.56	0.262	0.262
	RNWH	0.18	0.00	0.000	6.79	0.237	0.237
	LKWH	0.16	0.00	0.000	7.00	0.216	0.216
Nursery 0.19	LKTR	0.14	0.64	0.017	1.38	0.037	0.020
	CISC	0.25	0.00	0.000	2.30	0.109	0.109
	RNWH	0.18	0.00	0.000	2.12	0.074	0.074
	LKWH	0.16	0.00	0.000	2.19	0.068	0.068
Overwintering 0.19	LKTR	0.14	2.41	0.066	1.64	0.045	-0.021
	CISC	0.25	0.00	0.000	1.64	0.077	0.077
	RNWH	0.18	0.00	0.000	1.64	0.057	0.057
	LKWH	0.16	0.00	0.000	1.64	0.051	0.051
Total			13.60	0.40	75.92	2.89	2.49
Total by life stage	Spawning		0.64	0.02	7.99	0.29	0.27
	Rearing		4.71	0.16	26.99	1.18	1.02
	Foraging		5.19	0.14	26.37	0.91	0.77
	Nursery		0.64	0.02	7.99	0.29	0.27
	Overwintering		2.41	0.07	6.56	0.23	0.16
Total by species	LKTR		13.60	0.40	17.60	0.52	0.12
	CISC		0.00	0.00	17.37	0.89	0.89
	RNWH		0.00	0.00	20.31	0.78	0.78
	LKWH		0.00	0.00	20.64	0.70	0.70

Note: minor errors that may be present in the table are due to rounding of numbers

Table 2.7 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake E17

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	LKTR	0.14	0.98	0.027	1.67	0.045	0.019
0.19	CISC	0.25	0.00	0.000	2.67	0.126	0.126
	RNWH	0.18	0.00	0.000	2.37	0.083	0.083
	LKWH	0.16	0.00	0.000	2.71	0.084	0.084
Rearing	LKTR	0.14	7.28	0.250	8.66	0.297	0.047
0.24	CISC	0.25	0.00	0.000	7.21	0.429	0.429
	RNWH	0.18	0.00	0.000	9.95	0.439	0.439
	LKWH	0.16	0.00	0.000	10.06	0.393	0.393
Foraging	LKTR	0.14	7.84	0.213	9.57	0.260	0.047
0.19	CISC	0.25	0.00	0.000	7.21	0.340	0.340
	RNWH	0.18	0.00	0.000	9.21	0.322	0.322
	LKWH	0.16	0.00	0.000	9.55	0.295	0.295
Nursery	LKTR	0.14	0.98	0.027	1.67	0.045	0.019
0.19	CISC	0.25	0.00	0.000	2.67	0.126	0.126
	RNWH	0.18	0.00	0.000	2.37	0.083	0.083
	LKWH	0.16	0.00	0.000	2.71	0.084	0.084
Overwintering	LKTR	0.14	2.44	0.066	1.55	0.042	-0.024
0.19	CISC	0.25	0.00	0.000	1.55	0.073	0.073
	RNWH	0.18	0.00	0.000	1.55	0.054	0.054
	LKWH	0.16	0.00	0.000	1.55	0.048	0.048
Total			19.52	0.58	96.47	3.67	3.08
Total by life stage	Spawning		0.98	0.03	9.43	0.34	0.31
	Rearing		7.28	0.25	35.88	1.56	1.31
	Foraging		7.84	0.21	35.53	1.22	1.00
	Nursery		0.98	0.03	9.43	0.34	0.31
	Overwintering		2.44	0.07	6.19	0.22	0.15
Total by species	LKTR		19.52	0.58	23.13	0.69	0.11
	CISC		0.00	0.00	21.30	1.09	1.09
	RNWH		0.00	0.00	25.46	0.98	0.98
	LKWH		0.00	0.00	26.59	0.90	0.90

Note: minor errors that may be present in the table are due to rounding of numbers

Table 2.8 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake E21

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	LKTR	0.14	0.00	0.000	0.08	0.002	0.0022
0.19	CISC	0.25	0.00	0.000	0.51	0.024	0.0238
	RNWH	0.18	0.00	0.000	0.23	0.008	0.0082
	LKWH	0.16	0.00	0.000	0.39	0.012	0.0120
Rearing	LKTR	0.14	0.00	0.000	2.93	0.101	0.1006
0.24	CISC	0.25	0.00	0.000	2.17	0.129	0.1293
	RNWH	0.18	0.00	0.000	3.06	0.135	0.1347
	LKWH	0.16	0.00	0.000	3.09	0.121	0.1208
Foraging	LKTR	0.14	0.00	0.000	3.09	0.084	0.0840
0.19	CISC	0.25	0.00	0.000	2.17	0.102	0.1024
	RNWH	0.18	0.00	0.000	2.90	0.101	0.1011
	LKWH	0.16	0.00	0.000	3.13	0.097	0.0967
Nursery	LKTR	0.14	0.00	0.000	0.08	0.002	0.0022
0.19	CISC	0.25	0.00	0.000	0.51	0.024	0.0238
	RNWH	0.18	0.00	0.000	0.23	0.008	0.0082
	LKWH	0.16	0.00	0.000	0.39	0.012	0.0120
Overwintering	LKTR	0.14	0.00	0.000	0.72	0.019	0.0195
0.19	CISC	0.25	0.00	0.000	0.72	0.034	0.0338
	RNWH	0.18	0.00	0.000	0.72	0.025	0.0250
	LKWH	0.16	0.00	0.000	0.72	0.022	0.0222
Total			0.00	0.00	27.83	1.06	1.06
Total by life stage	Spawning		0.00	0.00	1.21	0.05	0.05
	Rearing		0.00	0.00	11.25	0.49	0.49
	Foraging		0.00	0.00	11.29	0.38	0.38
	Nursery		0.00	0.00	1.21	0.05	0.05
	Overwintering		0.00	0.00	2.87	0.10	0.10
Total by species	LKTR		0.00	0.00	6.90	0.21	0.21
	CISC		0.00	0.00	6.07	0.31	0.31
	RNWH		0.00	0.00	7.14	0.28	0.28
	LKWH		0.00	0.00	7.72	0.26	0.26

