

Investigation of the Aquatic Communities of the Salmon Trout River, Yellow Dog River, and Cedar Creek in Marquette County, Michigan, 2015.

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List of Abbreviations, Acronyms, and Symbols

AEM	Advanced Ecological Management LLC
\bar{x}	Average
CC	Cedar Creek
CAS No.	Chemical abstract service number
°C	Degrees Celsius
EQL	Estimated quantification limit
ft	Feet
e.g.	For example
gpm	Gallons per minute
GLEAS	Great Lakes and Environmental Assessment Section
KME	King & MacGregor Environmental
pH	Measure of acidity or alkalinity of a solution
MDEQ	Michigan Department of Environmental Quality
MNFI	Michigan Natural Features Inventory
$\mu\text{S/cm}$	MicroSiemens per centimeter
$\text{mg O}_2/\text{L}$	Milligrams of oxygen per liter of water
mg/kg	Milligrams per kilogram
ml	Milliliters
MDL	Minimum detection limit
N	North
n.a.	Not applicable
n.m.	Not measured
n.s.	Not sampled
P-51	Procedure Number 51
R	Range
n	Sample size
Sec	Section
s	Standard deviation
STRE	Salmon Trout River East Branch
STRM	Salmon Trout River Main Branch
T	Township
W	West
WCR	Wetland and Coastal Resources
YDR	Yellow Dog River

1.0 EXECUTIVE SUMMARY

The Eagle Project is located in northern Marquette County, Michigan as shown on Figure 1-1. Aquatic surveys have been conducted in the project vicinity since 2005 (WCR, 2005). These aquatic surveys have remained similar in scope, but sample station location has varied for some stations that have been affected by high water from beaver dams.

More recently, sample station locations have remained consistent since 2011 (Figure 1-2). Aquatic surveys were conducted in ten stations, including five stations within the Salmon Trout River, three stations within tributaries of the East Branch of the Salmon Trout River, one station in the Yellow Dog River, and one station in Cedar Creek.

Aquatic surveys at each station included an evaluation of fish, macroinvertebrate, and habitat community ratings according to the metrics outlined in the Great Lakes and Environmental Assessment Section (GLEAS) Procedure Number 51 (P-51), a survey protocol for wadable streams and rivers.

The aquatic systems that were investigated for these surveys are predominantly functioning as coldwater trout streams. Because most of the fish communities of the Salmon Trout River, its tributaries, and the Yellow Dog River were comprised of trout greater than 1% of the fish community composition, the P-51 fish community scores were determined from the macroinvertebrate community ratings for those streams. The macroinvertebrate communities within the Salmon Trout River have been scored by AEM as excellent or acceptable communities. Consistent with previous surveys conducted by AEM, the total number of macroinvertebrates collected from each station has varied annually. However, in most stations, the macroinvertebrate community rating was consistent with previous sampling efforts conducted by AEM, Wetland and Coastal Resources (WCR), and the Michigan Department of Environmental Quality (MDEQ; AEM, 2014; AEM, 2013; AEM, 2012a and b; AEM, 2009; AEM, 2008a; AEM, 2007; WCR, 2005; MDEQ/Premo et al., 2005, 2006).

The aquatic habitat was rated as excellent or good by AEM. The 2015 aquatic habitat scores were consistent with 2014 evaluations that were conducted by AEM (AEM, 2014). A summary of P-51 macroinvertebrate and aquatic habitat scores appears on Table 1-1.

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2.0 INTRODUCTION

In December 2007, Eagle Mine was granted a set of permits from the Michigan Department of Environmental Quality (MDEQ) to mine ore from an ore body located on the Yellow Dog Plains near the Main Branch of the Salmon Trout River (Figure 1-2). As part of a pre-mining environmental baseline, aquatic community investigations were conducted within the Salmon Trout River and its tributaries, the Yellow Dog River, and Cedar Creek (KME, 2005; WCR, 2005; MDEQ/Premo et al., 2005, 2006; AEM, 2007; AEM 2008a and b; AEM, 2009). This 2015 aquatic community survey represents the fifth annual aquatic survey that has been conducted by AEM on behalf of Eagle Mine since operations commenced in 2011. This 2015 aquatic survey is intended to satisfy mine permit requirements (Permit Condition L-40).

3.0 STUDY AREA

The principle area investigated for this study included portions of the Salmon Trout River and its tributaries, the Yellow Dog River, and Cedar Creek (Figure 1-2). These systems are all coldwater streams that flow through relatively undeveloped watersheds that are predominantly forested. The ore body and mine site are located near the headwaters of the Salmon Trout River Main Branch, which flows in a northeastern direction (Figure 1-2). The Salmon Trout River is characterized by a variety of habitat types in the vicinity of the stream segments investigated and includes slow-flowing segments with a silt substrate that have been heavily influenced by beaver activity (e.g., Stations 6 and 7), and high-gradient segments flowing through forested and hilly terrain with beaver dams intermittent throughout the watershed (e.g., Stations 1 and 8).

The Yellow Dog River flows to the west along the southern boundary of the Yellow Dog Plains (Figure 1-2). Cedar Creek flows to the north and is not located within the same watershed as the Eagle mining project. Cedar Creek serves as a reference stream for the Eagle Project.

4.0 METHODS

The 2015 aquatic survey was conducted according to the MDEQ's Surface Water Quality Division *Procedure #51 Survey Protocols for Wadable Rivers* (P-51; MDEQ, 2008). Ten stream segments (stations) were sampled in the summer of 2015 using the P-51 survey protocol (Figure 1-2).

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These sample stations are situated in the same sample locations, or close to the sample locations that were surveyed by AEM from 2011 through 2014 and in 2008. The 2015 aquatic survey follows protocol established in the Wetland and Coastal Resources survey of 2004, (WCR, 2005) in that fish collection data are summarized and P-51 scores are provided for macroinvertebrates and habitat quality.

4.1 Fish Collection

Survey stations were blocked at the upstream and downstream extents using seines that measured 4 feet by 50 feet, with a 0.19-inch mesh size. When adequate habitat conditions permitted, a multi-pass removal technique was used to evaluate fish abundance throughout each station (Van Deventer and Platts, 1983). A backpack electroshocker was used in narrow (approximately ≤ 10 feet), or difficult-to-access stations (e.g., areas with abundant woody debris). A barge-mounted electroshocker was used to sample stations that were deep (approximately 2 to 3 feet), wide (approximately > 10 feet), and where woody debris was sparse enough to permit the passage of the barge unit. Three consecutive passes were conducted, each in an upstream direction. The duration of electroshocking was recorded for each pass and stunned fish were placed in a live-well for identification and enumeration. Following the third pass and subsequent fish identification, fish were released within the station.

