Impact Analysis of Aquatic Issues Associated With the Steepbank Mine

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A INTRODUCTION

This report is one of a series that address potential environmental and socio-economic impacts related to Suncor Inc., Oil Sands Group's (Suncor) Steepbank Mine project (Figure A-1). In particular, this report addresses potential impacts on aquatic resources that are associated with construction, operation and extraction/upgrading activities related to the Steepbank Mine, production expansion of the existing mine, plus those associated with reclamation of Suncor's existing mine and the Steepbank Mine. Details of these activities are given in the Steepbank Mine Application (Suncor 1996).

Suncor is only one of several existing or proposed developments that may potentially affect aquatic resources in the region. For example, a number of upstream municipalities and pulp and paper mills discharge treated wastewater to the Athabasca River. In addition, future oil sands developments proposed by Syncrude Canada Ltd. (Syncrude) and Solv-Ex Corporation (Solv-Ex) may affect aquatic resources. The cumulative effects of these developments on aquatic resources are included in this assessment.

The information presented in this report consolidates data and analyses presented in a number of technical reports (Figure A-2). In particular, this impact assessment is based on testing specific hypotheses of potential impacts of the project on aquatic resources. The focus of these hypotheses is directed towards assessing the viability of fish populations, particularly as this relates to recreational, subsistence or commercial use. Hypotheses dealt with in this report (numbers 28 through 34) and by other reports (e.g., terrestrial, socio-economic) are presented in Table A-1.

The remainder of this report outlines the aquatic impact assessment framework, describes the existing environmental characteristics that are pertinent to the impact assessment, presents the results of the impact analysis, and discusses uncertainties in the assessment and activities proposed to monitor and test specific impact predictions.

TABLE A-1
STEEPBANK MINE EIA IMPACT HYPOTHESES SUMMARY LIST

SOCIO-ECONOMIC	
1	The Steepbank Mine Project will contribute additional local, provincial and national benefits through additional employment, the procurement of goods and services required for the project and the payment of local, provincial and national taxes and royalties.
2	Construction-related activities and employment and the associated temporary increase in population will result in increased demands on services and infrastructure within the Regional Municipality of Wood Buffalo.
3	Operations-related employment and the associated increase in population will result in increased demands on services and infrastructure within communities in the Regional Municipality of Wood Buffalo.
4	The social stability and quality of life of communities within Wood Buffalo will be maintained as a result of the continued operation of the Suncor project, through development of the Steepbank Mine.
5	The Steepbank project will contribute to a loss in the traditional resource base of the Fort McKay community and displace some traditional activities.
6	The cumulative demands from the Suncor, Solv-Ex and Syncrude projects combined with the expected demands from existing populations within the Municipality will result in increased demands on local communities and affect the quality of life of those communities.
HUMAN HEALTH	
7	The health and well being of people who live, work or engage in recreational activities within the study area may be affected by changes to Athabasca and Steepbank River water quality caused by water releases resulting from extraction, processing and reclamation of oil sands from Suncor's existing and proposed mines.
8	The health and well being of people who live, work or engage in recreational activities within the study area may be affected by air emissions resulting from extraction, processing and reclamation of oils sands from Suncor's existing or proposed mines.
9	The health and well being of people who live, work or engage in recreational activities within the study area may be affected by cumulative exposure to chemicals associated with water and air emissions from Suncor's activities and other developments within the regional study area.
10	The health of people who in the future may occupy and/or use the land reclaimed from Suncor's Lease 86/17 and Steepbank Mine may be affected by release of chemicals from the reclaimed landscapes.
11	The health and safety of on site workers may be affected by development and operations of the Steepbank Mine and related facilities.
TERRESTRIAL	
12	Valued Ecosystem Components in the Athabasca River valley could be affected by the development, operation and reclamation of the Steepbank Mine and Lease 86/17.
13	Existing and future use of the area's landscapes could be limited by the development, operation and reclamation of the Steepbank Mine and Lease 86/17.
14	Visual integrity of the Athabasca River Valley could be affected by the development, operation and reclamation of the Steepbank Mine and Lease 86/17.

15	Biodiversity could be affected by the development, operation and reclamation of the Steepbank Mine and Lease 86/17.
16	Wetlands could be affected by Lease 86/17 and Steepbank Mine development and operation, including mine dewatering, changes to subsurface drainage, and reclamation release water.
17	Air emissions from the Suncor operation could have an impact on vegetation and soils, as well as aquatic environments.
WILDLIFE	
18	Mine development will result in changes in the availability and quality of wildlife habitat which will bring about a reduction in wildlife populations
19	Disturbance associated with mechanical noise and human activity may result in reduced abundance of wildlife.
20	Direct mortality of wildlife caused by mine development could result in reduced abundance of wildlife.
21	Mine development will disrupt the movement patterns of wildlife in the vicinity of the Steepbank Mine, thereby reducing access to important habitat or interfering with population mechanisms, resulting in decreased abundance of wildlife.
22	Mine development could cause a reduction in wildlife resource use (hunting, trapping, non-consumptive recreational use).
23	Development of the Steepbank Mine could contribute to a loss of natural biodiversity.
SURFACE AND GROUNDWATER RESOURCES	
24	Flows in the Athabasca and Steepbank Rivers could be significantly changed by mine development withdrawals for extraction, upgrading and/or reclamation.
25	Ice jams, floods or other hydrological events could cause structure damage and flooding of facilities that will result in subsequent impacts to hydrological/aquatic systems and downstream uses.
26	Navigation along the Athabasca River could be affected by bridge construction.
27	Groundwater quality could be affected by contaminant migration from processing and extraction activities.
AQUATIC RESOURCES	
28	Construction, operational or reclamation activities might adversely affect aquatic habitat in the Steepbank River.
29	Construction, operational or reclamation activities might adversely affect aquatic habitat in the Athabasca River.
30	Water releases associated with construction, operational or reclamation activities might adversely affect aquatic ecosystem health in the Athabasca or Steepbank Rivers.
31	Water releases associated with construction, operational or reclamation activities might adversely affect the quality of fish flesh.
32	Construction, operational or reclamation activities might lead to changes in aquatic habitat and/or aquatic health which might result in a decline in fish abundance in the Athabasca or Steepbank Rivers.

33	Construction, operational or reclamation activities might lead to changes in fish abundance or quality of fish flesh which might result in a decreased use of the fish resource.
34	Construction, operational or reclamation activities might cause changes in Athabasca River water quality which limit downstream use of the water.
AIR	
35	Global climate change could be affected by increased release of greenhouse gases associated with production expansion related to the Steepbank Mine.
HISTORICAL RESOURCES	
36	Significant archaeological, paleontological or historical resources could be affected by the development and operation of the Steepbank Mine.

B STUDY BOUNDARIES

For any assessment of this type it is useful to define boundary conditions, both spatial and temporal, that provide a context in which to base the analysis. The location of the study area in Alberta is shown in Figure B-1. Suncor is one of several existing or proposed developments that may potentially affect aquatic resources in the region. Hence, the regional study area extends beyond the limits of the local study area to encompass other significant developments in the region, such as Syncrude's proposed Aurora Mine (Figure B-2). Potential impacts may extend beyond this regional study area since some fish that occur within the local study area move extensively throughout the Athabasca River Basin. For example, populations of lake whitefish, walleye and longnose sucker move from Lake Athabasca to well upstream of Fort McMurray. Hence, effects of mine development that potentially extend beyond the regional study area are also addressed in this report.

The local study area is within the regional study area and includes water bodies within and immediately adjacent to the Steepbank Mine site (Figure B-3). Water bodies included in the local study area include 25 km of the Athabasca River extending from Willow Island to immediately downstream of the confluence of the Steepbank River, the lower portion of the Steepbank River within the proposed mine area, Leggett, Poplar, Wood and McLean Creeks, an unnamed tributary to the Athabasca River and an unnamed tributary to the Steepbank River.

Four discrete time periods are included in this assessment: 1995, 1997-2001, 2002-2020, and long-term. These time periods were selected because each one includes unique conditions that may affect aquatic biota within the local study area. The 1995 date represents baseline conditions prior to development of the Steepbank Mine and, thus, is indicative of existing impacts associated with Suncor's current operations and all other upstream impacts. From 1997-2001, much of the construction activity for the Steepbank Mine will take place. The 2002-2020 time period represents the operational phase of the mine. Finally, the long-term time period represents conditions expected following mine closure and complete reclamation of the existing mines, the plant site and the Steepbank Mine.

C VEC SELECTION

It is not possible, nor is it necessary, to evaluate impacts on all aquatic biota potentially present in the Athabasca and Steepbank Rivers and other potentially affected water bodies. Instead, surrogate fish species were selected as a means to focus the assessment. These surrogates or Valued Ecosystem Components (VECs) are defined as "a biological resource that has ecological, social and/or economic significance and which, if affected by a project, would be of concern to scientists, managers, government regulators and the public" (Beanlands and Duiniker 1983). Components can be selected on the basis of a range of factors, such as their high ecological value (e.g., longnose sucker are ecologically important as they form the basis of the food chain for many predators), their high value to the public (e.g., walleye are important from a subsistence and recreational point of view), their sensitivity to disturbance (e.g., spawning habitats), or their rarity (e.g., endangered species).

To identify VECs for the Athabasca and Steepbank Rivers, a matrix was prepared that listed the fish species which occur within the study area and their important ecological, social and economical attributes. For each of these attributes, scoring criteria were developed (Table C-1). The scoring criteria were adapted from those designed for Environmental Effects Monitoring (EEM) investigations (Environment Canada and Department of Fisheries and Oceans 1993) and from a receptor screening process suggested for ecological risk assessments (Suter 1993). Each fish species was screened against these criteria and a preliminary score was obtained. Of the 14 species screened, goldeye, lake whitefish and walleye received the highest scores.

Further refinement to the VEC selection process was made during the public consultation process. The initial matrix was presented to the public to provide a basis for discussion of VECs. The results of the review of the VECs by the stakeholders (meeting of April 28, 1995) are presented in Tables C-2 and C-3. The stakeholders considered some attributes more important than others. Therefore, a weighting factor was applied to reflect these values. The following factors were considered of primary importance and received a weighting factor of two: residence/abundance; commercial, subsistence, and recreational importance; feasibility to study; and the amount of information available. Ecological attributes such as sensitivity to sediment exposure; spawning in study area;

benthic food preference; importance as prey; high growth rate and fecundity; and age to maturity were of secondary importance from the stakeholders' point of view and therefore given a weighting factor of one.

The application of a weighting factor resulted in walleye, lake whitefish, goldeye and longnose sucker scoring highest for the Athabasca River and longnose sucker and trout-perch scoring highest for the Steepbank River. Arctic grayling, white sucker, northern pike and mountain whitefish also scored high. These scores were reviewed by individuals from a number of government agencies (Alberta Environmental Protection, Alberta Energy and Utilities Board, Canadian Coastguard, Department of Fisheries and Oceans and Health Canada) and taken into account in the final VEC selection.

To be useful as a VEC, a fish species must be suitable for measurement of a number of physiological and population parameters. Fish health (biomarker) evaluation, in particular, has very specific requirements in terms of the type of data, the amount of information and the timing of data collection. Biomarking is done on fairly large fish just prior to spawning and at least 40 fish (20 of each sex) must be sacrificed. Therefore, VEC selection was limited to those species that fit the requirements for biomarking analysis. Of the four species (walleye, longnose sucker, lake whitefish and goldeye) that scored high for the Athabasca River, walleye and longnose sucker are reported to spawn in the area. In contrast, available information indicated that there probably would not be sufficient numbers of lake whitefish and goldeye spawners in the study area. Therefore, walleye and longnose sucker were chosen as VECs for the Athabasca River. Goldeye were added as a VEC when it was found that there were a sufficient number of fish in the study area to enable biomarking collection. In the Steepbank River, longnose sucker were chosen as the VEC, with trout-perch being eliminated due to their small size.

It must be emphasized that selection of these particular VECs does not imply that they have any greater inherent ecological value than other fish species. Rather, they serve as surrogates for broad groups of fish to help focus the assessment. Although viability of fish populations is a primary endpoint for this assessment, other components of the aquatic ecosystem (e.g., benthic invertebrates) are also assessed in this report since fish populations will only remain viable if all components of the ecosystem remain healthy.

TABLE C-1
SCORING CRITERIA FOR FISH VECs

1. residence and relative abundance: 1 = uncommon 2 = moderately abundant 3 = common
2. provincial importance: (or status, measure of the relative abundance and degree of management concern or aesthetic value) 0 = species abundant, no concern (green-listed) 1 = species rare, but not threatened or special status (yellow-listed) 2 = threatened or vulnerable species (blue-listed) 3 = endangered species (or red-listed)
3. commercial economic importance (importance to guides, outfitters, fisheries) 0 = no importance 1 = low importance 2 = moderate importance 3 = high importance
4. subsistence economic importance: (fish species important for subsistence) 0 = not fished for food 1 = low 2 = moderate 3 = high
5. recreational importance: (fish species important for recreational fishing) 0 = non-game species 1 = low 2 = moderate 3 = high
6. habitat niche/sediment exposure yes/no
7. spawning in study area yes/no
8. benthic food preference: yes/no
9. important as prey: yes/no
10. high fecundity: 1 = low fecundity 2 = moderate fecundity 3 = high fecundity
11. high growth rate: 1 = low growth rate 2 = high growth rate
12. age to maturity: 1 = long age to maturity 2 = moderate age to maturity 3 = short age to maturity
13. feasibility of studying 0 = none 1 = limited 2 = moderate 3 = abundant
14. availability of information: (the amount of information available for each species or species group) 0 = none 1 = limited 2 = moderate 3 = abundant

TABLE C-2

WEIGHTED POTENTIAL ATHABASCA RIVER FISH VECs FOR THE STEEPBANK MINE PROJECT AREA

Species	Residence/ Abundance	Political Importance	Commercial Importance	Subsistence Importance	Recreational Importance	Sediment Exposure	Spawning in Study Area	Benthic Food Preference	Important as Prey	High Fecundity	High Growth Rate	Age to Maturity	Feasibility To Study	Information Availability	Total
Weighting Factor	2	2	2	2	2	1	1	1	1	1	1	1	2	2	
Goldeye	6	0	2	6	2	No	No	Yes	Yes	3	2	2	0	2	27
Longnose Sucker	4	0	0	1	0	Yes	Yes	Yes	Yes	2	2	2	6	4	25
Northern Pike	2	0	0	2	4	No	No	No	No	3	2	3	2	4	22
Walleye	6	0	4	4	6	No	Yes	No	No	3	2	2	4	4	36
Lake Whitefish	4	0	6	6	2	No	?	Yes	Yes	2	2	2	4	4	34
White Sucker	2	0	0	0	0	Yes	Yes	Yes	Yes	2	2	3	4	4	21
Flathead Chub	4	0	0	0	0	No	Yes	Yes	Yes	1	2	3	4	4	21
Emerald Shiner	4	0	0	0	0	No	Yes	Yes	Yes	1	?	3	4	4	19
Trout - Perch	6	0	0	0	0	Yes	Yes	Yes	Yes	1	1	3	6	2	23
Lake Chub	4	0	0	0	0	No	?	Yes	Yes	?	?	3	2	2	13
Mountain Whitefish	2	0	0	0	0	No	No	Yes	Yes	2	2	2	0	4	14
Burbot	2	0	0	0	0	Yes	Yes	No	No	2	2	2	0	2	12
Arctic Grayling	4	2	0	0	6	No	No	Yes	No	2	2	2	0	4	23
Bull Trout	2	4	0	0	0	Yes	?	No	No	2	3	2	0	2	16

No = 0
Yes = 1
? = 0
(See Table C-1 for Scoring Criteria. Scores are multiplied by the weighting factor.)

TABLE C-3

WEIGHTED POTENTIAL STEEPBANK RIVER FISH VECs FOR THE STEEPBANK MINE PROJECT AREA

Species	Residence/ Abundance	Political Importance	Commercial Importance	Subsistence Importance	Recreational Importance	Sediment Exposure	Spawning in Study Area	Benthic Food Preference	Important as Prey	High Fecundity	High Growth Rate	Age to Maturity	Feasibility To Study	Information Availability	Total
Weighting Factor	2	2	2	2	2	1	1	1	1	1	1	1	2	2	
Goldeye	0	0	0	0	0	No	No	Yes	Yes	3	2	2	0	2	11
Longnose Sucker	4	0	0	0	0	Yes	Yes	Yes	Yes	2	2	2	6	4	24
Northern Pike	2	0	0	0	0	No	No	No	No	3	2	3	2	4	16
Walleye	4	0	1	0	0	No	Yes	No	No	3	2	2	4	4	21
Lake Whitefish	4	0	1	0	0	No	?	Yes	Yes	2	2	2	4	4	21
White Sucker	2	0	0	0	0	Yes	Yes	Yes	Yes	2	2	3	4	4	21
Flathead Chub	2	0	0	0	0	No	Yes	Yes	Yes	1	2	3	4	4	19
Emerald Shiner	2	0	0	0	0	No	Yes	Yes	Yes	1	?	3	4	4	17
Trout - Perch	6	0	0	0	0	Yes	Yes	Yes	Yes	1	1	3	6	2	23
Lake Chub	6	0	0	0	0	No	?	Yes	Yes	?	?	3	2	2	15
Mountain Whitefish	2	0	0	0	0	No	No	Yes	Yes	2	2	2	0	4	14
Burbot	2	0	0	0	0	Yes	No	No	No	2	2	2	0	2	11
Arctic Grayling	4	2	0	0	0	No	Yes	Yes	No	2	2	2	0	4	18
Bull Trout	2	4	0	0	0	Yes	?	No	No	2	3	2	0	2	16

No = 0
Yes = 1
? = 0
(See Table C-1 for Scoring Criteria. All scores in this table multiplied by weighting factor.)

D METHODS

D1.0 APPROACH

The general approach followed in this assessment is based on:

1. Defining pertinent issues of concern to stakeholders;
2. Developing impact hypotheses that describe the mechanisms through which project activities may affect aquatic resources and resource use;
3. Collecting and analyzing data to evaluate the hypotheses; and
4. Quantifying the degree of concern of potential impacts in terms of the magnitude and probability of occurrence.

D2.0 IDENTIFICATION OF ISSUES

Identification of pertinent issues is the critical first step in conducting an assessment of potential impacts of the new mine development on aquatic resources in the local and regional study areas. A number of issues were identified in the EIA scoping study and by Suncor. Issues that are pertinent to stakeholders were identified through three separate activities:

- Public meetings and workshops for the general public and government regulators;
- Review of historical data and reports pertinent to the study area; and
- Findings of the Oil Sands Water Release Technical Working Group (OSWRTWG).

D2.1 STAKEHOLDER CONSULTATION

A series of workshops were held to explain aspects of the Steepbank Mine project and solicit input from stakeholders. Stakeholders include First Nations, area residents, Suncor employees, interested organizations, and regulators (government agencies). Issues pertaining to aquatic impacts identified during these workshops and from ongoing consultations with stakeholders are summarized in Table I-1 (Appendix I).

D2.2 HISTORICAL OVERVIEW

Many studies have been conducted over the past two decades that are relevant to aquatic resource issues in the lower Athabasca River. These studies are described in detail in Golder (1996a). In total, more than 30 reports have been reviewed and relevant issues raised in these studies are summarized in Table I-1.

D2.3 OSWRTWG

The Oil Sands Water Release Technical Working Group (OSWRTWG) was jointly formed by industry together with provincial and federal government regulators and scientists to examine issues related to potential water releases from oil sands operations. The goal of OSWRTWG was to outline the scope of work needed to evaluate the acceptability of releasing process-affected waters to the environment. The findings of that work are detailed in OSWRTWG (1996) and pertinent issues identified by OSWRTWG are included in Table I-1.

D3.0 DEVELOPMENT OF IMPACT HYPOTHESES

Development of testable hypotheses for evaluating the potential impacts of mine development on aquatic resources requires:

- review of mine development plans so that pertinent activities can be identified,
- development of linkage diagrams that illustrate how the mine development activities are connected to the issues of concern,
- identification of impact hypotheses for evaluating the potential impact of mine development activities on aquatic resources, and
- evaluation of testable hypotheses to assess effect of mine life-cycle activities on measurable endpoints.

A detailed description of mine development plans is provided in Suncor (1996). Major mine development activities and related impact hypotheses are summarized in Table D3.0-1.

TABLE D3.0-1

SUMMARY OF MINE DEVELOPMENT PLANS AND FIXED PLANT EXPANSION

DEVELOPMENT ACTIVITY	POTENTIAL IMPACT - HYPOTHESIS
CONSTRUCTION	
Barge	
- Facility Construction	29, 32, 33
- Accidental Spills	30, 32, 33
- Barge Operation	29, 32, 33
- Dredging	29, 32, 33
Bridge	
- Ice Bridge	29, 32, 33
- Facility Construction	29, 32, 33
- Coffer dam/diversions	30, 32, 33
- Accidental Spills	30, 31, 32
- Abutments	29, 32, 33
Mine Construction	
- Transportation Corridor	29, 32, 33
OPERATION	
Bridge	
- Surface Runoff	30, 31, 32, 33, 34
- Hydrotransport spills/leaks	30, 31, 32, 33, 34
- Piers/Abutments	29, 32 33
Mine Operation	
- Dyke & Facilities Road Construction	29, 32, 33
- Mining Pits 1 and 2	29, 32, 33
Operational Waters	
- Refinery Effluent	30, 31, 32, 33, 34
- Mine Drainage Water	30, 31, 32, 33, 34
- Sewage Effluent	30, 31, 32, 33, 34
- Changes in surface and subsurface flow patterns	28, 29, 30
RECLAMATION	
Bridge	
Bridge Piers/Abutments	29, 32, 33
Mine Reclamation	
Drainage Reclamation	29
Reclamation Waters	
- CT Release Water	30, 31, 32, 33, 34
- Sand Dyke Drainage Water	30, 31, 32, 33, 34
- Changes in surface and subsurface flow patterns	28, 29, 30
Restoration of Leggett and Unnamed Creek	29, 32, 33

Most aquatics issues pertain directly or indirectly to the viability of fish populations, particularly as they relate to recreational, subsistence or commercial use. Seven primary categories of aquatic issues were addressed: aquatic habitat in the Steepbank River, aquatic habitat in the Athabasca River, aquatic ecosystem health, fish flesh quality, fish abundance, use of the fish resource and downstream use of Athabasca River water. The linkages among mine development activities, modes of impact and aquatic issues (as represented by impact hypotheses) are depicted in Figure D3.0-1. Impact hypotheses are as follows:

Hypothesis 28 Construction, operational or reclamation activities might adversely affect aquatic habitat in the Steepbank River.

Hypothesis 29 Construction, operational or reclamation activities might adversely affect aquatic habitat in the Athabasca River.

Hypothesis 30 Water releases associated with construction, operational or reclamation activities might adversely affect aquatic ecosystem health in the Athabasca or Steepbank Rivers.

Hypothesis 31 Water releases associated with construction, operational or reclamation activities might adversely affect the quality of fish flesh.

Hypothesis 32 Construction, operational or reclamation activities might lead to changes in aquatic habitat and/or aquatic ecosystem health which might result in a decline in fish abundance in the Athabasca or Steepbank Rivers.

Hypothesis 33 Construction, operational or reclamation activities might lead to changes in fish abundance or quality of fish flesh which might result in a decreased use of the fish resource.

Hypothesis 34 Construction, operational or reclamation activities might cause changes in Athabasca River water quality which might limit downstream use of the water.

D4.0 DATA COLLECTION AND ANALYSIS

A large database of historical data and technical reports was reviewed and incorporated, where appropriate, into this assessment. The primary sources of historical data include:

- Alberta Environmental Protection surface water quality monitoring data and reports,
- Northern River Basins Studies (NRBS),
- Panel for Energy Research and Developments (PERD) studies, and
- Oil sands industry technical reports.

In addition, a number of specific data collection activities were carried out in 1995 to further document existing (baseline) conditions and to provide information for testing the hypotheses discussed above. All work conducted for the Suncor Environmental Impact Assessment was carried out under a detailed Quality Assurance Project Plan (QAPP). The QAPP is presented in a separate document (Golder 1995) and specific details are provided in appendices to the background reports.

The data collection activities are synthesized in the following reports and summarized below:

- Steepbank Mine Baseline Aquatics Study (Golder 1996a),
- Fish Health Laboratory Study (HydroQual 1996), and
- Fish Tainting Study (Golder 1996b).

D4.1 STEEPBANK MINE BASELINE AQUATICS STUDY

The Steepbank Mine baseline aquatics study (Golder 1996a) included field surveys of several components of the aquatic ecosystem in the vicinity of Suncor (see Section B and Figure B-3) for a description of the study area). Data was collected on water quality (surface, porewater and sediment), benthic communities, fish habitat, fish communities and fish health. The rationale for the scope and design of each component of the study is described below.

D4.1.1 Water Quality

The water quality surveys developed for the Athabasca and Steepbank Rivers and other minor tributaries were based on collecting data for conventional parameters and trace organic compounds such as Polycyclic Aromatic Hydrocarbons (PAHs) associated with the McMurray Formation deposits. The rationale for the list of parameters that were tested is documented in Golder (1996c). Water quality was sampled in spring, summer and fall of 1995.

D4.1.2 Benthic Invertebrates

The benthic invertebrate surveys of the Athabasca and Steepbank Rivers were intended to verify the accuracy of the historical data regarding benthic invertebrate abundance, community composition and tissue chemical levels in the study area and to extend the spatial coverage of the available data by sampling areas previously not surveyed. Benthic invertebrates were sampled from natural substrates (i.e., natural habitats) and from artificial substrates[1].

D4.1.3 Fish Habitat

The key issues related to the proposed development of the Steepbank Mine with respect to fish habitat include: the potential for loss of recreational, subsistence or commercial fish production due to direct or indirect toxic effects and loss of critical habitats that precludes future fish production. In addition to addressing the above issues, it was necessary to verify habitat information documented in previous surveys. Therefore, the reaches of the Athabasca and Steepbank Rivers within the local study area were mapped. Physical habitat measurements included major habitat types, bank types, special habitat features, cover and channel types. Transects through representative habitat types were also taken to define riverbed contour, substrate and water velocity.

1 Artificial substrates are rock filled baskets that benthic invertebrates will colonize. They provide a standard substrate type for comparison of benthic invertebrate community structure among sites.

Habitat mapping of the Athabasca and Steepbank River was done primarily in the fall (between 3 and 14 October, 1995), when low flows and relatively clear water facilitated documentation of substrate type.

D4.1.4 Fish Community

Prior to 1995, major data gaps existed on the use of the Athabasca River in the vicinity of Suncor by fish for spawning, overwintering, summer feeding and rearing. Likewise, there were no published studies on Athabasca River fish population parameters since the 1974-75 studies of McCart et al. (1977). As well, information on fish habitat associations identifying critical habitats during the spring and fall spawning periods was limited. Therefore, the 1995 fish inventory surveys were developed with the intent of: (1) supplementing and confirming existing studies of the area; (2) documenting species presence and abundance in the study areas; and (3) filling the data gaps that existed with respect to fish population parameters in the Athabasca and Steepbank Rivers.

Habitat and fish inventory information from previous studies were utilized in the selection of sampling locations. For game and commercial fish species, sampling areas were selected that were representative of the habitats available within the study area and special habitat features such as tributary confluences. Sampling areas for game and commercial fish species included: snye and backwater areas, side channel habitat, and, potential spawning, rearing, feeding and overwintering habitats. Sampling areas for small fish species were restricted to areas that provided potential habitat for this species assemblage, including peripheral channel edge areas, backwaters and sandbar areas of shallow depths and slow velocities.

Fisheries sampling was conducted on a seasonal basis and included the following periods: spring spawning/migration prior to freshet (between 10 May and 2 June, 1995); mid-summer (between 28 July and 15 August, 1995); and fall spawning/migration (between 26 September and 16 October, 1995).

D4.1.5 Fish Health

There are several issues of concern related to fish health in the Steepbank Mine area:

- lack of chemical data for fish species most abundant in the study area;
- potential for loss of recreational, subsistence or commercial fish production due to direct or indirect impacts related to water releases;
- concerns for people's health from consumption of fish; and
- aesthetic concerns in relation to tainting of fish which might limit the use of the resource.

Since information on fish health in the vicinity of the Steepbank Mine was minimal, a fish health study was conducted in 1995 concurrently with the fish habitat and inventory studies. This study provided data on the chemical levels in fish tissue and the current state of fish health and provided a baseline for future monitoring. Fish tainting and exposure were addressed in laboratory studies by Golder (1996) and HydroQual (1996).

Fish health data were collected for the three VEC species: walleye, goldeye and longnose sucker. Walleye and goldeye were collected from the Athabasca River in the summer and longnose sucker were collected from the Muskeg River in the spring. The field study included collecting information from a suite of indicators, representing several levels of biological organization: biochemical, physiological, whole-organism, population and community. This suite of indicators produced baseline information about various levels of biological response to stress. The suite of indicators was necessary because stress effects on fish cannot be adequately evaluated by measurement of either a single response or several responses displayed at only one level of biological organization (Adams and Ryon 1994).

Biochemical and physiological indicators measured in the 1995 study included: mixed function oxidase activity (measured as ethoxyresorufin-o-deethylase (EROD) and aryl hydrocarbon hydroxylase (AHH), PAH metabolites in bile, PAH and metal concentrations in fillets, lactate, protein and glucose in blood serum, retinol in liver, and circulating sex steroids.

Whole-organism measurements are longer-term indicators of the overall response of an individual organism to stress. The whole-organism indicators measured were: condition factor, liver size, gonad size, fecundity, fat content, gross pathology and histopathology.

Population and community parameters are indicators of long-term responses that integrate the exposure to stressors over both time and space. These parameters are generally more ecologically relevant than those measured at lower levels of organization (e.g., physiological parameters), since they are directly related to survival, growth and reproduction of fish species (Adams et al. 1989). Population and community parameters assembled as part of the 1995 study included age-frequency, size-at-age, community species composition (presence/absence), and habitat utilization.

D4.2 FISH HEALTH LABORATORY STUDY

A series of laboratory studies were conducted by HydroQual (1996) to test the effects of exposure to oil sands wastewater on fish health. The studies included 4-day, 7-day and 28-day experiments. The 4-day experiments involved exposure of juvenile rainbow trout fingerlings to consolidated tails (CT) water, dyke seepage water, refinery wastewater and Athabasca River water from downstream of Syncrude and Suncor. The primary measurement endpoint for these short-term experiments was induction of the MFO system, measured as EROD activity. The 7-day and 28-day laboratory experiments involved exposure of juvenile walleye and rainbow trout as well as larval rainbow trout to a series of dilutions of Tar Island Dyke (TID) water, plus Athabasca River water and a 1% naphthenic acid solution. Endpoints included: survival, growth (weight gain over a 28-day period), condition factor, relative liver size, blood chemistry, blood cell counts, EROD induction, gross external and internal pathology, histopathology, swimming stamina and resistance to a bacterial challenge.

D4.3 FISH TAINTING STUDY

Golder (1996b) conducted a study to determine the possibility of fish flesh tainting (flavour impairment) from exposure to Suncor wastewater. Rainbow trout were exposed to different water regimes (0.5% Tar Island Dyke water, 0.5% Refinery Effluent Water, Athabasca River Water) for 14 days in the laboratory. Caged fish were also held for 14 days in the Athabasca River upstream of all of Suncor's water release points. Fillets from these fish were then submitted to a taste-test panel to determine the relationship between exposure of the fish to different water regimes and the flavour of the fillets.

D5.0 DEFINITION OF DEGREE OF CONCERN

Selecting appropriate criteria for defining and quantifying the degree of concern of the potential impact is an important component of the assessment. For this assessment, degree of concern integrates ecological and societal values and is defined as a function of the direction, severity, duration, and geographic extent of the effect. In particular, these attributes are explicitly defined as follows:

> Direction may be positive, neutral or negative with respect to the assessment endpoints (e.g., gain of spawning habitat for longnose sucker would be classed as positive whereas an increase in tainting would be negative).

Severity is a measure of the degree of change of a measurement endpoint and defined as:

- Negligible: No measurable change.
- Low: Measurable change but less than or equal to 10% change in measurement endpoints (e.g., gain of less than or equal to 10% in fish tumors, loss of less than 10% of overwintering habitat in the Steepbank River).
- Moderate: Change of greater than 10% but less than or equal to a 20% change in measurement endpoints.
- High: Greater than 20% change in measurement endpoints.

These definitions for degree of concern are conservative compared to that proposed by Suter et al. (1995) for characterizing ecological risks. Suter et al. (1995) presented evidence from water quality criteria, effluent toxicity tests and biological surveys, all of which indicate that a 20% reduction in ecological parameters is negligible with respect to population sustainability (Suter et al. 1995).

Duration refers to the length of time over which an environmental effect occurs and considers both the length of time over which the effect occurs and whether the effect is reversible once the source of the effect is removed. Reversibility is an indicator of how quickly the ecological endpoint might recover from the impact. In some cases, reversibility of effect is closely tied to duration (e.g., in the case of temporary loss of habitat due to barge construction). In other cases, the effect may extend well beyond the time period over which the activity creating the effect stops (e.g., a spill of chemicals might result in longer-term effects on fish health). Duration is defined as:

- Short-term: Effect restricted to the time period of the activity causing the effect, where the cause is of short duration and the effect is highly reversible. For example, an impact such as loss of spawning habitat for one spawning season would be a short-term impact because it would have no long-term effect on the reproductive success of the fish population.
- Medium-term: Effect extends for less than 30 years beyond the completion of the activity causing the effect and the effect is reversible, either by natural recovery processes (e.g., immigration) or by mitigation (e.g., stream bed enhancement).
- Long-term: Effect extends for more than 30 years beyond the completion of the activity causing the effect, and the effect is essentially irreversible, either by natural recovery processes or by mitigation.

Geographic extent refers to the area affected by the impact and is defined as:

- Local: Effect restricted to the local study area as defined in Section B.
- Regional: Effect extends beyond local study area into regional study area as defined in Section B.
- Beyond Regional: Effect extends beyond the regional study area.

The attributes listed above are defined for each hypothesis in which a pathway exists that links site activity to potential impact. Degree of concern is defined explicitly in Table D5.0-1 and described in a more general manner below:

- Nil: Impacts that are negligible in severity.
- Low: Impacts that are low in severity, restricted to the local area, and of short to medium duration.
- Moderate: Impacts that are intermediate between low and high.
- High: Moderate or high impact that is of long-term duration and/or extends beyond the regional area.

TABLE D5.0-1

DEFINITIONS OF DEGREE OF CONCERN FOR AQUATIC IMPACT HYPOTHESES

Direction	Severity	Duration	Extent	Degree of Concern
Negative	Negligible	Short	Local	Nil
			Regional	Nil
			Beyond	Nil
		Medium	Local	Nil
			Regional	Nil
			Beyond	Nil
		Long	Local	Nil
			Regional	Nil
			Beyond	Nil
	Low	Short	Local	Low
			Regional	Low
			Beyond	Low
		Medium	Local	Low
			Regional	Moderate
			Beyond	Moderate
		Long	Local	Low
			Regional	Moderate
			Beyond	Moderate
	Moderate	Short	Local	Moderate
			Regional	Moderate
			Beyond	High
		Medium	Local	Moderate
			Regional	High
			Beyond	High
		Long	Local	Moderate
			Regional	High
			Beyond	High
	High	Short	Local	Moderate
			Regional	High
			Beyond	High
		Medium	Local	Moderate
			Regional	High
			Beyond	High
		Long	Local	High
			Regional	High
			Beyond	High

E EXISTING ENVIRONMENT

E1.0 INTRODUCTION

A comprehensive field study was conducted in 1995 to:

- describe current conditions with respect to surface water, porewater and sediment quality, benthic invertebrates, fish habitat, fish communities and fish health; and
- provide a baseline for comparing future conditions.

The scope of each component is described in Section D4 and sampling stations are shown in Figures E1.0-1 and E1.0-2. The present study builds on the existing regional database formed by the Alberta Oil Sands Environmental Research Program (AOSERP), Northern River Basin Study (NRBS) and Alberta Environmental Protection studies. Details of the 1995 field study are given in Golder (1996a) and findings are summarized below:

- Naturally-occurring hydrocarbons can be found in river sediments and porewater; however, no significant changes in surface water chemistry are associated with Athabasca oil sands deposits or existing oil sands facilities.
- Benthic invertebrate communities are thriving and show no evidence of negative effects associated with exposure to naturally occurring hydrocarbon deposits or existing oil sands developments.
- Fish habitat in the Athabasca River within the study area is relatively poor for the endemic fauna because of the homogeneous habitat and shifting sand bottom. High quality habitat exists in the Steepbank River.
- There are diverse fish communities in the Athabasca and Steepbank River basins.
- There is evidence of exposure of fish to naturally-occurring hydrocarbons, although fish fitness and health indicators suggest that fish populations are healthy.

Laboratory studies were also performed in 1995 to explore the effects of Suncor wastewater on fish health (HydroQual 1996), fish tissue concentrations (HydroQual 1996) and the potential for tainting (flavour impairment) of fish flesh (Golder 1996b).

E2.0 SURFACE WATER, POREWATER AND SEDIMENT QUALITY

E2.1 SURFACE WATER QUALITY

Surface water quality was monitored in spring, summer and fall of 1995 in the Athabasca and Steepbank Rivers, several small tributaries of the Athabasca River, and Shipyard Lake. Sampling sites are shown in Figures E1.0-1 and E1.0-2. With the exception of the Athabasca River, none of these water bodies receive wastewater from anthropogenic sources.

River water within the study area is moderately alkaline with low to moderate dissolved salt concentrations and low to moderate levels of nutrients (Tables E2.0-1 and E2.0-2). Relatively high dissolved organic carbon concentrations indicate the influence of muskeg drainage. Concentrations of metals were non-detectable to low in all waterbodies sampled, with the exception of occasionally elevated metal levels associated with high suspended solid levels. Levels of organic chemicals in surface water were not markedly affected by naturally-occurring deposits of oil sands, although total hydrocarbons, PAHs, and naphthenic acids were detected at low concentrations in a few water samples. Water chemistry of Shipyard Lake was similar to that of Poplar, McClean, Wood and Leggett Creeks (Table E2.0-3).

Seasonal variability in water quality was low in the Steepbank River (Table E2.0-2). However, in the Athabasca River high summer flows caused a large increase in suspended sediments, which resulted in increased concentrations of associated water quality variables (e.g., nutrients, dissolved organic carbon, metals such as aluminum and iron) (Table E2.0-1).

TABLE E2.0-1

WATER QUALITY OF THE ATHABASCA RIVER

Parameter	Units	Above Ft. McMurray (1985-1995)*				Above Lease 19 (1995)			Below Lease 25 (1995)	
		Spring	Summer	Fall	Winter	Spring	Summer	Fall	Spring	Summer
Conventional Parameters and Nutrients										
pH		8.0	8.1	8.1	7.9	7.8	7.6	7.8	7.9	7.6
Total Dissolved Solids	mg/L	223	127	181	251	141	120	146	145	123
Non-Filterable Residue	mg/L	14	55	6	2	19	624	4	23	676
Dissolved Organic Carbon	mg/L	7.6	3.9	5.2	7.3	7.1	16.7	9.2	7.6	16.1
Hydrocarbons, Recoverabl	mg/L	--	--	--	--	<1	1	<1	<1	<1
Oil and Grease	mg/L	0.3	0.2	0.2	0.2	--	--	--	--	--
Total Ammonia	mg/L	0.02	<0.01	0.01	0.04	<0.01	0.04	<0.01	<0.01	0.04
Total Phosphorus	mg/L	0.064	0.045	0.016	0.019	0.048	0.390	0.028	0.040	0.440
Metals (Total)										
Aluminum	mg/L	0.02	0.60	0.08	0.03	0.17	8.64	0.11	0.15	10.10
Arsenic	mg/L	0.0004	0.0008	0.0008	0.0005	0.0006	0.0070	0.0005	0.0008	0.0070
Cadmium	mg/L	<0.001	0.001	<0.001	0.001	<0.003	<0.003	<0.003	<0.003	<0.003
Iron	mg/L	0.23	1.89	0.78	0.2	0.43	17.90	0.91	0.43	19.40
Mercury	µg/L	<0.1	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	mg/L	0.002	0.001	0.002	0.001	<0.003	<0.003	<0.003	0.004	<0.003
Vanadium	mg/L	0.003	0.004	0.003	0.002	<0.002	0.009	0.003	0.004	0.015
Zinc	mg/L	0.005	0.008	0.009	0.010	0.019	0.085	0.017	0.019	0.095
Organics										
Total PAHs	µg/L	--	--	--	--	ND	ND	ND	0.05	ND
Naphthenic Acids	mg/L	--	--	--	--	<1	<1	<1	<1	<1
Bacteria										
Total Coliforms	#/100 mL	68	24	44	28	--	--	--	--	--
Fecal Coliforms	#/100 mL	<4	10	14	4	--	--	--	--	--
Toxicity										
Microtox IC50	%	--	--	--	--	>100	>100	>100	>100	>100

NOTES:

* Median values; Data from NAQUADAT

ND = Not detected

-- = Not analyzed

TABLE E2.0-2

WATER QUALITY OF THE STEEPBANK RIVER

Parameter	Units	Near Mouth (1980-1989)*		At Mouth (1995)**			At Lease 19 Border (1995)		
		Spring	Winter	Spring	Summer	Fall	Spring	Summer	Fall
Conventional Parameters and Nutrients									
pH		8.2	7.8	7.9	7.9	7.8	7.4	7.7	7.7
Total Dissolved Solids	mg/L	342	355	134	100	127	111	87	115
Non-Filterable Residue	mg/L	--	5	<0.4-11	3	<0.4-1	<0.4	4	<0.4
Dissolved Organic Carbon	mg/L	12.6	12.5	16.3	23.1	23.4	15.7	23.3	22.6
Oil and Grease	mg/L	--	0.4	--	--	--	--	--	--
Hydrocarbons, Recoverable	mg/L	--	--	<1-1	<1	<1	1	2	<1
Total Ammonia	mg/L	0.06	0.06	<0.01-0.01	0.08	<0.01-0.02	0.02	0.07	0.03
Total Phosphorus	mg/L	0.059	0.074	0.038	0.030	0.043	0.057	0.041	0.038
Metals (Total)									
Aluminum	mg/L	0.01	0.07	<0.01	0.03	0.05	<0.01	0.05	0.02
Arsenic	mg/L	0.0006	--	0.0003	0.0004	<0.0002-0.0002	0.0004	0.0004	<0.0002
Cadmium	mg/L	0.002	--	<0.003-0.003	<0.003-0.003	<0.003	<0.003	0.005	<0.003
Iron	mg/L	0.83	0.81	0.43	0.65	0.71	0.81	0.74	0.57
Mercury	µg/L	<0.0001	<0.0001	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	mg/L	0.003	--	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Vanadium	mg/L	0.005	<0.001	<0.002-0.003	0.004	<0.002-0.003	0.004	0.004	<0.002
Zinc	mg/L	0.012	0.010	0.042	0.038	0.015	0.162	0.029	0.012
Organics									
Naphthenic Acids	mg/L	--	--	<1	<1	<1	<1	<1	<1
Total PAHs	µg/L	--	--	ND	ND	0.02	--	--	--
Bacteria									
Total Coliforms	#/100 mL	--	0	--	--	--	--	--	--
Fecal Coliforms	#/100 mL	--	6	--	--	--	--	--	--
Toxicity									
Microtox IC50	%	--	--	>100	>100	>100	>100	>100	>100

NOTES:

ND = Not detected

-- = Not analyzed

* Median values; Data from NAQUADAT

** Mean of three measurements; range shown if at least one value was below the detection limit

TABLE E2.0-3

WATER QUALITY OF SHIPYARD LAKE AND ATHABASCA RIVER TRIBUTARIES

Parameter	Units	Shipyard Lake Outlet (1995)			McLean Cr. at Mouth (1995)			Wood Cr. at Mouth(1995)			Legget Cr. at Mouth (1995)		Poplar Cr. near Mouth (1980-84)[2]				Poplar Cr. at Mouth (1995)		
		Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Summer	Fall	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Conventional Parameters and Nutrients																			
pH	units	7.6	7.8	7.6	7.7	8.2	8.0	7.9	8.2	8.1	7.6	7.4	7.8	8.1	8.0	8.0	7.9	8.3	8
Total Dissolved Solids	mg/L	268	190	196	339	156	167	328	191	207	167	188	270	253	259	471	273	203	206
Non-Filterable Residue	mg/L	30	2	79	46	17	1	9	87	5	10	211	9	6	6	8	2	4	117
Dissolved Organic Carbon	mg/L	25.5	25.4	25.6	12.0	21.9	21.4	12.3	27.5	23.0	25.7	26.2	20.9	26.6	27.4	26.8	21.9	22.5	25.3
Oil and Grease	mg/L	-[1]	-	-	-	-	-	-	-	-	-	-	0.4	0.4	0.6	1.3	-	-	-
Hydrocarbons, Recoverable	mg/L	<1	<1	<1	<1	1	<1	<1	9	<1	<1	<1	-	-	-	-	<1	<1	<1
Total Ammonia Nitrogen	mg/L	0.06	0.06	0.03	0.03	0.05	<0.01	0.01	<0.01	<0.01	0.03	0.03	0.05	0.05	0.05	0.17	0.02	0.07	0.02
Total Phosphorus	mg/L	0.075	0.030	0.102	0.048	0.033	0.014	0.037	0.049	0.021	0.019	0.196	0.051	0.040	0.041	0.040	0.031	0.023	0.043
Metals (Total)																			
Aluminum	mg/L	0.30	0.03	1.09	0.29	0.28	0.06	0.06	1.12	0.09	0.14	1.89	0.07	0.16	0.05	0.27	0.03	0.1	0.31
Arsenic	mg/L	0.0018	0.0008	0.001	0.0002	0.0003	0.0008	0.0003	0.0015	0.0003	0.0005	0.0012	0.0010	0.0018	0.0007	-	0.0005	0.0005	0.0005
Cadmium	mg/L	0.003	<0.003	<0.003	<0.003	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.001	<0.001	<0.001	<0.003	<0.003	0.003
Iron	mg/L	3.28	1.16	3.29	0.89	0.77	0.41	0.64	2.22	0.38	0.76	4.81	0.66	0.71	0.96	0.72	0.42	0.71	1.10
Mercury	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.0001	<0.0001	<0.0001	<0.0001	<0.05	<0.05	<0.05
Molybdenum	mg/L	0.003	<0.003	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	0.004	<0.001	<0.001	<0.001	-	<0.003	<0.003	<0.003
Vanadium	mg/L	0.002	0.002	<0.002	<0.002	0.007	<0.002	<0.002	<0.002	<0.002	0.006	0.008	0.001	0.001	0.001	<0.001	<0.002	<0.002	0.004
Zinc	mg/L	0.047	0.051	0.039	0.023	0.066	0.024	0.032	0.043	0.023	0.038	0.035	0.004	0.003	0.009	0.006	0.012	0.080	0.038
Organics																			
Naphthenic Acids	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	6	<1	<1
Toxicity																			
Microtox IC50	%	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	-	-	-	-	>100	>100	>100

NOTES:

[1] Data not available

[2] Median values; data from NAQUADAT

Surface water quality has not changed in the study area over the last decade as indicated by comparison of the 1995 data with historical data from the Alberta Environmental Protection NAQUADAT Database. As in previous years, wastewater discharges from Suncor did not have a discernible effect on the water quality of the Athabasca River (Hamilton et al. 1985, Noton and Shaw 1989, Noton and Saffran 1995).

E2.2 SEDIMENT QUALITY

Bottom sediment chemistry was assessed at one reference site in the Athabasca and Steepbank Rivers and at one site adjacent to Tar Island Dyke (TID) in the Athabasca River (Table E2.0-4). Athabasca River sediments contained detectable, but low levels of PAHs, as was also reported in a study conducted in 1994 (Golder 1994a). Hydrocarbon content was elevated at all three sites sampled, indicating the presence of varying amounts of oil sands in the sediments. Levels of metals were typical of sediments from other large rivers in Alberta (e.g., North Saskatchewan River; Shaw et al. 1994). In the Steepbank River, bottom sediments contained variable amounts of naturally-occurring hydrocarbons, and levels of metals were similar to those in the Athabasca River. Sediment chemistry adjacent to TID was similar to that at other locations in the Athabasca River and was not apparently affected by TID seepage (Table E2.0-4).

E2.3 POREWATER QUALITY

Porewater chemistry at reference sites (i.e., sites not affected by anthropogenic activities) in the Athabasca and Steepbank Rivers was variable in terms of concentrations of major ions, dissolved salts, ammonia and PAHs depending on the amount of oil sands in the substratum (Table E2.0-5). Naphthenic acid concentrations were low to moderate at all sites, and none of the samples were toxic, as evaluated by the Microtox™ test.

TABLE E2.0-4

SEDIMENT QUALITY OF THE ATHABASCA AND STEEPBANK RIVERS

Parameters	Units	Athabasca River 1994[1]			Athabasca River 1995			Steepbank River 1995			
		1 km Above TID[2]	At TID	At TID	1 km Above TID	At TID	At TID	At Lease 19 Border		At Mouth	
		Left Bank[3]	Right Bank	Left Bank	Left Bank	Right Bank	Left Bank	Spring	Fall	Spring	Fall
Total Organic Carbon	Weight %	1.07	1.31	0.49-1.61	1.39	0.49	1.02	1.36	2.17	2.12	3.51
Hydrocarbons, Recoverabl	mg/kg	-	-	-	2160	450	703	154	247	5720	17833
Total PAHs	µg/L	0.09	0.14	ND-0.13	0.66	0.07	0.13	-	-	0.73-1.65	37.76-76.81
Metals											
Aluminum	mg/kg	6420	7670	4250-7740	3910	3730	4890	3950	4990	3333	2330
Arsenic	mg/kg	1.7	2.1	1.3-2	0.6	0.9	1	1.1	1.7	1.0	1.2
Cadmium	mg/kg	<0.3	<0.3	<0.3	<0.3	0.6	0.5	<0.3	<0.3	0.3	<0.3
Iron	mg/kg	13600	16400	0200-1480	11000	9820	13100	10400	12600	10237	7280
Mercury	µg/kg	23	25	<20-27	25	36	30	<20	28	<20	<20
Molybdenum	mg/kg	1	1.2	0.9-1.4	<0.3	0.4	0.5	<0.3	1	<0.3	0.9
Vanadium	mg/kg	18.8	19.4	14-19.8	14.7	12.8	14.5	13.0	15.4	13.0	12.1
Zinc	mg/kg	35.6	43.6	26.3-46.1	29.9	27.6	39.6	22.8	30.5	24.2	15.7
Toxicity											
Microtox Screen	% Control	73-99	118	91-120	-	-	-	-	-	-	-

NOTES:

[1] Golder Associates (1994)

[2] Tar Island Dyke, Suncor

[3] Left bank, facing downstream

- = Not analyzed

ND = Not detected

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TABLE E2.0-5

POREWATER CHEMISTRY AND TOXICITY IN THE ATHABASCA RIVER AND STEEPBANK RIVER COMPARED WITH NATURAL AND PROCESS-AFFECTED POREWATER

Site or Water Type	Sodium (mg/L)	Total Dissolved Solids (mg/L)	Naphthenic Acids (mg/L)	Total Ammonia (mg/L)	Total PAHs (µg/L)	Microtox Screen (% Control)	Microtox IC50 (%)
Athabasca R. 1 km above TID[1], West Bank	1210	3220	17	0.78	0.04	-	>100
Athabasca River at TID, Left Bank	12.8	259	<1	0.58	ND	-	>100
Athabasca River at TID, Right Bank	423	1730	<1	0.59	ND	-	>100
Steepbank River at Lease 19 Border	11.5-26.1	125-228	<1-5	0.03-0.06	ND-0.03	-	>100
Steepbank River near Lot 3	380-5120	1370-14500	3-16	0.5-3.01	1.21-33.7	-	>100
Steepbank River at Mouth	12.6-26.5	240-374	2-4	0.47-0.62	ND-0.84	-	>100
Natural Porewater[2]	11.6-148	192-954	<1-13	0.01-0.72	ND-1	100	-
Intermediate Porewater[2]	62.1-306	234-1422	7-34	0.07-1.70	0.13-3	100	-
Process-affected Porewater[2]	100-336	309-948	19-68	0.44-4.51	ND-9.12	29-100	-

NOTES:

[1] Tar Island Dyke, Suncor

[2] Data from Golder Associates (1995a)

- = Not analyzed

ND = Not Detected

E3.0 BENTHIC INVERTEBRATES

E3.1 COMMUNITY STRUCTURE

Benthic invertebrate communities were surveyed during the fall of 1995 in the Athabasca and Steepbank Rivers (Figures E2.0-1 and E2.0-2). Various sampling techniques were used depending on habitat characteristics at the sampling sites (artificial substrates, Ekman grab, Neill cylinder). Both artificial and natural substrates were sampled in the Athabasca River. The Athabasca River is a relatively unproductive system compared to other large rivers in Alberta, and consequently invertebrate density is low.

