THE ROUGE RIVER PROJECT
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Rouge River National Wet Weather Demonstration Project

Wayne County, Michigan

TECHNICAL MEMORANDUM

Guidelines for Conducting an Outfall Inventory

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Rouge River National Wet Weather Demonstration Project

MISSION STATEMENT

The mission of the Rouge River National Wet Weather Demonstration Project is to demonstrate effective solutions to water quality problems facing an urban watershed highly impacted by wet weather and develop potential solutions and implement projects which will lead to the restoration of water quality in the Rouge River. The project will address both conventional and toxic pollutants to:

- provide a safe and healthy recreational river resource for present and future generations;
- re-establish a healthy and diverse ecosystem within the Rouge River Watershed;
- protect downstream water resources such as the Detroit River and Lake Erie; and
- help ensure compliance with federal, state and local environmental laws which protect human health and the environment.

This will be accomplish through the development, implementation and financial integration of technical, social and institutional frameworks leading to cost-efficient and innovative watershed-based solutions to wet weather problems. This watershed-based national demonstration project will provide other municipalities across the nation facing similar problems with guidance and potentially effective solutions.

PREFACE

The Rouge River and its watershed are a primary source of pollution to the Great Lakes. The Clean Water Act of 1972 intended to make waterways "fishable and swimmable" by 1972. Although that goal has not been reached, great progress has been made in improving water quality in most waterways. The Rouge River Remedial Action Plan (RAP) provided a basis for which The Rouge River National Wet Weather Demonstration Project (Rouge Project) efforts were created: it identified the major sources of pollution and measured the relative contributions of each. The RAP is the continuing foundation for the Rouge Project and presents a framework for addressing the problems within the Rouge River by looking beyond treatment and focusing instead on prevention methods.

The Rouge Project was established under the initial Rouge Grant 1 from the United States Environment Protection Agency, Region 5, and enabled Wayne County to initiate a comprehensive watershed-wide pollution-control approach that addresses combined sewer overflow (CSO), stormwater management, and other nonpoint source controls through the application of innovative technologies, progressive financial and institutional arrangements, and creative public involvement and education programs.

Rouge Grant 2 provides the framework for the progression and implementation of Project goals as Wayne County continues its mission to develop potential solutions and implement projects which will lead to the restoration of water quality in the Rouge River. The Project will address both conventional and toxic pollutants to:

- provide a safe and healthy recreational river resource for present and future generations;
- re-establish a healthy and diverse ecosystem within the Rouge River Watershed;
- protect downstream water resources such as the Detroit River and Lake Erie; and
- help ensure compliance with federal, state, and local environmental laws which protect human health and environment.

This will be accomplished through the development, implementation, and financial integration of technical, social, and institutional frameworks leading to cost-efficient and innovative watershed-based solutions to wet weather problems. This watershed-based national demonstration project will provide other municipalities across the nation facing similar problems with guidance and potentially effective solutions.

Under Rouge Grant 2, the Rouge Project will build on lessons learned from Grant 1 efforts and focus on further integration of the goals of the overall Mission. To this end, Rouge Grant 2 concentrates on the following key Project areas:

- **Watershed Management** will continue under Rouge Grant 2 with the development and evaluation of wet weather and stormwater alternatives, the planning of long-term monitoring programs, and the ongoing efforts to enhance instream water quality, monitor rain and flow levels, interpret data analysis, and present recommendations.

- **Nonpoint Source Pollution Control** will provide for the stormwater management, permit applications, and development of financial and institutional alternatives for wet-weather watershed management in concert with enhanced efforts to establish institutional partnerships. Toward the goal of institutional partnering, several community projects will be undertaken with watershed communities. Additional efforts include the inventory of wetlands and measurement of pollutant loads from abandoned dumps and air deposition with possible remediation of some sites.

- **CSO Construction Coordination** will continue to monitor the construction of CSO demonstration projects established under Grant 1. Additional planning and assistance will allow project coordinators to make additional recommendations on the design criteria of future CSO abatement facilities.

- **Public Involvement and Information** will reach and interact with more stakeholders, institutions, and regulatory agencies, thus fostering a renewed understanding and continued commitment to reducing pollution, and continuing the transfer of watershed management approaches way beyond the project. It will be the central mechanism for transmittal of the Project's Decision Support System tools, processes, and information necessary for sustaining a watershed management support system directly to varied audiences both within and outside the Rouge watershed.

Additional information on the Rouge River Project is available from many sources, including the Wayne County Department of Environment (WCDOE) and the Rouge Program Office (RPO).

ABSTRACT

Outfall inventory techniques have been performed from August 1996 - December 1996 within the Bell Branch/Tarabusi Creek tributaries of the Rouge River Watershed. These techniques have been evaluated to help communities more accurately define outfall information for future use in the preparation of stormwater discharge permits, and industrial discharges, as well as conducting river model calculations. These models will assist in correcting erosion, pollution, and flooding problems. It is hoped that the methods outlined in this document can be used by communities as a guideline for conducting their own outfall inventories. The primary method presented in this document for outfall location is the Global Positioning System (GPS). Other methods discussed include the United States Geographic Survey (USGS) Mapping Methods, and conventional surveying with electronic surveying equipment. Methods of mapping outfall locations have also been presented and evaluated. The Geographic Information System (GIS) and conventional computer drafting methods have been addressed as well. Primary parameters used to evaluate survey methods were cost and accuracy, with GPS surveying being recommended in conjunction with GIS data storage for outfall inventories. It is not essential that GIS and GPS technologies be used however, communities need to take a look at their resources and determine the appropriate and most economical method.

