

Investigation of the Aquatic Communities of the Salmon Trout River, Yellow Dog River, and Cedar Creek in Marquette County, Michigan, 2016.

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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 Surface Water Assessment Section (SWAS) 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 not applicable and were not determined for this survey.

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, 2015; 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 2016 aquatic habitat scores were consistent with 2015 evaluations that were conducted by AEM (AEM, 2015). A summary of P-51 macroinvertebrate and aquatic habitat scores appears on Table 1-1.

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 2016 aquatic community survey represents the sixth annual aquatic survey that has been conducted by AEM on behalf of Eagle Mine since operations commenced in 2011. This 2016 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 2016 aquatic survey was conducted according to the MDEQ's Surface Water Quality Division *Procedure #51 Survey Protocols for Wadable Rivers* (P-51; MDEQ, 2009). Ten stream segments (stations) were sampled in the summer of 2016 using the P-51 survey protocol (Figure 1-2).

These sample stations are situated in the same sample locations, or close to the sample locations that were surveyed by AEM from 2011 through 2015 and in 2008. The 2016 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, 2016) 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 (Bright, 2016; Merritt et al., 2008; 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, 2009):

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 2016, 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 2016 through 11 June 2016. Station 7 in the Salmon Trout River was sampled on 5 June 2016. Station 5 in the Yellow Dog River and Station 6 in the Salmon Trout River were sampled on 6 June 2016, Stations 2, 3, 9, and 10 in the Salmon Trout River were sampled on 7 June 2016, Stations 1 and 8 in the Salmon Trout River were sampled on 10 June 2016, and Station 4 in the Cedar Creek was sampled on 11 June 2016.

5.1 Fish

A total of 865 fish were collected from all stations in 2016, with 89% of the total number of fish captured in Station 6 (Table 5-2). A total of 575 fish were collected from all stations in 2015, with 86% of the total being captured in Station 6. Among all stations, a total of seven species of fish were observed during the 2016 aquatic survey (Table 5-2), which was consistent with the total number of species that were observed in the 2015 aquatic survey. 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, 2016).

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, 4, 8, 9, and 10 during June 2016.

A total of 10 brook trout were collected from Station 1 during 2016 (Table 5-2). Five more brook trout were collected from Station 1 during 2015, and a total of six brook trout were collected from Station 1 in 2014.

A total of 13 fish, including eight brook trout, four northern redbelly dace, and one brook stickleback were collected from Stations 2 and 3 in 2016 (Table 5-2). Two more brook trout were collected in 2016 compared to 2015 and five fewer northern redbelly dace were collected in 2016. In addition, one brook stickleback was collected in 2016 and none were collected in 2015. However, brook sticklebacks have been collected from Stations 2 and 3 in previous aquatic surveys. Fish community composition has remained consistent with previous surveys.

A total of 769 fish were collected from Station 6 in 2016. Northern redbelly dace were the most abundant species followed by brook sticklebacks, and two brook trout (Table 5-2). Fewer fish were collected in Station 6 during 2015, where a total of 492 fish were collected, with brook sticklebacks and northern redbelly dace recorded as the most abundant species. Although brook trout are not always collected from Station 6 during each annual aquatic survey, a total of four were also collected from Station 6 during 2015. 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 has been conducted within this station. The 2016 fish community of Station 7 remained consistent with previous surveys, and was comprised of 16 northern redbelly dace and two brook sticklebacks (Table 5-2). The 2015 Station 7 fish community was comprised of 11 northern redbelly dace and one brook stickleback.

A total of 10 brook trout were collected from Station 8 during 2016 (Table 5-2), which is five more than were collected in 2015. A total of 14 brook trout were collected from Station 9 in 2016 (Table 5-2), which is 10 more than were collected in 2015.

A total of five brook trout were collected from Station 10 in 2016 (Table 5-2). A total of three brook trout and one northern redbelly dace were collected from Station 10 in 2015. Fish community composition and relative abundance has remained consistent in Station 10.