The abundance of benthic invertebrates colonizing artificial substrates in the Athabasca River varied moderately among sites, but was similar at sites above and below Suncor discharge locations (Figure E3.0-1A). There was a trend of lower numbers of invertebrates on both banks downstream from the Steepbank River. Taxonomic richness (total number of taxa) and the composition of the benthic fauna were generally similar at all sampling sites on the Athabasca River (Figures E3.0-2A and E3.0-3A). Benthic invertebrates colonizing artificial substrates were dominated by stonefly nymphs and Plecoptera midge larvae (chironimidae). Chironomid dominance was most pronounced at the mouth of Poplar Creek and 5 km below the Steepbank River on the east bank, most likely due to greater amounts of organic detritus deposited from Poplar Creek and reduced current velocity relative to other sites, respectively. The benthic community colonizing artificial substrates was dominated by collector-gatherers and predators at all sampling sites in the Athabasca River.

Community composition and total abundance of benthic invertebrates were more variable on natural substrates in the Athabasca River than on artificial substrates, most likely as a result of greater variation in habitat characteristics. Taxonomic richness varied little among sites. On natural substrates the relative proportions of major functional feeding groups were similar to those on artificial substrates, but varied more among sites.

Results of the benthic invertebrate survey of the Athabasca River suggest that biological effects were absent at sites exposed to discharges from Suncor. Although not directly comparable to historical data due to differences in sampling locations and, potentially, habitat characteristics, results of this study are generally consistent with those of previous benthic surveys of the Athabasca River (McCart et al. 1977, Noton 1979, Barton and Wallace 1980, Noton and Anderson 1982).

Benthic communities in the Steepbank River varied moderately among sites, most likely as a result of differences in habitat characteristics. There was a trend of decreasing abundance and taxonomic richness from upstream to downstream stations, as well as a gradual decline in the proportion of chironomid larvae (Figures E3.0-1B, E3.0-2B and E3.0-3B). The relative proportions of different functional feeding groups were similar at all sites. The changes in benthic communities with distance downstream appeared to parallel the variation in current velocity and substratum composition.

E3.2 TISSUE CHEMISTRY

Concentrations of most metals analyzed were detectable in benthic invertebrate tissues, and were similar at all sites (Table E3.0-1). Concentrations of PAHs and PANHs were non-detectable or near the detection limit at the sites sampled in the Athabasca River. In the Steepbank River, concentrations of several organic compounds, particularly substituted phenanthrenes/anthracenes and dibenzothiophenes, were elevated relative to the other sites sampled, but levels were relatively low. These results probably reflect differences in the amount of oil sands present in the substratum in the rivers sampled. No marked differences in tissue concentrations of metals and organics were noted between samples taken in August 1994 and October 1995 in the Athabasca River.

TABLE E3.0-1

CONCENTRATIONS OF METALS IN BENTHIC INVERTEBRATE TISSUE FROM THE ATHABASCA RIVER, AUGUST 1994 AND OCTOBER 1995

Parameter	Units	August 1994[1]	October 1995 Station AT003
Antimony	µg/g	-	<0.2
Aluminum	µg/g	1330	1070
Arsenic	µg/g	0.9	<20
Barium	µg/g	24	29
Beryllium	µg/g	0.1	<0.1
Boron	µg/g	12	<1
Cadmium	µg/g	<0.3	<0.3
Calcium	µg/g	5110	3030
Chromium	µg/g	64.6	10.5
Cobalt	µg/g	3.3	1.4
Copper	µg/g	15.9	45
Iron	µg/g	3170	2400
Lead	µg/g	<2	<2
Lithium	µg/g	1.8	1.3
Magnesium	µg/g	1530	1530
Manganese	µg/g	166	314
Mercury	µg/kg	78	55
Molybdenum	µg/g	6.2	0.9
Nickel	µg/g	41	8.8
Phosphorus	µg/g	5640	5620
Potassium	µg/g	6610	6640
Selenium	µg/g	<0.2	<4
Silicon	µg/g	359	546
Silver	µg/g	2.4	0.4
Sodium	µg/g	7000	5140
Strontium	µg/g	15.4	16.4
Titanium	µg/g	22	16.4
Uranium	µg/g	<50	<50
Vanadium	µg/g	4.6	3.6
Zinc	µg/g	103	133

[1] Data from Golder (1994)

E4.0 FISH HABITAT

E4.1 ATHABASCA RIVER

The Athabasca River is a turbid cool-water habitat with dynamic shifting-sand channels. Single channels are the major channel type but near islands and sand bars, multiple channels are present. Islands in the study reach include the Stony/Willow Island complex and Inglis Island (Figure E1.0-1). Major habitat features include backwaters and snyes associated with islands and sandbars. The substrate is almost entirely sand with the exception of some rocky shoals along the east bank near Willow Island and McLean Creek. Instream cover is minimal except for that provided by depth and turbidity. River banks are mainly armoured or erosional with some depositional areas and one small area with cliffs.

E4.2 STEEPBANK RIVER

Habitat in the Steepbank River consists mainly of gravel/cobble/boulder substrate with pool/riffle and run/riffle sequences. Both gradients and the length of riffle areas decrease with distance downstream. The mid-reach of the river within the study area has defined meander bends and the riffles have less boulder and more cobble/gravel substrate than other reaches. The run/pool areas between the riffles are also slower in mid-reach with more fines and less instream cover from boulders than other reaches. The upper reach of the Steepbank River consists of swift, armoured riffles separated by run sections with the occasional pool occurring on meander bends. Riffles are less common than upstream, constituting 35% of the bottom area compared to 54% at the top of the study reach. Run is the most common type of habitat in this section of the river. Both runs and pools are fairly deep with good cover from boulders and fallen trees providing overhead cover along erosional bank areas.

E4.3 TRIBUTARIES

Habitat at the mouths of Unnamed Creek which drains Shipyard Lake and McLean and Wood Creeks was examined in the spring of 1995. Substrate at the creek mouths was dominated by fines and very little flow was present at the mouths of these creeks, making fish passage into the creeks unlikely. Since no fish habitat was present in Unnamed Creek, Shipyard Lake was not classified as fish habitat. (This conclusion will be confirmed by additional sampling in 1996.)

Similar to other small tributaries in the area, the mouth of Leggett Creek showed very little flow in the spring of 1995; water present at the mouth was backed up from the Athabasca River. Substrate at the mouth of Leggett Creek consists entirely of fines. Cobble/gravel substrate was present upstream of the mouth. A small wetlands (about 200 m long by 50 m wide) is present at the headwaters of Leggett Creek. Here the channel is poorly defined with substrate comprised entirely of fines and peat. Black spruce and larch dominate the wetlands vegetation.

Water at the mouth of Poplar Creek is slow and deep but less turbid than the Athabasca River. Substrate is all fines and deadfall is present at the creek mouth. Flows in Poplar Creek are affected by Ruth Lake, which drains into Poplar Creek through a spillway (Figure E1.0-1). Between the creek mouth and the confluence of the spillway there are long shallow runs and a series of riffles and pools with cobble/gravel substrate. Upstream of the spillway habitat consists mainly of sand/silt substrate and the occasional riffle and pool.

E5.0 FISH COMMUNITIES

E5.1 ATHABASCA RIVER

Fish inventory studies on the Athabasca River were carried out in spring, summer and fall of 1995 using a number of methods: boat electrofishing, backpack electrofishing, seining, gill netting, set lines, drift nets and minnow traps (see Figure E1.0-1 for sampling sites and Table E5.0-1 for common and scientific names of fish species). Twenty-seven species have been reported from the Athabasca River in the Suncor area (Table E5.0-2). In 1995, eighteen species were captured. Species abundance and distribution patterns are similar to those reported by the AOSERP studies of the late 1970s (McCart et al. 1977, Bond 1980, Tripp and McCart 1979, Tripp and Tsui 1980) and the recent NRBS fish inventories (R.L. &L. 1994). Fish species that use the Athabasca River near Suncor fall into two categories: migratory populations and resident fish species. Most of the large fish species are migratory (Figure E5.0-1).

TABLE E5.0-1

FISH SPECIES NAMES

SPECIES COMMON NAME	SCIENTIFIC NAME
Arctic Grayling	*Thymallus arcticus*
Brassy Minnow	*Hybognathus hankinsoni*
Brook Stickleback	*Culaea inconstans*
Bull Trout	*Salvelinus confluentus*
Burbot	*Lota lota*
Cisco	*Coregonus artedi*
Emerald Shiner	*Notropis atherinoides*
Fathead Minnow	*Pimephales promelas*
Finescale Dace	*Phoxinus neogaeus*
Flathead Chub	*Platygobio gracilis*
Goldeye	*Hiodon alosoides*
Iowa Darter	*Etheostoma exile*
Lake Chub	*Couesius plumbeus*
Lake Whitefish	*Coregonus clupeaformis*
Longnose Dace	*Rhinichthys cataractae*
Longnose Sucker	*Catostomus catostomus*
Mountain Whitefish	*Prosopium willamsoni*
Ninespine Stickleback	*Pungitius pungitius*
Northern Pike	*Esox lucius*
Northern Redbelly Dace	*Phoxinus eos*
Pearl Dace	*Semotilus margarita*
Rainbow Trout	*Oncorhynchus mykiss*
Slimy Sculpin	*Cottus cognatus*
Spoonhead Sculpin	*Cottus ricei*
Spottail Shiner	*Notropis hudsonius*
Trout Perch	*Percopsis omiscomaycus*
Walleye	*Stizostedion vitreum*
White Sucker	*Catostomus commersoni*
Yellow Perch	*Perca flavescens*

TABLE E5.0-2

FISH SPECIES UTILIZATION OF THE ATHABASCA RIVER NEAR SUNCOR

SPECIES	1995 STUDY	PAST STUDIES	SPAWNING	REARING	FEEDING	OVERWINTERING	MIGRATING
*Arctic Grayling		●			✓	✓	✓
*Burbot	●	●	✓	✓	✓		✓
*Emerald Shiner	●	●	✓	✓	✓	✓?	✓
*Flathead Chub	●	●	✓	✓	✓	✓?	
*Goldeye	●	●	✓?	✓	✓		✓
*Lake Chub	●	●	✓	✓	✓	✓	
*Lake Whitefish	●	●			✓		✓
*Longnose Sucker	●	●		✓	✓		✓
*Northern Pike	●	●			✓	✓	
*Spottail Shiner	●	●	✓	✓	✓	✓	
*Trout-perch	●	●		✓	✓	✓	
*Walleye	●	●		✓	✓		✓
*White Sucker	●	●		✓	✓		✓
Brassy Minnow	●	●			✓		
Brook Stickleback		●			✓		
Bull Trout		●			✓		
Fathead Minnow		●			✓		
Finescale Dace		●			✓		
Iowa Darter		●			✓		
Longnose Dace	●	●			✓		
Mountain Whitefish	●	●			✓		
Ninespine Stickleback		●			✓		
Northern Redbelly Dace		●			✓		
Pearl Dace		●			✓		
Slimy Sculpin	●	●	✓	✓	✓	✓	
Spoonhead Sculpin	●	●			✓		
Yellow Perch	●	●			✓		

*Common, wide-spread species in the Athabasca River. Note that Arctic grayling are mainly found in the tributaries during the open-water season.

-Data from Bond (1980), McCart et al. (1977), Tripp and McCart (1979), Tripp and Tsui, (1980), R.L.and L. (1994) and (1995) Suncor Study. See Golder (1996a) for details.

● present in study area

✓kind of habitat use

? may use habitat but use not confirmed

Longnose sucker, goldeye, lake whitefish, and walleye are the most abundant large fish species in the area downstream of Suncor in 1995. Longnose sucker migrate upstream in the spring and move into the tributaries to spawn. Shortly after spawning they move back into the Athabasca River, where they remain to feed for the rest of the open-water season. Immature goldeye are known to migrate near Suncor in the spring to feed. In contrast to previous studies, mature spent (i.e. recently spawned) goldeye were found near Suncor in spring 1995; which suggests that goldeye may spawn in this reach of river. Walleye also move upstream in the spring to spawn. The Athabasca River near Suncor provides important rearing and summer feeding habitat for walleye. Walleye spawning locations have not been located with certainty but there is evidence that they spawn at the rapids upstream of Fort McMurray (Tripp and McCart 1979). Lake whitefish spawn in the rapids upstream of Fort McMurray in the fall and the Athabasca River near Suncor is an important feeding and resting area for lake whitefish moving upstream to spawn.

Other game and commercial fish species captured in the Athabasca River near Suncor in 1995 include northern pike, burbot, mountain whitefish, white sucker and yellow perch. Yellow perch are uncommon in the Athabasca River but reside in some of the tributaries. White sucker use of the Athabasca River is similar to that of longnose sucker although white sucker are less abundant. Mountain whitefish also migrate within the Athabasca River system. A few were captured in the Athabasca River near Suncor. Feeding migrations of mountain whitefish often occur in the tributaries but spawning and overwintering locations are unknown (Bond 1980). Burbot use the mainstem Athabasca River throughout the open water season, although in the summer some burbot are thought to migrate back to Lake Athabasca to avoid warm water temperatures. Burbot spend part of the winter in Lake Athabasca but migrate into the river to spawn during late winter (January or February). Burbot spawning has been documented in the Athabasca River near Suncor (Bond 1980). Northern pike do not move as far afield as other large fish species. They spawn in the tributaries and in a few areas of the Athabasca River that have flooded vegetation. Northern pike are thought to overwinter in the Athabasca River. Similarly, Arctic grayling spawn in the tributaries and remain there until late fall when they return to the Athabasca River to overwinter.

The major small fish species noted in the Athabasca River in 1995 were flathead chub, spottail shiner, lake chub, trout-perch, slimy sculpin and emerald shiner. Most of these species utilize the local study area year-round except for emerald shiner which are thought to overwinter in the

Athabasca Delta and then migrate into the Athabasca River to spawn (Bond 1980). Flathead chub is one of the most common small fish species in the Athabasca River (McCart et al. 1977). They are generally confined to the mainstem and rarely enter tributaries. Spottail shiner also reside primarily in the mainstem Athabasca River. In contrast, lake chub are common in both the mainstem Athabasca River and in the tributaries. They likely spawn in the lower reaches of the tributaries and overwinter in both the tributaries and the Athabasca River. Trout-perch also spawn in the tributaries but feed and overwinter in the Athabasca River near Suncor (McCart et al. 1977). Slimy sculpin utilize both the tributaries and the Athabasca River; the presence of fry near Willow Island in 1995 indicates that the Athabasca River provides rearing and spawning habitat for this species.

E5.2 STEEPBANK RIVER

Three sections of the Steepbank River, representing the major habitat types, were surveyed using a portable boat electrofisher and zodiac in spring, summer and fall, 1995 (see Figure E1.0-2). The fish fauna of the Steepbank River is abundant and diverse. Twenty-five species of fish have been recorded from the Steepbank River, of which ten (Arctic grayling, northern pike, longnose sucker, white sucker, lake chub, pearl dace, longnose dace, trout-perch, brook stickleback and slimy sculpin) are common and widespread (Table E5.0-3).

Fish species that use the Steepbank River fall into three main categories: migratory populations, resident fish species and species that use the lower reaches for feeding and resting.

In the spring, longnose sucker, white sucker and Arctic grayling move into the Steepbank River to spawn. As well, spring feeding migrations of mountain whitefish are common. In the spring of 1995, mountain whitefish was the most common species captured, followed by Arctic grayling and longnose sucker. These species were most abundant in the upper section of the study area where riffle habitat is common and boulders provide excellent instream cover. White sucker also followed this pattern, although they were less abundant. Longnose sucker, white sucker and Arctic grayling spawning sites were documented throughout study area on the Steepbank River, but they were most common in the top half of the study reach.

TABLE E5.0-3

FISH SPECIES UTILIZATION OF THE STEEPBANK RIVER

SPECIES	1995 STUDY	PAST STUDIES	SPAWNING	REARING	FEEDING (LOWER REACHES ONLY)	FEEDING (UPPER AND LOWER REACHES	OVERWINTERING
*Arctic Grayling	●	●	✓	✓		✓	YOY?
*Brook Stickleback		●	✓	✓		✓	✓
*Lake Chub	●	●	✓?			✓	
*Longnose Dace	●	●	✓	✓		✓	✓
*Longnose Sucker	●	●	✓			✓	YOY?
*Northern Pike	●	●			✓	✓	
*Pearl Dace		●				✓	
*Slimy Sculpin		●	✓	✓		✓	✓
*Trout-perch	●	●	✓			✓	
*White Sucker	●	●	✓	✓		✓	YOY?
Brassy Minnow		●				✓	
Bull Trout		●			✓		
Burbot	●	●			✓		
Flathead Chub		●			✓		
Flathead Minnow		●				✓	
Goldeye	●	●			✓		
Lake Cisco		●			✓		
Lake Whitefish	●	●			✓		
Longnose Dace	●	●				✓	
Mountain Whitefish	●	●				✓	
Northern Redbelly Dace		●				✓	
Spoonhead Sculpin	●	●	✓	✓		✓	✓
Spottail Shiner		●				✓	
Yellow Perch		●			✓		
Walleye	●	●			✓		

*Common, wide-spread species in the Steepbank River. Pearl dace, brook stickleback, and slimy sculpin were not captured in 1995, likely because they are not easily susceptible to capture with a boat electrofisher. All species without an asterisk have been documented in the lower reaches of the Steepbank River but are not common inhabitants of it.

-Data from Sekerack and Walder (1980), Mackinak and Bond (1979), Bond (1980), 1995 Suncor Study. See Golder (1996a) for details.

●present in study area

✓habitat use of study area

? may use habitat but use not confirmed

The abundance of Arctic grayling, longnose sucker, white sucker and mountain whitefish changed throughout the year. Most adult longnose sucker and white sucker left the Steepbank River shortly after spawning while some juveniles remained throughout the open water season, possibly overwintering in the Steepbank River. Mountain whitefish abundance decreased progressively through summer and fall, indicating that the fish were moving out of the river or to areas further upstream. Both past and present studies indicate that Arctic grayling remain in the Steepbank River until just prior to freeze-up. Young-of-the-year Arctic grayling likely overwinter in the Steepbank River.

Several small fish species (lake chub, pearl dace, longnose dace, slimy sculpin, trout-perch and brook stickleback) are year-round residents of the Steepbank River (Sekerak and Walder 1980). In 1995, lake chub, longnose dace, and spoonhead sculpin were the most common small fish species.

Several additional species are confined to the lowermost portion of the Steepbank River. In 1995, goldeye, lake whitefish, longnose dace, northern pike, and walleye were captured near the mouth of the river. Post-spawning feeding migrations of northern pike have been reported in the lower reaches of the Steepbank River. Lake whitefish use the mouth of the river as an important staging and resting area on their upstream spawning migration.

E5.3 TRIBUTARIES

Spottail shiner was the only species captured in Leggett Creek. Poplar Creek had a more diverse fish fauna. Flathead minnow and lake chub were the most common species collected in Poplar Creek. Game and domestic fish species from this creek included white sucker, longnose sucker and yellow perch. As well, Arctic grayling and sucker (longnose and/or white sucker) spawning sites were documented.

Fish inventories were not done for Shipyard Lake, Unnamed, Wood or McLean Creeks since the absence of water in these creeks in spring 1995 precluded the use of these habitats by fish.

E5.4 VEC HABITAT REQUIREMENTS AND UTILIZATION

As described in Section C of this report, surrogate fish species, VECs, were selected as a means to focus the impact assessment. Walleye represent piscivores such as northern pike and burbot for most habitat requirements except spawning habitat. Longnose sucker represent benthic feeders including white sucker and mountain whitefish. Goldeye are opportunistic feeders and represent Arctic graying for feeding requirements, although longnose sucker are surrogates for Arctic grayling spawning requirements. Potential impacts on fish habitat are evaluated in the context of VEC species habitat requirements. Therefore, habitat requirements and habitat utilization within the Suncor local study area are described below. While impacts are generally evaluated in terms of the VEC species habitat requirements the impact assessment is not restricted to VECs. Where potentially impacted habitats are not used by the VECs or where a particular habitat utilization is not represented by a VEC species habitat requirements, appropriate species were used instead (e.g., burbot spawning in the Athabasca River, use of Athabasca River tributaries by small fish species).

E5.4.1 Walleye

Walleye are piscivores and feed on a variety of fish species (Scott and Crossman 1973). Adult and juvenile walleye generally feed in turbid waters where forage fish are abundant. Preferred water temperatures are 10 to 18°C in spring and fall and 20 to 24°C in summer (McMahon et al. 1984).

In rivers, walleye spawn on rocky shoals downstream of rapids and falls and along shallow shorelines. Lake populations spawn on cobble/boulder shoals. Spawning occurs in spring when water temperatures range from 5.6-11.1°C. Walleye fry remain close to the substrate for about 10 days after hatching. They enter the water column to feed on zooplankton until they reach 1.5 to 2.5 cm in length (about six weeks), at which point they begin feeding on fish.

Overwintering habitat is similar to summer feeding habitat except that in winter, walleye will avoid strong currents (Scott and Crossman 1973).

Walleye that are found in the Athabasca River near Suncor are thought to be part of the population that overwinters in Lake Athabasca (McCart et al. 1977). Walleye are known to spawn near the delta in Richardson Lake (Bond 1980). As well, upstream spawning migrations have been documented in both past and present studies (McCart et al. 1977, Tripp and Tsui 1980, Bond 1980). Spawning areas have still not been documented with certainty, although there is evidence of spawning upstream of Fort McMurray at Cascade rapids (Tripp and McCart 1979). Walleye spawning habitat is available near Suncor on rocky shoals near Willow Island and McClean Creek; however, spawning in this area has not been documented.

The Athabasca River near Suncor provides important feeding and rearing habitat for walleye. Habitat utilization patterns for walleye reported in the 1970s were similar in 1995. Backwaters and tributary mouths are important feeding areas. Since adult and juvenile walleye are found throughout the Athabasca River study reach, all of that reach is considered potential rearing and feeding habitat. In 1995, walleye stomach contents consisted primarily of fish remains but also contained amphibian remains, walleye fry and invertebrates, primarily dragonfly larvae (Odonata).

Walleye only occasionally use the Steepbank River, primarily for feeding in the lower reaches.

E5.4.2 Goldeye

Goldeye are surface feeding fish that occupy warm turbid lakes and rivers. They are opportunistic and survive on a wide variety of food types including invertebrates (terrestrial and aquatic), fish, mammals and fish eggs. Spawning occurs during May and June in firm bottomed pools and backwaters of turbid rivers in deep or shallow water (Kennedy and Sprules 1967). Since goldeye spawn in turbid water, spawning activity is difficult to observe (Scott and Crossman 1973). In contrast to other freshwater fishes in North America, goldeye eggs are semi-buoyant. Young fry float near the surface and drift downstream. Goldeye overwinter in deep areas of rivers and lakes.

In the Athabasca River system, goldeye overwinter in Lake Athabasca and spawn in the delta (McCart et al. 1977). Large numbers of immature goldeye are known to migrate into the Athabasca River from the delta (McCart et al. 1977). The Cascade Rapids upstream of Fort McMurray appear to be at least a partial barrier to goldeye movement (Tripp and Tsui 1980). Thus, the lower reaches of the Athabasca River are important feeding habitat. Goldeye enter the local study area in April and May to feed and migrate back to the delta by the end of October. Since goldeye are found throughout the study reach, all of that reach of the river is considered potential feeding habitat for this species. In 1995, stomach contents of goldeye captured from the Athabasca River near Suncor contained invertebrates (Orthoptera, Plecoptera, Trichoptera, Mollusca), mammal remains (shrews and deer mice), and walleye fry.

Previous studies have not documented goldeye spawning in the vicinity of Suncor and Syncrude. However, spent (i.e., recently spawned) individuals of both sexes were documented in the spring of 1995, indicating that this species is possibly spawning in the study area. Goldeye spawning activity is difficult to document since they spawn in turbid water. However, based on the presence of spent goldeye in the study area it was assumed that all of the Athabasca River near Suncor is potential goldeye spawning and rearing habitat.

Goldeye are mainly confined to the turbid waters of the Athabasca River mainstem and rarely enter the smaller tributaries such as the Steepbank River.

E5.4.3 Longnose Sucker

Longnose sucker are the most widespread sucker in northern Canada and are found in large numbers in most waterbodies with clear and cool waters (Lee et al. 1980). Longnose sucker spawning normally occurs in tributary steams rather than in lakes or in large rivers (Brown and Graham 1953). Longnose sucker require riffle habitats for spawning, where water velocities range from 0.3 to 1.0 m/s and clean gravel or cobble (1 to 20 cm in diameter) is present.

The fry of longnose sucker drift downstream following emergence from the gravel. Fry seek shelter from predation and swift flows in shallow areas of reduced velocity and vegetation. Fry have been reported to congregate near the water surface (within 150 mm of surface) and within 2 m of the shore or river bank (Hayes 1956). As young-of-the-year longnose sucker become larger (juveniles), they frequent shallow weedy areas and will seek out areas with some current velocity (Johnson 1971).

Longnose sucker feed on zooplankton and diatoms as fry and shift to larger organisms such as benthic macroinvertebrates as they become larger (Edwards et al. 1983). Adult longnose suckers in general feed on a wide range of food items based on availability; dominant items in the diet include amphipods, cladocerans, aquatic insect larvae and other invertebrates.

In areas with prolonged and extensive ice cover, overwintering habitats are critical to longnose suckers. The principle habitat requirements for longnose sucker winter habitat is an adequate oxygen supply and sufficient water depth to allow for ice cover and refugia from high water velocities.

In the Athabasca River system longnose sucker migrate widely. Most longnose sucker overwinter in Lake Athabasca and migrate into Athabasca River tributaries to spawn. The gravel/cobble substrate and moderate current velocities on the Steepbank River provide ideal sucker spawning habitat. Data from the spring of 1995 confirm that the Steepbank River is an important spawning area for longnose sucker. Longnose sucker spawning sites were found throughout the study reach on the Steepbank River but were most common in the top half of the study area. At a number of sites, longnose sucker spawning activity was observed, and at others eggs were collected. Also, the Steepbank River provides important rearing habitat for young-of-the-year and juvenile longnose sucker. Riffles with large boulders provide good cover for juvenile longnose sucker. Most adult longnose sucker vacate the Steepbank River shortly after spawning and spend the summer feeding in the Athabasca River. Longnose sucker were abundant in the Athabasca River near Suncor, particularly in backwater areas, throughout the summer and fall.

Habitat utilization by longnose sucker in the local Steepbank Mine study area can be quantified based on the fish inventory results from spring, summer and fall of 1995. In the Steepbank River, spawning sites were most common in the top two-thirds of the study area and only a few sites were found near the mouth of the river. Also, both juvenile and adult longnose sucker use of the Steepbank River is generally restricted to the top two-thirds of the study area. Hence, based on habitat utilization, about 67% of the Steepbank River (within the study area) is prime spawning, rearing and feeding habitat for longnose sucker. There is no spawning habitat for longnose sucker in the Athabasca River study reach.

Summer feeding habitat for longnose sucker was found throughout the study reach on the Athabasca River. There were areas of concentration of longnose sucker but since longnose sucker were captured throughout the study reach all of the area is considered summer feeding habitat.

Overwintering habitat in the Athabasca River mainstem is minimal. Overwintering habitat in the Steepbank River for juveniles and adults is possible in pools, although this has not been documented.

E6.0 FISH HEALTH

A combined field and laboratory study was completed to assess the current state of fish health (Sections D4.1, D4.2 and D4.3) and to provide sufficient information to assess potential impacts on fish health from Suncor's water releases. The fish health impact evaluation is described in detail in Golder (1996c) and summarized below.

E6.1 FIELD STUDY

Fish health data for walleye and goldeye were collected from the Athabasca River in summer 1995 and longnose sucker data were collected from the Muskeg River in spring 1995. To assess the current state of health of the fish community, a suite of indicators was examined at several levels of biological organization (i.e., biochemical, physiological, whole-organism, population and community). This comprehensive approach was followed because stress effects on fish cannot be adequately evaluated by measuring a single indicator at a single level of organization.

Biochemical and physiological measurements are short-term indicators of the response to stress, where stress can include exposure to chemicals, unfavourable temperatures, water velocity, sediment loads, reduced food availability, variations in dissolved oxygen and exposure to natural pathogens or parasites. The biochemical and physiological indicators measured in 1995 included mixed function oxidase activity (MFO) (measured as ethoxyresorufin-o-deethylase (EROD) and aryl hydrocarbon hydroxylase (AHH)), PAH metabolites in bile, PAH and metal concentrations in fillets, lactate, protein and glucose in blood serum, retinol in liver, and circulating sex steroids.

Activity of the liver MFO system and levels of PAH metabolites in the bile of fish collected near the Suncor site are elevated relative to fish collected at reference sites (Table E6.0-1). This finding is not unexpected given findings from an NRBS study that indicate MFO levels increase in fish exposed to naturally-occurring oil sands deposits (Parrott et al. 1996b).

Concentrations of lactate, glucose, and total protein in plasma may be used as general indicators of stress in fish. It is difficult to draw conclusions about fish health from these data because of the lack of comparable data for reference fish. Glucose appears to be somewhat elevated in the fish from the Suncor site (Folmar 1993); however, it is not known whether these changes are a response of exposure to chemicals, or simply due to changes in environmental factors such as pH, temperature, or water velocity (Hille 1980 cited in Folmar 1993). Retinol was measured in liver tissues of goldeye and walleye to provide baseline data for later comparisons; there are no comparable retinol data for upstream fish.

Body burdens of PAHs and metals are low to non-detectable in fish collected in the study area in 1995 (see Section E8.0 for discussion). The low body burdens of PAHs and metals in walleye, goldeye and longnose sucker indicate that bioaccumulation of these compounds is low. Since previous analyses indicate that the MFO system is induced and PAH metabolites are present in bile it is likely that the fish in the study area are successfully metabolizing and excreting PAHs, rather than storing PAHs in muscle tissue.

Whole-organism measurements are longer-term indicators of the overall response of an individual organism to stress. These measurements integrate the whole-organism response that may follow from a combination of biochemical and physiological responses; thus, they are somewhat more ecologically relevant than biochemical and physiological indicators. The whole-organism indicators measured in 1995 included condition factor, liver size, gonad size, fecundity, fat content, gross pathology and histopathology.

TABLE E6.0-1

LEVELS OF MIXED FUNCTION OXIDASE ACTIVITY MEASURED IN LIVER OF FISH COLLECTED FROM THE ATHABASCA RIVER BASIN AND OTHER RIVERS

Watercourse	EROD Activity (pmol/min/mg)			
	Longnose Sucker	Walleye	Goldeye	Reference
Other Rivers North Saskatchewan River Peace River Beaver-Cowan River	6 ± 5 (20) to 19 ± 10 (6)	6 ± 5 (20)	126 ± 128 (9)	Kloepper-Sams and Benton (1994) Brownlee pers. comm.
Athabasca River Above Oil Sands Region	11 ± 12 (12) to 34 ± 37 (12)	34 ± 25 (2) to 106 ± 68 (4)	36 ± 29 (5) to 71 ± 36 (5)	SENTAR (1994) Brownlee et al. (1993) Brownlee pers. comm.
Athabasca River In Oil Sands Region	195 ± 177 (2)	57 ± 31 (11) to 201 ± 143 (14)	125 ± 50 (5) to 431± 280 (6)	Golder (1996a) Brownlee et al. (1993) Brownlee pers. comm.

See Golder 1996c for details.
Values are mean ± STD (n)

Increases in liver size are common in fish exposed to organic chemicals such as petroleum hydrocarbons (Heath 1995); however, liver size of fish collected near the Suncor plant was generally smaller than that of fish collected upstream (Table E6.0-2). In addition, there was no pathological evidence of liver disease in fish collected at the Suncor site (GlobalTox 1995). Gonad size in male and female longnose sucker collected near Suncor was larger than that of comparable fish collected upstream (Table E6.0-2), and circulating sex steroid levels in the Suncor fish were considered within the normal range. These data, coupled with the presence of juvenile life stages of all three VECs in the study area suggest that Suncor's current operations are not affecting fish reproduction.

Population and community parameters are indicators of long-term responses that integrate the exposure to stressors over both time and space. Population and community-level indicators can demonstrate a pattern in health responses that are quite different from those indicated by physiological parameters (Adams and Ryon 1994). Population and community-level parameters are generally more ecologically relevant than those measured at lower organizational levels (e.g., physiological parameters), since they are directly related to survival, growth and reproduction of fish species (Adams et al. 1989).

Age-frequency and size-at-age are population parameters investigated in 1995. Age-frequency distributions for the three VECs show no unusual patterns, with no mortality of sensitive juvenile life stages indicated (Figure E6.0-1 to E6.0-3). Goldeye did show a downwards shift in age distribution, however this is most likely due to the behaviour and movements of this species than a result of Suncor's existing operation. Growth rates of all three VEC species are higher in the vicinity of the Suncor operations, relative to growth rates further upstream. This may be due to higher food availability in the Suncor area, although the exact cause of the higher growth rate is not known. The condition in longnose sucker and walleye collected for biomarker analysis near the Suncor operations is higher than comparable fish collected upstream (Table E6.0-2). This agrees with the observation of higher growth rates in this area, and supports the hypothesis of greater food availability in the area.

TABLE E6.0-2

CONDITION FACTOR, LIVER-SOMATIC INDEX, AND GONAD-SOMATIC INDEX FOR FISH FROM THE ATHABASCA RIVER

			Site	
Parameter	**Species**	**Sex**	**Above Oil Sands Region[4]**	**Oil Sands Region[5] (Steepbank Mine Study Area)**
Condition Factor[1]	Longnose Sucker	F	1.26±0.118 (23)	1.33±0.074 (21)
		M	1.25±0.130 (13)	1.30±0.175 (20)
	Walleye	F	0.92±0.113 (20)	1.05±0.091 (23)
		M	0.96±0.137(25)	1.09±0.098 (23)
Liver-Somatic Index[2]	Longnose Sucker	F	1.56±0.435 (20)	1.62±0.266 (21)
		M	1.57±0.606(13)	1.51±0.259 (20)
	Walleye	F	1.05±0.314 (20)	0.82±0.169 (14)
		M	0.99±0.333 (24)	0.94±0.424 (23)
Gonad-Somatic Index[3]	Longnose Sucker	F	10.7±2.24 (23)	11.2±2.36 (21)
		M	3.86±0.80(13)	4.88±0.88 (20)

[1]Condition Factor is a generalized indicator of overall fitness and can reflect the integrated effect of both nutrition and metabolic cost induced by stress (Adams et al. 1989). Condition Factor (K) = $W/L^3 \times 10^5$, where W=weight in grams, L=length in millimeteres, 10^5=scaling factor.

[2]Liver-Somatic Index (LSI) is a measure of the liver size relative to the body where LSI=liver weight/ total body weight x 10^2.

[3] Gonad-Somatic Index (GSI) is a measure of the size of the gonad relative to body size where GSI= gonad weight/ total body weightx10^2.

[4]Data from above oil sands region from Sentar 1994.

[5]Data from oil sands region from Golder 1996a.

Community parameters investigated in 1995 study included community species composition and habitat utilization. Presence/absence data reveal that the fish community in the vicinity of Suncor is similar in diversity to what was found historically in other parts of the Athabasca drainage basin, indicating no discernible effect of present refinery activities on the structure of the fish community (Tables E5.0-2 and E5.0-3). In addition, the fish continue to use different areas of the Athabasca River and its tributaries for spawning, feeding, and other activities; hence, habitat utilization does not appear to be affected by Suncor's existing operations (Tables E5.0-2 and E5.0-3).

In summary, analysis of a suite of biological parameters indicates that fish populations in the vicinity of Suncor are healthy and are not adversely affected by Suncor's existing operations.

E6.2 EXPERIMENTAL STUDIES

Information about effects on fish health from exposure to Suncor's operational and reclamation release waters are available from three studies: (1) Northern River Basins Study data; (2) short-term laboratory data for exposures to consolidated tailing water, dyke seepage water and Athabasca River water downstream of Syncrude as well as exposures to Suncor refinery wastewater; and (3) 7-day and 28-day laboratory data from fish exposed to water from Tar Island Dyke and the Athabasca River.

Pertinent NRBS work includes two studies that used semi-permeable membrane devices (SPMDs) to assess bioaccumulation of chemicals. SPMDs are polyethylene dialysis bags filled with triolein (a purified fish lipid). They act as accumulators of lipophilic (fat-soluble) compounds that are present in the water column. In the first study, the SPMDs were suspended in the water column for two weeks at several locations throughout the Athabasca River basin (Parrott et al. 1996a). The contents of the SPMDs were then extracted with hexane, concentrated and then applied to fish liver cell cultures. Induction of the mixed function oxidase detoxification system (measured as EROD activity) in the liver cell cultures was then measured and the potencies of the various SPMD extracts compared. The SPMD data showed that the Suncor refinery effluent contained potent EROD inducers. It also showed that EROD inducers were naturally present in the Athabasca River, both upstream and downstream of Suncor and that the level of induction downstream was no greater than that observed upstream. In the second study, SPMDs were developed at several locations in the lower Athabasca River, in Suncor's wastewater system, and in the Clearwater and Steepbank Rivers (Parrott et al. 1996b). Results of that study showed no differences in MFO responses between the tributaries, which flow over naturally-occurring oil sands deposits, versus Suncor's wastewater.

The short-term laboratory experiments involved 4-day exposures of rainbow trout fingerlings to consolidated tailings water (CT), dyke seepage water, Athabasca River water from downstream of Suncor (J. Parrott, 1996, person. commun.). The primary measurement endpoint for these short-term experiments was induction of the mixed function oxidase system, measured as EROD activity. Dyke seepage water and Athabasca River water (upstream and downstream of the oil sands operational area) did not cause a significant increase in EROD induction (Table E6.0-3). Consolidated tailing water and Suncor refinery effluent caused a significant increase in EROD induction at dilutions of greater than 32% and greater than 10%, respectively (Table E6.0-3).

The 7-day and 28-day laboratory experiments involved exposures of juvenile walleye and rainbow trout as well as larval rainbow trout to a series of dilutions of Tar Island Dyke water, plus Athabasca River water and a 1% naphthenic acid solution. (HydroQual 1996). Endpoints were survival, growth (weight gain over the 28-day period), condition factor, relative liver size (Liver Somatic Index), blood chemistry, blood cell counts, EROD induction, gross external and internal pathology; histopathology, swimming stamina and resistance to a bacterial challenge.

TABLE E6.0-3

SUMMARY OF EROD ACTIVITY (pmol/min/mg protein) IN FISH EXPOSED TO OIL SANDS WATERS

PERCENT (%) DILUTION	TROUT 4-DAY EXPOSURE[1]			TROUT 4-DAY	7-Day Exposure[2]					
					Tar Island Dyke			ATHABASCA RIVER		
	Consolidated Tailings	Dyke Seepage Water	Athabasca River	Suncor Wastewater	Small Trout	Large Trout	Walleye	Small Trout	Large Trout	Walleye
0.1	nd	nd	nd	0.5	7.8	1.9	5.7			
0.32	2.5	3.2		1						
1	2	1.8	3	1.9	10.4	2.7	4.7			
3.2	2.5	2.5	2.2	3.7						
10	5	3.3	1.9	6.9	5.4	3.3	5			
32	12	4.1	2.1	13						
50						1.8				
100	nd	nd	1.3	24.3				3	1.5	1.3

nd = not detected

[1] Parrott 1996, pers. comm.

[2] HydroQual 1996.

The results of the tests showed very little evidence for effects on fish health except at the highest concentrations tested. The only significant reduction in survival occurred in 50% TID water during the 7-day exposures. There was no significant effect on growth in either juvenile walleye or rainbow trout. Larval rainbow trout grew more quickly in Athabasca River water than in other treatments. The only change in condition factor occurred in juvenile trout exposed to 1% naphthenic acid (where the condition factor averaged 0.8 compared to 1.4 in controls). Enlarged livers occurred in juvenile trout exposed to 1% naphthenic acid. There were no differences in the incidence of gross external and internal pathology. Significant histopathological change (hepatic lipidosis) was noted in fish from the 10% TID and naphthenic acid treatments. The fish in the 10% TID treatment also exhibited some kidney degeneration and regeneration. Hematocrit was reduced in the 50% TID treatment during the 7-day experiment and in the 10% TID and 1% naphthenic acid treatments during the 28-day exposure experiment. Lactic acid levels were elevated in the severely stressed fish exposed to 50% TID water in the 7-day experiment. The longer-term, 28-day test produced lower lactic acid levels in the highest exposure (10% TID) as well as in the 1% naphthenic acid treatment. This result was attributed to the relative inactivity of fish in these treatments compared to lower concentrations and the controls. Plasma glucose levels were decreased in the 50% TID treatment of the 7-day test and in the 10% TID and 1% naphthenic acid treatments of the 28-day test. There were no differences in white blood cell ratios among treatments. The induction of EROD activity was significantly higher in the 10% TID treatment. There was no reduction in the ability to resist bacterial infection among fish exposed to TID water; the highest mortality in the bacterial challenge tests was observed in the Athabasca River water treatment. There was no relationship between exposure to TID water treatments and swimming stamina; fish exposed to Athabasca River water had less endurance than fish from other treatments.

The walleye and rainbow trout responses were very similar during the 28-day exposure test. Therefore, results from one species appear to be applicable to the other. This is important because the three VECs used for the baseline study and for predicted impacts on fish health are walleye, longnose sucker and goldeye. The laboratory data provide some reassurance that predictions based on rainbow trout and walleye can be used for longnose sucker and goldeye.

E7.0 FISH TAINTING

A direct test of the potential for tainting was conducted by exposing rainbow trout to various waters for 14 days and then submitting them to a tasting panel (Golder 1996b). The water regimes included 0.5% Tar Island Dyke Water, 0.5% Refinery Effluent water, and 0.5% Athabasca River water in the lab. In addition, caged fish were placed in the Athabasca River upstream of oil sands operations (i.e., Suncor and Syncrude). Samples of fish exposed to these water regimes were submitted to a tasting panel to determine if there was a difference in the taste and if there was a taste preference. A double triangle difference test was used to determine differences in taste. This test was two-part and only samples that were correctly identified in both tests were used to assess taste differences. Fish exposed to 0.5% Tar Island Dyke water and 0.5% Refinery Effluent Water were found to taste different than fish exposed to Athabasca River water either in the field or in the lab. In addition, fish exposed to Athabasca River water in the lab tasted different than control fish.

The fish samples were also ranked for overall preference in both Test 1 and Test 2 (Table E7.0-1). Only samples from fish exposed to 0.5% refinery effluent water were rejected. Hence, tainting was evident in the trout exposed to 0.5% wastewater (diluted with laboratory water), but not in dyke drainage water from Tar Island Dyke or Athabasca River water.

TABLE E7.0-1

FISH TAINTING STUDY: OVERALL PREFERENCE RANKINGS

Sample/Test	0.5%TID Water	Lab Athabasca River Water	Time Zero Control	0.5% Refinery Effluent Water	Field Athabasca River Water
Test 1	Preferred (99%C.L.)	Neither Preferred Nor Rejected	Preferred (95% C.L.)	Rejected (99% and 95% C.L.)	Trend for Preferred
Test 2	Neither Preferred Nor Rejected	Neither Preferred Nor Rejected	Preferred (99% C.L.)	Rejected (99% and 95% C.L.)	Preferred (95% C.L.)

For details see Golder (1996b)
C.L. = Confidence Limits

E8.0 FISH TISSUE CHEMICAL CONCENTRATIONS

A combined field and laboratory study was completed to address the question as to potential for accumulation of chemicals in fish flesh. These data are given in Golder (1996a) and HydroQual (1996) and synthesized and analyzed in Golder (1996c). Below is a summary of the results of these studies.

Walleye, goldeye and longnose sucker were collected as part of the 1995 baseline aquatics study (Golder 1996a) (see Section E6.0). Walleye and goldeye were captured in the Athabasca River near Suncor and longnose sucker were captured as they moved up the Muskeg River (a tributary to the Athabasca River) to spawn. All three species spend part of the open water season near Suncor. Composite (by sex and species) samples of fish tissue (fillets) were analyzed for organic chemicals and metals. The results of these analyses are presented in Table I-2 (Appendix 1). Longnose sucker composite samples showed detectable naphthalene levels of 0.04 μg/g and methyl naphthalene levels of 0.03 μg/g; however, other PAH parameters were not detectable (detection limits range from 0.02 to 0.04μg/g). PAH/PANH compounds were not detectable in walleye and goldeye.

Uptake of oil sands related chemicals into fish tissue was also investigated as part of a laboratory fish health study, using a dilution series design with a maximum concentration of 10% Tar Island Dyke water. Juvenile walleye and rainbow trout were held for 28 days, sacrificed and their tissues analyzed for PAHs and trace metals (HydroQual 1996). PAH concentrations in juvenile walleye and rainbow trout were below detection for nearly all chemicals except naphthalene and methyl naphthalene in rainbow trout which registered at, or just above the detection level (0.02-0.05 μg/g) (Table I-2). Hence, both field and laboratory studies indicate no significant accumulation of organic chemicals in fish.

Heavy metals, such as cadmium and lead were not detected in juvenile walleye and rainbow trout exposed to 10% TID water or Athabasca River or fish captured in the field (Table I-2). Mercury levels were detectable and of low magnitude in laboratory fish exposed to both TID water and Athabasca River water (Table I-2). NRBS also identified mercury as elevated in Athabasca River Water (NRBS 1996) Thus, no significant incremental accumulation of metals is indicated by either the laboratory studies or from fish collected from the local study area.

F IMPACT ANALYSIS

As discussed in Section D, there are seven key impact hypotheses pertaining to effects on aquatic resources from the development of the Steepbank Mine. Each of the hypotheses are assessed in detail below and the associated degree of concern defined according to the rationale given in Section D5.0.

F1.0 CHANGES IN AQUATIC HABITAT IN THE STEEPBANK RIVER

Hypothesis 28 Construction, operational or reclamation activities might adversely affect aquatic habitat in the Steepbank River.

Construction, operation and reclamation of the Steepbank Mine have the potential to affect fish habitat on a number of spatial and temporal scales. Fish habitat can be classified into macro-habitat and microhabitat. Macro-habitat involves general morphological features and water quality whereas microhabitat features include the distribution of features such as depth, velocity, substrate and cover. For the Steepbank Mine, no major changes in general morphological features of the Steepbank River are planned and water quality impacts are addressed under Impact Hypothesis 30 (Section F3.0). Hence, this assessment will focus on microhabitat impacts.

Benthic invertebrates are an important ecological link between fish habitat and fish populations, particularly for longnose sucker, which rely exclusively on benthic invertebrates for their diet. Therefore, impacts on benthic invertebrates are also included in this habitat impact assessment.

F1.1 VALIDITY OF LINKAGE BETWEEN ACTIVITY AND MODE OF ACTION

An overview of the relationship among major mine development activities, alterations to aquatic habitat, changes to fish habitat and benthic invertebrate communities is shown in Figure F1.0-1. Mine construction, development and/or reclamation activities may lead to changes in fish habitat directly as a result of alterations to river beds (e.g., instream construction) or indirectly as a result of on-lease activities (e.g., mine dewatering may lower river flows, dyke construction may increase suspended solids loads).

Link 1. Mining and Construction of North Overburden Dump

No construction activities are planned in the Steepbank River valley; however, construction of the North Overburden Dump will occur near the river so there is potential for sedimentation (Figure F1.0-2). Also, during the mining phase sedimentation could result from mining at the north end of Pit 1. In the reclamation phase, potential impacts as a consequence of mining near the Steepbank would no longer be an issue.

Link 2. Dewatering and Link 3. Reclamation

Dewatering and reclamation could alter surface and groundwater flows. Surface water drainage to the Steepbank River will be affected by: construction of the mine drainage system during the construction phase; construction of the North Overburden Dump, East Overburden Dump and mining of Pit 1 during the operational phase; and restoration of drainages during reclamation. Similarly, groundwater levels will be affected by mine development. No changes are anticipated during construction, but dewatering of the surficial aquifer will occur between 2001 and 2009. After 2009, Pit 1 will be filled with consolidated tails (CT) and renamed as Pond 7. Thus, seepage of CT water could potentially affect groundwater flows to the Steepbank River from 2009 onwards.

Link 4. Erosion and Sedimentation

Mining activities near the banks of the Steepbank River could potentially cause erosion, thus resulting in increased sedimentation in the river. Sedimentation affects benthic communities by increasing invertebrate drift (i.e., benthic invertebrates are dislodged and washed downstream), decreasing habitat quality and fouling body surfaces. Similarly, high suspended solids loads can directly affect fish and their habitat. High suspended solids concentrations may have effects on fish that range from sublethal to lethal. Spawning habitat is particularly sensitive to sedimentation. Sediment particles can cover spawning beds, fill in the interstitial spaces and adversely affect eggs and fry. Potential impacts on fish, fish habitat and benthic invertebrates from increased sedimentation are described in detail in Appendix II.

The validity of the linkage between nearshore mining activity and sedimentation depends on the proximity of mining operations to the river, mitigation activities such as erosion control measures and background levels of sediments in the watercourse. In the Steepbank River, suspended sediment levels are low and sedimentation is negligible (Golder 1996a). Thus, even small amounts of sediment might cause a measurable change in suspended sediment concentrations and sedimentation. However, mining operations will be set back from the banks of the Steepbank River. The setback of mining equipment will be at least 100 m from the edge of the escarpment of the river. A 100 m setback is recommended by Alberta Environmental Protection (1995a) in the Subregional Integrated Resource Plan. In addition, if required erosion control measures will be implemented. In particular, the following measures to minimize sedimentation as prepared by Alberta Transportation and Utilities and Alberta Forestry, Lands and Wildlife (1992) will be followed:

- Permanent and temporary erosion control measures will be shown on the construction drawings, and will be included in the special provisions of the contract or be otherwise provided to the construction project manager.
- The construction staff and the contractor will be advised of the mitigation measure notes in the contract and on the drawings.
- Water with excessive sediment from the work area will not be directly released into the stream. Methods of sediment removal will be considered, such as pumping into settling basins or discharging in a vegetated area.
- Excavated material that may increase suspended sediment concentrations beyond tolerable levels will be either isolated from the stream or relocated to an area where the sediment will not enter the stream.

