CUMBERLAND
RESOURCES LTD.

MEADOWBANK GOLD PROJECT

BASELINE FISH HABITAT REPORT

JANUARY 2005

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DESCRIPTION OF SUPPORTING DOCUMENTATION

Cumberland Resources Ltd. (Cumberland) is proposing to develop a mine on the Meadowbank property. The property is located in the Kivalliq region approximately 70 km north of the Hamlet of Baker Lake on Inuit-owned surface lands. Cumberland has been actively exploring the Meadowbank area since 1995. Engineering, environmental baseline studies, and community consultations have paralleled these exploration programs and have been integrated to form the basis of current project design.

The Meadowbank project is subject to the environmental review and related licensing and permitting processes established by Part 5 of the Nunavut Land Claims Agreement. To complete an environmental impact assessment (EIA) for the Meadowbank Gold project, Cumberland followed the steps listed below:

1. Determined the VECs (air quality, noise, water quality, surface water quantity and distribution, permafrost, fish populations, fish habitat, ungulates, predatory mammals, small mammals, raptors, waterbirds, and other breeding birds) and VSECs (employment, training and business opportunities; traditional ways of life; individual and community wellness; infrastructure and social services; and sites of heritage significance) based on discussions with stakeholders, public meetings, traditional knowledge, and the experience of other mines in the north.

2. Conducted baseline studies for each VEC and compared / contrasted the results with the information gained through traditional knowledge studies (see Column 1 on the following page for a list of baseline reports).

3. Used the baseline and traditional knowledge studies to determine the key potential project interactions and impacts for each VEC (see Column 2 for a list of EIA reports).

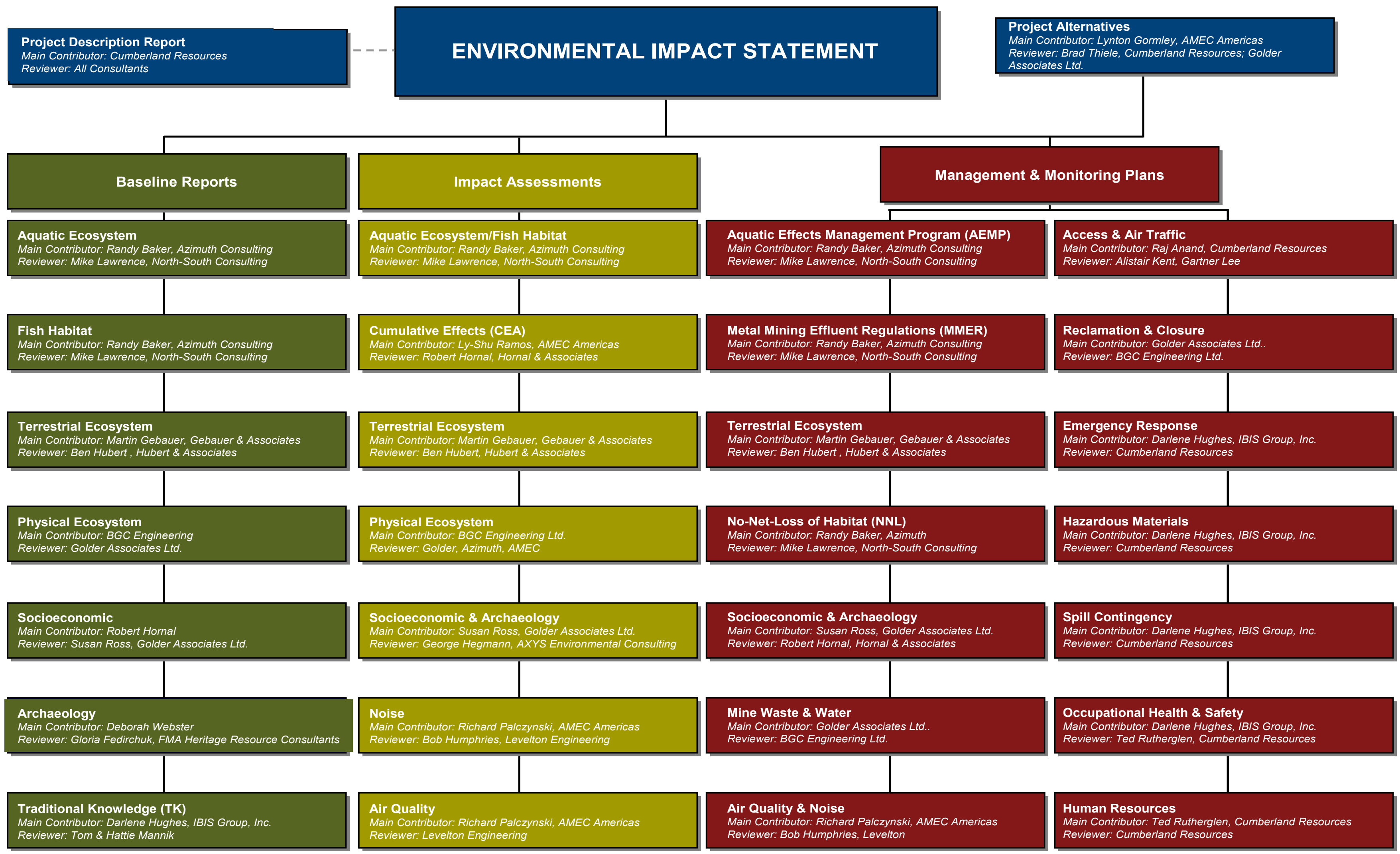
4. Developed preliminary mitigation strategies for key potential interactions and proposed contingency plans to mitigate unforeseen impacts by applying the precautionary principle (see Column 3 for a list of management plans).

5. Developed long-term monitoring programs to identify residual effects and areas in which mitigation measures are non-compliant and require further refinement. These mitigation and monitoring procedures will be integrated into all stages of project development and will assist in identifying how natural changes in the environment can be distinguished from project-related impacts (monitoring plans are also included in Column 3).

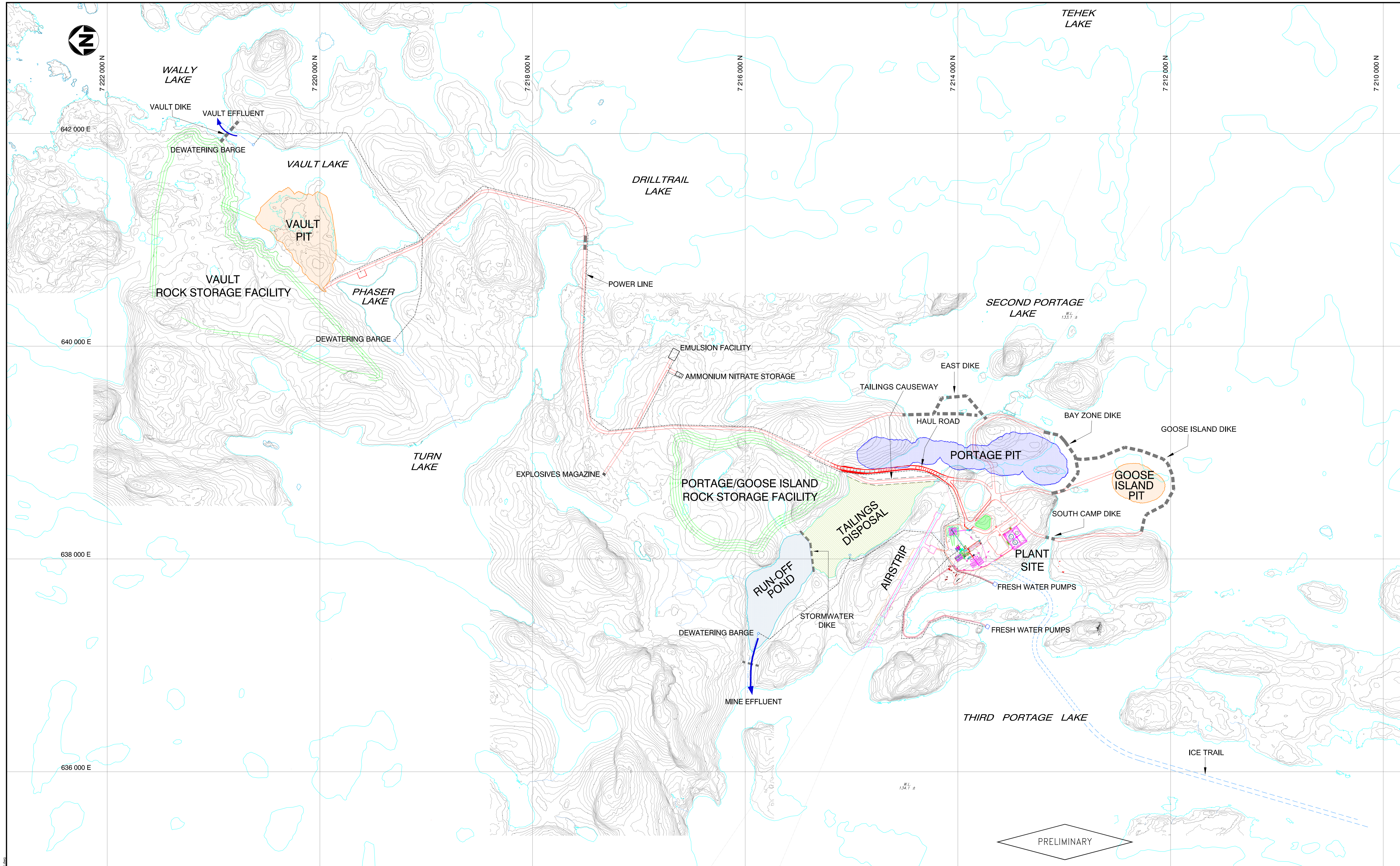
6. Produce and submit an EIS report to NIRB.

As shown on the following page, this report is part of the documentation series that has been produced during this six-stage EIA process.

SUPPORT DOCUMENTATION ORGANIZATION CHART



PROJECT LOCATION MAP



Proposed Mine Site Layout

CUMBERLAND RESOURCES LTD.

Meadowbank Gold Project

SOURCE: AMEC drawing 100-c000c.dwg

SECTION 1 • EXECUTIVE SUMMARY

This report describes and quantitatively maps the spatial distribution and relative abundance of fish habitat types within Second Portage, Third Portage, and Vault Lakes (project lakes) as part of Cumberland Resources Meadowbank Gold project baseline study program. The specific objectives of this study were to: (1) describe the nature, quantity, and distribution of habitat types, and (2) quantitatively map the relative abundance and value (high, moderate, low) of habitat types in the project lakes. This information is required to quantify the potential adverse effect of the Meadowbank project on fish habitat.

Initial interpretation of physical substrate and landform features from nearshore littoral and shoal habitat was described from stereoscopic pairs of 1:10,000 colour air photos (1999 and 2002 series) of the project lakes. These features were used to distinguish identifiable polygons, which were described according to four different habitat attributes including: sediment grain size (e.g., boulder, cobble), morphology (e.g., platform, shoal, shelf), depth (shallow, moderate, deep, very deep), and habitat complexity (low, moderate, or high complexity).

In August 2003 we groundtruthed representative habitat polygons identified from aerial photographs using underwater video photography. Using the photographs, empirical bathymetry data, and underwater video imagery, we were able to assign a habitat type to individual polygons. Six different habitat types were described, ranging from very coarse boulder gardens at shallow depths to fine (silt/clay) sediments at deep depths. Habitat types of individual polygons were then mapped and quantified using a geographic information system (GIS). A valuation and ranking system was then devised to score and assign a relative value to different habitat types, based on the unique habitat attributes identified within each polygon. Habitat types were ranked as having high, moderate, or low value, based on their relative contribution and importance as spawning, nursery, shelter, foraging, and overwintering habitat for fish. High, moderate, or low value habitats were quantified using GIS and mapped.

In Second and Third Portage lakes, the majority of habitat (70% and 81%, respectively) consisted of profundal basin habitat, >6 m depth with uniform silt/clay grain size and low complexity. Boulder platform and sediment apron habitats were next most abundant, and were characterized by heterogeneous substrates, shallow to moderate depths, moderate to high complexity, and were usually associated with shorelines and shoals. These habitat types were moderate and high value habitats.

In the Vault lakes, aerial (m^2) and relative proportions (%) of nearly all habitat types were much more even than the Portage lakes, with high percentages of boulder platform (38%), boulder shoal (19%), and mixed sediment apron (11%). Sediment basin habitat composed only 25% of surface area, proportionately much less than the Portage lakes, due to the relatively shallow depth and abundant shoals and platforms in the lakes. Shoreline development and complexity was high throughout the Vault lakes, which provides abundant habitat for all life history stages of lake trout and round whitefish, including spawning, nursery, shelter, feeding, and overwintering.

There is an inverse relationship between depth and habitat value. Deep, low complexity, fine grain size habitats dominated surface area of the Portage lakes and do not provide for spawning, nursery or shelter habitat for fish, although such habitats are valued for feeding and overwintering. Heterogeneous substrates found in moderate to deep depths (<4 to 6 m) with high complexity were less abundant than profundal habitats, but had much higher value because they provide spawning, nursery, shelter, and feeding habitat.

The project area lakes appear to have abundant and diverse habitats that are typical of Arctic lakes, and provide adequate habitat and physical conditions to support all life history stages of fall spawning fish populations.

SECTION 2 • INTRODUCTION

2.1 BACKGROUND

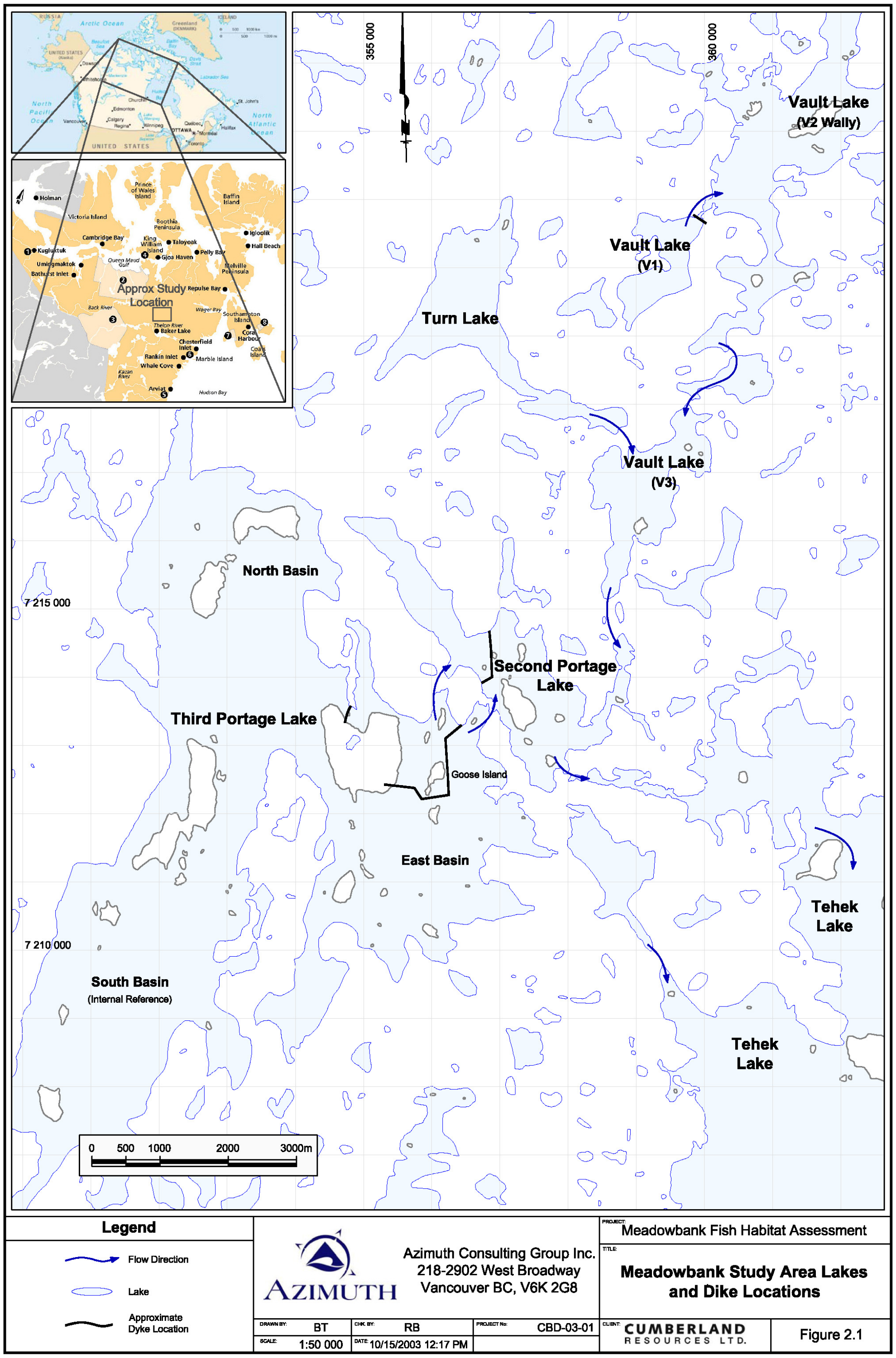
Cumberland Resources Ltd. (Cumberland) is evaluating the feasibility of establishing a gold mine at its Meadowbank property near Baker Lake, Nunavut (see Figure 2.1). The Meadowbank project, about 75 km north of the hamlet of Baker Lake, is situated within a number of Arctic, oligotrophic, fish-bearing lakes at the headwaters of the Quoich River system. The most notable lakes are Second Portage and Third Portage and the Vault lakes, which are located directly within the boundaries of the mineral zones being explored on the Meadowbank property. These headwater lakes drain into Tehek Lake, which flows via the Quoich River into the western end of Chesterfield Inlet and, eventually, into Hudson Bay. The surrounding terrain is typically barren-ground sub-arctic, with little relief, and is dominated by many small lakes and ponds with indistinct and complex drainage patterns. Parts of these lakes may be subject to direct or indirect environmental impacts related to mine development as a result of dike construction, dewatering, stream crossings, and effects on water quality.

Baseline studies have examined the physical (e.g., water depth, temperature, and substrate type), chemical (e.g., metals concentrations in water, sediment, and fish tissue), and/or ecological (e.g., phytoplankton, zooplankton, periphyton, benthic invertebrates, and fish) characteristics of the Meadowbank project study lakes. The objective of baseline studies has been to describe environmental conditions of these remote lakes prior to any disturbances as a result of mine-related development and operational activities (BAEAR, 2005).

An important question is, “how will certain development activities, particularly the isolation and impoundment of discrete portions of the study lakes, affect overall productivity of fish populations?” The federal fisheries act describes fish habitat as, “spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly to carry out their life processes.” Fish habitat is comprised of physical (e.g., substrate type and structure), chemical (e.g., nutrients, temperature), and biological (e.g., plankton, insects) attributes that combine to create a variety of conditions affecting the productivity of fish populations in a lake or stream. The federal ‘no net habitat loss principal’, described in the Department of Fisheries and Oceans (DFO) Fish Habitat Management Policy (DFO, 1987), strives to avoid any net loss of the productive capacity of fish habitat as a result of a development project, by following a set of guidelines or a hierarchy of options (DFO, 1998; DFO, 2003). In order of preference, these are:

- Relocation or physically moving of a project, or part of the project, to eliminate the potential for adverse effects.
- Redesign of a project to avoid adverse impacts.
- Mitigation of impacts in cases where relocation or redesign of a project is not possible. An example is installation of erosion-control measures or materials to minimize effects of introduced sediments on habitats.

Figure 2.1: Meadowbank Study Area Lakes & Dike Locations



- Compensation, which involves replacing harmfully altered, disrupted, or lost habitat with newly created habitat, or enhancement of existing habitat. This is DFO's least preferred option and is only considered when relocation, redesign, or mitigation measures fail to avoid harmful alteration, disruption, or destruction of fish habitat. There is also a hierarchy of compensation measures ranging from the creation of similar habitat at or near the development, to the least preferred, increase of productive capacity of fish habitat of a different species or stock off-site.

Habitat is generally grouped within four major categories: spawning and nursery; rearing; feeding; and overwintering. Certain physical features within discrete parts of each lake determine the extent to which habitat is utilized by different life history stages of fish. For example, shallow areas of lakes that may be important as a food source in summer may not be used by fish at all during winter, because depth is too shallow for overwintering.

Fish habitat, as it pertains to importance and utilization by different fish species at particular life history stages (e.g., larvae, juvenile, adult), is a complex mixture of physical, chemical, and biological features in lakes and streams. For example:

- Physical features include the type, size, shape, distribution, and slope of bottom sediment, ranging in size from fine material (clay, silt, and sand) to coarse material (gravel, cobble, and boulder). Water depth, exposure to wind forces, currents, ice scour, temperature, oxygen concentration, and proximity to sediment sources and tributary streams also affect habitat quality and utilization by fish.

- Chemical features affecting habitat quality include pH, nutrient concentration, organic carbon content of sediment, and contaminant concentrations (e.g., metals).

- Biological features affecting habitat quality include such factors as abundance of food sources (algae, zooplankton, benthic invertebrates), predators, and competing species.

The quality of fish habitat is a relative measure prescribed to different habitat types that can vary according to life history stage. Examples of habitat quality that can be indirectly measured include: the quantity and quality of food produced; the degree of protection afforded to developing eggs and hatching larvae; protection from predators; and overwintering success by fish.

An understanding of the relative abundance and spatial distribution of physical features and structure of habitat in lakes can be used to indirectly determine the quality of habitat, which is ultimately reflected in the abundance (i.e., biomass) and diversity of fish within a study lake. Abundance of fish differs between lakes as a result of a complex interaction between: quality and abundance of available habitat; quantity of critical habitats, such as spawning; availability and abundance of food resources (as dictated by lake productivity); and immigration or emigration by fish. For example, the absence of Arctic grayling (*Thymallus arcticus*) in study lakes is partly due to the near absence of stream habitat, which grayling depend on for spawning and foraging. In addition, the study lakes are near the northern geographic extent of the range of this species, and grayling have not been observed in the Quoich River watershed (Lawrence and Davies, 1977). Lake trout (*Salvelinus namaycush*) was the most abundant species found in all study lakes, which is typical of lakes at this latitude in this region of the Arctic.

2.2 OBJECTIVIES

This study quantitatively describes and maps the spatial distribution and relative abundance of fish habitat within the project lakes. This interpretation is based on an examination of physical substrate and landform features distinguished from stereoscopic pairs of 1:10,000 colour air photos of the study area (at a gross level), and groundtruthed with an underwater video camera system (at a fine scale).

The specific objective of this study is to describe the nature, quantity, and distribution of visible substrate types within each study lake, according to factors that influence quality of the substrate as it pertains to utilization by fish, including water depth, complexity, substrate, and morphology. The ultimate objective of this exercise will be to quantitatively map the relative abundance and distribution of habitat types within areas of Second and Third Portage lakes and Vault 1 Lake that are potentially adversely affected by mine development, relative to areas of these lakes that are unaffected by mine development. This will be determined as part of the environmental impact assessment (EIA) process to assess the magnitude of impacts to fish habitat, and the degree and type of mitigation and compensation required to strive for no net loss.

In addition, the determination of whether or not critical habitats (e.g., habitat types that might be limiting factors to fish production, such as spawning habitat) are captured within the proposed development area (Figure 2.1), that are not otherwise present or represented in similar abundance in areas outside of the proposed development area, is important in assessing the relative degree to which the Meadowbank project may have an impact on fish. This has direct implications about the significance of habitat loss and replacement.

Because this assessment is based on interpretation of physical features from air photos and underwater video photography, there are a number of inherent limitations in terms of the degree of sophistication of interpretation and confidence in habitat classification that can be made due to scale, water visibility, and depth. For example, the smallest feature that can clearly be distinguished from a 1:10,000 scale air photo is a boulder with a diameter of at least 2 m. Also, the vast majority of lake area is deeper than the maximum depth at which habitat features could be distinguished (about 6 m below the surface), so mapping and quantification from aerial photographs was limited to littoral areas near shorelines, platforms, and visible shoals less than 6 m in depth. It is presumed, based on baseline studies, that the majority of bottom substrate is comprised of fine sediments, primarily clay and silt, at depths greater than 6 or 8 m. This assumption was confirmed during field exercises.

To more accurately describe, classify, and quantify habitat types, an underwater video camera was used in 2003 to capture imagery of representative habitat types. This imagery provided essential groundtruthing of information acquired from air photo interpretation, to verify habitat descriptions, increase confidence of quantitative measures, and fill in data gaps. Note that our ability to quantitatively assess habitat quality was constrained somewhat by the very large area of the study lakes and limited spatial coverage possible using underwater photography; however, the level of information is adequate for baseline mapping purposes, and will serve as a guide for more detailed mapping, if necessary. Ultimately, this information will be used to quantify and assess the scope and magnitude of impact on fish habitat in the study lakes that occurs as a result of mine development.

2.3 APPROACH

The general approach of this study was as follows:

- Scan and integrate air photographs of study lakes into a GIS database.
- Interpret and map individual habitat polygons identified from air photos according to a classification scheme based on observed physical features (e.g., grain size, depth).
- Identify and describe six discrete habitat types based on four primary habitat attributes – substrate size and composition, depth, morphology, and complexity.
- Individual polygons were assigned a habitat type based on observable habitat attributes.
- Conduct a field survey to groundtruth air photograph information by capturing video and still imagery of representative habitat types within study lakes.
- Derive a ranking system to assess habitat quality, based on physical features inferred from air photos and video data, and on a professional understanding of habitat requirements and physical features that are of importance to fish.
- Classify habitat value in the study lakes as “high,” “moderate,” or “low.”
- Quantify (ha) and map high, moderate, and low value habitats using GIS.

It was not within the scope of this document to determine the relative quantity of high, moderate, or low value habitat within lake areas potentially affected by mine development, versus lake areas unaffected by mine development. This will be addressed within the EIA.