5.1.2 Yellow Dog River: Station 5

A total of 15 fish comprised of five species were collected from Station 5 during the 2016 aquatic survey (Table 5-2). Consistent with the 2015 aquatic survey, blacknose dace (*Rhinichthys atratulus*) and brook trout were the most frequently collected species. A total of 18 fish comprised of five species were collected during the 2015 aquatic survey.

5.1.3 Cedar Creek: Station 4

Station 4 is located in Cedar Creek outside of the project area drainage basin. The 2016 survey was conducted in the same location (immediately downstream of the road crossing) as the 2011-2015 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 has been conducted in Station 4.

The total number of brook trout collected from Station 4 has varied annually since 2011. A total of 11 brook trout were collected in 2016 (Table 5-2), compared to eight that were collected in 2015, 25 in 2014, 19 in 2013, 10 in 2012, and 44 in 2011.

5.2 Macroinvertebrates

A total of 2,224 macroinvertebrates were collected from all ten stations that were investigated in 2016 (Table 5-3), which was 63 fewer specimens than the total number collected in 2015 (total number collected = 2,287). 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 1,893 macroinvertebrates representing 51 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 2016. The greatest numbers of Salmon Trout River

macroinvertebrates were collected from Station 2 and the fewest number of macroinvertebrates were collected from Station 7 (Table 5-3).

A total of 234 macroinvertebrates were collected in Station 1 in 2016, with Ephemeropterans (mayflies), Trichopterans (caddisflies), and Dipterans (true flies) being the most frequently collected macroinvertebrates (Table 5-3). A total of 251 macroinvertebrates were collected from Station 1 in 2015, with mayflies, caddisflies, and Odonates (dragonflies and damselflies) being the most frequently collected macroinvertebrates.

A total of 294 macroinvertebrate were collected from Station 2, with caddisflies, Dipterans (true flies), and dragonflies and damselflies represented as the most frequently collected macroinvertebrates during 2016 (Table 5-3). A total of 159 macroinvertebrates were collected from Station 2 in 2015, with caddisflies, true flies, and mayflies being the most frequently collected macroinvertebrates.

A total of 270 macroinvertebrate were collected from Station 3, with caddisflies, mayflies, and true flies represented as the most frequently collected macroinvertebrates during 2016 (Table 5-3). A total of 204 macroinvertebrate were collected from Station 3 in 2015, with true flies, caddisflies, and mayflies represented as the most frequently collected macroinvertebrates.

A total of 285 macroinvertebrates were collected from Station 6, where amphipods (scuds), mayflies and caddisflies were the most frequently collected macroinvertebrates in 2016 (Table 5-3). A total of 348 macroinvertebrates were collected from Station 6 in 2015, where scuds, true bugs, and caddisflies were the most frequently collected macroinvertebrates. Macroinvertebrate community composition of Station 6 has generally remained consistent 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 135 macroinvertebrates were collected from Station 7 in 2016, compared to a total of 109 macroinvertebrates were collected in 2015. The 2016 macroinvertebrate community of Station 7 was predominantly comprised of scuds, mollusks (snails and clams), and

dragonflies and damselflies (Table 5-3), and the community composition of Station 7 has remained consistent among years.

A total of 254 macroinvertebrates were collected from Station 8 in 2016, where mayflies and caddisflies were the most frequently collected macroinvertebrates (Table 5-3). A total of 239 macroinvertebrates were collected from Station 8 in 2015 and community composition has remained consistent among years.

A total of 249 macroinvertebrates were collected from Station 9 in 2016, where true flies, caddisflies, and mayflies were the most abundant macroinvertebrates (Table 5-3). A total of 183 macroinvertebrates were collected from Station 9 in 2015, where caddisflies, mayflies and true flies were the most abundant macroinvertebrates, and community composition has remained consistent among years.

