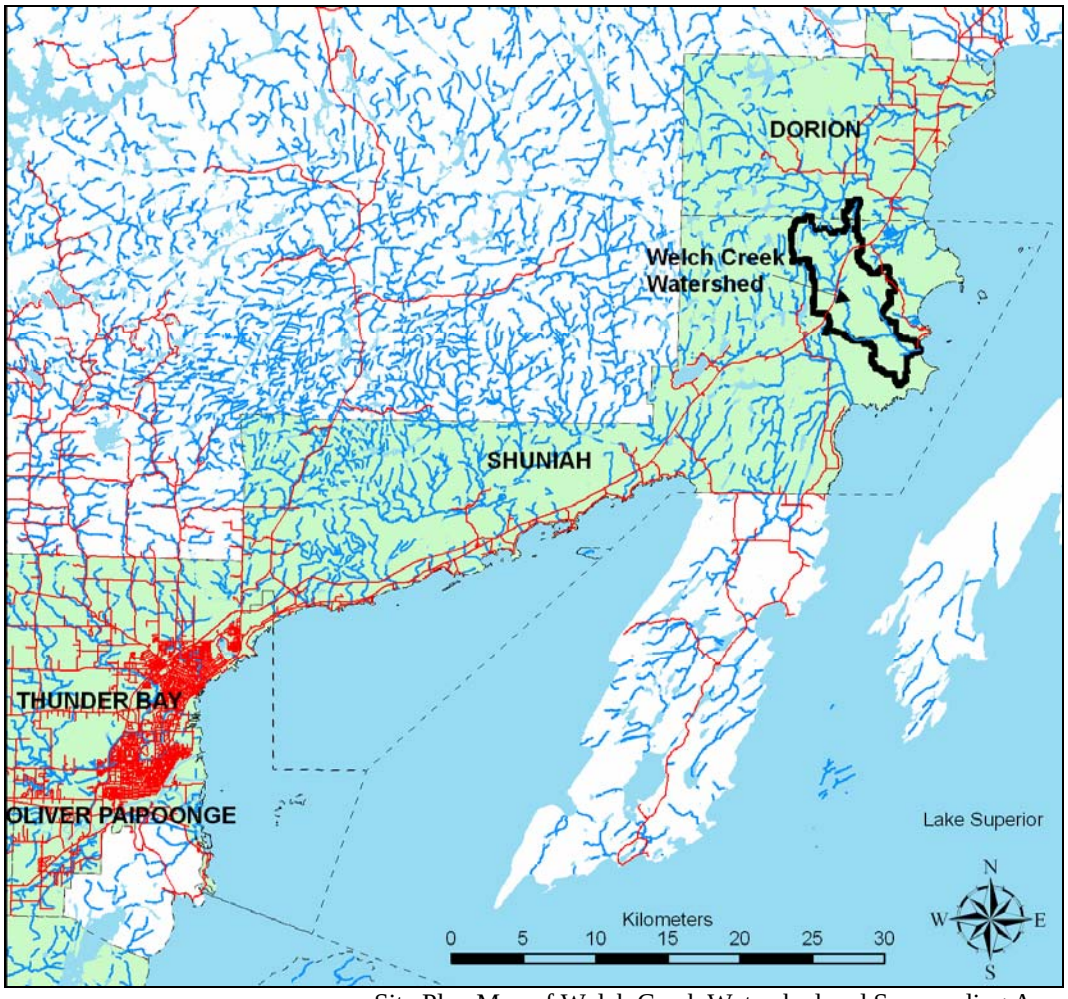
Welch Creek Watershed Assessment

2006



Site Plan Map of Welch Creek Watershed and Surrounding Area

Lakehead Region
Conservation Authority
Conserve Today...For A Better Tomorrow

Welch Creek Watershed
Assessment Report

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Executive Summary

The Welch Creek Watershed has an area of 44.994 square kilometres (km^2) and is located east of Thunder Bay in the geographic Township of McTavish, within the Municipality of Shuniah. The Municipality contains approximately 65 km of Lake Superior shoreline as well as a number of small inland lakes. The creek collects its flow from surrounding lakes including Mutt, Jeff and Samick's Lakes and drains into Moose Bay, located within Black Bay on Lake Superior.

For the report, four sample sites located within the Welch Creek Watershed were chosen based on a variety of attributes; accessibility, physical features, land use and areas that may experience human impacts.

The physical features of this watershed include: wooded areas, wetlands, cliffs, industrial buildings and rural residential dwellings. The watershed also spans across the Trans Canada Highway and Union Energy's Natural Gas pipeline structure. The watershed can be characterized as mostly undeveloped with some timber harvesting and localized residential and seasonal developments near the mouth of the creek, in the form of Superior Shores subdivision. The watershed is mostly zoned Use Limitation, Rural and Recreation.

The surficial geology that comprises the Welch Creek Watershed includes: rock land, organic terrain, bedrock knob, bedrock plain, outwash plain and glaciolacustrine plain. The soil types include: Black Bay, Lappe, Oskondoga, Ouimet, Organics and Rockland.

The tree species at each sample site varied, however the forest type remained mixed throughout. According to the Forest Resource Index, the Welch Creek Watershed is comprised of the following forest types: productive forest, treed muskeg, open muskeg, brush and alder, rock, developed agricultural land, and grass and meadow.

At each of the four sample locations, surface water samples and field measurements were collected on July 19th, 20th and August 10th and 11th, 2006. Surface water samples were analyzed by Accurassay Laboratories for total suspended solids, turbidity, conductivity, total phosphorus, cadmium, iron and lead, which were well below the Provincial Water Quality Objectives (PWQO), with the exception of Total Phosphorous which was slightly above the criterion. Due to a laboratory error, the surface water samples collected on July 19th and 20th were not analyzed.

Field Measurements indicated that pH levels during the assessment were all within the MOE PWQO guidelines. The pH levels ranged from 7.44 to 7.89, which was slightly basic. The water temperatures measured during the assessment ranged from 16.84 to 21.85 ^{o}C. Both the benthic life and aquatic vegetation appeared to be dynamic, and the species found along the watershed indicated a healthy ecosystem.

There was little evidence of human disturbances at most of the sample sites. Natural disturbances found within the watershed included beaver damming and a small amount of erosion. During the study most of the water crossings appeared to be functional, however there were a few that were dry, perched and/or had minor blockage.

As of the summer of 2006, the overall health of Welch Creek was excellent. There were limited signs of anthropological disturbances, and the creek water quality met the Provincial Water Quality Objectives with the exception of the Total Phosphorus level at site #2. The lab result was 37 μg/L, which exceeds the PWQO guideline of 30 μg/L. It should be noted that Site #2 had a significant amount of aquatic plant growth, and these levels were most likely occurring from natural sources, such as decaying plants or animals.

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1.0 Introduction

1.1 Watershed Assessment Objectives

The purpose of the Welch Creek Watershed Assessment is to establish a baseline inventory of the watershed's characteristics and to identify the physical condition of Welch Creek's water quality and quantity. In general, there is very little documentation of the condition of many of the smaller steams in the Thunder Bay area.

The goal of the report is to document the conditions of the watershed as observed in the summer of 2006, and then use the information to develop and maintain programs to sustain a healthy ecosystem, consistent with the Natural Hazards and Natural Heritage Policies of the Province. This report attempts to provide an understanding of the ecological form and function of the watershed.

The main objectives of assessing this watershed are as follows:

- Identify and locate Welch Creek and determine site accessibility
- Select representative sample sites of the watershed
- Collect field measurements at the chosen sites including: pH, depth, flow, conductivity, dissolved oxygen, water and air temperatures
- Collect water samples for laboratory analysis
- Identify and classify the flora and fauna observed along the watershed
- Summarize information regarding the natural features of the watershed such as: land uses, recreational uses, transportation corridors, soil types and pollution
- Conduct and document an inventory of active erosion sites
- Survey the condition of bridge/culvert stream crossings and structures
- Interpret results to create a record of the status and health of the watershed

1.2 Watershed Description

A watershed is comprised of land drained by a river and its tributaries. A sub-watershed is comprised of the land drained by an individual tributary to the main watercourse (MOE 1993). All water that flows into Welch Creek from a lake or stream and all runoff from the land define the Welch Creek Watershed. Welch Creek is identified as a sub-watershed, as it is a watershed that does not directly drain into an ocean, however it is connected to a watershed that ultimately does. Watersheds also act as boundaries for land use planning, in order to examine the relationships between the natural environment and human activities.

The Welch Creek Watershed has an area of 44.994 square kilometres (km^2) and is located east of Thunder Bay in the geographic Township of McTavish, within the Municipality of Shuniah, as shown on the Key Plan, Map M-1, attached. The Municipality contains approximately 65 kilometres of Lake Superior shoreline as well as a number of small inland lakes. Welch Creek collects its flow from surrounding lakes including Mutt, Jeff and Samick's Lakes and drains into

Moose Bay, located within Black Bay on Lake Superior, as shown on Map M-2, entitled Site Map.

Both the Canadian National Railway (CNR) and the Canadian Pacific Railway (CPR) lines run through the Welch Creek Watershed. The CNR was located north of the CPR, all sample sites were located to the south of both rail lines. The Trans Canada Pipeline was also built through the watershed, and crosses the creek in two locations.

The physical features of the watershed include: wooded areas, wetlands, cliffs, industrial buildings and residential dwellings. The watershed also spans across the TransCanada Highway and Union Energy Natural Gas pipeline. The watershed can be characterized as mostly undeveloped with some timber harvesting and localized residential and seasonal developments near the mouth of the Creek, in the form of the Superior Shores subdivision. The watershed is mostly zoned Use Limitation, Rural and Recreation, as shown on Map-3, Welch Creek Land Use. Welch Creek is considered to be a cold water stream.

A mine was historically located upstream from Sample Site #2 and was in operation from 1870 to 1876. It was owned and operated by Enterprise, and chiefly extracted lead, copper, silver and gold. The mine has since been rehabilitated, however there was a mine tailing dump near the railway tracks, which has the potential to leach metals into the creek.

1.3 Surficial Geology

The surficial geology of an area controls the drainage and may influence the steepness of the slope. All of the sample sites and the culverts occurred in a clay glaciolacustrine plain. Characteristics of this geology are gently sloping and level. The primary material that is present is clay, which is almost impervious to soil drainage.

Other types of geology encountered along Welch Creek are rock knob and organic terrain. An irregular bedrock surface and many slopes with varying steepness characterize rock knob. Most of the overburden consists of boulder and sand rich till. Map M-4, Surficial Geology, displays the surficial geology of the Welch Creek Watershed.

1.4 Soils

The soils of Welch Creek mainly consist of Rockland, which is exposed bedrock with pockets of soils and varying degrees of loam and organics. Other soil types included in the watershed include: Black Bay, Lappe, Oskondoga, Ouimet, Organics and Rockland. Map M-5, Soils, displays the soil composition of the Welch Creek Watershed.

Erosion depends on the type of soil present and the degree of slope. The organic terrain has a low erosion hazard. The clay and silt loams both have an erosion potential of low to moderate, depending on if the slope is greater than 10%. Rockland and peaty phases have a low erosion potential if less than a 10% grade, and a high potential if above. The slope of the watershed has been estimated to be approximately 3% from the northern extents of the watershed to the

TransCanada Highway, and 0.7% from the TransCanada Highway south to Lake Superior. Since the area is considered to have a slope less than 10%, the erosion hazard is considered to be low.

Frost heaving is the expanding and contracting from freeze-thaw action of water in the soils. Frost heaving may increase the amount of erosion by cracking the soil and decreasing overall stability. Rockland, organics and peaty phase, which are found in the watershed, all have a low potential for frost heaving. Silt loams have a moderate potential, while clay loams have a high rating.

1.5 Forest Ecosystem Classification

The Ministry of Natural Resources Forest Resource Index indicates that the vast majority of the Welch Creek watershed is productive forest of mainly black spruce and jack pine. There were a bedrock outcrops, mainly in the northwestern section down to the central area of the watershed. There were four sections of treed muskeg in the southeastern portion of the watershed. Two of the sample points were located in brush and alder sections, and two in productive forest.

Using the forest resource index classification sheet, the following sample sites were identified:

- Site # 1 classified as V10 Trembling Aspen – Black Spruce – Jack Pine / Low Shrub
- Site # 2 classified as V6 Trembling Aspen (White Birch) – Balsam Fir / Mountain Maple
- Site # 3 is classified as V24 White Spruce – Balsam Fir / Shrub Rich
- Site # 4 classified as V14 Balsam Fir – Mixed-wood.

Map M-6 displays the Forest Resource Index, attached. In addition, the Forest Ecosystem Classification for the Welch Creek Watershed is summarized in Appendix B, attached.

2.0 Methodology

General techniques used in the Watershed Assessment for data collection have been summarized in Appendix D, attached.

2.1 Sample Site Selection

Four sample sites were selected along Welch Creek to represent the Welch Creek Watershed. Sites were chosen in areas that had the potential to affect the watershed, including: downstream from an abandoned mine, near the TransCanada Highway and near railway crossings, as shown on Map M-2.

Welch Creek is located within an area that is considered to be mainly forest. Aside from a few residential areas found closer to Lake Superior, the area is remote and somewhat inaccessible. However, through the use of the GPS Trimble, access roads and railways were identified and used to access sample locations.

2.2 Water Sampling

Field analysis was performed on site for conductivity, pH, water and air temperature, dissolved oxygen and turbidity, using an YSI 556 MPS Meter and a Global Water 770 Turbidity Meter. A GPS was used to record the UTM co-ordinates and the elevation of each sample site. The width and depth of the creek was measured, and the flow was estimated by timing a stick to travel a known distance.

Water samples were collected in laboratory supplied water bottles and submitted to Accurassay Environmental Laboratories Ltd, in Thunder Bay for turbidity, conductivity, total dissolved solids, phosphorus, lead, iron and cadmium analysis.

Water quality analysis was completed at the four selected sample sites on two occasions. However, due to lab error regarding insufficient sample volume being collected resulting from inaccurate bottles supplied by the lab, one sample set was not analyzed.

2.3 Flora and Fauna Inventory

Several field guides were used to identify the tree, shrub, and herb species observed at the sample sites. Benthic and animal species were also identified and documented when encountered. The flora and fauna can give an indication of the health of the Welch Creek Watershed and are documented for further studies. Common and Latin names of plant species are summarized in Appendix A.

2.4 Culvert Inventory

Known culvert locations were inspected with general culvert data collected at each site. The physical characteristics of each culvert were measured (as indicated in Appendix F), UTM coordinates were recorded, photographs were taken and general observations were recorded at each location.

2.5 Equipment Used

- List of Equipment used in the Watershed Assessment:
    - Maps – road and topographic
    - GPS Trimble Geo XH
    - Compass
    - YSI 556 Multi Probe System – Field tests for dissolved oxygen, water temperature, pH, conductivity and total dissolved solids
    - Global Water WQ770 Turbidity Meter
    - Stick to measure flow
    - Stopwatch to measure flow
    - Air temperature thermometer
    - Dip net
    - Chest Waders
    - Pen, Paper, Clipboard
    - Sample bottles from Accurassay Environmental Laboratories Ltd.
    - Cooler and ice for sample storage prior to delivery to laboratory
    - Digital Camera
    - Field Guides:
        - A Field Guide to Trees and Shrubs
        - A Field Guide to Wildflowers of North Eastern and North-Central North America
        - Fern Finder
        - Vascular Plant Familiar

3.0 Applicable Criteria

In general, surface and groundwater quality in Ontario is to be managed to ensure a fair sharing, conservation and sustainability of the resource. The Provincial Water Quality Objectives (PWQO) dated July 1994 is a guideline, produced by the Ministry of the Environment (MOE), which establishes acceptable limits for water quality and quantity, consistent with the protection of the aquatic ecosystem and groundwater. The goal of the PWQO is "to ensure that the surface waters of the province are of the quality which is satisfactory for aquatic life and recreation". The PWQO guidelines have been used to compare field and laboratory results for the Welch Creek Watershed in order to gauge the overall general health of the watershed.

