SHOAL LAKES WATERSHED RIPARIAN AND AQUATIC ASSESSMENT

A Report Prepared for

WIWCD

Report Prepared by

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August 20th, 2014

Mrs. Linda Miller
Manager
West Interlake Watershed Conservation District
Box 732
9 Main Street
Lundar, MB R0C 1Y0

Dear Mrs. Linda Miller:

RE: Shoal Lakes Watershed Riparian and Aquatic Assessment

As requested, AAE Tech Services Inc. has conducted an aquatic and riparian assessment on the Shoal Lakes Watershed to document watershed health. Included within this report is a detailed description of the methods used and results obtained to better understand the current conditions and state of the Shoal Lakes Watershed.

If you require any additional information or have any questions regarding the attached report please feel free to contact myself at 204-997-3483 or via email at mlowdon@aaetechservices.ca

Sincerely,

Mark Lowdon
Fisheries Biologist
AAE Tech Services Inc.

SHOAL LAKES WATERSHED
RIPARIAN AND AQUATIC ASSESSMENT

May 2013 – March 2014

PREPARED FOR

WEST INTERLAKE WATERSHED CONSERVATION DISTRICT (WIWCD)

Prepared by

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AQUATIC, AGRICULTURAL AND ENVIRONMENTAL TECH SERVICES INC.

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1.0 INTRODUCTION

The Shoal Lakes watershed is a land-locked drainage basin located in Manitoba's Interlake region, comprised of North Shoal Lake, East Shoal Lake, West Shoal Lake, and their surrounding drainage network. Due to its lack of outflow and inflow to and from other large water systems, water levels within the Shoal Lakes can experience significant precipitation-dependent fluctuation from year to year, and have undergone several considerable changes over the last century (Bodnaruk 2010). In recent years, water levels within the lakes have consistently risen, and local agriculture and infrastructure have become increasingly affected by flooding.

In response to concerns over continued flooding, a steering committee was selected by the Province of Manitoba, consisting of representatives from Manitoba Water Stewardship, Manitoba Conservation, local rural municipalities and farmers' associations. This steering committee oversaw a multi-year study principally conducted by KGS Group (Bodnaruk 2010), which sought to evaluate possible flood mitigation measures and identify the most effective options. Three alternative measures for flood mitigation were assessed by KGS Group: construction of diversion channels to move excess water into Lake Manitoba; construction of upland storage areas to prevent water from building up within the Shoal Lakes themselves; and the government purchase of flood-prone lands. In the water diversion scenario, target water levels of 260.45 m for North Shoal Lake and 259.70 m for East and West Shoal Lakes were set by the steering committee. Of the three scenarios, a cost-benefit analysis concluded that the purchase of flooded and flood-prone lands was the most effective alternative, and subsequently a large amount of flooded farmland within the Shoal Lakes Watershed was purchased by the province.

As the original KGS study was primarily concerned with the economic impact of flooding on agricultural land, some environmental components of rising water levels within the watershed were not addressed. In particular, while the potential negative effect of lowering water levels on fish habitat was discussed, the present status of the fishery, fish communities and fish habitat on the Shoal Lakes was not investigated in detail.

Since 2009, the West Interlake Watershed Conservation District (WIWCD) has been actively involved in improving the health of the watersheds within the Interlake Region of Manitoba. The overall goal of the WIWCD is to design an integrated watershed management plan, in cooperation with all municipalities and area residents, to improve the function of each watershed within the conservation district (Figure 1, 2 & 3). Between 2009 and 2011, the WIWCD completed watershed assessments on the Swan Creek, Lake Francis, and Dog Lake Watersheds (Lowdon 2009, 2010, & 2011). Riparian, instream fish habitat, and water quality conditions were the primary parameters examined along with better understanding fish utilization of the tributaries within the watersheds. The WIWCD has used this information to start tackling high priority projects, aiming to restore healthy riparian zones and improve the water quality conditions currently found with the conservation district.

With assistance from the Manitoba Fisheries Enhancement Fund (FEF), the WIWCD initiated this assessment to gain a better understanding of those issues potentially affecting water quality, in-stream habitat, and the riparian health of the Shoal Lakes Watershed. In addition to the impacts on agriculture and infrastructure, the rise in lake levels has also affected the fish and wildlife present in the watershed. Flooding has created new channels and deepened existing ones, allowing the migration of new fish species into the Shoal Lakes. Simultaneously, increased depths have increased dissolved oxygen to a sufficient level to support fish populations, and significant improvements in the fishery have been reported by fishermen (Redekop 2014). In addition, bird populations have been affected by changes in water levels. The North, East, and West Shoal Lakes are classified as an Important Bird Area by BirdLife International. The area is especially important to the high numbers of migrating waterfowl and nesting pelicans, grebes, and, historically, plovers. The growing fish populations have supplied local birdlife with an abundant food source. Thus, management of the Shoal Lakes becomes a challenge to balance the needs of landowners and farmers with the fitness of the local fish and wildlife.

The primary objective of this project was to provide a comprehensive overview of the riparian zones and aquatic habitat conditions found within the Shoal Lakes Watershed. It also aims to identify areas within the watershed in need of habitat protection, rehabilitation and/or enhancement. Furthermore, this project will use the aforementioned information to provide recommendations for the development of a watershed management plan that will lessen the burden on landowners and farmers whilst protecting local fish and wildlife.
Specific objectives of the project include:

- Compile relevant historical data pertaining to water quality trends, in-stream flow and fish and bird utilization of the Shoal Lakes Watershed;
- Describe riparian conditions and adjacent land use practices that may be negatively effecting water quality and valuable fish and wildlife habitat along the relevant drains within the Shoal Lakes Watershed;
- Identify potential migration blockages or barriers to fish;
- Describe the physical characteristics of the watershed;

- Describe and evaluate the water quality of the watershed, including a focus on the dissolved oxygen requirements of present fish species;

- Gain a better understanding of fish species utilization of the watershed, especially in the drains;

- Produce a list prioritizing sites potential rehabilitation efforts can be undertaken to help improve water quality and in-stream habitat conditions within the watershed;

- Hold information meetings with the WIWCD Board; and

- Prepare a technical report to the WIWCD Board summarizing information gathered during field surveys.

This project will provide baseline data that the WIWCD can utilize to move forward and improve the riparian and aquatic habitat conditions that currently exist within the Shoal Lakes Watershed. This report also provides supporting documentation for future funding applications to carry out the enhancement initiatives. Manitoba Water Stewardship, Fisheries Branch authorized the scientific collection permit # 15-13 for the collection of biological specimens for this assessment.

1.1 STUDY AREA

The Shoal Lakes are located in the southeastern portion of Manitoba's Interlake region approximately 15 km east of Lake Manitoba (Bodnaruk, 2010). Historically, the Shoal Lakes formed a single large lake until the construction of Wagon Creek dropped lake levels by four to five meters, separating the single lake into three smaller lakes: North, East, and West Shoal Lake (IBA Canada, 2014). Over the past decade, above-average precipitation within the Interlake region has caused lake levels to progressively rise and the three lakes have somewhat converged once again (Redekop, 2014). Rising lake levels have also flooded into the roads and properties of local residents and farmers in the Interlake region. For the purposes of this study, the Shoal Lakes Watershed will include the network of drains and marshland draining into the three Shoal Lakes. This definition includes West Shoal Lake, which is part of the Lake Francis sub-district as defined by the WIWCD, due to the connection between East and West Shoal Lake (Figures 1 and 2).

Due to the topography of the land, there are very few defined natural drains within the Shoal Lakes Watershed (Bodnaruk, 2010). These drains are ephemeral in nature, flowing only during the spring and following periods of rainfall events, and some remain dry for much of the summer and autumn months. The four drains identified in the study include Crockatt Drain on North Shoal Lake, Swamp Lake Drain on West Shoal Lake, and two unnamed drains on East Shoal Lake.

Land within the watershed consists largely of native grasslands and open deciduous forest, although a number of areas are used for forage crops (Bodnaruk, 2010; IBA Canada, 2014). Because the land is very flat, regions of marshland have also developed in areas between the normal water levels and the elevated levels of recent years. Rocky flats and barrens also exist along some shorelines.

Although Manitoba Conservation previously stated that the Shoal Lakes have “severe limitations to fish productivity” (Bodnaruk, 2010), fish populations have recently increased with the rise of lake levels. Northern Pike (*Esox lucius*), Yellow Perch (*Perca flavescens*), and White Sucker (*Catostomus commersonii*) have been observed in abundance in the lakes, and the Province of Manitoba stocked North Shoal Lake with one million Walleye (*Sander vitreus*) in 2012.

The climate within the area is typical of the northern temperate zone, characterized by short, warm summers and cold winters. The mean annual temperature is 1.2^{o}C, the average growing season is 175 days, and growing degree-days number about 1500. The mean annual precipitation is approximately 510 mm, of which nearly one-quarter falls as snow. Precipitation varies greatly from year to year and is highest from spring through early summer.

1.2 BIRDLIFE WITHIN THE SHOAL LAKES WATERSHED

The Shoal Lakes have been classified as an Important Bird Area (IBA) by BirdLife International. Over twenty species of migratory and nesting birds have been documented within the IBA, often in vast numbers, making the area one of global significance for several species. Counts of 100,000 Canada Geese (*Branta canadensis*), 200,000 Lesser Snow Geese (*Chen caerulescens*) and 50,000 ducks of various species have been recorded (IBA Canada, 2014). Additional species of interest in the watershed include the Western Grebe (*Aechmophorus occidentalis*), Eared Grebe (*Podiceps nigricollis*), Black-crowned Night Heron (*Nycticorax nycticorax*), and Double-Crested Cormorant (*Phalacrocorax auritus*).

The Shoal Lakes area is also one of only a few areas in Manitoba where the Piping Plover (*Charadrius melodus circumcinctus*) has been historically documented. This species is currently listed as endangered by COSEWIC and protected under the federal Species At Risk Act, although steep declines have been documented in recent census surveys and the presence of the species on the Shoal Lakes is uncertain.

Piping Plover rely exclusively on sandy beach habitat for nesting. This habitat can be threatened either by the encroachment of vegetation, when water levels remain low for too long, or by flooding, when water levels are too high. Miller (2006) listed consistently high water levels as the primary reason for the decline of the plover population on West Shoal Lake. Lowering the level of the lake may thus prove beneficial for this species, making available previously flooded beach habitat. At the same time, some level of natural water level fluctuation is generally considered beneficial for clearing excess vegetation from plover nesting areas (Environment Canada, 2006).

As much as 2.3% of the world's estimated American White Pelican (*Pelecanus erythrorhynchos*) population have been reported in the area, and like other bird species have likely benefitted from increasing fish populations used as a food source. Pelicans generally nest in colonies on rocky islands in shallow lakes. Although their nesting success is less dependent on water level than the Piping Plover's, some susceptibility to changes in water level have been documented. High water levels can lead to the flooding of islands and gravel bars used as nesting grounds, while very low levels may risk connecting islands to the mainland, exposing nesting sites to mammalian predation (Evans 1972). Additionally, pelicans depend on healthy fish populations for food, and can thus be indirectly affected by changes in dissolved oxygen and productivity, as well as summerkill and winterkill events.

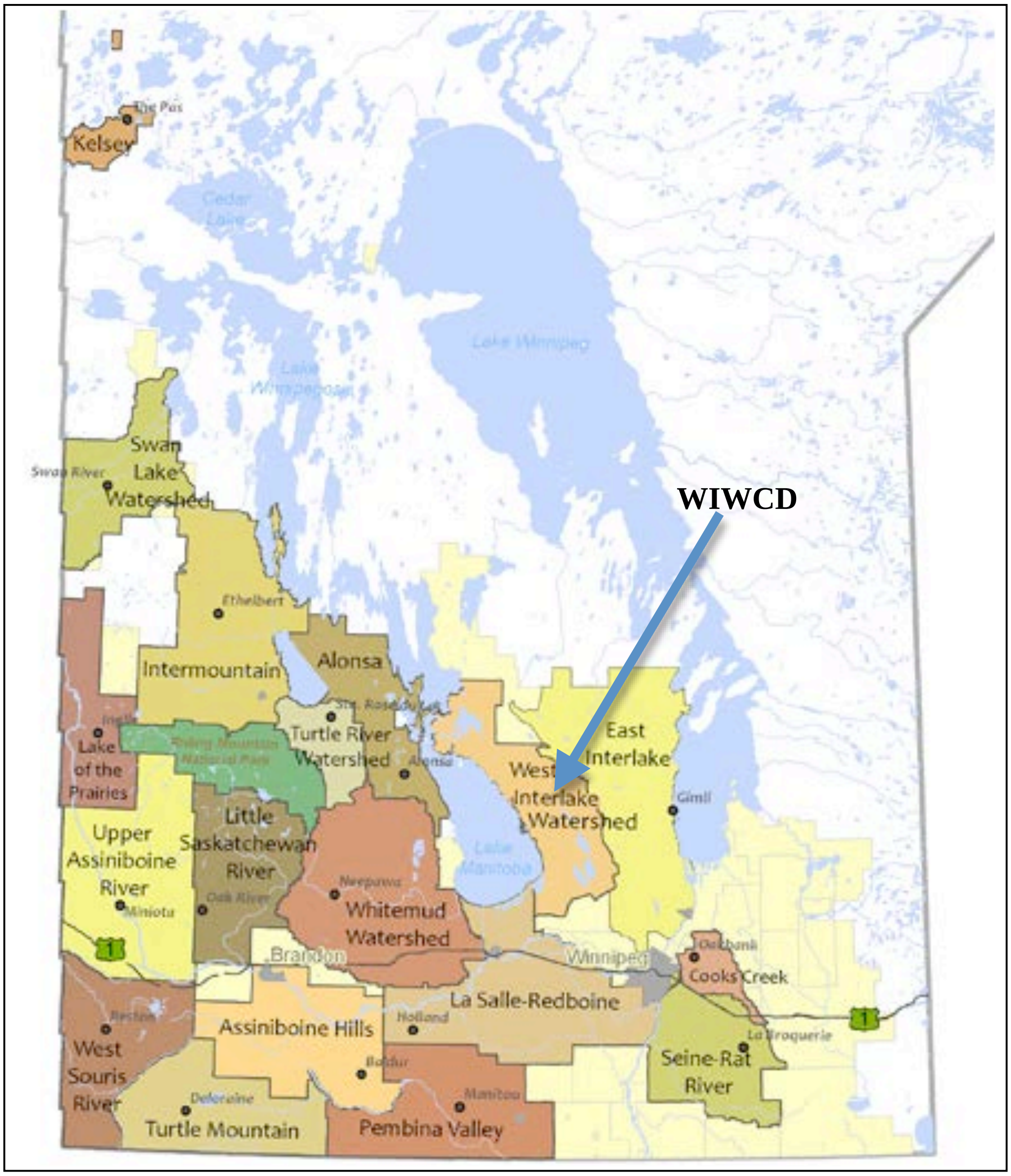


Figure 1. Map of the Manitoba Conservation District boundaries. WIWCD is located on the east shore of Lake Manitoba.

Figure 2. Sub-district watershed boundaries of the West Interlake Watershed Conservation District.

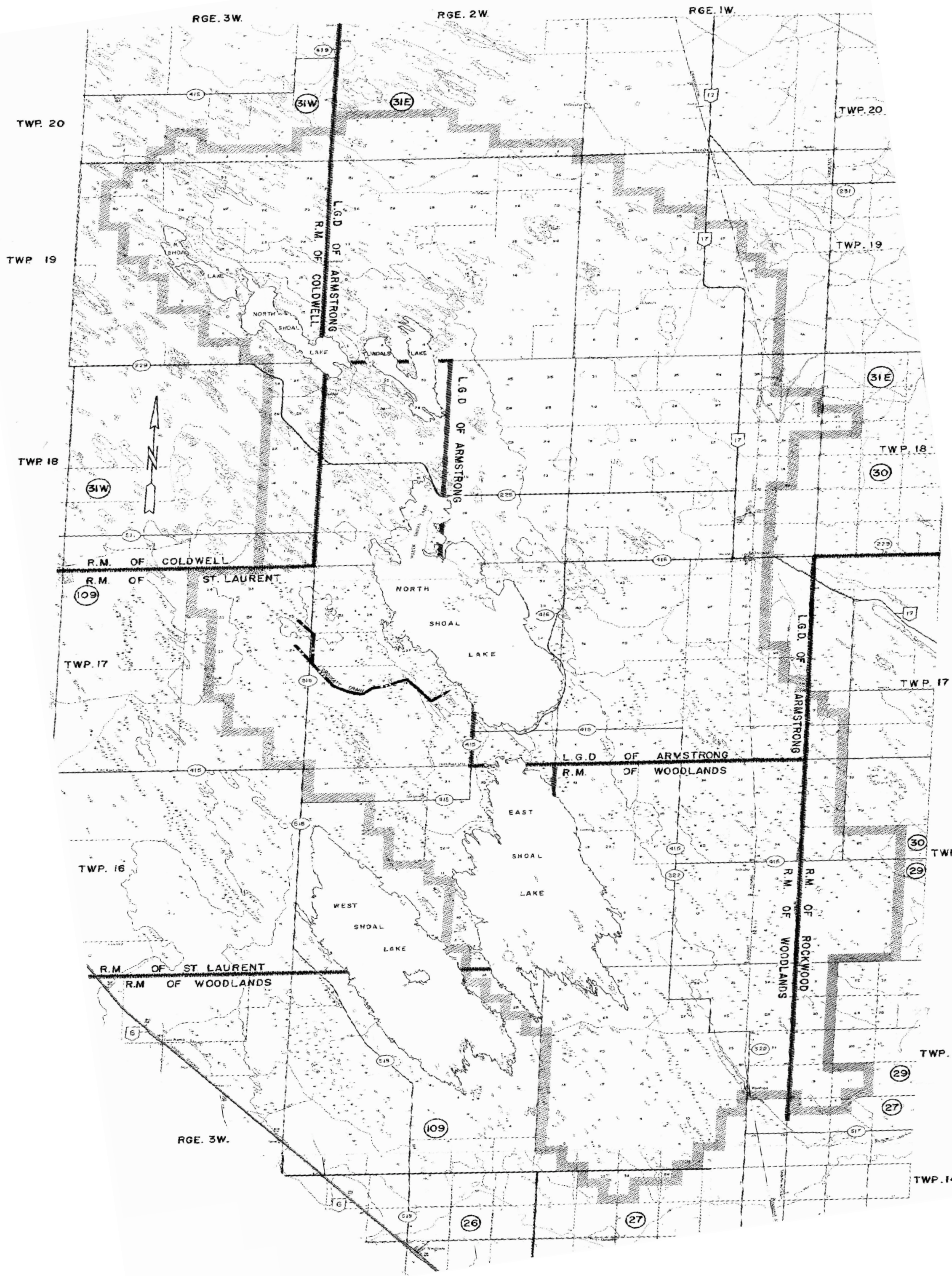


Figure 3. Overview map of the Shoal Lakes Watershed illustrating the network of lakes and drains found within.

2.0 APPROACH AND METHODOLOGY

To document the riparian and aquatic habitat conditions within the Shoal Lakes Watershed, various sampling methodologies were utilized, including aerial surveys, ground truthing surveys, physical characteristics and hydrology assessments, water quality sampling, fish utilization surveys, and benthic sampling. Refer to sections 2.1 to 2.6 for detailed descriptions of the methodologies used to assess the individual sections of the riparian and aquatic survey.

2.1 RIPARIAN AND LAND USE SURVEY

The riparian zone is defined as the transition zone between the terrestrial and aquatic environment. Found along lakes, rivers, streams, drains, and wetlands, a well-established riparian zone plays an important role for establishing a healthy ecosystem. Diverse vegetation within a riparian zone including plants, shrubs, trees, and/or grasses is essential for protecting the integrity of the aquatic environment. Healthy riparian zones provide:

- A natural filtration system preventing pollutants from entering the waterway (i.e., chemicals, pesticides, animal waste, high nutrient inputs, etc.),
- A natural means for protecting water quality within the aquatic environment,
- A means to control or alleviate erosion by stabilizing banks, and
- A means to reduce downstream flooding by slowing water movement along the boundaries of a waterway

Aerial and ground surveys were the primary methods used to document the state of the riparian zones along the drains of the Shoal Lakes Watershed. Specific characteristics examined during this assessment included documenting the width of the riparian zone, the type of vegetation within the riparian zone, and land use practices along the riparian corridors.

2.1.1 AERIAL SURVEYS

Aerial surveys were conducted along each drain and the shoreline of the Shoal Lakes within the Shoal Lakes Watershed to achieve three goals;

1) Provide digital still images of the riparian zone along each corridor to aid in riparian zone classification;
2) Identify and document potential rehabilitation project sites; and
3) Identify land use practices that may be negatively affecting water quality along the tributaries of the Shoal Lakes Watershed.

AAE Tech Services chartered a slow flying fixed-wing aircraft (Cessna 180) from the St Andrews Airport to conduct the aerial survey on June 21, 2013. A digital SLR 30-D Canon camera with image stabilization was used to take still images during flights. A Garmin 60CSx GPS unit was used to log and track the flight paths by recording waypoints (latitude and longitude coordinates) at one-second intervals. Photographs were then post-processed using a software program (GPS Photolink - standard edition) designed to link still images to their appropriate GPS coordinates by matching the time stamp produced by each device. In addition, the software program created files compatible with MapSource and ArcView software mapping programs to allow one to display the flight path and linked photographs. The aerial photographs can also be viewed using Google Earth software.

2.1.2 GROUND TRUTHING SURVEYS

Ground truthing surveys were conducted over the course of the study commencing on May 7, 2013 and ending March 19, 2014. Complementing the aerial photograph data, the primary objective of these surveys was to provide still images for riparian zone classification and potential rehabilitation site assessment. Coordinates of specific sites of interest were recorded using a Garmin GPS unit. Digital photographs were taken using a Canon 30-D SLR camera.

2.1.3 LAND USE CLASSIFICATION

The aerial surveys were also used, along with ground truthing photographs, to identify land use practices along shoreline of Shoal Lakes and its drains. Refer to Table 1 for a description of categories used to classify land use within the watershed.

Table 1. List of categories used for classification of land use adjacent to stream corridors in the Shoal Lakes Watershed.

Land Use Category	General Description of Category
Meadow Grass Vegetation	Grass land along waterways
Prairie/Natural Grasses	Native grasses used for forage (Native Hay)
Native Pasture	Grass land that is being grazed
Grazed Shrub and Brush	Shrub and brush land that is being grazed
Shrub and Brush	Shrubs and brush habitat
Forest Stands	Treed land
In Channel Reservoir	Dug outs or watering holes along waterway
Marsh and Bogs	Wetlands
Urban Development	Cottage development, housing, campgrounds
Confined Areas with Cattle	Fenced areas with a high density of cattle activity
Railway Crossing	Railway infrastructure
Road Crossing	Developed road infrastructure
Roadway Crossing	Undeveloped road infrastructure

2.1.4 RIPARIAN CLASSIFICATION

Once the aerial and ground truthing surveys were completed, data was analyzed and the riparian zone corridors along each tributary were classified into one of three categories.

- **Class A Habitat - Little or no impact to riparian corridors**. The riparian corridor within this category is considered adequate to protect the integrity of the aquatic environment. Typically, buffer zones are greater than 10 m on each side of the waterway. Erosion control problems and sediment loading is not a concern.

- **Class B Habitat - Moderate impacts to riparian corridors**. Riparian zones are typically less than 10 m and their function to the filter inputs (nutrients, sediment) into the waterway is degraded in comparison to a riparian zone with a Class "A" classification. Vegetation within the corridors may either be lacking as a result of minimal livestock grazing, is situated near a roadway, and/or agricultural practices encroach upon the waterway.