As part of the enumeration process, the number of each species present was recorded. One representative of each species that was not identifiable in the field was placed in a voucher jar containing 10% formalin for later identification. Each voucher jar was labeled according to the sample location and date. Fish were identified to species using various taxonomic references (Bailey et al., 2003; Coon, 2001; Becker, 1983). The Michigan County Element List (MNFI, 2015) was also reviewed to determine if any threatened, endangered, or special concern aquatic species occurred within the Salmon Trout River and its tributaries, the Yellow Dog River, or Cedar Creek.

4.2 Macroinvertebrates

Sampling of aquatic macroinvertebrates, including mussels and crayfish (Decapoda), was conducted according to the P-51 protocol. Upon completion of fish sampling, macroinvertebrates were collected within each station using D-framed kick-nets (Merritt et al., 1996). Stations were sampled for 45 minutes using two kick-nets (total sample time = 1.5 hours) and samples were collected in all habitat types within each station to

characterize the macroinvertebrate community. Collected specimens were stored in 250 ml plastic wide-mouth jars containing 70% ethanol, and were identified using various taxonomic references (Merritt et al., 2008; Bright, 2015; McCafferty, 1998; Cummings and Mayer, 1992; Peckarsky et al., 1990; Pennak, 1990).

The macroinvertebrate data were analyzed according to nine metrics identified in the P-51 methodology. The sum of the macroinvertebrate scores can range from –9 to +9; and are graded as excellent, acceptable, or poor according to the summation of the metric scores.

4.3 Stream Habitat Evaluation

Riparian and in-stream habitats were qualitatively described for each station during the aquatic survey. A description of stream morphology included run/riffle/pool/shallow pool configurations, substrate, substrate embeddedness, in-stream cover, vegetation, flow stability, and bank stability. Stream habitat was rated as excellent, good, marginal, or poor based on P-51 scores interpreted from 10 habitat metrics. Habitat was rated according to the following P-51 habitat scores (MDEQ, 2008):

Habitat characterization	Total Point Score
1. Excellent	> 154
2. Good	105 – 154
3. Marginal	56 – 104
4. Poor	< 56

Habitat conditions, water quality, and stream dimensions were documented during the aquatic survey. Photographs were taken at each station to illustrate the conditions during the sampling period (Exhibit C). Water temperature, dissolved oxygen, pH, and conductivity were measured as part of the stream habitat evaluation. These water quality parameters were measured using a Yellow Springs Instrument Professional Plus water quality meter.

Wetted stream width was measured at the lower, middle, and upper extent of each sample station. Depth was measured in the center, and at 20% and 80% of each stream width cross section. Stream flow was measured with a Marsh-McBirney Flo-Mate 2000®.

5.0 RESULTS

A total of ten stations were surveyed during June 2015, including one station in the Yellow Dog River, one station in Cedar Creek, five stations in the Main Branch of the Salmon Trout River, and three stations in tributaries of the East Branch of the Salmon Trout River (Table 5-1 and Figure 1-2). Aquatic community sampling was conducted for all stations from 5 June 2015 through 11 June 2015. Station 5 in the Yellow Dog River and Station 6 in the Salmon Trout River were sampled on 5 June 2015, Stations 2, 3, and 7 in the Salmon Trout River were sampled on 9 June 2015, Stations 8, 9 and 10 in the Salmon Trout River were sampled on 10 June 2015, and Station 1 in the Salmon Trout River was sampled on 11 June 2015. Station 4 in Cedar Creek was surveyed on 11 June 2015.

5.1 Fish

A total of 575 fish were collected from all stations with 86% of the total being captured in Station 6 (Table 5-2). Among all stations, a total of seven species of fish were observed during the aquatic survey (Table 5-2). Northern redbelly dace (*Phoxinus eos*), brook sticklebacks (*Culaea inconstans*), and brook trout (*Salvelinus fontinalis*) were the most frequently collected species among all stations.

No Michigan Natural Features Inventory (MNFI) listed threatened or endangered fish species were identified in the stations investigated in the Salmon Trout River and its tributaries, Yellow Dog River, or Cedar Creek in Marquette County, Michigan (MNFI, 2015).

5.1.1 Salmon Trout River Tributaries: Stations 1, 2, 3, 6, 7, 8, 9 and 10

Brook sticklebacks, northern redbelly dace, and brook trout were the most frequently observed species among all eight stations within the Salmon Trout River system (Table 5-2). Brook trout were the only species collected in Stations 1, 3, 8, and 9 during June 2015.

A total of 15 brook trout were collected from Station 1 during 2015 (Table 5-2). More brook trout were collected during 2015 compared to 2014 where a total of six brook trout were collected.

A total of 15 fish, including six brook trout and nine northern redbelly dace were collected from Stations 2 and 3. Three more brook trout were collected in 2015 compared to 2014

and 10 fewer northern redbelly dace were collected in 2015. Fish community composition has remained consistent with previous surveys.

A total of 492 fish were collected from Station 6 in 2015. Brook sticklebacks and northern redbelly dace were the most abundant species, and four brook trout were also collected (Table 5-2). More fish were collected in Station 6 during 2014, where a total of 1,266 fish were collected, with northern redbelly dace recorded as the most abundant species. No brook trout were collected in Station 6 during 2014. Consistent with previous surveys, Station 6 fish size has been characterized by small fish that typically have been three inches or less in length.

An abundance of woody debris in Station 7 continued to make it difficult to adequately block the station extents with nets to facilitate a multi-pass removal. Therefore, only a single-pass removal was conducted within this station. The 2015 fish community of Station 7 remained consistent with previous surveys, and was comprised of 11 northern redbelly dace and one brook stickleback (Table 5-2). The 2014 Station 7 fish community was comprised of six northern redbelly dace and a two brook sticklebacks.

Five brook trout were collected from Station 8 during 2015 (Table 5-2), which is the same amount and species that were collected in 2014. Only four brook trout were collected in Station 9 in 2015 (Table 5-2), which is four fewer than were collected in 2014 and 18 fewer than were collected in 2013.

The total number of fish collected from Station 10 in 2015 was three brook trout and one northern redbelly dace (Table 5-2). A total of five brook trout were collected in 2014. Fish community composition and relative abundance has remained consistent in Station 10.

5.1.2 Yellow Dog River: Station 5

Station 5 is located in the Yellow Dog River and a total of 18 fish comprised of five species were collected during June 2015 (Table 5-2). Blacknose dace (*Rhinichthys atratulus*), and brook trout were the most frequently collected species. A total of 19 fish, were collected during June 2014, which included 10 brook trout, six blacknose dace, and three mottled sculpin (*Cottus bairdii*).

5.1.3 Cedar Creek: Station 4

Station 4 is located in Cedar Creek outside of the project area drainage basin. The 2015 survey was conducted in the same location (immediately downstream of the road crossing) as the 2011-2014 surveys to maintain consistency with recent surveys. In addition, because of a channel braiding that occurred throughout much of the station, adequate blocking with nets was not possible. Therefore, a single pass removal was conducted in Station 4.

