FINAL REPORT
DUCK CREEK
NANCY STREET WETLAND
WATER QUALITY ASSESSMENT

JULY 2018

Organization Name: Southeast Alaska Watershed Coalition/ Juneau Watershed Partnership

Contact: Amy Sumner, Project Coordinator

Mailing Address: Southeast Alaska Watershed Coalition
1107 W. 8th Street, #4
Juneau AK 99801

Email: juneauwatersheds@gmail.com

JUNEAU WATERSHED PARTNERSHIP

Our mission is to promote watershed integrity in the City and Borough of Juneau through education, research and communication while encouraging sustainable use and development.

Cover Photo: View of the Nancy Street wetland from the observation deck looking toward the Mendenhall Glacier.

Acknowledgements: A special thanks to Drs. Eran Hood, Sonia Nagorski and Lisa Hoferkamp with the University of Alaska (UAS) for generously donating their time, monitoring equipment and lab space toward this project; Christin Khalsa, UAS student intern for the project, for her excellent work in the field and in the lab; Gretchen Pikul, DEC Project Manager, for her patience and support during the project; and the Southeast Alaska Watershed Coalition staff for their general project support.

This project has been funded in part by the U.S. Environmental Protection Agency (EPA) under assistance agreement number (00J84603) to the Department of Environmental Conservation (DEC) through the Alaska Clean Water Actions (ACWA) Program. The content of this document does not necessarily reflect the view and policies of the funders, nor do the funders endorse trade names or recommend the use of commercial products mentioned in this document.

Contents

Purpose and Need

Duck Creek is a small, clear-water stream located in the Mendenhall Valley, Juneau, Alaska. It has been listed as an impaired waterbody by the Alaska Department of Environmental Conservation (DEC) since 1994 due to non-attainment of state Water Quality Standards (WQS) for dissolved oxygen, residues/debris, metals (specifically iron), fecal coliform bacteria and turbidity.

Several gravel extraction ponds (the Alison, Church of the Nazarene, Nancy Street, and Forest Service ponds) were noted to have enhancement potential in the 1997 *Juneau Wetlands Management Plan*, making them a focal point for restoration efforts. These ponds were formed from dredging in the 1950s and 60s in support of development in the Mendenhall Valley. These extraction pits filled primarily with groundwater that was high in iron and low in dissolved oxygen. This affected the water quality of the downstream reaches of Duck Creek.

The Church of the Nazarene pond was converted into a wetland in 1998 and the Nancy Street pond followed in 2006. These created wetlands were intended to improve fish and wildlife habitat and water quality on the east fork of the stream. The wetland plants were anticipated to increase dissolved oxygen and decrease iron and sediment in downstream reaches by trapping the iron flocculent and fine sediments in the wetland. However, like many restoration projects throughout Juneau, little to no water quality monitoring tracked the success of the restoration of these gravel ponds. Water quality monitoring is necessary to evaluate the effectiveness of the Nancy Street Wetland restoration efforts.

The purpose of this project is to assess the effectiveness of the Nancy Street Wetland project on improving water quality in Duck Creek. To do this, water quality samples were collected at three locations on Duck Creek upstream, midstream and downstream of the Nancy Street wetland. The sites used in previous monitoring efforts were monitored during this project, to allow comparison of this project's data to historic data, WQS, and the total maximum daily load (TMDL) target values for assessing the effectiveness of the Nancy Street wetland enhancement project.

Background

Duck Creek Watershed

Duck Creek, located in the Mendenhall Valley, Juneau, Alaska, is approximately 3.5 miles long and discharges into the Mendenhall River directly upstream of the Juneau International Airport (Figure 1). Draining a watershed of approximately 1.7 square mile, Duck Creek is primarily a spring-fed system, but also relies on precipitation and some snow melt for water flow. Duck Creek is an anadromous stream that supports pink, chum, and coho salmon, Dolly Varden and cutthroat trout.

Duck Creek has one of the most intensely developed watersheds in Juneau. The Mendenhall Valley grew into a heavily populated suburban area within the last 60 years. This rapid development has led to channel relocations and alterations, disruption of groundwater and surface water inputs, decreased instream habitat complexity, and degraded water quality. As a result, in-stream conditions became highly unsuitable for salmon and the impact on the fisheries in Duck Creek became a major concern. The chum salmon run that consisted of 10,000 fish is now practically extinct (Koski and Lorenz 1999). The most recent weir counts now only show small numbers of coho salmon migrating upstream. For comparison, in 2005, 15 adult coho were counted in Duck Creek, whereas Jordan Creek supported 561 spawning adults (ADFG).

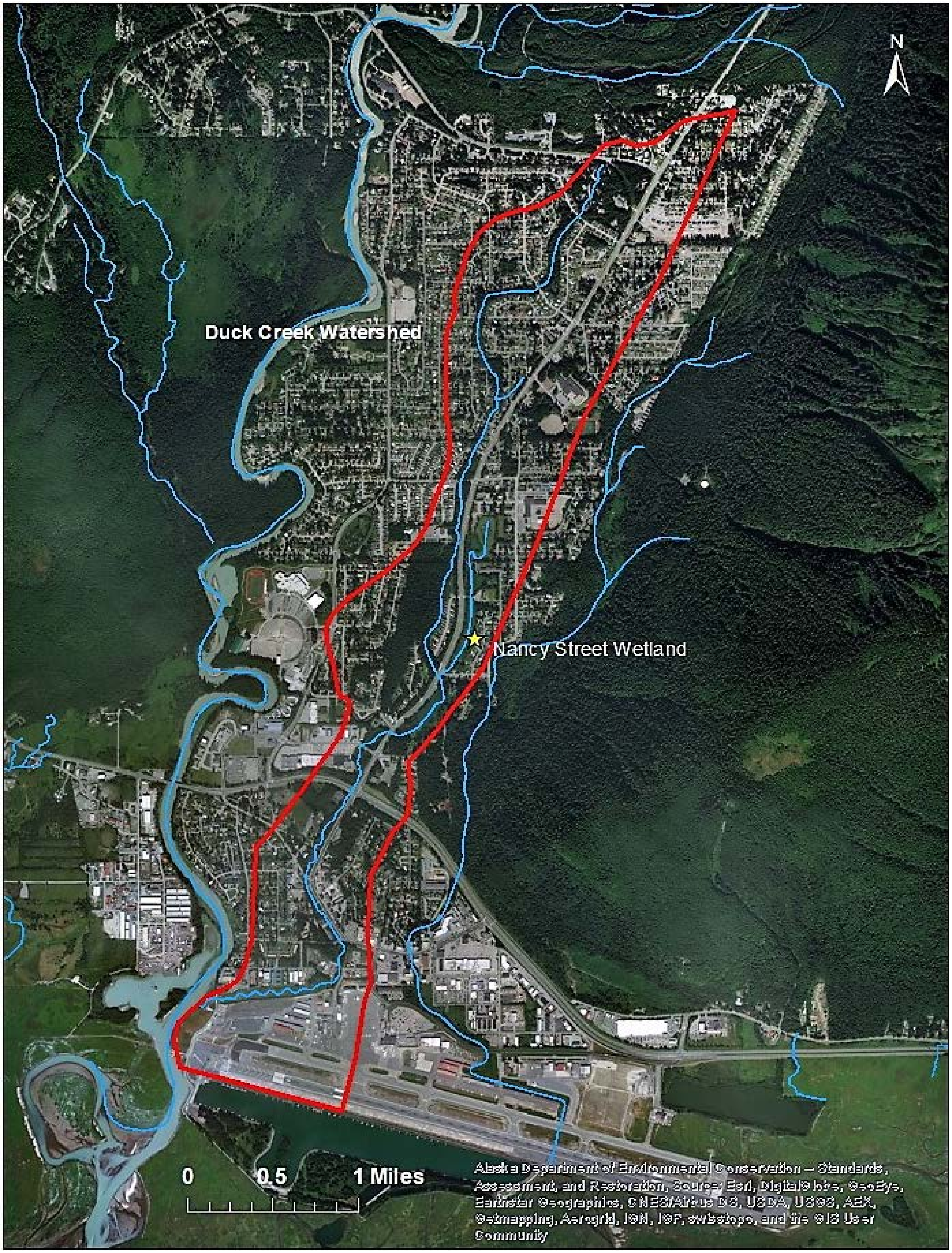


Figure 1. The Duck Creek watershed, located in the Mendenhall Valley, Juneau, AK. The location of the Nancy Street Wetland is indicated by the star.

When the *Duck Creek Watershed Management Plan* was produced by Koski and Lorenz in 1999 for the Duck Creek Advisory Group, urbanization and development was considered the primary reason for water quality problems. Indeed, Duck Creek is one of Juneau's most densely populated watersheds. Though challenges with urban development continue to stress the watershed, geologic processes are also affecting the creek's ability to recover. Instream conditions in Duck Creek are greatly affected by isostatic rebound, or the uplifting of the land due to reduced pressure as the Mendenhall Glacier recedes. This uplift induces changes in the groundwater-surface water interactions throughout the Mendenhall Valley, affecting base flow in Duck Creek and thereby exacerbating poor water quality and habitat conditions. The effects of isostatic rebound were not publicized until 2002-2003.

Due to the efforts of local advocacy groups and federal, state, tribal and local government agencies, numerous restoration projects have been completed on Duck Creek to improve water quality and salmon habitat. Restoration efforts on Duck Creek include: replacing undersized and perched culverts to improve fish passage and stream flow, revegetating stream banks, sediment removal and channel reconfiguration to help improve salmon spawning habitat, wetland creation to treat storm water and improve water quality and fish habitat, vacuum removal of iron flocculate, and stream bed lining and sealing to prevent surface water loss in downstream reaches. A relatively recent history of restoration projects on Duck Creek is described in: *Duck Creek Restoration Assessment Report* (Juneau Watershed Partnership, 2007). This study focuses on one of the many restoration projects on Duck Creek: the Nancy Street Wetland.

Nancy Street Wetland

The Nancy Street Wetland is located on the East Fork of Duck Creek (Figure 1). Its creation is the result of a partnership between the City and Borough of Juneau (CBJ), U.S. Fish and Wildlife Service (USFWS) and the Natural Resources Conservation Service (NRCS). This partnership formed when the Nancy Street gravel extraction pond (Figure 2) was identified as a viable waste disposal site for material extracted from the Thunder Mountain High School construction project. The viability of the restoration project was based on a number of factors: the CBJ had a willing seller in the former landowner and regulatory agency support, the site provided a cost-effective gravel disposal solution and avoided the use of other disposal sites important for community development, and the CBJ could effectively manage the site after completion of the project.

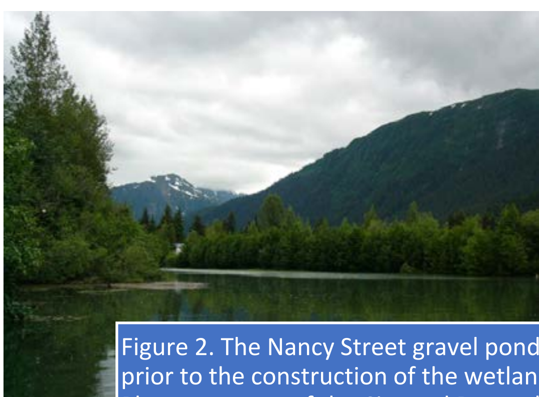


Figure 2. The Nancy Street gravel pond, prior to the construction of the wetland. Photo courtesy of the City and Borough of Juneau.

Figure 3. Nancy Street wetland after two growing seasons. Photo courtesy of the City and Borough of Juneau

Construction of the Nancy Street wetland began in September 2005 with the hauling and placing of fill and organic material, which took nine months to complete. Channel construction began in July 2006 and construction of the entire wetland was completed in October 2006. The wetland was designed and constructed to provide a variety of fish and wildlife habitat types. The channel was shaped to provide a meandering stream with ponds at both ends for juvenile coho overwintering habitat. Wetland benches, or "fingers," were shaped to provide adjacent low and high marsh habitat (Figure 4).

Low and High Marsh:
Marsh Marigold, *Caltha palustris*
Sitka Sedge, *Carex sitchensis*
Spike Rush, *Eleocharis palustris*
Small Leaved Bulrush, *Scirpus microcarpus*
Lyngbye's Sedge, *Carex lyngbyei*

Wet Meadow:
Western Columbine, *Aquilegia formosa*
Bluejoint Reedgrass, *Calamagrostis canadensis*
Tufted Hairgrass, *Deschampsia caespitosa*
Chocolate Lily, *Frittilaria camschatcensis*
Wild Iris, *Iris setosa*
Nootka Lupine, *Lupinus nootkatensis*
Sweet Grass, *Hierochloe odorata*

Upland Shrub:
Sitka Alder, *Alnus viridus,*
Goat's Beard, *Aruncus dioicus*
Red Twig Dogwood, *Cornus stolonifera,*
Salmonberry, *Rubus spectabilis*
Barclay's Willow, *Salix barclayi*
Red Fescue, *Festuca rubra*
Thimbleberry, *Rubus parviflorus*
Red Alder, *Alnus rubra*

Upland:
Red Alder, *Alnus rubra,*
Sitka Alder, *Alnus viridus*
Red Twig Dogwood, *Cornus stolonifera*
Sitka Spruce, *Picea sitchensis*
Black Cottonwood, *Populus balsamifera*
Salmonberry, *Rubus spectabilis*
Barclay's Willow, *Salix barclayi*
Thimbleberry, *Rubus parviflorus*
Red Fescue, *Festuca rubra*

Figure 4. The Nancy Street Wetland design and plant list. Figure modified from Wright and Czapla (nd).

Plants used in vegetating the wetland were selected based on success in previously constructed wetland sites in the region, the ability to be transplanted or seeded, as well as potential for phyto-remediation of iron. Transplanting plugs was the primary method of revegetation, to preserve local gene stock and minimize the need to purchase plants. Cuttings of willow and cottonwood were also used, with some seeding.

The Nancy Street Wetland was also designed for recreational use due to its proximity to a residential neighborhood. A trail follows the eastern side of the wetland and connects to the multiuse path that parallels Mendenhall Loop Road. An overlook platform is located at the southern end of the wetland, and features an interpretive sign, benches, garbage receptacle and a viewshed that includes the Mendenhall Glacier. A solitary bench is also provided on the north-end of the wetland.

The Nancy Street Wetland was presented as a case study in the *Alaska Coastal Revegetation and Erosion Control Guide* and the American Society of Landscape Artists and was featured in an article in the *Land and Water* Magazine.

Water Quality Assessment

Water quality generally refers to the condition of the chemical components of a waterbody. Traditional water quality parameters include water temperature, pH, dissolved oxygen (D.O.), turbidity, and specific conductance. Total suspended solids (TSS), total dissolved solids (TDS), dissolved iron, and other dissolved inorganic elements (sodium, chloride, sulfate, and potassium) are additional parameters that have been collected on Duck Creek.

The purpose of this project is to assess the effectiveness of the Nancy Street Wetland project on improving water quality in Duck Creek. To do this, water quality samples and measurements were collected at three monitoring stations located on Duck Creek upstream, midstream and downstream of the Nancy Street wetland (Figure 5). These three sites were used in previous monitoring efforts, allowing comparison of this project's data to historic data, State of Alaska Water Quality Standards (WQS), and the total maximum daily load (TMDL) target values for assessing the effectiveness of the Nancy Street wetland enhancement project.

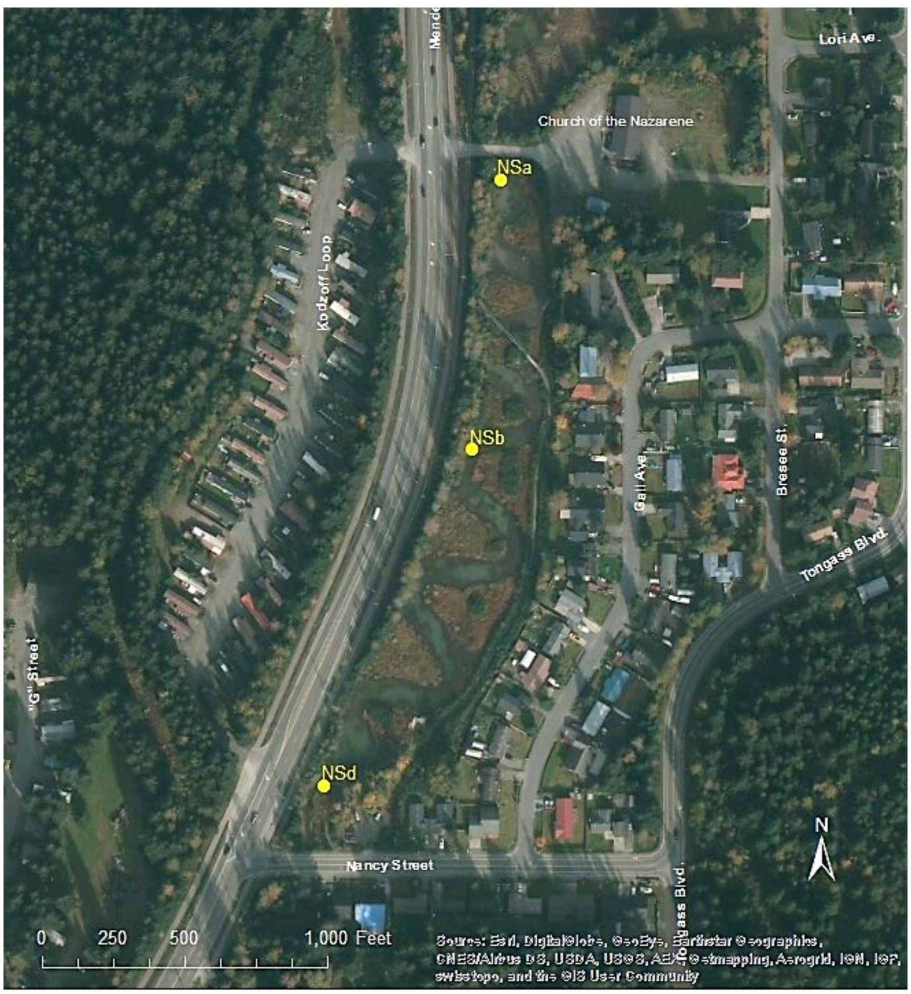


Figure 5. The Nancy Street wetland monitoring stations. The wetland inlet, NSa, is the upstream site where water flows into the wetland through a culvert under the Church od the Nazarene driveway. Site NSd is a midstream point within the wetland. Site NSd is just upstream of the wetland outlet, where the creek flows out of the wetland through two culverts under Nancy Street.

This project followed an above-and-below watershed monitoring design to analyze the effectiveness of the Nancy Street wetland. This monitoring design is described in detail in the *National Water Quality Handbook* (NRCS, 2003) and the EPA's *Technical Guidance for Designing a TMDL Effectiveness Monitoring Plans* (2011a) and *Technical Guidance for Exploring TMDL Effectiveness Monitoring Data* (2011b). This monitoring design can be used for evaluating the effects of a best management practice (BMP) or restoration effort on water quality by analyzing data from paired observations at monitoring stations above and below the BMP or restoration site, in this case, the Nancy Street wetland.

A Quality Assurance Project Plan (QAPP) was developed for this project to outline the sampling protocols and laboratory analysis procedures to be used in taking and analyzing water quality measurements so that data can be compared to historic data. The QAPP was approved by the DEC on January 17, 2017 and the DEC Project Manager responded on July 14, 2017 that the revised QAPP for the second grant cycle did not need to be resigned. The DEC-approved QAPP is provided on the JWP's webpage at the link noted in the References.

For the purposes of the above-and-below watershed monitoring design, the wetland inlet site (NSa) is considered the station above the Nancy Street wetland's influence. Since the measurements occurred right at the opening of the culvert in which Duck Creek flows into the Nancy Street wetland, it is assumed that there is little influence from the wetland itself. The wetland outlet site, (NSd), where Duck Creek leaves the wetland, is considered the station below the wetland. Measurements at the outlet occurred just above where the stream transitions into riffle habitat. Data from this project was compiled and analyzed with available historic data from the three monitoring sites. Raw data, including historic data, is provided in Appendix B.

For this study, several analyses were performed on the data and are discussed in this report. Summary statistics were calculated for each parameter over each sampling period (before, after and 2017) where data was available, and are provided in Appendix C. For parameters with WQS and TMDL target values, the probability of exceeding these standards (where the standard is a maximum value) was calculated using the procedure in the *National Water Quality Handbook* (NRCS, 2003). This procedure was modified to calculate the probability of being below the standard, where the standard was a minimum value. The procedure for, and the results of, this analysis are provided in Appendix D.

For an above-and-below watershed design, one way to determine the effect of a BMP or restoration effort is analyzing the difference between the above and below monitoring station data. This analysis looks at the water quality before it flows into the BMP/restoration area, and then again after it leaves, to see if there is a significant difference in the measurements. The significance is determined using a parametric or a non-parametric statistical test (NRCS, 2003; EPA 2011). For this study, the difference between the average of the inlet (NSa) and outlet (NSd) site data for each sampling period (before, after and 2017) and parameter was analyzed using a non-parametric test, the Wilcoxon paired sample test (also known as the Wilcoxon signed rank test). Since this analysis is based on paired measurements from the inlet and outlet (e.g. both measured on the same day), only the data was used where paired measurements exist. The results of the Wilcoxon paired sample tests for each parameter are provided in Appendix E.

Another way to determine the effect of a BMP or restoration effort is analyzing the change in the downstream difference before and after the BMP/restoration effort has been implemented. To do this, an above-and-below watershed study is conducted before and after implementation of the BMP or restoration effort using the same monitoring stations. This type of monitoring design can be treated as a basic form of a Before-After-Control-Impact (BACI) study, where the station above the BMP/restoration effort is used as a control site and the station below the BMP/restoration site is considered the impact site. The assumption of this analysis is that downstream change, or the difference between control and impact sites, is assumed to be constant over time. In other words, both sites are assumed to naturally fluctuate together, maintaining the same average difference. The effect of the BMP/restoration effort is assumed to change that downstream difference. (NRCS, 2003; EPA 2011).

The difference between the average of the downstream change before and after the creation of the Nancy Street wetland was analyzed using a non-parametric test, the Mann-Whitney test. This simple BACI analysis identifies whether there is a significant difference in the downstream change before and after the wetland. This analysis was only completed for turbidity, D.O., temperature and pH, due to the availability of data from the before and after sampling periods. The results of the Mann-Whitney tests for these parameters is provided in Appendix F and are discussed in this report.

The statistical tests were completed using Exstat, an Excel-based statistics tool (Peixoto and Montanher, 2013). The Exstat reports (Appendix E and F) show the results of parametric t-tests, which are an alternative to the non-parameteric tests used for the analysis. However, the data was **not** tested or transformed to ensure the assumptions of the t-test are met; therefore, their use is not advised, though it is noted that the t-test often agreed with the non-parametric tests.

Available Data

Monitoring stations on Duck Creek at the Nancy Street wetland have been previously established in various water quality studies. Three of these monitoring stations and their historic data were used in this study to determine the effectiveness of the Nancy Street Wetland project in improving water quality and fish habitat on Duck Creek. These sites are shown in Figure 5 and include the inlet to the wetland (NSa), a midstream point within the wetland (NSb) and a point near the outlet of the wetland (NSd).

The University of Alaska Southeast (UAS) Environmental Science Program faculty members (Drs. Hood, Hoferkamp, and Nagorski) monitored these sites during several joint and independent water quality studies on Duck Creek between July 2004 and March 2008. Their joint work was funded under the Alaska Department of Environmental Conservation's (DEC) Alaska Clean Water Actions (ACWA) Program, and Dr. Hoferkamp also received grant funding from the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) for her independent research.

These monitoring efforts were reported in the following studies, which can be accessed electronically (see References): *Duck and Jordan Creek Protection and Recovery* (Hood, Hoferkamp, and Hudson, 2005); *Watershed Protection and Recovery for Duck Creek, Juneau, AK* (Nagorski, Hood and Hoferkamp, 2006); *Inventory of Created Wetlands, Duck Creek, Juneau, Alaska: Baseline Data for Assessment of Existing Created Wetlands and Future Wetland Creation Sites* (Hoferkamp, 2008). The data from these reports have been compiled and is provided in Appendix B. Table 1 summarizes the parameters and monitoring sites of interest by study.

Table 1. Summary of data available from monitoring stations located at the Nancy Street wetland.

Study	Site(s) of Interest Located on Nancy St. Wetland	Parameters
Hood, Hoferkamp, Hudson, 2005	DC2: Duck Creek @ Church of Nazarene (outlet of wetland)	DO Temp Conductivity pH Turbidity TSS Fecal Coliforms
Nagorski, Hood, Hoferkamp, 2006	DC-B: Duck Creek @ Nancy St. Bridge (outlet of wetland; equivalent to DC2 in Hood, Hoferkamp, Hudson, 2005)	DO Temp Conductivity pH Turbidity TSS Anions/Cations
Hoferkamp, 2008	NSa (inlet to the wetland) NSb (mid-stream location within wetland) NSc (mid-stream location within wetland) NSd (equivalent to DC2 in Hood, Hoferkamp, Hudson, 2005; and DC-B in Nagorski, Hood, Hoferkamp, 2006)	DO Temp Conductivity pH Turbidity

This historic data covers the two years prior to (July 2004 – September 2006), and the two years following (November 2006 – March 2008), the implementation of the Nancy Street Wetland project. In this study, these are referenced as the before and the after sampling periods, respectively. The 2017 sampling effort occurred as part of this study and was funded by a two-year grant administered by the DEC under the AWCA Program. The 2017 sampling period only covered seven months (April to October 2017).

The available data has limitations. These periodic sampling events reflect pollutant concentrations at a moment in time and is unlikely to adequately characterize peak in-stream concentrations during a rainfall event, or any other episodic exceedances of WQS. In addition, some parameters (e.g. TDS and dissolved iron) monitored during the 2017 effort were not historically monitored at these sites, and other parameters (e.g. TSS, fecal coliforms) have limited historic data. Therefore, conclusions cannot be drawn about post-restoration improvements with regards to these parameters.

Finally, parameters such as temperature, pH and dissolved oxygen that have seasonal patterns should not be compared using the overall data since the 2017 data does not include the entire year. In these cases, an analysis of the growing season data (April 23 – October 11) was used for better comparability and analysis, since each sampling period included data for the growing season. In addition to data availability, the growing season was selected for analysis since any changes in parameters are anticipated to be caused, in part, by the wetland vegetation. The growing season was determined from the method described using the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual* and referencing the Western Regional Climate Center data for the Juneau International Airport weather station.

Water Quality Impairments

Water Quality Standards (WQS) are pollutant limit criteria established by the State to protect designated uses of a waterbody. In Alaska, all waterbodies are protected for all designated uses unless a use has been removed through a regulatory process; therefore, the most stringent criterion becomes the WQS. Waterbodies identified as not meeting the WQS so as not to support their designated uses are listed as an impaired waterbody. The freshwater WQS applicable to this study are provided in Appendix A.

Duck Creek has been listed as an impaired water body by the DEC since 1998 for non-attainment of sediment, dissolved oxygen, and residue (debris) standards. Stormwater runoff from urban areas was identified as being the major source of pollutant delivery to the stream. The entire length (~3.5 miles) of the Duck Creek mainstem is designated as impaired.

A Total Maximum Daily Load (TMDL) was developed to address each pollutant impairment. A TMDL represents the amount of a pollutant the waterbody can receive while maintaining compliance with applicable WQS. The Duck Creek TMDL for turbidity was approved December 1999; the TMDL for debris was approved September 2000; and the TMDL for fecal coliforms was approved December 2000. A single TMDL to address both D.O. and dissolved iron was approved October 2001. Since there is a U.S. Environmental Protection Agency approved TMDL for each pollutant impairment, Duck Creek is a Category 4a waterbody for each parameter.

Water Quality Parameters

The following sections are parameter-specific discussions.

Discharge

Stream discharge, measured in cubic feet per second (cfs), is the volume of water moving through a water body per unit of time. Discharge is monitored because it can influence the results of other parameters. For example, a higher discharge can convey more sediment which results in higher turbidity. In addition, discharge is required to determine the load, or amount, of a contaminant that is moving past a given point.

During this study, discharge was measured at the outlet (NSd) site during each sampling event (Figure 6). Discharge was historically monitored by the U.S. Geological Survey (USGS) on Duck Creek at a continuously-operating stream gaging station (#15053200) located just below the Nancy Street culverts. The USGS gage was discontinued in 2004. While discharge has been periodically measured during other studies, there is a lack of discharge data after the

Figure 6. Christin Khalsa, UAS project intern, measuring discharge at the Nancy Street wetland outlet (NSd) site.

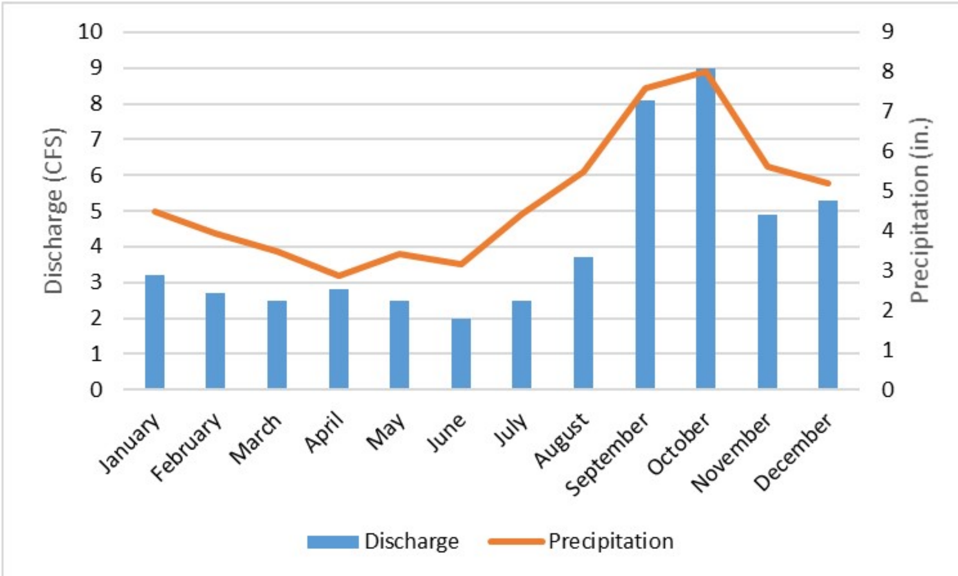


Figure 7. Mean monthly discharge in cubic feet per second (CFS) in relation to mean monthly precipitation in inches (in.). Discharge data is from the historic record (December 1993 – August 2004) at the U.S. Geological Survey (USGS) stream gage on Duck Creek below Nancy Street (Station #15053200), which was discontinued September 2004. Precipitation data is from the period of record for the Juneau International Airport weather station (#504100) as reported by the Western Regional Climate Center.

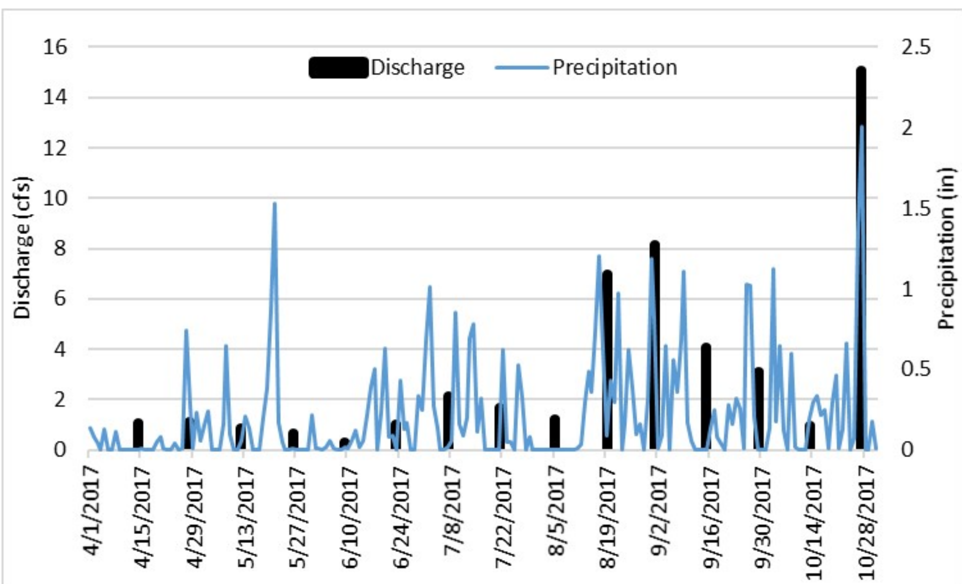


Figure 8. Discharge measurements in cubic feet per second (CFS) taken at the Nancy Street outlet site (NSd) between April and October 2017 in relation to precipitation in inches (in.). Precipitation data is from the National Weather Service.

iscontinuation of the USGS gage. Therefore, this report does not include an extensive analysis of discharge data, but rather includes a discussion of what is known about Duck Creek's discharge.

Duck Creek's flow is sustained by precipitation and from snow melt and groundwater, depending on the season. Overall, Duck Creek has low stream power with annual average flows of about 4 cfs. Duck Creek's discharge rises and falls in correlation with precipitation, but due to its small, flat watershed, Duck Creek responds more slowly than Jordan Creek (Curran, 2007). Peak flows occur in the fall (September and October) when Juneau experiences frequent rain storms. Low flows occur in winter (January to March) when the stream experiences freezing temperatures and in the summer (June – August) during prolonged periods of dry weather (Figure 7).

Research by Walter et al (2004) has concluded that Duck Creek's discharge has been decreasing at a rate of 0.003 cubic meters (0.106 cubic feet) per second per year. However, lack of more recent data would make it difficult to determine whether this trend has continued or if the rate of decrease in flow has changed.

Sampling conducted for this study in 2017 measured a range of flows found to be consistent with historic USGS data. The average flow measured during this period was 3.24 cfs. The lowest flow measured, 0.32 cfs, occurred during the June 9th sampling event. Although this sampling event did not follow the driest stretch of time during the sampling period, this is consistent with historic low flows occurring in June. The highest flow, 15.1 cfs, occurred during the October 27th sampling event, which occurred during a storm that produced nearly two inches of rain. Additional peaks were measured in late August and early September 2017 at about 7 and 8 cfs respectively (Figure 8).

The fact that the sampling occurred during a range of flows, including a particularly high flow, there is some confidence that measurements of the other parameters, such as turbidity, TSS, and TDS included a range of low and high values for comparability with the other sampling periods.

Figure 9a. A discharge of about 1 cubic foot per second measured at the Nancy Street wetland on 4/14/2017.

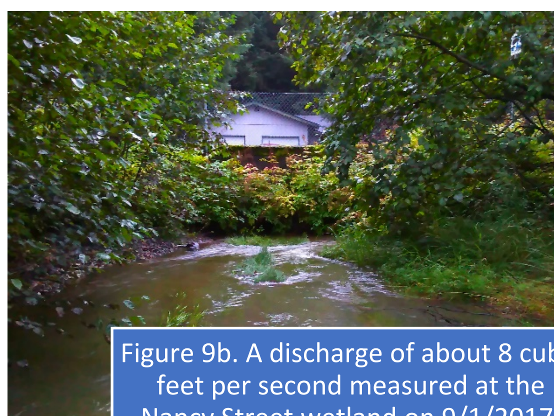


Figure 9b. A discharge of about 8 cubic feet per second measured at the Nancy Street wetland on 9/1/2017.

Residues-Debris

Residues-debris, for the purposes of the WQS, includes floating solids, debris, sludge, deposits, foam, scum, or other residues. The WQS for residues is any concentration that may impair designated uses, cause a nuisance or objectionable conditions, result in undesirable or nuisance species, or produce an objectionable odor or tastes.

Figure 10. An example of a chronic debris problem area on Duck Creek.

Duck Creek was listed as impaired for residues based on professional judgment. Due to this, a technical analysis of data to evaluate any improvements is not possible. Areas along Duck Creek continue to have problems with litter and debris that do not meet this criterion (Figures 10 and 11). Litter and debris observed in Duck Creek throughout the years include lumber scraps, plywood, paper, plastics, glass, metal, household garbage, clothing, and hazardous items such as fuel containers, batteries, and abandoned cars.

The Duck Creek TMDL for residues focuses solely on anthropogenic waste, or litter. The TMDL target value is set to zero, because the WQS does not allow for any unpermitted, human debris in Alaska waterbodies. However, since a complete adherence to this is not feasible, the TMDL recommends actions intended to reduce the amount of debris, including: public education and awareness, increased number and use of garbage receptacles, and increased enforcement.

The primary sources of residues-debris in the creek are direct inputs from littering or dumping, and indirect inputs from residential, commercial, and industrial areas where litter, or loose or improperly stored garbage, can be carried into the creek by wind, snowmelt, runoff, or wildlife. Litter is a chronic problem where roads and buildings are close to the creek but is especially pronounced near food and convenience store businesses in the lower portion of the creek. Litter is commonly associated with illegal campsites and dump sites throughout the watershed. The TMDL identified Taku and Mendenhall Boulevards, Kodzoff Acres, and Del Rae Road as problem areas.

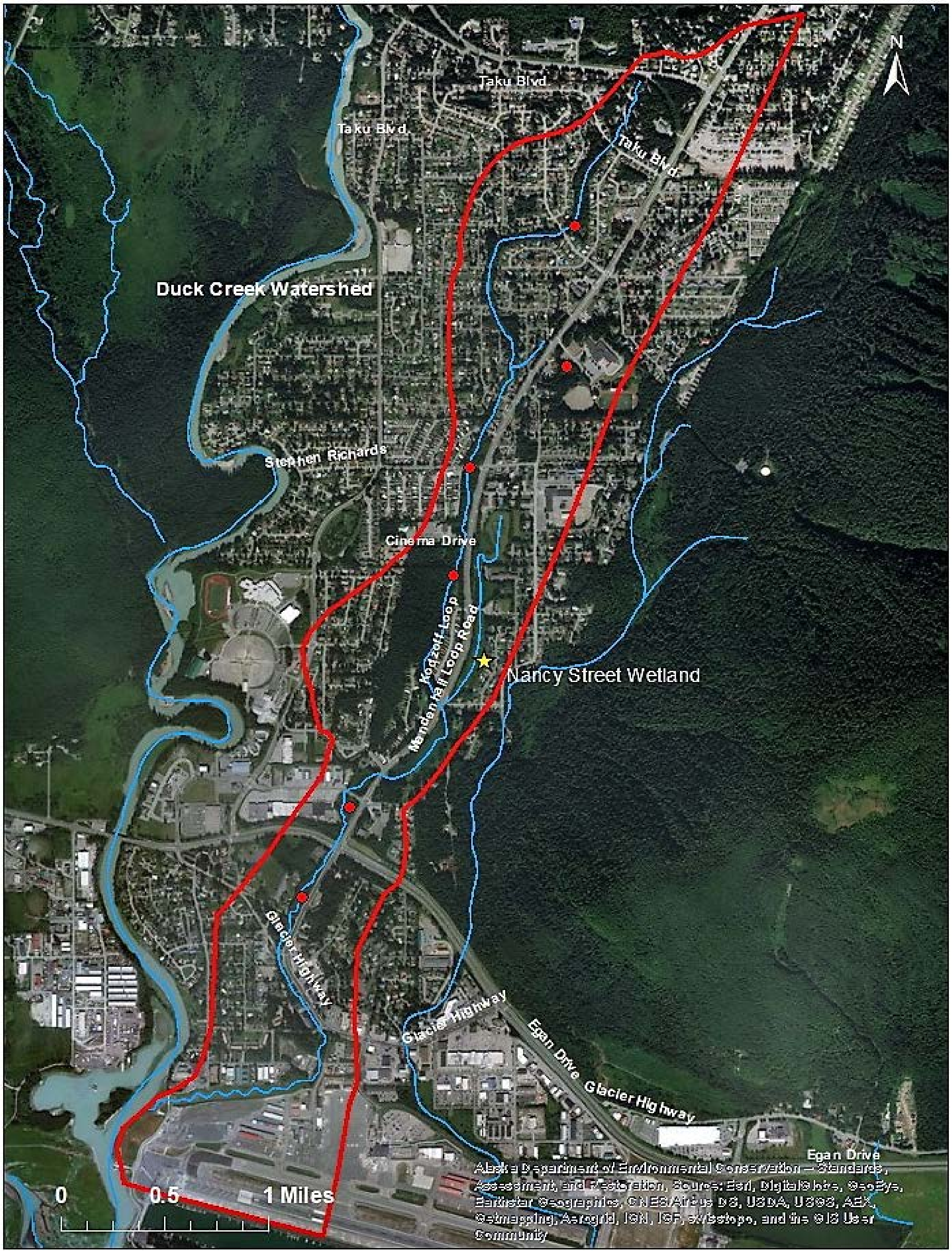


Figure 11. The location of areas with chronic debris problems on Duck Creek.

Litter Free, a non-profit organization committed to keeping Juneau clean and encouraging recycling, organizes a community-wide cleanup each spring where residents and volunteers pick up garbage throughout the city. The JWP participates in this annual clean-up event to encourage clean-up of streams, including Duck Creek. As part of the 2016 annual clean-up effort, the JWP initiated a garbage hotspot map to help direct volunteers to the worst sites along Juneau's streams (Figure 11). Problem areas identified in the Duck Creek TMDL for residues were still hotspots in 2016 and included in the map.

The Nancy Street Wetland does not appear to have a problem with litter. It was not identified as a problem area in the TMDL or the JWP's hotspot map. There is a garbage receptacle provided at the Nancy Street wetland observation deck, which helps encourage proper disposal. In the user survey, there were concerns expressed regarding individuals using the wetland leaving garbage and not picking up dog waste (results of the user survey discussed in more detail later in this report).

During the 2017 monitoring efforts, litter was rarely noted at the monitoring sites. However, other residues such as foam and oil sheen were noted, and often occurred during rain events. The Nancy Street Wetland also has biofilms that can be mistaken for oil sheen. These biofilms are a result of bacteria breaking down organic matter or nutrients and can be distinguished from oil sheens by disturbing the surface of the film using a stick - - oil sheens will immediately reform while biofilms will break into platelets (Figure 12).

Figure 12. A mixture of oil sheen and biofilm on Duck Creek at the Nancy Street Wetland inlet site NSa.

Turbidity

Turbidity (measured in nephelometric turbidity units, or NTUs) is a measurement of water clarity. Turbid water is murky or otherwise colored and will scatter light. It is affected by both organic and inorganic matter suspended or dissolved in the water column. Turbidity may closely parallel total suspended solids (TSS) data, depending on the size distribution of suspended matter.

Unnaturally high in-stream turbidity may contribute to high water temperature, low dissolved oxygen values and lower photosynthesis rates in plants. Increased fines suspended in the water column may also camouflage prey.

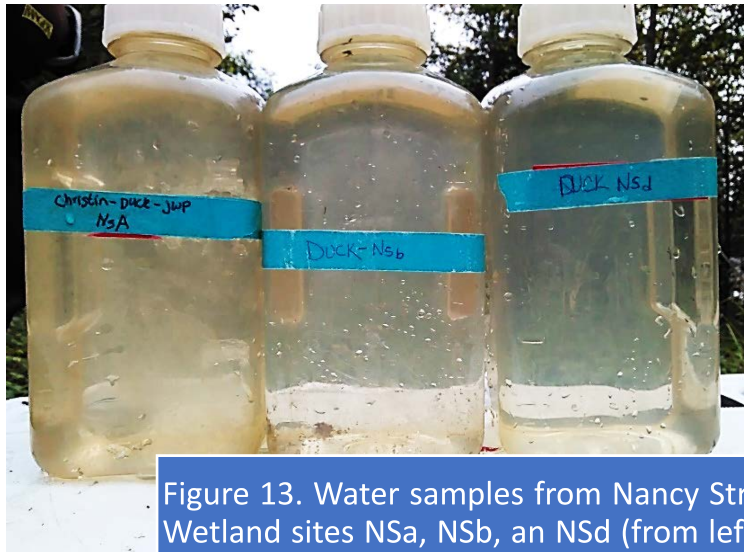


Figure 13. Water samples from Nancy Street Wetland sites NSa, NSb, an NSd (from left to right) showing the difference in turbidity.

The most stringent WQS for turbidity is that for water supply, which requires that measurements not exceed 5 NTUs above natural background conditions. Although less stringent, the WQS for the propagation of fish, which requires that measurements not exceed 25 NTUs above natural background conditions, is important to assess the effectiveness of the Nancy Street Wetland in improving fish habitat and, therefore, is also an applicable WQS to assess in this study.

The Duck Creek TMDL for turbidity uses turbidity, total suspended solids (TSS) and total suspended sediment concentration (SSC) as indicators for water clarity. TSS will be addressed in the next section; there is no data regarding SSC, as the TMDL is predicated on TSS and SSC being equivalent. The TMDL target value for turbidity is 9.4 NTU. This is 5 NTU above the Duck Creek watershed's background level of 4.4 NTU established at Taku Boulevard from data in the early 1990s. Therefore, the TMDL target value is based on the turbidity WQS for water supply. Using this same established background level, that would set a WQS target value for the propagation of fish to 29.4 NTU.

The 2017 data shows the expected seasonal trend, with turbidity increasing around late August when Juneau begins to have increased precipitation (Figure 14). During the 2017 sampling period, exceedances of the more stringent turbidity WQS for water supply (9.4 NTU) occurred at all sites during the fall sampling events starting with the August 19 sampling event. Prior to this, only periodic exceedances were captured at the inlet and midstream sites.

The less stringent turbidity WQS for the propagation of fish (29.4 NTU) was only exceeded twice, at the midstream site (NSb). This is an outlier that may have resulted from inadvertently disturbing streambed sediments during sampling. This seems to be a reasonable assumption given that the October 28th sampling event, which occurred during a large rain event, did not create enough turbidity to exceed this WQS (Figure 14).

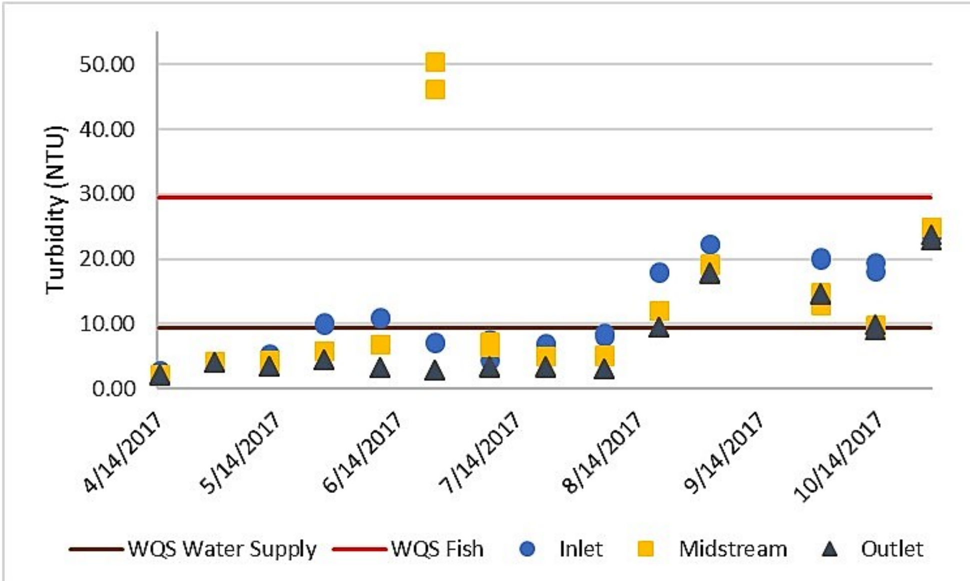


Figure 14. Turbidity measurements (in nephelometric turbidity units, or NTUs) of samples collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standards (WQS) for water supply (9.4 NTU) and for the propagation of fish (29.4 NTU) is shown. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

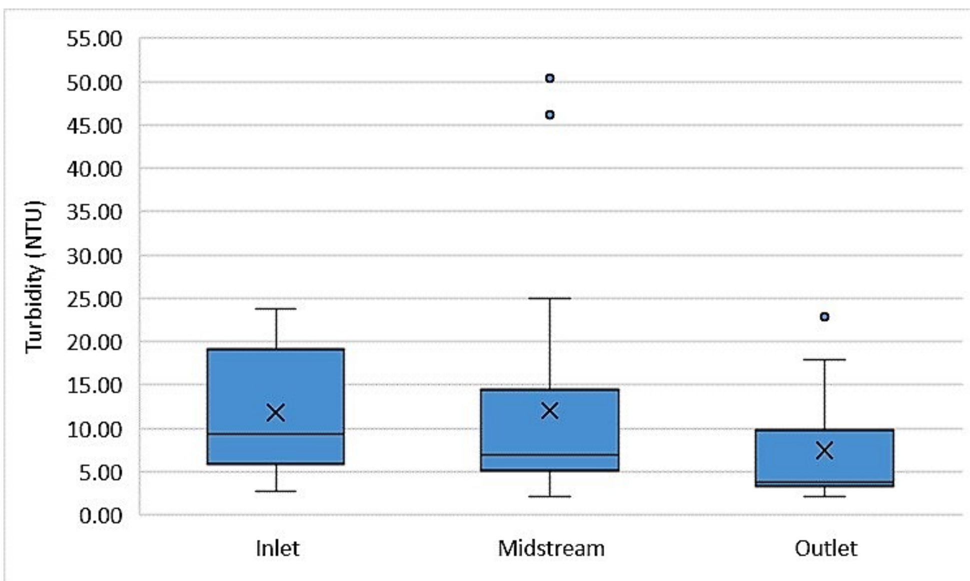


Figure 15. Boxplots (including outliers) comparing the turbidity measurements (in nephelometric turbidity units, or NTUs) of samples collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standards (WQS) for water supply is 9.4 NTU and for the propagation of fish is 29.4 NTU. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

Recall that the October 28th sampling event occurred during a large rain event, but even this storm did not create enough turbidity that the WQS for the propagation of fish (Figure 14).

From the 2017 data, there appears to be a downstream improvement in turbidity as Duck Creek flows through the wetland (Figures 13 through 15). Turbidity at the inlet (NSa) site is significantly different from the outlet (NSd) site, and the inlet tends to have higher turbidity (Appendix E).

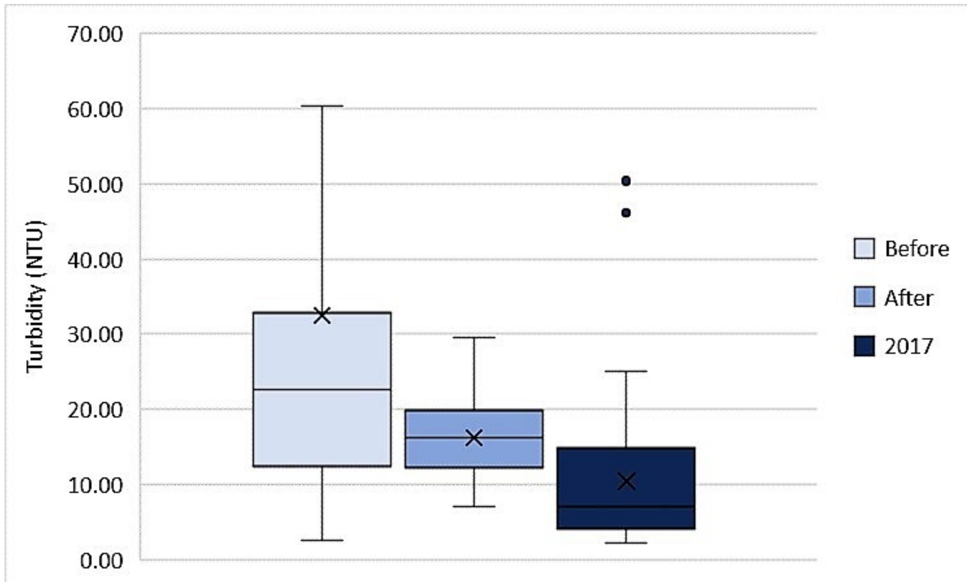


Figure 16. Boxplots comparing turbidity (in nephelometric turbidity units, or NTUs) measured at the Nancy Street wetland before and after the creation of the wetland. The "before" boxplot summarizes data from 122 measurements taken between July 2004 and October 2006. The "after" boxplot summarizes data from 93 measurements taken between November 2006 and March 2008. The 2017 boxplot summarizes data from 84 measurements taken between April and October 2017. The Water Quality Standards (WQS) for water supply is 9.4 NTU and for the propagation of fish is 29.4 NTU. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

Comparison of turbidity data collected before and after the creation of the wetland is shown in Figure 16. Although, the 2017 data does not cover a similar time-period as the other datasets, sampling occurred during a range of flows, including a particularly high flow, providing some confidence that measurements included a range of low and high values for relative comparability with the other sampling periods. From this comparison, it appears that the Nancy Street wetland is effective in improving water clarity.

Downstream trends before and after the Nancy Street wetland is shown in Figure 17. Before the wetland, there was a significant downstream increase in turbidity. However, the data from after the wetland was created shows no significant difference in the turbidity between the up- and downstream sites. The 2017 data exhibits a downstream decrease in turbidity values, as previously discussed (Appendix E). A change from a significant increase to a significant decrease in downstream turbidity after the creation of the Nancy Street wetland suggests that the wetland may have improved turbidity levels. The BACI analysis supports this finding, showing there was a significant difference in the downstream differences before and after the creation of the Nancy Street wetland (Appendix F).

Even with seeming improvement in turbidity levels, there are still periodic exceedances of the WQS and TMDL target values, as evidenced by the data. As expected, exceedances of the more stringent turbidity WQS for water supply occur more frequently than that for the propagation of fish, with a probability of exceedance in 2017 calculated at 54 percent and 1.4 percent, respectively. Since the WQS for water supply is also the TMDL target value, the TMDL target value is also exceeded about half the time.

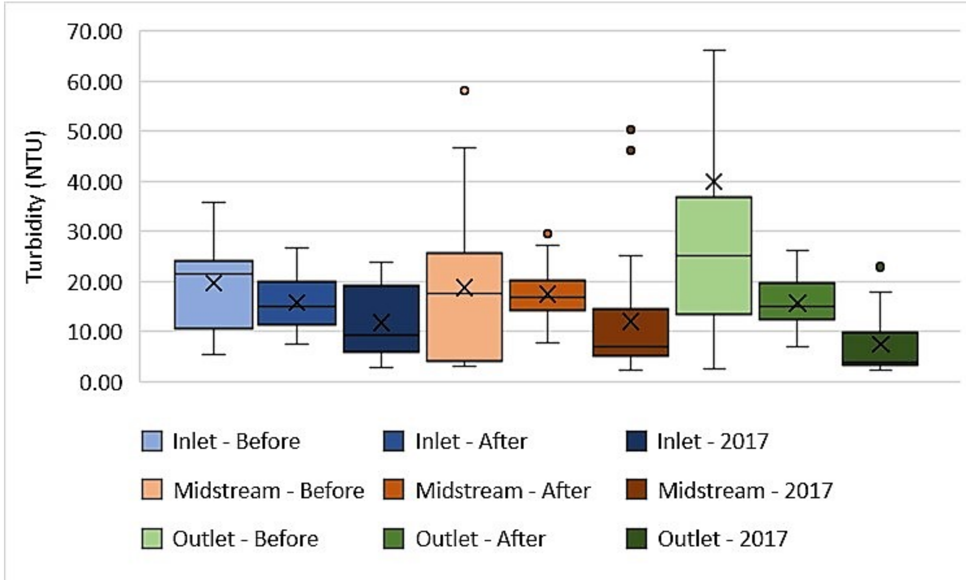


Figure 17. Boxplots comparing turbidity (in nephelometric turbidity units, or NTUs) measured at the Nancy Street wetland inlet (NSa), midstream (NSb) and outlet (NSd) sites before and after the creation of the wetland. The "before" boxplots summarizes data from measurements (23 at NSa, 21 at NSb and 78 at NSd) taken between July 2004 and October 2006. The "after" boxplot summarizes data from measurements (34 at NSa, 25 at NSb and 34 at NSd) taken between November 2006 and March 2008. The 2017 boxplot summarizes data from measurements (28 each at NSa, NSb and NSd) taken between April and October 2017. The Water Quality Standards (WQS) for water supply is 9.4 NTU and for the propagation of fish is 29.4 NTU. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

Although the WQS/TMDL target value of 9.4 NTU is applicable in regulatory terms, Duck Creek surface water is not used for water supply and likely will not be used as such in the future due to water quality and flow concerns; therefore, exceedances of this standard value do not present concern for human health in the practical sense. Duck Creek at the Nancy Street wetland does not appear to have chronic exceedances of the turbidity WQS for the propagation of fish. In addition to the low probability of exceeding this WQS, as demonstrated, even a large storm event did not appear to result in an exceedance of this standard and the only exceedances were likely a result of sampling error.

Total Suspended Solids

Total Suspended Solids (TSS), measured in milligrams per liter (mg/L), refers to solids (2 microns and greater diameter) that are not dissolved in solution and can be removed by filtration (Figure 18). Suspended solids include both organic and inorganic particles, and can impact water clarity (turbidity), conductivity, and temperature. High TSS levels in stream water may raise water temperature, harming aquatic life suited to lower temperatures, as well as impact cellular water balance within small aquatic organisms, affecting their hydration and buoyancy.

Figure 18. Dried filters with suspended solids from Nancy Street wetland samples.

Month	Loading Allocation (tons)
January	0.9
February	1.0
March	1.5
April	1.7
May	1.6
June	1.3
July	1.9
August	2.6
September	4.6
October	5.4
November	2.5
December	2.5

Table 2. Monthly sediment load allocations for Duck Creek. Table modified from DEC, 1999.

Nonglacial streams often transport the highest sediment loads during spring break-up or during periods of high rainfall, but seldom exceed 100 mg/L. The Mendenhall Valley Drainage Studies indicated that valley's non-glacial surface waters have TSS values typically ranged from 0 to 10 mg/L in the winter and 0 to 100 mg/L during the rest of the year.

The state has not outlined WQS for TSS concentration. However, the Duck Creek TMDL for turbidity uses TSS as an indicator for turbidity problems. The TMDL target value for TSS is 9.1 mg/L, which was used to calculate monthly sediment loading allocations necessary to meet WQS (Table 2). This calculation assumes that TSS and SCC are roughly equivalent.

During the 2017 sampling period, the TMDL target value was closely approached multiple times at the midstream (NSb) site but was exceeded only once. In general, TSS concentrations were found to be below the TMDL target value (Figures 19 and 20). From the 2017 data, there appears to be a downstream improvement in TSS concentrations as Duck Creek flows through the wetland (Figure 20). TSS concentrations at the inlet site is significantly different from the outlet site, and the inlet tends to have higher TSS (Appendix E).

TSS data collected before and after the creation of the wetland is shown in Figure 20. Historic data is only available for the outlet (NSd) site from prior to the creation of the wetland, and there is no TSS data from immediately after the creation of the wetland. Therefore, the 2017 data from the outlet site provides the only means for comparing TSS concentrations after the creation of the Nancy Street wetland.

Although, the 2017 data does not cover a similar time-period as the before sampling period, sampling occurred during a range of flows, including a particularly high flow, providing some confidence that measurements included a range of low and high values for relative comparability with the before sampling period.