A total of 172 macroinvertebrates were collected from Station 10 in 2016, where caddisflies and mayflies were the most abundant macroinvertebrates (Table 5-3). A total of 148 macroinvertebrates were collected from Station 10 in 2015 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, 3, 8, and 10 were rated as "Excellent", and Station 9 was rated as "Acceptable" in 2016. 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 113 macroinvertebrates representing 25 taxa identified to the Family level were collected in Station 5 from the Yellow Dog River during 2016 (Table 5-3). A total of 125 macroinvertebrates representing 21 taxa identified to the Family level were collected in Station 5 during 2015. Mayflies, dragonflies and damselflies, and caddisflies were the most frequently collected macroinvertebrates in 2016. Damselflies and dragonflies,

caddisflies, and true flies were the most frequently collected macroinvertebrates in 2015. Macroinvertebrate community composition has remained consistent among years. The macroinvertebrate community of Station 5 was rated as “Acceptable” in 2016 (Table 5-4).

5.2.3 Cedar Creek: Station 4

A total of 218 macroinvertebrates representing 25 taxa identified to the Family level were collected from Cedar Creek in Station 4 during 2016 (Table 5-3), where true flies, caddisflies, and mayflies were the most frequently collected macroinvertebrates. A total of 521 macroinvertebrates representing 20 taxa were identified to the Family level were collected from Station 4 during 2015. The community composition has remained consistent among years, except 2015 where black flies (Simuliidae) were the most abundant macroinvertebrate. The macroinvertebrate community of Station 4 was rated as “Excellent” in 2016 (Table 5-4), and was rated as “Acceptable” in 2015.

5.3 Stream Habitat

Stream habitat has remained consistent since 2011 when beaver activity affected several stations and required the relocation of two stations (Station 4 and Station 8) to conduct the survey. The habitat conditions for all stations surveyed are described below.

All streams sampled within the project vicinity are located in a region that is classified as a Northern Lakes and Forests ecoregion (Omernik and Gallant, 1988). Therefore, all P-51 scoring was based on metrics that relied on typical data from the Northern Lakes and Forest ecoregion.

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 7.1 feet ($s = 0.6$ 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 1,382 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 since 2013.

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 5.5 feet ($n = 3$; $s = 1.7$ feet), and average width of Station 3 was 6.9 feet ($n = 3$; $s = 0.9$ feet, Table 5-5). Average depth in Station 2 was 0.6 feet ($n = 9$; $s = 0.2$ feet), and average depth in Station 3 was 0.5 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 529 gpm in 2016 (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 2015 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 2015. 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 17.3 feet ($n = 3$; $s = 2.9$ feet) and the average depth was 1.8 feet ($n = 9$; $s = 0.2$ feet, Table 5-5). Stream flow was measured at the middle extent of Station 6 and discharge was estimated at 652 gpm (Table 5-5), which was 132 gpm lower than the 2015 discharge measurement (784 gpm).

The streambanks in Station 6 appeared similar to conditions observed throughout all annual aquatic surveys conducted by AEM, 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 observed during the aquatic

survey 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 5.0 feet ($n = 3$; $s = 0.4$ feet) and the average depth was 1.0 feet ($n = 9$; $s = 0.4$ 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 2015. 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 8.3 feet ($n = 3$; $s = 0.2$ feet) and the average depth was 0.5 feet ($n = 9$; $s = 0.2$ feet, Table 5-5). Stream flow was measured at the middle extent of Station 8 and discharge was estimated at 1,706 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 2016 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 8.9 feet ($n = 3$; $s = 1.1$ 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 1,215 gpm (Table 5-5).

Station 9 habitat conditions have tended to vary annually. At the time of the 2015 survey, most of the small pools within Station 9 appeared to have filled in with sand compared to 2013 and 2014 aquatic surveys. There appeared to be minor redevelopment of small pools within Station 9 at the time of the 2016 aquatic survey. Riparian habitat appeared consistent with the 2015 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 6.4 feet ($n = 3$; $s = 0.9$ feet) and average depth was 0.6 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 465 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 2015. 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 24.6 feet ($n = 3$; $s = 1.4$ feet) and average depth of 2.2 feet ($n = 9$; $s = 0.8$ feet, Table 5-5). The 2016 stream flow was measured at the downstream extent of Station 5 and discharge was estimated at 12,876 gpm (Table 5-5). The 2016 discharge was lower than the estimated discharge at the time of the 2015 aquatic survey (15,339 gpm).

