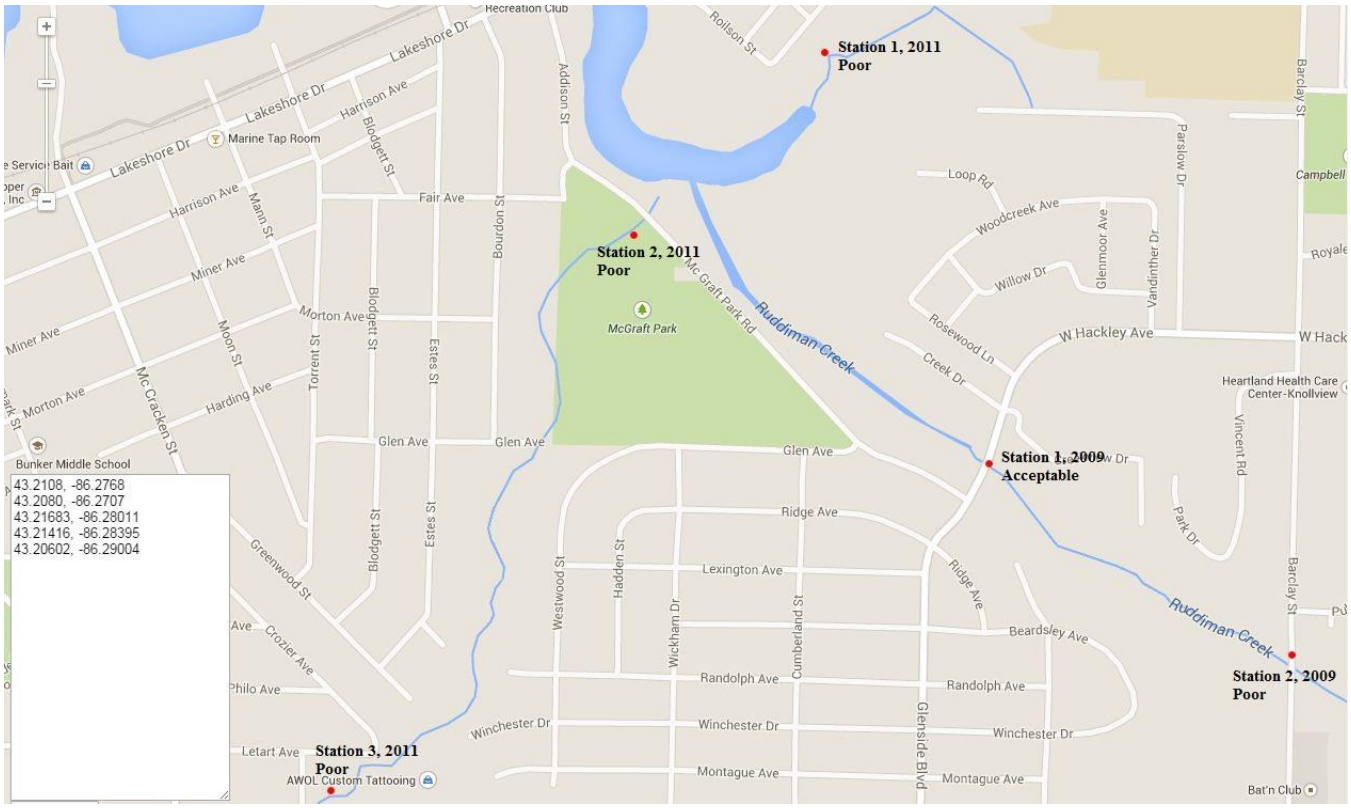
Ruddiman Creek

Sample Location	GPS Coordinates	Sample Date	P51 Macroinvertebrate Rating
Glenside Boulevard Station 1	43.2108, -86.2768	6.4.2009	Acceptable (-4)
Barclay Street Station 2	43.2080, -86.2707	6.4.2009	**Poor (-5)**

Sample Location	GPS Coordinates	Sample Date	P51 Macroinvertebrate Rating
Nolan Street Station 1	43.21683, -86.28011	7.15.2011	**Poor (-6)**
McGraft Park Road Station 2	43.21416, -86.28395	7.15.2011	**Poor (-6)**
Sherman Boulevard Station 3	43.20602, -86.29004	7.15.2011	**Poor (-6)**



Station 1, 2009, located at Glenside Boulevard, was found to have an acceptable macroinvertebrate rating, but was on the very low end of "acceptable." Station 2, 2009, located at Barclay Street, was rated "poor" for macroinvertebrate communities. Station 1, 2009 was found to have 14 taxa, which gave it a metric score of "0," as the 14 taxa found were within two standard deviations of excellent rated streams. This zero score gave Station 1, 2009 a one-point higher rating than Station 2, 2009. Station 2, 2009 had 9 total taxa, placing it below two standard deviations from excellent rated, and giving it a metric score of "-1."