The total number of brook trout collected from Station 4 has varied annually since 2011. A total of eight brook trout were collected in 2015 (Table 5-2), compared to 25 that were collected in 2014, 19 that were collected in 2013, 10 that were collected in 2012, and 44 that were collected in 2011.

5.2 Macroinvertebrates

A total of 2,287 macroinvertebrates were collected from all ten stations that were investigated in 2015, which was 313 more specimens than the total number collected in 2014 (total number collected = 1,974). Because of beaver dams in the vicinity of Station 6 and Station 7, the P-51 macroinvertebrate metrics evaluation protocol was not applied in these locations.

5.2.1 Salmon Trout River: Stations 1, 2, 3, 6, 7, 8, 9 and 10

A total of 1,641 macroinvertebrates representing 48 taxa identified to the Family level were observed collectively from Stations 1, 2, 3, 6, 7, 8, 9 and 10 in the Salmon Trout River and its tributaries during 2015. The greatest numbers of Salmon Trout River macroinvertebrates were collected from Station 6 and the fewest number of macroinvertebrates were collected from Station 7 (Table 5-3).

A total of 251 macroinvertebrates were collected in Station 1 in 2015 compared to 2014 where a total of 303 macroinvertebrates were collected. Ephemeropterans (mayflies), trichopterans (caddisflies), and Odonates (dragonflies and damselflies) were the most frequently collected macroinvertebrates in Station 1 (Table 5-3).

A total of 159 macroinvertebrate were collected from Station 2, with caddisflies, Dipterans (true flies), and mayflies represented as the most frequently collected macroinvertebrates during 2015 (Table 5-3). A total of 276 macroinvertebrates were collected from Station 2

in 2014, with flies, mayflies and caddiflies being the most frequently collected macroinvertebrates.

A total of 204 macroinvertebrate were collected from Station 3, with true flies, caddisflies, and mayflies represented as the most frequently collected macroinvertebrates during 2015 (Table 5-3). A total of 222 macroinvertebrates were collected from Station 3 in 2014 and community composition was consistent with the 2015 survey data.

A total of 348 macroinvertebrates were collected from Station 6, where amphipods (scuds), Hemipterans (true bugs), caddisflies and Odonates were the most frequently collected macroinvertebrates in 2015 (Table 5-3). A total of 260 macroinvertebrates were collected from Station 6 in 2014, where amphipods (scuds), caddisflies, and Odonates (dragonflies and damselflies) were the most frequently collected macroinvertebrates. Macroinvertebrate community composition of Station 6 has remained constant among years.

The total number of macroinvertebrates collected from Station 7 has been consistently low compared to other Stations located within the Salmon Trout River. A total of 109 macroinvertebrates were collected from Station 7 in 2015, compared to a total of 84 macroinvertebrates in 2014, and 158 macroinvertebrates in 2013. The 2015 macroinvertebrate community of Station 7 was predominantly comprised of scuds, Mollusks (snails and clams), and Odonates (Table 5-3), and the community composition of Station 7 has remained consistent among years.

A total of 239 macroinvertebrates were collected from Station 8 in 2015, where mayflies and caddisflies were the most frequently collected macroinvertebrates (Table 5-3). A total of 225 macroinvertebrates were collected from Station 8 in 2014 and community composition has remained consistent among years.

A total of 183 macroinvertebrates were collected from Station 9 in 2015, where caddisflies, mayflies and true flies were the most abundant macroinvertebrates (Table 5-3). A total of 124 macroinvertebrates were collected from Station 9 in 2014 and community composition has remained consistent among years.

A total of 148 macroinvertebrates were collected from Station 10 in 2015, where caddisflies and mayflies were the most abundant macroinvertebrates (Table 5-3). A total of 136 macroinvertebrates were collected from Station 10 in 2014 and community composition has remained consistent among years.

Where possible, macroinvertebrate collection data have been evaluated in accordance with the metrics outlined in P-51. Since Stations 6 and 7 are influenced by beaver dams, which affects the flow regime of these stations, macroinvertebrate data are collected, but community ratings are not considered for these stations as part of this aquatic survey. Table 5-4 summarizes the values and scores for the nine metrics for each station. P-51 station ratings for the Salmon Trout River have typically ranged from Acceptable to Excellent among years sampled by AEM. Stations 1, 2, 8, 9, and 10 were rated as "Excellent", and Station 3 was rated as "Acceptable" in 2015.

5.2.2 Yellow Dog River: Station 5

A total of 125 macroinvertebrates representing 21 taxa identified to the Family level were collected in Station 5 from the Yellow Dog River (Table 5-3). Odonates, caddisflies and true flies were the most frequently collected macroinvertebrates in 2015. A total of 83 macroinvertebrates representing 17 taxa identified to the Family level were collected in Station 5 in 2014. Macroinvertebrate community composition has remained consistent among years. The macroinvertebrate community of Station 5 was rated as "Acceptable" in 2015 (Table 5-4).

5.2.3 Cedar Creek: Station 4

A total of 521 macroinvertebrates representing 20 taxa identified to the Family level were collected from Cedar Creek in Station 4 during 2015 (Table 5-3), where true flies, caddisflies, and mayflies were the most frequently collected macroinvertebrates. A total of 261 macroinvertebrates representing 27 taxa identified to the Family level were collected from Cedar Creek in Station 4 during 2014. The community composition has remained consistent among years, except in 2015 where black flies (Simuliidae) were the most abundant macroinvertebrate. The macroinvertebrate community of Station 4 was rated as "Acceptable" in 2015 (Table 5-4).

5.3 Stream Habitat

Stream habitat has remained consistent since 2011 when beaver activity affected several stations and required the relocation of two stations to conduct the survey. The habitat conditions for all stations surveyed are described below.

5.3.1 Salmon Trout River: Stations 1, 2, 3, 6, 7, 8, 9 and 10

Station 1 is located in a narrow valley with relatively steep slopes rising more than 100 feet to the Yellow Dog Plains. Station 1 was 120 feet in length with an average width of 7.4 feet ($s = 1.1$ feet, $n = 3$), and average depth of 0.5 feet ($s = 0.1$ feet, $n = 9$, Table 5-5). Stream flow was measured at the downstream extent of Station 1 and discharge was estimated at 1,494 gallons per minute (gpm, Table 5-5).

The streambanks of Station 1 appeared consistent with conditions observed in previous surveys, and were vegetated with herbaceous and woody vegetation (Photographs C-1 and C-2). The streambed was characterized by a relatively steep gradient and the substrate was comprised of a variety of particles including sand, gravel, cobble, and boulders (Photographs C-1 and C-2). Woody debris was frequently observed throughout the station and appeared consistent with conditions observed in 2013 and 2014.

