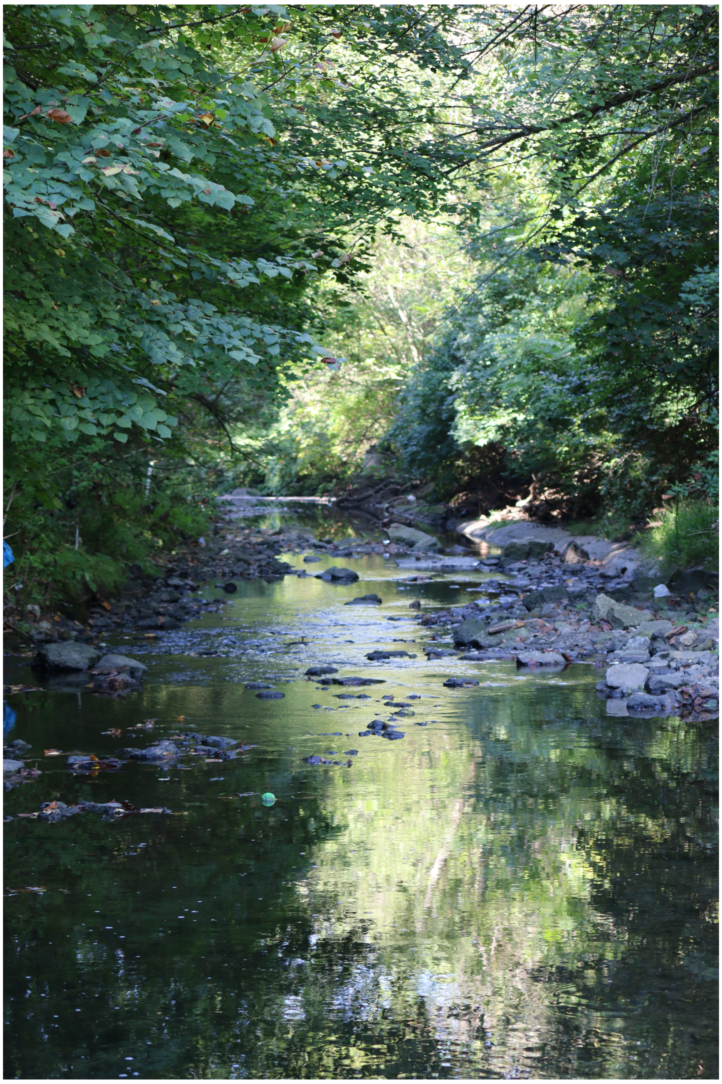

Nine Mile Run Watershed Association Presents:

"State of the Nine Mile Run Stream"
Supplemental Attachment to the 2015 Report Card

Acknowledgements

We would like to thank the Nine Mile Run Watershed Association Monitoring Committee for guidance in developing our monitoring program and for their collection and analysis of data. More specifically, we acknowledge the committee for their tremendous contributions to make this document possible.

Current Committee Members:

Daniel J. Bain, Erin Copeland, Emily Elliot, Joe Fedor, Kassia Groszewski, Sarah Lavin, Thomas J. Maier, Michael Koryak, Mary S. Kostalos, Brady Porter, Michael A. Takacs, Christopher Tracey, Ryan Utz, Jeanne M. VanBriesen

Past Committee Members:

Marc Wagner Margaret Zak, Bryan Dolney, John Buck, John Schombert, Marc Wagner, Peter Niederberger, Julie Ann Mountain, Michele Gregorich, Paige Wiegman

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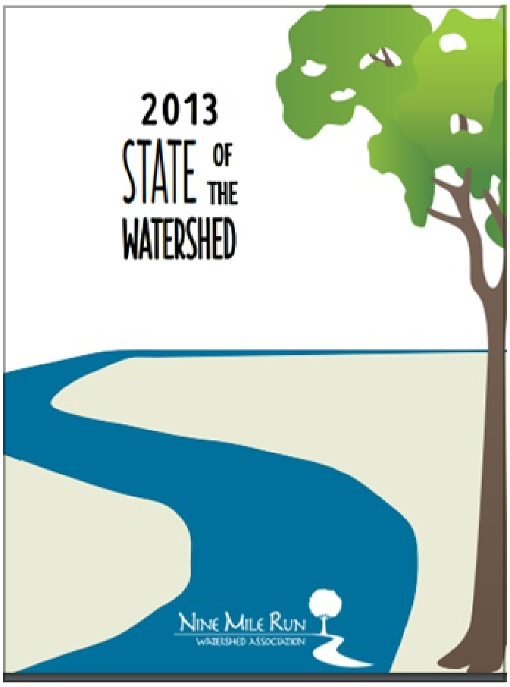

The Nine Mile Run Watershed Association (NMRWA) first began disseminating monitoring data on Nine Mile Run (NMR) to the public in 2007 with biannual State of the Watershed reports. Subsequent reports were issued in 2009, 2011, and 2013. Feedback on the reports showed a need for a shorter document that could communicate a simplified message clearly to the general public. A survey of best practices nationwide showed a report card format to be effective in achieving this goal. A Report Card would be intended to engage and educate the public, with a grading system for the water quality and ecological state of the stream based on data collected. The NMRWA Monitoring Committee is proud to present the first State of the Nine Mile Run Stream – A Report Card for the Community, which is the result of a collaborative three year process.

The State of the Stream – A Report Card for the Community includes the two-page Report Card, and, for those who desire more information, this Supplemental Narrative, and Appendices A & B. This narrative provides scientific descriptions of each parameter's grading and scoring methodology, data trends and limitations, areas for improvement in collection and analysis, and references. The parameters were divided into three main categories based on areas prioritized by the NMR monitoring program: Human Health Risk, Aquatic Habitat Support, and Wildlife. The parameters as described in these categories were chosen due to their relevance and temporal availability.

Overall Grading Methods

The data collected for each parameter, as outlined in the Table 1, were measured in various places in the NMR stream. In order to describe the state of the entire stream, the data were summarized and averaged spatially and temporally. The spatial extent is the entirety of the main stem of the Nine Mile Run stream. The temporal extent was sub-divided into three periods that surround the completion of the NMR restoration. Pre-restoration: 1999 to 2005; Post-restoration: 2006 to 2010; and Current: 2011 to 2015. These periods were chosen for their uniformity as approximate 5 year spans, allowing for the data to be averaged, completing missing gaps in data for certain parameters.

