

BUTLER COUNTY STORM WATER DISTRICT OUTFALL STREAM MAPPING AND SCREENING PROJECT



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STREAM MAPPING AND SCREENING PROJECT

PROTOCOL MANUAL

DLZ Ohio, Inc. 6121 Huntley Road Columbus, Ohio 43229

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1.0 THE FUNDAMENTALS

1.1 Introduction And Background

The Butler County Storm Water District (BCSWD) has obtained coverage under Ohio EPA NPDES General Permit OHQ000001 to discharge storm water from its Municipal Separate Storm Sewer System (MS4) to the surface Waters of the State. To fulfill the requirements of the NPDES Phase II permit, the District developed and submitted a Storm Water Management Plan (SWMP) in February 2003.

In order to obtain permit coverage, the SWMP addressed the following six Minimum Control Measures (MCMs) as required:

- Public Education and Outreach
- Public Involvement and Participation
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post-Construction Runoff Control
- Pollution Prevention and Good housekeeping

Outfall stream mapping and screening is a part of the Illicit Discharge Detection and Elimination MCM and is a major component of the process required to reduce the discharge of pollutants and protect water quality. Completion of the outfall inventory will also aid in satisfying the requirements of the Clean Water Act of 1972 and will provide the District with a functional mapping and water quality screening program.

This Manual has been developed to serve as a stand alone document outlining procedures for collecting, recording, identifying, and organizing the District's storm sewer system outfall data. It will serve as a guide and provide a framework for consistent inventory location, attribute collection, and dry weather screening and provide a systematic approach for completing the inventory.

The Manual will provide long-term guidance, instruction, and backup information for performing this task during initial location and dry weather screening as well as for future return visits for subsequent pollutant indicator testing and visual screening of outfalls.

1.2 Illicit Connections

Urban storm water runoff is traditionally defined as that portion of precipitation, which drains from municipal owned/operated surfaces exposed to precipitation and flows via natural or man-made drainage systems into receiving waters. Urban storm water runoff has been shown to contain many pollutants. Additionally, baseflows (also referred to as dry weather flow) are also common in storm drainage systems and have been found to be responsible for the majority of the annual pollutant



loading from storm drainage systems. These base flows contain water from many sources that find their way into storm drainage systems. Sources of some of this water can be identified and accounted for by examining current NPDES permit records. However, most of the water comes from other sources, including illicit and/or inappropriate entries to the storm drainage system. The term "illicit discharge" is defined in EPA's Phase II storm water regulations as "any discharge to a municipal separate storm sewer that is not composed entirely of storm water, except discharges pursuant to an NPDES permit and discharges resulting from fire-fighting activities."

Illicit discharges can be categorized as either direct or indirect.

Examples of direct illicit discharges:

- Sanitary wastewater piping that is directly connected from a home to the storm sewer
- Materials (e.g., used motor oil) that have been dumped illegally into a storm drain catch basin
- A shop floor drain that is connected to a storm sewer
- A cross-connection between a sanitary sewer and storm sewer

Examples of indirect illicit discharges:

- An old and damaged sanitary sewer line that is leaking fluids into a cracked storm sewer line
- A failing septic system that is leaking into a cracked storm sewer line or causing surface discharge into the storm sewer

In order to identify illicit discharges, all outfalls into water bodies need to be mapped and screened.

1.3 Outfall Inventory

1.3.1 What to Inventory

The definition of an outfall for this Manual will be any discharge point to a blue-line stream shown on the USGS Quadrangles within the designated mapping areas. A discharge point shall be considered any flowing or non-flowing closed pipe or open drainage channel 4-inches in diameter or greater, regardless of material, shape, dimension, or submergence that discharges into a "blue-line" stream as defined above.

If flow is present at any outfall located under appropriate "dry weather" conditions (greater than 48 hour period of no rainfall), then dry weather screening and sampling will be completed. Dry weather screening will consist of sensory observations relative to color, odor, turbidity and floatables. These visual observations will be the first indication of potential contamination by an illicit connection and will be conducted on all outfalls regardless of size. Dry weather sampling will be performed only on discharges at those outfalls that are 12-inches in diameter or greater and will require collecting a sample from a flowing outfall and performing field tests to identify possible contamination sources.



The following table further defines those outfalls to record versus those to skip.

snip.			
	Outfalls to record		Outfalls to skip
• • • • •	All 4" flowing and non-flowing outfalls are to be mapped All 12" or more flowing outfalls (discharges) are to be sampled for analysis Outfalls include pipes, open drainage channels (natural and manmade and ditches that are part of the storm drain infrastructure Outfalls that appear to be piped headwater streams -WOS Submerged or partially submerged outfalls Outfalls that are blocked with debris or sediment deposits Pipes that appear to be outfalls from storm water treatment practices Small diameter ductile iron pipes Pipes that appear to only drain roof downspouts but that are subsurface, preventing definitive confirmation	•	Drop inlets from roads in culverts (unless evidence of illegal dumping, dumpster leaks, etc.) Cross-drainage culverts in transportation right-of-way (i.e., can see daylight at other end) Weep holes Flexible HDPE pipes that are known to serve as slope drains Pipes that are clearly connected to roof downspouts via above- ground connections

1.3.2 Where to Inventory

The 2000 U.S. Census designated the majority of the southeast portion of Butler County as an Urbanized Area. The municipalities of Fairfield, Hamilton, Sharonville, Monroe, and Middletown have chosen to manage their respective storm water programs and are excluded from the BCSWD. The BCSWD has elected to map all outfalls in all of Butler County outside of the aforementioned municipalities. The primary focus will be on the townships that are considered an Urbanized Area as designated by the District and the OEPA. Those urbanized areas within the County are currently confined to the following townships, villages, and cities; West Chester, Liberty, Fairfield, Lemon, Madison, Saint Clair, Hanover, Ross, Millville, New Miami, Seven Mile, and Trenton. Fieldwork is anticipated to continue by township in this order. However, if a crew is mapping a stream that crosses over a township, city, or village boundary, the crew will continue mapping until the stream ends and/or enters a corporation or other jurisdictional boundary considered excluded by the scope. If the stream flows into another water body it will be considered an outfall on the downstream water body.

The remaining area within the County is not currently designated by the Ohio EPA as an MS4 Phase II area. However, this area will also be included in the Stream Mapping and Screening Project and consists of the following townships villages, and cities; Wayne, Milford, Oxford, Reily, and Morgan. These municipal areas will be mapped and screened



following the mapping and screening of the Urbanized Areas. It has not been determined whether DLZ or the Storm Water District will collect the remaining data.

Please refer to Figure 1-1 for the mapping and screening study area for this project. Section 5.0 provides additional information on the individual areas to be mapped and screened.

1.3.3 Inventory Data to Collect

A specific amount of data is collected for each outfall through both desktop and field data collection and includes location information, outfall attributes, dry weather visual screening and sampling. Details on the data collection for the outfall inventory may be found in Sections 2.0 and 3.0 of this Manual.

1.4 The Inventory Process

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The end product of the stream mapping and screening will be a complete database populated with the required information for all outfalls within the locations noted in Section 1.3. In order to create this populated database several steps are required and are summarized below. Detailed descriptions of each step are discussed in subsequent sections of this Manual.

- In-Office Research and Data Collection In-office analysis is initiated with identification of potential outfall locations and potential pollutants by a compilation of existing maps, watershed data, TMDL reports, and other applicable information. The data collected in this step is intended to streamline fieldwork and provide a basis for future data collection.
- ✓ Field Data Collection

Fieldwork involves using the information collected in the first phase to visit identified outfall locations and search for additional outfalls that may exist. Each outfall found is located with a GPS unit, assessed for the required attributes, and photographed. If dry weather conditions exist, the outfall is screened and sampled (if \geq 12-inches in width or diameter). Data collected in the field then undergoes quality control checks and is verified for completeness.

✓ Database Population

The data collected both in the field and the office is entered or imported into the Outfall Inventory Database, verified for completeness, and reviewed for quality. Daily and weekly downloads of field information will continuously populate the database for an up-to-date catalog. A shape file will need to be created from this database to show the locations of the outfalls on the base map and photographs will be embedded via a software program to enhance the GIS platform for which the database will be utilized.



The Inventory Process can be further defined graphically with the GIS Management flow chart in Figure 1.4-1.



Figure 1.4-1 GIS Management Workflow

The GIS Management flow chart can be explained through the following bullets:

- Import existing data into GIS & create data layers for fieldwork
- Delineate survey reaches (daily/weekly progress areas) & create field maps
- Customize Outfall Reconnaissance Inventory (ORI) form
- Download ORI form & field maps to GPS unit.
- Locate, inspect, and collect data for each outfall identified in the field including the GPS location and attributes of each outfall
- Photograph each outfall with a digital camera



- Collect water samples during dry weather flow conditions at outfalls with dry weather flow
- Conduct tests of the day's collected water samples and record results
- Download all field data collected including GPS/ORI data, sampling results, and photographs
- Post-process GPS location data with Pathfinder Office software & export corrected GPS location and outfall attributes to a database
- Import water quality results to a database
- Merge the water quality data and the GPS data into the customized Project Access Database (PAD)
- Match the photos and outfall data back in the office

The details of each step are discussed throughout subsequent sections of this Manual.

