MIDDLESEX TOWNSHIP,
CUMBERLAND COUNTY, PENNSYLVANIA

Illicit Discharge Detection & Elimination Program
(IDD&E)

Revised June 2026

MIDDLESEX TOWNSHIP, CUMBERLAND COUNTY, PENNSYLVANIA

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Revised June 30, 2026

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REVISIONS LIST

Revision #	Page #	Section	Modification Description	Date
1		General	Grammar and rephrasing edits throughout.	6/30/2026
2		Cover	Updated date.	6/30/2026
3		Title Page	Updated date and consultant name.	6/30/2026
4	1 & 2	1.2 Exceptions	Updated the designation of PA DEP as an EPA-designated agency to accurately reflect its role as the permitting authority for non-stormwater discharge categories. Updated list of non-stormwater discharge categories to reflect what is in the current Middlesex Township MS4 permit	6/30/2026

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ACRONYMS

CFR - Code of Federal Regulations

EPA - U.S. Environmental Protection Agency

IDD&E - Illicit Discharge Detection and Elimination

MS4 - Municipal Separate Storm Sewer System

OFS - Outfall Field Screening

PA DEP - Pennsylvania Department of Environmental Protection

SWM - Stormwater Management

DEFINITIONS (excerpted from Middlesex Township MS4 Permit)

Clean Water Act (CWA) means the Federal Water Pollution Control Act, as amended, 33 U.S.C.A. §§ 1251 - 1387.

Dry Weather means a condition in which there are no precipitation, snowmelt, drainage or other events producing a stormwater discharge for more than 48 consecutive hours.

Illicit Connection means any physical connection to a municipal separate storm sewer system that can convey illicit discharges into the system and/or is not authorized or permitted by the permittee.

Illicit Discharge means any discharge to a municipal separate storm sewer that is not composed entirely of stormwater, except non-stormwater discharges as described in the "Discharges Authorized by this Permit" section of this Permit. Examples of illicit discharges include dumping of motor vehicle fluids, household hazardous waste, grass clippings, leaf litter, animal wastes, or unauthorized discharges of sewage, industrial waste, restaurant wastes, or any other non-stormwater waste into a municipal separate storm sewer system. Illicit discharges can be accidental or intentional.

Municipal separate storm sewer means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to surface waters; (ii) Designed or used for collecting or conveying stormwater; (iii) Which is not a combined sewer; and (iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2. (25 Pa. Code § 92a.32(a) and 40 CFR § 122.26(b)(8))

Municipal Separate Storm Sewer System (MS4) means all separate storm sewers that are defined as "large" or "medium" or "small" municipal separate storm sewer systems pursuant to 40 CFR §§ 122.26(b)(4), (b)(7), and (b)(16), respectively, or designated under 40 CFR § 122.26(a)(1)(v). (25 Pa. Code § 92a.32(a) and 40 CFR §122.26(b)(18))

Municipality means a city, town, borough, county, township, school district, institution, authority or other public body created by or pursuant to State Jaw and having jurisdiction over disposal of sewage, industrial waste or other wastes. (25 Pa. Code § 92a.2)

New Permittee means any entity that has been designated as a regulated small MS4 and has not previously obtained permit coverage under the PAG-13 General Permit or obtained an Individual NPDES MS4 Permit.

Observation point means a location upstream of an outfall where a permittee must conduct dry weather screening in accordance with Part C 1.8.3.d of this permit if the permittee determines that screening at an outfall is infeasible, and the point at which stormwater discharges to storm sewers owned or operated by an adjoining municipality where dry weather screening must be conducted.

Ordinance means a law enacted by the government of a municipality.

Outfall means a point source as defined by 40 CFR § 122.2 at the point where a municipal separate storm sewer discharges to surface waters and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels or other conveyances which connect segments of the same stream or other surface waters and are used to convey surface waters. (25 Pa. Code § 92a.32(a) and 40 CFR § 122.26(b)(9))

Owner or Operator means the owner or operator of any "facility" or "activity" subject to regulation under the NPDES program. (25 Pa. Code § 92a.3(b)(1) and 40 CFR § 122.2)

Permittee means the owner or operator of a regulated small MS4 authorized to discharge under the terms of this permit.

Point Source means a discernible, confined, and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, Concentrated Aquatic Animal Production Facility (CAAP), Concentrated Animal Feeding Operation (CAFO), landfill leachate collection system, or vessel or other floating craft from which pollutants are or may be discharged. (25 Pa. Code § 92a.2)

Pollutant means any contaminant or other alteration of the physical, chemical, biological, or radiological integrity of surface water which causes or has the potential to cause pollution as defined in section 1 of the Pennsylvania Clean Streams Law, 35 P.S. § 691.1. (25 Pa. Code § 92a.2)

Regulated Small MS4 means any small MS4 that is covered by the federal Phase II stormwater program, either through automatic nationwide designation under 40 CFR § 122.32(a)(1) (via the Urbanized Area criteria) or by designation on a case-by-case basis by DEP pursuant to 40 CFR § 122.32(a)(2). "Regulated small MS4s" are a subset of "small MS4s" as defined in this section.

Riparian Forest Buffer means an area of permanent vegetation consisting of native trees, shrubs, forbs and grasses along surface water that is maintained in a natural state or sustainably managed to protect and enhance water quality, stabilize stream channels and banks, and buffer land use activities from surface waters.

Small Municipal Separate Storm Sewer System (Small MS4) means an MS4, as defined in this section, that is not a large or medium MS4 pursuant to 40 CFR §§ 122.26(b)(4) and 122.26(b)(7). The term small MS4 includes systems similar to separate storm sewer systems in municipalities, such as systems at military bases, large hospital or prison complexes, and highways and other thoroughfares. The term does not include separate storm sewers in very discrete areas, such as individual buildings. (25 Pa. Code § 92a.32(a) and 40 CFR§ 122.26(b)(16))

Stormwater means runoff from precipitation, snow melt runoff and surface runoff and drainage. "Stormwater" has the same meaning as "storm water." (25 Pa. Code § 92a.2)

Surface Waters means perennial and intermittent streams, rivers, lakes, reservoirs, ponds, wetlands, springs, natural seeps and estuaries, excluding water at facilities approved for wastewater treatment such as wastewater treatment impoundments, cooling water ponds and constructed wetlands used as part of a wastewater treatment process. (25 Pa. Code § 92a.2)

Total Maximum Daily Load (TMDL) means the sum of individual waste load allocations for point sources, load allocations for nonpoint sources and natural quality and a margin of safety expressed in terms of mass per time, toxicity or other appropriate measures. (25 Pa. Code § 96.1)

Urbanized Area (UA) means land area comprising one or more places (central place(s)) and the adjacent densely settled surrounding area (urban fringe) that together have a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile, as defined by the United States Bureau of the Census and as determined by the latest available decennial census. The UA outlines the extent of automatically regulated areas.

1.0 BASIS FOR THE PROGRAM

Middlesex Township (Township) is undertaking the Illicit Discharge Detection and Elimination (IDD&E) Program for the Municipal Separate Storm Sewer System (MS4) as part of coverage under its National Pollutant Discharge Elimination System (NPDES) permit. The MS4 NPDES Permit applies only to urban runoff that flows through municipally owned and operated stormwater infrastructure with an identifiable concentrated discharge (outfall) to a surface water. The urbanized area is the portion of the Township that is located within the Urbanized Area boundaries as defined by the 2010 U.S. Census.

The regulated portion of the Township consists of the urbanized area and the contributory region upgradient of the urbanized area flowing to and through the Township's storm sewer system. The MS4 system consists of the municipally owned and operated stormwater conveyance network, including roads with drainage systems, municipal streets, and a series of stormwater management facilities, including inlets, pipes, swales, outfalls, catch basins, curbs, gutters, ditches, man-made channels, and storm drains that collect and convey stormwater from impervious areas and discharge them into various locations.

The Township is a 26-square-mile municipality in Cumberland County, Pennsylvania. It is located northeast of the Borough of Carlisle and approximately 16 miles west of the state's capital, Harrisburg. The northern border follows the ridgeline of the Blue Mountains that separate Cumberland and Perry Counties, and it is surrounded to the north by Carroll and Rye Townships, to the east by Silver Spring Township, to the south by South Middleton Township, and to the west by North Middleton Township. The regulated Township MS4 area includes 4.4 square miles of the municipality as shown by **Figure 1 - Middlesex Township Urbanized and MS4 regulated Areas**. The Township MS4 is subject to the IDD&E procedures outlined in this manual.

The various components include impervious surfaces that produce increased runoff. The runoff is collected and conveyed through the MS4 and ultimately makes its way to surface waterways. The IDD&E program is the strategies to find, correct, and prevent contaminated stormwater discharges to the waters of the U.S./Commonwealth from the MS4.