Note: minor errors that may be present in the table are due to rounding of numbers

Table 2.9 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Each Species in East Island Lakes

Life Stage	Species	Normalized Weighting	Habitat Units (HUs): Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	LKTR	0.14	2.24	0.06	4.64	0.13	0.07
	CISC	0.25	0.83	0.04	8.17	0.39	0.34
	RNWH	0.18	0.45	0.02	6.94	0.24	0.23
	LKWH	0.16	0.55	0.02	7.87	0.24	0.23
	LKCH	0.06	0.33	0.00	0.33	0.00	0.00
	BURB	0.04	1.12	0.01	0.00	0.00	-0.01
	LNSC	0.15	2.12	0.07	0.00	0.00	-0.07
Rearing	LKTR	0.14	25.75	0.84	25.38	0.87	0.03
	CISC	0.25	8.15	0.40	21.82	1.30	0.90
	RNWH	0.18	8.49	0.31	29.84	1.32	1.00
	LKWH	0.16	8.49	0.28	30.01	1.17	0.90
	LKCH	0.06	1.09	0.01	1.09	0.01	0.00
	BURB	0.04	5.98	0.05	0.00	0.00	-0.05
	LNSC	0.15	12.82	0.39	0.00	0.00	-0.39
Foraging	LKTR	0.14	27.50	0.76	28.38	0.77	0.01
	CISC	0.25	8.15	0.40	21.82	1.03	0.62
	RNWH	0.18	8.09	0.30	27.09	0.95	0.65
	LKWH	0.16	8.47	0.28	28.36	0.88	0.60
	LKCH	0.06	1.09	0.01	1.09	0.01	0.00
	BURB	0.04	5.75	0.05	0.00	0.00	-0.05
	LNSC	0.15	11.84	0.36	0.00	0.00	-0.36
Nursery	LKTR	0.14	2.24	0.06	4.64	0.13	0.07
	CISC	0.25	0.83	0.04	8.17	0.39	0.34
	RNWH	0.18	0.45	0.02	6.94	0.24	0.23
	LKWH	0.16	0.55	0.02	7.87	0.24	0.23
	LKCH	0.06	0.33	0.00	0.33	0.00	0.00
	BURB	0.04	1.12	0.01	0.00	0.00	-0.01
	LNSC	0.15	2.12	0.06	0.00	0.00	-0.06
Overwintering	LKTR	0.14	9.62	0.26	5.57	0.15	-0.11
	CISC	0.25	1.69	0.08	5.57	0.26	0.18
	RNWH	0.18	1.69	0.06	5.57	0.19	0.13
	LKWH	0.16	1.69	0.05	5.57	0.17	0.12
	LKCH	0.06	0.29	0.00	0.29	0.00	0.00
	BURB	0.04	1.05	0.01	0.00	0.00	-0.01
	LNSC	0.15	1.95	0.06	0.00	0.00	-0.06
Total			174.90	5.41	293.35	11.09	5.68
Total by life stage	Spawning	Spawning	7.63	0.23	27.95	1.00	0.78
	Rearing	Rearing	70.77	2.28	108.14	4.67	2.39
	Foraging	Foraging	70.89	2.16	106.73	3.63	1.48
	Nursery	Nursery	7.63	0.21	27.95	1.00	0.79
	Overwintering	Overwintering	17.97	0.54	22.58	0.78	0.25
Total by species	LKTR	LKTR	67.35	1.98	68.61	2.05	0.06
	CISC	CISC	19.64	0.97	65.56	3.36	2.39
	RNWH	RNWH	19.17	0.70	76.38	2.94	2.24
	LKWH	LKWH	19.75	0.64	79.69	2.71	2.06
	LKCH	LKCH	3.11	0.04	3.11	0.04	0.00
	BURB	BURB	15.02	0.13	0.00	0.00	-0.13
	LNSC	LNSC	30.86	0.94	0.00	0.00	-0.94

Note: minor errors that may be present in the table are due to rounding of numbers

Table 2.10 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for All East Island Lakes

Life Stage	Lake	Habitat Units (HUs)				
		Lost due to construction		Gained from mitigation		Net Change
		No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	E3	0.33	0.00	0.33	0.00	0.00
	E7	0.96	0.03	0.00	0.00	-0.03
	E8	2.29	0.06	0.00	0.00	-0.06
	E10	1.97	0.08	0.00	0.00	-0.08
	E11	0.47	0.01	8.99	0.32	0.31
	E14	0.64	0.02	7.99	0.29	0.27
	E17	0.98	0.03	9.43	0.34	0.31
	E21	0.00	0.00	1.21	0.05	0.05
Rearing	E3	1.09	0.01	1.09	0.01	0.00
	E7	6.54	0.20	0.00	0.00	-0.20
	E8	12.26	0.24	0.00	0.00	-0.24
	E10	33.37	1.23	0.00	0.00	-1.23
	E11	5.53	0.19	32.93	1.44	1.25
	E14	4.71	0.16	26.99	1.18	1.02
	E17	7.28	0.25	35.88	1.56	1.31
	E21	0.00	0.00	11.25	0.49	0.49
Foraging	E3	1.09	0.01	1.09	0.01	0.00
	E7	6.20	0.19	0.00	0.00	-0.19
	E8	11.40	0.22	0.00	0.00	-0.22
	E10	33.09	1.22	0.00	0.00	-1.22
	E11	6.09	0.17	32.45	1.11	0.95
	E14	5.19	0.14	26.37	0.91	0.77
	E17	7.84	0.21	35.53	1.22	1.00
	E21	0.00	0.00	11.29	0.38	0.38
Nursery	E3	0.33	0.00	0.33	0.00	0.00
	E7	0.96	0.03	0.00	0.00	-0.03
	E8	2.29	0.04	0.00	0.00	-0.04
	E10	1.97	0.08	0.00	0.00	-0.08
	E11	0.47	0.01	8.99	0.32	0.31
	E14	0.64	0.02	7.99	0.29	0.27
	E17	0.98	0.03	9.43	0.34	0.31
	E21	0.00	0.00	1.21	0.05	0.05
Overwintering	E3	0.29	0.00	0.29	0.00	0.00
	E7	0.90	0.03	0.00	0.00	-0.03
	E8	2.10	0.04	0.00	0.00	-0.04
	E10	6.74	0.25	0.00	0.00	-0.25
	E11	3.09	0.08	6.66	0.23	0.15
	E14	2.41	0.07	6.56	0.23	0.16
	E17	2.44	0.07	6.19	0.22	0.15
	E21	0.00	0.00	2.87	0.10	0.10
Total		174.90	5.41	293.35	11.09	5.68