The PQWOs applicable to this report have been summarized in Appendix C. A general overview of applicable water quality parameters and their relevance to water quality has been summarized in Appendix E.

Other non-chemical factors such as loss of habitat and sedimentation, have been considered however are not compared to any quantifiable scale.

4.0 Results and Discussion

Laboratory Certificates of Analysis have been attached in Appendix G. Field measurement data and observations for each sample site have been summarized below.

The Graph Section of the report presents several graphs comparing the samples sites. Data graphed includes: sample site elevations, water quality parameters, air versus water temperature and dissolved oxygen versus water temperature.

4.1 Site #1

Table 4.1.1: *Location Reference for Site #1*

Location Description	The confluence of Welch Creek into Black Bay, Lake Superior
GPS Coordinate	5390417.608m N; 385603.405m E
Altitude/Elevation (metres)	187.897 m above mean sea level (MSL)

Table 4.1.2: *Field Measurement Data for Site #1*

Variable	July 19, 2006	August 10, 2006
Channel Width (metres)	14.90	14.60
Channel Depth (cm)	59	54
Flow (m/s)	0.192	0.151
Air Temperature (°C)	31	23
Water Temperature (°C)	20.43	17.29
pH	7.68	7.67
Conductivity (mS/cm)	0.282	0.27
Total Dissolved Solids (g/L)	0.201	0.21
Dissolved Oxygen (mg/L)	7.79	7.19
Dissolved Oxygen Saturation (%)	86.5	74.93
Turbidity (NTU)	26.5	38.0

Table 4.1.3: *Laboratory Water Quality Results for Site #1*

Variable	August 10, 2006
Turbidity (NTU)	1.43
Conductivity (mS/cm)	0.330
Total Phosphorus (µg/L)	25
Suspended Solids (mg/L)	< 3
Cadmium (µg/L)	<0.1
Iron (µg/L)	195
Lead (µg/L)	0.6

Table 4.1.4: *Flora & Fauna Observed for Site #1*

Tree Species	Paper Birch, White Birch, Balsam Fir, White Spruce, Black Spruce, Jack Pine, Trembling Aspen
Shrub Species	Speckled Alder, Green Alder, Beaked Hazel, Northern Oak Fern, Bladdernut, Wintergreen, Long Beech Fern, Black Spruce, Running Ground Pine, Twin Flower, Mountain Maple
Herb Species	Wild Sarsaparilla, Wintergreen, Spotted Joe-Pye Weed, Rose Twisted Stalk
Mosses / Aquatic plants	Schreber's Moss, Grasses and Sedges
Benthic species/ Insects	Minnows, Water Striders, Dragonflies, Dragonfly Nymphs
Terrestrial wildlife	None observed at time of site visits
Additional Comments	This site was just upstream from the confluence, and a seasonal residential dwelling is situated southeast on Superior Shores Road.

Table 4.1.5: *Physical Attributes of Site #1*

In stream material	Creek bed Characteristics	Bank Stability	Terrain Characteristics	Stream Cover
Fallen logs and branches	Poorly sorted from silt to boulders, muck, very loose packed soil	Stable	Mixed Forest at Confluence	Low

Discussion

Sample Site #1 was located approximately seven meters south of the south end of Superior Shores Road, marked by a footpath. This site was at the confluence where Welch Creek meets Lake Superior. Debris and sunken logs encompass the creek bed floor. The creek banks were very well defined, stable and very well vegetated. There was wide range of plant diversity along the sample site, indicating a healthy ecosystem.

The pH was well within the PWQO guidelines, situated in the middle of the range. Total dissolved solids levels were the highest for the sample sites, which is expected due to Site #1 being at the confluence, where the entire watershed drains and brings with it debris, sand, silt and clay. Total dissolved solid levels were still considered to be low indicating there was little disturbance in the creek. Dissolved oxygen was the lowest of the sample sites; however was acceptable based on the PWQO criterion. Water at this site was slightly turbid, however the flow on the observed day was elevated which could result in bed material becoming entrained.

Chemical analysis of Site #1 returned all analyzed parameters within the PWQO guidelines. Phosphorous results (25 μg/L) were approaching the limit for excessive plant growth in a stream, but still remained under the criterion of 30 μg/L.

4.2 Site # 2

Table 4.2.1: *Location Reference for Site #2*

Location Description	Southeast of the abandoned mine
GPS Coordinate	5392865.472m N; 380801.338m E
Altitude/Elevation (metres)	205.118 m above MSL

Table 4.2.2: *Field Measurement Data for Site #2*

Variable	July 19, 2006	August 10, 2006
Channel Width (metres)	13.70	13.40
Channel Depth (cm)	62	63
Flow (m/s)	0.038	0.05
Air Temperature (°C)	26	21.1
Water Temperature (°C)	21.85	18.96
pH	7.89	7.66
Conductivity (mS/cm)	0.305	0.30
Total Dissolved Solids (g/L)	0.211	0.22
Dissolved Oxygen (mg/L)	8.16	7.50
Dissolved Oxygen Saturation (%)	94.3	80.89
Turbidity (NTU)	39.5	26.5

Table 4.2.3: *Laboratory Water Quality Results for Site #2*

Variable- Site 2	August 10, 2006
Turbidity (NTU)	1.79
Conductivity (mS/cm)	0.350
Total Phosphorus (µg/L)	37
Suspended Solids (mg/L)	6
Cadmium (µg/L)	< 0.1
Iron (µg/L)	192
Lead (µg/L)	0.7

Table 4.2.4: *Flora and Fauna Observed for Site #2*

Tree Species	Jack Pine, Paper Birch, Balsam Fir, White Spruce, Trembling Aspen, River Birch
Shrub Species	Trembling Aspen, Speckled Alder, River Birch, Cat Tails, Wintergreen, Mountain Maple
Herb Species	Yarrow, Grasses, Sedges, Spotted Joe-Pye, Wild Sarsaparilla, Canada Mayflower
Aquatic Plants	Broad-leaved Arrowhead, Water Plantain, Blue Joint Grass, Sedges
Benthic species/Insects	Leeches, Snails, Tadpoles, Water Striders, Minnows
Terrestrial wildlife	Blue heron

Table 4.2.5: *Physical Attributes of Site #2*

In stream material	Creek bed Characteristics	Bank Stability	Terrain Characteristics	Stream Cover
Fallen logs/branches	Mucky marsh area	Stable	Marsh land / mixed forest	Low

Discussion

Site #2 was situated southwest of where the CNR crosses the TransCanada Pipeline. Access was an approximate 45-minute walk east of Highway 11/17 down a service road that connects to CNR, and a 500-meter walk north along the CNR lines until the natural gas pipeline was seen, on the left. The pipeline trail was followed approximately 400 meters east, until the creek was seen.

The creek was in a very flat area, with an abundance of waist-high grasses. The bank was well defined on the west edge, and less defined on the east towards a marshy area. There was a wide variety of diversity in the sample area, both on the edge and in the creek itself. At the time of sampling, the ecosystem appeared to be very healthy and abundant with life, including a blue heron sighting.

The pH was the most basic of all the sites, however was still well within the range set by the PWQO. Dissolved solids were very low at this site, indicating that there was very little disturbances or impacts. The amount of dissolved oxygen in the stream was plentiful enough to support an abundance of benthic species.

Chemical analysis returned a phosphorous reading that exceeded the PWQO standards (30 µg/L) for excessive plant growth, with a result of 37 µg/L. PWQO are considered to be general guidelines, and are mostly for aesthetic proposes. All other analyzed parameters were within the PWQO guidelines.

4.3 Site #3

Table 4.3.1: *Location Reference for Site #3*

Location Description	Southeast of Highway 11/17 culvert
GPS Coordinate	5394645.379m N; 379951.369m E
Altitude/Elevation (metres)	221.025 MSL

Table 4.3.2: *Field Measurement Data for Site #3*

Variable	July 19, 2006	August 10, 2006
Channel Width (metres)	14.63	n/a
Channel Depth (cm)	187	n/a
Flow (m/s)	0.038	0.032
Air Temperature (°C)	30	21
Water Temperature (°C)	17.01	16.84
pH	7.68	7.44
Conductivity (mS/cm)	0.190	0.24
Total Dissolved Solids (g/L)	0.145	0.18
Dissolved Oxygen (mg/L)	9.50	7.82
Dissolved Oxygen Saturation (%)	98.3	80.73
Turbidity (NTU)	8.5	26.5

Table 4.3.3: *Laboratory Water Quality Results for Site #3*

Variable- Site 3	August 10, 2006
Turbidity (NTU)	1.29
Conductivity (mS/cm)	0.300
Total Phosphorus (µg/L)	30
Suspended Solids (mg/L)	< 3
Cadmium (µg/L)	< 0.1
Iron (µg/L)	223
Lead (µg/L)	0.8

Table 4.3.4: *Flora and Fauna Observed*

Tree Species	White Spruce, Paper Birch, Black spruce, Trembling Aspen
Shrub Species	Speckled Alder, Common Witch-Hazel, Wintergreen, Wild Red Raspberry, Glade Fern, Trembling Aspen
Herb Species	Oxeye Daisy, Common Dandelion, Cranberry, White Snakeroot, Spotted Joe-Pye Weed, Red Osier Dogwood, Canada Goldenrod, Cow Vetch, Yarrow, Sensitive Plant, Large-Leaved Aster
Aquatic Plants	Grasses, Sedges, Blue Joint Grass
Benthic Species/Insects	Minnows, Bees, Humming Bird, Toad
Terrestrial wildlife	Chipmunk, Beaver
Additional Comments	Evidence of a beaver dam upstream and downstream from the culverts, East of Highway 11/17

Table 4.3.5: *Physical Attributes of Site #3*

In stream material	Creek bed Characteristics	Bank Stability	Terrain Characteristics	Stream Cover
Fallen logs/branches	Mucky marsh land	Stable	Marsh land, Mixed forest	Low – Moderate

Discussion

Site #3 was located southwest of the culvert on Highway 11/17. This site was selected in order to assess any runoff from the road that may interfere with the health of the watershed.

The depth at this site was fairly deep and restricted sampling to just three metres from the creek bank. The increase in depth was attributed to beaver damming both upstream and downstream of the culvert. Beaver damming also produced marshy conditions and a lower flow velocity.

The pH at this site was the lowest of the sample sites; however was still well within the PWQO guidelines. The conductivity and total dissolved solids were consistent with the other samples taken and meet the PWQO. There were sufficient amounts of dissolved oxygen with 80.73% saturation. The water was visibly turbid and had a reading of 26.5 NTU.

Additional analysis of heavy metals met the PWQO guidelines; however, iron levels were the highest of all the sites sampled at 223 μg/L, which was likely from a natural source such as iron-rich rocks.

4.4 Site #4

Table 4.4.1: *Location Reference for Site #4*

Location Description	Northeast of the CPR tracks, at confluence of two branches
GPS Coordinate	5396611.389m N; 380028.405m E
Altitude/Elevation (metres)	227.993 MSL

Table 4.4.2: *Field Measurement Data for Site #4*

Variable –Site 4	July 19, 2006	August 11, 2006
Channel Width (metres)	2.30	2.30
Channel Depth (cm)	21	21
Flow (m/s)	0.025	0.025
Air Temperature (°C)	27	15.5
Water Temperature (°C)	17.77	12.06
pH	7.69	7.56
Conductivity (mS/cm)	0.217	0.23
Total Dissolved Solids (g/L)	0.164	0.20
Dissolved Oxygen (mg/L)	10.84	10.07
Dissolved Oxygen Saturation (%)	114.0	93.65
Turbidity (NTU)	17	8.5

Table 4.4.3: *Laboratory Water Quality Results for Site #4*

Variable- Site 4	August 10, 2006
Turbidity (NTU)	1.44
Conductivity (mS/cm)	0.315
Total Phosphorus (µg/L)	27
Suspended Solids (mg/L)	< 3
Cadmium (µg/L)	< 0.1
Iron (µg/L)	<5
Lead (µg/L)	<0.9

Table 4.4.4: *Flora and Fauna Observed at Site #4*

Tree Species	Black Spruce, Balsam Fir, White Spruce, Jack Pine, Balsam Poplar, Trembling Aspen, White Cedar
Shrub Species	Wintergreen, Beaked Hazel, Trembling Aspen, Low Bush Honeysuckle, Twinflower,
Herb Species	Rose Twisted Stalk, Spotted Joe-Pye Weed, Wild Sarsaparilla
Aquatic Plants	Grasses, Sedges, Blue Joint Grass, Cattails, Bushy Pond-Weed, Water Plantain
Benthic Species/Insects	Minnows, Water Striders, Grass Hopper, Butterflies, Mosquitoes, Black flies
Terrestrial Wildlife	None spotted at time of observation
Additional Comments	Grassland / Mixed Forest

Table 4.4.5: *Physical Attributes of Site #4*

In stream material	Creek bed Characteristics	Bank Stability	Terrain Characteristics	Stream Cover
Fallen logs/branches	Loosely packed soil with stones	Low-Moderate stability	Grassland/ Mixed Forest	Low

Discussion

Site #4 was accessed by the CPR access road for Bowker Station, which was a short walk east along the tracks, and an approximate 80 metre hike through the forest. Site #4 was on a small tributary, where the width and depth were slight. There was evidence of historical higher flow with banks that were eroded higher, but at the time of sampling the water level was low. This was likely due to a lack of rainfall over the summer or from beaver dams further upstream. The area around the stream was mainly grass, which may be an indication of seasonal flooding. Site #4 had a wide diversity of species around and in the creek, even with the low depth.

Site #4 had a pH reading of 7.56, which was consistent with the other sampled sites. The sampling took place at 10:45 am on a cool day, which may explain the water temperature of 12.06 °C. Conductivity and the total dissolved solids were similar to all of the other sites sampled and were within the PWQO guidelines. Dissolved oxygen was also abundant and nearing saturation. Turbidity was the lowest of all the sampled sites (8.5 NTU) and did not have any visible signs of turbidity.

The additional parameters analyzed by the lab; TSS, turbidity, conductivity, phosphorus, cadmium, iron and lead, were below the maximum acceptable concentrations as defined by the PWQO.

5.0 Results of Culvert Assessments

Topographic maps and aerial photography were used to determine the culvert crossings. Culvert locations are displayed on Map M-2 Site Plan, attached. The watershed was relatively small in size, in a remote location and had very little human disturbances. Welch Creek had only five culverts along the creek, and four from railway activity. Additional information, figures and how measurements of each culvert were taken are attached in Appendix F - Culvert Data.