The 100 m setback combined with erosion control measures should minimize sediment loads to the Steepbank River. Hence, if mitigation measures are followed, nearshore erosion and sedimentation in the Steepbank River is not a an issue of concern with respect to aquatic habitat.

Link 5. Alterations to Flows

Mine operation and reclamation will result in changes to groundwater and surface flow patterns that might alter flows in the Steepbank River. Groundwater seepage rates into the Steepbank River are presented in Table F1.0-1. Sources of influent groundwater seepage include surficial deposits, bedrock deposits and CT units. Also, from 2001 to 2008 there will be groundwater flow out of the Steepbank River into Pit 1 as a result of dewatering. The net effect of these processes (compared to 1995 groundwater flows) is a withdrawal of water from the Steepbank River in 2001 (0.7 L/s), and addition of water to the Steepbank River in 2009 (0.88 L/s), 2020 (1.18 L/s) and long-term (1.18 L/s) (Klohn-Crippen 1996). To assess the potential magnitude of flow alterations in the Steepbank River, the percent change in mean monthly river flows was calculated for representative low, moderate and high flow years. For the low flow year, the highest percentage net change is predicted to result in only a 0.6% increase in mean month stream flows (Table F1.0-2). In moderate and high flow years, changes in Steepbank River discharge would range from a decrease of less than 0.3% (2001 scenario) to an increase of less than 0.5% (long-term scenario).

Klohn-Crippen (1996) did a comparable analysis of the potential effects of changes in river flows related to changes in surface flow patterns arising from mine development. Potential changes in surface flows to the river are slight and would result in less than 0.5% change in mean annual flows.

In terms of mean monthly flows, the combined effects of changes in surface and groundwater flows are not measurable and, therefore negligible. Thus, for the Steepbank River there will be no alteration in aquatic habitat as a result of changes to surface or groundwater flows.

F1.2 TEST OF IMPACT HYPOTHESES

Link 6. Fish Habitat

As discussed above, changes in flow of the Steepbank River are the only potential linkage between mine activities and impacts to aquatic habitat. However, since potential changes in flow are less than 0.6% they would not be measurable. Thus impacts to habitat either in the form of change in availability or in quality are defined as negligible.

Table F1.0-1

Flow Rates of Groundwater Discharge to Surface Water Bodies from Steepbank Mine Area

Destination	Groundwater Discharge, in L/s				
	1995	2001	2009	2020	Long-Term
Surficial Groundwater					
Athabasca River	0.44	0.44	0.2	0	0
Steepbank River	0.22	0.22	0	0	0
Shipyard Lake	0.17	0.17	0.4	0.2	0.2
Leggett Creek	0	0	0.23	0	0
Wood Creek	0	0	0	0.63	0.63
Bedrock Groundwater					
Athabasca River	0.93	0.93	0.93	0.93	0.93
Steepbank River	0.2	0.2	0.2	0.2	0.2
Shipyard Lake	0.56	0.56	0.56	0.56	0.56
Leggett Creek	0	0	0	0	0
Wood Creek	0	0	0	0	0
CT Water from Tailings Pond					
Athabasca River	0	0	2.2	5.8	5.8
Steepbank River	0	0	1.1	1.4	1.3
Shipyard Lake	0	0	0.3	0.4	0.4
Leggett Creek	0	0	0	0	0
Wood Creek	0	0	0	0	0

Data from Klohn-Crippen 1996.

TABLE F1.0-2

PERCENT CHANGE IN DISCHARGE (m^3/s) IN THE STEEPBANK RIVER FOR 2001, 2009, 2020, AND LONG-TERM COMPARED TO BASELINE (1995) BASED ON MEAN MONTHLY FLOWS FROM REPRESENTATIVE LOW, MODERATE AND HIGH FLOW YEARS

a) Low Flow Year

Month	Mean Discharge (m^3/s)	2001	2009	2020	Long-term
January	0.385	-0.18	0.23	0.31	0.28
February	0.325	-0.22	0.27	0.36	0.33
March	0.357	-0.20	0.25	0.33	0.30
April	3.11	-0.02	0.03	0.04	0.03
May	4.23	-0.02	0.02	0.03	0.03
June	3.74	-0.02	0.02	0.03	0.03
July	2.34	-0.03	0.04	0.05	0.05
August	1.86	-0.04	0.05	0.06	0.06
September	1.18	-0.06	0.07	0.10	0.09
October	1.62	-0.04	0.05	0.07	0.07
November	1.45	-0.05	0.06	0.08	0.07
December	0.212	-0.33	0.42	0.56	0.51

Change in Flows
2001 = -0.7 L/s
2009 = 0.88 L/s
2020 = 1.18 L/s
long-term = 1.08 L/s

b) Moderate Flow Year

Month	Mean Discharge (m^3/s)	2001	2009	2020	Long-term
January	0.396	-0.18	0.22	0.30	0.27
February	0.237	-0.30	0.37	0.50	0.46
March	0.647	-0.11	0.14	0.18	0.17
April	3.63	-0.02	0.02	0.03	0.03
May	15.4	0.00	0.01	0.01	0.01
June	8.38	-0.01	0.01	0.01	0.01
July	13.2	-0.01	0.01	0.01	0.01
August	6.84	-0.01	0.01	0.02	0.02
September	2.19	-0.03	0.04	0.05	0.05
October	2.85	-0.02	0.03	0.04	0.04
November	1.33	-0.05	0.07	0.09	0.08
December	0.665	-0.11	0.13	0.18	0.16

2001 = -0.7L/s
2009 = 0.88 L/s
2020 = 1.18 L/s
long-term = 1.08 L/s

c) High Flow Year

Month	Mean Discharge (m^3/s)	2001	2009	2020	Long-term
January	0.641	-0.11	0.14	0.18	0.17
February	0.438	-0.16	0.20	0.27	0.25
March	0.415	-0.17	0.21	0.28	0.26
April	2.65	-0.03	0.03	0.04	0.04
May	13.8	-0.01	0.01	0.01	0.01
June	14	-0.01	0.01	0.01	0.01
July	27.3	0.00	0.00	0.00	0.00
August	15.3	0.00	0.01	0.01	0.01
September	30.2	0.00	0.00	0.00	0.00
October	17.4	0.00	0.01	0.01	0.01
November	2.77	-0.03	0.03	0.04	0.04
December	0.719	-0.10	0.12	0.16	0.15

2001 = -0.7 L/s
2009 = 0.88 L/s
2020 = 1.18 L/s
long-term = 1.08L/s

Link 7. Benthic Invertebrate Communities

As noted above changes in flows on the Steepbank River would result in no measurable change in habitat area, so potential impacts on benthic invertebrate communities are defined as negligible.

F1.3 HYPOTHESIS IMPACT CLASSIFICATION

F1.3.1 Degree of Concern

Construction Phase: Changes in aquatic habitat or benthic invertebrate communities of the Steepbank River will not be measurable and are, hence, classed as negligible in severity.

Operational Phase: Changes in aquatic habitat or benthic invertebrate communities of the Steepbank River will not be measurable and are, hence, classed as negligible in severity.

Reclamation Phase: Changes in aquatic habitat or benthic invertebrate communities of the Steepbank River will not be measurable and are, hence, classed as negligible in severity.

Hence, the overall degree of concern for aquatic habitat in the Steepbank River is rated as negligible (Figure F1.0-1).

F1.3.2 Certainty

Given the low flows, lack of mining activity near the river, and mitigation measures to be followed, there is a high degree of confidence associated with the impact predictions for aquatic habitat in the Steepbank River. Both the seepage water and surface water estimates were based on conservative assumptions, thus actual changes in flows are likely to be smaller than the ones presented here (Klohn-Crippen 1996).

F1.3.3 Cumulative Impacts

No other activities currently exist or have been proposed that might affect the habitat of the Steepbank River. Hence the above analysis accounts for all known activities that might affect habitat in the river.

F2.0 CHANGES IN AQUATIC HABITAT IN THE ATHABASCA RIVER

Hypothesis 29 Construction, operational or reclamation activities might adversely affect aquatic habitat in the Athabasca River.

In addition to potential impacts on the Athabasca River there is also the potential for effects on three small tributaries to the river: Unnamed, Leggett and Wood Creeks. Potential impacts to these tributaries are assessed as part of Hypothesis 29.

An overview of the relationship between major mine development activities, alterations to aquatic habitat, changes to fish habitat and benthic invertebrates, and Impact Hypothesis 29 is shown in Figure F2.0-1. Links between alterations to aquatic habitat and specific mine development activities were determined for each phase of mine development. There are three primary linkages to alterations in aquatic habitat: barge terminal construction and operation (construction phase only), a bridge across the Athabasca River; and mine development (e.g., drainage of creeks, erosion from road construction). Within each of these primary linkages there are a number of activities that can potentially affect aquatic habitat. As with Hypothesis 28 (Steepbank River habitat), this assessment focuses primarily on microhabitat impacts except for effects on some Athabasca River tributaries since mine development will involve significant changes to the morphology of some small streams.

F2.1 VALIDITY OF LINKAGE BETWEEN ACTIVITY AND MODE OF ACTION

Link 1. Barge and Link 2. Bridge

Construction and operation of the barge terminal and permanent bridge could enhance near-shore erosion. This may cause increases in suspended sediment concentrations and sedimentation, both of which can have deleterious effects on aquatic habitat (see Appendix II for a discussion of potential impacts to fish, fish habitat and invertebrates). As well, temporary barge operation and dredging may disturb the river bottom substrate and cause sediment re-suspension, thereby increasing suspended sediment loads. The river bed would also be disturbed as a result of bridge construction, barge operation and dredging. Barge operation and/or dredging to maintain the barge channel will also result in an ongoing disturbance to the river bed. Hence, there is a potential link between these activities and sedimentation.

During the construction phase, prior to construction of the permanent bridge, an ice bridge will be used in winter to transport materials to the new mine. There is potential for the ice bridge to act as barrier to fish migration.

Once the permanent bridge is in place, the following alterations to aquatic habitat could occur: riparian erosion and sedimentation from abutments, loss of habitat at bridge abutments, pier footings, bridge pier scour holes, and increase in instream cover from bridge piers. Bridge abutments also may cause changes in flow characteristics along the banks and may result in erosion and sedimentation. An evaluation of the potential for sedimentation indicates that there will likely be sediment deposition upstream and downstream of the left abutment along the left bank (AGRA 1996). Loss of habitat at bridge abutments, pier footings, scour holes and a backwater downstream of each of the piers are legitimate linkages to physical alterations to aquatic habitat. Thus, these impacts are assessed.

Link 3. Mine

The transportation corridor at the base of Dyke 10 is a potential cause of erosion and hence, increased sediment loading and sedimentation as it is close to the Athabasca River.

Mine operation will also result in changes to three small watercourses. Mining in the south part of Pit 1 and the north end of Pit 2 will alter Unnamed Creek (Figure F1.0-2). Leggett Creek will be altered as mining is expanded into the south part of Pit 2. Flow from Leggett Creek will be diverted into the mine drainage system during the operational phase and following reclamation, through Shipyard Lake.

Mine operation will also result in changes in surface and subsurface flows to the Athabasca River.

Surface water flows to the Athabasca River will be altered through construction of the mine drainage system (from 1997 to 2000). Similarly, Pit 1 development plus construction of the North Overburden Dump will alter the Athabasca River drainage basin area (2001 to 2009). Potential alterations will also occur with the development of Pit 2 from 2009 to 2020. At mine closure, surface water drainage is expected to be altered from baseline conditions.

Subsurface flows will also be affected by mine development. In the construction phase, water wells drain water from the surficial aquifer that is adjacent to the Athabasca River. From 2000 to 2009 the surface aquifer will be dewatered and flows from the bedrock aquifers will be routed toward Pit 1. From 2009 to 2020 the mining of Pit 2, infilling of Pit 1 with CT (Pond 7), and continued dewatering of the surficial aquifer can also alter groundwater flow patterns. CT seepage could occur from 2009 to long-term.

Link 4. Erosion and Sedimentation

Increases in suspended sediments and sedimentation are well known effects of unmitigated near-shore construction and instream activity. The impact on aquatic habitats is related to the amount of sediments released and substrate characteristics. For the Athabasca River, background suspended sediment levels are variable, and are positively correlated to flow rates. For instance, in 1995, suspended sediment levels ranged from 4 mg/L in during low flow to over 600 mg/L during high flows (Golder 1996a). Suspended sediment levels potentially associated with nearshore and instream construction activities are specific to the type of activity; however, suspended sediment levels associated with dredging may be in the order of 100 mg\L (Golder 1994b). Thus changes to aquatic habitat in the Athabasca River outside the normal range of variation would only result from high loadings of suspended sediments over long periods of time.

A number of mine development activities that can potentially alter aquatic habitat can be successfully mitigated. Guidelines have been developed to prevent or minimize sedimentation from nearshore activities (Alberta Transportation and Utilities and Alberta Forestry, Lands and Wildlife 1992). These guidelines apply to bridge and barge construction and road/mining operations adjacent to the Steepbank and Athabasca Rivers. Along with these general guidelines for nearshore activities, specific guidelines have been developed for bridge construction. The guidelines described below will be followed during construction in order to minimize impacts to fish habitat and invertebrates from barge terminal and bridge construction activities.

- Where spring and/or fall spawning fish are known to be present, timing constraints may be applied to instream work. Several species are of interest for the Athabasca River: walleye, lake whitefish, longnose and white sucker, Arctic grayling and goldeye. Timing constraints identified by Fisheries Management Services Division include those for walleye and Arctic grayling migrations in the spring and lake whitefish migrations in the fall. No instream activity will occur during the walleye and Arctic grayling timing constraints (April 14 to July 5 for Arctic grayling and April 15 to June 30 for walleye). Instream construction can take place during the lake whitefish timing constraint (Oct 1 to May 30) as long as the river is not constricted so much that it prevents or impedes lake whitefish upstream movement (Larry Rhude, Fisheries Management Services Division, pers. comm.).
- Where practical, berms may be constructed before critical fish spawning periods. Berms may be removed during non-critical fish spawning and migration periods or as agreed with the regional habitat staff.
- For approach roadway ditches, erosion control measures will be used such as the following:
    - restoration of vegetation by seeding and mulching techniques,
    - check dams and ditch blocks,
    - diversion ditches discharging to vegetated areas,
    - filtering permeable berms,
    - siltation ponds, sediment traps or sumps,
    - gravel paving or riprapping,
    - synthetic material liners,
    - drop structures, and
    - parabolic or trapezoidal channels instead of v-ditching.

- For cut and fill slopes of approach roadways erosion control measures will be used such as the following:
  - step backslopes and sideslopes,
  - seed and mulch backslopes and sideslopes,
  - construct berms at tops of cuts to redirect surface drainage,
  - construct interceptor channels or diversion channels on cut slopes,
  - scarify and compact slopes to increase roughness, and
  - use of erosion control measures in channels as previously noted.

Where there is potential for the bridge structure to add significant sediment or otherwise affect fish in an intolerable manner, the following guidelines will be followed to minimize any such impact:

- Protect bridge headslopes with granular or other non-erodible materials such as concrete, rock riprap and vegetative cover;
- Avoid directing roadway drainage onto unprotected bridge headslopes; and
- Construct bridge headslopes that consist of erodible material with a minimum slope of 2:1 (horizontal:vertical) or otherwise protect with non-erodible facing.

In addition to the mitigation measures described above, coffer dams will be used during pier and abutment construction. Suspended sediment generated from construction activities within coffer dams will not be released into the Athabasca River. Since measures to prevent erosion will be implemented during construction, increase in sediment loads in the Athabasca River associated with barge and bridge construction should be minimal. Also, an environmental monitor will be present on site during bridge construction activities to ensure that mitigation measures are followed.

The facilities road will be constructed Dyke 10 and the Athabasca River. The width of the corridor between the dyke and the river is approximately 350 m. Within the corridor there needs to be sufficient room to construct the dyke and install a conveyer between the road and the dyke. Thus, the setback of the road from the Athabasca River will be 50 m.

Guidelines established by the Alberta Forest Service (1986) and Alberta Forestry Lands and Wildlife (1980) address road setbacks and buffer strips. To minimize erosion, a roadway should be setback at least 100 m from any permanent watercourse (Alberta Forestry Lands and Wildlife 1980) and within this 100 m zone there should be a 60 m buffer strip adjacent to the watercourse (Alberta Forest Service 1986). As well, the "Draft Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan" (Alberta Environmental Protection 1995a) recommends a 100 m setback from the edge of the escarpment on the river. Setbacks and buffers function to prevent erosion and sedimentation by acting as sediment traps, provide an area for runoff to infiltrate the ground, and provide bank stabilization. Given that the roadway will be built within 50 m of the river, these guidelines will not be met. However, several sediment/erosion control measures will be implemented to prevent sediment loading from the roadway. The road will be crowned (i.e., graded so that runoff will drain to either side of the road) and channels will be installed on both sides of the road. Runoff collected in the channels will be routed to a retention basin. Also, natural vegetation on the riverbank will be left intact to stabilize the bank. If necessary, further bank stabilization measures will be implemented to prevent erosion.

Link 5. Bed Disturbance/Physical Displacement of Habitat

The riverbed will be disturbed in the area of the barge channel. Since the disturbance will be ongoing, physical habitat in within the barge channel, an area of approximately 4.5 ha, will be unavailable to fish. Also, approximately 6.5 ha of physical habitat will be displaced by bridge pier footings and abutments.

6. Flows

Mine operation and reclamation will result in changes to groundwater and surface flow patterns. Groundwater seepage rates into the Athabasca River are presented in Table F1.0-1. Sources of influent groundwater seepage include surficial deposits, bedrock deposits and CT units. No change in groundwater seepage to the Athabasca River is predicted for 2001 and increases in seepage of 1.96 L/s in 2009, 5.36 L/s in 2020 and 5.86 L/s over the long-term are projected (Klohn-Crippen 1996). These estimates of seepage input to the Athabasca River are similar to that of the Steepbank River, and since the flows on the Athabasca River are one to two orders of magnitude greater than those of the Steepbank River, changes in Athabasca River flows would be insignificant (less than 0.01%).

Mine operation and reclamation will also cause changes to surface flow patterns in the Steepbank Mine area. The annual flows of surface water that discharge to the Athabasca River will decrease by approximately 26 L/s, which results in less than a 0.01% change in mean river flow (Klohn-Crippen 1996).

In terms of mean monthly flows, these changes in surface and groundwater flows are not measurable and, therefore, negligible. Thus, no physical alteration of aquatic habitat will occur in the Athabasca River as a result of changes in surface or groundwater flow regimes.

Link 7. Loss of Riparian Cover

A potential impact of barge and bridge construction is loss of riparian vegetation on the Athabasca River. However, the banks of the Athabasca River provide very little cover from riparian vegetation, and there is no riparian vegetation at the site of the bridge and barge crossing (Golder 1996a). Therefore, loss of riparian vegetation is not a potential impact on aquatic habitat.

Link 8. Barriers to Fish Migration

Ice bridges will be used during the construction period and possibly at a later date to take cable shovels across the river during the winter. Ice bridges are constructed on top of the existing river ice using a typhoon pump to flood the ice. The total depth of the ice bridge is about 1.5 m. The ice bridge is constructed across a transect of the Athabasca River that has two deep channels about 2.5 to 3.5 m deep. Thus, no impedance to fish movement (i.e., potential winter burbot spawning migration) will occur during winter the operation of the ice bridge. In spring, the ice bridge could potentially increase the frequency of ice jams during breakup and impede the passage of migrating fish such as goldeye, longnose sucker, white sucker, walleye, Arctic grayling and mountain whitefish. However, measures are taken to prevent ice jams during breakup. Crushed rocks and sand are placed on the ice bridge during early spring to increase ice melt. Four or five 25 cm wide cuts are also made in the ice bridge parallel to the flow of the river and over the deep channels. Suncor's past experience is that these cuts are sufficient to prevent ice jamming. Thus, since mitigation measures will be implemented, the ice bridge is not expected to create a barrier to fish migration.

F2.2 TEST OF HYPOTHESES

F2.2.1 Changes in Fish Habitat

a) Athabasca River

Fish habitat in the Athabasca River will be potentially affected by:

- bed disturbance caused by barge operation;
- habitat loss from bridge pier installation;
- bridge pier scour holes and backwaters;
- bridge pier sedimentation; and
- erosion associated with the transportation corridor alongside Dyke 10.

Hypotheses regarding fish habitat are tested against the habitat requirements for the VECs, except in a few cases where habitat requirements are not represented by those of the VECs (e.g., Arctic grayling feeding, burbot spawning). Habitat requirements of the VECs and habitat utilization within the Steepbank Mine study area are summarized in Section E5.4.

Barge operation and bridge installation would impact a very small portion of the walleye, goldeye and longnose sucker feeding habitat. Rearing habitat and spawning habitat for both walleye and goldeye is available in the local study area. However, detailed habitat mapping at the bridge crossing site indicated that neither rearing or spawning habitat is present at this site. Barge operation affects approximately 0.0005% (i.e., 4.5 ha) of the fish habitat in the Athabasca River local study area and bridge piers decrease the habitat availability in the local study area by approximately 0.0006 % (6.5 ha). Hence, the loss of habitat would not be measurable on the local scale and is, thus, rated as negligible in severity.

The extent of sediment deposition along the west bank near the west bridge abutment is dependent on several factors such as river flow conditions and ice jams (AGRA 1996). Creation of a sandbar increases habitat diversity and could provide backwaters which is a positive gain in fish habitat. However, this gain in fish habitat would be negligible on a local scale.

Fish habitat downstream of the bridge piers would be altered because the piers would create velocity breaks and backwaters. This would, improve fish habitat because it would be a source of instream cover and provide velocity breaks for fish to rest in. However, this gain in fish habitat would not be measurable on the local scale and is, thus, rated as negligible in severity.

b) <u>Tributaries</u>

Unnamed Creek (headwater of Shipyard Lake) and Leggett Creek will be displaced as a result of mine advance. Unnamed Creek is an ephemeral stream that has a small drainage area (approximately 44 km^2 compared to the Steepbank River which drains^2 1,370 km) (Klohn-Crippen 1996). Flows in this creek are low in summer (1.2 m^3/s) and negligible in winter (0.1 m^3/s) and thus, provides poor habitat for fish. Leggett Creek is also a small watercourse (drainage area 35 km^2). Habitat mapping and fish inventories of Leggett Creek in 1995 revealed poor aquatic habitat in this water body. Two spottail shiner were the only fish captured. The substrate at the mouth of Leggett Creek was composed of fine-sized material, and upstream of the mouth there was some cobble/gravel substrate. Low flows in the spring of 1995 precluded use of Leggett and Unnamed Creek for spawning and the poor fish habitat would limit the use of these streams by most fish species. However, since 1995 was a particularly dry year, fish habitat use in Unnamed and Leggett Creeks will be confirmed by additional sampling in the spring of 1996.

The approximate areal loss of aquatic habitat from Unnamed and Leggett Creeks is 80 ha, while that from Shipyard Lake is 151 ha (128 ha wetland shrub, 23 ha open water). Combined habitat loss represents approximately 2% of the local study area. This effect would be reversed during the reclamation phase when drainages are created that represent equivalent or better habitat. These habitats are of limited importance to fish, both locally and regionally. Therefore, impacts to fish habitat are considered negative, low severity (i.e., measurable but less than 10% of the habitat in the local study area), short-term and local.

Wood Creek is also a small ephemeral watercourse (drainage area 36 km^2) that has poor aquatic habitat. Flows are similar to Unnamed and Leggett Creek. Flows in Wood Creek are anticipated to increase by 140%, as natural runoff will be routed around Pit 2, though drainage structures, and into Wood Creek. There is a potential for increased sedimentation from this increase in runoff (Klohn-Crippen 1996). Sedimentation will be minimized through the use of sediment traps, lining channels with erosion resistant materials and/or controlling flow rates in the drainage channels (Klohn-Crippen 1996). Assuming that sedimentation will be controlled through mitigation, increases in flows in Wood Creek could increase fish habitat.

F2.1.2 Changes in Benthic Invertebrate Communities

Benthic invertebrates are a valuable resource for fish, so adverse impacts on these organisms can potentially affect fisheries.

In the Athabasca River, barge operation would preclude the establishment of benthic communities in the barge channel; however, only a very small area of habitat (approximately 0.004% of the local study area) would be affected. Similarly, bridge piers and abutments would represent a very small habitat loss (6.3 ha or 0.06% of the local study area). The shifting sand substrate of the Athabasca River represents poor quality invertebrate habitat. Thus both of these changes would have a negligible impact on benthic invertebrate communities in the Athabasca River. Bridge pier installation locations and downstream scour holes and velocity breaks from the pier could cause a change in substratum and a shift in community structure, but over such a small spatial scale that changes in benthic invertebrates would be negligible.

The displacement of Leggett and Unnamed Creeks would cause loss of benthic invertebrate communities in these streams. In the reclamation phase, when streams are created that represent equivalent of better habitat, this negative effect would be reversed.

In Wood Creek, flows will increase due to rerouting of the water from Leggett Creek. Increases in flows will cause increased velocity and scour. This might improve benthic invertebrate habitat quality. In the reclamation phase, when drainages are restored, this effect will be reversed.

F2.3 HYPOTHESIS IMPACT CLASSIFICATION

Based on the hypotheses presented above, one can conclude that:

F2.3.1 Degree of Concern

Construction Phase: Changes in aquatic habitat or benthic invertebrate communities of the Athabasca River will not be measurable on a local scale and are, hence classed as negligible.

Operational Phase: Changes in aquatic habitat or benthic invertebrate communities of the Athabasca River will not be measurable on a local scale and are, hence classed as negligible.

A negative, low severity, short-term, local impact to aquatic habitat would result from the diversion of two small watercourses (Unnamed and Leggett Creeks).

Reclamation Phase: Changes in aquatic habitat or benthic invertebrate communities of the Athabasca River will not be measurable on a local scale and are, hence classed as negligible.

Stream restoration will provide equivalent or better habitat than currently exists, reversing the negative, low severity, long-term local impact to aquatic habitat in these streams.

Hence the overall degree of concern is rated as negligible (Figure F2.0-2).

F2.3.2 Certainty

There is a high degree of confidence associated with the impact predictions for aquatic habitat in the Athabasca River. Habitat loss from the bridge pier footings and habitat gain from the piers is certain based on the current mine development plan.

The habitat loss from Leggett and Unnamed Creeks and from Shipyard Lake is certain. However, the habitat quality and quantity in these streams have not been documented in detail and, thus, need further quantification. Also, examination of the lower reaches of the tributaries in the spring of 1995 indicated no use by fish for spawning due to the absence of flow. However, since 1995 was a particularly dry year, the lack of use of these habitats is uncertain. The lower reaches of these creeks will be examined again in 1996 to confirm the extent of use by fish. As well aquatic habitat and fish communities in the upper and middle reaches of the water courses and Shipyard Lake will be documented.

F2.3.3 Cumulative Effects

Impacts to three small tributaries of the Athabasca River could contribute to cumulative impacts in the region. Syncrude will also be affecting some small watercourses, although the effects have not currently been quantified. Preliminary estimates indicate that about 50 ha of aquatic habitat will be affected by the Aurora Mine. All of these small tributaries represent poor fish habitat and will be restored to equivalent or better habitat after reclamation of both Suncor and Syncrude's mines. Thus, cumulative impacts associated with diversion of small tributaries will be negligible with respect to habitat for fish within the local and regional study areas.

F3.0 CHANGES IN AQUATIC ECOSYSTEM HEALTH

Hypothesis 30 Construction, operational or reclamation activities might adversely affect aquatic ecosystem health in the Athabasca and Steepbank Rivers.

The term ecosystem health provides a useful conceptual framework for assessing changes in ecosystems. Ecosystem health is a metaphor based loosely on the concept of human health and implies a state of well-being. A healthy ecosystem is self-sustaining and able to recover from stress (Karr 1993). With respect to assessing the effects of chemical exposures on ecosystems an adequate assessment of ecosystem health includes water chemistry, toxicity testing and ambient biological monitoring (Karr 1993). Ambient biological monitoring takes a multi-level, multi-scale approach where aspects of species composition, community structure, biological processes and individual health are measured. The focus of the following assessment is on the effects of chemical exposures on aquatic biota and it involves a combination of water quality assessment, laboratory toxicity testing, modelling and in-situ biological monitoring.

F3.1 VALIDITY OF LINKAGE BETWEEN ACTIVITY AND MODE OF ACTION

Figure F3.0-1 shows the linkages among activities, mode of action, testable hypotheses and the primary impact hypothesis. As noted in this figure, there are four primary activities that might result in changes to water quality in the Athabasca and/or Steepbank Rivers: release of operational water, release of reclamation water, accidental releases, and changes in surface and subsurface flow patterns.

Link 1. Operational Waters

The Oil Sands Water Release Technical Working Group (OSWRTWG) which consists of government and industry representatives, was established in 1995 to evaluate the issue of releases of water from oil sands operations to the Athabasca River. OSWRTWG (1996) classed water releases into two groups: operational and reclamation waters. Operational waters are those waters that are:

- discharged from a channel or outfall;
- discharged over the life of the project or a shorter time-frame;
- controllable;
- treatable in a managed treatment system;
- amenable to comparing to ambient water quality criteria; and
- potentially of concern with respect to regional off-site impacts.

Sources of operational waters include:

- consolidated tails
- drainage water collected from dykes and structures
- mine drainage
- upgrading process
- cooling water
- sewage treatment facility

An overview of the quality of these waters is given in Table I-3 (Appendix 1). Levels of trace organics, naphthenic acids, and some metals are considerably higher than in either the Athabasca or Steepbank Rivers. An overview of the discharge volumes from these sources is given in Table I-4 (Appendix 1) and the location of the discharge points shown in Figure F3.0-2. Given the elevated concentrations for some chemicals noted in operational waters plus the numerous discharges to the Athabasca River, there is potential that operational discharges will affect the water quality of the Athabasca River. There are, however, no plans to discharge any operational waters to the Steepbank River. Thus a link between release of operational waters and changes in water quality exists for the Athabasca River but not the Steepbank River. The linkage between operational water releases and potential changes in water quality will extend over the operational life of the plant.

Link 2. Reclamation Waters

Reclamation waters are defined according to OSWRTWG (1995) as those waters that are:

- non-point source diffuse waters, which may be directed through wetlands, streams or lakes prior to discharge into the Athabasca or Steepbank Rivers;
- released at slow rates over large areas for extended periods of time;
- non-controllable;
- non-treatable (but may be altered through natural systems or constructed wetlands);
- not amenable to conventional end-of-pipe approval requirements; and
- primarily an on-site water management system and a component of a maintenance-free reclamation landscape.

Sources of reclamation waters include surface runoff and groundwater seepage from:

- sand dumps and dykes
- CT deposits
- coke piles, gypsum storage units and other waste dumps
- overburden dumps and dykes
- wetlands treatment systems

An overview of water quality of these waters compared to natural surface waters is given in Table I-3. Levels of trace organics, naphthenic acids and some metals in are considerably higher than in either the Athabasca or Steepbank Rivers, particularly in the case of dyke drainage water and CT release water. An overview of the discharge volumes from these sources is given in Table I-4 and locations of the discharge points shown in Figure F3.0-2. With the exception of very low volumes of CT drainage waters, no reclamation waters will flow into the Steepbank River. The linkage between release of reclamation waters and changes in river water quality will extend well into the future, as a result of long-term leaching of chemicals from reclamation soils.

Link 3. Accidental Releases

Three types of accidental releases need to be considered with respect to impacts on the aquatic environment:

- Catastrophic releases related to failure of an engineered structure, e.g., breaching of a tailings dyke;
- Spills associated with hydrotransport, pipeline transport, or accidents on the bridge or barge; and
- Releases related to upset conditions, e.g., flooding of retention basins, failures in the wastewater treatment system.

Catastrophic Releases

In the more than thirty years of lease operations Suncor has maintained the stability of all retention structures including tailing dykes, waste dumps and other facilities. These structures have been designed and operated to accepted Canadian standards for fluid retention structures, and the design and safe operating conditions have been supported by an extensive monitoring program and reviewed by independent review boards and regulatory agencies. In the very unlikely event of a major instability, Suncor has developed an Emergency Response Plan which would provide warning to those who may be affected.

In addition, the stability of all structures will improve with time due to two important factors. Firstly, the removal of fluid like mature fine tails and the replacement with CT will assist in improving stability. Secondly the porewater pressures in the foundation and other elements of the structure will slowly decrease with time further increasing the stability of structure from the already acceptable conditions. When the removal of fine tailings and the infilling of the ponds is complete, these structures are no longer retain fluid. The seismic activity of this region is very low; thus the long term stability of all lease components in respect to earthquake considerations is also assured. A detailed discussion of the stability of existing and reclamation landforms is given Suncor's Steepbank Mine Application (Suncor 1996).

Spills

Spills associated with hydrotransport and pipeline transport across the bridge, accidents on the bridge or barge, and construction activities in or near watercourses could potentially affect fish health, benthic invertebrates and aquatic habitat. Several types of materials will be piped across the bridge: slurried oil sands prior to extraction, mine tailings, natural gas, diesel fuel, and hot water (see Steepbank Mine Application). Shop facilities will include storage areas for diesel fuel, gas and oil. Hence the most likely types of spills associated with hydrotransport, pipeline activities and shop facilities are from petroleum products. Typical impacts to aquatic ecosystems caused by oil spills include direct toxicity to aquatic organisms; death of algae, plankton, aquatic insects and fish as a result of coating with oil; impairment of photosynthesis from coating of plankton; and tainting of fish flesh (Alberta Forestry, Lands and Wildlife 1985).

Given the potential for negative impacts to aquatic biota, several features have been incorporated into the bridge design and into the design of the shop facilities to prevent or contain spills. The bridge is designed with a solid bridge deck below the pipes and a containment curb that will contain spills. Also, a gradient away from the center of the river (i.e., to each bank) would direct a spill to containment structures at the base of the bridge which are designed to contain the entire volume of the pipelines. Since the most likely place a pipe will burst is at the joints, a steel ring enclosure shroud is placed around each pipe joint to prevent spray into the river should the pipe burst. Also, in the event of a breakage, isolation valves at each end of the bridge ensure that the maximum volume released from the pipes would be the volume contained in the portion of the pipeline that extends across the bridge. As well, mitigation measures to prevent spills will be followed during nearshore and instream construction. These have been described in Section F2.1.

Shop facilities will also have features to prevent contamination of surface water. The shop facilities will have an independent surface water drainage system which will collect and contain surface runoff and sediment. Also, areas with high potential for contamination such as fuel islands, will have individual collection systems.

Upset Conditions

The Mine Drainage System (Ponds A, B, C and D) is designed to accommodate the 1 in 10 year annual runoff. This storage capacity is large enough to contain a 1 in 100 year flood (Klohn-Crippen 1996). Thus, overflow of retention basins would only occur under runoff conditions in excess of the 1 in 100 year flood or the 1 in 10 year annual runoff. Overflow of retention basins A, B, and C flows into the Athabasca River, whereas overflow from Pond D flows into to Shipyard Lake. In 2005, when Dyke 10 is complete, overflow can be diverted into Pit 1. Thus, flooding would only occur under extreme conditions (runoff in excess of the 1 in 100 year flood) and it is limited the early stages of mine development (1997 to 2005).

In summary, the potential for accidental releases to the Athabasca River is low given the features discussed above. In the event of an accidental release, Suncor's Environmental Management Plan provides a protocol for dealing with these events. Suncor has a fully trained in-house emergency response team and specialized equipment for handling oil spills. Mutual aid agreements with the Fort McMurray Fire Department and Syncrude provide immediate additional backup should it be necessary.

Link 4. Changes in Surface and Groundwater Flow Patterns

As noted above there will be a number of different sources of operational and reclamation waters that will be released to the Athabasca and/or Steepbank Rivers. In additions, changes in natural drainage patterns and/or hydraulic gradients may potentially affect the volumes of water in the Athabasca and Steepbank Rivers. This in turn has the potential to affect water quality because of changes in dilution and mixing of chemicals within the rivers. However, the changes in flow rates within the rivers will be negligible (see Section F1 and F2), so this linkage does not exist, and is not a factor with respect to potential water quality changes in these rivers.

Link 5. Changes in Water Quality

The mode of action in which all of the above activities are expressed is the potential for changes in water quality in the Athabasca and Steepbank Rivers, particularly with respect to those chemicals that may adversely affect aquatic ecosystem health. Given the wide range in both water quality and discharges from operational and reclamation water, the cumulative loads from these sources need to be accounted for in the predictions of changes in water quality.

The total volumes of operational and reclamation waters that may be released to the Athabasca River are small relative to flow conditions in the river. For example, current flows from the wastewater effluent (1995: 0.33 m^3/s; Table I-4) are only 0.3% of 7Q10 flows (the lowest mean flow over a seven day-period that occurs, on average, once every ten years: 114 m^3/s; Noton and Shaw 1989) and only 0.05% of mean annual flows (667 m^3/s; Environment Canada 1991). Similarly, the sum of all other operational and reclamation water releases (0.68 m^3/s; Table I-4) are only 0.6% of 7Q10 flows and only 0.1% of mean annual flows. Changes in concentrations of a number of water quality parameters predicted to occur as a result of this additional load are slight. Table I-5 (Appendix 1) shows predicted concentrations within the mixing zone, based on maximum concentrations in the release waters. The largest changes in concentrations will occur immediately below the discharge points, particularly the refinery discharge (combined wastewater and cooling pond effluent) as it currently accounts for 93% of all water released as a result of Suncor's operations. Dispersion and mixing processes will act to reduce concentrations with distance as one moves downstream from Suncor and from the west to east banks of the river (e.g., predicted ammonia concentrations are shown in Figure F3.0-3).

The maximum volume of CT water that might enter the Steepbank River (as a result of seepage from the CT tailings pond) is estimated at only 0.0014 m^3/s (Klohn-Crippen 1996). That volume represents 0.3% of mean winter flows (December to March: 0.478 m^3/s; Environment Canada 1991) and only 0.02% of mean annual flows (7.27 m^3/s; Environment Canada 1991). Changes in concentrations of a number of water quality parameters predicted to occur as a result of this additional load are slight and summarized in Table I-6 (Appendix 1).

In summary, slight changes to river water quality will occur as a result of discharge of both operational and reclamation waters. However, the changes in concentration will be negligible for most chemicals and would not be detectable in the field (given current precision of most chemical analyses). Even so, there is potential that these slight increases could adversely affect ecosystem health, so the linkage between water quality and discharge of operational and reclamation waters exists. This linkage will extend well into the future as a result of long-term loading from reclamation waters.

F3.2 TEST OF IMPACT HYPOTHESES

As noted above, concentrations of some chemicals will increase slightly in the Athabasca River alongside and downstream of Suncor's leases. Thus, there is a linkage between mine development and changes in water quality. However, the change in chemical concentrations will be very small, and in most cases will not be measurable. Even so, a combined field and laboratory study was carried out to quantify aquatic ecosystem health parameters so that the impact of the changes in water quality could be tested. In particular, three testable hypotheses were evaluated (Figure F3.0-1):

- Changes in water chemistry will result in acute and/or chronic toxicity to bacteria, invertebrates, plants or fish within the Athabasca or Steepbank Rivers;
- Changes in water chemistry will adversely affect fish health within the Athabasca or Steepbank Rivers; and
- Changes in water chemistry will result in changes to benthic invertebrate community structure.

Each of these hypotheses are tested as described below:

Link 6. Trophic Level Toxicity Testing

A sustainable aquatic ecosystem requires that all major components of the ecosystem (bacteria, plants, animals) are viable. Alberta Environmental Protection (1995b) suggests using a battery of toxicity tests to help evaluate aquatic ecosystem health. The toxicity tests done for this assessment include acute tests for mortality to rainbow trout and zooplankton (*Daphnia magna*) and inhibition of light production by bacteria (*Photobacterium phosphoreum* or *Vibrio fischeri*), plus chronic tests for reproduction and survival of a zooplankton (*Ceriodaphnia*) and growth of an aquatic plant (the algae, *Selenastrum*).

Toxicity data are summarized in Table F3.0-1. With the exception of TID or CT release water, there is little evidence of acute toxicity in either reclamation or operational waters, and no evidence of acute or chronic toxicity in either the Athabasca or Steepbank Rivers. *Ceriodaphnia* reproduction is the most sensitive chronic endpoint, and the highest levels of response were noted for CT water with a 14% concentration of CT water causing an inhibition of *Ceriodaphnia* reproduction of 25% (IC25 14%).

The potential impacts associated with release of these waters to the Athabasca River can be assessed using a dilution model (see Golder 1996c for a detailed discussion of this model). Figure F3.0-4 shows predicted levels of toxic units (inverse of no observed effect concentration (NOEC) for *Ceriodaphnia*, expressed as a fraction) in the Athabasca River, alongside and downstream of Suncor. Toxic units are useful for modelling purposes because they can be used to compute a toxic unit loading rate, so that potential toxicity in receiving waters can be predicted. Alberta Environmental Protection suggest an in-stream guideline for toxic units for chronic endpoints (TUc) of 1.0, which is equivalent to the NOEC of the most sensitive test organism. It is evident from Figures F3.0-4 to F3.0-8 that in-stream concentrations are considerably lower than the 1.0 TUc guideline, even directly adjacent to Suncor's existing facility under 7Q10 flows (i.e., the lowest flows that occur over seven consecutive days, on average, once every 10 years). Hence, no toxicity is expected in the Athabasca River as a result of the cumulative discharge of operational and reclamation waters.

TABLE F3.0-1

TOXICITY OF SUNCOR'S OPERATIONAL AND RECLAMATION WATERS TO AQUATIC BIOTA

Test	Type/Length	Endpoint Statistic	TID Water[1]			CT Pit[2]			Mine Drainage[3]			Wastewater System4			Cooling Pond E[5]			Sewage Lagoon[6]		
			Range	Median	n	Rang	Median	n	Range	Median	n	Range	Median	n	Range	Median	n	Range	Median	n
Algal Growth Inhibition Test[7]	72-hour	IC25 (%)	42-62	52.5	4		45	1	10 ->100	>100	11	12->100	>100	4	46 - >100	>100	4		58	1
		IC50 (%)	92->100	>99.5	4		78	1		>100	11		>100	4		>100	4		79	1
		NOEC (%)	25-50	37.5	4		25	1	6.25-100	100	11	6.25-100	50	4	50 - 100	100	4		50	1
		LOEC (%)	50-100	75	4		50	1	12.5->100	>100	10	12.25 - >100	100	4	100 - >100	>100	4		100	1
Bacterial Luminescence Test[8]	Screening Test	% of Control	15-42	31.5	4		40	1	83 - 114	106	9	74 - 99	81	4	91 - 129	100	4		100	1
Trout Survival Test[9]	96-hour Acute	IC25 (%)					31	1		>100	9		>100	4		>100	4			
		IC50 (%)	35-55	49	4		37	1		>100	9		>100	4		>100	4		80	1
		NOEC (%)		25	3		25	1		100	9	50 - 100	100	4		100	4		50	1
		LOEC (%)		50	3		50	1		>100	9	100->100	>100	4		>100	4		100	1
Ceriodaphnia Survival Test[10]	7-day Static Renewa	IC25 (%)	43.8-96	73	4		43.8	1	88 - >100	>100	9	30 - >100	>100	4		>100	4		69	1
		IC50 (%)	66.7->100	>86	4		64.3	1		>100	9	38 - >100	>100	4		>100	4		92	1
		NOEC (%)		50	4		50	1	50-100	100	9	25 - 100	100	4		100	4		50	1
		LOEC (%)		100	4		100	1	100 - >100	>100	9	50 - >100	>100	4		>100	4		100	1
Ceriodaphnia Reproduction Test	7-day Static Renewa	IC25 (%)	16-25	21.7	4		13.9	1	12->100	>100	9	25 - 99	36	4	34 - 87	83	4		36	1
		IC50 (%)	22-52	31.9	4		19.9	1	100->100	>100	9	35 - >100	59	4		>100	4		64	1
		NOEC (%)	12.5-25	12.5	4		12.5	1	6.25-100	100	9	25 - 50	25	4	12.5 - 50	50	4		25	1
		LOEC (%)	25-50	25	4		25	1	12.5->100	>100	9	50 - 100	50	4	25 - 100	100	4		50	1
Daphnia Survival Test[11]	48-hour Acute	IC25 (%)		>100	3		>100	1		>100	8		>100	4		>100	4		>100	1
		IC50 (%)		>100	4		>100	1		>100	9		>100	4		>100	4		>100	1
		NOEC (%)		100	3		100	1		100	8		100	4		100	4		100	1
		LOEC (%)		>100	3		>100	1		>100	8		>100	4		>100	4		>100	1

NOTES:

[1]TID water taken from TID collection system, sample RW127.
[2]CT water is composite sample from CT pits, sample RW159.
[3]Mine Drainage water is taken from Suncor's drainage collection system, samples RW250, 251, 252.
[4]Wastewater System water is taken from Suncor's wastewater collection system, sample RW254.
[5]Cooling Pond E water is taken from Suncor's cooling water system, sample RW256.
[6]Sewage Lagoon water was obtained from sewage effluent system, sample RW258.
[7]Algal growth test was performed with fresh water alga, *Selanastrum capricornutum*.
[8]Bacterial luminescence test was performed with either, *Photobacterium phosphoreum* or *Vibrio fischeri*.
[9]Trout toxicity test performed with *Oncorhynchus mykiss*
[10]Ceriodaphnia test performed with the cladoceran, *Ceriodaphnia dubia*.
[11]Daphnia toxicity test performed with *Daphnia magna*.

Similarly for the Steepbank River, the maximum TUc level is estimated at only 0.02 TUc (based on Ceriodaphnia NOEC of 12.5% for CT water from Table F3.0-1 which gives a TUc of 8, CT seepage to river of 0.0014 m^3/s and mean winter river flows of 0.48 m^3 /s and a TUc of 0 for the background river; hence, a simple dilution calculation gives [8 TUc x 0.0014 m^3/s + 0 TUc x 0.48 m^3/s] ([0.0014 m^3/s + 0.48 m^3/s] = 0.023 TUc). Thus, as for the Athabasca River, no toxicity is expected in the Steepbank River as a result of the inflow of CT reclamation waters, even under low-flow, winter conditions.

In summary, there is no evidence from all the laboratory toxicity tests used that the cumulative impact from operational and reclamation waters will adversely affect ecosystem health in either the Athabasca or Steepbank Rivers. This finding is consistent with that from a recent NRBS study that concluded the oil sands region was not contributing to toxicity of test animals (Dobson et al. 1996). Thus, changes in trophic level health are rated as negligible.

*7. **Fish Health***

A combined field and laboratory study was completed to address the question as to potential impacts on fish health (see Section E6.0 for an overview of results of the studies). The fish health impact evaluation is described in detail in (Golder 1996c) and summarized below.

This evaluation focuses on maintaining healthy, sustainable populations of walleye, goldeye and longnose sucker (and by inference other fish species) in the Athabasca River. The measurement endpoints used to support this evaluation cover three levels of organization: (1) population, (2) whole-organism, and (3) biochemical/physiological. The population-level endpoints include age distribution (an indicator of age-specific survival), size-at-age (an indicator of growth), GSI and fecundity (two indicators of reproductive capability). Data for these endpoints are from the field component of the study as summarized in Golder (1996a). Whole organism endpoints include condition, short-term growth, pathology, disease resistance, and, swimming stamina. Data for these endpoints are from the field component of the 1995 field study and/or laboratory experiments (HydroQual 1996). Biochemical and physiological endpoints include relative liver size, blood chemistry, blood cell counts, mixed function oxidases, and chemical concentrations in tissue. Data for these endpoints are from the 1995 baseline field study (Golder 1996b) and/or laboratory experiments (HydroQual 1996a).

The method used to arrive at predicted impacts was as follows:

1. Assemble experimental data on the effects of chronic exposure to Suncor wastewaters.
2. Derive no effect levels (NOELs) and lowest effect levels (LOELs) for the suite of fish health parameters used in laboratory experiments (primarily the biochemical/physiological measurement endpoints).
3. Compare LOELs and NOELs to the modelled concentrations in the river for the years 1995, 2001, 2010, 2020 and long-term (post reclamation).
4. Predict impacts on the biochemical/physiological endpoints.
5. Predict impacts on the whole-organism and population-level measurement endpoints (using observed effects in laboratory experiments and comparing what the laboratory data would predict with what was observed in the field).
6. Draw a conclusion regarding the health and sustainability of fish populations.

The results of the 28-day exposure experiment using TID water were consistent among all of the measurement endpoints. The LOEL for the sensitive physiological endpoints and for histopathology was 10% (Table F3.0-2). Other "higher-order" whole-organism endpoints such as (growth and swimming stamina) that integrate the effects of all stress (including that caused by laboratory handling) showed no effect at any of the treatment concentrations (Table F3.0-2). There were no effects on the sensitive physiological endpoints at 1% or less. Therefore, the estimated NOEL is 1%. The actual NOEL is unknown, but would lie between 1% and 10%.

Based upon the short-term laboratory results (4 and 7 day exposures), the LOEL for CT water and refinery wastewater is 10% and the NOEL is 1%. EROD induction was the only endpoint used in these experiments, but since it is the most sensitive endpoint it is unlikely that any other endpoint would yield lower LOELs or NOELs. Therefore, based on the results of both the short and long-term laboratory results, the LOEL for exposure to operational and reclamation waters released to the Athabasca River is 10%. The NOEL for all endpoints is assumed to be 1%. The actual NOEL for all endpoints may be greater than 1% but it is not less than 1%.

TABLE F3.0-2

SUMMARY OF OBSERVATIONS FOR THE 28-DAY EXPERIMENT (using 0.01%, 0.1%, 1% and 10% concentrations)

END POINT	Tar Island Dyke		1 % NAPHTHENIC ACID	ATHABASCA RIVER
	LOEL[1]	NOEL[2]		
Survival	No Effect	No Effect	No Effect	No Effect
Growth	No Effect	> 10%	No Effect	Increase
Condition Factor	No Effect	> 10%	Decrease	No Effect
Liver Somatic Index	No Effect	> 10%	Increase	No Effect
Gross Pathology	No Effect	> 10%	No Effect	No Effect
Histopathology	10%	1%	Increase	No Effect
Hematocrit	10%	1%	Decrease	No Effect
Hemoglobin	No Effect	> 10%	No Effect	No Effect
Glucose	10%	1%	Decrease	No Effect
Protein	No Effect	> 10%	No Effect	No Effect
Lactic Acid	10%	1%	Increase	No Effect
White Blood Cells	No Effect	> 10%	No Effect	No Effect
EROD Activity	10%	1%	No Effect	No Effect
Disease Resistance	No Effect	> 10%	No Effect	Decrease
Swimming Stamina	No Effect	> 10%	No Effect	Decrease

[1]LOEL - lowest observed effect level
[2]NOEL - no observed effect level
Data from HydroQual (1996)

The derived NOELs and LOELs were compared to predicted concentrations of operational and reclamation waters in the Athabasca River during five time periods: 1995, 2001, 2010, 2020 and long-term. For each time period, concentrations were predicted based on mean annual flows and 7Q10 flows (low flows). The 7Q10 flows in the year 2020 represent the worst case scenario (i.e., highest concentrations of wastewater in the Athabasca River) (Figure F3.0-9). A zone of 2% concentration about 14 km long and occupying about one tenth of the river width exists along the west bank of the river. A very small area of 5% concentration occurs immediately adjacent to the refinery wastewater discharge. All other modelled concentrations are less than or equal to the NOEL. The area occupied by the 2% zone is used by several fish species during the open-water season, as noted above. However, since low-flow periods occur in late fall and winter, and since overwintering habitat is not plentiful in the 2% zone, the overall exposure of fish to this concentration will be minimal. In post-reclamation conditions, concentrations are much lower than in 2020 (Figure F3.0-10). All concentrations are well below the NOEL. Thus, no effects on fish populations would be expected in post-reclamation conditions (for discussion of other scenarios see Golder 1996c).