Therefore, the comparison of the outlet data from before the wetland and the 2017 sampling effort provided by Figure 21 could still be informative. This suggests that at least TSS concentrations at the outlet site have improved.

The one exceedance of the TMDL target value in the 2017 data is an outlier that may have resulted from inadvertently disturbing streambed sediments during sampling. The overall probability of exceedance of the TMDL target value (9.1 mg/L) calculated from the 2017 data is about 27 percent. The probability of an exceedance at the outlet site based on 2017 data is less than one percent (Appendix D). TSS does not appear to be a water quality concern at the Nancy Street wetland.

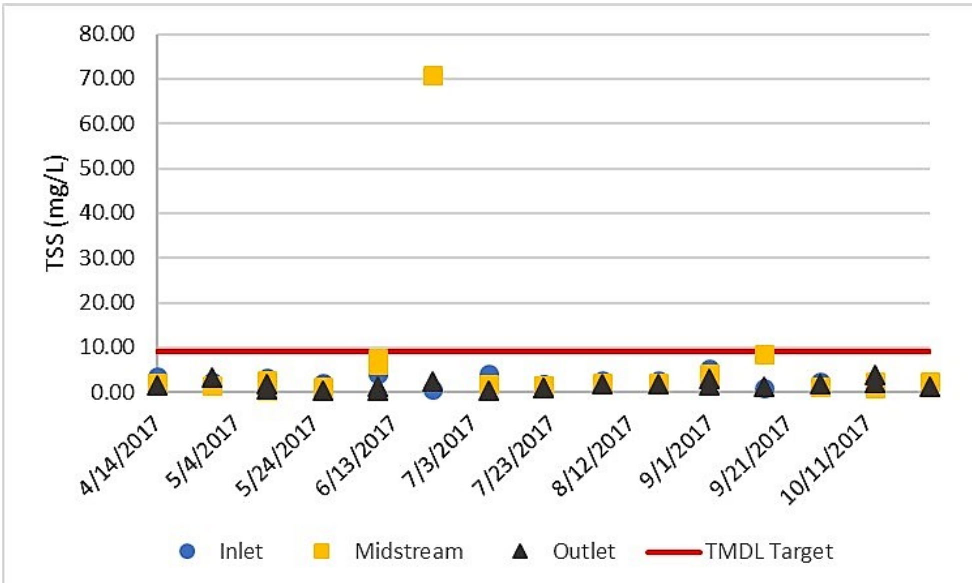


Figure 19. Concentration of total suspended solids (in milligrams per liter, or mg/L) of samples collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Total Maximum Daily Load (TMDL) target value (9.1 mg/L) is shown by the line.

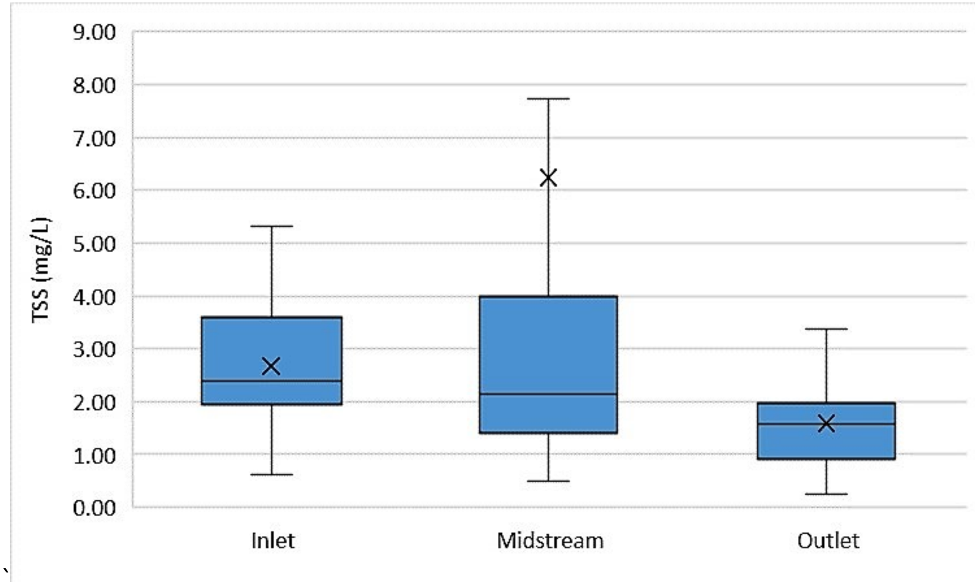


Figure 20. Boxplots comparing total suspended solids concentrations (in milligrams per liter, or mg/L) of samples collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017 (without outlier of 70 mg/L for the midstream site). The Total Maximum Daily Load (TMDL) target value for TSS is 9.1 mg/L.

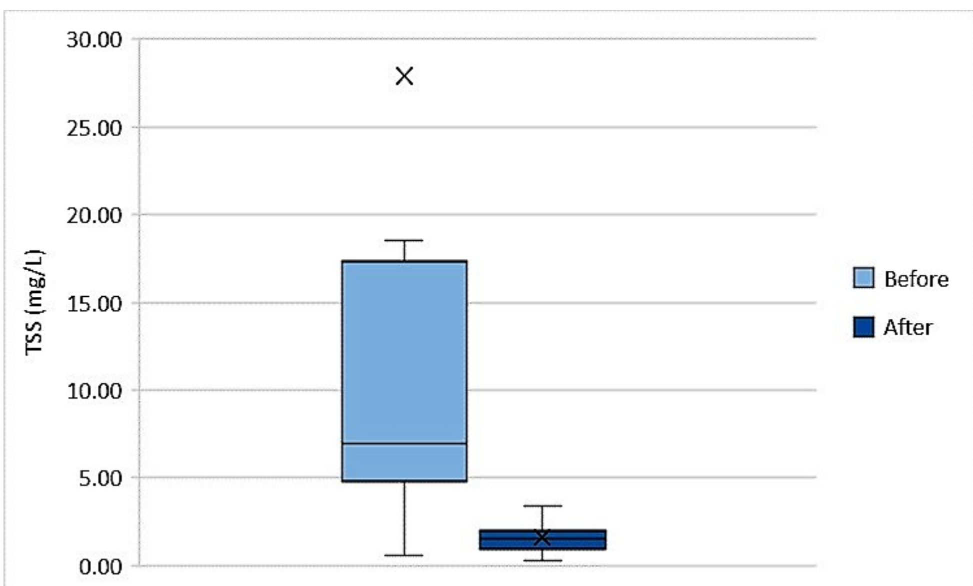


Figure 21. Boxplots (without outliers) comparing the concentration of total suspended solids (in milligrams per liter, or mg/L) of samples collected at the outlet (NSd) site of the Nancy Street wetland before and after the creation of the wetland. The “before” boxplot summarizes data from 34 samples taken between October 2004 and June 2006. The “after” boxplot summarizes data from 20 samples taken between April 2017 and October 2017. The Total Maximum Daily Load (TMDL) target value for TSS is 9.1 mg/L.

Dissolved Oxygen

Dissolved oxygen (D.O.) is a measure of oxygen content in water, expressed in units of milligrams per liter (mg/L). Introduced by aquatic plants and moving water, D.O. is essential to aquatic organism health. D.O. has daily and seasonal patterns associated with photosynthetic rates and water temperature. Aquatic plants can add oxygen to the water. In addition, colder water can hold more dissolved oxygen.

Dissolved oxygen is consumed by microorganisms in the breakdown of organic wastes and the respiratory processes of aquatic organisms like fish and aquatic insects. Low D.O. levels may indicate upstream inputs from wastewater, stormwater runoff, or failing septic systems. D.O. availability is important in both the water column and in the water within the interstitial spaces between streambed gravels. Both are critical for fish survival. Salmonids will seek areas that have adequate dissolved oxygen concentrations.

There are separate WQS for interstitial D.O. and water column D.O. for waterbodies in Alaska. However, interstitial D.O. was not considered in this study. The WQS for D.O. for the propagation of fish requires concentrations greater than 7 mg/L in waters used by anadromous or resident fish. In addition, the concentration of total dissolved gas may not exceed 110 percent saturation at any point of sample collection. The Duck Creek TMDL target value is set to the WQS of 7 mg/L.

During the 2017 sampling period, each site periodically did not meet the WQS. D.O. concentrations dropped below the WQS beginning in June (Figure 22), when concentrations are expected to fall due to increased water temperatures and low flows. While each site had periodic violations of the WQS, the outlet site (NSd) tended towards higher dissolved oxygen concentrations than the upstream sites (Figure 23). The D.O. concentration at the inlet site is significantly different from the outlet site, with the outlet having higher D.O. (Appendix E).

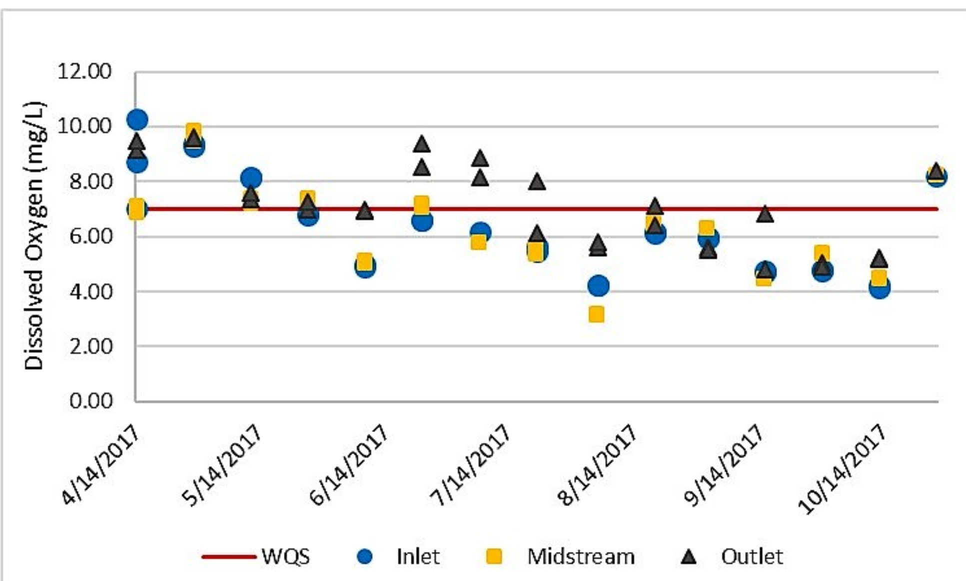


Figure 22. Concentration of dissolved oxygen (in milligrams per liter, or mg/L) of samples collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standard (WQS) (7 mg/L) is shown by the line. The Total Maximum Daily Load (TMDL) target value is set to the WQS.

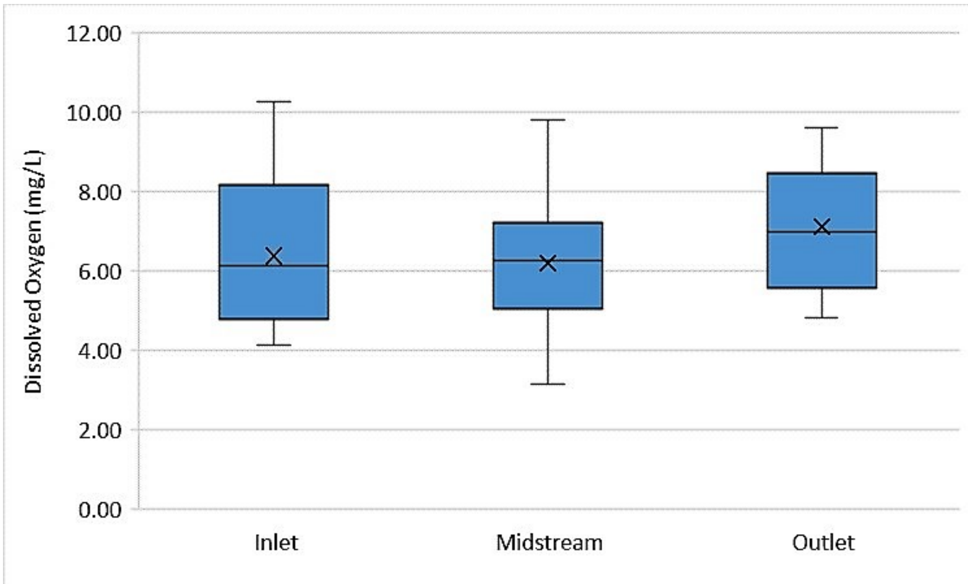


Figure 23. Boxplots comparing the concentration of dissolved oxygen (in milligrams per liter, or mg/L) of measurements taken at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standard (WQS) is 7 mg/L. The Total Maximum Daily Load (TMDL) target value is set to the WQS.

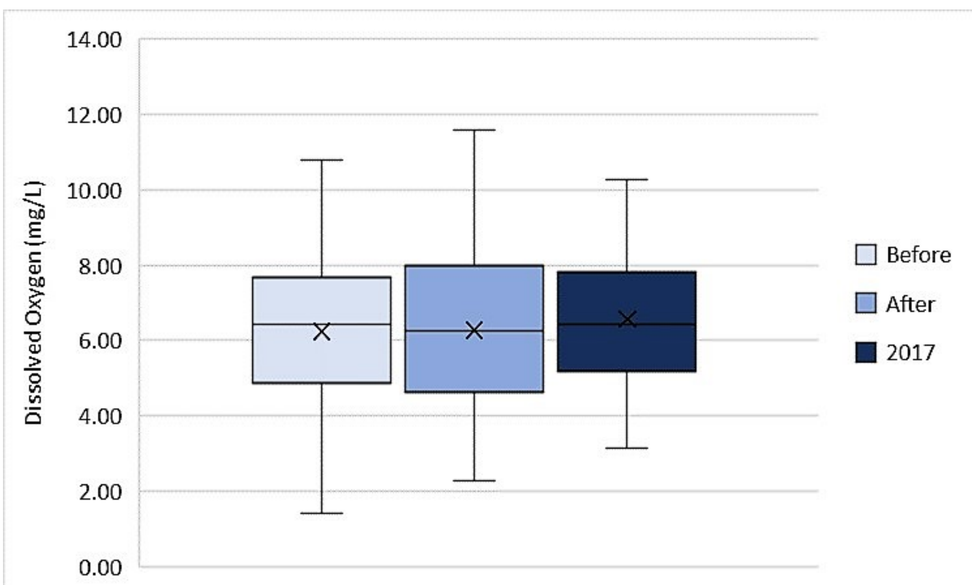


Figure 24. Boxplots comparing dissolved oxygen concentrations (in milligrams per liter, or mg/L) measured at the Nancy Street wetland before and after the creation of the wetland. The “before” boxplot summarizes data from 124 measurements taken between July 2004 and October 2006. The “after” boxplot summarizes data from 93 measurements taken between November 2006 and March 2008. The 2017 boxplot summarizes data from 89 measurements taken between April and October 2017. The Water Quality Standards (WQS) is 7.0 mg/L. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

Comparison of D.O. data collected before and after the creation of the Nancy Street wetland is shown in Figure 24. From this, D.O. concentrations do not appear to have been greatly affected. The average D.O. concentrations were 6.24 mg/L, 6.28mg/L, 6.56 mg/L for the before, after and 2017 periods respectively.

Downstream trends before and after the Nancy Street wetland as shown in Figure 25. For each sampling period (before, after and 2017), the D.O. concentration of the inlet site was significantly different from the outlet site, with the outlet tending to have higher D.O. concentrations (Appendix E). The BACI analysis indicates that there was a significant difference in the downstream change in D.O. concentrations before and immediately after the creation of the wetland, but that there was no difference between the before and 2017 data (Appendix F).

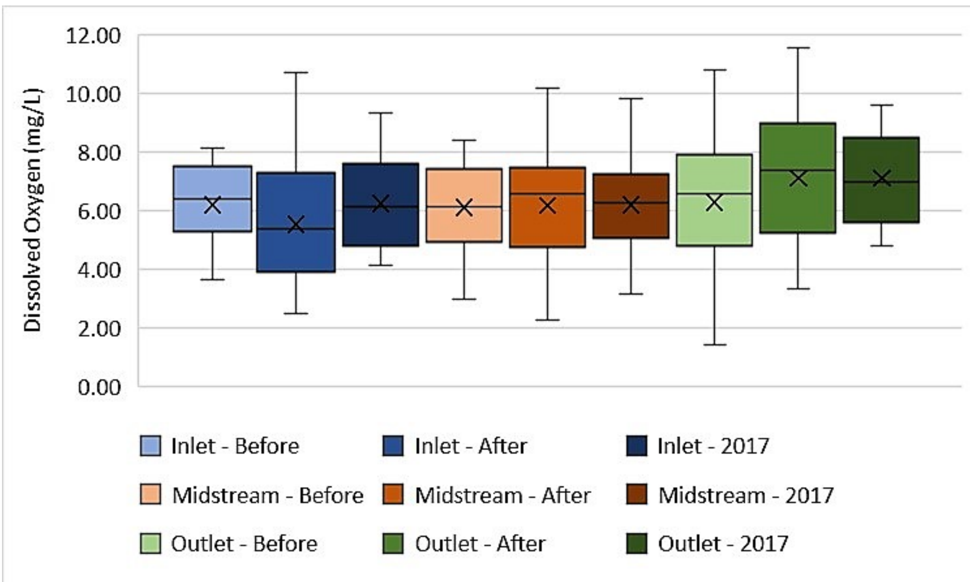


Figure 25. Boxplots (without outliers) comparing dissolved oxygen concentrations (in milligrams per liter, or mg/L) measured at the Nancy Street wetland inlet (NSa), midstream (NSb) and outlet (NSd) sites before and after the creation of the wetland. The “before” boxplots summarizes data from measurements (24 at NSa, 21 at NSb and 79 at NSd) taken between July 2004 and October 2006. The “after” boxplot summarizes data from measurements (34 at NSa, 25 at NSb and 34 at NSd) taken between November 2006 and March 2008. The 2017 boxplot summarizes data from measurements (30 each at NSa and NSb, and 29 NSd) taken between April and October 2017. The Water Quality Standard (WQS) is 7.0 mg/L. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

Since the 2017 data does not include measurements from throughout the year like data from the before and after sampling periods, the comparison of the entire dataset for each period could be misleading due to seasonal trends in D.O. For example, the 2017 data lacks measurements from months where dissolved oxygen levels would be expected to decrease due to plant die-off and ice (e.g. winter months), so lower D.O. limits are not accounted for in the 2017 data. To account for this, growing season (April 23 – October 11) data was analyzed separately.

Growing season D.O. for each sampling period are shown in Figure 26. As with the previous analysis, it appears that there was an initial improvement in growing season D.O. levels, but that current conditions are not significantly different than pre-wetland conditions. Average growing season D.O. concentrations were 6.57 mg/L, 7.12 mg/L, and 6.43 mg/L for the before, after and 2017 sampling periods respectively (Appendix B).

Figure 26. Boxplots comparing dissolved oxygen concentrations (in milligrams per liter, or mg/L) measured at the Nancy Street wetland before and after the creation of the wetland. The "before" boxplot summarizes data from 64 measurements taken between July 2004 and October 2006. The "after" boxplot summarizes data from 33 measurements taken between November 2006 and March 2008. The 2017 boxplot summarizes data from 71 measurements taken between April and October 2017. The Water Quality Standard (WQS) is 7.0 mg/L. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

In analyzing the downstream trends of the growing season data for each sampling period, there was no significant difference between the D.O. concentrations at the inlet (NSa) and the outlet site (NSd) before the wetland. However, there was a significant difference between the sites during the after and 2017 sampling periods, with the outlet having higher D.O. (Appendix E). This differs from the previous analysis.

The BACI analysis of the growing season D.O. data replicated the results of the BACI analysis on the overall data. The downstream change in D.O. levels initially had a significant increase after the creation of the wetland, but the magnitude of the downstream change in D.O. levels in 2017 is not significantly different from that before the wetland (Appendix F).

From the 2017 data, D.O. levels are a water quality concern at the wetland. The probability of not meeting the D.O. WQS (7 mg/L) based on 2017 growing season data is 65.5 percent (Appendix D). Even though D.O. appears to be increasing as Duck Creek moves through the wetland, the downstream increase is not always enough for Duck Creek to meet the WQS at the outlet (NSd) site.

Dissolved Iron

Iron is a heavy metal that can affect water quality and habitat and is of concern in Duck Creek. Dissolved iron is present in the groundwater throughout the Mendenhall Valley. The Duck Creek mainstem is located along groundwater that has iron concentrations that varies from less than 1 parts per million (ppm) to greater than 2 ppm, with the Nancy Street wetland being located over groundwater on the lower end of that range (Barnwell and Boning, 1968).

Figure 27. Iron flocculent at the Nancy Street wetland site NSa.

Dissolved iron in groundwater is usually in the form of reduced, or ferrous, iron (Fe2+). This iron enters surface waters through disruption of groundwater flow by activities such as land clearing and grubbing, placing fill, gravel extraction and road construction (Carson Dorn 2002).

Ferrous iron (Fe2+) oxidizes to ferric iron (Fe3+), which is insoluble and can form a visible precipitate (called flocculent, or floc). This reaction occurs when dissolved iron interacts with dissolved oxygen available in the water, and when dissolved iron is used in the metabolic processes of iron bacteria. Iron bacteria present in Duck Creek likely include the genera *Gallionella*, *Leptothris*, and *Sphaerotilus*. Iron flocculent is present in various locations throughout Duck Creek, including the Nancy Street wetland (Figure 27). Both the chemical reaction and iron bacteria metabolic processes that form iron flocculent decreases the amount of D.O. that can be utilized by aquatic organisms. Furthermore, iron floc settles on the stream bed, fills in the spaces in the gravel, and decreases the habitat quality of fish and aquatic insects.

The most stringent WQS for iron is for water supply, which allows 0.3 mg/L of dissolve iron. However, the WQS for the propagation of fish allows for 1,000 µg/l (or 1 mg/L) of dissolved iron; although less stringent, this is applicable for assessing the Nancy Street wetland's effectiveness in improving fish habitat. The Duck Creek TMDL target value for iron is 0.3 mg/L, with a loading capacity for Nancy Street set at 0.07 tons/year.

During the 2017 sampling period, there were periodic exceedances of both the WQS for water supply and the propagation of fish (Figure 28). However, there appears to be a downstream improvement in iron concentrations, as Duck Creek flows through the wetland (Figures 28 and 29). Dissolved iron concentrations at the inlet site is significantly different from the outlet site, with the inlet tending to have higher iron concentrations (Appendix E).

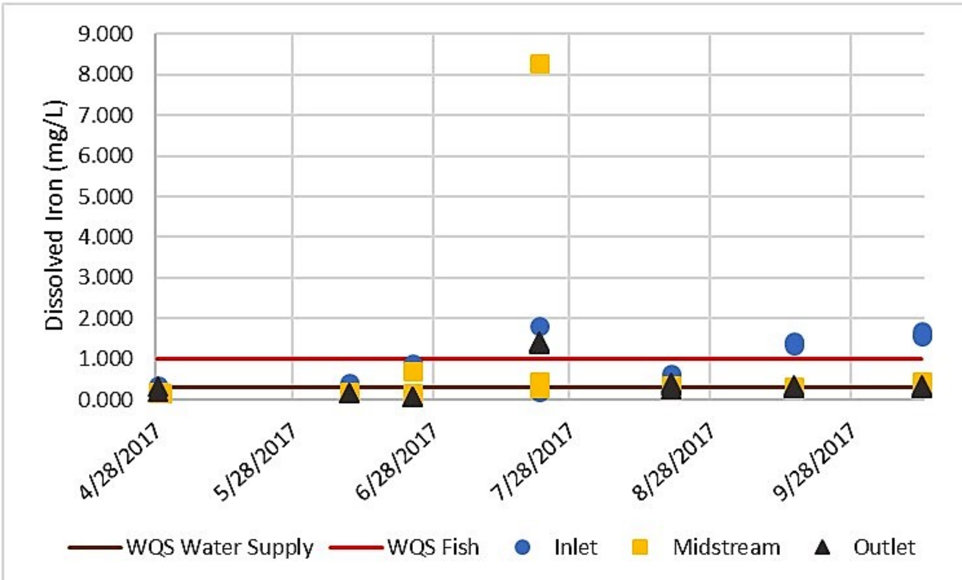


Figure 28. Concentration of dissolved iron (in milligrams per liter, or mg/L) of samples collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standard (WQS) for water supply (0.3 mg/L) and for the propagation of fish (1 mg/L) is shown by the lines. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

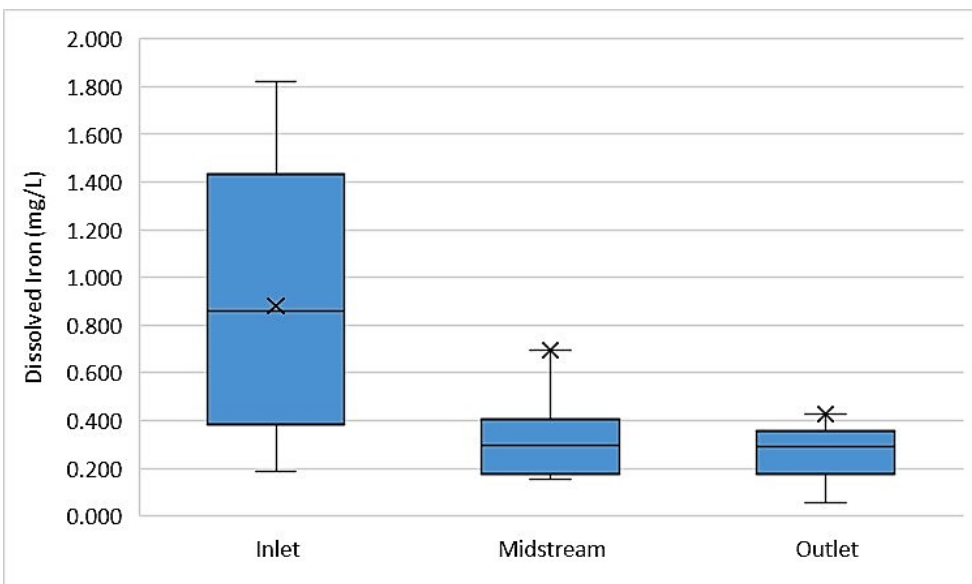


Figure 29. Boxplots comparing the concentration of iron (in milligrams per liter, or mg/L) of samples collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standard (WQS) for water supply (0.3 mg/L) and for the propagation of fish (1 mg/L) is shown by the lines. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

Firm conclusions cannot be made about the effect of the Nancy Street wetland on dissolved iron concentrations, as there is no data from the Nancy Street wetland sites prior to the creation of the wetland.

Hoferkamp (2008) includes data from samples taken at the Church of the Nazarene wetland, at a site denoted as CoN2 just upstream from the Nancy Stream wetland inlet (NSa) from before the Nancy Street wetland. The CoN2 data is provided in Figure 30 for information purposes only and should not be used to draw conclusions regarding the Nancy Street wetland's effectiveness in influencing iron concentrations in Duck Creek.

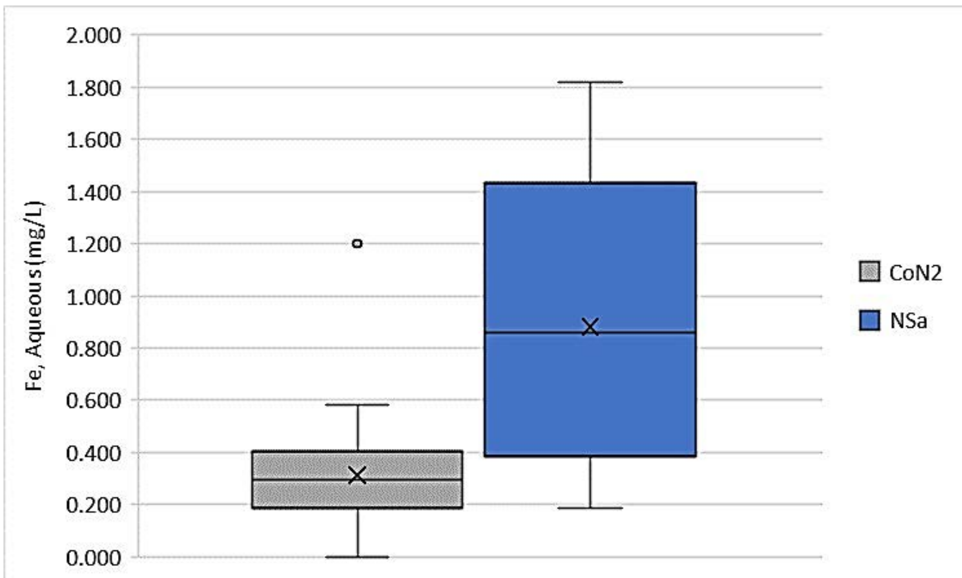


Figure 30. Boxplots (excluding outliers) comparing the concentration of iron (in milligrams per liter, or mg/L) of samples collected at the Church of the Nazarene (CoN2) site taken between xx, and the Nancy Street wetland inlet (NSa) site taken between April and October 2017. The Water Quality Standard (WQS) for water supply (0.3 mg/L) and for the propagation of fish (1 mg/L) is shown by the lines. The Total Maximum Daily Load (TMDL) target value is set to the WQS for water supply.

The CoN2 site is not appropriate surrogate for the Nancy Street wetland inlet (NSa) site conditions prior to the creation of the wetland. The Church of the Nazarene wetland, though formerly a gravel pit pond as well, had been established for almost a decade at the time the measurements were taken. Since the Nancy Street wetland was still an open water gravel pit pond, it likely had more groundwater inputs and different hydrologic characteristics. In addition, the Church driveway and culvert separate the two waterbodies, which could have varying influences on the hydrology of the two locations.

Based on the 2017 data alone, exceedances are likely to occur even with some downstream improvement. The average concentration at each site tends to be higher than the more stringent WQS of 0.3 mg/L, resulting in a probability of exceedance is 61.8 percent. The probability of exceeding the WQS for the propagation of fish is 38.2 percent (Appendix D).

Fecal Coliform Bacteria and Escherichia Coli

Fecal coliform bacteria are found in human and animal feces, and their presence may indicate pathogenic (disease-causing) microorganisms associated with fecal wastes may also be present. *Escherichia coli* (*E. coli*) is one species of fecal coliform bacteria that is specially found in human waste and feces of warm-blooded animals. In 2012, the Environmental Protection Agency (EPA) updated the water quality criteria recommendations for recreational waters, which included the use of *E. coli* as an indicator for freshwater. This recommendation is based on studies that have shown *E. coli* to be a better indicator than fecal coliforms when identifying an acceptable risk to human health.

The most stringent WQS for fecal coliform bacteria is for water supply for drinking water, culinary uses and food processing, which requires that in a 30-day period, the geometric mean may not exceed 20 fecal coliform (FC)/100 milliliters (ml) of water, and not more than 10 percent of the samples may exceed 40 FC/100 ml. The TMDL target value is attainment of this WQS.

The WQS pertaining to *E. coli* is for recreational waters. This does not allow the geometric mean of samples taken within a 30-day period to exceed 126 *E. coli* colony forming units (CFU)/100ml, and not more than 10% of the samples may exceed a statistical threshold value (STV) of 410 *E. coli* CFU/100 ml. Since the *E. coli* WQS was recently adopted into the state WQS, Duck Creek does not have a TMDL target value.

Sources of fecal coliforms in Duck Creek identified in the TMDL include direct inputs from ducks and other waterfowl, and dog waste indirectly conveyed by stormwater, which is the primary means fecal coliform bacteria are transported to the creek.

The TMDL for fecal coliform bacteria, which was produced in 2000 prior to the creation of the wetland, noted that the ponded areas ending at Nancy Street may have been a source of elevated fecal coliform bacteria due to the wetland attracting ducks. Although the pond was converted to a wetland in 2006, ducks still visit the area. However, there is no data to determine whether the duck population utilizing the area increased, decreased or was unaffected by the conversion.

During the 2017 sampling period, fecal coliform bacteria and *E. coli* were only measured at the Nancy Street wetland outlet (NSd) site. The WQS for both fecal coliforms and *E. coli* were

Date	Fecal Coliform (cfu/100ml)
7/21/2017	8
7/25/2017	2
7/25/2017	2
8/02/2017	15
8/10/2017	2
8/17/2017	8
Geometric Mean	10.61

Table 4. Fecal coliform bacteria concentrations (in colony forming units per 100 milliliters, or cfu/100ml) of six samples collected at the outlet (NSd) site of the Nancy Street wetland during a 30-day period between July 2017 and August 2017, and the mean concentration for comparison with the Water Quality Standard (WQS), which requires that in a 30-day period, the geometric mean may not exceed 20 FC/100 ml of water, and not more than 10 percent of the samples may exceed 40 FC/100 ml.

Date	E. Coli (MPN/100ml)
7/21/2017	4
7/25/2017	5
7/25/2017	4
8/02/2017	19
8/10/2017	6
8/17/2017	4
Mean	7.00

Table 3. *Escherichia coli* (*E. coli*) bacteria concentrations of six samples collected at the outlet (NSd) site of the Nancy Street wetland during a 30-day period between July 2017 and August 2017, and the mean concentration for comparison with the Water Quality Standard (WQS), which does not allow the geometric mean of samples taken within a 30-day period to exceed 126 CFU/100ml, and not more than 10% of the samples may exceed a statistical threshold value (STV) of 410 *E. coli* CFU/100 ml.

met (Tables 3 and 4). During this monitoring effort, dog feces were noted several times on the wetland trail. Bear scat was also noted, and a long-time resident indicated bears are commonly found at the wetland early in the morning during the summer. Also, early this year, a beaver constructed a dam at the wetland outlet, and was subsequently found and removed from the area.

There was limited fecal coliform bacteria data from before the creation of the wetland. There is no historic data for *E. coli*. Samples were only collected at the outlet site in 2017. Therefore, analysis of the downstream differences and BACI analysis could not be completed. Therefore, it difficult to draw conclusions about the effect of the Nancy Street wetland on these bacteria. In addition, with this very limited data it is difficult to say how much of a concern bacteria are at the wetland.

Total Dissolved Solids

Total dissolved solids (TDS) concentration, measured in milligrams per liter (mg/L) refers to solids (less than 2 microns in diameter) that are dissolved in solution and cannot be removed by filtration. TDS concentrations are important to monitor because it has the potential to affect osmoregulation, or the water balance, in the cells of aquatic organisms. Since water moves to areas with higher concentrations of dissolved solids, water will leave or enter the cell depending on whether the surrounding water has more or less dissolved solids than the cell. This could affect buoyancy and survival in aquatic organisms.

The most stringent WQS for TDS is that for water supply, which does not allow TDS from all sources to exceed 500 mg/L. Although less stringent, the WQS for the propagation of fish is applicable for assessing the Nancy Street wetland's effectiveness in improving fish habitat. This WQS does not allow TDS to exceed 1,000 mg/L and, in no case, can the concentration of TDS in water causes or reasonably could be expected to cause an adverse effect to aquatic life. There is no TMDL target value for TDS, as Duck Creek is not impaired for this parameter.

During the 2017 sampling period, there were only two exceedances of the WQS. Generally, TDS concentrations remained below the more stringent WQS of 500 mg/L (Figures 31 and 32). The probability of exceeding the water supply WQS for TDS is 11.5 percent and the WQS for the propagation of fish is less than 1 percent (Appendix D). The 2017 downstream trend in TDS concentrations is shown in Figure 32. The 2017 concentrations at the inlet and outlet site are not significantly different (Appendix E). As there is no TDS data from samples taken at the Nancy Street wetland sites during the before and after periods, an analysis of downstream differences in TDS during these periods and the BACI analysis could not be completed.

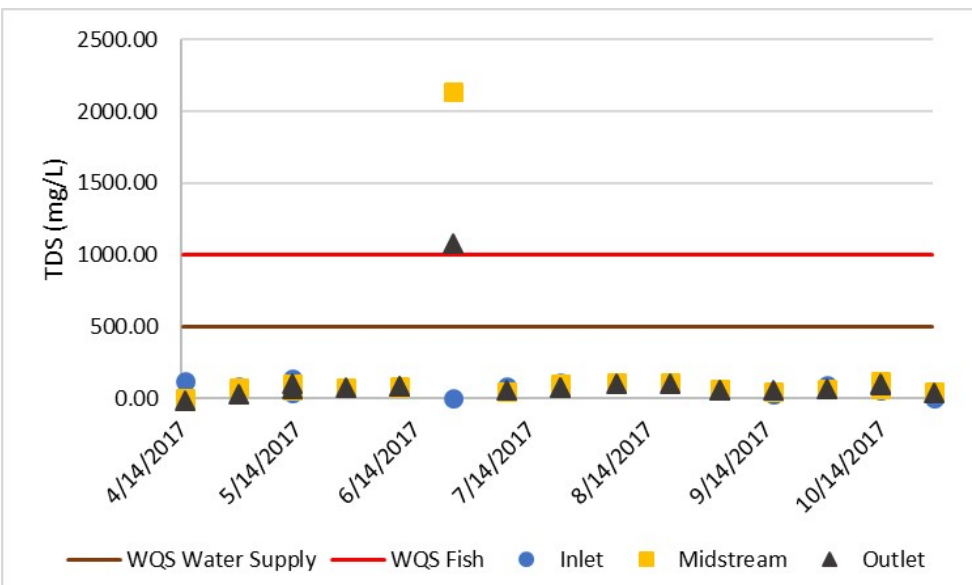


Figure 31. Concentration of total dissolved solids (in milligrams per liter, or mg/L) of samples collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standard (WQS) for water supply (500 mg/L) and for the propagation of fish (1000 mg/L) is shown by the lines.

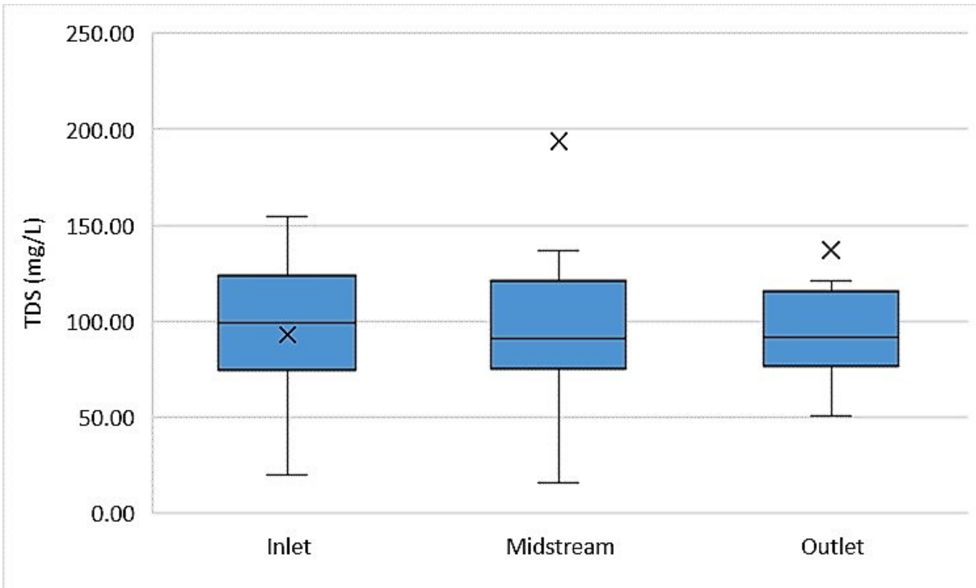


Figure 32. Boxplots (excluding outliers) comparing the TDS concentration (in milligrams per liter, or mg/L) of samples collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standard (WQS) for water supply is 500 mg/L and for the propagation of fish is 1000 mg/L.

The limited data makes it difficult to draw conclusions about the effect of the Nancy Street wetland on TDS concentrations. From the 2017 data alone, there does not appear to be a downstream effect. However, from the data, TDS does not appear to be a water quality concern.

Specific Conductance

Specific conductance, or conductivity (measured in microsiemens per centimeter), is a measure of the water's ability to conduct an electrical current. It is indicative of the total dissolved inorganic solids in a water sample, since inorganic solids can form ions, or charged particles. This includes both negatively charged (chloride, nitrate, sulfate, and phosphate anions) and positively charged (sodium, magnesium, calcium, iron, and aluminum cations). In addition, water temperature is positively correlated to conductivity, i.e. higher water temperature results in higher conductivity.

Conductivity is monitored for background purposes. Watersheds tend to have a relatively constant range of conductivity, which is influenced by its geology. Once the background levels are established, an unusually high or low measurement may indicate pollution problems. For example, a failing septic system upstream could produce a relatively high measurement, while an unusually low measurement may indicate an oil spill upstream.

The DEC has not outlined specific WQS for conductivity. Since Duck Creek is not impaired for conductivity, there is no TMDL target value for this parameter. Therefore, there are no standards by which to compare the 2017 data. During the 2017 monitoring effort, conductivity ranged between 100 and 181 uS/cm, with the average around 150 uS/cm (Appendix B). The 2017 downstream trend is shown in Figure 33. There is no significant difference in the conductivity measurements of the inlet and outlet sites (Appendix E). Comparison of conductivity data collected before and after the creation of the Nancy Street wetland is shown in Figure 34. From this, it appears that the Nancy Street wetland has reduced the range in conductivity of stream water flowing through the wetland.

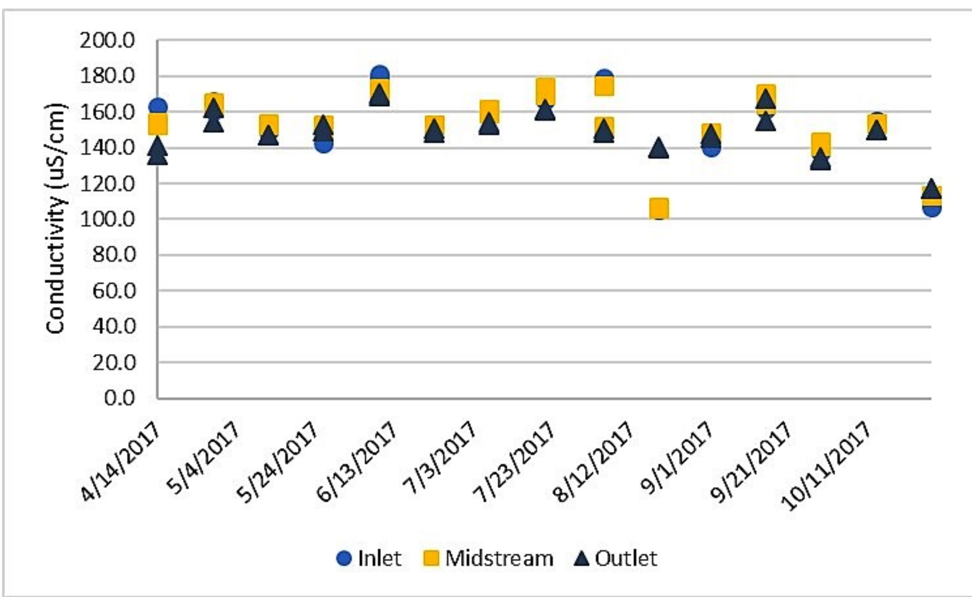


Figure 33. Conductivity (in microsiemens per centimeter, or uS/cm) of measurements taken at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017.

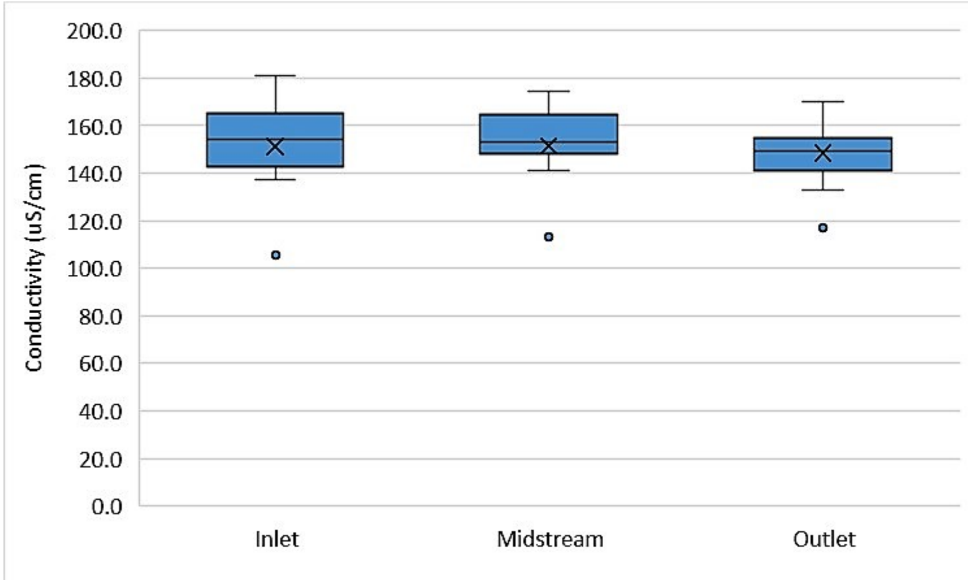


Figure 34. Boxplots (including outliers) comparing the conductivity (in microsiemens per centimeter (uS/cm) measurements taken at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017 (29 at NSa, and 30 each at NSb and NSd).

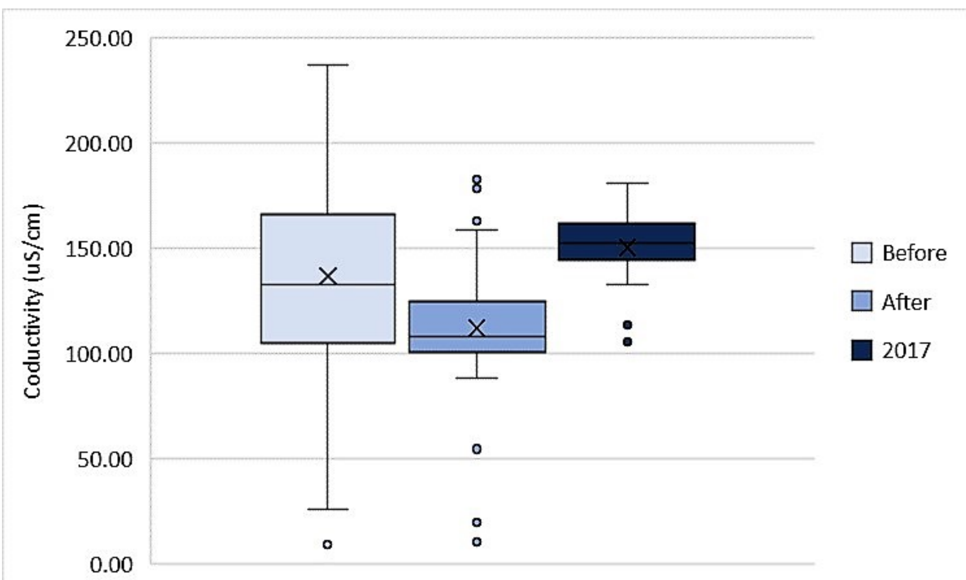


Figure 35. Boxplots comparing the conductivity (in microsiemens per centimeter, or uS/cm) measurements taken at the Nancy Street wetland before and after the creation of the wetland. The "before" boxplot summarizes data from 123 measurements taken between July 2004 and October 2006. The "after" boxplot summarizes data from 87 measurements taken between November 2006 and March 2008. The 2017 boxplot summarizes data from 89 measurements taken between April and October 2017.

Water Temperature

Water temperature (typically measured in degrees Celsius, ˚C) affects many processes in aquatic habitats such as the rate of photosynthesis, the amount of dissolved oxygen, metabolic rates of organisms, salmon egg development and survival, and susceptibility of organisms to toxic chemicals, diseases, and parasites. Various species can only live within a specific range of temperatures.

The WQS for water temperature for the propagation of fish does not allow temperatures to exceed 20˚C at any time, but also sets a maximum of 13˚C for spawning areas and egg and fry incubation and a maximum of 15˚C for migration routes and rearing areas. The *Anadromous Waters Catalog* identifies the Nancy Street Wetland as both spawning and rearing habitat, so both criteria apply. The WQS does not set minimum temperatures, though low temperatures can also be problematic for salmonids. Since Duck Creek is not impaired for temperature, there is no TMDL target value for this parameter.

During the 2017 sampling period, each site periodically did not meet the WQS for water temperature. Exceedances began in late May and persisted through early August. However, at no point during the sampling period were temperatures measured above the 20˚C (Figure 36).

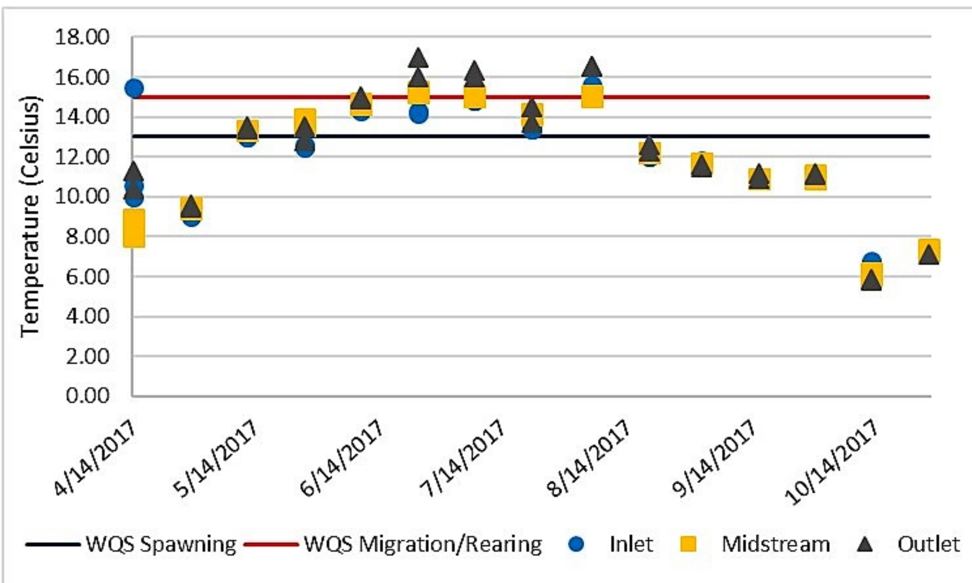


Figure 36. Water temperature (in degrees Celsius) measurements collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standard (WQS) for salmon spawning and egg incubation (13˚C) and for and for migration routes and rearing (15˚C) is shown by the lines.

From the 2017 data, there appears to be a slight downstream increase in temperature as Duck Creek flows through the wetland (Figures 36 and 37). However, temperatures at the inlet and outlet sites are not significantly different (Appendix E).

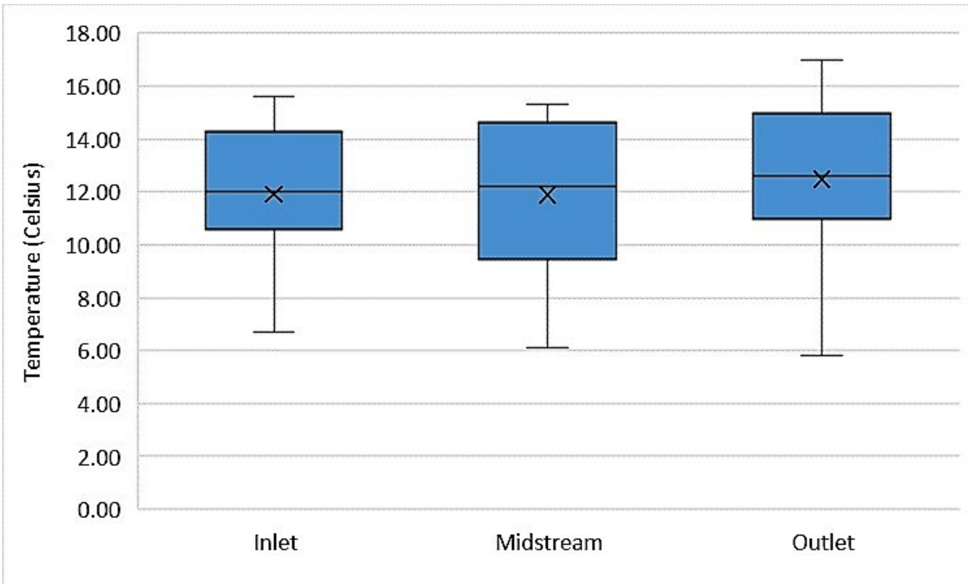


Figure 37. Boxplots comparing water temperature (in degrees Celsius) measurements collected at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017 (30 measurements each at NSa and NSb, and 29 NSd). The Water Quality Standard (WQS) for salmon spawning and egg incubation is 13˚C and for migration routes and rearing is 15˚C.

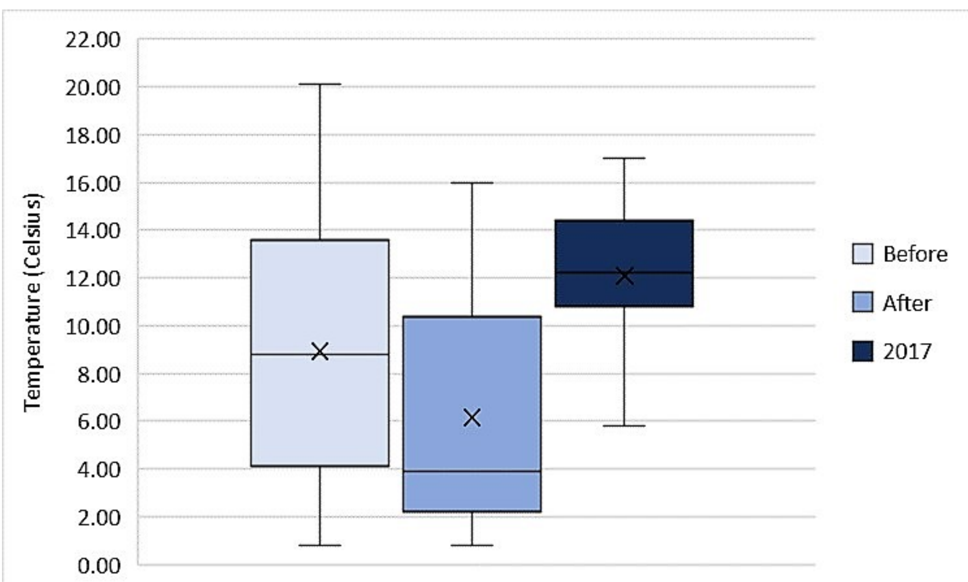


Figure 38. Boxplots comparing water temperature (in degrees Celsius) measured at the Nancy Street wetland before and after the creation of the wetland. The "before" boxplot summarizes data from 127 measurements taken between July 2004 and October 2006. The "after" boxplot summarizes data from 93 measurements taken between November 2006 and March 2008. The 2017 boxplot summarizes data from 90 measurements taken between April and October 2017. The Water Quality Standard (WQS) for salmon spawning and egg incubation is 13˚C and for migration routes and rearing is 15˚C.

Comparison of water temperature data collected before and after the creation of the Nancy Street wetland is shown in Figure 38. The wetland appears to have had an initial cooling effect on the stream. Average water temperatures before the wetland was 8.92˚C while the average was 6.16˚C after the creation of the wetland (Appendix B).

Downstream trends for each period is shown in Figure 39. Water temperature of the inlet site (NSa) was not significantly different from the outlet site (NSd) for each sampling period (Appendix E). The BACI analysis showed no significant difference in the downstream change between the inlet and outlet sites before and after the creation of the wetland (Appendix F).

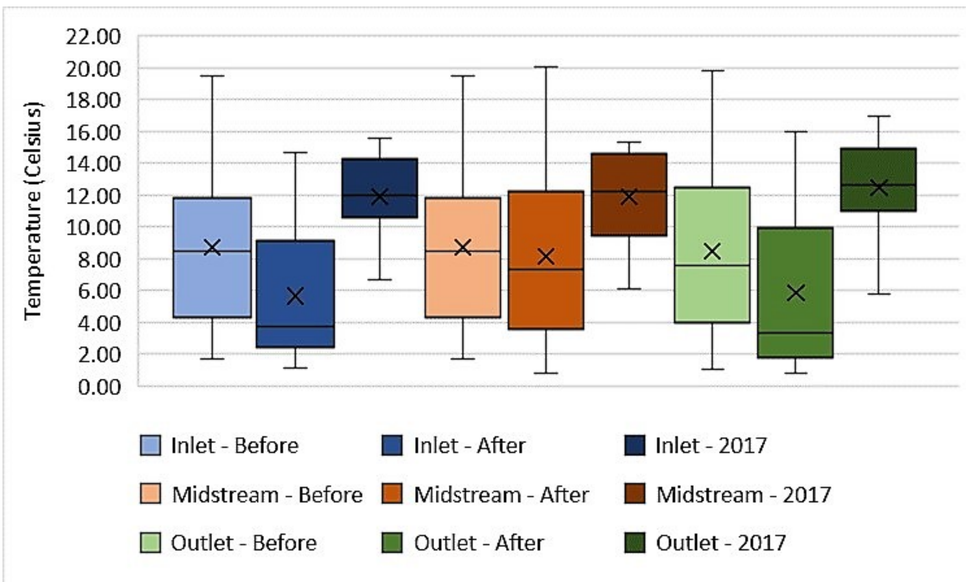


Figure 39. Boxplots comparing the water temperature (in degrees Celsius) measured at the Nancy Street wetland inlet (NSa), midstream (NSb) and outlet (NSd) sites before and after the creation of the wetland. The “before” boxplots summarizes measurements (24 at NSa, 21 at NSb and 82 at NSd) taken between July 2004 and October 2006. The “after” boxplot summarizes measurements (34 at NSa, 25 at NSb and 34 at NSd) taken between November 2006 and March 2008. The 2017 boxplot summarizes measurements (30 each at NSa and NSb, and 29 NSd) taken between April and October 2017. The Water Quality Standard (WQS) for salmon spawning and egg incubation is 13˚C and for migration routes and rearing is 15˚C.

Since the 2017 data does not include measurements from throughout the year like data from the before and after periods, the comparison of the entire dataset for each sampling period could be misleading due to seasonal trends in water temperature. To account for this, growing season (April 23 – October 11) data was analyzed separately to identify any differences in water temperature.

Growing season temperatures for each period are shown in Figure 40. Some of the results differed from that when utilizing all data. As with the original analysis, it appears that growing season water temperatures initially lowered after the creation of the wetland, but then increased to pre-wetland temperatures. Average growing season water temperatures were 12.97˚C, 11.92˚C, and 12.87˚C for the before, after and 2017 sampling periods respectively (Appendix C). During the growing season, water temperature of the inlet site (NSa) was significantly different from the outlet site (NSd) for each sampling period, with the outlet site tending to be warmer than the inlet site (Appendix E). This indicates a downstream warming effect during all sampling periods.