Total by Lake	E3	3.11	0.04	3.11	0.04	0.00
	E7	15.55	0.48	0.00	0.00	-0.48
	E8	30.33	0.59	0.00	0.00	-0.59
	E10	77.15	2.85	0.00	0.00	-2.85
	E11	15.65	0.46	90.02	3.43	2.97
	E14	13.60	0.40	75.92	2.89	2.49
	E17	19.52	0.58	96.47	3.67	3.08
	E21	0.00	0.00	27.83	1.06	1.06

Note: minor errors that may be present in the table are due to rounding of numbers

Table 2.11 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Each Species in All East Island Lakes Excluding E3 and E21

Life Stage	Species	Weight	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	LKTR	0.14	2.24	0.06	4.56	0.12	0.06
	CISC	0.25	0.83	0.04	7.67	0.36	0.32
	RNWH	0.18	0.45	0.02	6.70	0.23	0.22
	LKWH	0.16	0.55	0.02	7.48	0.23	0.21
	LKCH	0.06	0.33	0.00	0.00	0.00	0.00
	BURB	0.04	1.12	0.01	0.00	0.00	-0.01
	LNSC	0.15	2.12	0.07	0.00	0.00	-0.07
Rearing	LKTR	0.14	25.75	0.84	22.45	0.77	-0.07
	CISC	0.25	8.15	0.40	19.65	1.17	0.77
	RNWH	0.18	8.49	0.31	26.79	1.18	0.87
	LKWH	0.16	8.49	0.28	26.92	1.05	0.77
	LKCH	0.06	1.09	0.01	0.00	0.00	-0.01
	BURB	0.04	5.98	0.05	0.00	0.00	-0.05
	LNSC	0.15	12.82	0.39	0.00	0.00	-0.39
Foraging	LKTR	0.14	27.50	0.76	25.28	0.69	-0.07
	CISC	0.25	8.15	0.40	19.65	0.93	0.52
	RNWH	0.18	8.09	0.30	24.20	0.84	0.55
	LKWH	0.16	8.47	0.28	25.23	0.78	0.50
	LKCH	0.06	1.09	0.01	0.00	0.00	-0.01
	BURB	0.04	5.75	0.05	0.00	0.00	-0.05
	LNSC	0.15	11.84	0.36	0.00	0.00	-0.36
Nursery	LKTR	0.14	2.24	0.06	4.56	0.12	0.06
	CISC	0.25	0.83	0.04	7.67	0.36	0.32
	RNWH	0.18	0.45	0.02	6.70	0.23	0.22
	LKWH	0.16	0.55	0.02	7.48	0.23	0.21
	LKCH	0.06	0.33	0.00	0.00	0.00	0.00
	BURB	0.04	1.12	0.01	0.00	0.00	-0.01
	LNSC	0.15	2.12	0.06	0.00	0.00	-0.06
Overwintering	LKTR	0.14	9.62	0.26	4.85	0.13	-0.13
	CISC	0.25	1.69	0.08	4.85	0.23	0.15
	RNWH	0.18	1.69	0.06	4.85	0.17	0.11
	LKWH	0.16	1.69	0.05	4.85	0.15	0.10
	LKCH	0.06	0.29	0.00	0.00	0.00	0.00
	BURB	0.04	1.05	0.01	0.00	0.00	-0.01
	LNSC	0.15	1.95	0.06	0.00	0.00	-0.06
Total			174.90	5.41	262.41	9.99	4.58
Total by life stage	Spawning	Spawning	7.63	0.23	26.42	0.95	0.72
	Rearing	Rearing	70.77	2.28	95.80	4.17	1.89
	Foraging	Foraging	70.89	2.16	94.36	3.24	1.08
	Nursery	Nursery	7.63	0.21	26.42	0.95	0.74
	Overwintering	Overwintering	17.97	0.54	19.42	0.68	0.14
Total by species	LKTR	LKTR	67.35	1.98	61.71	1.84	-0.14
	CISC	CISC	19.64	0.97	59.48	3.05	2.07
	RNWH	RNWH	19.17	0.70	69.24	2.66	1.96
	LKWH	LKWH	19.75	0.64	71.97	2.44	1.80
	LKCH	LKCH	3.11	0.04	0.00	0.00	-0.04
	BURB	BURB	15.02	0.13	0.00	0.00	-0.13
	LNSC	LNSC	30.86	0.94	0.00	0.00	-0.94

Note: minor errors that may be present in the table are due to rounding of numbers

3. AREA ANALYSIS FOR HABITAT CHANGE

3.1 LAC DE GRAS

Dike construction would alter some fish habitat in Lac de Gras from baseline conditions. However, the dikes (A154, A418 and A21) would be constructed in a manner that creates habitat for fish in Lac de Gras. A detailed description of predicted habitat losses and gains in Lac de Gras is presented in the Diavik No Net Loss Plan (Diavik 1998a). The external edges of the dikes would provide some habitat immediately upon completion. Upon closure, the dikes around each pit would be breached and the pit flooded to provide additional habitat for fish. For most species, this new habitat would be suitable for use during all life stages (spawning, nursery, rearing and foraging) and an overall net gain in habitat is predicted (see Section 5). The unweighted areas (in ha) for each habitat type that will be lost in Lac de Gras are presented in Table 3.1. The unweighted areas (in ha) for each habitat type that will be gained through mitigation efforts are presented in Table 3.2.