The "total number of taxa" metric was the only difference between Stations 1 and 2 sampled in 2009. No pollution intolerant taxa were found at either location, and at both locations the taxon was overwhelmingly chironomids and oligochetes, both pollution tolerant flies and worms, respectively.

Stations 1 and 2 from 2009 were both found to have impaired habitat use. Both stations were found to have heavy sedimentation, silt deposits, channelization, and visible surface scums and trash. However, Station 1, 2009, received a "marginal" habitat rating, indicating moderately impaired habitat use, and Station 2, 2009, received a "good" habitat rating, indicating slightly impaired habitat use. Stations 1, 2009 and 2, 2009 appear to suffer mostly from a lack of epifaunel substrate and inconsistent (flashy) stream flow. This is most likely due to this stream being mostly urban, and subject to the inconsistent input of storm water runoff. While rating as low as possible for stream flow consistency, both locations rated moderately well for riparian zone vegetation and bank structure, with Station 1, 2009 rating higher than Station 2, 2009 for this metric.

All three stations sampled in 2011 scored poorly for macroinvertebrate communities. None of the stations sampled in 2011 had pollution intolerant species, and were dominated by pollution tolerant taxa. Station 1, 2011, located off Nolan Street, is the North Branch of Ruddiman Creek. This station was dominated by amiphods (68%) and isopods (29%). Stations 2, 2011 and 3, 2011 represented the west branch of Ruddiman Creek. Station 2, 2011, located at McGraft Park Road, was dominated by amphipods (67%), isopods and chironomids. Station 3, 2011, located upstream from Sherman Boulevard, was dominated by amphipods (63%) and oligochetes. The strong taxa dominance gave all three locations a "-1" metric score, as the percent dominance was outside of two standard deviations from excellent rated streams.

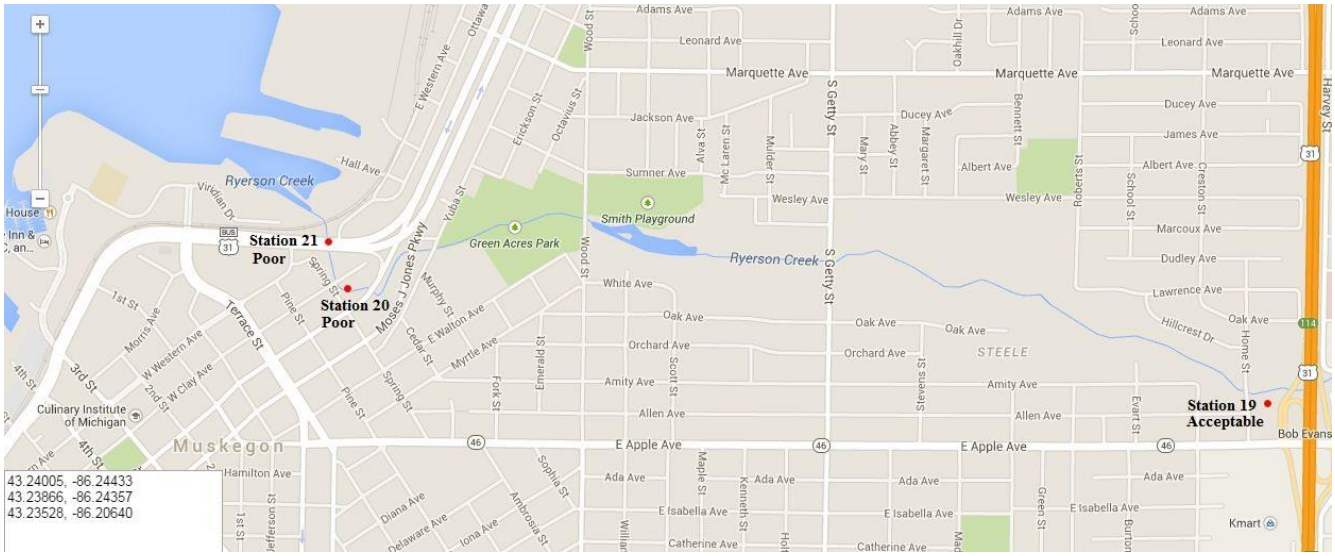
Stations 1 and 2, 2011 were found to have sufficient taxon diversity for a "0" metric rating, meaning that the number of taxa found were within two standard deviations from excellent rated streams. However, both locations scored a "-1" metric rating for seven of the remaining eight metrics, with the exception of "percent surface breathers" at both locations. Water breathing macroinvertebrates are important water quality indicators, as the presence of many of these macroinvertebrates can indicate very poor water quality. This is because these macroinvertebrates can survive in highly polluted, anoxic conditions, as they breathe surface oxygen and do not rely on oxygen present within the streams. Surface air breathing macroinvertebrates include water striders (Gerridae), water boatman (Corixidae), and the mosquito (Culicidae). Thus, the less surface air dependent taxa found at a location, the better the rating for the stream. The "percent surface breathers" was actually found to be of above average quality for excellent rated streams for all three stations (less than one surface dependent taxon).

