305(b)/303(d) Water Quality Integrated Report to Professor Lau for the Period of August 12, 2020 and November 20, 2020

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Executive Summary

The objective for the stream monitoring program on Connelly's Run, upstream of the landfill, was to evaluate the ecological state of the overall stream, where this program focused on the biotic and abiotic factors that affect a stream's health. To describe further, we looked at the physical, chemical, and biological components of Connelly's Run to gain an understanding of the stream's state. In order to gain this understanding, a 305(b)/303(d) report was created, where these types of reports use a mathematical approach to understand the underlying factors that would affect a stream's health. Some of the factors include poor physical attributes, increased chemical concentrations, and low benthic macroinvertebrate counts. Combining these attributes, the overall stream health is determined based on the EPA's five categories for stream health.

After conducting the assessment, the results showed that the stream was impaired due to various sources. To explain, the nitrate concentration (mg/L) exceeded the threshold for impairment by a large margin (~28 mg more than the recommended amount for a stream to be supporting life), and turbidity also passed the threshold for impairment. However, the turbidity measurement could be faulty because the sample we collected at a suboptimal time. Also, total dissolved solids (TDS) was indeterminate, where TDS is affecting the organisms but not drastically harming them, compared to nitrates. For the physical habitat, the rapid habitat assessment showed there was some factors of Connelly's run, such as low canopy cover percentage and poor riffle/pool ratio, were impairing the stream, but there were also some factors of the stream, such as sinuosity and organic habitats, that supports macroinvertebrates, so this assessment was indeterminate. Lastly, the benthic macroinvertebrate assessment, through the VSCI index, showed that Connelly's Run is supporting these organisms; however, there was a very small sample collected, where only 43 total organisms were collected out of the necessary 180-220. Because of this low count, we determined that the macroinvertebrates were impaired within the stream, even though we had a score that suggests overwise. Because of the high nitrates, high turbidity, and impaired macroinvertebrate count, the health of Connelly's Run was determined to be impaired and needs to be put on a restoration plan. This plan should focus on eliminating extra nitrates from entering the stream and assessing other components that were indeterminant from our assessment.

Introduction

Interconnections within a Stream.

In fluvial ecosystems, there are many interconnections between the physical habitat, water chemistry, macroinvertebrate assemblage, and the ecosystem's health. For example, Allen and Castillo (2007) demonstrates many of these relationships and how they interconnect. One topic they described is the effects of local seasonal patterns, such as the increase in temperature and decrease of precipitation from spring to summer, by showing the changes in pH, dissolved oxygen and carbon dioxide levels, hardness and ion concentrations in streams between the seasons. Also, natural phenomena, such as a hurricane or extreme thunderstorms, can also contribute these changes because they can introduce large amounts of water to an ecosystem rapidly or cause undesirable changes to the physical habitat that would not happen rapidly, such as a large boulder blocking a section of the stream because of strong winds. To continue, they connected the idea that streams change periodically with the combination of seasonal patterns and the physical landscape around the area, such as having large deposits of limestone form a nearby cave. Earlier in their book, they talked about the physical habitat of the fluvial ecosystem, such as sedimentation, erosion, sinuosity, and discharge velocity, and how these attributes influence the wildlife because of the resources these streams may provide and the environmental stresses the organisms must adapt to, like fast rapids or large gravel. These events promote certain functional feeding groups, such as scrapers, shredders, or collectors, that use the environmental situation, such as leaf litter from nearby trees, in order to thrive in these harsh conditions.