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EXECUTIVE SUMMARY

This technical memorandum serves as a guidance document for conducting an outfall survey and inventory. The methods presented herein were developed as part of an inventory of a portion of the Upper 2 (Bell Branch/Tarabusi Creek) subwatershed. The results presented in this memorandum were adopted from a survey performed in Northville and Redford Townships and the cities of Livonia, Farmington Hills, and Farmington in Wayne and Oakland counties.

The goal of this survey and memorandum outlining the summary of the Bell Branch/Tarabusi Creek outfall inventory results is to create and demonstrate various techniques for performing outfall inventories, in an attempt to establish a template for interested communities for use in their own outfall inventories. There are four basic steps to accomplish an outfall inventory. The first step is to collect all available drainage maps for the area under investigation as well as information about outfall ownership and maintenance of outfall structures. The next step is to conduct the field inventory using appropriate survey methods which correspond to the community budget constraints and meet their goals for the inventory. The third step is to compare information collected to the existing information and update it if necessary. Finally, a report and full documentation of the investigation should be prepared so that communities can use this information for future watershed management.

The different survey procedures outlined in this technical memorandum are: Global Positioning System surveys (GPS), United States Geological Survey (USGS) mapping techniques, and Conventional Topographic Surveying or a traverse survey. They all can be useful in determining the position of outfalls within a watershed with some advantages and disadvantages. In terms of accuracy, a conventional traverse survey provides a level of accuracy beyond what is required for an outfall inventory. GPS surveying, being a close second in accuracy, provides adequate levels of accuracy for an outfall inventory. USGS mapping techniques of placing a point on a topographical map by obtaining distances and compass angles from reference points also provides a reasonable level of accuracy for an outfall inventory. In terms of cost, the USGS mapping procedure would be the cheapest method of determining the position of outfalls. GPS surveying would be comparable in cost to a USGS mapping survey, but has high equipment costs associated with it. A traverse survey with high equipment costs and labor is more expensive due to the time required to perform such a survey.

For outfall inventories, there are steps common for all three types of surveying. Survey forms must be filled out at every outfall, detailing the location, condition, and water quality at every site, and data that are collected must be compiled and stored in a useful format for future update and maintenance. Maps utilizing Geographic Information System (GIS) technology or other conventional means should be prepared or updated to reflect features that exist in the field.

1.0 INTRODUCTION.

The Rouge River Watershed is located in southeastern Michigan and is among the most highly urbanized areas in the state. With an estimated 1.5 million people, the watershed covers approximately 438 square miles including 48 municipalities and parts of three counties. The watershed is more than 50 percent urbanized and contains more than 400 lakes, impoundments and ponds. The watershed is divided into four subwatersheds which follow the four main branches of the Rouge River: the Main, Upper, Middle, and Lower. These watersheds are further divided. The information presented in this technical memorandum was compiled for the Bell Branch/Tarabusi Creek subwatershed, also known as the Upper 2 subwatershed.

One of the goals of the Rouge Project is to establish a watershed-wide stormwater management system. As part of this goal, Wayne County, in conjunction with the RPO, conducted an inventory of all outfalls, including storm and combined sewers, discharging into the Bell Branch/Tarabusi Creek tributaries of the Rouge River.

1.1 GOALS OF THE OUTFALL INVENTORY.

The main objective of this survey was to locate, inventory and document all the outfalls along the streams surveyed, as well as identify the type of outfall located and the quality of the water being discharged. An outfall inventory is an important element in establishig a Stormwater Management Program for an area as it provides information necessary for municipal stormwater applications, and permits. These permits include Phase 1 National Pollutant Discharge Elimination System (NPDES) permits, and Department of Environment Qualtiy (DEQ) General Permits, and Department of Environmental Quality (DEQ) General Permits for Stormwater. These inventories are valuable as a planning tool for communities and drainage commissioners in managing their river resources, as well as assisting in river model calibrations by adequately estimating the river flow rates.

In addition, the purpose of this survey was to create and demonstrate various techniques for performing outfall inventories, in an attempt to establish a template that other communities can use for their own outfall inventories. Another purpose for the investigation was to compile data for the watershed that did not exist previously so that problems could be identified and dealt with. The water quality data collected will help to identify point source pollution problems resulting from stormwater discharges. A third purpose of the investigation was to compile a set of community drainage maps and verify what was shown on them to see if they accurately reflected what was present in the field.

This technical memorandum serves as a guidance document for conducting an outfall inventory. The methods presented herein were developed as part of an inventory of the Upper 2 (Bell Branch/Tarabusi Creek) subwatershed. The survey was performed in Redford Township and the cities of Livonia, Farmington Hills, and Farmington in Wayne and Oakland Counties.

1.2 BACKGROUND. Outfalls are a necessary component of all drain systems to convey storm runoff to receiving waters. It is important for communities to keep track of outfalls within their boundaries. Depending on the size and number of outfalls discharging into the river, there may be a significant volume of water added which could cause downstream erosion or water quality problems. For these reasons, it is important for communities to take inventories of sewer outfalls, and keep records of new outfalls being installed.

There are four basic types of outfalls that can be found in any drainage system:

Storm Sewer Outfalls are used to allow stormwater collected in a separate storm sewer system to drain into receiving waters. The typical pollutants that can be discharged from storm sewer outfalls are road salts, various types of hydrocarbons and metals washed from roadways, sediment, nutrients, and particulate matter.