All three stations were found to have impaired habitat quality. Station 1, 2011 suffers from sedimentation and siltation, as well as low epifaunel substrate. Sediment was also found to contain heavy metals and polycyclic aromatic hydrocarbons, and exceeded the threshold effect concentration. Station 2, 2011 had heavy siltation, with fine sediment being deeper than 3 feet at certain locations. Any epifaunel substrate present was covered with silt, and thus unavailable as habitat for most macroinvertebrates. Station 3, 2011 was found to have heavy siltation, channelization, inconsistent flow due to culverts, and bank scouring.

Ruddiman Creek has had large-scale remediation work performed. Previous work at all sampled locations include the inclusion of riffle structures, the addition of diversion channels, a sump pit, retention basins, and seeding of the riparian zone. Between 2005 and 2006, extensive dredging occurred. This dredging removed over 68 thousand cubic meters of contaminated sediments.

Ryerson Creek

Sample Location	GPS Coordinates	Sample Date	P51 Macroinvertebrate Rating
Home Street Station 19	43.23528, -86.20640	7.13.2011	Acceptable (-3)
Clay Avenue Station 20	43.23866, -86.24357	7.13.2011	**Poor (-5)**
Shoreline Drive Station 21	43.24005, -86.24433	7.12.2011	**Poor (-6)**



Station 19 is located at Home Street. The macroinvertebrate community rated negatively, indicating a trend toward impaired use. This station was two standard deviations outside of excellent rated streams for the number of caddisfly and stonefly taxa, percent caddisfly composition, and percent isopod, snail, and leech composition. However, this location was above excellent for percent surface breathers, and within two standard deviations for all other metrics. These scores gave this location an "acceptable" -3 overall rating. The Home Street location tested "good" for habitat quality, indicating only slight impairment. This is the only location tested on Ryerson Creek that has not received channel modifications. This site received a "fair" score for sediment deposition, as well as a "fair" score for bottom substrate and available cover. This site scored high for vegetative riparian protection, and moderately well for bank stability. Of the three locations sampled on Ryerson Creek, this was the only station to be found "acceptable" for macroinvertebrates and habitat, respectively. However, individual metrics for macroinvertebrate, such as number of pollution intolerant species, and habitat evaluation, such as instream substrate cover, indicate that Station 21 is impaired.

Station 20 is located just upstream of Clay Avenue. There was only 1 pollution intolerant taxa found at the Clay Avenue location, representing only 0.27% of all invertebrates found. This station was two standard deviations from excellent streams in every macroinvertebrate metric except total number of taxa, percent dominant taxa, and percent surface air breathers. Percent surface air breathers was found to be