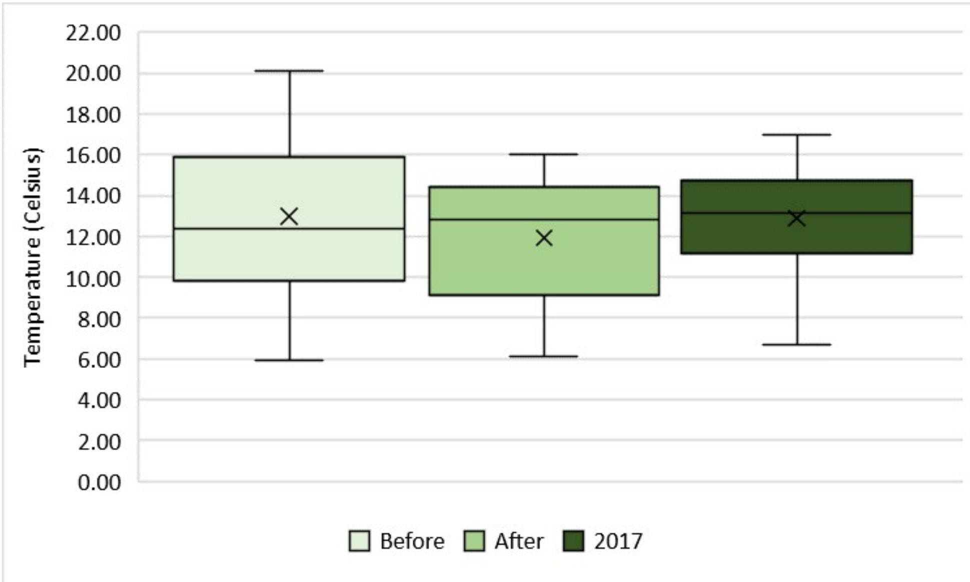


Figure 40. Boxplots comparing growing season (April 23 – October 11) water temperature (in degrees Celsius) measured at the Nancy Street wetland before and after the creation of the wetland. The "before" boxplot summarizes data from 67 measurements taken between July 2004 and October 2006. The "after" boxplot summarizes data from 33 measurements taken between November 2006 and March 2008. The 2017 boxplot summarizes data from 74 measurements taken between April and October 2017. The Water Quality Standard (WQS) for salmon spawning and egg incubation is 13˚C and for migration routes and rearing is 15˚C.

The BACI analysis of the growing season data indicates that there was a significant difference in the downstream change in water temperature before and immediately after the creation of the wetland. Though there was a lowering of temperatures after the creation of the wetland, the magnitude of the downstream difference in water temperatures significantly increased after the wetland was created. However, there was no difference in the downstream change in water temperature between the before and 2017 sampling periods (Appendix F).

From the 2017 data, temperature levels are a water quality concern at the wetland. Water temperature significantly increases as Duck Creek moves through the wetland during the growing season. With a current growing season average temperature near the lower WQS of 13 ˚C, the probability of exceeding this standard is 46 percent. As expected, the probability of exceeding the upper WQS of 15 ˚C is less frequent, at about 16 percent (Appendix D).

pH

pH is unit-less, measured on a scale of 0 to 14, that indicates the acidity or alkalinity of a water sample. A pH of 7 is considered neutral; with acidity increasing as the pH gets lower and the alkalinity increasing as the pH get higher. Most aquatic species live in waters between pH 6.5 and pH 8, with the survival of aquatic organisms greatly diminishing as pH becomes more than 9.0 or less than 5.0. The WQS for the propagation of fish for pH ranges from 6.5 to 8.5. Since Duck Creek is not impaired for pH, there is no TMDL target value for this parameter.

During the 2017 sampling effort, the pH generally stayed within the WQS, with periodic exceedances of the lower pH WQS at the inlet site during late summer/early fall (Figure 41). Generally, the midstream (NSb) and outlet (NSd) sites had a smaller range in pH measurements, with the mean and median measurements near neutral pH. The inlet (NSa) site had a greater range in pH and tended to be slightly more acidic on average (Figure 42). The median pH of the inlet site is significantly different from the outlet site, with the inlet tending to have lower pH (Appendix E).

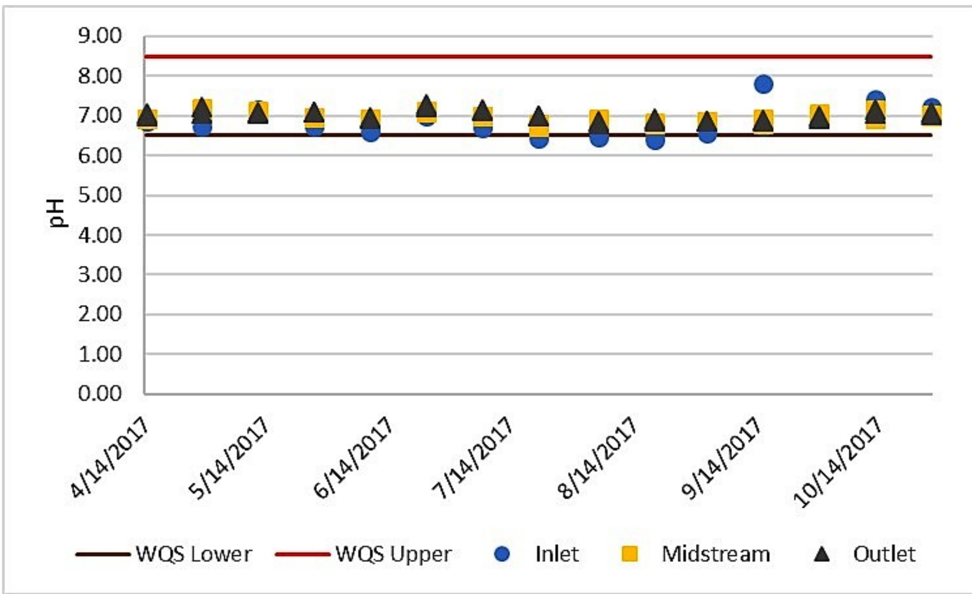


Figure 41. pH measurements taken at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The lower (6.5) and upper (8.5) Water Quality Standard (WQS) are shown by the lines.

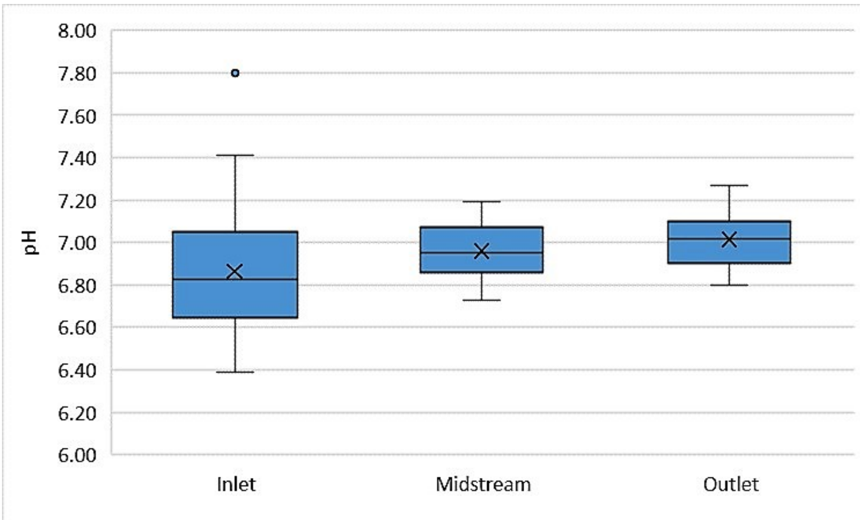


Figure 42. Boxplots comparing pH measured at the inlet (NSa), midstream (NSb) and outlet (NSd) sites of the Nancy Street wetland between April and October 2017. The Water Quality Standard (WQS) for salmon spawning and egg incubation is 13˚C and for migration routes and rearing is 15˚C.

Comparison of pH data collected before and after the creation of the Nancy Street wetland is shown in Figure 43. From this, pH appears to have been initially lowered by the creation of the wetland. The average pH was 6.51, 6.11, and 6.95 for the before, after and 2017 periods respectively.

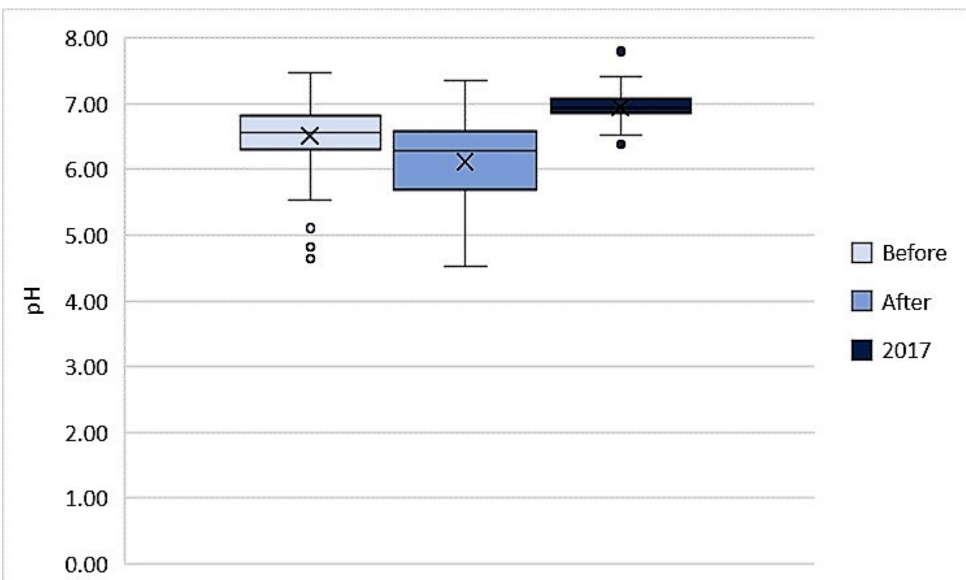


Figure 43. Boxplots comparing pH measured at the Nancy Street wetland before and after the creation of the wetland. The “before” boxplot summarizes data from 120 measurements taken between July 2004 and October 2006. The “after” boxplot summarizes data from 92 measurements taken between November 2006 and March 2008. The 2017 boxplot summarizes data from 90 measurements taken between April and October 2017. The Water Quality Standard (WQS) for pH is between 6.5 and 8.5.

Downstream trends before and after the Nancy Street wetland as shown in Figure 44. pH at the inlet is significantly different from the outlet site (NSd) for each period, with the outlet having higher pH (Appendix E). However, the BACI analysis showed no significant difference in the downstream change between the inlet and outlet sites before and after the creation of the wetland (Appendix F).

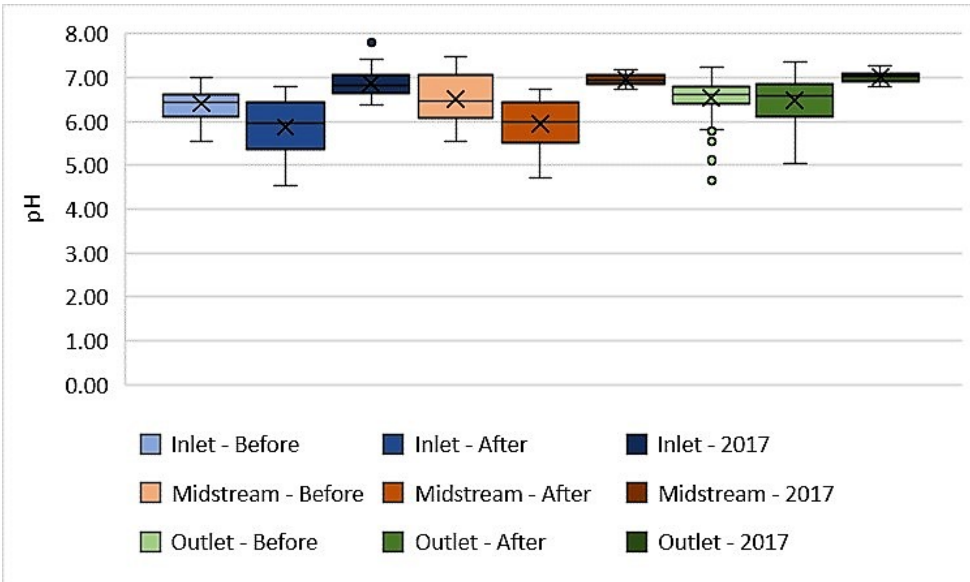


Figure 44. Boxplots comparing pH measured at the Nancy Street wetland inlet (NSa), midstream (NSb) and outlet (NSd) sites before and after the creation of the wetland. The "before" boxplots summarizes measurements (21 at NSa, 21 at NSb and 78 at NSd) taken between July 2004 and October 2006. The "after" boxplot summarizes measurements (33 at NSa, 25 at NSb and 34 at NSd) taken between November 2006 and March 2008. The 2017 boxplot summarizes measurements (30 each at NSa and NSb, and NSd) taken between April and October 2017. The Water Quality Standard (WQS) for pH is between 6.5 and 8.5.

Since the 2017 data does not include measurements from throughout the year like data from the before and after periods, the comparison of the entire dataset for each period could be misleading due to seasonal trends in pH. To account for this, growing season (April 23 – October 11) data was isolated to identify any differences.

Growing season pH for each period are shown in Figure 45. From this, the wetland appeared to initially create relatively acidic conditions during the growing season. In analyzing the downstream trends of the growing season data for each sampling period, there was no significant difference between pH at the inlet (NSa) and the outlet site (NSd) before the wetland, but there was a significant difference between the sites during the after and 2017 sampling periods, with the outlet having higher pH (Appendix E).

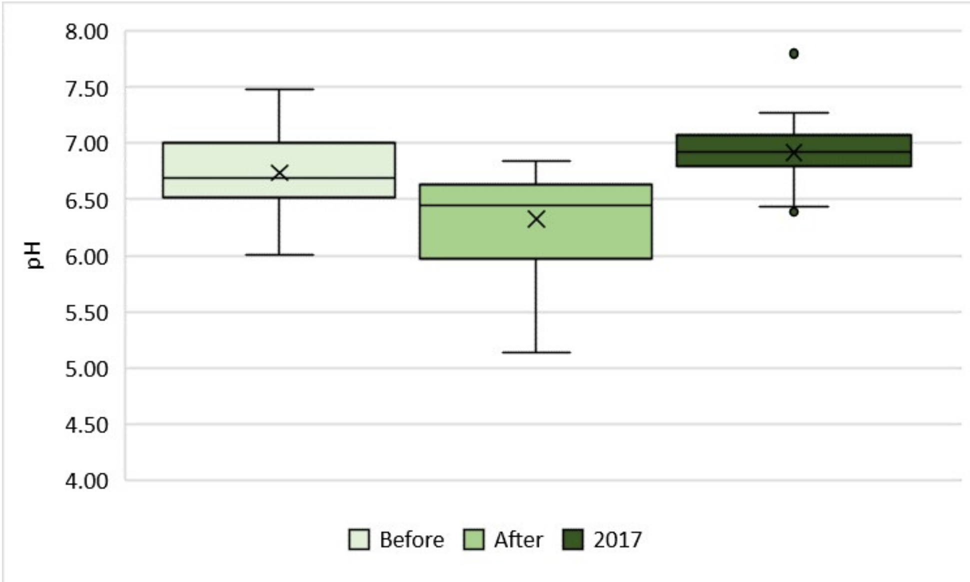


Figure 45. Boxplots comparing growing season (April 23 – October 11) pH measured at the Nancy Street wetland before and after the creation of the wetland. The "before" boxplot summarizes data from 63 measurements taken between July 2004 and October 2006. The "after" boxplot summarizes data from 33 measurements taken between November 2006 and March 2008. The 2017 boxplot summarizes data from 72 measurements taken between April and October 2017. The Water Quality Standard (WQS) for pH is between 6.5 and 8.5.

However, the BACI analysis conducted for the growing season data indicates that there was a significant difference in the downstream change in pH before and immediately after the creation of the wetland. Though there was a lowering of pH during this period, the downstream difference in pH increased after the creation of the wetland. However, there was no difference in the downstream change in pH in the before and 2017 data (Appendix F).

From the 2017 data, pH is not a water quality concern at the wetland. The pH significantly increases as Duck Creek moves through the wetland during the growing season. With a growing season average pH of about 6.9, the probability of not meeting the WQS of 6.5 is 2 percent and the probability of exceeding a pH of 8.5 is less than 1 percent (Appendix D).

User Survey

The JWP conducted an online survey using SurveyMonkey to assess public opinion regarding Duck Creek and the Nancy Street wetland. Only eighteen responses were obtained. The SurveyMonkey data is presented in Appendix H. The following section summarizes and discusses the responses.

The majority of respondents (61%) felt that Duck Creek is not a healthy stream but a majority (83%) also felt that conditions could be improved. A majority also felt that Duck Creek is important to the community.

Fish and wildlife habitat was ranked by respondents as the greatest benefit provided by the wetland. One respondent noted the importance of the Nancy Street wetland for birds such as red wing blackbirds, kinglets, and common yellowthroats that return to the wetland each year to nest and rear their young. Two respondents also noted that domestic cats are loose in the area and noted the potential impact they may be having on nesting birds.

Recreation was ranked fourth following flood control and stormwater treatment as a benefit. A majority of respondents (61%) indicated that they use the Nancy Street wetland for some sort of recreational activity, with 46 percent of these respondents visiting at least once per month. Dog walking and bike riding were the most popular activities noted. Three of the respondents indicated that they were teachers and use the wetland for activities with their students.

Approximately 39 percent (or 7 of the 18 respondents) indicate that they do not use the wetland for recreational activities. While the reason for these individuals' lack of use was not captured in the survey, one respondent did express concerns about safety, indicating that suspicious activities and the potential for bear encounters discourages their use.

Garbage and litter was ranked by the respondents as the greatest threat to the wetland, with dog waste ranked as third. Respondents indicated concern with folks not picking up after themselves or their dogs. As mentioned, dog walking is a popular use of the wetland. The majority (56%) of respondents that walk their dogs have only one dog, while only 11 percent have three or more dogs.

Invasive plant species was ranked last among the potential threats to the wetland. Respondents were split equally on whether they would support the responsible use of herbicides in combination with non-chemical measures, with 33 percent not supporting this proposal, 33 percent in support of this proposal, and 33 percent as undecided/wanting more information. A split was expected, given the potential controversial nature on herbicide use.

Nancy Street Wetland Functional Assessment

A functional assessment of the Nancy Street Wetland was completed by Dr. Paul Adamus in 2013 using the WESPAK-SE method as modified for the CBJ. The scores of that assessment were provided by Dr. Adamus and are shown in Table 5. The highest rated functions include: Stream Flow Support, Streamwater Warming, Anadromous Fish Habitat, Aquatic Invertebrate Habitat, Amphibian Habitat, and Waterbird Feeding and Nesting Habitat.

Specific Functions (F) or Values (V):	F	V
Surface Water Storage (WS)	2.60	7.71
Stream Flow Support (SFS)	7.36	6.20
Streamwater Cooling (WC)	3.36	6.71
Streamwater Warming (WW)	6.67	3.23
Sediment & Toxicant Retention & Stabilization (SR)	3.18	11.67
Phosphorus Retention (PR)	4.48	3.47
Nitrate Removal & Retention (NR)	5.53	6.58
Carbon Sequestration (CS)	4.39	
Organic Nutrient Export (OE)	4.52	
Anadromous Fish Habitat (FA)	6.09	6.67
Resident & Other Fish Habitat (FR)	5.80	6.67
Aquatic Invertebrate Habitat (INV)	6.22	9.70
Amphibian Habitat (AM)	7.70	5.00
Waterbird Feeding Habitat (WBF)	6.03	5.94
Waterbird Nesting Habitat (WBN)	6.40	4.85
Songbird, Raptor, & Mammal Habitat (SBM)	3.54	4.85
Pollinator Habitat (POL)	1.63	3.23
Native Plant Habitat (PH)	5.18	4.85
Public Use & Recognition (PU)		8.50
Subsistence & Provisioning Services (Subsis)		0.00
Wetland Sensitivity		4.59
Wetland Ecological Condition		2.81
Wetland Stressors (higher score means more)		4.98
Summary Ratings for Grouped Functions:		
HYDROLOGIC GROUP	7.36	7.36
WATER QUALITY GROUP	6.67	6.67
CARBON GROUP	4.52	
FISH GROUP	6.09	6.09
AQUATIC SUPPORT	7.70	7.70
TERRESTRIAL SUPPORT	5.18	5.18
SOCIAL GROUP		8.50
WETLAND CONDITION		2.81
WETLAND RISK		4.79

Streamflow Support

A section of Duck Creek immediately downstream from Egan Drive is known to dewater during the summer and winter months. The Nancy Street wetland is upstream from this section of Duck Creek. Although it is indicated by the functional assessment to provide streamflow support, there is no data to demonstrate that the Nancy Street wetland has improved streamflow in the lower sections of Duck Creek.

Streamwater Warming

Same-day measurements of stream water temperatures show that the Duck Creek's temperature increases as it flows through the wetland. For the growing season data, the downstream difference between the inlet and outlet sites was found to be significant. Therefore, the data supports this as a wetland function.

Anadromous Fish Habitat

The Nancy Street wetland was added to the catalogued anadromous waters of Duck Creek in 1990 (Catalog # 111-50-10500-2002-3014), when it was a former gravel extraction pond. The nomination form noted coho salmon and cutthroat trout rearing and coho spawning. This section is currently listed for coho spawning and rearing only. It should be noted that the Alaska Department of Fish and Game has determined the Nancy Street wetland outlet culverts are likely impacting fish passage.

Fish trapping was not conducted as part of the 2017 monitoring effort. However, field observations did note presence of fish during monitoring effort. Most observations could not confirm species, though underwater photos and the aquatic invertebrate presence survey did confirm presence of three-spine stickleback. Hoferkamp (2008) reported capturing coho, Dolly Varden. cutthroat trout and stickleback during fish trapping surveys in 2006 and 2007. Based on a mark-recapture study, Hoferkamp (2008) estimated the wetland's population of juvenile coho at 201 – 356 individuals with an average length of 104±13 mm.

Aquatic Invertebrate Habitat

JWP and SAWC conducted an aquatic invertebrate survey for informational purposes. Riffle, deep water, aquatic vegetation and bottom habitats from the Nancy Street outlet (NSd) site to the observation deck were sampled using a kick-net, and representatives of aquatic invertebrates were preserved for identification. The survey was not conducted in accordance with acceptable protocols for water quality assessments using macroinvertebrate indices; therefore, this data should not be used as an indication of water quality. Macroinvertebrates species identified as being present in the Nancy Street wetland are as follows:

Taxon	Family	Genus	Species	Common Name
Cladocera				Water flea
Colembolla				Springtail
Coleptera	Dytiscidae			Predacious diving beetle
	Gyrinidae	Gyrinus		Whirligig beetle
	Scirtidae			Marsh beetle
Diptera	Chironomidae		At least 3 unidentified species	Midge
	Dixidae			Dixid midge
Ephemeroptera	Leptophlebiidae	Paraleptophlebia		Prong-gilled mayfly
Gastropoda			At least 2 unidentified species	Snail
Hemiptera	Gerridae			Water strider
Hydracarina				Mite
Odonata	Aeshnidae	Aeshna		Mosaic damer dragonfly
	Coenagrionidae	Enallagma		Bluet damselfly
Oligochaeta				Worm
Tricoptera	Limnephilidae	Glyphopsyche	irrorata	Caddisfly
		Nemotaulius	hostilis	Caddisfly
	Phryganeidae			Caddisfly

Due to the variety of aquatic invertebrates present in the wetland, the data confirms the Nancy Street wetland supports aquatic invertebrate habitat.

Amphibian Habitat

No historic data exists on amphibian presence in the Nancy Street wetland and amphibian surveys were not completed as part of this study and not chance observations occurred. Therefore, currently, there is no data to confirm whether the Nancy Street wetland supports amphibian habitat.

Waterbird Feeding and Nesting Habitat

Mallards were the only waterbirds observed during the 2017 monitoring effort. Although ducks were known to frequent the area prior to the creation of the wetland, there is not enough data to confirm whether their presence increased or decreased with the creation of the wetland. However, it is apparent that the wetland supports mallard habitat.

Conclusion and Discussion

Given data limitations, it is difficult to make many firm conclusions regarding the Nancy Street wetland's effect on water quality of Duck Creek.

Turbidity was one parameter in which the data suggests the Nancy Street wetland had positive mitigating effects. Data analysis showed that downstream differences in turbidity changed from a significant increase in turbidity to a significant decrease in turbidity after the creation of the wetland. This suggests the wetland is effective in trapping suspended sediments and other particulates. While turbidity at the Nancy Street wetland had a high probability of exceeding the WQS of 9.4 NTU, this is not considered a practical water quality concern, as Duck Creek surface water is unlikely to support drinking water uses. The WQS of 29.4 NTU only has a probability of 1.8 percent. Therefore, turbidity does not appear to be a water quality concern at the Nancy Street wetland.

Since TSS and turbidity are moderately positively correlated (Appendix C), the positive effects on turbidity could be cautiously extrapolated to TSS as well, with the caveat that there is less data to support this assertion.

No direct conclusions can be drawn regarding the effectiveness of the wetland in improving TDS, dissolved iron, fecal coliforms and *e. coli* due to the lack of data from prior to the creation of the Nancy Street wetland. Even so, the 2017 data indicates that TDS, fecal coliforms and *e. coli* are not an apparent water quality concern at the wetland. Dissolved iron data, on the other hand, suggest that this parameter is a concern. While there was significant downstream improvement in dissolved iron levels, the average 2017 concentration was above the WQS of 0.3 mg/L, resulting in a calculated high probability of exceeding the standard. However, the exceedances in the dissolved iron WQS may be a result of the Nancy Street wetland performing an intended function. While the wetland was intended to reduce dissolved iron inputs by limiting groundwater influx of ferrous iron (Fe^{2+}), the wetland was also intended to trap iron flocculent (ferric iron, Fe^{3+}) to prevent downstream transport. Both ferrous and ferric iron contribute to the total dissolved iron concentrations measured in the wetland.

The analysis is inconclusive regarding the Nancy Street wetland's effect on D.O., water temperature and pH levels. Growing season data indicated improvements in D.O. and temperatures, but a worsening of low pH conditions during the two years immediately after the creation of the wetland. Each of these parameters had significant differences between the inlet and outlet site's growing season values after the creation of the wetland, with the outlet site having higher D.O., temperatures, and pH. The BACI analysis suggests that the magnitude of the downstream change for each of these parameters was only significantly different between the before and after sampling periods. This suggests an initial effect in these parameters after the creation of the Nancy Street wetland, but one that is no longer influencing water quality of the creek. These findings are consistent with Hoferkamp (2008), which suggested that there were small but noticeable changes in D.O., temperature, pH, conductivity and turbidity immediately after the creation of the wetland. However, there are several concerns that should be considered in these analyses.

First is that climatic, hydrological, and site-specific variations can make effects difficult to detect, or can lead to a false-positive identification of change associated with the BMP or restoration effort. A cursory review of climate data shows that 2004, 2005 and 2017 had higher temperatures and less precipitation than 2007 and 2008 (Appendix B). Although a thorough analysis of climatic influences on the wetland over time was not conducted, it is possible that the difference in climate may have factored into the noted decrease in water temperatures and increase in D.O. in the after sampling period, given the strong correlation between air temperature and water temperatures at the wetland. Further, a report to the CBJ by Kelly et al (2007) that presents current and potential future impacts to Juneau resulting from climate change shows that air temperatures in Juneau have been increasing over time. Therefore, it is quite possible that climatic factors are exerting more influence on these parameters than can be mitigated by the wetland.

Also underlying this same concern is that the transformation of this section of Duck Creek from a deep-water gravel extraction pond to a functioning wetland likely affected the variability in D.O., pH and temperature in complex ways. For example, while wetland plants add dissolved oxygen to the system, the wetland may have higher biological oxygen demand due to improved habitat for fish and aquatic insects, and increased decomposition processes of organic matter. In addition, the fill placed to create the wetland was intended to reduce influx of groundwater, but groundwater also helps moderate stream temperatures as shown in Hoferkamp (2008) for the Church of the Nazarene wetland. Further, the wetland is intended to slow water to trap sediment, which could aggrade the channel, reducing the stream depth and allowing the water to warm more easily. While none of these processes were studied, these anecdotes are intended to point out that there may be trade-offs as the wetland becomes established and performs its functions over time.

Finally, another concern is that studies do not often collect enough data to detect small statistically significant changes. While the UAS studies collected data before and after the creation of the wetland, this did not appear to be done in a manner to meet a target number of samples for all parameters during the before and after sampling periods. This study had to rely on this historic data, which could have affected the ability to identify any effects. Using the EPA's TMDL Effectiveness Monitoring Tool, the estimated sample size needed to detect a 10, 15, and 20 percent minimum detectable change for D.O, temperature, and pH was calculated based on the data from the sampling period before the creation of the wetland. Based on this, there may have only been enough samples to detect between a 15 and 20 percent change in D.O. and a 10 percent or greater change in pH. Any changes smaller than this will not be identified by tests as statistically significant. For temperature, there was not enough samples per site to detect a 20 percent change or less (Appendix G).

Even though the picture is unclear in terms of the Nancy Street wetland's effect on D.O., pH, and temperature, what is clear is that the 2017 data indicates D.O. and temperature are a water quality concern at the wetland during the growing season. During the growing season, the probability of D.O. dropping below the WQS of 7 mg/L is 65.5 percent. For temperature, the probability of exceeding the WQS of 13 C and 15 C is 46 and 16 percent respectively. While there may be D.O. and temperature gradients throughout the Nancy Street wetland, with some areas providing better conditions than others, this suggests that there is a high possibility of stressful conditions for anadromous fish during spawning and rearing.

Unfortunately, the 2017 data does not provide adequate information on the non-growing season conditions of these parameters. Overwintering habitat is important for juvenile salmonids, and the wetland was designed to provide two overwintering pools at the inlet and outlet. Non-growing season data from the after sampling period shows a drop in D.O., temperature, and pH levels, but there is no recent data covering the entire non-growing season to tell whether this problem currently persists. Periodic, unofficial measurements made by USFWS staff at the wetland indicate that D.O. levels drop extremely low, to lethal levels, during the winter (Hudson, personal communication). This is possible, given the assumption of low winter flows and potential freezing that could limit habitat suitability.

In terms of influencing overall water quality on Duck Creek, the Nancy Street wetland is not ideally located to exert watershed-wide influence. Being located on the east fork of Duck Creek, the Nancy Street wetland treats a relatively small proportion of the Duck Creek watershed. Though the Nancy Street wetland was intended to improve downstream conditions with regards to DO and dissolved iron, this study did not look at any downstream sites on the mainstem to determine if any improvements have been realized outside of the wetland's immediate influence. Even so, the Nancy Street wetland appears to have at least been responsible for some initial improvements in D.O. and water temperature, and on-going improvements in turbidity and, possibly, TSS. Though exceedances of WQS are highly probable for D.O., temperature, and dissolved iron, this may be, in part, due to the wetland serving its intended functions and the complex interactions between these interdependent parameters. In spite of these exceedances, there is still some evidence that the Nancy Street wetland provides suitable habitat for fish and wildlife. In addition, the Nancy Street wetland also has perceived community value as demonstrated by the user survey.

References

Adamus Resource Assessment, Inc. 1987. Juneau wetlands: functions and values. Prepared for City and Borough of Juneau, Alaska Department of Community Development. http://people.oregonstate.edu/~adamusp/Alaska%20Wetland%20Assessment%20Methods/Juneau_Wetlands/Juneau_Wetlands%201987.pdf

Adamus, Paul. Personal communication. Nancy Street wetland WESPAK assessment data.

Alaska Department of Environmental Conservation (DEC). 1999. TMDL for Turbidity in the Waters of Duck Creek in the Mendenhall Valley, Alaska. http://dec.alaska.gov/water/tmdl/pdfs/duckcreekturbiditytmdl.pdf

--- . 2000a. TMDL for Debris in the Waters of Duck Creek in the Mendenhall Valley, Alaska. http://dec.alaska.gov/water/tmdl/pdfs/duckcreekdebris.pdf

--- . 2000b. TMDL for Fecal Coliform Bacteria in the Waters of Duck Creek in the Mendenhall Valley, Alaska. http://dec.alaska.gov/water/tmdl/pdfs/duckcreekfecaltmdl.pdf

--- . 2001. TMDL for Dissolved Oxygen and Iron in the Waters of Duck Creek in the Mendenhall Valley, Alaska. http://dec.alaska.gov/water/tmdl/pdfs/duckcreekfedo.pdf

Alaska DEC. 2018. State of Alaska Water Quality Standards, 18 AAC 70. [online] URL: http://dec.alaska.gov/water/water-quality/standards/

Alaska Dept. of Fish and Game. Fish Resource Monitor Interactive Map. http://extra.sf.adfg.state.ak.us/FishResourceMonitor/?mode=culv

American Society of Landscape Architects. Nd. Green Infrastructure and Stormwater Management Case Study No. 398: Nancy Street Wetland Enhancement. Accessed online at: https://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20398%20Nancy%20Street%20Wetland%20Enhancement,%20Juneau,%20AK.pdf

Barnwell, W.W., and Boning, C.W., 1968, Water resources and surficial geology of the Mendenhall Valley, Alaska: U.S. Geological Survey Hydrologic Investigations Atlas 259, 6 p., 1 sheet, scale 1:31,680. http://www.dggs.alaska.gov/pubs/id/13641
https://pubs.er.usgs.gov/publication/ha259

Curran, J.H. 2007. Hydrology and Flood Profiles of Duck Creek and Jordan Creek Downstream from Egan Drive, Juneau, Alaska. USGS Scientific Investigations Report 2006-5323. [online] URL: http://pubs.usgs.gov/sir/2006/5323/

U.S. Environmental Protection Agency. 2011a. Technical Guidance for Designing a TMDL Effectiveness Monitoring Plan. Prepared by the Cadmus Group for EPA Region 10 and Washington Department of Ecology. (accessed online at: https://www.epa.gov/sites/production/files/2015-07/documents/techguide_design_tmdl_effective_monitorp_123011-2.pdf)

---. 2011b. Technical Guidance for Exploring TMDL Effectiveness Monitoring Data. Prepared by the Cadmus Group for EPA Region 10 and Washington Department of Ecology. (accessed online at: https://www.epa.gov/sites/production/files/2015-07/documents/techguide_explore_tmdl_effective_monitor_data_123011.pdf)

Hoferkamp, L. 2008. Inventory of Created Wetlands, Duck Creek, Juneau, Alaska: Baseline Data for Assessment of Existing Created Wetlands and Future Wetland Creation Sites. (accessed online at: http://dec.alaska.gov/water/nonpoint-source-control/waters-in-the-spotlight/juneau-watersheds-water-quality-monitoring-activities/)

Hood, E.; Hoferkamp, L; and Hudson, J. 2005. Duck and Jordan Creek Protection and Recovery. (accessed online at: http://dec.alaska.gov/water/nonpoint-source-control/waters-in-the-spotlight/juneau-watersheds-water-quality-monitoring-activities/)

Hudson, et al. 1982. Regional uplift in southeastern Alaska, in W.L. Conrad (ed.) The U.S. Geological Survey in Alaska - Accomplishments during 1980. U.S. Geological Survey Circular 844: 132-135.

Kelly, B.P., T. Ainsworth, D.A. Boyce Jr., E. Hood, P. Murphy, and J. Powell. 2007. Climate Change: Predicted Impacts on Juneau. Prepared for the City and Borough of Juneau. [online] URL: http://www.juneau.lib.ak.us/clerk/boards/Climate_Change/CBJ%20_Climate_Report_Final.pdf

Koski, K. and M. Lorenz. 1999. Duck Creek Watershed Management Plan. Prepared for The Duck Creek Advisory Group and the 319 Program of the Clean Water Act, July. (accessed online at: http://dec.alaska.gov/water/nonpoint-source-control/waters-in-the-spotlight/juneau-watersheds-water-quality-monitoring-activities/)

Nagorski, S.; E. Hood; and L. Hoferkamp. 2006. Watershed Protection and Recover for Duck Creek, Juneau, AK. (accessed online at: http://dec.alaska.gov/water/nonpoint-source-control/waters-in-the-spotlight/juneau-watersheds-water-quality-monitoring-activities/)

National Weather Service. Juneau, AK Weather Data. https://w2.weather.gov/climate/index.php?wfo=PAJK

Natural Resources Conservation Service (NRCS). 2003. National Water Quality Handbook. (accessed online at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044775.pdf)

Peixoto, Pedro S. and Montanher, Tiago M. EXSTAT - Excel Statistical Calculator. Version 2.0, Set 2013. Available at: www.ime.usp.br/~pedrosp

R & M Engineering 1996. Mendenhall Valley Drainage Study.

U. S. Army Corps of Engineers. 2013. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Alaska Region. Version 2.0. https://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/reg_supp/erdc-el_tr-07-24.pdf

Western Regional Climate Center. Monthly climate summary for Juneau International Airport, Alaska (Station #504100). [online] URL: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak4100

Wright, S.J. and P.K. Czapla. Nd. Alaska Coastal Revegetation and Erosion Control Guide. State of Alaska Department of Natural Resources, Division of Agriculture, Plant Materials Center.

Appendix A. 2017 Water Quality Standards

Fecal Coliforms/E. Coli

Designated Use		Water Quality Standard
Water Supply	drinking, culinary, and food processing	In a 30-day period, the geometric mean may not exceed 20 fecal coliform/100 ml, and not more than 10% of the samples may exceed 40 fecal coliform/100 ml. For groundwater, the fecal coliform concentration must be less than 1 fecal coliform/100 ml, using the fecal coliform Membrane Filter Technique, or less than 3 fecal coliform/100 ml, using the fecal coliform most probable number (MPN) technique.
	agriculture, including irrigation and stock watering	In a 30-day period, the geometric mean of samples may not exceed 200 fecal coliform/100 ml, and not more than 10% of the samples may exceed 400 fecal coliform/100 ml. For products not normally cooked and for dairy sanitation of unpasteurized products, the criteria for drinking water supply, (2)(A)(i), apply.
	aquaculture	For products normally cooked, the geometric mean of samples taken in a 30-day period may not exceed 200 fecal coliform/100 ml, and not more than 10% of the samples may exceed 400 fecal coliform/100 ml. For products not normally cooked, the criteria for drinking water supply, (2)(A)(i), apply.
	industrial	Where worker contact is present, the geometric mean of samples taken in a 30-day period may not exceed 200 fecal coliform/100 ml, and not more than 10% of the samples may exceed 400 fecal coliform/100 ml.
Water Recreation	contact recreation	In a 30-day period, the geometric mean of samples may not exceed 126 *Escherichia coli (E. coli*) colony forming units (CFU)/ 100ml, and not more than 10% of the samples may exceed a statistical threshold value (STV) of 410 *E. coli* CFU/100 ml.
	secondary recreation	In a 30-day period, the geometric mean of samples may not exceed 200 fecal coliform/100 ml, and not more than 10% of the total samples may exceed 400 fecal coliform/100 ml.
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife		Not applicable.

Dissolved Oxygen

Designated Use		Water Quality Standard
Water Supply	drinking, culinary, and food processing	Dissolved oxygen (D.O.) must be greater than or equal to 4 mg/l (this does not apply to lakes or reservoirs in which supplies are taken from below the thermocline, or to groundwater).
	agriculture, including irrigation and stock watering	D.O. must be greater than 3 mg/l in surface waters.
	aquaculture	D.O. must be greater than 7 mg/l in surface waters. The concentration of total dissolved gas may not exceed 110% of saturation at any point of sample collection.
	industrial	May not cause detrimental effects on established water supply treatment levels.
Water Recreation	contact recreation	D.O. must be greater than or equal to 4 mg/l.
	secondary recreation	
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife		D.O. must be greater than 7 mg/l in waters used by anadromous or resident fish. In no case may D.O. be less than 5 mg/l to a depth of 20 cm in the interstitial waters of gravel used by anadromous or resident fish for spawning (see note 2). For waters not used by anadromous or resident fish, D.O. must be greater than or equal to 5 mg/l. In no case may D.O. be greater than 17 mg/l. The concentration of total dissolved gas may not exceed 110% of saturation at any point of sample collection.

Total Dissolved Solids

Designated Use		Water Quality Standard
Water Supply	drinking, culinary, and food processing	Total dissolved solids (TDS) from all sources may not exceed 500 mg/l. Neither chlorides nor sulfates may exceed 250 mg/l.
	agriculture, including irrigation and stock watering	TDS may not exceed 1,000 mg/l. Sodium adsorption ratio must be less than 2.5, sodium percentage less than 60%, and residual carbonate less than 1.25 milliequivalents/liter.
	aquaculture	TDS may not exceed 1,000 mg/l. A concentration of TDS may not be present in water if that concentration causes or reasonably could be expected to cause an adverse effect to aquatic life.
	industrial	No amounts above natural conditions that can cause corrosion, scaling, or process problems.
Water Recreation	contact recreation	Not applicable.
	secondary recreation	Not applicable.
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife		TDS may not exceed 1,000 mg/l. A concentration of TDS may not be present in water if that concentration causes or reasonably could be expected to cause an adverse effect to aquatic life.

pH

Designated Use		Water Quality Standard
Water Supply	drinking, culinary, and food processing	May not be less than 6.0 or greater than 8.5.
	agriculture, including irrigation and stock watering	May not be less than 5.0 or greater than 9.0.
	aquaculture	May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.
	industrial	May not be less than 6.5 or greater than 8.5. If the natural condition pH is outside this range, substances may not be added that cause an increase in the buffering capacity of the water.
Water Recreation	contact recreation	May not be less than 6.5 or greater than 8.5. If the natural condition pH is outside this range, substances may not be added that cause an increase in the buffering capacity of the water.
	secondary recreation	May not be less than 5.0 or greater than 9.0.
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife		May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.

Residues

<table>
<tr><td colspan="2">Designated Use</td><td>Water Quality Standard</td></tr>
<tr><td rowspan="4">Water Supply</td><td>drinking, culinary, and food processing</td><td rowspan="6">Residues are not allowed in surface waters of the state, in concentrations or amounts that have the following effects:
• may impair designated uses;
• cause nuisance or objectionable conditions;
• result in undesirable or nuisance species; or
• produce objectionable odor or taste.</td></tr>
<tr><td>agriculture, including irrigation and stock watering</td></tr>
<tr><td>aquaculture</td></tr>
<tr><td>industrial</td></tr>
<tr><td rowspan="2">Water Recreation</td><td>contact recreation</td></tr>
<tr><td>secondary recreation</td></tr>
<tr><td>Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife</td><td></td><td>Residues are not allowed in surface waters of the state, in concentrations or amounts that have the following effects:
• may impair designated uses;
• cause nuisance or objectionable conditions; or
• result in undesirable or nuisance species.</td></tr>
</table>

Sediment

Designated Use		Water Quality Standard
Water Supply	drinking, culinary, and food processing	No measurable increase in concentration of settleable solids above natural conditions, as measured by the volumetric Imhoff cone method (see note 11).
	agriculture, including irrigation and stock watering	For sprinkler irrigation, water must be free of particles of 0.074 mm or coarser. For irrigation or water spreading, may not exceed 200 mg/l for an extended period of time.
	aquaculture	No imposed loads that will interfere with established water supply treatment levels.
	industrial	No imposed loads that will interfere with established water supply treatment levels.
Water Recreation	contact recreation	No measurable increase in concentration of settleable solids above natural conditions, as measured by the volumetric Imhoff cone method (see note 11).
	secondary recreation	May not pose hazards to incidental human contact or cause interference with the use.
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife		The percent accumulation of fine sediment in the range of 0.1 mm to 4.0 mm in the gravel bed of waters used by anadromous or resident fish for spawning may not be increased more than 5% by weight above natural conditions (as shown from grain size accumulation graph). In no case may the 0.1 mm to 4.0 mm fine sediment range in those gravel beds exceed a maximum of 30% by weight (as shown from grain size accumulation graph) (see notes 3 and 4). In all other surface waters no sediment loads (suspended or deposited) that can cause adverse effects on aquatic animal or plant life, their reproduction or habitat may be present.

Temperature

<table>
<tr><td colspan="2">Designated Use</td><td>Water Quality Standard</td></tr>
<tr><td rowspan="4">Water Supply</td><td>drinking, culinary, and food processing</td><td>May not exceed 15C.</td></tr>
<tr><td>agriculture, including irrigation and stock watering</td><td>May not exceed 30C.</td></tr>
<tr><td>aquaculture</td><td>May not exceed 20C at any time. The following maximum temperatures may not be exceeded, where applicable:
Migration routes 15C
Spawning areas 13C
Rearing areas 15C
Egg & fry incubation 13C
For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms.</td></tr>
<tr><td>industrial</td><td>May not exceed 25C.</td></tr>
<tr><td rowspan="2">Water Recreation</td><td>contact recreation</td><td>May not exceed 30C.</td></tr>
<tr><td>secondary recreation</td><td>Not applicable.</td></tr>
<tr><td>Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife</td><td></td><td>May not exceed 20C at any time. The following maximum temperatures may not be exceeded, where applicable:
Migration routes 15C
Spawning areas 13C
Rearing areas 15C
Egg & fry incubation 13C
For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms.</td></tr>
</table>

Turbidity

Designated Use		Water Quality Standard
Water Supply	drinking, culinary, and food processing	May not exceed 5 nephelometric turbidity units (NTU) above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 25 NTU.
	agriculture, including irrigation and stock watering	May not cause detrimental effects on indicated use.
	aquaculture	May not exceed 25 NTU above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.
	industrial	May not cause detrimental effects on established water supply treatment levels.
Water Recreation	contact recreation	May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU. May not exceed 5 NTU above natural turbidity for all lake waters.
	secondary recreation	May not exceed 10 NTU above natural conditions when natural turbidity is 50 NTU or less, and may not have more than 20% increase in turbidity when the natural turbidity is greater than 50 NTU, not to exceed a maximum increase of 15 NTU. For all lake waters, turbidity may not exceed 5 NTU above natural turbidity.
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife		May not exceed 25 NTU above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.

Appendix B. Summary Statistics

B.1 Turbidity

	Before	After	2017	Grand Total
Inlet				
Count of Turb (NTU)	23	34	28	85
Min of Turb (NTU)	5.44	7.4	2.78	2.78
Average of Turb (NTU)	19.68391304	15.80205882	11.79571429	15.53270588
Max of Turb (NTU)	35.8	26.6	23.8	35.8
StdDev of Turb (NTU)	8.693954398	5.471040441	7.147135364	7.574763298
Var of Turb (NTU)	75.58484308	29.93228351	51.08154392	57.37703902
Midstream				
Count of Turb (NTU)	21	25	28	74
Min of Turb (NTU)	3.05	7.6	2.19	2.19
Average of Turb (NTU)	18.72333333	17.432	12.05071429	15.7622973
Max of Turb (NTU)	58.1	29.6	50.4	58.1
StdDev of Turb (NTU)	15.0634841	5.381427939	12.02950106	11.57458808
Var of Turb (NTU)	226.9085533	28.95976667	144.7088958	133.9710892
Outlet				
Count of Turb (NTU)	78	34	28	140
Min of Turb (NTU)	2.55	6.98	2.13	2.13
Average of Turb (NTU)	39.99064103	15.67470588	7.475357143	27.58228571
Max of Turb (NTU)	735	26.2	23.7	735
StdDev of Turb (NTU)	84.14296972	4.766356995	6.526989824	64.32904265
Var of Turb (NTU)	7080.039354	22.718159	42.60159616	4138.225729
Total Count of Turb (NTU)	**122**	**93**	**84**	**299**
Total Min of Turb (NTU)	**2.55**	**6.98**	**2.13**	**2.13**
Total Average of Turb (NTU)	**32.50155738**	**16.19365591**	**10.44059524**	**21.23147157**
Total Max of Turb (NTU)	**735**	**29.6**	**50.4**	**735**
Total StdDev of Turb (NTU)	**68.24264861**	**5.197414446**	**9.055908056**	**44.88738582**
Total Var of Turb (NTU)	**4657.059089**	**27.01311692**	**82.00947073**	**2014.877406**

B.2 Total Suspended Solids

	Before	2017	Grand Total
Inlet			
Count of TSS (mg/l)		20	
Min of TSS (mg/l)		0.626959248	
Average of TSS (mg/l)		2.671765702	
Max of TSS (mg/l)		5.31	
StdDev of TSS (mg/l)		1.170235557	
Var of TSS (mg/l)		1.369451259	
Midstream			
Count of TSS (mg/l)		20	
Min of TSS (mg/l)		0.49	
Average of TSS (mg/l)		6.242881012	
Max of TSS (mg/l)		70.76271186	
StdDev of TSS (mg/l)		15.34482181	
Var of TSS (mg/l)		235.4635563	
Outlet			
Count of TSS (mg/l)	34	20	54
Min of TSS (mg/l)	0.6	0.26	0.26
Average of TSS (mg/l)	27.90470588	1.595384131	18.16051264
Max of TSS (mg/l)	377	3.75	377
StdDev of TSS (mg/l)	67.86024624	0.978571984	55.06427977
Var of TSS (mg/l)	4605.01302	0.957603127	3032.074906
Total Count of TSS (mg/l)	**34**	**60**	
Total Min of TSS (mg/l)	**0.6**	**0.26**	
Total Average of TSS (mg/l)	**27.90470588**	**3.503343615**	
Total Max of TSS (mg/l)	**377**	**70.76271186**	
Total StdDev of TSS (mg/l)	**67.86024624**	**8.977145682**	
Total Var of TSS (mg/l)	**4605.01302**	**80.58914459**	

B.3.a Dissolved Oxygen (summary statistics using all data)

	Before	After	2017	Grand Total
Inlet				
Count of DO (mg/L)	24	34	30	88
Min of DO (mg/L)	3.65	2.46	4.14	2.46
Average of DO (mg/L)	6.190833333	5.526470588	6.384666667	6.000227273
Max of DO (mg/L)	8.13	10.7	10.26	10.7
StdDev of DO (mg/L)	1.389450679	2.08649319	1.732223473	1.819502886
Var of DO (mg/L)	1.930573188	4.353453832	3.000598161	3.310590752
Midstream				
Count of DO (mg/L)	21	25	30	76
Min of DO (mg/L)	2.96	2.28	3.15	2.28
Average of DO (mg/L)	6.105238095	6.1696	6.206333333	6.166315789
Max of DO (mg/L)	8.41	10.2	9.82	10.2
StdDev of DO (mg/L)	1.549259885	2.037368564	1.620743727	1.727924259
Var of DO (mg/L)	2.40020619	4.150870667	2.62681023	2.985722246
Outlet				
Count of DO (mg/L)	79	34	29	142
Min of DO (mg/L)	1.42	3.33	4.81	1.42
Average of DO (mg/L)	6.293417722	7.107352941	7.115517241	6.656197183
Max of DO (mg/L)	10.8	11.58	9.63	11.58
StdDev of DO (mg/L)	2.016201612	2.161918773	1.566601386	1.99905713
Var of DO (mg/L)	4.065068939	4.673892781	2.454239901	3.996229408
Total Count of DO (mg/L)	**124**	**93**	**89**	**306**
Total Min of DO (mg/L)	**1.42**	**2.28**	**3.15**	**1.42**
Total Average of DO (mg/L)	**6.241693548**	**6.277311828**	**6.562696629**	**6.345882353**
Total Max of DO (mg/L)	**10.8**	**11.58**	**10.26**	**11.58**
Total StdDev of DO (mg/L)	**1.826069448**	**2.187926922**	**1.670386975**	**1.900869009**
Total Var of DO (mg/L)	**3.334529629**	**4.787024217**	**2.790192646**	**3.613302989**

B.3.b Dissolved Oxygen (summary statistics using growing season data)

	Before	After	2017	Grand Total
Inlet				
Count of DO (mg/L)	13	11	23	47
Min of DO (mg/L)	3.65	3.6	4.26	3.6
Average of DO (mg/L)	6.101538462	6.210909091	6.12	6.136170213
Max of DO (mg/L)	8.13	8.31	9.36	9.36
StdDev of DO (mg/L)	1.457062377	1.555837103	1.482605201	1.460526339
Var of DO (mg/L)	2.123030769	2.420629091	2.198118182	2.133137188
Midstream				
Count of DO (mg/L)	14	11	24	49
Min of DO (mg/L)	4.51	4.4	3.15	3.15
Average of DO (mg/L)	6.355	6.672727273	6.118333333	6.310408163
Max of DO (mg/L)	8.41	8.68	9.82	9.82
StdDev of DO (mg/L)	1.314082014	1.28753323	1.625336531	1.458757975
Var of DO (mg/L)	1.726811538	1.657741818	2.641718841	2.12797483
Outlet				
Count of DO (mg/L)	37	11	24	72
Min of DO (mg/L)	2.7	6.18	4.81	2.7
Average of DO (mg/L)	6.808108108	8.482727273	7.03875	7.140833333
Max of DO (mg/L)	9.18	10.37	9.63	10.37
StdDev of DO (mg/L)	1.673092343	1.197164073	1.469212485	1.631148174
Var of DO (mg/L)	2.799237988	1.433201818	2.158585326	2.660644366
Total Count of DO (mg/L)	**64**	**33**	**71**	**168**
Total Min of DO (mg/L)	**2.7**	**3.6**	**3.15**	**2.7**
Total Average of DO (mg/L)	**6.56546875**	**7.122121212**	**6.43**	**6.617559524**
Total Max of DO (mg/L)	**9.18**	**10.37**	**9.82**	**10.37**
Total StdDev of DO (mg/L)	**1.564963542**	**1.647292774**	**1.568443268**	**1.594154553**
Total Var of DO (mg/L)	**2.449110888**	**2.713573485**	**2.460014286**	**2.541328739**

B.3.c Dissolved Oxygen (summary statistics using non-growing season data)

	2017	After	Before	Grand Total
Inlet				
Count of DO (mg/L)	7	23	11	41
Min of DO (mg/L)	4.14	2.46	3.84	2.46
Average of DO (mg/L)	7.254285714	5.199130435	6.296363636	5.844390244
Max of DO (mg/L)	10.26	10.7	7.97	10.7
StdDev of DO (mg/L)	2.300506155	2.254693918	1.367503365	2.168137506
Var of DO (mg/L)	5.292328571	5.083644664	1.870065455	4.700820244
Midstream				
Count of DO (mg/L)	6	14	7	27
Min of DO (mg/L)	4.46	2.28	2.96	2.28
Average of DO (mg/L)	6.558333333	5.774285714	5.605714286	5.904814815
Max of DO (mg/L)	8.25	10.2	7.61	10.2
StdDev of DO (mg/L)	1.702273969	2.450606563	1.955145836	2.138679266
Var of DO (mg/L)	2.897736667	6.005472527	3.822595238	4.573949003
Outlet				
Count of DO (mg/L)	5	23	42	70
Min of DO (mg/L)	5.16	3.33	1.42	1.42
Average of DO (mg/L)	7.484	6.449565217	5.84	6.157714286
Max of DO (mg/L)	9.5	11.58	10.8	11.58
StdDev of DO (mg/L)	2.136054775	2.227376113	2.196819208	2.220646969
Var of DO (mg/L)	4.56273	4.961204348	4.826014634	4.931272961
Total Count of DO (mg/L)	**18**	**60**	**60**	**138**
Total Min of DO (mg/L)	**4.14**	**2.28**	**1.42**	**1.42**
Total Average of DO (mg/L)	**7.086111111**	**5.812666667**	**5.896333333**	**6.015144928**
Total Max of DO (mg/L)	**10.26**	**11.58**	**10.8**	**11.58**
Total StdDev of DO (mg/L)	**1.987526216**	**2.318188851**	**2.025212244**	**2.178461667**
Total Var of DO (mg/L)	**3.950260458**	**5.373999548**	**4.101484633**	**4.745695234**

B.4 Dissolved Iron

	2017
Inlet	
Count of Fe, aqueous (mg/L)	19
Min of Fe, aqueous (mg/L)	0.187
Average of Fe, aqueous (mg/L)	0.881210526
Max of Fe, aqueous (mg/L)	1.821
StdDev of Fe, aqueous (mg/L)	0.57237736
Var of Fe, aqueous (mg/L)	0.327615842
Midstream	
Count of Fe, aqueous (mg/L)	20
Min of Fe, aqueous (mg/L)	0.154
Average of Fe, aqueous (mg/L)	0.6962
Max of Fe, aqueous (mg/L)	8.291
StdDev of Fe, aqueous (mg/L)	1.792475078
Var of Fe, aqueous (mg/L)	3.212966905
Outlet	
Count of Fe, aqueous (mg/L)	19
Min of Fe, aqueous (mg/L)	0.056
Average of Fe, aqueous (mg/L)	0.427736842
Max of Fe, aqueous (mg/L)	1.429
StdDev of Fe, aqueous (mg/L)	0.445040802
Var of Fe, aqueous (mg/L)	0.198061316
Total Count of Fe, aqueous (mg/L)	**58**
Total Min of Fe, aqueous (mg/L)	**0.056**
Total Average of Fe, aqueous (mg/L)	**0.668862069**
Total Max of Fe, aqueous (mg/L)	**8.291**
Total StdDev of Fe, aqueous (mg/L)	**1.127681513**
Total Var of Fe, aqueous (mg/L)	**1.271665595**

B.5 Conductivity

	Before	After	2017	Grand Total
Inlet				
Count of Conductivity	23	32	29	84
Min of Conductivity	89.8	19.37	105.4	19.37
Average of Conductivity	126.073913	116.2553125	151.2413793	131.0222619
Max of Conductivity	193.5	179.5	181	193.5
StdDev of Conductivity	26.79486412	27.89205633	21.45349651	29.49290813
Var of Conductivity	717.9647431	777.9668064	460.2525123	869.8316298
Midstream				
Count of Conductivity	21	23	30	74
Min of Conductivity	8.87	10.1	106.2	8.87
Average of Conductivity	111.8890476	111.3230435	151.6	127.8121622
Max of Conductivity	160.5	182.7	174.7	182.7
StdDev of Conductivity	36.08574399	37.33672984	18.94669473	36.20270876
Var of Conductivity	1302.180919	1394.031395	358.9772414	1310.636121
Outlet				
Count of Conductivity	79	32	30	141
Min of Conductivity	65	19.48	116.9	19.48
Average of Conductivity	146.4987342	108.380625	148.38	138.2480851
Max of Conductivity	237	164.3	170.2	237
StdDev of Conductivity	40.73743787	27.31348739	12.67915476	37.24786306
Var of Conductivity	1659.538845	746.0265931	160.7609655	1387.403303
Total Count of Conductivity	**123**	**87**	**89**	**299**
Total Min of Conductivity	**8.87**	**10.1**	**105.4**	**8.87**
Total Average of Conductivity	**136.7704878**	**112.0549425**	**150.3977528**	**133.6352843**
Total Max of Conductivity	**237**	**182.7**	**181**	**237**
Total StdDev of Conductivity	**39.91709932**	**30.29341121**	**17.88397567**	**35.15029585**
Total Var of Conductivity	**1593.374818**	**917.6907625**	**319.8365858**	**1235.543298**

B.6.a Temperature (summary statistics using all data)