A number of assumptions were required to achieve our objective of quantifying habitat. Given the scale of the project, it was not possible to acquire video imagery of all areas within the project lakes. Thus, we had to assume that certain habitat types identified and grouped within common categories had similar features, such as grain size and complexity. There are limited bathymetry data for the project area lakes, so depth was inferred based on colour signature of the air photos and groundtruthed with video at select locations. Finally, it is difficult to distinguish subtle features from air photos, such as degree of ice scouring, cover by periphyton, and presence of fine sediments draped over coarse sediment. Underwater video photography of representative habitat types in the lakes was used in an attempt to resolve these assumptions and reduce uncertainty in habitat quantification.

SECTION 3 • METHODS

3.1 BASE MAP

The entire area of Second Portage Lake was quantitatively mapped and assessed, as well as the northern and eastern basins of Third Portage Lake, the southern basin of Third Portage Lake (which serves as the internal reference area for the study), and the Vault Area lakes (Figure 2.1). Lake areas identified as being potentially affected by mine development are delineated on the map. The lines indicate dike locations that would capture and impound lake areas that would be drained to accommodate mining operations.

The first step of the assessment was to create a base map by scanning 1:10 000 aerial photographs and transferring the data to GIS for analysis. Visible substrate features were then classified in shallow and littoral zones of study area lakes, according to grain size, morphology, depth, and complexity. Major visible features were inferred from various colour signatures that were visible in the aerial photos. Such a characterization allowed the areas, the types of habitat, and habitat values to be assessed. This information will be used in the EIA to compare the area and type of affected habitat to the area and type of unaffected habitat in project lakes.

All habitat polygons were overlain on an electronic National Topographic Survey (NTS) 1:50,000 scale base map. These data are in UTM projection, Zone 14 using NAD83 datum. In some locations, shorelines were missing, incorrect, or derived at a smaller scale. Efforts were made to correct obvious shoreline errors by digitizing new shoreline from the air photos, or supplementing the gaps with 1:250,000 shoreline.

3.2 AIR PHOTO ANALYSIS

Two sets of aerial photos were used in the assessment: 1998 aerial photography (5,544 ft survey altitude) that was collected by Eagle Mapping Services Ltd.; and 2002 aerial photography (5,657 ft survey altitude), collected by Geographic Air Survey Ltd. The effective scale of this photography is 1:10,000. It is important to note that these air photos were not orthorectified; this required some additional processing to match the aerial imagery with the base map.

Interpretation of the air imagery required four steps: scanning, registering, warping, and interpretation.

3.2.1 Scanning

Photos were scanned at a resolution of 300 dpi using a Canon Lide30 scanner. To improve the quality of the image for classification purposes, Adobe Photoshop was used to brighten the image (+30-35) and to increase the contrast (+15-20). This allowed the interpreter to better distinguish finer features such as deep-water reefs and complexity of habitat polygons.

3.2.2 Registration

Images were imported into ArcView and registered using the register and transform extension. Prominent shoreline features were registered against the NTS base map. It was our goal to maximize accuracy by keeping the registration error to within 3 m. This was not possible in all cases, particularly in aerial transects 3 and 8.

3.2.3 Warping/Rubbersheeting

As the air imagery was not digitally orthorectified, it required rubbersheeting to match our 1:50,000 base map. Given the disparity between the two scales (photos = 1:10,000 and map = 1:50,000), some degree of adjustment was to be expected. In most cases, a great deal of warping was not required. Photos from transect 8 did require a larger degree of modification. Warping using the ArcView extension ImageWarp, produced by Spatial Solutions Inc., allowed us to rubber-sheet the scanned imagery using second- or third-order transformations.

3.3 SCALE OF INTERPRETATION & MAPPING

Air photos were interpreted at a scale of 1:5,000. Although features could be mapped at finer scales, it was judged that 1:5,000 provided the best mix between detail and spatial continuity for the project. Features that could not be reasonably distinguished at this scale were lumped into larger classes (i.e., small groupings or patches of boulder veneer would be lumped into the dominant category). Zooming in to assist in the mapping of larger features was used in some cases.

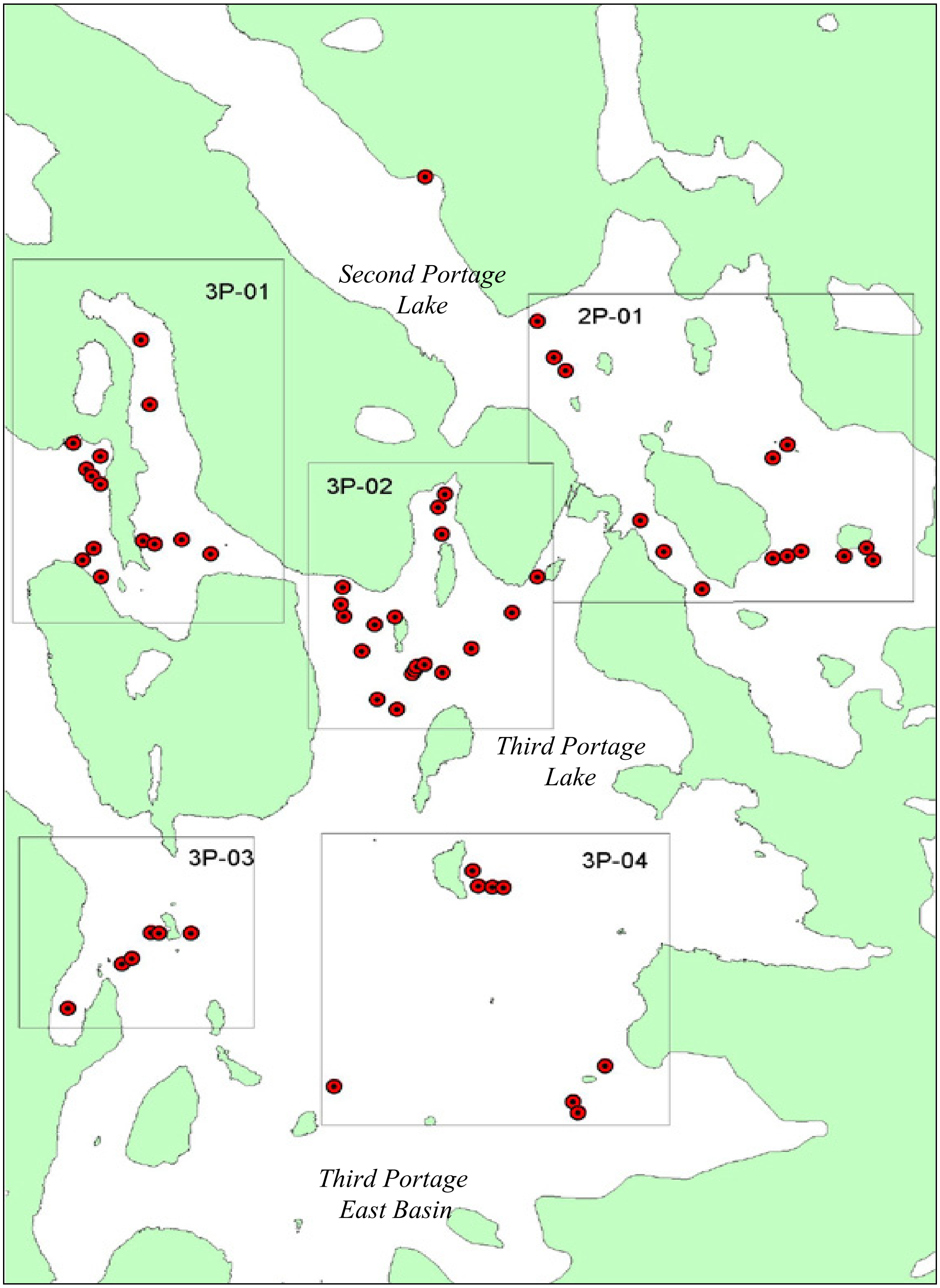
Features were digitized in ArcView and assigned attributes using information from a combination of sources: the scanned digital images; the original aerial photographs; and water depth, based on ground penetrating radar (GPR) transects and interpolated bathymetry that were acquired from discrete areas of Second and Third Portage lakes where the majority of mine development is proposed.

Features that were less than 2 mm on the physical air photo (i.e., 20 m in width) were excluded from interpretation. This included some areas of steep shoreline cliff and rapid increases in depth. The landward edges of nearshore polygons were snapped to the shoreline of the 1:50,000 NTS base map.

3.4 UNDERWATER VIDEO PHOTOGRAPHY

In August 2003, an underwater video survey of representative habitat areas, as determined from aerial photographs, was undertaken within the study lakes, focusing on lake areas contained within the proposed dike locations on Second and Third Portage lakes (see Figure 3.1). Underwater imagery was recorded using a video drop camera attached to an onboard Sony portable mini-DV recorder with viewing screen so that captured imagery could be viewed on the boat in real time. Pre-selected stations were navigated to using a Garmin 12 hand held global positioning system (GPS), aerial photographs, and topographic maps. Once on station, the boat was anchored and water depth was determined with a hand held digital depth meter (accurate within +/- 0.1 m). The camera was then deployed over the side of the boat and lowered to between 1 and 2 m from the bottom. Between

Figure 3.1: Distribution of Drop Camera Video Stations in Second Portage & Third Portage Lake East Basin



30 seconds and 2 minutes of video imagery was captured per station. Surface winds pushed the boat and camera around in a several metre radius area over the bottom, resulting in a zone of filming around the station anchor.

Video imagery was acquired from 64 stations (video was not acquired from 3 stations because of very shallow depth, and shallow, heavy boulder coverage) that were identified from aerial photographs prior to going into the field, and from stations that were visited opportunistically during the field survey. Figure 3.1 depicts the distribution of all stations visited in August 2003 in Second (2P-01) and Third Portage lakes (3P-01 to 3P-04). Appendix A provides the location (UTM NAD 83 coordinates), a general description of habitat features, and depth of each station visited.

Appendix B provides a series of five aerial photograph images depicting all prescribed and opportunistically visited stations in Second and Third Portage lakes (Figure 3.1) from which video imagery was acquired. The intent of opportunistic drop camera stations was to gather video imagery of key bottom features identified while in the field. Imagery was captured from areas that were either considered typical of a larger area, had unusual features, or were deep (>10 m), to verify our assumption that bottom sediment in deeper areas, beyond the discernable depth of the aerial photographs (about 6 m), consisted of fine substrate (silt/clay). The locations of the stations are overlain on the appropriate aerial photograph in Appendix B, and correspond to descriptions given in Appendix A.

Overall, there was good coverage of representative habitat types ranging from very shallow boulder garden type habitat to habitat consisting of fine sediments (silt/clay) in deeper water (>8 m).

Brief video clips and still images from each station have been extracted from the mini-DV tapes and placed on a CD-ROM, which is included with this report. To view the video imagery, follow these steps:

- Place the CD in a computer drive and go to the appropriate folder or drive from Windows Explorer.
- Double click on CumberlandMovies.htm. This will direct you to an overview map of all prescribed stations.
- Click on the particular map sheet (e.g., 3P-03, 2P-01) that you wish to view video imagery. This will bring up an aerial photograph of all video stations for that map sheet.
- Click on the particular station to view imagery for that station. Your computer will open Windows Media Player and a 7 to 20 second video clip will automatically play, showing bottom substrate from that station and habitat type (Appendix A).
- To view still photographs from the same stations, captured from the video imagery, follow exactly the same steps, except begin the process by double clicking on CumberlandImages.htm. Note that depth in metres is noted on the bottom right hand corner of each still image.

A select number of still images captured from the video imagery, representing typical features of representative habitat types, is provided in Appendix D.

3.5 ATTRIBUTE CLASSIFICATION

The following habitat attributes were used to delineate polygon boundaries and to describe visible features of each polygon:

- *Substrate* – an estimate of the substrate composition (gravel, cobble, boulder).
- *Morphology* – the general form of the polygon feature.
- *Depth* – an estimate of depth based on colour, position, and empirical bathymetry data.
- *Complexity* – a qualitative estimate about the composition and spatial heterogeneity of the habitat.

During aerial photograph interpretation, a total of 627 unique, identifiable polygons were delineated in Vault 1 Lake (24 polygons), Wally (Vault 2 Lake, 112 polygons), Second Portage Lake (66 polygons; 14 of which were identified in the proposed impoundment) and Third Portage Lake (425 polygons, 208 of which were identified in the proposed impoundment). The circumference (m) and area (m^2) of each individual polygon was measured and examined to define habitat attributes according to the four main attributes above. Detailed results of this exercise are presented in Appendix C. Although the slope of each polygon was estimated, these data were not factored into the final analysis because there was too much uncertainty in estimating slope from the aerial photographs. This attribute was captured indirectly by sediment grain size.

Detailed maps illustrating the spatial distribution of each of the four habitat attributes for the Portage lakes (Second and Third) and the Vault lakes (Vault 1 and Vault 2) are presented in Appendices E and F, respectively. Different substrate, complexity, morphology, and depth categories have been assigned unique colours to provide a visual depiction of details of habitat attributes. The relative contribution of each habitat attribute, as it contributes to overall quality of habitat for fish, is discussed in Section 3.1.2.

3.5.1 Substrate

Lakebed substrate is a key habitat attribute that dictates the function of the habitat (e.g., spawning, feeding) and extent to which fish utilize particular habitats, and is a major factor in assessing habitat value. In general, coarser, heterogeneous sediment mixtures are considered to have a higher habitat value because of greater diversity and structure, as well as suitability as spawning habitat. Sediment composed of an even mixture of fine substrates with little or no complexity is very common and provides feeding habitat only. It is therefore considered to have lesser overall value than heterogeneous substrates.

Substrate of each habitat polygon was classified according to one of four categories: boulder dominated substrate; boulder/cobble; sediment dominated with cobble/boulder; and fine sediment dominated. Some of the cues used in classifying the substrate from aerial photographs included: appearance of the immediate shoreline edge (rough or smooth; presence of boulder veneer at shoreline edge); sharpness of platform/shoal's edge (definite or fuzzy boundaries, gradation of colour); complexity of coloration; and visible boulders in the photo. Lakebed imagery, collected from drop-camera stations, also provided insight into grain size and depth when combined with colour gradations visible from the aerial photographs.

A description of the four substrates categories is as follows. Examples of each substrate type can be seen in the still and video imagery, using habitat types described in Appendix A as a guide:

- *Boulder* – defined as consisting predominantly of boulder to cobble substrates. These may be ice-scoured in very shallow platforms and have light to heavy periphyton coverage. These locations ranged from fractured boulder-rubble to rounded boulder-cobble-pebble, although these finer distinctions are not readily discernable in the aerial photos. This substrate type was most common in shallow water.

- *Boulder/Cobble* – a heterogeneous mixture of boulder-cobble substrate interspersed with some fine sediment patches. It appears as if boulders and cobbles are pressed into fines; the pattern on the air photos resembles polygonal fracture patterns seen in permafrost. These lightly coloured polygons appear compacted with consolidated clay, as opposed to the sandy, silt/clay sediment at other locations. This substrate type is most common in shallow water. Shallow boulder surfaces have a covering of periphyton.

- *Sediment with Boulder/Cobble* – a heterogeneous mixture of sediment (i.e., sands and silt/clay) with occasional boulder-cobble coverage (between 10 and 50%). Boulders and cobble may have a light veneer of fines draped over the surface. This substrate occurs primarily on the aprons, in the transition zone between shallow boulder cover and deeper fine sediments, in depths of 2 to 6 m.

- *Sediment Fines (Silt/Clay)* – predominantly silt/clay sediment (90%) with some sand (<5%); occasionally it will have patchy boulder/cobble (<5%). Occasional worm-like trails can be observed on the sediment surface, as well as small burrows, likely created by chironomid larvae. Most common in water depths >6 m.

Spatial distribution of habitat polygons in Second and Third Portage lakes and the Vault lakes, by substrate type, are provided in Appendices E and F, respectively. Area (ha) of each substrate type within each lake is quantified and used to determine habitat value.

3.5.2 Morphology

Morphology of habitat is a term used to describe large, discrete units of substrate features (i.e., polygons) that can be delineated and quantified, and which are distinct from adjacent units. For example, a visible offshore shoal, surrounded by deeper, indistinct sediment, is captured and measured as a discrete unit and quantified using GIS.

The three categories of habitat morphology are defined as follows:

- *Platform* – a continuous, low-slope polygon, usually adjacent to the shoreline. Generally, platform habitat predominantly consists of coarse, boulder substrate, but occasionally may include a discontinuous veneer of boulder cobble over bedrock. Complexity is moderate to high.

- *Apron* – occur lakeward of platforms or shoals, and generally have a steeper slope than platforms. Substrate of aprons is finer than sediment found at platforms or shoals, and represents transitional habitat between shallow littoral areas and deep (>6 m) zones of the lake with fine to intermediate (sand or silt/clay) sediments.

- *Shoal* – may or may not be associated with platforms; offshore width may be as wide as alongshore length. Shoals are most commonly not attached to land, and are found at depths of 2 m and deeper. Substrate typically consists of a mixture of coarse material (boulder, cobble), but may have a veneer of fine sediment draped over the surface. Complexity is usually moderate.

- *Sediment Basin* – represented by large, low-slope continuous polygons, offshore of aprons, shoals, and platforms. Generally characterized by deep depths (>8 m), with predominantly fine substrates (silt/clay) with some itinerant boulder or cobble patches in discrete areas. Complexity is low and uniform.

Morphology can influence habitat quality in term of proximity to food sources such as periphyton and insects; these food sources are more commonly associated with platforms. The morphology is also an indicator of lakebed complexity, with more complexity associated with platforms, less complexity associated with aprons, and low complexity in deep, sediment basin habitats.

Spatial distribution of habitat polygons in Second and Third Portage lakes and the Vault lakes by morphology are provided in Appendices E and F, respectively.

3.5.3 Depth

Depth was assigned to lake areas, from which depth polygons were derived and quantified using GIS. Depth in meters was estimated from features that could be distinguished from the air photos and groundtruthed from actual depths measured in the field using underwater video photography. For example, nearshore areas with visible boulders penetrating the water surface are obviously quite shallow. Colour was also used to determine relative depth. Generally, the deeper the blue colour of the air photo, the greater the depth. An approximate relationship between colour and depth was also derived from:

- Preliminary (2002) bathymetric data of parts of Second and Third Portage lakes, especially in proximity to proposed development areas.
- Expanded (2003) bathymetry dataset from Second and Third Portage lakes (North basin), which provided additional calibration for the air photo interpretations.
- Soundings acquired at drop camera locations during the 2003 field program.

Classifying depth is important in ranking habitat quality because of the influence of ice, wind driven currents, and wave action on nearshore and shoal habitat features. For example, ice can scour shallow, littoral zones to a depth of 2 m, minimizing colonization by benthic invertebrates and limiting the growing season of attached algae. Fish eggs will not survive freezing and fish do not spawn within several metres of the water surface for this reason. Wave action and exposure determines sediment grain size and sedimentation rate in shallower waters.

Depth was classified into four categories.

- *Shallow* – less than 2 m depth. Shallow areas were typically found adjacent to shoreline and were associated with platforms and sometimes shoals. Boulders and/or cobbles may protrude from the water's surface, and are assumed to freeze to the lakebed in winter.

- *Moderate* – from 2 to 4 m depth. Moderate depth areas may provide optimum depth for spawning because of favourable substrate size and distribution. Shoals and aprons typically have moderate depth. It has been determined from other recent studies (e.g., Diavik, Snap Lake) that this depth is preferentially used by lake trout for spawning.

- *Deep* – from 4 to 6 m depth. Deep areas are generally found lakeward of platform habitat, and are most often associated with aprons and shoals. The lower limit of depth class was estimated from field observations of depth and comparison of visual limits to surveyed bathymetry of the lakes. The 6 m lower limit of this class frequently corresponded to the outer edge of platforms, and was estimated from overlay of bathymetric survey data.

- *Very Deep* – greater than 6 m depth. Bottom substrate features at depths greater than 6 m could not be distinguished from the air photos, and therefore could not be effectively classified or ranked, except from drop camera images at representative stations and depths. Based on results of sediment sampling from previous field studies (see Baseline Aquatic Environment Assessment Report) and drop camera observations in the 2003 field program, substrate at these depths and greater consist almost exclusively of fine (clay/silt) sediment.

Spatial distribution of polygons according to depth for Second and Third Portage lakes and the Vault lakes is provided in Appendices E and F, respectively.

3.5.4 Complexity

Complexity of substrate describes the relative diversity, roughness, and heterogeneity of bottom substrate visible from air photos and from underwater video. There is assumed to be a positive correlation between substrate complexity and habitat quality. Complex, three-dimensional habitats have a large surface area that provides for optimal conditions for spawning, nursery, rearing, and shelter habitat for fish because of the diversity of microhabitats. For example, soft sediment with uniform slope and grain size has low diversity and surface area, relative to habitat that consists of sand with a complex mixture of cobble and boulder with uneven slope. The latter habitat is considered to have higher relative quality because it satisfies habitat requirements of several life history stages of fish and will thus rank higher when valued. Habitat complexity was described as follows:

- *Complex* – mapping unit shows considerable surface roughness (e.g., boulder veneer on bedrock), and a diversity of microhabitats is likely within the polygon. Complex habitats were more frequently observed at shallow to moderate depths (0 to 4 m), and were associated with platform and shoal habitats.

- *Moderately Complex* – mapping unit shows some (25% to 50% of total polygon area) surface roughness that contributes to diversity of microhabitats. Moderately complex habitat was usually found at depths greater than 3 or 4 m, and was associated with shoal and apron habitat.

- *Uniform* – mapping unit shows little or no surface roughness and there is likely a low diversity of microhabitats (e.g., flat rock platform, fine sediment). Habitat polygons with uniformly low complexity were usually associated with fine sediment in deeper (>8 m) depths.

Spatial distribution of complexity polygons in Second and Third Portage lakes and the Vault lakes, by complexity, are provided in Appendices E and F, respectively.

SECTION 4 • RESULTS & DISCUSSION

4.1 DEFINITION OF FISH HABITAT TYPES

Information generated by this document will be used to evaluate the potential impact of the proposed mine development on fish habitat in the project area lakes (Figure 2.1). This assessment will form the basis for determining the form and magnitude of habitat compensation under DFO's no net loss principal, as described in their policy for fish habitat management (DFO, 1987).

To synthesize interpretation of the physical habitat attributes described in Section 2.5, attributes were grouped within identifiable units (i.e., polygons) that could be mapped, quantified, and eventually ranked to derive an estimation of habitat value. Based on examination of the 1:10,000 air photo series, we identified six discrete, repeatable habitat types in nearshore littoral zones, shoals, and offshore areas in the project lakes. Habitat types were defined according to unique combinations of substrate, morphology, depth, and complexity, as distinguished from aerial photograph interpretation and groundtruthed with underwater video as follows:

- *Boulder Platform* – situated adjacent to shorelines, substrate is typically very coarse, dominated by large boulders (<75%) and cobble. Depth is shallow (<2 m) with high complexity.

- *Boulder Shoal* – situated offshore of landforms, unconnected to shorelines. Substrate is very heterogeneous and comprised of boulders (75%), with mixed sediment including cobble and coarse gravel. Depth ranges from moderately shallow (2 m) to moderate depth (2 to 4 m) with high complexity.

- *Boulder Apron* – transition habitat between platforms or shoals and deep sediment basin habitat in deeper water. Substrate typically comprised of a complex mixture boulders and cobble (>70%). Depth is usually shallow to moderate (2 to 4 m), although some polygons were deeper (6 m) with high or moderate complexity.

- *Mixed Sediment Apron* – transition habitat consisting predominantly of fine sediments (sand, silt, clay >50%) with occasional boulder and cobble embedded in sediment. Has moderate complexity and found at moderate depth (2 to 4 m).

- *Sediment Apron* – transition habitat with small amounts of coarse substrate (boulder/cobble <25%) and moderate to low complexity. With increasing depth, there is transition to higher amounts of fines (silt/clay) and reduced complexity. Moderate to uniform complexity typically at depths of 4 to 6 m.

- *Sediment Basin* – typically inferred from drop camera observations where substrate is dominated by fines (>90%), with few occasional boulders or small cobble patches. Morphology is flat with uniform complexity. Found in depths greater than 8 m. Sediment grain size of sediment basin habitat in depths greater than 8 m was assumed to consist exclusively of fine silt/clay, based on field observations from sediment grabs.

It is important to note that certain habitat types do not exist, such as sandy beaches, or boulder shoal habitat in depths deeper than 6 or 8 m. There were no areas identified within the project lakes where fine sediments dominated grain size in shallow water, nor were there areas where very coarse sediments dominated grain size in deep (>6 m) areas. There was generally an inverse relationship between sediment grain size and depth. Ice scouring, wind, and wave erosion result in very coarse grain sediments (e.g., boulder garden) found along shorelines in shallow waters, and fine grain sediments (silt/clay) in transition and profundal (i.e., sediment basin habitat) areas. The six habitat types described here encompass the range of habitat types observed, and representative photographs of these types are shown in Appendix D.

4.2 RANKING OF HABITAT TYPES

Each of the 627 polygons identified from the aerial photograph mapping exercise was ascribed a habitat type based on the particular combination of habitat attributes observed. The relative value of individual polygons in terms of providing spawning, nursery, rearing, feeding, and overwintering for fish is determined by the particular habitat attributes of each polygon.

Thus, to determine relative value of habitat polygons, attributes were ranked and scored in order of potential importance to fish species in the project lakes. This was accomplished by assigning values to different habitat attributes (Appendix C), according to their relative importance, based on professional judgment and fish habitat requirements as noted in the general literature. The most important fish species in the Meadowbank project area lakes are lake trout, round whitefish, and Arctic char. These three species are all fall spawning species, and account for 99% of all fish captured in project lakes (BAEAR, 2005). Although there are minor differences in habitat preference among species at different life history stages, the general habitat requirements of each species, especially for spawning, nursery, rearing, and overwintering are very similar. The main difference among these species is dietary preference and feeding habitat.