5.1 Culvert 1

Culverts 1a and 1b, were located on the Canadian National Railway lines, at railway marker "159". There were two concrete openings, indicating that this area can experience significant flows of water. Culvert 1a was the west culvert and culvert 1b was the east culvert. During the time of survey the water flow was low. There was a diverse amount of vegetation up and down stream of the culverts. The fill slope was 30 degrees and filled with cobbles to prevent erosion. The slope was not vegetated.

Table 5.1.1: *Measurements of Culverts 1a and 1b*

Variable	**Culvert 1a**	**Culvert 1b**
Inspection Date	20/07/2006	20/07/2006
Road Surface (J – K)	8.90 m	8.90 m
Length of Covered Stream (H – I)	38.355 m	38.355 m
Fill Height Upstream (N – O)	8.9 m	8.9 m
Fill Height Downstream (L – M)	12.61 m	12.61 m
Width of Opening (A – D)	215 cm	215 cm
Inside Top to High Water (A – B)	113 cm	100 cm
Inside Top to Water Surface (A – C)	161 cm	173 cm
Height Above Outlet Pool (A – E)	161 cm	190 cm
Outlet Pool Water Surface to outlet Pool High Water Mark (E – G)	0.21 cm	22 cm
Inside Top to Bottom of Stream (A – F)	227 cm	256 cm
Fill Slope Angle Upstream	30º	30º
Fill Slope Angle Downstream	30º	30º
UTM Coordinates: 5393149.729m N; 380722.649m E; 218.990m MSL		
Details: Double concrete culvert, with culvert 1a on the west and culvert 1b on the east		

5.2 Culvert 2

Culvert 2 was also located on the CNR and was approximately 2.1 km northwest of Culvert 1a/1b. This culvert was dry at the time of sampling. Surrounding the location was a very diverse and thick-forested area, which made taking a photo impractical. The rust line indicated that the culvert did pass flow, although not at a very high level. Fill slope at this location was steep at 40 degrees, however was well-vegetated and showed no signs of erosion. The culvert was perched at the time of inspection

Table 5.2.1: *Measurements of Culvert 2*

Variable	Culvert 2
Inspection Date	20/07/2006
Road Surface (J – K)	6.5 m
Length of Covered Stream (H – I)	9.83 m
Fill Height Upstream (N – O)	7.12 m
Fill Height Downstream (L – M)	7.43 m
Width of Opening (A – D)	75 cm
Inside Top to High Water (A – B)	68 cm
Inside Top to Water Surface (A – C)	n/a
Height Above Outlet Pool (A – E)	n/a
Outlet Pool Water Surface to outlet Pool High Water Mark (E – G)	n/a
Inside Top to Bottom of Stream (A – F)	135 cm
Fill Slope Angle Upstream	40º
Fill Slope Angle Downstream	40º
UTM Coordinates: 5394608.828m N; 382259.531m E; 222.054m MSL	
Details: Culvert is corrugated metal. Stream during sampling was dry.	

5.3 Culvert 3

This culvert crossed the TransCanada Highway and was the only culvert crossing at a roadway. Beaver dams were observed both up and down stream of the culvert, which meant that the outflow was a large marsh area with low flow. The surrounding area of the culvert was well vegetated and diverse. The fill slope angle was significant, but the bottom half was vegetated and the top half was filled with cobbles. The slope had no signs of erosion.

Table 5.3.1: *Measurements of Culvert 3*

Variable	Culvert 3
Inspection Date	24/07/2006
Road Surface (J – K)	15.501 m
Length of Covered Stream (H – I)	53.290 m
Fill Height Upstream (N – O)	7.112 m
Fill Height Downstream (L – M)	6.844 m
Width of Opening (A – D)	235 cm
Inside Top to High Water (A – B)	168 cm
Inside Top to Water Surface (A – C)	141 cm
Height Above Outlet Pool (A – E)	141 cm
Outlet Pool Water Surface to outlet Pool High Water Mark (E – G)	110 cm
Inside Top to Bottom of Stream (A – F)	275 cm
Fill Slope Angle Upstream	32º
Fill Slope Angle Downstream	48º
UTM Coordinates: 5394650.928m N; 379933.357m E; 222.807m MSL	
Details: Corrugated metal culvert off Highway 11/17.	

5.4 Culvert 4

Culvert 4 was located along the Canadian Pacific Railway lines, approximately 1.5 km east from the Bowker Station service road from highway 11/17. It was a corrugated metal culvert that had a large pool of water on the outflow. There were signs of erosion just downstream of the culverts, with boulders placed along the banks to help reduce erosion from occurring. The fill slope angle on the outflow side of the culvert was extreme. Mesh was present on the slope to reduce erosion and to allow vegetation growth, in order to increase the stability of the slope.

Table 5.4.1: *Measurements of Culvert 4*

Variable	**Culvert 4**
Inspection Date	09/08/2006
Road Surface (J – K)	14.1 m
Length of Covered Stream (H – I)	54.2 m
Fill Height Upstream (N – O)	11.65 m
Fill Height Downstream (L – M)	13.45 m
Width of Opening (A – D)	235 cm
Inside Top to High Water (A – B)	148 cm
Inside Top to Water Surface (A – C)	185 cm
Height Above Outlet Pool (A – E)	148 cm
Outlet Pool Water Surface to outlet Pool High Water Mark (E – G)	51 cm
Inside Top to Bottom of Stream (A – F)	218 cm
Fill Slope Angle Upstream	48º
Fill Slope Angle Downstream	62º
UTM Coordinates: 5395099.74m N; 379619.79m E; 228.92mMSL	
Details: Culvert along rail lines 1.5 km S of Bowker Station	

5.5 Culvert 5

Culvert 5 was also along the Canadian Pacific Railway lines, approximately 400 metres east of Culvert 4. This culvert was for a small branch of Welch Creek that is only approximately 1 km long. The culvert was dry during the time of sampling, and the rust line indicated high water was not measurable, showing that this culvert does not experience a significant amount of flow. The fill slope angle varied, it was 20º on the inflow side, and 60º on the outflow side. There were no signs of erosion, since there was a plentiful amount of vegetation along the slope.

Table 5.5.1: *Measurements of Culvert 5*

Variable	**Culvert 5**
Inspection Date	09/08/2006
Road Surface (J – K)	13.4 m
Length of Covered Stream (H – I)	30.6 m
Fill Height Upstream (N – O)	3.81 m
Fill Height Downstream (L – M)	4.35 m
Width of Opening (A – D)	118 cm
Inside Top to High Water (A – B)	118 cm
Inside Top to Water Surface (A – C)	n/a
Height Above Outlet Pool (A – E)	n/a
Outlet Pool Water Surface to outlet Pool High Water Mark (E – G)	n/a
Inside Top to Bottom of Stream (A – F)	112 cm
Fill Slope Angle Upstream	40º
Fill Slope Angle Downstream	60º
UTM Coordinates: 5394698.52m N, 379488.93m E, 230.13m MSL	
Details: Stream was dry during sampling	

5.6 Culvert Discussion

The inspected culverts along Welch Creek did not show significant signs of deterioration. The fill slopes did not have any significant erosion, as preventative measures have been effective. A steep area near culvert #4 incorporated mesh to encourage slope vegetation to grow. The summer of 2006 experienced extremely dry conditions, which may have accounted for culverts 2 and 5 being dry. There was some debris inside the culverts however not enough to create blockages.

6.0 Overall Discussion

As of the summer of 2006, the overall health of Welch Creek appeared to be excellent. There were limited signs of anthropological disturbances, and the creek water quality met the Provincial Water Quality Objectives with the exception of the Total Phosphorus level at site #2. Laboratory analysis reported that Site #2 had a Total Phosphorous level of 37 μg/L, which exceeds the PWQO guideline of 30 μg/L. It should be noted that Site #2 had a significant amount of aquatic plant growth, and these levels were most likely occurring from natural sources, such as decaying plants or animals.

The highest elevation that was sampled was at Site #4, which was 227.993 metres above mean sea level and 40.1 metres above the confluence at Site #1. Graph #1 (G-1) displays the range of elevation of all sites. Elevation was significant, because it compares velocity and quantity of water throughout the watershed.

The mean creek depth from the four sample sites was 63.25 cm. Average flow was very low, 0.0645 m/s, due to the very gentle slope of the watershed. The pH of the four sites ranged between 7.4 and 7.9, with an average pH reading of 7.58, which met the PWQO guideline ranges. July pH levels tended to be higher than August, which indicated that the water was more basic in July. Graph #7, (G-7), displays the pH comparisons for July and August.

July air temperature ranged between 16 to 31 degrees Celsius, and the water temperature ranged between 17 to 21.8 degrees Celsius. August air temperatures ranged from 15.5 to 23 degrees Celsius and water temperatures ranged from 12.6 to 18.9 degrees Celsius. The air and water temperatures decreased in August, which is normal for the changing seasons. The water temperature dropped due to cooler temperatures at night and changes in creek depth. Width and depth generally remained the same from July to August, aside from site #3, which was too deep to measure. Graphs 4 and 5 (G-4, G-5) compare the air temperature versus the water temperatures observed in July and August.

Total dissolved solids averaged at 0.20 g/L, which was well below the 500 g/L criterion. The dissolved oxygen for the creek averaged at 82.55 % saturation, well above the 54 percent criterion. A comparison of site levels of total dissolved solids, conductivity and dissolved oxygen, can be found on Graphs #2 and 3 (G-2, G-3). The graphs display that the parameters for all of the sample sites tested in July and August are within the acceptable range. The only noticeable change was the conductivity increase at site #3 from July to August. Generally, high conductivity values are characteristic of a varying degree of human disturbance. Other contributing factors may be attributed to the beaver damming and/or the location of the site, which was along the highway and was undergoing construction.

The average turbidity of Welch Creek was 24.88 NTU; the water was slightly cloudy, although you could still see the bed in most places. Turbidity measured with the handheld meter and the turbidity results from the laboratory analysis vary by a significant amount. This may be attributed to the creek bed floor becoming stirred up while turbidity readings were taken. Another possibility may be the difference between depths when collecting the sample and

collecting the field measurement. The turbidity tested during July and August did not show any significant trend, however the greatest change was at site #3, with an increase of 17 NTU from July to August. This may be due to the beaver damming that occurred during August. Varying amount of debris were moving down the creek and may have been trapped in the deep and slow moving waters at site #3, which could account for the increased turbidity. See Graph #6 (G-6) for a comparison of turbidity results.

Water analysis conducted by Accurassay Labs for total suspended solids, cadmium, iron, and lead were within the PWQO guidelines, however Total Phosphorus exceeded the recommended levels at site #2 by 7 μg/L. Lead steadily climbed further up stream but did not exceed the PWQO guidelines. Lead levels from Site #2, near the abandoned mine, correlate to the other sites tested, which indicates there were no significant signs of lead leaching from the mine.

The culvert crossings were all in good condition, with no obvious signs of disrepair. Overall, there was minimal evidence of erosion of the fill slopes and riverbanks around the culverts. Culvert #4 appeared to be the only site where erosion took place, and remediation efforts were already in place. The placement of nylon mesh to encourage vegetation growth was effective.

The vegetation and aquatic life observed at all sample sites and culvert crossings appeared to be in a naturally healthy state. The vegetation was variable and diverse with a conifer, mixedwood and hardwood forest composition. Common tree species in the Welch Creek Watershed were black spruce, balsam fir, trembling aspen, jack pine, white spruce, red pine and white pine. The shrub layers of the areas were generally rich in speckled alder and beaked hazel. Other shrubs and plants were identified during the August observations, as many plants were not fully bloomed in early July. Herbaceous plants were also abundant around the creek and were also quite diverse.

During the assessment minimal wildlife was observed, however there was evidence of animals living in the area as their droppings, footprints and homes were recognized. Beaver dams were observed at Site #3, and appeared to have changed the creeks depth, width and flow. One species in particular, observed at Site #2, was the blue heron. Blue herons are usually found along shallow water bodies where they will feed on small fish. They were an indication that the creek was in good health, as fish are suspected to be living in the creek. Overall, the plant and species living in this watershed during July and August 2006 were generally diverse and gave a good indication of a healthy environment and ecosystem.

Overall, with the diversity of plant and benthic species observed, and with water quality analysis below the PWQO guidelines, it can be concluded, that at the time of study, the Welch Creek Watershed appeared to be a healthy ecosystem.

7.0 Future Recommendations

Welch Creek watershed was in good health for the months of July and August 2006, however additional testing of Welch Creek should be conducted to create a more thorough assessment. This is especially recommended since only one round of sampling was conducted, due to a laboratory error. The area of Welch Creek should be monitored for; terrestrial and aquatic species, erosion, water quality and culvert health once again, as time and resources permit.

With two of the culverts being dry during the July assessment, testing should be considered in the spring, during the wet season, in order to be able to measure water levels.

A copy of this report should be made available to the Municipality of Shuniah. This report will be kept on file at the Lakehead Region Conservation Authority office for review by interested parties. Copies will be made available on a cost recovery basis.

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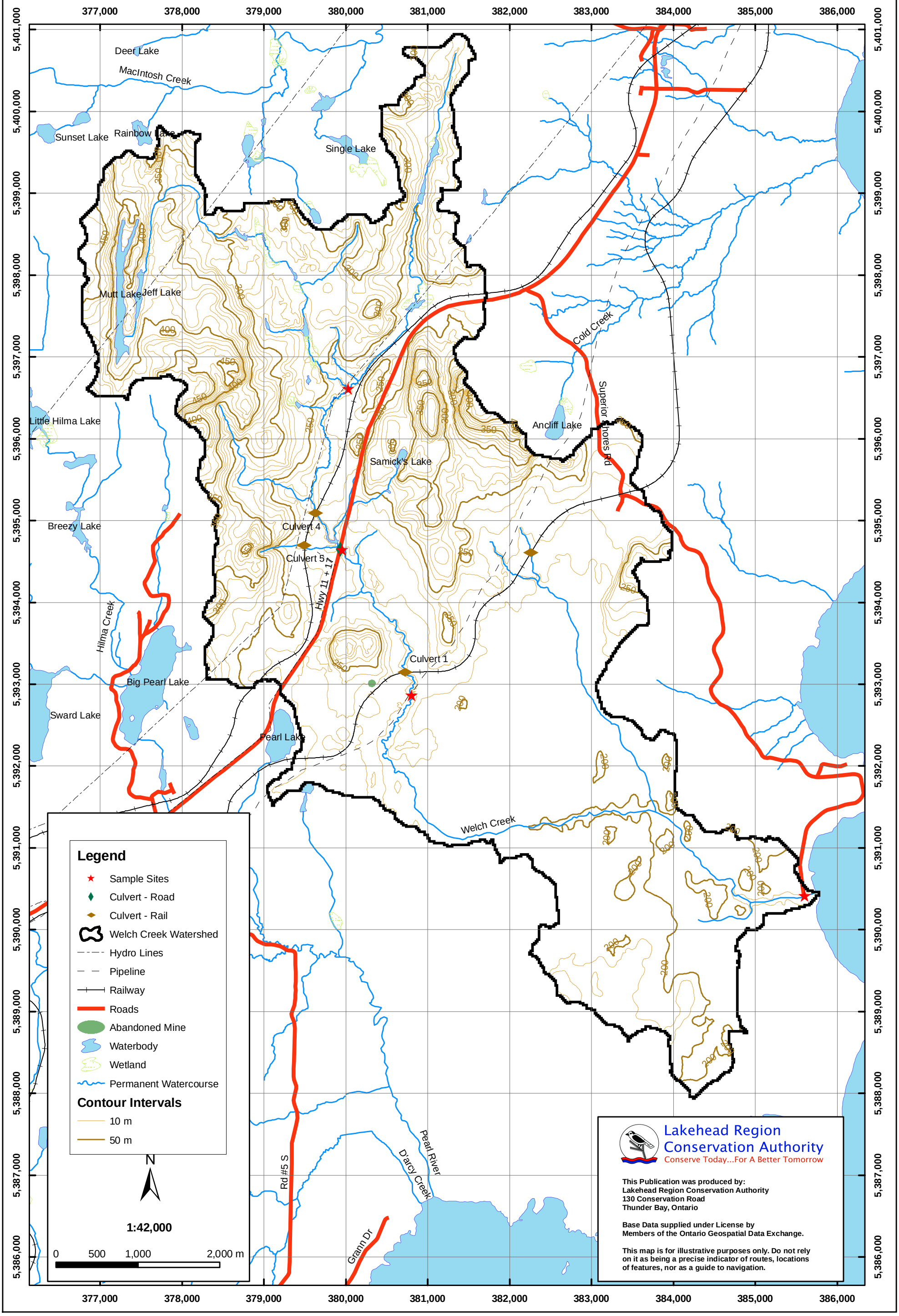
Welch Creek Watershed