	Before	After	2017	Grand Total
Inlet				
Count of Temp (C)	24	34	31	89
Min of Temp (C)	1.7	1.1	6.7	1.1
Average of Temp (C)	8.716666667	5.670588235	11.90935484	8.66505618
Max of Temp (C)	19.5	14.7	15.6	19.5
StdDev of Temp (C)	4.674878903	4.410767089	2.617666818	4.745159525
Var of Temp (C)	21.85449275	19.45486631	6.85217957	22.51653892
Midstream				
Count of Temp (C)	21	25	30	76
Min of Temp (C)	0.8	1.3	6.1	0.8
Average of Temp (C)	10.98571429	7.236	11.89333333	10.11052632
Max of Temp (C)	20.1	15.5	15.3	20.1
StdDev of Temp (C)	5.439971113	4.9176451	2.911799223	4.811308317
Var of Temp (C)	29.59328571	24.18323333	8.478574713	23.14868772
Outlet				
Count of Temp (C)	82	34	29	145
Min of Temp (C)	1	0.8	5.8	0.8
Average of Temp (C)	8.449146341	5.852941176	12.46896552	8.644344828
Max of Temp (C)	19.8	16	17	19.8
StdDev of Temp (C)	5.188413302	5.171555964	3.05977397	5.281960365
Var of Temp (C)	26.9196326	26.74499109	9.362216749	27.8991053
Total Count of Temp (C)	**127**	**93**	**90**	**310**
Total Min of Temp (C)	**0.8**	**0.8**	**5.8**	**0.8**
Total Average of Temp (C)	**8.919133858**	**6.158064516**	**12.08433333**	**9.009741935**
Total Max of Temp (C)	**20.1**	**16**	**17**	**20.1**
Total StdDev of Temp (C)	**5.182228335**	**4.828905776**	**2.844114779**	**5.042570548**
Total Var of Temp (C)	**26.85549051**	**23.318331**	**8.088988876**	**25.42751773**

B.6.b Temperature (summary statistics using growing season data)

	2017	After	Before	Grand Total
Inlet				
Count of Temp (C)	26	11	13	50
Min of Temp (C)	6.7	6.1	6.1	6.1
Average of Temp (C)	12.25384615	11.28181818	11.96923077	11.966
Max of Temp (C)	15.6	14.7	19.5	19.5
StdDev of Temp (C)	2.372885293	2.66676515	3.698059089	2.796835676
Var of Temp (C)	5.630584615	7.111636364	13.67564103	7.822289796
Midstream				
Count of Temp (C)	24	11	14	49
Min of Temp (C)	9.4	6.2	9.1	6.2
Average of Temp (C)	13.0375	12	13.93571429	13.06122449
Max of Temp (C)	15.3	15.5	20.1	20.1
StdDev of Temp (C)	1.900529103	3.018608951	3.870322416	2.857870443
Var of Temp (C)	3.61201087	9.112	14.9793956	8.167423469
Outlet				
Count of Temp (C)	24	11	40	75
Min of Temp (C)	9.5	6.3	5.9	5.9
Average of Temp (C)	13.37916667	12.48181818	12.96475	13.02653333
Max of Temp (C)	17	16	19.8	19.8
StdDev of Temp (C)	2.285679267	3.201817666	3.432661364	3.05052122
Var of Temp (C)	5.22432971	10.25163636	11.78316404	9.305679712
Total Count of Temp (C)	**74**	**33**	**67**	**174**
Total Min of Temp (C)	**6.7**	**6.1**	**5.9**	**5.9**
Total Average of Temp (C)	**12.87297297**	**11.92121212**	**12.97447761**	**12.73155172**
Total Max of Temp (C)	**17**	**16**	**20.1**	**20.1**
Total StdDev of Temp (C)	**2.223060786**	**2.919627285**	**3.576987595**	**2.949580044**
Total Var of Temp (C)	**4.94199926**	**8.524223485**	**12.79484025**	**8.700022434**

B.6.c Temperature (summary statistics using non-growing season data)

	2017	After	Before	Grand Total
Inlet				
Count of Temp (C)	5	23	11	39
Min of Temp (C)	7.2	1.1	1.7	1.1
Average of Temp (C)	10.118	2.986956522	4.872727273	4.433076923
Max of Temp (C)	15.5	7.8	8	15.5
StdDev of Temp (C)	3.378996893	1.636321914	1.961678317	3.055949464
Var of Temp (C)	11.41762	2.677549407	3.848181818	9.338827126
Midstream				
Count of Temp (C)	6	14	7	27
Min of Temp (C)	6.1	1.3	0.8	0.8
Average of Temp (C)	7.316666667	3.492857143	5.085714286	4.755555556
Max of Temp (C)	8.9	7.9	7.9	8.9
StdDev of Temp (C)	1.068488028	1.828603623	2.295959183	2.347229682
Var of Temp (C)	1.141666667	3.343791209	5.271428571	5.509487179
Outlet				
Count of Temp (C)	5	23	42	70
Min of Temp (C)	5.8	0.8	1	0.8
Average of Temp (C)	8.1	2.682608696	4.148571429	3.949142857
Max of Temp (C)	11.3	7.4	8.9	11.3
StdDev of Temp (C)	2.581666129	1.725912716	1.770573245	2.237487426
Var of Temp (C)	6.665	2.978774704	3.134929617	5.006349979
Total Count of Temp (C)	**16**	**60**	**60**	**136**
Total Min of Temp (C)	**5.8**	**0.8**	**0.8**	**0.8**
Total Average of Temp (C)	**8.436875**	**2.988333333**	**4.390666667**	**4.248014706**
Total Max of Temp (C)	**15.5**	**7.9**	**8.9**	**15.5**
Total StdDev of Temp (C)	**2.585425094**	**1.71544249**	**1.873282143**	**2.521175158**
Total Var of Temp (C)	**6.684422917**	**2.942742938**	**3.509185989**	**6.356324178**

B.7.a pH (summary statistics using all data)

	Before	After	2017	Grand Total
Inlet				
Count of pH	21	33	30	84
Min of pH	5.54	4.53	6.39	4.53
Average of pH	6.402857143	5.864545455	6.864	6.356071429
Max of pH	7.01	6.8	7.8	7.8
StdDev of pH	0.362065503	0.65309882	0.30947787	0.64758126
Var of pH	0.131091429	0.426538068	0.095776552	0.419361489
Midstream				
Count of pH	21	25	30	76
Min of pH	5.53	4.72	6.73	4.72
Average of pH	6.513333333	5.94	6.959333333	6.500789474
Max of pH	7.48	6.72	7.19	7.48
StdDev of pH	0.583595179	0.549598338	0.122500762	0.618272352
Var of pH	0.340583333	0.302058333	0.015006437	0.382260702
Outlet				
Count of pH	78	34	30	142
Min of pH	4.65	5.04	6.8	4.65
Average of pH	6.542179487	6.482647059	7.014666667	6.627746479
Max of pH	7.24	7.35	7.27	7.35
StdDev of pH	0.47717417	0.526234818	0.125085718	0.483067025
Var of pH	0.227695188	0.276923084	0.015646437	0.233353751
Total Count of pH	**120**	**92**	**90**	**302**
Total Min of pH	**4.65**	**4.53**	**6.39**	**4.53**
Total Average of pH	**6.51275**	**6.113478261**	**6.946**	**6.520231788**
Total Max of pH	**7.48**	**7.35**	**7.8**	**7.8**
Total StdDev of pH	**0.478857117**	**0.64166753**	**0.212395645**	**0.577292581**
Total Var of pH	**0.229304139**	**0.411737219**	**0.04511191**	**0.333266724**

B.7.b pH (summary statistics using growing season data)

	2017	After	Before	Grand Total
Inlet				
Count of pH	24	11	11	46
Min of pH	6.39	5.78	6.01	5.78
Average of pH	6.800416667	6.264545455	6.527272727	6.606956522
Max of pH	7.8	6.8	6.91	7.8
StdDev of pH	0.300658396	0.336641163	0.285415168	0.373713316
Var of pH	0.090395471	0.113327273	0.081461818	0.139661643
Midstream				
Count of pH	24	11	14	49
Min of pH	6.73	5.13	6.17	5.13
Average of pH	6.953333333	6.148181818	6.821428571	6.734897959
Max of pH	7.19	6.72	7.48	7.48
StdDev of pH	0.130439613	0.48940409	0.407333867	0.45597936
Var of pH	0.017014493	0.239516364	0.165920879	0.207917177
Outlet				
Count of pH	24	11	38	73
Min of pH	6.8	6.01	6.39	6.01
Average of pH	7.002083333	6.559090909	6.770526316	6.814794521
Max of pH	7.27	6.84	7.24	7.27
StdDev of pH	0.135228604	0.275661189	0.253866824	0.268757995
Var of pH	0.018286775	0.075989091	0.064448364	0.07223086
Total Count of pH	**72**	**33**	**63**	**168**
Total Min of pH	**6.39**	**5.13**	**6.01**	**5.13**
Total Average of pH	**6.918611111**	**6.323939394**	**6.739365079**	**6.734583333**
Total Max of pH	**7.8**	**6.84**	**7.48**	**7.8**
Total StdDev of pH	**0.219553359**	**0.406016775**	**0.310623063**	**0.368557398**
Total Var of pH	**0.048203678**	**0.164849621**	**0.096486687**	**0.135834556**

B.7.c pH (summary statistics using non-growing season data)

Row Labels	2017	After	Before	Grand Total
Inlet				
Count of pH	24	11	11	46
Min of pH	6.39	5.78	6.01	5.78
Average of pH	6.800416667	6.264545455	6.527272727	6.606956522
Max of pH	7.8	6.8	6.91	7.8
StdDev of pH	0.300658396	0.336641163	0.285415168	0.373713316
Var of pH	0.090395471	0.113327273	0.081461818	0.139661643
Midstream				
Count of pH	24	11	14	49
Min of pH	6.73	5.13	6.17	5.13
Average of pH	6.953333333	6.148181818	6.821428571	6.734897959
Max of pH	7.19	6.72	7.48	7.48
StdDev of pH	0.130439613	0.48940409	0.407333867	0.45597936
Var of pH	0.017014493	0.239516364	0.165920879	0.207917177
Outlet				
Count of pH	24	11	38	73
Min of pH	6.8	6.01	6.39	6.01
Average of pH	7.002083333	6.559090909	6.770526316	6.814794521
Max of pH	7.27	6.84	7.24	7.27
StdDev of pH	0.135228604	0.275661189	0.253866824	0.268757995
Var of pH	0.018286775	0.075989091	0.064448364	0.07223086
Total Count of pH	**72**	**33**	**63**	**168**
Total Min of pH	**6.39**	**5.13**	**6.01**	**5.13**
Total Average of pH	**6.918611111**	**6.323939394**	**6.739365079**	**6.734583333**
Total Max of pH	**7.8**	**6.84**	**7.48**	**7.8**
Total StdDev of pH	**0.219553359**	**0.406016775**	**0.310623063**	**0.368557398**
Total Var of pH	**0.048203678**	**0.164849621**	**0.096486687**	**0.135834556**

	DO (mg/L)	*DO (% sat)*	*Temp (C)*	*Cond (uS/cm)*	*pH*	*Turb (NTU)*	*TSS (mg/l)*	*TDS (mg/l)*	*TDS (ppm)*	*Fe2+ (mg/l)*	*Fe3+ (mg/l)*	*Fe, aqueous (mg/L)*	*Discharge (ft3/s)*	*Air Temp*	*Precip*
DO (mg/L)	1														
DO (% sat)	0.959955683	1													
Temp (C)	-0.035941638	0.214009856	1												
Cond (uS/cm)	-0.224370852	-0.145251242	0.359368	1											
pH	0.297039451	0.249156305	-0.2497	-0.067135014	1										
Turb (NTU)	-0.176204641	-0.233500559	-0.24587	-0.44461598	0.006473	1									
TSS (mg/l)	0.009845347	0.053099962	0.143013	0.03490414	0.072628	0.640097414	1								
TDS (mg/l)	0.124744569	0.199890909	0.248292	0.012909707	0.161976	0.497640301	0.878487988	1							
TDS (ppm)	-0.053427204	0.059481142	0.454399	0.819154537	-0.07796	-0.582220026	0.015534121	0.028247556	1						
Fe2+ (mg/l)	-0.097540064	-0.099199589	-0.03369	-0.469465381	-0.38627	0.138822438	-0.048520945	-0.037922882	-0.304644466	1					
Fe3+ (mg/l)	-0.223667844	-0.196629813	0.050175	0.132359928	-0.04861	-0.081557458	-0.110273265	-0.114492984	0.023933069	0.000983641	1				
Fe, aqueous (mg/L)	-0.226061978	-0.199082794	0.049273	0.120126891	-0.05859	-0.077862991	-0.111480248	-0.115424579	0.016031219	0.02682207	0.999666123	1			
Discharge (ft3/s)	0.076757736	-0.041536581	-0.39205	-0.713896463	-0.03126	0.551476091	-0.062450019	-0.125031912	-0.851960457	0.405628144	-0.054729809	-0.044229208	1		
Air Temp	-0.305588895	-0.120346541	0.813213	0.27530979	-0.41628	-0.091436585	0.062952876	0.092226913	0.225357602	0.021358513	0.176631096	0.177119512	-0.00740371	1	
Precip	0.237546525	0.09299866	-0.49326	-0.570461585	0.127909	0.495790412	-0.056581612	-0.119564111	-0.666699538	0.019295791	-0.159283062	-0.158727253	0.855569195	-0.199054287	1

Appendix C. Raw Data

Date	Time	Site	Location	DO (mg/L)	DO (% sat)	Temp (C)	Cond (uS/cm)	pH	Turb (NTU)	TSS (mg/l)	TDS (mg/l)	TDS (ppm)	Fe2+ (mg/l)	Fe3+ (mg/l)	Fe, aqueous (mg/L)	FC	E. Coli	Discharge (ft3/s)	Air Temp	Precip
4/14/2017	4:12:00 PM	NSa	Inlet	10.26	103.10	15.50	154.30	6.85	2.78	3.67	138.54							1.08	43.50	0.00
4/14/2017	4:28:00 PM	NSa	Inlet	8.71	78.40	10.60	163.00	6.91	2.85									1.08	43.50	0.00
4/14/2017	5:31:00 PM	NSa	Inlet	7.04	61.10	9.99												1.08	43.50	0.00
4/14/2017	4:58:00 PM	NSb	Midstream	6.84	57.80	8.00	154.00	6.91	2.19	2.24	15.63							1.08	43.50	0.00
4/14/2017	5:08:00 PM	NSb	Midstream	7.07	60.90	8.90	153.00	6.91	2.19									1.08	43.50	0.00
4/14/2017	5:47:00 PM	NSd	Outlet	9.15	83.90	11.30	136.00	7.00	2.22	1.65	0.71							1.08	43.50	0.00
4/14/2017	6:00:00 PM	NSd	Outlet	9.50	85.10	10.40	141.30	7.05	2.13									1.08	43.50	0.00
4/28/2017	5:03:00 PM	NSa	Inlet	9.30	81.40	9.30	160.70	6.74	4.13	2.27	100.38	80.00	0.00	0.19	0.20			1.12	40.50	0.28
4/28/2017	5:14:00 PM	NSa	Inlet	9.36	81.30	9.00	165.70	6.93	4.16			84.00	0.00	0.35	0.35			1.12	40.50	0.28
4/28/2017	5:45:00 PM	NSb	Midstream	9.45	82.90	9.50	163.40	7.16	4.24	1.44	90.42	83.00	0.00	0.18	0.18			1.12	40.50	0.28
4/28/2017	5:54:00 PM	NSb	Midstream	9.82	81.20	9.40	164.90	7.19	4.20			83.00	0.00	0.17	0.18			1.12	40.50	0.28
4/28/2017	6:20:00 PM	NSd	Outlet	9.63	84.60	9.60	162.10	7.05	3.99	3.38	50.65	83.00	0.00	0.33	0.32			1.12	40.50	0.28
4/28/2017	6:31:00 PM	NSd	Outlet	9.55	84.10	9.50	154.50	7.22	4.08			82.00	0.00	0.20	0.20			1.12	40.50	0.28
4/29/2017		NSb	Midstream										0.00	0.15	0.15			1.12	40.50	0.28
4/29/2017		NSd	Outlet										0.00	0.19	0.19			1.12	40.50	0.28
5/12/2017	5:00:00 PM	NSa	Inlet	8.17	77.80	13.00	148.90	7.14	5.46	2.75	56.42	77.00						0.87	50.50	0.06
5/12/2017	5:19:00 PM	NSa	Inlet	8.17	77.50	13.00	151.70	7.16	5.30	3.34	154.65	78.00						0.87	50.50	0.06
5/12/2017	5:38:00 PM	NSb	Midstream	7.40	70.60	13.30	152.60	7.13	4.10	2.69	74.17	81.00						0.87	50.50	0.06
5/12/2017	5:48:00 PM	NSb	Midstream	7.20	68.70	13.30	153.50	7.08	4.40	0.49	122.87	81.00						0.87	50.50	0.06
5/12/2017	6:09:00 PM	NSd	Outlet	7.33	70.30	13.40	147.20	7.08	3.53	1.77	80.49	77.00						0.87	50.50	0.06
5/12/2017	6:27:00 PM	NSd	Outlet	7.60	73.00	13.50	146.80	7.07	3.37	0.51	117.47	80.00						0.87	50.50	0.06
5/26/2017	5:15:00 PM	NSa	Inlet	6.83	64.50	12.60	142.80	6.74	10.20	2.22	93.91	80.00						0.68	48.00	0.01
5/26/2017	5:34:00 PM	NSa	Inlet	6.79	63.80	12.50	152.20	6.80	9.95			82.00						0.68	48.00	0.01
5/26/2017	6:06:00 PM	NSb	Midstream	7.40	71.10	13.60	150.00	6.96	5.84	1.16	90.99	77.00						0.68	48.00	0.01
5/26/2017	6:15:00 PM	NSb	Midstream	7.31	70.50	13.90	152.90	6.97	5.81			80.00						0.68	48.00	0.01
5/26/2017	6:48:00 PM	NSd	Outlet	6.98	66.10	12.80	148.80	7.10	4.49	0.27	91.18	80.00						0.68	48.00	0.01
5/26/2017	6:58:00 PM	NSd	Outlet	7.26	69.30	13.50	152.60	7.08	4.45			77.00						0.68	48.00	0.01
6/9/2017	5:46:00 PM	NSa	Inlet	4.98	48.80	14.40	178.80	6.61	10.90	4.04	102.48	91.00	0.01	0.24	0.24			0.32	54.50	0.02
6/9/2017	6:00:00 PM	NSa	Inlet	4.91	47.90	14.30	181.00	6.74	11.00	4.44	105.08	93.00	0.00	0.41	0.41			0.32	54.50	0.02
6/9/2017	6:22:00 PM	NSb	Midstream	5.09	50.10	14.60	171.30	6.91	6.87	6.14	91.23	90.00	0.00	0.19	0.19			0.32	54.50	0.02
6/9/2017	6:29:00 PM	NSb	Midstream	5.00	49.40	14.70	173.40	6.91	6.90	7.72	104.03	87.00	0.01	0.16	0.16			0.32	54.50	0.02
6/9/2017	6:55:00 PM	NSd	Outlet	6.98	68.40	15.00	168.80	6.95	3.34	1.37	99.73	90.00	0.01	0.16	0.17			0.32	54.50	0.02
6/9/2017	7:08:00 PM	NSd	Outlet	6.95	68.70	14.90	170.20	6.94	3.25	0.28	100.00	89.00	0.00	0.17	0.18			0.32	54.50	0.02
6/23/2017	5:00:00 PM	NSa	Inlet	6.61	64.40	14.20	151.90	6.99	7.04	0.63	20.75	73.00	-0.03	0.91	0.88			1.01	54.00	0.00
6/23/2017		NSa	Inlet	6.62	64.40	14.30	152.70	7.02	7.30			73.00	-0.03	0.89	0.86			1.01	54.00	0.00
6/23/2017		NSa	Inlet										-0.03	0.89	0.86			1.01	54.00	0.00
6/23/2017		NSb	Midstream	7.05	70.40	15.20	152.80	7.11	50.40	70.76	2153.19	75.00	0.00	0.16	0.16			1.01	54.00	0.00
6/23/2017		NSb	Midstream	7.21	72.00	15.30	152.60	7.08	46.20			75.00	0.00	0.17	0.17			1.01	54.00	0.00
6/23/2017		NSb	Midstream										-0.02	0.71	0.69			1.01	54.00	0.00
6/23/2017		NSd	Outlet	9.36	96.60	17.00	148.70	7.23	2.80	2.29	1097.98	75.00	0.01	0.05	0.06			1.01	54.00	0.00
6/23/2017	7:00:00 AM	NSd	Outlet	8.55	85.50	16.00	150.60	7.27	2.80			74.00	0.01	0.05	0.06			1.01	54.00	0.00
6/23/2017		NSd	Outlet										0.01	0.05	0.06			1.01	54.00	0.00
7/7/2017		NSa	Inlet	6.16	60.80	14.80	159.80	6.69	4.44	4.15	97.63	78.00						2.13	57.00	0.02
7/7/2017		NSa	Inlet	6.00	59.20	14.80	162.30	6.89	7.75			78.00						2.13	57.00	0.02
7/7/2017		NSb	Midstream	5.78	56.20	15.00	161.60	7.00	6.48	1.76	66.18	78.00						2.13	57.00	0.02
7/7/2017		NSb	Midstream	5.78	57.30	15.10	159.10	6.98	7.23			78.00						2.13	57.00	0.02
7/7/2017		NSd	Outlet	8.15	82.30	16.00	153.90	7.16	3.31	0.26	76.35	76.00						2.13	57.00	0.02
7/7/2017		NSd	Outlet	8.88	89.80	16.30	152.60	7.12	3.37			74.00						2.13	57.00	0.02
7/17/2017			Outlet													8.00				
7/17/2017			Outlet														4.00			
7/21/2017	5:06:00	NSa	Inlet	5.65	54.20	13.40	166.50	6.43	7.09	1.85	103.15	81.00	0.01	1.82	1.82			1.69	60.50	0.00
7/21/2017	5:15:00	NSa	Inlet	5.48	52.40	13.40	168.30	6.66	6.90	1.95	129.42	81.00	0.01	0.18	0.19			1.69	60.50	0.00
7/21/2017	5:15:00	NSa	Inlet										0.01	0.37	0.38			1.69	60.50	0.00
7/21/2017	5:49:00	NSb	Midstream	5.60	54.80	14.20	174.10	6.73	5.15	1.41	102.92	82.00	0.01	0.43	0.44			1.69	60.50	0.00
7/21/2017	6:00:00	NSb	Midstream	5.33	51.50	14.10	169.50	6.78	5.16	1.63	116.12	81.00	0.02	8.27	8.29			1.69	60.50	0.00
7/21/2017	6:20:00	NSd	Outlet	6.11	58.70	13.70	160.50	7.00	3.47	0.86	95.08	80.00	0.01	1.37	1.37			1.69	60.50	0.00
7/21/2017	6:35:00	NSd	Outlet	8.00	78.10	14.50	161.30	7.00	3.30	1.07	91.89	78.00	0.01	1.39	1.40			1.69	60.50	0.00
7/21/2017													0.01	0.28	0.29			1.69	60.50	0.00
7/21/2017													0.01	1.42	1.43			1.69	60.50	0.00
7/25/2017			Outlet													2.00				
7/25/2017			Outlet													2.00				
7/25/2017			Outlet														5.00			
7/25/2017			Outlet														4.00			
8/2/2017			Outlet													15.00				
8/2/2017			Outlet														19.00			

Date	Time	Site	Location	DO (mg/L)	DO (% sat)	Temp (C)	Cond (uS/cm)	pH	Turb (NTU)	TSS (mg/l)	TDS (mg/l)	TDS (ppm)	Fe2+ (mg/l)	Fe3+ (mg/l)	Fe, aqueous (mg/L)	FC	E. Coli	Discharge (ft3/s)	Air Temp	Precip
08/05/17		NSa	Inlet	4.26	42.50	15.60	178.40	6.48	8.63	2.60	130.67	80.00						1.25	65.00	0.00
08/05/17		NSa	Inlet	4.26	42.40	15.20	178.90	6.56	8.10			81.00						1.25	65.00	0.00
08/05/17		NSb	Midstream	3.15	31.10	15.00	174.70	6.85	5.30	2.05	128.21	81.00						1.25	65.00	0.00
08/05/17		NSb	Midstream	3.16	31.50	15.10	152.30	6.93	5.08			84.00						1.25	65.00	0.00
08/05/17		NSd	Outlet	5.59	57.40	16.50	150.30	6.80	3.02	1.95	120.98	80.00						1.25	65.00	0.00
08/05/17		NSd	Outlet	5.79	59.10	16.50	148.60	6.86	3.00			80.00						1.25	65.00	0.00
8/10/2017			Outlet													2.00				
8/10/2017			Outlet														6.00			
8/17/2017			Outlet													8.00				
8/17/2017			Outlet														4.00			
08/19/17		NSa	Inlet	6.15	57.10	12.00	105.40	6.39	18.10	2.60	130.67	64.00	0.22	0.42	0.64			7.00	51.50	0.09
08/19/17		NSa	Inlet	6.12	56.80	12.00	106.50	6.52	17.90			66.00	0.03	0.45	0.48			7.00	51.50	0.09
08/19/17		NSa	Inlet										0.03	0.38	0.41			7.00	51.50	0.09
08/19/17		NSb	Midstream	6.43	60.10	12.20	107.00	6.81	12.10	2.05	128.21	64.00	0.01	0.32	0.33			7.00	51.50	0.09
08/19/17		NSb	Midstream	6.50	60.50	12.20	106.20	6.78	12.10			64.00	0.01	0.29	0.30			7.00	51.50	0.09
08/19/17		NSb	Midstream										0.01	0.33	0.34			7.00	51.50	0.09
08/19/17		NSd	Outlet	7.11	67.00	12.60	139.50	6.92	9.45	1.95	120.98	62.00	0.01	0.34	0.35			7.00	51.50	0.09
08/19/17		NSd	Outlet	6.42	60.10	12.30	140.50	6.86	9.43			61.00	0.01	0.42	0.43			7.00	51.50	0.09
08/19/17		NSd	Outlet										0.01	0.24	0.25			7.00	51.50	0.09
9/1/2017		NSa	Inlet	6.00	55.40	11.80	140.50	6.57	22.30	5.31	82.42	65.00						8.14	54.50	0.81
9/1/2017		NSa	Inlet	5.95	54.70	11.60	146.40	6.73	22.40	2.50	73.85	66.00						8.14	54.50	0.81
9/1/2017		NSb	Midstream	6.28	58.00	11.70	148.20	6.86	19.30	4.09	79.40	64.00						8.14	54.50	0.81
9/1/2017		NSb	Midstream	6.27	58.00	11.70	147.90	6.86	19.20	3.66	79.68	64.00						8.14	54.50	0.81
9/1/2017		NSd	Outlet	5.59	51.40	11.60	147.40	6.86	17.70	1.49	74.23	64.00						8.14	54.50	0.81
9/1/2017		NSd	Outlet	5.49	50.50	11.50	145.50	6.86	17.90	2.91	77.19	64.00						8.14	54.50	0.81
9/15/2017		NSa	Inlet	4.69	42.50	10.90	161.80	6.74		1.04	47.13	74.00	0.01	1.39	1.39			4.08	52.00	0.00
9/15/2017		NSa	Inlet	4.74	43.00	10.90	164.60	7.80				75.00	0.01	1.43	1.43			4.08	52.00	0.00
9/15/2017		NSa	Inlet										0.01	1.34	1.35			4.08	52.00	0.00
9/15/2017		NSb	Midstream	4.43	40.30	10.90	164.50	6.94		8.49	66.99	74.00	0.01	0.29	0.30			4.08	52.00	0.00
9/15/2017		NSb	Midstream	4.45	40.30	10.90	170.40	6.80				73.00	0.01	0.29	0.30			4.08	52.00	0.00
9/15/2017		NSb	Midstream										0.01	0.30	0.31			4.08	52.00	0.00
9/15/2017		NSd	Outlet	6.85	47.60	11.20	167.30	6.85		1.27	76.33	73.00	0.01	0.28	0.29			4.08	52.00	0.00
9/15/2017		NSd	Outlet	4.81	43.60	10.90	155.10	6.88				74.00	0.01	0.28	0.29			4.08	52.00	0.00
9/15/2017		NSd	Outlet										0.01	0.35	0.36			4.08	52.00	0.00
9/29/2017		NSa	Inlet	4.80	43.70	11.10	137.10	6.97	20.30	2.29	106.66	61.00						3.14	46.50	0.00
9/29/2017		NSa	Inlet	4.76	43.20	11.00	143.10	6.91	20.00			70.00						3.14	46.50	0.00
9/29/2017		NSb	Midstream	5.40	49.20	11.10	143.40	7.07	14.90	1.34	80.60	69.00						3.14	46.50	0.00
9/29/2017		NSb	Midstream	5.35	48.40	10.90	140.90	6.99	12.90			68.00						3.14	46.50	0.00
9/29/2017		NSd	Outlet	5.06	46.40	11.20	133.00	6.98	14.50	1.82	84.86	64.00						3.14	46.50	0.00
9/29/2017		NSd	Outlet	4.89	44.40	11.10	134.60	6.91	14.80			64.00						3.14	46.50	0.00
10/13/2017		NSa	Inlet	4.24	34.80	6.80	154.70	7.41	18.20	1.61	91.68	68.00	0.01	1.56	1.57			0.97	35.00	0.19
10/13/2017		NSa	Inlet	4.14	33.80	6.70	154.90	7.16	19.50	2.20	76.52	77.00	0.01	1.69	1.70			0.97	35.00	0.19
10/13/2017		NSa	Inlet										0.01	1.60	1.61			0.97	35.00	0.19
10/13/2017		NSb	Midstream	4.52	36.60	6.20	153.40	7.14	9.42	0.89	85.95	76.00	0.01	0.42	0.43			0.97	35.00	0.19
10/13/2017		NSb	Midstream	4.46	36.20	6.10	153.50	6.93	9.86	2.32	137.08	77.00	0.01	0.43	0.44			0.97	35.00	0.19
10/13/2017		NSb	Midstream										0.01	0.27	0.28			0.97	35.00	0.19
10/13/2017		NSd	Outlet	5.21	41.80	5.90	149.50	7.15	9.10	3.75	120.79	74.00	0.01	0.34	0.35			0.97	35.00	0.19
10/13/2017		NSd	Outlet	5.16	41.60	5.80	150.10	7.06	9.91	1.97	109.18	74.00	0.01	0.28	0.29			0.97	35.00	0.19
10/13/2017		NSd	Outlet										0.01	0.28	0.29			0.97	35.00	0.19
10/27/2017		NSa	Inlet	8.20	68.00	7.30	107.20	7.21	23.80	1.97	20.08	51.00						15.10	46.00	2.01
10/27/2017		NSa	Inlet	8.19	67.80	7.20	108.20	7.17	23.80			57.00						15.10	46.00	2.01
10/27/2017		NSb	Midstream	8.25	68.70	7.40	113.50	7.02	25.00	2.53	64.55	57.00						15.10	46.00	2.01
10/27/2017		NSb	Midstream	8.21	68.10	7.30	113.40	6.99	24.90			55.00						15.10	46.00	2.01
10/27/2017		NSd	Outlet	8.40	69.30	7.10	116.90	7.10	22.90	1.09	59.12	55.00						15.10	46.00	2.01
10/27/2017		NSd	Outlet				117.20	7.03	23.70			54.00						15.10	46.00	2.01

Date	Site	Location	Timing	DO (mg/L)	T	Cond (uS/cm)	pH	Turb (NTU)	TSS (ppm)	TSS (mg/l)	FC	Discharge (ft3/s)	Source
7/7/2004	NSd	Outlet	Before	7.80	17.00	139.80	7.12	4.81				0.63	Hoferkamp, 2008; USGS Discharge
7/21/2004	NSb	Midstream	Before	8.41	17.60	142.80	7.00	3.47				0.28	Hoferkamp, 2008; USGS Discharge
7/21/2004	NSd	Outlet	Before	6.69	17.80	142.60	6.71	3.99				0.28	Hoferkamp, 2008; USGS Discharge
7/28/2004	NSb	Midstream	Before	5.11	16.40	131.70	7.05	3.21				1.96	Hoferkamp, 2008; USGS Discharge
7/28/2004	NSd	Outlet	Before	5.38	15.50	123.60	6.98	5.74				1.96	Hoferkamp, 2008; USGS Discharge
8/6/2004	NSb	Midstream	Before	6.90	16.70	133.00	7.16	3.36				0.80	Hoferkamp, 2008; USGS Discharge
8/6/2004	NSd	Outlet	Before	6.20	16.80	130.50	7.16	2.72				0.80	Hoferkamp, 2008; USGS Discharge
8/11/2004	NSb	Midstream	Before	8.40	15.40	139.90	7.48	3.05				0.80	Hoferkamp, 2008; USGS Discharge
8/11/2004	NSd	Outlet	Before	8.03	18.30	138.20	7.23	2.55				0.80	Hoferkamp, 2008; USGS Discharge
8/18/2004	NSb	Midstream	Before	7.36	18.00	146.10	7.04	3.18				0.54	Hoferkamp, 2008; USGS Discharge
8/18/2004	NSd	Outlet	Before	6.53	18.40	142.50	6.99	3.13				0.54	Hoferkamp, 2008; USGS Discharge
8/29/2004	NSb	Midstream	Before	6.32	16.40	135.70	7.00	4.68				0.73	Hoferkamp, 2008; USGS Discharge
8/29/2004	NSd	Outlet	Before	5.05	16.10	137.50	6.69	7.53				0.73	Hoferkamp, 2008; USGS Discharge
9/8/2004	NSb	Midstream	Before	5.38	15.10	132.20	7.12	9.29				1.96	Hoferkamp, 2008; USGS Discharge
9/8/2004	NSd	Outlet	Before	4.32	13.60	125.50	6.80	12.80				1.96	Hoferkamp, 2008; USGS Discharge
9/26/2004	NSb	Midstream	Before	4.76	9.70	102.70	6.92	21.90				4.60	Hoferkamp, 2008; USGS Discharge
9/26/2004	DC2	Outlet	Before	8.86	9.79	155.00	6.60	23.30	0.00			4.60	Hood, Hoferkamp, Hudson, 2005
9/26/2004	NSd	Outlet	Before	4.73	9.90	106.30	6.59	23.70				4.60	Hoferkamp, 2008
10/10/2004	DC2	Outlet	Before	9.18	9.28	166.00	6.63	22.30	7.19				Hood, Hoferkamp, Hudson, 2005
10/23/2004	NSb	Midstream	Before	2.96	5.80	101.80	5.69	25.60					Hoferkamp, 2008
10/23/2004	NSd	Outlet	Before	2.96	4.90	99.20	6.43	30.80					Hoferkamp, 2008
10/24/2004	DC2	Outlet	Before	4.64	4.38	166.00	6.50	21.30	7.25				Hood, Hoferkamp, Hudson, 2005
11/7/2004	DC2	Outlet	Before	6.63	3.97	161.00	6.55	22.70	8.04				Hood, Hoferkamp, Hudson, 2005
11/13/2004	NSb	Midstream	Before	3.41	4.70	94.80	5.98	24.50					Hoferkamp, 2008
11/13/2004	NSd	Outlet	Before	4.39	3.90	94.00	6.29	15.00					Hoferkamp, 2008
11/21/2004	DC2	Outlet	Before	8.00	4.91	176.00	5.11	26.90	8.39				Hood, Hoferkamp, Hudson, 2005
12/5/2004	DC2	Outlet	Before	6.46	4.12	172.00	5.55	23.30	8.73				Hood, Hoferkamp, Hudson, 2005
12/22/2004	DC2	Outlet	Before	10.70	3.40	172.00	5.82	47.40	47.60				Hood, Hoferkamp, Hudson, 2005
1/4/2005	DC2	Outlet	Before	3.54	3.35	174.00	6.40	21.30	5.45				Hood, Hoferkamp, Hudson, 2005
1/28/2005	NSd	Outlet	Before	1.42	1.70	101.70	6.64	6.90					Hoferkamp, 2008
2/17/2005	DC2	Outlet	Before	3.54	2.14	188.00	6.21	8.20	5.31				Hood, Hoferkamp, Hudson, 2005
2/28/2005	NSb	Midstream	Before	7.52	0.80	25.70	5.53	13.00					Hoferkamp, 2008
2/28/2005	NSd	Outlet	Before	3.71	2.50	95.70	6.46	12.50					Hoferkamp, 2008
3/11/2005	DC2	Outlet	Before	4.81	3.99	155.00	6.46	36.50	6.42		10.00		Hood, Hoferkamp, Hudson, 2005
3/27/2005	DC2	Outlet	Before	2.84	5.14	180.00	6.22	32.80	5.96				Hood, Hoferkamp, Hudson, 2005
3/31/2005	NSb	Midstream	Before	7.61	5.30	104.90	5.90	17.70					Hoferkamp, 2008
3/31/2005	NSd	Outlet	Before	7.06	5.50	103.40	6.32	15.90					Hoferkamp, 2008
4/10/2005	DC2	Outlet	Before	8.47	7.64	177.00	6.90	15.00	5.29		36.00		Hood, Hoferkamp, Hudson, 2005
4/24/2005	DC2	Outlet	Before	8.94	10.49	172.00	7.14	12.10	2.26				Hood, Hoferkamp, Hudson, 2005
5/17/2005	DC2	Outlet	Before	7.07	11.66	175.00	6.64	5.79	2.32				Hood, Hoferkamp, Hudson, 2005
6/3/2005	DC2	Outlet	Before	7.23	15.70	140.00	7.24		2.35				Hood, Hoferkamp, Hudson, 2005
7/18/2005	NSd	Outlet	Before	8.31	15.10	170.00	6.83						Hoferkamp, 2008
8/2/2005	DCB	Outlet	Before		14.63	169.00	6.72	10.40					Nagorski, Hood, Hoferkamp, 2006
8/10/2005	NSa	Inlet	Before	7.68	19.50	160.50		6.15					Hoferkamp, 2008
8/10/2005	NSb	Midstream	Before	7.85	20.10	160.50	7.06	6.15					Hoferkamp, 2008
8/10/2005	NSd	Outlet	Before	8.30	19.80	155.00	7.15	4.56					Hoferkamp, 2008
8/20/2005	DCB	Outlet	Before		14.26	175.00	6.64	60.40		0.60			Nagorski, Hood, Hoferkamp, 2006
9/6/2005	NSb	Midstream	Before	6.80	11.80	121.00	6.46	25.70					Hoferkamp, 2008
9/6/2005	NSd	Outlet	Before	8.20	12.20	122.80	6.82	22.00					Hoferkamp, 2008

Date	Site	Location	Timing	DO (mg/L)	T	Cond (uS/cm)	pH	Turb (NTU)	TSS (ppm)	TSS (mg/l)	FC	Discharge (ft3/s)	Source
9/10/2005	DCB	Outlet	Before		11.48	176.00	6.44	66.20		9.70			Nagorski, Hood, Hoferkamp, 2006
9/24/2005	NSb	Midstream	Before	6.14	10.50	113.50	6.17	58.10					Hoferkamp, 2008
9/24/2005	DCB	Outlet	Before	5.70	10.30		6.50	58.70		16.90			Nagorski, Hood, Hoferkamp, 2006
9/24/2005	NSd	Outlet	Before	5.83	10.40	110.90	7.01	55.80					Hoferkamp, 2008
10/9/2005	NSa	Inlet	Before	4.33	9.10	118.70	6.56	21.10					Hoferkamp, 2008
10/9/2005	NSb	Midstream	Before	4.51	9.10	118.00	6.18	27.20					Hoferkamp, 2008
10/9/2005	DCB	Outlet	Before	2.70	8.80			112.00		54.90			Nagorski, Hood, Hoferkamp, 2006
10/9/2005	NSd	Outlet	Before	2.88	8.80	106.00	6.39	87.50					Hoferkamp, 2008
10/22/2005	NSa	Inlet	Before	6.40	7.30	106.10	6.34	21.70					Hoferkamp, 2008
10/22/2005	NSb	Midstream	Before	7.10	7.00	104.70	5.56	46.80					Hoferkamp, 2008
10/22/2005	NSd	Outlet	Before	5.93	7.30	98.00	6.79	91.90					Hoferkamp, 2008
10/22/2005	DCB	Outlet	Before	8.80	6.90	79.00	6.30	37.20		42.60			Nagorski, Hood, Hoferkamp, 2006
11/4/2005	DCB	Outlet	Before	5.90	5.10	167.00	6.40	54.30		18.50			Nagorski, Hood, Hoferkamp, 2006
11/6/2005	NSa	Inlet	Before	6.36	4.20	97.40							Hoferkamp, 2008
11/6/2005	NSd	Outlet	Before	6.57	3.80	91.50							Hoferkamp, 2008
11/18/2005	DCB	Outlet	Before	10.80	4.90	65.00	6.60	147.50		150.00			Nagorski, Hood, Hoferkamp, 2006
11/26/2005	NSa	Inlet	Before	7.89	5.70		5.54	17.40					Hoferkamp, 2008
11/26/2005	NSd	Outlet	Before	7.51	4.00		4.65	24.60					Hoferkamp, 2008
12/3/2005	DCB	Outlet	Before	5.30	3.10	186.00	6.50	26.50		4.40			Nagorski, Hood, Hoferkamp, 2006
12/10/2005	NSa	Inlet	Before	7.97	3.60	143.50	6.17	24.10					Hoferkamp, 2008
12/10/2005	NSd	Outlet	Before	7.90	2.90	145.00	5.78	27.60					Hoferkamp, 2008
12/17/2005	DCB	Outlet	Before	6.90	4.40	165.00	6.50	31.10		7.40			Nagorski, Hood, Hoferkamp, 2006
12/26/2005	NSa	Inlet	Before	7.00	4.00	96.70	5.90	22.80					Hoferkamp, 2008
12/26/2005	NSd	Outlet	Before	7.57	3.70	91.90	6.70	36.60					Hoferkamp, 2008
1/14/2006	NSa	Inlet	Before	5.28	1.70	102.80	6.37	31.60					Hoferkamp, 2008
1/14/2006	NSd	Outlet	Before	7.08	2.40	101.60	6.59	30.30					Hoferkamp, 2008
1/14/2006	DCB	Outlet	Before	7.30	2.60	142.00	6.30	33.60		4.90		1.70	Nagorski, Hood, Hoferkamp, 2006
1/27/2006	DCB	Outlet	Before	4.00	2.00	205.00	6.30	39.40		8.70		0.87	Nagorski, Hood, Hoferkamp, 2006
1/28/2006	NSd	Outlet	Before	8.35	1.00	94.20	4.82	36.70					Hoferkamp, 2008
2/11/2006	NSa	Inlet	Before	3.84	3.50	102.20	6.60	35.80					Hoferkamp, 2008
2/11/2006	NSd	Outlet	Before	4.75	5.00	103.10	6.87	42.90					Hoferkamp, 2008
2/11/2006	DCB	Outlet	Before	3.00	2.30	226.00	6.10	35.00		6.70		1.08	Nagorski, Hood, Hoferkamp, 2006
2/25/2006	NSd	Outlet	Before	2.94	4.00	112.30	6.27	9.42					Hoferkamp, 2008
2/25/2006	DCB	Outlet	Before	4.80	2.40	220.00	6.20	14.20		2.60		0.72	Nagorski, Hood, Hoferkamp, 2006
3/11/2006	NSd	Outlet	Before	3.08	4.70	109.50	7.13	25.80					Hoferkamp, 2008
3/15/2006	DCB	Outlet	Before	6.80	1.90	235.00	6.80						Nagorski, Hood, Hoferkamp, 2006
3/25/2006	DCB	Outlet	Before	6.10	2.70	223.00	6.00	16.40		6.40		0.41	Nagorski, Hood, Hoferkamp, 2006
3/28/2006	NSa	Inlet	Before	6.55	3.70	117.40	5.99	29.00					Hoferkamp, 2008
3/28/2006	NSd	Outlet	Before	5.27	4.60	117.90	6.85	18.80					Hoferkamp, 2008
4/7/2006	DCB	Outlet	Before	5.90	4.00	237.00	6.20	735.00		377.00		0.40	Nagorski, Hood, Hoferkamp, 2006
4/8/2006	NSa	Inlet	Before	7.82	7.30	126.30	7.01	13.70					Hoferkamp, 2008
4/8/2006	NSd	Outlet	Before	2.77	8.90	146.70	6.92	32.90					Hoferkamp, 2008
4/21/2006	DCB	Outlet	Before	8.30	6.30	197.00		80.30		52.70		0.72	Nagorski, Hood, Hoferkamp, 2006
4/27/2006	NSa	Inlet	Before	6.20	6.10	193.50	6.06	22.30					Hoferkamp, 2008
4/27/2006	NSd	Outlet	Before	4.84	7.50	113.20	7.18	96.30					Hoferkamp, 2008
5/5/2006	DCB	Outlet	Before	8.80	5.90	169.00	6.40	88.50		48.90			Nagorski, Hood, Hoferkamp, 2006
5/14/2006	NSa	Inlet	Before	8.13	8.90	122.10	6.01	18.40					Hoferkamp, 2008
5/14/2006	NSd	Outlet	Before	8.70	10.10	126.10	7.10	26.90					Hoferkamp, 2008
5/19/2006	DCB	Outlet	Before	7.90	9.90	200.00	6.50	27.10		3.50		1.82	Nagorski, Hood, Hoferkamp, 2006

Date	Site	Location	Timing	DO (mg/L)	T	Cond (uS/cm)	pH	Turb (NTU)	TSS (ppm)	TSS (mg/l)	FC	Discharge (ft3/s)	Source
5/27/2006	NSa	Inlet	Before	5.35	16.20	166.40	6.52	10.50					Hoferkamp, 2008
5/27/2006	NSd	Outlet	Before	7.92	16.30	162.90	6.56	14.40					Hoferkamp, 2008
6/2/2006	DCB	Outlet	Before	7.10	15.00	219.00	6.60	13.50		3.30		1.40	Nagorski, Hood, Hoferkamp, 2006
6/10/2006	NSa	Inlet	Before	6.95	15.30	151.00	6.60	9.42					Hoferkamp, 2008
6/10/2006	NSd	Outlet	Before	6.97	14.50	148.20	6.52	14.20					Hoferkamp, 2008
6/16/2006	DCB	Outlet	Before	6.10	15.90	210.00	6.70	17.40		6.50		1.53	Nagorski, Hood, Hoferkamp, 2006
6/24/2006	NSa	Inlet	Before	8.12	12.00	142.00		6.88					Hoferkamp, 2008
6/24/2006	NSd	Outlet	Before	8.54	12.40	141.30		13.40					Hoferkamp, 2008
6/30/2006	DCB	Outlet	Before	6.80	12.80	192.00	6.60	38.10				2.14	Nagorski, Hood, Hoferkamp, 2006
7/8/2006	NSa	Inlet	Before	6.45	14.10	152.30	6.44	9.74					Hoferkamp, 2008
7/8/2006	NSd	Outlet	Before	7.45	15.70	154.00	6.59	5.62					Hoferkamp, 2008
7/21/2006	NSa	Inlet	Before	6.98	14.00	150.80	6.91	5.44					Hoferkamp, 2008
7/21/2006	NSd	Outlet	Before	8.87	15.70	154.80	6.91	8.81					Hoferkamp, 2008
8/19/2006	NSa	Inlet	Before	5.55	10.90	118.20	6.84	21.50					Hoferkamp, 2008
8/19/2006	NSd	Outlet	Before	6.43	11.40	117.40	6.61	24.60					Hoferkamp, 2008
9/3/2006	NSa	Inlet	Before	5.50	11.20	114.40	6.79	30.90					Hoferkamp, 2008
9/3/2006	NSd	Outlet	Before	5.70	11.40	109.80	6.77	36.80					Hoferkamp, 2008
9/17/2006	NSa	Inlet	Before	3.65	9.10	122.10	6.51	29.30					Hoferkamp, 2008
9/17/2006	NSb	Midstream	Before	5.96	9.10	122.20	6.52	35.70					Hoferkamp, 2008
9/17/2006	NSd	Outlet	Before	6.82	9.00	118.60	6.63	36.10					Hoferkamp, 2008
10/2/2006	NSa	Inlet	Before	4.43	9.20	102.10	6.56	24.20					Hoferkamp, 2008
10/2/2006	NSb	Midstream	Before	5.07	9.20	103.70	6.34	23.20					Hoferkamp, 2008
10/2/2006	NSd	Outlet	Before	5.03	9.00	98.90	6.59	28.80					Hoferkamp, 2008
10/15/2006	NSa	Inlet	Before	4.62	8.00	103.40	6.36	18.40					Hoferkamp, 2008
10/15/2006	NSb	Midstream	Before	4.60	7.90	105.90	6.19	20.30					Hoferkamp, 2008
10/15/2006	NSd	Outlet	Before	5.40	7.90	101.60	6.80	25.70					Hoferkamp, 2008
10/29/2006	NSa	Inlet	Before	5.53	4.60	89.80	6.38	22.40					Hoferkamp, 2008
10/29/2006	NSb	Midstream	Before	6.04	4.10	8.87	6.43	17.10					Hoferkamp, 2008
10/29/2006	NSd	Outlet	Before	7.09	3.90	83.70	6.78	30.50					Hoferkamp, 2008
11/12/2006	NSa	Inlet	After	2.66	2.80	103.10	6.42	22.50					Hoferkamp, 2008
11/12/2006	NSb	Midstream	After	2.28	2.10	10.10	6.37	22.80					Hoferkamp, 2008
11/12/2006	NSd	Outlet	After	3.73	2.50	96.80	6.30	20.30					Hoferkamp, 2008
12/10/2006	NSa	Inlet	After	2.92	2.60	107.00	6.37	21.80					Hoferkamp, 2008
12/10/2006	NSb	Midstream	After	2.43	2.40	104.50	6.49	25.60					Hoferkamp, 2008
12/10/2006	NSd	Outlet	After	3.33	1.70	101.70	6.44	23.90					Hoferkamp, 2008
12/24/2006	NSa	Inlet	After	3.23	2.70	114.00	5.44	19.70					Hoferkamp, 2008
12/24/2006	NSb	Midstream	After	3.50	2.60	114.90	5.66	20.70					Hoferkamp, 2008
12/24/2006	NSd	Outlet	After	5.32	2.00	107.70	5.74	19.90					Hoferkamp, 2008
1/20/2007	NSa	Inlet	After	7.43	2.70	105.20	6.74	25.70					Hoferkamp, 2008
1/20/2007	NSb	Midstream	After	6.90	2.70	106.30	6.43	27.20					Hoferkamp, 2008
1/20/2007	NSd	Outlet	After	9.07	2.00	101.80	6.94	26.20					Hoferkamp, 2008
2/4/2007	NSa	Inlet	After	5.39	2.40	112.30	6.45	12.10					Hoferkamp, 2008
2/4/2007	NSb	Midstream	After	3.68	2.20	110.10	6.08	19.50					Hoferkamp, 2008
2/4/2007	NSd	Outlet	After	5.52	1.80	107.40	6.03	17.50					Hoferkamp, 2008
2/18/2007	NSa	Inlet	After	4.62	2.50	125.10	5.41	19.30					Hoferkamp, 2008
2/18/2007	NSb	Midstream	After	3.75	2.40	123.50	5.39	19.60					Hoferkamp, 2008
2/18/2007	NSd	Outlet	After	5.21	2.10	116.20	6.70	22.90					Hoferkamp, 2008
3/4/2007	NSa	Inlet	After	2.46	1.10	112.30		17.60					Hoferkamp, 2008
3/4/2007	NSd	Outlet	After	4.68	0.80	107.40	7.16	18.90					Hoferkamp, 2008

Date	Site	Location	Timing	DO (mg/L)	T	Cond (uS/cm)	pH	Turb (NTU)	TSS (ppm)	TSS (mg/l)	FC	Discharge (ft3/s)	Source
3/20/2007	NSa	Inlet	After	2.61	1.10	134.30	6.02	26.60					Hoferkamp, 2008
3/20/2007	NSd	Outlet	After	5.25	0.80	122.50	7.35	12.00					Hoferkamp, 2008
4/1/2007	NSa	Inlet	After	4.68	1.80	131.40	5.22	23.60					Hoferkamp, 2008
4/1/2007	NSb	Midstream	After	5.08	1.30	123.70	6.24	20.10					Hoferkamp, 2008
4/1/2007	NSd	Outlet	After	6.15	2.20	124.80	7.12	14.90					Hoferkamp, 2008
4/15/2007	NSa	Inlet	After	10.70	4.00	178.40	5.83	17.50					Hoferkamp, 2008
4/15/2007	NSb	Midstream	After	9.17	3.90	106.20	6.08	20.20					Hoferkamp, 2008
4/15/2007	NSd	Outlet	After	9.74	4.10	101.40	6.06	18.60					Hoferkamp, 2008
4/29/2007	NSa	Inlet	After	7.35	6.10	120.10	5.85	14.70					Hoferkamp, 2008
4/29/2007	NSb	Midstream	After	7.45	6.20	120.00	5.13	16.70					Hoferkamp, 2008
4/29/2007	NSd	Outlet	After	9.44	6.30	117.50	6.01	15.10					Hoferkamp, 2008
5/12/2007	NSa	Inlet	After	6.94	8.30	118.50	6.31	14.80					Hoferkamp, 2008
5/12/2007	NSb	Midstream	After	7.52	8.80	122.30	5.94	13.70					Hoferkamp, 2008
5/12/2007	NSd	Outlet	After	8.60	9.30	118.10	6.42	13.30					Hoferkamp, 2008
5/27/2007	NSa	Inlet	After	8.31	10.00	123.40	6.31	12.80					Hoferkamp, 2008
5/27/2007	NSb	Midstream	After	8.30	10.80	125.60	5.98	14.70					Hoferkamp, 2008
5/27/2007	NSd	Outlet	After	10.37	11.70	130.40	6.59	13.00					Hoferkamp, 2008
6/9/2007	NSa	Inlet	After	7.37	12.80	140.20	6.67	9.43					Hoferkamp, 2008
6/9/2007	NSb	Midstream	After	6.56	12.80	139.20	6.53	11.20					Hoferkamp, 2008
6/9/2007	NSd	Outlet	After	8.75	14.50	143.50	6.74	10.70					Hoferkamp, 2008
7/8/2007	NSa	Inlet	After	5.63	14.70	19.37	6.45	10.00					Hoferkamp, 2008
7/8/2007	NSb	Midstream	After	6.73	15.00	19.53	6.45	10.30					Hoferkamp, 2008
7/8/2007	NSd	Outlet	After	9.48	16.00	19.48	6.84	6.98					Hoferkamp, 2008
7/23/2007	NSa	Inlet	After	5.40	13.20	134.60	6.80	9.85					Hoferkamp, 2008
7/23/2007	NSb	Midstream	After	5.39	13.80	133.70	6.72	11.10					Hoferkamp, 2008
7/23/2007	NSd	Outlet	After	7.03	14.30	133.70	6.83	9.59					Hoferkamp, 2008
8/6/2007	NSa	Inlet	After	6.03	13.20	150.20	5.96	7.49					Hoferkamp, 2008
8/6/2007	NSb	Midstream	After	6.72	13.90	148.90	6.37	10.10					Hoferkamp, 2008
8/6/2007	NSd	Outlet	After	8.06	14.60	149.00	6.59	7.78					Hoferkamp, 2008
8/20/2007	NSa	Inlet	After	8.23	13.60	152.30	6.50	11.70					Hoferkamp, 2008
8/20/2007	NSb	Midstream	After	8.68	15.50	162.80	6.60	17.20					Hoferkamp, 2008
8/20/2007	NSd	Outlet	After	9.35	16.00	158.40	6.76	11.40					Hoferkamp, 2008
9/2/2007	NSa	Inlet	After	5.13	12.20		6.31	12.90					Hoferkamp, 2008
9/2/2007	NSb	Midstream	After	6.22	14.70		6.45	15.70					Hoferkamp, 2008
9/2/2007	NSd	Outlet	After	7.95	14.00		6.75	9.99					Hoferkamp, 2008
9/15/2007	NSa	Inlet	After	3.60	11.20	179.50	5.97	25.20					Hoferkamp, 2008
9/15/2007	NSb	Midstream	After	4.40	11.60	182.70	5.85	29.60					Hoferkamp, 2008
9/15/2007	NSd	Outlet	After	8.10	11.90	164.30	6.15	14.60					Hoferkamp, 2008
9/29/2007	NSa	Inlet	After	4.33	8.80		5.78	15.00					Hoferkamp, 2008
9/29/2007	NSb	Midstream	After	5.43	8.90		5.61	15.90					Hoferkamp, 2008
9/29/2007	NSd	Outlet	After	6.18	8.70		6.47	17.00					Hoferkamp, 2008
10/13/2007	NSa	Inlet	After	5.38	7.80	104.10	6.35	16.70					Hoferkamp, 2008
10/13/2007	NSb	Midstream	After	5.64	7.90	106.10	5.97	15.60					Hoferkamp, 2008
10/13/2007	NSd	Outlet	After	7.30	7.40	101.50	6.28	17.10					Hoferkamp, 2008
10/30/2007	NSa	Inlet	After	6.25	6.40	95.10	5.43	17.20					Hoferkamp, 2008
10/30/2007	NSb	Midstream	After	7.20	6.40	97.10	5.23	16.20					Hoferkamp, 2008
10/30/2007	NSd	Outlet	After	7.50	6.10	95.00	5.70	19.80					Hoferkamp, 2008
11/11/2007	NSa	Inlet	After	5.22	4.10	102.20	5.10	18.10					Hoferkamp, 2008
11/11/2007	NSb	Midstream	After	6.34	3.50	99.10	5.09	17.70					Hoferkamp, 2008

Date	Site	Location	Timing	DO (mg/L)	T	Cond (uS/cm)	pH	Turb (NTU)	TSS (ppm)	TSS (mg/l)	FC	Discharge (ft3/s)	Source
11/11/2007	NSd	Outlet	After	7.60	3.20	94.20	5.46	21.80					Hoferkamp, 2008
11/27/2007	NSa	Inlet	After	6.52	3.90	100.30	5.61	21.60					Hoferkamp, 2008
11/27/2007	NSb	Midstream	After	6.66	3.00	98.30	5.30	20.30					Hoferkamp, 2008
11/27/2007	NSd	Outlet	After	8.95	3.40	97.70	6.11	19.60					Hoferkamp, 2008
12/11/2007	NSa	Inlet	After	4.24	2.70	99.60	4.96	8.00					Hoferkamp, 2008
12/11/2007	NSd	Outlet	After	4.59	1.70	88.50	5.04	12.60					Hoferkamp, 2008
12/26/2007	NSa	Inlet	After	4.03	2.70	116.80	4.90	20.20					Hoferkamp, 2008
12/26/2007	NSd	Outlet	After	4.63	2.00	108.10	5.91	21.20					Hoferkamp, 2008
1/7/2008	NSa	Inlet	After	2.60	2.00	119.40	6.65	13.20					Hoferkamp, 2008
1/7/2008	NSd	Outlet	After	3.85	1.60	117.00	6.65	14.80					Hoferkamp, 2008
1/21/2008	NSa	Inlet	After	6.25	1.20	102.50	5.33	14.20					Hoferkamp, 2008
1/21/2008	NSd	Outlet	After	7.16	1.60	99.60	6.92	16.20					Hoferkamp, 2008
2/2/2008	NSa	Inlet	After	3.20	1.40	105.00	4.53	7.40					Hoferkamp, 2008
2/2/2008	NSd	Outlet	After	4.04	0.80	54.50	6.53	12.50					Hoferkamp, 2008
2/16/2008	NSa	Inlet	After	4.84	2.10	106.20	6.56	14.60					Hoferkamp, 2008
2/16/2008	NSd	Outlet	After	5.82	1.50	101.80	6.70	14.20					Hoferkamp, 2008
3/4/2008	NSa	Inlet	After	7.25	3.50	100.00	4.75	16.40					Hoferkamp, 2008
3/4/2008	NSb	Midstream	After	8.01	3.30	97.50	4.72	16.50					Hoferkamp, 2008
3/4/2008	NSd	Outlet	After	8.30	3.10	88.90	7.15	16.20					Hoferkamp, 2008
3/14/2008	NSa	Inlet	After	7.45	2.40	98.30	4.87	10.70					Hoferkamp, 2008
3/14/2008	NSd	Outlet	After	9.02	3.70	95.30	7.03	13.60					Hoferkamp, 2008
3/29/2008	NSa	Inlet	After	9.65	4.80	109.40	5.68	8.70					Hoferkamp, 2008
3/29/2008	NSb	Midstream	After	10.20	5.20	108.30	5.82	7.60					Hoferkamp, 2008
3/29/2008	NSd	Outlet	After	11.58	5.60	104.00	6.94	8.80					Hoferkamp, 2008

Appendix D. Probability of Exceeding Water Quality Standards and TMDL Target Values

Procedure for calculating the probability for exceeding a standard, excerpted from the National Water Quality Handbook (NRCS, 2003.)