- **Class C Habitat - Severe impacts to riparian corridors**. Riparian zones are less than 5 m on at least one side of the waterway and nutrient loading is likely. Vegetation within the corridors has extensive damaged as a result of either the presence of feedlots or livestock trampling near watering areas. Buffer zones are inadequate to protect the aquatic environment.

2.1.5 PROJECT SITE EVALUATION

Upon completion of the aerial and ground surveys, a list of potential rehabilitation sites was generated. The primary focus was to provide the WIWCD with a list of prioritized sites exerting the most negative impact on the watershed to focus on during water quality and fish habitat enhancement efforts. The list included three types of sites: barriers to fish movement, confined cattle access areas negatively impacting the aquatic environment, and sites with limited riparian zones which are inadequate to protect the waterways. General guidelines or recommendations on how to improve the habitat and water quality currently found within the Shoal Lakes Watershed were also provided.

2.2 HABITAT ASSESSMENT

Fish habitat is defined as those parts of the environment "on which fish depend directly or indirectly in order to carry out their life processes" (Fisheries and Oceans Canada 1986). This includes habitat used for migration, spawning, feeding and refuge. Diverse habitat makes for good fish habitat. Natural run, riffle, and pool features found with natural waterways serve as excellent habitat for fish throughout their life cycles. Cover in the form of water depth, woody debris, aquatic vegetation, boulders or undercut banks increase habitat diversity and thus create better fish habitat. Substrates dominated by sand, gravel, cobble and boulders are typically those selected by fish for spawning. All of these characteristics are typically found in pristine waterways undisturbed by man.

Habitat assessment was conducted in conjunction with the riparian survey. Along each lake and drain, descriptions of the general habitat were recorded. Areas containing preferable fish habitat, especially spawning habitat, were described and photographed.

2.3 BARRIERS TO FISH MIGRATION

For the purpose of this study, a barrier was classified as any structure, anthropogenic or natural, which potentially obstructs fish movement. Anthropogenic barriers include structures such as perched culverts or undersized culverts (resulting in high water velocity), bridges, concrete structures, or commercial fishing nets. Natural barriers include structures such as beaver dams, debris, log jams, rapids, or drying of ephemeral channels.

Each barrier identified within this survey was photographed and location information was recorded using a Garmin GPS unit.

2.4 PHYSICAL CHARACTERISTICS AND TOPOGRAPHY

To gain a better understanding of the physical characteristics and topography of the lakes and drains within the Shoal Lakes Watershed, longitudinal profiles, cross-sectional profiles and sinuosity were assessed to measure slope, channel width, and curvature of the channel. Additionally, bathymetric surveys were used to measure bottom depth, substrate, vegetation coverage, and vegetation height across each lake.

2.4.1 LONGITUDINAL PROFILES

To measure the slope of each drain, longitudinal profiles were conducted using topographic maps and Google Earth software. Longitudinal profile methodologies were performed using the methods outlined in *Stream Channel Reference Sites: An Illustrated Guide to Field Technique* (Harrelson et al. 1994).

2.4.2 CROSS-SECTIONAL PROFILES

To assess the width the drains within the Shoal Lakes Watershed, six cross-sectional profiles were conducted in total, three on both Unnamed Drains 1 and 2. To construct the profiles, a tape measure was extended across each drain to include approximately 5m of shoreline on each side of the waterline. Elevation was recorded at 0.5m intervals using a Top Con laser level and waterline locations along each profile were recorded. A Garmin GPS unit was used to mark sampling locations. Swamp Lake profiles constructed for the comparable Lake Francis Watershed report (Lowdon, 2010) were used for drain width analysis.

2.4.3 BATHYMETRIC SURVEY

A BioSonics MX Echosounder with Visual Acquisition 6 software was used to collect bathymetric data. The transducer was mounted to a board to hang over the boat's edge and into the water. The depth of the transducer head below the water surface was measured and entered into Visual Acquisition at the beginning of each sampling day and any time the transducer position was adjusted. Data was collected by slowly driving the boat in a straight transect line from shoreline to shoreline. Each lake was sampled along both longitudinal and cross-sectional transects spaced 500 m apart. The exact position of the transducer was measured by an internal GPS and automatically coupled with bathymetric data. At scattered points on each lake, substrate was identified manually using a survey rod to provide a ground-truthing method for identifying substrate from the bathymetric data.

Due to the sensitivity of the Echosounder to interference and instability, there were a number of limitations on sampling, including:

- **Wind speed and direction**: Waves produced by steady or gusting wind were consistent limitations to sampling efficiency. Winds above 10 km/h necessitated lower boat speeds, and above 20 km/h often rendered sampling impossible. Crosswinds in particular limited sampling by rocking the boat, changing the angle of the transducer significantly and causing immediate loss of signal.

- **Boat speed**: Maximum boat speed varied with wind conditions. In calm conditions, boat speed of up to 10 km/h was possible while maintaining data quality, while under moderately windy conditions speeds above 6.5 km/h frequently resulted in loss of data.

- **Vegetation**: While the MX Echosounder is usually capable of detecting both plant canopy and bottom depth/type simultaneously, very thick plant coverage sometimes prevented signals from adequately reaching or returning from the lake bottom, leading to a loss of bottom depth and substrate data. In most cases, however, this was correctible during post-processing analysis.

Data was post-processed using Visual Habitat software from BioSonics to determine. Data from all transects was loaded into Visual Habitat and analyzed for bottom depth, plant canopy height, and plant coverage using the program's default algorithms. Each transect was then visually inspected to identify anomalies in bottom depth or plant identification, such as gaps where the lake bottom was not detected by the algorithm, or patches of boat wake misidentified as vegetation. All identified errors were corrected using the program's manual editing tool. Finally, bottom type was analyzed using a Principal Component Analysis algorithm, with the number of clusters (substrate types) set manually based on the number and types of substrates encountered during manual substrate sampling. Finally, all analyzed data was exported to KML format for visualization in Google Earth software.

2.5 WATER QUALITY

Water quality was analyzed during the summer and winter months to document the seasonal changes in water quality. Studies focused on overall water quality, winter dissolved oxygen levels, water temperature, and benthic invertebrate sampling.

2.5.1 IN-FIELD AND LABORATORY SAMPLING

During the summer, some basic water quality parameters were periodically measured in conjunction with ground truthing using a YSI multi meter (model 556) and a LaMotte 2020e/I turbidity meter. Parameters examined include dissolved oxygen (DO), pH, conductivity, turbidity, and water temperature. A Garmin GPS 276 unit was used to record locations of each sampling site.

Water samples were also collected from East and West Shoal Lake on July 23, 2013 and March 19, 2014. Samples collected were delivered to ALS Laboratory Group located in Winnipeg within 24 hours of their collection. Water quality parameters analyzed included: ammonia (NH_3), chlorophyll a, nitrate-N and nitrite-N, total phosphorous, total dissolved phosphorous, total dissolved solids, total suspended solids, and total kjeldahl nitrogen.

2.5.2 DISSOLVED OXYGEN PROFILES

Because DO reaches its minimum during the winter months, profiles were conducted on March 19, 2014 to assess the availability of DO for fish within the Shoal Lakes. Three sites on each lake were randomly selected for DO profiling. A Garmin GPS 276 unit was used to record locations of each sampling site. At each site, ice was drilled through and ice thickness was recorded. DO, temperature, and pH were measured at 0.5m intervals from the surface of the lake to the bottom using a YSI multi meter (model 556).

2.5.3 WATER TEMPERATURE

In addition to the periodic temperature readings using the YSI multi meter, water temperature loggers (Hobo® Water Temp Pro) were used to provide year-round information on water temperature. Two loggers were positioned in the Shoal Lakes on May 7, one in North Shoal Lake and one in West Shoal Lake near the mouth of Swamp Lake drain. The locations of these loggers were recorded using a Garmin GPS 60CSx unit. Loggers were set to record and monitor water temperature every hour for the duration of the project. Minimum and maximum temperatures were therefore recorded daily at approximately 8:00 am and 8:00 pm respectively. The logger at West Shoal Lake was successfully retrieved on August 26th, 2014, while the logger in North Shoal Lake was destroyed during road construction.

2.5.4 BENTHIC INVERTEBRATE SAMPLING

Examining the benthic invertebrate communities within these water bodies is an important tool and good indicator for determining water quality within the waterways found within the Shoal Lakes Watershed (Table 3). The absence of specific invertebrates, such as those in the orders Ephemeroptera (mayflies), Odonata (dragonflies), and Trichoptera (caddis flies), can signify poor water quality. Invertebrates within these orders are typically sensitive to poor water quality conditions and do not tolerate or inhabit these types of environments. In contrast, invertebrates such as Oligochaeta, (also known as tuberficid worms) or Chironomidae larva (order Diptera) do tolerate poor water quality conditions and sometimes flourish with increased nutrient loading. Thus, identification of invertebrates within a community can provide an additional means for assessing the water quality without the use of costly water quality samples.

Due to a limited budget, quantitative invertebrate sampling was not conducted. However, invertebrates were collected during riparian zone assessment and identified to order or family level. Sampling was conducted at various locations within each drain and along the shoreline of each of the Shoal Lakes.

2.6 FISH UTILIZATION

Based on recommendations from the province, this assessment focused more strongly on habitat analysis than on fish capture. Therefore, much information pertaining to fish utilization within the Shoal Lakes Watershed was obtained through visual surveying, literature review, and opportunistic interviews with commercial fishermen and local residents. Observation of the drains was also conducted to investigate seasonal changes in drain usage and to identify important spawning habitats within the sampled reaches. Due to the substantial decrease in fish density, procedures varied between the spring and summer study periods.

Most information was obtained from careful observation while conducting riparian surveys. Fish densities (qualitative) and species were documented locations of valuable spawning habitat were recorded using a Garmin GPS 276 unit. During periods of high fish density, sample fish were captured using scoop nets, identified, and released alive. Based on these samples and visual observations of the entire population, fish species composition was estimated.

Additionally, electrofishing was performed within the Shoal Lake drains on July 4th to capture and identify all species in a given area. For this, a Smith-Root Model LR24 backpack electroshocker was used. Captured fish were placed in a holding tank for a short period before they were identified, measured for fork length, and released alive.

3.0 RESULTS AND DISCUSSION

Results of this assessment identified several issues negatively affecting water quality and instream fish habitat within the Shoal Lakes Watershed. Similar to the three previous studies conducted on the Swan Creek, Lake Francis and the Dog Lake Watersheds, types of impacts identified within this study include:

- Point source nutrient and sediment loading from confined cattle areas reduced water quality conditions within some of the drains assessed;
- Unrestricted livestock access to the drains within the watershed degraded spawning habitat and reduced water quality conditions;
- Surface water runoff from roadways into adjacent riparian zones reduced water quality conditions;
- A lack of cover within large areas of the Shoal Lakes and their drains results in reduces available spawning habitat;
- Extensive channelization of natural waterways reduced fish habitat diversity and altered natural flow regimes;
- Under the conditions of decreased water flow, perched culverts under numerous road crossings may act as barriers, preventing access to spawning and nursing grounds

3.1 RIPARIAN AND LAND USE SURVEY

3.1.1 AERIAL AND GROUND TRUTHING SURVEYS

All aerial photographs taken during this project for both flights are included within the attached CD. The photographs are organized and separated into folders identified by location. Displayed on each photograph is the location, latitude and longitude, and time and date each photo was taken. In addition, files compatible with MapSource, ArcView, and Google Earth are included within the attached CD. These files allow one to display the flight path and location of the individual photographs using the selected software program (Figure 4).

Representative aerial and ground-truthing photographs of each lake and drain can also be found within Appendix C. These photographs were compiled to provide a general summary of the habitats found along each lake and drain within the Shoal Lakes Watershed. All photographs were captured at an altitude of approximately 500 feet.

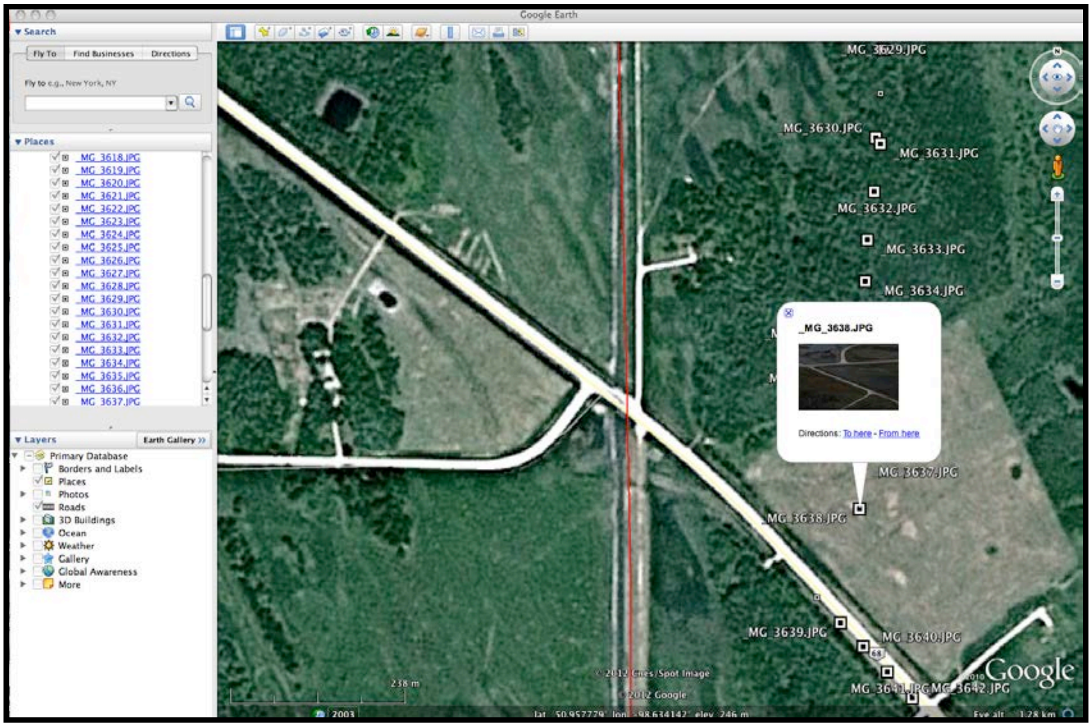
3.1.2 LAND USE CLASSIFICATION

Refer to Table 2 for a summary of the land use practices found along each tributary assessed within the Shoal Lakes Watershed. Also, refer to Table 1 for a more in-depth description of the land use practices identified along each drain examined within the watershed.

A total of 180.7 km of shoreline and 18.4 km of drains within four main tributaries of the Shoal Lakes Watershed were assessed during this study. Along the lake shoreline, native pasture was the most abundant land use type, accounting for 55.1% of the total shoreline. Marsh and bogs, often consisting of flooded land previously used as pasture, made up a further 32%. Shoreline consisting of developed road infrastructure accounted for 7.6%, primarily where roads crossed through the lakes, having been built up to withstand rising water levels. Forest stands were found along 2.8% of lake shoreline, confined areas with high cattle activity were found along 2.5%, and undeveloped roadway crossings accounted for less than 0.1%.

Native pasture land was also the most common land use practice identified along the drains, accounting for 57.5% of total land use. Marsh and bogs accounted for 13.4% of land use along drains, much of which consisted of flooded land previously used as pasture. Grazed and non-grazed shrub & brush made up 10.1 and 6.5%, respectively. Forest stands (6.6%), confined areas with cattle (2.9%), road crossings (1.6%), meadow grasses (1.1%) and roadway crossings (0.3%) accounted for the remaining 12.5% of the land used practices identified within drains.

A)



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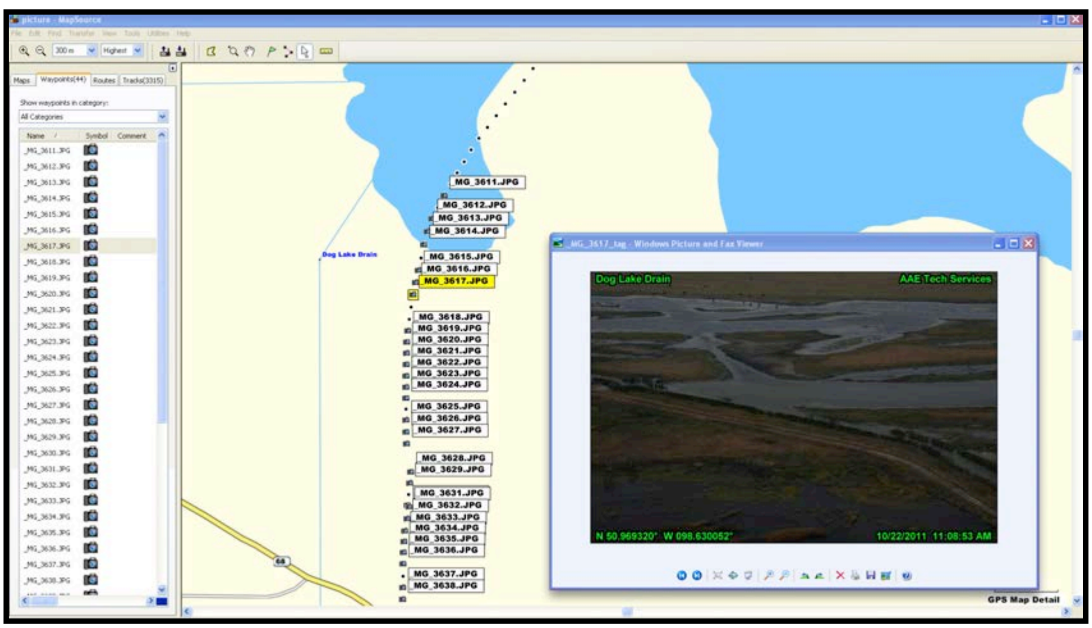

Figure 4. A sample computer screen image of the flight path and associated aerial photograph of a reach within a waterway using A) Google Earth and B) Map Source software.

Table 2. Land use practices of the lakes and drains within the Shoal Lakes Watershed.

Location	Land Use Class	# of Reaches	Length (km)	Land Use % of Total
North Shoal Lake	Native Pasture	7	46.10	46.1
	Marsh and Bogs	6	39.20	39.2
	Road Crossing	5	11.80	11.8
	Confined Areas with Cattle	2	2.90	2.9
	Total	**20**	**100.00**	**100.0**
East Shoal Lake	Native Pasture	7	21.44	60.0
	Marsh and Bogs	3	10.56	29.6
	Forest Stands	2	2.81	7.9
	Confined Areas with Cattle	2	0.87	2.4
	Roadway Crossing	2	0.04	0.1
	Total	**16**	**35.72**	**100.0**
West Shoal Lake	Native Pasture	5	32.00	71.1
	Marsh and Bogs	1	8.16	18.1
	Forest Stands	2	2.20	5.0
	Road Crossing	2	1.92	4.3
	Confined Areas with Cattle	1	0.70	1.5
	Total	**11**	**44.99**	**100.0**
Crockatt Drain	Native Pasture	2	3.92	64.4
	Marsh and Bogs	1	1.62	26.7
	Confined Areas with Cattle	1	0.54	8.9
	Total	**4**	**6.08**	**100.0**
Swamp Lake Drain	Meadow Grass	1	0.20	14.8
	Native Pasture	3	0.63	45.7
	Grazed Shrub and Brush	2	0.32	23.3
	Marsh and Bogs	1	0.19	13.5
	Road Crossing	1	0.04	2.7
	Total	**8**	**1.38**	**100.0**
Unnamed Drain 1	Native Pasture	8	4.35	53.3
	Shrub and Brush	6	0.44	5.3
	Grazed Shrub and Brush	7	1.56	19.1
	Marsh and Bogs	2	0.63	7.7
	Forest Stands	4	1.00	12.3
	Road Crossing	13	0.19	2.4
	Total	**40**	**8.17**	**100.1**
Unnamed Drain 2	Native Pasture	4	1.78	60.7
	Shrub and Brush	2	0.76	26.0
	Marsh and Bogs	1	0.05	1.6
	Forest Stands	1	0.23	7.7
	Road Crossing	3	0.07	2.3
	Roadway Crossing	1	0.05	1.7
	Total	**12**	**2.93**	**100.0**
	Total	**111**	**199.23**	**100.0**

3.1.3 RIPARIAN CLASSIFICATION

Refer to Table 3 for a summary of riparian zone classifications and Appendix A for habitat-featured maps illustrating the different classifications assigned to the riparian zones along the lakes and drains within the Shoal Lakes Watershed.

A total of 199.2 km of riparian habitat were assessed during this survey, including 180.7 km of lake shoreline and 18.4 km of drains within four tributaries. Riparian zones within the Shoal Lakes Watershed were generally sufficient to protect the aquatic environment from pollutants or nutrients entering the waterways. Except where flooding brought the lake into close contact with cattle enclosures or road infrastructure, riparian zones extended beyond 10 m and were adjacent native pasture or wetland, where chemicals, fertilizers and pesticides are rarely applied.

Class A habitat was the most prevalent riparian class on all three lakes, accounting for 80.7% of total assessed shoreline. Along drains within the watershed, Class A habitat represented 16.7% of all riparian zones. Class A habitat was typically observed along native pasture without heavy cattle activity, along wetland habitat, and in some areas along forest stands. Treed habitat is prevalent throughout the watershed, although not often immediately adjacent to shoreline. Forest stands and shrubs and brush along waterways can increase habitat complexity within a watershed and provide fish with additional cover for refuge and thermal protection.

Class B habitat accounted for 16.3% of shoreline along the three lakes and 77.9% of habitat within drains. Class B habitat is characterized by having moderately impacted riparian zones as a result of either marginal livestock grazing or encroachment of road infrastructure upon the waterways. These riparian zones were typically less than 10 m in width, but appeared adequate to protect the integrity of the aquatic environment. Cattle activity which was not confined to a high-density area were judged to have little significant impact on the overall filtration function of the riparian zone, and these areas were labeled Class B habitat. Waterways along roads were also included as Class B habitat, as surface water runoff may likely enter the aquatic environment.

Class C habitat consisted of severely impacted habitat as a result of culverts, extensive erosion, or intensive cattle trampling around watering areas. Riparian zones within this category are typically less than 5 m in width and appear inadequate to protect the integrity of the aquatic environment. Class C riparian zone habitat accounted for 3.0% of all riparian habitat along lake shoreline and 5.4% of all habitat within drains. Refer to Appendix A and the compiled list of potential rehabilitation project sites (Appendix H) for more details regarding the Class C habitats identified within the watershed.

Table 3. Riparian zone classification of the lakes and drains located within the Shoal Lakes Watershed.

Waterbody	Riparian Zone Classification	# of Reaches	Length (km)	% of Tributary
North Shoal Lake	Class A	6	79.88	79.9
	Class B	10	16.78	16.8
	Class C	3	3.34	3.3
	Total	**19**	**100.00**	**100.0**
East Shoal Lake	Class A	6	33.809	94.7
	Class B	4	1.037	2.9
	Class C	2	0.871	2.4
	Total	**12**	**35.72**	**100.0**
West Shoal Lake	Class A	11	32.20	71.6
	Class B	11	11.64	25.9
	Class C	2	1.15	2.5
	Total	**24**	**44.99**	**100.0**
Crockatt Drain	Class A	1	2.01	33.0
	Class B	2	3.53	58.0
	Class C	1	0.55	9.0
	Total	**4**	**6.08**	**100.0**
Swamp Lake Drain	Class A	1	0.21	14.8
	Class B	1	1.03	74.6
	Class C	1	0.15	10.6
	Total	**3**	**1.38**	**100.0**
Unnamed Drain 1	Class A	1	0.29	3.5
	Class B	14	7.66	93.7
	Class C	13	0.23	2.8
	Total	**28**	**8.17**	**100.0**
Unnamed Drain 2	Class A	1	0.58	20.5
	Class B	4	2.15	76.8
	Class C	3	0.08	2.7
	Total	**8**	**2.81**	**100.0**
	Total	**98**	**199.15**	**100.0**

3.1.4 PROJECT SITE EVALUATION

All identified drains flowing into the Shoal Lakes are straight and channelized to allow water to leave the land as quickly as possible and reduce flooding on agricultural land. Natural fish habitat within the tributaries could thus be described as uniform with little diversity and uniform (if any) flow. In addition, very little cover was observed within the tributaries, with the exception of isolated patches of forest stands or brush. While some good spawning habitat has been previously identified within Swamp Lake Drain (Lowdon 2010), slope and flow along all drains was found to be very low. Low drainage slopes can often lead to the absence of coarse substrate within waterways, as fine substrate such as silt and clay are allowed to settle rather than being carried along with water flow. Within the lakes themselves, clay, silt and sand were the dominant substrates, and the presence of coarser substrates such as gravel and cobble was very minimal.