Category	Parameter
Human Health Risk	Bacteria
	Aluminum
	Lead
Aquatic Habitat Support	pH
	Dissolved Oxygen
	Nitrogen
Wildlife	Macroinvertebrates
	Fish

Table 1: Monitoring Parameters

The data for each parameter were scored on each individual time period, based on an equal weight model, and assigned a grade based on the score (see Table 2). The resulting scores from each parameter were averaged over all three periods and assigned a grade based on their score range as defined in Table 2. The data for each parameter were scored on each individual time period, based on an equal weight model, and assigned a grade based on the score (see Table 2). The resulting scores from each parameter were averaged over all three periods and assigned a grade based on their score range as defined in Table 2.

The result of this process provided the overall grades and scores as defined in Table 3, which reveals a distinct trend. Prior to any restoration, the stream was in extremely poor ecological health, but after the restoration, the ecological health has gradually improved. It should be noted that this narrative

Grade	Score Range	Score	Description
A+	100	100	Most healthy
A	80-100	90	Supports growth
B	60-80	70	Supports spawning
C	40-60	50	Moderate stress
D	20-40	30	Severe Stress
F	0-20	10	Fatal

Table 2: Grading & Score Ranges

Years	1999-2005	2006-2010	2011-2015
Grade	F	D	C
Score	16	35	44

Table 3: Overall Scores – pre, post, and current

does not describe the data collection methods (refer to the Stream Monitoring Protocols document for further information), nor does this report discuss any remediation approaches to the trends shown by the data.

Overall Analysis Limitations

It should also be noted that there are some limitations to the Report Card grading system. First, while most of the thresholds applied on grading the parameters are based on State and/or Federal standards, some were adapted specifically for NMR. Such adaptations of thresholds allowed us to reveal the progression in water quality of NMR over the past 15 years (disclosure of specific thresholds is outlined in each parameter sections).

Another analytical limitation was that the data averages the entire 2.2 miles of above ground stream, thus not accounting for any inter-stream variability at specific locations. Additionally, the use of 5 year periods does not portray the seasonal variability of the parameters.

Through this process, the Monitoring Committee and NMRWA identified data gaps and areas that need improvement in the program to create a more robust and accurate monitoring program. Each parameter addresses specific areas of improvement, but overall the process revealed the importance of consistent and purposeful monitoring. Going forward, overall goals of future report cards are to include more parameters and increase the capture of data during various seasons and wet weather events.

The Report Card contains a set of parameters that the NMRWA Monitoring Committee monitors in the stream. As stated previously, the parameters contained within these analyses were chosen not only for their ability to indicate ecological health, but also based on the availability of complete data sets over the past 15 years. Other parameters such as, temperature and Streamflow are monitored, but were not analyzed for this Report Card. Refer to the NMRWA Stream Monitoring Protocols for a complete list of parameters monitored.

Human Health Risk

The eventual goal for the waterways in our region is to be fishable and swimmable. NMR is committed to this goal especially given that the stream is within a public park with visitors having daily access. Bacteria, fecal coliform, and the metals, aluminum and lead, are typical parameters used to measure the risk humans may experience due to stream exposure. Additional parameters that the Monitoring Committee is considering collecting and analyzing include lead, chromium, and barium.

Bacteria

Bacteria and viruses occur naturally in fresh water systems and in the intestines of humans and animals. Most are harmless to humans and animals, but some are pathogenic and can cause illness. Pathogens can come from the feces of humans, pets, and wildlife. In addition to the possible health risk associated with elevated concentrations of pathogens, they can also cause cloudy water and unpleasant odors.

Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for the presence of indicator bacteria instead. Fecal coliform bacteria are often referred to as "indicator organisms" because they indicate the potential presence of disease-causing bacteria in water. Total coliforms are a group of bacteria that are widespread in nature, and fecal coliforms are a subset of this group, which is more specific in origin (i.e. originating from feces). The presence of coliform bacteria in water does not guarantee that the water will cause an illness. Most types of coliform bacteria are harmless to humans, but some can cause mild illnesses and a few can lead to serious waterborne diseases.

Aside from the health risk, measuring the bacteria levels can also help to quantify the impact of sanitary sewage and animal waste impacting the stream. Sources of bacterial contamination include illicit sewage discharges, combined sewer and sanitary sewer overflows, leaky sewer lines, storm water runoff, and pets and/or wildlife.

Grading Method

The grades for analyzing the fecal coliform counts are based on Pennsylvania Standards as defined in the Pennsylvania State Code, Chapter 93, Section 7 "Water Quality Standards" (referred to as 'PA code quality standard' hence forth), see Table 4 for thresholds (see Appendix B for a copy of the standard guidelines). The EPA recommends Escherichia coli (E. coli) as the best indicator of health risk from water contact in recreational waters. For the purposes of this report, the metric is based on the state standard of fecal coliform counts.

Threshold (cfu/ ml)	Grade	Score
0	A+	100
<200	A	90
200 - 2,000	B	70
2,001 - 20,000	C	50
20,001 - 200,000	D	30
>200,000	F	10

Table 4: Thresholds for grading fecal counts

The grading scale, as defined in Table 4, is based on both the recreational season (April 1 through September 30) standard of 200 total colony forming units (cfu)/ 100 mL and the non-recreational season (October 1 through March 31) standard of 2,000 cfu/100 mL. The scale is a log-scale combination of the recreational and non-recreational state threshold standards. The scale uses both the recreational and non-recreational season standards because the samples are taken throughout the year in the dataset and thus it was important to incorporate both seasons since the grade and score is an overall average. Additionally, the scale was developed to be realistic for the NMR environment and truly disclose the positive trend of reduction in sewage in NMR over the last 15 years. When only the recreational standard was applied to the dataset, the data failed to ever meet the threshold, showing no improvement. This was one example where State and Federal standards were adapted to better fit the Report Card.

Results Summary

The average bacteria (fecal coliform) levels in NMR from 1999-2015 are displayed in Figure 1. The average for the three analyzed eras, pre-, post-, and current, are displayed in Table 5. Over the past 15 years, there has been a significant decrease in fecal coliform levels in the stream but compared to the standards required for recreation, NMR remains considerably higher than the 200 cfu maximum for recreational exposure.

