

# **“SHERLOCKS OF STORMWATER” EFFECTIVE INVESTIGATION TECHNIQUES FOR ILLICIT CONNECTION AND DISCHARGE DETECTION**

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## **ABSTRACT**

“Come, Watson, Come! The Game is afoot!...” (Doyle, 1930) Wayne County has operated an Illicit Connection and Discharge Elimination Program for over 15 years. Its staff has gained valuable investigative expertise by experimenting with many different methods, committing lots of trial and error, and having a little bit of luck. Investigating for illicit discharges in the field is very similar to Holmes and Watson solving a case - it requires a mix of science, detection, deduction, and persistence.

This paper presents investigation techniques used effectively to identify illicit connections and discharges. These techniques are: Identifying priority areas (i.e. “hot spots”), outfall survey, facility dye testing, televising sewer systems, intensive water sampling, smoke testing, and other creative means. Each technique, its advantages and disadvantages, and the best application for each method are described in detail.

In 1999, the Illicit Connection Discharge Elimination Training Program was created and implemented by the Wayne County Department of Environment, Watershed Management Division (WCDOE-WMD). The program was developed to provide training for local and regional governments responsible for locating and eliminating illicit discharges to surface waters. Wayne County determined that such a program is an effective means of transferring technology to others. The key goals of the training program are: Sharing our expertise with other local units of government involved in stormwater management and collaborating efforts to reduce improper discharges to surface water.

The Wayne County Training Program is consistent with the Illicit Discharge Elimination Plan (IDEP) requirements of the Michigan Voluntary Storm Water Permit (MIG6100000) and the EPA Phase II Stormwater Permit Regulations. The training program consists of five modules and two specialty training sessions. The modules are: Overview, Basic Investigations, Advanced Investigations, Construction Related Illicit Discharges, Combined Basic/Advanced Investigations and two specialty training sessions. The specialty training sessions are titled “Recognizing and Reporting Illicit Discharges” and “Illicit Discharge Investigation Exercise.” Nearly 800 people, representing various local units of government, attended the training sessions through September 23, 2002. As a result of these training efforts, 82 illicit discharges were eliminated, preventing an estimated 3.5 million gallons/year of polluted water from entering Michigan surface waters. Wayne County will explain its experiences and those of other agencies with selected investigative methods. A case study based on an actual investigation exemplifying how some of the techniques are used in the field is presented.

The “Sherlocks of Stormwater” will assist others needing to prepare and implement an Illicit Discharge Elimination Plan.

## **Introduction**

“Come, Watson, Come! The Game’s afoot!’ ....” (Doyle, 1930) Wayne County has operated an Illicit Connection and Discharge Elimination Program for over 15 years. Its staff gained valuable investigative expertise by experimenting with many different methods, committing lots of trial and error, and having a little bit of luck. Investigating for illicit discharges in the field is very similar to Holmes and Watson solving a case - it needs a mix of persistence, science, detection, and deduction. A brief overview of the Rouge River National Wet Weather Demonstration Project, geography of the Rouge River Watershed and illicit connection and illicit discharge definitions are provided. Wayne County’s Illicit Discharge Elimination Program, training program, and the reasons why they are necessary is introduced.

The Illicit Discharge Elimination Plan (IDEP) Training curriculum, formulation and content are outlined. The primary focus of this paper is introducing the variety of techniques used to identify illicit connections and discharges used by Wayne County and other local agencies. Based on Wayne County’s experience in IDEP investigations, each technique is described and the advantages and disadvantages to each method listed. A case study illustrates how the different techniques are used in field investigations. In conclusion, Wayne County presents the successes achieved by the implementation of its IDEP Plan and IDEP Training Program.

## **Rouge River Project Overview**

The Rouge River is located in the southeast region of lower Michigan. It encompasses an area of about 467 square miles and is highly urbanized. Approximately 1.5 million residents of 48 municipalities live and work in the watershed.

The Rouge River is tributary of the Detroit River, a part of the southeast Michigan area identified as an “area of concern”, by the International Joint Commission (IJC). In response to this bleak assessment and demands of local residents for improved water quality, the State of Michigan created a series of Remedial Action Plans (RAP) to address specific sources of pollution of the state surface waters.