Station 2 is located south of Triple A Road and Station 3 is located north of Triple A Road (Figure 1-2 and Table 5-1). Station 2 was 100 feet in length and Station 3 was 200 feet in length. Average width of Station 2 was 5.8 feet ($n = 3$; $s = 1.1$ feet), and average width of Station 3 was 6.3 feet ($n = 3$; $s = 0.6$ feet, Table 5-5). Average depth in Station 2 was 1.1 feet ($n = 9$; $s = 0.5$ feet), and average depth in Station 3 was 0.4 feet ($n = 9$; $s = 0.2$ feet). Stream flow for Stations 2 and 3 was measured at the downstream extent of Station 3, and discharge was estimated at 893 gpm in 2015 (Table 5-5).

Station 2 was surrounded by an abundance of speckled alder (*Alnus rugosa*) and bluejoint grass (*Calamagrostis canadensis*, Photographs C-3 to C-4). Habitat conditions of Station 2 were consistent with 2014 observations. Evidence of beaver activity was present with the upstream extent of Station 2 and two partially constructed dams were present within the stream channel. Silt and organic matter appeared to be more abundant within the upstream extent of Station 2.

The streambank vegetation within Station 3 appeared similar to conditions observed in 2014. The vegetation within Station 3 was predominantly speckled alder with an understory of bluejoint grass and sedge (*Carex* sp., Photographs C-5 to C-6). Watercress (*Nasturtium* sp.) was present within portions of the stream channel of Station 3.

Station 6 is located in the vicinity of the ore body (Figure 1-2). Station 6 is 300 feet in length and was influenced by beaver dams that were located downstream and upstream of the station. The average width of Station 6 was 17.6 feet ($n = 3$; $s = 6.1$ feet) and the average depth was 2.1 feet ($n = 9$; $s = 0.5$ feet, Table 5-5).. Stream flow was measured at the middle extent of Station 6 and discharge was estimated at 784 gpm (Table 5-5), which was 706 gpm higher than the 2014 discharge measurement (78 gpm).

The streambanks in Station 6 appeared similar to conditions observed in 2014, and were characterized by tussock sedge (*Carex stricta*), iris (*Iris* sp.), rush (*Juncus* sp.), willows (*Salix* sp.) and speckled alder (Photographs C-7 to C-8). Much of the aquatic vegetation seen during the summer sampling event was growing on organic matter that appeared to function as a floating mat of vegetation. The substrate of Station 6 was predominantly comprised of organic matter and fine sediments, such as silt and clay. Woody debris was present throughout the stream channel.

Station 7 is located near the headwaters of the Salmon Trout River and is influenced by beaver dams throughout the vicinity. Station 7 is 100 feet in length and a beaver dam is located at the upstream extent of this station. The average width of Station 7 was 5.1 feet ($n = 3$; $s = 0.7$ feet) and the average depth was 1.4 feet ($n = 9$; $s = 0.2$ feet, Table 5-5). Stream flow was not measured in Station 7 because of channel braiding due to beaver activity.

The streambanks of Station 7 were vegetated with speckled alder, tussock sedge, rush, and iris (Photographs C-9 and C-10), and appeared similar to conditions observed in 2014. The substrate was comprised of organic matter and silt. Woody debris was abundant throughout this station.

Because of high water from a beaver dam that was constructed in 2008, Station 8 was relocated in 2011 from approximately 50 feet southwest of Northwestern Road to

approximately 75 feet northeast of Northwestern Road, and extending downstream (northeast) for 135 feet (Figure 1-2, Table 5-1). The average width of Station 8 was 9.3 feet ($n = 3$; $s = 0.9$ feet) and the average depth was 0.8 feet ($n = 9$; $s = 0.4$ feet, Table 5-5). Stream flow was measured at the middle extent of Station 8 and discharge was estimated at 1,807 gpm (Table 5-5).

The stream channel of Station 8 was largely shaded by a dense canopy of speckled alder with an abundance of sedge growing along the streambank (Photographs C-11 and C-12). Small woody debris and undercut banks were present throughout the station, and the stream substrate was predominantly comprised of sand and small gravel. Habitat conditions observed at the time of the 2015 survey appeared consistent with previous surveys.

Station 9 is located immediately southwest of Northwestern Road and is approximately 85 feet in length (Figure 1-2). The average width of Station 9 was 7.9 feet ($n = 3$; $s = 0.4$ feet) and average depth was 0.7 feet ($n = 9$; $s = 0.3$ feet, Table 5-5). Stream flow was measured at the downstream extent of Station 9 and discharge was estimated at 1,135 gpm (Table 5-5).

At the time of the 2015 survey, most of the small pools within Station 9 appeared to have filled in with sand since the 2013 aquatic survey, which may account for the reduction in number of brook trout that have been collected within the station over the past three years. Riparian habitat appeared consistent with the 2014 survey where the understory of Station 9 was predominately sedge, while speckled alder covered much of the stream channel and contributed to in-stream cover (Photographs C-13 to C-14). The substrate throughout the station was predominantly comprised of sand and silt.

Station 10 is located immediately southwest of Northwestern Road and is approximately 100 feet in length (Figure 1-2). Average width of Station 10 was 6.8 feet ($n = 3$; $s = 0.7$ feet) and average depth was 0.5 feet ($n = 9$; $s = 0.2$ feet, Table 5-5). Stream flow was measured at the downstream extent of Station 10 and discharge was estimated at 501 gpm (Table 5-5).

The streambanks within Station 10 were vegetated with large deciduous trees, speckled alder, and other herbaceous vegetation (Photographs C-15 and C-16), and appeared similar to conditions observed in 2014. Woody debris and undercut banks provided in-stream cover throughout this station. The substrate was predominantly comprised of sand, silt and some gravel; although cobble and large boulders were also present.

5.3.2 Yellow Dog River: Station 5

Station 5 is located immediately west of an unnamed road that crosses the Yellow Dog River in a north-south orientation and links to Triple A Road approximately 1.5 miles north of the river (Figure 1-2). The station is 300 feet in length, with an average width of 23.7 feet ($n = 3$; $s = 3.4$ feet) and average depth of 2.5 feet ($n = 9$; $s = 0.8$ feet, Table 5-5). The 2015 stream flow was measured at the downstream extent of Station 5 and discharge was estimated at 15,339 gpm (Table 5-5). The 2015 discharge was much higher than the estimated discharge at the time of the 2014 aquatic survey (9,337 gpm).

Streambanks appeared consistent with the 2014 survey and were vegetated with a dense covering of speckled alder, which contributed to in-stream cover and woody debris within the channel (Photographs C-17 to C-18). The substrate was predominantly comprised of sand and silt.

5.3.3 Cedar Creek: Station 4

The downstream extent of Station 4 was relocated from approximately 117 feet upstream (south) of Northwestern Road to approximately 300 feet downstream (north) of Northwestern Road in 2011 because of high water from beaver dams (Figure 1-2). Station 4 was 300 feet in length, with an average width of 22.3 feet ($n = 3$; $s = 2.5$ feet) and average depth of 1.0 feet ($n = 9$; $s = 0.5$ feet, Table 5-5). Stream flow was measured at the upstream extent of Station 4 and discharge was estimated at 4,992 gpm (Table 5-5).