Combined Sewer Overflows (CSOs) discharge sanitary waste as well as stormwater during wet weather. When the capacity of the combined sewer system or the wastewater treatment is reached, the combined sewage and stormwater overflows into a receiving water. CSOs contain all the pollutants associated with stormwater as well as contaminants from human waste.

Permitted Industrial Discharge Outfalls are used to dispose of waste water from industrial processes. These outfalls generally discharge water used for washing cooling purposes and should be treated at the source if required. These types of outfalls require an NPDES permit.

Private Drains: There may also be private outfalls from roof drains or basements to direct stormwater and seepage away from houses as well as some illicit septic outfalls from homes in the watershed. It is important for communities to perform outfall inventories and know the quantity, type and location of outfalls that are within their boundaries. Then they can effectively begin to manage stormwater and take steps to remove illegal or combined sewage outfalls. Communities with CSOs should consider methods to detain combined sewage flow until it can be treated.

1.3 OUTLINE OF DOCUMENT. Section 2.0 of this technical memorandum outlines three different types of survey procedures that may be used for conducting an outfall inventory. The discussions include a description of the field crew and their responsibilities, procedures for performing the surveys, and options for digitally storing the collected data. Section 3.0 describes the suggested steps for completing an outfall inventory from start to finish. Section 4.0 is a brief discussion about the problems resulting from wet weather and includes a paragraph about NPDES regulations pertaining to stormwater discharges. It further discusses the benefits and shortcomings of some of the outlined survey techniques. Section 5.0 is a list of the references used to prepare this document. A list of acronyms used in this technical memorandum is included in Appendix A. Appendix B is a list of the equipment used for the Bell Branch/Tarabusi Creek subwatershed outfall inventory. Sample survey and observation worksheets are provided in Appendices C and D. Examples of compiled data from the Bell Branch/Tarabusi Creek subwatershed survey are included for illustration purposes in Appendix E.

2.0 METHODS FOR CONDUCTING OUTFALL INVENTORIES. In conducting an outfall inventory one of the key elements of information that needs to be investigated is the location of the outfalls. There are several ways to determine the location of surveyed outfalls. The deciding factors in selecting a surveying method are probably cost and accuracy. If accuracy is not a high priority then a more cost effective method may be chosen. The three methods outlined in this memorandum have their advantages and disadvantages regarding cost and accuracy. Communities performing outfall inventories must decide which criterion is more important. The methods outlined herein include GPS survey, USGS map estimating, and Traverse survey. The traverse survey provides high levels of accuracy which are not required and costly, whereas the map estimating is the most inexpensive and may provide adequate levels of accuracy.

2.1 BEST PRACTICES FOR OUTFALL INVENTORIES. Regardless of the method selected for an outfall inventory, it should be the first step of every survey to obtain as much information as possible about drainage patterns and outfalls to a receiving water. Preparation and compilation of a list of community maps with known outfall locations, and community maps showing any available outfall drainage area delineations are essential tasks. Where drainage area delineations are available, the corresponding outfall to each drainage area should be identified. Discrepancies from maps gathered from different sources should be noted and later corrected after being checked in the field.

Access to the survey area should be limited to public right of ways only. Infringement on private property should be kept to a minimum and avoided when possible. Road crossings and public parks/facilities are excellent areas to gain access to rivers, lakes and streams. If it should become necessary to use private land as an access point, then permission from the land owner should be obtained first. Each situation should be handled on a case by case basis.

In some areas, access to the receiving water may be restricted or limited due to heavy vegetation. Brush may also mask outfall locations. It is best to perform these surveys in the late fall to early spring when vegetation is lightest. In areas where water levels are low, it may be beneficial to conduct the survey by walking in the water itself and looking at the banks. Again, situations should be handled on a case by case basis. If there is an interest in water quality of outfall discharge then surveys should be performed in the spring. At this time, more of the outfalls will be flowing due to precipitation and runoff from snow thaw.

2.2 DESCRIPTION OF FIELD CREW. A typical field crew should consist of three people. Two people are required to walk the river bank to search for outfalls. The third person is responsible for coordinating the survey from a vehicle at street level. It is the third person's responisbility to collect notes on the land use around the river as well as take notes describing the location of the survey, weather conditions and any other information considered relevant or helpful to the survey. In addition, the third person or driver is responsible for transporting the crew from site to site. This greatly reduces the time required for getting back to the vehicle and moving to new sites, and results in more time spent in the field.

2.2.1 Field Crew Preparation. The field crew is responsible for several tasks before surveying begins. The first step should be to notify the proper individuals that a survey will be taking place in their neighborhood or community and provide awareness to the people of the necessity for field personnel to cross properties adjacent to the river. When conducting the survey, it is important for crews to be professional when crossing private property. Cooperation from citizens is essential and it is important for field crews to be tactful when dealing with the public. Next, crews should focus on gathering as much information as possible on the area of the river being surveyed. Maps and aerial photos can be helpful tools when trying to locate outfalls and small tributaries. Any information on existing outfalls should be obtained and then later confirmed in the field.

2.2.2 Field Crew Responsibilities. The two crew members walking along the river are responsible for the actual survey of the river. It is their job to find the outfalls, make observations about the river water quality, alert the proper individuals to excessive pollution problems and gather all the information required for the successful completion of the inventory. Crew members are also responsible for their own safety. At no time should field staff compromise their personal safety, or that of the rest of their crew to obtain data. Field personnel should never enter any confined space unless they have proper equipment and training. Crew members should exercise their own judgement on what they feel comfortable doing and not be pressured into performing beyond their safe limits.