1.5 Software and Hardware Requirements

There are several fundamental electronic components that are necessary to perform the Inventory Process introduced in the previous Section. Hardware requirements include a personal computer (PC) for Desktop Research and Data Collection and a Geographical Positioning System (GPS) handheld unit for Field Data Collection. Post processing of the collected field location data as well as the communication between the GPS unit and the PC shall be handled by existing GPS and/or GIS software. DLZ will utilize Trimble software including Terrasync for the GPS unit and Pathfinder Office for the PC. Database development and enhancement and GIS work are recommended to utilize ESRI ArcGIS and MS Access.

Table 1.5-1 indicates the software and hardware that is recommended for use and that will be utilized by DLZ for the Inventory Process and GIS management.



Name	Vender	Platform	Description
Software			
Pathfinder Office	Trimble	XP*	 Construct and edit data dictionaries Transfer files to and from GPS receivers Display and edit collected data in the office Process the GPS positional data to improve its accuracy Export the collected, processed, and edited data to a GIS, database.
Terrasync	Trimble	CE*	 Graphical navigation and real-time map display Feature collection Attributes collection Data Dictionary support
ArcGIS 9	ESRI	XP*	GIS management
MS Access	Microsoft	XP*	 QA/QC of field data Entering water quality data Generating report
Hardware			
Dell Precision 370	DELL	XP*	• Pentium 4 2.80GHz, 512M RAM
GeoXH	Trimble	CE*	 Sub-foot potential GPS receiver 416 MHz CPU, 512M Memory

Table 1.5-1 Software and Hardware

*XP: WindowsXP on desktop

CE: Microsoft® Windows Mobile™ Version 5.0

2.0 DESKTOP RESEARCH AND DATA COLLECTION

2.1 In-Office Research and Data Collection Objectives

This step is important in establishing the framework for the field data collection and to provide a means to streamline the fieldwork through proper planning and location analysis.

2.2 Water Quality Data Review

The federal Clean Water Act, and guidance from the US EPA, directs States to prepare a water quality inventory of the Waters of the State and a list of impaired water bodies based upon established standards. The Ohio EPA submits an integrated report to the US EPA every two years to fulfill these requirements. The Ohio EPA's most recent report "Ohio 2004 Integrated Water Quality Monitoring and Assessment Report" discusses the current status of the State's surface waters and provides information and direction to much of the water quality planning, monitoring, permitting, non-point source, and financial and technical programs within the State. A copy of the named report may be downloaded from the Ohio EPA at the following location:

www.epa.state.oh.us/dsw/tmdl/2004IntReport/final_2004IR_main_text.pdf



2.2.1 Ohio Administrative Code

The Ohio Administrative Code (OAC) has established water quality criteria for the State. Section 3745-1-4 of the OAC addresses criteria for all waters of the State and provides baseline information on visual screening characteristics and fecal coliform and E. coli limits. Section 3745-1-07 designates water use and statewide criteria for all other chemical testing threshold limits for water quality. Sections 3745-1-17, 3745-1-18, 3745-1-21, and 3745-1-30 further defines the major drainage basins within Butler County each water body segment name and use designation (the aquatic life habitat, water supply, or recreation).

2.2.2 Watersheds

Butler County and the study area comprising the BCSWD are part of four main 8-digit USGS Hydrological Unit Codes (HUC). Figure 2.2-1 illustrates the main 8-digit HUC areas within Butler County as they are listed below with their names:

05080002 -- Lower Great Miami 05080003 -- Whitewater 05090202 -- Little Miami 05090203 -- Middle Ohio-Laughery

Each of these units can be further subdivided into smaller units by the use of a 3-digit extension onto the previous HUC (making this an 11-digit HUC) and are referred to as a Watershed Assessment Unit (WAU) and are designated by the following in Table 2.2-1:

<u>8-digit</u> <u>HUC</u>	<u>3-digit</u> extension WAU	WAU Name
05080002	020	Great Miami River (upstream Bear Creek to upstream Twin Creek) excluding GMR mainstream
05080002	040	Twin Creek (upstream Bantas Fork to mouth)
05080002	050	Great Miami River (downstream Twin Creek to upstream Fourmile Creek) excluding GMR mainstem
05080002	060	Sevenmile Creek
05080002	070	Fourmile Creek (excluding Sevenmile Creek)
05080002	080	Indian Creek
05080002	090	Great Miami River (downstream Fourmile Creek to mouth) excluding GMR mainstem
05080003	080	Whitewater River (downstream East Fork Whitewater Ri. – Indiana, to mouth) excluding Whitewater Ri. mainstem
05090202	060	Little Miami River (downstream Caesar Creek to downstream Turtle Creek) excluding LMR mainstem
05090202	090	Little Miami River (downstream Turtle Creek to downstream O'Bannon Creek) excluding LMR mainstem
05090203	010	Mill Creek

Table 2.2-1 Watershed Assessment Units - 11-Digit HUC

The Watershed Assessment Units can be further segmented into smaller 14-digit watersheds; however, the Ohio EPA is still in the process of revising these areas and it is not recommended to utilize the 14-digit



watershed until the revisions are complete. Additional details on each watershed and mapping area are further elaborated in Section 5.0.

2.2.3 Impaired Waters and Total Maximum Daily Loading Reports

The 2004 Integrated Report identifies several water bodies within Butler County that were categorized as impaired due to Fish Consumption Advisory because of PCBs, lead or mercury. The Ohio EPA continues to collect data on each WAU and use this data to categorize each into one of five categories with Category 1 being of the highest water quality and Category 5 being of the poorest water quality, please refer to the 2004 Integrated Report for additional information.

The outfall sampling parameters typically are supplemented with information and background water quality inputs from existing TMDL Reports. However, only one TMDL study is currently complete with three others in progress. The Millcreek TMDL study, scheduled for completion in 2005, has been approved and implemented. Twin Creek, Fourmile and Sevenmile TMDL studies are in their draft phase and scheduled for submittal to the US EPA in 2006.

The Mill Creek watershed was identified as a priority impaired water on Ohio's 1998, 303(d) list and in subsequent submissions of the list. The pilot mapping and screening area of West Chester Township comes under the purview of the Upper Millcreek basin. Biological and chemical stream surveys indicate nutrients, bacteria, organic enrichment, organic chemical pollutants, metals and habitat alterations are some of the primary causes of impairment in the watershed.

2.3 Existing GIS Information

This step includes obtaining existing GIS information from several sources as shown in Table 2.3-1 on the following page.

Combining the aerial photos, USGS maps, NRCS soil surveys, and MS4 area base maps provide a framework for establishing potential outfall locations along the "blue-line" streams and will streamline the field data collection.



Data	Source	Projection	Format
Sub-watershed	ODNR	SPC*	Coverage
Soil Survey	NRCS		-
USGS Quad Maps	USGS	UTM*	TIF
USGS National Hydrography	USGS	GCS*	Geodatabase
Dataset (NHD)			
USGS Aerial photos	USGS	SPC*	Mr.Sid
Storm drain system, 1" = 200' scale	Butler	SPC*	Geodatabase
or better			
Street map	Butler	SPC*	Geodatabase
Contour	Butler	SPC*	Geodatabase
Municipal Boundaries	Butler	SPC*	Geodatabase
County Aerial Photos	Butler		
Official Transportation Map 2005	Butler	SPC*	Paper

Table 2.3-1 Existing GIS data

*SPC: NAD_1983_StatePlane_Ohio_South_FIPS_3402

*UTM: NAD_1927_UTM_Zone_16N

*GCS: GCS_North_American_1983

Existing data is processed and re-projected to the projection of NAD_1983_StatePlane_Ohio_South_FIPS_3402 for location accuracy.

2.3.1 Butler County Base Mapping Review

The existing Butler County GIS base map, including the Municipal Storm Sewer System (MS4), was obtained and reviewed for outfall inventory areas, location information, and accuracy. The accuracy of the spatial information will be an issue when outfall locations are transposed to the base mapping in that the accuracy of the outfall locations will be submeter. The existing County mapping appears to be less accurate than sub-meter based on select location points tested during the initial review. Therefore, the surface waters may be shown inaccurately and outfall points may appear to be located apart from the stream to which they drain. Outfall locations will not be adjusted to meet the stream as future base mapping will become more accurate as technology allows the infrastructure to catch up.

2.3.2 Water Resources Mapping Review

Regulated water resources mapping such as existing USGS topographic maps, NRCS soil surveys, and watershed maps were obtained and made a part of the base mapping utilized for this Inventory. The USGS topographic maps provide the identification of the "blue-line" streams, which were established as the basis for stream mapping in this project. Each of these maps provides a basis for which to determine potential outfall locations.

The most recent USGS quadrangle maps available for Butler County, based on the USGS Mapfinder Catalog, are summarized in Table 2.3-2. These maps are digitally available as Digital Raster Graph (DRG) files.



Map Name	Stock No.	Date
College Corner	TOH0146	1992
Oxford	TOH0523	1988
West Elkton	TOH0715	1988
Middletown	TOH0415	1979
Franklin	TOH0233	1988
Reily	TOH0570	1992
Millville	TOH0423	1988
Hamilton	TOH0278	1988
Trenton	TOH0670	1988
Monroe	TOH0429	1988
Harrison	TOH0283	1996
Shandon	TOH0611	1988
Greenhills	TOH0268	1965
Glendale	TOH0254	1987
Mason	TOH0394	1979

Table 2.3-2 USGS Topographic (Quadrangle) Maps in Butler County

2.3.3 Aerial Photo Review

Aerial photos were provided by the County and were reviewed for establishing the accuracy of existing mapping, potential outfall locations, and for the use of field maps to aid in field data collection.