(d) Probability of exceeding standard

An alternative method for determining the priority of variables to monitor would be to select those with the highest probability of exceeding a particular standard (Moser & Huibregtse, 1976). To determine this probability requires knowledge of the mean ($\overline{X}$), standard deviation (S), and numerical standard value (X_{std}) not to be exceeded. The probability is determined from the Z-statistic as:

$$Z = \frac{X_{std} - \overline{X}}{S} \qquad [6\text{–}2]$$

Using a standard Z-table (appendix A), the probability would be obtained. Not all variables have adopted numerical values for standards. For example, nitrogen and phosphorus generally are not included in lists of numeric standards. In such cases a eutrophication value, such as 0.05 mg/L for total phosphorus could be used. Another alternative would be to set a concentration goal to achieve and substitute that for a standard value.

Results (*probability to not meet, or fall below, these standards was calculated as this is a lower limit and, therefore an exceedance is not a concern):

Parameter/Standard	Before		After		2017	
	Z-Statistic	**Probability**	Z-Statistic	**Probability**	Z-Statistic	**Probability**
Turbidity **9.4 NTU**	-0.33851114	**0.6179**	-1.30576923	**0.9032**	-0.114790287	**0.5398**
Turbidity **29.4 NTU**	-0.0454279	**0.5398**	2.540384615	**0.0062**	2.092715232	**0.0179**
Total Suspended Solids **9.1 mg/L**	-0.27718833	**0.6179**			0.623608018	**0.2743**
Dissolved Oxygen* **7 mg/L**	0.415300546	**0.6554**	0.328767123	**0.6179**	0.263473054	**0.6179**
Growing Season DO* **7 mg/L**	0.275641026	**0.6179**	-0.07272727	**0.4602**	0.363057325	**0.6554**
Dissolved Iron **0.3 mg/L**					-0.32743363	**0.6179**
Dissolved Iron **1.0 mg/L**					0.292035398	**0.3821**
Total Dissolved Solids **500 mg/L**					1.211262372	**0.1151**
Total Dissolved Solids **1000 mg/L**					2.900280377	**0.0019**
Temperature **13 C**	0.787644788	**0.2119**	1.416149068	**0.0808**	0.348591549	**0.3446**
Growing Season Temperature **13 C**	0.008379888	**0.5**	0.369863014	**0.3446**	0.058558559	**0.4602**
Temperature **15 C**	1.173745174	**0.1151**	1.830227743	**0.0359**	1.052816901	**0.1587**
Growing Season Temperature **15 C**	0.567039106	**0.2743**	1.054794521	**0.1357**	0.959459459	**0.1587**
pH * **6.5**	-0.02083333	**0.5**	0.609375	**0.2743**	-2.142857143	**0.0179**
Growing Season pH * **6.5**	-0.77419355	**0.2119**	0.43902439	**0.6554**	-1.909090909	**0.0228**
pH **8.5**	4.14833333	**0.0003**	3.734375	**0.0003**	7.380952381	**0.0003**
Growing Season pH **8.5**	5.677419355	**0.0003**	5.317073171	**0.0003**	7.181818182	**0.0003**

Appendix E. Analysis of Downstream Differences using Wilcoxon Signed Rank Tests

Return

Two correlated groups tests

Title:	Turbidity - Before
Y-Axis:	Turbidity (NTUs)

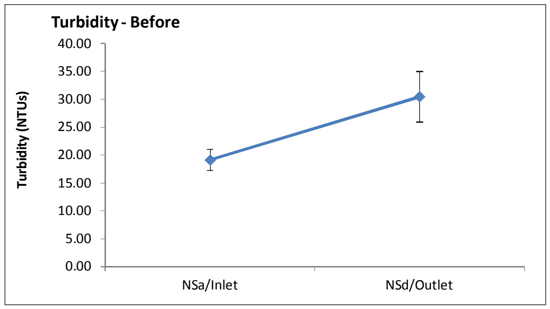
Paste your data here

Change the group names if you wish

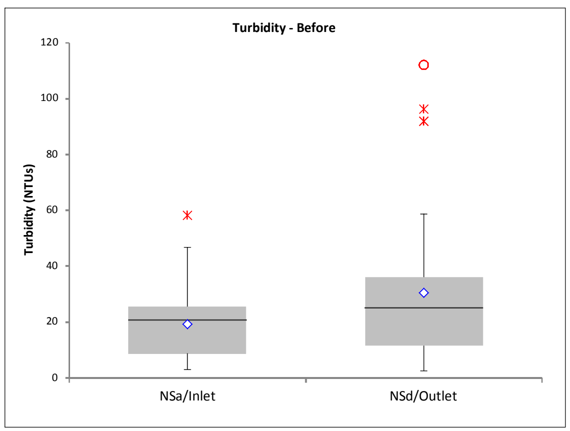
Samples must have the same size

NSa/Inlet	NSd/Outlet
6.15	4.56
21.10	112.00
21.70	91.90
22.80	36.60
31.60	30.30
35.80	42.90
29.00	18.80
13.70	32.90
22.30	96.30
18.40	26.90
10.50	14.40
9.42	14.20
6.88	13.40
9.74	5.62
5.44	8.81
21.50	24.60
30.90	36.80
29.30	36.10
24.20	28.80
18.40	25.70
22.40	30.50
3.47	3.99
3.21	5.74
3.36	2.72
3.05	2.55
3.18	3.13
4.68	7.53
9.29	12.80
21.90	23.30
25.60	30.80
24.50	15.00
13.00	12.50
17.70	15.90
6.15	4.56
25.70	22.00
58.10	58.70
27.20	112.00
46.80	91.90
35.70	36.10
23.20	28.80
20.30	25.70
17.10	30.50

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	19.15	30.44
Median	20.70	25.15
Standard Deviation	12.28	29.26
Standard Error	1.90	4.51

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	**0.219%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**0.014%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Turbidity - After
Y-Axis:	Turbidity (NTUs)

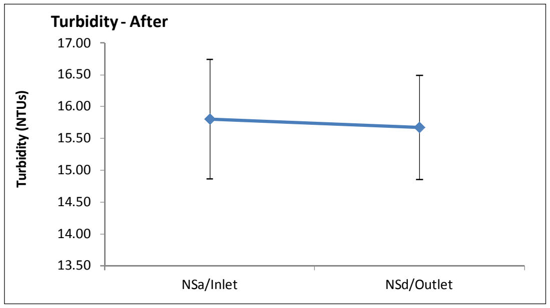
Paste your data here

Change the group names if you wish

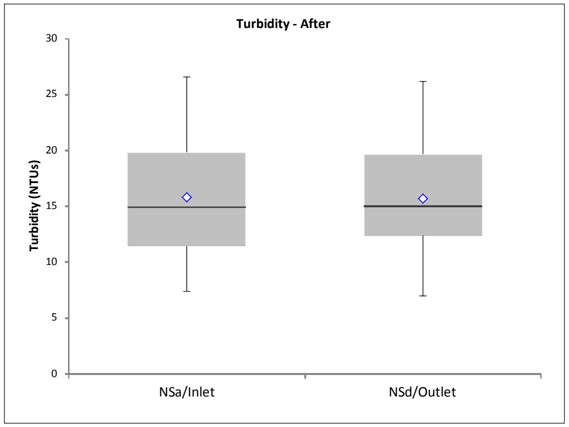
Samples must have the same size

NSa/Inlet	NSd/Outlet
22.50	20.30
21.80	23.90
19.70	19.90
25.70	26.20
12.10	17.50
19.30	22.90
17.60	18.90
26.60	12.00
23.60	14.90
17.50	18.60
14.70	15.10
14.80	13.30
12.80	13.00
9.43	10.70
10.00	6.98
9.85	9.59
7.49	7.78
11.70	11.40
12.90	9.99
25.20	14.60
15.00	17.00
16.70	17.10
17.20	19.80
18.10	21.80
21.60	19.60
8.00	12.60
20.20	21.20
13.20	14.80
14.20	16.20
7.40	12.50
14.60	14.20
16.40	16.20
10.70	13.60
8.70	8.80

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	15.80	15.67
Median	14.90	15.00
Standard Deviation	5.47	4.77
Standard Error	0.94	0.82

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	42.959%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	12.689%

Cannot reject equality of medians

Return

Two correlated groups tests

Title:	Turbidity - 2017
Y-Axis:	Turbidity (NTUs)

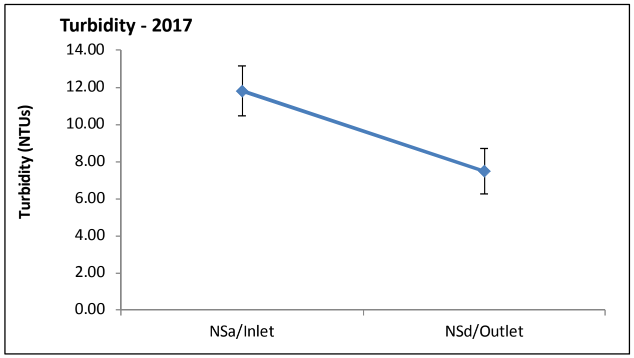
Paste your data here

Change the group names if you wish

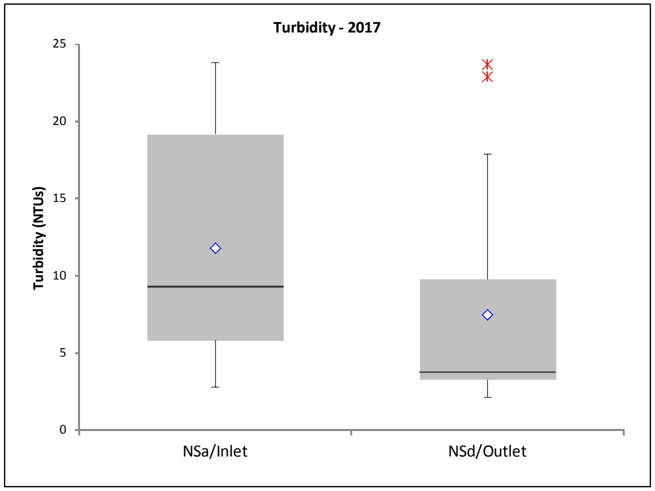
Samples must have the same size

NSa/Inlet	NSd/Outlet
2.78	2.22
2.85	2.13
4.13	3.99
4.16	4.08
5.46	3.53
5.30	3.37
10.20	4.49
9.95	4.45
10.90	3.34
11.00	3.25
7.04	2.80
7.30	2.80
4.44	3.31
7.75	3.37
7.09	3.47
6.90	3.30
8.63	3.02
8.10	3.00
18.10	9.45
17.90	9.43
22.30	17.70
22.40	17.90
20.30	14.50
20.00	14.80
18.20	9.10
19.50	9.91
23.80	22.90
23.80	23.70

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	11.80	7.48
Median	9.29	3.76
Standard Deviation	7.15	6.53
Standard Error	1.35	1.23

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**0.000%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median > NSd/Outlet median
p-value:	**0.000%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Total Suspended Solids
Y-Axis:	TSS (mg/L)

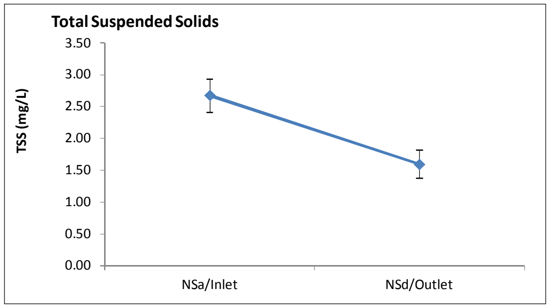
Paste your data here

Change the group names if you wish

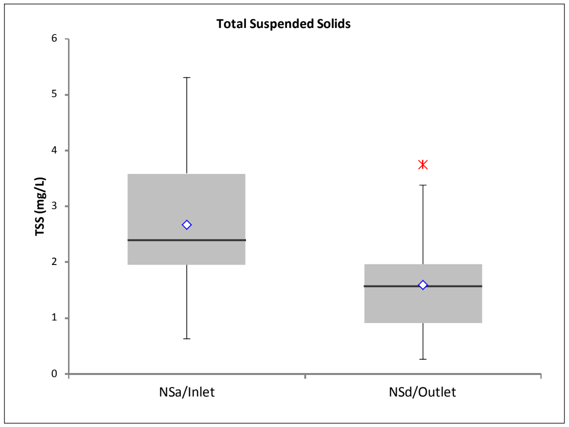
Samples must have the same size

NSa/Inlet	NSd/Outlet
3.67	1.65
2.27	3.38
2.75	1.77
3.34	0.51
2.22	0.27
4.04	1.37
4.44	0.28
0.63	2.29
4.15	0.26
1.85	0.86
1.95	1.07
2.60	1.95
2.60	1.95
5.31	1.49
2.50	2.91
1.04	1.27
2.29	1.82
1.61	3.75
2.20	1.97
1.97	1.09

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	2.67	1.60
Median	2.40	1.57
Standard Deviation	1.17	0.98
Standard Error	0.26	0.22

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**0.706%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median > NSd/Outlet median
p-value:	**0.957%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Dissolved Oxygen - Before
Y-Axis:	DO (mg/L)

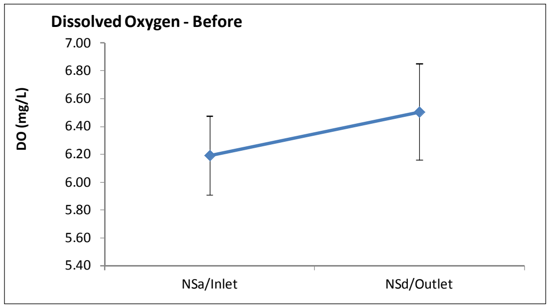
Paste your data here

Change the group names if you wish

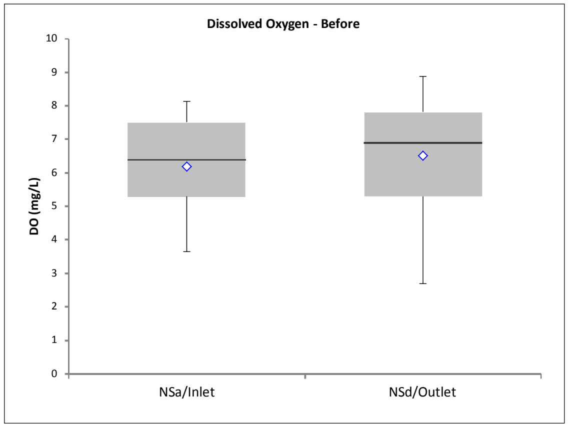
Samples must have the same size

NSa/Inlet	NSd/Outlet
7.68	8.30
4.33	2.70
6.40	5.93
6.36	6.57
7.89	7.51
7.97	7.90
7.00	7.57
5.28	7.08
3.84	4.75
6.55	5.27
7.82	2.77
6.20	4.84
8.13	8.70
5.35	7.92
6.95	6.97
8.12	8.54
6.45	7.45
6.98	8.87
5.55	6.43
5.50	5.70
3.65	6.82
4.43	5.03
4.62	5.40
5.53	7.09

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	6.19	6.50
Median	6.38	6.90
Standard Deviation	1.39	1.69
Standard Error	0.28	0.35

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	17.641%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	4.390%

Reject equality of medians

Return

Two correlated groups tests

Title:	Dissolved Oxygen - After
Y-Axis:	DO (mg/L)

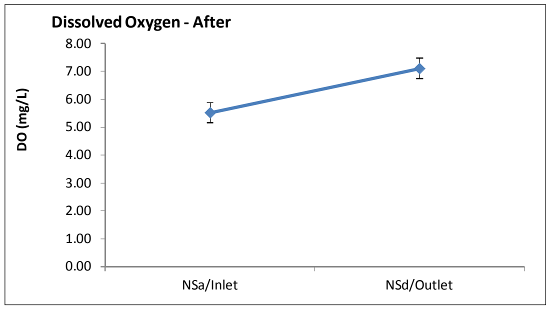
Paste your data here

Change the group names if you wish

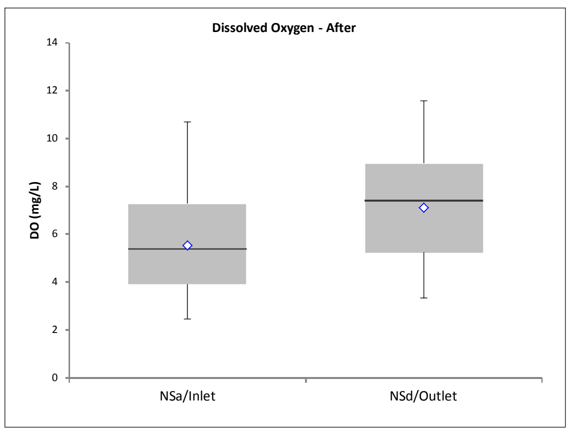
Samples must have the same size

NSa/Inlet	NSd/Outlet
7.43	9.07
5.39	5.52
4.62	5.21
2.46	4.68
2.61	5.25
4.68	6.15
10.70	9.74
7.35	9.44
6.94	8.60
8.31	10.37
7.37	8.75
5.63	9.48
5.40	7.03
6.03	8.06
8.23	9.35
5.13	7.95
3.60	8.10
4.33	6.18
5.38	7.30
6.25	7.50
5.22	7.60
6.52	8.95
4.24	4.59
4.03	4.63
2.60	3.85
6.25	7.16
3.20	4.04
4.84	5.82
7.25	8.30
7.45	9.02
9.65	11.58
2.66	3.73
2.92	3.33
3.23	5.32

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	5.53	7.11
Median	5.39	7.40
Standard Deviation	2.09	2.16
Standard Error	0.36	0.37

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	0.000%

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	0.000%

Reject equality of medians

Return

Two correlated groups tests

Title:	Dissolved Oxygen - 2017
Y-Axis:	DO (mg/L)

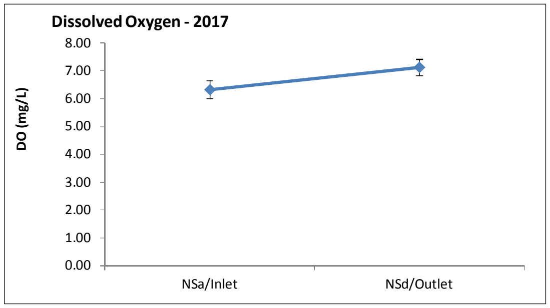
Paste your data here

Change the group names if you wish

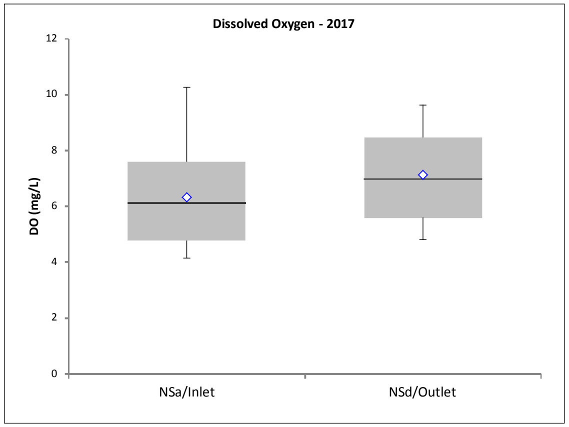
Samples must have the same size

NSa/Inlet	NSd/Outlet
10.26	9.15
8.71	9.50
7.04	9.63
9.30	9.55
9.36	7.33
8.17	7.60
8.17	6.98
6.83	7.26
6.79	6.98
4.98	6.95
4.91	9.36
6.61	8.55
6.62	8.15
6.16	8.88
5.65	6.11
5.48	8.00
4.26	5.59
4.26	5.79
6.15	7.11
6.12	6.42
6.00	5.59
5.95	5.49
4.69	6.85
4.74	4.81
4.80	5.06
4.76	4.89
4.24	5.21
4.14	5.16
8.20	8.40

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	6.32	7.12
Median	6.12	6.98
Standard Deviation	1.73	1.57
Standard Error	0.32	0.29

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**0.209%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**0.287%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Growing Season DO - Before
Y-Axis:	Dissolved Oxygen (mg/L)

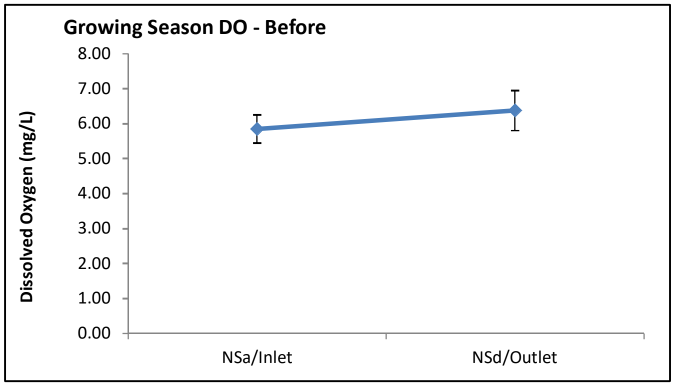
Paste your data here

Change the group names if you wish

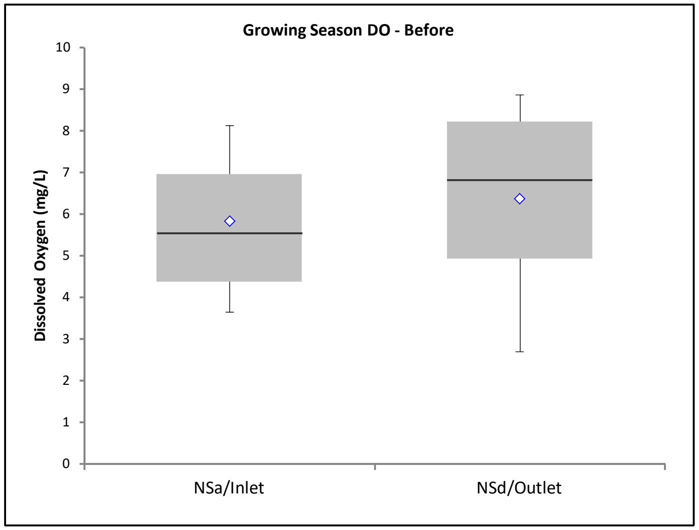
Samples must have the same size

NSa/Inlet	NSd/Outlet
4.33	2.70
4.33	2.88
6.20	4.84
8.13	8.70
5.35	7.92
6.95	6.97
8.12	8.54
6.45	7.45
6.98	8.87
5.55	6.43
5.50	5.70
3.65	6.82
4.43	5.03

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	5.84	6.37
Median	5.55	6.82
Standard Deviation	1.45	2.06
Standard Error	0.40	0.57

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	10.907%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	10.108%

Cannot reject equality of medians

Return

Two correlated groups tests

Title:	Growing Season DO - After
Y-Axis:	Dissolved Oxygen (mg/L)

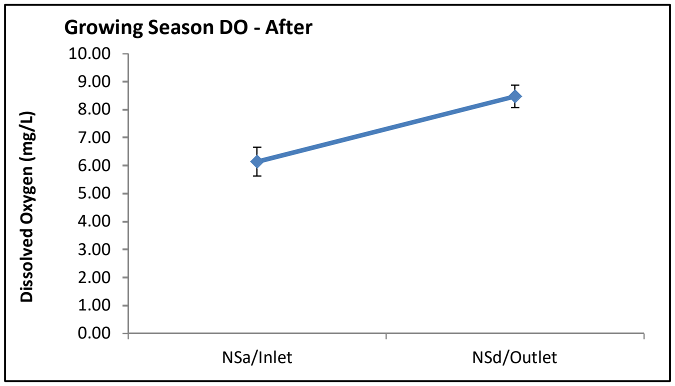
Paste your data here

Change the group names if you wish

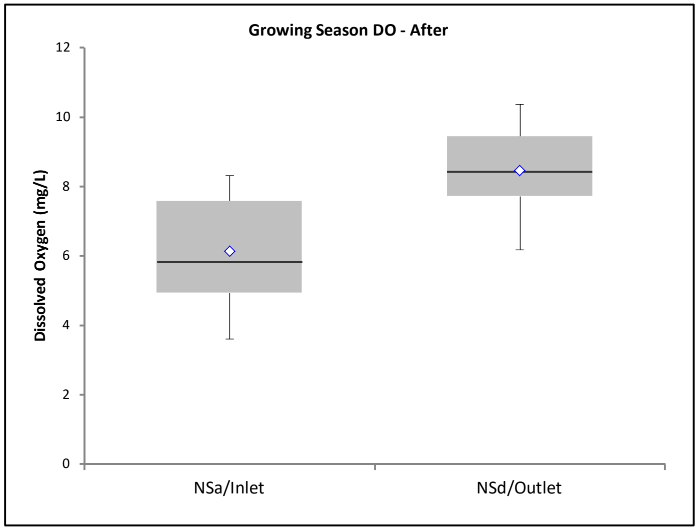
Samples must have the same size

NSa/Inlet	NSd/Outlet
7.35	9.44
8.31	10.37
7.37	8.75
5.63	9.48
5.40	7.03
6.03	8.06
8.23	9.35
5.13	7.95
3.60	8.10
4.33	6.18

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	6.14	8.47
Median	5.83	8.43
Standard Deviation	1.62	1.26
Standard Error	0.51	0.40

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**0.004%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**0.000%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Growing Season DO - 2017
Y-Axis:	Dissolved Oxygen (mg/L)

Descriptive	NSa/Inlet	NSd/Outlet
Mean	6.32	7.12
Median	6.12	6.98
Standard Deviation	1.73	1.57
Standard Error	0.32	0.29

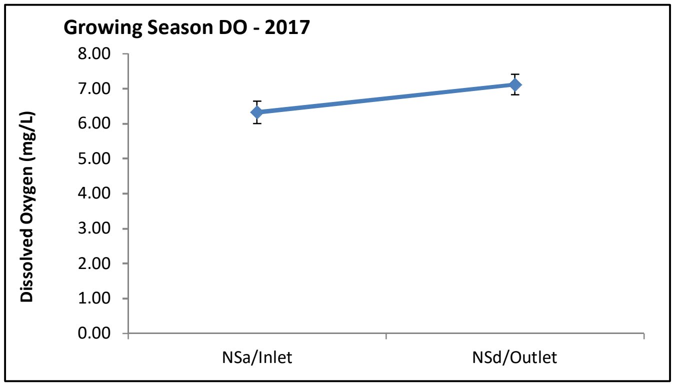
Paste your data here ↓

Change the group names if you wish

Samples must have the same size

NSa/Inlet	NSd/Outlet
10.26	9.15
8.71	9.50
7.04	9.63
9.30	9.55
9.36	7.33
8.17	7.60
8.17	6.98
6.83	7.26
6.79	6.98
4.98	6.95
4.91	9.36
6.61	8.55
6.62	8.15
6.16	8.88
5.65	6.11
5.48	8.00
4.26	5.59
4.26	5.79
6.15	7.11
6.12	6.42
6.00	5.59
5.95	5.49
4.69	6.85
4.74	4.81
4.80	5.06
4.76	4.89
4.24	5.21
4.14	5.16
8.20	8.40

Average and standard error bar chart:



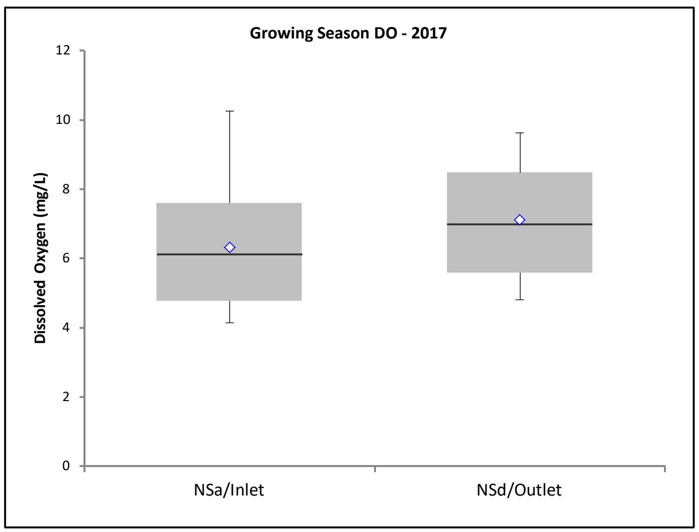
Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**0.209%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**0.287%**

Reject equality of medians

Boxplot:



Return

Two correlated groups tests

Title:	Dissolved Iron
Y-Axis:	Fe, aqueous (mg/L)

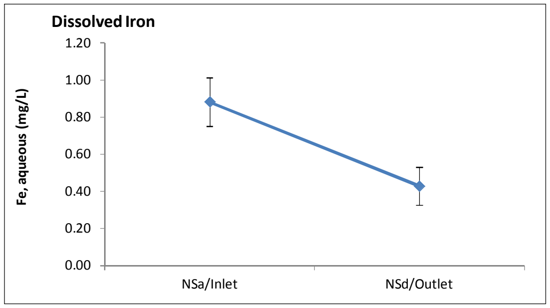
Paste your data here

Change the group names if you wish

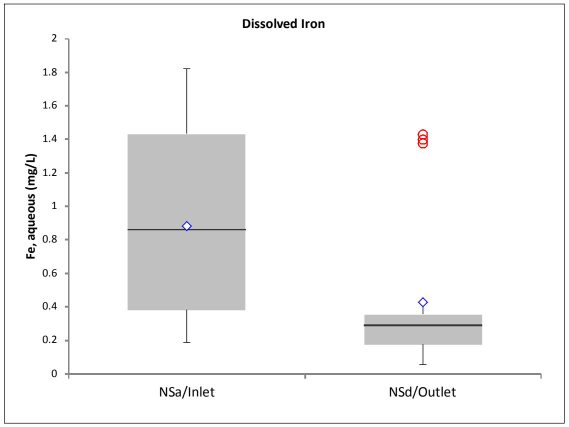
Samples must have the same size

NSa/Inlet	NSd/Outlet
0.196	0.323
0.345	0.201
0.243	0.167
0.407	0.176
0.879	0.056
0.863	0.059
0.860	0.060
1.821	1.373
0.187	1.397
0.382	1.429
0.635	0.351
0.476	0.427
0.407	0.248
1.393	0.288
1.432	0.290
1.348	0.355
1.565	0.347
1.697	0.287
1.607	0.293

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	0.88	0.43
Median	0.86	0.29
Standard Deviation	0.57	0.45
Standard Error	0.13	0.10

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**0.751%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median > NSd/Outlet median
p-value:	**0.578%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Total Dissolved Solids
Y-Axis:	TDS (mg/L)

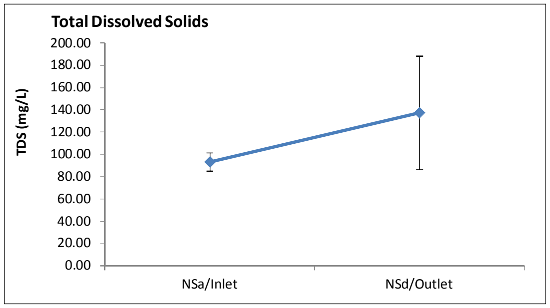
Paste your data here

Change the group names if you wish

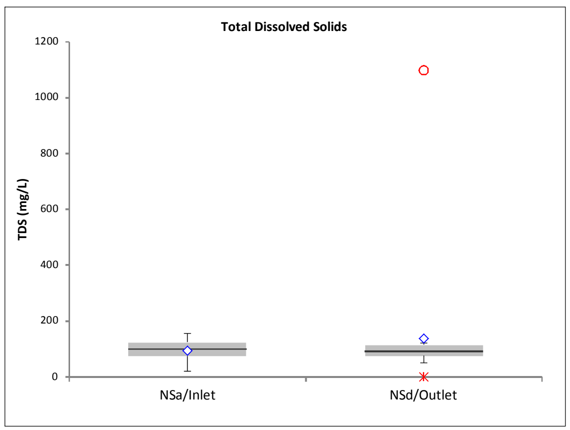
Samples must have the same size

NSa/Inlet	NSd/Outlet
138.54	0.71
100.38	50.65
56.42	80.49
154.65	117.47
93.91	91.18
102.48	99.73
105.08	100.00
20.75	1097.98
97.63	76.35
103.15	95.08
129.42	91.89
130.67	120.98
130.67	120.98
82.42	74.23
73.85	77.19
47.13	76.33
106.66	84.86
91.68	120.79
76.52	109.18
20.08	59.12

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	93.10	137.26
Median	99.00	91.54
Standard Deviation	36.54	227.91
Standard Error	8.17	50.96

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	21.623%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median > NSd/Outlet median
p-value:	29.093%

Cannot reject equality of medians

Return

Two correlated groups tests

Title:	Conductivity - Before
Y-Axis:	Conductivity (microsemens/cm)

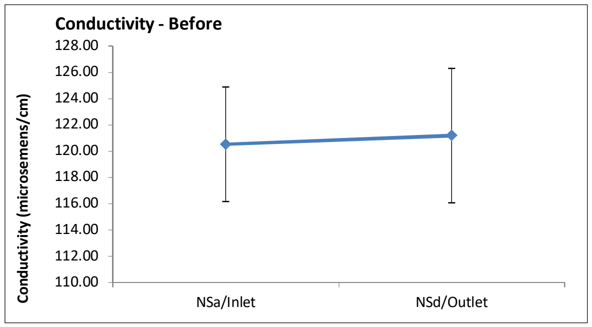
Paste your data here

Change the group names if you wish

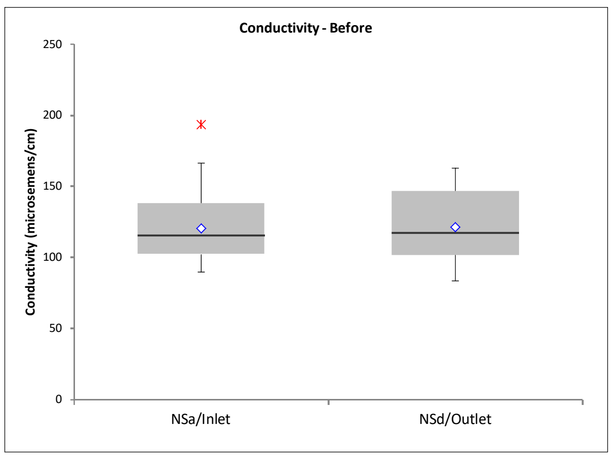
Samples must have the same size

NSa/Inlet	NSd/Outlet
160.50	155.00
118.70	106.00
106.10	98.00
97.40	91.50
143.50	145.00
96.70	91.90
102.80	101.60
102.20	103.10
117.40	117.90
126.30	146.70
193.50	113.20
122.10	126.10
166.40	162.90
151.00	148.20
142.00	141.30
152.30	154.00
150.80	154.80
118.20	117.40
114.40	109.80
122.10	118.60
102.10	98.90
103.40	101.60
89.80	83.70
99.60	
116.80	
119.40	
102.50	
105.00	
106.20	
100.00	
98.30	
109.40	

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	120.53	121.18
Median	115.60	117.40
Standard Deviation	24.60	24.49
Standard Error	4.35	5.11

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	9.747%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**1.570%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Conductivity - 2017
Y-Axis:	Conductivity (microsemens/cm)

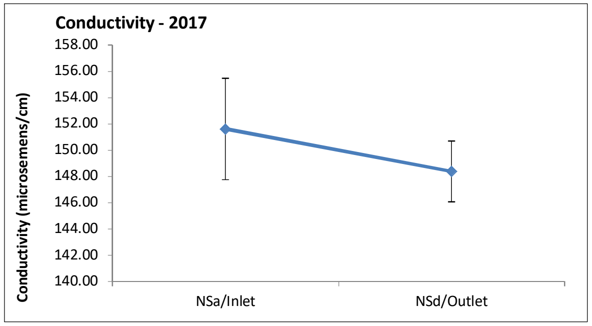
Paste your data here

Change the group names if you wish

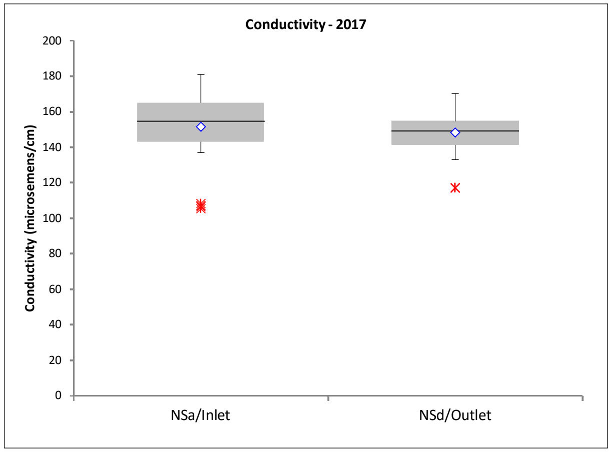
Samples must have the same size

NSa/Inlet	NSd/Outlet
154.3	136.0
163.0	141.3
160.7	162.1
165.7	154.5
148.9	147.2
151.7	146.8
142.8	148.8
152.2	152.6
178.8	168.8
181.0	170.2
151.9	148.7
152.7	150.6
159.8	153.9
162.3	152.6
166.5	160.5
168.3	161.3
178.4	150.3
178.9	148.6
105.4	139.5
106.5	140.5
140.5	147.4
146.4	145.5
161.8	167.3
164.6	155.1
137.1	133.0
143.1	134.6
154.7	149.5
154.9	150.1
107.2	116.9
108.2	117.2

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	151.61	148.38
Median	154.50	149.15
Standard Deviation	21.18	12.68
Standard Error	3.87	2.31

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	10.730%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median > NSd/Outlet median
p-value:	**2.957%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Conductivity - After
Y-Axis:	Conductivity (microsemens/cm)

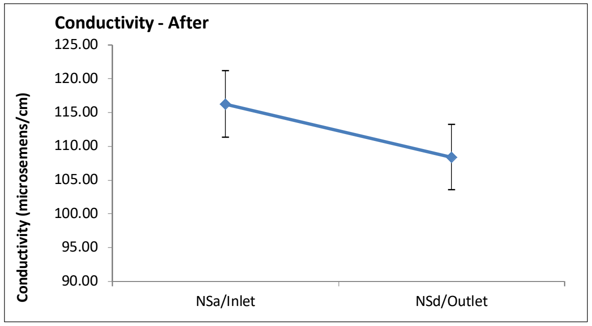
Paste your data here

Change the group names if you wish

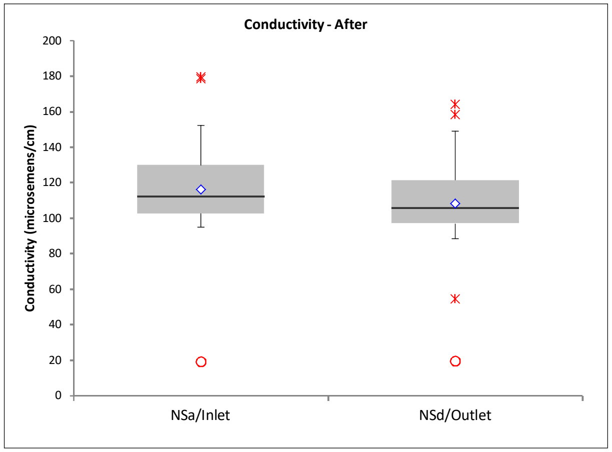
Samples must have the same size

NSa/Inlet	NSd/Outlet
103.10	96.80
107.00	101.70
114.00	107.70
105.20	101.80
112.30	107.40
125.10	116.20
112.30	107.40
134.30	122.50
131.40	124.80
178.40	101.40
120.10	117.50
118.50	118.10
123.40	130.40
140.20	143.50
19.37	19.48
134.60	133.70
150.20	149.00
152.30	158.40
179.50	164.30
104.10	101.50
95.10	95.00
102.20	94.20
100.30	97.70
99.60	88.50
116.80	108.10
119.40	117.00
102.50	99.60
105.00	54.50
106.20	101.80
100.00	88.90
98.30	95.30
109.40	104.00

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	116.26	108.38
Median	112.30	105.70
Standard Deviation	27.89	27.31
Standard Error	4.93	4.83

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**0.414%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median > NSd/Outlet median
p-value:	**0.005%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Water Temperature - Before
Y-Axis:	Temperature (C)

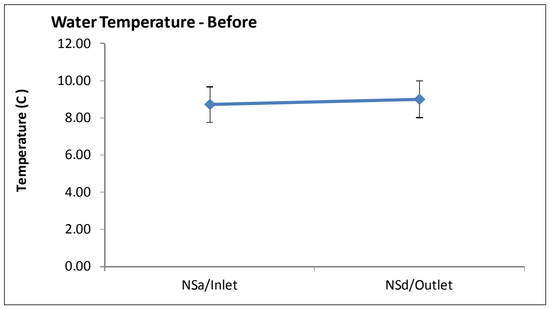
Paste your data here

Change the group names if you wish

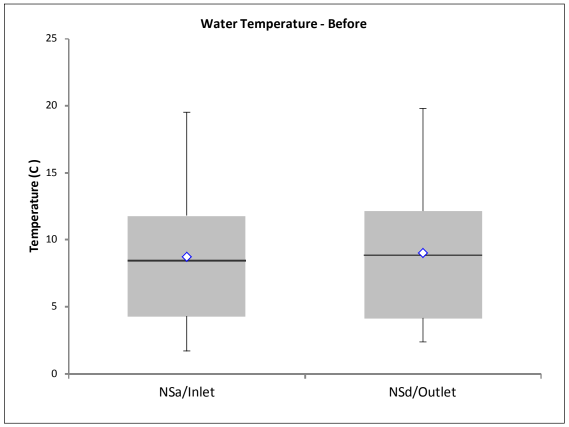
Samples must have the same size

NSa/Inlet	NSd/Outlet
19.50	19.80
9.10	8.80
7.30	7.30
4.20	3.80
5.70	4.00
3.60	2.90
4.00	3.70
1.70	2.40
3.50	5.00
3.70	4.60
7.30	8.90
6.10	7.50
8.90	10.10
16.20	16.30
15.30	14.50
12.00	12.40
14.10	15.70
14.00	15.70
10.90	11.40
11.20	11.40
9.10	9.00
9.20	9.00
8.00	7.90
4.60	3.90

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	8.72	9.00
Median	8.45	8.85
Standard Deviation	4.67	4.86
Standard Error	0.95	0.99

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	6.764%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	8.917%

Cannot reject equality of medians

Return

Two correlated groups tests

Title:	Water Temperature - After
Y-Axis:	Temperature (C)

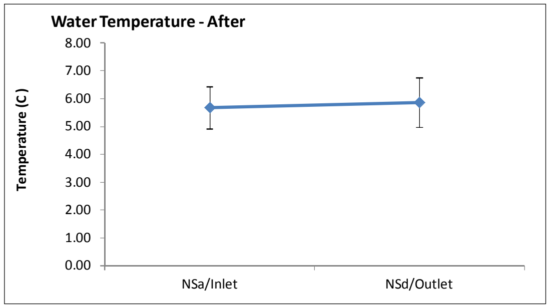
Paste your data here

Change the group names if you wish

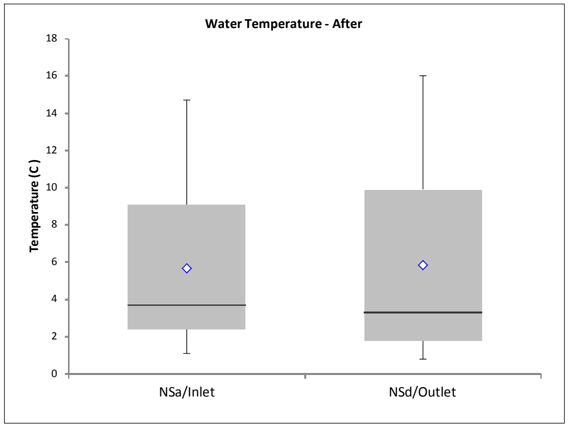
Samples must have the same size

NSa/Inlet	NSd/Outlet
2.80	2.50
2.60	1.70
2.70	2.00
2.70	2.00
2.40	1.80
2.50	2.10
1.10	0.80
1.10	0.80
1.80	2.20
4.00	4.10
6.10	6.30
8.30	9.30
10.00	11.70
12.80	14.50
14.70	16.00
13.20	14.30
13.20	14.60
13.60	16.00
12.20	14.00
11.20	11.90
8.80	8.70
7.80	7.40
6.40	6.10
4.10	3.20
3.90	3.40
2.70	1.70
2.70	2.00
2.00	1.60
1.20	1.60
1.40	0.80
2.10	1.50
3.50	3.10
2.40	3.70
4.80	5.60

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	5.67	5.85
Median	3.70	3.30
Standard Deviation	4.41	5.17
Standard Error	0.76	0.89

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	13.295%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median > NSd/Outlet median
p-value:	22.982%

Cannot reject equality of medians

Return

Two correlated groups tests

Title:	Water Temperature - 2017
Y-Axis:	Temperature (C)

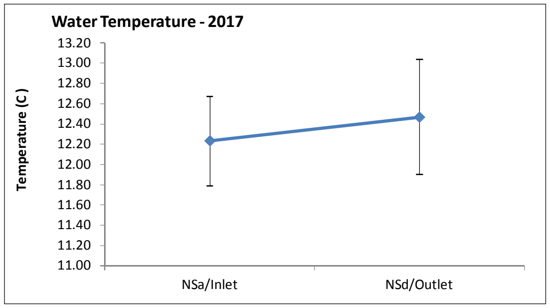
Paste your data here

Change the group names if you wish

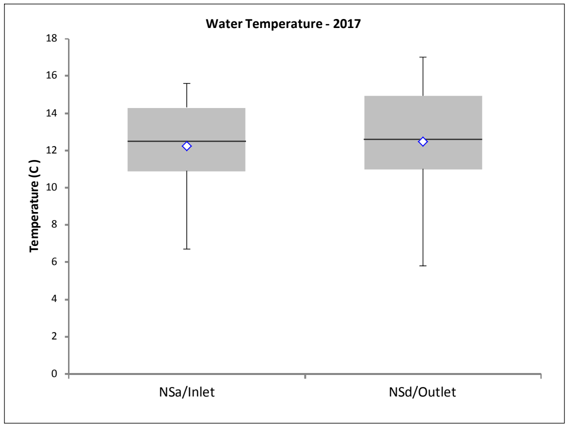
Samples must have the same size

NSa/Inlet	NSd/Outlet
15.50	11.30
10.60	10.40
9.99	9.60
9.30	9.50
9.00	13.40
13.00	13.50
13.00	12.80
12.60	13.50
12.50	15.00
14.40	14.90
14.30	17.00
14.20	16.00
14.30	16.00
14.80	16.30
14.80	13.70
13.40	14.50
13.40	16.50
15.60	16.50
15.20	12.60
12.00	12.30
12.00	11.60
11.80	11.50
11.60	11.20
10.90	10.90
10.90	11.20
11.10	11.10
11.00	5.90
6.80	5.80
6.70	7.10

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	12.23	12.47
Median	12.50	12.60
Standard Deviation	2.38	3.06
Standard Error	0.44	0.57

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	25.770%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	12.815%

Cannot reject equality of medians

Return

Two correlated groups tests

Title:	Growing Season Temperature - Before
Y-Axis:	Temperature (C)

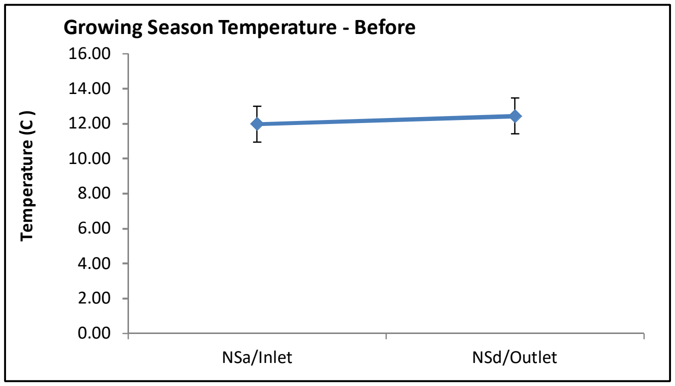
Paste your data here

Change the group names if you wish

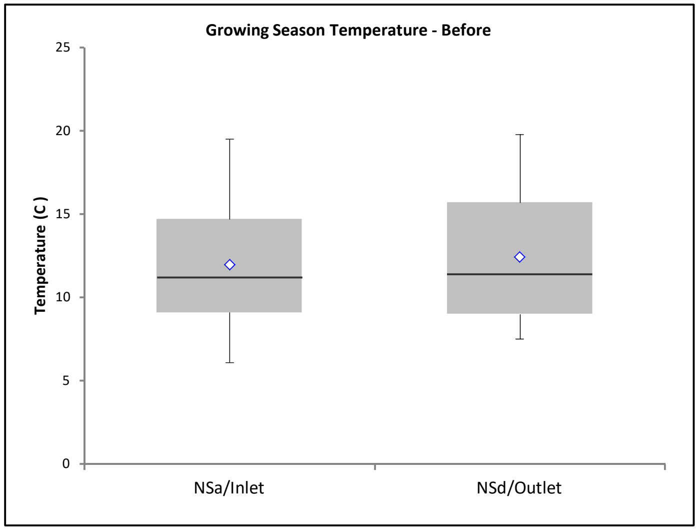
Samples must have the same size

NSa/Inlet	NSd/Outlet
19.50	19.80
9.10	8.80
6.10	7.50
8.90	10.10
16.20	16.30
15.30	14.50
12.00	12.40
14.10	15.70
14.00	15.70
10.90	11.40
11.20	11.40
9.10	9.00
9.20	9.00

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	11.97	12.43
Median	11.20	11.40
Standard Deviation	3.70	3.69
Standard Error	1.03	1.02

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**2.789%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**2.843%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Growing Season Temperature - After
Y-Axis:	Temperature (C)

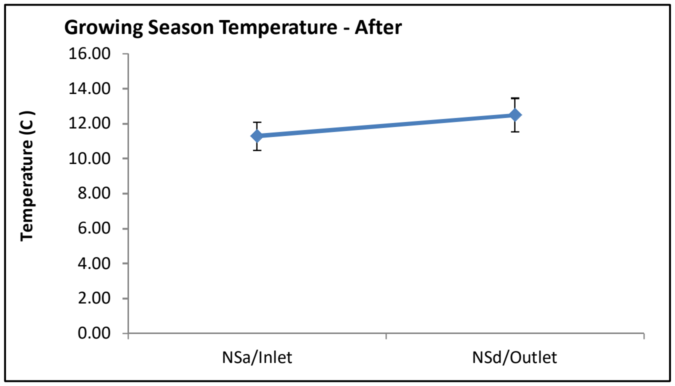
Paste your data here

Change the group names if you wish

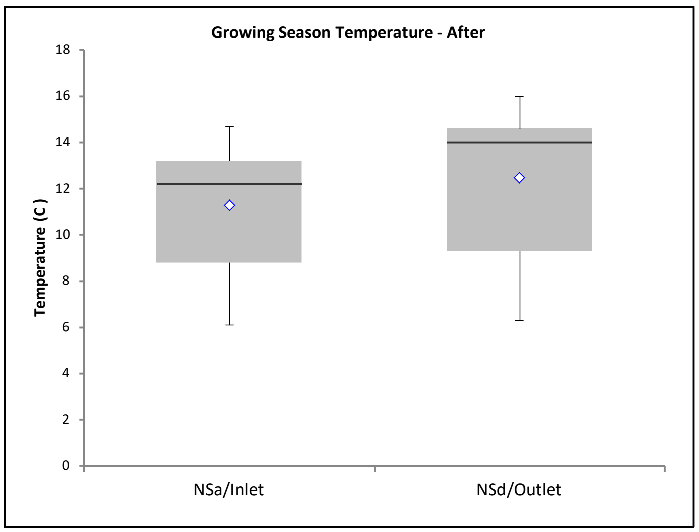
Samples must have the same size

NSa/Inlet	NSd/Outlet
6.10	6.30
8.30	9.30
10.00	11.70
12.80	14.50
14.70	16.00
13.20	14.30
13.20	14.60
13.60	16.00
12.20	14.00
11.20	11.90
8.80	8.70

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	11.28	12.48
Median	12.20	14.00
Standard Deviation	2.67	3.20
Standard Error	0.80	0.97

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	**0.014%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**0.100%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Growing Season Temperature - 2017
Y-Axis:	Temperature (C)

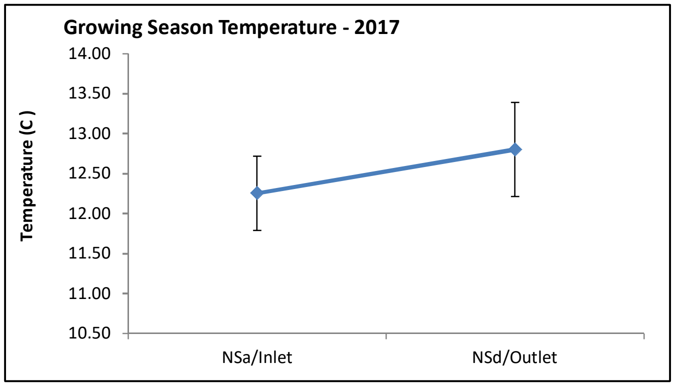
Paste your data here

Change the group names if you wish

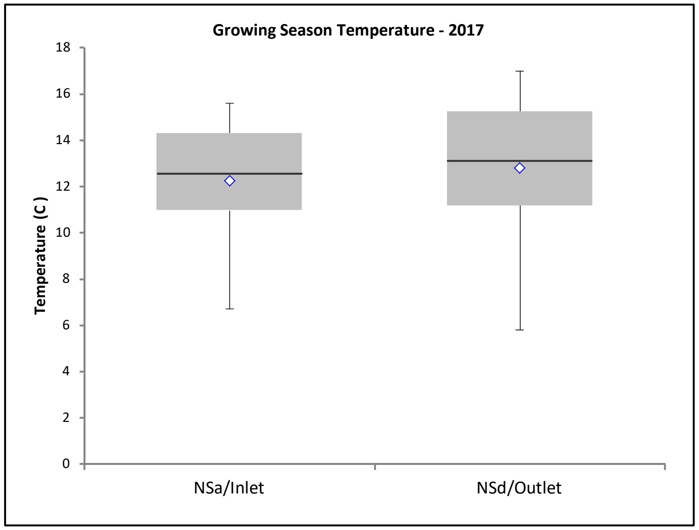
Samples must have the same size

NSa/Inlet	NSd/Outlet
9.30	9.60
9.00	9.50
13.00	13.40
13.00	13.50
12.60	12.80
12.50	13.50
14.40	15.00
14.30	14.90
14.20	17.00
14.30	16.00
14.80	16.00
14.80	16.30
13.40	13.70
13.40	14.50
15.60	16.50
15.20	16.50
12.00	12.60
12.00	12.30
11.80	11.60
11.60	11.50
10.90	11.20
10.90	10.90
11.10	11.20
11.00	11.10
6.80	5.90
6.70	5.80

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	12.25	12.80
Median	12.55	13.10
Standard Deviation	2.37	3.00
Standard Error	0.47	0.59

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	**0.074%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**0.050%**

Reject equality of medians

Return

Two correlated groups tests

Title:	pH - Before
Y-Axis:	

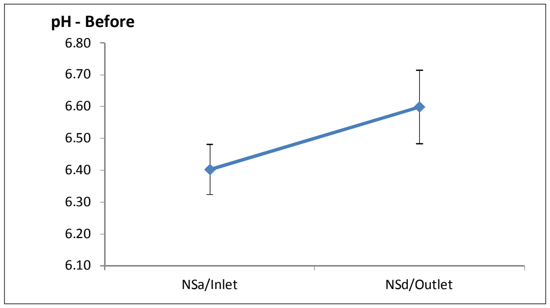
Paste your data here

Change the group names if you wish

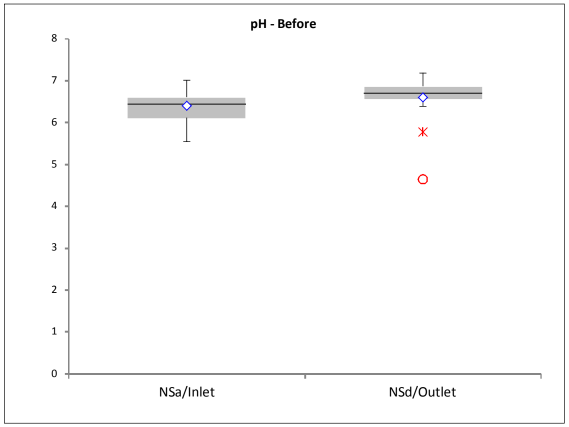
Samples must have the same size

NSa/Inlet	NSd/Outlet
6.56	6.39
6.34	6.79
5.54	4.65
6.17	5.78
5.90	6.70
6.37	6.59
6.60	6.87
5.99	6.85
7.01	6.92
6.06	7.18
6.01	7.10
6.52	6.56
6.60	6.52
6.44	6.59
6.91	6.91
6.84	6.61
6.79	6.77
6.51	6.63
6.56	6.59
6.36	6.80
6.38	6.78

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	6.40	6.60
Median	6.44	6.70
Standard Deviation	0.36	0.53
Standard Error	0.08	0.12

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average < NSd/Outlet average
p-value:	**4.028%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**4.047%**

Reject equality of medians

Return

Two correlated groups tests

Title:	pH - After
Y-Axis:	