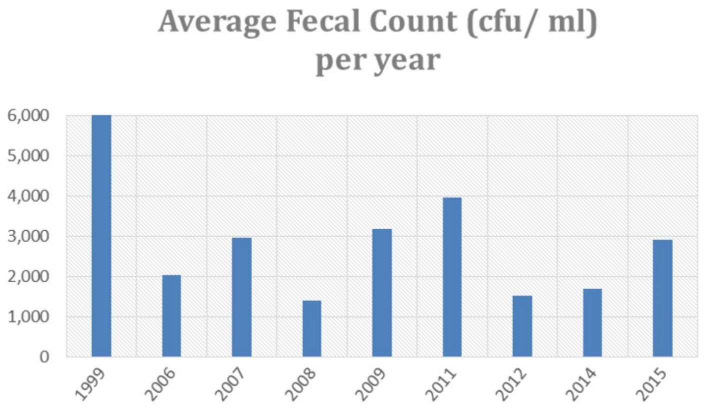

Figure 1: Average Annual Fecal Count

Throughout the time span of monitoring the stream, bacteria levels have decreased from an average of 320,000 cfu in the 1990's to closer to an average of 2,000 cfu, which approaches the non-recreational standard level. An overall analysis of the data indicates that during dry weather conditions, the bacteria levels in the stream decrease from the top moving downstream. Several factors may account for the decrease during dry weather periods including dilution of the stream through the inflow of clean groundwater and/or the natural decay of bacteria, caused by sunlight, temperature, nutrients, or salinity.

Bacteria levels, however, remain high throughout the stream during wet weather conditions. In the NMR watershed and the Pittsburgh region, increased rainfall overloads the combined sewer system and causes overflows that discharge directly into the waterways. In Figure 2, this trend is highlighted for our region. Along NMR, there are 3 combined sewer overflows (CSO's) and 3 sanitary sewer overflows (SSO's). In addition to the discharge of sewage into the stream during wet weather, bacteria levels are attributed to leaks in the aged pipes that crisscross the stream, as well as inflow and infiltration between old and damaged sanitary and storm sewer lines in the watershed. Bacteria loads in NMR are also caused by pet and wildlife feces.

Years	1999-2005	2006-2010	2011-2015
Fecal Count (cfu)	320,000	2,618	2,197
Grade	F	C	C
Score	10	50	50

Table 5: Average Fecal Count per temporal period

The spike of cfu's in 2011 can be attributed to a very intense rainfall year. The bacteria levels within the stream continue to exceed the PADEP primary contact threshold criterion of 200 Total cfu/100ml during the recreational season. During the non-recreational season, the bacterial levels are periodically below the criterion level of 2,000 cfu/100 ml. Primary contact activities include bathing, swimming, wading, and water contact sports. Secondary contact activities include boating and fishing.

Analyses of stream nitrogen concentration and isotope signature data by the University of Pittsburgh indicates that sewage-influenced water is present in Nine Mile Run during both normal stream flow and stormflows.

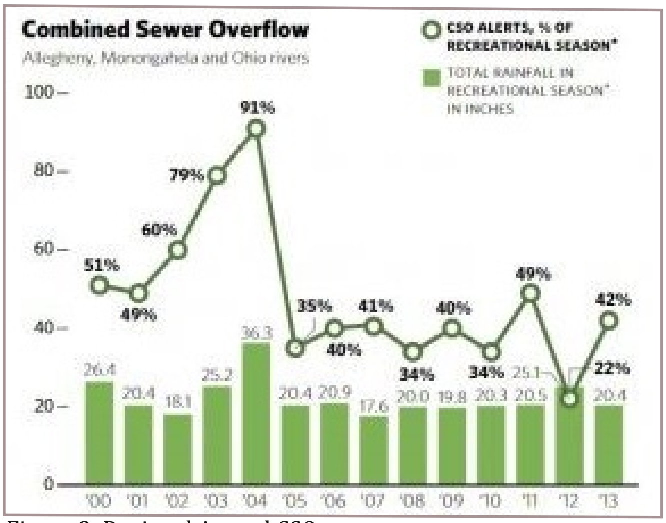

Figure 2: Regional Annual CSOs

Potential improvements to allow a better understanding of levels of bacteria in NMR include both sampling the stream all year long on a monthly basis (both the recreation and non-recreation season), and analyzing the difference between wet and dry weather conditions. To better understand the source of bacteria requires analysis of the nitrogen signatures present within the samples.

Metals

Given that all natural water contains some dissolved metal concentrations, water quality evaluations determine "how much metal" (i.e., the concentration of metals) is in the water. The quantity and mobilizations of specific metals can increase risks for human health in recreation but can also limit the diversity and size of fish and macroinvertebrate populations. Identifying metals can also contribute to understanding the source of specific pollution in the stream from the surrounding watershed. There are many metallic elements that may be found in freshwater. For the 2016 report card we focus on aluminum (Al) and lead (Pb). Aluminum will dissolve in both highly acidic and basic environments, making it sensitive to both acidic mine drainage, unlikely in the NMR watershed, and basic steel slag leachate, which is present in the NMR Watershed. Lead can indicate a wide variety of contamination sources ranging from historic lead anti-knocking agents in vehicle exhaust to coal combustion. Pittsburgh's long history of industrial production has imparted a substantial amount of metal contamination. Al and Pb were selected for analysis for the range of sources they can indicate and because there is historical data available. As stream monitoring continues, it is likely additional indicator metals can be added to the Report Card.

Grading Method

Al Thresholds (ppb)	Grade	Score
<80	A+	100
80-87	A	90
87-100	B	70
100-200	C	50
200-300	D	30
>300	F	10

Table 6: Thresholds for grading Aluminum

Pb Thresholds (ppb)	Grade	Score
0	A+	100
0.5	A	90
.5-1.5	B	70
1.5-2.0	C	50
2.0-2.5	D	30
>2.5	F	10

Table 7: Thresholds for grading Lead (Pb)

Grades are based on the US Environmental Protection Agency's (USEPA's) "Water Quality and Aquatic Life Criteria". Metal concentrations are evaluated against levels that will harm freshwater life. Both lead and aluminum were compared to the chronic levels. As a reminder, chronic exposures would be those that occur on a regular basis, while acute exposures are harmful if exposure occurs for even a very brief period.

For Al, the maximum concentration of "total" aluminum are 87 parts per billion (ppb) for chronic exposures and 750 ppb for acute exposures are considered harmful. A scale for aluminum was developed based on the maximum chronic threshold as 87 ppb. See Table 6 for grading thresholds of Aluminum.

Chronic exposure to dissolved Pb greater than 2.5 ppb and acute exposure greater than 65 ppb are considered harmful. The lead levels varied, and the grading thresholds in Table 7 were applied to the data, based on the defined maximum chronic threshold of 2.5 ppb.

