Appendix G

Illicit Discharge Elimination Program (IDEP)

Protocol Manual

Illicit Discharge Elimination Program

Field Protocol Manual

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AECOM

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Valid Through April 1, 2025

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Introduction

Illicit Discharge Elimination Program (IDEP) Permit Requirements

The Michigan Department of Transportation (MDOT) operates under a statewide Phase II Municipal Separate Storm Sewer System (MS4) permit (Permit No. MI0057364) from the Michigan Department of Environment, Great Lakes, and Energy (EGLE). MDOT must implement the IDEP to the maximum extent practicable and will thoroughly investigate any suspected illicit connection or discharge within its ROW. The following minimum requirements are included in the permit for an IDEP:

1. An available, up-to-date storm sewer system map identifying the following: the storm sewer system, location of all outfalls and points of discharge the permittee owns or operates in the regulated area, and the names and location of all surface waters of the state that receive discharges from the permittee's MS4.

2. A plan to detect and eliminate non-stormwater discharges to the permittee's MS4, including illegal dumping and spills. The plan includes the following:

   Procedures for identifying priority areas for field observations and for conducting field observations, field screening, and source investigations. The permittee shall conduct a field observation in accordance with the procedure during dry weather at least once during the term of the permit.

3. An employee training program that includes:

   Training on techniques for identifying illicit discharges and connections, including field observations, field screening, and source investigations; Training on procedures for reporting, responding to, and eliminating an illicit discharge or connection and the proper enforcement response; and

   A schedule and requirement for training at least once during the term of the permit for existing staff and within the first year of hire for new staff.

4. A procedure for IDEP evaluation and determining the overall effectiveness of IDEP.

What is a Point Source Discharge?

A Point Source Discharge (PSD) means a discharge from any discernible, confined, discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, or rolling stock where the runoff from the site is discharged to waters of the state.

What is a Point of Discharge?

A Point of Discharge (POD) is the location of a point source discharge where stormwater is discharged directly into a non-MDOT separate storm sewer system.

What is an Outfall?

An outfall is the location at which a point source discharge first enters a surface water of the state.

What is an Illicit Connection?

An illicit connection means a physical connection to MDOT's MS4 that is not authorized or permitted by MDOT.

What is an Illicit Discharge?

An illicit discharge means any discharge to, or seepage into, MDOT's MS4 that is not composed entirely of stormwater or uncontaminated groundwater. Examples of illicit discharges include non-stormwater discharges through pipes or other physical connections; dumping of motor vehicle fluids, household hazardous wastes, domestic animal wastes or litter; collection and intentional dumping of grass clippings or leaf litter; or unauthorized discharges of sewage, industrial waste, restaurant wastes, or any other non-stormwater waste directly into a separate storm sewer system.

What are Acceptable Non-Stormwater Discharges?

Non-stormwater discharges to a MS4 may be allowed by the permittee unless they are identified as significant contributors of pollutants to the regulated stormwater drainage system. Acceptable non-stormwater discharges include:

1) Water line flushing
2) Landscape irrigation runoff
3) Diverted stream flows
4) Rising groundwaters
5) Uncontaminated groundwater infiltration
6) Pumped groundwater (except for groundwater cleanups not specifically authorized by NPDES permits)
7) Discharges from potable water sources
8) Foundation drains
9) Air conditioning condensate
10) Irrigation water
11) Springs
12) Water from crawl space pumps
13) Footing drains
14) Lawn watering runoff
15) Water from non-commercial car washing
16) Flows from riparian habitats and wetlands
17) Residential swimming pool water and other dechlorinated swimming pool water providing any filter backwash water that is present is treated
18) Residual street wash waters
19) Discharges or flows from emergency firefighting activities

NOTE: Permits may be required to discharge these non-stormwater discharges to the MDOT drainage system.

Dry Weather Screening Field Work Preparation

The preparation for field work includes three steps, shown in **Figure 1**.