Different habitat attributes (e.g., substrate, depth) make different relative contributions to overall value. Substrate type and complexity have the greatest influence on how habitat is used by fish (e.g., for spawning, nursery), greater than morphology and depth; thus, these two attributes were weighted higher in terms of contribution to overall value. Table 4.1 presents the weighting and ranking system used to determine the score of each habitat polygon identified from air photos and groundtruthed with video imagery. The rationale for scoring habitat features within each habitat attribute is described below and summarized in Table 4.1.

Substrate (rank range: 1 to 4) – Substrate features, to a large extent, dictate the life history function, and contribute significantly to the overall quality, of habitat. To recognize the contribution of substrate to habitat value, a range of scores was assigned, depending on sediment composition. Heterogeneous mixtures of coarse sediment (boulder, cobble, gravel) were assigned a maximum score of 4. Sediment dominated exclusively by boulders, generally found in shallow water (<2 m), was ranked lower (3) because of the lower diversity and surface area. As sediment grain size became increasingly smaller and more uniform in composition, overall value was diminished and assigned a score of 2 or 1, in the case of silt/clay sediment, which was found at deeper depths.

Table 4.1: Scores Assigned to Habitat Classes Described from Project Lakes

Habitat Attribute	Weighting[1]	Class	Rank[2]	Feature Score[3]
Substrate	2	Boulder	3	6
	2	Boulder/Cobble	4	8
	2	Boulder/Cobble/Fines	2	4
	2	>90% Fines	1	2
Complexity	2	Uniform	1	2
	2	Moderate	2	4
	2	Complex	3	6
Morphology	1	Apron	2	2
	1	Shoal	3	3
	1	Platform	4	4
	1	Sediment Basin	1	1
Depth	1	Shallow (0 to 2 m)	1	1
	1	Moderate (2 to 4 m)	4	4
	1	Deep (4 to 6 m)	3	3
	1	Very Deep (>6m)	2	2

Notes: 1. Weighting indicates the relative importance of each habitat attribute as a determinant of habitat value. **2.** Ranking indicates relative importance of features within habitat attributes. **3.** Feature score is the product of weight x rank, and indicates the relative importance of habitat attributes as they contribute to overall habitat value.

Morphology (rank range: 1 to 4) – The shape, topography, and slope of individual polygons determines the particular life history function that the polygon provides to fish, such as feeding, overwintering, or spawning. For example, boulder shoals are particularly important as spawning areas, whereas nearshore, boulder platforms are important as feeding and rearing areas. Platforms and shoals consisting of heterogeneous substrates were ranked higher (3 or 4) than aprons because of good light penetration, low ice scour, and good water circulation. Aprons represent transitional habitats consisting of lesser periphyton growth, reduced circulation, and lower diversity substrates (boulder/cobble <50%; rank 2) or predominantly fines (rank 1). Platforms and shoals have a lower slope, less accumulated sediment on the rock surfaces, and have a greater abundance of periphyton growth than aprons, and therefore scored higher. Deep sediment basin polygons (aprons, profundal areas) consisting predominantly of fine sediments with low diversity and no cover were ranked lowest (1).

Depth (rank range: 1 to 4) – Depth has a strong, direct influence on habitat value, primarily because of the relationship between ice scour and depth, light penetration, biological productivity (e.g., periphyton growth and benthic community), water circulation, currents, and exposure. Habitat polygons in moderate depth (2 to 4 m) ranked higher (4) than habitats deeper than 4 m (rank 3) because of greater light penetration, periphyton growth, water mixing, and exposure to nutrients. Deep, sediment basin habitats provide good foraging and overwintering habitat, but there is no cover habitat for spawning or nursery areas, and so such habitats received a lower rank (2). Shallow boulder platform habitat at depths of 2 m or less that are ice scoured, exposed, and subject to high wave energy, received the lowest rank (1). Shallow habitats that freeze completely during winter are only available to fish during the open water season.

Complexity (rank range: 1 to 3) – Polygons with highly complex habitat attributes received the highest rank (3). Highly complex polygons showed high diversity in surface roughness, substrate heterogeneity, slope, and dimensionality due to depth. Polygons that displayed intermediate complexity attributes were scored as moderate (2), while habitat polygons that displayed low spatial and vertical complexity, and uniformity in sediment grain size, slope, and depth received the lowest rank (1).

4.3 DETERMINING FISH HABITAT VALUE

The relative importance of the habitat attributes substrate, morphology, depth, and complexity, within the project area lakes was ranked from 1 (low value) to 3 or 4 (high value), according to its relative importance. We then applied a weighting factor to the rank, depending on the relative importance of different habitat attributes. Two of the attribute classes, substrate type and complexity, were assigned a weighting factor of 2, reflecting the greater relative importance of these attributes than morphology and depth, to overall habitat quality. Morphology and depth were assigned a weighting of 1. The rank and weighting were multiplied to produce a score for each habitat attribute (Table 4.1).

Habitat value was then determined by summing the score of each habitat attribute within each habitat type (see Section 3.1.2) to produce a numeric score representing the relative value of each habitat type. Based on the scoring system, the highest possible score was 22. To further simplify the classification system, habitat types with a total score of 18 to 22 were assigned a value of high; scores of 13 to 17, a value of moderate; and a score of 12 or less, a value of low. Total area (ha) of high, moderate, and low value habitat polygons within Second Portage, Third Portage, and the Vault lakes were summed using GIS and mapped. As part of the EIA, the relative proportions of high, moderate, and low value habitat will be compared to determine the relative amount and quality of habitat potentially affected in each lake by the proposed mine development.

4.4 LIMITATIONS & ASSUMPTIONS

The procedures followed in this assessment have focused on quantifying the relative importance of habitat. The absolute value of fish habitat is related to measures of fish production and, only possible through intensive study, is well beyond the scope of baseline environmental studies. The reader should be aware that there is no established, widely recognized procedure or protocol for mapping and valuing fish habitat in Arctic lakes. Although the same basic principles are used, different environmental assessments of northern mining projects (e.g., Diavik, Ekati) have used different approaches on a site-specific basis.

When assessing and quantifying habitat value, it is acknowledged that some subjectivity is required to assess and assign scores to individual habitat attributes. Fortunately, video data acquired from the 2003 field survey revealed that the composition and diversity of habitats was relatively simple. This allowed for some general assumptions to be made, which simplified the assessment and increased robustness of data interpretation. For example, substrate composition, complexity, and periphyton growth was inversely related to increasing depth. Observations revealed that there were no macrophytes; algal production by periphyton was limited to coarse substrates within the upper 4 m; ice scouring affected periphyton within the upper 2 m. No clean, coarse substrates or shoal habitats could be identified in water that was deeper than 6 m; and bottom substrates deeper than 8 m consisted of fine sediment composed of silt/clay. Given the above information, the following assumptions were made:

- Habitat in depths greater than 6 m, which could not be distinguished clearly from air photos, was assumed to have a uniform grain size (silt/clay), based on sediment sampling data and video imagery, relative lack of complexity and cover, and unsuitability as spawning habitat. For the purposes of this assessment, it was assumed that all habitat polygons greater than approximately 8 m depth were uniform in slope, complexity, composition, and morphology, and were ranked accordingly.
- Shallow habitat less than 2 m depth was assumed to have moderate to high habitat value. Although boulder platform habitats freeze to this depth in winter, rendering it unsuitable for spawning and overwintering, this habitat is important as nursery, shelter, and foraging habitat for fish, given the abundant algal growth (periphyton) on rock surfaces that is responsible for much of the productivity in early spring and summer.
- Habitat with diversity in substrate size and composition, intermediate depth (2 to 4 m), and complex composition and morphology was assumed to have greater relative value because this habitat has the potential to support several habitat requirements, including spawning by lake trout and round whitefish, and for nursery, rearing, and feeding.

4.5 LAKE AREAS SURVEYED

Habitat types mapped from air photos of Second Portage Lake, Third Portage Lake, and the Vault lakes fell within two main categories based on depth. Substrate and morphological features of habitat types in water depths shallower than 8 m were distinguished and quantified from air photos and groundtruthing from video imagery. Habitat at deeper depths could not be distinguished from aerial photographs; however, based on sediment sampling (BAEAR, 2005) and underwater video imagery, these deeper areas were assumed to consist exclusively of silt/clay basin habitat with low diversity and habitat complexity that is not used for spawning by fish.

A total of 383 ha was mapped in Second Lake, combined over all habitat types (see Table 4.2). The Vault lakes are orientated in a north to south direction, and water flows south, eventually connecting with Second Portage, just upstream of its outlet to Tehek Lake. Vault 1 is a small lake adjacent to the Vault deposit while Vault 2 Lake, also known as Wally Lake, is a large, convoluted lake immediately adjacent to Vault 1. Vault 2 connects via a small connecting lake (Vault 3) to Second Portage Lake (Figure 2.1). Combined, Vault 1 and Vault 2 lakes have a surface area of 732 ha, of which 697 ha (95%) was mapped. Habitat was assessed and quantified for the entire area of Second Portage Lake.

Table 4.2: Total Area (ha) of Project Area Lakes Relative to Area Classified for Fish Habitat

	Total Area (ha)	Total classified area (ha)	% Area Classified
Second Portage	383	383	100
Third Portage	3,600	2,593	72
Vault Lakes	732	697	95

Third Portage Lake is much larger than the other lakes, totalling about 3,600 ha. Approximately 2,593 ha of Third Portage Lake habitat was quantified, which is nearly three quarters (72%) of the total area of Third Portage Lake (Table 4.2). Because of its very large size, the entire lake was not mapped; however, the northern basin and the southern basins (i.e., the internal reference area) were mapped because of their importance as a reference area (see the BAEAR, 2005). Note that areas presented here are plan view areas and do not incorporate the effects of slope on actual area. That is, the area of high quality habitat along shorelines may actually be slightly higher than estimated from air photos (two dimensions) because of the slope of lakebed; however, this difference is likely consistent for all of the lakes and probably represents only a small difference.

4.6 DISTRIBUTION & ABUNDANCE OF HABITAT TYPES

4.6.1 Portage Lakes

The spatial distribution of all six habitat types (i.e., boulder platform, boulder shoal, boulder apron, mixed sediment apron, sediment apron, and sediment basin), interpreted from aerial photographs and underwater video imagery (see enclosed CD-ROM), is presented in Appendix E for Second and Third Portage lakes and Appendix F for the Vault lakes. Individual habitat types for all polygons were quantified by area (ha) using GIS, mapped, and assigned a unique colour to allow easy visual interpretation of the spatial distribution and abundance of each type. The same procedure was followed for habitat attributes: morphology (platform, shoal, apron, profundal basin), depth (shallow, moderate, deep), substrate (boulder, boulder-sediment, sediment-boulder, fine sediment), and complexity.

The majority of lake area in Second Portage is deeper than 6 m, the visual limit of resolution from the air photos. Bathymetry for Second Portage Lake confirms that the majority of the lake, particularly the north arm, is quite deep, up to 38 m. In addition, the shorelines of this arm slope steeply away from the shore and are composed of bedrock slopes and heavy boulder veneer. Sixty percent of the total area of Second Portage Lake consists of profundal basin sediment, greater than 6 m depth (Table 4.2). The extreme north end of the north arm is about 6 to 10 m deep, and the bottom consists predominantly of silt/clay (Appendix E).

South of the north arm, in the vicinity of the group of islands near the connection between Third Portage and Second Portage Lake, the habitat becomes much more diverse, with many boulder platforms and shoals. The complexity and distribution of the platform and shoal habitat in this vicinity of Second Portage Lake can clearly be seen in Appendix B, from the aerial photograph depicting drop camera locations. There are many submerged shoals and platforms extending from islands and shorelines. This habitat is preferred for spawning by lake trout and round whitefish (Scott and Crossman, 1979). Examples of each habitat type identified from aerial photographs are illustrated in Figures 4.1 and 4.2.

Boulder platform habitat (103 ha) is the dominant habitat type <4 m depth in Second Portage Lake, composing 27% of the total lake area (see Table 4.3). Sediment apron (9.5%) and boulder shoals (1.7%) comprised the remainder of habitat in shallow depths in Second Portage Lake.

Figure 4.1: Nearshore Habitat Types from Air Photo Image of Third Portage Lake

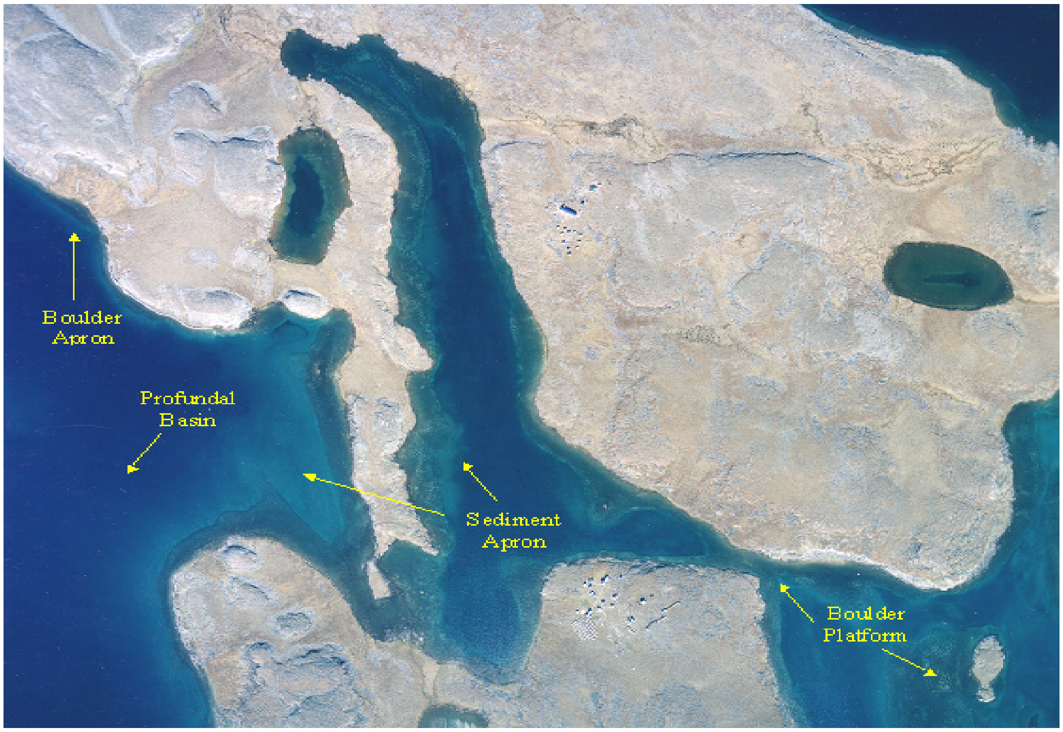


Figure 4.2: Offshore Habitat Types from Air Photo Image of Third Portage Lake East Basin

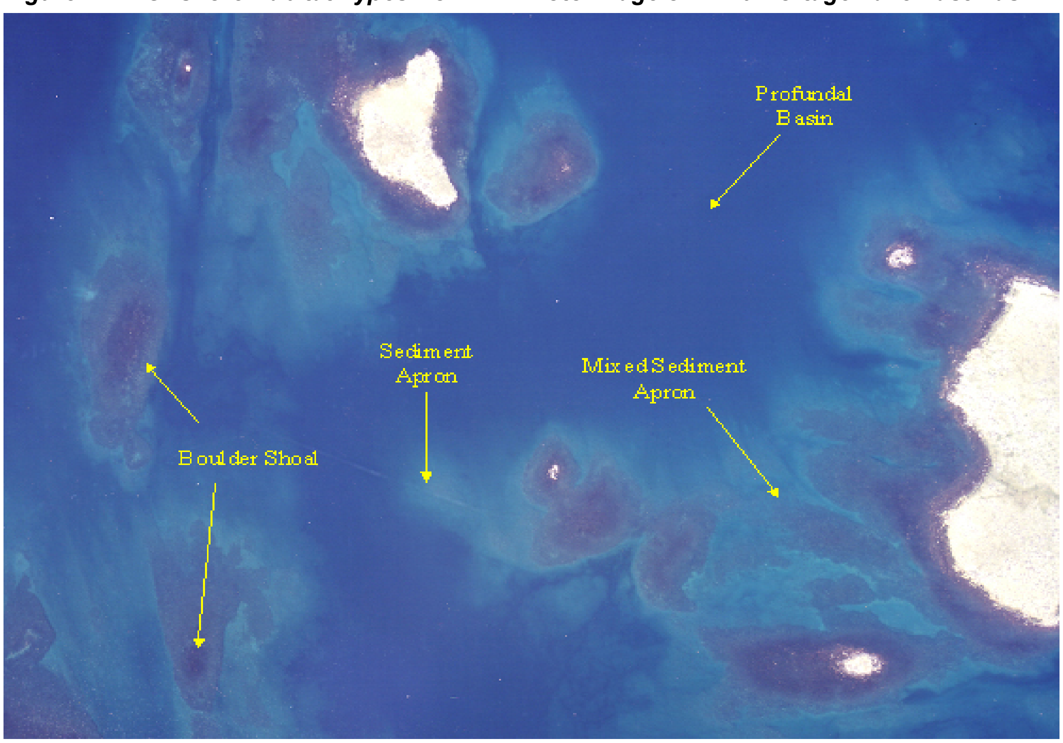


Table 4.3: Total Area (ha) & Relative Abundance (%) of Habitat Types within Project Area Lakes

Habitat Type	Second Portage Lake		Third Portage Lake		Vault Lakes	
	Total Area (ha)	**Percent (%) of Total**	**Total Area (ha)**	**Percent (%) of Total**	**Total Area (ha)**	**Percent (%) of Total**
Boulder Platform	103.4	27.0	316.1	12.2	264.4	37.9
Boulder Shoal	6.4	1.7	104.1	4.0	131.4	18.9
Boulder Apron	-	-	20.2	0.8	17.6	2.5
Mixed Sediment Apron	6.6	1.7	33.0	1.3	77.5	11.1
Sediment Apron	36.3	9.5	496.3	19.1	32.8	4.7
Sediment Basin	229.7	60.0	1,623.5	62.6	173.2	24.9
Grand Total	382.4	100.0	2,593.2	100.0	696.9	100.0

The relative proportions of habitat in Third Portage Lake were similar to those of Second Portage Lake. There are several large, deep basins in Third Portage Lake (up to 35 m deep in the South Basin, based on field data), which compose 62.6% of the total area. Sediment apron habitat composed 19% of the lake by surface area, and was found predominantly in the East Basin, west and south of Goose Island. This habitat is moderately deep (2 to 4 m), with abundant mixed boulder/cobble shoals interspersed with fine sediments. Air photograph interpretation did not reveal the complexity of substrate types here; however, field observations and underwater video imagery indicated that bottom substrates are more heterogeneous than air photos suggested. Hence, there was an abundance of habitat classified as sediment apron in this basin. Boulder platform habitat was the next most abundant type (12.2%), with smaller amounts of boulder apron, boulder shoal (especially around Goose Island and in the North Basin) and mixed sediment apron habitats (Table 4.3).

The diversity of habitat types was greater in Third Portage Lake than in Second Portage Lake because of its much greater size, thus rare or less frequently occurring habitat types such as boulder apron and shoals were present in Third Portage Lake but not in Second Portage Lake.

4.6.2 Vault Lakes

The Vault lakes are headwater lakes, lying west of the Portage lakes just south of the Meadowbank River drainage. This lake system has very complex shorelines and great spatial diversity in depth, substrate type, and morphology (Appendix F), and is about double the surface area of Second Portage Lake. Within the Vault lakes there are a few, scattered deep sediment basin habitats that compose a small area of the overall habitat (25% of total area; Table 4.3). Boulder platforms and mixed sediment aprons dominate nearshore habitats. The spatial distributions of habitat types, substrates, and depths are complex, contributing to the high overall spatial complexity of habitat within these lakes (Appendix F.5). Drop camera imagery was not acquired from the Vault lakes, so habitat attributes were inferred from aerial photographs and from assumptions made from drop camera imagery of the Portage lakes.

Abundance of major habitat types was more equal in the Vault lakes than the Portage lakes. The most abundant habitat type was boulder platform (38%) followed by sediment basin (25%), boulder shoals (19%), and mixed sediment apron (11%). Boulder apron habitat also composed more habitat by area and as a percentage than in the Portage lakes. Relative abundance of sediment apron habitat was proportionally less in the Vault lakes (4.7%) than the Portage lakes (9 to 19%) because of the lack of transition habitat associated with sediment basin habitat in the Portage lakes. Overall, habitat attributes of the Vault lakes appear to be diverse and provide abundant quality habitat for all life history stages for fish; however, the relatively low proportion of deep, overwintering habitat may constrain abundance of fish in these lakes or force fish to vacate these lakes in fall in search of deeper water (such as in Second Portage Lake or Tehek Lake).

4.7 HABITAT VALUE

Based on the ranking system described in Section 3.1.3, the relative value as fish habitat of areas within Second and Third Portage lakes (Figure 4.3) and the Vault lakes (Figure 4.4) was mapped and quantified (Table 4.4). The value of fish habitat potentially affected by mine development relative to habitat in the remainder of the lakes, unaffected by development, will be determined as part of the EIS and was not within the scope of this study. Here we compare the number of hectares and relative percentages of high, moderate, and low value habitat in each project lake.

Table 4.4: Total Area & Relative Abundance of High, Moderate & Low Value Habitat in Project Lakes

	Second Portage		Third Portage		Vault Lakes	
Habitat Quality	**Total Area (ha)**	**Percentage of Total**	**Total Area (ha)**	**Percentage of Total**	**Total Area (ha)**	**Percentage of Total**
High	100.7	26.3	376.8	14.5	246.2	35.3
Moderate	27.9	7.3	154.2	5.9	244.8	35.1
Low	254.0	66.4	2,062.3	79.6	206.1	29.6
Total	382.6	100.0	2,593.3	100.0	697.1	100.0

4.7.1 Second Portage Lake

Of the 383 ha of habitat in Second Portage Lake, 100.7 ha, representing 26.3% of total lake area, was ranked as high value habitat. High quality habitat was distributed primarily around shorelines and islands and was associated with boulder platforms and boulder shoals of shallow to moderate depth and high complexity. The abundance of deep, sediment basin habitat was ranked as low quality as it provides only for overwintering and feeding by fish.

Moderate value habitat composed 27.9 ha (7.3%) of the total lake area. These habitats were limited to Shoals of moderate depth. It may be that additional moderate value habitat exists within transition zones elsewhere in Second Portage Lake, especially in the north end of the north arm and in the southern basin. Underwater video imagery suggested greater complexity in habitat than could be distinguished from aerial photographs.