Results Summary

The average total Aluminum levels in NMR per year from 1999- 2015 are displayed in Figure 3. The average for the 3 analyzed eras, pre-, post-, and current, are displayed in Table 8. The aluminum levels exceeded the chronic level of 87 ppb every year but did not surpass the acute level of 750 ppb. Comparing the pre-restoration and current vales of Al, a decrease of 24 ppb is noted. The elevated concentration in 2009, the highest average of 749 ppb, may have been caused by the seep abatement failure, which was subsequently repaired (see discussion in the pH section on page 10).

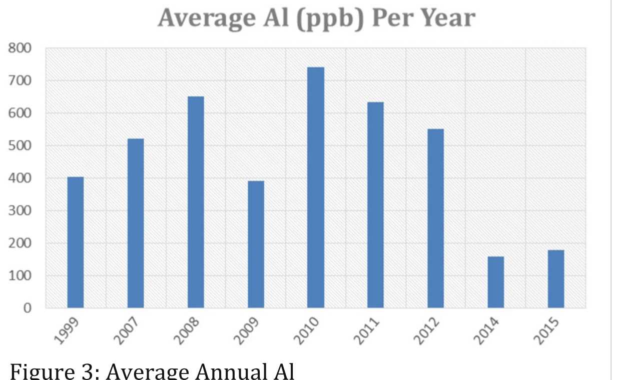

Figure 3: Average Annual Al

Years	1999-2005	2006-2010	2011-2015
Al (ppb)	405	576	381
Grade	F	F	F
Score	10	10	10

Table 8: Aluminum (Al) – pre, post, & current

The most current years, 2014 and 2015, show a significant decrease, which could be due to the implementation of a standardized sampling methodology (see protocols for more information).

The average Total Pb levels in NMR per year from 1999-2015 are displayed in Figure 4. The average for the 3 analyzed eras, pre-, post-, and current, are displayed in Table 9. Overall, there has been a slight decrease in the Total Pb levels . Based on available data, there has been an increase in total lead concentrations.

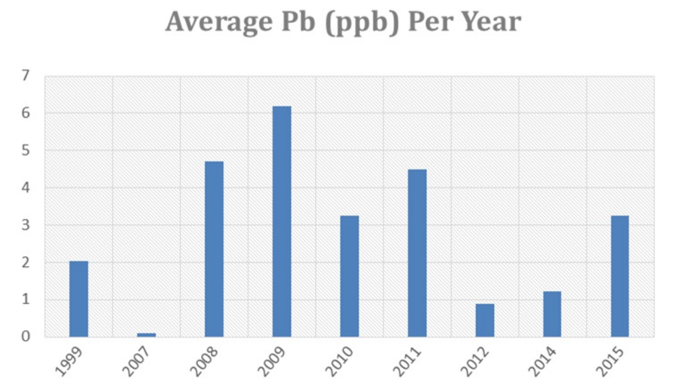

Figure 4: Average Annual Pb

Years	1999-2005	2006-2010	2011-2015
Pb (ppb)	2.03	1.91	2.27
Grade	D	C	D
Score	30	50	30

Table 9: Lead (Pb) – pre, post, & current

In both chronic and acute cases, water quality in Nine Mile Run is poor. Lead concentrations have consistently been above the chronic exposure level. Worse, while aluminum is consistently above the chronic exposure level, it also exceeds acute exposure levels in multiple individual samples through time. It is possible that a background, up-gradient source exists for aluminum. The identification of this potential source is beyond the scope of the stream monitoring efforts.

It is likely that the reported Al and Pb are over estimates. The available lead concentrations used for the report card are "total" Pb. In other words, the Pb concentrations are measured without filtering the water. Lead that is attached to suspended sediments in the water is much less available to aquatic life. As monitoring continues and true "dissolved" Pb concentrations (i.e., the suspended sediments are removed prior to measurement) are collected it may emerge that the Pb concentrations are lower than reported here. Likewise, while these Al concentrations are used by the USEPA, the written guidance recognizes the fact that "total" measures of Al can appear elevated due to suspended clay particles. Clay particle impacts to gill tissue are much less than that of dissolved Al. The proposal to change the Al fresh water criteria is long standing. One possibility is that the Al measurements are elevated in part due to clay materials collected in the sample and the actual impact to aquatic life is overstated in this report.

There are several potential improvements we could incorporate to better understand the trend levels of metals in NMR, such as, installing in-stream sensors to capture data at high temporal resolution. Another important improvement would be to capture, analyze and report "dissolved" concentrations in addition to analyzing other critical metallic elements.

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Aquatic Habitat Support

The NMR stream is not only used by public park visitors, but is also an important urban ecosystem providing habitat for a variety of animals, both below the water's surface and above. This category addresses the needs for wildlife below the water's surface: macroinvertebrates, fish, amphibians, and reptiles. The following 3 parameters, pH, dissolved oxygen, and nitrogen, were chosen to physically describe the NMR's aquatic habitat. Additional parameters that the Monitoring Committee is considering analyzing in the future include: salinity, turbidity, trash, sodium and chloride ions, and conductivity.

pH

pH is a measurement of free hydrogen and hydroxyl ions in water. In freshwater streams, fish and macroinvertebrates specifically prefer a neutral pH range of 6 to 8 with very high (>9.5) or very low (<4.5) pH values unsuitable for most aquatic organisms. A higher pH indicates an alkaline or basic condition, with a high concentration of hydroxyl ions, which can be harmful for some aquatic organisms. For example, a pH above 9.4 can cause the release of toxic concentrations of ammonia or a harmful algae bloom. A high pH can also cause the precipitation of calcium, magnesium and aluminum ions, leading to other imbalances that can have detrimental effects on aquatic life.

Low pH indicates an acidic condition that increases the solubility of any existing heavy metals. As the level of hydrogen ions increases, metals such as aluminum, lead, copper and cadmium are released into the water. As the concentrations of heavy metals increase, their toxicity to aquatic life also increases. Young fish and immature stages of aquatic insects are extremely sensitive to pH levels below 5.

Grading Method

The NMR pH grade was based on the standards required for aquatic habitat support. The PA code quality standard (see Appendix B) defines a pH range of 6.0 to 9.0, inclusive, as acceptable to support aquatic life, specifically fish populations.