Table 3.1 Areas of Predicted Habitat Loss in Lac de Gras by Habitat Category

Habitat Category	Type	Area of Habitat Lost (ha)				TOTAL
		A154	A418	A21	North Inlet	
Shorelines[1]	1[4]	8.9	2.5	23.1	10.7	45.2
	2	0.2	0.5	0	0	0.7
	3	0	0	3.9	0	3.9
	4a/b	0	0	0	0	0
	5	0	0	0	0	0
	Sub-total	**9.1**	**3.0**	**27.0**	**10.7**	**49.8**
Shoals[2]	1	8.2	0.7	0	0	8.9
	2	7.6	0	3.2	0	10.8
	3	0.2	0	0	0	0.2
	4	0.5	0	0	0	0.5
	5	0.6	0	0	0	0.6
	Sub-total	**17.1**	**0.7**	**3.2**	**0**	**21.0**
Deep Water[3]	Sheltered 6-10 m[5] deep	0	0	0	6.5	6.5
	Sheltered >10 m[5] deep	0	0	0	3.5	3.5
	Open 6-10 m deep	29.9	4.9	5.5	0	40.3
	Open >10 m deep	51.2	17.4	44.0	0	112.6
	Sub-total	**81.1**	**22.3**	**49.4**	**10.0**	**162.8**
	TOTAL	**107.3**	**26.0**	**79.6**	**20.7**	**233.6**

1 – shorelines were separated into five discrete types based on physical description (see NNL Plan, Appendix II, Table II-1)

2 – shoals were separated into five discrete types based on physical description (see NNL Plan, Appendix III, Table III-1)

3 – deep water habitat was separated into four discrete types based on depth and exposure (i.e., proximity) to large deep areas (>20 m deep) in Lac de Gras (see NNL Plan, Appendix IV). The total area of deep water represents the area within the dikes where productivity will be foregone for the lifetime of the mine

4 – includes 10.7 ha of shoreline habitat lost in the North Inlet

5 – represents all deep water habitat lost in the North Inlet

Table 3.2 Areas of Predicted Habitat Gain Through Mitigation Efforts in Lac de Gras by Habitat Category

Habitat Category[1]	Type	Area of Habitat Modified (ha)	Area of Habitat Created (ha)
External Edges of Dikes[2]	A154	2.9	-
	A418	1.2	-
	A21	2.6	-
Internal Edges of Dikes[2]	A154	1.4	-
	A418	0.5	-
	A21	1.1	-
East Island Shoreline Returned[2]	A154	-	0.5
	A418	-	0.6
	A21	-	0.8
Pit Shelves	A154	59.9	-
	A418	8.7	-
	A21	54.1	-
Flooded Pits	A154	55.2	-
	A418	41.9	-
	A21	29.3	-
TOTAL		**258.8**	**1.9**

1 – specific description of all habitat mitigation plans are presented in the NNL Plan, Appendix VII
2 – external and internal edges of the dikes and the reclaimed shoreline of the east island will be constructed to mimic Type 1 shoreline habitat (see NNL Plan, Appendix II, Table II-1)

3.2 INLAND/SMALL LAKES

Construction of mine infrastructure on the east island would result in the permanent loss of three small lakes (lakes e7, e8, and e10). In addition, two other small lakes would be used as a component of the water management system during mine operation (lakes e3 and e21). Lake e3, which contains lake chub only, would be reclaimed without physical modification upon closure of the mine and the fish community would be restored (water quality permitting). Lake e21, which currently does not contain fish, would be modified to provide more suitable habitat and a fish community would be established (water quality permitting). The habitat in lakes e11, e14 and e17 would be enhanced. Details of the mine plan and the predicted effects on east island small lakes are presented in the Diavik No Net Loss Plan (Diavik 1998a).

The areas of each type of habitat in the small lakes of interest, both before and after the mitigation work is complete, are presented in Table 3.3.

Table 3.3 Areas of Shoreline and Deep Water (>3m) Habitat in the Inland Lakes Under Baseline and Post-Mitigation Conditions

		Baseline Conditions			Post-Mitigation Conditions		
Lake	Surface Area (ha)	Shoreline[1] (ha)	Deep Water[2] (ha)	Proportion >3m deep	Shoreline[1] (ha)	Deep Water[2] (ha)	Proportion >3m deep
e3	0.90	0.53	0.29	32%	0.53	0.29	32%
e7	6.35	3.19	0.90	14%	-	-	-
e8	6.13	3.44	1.05	17%	-	-	-
e10	9.52	4.38	1.69	18%	-	-	-
e11	7.10	2.56	3.09	44%	4.64	1.67	23%
e14	5.68	2.12	2.41	42%	3.59	1.64	29%
e17	7.82	3.70	2.44	31%	5.09	1.55	20%
e21	2.69	2.14	0.15	6%	1.97	0.72	27%

1 – shorelines are defined as all areas that are <1 m deep
2 – value shown is the area of the lake >3 m in depth. This represents the area below the maximum ice depth and therefore represents available overwintering habitat for resident fish.

During baseline field investigations, lake e10 was found to contain four species of fish (lake trout, lake whitefish, round whitefish and cisco) in much higher abundance, relative to other small lakes surveyed (Golder Associates 1997). Approximately 80% of the surface area of lake e10 is less than 3 metres deep; the remaining 20% of the surface area represents the portion of the lake available for overwintering. It is hypothesized that the bathymetry of lake e10 is the key factor that allowed the establishment of a relatively complex fish community in a small lake. During 1996 field investigations, shallow littoral areas (<3 m deep) in lake e10 were observed to have large accumulations of attached algae, relative to other east island lakes. These areas provide high quality rearing and foraging areas for fish and act to increase the overall productivity of the lake.

As discussed in the No Net Loss Plan (see Appendix VII), it is proposed that lake e10 be used as a template for modification of lakes e11, e14, and e17 by filling in a portion of them to create more shallow littoral zone habitat. Lake e21, which is currently shallow and does not contain fish (Golder Associates 1997), would be excavated to increase the proportion of the lake available for fish overwintering. Lake e3, which along with lake e21 would be used as a component of the water management system during operations, would be re-filled with water without physical modification upon mine closure.