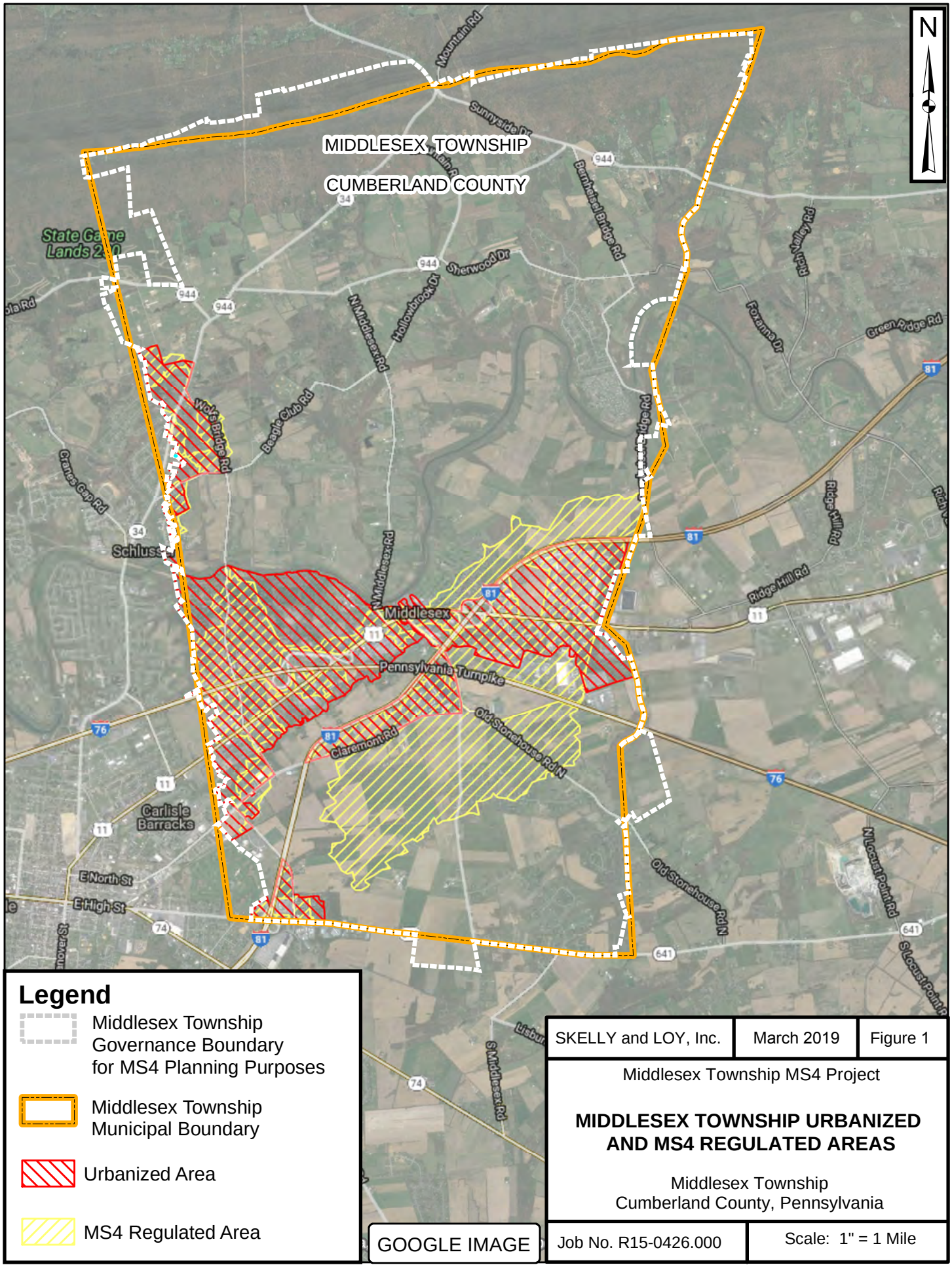
1.1 Enabling Legislation

This Program applies to monitoring discharges within the current MS4 area to comply with Pennsylvania's Chapter 92a *National Pollutant Discharge Elimination System (NPDES) Permitting, Monitoring and Compliance*, specifically regarding compliance with stormwater discharges (25 Pa. Code § 92a.32) and the Clean Water Act (CWA) *U.S. Code of Federal Regulations* (CFR). Title 40: Protection of Environment. Minimum Control Measure (MCM) #3 (40 CFR§ 122.34(b)(3)) explains the federal requirement for MS4 permit holders to identify and eradicate sources of stormwater-borne pollutants to U.S. surface waters as part of the permittee's Stormwater Management (SWM) Program.

1.2 Exceptions

Illicit discharges are any flows from the stormwater system that are non-stormwater, however, there are a few exceptions. PA DEP identifies the following categories of non-stormwater discharges that do not require elimination unless the Township designates them as significant contributors of pollutants. The categories include:

- Discharges or flows from firefighting activities
- Discharges from potable water sources including water line flushing and fire hydrant flushing, if such discharges do not contain detectable concentrations of Total Residual Chlorine (TRC)
- Non-contaminated irrigation water, water from lawn maintenance, landscape drainage and flows from riparian habitats and wetlands
- Diverted stream flows and springs
- Non-contaminated pumped ground water and water from foundation and footing drains and crawl space pumps
- Non-contaminated HVAC condensation and water from geothermal systems
- Residential (i.e., not commercial) vehicle wash water where cleaning agents are not utilized
- Non-contaminated hydrostatic test water discharges, if such discharges do not contain detectable concentrations of TRC



Legend

- Middlesex Township Governance Boundary for MS4 Planning Purposes
- Middlesex Township Municipal Boundary
- Urbanized Area
- MS4 Regulated Area

GOOGLE IMAGE

SKELLY and LOY, Inc.	March 2019	Figure 1

Middlesex Township MS4 Project

MIDDLESEX TOWNSHIP URBANIZED AND MS4 REGULATED AREAS

Middlesex Township
Cumberland County, Pennsylvania

Job No. R15-0426.000	Scale: 1" = 1 Mile

1.3 Required Program Components:

Per Middlesex Township's MS4 permit, Best Management Practice (BMP) #1 under Minimum Control Measure (MCM) #3 requires the following to be accomplished by the Township Stormwater Management Program:

The permittee shall develop, implement and enforce a program to detect and eliminate illicit discharges into the permittee's regulated small MS4.

a) **BMP #1**: The permittee shall develop and implement a written program for the detection, elimination, and prevention of illicit discharges into the regulated small MS4. The program shall include the following:

- Procedures for identifying priority areas. These are areas with a higher likelihood of illicit discharges, illicit connections or illegal dumping. Priority areas may include areas with older infrastructure, a concentration of high-risk activities, or past history of water pollution problems.
- Procedures for screening outfalls in priority areas. The program shall include dry weather field screening of outfalls for non-stormwater flows, and sampling of dry weather discharges for selected chemical and biological parameters. Test results shall be used as indicators of possible discharge sources.
- Procedures for identifying the source of an illicit discharge when a contaminated flow is detected at a regulated small MS4 outfall.
- Procedures for eliminating an illicit discharge.
- Procedures for assessing the potential for illicit discharges caused by the interaction of sewage disposal systems (e.g., on-lot septic systems, sanitary piping) with storm drain systems.
- Mechanisms for gaining access to private property to inspect outfalls (e.g., land easements, consent agreements, search warrants) and for investigating illicit connections and discharges.
- Procedures for program documentation, evaluation and assessment. Records shall be kept of all outfall inspections, flows observed, results of field screening and testing, and other follow-up investigation and corrective action work performed under this program.
- Procedures for addressing information or complaints received from the public.

1.4 Township Authority to Prohibit Illicit Connection and Dumping into the MS4

Article VII of the Township Stormwater Ordinance (Ord. No. 6 – 2011) addresses issues related to runoff, including critical IDD&E factors. The statutes and policy provide the Township with the enforcement capability to eliminate illicit discharges from the Township's storm sewer system. Specifically, Article VII Prohibitions prohibits "any non-stormwater discharge, including sewage, process wastewater, and wash water to enter the municipality's separate storm water system or waters of the Commonwealth".

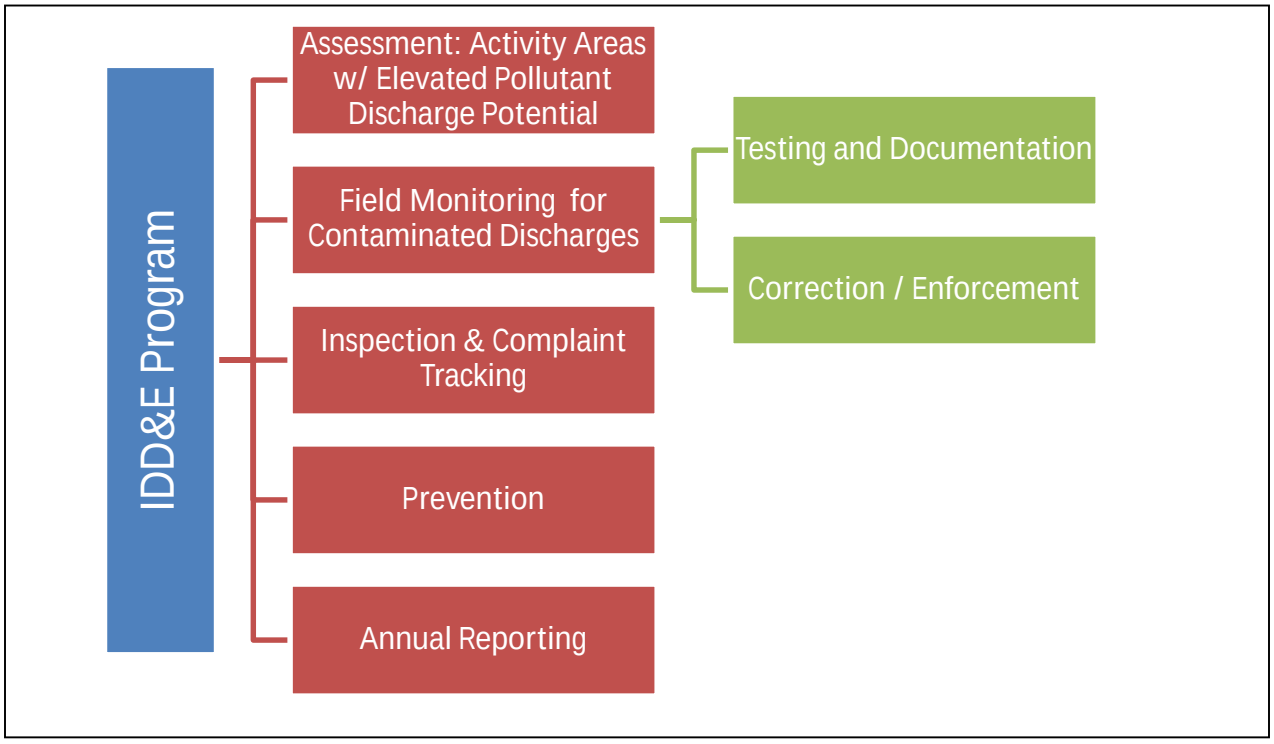
Article VIII allows the Township to enter a property and to inspect any aspect regulated by the Stormwater Ordinance.

2.0 PROGRAM FUNDAMENTALS

The Township's IDD&E Program contains the same fundamental components practiced by MS4's nationwide. The primary elements of the Program were originally outlined by the Center for Watershed Protection (CWP) in its publication, Illicit Discharge Detection and Elimination – A Guidance Manual for Program Development and Technical Assessments (IDD&E Guidance) and are diagrammed below.

(https://www3.epa.gov/npdes/pubs/idde_manualwithappendices.pdf)

Figure 2: IDD&E Program Elements



The Township IDD&E Program utilizes the CWP IDD&E Guidance to the extent practical because it is featured by the U.S. Environmental Protection Agency (EPA) as a primary resource for developing an IDD&E Program and is an agency-accepted methodology for recognizing and eliminating potential stormwater-borne pollution. (The CWP IDD&E Guidance is also provided as a resource on the PADEP MCM #3 webpage https://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater/MCM/Pages/MCM-3-Illicit-Discharges.aspx)

3.0 PROCEDURES FOR IDENTIFYING PRIORITY AREAS/ PRIORITY OUTFALLS

The goal of priority areas is to identify regions within the Township MS4 with the strongest potential to release illicit discharges. There are two methods to identify Priority Areas, including (1) likelihood of potential illicit discharge based on desktop assessment and (2) history of confirmed illicit discharges based on field testing.

3.1 Desktop Assessment

Desktop Assessment includes review of aerial mapping sources such as Google Earth, review of subdivision and land development plans, and other documentation, such as building and industrial NPDES permits, to identify intensely developed areas land uses having elevated pollutant discharge potential.

The 'Miracle Mile' was identified as a Priority Area in the initial term through desktop assessment. The Miracle Mile, as it is known locally, includes the north-south Interstate 81 (I-81) angled across the Township from its southwest corner to the middle of the eastern municipal boundary. The Turnpike and I-81 have interchanges along U.S. Route 11 separated by a little over one mile. The nexus of these roads defines the most intensive land uses in the region with high concentrations of long-haul trucking terminals, service plaza, hotels, eateries, and several transportation-dependent headquarters (such as Giant Foods and AHOLD, Inc.).