Map M-1:Key Map

Welch Creek Watershed

M-2: Site Map



Lakehead Region Conservation Authority
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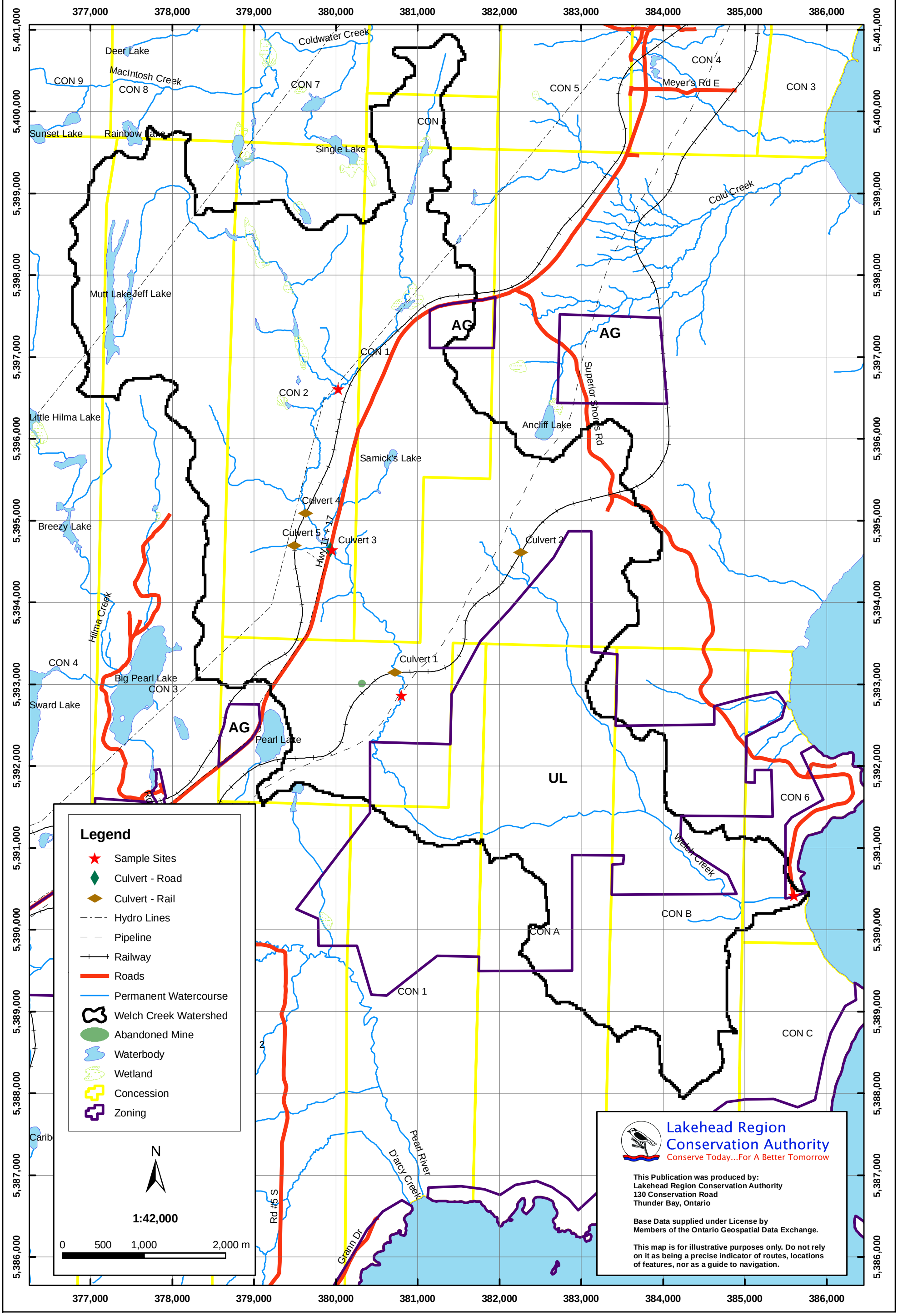
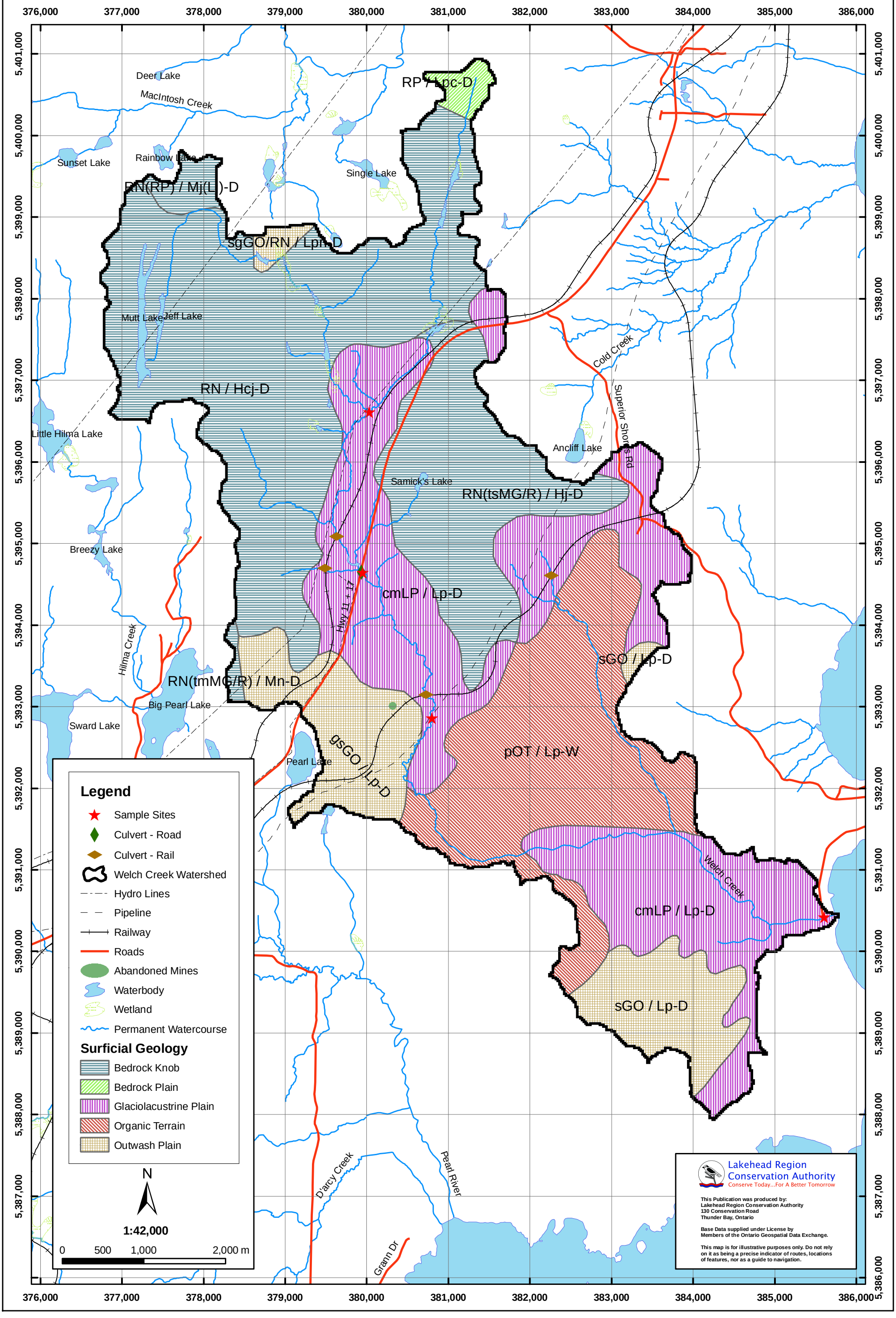
Welch Creek Watershed