The riparian vegetation throughout much of the relocated Station 4 was mature northern white cedars (*Thuja occidentalis*), and white pines (*Pinus strobus*). Speckled alder was also present along the stream channel in the upstream and downstream extents of the station (Photographs C-19 and C-20). The river channel was braided throughout the middle portion of the station, with frequent undercut banks, large woody debris and variety of substrate, including sand, gravel, cobble and boulders contributing to habitat complexity.

There was evidence of a recent high-water event in Station 4 at the time of the survey. Woody debris, presumably from a beaver dam failure/removal that was located upstream of Station 4 was lodged in the riparian vegetation and portions of the streambank received sediment deposition from the high-water event (Photograph C-19).

5.3.4 P-51 Habitat Scores

Stations sampled during 2015 were rated as “Good” or “Excellent” habitat quality (Table 5-6). Station 9 habitat changed from an “Excellent” rating in previous years to a “Good” rating in 2014 and 2015. The change in the habitat rating of Station 9 was due to sand moving into the station from upstream and filling the pools. The 2015 P-51 habitat ratings for all other stations were consistent with previous surveys conducted by AEM (AEM, 2014, 2013, 2012a and b; AEM, 2008a; AEM, 2007).

5.4 Water Quality

Water temperature ranged from 10.2°C in Station 9 to 18.4°C in Station 3 during 2015 (Table 5-7). Water temperature in Station 6 was 12.1°C in 2015 compared to 16.5°C in 2014. The lower water temperature may account for the fewer number of fish overall observed in Station 6 in 2015 and for the presence of brook trout in 2015, which were not observed in 2014, as they are known to prefer cold water (Becker, 1983).

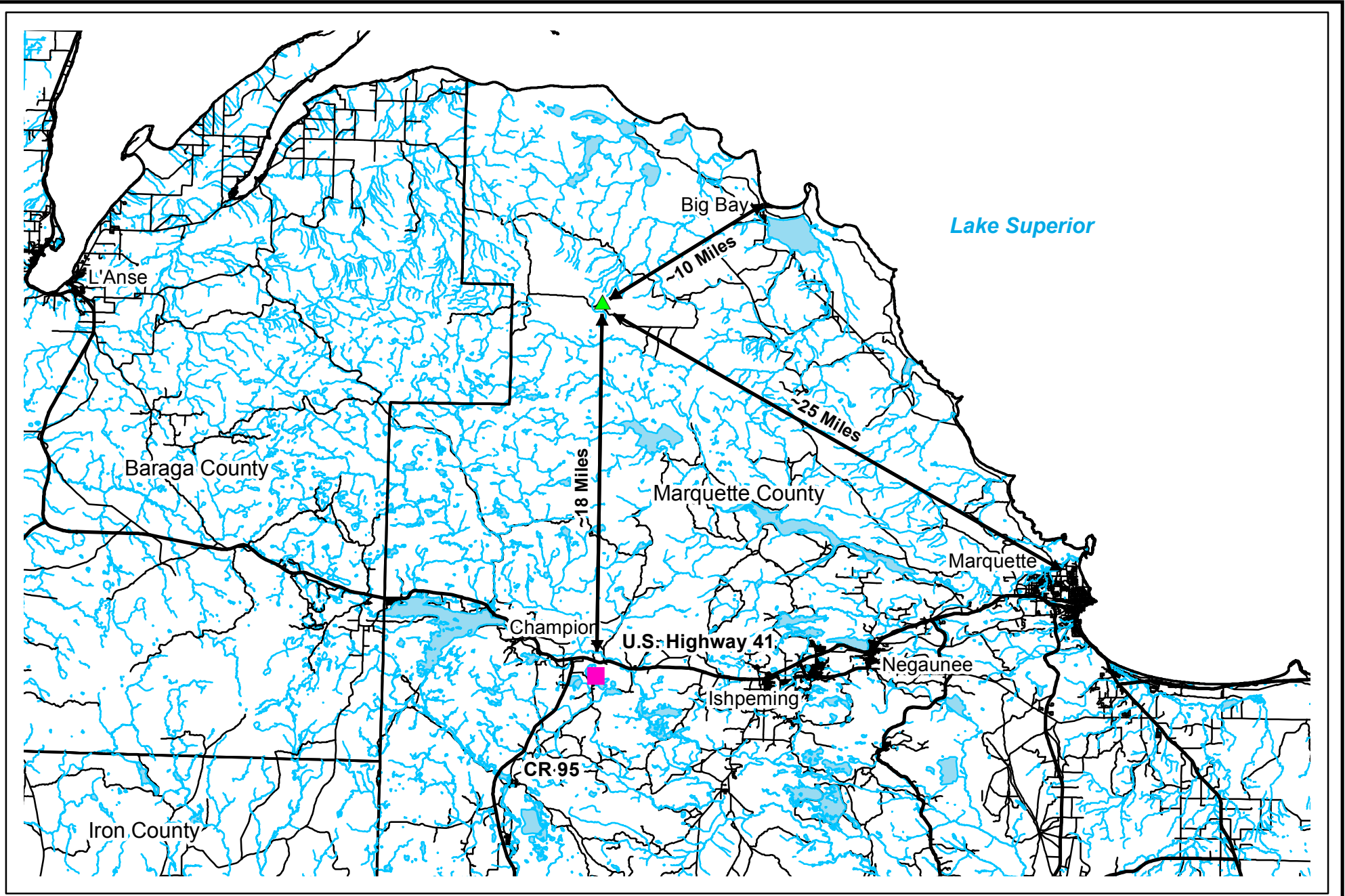
Dissolved oxygen was lowest in Station 7 at 4.7 mg/L and was highest in Stations 4 and 9 at 9.5 mg/L in. Average pH ranged from 6.2 in Station 7 to 7.6 in Station 9. Conductivity was low in all stations, ranging from 38 microSiemens per cm ($\mu\text{S}/\text{cm}$) in Station 5 to 107 $\mu\text{S}/\text{cm}$ in Station 4 (Table 5-7).