Given these factors, AAE Tech Services recommends installing spawning shoals or habitat within the tributaries flowing into the three Shoal Lakes. This involves the insertion of sand, gravel and cobble substrates, which is sought after for spawning by some of the more economically important fish species (i.e. Walleye). A very large number of fish were observed to be using the East Shoal Lake tributaries during the spring of 2013 (see section 3.5). Installation of spawning habitat within the lakes themselves may also be beneficial both to increase the amount of overall spawning habitat and to provide an alternative to the drains, which are ephemeral and not always accessible to fish depending on water levels and flow conditions.

Extensive channelization of waterways likely reduced the amount of “good” fish habitat available to the fish community within these specific drains. Spring runoff is allowed to leave the land more quickly, increasing the chance of stranding eggs, larval or adult fish. In addition, agricultural practices such as intensive cattle activity along waterways may also have negative impacts to the aquatic environment both within drains and along stretches the Shoal Lakes themselves, as excess nutrients have the potential to enter the water column. Livestock grazing within the waterways likely degrades spawning habitat within waterways as coarse material is pushed beneath the silt and fine particles residing in the waterway. Protective dykes around high-density cattle grazing areas thus serve two beneficial functions, both protecting the land from the encroachment of rising water levels and, to an extent, protecting the aquatic habitat from excess nutrients and physical disturbance. Finally, barriers within waterways, including culverts at road crossings, can impede fish movement and ultimately reduce the available habitat for the fish communities. All of these factors can limit or degrade fish habitat within waterways and affect the state of the fishery and fish communities.

3.2 BARRIERS TO FISH MIGRATION

Barriers have the potential to either segment habitat or reduce the amount of valuable habitat available to fish communities. Furthermore, the longer a barrier is situated within a tributary and blocking fish movement, the greater impact that barrier will likely have on the fish community. Valuable fish habitat is essential for maintaining and/or improving the fish stocks for those fish utilizing the Shoal Lakes Watershed.

Unlike the Swan Creek and Lake Francis watersheds which contained numerous anthropogenic blockages or the Dog Lake Watershed which contained barriers largely relating to high water velocities at culvert crossings, the only barriers identified in the Shoal Lakes Watershed were related to seasonal decreases in water levels in the ephemeral drains. Due to the numerous roadways across the drains, especially on the East Shoal drains, numerous culverts are present within each drain. Some of these culverts become perched during periods of low flow, truncating the drains. This creates a barrier to fish migration and cuts off potential habitat for most of the year.

Largely, perched culverts and low flows in the ephemeral drains do not appear to exert a strongly negative impact on fish populations. Habitat assessment of the drains demonstrated that although the drains are densely populated during spawning season, fish density drops to nearly zero post-spawning even while drain water levels remain high. This may be explained by the absence of protective cover and favorable substrate from most areas of the drains. However, areas of existing favorable habitat within the drains, whether naturally-occurring (i.e. Swamp Lake Drain) or installed (i.e. Unnamed Drains 1 and 2), are more affected by the perched culverts. Only the raising of water levels or the lowering of the culverts would provide better access to these habitats. Additionally, although very unlikely, the disconnection between Vassar Creek and the Goulet Lakes during periods of greater water flow could be an important barrier to fish migration between the Shoal Lakes Watershed and Lake Manitoba for smaller fish species.

3.3 PHYSICAL CHARACTERISTICS

This section of the report summarizes the physical characteristics of the lakes and drains within the Shoal Lakes Watershed including information regarding the drainage area, slope, length, and depth. All data is displayed in Appendix D, E, and F. In addition, representative photographs for each lake and drain are displayed within Appendix C. Descriptions and a summary of the fish habitat within each drain are also included within this section of the report.

North Shoal Lake

North Shoal Lake is the northernmost lake and is more isolated from the East and West Shoal Lakes. Present water levels have connected the lake to East Shoal Lake at its southern tip, and extended its northern boundary considerably, flooding significant areas of native pasture land. Riparian habitat along the lake consists primarily of native pasture (46.1%) and marsh and bogs (39.2%), with road infrastructure (11.8%) and confined areas with cattle (2.9%) comprising the remainder. With the exception of identified areas sustaining intensive cattle use, the riparian zone is considered adequate to protect the aquatic environment, with 79.9% listed as Class A and 16.7% listed as Class B.

North Shoal is the shallowest of the three lakes, reaching a maximum depth of 3.68 m just west of the lake's center. Water elevation at the time of the bathymetric survey was 261.629 m according to data obtained from Manitoba Infrastructure and Transportation (MIT). If lake levels were reduced to the target levels stated in Bodnaruk (2010), maximum lake depth is expected drop to approximately 2.5 m, while most of the lake would be just over or less than two meters deep.

Substrate within North Shoal Lake was comprised of approximately 50% clay, 30% silt, and 20% sand. As of November 6th, plant coverage was at less than 30% across almost the entire lake. Most plant height was below 0.10 m, although small regions of plant height up to and exceeding 0.50 m were identified.

East Shoal Lake

East Shoal Lake is located directly south of North Shoal Lake and just east of West Shoal Lake, with which it overlaps greatly at current water levels. Native pasture (60.0%) and marsh and bogs (29.6%) comprise most of the riparian habitat, with forest stands (7.9%), confined areas with cattle activity (2.4%) and undeveloped roadway crossings (0.1%) making up the remainder. The vast majority of riparian habitat (94.7%) is Class A, with flooded roadway infrastructure and areas of moderate cattle usage representing the only Class B habitat (2.9%). Class C habitat was identified along 2.4% of the shoreline, localized to two enclosed lots on the western shore sustaining heavy use by cattle herds.

According to data obtained from MIT, water elevation on East Shoal Lake was 261.824 m on August 1st, 2013. The bathymetric survey conducted near this time measured water depths ranging up to 4.47 m. If lake levels were lowered to target levels set by the steering committee, the maximum depth is expected to drop to approximately 2.35 m, while most of the lake would be reduced to under two meters in depth.

Substrate was comprised of approximately 50% clay, 30% silt, and 20% sand. Plant coverage was less than 30% across most of the lake, but a small region on the northern side reached nearly 100% coverage in some areas. Plant height ranged from less than 0.2 m to about 0.5 m and was generally greater in the northern half of the lake.

West Shoal Lake

West Shoal Lake is located directly west of East Shoal Lake and southwest of North Shoal Lake. Native pasture makes up the majority of the riparian habitat along the lake (71.1%), while significant marsh and bog habitat (18.1%) was identified along flooded land at the south end of the lake. Forest stands (5.0%), road crossings and infrastructure (4.3%) and confined areas with cattle (1.5%) accounted for the remainder. Riparian habitat was judged to be sufficient to protect fish habitat along the majority of the lake, with 71.6% of the riparian zone listed as Class A, 25.9% as Class B, and 2.5% as Class C. All Class C habitat was identified along enclosures containing a high density of cattle within the riparian zone.

The bathymetric survey measured a maximal depth of 5.40 m just west of the lake's center, while water elevation as obtained from MIT was 261.777 m. Reduction in water elevation to target levels is expected to reduce the maximum depth of West Shoal Lake to approximately 3.32 m, while most of the lake would become two to three meters deep.

Substrate in West Shoal Lake consisted of approximately 40% clay, 40% sand, and 20% silt. Plant coverage was at less than 30% across most of the lake, but a narrow region on the north half of the lake reaches 100% coverage in some areas. Plant height ranged from less than 0.2 m to about 0.5 m and was generally greater in the northern half of the lake.

Crockatt Drain

Previous records have listed Crockatt Drain as beginning at highway 518 as two drains, before converging into a single channel and flowing into southwestern North Shoal Lake (Figure 3). However, very little water was observed in the drain during the study, and a measurement of the slope of the drain along its previously recorded route was 0.00%. Because it is an ephemeral drain, it flows only during the spring and post-precipitation, drying nearly completely during the summer.

Riparian habitat was assessed along approximately 6.1 km of the drain, beyond which it became impossible to identify using aerial photographs and Google Earth software. The measured drainage area for this identifiable reach was 2.79 km^2. No physical barriers were observed along the drain, although the drain's ephemeral nature creates a barrier to fish migration and cuts off potential habitat for most of the year.

Swamp Lake Drain

Swamp Lake Drain originates within Swamp Lake, a wetland west of West Shoal Lake. The drain has a slope of 0.048%, and a drainage area of 19.6 km^2. It is a third-order tributary, 1.4 km in length, and flows only when water levels within Swamp Lake temporarily increase after rainfall events. The drain originates in meadow grass habitat, comprising 14.8% of its total land use. It passes through native pasture and grazed shrub and brush (45.7% and 25.3% of land use, respectively), ending in flooded marsh and bog habitat (13.5%) and a road crossing (2.7%). Class C riparian habitat was identified at the site of the crossing, which has been built up in response to rising water levels. The rest of the drain contained habitat considered sufficient to protect the aquatic environment, with 74.5% listed as Class B and 14.8% as Class A.

Swamp Lake Drain is the only tributary of West Shoal Lake and is therefore selected by many fish for spawning. Regions of sand, gravel, cobble, and boulder substrate serve as excellent spawning habitat and the grass observed provides cover and excellent habitat for egg deposition, especially for White Sucker. Northern Pike, also observed within this drain during spring movement, likely utilize the upstream habitat for spawning as well.

Unnamed Drain 1

Unnamed Drain 1 is the longest drain identified within the Shoal Lakes Watershed. Originating just east of Erinview, it travels straight west along Highway 415 into East Shoal

Lake. The drain is 8.2 km in length and remained dry for most of the 2013 year except for brief periods following rain. Its drainage area is 14.4 km^2 and slope of the drain is 0.061%.

Native pasture land comprised 53.2% of the land use within the drain's riparian corridor. Grazed shrub and brush was the next most prevalent habitat, accounting for 19.1% of total land use, followed by forest stands (12.3%). Wetland and shrub and brush habitat comprise 7.7% and 5.3% of land use, respectively. Thirteen road crossings were identified, accounting for the remaining 2.8% of land use along the drain. Road crossings were identified as Class C habitat, while a reach at the mouth of the drain which was more than 10 m from the highway was classified as Class A (3.5%). All other habitat was listed as Class B habitat (93.7%), as it may be moderately impacted by surface runoff from the adjacent highway.

While fewer fish were observed in this drain than in Unnamed Drain 2 located just to the north, considerable numbers were nonetheless identified at installed spawning shoal sites (Figure 6). Substrate types outside the installed spawning habitat are dominated by silt when exposed. Although a barbed wire fence crosses the drain, the wires remained above water level even during early May and it therefore is not a barrier to fish movement. Road crossings may represent more significant barriers to fish movement under lower flow conditions.

<u>Unnamed Drain 2</u>

Unnamed Drain 2, located just north of Unnamed Drain 1, is the second shortest drain within the Shoal Lakes Watershed. Originating as a brief split at highway 415 northwest of Erinview, it converges into a single, straight channel flowing directly west into East Shoal Lake. The drain is 2.8 km in length and is ephemeral, flowing only during the spring and after rainfall events. Its drainage area is 2.86 km^2 and the slope of the drain is 0.072%.

Land use and riparian zones were similar to that identified in Unnamed Drain 1, the main difference being fewer road crossings and more Class A riparian habitat. Native pasture predominated, accounting for 60.7% of all land use along the drain, while shrub and brush made up 26%, all located along the northern branch. Forest stands and marsh and bogs comprised 7.7% and 1.6% of the riparian zone respectively. One undeveloped roadway crossing and three road crossings were identified and made up the remaining land use. Road crossings were identified as Class C habitat, and as in the previous drain, the culverts under these crossings may act as barriers to fish movement when water levels do not allow fish to swim easily through them. Habitat along the northern reach was identified as Class A (20.5%), while most of the drain along the highway was listed as Class B due to the potential for surface runoff combined with the presence of some riparian cover and the non-invasive nature of the land use. Algal blooms noted in July may indicate nutrient drainage from nearby farmland.

The drain provides superior spawning habitat to Unnamed Drain 1. Six spawning shoals have been installed along the drain, and these regions of sand, gravel, cobble, and boulder serve as excellent spawning habitat. In May, it was the most densely populated drain observed during this study. High densities of spawning White Sucker and some Northern Pike filled the drain during spawning season and returned to the lake post-spawning.

3.3.1 FISH HABITAT IN THE SHOAL LAKES

The Shoal Lakes were found to contain a number of the components of quality fish habitat, but improvements in some areas may be necessary to enhance fish populations within the lake.

Bathymetric surveys yielded considerable data on habitat characteristics of the three lakes. Zones of plant coverage was found on all three lakes, with plant height ranging from 0.5 m to 1.0 m, although these zones occupied a small portion of each lake. Aquatic vegetation provides cover for many fish species as well as excellent spawning and nursery habitat for Northern Pike and Yellow Perch. Vegetation was also observed in abundance along shorelines, providing additional cover for these species. Additionally, lake depth itself, irrespective of its effects on oxygen and temperature, is an important component of fish habitat. Walleye in particular prefer deeper water, which is less exposed to damaging sunlight, and thus current water levels may provide favorable conditions for Walleye which were not previously available.

While spawning habitat for Northern Pike and Yellow Perch was present in the form of aquatic vegetation, Walleye usually spawn over gravel or cobble in shallow reaches, and these coarser substrates were not detected during bathymetric surveys. While both natural and artificial habitat for Walleye spawning exist within the studied drains, these drains are relatively small, and as they are ephemeral they may not always be accessible during spawning season. Given these facts, available spawning habitat within the lakes themselves would improve the likelihood of sustaining a Walleye fishery. If any favorable Walleye spawning habitat currently exists within the Shoal Lakes, it is likely along recently flooded roads and roadways where gravel has become part of the littoral substrate, and is thus likely dependent upon continued high water levels.

3.4 WATER QUALITY

Good water quality is the foundation for having a healthy aquatic environment and balanced ecosystem. Fish, wildlife, area residents, agricultural producers, commercial and recreational fishermen, and those using the waterways for recreational activities depend on clean, healthy water.

3.4.1 IN-FIELD AND LABORATORY SAMPLING

Results of this study indicated that water quality within the tributaries within the region was quite good (Table 4). Based on the classification system developed by Dodds et al. (1998), using Total Phosphorus (TP) as the indicator, all creeks within Shoal Lake Watershed would be classified as Oligotrophic to Mesotrophic as TP was well below 0.075mg/L, the boundary between Mesotrophic/Eutrophic.

Water quality profiles on July 4 and 27 provided information about general water quality during the hottest time of year. On July 4, DO was 8.00 mg/L, water temperature was 21.80ºC, pH was 7.54, conductivity was 653 µS/cm, and turbidity was 4.05 NTU. On July 27, DO was 11.94 mg/L, water temperature was 19.93ºC, pH was 8.20, and conductivity was 1289 µS/cm. These measurements are well within the normal limits of a healthy, alkaline lake. Additionally, water quality parameters were consistent between depths at each site, indicating complete mixing of the lake. The only negative characteristic observed during sampling was an algal bloom during July in Unnamed Drain 2, indicating possible nutrient drainage from nearby farmland.

Table 4. Results of water quality samples collected within the Shoal Lakes Watershed.

Water Quality Parameter	Units	West Shoal Lake, July 23	East Shoal Lake, July 23	West Shoal Lake, March 19	East Shoal Lake, March 19
Ammonia (NH3), Total	mg/L	<0.050	<0.050	0.100	0.027
Chlorophyll a	µg/L	3.33	4.21	<0.60	1.15
Phosphorus, Total	mg/L	0.0443	0.0541	0.106	0.090
Total Dissolved Phosphorus	mg/L	0.0288	0.0199	0.095	0.081
Total Dissolved Solids	mg/L	1505	1378	2140	1410
Total Suspended Solids	mg/L	<5.0	<5.0	10.0	7.0
Nitrate+Nitrite-N	mg/L	<0.71	<0.71	0.35	0.44
Nitrite-N	mg/L	<0.25	<0.25	<0.25	<0.25
Total Kjeldahl Nitrogen	mg/L	1.22	1.38	2.74	2.51
Total Nitrogen	mg/L	1.44	1.38	3.09	2.95

3.4.2 DISSOLVED OXYGEN PROFILES

The nine DO profiles provide information on DO in each of the three Shoal Lakes at various depths during the winter (Figure 5). Ice thickness ranged from 85 to 95 cm across sites. At each site, DO reached its maximum within one meter and then decreased with depth. Maximum concentrations at each site ranged from 5.65 to 10.53 mg/L while bottom of each lake reached minimum values of 0.71 to 1.79 mg/L. Water temperature ranged from 0.07ºC at the surface of East Shoal Lake Site 3 to 4.90ºC at the bottom of West Shoal Lake Site 2. Within each site, water temperature typically ranged by about three to four degrees. The pH ranged from 7.69 to 8.10 between sites.

To relate these values to the oxygen requirements of the fish species present in the Shoal Lakes, a literature review was conducted. More specifically, the review explored the DO required for a) normal growth and development, and b) survival for several species. Based on observations and previous research, seven species were selected for study based on their importance/prevalence in the Shoal Lakes: Walleye, Northern Pike, Yellow Perch, White Sucker, and the foraging species Spottail Shiner (*Notropis hudsonius*), Brook Stickleback (*Culaea inconstans*), and Central Mudminnow (*Umbra limi*). Given threshold values serve only as an estimation, as exact DO requirements vary significantly both between and within species in response to factors such as water temperature, exposure period, and maturity. In particular, the relationship between temperature and DO is complex. Although oxygen solubility decreases at warmer temperatures, fish tend to have lower requirements during winter due to reductions in activity and metabolism. However, management efforts striving to maintain lake oxygen levels above the incipient limiting levels of its fish species year-round maximize the likelihood of long-term success of its species (Gee et al. 1977).

Table 6 displays the species-specific DO requirements of the seven fish species of interest. Species-specific data was often limited and inconsistent due to differences between methods and experimental conditions. Available incipient limiting levels ranged from 1.2 mg/L for Spottail Shiner to 5.0 mg/L for Yellow Perch. Although the smaller foraging species were less represented in the literature, their lethal limits were similar or somewhat lower than those of the larger species, so we may presume that the optimal limits probably do not exceed 5.0 mg/L. This indicates that of the fish studied, Yellow Perch appears to be the most oxygen-dependent and may be the first to experience negative changes to its growth and development. Oxygen profile results indicate that each of the Shoal Lakes currently contains regions of optimal oxygen levels for all species ($\geq$5.0 mg/L), although bottom concentrations at each site were hypoxic for most of the fish species analyzed.

According to data obtained from Manitoba Infrastructure and Transportation, water elevations in the Shoal Lakes were approximately 1.2 m (in North Shoal) and 2 m (in East and West

Shoal) higher than the steering committee's target levels at the present study was conducted (target levels taken from Bodnaruk 2010). Significant lowering of lake levels can have a large impact on overall DO concentrations. At warmer temperatures, lower lake levels can result in decreased DO availability due to increased fish density and decreased oxygen solubility as the smaller lake reaches higher temperatures. Especially when coupled with rapid decomposition following algal blooms or during hot, calm periods of weather, summerkills can occur. Negative effects can also carry over into the winter as well when ice cover prevents air mixing and surface gulping (for most species), a mechanism used during the summer to alleviate oxygen deprivation (Gee et al. 1977). Even though decreased activity reduces winter DO requirements, large decreases in water levels can lead to winterkills. Negative effects resulting from a significant water level drop seem even more likely when coupled with the observations that a) the rise in fish populations in this watershed has been closely associated with increased water levels, and b) North Shoal Lake, the shallowest of the three lakes, had the lowest maximum and minimum DO.

Together, this indicates that an overall decrease in lake levels would likely decrease DO, but the precise drop in DO associated with any given reduction in water level is impossible to quantify using the present data. Further monitoring of dissolved oxygen during both summer and winter months is recommended to establish a relationship between varying water levels and changes in DO in the watershed. If water levels are artificially lowered in the future, this should be done gradually, while continuing to monitor DO and the health of the fish community.

3.4.3 WATER TEMPERATURE

Water temperature data from the logger placed at the mouth of Swamp Lake drain is presented in Appendix G. Monthly water temperatures averaged across both years ranged from -0.96°C in February to 22.4°C in July (Table 5). Daytime highs of over 20°C were reached for much of June, July and August in both years and temperatures at or above 25°C were recorded several times during these months, with a maximum of 28.97ºC recorded on July 4th 2013. Sustained high summer water temperatures (approaching 25°C) associated with lower lake levels may be problematic for the Shoal Lakes, as water at this temperature often contains too little oxygen to support fish populations.

Table 5. Average monthly water temperature recorded in Swamp Lake Drain, West Shoal Lake.

Month	Average Water Temperature (°C)
January	-0.61
February	-0.96
March	-0.60
April	1.24
May	13.7
June	19.7
July	22.4
August	22.1
September	16.6
October	6.98
November	2.14
December	0.08

3.4.4 BENTHIC INVERTEBRATE SAMPLING

The invertebrate community within the Shoal Lakes Watershed, although not heavily sampled, appeared diverse. Dragonflies (Odonata), mayflies (Ephemeroptera), and caddisflies (Trichoptera), the most sensitive species to poor water quality, were collected in all of the tributaries sampled. However, more effort should be taken to sample the invertebrate community within known livestock watering areas, areas with limited diversity, and areas where riparian zones appear inadequate. By having a good understanding which types of invertebrates are found within different areas of the watershed, the WIWCD will be able to determine how healthy each system is.