To describe further, Poff et. al (1997) describes the natural flow regime and its components, where many streams and rivers have very different patterns. These patterns can be seasonal, annual, or monthly. These patterns influence the physical habitat and the functional feeding groups living in the stream. For example, a periodic flood can wash important nutrients into a floodplain that promotes local plants to thrive or remove trees that would become a macrohabitat and a food source to many organisms. This type of flooding may also be necessary for reproductive processes for many organisms living there because they might not have a reliable method of spreading sperm or eggs (particularly filter feeders like clams), and this periodic flooding is necessary to prevent non-native species from thriving in the fluvial environment because the native species is well-adapted to the floods that a particular stream may have. However, humans also have a large contribution to the natural flow regime of streams. Many of these contributions are negatively affecting the streams. An example of a human disturbance is the use of dams, which causes a disruption of the magnitude and frequency of floods that the fluvial ecosystem depends on for reproduction and food, while also promoting invasive species to dominate areas that are losing less hardy native animals and plants.

Lastly, Gresens et. al (2009) describes abiotic and biotic factors that also affects the macroinvertebrates that live in the fluvial ecosystems, which also affects the total ecosystem in and near the water. For example, they describe food availability and quality, the flow regime, habitat quality, biological interactions, and the condition of the riparian land use (e.g. deciduous forest, recreational, fields, etc.). Because of these factors, having a metric that can measure the amount of impact, such as looking at the tolerance of macroinvertebrates and the certain taxa that are present in the stream, helps to identify the stream's state over a relatively large period of time. Based on all these interconnections, there was a need for a universal system to state a fluvial ecosystem's health and find a way in order to repair ones that are deemed "unhealthy," where one feudal attempt at this system is the Clean Water Act.

Clean Water Act.

During the 1970s, the societal want for more effective environmental stances started to rise (Stradling & Stradling, 2008). One event that led to this drastic desire was Cleveland's Cuyahoga River fire of 1969, even though there were countless river fires before it. Even though the response to the environmental problem was much later and did not really start until the deindustrialization of Cleveland, the 1969 fire did help form the EPA and the Clean Water Act that Americans know today. To describe further, the purpose of the Clean Water Act was to create an understanding of stream/river health instead of the societal definition of "health" as the societal meaning cannot be applied here (Karr, 1999). Understanding the meaning of "health" in terms of a stream or river is supposed to help society learn how to restore and maintain the composition and the ecosystem of these fluvial systems. During this process, new models were founded, where they rely on multivariate statistical methods and multimetric indexes (e.g., the Virginia Stream Condition Index) for measuring biological patterns in these ecosystems. These methods of analyzing stream health help scientist see how much human activity alters a fluvial system and try to fix the consequences of those actions.

However, there is another body of quality insurance that was created in order to protect and repair streams: the 305(b) report. According to the Virginia Department of Environmental Quality (n.d.), the purpose of the 305(b)/ 303(d) report is to provide a summary of Virginia's fluvial ecosystems and their health based on an index they determined though research. However, all states in the US does have a version of the 305(b)/303(d) report that Virginia uses that can be applied to their specific stream types. This report is created to inform citizens and public officials of the water quality of these systems, while also setting plans on repairing streams that are deemed “undesirable” or protecting ones that are healthy. Also, with this collection of data, the 305(b) report determines the causes of the damage to a stream, either at the stream’s location or upstream of the site from a different fluvial ecosystem. The determination of the stream damage can be done through chemical and biological analyses, where a plan is made with the collected data based on the results of the analyses. This plan would follow state and federal criteria and guidelines in order to repair the damage or protect the stream from future damage. To describe the state’s guidelines, Burton & Gerritsen (2003) created a method for identifying Virginia’s macroinvertebrate condition for streams across the state that look at the factors, as described by Gresens et. al (2009), using the insects that are native to the region and a mathematical-based system to figure out the state of the stream. Many states use their own version of Virginia’s score system (called the Virginia Stream Condition Index [VSCI]) in order to learn about the condition of their streams. This information is also considered within the 305(b) reports in order to have a more concise conclusion on a stream’s state of health. To summarize, the combination of the Clean Water Act and the 305(b) report work together in order to provide a standard for streams and rivers in order to have a functional and healthy ecosystem.