2.3 GLOBAL POSITIONING SYSTEM SURVEY METHOD. If a GPS survey is selected, the following section outlines the procedures to follow, and errors to watch out for. A GPS unit is not required to perform an outfall inventory, but it provides increased accuracy compared to map estimating, allows survey staff to move quickly between outfalls, and has a diversity of models suitable for almost any budget. Advantages of the GPS unit are its ease of operation, its light weight, and its quick way to accurately determine positions. Disadvantages included are its initial cost and the regular unavailability of satellites to determine positions.

2.3.1 Field Inventory. Survey crews should be educated in the use of a GPS unit and understand the basic operating principals and procedures. Field inventory should be conducted using a team of three people. Two of the three people should be located on either side of the river. Their job is to walk along the river and look on either side to spot any outfalls they may encounter.

The third person should remain at street level and keep in radio contact with the other two crew members. The purpose of the third person is to find the source of any outfalls that the other two encounter. He or she will bang on manhole covers in the vicinity of the stream until the sound is heard at the outfall end. In addition, the third crew member should take notes of any relevance to the physical characteristics or water quality of the river such as land use in the area, or location of any potential pollution sources.

At every outfall the crew will fill out survey forms such as those examples shown in Appendix C and D. These sheets include information with regard to time and date of the survey as well as location, pipe information, stream conditions and water quality. In addition, the outfalls should be numbered to correspond to a map location that will later be catalogued in a Geographic Information System (GIS) database, or other appropriate mapping system. Crews may either walk upstream or downstream numbering outfalls as they go, but it is important that they remain consistent. The location of the outfalls should be determined through the use of a hand held GPS unit. It is recommended that a portable unit be used in conjunction with a Base Station for increased accuracy.

2.3.2 Errors Involved With GPS Surveying. The accuracy of a position determined using a GPS unit is dependent on a number of factors. Some of these factors cannot be controlled by the user but can be reduced through proper post processing. The GPS receiver can determine a position with an error of less than 25 meters. However, for security reasons the U.S. Government purposely inserts random errors into the data which reduces the accuracy to within 100 meters. To overcome these errors, a technique known as differential positioning is used. Differential positioning involves setting up a base station at a known location or control point. The field receiver and the base station both collect positional data and the assumption is made that they are subject to the same error. By comparing the difference between the two positions, the field location can then be determined in reference to the base station, thus reducing the error in the measurement. Differential positioning can increase the accuracy of the locational data to within 1 meter.

Positional Dilution of Precision (PDOP) can also affect the accuracy of the GPS signal. PDOP is a measure of the strength of the satellite configuration. The ideal configuration would be to have one satellite directly above the receiver and three other satellites equally spaced around the horizon, as low as possible. More accurate positional data will be collected when the PDOP value is low. Satellite schedules are available each day which list these values at different times. Data should only be collected when the PDOP is below a predetermined value established for minimum accuracy. The field crew can increase the accuracy of the data collected by planning their schedule properly.

Another factor that can be controlled is multipath reflection. Satellite signals can reflect or bounce off of solid objects and be received by the GPS unit. The field crew should avoid setting up the receiver near solid objects, such as buildings, that could reflect a signal. This effect can be partially reduced by setting a mask angle on the receiver. A mask angle is an angle measured above the horizon, below which no signals are allowed to be received by the GPS unit. This will eliminate signals that could come in low and bounce off the earth to the receiver.

2.3.3 GPS Field Survey Steps.

- Preplanning should be done in the office before the crew leaves for the field each morning. Using information collected from maps of the watershed, the crew should mark on a field map where outfalls are expected to be located to verify current information. At this time, satellite schedules should be printed and examined for times when satellite coverage is inadequate for a GPS fix in the survey area. An up-to-date satellite almanac must be collected at this time as well. An almanac contains information on the location and condition of each satellite in the constellation. Since this information is always changing, new almanacs should be collected approximately every three months to ensure more accurate planning. Each satellite transmits a complete almanac file and it can be sent directly to the GPS receiver. This process should take between 10 and 15 minutes depending on the strength of the signal.

The following is a summary of the procedure performed in the outfall inventory conducted for the Bell Branch/Tarabusi Creek subwatershed of the Rouge River Watershed and is presented herein as an operating procedure for any future outfall inventory:

- Two members of the crew should walk on opposite sides of the river being surveyed. Each should be walking upstream while looking across the river to the other side to check for outfalls. The third member of the crew should remain at street level. The crew should remain in communication by means of two way radios.

- When an outfall is encountered the crew should:

  1. Check the satellite schedule to make sure that there are enough satellites in the area and that they are positioned properly to get an accurate fix.
  2. Proceed with collecting GPS data for approximately 15 minutes[1].
  3. If a GPS fix cannot be taken on the outfall, then it should be taken near it, and the distance and angle should be measured from the GPS to the pipe so that it can be plotted on a map. It is not always necessary to take a GPS reading at every outfall. If several outfalls are located near one another then they may all be referenced from the same GPS location.
  4. Place a point on the field map to indicate the approximate position of the outfall. If the outfall is one that was expected, confirm that the data from the preplanning session is correct.
  5. The crew member at street level should attempt to locate the source of the outfall by banging on manhole covers in the area with a hammer. If the correct manhole is located, the sound will be heard at the outfall.
  6. Identify the outfall by painting an appropriate number on the pipe. This number

[1] A time of 15 minutes was arrived upon through a process of trial and error to determine the minimum time required to obtain suitable data for differential positioning.

should be associated with the name of the GPS data file for easy identification.