During the initial permit cycle, only one potential illicit discharge was flagged through outfall inspection. The source of illicit discharge was from an adjacent MS4 and was not illicit. Because of its track record, the geographic area known as the Miracle Mile will now follow the routine inspection cycle described in Section 4.0 below.

New and reconstructed properties will continue to be evaluated and will be added as a Priority Area if they are suspected to have elevated polluting potential.

3.2 Field Assessment

Outfalls with a history of illicit discharges or where collected samples of dry weather water exceed pre-determined indicators (See Appendices B and C) two or more times in a single permit period will be classified as Priority Outfalls. Additionally, outfalls can become classified as Priority Outfalls based on the frequency of past discharge complaints, stormwater complaint reports, and spill responses within the contributing drainage area.

4.0 PROCEDURES FOR SCREENING OUTFALLS

4.1 Overview

As an existing permittee, stormwater outfalls regulated by the Township MS4 NPDES permit must be inspected at least one time (1x) during the five-year (5-year) permit term, as specified by BMP #4 under MCM#3 of Middlesex Township's MS4 Individual Permit. An outfall with confirmed illicit discharge will be classified as a Priority Outfall. It will be inspected every 6 months until a history of four consecutive compliant inspections are completed, and it can be removed from the Priority Outfall list. Middlesex Township outfalls located in, or that have collection/conveyance infrastructure in Priority Areas will be inspected for illicit discharges two times (2x) time per five-year (5-year) permit term, unless the outfalls have met the four consecutive compliant inspection threshold, at which time the outfalls will transfer to the one time (1x) inspection during the five-year (5-year) permit term cycle.

An outfall located in an area that is dangerous or infeasible to access via the Township right-of-way will be screened at the closest identified observation point within the common drainage conveyance of the outfall. IDD&E screening for an outfall located outside of the Township property falls under the responsibility of the adjacent municipal or MS4 permit holder. The Township will share the location of observation points associated with these adjacent MS4 outfalls with the respective municipalities. The Township will only perform IDD&E screening at observation points when searching for a source of pollution and during a monitoring period following resolution of a confirmed illicit discharge.

Outfalls identified in the original permit are numbered from downstream to upstream, starting with '0' for the furthest downstream outfall. The outfall numbers correspond to the Township's storm sewer system maps, which are maintained in the Township GIS database that is stored on in an ESRi cloud-based system and are subject to periodic updates as necessary. Added outfalls will not trigger renumbering of the system to retain the downstream to upstream sequence; they will be the next consecutive number. Outfalls within Priority Areas are identified as such within the database.

4.2 Outfall Field Screening (OFS) Protocol

4.2.1 Dry-weather Screening Responsible Party

The Outfall Field Screening is performed by trained professional consultants to verify the outfall locations and field-test data collection tools and reporting forms. Middlesex Township reserves the option to transition the Township's Outfall Screening to municipal maintenance personnel trained by the Township's professional consultants. If discharge is discovered during a dry-weather screening and characterized as a potential illicit discharge, investigation duties to identify the pollutant will be performed by the Township's professional consultant.

4.2.2 Outfall Screening Documentation

The PA DEP MS4 Outfall Field Screening (OFS) Report (3800-FM-BCW0521-see Appendix B) will be used to record findings. This reporting form standardizes the Township's field monitoring and reporting between seasons and from year to year for efficient recordkeeping. OFSs corresponding to outfalls scheduled for the current field screening season will be pre-populated with available data (e.g. subwatershed, outfall ID, latitude/longitude, land use, etc.) and accompanied by tailored maps or mobile GIS applications to guide personnel in the field.

At the outfall location, photo-documentation will take place and data collected as prompted by the OFS, regardless of the presence or absence of flows. For flowing outfalls, the Dry Weather Flow Evaluation of the OFS will be completed based on observations and preliminary screening, as necessary. Field screening reports will be uploaded to GIS and digitally stored at the Township Office.

4.2.3 Screening Methods Reference

Selected text from A Guide to Indicators and Monitoring Methods, downloaded from PA DEP's MS4 Resources webpage, is provided in Appendix C. (The Guidance was excerpted by PA DEP from a publication entitled *Designing Your Monitoring Program - A Technical Handbook for Community-based Monitoring in Pennsylvania*.) As stated above, Maintenance personnel will conduct preliminary screening to determine if discharges are present. A trained consultant will determine if the discharges are illicit in nature and conduct field parameter testing for determining if follow-up investigative measures are necessary to eliminate an illicit discharge.

4.2.4 Planning and Testing

For dry weather field screenings, the goal is to observe outfalls during dry conditions (48 consecutive hours of less than 0.1" of rainfall). It will be the responsibility of the field team to monitor weather reports and plan the field work accordingly.

Whether or not illicit discharges are detected from dry-weather field screenings, the MS4 Outfall Screening Report (PA DEP Form 3800-FM-BCW0521) provided in Appendix B, or Township equivalent form, should be completed for each observed outfall. The following list identifies the critical data fields for reporting:

- Outfall identification number
- Date and Time of Screening
- Individual(s) performing the screening
- Approximate Date of Last Rain
- Land Use in Contributing Drainage Area
- Outfall Description (Type, Material, Shape, Dimensions, Submerged)
- Dry Weather Flow Presence
- Description of Flow Rate
- Dry Weather Flow Evaluation
- Field/Laboratory Analysis (Field Screening of pH, Temperature, Specific Conductance, Dissolved Oxygen)

If a discharge is observed from any outfall during dry weather screenings, the discharge shall be inspected for color, odor, floating solids, scum, sheen, and substances that result in observed deposits in the surface waters. In addition, the discharge cannot contain substances that result in deposits in the receiving waters or produce an observable change in the color, odor, or turbidity of the receiving water. If the discharge exhibits any of the above characteristics or the field-testing parameters (pH, temperature, conductivity, dissolved oxygen) are abnormal to the local system and indicate that there is a possible illicit discharge, the screening personnel will report the outfall for follow-up investigation.

Dry-weather flows without any sign of illicit discharge may be permissible. A list of EPA permissible non-stormwater discharges is previously described in Section 1.2. This in-field determination should be noted on the OFS, effectively ending the investigation.

Investigations of illicit discharges are to be documented completely using the OFS form, pictures, and supplemental information as warranted (e.g., test results). Documentation will be forwarded for filing in the IDD&E Case Files at the Township Office. These files are a repository for IDD&E cases triggered by scheduled outfall inspections as well as those initiated by Township personnel, municipal residents, or business observations. Field work, communication documentation, and desktop analysis relating to a given case are maintained at this single location for quick reference. Copies of OFSs for outfalls with dry-weather flows determined not to be illicit discharges in the field are also kept with the case files but are considered closed.

5.0 PROCEDURES FOR IDENTIFYING THE SOURCE OF ILLICIT DISCHARGES

Where a violation constitutes an immediate danger to public health or safety, the Township personnel or first responders must act swiftly to cut off pollution to surface waterways and eliminate the source.

5.1 Illicit Discharge Notifications

If an Illicit discharge is identified at any time, including during a dry weather outfall screening meeting the criteria in the commentary below, the Township must also take the action prescribed below to report the issue to PA DEP.

According to 25 PA Code §91.33 and §92a.41(b), the permittee shall immediately report any incident causing or threatening pollution. The following steps will be initiated by notification by the field municipal personnel to the Township's MS4 Coordinator or the Coordinator's designee.

1. *If*, because of an accident or other activity or incident a toxic substance which would endanger users downstream from the discharge or would otherwise result in pollution or create a danger of pollution or would damage property, the Township shall immediately notify PA DEP by telephone of the location and nature of the danger. Oral notification to the department is required as soon as possible, but no later than four (4) hours after the Township becomes aware of the incident threatening pollution.
2. If reasonably possible to do so, the Township shall immediately notify downstream users of the waters of the Commonwealth to which the substance was discharged. Such notice shall include the location and nature of the danger.
3. The Township shall immediately take or cause to be taken steps necessary to prevent injury to property and downstream users of the waters from pollution or a danger of pollution and, in addition, within 15 days from the incident, shall remove the residual substances contained thereon or therein from the ground and from the affected waters of the Commonwealth to the extent required by applicable law.

In the case of any unanticipated non-compliance incident which may endanger health or the environment, the Township shall follow the requirements of 40 CFR §122.41(l)(6). The following requirements will be initiated by notification by municipal field personnel to the Township's MS4 Coordinator or the Coordinator's designee. These requirements include the following obligations:

4. *24 Hour Reporting - The Township shall orally report any non-compliance with this MS4 permit which may endanger health or the environment within 24 hours from the time the Township becomes aware of the circumstances.*
5. *Written Report – A written submission shall also be provided within 5 days of the time the Township becomes aware of any non-compliance which may endanger the health or the environment. The written submission shall contain a description of the non-compliance and its cause; the period of non-compliance, including exact dates and times, and if the non-compliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate and prevent reoccurrence of the non-compliance.*
6. *Waiver of the Written Report – PA DEP may waive the written report on a case-by-case basis if the associated oral report has been received within 24 hours of the time the Township becomes aware of the circumstances which may endanger health or the environment. Unless such a waiver is expressly granted by PA DEP, the Township shall submit a written report in accordance with this paragraph. (25 PA Code §92.a.3(c) and 40 CFR § 122.41(l)(6)(iii)).*

5.2 Illicit Discharge Response: Within the Township Boundary

Discharges within the Township's control will be traced upstream from the discharge to search for the source of the pollution. The pollutant source will be eliminated through the combination of education and maintenance operations. The outfall will be revisited and retested, as appropriate, until the elimination of the pollution has been verified. Outfalls identified as having an illicit discharge shall be placed on the priority outfall screening priority list and the procedures detailed in Section 6.0 Procedure for Eliminating an Illicit Discharge will be implemented**.**

5.3 Illicit Discharge Response: Outside the Township Boundary

Since the Township has no legal authority beyond its Township boundaries, it may not be possible to identify the source of an apparent illicit discharge if dry-weather flows are present and not originating within Township boundaries. Using the Township's storm sewer system map, the municipal inspector who is tracking the illicit discharge should identify the name of the adjacent municipality or MS4 permittee from which the discharge is emanating and provide the information to the Township's MS4 Coordinator or the Coordinator's designee.

The Township's MS4 Coordinator or the Coordinator's designee will be responsible for the subsequent notifications that will follow a tiered approach.

1. The adjacent municipality/MS4 will be contacted by phone to alert the municipality/MS4 of the illicit discharge and to inform them that the PA DEP will be notified, as required by regulation.
2. If the adjacent municipality/MS4 cannot be reached or is non-responsive, notifications to the PA DEP should be made as described above in Section **5.1 Illicit Discharge Notification**s without delay.