Figure 4-3: Relative Value of Fish Habitat in Second & Third Portage Lakes

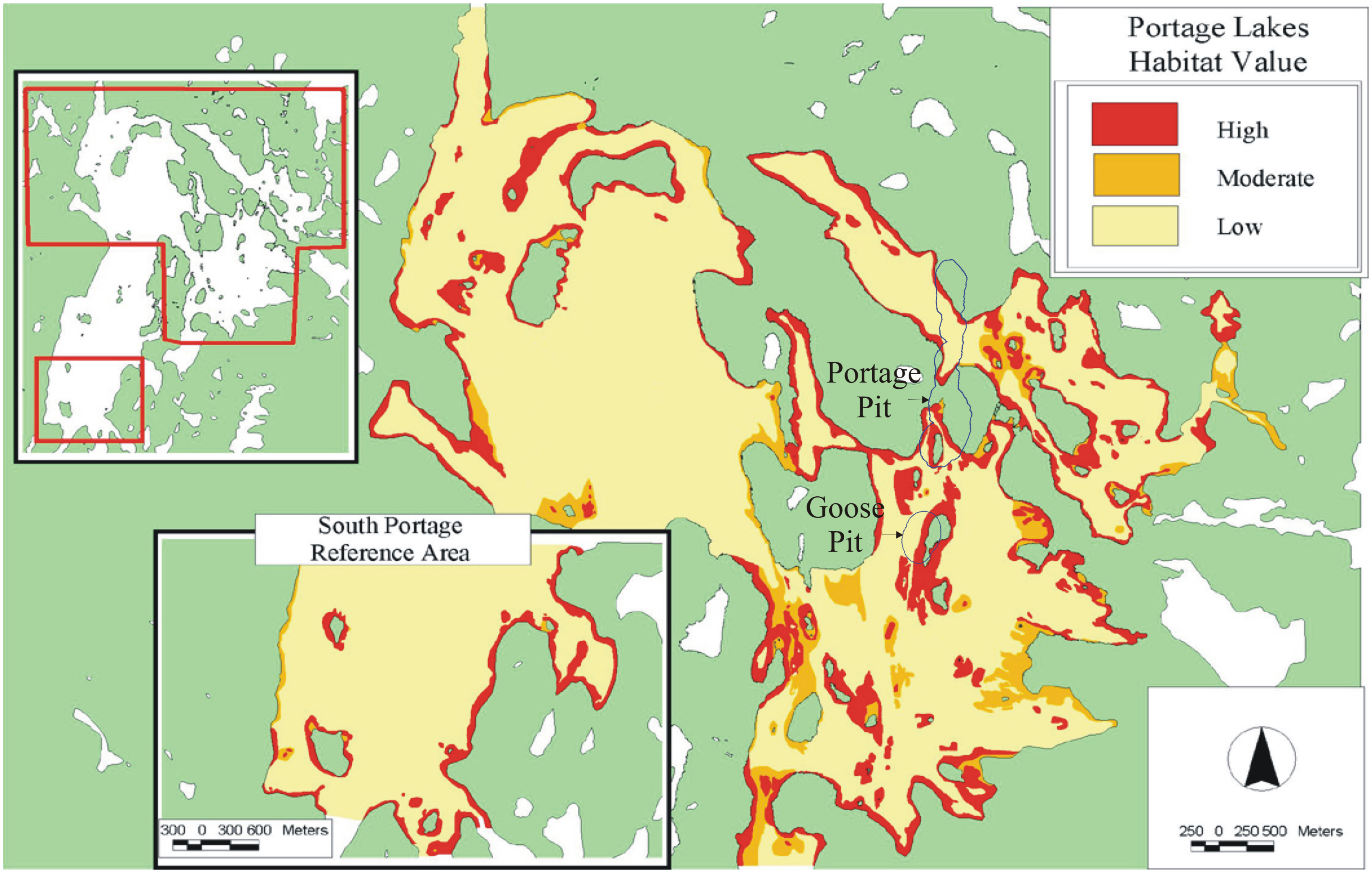
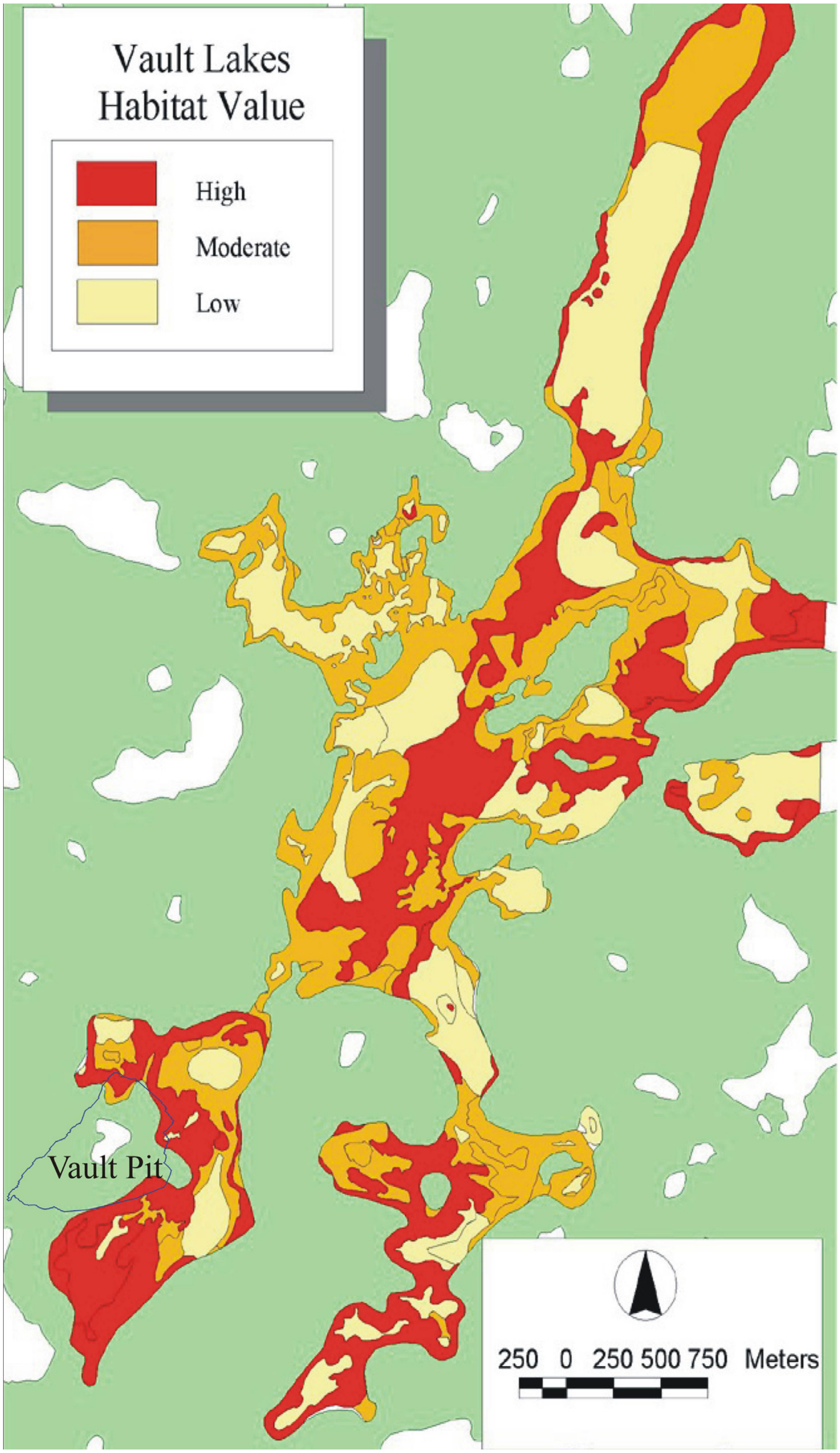


Figure 4-4: Relative Value of Fish Habitat in Vault Area Lakes



The majority (66.4%) of habitat (254 ha) in Second Portage Lake is considered low value, composed mostly of the deep, fine substrate, low complexity habitat that is prevalent throughout the lake, and especially in the northern arm of the lake (Figure 2.1).

4.7.2 Third Portage Lake

About 72% of the surface area of Third Portage Lake was quantified. The values presented here are relative to actual areas surveyed and are not based on total surface area of the lake. Given the large area surveyed relative to the total, however, areas of habitat types and relative percentages could be extrapolated to determine relative proportions of different habitat types and relative habitat value throughout the lake.

In Third Portage Lake, 376.8 ha of habitat was ranked as high value, constituting approximately 14.5% of the lake area surveyed. High value habitats were situated along shorelines of moderate depth, as well as adjacent to some islands and over submerged shoals, especially in the East Basin. A good proportion of high value habitat is situated around and adjacent to Goose Island.

The total area of moderate value habitat was 154.2 ha, or 5.9% of mapped surface area. Moderate value habitat was associated primarily with shoals and sediment apron, and with mixed sediment apron habitat with a heterogeneous substrate composition, including fines. It is not known to what extent moderate value is used for spawning by lake trout and round whitefish. Use of moderate value habitat by fish for spawning is probably very site-specific and depends in large part on depth and substrate characteristics and abundance of fines (the greater the abundance of fines, the lower the value for spawning).

Similar to Second Portage Lake, the majority of habitat in Third Portage Lake was scored as low value (79.6%). This is because a great deal of the habitat in Third Portage Lake is deep habitat, especially in the north and south basins of the lake. Fine sediments with little or no boulder/cobble and very low complexity characterize these areas; although, areas of intermediate depth (4 to 12 m) provide good feeding habitat for round whitefish because of abundant benthic invertebrate populations (see the BAEAR, 2005).

4.7.3 Vault Lakes

A relatively high proportion of the surface area of Vault area (i.e., Vault 1 and Vault 2) lakes (246 ha) was scored as high value habitat (35.3%), nearly double the proportion of high value habitat in the Portage lakes (Table 4.4; Figure 4.4). High value habitat was abundant and distributed evenly throughout the lake system, especially in the central region of Vault 2 Lake and much of Vault 1 Lake. High value habitat was typically associated with boulder platforms with heterogeneous substrates, shallow to moderate depth, and high complexity (Appendix F).

The total area of moderate value habitat was 244.8 ha, or 35.1% of mapped surface area. This was very similar to the proportion of high value habitat and considerably more than the area and proportion of moderate value habitat than in the Portage lakes. Moderate value habitat was associated with boulder apron and mixed sediment aprons dominated by coarse substrates, in water of shallow to moderate depth, and high complexity. Similar to the Portage lakes, use of moderate habitat by fish for spawning is probably very site-specific. Given the abundance of high and moderate value habitat in the Vault lakes, this area is not limited by physical habitat attributes, and productivity of fish is most likely limited by lack of nutrients, given the oligotrophic status of the project lakes.

The abundance (206.1 ha) of low value habitat in the Vault lakes was less than abundance of moderate and high value habitat. In terms of relative abundance (29.6%), low value habitat in the Vault lakes was considerably less abundant than in the Portage lakes, because of the small amount of deep, sediment basin habitat. Large proportions of the lake are less than 8 to 10 m deep. (Note that it is difficult to distinguish between moderate and deep depths from aerial photographs without bathymetry, of which there is none for Vault 2 Lake.)

4.8 SIGNIFICANCE OF HABITAT LOSS

The absolute and relative amounts of habitat potentially affected by the Meadowbank project as currently proposed by Cumberland (Figure 2.1) can be determined from information generated by the aerial photographs and drop camera video imagery as presented in this document. It is very difficult, however, to predict what the impact of habitat loss and alteration on fish population abundance will be in these lakes. The prediction of impacts will be based on answers to the following questions:

- Is the amount of affected habitat consequential relative to the total amount of non-affected habitat available elsewhere?
- Is critical habitat lost within affected areas that is not available or does not exist in non-affected areas?
- Are presence and abundance of specific habitat types actually a limiting factor to the production of fish in the study lakes?

These questions will be addressed within the EIA by comparing the area and relative proportions of high, moderate, and low value habitat affected or impaired by construction and operation of the mine, as well as the post-closure scenario for Meadowbank, relative to baseline. Answers to these questions are required to address the DFO no net habitat loss principal in order to determine the extent of mitigation/compensation plans necessary as the project moves through the regulatory approvals phase.

The project area lakes appear to have abundant and diverse habitats that are typical of Arctic lakes and provide adequate habitat and physical conditions to support all life history stages of fall spawning fish populations.

SECTION 5 • REFERENCES

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APPENDIX A

Description of Habitat Attributes from Drop Camera Imagery of Third Portage (3P) & Second Portage (2P) Lake Stations

Table A.1: Description of Habitat Attributes from Drop Camera Imagery of Third Portage (3P) & Second Portage (2P) Lake Stations

Station Number	Habitat Type	Date	Tape #	Location: Easting 14W	Location: Northing	Depth (m)	Substrate & Comments
3P-1	Boulder shoal	26Aug	1	637269	7213763	4.2	Patchy fines interspersed with cobble and boulder cover; heterogeneous mixture of substrates
3P-2	Boulder platform	26Aug	1	637323	7213642	2.1	Rocky boulder substrate dominated by flat rock slabs
3P-3	Boulder platform	26Aug	1	637346	7213608	0.8	1 m diameter shallow boulder garden; uniform dense boulder cover No fine sediment; good periphyton coverage; Photos 1 and 2.
3P-4	Boulder platform	26Aug	1	637382	7213568	0.8	Compacted cobble and boulder rubble with heterogeneous size distribution; 20 m from shoreline
3P-5	Boulder platform	26Aug	1	637384	7213702	1.3	Boulder garden; very mixed size; some cobble
3P-6	Mixed sediment apron	26Aug	1	637355	7213264	3.7	Heterogeneous mixture of rubble, cobble and fines; patchy
3P-7	Boulder platform	26Aug	1	637308	7213208	1.2	Very heavy rock boulder garden; no fines; heavy periphyton coverage
3P-33	Boulder platform	26Aug	1	637385	7213128	0.6	Very large boulders densely packed; some periphyton coverage
3P-44	Sediment apron	26Aug	1	637244	7211083	3.7	Bottom appears soft consisting of sand/silt? No larger material visible
3P-45	Boulder platform	26Aug	1	637473	7211293	1.0	Boulder and cobble bottom; some periphyton
3P-46	Boulder shoal	26Aug	1	637516	7211319	2.1	Heterogeneous boulder/cobble bottom with some gravel and sand; patchy distribution of material
3P-47	Boulder platform	26Aug	1			0.3	No video taken. Very shallow shoal of flat, exposed bedrock slabs
3P-48	Boulder apron	26Aug	1	637580	7211454	3.3	Large cobble, small boulder coverage (70%) with patchy sand/silt sediment between clusters of boulders
3P-49	Boulder platform	26Aug	1	637630	7211439	1.2	Boulder cobble bottom; 10% fines; abundant periphyton cover on boulders
3P-8	Boulder platform	26Aug	1	637563	7213301	1.0	Dense boulder garden
3P-9	Sediment apron	26Aug	1	637613	7213285	5.3	Heterogeneous mixture of different size substrates ranging from sand/ silt to boulder and rock pieces. Fine cover of silt on large substrates

Table A.1 – Continued

Station Number	Habitat Type	Date	Tape #	Location Easting 14W	Location Northing	Depth (m)	Substrate & Comments
3P-10	Profundal basin	26Aug	1	637726	7213304	15.3	Soft bottom; possible some gravel and stones on bottom (ice rafted?) drifted 60 m over bottom in strong wind to shallower water
2P-51	Boulder shoal	27Aug	2	640284	7213755	1.3	Boulder garden; very large substrate with abundant periphyton
2P-52	Sediment basin	27Aug	2	640223	7213693	13.9	50 m N of prescribed location was 18.5 m; drifted off anchor to 100 m S ending at 0640226 7213515
2P-38	Boulder platform	27Aug	2			0.2	No video. Very rocky boulder garden
2P-39	Boulder platform	27Aug	2	640221	7213216	1.2	Rocky boulder garden; abundant periphyton
2P-40	Sediment apron	27Aug	2	640284	7213227	4.4	Heterogeneous bottom; mostly fines, some cobble and rock (review)
2P-41	Boulder shoal	27Aug	2	640341	7213250	1.7	Large boulder garden and rock slabs; some periphyton growth
2P-100	Mixed sediment apron	27Aug	2	640618	7213266	4.1	Transition habitat adjacent to rocky island shelf (see photo #16) mostly soft silt/clay with stones, cobble, few small boulders
2P-42	Boulder platform	27Aug	2	640524	7213228	1.0	Boulder garden
2P-43	Sediment apron	27Aug	2	640647	7213209	2.8	Interesting heterogeneous mix of substrates; mostly fines, patches of stone and itinerant boulders; periphyton
2P-101	Sediment basin	27Aug	2	639923	7213072	3.7	Mostly boulder and cobble; some fines at deeper depths between boulders
2P-27	Boulder shoal	27Aug	2	639762	7213249	3.1	Heterogeneous mix of boulder, cobble, rocks and fines; transition area patchy fines increase with depth
2P-28	Sediment basin	27Aug	2	639662	7213396	8.2	Mostly fines; itinerant boulders; patchy cobble 30 m W of prescribed stn @ 13 m; mid channel below hill to east
2P-102	Sediment basin	27Aug	2	639229	7214340	6.0	Mostly fines; some buried stone and boulder, cobble pieces 75 m from shore
2P-103	Sediment basin	27Aug	2	639240	7214293	5.3	Mostly fines; very few stones; long video sequence because of drift off station; worm trails in sediment?
2P-104	Sediment apron	27Aug	2	639298	7214170	5.1	Mostly fines; scattered rubble, few boulders, cobble; very mixed
2P-105	Mixed sediment apron	27Aug	2	639347	7214107	4.0	Scattered rubble and boulder; 20% fines, very heterogeneous bottom

Table A.1 – Continued

Station Number	Habitat Type	Date	Tape #	Location: Easting 14W	Location: Northing	Depth (m)	Substrate & Comments
2P-106	Mixed sediment apron	27Aug	2	638753	7215026	3.7 - 5.5	Transition from rock and boulder cobble to mostly fines at 5 m depth steep slope 20 m from shore
3P-20	Boulder platform	28Aug	2	638837	7213520	1.1	Large rocky boulder garden; periphyton on rocks.
3P-21	Sediment apron	28Aug	3	638808	7213459	3.1	Mostly fines; some loose cobble and fines draped over boulders
3P-22	Boulder platform	28Aug	3	638824	7213330	1.3	Boulder garden; heterogeneous mixture of fines and rubble in deeper water NE of island
3P-11	Boulder platform	28Aug	3	638405	7213079	1.2	Boulder garden; periphyton covered rock
3P-13	Sediment apron	28Aug	3	638399	7212998	3.4	70% fines; Itinerant boulders and cobble embedded in sediment
3P-12	Sediment apron	28Aug	3	638410	7212940	5.8	Fines. No visible boulders; worm trails?
3P-18	Boulder platform	28Aug	3	638541	7212903	1.2	Compacted rubble and boulder garden; some interspersed fines between rubble pieces
3P-19	Boulder platform	28Aug	3	638627	7217940	<1.0	Very rocky boulder garden Emerged boulders…dangerous boating
3P-14	Sediment apron	28Aug	3	638700	7212670	4.9	Appears to be uniform silt/clay bottom. No boulder or cobble
3P-200	Boulder platform	28Aug	3	638486	7212777	1.3	Rocky shelf/reef consisting of compact boulder and cobble representative of uniform shallow rocky area between camp & Goose Island
3P-15	Sediment apron	28Aug	3	638710	7212688	3.4	Mostly fines. Itinerant boulder, rubble/cobble
3P-16	Boulder shoal	28Aug	3	638718	7212705	2.4	Boulder and cobble garden; complex rock, poss. spawn area
3P-17	Boulder shoal	28Aug	3	638752	7212715	2.8	Cobble/rubble and boulder; very few fines; very complex
3P-201	Sediment apron	28Aug	3	638827	7212675	5.9	Silt/clay; uniform fine sediment
3P-23	Boulder platform	28Aug	3	638949	7212791	1.9	Boulder garden; some periphyton coverage
3P-202	Sediment apron	28Aug	3	639121	7212958	5.2	Fines; very few buried boulders
3P-26	Boulder platform	28Aug	3	639229	7213128	<1.0	Boulder field very near shore; exposed rock and boulder; big trouble

Table A.1 – Continued

Station Number	Habitat Type	Date	Tape #	Location: Easting 14W	Location: Northing	Depth (m)	Substrate & Comments
3P-50	Sediment basin	29Aug	3	637765	7211440	10.3	Fines; uniform silt/clay bottom 80 m W of prescribed station which was 17.3 m depth
3P-29	Boulder shoal	29Aug	3	638920	7211735	<1.0	Very shallow rocky boulder garden
3P-30	Sediment apron	29Aug	3	638978	7211663	3.8	75% fines; Itinerant boulder, cobble
3P-31	Boulder shoal	29Aug	3	639021	7211667	1.5	Very rocky boulder garden; periphyton growth on rocks
3P-32	Boulder shoal	29Aug	3	639084	7211656		Very rocky boulder field
3P-36	Sediment apron	29Aug	3	638369	7210713	5.7	Mostly fines; very foliose looking bottom; periphyton? View 1 km west of prescribed station 3P-36A
3P-53	Sediment apron	29Aug	3	639399	7210588	6.1	Mostly fines; Itinerant boulders
3P-36A	Sediment basin	29Aug	3	639370	7210662	6.0	Fines; edge of boulder field 20 m to the north
3P-37	Mixed sediment apron	29Aug	3	639515	7210811	3.4	Mostly fines; few itinerant boulders and cobble at edge of boulder garden just south of station
3P-24	Sediment apron	29Aug	3	638634	7212502	4.1	Mostly fines; Itinerant and scattered boulders
3P-25	Boulder platform	29Aug	3	638552	7212547	2.1	Very large boulder garden; no fines; periphyton coverage
3P-203	Sediment basin	29Aug	3	637848	7213237	7.2	Fines. Many worm tubes/holes visible. Interesting bottom; benthos?
3P-204	Boulder apron	29Aug	3	637554	7214252	1.8 - 3.0	Transition zone; rubble field over boulders; periphyton coverage transition to fines with deeper depth >3 m. N head of inlet W of N Camp.
3P-205	Sediment apron	29Aug	3	637592	7213946	4.8	Fines. Many interesting worm holes. Drifted at start of video. Opposite north camp at transition to deeper water from rocky shelf