7. Take a photograph of the outfall.
8. Fill out a GPS Survey Sheet and River Aesthetics Form which are attached in Appendices C and D. Information includes pipe size, material, stream conditions at the outfall, and any damage that is observed.
9. If the outfall is flowing, use a temperature, pH, conductivity meter to determine the water quality, and record this data on the survey forms.
10. If there is obvious pollution, crews should fill out the appropriate Water Quality Alert Checklist forms and notify the appropriate agency.

- After the field work is performed, the data from the GPS should be downloaded to a desktop computer for post processing.

Different variations of the above procedure may be adopted to suit individual communities. The important steps involve collecting information such as size, material and source of the outfalls. If using a portable GPS unit in conjunction with a base station, 15 minutes should be regarded as the minimum time for data collection. This procedure provides enough time for the base station and the portable unit to receive overlapping data required for sub-meter accuracy in post processing. It also gives the field crew a chance to fill out all the necessary paper work and attempt to find a source at each outfall.

If a base station is not used, less time is needed for a position fix, however, accuracy is greatly reduced due to random errors inserted by the Department of Defense. These random errors include ephemeris error, which are errors in orbit data transmitted by the satellite, and clock errors.

Portable GPS units may be used either with or without an external antenna. External antennas increase reception and are recommended for areas where overhead foliage is thick, but are not necessary for more accurate results. Similar results can be obtained using the unit's antenna, but position fixes may have to be taken in areas free of overhead obstructions. Use of an external antenna does not guarantee increased accuracy. Accuracy depends on the number and position of satellites received. The antenna increases signal strength and allows the receiver to obtain more satellite information. Satellite signals cannot be received through trees, buildings, or people. Note that in setting up your GPS for a fix, the GPS must also be relatively uninterrupted during the 15 minutes of data collection, therefore thought and care must be given to where the position fix should be taken.

For ongoing surveys which cover large areas and require more time, it is recommended that a dual frequency receiver be used. Satellites broadcast two continuous data signals. If a receiver is capable of collecting both signals, this will reduce the time that is required for data acquisition. The added cost of a dual frequency receiver may be offset by the reduction in time spent in the field.

It is recommended for a GPS survey that the crew members walking the river have a complete set of equipment, because it is not always convenient to cross the river (See Appendix B for an equipment list). It may not be practical for a crew to have two of everything due to cost, and some compromises may be required. At the very least each crew member walking the river should have his or her own clipboard with survey sheets, marking paint, compass, and steel tape measure for measuring the size of the outfalls. The rest of the equipment can be shared. It would be good for all crew members to have a radio for communication, but if this is not possible, then at least two radios should be used for communication between those along the river and the other crew member at street level.

2.3.4 Post Processing GPS Data. The data from a GPS receiver should be downloaded to a computer for processing. If differential positioning is used, the data needs to be compared to calculate the difference between the remote receiver and the base station. Errors caused by cycle slips, atmospheric delays, bad ephemeris data, and clock discrepancies can be reduced at this time. If any locations were determined in reference to a common GPS fix, the individual locations need to be calculated from the corrected GPS location.

2.4 UNITED STATES GEOLOGICAL SURVEY MAP METHOD. If a map method survey is selected, the following section outlines the procedures to follow, and errors associated with this method. A map survey allows survey staff to move quickly between outfalls because there is no field surveying between outfalls. The main advantage of this survey is its low equipment cost and simplicity, however, accuracy can be questionable when in areas with few reference points.

The USGS maps are topographical maps which show details of an area or quadrangle. Quadrangle maps with a 1:24,000 scale are adequate for this type of survey. The USGS maps include contours showing elevation data for an area, symbols to identify different man made features, and shading to represent forested or urbanized areas. Other USGS map features include latitude and longitude, community or township names, and names of state and county highways and major streets in the cities. These maps show details that are not available on a standard road map and are available for sale from the USGS.

2.4.1 Field Inventory. Survey crews will conduct this type of survey the same way as the GPS survey. Two of the crew members walk along the river searching for outfalls and filling out all of the same survey forms. The third crew member will still remain at street level and search for the source of any outfalls discovered by the others. The only difference between the GPS survey and the USGS map estimate is that instead of taking a GPS reading, the crew walking the river will estimate their position and place a point on a USGS map to represent their approximate position. Alternatively, if there is a nearby reference point that is shown on the map, then crews can take distance and compass measurements to more accurately determine their position. If high levels of accuracy are not important, then this method is the most cost effective technique to determine stream characteristics, and outfall conditions in the river.

When conducting this type of survey, it is important that the latest versions of maps be used for referencing outfalls. Older maps may be less accurate because features may have changed either naturally or by man, and these maps may not always reflect the information that is in the field. Aerial photos, if they are available, may be helpful in identifying landmarks which would aid in placement of points on the maps to represent outfalls.

2.5 TRAVERSE SURVEY - TOTAL STATION. A traverse is a method of surveying which utilizes angles and distances to tie a series of established stations together. An open traverse can be used to map existing features or intermediate sites between established stations known as control points. An open traverse starts at one control point and finishes at another, while determining coordinates of intermediate sites along the way. This method of surveying is expensive, time consuming and provides a high level of accuracy that is not required for outfall inventories. It is therefore not recommended but merely presented here as an option.

