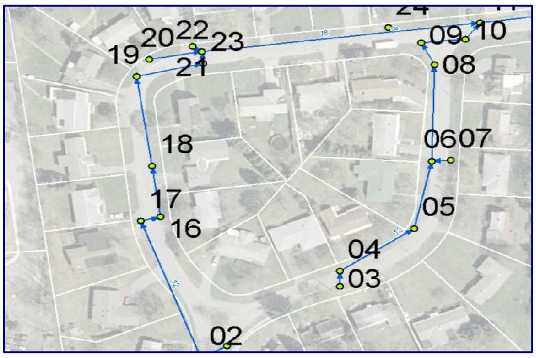
STORMWATER SYSTEMS: UNIFORM MAPPING PROTOCOL (SSUMP)

Herkimer-Oneida Counties Comprehensive Planning Program



December 2010

This project has been funded by the American Recovery and Reinvestment Act with support from the New York State Department of Environmental Conservation and New York State Economic Recovery and Reinvestment Cabinet. For more information, please visit: www.recovery.gov, www.dec.ny.gov or www.recovery.ny.gov.

TABLE OF CONTENTS

This document was developed by staff of the Herkimer-Oneida Counties Comprehensive Planning Program. Principal authors were Richard Reichert, Senior GIS Analyst and Jessica Breiten, Chief Planner and ARRA Program Coordinator. Questions may be directed to HOCCPP at 315-798-5710.

HOCCPP ● 321 Main Street ● Utica, NY 13501

STORMWATER SYSTEMS: UNIFORM MAPPING PROTOCOL (SSUMP)

Section 1: INTRODUCTION

During 2009 through 2010, the Herkimer-Oneida Counties Comprehensive Planning Program (HOCCPP) was able to utilize American Recovery and Reinvestment Act (ARRA) funding to develop and apply a regionally-based protocol for mapping stormwater systems, outfalls and sewersheds to better enable regulated communities to meet the program requirements of the NYS General Permit for Stormwater Discharges from Municipal Separate Storm Sewer Systems (MS4s). These permit requirements are further summarized in Section 3 below.

Initially, the stormwater system mapping protocol was developed for regulated communities within the Herkimer and Oneida Counties region - to insure consistency in mapping and data collection efforts across municipal boundaries. However, it quickly became evident that certain procedures, policies, recommendations, and components of the protocol would have statewide benefit and applicability. In response, the NYS Department of Environmental Conservation requested that HOCCPP "provide a detailed written protocol that others could use". The following is offered as a guidance document. It is based on federal and state guidance, and the findings and experience gained by HOCCPP while developing and implementing the protocol within the region. The protocol emphasizes and incorporates GIS-based technology with stormwater management program planning, implementation, and information management.

In addition to detailing field data collection and stormwater system mapping techniques, the protocol incorporates the mapping and information associated with each feature into a computer-based information management system that allows regulated communities to manage, track, update and undertake associated Phase II requirements such as illicit discharge detection and tracking programs, outfall reconnaissance surveys, and routine maintenance and inspection.

Recognizing that many small regulated communities often do not have the technical resources or personnel to undertake this level of data collection and manipulation, the following protocol may also be incorporated or used in a request for proposals that seeks assistance from outside agencies and/or consultants.

Section 2: PURPOSE OF THE PROTOCOL

The primary purpose of developing the *Stormwater Systems - Uniform Mapping Protocol* is to provide for consistency in mapping and data collection efforts. Whether the mapping and data collection is done at the local, county, regional or state level, by following this protocol, we can insure that a minimum set of standards are reached and that data is consistent, accurate, transferrable and usable to each of these levels. This is especially important in communities where stormwater systems and discharges often cross municipal boundaries. It seems logical that each community would collect similar types of information, map similar features, and/or have the capacity to easily share information with the adjoining community.

The protocol provides an outline of standardized considerations, consistent procedures, and recommendations. For example, through the use of GPS technology, the data entry and data features can be easily standardized for field collection. The protocol also recommends that information be quality controlled to insure accuracy and usability.

Other benefits and reasons for establishing this protocol include:

- to establish a minimum level of data collection.
- to establish baseline mapping techniques and standards.
- to provide the capacity to establish a centralized data warehouse of stormwater systems information.
- to insure accessibility to data and mapping products.
- to provide the regulated community with the ability to view and use information to meet other program requirements.

Section 3: STATE REQUIREMENTS

With regard to stormwater mapping elements, the NYS DEC General Permit for Stormwater Discharges from MS4's requires three basic mapping products including: 1) stormwater outfall mapping, 2) drainage system network (infrastructure) mapping, and 3) sewershed (or drainage area boundary) mapping.

HOCCPP feels that these maps are absolutely necessary and play an integral role in helping the regulated entity to meet many of the related program elements such as illicit discharge detection and track-down, outfall reconnaissance surveys, system inspection, and system maintenance. Without highly accurate and complete stormwater system and detailed sewershed mapping, these related program requirements prove difficult, if not impossible, to adequately implement.

The following list highlights some of the requirements within the State permit that can be accomplished and/or supported through the development of system mapping, outfall mapping and sewershed mapping.

- Development and implementation of an Illicit Discharge Detection and Elimination (IDDE) program.
- The location of all outfalls and the names and location of all surface waters of the State that receive discharges from those outfalls.
- The boundaries of the permittee's stormwater sewersheds (also important to facilitate IDDE trackdown).
- Development and maintenance of a map showing the permittee's complete stormwater system.
- Field verification of outfall locations (can be done as the system is mapped).

- Completion of an outfall reconnaissance inventory at least once every five years.
- Mapping of new outfalls as they are constructed or newly discovered.
- Development and implementation of a program to detect and address non-stormwater discharges - including illegal dumping - and procedures for identifying and describing priority areas of concern and for identifying and locating illicit discharges (trackdown).
- Reporting on program accomplishments such as: the number and percent of outfalls mapped; number of illicit discharges detected and eliminated; and percent of outfalls for which an outfall reconnaissance inventory has been performed.

Section 4: THE DATA COLLECTION AND MAPPING PROCESS

This section of the protocol will document the standards and technical processes used by HOCCPP to collect data and map stormwater systems, outfalls and sewersheds.

● Sequencing ●

The sequence of mapping tasks as implied in the State permit suggests that the regulated community first identify stormwater system outfall locations (e.g. outfall mapping). Following this the State then suggests focusing on the delineation of stormwater system sewersheds (e.g. sewershed mapping). And, finally (primarily due to cost considerations), the State suggests that “when grant funds are made available or the sewer lines are surveyed during an illicit discharge trackdown” the community must develop and maintain a map showing the complete storm sewer system (e.g. system mapping).

State Permit Sequence	Recommended Sequence
1. Outfall Mapping	1. System Mapping
2. Sewershed Mapping	2. Outfall Mapping
3. System Mapping	3. Sewershed Mapping

Rather than this approach, it is HOCCPP’s recommendation that regulated communities first consider investing the time and resources to complete system mapping. As communities complete the system mapping, it easily becomes evident where outfalls and sewersheds are located. Further, the required “field verification of outfalls” becomes part of the initial process of system mapping and does not require additional manpower, resources or trips into the field. In fact, system mapping and outfall mapping can be done simultaneously. Additionally, because sewersheds do not necessarily follow the surface topography and drainage patterns, it is important to have a complete understanding of the storm sewer system including collection points, discharge points, and conveyances PRIOR to attempting to delineate the sewershed.

Other factors regarding sequencing - such as whether to complete certain data collection during wet-weather or dry-weather - must also be considered when completing system mapping or when conducting outfall reconnaissance and/or illicit discharge detection. These considerations will be discussed in more detail later.

This protocol utilizes both in-house desktop and mobile field data collection formats. The desktop provides the framework in which the storm water system features are researched, managed and edited. The mobile application provides a tool for the field collection, verification, inspection and IDDE screening. HOCCPP recommends a combination of both in-house work and field work. Generally, work should begin in-house, progress to work in the field, and then move back in-house for final data manipulation and management. Use of the data can be accomplished both in-house and in the field.

● Preliminary Assessment ●

The process should begin, in-house, with a thorough understanding and collection of resource material. It is necessary to know exactly what is required - both from a regulatory perspective and with regard to mapping and data collection elements. It is equally important to know what level of information already exists.

KNOW WHAT IS REQUIRED

The process HOCCPP utilized and the foundation of this protocol are based on the guidance documents and data listed within **Appendix A**. Following the review of these documents, it quickly became apparent that the best approach to this process would require a Geographic Information System (GIS) end product combined with Global Positioning System (GPS) data collection. Although the State permit program allows for "hard-copy" mapping of outfalls, stormwater systems and sewersheds, use of GIS technologies will provide regulated communities with the capacity to more easily manage and use information collected to meet other permit requirements - such as illicit discharge detection and track down, system inspections, and routine maintenance.

Preliminary stormwater system information may be available from as-built and design drawings - whether in paper or digital format. Design drawings may be available as part of municipal infrastructure projects, subdivision proposals and other development plans. In HOCCPP's experience, however, such documentation was rarely available. If such information is found, the GPS can be used in the field to more easily collect and verify system point features, locations and attributes.

Municipalities may also have maintenance records of the stormwater system and may have entered into maintenance agreements with developers and/or adjoining municipalities. This information is important to review to insure the complete system is collected and includes all features under the jurisdiction of the regulated MS4.