Streambanks appeared consistent with the 2015 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 25.1 feet ($n = 3$; $s = 2.5$ feet) and average depth of 0.9 feet ($n = 9$; $s = 0.3$ feet, Table 5-5). Stream flow was measured at the upstream extent of Station 4 and discharge was estimated at 6,488 gpm during the 2016 aquatic survey (Table 5-5). The 2016 stream flow was 1,496 gpm greater than the 2015 estimated discharge (4,992 gpm).

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.

5.3.4 P-51 Habitat Scores

Stations sampled during 2016 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, which has remained since 2014. The change in the habitat rating of Station 9 was due to sand moving into the station from upstream and filling the pools. The 2016 P-51 habitat ratings for all other stations has remained consistent with previous surveys conducted by AEM (AEM, 2015, 2014, 2013, 2012a and b; AEM, 2008a; AEM, 2007).

5.4 Water Quality

Water temperature ranged from 8.6°C in Station 9 to 16.8°C in Station 4 during 2016 (Table 5-7). Water temperature in Station 6 during 2016 was 12.4°C in 2016 and was consistent with the water temperature at the time of the 2015 aquatic survey (12.1°C). The lower water temperature in Station 6 in 2015 and 2016 may account for the presence

of the brook trout, which were not observed in 2014 (average water temperature = 16.5°C), as they are known to prefer cold water (Becker, 1983).

Dissolved oxygen was lowest in Station 7 at 6.4 mg O₂/L and was highest in Station 9 at 10.9 mg O₂/L in (Table 5-7). Dissolved oxygen has typically been the lowest in Station 7 among most survey years and Station 9 has consistently been one of the highest dissolved oxygen readings measured by AEM.

Average pH ranged from 6.5 in Station 6 to 7.8 in Station 8 in 2016 (Table 5-7). Average pH ranged from 6.2 in Station 7 to 7.6 in Station 9 in 2015. Conductivity has consistently remained low among all stations surveyed by AEM, and ranged from 37 microSiemens per cm (µS/cm) in Station 5 to 120 µS/cm in Station 4 in 2016 (Table 5-7). The lowest conductivities have typically been recorded in Stations 5, 6, and 7, and the highest conductivities have typically been recorded in Station 4 and Station 10 (AEM, 2015, 2014, 2013, 2012a and b; AEM, 2008a; AEM, 2007).