An electronic tacheometer instrument (ETI) or total station is a device capable of measuring angles and distances, and using them to calculate three-dimensional coordinates. In areas of a river where the vegetation is light and outfalls are easily accessible, it may be feasible to conduct a traverse survey as a method of finding the coordinates of the outfalls. This survey will eliminate the time required to post process GPS data, and the expense of a GPS unit and base station. In addition, only a few minutes are needed to fill out survey forms at each outfall, and not the 15 minutes recommended to obtain a differential GPS fix. Outfalls are referenced from a control point by obtaining distance and angle measurements from the control point to calculate the position of the outfalls.

2.5.1 Control Points. A horizontal control point is a point for which the exact coordinates are known. A benchmark is a point of known elevation. Control points and benchmarks are required for any traverse survey so that new points surveyed can be accurately placed on a map. Lack of these reference points will complicate the transfer of the compiled information to the map. Lists of the control point locations can be obtained from municipal planning or engineering departments. It is a good surveying practice to start and finish a survey on a control point. It is known as a closed traverse which allows the surveyors to check the accuracy of their results.

2.5.2 Field Inventory. Survey crews should be familiar with the operating principals and procedures associated with performing a traverse survey using a total station. Total stations work by setting up the instrument at a known point in the field and then measuring distances and angles from the ETI to the outfall to calculate its coordinates and elevation. Targets are used to reflect light waves back to the ETI and determine distances the same way as sonar. Field crews may consist of three or four people. Two people will be required to operate the instrument and target, one person will be needed for locating outfall sources, and an additional person may be required to take notes. If two targets are available then two crew members should walk on opposite sides of the river and shoot the outfalls as they find them, while the instrument operator remains on one side of the river. Outfall information should be recorded by one of the two field personnel with the targets. All other procedures should be the same as those described in Section 2.3.3 of the GPS survey method when an outfall is discovered. Steps one through three of Section 2.3.3 should be disregarded when surveying with a total station.

2.6 GEOGRAPHIC INFORMATION SYSTEM DATABASE CREATING/UPDATING.

Before discussing the GIS mapping and database creation, it should be noted that it is not the only method of digitally storing data. Other types of software are available to perform similar operations. The benefit of the GIS data storage is the capability to store data by geographic location and present it on a digital map linked to all the database information. The drawback to GIS is its high initial start up cost, and it may not be a viable option for smaller communities. The following discussion relates to the use of GIS in coordination with GPS location of outfalls.

Field crews should coordinate with a GIS mapping team for input of outfall data into a base map of the community. GIS is a computerized database with the capability of expanding the information provided on a map to include the compiled database information. A GIS system can combine different data sets by using their geographic locations and link them with a variety of useful parameters needed to manage and predict. For example, outfall inventory data can be linked geographically with water quality data from another investigation to determine problem areas created by wet weather pollution from stormwater discharges.

For use in an outfall inventory, the locations of each outfall are layered on a GIS map as well as the information pertaining to the outfall size, shape, material, and water quality from any flowing outfalls. When this information is all incorporated in the database, it can be easily updated to include new information and models can be used to investigate the impacts of new outfalls. This will allow communities to forecast problems before they occur. In addition, if there are areas of the river with poor water quality that are found to coincide with outfall locations, then actions can be taken to reduce the pollution from that particular outfall. Communities with this ability will be able to effectively manage their watersheds and control pollution problems.

3.0 SUGGESTED STEPS TO COMPLETE AN OUTFALL INVENTORY.

Step 1: Compile Available Outfall Information. Compile all available outfall information including maps, plans of existing sewer systems, and drainage area delineations from local communities in the watershed. If drainage area delineations are available, then identify the outfalls and their drainage areas. It is a good idea to research the ownership as well as maintenance of the outfalls. The data should be included in databases and can be determined from map sources. Department of Transportation (DOT) maps will only show outfalls owned and maintained by the DOT, and city drainage maps should show outfalls owned by the city. Other outfalls with no apparent source may be listed as privately owned. Some of these include tile underdrains from large areas such as golf courses and parks. A follow up investigation should be performed to confirm these ownerships. Also, at this time, CSO permits may be obtained to determine the location of CSOs in the survey area. Permits should include locational and geometric information about CSO outfalls. Take notes of any inconsistencies between information collected from different sources. These differences should be checked in the field and necessary corrections should be made. Finally, spreadsheets or other electronic data storage systems should contain existing information and be updated after the field survey.

Step 2: Field Inventory. Choose a survey procedure and design outfall inventory data sheets to be used for information gathering at each outfall. Samples of the survey forms used in the Bell Branch/Tarabusi Creek subwatershed inventory are shown as a prototype in Appendix C. A river aesthetic form should be prepared and filled out at each outfall as well. This form is provided as a sample in Appendix D. Representatives of the communities, residents, and property owners should be notified officially before field investigations commence. Input and cooperation from citizens should be encouraged. Everyone will benefit from improved water quality and the more people involved and educated about the problem, the quicker these improvements can be realized. Joint effort between citizens and communities should be encouraged to expedite the surveying and inventory process.

When survey crews encounter any damaged outfall structures or obvious pollution problems, they should notify individuals that are responsible for repair of these structures and clean up of the waterbody. Damaged outfalls cause bank erosion problems and should be fixed promptly. The source of pollution problems should be identified and dealt with to ensure that pollution does not continue in the future.

Step 3: Update Outfall Map and Spreadsheets. Survey information should be compared to information compiled from other sources and discrepancies should be corrected. Transfer the data from the river aesthetic forms into a spreadsheet. Samples of the spreadsheets created for the Bell Branch/Tarabusi Creek subwatershed survey are included in Appendix E. Data from surveys should be entered into a GIS database if selected to be the database management procedure. GIS data should include information about outfalls and water quality.