The modelled concentrations for both the current (1995) case and future cases were all well below the observed LOEL for biochemical and physiological responses in fish. This was true even for 7Q10 extreme low-flow conditions. Thus, it is very unlikely that exposure to operational and reclamation water releases will cause biochemical or physiological responses in fish in the Athabasca River. However, the presence of areas of concentration below the LOEL but above the NOEL indicate that there may still be a potential for effects on these endpoints. These endpoints are very sensitive and are indicative of exposure to a stressor or stressors and the fish's response to that stressor. A response by one of the biochemical or physiological systems does not necessarily predict adverse effects on the whole organism; in fact, early responses to stressors are often detoxification or adaptive responses that are designed to prevent whole organism effects. Therefore, threshold-effect concentrations based upon biochemical or physiological endpoints are conservative with respect to protecting fish from effects on individuals (whole organism) and even more conservative with respect to protecting fish populations.

The assessment endpoint for fish health is to maintain healthy populations of walleye, goldeye and longnose sucker which show no greater than 10% change in survival, growth or reproduction

(Golder 1996c). The predicted effects on survival, growth and reproduction show that this assessment endpoint will be met. These predictions are borne out by observations of current fish populations, which have been exposed to water releases from Suncor operations for at least part of the year for two decades. These populations continue to successfully utilize habitat in the Suncor study area, and exhibit normal growth and reproduction. Since future concentrations of water releases to the Athabasca River are predicted to be lower than current conditions, future populations of fish should continue to be healthy. In summary, no impacts on fish health are expected as a result of releases of Suncor's waters to the Athabasca or Steepbank Rivers.

8. Benthic Invertebrate Community Structure

Benthic invertebrate communities in the Athabasca River are typical of the depositional reaches of large rivers. Communities are characterized by low density and taxonomic richness, and are dominated by Chironomid midges. Densities of other insect groups and oligochaete worms are low but variable, depending largely on substratum characteristics. The benthic fauna of the Athabasca river consists largely of collector-gatherers and predators. Discharges from Suncor and seepage from TID did not cause measurable benthic community alteration at any of the sites sampled in 1995. Given that in the future the total loading from the existing wastewater will be reduced substantially it is unlikely that future water releases will result in changes to benthic invertebrate community structure. This is supported by the results of the trophic level testing discussed above, which indicated that no toxicity is expected in either the Athabasca or Steepbank Rivers as a result of cumulative loads of all operational and reclamation waters. In addition, nutrient loads and biological oxygen demands (BOD) are low, so eutrophication or oxygen depletion will not be a problem.

F3.3 HYPOTHESIS IMPACT CLASSIFICATION

F3.3.1 Degree of Concern

Based on the testable hypothesis presented above, one can conclude that:

Construction Phase: There is no evidence that construction activities will adversely affect fish health or benthic invertebrate community structure. This impact is considered negligible.

Operational Phase: There is no evidence that operational activities will adversely affect fish health or benthic invertebrate community structure. This impact is considered negligible.

Post-Reclamation: There is no evidence that reclamation activities will adversely affect fish health or benthic invertebrate community structure. This impact is considered negligible.

Hence, the overall degree of concern for aquatic ecosystem health is rated as negligible (Figure F3.0-11).

F3.3.2 Certainty

The conclusion above was based on a diverse set of field, experimental and modelling studies, all of which point to the above conclusion. Additional laboratory studies have been initiated using refinery wastewater to confirm if the existing lab study (done on TID water) holds for other wastewaters. Therefore, there is a high degree of certainty associated with these conclusions.

F3.3.3 Cumulative Impacts

This assessment was based on taking into account all current upstream sources (i.e. all pulp mills, municipal effluents and non-point discharges) by monitoring existing water quality. Proposed developments such as Solv-Ex and Syncrude could contribute to cumulative impacts on aquatic ecosystem health. Solv-Ex will not release effluent unless it meet AEPs surface water quality objectives (Bovar-Concord 1995) no other information is available on water releases from this source so it was not included; however, releases are expected to be minor and would not affect the conclusion of this study. The Solv-Ex operations will not affect river water quality and thus will not affect aquatic ecosystem health. Syncrude's reclamation of existing mines involves construction of end-pit lakes. The water quality of these lakes is expected to develop over time to moderately productive lakes comparable to natural lakes in the region. Water quality in the lakes will be suitable for sensitive aquatic biota within a few years following capping, and prior to any release from the lake to the Athabasca River. Hence, discharge is not expected to add a significant source of load to the Athabasca River; even so this source of water was incorporated into the future water quality projections. Presently, no information is available on water releases from Syncrude's proposed Aurora Mine. Thus, potential contributions to cumulative impacts from the Aurora Mine are not included in this assessment. They will, however be assessed as part of the Aurora Mine EIA.

Based on the above discussion and ratings of potential impacts, the contribution to cumulative impacts to ecosystem health in the region is negligible.

F4.0 CHANGES IN FISH FLESH QUALITY

Hypothesis 31 Water releases associated with construction, operational, or reclamation activities might adversely affect the quality of fish flesh.

Figure F4.0-1 shows the linkages among activities, mode of action, testable hypotheses and the primary impact hypothesis. As noted in this figure, there are four primary activities that might result in changes to water quality in the Athabasca and/or Steepbank River: release of operational and reclamation waters, accidental spills, and changes in surface and subsurface flow patterns.

F4.1 VALIDITY OF LINKAGE BETWEEN ACTIVITY AND MODE OF ACTION

Links 1, 2, 3, and 4. Activities

The linkages between mining activities and mode of action are described in Section F3.

Link 5. Changes in Water Quality

The mode of action in which all of the activities are expressed is the potential for changes in water quality in the Athabasca and Steepbank Rivers, particularly with respect to those chemicals that may adversely cause tainting or affect fish flesh chemical concentrations. The primary chemicals of concern with respect to tainting include simple aromatic compounds such as phenol, alkalated benzenes, alkalated naphthalenes and polycyclic aromatic sulphur heterocycles (PASHs). Some of these compounds such as dibenzothiophene are present in Suncor's wastewater, and to a lesser degree in dyke drainage water, but most have not been detected in CT release water (Table I-3; Jardine and Hrudey 1988). Hence, there is potential that changes in river water quality resulting from water releases might lead to tainting.

With respect to changes in chemicals that might concentrate in fish flesh, the chemical of primary concern is mercury, which is detectable in wastewater and is known to bioconcentrate in fish tissues (CCREM 1987). PAHs are unlikely to bioconcentrate given that fish have enzyme systems to eliminate these chemicals from their body. Naphthenates are water soluble and unlikely to bioconcentrate in fish tissue.

F4.2 TEST OF IMPACT HYPOTHESES

As noted above, concentrations of some chemicals will increase slightly in the Athabasca River alongside and downstream of Suncor's leases. Thus, there is a linkage between mine development and changes in water quality. However, the change in chemical concentrations will be very small, and in most cases will not be measurable. Even so, a combined field and laboratory study was carried out to quantify potential for tainting and accumulation of chemicals in fish tissue. In particular, two testable hypotheses were evaluated:

- Changes in water chemistry will result in fish flesh tainting; and
- Changes in water chemistry will result in changes in chemical concentrations in fish tissue.

These hypotheses are tested as described below:

6. Fish Tainting

Tainting is not a human health issue and does not affect fish health but it is significant nonetheless because tainting will limit the use of the fish resource.

A direct test of the potential for tainting was conducted by exposing rainbow trout to various waters and submitting them to a tasting panel (Golder 1996b). The results of this test are described in Section E5.6. Tainting was evident in trout exposed to 0.5% wastewater (diluted with laboratory water), but not in fish exposed to TID water or Athabasca River water. Dilution with Athabasca River water reduces wastewater concentrations to only 0.5%, immediately below the outfall under typical river flow conditions. Even under low flow conditions (7Q10 flows), the 0.5% dilution zone is restricted to a small section of river immediately adjacent and downstream of the wastewater effluent (Figure F4.0-2). However, since a lower bound for tainting was not identified in this study, one cannot delineate the extent of river in which tainting might occur.

Wastewater effluent will be reduced from the existing 0.34 m^3/s, to 0.25 m^3/s in 2000 so potential for tainting should be reduced proportionally. In addition, Suncor has initiated a series of studies to further its understanding of the Wastewater Treatment System. These studies include chemical and toxicological assessments of the various waters which feed into the system. An engineering evaluation is also underway to identify options available for handling these waters. Coupled with the above is a combined fish health and tainting assessment which is being conducted on the Wastewater Treatment System effluent. This study will follow the protocols employed during the 1995 fish health study (HydroQual 1996). One addition for the 1996 study is an assessment of tainting depuration rates. However, until the results of these studies are known tainting has been defined as a moderate impact of moderate duration (i.e., restricted to the operation of the plant).

7. Fish Tissue Chemical Concentrations

A combined field and laboratory study was conducted to assess the potential for accumulation of chemicals in fish tissue (HydroQual 1996a, Golder 1996a). The results of these studies are analysed in Golder (1995b) and summarized in Section E8. Concentrations of organic chemicals (e.g., PAHs) in fish captured from the Athabasca River in the vicinity of Suncor were low to non-detectable

(Table I-3). Laboratory tests showed that uptake of these chemicals by fish is unlikely. Similarly, analyses of metals in fish collected from the field and fish exposed to Tar Island Dyke water in the laboratory were low to non-detectable (Table I-3). Mercury concentrations were low, but detectable, for both control and TID exposed fish. Thus, no significant accumulation of metals or organic chemicals is indicated by either laboratory exposures of fish to TID water or under current field conditions.

F4.3 HYPOTHESIS IMPACT CLASSIFICATION

F4.3.1 Degree of Concern

Construction Phase: There is potential for moderate-level tainting of flesh in fish exposed for a long-time periods at a site immediately below Suncor's wastewater effluent; however, no measurable increase in fish tissue chemical concentrations is expected. This impact is considered negative, moderate in severity, moderate-term in duration, and local in extent.

Operational Phase: There is potential for moderate-level, tainting of fish flesh to fish exposed for a long-time periods at a site immediately below Suncor's wastewater effluent; however, no measurable increase in fish tissue chemical concentrations is expected. This impact is considered negative, moderate in severity, moderate-term in duration, and local in extent.

Post-Reclamation: There is no evidence of impact on fish tainting or fish tissues once the wastewater effluent is removed.

Hence, the overall degree of concern for fish flesh quality is rated as moderate (Figure F4.0-3).

F4.3.2 Certainty

There is a high degree of certainty in prediction of fish tissue chemical levels given information from both laboratory and field studies. However, prediction of impacts on tainting are less certain since a "No Observed Effect Level" has not been established and no field data were collected for submission to tainting panels. As a result, a more comprehensive study has been established to define potential areal extent of the tainting zone in the river; this study will be completed by summer 1996.

F4.3.3 Cumulative Impacts

Based on the above discussion and ratings of potential impacts on fish tissue concentrations, the contribution to cumulative effects in the region is negligible. Potential for fish tainting is likely restricted to releases from Suncor's wastewater. Other oil sands developments (Syncrude and Solv-Ex) do not or will not release refinery wastewaters (Bovar-Concord 1995).

F5.0 CHANGES IN FISH ABUNDANCE

Hypothesis 32 Construction, operational or reclamation activities might lead to changes in aquatic habitat and/or aquatic health which might result in a decline in fish abundance in the Athabasca or Steepbank Rivers.

Figure F5.0-1 shows the linkages among activities, mode of action, testable hypotheses and the primary impact hypothesis. As noted in this figure, there are six primary activities that might result in changes to fish abundance: changes in aquatic habitat, release of operational and reclamation waters, accidental spills, and changes in surface and subsurface flow patterns, and construction of a bridge which could lead to increased access for anglers.

F5.1 VALIDITY OF LINKAGE BETWEEN ACTIVITY AND MODE OF ACTION

Link 1, 2, 3, 4 and 5. Activities

The linkages between mining activities and mode of action are described in Section F3.1.

Link 6. Increased Access

Construction of a bridge across the Athabasca River provides ready access to the Steepbank River and the potential for increased fishing pressure. The bridge will not be open to the general public during the operational phase of the mine. Suncor employees will have access to the Steepbank River via the bridge, however access for recreational activities will be restricted. Thus, this linkage is restricted to post-reclamation conditions when general public may have access to the Steepbank River via the bridge.

Link 7. Changes in Water Quality

The potential for changes in water quality was described in Section F6.1.

F5.2 TESTS OF IMPACT HYPOTHESES

Link 8. Changes in Aquatic Habitat

Potential changes in aquatic habitat were evaluated in Sections F1 and F2 and rated as negligible.

Link 9. Changes in Aquatic Ecosystem Health

Potential changes in aquatic ecosystem health were evaluated in Section F3 and rated as negligible.

Link 10. Increased Fishing Pressure

Increased fishing pressure in the post-reclamation phase may result from use of the bridge to access the Steepbank River area. An increase in fishing pressure could cause a decrease in fish abundance. However, regulation of angling is the responsibility of Fisheries Management Services Division, Alberta Environmental Protection. It is assumed that decreases in fish abundance would be prevented by appropriate enforcement of legislation by Fisheries Management Services Division, Alberta Environmental Protection.

F5.3 HYPOTHESIS IMPACT CLASSIFICATION

The loss of fish habitat is minimal and not expected to reduced fish abundance. Similarly, no changes in fish health are expected so the linkage between fish health and fish abundance is incomplete.

F5.3.1 Degree of Certainty

Construction Phase: Changes in fish abundance will be negligible.

Operational Phase: Changes in fish abundance will be negligible.

Post-Reclamation: Changes in fish abundance will be negligible.

Hence, the overall degree of concern for changes in fish abundance is rated as negligible (Figure F5.0-2).

F5.3.2 Certainty

Given the certainty in the assessment of the hypotheses that potentially lead to changes in fish abundance, there is a high degree of certainty in this assessment. Habitat loss of small tributaries need to be further documented; however, overall habitat loss in the local study area is small. The combined use of laboratory and field data for assessing aquatic ecosystem health, plus the multi-level approach give a high certainty in the assessment of potential impacts to ecosystem health.

F5.3.3 Cumulative Impacts

Since the potential impacts on fish abundance are low, the potential contribution to cumulative impacts in the region is negligible. Cumulative impacts are possible from habitat loss of small tributaries associated with the Aurora Mine project (prior to reclamation), but these constitute a small area of the available aquatic habitat in the region and are not critical fish habitat.

F6.0 CHANGES IN FISH RESOURCE USE

Hypothesis 33 Construction, operational, or reclamation activities might lead to changes in fish abundance or quality of fish flesh which might result in a decreased use of the fish resource.

Figure F6.0-1 shows the linkages among activities, mode of action, testable hypotheses and the primary impact hypothesis. As noted in this figure, there are six primary activities that might result in changes to fish resource use: changes in aquatic habitat, release of operational and reclamation waters, accidental releases, and changes in surface and subsurface flow patterns, and construction of a bridge, potentially leading to increased angler access to the Steepbank River.

F6.1 VALIDITY OF LINKAGE BETWEEN ACTIVITY AND MODE OF ACTION

Link 1, 2, 3, 4, 5, 6 and 7. Activities

The linkages between mining activities and mode of action are described in Section F3.1. Four main activities (release of operational water, release of reclamation water, accidental spills and changes in surface and subsurface flow patterns) can potentially lead to changes in water quality, and possibly affect ecosystem health and fish flesh quality. Linkages exist between releases of both operational and reclamation waters and changes in water quality. Also linkages exist between barge and bridge operation and construction and aquatic habitat alterations. As well, mining activities adjacent to the Athabasca River are a valid linkage.

F6.2 TEST OF IMPACT HYPOTHESES

The potential for changes in fish abundance is described in Section F5 and is rated as negligible; the potential for fish flesh tainting is described in Section F4 and rated as negative, moderate in severity, moderate-term in duration, and local in extent. Golder (1996c) conducted a detailed human health risk assessment to evaluate potential health implications for people consuming fish from the Athabasca River. They concluded that ingestion of fish would not adversely affect people's health.

F6.3 HYPOTHESIS IMPACT CLASSIFICATION

F6.3.1 Degree of Concern

Construction Phase: There is potential for low-level, tainting of fish flesh to fish exposed for a long-time periods at a site immediately below Suncor's wastewater effluent; however, no impacts on people's health or fish abundance are expected. This impact is considered negative, moderate in severity, moderate-term in duration, and local in extent.

Operational Phase: There is potential for low-level, tainting of fish flesh to fish exposed for a long-time periods at a site immediately below Suncor's wastewater effluent; however, no impacts on human health or fish abundance are expected. This impact is considered negative, moderate in severity, moderate-term in duration, and local in extent.

Post-Reclamation: There is no evidence of impact on fish tainting or fish tissues once the wastewater effluent is removed.

Hence, the overall degree of concern for decreased used of fish resources is rated as moderate (Figure F6.0-2).

F6.3.2 Certainty

Given the certainty in the assessment of the hypotheses that potentially lead to changes in the use of fish abundance there is a high degree of certainty in this aspect of the assessment. The potential for fish tainting is less certain and will be addressed by Suncor with further laboratory and field studies.

F6.3.3 Cumulative Impacts

Since the potential impacts on fish abundance are low, the potential contribution to cumulative impacts in the region is negligible.

F7.0 CHANGES IN USE OF ATHABASCA RIVER WATER

Hypothesis 34 Construction, operational or reclamation activities might cause changes in Athabasca River quality which might limit downstream use of the water.

Figure F7.0-1 shows the linkages among activities, mode of action, testable hypotheses and the primary impact hypothesis. As noted in this figure, there are four primary activities that might result in changes to water quality in the Athabasca and/or Steepbank River: release of operational and reclamation waters, accidental spills, and changes in surface and subsurface flow patterns.

F7.1 VALIDITY OF LINKAGE BETWEEN ACTIVITY AND MODE OF ACTION

Links 1, 2, 3, 4 and 5. Activities

The linkages between mining activities and mode of action are described in Section F3.

F7.2 TESTS OF IMPACT HYPOTHESES

The potential for changes in water quality are described in Section F3 and are negligible. Golder (1996c) provides a detailed assessment of potential for human health impacts and no impacts are expected from occasionally drinking untreated water downstream of Suncor's site (based on analysis of chemical exposures, this does not imply that water should be consumed without treatment as naturally-occurring pathogens occur in the water). For other users, e.g., downstream industrial users, changes in water quality are negligible and not a concern (see Table I-3).

F7.3 HYPOTHESIS IMPACT CLASSIFICATION

F7.3.1 Degree of Concern

Construction Phase: There is no evidence that construction activities will adversely affect downstream water use.

Operational Phase: There is no evidence that operational activities will adversely affect downstream water use.

Post-Reclamation: There is no evidence that reclamation activities will adversely affect downstream water use.

Hence, the overall degree of concern for downstream water use is negligible (Figure F7.0-2).

F7.3.2 Certainty

Given the certainty in the assessment for potential water quality changes and human health concerns, the certainty of this assessment is high.

F7.3.3 Cumulative Impacts

Since there are no potential impacts on water use, the potential contribution to cumulative impacts to water use in the region is negligible.

G RESIDUAL IMPACTS AND NET BENEFITS SUMMARY

There are seven key hypothesis pertaining to effects on aquatic resources from the development of the Steepbank Mine. The degree of concern for each of these impact hypotheses are defined in detail in Section F and the residual impacts summarized below:

Hypothesis 28 Changes in fish habitat in the Steepbank River

Aquatic habitat impacts were evaluated in the context of benthic invertebrate communities and fish VEC (walleye, goldeye and longnose sucker) habitat requirements. In the analysis of linkages between mining activities and aquatic habitat it was shown that impacts to the Steepbank River would be nonexistent due to the setback of mining equipment and lack of construction activities in the vicinity of the river. As well, alterations in flows due to changes in surface and sub-surface flow patterns would be negligible. Therefore, impacts on benthic invertebrates and fish habitat would be negligible for all phases of mine development.

Hypothesis 29 Changes in fish habitat in the Athabasca River

A number of linkages between mine development activities and Athabasca River aquatic habitat were determined; however, many of these will be prevented through mitigation (i.e. erosion and sedimentation from barge, ice bridge, permanent bridge and road construction will be prevented). Operation of the barge will cause habitat disturbance for a short time period (i.e. one or two seasons) and the bridge piers and abutments will represent habitat loss for the long-term. Both of these impacts affect less than 1% of the aquatic habitat within the local study area. Thus, impacts to benthic invertebrate communities and fish habitat in the Athabasca River are negligible. Drainage of Unnamed and Leggett Creeks represent a negative short-term local impact during the operational phase. This impact will be reversed in the reclamation phase when streams will be created that have equivalent or better aquatic habitat.

Hypothesis 30 Changes in the aquatic ecosystem health

An evaluation of linkages between water releases and water quality indicates that accidental spills are unlikely given the mitigation measures that are built into the project. However, slight changes in water quality will occur as a result of discharge of both operational and reclamation waters. Changes in ecosystem health were evaluated in the context of fish health, benthic community structure and acute and chronic toxicity to various trophic levels.

Toxicity of Suncor's wastewater was assessed in the laboratory, and based on these results was modelled in the Athabasca River. The results showed that for all phases of mine development instream toxicity in the Athabasca River was less than 1.0 Toxic Unit (AEP's guideline). Similarly, modelled toxic units in the Steepbank River are even lower than those in the Athabasca River. Thus, no impacts are anticipated on trophic level health of aquatic biota in the Athabasca of Steepbank Rivers from operational and reclamation waters.

Potential impacts on fish health were examined with laboratory experiments in conjunction with field data. The results indicated that Athabasca River fish communities found near Suncor are healthy and that deleterious effects from future water releases are unlikely.

Benthic invertebrate communities in the Athabasca River are typical of the depositional reaches of large rivers. Field investigations showed that discharges from Suncor and seepage from TID did not cause measurable benthic community alteration at any of the sites sampled in 1995. Given that in the future, total loading from the existing wastewater will be reduced substantially it is unlikely that future water releases will result in changes to benthic invertebrate community structure.

In summary, there is no evidence of potential adverse effects to benthic invertebrate communities, fish health and other trophic levels. Thus, for all three phases on mine development impacts to aquatic ecosystem health are considered negligible.

Hypothesis 31 Changes in the quality of fish flesh

Two aspects of fish flesh quality were examined: the potential for tainting and the potential for changes in chemical concentrations in fish tissue. A combined field and laboratory study was used to examine the potential for changes in chemical concentrations in fish tissue. No measurable increases in fish tissue concentrations of metals or organic chemicals are expected.

Tainting is not a human health concern and is does not impact fish health but it is significant nonetheless because tainting will limit the use of the fish resource. The potential for fish tainting was examined by exposing rainbow trout to various waters (0.5%TID water, 0.5% refinery effluent water and Athabasca River water) and submitting them to a tasting panel. Tainting was evident in fish exposed to refinery wastewater but not to TID or Athabasca River water and under low flow conditions it is possible tainting might occur in fish living in the effluent plume immediately downstream of Suncor's wastewater discharge. As a result, this impact has been identified as a moderate impact of moderate duration during the construction and operational phases. In post-reclamation conditions no impact is anticipated because the potential for tainting ceases once the wastewater effluent stops.

Hypothesis 32 Decline in fish abundance

The loss of fish habitat is minimal and not expected to reduce fish abundance. Similarly, no changes in fish health are expected so the linkage between fish health and fish abundance is incomplete. Another possible linkage between mine development and fish abundance is increased fishing pressure from use of the bridge to access the Steepbank River. The bridge will not be open to the general public during the operational phase of the mine. Thus this linkage would be restricted to post-reclamation conditions. Regulation of angling is the responsibility of Fisheries Management Services Division, Alberta Environmental Protection and it is assumed that decreases in fish abundance would be prevented by appropriate enforcement of legislation.

Hypothesis 33 Decrease use of fish resource

As discussed above, no changes in fish abundance are anticipated. No measurable increase in fish tissue concentrations of organic chemicals or metals is expected; however, there is potential for moderate-level tainting of fish flesh to fish exposed for long-time periods at a site immediately below Suncor's wastewater effluent. This impact, which is considered negative, moderate in severity and duration and local in extent, may contribute to a decreased use of the fish resource. Thus, a negative, moderate, short-term, local impact to use of the fish resource is anticipated in the construction and operational phases. Once the wastewater effluent is removed in the reclamation phase, no further impact on use of the fish resource will occur.

Hypothesis 34 Decrease use of Athabasca River

Potential impacts to human health from drinking water downstream of Suncor's site were assessed in detail by Golder (1996c) and found to be negligible. For other users, (e.g., downstream industrial users), changes in water quality are negligible and are not a concern.

H ENVIRONMENTAL MONITORING

All predictions of potential ecological impacts are subject to uncertainty as a result of: 1) inherent variability in natural systems; and 2) incomplete knowledge of natural systems. In the impact analysis it became clear that studies were needed to confirm some of the impact predictions and to further quantify the extent of the impacts. Fish tainting needs to be further explored. Also, aquatic habitat and fish use of Athabasca River tributaries (Unnamed, Leggett and Wood Creeks), Shipyard Lake and Horseshoe Lake need to be quantified.

H1.0 CONFIRMATORY STUDIES

The potential for fish tainting from Suncor's wastewater has been determined from a combined laboratory and field study (Golder 1996b). However, a lowest observed effect level was not determined (i.e., the concentration of wastewater that causes no tainting) was not determined, nor were data from field exposures to wastewater collected. Thus, Suncor has initiated a study to define the potential area extent of tainting in the river. This study will also include an investigation of potential tainting compounds. Once tainting compounds are identified, mitigation measures will be developed to remove or minimize the tainting compounds.

Examination of the lower reaches of Unnamed, Leggett and Wood Creeks in the spring of 1995 indicated little to no flow in these creeks, which precluded the use of these creeks for spawning. However, 1995 was a particularly dry year and may not be representative of typical conditions. These creeks will be resurveyed in 1996 to determine if fish use these creeks to spawn. In addition, fish surveys will be conducted on Shipyard Lake, Horseshoe Lake and the upper reaches of the tributaries. Habitat mapping of will also be conducted on representative sections of Unnamed, Leggett and Wood Creeks. Habitat information will be used to quantify area loss of habitat and to ensure that aquatic habitat created during reclamation is of equivalent or better quality than existing habitat.

H2.0 LONG-TERM MONITORING

Upon completion of the confirmatory studies a long-term monitoring program will be developed. Recommendations from the NRBS study will be integrated, where appropriate, into the monitoring program.

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J GLOSSARY OF TERMS

AOSERP	Alberta Oil Sands Environmental Research Program.
Backwater	Discrete, localized area exhibiting reverse flow direction and, generally, lower stream velocity than main current; substrate similar to adjacent channel with more fines.
BaP	Benzo-a-pyrene. A metabolite of PAH that accumulates in body tissues and fluids, specifically bile, following PAH biotransformation. Often metabolite concentration is more easily detected than the parent chemical concentration and serves as a biomarker of exposure to that parent chemical.
Benthic Invertebrates	Invertebrate organisms living at, in, or associated with the bottom (benthic) substrate of lakes, ponds and streams. Examples of benthic invertebrates include several aquatic insect species (such as caddisfly larvae) which spend at least part of their lifestages dwelling on bottom sediments in the river. These organisms play several important roles in the aquatic community. They are involved in the mineralization and recycling of organic matter produced in the open water above or brought in from external sources, and they are important second and third links in the trophic sequence of aquatic communities. Many benthic invertebrates are major food sources for small fishes.
Bile	An alkaline secretion of the vertebrate liver. Bile which is temporarily stored in the gall bladder, is composed of organic salts, excretion products, and bile pigment. Its primarily functions in emulsifying fats in the small intestine.

Bioaccumulation	A general term, meaning that an organism stores within its body, a higher concentration of a substance than is found in the environment. This is not necessarily harmful. For example, freshwater fish must bioaccumulate salt to survive in intertidal waters. Many toxicants, such as arsenic, are not included among the dangerous bioaccumulative substances because they can be handled and excreted by aquatic organisms.
Biological Indicators	Any biological parameter that is used to indicate the response of individuals, populations or ecosystems to environmental stress. For example, growth is a biological indicator.
Biomarker	Biomarker refers to a chemical, physiological or pathological measurement of exposure or effect in an individual organism from the laboratory or the field. Examples include: contaminants in liver enzymes, bile, and sex steroids.
BOD	Biological Oxygen Demand.
Bottom Sediments	Substrates which lie at the bottom of a body of water. For example, they are soft mud, silt, sand, gravel, rock and organic litter, which make up the river bottom.
Bottom-feeding Fish	Fish which feed on the substrates and/or organisms associated with the river bottom.

Condition Factor A measure of the relative "fitness" of an individual or population of fishes by examining the mathematical relationship between length and weight. The values calculated show the relationship between growth in length relative to growth in weight. In populations where increases in length are matched by increases in weight, the growth is said to be isometric. Allometric growth, the most common situation in wild populations, occurs when increases in either length or weight are disproportionate.

Conductivity A measure of a water's capacity to conduct an electrical current. It is reciprocal of resistance. This measurement provides the limnologist with an estimation of the total concentration of dissolved ionic matter in the water. It allows for a quick check of the alteration of total water quality due to the addition of pollutants to the water.

CWQG Canadian Water Quality Guidelines. Numerical concentrations or narrative statements recommended to support and maintain a designated water use in Canada. The guidelines contain recommendations for chemical, physical, radiological and biological parameters necessary to protect and enhance designated uses of water.

DL Detection Limit. The lowest concentration at which individual measurement results for a specific analyte are statistically different from a blank (that may be zero) with a specified confidence level for a given method and representative matrix.

Ecosystem An integrated and stable association of living and nonliving resources functioning within a defined physical location.

EROD

Ethoxyresorufin-O-deethylase (EROD) are enzymes which can increase in concentration and activity following exposure of some organisms to chemicals such as polycyclic aromatic hydrocarbons. EROD measurement indirectly measures the presence of catalytical proteins that remove a CH_3CH_2-group from the substrate ethoxyresorufin. This substrate was chosen because the fluorescent product formed is very easy to monitor in the laboratory. In animals, various compounds can be biotransformed by this enzyme to more polar products, which prepare them for eventual eliminations from the body. Thus, this is a "detoxification" or defence system that reduces the amounts of potentially harmful foreign substances in the body. Cytochrome P4501A is the scientific designation of the dominant protein which carries out this catalytic function in mammals and fish. EROD activity refers to the rate of the deethylation and indirectly reflects the amount of enzyme present.

Fecundity

The most common measure of reproductive potential in fishes. It is the number of eggs in the ovary of a female fish. It is most commonly measured in gravid fish. Fecundity increases with the size of the female.

Fish Health Parameters	Parameters used to indicate the health of an individual fish. May include, for example, short-term response indicators such as changes in liver mixed function oxidase activity and the levels of plasma glucose, protein and lactic acid. Longer-term indicators include internal and external examination of exposed fish, changes in organ characteristics, hematocrit and hemoglobin levels. May also include challenge tests such as disease resistance and swimming stamina.
GSI	Gonad-Somatic Index. The proportion of reproductive tissue in the body of a fish. It is calculated by dividing the total gonad weight by the total body weight and multiplying the result by 100. It is used as an index of the proportion of growth allocated to reproductive tissues in relation to somatic growth.
Golder	Golder Associates Ltd.
Gonads	Organs which are responsible for producing haploid reproductive cells in multi-cellular animals. In the male, these are the testes and in the female, these are the ovaries.
Habitat	The place where an animal or plant naturally or normally lives and grows, for example, a stream habitat or forest habitat.
Histology/ Histological	The microscopic study of tissues.

ICP (Metals)	Inductively Coupled Plasma (Atomic Emission Spectroscopy). This analytical method is a United States Environmental Protection Agency designated method (Method 6010). The method determines elements within samples of groundwater, aqueous samples, leachates, industrial wastes, soils sludges, sediments and other solids wastes. Samples require chemicals digestion prior to analysis.
Induction	Response to a biologically-active compound - involves new or increased gene expression resulting in enhanced synthesis of a protein. Such induction is commonly determined by measuring increases in protein levels and/or increases in the corresponding enzyme activity. For example, induction of EROD would be determined by measuring increases in cytochrome P4501A protein levels and/or increases in EROD activity.
LOEL	Lowest Observed Effect Level. In toxicity testing it is the lowest concentration at which effects on the measurement end point are observed.
LSI	Liver Somatic Index. Ratio of liver versus total body weight. Expressed as a percentage of total body weight.
Lesions	Pathological change in a body tissue.
m^3/s	Cubic metres per second. The standard measure of water flow in rivers; i.e., the volume of water in cubic metres that passes a given point in one second.

Metabolism	Metabolism is the total of all enzymatic reactions occurring in the cell; a highly coordinated activity of interrelated enzyme systems exchanging matter and energy between the cell and the environment. Metabolism involves both the synthesis and breakdown (catabolism) of individual compounds.
Metabolites	Organisms alter or change compounds in many various ways like removing parts of the original or parent compound or in other cases adding new parts. Then, the parent compound has been metabolized and the newly converted compound is called a metabolite.
MFO	Mixed Function Oxidase. A term for reactions catalyzed by the Cytochrome P450 family of enzymes, occurring primarily in the liver. These reactions transform organic chemicals, often altering toxicity of the chemicals.
NOEL	No Observed Effect Level. In toxicity testing it is the highest concentration at which no effects on the measurement end point are observed.
Naphthalene	A metabolite of PANH that accumulates in body tissues and fluids, specifically bile, following PAH biotransformation. See BaP.
Nutrients	Environmental substances (elements or compounds), such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Overwintering Habitat	Habitat used during the winter as a refuge and for feeding.

PAH(s)	Polycyclic Aromatic Hydrocarbon. A chemical by-product of petroleum-related industry. Aromatics are considered to be highly toxic components of petroleum products. PAHs are composed of at least two fused benzene rings, many of which are potential carcinogens. Toxicity increases along with molecular size and degree of alkylation of the aromatic nucleus.
PANH	Polycyclic Aromatic Nitrogen Heterocycle. See PAH.
PASH	Polycyclic Aromatic Sulphur Heterocycle.
Pathology	The science which deals with the cause and nature of disease or diseased tissues.
Physiological	Related to function in cells, organs or entire organisms, in accordance with natural processes of life.
QAPP	Quality Assurance Project Plan.
QA/QC	Quality Assurance/Quality Control refers to a set of practices that ensure the quality of a product or a result. For example, "Good Laboratory Practice" is part of QA/QC in analytical laboratories and involves such things as proper instrument calibration, meticulous glassware cleaning and an accurate sample information system.
Rearing Habitat	Habitat used by young fish for feeding and/or as a refuge from predators.
Relative Abundance	The proportional representation of a species in a sample or a community.

Riffle Habitat	Shallow rapids where the water flows swiftly over completely or partially submerged materials to produce surface agitation.
Run Habitat	Areas of swiftly flowing water, without surface waves, which approximates uniform flow and in which the slope of water surface is roughly parallel to the overall gradient of the stream reach.
Snye	Discrete section on non-flowing water connected to a flowing channel only at its downstream end, generally formed in a side channel or behind a peninsula (bar).
Spawning Habitat	A particular type of area where a fish species chooses to reproduce. Preferred habitat (substrate, water flow, temperature) varies from species to species.
Species Composition	A term that refers to the species found in the sampling area.
Species Distribution	Where the various species in an ecosystem are found at any given time. Species distribution varies with season.
Standard Deviation	A measure of the variability or spread of the measurements about the mean. It is calculated as the positive square root of the variance.
Suncor	Suncor Inc., Oil Sands Group.
Suspended Sediments	Particles of matter suspended in the water. Measured as the oven dry weight of the solids, in mg/L, after filtration through a standard filter paper. Less than 25 mg/L would be considered clean water, while an extremely muddy river might have about 200 mg/L of suspended sediments.
Syncrude	Syncrude Canada Ltd.

TDS	Total dissolved solids. See filterable residue.
TOC	Total Organic Carbon. TOC is composed of both dissolved and particulate forms. TOC is often calculated as the difference between total carbon (TC) and total inorganic carbon (TIC). TOC has a direct relationship with both biochemical and chemical oxygen demands, and varies with the composition of organic matter present in the water. Organic matter in soils, aquatic vegetation and aquatic organisms are major sources of organic carbon.
Toxic	A substance, a dose, or a concentration that is harmful to a living organism.
Toxic Threshold	Almost all compounds become toxic at some level with no evident harm or adverse effect below that level. Scientists refer to the level or concentration where they can first see evidence for an adverse effect on an organism as the toxic threshold.
TSS	Total suspended solids. See non-filterable residue.
Valued Ecosystem Component (VEC)	Components of an ecosystem (either plant, animal, or abiotic feature) considered valuable by various sectors of the public.
WSC	Water Survey of Canada.
YOY	Young of the year. Fish at age 0, within the first year after hatching.

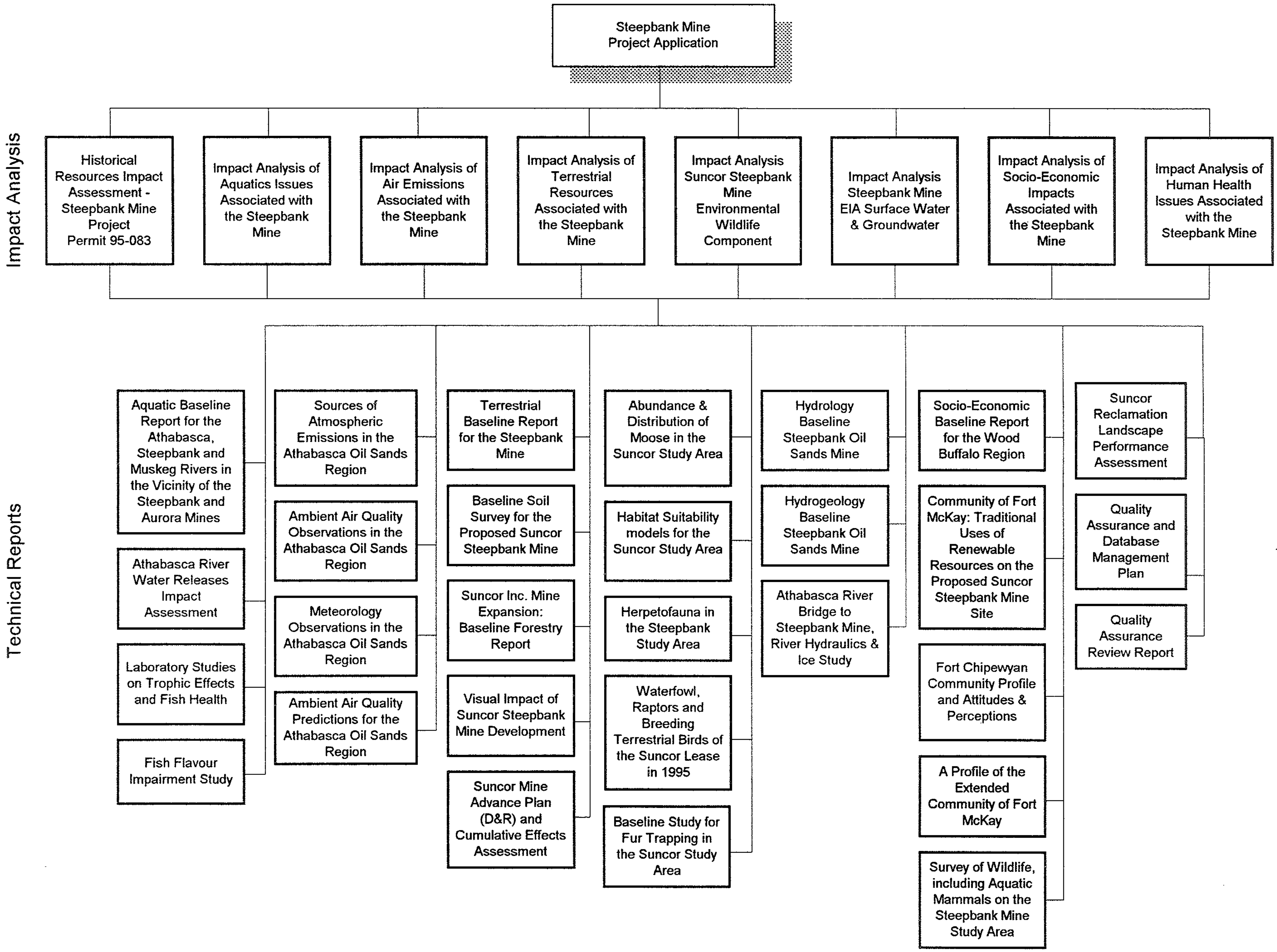

Figure A-1 Reports Prepared for the Steepbank Mine Environmental Assessment

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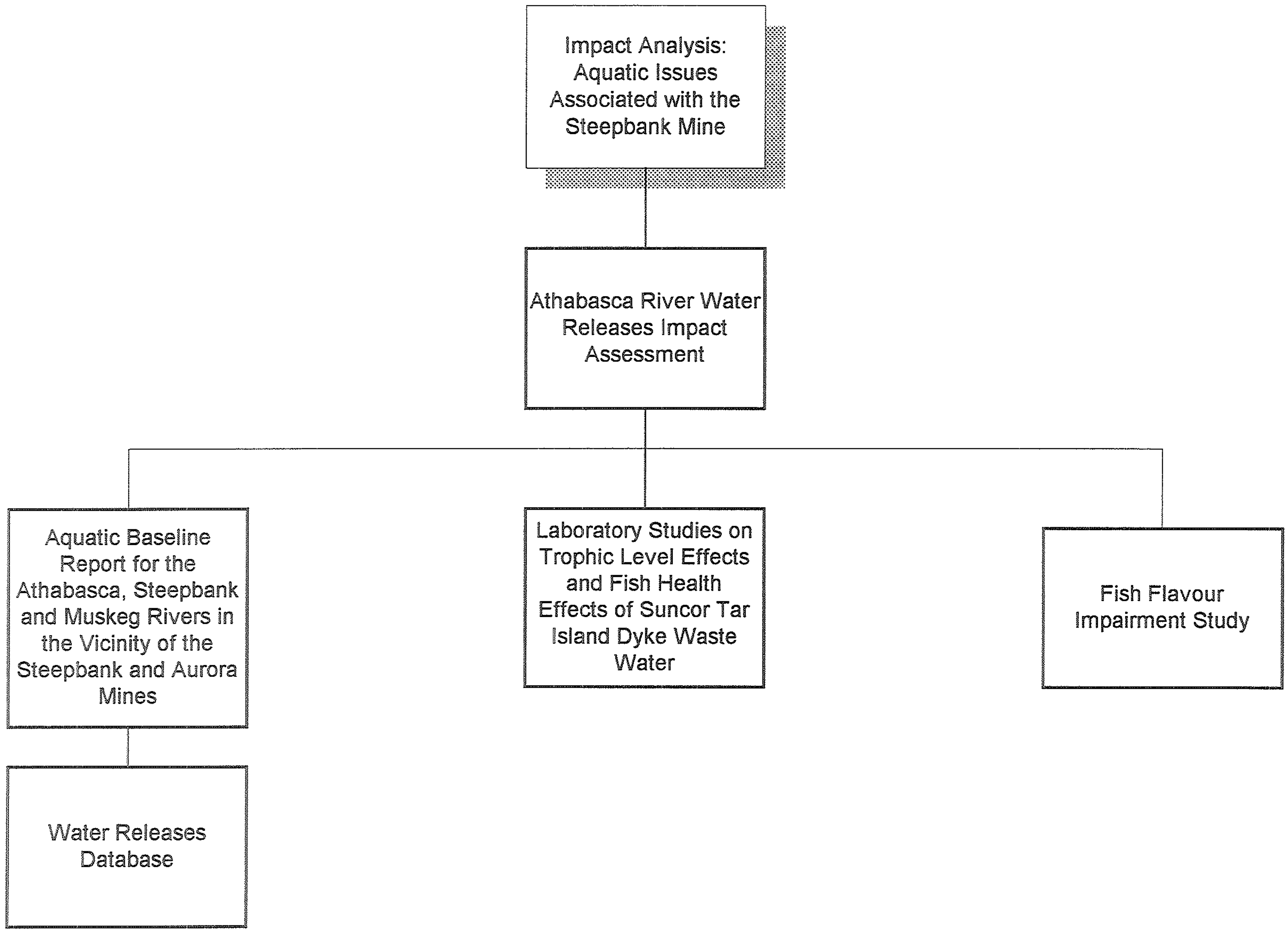

FIGURE A-2 Overview of Aquatic Technical Reports

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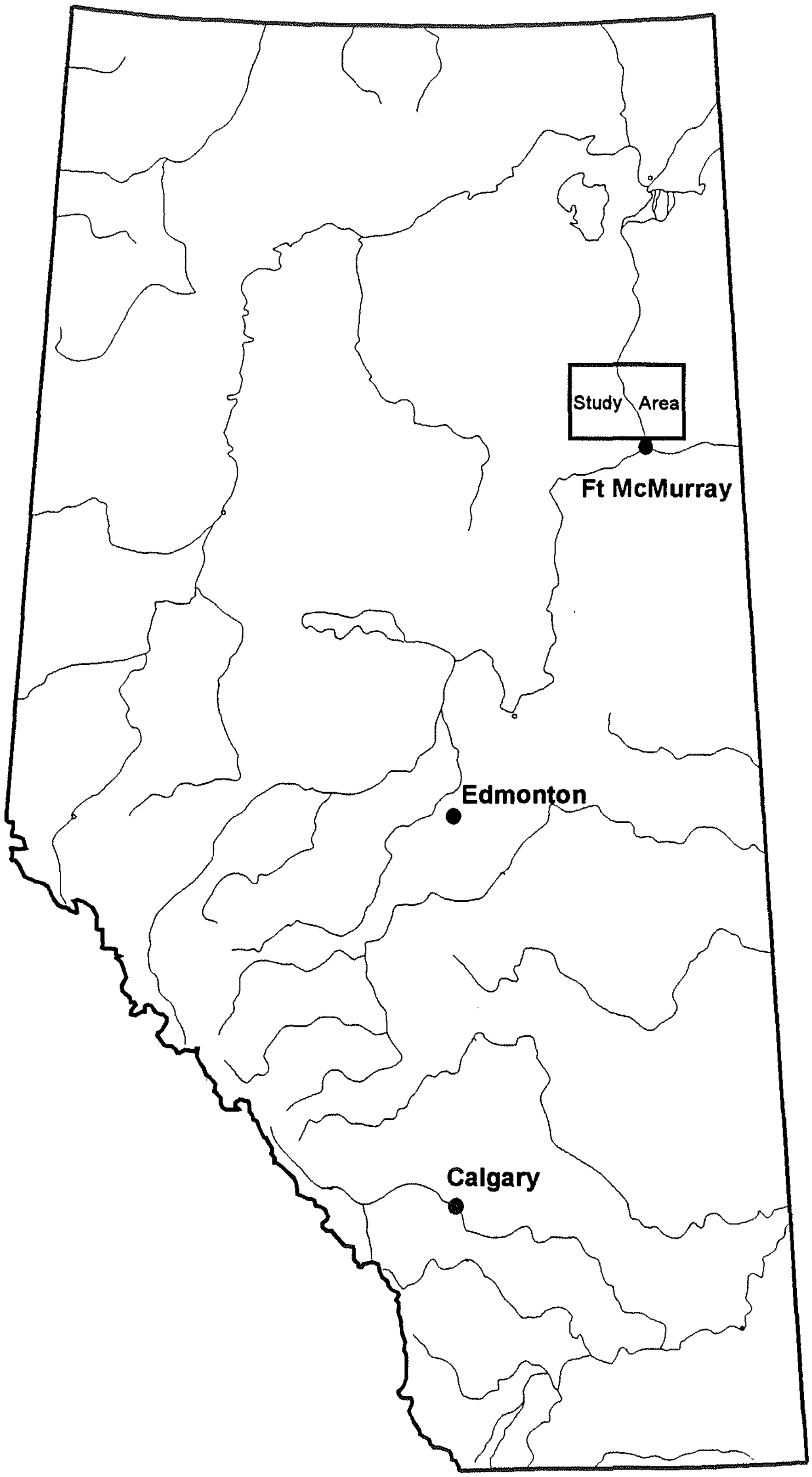
Location of the Study Area Within Alberta