APPENDIX B

Aerial Photographs of Drop Camera Video Stations in
Second & Third Portage Lakes

Figure 1: Aerial Photograph of Drop Camera Stations in Second Portage Lake

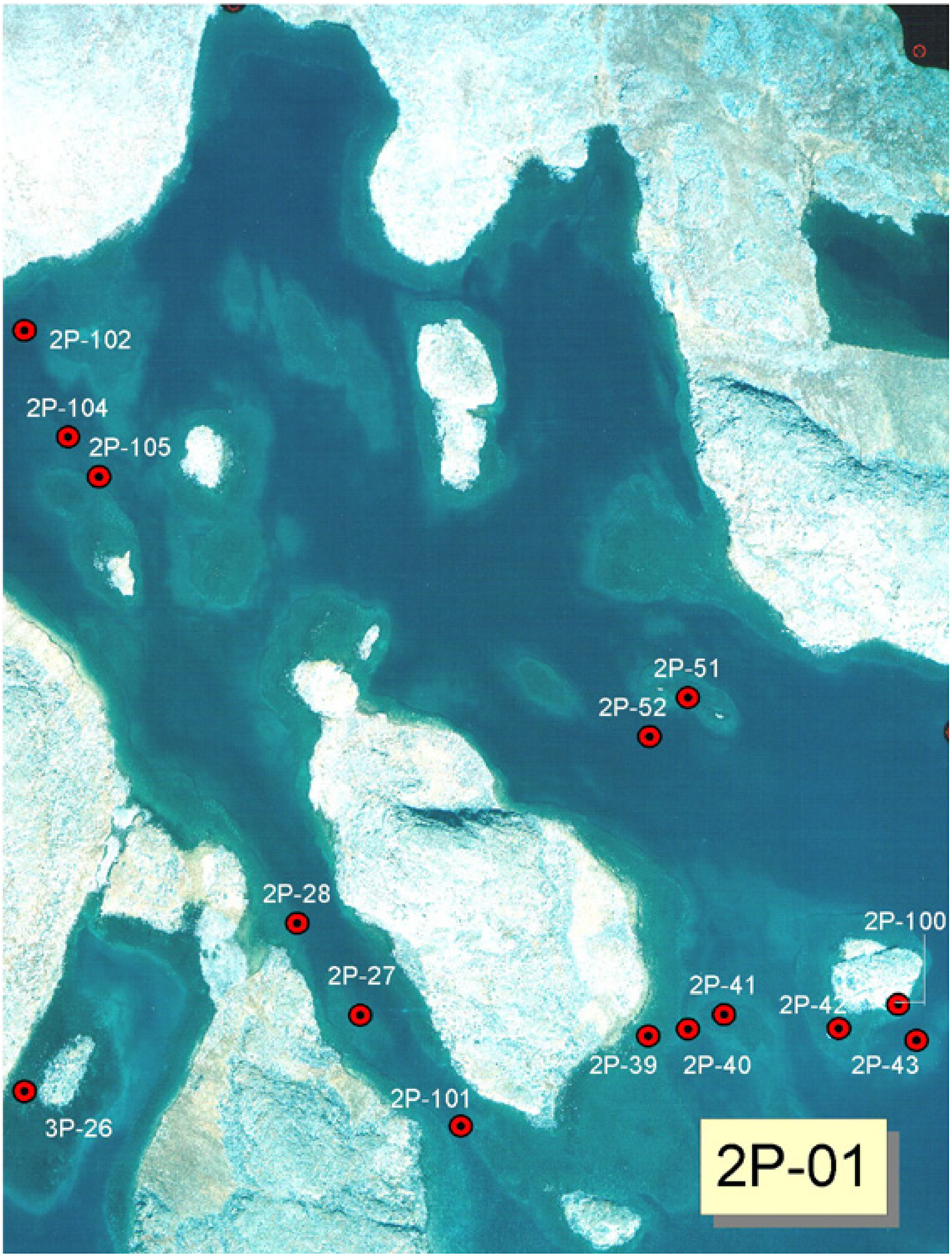


Figure 2: Aerial Photograph of Drop Camera Stations in Third Portage Lake

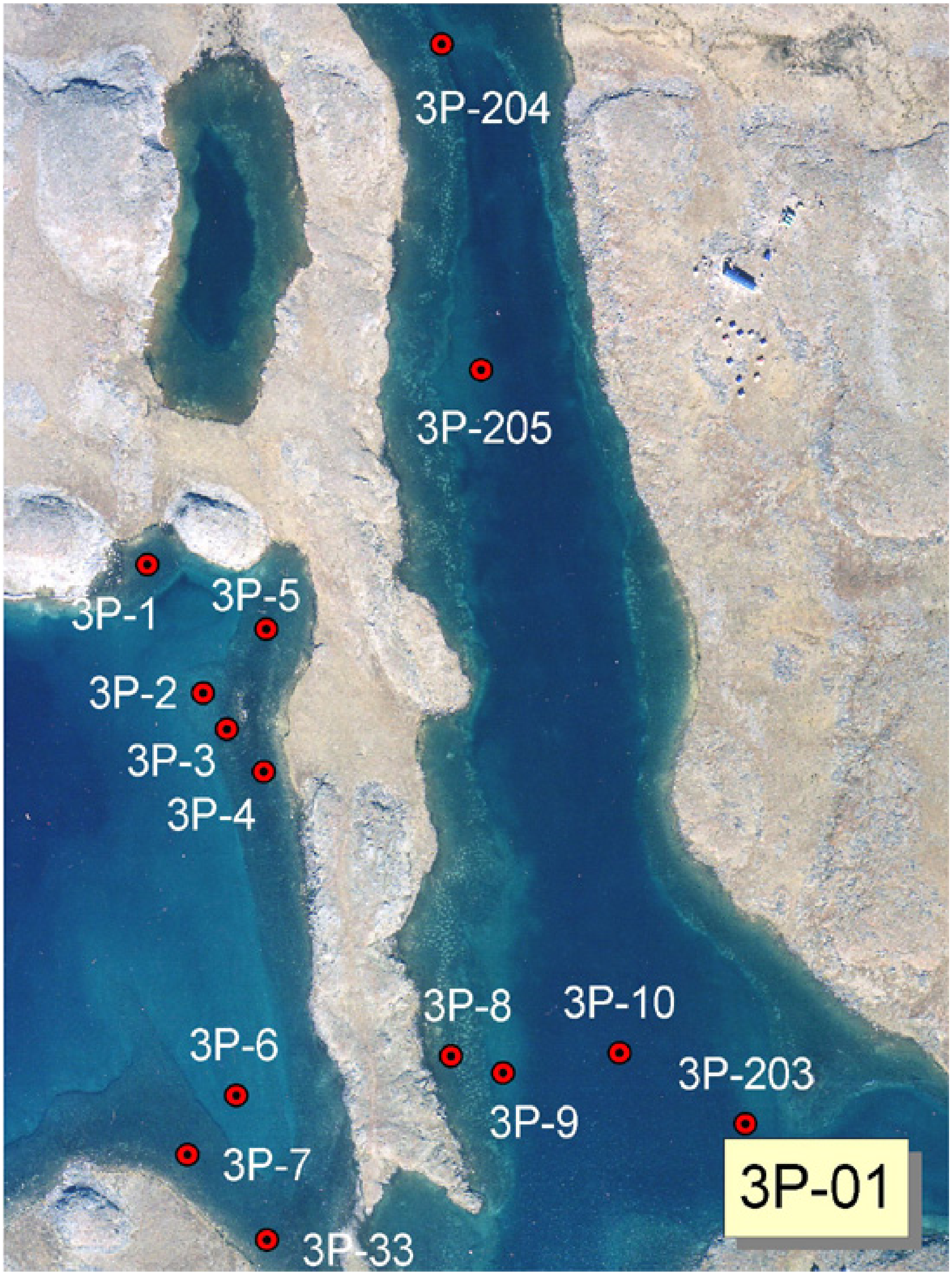


Figure 3: Aerial Photograph of Drop Camera Stations in Third Portage Lake

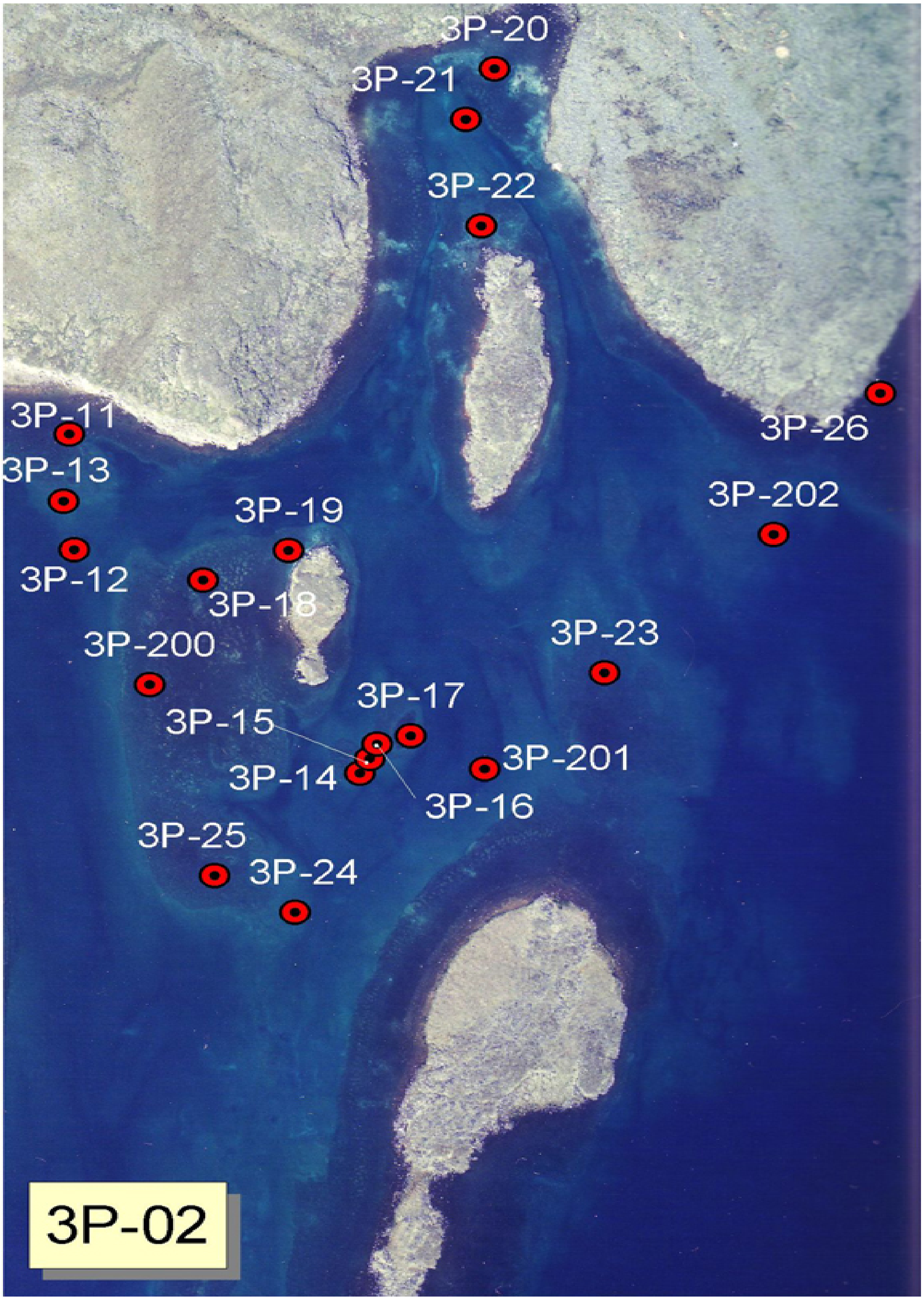


Figure 4: Aerial Photograph of Drop Camera Stations in Third Portage Lake

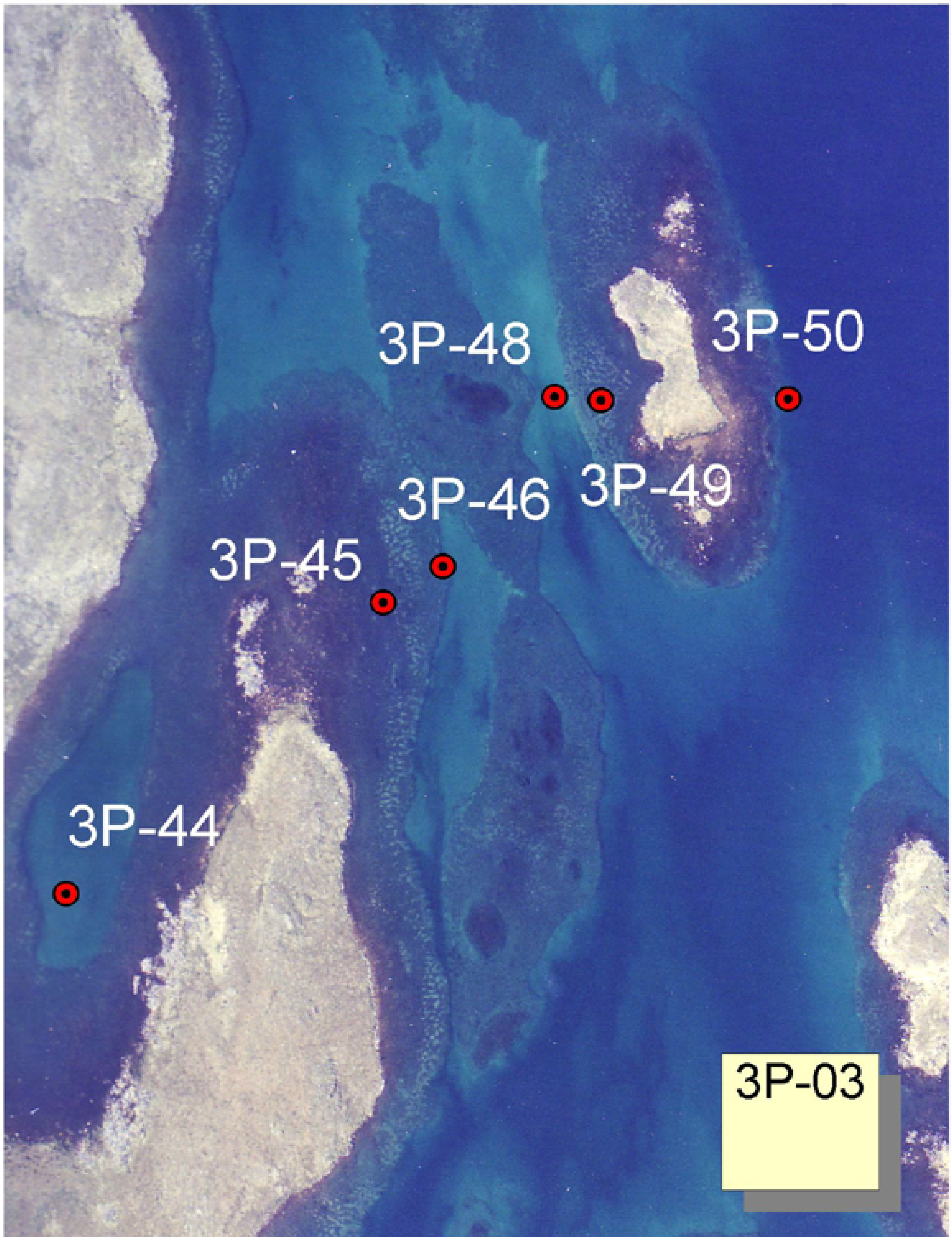
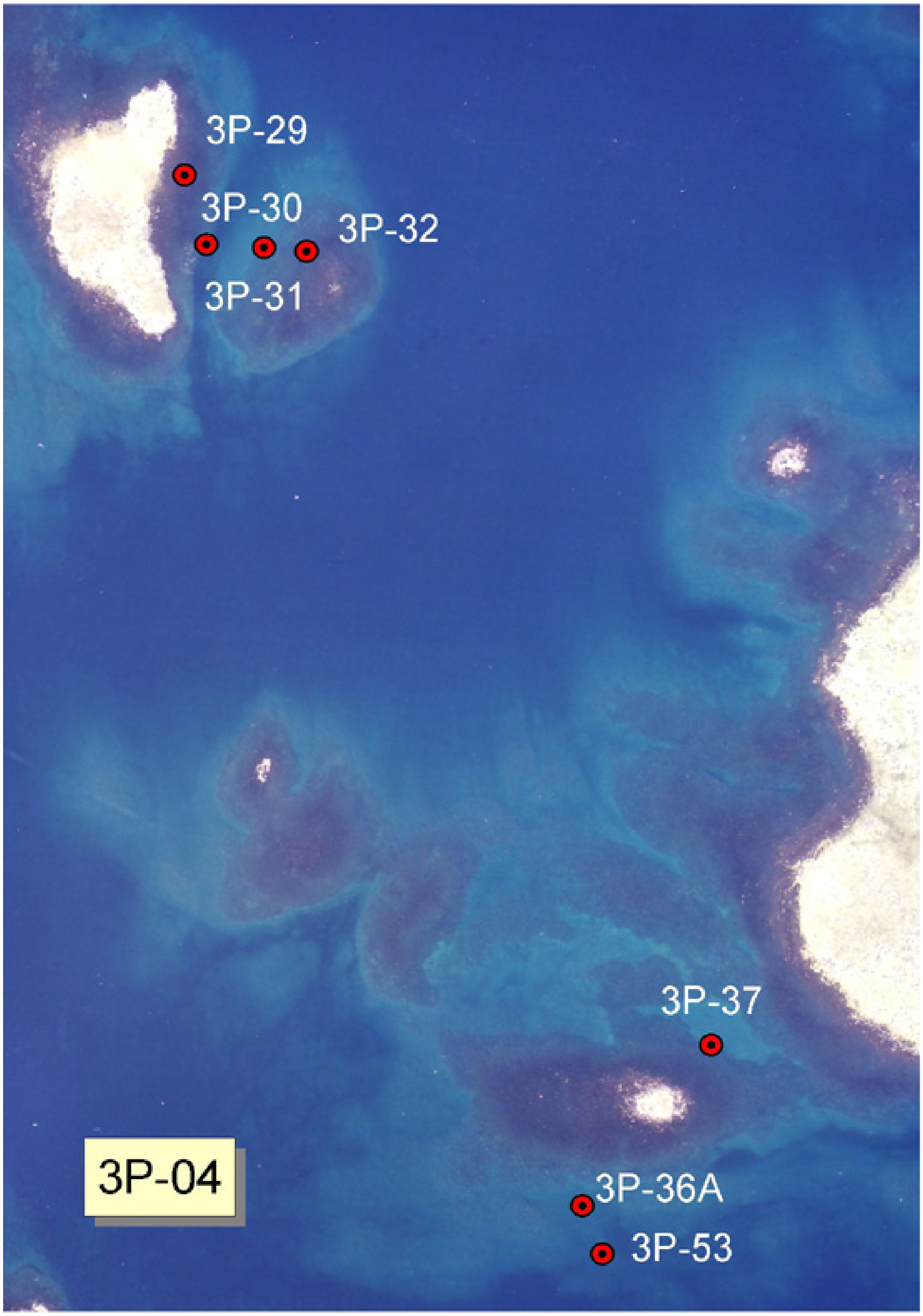


Figure 5: Aerial Photograph of Drop Camera Stations in Third Portage Lake



APPENDIX C

Surface Area, Fish Habitat Attributes & Scoring of Habitat Polygons from Project Area Lakes

Table C.1: Surface Area, Fish Habitat Attributes & Scoring of Habitat Polygons from Project Area Lakes

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
S	S	A	M	U	SA	Second Portage	1.16	2	2	2	4	10	Low
S	M	PS	VD	U	SB	Second Portage	63.58	2	2	1	2	7	Low
B	F	P	S	C	BP	Second Portage	0.34	6	6	4	1	17	Moderate
SB	F	P	S	C	MSA	Second Portage	0.72	4	6	4	1	15	Moderate
S	M	PS	VD	U	SB	Second Portage	21.90	2	2	1	2	7	Low
BS	F	P	S	C	BP	Second Portage	28.63	8	6	4	1	19	High
BS	M	S	M	C	BS	Second Portage	0.99	8	6	3	4	21	High
BS	F	S	S	C	BS	Second Portage	1.06	8	6	3	1	18	High
B	F	P	S	C	BP	Second Portage	0.30	6	6	4	1	17	Moderate
BS	F	P	S	C	BP	Second Portage	0.50	8	6	4	1	19	High
S	M	S	M	U	SA	Second Portage	7.25	2	2	3	4	11	Low
S	M	S	M	U	SA	Second Portage	4.46	2	2	3	4	11	Low
BS	F	P	S	C	BP	Second Portage	1.39	8	6	4	1	19	High
SB	M	A	S	C	MSA	Second Portage	0.85	4	6	2	1	13	Moderate
B	F	P	S	C	BP	Second Portage	0.27	6	6	4	1	17	Moderate
SB	F	P	S	C	SBA	Second Portage	1.56	4	6	4	1	15	Moderate
B	F	P	S	C	BP	Second Portage	0.85	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Second Portage	0.18	6	6	4	1	17	Moderate
BS	F	P	S	C	BP	Second Portage	0.80	8	6	4	1	19	High
S	M	S	M	U	SA	Second Portage	2.52	2	2	3	4	11	Low
BS	F	S	S	C	BS	Second Portage	0.46	8	6	3	1	18	High
SB	F	P	S	C	MSA	Second Portage	4.24	4	6	4	1	15	Moderate
B	F	P	S	C	BP	Second Portage	0.17	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Second Portage	0.62	6	6	4	1	17	Moderate
S	M	PS	VD	U	PB	Second Portage	3.38	2	2	1	2	7	Low
B	F	P	S	C	BP	Second Portage	0.55	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Second Portage	0.18	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Second Portage	0.40	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Second Portage	0.00	6	6	4	1	17	Moderate
S	S	A	M	U	SA	Second Portage	0.49	2	2	2	4	10	Low
BS	F	P	S	C	BP	Second Portage	16.55	8	6	4	1	19	High
BS	F	P	S	C	BP	Second Portage	3.56	8	6	4	1	19	High

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
BS	F	S	S	C	BS	Second Portage	1.52	8	6	3	1	18	High
S	S	PS	VD	U	PB	Second Portage	2.45	2	2	1	2	7	Low
B	F	P	S	C	BP	Second Portage	0.60	6	6	4	1	17	Moderate
BS	F	P	S	U	BP	Second Portage	4.13	8	2	4	1	15	Moderate
B	F	P	S	C	BP	Second Portage	0.63	6	6	4	1	17	Moderate
S	M	A	M	U	SA	Second Portage	1.11	2	2	2	4	10	Low
BS	F	S	S	C	BS	Second Portage	0.21	8	6	3	1	18	High
BS	M	S	M	C	BS	Second Portage	0.12	8	6	3	4	21	High
BS	M	S	M	C	BS	Second Portage	0.59	8	6	3	4	21	High
S	M	S	M	M	SA	Second Portage	0.50	2	4	3	4	13	Moderate
S	M	S	M	U	SA	Second Portage	0.33	2	2	3	4	11	Low
S	M	S	M	U	SA	Second Portage	0.12	2	2	3	4	11	Low
BS	F	S	M	C	BS	Second Portage	0.15	8	6	3	4	21	High
BS	M	S	M	C	BS	Second Portage	0.01	8	6	3	4	21	High
BS	F	S	M	C	BS	Second Portage	0.25	8	6	3	4	21	High
BS	F	S	S	C	BS	Second Portage	0.62	8	6	3	1	18	High
BS	F	S	S	C	BS	Second Portage	0.03	8	6	3	1	18	High
B	F	P	S	C	BP	Second Portage	0.01	6	6	4	1	17	Moderate
BS	F	P	S	C	BP	Second Portage	15.16	8	6	4	1	19	High
BS	F	P	S	C	BP	Second Portage	13.19	8	6	4	1	19	High
S	M	PS	VD	U	BS	Second Portage	138.41	2	2	1	2	7	Low
S	S	A	M	M	SA	Second Portage	2.12	2	4	2	4	12	Low
S	M	S	M	U	SA	Second Portage	1.51	2	2	3	4	11	Low
BS	F	P	S	C	BP	Second Portage	2.51	8	6	4	1	19	High
BS	F	P	S	C	BP	Second Portage	6.49	8	6	4	1	19	High
S	M	S	M	M	SA	Second Portage	8.06	2	4	3	4	13	Moderate
S	M	S	M	U	SA	Second Portage	2.04	2	2	3	4	11	Low
BS	F	P	S	C	BP	Second Portage	0.25	8	6	4	1	19	High
BS	F	P	S	C	BP	Second Portage	2.10	8	6	4	1	19	High
S	S	A	M	M	SA	Second Portage	0.24	2	4	2	4	12	Low
BS	F	S	S	C	BS	Second Portage	0.45	8	6	3	1	18	High
S	S	A	M	M	SA	Second Portage	0.43	2	4	2	4	12	Low
S	S	A	M	U	SA	Second Portage	0.55	2	2	2	4	10	Low

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
BS	F	P	S	C	BP	Second Portage	3.07	8	6	4	1	19	High
S	M	A	M	M	SA	Third Portage	0.73	2	4	2	4	12	Low
B	F	P	S	M	BP	Third Portage	0.59	6	4	4	1	15	Moderate
S	M	A	S	C	SA	Third Portage	0.08	2	6	4	1	13	Moderate
S	M	A	S	C	SA	Third Portage	0.15	2	6	4	1	13	Moderate
S	S	A	M	U	SA	Third Portage	1.01	2	2	2	4	10	Low
B	F	P	S	C	BP	Third Portage	0.48	6	6	4	1	17	Moderate
S	S	PS	VD	U	PB	Third Portage	22.24	2	2	1	2	7	Low
S	S	A	M	U	SA	Third Portage	0.86	2	2	2	4	10	Low
BS	F	S	S	C	BS	Third Portage	0.04	8	6	3	1	18	High
BS	F	S	M	C	BS	Third Portage	0.10	8	6	3	4	21	High
BS	F	S	M	C	BS	Third Portage	0.24	8	6	3	4	21	High
BS	M	S	S	C	BS	Third Portage	0.07	8	6	3	1	18	High
S	M	S	M	U	SA	Third Portage	28.54	2	2	3	4	11	Low
S	M	PS	VD	U	PB	Third Portage	0.30	2	2	1	2	7	Low
BS	F	P	S	C	BP	Third Portage	2.36	8	6	4	1	19	High
B	F	P	S	C	BP	Third Portage	0.12	6	6	4	1	17	Moderate
BS	F	P	S	C	BP	Third Portage	19.66	8	6	4	1	19	High
BS	F	P	S	C	BP	Third Portage	13.21	8	6	4	1	19	High
BS	M	S	M	C	BS	Third Portage	0.00	8	6	3	4	21	High
BS	M	S	M	C	BS	Third Portage	0.00	8	6	3	4	21	High
S	M	S	M	M	SA	Third Portage	3.47	2	4	3	4	13	Moderate
BS	F	P	M	C	BP	Third Portage	7.21	8	6	4	4	22	High
BS	F	S	M	C	BS	Third Portage	0.04	8	6	3	4	21	High
BS	F	S	M	C	BS	Third Portage	0.66	8	6	3	4	21	High
BS	F	P	S	C	BP	Third Portage	0.00	8	6	4	1	19	High
BS	F	P	S	C	BP	Third Portage	3.32	8	6	4	1	19	High
B	M	S	M	M	BS	Third Portage	0.30	6	4	3	4	17	Moderate
S	M	S	M	U	SA	Third Portage	18.74	2	2	3	4	11	Low
B	F	P	S	C	BP	Third Portage	0.10	6	6	4	1	17	Moderate
BS	F	P	S	C	BP	Third Portage	3.00	8	6	4	1	19	High
B	F	P	S	C	BP	Third Portage	0.23	6	6	4	1	17	Moderate
BS	F	S	M	C	BS	Third Portage	0.11	8	6	3	4	21	High

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
S	M	A	M	U	SA	Third Portage	0.18	2	2	2	4	10	Low
B	F	P	S	M	BP	Third Portage	9.28	6	4	4	1	15	Moderate
BS	F	P	S	C	BP	Third Portage	20.23	8	6	4	1	19	High
S	M	A	M	U	SA	Third Portage	0.04	2	2	2	4	10	Low
BS	F	P	S	C	BP	Third Portage	2.75	8	6	4	1	19	High
SB	M	A	S	C	MSA	Third Portage	0.33	4	6	2	1	13	Moderate
SB	F	P	S	C	MSA	Third Portage	0.53	4	6	4	1	15	Moderate
SB	F	P	S	C	MSA	Third Portage	0.16	4	6	4	1	15	Moderate
BS	F	S	S	C	BS	Third Portage	0.16	8	6	3	1	18	High
SB	S	A	M	M	MSA	Third Portage	0.28	4	4	2	4	14	Moderate
B	F	P	S	M	BP	Third Portage	1.14	6	4	4	1	15	Moderate
BS	F	P	S	C	BP	Third Portage	2.03	8	6	4	1	19	High
S	M	A	S	C	SA	Third Portage	0.09	2	6	4	1	13	Moderate
SB	M	P	M	C	MSA	Third Portage	1.90	4	6	4	4	18	High
B	F	P	S	C	BP	Third Portage	0.14	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Third Portage	0.27	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Third Portage	0.71	6	6	4	1	17	Moderate
BS	M	S	S	C	BS	Third Portage	0.67	8	6	3	1	18	High
SB	F	P	S	C	MSA	Third Portage	1.02	4	6	4	1	15	Moderate
SB	F	P	S	C	MSA	Third Portage	0.32	4	6	4	1	15	Moderate
B	F	P	S	M	BP	Third Portage	0.57	6	4	4	1	15	Moderate
S	M	A	M	U	SA	Third Portage	19.25	2	2	2	4	10	Low
B	S	A	M	M	BA	Third Portage	2.16	8	4	2	4	18	High
BS	F	S	S	C	BS	Third Portage	0.17	8	6	3	1	18	High
BS	M	S	S	C	BS	Third Portage	1.35	8	6	3	1	18	High
B	F	P	S	C	BP	Third Portage	2.99	6	6	4	1	17	Moderate
B	F	P	S	M	BP	Third Portage	3.85	6	4	4	1	15	Moderate
BS	M	S	M	C	BS	Third Portage	0.12	8	6	3	4	21	High
B	F	P	S	C	BP	Third Portage	0.20	6	6	4	1	17	Moderate
BS	F	P	S	C	BP	Third Portage	6.38	8	6	4	1	19	High
S	M	A	M	U	SA	Third Portage	1.78	2	2	2	4	10	Low
B	F	P	S	C	BP	Third Portage	0.17	6	6	4	1	17	Moderate
B	S	A	M	M	BA	Third Portage	0.38	8	4	2	4	18	High

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
B	S	A	M	M	BA	Third Portage	0.97	8	4	2	4	18	High
BS	F	S	M	M	BS	Third Portage	2.86	8	4	3	4	19	High
S	M	S	M	U	SA	Third Portage	13.92	2	2	3	4	11	Low
S	M	S	M	U	SA	Third Portage	1.24	2	2	3	4	11	Low
B	M	S	M	U	BS	Third Portage	0.45	6	2	3	4	15	Moderate
B	F	P	S	M	BP	Third Portage	0.52	6	4	4	1	15	Moderate
S	S	A	M	U	SA	Third Portage	1.51	2	2	2	4	10	Low
B	M	A	S	M	BA	Third Portage	3.43	8	4	2	1	15	Moderate
B	M	S	S	U	BS	Third Portage	0.12	6	2	3	1	12	Low
B	F	P	S	C	BP	Third Portage	0.64	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Third Portage	0.75	6	6	4	1	17	Moderate
BS	F	S	S	C	BS	Third Portage	1.17	8	6	3	1	18	High
B	M	S	M	M	BS	Third Portage	5.91	6	4	3	4	17	Moderate
SB	M	A	S	C	MSA	Third Portage	0.34	4	6	2	1	13	Moderate
B	F	P	S	C	BP	Third Portage	0.78	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Third Portage	0.54	6	6	4	1	17	Moderate
SB	F	P	S	C	MSA	Third Portage	0.00	4	6	4	1	15	Moderate
S	M	S	M	U	SA	Third Portage	1.12	2	2	3	4	11	Low
B	S	A	M	M	BA	Third Portage	1.45	8	4	2	4	18	High
SB	F	P	S	C	MSA	Third Portage	0.18	4	6	4	1	15	Moderate
S	M	A	M	U	SA	Third Portage	0.86	2	2	2	4	10	Low
S	M	A	M	U	SA	Third Portage	0.72	2	2	2	4	10	Low
BS	F	P	S	C	BP	Third Portage	6.20	8	6	4	1	19	High
S	M	PS	VD	U	SB	Third Portage	11.62	2	2	1	2	7	Low
S	S	A	M	U	SA	Third Portage	1.37	2	2	2	4	10	Low
B	F	P	S	M	BP	Third Portage	0.77	6	4	4	1	15	Moderate
B	F	S	M	M	BS	Third Portage	1.16	6	4	3	4	17	Moderate
BS	F	P	S	C	BP	Third Portage	6.53	8	6	4	1	19	High
BS	F	P	S	C	BP	Third Portage	1.24	8	6	4	1	19	High
BS	F	P	S	C	BP	Third Portage	7.69	8	6	4	1	19	High
S	M	A	M	U	SA	Third Portage	1.58	2	2	2	4	10	Low
S	M	S	D	U	SA	Third Portage	17.54	2	2	3	3	10	Low
B	F	P	S	C	BP	Third Portage	1.52	6	6	4	1	17	Moderate