In instances where direct coordination with the upstream municipality/MS4 is unsuccessful, the Township, in its initial outreach to PA DEP, should confirm that PA DEP will complete notification to the upstream municipality(ies)/MS4(s) to the point of illicit discharge origin. The Township will re-evaluate the observation point within 30 days of the Township-observed illicit discharge. If the illicit discharge remains unresolved, the Township will issue follow up letters to the upstream municipality/MS4 and to PA DEP and include a request that PA DEP and the adjacent municipality/MS4 notify the Township when the illicit discharge has been resolved.

When notification of illicit discharge resolution is received from PA DEP and/or the upstream municipality/MS4, the observation point will be identified as a Priority Area and will be inspected as described in Section **4.0 Procedures for Screening Outfalls.**

5.4 Procedures for Tracking Pollution Sources

There are several methods that may be employed to locate the source of an illicit discharge. The Township will predominately rely on visual/sensory inspections, but may also use video inspection, dye testing, or smoke testing.

5.4.1 Visual/Sensory Inspections

Once an illicit discharge has been verified, the inspection team will refer to the stormwater network map to familiarize themselves with the contributing system and identify if there is a connection to an upstream MS4 (referred to as an Observation Point). Generally, any connection to an upstream MS4 will be inspected first to determine if the source of the discharge is within the jurisdiction of the Township or if it is emanating from the upstream municipality/MS4. This inspection will rely on observations that the inspectors can make using sight and smell to observe color, odor, floating solids, scum, sheen, and substances that result in observed deposits in the surface waters indicating the presence of materials other than stormwater within the stormwater network that discharges to the polluted outfall. If the source is confirmed to be emanating from the upstream municipality/MS4, the Township will notify the adjacent municipality/MS4 and PA DEP as stated above in Section 5.5 **Illicit Discharge Response: Outside the Township Boundary**.

If there is no evidence of the pollutant at an upstream Observation Point, the inspection team will systematically visually examine the flow path of the stormwater runoff beginning at the compromised outfall and working upstream along the conveyance system until the source of the illicit discharge is located. Observations for stormwater enclosed in pipes will be made at inlets and manholes. Only properly certified personnel for confined spaces will be permitted to enter stormwater pipes, inlets, and manholes.

5.4.2 Dye Testing

Dye testing requires non-toxic dyes to be flushed down facility toilets and sinks. Pre-positioned observers watch for the passage of the dye at sanitary and storm manholes. The presence of dye in the stormwater system would indicate an interconnection of the stormwater and sanitary system. The Township is unlikely to use this method to identify connections from outside the Township right-of-way since the Township cannot require

private property owners to allow the injection of dye through their toilets and sinks.

5.4.3 Smoke Testing

Smoke testing is a relatively simple process that consists of blowing smoke mixed with large volumes of air into the sanitary sewer line usually induced through the manhole. The smoke travels the path of least resistance and quickly shows up at sites that allow surface water inflow. Where the Township is served by public sewer, and smoke testing is selected as a means or determining infiltration and inflow, the Township will coordinate with the local sanitary sewer provider.

Once sanitary sewer interaction is discovered, it can be resolved directly by the Township or by requiring a vendor or co-located sanitary sewer utility operator to take the required corrective actions.

5.4.4 Video Inspection

While expensive and time consuming, remotely operated mobile video cameras can be used to examine storm sewer lines to observe possible illegal connections into the storm sewer system. The method allows definitive identification of unauthorized connection and video imaging provides reliable documentation.

6.0 PROCEDURE FOR ELIMINATING AN ILLICIT DISCHARGE

If the source of an illicit discharge is Middlesex Township, the Township will determine the appropriate approach to eliminate the illicit discharge depending on the type and volume of pollutant discharge. Corrective action will be documented.

The Township has authority to compel the owners of properties discharging pollution to take corrective measures to eliminate the source of pollution. The Township:

- Regulates stormwater management and sanitary sewage activities within the Township. Therefore, the Township has authority to investigate the source of pollution even if the source of illicit discharge is emanating from private property.
- Can use land easements, consent agreements, and search warrants to access private property.
- Has the authority to directly implement corrective measures and subsequently invoice the owner of the property generating the pollution for the corrective action taken by the Township.
- Has the authority to place liens on a property for nonpayment of reimbursement to the Township compensating the municipality for intervention to eliminate the source of pollution.

Any illicit discharge emanating from outside the Township property is under adjacent municipal/MS4 jurisdiction and is their responsibility. As stated in Section **5.0 Procedures for Identifying the Source of Illicit Discharges**, the Township will notify the upstream municipality/MS4 of the illicit discharge so that corrective action can be pursued by the municipality or MS4. If the municipality/MS4 cannot be reached, PA DEP will be contacted for managing corrective action. The Township will request that the municipality/MS4 and/or DEP provide confirmation of elimination and actions taken to eliminate the illicit discharge.

7.0 PROCEDURES FOR ASSESSING POTENTIAL ILLICIT DISCHARGE BY THE INTERACTION OF SEWAGE DISPOSAL SYSTEMS

Interactions between sewage disposal systems and stormwater systems located on Township property or within Township rights-of-way are most commonly related to the uses listed below.

- Schools
- Businesses
- Churches
- Residences

Once evidence of sanitary sewage is discovered at an outfall, the same discovery procedure described in Section 5.6 Procedures for Tracking Pollution Sources will be followed. The First step will be to determine if the source is on property owned and operated by the Township, a privately-owned property, another property with a public-sector owner, or emanating from an upstream municipality/MS4. This will be accomplished through the

inspection of observation points where the upstream municipality or MS4's stormwater enters the Township MS4.

The Township will then examine potential sources within the Township boundary. To aid in identification of the source the sanitary sewer interaction, the Township might rely on Dye or Smoke Testing or by use of a Video Inspection (See Section **5.6 Procedures for Tracking Pollution Sources**).

7.1 Interaction between sewage systems located outside the Township Boundary

Interaction of sewage systems located outside the Township boundary is under another municipality or MS4's jurisdiction and is their responsibility. As stated in Section **5.0. Procedures for Identifying the Source of Illicit Discharges**, the Township will notify the upstream municipality/MS4 and PA DEP of the illicit discharge so that corrective action can be pursued by the municipality/MS4 and/or PA DEP.

8.0 PROCEDURES FOR PROGRAM DOCUMENTATION, EVALUATION AND ASSESSMENT

Reporting shall be performed based on a reporting period of July 1 to June 30. At the conclusion of each reporting year, an activity report will be produced to detail that year's work under the IDD&E Program. The IDD&E work will be an integral part of the MS4 Annual Status Report (3800-FM-BCW0491) and will consist of the following elements, as applicable:

1. Written Program Review
2. MS4 Mapping Updates
3. Storm Sewer Collection System Mapping Updates
4. Outfall Screening Activities (including results from any lab testing)
5. Employee & Public Education

9.0 PROCEDURES FOR ADDRESSING INFORMATION OR COMPLAINTS RECEIVED FROM THE PUBLIC

The Middlesex Combined Public Education and Outreach Program (PEOP) and Public Involvement/ Participation Program (PIPP) is a way for municipal residents and businesses to become involved with the IDD&E process. Part of the Township's public awareness campaign is using municipal residents and businesses to report any unusual fluids entering or discharging from the storm sewer system, especially during dry weather conditions.

The role of Township staff is to investigate and pursue remedies for illicit discharges reported by municipal residents and businesses or observed by Township personnel. Public comments are recorded, tracked, and stored at the Township Office. A prompt visual inspection of the site will take place, resulting in an assessment of the perceived illicit discharge through photo-documentation and tracking it back to a potential source or to the Township's upstream MS4 boundary. If pollutants are suspected, the subsequent process will mirror that which is used in the Township regularly scheduled field monitoring regimen.

The Township receives complaints from the public via the Township phone number. Calls are fielded by the Township receptionist and then transferred to the MS4 Coordinator or the Coordinator's designee, who determines if the complaint requires an emergency response or is a non-emergency issue. Emergency responses are managed by the MS4 Coordinator or the Coordinator's designee who notifies emergency responders and federal, state, and local offices. Non-emergency issues are directed through the Township's Stormwater Complaint Process for response by the MS4 Coordinator or the Coordinator's designee.

Appendix A
Middlesex Township Cumberland County Ordinance No. 6 – 2011, Article VII and VIII

(Amending the Subdivision and Land Development Ordinance and Adopting a Stormwater Management Ordinance)

ARTICLE VII - PROHIBITIONS

Section 701. Prohibited Discharges and Connections

A. Any drain or conveyance, whether on the surface or subsurface, which allows any non-stormwater discharge including sewage, process wastewater, and wash water to enter the waters of this Commonwealth is prohibited.

B. No person shall allow, or cause to allow, discharges into surface waters of this Commonwealth which are not composed entirely of stormwater, except (1) as provided in subsection C below, and (2) as allowed under a state or federal permit.

C. The following discharges are authorized unless they are determined to be significant contributors to pollution to the waters of this Commonwealth. In the event that Middlesex Township or DEP determines that any of the discharges identified in Subsection C, significantly contribute to pollution of the waters of this Commonwealth, Middlesex Township or DEP will notify the responsible person(s) to cease the discharge.

-Discharges from fire fighting activities	-Flows from riparian habitats and wetlands
-Potable water sources including water line flushing	-Uncontaminated water from foundations or from footing drains
-Irrigation drainage	-Lawn watering
-Air conditioning condensate	-Dechlorinated swimming pool discharges
-Springs	-Uncontaminated groundwater
-Water from crawl space pumps	-Water from individual residential car washing
-Pavement wash waters where spills or leaks of toxic or hazardous materials have not occurred (unless all spill material has been removed) and where detergents are not used	-Routine external building wash down (which does not use detergents or other compounds)

Section 702. Roof Drains and Sump Pumps

Roof drains and sump pumps shall not discharge to any impervious area, subject to site conditions.

Section 703. Alteration of SWMP BMPs

No person shall modify, remove, fill, landscape, or alter any BMP, facilities, areas, or structures, without the written approval of Middlesex Township.

ARTICLE VIII - ENFORCEMENT AND PENALTIES

Section 801. Right-of-Entry

Upon presentation of proper credentials, the representatives of Middlesex Township may enter at reasonable times upon any property within the Township to inspect the condition of the BMPs in regard to any aspect regulated by this Ordinance.

Section 802. Enforcement

A. It shall be unlawful for a person to undertake any Regulated Activity except as provided in an approved SWMP, unless specifically exempted in *Section 106* of this Ordinance.

B. Inspections regarding compliance with the SWMP during project construction are a responsibility of the applicant. Middlesex Township reserves the right to conduct inspections at any time during and after construction.

Section 803. Suspension and Revocation

A. Any approval or permit issued by Middlesex Township may be suspended or revoked for:

1. Non-compliance with or failure to implement any provision of the approved SWMP or Operation and Maintenance Agreement.