Our team’s mission is to accomplish the goals of the Clean Water Act and Virginia's 305(b) report for a stream in Radford, VA. By accomplishing our mission, we help provide necessary information about the health of the stream and its ecosystem, where outside resources may be needed. The information we collected will help with the goal of the act and the report as they were created to provide a standard of health for streams across the United States, so scientists and researchers can take the necessary steps to protect or repair the stream. This standard will also evolve with more information, so completing our steam assessment will further provide information about the true state of streams across America and find ways to protect them for both societal and ecological uses.

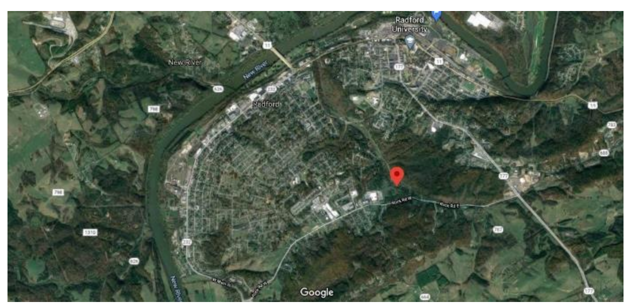

Figure 1. Location of Steam within Radford, VA

Stream Monitoring Program

For our stream assessment, we completed a stream monitoring program that focuses on assessing the ecological state of a stream in Radford, VA. As described by Downes et. al. (2002), the purpose of this monitoring program is to identify possible harmful activity near a stream that would negatively affect the wildlife population. Through this program, we can see if a stream is

Figure 2. Location of Stream next to Landfill in Radford, VA.

impaired and needs to be monitored and repaired, so the current fluvial ecosystem does not continue to deteriorate.

Table 1: Physical habitat measurments upstream of the landfill, Radford, VA. Fall 2020.

Variable	Connelly's Run
Wetted Width (m)	
mean	3.47
standard deviation	1.15
Depth (mm)	
mean	136.72
standard deviation	28.39
coefficient of variation	0.21
Channel Units (%)	
Riffle	36.00
Glide	42.00
Pool	22.00
Other	0.00
Riparian Canopy (%)	80.21
Land Use (%)	
Deciduous forest	72.73
Field	27.27
Particle Size	
% fines	13.00
D_{50} (mm)	26.28
Discharge (m^3/s)	0.050
Turbidity (mm)	53

Description of the Stream

For the steam, we chose to conduct the stream assessment on Connelly's run, particularly upstream of the landfill (the location of the retired incinerator) that is located southeast of Radford, VA (figure 1 and 2). There are four main ways to describe a channel, which are the following: the stream order, the channel type, the channel pattern, and the process domain. To start, the stream order for Connelly's run is a first-order channel since it does not have two or more streams connecting to it at its starting point. While stream order is a basic method for describing streams, there are more ways that Connelly's run can be described. For example, the stream type of Connelly's run is a riffle/pool stream as, according to Kondolf et. al. (2005), this stream type has alternating riffles and pools with a relatively large D_{50} (13 mm < x < 50 mm), while also having sediment deposits around the turns of the stream. For the stream pattern, Connelly's run seems to have a wandering pattern because of the high sinuosity and the formation of large gravel beds within the stream (figure 3 and 4). Lastly, the Hjusltröm Classification, which describes the type of sedimentation zone of a stream, for Connelly's run is a depositional zone because, according to Allen and Castillo (2007), the velocity of the water at Connelly's run is too slow to move sediments that has a medium to large D_{50}, where the D_{50} of Connelly's run is considered to be about the size of course gravel. For exact physical measurements, table 1 represents measurable physical characteristics that was calculated during the stream assessment. For example, the average depth of Connelly's Run was about 136.72 mm, while the stream also had an average wetted width of 3.47 m. To summarize, Connelly's run is a first-order, pool/riffle stream with wandering channel patterns, where this part of the stream is a depositional zone of relatively large sediments.

Figure 3. Example of gravel pit within the Stream.

Why We Chose this Monitoring Program?