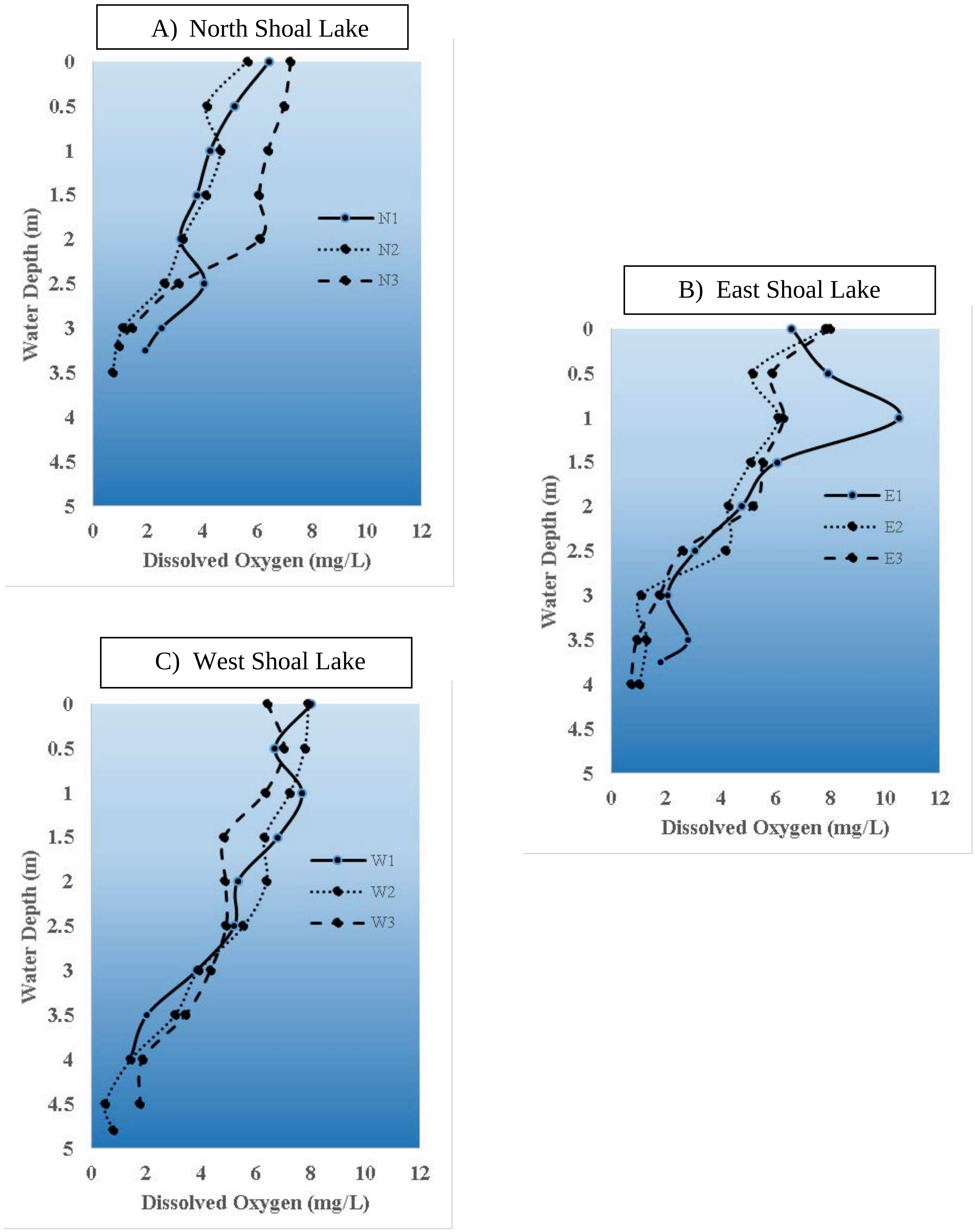

Figure 5. Winter dissolved oxygen profiles obtained at three sites within a) North Shoal Lake, b) East Shoal Lake, and c) West Shoal Lake.

Table 6. Dissolved oxygen requirements for seven fish species found in the Shoal Lakes.

Fish Species	Temperature (^oC)	Incipient Limiting Level (mg/l)	Incipient Lethal Limit (mg/l)	Preferred Levels (mg/l)	Notes	Source
Walleye	Range, summer	-	-	>3-5		Dendy, 1948
	22	-	1	-		Scherer 1971
Northern Pike	19	3.0-3.35*	-	-	Studied only during period between fertilization and feeding larvae.	Siefert et al. 1973
	Range, winter	-	1	-	Tolerate extreme conditions (0.1-0.4mg/l) for several days if gradual	Inskip, 1982
	28	-	1.5	-		Casselman, 1978
Yellow Perch	Range, summer	5	0.2 - 1.5	-		Krieger et al. 1983
	26	-	3.1	-		Moore, 1942
White Sucker	18	<2.5*	1.2	-	Limiting level measured for fry, lethal limit measured for juveniles	Siefert and Spoor, 1974
	Range, summer	-	-	>2.4	Preferred level estimated by the range that adults tend to avoid	Dence, 1948
Spottail Shiner	16	<1.2	<1.1	-	Values likely underestimated due to short testing period	Gee et al. 1977
Brook Stickleback	16	-	<1.2	-	Value likely underestimated due to short testing period	Gee et al. 1977
	1	-	<0.3	-		Klinger et al. 1982
Central Mudminnow	1	-	<0.3	-	Limits likely much higher during the summer	Klinger et al. 1982

3.5 FISH UTILIZATION

Observation and local reports indicated that the predominant fish species present in the Shoal Lakes Watershed were Yellow Perch, Northern Pike, and White Sucker (Redekop, 2014). Although very few have been captured to date and none were observed during this study, one million Walleye fry were also stocked into North Shoal Lake on May 15, 2012 approximately 5 km north of Harperville (Manitoba Conservation and Water Stewardship, 2012). Black bullheads were also identified in a shallow pond near West Shoal Lake that froze completely during the winter. However, some smaller and/or less prevalent species are likely also present (Table 7).

Fish were not commonly observed in the Shoal Lakes due to depth, but they were easily observable in the drains. Within the drains, maximal fish densities were reached during the spawning season (Figure 6). Of the four drains, Unnamed Drain 2 contained the highest density of fish. Regions of sand, gravel, cobble, and boulder within the drain provided valuable spawning habitat; however, habitat of this type was limited. On May 9, a sample of fish was taken from Unnamed Drain 2 and used to estimate the species distribution as approximately 95% White Sucker and 5% Northern Pike. Both Unnamed Drain 1 and Swamp Lake Drain were also densely packed with fish during this period. Because it is the only tributary of West Shoal Lake and it contains regions of valuable spawning habitat, this is not surprising of Swamp Lake Drain. Post-spawning, fish density quickly decreased in all drains to almost zero even while water levels were high within the drains. Electrofishing within Unnamed Drain 2 on June 4 demonstrated a near complete absence of fish.

Although not surveyed, reports from locals indicate that fish populations have progressively grown as water levels have risen (Redekop, 2014). Increasing fish populations have drawn fishermen into the area, especially for Northern Pike and Master Angler-size perch. Due to the high abundance of food and suitable habitat, fish populations could become even greater if water levels do not decrease.

Table 7. Fish species potentially utilizing the Shoal Lakes Watershed. Information collected from Stewart and Watkinson (2004).

Presence in Shoal Lakes Watershed	Common Name	Family	Genus	Species	Occurrence	COSEWIC Status	Known Occurrences
Observed	White Sucker	Catostomidae	*Catostomus*	*commersonii*	Native	not listed	**Shoal Lakes Watershed**
	Northern Pike	Esocidae	*Esox*	*lucius*	Native	not listed	**Shoal Lakes Watershed**
	Yellow Perch	Percidae	*Perca*	*flavescens*	Native	not listed	**Shoal Lakes Watershed**
	Black Bullhead	Ictaluridae	*Ameiurus*	*melas*	Native Recent	not listed	**Shoal Lakes Watershed**
Likely	Brown Bullhead	Ictaluridae	*Ameiurus*	*nebulosus*	Native Recent	not listed	Delta Marsh - Lake Manitoba
	Brook Stickleback	Gasterosteidae	*Culaea*	*inconstans*	Native	not listed	Dog Lake Watershed
	Walleye	Percidae	*Sander*	*vitreus*	Native	not listed	Dog Lake Watershed
	Iowa Darter	Percidae	*Etheostoma*	*exile*	Native	not listed	Dog Lake Watershed
	Johnny Darter	Percidae	*Etheostoma*	*nigrum*	Native	not listed	Lake Manitoba
	Common Carp	Cyprinidae	*Cyprinus*	*carpio*	Introduced	not listed	Dog Lake Watershed
	Spottail Shiner	Cyprinidae	*Notropis*	*hudsonius*	Native	not listed	Dog Lake Watershed
	Northern Redbelly Dace	Cyprinidae	*Phoxinus*	*eos*	Native Rare, Tributaries	not listed	Lake Manitoba
	Finescale Dace	Cyprinidae	*Phoxinus*	*neogaeus*	Native Rare, Tributaries	not listed	Lake Manitoba
	Fathead Minnow	Cyprinidae	*Pimephales*	*promelas*	Native	not listed	Dog Lake Watershed
	Longnose Dace	Cyprinidae	*Rhinichthys*	*cataractae*	Native	not listed	Unknown
	Central Mudminnow	Umbridae	*Umbra*	*limi*	Native Recent	not listed	Dog Lake Watershed
Possible	Logperch	Percidae	*Percina*	*caprodes*	Native	not listed	Lake Manitoba
	Emerald Shiner	Cyprinidae	*Notropis*	*antherinoides*	Native	not listed	Lake Manitoba
	Trout Perch	Percopsidae	*Percopsis*	*omiscomaycus*	Native	not listed	Lake Manitoba
	Burbot	Gadidae	*Lota*	*lota*	Native	not listed	Lake Manitoba

Figure 6. Fish densities during spawning in Unnamed Drain 1 (bottom) and 2 (top).

4.0 POTENTIAL REHABILITATION SITES

A list of enhancement and rehabilitation projects that AAE Tech Services feel are important to improve the aquatic ecosystem within the Shoal Lakes Watershed can be found within Appendix H. The projects range from riparian enhancement to removing or providing fish passage at those barriers identified within the waterways. General recommendations are also provided to enhance or create fish spawning habitat within the selected tributaries and lakes. Efforts are encouraged for the WIWCD to work and collaborate with local landowners, government agencies, municipalities and producers to jointly improve the conditions within the Shoal Lakes Watershed and other watersheds within the conservation district.

5.0 SUMMARY

The WIWCD initiated this study to better understand the waterways, fish community and fish habitat within the conservation district, and to evaluate the ability of the Shoal Lakes Watershed to support a healthy fishery. The results of the study are also intended to assist the WIWCD to effectively restore, enhance, and protect the aquatic environment within their conservation district to develop a healthy aquatic ecosystem for the benefit of all user groups.

Assessments of riparian zones and land use practices along the Shoal Lakes and their drainage networks revealed a largely healthy riparian habitat consisting mainly of native pasture and flooded marshland formerly used as pasture. These types of environments are not typically associated with excessive nutrient loading to the aquatic environment, with the exception of heavily grazed sections where bank trampling is common. Approximately 75% of the riparian habitat assessed in this survey fit the criteria for "Class A" habitat, capable of protecting the aquatic environment from surface runoff, pollution and physical disturbance. The primary areas for improvement were located along flooded and built-up roadway infrastructure, culverts and road crossings, and confined areas where dense cattle activity encroaches upon riparian habitat.

The physical characteristics of the lakes and drains within the watershed were described. Drains were ephemeral, flowing only in spring and after precipitation events. The drains tended to be very straight and uniform with low slopes, but the presence of good spawning habitat and cover was noted along several reaches. Numerous road crossings along several drains were noted as potential barriers to fish movement, should water levels recede. Bathymetric surveys conducted within each lake provided detailed information on depth, bottom shape, substrate composition, and vegetation. Maximum depths of 3.68 m, 4.47 m and 5.40 m were measured on North, East and West Shoal Lake respectively. The substrate of all three lakes was made up of a mixture of sand, silt and clay, while coarser substrates such as gravel and cobble were not detected.

Observations of dense fish spawning within drains confirmed the presence of White Sucker, Northern Pike and Yellow Perch in the watershed, as well as the ability of the drains to support fish spawning, particularly within installed spawning shoals. However, further sampling to evaluate the success of eggs, larvae and fry within the lakes is recommended.

A literature review investigated the current status of certain bird communities and habitat within the watershed, and possible impacts of rising or receding water levels. The Piping Plover, an endangered species whose current presence in the watershed is unknown or in doubt, relies on sandy beach habitat which has been severely flooded in the last 15 years, but also benefits from natural fluctuations in water levels to maintain this habitat. Colonial birds, very prevalent on the Shoal Lakes, may be affected by changes in water level which either remove protected island habitat or connect it to the mainland.

The literature review also indicated that current dissolved oxygen levels within the Shoal Lakes are sufficient to support a healthy fish community. Measurements during the summer months indicated complete mixing, while stratification in oxygen profiles was observed during winter, with deeper waters dropping to anoxic conditions. Both summer kill and winter kill events were discussed as possibilities should water levels recede in the future, though summer and winter sampling of dissolved oxygen is recommended before any target water level thresholds can be accurately suggested.

A number of enhancement efforts can be undertaken to improve habitat within the watershed. To achieve these enhancements, the WIWCD should partner with local landowners, agricultural producers, municipalities, and government agencies to accomplish the ultimate goal of providing a healthy ecosystem within the watershed to benefit all user groups. This project was intended to provide baseline information on the fishery and fish habitat, as well as recommendations on how to improve the health and sustainability of the watershed for user groups and fish and wildlife. Numerous recommendations can be found below.

6.0 RECOMMENDATIONS

The recommendations below are based on the results of this study and discussions had with the West Interlake Watershed Conservation District and Provincial and Federal Government Agencies.

- Hold information meetings with local landowners to discuss future plans of the WIWCD. By getting everyone involved within the community will help with future enhancement initiatives.

- Use this report to tackle or enhance the potential rehabilitation sites listed within to improve fish habitat, water quality and the health of the aquatic ecosystem.

- Build spawning shoals within all tributaries to increase habitat diversity and provide additional spawning habitat for fish. Fish habitat within these drains was marginal in terms of a lack of valuable Walleye spawning habitat (gravel, cobble substrates).

- Erect riparian fencing along sections of the waterways within the watershed where cattle have direct access. Efforts should first be directed to the most heavily affected areas on North and West Shoal Lakes.

- Work with landowners along the waterways to develop management strategies to limit cattle from entering the waterways.

- Conduct more thorough studies on the Shoal Lakes, documenting bathymetry (water depth), dissolved oxygen levels, fish utilization, and the macrophyte communities found within the Lake. Depending on the result of future studies, constructing spawning reefs or shoals may be a good management strategy to increase spawning habitat to ultimately help increase fish stocks within the lake. Currently there appears to be ample spawning habitat for Northern Pike and Yellow Perch.

- Conduct additional monitoring at the culvert crossings identified as barriers during this assessment. The culverts may or may not be barriers under certain flow conditions.

7.0 ACKNOWLEDGEMENTS

Thanks to everyone on the West Interlake Watershed Conservation District for giving AAE Tech Services the opportunity to conduct this riparian and aquatic survey on the Shoal Lakes Watershed.

Special thanks to Linda Miller, Manager of the WIWCD, Doug Oliver and the rest of the WIWCD board for their dedication and support with the project and to the Conservation District. Thanks to Lyndon and Derrick Jameson, Wes Johnson, Logan Queen, Alan Johnson, and Kristin–Yaworski-Lowdon for assisting with the fieldwork component of the project. Thanks to St. Andrews Airport for assisting with aerial photography. Thanks to the landowners who provided knowledge with regards to historical fish catches and fish movements within the tributaries of the watershed. Thanks to Laureen Janusz (Manitoba Water Stewardship) for the providing the collection permit. If we have missed anyone, we sincerely apologize. There were so many individuals that helped to make this project a success.

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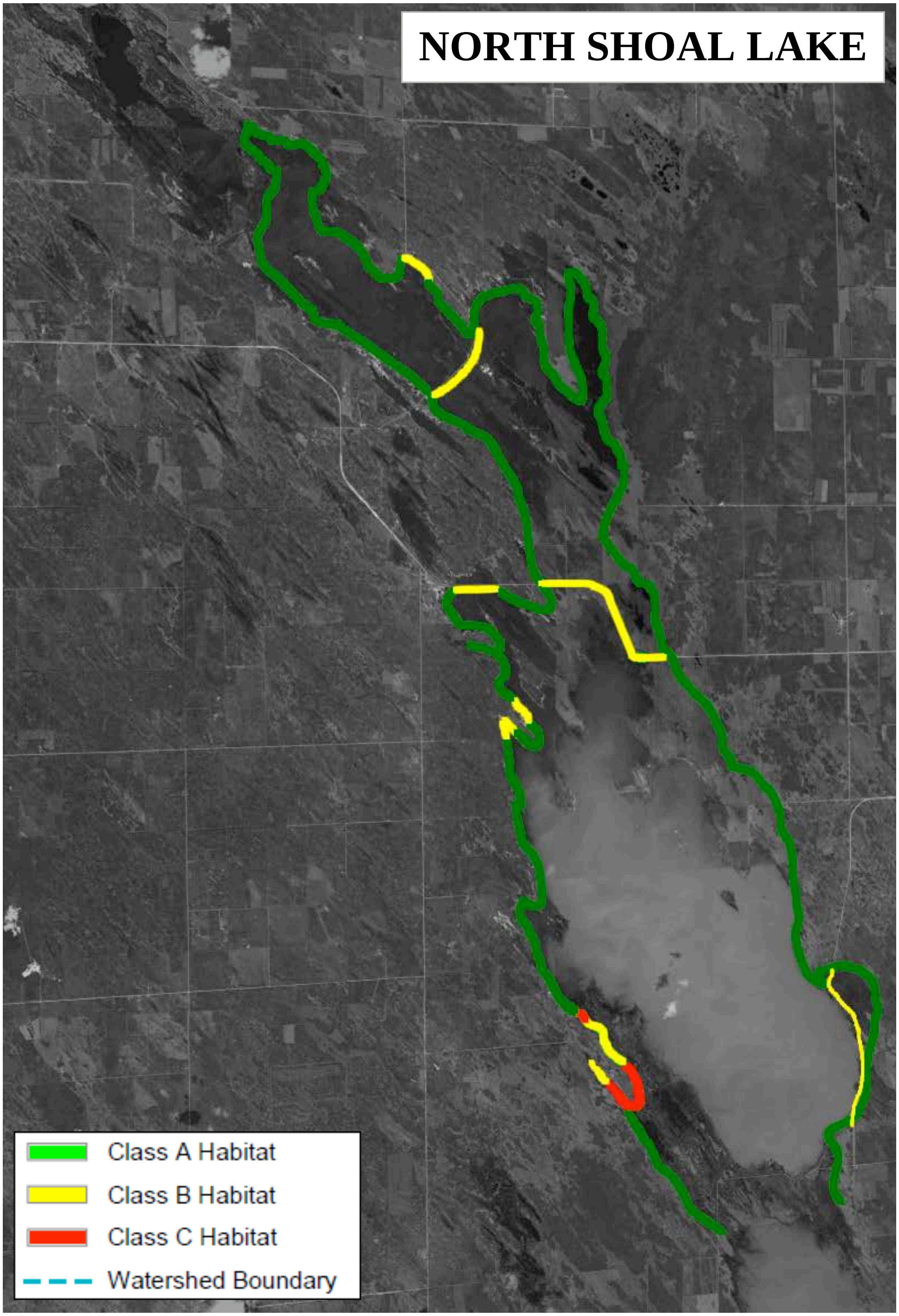
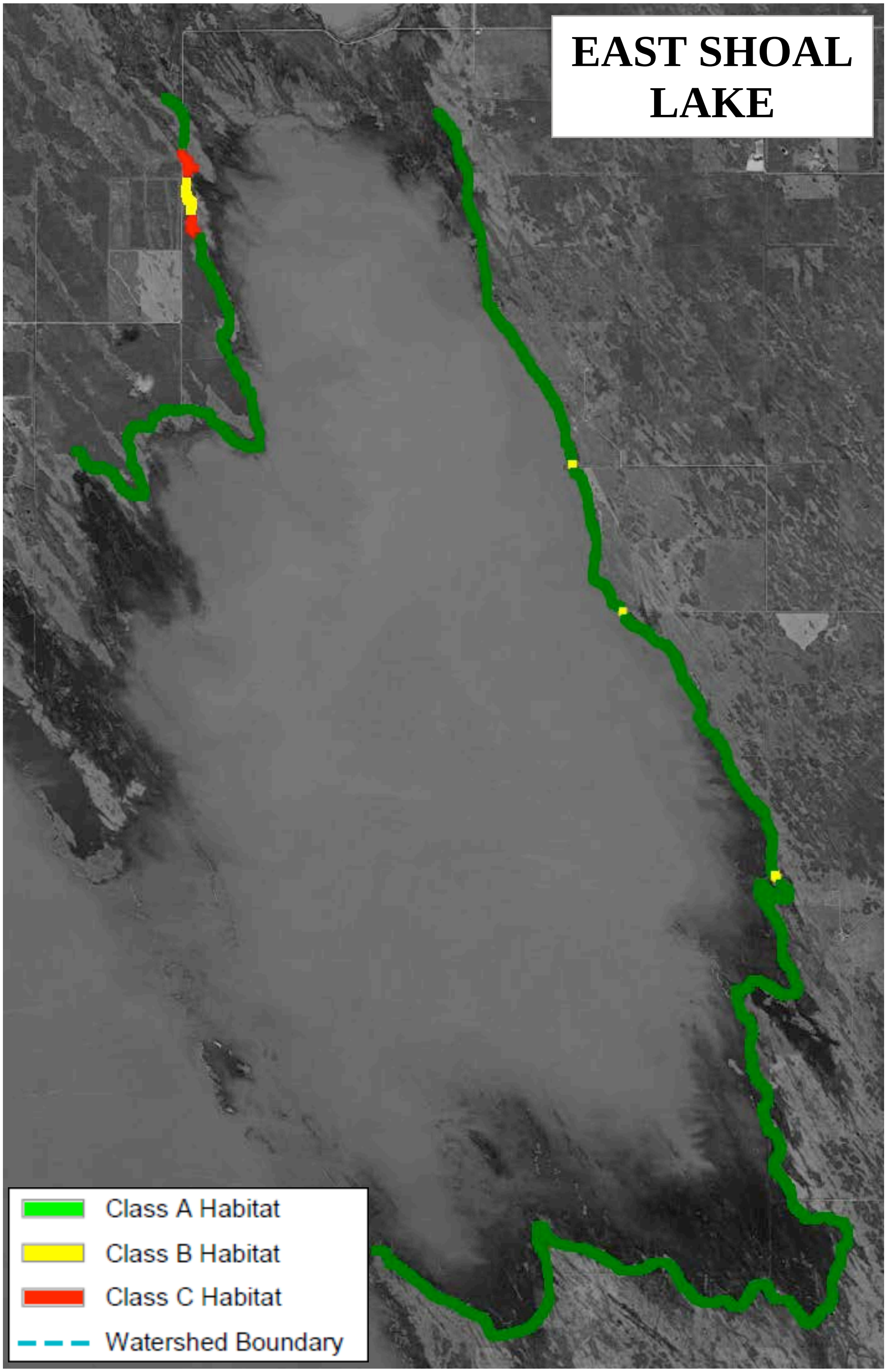
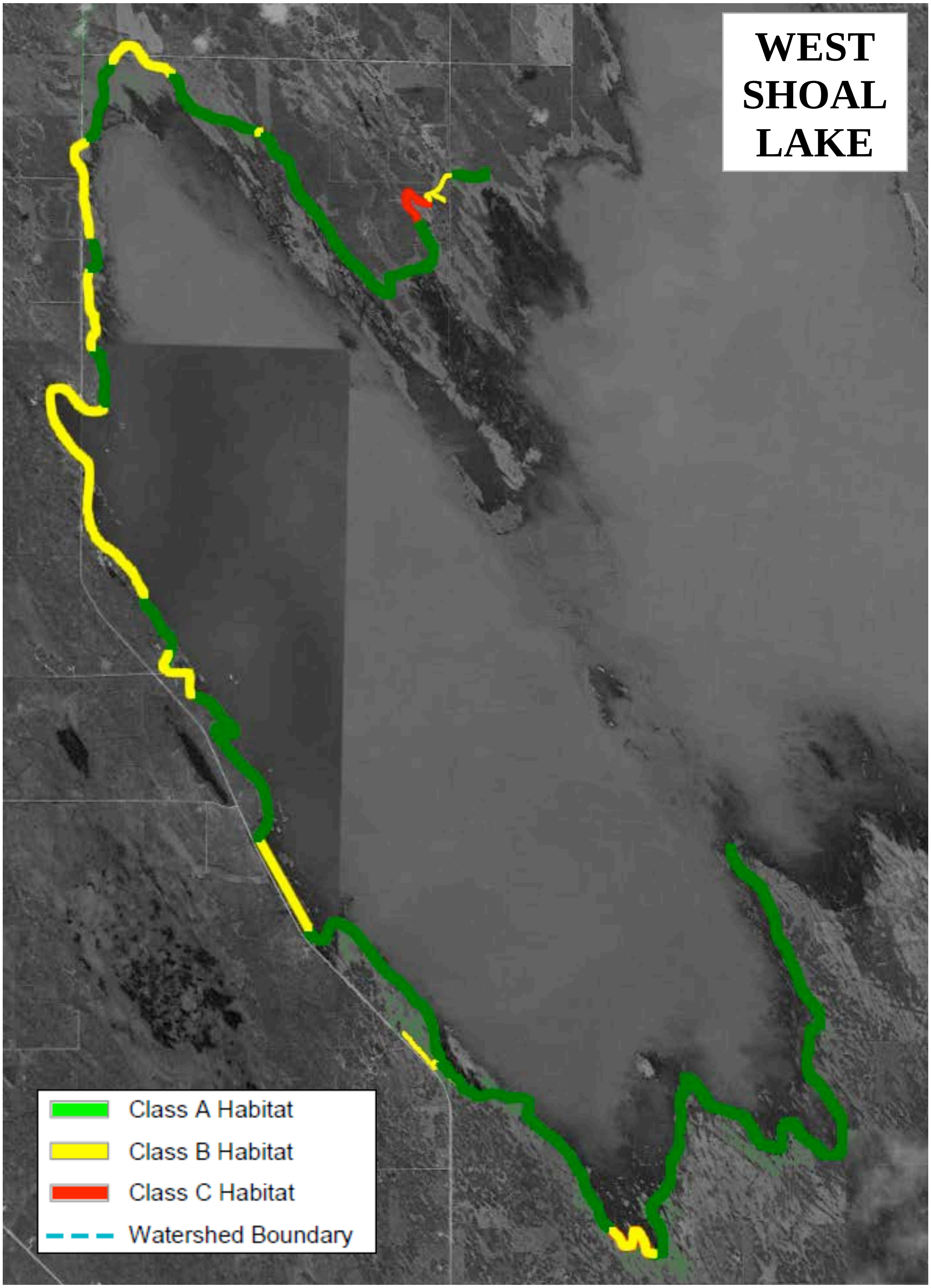
APPENDIX A: Habitat featured maps of riparian zone classification of the lakes and drains within the Shoal Lakes Watershed.