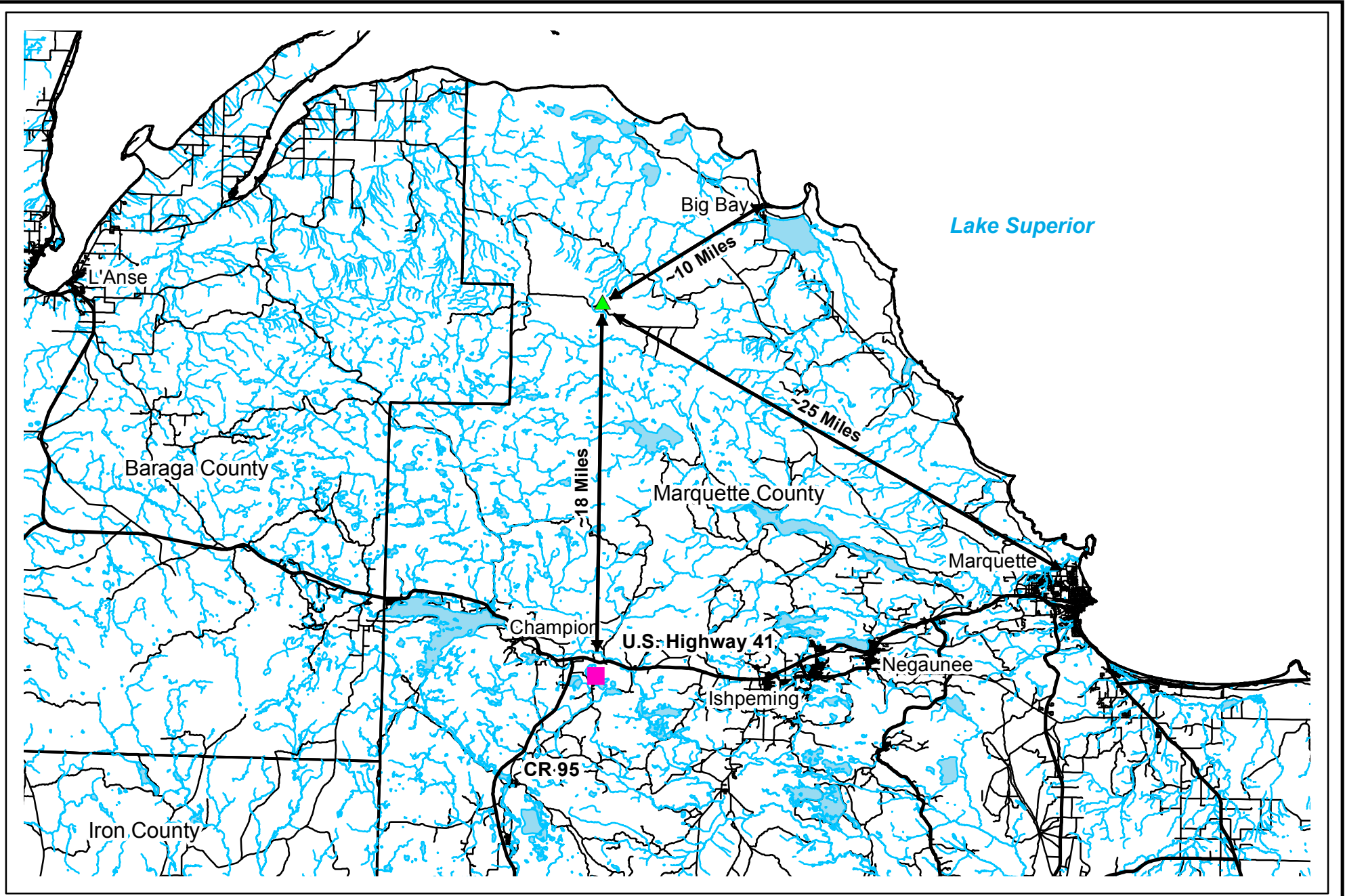
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EXHIBIT A
REPORT FIGURES