We decided to use this steam for our monitoring program because this part of Connelly's Run is upstream of many recreational spaces, and this part of the stream is the closest to the start of the stream itself. Along with our group, three other groups have also conducted a stream assessment on different parts of Connelly's Run to see if their site experiences negative impacts. With our information included, we can see the exact location of possible negative inputs into the ecosystem, as a class, and how these inputs spread throughout Connelly's Run, along with knowing if the overall stream supports the local ecosystem or not. For the biotic analysis, we looked at the aquatic organisms, particularly the benthic macroinvertebrates, because the impact of many disturbances affects the steam's organisms for generations. So, looking at the macroinvertebrates provides an overview of a stream's total health over a longer period than just looking at the chemical and physical attributes during the collection process.

Figure 4. Wondering pattern characteristics seen within the stream

Assessment Methodology

Assessment Unit

The stream's assessment unit was the stream reach length, where this was determined by measuring random wetted widths (m) at 5 non-predetermined locations with approximately 5-10 meters between each of these measurements. These 5 measurements were then averaged and multiplied by 40 to get the reach length that we used for our assessment.

Quantitative Measurements

Water Chemistry. Basic water chemistry was measured using a Yellow Springs Instrument (ID: 17C105261), including water temperature (℃), barometric pressure (mm Hg), dissolved oxygen (%L and mg/L), SPC (uS/cm), conductivity (uS/cm), salinity(mg/L), nitrate YSI (mg/L), and pH. Lastly, a turbidimeter was used to measure turbidity (mm) of the stream. This data was later used as a standard for stream health by specific intervals the VDEQ provides.

Microclimate. The microclimate was measured using a Kestral 550 Environmental Meter (ID: 2304528), including the wind direction (deg), wind speed (m/s), crosswind (m/s), headwind (m/s), air temperature (℃), wind chill (℃), relative humidity (%), heat index (℃), dew point (℃), wet bulb temperature (℃), ambient pressure (in Hg), and barometric pressure (in Hg and mm Hg). Also, altitude (m) and density altitude (m) was calculated later, while general observations was also noted, such

Table 2: Summarizing the weather upstream of the landfill, Radford, VA. Fall 2020.

Variable	Connelly's Run
Wind	
Direction (Degrees)	SSE 164
Speed (m/s)	0.0
Crosswind (m/s)	0.0
Headwind (m/s)	0.0
Chill (^{o}C)	16.4
Air (^{o}C)	
Dry Temperature	16.4
Wet Bulb Temperature	15.3
Heat Index	16.6
Dew Point	14.7
Barometric Pressure (mmHg)	713
Altitude (m)	533
Density Altitude (m)	774

Figure 5. Example of the longitudinal profile being taken.

as general weather, precipitation, and stream flow. Table 2 shows the weather data on the data collection day.

Physical measurements. The physical habitat was measured in three dimensions: length (also known as the longitudinal profile), width (known as the lateral profile), and depth. The transect length (m) was determined by dividing the reach length by 10 to get 11 total transects. At each transect, we measured the wetted width (m) and left and right canopy cover. The canopy cover was measured by using a densiometer that had tape on 20 of the possible 37 points, where the number of points covered by the canopy cover was recorded. Then, we classified the left and right bank primary land use in the corresponding area, such as recreation, deciduous forest, or field. Finally, we determined the cross-sectional depth profile by measuring the depth at 11 equidistant locations (i.e., dividing the wetted width by 10).

The longitudinal depth of the water (mm) and channel unit classifications (e.g., riffle, pool, or glide) were measured longitudinally in the Thalweg, which represents the flow of the water. Depths and channel unit classifications were measured at equidistant locations from Transect A to K. These distances were determined by dividing the transect length (m) by 10 (i.e., dividing the reach length by 100). Figure 5 shows an example of using the calculated distance between each section of the transect to calculate the Thalweg at Connelly's Run.