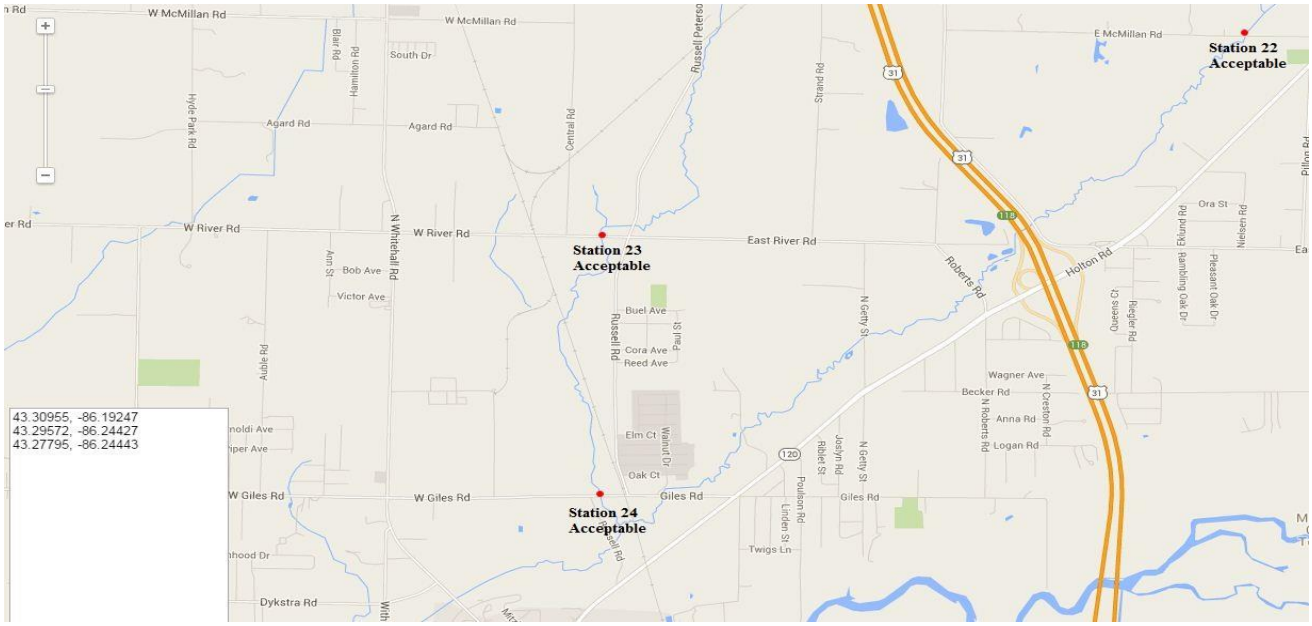
above average, while total number of taxa and percent dominant taxa were found to be within two standard deviations from excellent streams. The number of metrics found outside two standard deviations from excellent streams at this location gave this location a "poor" -5 overall rating. Nearly 50% of all macroinvertebrates found at this station were isopods, snails, or leeches. The Clay Avenue location tested "marginal" for habitat quality, indicating moderate impairment. Riparian vegetation zones on both the left and right sides of the stream, as well as substrate and in-stream cover, received very low scores. Substrate and in-stream cover metrics scored at about 50% of excellent rated streams, while riparian vegetation zones scored at 20% of excellent rated streams. The riparian vegetation zone for this location scored the poorest among the three sampled locations.

Station 21 is located downstream of Shoreline Drive, adjacent to the bike path. There were zero pollution intolerant taxa found at this location, and over 50% of macroinvertebrates sampled were isopods, snails or leeches. However, this site, while rated the poorest for macroinvertebrate communities, did have the highest species diversity of Ryerson Creek locations sampled. All other metric measurements for station 21 were found to be more than two standard deviations from excellent rated streams, with the exception of percent surface air breathers, which was found to be within two standard deviations of excellent streams. The negative metrics combined gave this station a "poor" -6 overall rating. The habitat quality was rated "good," indicating slight impairment. Substrate and available cover was rated "fair," which was better than the other locations by 1 metric point. This site had the least amount of sediment deposition, but riparian vegetation zones were rated very low- at 30% of excellent rated streams.

Previous work on Ryerson Creek includes dredging, bank stabilization and culvert replacement at the Clay Avenue location. Dredging also occurred at the Shoreline Drive location. There has been no previous work at the Home Street location.