2.3.4 GIS Project Base Layers

Upon compilation of existing GIS data a project base is established. Table 2.3-3 lists the data layers in the GIS project base.

Data	Processing	Format
Sub-watershed	C*, P*	Coverage
USGS Blue lines	**	Geodatabase
Survey Reaches	**	Geodatabase
USGS Aerial photos		Mr.Sid
Storm drain system, 1" = 200' scale		Geodatabase
or better		
Street map		Geodatabase
Contour		Geodatabase
Municipal Boundaries		Geodatabase
Official Transportation Map 2005	S*	TIFF
Project Access Database	***	Access
		Database

Table 2.3-3 GIS Project Base Layers

* C: Conversion

P: Reprojection

S: Scanned

**: See Table 2.3-1

***: A database for database enhancement, such as generating statistics, etc.

2.4 Project Access Database

The Project Access Database (PAD) was developed to provide a custom database for the Stream Mapping and Screening project. The database was developed in MS ACCESS and was created to have the following features:



- Field data quality inspection tool
- Water quality entry tool
- Report tool

This database will be the backbone of the Outfall Reconnaissance Inventory sheet and will contain all of the information collected in the field as well as the required in-office research information collected. The field data exported from Pathfinder Office will be imported into the PAD for enhancement as well as the water quality data.

2.5 GPS Data Dictionary for Field Collection

The data dictionary is a tool utilized within the GPS unit to log information pertinent to the project. The data dictionary is customized for each project based upon the information sought in the field. Quality assurance is apparent with the use of a data dictionary as this tool prompts users to input information and allows the creator to give specific multiple choice style answers for the user to choose from. This decreases the amount of attribute variables allowed for each outfall and controls the names, materials, etcetera that may be used by the field personnel in their This in turn limits the entries and reduces office time descriptions. typically required to sort the descriptions utilized by the field staff while increasing the consistency of the PAD and geodatabase. The Outfall Reconnaissance Inventory data dictionary was developed following the basic ORI sheet recommended by the EPA and was customized for the testing parameters to be utilized in dry weather sampling. The ORI data dictionary file may be found In Appendix C and additional discussion on the ORI form may be found in Section 3.0.

2.6 Outfall ID/Naming Convention

The Outfall ID is an important element in the geodatabase design. It is the key to identifying each outfall both in the database and in the field and it must be:

- Unique
- Easy to generate in the field
- Able to provide sufficient location information for both QA/QC and future field reference

Therefore, the Outfall ID generated in the field will be a random number assigned to it by the GPS software. The GPS software will be programmed to assign a unique number to each outfall, resulting in an easy and efficient way to generate the ID number in the field. The coordinate location and photographs will provide sufficient information for both QA/QC and for future field reference in that any outfall may be referenced to all of the collected desktop information via GIS and the geodatabase developed for this project, to provide sufficient information for future return field visits.



An additional input into the data dictionary will also provide for future field reference as each outfall will be noted as located on the left or right side of the bank of the stream, when facing downstream.

2.7 Survey Reaches

Survey reaches are discrete stream segments or areas that were developed for this project for planning and quality control purposes. In utilizing basic survey reaches, field data collection is completed sequentially and with the pattern established. The delineation of survey reaches is based upon the location of the stream, tributaries, pollutants to test, etc. There is only limited reasoning behind the delineation in that a crew should not skip around to different parts of a mapping area but rather maintain a course on a particular stream and its tributaries until it is complete or outside of the designated mapping limits.

2.8 Field Maps

Baseline mapping containing information on the storm water drainage system and receiving USGS "blue-line" streams is central to the detection and mapping of outfalls and discharges to the receiving water bodies. Base field maps are generated in this first step of the process as both paper and electronic form to aid in locating known outfalls. The GPS unit being utilized is capable of using a base map in the background thus the electronic field maps are loaded into the GPS unit with the Pathfinder Office software.

The field maps have the following layers to aid in the mapping of outfalls:

- Streets
- Streams
- Aerial photo
- Property boundaries
- Storm sewer infrastructure

The real-time map display and waypoint functions of the GPS unit, via the Terrasync software, will be vital to field data collection and the timeliness thereof.

3.0 FIELD DATA COLLECTION

3.1 Objective of Field Data Collection

The objective of the field data collection phase is to visit potential outfall locations as identified in Section 2.0 as well as search for additional outfalls, which were not installed or recorded as a part of the existing storm sewer system. Potential outfalls are assessed using the process described in Section 1.3 and 1.4. Each outfall located in the field is recorded and the required attributes of the outfall and a GPS coordinate are collected. If dry weather flow conditions exist, the outfall is screened and sampled following the parameters discussed in this Section. Data collected in the field is then verified for completeness and quality.



The field survey and investigation is the largest resource consuming effort within the Illicit Discharge Detection and Elimination Minimum Control Measure. It is important that proper planning be performed in order to accomplish quality execution of the field investigation. The desktop research discussed in Section 2.0 provides this planning phase of the project.

The specific field objectives of the data collection are as follows:

- Locate, sequentially number, inspect, document and map all outfalls and discharges along receiving water bodies of the County, within the designated areas as described in Section 1.3
- Obtain GPS coordinates of the outfall location
- Assess the general condition of each outfall
- Measure the flow rate of each flowing outfall if adequate to assess the dry weather loading
- Collect water quality samples to characterize dry weather discharges
- Perform water quality tests to provide indications of pollutants
- Document each outfall condition with digital photograph
- Perform all fieldwork in a safe manner

3.2 Field Safety

All individuals working on this project shall be cognizant of their personal safety as well as the safety of the public, including the following potential safety issues:

- Use of personal protective equipment, including a high visibility safety vest at all times
- Cold weather (frostbite, hypothermia)
- Hot weather (sunburn, heat stress, exhaustion, and stroke)
- Recognition of poisonous plants, animals, and insects
- Other insects: mosquitoes (West Nile Virus) and ticks (Lyme disease)
- Driver safety and awareness, especially in winter weather
- Hazardous or sharp items
- Illicit (non-storm water) discharges into the MS4 and the Waters of the State, which may contain pathogens
- Water safety: flash floods, drowning, unsafe for drinking, use of life vests, especially when use of boat is necessary on larger streams
- Maintaining communication with co-workers
- Steep slopes
- Uneven footing
- Use of waders and/or rubber boots, when necessary
- Extreme caution when use of a machete is required for clearing to collect outfall attributes.

3.3 Field Maps

The baseline map containing information on the storm water drainage system and receiving USGS "blue-line" streams is central to the detection and mapping of outfalls and discharges to the receiving water bodies. Base field maps are generated in the first step of the process as discussed in Section 2.0. The maps will be in both paper and electronic



form for ease of use. The GPS unit being utilized is capable of using a base map in the background and provides a real-time view of the location of the field crew as they walk along the streams. This will reduce the time required to locate known outfall locations and potentially eliminate heavy clearing required during the growing season.

3.4 Base Field Data Collection

The data collected in this second phase is important as it provides the BCSWD with a complete map of the outfalls located within their MS4 and forms the basis for return visits to perform subsequent water quality testing and assess specifics for each illicit discharge found.

Appendix D contains an example data form (to be completed upon initial field survey to establish working documents).

A field survey is necessary to specify or verify the location of each outfall. The precise location of the outfall shall be uploaded to the baseline map that was developed from the initial exercise and discussed therein as well as in Section 4.0. The outfall location field survey will also allow for precise discharge verification and sampling for pollutants. Field outfall surveys include the following steps:

- Notify the community of the presence of field crews in the area and note that these crews shall be allowed within the stream banks and access ways to the streams per the Ohio Revised Code. Notification of the community can also tip off illegal dischargers and a general time frame should be mentioned for the survey. Notification to be completed by the BCSWD.
- Survey outfalls during either dry or wet weather. However, dry weather survey of outfalls is recommended, as it will also allow for observation, verification, sampling and testing of discharges as discussed in Section 3.6.
- Keep safety considerations at the forefront of survey procedures at all times.
- Survey receiving waters on foot or by boat to look for all outfalls and discharges. Wade small receiving waters or use a boat for larger receiving waters.
- Surveys shall be comprised of two-person field crews walking along the banks and through the beds of the receiving waters surveying the banks and the water level for visible outfalls and discharges.
- Each outfall located is to be numbered individually and its attributes recorded as described in this section. The outfall I.D. number shall also be written on a marked board and the outfall photographed using a digital camera. The physical attributes of each outfall or discharge that includes structural deficiencies and characteristics such as head walls, embankments, pipes, flows, deposits, stains, and presence of disposed waste are to be captured in the photograph.
- Each outfall shall be located using a GPS unit to determine its positional coordinates.



 Field data collected shall be downloaded to the desktop computer where additional software will post-process the survey data and allow it to be exported to the PAD (see Section 4.0).

The field survey will generate significant amount of field data to be organized and interpreted. The Outfall Reconnaissance Inventory (ORI) is the base field inspection form provided to crews as an electronic data dictionary within the GPS unit with an organized methodology to investigate outfalls/discharges.

Field crews conduct an ORI by walking all streams and channels to find outfalls/discharges and record their location spatially with a GPS. Crews photograph each outfall and character dimensions, shape, and component material, and record observations on physical indicators. If dry weather flow occurs at the outfall, additional flow and water quality data are collected using field test kits that measure the required pollutant indicators.

The ORI database in this case has been integrated with the GPS unit via the data dictionary. The field form corresponds with the GPS database for electronic data entry and transfer, eliminating the need for additional data handling during this and future data evaluation.