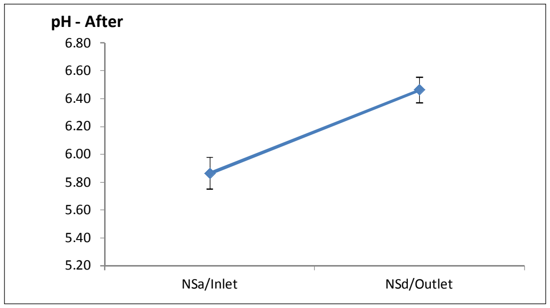
Paste your data here

Change the group names if you wish

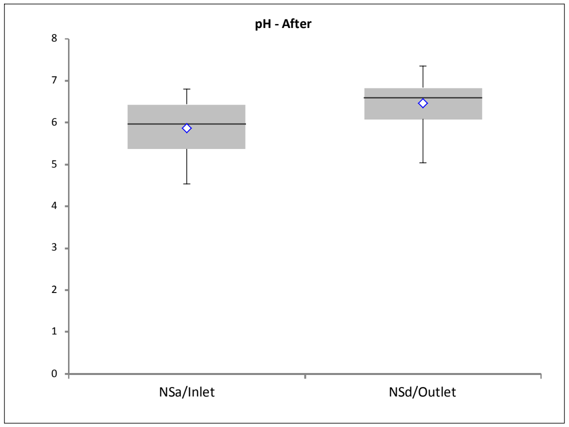
Samples must have the same size

NSa/Inlet	NSd/Outlet
6.42	6.30
6.37	6.44
5.44	5.74
6.74	6.94
6.45	6.03
5.41	6.70
6.02	7.35
5.22	7.12
5.83	6.06
5.85	6.01
6.31	6.42
6.31	6.59
6.67	6.74
6.45	6.84
6.80	6.83
5.96	6.59
6.50	6.76
6.31	6.75
5.97	6.15
5.78	6.47
6.35	6.28
5.43	5.70
5.10	5.46
5.61	6.11
4.96	5.04
4.90	5.91
6.65	6.65
5.33	6.92
4.53	6.53
6.56	6.70
4.75	7.15
4.87	7.03
5.68	6.94

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	5.86	6.46
Median	5.96	6.59
Standard Deviation	0.65	0.52
Standard Error	0.11	0.09

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	0.002%

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	0.001%

Reject equality of medians

Return

Two correlated groups tests

Title:	pH - 2017
Y-Axis:	

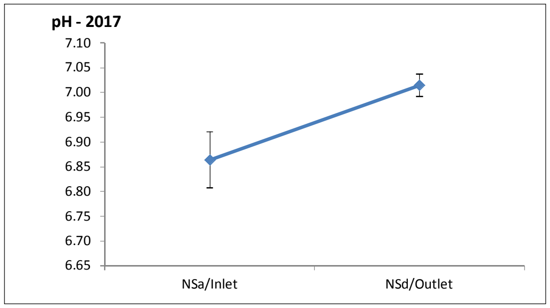
Paste your data here

Change the group names if you wish

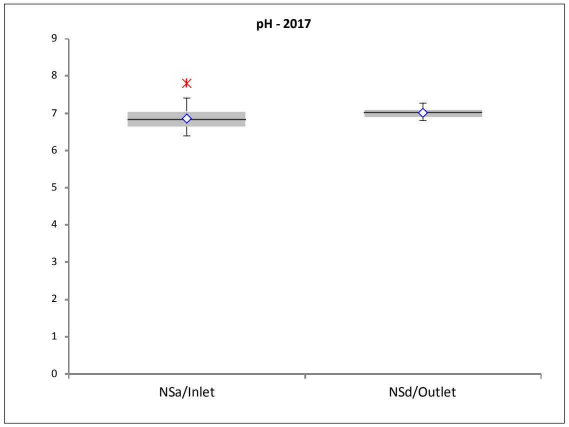
Samples must have the same size

NSa/Inlet	NSd/Outlet
6.85	7.00
6.91	7.05
6.74	7.05
6.93	7.22
7.14	7.08
7.16	7.07
6.74	7.10
6.80	7.08
6.61	6.95
6.74	6.94
6.99	7.23
7.02	7.27
6.69	7.16
6.89	7.12
6.43	7.00
6.66	7.00
6.48	6.80
6.56	6.86
6.39	6.92
6.52	6.86
6.57	6.86
6.73	6.86
6.74	6.85
7.80	6.88
6.97	6.98
6.91	6.91
7.41	7.15
7.16	7.06
7.21	7.10
7.17	7.03

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	6.86	7.01
Median	6.83	7.02
Standard Deviation	0.31	0.13
Standard Error	0.06	0.02

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	0.385%

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	0.060%

Reject equality of medians

Return

Two correlated groups tests

Title:	Growing Season pH - Before
Y-Axis:	pH

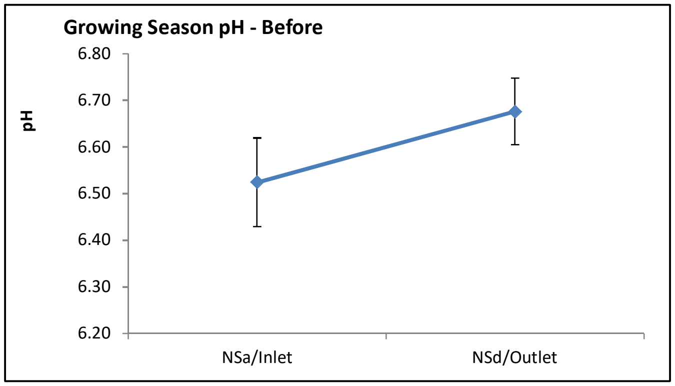
Paste your data here

Change the group names if you wish

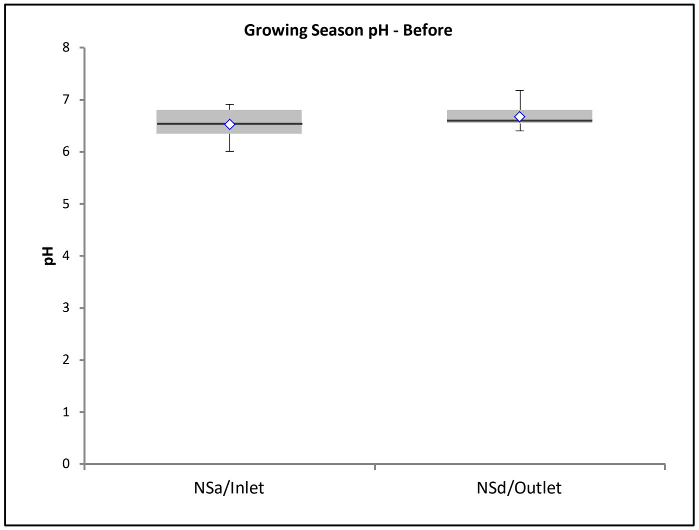
Samples must have the same size

NSa/Inlet	NSd/Outlet
6.06	7.18
6.01	6.40
6.52	6.56
6.60	6.52
6.44	6.59
6.91	6.91
6.84	6.61
6.79	6.77
6.51	6.63
6.56	6.59

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	6.52	6.68
Median	6.54	6.60
Standard Deviation	0.30	0.22
Standard Error	0.10	0.07

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	11.673%

Cannot reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	12.500%

Cannot reject equality of medians

Return

Two correlated groups tests

Title:	Growing Season pH - After
Y-Axis:	pH

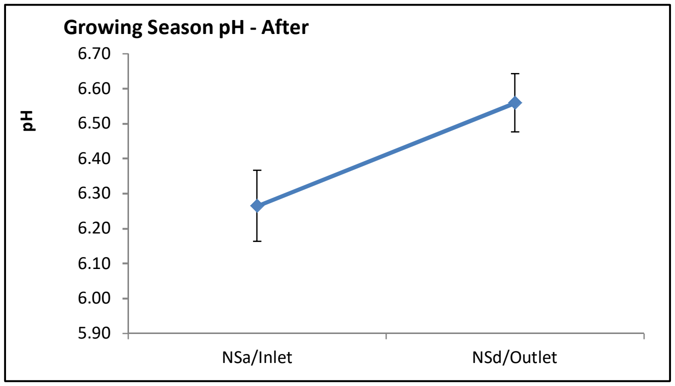
Paste your data here

Change the group names if you wish

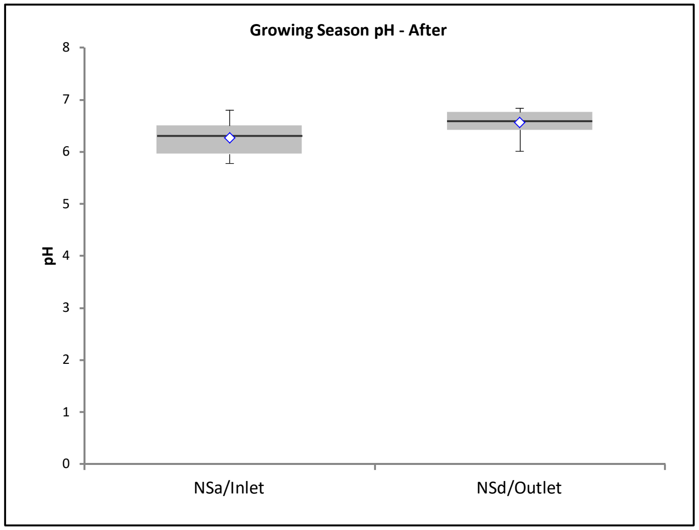
Samples must have the same size

NSa/Inlet	NSd/Outlet
5.85	6.01
6.31	6.42
6.31	6.59
6.67	6.74
6.45	6.84
6.80	6.83
5.96	6.59
6.50	6.76
6.31	6.75
5.97	6.15
5.78	6.47

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	6.26	6.56
Median	6.31	6.59
Standard Deviation	0.34	0.28
Standard Error	0.10	0.08

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**0.064%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**0.000%**

Reject equality of medians

Return

Two correlated groups tests

Title:	Growing Season pH - 2017
Y-Axis:	pH

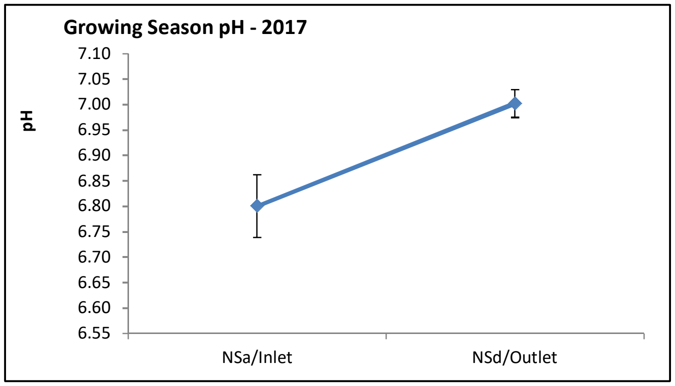
Paste your data here

Change the group names if you wish

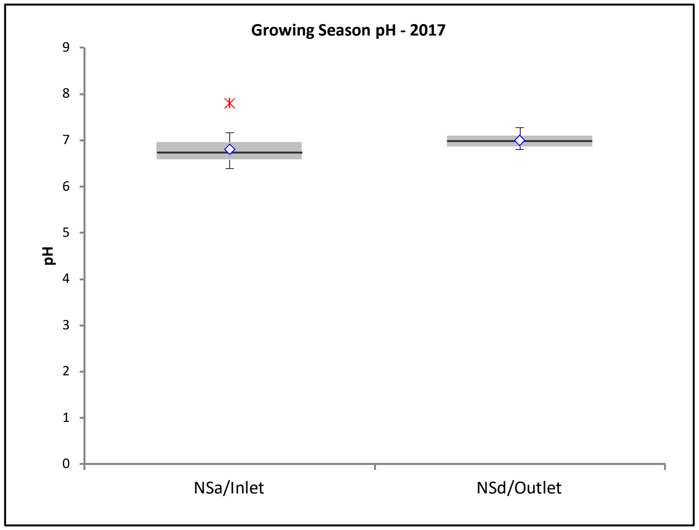
Samples must have the same size

NSa/Inlet	NSd/Outlet
6.74	7.05
6.93	7.22
7.14	7.08
7.16	7.07
6.74	7.10
6.80	7.08
6.61	6.95
6.74	6.94
6.99	7.23
7.02	7.27
6.69	7.16
6.89	7.12
6.43	7.00
6.66	7.00
6.48	6.80
6.56	6.86
6.39	6.92
6.52	6.86
6.57	6.86
6.73	6.86
6.74	6.85
7.80	6.88
6.97	6.98
6.91	6.91

Average and standard error bar chart:



Boxplot:



Descriptive	NSa/Inlet	NSd/Outlet
Mean	6.80	7.00
Median	6.74	6.99
Standard Deviation	0.30	0.14
Standard Error	0.06	0.03

Paired T-Student Test	
H0:	NSa/Inlet average= NSd/Outlet average
HA:	NSa/Inlet average > NSd/Outlet average
p-value:	**0.128%**

Reject equality of means

Wilcoxon Signed Rank Test	
H0:	NSa/Inlet median= NSd/Outlet median
HA:	NSa/Inlet median < NSd/Outlet median
p-value:	**0.042%**

Reject equality of medians

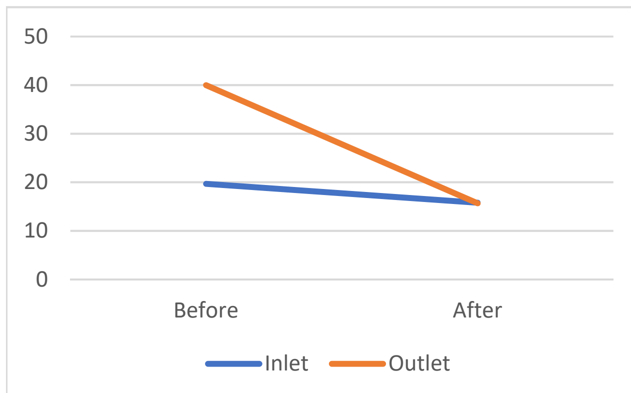
Appendix F. Before-After-Control-Impact (BACI) Analysis using Mann-Whitney Tests

F.1. Turbidity

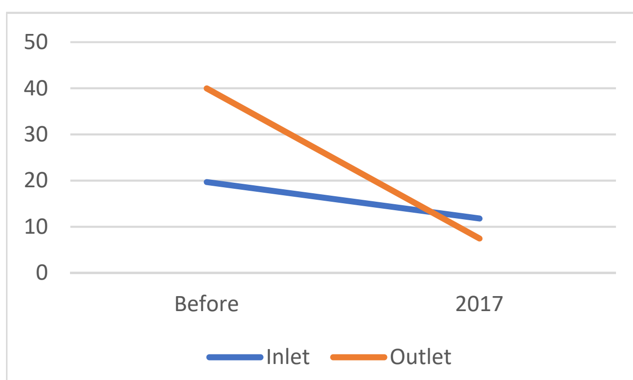
Table F.1 Calculation of the difference in turbidity for use in the Mann-Whitney Test

Date	Timing	Outlet Turb (NTU)	Inlet Turb (NTU)	Difference Turb (NTU)
4/14/2017	2017	2.78	2.22	0.56
4/14/2017	2017	2.85	2.13	0.72
4/28/2017	2017	4.13	3.99	0.14
4/28/2017	2017	4.16	4.08	0.08
5/12/2017	2017	5.46	3.53	1.93
5/12/2017	2017	5.30	3.37	1.93
5/26/2017	2017	10.20	4.49	5.71
5/26/2017	2017	9.95	4.45	5.50
6/9/2017	2017	10.90	3.34	7.56
6/9/2017	2017	11.00	3.25	7.75
6/23/2017	2017	7.04	2.80	4.24
6/23/2017	2017	7.30	2.80	4.50
7/7/2017	2017	4.44	3.31	1.13
7/7/2017	2017	7.75	3.37	4.38
7/21/2017	2017	7.09	3.47	3.62
7/21/2017	2017	6.90	3.30	3.60
08/05/17	2017	8.63	3.02	5.61
08/05/17	2017	8.10	3.00	5.10
08/19/17	2017	18.10	9.45	8.65
08/19/17	2017	17.90	9.43	8.47
9/1/2017	2017	22.30	17.70	4.60
9/1/2017	2017	22.40	17.90	4.50
9/29/2017	2017	20.30	14.50	5.80
9/29/2017	2017	20.00	14.80	5.20
10/13/2017	2017	18.20	9.10	9.10
10/13/2017	2017	19.50	9.91	9.59
10/27/2017	2017	23.80	22.90	0.90
10/27/2017	2017	23.80	23.70	0.10
11/12/2006	After	22.50	20.30	2.20
12/10/2006	After	21.80	23.90	-2.10
12/24/2006	After	19.70	19.90	-0.20

BACI Plots – mean turbidity at the control (Inlet, NSa) site and the impact (Outlet, NSd) site before and after implementation of the Nancy Street wetland. Parallel lines indicate that there is no mean difference in the downstream change in turbidity before and after the creation of the wetland (i.e. no effect).



Mean Turbidity		Before	After
	Inlet	19.68	15.80
	Outlet	39.99	15.67



Mean Turbidity		Before	2017
	Inlet	19.68	11.79
	Outlet	39.99	7.4

Table F.1 Calculation of the difference in turbidity for use in the Mann-Whitney Test				
1/20/2007	After	25.70	26.20	-0.50
2/4/2007	After	12.10	17.50	-5.40
2/18/2007	After	19.30	22.90	-3.60
3/4/2007	After	17.60	18.90	-1.30
3/20/2007	After	26.60	12.00	14.60
4/1/2007	After	23.60	14.90	8.70
4/15/2007	After	17.50	18.60	-1.10
4/29/2007	After	14.70	15.10	-0.40
5/12/2007	After	14.80	13.30	1.50
5/27/2007	After	12.80	13.00	-0.20
6/9/2007	After	9.43	10.70	-1.27
7/8/2007	After	10.00	6.98	3.02
7/23/2007	After	9.85	9.59	0.26
8/6/2007	After	7.49	7.78	-0.29
8/20/2007	After	11.70	11.40	0.30
9/2/2007	After	12.90	9.99	2.91
9/15/2007	After	25.20	14.60	10.60
9/29/2007	After	15.00	17.00	-2.00
10/13/2007	After	16.70	17.10	-0.40
10/30/2007	After	17.20	19.80	-2.60
11/11/2007	After	18.10	21.80	-3.70
11/27/2007	After	21.60	19.60	2.00
12/11/2007	After	8.00	12.60	-4.60
12/26/2007	After	20.20	21.20	-1.00
1/7/2008	After	13.20	14.80	-1.60
1/21/2008	After	14.20	16.20	-2.00
2/2/2008	After	7.40	12.50	-5.10
2/16/2008	After	14.60	14.20	0.40
3/4/2008	After	16.40	16.20	0.20
3/14/2008	After	10.70	13.60	-2.90
3/29/2008	After	8.70	8.80	-0.10
8/10/2005	Before	6.15	4.56	1.59
12/10/2005	Before	24.10	27.60	-3.50
12/26/2005	Before	22.80	36.60	-13.80
1/14/2006	Before	31.60	33.60	-2.00
2/11/2006	Before	35.80	42.90	-7.10
3/28/2006	Before	29.00	18.80	10.20
4/8/2006	Before	13.70	32.90	-19.20
4/27/2006	Before	22.30	96.30	-74.00
5/14/2006	Before	18.40	26.90	-8.50

Table F.1 Calculation of the difference in turbidity for use in the Mann-Whitney Test				
5/27/2006	Before	10.50	14.40	-3.90
6/10/2006	Before	9.42	14.20	-4.78
6/24/2006	Before	6.88	13.40	-6.52
7/8/2006	Before	9.74	5.62	4.12
7/21/2006	Before	5.44	8.81	-3.37
8/19/2006	Before	21.50	24.60	-3.10
9/3/2006	Before	30.90	36.80	-5.90
9/17/2006	Before	29.30	36.10	-6.80
10/2/2006	Before	24.20	28.80	-4.60
10/15/2006	Before	18.40	25.70	-7.30
10/29/2006	Before	22.40	30.50	-8.10

Return

Two independent groups tests

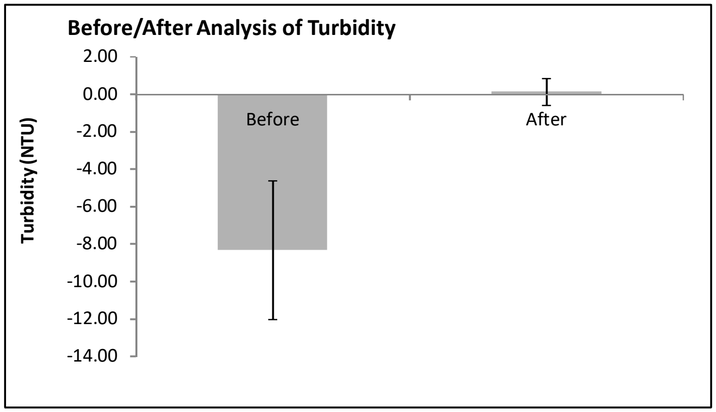
Title:	Before/After Analysis of Turbidity
Y-Axis:	Turbidity (NTU)

Paste your data here ↓

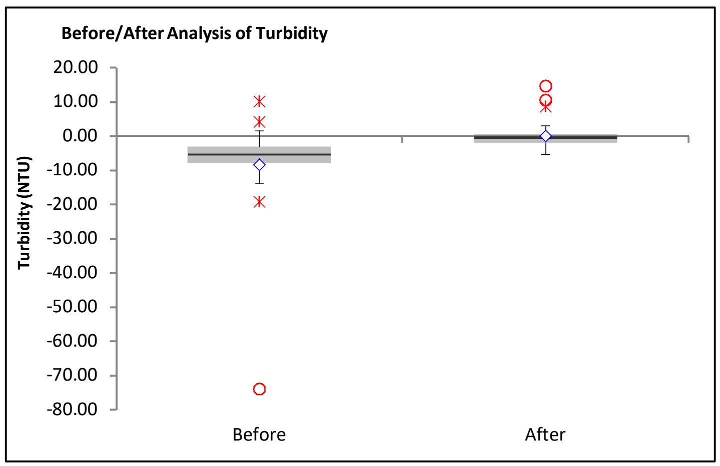
Change the group names if you wish

Before	After
1.59	2.20
-3.50	-2.10
-13.80	-0.20
-2.00	-0.50
-7.10	-5.40
10.20	-3.60
-19.20	-1.30
-74.00	14.60
-8.50	8.70
-3.90	-1.10
-4.78	-0.40
-6.52	1.50
4.12	-0.20
-3.37	-1.27
-3.10	3.02
-5.90	0.26
-6.80	-0.29
-4.60	0.30
-7.30	2.91
-8.10	10.60
	-2.00
	-0.40
	-2.60
	-3.70
	2.00
	-4.60
	-1.00
	-1.60
	-2.00
	-5.10
	0.40
	0.20
	-2.90
	-0.10

Average and standard error bar chart:



Boxplot:



Descriptive	Before	After
n	20	34
Mean	-8.33	0.13
Median	-5.34	-0.40
Standard Deviation	16.60	4.15
Standard Error	3.71	0.71

F-Test - Variance	
H0:	Before variance= After variance
HA:	Before variance < After variance
p-value:	**0.000%**

Reject equality of variances - Use Heteroscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**0.321%**

Reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**1.827%**

Reject equality of means

Mann-Whitney Test	
H0:	Before median = After median
HA:	Before median < After median
p-value:	**0.007%**

Reject equality of medians

Return

Two independent groups tests

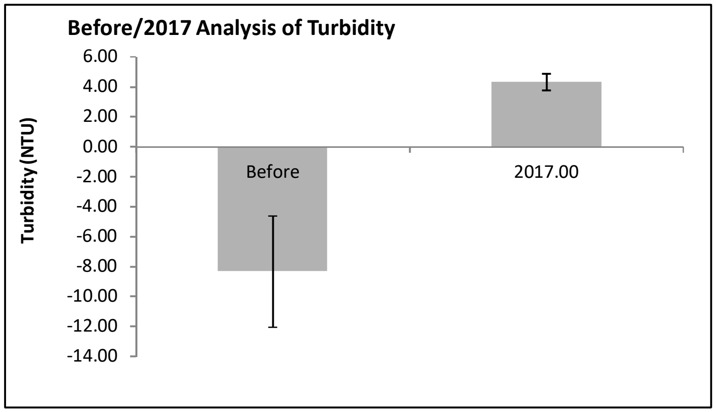
Title:	Before/2017 Analysis of Turbidity
Y-Axis:	Turbidity (NTU)

Paste your data here

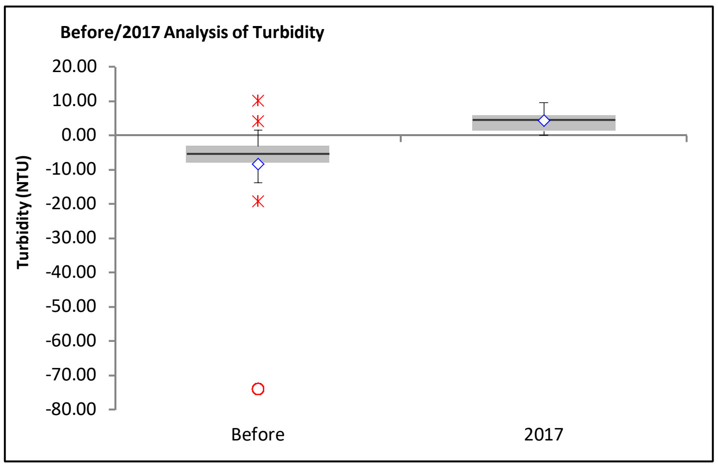
Change the group names if you wish

Before	2017
1.59	0.56
-3.50	0.72
-13.80	0.14
-2.00	0.08
-7.10	1.93
10.20	1.93
-19.20	5.71
-74.00	5.50
-8.50	7.56
-3.90	7.75
-4.78	4.24
-6.52	4.50
4.12	1.13
-3.37	4.38
-3.10	3.62
-5.90	3.60
-6.80	5.61
-4.60	5.10
-7.30	8.65
-8.10	8.47
	4.60
	4.50
	5.80
	5.20
	9.10
	9.59
	0.90
	0.10

Average and standard error bar chart:



Boxplot:



Descriptive	Before	2017.00
n	20	28
Mean	-8.33	4.32
Median	-5.34	4.50
Standard Deviation	16.60	2.93
Standard Error	3.71	0.55

F-Test - Variance	
H0:	Before variance= 2017 variance
HA:	Before variance < 2017 variance
p-value:	**0.000%**

Reject equality of variances - Use Heteroscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	**0.013%**

Reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	**0.153%**

Reject equality of means

Mann-Whitney Test	
H0:	Before median = 2017 median
HA:	Before median < 2017 median
p-value:	**0.000%**

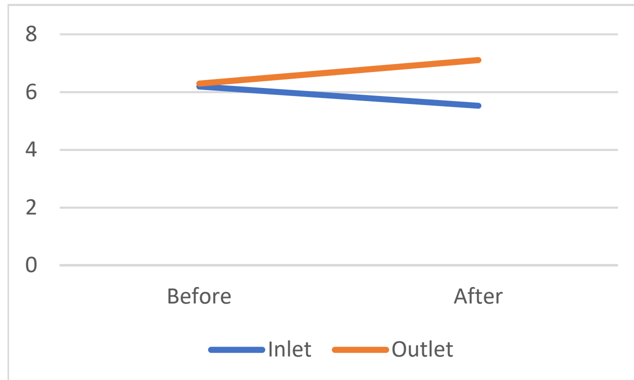
Reject equality of medians

F.2. Dissolved Oxygen (using all data)

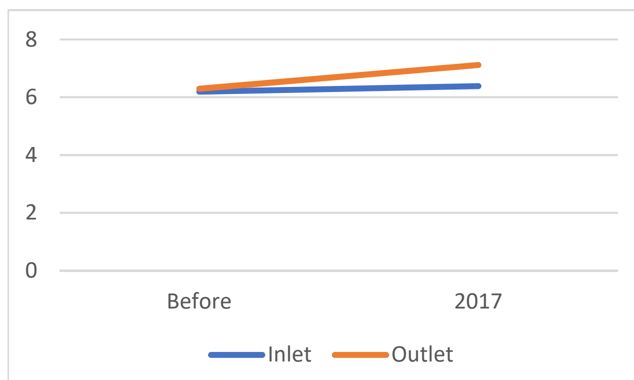
Table F.2 Calculation of the difference in D.O. for use in the Mann-Whitney Test

Date	Timing	Outlet DO (mg/L)	Inlet DO (mg/L)	Difference
4/14/2017	2017	9.15	10.26	-1.11
4/14/2017	2017	9.50	8.71	0.79
4/14/2017	2017	9.63	7.04	2.59
4/28/2017	2017	9.55	9.30	0.25
4/28/2017	2017	7.33	9.36	-2.03
5/12/2017	2017	7.60	8.17	-0.57
5/12/2017	2017	6.98	8.17	-1.19
5/26/2017	2017	7.26	6.83	0.43
5/26/2017	2017	6.98	6.79	0.19
6/9/2017	2017	6.95	4.98	1.97
6/9/2017	2017	9.36	4.91	4.45
6/23/2017	2017	8.55	6.61	1.94
6/23/2017	2017	8.15	6.62	1.53
7/7/2017	2017	8.88	6.16	2.72
7/21/2017	2017	6.11	5.65	0.46
7/21/2017	2017	8.00	5.48	2.52
08/05/17	2017	5.59	4.26	1.33
08/05/17	2017	5.79	4.26	1.53
08/19/17	2017	7.11	6.15	0.96
08/19/17	2017	6.42	6.12	0.30
9/1/2017	2017	5.59	6.00	-0.41
9/1/2017	2017	5.49	5.95	-0.46
9/15/2017	2017	6.85	4.69	2.16
9/15/2017	2017	4.81	4.74	0.07
9/29/2017	2017	5.06	4.80	0.26
9/29/2017	2017	4.89	4.76	0.13
10/13/2017	2017	5.21	4.24	0.97
10/13/2017	2017	5.16	4.14	1.02
10/27/2017	2017	8.40	8.20	0.20
1/20/2007	After	9.07	7.43	1.64
2/4/2007	After	5.52	5.39	0.13
2/18/2007	After	5.21	4.62	0.59
3/4/2007	After	4.68	2.46	2.22
3/20/2007	After	5.25	2.61	2.64
4/1/2007	After	6.15	4.68	1.47

BACI Plots – mean dissolved oxygen (D.O.) at the control (Inlet, NSa) site and the impact (Outlet, NSd) site before and after implementation of the Nancy Street wetland. Parallel lines indicate that there is no mean difference in the downstream change in D.O. before and after the creation of the wetland (i.e. no effect).



Mean D.O.	Before	After
Inlet	6.19	5.53
Outlet	6.29	7.11



Mean D.O.	Before	2017
Inlet	6.19	6.38
Outlet	6.29	7.12

Table F.2 Calculation of the difference in D.O. for use in the Mann-Whitney Test				
4/15/2007	After	9.74	10.70	-0.96
4/29/2007	After	9.44	7.35	2.09
5/12/2007	After	8.60	6.94	1.66
5/27/2007	After	10.37	8.31	2.06
6/9/2007	After	8.75	7.37	1.38
7/8/2007	After	9.48	5.63	3.85
7/23/2007	After	7.03	5.40	1.63
8/6/2007	After	8.06	6.03	2.03
8/20/2007	After	9.35	8.23	1.12
9/2/2007	After	7.95	5.13	2.82
9/15/2007	After	8.10	3.60	4.50
9/29/2007	After	6.18	4.33	1.85
10/13/2007	After	7.30	5.38	1.92
10/30/2007	After	7.50	6.25	1.25
11/11/2007	After	7.60	5.22	2.38
11/27/2007	After	8.95	6.52	2.43
12/11/2007	After	4.59	4.24	0.35
12/26/2007	After	4.63	4.03	0.60
1/7/2008	After	3.85	2.60	1.25
1/21/2008	After	7.16	6.25	0.91
2/2/2008	After	4.04	3.20	0.84
2/16/2008	After	5.82	4.84	0.98
3/4/2008	After	8.30	7.25	1.05
3/14/2008	After	9.02	7.45	1.57
3/29/2008	After	11.58	9.65	1.93
11/12/2006	After	3.73	2.66	1.07
12/10/2006	After	3.33	2.92	0.41
12/24/2006	After	5.32	3.23	2.09
8/10/2005	Before	8.30	7.68	0.62
10/9/2005	Before	2.70	4.33	-1.63
10/22/2005	Before	5.93	6.40	-0.47
11/6/2005	Before	6.57	6.36	0.21
11/26/2005	Before	7.51	7.89	-0.38
12/10/2005	Before	7.90	7.97	-0.07
12/26/2005	Before	7.57	7.00	0.57
1/14/2006	Before	7.08	5.28	1.80
2/11/2006	Before	4.75	3.84	0.91
3/28/2006	Before	5.27	6.55	-1.28
4/8/2006	Before	2.77	7.82	-5.05

Table F.2 Calculation of the difference in D.O. for use in the Mann-Whitney Test				
4/27/2006	Before	4.84	6.20	-1.36
5/14/2006	Before	8.70	8.13	0.57
5/27/2006	Before	7.92	5.35	2.57
6/10/2006	Before	6.97	6.95	0.02
6/24/2006	Before	8.54	8.12	0.42
7/8/2006	Before	7.45	6.45	1.00
7/21/2006	Before	8.87	6.98	1.89
8/19/2006	Before	6.43	5.55	0.88
9/3/2006	Before	5.70	5.50	0.20
9/17/2006	Before	6.82	3.65	3.17
10/2/2006	Before	5.03	4.43	0.60
10/15/2006	Before	5.40	4.62	0.78
10/29/2006	Before	7.09	5.53	1.56

Return

Two independent groups tests

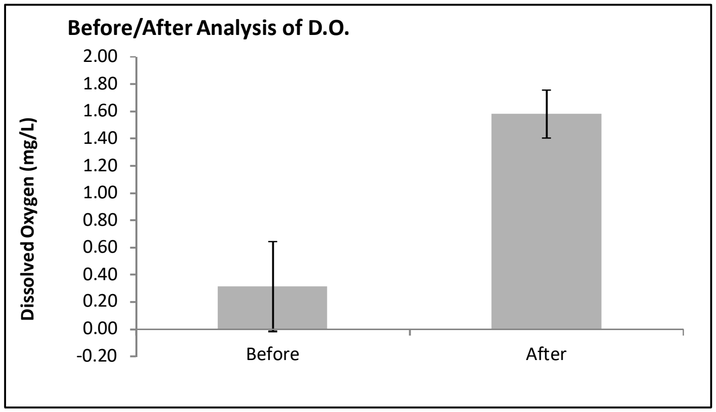
Title:	Before/After Analysis of D.O.
Y-Axis:	Dissolved Oxygen (mg/L)

Paste your data here

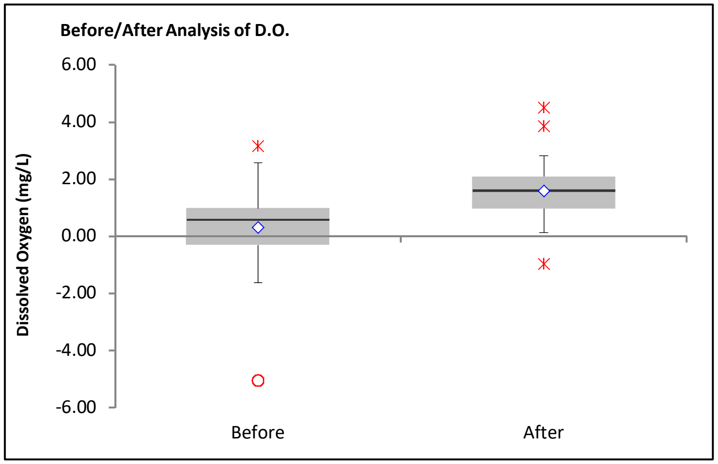
Change the group names if you wish

Before	After
0.62	1.64
-1.63	0.13
-0.47	0.59
0.21	2.22
-0.38	2.64
-0.07	1.47
0.57	-0.96
1.80	2.09
0.91	1.66
-1.28	2.06
-5.05	1.38
-1.36	3.85
0.57	1.63
2.57	2.03
0.02	1.12
0.42	2.82
1.00	4.50
1.89	1.85
0.88	1.92
0.20	1.25
3.17	2.38
0.60	2.43
0.78	0.35
1.56	0.60
	1.25
	0.91
	0.84
	0.98
	1.05
	1.57
	1.93
	1.07
	0.41
	2.09

Average and standard error bar chart:



Boxplot:



Descriptive	Before	After
n	24	34
Mean	0.31	1.58
Median	0.57	1.60
Standard Deviation	1.62	1.03
Standard Error	0.33	0.18

F-Test - Variance	
H0:	Before variance= After variance
HA:	Before variance < After variance
p-value:	**0.875%**

Reject equality of variances - Use Heteroscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**0.030%**

Reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**0.089%**

Reject equality of means

Mann-Whitney Test	
H0:	Before median = After median
HA:	Before median < After median
p-value:	**0.033%**

Reject equality of medians

Return

Two independent groups tests

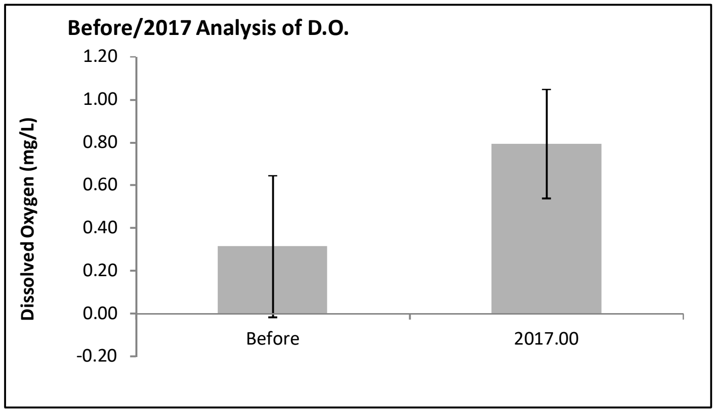
Title:	Before/2017 Analysis of D.O.
Y-Axis:	Dissolved Oxygen (mg/L)

Paste your data here

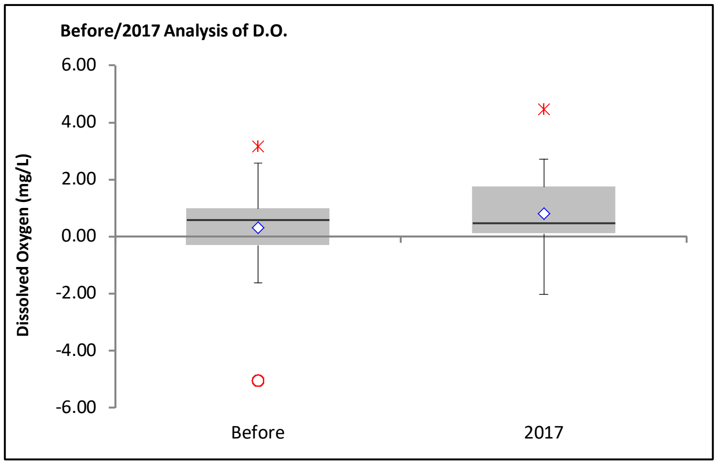
Change the group names if you wish

Before	2017
0.62	-1.11
-1.63	0.79
-0.47	2.59
0.21	0.25
-0.38	-2.03
-0.07	-0.57
0.57	-1.19
1.80	0.43
0.91	0.19
-1.28	1.97
-5.05	4.45
-1.36	1.94
0.57	1.53
2.57	2.72
0.02	0.46
0.42	2.52
1.00	1.33
1.89	1.53
0.88	0.96
0.20	0.30
3.17	-0.41
0.60	-0.46
0.78	2.16
1.56	0.07
	0.26
	0.13
	0.97
	1.02
	0.20

Average and standard error bar chart:



Boxplot:



Descriptive	Before	2017.00
n	24	29
Mean	0.31	0.79
Median	0.57	0.46
Standard Deviation	1.62	1.37
Standard Error	0.33	0.25

F-Test - Variance	
H0:	Before variance= 2017 variance
HA:	Before variance < 2017 variance
p-value:	19.626%

Cannot reject equality of variances - Use Homoscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	12.423%

Cannot reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	12.834%

Cannot reject equality of means

Mann-Whitney Test	
H0:	Before median = 2017 median
HA:	Before median > 2017 median
p-value:	19.324%

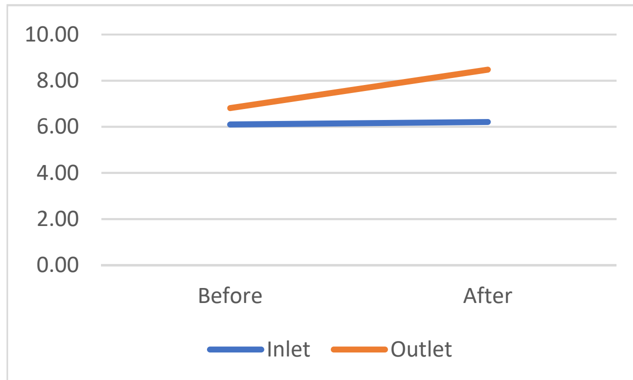
Cannot reject equality of medians

F.3. Dissolved Oxygen (using growing season data)

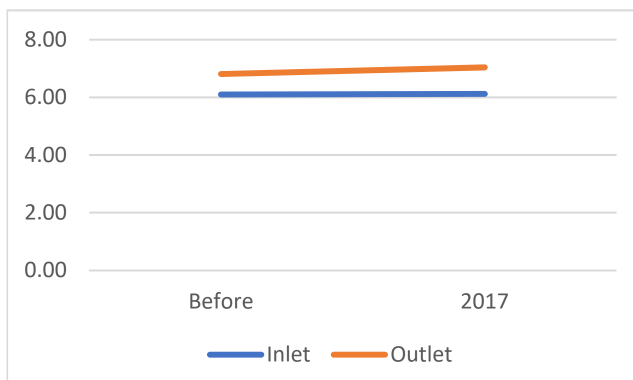
Table F.3 Calculation of the difference in growing season D.O. for use in the Mann-Whitney Test

Date	Timing	Outlet DO (mg/L)	Inlet DO (mg/L)	Difference
10/9/2005	Before	2.70	4.33	-1.63
10/9/2005	Before	2.88	4.33	-1.45
4/27/2006	Before	4.84	6.20	-1.36
5/14/2006	Before	8.70	8.13	0.57
5/27/2006	Before	7.92	5.35	2.57
6/10/2006	Before	6.97	6.95	0.02
6/24/2006	Before	8.54	8.12	0.42
7/8/2006	Before	7.45	6.45	1.00
7/21/2006	Before	8.87	6.98	1.89
8/19/2006	Before	6.43	5.55	0.88
9/3/2006	Before	5.70	5.50	0.20
9/17/2006	Before	6.82	3.65	3.17
10/2/2006	Before	5.03	4.43	0.60
4/29/2007	After	9.44	7.35	2.09
5/27/2007	After	10.37	8.31	2.06
6/9/2007	After	8.75	7.37	1.38
7/8/2007	After	9.48	5.63	3.85
7/23/2007	After	7.03	5.40	1.63
8/6/2007	After	8.06	6.03	2.03
8/20/2007	After	9.35	8.23	1.12
9/2/2007	After	7.95	5.13	2.82
9/15/2007	After	8.10	3.60	4.50
9/29/2007	After	6.18	4.33	1.85
4/14/2017	2017	9.15	10.26	-1.11
4/14/2017	2017	9.50	8.71	0.79
4/14/2017	2017	9.63	7.04	2.59
4/28/2017	2017	9.55	9.30	0.25
4/28/2017	2017	7.33	9.36	-2.03
5/12/2017	2017	7.60	8.17	-0.57
5/12/2017	2017	6.98	8.17	-1.19
5/26/2017	2017	7.26	6.83	0.43
5/26/2017	2017	6.98	6.79	0.19
6/9/2017	2017	6.95	4.98	1.97
6/9/2017	2017	9.36	4.91	4.45

BACI Plot – mean growing season dissolved oxygen (D.O.) at the control (Inlet, NSa) site and the impact (Outlet, NSd) site before and after implementation of the Nancy Street wetland. Parallel lines indicate that there is no mean difference in the downstream change in D.O. before and after the creation of the wetland (i.e. no effect).



Mean D.O.	Before	After
Inlet	6.10	6.21
Outlet	6.81	8.48



Mean D.O.	Before	2017
Inlet	6.19	6.12
Outlet	6.29	7.04

Table F.3 Calculation of the difference in growing season D.O. for use in the Mann-Whitney Test				
6/23/2017	2017	8.55	6.61	1.94
6/23/2017	2017	8.15	6.62	1.53
7/7/2017	2017	8.88	6.16	2.72
7/21/2017	2017	6.11	5.65	0.46
7/21/2017	2017	8.00	5.48	2.52
08/05/17	2017	5.59	4.26	1.33
08/05/17	2017	5.79	4.26	1.53
08/19/17	2017	7.11	6.15	0.96
08/19/17	2017	6.42	6.12	0.30
9/1/2017	2017	5.59	6.00	-0.41
9/1/2017	2017	5.49	5.95	-0.46
9/15/2017	2017	6.85	4.69	2.16
9/15/2017	2017	4.81	4.74	0.07
9/29/2017	2017	5.06	4.80	0.26
9/29/2017	2017	4.89	4.76	0.13
10/13/2017	2017	5.21	4.24	0.97
10/13/2017	2017	5.16	4.14	1.02
10/27/2017	2017	8.40	8.20	0.20

Return

Two independent groups tests

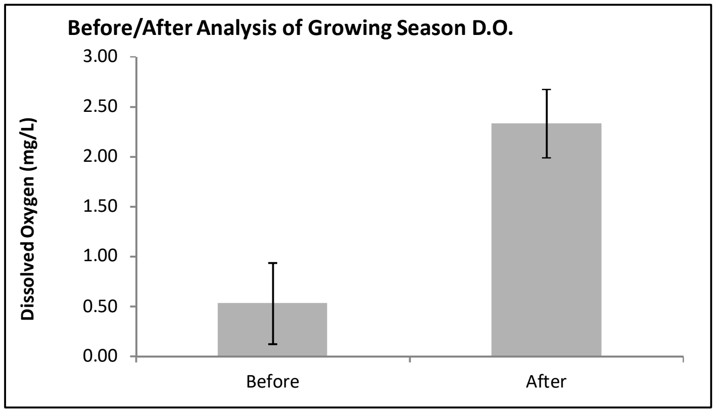
Title:	Before/After Analysis of Growing Season D.O
Y-Axis:	Dissolved Oxygen (mg/L)

Paste your data here ↓

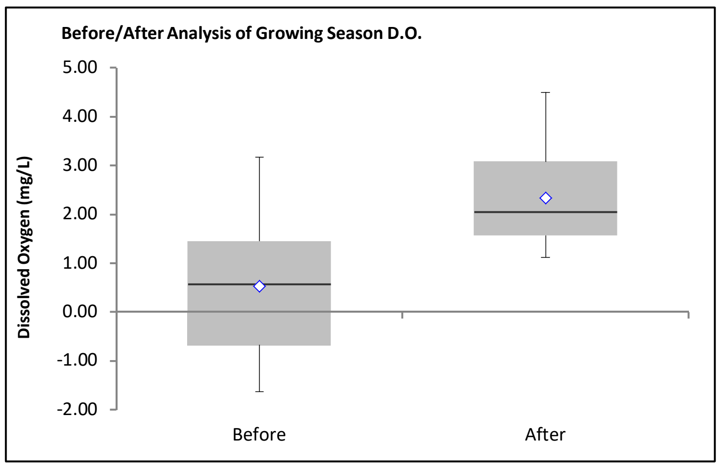
Change the group names if you wish

Before	**After**
-1.63	2.09
-1.45	2.06
-1.36	1.38
0.57	3.85
2.57	1.63
0.02	2.03
0.42	1.12
1.00	2.82
1.89	4.50
0.88	1.85
0.20	
3.17	
0.60	

Average and standard error bar chart:



Boxplot:



Descriptive	**Before**	**After**
n	13	10
Mean	0.53	2.33
Median	0.57	2.05
Standard Deviation	1.47	1.08
Standard Error	0.41	0.34

F-Test - Variance	
H0:	Before variance= After variance
HA:	Before variance < After variance
p-value:	18.369%

Cannot reject equality of variances - Use Homoscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**0.189%**

Reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**0.138%**

Reject equality of means

Mann-Whitney Test	
H0:	Before median = After median
HA:	Before median < After median
p-value:	**0.217%**

Reject equality of medians

Two independent groups tests

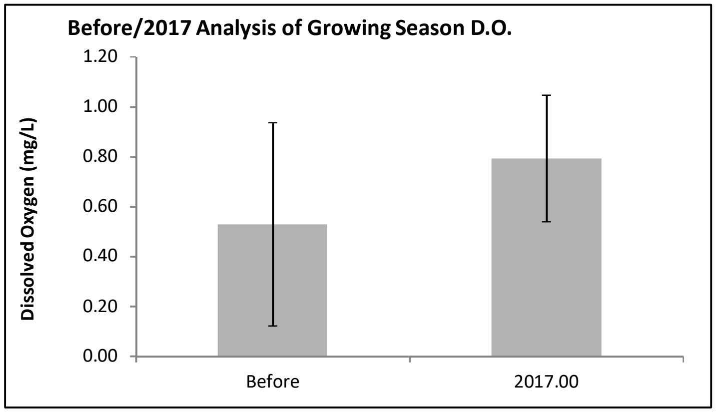
Title:	Before/2017 Analysis of Growing Season D.O
Y-Axis:	Dissolved Oxygen (mg/L)

Paste your data here

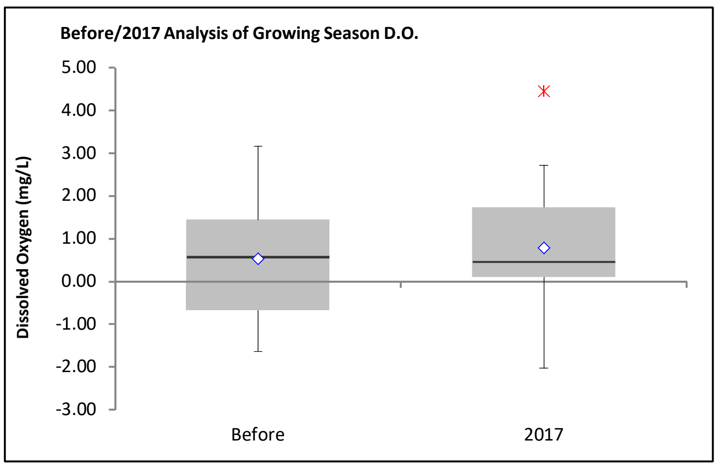
Change the group names if you wish

Before	2017
-1.63	-1.11
-1.45	0.79
-1.36	2.59
0.57	0.25
2.57	-2.03
0.02	-0.57
0.42	-1.19
1.00	0.43
1.89	0.19
0.88	1.97
0.20	4.45
3.17	1.94
0.60	1.53
	2.72
	0.46
	2.52
	1.33
	1.53
	0.96
	0.30
	-0.41
	-0.46
	2.16
	0.07
	0.26
	0.13
	0.97
	1.02
	0.20

Average and standard error bar chart:



Boxplot:



Descriptive	Before	2017.00
n	13	29
Mean	0.53	0.79
Median	0.57	0.46
Standard Deviation	1.47	1.37
Standard Error	0.41	0.25

F-Test - Variance	
H0:	Before variance= 2017 variance
HA:	Before variance < 2017 variance
p-value:	36.297%

Cannot reject equality of variances - Use Homoscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	28.767%

Cannot reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	29.408%

Cannot reject equality of means

Mann-Whitney Test	
H0:	Before median = 2017 median
HA:	Before median > 2017 median
p-value:	29.431%

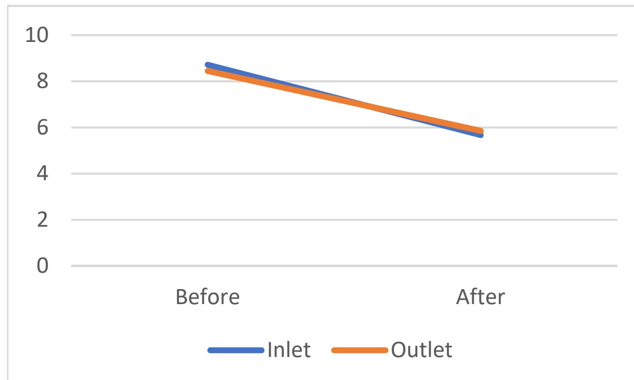
Cannot reject equality of medians

F.4. Temperature (using all data)

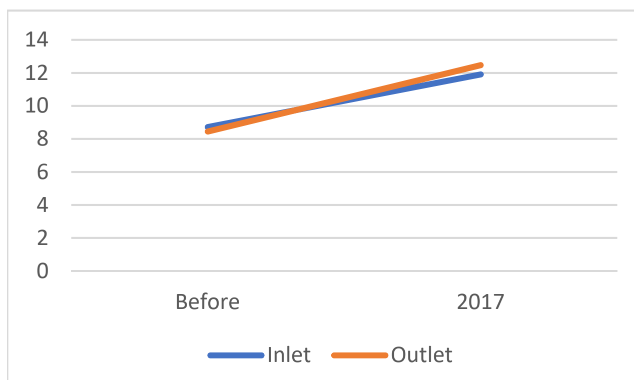
Table F.4 Calculation of the difference in temperature for use in the Mann-Whitney Test

Date	Timing	Outlet Inlet Temp (C)	Inlet Temp (C)	Difference
4/14/2017	2017	11.30	15.50	-4.20
4/14/2017	2017	10.40	10.60	-0.20
4/14/2017	2017	9.60	9.99	-0.39
4/28/2017	2017	9.50	9.30	0.20
4/28/2017	2017	13.40	9.00	4.40
5/12/2017	2017	13.50	13.00	0.50
5/12/2017	2017	12.80	13.00	-0.20
5/26/2017	2017	13.50	12.60	0.90
5/26/2017	2017	15.00	12.50	2.50
6/9/2017	2017	14.90	14.40	0.50
6/9/2017	2017	17.00	14.30	2.70
6/23/2017	2017	16.00	14.20	1.80
6/23/2017	2017	16.00	14.30	1.70
7/7/2017	2017	16.30	14.80	1.50
7/7/2017	2017	13.70	14.80	-1.10
7/21/2017	2017	14.50	13.40	1.10
7/21/2017	2017	16.50	13.40	3.10
08/05/17	2017	16.50	15.60	0.90
08/05/17	2017	12.60	15.20	-2.60
08/19/17	2017	12.30	12.00	0.30
08/19/17	2017	11.60	12.00	-0.40
9/1/2017	2017	11.50	11.80	-0.30
9/1/2017	2017	11.20	11.60	-0.40
9/15/2017	2017	10.90	10.90	0.00
9/15/2017	2017	11.20	10.90	0.30
9/29/2017	2017	11.10	11.10	0.00
9/29/2017	2017	5.90	11.00	-5.10
10/13/2017	2017	5.80	6.80	-1.00
10/13/2017	2017	7.10	6.70	0.40
11/12/2006	After	2.50	2.80	-0.30
12/10/2006	After	1.70	2.60	-0.90
12/24/2006	After	2.00	2.70	-0.70
1/20/2007	After	2.00	2.70	-0.70

BACI Plots – mean temperature at the control (Inlet, NSa) site and the impact (Outlet, NSd) site before and after implementation of the Nancy Street wetland. Parallel lines indicate that there is no mean difference in the downstream change in temperature before and after the creation of the wetland (i.e. no effect).