2. A violation of any provision of this Ordinance or any other applicable law, ordinance, rule or regulation relating to the Regulated Activity.

3. The creation of any condition or the commission of any act during the Regulated Activity which constitutes or creates a hazard or nuisance, pollution, or which endangers the life or property of others.

B. A suspended approval may be reinstated by Middlesex Township when:

1. Middlesex Township has inspected and approved the corrections to the violations that caused the suspension.

2. Middlesex Township is satisfied that the violation has been corrected.

C. An approval that has been revoked by Middlesex Township cannot be reinstated. The Applicant may apply for a new approval under the provisions of this Ordinance.

D. If a violation causes no immediate danger to life, public health, or property, at its sole discretion, Middlesex Township may provide a limited time period for the owner to correct the violation. In these cases, the Township will provide the owner, or the owner's designee, with a written notice of the violation and the time period allowed for the owner to correct the violation. If the owner does not correct the violation within the allowed time period, the Township may revoke or suspend any, or all, applicable approvals and permits pertaining to any provision of this Ordinance.

Section 804. Penalties

A. Anyone violating the provisions of this Ordinance shall be guilty of a summary offense, and upon conviction shall be subject to a fine of not more than $1,000 for each violation, recoverable with costs. Each day that the violation continues shall be a separate offense and penalties shall be cumulative.

B. In addition, Middlesex Township may institute injunctive, mandamus, or any other appropriate action or proceeding at law or in equity for the enforcement of this Ordinance. Any court of competent jurisdiction shall have the right to issue restraining orders, temporary or permanent injunctions, mandamus, or other appropriate forms of remedy or relief.

Section 805. Appeals

A. Any person aggrieved by any action of Middlesex Township or its designee, relevant to the provisions of this Ordinance, may appeal to Middlesex Township within thirty (30) days of that action giving rise to the appeal.

B. Any person aggrieved by any decision of Middlesex Township as a result of a timely appeal made as provided in Section 805.A, above, may appeal to the Cumberland County Court of Common Pleas within thirty (30) days of the decision of Middlesex Township.

Appendix B
PA DEP MS4 Outfall Field Screening Report (OFS)
[PADEP Form 3800-FM-BCW0521]

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF CLEAN WATER

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

MS4 OUTFALL FIELD SCREENING REPORT

BACKGROUND INFORMATION

Permittee Name:	NPDES Permit No.: PA
Date of Inspection:	Outfall ID No.:
Land Uses in Outfall Drainage Area (Select All):	Latitude: ____° ____' ____"
☐ Industrial ☐ Urban Residential	Longitude: ____° ____' ____"
☐ Commercial ☐ Suburban Residential	Dry Weather Inspection? ☐ Yes ☐ No
☐ Open Space ☐ Other:	Date of Previous Precipitation:
	Amount of Previous Precipitation: in
Inspector Name(s):	Were Photographs Taken? ☐ Yes ☐ No
	Are Photographs Attached? ☐ Yes ☐ No

OUTFALL DESCRIPTION

TYPE	MATERIAL	SHAPE	DIMENSIONS	SUBMERGED
☐ Closed Pipe	☐ RCP ☐ CMP ☐ PVC ☐ HDPE ☐ Steel ☐ Other	☐ Circular ☐ Single ☐ Elliptical ☐ Double ☐ Box ☐ Triple ☐ Other ☐ Other	Diameter: ____ in	☐ In Water ☐ With Sediment
☐ Open Channel	☐ Concrete ☐ Earthen ☐ Rip-Rap ☐ Other	☐ Trapezoid ☐ Parabolic ☐ Other	Depth: ____ in Top Width: ____ in Bottom Width: ____	

Dry Weather Flow Present at Outfall During Inspection? ☐ Yes ☐ No *(If No, skip to Certification Section)*

Description of Flow Rate: ☐ Trickle ☐ Moderate ☐ Significant ☐ N/A

DRY WEATHER FLOW EVALUATION

Does the dry weather flow contain color? ☐ Yes ☐ No If Yes, provide a description below.

Does the dry weather flow contain an odor? ☐ Yes ☐ No If Yes, provide a description below.

Is there an observed change in the receiving waters as a result of the discharge? ☐ Yes ☐ No
If Yes, provide a description below.

Does the dry weather flow contain floating solids, scum, sheen or substances that result in deposits? ☐ Yes ☐ No
If Yes, provide a description below.

Were sample(s) collected of the dry weather flow? ☐ Yes ☐ No (If Yes, No. Samples: _____)

FIELD / LABORATORY ANALYSIS

PARAMETER	RESULTS	UNITS	PARAMETER	RESULTS	UNITS
Flow Rate		GPM	Fecal Coliform		No./100 mL
pH		S.U.	COD		mg/L
Total Residual Chlorine (TRC)		mg/L	BOD5		mg/L
Conductivity		µmhos/cm	TSS		mg/L
Ammonia-Nitrogen		mg/L	TDS		mg/L
Other: _____			Oil and Grease		mg/L
Other: _____			Other: _____		

Indicate the parameters above that were analyzed by a DEP-certified laboratory:

ILLICIT DISCHARGES

Is the dry weather flow an illicit discharge? ☐ Yes ☐ No

If Yes, describe efforts made to determine the source(s) of the illicit discharge.

Describe corrective actions taken by the permittee in response to the finding of an illicit discharge.

Inspector Comments:

RESPONSIBLE OFFICIAL CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowledge of violations. See 18 Pa. C.S. § 4904 (relating to unsworn falsification).

Responsible Official Name	Signature
Telephone No.	Date

Appendix C
Guide to Indicators and Monitoring Methods

[Adapted From: Illicit Discharge Detection and Elimination – A Guidance Manual for Program Development and Technical Assessments]

APPENDIX C

GUIDE TO INDICATORS AND MONITORING METHODS (Selected Text)

This appendix contains general information about watershed indicators and methods.

Descriptions of Common Water Sampling and Analysis Indicators and Methods Used in this Handbook

General Terms Used In Water Sampling

- **Grab Sampling:** Samples are collected in some type of container by dipping the container in the water and filling it to some pre-determined level.
- **Integrated Sampling:** Samples are collected from various depths or locations across a transect that are combined into one sample for analysis.
- **Multiple Depth Sampling:** Individual samples are collected at various depths and analyzed separately.
- **Direct Measurement:** The indicator is measured directly from the water without collecting a sample.

Sample Handling Requirments

From Standard Methods

Indicator	Container Type	Minimum Size (mL)	Preservation	Max. Holding Time
Alkalinity	P, G	200	Ref.	24 h
Bacteria	P, G (S)	200	Ref.	6 h
BOD	P, G	1000	Ref.	6 h
Chlorophyll	P, G	500	Dark	30 d
Conductivity	P, G	500	Ref.	28 d
N-Ammonia	P, G	500	ASAP or acidify	7 d
N-Nitrate	P, G	100	ASAP or ref.	48 h
N-Kjeldahl	P, G	500	Ref., acidify	7d
Oxygen	G-BOD	300	Fix	8 h
PH	P, G	-	ASAP	2h
Phosphate	G(A)	100	Ref.	48 h
Solids	P, G	-	Ref.	7 d
Turbidity	P, G	-	Ref., Dark	24 h

Abbreviations

P = Plastic, G = Glass
G(A) = acid-rinsed glass
(S) = sterile
Ref. = refrigerate
h = hours, d = days

General Terms Used In Water Analysis Methods

This section describes the basic laboratory methods used to analyze water samples. These methods are referred to in the next section on methods for each indicator.

- **Titration:** Determining the concentration of an indicator in a sample by adding to it a standard reagent of known concentration in carefully measured amounts until a color change or electrical measurement is achieved, and then calculating the unknown concentration. Common indicators measured this way are dissolved oxygen and alkalinity.
- **Colorimetric:** Determining the concentration of an indicator in a sample by adding to it a reagent that causes a color change in direct proportion to the concentration of the indicator being measured. The intensity of the color (as measured by the extent to which it absorbs or transmits light) is either read with a visual color comparator or measured using a meter and either read directly in appropriate reporting units or read in "% absorbance" or "% transmittance" units and converted to reporting units. Common indicators measured this way are nutrients.
- **Electrometric:** Determining the concentration of an indicator in a sample by using a meter with an attached electrode that measures the electric potential (millivolts) of the sample. This amount of electric potential is a function of the activity of ions or molecules in the sample and proportional to the concentration of the indicator being measured. The electrode is selected based on its response to specific ions (known as an "Ion Selective Electrode" (or ISE), general ionic activity (conductivity) or molecules (for example, a Membrane Electrode). The meters can either display results in millivolts (mV) or in appropriate reporting units. Common indicators measured this way are dissolved oxygen, pH, conductivity and nutrients.
- **Gravimetric:** Determining the concentration of an indicator in a sample by filtering a specified quantity of the sample and determining the weight of the material retained on the filter. Common indicators measured this way are total solids and total suspended solids.
- **Nephelometric:** Determining the clarity of a sample by measuring the intensity of light scattered by particles in the sample and comparing this with a known solution. The higher the intensity of the scattered light, the higher the turbidity reported in nephelometric turbidity units (NTU's).
- **Membrane Filtration and Incubation:** Determining the bacteria concentration of a water sample by filtering a specified quantity through a specified gridded membrane filter, which retains the bacteria and other particles larger than 0.45 microns. After filtration, the membrane containing the bacterial cells is placed on a specific nutrient medium and then incubated at a specified temperature for a specified length of time. Colonies of a specified color growing on the filter are then counted.

Acidity

Acidity is the water's ability to resist a change in pH when a base is added. This is largely caused by carbon dioxide, salts of strong acids and weak bases and other factors. Above a pH of 8.3, there is no measurable acidity. Acidity is the reverse of the alkalinity buffering effect. It is measured as the concentration of $CaCO_3$.

Analytical Methods

Acidity is measured by titrating a sample to either 3.7 (methyl orange acidity using bromphenol blue indicator) or 8.3 phenolpthalein acidity using penolpthalein indicator). Acidity (in mg/L as $CaCO_3$) is calculated from the amount of titrant (sodium hydroxide) needed to bring the sample to either pH.

Alkalinity, Total

This is a measure of the water's ability to neutralize acids -- the higher the alkalinity levels, the more acid-neutralizing capacity the water has. This is important for aquatic ecosystems because it protects against changes in pH, which can harm aquatic life.

Analytical Methods

Basic methods use titration. The advanced method uses a meter to measure the pH at two endpoints.

Basic Methods	**Advanced Methods**
Sulfuric Acid Titration w/ Bromcresol Green/Methyl Red	*Double End Point Sulfuric Acid Titration w/ pH Meter*
1) The sample is collected and treated with bromcresol green-methyl red. 2) It is then titrated with sulfuric acid until the solution turns pink. 3) The amount of acid added to reach this point is converted to total alkalinity.	1) The sample is collected and the pH measured 2) It is then titrated with sulfuric acid until the pH is 4.5 3) The amount of acid added to reach this point is converted to total alkalinity.