The Federal Aquatic Water Quality Criteria (AWQC, see Appendix B) defines 6.5 to 9.0, inclusive, as the acceptable pH range for freshwater. Table 10 describes the threshold grading scale applied to the pH data with the most optimal conditions being defined as 7.4 to 7.6. Any conditions below 4.0 or above 11.0 were designated as fatal conditions. Amphibians require a different pH range (see Image: Minimum pH Levels), but this was not taken into account in the assessment.

pH Thresholds	Grade	Score %
7.4-7.6	A+	100
6.5-7.4 & 7.6-8.5	A	80
6.0-6.5 & 8.5-9.0	B	70
5.0-6.0 & 9.0-1.0	C	50
4.0-5.0 & 10.0-11.0	D	30
<4.0 & >11.0	F	15

Table 10: Thresholds for grading pH

Results Summary

The average pH measurements in NMR from 1999-2015 are displayed in Figure 5. Averages for the three analyzed eras, pre-, post-, and current, are displayed in Table 11. Overall, there has been a significant decrease in the average pH measurements, resulting in much healthier aquatic habitat.

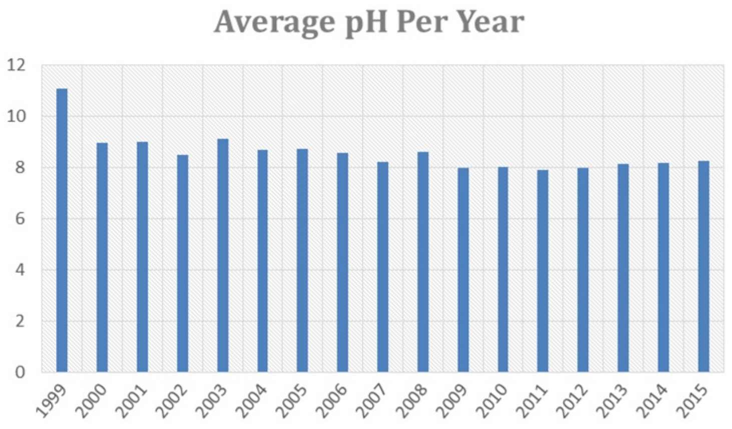

Figure 5: Annual Average pH

Years	1999-2005	2006-2010	2011-2015
pH	11.0	8.6	8.1
Grade	F	B	A
Score	15	70	80

Table 11: pH past, present, and Future

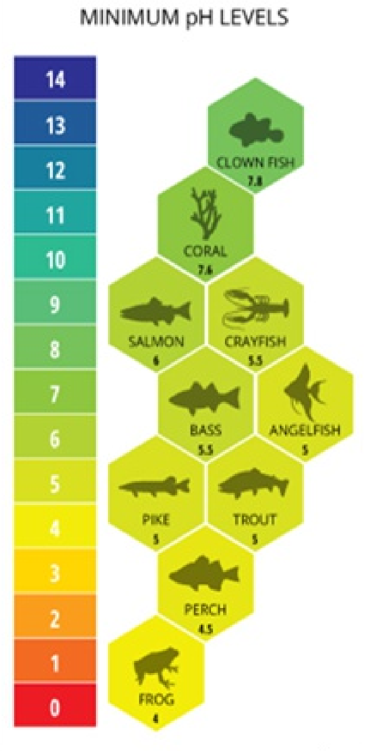

Figure 6: Recommended minimum pH levels for aquatic life (Source: Fondreist)

Prior to 2005, the slag pile, which was the major point source of pollution, caused high alkaline levels in NMR, increasing pH up to 12. A seep abatement project was completed by the Urban Redevelopment Authority (URA) in 2005 to trap leachate from seeps along the historic slag heap and to direct them to Pittsburgh Water and Sewer Authority (PWSA) lines that transport the water to Allegheny County Sanitary Authority (ALCOSAN) for treatment. The seep abatement runs along the lower portion of the stream, across from the neighborhood of Duck Hollow. This abatement effort has rerouted pollution from discharging directly into the stream. Monitoring results indicate this project was a success, as the mass/diversity of fish and benthic organisms in NMR has increased. The analytical results suggest that there is no systematic impact on NMR from the slag heap during low flow conditions. However, in 2009, the seep abatement failed and discharged high pH water before being repaired by the URA, the pH and metal concentrations were impacted.

Other causes to pH fluctuations include the high amount of stormwater runoff from the upper urban watershed and sanitary wastes discharge. With the use of road salt, stormwater runoff carries salts to the stream which decreases the amount of hydrogen ions and increases the pH. The riparian and wetland restoration were instrumental for protecting the pH of the stream since the vegetation can filter out the pollutants before reaching the stream. It should be noted that with the random spot checks, there is a bias in the data and the seasonality and/or variability of pH may not be captured.

Another impact to pH is the local photosynthesis process; plant respiration increases pH whereas plant decomposition lowers pH levels. Most bodies of water are able to buffer these changes, so small or localized fluctuations are quickly modified. IN NMR, the buffering capacity nor any spike or shocks of pH are not detected since measurements are recorded at the same time of day only about once a month (refer to the Protocols for specific methodology). In the future this is important to assess because prolonged and consistent shocks of pH extremes can have detrimental effects on the wildlife communities dependent on NMR.

Potential improvements to better understand pH levels in NMR include installing in-stream sensors to increase temporal resolution. With increased temporal data points, analyses of pH flashiness and seasonality may reveal a pattern. Another potential improvement would be to compare pH to alkalinity to measure the buffer capacity of NMR.

Dissolved Oxygen (DO)

Non-compound oxygen, or free oxygen (O2), is oxygen that is not bonded to any other element. Dissolved oxygen is the presence of these free O2 molecules within water. Dissolved oxygen (DO) is necessary to many forms of life including fish, invertebrates, bacteria, and plants. These organisms use oxygen in respiration, similar to organisms on land. Fish and crustaceans obtain oxygen for respiration through their gills, while plant life and phytoplankton require dissolved oxygen for respiration when there is no light for photosynthesis.

DO Thresholds (mg/L)	Grade	Score %
>9.0	A+	100
>7.0 <9.0	A	80
6.0-7.0	B	70
5.0-6.0	C	50
3.0-5.0	D	30
<3.0	F	15

Table 12: Thresholds for grading DO

Oxygen enters a stream mainly from the atmosphere, and through groundwater discharge, in areas where that accounts for a large portion of streamflow. Rapidly moving water, such as in a mountain stream or large river, tends to contain a lot of dissolved oxygen, whereas stagnant water contains less. Bacteria in water can consume oxygen as organic matter decays. Thus, excess organic material in lakes and rivers can cause eutrophic conditions, which is an oxygen-deficient situation that can cause a water body "to die."

Grading Method

Due to the certain limitations, the Committee decided to not grade the DO dataset. If the DO was graded, Table 12 would be applied. While most aquatic life utilizes DO to respire, the thresholds in this analysis are specifically based on fish standards from the Water Research Center (see references).