Bear Creek and Little Bear Creek/Unnamed Tributary

Sample Location	GPS Coordinates	Sample Date	P51 Macroinvertebrate Rating
McMillan Road Station 22	43.30955, -86.19247	7.13.2011	Acceptable (4)
River Road Station 23	43.29572, -86.24427	7.13.2011	Acceptable (-2)
Giles Road Station 24	43.27795, -86.24443	7.19.2011	Acceptable (0)



Station 22 is located where Bear Creek crosses McMillan Road. This station had excellent biodiversity, with 32 different taxa being found. There were nine total taxa found in the mayfly and caddisfly groups, but none in the stonefly group- which is the only negative mark this station received. All other scoring metrics for this station were found to be either within two standard deviations for excellent streams, or above average for excellent streams. With the positive above average "1" scores and the lack of "-1" scores, this station received an overall "acceptable" 4 rating. This station only had a 3.5% composition of macroinvertebrates in the isopod, snail and leech group, indicating good water quality. The McMillan road location habitat was rated "good," indicating slight impairment. The substrate and in-stream cover metric, as well as the channel morphology metric, rated poorly- with substrate and in-stream cover rating the lowest at this location.

Station 23 is located just downstream of River Road. Station 23 corresponds to Sample Station D1 from the 1987 RAP, and is just downstream of where the unnamed tributary and Little Bear Creek meet. There were seven pollution intolerant taxa found from the mayfly and caddisfly groups, and less than 14% of all macroinvertebrates sampled were from the isopod, snail and leech group. This station was more than two standard deviations from excellent streams for number of stonefly taxa, percent isopod, snail and leech composition, and percent surface air breather composition. This station was within two standard deviations from excellent streams for all other metrics except number of mayfly taxa, in which it was above average for excellent streams. Overall, this station received an "acceptable" -2 rating. The River Road station received a "good" habitat rating, indicating slight impairment. The riparian and bank structure metrics rated very high, while channel morphology rated low. This site was receiving AOC support at the time of the 2011 study. Though this station does correspond with the 1987 RAP sample station location, it is in fact not on the unnamed tributary. It is downstream of where the unnamed tributary and Little Bear Creek meet. The unnamed tributary was not sampled in 2011 due to damming causing wooded wetlands, intermittent flow, and excessive duckweed cover.

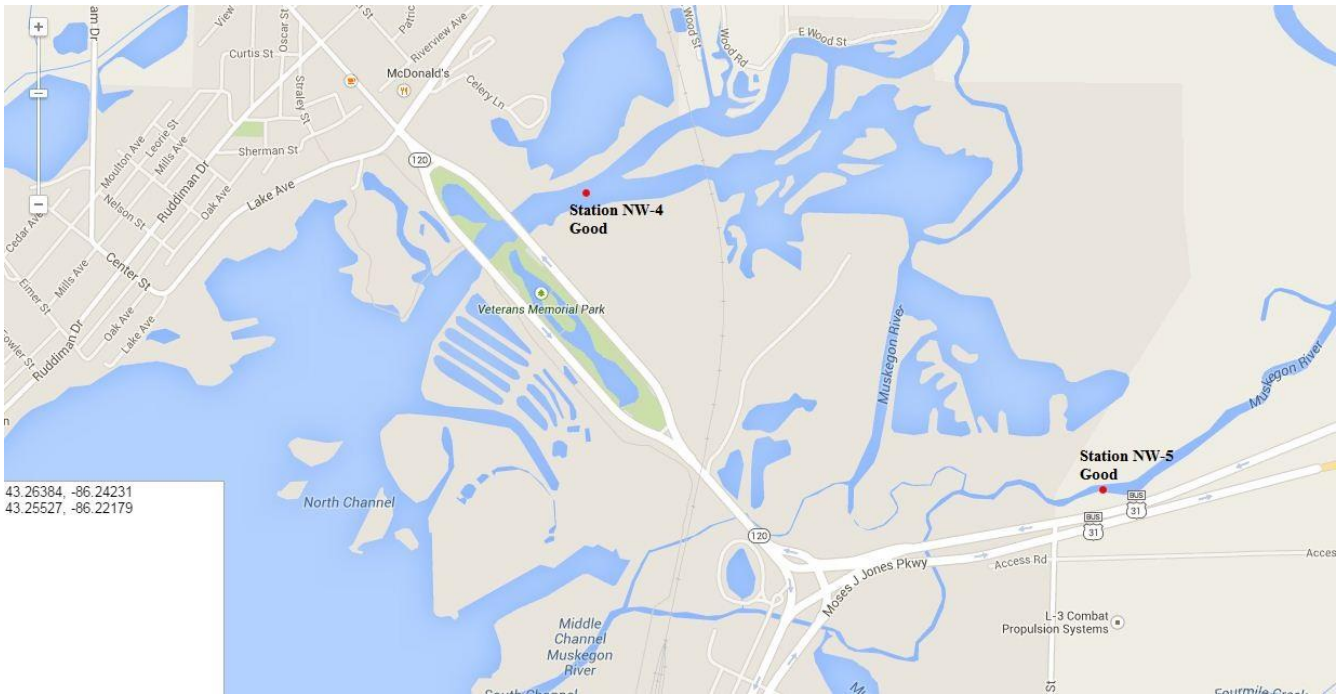
Station 24 is located where the stream crosses under Giles Road, and is downstream of Station 23. This station had considerably more biodiversity than the upstream Station 23, and an even smaller