3.3 STREAMS

Streams on the east island generally flow for a very short period during the spring snowmelt. As a result, none of the streams provide spawning or nursery habitat for either of the stream spawning species resident in Lac de Gras (Arctic grayling and longnose sucker). However, several of the streams could potentially provide habitat in the form of a migration corridor between some small lakes on the east island and Lac de Gras. A summary of the area of migration habitat in each stream is presented in Table VI-12, Appendix VI, of the No Net Loss Plan (Diavik 1998a). A modified version of Table VI-12, showing only streams that provide migration corridor habitat, is presented below (Table 3.4).

Table 3.4 Migration Corridor Habitat Available for All Fish Species in Streams Affected by the Proposed Project

Stream ID	Length (m)	Area[1] (m^2)	Area (ha)
es5	49	44	0.004
es6	172	155	0.015
es7	36	32	0.003
es11	167	150	0.015
es12	250	225	0.023
es14	81	73	0.007
es19	476	428	0.043
es29	416	374	0.037
es30	209	188	0.019
TOTAL	**1856**	**1670**	**0.167**

1 - Stream width was estimated as 0.9 m (see NNL Plan for details)
Note: Table modified from Table VI-12 in Appendix VI of the NNL Plan

4. DEFINITION AND CRITERIA FOR THE "NO FISH HABITAT" DESIGNATION IN INLAND LAKES

The criteria for the designation of inland lakes having "no fish habitat" were:

- Depth (< 3 m)
- Size (< 1 ha)
- Degree of isolation (no direct connection to a water body containing fish)

Depth: The 3 m depth limit was selected because no lakes surveyed on the east island, west island or mainland that were shallower than 3 m were found to have overwintering fish populations.

Size: The 1 ha limit was selected as no lakes surveyed on the east island, west island or mainland that had a surface area < 1 ha were found to have permanent fish populations.

Degree of isolation: Lakes with no fish populations and no direct connection to an inland lake containing a permanent fish population or Lac de Gras were classified as non-fish habitat. These lakes have no potential for the establishment of a fish population through emigration.

5. CHANGES IN WSA/HU VALUES IN LAC DE GRAS (TABLE 4-2)

Table 4-2 in the No Net Loss Plan presented the fish habitat assessment results for Lac de Gras prior to using the weighted suitable areas (WSA) approach to calculating habitat units. Table 4-2 has been modified in this addendum to show separate values for habitat loss and gain for shallow and deep water habitats (Table 5.1). Habitat units presented in Table 5.1 have not been weighted using the WSA approach. As discussed with DFO, habitat units have been weighted based on the total habitat available for fish species and life stage, as opposed to weighting based on habitat type (e.g., shorelines, shoals, etc.).

Table 5.1 Habitat Units Lost versus Habitat Units Gained in Lac de Gras Due to Dike Construction (Revised)

Habitat Type	Temporary and Permanent Habitat Units		
	Losses	Gains	Net
Shoreline	-790	+175	-615
Shoal	-362	0	-362
Shallow Water[1]	-633	+1,779	+1,146
Deep Water[2]	-647	+664	+17
Total	**-2,432**	**+2,618**	**+186**

Note: Habitat Units (HUs) are in hectares indexed by a measure of quality (HSI value)
1 – represents habitat available in areas between 6-10 m deep
2 – represents habitat available in areas that are >10 m deep

As described in Section 1 of this addendum, a weighted suitable area (WSA) approach has been applied to the habitat calculations for fish species in Lac de Gras. These calculations were prepared in consultation with DFO (K. Minns, pers. com.). The revised habitat calculations for Lac de Gras are presented below in Table 5.2.

Table 5.2 **No Net Loss Habitat Summary "Ac**

Life Stage		nge ted
Spawning		-1.49
		0
	0.	-1.84
		0.22
		-0.55
		-0.30
		-0.34
		0
		1.01
Rearing		10.58
		-0.18
	0.	8.73
		0.48
		1.65
		0.63
		-0.20
		0
		0.47
Foraging		-2.14
		-0.17
	0.	1.32
		-0.70
		0.42
		-0.10
		-0.33
		0
		0.39
Nursery		-1.55
		0
	0.2	-1.84
		0.22
		-0.55
		-0.30
		-0.34
		0
		1.01
Total		14.22
Total by life stage		-3.28
		22.15
		-1.31
		-3.35
Total by species		5.40
		-0.35
		6.37
		0.23
		0.98
		-0.07
		-1.21
		0.00
		2.87

* - specie

** - habita the propos

6. CHANGES IN BATHYMETRIC DIVERSITY ASSOCIATED WITH THE DIKES

Information on changes to bathymetric diversity associated with the dikes is summarized in Section 3.1 of this addendum.

7. REPLACING INTERIM PRODUCTIVITY LOSSES

Diavik has acknowledged that Lac de Gras fish habitat would be reduced during the period when the area behind the proposed dikes is dewatered. This period varies from around 5 to 20 years depending upon the dike area considered. During that time period the productive capacity of fish habitat in Lac de Gras would not be significantly affected as: a) the amount of temporary habitat reduction is small relative to the amount available in Lac de Gras; and, b) it is more likely that primary productivity is the limiting factor controlling the productive capacity of fish habitat in Lac de Gras as opposed to the availability of physical habitat. To compensate for the temporary loss of fish habitat, habitat would be created upon closure of the mine such that the post-closure amount of habitat exceeds the amount of habitat at baseline. This small increase in habitat that would be available for fish forever would off-set the much shorter duration habitat reduction during operations.

8. TIMING AND EVALUATION OF COMPENSATION ACTIVITIES

Several opportunities have been identified to date to gain early insights into the efficacy of compensation measures and allow for adaptive management. It is expected that additional opportunities may be identified by communities, government scientists and Diavik during the final design and implementation of the proposed No Net Loss Plan. Three opportunities of note are:

1. Habitat enhancement is proposed for several inland lakes. The enhancements would be conducted one lake at a time starting early in the mine development. Examination of the effectiveness of habitat enhancement in one lake can provide valuable information that can be used to adapt designs prior to implementation of enhancement in the next lake.