The base field data/attributes to be collected for all outfalls include the following:

- Date of Outfall Survey
- Location of the Outfall (generated by GPS Unit)
 - Latitude WGS 1984
 - o Longitude WGS 1984
 - Ohio State Plane Coordinate Northing
 - o Ohio State Plane Coordinate Easting
- Outfall ID & Township (random number generated by software utilized in data collection)
- Digital Photograph of Outfall
 - Use dry erase board to write outfall number generated by the data dictionary software and position in picture next to outfall
 - One photograph is all that is required no more than three should be taken due to limited storage space
 - Photograph should include an overall site setting rather than a close range shot of the actual outfall.
 - An additional photo taken at close range should be used to document suspected illicit discharges (include the dry erase board with outfall number in picture)
- Type of Outfall
 - o Closed Pipe
 - Open Channel
- Deposits/stains (none, oily, flow line, paint, other)
- Abnormal vegetation growth (none, excessive, inhibited)
- Poor pool quality (none, odors, colors, floatables, oil sheen, suds, algae, other)
- Benthic growth on pipe surfaces (none, brown orange, green, other)



The following attributes will be collected for Closed Pipe Outfalls ONLY:

- Pipe Material
 - Reinforced Concrete Pipe (RCP) or any concrete pipe
 - Vitrified Clay Pipe (VCP)
 - Poly-Vinyl Chloride Pipe (PVC)
 - Corrugated Metal Pipe (CMP)
 - Corrugated Plastic Pipe (CPP)
 - Cast Iron/Ductile Iron Pipe (DIP)
 - o Other
- Pipe Shape
 - o Circular
 - o Elliptical
 - o Egg
 - o Rectangular
 - o Other
- Pipe Diameter (inches)
 - o Diameter
- Submerged
 - o In water (no, partially, fully)
 - o In sediment (no, partially, fully)

The following attributes will be collected for Open Channel Outfalls ONLY:

- Channel Material
 - o Concrete
 - o Earthen
 - o Rip-rap
 - o Other
 - Channel Shape
 - o Trapezoid
 - Parabolic
 - o Other
- Channel Dimensions
 - o Height
 - o Width
- 3.5 Field Equipment

The proper field equipment is essential in creating and maintaining the quality control required as well as providing the tools necessary to seamlessly conduct the field investigation. The following equipment is required for base field data collection:

- GIS-grade GPS receiver
 - Positional accuracy of 1 meter
 - o Data integration capability a plus
- Digital camera
 - Photos shall have a minimum resolution of 1280x960 or approximately 1.2 mega pixels
 - Supports *.jpg, *.tif, or *.bmp files



- Tape measure or folding ruler
- Dry erase board for outfall number for photos
- Safety equipment
 - o First aid kit and pocket knife
 - Self-protection pepper spray
- Base maps
- PDA with ORI sheets loaded or hard copies of ORI sheets & writing tool (if ORI sheets not loaded in GPS unit with data integration capability – data dictionary)
- Backpack to carry equipment
- Waders/rubber boots
- Machete if growing season

The following equipment is also required for dry weather discharge screening and sampling:

- Stop watch or watch with seconds place
- Milk jug with liter mark and top cut open to measure discharge rates
- Basic water quality testing meter (temperature, pH, turbidity, TDS)
- Waterproof pen
- Glass sample containers (100 mL)
- Grab water sampler (dipper on long pole)
- Field water quality sampling kit with reagents required to test for indicators as discussed in Section 5.0

3.6 Dry Weather Data Collection

Dry weather data collection for non-storm water flows is a requirement of the MS4 permit and the basis for establishing illicit discharge connections and the elimination thereof. Dry weather data collection shall occur on all outfalls when the following conditions are met.

- Outfall inventory collection occurs during dry or wet weather. Dry weather screening and sampling will only be performed during dry weather conditions.
- Dry weather conditions exist as defined by: a minimum period of 48 hours with no significant rainfall. Significant rainfall is defined as one-tenth of an inch of rain in any 24-hour period.

Weather events in the inventory shall be monitored consistently and thoroughly to document precipitation amounts and occurrences. Weather information can be obtained from the NOAA/National Weather Service at the following web address: <u>http://weather.noaa.gov/index.html</u>.

3.6.1 Dry Weather Flow Rate Measurements

When feasible, field crews shall measure the rate of flow by recording the time it takes to fill a container of a known volume, such as a one-liter sample bottle. Measuring the flow rate requires the use of a "homemade" container to capture flow, such as a cut out plastic milk container that is marked to show a one-liter volume. The shape and flexibility of plastic containers allows crews to capture relatively flat and shallow flow. The



volume is determined as the volume of flow captured in the container per unit time and is recorded in the ORI form.

3.6.2 Dry Weather Visual/Sensory Field Screening

Dry weather flow data collected shall include the following sensory and physical indicators and shall be recorded as noted in parenthesis:

- Odor type (none, musty, sewage, sulfur, oil, gasoline, solvent, other)
- Odor strength (strong, medium, none)
- Color (based on meter reading discussed in Section 3.6.3)
- Turbidity (based on meter reading discussed in Section 3.6.3)
- Floatable debris (none, oil sheen, sewage, algae, foam/bubbles)

Sensory indicators can be detected by smell or sight, and require no measurement equipment. These indicators do not always reliably predict illicit discharge, since the senses can be fooled, and may result in a "false negative" (i.e., sensory indicators fail to detect an illicit discharge when one is actually present

The odor strength is recorded using an associated severity rating. Since noses have different sensitivities, the entire field crew should reach consensus about whether an odor is present and its severity. The severity was approximated as low, medium, or high.

Physical indicators can reveal the impact of past discharges and most will be collected for both flowing and non-flowing outfalls (see Section 3.4). Many of these physical conditions can indicate that an intermittent or transitory discharge has occurred in the past, even if the pipe is not currently flowing. Physical indicators are not ranked according to their severity, because they are often subtle, difficult to interpret and could be caused by other sources. Still, physical indicators can provide strong clues about the discharge history of a storm water outfall, particularly if other discharge indicators accompany them. The following paragraph on floatable debris shows the importance of the physical indicators.

<u>Floatable debris</u>: Floatable materials in the discharge or the plunge pool below the outfall may or may not indicate an illicit discharge. In some cases, surface sheens may not be related to oil discharges, but instead are created by in-stream processes. A thick or swirling sheen associated with a petroleum-like odor may be diagnostic of an oil discharge. Some streams have naturally occurring foams due to the decay of organic matter and suds may simply reflect this or water turbulence and do not necessarily have an illicit origin. On the other hand, suds that are accompanied by a strong organic or sewage like odor may indicate a sanitary sewer leak or connection. If the suds have a fragrant odor, they may indicate the presence of laundry water or similar wash waters.

3.6.3 Dry Weather Sampling

Dry weather flow occurrences will also be sampled for water quality tests. The water quality indicators used to test the samples may vary depending



upon the watershed, majority of type of land use in an area, existing TMDL reports, and the Ohio Administrative Code.

Indicator parameters: Certain water quality parameters can serve as indicators of the likely presence or absence of a specific type of discharge. There are wide range of indicator parameters and analytical methods to choose from when determining the presence and source of pollutants in discharges. The exact combination of indicator parameters and methods selected for a drainage area is often unique. Parameters can be measured in the field with probes or test kits. A wide variety of water quality parameters can be measured during the survey. Some of the more commonly used and useful parameters are elaborated in Appendix E.

Sampling: Clean and washed 100 mL polyethylene bottles shall be used to collect samples. The bottles must be rinsed with the discharge from the outfall before collecting the sample.

The following water quality indicators will be recorded in the field with a field-test meter for all flowing outfalls greater than or equal to 12-inches in width or diameter, when plausible:

- Flow rate (as described in Section 3.6.1)
- Temperature
- pH
- Turbidity
- Color
- TDS (total dissolved solids)

Additional water quality indicators may be recorded for flowing outfalls that are greater than or equal to 12-inches in width or diameter. The indicators may include one or more of the following tests and will be utilized as selected for each watershed/township area as discussed above and in Section 5.0. The following water quality indicators may be recorded when plausible and as discussed in referenced section:

- Ammonia
- Detergents
- Copper
- Hardness
- Chlorine

3.7 Quality Assurance and Control

QA/QC efforts are error prevention processes consisting of up-front decision-making and early reviews to prevent potential problems. QC is defined, as the error-checking procedure implemented to assure that project documents and calculations are free of errors. Training the field crews in proper sampling and analytical methods assure that the quality of the samples is not compromised.

To ensure that the data collection and documentation thereof are being performed correctly by multiple field personnel, randomly selected outfalls shall be field reviewed as a part of the process. The outfall data set(s)



including all of the attributes collected, shall be reviewed to ensure that documented observations are accurate, complete, and were performed in accordance with this Manual.

QA/QC efforts shall be initiated in the early stages of the inventory collection so that corrective action can be implemented to correct any inconsistencies.

3.8 Limiting Issues

Weather may restrict the feasibility of conducting some fieldwork. In winter weather, snow and ice may inhibit the ability to locate outfalls or collect data and also create a safety risk for walking, driving, or boating. In warm weather, vegetation cover may inhibit the use of the GPS unit as well as mask the outfalls. In addition, wet weather may create safety concerns, reduce the efficiency of the outfall mapping/screening, and raise water levels above the elevation of the outfalls making them impossible to locate or screen. As described in a previous section, the dry weather sensory screening is limited by both seasonal and precipitation events.