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EXHIBIT A
REPORT FIGURES

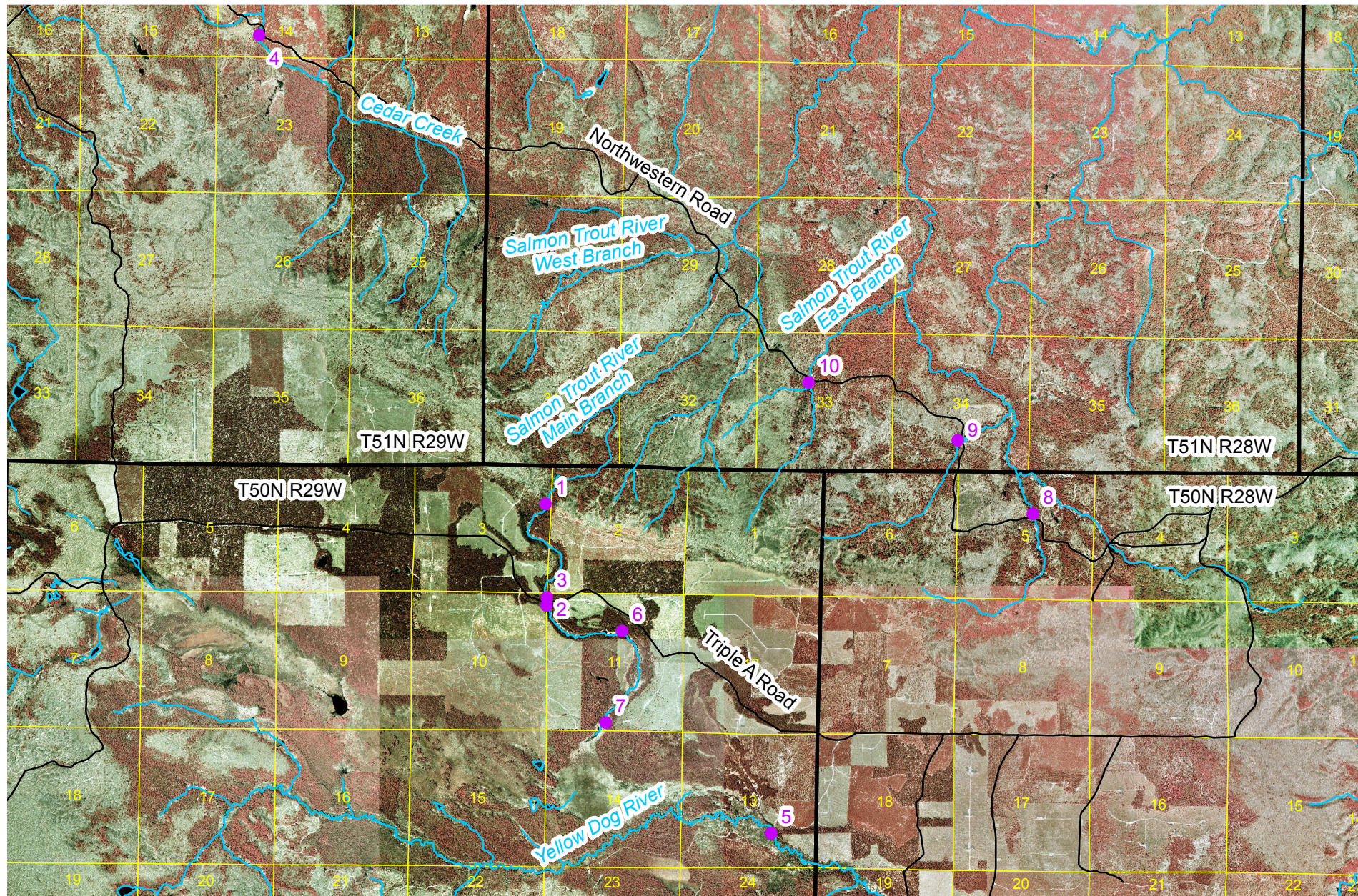


Legend

- ▲ Eagle Mine
- Humboldt Mill
- Lakes and Rivers
- Roads and Highways
- Counties

**ADVANCED
ECOLOGICAL
MANAGEMENT**

PROJECT	Eagle Mine
TITLE	Project Location
FIGURE	1-1



Legend

- Survey Stations
- Rivers
- Township/Range
- Sections



0 0.375 0.75 1.5 2.25 3 Miles

AeM

ADVANCED
ECOLOGICAL
MANAGEMENT

PROJECT	Eagle Mine
TITLE	Aquatic Sampling Locations
FIGURE	1-2

EXHIBIT B
REPORT TABLES

Table 1-1. Summary of the Procedure 51 Macroinvertebrate and Aquatic Habitat Scores for All Stations, 2015.

System Station Number	STRM 1	STRM 2	STRM 3	CC 4	YDR 5	STRM 6	STRM 7	STRE 8	STRE 9	STRE 10
Fish Score	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Macroinvertebrate Score	Excellent	Excellent	Acceptable	Acceptable	Acceptable	n.a.	n.a.	Excellent	Excellent	Excellent
Stream Habitat Score	Excellent	Good	Excellent	Excellent	Good	n.a.	n.a.	Excellent	Good	Excellent

STRM – Salmon Trout River Main Branch**STRE – Salmon Trout River East Branch****CC – Cedar Creek****YDR – Yellow Dog River****n.a. – Not applicable**

Table 5-1. Sample Station Location Description.

Station Number	Stream Name	Latitude/Longitude NAD 1983	Township/Range/ Section	Location Description
1	Salmon Trout River Main Branch	N 46.76130 W 87.90807	Michigamme Twp. T50N, R29W, Sec 3	Approximately 5,220 feet S of AAA Road and continuing S 120 feet.
2	Salmon Trout River Main Branch	N 46.75059 W 87.90720	Michigamme Twp. T50N, R29W, Sec. 11	Upstream extent located immediately S of AAA Road and continuing upstream 100 feet.
3	Salmon Trout River Main Branch	N 46.75148 W 87.90736	Michigamme Twp. T50N, R29W, Sec. 11	Downstream extent located immediately N of AAA Road and continuing downstream 200 feet.
4	Cedar Creek	N 46.81066 W 87.95323	Powell Twp. T51N, R29W, Sec. 14	Downstream extent located 300 feet N of Northwestern Road and continuing upstream to road crossing.
5	Yellow Dog River	N 46.72694 W 87.87268	Michigamme Twp. T50N, R29W, Sec. 13	Downstream extent located immediately upstream of unnamed road and continuing upstream 300 feet.
6	Salmon Trout River Main Branch	N 46.74793 W 89.89584	Michigamme Twp. T50N, R29W, Sec. 11	Downstream extent located approximately 4,600 feet upstream of AAA Road and continuing upstream 300 feet.
7	Salmon Trout River Main Branch	N 46.73808 W 87.89810	Michigamme Twp. T50N, R29W, Sec. 11	Near headwaters and N 100 feet.
8	Tributary to the East Branch of the Salmon Trout River	N 46.760113 W 87.83224	Champion Twp. T50N, R28W, Sec. 5	Upstream extent located 75 feet NE of Northwestern Road and continuing NE for 135 feet.
9	Tributary to the East Branch of the Salmon Trout River	N 46.76862 W 87.84377	Powell Twp. T51N, R28W, Sec. 34	Downstream extent located immediately SW of Northwestern Road and continuing SW for 85 feet.
10	Tributary to the East Branch of the Salmon Trout River	N 46.77471 W 87.86767	Powell Twp. T51N, R29W, Sec. 33	Downstream extent located immediately SW of Northwestern Road and continuing SW for 100 feet.