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
B	M	A	S	M	BA	Third Portage	0.33	8	4	2	1	15	Moderate
BS	M	S	S	C	BS	Third Portage	0.44	8	6	3	1	18	High
BS	M	S	M	C	BS	Third Portage	0.88	8	6	3	4	21	High
BS	M	S	S	C	BS	Third Portage	1.08	8	6	3	1	18	High
B	F	P	S	C	BP	Third Portage	1.85	6	6	4	1	17	Moderate
B	M	A	S	M	BA	Third Portage	2.76	8	4	2	1	15	Moderate
BS	F	S	S	C	BS	Third Portage	0.29	8	6	3	1	18	High
B	M	S	S	U	BS	Third Portage	0.07	6	2	3	1	12	Low
B	M	S	S	U	BS	Third Portage	0.09	6	2	3	1	12	Low
B	M	S	S	U	BS	Third Portage	0.06	6	2	3	1	12	Low
B	M	S	S	U	BS	Third Portage	0.14	6	2	3	1	12	Low
S	M	A	M	U	SA	Third Portage	1.15	2	2	2	4	10	Low
BS	M	S	S	C	BS	Third Portage	0.17	8	6	3	1	18	High
BS	M	S	S	C	BS	Third Portage	1.54	8	6	3	1	18	High
BS	M	S	S	C	BS	Third Portage	1.17	8	6	3	1	18	High
BS	M	S	M	C	BS	Third Portage	0.32	8	6	3	4	21	High
BS	F	S	S	C	BS	Third Portage	1.01	8	6	3	1	18	High
BS	F	S	S	C	BS	Third Portage	0.13	8	6	3	1	18	High
BS	M	S	M	C	BS	Third Portage	0.92	8	6	3	4	21	High
S	F	S	M	U	SA	Third Portage	0.86	2	2	3	4	11	Low
BS	M	S	S	C	BS	Third Portage	0.83	8	6	3	1	18	High
BS	M	S	S	C	BS	Third Portage	0.21	8	6	3	1	18	High
B	F	S	M	M	BS	Third Portage	0.35	6	4	3	4	17	Moderate
BS	F	S	S	C	BS	Third Portage	0.15	8	6	3	1	18	High
BS	F	S	M	C	BS	Third Portage	1.07	8	6	3	4	21	High
BS	M	S	M	C	BS	Third Portage	0.55	8	6	3	4	21	High
BS	F	S	M	C	BS	Third Portage	0.29	8	6	3	4	21	High
BS	F	S	M	C	BS	Third Portage	0.16	8	6	3	4	21	High
S	M	S	M	U	SA	Third Portage	0.93	2	2	3	4	11	Low
BS	M	S	S	C	BS	Third Portage	0.23	8	6	3	1	18	High
BS	F	S	S	C	BS	Third Portage	0.08	8	6	3	1	18	High
BS	F	S	S	C	BS	Third Portage	0.53	8	6	3	1	18	High
BS	M	S	S	C	BS	Third Portage	1.92	8	6	3	1	18	High

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
S	M	S	M	U	SA	Third Portage	0.79	2	2	3	4	11	Low
S	M	PS	VD	U	SB	Third Portage	0.61	2	2	1	2	7	Low
S	M	PS	D	U	SB	Third Portage	2.40	2	2	1	3	8	Low
S	M	PS	VD	U	SB	Third Portage	0.84	2	2	1	2	7	Low
S	S	S	D	U	SA	Third Portage	0.93	2	2	3	3	10	Low
S	M	S	D	U	SA	Third Portage	2.14	2	2	3	3	10	Low
S	M	PS	D	U	PB	Third Portage	9.28	2	2	1	3	8	Low
BS	F	S	M	C	BS	Third Portage	0.63	8	6	3	4	21	High
S	M	S	D	U	SA	Third Portage	0.85	2	2	3	3	10	Low
BS	F	S	S	C	BS	Third Portage	0.07	8	6	3	1	18	High
BS	M	S	S	C	BS	Third Portage	0.37	8	6	3	1	18	High
BS	M	S	M	C	BS	Third Portage	0.18	8	6	3	4	21	High
S	M	PS	D	U	PB	Third Portage	4.45	2	2	1	3	8	Low
BS	F	S	S	C	BS	Third Portage	0.07	8	6	3	1	18	High
BS	F	S	S	C	BS	Third Portage	0.05	8	6	3	1	18	High
BS	M	S	S	C	BS	Third Portage	0.17	8	6	3	1	18	High
BS	M	S	S	C	BS	Third Portage	0.02	8	6	3	1	18	High
S	F	S	M	U	SA	Third Portage	0.45	2	2	3	4	11	Low
S	M	S	M	M	SA	Third Portage	8.94	2	4	3	4	13	Moderate
BS	M	S	M	C	BS	Third Portage	0.33	8	6	3	4	21	High
BS	F	S	S	C	BS	Third Portage	0.27	8	6	3	1	18	High
B	F	P	S	M	BP	Third Portage	2.38	6	4	4	1	15	Moderate
B	M	A	M	M	BA	Third Portage	1.09	8	4	2	4	18	High
SB	M	A	S	C	MSA	Third Portage	0.51	4	6	2	1	13	Moderate
S	M	S	M	U	SA	Third Portage	91.52	2	2	3	4	11	Low
S	M	S	M	M	SA	Third Portage	17.19	2	4	3	4	13	Moderate
S	M	PS	VD	U	SB	Third Portage	210.18	2	2	1	2	7	Low
SB	F	P	S	C	MSA	Third Portage	1.16	4	6	4	1	15	Moderate
BS	F	P	S	C	BP	Third Portage	20.26	8	6	4	1	19	High
BS	F	P	S	C	BP	Third Portage	28.14	8	6	4	1	19	High
BS	F	P	S	C	BP	Third Portage	0.00	8	6	4	1	19	High
S	M	S	M	M	SA	Third Portage	5.96	2	4	3	4	13	Moderate
S	M	A	M	U	SA	Third Portage	11.73	2	2	2	4	10	Low

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
BS	F	P	S	C	BP	Third Portage	16.81	8	6	4	1	19	High
B	F	P	S	C	BP	Third Portage	1.29	6	6	4	1	17	Moderate
BS	F	P	S	C	BP	Third Portage	6.35	8	6	4	1	19	High
BS	F	P	S	C	BP	Third Portage	14.58	8	6	4	1	19	High
S	M	S	M	U	SA	Third Portage	29.70	2	2	3	4	11	Low
BS	F	P	S	C	BP	Third Portage	3.06	8	6	4	1	19	High
SB	M	P	S	C	MSA	Third Portage	23.48	4	6	4	1	15	Moderate
BS	M	S	M	C	BS	Third Portage	11.46	8	6	3	4	21	High
S	M	S	M	M	SA	Third Portage	10.27	2	4	3	4	13	Moderate
S	M	S	M	M	SA	Third Portage	4.24	2	4	3	4	13	Moderate
B	F	P	S	M	BP	Third Portage	0.72	6	4	4	1	15	Moderate
B	F	S	M	U	BS	Third Portage	0.33	6	2	3	4	15	Moderate
S	M	A	M	M	SA	Third Portage	44.56	2	4	2	4	12	Low
S	M	S	M	M	SA	Third Portage	9.96	2	4	3	4	13	Moderate
SB	F	P	S	C	MSA	Third Portage	0.66	4	6	4	1	15	Moderate
B	M	S	S	U	BS	Third Portage	0.27	6	2	3	1	12	Low
B	F	S	S	M	BS	Third Portage	1.88	6	4	3	1	14	Moderate
S	M	A	M	U	SA	Third Portage	2.49	2	2	2	4	10	Low
BS	M	S	S	C	BS	Third Portage	2.56	8	6	3	1	18	High
BS	F	P	S	C	BP	Third Portage	1.08	8	6	4	1	19	High
BS	M	S	S	C	BS	Third Portage	0.15	8	6	3	1	18	High
B	F	S	S	M	BS	Third Portage	2.71	6	4	3	1	14	Moderate
B	F	S	S	M	BS	Third Portage	3.53	6	4	3	1	14	Moderate
BS	M	S	S	C	BS	Third Portage	0.15	8	6	3	1	18	High
BS	M	S	M	C	BS	Third Portage	0.32	8	6	3	4	21	High
BS	F	P	S	C	BP	Third Portage	2.17	8	6	4	1	19	High
BS	M	S	S	C	BS	Third Portage	6.16	8	6	3	1	18	High
BS	M	S	M	C	BS	Third Portage	0.85	8	6	3	4	21	High
BS	M	S	M	C	BS	Third Portage	1.82	8	6	3	4	21	High
BS	F	S	M	C	BS	Third Portage	2.10	8	6	3	4	21	High
BS	F	S	S	C	BS	Third Portage	1.43	8	6	3	1	18	High
S	M	A	M	U	SA	Third Portage	0.89	2	2	2	4	10	Low
S	M	A	M	U	SA	Third Portage	1.56	2	2	2	4	10	Low

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
BS	F	S	S	C	BS	Third Portage	1.04	8	6	3	1	18	High
SB	M	A	S	C	MSA	Third Portage	1.33	4	6	2	1	13	Moderate
BS	M	S	S	C	BS	Third Portage	3.06	8	6	3	1	18	High
BS	F	S	M	C	BS	Third Portage	2.64	8	6	3	4	21	High
BS	F	P	S	C	BP	Third Portage	15.75	8	6	4	1	19	High
S	M	S	M	U	SA	Third Portage	93.79	2	2	3	4	11	Low
BS	F	S	M	C	BS	Third Portage	11.97	8	6	3	4	21	High
S	M	PS	VD	U	SB	Third Portage	794.85	2	2	1	2	7	Low
S	M	S	M	U	SA	Third Portage	1.49	2	2	3	4	11	Low
BS	F	S	S	C	BS	Third Portage	1.01	8	6	3	1	18	High
B	F	P	S	C	BP	Third Portage	0.09	6	6	4	1	17	Moderate
BS	M	S	M	C	BS	Third Portage	0.08	8	6	3	4	21	High
BS	F	S	M	C	BS	Third Portage	0.06	8	6	3	4	21	High
BS	F	S	S	C	BS	Third Portage	0.20	8	6	3	1	18	High
BS	M	S	S	C	BS	Third Portage	0.12	8	6	3	1	18	High
BS	F	S	M	C	BS	Third Portage	0.14	8	6	3	4	21	High
BS	F	S	S	C	BS	Third Portage	1.23	8	6	3	1	18	High
BS	F	S	M	C	BS	Third Portage	0.18	8	6	3	4	21	High
S	S	A	M	M	SA	Third Portage	0.14	2	4	2	4	12	Low
BS	M	A	M	C	BA	Third Portage	0.40	8	6	2	4	20	High
B	M	S	M	M	BS	Third Portage	0.10	6	4	3	4	17	Moderate
S	M	S	M	U	SA	Third Portage	9.30	2	2	3	4	11	Low
BS	F	P	S	C	BP	Third Portage	4.65	8	6	4	1	19	High
B	F	P	S	C	BP	Third Portage	0.81	6	6	4	1	17	Moderate
BS	F	P	S	C	BP	Third Portage	24.00	8	6	4	1	19	High
S	M	S	M	U	SA	Third Portage	5.22	2	2	3	4	11	Low
BS	F	P	S	C	BP	Third Portage	17.86	8	6	4	1	19	High
S	M	PS	VD	U	SB	Third Portage	566.87	2	2	1	2	7	Low
BS	M	S	M	C	BS	Third Portage	1.00	8	6	3	4	21	High
BS	F	P	S	C	BP	Third Portage	6.21	8	6	4	1	19	High
S	M	A	M	U	SA	Third Portage	0.33	2	2	2	4	10	Low
B	F	P	S	C	BP	Third Portage	0.46	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Third Portage	0.31	6	6	4	1	17	Moderate

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
S	M	A	M	U	SA	Third Portage	0.05	2	2	2	4	10	Low
BS	F	P	S	C	BP	Third Portage	1.70	8	6	4	1	19	High
B	M	A	S	M	BA	Third Portage	7.21	8	4	2	1	15	Moderate
S	M	A	M	U	SA	Third Portage	5.38	2	2	2	4	10	Low
S	M	S	M	U	SA	Third Portage	9.16	2	2	3	4	11	Low
S	M	S	M	M	SA	Third Portage	1.56	2	4	3	4	13	Moderate
S	M	A	M	U	SA	Third Portage	4.43	2	2	2	4	10	Low
S	M	A	M	U	SA	Third Portage	4.38	2	2	2	4	10	Low
BS	F	P	S	C	BP	Third Portage	7.69	8	6	4	1	19	High
S	M	A	M	U	SA	Third Portage	2.76	2	2	2	4	10	Low
BS	M	S	M	C	BS	Third Portage	0.38	8	6	3	4	21	High
BS	F	P	S	C	BP	Third Portage	2.90	8	6	4	1	19	High
BS	F	P	S	C	BP	Third Portage	3.61	8	6	4	1	19	High
BS	F	P	S	C	BP	Third Portage	3.21	8	6	4	1	19	High
B	F	S	S	C	BS	Vault/Wally	1.18	6	6	3	1	16	Moderate
B	M	S	S	C	BS	Vault/Wally	0.34	6	6	3	1	16	Moderate
S	M	A	M	U	SA	Vault/Wally	0.27	2	2	4	4	12	Low
B	M	S	M	C	BS	Vault/Wally	0.32	6	6	3	4	19	High
S	M	A	M	U	SA	Vault/Wally	0.34	2	2	4	4	12	Low
S	M	A	M	U	SA	Vault/Wally	0.20	2	2	4	4	12	Low
S	M	A	M	U	SA	Vault/Wally	0.03	2	2	4	4	12	Low
S	M	A	M	U	SA	Vault/Wally	0.40	2	2	4	4	12	Low
S	M	A	M	U	SA	Vault/Wally	0.14	2	2	4	4	12	Low
B	M	S	S	C	BS	Vault/Wally	0.55	6	6	3	1	16	Moderate
B	M	S	S	C	BS	Vault/Wally	0.20	6	6	3	1	16	Moderate
B	M	S	M	C	BS	Vault/Wally	0.07	6	6	3	4	19	High
B	F	P	S	C	BP	Vault/Wally	1.11	6	6	4	1	17	Moderate
S	M	PS	VD	U	SB	Vault/Wally	4.20	2	2	1	2	7	Low
B	M	S	M	C	BS	Vault/Wally	0.17	6	6	3	4	19	High
B	M	S	M	C	BS	Vault/Wally	0.13	6	6	3	4	19	High
S	M	PS	VD	U	SB	Vault/Wally	1.24	2	2	1	2	7	Low
B	M	S	S	C	BS	Vault/Wally	0.16	6	6	3	1	16	Moderate
S	M	A	M	U	SA	Vault/Wally	0.50	2	2	4	4	12	Low

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
S	M	A	M	U	SA	Vault/Wally	0.35	2	2	4	4	12	Low
B	M	S	S	C	BS	Vault/Wally	0.46	6	6	3	1	16	Moderate
B	M	S	S	C	BS	Vault/Wally	0.37	6	6	3	1	16	Moderate
S	M	A	M	U	SA	Vault/Wally	0.18	2	2	4	4	12	Low
S	M	A	M	U	SA	Vault/Wally	0.17	2	2	4	4	12	Low
S	M	A	M	U	SA	Vault/Wally	4.22	2	2	4	4	12	Low
S	M	A	M	U	SA	Vault/Wally	2.13	2	2	4	4	12	Low
B	M	S	M	C	BS	Vault/Wally	0.19	6	6	3	4	19	High
S	M	A	M	U	SA	Vault/Wally	1.85	2	2	4	4	12	Low
S	M	A	M	U	SA	Vault/Wally	0.26	2	2	4	4	12	Low
S	M	PS	VD	U	SB	Vault/Wally	0.35	2	2	1	2	7	Low
B	S	A	M	C	BA	Vault/Wally	0.54	8	6	2	4	20	High
B	F	P	S	C	BP	Vault/Wally	0.27	6	6	4	1	17	Moderate
S	M	A	M	U	SA	Vault/Wally	1.93	2	2	4	4	12	Low
B	F	P	S	C	BP	Vault/Wally	0.83	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	0.66	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	0.28	6	6	4	1	17	Moderate
S	M	A	S	U	SA	Vault/Wally	0.12	2	2	4	1	9	Low
S	M	A	M	U	SA	Vault/Wally	2.07	2	2	4	4	12	Low
B	F	P	S	C	BP	Vault/Wally	0.39	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	1.00	6	6	4	1	17	Moderate
SB	S	A	M	M	MSA	Vault/Wally	1.94	4	4	2	4	14	Moderate
SB	S	A	M	M	MSA	Vault/Wally	1.92	4	4	2	4	14	Moderate
S	M	PS	VD	U	SB	Vault/Wally	6.63	2	2	1	1	6	Low
S	M	A	M	U	SA	Vault/Wally	1.07	2	2	4	4	12	Low
B	M	S	M	C	BS	Vault/Wally	11.59	6	6	3	4	19	High
B	S	A	M	C	BA	Vault/Wally	2.54	8	6	2	4	20	High
B	F	P	S	C	BP	Vault/Wally	0.54	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	0.64	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	0.12	6	6	4	1	17	Moderate
BS	S	A	M	C	BA	Vault/Wally	0.50	8	6	2	4	20	High
B	M	S	S	C	BS	Vault/Wally	0.41	6	6	3	1	16	Moderate
BS	F	P	S	C	BP	Vault/Wally	22.69	8	6	4	1	19	High

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
SB	S	A	M	M	MSA	Vault/Wally	0.68	4	4	2	4	14	Moderate
B	M	S	S	C	BS	Vault/Wally	22.86	6	6	3	1	16	Moderate
B	S	A	M	C	BA	Vault/Wally	1.13	8	6	2	4	20	High
B	F	P	S	C	BP	Vault/Wally	1.56	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	0.39	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	1.44	6	6	4	1	17	Moderate
B	M	S	S	C	BS	Vault/Wally	0.61	6	6	3	1	16	Moderate
B	M	S	S	C	BS	Vault/Wally	2.66	6	6	3	1	16	Moderate
B	F	P	S	C	BP	Vault/Wally	0.48	6	6	4	1	17	Moderate
SB	S	A	M	M	MSA	Vault/Wally	5.71	4	4	2	4	14	Moderate
S	M	PS	VD	U	SB	Vault/Wally	2.63	2	2	1	2	7	Low
B	S	A	M	C	BA	Vault/Wally	0.43	8	6	2	4	20	High
B	F	P	S	C	BP	Vault/Wally	5.32	6	6	4	1	17	Moderate
BS	S	A	M	C	BA	Vault/Wally	2.51	8	6	2	4	20	High
B	F	P	S	C	BP	Vault/Wally	8.53	6	6	4	1	17	Moderate
S	M	PS	VD	U	SB	Vault/Wally	5.13	2	2	1	2	7	Low
B	F	P	S	C	BP	Vault/Wally	0.66	6	6	4	1	17	Moderate
S	M	PS	VD	U	SB	Vault/Wally	11.35	2	2	1	2	7	Low
B	F	P	S	C	BP	Vault/Wally	0.30	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	0.17	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	0.35	6	6	4	1	17	Moderate
SB	S	A	M	M	MSA	Vault/Wally	13.59	4	4	2	4	14	Moderate
SB	S	A	M	M	MSA	Vault/Wally	4.55	4	4	2	4	14	Moderate
S	M	PS	VD	U	SB	Vault/Wally	3.08	2	2	1	2	7	Low
S	M	A	M	U	SA	Vault/Wally	1.92	2	2	4	4	12	Low
B	M	S	S	C	BS	Vault/Wally	0.60	6	6	3	1	16	Moderate
BS	F	P	S	C	BP	Vault/Wally	4.85	8	6	4	1	19	High
B	S	A	M	C	BA	Vault/Wally	0.56	8	6	2	4	20	High
B	M	S	S	C	BS	Vault/Wally	3.55	6	6	3	1	16	Moderate
B	M	S	M	C	BS	Vault/Wally	17.94	6	6	3	4	19	High
B	F	P	S	C	BP	Vault/Wally	4.08	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	1.38	6	6	4	1	17	Moderate
SB	S	A	M	M	MSA	Vault/Wally	0.10	4	4	2	4	14	Moderate

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
S	M	PS	VD	U	SB	Vault/Wally	0.57	2	2	1	2	7	Low
SB	S	A	M	M	MSA	Vault/Wally	0.26	4	4	2	4	14	Moderate
B	S	A	M	C	BA	Vault/Wally	0.65	8	6	2	4	20	High
SB	S	A	M	M	MSA	Vault/Wally	1.44	4	4	2	4	14	Moderate
S	M	PS	VD	U	SB	Vault/Wally	0.62	2	2	1	2	7	Low
SB	S	A	M	M	MSA	Vault/Wally	0.50	4	4	2	4	14	Moderate
B	F	P	S	C	BP	Vault/Wally	0.23	6	6	4	1	17	Moderate
B	M	S	M	C	BS	Vault/Wally	10.99	6	6	3	4	19	High
S	M	PS	VD	U	SB	Vault/Wally	12.03	2	2	1	2	7	Low
BS	S	A	M	M	BA	Vault/Wally	0.87	8	4	2	4	18	High
BS	S	A	M	C	BA	Vault/Wally	2.99	8	6	2	4	20	High
S	M	PS	VD	U	SB	Vault/Wally	13.07	2	2	1	2	7	Low
S	M	A	M	U	SA	Vault/Wally	10.57	2	2	4	4	12	Low
B	M	S	S	C	BS	Vault/Wally	5.83	6	6	3	1	16	Moderate
S	S	A	M	U	SA	Vault/Wally	1.48	2	2	2	4	10	Low
S	M	PS	VD	U	SB	Vault/Wally	10.55	2	2	1	2	7	Low
B	F	P	S	C	BP	Vault/Wally	0.43	6	6	4	1	17	Moderate
BS	M	A	M	M	BA	Vault/Wally	0.25	8	4	2	4	18	High
S	M	A	M	U	SA	Vault/Wally	0.23	2	2	4	4	12	Low
SB	S	A	M	M	MSA	Vault/Wally	2.20	4	4	2	4	14	Moderate
B	F	P	S	C	BP	Vault/Wally	0.10	6	6	4	1	17	Moderate
B	F	P	S	C	BP	Vault/Wally	0.17	6	6	4	1	17	Moderate
B	F	P	S	M	BP	Vault/Wally	0.26	6	4	4	1	15	Moderate
BS	M	A	M	C	BA	Vault/Wally	1.01	8	6	2	4	20	High
BS	M	S	M	C	BS	Vault/Wally	3.13	8	6	3	4	21	High
B	S	A	M	C	BA	Vault/Wally	3.23	8	6	2	4	20	High
BS	F	P	S	M	BP	Vault/Wally	0.54	8	4	4	1	17	Moderate
S	M	A	M	U	SA	Vault/Wally	0.23	2	2	2	4	10	Low
BS	S	A	M	M	BA	Vault/Wally	0.38	8	4	2	4	18	High
B	F	P	S	C	BP	Vault/Wally	0.72	6	6	4	1	17	Moderate
S	M	PS	VD	U	SB	Vault/Wally	3.27	2	2	1	2	7	Low
BS	F	P	S	M	BP	Vault/Wally	1.86	8	4	4	1	17	Moderate
B	M	S	M	C	BS	Vault/Wally	1.19	6	6	3	4	19	High

Table C.1 – Continued

Substrate	Slope	Morphology	Depth	Complexity	Habitat Type	Lake	Polygon Area (ha)	Score				Total Score	Overall Value
								Substrate	Complexity	Morphology	Depth		
S	M	PS	VD	U	SB	Vault/Wally	16.76	2	2	1	2	7	Low
S	S	A	M	U	SA	Vault/Wally	0.83	2	2	2	4	10	Low
BS	F	P	S	C	BP	Vault/Wally	41.00	8	6	4	1	19	High
SB	S	A	M	M	MSA	Vault/Wally	7.87	4	4	2	4	14	Moderate
SB	F	P	S	C	MSA	Vault/Wally	15.01	4	6	4	1	15	Moderate
BS	F	P	S	C	BP	Vault/Wally	44.48	8	6	4	1	19	High
SB	S	A	M	M	MSA	Vault/Wally	14.23	4	4	2	4	14	Moderate
SB	S	A	M	M	MSA	Vault/Wally	2.32	4	4	2	4	14	Moderate
S	M	PS	VD	U	SB	Vault/Wally	50.91	2	2	1	2	7	Low
B	F	P	S	C	BP	Vault/Wally	67.08	6	6	4	1	17	Moderate
B	M	S	M	C	BS	Vault/Wally	45.86	6	6	3	4	19	High
S	M	PS	VD	U	PB	Vault/Wally	12.86	2	2	1	2	7	Low
BS	F	P	S	C	BP	Vault/Wally	24.06	8	6	4	1	19	High
B	F	P	S	C	BP	Vault/Wally	22.66	6	6	4	1	17	Moderate
S	M	PS	VD	U	SB	Vault/Wally	18.00	2	2	1	2	7	Low
S	M	A	S	U	SA	Vault/Wally	1.37	2	2	2	1	7	Low
SB	S	A	M	M	MSA	Vault/Wally	5.19	4	4	2	4	14	Moderate
B	F	P	S	M	BP	Vault/Wally	2.82	6	4	4	1	15	Moderate