percentage of its sampled taxa from the isopod, snail and leech group (~5%). This station was more than two standard deviations from excellent streams in number of stonefly taxa and percent dominant taxa. Number of caddisfly taxa and percent air breather composition were found to be better than average for excellent streams. All other metrics were rated within two standard deviations from excellent streams. Thus, this location rated an "acceptable" score of 0. The Giles Road location rated "good" in habitat quality, indicating slight impairment. The riparian and bank structure metrics rated very high, while the substrate and in-stream cover metric rated low.

There has been no remediation work performed at any of the sampling locations on Little Bear Creek or Bear Creek. However, there is remediation work currently being performed on the unnamed tributary as part of the remediation efforts of the Cordova/Ott-Story Chemical Company superfund site.

Muskegon River North & South Branch

Sample Location	GPS Coordinates	Sample Date	Non-Wadable Streams Macroinvertebrate Rating
North; Upstream from Muskegon Lake Mouth Station NW-4	43.26384, -86.24231	6.29.2011	Good (53)
South; Teledyne Station NW-5	43.25527, -86.22179	6.30.2011	Good (74)



The North and South Branches of the Muskegon River were sampled using a protocol that at the time was still in development for non-wadable rivers (now called P-22, developed 2013). Thus, the scoring metrics for these two stations are different than the previously scored wadable-reach stations.

Station 4 (North Branch) scored moderately well for species richness. This station was predominately amphipods, but there was also a large number of mayflies found. Station 4 scored moderately well for filter feeder group diversity, and all measure filter feeder groups- including scrapers, shredders, collector-gatherers, collector-filterers, and predators- were found at this station. Station 4 received an overall metric score of 53, placing it as "good" for macroinvertebrate communities.

Station 5 (South Branch) had a much higher species richness than Station 4. Station 5 had 32 different species sampled as opposed to Station 4's 19 species sampled. However, this may be because Station 4 is located at the mouth of the Muskegon River, where as Station 5 was located mid-reach. Station 5 was found to have a large number of amphipods, stoneflies, and caddisflies, and a moderate number of mayflies. This station received the highest scores possible for the metrics "% trichoptera," "filter feeder group diversity," and "total richness." Overall, Station 5 received a combined metric score of 74, placing it higher than Station 4 and in the "good" category for macroinvertebrate communities.

Both locations were found to have high EPT and overall richness, as well as having all three pollution intolerant indicator species (ephemeroptera, plecoptera and trichoptera). However, both locations scored poorly for "habitat stability FFG surrogate." The FFG surrogate metric for habitat stability is a metric that allows surveyors to quantify the availability of steady surfaces for the collection and scraping of fine particulate organic matter (FPOM). Filtering-collectors and scrapers require stead surfaces within the stream for nutrient gathering, as opposed to gathering-collectors and shredders, which utilize FPOM benthos. Thus, scoring low in this metric indicates that this station lacks stable surfaces to support a scraping/filtering-collector functional feeding group.

Station 4 was found to have 86 scrapers, but only 3 filtering-collectors (out of 448 collected macroinvertebrates), and received a score of 8 (out of a possible 25) for the "habitat stability FFG surrogate" metric, which corresponds to a score of "marginal." The lack of filter-collectors, again, may be attributed to this station being located at the mouth of the river. Station 5 was found to have 51 scrapers and 98 filtering-collectors (out of 654 collected macroinvertebrates), and also received a score of 8 for the "habitat stability FFG surrogate metric."

The habitat survey was performed qualitatively, as the quantitative habitat survey now found in P-22 was not yet established. Both locations were found to have adequate riparian zone vegetation, adequate stream bank stability, and evidence of human impact. No remediation work has previously been performed at either station.