The sediment size (mm) was measured using the Wolman pebble count procedure. We used a gravelometer to classify the size of random rocks or sediment into specific categories of sizes (i.e., fine sand, coarse sand, fine gravel, boulder, bedrock, etc.).

Velocity (m/s) was measured using the bobber method. We measured the time (s) the bobber travelled within a 4.87 m section of transect K five times. Velocity was calculated by multiplying the surface velocity (m/s) measurements, which was found by dividing the distance (m) by the average time (s), and a correction factor to account for bed roughness. Discharge was then calculated by multiplying the velocity with the area (mean wetted width (m) x mean depth (m)) of the selected section from transect K.

Benthic macroinvertebrates. Benthic macroinvertebrates were collected using a 0.33 m^2 dip net in 6 different riffles. Rocks were cleaned off using our hands in the net, and the sediment was disturbed to allow organisms to flow into the net. Afterwards, the macroinvertebrates were preserved in 90% ethanol. Next, we classified each of the found taxa to their respective functional feeding groups. Lastly, we used the Virginia Stream Condition Index (VSCI) to determine the condition of our stream based on the prevalence of certain taxa within our sample.

Qualitative Measurements

During the assessment, physical characteristics were recorded through pictures. Using these photos and some of the quantitative data we collected, we used the Rapid Habitat Assessment to determine stream impairment from the physical environment. To describe, the following descriptions of the stream was turned into a numeric score: epifaunal and pool substrate, sediment deposition, stream variability, channel flow status, channel alteration, channel sinuosity, left and right bank stability, left and right bank vegetative protection, and left and right bank riparian zone width. The scores of all the characteristics were summed and compared to the VDEQ's interval for a rapid habitat assessment.

Standards to Determine Impairment

We determined the health of the stream by comparing the water chemistry, physical habitat, and benthic macroinvertebrate assemblage to determine if Connelly's Run was impaired. For all the assessments used, there was a given interval that characterizes the data variable as either supporting, indeterminate, or impairing. For all the collected measurements, the VDEQ (2016) reported the interval values for the all the attributes, as described earlier, in their 305(b)/303(d) reports. Because our procedure is based on the VDEQ's reports, we used the same intervals that they used for our data.

Quality Assurance and Quality Control (QA/QC)

We performed QA/QC training before starting our assessment for two main reasons: consistency and bias. In order to be able to compare results with all the class, consistency of the data collection process was needed, where this was done through the specific training before the assessment. Also, this training prevented possible bias that may happen during the collection process, where this bias could come from improper use of equipment or incorrect sample techniques. This training was done with Dr. Lau earlier in the semester in order to learn the data collection process with the necessary steps needed for each data category.

Assessment Results

After conducting a thorough assessment on the stream in Connelly's Run, we found quite a few problems within the stream that impairs the local wildlife. For example, looking at the chemical data, we found that our stream had impaired nitrate levels (table 3), where the concentration was about 30x more than the maximum amount for a healthy stream. Also, the stream was in the indeterminate stage for total dissolved solids (TDS), where the TDS could be affecting the local macroinvertebrates, but the overall impact cannot be fully determined. However, water temperature and dissolved oxygen were supported, so some portions of the stream did support a fluvial ecosystem.

Next, the physical landscape was given a status of indeterminate (table 4) because there were some portions of the stream that did not support life (e.g., unbalanced pool/riffle ratio, high fine sediment, etc.) while other parts did (e.g. lots of canopy cover, lots of organic material in some portions, sinuous stream pattern, etc.). One example of a physical characteristic that impairs the stream, as seen in figure 3, was large gravel beds in

Table 3: Chemical measurments upstream of the landfill, Radford, VA. Fall 2020.

Variable	Connelly's Run	Status
Water Temperature (^oC)	16.6	Supporting
pH	8.16	Supporting
Dissolved Oxygen		
DO (%L)	92.7	
DO (mg/L)	8.3	Supporting
Total Dissolved Solids	338	Indeterminate
Conductivity		
SPC (uS/cm)	520.5	
Conductivty (uS/cm)	435.5	
Salinity (mg/L)	0.25	
Nitrate (mg/L)	29.54	Impaired

Table 4: Summarizing the rapid habitat assessment for Connelly's Run upstream of the landfill, Radford, Virginia. September 30, 2020.