Results Summary

The average for the three analyzed eras, pre-, post-, and current, are displayed in Table 13. While there is a noted increase in available DO and levels that meet the threshold of exceeding 9.0 mg/L in the stream, the data was determined to be insufficient, due to bias discovered in the collection method.

Years	1999-2005	2006-2010	2011-2015
DO (mg/L)	8.8	No Data	12.5
Grade	n/a		n/a
Score	n/a		n/a

Table 13: DO pre, post, and current

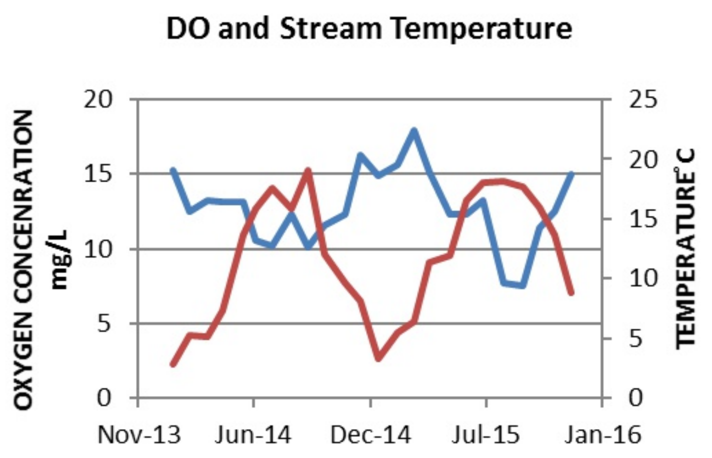

Figure 7: Average Annual Concentration of DO in NMR

The primary bias in the collection method was the time of day (TOD) DO was recorded. The DO measurements were recorded in the late morning. Typically, DO is higher at these times due to high photosynthesis rates. This time of day does not account for the drops in DO that occur at night nor the flashiness of isolated events such as road salt runoff, storm events, etc. In 2016, a sensor was installed, capturing DO at a high temporal scale. From the 2016 data, it has thus far been concluded that there are significant diurnal and event-related trends. Even in winter there were documented extreme decreases in DO. More analysis on the 2016 and continual data is needed in the future.

Another bias to the data is the seasonal impact. The DO measurements and air temperatures recorded for NMR (see Figure 6) align with seasonal variations as predicted for general freshwater systems (see Figure 7). Higher temperature decrease DO, resulting in a stressful environment for aquatic life. Compare Figures 6 and 7 for reference. Based on the NMR data in Figure 6, there is a noticeable lack of variance in the DO levels in correlation with air temperature. Two contributing factors could be slow salt release rates and the presence of high levels of organic matter.

Potential improvements to better understand the DO levels in NMR include installing in-stream sensors to capture pH at a high temporal resolution. With increased temporal data points, an analysis of DO flashiness, diurnal fluxes, and seasonality may reveal a pattern. Another potential improvement would be to further compare DO to stream water temperature, salinity, or precipitation to better understand relationships and causes of water quality in NMR.

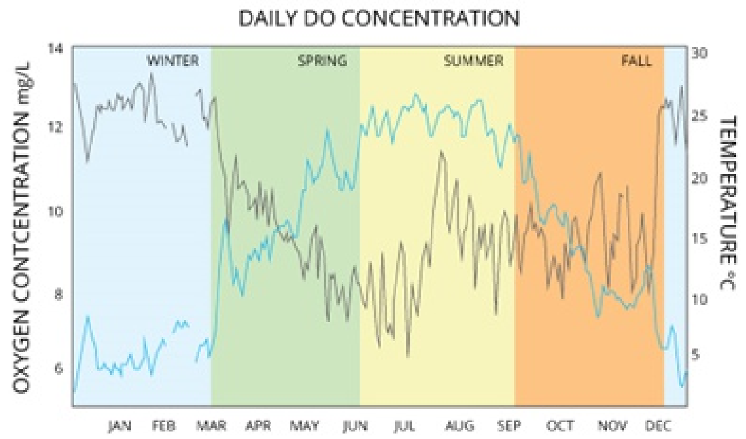

Figure 8: Daily DO Concentrations

Nitrogen

Section under construction.

Wildlife

Wildlife living below the water's surface that NMR monitors includes macroinvertebrates and fish. These organisms are sensitive to water quality and local habitat regimes, which makes them terrific indicators of overall ecological health. Other indicator species the Monitoring Committee is considering collecting data on include birds, reptiles, and amphibians.

Macroinvertebrates

The diversity (number of different species) and numbers (biomass) of aquatic macroinvertebrates (insects, crustaceans, and various worm-like organisms) are important indicators of stream condition and overall ecological health.

Clean and healthy streams are full of aquatic life. If you were to look underneath rocks and stir up the sediment in a stream, you would often find tiny creatures called benthic macroinvertebrates. These are freshwater organisms that live in and on the stream bottom. The abundance and diversity of these organisms are good indicators of local stream health because they have limited mobility (compared to fish) and they respond quickly to pollutants and other environmental stressors. Typically, macroinvertebrates will settle in areas most suitable for their survival – therefore providing a simple method to assess water quality in a stream. Since macroinvertebrates differ in their ability to tolerate pollution, if the macroinvertebrate population in a stream consists exclusively of pollution tolerant species, you can assume poor water quality conditions.

Grading Method

Macroinvertebrates were identified to lowest taxa level possible, then each group was assigned a Pollution Tolerant Value (PTV), as defined by the 2012 PAEP Manual, A Benthic Macroinvertebrate Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania (referred to as 'PADEP manual' hence forth). See Appendix A, Table 1A for reference of the individuals, counts, and PTV assigned. The PTV's are defined by the PADEP manual, Appendix D: Table of Taxa. The aquatic macroinvertebrates were scored on an index modeled after the index of biotic integrity (IBI) defined by the PADEP manual.

The Committee decided to adapt the PADEP manual IBI scoring method, because NMR is an urban stream and therefore does not compare well with other streams of its size in less negatively impacted environments. The macroinvertebrates of NMR were, and remain, so severely impacted that the scored data registers at the lower end of the overall state spectrum. Therefore, we adapted the IBI method to better portray the progress of macroinvertebrate communities within NMR as described below.