Notes: Habitat: B = Boulder, BS = Boulder/cobble with sediment, SB = Sediment with boulder/cobble, S = Fine sediment, Substrate: B = Boulder, BS = Boulder/cobble with sediment, SB = Sediment with boulder/cobble, S = Fine sediment, Slope: S = Shallow, M = Moderate, S = Steep, Depth: S = Shallow (0-2 m), M = Moderate (2-4 m), D = Deep (4-6 m), VD = Very deep (>6 m), Complexity: U = Uniform, M = Moderate, C = Complex, Habitat Type: BP = Boulder Platform, BS = Boulder Shoal, BA = Boulder Apron, MSA = Mixed Sediment Apron, SA = Sediment Apron, SB = Sediment Basin

APPENDIX D

Drop Camera Images of Representative Habitat Types
in Project Area Lakes

Figure 1: Boulder Platform Habitat, Station 2P-200

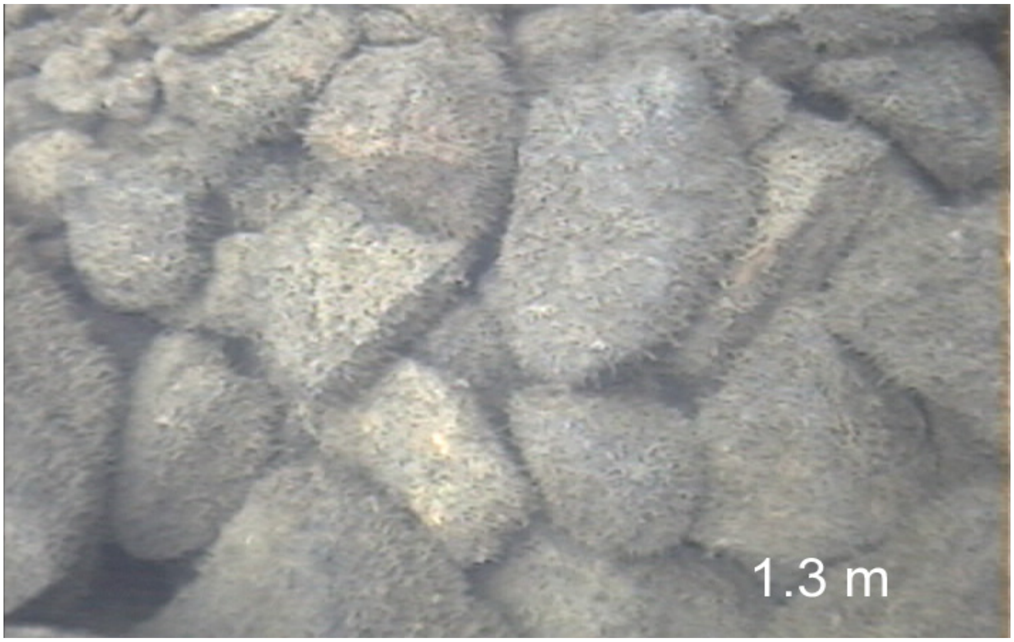


Figure 2: Boulder Platform Habitat, Station 3P-22

Figure 3: Boulder Apron Habitat, Station 3P-204

Figure 4: Boulder Apron Habitat, Station 3P-48

Figure 5: Boulder Shoal Habitat, Station 3P-1

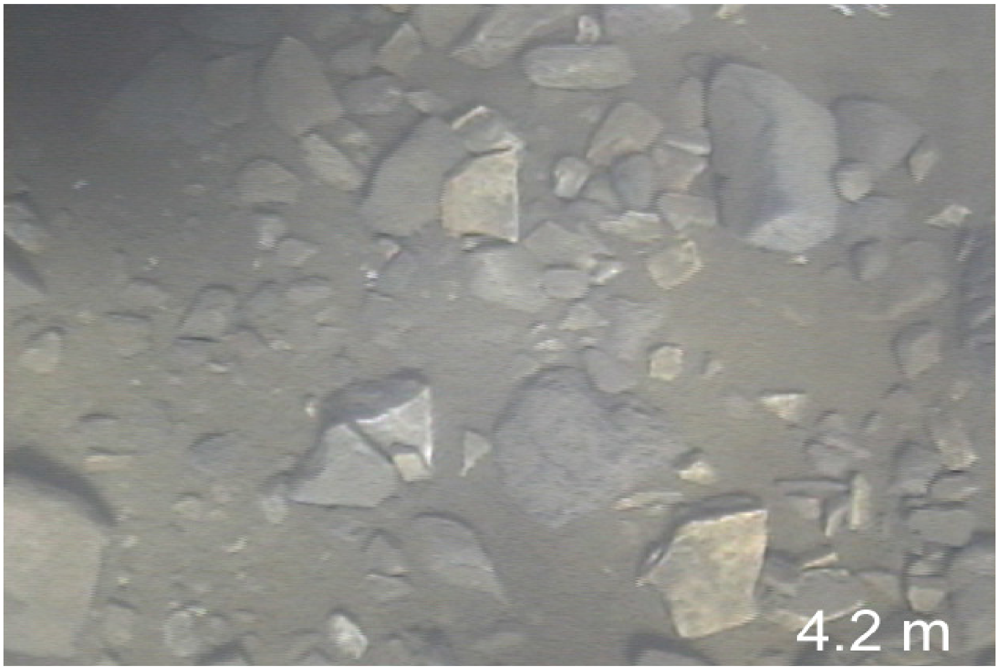


Figure 6: Boulder Shoal Habitat, Station 3P-17

Figure 7: Mixed Sediment Apron Habitat, Station 2P-100

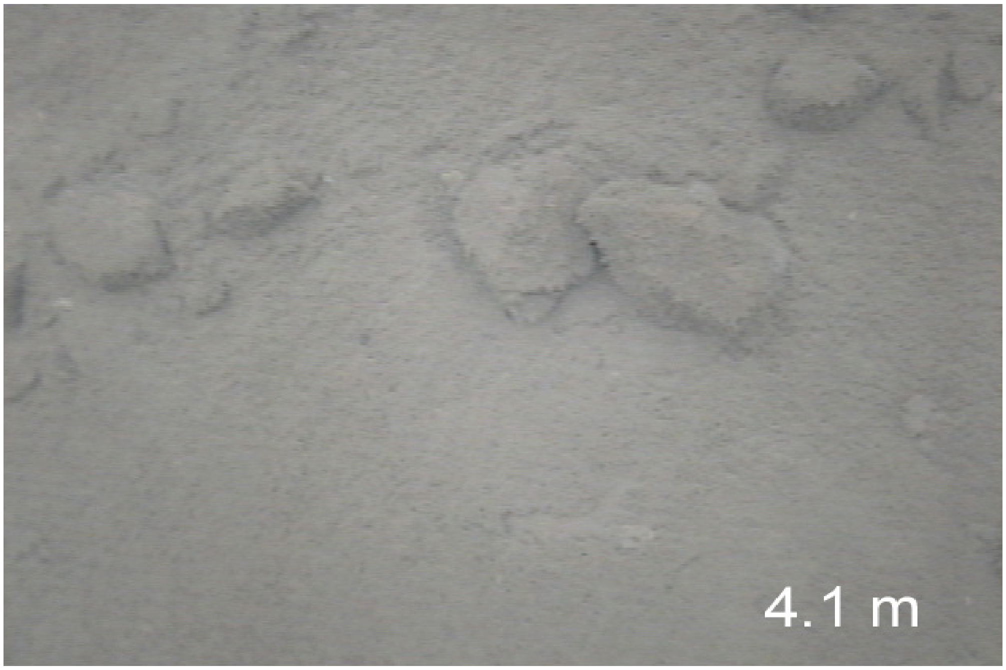


Figure 8: Mixed Sediment Apron Habitat, Station 3P-37

Figure 9: Sediment Apron Habitat, Station 3P-205, showing Benthic Activity

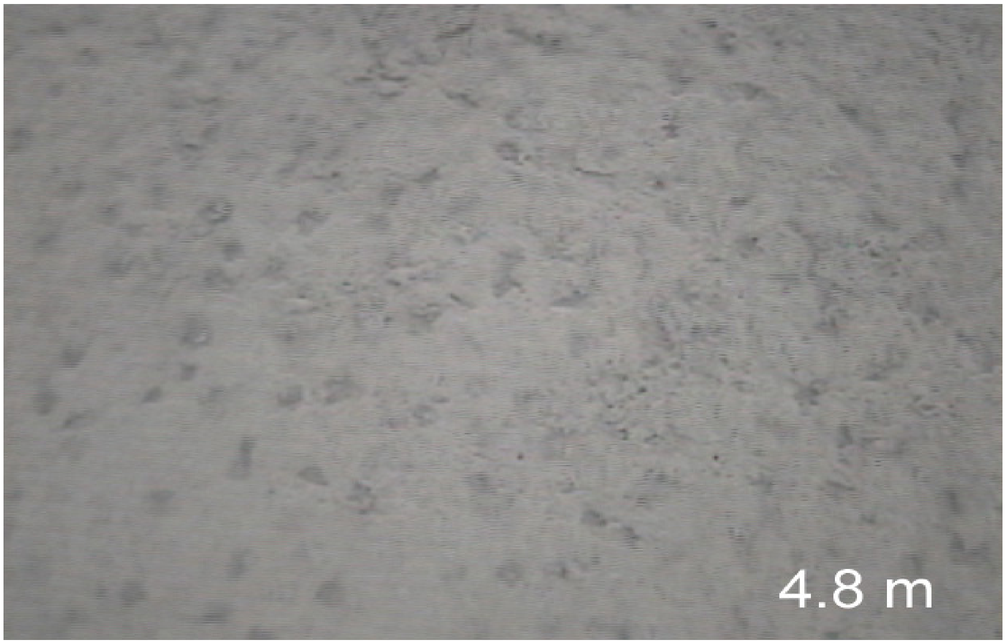


Figure 10: Sediment Apron Habitat, Station 3P-15

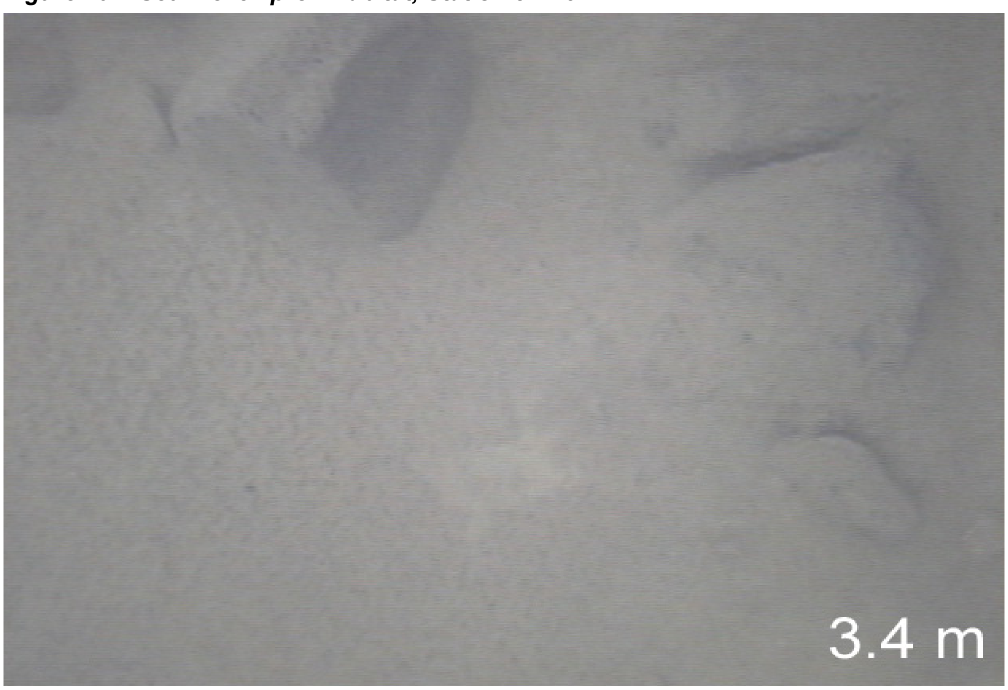


Figure 11: Sediment Basin Habitat, Station 2P-103, showing Sediment Trails

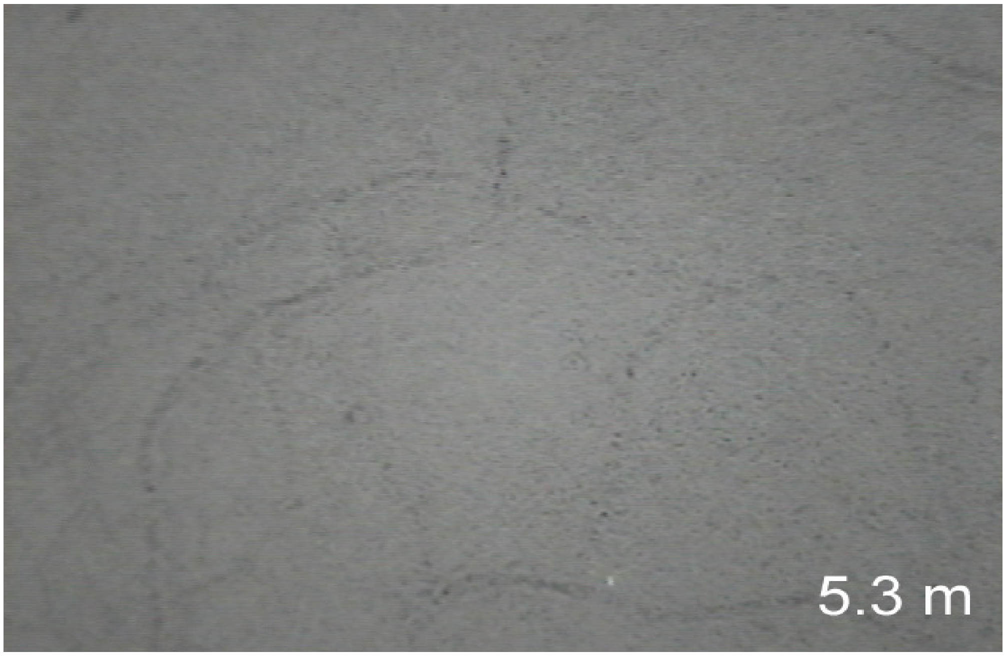
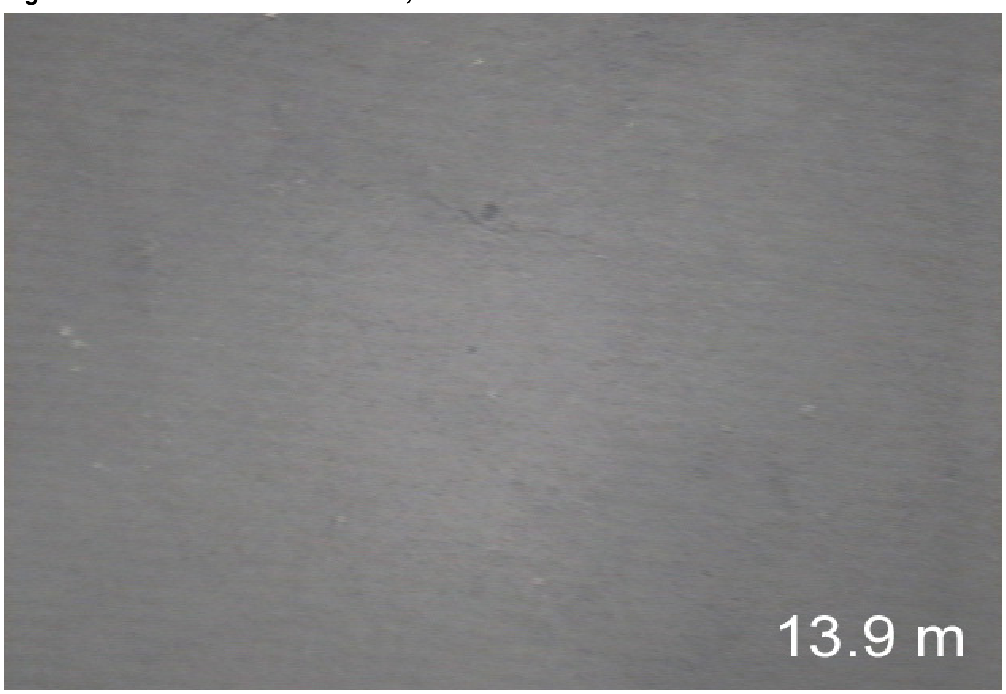


Figure 12: Sediment Basin Habitat, Station 2P-52



APPENDIX E

Spatial Distribution of Fish Habitat Attributes –
Second & Third Portage Lakes

Figure 1: Portage Area Lakes – Habitat Types from Aerial Photographs

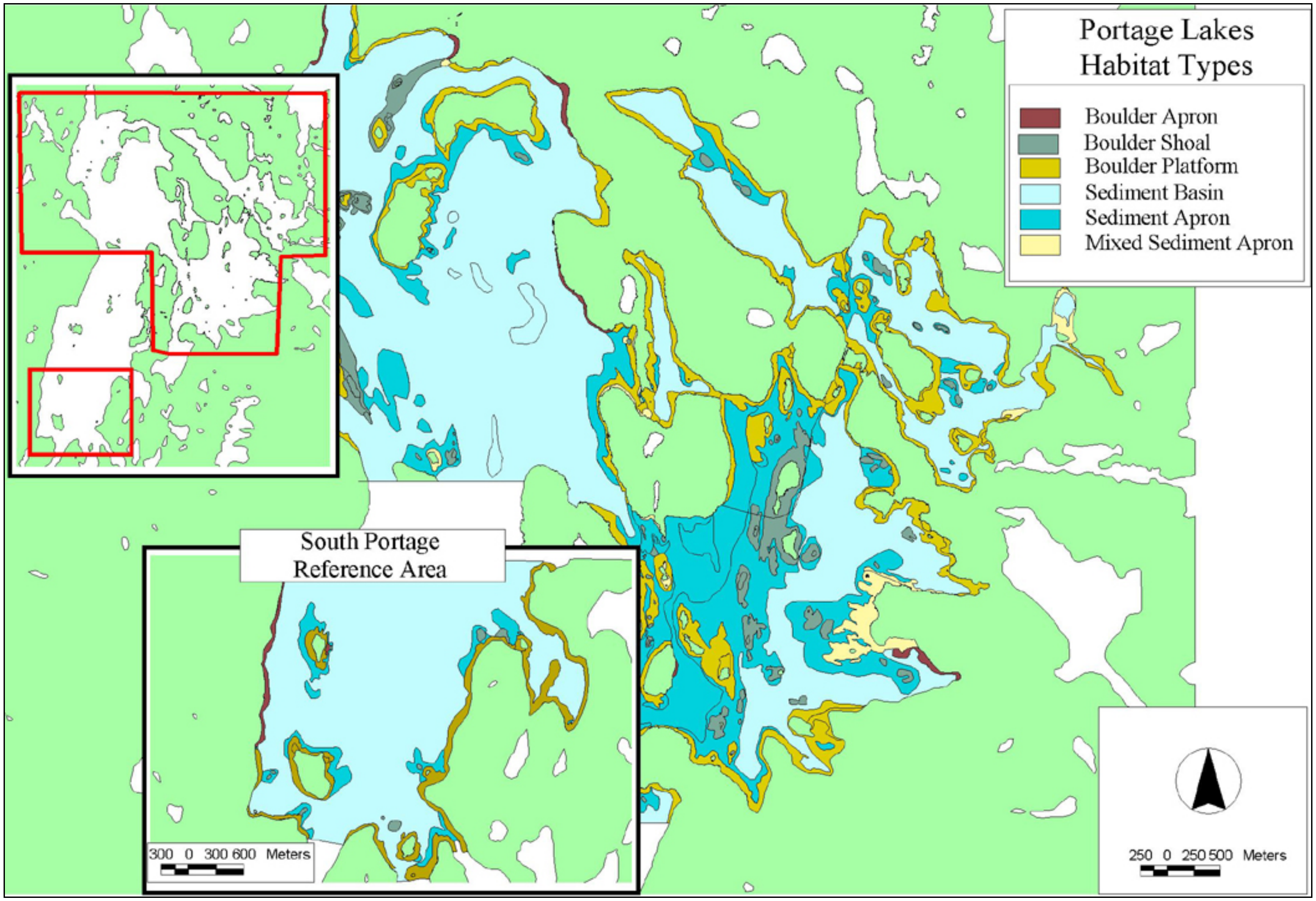


Figure 2: Portage Area Lakes – Habitat Morphology Types from Aerial Photographs

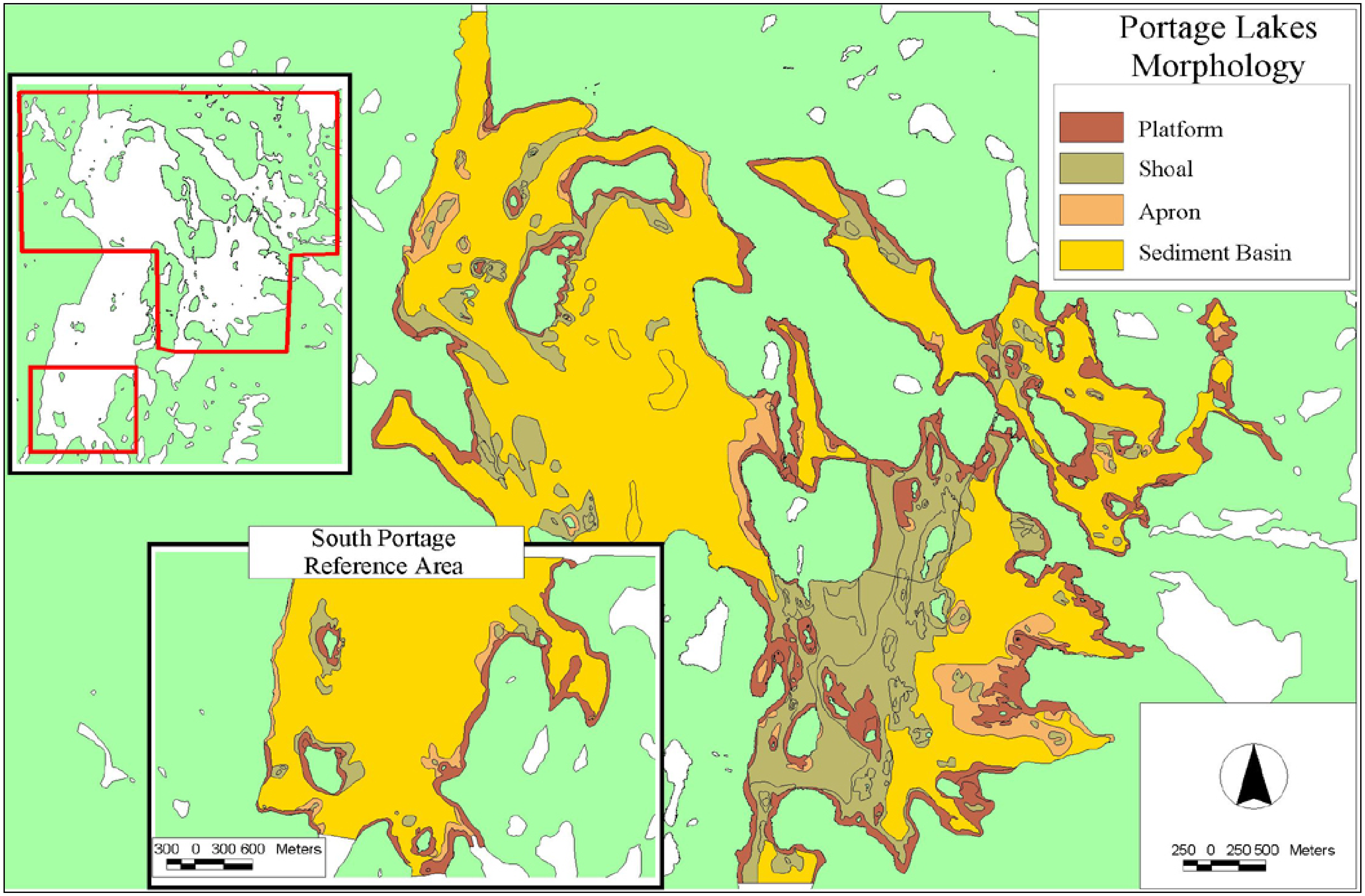


Figure 3: Portage Area Lakes – Habitat Polygons According to Shallow (<2 m), Moderate (2 to 4 m), Deep (4 to 6 m) & Very Deep (>6 m) Depth Classification