Biochemical Oxygen Demand (BOD)

BOD is a measurement of the amount of oxygen consumed by organic matter and associated microorganisms and through chemical oxidation in the water over a period of time, usually five days. Measuring the biochemical oxygen demand (BOD) of the water tells us whether oxygen demanding wastes might cause low dissolved oxygen (DO) levels at times.

Analytical Methods

Basic and advanced methods use a version of Winkler Titration. As with dissolved oxygen (DO), the main difference is the type of titrator or use of a meter.

Basic Methods	**Advanced Methods**
Modified BOD-5 Day Method (Hach via Mitchell & Stapp) 1) Two samples are collected in glass-stoppered BOD bottles (one clear and one black) as in the DO method. 2) The DO is determined for the clear bottle, using Modified Winkler Titration with a syringe or eyedropper. 3) The black bottle is placed in the dark and incubated for five days at 68°F. 4) The DO for this sample is then determined the same way. 5) BOD is determined by subtracting the DO level of the black bottle from the clear bottle.	*Modified BOD-5 Day Method w/ modified Winkler Titration or Meter (Standard Methods #521 O-B or equivalent)* 1) Two samples are collected in glass-stoppered BOD bottles (one clear and one black) as in the DO method. 2) The DO is determined for the clear bottle, using Modified Winkler Titration with a buret, syringe, digital titrator or meter 3) The black bottle is placed in the dark and incubated for five days at 68°F. 4) The DO for this sample is then determined the same way. 5) BOD is determined by subtracting the DO level of the black bottle from the clear bottle.

Chlorophyll *a*

Chlorophyll *a* is a green pigment found in all plants. It is used to quantify the abundance of algae in water. When chlorophyll *a* degrades, it converts to pheophytin. The ratio of chlorophyll *a* to pheophytin is used to determine the health of the algae sampled.

Analytical Methods

Measuring chlorophyll *a* involves a sophisticated process for which there are no simple methods.

Basic Methods	Advanced Methods
None	*Pigment extraction followed by spectrophotometry (Adapted by Paul Godfrey from Standard Methods #10200 H)* **1)** Collect an integrated water sample using a clean container (at least one quart). **2)** Filter subsample (quantity depends on a Secchi reading) using a glass fiber filter and vacuum pump. **3)** Analyze filters immediately, frozen or dried. **4)** Extract pigment by grinding the filter, steeping the ground mass in 90% acetone, and centrifuging in tubes to de-suspend fibers from the solution. **5)** Read color with a spectrophotometer and calculate concentration. **6)** Add hydrochloric acid to the sample to convert all chlorophyll *a* to pheophytin. **7)** Read color again with a spectrophotometer and calculate the concentration of pheophytin.

Chlorine, Total Residual

Chlorine is a gas in its natural state. It is toxic to microbes and animals and is widely used to disinfect drinking water and wastewater. It can also combine with a wide variety of organic and inorganic chemicals to produce toxic compounds. It does not appear to be toxic to humans, except when it combines with other compounds. Total Residual Chlorine consists of Free Chlorine (hypochlorite ion, hypochlorous acid – the disinfecting agent) and chloramines (formed when chlorine reacts with ammonia or nitrogen).

Analytical Methods

Amperometric Titration: Chlorine is tricky to sample because it is volatile (tends to convert to gas quickly) and has tricky flow patterns. We recommend consulting with your regional DEP biologist. The analytical method involves titrating a prepared sample with Phenylarsine Oxide with an Amperometric Titrator to an endpoint.

Conductivity

This is a measure of the water's ability to pass an electrical current. This ability depends on the presence of inorganic dissolved solids made up of ions (particles that carry a positive or negative electrical charge). Since it measures a wide range of materials, its primary importance is as an indicator of general pollution, rather than a specific pollutant.

Analytical Methods

Basic and advanced methods use a conductivity meter. This meter contains a probe with two electrodes. The probe is lowered into the water, voltage applied, and the drop in voltage caused by the resistance of the water is measured and converted to conductivity. The basic method uses a relatively inexpensive "pen." The advanced method uses a high-quality meter to measure the conductivity.

Basic Methods	**Advanced Methods**
Electrometric Using A Conductivity Pen 1) Collect water sample or measure directly with pen. 2) Measure collected sample with pen.	*Electrometric Using A Conductivity Meter (EPA Method 120.1)* 1) Collect water sample or measure directly with meter. 2) Measure collected sample with meter.

Dissolved Oxygen (DO)

DO is the presence of oxygen gas molecules in the water. Since it is critical to many biological and chemical processes in the water and essential for aquatic life, dissolved oxygen is an indicator of the capability of the aquatic ecosystem to support life.

Analytical Methods

Basic and advanced methods use a version of Winkler Titration. The main difference is the size of the increment of titrant added to the sample – smaller increments increase sensitivity.

Basic Methods	Advanced Methods
Modified Winkler Titration with a syringe or eyedropper (Hach via Mitchell & Stapp) This is essentially the Modified Winkler Titration described above, with some changes. The titrant is phenylarsine oxide solution and the titrator is an eyedropper. The eyedropper gives less accuracy and sensitivity than other titrators because it dispenses larger drops -- each drop equals 0.5 mg/l.	*Modified Winkler Titration with a buret, syringe or digital titrator: Standard Method #4500-OG (or equivalent)* **1)** Collect surface samples in 300 mL "BOD" bottles with glass stoppers so that no air bubbles are trapped. In lakes, an integrated sample is collected using a length of garden hose. **2)** Samples must be analyzed immediately or fixed and analyzed within eight hours. **3)** The level of oxygen in the sample is "fixed" by adding reagents which produce a chemical reaction producing iodine in direct proportion to the amount of oxygen in the water. **4)** Sodium thiosulfate is then added incrementally using a digital titrator (Hach) or syringe (Lamotte). The amount of sodium thiosulfate it takes to turn the solution clear is proportional to the amount of iodine (which has taken the place of the oxygen) in the sample.
	Meter (Membrane Electrode) Method: Standard Methods #4500-OG (or equivalent) 1) A membrane-covered electrode probe is lowered into the water. 2) The meter electronically measures the diffusion of oxygen from the water across a membrane-covered electrode, which is directly proportional to the DO concentration.

Notes On Methods

- Water samples for dissolved oxygen should be collected in glass-stoppered BOD bottles or other container designed so that no air is trapped in the sample.
- If you have a limited budget for this indicator (<$300), we recommend that you use the Hach or Lamotte Adaptation of Winkler Titration. The Hach digital titrator dispenses smaller increments of the sodium thiosulfate than the Lamotte syringe and therefore increases the sensitivity. But, it's more expensive.
- If you have the budget ($600-800) to purchase a meter and you need frequent (or continuous) measurements from a few sites, a meter will work best. However, if you have a large number of sites and can only use one meter, we recommend titration.

Fecal Coliform and *E. coli* Bacteria

Fecal coliforms and *E. coli* are bacteria that are common in the intestines and feces of warm-blooded animals. They are used both as an indicator of the presence of sewage or animal manure in the water and as an indicator of the health risk of swimming and other water contact recreation. Fecal coliforms are the indicator used in Pennsylvania's water quality standards. *E. coli* (a species of fecal coliforms) are used in other states, per their water quality standards.

Analytical Methods

The basic methods will either detect the presence of bacteria (but won't give you a count) or they give you an estimate of density (but not a reliable count). Advanced methods are EPA-approved and give reliable counts. The most reliable count is produced by the mTEC method. Note that the mColiBlue method does not identify fecal coliforms. *E. coli* colonies are used as the equivalent, but these counts will underestimate fecal coliforms.

Basic Methods	Advanced Methods
Estimates of Density These methods estimate the number of bacteria in a sample in various ways: 1) Easygel: Using one subsample size, usually 1-5 mL, bacteria are grown on nutrient medium without filtration. Colonies of specified color are counted. Estimates total coliforms and E. coli. Fecal coliforms are estimated using E. coli counts. 2) Colilert: A reagent is added to various subsample sizes, which turns yellow if coliforms are present and fluoresces if they are *E. coli*. A statistical table is used to estimate density based on which subsamples turn yellow and/or fluoresce.	*Fecal coliforms and E. coli: Membrane Filtration Using mTEC: EPA Method #1103.1* **1)** Collect water sample in sterile container. **2)** Filter several subsample sizes through 0.45 micron filters. **3)** Dry incubate on mTEC nutrient medium in petri plates at 35°C for two hours. **4)** Incubate at 44.5°C in a water bath for 22 hours. **5)** Count fecal coliforms after incubation. **6)** Incubate at room temperature for 20 minutes on a urea solution and count *E. coli*.
Presence-Absence These methods detect the presence of selected bacteria types by whether or not bacteria grows on the plate (as detected by a certain color) or whether a special broth turns color when exposed to sample water. These methods tell you bacteria is present, but do not indicate the number of bacteria	*Fecal Coliforms: Membrane Filtration Using mFC: Standard Methods #9222 D* **1)** Collect water sample in sterile container. **2)** Filter several subsample sizes through 0.45 micron filters. **3)** Incubate at 44.5°C in a water bath for 24 hours on mFC nutrient medium in petri plates. **4)** Count fecal coliforms after incubation.
	Fecal Coliforms: Membrane Filtration Using mColiBlue24 (Hach) **1)** Collect water sample in sterile container. **2)** Filter several subsample sizes through 0.45 micron filters. **3)** Incubate at 44.5°C in a water bath for 24 hours on mColiBlue nutrient medium in petri plates. **4)** Count *E. coli* colonies after incubation (use to estimate fecal coliforms).

Hardness

Hardness is a measure of the calcium and magnesium positively charged ions in the water. These ions reduce the surface tension of the water, and soap does not produce lather in hard water. When hardness is primarily calcium, it is closely related to alkalinity. Hardness frequently reduces the impacts of metals on aquatic life: the higher the hardness, the lower the toxicity. Hardness is reported as mg/l of $CaCO_3$ at a given pH.

Analytical Methods

There are no basic methods. The advanced method involves either a titration or calculating the hardness from previously-determined calcium and magnesium concentrations.

Basic Methods	Advanced Methods
None	*EDTA Titration Method (Standard Method 2340C, EPA Method 130.2)* 1) Collect water sample. 2) Add dye (EBT indicator) which turns sample purple. 3) Titrate with EDTA reagent until solution turns blue. 4) Calculate hardness from amount of titrant used as $CaCO_3$.

Nitrogen

Nitrogen is a gas in the atmosphere. It combines with oxygen or hydrogen to produce various compounds -- ammonia, nitrites and nitrates. It is an essential nutrient for plant growth and metabolic reactions in plants and animals. Together with phosphorus, it is the primary source of food energy in the aquatic ecosystem. Too much of certain forms of nitrogen can cause too much biological activity and cause undesirable effects. It is also toxic to babies in high concentrations. Nitrogen occurs in various forms, both organic and inorganic in the water, some of which are more available for plant growth than others. In some waters, nitrogen is the nutrient in short supply, so that relatively small amounts can cause impacts. Three forms of nitrogen are recommended as indicators in this handbook: ammonia, nitrates and total. Their descriptions and methods follow:

Nitrogen - Ammonia Nitrogen

Ammonia (NH_3) is produced when organic nitrogen and/or urea break down. It is a byproduct of sewage decomposition. It is naturally present in surface waters, and can be toxic to aquatic life at relatively low concentrations (<1.0 mg/l).