Table 5-2. 2015 Summer Fish Collection Data – Stations 1-10.

Scientific Name	Common Name	Station Number									
		1	2	3	4	5	6	7	8	9	10
<i>Cattostomus commersonii</i>	White sucker					1					
<i>Cottus bairdii</i>	Mottled sculpin					1					
<i>Culaea inconstans</i>	Brook stickleback						275	1			
<i>Phoxinus eos</i>	Northern redbelly dace		9		2		213	11			1
<i>Rhinichthys atratulus</i>	Blacknose dace					8					
<i>Salvelinus fontinalis</i>	Brook trout	15	4	2	8	5	4		5	4	3
<i>Semotilus atromaculatus</i>	Creek chub					3					
Total Number		15	13	2	10	18	492	12	5	4	4

Stations 1, 2, 3, 6, 7 - Salmon Trout River Main Branch

Stations 8, 9 and 10 - Salmon Trout River East Branch

Station 4 - Cedar Creek

Station 5 - Yellow Dog River

Table 5-3. 2015 Macroinvertebrate Community – Stations 1-10.

TAXA	1	2	3	4	5	6	7	8	9	10
ANNELIDA (segmented worms)										
Hirudinea (leeches)					1					1
ARTHROPODA										
Amphipoda (scuds)		5		1		205	39	1		
Insecta										
Ephemeroptera (mayflies)										
Baetiscidae					1					
Baetidae	48	10	6	71	3			56	33	
Caenidae					2	4	1			
Ephemerellidae	79			42				3	17	17
Ephemeridae		2			1					
Heptageniidae	3	2		9	3			16		1
Leptophlebiidae	16	5	32	13				47		9
Siphonuridae										1
Odonata										
Anisoptera (dragonflies)										
Aeshnidae		2			6	6	1			7
Cordulegastridae	22	3	8	6	14				1	5
Corduliidae						4	3			
Gomphidae					24					
Libellulidae						15				
Zygoptera (damselflies)										
Calopterygidae	2	5	1		1					1
Coenagrionidae						5	5			
Plecoptera (stoneflies)										
Chloroperlidae	2							1		2
Leuctridae								1	7	3
Nemouridae	1							1	7	
Perlodidae	8	2		9	4					
Pteronarcyidae	4			1						
Hemiptera (true bugs)										
Corixidae	1					31	4			
Gerridae	5	2	1	1		5	2			
Notonectidae						3	2			
Megaloptera										
Corydalidae (dobson flies)			3							1
Sialidae (alder flies)		1	1		1				1	

Stations 1, 2, 3, 6, 7 - Salmon Trout River Main Branch**Stations 8, 9, 10 - Salmon Trout River East Branch****Station 4 - Cedar Creek****Station 5 - Yellow Dog River**

TAXA	1	2	3	4	5	6	7	8	9	10
Trichoptera (caddisflies)										
Brachycentridae								7	2	4
Glossosomatidae		5	5					1	3	
Hydropsychidae	2	42	15	28	1			7	8	16
Lepidostomatidae	17	8	2	25	4			43	12	
Limnephilidae	2	8	3		26	36	7	2	10	23
Philopotamidae	3	1	18	72				33		11
Phryganaeidae						1	1			
Polycentropodidae		1						1		
Rhyacophilidae	11		1	5					2	2
Uenoidae	3	15	15	4				7	44	30
Coleoptera (beetles)										
Dytiscidae (total)										2
Haliplidae (adults)						6	1			
Hydrophilidae (total)	1							1	1	1
Elmidae	2	9	1	2	1					
Gyrinidae				1						
Diptera (flies)										
Athericidae	3			5					3	
Chironomidae	2	11	8	18	18	6	7	7	17	4
Empididae		1							1	
Psychodidae										1
Simuliidae	7	18	84	208	3			3	10	3
Tabanidae						5			2	
Tipulidae	7				1			1	2	3
MOLLUSCA										
Gastropoda (snails)										
Physidae					1	1				
Planorbidae					6	12	20			
Pisidiidae		1			3	3	1			
Sphaeriidae (clams)							15			

[illegible]

Table 5-4. 2015 Macroinvertebrate Scores and Community Ratings – Stations 1-10.

Metric	1		2		3		4		5	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Total Number of Taxa	24	1	23	1	17	1	18	0	22	0
Number of Mayfly Taxa	4	1	4	1	2	0	4	0	5	1
Number of Caddisfly Taxa	6	1	7	1	7	1	5	0	3	0
Number of Stonefly Taxa	4	1	1	1	0	-1	2	1	1	0
Percent Mayfly Comp.	58.17	1	11.95	0	18.63	0	25.91	1	8.00	0
Percent Caddisfly Comp.	15.14	0	50.31	1	28.92	0	25.72	0	24.80	0
Percent Dominant Taxon	31.47	-1	26.42	0	41.18	-1	39.92	-1	20.80	0
Percent Isopod, Snail, Leech	0.00	1	0.00	1	0.00	1	0.00	1	6.40	0
Percent Surf. Air Breathers	2.79	1	1.26	1	0.49	1	0.19	1	0.00	1
Total Score		6		7		2		3		2
Community Rating	Excellent		Excellent		Acceptable		Acceptable		Acceptable	

Metric	6		7		8		9		10	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Total Number of Taxa	17	0	15	1	20	0	20	0	23	1
Number of Mayfly Taxa	1	-1	1	0	4	1	2	0	4	1
Number of Caddisfly Taxa	2	-1	2	-1	8	1	7	1	6	1
Number of Stonefly Taxa	0	-1	0	-1	3	1	2	1	2	1
Percent Mayfly Comp.	1.15	0	0.92	-1	51.05	1	27.32	1	18.92	0
Percent Caddisfly Comp.	10.63	0	7.34	0	42.26	1	44.26	1	58.11	1
Percent Dominant Taxon	58.91	-1	35.78	-1	23.43	0	24.04	0	20.27	0
Percent Isopod, Snail, Leech	3.74	1	18.35	-1	0.00	1	0.00	1	0.68	1
Percent Surf. Air Breathers	12.93	0	8.26	0	0.42	1	0.55	1	2.03	1
Total Score		-3		-4		7		6		7
Community Rating	n.a.		n.a.		Excellent		Excellent		Excellent	

Stations 1, 2, 3, 6, 7 - Salmon Trout River Main Branch

Stations 8, 9, 10 - Salmon Trout River East Branch

Station 4 - Cedar Creek

Station 5 - Yellow Dog River

n.a. – Not applicable

Table 5-5. 2015 Summer Physical Stream Dimensions – Stations 1-10.