2. Construction of the dikes is proposed to be staggered by several years (A154 in 2000, A418 in 2007 and A21 in 2010). Monitoring information on the effectiveness of habitat created on the outside of the A154 dike could be used to modify the exterior surface of A418 and A21.

3. Mining would be complete in A21 years before mining ceased in either A418 or A154. Habitat creation in the interior areas of A21 could be monitored for effectiveness, and results utilized to help with finalizing the design of the A418 or A154 interior fish habitats.

9. ALTERNATE COMPENSATION SCENARIOS

A variety of alternative strategies have been considered in the development of the No Net Loss Plan. For example, alternatives to the enhancement of lakes e11, e14, e17, and e21, and the reclamation of e3 included enhancement activities on inland lakes on both the west island and the mainland. As an example, a possible option for habitat enhancement was to create more permanent channels joining lakes m1, m2, and m3 on the mainland (Figure 1).

Under baseline conditions, lakes m1, m2 and m3 are joined by streams that flow only during the spring runoff period and, as a result, the ability of fish to migrate between the lakes is severely restricted. The lake complex that would be created by joining lake m1, m2 and m3 would greatly increase the amount and diversity of habitat accessible to fish, at least during the open-water season.

Fish capture results during the environmental baseline program found round whitefish in each of lakes m1 and m2 (Golder Associates 1997). Fish were not captured in lake m3. Weighted Suitable Area (WSA) calculations for habitat in lakes m1, m2, and m3 have been compiled based on the inland lakes weighting scheme presented in Section 1 of this addendum. The calculations have assumed that these lakes, once they are joined together, could support a fish community similar to that found in lake e10 (e.g., lake trout, round whitefish, lake whitefish, and cisco). Tables 9.1 to 9.3 present the WSA for habitat units present in lakes m1, m2 and m3, respectively, both before and after mitigation activities have been completed. Table 9.4 and 9.5 present the overall results for habitat units in all three mainland lakes before and after mitigation efforts. Table 9.4 contains a summary of WSA habitat units separated by species and Table 9.5 contains a similar summary with the WSA habitat units separated by lake.

Other mitigation alternatives considered during the development of the No Net Loss Plan included creating migration corridor habitat between Lac de Gras and inland lakes that could either support seasonal habitat use by fishes from Lac de Gras, or could support permanent fish populations but were apparently fishless. Other alternative compensation strategies considered include enhancing inland lakes on the mainland using the strategies developed for the inland lakes on the east island, as well as whole lake fertilization programs.