PADEP IBI		NMR IBI	
Metric	Standard Factor for Smaller streams (1st to 3rd order, < 25 square miles)	**Metric**	Standard Factor for Smaller streams (1st to 3rd order, < 25 square miles)
Total Taxa Richness	33	**% Taxa Richness**	33
EPT Taxa Richness (PTV 0-4 only)	19	**% Dominance Individuals**	0
Beck's Index (version 3)	38	**% Sensitive Individuals (PTV 0-3 only)**	0
Hilsenhoff Biotic index	1.89	**% EPT Individuals**	0
Shannon Diversity	2.86		
% Sensitive Individuals (PTV 0-3 only)	84.5		

Table 16: PA IBI compared to NMR IBI metrics for grading macroinvertebrates

IBI Score	Grade	Score %
100	A+	100
≥85 -<100	A	80
≥65 - <85	B	70
≥55 - >65	C	50
≥25 - >55	D	30
0 - <25	F	15

Table 17: Thresholds for Grading

The PADEP utilizes 6 metrics and standard factors for the IBI. For the assessment of NMR, a NMR IBI was created which the PADEP IBI score modified the PADEP IBI and uses only 4 metrics and 1 standard factor. Additionally the 4 metrics are calculations of percent individuals. When the PA IBI with the standardization factors were applied to the NMR data, there was zero progress indicated. The PADEP manual applies a standardization factor to the observed metric values to account for stream size and comparison. In the NMR score, we did not apply the standardization score, only accounted the observed values (with the exception of % Total Taxa Richness), in order to disclose the relevant biodiversity patterns. Table 16 compares the PADEP manual index metrics to the metrics used for NMR index.

The metric IBI's were calculated, equal weight, for each year. The metric IBI's were then summed, and equally weighted to derive an overall IBI for each year. The average IBI for each time period (pre, post, and current) was calculated. The average IBI was compared to the grading scale (see Table 17) and a grade was assigned to each time period (pre, post, and current).

Results Summary

The numbers and diversity of aquatic macroinvertebrates are important indicators of stream condition and overall health. Occasional intermittent studies prior to 1990, found few pollution tolerant organisms. In 2000, a standardized sampling protocol was established to gather baseline data before the restoration work started in 2006. Two different sites were consistently sampled, the Commercial Street site and the Duck Hollow site, a few hundred yards upstream where NMR empties into the Monongahela River. The samples have been aggregated into three time periods: 2000-2005 (pre restoration), 2006-2010 (construction- immediate post-restoration), and 2010-2015 (current). The samples were grouped to account for considerable variations from sample to sample and year to year based on weather conditions just prior to sampling and other factors.

The average macroinvertebrate IBI scores in NMR from 2000-2015 are displayed in Figure 9. The average for the three analyzed eras, pre-, post-, and current, are displayed in Table 18. Overall, based on the applied criteria, the IBI scores have increased over time.

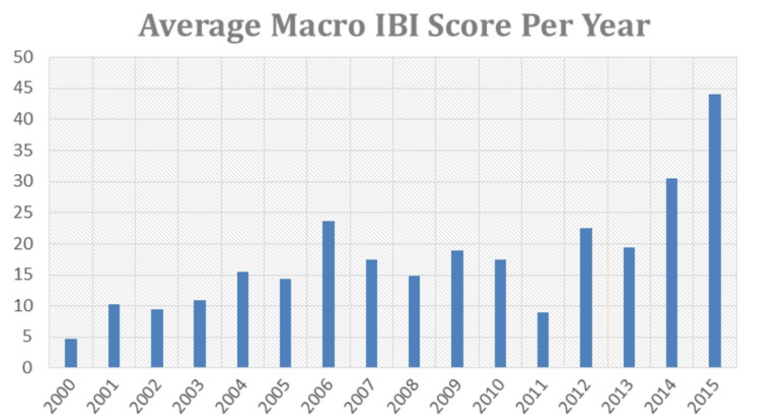

Figure 10: Average Annual Macro IBI Score

Years	2000-2005	2006-2010	2011-2015
IBI Score	11	17	25
Grade	F	F	D
Score	15	15	30

Table 18: Macroinvertebrates – pre, post, & current

The results from the pre-restoration data (2000-2005) show that the samples are dominated by three species, midges, blackflies and sludge worms, all of which are very pollution-tolerant and indicate severe sewage pollution. Total diversity was low, ranging from 2-10 different species of aquatic macroinvertebrates with an average of 6 different species/sample and an average IBI score of 11.

Improvement was noted during the first years after restoration (2006-2010) with an average IBI score of 17. Although midges continued to be one of the most common organisms, the numbers of blackflies and sludge worms decreased, especially at the Commercial Street site. Both caddisflies and mayflies became established in the stream and were found in much higher numbers, compared to the pre-construction data. Diversity showed a slight increase with 4-9 different species found/sample with an average of 7 species/sample.

The data for the current period (2011-2015) show even more improvement with an average IBI score 25. In 2015, the overall stream average IBI score is recorded to be 44, which alone would be a 'C' grade. In 2011, there was a registered decrease in IBI, as correlated with other parameters due to a significant rain event. The numbers of both caddisflies and mayflies increased substantially. At both sites the numbers of midges, blackflies and sludge worms were reduced. In many samples there were no blackflies or sludge worms. Species diversity increased. There are now three different species of caddisfly that are found routinely in the stream. Planaria are routinely found in substantial numbers, riffle beetles and damselfly larva found occasionally. The total diversity increased, ranging from 5-16 different species with an average of 10 different species/ sample.

However, macroinvertebrates have not increased in number as dramatically as fish. One plausible explanation for this is that as the number of fish in the stream has increased, the fish have begun to consume increasing numbers of invertebrates. Many species of fish feed partially or largely on invertebrates. More research needs to be done to test this hypothesis. It should be noted that, because a relatively small area of the stream is sampled, rare or extremely mobile organisms may be missed. In addition, since sampling sites are limited to riffles and rocky areas in the stream, some benthic macro-invertebrates that normally inhabit pools may not be represented.

Although the stream still has significant problems with flash flooding, sewage, and other pollutants, the restoration has helped control flooding and increase habitat diversity. This has resulted in a steady improvement in the numbers and diversity of stream macroinvertebrates.

Potential improvements to better understand the trend of macroinvertebrate communities in NMR include collecting specimens in the spring and fall seasons and including varietal habitat in sampling. Another important improvement is to incorporate assessments of the macroinvertebrate communities present in the two ephemeral tributaries to NMR, i.e., Fern Hollow and Falls Ravine. Lastly, another potential improvement would be to coordinate water quality sampling more closely with macroinvertebrate and fish sampling to be able to draw potential correlations.

Fish

Fish are key indicators of stream health for a variety of reasons, including the fact that their entire lifecycle (typically 2-10 years) occurs in the water. This makes them valuable for assessing both short and long-term water quality conditions. However, simply knowing whether or not fish live in the stream is not enough. We also need information about the presence, condition, numbers, and species of fish, since different species vary in their tolerance to pollution.