Step 4: Document Outfall Inventory Results. A final report should be made including all information compiled from the survey and include a discussion on effectiveness of survey procedures. The results can be used as a tool to develop use permits or other enforceable documents to validate or confirm compliance with NPDES standards. The data is also important for stream flow model calculations used to estimate areas of concern for flooding after heavy precipitation. Provisions should be made to easily allow future updates to the data so that new models can be generated as the need arises.

4.0 DISCUSSION.

DISCUSSION. The Rouge Project is intended to evaluate each of the various sources of wet weather pollution and implement feasible remedial solutions. The Rouge River suffers from the stress of pollutant loadings from various sources. A large variety of continuous point sources have been eliminated through the issuance and enforcement of NPDES permits for municipal and industrial process wastewater dischargers. However, the river continues to suffer from the pollution associated with wet weather flow.

Before October 1,1992, federal requirements stated that discharges composed exclusively of stormwater did not require an NPDES permit unless: 1) a permit was issued for the discharge prior to February 4, 1987; 2) they were industrial discharges; 3) they were discharging from a large[2] municipal separate storm sewer system; 4) They were discharged from a medium[3] municipal separate storm sewer system; or 5) a Director or EPA regional administrator determines that a significant degradation of water quality would result from the discharge. Permits are required for all large and medium-sized separate storm sewer systems. The Director may issue distinct permits for appropriate discharges or he/she may issue a system-wide permit covering all outfalls from a municipal separate storm sewer system.

Outfall inventories are useful tools to identify the quantity and location of outfalls within communities, but the source of these outfalls may not always be clear. Sound conduction can be used to determine whether an outfall is connected to a storm sewer manhole, but it does not determine what may be connected further upstream in the sewer, or whether the outfall is a combined sewer overflow. There are always outfalls to which a source cannot be determined. Foundation drains, roof drains, lawn tile drains or illegal septic drains do not have any ground level structures that would help field crews to determine what they are or where they are coming from. Part of performing an outfall inventory should include finding out who owns and maintains the individual outfalls. This process is important to investigate if there is damage to report, then it can be reported to the proper individuals.

When performing outfall inventories, portable GPS units provide the easiest method of determining the position of the outfalls in the field. Field crews can simply walk and find the outfalls without having to traverse from a benchmark. GPS units are compact and light, easy to operate and allow field personnel to easily pass through areas of dense vegetation where a total station and tripod would be cumbersome. The major disadvantage of the GPS survey is the cost of the equipment. Total station traverse surveys are expensive, time consuming and provide accuracy beyond what is required, and therefore is not the best option for an outfall inventory. For communities with limited budgets, and topographical map estimating procedure may be the best way to determine the position of outfalls. It is the most

[2] A large sewer system is considered to be one located in an incorporated place with a population greater than 250,000 as determined by the latest Census. A regional Director has the authority to deem a separate sewer system to be large based on other site specific criteria in the area.

[3] A medium separate sewer system is considered to be one located in an incorporated place with a population between 100,000 and 250,000 as determined by the latest Census. A regional Director has the authority to deem a separate sewer system to be medium based on other site specific criteria in the area.

inexpensive alternative and provides results that are acceptable for the purpose of an outfall inventory.

In the future, communities may be required to perform outfall inventories to obtain the necessary information required for NPDES permits for stormwater. Specific outfall information will be required for model calculations and planning and management of a watershed. These outfall inventory guidelines are intended to be used as a tool to help communities perform their own outfall inventories and compile data to establish their own GIS database. Once information is entered into a GIS database it can be easily manipulated or updated to help manage stormwater discharges. GIS databases are excellent planning tools, because they allow the integration of different types of information to be overlaid and projected onto one another. This process allows the user to make decisions and consider all of the effects which may be felt by a community or watershed. GIS is an ideal usage for information concerning water quality because it allows the user, or in this case the community to ask "what if"?, and see the answer instantly without negatively affecting the watershed. GIS is not the only database management tool available, but it provides the easiest means of viewing data in relation to geographic location. Outfall inventories are not only an important means of collecting outfall information, but survey crews can also gather valuable aesthetic data which helps to identify problem points in the river. With this information, clean up crews can move more efficiently and hazardous wastes such as drums that are discarded by the river can be removed.

5.0 REFERENCES.

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APPENDIX A
Acronyms

Appendix A
ACRONYMS

CSO	Combined Sewer Overflow
DEQ	Department of Environmental Transportation
DOT	Department of Transportation
ETI	Electronic Tacheometer Instrument
GIS	Geographic Information System
GPS	Global Positioning System
PDOP	Positional Dilution of Precision
RAP	Remedial Action Plan
RPO	Wayne County Rouge Program Office
USGS	United States Geographic Survey
WCDOE	Wayne County Department of Environment

APPENDIX B
Equipment List

Appendix B
EQUIPMENT LIST

Bell Branch/Tarabusi Creek Subwatershed Survey
August through December, 1996

Two-Way Portable Radios
35mm Camera
Film - 24 and 36 - Exposure 35mm, 200 ISO
Conductivity, Temperature, pH meter
Clip Boards (2)
Compasses (2)
100 foot fiberglass tape
16 foot steel tape measure
Spray Paint
Backpacks (2)
Steel Surveyor's Chaining Pins
Chest Waders (2)
GPS Survey Forms
Field Observation Worksheets - River Aesthetics
Water Quality Alert Checklists
Sledge Hammer
Pocket Knife
Orange Fluorescent Vests
Rain Ponchos
Magellan Pro Mark X Portable GPS Unit
Magellan Multi-Path Resistance Sub Meter Antenna w/ Tri-Pod
First Aid Kit
Maps - Various USGS and Quadrangle Maps
Machete
AA Rechargeable Batteries (12)
Nickel Cadmium Battery Chargers (2)
Batteries - Alkaline
Bug Repellent