Part of the preliminary in-house assessment should also include an examination of what level of information already exists. Existing GIS information and data layers will help in the development, mapping, and use of the end product. For example, high resolution aerial imagery can assist in locating system features during field collection. Tax parcel information can provide a direct link of system features to adjoining property owners or provide information on property classifications that might help with illicit discharge track down. It is also important to create a base map for reference including elements such as street centerlines, street names, municipal boundaries, and streams. The following table identifies some of the data layers used by HOCCPP and provides a summary of potential use throughout the process.

Figure 1 - *Useful Data Layers*:

Data Layer	Use
Roads/Street Centerlines	Standard reference for locating system features.
Municipal Boundaries	Determination of jurisdictional boundaries of mapping effort
MS4 Boundaries	Determination of jurisdictional boundaries of mapping effort
Aerial Imagery	Standard reference for locating system features. Both in-house and in the field.
Hydrologic Features (streams, wetlands, etc.)	Improved understanding of surface flow and potential outfall locations.
Watershed Boundaries	Improved understanding of surface flow. Identification of required Watershed Identification Number (WIN).associated with outfalls
Topography	Improved understanding of surface flow.
LiDAR	Improved understanding of surface flow and capacity to model flow accumulations.
Tax Parcels	Standard reference for locating system features. Assistance with IDDE track down and maintenance.

These and other suggested data layers are discussed in more detail under the heading “In-house Data Collection and Organization”.

● Equipment Needs ●

Before going into the field, it is important to determine the types of equipment needed. HOCCPP has had extensive experience with infrastructure system mapping, including both sanitary sewer and water supply systems. We have used this experience to help determine what equipment (e.g. field equipment, hardware and software) would be required to complete stormwater system mapping and other program requirements such as IDDE and inspection.

HAVE THE RIGHT EQUIPMENT

Although there are numerous options - especially associated with computer hardware and software, we will describe the systems and equipment HOCCPP used in creating this protocol.

Within the office, HOCCPP relies on Hewlett-Packard Compaq desktop computers with Intel Core 2 Duo processors at 2.33 GHz with 3.5 GB of RAM running Microsoft Windows XP. Given the need for extensive data processing throughout this process, HOCCPP suggests having more, rather than less RAM. A comprehensive list of equipment used is summarized in **Appendix B**.

For GPS data collection HOCCPP used a pole mounted Trimble Pathfinder ProXH receiver and Ranger handheld computer running TerraSync software. In HOCCPP's experience, GPS data collected with a fairly high confidence of positional accuracy proves infinitely more useful than data that is not collected to this level. While less expensive hand held GPS units can be used to collect point positions, the usability of data may be degraded as a feature's positional accuracy can deviate 30 meters or more from its true location. This degree of variation complicates the mapping process but also creates problems with the relational accuracy of these collected points with other system and/or environmental features. For example, positional shifts are readily apparent when such GPS points are combined with more accurate base data such as the aerial imagery available through the NYS GIS Clearinghouse. In this example, point features may appear to be located in residential front yards or within buildings rather than on the edge of the street. It is also important to note that inexpensive GPS equipment is rarely designed to accommodate extensive data entry and point attribution, thereby removing much of the 'smart data' potential of a project.

ACCURACY IS IMPORTANT

It is important to confirm the accuracy of equipment proposed to be used and the data to be collected. HOCCPP has field tested its GPS accuracy against locally established survey benchmarks using a variety of collection methodologies. HOCCPP found that collecting non-real time corrected data and then post-processing using local National Geodetic Survey (NGS) Continuously Operating Reference Stations (CORS) RINEX data files produced the best results. Additionally, HOCCPP determined that a 2 minute collection time with a 5 second position interval (24 positions collected over 2 minutes) provided the best accuracy relevant to time spent at each point. Spending less time collecting a feature generally led to notable degradation in positional accuracy while spending much longer on a point (HOCCPP tested up to 5 minutes) didn't significantly increase accuracy.

The raw data, once post processed using the deltas in the RINEX files, always led to sub-meter horizontal accuracy and often produced sub-foot results. It is important to note, for those seeking to post-process data, that the NGS often releases estimated reference positions in their RINEX correction files. To avoid degrading your data, it is important to verify and use the survey position available in the data sheet for your CORS (See example).

The NGS Data Sheet

```
See file  dsdata.txt for more information about the datasheet.
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.85
1        National Geodetic Survey,   Retrieval Date = NOVEMBER 23, 2010
 DI0618 ***********************************************************************
 DI0618  CORS         -  This is a GPS Continuously Operating Reference Station.
 DI0618  DESIGNATION -  ROME CORS ARP
 DI0618  CORS_ID      -  NYRM
 DI0618  PID          -  DI0618
 DI0618  STATE/COUNTY-  NY/ONEIDA
 DI0618  USGS QUAD    -  ROME (1955)
 DI0618
 DI0618                         *CURRENT SURVEY CONTROL
 DI0618  ___________________________________________________________________
 DI0618* NAD 83(CORS)-  43 10 40.02865(N)    075 29 13.88253(W)     ADJUSTED
 DI0618* NAVD 88      -      161.147  (meters)     528.70   (feet)  ADJUSTED
 DI0618  ___________________________________________________________________
 DI0618  EPOCH DATE   -       2002.00
 DI0618  X            -   1,167,417.268 (meters)                     COMP
 DI0618  Y            -  -4,509,907.650 (meters)                     COMP
 DI0618  Z            -   4,342,013.776 (meters)                     COMP
 DI0618  ELLIP HEIGHT-         128.551 (meters)         (07/??/06) ADJUSTED
 DI0618  GEOID HEIGHT-         -32.61  (meters)                     GEOID09
 DI0618  HORZ ORDER   -  SPECIAL (CORS)
 DI0618  VERT ORDER   -  SECOND    CLASS II
 DI0618  ELLP ORDER   -  SPECIAL (CORS)
```

Additional information on RINEX correction files can be obtained at http://www.ngs.noaa.gov/cgi-cors/corsage.prl?site=NYRM

HOCCPP was also able to complete a number of necessary tasks using Trimble's Pathfinder Office software on the desktop computers. HOCCPP used this software to create data dictionaries, track satellite availability, post process raw data, and export processed data into a GIS format.

With regard to GIS mapping, editing, and modeling, HOCCPP used ESRI's ArcMap 9.3. ArcMap is one of the industry standard GIS software products available and is capable of performing all of the advanced mapping tasks that this process requires. It is important to note that there are different licensing levels available for ArcMap. However, the base level ArcView license combined with 3D Analyst and Spatial Analyst extensions is adequate for this project.

For communities that can not afford higher end software, HOCCPP suggests examining free software. For example, ESRI's ArcReader software is a good alternative and, although it limits the ability to modify data, it is excellent for viewing and querying finalized data.

A digital camera also proves useful in the field and while verifying data in-house. A digital camera allows you to take 'snapshots in time' which prove useful for feature verification and analysis, inspection, and IDDE. HOCCPP suggests selecting a camera with good image quality, adequate storage capacity, and a battery that will last through a standard work day. A rechargeable camera is best or one with an interchangeable power source.

In addition to the above listed digitally-based software and hardware, a few other items are suggested. A metal pick or heavy duty hook is needed to open many features, such as manhole covers, for thorough inspection. HOCCPP found that many system features often have debris such as road tar, gravel, sand, or vegetation obstructing them. Proper tools, a metal detector, a large flat head screwdriver and shovel are typically very useful. In high traffic areas it is important to consider safety and provide vests, traffic cones, or necessary signage. Thought should also be given to smaller equipment items such as a tape measure, compass, latex gloves, and small plastic bottles for samples.

● In-House Data Collection and Organization ●

Upon completing the preliminary assessment and identifying the needed equipment, HOCCPP's process proceeded to the development of a "data dictionary" which is the template of all attributes to be collected in the field.

ORGANIZE THE DATA

The template menus are used to record all desired attribute information while simultaneously collecting a feature's location using GPS. These attributes, once collected, are stored in a database that is associated with each GPS spatial feature. Using the data dictionary, HOCCPP defined data types, ranges, field sizes, and more - allowing the creation of a consistent data structure that minimized potential for user introduced errors.

HOCCPP used the Pathfinder Office software to create the data dictionary. The data dictionary was organized to address attribute data associated with outfalls and "non-outfall" features. For features that were easily determined not to be outfalls, standard information such as feature type, location, pipe size, pipe material, direction of flow, etc. was collected. When a feature was likely to be an outfall or discharge point, additional attribute data was collected regarding potential odors, discoloration, turbidity, presence of floatables, etc. This information, in addition to the GPS location, meets the permit requirements for the field verification of outfalls, the outfall reconnaissance survey and first round of required system inspection. Below is a sample of HOCCPP's Data Dictionary. A complete overview of HOCCPP's data dictionary structure is included within **Appendix C**.