Figure B-1



PROJECT 952-2307.6560 DRAWN RP REVIEWED DATE 15 February 1996

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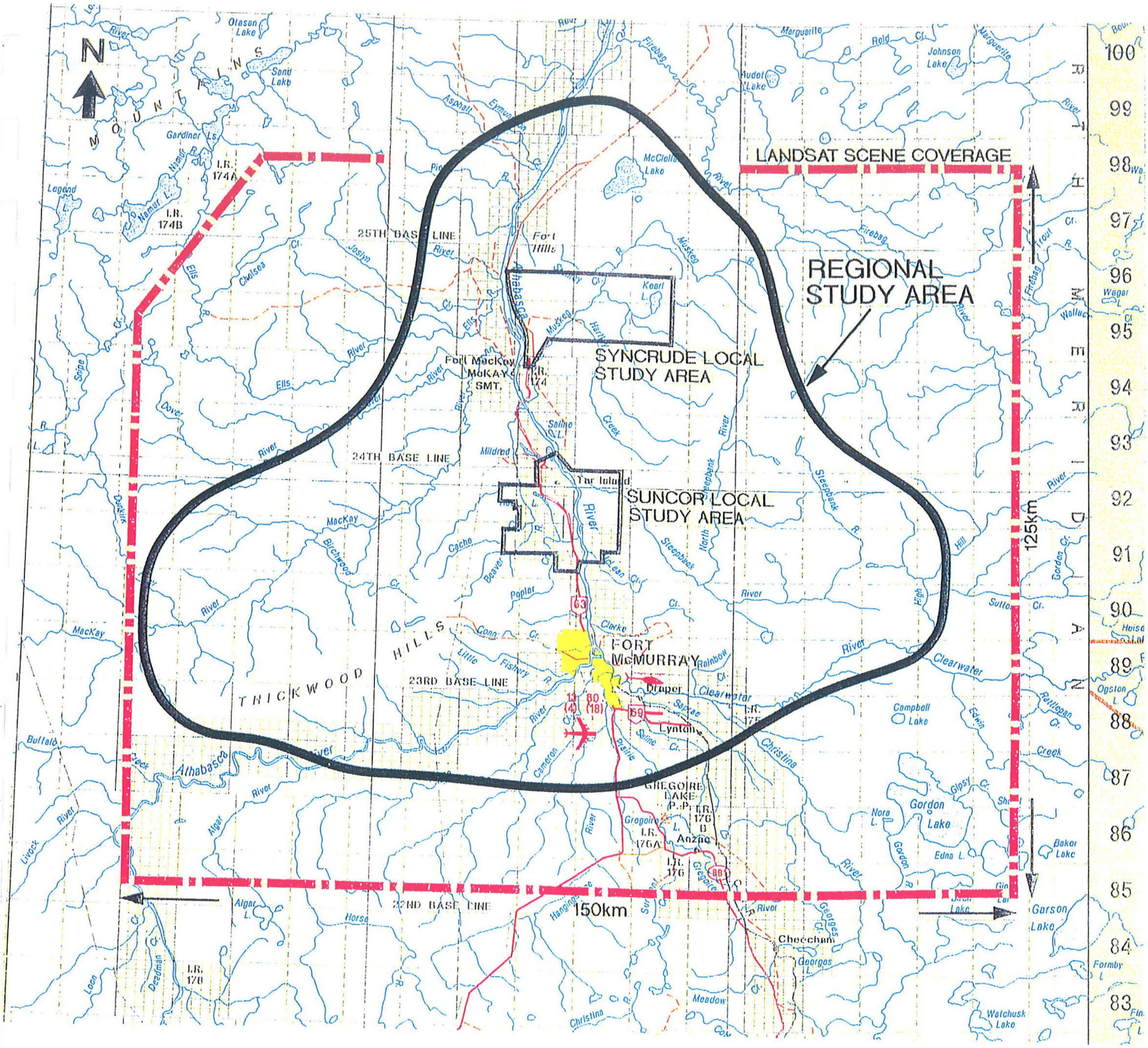
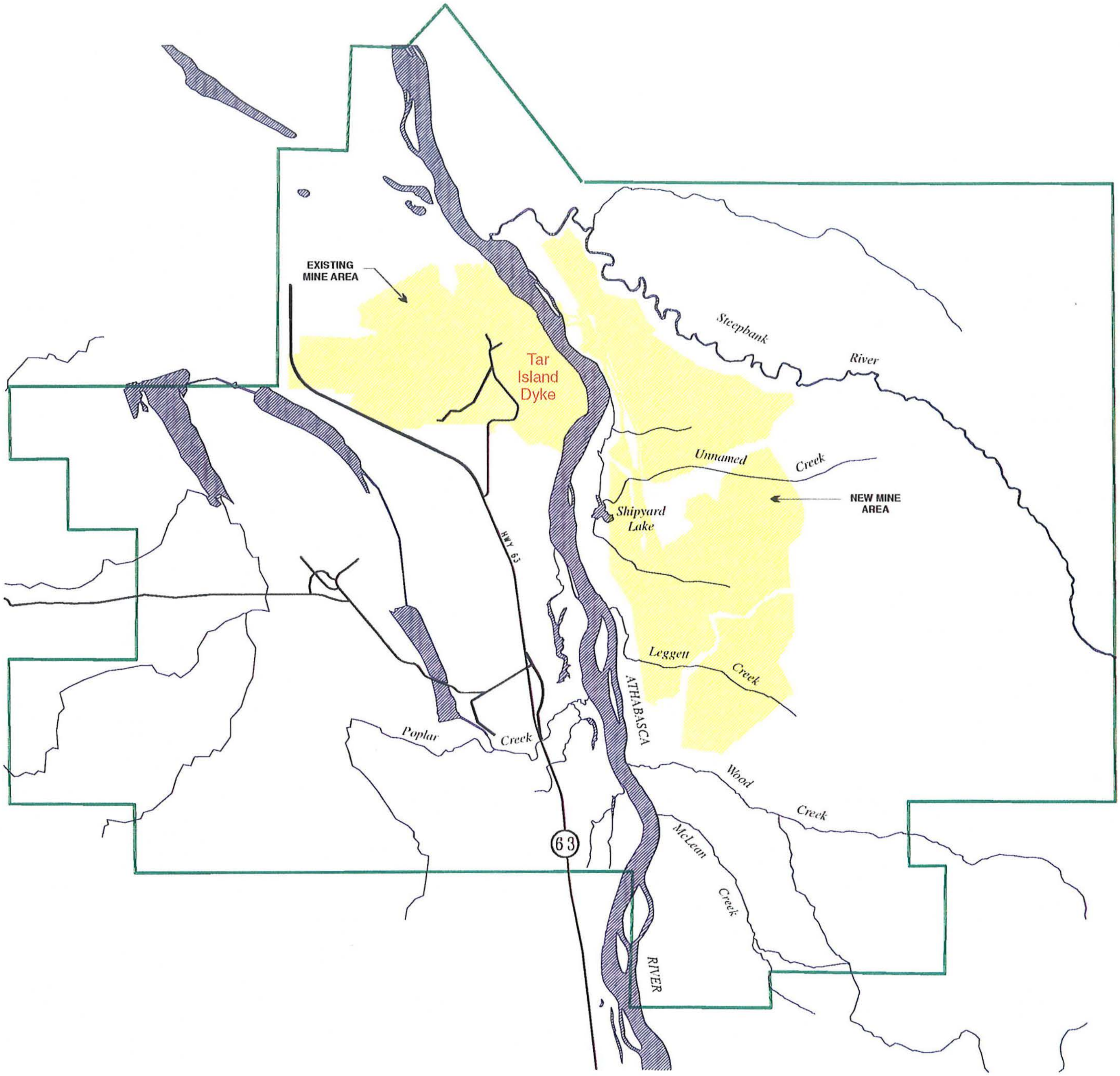
Figure B-2

Joint Suncor/Syncrude Regional Study Area



Local Study Area for the Steepbank Mine	Figure B-3



PROJECT 952-2307.5290 DRAWN RP REVIEWED DATE 20 March 1996

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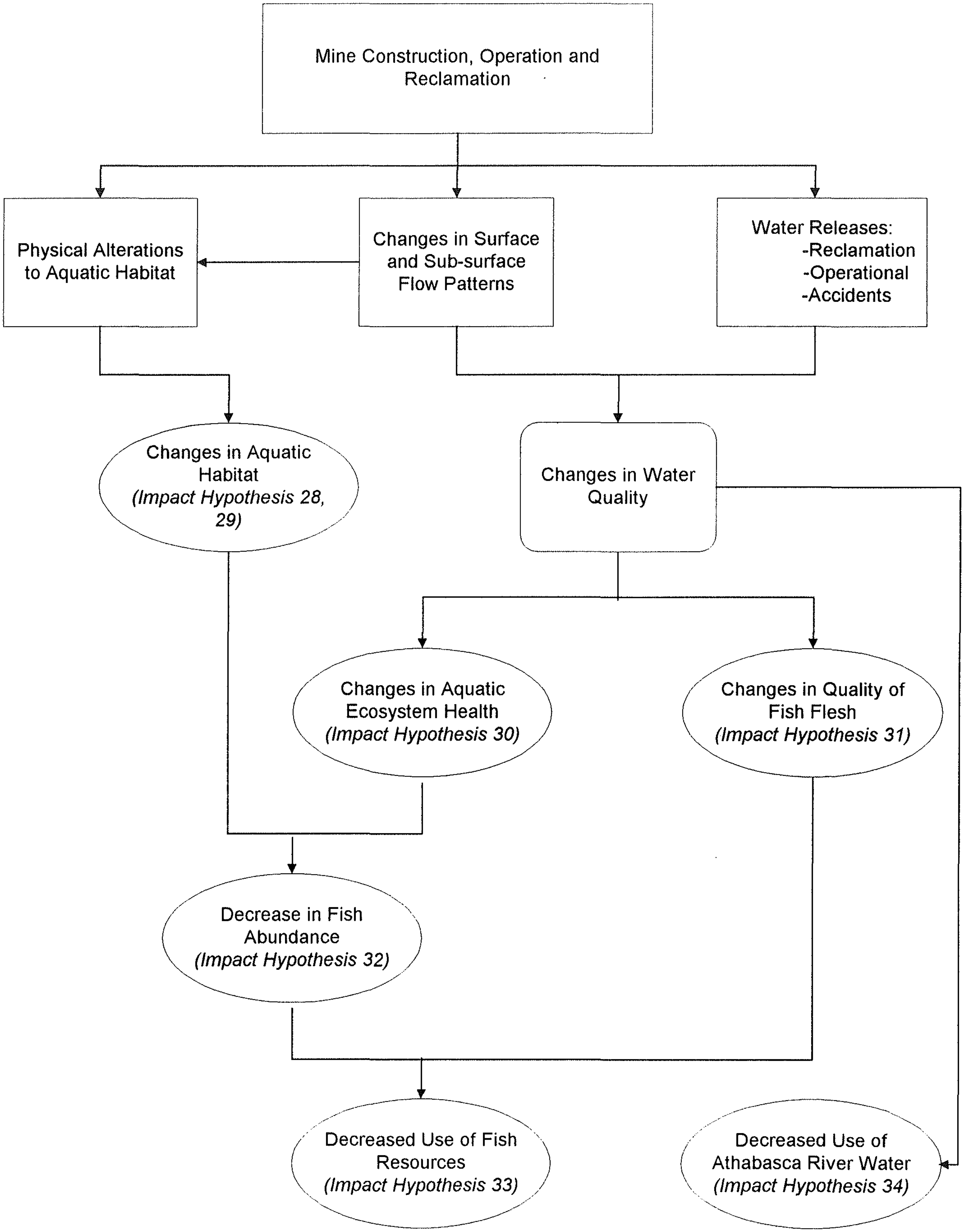


Figure D3.0-1 Linkages Among Mine Activities, Modes of Impact and Potential Impacts on Aquatic Resources

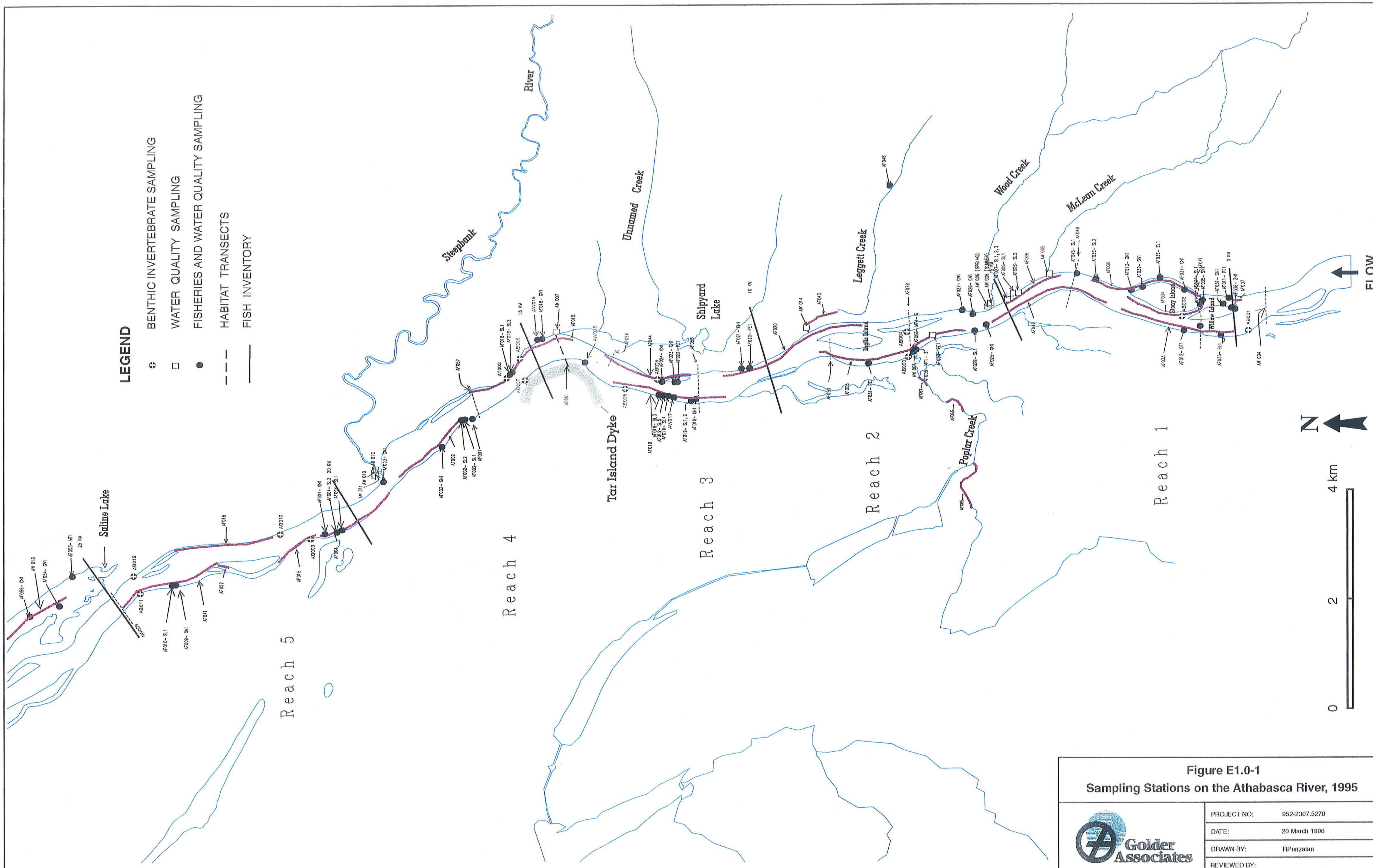


Figure E1.0-1
Sampling Stations on the Athabasca River, 1995

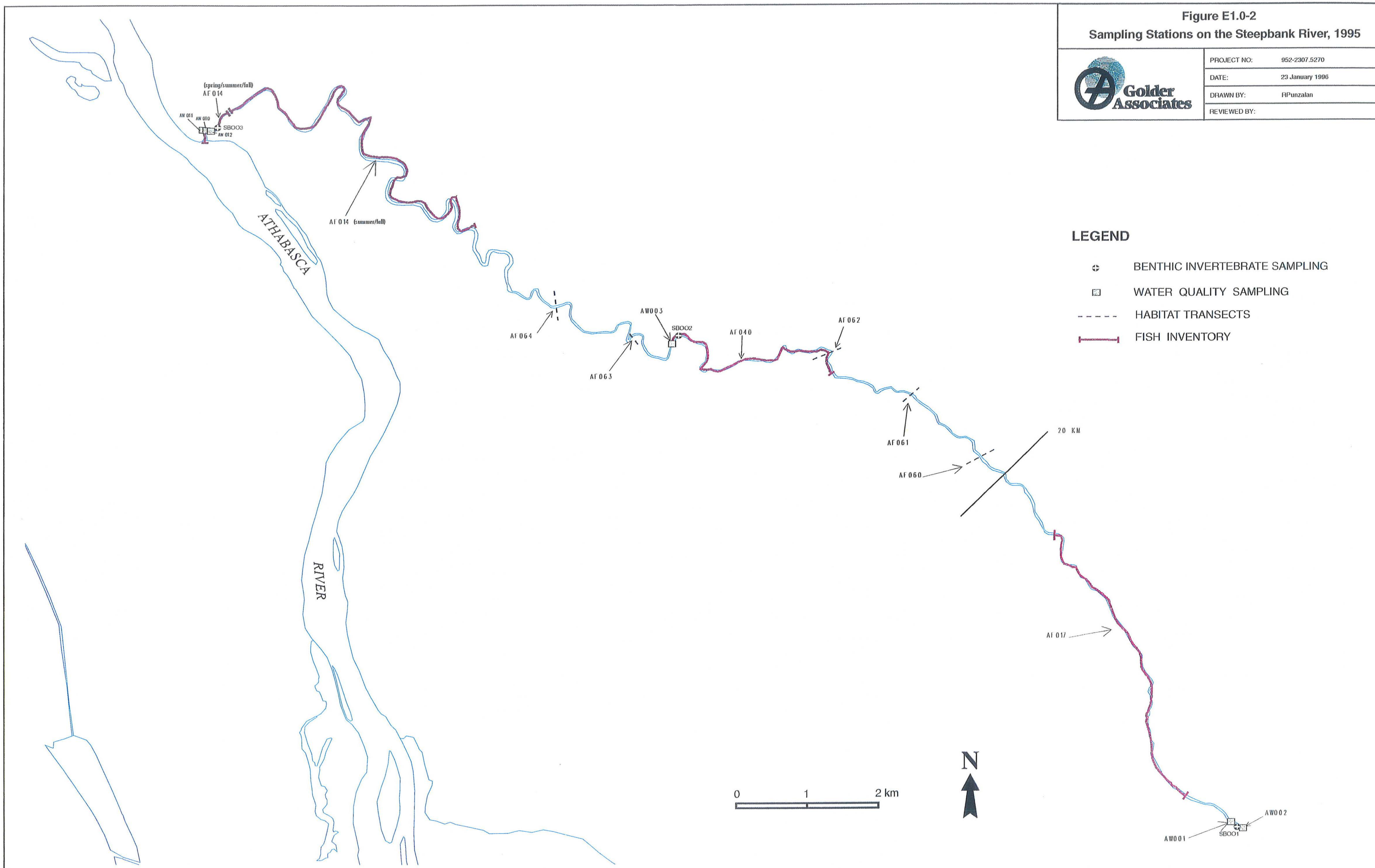
PROJECT NO:	952-2307.5270
DATE:	20 March 1996
DRAWN BY:	RPunzalan
REVIEWED BY:	

Golder Associates

Figure E1.0-2

Sampling Stations on the Steepbank River, 1995

PROJECT NO:	952-2307.5270
DATE:	23 January 1996
DRAWN BY:	RPunzalan
REVIEWED BY:	



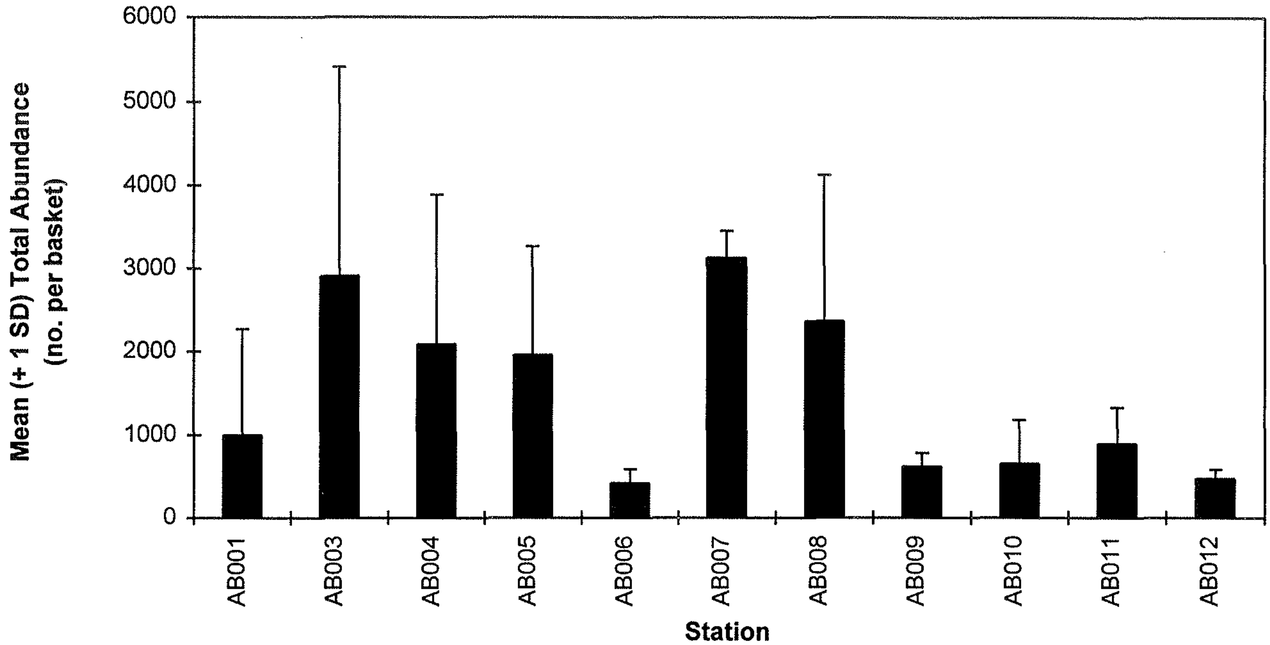


Figure E3.0-1A Mean Total Abundance of Benthic Invertebrates Collected in the Athabasca River Using Artificial Substrates (SD = standard deviation)

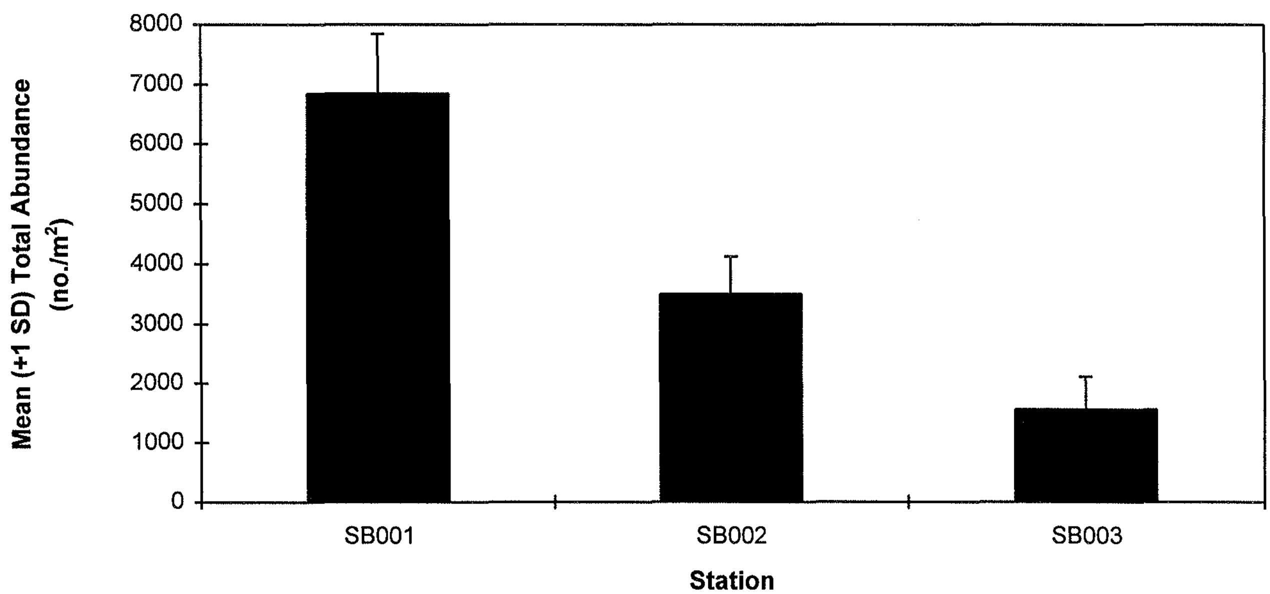


Figure E3.0-1B Mean Total Abundance of Benthic Invertebrates Collected in the Steepbank River Using a Hess Sampler (SD = standard deviation)

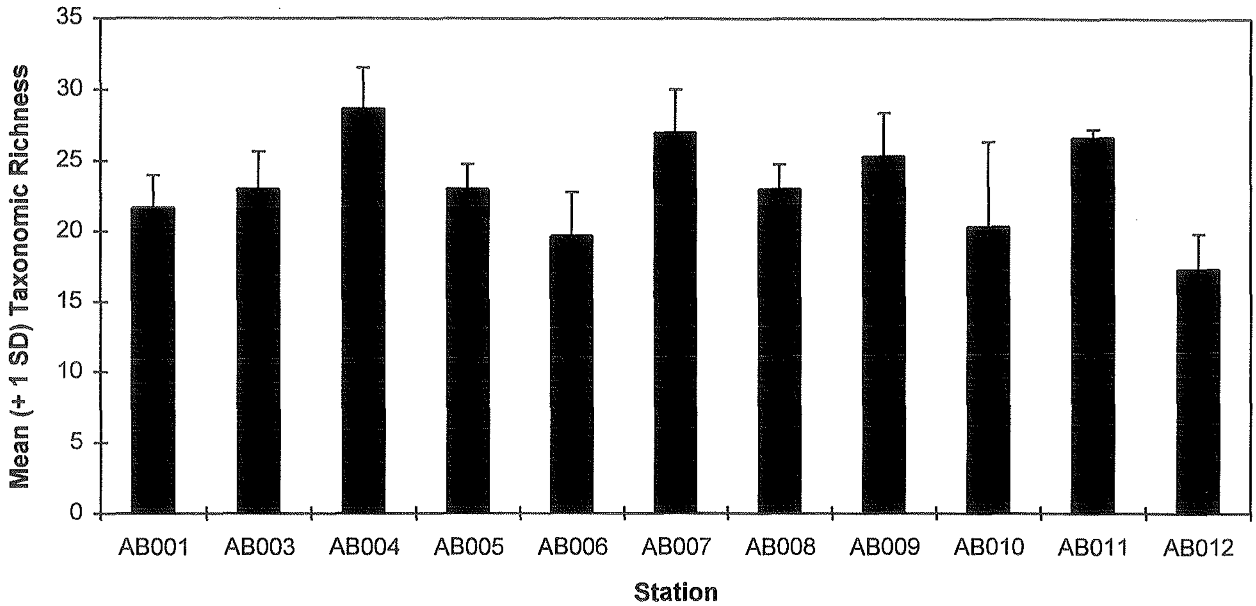


Figure E3.0-2A Mean Taxonomic Richness of Benthic Invertebrates Collected in the Athabasca River Using Artificial Substrates (SD = standard deviation)

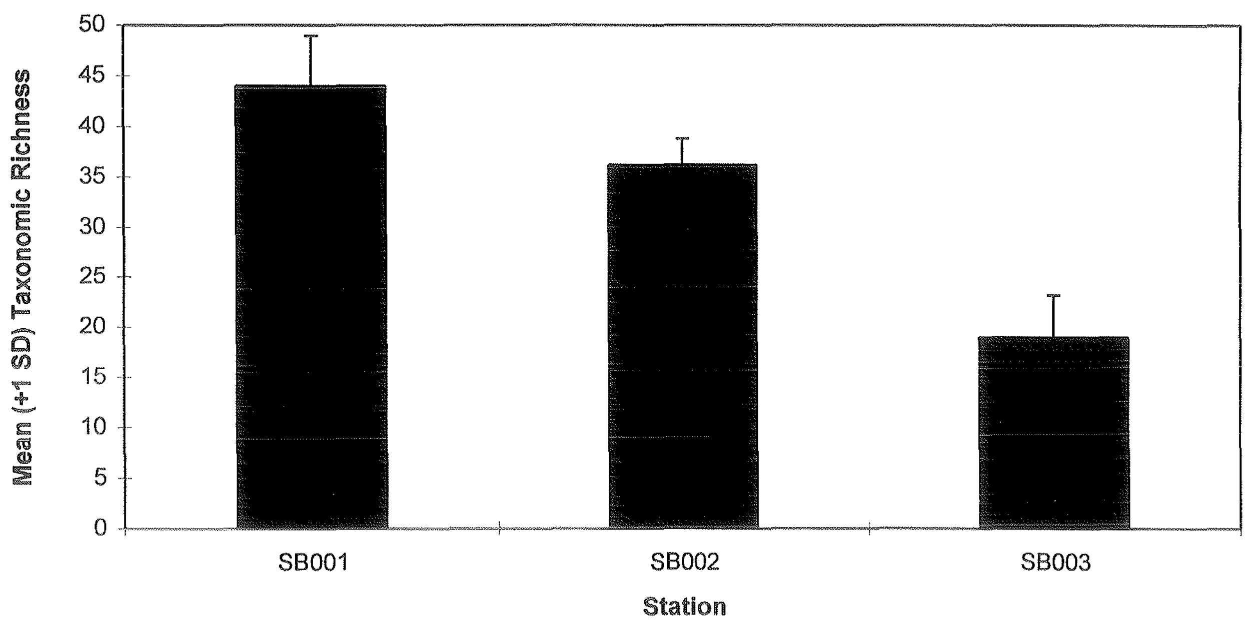


Figure E3.0-2B Mean Taxonomic Richness of Benthic Invertebrates Collected in the Steepbank River Using a Hess Sampler (SD = standard deviation)

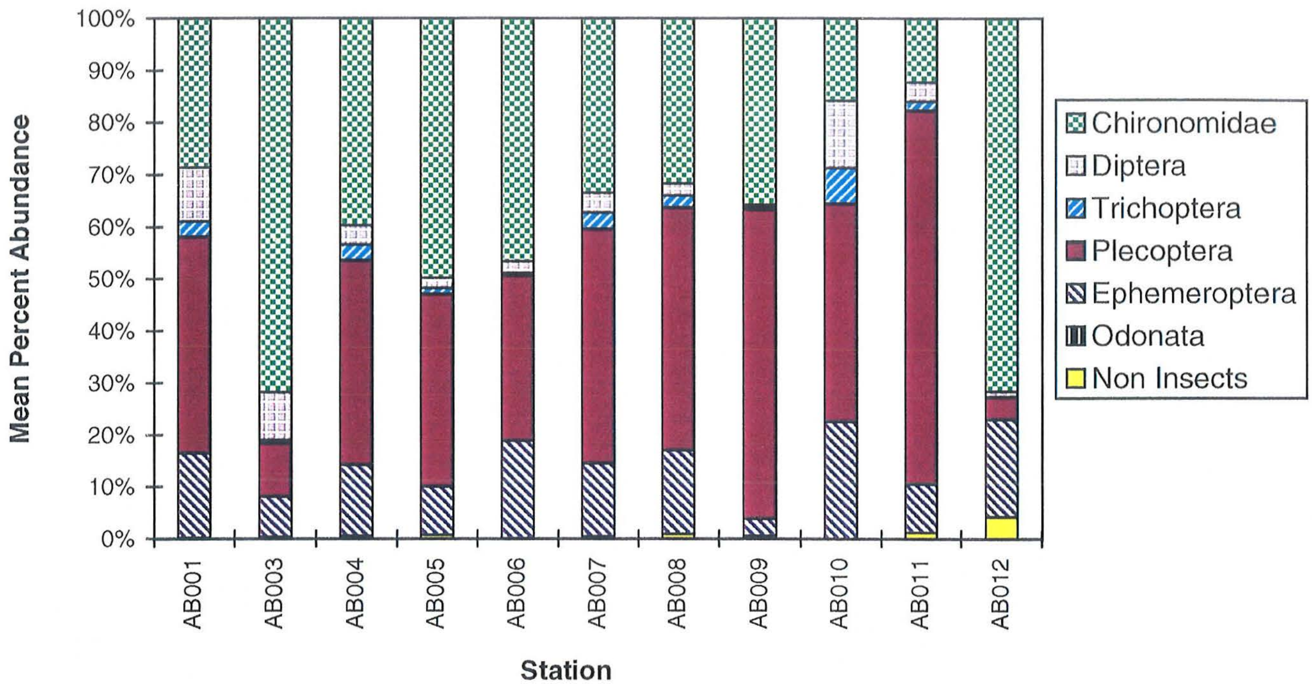


Figure E3.0-3A Percent Abundance of Major Taxonomic Groups Collected in the Athabasca RiverUsing Artificial Substrates

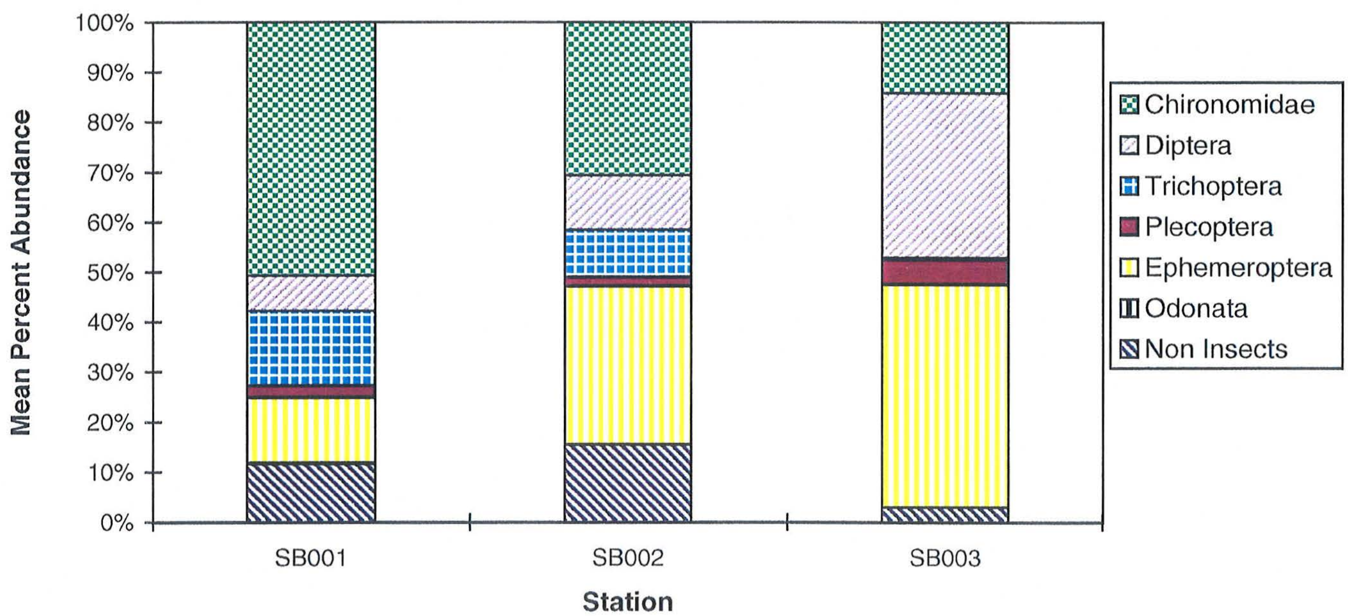


Figure E3.0-3B Percent Abundance of Major Taxonomic Groups Collected in the Steepbank River Using a Hess Sampler

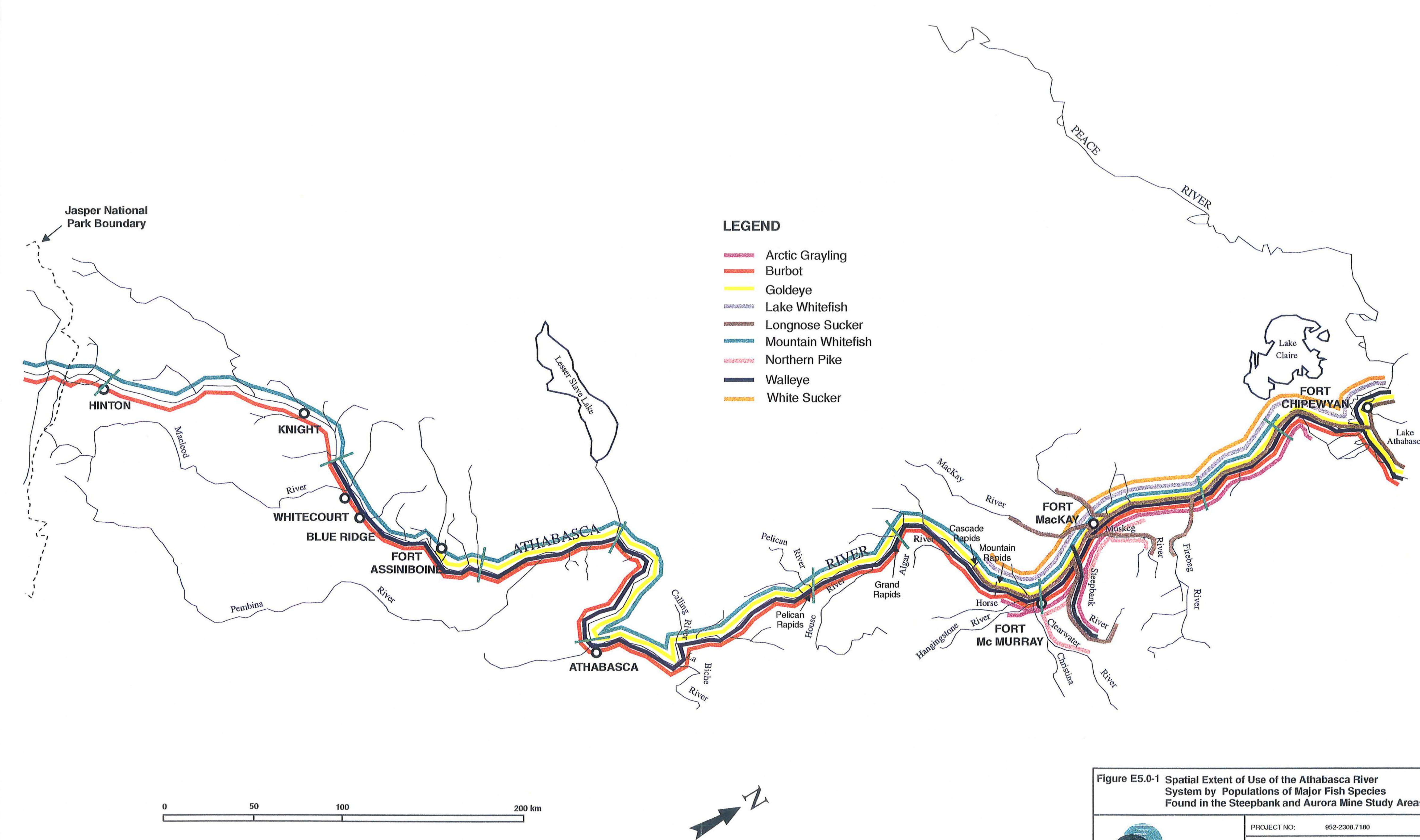


Figure E5.0-1 Spatial Extent of Use of the Athabasca River System by Populations of Major Fish Species Found in the Steepbank and Aurora Mine Study Areas

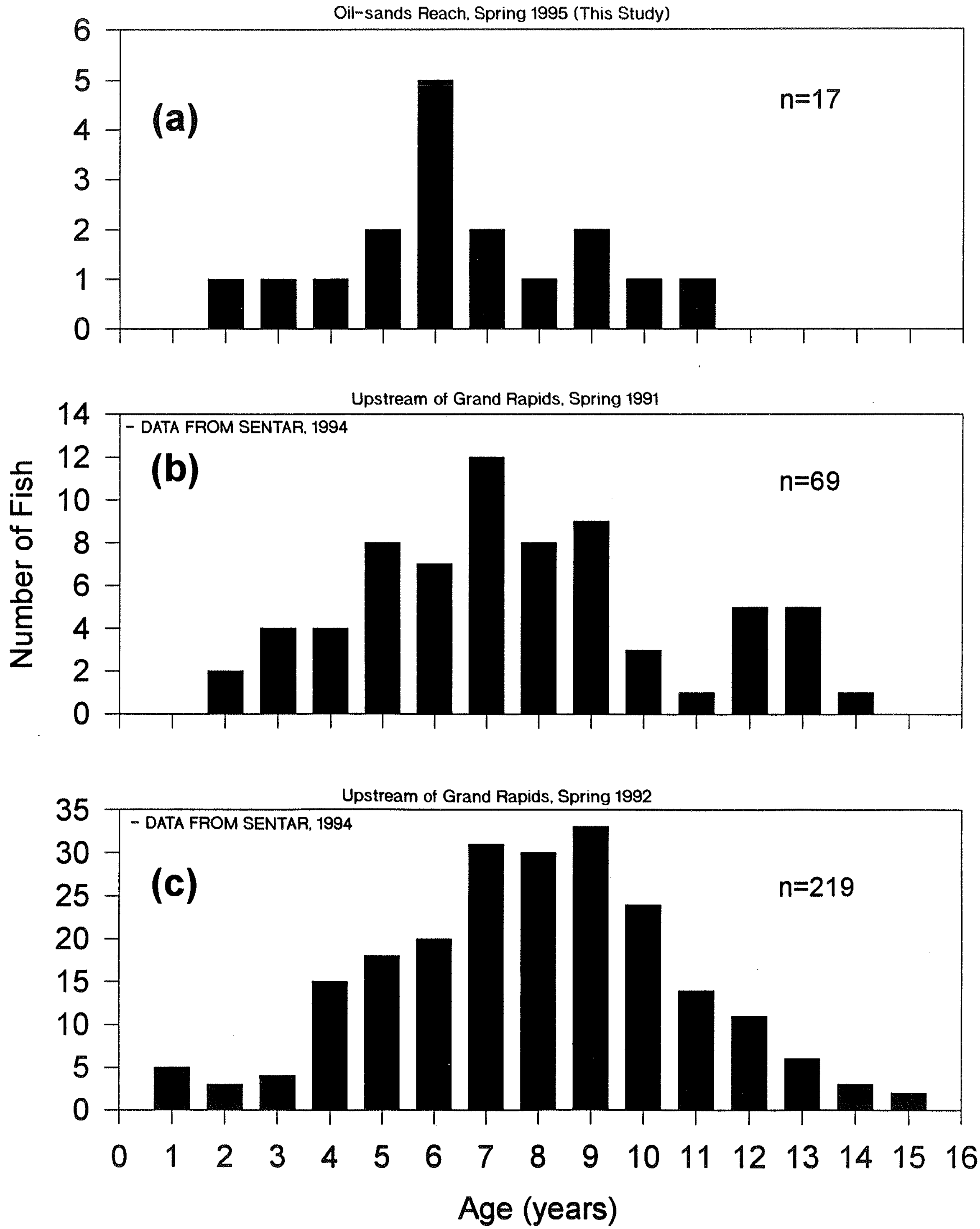
Golder Associates

PROJECT NO:	952-2308.7180
DATE:	7 December 1995
DRAWN BY:	RPunzalan
REVIEWED BY:	

Age-Frequency Distribution for
Athabasca River System
Longnose Sucker

Figure E6.0-1

* DATA ARE FROM A SUBSAMPLE OF FISH NON-DESTRUCTIVELY SAMPLED BY ALL COLLECTING METHODS

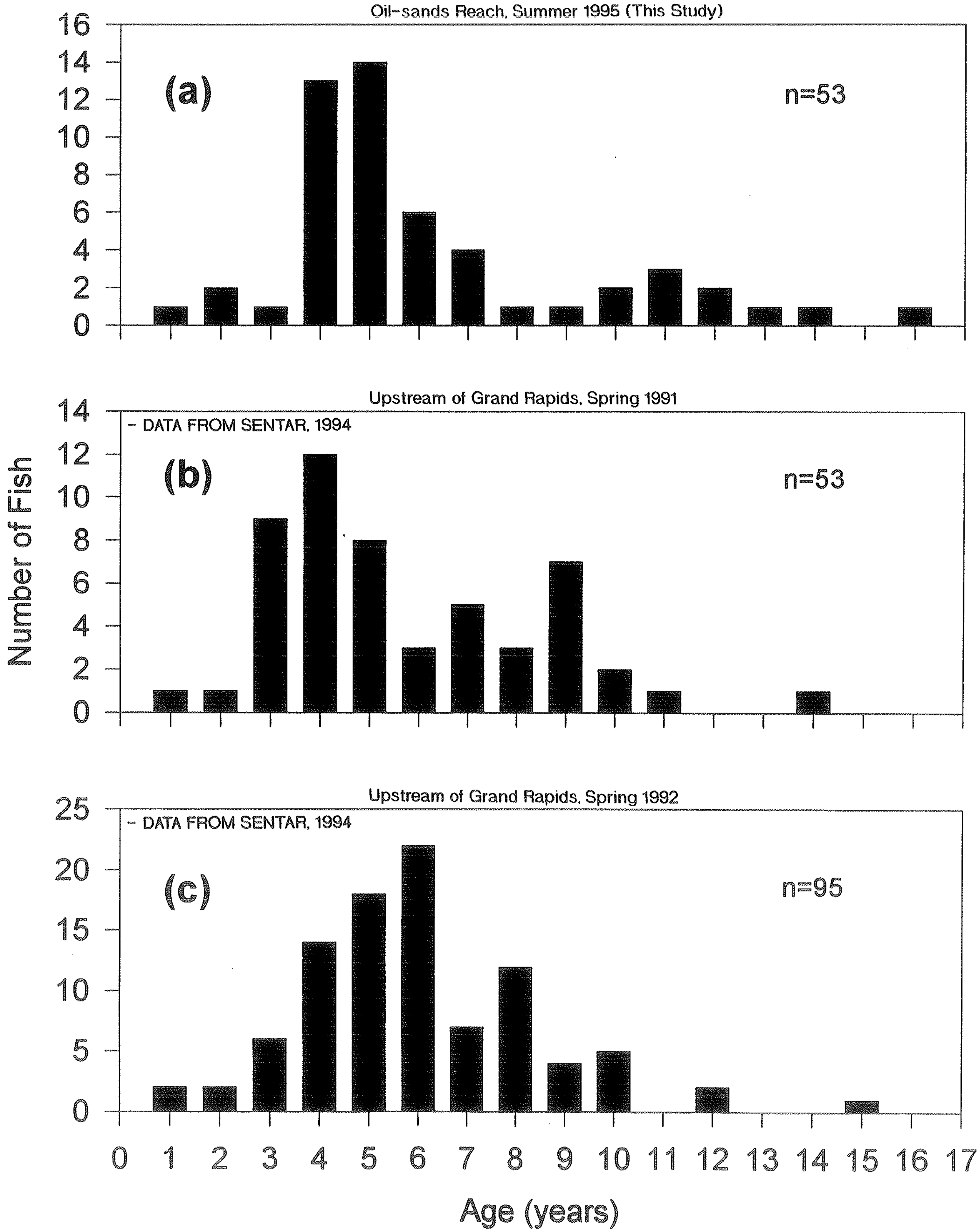


PROJECT 952-2307 DRAWN MVZ REVIEWED DATE 7 FEB 96 952-2307.5140

Age-Frequency Distribution for Athabasca River Walleye

Figure E6.0-2

* DATA ARE FROM A SUBSAMPLE OF FISH NON-DESTRUCTIVELY SAMPLED BY ALL COLLECTING METHODS



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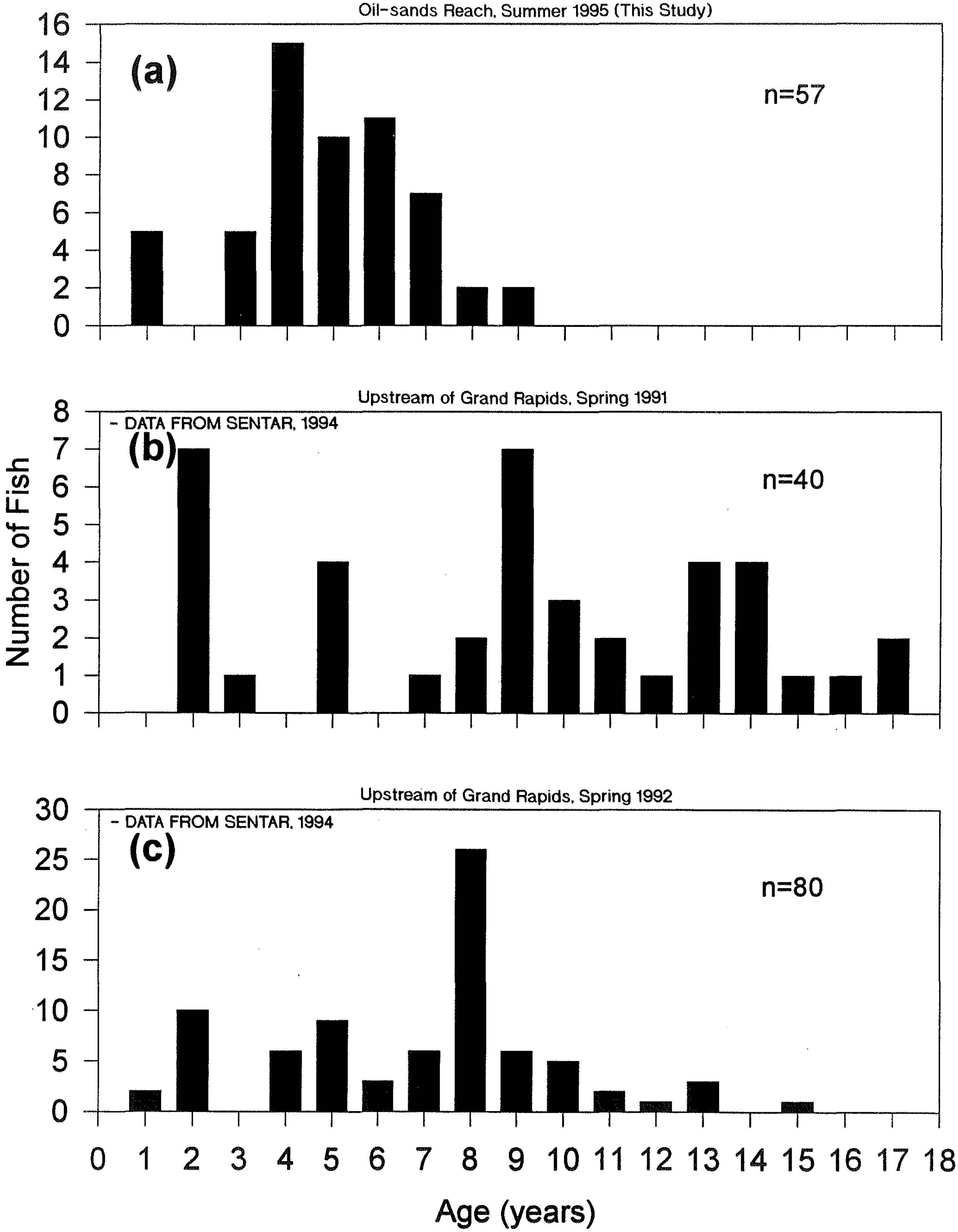
PROJECT 952-2307 DRAWN MVZ REVIEWED DATE 7 FEB 96 952-2307.5140