Mean Temperature	Before	After
Inlet	8.72	5.67
Outlet	8.45	5.85



Mean Temperature	Before	2017
Inlet	8.72	11.91
Outlet	8.45	12.47

Table F.4 Calculation of the difference in temperature for use in the Mann-Whitney Test				
2/4/2007	After	1.80	2.40	-0.60
2/18/2007	After	2.10	2.50	-0.40
3/4/2007	After	0.80	1.10	-0.30
3/20/2007	After	0.80	1.10	-0.30
4/1/2007	After	2.20	1.80	0.40
4/15/2007	After	4.10	4.00	0.10
4/29/2007	After	6.30	6.10	0.20
5/12/2007	After	9.30	8.30	1.00
5/27/2007	After	11.70	10.00	1.70
6/9/2007	After	14.50	12.80	1.70
7/8/2007	After	16.00	14.70	1.30
7/23/2007	After	14.30	13.20	1.10
8/6/2007	After	14.60	13.20	1.40
8/20/2007	After	16.00	13.60	2.40
9/2/2007	After	14.00	12.20	1.80
9/15/2007	After	11.90	11.20	0.70
9/29/2007	After	8.70	8.80	-0.10
10/13/2007	After	7.40	7.80	-0.40
10/30/2007	After	6.10	6.40	-0.30
11/11/2007	After	3.20	4.10	-0.90
11/27/2007	After	3.40	3.90	-0.50
12/11/2007	After	1.70	2.70	-1.00
12/26/2007	After	2.00	2.70	-0.70
1/7/2008	After	1.60	2.00	-0.40
1/21/2008	After	1.60	1.20	0.40
2/2/2008	After	0.80	1.40	-0.60
2/16/2008	After	1.50	2.10	-0.60
3/4/2008	After	3.10	3.50	-0.40
3/14/2008	After	3.70	2.40	1.30
3/29/2008	After	5.60	4.80	0.80
8/10/2005	Before	19.80	19.50	0.30
10/9/2005	Before	8.80	9.10	-0.30
10/22/2005	Before	7.30	7.30	0.00
11/6/2005	Before	3.80	4.20	-0.40
11/26/2005	Before	4.00	5.70	-1.70
12/10/2005	Before	2.90	3.60	-0.70
12/26/2005	Before	3.70	4.00	-0.30
1/14/2006	Before	2.40	1.70	0.70
2/11/2006	Before	5.00	3.50	1.50
3/28/2006	Before	4.60	3.70	0.90

Table F.4 Calculation of the difference in temperature for use in the Mann-Whitney Test				
4/8/2006	Before	8.90	7.30	1.60
4/27/2006	Before	7.50	6.10	1.40
5/14/2006	Before	10.10	8.90	1.20
5/27/2006	Before	16.30	16.20	0.10
6/10/2006	Before	14.50	15.30	-0.80
6/24/2006	Before	12.40	12.00	0.40
7/8/2006	Before	15.70	14.10	1.60
7/21/2006	Before	15.70	14.00	1.70
8/19/2006	Before	11.40	10.90	0.50
9/3/2006	Before	11.40	11.20	0.20
9/17/2006	Before	9.00	9.10	-0.10
10/2/2006	Before	9.00	9.20	-0.20
10/15/2006	Before	7.90	8.00	-0.10
10/29/2006	Before	3.90	4.60	-0.70

Return

Two independent groups tests

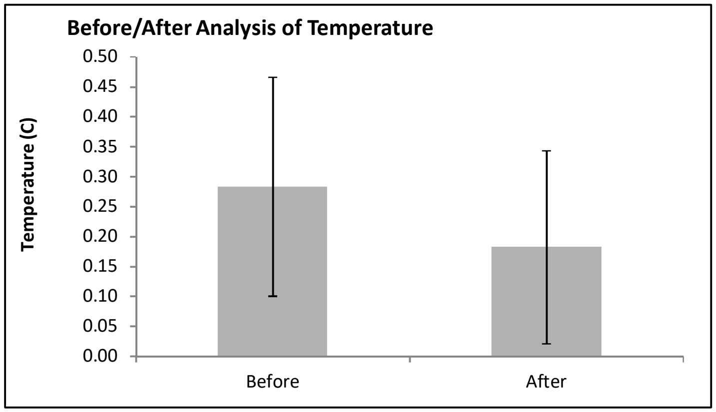
Title:	Before/After Analysis of Temperature
Y-Axis:	Temperature (C)

Paste your data here ↓

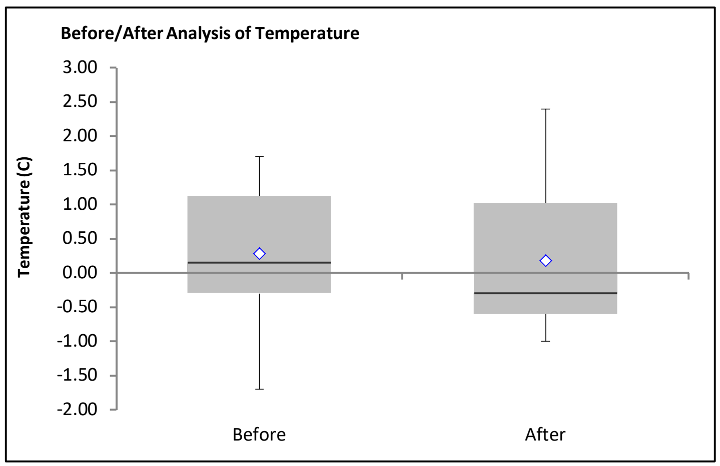
Change the group names if you wish

Before	**After**
0.30	-0.30
-0.30	-0.90
0.00	-0.70
-0.40	-0.70
-1.70	-0.60
-0.70	-0.40
-0.30	-0.30
0.70	-0.30
1.50	0.40
0.90	0.10
1.60	0.20
1.40	1.00
1.20	1.70
0.10	1.70
-0.80	1.30
0.40	1.10
1.60	1.40
1.70	2.40
0.50	1.80
0.20	0.70
-0.10	-0.10
-0.20	-0.40
-0.10	-0.30
-0.70	-0.90
	-0.50
	-1.00
	-0.70
	-0.40
	0.40
	-0.60
	-0.60
	-0.40
	1.30
	0.80

Average and standard error bar chart:



Boxplot:



Descriptive	**Before**	**After**
n	24	34
Mean	0.28	0.18
Median	0.15	-0.30
Standard Deviation	0.90	0.94
Standard Error	0.18	0.16

F-Test - Variance	
H0:	Before variance= After variance
HA:	Before variance > After variance
p-value:	41.408%

Cannot reject equality of variances - Use Homoscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = After average
HA:	Before average > After average
p-value:	34.142%

Cannot reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = After average
HA:	Before average > After average
p-value:	34.027%

Cannot reject equality of means

Mann-Whitney Test	
H0:	Before median = After median
HA:	Before median > After median
p-value:	37.855%

Cannot reject equality of medians

Return

Two independent groups tests

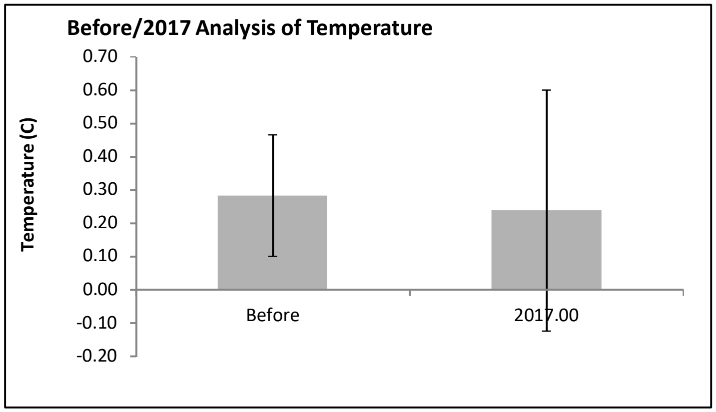
Title:	Before/2017 Analysis of Temperature
Y-Axis:	Temperature (C)

Paste your data here

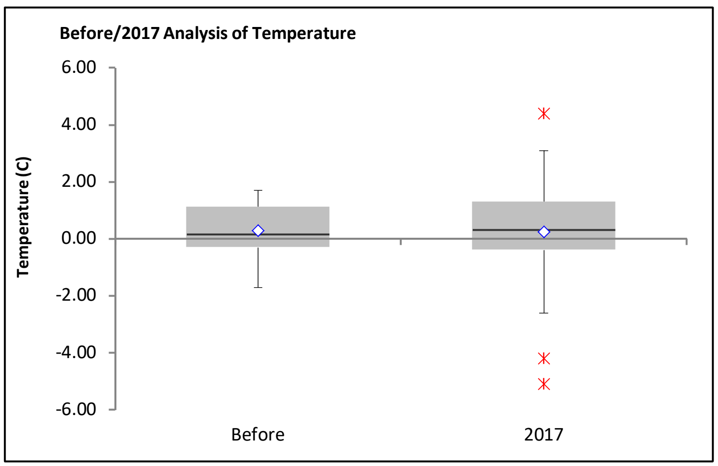
Change the group names if you wish

Before	2017
0.30	-4.20
-0.30	-0.20
0.00	-0.39
-0.40	0.20
-1.70	4.40
-0.70	0.50
-0.30	-0.20
0.70	0.90
1.50	2.50
0.90	0.50
1.60	2.70
1.40	1.80
1.20	1.70
0.10	1.50
-0.80	-1.10
0.40	1.10
1.60	3.10
1.70	0.90
0.50	-2.60
0.20	0.30
-0.10	-0.40
-0.20	-0.30
-0.10	-0.40
-0.70	0.00
	0.30
	0.00
	-5.10
	-1.00
	0.40

Average and standard error bar chart:



Boxplot:



Descriptive	Before	2017.00
n	24	29
Mean	0.28	0.24
Median	0.15	0.30
Standard Deviation	0.90	1.95
Standard Error	0.18	0.36

F-Test - Variance	
H0:	Before variance= 2017 variance
HA:	Before variance > 2017 variance
p-value:	**0.016%**

Reject equality of variances - Use Heteroscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = 2017 average
HA:	Before average > 2017 average
p-value:	45.862%

Cannot reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = 2017 average
HA:	Before average > 2017 average
p-value:	45.602%

Cannot reject equality of means

Mann-Whitney Test	
H0:	Before median = 2017 median
HA:	Before median < 2017 median
p-value:	25.468%

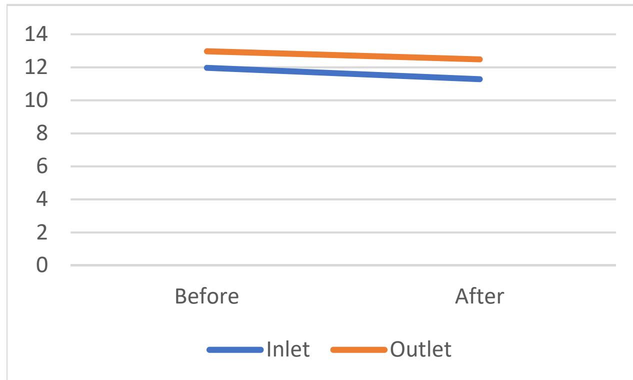
Cannot reject equality of medians

F.5. Temperature (using growing season data)

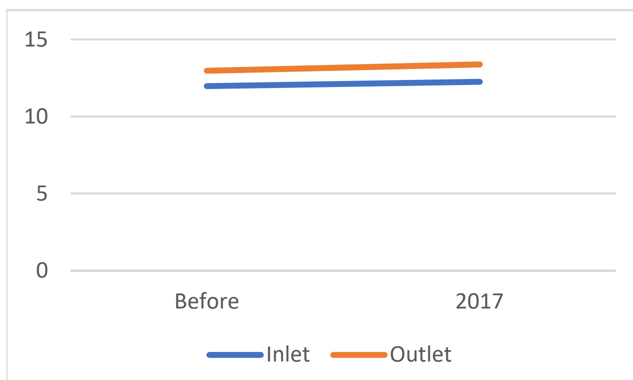
Table F.5 Calculation of the difference in growing season temperature for use in the Mann-Whitney Test

Date	Timing	Outlet Inlet Temp (C)	Inlet Temp (C)	Difference
4/29/2007	After	6.30	6.10	0.20
5/12/2007	After	9.30	8.30	1.00
5/27/2007	After	11.70	10.00	1.70
6/9/2007	After	14.50	12.80	1.70
7/8/2007	After	16.00	14.70	1.30
7/23/2007	After	14.30	13.20	1.10
8/6/2007	After	14.60	13.20	1.40
8/20/2007	After	16.00	13.60	2.40
9/2/2007	After	14.00	12.20	1.80
9/15/2007	After	11.90	11.20	0.70
9/29/2007	After	8.70	8.80	-0.10
8/10/2005	Before	19.80	19.50	0.30
10/9/2005	Before	8.80	9.10	-0.30
4/27/2006	Before	7.50	6.10	1.40
5/14/2006	Before	10.10	8.90	1.20
5/27/2006	Before	16.30	16.20	0.10
6/10/2006	Before	14.50	15.30	-0.80
6/24/2006	Before	12.40	12.00	0.40
7/8/2006	Before	15.70	14.10	1.60
7/21/2006	Before	15.70	14.00	1.70
8/19/2006	Before	11.40	10.90	0.50
9/3/2006	Before	11.40	11.20	0.20
9/17/2006	Before	9.00	9.10	-0.10
10/2/2006	Before	9.00	9.20	-0.20
4/28/2017	2017	9.60	9.30	0.30
4/28/2017	2017	9.50	9.00	0.50
5/12/2017	2017	13.40	13.00	0.40
5/12/2017	2017	13.50	13.00	0.50
5/26/2017	2017	12.80	12.60	0.20
5/26/2017	2017	13.50	12.50	1.00
6/9/2017	2017	15.00	14.40	0.60
6/9/2017	2017	14.90	14.30	0.60
6/23/2017	2017	17.00	14.20	2.80

BACI Plots – mean growing season temperature at the control (Inlet, NSa) site and the impact (Outlet, NSd) site before and after implementation of the Nancy Street wetland. Parallel lines indicate that there is no mean difference in the downstream change in temperature before and after the creation of the wetland (i.e. no effect).



Mean Temperature	Before	After
Inlet	11.97	11.28
Outlet	12.97	12.48



Mean Temperature	Before	2017
Inlet	11.97	12.25
Outlet	12.97	13.38

Table F.5 Calculation of the difference in growing season temperature for use in the Mann-Whitney Test				
6/23/2017	2017	16.00	14.30	1.70
7/7/2017	2017	16.00	14.80	1.20
7/7/2017	2017	16.30	14.80	1.50
7/21/2017	2017	13.70	13.40	0.30
7/21/2017	2017	14.50	13.40	1.10
08/05/17	2017	16.50	15.60	0.90
08/05/17	2017	16.50	15.20	1.30
08/19/17	2017	12.60	12.00	0.60
08/19/17	2017	12.30	12.00	0.30
9/1/2017	2017	11.60	11.80	-0.20
9/1/2017	2017	11.50	11.60	-0.10
9/15/2017	2017	11.20	10.90	0.30
9/15/2017	2017	10.90	10.90	0.00
9/29/2017	2017	11.20	11.10	0.10
9/29/2017	2017	11.10	11.00	0.10
10/13/2017	2017	5.90	6.80	-0.90
10/13/2017	2017	5.80	6.70	-0.90

Return

Two independent groups tests

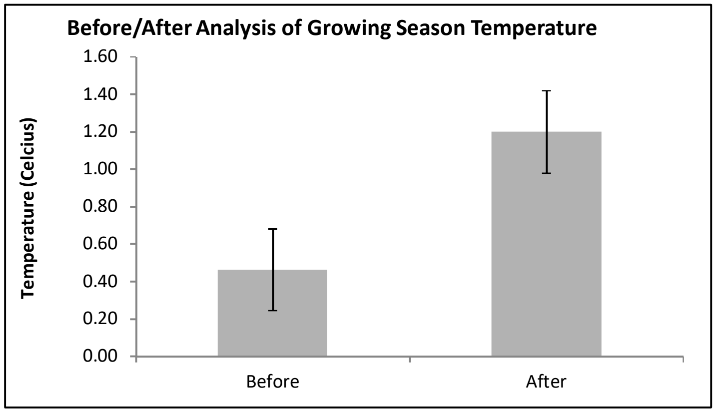
Title:	Before/After Analysis of Growing Season Ten
Y-Axis:	Temperature (Celcius)

Paste your data here

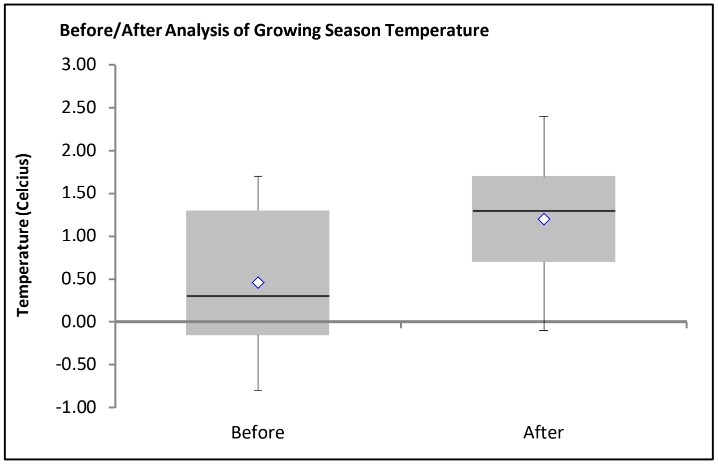
Change the group names if you wish

Before	After
0.30	0.20
-0.30	1.00
1.40	1.70
1.20	1.70
0.10	1.30
-0.80	1.10
0.40	1.40
1.60	2.40
1.70	1.80
0.50	0.70
0.20	-0.10
-0.10	
-0.20	

Average and standard error bar chart:



Boxplot:



Descriptive	Before	After
n	13	11
Mean	0.46	1.20
Median	0.30	1.30
Standard Deviation	0.79	0.73
Standard Error	0.22	0.22

F-Test - Variance	
H0:	Before variance= After variance
HA:	Before variance < After variance
p-value:	41.468%

Cannot reject equality of variances - Use Homoscedastic T-Tes

T-Student Test (Homoscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**1.355%**

Reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**1.318%**

Reject equality of means

Mann-Whitney Test	
H0:	Before median = After median
HA:	Before median < After median
p-value:	**2.129%**

Reject equality of medians

Return

Two independent groups tests

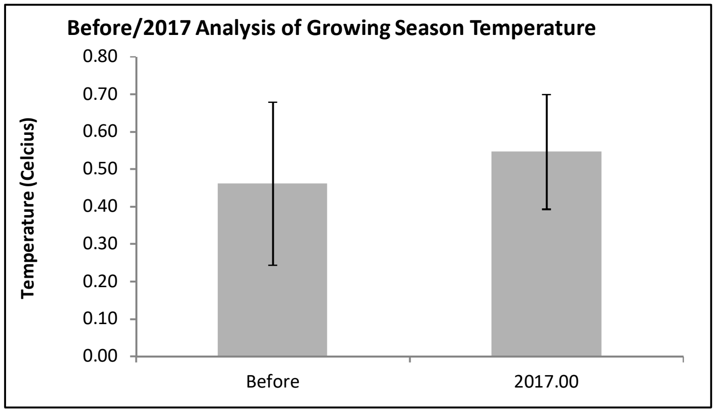
Title:	Before/2017 Analysis of Growing Season Ten
Y-Axis:	Temperature (Celcius)

Paste your data here

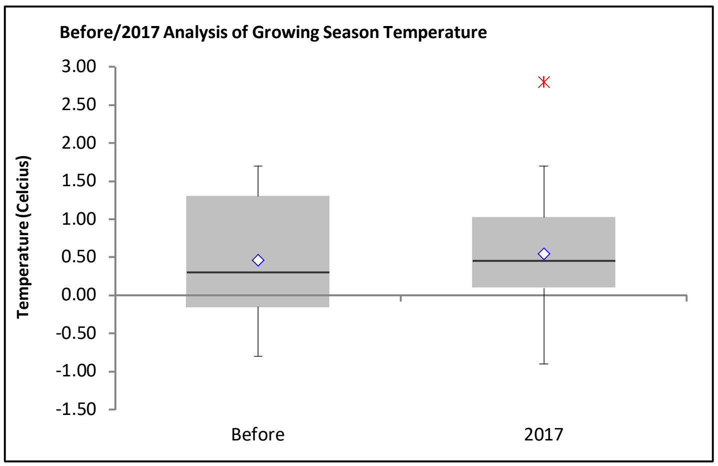
Change the group names if you wish

Before	2017
0.30	0.30
-0.30	0.50
1.40	0.40
1.20	0.50
0.10	0.20
-0.80	1.00
0.40	0.60
1.60	0.60
1.70	2.80
0.50	1.70
0.20	1.20
-0.10	1.50
-0.20	0.30
	1.10
	0.90
	1.30
	0.60
	0.30
	-0.20
	-0.10
	0.30
	0.00
	0.10
	0.10
	-0.90
	-0.90

Average and standard error bar chart:



Boxplot:



Descriptive	Before	2017.00
n	13	26
Mean	0.46	0.55
Median	0.30	0.45
Standard Deviation	0.79	0.78
Standard Error	0.22	0.15

F-Test - Variance	
H0:	Before variance= 2017 variance
HA:	Before variance < 2017 variance
p-value:	46.452%

Cannot reject equality of variances - Use Homoscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	37.590%

Cannot reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	37.670%

Cannot reject equality of means

Mann-Whitney Test	
H0:	Before median = 2017 median
HA:	Before median < 2017 median
p-value:	20.407%

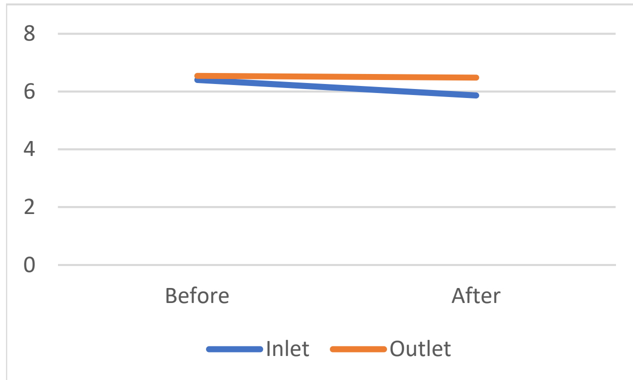
Cannot reject equality of medians

F.6. pH (using all data)

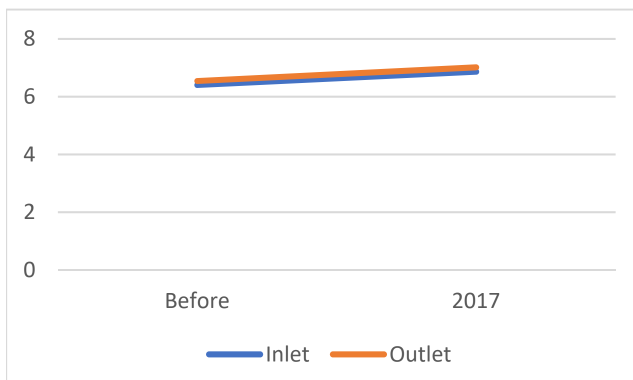
Table F6 Calculation of the difference in pH for use in the Mann-Whitney Test

Date	Timing	Outlet pH	Inlet pH	Difference
4/14/2017	2017	7.00	6.85	0.15
4/14/2017	2017	7.05	6.91	0.14
4/28/2017	2017	7.05	6.74	0.31
4/28/2017	2017	7.22	6.93	0.29
5/12/2017	2017	7.08	7.14	-0.06
5/12/2017	2017	7.07	7.16	-0.09
5/26/2017	2017	7.10	6.74	0.36
5/26/2017	2017	7.08	6.80	0.28
6/9/2017	2017	6.95	6.61	0.34
6/9/2017	2017	6.94	6.74	0.20
6/23/2017	2017	7.23	6.99	0.24
6/23/2017	2017	7.27	7.02	0.25
7/7/2017	2017	7.16	6.69	0.47
7/7/2017	2017	7.12	6.89	0.23
7/21/2017	2017	7.00	6.43	0.57
7/21/2017	2017	7.00	6.66	0.34
08/05/17	2017	6.80	6.48	0.32
08/05/17	2017	6.86	6.56	0.30
08/19/17	2017	6.92	6.39	0.53
08/19/17	2017	6.86	6.52	0.34
9/1/2017	2017	6.86	6.57	0.29
9/1/2017	2017	6.86	6.73	0.13
9/15/2017	2017	6.85	6.74	0.11
9/15/2017	2017	6.88	7.80	-0.92
9/29/2017	2017	6.98	6.97	0.01
9/29/2017	2017	6.91	6.91	0.00
10/13/2017	2017	7.15	7.41	-0.26
10/13/2017	2017	7.06	7.16	-0.10
10/27/2017	2017	7.10	7.21	-0.11
10/27/2017	2017	7.03	7.17	-0.14
11/12/2006	After	6.30	6.42	-0.12
12/10/2006	After	6.44	6.37	0.07
12/24/2006	After	5.74	5.44	0.30
1/20/2007	After	6.94	6.74	0.20
2/4/2007	After	6.03	6.45	-0.42

BACI Plots – mean pH at the control (Inlet, NSa) site and the impact (Outlet, NSd) site before and after implementation of the Nancy Street wetland. Parallel lines indicate that there is no mean difference in the downstream change in pH before and after the creation of the wetland (i.e. no effect).



Mean pH	Before	After
Inlet	6.40	5.86
Outlet	6.54	6.48



Mean pH	Before	2017
Inlet	6.40	6.86
Outlet	6.54	7.02

Table F6 Calculation of the difference in pH for use in the Mann-Whitney Test				
2/18/2007	After	6.70	5.41	1.29
3/20/2007	After	7.35	6.02	1.33
4/1/2007	After	7.12	5.22	1.90
4/15/2007	After	6.06	5.83	0.23
4/29/2007	After	6.01	5.85	0.16
5/12/2007	After	6.42	6.31	0.11
5/27/2007	After	6.59	6.31	0.28
6/9/2007	After	6.74	6.67	0.07
7/8/2007	After	6.84	6.45	0.39
7/23/2007	After	6.83	6.80	0.03
8/6/2007	After	6.59	5.96	0.63
8/20/2007	After	6.76	6.50	0.26
9/2/2007	After	6.75	6.31	0.44
9/15/2007	After	6.15	5.97	0.18
9/29/2007	After	6.47	5.78	0.69
10/13/2007	After	6.28	6.35	-0.07
10/30/2007	After	5.70	5.43	0.27
11/11/2007	After	5.46	5.10	0.36
11/27/2007	After	6.11	5.61	0.50
12/11/2007	After	5.04	4.96	0.08
12/26/2007	After	5.91	4.90	1.01
1/7/2008	After	6.65	6.65	0.00
1/21/2008	After	6.92	5.33	1.59
2/2/2008	After	6.53	4.53	2.00
2/16/2008	After	6.70	6.56	0.14
3/4/2008	After	7.15	4.75	2.40
3/14/2008	After	7.03	4.87	2.16
3/29/2008	After	6.94	5.68	1.26
10/9/2005	Before	6.39	6.56	-0.17
10/22/2005	Before	6.79	6.34	0.45
11/26/2005	Before	4.65	5.54	-0.89
12/10/2005	Before	5.78	6.17	-0.39
12/26/2005	Before	6.70	5.90	0.80
1/14/2006	Before	6.59	6.37	0.22
2/11/2006	Before	6.87	6.60	0.27
3/28/2006	Before	6.85	5.99	0.86
4/8/2006	Before	6.92	7.01	-0.09
4/27/2006	Before	7.18	6.06	1.12
5/14/2006	Before	7.10	6.01	1.09
5/27/2006	Before	6.56	6.52	0.04

Table F6 Calculation of the difference in pH for use in the Mann-Whitney Test				
6/10/2006	Before	6.52	6.60	-0.08
7/8/2006	Before	6.59	6.44	0.15
7/21/2006	Before	6.91	6.91	0.00
8/19/2006	Before	6.61	6.84	-0.23
9/3/2006	Before	6.77	6.79	-0.02
9/17/2006	Before	6.63	6.51	0.12
10/2/2006	Before	6.59	6.56	0.03
10/15/2006	Before	6.80	6.36	0.44
10/29/2006	Before	6.78	6.38	0.40

Return

Two independent groups tests

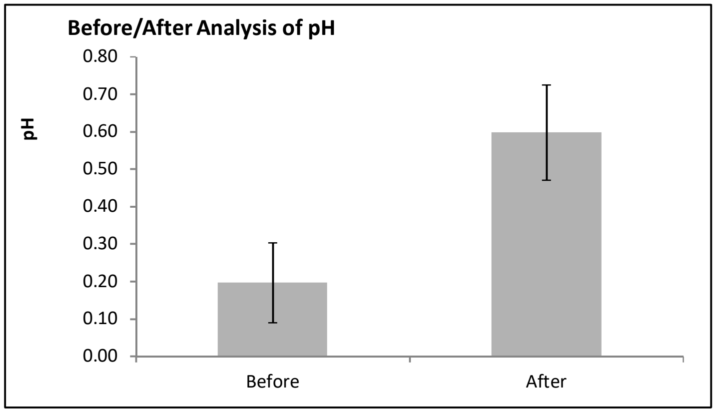
Title:	Before/After Analysis of pH
Y-Axis:	pH

Paste your data here

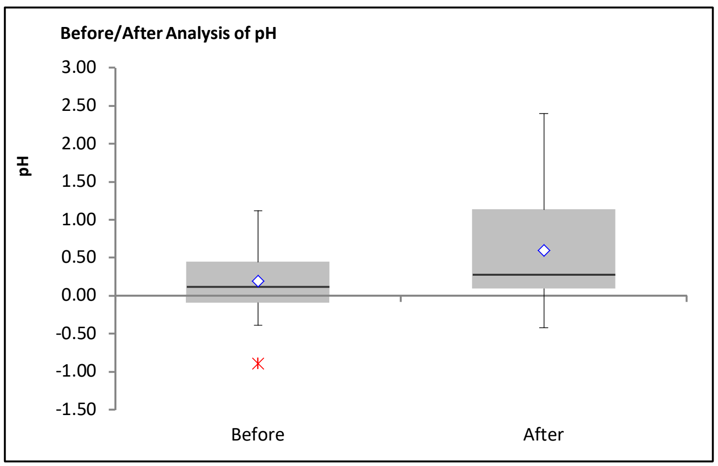
Change the group names if you wish

Before	After
-0.17	-0.12
0.45	0.07
-0.89	0.30
-0.39	0.20
0.80	-0.42
0.22	1.29
0.27	1.33
0.86	1.90
-0.09	0.23
1.12	0.16
1.09	0.11
0.04	0.28
-0.08	0.07
0.15	0.39
0.00	0.03
-0.23	0.63
-0.02	0.26
0.12	0.44
0.03	0.18
0.44	0.69
0.40	-0.07
	0.27
	0.36
	0.50
	0.08
	1.01
	0.00
	1.59
	2.00
	0.14
	2.40
	2.16
	1.26

Average and standard error bar chart:



Boxplot:



Descriptive	Before	After
n	21	33
Mean	0.20	0.60
Median	0.12	0.28
Standard Deviation	0.49	0.73
Standard Error	0.11	0.13

F-Test - Variance	
H0:	Before variance= After variance
HA:	Before variance < After variance
p-value:	**3.063%**

Reject equality of variances - Use Heteroscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**1.555%**

Reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	**0.960%**

Reject equality of means

Mann-Whitney Test	
H0:	Before median = After median
HA:	Before median < After median
p-value:	8.975%

Cannot reject equality of medians

Return

Two independent groups tests

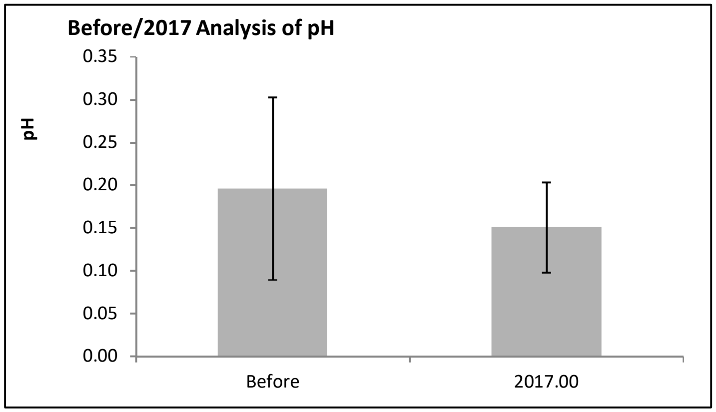
Title:	Before/2017 Analysis of pH
Y-Axis:	pH

Paste your data here

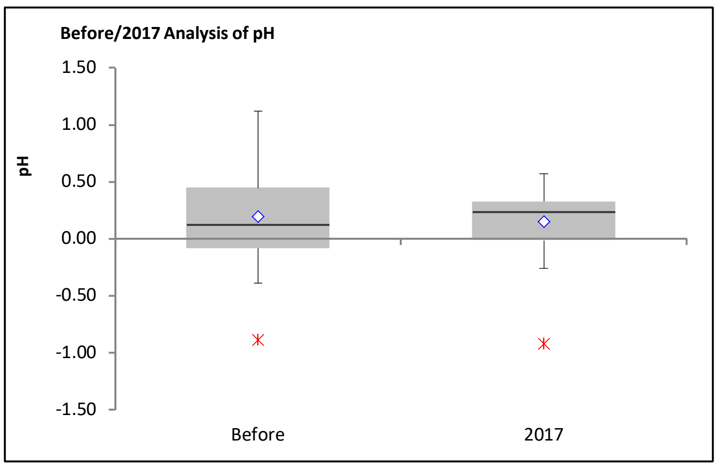
Change the group names if you wish

Before	2017
-0.17	0.15
0.45	0.14
-0.89	0.31
-0.39	0.29
0.80	-0.06
0.22	-0.09
0.27	0.36
0.86	0.28
-0.09	0.34
1.12	0.20
1.09	0.24
0.04	0.25
-0.08	0.47
0.15	0.23
0.00	0.57
-0.23	0.34
-0.02	0.32
0.12	0.30
0.03	0.53
0.44	0.34
0.40	0.29
	0.13
	0.11
	-0.92
	0.01
	0.00
	-0.26
	-0.10
	-0.11
	-0.14

Average and standard error bar chart:



Boxplot:



Descriptive	Before	2017.00
n	21	30
Mean	0.20	0.15
Median	0.12	0.24
Standard Deviation	0.49	0.29
Standard Error	0.11	0.05

F-Test - Variance	
H0:	Before variance= 2017 variance
HA:	Before variance > 2017 variance
p-value:	**0.480%**

Reject equality of variances - Use Heteroscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = 2017 average
HA:	Before average > 2017 average
p-value:	33.890%

Cannot reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = 2017 average
HA:	Before average > 2017 average
p-value:	35.223%

Cannot reject equality of means

Mann-Whitney Test	
H0:	Before median = 2017 median
HA:	Before median < 2017 median
p-value:	15.567%

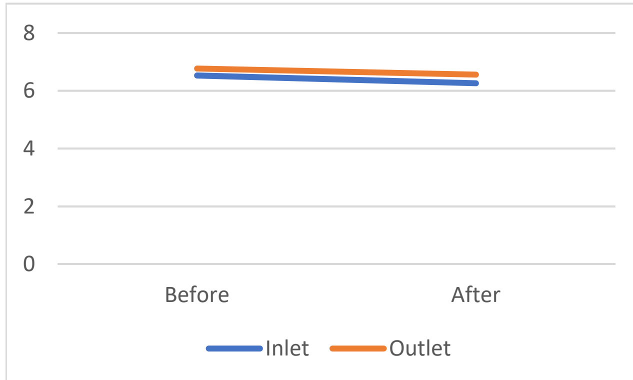
Cannot reject equality of medians

F.7. pH (using growing season data)

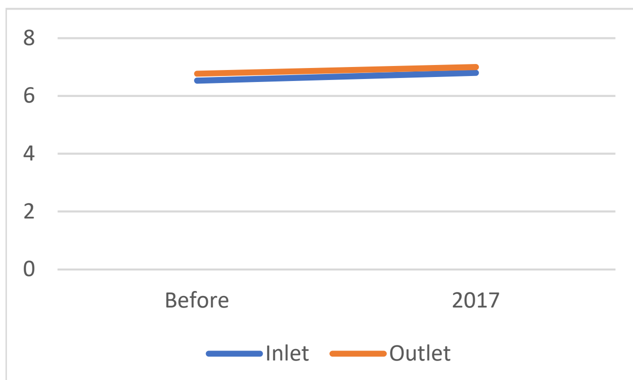
Table F7 Calculation of the difference in growing season pH for use in the Mann-Whitney Test

Date	Timing	pH Outlet	pH Inlet	Difference
4/27/2006	Before	7.18	6.06	1.12
5/5/2006	Before	6.40	6.01	0.39
5/27/2006	Before	6.56	6.52	0.04
6/10/2006	Before	6.52	6.60	-0.08
7/8/2006	Before	6.59	6.44	0.15
7/21/2006	Before	6.91	6.91	0.00
8/19/2006	Before	6.61	6.84	-0.23
9/3/2006	Before	6.77	6.79	-0.02
9/17/2006	Before	6.63	6.51	0.12
10/2/2006	Before	6.59	6.56	0.03
4/29/2007	After	6.01	5.85	0.16
5/12/2007	After	6.42	6.31	0.11
5/27/2007	After	6.59	6.31	0.28
6/9/2007	After	6.74	6.67	0.07
7/8/2007	After	6.84	6.45	0.39
7/23/2007	After	6.83	6.80	0.03
8/6/2007	After	6.59	5.96	0.63
8/20/2007	After	6.76	6.50	0.26
9/2/2007	After	6.75	6.31	0.44
9/15/2007	After	6.15	5.97	0.18
9/29/2007	After	6.47	5.78	0.69
4/28/2017	2017	7.05	6.74	0.31
4/28/2017	2017	7.22	6.93	0.29
5/12/2017	2017	7.08	7.14	-0.06
5/12/2017	2017	7.07	7.16	-0.09
5/26/2017	2017	7.10	6.74	0.36
5/26/2017	2017	7.08	6.80	0.28
6/9/2017	2017	6.95	6.61	0.34
6/9/2017	2017	6.94	6.74	0.20
6/23/2017	2017	7.23	6.99	0.24
6/23/2017	2017	7.27	7.02	0.25
7/7/2017	2017	7.16	6.69	0.47
7/7/2017	2017	7.12	6.89	0.23
7/21/2017	2017	7.00	6.43	0.57

BACI Plots – mean growing season pH at the control (Inlet, NSa) site and the impact (Outlet, NSd) site before and after implementation of the Nancy Street wetland. Parallel lines indicate that there is no mean difference in the downstream change in pH before and after the creation of the wetland (i.e. no effect).



Mean pH	Before	After
Inlet	6.53	6.26
Outlet	6.77	6.56



Mean pH	Before	2017
Inlet	6.53	6.80
Outlet	6.77	7.00

Table F7 Calculation of the difference in growing season pH for use in the Mann-Whitney Test				
7/21/2017	2017	7.00	6.66	0.34
8/05/2017	2017	6.80	6.48	0.32
8/05/2017	2017	6.86	6.56	0.30
8/19/2017	2017	6.92	6.39	0.53
8/19/2017	2017	6.86	6.52	0.34
9/1/2017	2017	6.86	6.57	0.29
9/1/2017	2017	6.86	6.73	0.13
9/15/2017	2017	6.85	6.74	0.11
9/15/2017	2017	6.88	7.80	-0.92
9/29/2017	2017	6.98	6.97	0.01
9/29/2017	2017	6.91	6.91	0.00

Return

Two independent groups tests

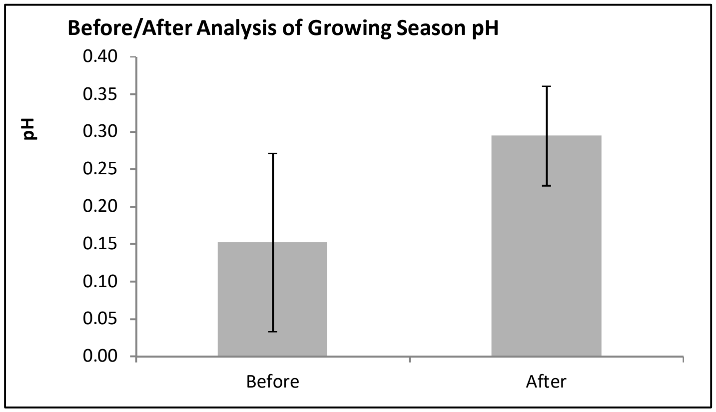
Title:	Before/After Analysis of Growing Season pH
Y-Axis:	pH

Paste your data here

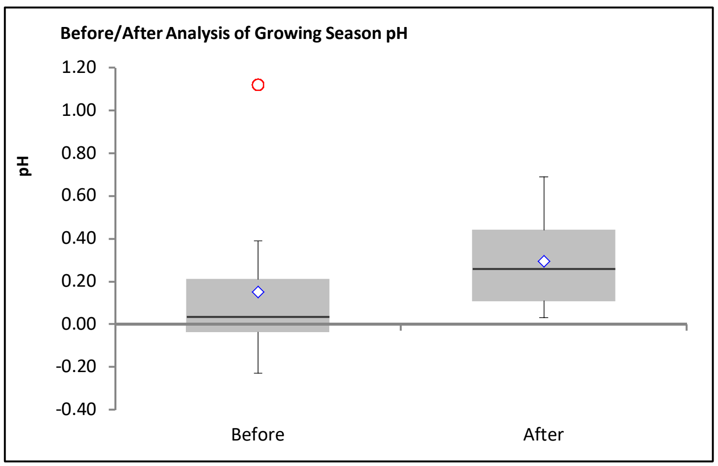
Change the group names if you wish

Before	After
1.12	0.16
0.39	0.11
0.04	0.28
-0.08	0.07
0.15	0.39
0.00	0.03
-0.23	0.63
-0.02	0.26
0.12	0.44
0.03	0.18
	0.69

Average and standard error bar chart:



Boxplot:



Descriptive	Before	After
n	10	11
Mean	0.15	0.29
Median	0.04	0.26
Standard Deviation	0.38	0.22
Standard Error	0.12	0.07

F-Test - Variance	
H0:	Before variance= After variance
HA:	Before variance < After variance
p-value:	5.559%

Cannot reject equality of variances - Use Homoscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	14.865%

Cannot reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = After average
HA:	Before average < After average
p-value:	15.656%

Cannot reject equality of means

Mann-Whitney Test	
H0:	Before median = After median
HA:	Before median < After median
p-value:	**2.750%**

Reject equality of medians

Return

Two independent groups tests

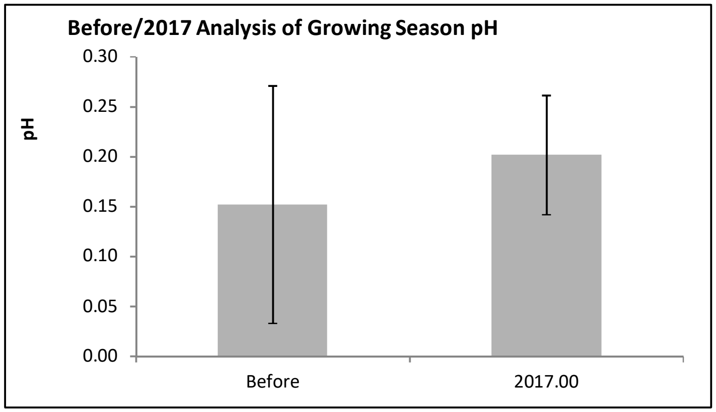
Title:	Before/2017 Analysis of Growing Season pH
Y-Axis:	pH

Paste your data here

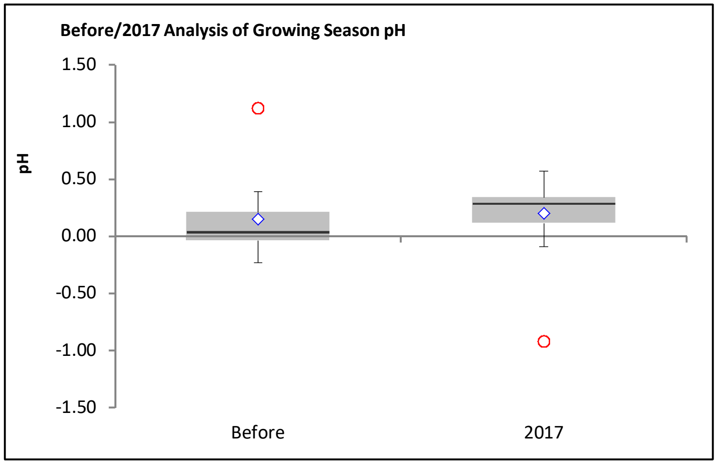
Change the group names if you wish

Before	2017
1.12	0.31
0.39	0.29
0.04	-0.06
-0.08	-0.09
0.15	0.36
0.00	0.28
-0.23	0.34
-0.02	0.20
0.12	0.24
0.03	0.25
	0.47
	0.23
	0.57
	0.34
	0.32
	0.30
	0.53
	0.34
	0.29
	0.13
	0.11
	-0.92
	0.01
	0.00

Average and standard error bar chart:



Boxplot:



Descriptive	Before	2017.00
n	10	24
Mean	0.15	0.20
Median	0.04	0.29
Standard Deviation	0.38	0.29
Standard Error	0.12	0.06

F-Test - Variance	
H0:	Before variance= 2017 variance
HA:	Before variance < 2017 variance
p-value:	15.686%

Cannot reject equality of variances - Use Homoscedastic T-Test

T-Student Test (Homoscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	34.049%

Cannot reject equality of means

T-Student Test (Heteroscedastic)	
H0:	Before average = 2017 average
HA:	Before average < 2017 average
p-value:	35.737%

Cannot reject equality of means

Mann-Whitney Test	
H0:	Before median = 2017 median
HA:	Before median < 2017 median
p-value:	5.410%

Cannot reject equality of medians

Appendix G. Estimated Sample Sizes

Sample Size Worksheet - *Estimate the sample size needed to detect a statistically significant change.*

How many samples are needed to detect a statistically significant water quality change? This question can be answered using power analysis. As its name implies, power analysis involves the power of a statistical test. Statistical power is the likelihood that a change which has actually occurred will be detected as statistically significant. The statistical power of a test is based on five factors:

1) The statistical test being applied;
2) The desired confidence level of the test (the level of certainty that a statistically significant change has actually occurred);
3) The variability of the data being tested;
4) The size of the change; and
5) The number of samples included in analysis.

This worksheet asks users to provide information on factors 1-4 and desired power to estimate the sample size needed to detect a statistically significant change. Required input is displayed in GREEN cells.

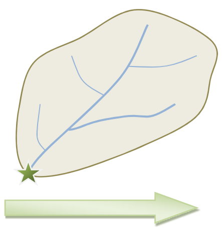
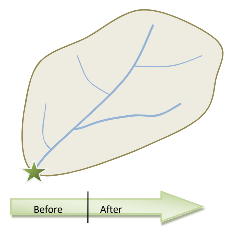
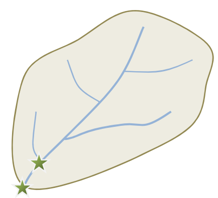
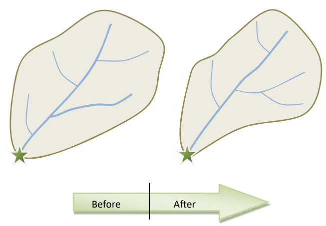
Step 1.
Select a Water Quality Parameter & Data Transformation Option

Parameter: **Dissolved Oxygen**

Data Transformation: (•) **None** ( ) **Log(x+1)** ( ) **Square Root** ( ) **Logarithm** ( ) **Square** ( ) **Reciprocal Root**

Select the transformation option that provides data that are approximately normally-distributed (distributions can be explored in the Data Exploration worksheet). Sample size calculations assume that normally-distributed data will be used to detect post-TMDL water quality change and that a parametric statistical test will be applied. An alternative nonparametric statistical test will generally require an equivalent, or fewer, number of samples.

Step 2.
Select the study design that will be used to evaluate TMDL effectiveness *- Sample size estimates vary based on the study design (and associated statistical test) that will be used.*

( ) **Trend Monitoring**	( ) **Before/After Study**	( ) **Upstream/Downstream Study**	(•) **Paired Watersheds Study**
			
Assumes a linear regression with time will be applied to detect water quality change.	*Assumes a two-sample t-test will be applied to detect water quality change.*	*Assumes a two sample t-test will be applied to detect water quality change.*	*Assumes a paired t-test will be applied to detect water quality change.*

Step 3.
Enter Desired Power and Confidence Level - *Sample size increases with increased statistical power and confidence level.*

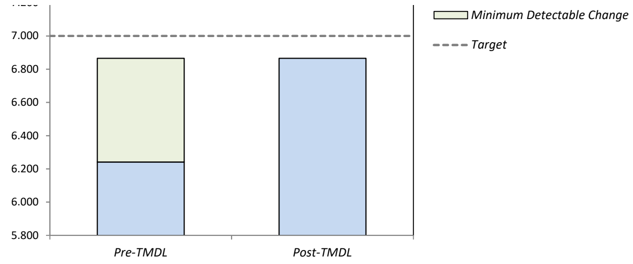
Statistical Power	0.80	*Statistical power is the probability (0 to 1) that a water quality change will be detected given that a change has actually occurred. The minimum recommended value is 0.8.*
Confidence Level	0.90	*The confidence level is the probability (0 to 1) that a water quality change that is detected has actually occurred. The minimum recommended value is 0.9.*

Step 4.
Estimate Data Variability (Standard Deviation) - *Sample size increases with increased data variability.*

Standard Deviation (from pilot data)	1.826	*The standard deviation of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation was applied in Step 1, the standard deviation of the transformed dataset is used for estimating sample size and is displayed here.*

Step 5.
Enter Minimum Detectable Change - *Water quality changes less than the minimum detectable change cannot be detected with statistical significance. Sample size increases with decreased minimum detectable change.*

Pre-TMDL Mean (from pilot data)	6.242	*The mean of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation is applied, the mean of transformed values is displayed in untransformed units.*
Change Type & Direction	(•) **Percent** ( ) **Absolute** ( ) **Decrease** (•) **Increase**	*The minimum detectable change can be entered as a percent change (e.g., a 10% decrease) or absolute change (e.g., a 0.1 mg/L decrease).*
Minimum Detectable Change	10.000 %	*Enter the desired minimum detectable change as a percent change or absolute change in untransformed units.*
Water Quality Target	7.000	*Enter the water quality target. This value is for display purposes and is not used in sample size calculations.*



The plot on the left displays three factors to take into account when selecting a minimum detectable change value:

1) The pre-TMDL condition (displayed here as the pre-TMDL mean);
2) The expected post-TMDL condition (displayed here as the pre-TMDL mean minus the minimum detectable change); and
3) The post-TMDL target.

Users may wish to designate the minimum detectable change as the change needed to achieve the water quality target (the difference between the pre-TMDL mean and the target). However, incremental changes which are less than this difference will not be detected as statistically significant. If a goal of the monitoring study is to identify incremental changes (i.e., the target is not expected to be met during the study period), a smaller minimum detectable change value should be entered.

Step 6.

Estimate Sample Size *Click the* ***Estimate Sample Size*** *button to calculate the minimum number of samples needed to satisfy the conditions specified in steps 2 - 5.*

Total Sample Size	110
Samples per Site (after calibration) (Total Sample Size / 2)	55

Save Sample Size *Click the* ***Save Sample Size*** *button to add the sample size estimate to the Cost Estimation worksheet.*

Before moving on, please note that this power analaysis includes several assumptions:
-Data are normally distributed.
-An unpaired or paired t-test, or linear regression with time, will be used to evaluate water quality changes.
-Pilot data are representative of TMDL effectiveness monitoring data.
-Samples are independent/random (not autocorrelated).
If these assumptions are not met, sample size estimates will be skewed and should be viewed as general approximations only.

Sample Size Worksheet - *Estimate the sample size needed to detect a statistically significant change.*

How many samples are needed to detect a statistically significant water quality change? This question can be answered using power analysis. As its name implies, power analysis involves the power of a statistical test. Statistical power is the likelihood that a change which has actually occurred will be detected as statistically significant. The statistical power of a test is based on five factors:

1) The statistical test being applied;
2) The desired confidence level of the test (the level of certainty that a statistically significant change has actually occurred);
3) The variability of the data being tested;
4) The size of the change; and
5) The number of samples included in analysis.

This worksheet asks users to provide information on factors 1-4 and desired power to estimate the sample size needed to detect a statistically significant change. Required input is displayed in GREEN cells.

Step 1.
Select a Water Quality Parameter & Data Transformation Option

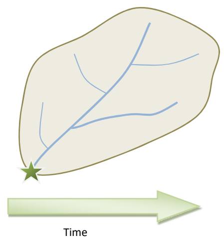
Parameter: Dissolved Oxygen

Data Transformation: (•) **None** ( ) **Log(x+1)** ( ) **Square Root** ( ) **Logarithm** ( ) **Square** ( ) **Reciprocal Root**

Select the transformation option that provides data that are approximately normally-distributed (distributions can be explored in the Data Exploration worksheet). Sample size calculations assume that normally-distributed data will be used to detect post-TMDL water quality change and that a parametric statistical test will be applied. An alternative nonparametric statistical test will generally require an equivalent, or fewer, number of samples.

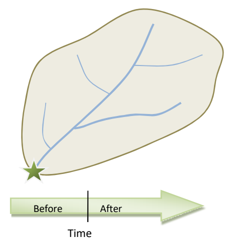
Step 2.
Select the study design that will be used to evaluate TMDL effectiveness *- Sample size estimates vary based on the study design (and associated statistical test) that will be used.*

( ) **Trend Monitoring**



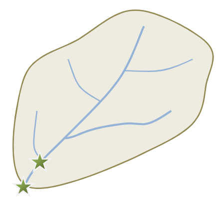
Assumes a linear regression with time will be applied to detect water quality change.

( ) **Before/After Study**



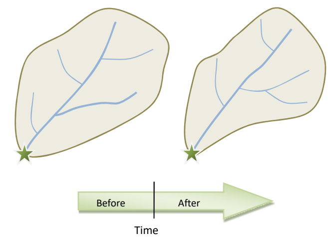
Assumes a two-sample t-test will be applied to detect water quality change.

( ) **Upstream/Downstream Study**



Assumes a two sample t-test will be applied to detect water quality change.

(•) **Paired Watersheds Study**



Assumes a paired t-test will be applied to detect water quality change.

Step 3.
Enter Desired Power and Confidence Level - *Sample size increases with increased statistical power and confidence level.*

Statistical Power	0.80	*Statistical power is the probability (0 to 1) that a water quality change will be detected given that a change has actually occurred. The minimum recommended value is 0.8.*
Confidence Level	0.90	*The confidence level is the probability (0 to 1) that a water quality change that is detected has actually occurred. The minimum recommended value is 0.9.*

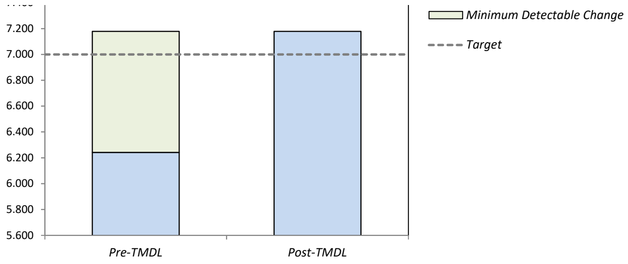
Step 4.
Estimate Data Variability (Standard Deviation) - *Sample size increases with increased data variability.*

Standard Deviation (from pilot data)	1.826	*The standard deviation of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation was applied in Step 1, the standard deviation of the transformed dataset is used for estimating sample size and is displayed here.*

Step 5.
Enter Minimum Detectable Change - *Water quality changes less than the minimum detectable change cannot be detected with statistical significance. Sample size increases with decreased minimum detectable change.*

Pre-TMDL Mean (from pilot data)	6.242	*The mean of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation is applied, the mean of transformed values is displayed in untransformed units.*
Change Type & Direction	(•) **Percent** ( ) **Absolute** ( ) **Decrease** (•) **Increase**	*The minimum detectable change can be entered as a percent change (e.g., a 10% decrease) or absolute change (e.g., a 0.1 mg/L decrease).*
Minimum Detectable Change	15.000 %	*Enter the desired minimum detectable change as a percent change or absolute change in untransformed units.*
Water Quality Target	7.000	*Enter the water quality target. This value is for display purposes and is not used in sample size calculations.*

7.400



The plot on the left displays three factors to take into account when selecting a minimum detectable change value:

1) The pre-TMDL condition (displayed here as the pre-TMDL mean);
2) The expected post-TMDL condition (displayed here as the pre-TMDL mean minus the minimum detectable change); and
3) The post-TMDL target.

Users may wish to designate the minimum detectable change as the change needed to achieve the water quality target (the difference between the pre-TMDL mean and the target). However, incremental changes which are less than this difference will not be detected as statistically significant. If a goal of the monitoring study is to identify incremental changes (i.e., the target is not expected to be met during the study period), a smaller minimum detectable change value should be entered.

Step 6.

Estimate Sample Size *Click the* ***Estimate Sample Size*** *button to calculate the minimum number of samples needed to satisfy the conditions specified in steps 2 - 5.*

Total Sample Size	50
Samples per Site (after calibration) (Total Sample Size / 2)	25

Save Sample Size *Click the* ***Save Sample Size*** *button to add the sample size estimate to the Cost Estimation worksheet.*

Before moving on, please note that this power anaalysis includes several assumptions:
- *Data are normally distributed.*
- *An unpaired or paired t-test, or linear regression with time, will be used to evaluate water quality changes.*
- *Pilot data are representative of TMDL effectiveness monitoring data.*
- *Samples are independent/random (not autocorrelated).*

If these assumptions are not met, sample size estimates will be skewed and should be viewed as general approximations only.

Sample Size Worksheet - ***Estimate the sample size needed to detect a statistically significant change.***

How many samples are needed to detect a statistically significant water quality change? This question can be answered using power analysis. As its name implies, power analysis involves the power of a statistical test. Statistical power is the likelihood that a change which has actually occurred will be detected as statistically significant. The statistical power of a test is based on five factors:

1) The statistical test being applied;
2) The desired confidence level of the test (the level of certainty that a statistically significant change has actually occurred);
3) The variability of the data being tested;
4) The size of the change; and
5) The number of samples included in analysis.

This worksheet asks users to provide information on factors 1-4 and desired power to estimate the sample size needed to detect a statistically significant change. Required input is displayed in GREEN cells.

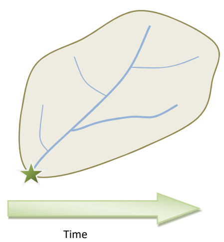
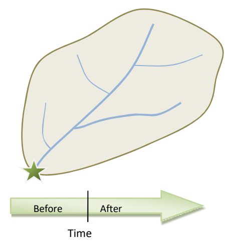
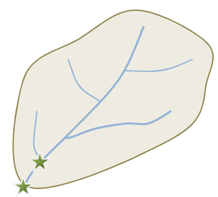
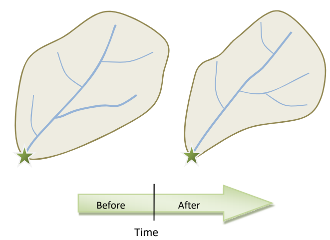
Step 1.
Select a Water Quality Parameter & Data Transformation Option

Parameter: **Dissolved Oxygen**

Data Transformation: **None** **Log(x+1)** **Square Root** **Logarithm** **Square** **Reciprocal Root**

Select the transformation option that provides data that are approximately normally-distributed (distributions can be explored in the Data Exploration worksheet). Sample size calculations assume that normally-distributed data will be used to detect post-TMDL water quality change and that a parametric statistical test will be applied. An alternative nonparametric statistical test will generally require an equivalent, or fewer, number of samples.

Step 2.
Select the study design that will be used to evaluate TMDL effectiveness *- Sample size estimates vary based on the study design (and associated statistical test) that will be used.*

Trend Monitoring	**Before/After Study**	**Upstream/Downstream Study**	**Paired Watersheds Study**
			
Assumes a linear regression with time will be applied to detect water quality change.	*Assumes a two-sample t-test will be applied to detect water quality change.*	*Assumes a two sample t-test will be applied to detect water quality change.*	*Assumes a paired t-test will be applied to detect water quality change.*

Step 3.
Enter Desired Power and Confidence Level - *Sample size increases with increased statistical power and confidence level.*

Statistical Power	0.80	*Statistical power is the probability (0 to 1) that a water quality change will be detected given that a change has actually occurred. The minimum recommended value is 0.8.*
Confidence Level	0.90	*The confidence level is the probability (0 to 1) that a water quality change that is detected has actually occurred. The minimum recommended value is 0.9.*

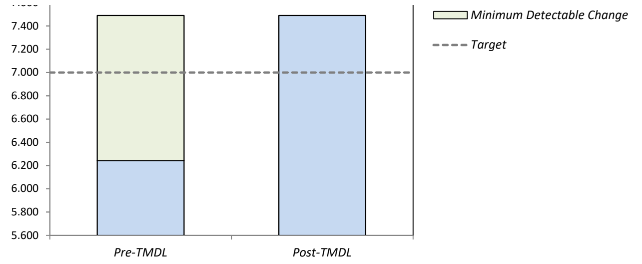
Step 4.
Estimate Data Variability (Standard Deviation) - *Sample size increases with increased data variability.*

Standard Deviation (from pilot data)	1.826	*The standard deviation of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation was applied in Step 1, the standard deviation of the transformed dataset is used for estimating sample size and is displayed here.*

Step 5.
Enter Minimum Detectable Change - *Water quality changes less than the minimum detectable change cannot be detected with statistical significance. Sample size increases with decreased minimum detectable change.*

Pre-TMDL Mean (from pilot data)	6.242	*The mean of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation is applied, the mean of transformed values is displayed in untransformed units.*
Change Type & Direction	**Percent** **Absolute** **Decrease** **Increase**	*The minimum detectable change can be entered as a percent change (e.g., a 10% decrease) or absolute change (e.g., a 0.1 mg/L decrease).*
Minimum Detectable Change	20.000 %	*Enter the desired minimum detectable change as a percent change or absolute change in untransformed units.*
Water Quality Target	7.000	*Enter the water quality target. This value is for display purposes and is not used in sample size calculations.*

7.600



The plot on the left displays three factors to take into account when selecting a minimum detectable change value:

1) The pre-TMDL condition (displayed here as the pre-TMDL mean);
2) The expected post-TMDL condition (displayed here as the pre-TMDL mean minus the minimum detectable change); and
3) The post-TMDL target.

Users may wish to designate the minimum detectable change as the change needed to achieve the water quality target (the difference between the pre-TMDL mean and the target). However, incremental changes which are less than this difference will not be detected as statistically significant. If a goal of the monitoring study is to identify incremental changes (i.e., the target is not expected to be met during the study period), a smaller minimum detectable change value should be entered.

Step 6.