4.0 DATABASE POPULATION

4.1 Objective of Database Population

The objective of populating the database is to create a working Outfall Geodatabase that includes all of the outfall location and attribute information collected in the field and the office as well as the digital photographs and water quality results.

Populating the database includes the following processes:

- Differential correction of GPS location (Pathfinder Office)
- Field data enhancement (Project Access Database)
- Linking water quality data to field data (Project Access Database)
- Linking photo to field data
- Exporting project ORI Geodatabase (ArcGIS)

Data collected in the office and field is prepared for entry into the Project Access Database (PAD). Randomly selected data is verified for completeness and accuracy. Data is imported into the PAD. Photographs are downloaded to the computer and matched to the correct outfall in the PAD.

4.2 Differential Correction or Post-Processing

Differential correction is a commonly used post-processing technique to achieve sub-meter accuracy. Several manufacturers even claim that subfoot accuracy is possible with additional antennae. Differential correction post-processing retrieves the error information from accurately surveyed reference base stations that are in close proximity to the field GPS



locations collected, and then uses the information to correct the collected field GPS locations.

In Pathfinder Office, the field data will be downloaded and post-processed and then exported as an Access Database.

4.3 Project Access Database

As discussed in Section 2.4, the project Access Database (PAD) is developed to provide a custom database for the Stream Mapping and Screening project. The database is developed in MS ACCESS and has been customized with the following features:

- Field data quality inspection tool
- Water quality entry tool
- Report tool

This database will be the backbone of the Outfall Reconnaissance Inventory sheet and will contain all of the information collected in the field as well as the required desktop research information collected. The field data exported from Pathfinder Office will be imported into the PAD for enhancement as well as the water quality data.

4.4 GPS Photolink

GPS Photolink is third-party software that links GPS data and photos. It was only used to put the date onto the photos since they were collected without the date visible.

4.5 Outfall Reconnaissance Inventory Geodatabase

The ORI Geodatabase is a comprehensive GIS database containing all of the data collected in the office and field that pertains to the inventory of each outfall and the attributes thereof. The ORI database will provide the District with a complete map of the outfalls within the jurisdiction to which this project is completed and a tool to identify and eliminate illicit discharges within the MS4.

There are three feature classes in the ORI Geodatabase: ORI, Watershed and USGS blue lines. Tables 4.5-1, -2, and -3 illustrate a sample structure of each of these feature classes. The ORI feature class holds the location, attributes, water quality and photo data of the outfall inventory. The USGS blue lines feature class defines the geographic extent of the work.

The Watershed feature class defines the look up table for the HUC fields in the ORI feature class.

ORI	Geometry Point Contains M values No
	Contains Z values No
Field	Туре

Table 4.5-1 ORI Feature Class



Primary Key	Lona Inteaer
HUC 8-digit	String
HUC 3-digit extension	String
Outfall ID	String
Date of Survey	Date
Time (MIL)	Time
	String
Form Completed By	String
	String
All Temp. (F)	String
Raintail: last 24 (in)	String
Rainfall: last 48 (in)	String
Lat:Degree	String
Lat:Minutes	String
Lat:Seconds	String
Long:Degree	String
Long:Minutes	String
Long:Seconds	String
GPS Mark #	String
GPS Unit	String
Camera	String
Photo #s	String
Land Use:Industrial	Short integer
Land Use: Ultra-Urban Residential	Short integer
Land Use: Suburban Resdintial	Short integer
Land Use: Commercial	Short integer
Land Use: Open Space	Short integer
Land Use: Institutional	Short integer
Land Use: Other	Short integer
Land Use: Other Desc	String
Know Industries	String
Rackground data notes	String
Outfall: Location: Closed Pine	Short integer
Outfall:Closed Pipe:Material	Short integer
Outfall:Closed Pipe.Material:Other Dece	String
	String
Outiall.Closed Pipe.Shape	String
Outiall.Closed Fipe.Shape.Other Desc	String
Outrall. Closed Pipe. Shape2	String
Outiall.Closed Pipe.Shape2.Other Desc	String
Outrall: Closed Pipe: Dimensions/Diameter	String String
Outrall:Closed Pipe:Submerged:In Water	String
Outfall: Closed Pipe: Submerged: with Sediment	String
Outrall:Location:Open Drainage	Short Integer
	String
Outfall:Open Drian:Material:Other Desc	String
Outfall:Open Drian:Shape	String
Outfall:Open Drian:Shape: Other Desc	String
Outfall:Open Drian:Dimensions: Depth	String
Outfall:Open Drian:Dimensions:TopWidth	String
Outfall:Open Drian:Dimensions:Bottom Width	String
Outfall:In-Stream	Short integer
Outfall:Flow Present	Short integer
Outfall:Flow Desc	String
Quantitative:Parameter:Flow #1	Short integer
Quantitative: Parameter: Flow #1:\/olume	String
Quantitative: a anneter: Flow #1. Volume	String
Quantitative: a anneter: Now #1.11116 to 111	Short integer
Quantitative:Parameter:Elow #2:Elow Death	Short integer
Quantitative: Farameter: Flow #2. Flow Depth	String
	Sunny
_	B 1 B 1 B 1 B 1 B 1 B 1 B 1 B 1 B 1 B 1 B B 1 B B B B B B B B B B
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Quantitative:Parameter:Flow #2:Flow Width:Inches	String
Quantitative:Parameter:Flow #2:Measured	String
Length:Feet	- · · J
Quantitative:Parameter:Flow #2:Measured	String
Quantitative:Parameter:Flow #2:Time of travel	String
Quantitative: Parameter: Temperature	String
Quantitative:Parameter:pH	String
Quantitative:Parameter:Ammonia	String
Flowing Outfall Indicators: Physical Indicators	Short integer
Present	onoreinteger
Flowing Outfall Indicators:Odor	Short integer
Flowing Outfall Indicators:Odor: Sewage	Short integer
Flowing Outfall Indicators:Odor:Bancid/Sour	Short integer
Flowing Outfall Indicators:Odor:Rancid/Sour	Short integer
Flowing Outfall Indicators:Odor: Petroledin/Gas	Short integer
Flowing Outfall Indicators:Odor:Other	Short integer
Flowing Outfall Indicators:Odor:Other Dece	Short integer
Flowing Outfall Indicators.Odor.Outlet Desc	Stillig Short integer
Flowing Outfall Indicators.Odor.Seventy.Faint	Short integer
Flowing Outfall Indicators.Odor.Sevenity.Easily	Short integer
Flowing Outlan Indicators.Odor.Seventy.Noticeable	Short integer
Flowing Outfall Indicators:Color	Short integer
Flowing Outial Indicators: Color: Clear	Short integer
Flowing Outfall Indicators:Color:Brown	Short integer
Flowing Outfall Indicators:Color:Grey	Short integer
Flowing Outfall Indicators: Color: Yellow	Short Integer
Flowing Outfall Indicators: Color: Green	Short integer
Flowing Outfall Indicators:Color:Orange	Short integer
Flowing Outfall Indicators:Color:Red	Short integer
Flowing Outfall Indicators:Color:Other	Short integer
Flowing Outfall Indicators:Color:Other Desc	String
Flowing Outfall Indicators:Color:Severity:Faint	Short integer
Flowing Outfall Indicators:Color:Clearly visible in	Short integer
Dottle	
Flowing Outrall Indicators:Color:Cleary Visible In	Short integer
	0
Flowing Outfall Indicators: Lurbidity	Short integer
Flowing Outfall Indicators: Turbidity:Slight Cloudiness	Short integer
Flowing Outfall Indicators: Turbidity:Cloudy	Short integer
Flowing Outfall Indicators: Turbidity:Opaque	Short integer
Flowing Outfall Indicators: Floatables	Short integer
Flowing Outfall Indicators: Floatables: Sewage	Short integer
Flowing Outfall Indicators: Floatables: Petroleum	Short integer
Flowing Outfall Indicators: Floatables: Other	Short integer
Flowing Outfall Indicators: Floatables: Other Desc	String
Flowing Outfall Indicators: Floatables: Few/slight	Short integer
Flowing Outfall Indicators: Floatables: Some	Short integer
indications of orgin	.
Flowing Outfall Indicators: Floatables: Some orgin	Short integer
clear	.
Both Indicators:Not Related to Flow Present	Short integer
Both Indicators:Outfall Damage	Short integer
Both Indicators:Outfall Damage:Spalling, cracking,	Short integer
chipping	ener integer
Both Indicators:Outfall Damage:Peeling Paint	Short integer
Both Indicators:Outfall Damage:Corrosion	Short integer
Both Indicators:Outfall Damage:Comments	String
Both Indicators: Deposits	Short integer
Both Indicators: Deposits: Oilv	Short integer
	Choreintogol