M-3: Land Use



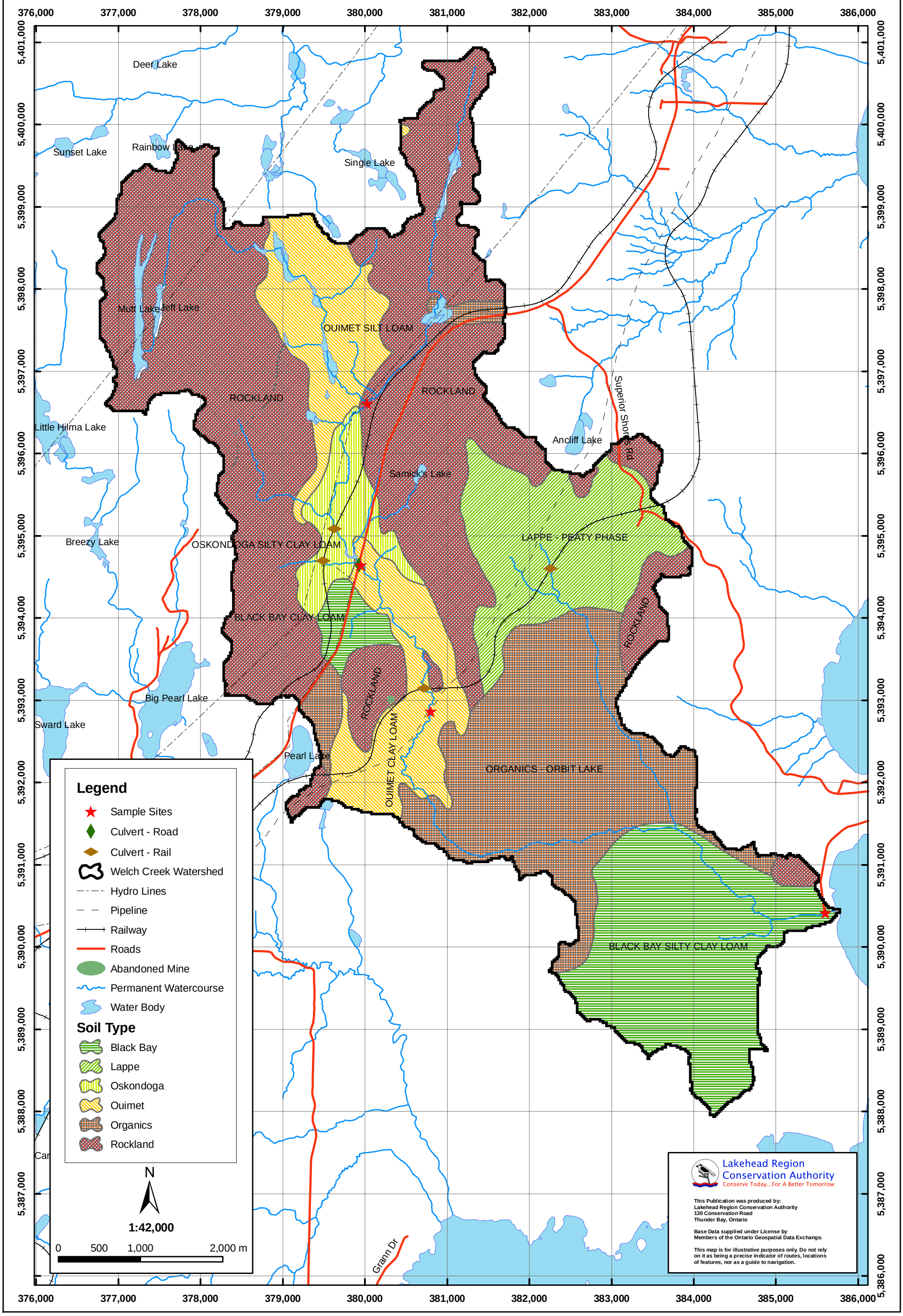
Welch Creek Watershed

M-4: Surficial Geology



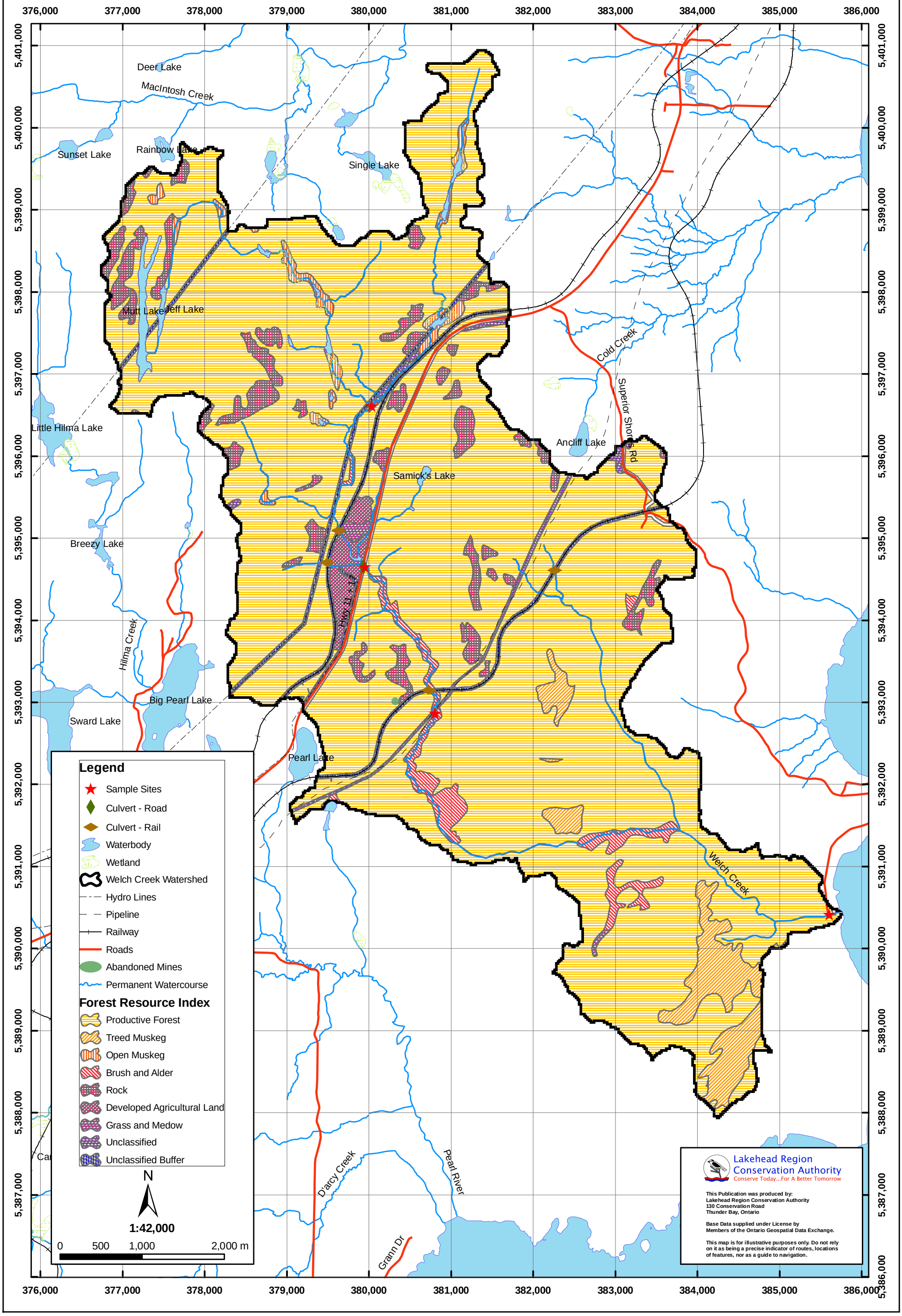
Welch Creek Watershed

M-5: Soils

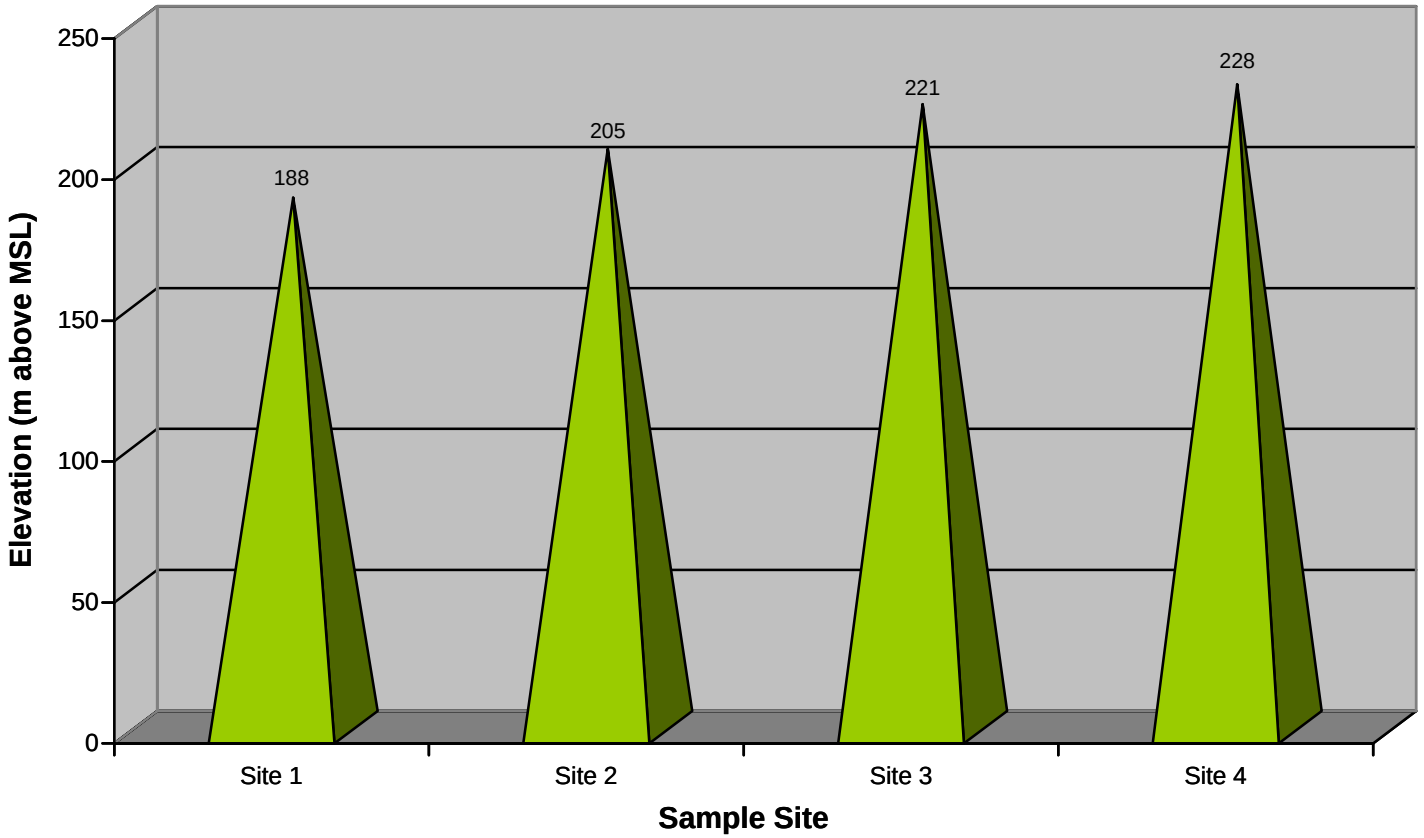


Welch Creek Watershed

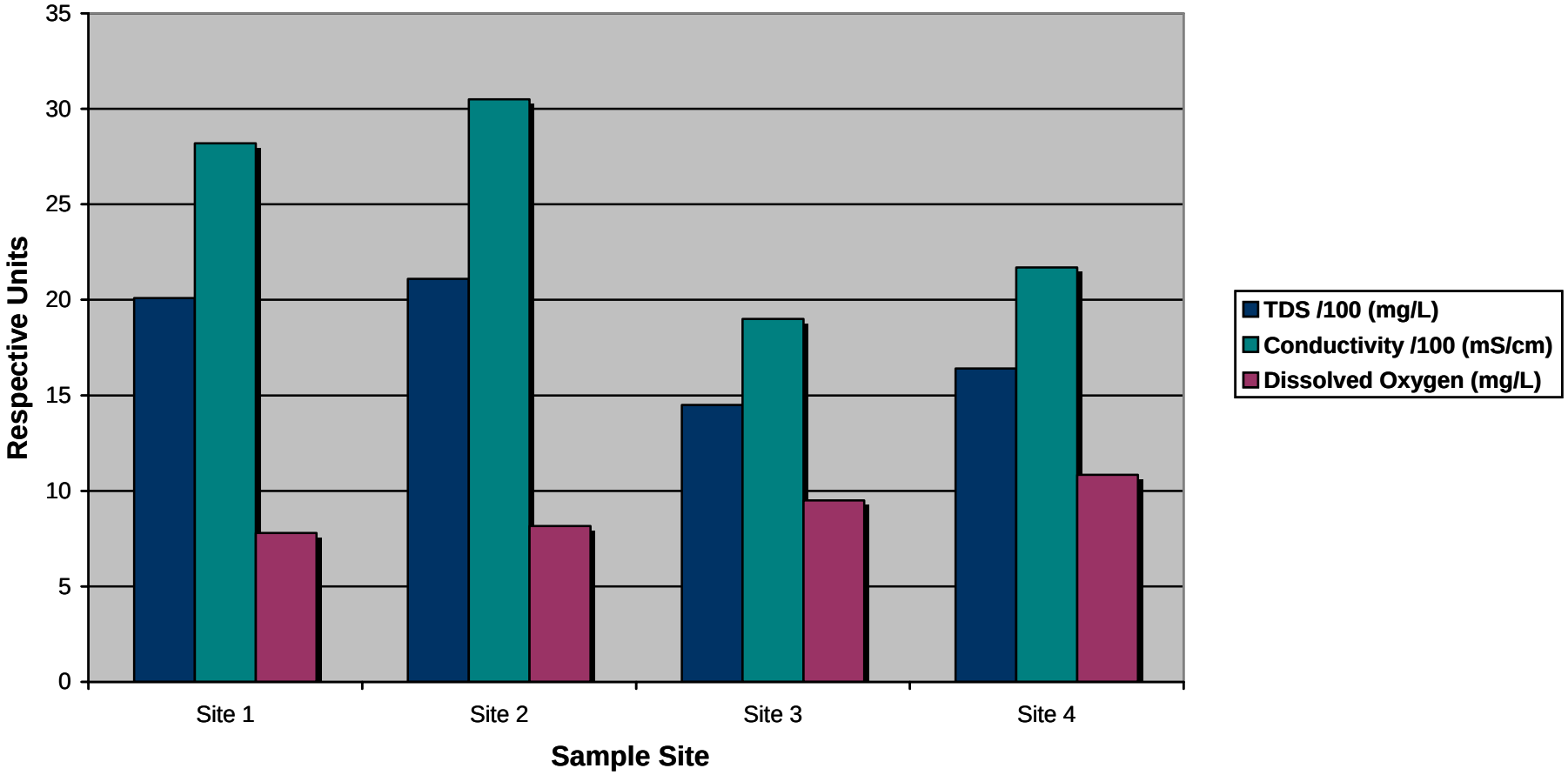
Map M-6: Forest Resource Index



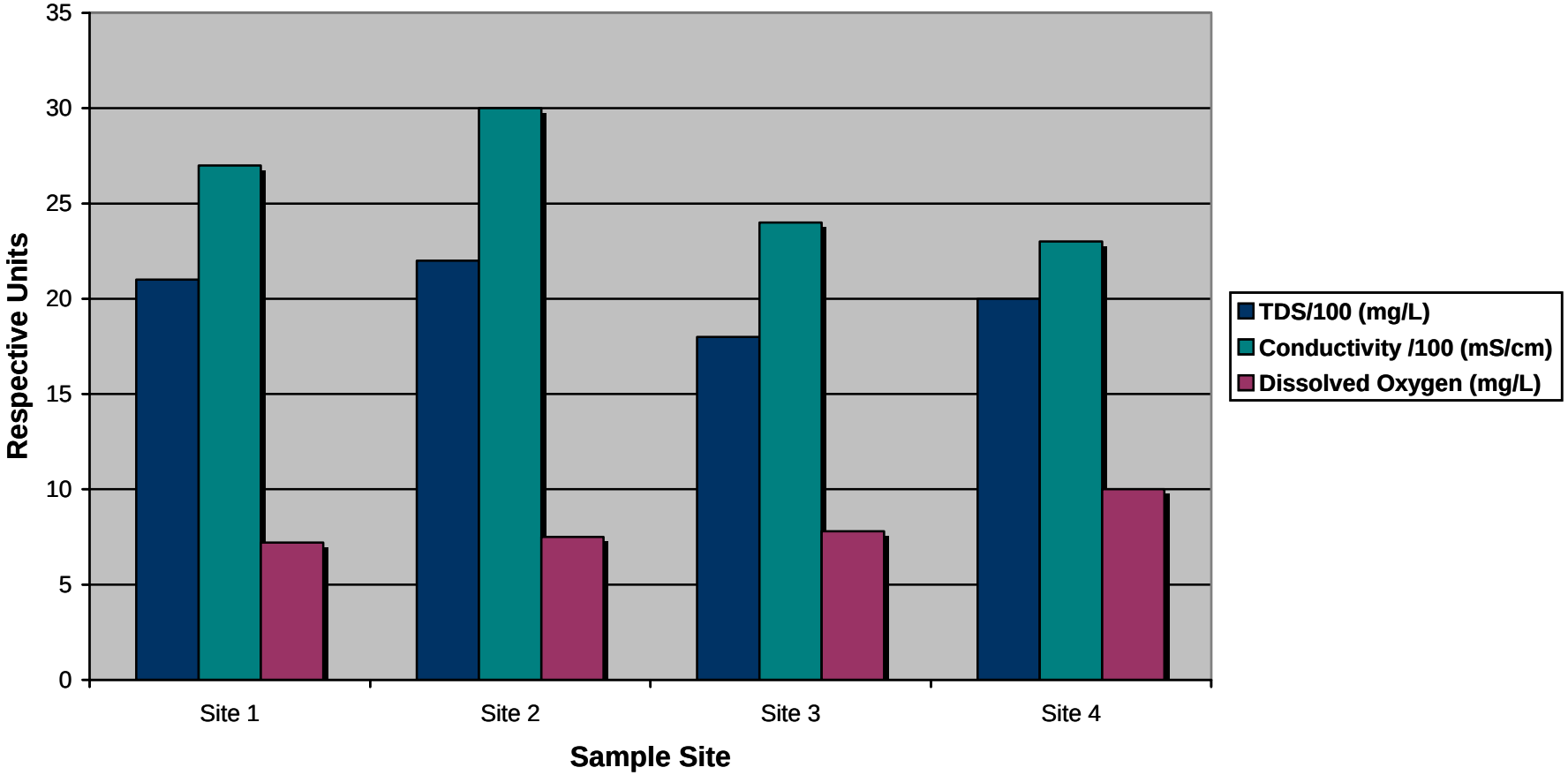