Metric	Score
Epifaunal Substrate	8
Pool Substrate	5
Pool Variability	13
Sediment Deposition	12
Channel Flow Status	14
Channel Alteration	17
Channel Sinuosity	15
Left Bank Stability	9
Right Bank Stability	8
Left Bank Vegetative Protection	8
Right Bank Vegetative Protection	6
Left Bank Riparian Zone Width	4
Right Bank Riparian Zone Width	8
Total Score	127
Status	Indeterminate

Connelly's Run. Also, turbidity of the water was impaired, as it is supposed to be above 120 mm, but it was 53 mm (table 1). Because of the indeterminate status for the physical habitat, more sampling in the future would be needed in order to keep a careful watch. This watch is necessary to help make sure the physical habitat's health does not decline.

Table 5. Summarizing the Virginia Stream Condition Index (VSCI) for Connelly's Run upstream of the landfill, Radford, VA. September 30, 2020.

Metric	Metric Value	Metric Score
Total Taxa	11	50.0
EPT Taxa	6	54.5
% Ephemeroptera	2.3	3.8
% Plec + Tric less Hydro	18.6	52.3
% Scrapers	60.5	100.0
% Chironomidae	4.7	95.3
% Top 2 Dom	60.5	57.1
HBI	5.0	73.5
VSCI Score		60.8
Status		Supported

Lastly, the number of macroinvertebrates was incredibly low (table 5). During the data collection process, we sampled the macroinvertebrates twice (supposed to do 3 riffles, but we did 6 instead) due to the low sample size that we collected. However, we still only had 43 macroinvertebrates compared to the expected 180-220. According to the VDEQ's 2016 305(b) report, our stream is supported for macroinvertebrates; but due to the low count we collected, we did not have the total number of invertebrates to say that the streams was fully supported. This low count tells us that our stream was, in fact, impaired in the category of macroinvertebrates, but we should sample again in the future. Table 6 shows the exact taxa seen within the stream, along with the tolerance level towards pollutants and the total number of these taxa seen in the sample collected.

Overall, this stream should be sampled again in order to get a more accurate collection of data for the physical aspect, as well as the macroinvertebrates. With the supporting and impaired qualifications in mind, the state of Connelly's run was determined to be a category 4 on the EPA categories list used to classify the health of a stream, where this stream must be put on the 303(d) list as impaired.

Table 6: Listing the macroinvertebrates collected at Connelly's Run upstream of the landfill, Radford, Virginia. September 30, 2020.

Order	Family	Common Name	Functional Feeding Group	Tolerance Value	Abundance
Achatinoidca	Lymnaeidae	Snails	Scraper	7	11
Colecoptera	Elmidae	Riffle Bettles	Scraper	4	15
Dipera	Chironomidae	Sand Flies	Collector	6	2
Diptera	Perlodidae	Stone Fly	Predator	2	2
Ephemeroptera	Limoniidae	Crane fly	Predator	4	1
Lumbriculida	Lumbriculidae	Worms	Shredder	8	1
Plecoptera	Baetidae	Small Mayflies	Collector	1	1
Plecoptera	Perlidae	Golden Stones	Predator	1	1
Trichopetra	Helicopsychidae	snail-cased caddisfly	Shredder	3	1
Trichopetra	Philopotamidae	finger-net caddisfly	Collector	3	1
Trichopetra	Hydropsychidae	net-spinning caddisfly	Filter	6	7

303(d) List

When analyzing our results, we concluded that Connelly's Run is impaired for several factors, where it was considered a category 4 stream. To explain, we learned that the nitrate concentration (mg/L) in our stream was the most probable cause for our stream to be impaired, which we concluded may be a main reason why we did not have many macroinvertebrates in our sample. However, there were several other attributes that were considered impaired. For example, the turbidity was impaired. There were also some indeterminate factors within our data, such as the physical habitat assessment and the TDS, that could also play a role in the drastically small benthic macroinvertebrate count.