Age-Frequency Distribution for Athabasca River Goldeye

Figure E6.0-3

* DATA ARE FROM A SUBSAMPLE OF FISH NON-DESTRUCTIVELY SAMPLED BY ALL COLLECTING METHODS



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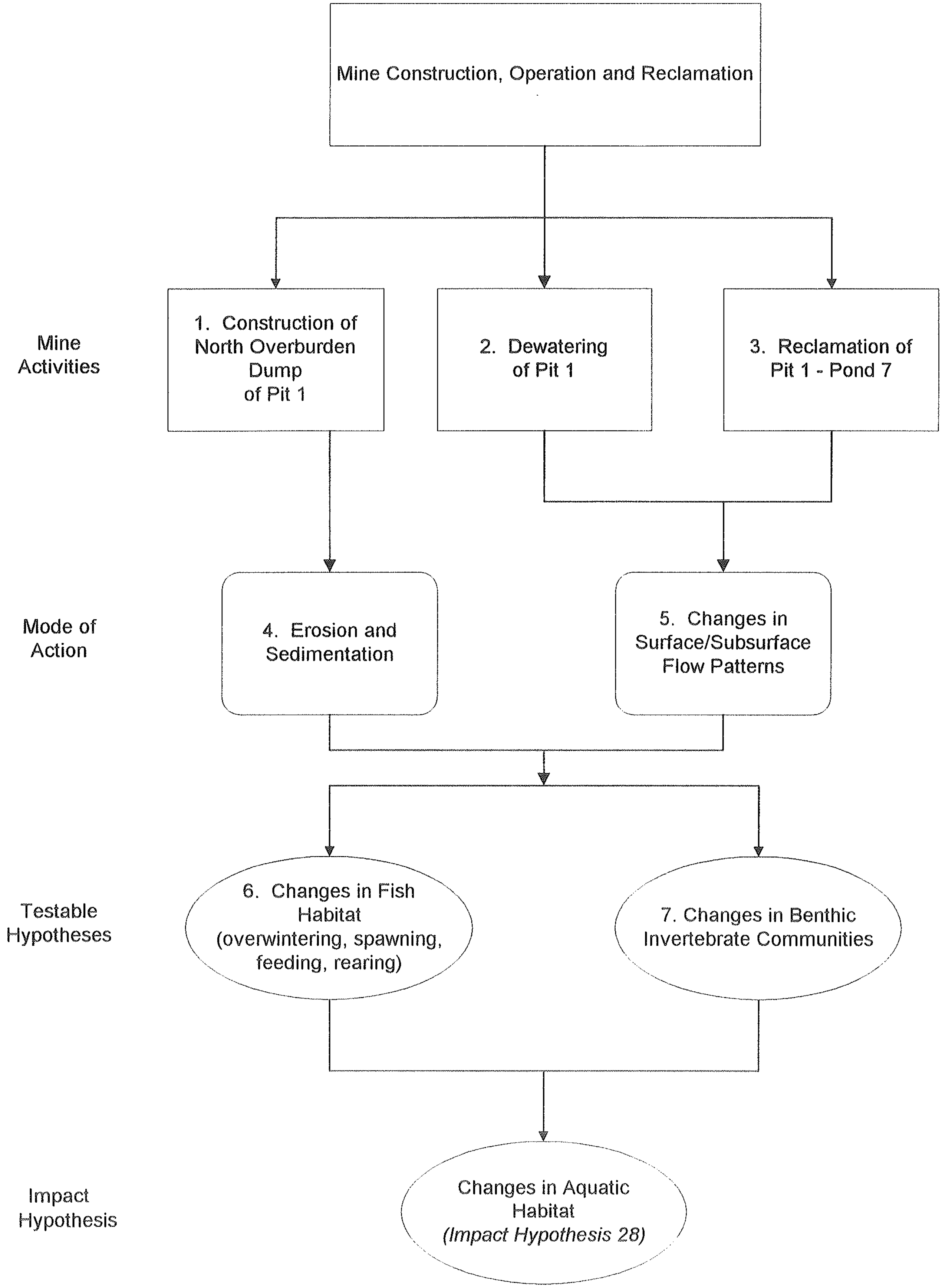


Figure F1.0-1 Linkages Among Mine Activities, Mode of Action and Potential Impacts to Aquatic Habitat in the Steepbank River

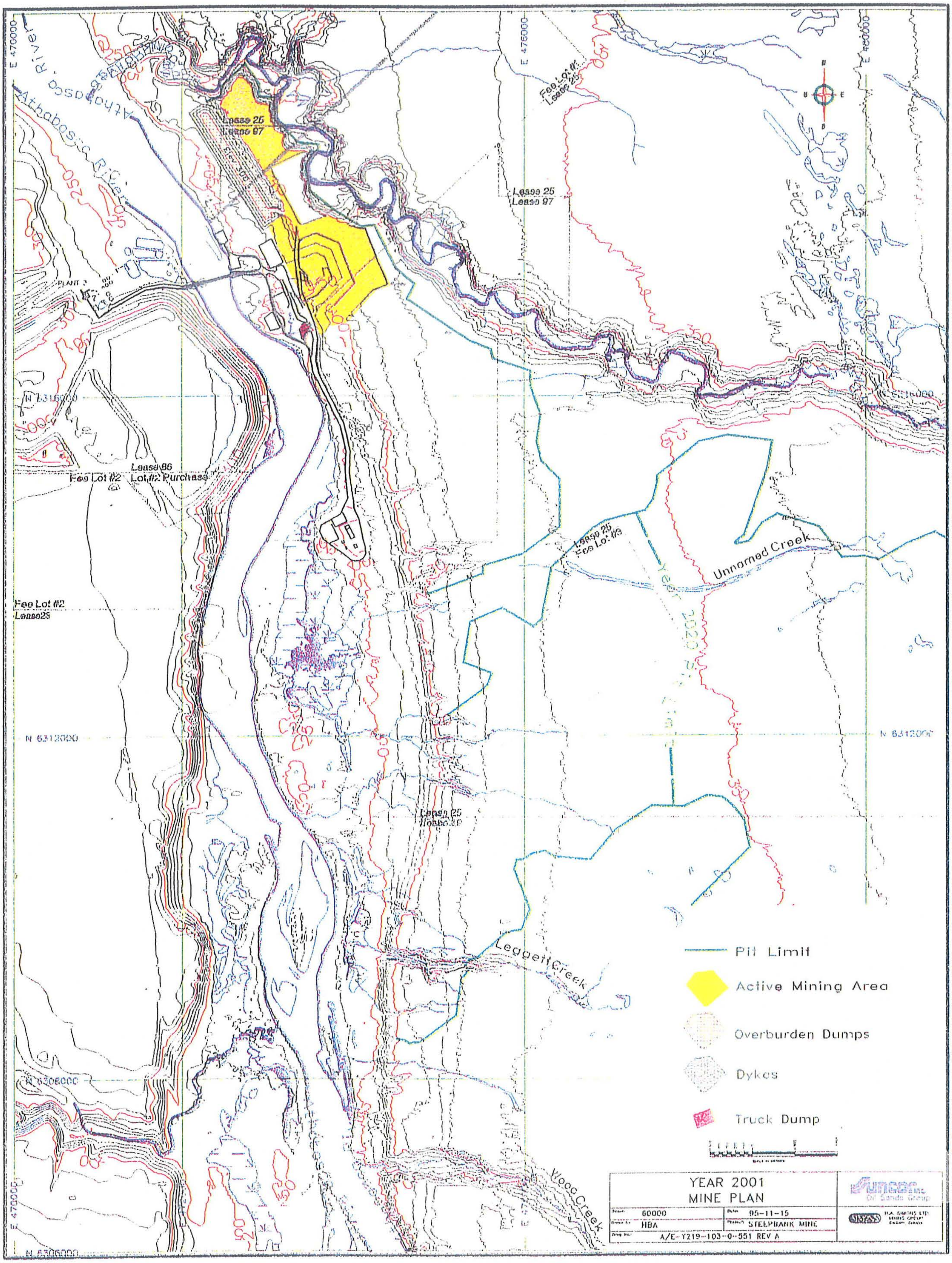
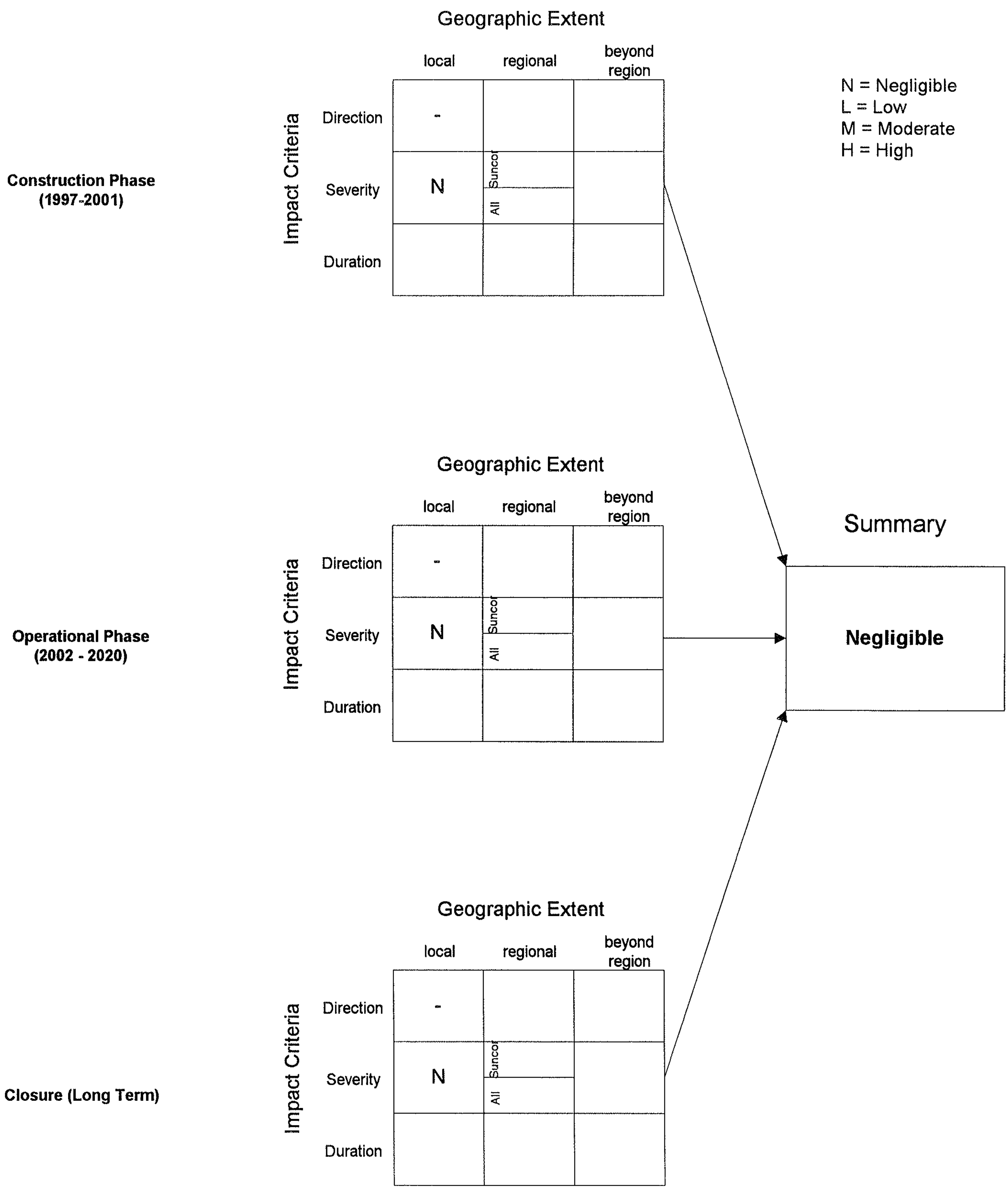


Figure F1.0-2 Mine Plan Showing Location of North Overburden Dump and Mining Area

Figure F1.0-3
Impact Hypothesis Classification - Hypothesis 28

Construction, Operational or Reclamation Activities Might Adversely Affect Aquatic Habitat in the Steepbank River



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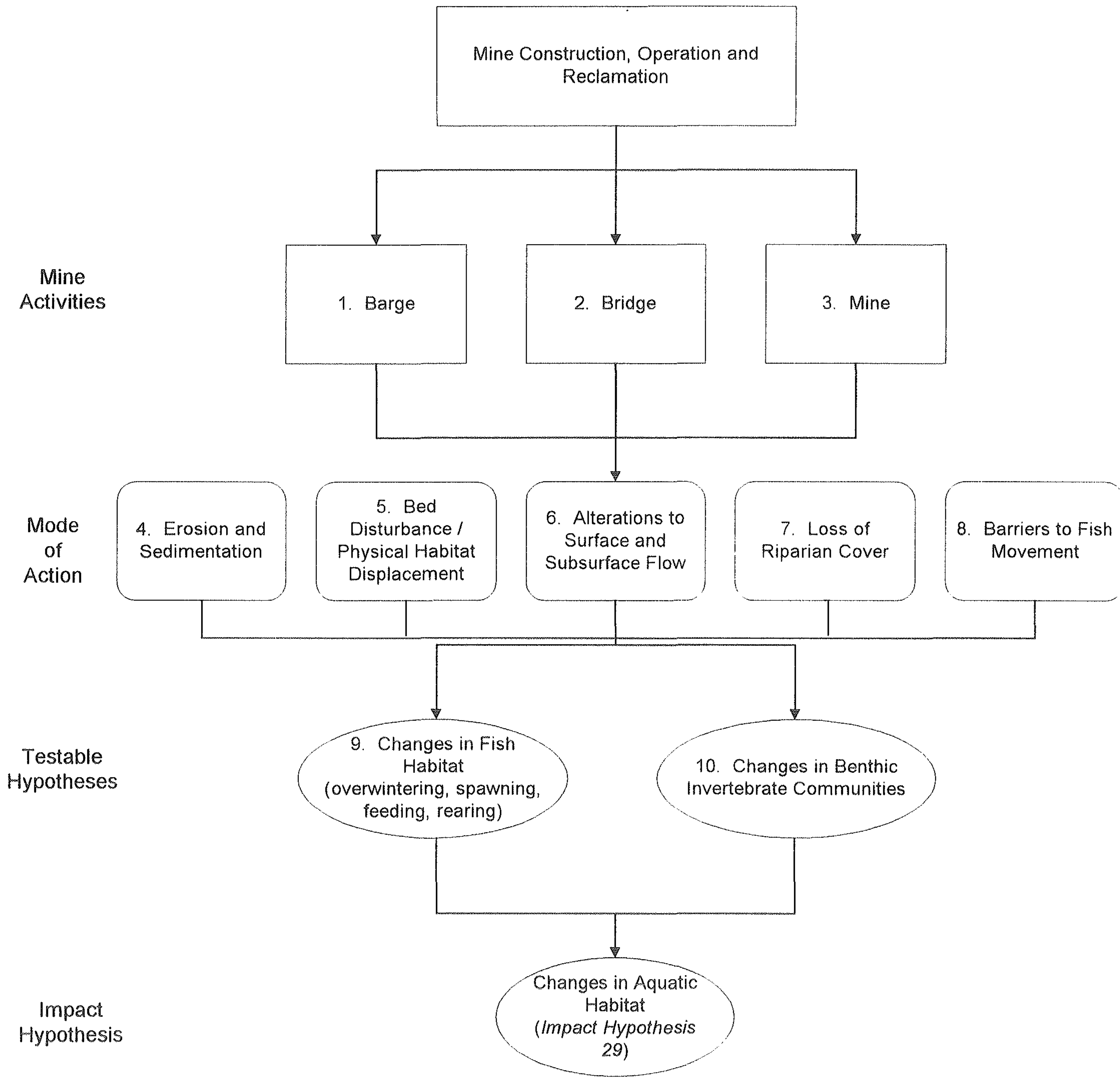
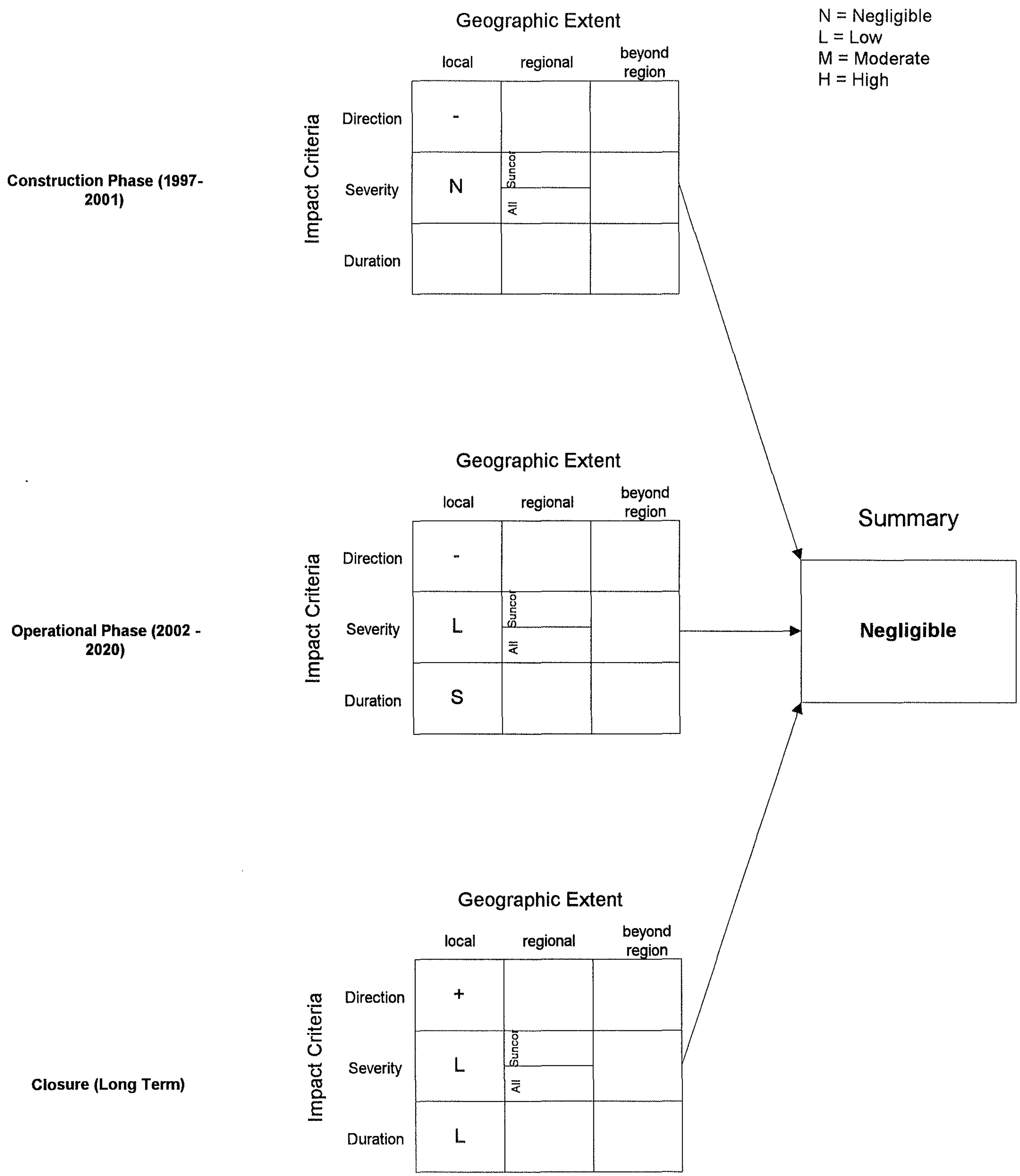


Figure F2.0-1 Linkages Among Mine Activities, Mode of Action and Potential Impacts to Aquatic Habitat in the Athabasca River

Figure F2.0-2
Impact Hypothesis Classification - Hypothesis 29

Construction, Operational or Reclamation Activities Might Adversely Affect Aquatic Habitat in the Athabasca River



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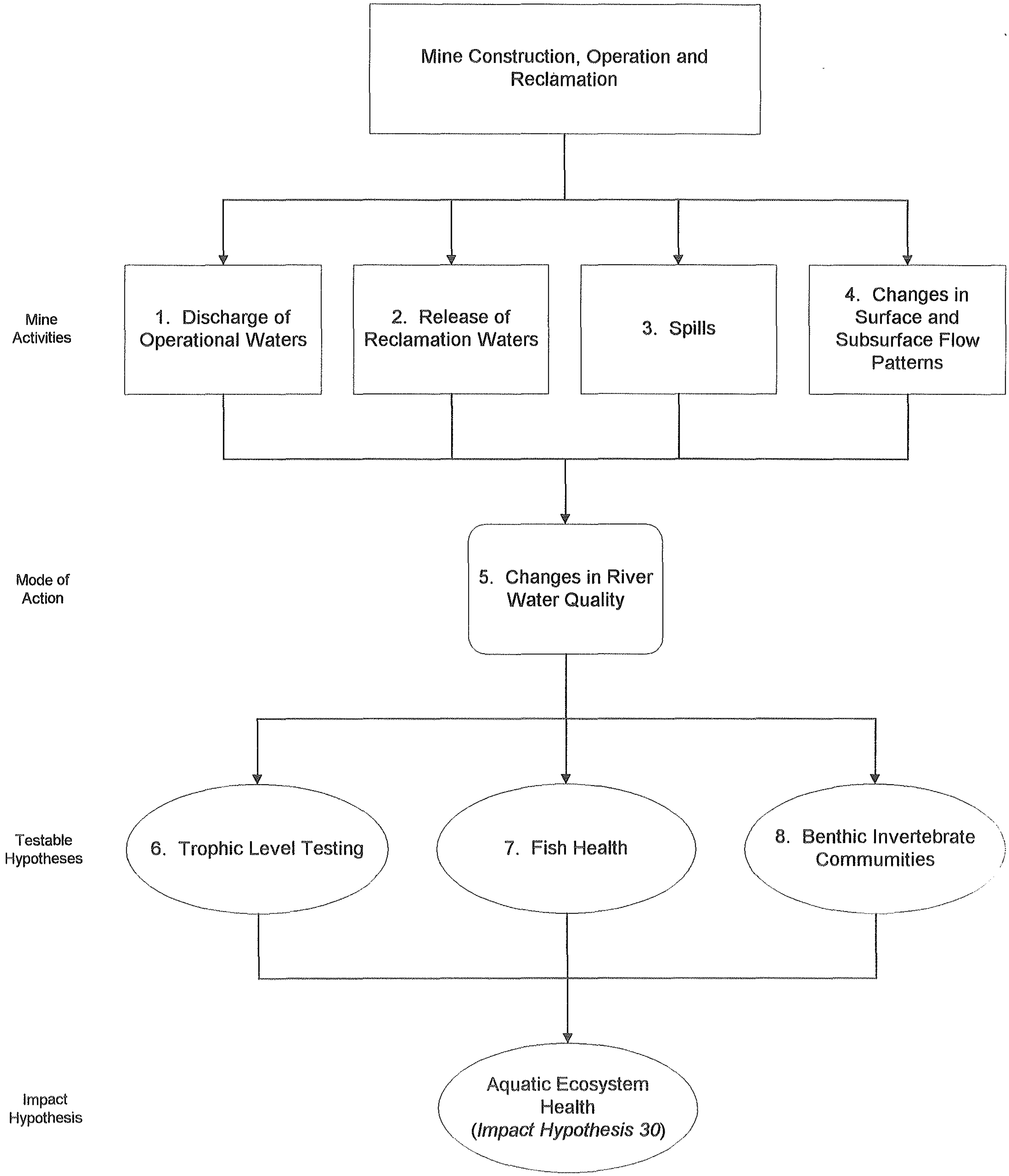


Figure F3.0-1 Linkages Among Mine Activities, Mode of Action and Potential Impact to Aquatic Ecosystem Health

LOCATIONS OF DISCHARGE SOURCES

Figure F3.0-2

LEGEND

S1 Shipyard Lake Groundwater

S2 South Mine Drainage Discharge Point

S3 TID seepage

S4 Wastewater Discharge Point

S5 Steepbank Mine Groundwater

S6 Mid-Plant Dishcharge Point

S7 Pond 4 Seepage

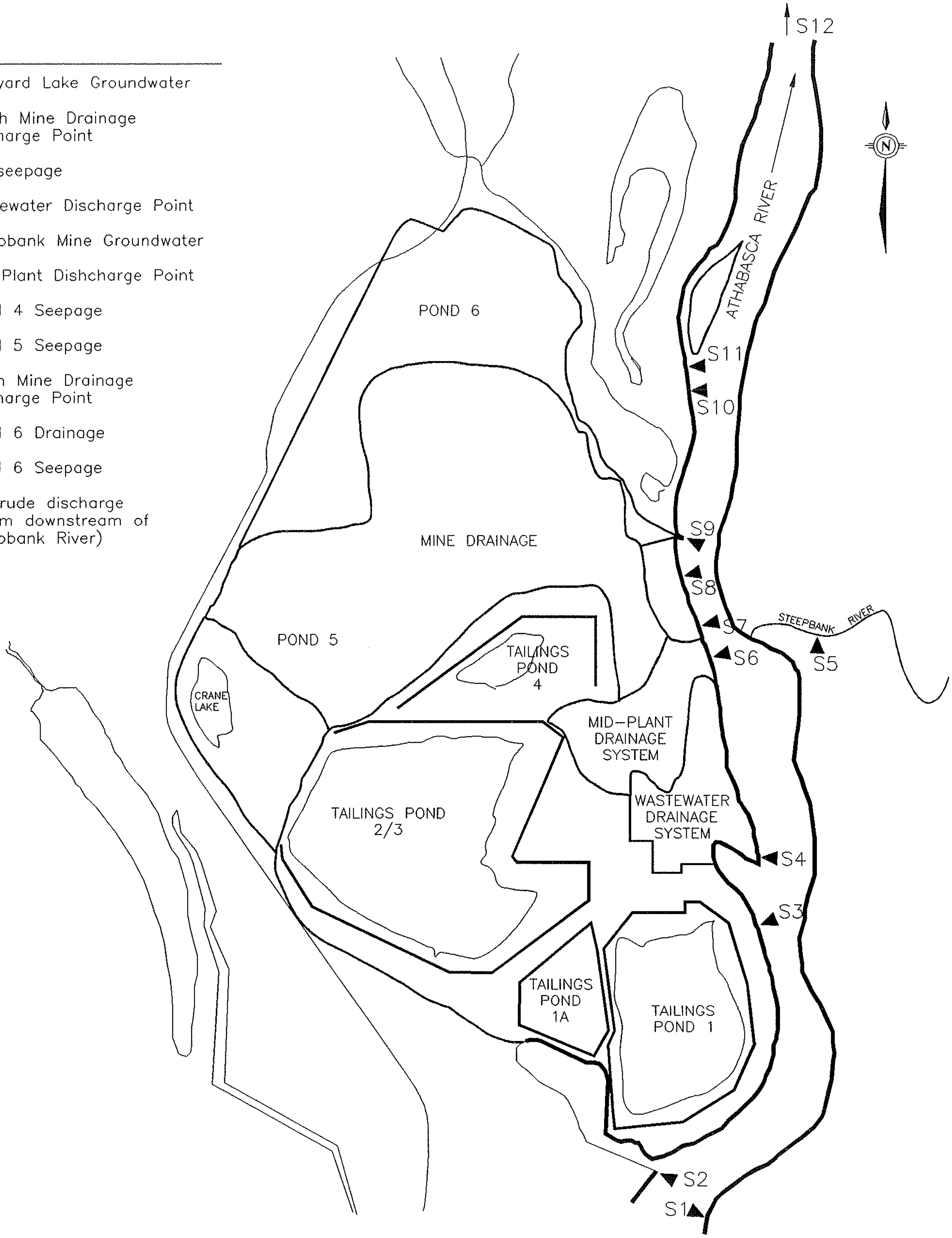
S8 Pond 5 Seepage

S9 North Mine Drainage Discharge Point

S10 Pond 6 Drainage

S11 Pond 6 Seepage

S12 Syncrude discharge (14km downstream of Steepbank River)



PROJECT 952-2307.5126 DRAWN CG REVIEWED DATE 23 APR 96 SURFDRN

Figure F3.0-3
Predicted Ammonia Levels (mg/L) in the Athabasca River
Mean Annual Flow, 1995

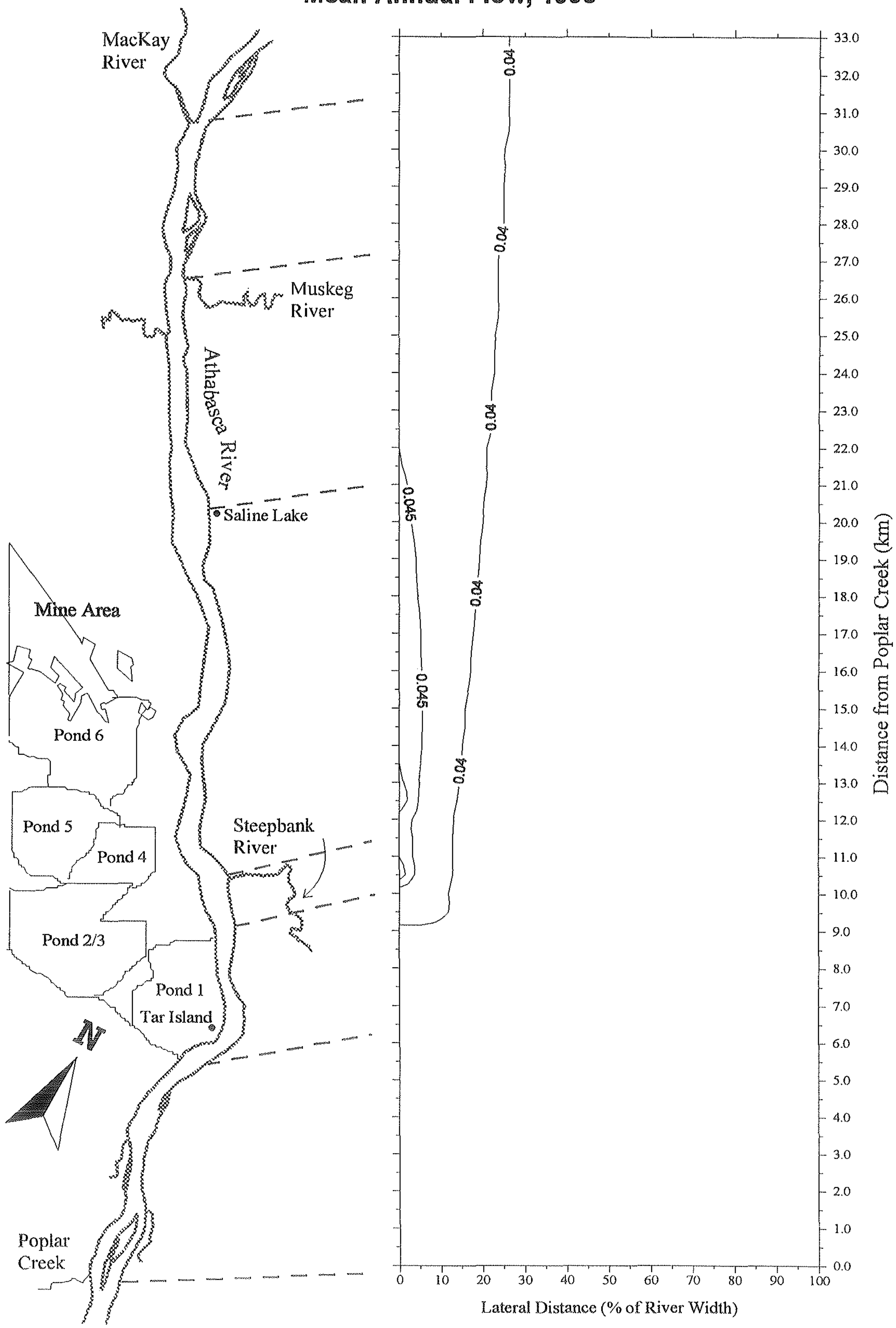


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Figure F3.0-4
Predicted Toxicity Levels (TUc) in the Athabasca River
7Q10 Flow, 1995

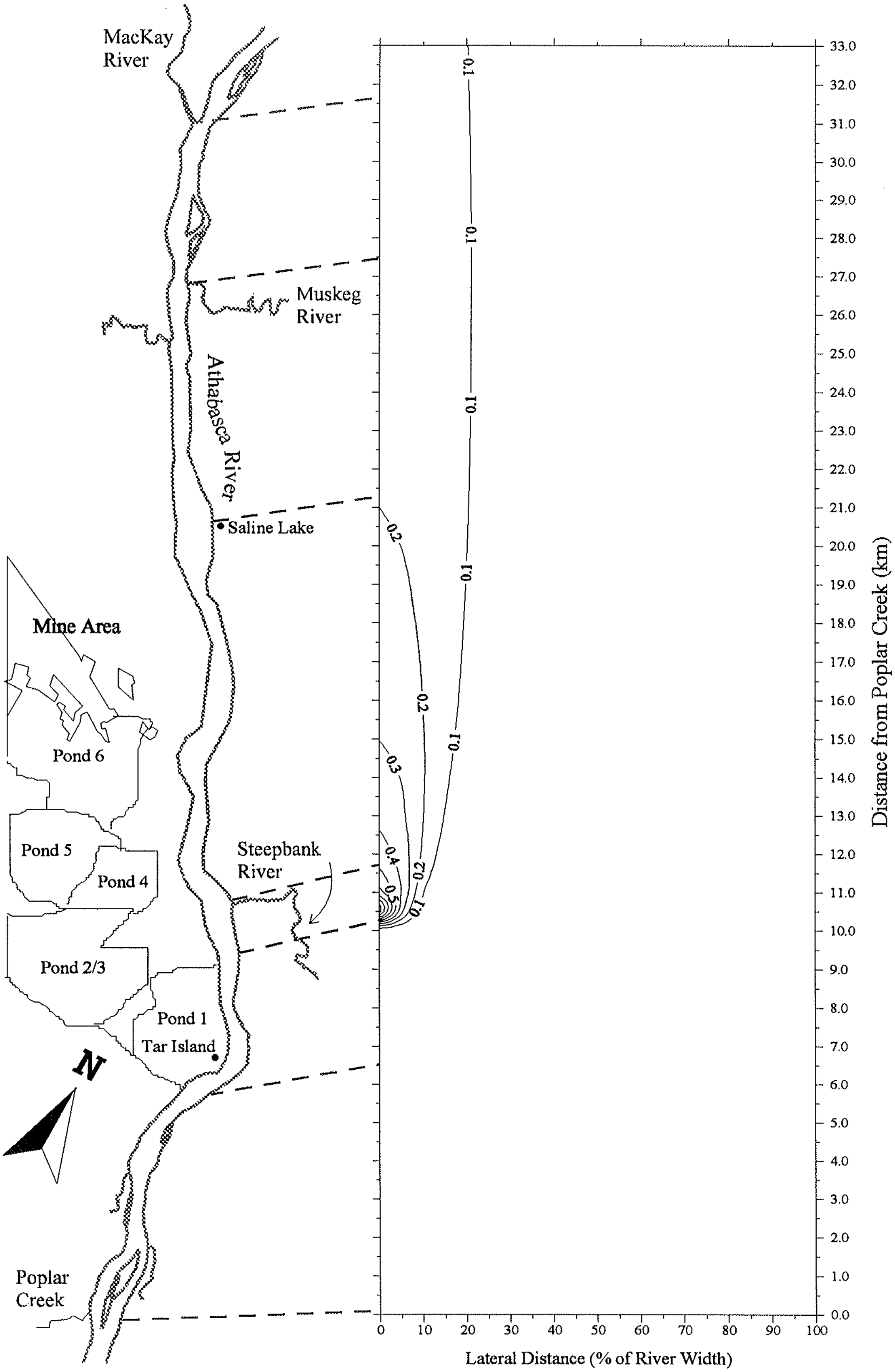

Figure F3.0-5
Predicted Toxicity Levels (TUc) in the Athabasca River
7Q10 Flow, 2001

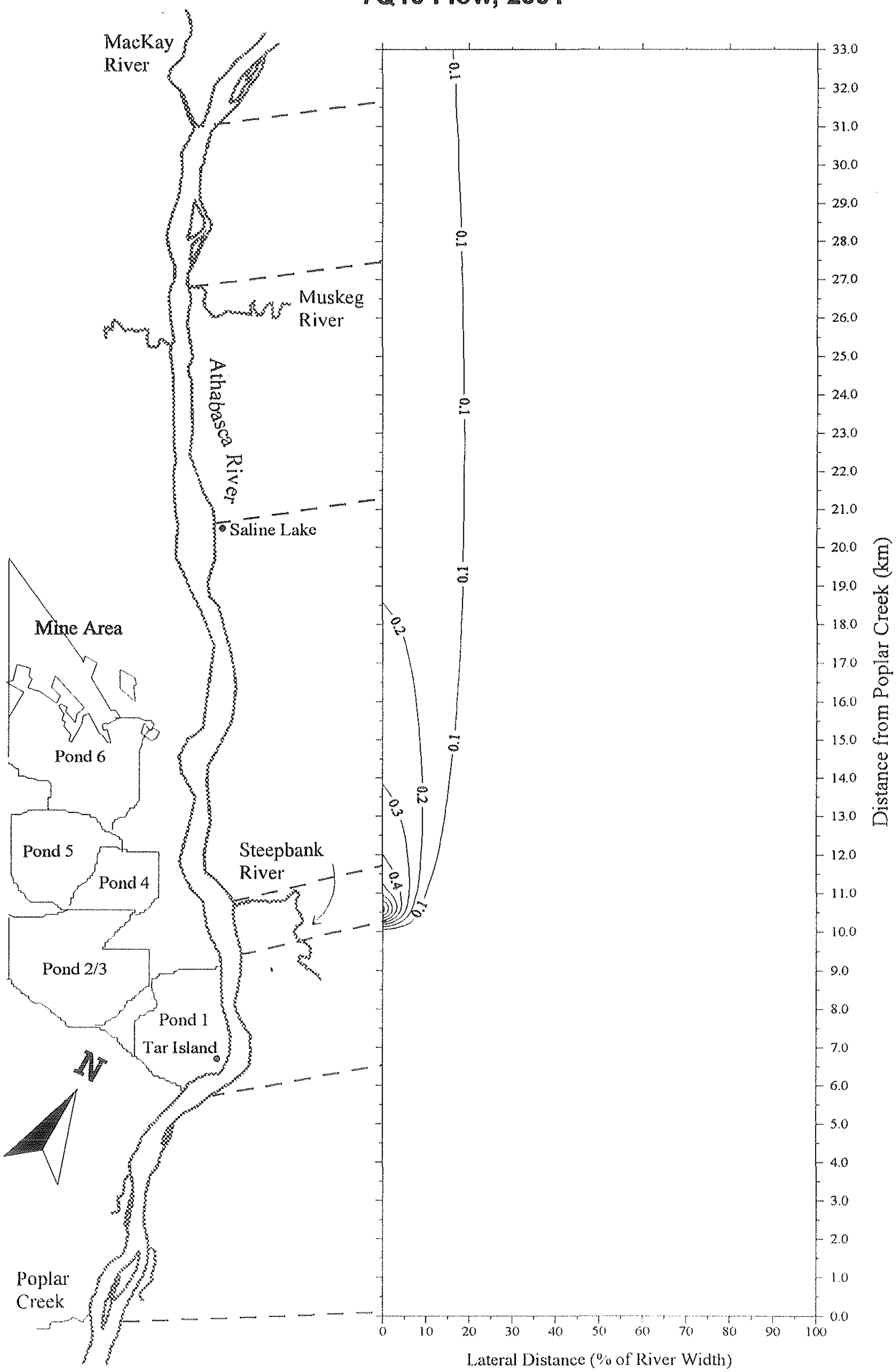

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Figure F3.0-6
Predicted Toxicity Levels (TUc) in the Athabasca River
7Q10 Flow, 2010

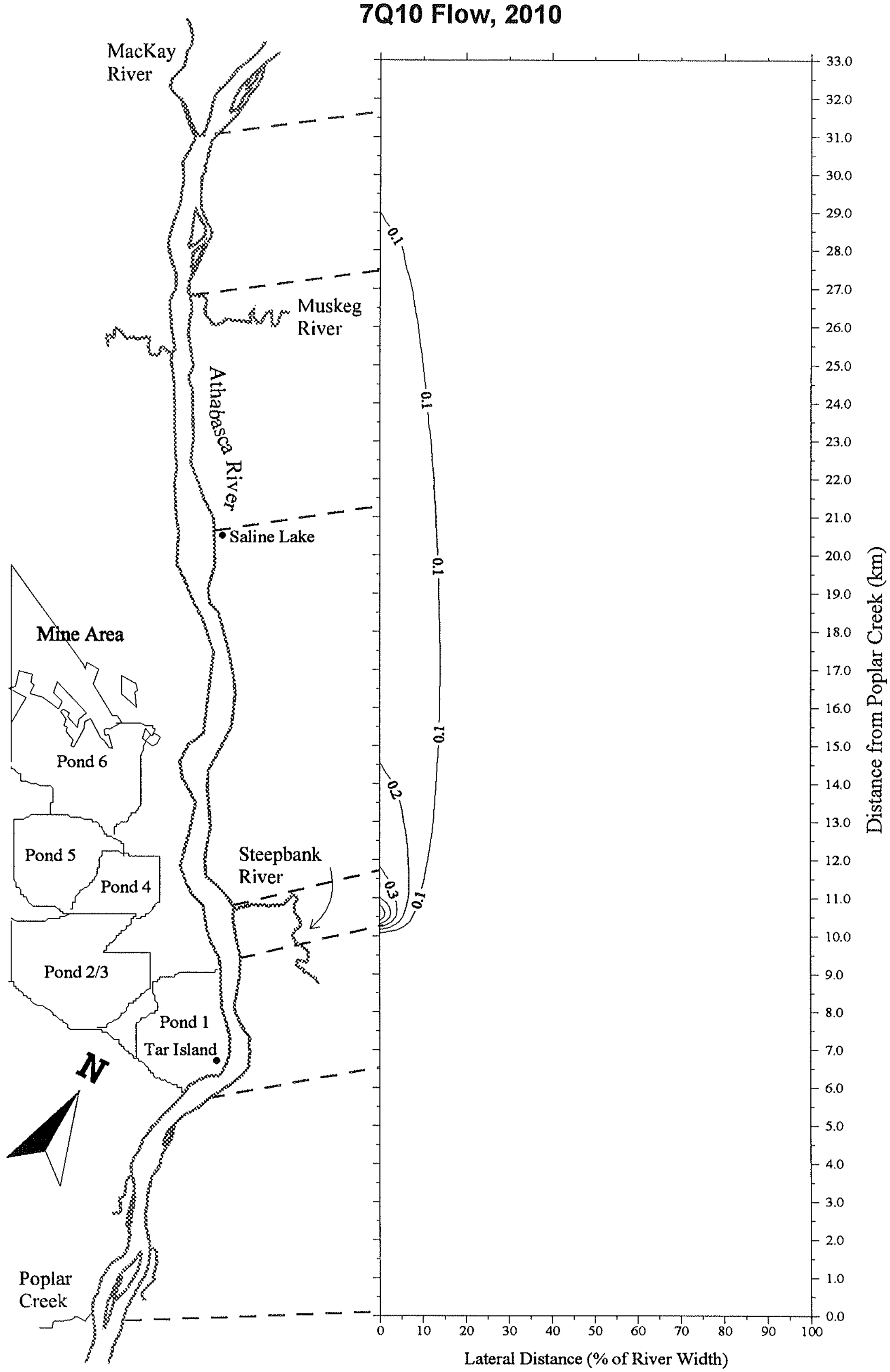

Figure F3.0-7
Predicted Toxicity Levels (TUc) in the Athabasca River
7Q10 Flow, 2020

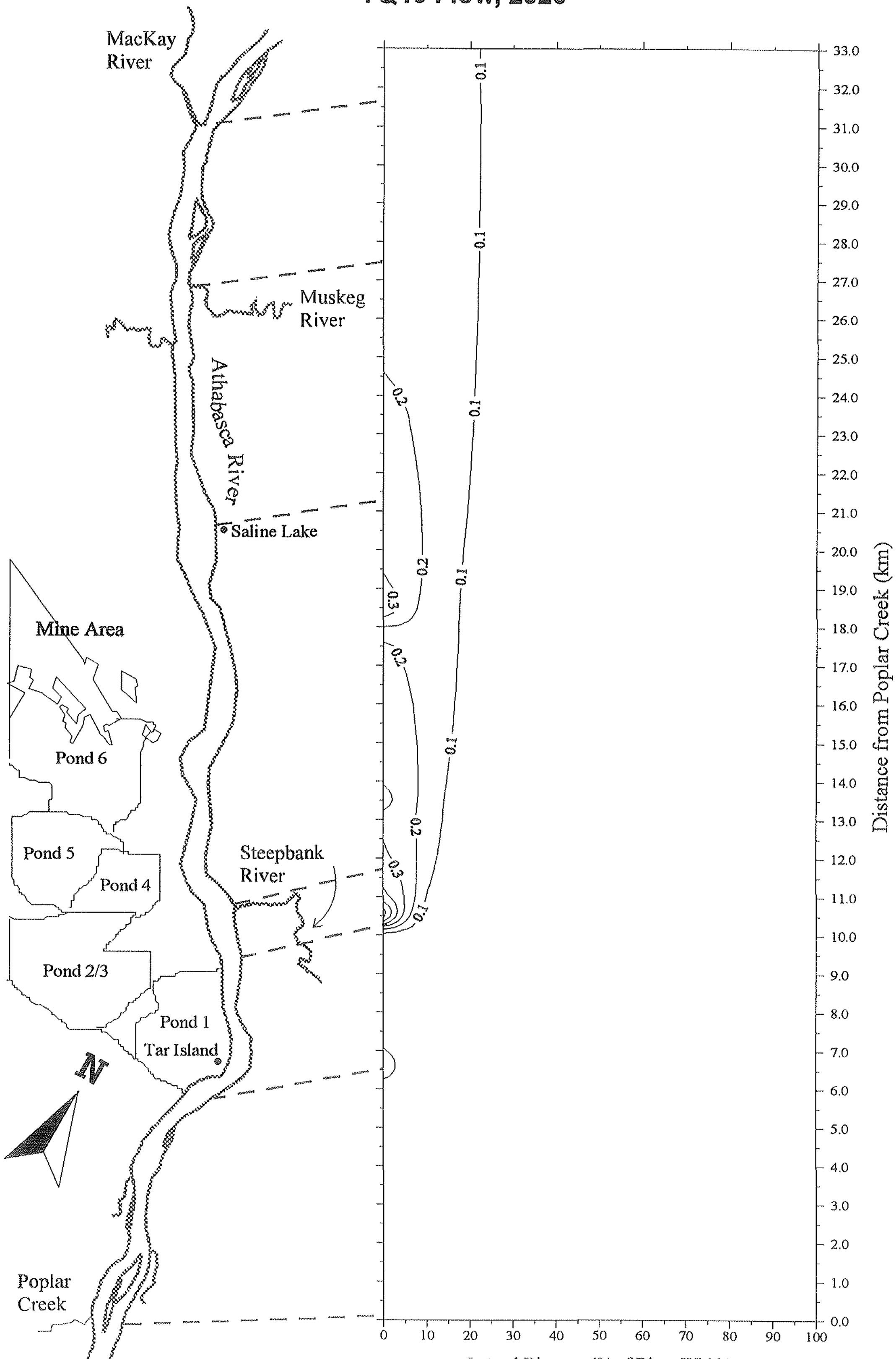

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Figure F3.0-8
Predicted Toxicity Levels (TUc) in the Athabasca River
7Q10 Flow, Long-term

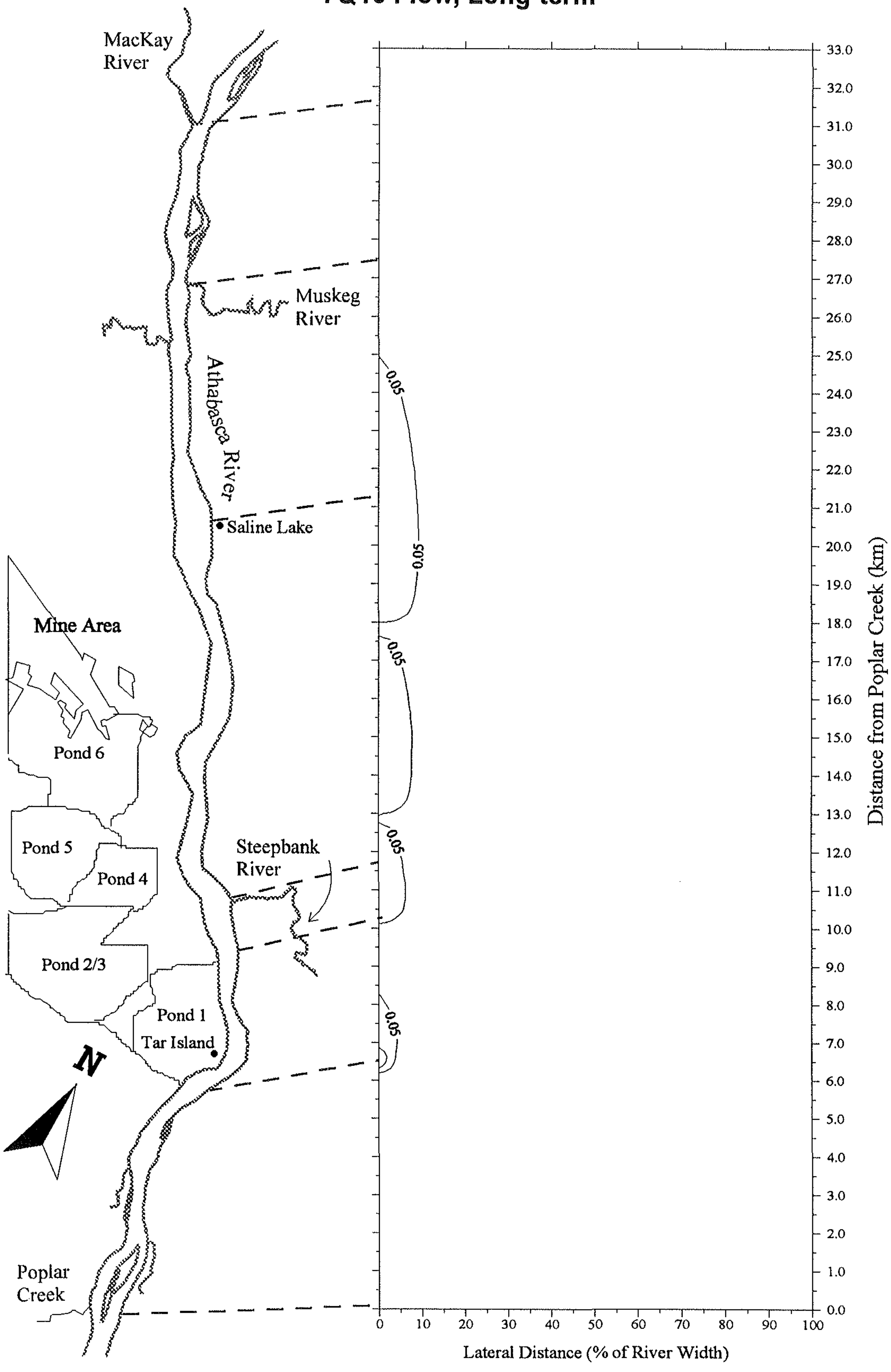

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Figure F3.0-9
Percent Dilution of Suncor Water Releases in the Athabasca River
7Q10 Flow, 2020