Graph #1: Elevations



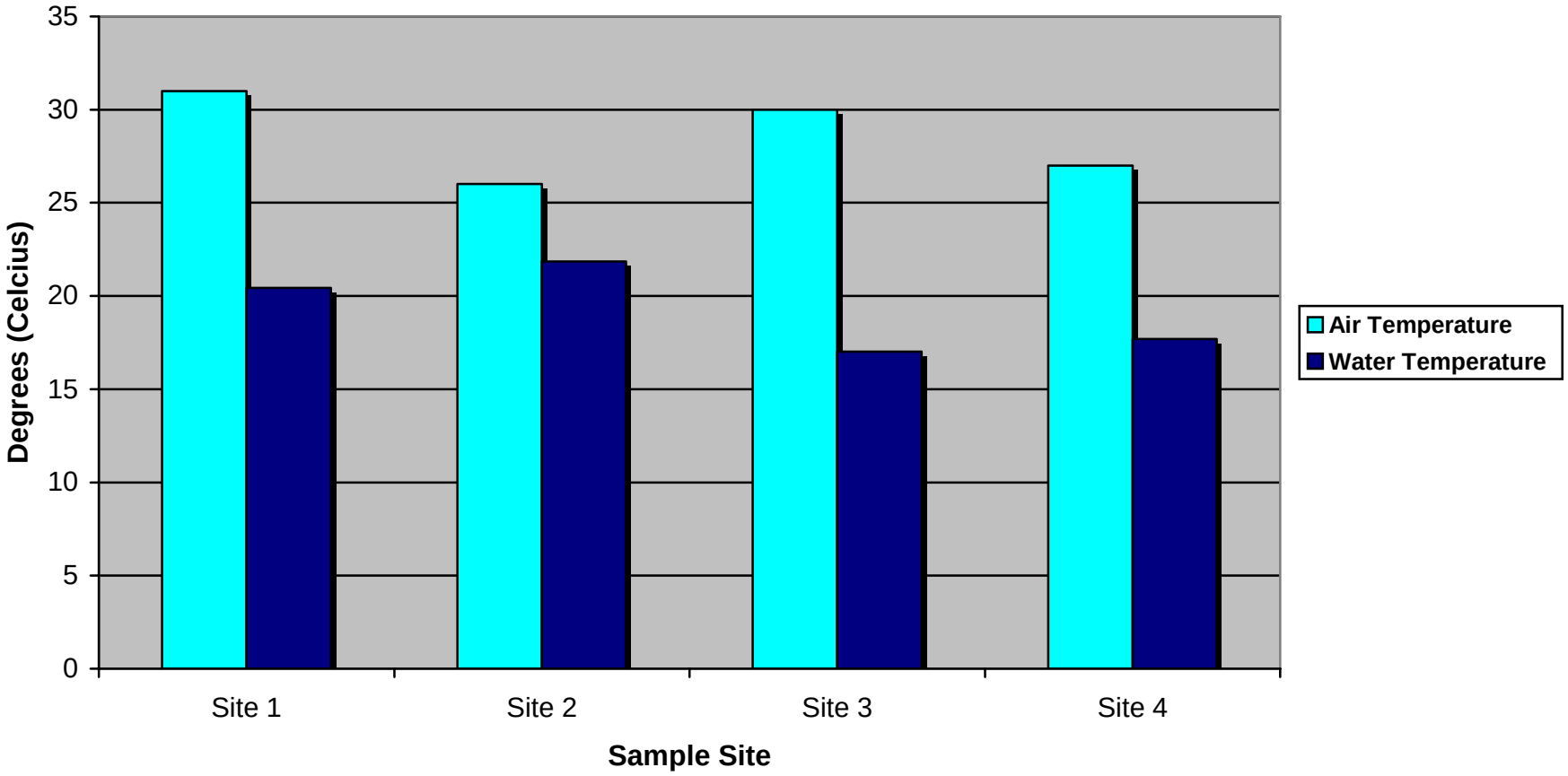
Graph #2: July Water Sample Data



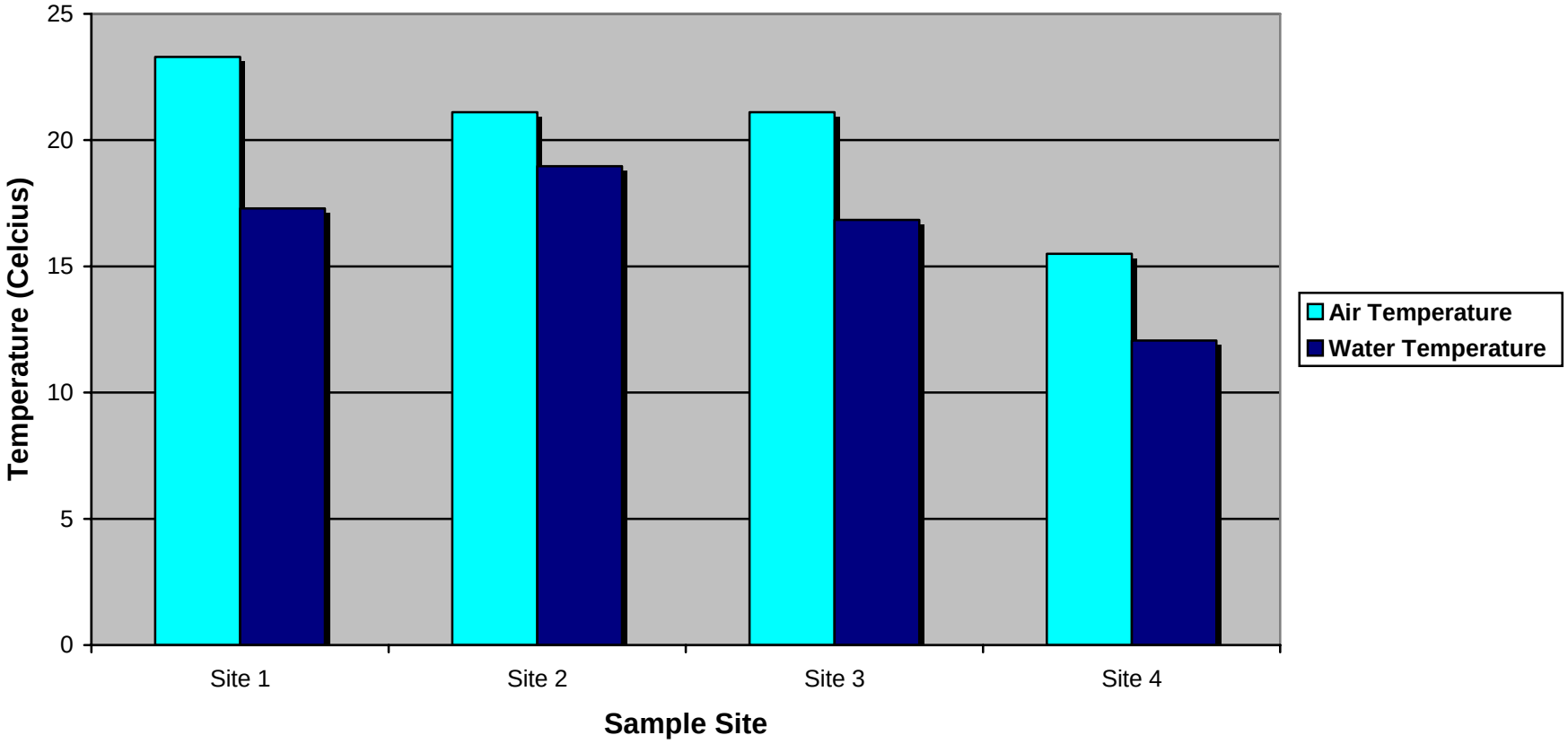
Graph #3: August Water Sample Data



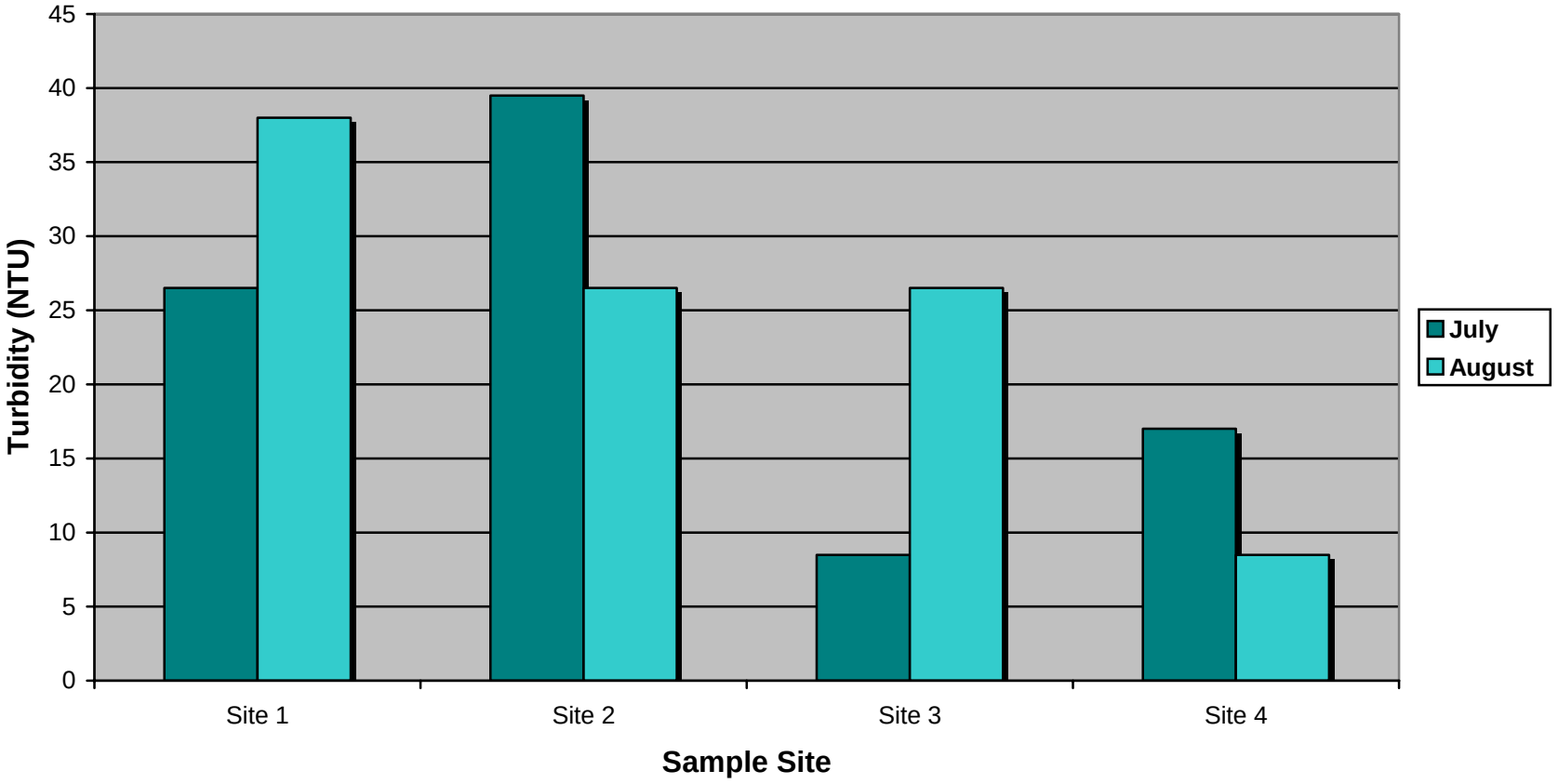
Graph #4 : July Air vs. Water Temperature



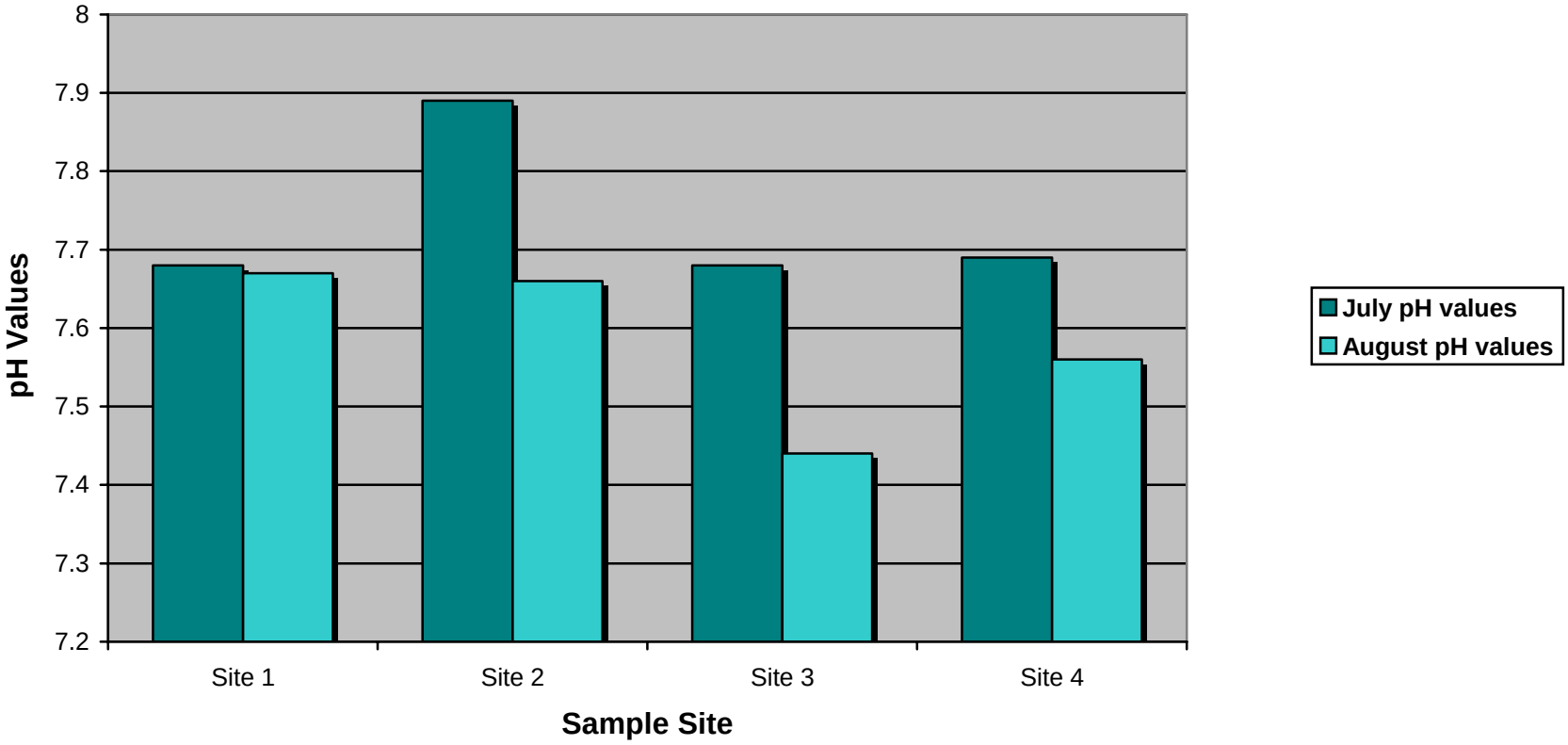
Graph #5: August Air vs. Water Temperature