We determined that the nitrate levels are so high in this stream due to the mass amount of human disturbance from the surroundings. One example we found was farming, which is conducted on the land surrounding the stream. This nitrate issue happens because the soil from plants and manures from animals can cause harmful runoff, which will cause high levels of nitrate to enter nearby bodies of water, like we see at Connelly's Run. Another example that could contribute to the high nitrates was the road located parallel to the stream, where the pollutants from the road can come the automobiles that drive on the road and the pavement itself. Lastly, tire tracks were found going across the stream in some areas and found throughout the surrounding field. This can also have a negative impact on the nitrate levels in the water because it is a disturbance to the naturality of the stream, and the vehicle can directly add harmful substances.

To describe further, there are many disturbances that could cause a decrease in the turbidity, where the most probable reason was ourselves at the time. This reason for the decline in turbidity was determined because during the collection process, we did suspend a lot of sediment from the stream bed as we walked downstream to the area that we started the assessment, where we collected a sample not long after. However, this disturbance may happen throughout the year as there are other possible events that can disturb the stream bed. For example, the tire tracks, as described earlier, does go through the stream, which can cause more erosion of the banks, and the vehicle that created those tire tracks will disturb the sediment.

Lastly, there were some indeterminate factors within our data. For example, the physical habitat assessment showed that there were issues with the stream in certain aspects, like the poor pool/riffle ratio and lack of canopy cover in certain sections of the stream. On the other hand, there were some aspects of Connelly's Run that did support life, such as organic material for macrohabitats and sinuosity. In the end, the stream had characteristics that supported and impaired the local macroinvertebrates. Also, the TDS were also indeterminate, where the possible disturbances are the same as the turbidity.

With all those impairments, the benthic macroinvertebrates were considered impaired, even though the VSCI gave a passing score. The main reason for stating it "impaired" was the lack of a sample to thoroughly analyze the state of the stream through the VSCI. However, there was another factor that may contribute to the lack of macroinvertebrates: the weather the days before. Heavy rainfall was recorded the day prior to our stream assessment, where this could heavily influence our nitrate level due to the increase in erosion and runoff. Also, this increased rain would increase the velocity of the stream water, which may carry macroinvertebrates downstream. In summary, there were a lot of chemical attributes that harmed the local organisms in the stream, but this could be fixed over time.

Restoration Plan

One way we can improve Connelly's Run is by limiting the total maximum daily load (TMDL) of nitrate. This limitation can be done by reducing the amount of harmful runoff from farming, reducing traffic in the landfill area, and limiting how often trucks drive through the water. For example, growing native plants around the stream, especially in areas where the stream has no canopy cover, would help uptake some of the nitrates entering the stream and provide more macrohabitats for the organisms in the area. To continue describing, planting these native plants could help with the issue of turbidity as the root systems of these plants will help reduce erosion along the banks. Also, limiting human traffic near and in the stream would help reduce the amount of debris entering the stream, and probably increase the health of the overall stream.

To continue, there should be a stream “clean-up” session to remove debris that could release harmful particles or chemicals into the water, such as pipes and tires. This process would prevent further harm to the local environment and will make it safer for the recreational sites downstream of Connelly’s Run. Afterwards, a new assessment of the stream’s physical habitat, since this assessment was deemed “indeterminant”, and a new sample of macroinvertebrates, where this will be done after reducing the TMDL of nitrates and the clean-up session, should be collected. Because of the rain before, assessing the stream before any unseasonal flooding would be helpful to see if the flooding before contributed to any findings we collected. Once the restoration plan is complete, the stream should be monitored once every two to three years in order to make sure the stream does not revert to being impaired again.

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