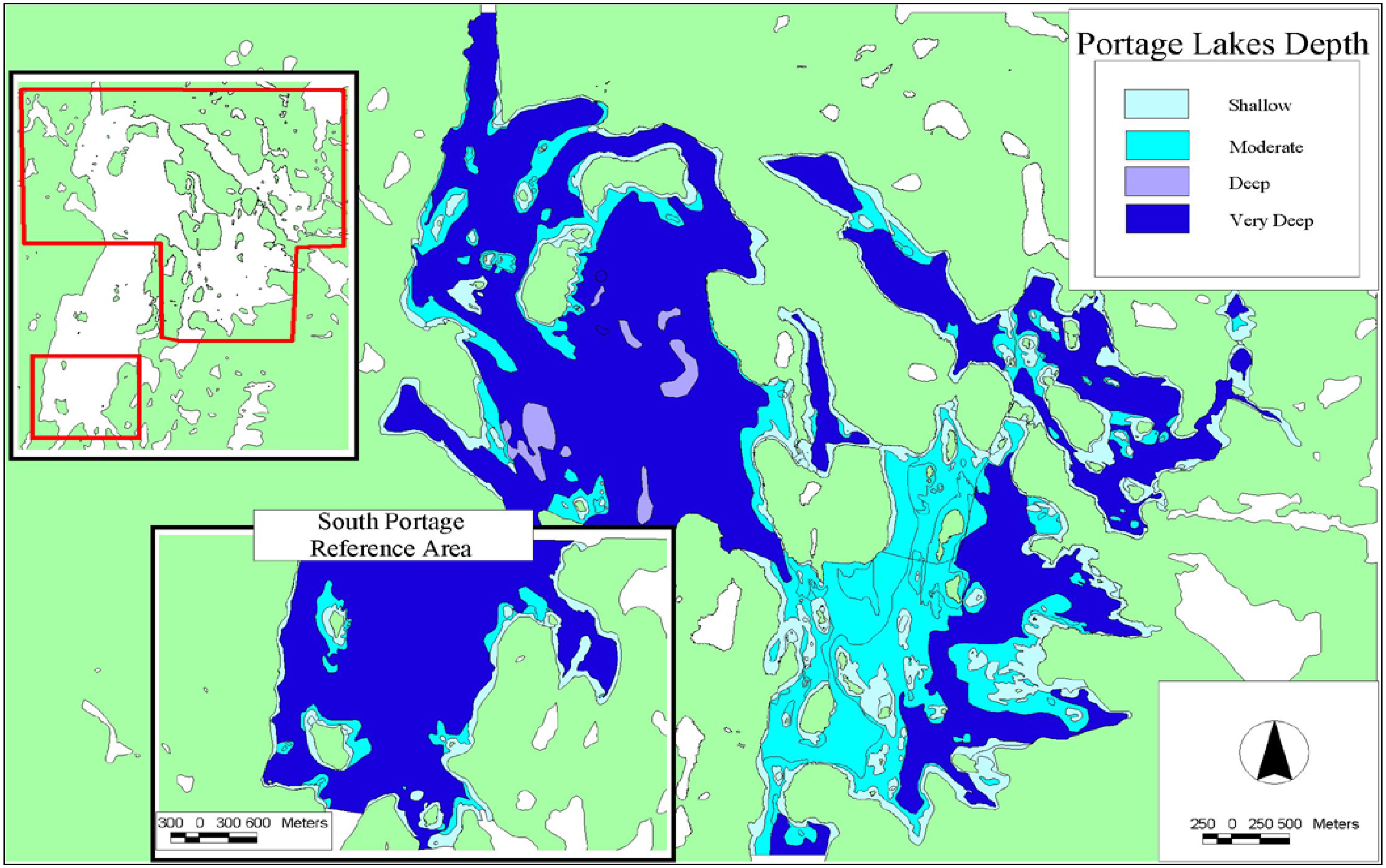


Figure 4: Portage Area Lake Substrate Classification from Aerial Photographs & Drop Camera Images

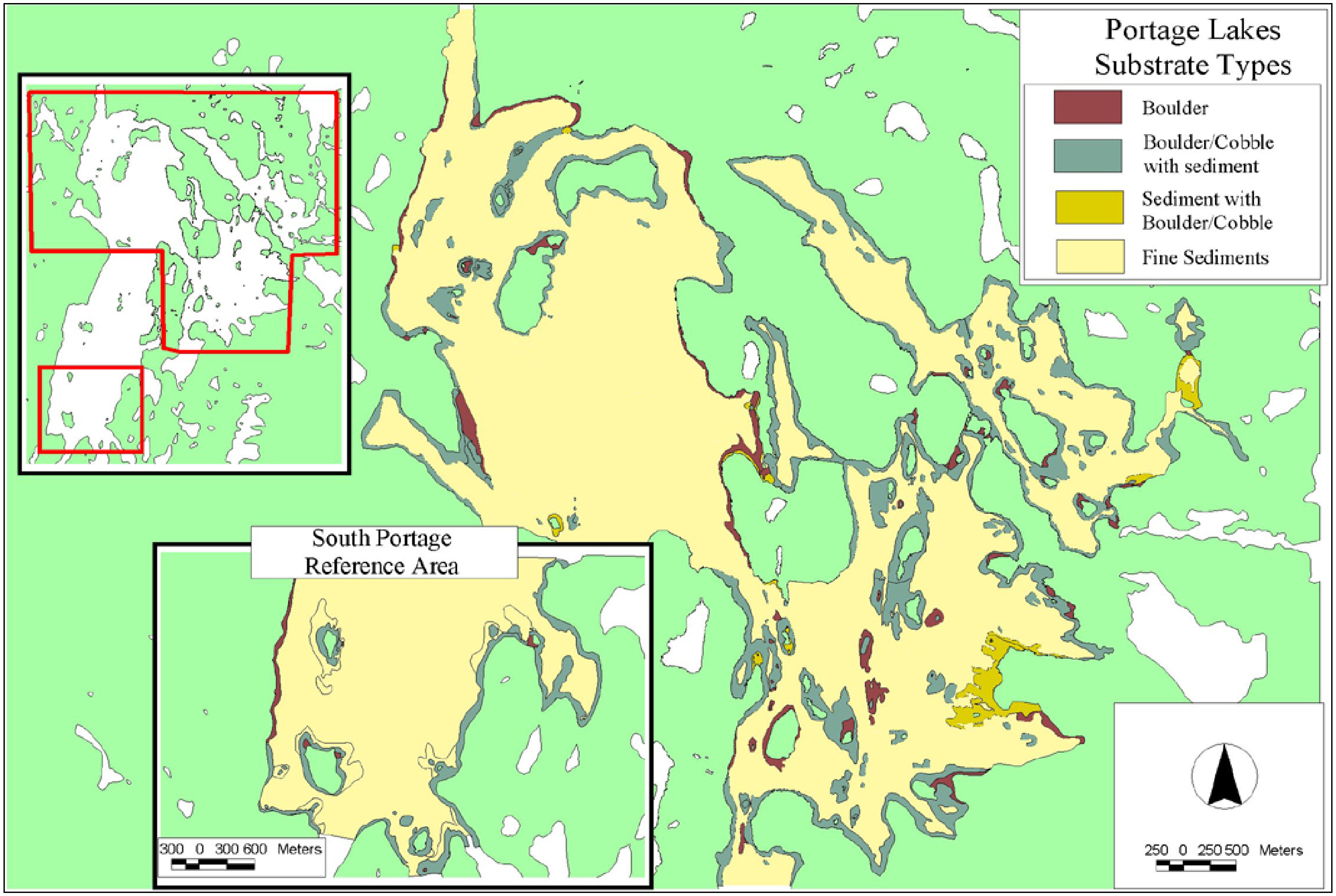
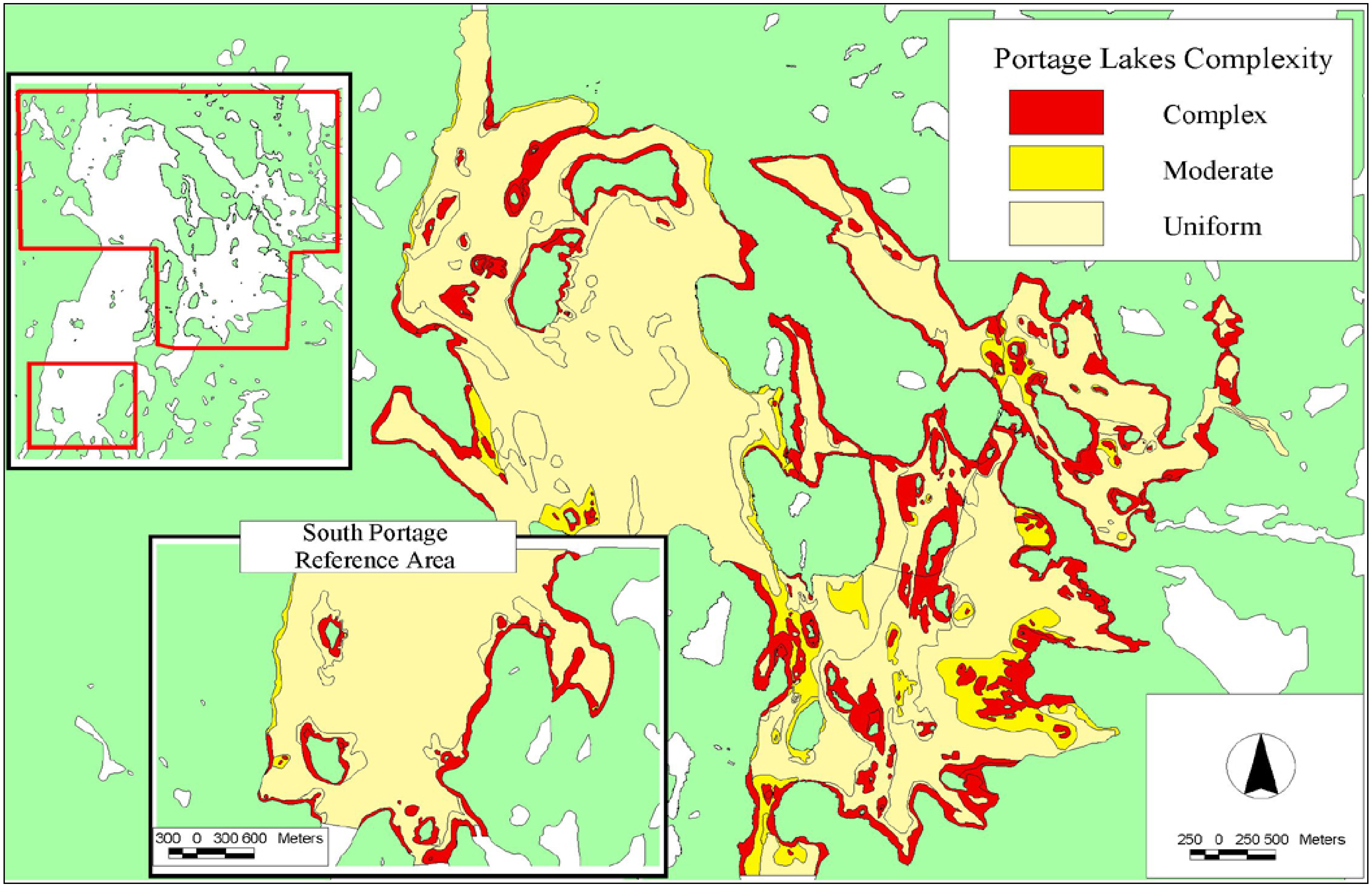


Figure 5: Portage Area Lakes – Habitat Complexity from Aerial Photographs



APPENDIX F

Spatial Distribution of Fish Habitat Attributes –
Vault Area Lakes

Figure 1: Vault Area Lakes – Habitat Types from Aerial Photographs

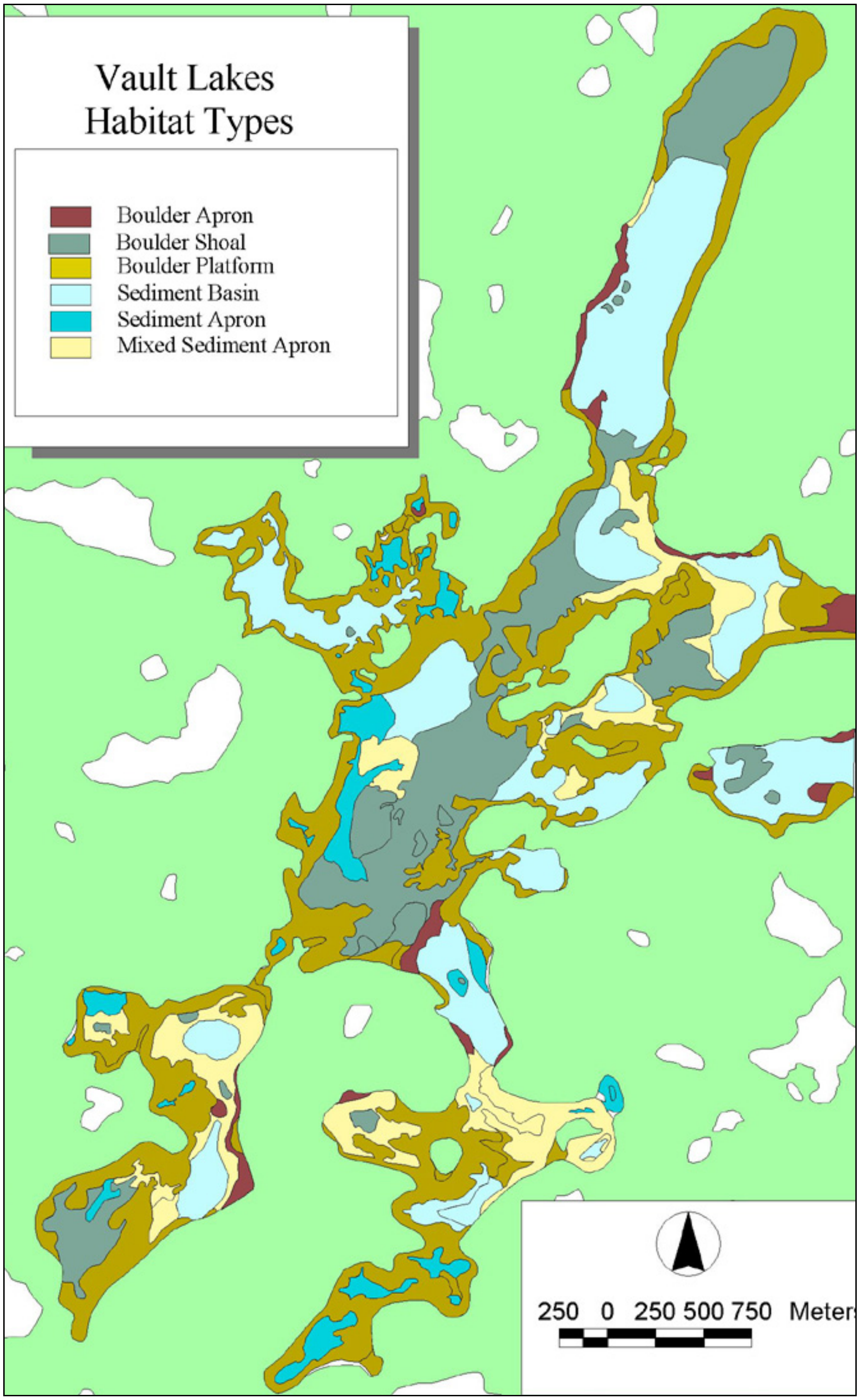


Figure 2: Vault Area Lakes – Habitat Morphology Types from Aerial Photographs

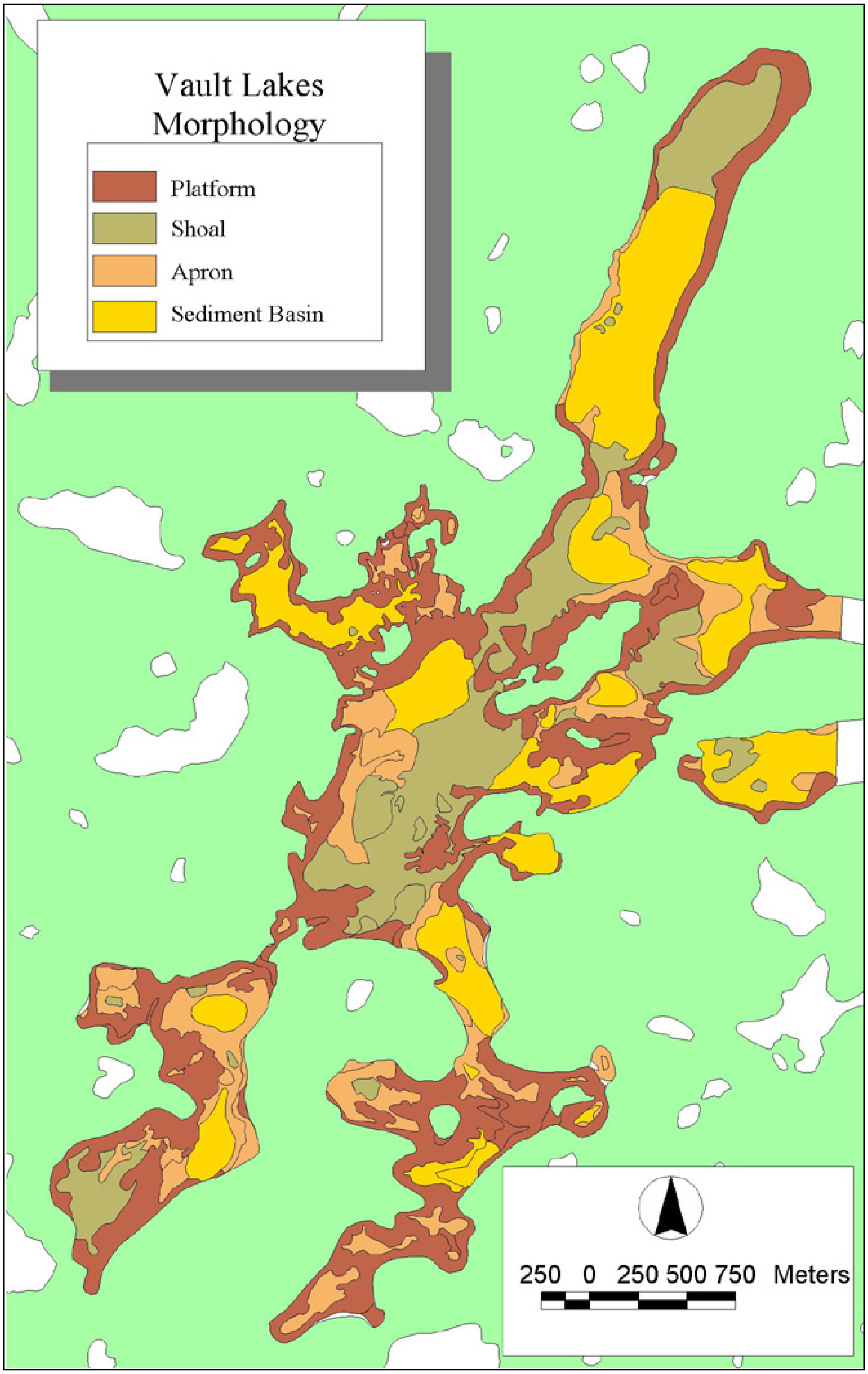


Figure 3: Vault Area Lakes – Habitat Polygons According to Shallow (<2 m), Moderate (2 to 4 m), Deep (4 to 6 m) & Very Deep (>6 m) Depth Classification

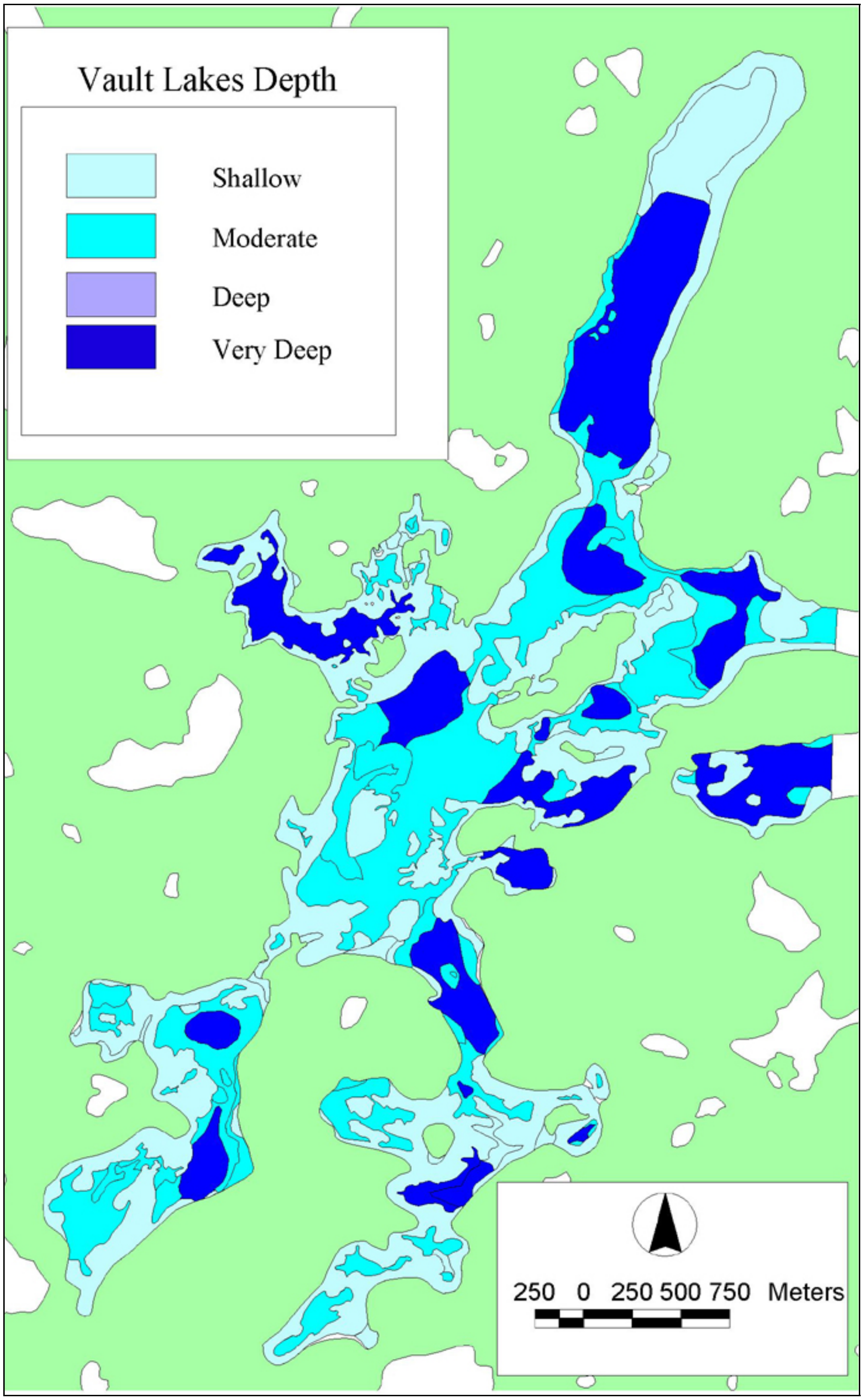


Figure 4: Vault Area Lakes Substrate Type from Aerial Photographs

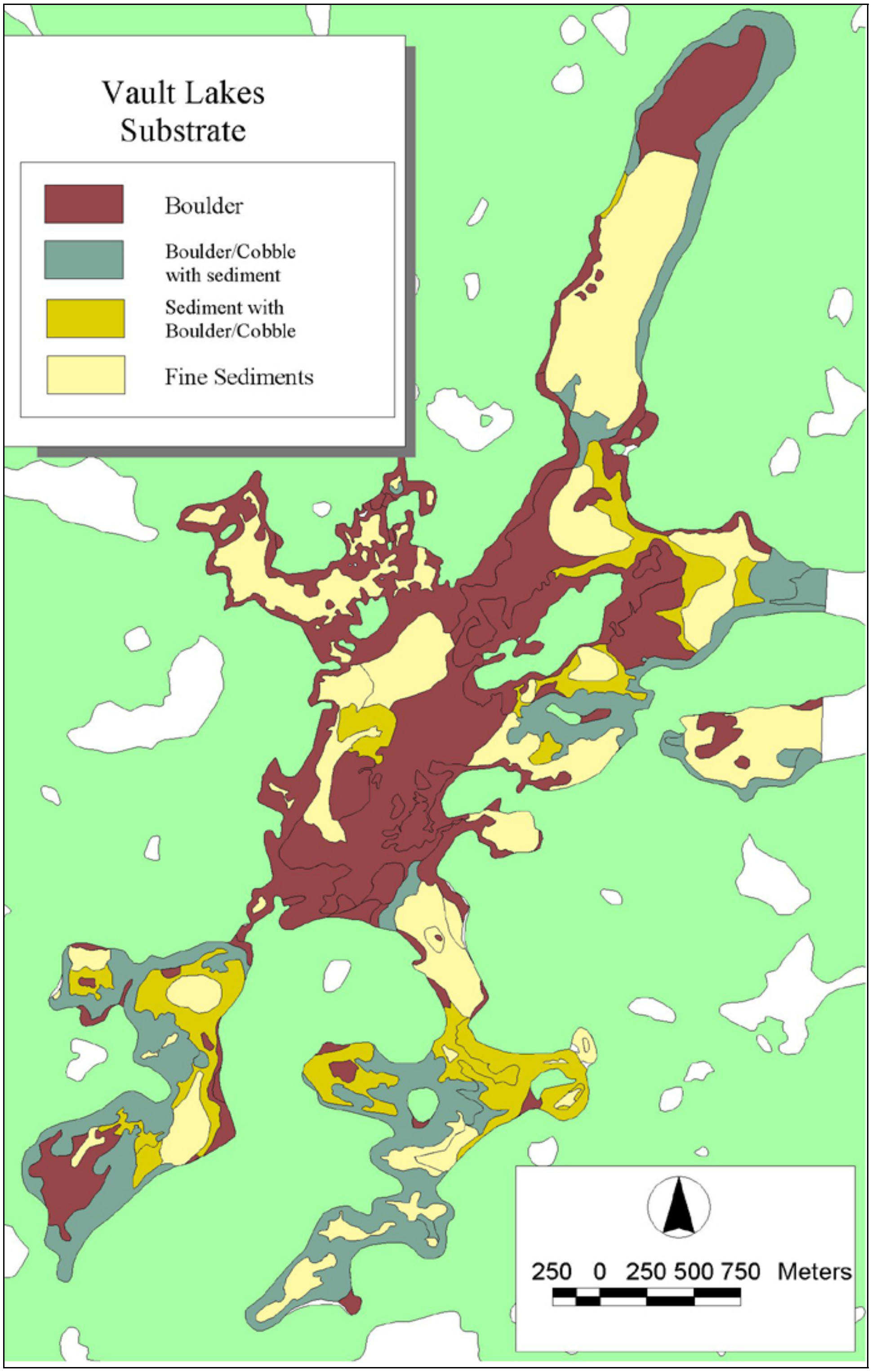


Figure 5: Vault Area Lakes – Habitat Complexity from Aerial Photographs