Analytical Methods

Measuring ammonia involves a sophisticated process for which there are no simple methods. The Hach adaptation is the easiest, though it uses the distillation step only if known interferences are present.

Basic Methods	Advanced Methods
None	*Distillation followed by Nesslerization (Standard Methods #4500-NH3 C or equivalent)* **1)** Add borate solution to sample for buffering. **2)** Distill[1] sample using a distillation apparatus. This removes certain interferences. **3)** Nesslerization. This involves pretreatment to remove turbidity-producing compounds and adding a Nessler reagent. **4)** This produces a yellow to brown color that is measured with a spectrophotometer. **5)** The reading is compared with a set of standard concentrations and reported as mg/l NH_3 -N.

Nitrogen - Nitrate Nitrogen

Nitrate (NO_3) is produced naturally by nitrogen-fixing plants and lightning acting on atmospheric nitrogen or ammonia. Nitrate is a form of nitrogen readily used by plants. In excess, it can cause excessive biological activity in surface waters and can be toxic to infants.

Analytical Methods

Basic and advanced methods use a variation on the same procedure, except that in the basic method the color is read using a visual color comparator. In the advanced method, the color is read using an electronic meter.

Basic Methods	Advanced Methods
Cadmium Reduction followed by Color Comparator (Hach via Mitchell & Stapp) *1)* A cadmium reduction reagent is added to a water sample. This causes a chemical reaction and turns the sample pink. *2)* The sample color is matched to colors labeled in pH units on a color comparator. *3)* The analyst determines the closest color match and records the nitrate concentration.	*Cadmium Reduction followed by spectrophotometry (Standard Methods #4500-NO_3- E or equivalent)* **1)** A cadmium reduction reagent is added to a water sample. This causes a chemical reaction and turns the sample pink. **2)** This color is measured with a spectrophotometer. **3)** The reading is compared with a set of standard concentrations and reported as mg/l NO_3 -N.

Notes on Methods

- The basic method should be considered an approximation only. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Nitrogen - Total Kjeldahl Nitrogen (TKN)

This refers to the total of organically bound nitrogen and ammonia. By analyzing samples for both ammonia and total Kjeldahl nitrogen, organic nitrogen can be calculated. This enables you to

[1] Distillation involves boiling the sample and collecting the steam.

estimate how much nitrogen in the system is in organic form, intermediate form (ammonia) and inorganic form (nitrate). It may tell you how much comes from sewage, versus fertilizer, for example.

Analytical Methods

Measuring TKN involves a sophisticated process for which there are no simple methods. The Hach adaptation is the easiest, though it uses the distillation step only if known interferences are present.

Basic Methods	**Advanced Methods**
None	*Digestion followed by Nesslerization followed by spectrophotometry (Standard Methods #4500-Norg B or equivalent)* **1)** Digest[2] water sample to convert organic and ammonia compounds to ammonia nitrogen. **2)** Ammonia is then measured using the Nesslerization Method (see ammonia methods). **3)** The reading is compared with a set of standard concentrations and reported as mg/l TKN.

pH

pH is a measure of the acidity of the water. Since pH affects many biological and chemical reactions in the water and most organisms have a preferred range, it is a good indicator of capability of the aquatic ecosystem to support life.

[2] The process of disintegration by means of chemical action, heat, and/or moisture.

Analytical Methods

Basic methods use colorimetry. The advanced method uses a meter.

Basic Methods	Advanced Methods
Colorimetric Method (Hach via Mitchell & Stapp) 1) This method involves the addition of pH indicator solution to a water sample which changes color according to the pH. 2) The sample color is matched to colors labeled in pH units in a color comparator. 3) The analyst determines the closest color match and records the pH. This should be considered an approximation only.	*Electrometric Method (EPA Method 050.1 or Equivalent)* **1)** Collect sample or measure directly with a meter. **2)** Measure on a collected sample using a laboratory-quality meter with an electrode suitable for ionic-strength of waters. **3)** There are less expensive pH pens or "pocket pals" on the market. These should be checked against a reliable, laboratory-quality meter to establish accuracy and precision.
pH Paper This is similar to the colorimetric method, except that a specially coated paper is dipped in the sample and turns color according to the pH. This should be considered an approximation only.	

Notes on Methods

- For waters that are low in ionic strength, accurate pH measurements require a probe that will respond in these types of waters.
- pH samples should be collected so that no air is trapped in the sample.
- The colorimetric method is subject to variation in the light source and the judgments of the analyst. It is inherently imprecise.

Phosphorus

Phosphorus is an essential nutrient for plant growth and metabolic reactions in plants and animals. Together with nitrogen, it is a key element in the aquatic ecosystem. Too much phosphorus can cause too much biological activity and cause undesirable effects. Phosphorus occurs in various forms in the water, some of which are more available for plant growth than others.

Phosphorus - Total Orthophosphates

This is primarily the dissolved and most available form. It is a good indicator of enrichment from various sources, such as sewage, manure or fertilizer.

Analytical Methods

Basic and advanced methods are basically the same colorimetric method. The main difference is that the advanced method measures the color of the treated sample using an electronic instrument.

Basic Methods	Advanced Methods
Ascorbic Acid Method 1) Collect a sample in a phosphorus-free container. 2) Analyze by adding ascorbic acid reagent which turns the sample blue (ascorbic acid method) in proportion to the amount of phosphorus in the sample. 3) Compare this blue color to various shades using a visual color comparator to get a concentration.	*Ascorbic Acid Method (EPA Method #365.2 or equivalent)* 1) Collect a sample in a phosphorus-free container. 2) Analyze by adding ascorbic acid reagent which turns the sample blue (ascorbic acid method) in proportion to the amount of phosphorus in the sample. 3) Measure the intensity of this blue color using a spectrophotometer or colorimeter and compare with results for a set of standard concentrations.

Notes on Methods

- The basic method should be considered an approximation only. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Phosphorus, Total

Total phosphorus includes all the forms. It is a good indicator of enrichment from various sources, such as sewage, manure, or fertilizer.

Analytical Methods

Basic and advanced methods are basically the same colorimetric method. The main difference is that the advanced method measures the color of the treated sample using an electronic instrument.

Basic Methods	Advanced Methods
Persulfate Digestion Followed by Ascorbic Acid Method 1) Collect a sample in a phosphorus-free container. 2) Boil, acidify and oxidize a sub-sample to convert all forms of phosphorus to orthophosphate (persulfate digestion). 3) Analyze Orthophosphate by adding ascorbic acid reagent which turns the sample blue (ascorbic acid method) in proportion to the amount of phosphorus in the sample. 4) Compare this blue color to various shades using a visual color comparator to get a concentration.	*Persulfate Digestion Followed by Ascorbic Acid Method (EPA Method #365.2 or equivalent)* 1) Collect a sample in a phosphorus-free container. 2) Boil, acidify and oxidize a sub-sample to convert all forms of phosphorus to orthophosphate (persulfate digestion). 3) Analyze Orthophosphate by adding ascorbic acid reagent which turns the sample blue (ascorbic acid method) in proportion to the amount of phosphorus in the sample. 4) Measure the intensity of this blue color using a spectrophotometer or colorimeter and compare with results for a set of standard concentrations.

Notes on Methods

- The basic method should be considered an approximation only. This method is not acceptable for federal and state agency assessment, but is fine for education and awareness and some community assessments.

Phosphorus, Total Dissolved

Total dissolved phosphorus includes all the forms after a sample is filtered. It is a good indicator of the available forms from various sources, such as sewage, manure or fertilizer.

Analytical Methods

Basic and advanced methods are basically the same as the method for total phosphorus, with the addition of filtering the sample before digestion and analysis.

Solids

Solids include materials that are dissolved, suspended or settled in the water column. *Total solids* include all of these.

Solids - Total Suspended

Total suspended solids consist of solids that are filtered out of a water sample. Suspended solids affect water clarity and can reduce photosynthesis and cause higher temperatures.

Analytical Methods

Measuring total suspended solids involves a sophisticated process for which there are no simple methods.

Basic Methods	**Advanced Methods**
None	*Gravimetric Method: Total Suspended Solids Dried at 103-105° C (Standard Methods #2540D)* **1)** Weigh a glass fiber filter. **2)** Filter a sample through the filter, and transfer it to a Gooch crucible. **3)** Dry filters and crucibles in an oven at 103-105°C for an hour. **4)** Weigh filters and crucibles again. **5)** Calculate total dissolved solids by subtracting the weight of the filter and crucible from the weight after filtering and drying. Results are reported as mg/l.

Solids - Total Dissolved

Dissolved *solids* include various ions of calcium, chlorides, nitrate, phosphate, iron, sulfur and others that will pass though a two-micron pore. These affect the water balance in the cells of aquatic organisms, making it difficult for them to maintain position in the water column.

Basic Methods	Advanced Methods
None	*Gravimetric Method: Total Dissolved Solids Dried at 180°C (Standard Methods #2540C)* **1)** Filter a sample through a glass fiber filter. **2)** Weigh a ceramic dish. **3)** Pour the filtered sample into the dish. **4)** Evaporate the water in an oven at 180°C, and weigh the dish plus residue. **5)** Calculate total dissolved solids by subtracting the weight of the dish from the weight of the dish with residue. Results are reported as mg/l.

Secchi Depth Transparency (for lakes only)

Transparency describes scattering and absorption of light by small particles and molecules in the water. This is most commonly expressed as the depth at which a black and white patterned device known as a *Secchi disk* disappears from sight. The more transparent the water, the lower the depth at which the disk disappears. Reduced transparency has the same effects as elevated turbidity.

Basic Methods	Advanced Methods
Secchi Disk ***1)*** Lower Secchi disk into the water until it disappears from sight. ***2)*** Bring disk up until it appears again. ***3)*** The average of these two depths is the Secchi depth transparency.	*Same as basic*

Temperature

Since temperature affects many biological and chemical reactions in the water and most organisms have a preferred range, it is a good indicator of capability of the aquatic ecosystem to support life. It is measured in degrees Fahrenheit (°F) or degrees Celsius (°C).

Analytical Methods

Basic Methods	Advanced Methods
Direct measurement with thermometer	*Direct measurement with thermometer, thermocouple, thermistor or a multi-use meter*

Turbidity (for streams only)

Turbidity describes how the particles suspended in the water affect its clarity by scattering light. It is an indicator of the presence of suspended sediment from erosion, which can decrease biological activity, raise water temperatures and clog fish gills and gravel spawning areas. Turbidity results are usually reported as nephelometric turbidity units (NTUs).