The Rouge River Remedial Action Plan (RAP) is an ambitious 20-year plan to clean up and restore the river to a fishable and swimmable state. The RAP focused on sources of pollution such as Combined Sewer Overflows (CSOs), Industrial Pollutant Discharges, and Non-Point Source Pollution. The RAP contains a recommendation that “programs to eliminate improper connections to storm drains should be implemented...” (SEMCOG, 1988). In 1987, Wayne County developed and implemented a program for reducing pollutant loadings to the Rouge River. This program detects and eliminates illicit discharges and/or improper/illegal connections to Wayne County storm sewers and surface waters. An illicit connection is defined as a pipe intended for a sanitary sewer that is directly connected to, or indirectly drains to a storm sewer system or surface water body. An illicit discharge is the indirect migration of pollutants by storm water to a surface water body. Examples of illicit discharges are: failing on-site sewage disposal systems, spilling or dumping of materials, and illicit connections.

In November 1999, the U.S. Environmental Protection Agency (USEPA) promulgated Phase II of the National Pollutant Discharge Elimination System (NPDES) storm water regulations, which affects virtually all communities in southeast Michigan, including Wayne County. Wayne County, through its Rouge River National Wet Weather Demonstration Project (Rouge Project) assisted the Michigan Department of Environmental Quality (MDEQ) in the development of a new watershed-based General Permit for

municipal storm water discharges (General Permit). The MDEQ General Permit was approved by EPA as an option available to local communities and other public agencies to comply with the requirements of the Phase II federal NPDES storm water regulations.

One of the requirements of the federal Phase II NPDES storm water regulations and the MDEQ General Permit is to develop, implement, and enforce a program to eliminate improper connections to the storm sewer system and other improper discharges to surface waters. During 1999, over 45 communities and agencies in the Rouge River watershed, including Wayne County, have received coverage under the MDEQ storm water General Permit and have initiated the illicit discharge elimination program (IDEP) requirements of the permit. Wayne County recognized this as an opportunity to share our considerable expertise in illicit discharge investigations with others.

The Wayne County Illicit Connection/Discharge Elimination Plan (IDEP) Training Program was created and implemented in 1999-2000. The training program was developed to provide training for county and local community staff responsible for locating and eliminating illicit discharges to surface waters, as required under the federal National Pollutant Discharge Elimination System (NPDES) regulations for municipal storm water discharges. The training program consists of five modules and two specialty training sessions. The modules are: Overview, Basic Investigations, Advanced Investigations, Construction Related Illicit Discharges, and Combined Basic/Advanced Investigations. The Specialty Training Sessions are entitled “Recognizing and Reporting Illicit Discharges” and “Illicit Discharges Investigation Exercise”.

This paper provides a basic overview of the Advanced Investigations IDEP Training Module. It introduces the techniques used to effectively identify illicit connections.

## **Finding the Problem Area: “In Quest Of A Solution”**

Where to begin an investigation for illicit discharges?

Wayne County sewer sleuths begin compiling information on the targeted area. Information and data can be gathered from many different sources; outfall surveys, referrals from other departments, known areas of concern, review of existing water quality data, and complaint response. All this data is reviewed and compared with existing data to determine if potential problems (i.e., “hot spots”) exist. The goal of identifying “hot spots” is to isolate the area where the problem exists and then locate the pollutant source. Specifying the problem allows the investigator to select the type of parameters for field measurement. For example, if sewage is the suspect problem, sampling for bacteria is useful in verification. Once the problem is identified, additional sampling is performed, upstream and downstream of the “hot spot.” Data from the sampling events is compared and utilized to determine the area where the values are the highest. Once the suspect pollutant is identified, sampling may be repeated as necessary to narrow down the geographical area to a manageable size.

Outfall survey is also used as a screening tool to define investigation areas. It involves field observations of the stream channel and conditions at outfall locations. If suspicious discharges or signs of past discharges are seen, physical and chemical parameters are selected to identify the type of discharge. If observations at an outfall triggers an investigation, tracking the suspect source moves upstream from the outfall along the storm sewer system. Storm sewer manholes are opened and visual and physical observations for signs of suspicious discharges are made. This process continues upstream and along sewer laterals until signs of a

discharge are found. Once this area is isolated, the investigator can choose from the variety of techniques to help track the source.

## **IDEP Tracking Techniques: “The Science of Deduction”**

Like Sherlock Holmes, modern day IDEP detectives utilize their skills and knowledge to solve their cases. However, there are techniques available to make detection of illicit discharges and connections more than just deduction. There are four techniques commonly used by Wayne County and other local governmental agencies in southeast Michigan when searching for sources of illicit discharges. Each of the techniques has its advantages and disadvantages and there’s no one “right” way. In some cases, a combination of methods may be used in quest of a solution.