Legend

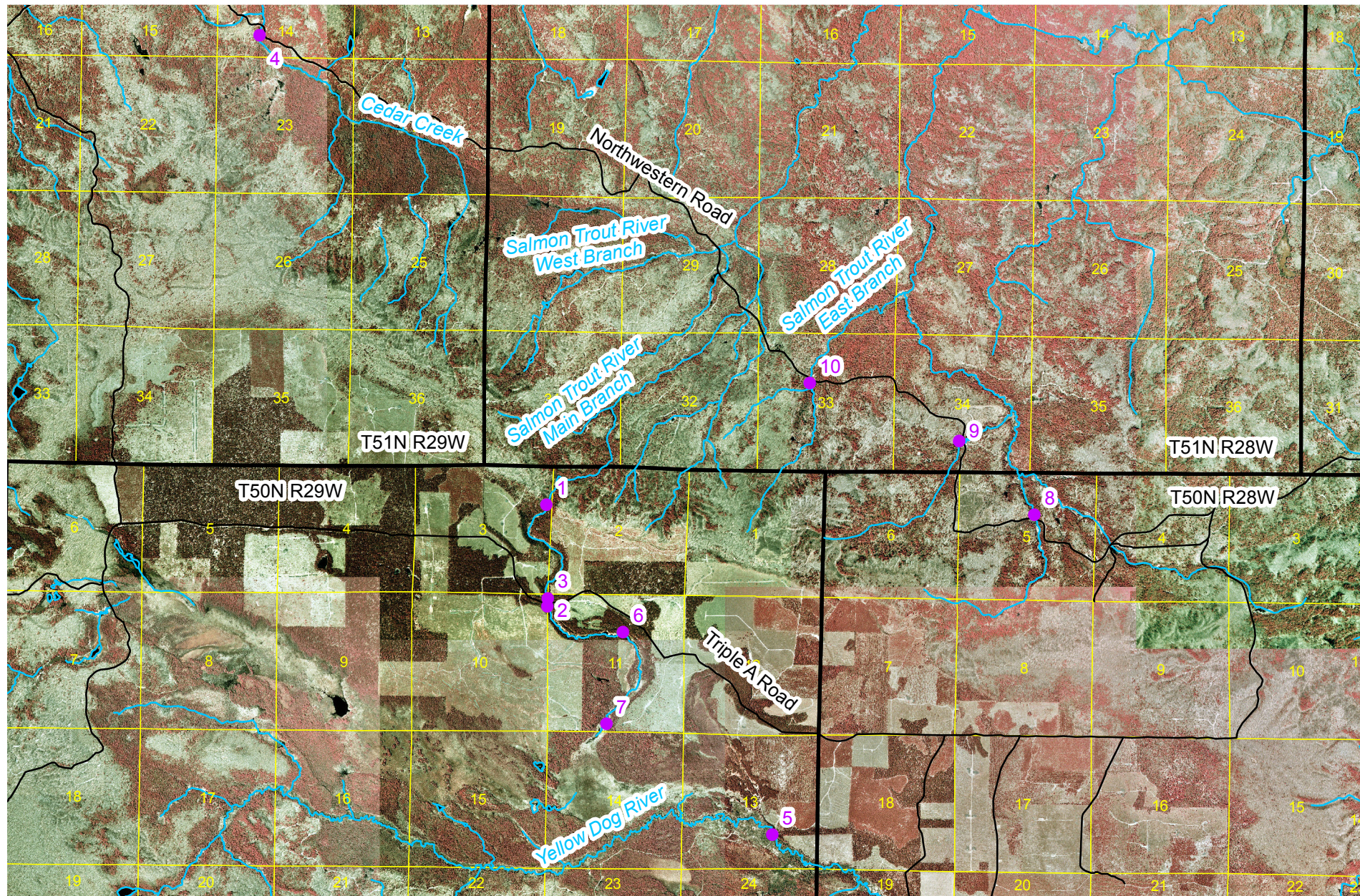
- Eagle Mine
- Humboldt Mill
- Lakes and Rivers
- Roads and Highways
- Counties

N

0 2.5 5 10 15 20 Miles

AeM | **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, 2016.

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	Excellent	Excellent	Acceptable	n.a.	n.a.	Excellent	Acceptable	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. 2016 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		1				197	2			
<i>Phoxinus eos</i>	Northern redbelly dace		4				570	16			
<i>Rhinichthys atratulus</i>	Blacknose dace					6					
<i>Salvelinus fontinalis</i>	Brook trout	10	4	4	11	4	2		10	14	5
<i>Semotilus atromaculatus</i>	Creek chub					3					
Total Number		10	9	4	11	15	769	18	10	14	5

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. 2016 Macroinvertebrate Community – Stations 1-10.