Analytical Methods

The basic methods involve measuring transparency, which includes both light scattering and absorption. The advanced method measures just light scattering. Thus, the results of basic and advanced methods are not comparable with each other. The "advanced" method is actually fairly simple, though it involves an expensive meter.

Basic Methods	**Advanced Methods**
Turbidity Tubes (Lamotte) 1) Two graduated cylinders with black dots on the bottom are filled to a specific volume -- one with sample water the other with turbidity-free water. 2) A reagent is added to the turbidity-free water cylinder, until the visibility of the dot on the bottom is equivalent to that of the cylinder with the sample. 3) The results are reported in unspecified units. 4) This method actually measures absorbance plus scattering, so the results are not actually NTUs.	*Nephelometric Method (Standard Methods #2130 or equivalent)* **1)** Turbidity is measured by collecting and analyzing a water sample using a nephelometer. **2)** A nephelometer consists of a light source that projects a beam of light through the water sample and a photo-electric cell that measures the intensity of light scattered by particles at a 90° angle from its original path. **3)** The results are reported as nephelometric turbidity units (NTUs).
Turbidity Tube (Tennessee Valley Authority) 1) These tubes are marked in increments of NTUs on the side and a wave pattern on the bottom. 2) The sample is poured into the tube until the wave pattern disappears. 3) The NTU increment level of the sample is reported. 4) This method actually measures absorbance plus scattering, so the results are not actually NTUs. In fact, they should be reported in centimeters or inches.	

Notes on Methods

- Measure turbidity in rivers.
- Make sure that the meter you purchase is a nephelometer that measures light scattered at a 90° angle.
- Turbidity tubes are not acceptable substitutes for a nephelometer, since they actually measure transparency (light scattering and absorption), rather than just light scattering. Because of this, they are unreliable in colored waters, which absorb light, though may not be turbid at all. They are really more analogous to Secchi disks, in that your eye responds to absorption. If you use these tubes, report your results as a depth (in centimeters or inches) rather than NTUs.

Water Column Metals and Other Elements Recommended for Sampling Only (Advanced Assessments)

Many naturally-occurring metals are toxic to aquatic life, when present in high enough concentrations. The most common process is when they bind to gill surfaces on fish and insects. The metals of concern are mostly those that are "available" as dissolved ions in the water column.

The following metals and other elements are recommended by several of the advanced assessments. However, the analysis methods require techniques and equipment beyond the means of community-based groups and schools (except universities). Therefore, we recommend sampling only. Even for sampling, we recommend consulting with your regional DEP biologist as to sampling procedure

Sampling (Standard Methods 3010B)

Because some metals are toxic in very small amounts (micrograms per liter), the methods must be able to detect very low concentrations. Contamination of sampling containers is a real concern. Samples for metals are usually collected in special acid-rinsed containers made of polypropylene, linear polyethylene or borosilicate glass. Samples to be analyzed for dissolved metals are immediately filtered through a 0.45 micron filter. Otherwise they are preserved by acidifying with concentrated nitric acid to a pH of <2.

Analytical Method (EPA Method 200.7)

Various forms of metals can be analyzed, depending on how the sample is treated:

- Dissolved Metals: The filtered sample is analyzed.
- Suspended Metals: Metals are trapped on the filter.
- Total Metals: Metals are detected in an unfiltered sample after digestion or the sum of dissolved and suspended metals are added together.
- Acid-extractable Metals: Metals in solution after treatment of the sample with hot mineral acid.

Metals are usually analyzed as a suite using *Inductively Coupled Plasma - Atomic Emission Spectrometry*. An inductively coupled plasma source (a machine) vaporizes the sample and heats it to about 6000-8000°C. Molecules separate and atoms become active and ionized (reactive). In this state, each element produces a unique spectral (colored) pattern which is read by a spectrometer.

Needless to say, this is an extremely technical and expensive method beyond the reach of volunteer monitoring programs.

Aluminum (sampling only)

Aluminum is a naturally occurring element in rocks, soils and the waters in contact with them. It occurs as a soluble salt, a colloid or an insoluble compound. Aluminum toxicity for aquatic life depends on pH.

Arsenic (sampling only)

Arsenic is a naturally occurring element in rocks, soils and the waters in contact with them. Recognized as a toxic element for centuries, arsenic today also is a human health concern because it can contribute to skin, bladder and other cancers (National Research Council, 1999).

Arsenic is widely distributed throughout the earth's crust and is used commercially, primarily in alloying agents. It is introduced into water through the dissolution of minerals and ores, from industrial effluents and from atmospheric deposition; concentrations in groundwater in some areas are elevated as a result of erosion from local rocks

Arsenic is highly toxic, though its toxicity is dependent on its form and environmental conditions.

Used in groundwater assessment only.

Barium (sampling only)

Barium is a lustrous, machinable metal that exists in nature only in ores containing mixtures of elements. It is used in making a wide variety of electronic components, in metal alloys, bleaches, dyes, fireworks, ceramics and glass. In particular, it is used in well drilling operations where it is directly released into the ground.

EPA has found barium to potentially cause gastrointestinal disturbances and muscular weakness when people are exposed to it at unsafe levels for relatively short periods of time

In water, the more toxic soluble barium salts are likely to be converted to insoluble salts that precipitate. Barium does not bind to most soils and may migrate to groundwater. It has a low tendency to accumulate in aquatic life and does not seem to be an aquatic life health concern.

Used in groundwater assessment only.

Cadmium (sampling only)

Cadmium is a metal found in natural deposits as ores containing other elements. The greatest use of cadmium is primarily for metal plating and coating operations, including transportation equipment, machinery and baking enamels, photography and television phosphors. It is also used in nickel-cadmium and solar batteries and in pigments.

EPA has found cadmium to potentially cause vomiting, diarrhea, muscle cramps, nausea, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure when people are exposed to it at unsafe levels for relatively short periods of time. Cadmium has the potential to cause kidney, liver, bone and blood damage from a lifetime exposure at unsafe levels.

Cadmium occurs naturally in zinc, lead, copper and other ores that can serve as sources to ground and surface waters, especially when in contact with soft, acidic waters. Major industrial releases of cadmium are due to waste streams and leaching of landfills, and from a variety of operations that involve cadmium or zinc. In particular, cadmium can be released to drinking water from the corrosion of some galvanized plumbing and water main pipe materials.

Some cadmium compounds are able to leach through soils to groundwater. When cadmium compounds do bind to the sediments of rivers, they can be more easily bioaccumulated or re-dissolved when sediments are disturbed, such as during flooding. Its tendency to accumulate in aquatic life is great in some species, low in others. Toxicity increases as hardness decreases.

Calcium (sampling only)

Calcium is a naturally-occurring element that enters surface water from surrounding rocks. It is a vital micro-nutrient for both plants and animals. In various compounds, calcium is an important part of the water's buffering system (see alkalinity, acidity, hardness). Used in groundwater assessment only.

Chromium (sampling only)

Chromium is a metal found in natural deposits as ores containing other elements. Though chromium occurs in nature mostly as chrome iron ore and is widely found in soils and plants, it is rare in natural waters. The greatest use of chromium is in metal alloys such as stainless steel; protective coatings on metal; magnetic tapes; and pigments for paints, cement, paper, rubber, composition floor covering and other materials. Its soluble forms are used in wood preservatives.

Short-term: EPA has found chromium to potentially cause skin irritation or ulceration when people are exposed to it at unsafe levels for relatively short periods of time. Chromium has the potential to cause damage to liver, kidney, circulatory and nerve tissues; and cause skin irritation from a lifetime exposure at unsafe levels.

When released to land, chromium compounds bind to soil and are not likely to migrate to groundwater. They are very persistent in water as sediments. There is a high potential for accumulation of chromium in aquatic life.

Copper (sampling only)

Copper is a metal found in natural deposits as ores containing other elements. It is widely used in household plumbing materials.

Copper is an essential nutrient, required by the body in very small amounts. However, EPA has found copper to potentially cause stomach and intestinal distress, liver and kidney damage, and anemia when people are exposed to it at high levels for relatively short periods of time.

Copper may occur in drinking water either by contamination of the source water used by the water system, or by corrosion of copper plumbing. Corrosion of plumbing is by far the greatest cause for concern. Copper is rarely found in source water, but copper mining and smelting operations and municipal incineration may be sources of contamination.

All water is corrosive toward copper to some degree, even water termed non-corrosive or water treated to make it less corrosive. Corrosivity toward copper is greatest in very acidic water. Many of the other factors that affect the corrosivity of water toward lead can also be expected to affect the corrosion of copper.

Copper is toxic to aquatic life at high levels, though it does not appear to accumulate in the edible portions of freshwater fish. Toxicity increases as hardness decreases.

Iron, Total (sampling only)

Iron is a metal common in rocks and soils and in varying quantities in surface water. It is an essential trace element required by both plants and animals. Iron is not considered a problem for aquatic life, except for physical effects from iron precipitate.

Lead (sampling only)

Lead is a metal found in natural deposits as ores containing other elements. It is sometimes used in household plumbing materials or in water service lines used to bring water from the main to the home.

Lead can cause a variety of adverse health effects when people are exposed to it at usafe levels for relatively short periods of time. These effects may include interference with red blood cell chemistry, delays in normal physical and mental development in babies and young children, slight deficits in the attention span, hearing and learning abilities of children, and slight increases in the blood pressure of some adults. Lead has the potential to cause stroke, cancer and kidney disease from a lifetime exposure at unsafe levels.

Lead may occur in drinking water either by contamination of the source water used by the water system, or by corrosion of lead plumbing or fixtures. Lead is rarely found in source water, but lead mining and smelting operations may be sources of contamination. Corrosion of plumbing is by far the greatest cause for concern.

When released to land, lead binds to soils and does not migrate to groundwater. In water, it binds to sediments. It does not accumulate in fish, but does in some shellfish, such as mussels. Toxicity increases as hardness decreases.

Used in groundwater assessment only.

Manganese (sampling only)

Manganese does not occur naturally as a metal. It is frequently found in various salts and minerals, frequently with iron. It is a vital micro-nutrient for both plants and animals. It occurs in surface waters in soluble or suspended form, but rarely in concentrations considered toxic to aquatic life.

Potassium (sampling only)

Potassium is an abundant element found in many minerals. It is an essential plant and animal nutrient and is also common in fertilizers. Used in groundwater assessment only.

Silica (sampling only)

Silicon is an abundant element and most waters contain it in the form of silica (SiO_2) and silicates. The chief concern is deposits on industrial equipment. Used in groundwater assessment only.

Sulfate (sampling only)

Sulfate occurs in natural waters in a wide variety of concentrations. It can occur in high concentrations in mine drainage from the oxidation of pyrite and the use of sulfuric acid.

Zinc (sampling only)

Zinc is common in natural waters, but is increased by the deterioration of galvanized pipes. It is essential to human metabolism, but can be toxic to aquatic life.