Figure 2 - *Sample of Data Dictionary:*

Name	Description	Entry Type	Field Length	Options
Feat_ID	Feature Identifier - This is a unique identifier assigned to each feature collected with the GPS unit	Text	12 Characters	Manually Entered
FeatType	Feature Type - This is the type of feature being collected.	Menu	n/a	Manhole (Default) Culvert Catch Basin Catchment Other
CatchMat	Catchment Material - The construction material for catch basins and catchment	Menu	n/a	Pre-Cast Concrete (Default) Overland-Earthen Brick Stone Other

Following the creation of the data dictionary, HOCCPP pooled together all of the preliminary data and available resources and added multiple GIS layers into an ArcGIS map document. Useful GIS data layers may include:

Figure 3 - *Useful Data Layers:*

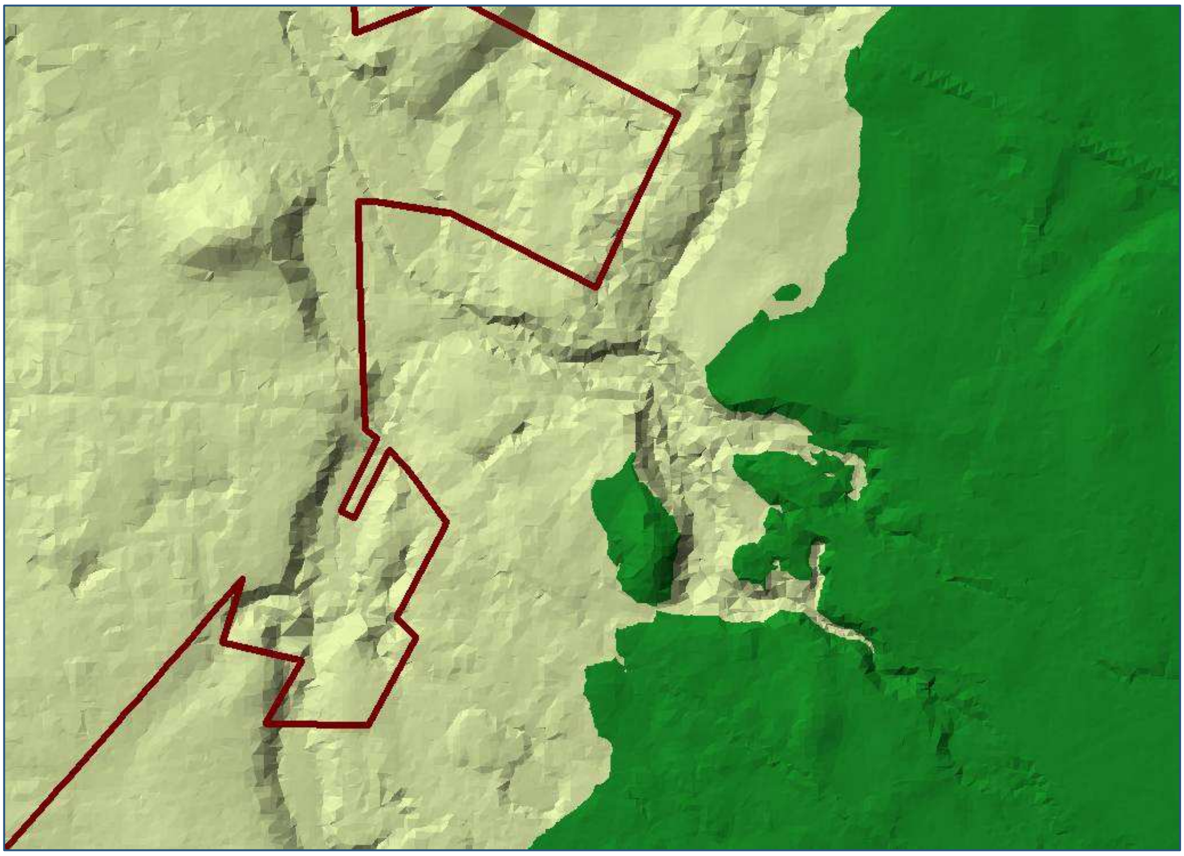
Data	Type	Sample Sources for Existing Data
Tax Parcels	Vector	Local Finance/Planning/Tax Mapping department
Aerial Imagery	Raster	CSCIC (NYS Office of Cyber Security)
Hydrologic Features	Vector	DOT/USGS/NYSDEC
Watershed Boundaries	Vector	NYSDEC
Terrain Data	Grid	USGS/custom derived
Street Centerlines	Vector	DOT/US Census TIGER/CSCIC
Municipal Boundaries	Vector	Census/DOT/local government departments
Contour Elevations	Vector	USGS/Custom derived
USGS 7.5 minute Quadrangles	Raster	USGS

It is important to ensure that all GIS data is used within the same coordinate system. ArcMap has the ability to realign spatially defined data layers on the fly, but can encounter problems when dealing with non-vector data sets. HOCCPP works almost exclusively with data sets in Universal Transverse Mercator (UTM) coordinates (Zone 18) using the horizontal North American Datum of 1983 (NAD83).

HOCCPP also derived custom data layers which were useful in the analysis and field collection processes. These layers are discussed in more detail below and included contour lines, flow accumulation models, flow direction models, and surface flow basins.

In 2008 Oneida County obtained Light Detection and Ranging (LiDAR) data for a large portion of the county that coincidently included all areas within the MS4 designated areas. LiDAR is a remote sensing technology used to generate high accuracy ground surface elevations. This data meets a vertical accuracy of 18.5 cm. The LiDAR data, provided in a terrain format, uses multi-resolution Triangular Irregular Networks (TIN) to generate a representation of the earth's surface. The following graphic provides an example of this representation of the earths's surface.

Figure 4 - *LiDAR Terrain File:*



In the absence of LiDAR data, the National Elevation Dataset (NED) 10 Meter Digital Elevation Model (DEM) derived grids can be used. While this data will not have the same degree of detail, it can still be very useful.

The terrain data was converted into a raster file format so that ArcMap could use it as a basis to generate the flow accumulation and flow direction models. HOCCPP converted the data into both 2 meter and 10 meter cell formats using the 3D Analyst extension in ArcMap (3D Analyst Tools/Conversion/From TIN/TIN to Raster).

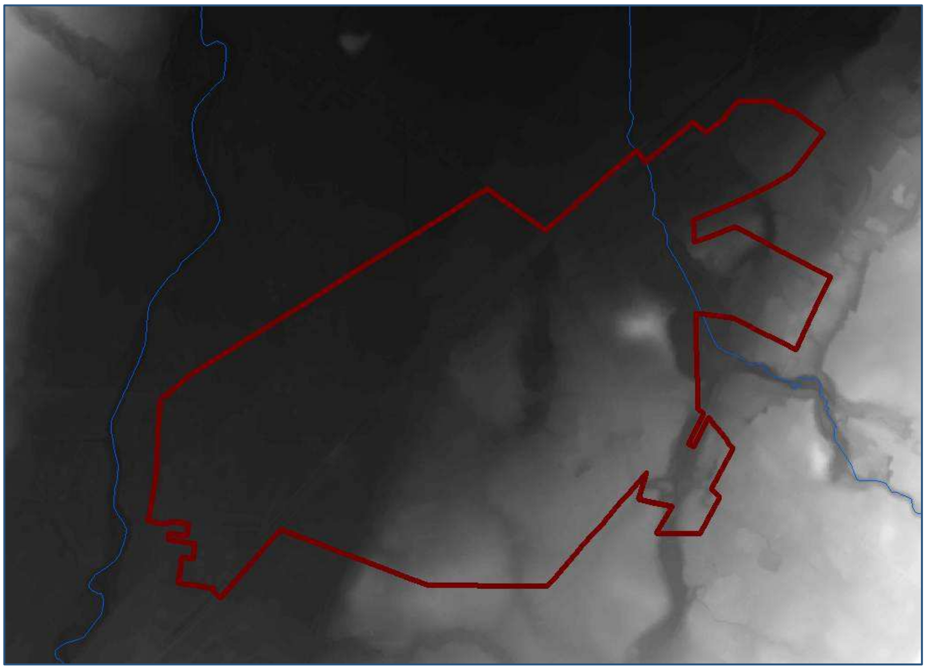


Figure 5 - ArcMap *3D Analyst:*

With regard to enhanced contour mapping, HOCCPP found that a 1 meter contour interval derived from the 2 meter raster provided the necessary level of detail within the study area. To generate the custom contours from the raster, HOCCPP used the Spatial Analyst extension (Spatial Analyst tools/Surface/Contour).