Both Indicators:Deposits:Flow Line	Short integer
Both Indicators:Deposits:Paint	Short integer
Both Indicators:Deposits:Other	Short integer
Both Indicators:Deposits:Other Desc	String
Both Indicators:Deposits:Comments	String
Both Indicators: Abnormal Veg	Short integer
Both Indicators: Abnormal Veg: Excessive	Short integer
Both Indicators: Abnormal Veg: Inhibited	Short integer
Both Indicators: Abnormal Veg: Comments	String
Both Indicators: Poor Pool Quality	Short integer
Both Indicators: Poor Pool Quality: Odors	Short integer
Both Indicators: Poor Pool Quality: Colors	Short integer
Both Indicators: Poor Pool Quality: Floatables	Short integer
Both Indicators: Poor Pool Quality: Oil Sheen	Short integer
Both Indicators:Poor Pool Quality:Suds	Short integer
Both Indicators:Poor Pool Quality:Excessive Algea	Short integer
Both Indicators:Poor Pool Quality:Other	Short integer
Both Indicators: Poor Pool Quality: Other Desc	String
Both Indicators: Poor Pool Quality: Comments	String
Both Indicators: Pipe Benthic Growth	Short integer
Both Indicators: Pipe Benthic Growth: Brown	Short integer
Both Indicators: Pipe Benthic Growth: Orange	Short integer
Both Indicators: Pipe Benthic Growth: Green	Short integer
Both Indicators: Pipe Benthic Growth: Other	Short integer
Both Indicators: Pipe Benthic Growth: Other Desc	String
Both Indicators: Pipe Benthic Growth: Comments	String
Characterization:No Indication of illicit discharges	Short integer
Characterization:Some Likelihood of III Disc	Short integer
Characterization:Almost certian III Disc exsits	Short integer
Data Collection:Sample for Lab	Short integer
Data Collection: If yes collected from	String
Data Collection:OBM Trap Set	Short integer
Any non-Illicit Discharge Concerns	String

Table 4.5-2 USGS Blue Lines Feature Class

USGS Blue lines		Geometry Polyline
		Contains M values Yes
		Contains Z values Yes
Fields*	Data Type	Description
FCode	Long integer	A unique five-digit feature code
Description	String	Description of the feature

*See NHD Data Model Schema for other fields information¹⁶

Table 4.5-3 Watershed Feature Class

Oh14dig*		Geometry Polygon
	Contains M values No	
		Contains Z values No
HUC_11	Text	11-digit watershed ID
NARRATIVE	String	Narrative watershed name



*From NRCS: http://www.oh.nrcs.usda.gov/technical/14digit/download.html

The database also contains several columns for illicit discharge connection/detection. These columns will be based statistically upon field observations and provide a potential list of illicit discharges. The following status will be shown.

- Low priority. Clean Flow. No positive sensory/physical observations (odor, color, turbidity, floatables) identified and minimal flow (<10 gpm or < 1 gallon every 6 secs).
- Medium priority. One positive sensory/physical observations (odor, color, turbidity, floatables) identified and minimal flow (<10 gpm or < 1 gallon every 6 secs).
- High priority. Two positive sensory/physical observations (odor, color, turbidity, floatables) identified or one positive observation and significant flow (>10 gpm or > 1 gallon every 6 secs).
- No Flow Condition.

The database will also contain a section on the source of the potential illicit discharge and will be based primarily upon the results of the water quality indicators utilized. The goal of this is not to direct the County to the exact point of illicit connection but rather to provide a tool and an initial reading to allow the County to perform subsequent field investigations to determine the source.

Potential sources of illicit discharges will be indicated as follows:

- None
- Unknown
- Home sewage treatment system HSTS)
- Industrial
- Commercial

5.0 STUDY AREAS

The Butler County Storm Water District was separated into Urbanized Areas and non-urbanized areas to prioritize the work as discussed in Section 1.0. The following subsections discuss the particulars of each Urbanized Area and include several figures within each to aid in the discussion.

5.1 West Chester Township (Pilot Area)



West Chester Township is the pilot study area as determined by the District. Figure 5.1-1 illustrates the USGS "Blue-Line" streams in West Chester Township that will be walked for outfall inventory. The total USGS Blue-Line miles are 52.86. The outfalls will be dry weather screened and sampled as described in previous sections of this Manual.

Figure 5.1-2 illustrates the 8-digit watershed HUCs located within West Chester Township and include 05080002, 05090202, and 05090203. Figure 5.1-3 illustrates the designated subwatersheds, or 11-digit WAUs, within West Chester Township and includes 05080002050, 05090202060, 05090202040, and 05090203010.

A short stream segment will be walked, outfalls inventoried, and dry weather flow screening conducted (was completed on 12/01/2005). This will be completed within one day. The field data collected will be brought back to the office, loaded into the desktop/software described herein, and ran through the processes as described to check for compatibility, accuracy, and the functioning of all of the components of the project. This initial test is important to determine if all components of the project database and collection are working together and accurately. Upon successful completion of this test, fieldwork will continue until the outfall inventory for the pilot study area is complete.

Upon completion of the outfall inventory for West Chester Township, a representative ORI Geodatabase will be delivered to the County to review and comment.

5.2 Liberty Township

Figure 5.2-1 illustrates the USGS "Blue-Line" streams in Liberty Township that will be walked for outfall inventory. The total USGS Blue-Line miles are 45.13. The outfalls will be dry weather screened and sampled as described in previous sections of this Manual.

Figure 5.2-2 illustrates the 8-digit watershed HUCs located within Liberty Township and include 05080002, 05090202, and 05090203. Figure 5.2-3 illustrates the designated subwatersheds, or 11-digit WAUs, within Liberty Township and includes 05080002050, 05090202060, and 05090203010.

To be completed as mapping progresses

5.3 Fairfield Township

Figure 5.3-1 illustrates the USGS "Blue-Line" streams in Fairfield Township that will be walked for outfall inventory. The total USGS Blue-Line miles are 31.76. The outfalls will be dry weather screened and sampled as described in previous sections of this Manual.

Figure 5.3-2 illustrates the 8-digit watershed HUCs located within Fairfield Township and include 05080002 and 05090203. Figure 5.3-3 illustrates



the designated subwatersheds, or 11-digit WAUs, within Fairfield Township and includes 05080002050, 05080002090, and 05090203010.

5.4 Lemon Township

Figure 5.4-1 illustrates the USGS "Blue-Line" streams in Lemon Township that will be walked for outfall inventory. The total USGS Blue-Line miles is 14.96. The outfalls will be dry weather screened and sampled as described in previous sections of this Manual.

Figure 5.4-2 illustrates the 8-digit watershed HUC located within Lemon Township and includes 05080002. Figure 5.4-3 illustrates the designated subwatershed, or 11-digit WAU, within Lemon Township and includes 05080002050.

5.5 Madison Township and City of Trenton

Figure 5.5-1 illustrates the USGS "Blue-Line" streams in Madison Township and City of Trenton that will be walked for outfall inventory. The total USGS Blue-Line miles are 93.39 and 0.68 for Madison Township and City of Trenton respectively. The outfalls will be dry weather screened and sampled as described in previous sections of this Manual.

Figure 5.5-2 illustrates the 8-digit watershed HUC located within Madison Township and City of Trenton and includes 05080002. Figure 5.5-3 illustrates the designated subwatersheds, or 11-digit WAUs, within Madison Township and City of Trenton and includes 05080002050 and 05080002040.

5.6 Saint Clair Township, City of New Miami and City of Seven Mile

Figure 5.6-1 illustrates the USGS "Blue-Line" streams in Saint Clair Township, City of New Miami and City of Seven Mile that will be walked for outfall inventory. The total USGS Blue-Line miles are 30.65, 1.67 and 0.30 for Saint Clair Township, City of New Miami and City of Seven Mile respectively. The outfalls will be dry weather screened and sampled as described in previous sections of this Manual.

Figure 5.6-2 illustrates the 8-digit watershed HUC located within Saint Clair Township, City of new Miami and City of Seven Mile and includes 05080002. Figure 5.6-3 illustrates the designated subwatersheds, or 11-digit WAUs, within Saint Clair Township, City of new Miami and City of Seven Mile and includes 05080002050, 05080002060, 05080002070, and 05080002090.

5.7 Hanover Township and City of Millville

Figure 5.7-1 illustrates the USGS "Blue-Line" streams in Hanover Township and City of Millville that will be walked for outfall inventory. The total USGS Blue-Line miles are 49.64 and 1.86 for Hanover Township



and City of Millville respectively. The outfalls will be dry weather screened and sampled as described in previous sections of this Manual.

Figure 5.7-2 illustrates the 8-digit watershed HUC located within Hanover Township and City of Millville and includes 05080002. Figure 5.7-3 illustrates the designated subwatersheds, or 11-digit WAUs, within Hanover Township and City of Millville and includes 05080002050, 05080002070, and 05080002090.

5.8 Ross Township

Figure 5.8-1 illustrates the USGS "Blue-Line" streams in Ross Township that will be walked for outfall inventory. The total USGS Blue-Line miles are 62.37. The outfalls will be dry weather screened and sampled as described in previous sections of this Manual.

Figure 5.8-2 illustrates the 8-digit watershed HUC located within Ross Township and includes 05080002. Figure 5.8-3 illustrates the designated subwatersheds, or 11-digit WAUs, within Ross Township and includes 05080002080 and05080002090.