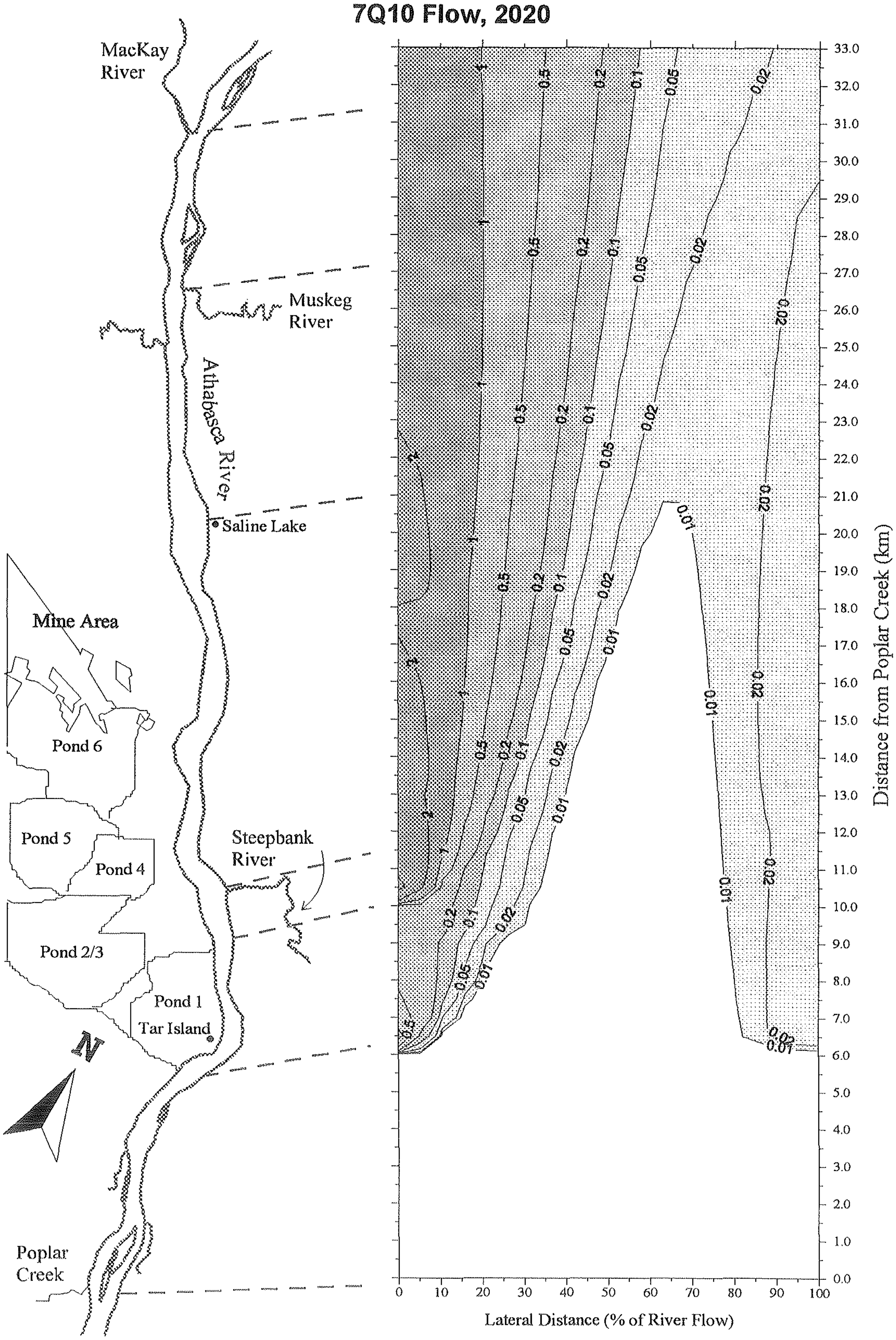

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Figure F3.0-10
Percent Dilution of Suncor Water Releases in the Athabasca River
7Q10 Flow, Long-term

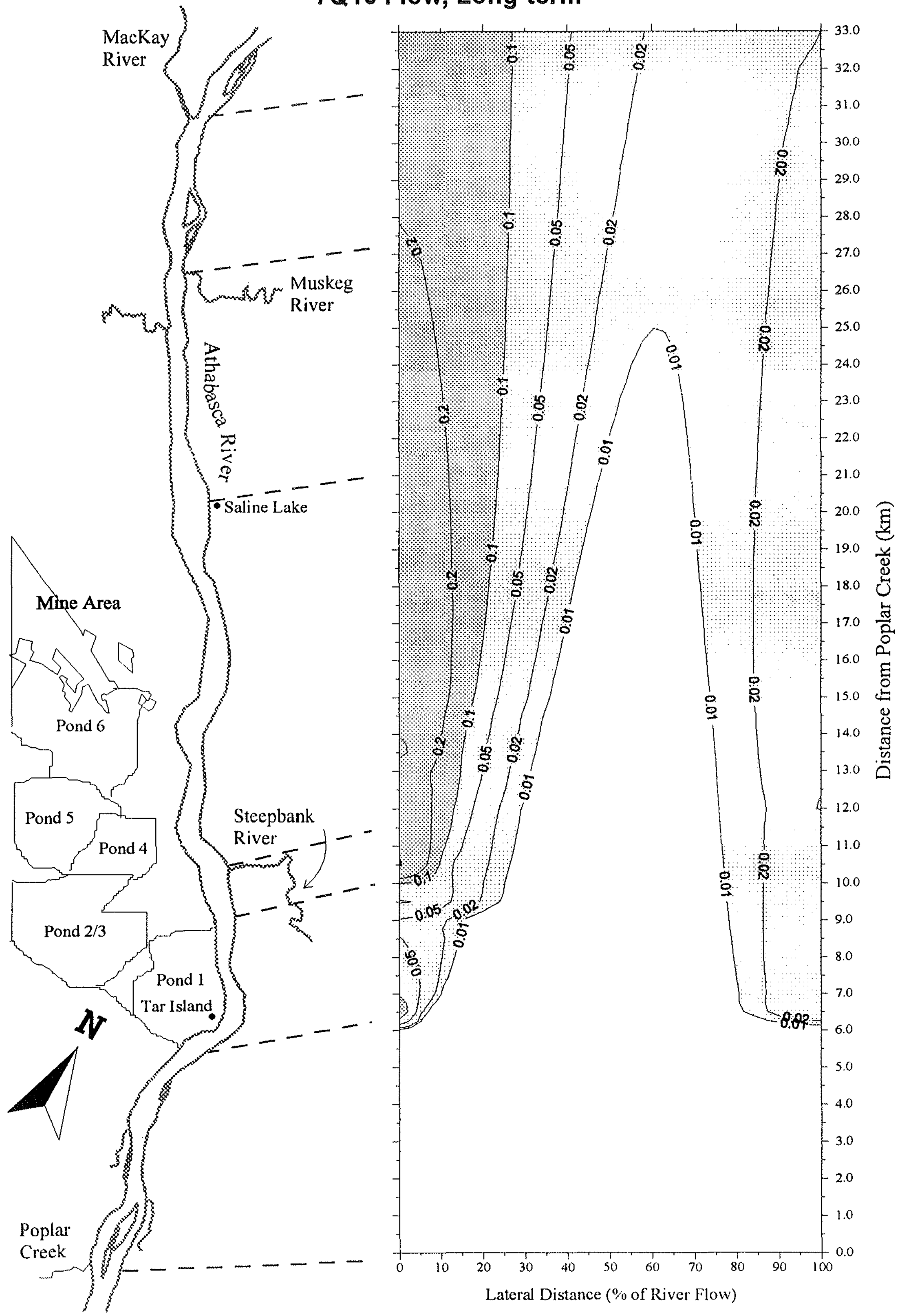

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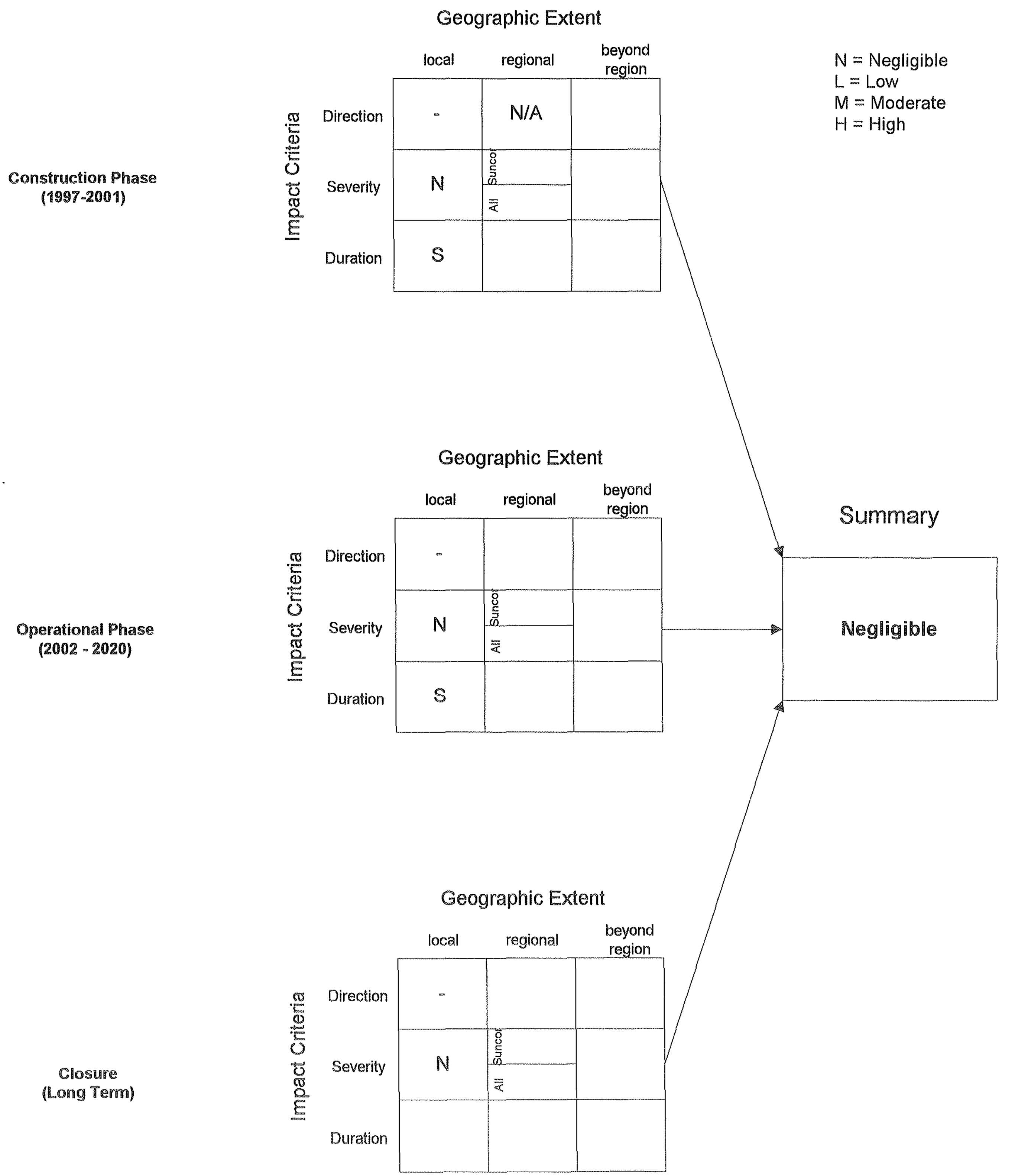
Figure F3.0-11
Impact Hypothesis Classification- Hypothesis 30

Water Releases Associated with Construction, Operational or Reclamation Activities Might Adversely Affect Aquatic Ecosystem Health in the Athabasca or Steepbank Rivers



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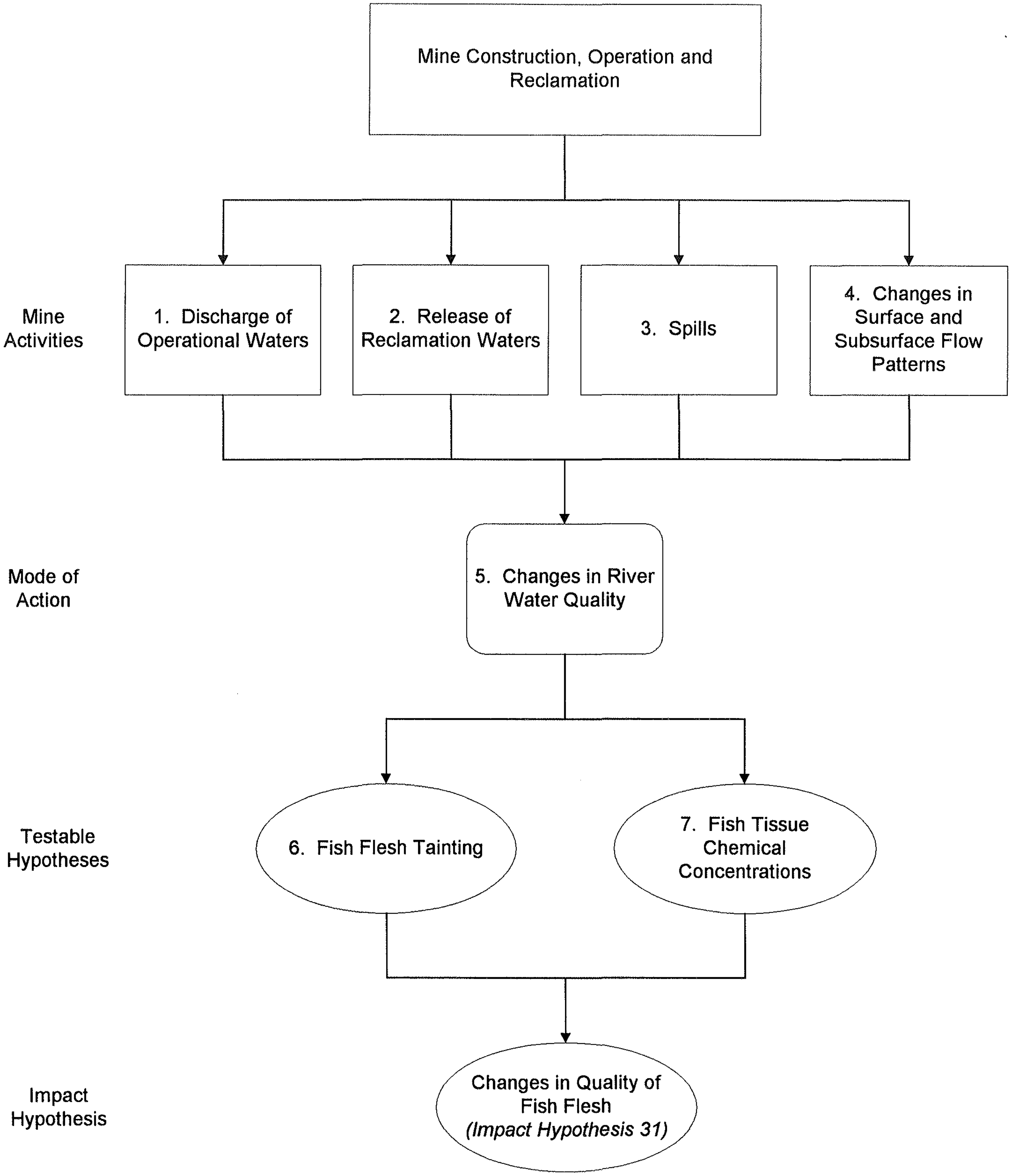

Figure F4.0-1 Linkages Among Mine Activities, Mode of Action and Potential Impacts on Fish Flesh Quality

Figure F4.0-2
Percent Dilution of Suncor's Wastewater in the Athabasca River
7Q10 Flow, 1995

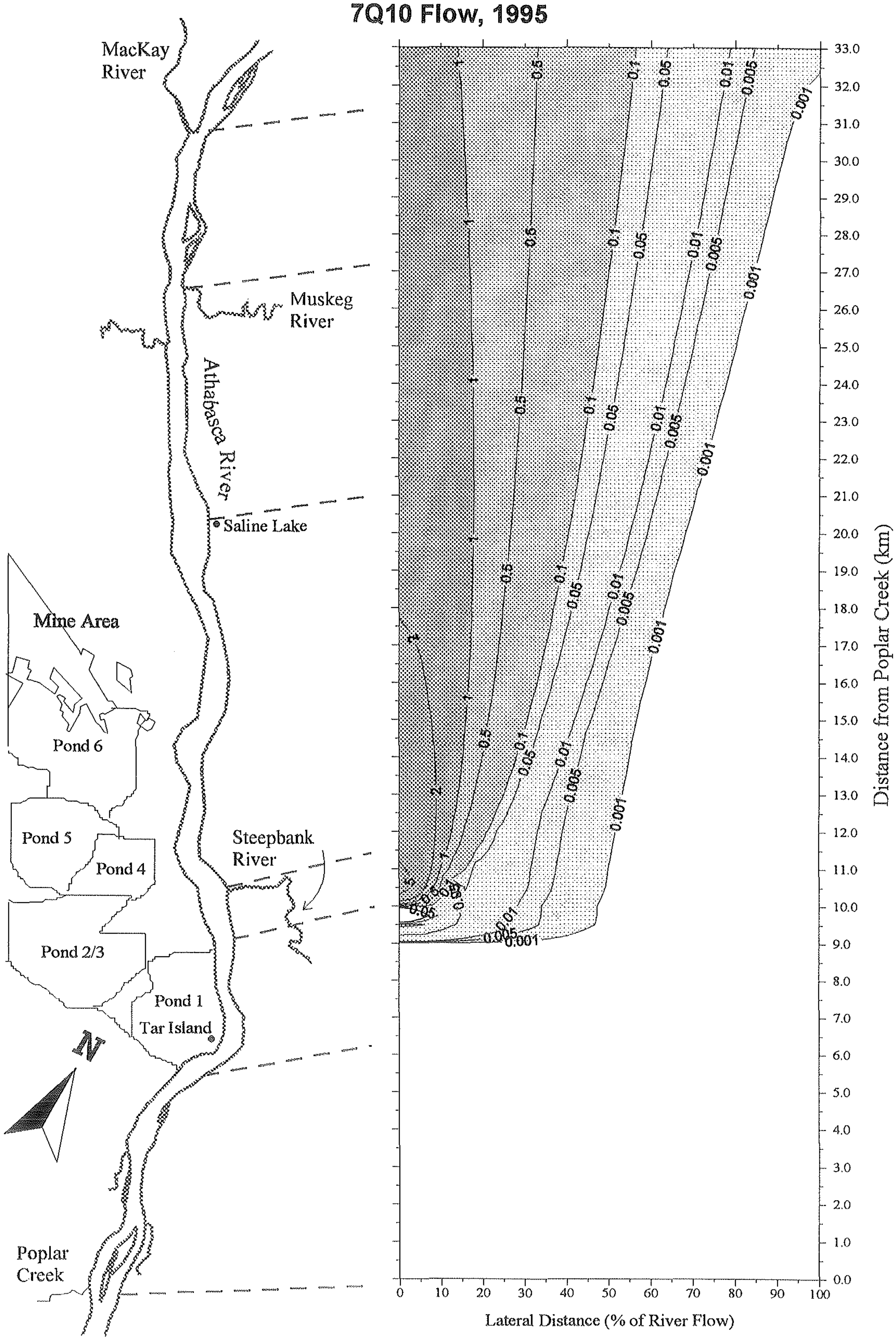

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Figure F4.0-3
Impact Hypothesis Classification - Hypothesis 31

Water Releases Associated with Construction, Operational or Reclamation Activities Might Adversely Affect the Quality of Fish Flesh

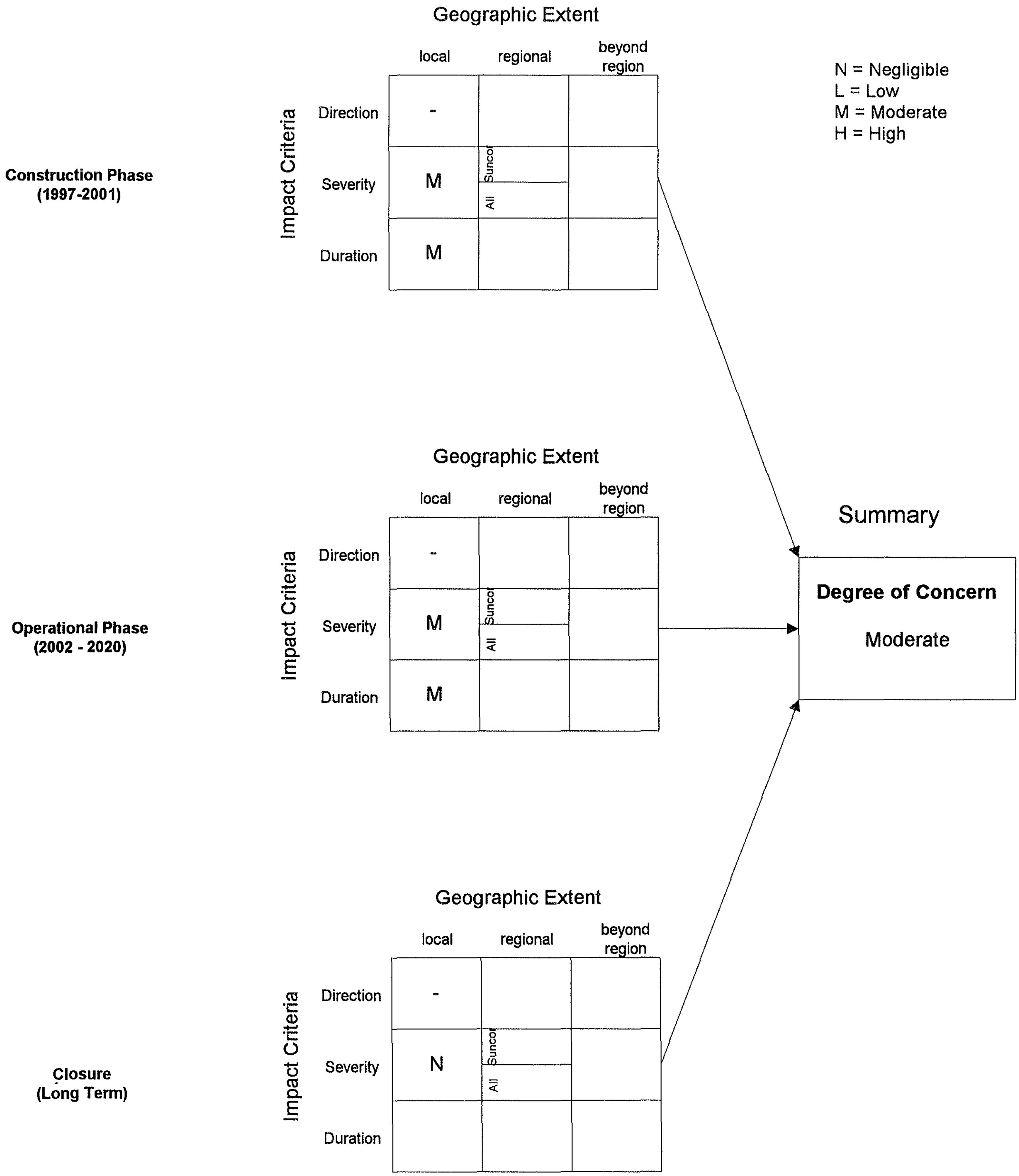

Figure F5.0-1 Linkages Among Mine Activities, Modes of Action and Potential Impacts on Fish Abundance

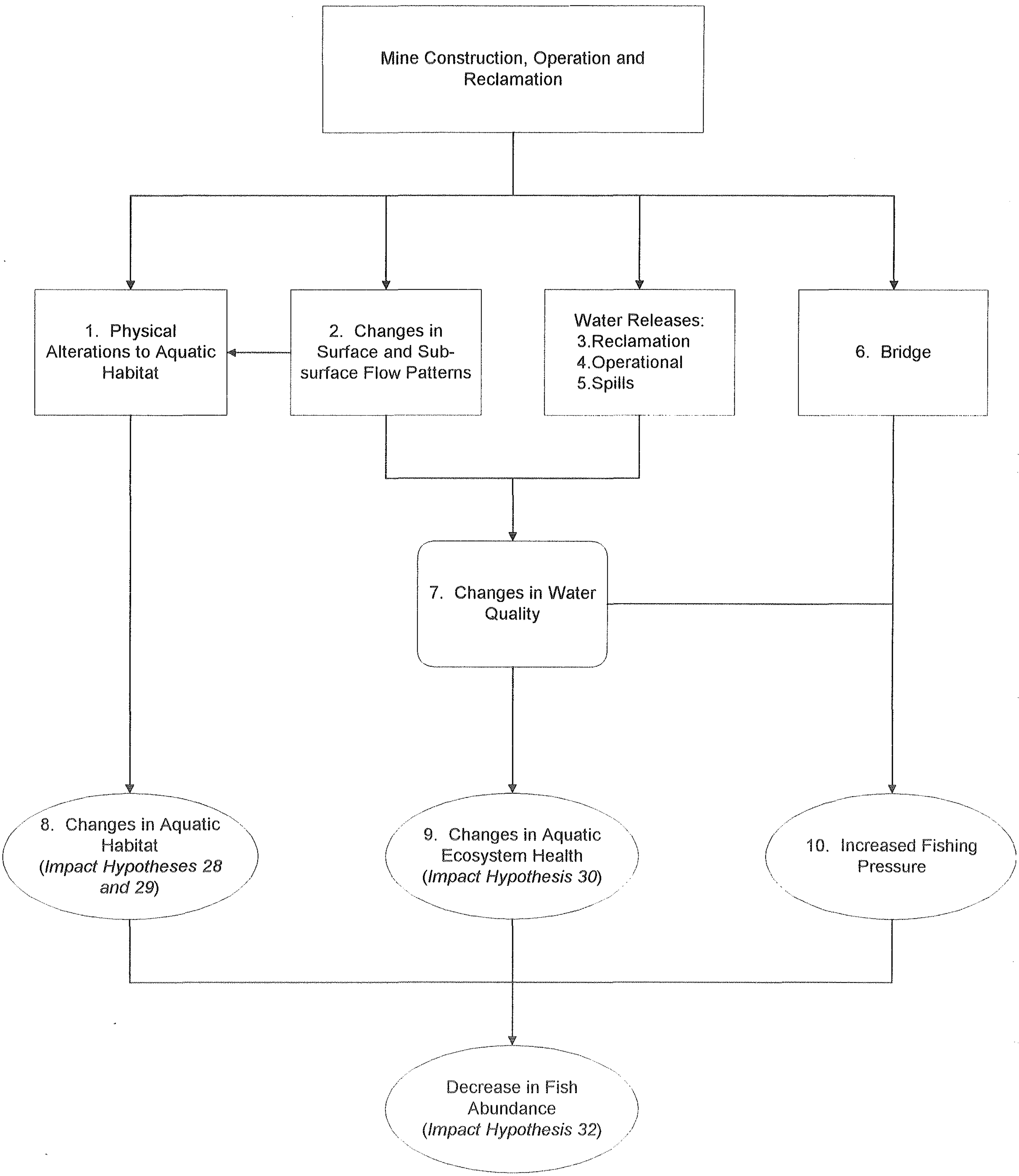

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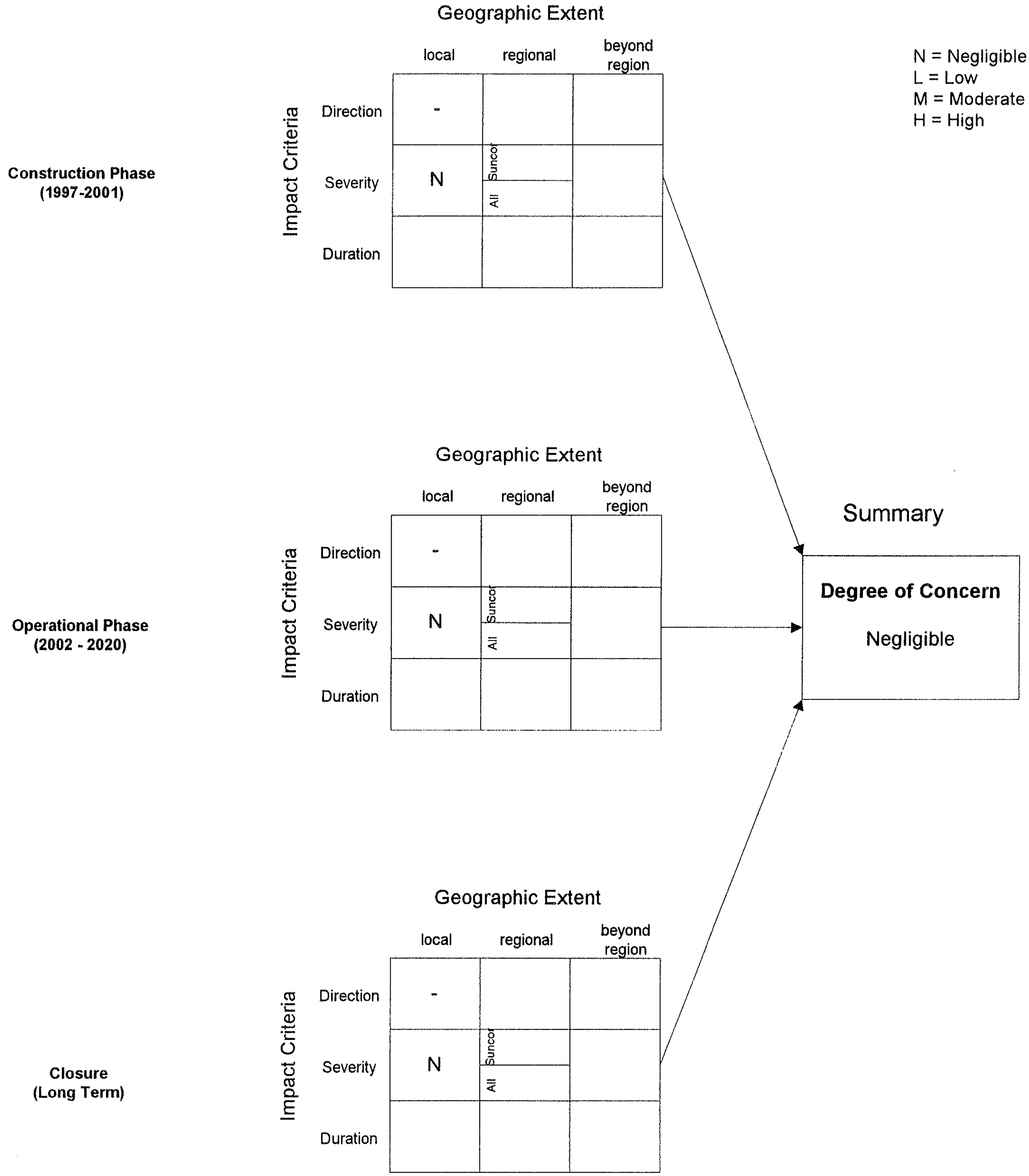
Figure F5.0-2
Impact Hypothesis Classification - Hypothesis 32

Construction, Operational or Reclamation Activities Might Lead to Changes in Aquatic Habitat and/or Aquatic Health Which Might Result in a Decline in Fish Abundance in the Athabasca or Steepbank Rivers



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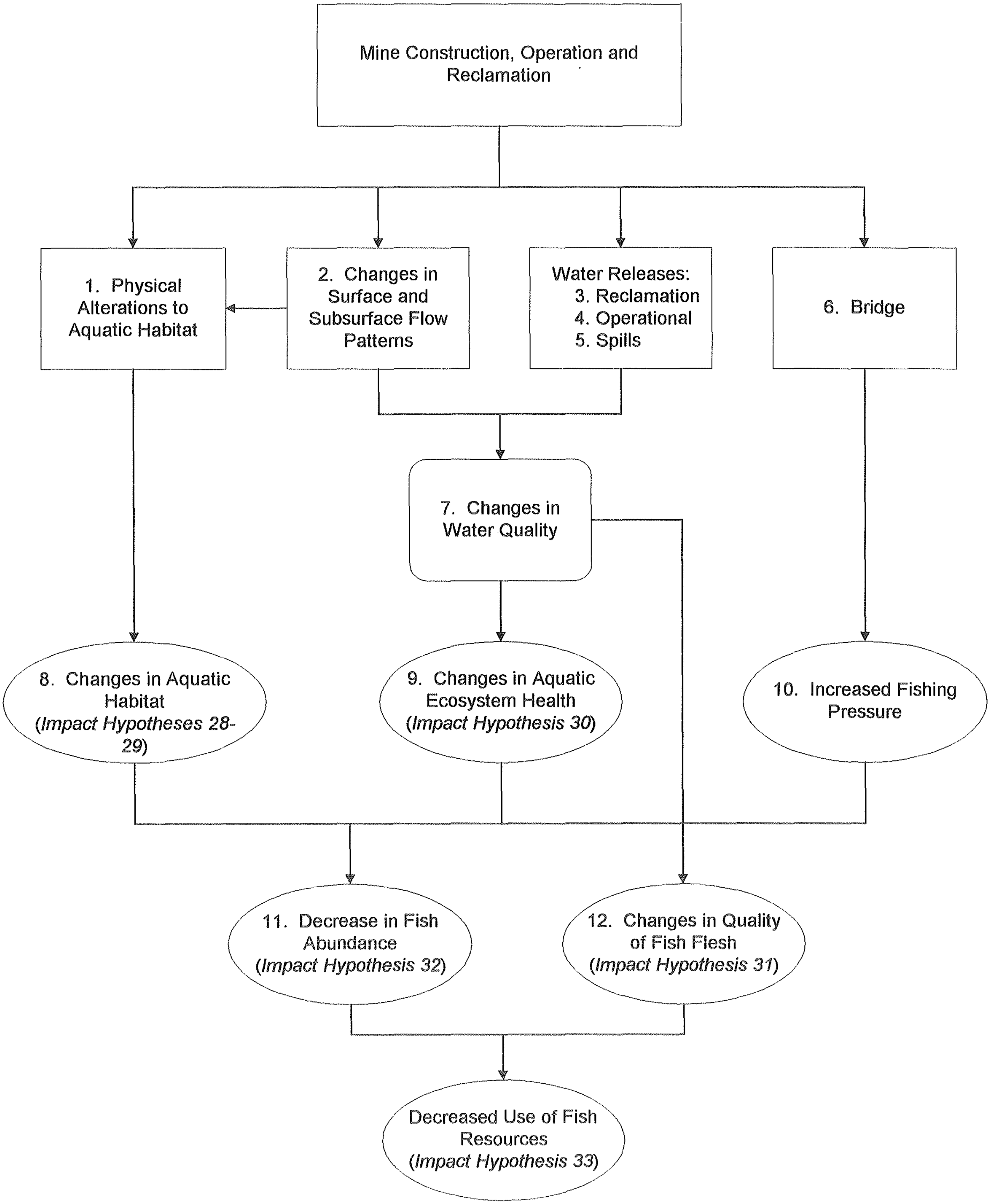
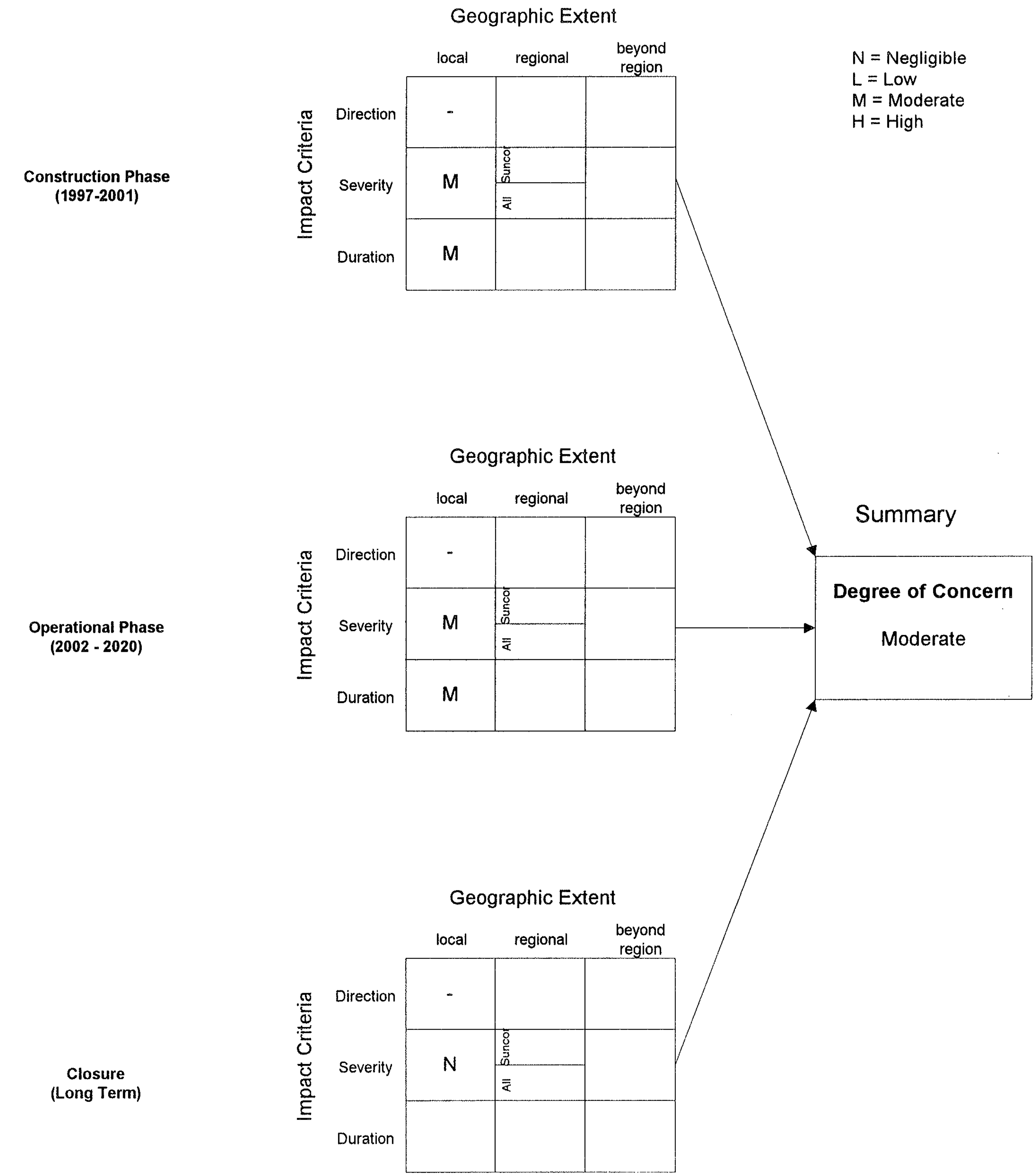


Figure F6.0-1 Linkages Among Mine Activities, Modes of Action and Potential Impacts to Use of Fish Resources

Figure F6.0-2
Impact Hypothesis Classification - Hypothesis 33

Construction, Operational or Reclamation Activities Might Lead to Changes in Fish Abundance or Quality of Fish Flesh Which Might Result in a Decreased use of the Fish Resource



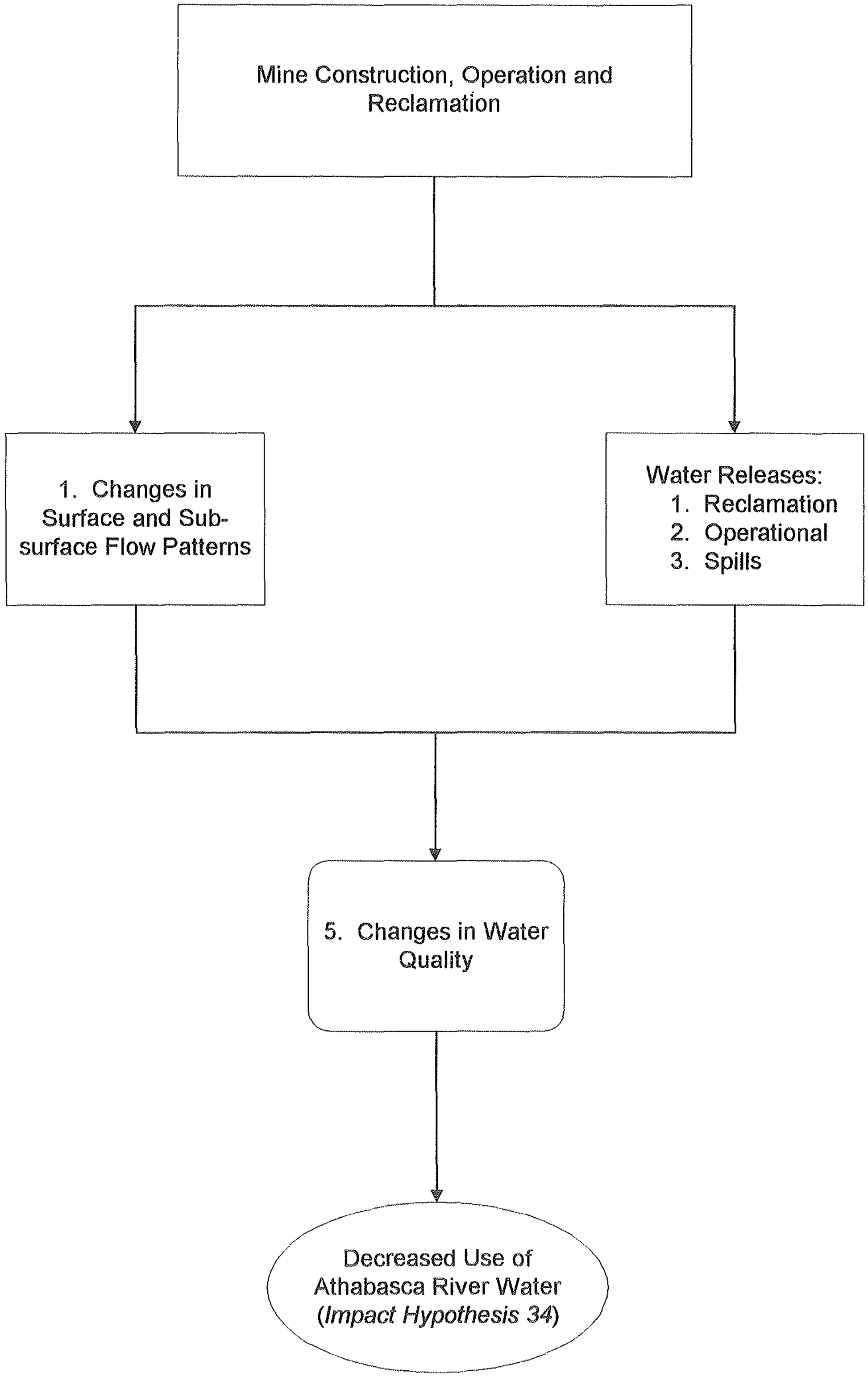


Figure F7.0-1 Linkage Among Mine Activities, Modes of Action and Potential Impacts to Use of Athabasca River Water

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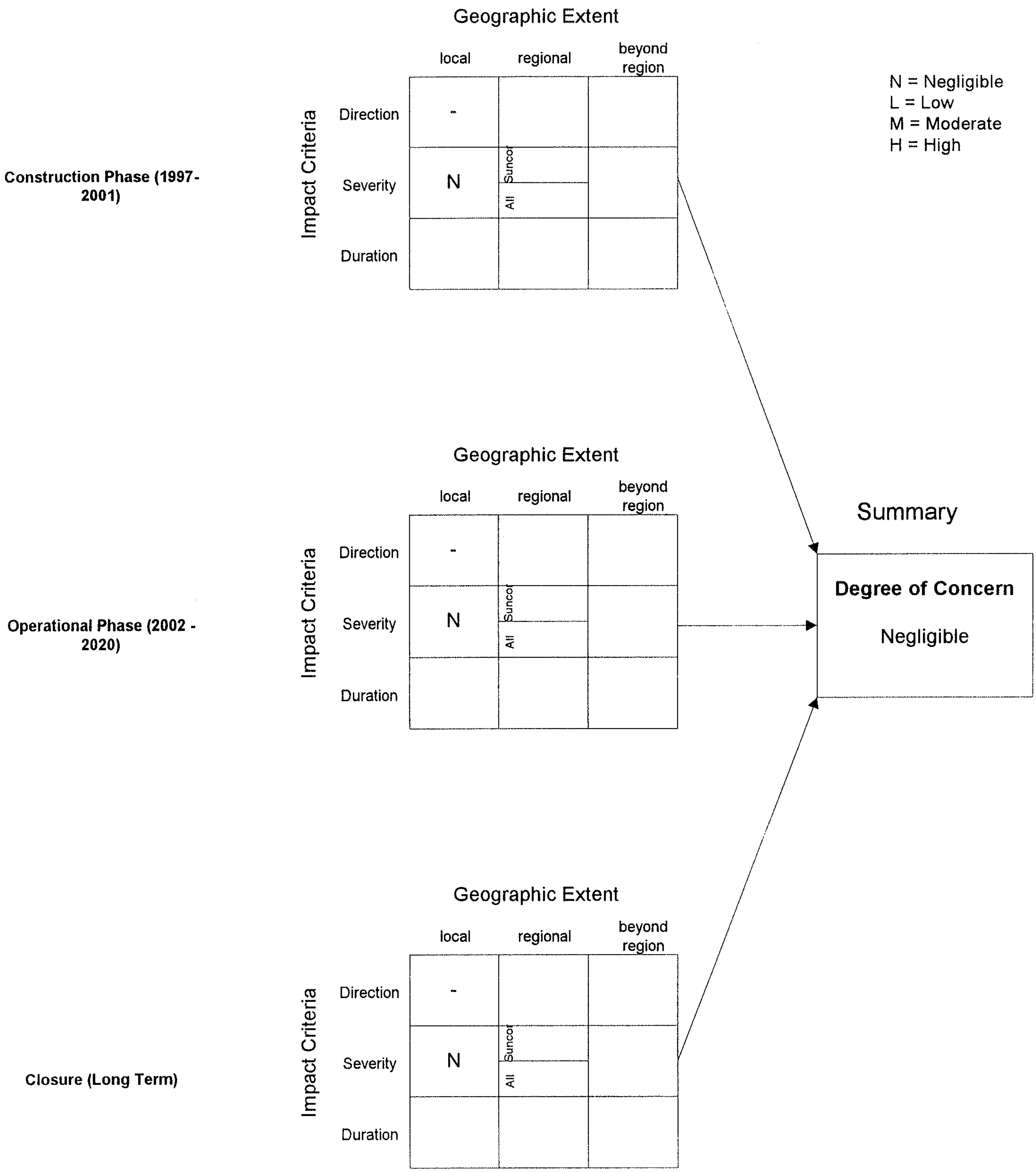
Figure F7.0-2
Impact Hypothesis Classification - Hypothesis 5.7

Construction, Operational or Reclamation Activities Might Cause Changes in Athabasca River Water Quality Which Might Limit Downstream use of the Water



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APPENDIX I

DATA TABLES

TABLE I-1

RESPONSE TO ISSUES ON STAKEHOLDERS' DATABASE

Throughout the planning for the Steepbank Mine, stakeholders were invited to express their concerns about the project. Below is a listing of the issues that have been raised. The final column indicates where the concern is addressed. In most cases, the issue is investigated in an Impact Hypothesis in the Aquatic EIA document and the relevant section is cited. In other cases, Suncor is responding through other mechanisms (e.g., Aboriginal Affairs Policy), or the information is included in the project description and operating plan chapters of the Application.