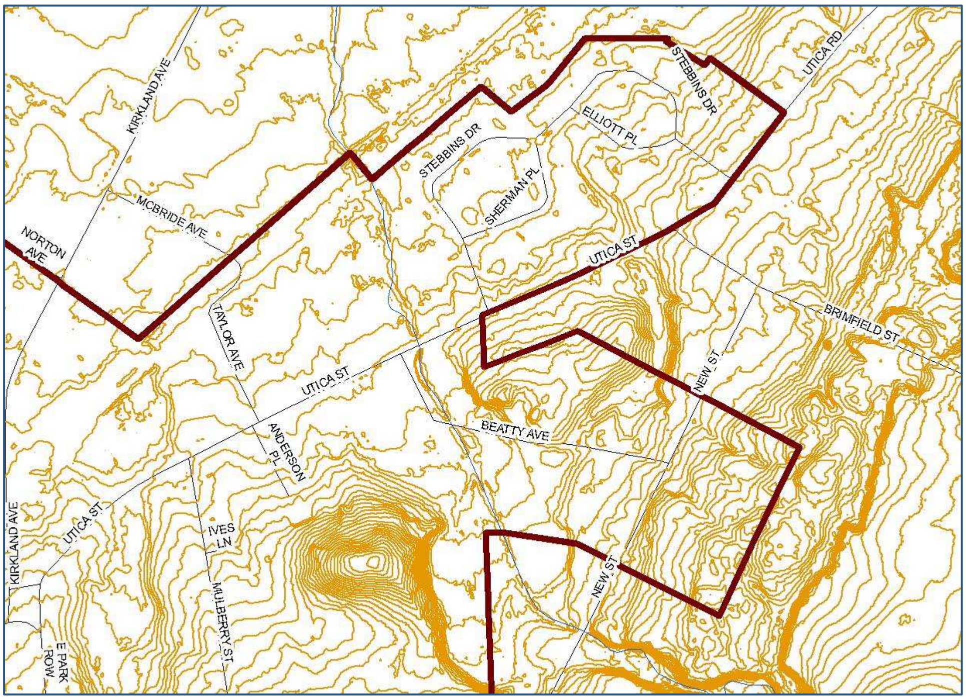
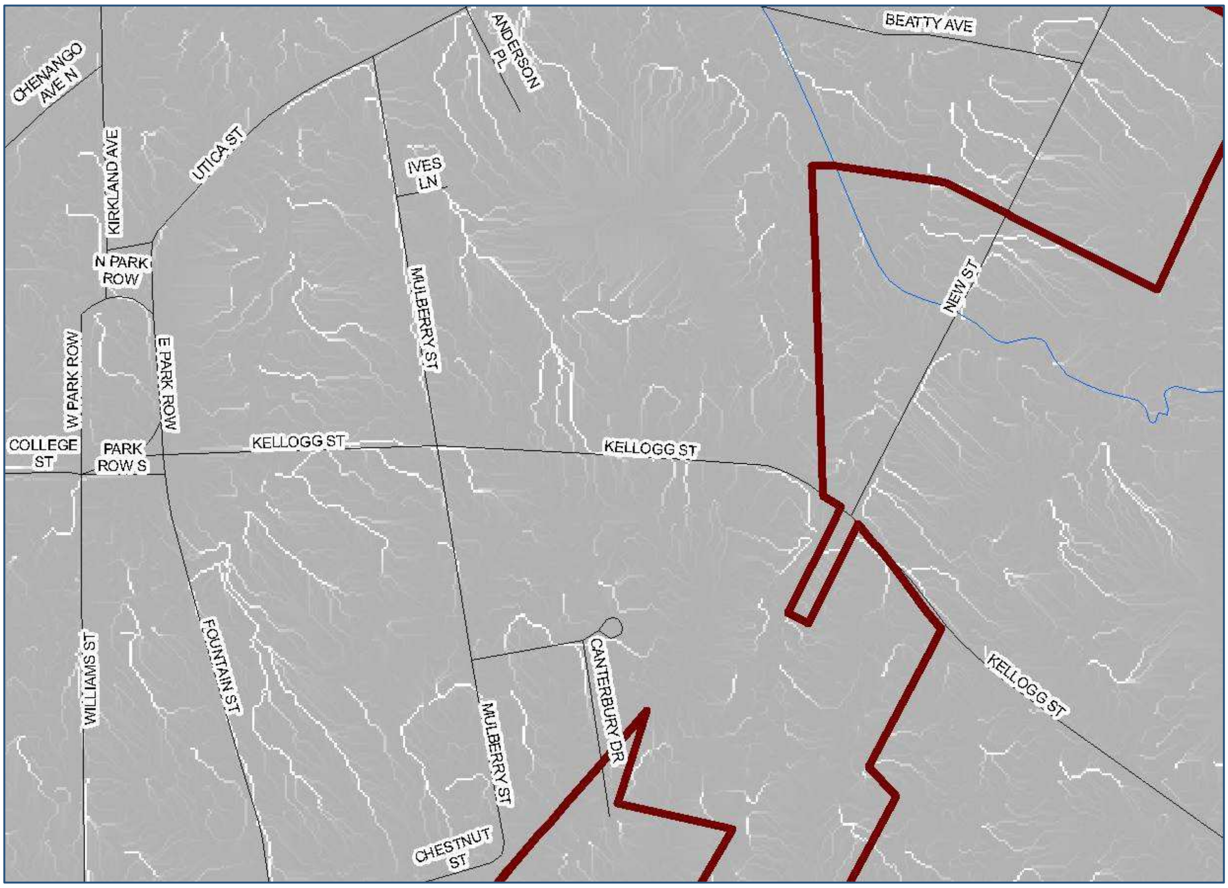


Figure 6 - *Surface Contours*

Using this same data, HOCCPP also created a flow accumulation model (Spatial Analyst tools/Hydrology/Flow Accumulation). This model is useful in identifying the surface flow simulated from a rain event. As an area collects more and more surface flow, the image appears as a thicker white line. This information is helpful to identify which catch basins and conveyances are likely to be intercepting surface flow. The model was created using both 2 meter and 10 meter raster files to provide varying levels of detail.

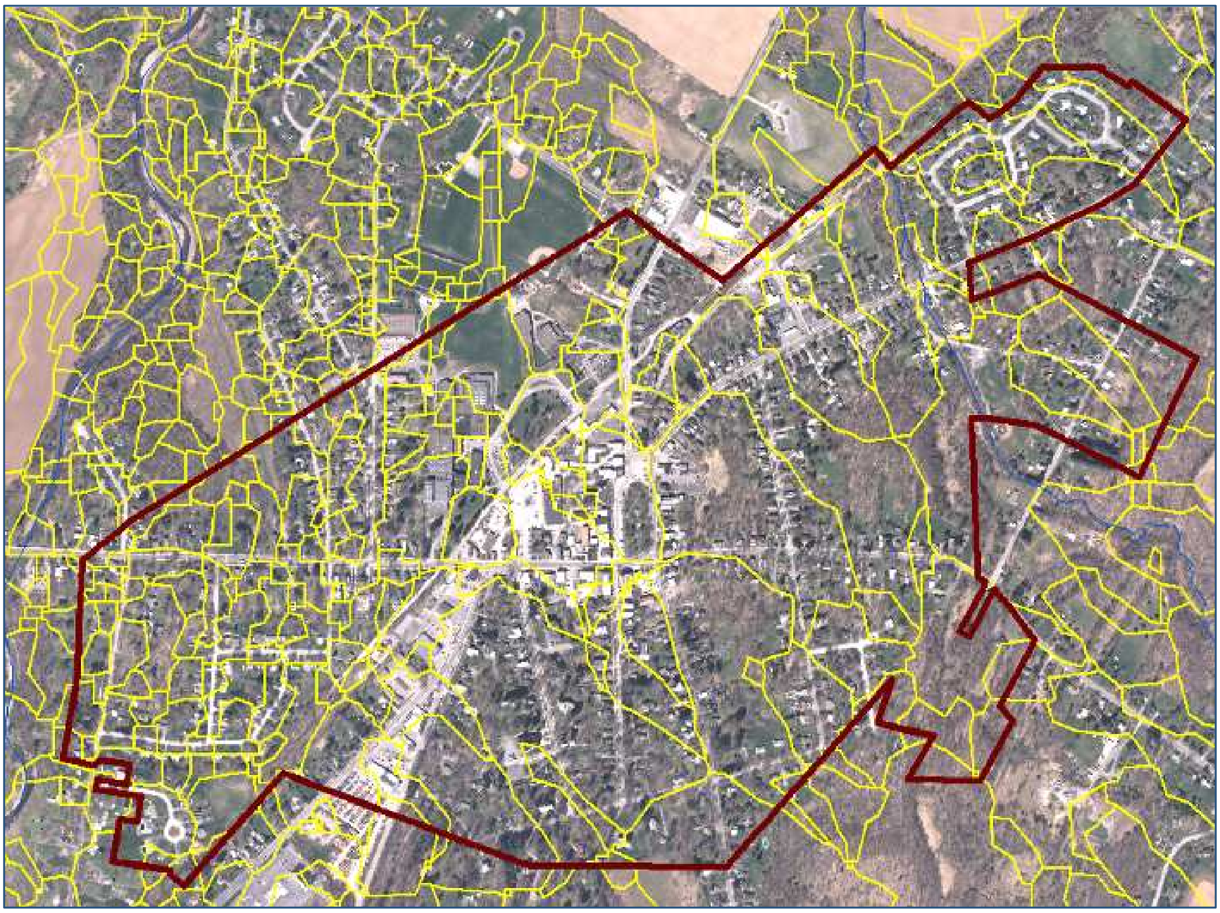
Figure 7 - Flow Accumulation Model:



The direction of flow was derived using the Flow Direction tool (Spatial Analyst, Hydrology/Flow Direction too)l. Again, the layer was created using both 2 meter and 10 meter raster files to provide varying levels of detail.

In ArcMap, HOCCPP used each of the aforementioned flow direction files in an effort to define multiple surface flow drainage basins (Spatial Analyst, Hydrology/Watershed). These drainage basins are not influenced by the underlying, stormwater collection system, however, the resulting files depict detailed natural drainage basin polygons that can be used to assist in the delineation of the sewershed maps - representing a combination of catchment areas and associated outfall locations. It should be noted that the following illustration includes only natural surface flow drainage basins and is NOT a “sewershed” map. The methodology that HOCCPP used to create sewershed maps is discussed later.

Figure 8 - *Surface Drainage Basins:*



● Field Data Collection ●

Following the extensive preparatory work, HOCCPP progressed to GPS data collection in the field. This activity, however, does involve additional (in-house) data processing as field data is brought back to the office. HOCCPP established that, on average, during a 5 day work week data was collected in the field 3 of those days while processing and updating data back in the office involved 2 days a week.

COLLECT NEW DATA

It is possible to complete field data collection with one person who is proficient in GPS technologies. However, HOCCPP recommends that one GIS person should work with a representative from the community who is knowledgeable about the stormwater system. Typically, this includes an employee of the public works department or the community engineer. It is especially useful for the municipal employee to coordinate removal of manhole covers and/or traffic control while the GPS data is being collected.

The collection of field data begins by first confirming that a feature is part of the stormwater system. Special attention should be observed to insure, for example, that a manhole being collected is not part of the water supply or sanitary sewer system. HOCCPP collected all identifiable stormwater system features including: manholes, culverts, catch basins, catchments, ditches and overland conveyances, and outfalls.