6.0 **REFERENCES**

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ftp://nhdftp.usgs.gov/SubRegions/Medium/NHDM0509.zip http://www.usgsquads.com/mapfinder.html http://nhd.usgs.gov/quickstart.html http://nhd.usgs.gov/NHD.pdf



<u>APPENDIX A</u>

FIGURES







	FIGURE 2.2-1 Watershed HUCs within
05090202140	05090203010
05080003080	05090202060
05080002070	05080002080
05080002040	05080002050
1- Digit	

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Butler County






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FIGURE 5.1-2 Designated Watersheds (8-digit HUC) within Westchester Township







Ζ





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Liberty Township FIGURE 5.2-1 USGS Bluelines within







FIGURE 5.2-2 Designated Watersheds (8-digit HUC) within Liberty Township













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Fairfield Township FIGURE 5.3-1 USGS Bluelines within









FIGURE 5.3-2 Designated Watersheds (8-digit HUC) within Fairfield Township





Liberty Fairfield



FIGURE 5.3-3 Designated Watersheds (11-digit HUC) within Fairfield Township



Liberty Fairfield













FIGURE 5.4-1 USGS Bluelines within Lemon Township









Z

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FIGURE 5.4-2 Designated Watersheds (8-digit HUC) within Lemon Township



















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St. Claire Township, City of New Miami and City of Seven Mile FIGURE 5.6-1 USGS Bluelines within





Feet







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FIGURE 5.6-2 Designated Watersheds (8-digit HUC) within St. Claire Township, City of New Miami and City of Seven Mile









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Hanover Township and City of Milleville FIGURE 5.7-1 USGS Bluelines within







FIGURE 5.7-2 Designated Watersheds (8-digit HUC) within Hanover Township and City of Milleville











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FIGURE 5.7-3 Designated Watersheds (11-digit HUC) within Hanover Township and City of Milleville









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FIGURE 5.8-1 USGS Bluelines within **Ross Township**







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FIGURE 5.8-3 Designated Watersheds (11-digit HUC) within Ross Township





APPENDIX B

GLOSSARY AND ACRONYMNS



GLOSSARY AND ACRONYMNS

<u>11-digit Hydrologic Unit Code (HUC)</u>: A watershed with a typical size of 40,000 to 250,000 acres. Each 11-digit HUC is completely contained within an 8-digit HUC. The 11-digit HUC boundaries were delineated by USGS based on 1:24000 scale USGS topographic maps, also commonly referred to as quadrangle maps.

<u>7.5 Minute Topographic Quadrangle</u>: the smallest topographic quadrangle commonly published by the U.S. Geological Survey, which measure 7.5 minutes of latitude and longitude. The 7.5-minute quadrangles display the topography, water features including permanent and ephemeral streams, and various man-made features.

BCSWD: Butler County Storm Water District

<u>Best Management Practice (BMP)</u>: Practices that are used to control urban storm water runoff. There are two types of BMPs. Structural BMPs such as infiltration devices, ponds, filters and constructed wetlands, and Non-structural BMPs – low impact development practices and management measures such as maintenance practice, street sweeping, public education, and outreach programs.

<u>Captured Stream</u>: A water of the State that has been rerouted and contained in a manmade structure.

<u>Clean Water Act (CWA)</u>: The Act established the basic structure for regulating discharges of pollutants into the waters of the United States.

<u>CMP</u>: Corrugated Metal Pipe.

<u>CPP</u>: Corrugated Plastic Pipe.

<u>County Soil Survey</u>: County specific surveys prepared in a joint effort of Federal and State agencies, universities, and professional societies to display soil and geomorphic information, including drainage patterns.

- DIP: Ductile Iron Pipe.
- DRG: Digital Raster Graph.
- <u>EPA</u>: Environmental Protection Agency.
- <u>GIS:</u> Geographical Information System.
- <u>GPS</u>: Global Positioning System.

HDPE: High Density Poly-Ethylene Pipe.

<u>HSTS</u>: Home Sewage Treatment System – privately owned and operated domestic sewage treatment systems including septic systems.

HUC: Hydrological Unit Codes.



Localized Rain Event: A rain event that only occurs in a part of a locality.

MCM: Minimum Control Measure.

<u>MEP</u>: Maximum Extent practicable – the technology-based discharge standard for Municipal Separate Storm Sewer Systems to reduce pollutants in storm water discharges that was established by CWA §402(p). A discussion of MEP as it applies to small MS4s is found at 40 CFR 122.34.

<u>Municipal Separate Storm Sewer System (MS4)</u>: A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) that are:

- Owned or operated by the federal government, state, municipality, township, county, district, or other public body (created by or pursuant to state or federal law) including special district under state law such as a sewer district, flood control district, or drainage districts, or similar entity or a designated and approved management agency under Section 208 of the act that discharges into surface waters of the state; and

Designed or used for collecting or conveying solely storm water;

- Which is not a combined sewer; and
- Which is not a part of a publicly owned treatment works.

<u>National Pollution Discharge Elimination System (NPDES)</u>: An EPA program that controls water pollution by regulating point sources that discharge pollutants into waters of the United States.

NRCS: National Resource Conservation Service.

NOAA: National Oceanic and Atmospheric Administration.

OAC: Ohio Administrative Code.

<u>OEPA</u>: Ohio Environmental Protection Agency.

ORI: Outfall Reconnaissance Inventory.

<u>Outfall</u>: A point source as defined by 40 CFR 122.2 at the point where a municipal separate storm sewer discharges to waters of the United States 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 waters of the United States and are used to convey waters of the United States.

PAD: Project Access Database.

PC: Personnel Computer.

PDA: Personnel Digital Assistant

<u>Phase I</u>: Phase I requires NPDES permits for storm water discharge from a large number of priority sources including medium and large MS4s generally serving populations of 1000,000 or more and several categories of industrial activity, including construction activity that disturbs five or more acres of land.



<u>Phase II</u>: Phase II addresses storm water runoff of MS4s serving populations less than 100,000 called small SM4s. Phase II addresses MS4s in urbanized areas, areas that are becoming urbanized, and those which discharge to surface waters with impaired water quality.

<u>Point Source</u>: Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.

<u>PVC</u>: Poly Vinyl Chloride.

<u>Quality Assurance (QA)</u>: The process assuring the overall quality of products or processes by reviewing representative subsets of the whole.

<u>Quality Control (QC)</u>: Procedures and techniques to verify the quality, accuracy, and consistency of products or processes.

<u>RCP</u>: Reinforced Concrete Pipe or Rock Channel Protection.

Significant Rain Event: A rainfall that is greater than 0.1 inches of rain in a 24-hour time period.

Spalling: The appearance of a concrete pipe to break up as if by chipping with a hammer.

<u>Storm Water</u>: Discharges that are generated by runoff from land and impervious areas such as paved streets, parking lots, and building rooftops during rainfall and snow events that often contain pollutants in quantities that could adversely affect water quality.

Suburban: The area exhibiting a combination of both rural and urban characteristics.

<u>SWMP</u>: Storm Water Management Plan.

TDS: Total Dissolved Solids.

TMDL: Total Maximum Daily Load.

<u>Turbidity</u>: Thick or opaque water with or as if with roiled sediment.

<u>Urban</u>: An urban area includes a census place with an urban population of 5,000 to 49,000, or a designated urban area with a population of 50,000 or more.

<u>Urbanized</u>: A 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.

VCP: Vitrified Clay Pipe.



<u>Water of the United States</u>: Means all streams, lakes, reservoirs, ponds, marshes, wetlands, or other waterways which are situated wholly or partly within the boundaries of the State, except those private waters which do not combine or affect a junction with a surface water. Waters defined as sewerage systems, treatment works, or disposal systems in Section 6111.01 of the ORC are not included.

<u>Watershed</u>: The area of land where all of the water that is under it or drains off of it goes into the same place.

WAU: Watershed Assessment Unit.



APPENDIX C

SAMPLE DATA DICTIONARY



SAMPLE DATA DICTIONARY

"Butler", Dictionary, "Revised 11-28-2005" "Outfall", point, "", 5, seconds, 1, Code "Sec.1:Background", caption "OUTFALL FIELD ID CD", text, 3, required, "Outfall Identification", normal "Side_LookUpstream_CD", menu, required, "Side of the stream", normal, Label1 "Left".[L] "Right",[R] "Outfall Attributes", caption "OUTFALL SURVEY DT", date, auto, dmy, manual, normal, "Date of Collection", normal "Sec.2:Outfall Desc. ", caption "OUTFALL TYPE CD", menu, normal, "Type of Outfall", normal "Pipe", [P], default "OpenChannel".[O] "ROCK_CHANNEL_PROTECT", menu, normal, "Rock Channel Protection?", normal "YES",[Y] "NO",[N], default "LITTER PRESENT IND", menu, normal, "Litter at Outfall", normal "YES",[Y] "NO".[N]. default "OUTFALL COMMENTS TXT", text, 100, normal, "Field Comments", normal "Closed Pipe Data", caption "PIPE_SHAPE_CD", menu, normal, "Shape of Outfall Pipe", normal "Circular".[1] "Rectangular",[2] "Elliptical",[3] "Egg",[4] "Other",[5] "Submerged", menu, normal, "If Pipe is submerged", normal "Fully",[F] "No",[N], default "Partially",[P] "Sediment", menu, normal, "Sediment Condition", normal "Fully",[F] "No",[N], default "Partially",[P] "Pipe_Dimension_NBR", numeric, 0, 0, 20, 4, normal, normal "PIPE_MATERIAL_CD", menu, normal, "Pipe Material", normal "RCP",[1] "CPP",[7] "VCP",[2] "CMP",[3] "PVC",[4] "Cast Iron",[5] "Other",[6] "Skip Closed Pipe", menu, required, normal "Yes",[Y] "No",[N] "Open Channel Data", caption "Channel SHAPE CD", menu, normal, "Shape of Open Channel", normal