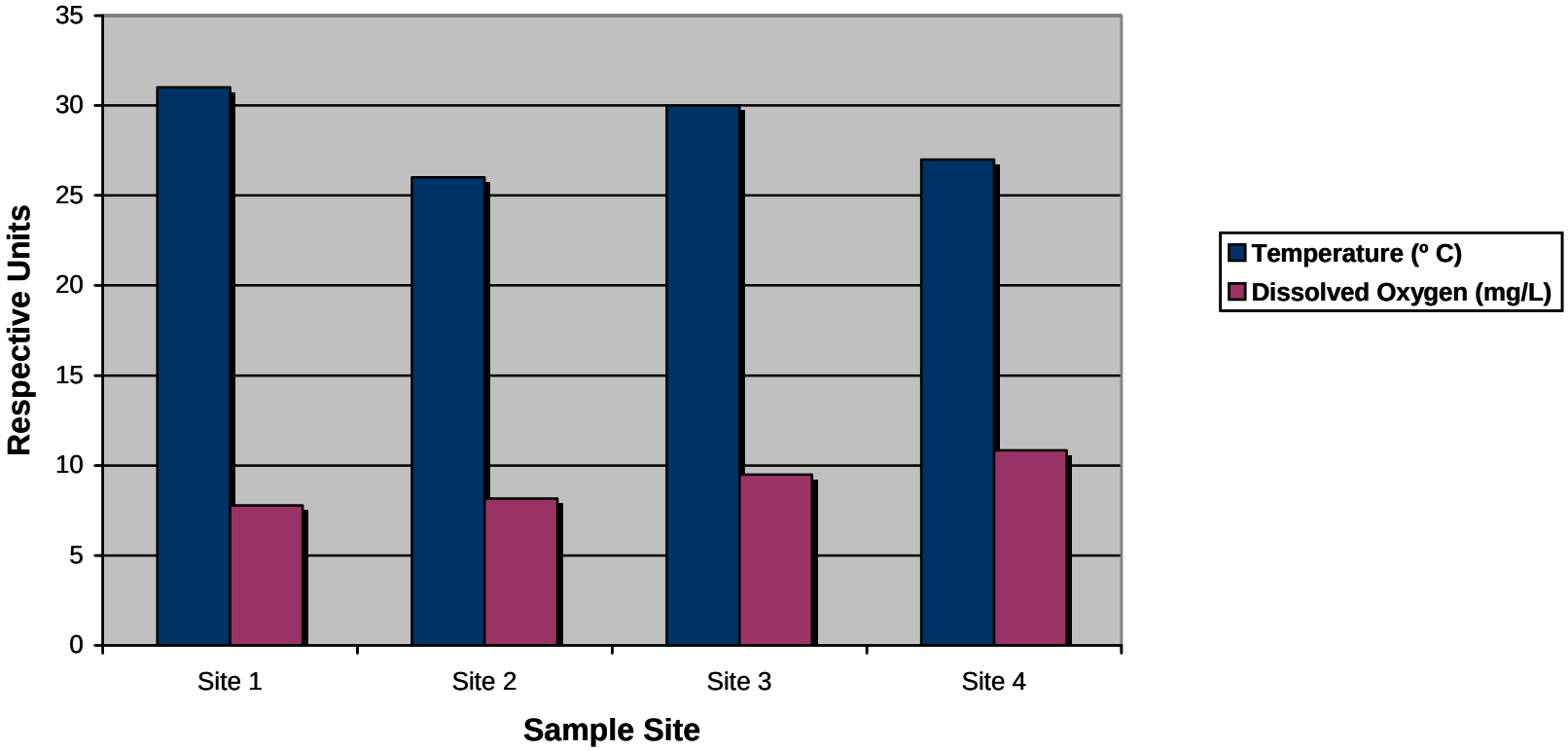
Graph #6: Turbidity Comparison



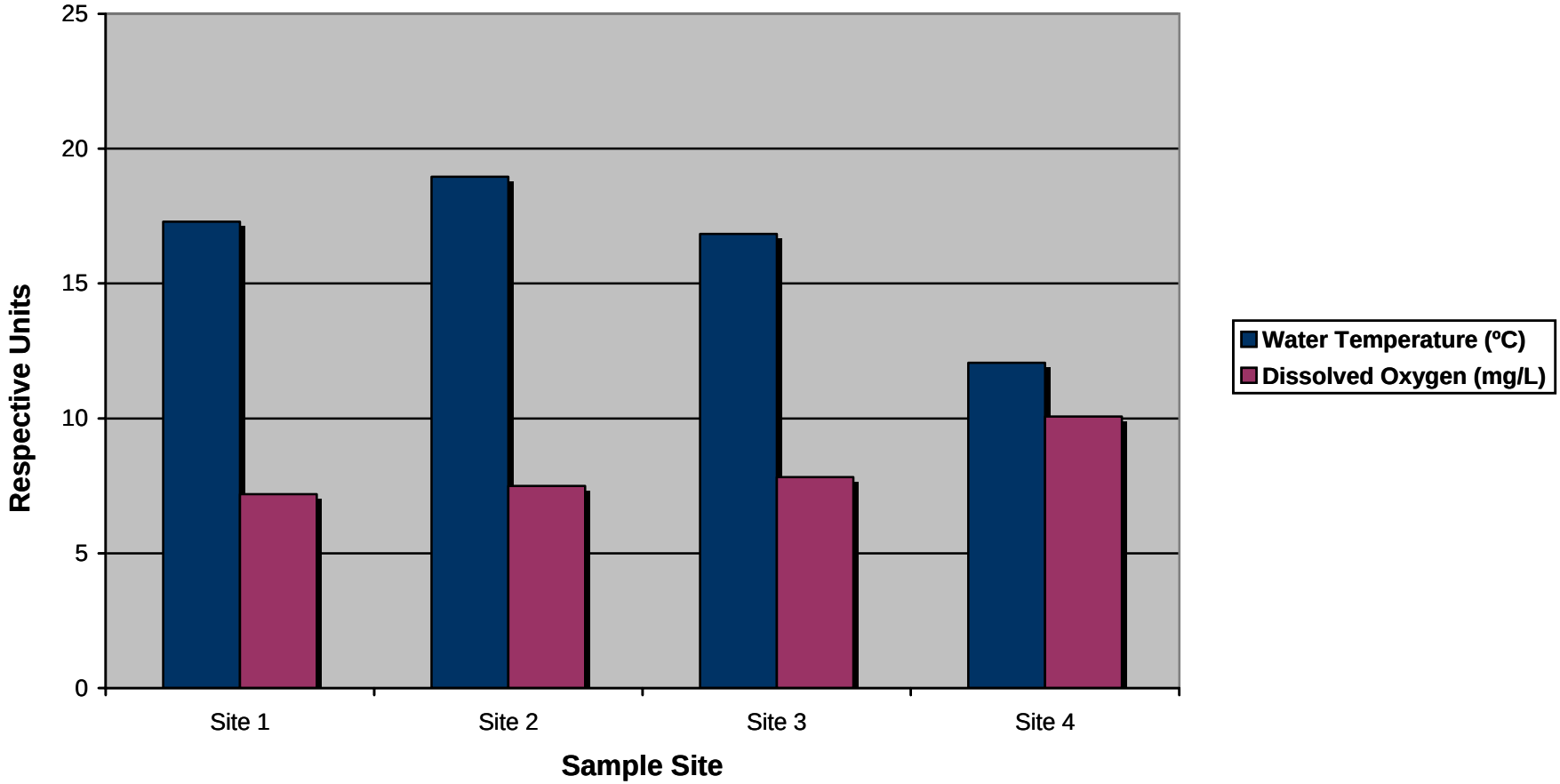
Graph #7: July and August pH Comparison



Graph #8: July Dissolved Oxygen vs. Water Temperature



Graph #9: August Dissolved Oxygen vs. Water Temperature



Appendix A: Common and Latin Names of Plant Species

Trees	
Abies balsamea	balsam fir
Betula papyrifera	white birch
Picea glauca	white spruce
Picea mariana	black spruce
Pinus banksiana	jack pine
Populus tremuloides	trembling aspen
Shrubs	
Acer spicatum	mountain maple
Alnus crispa	green alder
Alnus rugosa	speckled alder
Amelanchier spp	serviceberry
Cornus stolonifera	red osier dogwood
Corylus cornuta	beaked hazel
Diervilla lonicera	bush honeysuckle
Linea borealis	twin flower
Lonicera canadensis	Canada fly honeysuckle
Rosa acicularis	prickly rose
Rubus idaeus var. strigosus	wild red raspberry
Rubus pubescens	dwarf raspberry
Vaccinium angustifolium	low bush blueberry
Vaccinium myrilloides	velvet leaf blueberry
Herbs	
Achillea millefolium	yarrow
Ageratina altissima	white snakeroot
Anemone quinquefolia	wood anemone
Araulia nudicaulis	wild sarsaparilla
Aster macrophyllus	large-leaved aster
Calamagrastis canadensis	blue joint grass
Carex spp.	Sedge
Chrysanthemum leucanthemum	ox-eye daisy
Clintonia borealis	blue bead lily
Cornus Canadensis	bunchberry
Coptis trifolia	three-leaved goldthread
Eupatorium maculatum	spotted Joe-pye weed
Epilobium angustifolium	fireweed
Galium triflorum	fragrant bedstraw
Gaultheria procumbens	wintergreen
Lycopodium dendroidium	ground pine
Mitella nuda	naked miterwort
Maianthemum canadense	cow parsnip

Najas gracillima	bushy pond-weed
Petasites palmatus	sweet coltsfoot
Sagittaria latifolia	broad-leaved arrowhead
Solidago canadensis	Canada goldenrod
Staphylea trifolia	bladdernut
Streptopus roseus	rose twisted stalk
Taraxacum officinale	dandelion
Trentalis borealis	starflower
Typha latifolia	common cattail
Vicia spp.	vetch
Viola renifolia	kidney leaf violet

Ferns

Athryium pycnocarpon	glade fern
Gymnocarpium robertianum	northern oak fern
Phegopteris connectilis	long beech fern

Mosses

Dicranum polysetum	broom moss
Hylocomium splendens	stair step moss
Pleurozium schreberi	Schreber's moss
Ptilium crista-castrensis	plume moss
Rhytidiadelphus triquetrus	shaggy moss

Aquatic Plants

Alisma subcordatum	water-plantain

Aquatic Invertebrates/Minnows

Coleoptera spp.	water beetle
Gerrida-Hemiptera	water strider
Hirudinea spp.	leech
Mollusca- Gastropoda	snail
Phoxinus	minnow

Appendix B: Forest Ecosystem Classification

Site 1: **V10 Trembling Aspen – Black Spruce – Jack Pine / Low Shrub**

Description:

- Hardwood mixedwoods with black spruce and jack pine as the primary conifer tree species
- Rich herb and low shrub layers typically in broadleaved species, such as Bush Honeysuckle and Large-leaved aster
- Deep, fresh, well to rapidly drained mineral soils

Common Overstory Species:
Trees: trembling aspen, black spruce, jack pine, white birch, balsam fir, white spruce

Common Understory Species:
Shrubs: bush honeysuckle, twin flower, dwarf raspberry, balsam fir, velvet leaf blueberry, late low blueberry, trembling aspen, prickly rose, serviceberries, black spruce, green alder, canada fly honeysuckle

Herbs: bunchberry, cow parsnip, wild sarsaparilla, blue bead lily, rose twisted stalk, large leafed aster, starflower, kidney leaf violet, three-leafed goldenthread, fireweed, running ground pine

Mosses: schreber's moss, plume moss, droom moss

Forest Floor Cover:

Broadlead litter: 73 Moss:10 Conifer litter:10 Wood: 6

Site 2: **V6 Trembling Aspen (White Birch) – Balsam Fir / Mountain Maple**

Description:

- Hardwood mixedwood stands with balsam fir as the main conifer tree species
- Canopy is dispersed and two-tiered with aspen or aspen-birch in the overstory and balsam fir in the second layer
- Understory is herb and shrub rich with speckled alder, Wild Sarsaparilla and large leaf aster
- Deep, fresh, well to rapidly drained, upland mineral soils

Common Overstory Species:
Trees: Balsam fir, trembling aspen, white birch, white spruce, black spruce, jack pine

Common Understory Species:
Shrubs: balsam fir, mountain maple, dwarf raspberry, trembling aspen, bush honeysuckle, beaked hazel, twin flower, canada fly honeysuckle, prickly wild rose

Herbs: wild sarsaparilla, rose twisted stalk, canada may flower, bunchberry, blue bead lily, large-leaved aster, kidney leaf violet, starflower, fragrant bedstraw, naked mitrewort, wood anemone

Shrubs: schreber's moss, woodsy mnium, shaggy moss, plume moss

Forest Floor Cover:

Broadleaf litter: 81 Moss: 7 Wood: 7

Site 3: **V24 White Spruce – Balsam Fir/ Shrub Rich**

Description:

- Conifer Type with balsam fir or white spruce as the main canopy species
- The shrub understory tends to be speckled alder, beaked hazel, balsam fir, and mountain maple
- Herb layer varies from rich to poor
- Deep, fresh to moist, mineral soils across a range of texture classes

Common Overstory Species
Trees: white spruce, balsam fir, black spruce, jack pine, white birch

Common Understory Species
Shrubs: balsam fir, dwarf raspberry, serviceberry, showy mountain ash, mountain maple, beaked hazel, bush honeysuckle, twin flower, prickly wild rose
Herbs: blue beaded lily, wild sarsaparilla, bunchberry, fragrant bedstraw, wild lily of the Valley, rose twisted stalk, large leaf aster, starflower, naked miterwort, wood anemone or wildflower, kidney-leaved violet, sweet coltsfoot, wild strawberry
Mosses: schreber's Moss, stair-step moss, shaggy moss, dicranum polysetum

Forest Floor Cover:
Conifer litter: 34 Moss: 32 Broadleaf litter: 23 Wood: 7

Site 4: **V14 Balsam Fir Mixedwood**

Description:

- Inconsistent mixedwood type forest
- Canopy consists mainly of balsam fir, and may contain a mixture of several species
- Understory is shrub rich to moderately herb and shrub poor
- Deep, fresh to moist, mineral soils but encompassing a wide range of soil and site conditions

Common Overstory Species:
Trees: balsam fir, trembling aspen, white birch, white spruce, black spruce, jack pine, balsam poplar, white cedar

Common Understory Species:
Shrubs: balsam fir, mountain maple, dwarf raspberry, twin flower, bush honeysuckle, canada fly honeysuckle, trembling aspen, beaked hazel, prickly rose, serviceberries

Herbs: cow parsnip, wild sarsaparilla, blue bead lily, low bush honeysuckle, rose twisted stalk, bunchberry, starflower, kidney lead violet, naked miterwort, large-leaved aster, fragrant bedstraw, three lead goldenthread, sweet coltsfoot, wood anemone

Mosses: schreber's moss, plume moss, stair step moss, woodsy mnium

Forest Floor Cover
Broadleaf litter: 66 Conifer litter: 14 Moss: 12 Wood: 6

Appendix C: MOE Water Quality Guidelines

The following are taken from the Ministry of the Environment water quality guidelines, Provincial Water Quality Objectives (PWQO), July 1994.

Alkalinity:
Alkalinity should not be decreased by more than 25% of the natural concentration.

Dissolved oxygen:
Dissolved oxygen concentrations should not be less than the values specified below for cold water biota (e.g. salmonid fish communities) and warm water biota (e.g. centrarchid fish communities):

Dissolved Oxygen Concentration				
Temperature	Cold Water Biota		Warm Water Biota	
°C	% Saturation	mg/L	% Saturation	mg/L
0	54	8	47	7
5	54	7	47	6
10	54	6	47	5
15	54	6	47	5
20	57	5	47	4
25	63	5	48	4

In waters inhabited by sensitive biological communities, or in situations where additional physical or chemical stressors are operating, more stringent criteria may be required. For example, a sensitive species such as lake trout may require more specific water quality objectives.

In some hypolimnetic waters, dissolved oxygen is naturally lower than the concentrations specified in the above table. Such a condition should not be altered by adding oxygen-demanding materials causing a depletion of oxygen.

Turbidity:
Suspended matter should not be added to surface water in concentrations that will change the natural Secchi disc reading by more than **10 percent**.

***Cadmium**:*
The amount of Cadmium should not exceed **0.2µg/L**.

Hardness as CaCO3 (mg/L)	PWQO(µg/L)
0 - 100	0.1
>100	0.5

***Iron**:*
The amount of Iron should not exceed **300µg/L**.

Lead:
Lead amounts should not exceed the following:

Hardness as CaCO3 (mg/L)	Interim PWQO (µg/L)
< 30	1
30 to 80	3
> 80	5

Phosphorus:
Current scientific evidence is insufficient to develop a firm Objective at this time. Accordingly, the following phosphorus concentrations should be considered as general guidelines, which should be supplemented by site-specific studies:

To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20µg/L;

A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10µg/L or less. This should apply to all lakes naturally below this value.

Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30µg/L.

Appendix D: Techniques for Data Collection

Location
The sample sites were chosen from using a 1:20,000 scale topographic map, aerial photography and road maps of Welch Creek. The sample sites are also described in road access as well as hiking and driving distances.

Latitude, Longitude, and Elevation
The coordinates for each site were measured with a Trimble GeoXH GPS unit.

Channel width & depth
The width and depth were measured by a nylon measuring tape with a weighted end.

Flow
The velocity of the creek was measured by placing floating debris (usually a stick) in the stream and measured the amount of time it took to travel a specified distance. The flow was later calculated to metres per second.

Air Temperature
The air temperature was measured with a basic alcohol air thermometer.

Water Temperature
Water temperature was measured with the YSI 556 MPS. The readings were taken after the probe was submerged and all variables on the meter are stabilized.

Conductivity
Conductivity was measured with the YSI 556 MPS. The accuracy of the reading was ±0.001 mS/cm or ±1.0%; whichever is greater. The readings were recorded once the probe was completely submerged and all readings stabilized.