Collection was limited to those system features under the direct jurisdiction of the regulated community and did not include privately owned connections, features, or systems (unless there was a maintenance agreement or other agreement that transferred jurisdiction to the community). Often the community's stormwater system may cross privately owned property. In these instances, HOCCPP and/or the community representative made special attempts to gain the permission of the property owner before entering the property.

Due to the constraints of and concern for the equipment, HOCCPP did not collect GPS data during rain events but did document when data was collected within 24 hours or 48 hours of a rain event. Such conditions could have an influence on supplemental inspection and/or outfall reconnaissance information collected during these times. State and Federal guidance specifically suggests that field screening for potential illicit discharges be done during the dry season and after a dry period of at least 48 hours. However, HOCCPP found that the system mapping was somewhat easier if a flow was present - making the determination of direction of flow and potential connectivity more evident.

Once a feature was identified for collection, an external photograph was taken of the feature and the surrounding area. It is important that the photo contain an easily identifiable reference point such as a street sign or adjoining structure. This photo is useful as a reference for specific location and as a reference of the conditions of the feature at the time data was collected.

When collecting data for manholes, the cover was opened and an internal photograph was taken. All internal photographs were taken so that the top of the photo was oriented to the North. This photo becomes useful as an additional check on the number of inlets or outlets, pipe condition, and flow direction. Further, these photographs are useful to verify types of construction materials, maintenance requirements, and more. When necessary and possible, the feature was cleared of any debris or obstructions.

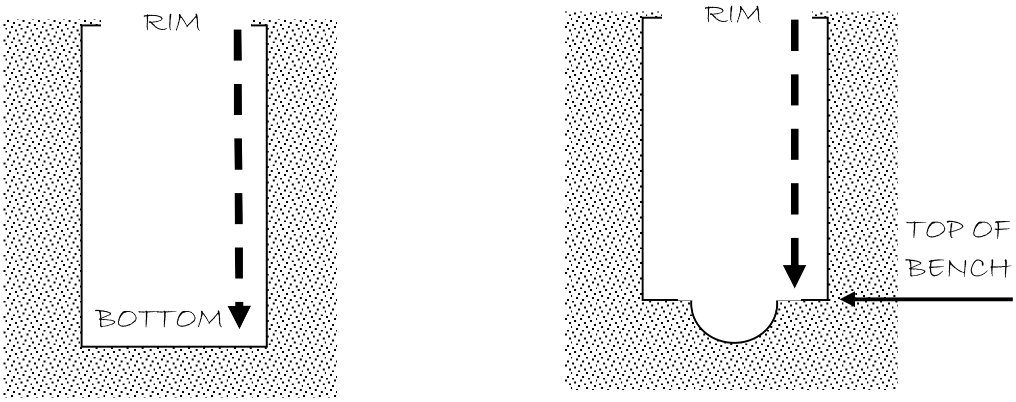
Each photo was then stored with a file name that corresponded with its unique system point feature identifier (Feat_ID in the data dictionary). For example, these are the two photographs for feature number 15.

Figure 9 - *External Photo*

Figure 10 - *Internal Photo*

After taking the photos, HOCCPP measured the depth (in inches) from the cover rim to the bottom of the feature. Sometimes, however, storm sewer manholes contain a bench or channel cut into the bottom of the feature. In these instances, HOCCPP would measure from the rim to the top of the bench and add the radius of the outlet pipe. This method is also useful if the bottom of the feature is submerged or to avoid inserting the tape measure into the discharge. The following figure illustrates a cross-section of these measurement options.

Figure 11 - *Measurement Options*



No Bench = Rim to Bottom **With Bench = Rim to Bench (+ Radius)**

In practice, HOCCPP found that in stormwater systems, a true bench was usually absent or the entire bottom of the feature was submerged. In these cases, measurements were taken to either the high water level or to the exposed portion of the feature.

Additional distance measurements are required within the data dictionary such as the diameter of pipes flowing in or out of the feature, and the height of the pipes flowing in or out of the feature. For irregular or open channels, HOCCPP measured feature height and width. While HOCCPP did not often use these measurements in creating the necessary stormwater system maps, this data can be extremely valuable if system flow modeling is necessary.

Once the basic depth measurements were taken, HOCCPP would spend approximately two minutes collecting spatial data for each feature using the GPS unit. During this time, HOCCPP simultaneously completed the assessment of the feature and entered the appropriate attribute and inspection information into the Ranger handheld computer. Note, this attribute data is based on and was previously structured within the data dictionary (See Appendix C).

HOCCPP also recommends collecting data at each point where a conveyance type may change. For example, conveyances that progress from a contained pipe to an open ditch, or, from a reinforced, armored ditch to an open ditch, etc.

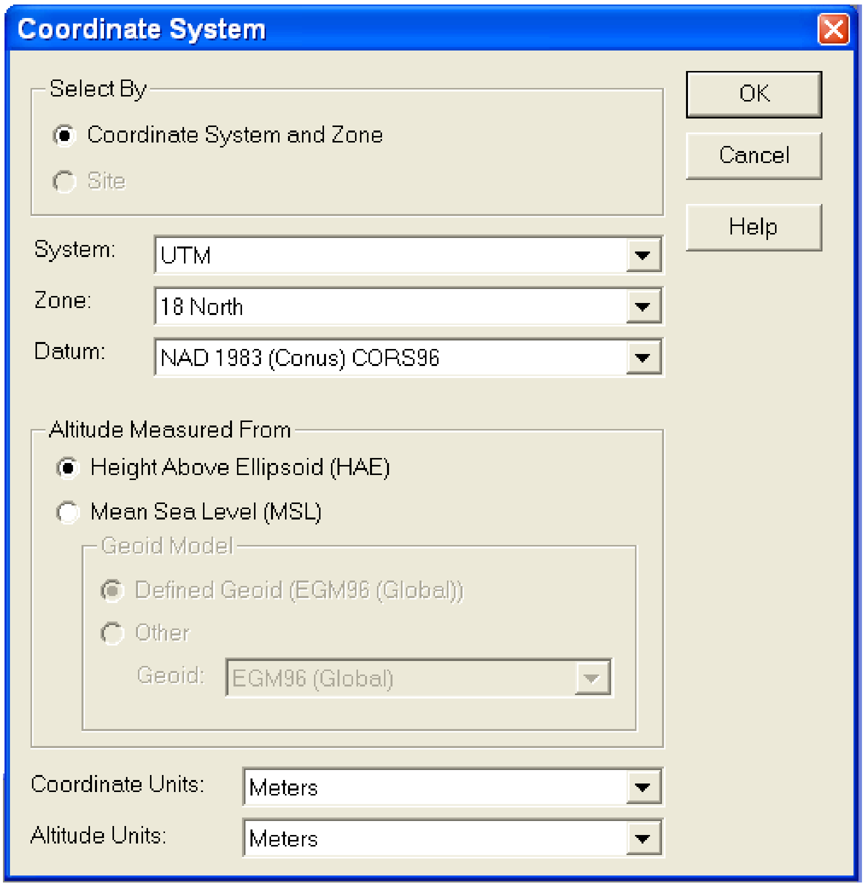
The primary attributes that are covered in the data dictionary relate to the common physical description and location of the features and are not intended to cover all potential conditions. As part of the data dictionary, HOCCPP recommends the inclusion of extra text fields where comments and notes can be added.

● Data Post-Processing and Final Analysis ●

Once collected, the GPS field data (.ssf format) was then transferred to a desktop computer using the Pathfinder Office software 'Data Transfer' tool. The raw data was then post-processed using the previously mentioned RINEX files from a local CORS. Prior to post-processing, however, HOCCPP set up the appropriate coordinate system within the software (Figure 12). The coordinate system used in the software should match the coordinate system in which the data was collected.

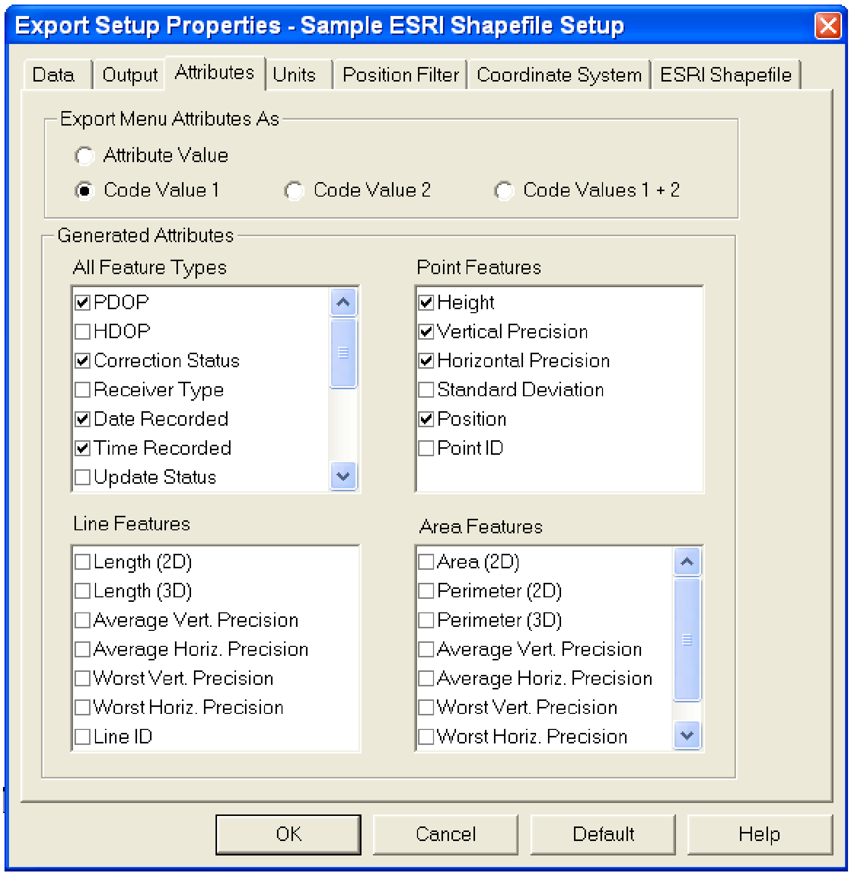
MAKE SURE THE DATA IS ACCURATE

Figure 12 - *Coordinate System*



After post-processing, the data was then exported into a GIS format (shapefile). There are several set-up options for the export process that will vary depending upon individual circumstances. Again, however, HOCCPP ensured that the export coordinate system matched that of the collected data as well as set the optional export data fields that were to be included in the database (See Figure 13).