TAXA	1	2	3	4	5	6	7	8	9	10
ANNELIDA (segmented worms)										
Hirudinea (leeches)	1			3	1		1			
ARTHROPODA										
Amphipoda (scuds)	1	4		1	5	191	55	1		
Insecta										
Ephemeroptera (mayflies)										
Ameletidae					1					
Baetiscidae					4					
Baetidae	66	15	7	30	11		1	96	36	10
Caenidae					1	10	3			
Ephemerellidae	42	1	2	6	2	14		2	24	15
Ephemeridae			1		8			2	1	2
Heptageniidae	6	4	3		4			2		7
Leptophlebiidae	26	11	72	8			2	47		27
Odonata										
Anisoptera (dragonflies)										
Aeshnidae	1	6	3	1	2		2			3
Cordulegastridae		15	7	1	7			1		16
Corduliidae					4	6	5			
Gomphidae					3					
Libellulidae						1	3			
Zygoptera (damselflies)										
Calopterygidae	11	16	2	2	9					1
Coenagrionidae							5			
Plecoptera (stoneflies)										
Chloroperlidae	4	1		1						
Leuctridae									4	7
Nemouridae								2		
Perlodidae	5		3	1	1				7	2
Pteronarcyidae	2									
Hemiptera (true bugs)										
Corixidae					1	12	5			
Gerridae	2	1	2	1	1	3	1	2	2	3
Notonectidae						2				
Megaloptera										
Corydalidae (dobson flies)			2							
Sialidae (alder flies)		1			3				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	1	1	2					1	3	1
Glossosomatidae		14	6	9					1	7
Hydropsychidae		76	72	7				16	37	11
Lepidostomatidae	13	11	1	37	2			25	2	21
Limnephilidae		6	1	1	20	18	4	1	7	
Molannidae		1								
Philopotamidae	2	38	40	7				16		5
Polycentropodidae	1	2			1					
Rhyacophilidae	7							1	8	1
Uenoidae	20	3	10	7					6	15
Coleoptera (beetles)										
Dytiscidae (total)				1		3				
Haliplidae (adults)					1	1	1			
Hydrophilidae (total)									2	1
Elmidae	1									
Gyrinidae				1			1			
Diptera (flies)										
Athericidae			1	3				1		
Ceratopogonidae				1				1		
Chironomidae	7	37	12	41	16	14	8	11	18	9
Culicidae								3		
Simuliidae	14	24	21	43			1	21	85	5
Tabanidae	1					1	1		1	
Tipulidae		1		4				1	4	2
MOLLUSCA										
Gastropoda (snails)										
Lymnaeidae		1		1						
Physidae		1				1				
Planorbidae					4	4	18			
Pisidiidae (clams)		3			1	4		1		
Sphaeriidae (clams)							18			

[illegible]

Table 5-4. 2016 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	22	1	26	1	21	1	25	0	25	0
Number of Mayfly Taxa	4	1	4	1	5	1	3	0	7	1
Number of Caddisfly Taxa	6	1	9	1	7	1	6	1	3	0
Number of Stonefly Taxa	3	1	1	1	1	0	2	1	1	0
Percent Mayfly Comp.	59.83	1	10.54	0	31.48	1	20.18	0	27.43	1
Percent Caddisfly Comp.	18.80	0	51.70	1	48.89	1	31.19	1	20.35	0
Percent Dominant Taxon	28.21	-1	25.85	0	26.67	0	19.72	0	17.70	0
Percent Isopod, Snail, Leech	0.43	1	0.68	1	0.00	1	1.83	1	4.42	0
Percent Surf. Air Breathers	0.85	1	0.34	1	0.74	1	1.38	1	2.65	1
Total Score		6		7		7		5		3
Community Rating	Excellent		Excellent		Excellent		Excellent		Acceptable	

Metric	6		7		8		9		10	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Total Number of Taxa	16	0	19	1	22	1	19	0	23	1
Number of Mayfly Taxa	2	-1	3	1	5	1	3	0	5	1
Number of Caddisfly Taxa	1	-1	1	-1	6	1	7	1	7	1
Number of Stonefly Taxa	0	-1	0	-1	1	0	2	1	2	1
Percent Mayfly Comp.	8.42	0	4.44	0	58.66	1	24.50	1	35.47	1
Percent Caddisfly Comp.	6.32	0	2.96	0	23.62	0	25.70	0	35.47	1
Percent Dominant Taxon	67.02	-1	40.74	-1	37.80	-1	34.14	-1	15.70	1
Percent Isopod, Snail, Leech	1.75	1	14.07	-1	0.00	1	0.00	1	0.00	1
Percent Surf. Air Breathers	7.37	0	5.93	0	1.97	1	1.61	1	2.33	1
Total Score		-3		-2		5		4		9
Community Rating	n.a.		n.a.		Excellent		Acceptable		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. 2016 Summer Physical Stream Dimensions – Stations 1-10.