Total Dissolved Solids
The total dissolved solids (TDS) are measured from the conductivity reading.

Dissolved Oxygen
The YSI 556 MPS determined dissolved oxygen for the samples. The readings were recorded once the probe was submerged in the water and all variables were stabilized.

Tree, Shrub & Herb Species
Vegetative species are closely linked to the overall health of the ecosystem. The greater the diversity of the area, the better the health is of the ecosystem. Identification was made in the vicinity of the sample sites, approximately 10m for shrub and herb and 200m for tree species.

Aquatic Plants
Aquatic plants were determined through careful observation and identification via a field guide.

Benthic species / Terrestrial
Through the use of dip nets and observations, the benthic species was identified by observation and verified by the use of field guides.

In Creek Material
The bed material was described through observation and recorded for each site.

Bed Description
The bed description was given though a set of categories or varying grain sizes.

Boulder	> 25.6 cm in diameter
Cobbles	6.4 - 25.6 cm in diameter
Gravel	0.2 – 6.4 cm in diameter
Sand	< 0.2 cm in diameter
Silt	Finer inorganic material than sand
Muck	Mainly organic combination of silt and clay
Clay	Inorganic origin with no apparent structure

Bank Stability / Erosion
Evidence of erosion or the potential of erosion was observed, categorized as either stable or unstable. A bank is stable if there is little to no erosion present, well vegetated or has a low slope. Unstable is defined as having visible signs of erosion, little to no vegetation on the bank or a steep slope.

Stream Cover / Forest Density
A measure of the forest and vegetation found within the sampling site stream bank and is no more than 5 m from the water's edge.

Dense	75-100% shaded by canopy
Partly Open	25-74% shaded by canopy
Open	0-25% shaded by canopy

Forest and Surficial Geology Characteristics

The surficial geology that comprise the watershed are as follows:
- Bedrock Knob (RN) – Irregular bedrock surface, muck, boulders, sand-rich
- Bedrock Plain (RP) – Rolling bedrock surface, boulders and sand
- Outwash Plain (GO) – Mostly sand and gravel, pitted/kettled surface, good drainage
- Glaciolacustrine Plain (LP) – Fine grained material, impervious excellent drainage
- Organic Terrain (OT) – Muck and peat marshes, swamps, ferns and bogs, poor drainage

The vegetation present at each sampling site is categorized by the following characteristics:
- Conifer Mixed wood – mainly conifer with some hardwood species
- Mainly Hardwood – majority of tree species are hardwood (poplar, birch, etc)
- Swamp Conifer – tree species mainly cedar or tamarack
- Meadow – open field/pasture land

Appendix E: Test Parameters

Water Temperature
Water temperature does not change as readily as air temperature, but takes into account the temperature of the source water, solar radiation, depth, flow and amount of shading by vegetation. Water temperature is important for a variety of reasons. When fish species adapt to the current temperature, a fluxuation of this temperature can add stresses to the inhabiting fish. The temperature has an important role in influencing chemical, biological and physical processes. Change in temperature influences the waters ability to hold dissolved gasses, the warmer the water, the less gas it can hold. Warmer water is a better host to bacteria and adds to the natural diversity of the habitat.

pH
pH measures the acidity or the alkalinity of the water on a logarithmic scale of 0 to 14. The pH of water must be between 6.5 and 8.5 in order to meet PWQO guidelines. Drinking water should be slightly basic to neutral. A healthy balance of pH is required for aquatic species to thrive; being on either end of the pH scale is harmful to the plants, organisms, aquatic and terrestrial life.

Dissolved Oxygen
Aquatic species require oxygen for respiration that aquatic plants and the atmosphere replenish. If there is an imbalance of dissolved oxygen in the water, this can be harmful to the ecosystem's diversity and the species that exist. Deficient levels of oxygen will decrease fish population, where as supersaturation can lead to gas bubble disease. PWQO has a range of dissolved oxygen in water dependant upon temperature; at 20° C the minimum amount of dissolved oxygen is 5 mg/L.

Conductivity
Conductivity is a measure of the water's resistance to electrical conductance in water, measured in micro seimens per centimetre. This reading is used to determine the total dissolved solids in the sample. TDS may originate from natural sources including: mineral springs, salt deposits, carbon deposits, and also originates from anthropogenic uses such as: sewage or urban run-off. High levels of total dissolved solids are not necessarily a risk to water quality, however it may affect the aesthetic quality of the water. Low TDS may indicate corrosive waters, which may involve the leaking of metals such as: lead and copper. If these metals have elevated levels, it may pose as a health hazard.

Specific Conductivity
Specific conductivity is similar to conductivity, however the water temperature is taken into account and the reading is corrected. By adjusting the temperature comparisons can be made with different samples.

Total Dissolved Solids
The level of the total dissolved solids in water is an indicator of disturbances upstream such as erosion or pollution. The amount of dissolved solids is expected to be higher at the confluence

of the watercourse as all of the dissolved solids have accumulated to this point. PWQO requires that the total dissolved solids be less than 500 mg/L, with the Ontario range of water bodies being between 150 mg/L to 500mg/L.

Total Suspended Solids
Total suspended solids are particles larger than what is measured in dissolved solids, however they are indefinitely suspended in the water. High levels of suspended solids may initiate siltation of the riverbed, smothering of aquatic life, increased turbidity, and absorption of heavy metals, nutrients and organic compounds.

Turbidity
Turbidity is classified as the cloudy condition that reduces transparency caused by suspended solids in the water. Any suspended solids such as silt, clay, debris and microscopic organisms will affect the turbidity. Turbidity is related to the diversity in the water by determining the amount of sunlight reaching under the surface to plant and fish species. Drinking water standards for water treatment plants are below 1 Nephelometric Turbidity Units (NTU), where PWQO requires the turbidity must not change more than 10% of base levels.

Total Phosphorous
Phosphorus is important for living organisms, although it contributes to an increased tropic level of water bodies. It is also important for the decomposition of dead organisms, and it is then converted to its initial state of oxidation in the phosphorus cycle. Low phosphorus in water can limit plant growth, where as too much can create eutrophication or algal blooms. Phosphates can enter into the environment via minerals in the ground, but majority of it will come from human sources like fertilizers, pesticides and detergents. PWQO guidelines have a level of 20 μg/L in lakes and 30 μg/L in rivers and streams.

Cadmium
Cadmium is an extremely toxic metal even in low concentrations that can enter into the environment from mining, fertilizers and rechargeable batteries. Cadmium poisoning can lead to itai-itai disease, which initiates bone softening, joint pain and kidney failure. The maximum concentration of cadmium under PWQO guidelines is 0.2 μg/L.

Iron
Iron can occur in streams naturally if there are rich iron rocks present in the watercourse. Iron in rocks can be identified by a red colour or tint, and iron in water can be identified by a metallic taste. The PWQO guideline stipulates that the levels of iron in the water must be below 300 μg/L.

Lead
Lead is a very toxic metal to all forms of life, causing neurological damage and even death. Although natural occurrences can occur from precipitation and the weathering of ores; the majority of lead in watercourses comes from anthropogenic sources. The PWQO requirement for lead varies with different alkalinity as $CaCO_3$ (mg/L); the maximum lead concentration is 25 μg/L.

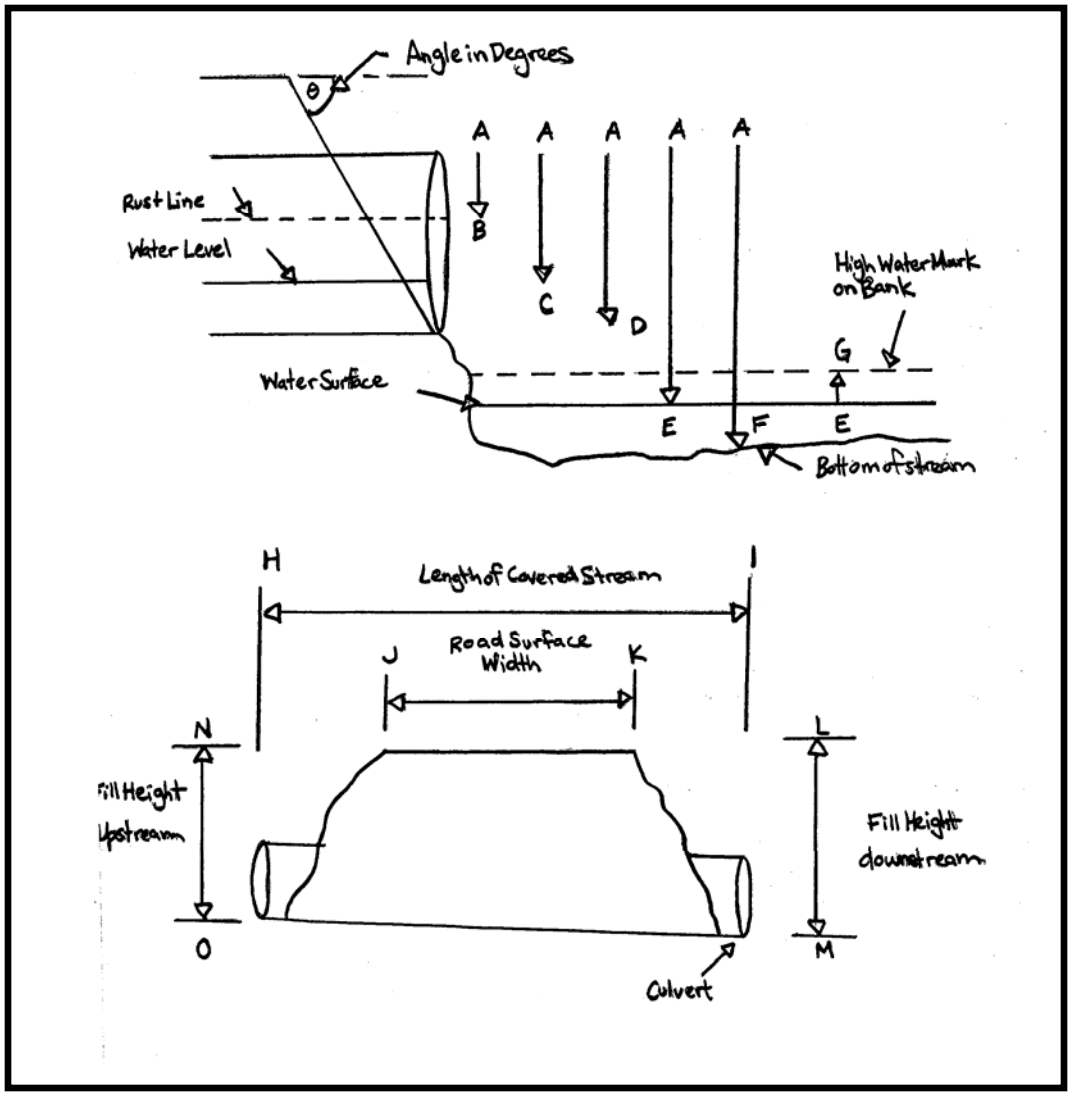


Diagram of Culvert Measurements

Table F.1: Culvert Measurements Overview Chart

Culvert Number	J – K Road Surface Width (m)	H – I Length of Covered Stream (m)	N – O Fill Height Upstream (m)	L – M Fill Height Downstream (m)	A – D Width of Opening (cm)	A – B Inside Top to High Water (cm)	A – C Inside Top to Water Surface (cm)	A – E Height above Outlet Pool (cm)	E – G Outlet Pool Water Surface to Outlet Pool High Water Mark (cm)	A – F Inside Top to Bottom of Stream (cm)	Fill Slope Angle (°)
1a	8.90	38.355	8.9	12.61	215	113	161	161	0.21	227	Upstream: 30 Downstream: 30
1b	8.90	38.355	8.9	12.61	215	100	173	190	22	256	Upstream: 30 Downstream: 30
2	6.5	9.83	7.12	7.43	75	68	n/a	n/a	n/a	135	Upstream: 40 Downstream: 40
3	15.501	53.290	7.112	6.844	235	168	141	141	110	275	Upstream: 32 Downstream: 48
4	14.1	54.2	11.65	13.45	235	148	185	148	51	218	Upstream: 48 Downstream: 62
5	13.4	30.6	3.81	4.35	118	118	n/a	n/a	n/a	112	Upstream: 40 Downstream: 60

Culvert 1a, 1b

Location: East of Highway 11/17 and 800 metres along a CN Access Road to get to the rail lines, then 300m Northeast of the line at the marked CN 159 sign.

UTM Coordinates: 5393149.729m N; 380722.649m E; 218.990m MSL

Description: This concrete culvert system was comprised of two culverts, however during the first observation only one was transporting water. Both culverts 1a and 1b covered 38.355 metres of stream and had an opening width of 215 centimetres. During the second observation we noticed water running through both culverts. This may be due to added precipitation in late July. An abundance of vegetation surrounded the opening of both culverts, signifying that the plant life depended on the flowing water. The two culverts were flowing steadily; however a few twigs and logs inside the culverts may contribute to minor flow impediment.

Inflow

Outflow

Culvert 2

Location: An additional 1.1km northeast past culvert 1, past the marked CN 158 sign

UTM Coordinates: 5394608.828m N; 382259.531m E; 222.054m MSL

Description: This culvert was dry at the time of sampling however showed signs of previously transporting water. This culvert covered 9.83 metres of the stream and the width of the opening was 75 centimetres. At some point this culvert does pass flow as indicated by the evidence of the rust line, which is seen in the outflow picture. This culvert was difficult to find because it had many trees, shrubs, logs and rocks surrounding it. The culvert was perched at the time of inspection.

Inflow

Outflow

Culvert 3

Location: East off of Highway 11/17

UTM Coordinates: 5394650.928m N; 379933.357m E; 222.807m MSL

Description: This was a solid culvert system that allows traffic on Highway 11/17 to cross over Welch Creek. The culvert covered 53.29 metres of stream and an opening of 235 centimetres. An abundance of grasses and swampy ground made up this portion of Welch Creek. Both upstream and downstream of the culvert were beaver dams, causing a low stream quantity and flow velocity. The depth of the creek downstream from the culvert had widened and deepened during the summer of 2006 due to beaver activity on the creek.

Inflow

Outflow

Culvert 4

Location: A 1.5 km hike along the Canadian Pacific Railway lines from Bowker Station entrance, west of Highway 11/17.

UTM Coordinates: 5395099.74 M N; 379619.79 m E; 228.92 MSL

Description: A tributary of Welch Creek flows underneath the railway line west of highway 11/17 through culvert 4. This culvert covered 54.2 metres of stream and its opening width was 235 centimetres. Large boulders and rocks made up the creek bed, and appear to have been deliberately placed along the inflow and outflow banks. The banks were protected with rip rap. The slopes surrounding the Creek are protected with mesh to prevent any further erosion from occurring, and allow vegetation to continue to grow and secure the soil. The inflow side of the creek was narrow and flowed into a large stagnant pool on the outflow.

Inflow

Outflow

Culvert 5

Location: A 500 m hike past culvert 4 along the Canadian Pacific railway lines.

UTM Coordinates: 5394698.52 m N, 379488.93 m E, 230.13 MSL

Description: This culvert system is used for a tributary of Welch Creek, and at the time of observation was dry. It covered 30.6 metres of stream and had width of 118 centimetres at the opening. The rust line was not measurable, indicating that this culvert has not experienced a significant amount of flow.

Inflow

Outflow