Figure 13 - *Export Set-up Properties*



It should be noted that the “PDOP” field is important to include as it measures satellite geometry. A high measurement in this field is an indication of poor satellite geometry which can result in increased spatial errors in the data. In general, if HOCCPP encountered a PDOP higher than 5 for any of the points, the point accuracy was further verified and, if necessary, was recollected.

Once exported into GIS format, the point files were loaded into the Map Document for further analysis and compilation. Using the point files as the system base, a polyline file was created representing the systems pipes and channels. These lines were manually digitized in the direction of flow, beginning with the upstream point and finishing with the next downstream feature. Care was taken to ensure that line vertices were ‘snapped’ to the appropriate point features. The line segment symbology was set to display arrows pointing in the system’s direction of flow.

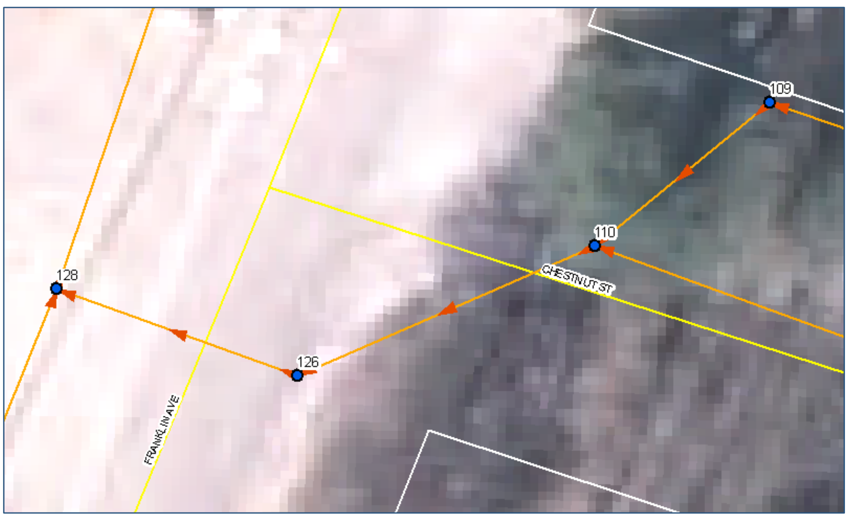
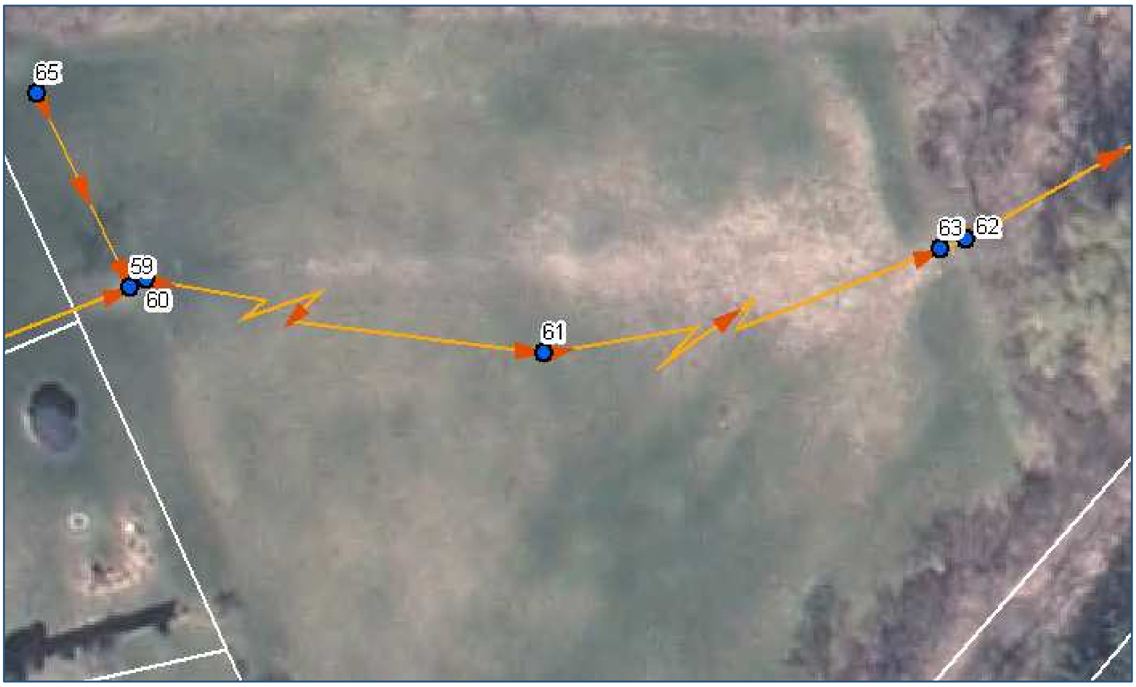


Figure 14 - *Direction of Flow Symbology*

In some circumstances, flow did not follow defined channels, or flowed through complex channels that exceeded the level of detail HOCCPP was representing (such as a small meandering stream channel). In these circumstances, the lines were digitized with a 'zig-zag' type jog that was intended to represent these exceptions.

Figure 15 - '*Undefined' Flow Symbol through large catch basin*



HOCCPP also recommends using unique symbology to identify points of intermunicipal connections and conveyances.

HOCCPP continued the process by adding the attribute fields to the line file and populated these using the GPS collected information. These fields included pipe type, diameter, width, height, material, and length. Each length of pipe segment between system features was calculated using the GIS - thus saving time and expense in the field.

Additionally, the collected attribute data was compared with any previously existing documents for the purpose of quality control. This process continued as additional data was field collected. The daily collections of GPS point data were combined into a single file using the Append tool in ArcMap (Data Management Tools/General).

• Outfalls and Sewersheds •

DEFINE OUTFALLS AND SEWERSHEDS

As was previously mentioned, the data dictionary was organized into two separate structures for attributes associated with outfalls and attributes associated with non-outfalls. Given the additional permit requirements associated with outfalls, HOCCPP identified, collected and processed outfall locations in a separate GIS file.

In most instances, the identification of a system feature as an outfall was relatively easy. If the feature was an obvious, end-discharge point into a receiving waterbody - it was likely an outfall. If the feature was the last along a series of conveyances before entering an adjoining municipality - it was likely an outfall. The NYS DEC has provided some guidance in determining outfall locations within the 2005 Draft “Outfall and System Mapping Reqyuirements for IDDE in NY”.

However, in some instances an outfall may be located in an obscure or unexpected place and is not identified until total system mapping and connectivity is fully analyzed. Throughout the system mapping process, if a feature was not initially identified as an outfall, but was later determined to be an outfall, an additional field visit would be made to gather the information needed to complete outfall reconnaissance. Again, **Appendix C** includes a complete data dictionary for all attributes collected at each outfall.

With regard to the delineation of sewersheds, the State Permit does not specify the level of the sewershed to be defined. For example, many question whether the sewershed is equivalent to the watershed of the receiving waterbody. Given that the State’s MS4 Stormwater Permit emphasizes the use of outfall and system mapping to assist with illicit discharge track down, HOCCPP recommends that sewersheds be delineated at a scale that would allow for management of the areas directly contributing to <u>each</u> outfall. By using this technique, if an outfall shows signs of an illicit discharge, the area contributing to this outfall is immediately known via the sewershed map. Although not used by HOCCPP, ArcMap also has the Network Analyst extension that helps to track connectivity of the system by highlighting “upstream” system features.

In a few instances, HOCCPP encountered non-channelized surface flow that did not lead to a distinct outfall. The drainage basin was delineated but did not indicate a point specific outfall location. In these cases, it was determined that these areas were likely not part of the Municipal Separate Storm Sewer System and were likely resulting in natural infiltration or the collection of flow by an adjoining community.