Estimate Sample Size *lick the **Estimate Sample Size** button to calculate the minimum number of samples needed to satisfy the conditions specified in steps 2 - 5.*

Total Sample Size	30
Samples per Site (after calibration) (Total Sample Size / 2)	15

Save Sample Size *lick the **Save Sample Size** button to add the sample size estimate to the Cost Estimation worksheet.*

Before moving on, please note that this power analaysis includes several assumptions:
-Data are normally distributed.
-An unpaired or paired t-test, or linear regression with time, will be used to evaluate water quality changes.
-Pilot data are representative of TMDL effectiveness monitoring data.
-Samples are independent/random (not autocorrelated).
If these assumptions are not met, sample size estimates will be skewed and should be viewed as general approximations only.

Sample Size Worksheet - *Estimate the sample size needed to detect a statistically significant change.*

How many samples are needed to detect a statistically significant water quality change? This question can be answered using power analysis. As its name implies, power analysis involves the power of a statistical test. Statistical power is the likelihood that a change which has actually occurred will be detected as statistically significant. The statistical power of a test is based on five factors:

1) The statistical test being applied;
2) The desired confidence level of the test (the level of certainty that a statistically significant change has actually occurred);
3) The variability of the data being tested;
4) The size of the change; and
5) The number of samples included in analysis.

This worksheet asks users to provide information on factors 1-4 and desired power to estimate the sample size needed to detect a statistically significant change. Required input is displayed in GREEN cells.

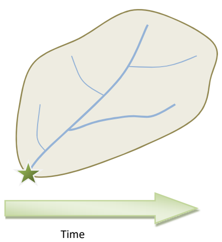
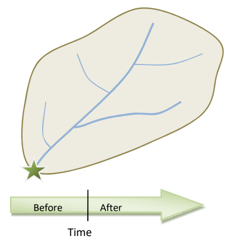
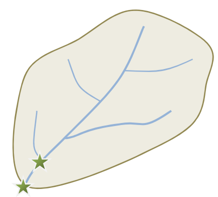
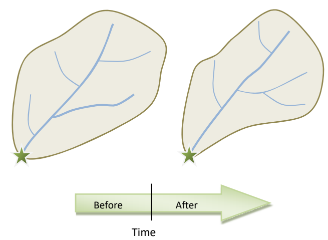
Step 1.
Select a Water Quality Parameter & Data Transformation Option

Parameter: **Temperature**

Data Transformation: (•) **None** ( ) **Log(x+1)** ( ) **Square Root** ( ) **Logarithm** ( ) **Square** ( ) **Reciprocal Root**

Select the transformation option that provides data that are approximately normally-distributed (distributions can be explored in the Data Exploration worksheet). Sample size calculations assume that normally-distributed data will be used to detect post-TMDL water quality change and that a parametric statistical test will be applied. An alternative nonparametric statistical test will generally require an equivalent, or fewer, number of samples.

Step 2.
Select the study design that will be used to evaluate TMDL effectiveness *- Sample size estimates vary based on the study design (and associated statistical test) that will be used.*

( ) **Trend Monitoring**	( ) **Before/After Study**	( ) **Upstream/Downstream Study**	(•) **Paired Watersheds Study**
			
Assumes a linear regression with time will be applied to detect water quality change.	*Assumes a two-sample t-test will be applied to detect water quality change.*	*Assumes a two sample t-test will be applied to detect water quality change.*	*Assumes a paired t-test will be applied to detect water quality change.*

Step 3.
Enter Desired Power and Confidence Level - *Sample size increases with increased statistical power and confidence level.*

Statistical Power	0.80	*Statistical power is the probability (0 to 1) that a water quality change will be detected given that a change has actually occurred. The minimum recommended value is 0.8.*
Confidence Level	0.90	*The confidence level is the probability (0 to 1) that a water quality change that is detected has actually occurred. The minimum recommended value is 0.9.*

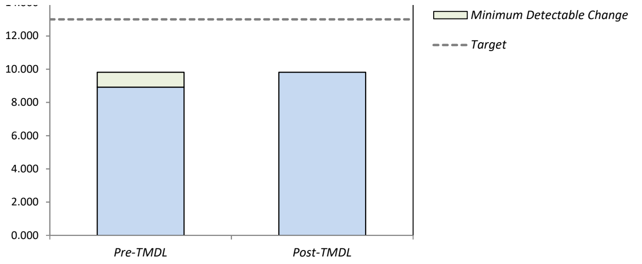
Step 4.
Estimate Data Variability (Standard Deviation) - *Sample size increases with increased data variability.*

Standard Deviation (from pilot data)	5.182	*The standard deviation of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation was applied in Step 1, the standard deviation of the transformed dataset is used for estimating sample size and is displayed here.*

Step 5.
Enter Minimum Detectable Change - *Water quality changes less than the minimum detectable change cannot be detected with statistical significance. Sample size increases with decreased minimum detectable change.*

Pre-TMDL Mean (from pilot data)	8.919	*The mean of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation is applied, the mean of transformed values is displayed in untransformed units.*
Change Type & Direction	(•) **Percent** ( ) **Absolute** ( ) **Decrease** (•) **Increase**	*The minimum detectable change can be entered as a percent change (e.g., a 10% decrease) or absolute change (e.g., a 0.1 mg/L decrease).*
Minimum Detectable Change	10.000 %	*Enter the desired minimum detectable change as a percent change or absolute change in untransformed units.*
Water Quality Target	13.000	*Enter the water quality target. This value is for display purposes and is not used in sample size calculations.*

14.000



The plot on the left displays three factors to take into account when selecting a minimum detectable change value:

1) The pre-TMDL condition (displayed here as the pre-TMDL mean);
2) The expected post-TMDL condition (displayed here as the pre-TMDL mean minus the minimum detectable change); and
3) The post-TMDL target.

Users may wish to designate the minimum detectable change as the change needed to achieve the water quality target (the difference between the pre-TMDL mean and the target). However, incremental changes which are less than this difference will not be detected as statistically significant. If a goal of the monitoring study is to identify incremental changes (i.e., the target is not expected to be met during the study period), a smaller minimum detectable change value should be entered.

Step 6.

Estimate Sample Size *Click the **Estimate Sample Size** button to calculate the minimum number of samples needed to satisfy the conditions specified in steps 2 - 5.*

Total Sample Size	422
Samples per Site (after calibration) (Total Sample Size / 2)	211

Save Sample Size *Click the **Save Sample Size** button to add the sample size estimate to the Cost Estimation worksheet.*

Before moving on, please note that this power analaysis includes several assumptions:
-Data are normally distributed.
-An unpaired or paired t-test, or linear regression with time, will be used to evaluate water quality changes.
-Pilot data are representative of TMDL effectiveness monitoring data.
-Samples are independent/random (not autocorrelated).
If these assumptions are not met, sample size estimates will be skewed and should be viewed as general approximations only.

Sample Size Worksheet - *Estimate the sample size needed to detect a statistically significant change.*

How many samples are needed to detect a statistically significant water quality change? This question can be answered using power analysis. As its name implies, power analysis involves the power of a statistical test. Statistical power is the likelihood that a change which has actually occurred will be detected as statistically significant. The statistical power of a test is based on five factors:

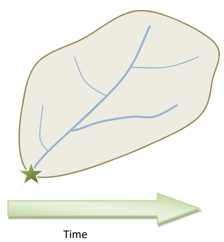
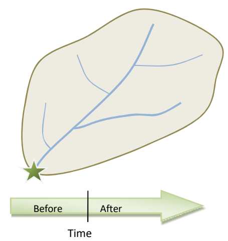
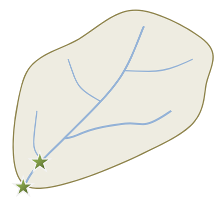
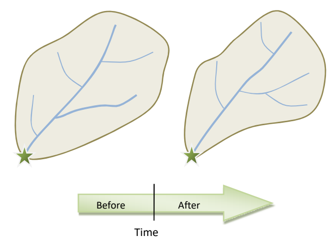
1) The statistical test being applied;
2) The desired confidence level of the test (the level of certainty that a statistically significant change has actually occurred);
3) The variability of the data being tested;
4) The size of the change; and
5) The number of samples included in analysis.

This worksheet asks users to provide information on factors 1-4 and desired power to estimate the sample size needed to detect a statistically significant change. Required input is displayed in GREEN cells.

Step 1.
Select a Water Quality Parameter & Data Transformation Option

Parameter:	**Temperature**	*Select the transformation option that provides data that are approximately normally-distributed (distributions can be explored in the Data Exploration worksheet). Sample size calculations assume that normally-distributed data will be used to detect post-TMDL water quality change and that a parametric statistical test will be applied. An alternative nonparametric statistical test will generally require an equivalent, or fewer, number of samples.*
Data Transformation:	(selected) **None** / **Log(x+1)** / **Square Root** / **Logarithm** / **Square** / **Reciprocal Root**	

Step 2.
Select the study design that will be used to evaluate TMDL effectiveness *- Sample size estimates vary based on the study design (and associated statistical test) that will be used.*

Trend Monitoring	**Before/After Study**	**Upstream/Downstream Study**	(selected) **Paired Watersheds Study**
			
Assumes a linear regression with time will be applied to detect water quality change.	*Assumes a two-sample t-test will be applied to detect water quality change.*	*Assumes a two sample t-test will be applied to detect water quality change.*	*Assumes a paired t-test will be applied to detect water quality change.*

Step 3.
Enter Desired Power and Confidence Level - *Sample size increases with increased statistical power and confidence level.*

Statistical Power	0.80	*Statistical power is the probability (0 to 1) that a water quality change will be detected given that a change has actually occurred. The minimum recommended value is 0.8.*
Confidence Level	0.90	*The confidence level is the probability (0 to 1) that a water quality change that is detected has actually occurred. The minimum recommended value is 0.9.*

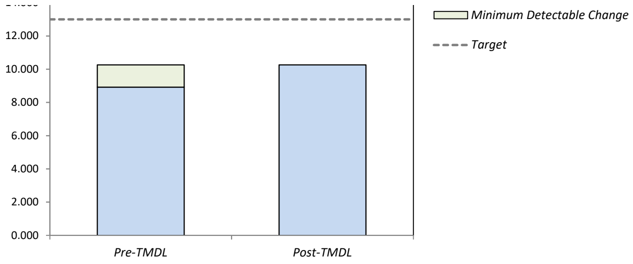
Step 4.
Estimate Data Variability (Standard Deviation) - *Sample size increases with increased data variability.*

Standard Deviation (from pilot data)	5.182	*The standard deviation of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation was applied in Step 1, the standard deviation of the transformed dataset is used for estimating sample size and is displayed here.*

Step 5.
Enter Minimum Detectable Change - *Water quality changes less than the minimum detectable change cannot be detected with statistical significance. Sample size increases with decreased minimum detectable change.*

Pre-TMDL Mean (from pilot data)	8.919	*The mean of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation is applied, the mean of transformed values is displayed in untransformed units.*
Change Type & Direction	(selected) **Percent** / **Absolute** / **Decrease** / (selected) **Increase**	*The minimum detectable change can be entered as a percent change (e.g., a 10% decrease) or absolute change (e.g., a 0.1 mg/L decrease).*
Minimum Detectable Change	15.000 %	*Enter the desired minimum detectable change as a percent change or absolute change in untransformed units.*
Water Quality Target	13.000	*Enter the water quality target. This value is for display purposes and is not used in sample size calculations.*

14.000



The plot on the left displays three factors to take into account when selecting a minimum detectable change value:

1) The pre-TMDL condition (displayed here as the pre-TMDL mean);
2) The expected post-TMDL condition (displayed here as the pre-TMDL mean minus the minimum detectable change); and
3) The post-TMDL target.

Users may wish to designate the minimum detectable change as the change needed to achieve the water quality target (the difference between the pre-TMDL mean and the target). However, incremental changes which are less than this difference will not be detected as statistically significant. If a goal of the monitoring study is to identify incremental changes (i.e., the target is not expected to be met during the study period), a smaller minimum detectable change value should be entered.

Step 6.

Estimate Sample Size *Click the* ***Estimate Sample Size*** *button to calculate the minimum number of samples needed to satisfy the conditions specified in steps 2 - 5.*

Total Sample Size	190
Samples per Site (after calibration) (Total Sample Size / 2)	95

Save Sample Size *Click the* ***Save Sample Size*** *button to add the sample size estimate to the Cost Estimation worksheet.*

Before moving on, please note that this power analaysis includes several assumptions:
- *Data are normally distributed.*
- *An unpaired or paired t-test, or linear regression with time, will be used to evaluate water quality changes.*
- *Pilot data are representative of TMDL effectiveness monitoring data.*
- *Samples are independent/random (not autocorrelated).*

If these assumptions are not met, sample size estimates will be skewed and should be viewed as general approximations only.

Sample Size Worksheet - *Estimate the sample size needed to detect a statistically significant change.*

How many samples are needed to detect a statistically significant water quality change? This question can be answered using power analysis. As its name implies, power analysis involves the power of a statistical test. Statistical power is the likelihood that a change which has actually occurred will be detected as statistically significant. The statistical power of a test is based on five factors:

1) The statistical test being applied;
2) The desired confidence level of the test (the level of certainty that a statistically significant change has actually occurred);
3) The variability of the data being tested;
4) The size of the change; and
5) The number of samples included in analysis.

This worksheet asks users to provide information on factors 1-4 and desired power to estimate the sample size needed to detect a statistically significant change. Required input is displayed in GREEN cells.

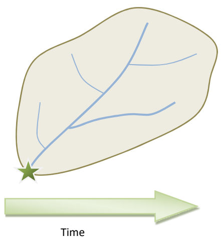
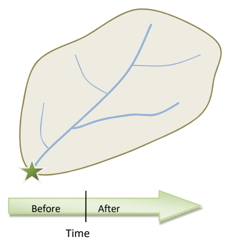
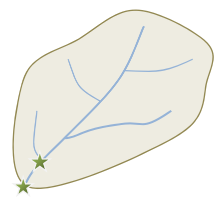
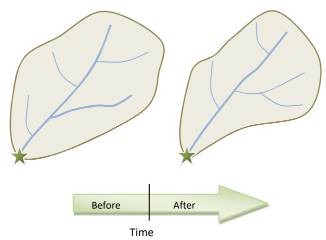
Step 1.
Select a Water Quality Parameter & Data Transformation Option

Parameter: **Temperature**

Data Transformation: (•) **None** ( ) **Log(x+1)** ( ) **Square Root** ( ) **Logarithm** ( ) **Square** ( ) **Reciprocal Root**

Select the transformation option that provides data that are approximately normally-distributed (distributions can be explored in the Data Exploration worksheet). Sample size calculations assume that normally-distributed data will be used to detect post-TMDL water quality change and that a parametric statistical test will be applied. An alternative nonparametric statistical test will generally require an equivalent, or fewer, number of samples.

Step 2.
Select the study design that will be used to evaluate TMDL effectiveness *- Sample size estimates vary based on the study design (and associated statistical test) that will be used.*

( ) **Trend Monitoring**	( ) **Before/After Study**	( ) **Upstream/Downstream Study**	(•) **Paired Watersheds Study**
			
Assumes a linear regression with time will be applied to detect water quality change.	*Assumes a two-sample t-test will be applied to detect water quality change.*	*Assumes a two sample t-test will be applied to detect water quality change.*	*Assumes a paired t-test will be applied to detect water quality change.*

Step 3.
Enter Desired Power and Confidence Level - *Sample size increases with increased statistical power and confidence level.*

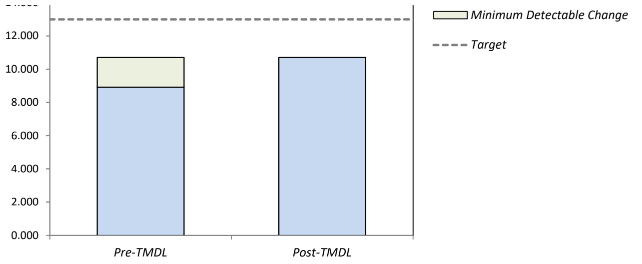
Statistical Power	0.80	*Statistical power is the probability (0 to 1) that a water quality change will be detected given that a change has actually occurred. The minimum recommended value is 0.8.*
Confidence Level	0.90	*The confidence level is the probability (0 to 1) that a water quality change that is detected has actually occurred. The minimum recommended value is 0.9.*

Step 4.
Estimate Data Variability (Standard Deviation) - *Sample size increases with increased data variability.*

Standard Deviation (from pilot data)	5.182	*The standard deviation of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation was applied in Step 1, the standard deviation of the transformed dataset is used for estimating sample size and is displayed here.*

Step 5.
Enter Minimum Detectable Change - *Water quality changes less than the minimum detectable change cannot be detected with statistical significance. Sample size increases with decreased minimum detectable change.*

Pre-TMDL Mean (from pilot data)	8.919	*The mean of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation is applied, the mean of transformed values is displayed in untransformed units.*
Change Type & Direction	(•) **Percent** ( ) **Absolute** ( ) **Decrease** (•) **Increase**	*The minimum detectable change can be entered as a percent change (e.g., a 10% decrease) or absolute change (e.g., a 0.1 mg/L decrease).*
Minimum Detectable Change	20.000 %	*Enter the desired minimum detectable change as a percent change or absolute change in untransformed units.*
Water Quality Target	13.000	*Enter the water quality target. This value is for display purposes and is not used in sample size calculations.*



The plot on the left displays three factors to take into account when selecting a minimum detectable change value:

1) The pre-TMDL condition (displayed here as the pre-TMDL mean);
2) The expected post-TMDL condition (displayed here as the pre-TMDL mean minus the minimum detectable change); and
3) The post-TMDL target.

Users may wish to designate the minimum detectable change as the change needed to achieve the water quality target (the difference between the pre-TMDL mean and the target). However, incremental changes which are less than this difference will not be detected as statistically significant. If a goal of the monitoring study is to identify incremental changes (i.e., the target is not expected to be met during the study period), a smaller minimum detectable change value should be entered.

Step 6.

Estimate Sample Size *Click the* ***Estimate Sample Size*** *button to calculate the minimum number of samples needed to satisfy the conditions specified in steps 2 - 5.*

Total Sample Size	108
Samples per Site (after calibration) (Total Sample Size / 2)	54

Save Sample Size *Click the* ***Save Sample Size*** *button to add the sample size estimate to the Cost Estimation worksheet.*

Before moving on, please note that this power analaysis includes several assumptions:
-Data are normally distributed.
-An unpaired or paired t-test, or linear regression with time, will be used to evaluate water quality changes.
-Pilot data are representative of TMDL effectiveness monitoring data.
-Samples are independent/random (not autocorrelated).
If these assumptions are not met, sample size estimates will be skewed and should be viewed as general approximations only.

Sample Size Worksheet - *Estimate the sample size needed to detect a statistically significant change.*

How many samples are needed to detect a statistically significant water quality change? This question can be answered using power analysis. As its name implies, power analysis involves the power of a statistical test. Statistical power is the likelihood that a change which has actually occurred will be detected as statistically significant. The statistical power of a test is based on five factors:

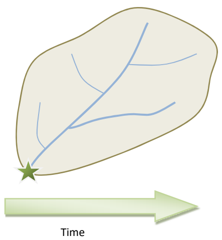
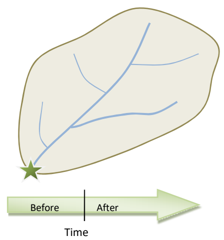
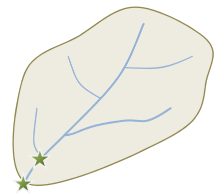
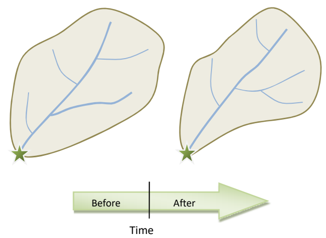
1) The statistical test being applied;
2) The desired confidence level of the test (the level of certainty that a statistically significant change has actually occurred);
3) The variability of the data being tested;
4) The size of the change; and
5) The number of samples included in analysis.

This worksheet asks users to provide information on factors 1-4 and desired power to estimate the sample size needed to detect a statistically significant change. Required input is displayed in GREEN cells.

Step 1.
Select a Water Quality Parameter & Data Transformation Option

Parameter: PH *Data Transformation:* None / Log(x+1) / Square Root / Logarithm / Square / Reciprocal Root	*Select the transformation option that provides data that are approximately normally-distributed (distributions can be explored in the Data Exploration worksheet). Sample size calculations assume that normally-distributed data will be used to detect post-TMDL water quality change and that a parametric statistical test will be applied. An alternative nonparametric statistical test will generally require an equivalent, or fewer, number of samples.*

Step 2.
Select the study design that will be used to evaluate TMDL effectiveness *- Sample size estimates vary based on the study design (and associated statistical test) that will be used.*

Trend Monitoring	Before/After Study	Upstream/Downstream Study	Paired Watersheds Study
			
Assumes a linear regression with time will be applied to detect water quality change.	*Assumes a two-sample t-test will be applied to detect water quality change.*	*Assumes a two sample t-test will be applied to detect water quality change.*	*Assumes a paired t-test will be applied to detect water quality change.*

Step 3.
Enter Desired Power and Confidence Level - *Sample size increases with increased statistical power and confidence level.*

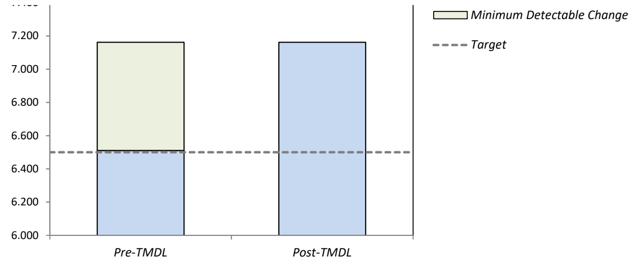
Statistical Power	0.80	*Statistical power is the probability (0 to 1) that a water quality change will be detected given that a change has actually occurred. The minimum recommended value is 0.8.*
Confidence Level	0.90	*The confidence level is the probability (0 to 1) that a water quality change that is detected has actually occurred. The minimum recommended value is 0.9.*

Step 4.
Estimate Data Variability (Standard Deviation) - *Sample size increases with increased data variability.*

Standard Deviation (from pilot data)	0.480	*The standard deviation of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation was applied in Step 1, the standard deviation of the transformed dataset is used for estimating sample size and is displayed here.*

Step 5.
Enter Minimum Detectable Change - *Water quality changes less than the minimum detectable change cannot be detected with statistical significance. Sample size increases with decreased minimum detectable change.*

Pre-TMDL Mean (from pilot data)	6.511	*The mean of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation is applied, the mean of transformed values is displayed in untransformed units.*
Change Type & Direction	Percent / Absolute Decrease / Increase	*The minimum detectable change can be entered as a percent change (e.g., a 10% decrease) or absolute change (e.g., a 0.1 mg/L decrease).*
Minimum Detectable Change	10.000 %	*Enter the desired minimum detectable change as a percent change or absolute change in untransformed units.*
Water Quality Target	6.500	*Enter the water quality target. This value is for display purposes and is not used in sample size calculations.*



The plot on the left displays three factors to take into account when selecting a minimum detectable change value:

1) The pre-TMDL condition (displayed here as the pre-TMDL mean);
2) The expected post-TMDL condition (displayed here as the pre-TMDL mean minus the minimum detectable change); and
3) The post-TMDL target.

Users may wish to designate the minimum detectable change as the change needed to achieve the water quality target (the difference between the pre-TMDL mean and the target). However, incremental changes which are less than this difference will not be detected as statistically significant. If a goal of the monitoring study is to identify incremental changes (i.e., the target is not expected to be met during the study period), a smaller minimum detectable change value should be entered.

Step 6.

Estimate Sample Size *Click the* ***Estimate Sample Size*** *button to calculate the minimum number of samples needed to satisfy the conditions specified in steps 2 - 5.*

Total Sample Size	12
Samples per Site (after calibration) (Total Sample Size / 2)	6

Save Sample Size *Click the* ***Save Sample Size*** *button to add the sample size estimate to the Cost Estimation worksheet.*

Before moving on, please note that this power analaysis includes several assumptions:
- *-Data are normally distributed.*
- *-An unpaired or paired t-test, or linear regression with time, will be used to evaluate water quality changes.*
- *-Pilot data are representative of TMDL effectiveness monitoring data.*
- *-Samples are independent/random (not autocorrelated).*

If these assumptions are not met, sample size estimates will be skewed and should be viewed as general approximations only.

Sample Size Worksheet - *Estimate the sample size needed to detect a statistically significant change.*

How many samples are needed to detect a statistically significant water quality change? This question can be answered using power analysis. As its name implies, power analysis involves the power of a statistical test. Statistical power is the likelihood that a change which has actually occurred will be detected as statistically significant. The statistical power of a test is based on five factors:

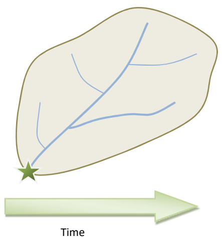
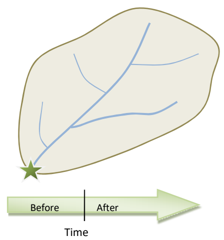
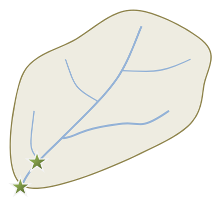
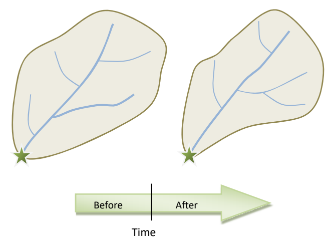
1) The statistical test being applied;
2) The desired confidence level of the test (the level of certainty that a statistically significant change has actually occurred);
3) The variability of the data being tested;
4) The size of the change; and
5) The number of samples included in analysis.

This worksheet asks users to provide information on factors 1-4 and desired power to estimate the sample size needed to detect a statistically significant change. Required input is displayed in GREEN cells.

Step 1.
Select a Water Quality Parameter & Data Transformation Option

Parameter: PH	
Data Transformation: (•) None ( ) Log(x+1) ( ) Square Root ( ) Logarithm ( ) Square ( ) Reciprocal Root	*Select the transformation option that provides data that are approximately normally-distributed (distributions can be explored in the Data Exploration worksheet). Sample size calculations assume that normally-distributed data will be used to detect post-TMDL water quality change and that a parametric statistical test will be applied. An alternative nonparametric statistical test will generally require an equivalent, or fewer, number of samples.*

Step 2.
Select the study design that will be used to evaluate TMDL effectiveness *- Sample size estimates vary based on the study design (and associated statistical test) that will be used.*

( ) Trend Monitoring	( ) Before/After Study	( ) Upstream/Downstream Study	(•) Paired Watersheds Study
			
Assumes a linear regression with time will be applied to detect water quality change.	*Assumes a two-sample t-test will be applied to detect water quality change.*	*Assumes a two sample t-test will be applied to detect water quality change.*	*Assumes a paired t-test will be applied to detect water quality change.*

Step 3.
Enter Desired Power and Confidence Level - *Sample size increases with increased statistical power and confidence level.*

Statistical Power	0.80	*Statistical power is the probability (0 to 1) that a water quality change will be detected given that a change has actually occurred. The minimum recommended value is 0.8.*
Confidence Level	0.90	*The confidence level is the probability (0 to 1) that a water quality change that is detected has actually occurred. The minimum recommended value is 0.9.*

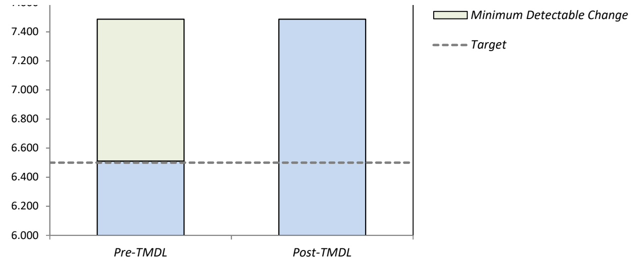
Step 4.
Estimate Data Variability (Standard Deviation) - *Sample size increases with increased data variability.*

Standard Deviation (from pilot data)	0.480	*The standard deviation of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation was applied in Step 1, the standard deviation of the transformed dataset is used for estimating sample size and is displayed here.*

Step 5.
Enter Minimum Detectable Change - *Water quality changes less than the minimum detectable change cannot be detected with statistical significance. Sample size increases with decreased minimum detectable change.*

Pre-TMDL Mean (from pilot data)	6.511	*The mean of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation is applied, the mean of transformed values is displayed in untransformed units.*
Change Type & Direction	(•) Percent ( ) Absolute ( ) Decrease (•) Increase	*The minimum detectable change can be entered as a percent change (e.g., a 10% decrease) or absolute change (e.g., a 0.1 mg/L decrease).*
Minimum Detectable Change	15.000 %	*Enter the desired minimum detectable change as a percent change or absolute change in untransformed units.*
Water Quality Target	6.500	*Enter the water quality target. This value is for display purposes and is not used in sample size calculations.*

7.600



The plot on the left displays three factors to take into account when selecting a minimum detectable change value:

1) The pre-TMDL condition (displayed here as the pre-TMDL mean);
2) The expected post-TMDL condition (displayed here as the pre-TMDL mean minus the minimum detectable change); and
3) The post-TMDL target.

Users may wish to designate the minimum detectable change as the change needed to achieve the water quality target (the difference between the pre-TMDL mean and the target). However, incremental changes which are less than this difference will not be detected as statistically significant. If a goal of the monitoring study is to identify incremental changes (i.e., the target is not expected to be met during the study period), a smaller minimum detectable change value should be entered.

Step 6.

Estimate Sample Size *Click the* ***Estimate Sample Size*** *button to calculate the minimum number of samples needed to satisfy the conditions specified in steps 2 - 5.*

Total Sample Size	8
Samples per Site (after calibration) (Total Sample Size / 2)	4

Save Sample Size *Click the* ***Save Sample Size*** *button to add the sample size estimate to the Cost Estimation worksheet.*

Before moving on, please note that this power analaysis includes several assumptions:
- *-Data are normally distributed.*
- *-An unpaired or paired t-test, or linear regression with time, will be used to evaluate water quality changes.*
- *-Pilot data are representative of TMDL effectiveness monitoring data.*
- *-Samples are independent/random (not autocorrelated).*

If these assumptions are not met, sample size estimates will be skewed and should be viewed as general approximations only.

Sample Size Worksheet - *Estimate the sample size needed to detect a statistically significant change.*

How many samples are needed to detect a statistically significant water quality change? This question can be answered using power analysis. As its name implies, power analysis involves the power of a statistical test. Statistical power is the likelihood that a change which has actually occurred will be detected as statistically significant. The statistical power of a test is based on five factors:

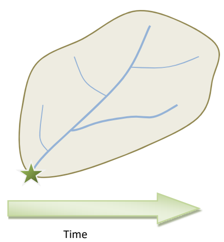
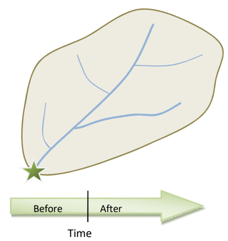
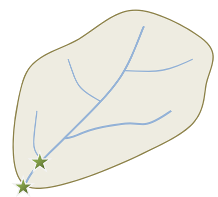
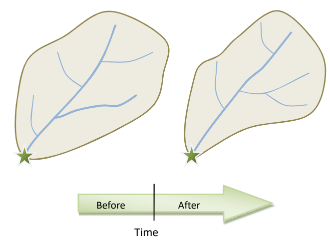
1) The statistical test being applied;
2) The desired confidence level of the test (the level of certainty that a statistically significant change has actually occurred);
3) The variability of the data being tested;
4) The size of the change; and
5) The number of samples included in analysis.

This worksheet asks users to provide information on factors 1-4 and desired power to estimate the sample size needed to detect a statistically significant change. Required input is displayed in GREEN cells.

Step 1.
Select a Water Quality Parameter & Data Transformation Option

Parameter: PH	
Data Transformation: (•) None ( ) Log(x+1) ( ) Square Root ( ) Logarithm ( ) Square ( ) Reciprocal Root	*Select the transformation option that provides data that are approximately normally-distributed (distributions can be explored in the Data Exploration worksheet). Sample size calculations assume that normally-distributed data will be used to detect post-TMDL water quality change and that a parametric statistical test will be applied. An alternative nonparametric statistical test will generally require an equivalent, or fewer, number of samples.*

Step 2.
Select the study design that will be used to evaluate TMDL effectiveness *- Sample size estimates vary based on the study design (and associated statistical test) that will be used.*

( ) Trend Monitoring	( ) Before/After Study	( ) Upstream/Downstream Study	(•) Paired Watersheds Study
			
Assumes a linear regression with time will be applied to detect water quality change.	*Assumes a two-sample t-test will be applied to detect water quality change.*	*Assumes a two sample t-test will be applied to detect water quality change.*	*Assumes a paired t-test will be applied to detect water quality change.*

Step 3.
Enter Desired Power and Confidence Level - *Sample size increases with increased statistical power and confidence level.*

Statistical Power	0.80	*Statistical power is the probability (0 to 1) that a water quality change will be detected given that a change has actually occurred. The minimum recommended value is 0.8.*
Confidence Level	0.90	*The confidence level is the probability (0 to 1) that a water quality change that is detected has actually occurred. The minimum recommended value is 0.9.*

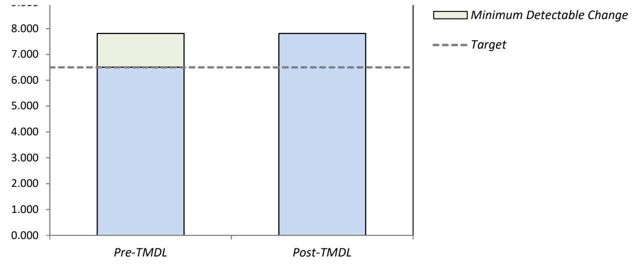
Step 4.
Estimate Data Variability (Standard Deviation) - *Sample size increases with increased data variability.*

Standard Deviation (from pilot data)	0.480	*The standard deviation of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation was applied in Step 1, the standard deviation of the transformed dataset is used for estimating sample size and is displayed here.*

Step 5.
Enter Minimum Detectable Change - *Water quality changes less than the minimum detectable change cannot be detected with statistical significance. Sample size increases with decreased minimum detectable change.*

Pre-TMDL Mean (from pilot data)	6.511	*The mean of the selected parameter is calculated from data entered in the Pilot Data worksheet. If a transformation is applied, the mean of transformed values is displayed in untransformed units.*
Change Type & Direction	(•) Percent ( ) Absolute ( ) Decrease (•) Increase	*The minimum detectable change can be entered as a percent change (e.g., a 10% decrease) or absolute change (e.g., a 0.1 mg/L decrease).*
Minimum Detectable Change	20.000 %	*Enter the desired minimum detectable change as a percent change or absolute change in untransformed units.*
Water Quality Target	6.500	*Enter the water quality target. This value is for display purposes and is not used in sample size calculations.*

9.000



The plot on the left displays three factors to take into account when selecting a minimum detectable change value:

1) The pre-TMDL condition (displayed here as the pre-TMDL mean);
2) The expected post-TMDL condition (displayed here as the pre-TMDL mean minus the minimum detectable change); and
3) The post-TMDL target.

Users may wish to designate the minimum detectable change as the change needed to achieve the water quality target (the difference between the pre-TMDL mean and the target). However, incremental changes which are less than this difference will not be detected as statistically significant. If a goal of the monitoring study is to identify incremental changes (i.e., the target is not expected to be met during the study period), a smaller minimum detectable change value should be entered.

Step 6.

Estimate Sample Size *Click the* ***Estimate Sample Size*** *button to calculate the minimum number of samples needed to satisfy the conditions specified in steps 2 - 5.*

Total Sample Size	6
Samples per Site (after calibration) (Total Sample Size / 2)	3

Save Sample Size *Click the* ***Save Sample Size*** *button to add the sample size estimate to the Cost Estimation worksheet.*

Before moving on, please note that this power analaysis includes several assumptions:
- *-Data are normally distributed.*
- *-An unpaired or paired t-test, or linear regression with time, will be used to evaluate water quality changes.*
- *-Pilot data are representative of TMDL effectiveness monitoring data.*
- *-Samples are independent/random (not autocorrelated).*

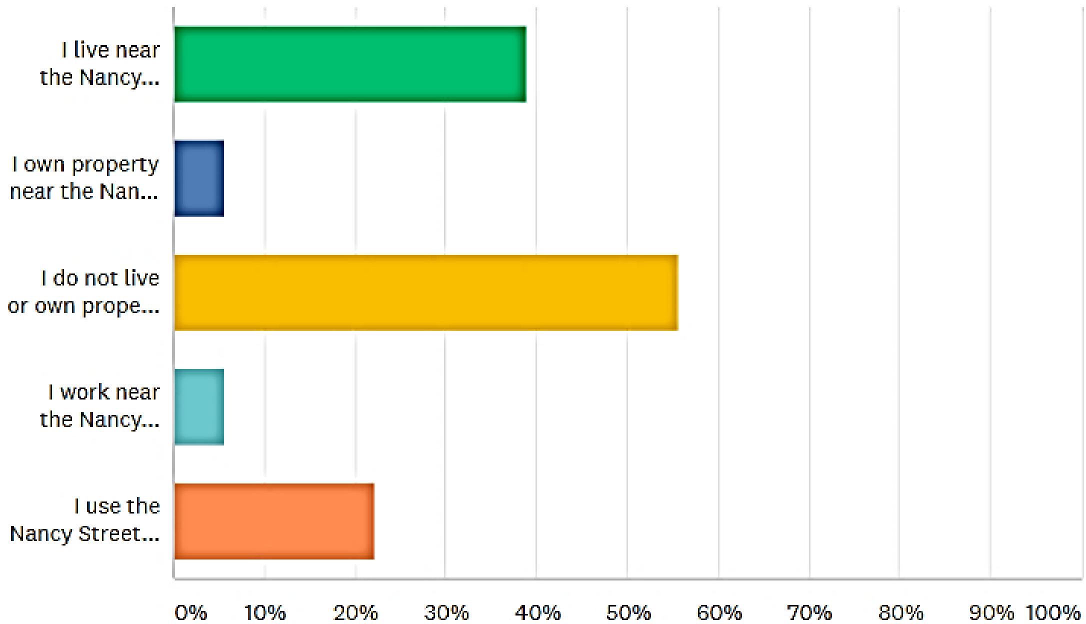
If these assumptions are not met, sample size estimates will be skewed and should be viewed as general approximations only.

Appendix H. Nancy Street Wetland User Survey Responses

Nancy St. Wetland User Survey Data as of 12/31/2017

Q1 Which of the following describes you? (check all that apply)

Answered: 18 Skipped: 0

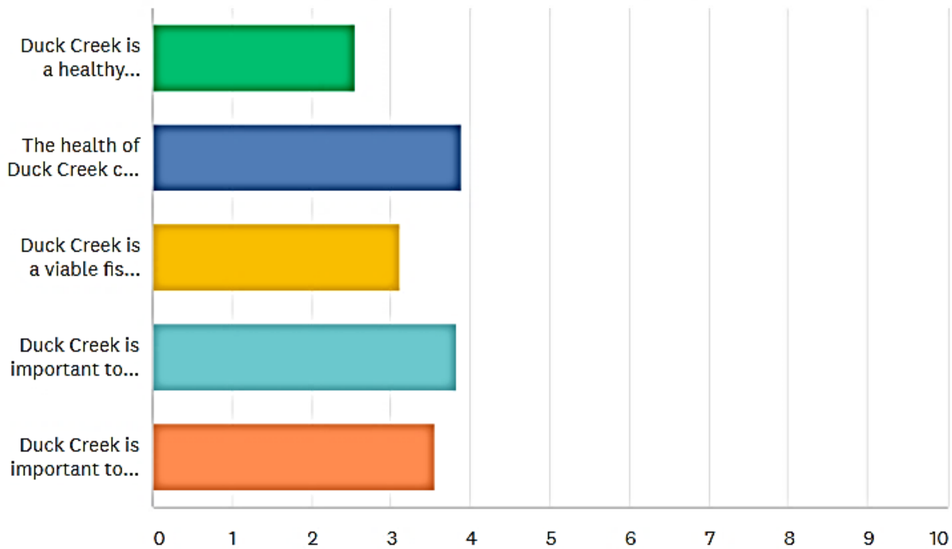


ANSWER CHOICES	RESPONSES	
I live near the Nancy Street Wetland, in the Tall Timbers Subdivision (includes Nancy St., Gail Ave., Bresee St., Tongass Blvd., Marilyn Ave., Malissa Dr.)	38.89%	7
I own property near the Nancy Street Wetland, in the Tall Timbers Subdivision (as described above).	5.56%	1
I do not live or own property near in the Nancy Street Wetland (as described above).	55.56%	10
I work near the Nancy Street Wetland (includes Glacier Valley Elementary, Glacier Cinema, and Church of Nazarene).	5.56%	1
I use the Nancy Street Wetland for recreation.	22.22%	4

Nancy St. Wetland User Survey Data as of 12/31/2017

Q2 Do you agree with the following statements?

Answered: 18   Skipped: 0

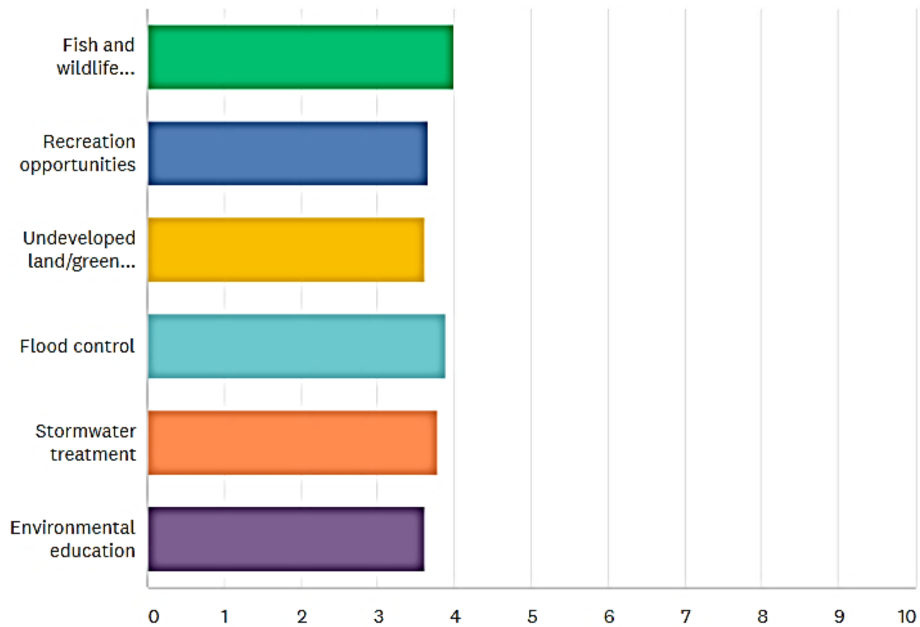


	STRONGLY DISAGREE	DISAGREE	NO OPINION	AGREE	STRONGLY AGREE	TOTAL	WEIGHTED AVERAGE
Duck Creek is a healthy stream	0.00% 0	61.11% 11	22.22% 4	16.67% 3	0.00% 0	18	2.56
The health of Duck Creek can be improved	0.00% 0	5.56% 1	11.11% 2	72.22% 13	11.11% 2	18	3.89
Duck Creek is a viable fish stream	5.56% 1	27.78% 5	27.78% 5	27.78% 5	11.11% 2	18	3.11
Duck Creek is important to me as a resident of Juneau	5.56% 1	11.11% 2	5.56% 1	50.00% 9	27.78% 5	18	3.83
Duck Creek is important to the community of Juneau	11.11% 2	11.11% 2	11.11% 2	44.44% 8	22.22% 4	18	3.56

Nancy St. Wetland User Survey Data as of 12/31/2017

Q3 Do you agree that the following are benefits/values of the Nancy St. Wetland?

Answered: 18 Skipped: 0

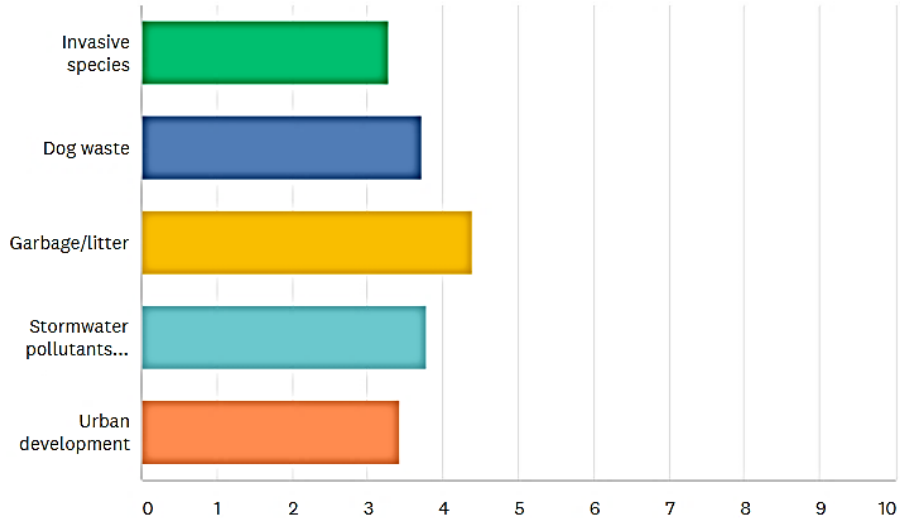


	STRONGLY DISAGREE	DISAGREE	NO OPINION	AGREE	STRONGLY AGREE	TOTAL	WEIGHTED AVERAGE
Fish and wildlife habitat	5.56% 1	5.56% 1	11.11% 2	38.89% 7	38.89% 7	18	4.00
Recreation opportunities	5.56% 1	11.11% 2	16.67% 3	44.44% 8	22.22% 4	18	3.67
Undeveloped land/green space	11.11% 2	5.56% 1	22.22% 4	33.33% 6	27.78% 5	18	3.61
Flood control	5.56% 1	0.00% 0	22.22% 4	44.44% 8	27.78% 5	18	3.89
Stormwater treatment	5.56% 1	5.56% 1	22.22% 4	38.89% 7	27.78% 5	18	3.78
Environmental education	5.56% 1	5.56% 1	33.33% 6	33.33% 6	22.22% 4	18	3.61

Nancy St. Wetland User Survey Data as of 12/31/2017

Q4 Do you agree that the following are threats to the Nancy Street Wetland's health?

Answered: 18 Skipped: 0



–	STRONGLY DISAGREE	DISAGREE	NO OPINION	AGREE	STRONGLY AGREE	TOTAL	WEIGHTED AVERAGE
Invasive species	11.11% 2	16.67% 3	16.67% 3	44.44% 8	11.11% 2	18	3.28
Dog waste	0.00% 0	16.67% 3	16.67% 3	44.44% 8	22.22% 4	18	3.72
Garbage/litter	0.00% 0	0.00% 0	0.00% 0	61.11% 11	38.89% 7	18	4.39
Stormwater pollutants (e.g. sediment, oils, fuels)	5.56% 1	11.11% 2	5.56% 1	55.56% 10	22.22% 4	18	3.78
Urban development	11.11% 2	11.11% 2	16.67% 3	44.44% 8	16.67% 3	18	3.44

Nancy St. Wetland User Survey Data as of 12/31/2017

Q5 What do you perceive to be the greatest benefit/value of the Nancy Street Wetland? The greatest threat? This can be a benefit, value or threat identified from the previous questions, or something different.

- Answered: 18
- Skipped: 0

RESPONSES (18)

There was not enough information to make a determined opinion but I know that since the city turned it into what it is now only became an activity for hangouts for suspicious activities- the brush is overgrown I'm afraid to walk through the walk because of bears - And then to run into suspicious people and cars and boats and campers camping out there - you all Just made it into a hide out for suspicious activity
10/18/2017 8:20 PM

Migratory birds nesting in the area easily seen due to the the trail . Loose cats in area
10/18/2017 8:40 AM

Keep it healthy
10/15/2017 4:07 PM

Walkable green space . Easy access to view Birds and their young !!!! This wetland is very important for migratory birds " like red wing black birds , kinglets , and common yellowthroats that return each year to nest and rear their young. The greatest threat to any accessible green space are irresponsible humans not packing out their trash or picking up their dog waste . Loose cats are another threat , years ago we use to have sandpipers nest in the area , but cats wiped them out .
10/15/2017 1:05 PM

Over the top wetland conservationist
10/15/2017 12:14 PM

Fish habitat
10/15/2017 9:27 AM

Undeveloped land, parklike area
10/15/2017 8:22 AM

Invasive species.
10/14/2017 11:51 PM

Nancy St. Wetland User Survey Data as of 12/31/2017

Fish and wild life habit, great threat glacier rebound
10/14/2017 11:17 PM

Stormwater treatment is biggest benefit
10/14/2017 11:06 PM
.
10/14/2017 11:04 PM

Top benefit- wildlife habitat Top threat- litter
10/14/2017 10:48 PM

Benefit = Green space
10/14/2017 10:22 PM

Value: Fish and wildlife habitat. Threat: pollutants from runoff
10/14/2017 9:39 PM

Too many weeds in the stream and the trail is not maintained that well.
10/13/2017 9:10 PM

Benefit - open space and stormwater treatment.
10/7/2017 8:25 PM

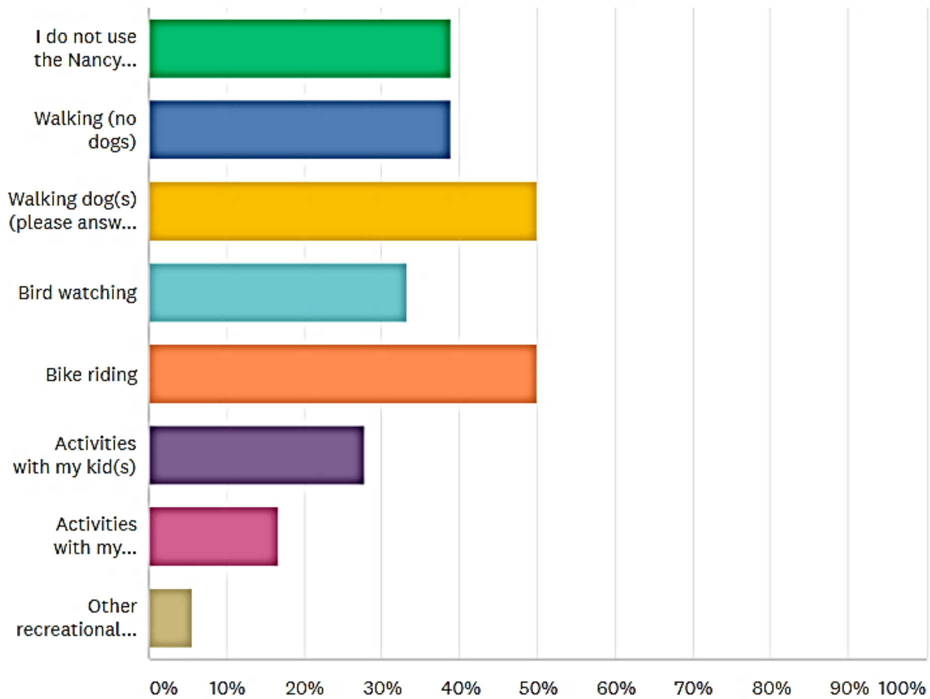
Stop wasting my tax dollars on this and fill it in, we need the land and housing so much more than this waste of time and effort.
10/7/2017 5:12 PM

Clean water. Bird habitat.
10/7/2017 1:38 PM

Nancy St. Wetland User Survey Data as of 12/31/2017

Q6 Do you use the Nancy Street Wetland for any of the following activities? (Select all that apply)

Answered: 18 Skipped: 0

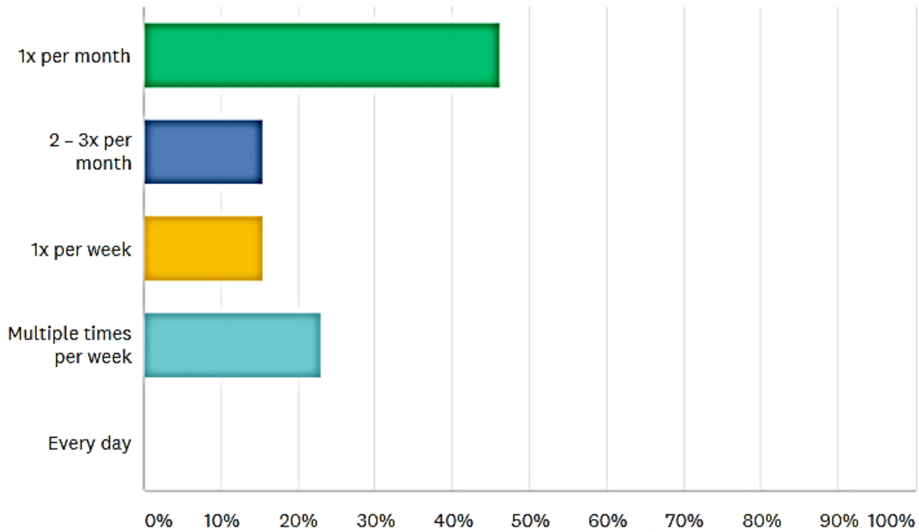


ANSWER CHOICES–	RESPONSES
I do not use the Nancy Street Wetland (skip Questions #7 and #8, continue to Question #9)	38.89% 7
Walking (no dogs)	38.89% 7
Walking dog(s) (please answer Question #8)	50.00% 9
Bird watching	33.33% 6
Bike riding	50.00% 9
Activities with my kid(s)	27.78% 5
Activities with my students (if you’re a teacher)	16.67% 3
Other recreational activities not listed	5.56% 1

Nancy St. Wetland User Survey Data as of 12/31/2017

Q7 If you use the Nancy Street Wetland for any of the activities listed in Question #6, how often do you visit? (select the best that describes the frequency of your visits)

Answered: 13   Skipped: 5

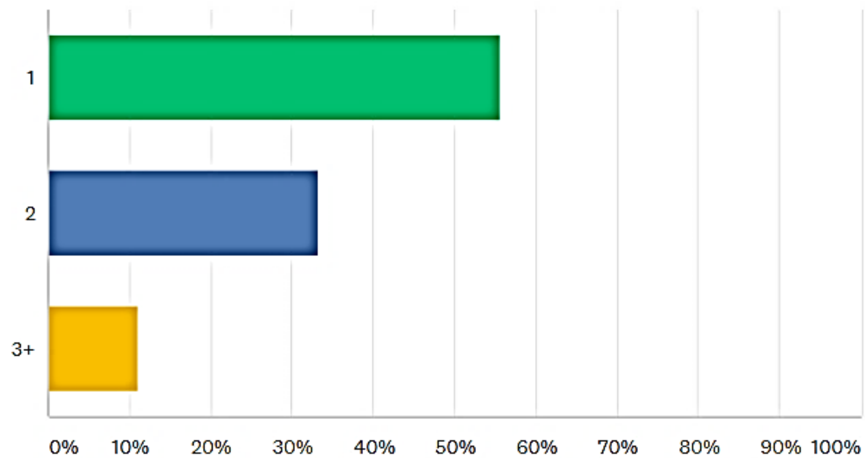


ANSWER CHOICES	RESPONSES
1x per month	46.15% 6
2 – 3x per month	15.38% 2
1x per week	15.38% 2
Multiple times per week	23.08% 3
Every day	0.00% 0

Nancy St. Wetland User Survey Data as of 12/31/2017

Q8 If you walk your dog(s) at the Nancy St. Wetland, how many dog(s) do you have? (Please skip if you do not walk your dog(s) at the wetland)

Answered: 9   Skipped: 9

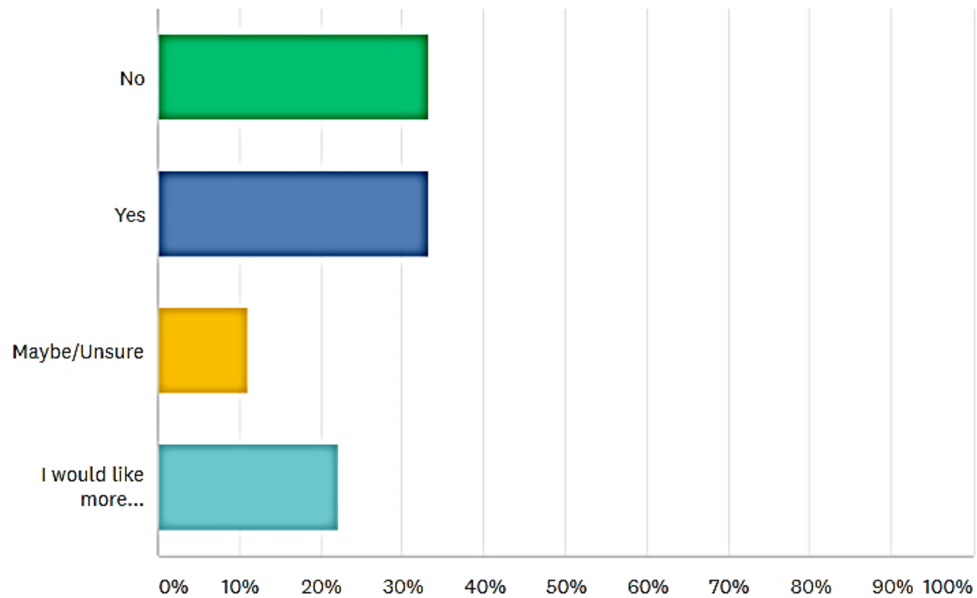


ANSWER CHOICES	RESPONSES	
1	55.56%	5
2	33.33%	3
3+	11.11%	1

Nancy St. Wetland User Survey Data as of 12/31/2017

Q9 Invasive plants are moving into the Nancy Street Wetland. Some invasive plants, like reed canarygrass, are difficult to manage without herbicide. Would you support the responsible use of herbicides in combination with non-chemical measures for controlling invasive plants.

Answered: 18 Skipped: 0



ANSWER CHOICES	RESPONSES
No	33.33% 6
Yes	33.33% 6
Maybe/Unsure	11.11% 2
I would like more information before deciding	22.22% 4

Nancy St. Wetland User Survey Data as of 12/31/2017

Q10 Anything you'd like to share about the Nancy Street Wetland or Duck Creek? This can be things you love about the wetland or Duck Creek, improvements you want to see, or concerns you have regarding their future. Thank you for participating in our survey!

- Answered: 6
- Skipped: 12

RESPONSES (6)

See previous input
10/18/2017 8:20 PM

It a thriving wetlands, and getting better each year
10/18/2017 8:40 AM

This is a special wetlands among our community that is increasing each year with more birds and wildlife looking to take refuge . This allows families to view such wildlife in their own backyard when they would not be able to otherwise. This wetlands deserves our protection..... fish (salmon fry etc....) are increasing in the area as well .
10/15/2017 1:05 PM

Keep the druggies and homeless out and you won't as much garbage.
10/15/2017 12:14 PM

More public education about this particular resource.
10/14/2017 9:39 PM

Stop wasting tax dollars on Nancy Street Wetlands, fill it in, we need the land and housing so much more than this waste of time and effort.
10/7/2017 5:12 PM