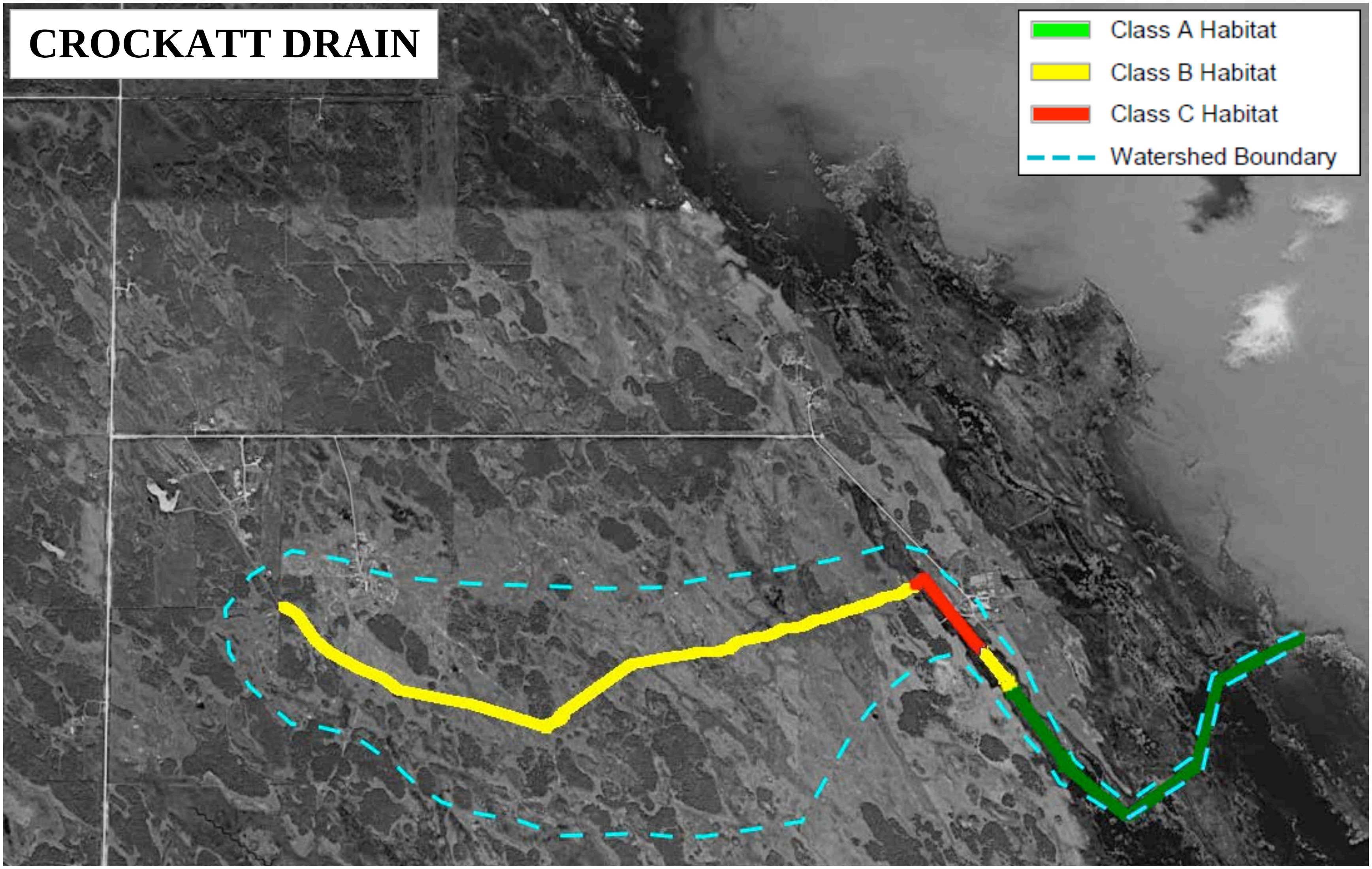
Appendix A-1. North Shoal Lake riparian zone classification habitat featured map.



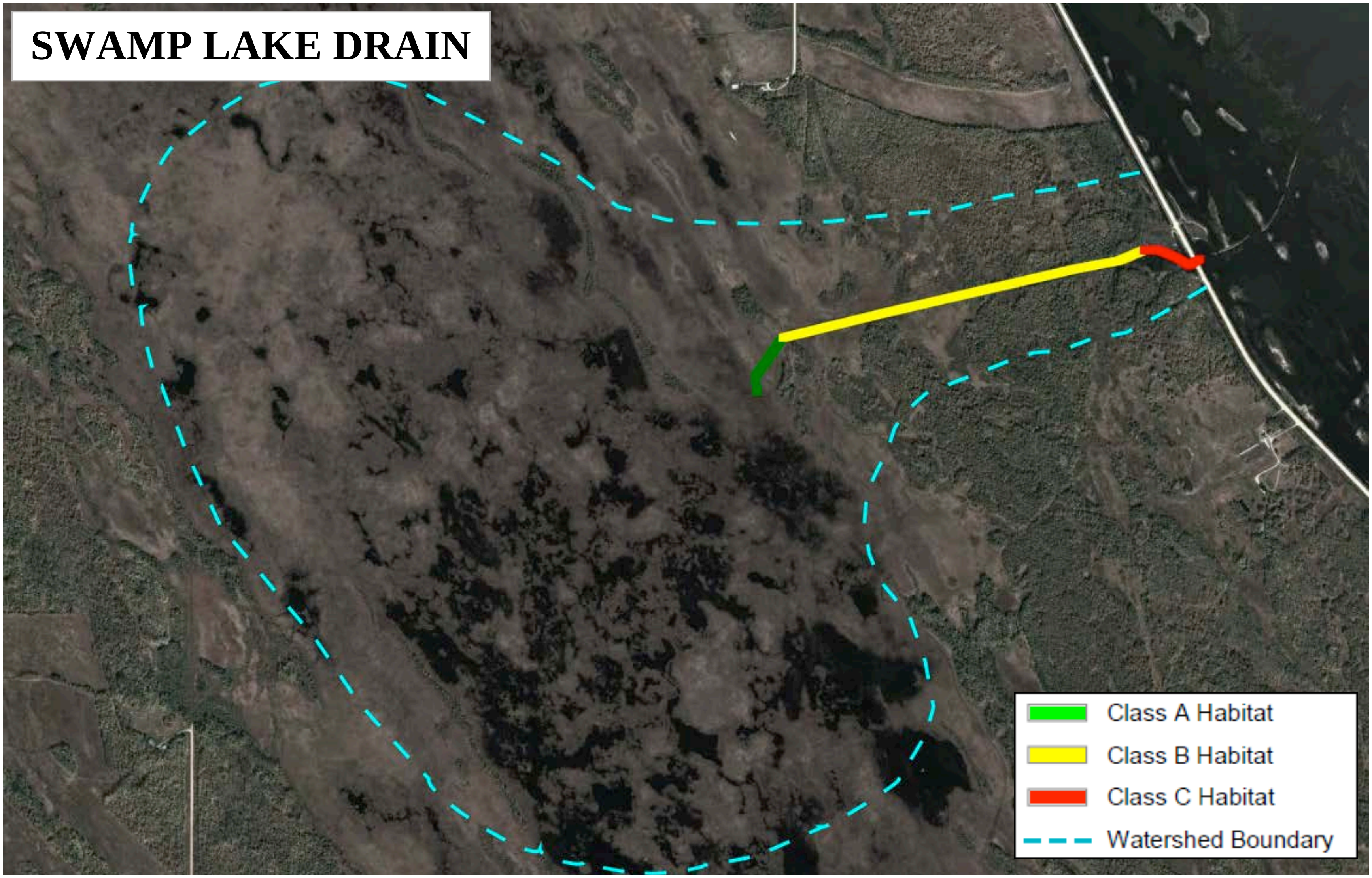
Appendix A-2. East Shoal Lake riparian zone classification habitat featured map.



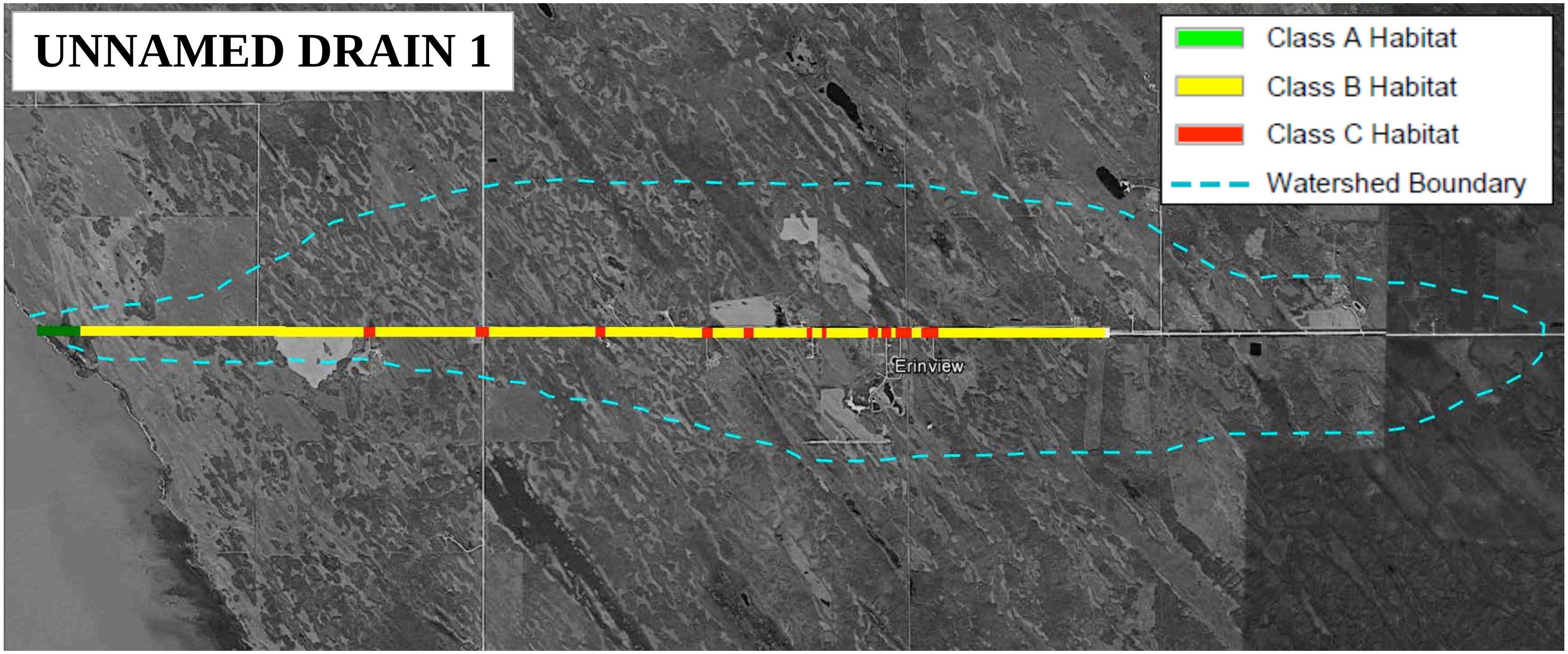
Appendix A-3. West Shoal Lake riparian zone classification habitat featured map.



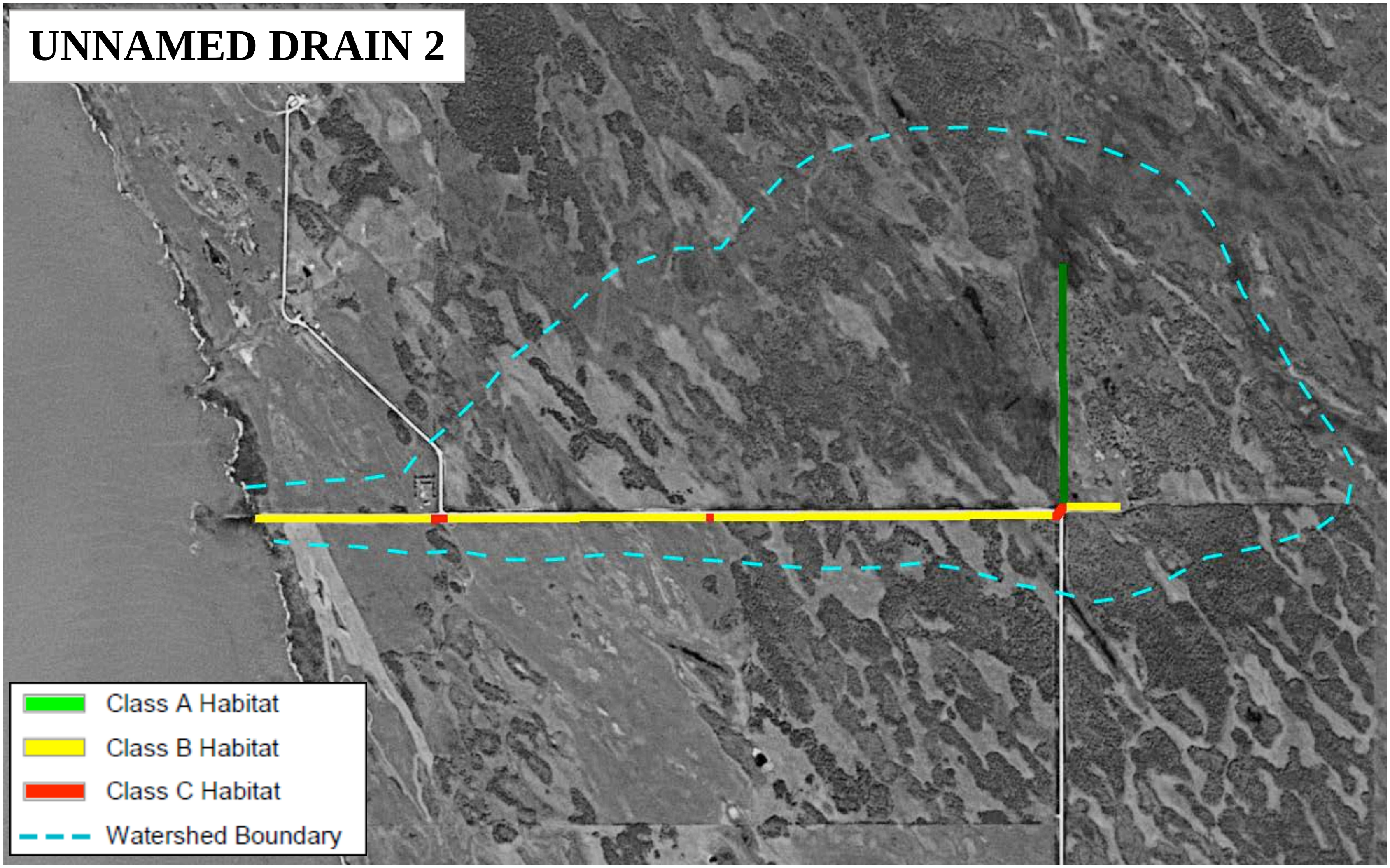
Appendix A-4. Crockatt Drain riparian zone classification habitat featured map.



Appendix A-5. Swamp Lake Drain riparian zone classification habitat featured map.

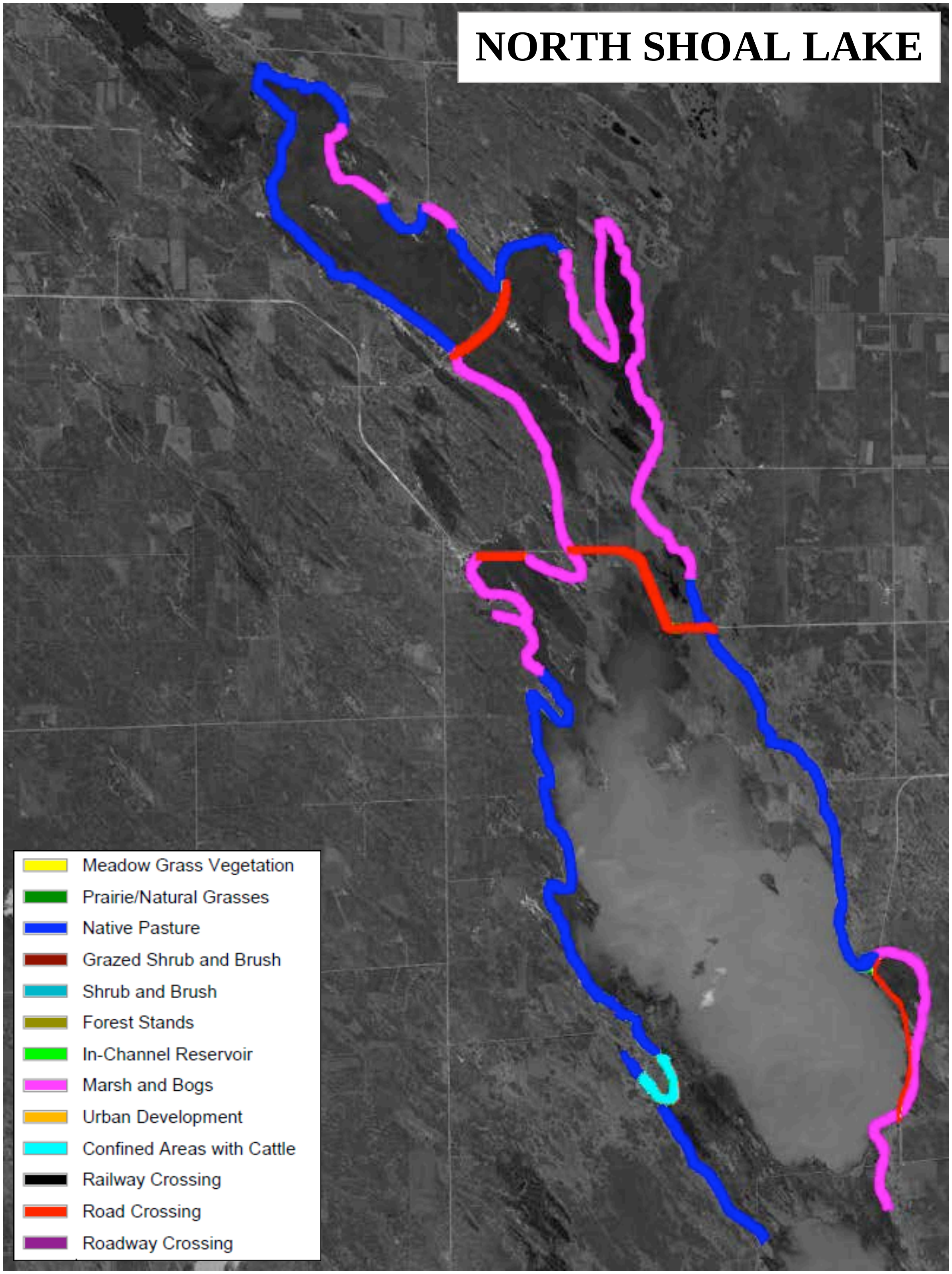


Appendix A-6. Unnamed Drain 1 riparian zone classification habitat featured map.

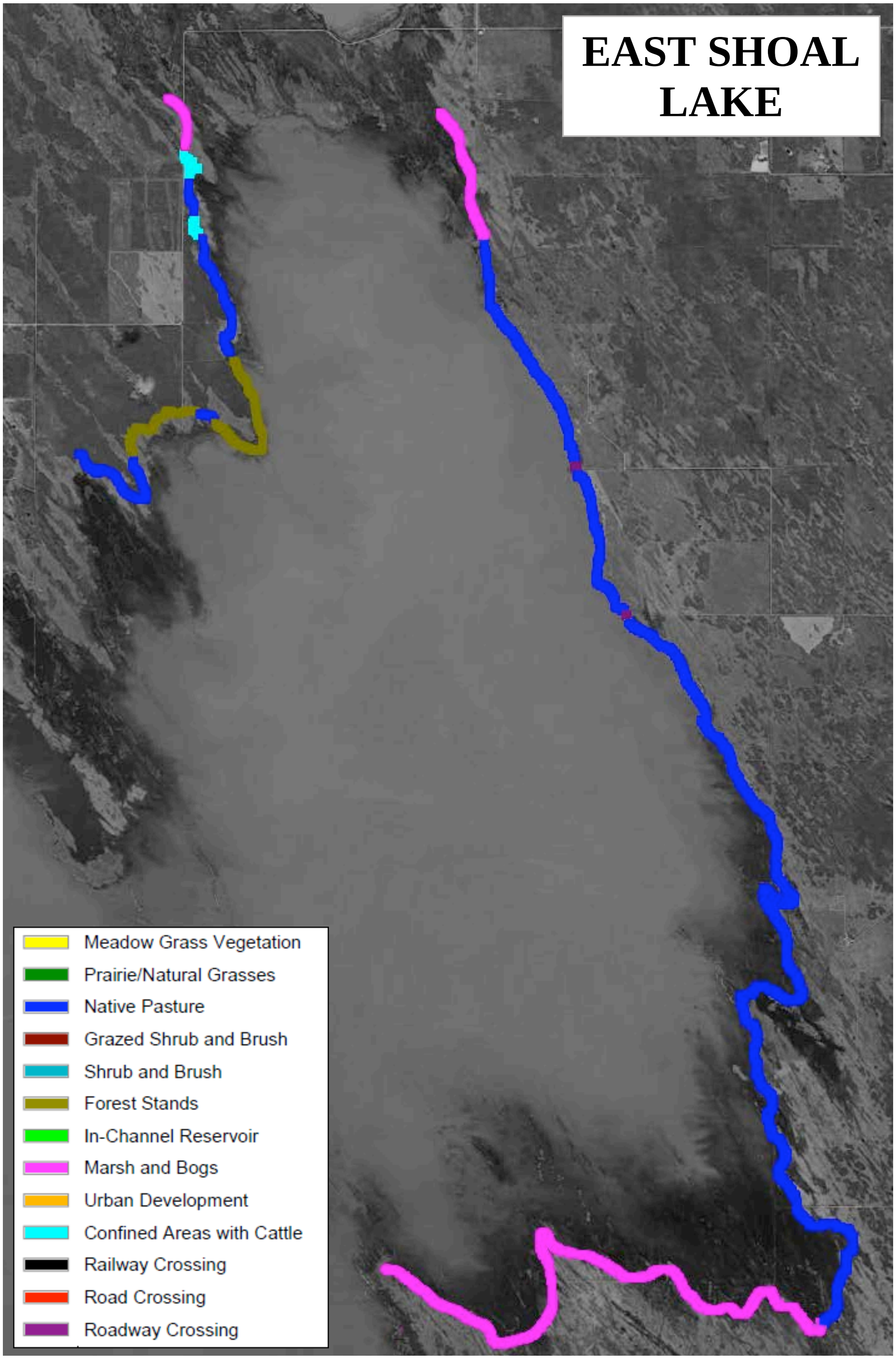


Appendix A-7. Unnamed Drain 2 riparian zone classification habitat featured map.