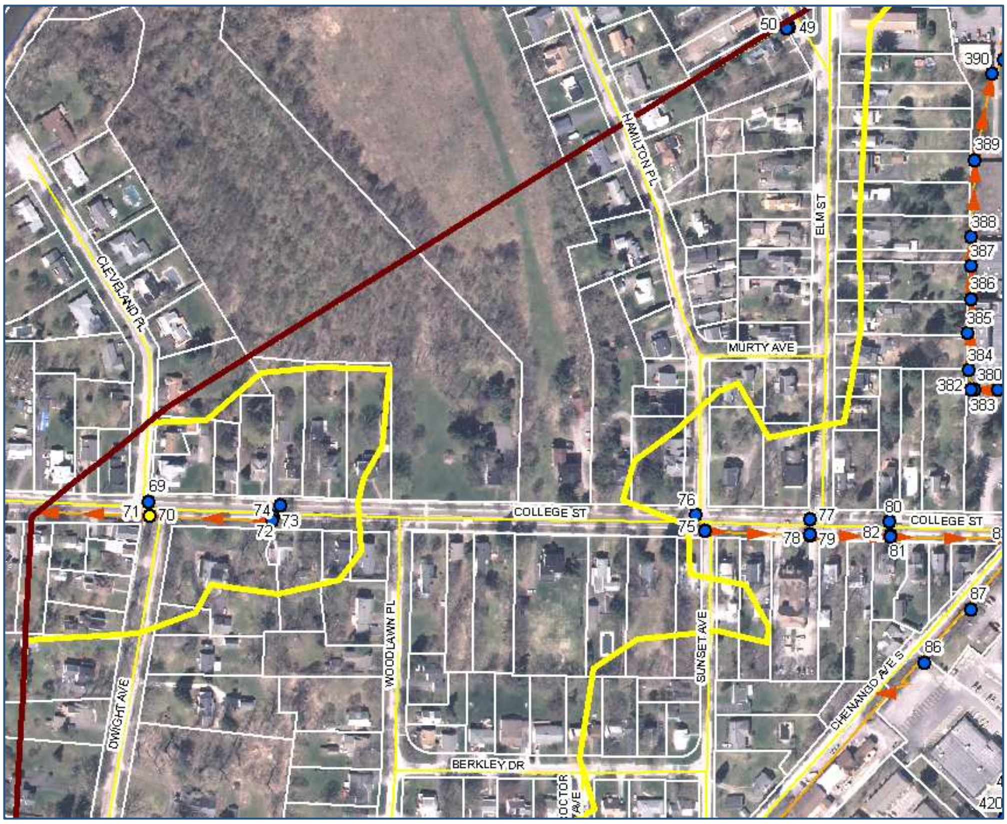


Figure 16 - *Sewershed with no outfall*

Section 5: DATA MANAGEMENT AND USEAGE

The product that is ultimately created can be characterized as much more than just outfall, system or sewershed mapping. The system provides the following information about the stormwater system and provides the capacity for the regulated community to use the information in meeting many permit requirements.

Products of the
Stormwater Systems Uniform Mapping Protocol

- Accurate location of storm sewer lines, manholes and other features
- Assignment of unique Feature Identifier (ID #)
- Direction of flow
- Size of lines
- Type of construction materials
- Condition of features
- Field verification of outfall locations
- First round of ‘Outfall Reconnaissance Survey’
- First round of ‘System Inspections’
- Identification of potential illicit discharges
- Location of inter-connections with other municipal and private systems
- Location of streams and drainageways tributary to the stormwater system
- Identification of system maintenance needs
- Location of buried or ‘lost’ manholes or system features
- Identification of un-sewered areas
- Centralized data repository
- Data sharing and data accessibility
- Capacity for future flow modeling

With regard to the use of the data by the regulated community, once all of the data was organized, collected, processed and analyzed, HOCCPP created an ESRI ArcReader project. This freely available GIS software allows end user to view, analyze, and query data as well as print simple maps. It does not, however, allow the user to directly modify the data.

In addition to the ArcReader project, HOCCPP provided the community with large (34” X 44”) hard copy system and sewershed maps as well as a hard copy of all system photos organized into an album. If desired by the community, the photographs of system features were also hyperlinked directly to the GIS for quick and easy reference of each feature.

Appendix A
Guidance Resources

Regional:

● *Monroe County*
Rochester Pure Water District – Illicit Discharge Detection and Elimination: Outfall Inspection Procedures. April, 2010.

● Chemung County
Southern Tier Central Regional Planning and Development Board. MS4 Metadata for Elmira. January 8, 2008.

State:

● *New York State Department of Environmental Conservation (NYSDEC)*
Outfall and System Mapping Requirements For Illicit Discharge Detection and Elimination (IDDE) in NY. Draft July 7, 2005.

● *New York State GIS Clearinghouse*
http://www.nysgis.state.ny.us/

Federal:

● *Environmental Protection Agency (EPA)*
Brown, Edward et al. Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments. Center for Watershed Protection. October 2004. http://www.epa.gov/npdes/pubs/idde_manualwithappendices.pdf

● *National Geodetic Survey (NGS)*
Continuously Operating Reference Stations (CORS). http://www.ngs.noaa.gov/CORS/

● *United States Geological Survey (USGS)*
Digital Elevation Model Data
http://ned.usgs.gov/

Appendix B

Equipment

Hardware:

HP Compaq desktop computer with Intel Core 2 Duo processors at 2.33 GHz with 3.5 GB of RAM
Trimble Pathfinder ProXH receiver and Ranger handheld computer (with mounting pole)
Digital camera

Software:

Microsoft Windows XP (desktop)
GPS Pathfinder Office 4.0 (desktop)
ESRI ArcMap 9.3 (ArcView) with Spatial Analyst and 3D Analyst extensions
TerraSync (handheld)
Microsoft Windows Mobile 5.0 (handheld)
ESRI ArcReader (desktop)

Tools and Supplies:

Steel pick or heavy duty hook
Metal detector
Large flat head screwdriver
Shovel
Pen and paper
Clipboard
Safety vests
Traffic cones and signs
Tape measure
Compass
Latex gloves
Small plastic bottles
Field maps

Appendix C
Detailed Data Dictionary

• Attributes for Non-Outfalls:

Feat_ID
Description: Feature Identifier. This is the unique identifier assigned to each feature we collect with the GPS unit.
Type: Text Field Length: 12 Options: Manually entry

FeatType
Description: Feature Type. This is the type of feature being collected.
Type: Menu Field Length: N/A Options: Manhole (default), Culvert, Catch Basin, Catchment, Other

CatchMat
Description: Catchment Material. Construction material for catch basins and catchments.
Type: Menu Field Length: N/A Options: Pre-Cast Concrete (default), Overland-Earthen, Brick, Stone, Other

ChanType
Description: Channel Type. The type of channel used for drainage.
Type: Menu Field Length: N/A Options: Closed Pipe (default), Open Ditch, Swale, Other

ChanMatIn1
Description: Input 1 channel material. Construction material for pipes or channels.
Type: Menu Field Length: N/A Options: RCP – Reinforced Concrete Pipe (default), CMP – Corrugated Metal Pipe, PVC – Poly Vinyl Chloride (plastic), HDPE – High Density Polyethylene (corrugated), VC – Vitrified Clay, Earthen, Steel, Rip-Rap, Other

ChanMatIn2
Description: Input 2 channel material. Construction material for pipes or channels.
Type: Menu Field Length: N/A Options: See ChanMatIn1

ChanMatIn3
Description: Input 3 channel material. Construction material for pipes or channels.
Type: Menu Field Length: N/A Options: See ChanMatIn1

ChanMatOut
Description: Output channel material. Construction material for pipes or channels.
Type: Menu Field Length: N/A Options: RCP – Reinforced Concrete Pipe (default), CMP – Corrugated Metal Pipe, PVC – Poly Vinyl Chloride (plastic), HDPE – High Density Polyethylene (corrugated), VC – Vitrified Clay, Earthen, Steel, Rip-Rap, Other

ChanShape
Description: Channel Shape. The shape of pipe or channel used for drainage.
Type: Menu Field Length: N/A Options: Circular (default), Elliptical, Box, Other

TextIn1
Description: Channel Texture. The texture of pipe or channel used for drainage.
Type: Menu Field Length: N/A Options: Smooth (default), Tiled, Corrugated, Other

TextIn2
Description: Channel Texture. The texture of pipe or channel used for drainage.
Type: Menu Field Length: N/A Options: Smooth (default), Tiled, Corrugated, Other

TextIn3
Description: Channel Texture. The texture of pipe or channel used for drainage.
Type: Menu Field Length: N/A Options: Smooth (default), Tiled, Corrugated, Other

TextOut
Description: Channel Texture. The texture of pipe or channel used for drainage.
Type: Menu Field Length: N/A Options: Smooth (default), Tiled, Corrugated, Other

InputNumb
Description: Input Number. The number of pipes or channels flowing in to a feature.
Type: Integer (Numeric) Field Length: N/A Options: 1-10

OutNumb
Description: Output Number. The number of pipes or channels flowing out of a feature.
Type: Numeric (Integer) Field Length: N/A Options: 1-10

PipeDiamIn
Description: Input Pipe Diameters. The diameter, in inches, of pipes flowing in to a feature.
Type: Text Field Length: 20 Options: Text Entry

PipeDiamOut
Description: Output Pipe Diameters. The diameter, in inches, of pipes flowing out of a feature.
Type: Text Field Length: 20 Options: Text Entry

FeatHeightIn
Description: Input Channel Height. The height of channels, in inches, flowing in to a feature.
Type: Text Field Length: 20 Options: Text Entry

FeatHeightOut
Description: Output Channel Height. The height of channels, in inches, flowing out of a feature.
Type: Text Field Length: 20 Options: Text Entry

FeatWidthIn
Description: Input Channel Width. The width of channels, in inches, flowing in to a feature.
Type: Text Field Length: 20 Options: Text Entry

FeatWidthOut
Description: Output Channel Width. The width of channels, in inches, flowing out of a feature.
Type: Text Field Length: 20 Options: Text Entry

BenchDepth
Description: Bench Depth. The depth to the bench of a manhole (top of channel opening) measured in inches from the cover height down.
Type: Text Field Length: 6 Options: Text Entry

FeatLoc
Description: Feature Location. Ground cover around feature.
Type: Menu Field Length: N/A Options: Concrete (default), Blacktop, Gravel, Vegetation, Dirt, Other

FeatLev
Description: Feature Level. Relation to surrounding grade.
Type: Menu Field Length: N/A Options: Level with Surface (default), Below Grade, Above Grade