ISSUE	WHERE ADDRESSED
AQUATICS, SURFACE AND GROUNDWATER	
Will there be a loss of recreational, subsistence or commercial fish production due to direct or indirect toxic effects?	F3
Lot 3 wetland may be affected by changes to surface and groundwater recharge, and overburden dump; loss of vegetation habitat due to direct loss, degradation, contamination, erosion of wetlands.	F2
Proximity to rivers is a major environmental issue.	F1, F2
Human health -- will fish consumption be a concern?	Human Health EIA, F7
Is mercury a concern in fish?	E8, F4
Will fish tainting limit use of the resource?	E7, F4, F6
Could there be a loss of fish production due to direct or indirect toxic effects?	F3, F5
Could there be a potential loss of recreational, subsistence or commercial fish production due to direct or indirect toxic effects?	F3, F5
Will there be a loss of habitats that will preclude future fish production (Steepbank and Athabasca Rivers)?	F2, F3, F5
Will the aquatic cumulative effects including Syncrude future expansion be considered?	F2.3.3, F3.3.3, F4.3.3, F5.3.3, F6.3.3
Are biomarkers the same as bioindicators?	F3.2, C
What about naphthenic acids in relation to fish?	Water Releases Impact Assessment
What is known about MFO's?	E6, F3
Adjust and pare down organics list.	Water Release Impact Assessment

TABLE I-1

RESPONSE TO ISSUES ON STAKEHOLDERS' DATABASE

ISSUE	WHERE ADDRESSED
What will be the effects resulting from discharge of mine drainage water (i.e., water quality, flows); effects of water discharge from facilities (e.g., camp, plant runoff, extraction, upgrading); effects of shop/maintenance facility to water quality in wetland, effects of sewage and garbage disposal, landfill contamination, storage and disposal of fuel, cleaners, run-off from sizers/surge bin/conveyors?	Surface Water and Groundwater Impact Assessment, F1, F2, F3
What will be the effects to groundwater quality from contaminant migration from landfill, tailings ponds, coke pile, sulphur; spills from tanks, pipeline breaks and leaks, diesel fuel from conveyors, etc?	Surface Water and Groundwater Impact Assessment, F3
What is the hazard of catastrophic tailings release into the Athabasca River?	F3.1
Will there be impacts to water quality from seepage through tailings dykes?	F3.1
What is the toxicity of surface runoff and seepage water and discharge from tailings?	F3
Will the be bioaccumulation of hydrophobic compounds?	E8, F4
Will disposal of basal aquifer water affect surface water quality? Can saline basal aquifer water be used in the recycle system?	F3
Will there be impacts to Steepbank River from sediment run-off from mining?	F1
Will there be river contamination from spills from bridge (paints, salt, etc.)? What is the potential for contamination from pipeline spills/leaks (emergency dumps, freezeup protection, line abrasion and breakage, emergency plans)? What are the potential effects of hydrotransport building failure (e.g., freeze-up), general facility run-off, fire water source and spillage, fate of degreasers and other materials associated with clean-up and rejects disposal?	F2, F3
River ecology impact concerns from the sewage lagoon and coke handling and storage.	F3
What impacts to the river could be caused by providing water to operate the hydrotransport system?	F2

TABLE I-1

RESPONSE TO ISSUES ON STAKEHOLDERS' DATABASE

ISSUE	WHERE ADDRESSED
Groundwater and surface water flow patterns could be affected by dewatering.	Surface Water and Groundwater Impact Assessment, F1, F2
What will be the effects to wetlands and other water bodies from mine water discharge?	Surface Water and Groundwater Impact Assessment, F1, F2, F3
Will there be water discharges to Steepbank River?	Application, Surface Water and Groundwater Impact Assessment, F1, F3
What will be the water impacts from mining (e.g., altered hydrology, sediment or nutrient loading)?	Surface Water and Groundwater EIA, F1, F2, F3
Groundwater discharge and alteration of surface flows to the Steepbank River may affect flow conditions (including base flows) and may affect fish.	Surface Water and Groundwater EIA, F1
What will be the impact to riparian and aquatic habitat impacts to Athabasca River caused by bridge construction (pilings, barrier, siltation, etc.)?	F2
What will be the effects to spawning habitat for grayling, and to bull trout in area?	F1
Will there be impacts from ice jamming to bridge, river bed and water intake?	River Hydraulics and Ice Study
Will the valley development be susceptible to ice buildup, flooding?	River Hydraulics and Ice Study
Will the bridge provide access to previously remote areas or spills?	F2, F5
What will be the impacts of bridge approaches to erosion, stabilization and habitat loss?	F2
Will there be impacts to navigation from changed channel depth or bridge height?	River Hydraulics and Ice Study
Could a tunnel be constructed under the river? How many piers will be in the river? Will there be public access?	Application, F2, F5
Mining on north side of Steepbank River would require a bridge with impacts to river.	Application, F2
Increased bank erosion, instability and other impacts could result from waste dump placement near river.	F2

TABLE I-1

RESPONSE TO ISSUES ON STAKEHOLDERS' DATABASE

ISSUE	WHERE ADDRESSED
What approvals are required for a private bridge?	Application
Will Heritage River status of Clearwater River be an issue with Athabasca River bridge?	Application
Restricted access to east side for employees	F5
Provide an overview of how the aquatic ecosystem might be affected.	Figure D3.0-1
What chemicals and what are the long-term river ecology impacts and water quality?	F3
What are detection limits for parameter groups?	F3

TABLE I-2

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN FISH AND AQUATIC MACROINVERTEBRATES

CHEMICAL	BACKGROUND							TREATMENT					
	Chironomid Larvae[1]	Benthic Macroinvertebrates[2]	Emergent Insects[3]	Benthic Macroinvertebrates[4]	Athabasca River Baseline[5]	Rainbow Trout[6]	Walleye[7]	Chironomid Larvae[8]	Benthic Macroinvertebrates[9]	Emergent Insects[10]	Rainbow Trout[11]	Walleye[12]	Rainbow Trout[13]
	Control Wetlands	Control Wetlands	Control Wetlands	Athabasca River	Athabasca River Water	Athabasca River Water	Athabasca River Water	Suncor Dyke Drainage Wetlands	Suncor Dyke and Split Dyke Drainage Wetlands	Suncor Dyke Drainage Wetlands	10% TID Water	10% TID Water	Syncrude Pond #5
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
ORGANICS													
Total Extractable Hydrocarbons	-	14-99.8	-	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons													
1-Methyl-7-isopropyl phenanthracene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Acenaphthene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.001
Acenaphthylene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.0002
Anthracene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.0006
Benzo(a)anthracene	-	-	-	-	-	-	-	-	-	-	-	-	<0.00009
Benzo(a)anthracene/chrysene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Benzo(a)pyrene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	0.001
Benzo(e)pyrene	-	-	-	-	-	-	-	-	-	-	-	-	0.001
Benzo(b&k)fluoranthene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.0008
Benzo(ghi)perylene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.001
Biphenyl	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C1 dibenzothiophene	-	-	-	-	-	-	-	-	-	-	-	-	<0.01
C1 naphthalenes	-	-	-	-	-	-	-	-	-	-	-	-	0.006
C1 phenanthrene/anthracene	-	-	-	-	-	-	-	-	-	-	-	-	<0.01
C2 sub'd benzo(a)anthracene/ chrysene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C2 sub'd benzo(b&k)fluoranthene/ benzo(a)pyrene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C2 sub'd biphenyl	-	-	-	0.06	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C2 sub'd dibenzothiophene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C2 sub'd fluorene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C2 sub'd naphthalene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C2 sub'd phenanthrene/antharacene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C3 sub'd dibenzothiophene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C3 sub'd naphthalene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C3 sub'd phenanthrene/anthracene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C4 sub'd dibenzothiophene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C4 sub'd naphthalene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C4 sub'd phenanthrene/anthracene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
Chrysene	-	-	-	-	-	-	-	-	-	-	-	-	<0.00007
Dibenzo(a,h)anthracene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.002
Dibenzothiophene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.01
Fluoranthene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.001
Fluorene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	0.003
Indeno(c,d-123)pyrene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.001
Methyl acenaphthene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl benzo(a)anthracene/chrysene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl benzo(b&k)fluoranthene/ benzo(a)pyrene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl biphenyl	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl dibenzothiophene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl fluoranthene/pyrene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl fluorene	-	-	-	0.06	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl naphthalene	-	-	-	<0.02	<0.02-0.03	0.03	<0.02	-	-	-	0.03	<0.02	-
Methyl phenanthrene/anthracene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Naphthalene	-	-	-	<0.02	<0.02-0.04	0.02	<0.02	-	-	-	0.03	<0.02	0.005
Perylene	-	-	-	-	-	-	-	-	-	-	-	-	<0.001
Phenanthrene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	0.001
Pyrene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.0008
Polycyclic Aromatic Nitrogen Heterocycles													
7-Methyl quinoline	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Acridine	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
C2 Alkyl subst'd carbazoles	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
C2 Alkyl subst'd quinolines	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
C3 Alkyl subst'd quinolines	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Carbazole	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-

TABLE I-2

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN FISH AND AQUATIC MACROINVERTEBRATES

CHEMICAL	BACKGROUND							TREATMENT					
	Chironomid Larvae[1]	Benthic Macroinvertebrates[2]	Emergent Insects[3]	Benthic Macroinvertebrates[4]	Athabasca River Baseline[5]	Rainbow Trout[6]	Walleye[7]	Chironomid Larvae[8]	Benthic Macroinvertebrates[9]	Emergent Insects[10]	Rainbow Trout[11]	Walleye[12]	Rainbow Trout[13]
	Control Wetlands	Control Wetlands	Control Wetlands	Athabasca River	Athabasca River Water	Athabasca River Water	Athabasca River Water	Suncor Dyke Drainage Wetlands	Suncor Dyke and Split Dyke Drainage Wetlands	Suncor Dyke Drainage Wetlands	10% TID Water	10% TID Water	Syncrude Pond #5
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Methyl acridine	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Methyl carbazoles	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Phenanthridine	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Quinoline	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
INORGANICS													
General	-	-	-				-	-	-	-	-	-	-
Calcium	-	-	-	7940	246-680	2260	7090	-	-	-	261	7660	-
Magnesium	-	-	-	2230	277-331	380	457	-	-	-	302	371	-
Phosphorus	-	-	-	3950	2140-2960	3620	6060	-	-	-	2640	5820	-
Potassium	-	-	-	4560	3950-5190	4840	5090	-	-	-	4880	4390	-
Sodium	-	-	-	4270	338-409	471	635	-	-	-	480	748	-
Metals and Trace Elements	-	-	-										
Aluminum	17.9-71.0	70-220	20-40	-	<2-11	18	14	15.8-18.4	100-1800	20-70	12	12	-
Arsenic	-	-	-	0.8	<0.5	<0.1	2.3	-	-	-	<0.1	1.1	-
Barium		7-52.6	<2-41	44	<0.5	<0.5	0.9	-	8-71.5	<20-84.4	<0.5	0.9	-
Beryllium	-	-	-	0.2	<0.5	<1	<1	-	-	-	<1	<1	-
Boron	-	-	-	10	<5	<5	<5	-	-	-	<5	<5	-
Cadmium	0.06-0.34	<1	<1	<0.3	<0.5	<0.5	<0.5	0.17-0.57	<1	<1	<0.5	<0.5	-
Chromium	-	-	-	31.8	<0.5	<0.5	<0.5	-	-	-	<0.5	<0.5	-
Cobalt	-	-	-	3.5	<0.5	<1	<1	-	-	-	<1	<1	-
Copper	-	<8-20	<60-70	13.7	<1-2	<1	<1	-	10-40	60-70	<1	<1	-
Iron	3080-4528	810-2100	420-1800	5660	7-16	23	8	1431-6590	1070-2970	220-650	4	<1	-
Lead	0.9-2.4	<1	<1	3	<2	<5	<5	3.84-5.73	<1	<1	<5	<5	-
Lithium	-	-	-	3.2	-	-	-	-	-	-	-	-	-
Manganese	-	20-46	20-80	193	<0.5-0.9	0.9	5.1	-	20-110	<30-190	0.2	6.1	-
Mercury	3.0-8.5	<1	<1	0.06	-	0.04	0.45	3.84-5.39	<1	<1	0.03	0.44	-
Molybdenum	-	-	-	2.2	<1	<1	<1	-	-	-	<1	<1	-
Nickel	-	-	-	23	<1-2	<2	<2	-	-	-	<2	<2	-
Selenium	-	-	-	<0.2	<0.5-0.3	0.3	0.4	-	-	-	<0.4	0.4	-
Silicon	-	-	-	654	4-12	<50	<50	-	-	-	<50	<50	-
Silver	-	-	-	<0.2	-	<1	<1	-	-	-	<1	<1	-
Strontium	-	-	-	21.7	<0.5-0.9	2	8	-	-	-	<1	8	-
Thallium	-	-	-	-	<1	<1	<1	-	-	-	<1	<1	-
Tin	-	-	-	-	<2	<5	<5	-	-	-	<5	<5	-
Titanium	-	3-9	<3-<30	38.9	-	-	-	-	4-30	8-10	-	-	-
Uranium	-	-	-	<50	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	9.7	<1	<1	<1	-	-	-	<1	<1	-
Zinc	69.2-234	42-94	89-200	78.1	5-6	8.9	17.2	131-145	60-110	80-220	10.3	17.5	-

[1]Chironomid larvae background uptake data from EVS wetland study (1994). Chironomid larvae collected from control sites (n=3).
[2]Benthic macroinvertebrate background uptake data from EVS wetland study (1994). Macroinvertbrates collected from control sites (n=3)
[3]Emergent insect background uptake data from EVS wetland study (1994). Emergent insects collected from control sites (n=9).
[4]Benthic Macroinvertebrates collected from Athabasca River upstream of TID (Golder TID Study 1994b, n=1)
[5]Athabasca river baseline uptake data from Golder Associates Ltd (1996a). Data are ranges of composite samples based on filets from 10 fish/composite, seperated by gender and species (walleye, goldeye and longnose sucker; n=6-7)
[6]Rainbow trout background uptake data from HydroQual (1996). Fish were held for 28 days in Athabasca River water (n=1).
[7]Walleye background uptake data from HydroQual (1996). Fish were held for 28 days in Athabasca River water (n=1)
[8]Chironomid uptake data from EVS wetland study (1994). Chironomids sampled from Suncor Dyke Drainage trenches (n=3).
[9]Benthic macroinvertebrate uptake data from EVS wetland study (1994). Macroinvertebrates sampled from Suncor Dyke Drainages and Split Dyke Drainages (n=9)
[10]Emergent insect uptake data from EVS wetland study (1994). Emergent insects collected from Suncor Dyke Drainages (n=9).
[11]Rainbow trout uptake data from HydroQual (1996). Fish were held for 28 days in 10% Tar Island Dyke Water (n=1).
[12]Walleye uptake data from HydroQual (1996). Fish were held for 28 days in 10% Tar Island Dyke Water (n=1)
[13]Rainbow trout uptake data from Syncrude (1992; unpublished data). Fish were held for 10 weeks in water from Syncrude Pond #5 (n=1).

Data Revised April 16, 1996

TABLE I-3

SUMMARY OF CHEMICAL CONCENTRATIONS OF SUNCOR'S OPERATIONAL WATERS

	NATURAL WATERS		OPERATIONAL/RECLAMATION WATERS						
Chemical	Athabasca River[1]	Reference Tributaries[2]	Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
ORGANICS									
Total Petroleum Hydrocarbons (mg/L)									
Total Petroleum Hydrocarbons	-	-	-	-	-	-	99-113	-	-
Hydrocarbons, Recoverable	<1-1	<1-9	<1-22	<1-19	-	<1	<1	<1	-
Total Extractable Hydrocarbons (mg/L)									
Total Extractable Hydrocarbons	-	-	38.9-59.8	-	-	-	<1	<1	-
Naphthenic Acids (mg/L)									
Naphthenic acids	<1	<1	62-94	47-55	-	<2-5	<1-4	<1-5	-
Polycyclic Aromatic Hydrocarbons (µg/L)									
1-Methyl-7-isopropylphenanthrene (Retene)	<0.04	<0.04	<0.04	<0.04	<0.04-<0.1	<0.04	<0.04	<0.04	-
Acenaphthene	<0.02	<0.02	<0.02-<0.08	<0.02	<0.02-0.12	<0.02	<0.02	<0.02	-
Acenaphthylene	<0.02	<0.02	<0.02-0.16	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Anthracene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Benzo(a)anthracene/chrysene	<0.02	<0.02	<0.02-0.27	<0.02	<0.02-0.1	<0.02	<0.02-1	<0.02	-
Benzo(a)pyrene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-0.02	<0.02	<0.02	<0.02	-
Benzo(b&k)fluoranthene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Benzo(ghi)perylene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-0.03	<0.02	0.02-0.03	<0.02	-
Biphenyl	<0.04	<0.04	<0.04-0.08	<0.04	<0.04-<0.1	<0.04	<0.04	<0.04	-
C2 sub'd benzo(a)anthracene/chrysene	<0.04	<0.04	<0.04-0.83	<0.04	<0.04-0.05	<0.04	<0.04-0.12	<0.04	-
C2 sub'd benzo(b&k)fluoranthene/ benzo(a)pyrene	<0.04	<0.04	<0.04-0.18	<0.04	<0.04-0.04	<0.04	<0.04-0.07	<0.04	-
C2 sub'd biphenyl	<0.04	<0.04	<0.04-0.25	<0.04	<0.04-<0.1	<0.04	<0.04	<0.04	-
C2 sub'd dibenzothiophene	<0.04	<0.04	<0.04-2.2	<0.04	<0.1-0.52	<0.04	<0.04-0.19	<0.04	-
C2 sub'd fluorene	<0.04	<0.04	<0.04-1.1	<0.04-0.28	<0.04-0.35	<0.04	<0.04-0.16	<0.04	-
C2 sub'd naphthalene	<0.04	<0.04	<0.04-0.25	<0.04-0.07	0.25-0.3	<0.04	<0.04-0.04	<0.04	-
C2 sub'd phenanthrene/anthracene	<0.04	<0.04	<0.04-4.5	<0.04-0.06	<0.1-0.39	<0.04	<0.04-0.22	<0.04	-
C3 sub'd dibenzothiophene	<0.04	<0.04	<0.04-4.1	<0.04	<0.1-0.08	<0.04	<0.04-0.12	<0.04	-
C3 sub'd naphthalene	<0.04	<0.04	<0.04-0.3	<0.04-0.27	<0.1-0.78	<0.04	<0.04-0.34	<0.04	-
C3 sub'd phenanthrene/anthracene	<0.04	<0.04	<0.04-3.6	<0.06-0.12	<0.1-0.21	<0.04	<0.04-0.25	<0.04	-
C4 sub'd dibenzothiophene	<0.04	<0.04	<0.04-4.4	<0.04	<0.1-0.06	<0.04	<0.04	<0.04	-
C4 sub'd naphthalene	<0.04	<0.04	<0.04-2	0.04-0.56	<0.1-0.6	<0.04	<0.04-0.09	<0.04	-
C4 sub'd phenanthrene/anthracene	<0.04	<0.04	<0.04-1.7	<0.04-0.06	<0.04-<0.1	<0.04	<0.04-0.33	<0.04	-
Dibenzo(a,h)anthracene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Dibenzothiophene	<0.02	<0.02	<0.02-0.07	<0.02	<0.02-0.03	<0.02	<0.02-0.09	<0.02	-
Fluoranthene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-0.03	<0.02	<0.02	<0.02	-
Fluorene	<0.02	<0.02	<0.02-0.03	<0.02	<0.02-0.14	<0.02	<0.02	<0.02	-
Indeno(c,d-123)pyrene	<0.02	<0.02	<0.02	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Methyl acenaphthene	<0.04	<0.04	<0.04-0.19	<0.04-0.28	<0.04-<0.1	<0.04	<0.04	<0.04	-
Methyl benzo(a)anthracene/chrysene	<0.04	<0.04	<0.04-0.5	<0.04	<0.04-0.11	<0.04	<0.04-0.12	<0.04	-

TABLE I-3

SUMMARY OF CHEMICAL CONCENTRATIONS OF SUNCOR'S OPERATIONAL WATERS

	NATURAL WATERS		OPERATIONAL/RECLAMATION WATERS						
Chemical	Athabasca River[1]	Reference Tributaries[2]	Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
Methyl benzo(b&k) fluoranthene/ methyl benzo(a)pyrene	<0.04	<0.04	<0.04-0.3	<0.04	<0.04-0.05	<0.04	<0.04-0.07	<0.04	-
Methyl biphenyl	<0.04	<0.04	<0.04-<0.08	<0.04	<0.04-<0.1	<0.04	<0.04	<0.04	-
Methyl dibenzothiophene	<0.04	<0.04	<0.04-0.65	<0.04-0.05	<0.1-0.21	<0.04	<0.04-0.21	<0.04	-
Methyl fluoranthene/pyrene	<0.04	<0.04	<0.04-0.65	<0.04-0.08	<0.1-0.12	<0.04	<0.04-0.31	<0.04	-
Methyl fluorene	<0.04	<0.04	<0.04-0.3	<0.04-0.26	<0.04-0.25	<0.04	<0.04	<0.04	-
Methyl naphthalene	<0.02-<0.1	<0.02	<0.02-<0.08	<0.02-0.05	<0.02-0.34	<0.02	<0.02-0.1	<0.02	-
Methyl phenanthrene/anthracene	<0.04	<0.04	<0.04-0.79	<0.04-0.07	<0.1-0.46	<0.04	<0.04-0.19	<0.04	-
Naphthalene	<0.02	<0.02-0.02	<0.02-0.05	<0.02-0.09	0.23-0.56	<0.02	<0.02	<0.02	-
Phenanthrene	<0.02	<0.02	<0.02-0.09	<0.02	<0.02-0.12	<0.02	<0.02	<0.02	-
Pyrene	<0.02	<0.02	<0.02-0.04	<0.02	<0.02-0.09	<0.02	<0.02-0.16	<0.02	-
Polycyclic Aromatic Nitrogen Heterocycles (µg/L)									
7-Methyl quinoline	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.12-0.46	<0.02	-
Acridine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02-0.13	<0.02	-
C2 Alkyl subst'd carbazoles	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
C2 Alkyl subst'd quinolines	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.09-0.4	<0.02	-
C3 Alkyl subst'd quinolines	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Carbazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Methyl acridine	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02	<0.02	<0.02-0.6	<0.02	-
Methyl carbazoles	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Phenanthridine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02-0.21	<0.02	-
Quinoline	<0.02	<0.02	<0.02	<0.02-0.09	<0.02	<0.02	<0.02-0.71	<0.02	-
Phenols (µg/L)									
2,4-Dimethylphenol	<0.1	<0.1	<0.2-1	<0.02	<0.1	<0.1	<0.1-1	<0.1	-
2,4-Dinitrophenol	<2	<2	<4-<20	<1-<20	<20	<2	<2	<2	-
2-Nitrophenol	<0.2	<0.2	<0.4-<2	<0.4-<2	<2	<0.2	<0.2	<0.2	-
4,6-Dinitro-2-methylphenol	<2	<2	<20	<4-<20	<20	<2	<2	<2	-
4-Nitrophenol	<2	<2	<4-<20	<4-<20	<20	<2	<2	<2	-
m-Cresol	<0.1	<0.1	<0.1-<1	<0.1-<1	<0.1	<0.1	<0.1	<0.1	-
o-Cresol	<0.1	<0.1	<0.1-<1	<0.1-<1	<0.1	<0.1	<0.1	<0.1	-
p-Cresol	<0.1	<0.1	<0.1-<1	<0.1-<1	<0.1	<0.1	<0.1	<0.1	-
Phenol	<0.1	<0.1	<0.1-<1	<0.1-<1	<0.1	<0.1	<0.1	<0.1	-
Phenols	-	-	<0.002	<0.002	-	<0.002	<0.002	<0.002	-
Volatiles (µg/L)									
1,1,1-Trichloroethane	<1	<1	<1-<15	<1	<1	<1	<1-4	<1	-
1,1,2,2-Tetrachloroethane	<5	<5	<5-<75	<5	<5	<5	<5	<5	-
1,1,2-Trichloroethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,1-Dichloroethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,1-Dichloroethene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,2,3-Trichloropropane	<2	<2	<2-<30	<2	<2	<2	<2	<2	-
1,2-Dichlorobenzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-

TABLE I-3

SUMMARY OF CHEMICAL CONCENTRATIONS OF SUNCOR'S OPERATIONAL WATERS

	NATURAL WATERS		OPERATIONAL/RECLAMATION WATERS						
Chemical	Athabasca River[1]	Reference Tributaries[2]	Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
1,2-Dichloroethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,2-Dichloropropane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,3-Dichlorobenzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,4-Dichlorobenzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
2-Butanone (MEK)	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
2-Chloroethylvinylether	<5	<5	<5-<75	<5	<5	<5	<5	<5	-
2-Hexanone	<200	<200	<200-<3000	<200	<200	<200	<200	<200	-
4-Methyl-2-pentanone (MIBK)	<200	<200	<200-<3000	<200	<200	<200	<200	<200	-
Acetone	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Acrolein	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Acrylonitrile	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Benzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Bromodichloromethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Bromoform	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Bromomethane	<10	<10	<10-<150	<10	<10	<10	<10	<10	-
Carbon disulfide	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Carbon tetrachloride	<1	<1	<1-<15	<1	<1	<1	<1-3	<1	-
Chlorobenzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Chloroethane	<10	<10	<10-<150	<10	<10	<10	<10	<10	-
Chloroform	<1	<1	<1-<15	<1	<1	<1	<1-3	<1	-
Chloromethane	<10	<10	<10-<150	<10	<10	<10	<10	<10	-
cis-1,3-Dichloropropene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
cis-1,4-Dichloro-2-butene	<2	<2	<2-<30	<2	<2	<2	<2	<2	-
Dibromochloromethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Dibromomethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Dichlorodifluoromethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Ethanol	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Ethyl methacrylate	<200	<200	<200-<3000	<200	<200	<200	<200	<200	-
Ethylbenzene	<1	<1	<1-<15	<1-1.5	<1	<1-1.2	<1-1.2	<1-1.5	-
Ethylene dibromide	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Iodomethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
m+p-Xylenes	<1	<1	<1-15	<1-5	<1	<1 - 4.1	<1-4.5	<1-5.7	-
Methylene chloride	<1	<1	<1-<30	<1	<1	<1	<1-5.7	<1	-
o-Xylene	<1	<1	<1-15	<1-2.7	<1	<1-1.7	<1-2.2	<1-2.8	-
Styrene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Tetrachloroethylene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Toluene	<1	<1	<1-<15	<1	<1	<1	<1-1	<1	-
trans-1,2-Dichloroethene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
trans-1,3-Dichloropropene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
trans-1,4-Dichloro-2-butene	<5	<5-5	<5-<75	<5	<5	<5	<5	<5	-
Trichloroethene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-

TABLE I-3

SUMMARY OF CHEMICAL CONCENTRATIONS OF SUNCOR'S OPERATIONAL WATERS

	NATURAL WATERS		OPERATIONAL/RECLAMATION WATERS						
Chemical	Athabasca River[1]	Reference Tributaries[2]	Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
Trichlorofluoromethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Vinyl acetate	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Vinyl chloride	<20	<20	<20-<300	<20	<20	<20	<20	<20	-
INORGANICS									
General (mg/L)									
pH (pH units)	7.63-7.82	7.4-8.18	7.91-8.54	7.99-8.2	8.01-8.07	7.66-8.31	6.8-8.9	7.3-8.4	6.6
Specific Conductance (µS/cm)	200-268	159-572	1891-4900	1325-1514	1740-1790	588-747	381-1650	209-465	-
Calcium	27-33	19-60	33.3-118	23.5-57.1	29.9-43.2	54-99	32-69	26-55	-
Chloride	3.1-14.8	<0.5-57	45.4-510	15.3-17.3	<0.5-33.4	29-41	30-354	1.0-18	-
Magnesium	7.9-21	6.4-18.4	7.2-28	8.7-11.3	2.73-18.1	19-30	8-18.7	6.0-16	-
Potassium	0.9-2.65	0.41-2.2	<11.5-29	8.4-10.8	.0.5-18.9	1.9-3.1	1.2-9.3	0.7-8	-
Sodium	8.6-25	7.5-61	347-1170	273-335	7.7-16600	26-53	28-246	5.0-23	-
Bicarbonate	108-267	97-29	330.84-800	847-884	34-1210	222-309	116-220	116-207	-
Carbonate	<0.5-10	<0.5	<0.05-20	<0.5	<0.5	<0.5-4	<0.5-10	<0.5-5	-
Biological Oxygen Demand	0.1-3.3	-	1.6-6.9	5-9.6	-	<0.1-0.9	<0.1-11.2	<0.1-2.5	-
Chemical Oxygen Demand	<5-28	-	200-430	120-360	-	19-47	11-305	<5-49	-
Dissolved Organic Carbon	1-17.2	12-27.5	52-65.3	36.1-42.5	-	9.8-15	5.0-42	4.0-17	-
Nitrate & Nitrite	<0.001-0.19	<0.003-0.1	<0.003-0.05	0.11-0.26	0.011	<0.003-0.01	<0.003-0.01	<0.003-0.12	0.2
Phenols	<0.001-0.01	<0.001-0.005	<0.002-0.02	<0.001-0.004	0.01	<0.001-0.08	<0.001	<0.001-0.001	-
Sulphate	13.1-58	1.6-53	555-1290	29.1-143	6.7-118	60-142	30-116	15-49	-
Sulphide	<0.001-0.002	-	-	-	-	-	-	-	-
Total Ammonia	<0.01-0.08	<0.01-0.11	0.098-3.98	4.37-6.01	17.2-19.9	<0.001-0.04	<0.006-25	<0.01-0.22	-
Total Dissolved Solids	117-319	87-339	1400-1805	878-1007	1090-1100	365-518	440-510	145-175	-
Total Kjeldahl Nitrogen	0.26-0.46	-	0.95-6.8	7.4-8.75	-	0.3-0.44	0.5-36.3	0.19-0.7	-
Total Organic Carbon	3.2-19	-	56.1-68	38.4-45	-	10.1-12.2	8.2-16	6.5-15.3	-
Total Phosphorus	0.003-0.39	0.014-0.20	0.006-0.1	0.14-0.43	<0.1-0.2	0.01-0.04	<0.003-0.29	0.02-0.17	-
Total Sulphur	6.6	2.1-17.3	186-266	12.7-48.4	5.6-12.2	20.5-44	15-19	5.9-7.9	-
Total Suspended Solids	4-624	0.4-211	<0.4-17	17-64		<0.4-20	6.0-27	2-126	-
Metals and Trace Elements (mg/L)									
Aluminum	<0.01-8.64	<0.01-1.89	<0.01-1.92	0.08-1.15	<0.01-0.88	<0.01-0.07	0.23-5.93	0.05-1.15	-
Antimony	<0.0002 - 0.0002	<0.0002-0.0003	-	-	0.0006	-	0.002	-	<0.2
Arsenic	0.0004-0.007	<0.0002-0.002	0.0007-0.0058	0.0026-0.003	0.0036	<0.0002-0.002	<0.0001-0.17	0.0002-0.004	<0.2
Barium	0.04-0.2	0.02-0.07	0.05-0.18	0.08-0.1	0.15-0.77	0.07-0.12	0.05-0.1	0.05-0.1	0.13
Beryllium	<0.001-0.004	<0.001-0.004	<0.001-0.004	<0.001-0.002	<0.001	<0.001-0.003	<0.001-0.005	<0.001-0.002	<0.01
Boron	0.01-0.09	0.05-0.14	2.26-4.26	1.65-1.88	0.21-2.31	0.12-0.22	0.05-0.15	0.01-0.07	1.21
Cadmium	<0.0002-0.003	<0.003-0.005	<0.003-0.007	<0.003-0.004	<0.0002-<0.001	<0.003-0.003	<0.001-0.01	<0.001-0.003	<0.01
Chromium	<0.002-0.032	<0.002-0.014	<0.002-0.003	<0.002-0.002	<0.002-0.03	<0.002-0.002	<0.0002-0.03	<0.002-0.01	<0.005
Cobalt	<0.001-0.01	<0.003-0.005	<0.003-0.007	<0.003-0.005	0.003-0.02	<0.003-0.01	<0.001-0.01	<0.001-0.004	<0.02
Copper	<0.001-0.01	<0.001-0.002	<0.001-0.004	0.002-0.01	<0.001	<0.001-0.01	<0.001-0.064	0.006-0.03	0.01
Cyanide	<0.001-0.005	<0.001-0.03	<0.001-0.06	0.001-0.002	-	<0.001-0.002	<0.002-0.003	<0.001-0.001	0.07
Fluoride	0.08-0.18	0.14-0.24	-	-	2.1-2.8	-	0.07-0.38	-	0.9

TABLE I-3

SUMMARY OF CHEMICAL CONCENTRATIONS OF SUNCOR'S OPERATIONAL WATERS

	NATURAL WATERS		OPERATIONAL/RECLAMATION WATERS						
Chemical	Athabasca River[1]	Reference Tributaries[2]	Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
Iron	0.101-17.9	0.38-4.81	<0.01-1.01	1.24-2.21	0.01-22.5	0.007-0.3	0.005-2.56	0.22-2.28	0.35
Lead	<0.001-0.01	<0.02	<0.0003-0.02	<0.02	<0.0003-<0.01	<0.02	<0.002-0.05	<0.02-<0.05	<0.05
Lithium	<0.005-0.02	0.006-0.02	0.16-0.27	0.12-0.14	0.19-0.23	<0.013-0.02	0.009-0.022	0.004-0.01	-
Manganese	<0.004-0.51	0.014-0.21	<0.001-0.06	0.12-0.21	0.06 - 1.76	0.02-0.11	<0.001-0.12	0.012-0.15	1.41
Mercury(µg/L)	<0.05-0.2	<0.05	<0.05-0.05	<0.05-0.26	0.4	<0.05-0.52	<0.05-0.62	<0.05-0.52	<0.1
Molybdenum	<0.001-0.01	<0.003-0.004	0.15-1.42	<0.003-0.02	<0.003-0.07	<0.003-0.003	<0.004-0.6	<0.002-0.002	2.23
Nickel	<0.005-0.01	<0.005-0.012	<0.005-0.03	<0.005-0.01	0.005-0.06	<0.005-0.01	<0.002-0.15	<0.001-0.02	0.5
Selenium	<0.0001-0.0004	<0.0002-0.0003	<0.0002-0.004	<0.0002-0.0002	<0.00004	<0.0002	<0.0001-0.006	<0.0001-0.0005	<0.2
Silicon	2.12	1.13-3.6	2.32-5.58	5.63-10.1	1.1-6.12	2.82-3.89	2.45-3.53	2.17-5.05	-
Silver	<0.001-0.001	<0.002-0.003	<0.0002-0.002	<0.002	<0.0002-<0.001	<0.002-0.002	<0.002-0.005	<0.002	<0.01
Strontium	0.18-0.36	0.073-0.21	0.75-2.12	0.27-0.34	0.42-0.77	0.15-0.28	0.24-0.29	0.18-0.22	-
Thallium	-	-	-	-	<0.0003-<0.01	-	<0.01-<1	<0.1	<0.05
Tin	-	-	-	-	<0.0003-0.44	-	-	-	-
Titanium	0.004-0.09	<0.003-0.05	<0.003-0.02	<0.003-0.02	0.004-0.01	<0.003-0.003	<0.003-0.047	<0.003-0.01	-
Uranium	<0.5	<0.5	<0.5-0.007	<0.5	<0.0002-<0.1	<0.5	<0.5	<0.5	<0.2
Vanadium	<0.002-0.02	<0.002-0.008	<0.002-0.17	0.003-0.01	<0.002-0.05	<0.002-0.005	0.005-1.61	<0.002-0.013	0.13
Zinc	<0.001-0.09	0.012-0.16	0.003-0.06	0.01-0.06	0.01-0.07	0.003-0.04	0.001-0.273	<0.005-0.05	0.12
Zirconium	-	-	-	-	0.0012-0.0013	-	-	-	-

[1] Golder, 1995 unpublished data (site: upstream of L19, n= 1 to 4); NAQUADAT (code: 00AL07CC0600, 1985-1995, n= 1 to 26).
[2] Data from the tributaries were grouped and included data from Legget Creek, McLean Creek, Steepbank River and Wood Creek sampled by Golder during 1995(Golder 1995c; n= 1 to 20)
[3] Suncor and Syncrude, 1995, unpublished data from CT field studies, (n= 6 to 18).
[4] Suncor, 1995, unpublished data from Lease 86 Study, ID: RW 127, (n= 1 to 4).
[5] Suncor, 1995, unpublished data, samples from Plant 4 Beach #2 aqueous extract and RG088/089, (n=1 to 4).
[6] Suncor, 1995, unpublished data from Lease 86 Study (Suncor ID: RW250 & 252, n= 2 to 8).
[7] Suncor, 1995, unpublished data from Lease 86 Study (Suncor ID: RW254, n= 2 to 4); NAQUADAT (codes: 20AL07DA1000/1001, 1980-1995, (n=1 to 80); Suncor's Monthly Water Monitoring Reports.
[8] Suncor, 1995, unpublished data from Lease 86 Study (Suncor ID: RW256, n= 1 to 4); NAQUADAT (code: 20AL07DA1013, 1980-1995, n= 1 to 18); Suncor's Monthly Water Monitoring Reports.
[9] Suncor, 1995, unpublished FGD Pilot Study (Sample is 50% gypsum : 50% flyash, n=1).

TABLE I-4

FLOW RATES OF DISCHARGE SOURCES FROM MINE SITE (L/s)

		Year 1995		Year 2001		Year 2010		Year 2020		Long-term	
Outfall ID	Outfall Description	Flow Type	Flow Rate	Flow Type	Flow Rate	Flow Type	Flow Rate	Flow Type	Flow Rate	Flow Type	Flow Rate
S1	Shipyard Lake Groundwater					Shipyard Lake CT as runoff	0.30	Shipyard Lake CT seepage	0.40	Shipyard Lake CT seepage	0.50
						CT Seepage	2.20	Steepbank Mine CT Seepage	5.80	Steepbank Mine CT Seepage	6.30
		Sub Total	0.00	Sub Total	0.00	Sub Total	2.50	Sub Total	6.20	Sub Total	6.80
S2	South Mine Discharge Point	Runoff	15.29	South mine runoff	15.29	South mine runoff	16.26	Surface runoff	16.26	Pond 1 & 2/3 Runoff	40.44
				Bsn #1 runoff	10.54	Pond 2/3 seepage	14.55	Pond 5 runoff	30.11	Pond 4 &5 runoff	19.54
				Pond 2/3 seepage	2.43			Pond 5 CT runoff	31.25	Basin 1 CT runoff	0.16
								Pond 5 FGD seepage	10.99	Pond 5 FGD seepage	0.08
								Pond 2/3 seepage	14.55	Pond 2/3 CT seepage	5.69
		Sub Total	15.29	Sub Total	28.26	Sub Total	30.81	Sub Total	103.16	Sub Total	65.91
S3	TID Seepage	Seepage	19.00	Seepage	19.00	Seepage	19.00	Pond 1 TID Seepage	15.00	Seepage	5.70
		Sub Total	19.00	Sub Total	19.00	Sub Total	19.00	Sub Total	15.00	Sub Total	5.70
S4	Wastewater/Cooling Pond E	Wastewater	334.00	Wastewater	253.00	wastewater	253.00	Wastewater effluent	253.00	River Side CT Seepage	11.80
		Cooling Pond E	610.00	CT seepage	153.00	Cooling Pond E	184.00	Cooling Pond E effluent	184.00	River Side runoff	1.03
		River Side seepage	1.88	Pond 1/1A runoff	17.00	Riverside seepage	1.88	River side runoff	2.81	Pond 2/3 Seepage	1.00
		Pond 2/3 seepage	5.00	Cooling Pond E	184.00	Pond 2/3 seepage	5.00	Riverside seepage	13.64	South Terrace runoff	9.81
				Pond 2/3 seepage	5.00			Pond 2/3 seepage	5.00	Pond 2/3 CT seepage	11.37
				River Side seepage	1.88						
		Sub Total	950.88	Sub Total	613.88	Sub Total	443.88	Sub Total	458.45	Sub Total	35.01
S5	Steepbank Mine Groundwater					Steepbank CT GW	1.10	CT Seepage	1.40	Steepbank Mine Groundwater	1.40
		Sub Total	0.00	Sub Total	0.00	Sub Total	1.10	Sub Total	1.40	Sub Total	1.40
S6	Mid-Plant Discharge Point	Mid Plant drainage runoff	0.34	Mid-plant Runoff	0.34	Mid-Plant runoff	0.34	Mid-Plant runoff	0.34		
		Sewage Effl.	12.20	Effluent	12.20	Sewage effluent	12.20	Sewage effluent	12.20		
		Sub Total	12.54	Sub Total	12.54	Sub Total	12.54	Sub Total	12.54	Sub Total	0.00
S7	Pond 4 Seepage	Pond 4 seepage	1.00	Pond 4 seepage	1.00	Seepage	1.00	Pond 4 Seepage	1.00	Pond 4 Seepage	1.00
		Sub Total	1.00	Sub Total	1.00	Sub Total	1.00	Sub Total	1.00	Sub Total	1.00
S8	Pond 5 Seepage					CT Seepage	3.50	Pond 5 CT Seepage	3.50	Pond 5 Seepage	4.70
		Sub Total	0.00	Sub Total	0.00	Sub Total	3.50	Sub Total	3.50	Sub Total	4.70
S9	North Mine	North Mine drainage runoff	14.65	Runoff	3.51	North mine drainage	3.51	North terrace runoff	13.52	North Terrace runoff	10.48
								North mine drainage	3.51	North Terrace CT Seepage	18.56
								North terrace CT seepage	17.81	North Terrace FGD Seepage\	3.79
								North terrace FGD seepage	24.25		
		Sub Total	14.65	Sub Total	3.51	Sub Total	3.51	Sub Total	59.09	Sub Total	32.83
S10	Pond 6 Drainage Outlet							Pond 6 drainage runoff	53.95	Pond 6 runoff	30.42
								Pond 6 CT runoff	77.13	Pond 6 CT seepage	0.76
								CT Pond 5 seepage	6.82		
		Sub Total	0.00	Sub Total	0.00	Sub Total	0.00	Sub Total	137.90	Sub Total	31.18
S11	Pond 6 Seepage					Pond 6 direct seepage	6.80	Pond 6 direct seepage	6.80	Pond 6 direct seepage	3.60
		Sub Total	0.00	Sub Total	0.00	Sub Total	6.80	Sub Total	6.80	Sub Total	3.60
		Total	**1013.36**	**Total**	**678.19**	**Total**	**524.64**	**Total**	**805.04**	**Total**	**188.13**

Note: - Flow data sources are from AGRA (1996) and correspondence between Golder and Suncor personnel.

TABLE I-5a

ATHABASCA RIVER CONCENTRATIONS IN 10% RIVER FLOW MIXING ZONE AT A CROSS-SECTION 1 KM DOWNSTREAM OF POND 6 DRAINAGE DISCHARGE OUTFALL, 7Q10 FLOW

Parameter	Unit	River Background U/S of Suncor	Scenario				
			1995	2001	2010	2020	Long-term
Ammonia	mg/L	0.040	0.062	0.089	0.062	0.113	0.054
Total Dissolved Solids	mg/L	251	278	284	269	298	266
Total Phosphorus	mg/L	0.019	0.028	0.028	0.026	0.028	0.028
Aluminum	mg/L	0.030	0.239	0.178	0.144	0.180	0.050
Arsenic	mg/L	0.0005	0.0036	0.0085	0.0028	0.0029	0.0005
Barium	mg/L	0.091	0.096	0.098	0.094	0.097	0.093
Beryllium	mg/L	0.0	0.00011	0.00008	0.00005	0.00012	0.00003
Cadmium	mg/L	0.001	0.002	0.026	0.001	0.002	0.002
Chromium	mg/L	0.003	0.004	0.003	0.003	0.004	0.003
Cobalt	mg/L	0.0012	0.0015	0.0014	0.0014	0.0016	0.0014
Copper	mg/L	0.002	0.004	0.004	0.003	0.004	0.003
Cyanide (Total)	mg/L	0.0005	0.0012	0.0014	0.0010	0.0016	0.0007
Iron	mg/L	0.189	0.310	0.258	0.251	0.281	0.207
Lead	mg/L	0.002	0.003	0.003	0.003	0.003	0.002
Molybdenum	mg/L	0.002	0.013	0.023	0.011	0.026	0.008
Nickel	mg/L	0.005	0.008	0.007	0.007	0.008	0.005
Phenolics	mg/L	0.002	0.002	0.002	0.002	0.002	0.002
Selenium	mg/L	0.0001	0.0002	0.0005	0.0002	0.0006	0.0002
Strontium	mg/L	0.3400	0.3531	0.3647	0.3481	0.3709	0.3493
Vanadium	mg/L	0.003	0.037	0.028	0.026	0.029	0.004
Zinc	mg/L	0.013	0.017	0.016	0.015	0.016	0.013
Naphthenic Acids	mg/L	0.5	0.8	1.5	0.7	1.8	0.9
Mercury	ug/L	0	0.0300	0.0157	0.0152	0.0198	0.0035
Silver	ug/L	0	0.0013	0.0027	0.0019	0.0155	0.0126
o-Xylene	ug/L	0	0.126	0.185	0.073	0.233	0.064
Chloroform	ug/L	0	0.055	0.027	0.027	0.027	0.000
Ethylbenzene	ug/L	0	0.067	0.035	0.035	0.047	0.008
Fluoranthene	ug/L	0	0.006	0.004	0.004	0.004	0.000
m,p-Xylene	ug/L	0	0.254	0.250	0.139	0.320	0.079
Naphthalene	ug/L	0	0.011	0.008	0.008	0.008	0.000
Toxicity	T.U.	0	0.26	0.22	0.16	0.30	0.08

TABLE I-5b

ATHABASCA RIVER CONCENTRATIONS IN 10% RIVER FLOW MIXING ZONE AT A CROSS-SECTION 1 KM DOWNSTREAM OF POND 6 DRAINAGE DISCHARGE OUTFALL, MEAN ANNUAL FLOW

Parameter	Unit	River Background U/S of Suncor	Scenario				
			1995	2001	2010	2020	Long-term
Ammonia	mg/L	0.040	0.045	0.052	0.045	0.057	0.043
Total Dissolved Solids	mg/L	251	258	260	256	262	255
Total Phosphorus	mg/L	0.019	0.021	0.022	0.021	0.021	0.021
Aluminum	mg/L	0.030	0.085	0.069	0.060	0.068	0.035
Arsenic	mg/L	0.0005	0.0013	0.0026	0.0011	0.0011	0.0005
Barium	mg/L	0.091	0.092	0.093	0.092	0.092	0.091
Beryllium	mg/L	0	0.00003	0.00002	0.00001	0.00003	0.00001
Cadmium	mg/L	0.001	0.001	0.008	0.001	0.001	0.001
Chromium	mg/L	0.003	0.003	0.003	0.003	0.003	0.003
Cobalt	mg/L	0.0012	0.0013	0.0013	0.0012	0.0013	0.0013
Copper	mg/L	0.002	0.003	0.003	0.003	0.003	0.002
Cyanide (Total)	mg/L	0.0005	0.0007	0.0007	0.0006	0.0008	0.0006
Iron	mg/L	0.189	0.220	0.207	0.205	0.212	0.193
Lead	mg/L	0.002	0.002	0.002	0.002	0.002	0.002
Molybdenum	mg/L	0.002	0.005	0.008	0.005	0.008	0.004
Nickel	mg/L	0.005	0.006	0.006	0.005	0.006	0.005
Phenolics	mg/L	0.002	0.002	0.002	0.002	0.002	0.002
Selenium	mg/L	0.0001	0.0001	0.0002	0.0001	0.0002	0.0001
Strontium	mg/L	0.3400	0.3435	0.3465	0.3421	0.3470	0.3423
Vanadium	mg/L	0.003	0.012	0.010	0.009	0.010	0.004
Zinc	mg/L	0.013	0.014	0.014	0.013	0.014	0.013
Naphthenic Acids	mg/L	0.5	0.6	0.8	0.6	0.8	0.6
Mercury	ug/L	0	0.0079	0.0041	0.0040	0.0050	0.0008
Silver	ug/L	0	0.0004	0.0007	0.0005	0.0035	0.0031
o-Xylene	ug/L	0	0.033	0.049	0.019	0.053	0.016
Chloroform	ug/L	0	0.014	0.007	0.007	0.007	0.000
Ethylbenzene	ug/L	0	0.018	0.009	0.009	0.012	0.002
Fluoranthene	ug/L	0	0.002	0.001	0.001	0.001	0.000
m,p-Xylene	ug/L	0	0.067	0.066	0.037	0.076	0.020
Naphthalene	ug/L	0	0.003	0.002	0.002	0.002	0.000
Toxicity	T.U.	0	0.07	0.06	0.04	0.07	0.02

TABLE I-6

Steepbank River Concentrations as a result of CT water discharge from the Steepbank Mine site
Steepbank River flow: mean winter flow (0.478 cms)

Parameter	Unit	River Background U/S of Suncor	Scenario				
			1995	2001	2010	2020	Long-term
Ammonia	mg/L	0.098	0.098	0.098	0.107	0.109	0.109
Total Dissolved Solids	mg/L	238	238	238	242	243	243
Total Phosphorus	mg/L	0.053	0.053	0.053	0.053	0.053	0.053
Aluminum	mg/L	0.065	0.065	0.065	0.069	0.070	0.070
Arsenic	mg/L	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Barium	mg/L	0.030	0.030	0.030	0.030	0.030	0.030
Chromium	mg/L	0.004	0.004	0.004	0.003	0.003	0.003
Copper	mg/L	0.016	0.016	0.016	0.016	0.016	0.016
Cyanide (Total)	mg/L	0.0030	0.0030	0.0030	0.0031	0.0032	0.0032
Iron	mg/L	0.640	0.640	0.640	0.641	0.641	0.641
Lead	mg/L	0.008	0.008	0.008	0.008	0.008	0.008
Molybdenum	mg/L	0	0	0	0.003	0.004	0.004
Strontium	mg/L	0.0840	0.0840	0.0840	0.0887	0.0899	0.0899
Zinc	mg/L	0.010	0.010	0.010	0.010	0.010	0.010
Naphthenic Acids	mg/L	0	0	0	0.2	0.3	0.3
Beryllium	ug/L	0	0	0	0.0092	0.0117	0.0117
Cadmium	ug/L	0	0	0	0.152	0.193	0.193
Cobalt	ug/L	0	0	0	0.0161	0.0204	0.0204
Mercury	ug/L	0	0	0	0.0001	0.0001	0.0001
Nickel	ug/L	0	0	0	0.068	0.086	0.086
Phenolics	ug/L	0	0	0	0.005	0.006	0.006
Selenium	ug/L	0	0	0	0.0918	0.1168	0.1168
Vanadium	ug/L	0	0	0	0.390	0.496	0.496
o-Xylene	ug/L	0	0	0	0.034	0.044	0.044
m,p-Xylene	ug/L	0	0	0	0.034	0.044	0.044
Toxicity	T.U.	0	0	0	0.02	0.02	0.02

APPENDIX II

MODES OF IMPACT OF SEDIMENTATION AND SUSPENDED SEDIMENTS ON AQUATIC ECOSYSTEMS

Modes of Impact of Sedimentation and Suspended Sediments on Aquatic Ecosystems

Sediment Impacts on Fish Physiology

Behavioural responses are typically the first impacts evoked by increased concentrations of suspended sediments. Typical responses include an increased frequency of the cough reflex, avoidance of suspended sediments, a reduction in feeding and a temporary disruption in territoriality. Most behavioural responses are temporary and do not result in health effects. However, alterations in behaviour can alter growth patterns or increase susceptibility of fish to predation. The magnitude of the physiological change is a graded response and is dependent on the concentration of sediment release, duration of exposure, water quality parameters (e.g. temperature) and physical properties of the sediment particle. Low concentrations or short exposure periods generally result in minor physiological changes which revert to normal conditions once the sediment concentration returns to background levels. The impact of exposure to higher concentrations or longer exposure periods are manifested in a greater severity of change. In the extreme case this will lead to fish death.

Sediment Impacts on Fish Habitat

In addition to the direct impacts of suspended sediments on fish, increases in sediment loads can also alter fish habitat or the utilization of habitats by fish (Scullion and Milner 1979, Lisle and Lewis 1992). High sediment loads can alter fish habitats temporarily by affecting water quality, making a stream reach unsuitable for use by fish. This exclusion of fish from their habitat, if timed inappropriately, could have impacts on a fish population if the habitat within the stream reach affected is critical to the population during the period of the sediment release episode. This principle of habitat exclusion is very important in considering the timing of sediment release episodes; however, this issue is separate from the issue of direct habitat alteration which will be discussed below. Sediment episodes can have a prolonged effect on the suitability of habitats within a stream reach through increased levels of sedimentation. In fact, sedimentation is the single most important effect associated with sediment load increases, since sediment loads can alter the gross morphology of streams as well as the composition of the stream bed.

Sedimentation can have deleterious effects on spawning habitats by infilling the interstitial spaces that are used for egg deposition. As well, sedimentation is the primary cause of egg death. Thin coverings (a few mm) of fine particles are believed to disrupt the normal exchange of gases and metabolic wastes between the egg and water. Sedimentation rates of 0.03 to 0.14 g dry weight sediment/cm^2 (i.e., 1-4 mm depth of silt and clay) significantly reduced the survival of lake whitefish (*Coregonus clupeaformis*) eggs (Fudge and Bodaly 1984). The effects upon egg mortality appear to be more closely related to the sedimentation of particles and less related to the concentration of suspended sediments. Zallen (1931) observed that concentrations of 1000 to 3000 mg/L had no effect upon the survival of mountain whitefish eggs (*Prosopium williamsoni*). Campbell (1954 cf Singleton 1985), however, found 100 percent mortality in rainbow trout eggs exposed to TSS concentrations of 1000 to 2500 mg/L. Campbell (1954 cf Singleton 1985) suggests that the primary mechanism of death was from sedimentation. The dose of sediment required to induce egg mortality is greatly influenced by the physical characteristics of the stream which affect flow rates and the capacity to maintain sediments in suspension or otherwise to result in their deposition.

Sediment deposition also affects rearing habitat of juvenile fish since young fish frequently use the interstitial spaces in the stream bed for cover. Thus, reductions in the suitability of potential rearing habitat as a result of sediment introduction is related to a reduction in the space available for occupancy (Reiser et al. 1985). When pools and interstitial spaces in gravel are filled with sediment, the total amount of habitat available for rearing is reduced (Bjornn et al 1977). In addition, interstitial spaces in gravel also provide important cover for fry. Griffith and Smith (1993) found that numbers of juvenile rainbow and cutthroat trout were decreased due to lack of available cover in heavily embedded gravel substrata. Intersitial space is particularly important during winter because juvenile fish live in these areas making them especially susceptible to impacts from increased sedimentation (Bjornn et al 1977). Without these inter-gravel refugia, the young fish may be forced out of the stream system or into less suitable areas where survival rate may be reduced.

Sediment Effects on Primary Productivity

Sedimentation can have an effect on fish populations through an alteration in the available food supply. Increased sediment load and increased sedimentation can effect primary and secondary productivity and invertebrate populations. Suspended sediments can decrease light penetration, and in turn reduce primary productivity. A reduction in primary productivity has the potential to appreciably decrease the food supply of macrobenthos which graze on periphyton.

Sediment Effects on Benthic Invertebrates

Increased sediment loads in streams can also have an effect on zooplankton and macrobenthos. Sediment release can effect the density, diversity and structure of resident invertebrate communities (Gammon 1970, Lenat *et al.* 1981). A number of studies have demonstrated decreases in invertebrate densities and biomass following sedimentation events (Wagener 1984). Increases in sediment input may reduce the density of invertebrates by directly impacting aspects of their physiology or by altering their habitat. Suspended sediments can have an abrasive effect on invertebrates and interfere with the respiratory and feeding activities of the benthic animals (Tsui and McCart 1981). Increased sediment deposition may also reduce the biomass of invertebrates by filling the interstitial spaces of the bottom substrata with sediments and by increasing invertebrate drift or covering the benthic community in a blanket of silt (Cordone and Kelley 1961, Tsui and McCart 1981). A change in particle-size distribution in the streambed can significantly alter the habitat and make it unsuitable for certain species of invertebrates.

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