"Trapezoid",[6] "Parabolic",[7] "Other",[8] "CHANNEL HEIGHT NBR", numeric, 1, 0.0, 144.0, 0.0, normal, "Pipe Height (inches)", normal "CHANNEL WIDTH NBR", numeric, 1, 0.0, 144.0, 0.0, normal, "Pipe Width (inches)", normal "CHANNEL_Bottom_Width", numeric, 0, 0, 20, 5, normal, normal "Channel MATERIAL CD", menu, normal, "Channel Material", normal "Concrete",[10] "Earthen",[11] "rip-rap",[12] "Other",[13] "Skip Open Channel", menu, required, normal "Yes",[Y] "No",[N] "Section 3: Qty. Char", caption, "Quantitative characterization" "DRYWEATHER_VS_DT", date, auto, dmy, manual, normal, "Visual Screening Date", normal "Flow Present", menu, required, normal "Yes",[Y] "No",[N] "Flow_Volume_NRB", numeric, 0, 0, 10, 5, normal, normal "Time to fill NBR", numeric, 0, 0, 60, 10, normal, normal "Temperature", numeric, 0, 0, 60, 30, normal, normal "pH", numeric, 0, 0, 60, 30, normal, normal "Conductivity", numeric, 0, 0, 10000, 30, normal, normal "TDS NRB", numeric, 0, 0, 10000, 5, normal, normal "Turbidity NBR", numeric, 0, 0, 10000, 0, normal, "Turbidity", normal, Label2 "AMMONIA NRB", numeric, 0, 0, 1000, 5, normal, normal "NITRATE_NRB", numeric, 0, 0, 10000, 5, normal, normal "PHOSPHATE NRB", numeric, 0, 0, 100000, 5, normal, normal "COLIFORM NRB", numeric, 0, 0, 100000, 5, normal, normal "Parameter", menu, normal, "parameter", normal "TDS",[TDS] "Turbidity",[Turbid], default "Ammonia",[Ammoni] "Nitrate",[Nitrat] "Phosphate",[P] "Surfactants",[Surfac] "Coliform",[Coli] "Value_NBR", numeric, 0, 0, 1000, 0, normal, normal "Sec.4:Phy. Indicator", caption "ODOR CD", menu, normal, "Odor Observation", normal "None",[NONE] "Musty",[MUST] "Sewage".[SEWA] "Solvent",[SOLV] "Sulfer",[SULF] "Oil",[OIL] "Gasoline",[GASO] "Other",[OTHR] "COLOR CD", menu, normal, "Color Observation", normal



"None",[NONE] "Yellow",[YELO] "Green",[GREE] "Brown",[BROW] "Gray",[GRAY] "Other",[OTHR] "FLOATABLES_CD", menu, normal, "Floatables Observation", normal "None",[NONE] "Oil Sheen",[OIL] "Sewage",[SEWA] "Foam / Bubbles",[FOAM] "Algae",[ALGE] "PHY_COMMENTS_TXT", text, 100, normal, "Field Comments", normal "Sec.8 Illicit Disch.", caption "ILLICIT_SOURCE_CD", menu, normal, "Source Observation", normal "None",[NONE] "HSTS",[HSTS] "Industrial",[INDU] "Commercial",[COMM] "Other",[OTHR] "ILLICIT_SOURCE_GUESS", text, 100, normal, "Addl. Source Information", normal



APPENDIX D

DATA FORM WITH PHOTOS



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	Color None	9	-			
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TURBIDITY_CD	Turbidity		(ppm)	test could not be performed in the field because of the amount of time required
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	Hardness		(ppm)	Analysis started after 1/23/2006
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APPENDIX E

POTENTIAL ANALYTICAL METHODS


POTENTIAL ANALYTICAL METHODS

AMMONIA

Ammonia is a good indicator of sewage, since its concentration is much higher in the sewage than in groundwater or tap water. High ammonia concentrations may also indicate liquid wastes from some industrial sites. Ammonia is relatively simple and safe to analyze. Some challenges include the tendency for ammonia to volatilize (turn into a gas and become non-conservative) and its potential generation from non-human sources, such as pets or wildlife.

Salicyclate colorimetric method: Salicylate and ammonia react at high pH in the presence of a chlorine donor and an iron catalyst to form a blue indophenol dye, the concentration of which is proportional to the ammonia concentration in the sample.

Sample handling and preservation: Ammonia solutions tend to be unstable and should be analyzed immediately. Samples may be stored for 24 hours at 4°C or 28 days at – 20°C.

Interferences: There is little interference in most natural waters. High concentrations of reducing agents, such as hydrazine, react with the chlorine donor and can result in negative interferences. Color and turbidity can also interfere.

CODE 3659-01-SC RANGE: 0.00 - 1.00 ppm Ammonia-Nitrogen

CONDUCTIVITY

Conductivity, or specific conductance, is a measure of how easily electricity can flow through a water sample. Conductivity is often strongly correlated with the total amount of dissolved material in water, known as Total Dissolved Solids. The utility of conductivity as an indicator depends on whether concentrations are elevated in "natural" or clean waters. Conductivity has some value in detecting industrial discharges that can exhibit extremely high conductivity readings. Conductivity is extremely easy to measure with field probes, so it has the potential to be a useful supplemental indicator in watersheds that are dominated by industrial land uses.

COPPER

The copper content of drinking water generally falls below 0.03 ppm, but copper levels as high as 1.0 ppm will give water a bitter taste. Waters testing as high as 1.0 ppm copper has probably been treated with a copper compound, like those used in the control of algae, or have become contaminated from untreated industrial wastes. Acid waters and those high in free carbon dioxide may cause the corrosion or "eating away" of copper, brass and bronze pipes and fittings. This corrosion results in the addition of copper to the water supply.

Cuprizone colorimetric method: Copper ions form a blue complex with cuprizone, in a 1 to 2 ratio, at a pH of about 8, in proportion to the concentration of copper in the sample.

Sample handling and preservation: Copper has a tendency to be adsorbed to the surface of the sample container. Samples should be analyzed as soon as possible after



collection. If storage is necessary, 0.5 mL of 20% hydrochloric acid per 100 mL of sample will prevent "plating out". However, a correction must be made to bring the reaction into the optimum pH range.

Interferences: Hg⁺¹ at 1 ppm. Cr⁺³, Co⁺², and silicate at 10 ppm. As⁺³, Bi⁺³, Ca⁺², Ce⁺³, Ce⁺⁴, Hg⁺², Fe⁺², Mn⁺², Ni⁺² and ascorbate at 100 ppm. Many other metal cations and inorganic anions at 1000 ppm. EDTA at all concentrations. CODE 4023 RANGE: 0.00–2.00 ppm Copper

CHEMetrics DETERGENTS 9400

Ion Pair Extraction - Bromphenol Blue Indicator Method: The presence of Linear Alkyl Sulfonates (LAS) in the water sample causes the transfer of bromphenol blue dye from the organic reagent layer to the aqueous layer. The amount of color in the aqueous layer is proportional to the concentration of the LAS in the sample. LAS are Methylene Blue Active Substances (MBAS). This calibration is based on sodium lauryl sulfate (dodecyl sodium sulfate). Some linear alkyl sulfonates may have a slightly different response. Prepare standards of a known concentration and follow the test procedure below to determine a conversion factor.

Sample handling and preservation: Analyze samples as soon as possible. May be stored at 4°C for 24 hours. Warm to room temperature before testing.

Interferences: Cationic surfactants and nonionic surfactants.

CODE 4876 RANGE: 0.5–8.0 as LAS

TEMPERATURE

Temperature measurements may be useful in situations where the screening activities are conducted during cold months, or in areas having industrial activity. It may be possible to identify an outfall that is grossly contaminated with sanitary wastewater or cooling water during very cold weather. Both sanitary wastewater and cooling water could substantially increase outfall discharge temperatures. Elevated baseflow temperatures (compared to baseflows at other outfalls being screened) could be an indicator of substantial contamination by these warmer source flows.

TOTAL DISSOLVED SOLIDS

TDS is another parameter to consider in a pollutant analysis for industrial areas. However, it is recommended that conductivity measurements, conducted in the field, be used as an indicator of total dissolved solids concentrations.

TURBIDITY

Turbidity is a measure of water clarity and is independent of color. Undissolved and suspended solids cause turbidity. Mud, silt, algae, and microorganisms can all cause turbidity. Turbidity is a gross measurement of water quality. Turbidity, or the clarity of water is often affected by the degree of gross contamination. Dry-weather industrial flows with moderate turbidity can be cloudy and difficult to see through, while high turbidity flows will be opaque and practically impossible to see through. High turbidity is



often a characteristic of undiluted dry-weather industrial discharges, such as those coming from some continual flow sources, or some intermittent spills. Sanitary sewage is also often cloudy in nature.

Test method: visual observation

HARDNESS

Water hardness is caused almost entirely by calcium and magnesium ions. Other di- and trivalent metals have a similar effect, but usually are not present in high enough concentration in potable waters to cause problems. Hardness increases soap consumption in laundries and causes scale in boilers.

Method / Chemistry	Range (mg/L)	Steps	Number of Tests
Test Strips	0-425	0, 25, 50, 120, 250, 425	50
	(0-25 gpg)	(0, 1.5, 3, 7, 15, 25 gpg)	
	1gpg = 17.1 - mg/L or 17.1 ppm		

CHLORINE

The most widely used disinfectant for drinking water, chlorine is also important for sanitizing swimming pools, cooling towers, other industrial equipment, and in the treatment of municipal wastewater. Its measurement and control are vital for both safety and economic reasons.

Chlorine exists in water as "free" chlorine (hypochlorite) or "combined" chlorine (chloramines). The total chlorine test detects both forms.

Method / Chemistry	Range	Steps (ppm)	Approx. Number of Tests
Test Strips	0-10 mg/L	0, 0.5, 1.0, 2.0, 4.0, 10.0	50



APPENDIX F

PROJECT ACCESS DATABASE ON DVD PHOTOGRAPHS ON DVD