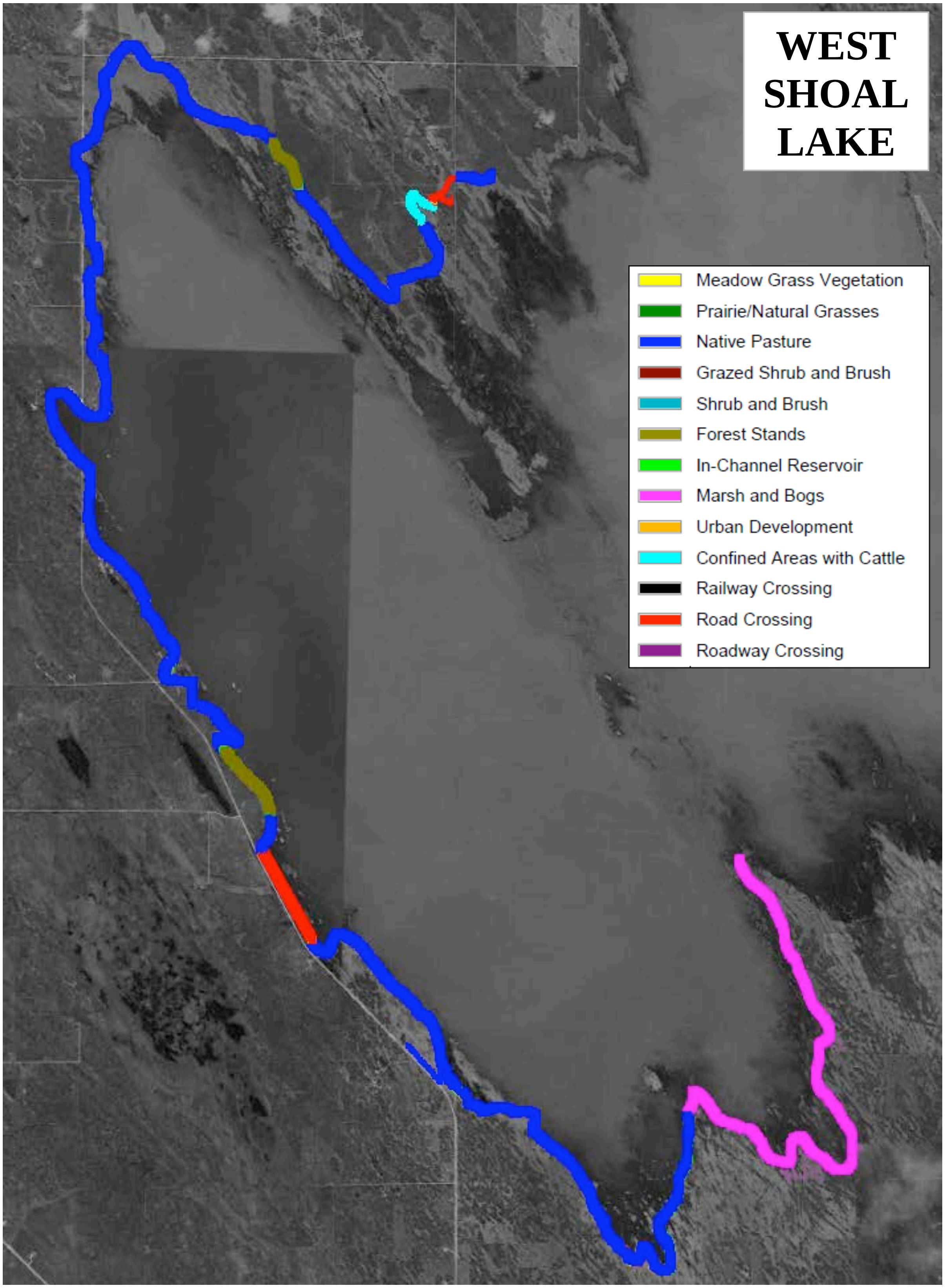
APPENDIX B: Land use classification maps of the lakes and drains within the Shoal Lakes Watershed.



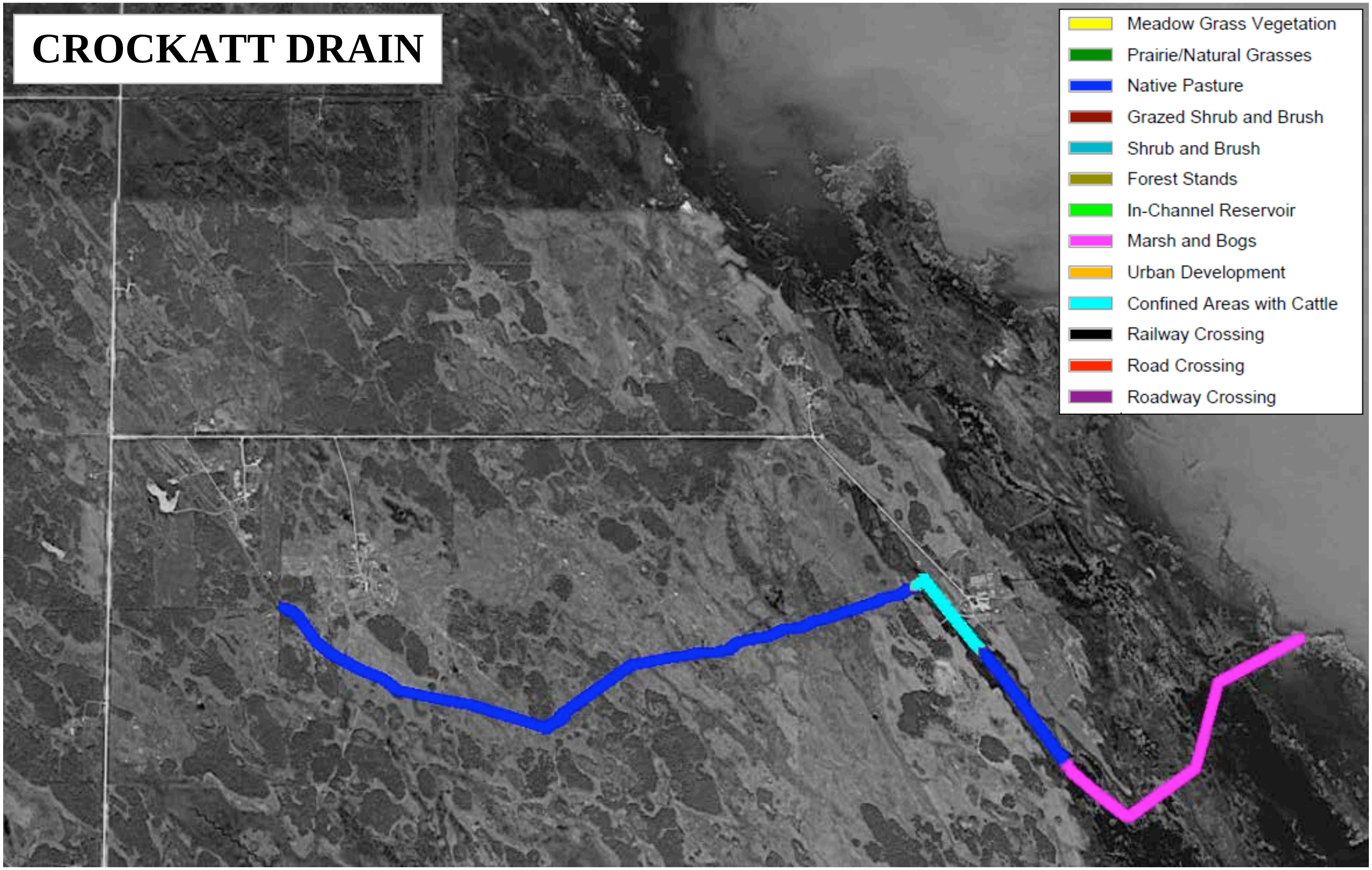
Appendix B-1. North Shoal Lake land use classification map.



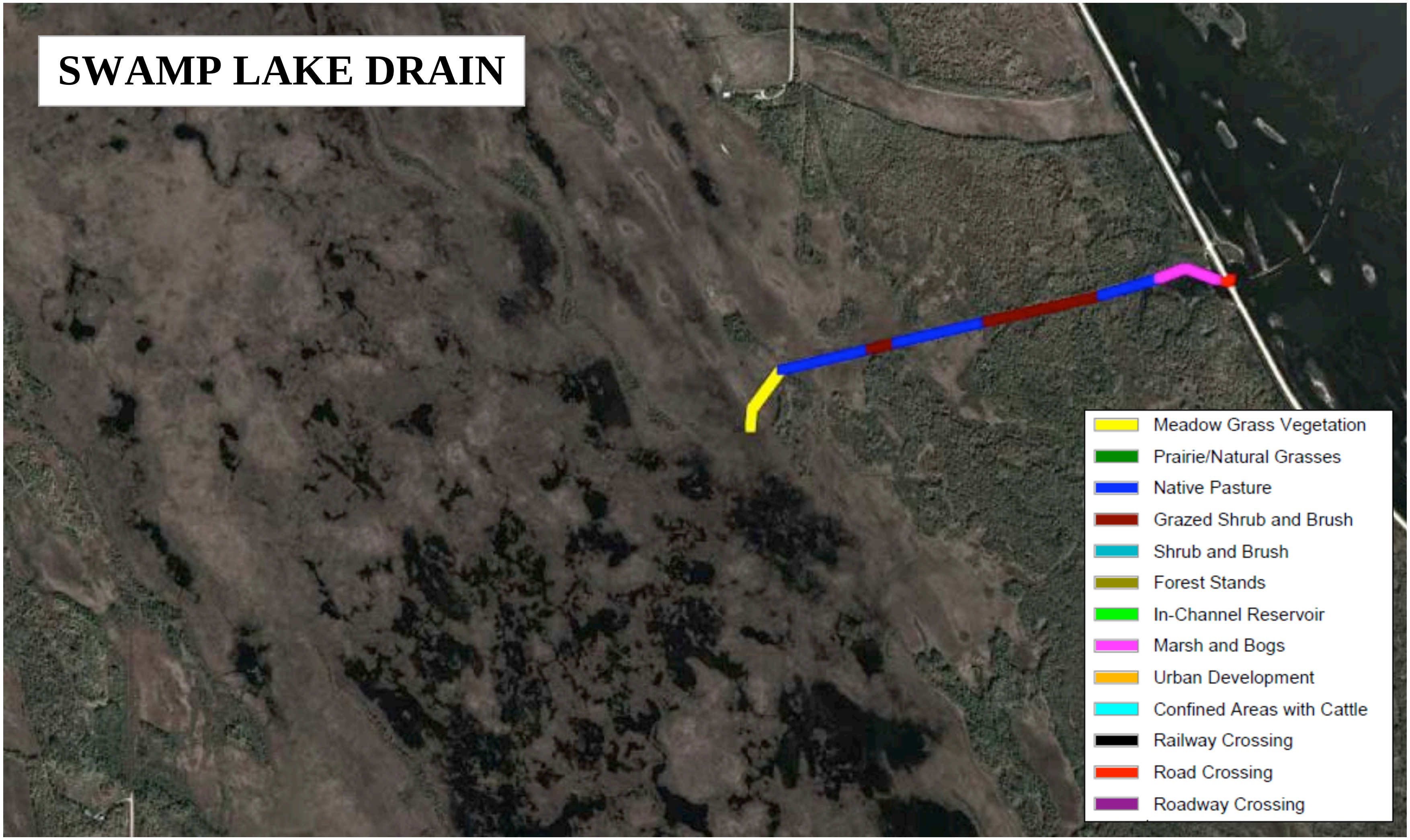
Appendix B-2. East Shoal Lake land use classification map.



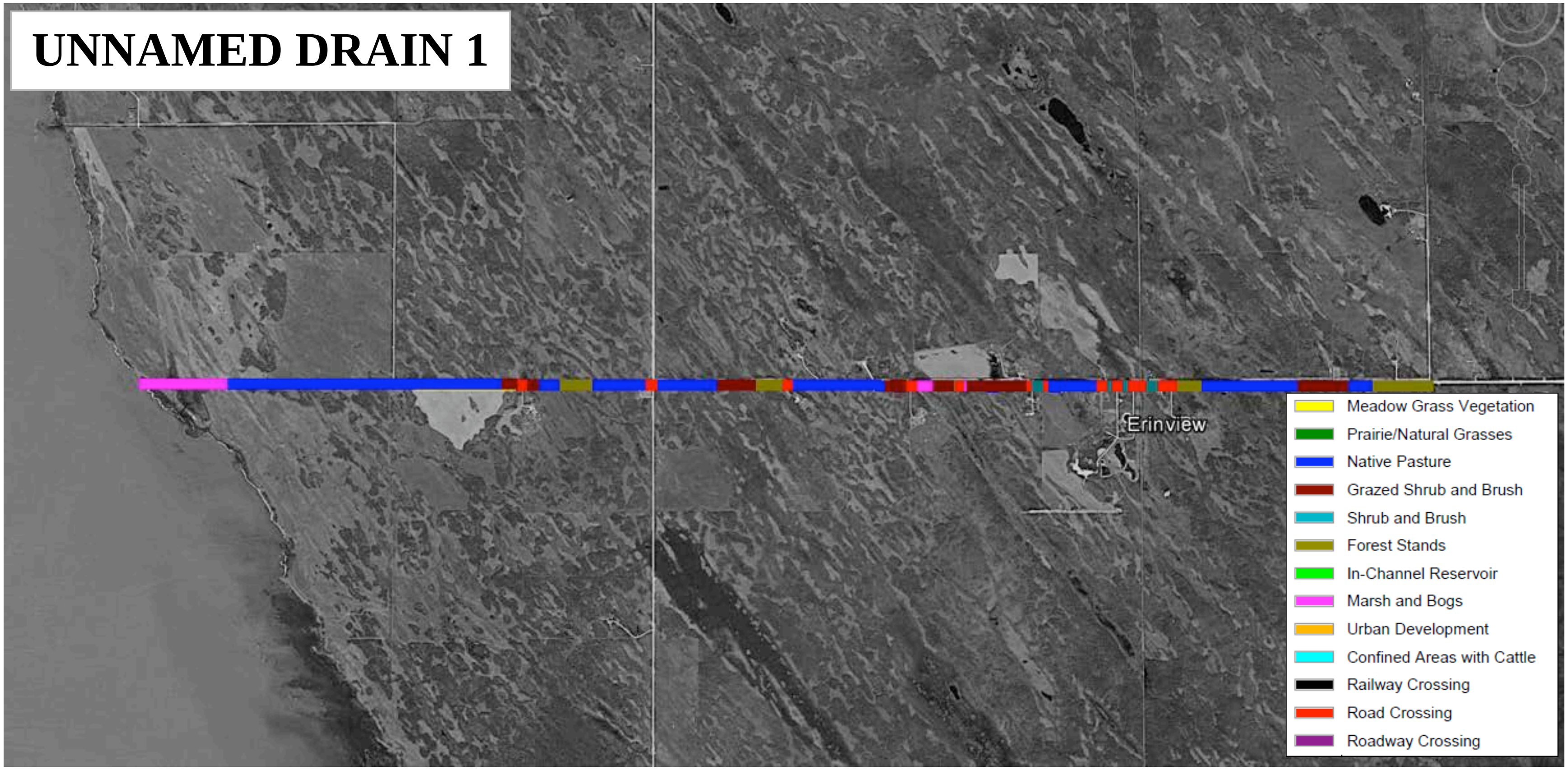
Appendix B-3. West Shoal Lake land use classification map.



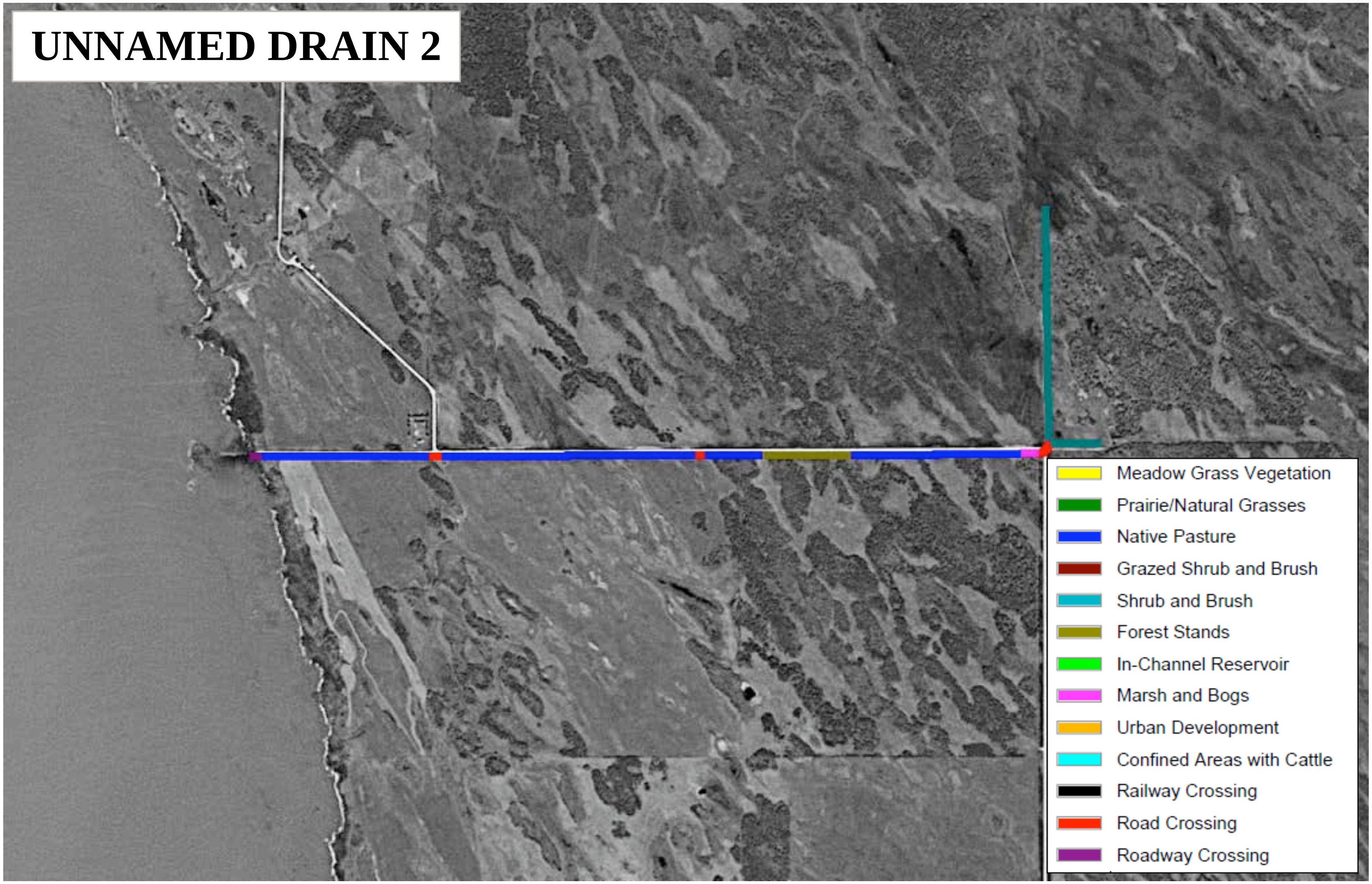
Appendix B-4. Crockatt Drain land use classification map.



Appendix B-5. Swamp Lake Drain land use classification map.



Appendix B-6. Unnamed Drain 1 land use classification map.



Appendix B-7. Unnamed Drain 2 land use classification map.

APPENDIX C: Aerial and ground photographs representing the characteristics of the Shoal Lakes Watershed lakes and drains.

NORTH SHOAL LAKE
(Appendix C-1)

EAST SHOAL LAKE
(Appendix C-2)

WEST SHOAL LAKE
(Appendix C-3)

CROCKATT DRAIN
(Appendix C-4)

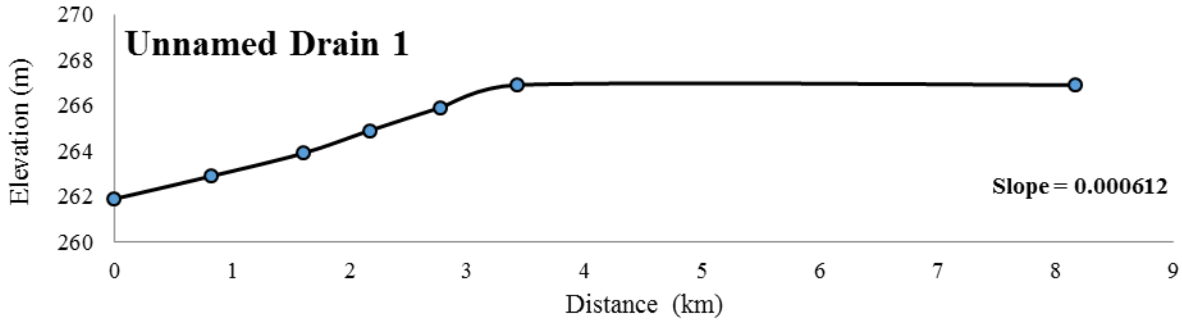
SWAMP LAKE DRAIN
(Appendix C-5)

UNNAMED DRAIN 1
(Appendix C-6)

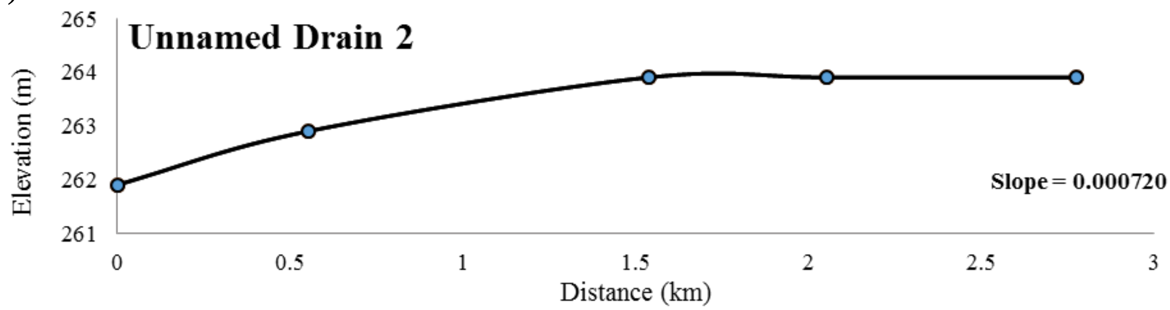
UNNAMED DRAIN 2
(Appendix C-7)

APPENDIX D: Longitudinal profiles of tributaries within the Shoal Lakes Watershed, produced using Google Earth Software.