Figure 1 **Location of Inland Lakes Exami**

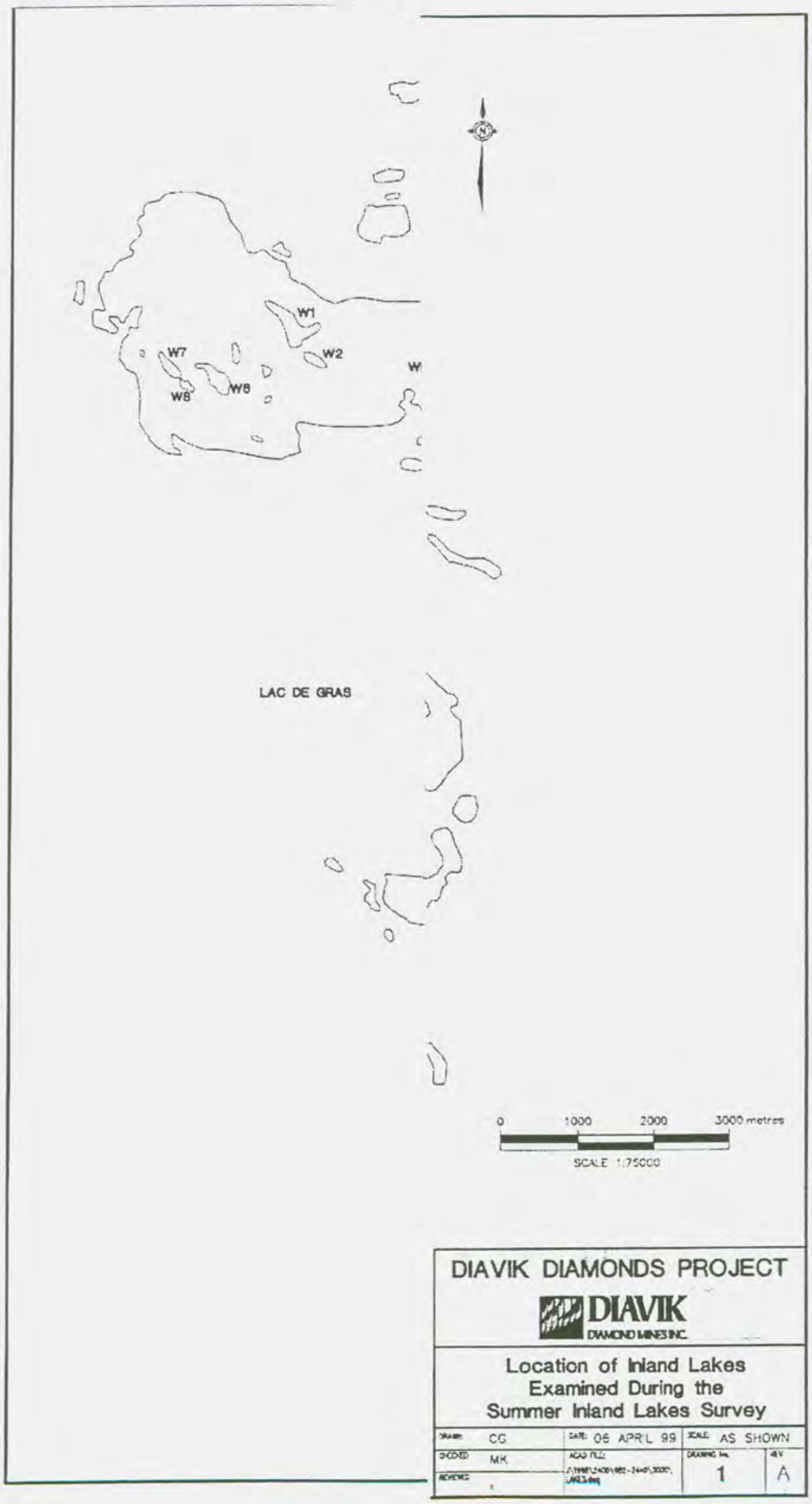

Table 9.2 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake m2

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	LKTR	0.14	0.00	0.00	0.42	0.01	0.01
0.19	CISC	0.25	0.00	0.00	0.41	0.02	0.02
	RNWH	0.18	0.44	0.02	0.44	0.02	0.00
	LKWH	0.16	0.00	0.00	0.51	0.02	0.02
Rearing	LKTR	0.14	0.00	0.00	3.62	0.12	0.12
0.24	CISC	0.25	0.00	0.00	3.34	0.20	0.20
	RNWH	0.18	3.88	0.17	3.88	0.17	0.00
	LKWH	0.16	0.00	0.00	3.86	0.15	0.15
Foraging	LKTR	0.14	0.00	0.00	3.77	0.10	0.10
0.19	CISC	0.25	0.00	0.00	3.34	0.16	0.16
	RNWH	0.18	3.75	0.13	3.75	0.13	0.00
	LKWH	0.16	0.00	0.00	3.77	0.12	0.12
Nursery	LKTR	0.14	0.00	0.00	0.42	0.01	0.01
0.19	CISC	0.25	0.00	0.00	0.41	0.02	0.02
	RNWH	0.18	0.44	0.02	0.44	0.02	0.00
	LKWH	0.16	0.00	0.00	0.51	0.02	0.02
Overwintering	LKTR	0.14	0.00	0.00	0.00	0.00	0.00
0.19	CISC	0.25	0.00	0.00	0.00	0.00	0.00
	RNWH	0.18	0.00	0.00	0.00	0.00	0.00
	LKWH	0.16	0.00	0.00	0.00	0.00	0.00
Total			8.51	0.33	32.89	1.28	0.94
Total by life stage	Spawning		0.44	0.02	1.78	0.06	0.05
	Rearing		3.88	0.17	14.71	0.65	0.47
	Foraging		3.75	0.13	14.63	0.51	0.38
	Nursery		0.44	0.02	1.78	0.06	0.05
	Overwintering		0.00	0.00	0.00	0.00	0.00
Total by species	LKTR		0.00	0.00	8.22	0.25	0.25
	CISC		0.00	0.00	7.50	0.40	0.40
	RNWH		8.51	0.33	8.51	0.33	0.00
	LKWH		0.00	0.00	8.65	0.30	0.30

Note: minor errors that may be present in the table are due to rounding of numbers

Table 9.3 No Net Loss Habitat Summary "Accounting" Showing Habitat Units for Lake m3

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs): Lost due to construction – No Weighting	Lost due to construction – Weighted	Gained from mitigation – No Weighting	Gained from mitigation – Weighted	Net Change – Weighted
Spawning	LKTR	0.14	0.00	0.00	0.06	0.00	0.00
0.19	CISC	0.25	0.00	0.00	0.07	0.00	0.00
	RNWH	0.18	0.00	0.00	0.08	0.00	0.00
	LKWH	0.16	0.00	0.00	0.08	0.00	0.00
Rearing	LKTR	0.14	0.00	0.00	2.36	0.08	0.08
0.24	CISC	0.25	0.00	0.00	1.99	0.12	0.12
	RNWH	0.18	0.00	0.00	2.29	0.10	0.10
	LKWH	0.16	0.00	0.00	2.29	0.09	0.09
Foraging	LKTR	0.14	0.00	0.00	2.25	0.06	0.06
0.19	CISC	0.25	0.00	0.00	1.99	0.09	0.09
	RNWH	0.18	0.00	0.00	2.26	0.08	0.08
	LKWH	0.16	0.00	0.00	2.26	0.07	0.07
Nursery	LKTR	0.14	0.00	0.00	0.06	0.00	0.00
0.19	CISC	0.25	0.00	0.00	0.07	0.00	0.00
	RNWH	0.18	0.00	0.00	0.08	0.00	0.00
	LKWH	0.16	0.00	0.00	0.08	0.00	0.00
Overwintering	LKTR	0.14	0.00	0.00	0.80	0.02	0.02
0.19	CISC	0.25	0.00	0.00	0.80	0.04	0.04
	RNWH	0.18	0.00	0.00	0.80	0.03	0.03
	LKWH	0.16	0.00	0.00	0.80	0.02	0.02
Total			0.00	0.00	21.45	0.83	0.83
Total by life stage	Spawning		0.00	0.00	0.29	0.01	0.01
	Rearing		0.00	0.00	8.92	0.39	0.39
	Foraging		0.00	0.00	8.76	0.30	0.30
	Nursery		0.00	0.00	0.29	0.01	0.01
	Overwintering		0.00	0.00	3.19	0.11	0.11
Total by species	LKTR		0.00	0.00	5.53	0.17	0.17
	CISC		0.00	0.00	4.91	0.26	0.26
	RNWH		0.00	0.00	5.51	0.21	0.21
	LKWH		0.00	0.00	5.51	0.19	0.19

Note: minor errors that may be present in the table are due to rounding of numbers

Table 9.4 No Net Loss Habitat Summary "Accounting" Showing Habitat Units Grouped by Fish Species in Mainland Lakes m1, m2, and m3