Station	Length (ft)	Wetted width (ft)		Depth (ft)		Discharge (gpm)
		Average*	s	Average	s	
1	120	7.4 (3)	1.1	0.5 (9)	0.1	1,494
2	100	5.8 (3)	1.0	1.1 (9)	0.5	893
3	200	6.3 (3)	0.6	0.4 (9)	0.2	893
4	300	22.3 (3)	2.5	1.0 (9)	0.5	4,992
5	300	23.7 (3)	3.4	2.5 (9)	0.8	15,339
6	300	17.6 (3)	6.1	2.1 (9)	0.5	784
7	100	5.1 (3)	0.7	1.4 (9)	0.2	n.m.
8	135	9.3 (3)	0.9	0.8 (9)	0.4	1,807
9	85	7.9 (3)	0.4	0.7 (9)	0.3	1,135
10	100	6.8 (3)	0.7	0.5(9)	0.2	501

Stations 1, 2, 3, 6, 7 - Salmon Trout River Main Branch

Stations 8, 9, 10 - Salmon Trout River East Branch

Station 4 - Cedar Creek

Station 5 - Yellow Dog River

*sample size is indicated within ()

s = standard deviation

gpm = Gallons per minute

n.m. = Not measured

Table 5-6. 2015 Procedure 51 Habitat Evaluation Scores – Stations 1-10.

Habitat Metric	Sample Station									
	1 riffle/run	2 glide/pool	3 riffle/run	4 riffle/run	5 glide/pool	6 n.a.	7 n.a.	8 riffle/run	9 glide/pool	10 riffle/run
Substrate and In-stream Cover										
Epifaunal Substrate/Avail. Cover	19	13	18	18	10	-	-	15	12	18
Embeddedness	19		14	12		-	-	18		15
Pool Substrate Characterization		13			10	-	-		10	
Velocity Depth Regime	15		14	14		-	-	15		10
Pool Variability		10			14	-	-		11	
Sediment Deposition	15	12	15	14	14	-	-	17	11	17
Channel Morphology										
Maintained Flow Volume	9	9	9	9	9	-	-	9	10	7
Flashiness	9	7	8	7	7	-	-	9	8	7
Channel Alteration	20	16	18	19	20	-	-	20	15	15
Frequency of Riffles/Bends	19		15	15		-	-	12		17
Channel Sinuosity		12			14	-	-		14	
Riparian and Bank Structure										
Bank Stability (L)	9	9	9	9	7	-	-	9	10	10
Bank Stability (R)	9	9	9	9	7	-	-	9	10	10
Vegetative Protection (L)	10	10	10	10	10	-	-	10	10	10
Vegetative Protection (R)	10	10	10	10	10	-	-	10	10	10
Riparian Veg. Zone Width (L)	10	10	10	10	10	-	-	10	10	10
Riparian Veg. Zone Width (R)	10	10	10	10	10	-	-	10	10	10
Total Score	183	150	169	166	152	n.a.	n.a.	173	151	166
Habitat Rating	Excellent	Good	Excellent	Excellent	Good	n.a.	n.a.	Excellent	Good	Excellent

Stations 1, 2, 3, 6, 7 - Salmon Trout River Main Branch

Stations 8, 9, 10 - Salmon Trout River East Branch

Station 4 - Cedar Creek

Station 5 - Yellow Dog River

n.a. – Not applicable

Table 5-7. 2015 Average Water Quality Parameters – Stations 1-10.

Station Number	Date	Time	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Dissolved Oxygen	pH	Conductivity (µS/cm)
1	6/11/2015	16:02	13.4 (0.1)	8.9 (0.3)	85.7 (2.3)	7.3 (0.8)	57 (0.3)
2	6/9/2015	14:42	18.1 (0.2)	7.6 (0.1)	79.6 (0.5)	6.6 (0.0)	47 (0.5)
3	6/9/2015	16:00	18.4 (0.1)	7.6 (0.2)	80.5 (2.2)	6.7 (0.1)	49 (0.6)
4	6/11/2015	11:00	10.8 (0.1)	9.5 (0.1)	85.7 (1.3)	7.5 (0.1)	107 (0.1)
5	6/5/2015	16:41	14.1 (0.1)	7.9 (0.3)	76.5 (3.0)	6.5 (0.2)	38 (0.1)
6	6/5/2015	14:48	12.1 (0.1)	7.8 (0.4)	72.1 (3.9)	6.5 (0.1)	52 (0.2)
7	6/9/2015	12:12	16.8 (0.1)	4.7 (0.1)	47.9 (0.7)	6.2 (0.2)	42 (0.2)
8	6/10/2015	14:07	13.6 (0.0)	9.0 (0.2)	87.3 (1.3)	7.5 (0.0)	100 (0.1)
9	6/10/2015	12:16	10.2 (0.1)	9.5 (0.3)	84.2 (0.9)	7.6 (0.0)	92 (0.4)
10	6/10/2015	10:10	13.7 (0.0)	8.4 (0.1)	80.9 (1.1)	7.3 (0.1)	103 (0.3)

Stations 1, 2, 3, 6, 7 - Salmon Trout River Main Branch

Stations 8, 9, 10 - Salmon Trout River East Branch

Station 4 - Cedar Creek

Station 5 - Yellow Dog River

°C = Degrees Celsius

mg/L = Milligrams per liter

µS/cm = MicroSiemens per centimeter

standard deviation is indicated within ()

EXHIBIT C
STATION PHOTOGRAPHS



Photograph C-1. Station 1 - Downstream Extent View South, June, 2015.



Photograph C-2. Station 1 - Upstream Extent View North, June, 2015.



Photograph C-3. Station 2 – Downstream Extent View South, June, 2015.



Photograph C-4. Station 2 – Upstream Extent View Northwest, June, 2015.



Photograph C-5. Station 3 – Downstream Extent View South, June, 2015.



Photograph C-6. Station 3 –Upstream Extent View North, June, 2015.



Photograph C-7. Station 6 – Downstream Extent View South, June, 2015.



Photograph C-8. Station 6 – Upstream Extent View Southwest, June, 2015.



Photograph C-9. Station 7 – Downstream Extent View Southwest, June, 2015.



Photograph C-10. Station 7 – Upstream Extent View North, June, 2015.



Photograph C-11. Station 8 – Downstream Extent View Southwest, June, 2015.



Photograph C-12. Station 8 – Upstream Extent View North, June, 2015.



Photograph C-13. Station 9 – Downstream Extent View South, June, 2015.



Photograph C-14. Station 9 – Upstream Extent View North, June, 2015.



Photograph C-15. Station 10 – Downstream Extent View Southwest, June, 2015.



Photograph C-16. Station 10 – Upstream Extent View Northeast, June, 2015.



Photograph C-17. Station 5 – Downstream Extent View West, June, 2015.



Photograph C-18. Station 5 – Upstream Extent View Southeast, June, 2015.



Photograph C-19. Station 4 – Downstream Extent View South, June, 2015.



Photograph C-20. Station 4 – Upstream Extent View North, June, 2015.