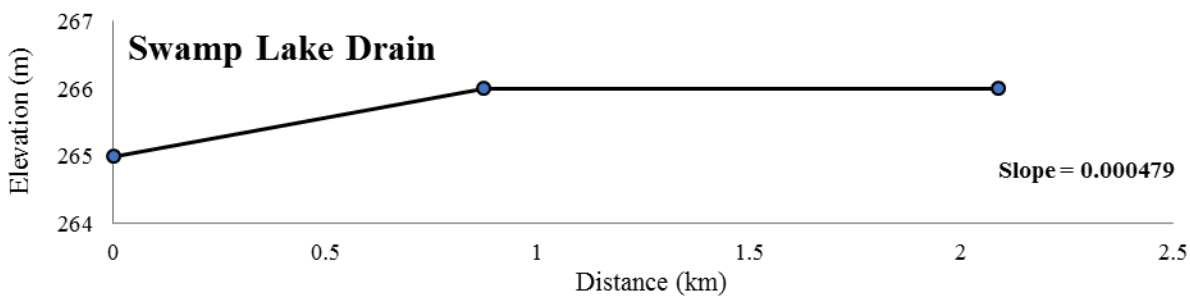
A)



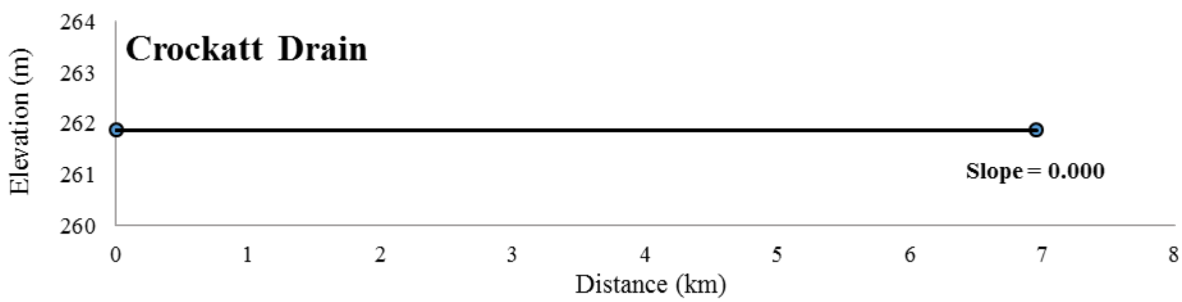
B)



C)

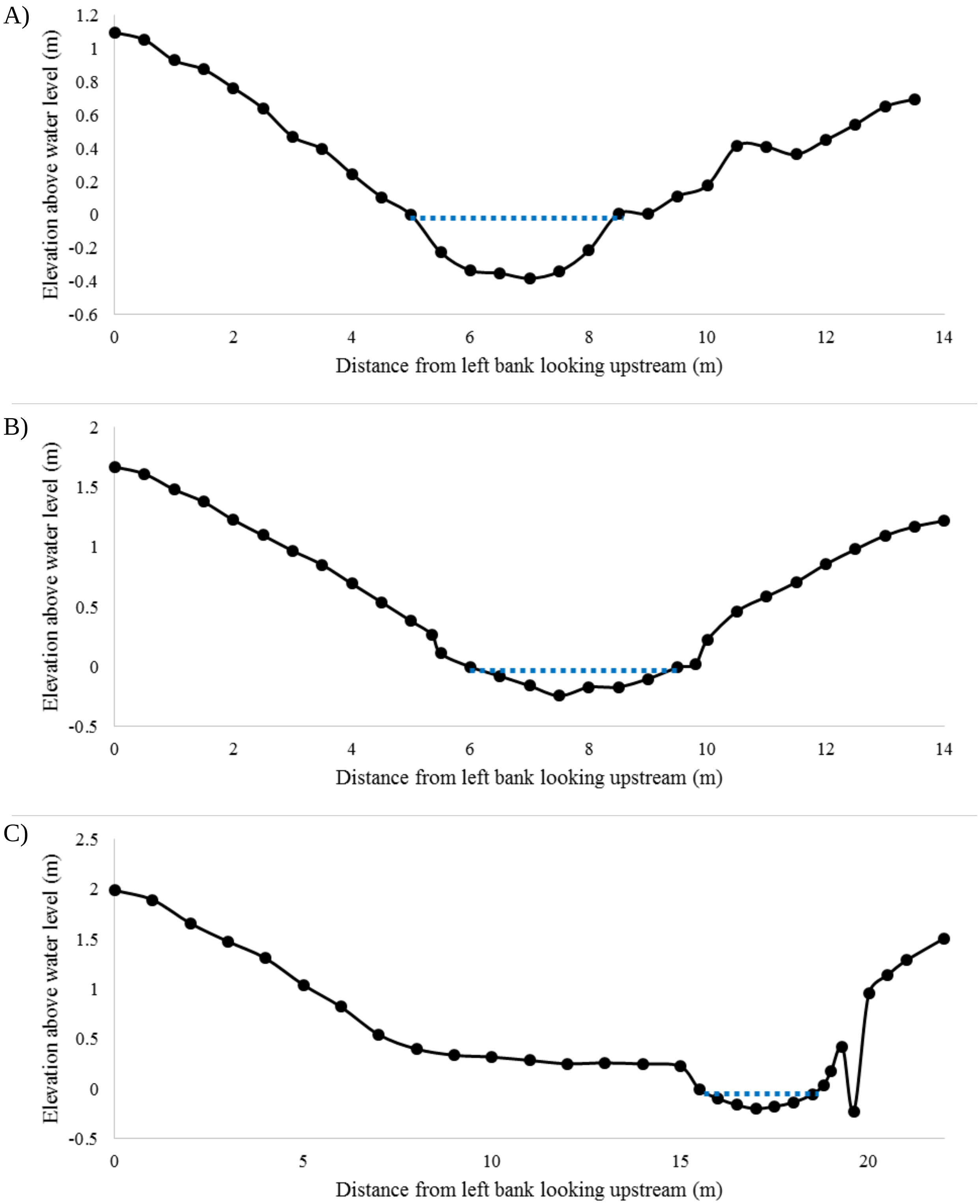


D)

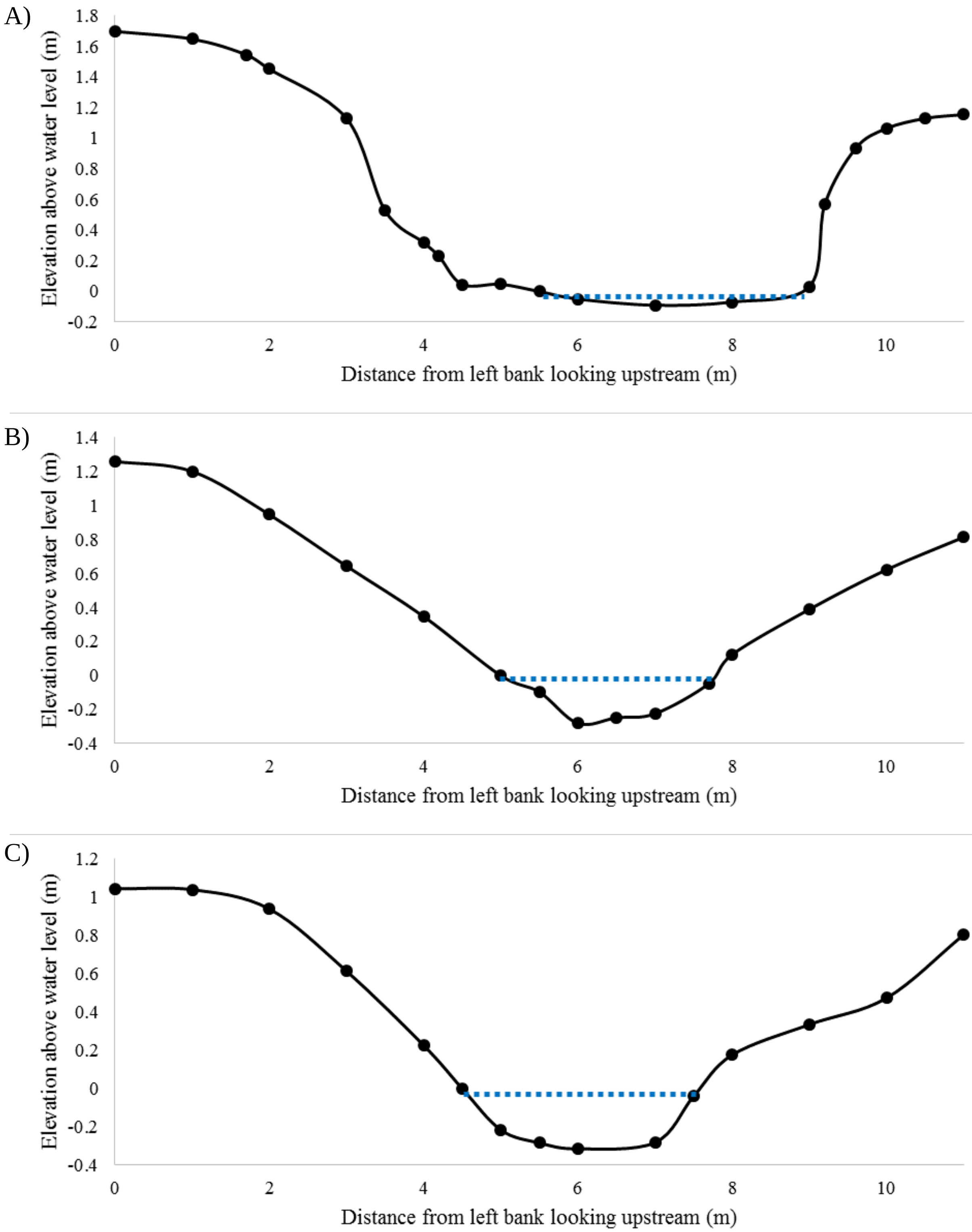


Appendix D-1. Longitudinal profiles for the four drains of the Shoal Lakes Watershed: A) Unnamed Drain 1, B) Unnamed Drain 2, C) Swamp Lake Drain, and D) Crockatt Drain.

APPENDIX E: Cross-sectional profiles of Unnamed Drains 1 and 2 of the Shoal Lakes Watershed.

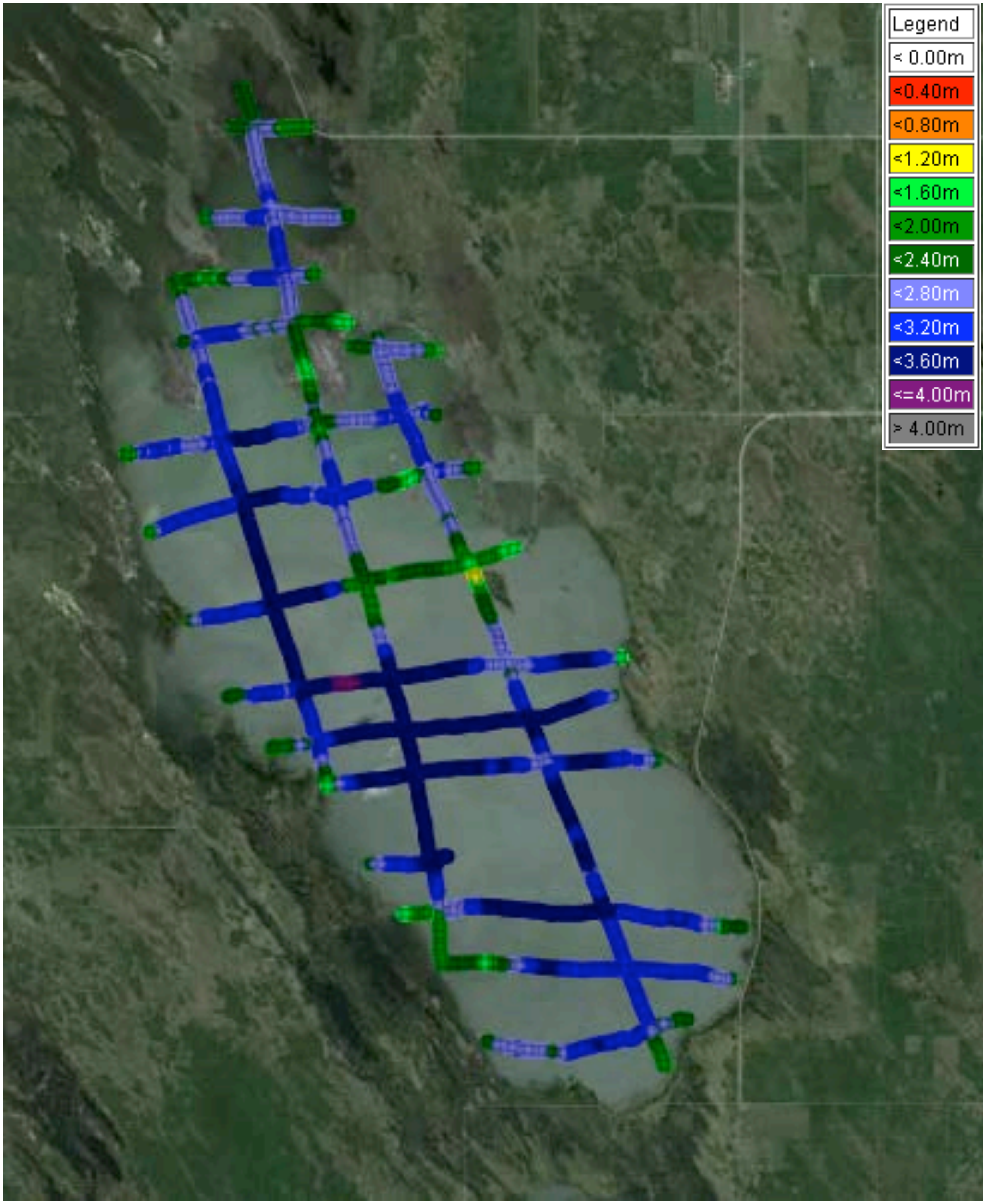


Appendix E-1. Unnamed Drain 1 cross-sectional profiles for the A) lower, B) middle, and C) upper reaches of the drain.

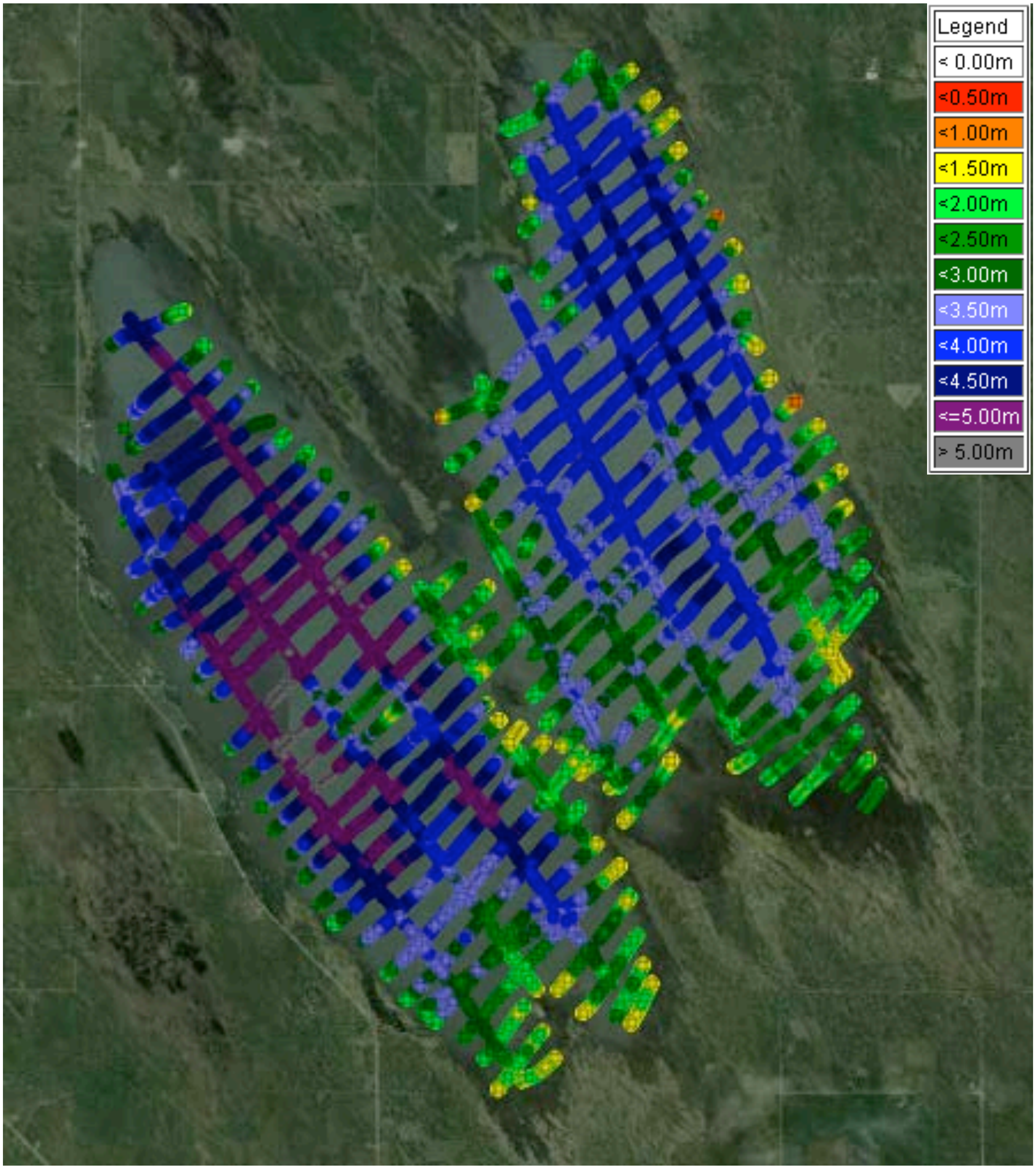


Appendix E-2. Unnamed Drain 2 cross-sectional profiles for the A) lower, B) middle, and C) upper reaches of the drain.

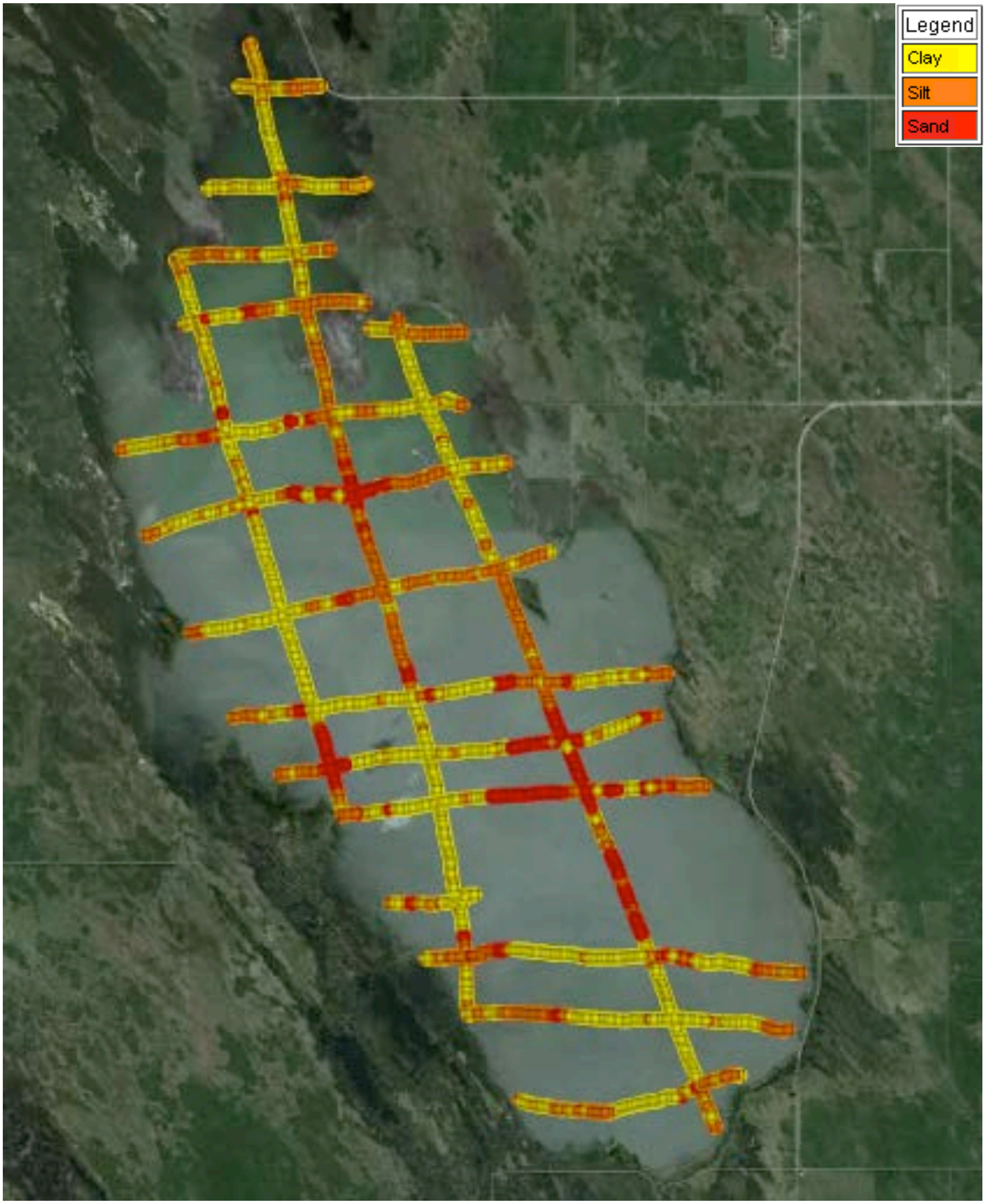
APPENDIX F: Maps of bathymetry, bottom type, plant coverage, and plant height in the Shoal Lakes.