Life Stage and Weighting	Species	Normalized Weighting	Habitat Units (HUs)				
			Lost due to construction		Gained from mitigation		Net Change
			No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	LKTR	0.14	0.00	0.00	0.86	0.02	0.023
0.19	CISC	0.25	0.00	0.00	1.47	0.07	0.069
	RNWH	0.18	1.01	0.04	1.09	0.04	0.003
	LKWH	0.16	0.00	0.00	1.73	0.05	0.053
Rearing	LKTR	0.14	0.00	0.00	11.24	0.39	0.386
0.24	CISC	0.25	0.00	0.00	12.36	0.74	0.736
	RNWH	0.18	8.98	0.40	11.27	0.50	0.101
	LKWH	0.16	0.00	0.00	11.49	0.45	0.449
Foraging	LKTR	0.14	0.00	0.00	11.40	0.31	0.310
0.19	CISC	0.25	0.00	0.00	12.36	0.58	0.582
	RNWH	0.18	9.00	0.31	11.27	0.39	0.079
	LKWH	0.16	0.00	0.00	11.53	0.36	0.356
Nursery	LKTR	0.14	0.00	0.00	0.86	0.02	0.023
0.19	CISC	0.25	0.00	0.00	1.47	0.07	0.069
	RNWH	0.18	1.01	0.04	1.09	0.04	0.003
	LKWH	0.16	0.00	0.00	1.73	0.05	0.053
Overwintering	LKTR	0.14	0.00	0.00	3.83	0.10	0.104
0.19	CISC	0.25	0.00	0.00	3.83	0.18	0.181
	RNWH	0.18	3.03	0.11	3.83	0.13	0.028
	LKWH	0.16	0.00	0.00	3.83	0.12	0.118
Total			23.04	0.89	118.54	4.61	3.73
Total by life stage	Spawning		1.01	0.04	5.15	0.18	0.15
	Rearing		8.98	0.40	46.36	2.07	1.67
	Foraging		9.00	0.31	46.55	1.64	1.33
	Nursery		1.01	0.04	5.15	0.18	0.15
	Overwintering		3.03	0.11	15.32	0.54	0.43
Total by species	LKTR		0.00	0.00	28.20	0.85	0.85
	CISC		0.00	0.00	31.48	1.64	1.64
	RNWH		23.04	0.89	28.55	1.10	0.21
	LKWH		0.00	0.00	30.31	1.03	1.03

Note: minor errors that may be present in the table are due to rounding of numbers

Table 9.5 No Net Loss Habitat Summary "Accounting" Showing Habitat Units Grouped by For All Three Mainland Lakes of Interest (Lakes m1, m2, and m3)

Life Stage	Lake	Habitat Units (HUs)				
		Lost due to construction		Gained from mitigation		Net Change
		No Weighting	Weighted	No Weighting	Weighted	Weighted
Spawning	m1	0.57	0.02	3.09	0.11	0.09
	m2	0.44	0.02	1.78	0.06	0.05
	m3	0.00	0.00	0.29	0.01	0.01
Rearing	m1	5.10	0.23	22.73	1.03	0.81
	m2	3.88	0.17	14.71	0.65	0.47
	m3	0.00	0.00	8.92	0.39	0.39
Foraging	m1	5.25	0.18	23.16	0.83	0.65
	m2	3.75	0.13	14.63	0.51	0.38
	m3	0.00	0.00	8.76	0.30	0.30
Nursery	m1	0.57	0.02	3.09	0.11	0.09
	m2	0.44	0.02	1.78	0.06	0.05
	m3	0.00	0.00	0.29	0.01	0.01
Overwintering	m1	3.03	0.11	12.13	0.42	0.32
	m2	0.00	0.00	0.00	0.00	0.00
	m3	0.00	0.00	3.19	0.11	0.11
Total		23.04	0.89	118.54	4.61	3.73
Total by Lake	m1	14.53	0.55	64.19	2.51	1.96
	m2	8.51	0.33	32.89	1.28	0.94
	m3	0.00	0.00	21.45	0.83	0.83

Note: minor errors that may be present in the table are due to rounding of numbers

10. IMPACT OF MINING ACTIVITIES ON THE NET CHANGE ANALYSIS

An assessment of effects in Lac de Gras and in the inland lakes due to all potential pathways, including dust deposition, mine water discharges, and rockpile runoff and drainage, was provided in the Environmental Effects Report, Fish and Water (Diavik 1998b). In Lac de Gras, the areas that could exceed chronic water quality guidelines are expected to be very localized and would not affect the no net loss analysis. Runoff and drainage (based on current predictions) could result in two lakes (e3 and e21) having metals levels that exceed water quality guidelines after closure. The assessment was based of conservative (worst-case) assumptions regarding drainage water quality, and Diavik believes that, with proper management of runoff and drainage, water quality in these lakes will be acceptable for aquatic life. Water quality would be monitored prior to opening the water collection system to ensure quality.

Diavik has developed a comprehensive Aquatic Effects Monitoring Program (Diavik 1998c) that has two main objectives. The first objective of the monitoring program is to monitor sources of water to detect unforeseen levels of constituents or toxicity so that appropriate actions can be taken with respect to mine operations to mitigate any effects before the water reaches Lac de Gras or inland lakes. The second objective is to monitor water quality and aquatic life in Lac de Gras and inland lakes to detect changes due to Diavik's operations. If monitoring results show that changes in water quality or aquatic life is reducing the amount of available fish habitat beyond what has been predicted, then alternative mitigation measures would be investigated to ensure that the No Net Loss principle is met.

11. REFERENCES

Diavik Diamond Mines Inc. (Diavik). 1998a. No Net Loss Plan.

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RioTinto

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22 January 2019

Dear Ms. McLellan:

Subject: DDMI Fisheries Act Authorization(s)

Diavik Diamond Mines (2012) Inc. (DDMI) hereby gives permission to Fisheries and Oceans Canada (DFO) to share the following documentation with the Wek'èezhìi Land and Water Board and reviewers of DDMI's Water License W2015L2-0001 Amendment Request for the Deposition of Processed Kimberlite to Mine Workings:

- The *Fisheries Act* Authorization(s), No Net Loss Plan, and No Net Loss Plan Addendum associated with the Diavik Diamond Mine; and
- Correspondence from Bruce Hanna and Stu Niven of DFO regarding the status of the *Fisheries Act* Authorization(s).

Please do not hesitate to contact the undersigned if you have any questions related to this correspondence.

Yours sincerely,

Sean Sinclair
Superintendent, Environment