Station	Length (ft)	Wetted width (ft)		Depth (ft)		Discharge (gpm)
		Average*	s	Average	s	
1	120	7.1 (3)	0.6	0.5 (9)	0.1	1,382
2	100	5.5 (3)	1.7	0.6 (9)	0.2	529
3	200	6.9 (3)	0.9	0.5 (9)	0.2	529
4	300	25.1 (3)	2.5	0.9 (9)	0.3	6,488
5	300	24.6 (3)	1.4	2.2 (9)	0.8	12,876
6	300	17.3 (3)	2.9	1.8 (9)	0.2	652
7	100	5.0 (3)	0.4	1.0 (9)	0.4	n.m.
8	135	8.3 (3)	0.2	0.5 (9)	0.2	1,706
9	85	8.9 (3)	1.1	0.7 (9)	0.3	1,215
10	100	6.4 (3)	0.9	0.6 (9)	0.2	465

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. 2016 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	13	17
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	152	165
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. 2016 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	6/10/2016	9:32	11.1 (0.1)	9.8 (0.0)	88.9 (0.3)	7.4 (0.1)	56 (0.1)
2	6/7/2016	9:58	11.2 (0.2)	8.1 (0.4)	73.8 (2.7)	6.9 (0.0)	45 (1.5)
3	6/7/2016	12:10	10.8 (0.1)	8.8 (0.1)	78.9 (1.4)	7.0 (0.1)	45 (0.1)
4	6/11/2016	13:43	16.8 (0.1)	8.9 (0.1)	90.7 (0.8)	7.6 (0.0)	120 (0.6)
5	6/6/2016	15:39	13.6 (0.0)	8.4 (0.1)	80.4 (0.8)	6.6 (0.0)	37 (0.8)
6	6/6/2016	13:06	12.4 (0.3)	6.9 (0.2)	68.1 (0.6)	6.5 (0.2)	53 (4.6)
7	6/5/2016	17:47	15.7 (0.1)	6.4 (0.4)	64.8 (4.1)	6.7 (0.4)	40 (0.1)
8	6/10/2016	12:28	12.9 (0.0)	9.9 (0.3)	93.8 (2.4)	7.8 (0.0)	96 (0.3)
9	6/7/2016	15:13	8.6 (0.1)	10.9 (0.2)	93.4 (1.6)	7.7 (0.0)	84 (0.2)
10	6/7/2016	13:34	10.3 (0.1)	9.2 (0.2)	85.7 (7.7)	7.4 (0.0)	78 (0.9)

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, 2016.



Photograph C-2. Station 1 - Upstream Extent View North, June, 2016.



Photograph C-3. Station 2 – Downstream Extent View South, June, 2016.



Photograph C-4. Station 2 – Upstream Extent View Northwest, June, 2016.



Photograph C-5. Station 3 – Downstream Extent View South, June, 2016.



Photograph C-6. Station 3 –Upstream Extent View North, June, 2016.



Photograph C-7. Station 6 – Downstream Extent View South, June, 2016.



Photograph C-8. Station 6 – Upstream Extent View Southwest, June, 2016.



Photograph C-9. Station 7 – Downstream Extent View Southwest, June, 2016.



Photograph C-10. Station 7 – Upstream Extent View North, June, 2016.



Photograph C-11. Station 8 – Downstream Extent View Southwest, June, 2016.



Photograph C-12. Station 8 – Upstream Extent View North, June, 2016.



Photograph C-13. Station 9 – Downstream Extent View South, June, 2016.



Photograph C-14. Station 9 – Upstream Extent View North, June, 2016.



Photograph C-15. Station 10 – Downstream Extent View Southwest, June, 2016.



Photograph C-16. Station 10 – Upstream Extent View Northeast, June, 2016.



Photograph C-17. Station 5 – Downstream Extent View West, June, 2016.



Photograph C-18. Station 5 – Upstream Extent View Southeast, June, 2016.



Photograph C-19. Station 4 – Downstream Extent View South, June, 2016.



Photograph C-20. Station 4 – Upstream Extent View North, June, 2016.