## **Investigative Methods: “The Sign of Four”**

### ***Intensive Sampling***

Intensive sampling is defined as one of the two following situations: 1) many samples collected at many locations, and 2) many samples collected at the same location over a specific period of time. This method is effective if intermittent flows in a storm sewer or when a source is active in hours where routine sampling is ineffective. For example, if a suspected source is a residence where persons are not home during the day, peak flows typically occur during early morning or early evening.

Taking many samples at many locations is useful when isolating the area of a suspected illicit discharge, especially when the survey area is large. The sample data can help narrow down an area where a problem may exist, by comparing sampling data from different locations along the storm sewer line or stream channel. Degree of concentration, or presence and/or absence of a pollutant demonstrated in the data, can lead an investigator to an area of the potential source.

Intensive sampling techniques are good for isolating source areas for investigation, completing field data gaps present between sampling events, off-hour sampling events (because staffing is unnecessary for automatic sample collection), and in residential areas where intermittent flows are common.

There are also several disadvantages to the method. For example, it does not pinpoint the pollutant source exactly and data variances may exist which makes it difficult to establish trends. Also, limited holding times for certain parameters make it difficult to time sampling sessions and collecting many samples may be expensive and require laboratory analysis and holding times. Finally, placing flow meters or automatic samplers at a site may involve confined space entry, which requires additional training and equipment.

### ***Dye Testing***

Dye testing is an investigative technique that involves placing tracing dyes in a sewer system to determine path of the flow. This method is effective for determining if illicit connections exist in a facility, or if there are interconnections between sewer systems.

Wayne County extensively uses dye testing for illicit connection detection. When performing a dye test, field staff walk through the facility to determine where the plumbing fixtures are and observe interior and

exterior housekeeping practices. A dye testing plan is prepared and tracing dye is placed into plumbing fixtures. The dye is flushed through the system with running water. A person is stationed at the sanitary manhole down stream of the tested facility and alerts the team member inside the building when the dye is observed in the sanitary sewer. Alternate dye colors are used so multiple fixtures can be tested simultaneously. If dye is not observed in the sanitary sewer, the dye test is repeated until it is confirmed in the sanitary sewer or in a storm sewer, or surface water body. If the dye from a fixture inside the building is discovered in a location other than a sanitary sewer, it is an illicit connection.

Advantages of using dye testing for illicit connection detection are that dye testing is inexpensive, relatively easy to do, points to a specific source, and does not require confined space entry.

Disadvantages to dye testing are that it may be difficult to see the dye in high-flow or turbid conditions, it is time consuming in low flows, and entering a facility is necessary in order to conduct the test.

### ***Televising***

A remote camera with a video recorder is another means to search for illicit connections and discharges. The self propelled camera is placed into the sewer line and the operator can view live footage of the sewer line, so the condition of the sewer line and evidence of illicit taps can be seen. Televising is an effective technique because it views active taps, provides a record of observations, and is the only way to observe pipes between manholes. It can, however, be expensive, ineffective in determining if inactive taps convey illicit discharges, time-consuming to interpret results, and is impractical in water-filled or obstructed sewers.

### ***Other Techniques***

There are other methods various agencies use to search for illicit connections. Some municipalities use smoke testing of storm sewers. A non-toxic smoke is introduced into a storm sewer and an illicit tap is suspected if the smoke is observed in a sewer vent from a building. Some communities have sent stout-hearted workers to survey storm sewers big enough to walk into in order to do “up-close” illicit discharge surveys. Searching for illicit discharges is part art and part science. Imaginative ways are created to do investigations often because no specific equipment exists, or because of cost-effectiveness. Ingenuity leads to effective methods like placing a rope with oil-absorbent pads tied at measured intervals into a storm sewer manhole located upstream of a facility where leaky underground oil storage tank was suspected. The rope was pulled out of the sewer, and measured off to where oil was present. The distance was walked off on the surface and the investigators ended up in front of the suspect facility. When presented with the evidence, the owner admitted to the problem and repaired the leaky tank.

### **A Case Study: “Sherlock Holmes Gives a Demonstration”**

“A Study in Scarlet” – Restoring Rouge River Recreational Opportunities

A goal of Wayne County is to return canoeing to selected portions of the Rouge River. To support that goal, water quality must meet the State of Michigan bathing beach standards for *Escherichia coliform* (*E. coli*). This standard is the daily geometric mean of three samples must be less than 300 cfu/100ml of water. The geometric mean of five sample events collected over 30 days must be less than 300 cfu/100mls of water.