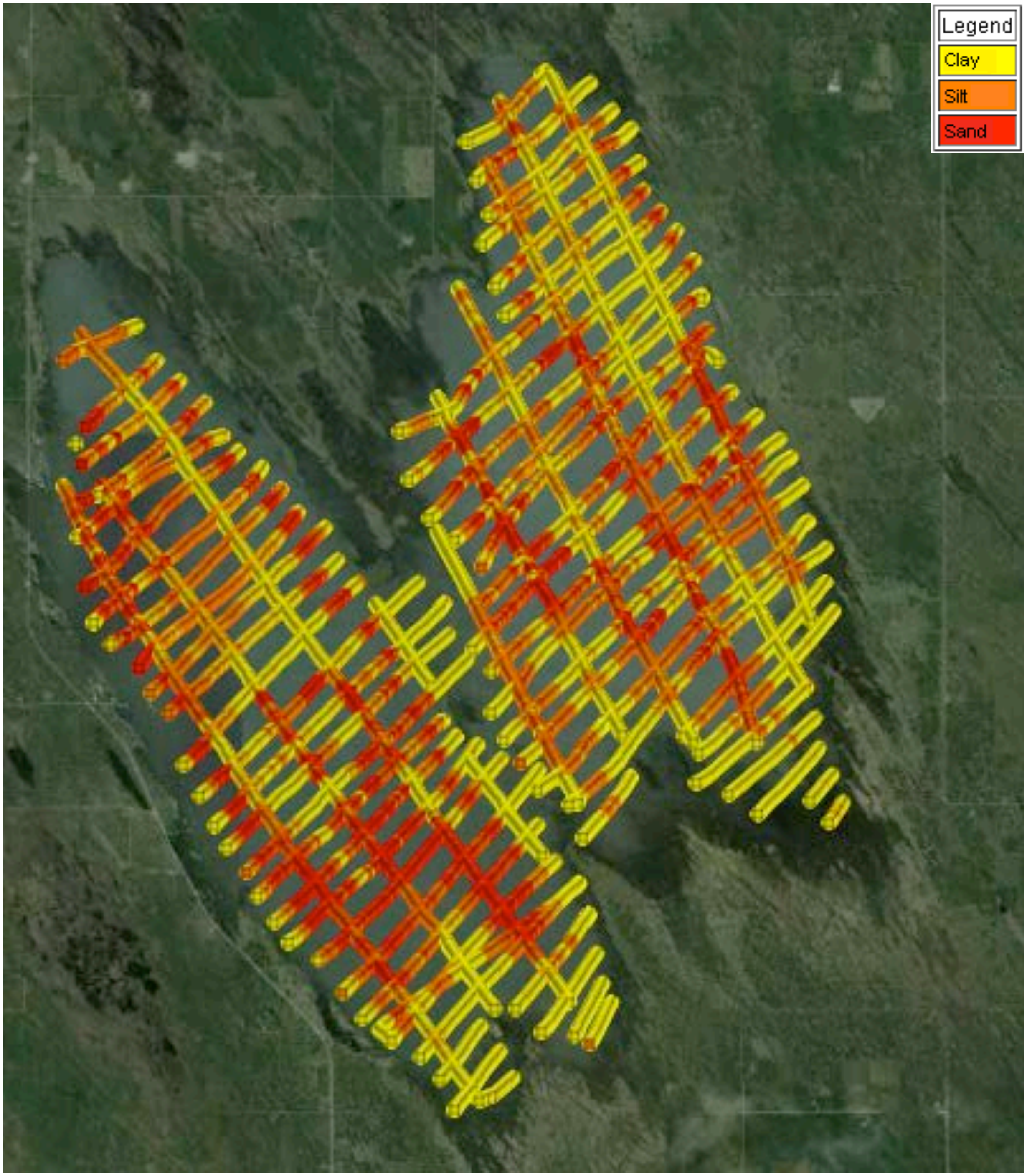
APPENDIX F-1. Bathymetric map for North Shoal Lake.



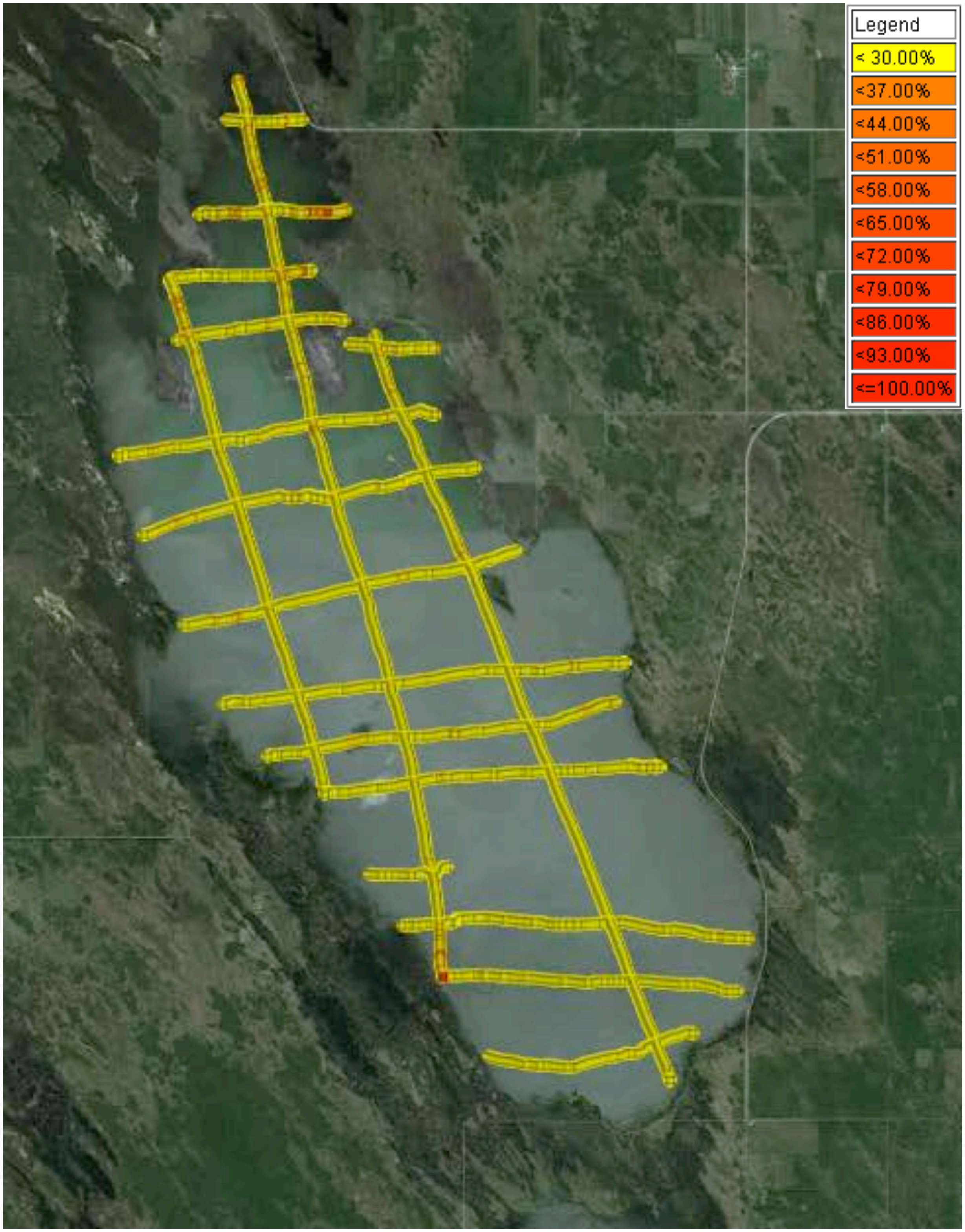
APPENDIX F-2. Bathymetric map for the East and West Shoal Lakes.



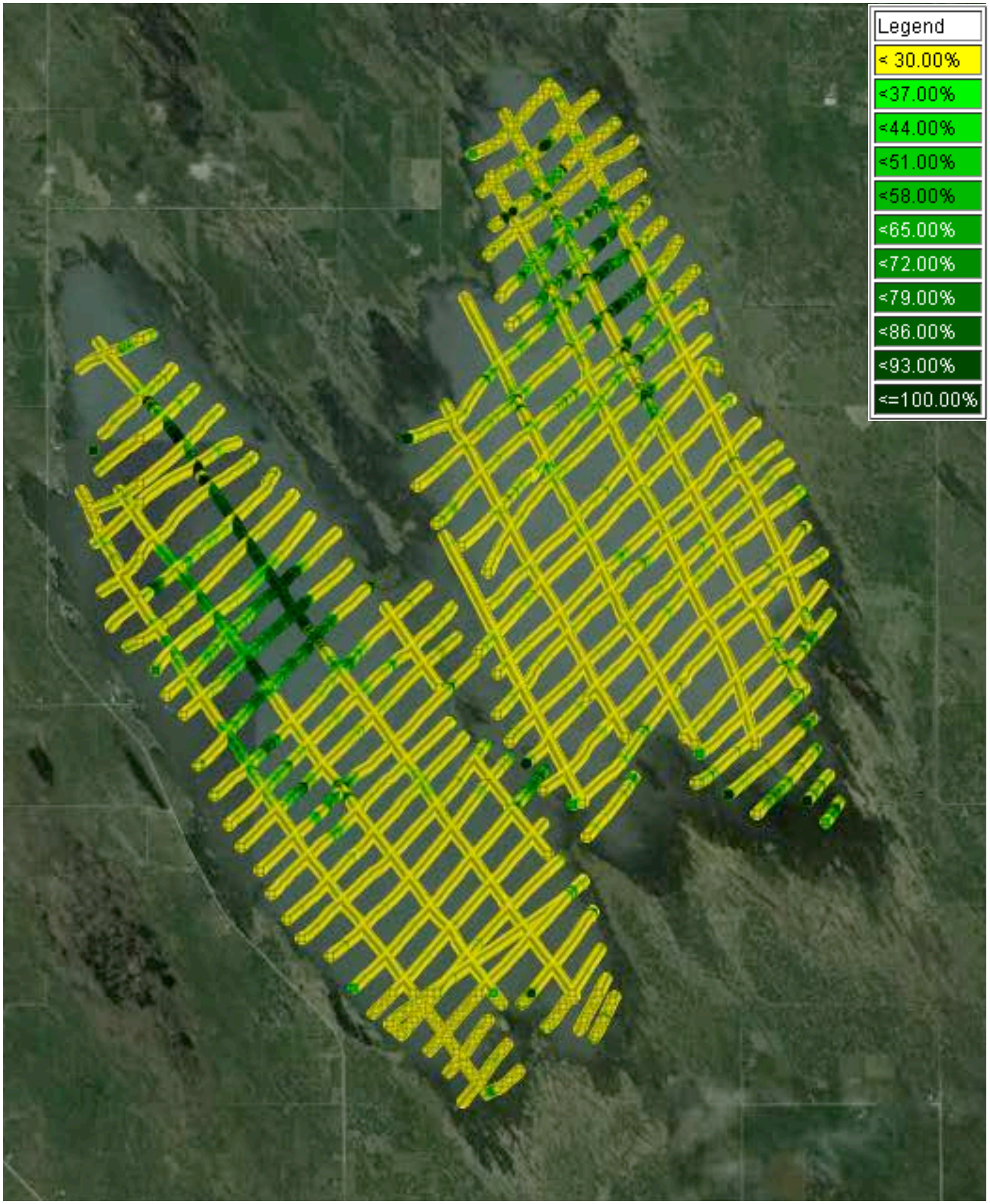
APPENDIX F-3. Bottom type map for North Shoal Lake.



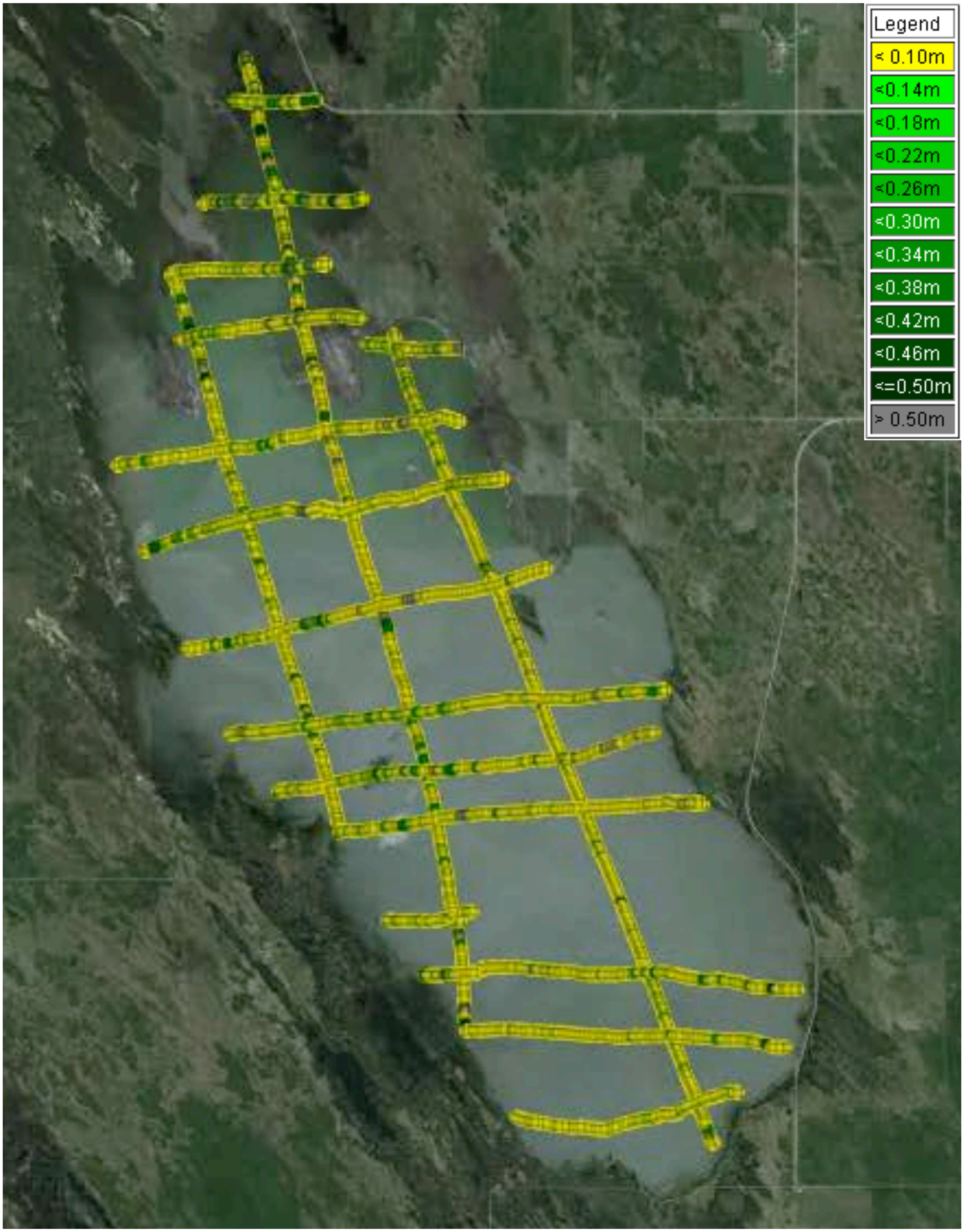
APPENDIX F-4. Bottom type map for the East and West Shoal Lakes.



APPENDIX F-5. Plant coverage map for North Shoal Lake.



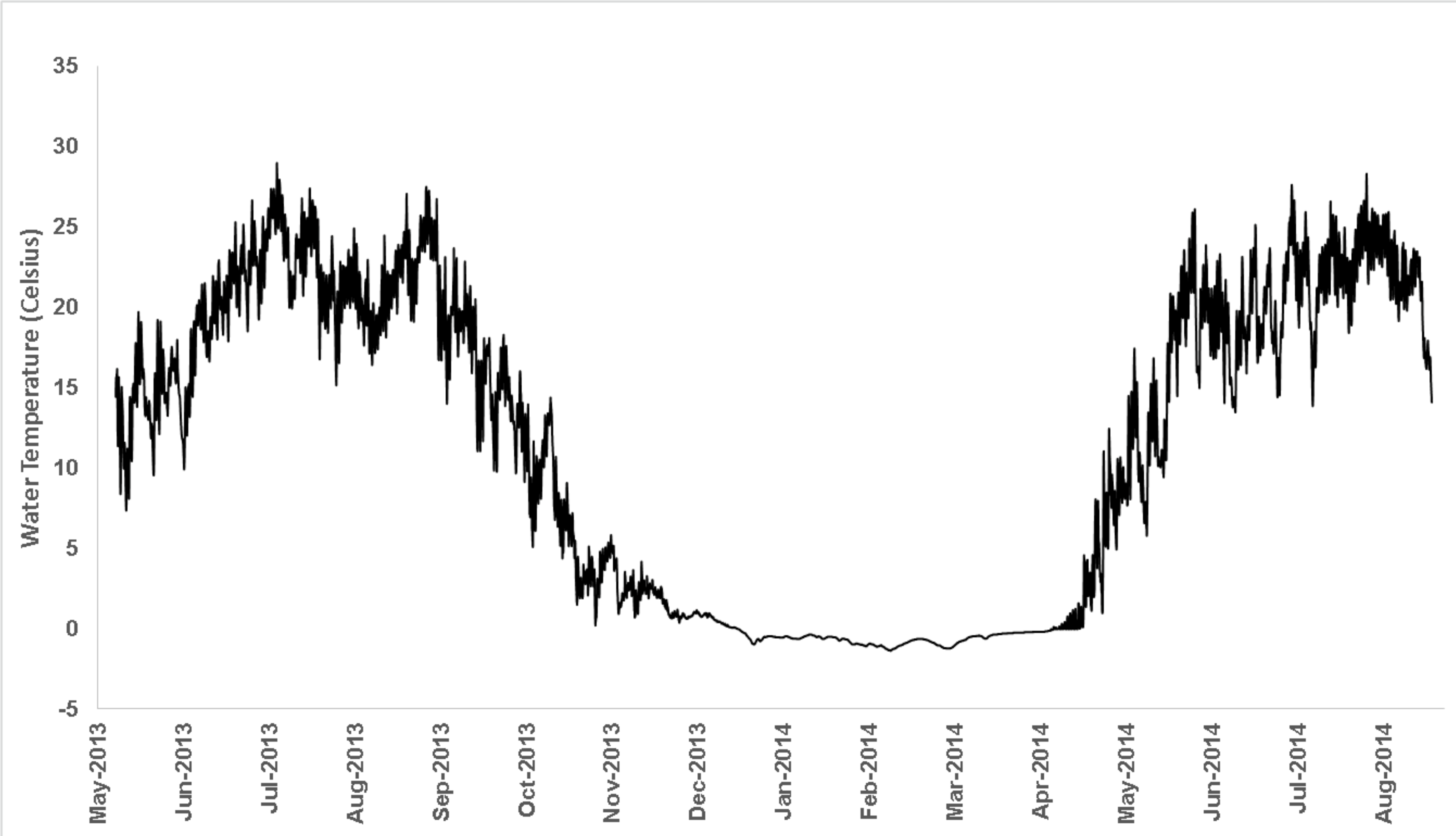
APPENDIX F-6. Vegetation coverage map for East and West Shoal Lakes.



APPENDIX F-7. Plant height map for North Shoal Lake.

APPENDIX F-8. Plant height map of East and West Shoal Lakes.

APPENDIX G: Water temperature at the mouth of Swamp Lake drain in West Shoal Lake between May 7th, 2013 and August 26th, 2014.



Appendix G-1. Water temperature at the mouth of Swamp Lake drain in West Shoal Lake between May 7th, 2013 and August 26th, 2014.

APPENDIX H: Potential Rehabilitation Sites.

Appendix H. A list of potential rehabilitation sites to improve water quality and fish habitat within the Shoal Lakes Watershed.

Location	Type	Comment	Rehabilitation Efforts	Benefits	Northing	Easting
North Shoal Lake	Class C Habitat	- Reaches along shoreline are situated where confined livestock operations are found - The habitat and riparian zones are significantly impacted by livestock trampling at these reaches, reducing water quality, fish habitat, and the health of the aquatic environment	- Provide off site watering stations - Fence off riparian zone to prevent livestock trampling - Remove fencing from flooded areas no longer used as pasture	- Increase riparian habitat and water quality within the lake - Protect and enhance fish habitat	N50.45394	W97.67739
East Shoal Lake	Class C Habitat	- Reaches along shoreline are situated where confined livestock operations are found - The habitat and riparian zones are significantly impacted by livestock trampling at these reaches, reducing water quality, fish habitat, and the health of the aquatic environment.	- Provide off site watering stations - Fence off riparian zone to prevent livestock trampling	- Increase riparian habitat and water quality within the lake - Protect and enhance fish habitat	N50.40760 N50.41923	W97.63862 W97.64339
West Shoal Lake	Class C Habitat	- Reaches along shoreline are situated where confined livestock operations are found - The habitat and riparian zones are significantly impacted by livestock trampling at these reaches, reducing water quality, fish habitat, and the health of the aquatic environment.	- Provide off site watering stations - Fence off riparian zone to prevent livestock trampling	- Increase riparian habitat and water quality within the lake - Protect and enhance fish habitat	N50.45394	W97.67739

Appendix H. Continued…

Location	Type	Comment	Rehabilitation Efforts	Benefit	Northing	Easting
All Shoal Lakes (various locations)	Fish Habitat Enhancement	- Enhancement efforts could significantly improve the spawning potential of valuable sport fish species, particularly Walleye	- Construct spawning reefs within the lakes in shallow reaches, consisting of coarse substrate (sand, gravel and cobble)	- Creation of spawning habitat to increase long-term sustainability of stocked Walleye and other species	-	-
Crockatt Drain	Class C Habitat	- The drain flows through high-density livestock area near the drain mouth - The habitat and riparian zones are significantly impacted by livestock trampling at these reaches, reducing water quality, fish habitat, and the health of the aquatic environment	- Provide off site watering stations - Fence off riparian zone to prevent livestock trampling -	- Increase water quality within drain - Protect and enhance fish habitat	N50.45587	W97.68255
Swamp Lake Drain	Class C Habitat	- Flooding has moved the mouth of Swamp Lake Drain inland, and much of the mouth is now crossed by built-up road infrastructure which may act as a barrier to fish movement and lead to surface runoff -Swamp Lake drain contains natural spawning habitat for Walleye and other species, and could serve as excellent spawning grounds if kept healthy and accessible to fish	- Improve riparian habitat along mouth of the drain, either by improving drainage or re-seeding channel to prevent erosion - Provide additional spawning habitat by constructing spawning shoals or riffles within the channel	- Increase water quality within drain - Protect and enhance fish habitat - Creation of spawning habitat to increase success of Shoal Lakes fish species	N50.30159	W97.69843

Appendix H. Continued…

Location	Type	Comment	Rehabilitation Efforts	Benefit	Northing	Easting
Unnamed Drains 1 & 2	Class C Habitat	- Numerous road crossings and culverts may act as barriers under lower flow conditions, restricting fish access to excellent existing spawning habitat	- Monitor culverts within the drain under varying flow conditions to determine the extent to which they may act as a barrier to fish movement - If problems are consistently observed, alter culvert crossing to improve fish access	- Monitoring may save money; if culverts do not act as a barrier to fish spawning success, or do so only rarely, improvements may be unnecessary If the problem is consistent, altering the culvert will provide access to and from spawning habitat for many Shoal Lakes fish species	N50.37436 N50.38912	W97.54110 W97.57564
	Class B Habitat	- The habitat and riparian zones are moderately impacted by runoff from adjacent road infrastructure, livestock access, and some lack of vegetative cover	- Re-seed channel preventing erosion, adding cover and decreasing turbidity within the waterway; fence off riparian zone to prevent livestock trampling	- Protect and enhance fish habitat - Increase water quality within drain		

Appendix H. Continued…

Location	Type	Comment	Rehabilitation Efforts	Benefit	Northing	Easting
Throughout the Shoal Lakes Watershed	Fishery Promotion and Awareness	- While the fishery on the Shoal Lakes has improved, attracting the public to the area will be important to provide the resources necessary to maintain and monitor the Shoal Lakes fishery going forward	- Promote the fishery and the area in local and provincial publications - Erect signage to educate the public about the fishery and improvement efforts such as spawning shoals and Walleye stocking - Improve tourism-related infrastructure within the watershed, e.g. construction of walking trails, boat launch areas, and platforms for viewing scenery and birdwatching	- Raising awareness of, and access to, the recently improved fishing on the Shoal Lakes increases the value of the fishery and other tourist attractions within the watershed	-	-
	Ongoing Improvements and Research	- Continued stocking efforts will help to maintain and grow the fishery, while further monitoring will assist management in evaluating tradeoffs between the health of fish & wildlife habitat and curbing of rising water levels	- Stock the Shoal Lakes with fingerling Walleye - Continue monitoring dissolved oxygen and water quality, in both summer and winter months	- Potential creation of a healthy recreational fishery for Walleye, the most popular sport fish in the province - Ongoing water quality monitoring will help to determine the potential resiliency of the fishery to variation in water levels, temperature and trophic conditions	-	-