APPENDIX C
Sample GPS Survey Sheet

Appendix C

SAMPLE GPS SURVEY SHEET

SITE ID:__________________________ **CREW INITIALS:** 1.__________

DATE:___________________________ 2.__________

PHOTOGRAPH #:_________________ 3.__________

PHOTO ROLL #:__________________

LOCATION:

STREAM:____

CITY:____

ADDRESS (if possible):______________________________

GPS LATITUDE:___________________________________

GPS LONGITUDE:__________________________________

OUTFALL CONDUIT INFORMATION:

SHAPE: circular elliptical rectangular

SIZE: diameter:_____________

width:_______________

height:______________

MATERIAL: PVC iron steel concrete clay tiles other:______________

OUTFALL TYPE: CS outfall SS outfall miscellaneous

tributary landfill/dump

DAMAGE TO OUTFALL STRUCTURE: none cracking flaking chipping

paint peeling metal corrosion

OUTFALL CONDITION:

ACTIVE DISCHARGE: yes no

ESTIMATED FLOW RATE: none slow moderate fast

ODOR: none sewage rotten egg gas oil other:_________

OUTFALL CONDITION (CONTINUED)

VISUAL APPEARANCE: clear muddy black grey other:_________

FLOATABLES: None petroleum sheen sewage other:__________

DEPOSITS/STAINS: none sediment oily other:__________________

STREAM CONDITIONS

COLOR: clear green black other:__________

ODOR: none sewage rotten egg oily other:__________

VEGETATION:

Outfall Side: brush bare soil trees weeds debris other:__________

Opposite Side of Outfall: brush bare soil trees weeds debris other__________

pH:

TEMPERATURE (^{0}C):

CONDUCTIVITY:

REMARKS:

APPENDIX D
Sample Field Observations Worksheet

Appendix D

SAMPLE FIELD OBSERVATIONS WORKSHEET
RIVER AESTHETICS

Date:________________ Site/Station ID:__________

Time:________________ Crew:__________

Weather: Rain Today__________ Clear_________

Rain Yesterday_______ Cloudy________

Other Comments:____

Depth of Stream:_________________

Water Clarity		Water Color	
Clear	_____	Clear_______	Brown:
Slightly Turbid	_____	Green_______	Light_______
Moderately Turbid	_____	Gray_______	Medium_______
Highly Turbid	_____	Black_______	Dark_______
Opaque	_____	Milky/White_______	

ODOR		VISIBLE DEBRIS/OBVIOUS POLLUTION	
None/Natural		None_____	Natural_____
Musty:			(leaves, limbs, weeds)
Faint_____	Strong_____	Foam_____	Oil Film_____
Sewage/Fishy:		Trash:	
Faint_____	Strong_____	Floating_____	Fixed_____
Anaerobic/Septic:		Sewage Solids:	
Faint_____	Strong_____	Floating_____	Fixed_____
		Floating Green Scum_____	

ADDITIONAL COMMENTS/OBSERVATIONS:

____

____

APPENDIX E
Sample Spreadsheets and Data

Appendix E

SAMPLE SPREADSHEETS AND DATA

Sample River Aesthetics Spreadsheet and Data

SURVEY DATA						OUTFALL CONDITIONS					EFFLUENT QUALITY			STREAM CONDITIONS						
						Flow		Visual				Temp	Conduct.			Water		Visible	Outfall Bank	Opposite Bank
Site ID	Stream	City	Date	Time	Weather	Rate	Odor	Appear.	Floatables	Deposits	pH	(F)	(uS)	Depth	Turbidity	Color	Odor	Debris	Conditions	Conditions
U2008101	Bell Branch	Redford Twp.	8 -15-96	12:00 PM	Rain (w/i 24), Partly Cloudy	None	None	Muddy	None	Sediment	NA	NA	NA	18"	Moderate	Green	None	Natural, Fixed trash	Brush, Bare soil, Trees	Brush, Bare soil, Trees
U2008102	Bell Branch	Redford Twp.	8-15-96	03:00 PM	Rain (w/i 24), Partly Cloudy	None	None	NA	None	None	NA	NA	NA	10"	Clear	Lt. Brown	None	Natural, Fixed & Floating trash	Brush, Bare soil, Trees	Brush, Bare soil, Trees

Sample GPS Survey Spreadsheet Data

SURVEY DATA							LOCATION			OUTFALL CONDUIT INFORMATION								OUTFALL CONDITIONS					EFFLUENT QUALITY		
Site					Photo	Roll						Measured	Map	Map			Outfalls	Flow		Visual				Temp	Conduct.
ID	Stream	Date	Latitude	Longitude	#	#	City	Address	Bank	Type	Shape	Size	Size	Source	Material	Damage	< 6"	Rate	Odor	Appear.	Floatables	Deposits	pH	(F)	(uS)
U2008101	Bell Branch	8 -15-96			1	1	Redford Twp.	Downstream of Graham & Sarasota	Right		Circular	24"			Steel	Corrode	(2) 2"	None	None	Muddy	None	Sediment	NA	NA	NA
U2008102	Bell Branch	8-15-96			2	1	Redford Twp.	Rossand Sarasota	Left		Circular	18"			Steel	Cracks	NA	None	None	NA	None	None	NA	NA	NA