Review of available data and additional sampling found two impoundments, and a mile of river between them, safe for canoeing during dry weather. Canoeing on the upstream impoundment became a reality and received an overwhelmingly positive public response. Based on the success upstream, a second goal to extend canoeing downstream of the second impoundment was set. Sampling of this stream section found that *E. coli* levels were very high below the dam of the second impoundment. A nine-foot wide storm sewer outfall discharged at this location, making it a prime target for investigations. Wayne County sewer sleuths were assigned to the case and set out to unravel the matter.

The sewer drainage area is approximately 157 acres, contains over 5.5 miles of enclosed storm sewer and over 350 manholes. The storm sewer has one main line with many connecting branches. The land use in this area is primarily residential.

Samples were collected along the main line at a variety of locations. A branch coming into the main line near the outfall had higher *E. coli* levels than the others. Confirming sampling found very high levels of *E. coli*, indicating a significant bacteria source upstream at this suspected branch. After using a very extensive sample regime designed to narrow the search area, efforts switched to sampling the main line at a variety of locations to isolate the branch that contained the source. One ¼ mile long branch line had significant levels of *E. coli*. Storm sewers from adjacent branches with similar land use had extremely low levels of *E. coli*.

Sampling up the line revealed increasing levels of *E. coli*. Results at one manhole were over 160,000 cfu/100ml. On the basis of this result, it was suspected that this short section of sewer line contained a problem. This suspicion, and supporting data, was shared with the City representatives. During this meeting, the County learned that a storm sewer separation project occurred in this area several years ago. A sewer line or a tap may be misconnected, discharging sewage into the storm sewer and causing the bacteria problem. The City and the County agreed on a plan of action to find the source of the *E. coli*. The City agreed to televise the storm sewers. At one location on the sewer line, the camera dipped below the water. Otherwise, no taps were found. The City agreed to dye test the homes along the sewer line for illicit connections. The County drafted a letter and provided the City educational materials for mailing to the homeowners. Dye testing did not uncover any illicit connections.

Subsequent sampling of the sewer line found very low levels of *E. coli*. Repeated sampling up to two years later found extremely low *E. coli* levels. The problem seemed to disappear. What happened? The theory is that someone in the neighborhood owned a recreational vehicle and discharged its holding tank into the storm sewer or performed some other inappropriate action. With all of the activity in the neighborhood, the County and City staff interacting with the residents, and the public education mailing, the culprit realized their actions caused a problem and stopped. This is an investigation where a blend of intensive sampling, sewer televising, dye testing and public education techniques were used in attempting to resolve the problem.

## **Success of Wayne County's IDEP and Training Program**

From October 1987, when the Illicit Discharge Elimination Plan was implemented, through December 2001, Wayne County inspected 4,887 commercial, retail and industrial facilities for illicit connections. During these inspections, field staff discovered 1,243 illicit connections at 326 facilities. Finding and eliminating these illicit connections prevents and estimated 18 million gallons/year of polluted water and 4,600

pounds/year of biological oxygen demand (BOD) and 16,000 pounds/year of total suspended solids (TSS) from entering Wayne County surface waters.

Nearly 800 people, representing various agencies and communities throughout Michigan, and two neighboring states, attended training sessions conducted by the County through September 30, 2002. Ninety-eight percent of training session participants surveyed encourage persons with similar responsibilities to attend the training course(s). One participant commented “This is the best training session I have had in 20 years.” The information these individuals gained from attending the training session helped them in creating their own IDEPs. Successful programs include those implemented by neighboring counties. Eighty-two illicit discharges were identified by IDEP investigations performed in the Counties of Oakland, Washtenaw, and Wayne. The pollutant load into Michigan’s surface waters from these discharges is estimated to be 3.5 million gal/year of polluted water, 7,200 lbs/yr BOD, and 25,000 lbs/yr TSS.

### **Conclusion: “Light In The Darkness”**

There is no “cookbook” or standard operating procedure for investigating illicit discharges and connections. A combination of using the techniques presented here and ingenuity, plus a little luck, will go far in the “Quest of a Solution.”

“Eliminate all other factors, and the one which remains must be the truth.” – Sherlock Holmes (Doyle, 1930).

Happy Hunting!

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Conan Doyle, Sir Arthur "*The Complete Casebook of Sherlock Holmes*", Double Day, 1930.

Note: All sections with titles in quotations are either titles of Sir Arthur Conan Doyle's short stores or novels.

*Remedial Action Plan for the Rouge River Basin*, (SEMCOG), 1988)