CoverGrate
Description: Cover Grate. Physical condition of the feature cover or grate.
Type: Menu Field Length: N/A Options: Good (default), Fair, Poor, N/A

BarrelCond
Description: Barrel Condition. Physical condition of the manhole barrel.
Type: Menu Field Length: N/A Options: Good (default), Fair, Poor, N/A

RungCond
Description: Rung Condition. Physical condition of the manhole ladder rungs.
Type: Menu Field Length: N/A Options: Good (default), Fair, Poor, N/A

CastCond
Description: Cast Condition. Physical condition of the manhole cast.
Type: Menu Field Length: N/A Options: Good (default), Fair, Poor, N/A

GenCond
Description: General Condition. Physical condition of the feature overall.
Type: Menu Field Length: N/A Options: Good (default), Fair, Poor, N/A

FlowIn
Description: Flow In. Quantity of flow entering feature.
Type: Menu Field Length: N/A Options: None, Moist, Trickle, Moderate, Substantial

FlowOut
Description: Flow Out. Quantity of flow leaving feature.
Type: Menu Field Length: N/A Options: None, Moist, Trickle, Moderate, Substantial

Odor
Description: Odor. Detectable smell.
Type: Menu Field Length: N/A Options: None (default), Sewage, Oil/Gas, Sulfide, Soapy, Rancid/Sour, Other

OdorSev
Description: Odor Severity. Strength of odor.
Type: Menu Field Length: N/A Options: 1 (least), 2, 3 (highest), N/A (default)

Color
Description: Color. Visible coloration.
Type: Menu Field Length: N/A Options: None (default), White, Gray, Brown, Yellow, Green, Red, Other

ColorSev
Description: Color Severity. Strength of color.
Type: Menu Field Length: N/A Options: 1 (least), 2, 3 (highest), N/A (default)

Turbidity
Description: Turbidity. Strength of turbidity (stirred up particles, murkiness).
Type: Menu Field Length: N/A Options: 1 (least), 2, 3 (highest), N/A (default)

Floatables
Description: Floatables. Types of floating material.
Type: Menu Field Length: N/A Options: None (default), Sewage, Suds, Oil/Sheen, Other

FloatSev
Description: Floatable Severity. Quantity of floatables.
Type: Menu Field Length: N/A Options: 1 (least), 2, 3 (highest), N/A (default)

FlowDir
Description: Flow. Direction of flow.
Type: Menu Field Length: N/A Options: N, S, E, W, NE, SW, SE, NW

Comment
Description: Comment. Additional information about feature.
Type: Text Field Length: 50 Options: Text Entry.

NeedsClean
Description: Feature requires cleaning
Type: Menu Field Length: N/A Options: Yes, No, N/A (default)

● Attributes for Outfalls:

Feat_ID
Description: Feature Identifier. This is the unique identifier assigned to each feature we collect with the GPS unit.
Type: Text Field Length: 12 Options: Manually entry

MS4Name
Description: MS4 Name. Identifier for MS4.
Type: Text Field Length: 30 Options: Village of Clinton (Project pre-set)

WShedNam
Description: Watershed Name. Identifiable watershed name (11 digit HUC name).
Type: Text Field Length: 30 Options: Oriskany Creek (Project pre-set)

RecWatBdy
Description: Receiving Water Body. Name of body of water receiving discharge, if known.
Type: Text Field Length: 30 Options: Manual text entry

HUC
Description: Hydrologic Unit Code. 11 digit number representing watershed ID.
Type: Text Field Length: 11 Options: 02020004040

WIN
Description: Water Index Number. Identifier for Water of U.S. that is the outfall receiver.
Type: Text Field Length: 30 Options: Manual Entry

MS4PermNo
Description: MS4 Permit Number. Identifier for MS4 Permit area.
Type: Text Field Length: 30 Options: NYR20A129 (Project pre-set)

GenCond
Description: General Condition. Physical condition of the outfall overall.
Type: Menu Field Length: N/A Options: Good (default), Fair, Poor, N/A

ChanType
Description: Channel Type. The type of channel used for drainage.
Type: Menu Field Length: N/A Options: Closed Pipe (default), Open Ditch, Swale, Other

ChanMat
Description: Channel Material. Construction material for pipes or channels.
Type: Menu Field Length: N/A Options: RCP – Reinforced Concrete Pipe (default), CMP – Corrugated Metal Pipe, PVC – Poly Vinyl Chloride (plastic), HDPE – High Density Polyethylene (corrugated), VC – Vitrified Clay, Earthen, Steel, Rip-Rap, Other

ChanShape
Description: Channel Shape. The shape of pipe or channel used for drainage.
Type: Menu Field Length: N/A Options: Circular (default), Elliptical, Box, Other

ChanText
Description: Channel Texture. The texture of pipe or channel used for drainage.
Type: Menu Field Length: N/A Options: Smooth (default), Tiled, Corrugated, Other

InputNumb
Description: Input Number. The number of pipes or channels flowing in to a feature.
Type: Numeric (Integer) Field Length: N/A Options: 0-10 (default 1)

PipeDiamIn
Description: Input Pipe Diameters. The diameter, in inches, of pipes flowing in to a feature.
Type: Text Field Length: 20 Options: Text Entry

PipeDiamOut
Description: Output Pipe Diameters. The diameter, in inches, of pipes flowing out of a feature.
Type: Text Field Length: 20 Options: Text Entry

FeatHeightIn
Description: Input Channel Height. The height of channels, in inches, flowing in to a feature.
Type: Text Field Length: 20 Options: Text Entry

FeatHeightOut
Description: Output Channel Height. The height of channels, in inches, flowing out of a feature.
Type: Text Field Length: 20 Options: Text Entry

FeatWidthIn
Description: Input Channel Width. The width of channels, in inches, flowing in to a feature.
Type: Text Field Length: 20 Options: Text Entry

FeatWidthOut
Description: Output Channel Width. The width of channels, in inches, flowing out of a feature.
Type: Text Field Length: 20 Options: Text Entry

Flow
Description: Flow. Fluid rate of flow at feature.
Type: Menu Field Length: N/A Options: None, Moist, Trickle, Moderate, Substantial

Odor
Description: Odor. Type of detectable odor at feature.
Type: Menu Field Length: N/A Options: None (default), sewage, Oil/Gas, Sulfide, Soapy, Rancid/Sour, Other

OdorSev
Description: Odor Severity. Strength of odor.
Type: Menu Field Length: N/A Options: 1 (least), 2, 3 (highest), N/A (default)

Color
Description: Color. Visible coloration.
Type: Menu Field Length: N/A Options: None (default), White, Gray, Brown, Yellow, Green, Red, Other

ColorSev
Description: Color Severity. Strength of color.
Type: Menu Field Length: N/A Options: 1 (least), 2, 3 (highest), N/A (default)

Turbidity
Description: Turbidity. Strength of turbidity (stirred up particles, murkiness).
Type: Menu Field Length: N/A Options: 1 (least), 2, 3 (highest), N/A (default)

Floatables
Description: Floatables. Types of floating material.
Type: Menu Field Length: N/A Options: None (default), Sewage, Suds, Oil/Sheen, Other

FloatSev
Description: Floatable Severity. Quantity of floatables.
Type: Menu Field Length: N/A Options: 1 (least), 2, 3 (highest), N/A (default)

FlowDir
Description: Flow. Direction of flow.
Type: Menu Field Length: N/A Options: N, S, E, W, NE, SW, SE, NW

InspDate
Description: Inspection date. Date the manhole was inspected.
Type: Date Field Length: N/A Options: Auto Generated.

InspTime
Description: Inspection time. Time the manhole was inspected.
Type: Time Field Length: N/A Options: Auto Generated.

Last24HrRain
Description: Last 24 Hour Rain. Significant rainfall in the last 24 hours.
Type: Menu Field Length: N/A Options: Y, N.

Last48HrRain
Description: Last 24 Hour Rain. Significant rainfall in the last 48 hours.
Type: Menu Field Length: N/A Options: Y, N.

OutOrigin
Description: Outfall Origin. Description of origin of outfall if known.
Type: Menu Field Length: 50 Options: Manual Entry.

Submerged
Description: Submerged. Whether or not the outfall is underwater.
Type: Menu Field Length: N/A Options: Y, N (default).

Deposits
Description: Deposits. Type of deposited material around outfall.
Type: Menu Field Length: N/A Options: None (default), Mineral, Oily, Paint, Other

Benthic
Description: Benthic. Whether or not there is benthic (underwater ground vegetation growth).
Type: Menu Field Length: N/A Options: Y, N (default).

Vegetation
Description: Vegetation. Quantity of vegetative growth around outfall.
Type: Menu Field Length: N/A Options: Normal (default), Excessive, Inhibited

IllDisPot
Description: Illicit Discharge Potential. Likelihood that the outfall is a location for illicit discharges.
Type: Menu Field Length: N/A Options: Unlikely (default), Potential, Likely

Samples
Description: Samples. Whether or not fluid samples were collected.
Type: Menu Field Length: N/A Options: Y, N (default).

SampleNo
Description: Sample number. Sample Identification number(s).
Type: Text Field Length: 30 Options: Manual Entry

SampleColl
Description: Sample Collected. Location of sample collection.
Type: Menu Field Length: N/A Options: Outfall Flow (default), Pool

Comment
Description: Comment. Other information about feature.
Type: Text Field Length: 50 Options: Manual Entry

NeedsClean
Description: Feature requires cleaning
Type: Menu Field Length: N/A Options: Yes, No, N/A (default)