Grading Method

Fish grades in this report card are based on fish community structure data collected by annual electrofishing surveys. The fish of NMR are indentified to species level. See Appendix A, Table 2A for reference of the specific species and counts recorded per year. It should be noted that data from 2006 – 2015 was collected by the NMRWA Monitoring Committee and the data from previous years were collected from other agencies (as noted). Fish surveys were not conducted between 2000 and 2005.

Metrics in OEPA Fish IBI
Total number of fish species
Number of darter/scuplin species
Number of sunfish species
Number of sucker species
Number of minnow species
Number of intolerant species
Percent tolerant species
Percent omnivores/generalists
Percent insectivorous species
Percent top carivores/piscivores
Number of individuals/300 meters
Percent abundance of blacknose dace

Table 19: Metrics in OEPA fish IBI

The IBI values determined from standard set for in the Ohio Environmental Protection Agency, published in 1988. The metrics used to calculate the score are defined below in Table 19. For detailed metric results for the stations in NMR, see Appendix A, Table 2A, 3A, and 4A. Narrative score ratings are defined by the Ohio EPA as follows: 50 exceptional, 35-49 good, 25-34 fair, 15-24 poor, and 14 very poor. Based on the defined narrative score rating groups, the scoring and grading outlined in Table 20 was developed for NMR. Each year was scored on the IBI scale. The IBI scores were averaged for pre, post, and current time frames, assigned a grade, then assigned a score based on the overall scoring system.

Threshold (IBI Score)	Grade	Score %
50	A+	100
35-49	A	80
25-34	B	70
15-24	C	50
14	D	30
0-13	F	15

Table 20: IBI score thresholds for grading

Results Summary

The average fish IBI scores in NMR per year from 1999-2015 are displayed in Figure 10. The average for the 3 analyzed eras, pre-, post-, and current, are displayed in Table 21. Overall, based on the applied criteria, the IBI scores of fish diversity have increased over time.

Years	1990-2005	2006-2010	2011-2015
IBI	5.8	19.4	26.9
Grade	F	C	B
Score	15	50	70

Table 21: Fish – pre, post, & current

The restoration and efforts have improved water quality and physical habitat, resulting in increased fish diversity. Pre-restoration surveys showed very little diversity, with fish only present in the lower reach of NMR. In 1990, zero fish were detected in a survey conducted by the PA Fish and Boat Commission. The fish documented in 1999 and 2000 comprised of four pollution-tolerant species. In 2006 (the first year post-restoration), the IBI score increases almost two-fold from 9.5 to 19.5 compared to 2000. Fish diversity has continued to increase since 2006.

The fish community in the lower reach of Nine Mile Run is significantly influenced by transient fish from the Monongahela River. See Table 2A in Appendix A for specific fish species recorded. Over time, the fish community has become much more diverse with less tolerant species represented. As a result, IBI scores are much higher along the lower reach of the stream with grades ranging from high C to B. See Table 3A and 4A in Appendix A for IBI scores between the upper and lower stations in the stream. The lower reach improvements are the driving factor in the overall average increase present in Figure 9. A comparison of the upper and lower stream sites however is beyond the scope of this report.

While the IBI score has increased and is higher that pre-restoration values, in the 'current' era, 2011-2015, the IBI scores have leveled off (variance of the 'current' era is 2.05). The barriers to continued diversity improvement could include reduction of habitat intactness (often referred to as "longitudinal connectivity" in lotic habitat) or system shocks in water quality (example is a spike in pH or suspended sediment). Ongoing research should be conducted to explain the links between these causes.

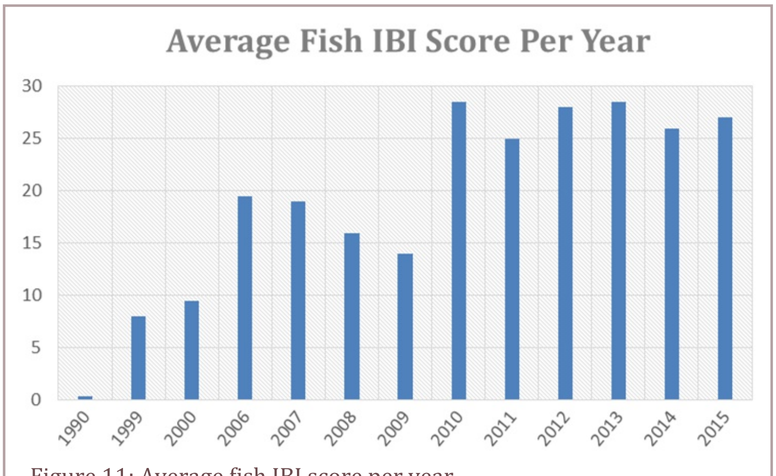

Figure 11: Average fish IBI score per year

Although the stream still has significant problems with pollution, the restoration has increased water and habitat quality, which has resulted in a steady improvement in the numbers and diversity of fish populations.

Potential improvements to better understand the trend of fish communities in NMR include collecting specimens in the spring season to analyze any seasonal influences, standardizing the length of each reach and analyzing the upper versus lower reaches. Further research into the diet of communities present and heavy metal concentrations in the tissues would also improve our understanding. A comparison between the trend in diversity against other water quality parameters (for example: pH, temperature, or DO) to potentially identify any relationships would also increase assessment understanding. Another potential improvement would be to coordinate water quality sampling more closely with macroinvertebrate and fish sampling to be able to draw potential correlations.

Conclusion

While there is still much room for improvement, overall trends in stream health indicators prove promising. The Nine Mile Run Watershed Association and its regional partners will continue to advocatefor policies and actions that will aid in thecontinuing advancement of water quality in Nine Mile Run and the Pittsburgh region.

For further information, please contact the NMRWA Restoration Stewardship Coordinator, Lindsey-Rose Flowers at *lindsey.rose@ninemilerun.org* or 412.371.8779 ext. 123.

	Pre	Post	Current
Bacteria	F	C	C
Aluminum	F	F	C
Lead	D	F	C

Table 22: Human health risk grades - pre-, post-, and current

	Pre	Post	Current
pH	F	A-	A-
Dissolved Oxygen	Insufficient Data		A+
Nitrogen (NO3)	D	D	D

Table 23: Habitat support grades - pre-, post-, and current

	Pre	Post	Current
Macroinvertebrates	F	F	D
Fish	F	C	B

Table 24: Wildlife grades - pre-, post-, and current

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