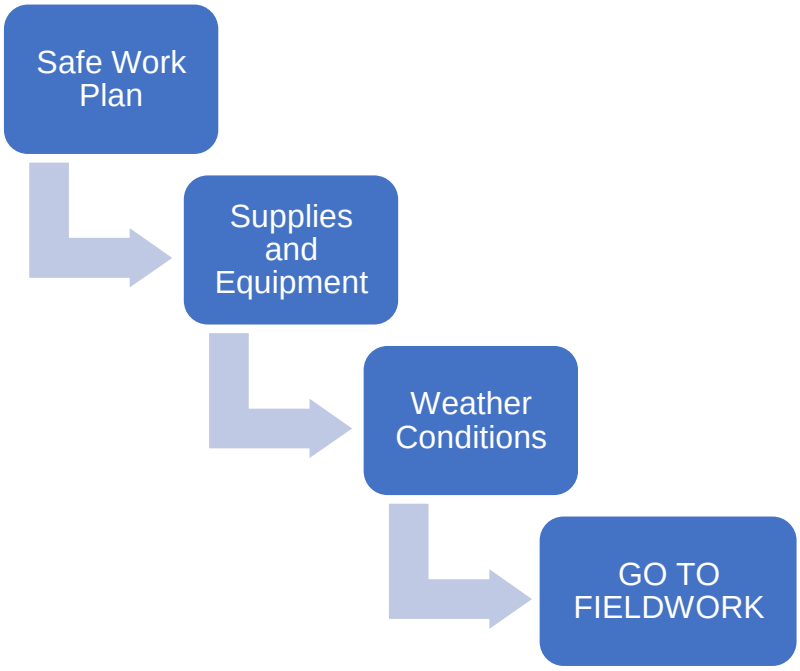


Figure 1. Preparation Flow Chart

Safe Work Plan in the Right of Way

Safety of employees during fieldwork is a top priority. Workers in the MDOT right of way must wear personal protective equipment including hard hats, eye protection, high-visibility safety apparel (ANSI class 2 minimum), and safety footwear,

Working next to and near traffic is one of the largest safety risks to those working in the right of way. Always consider the following concepts while working near traffic:

- Never get complacent or used to working near traffic
- Always pay attention to where you are and where you are walking
- Do not turn your back to traffic
- Never assume motorists see you or are driving safely
- Pay attention to work equipment and operators
- Always have an escape path
- Do not walk side by side

Workers must be protected during water sampling as well. Some sampling requires the use of acids to preserve samples. All best safety practices must be followed when handling these materials.

Sampling must be performed in a manner that eliminates or reduces exposure to confined spaces. MDOT has a confined space procedure to ensure workers are protected when working in confined spaces. The procedure follows MIOSHA's general industry standard Part 90. Contact the MDOT Safety and Security Administration for additional information. Workers must not enter confined spaces without appropriate training, testing equipment, and safety gear.

Intent of Work Notification

Work conducted on the MDOT right-of-way by non-MDOT employees requires authorization through the Construction Permit System (CPS). No work shall start until an approved notice is emailed to the permittee.

Supplies and Equipment

Inventory supplies and equipment prior to scheduled fieldwork days to allow supply orders to be filled.

Calibrate all equipment according to manufacturer's specifications prior to beginning any field work. Maintain any calibration logs to ensure equipment is functioning properly and providing consistent readings. See Table 1 for a suggested list of supplies and equipment for visiting PSDs.

Weather Conditions

Visit outfalls during periods of dry weather to minimize the change of observing stormwater runoff in the storm sewer system. Dry weather is defined as 72 hours of less than 0.10 inches of total precipitation.

Fieldwork must be planned several days in advance based on the precipitation total and the forecast. This data can be obtained from www.accuweather.com.

Table 1. Example field equipment and supplies list

Traffic Safety

- ☐ Truck with beacon
- ☐ Traffic cones
- ☐ Personal protective equipment
- ☐ Arrow board

Inventory

- ☐ Manhole hook
- ☐ Grade rod
- ☐ Survey tape
- ☐ Folding ruler
- ☐ Sledgehammer
- ☐ Survey wheel
- ☐ Cell phone and charger

Screening

- ☐ Stopwatch
- ☐ Water marking paste
- ☐ Disposable syringes mounted to grade rod with pull string and duct tape
- ☐ Disposable 60 mL syringes
- ☐ pH pen
- ☐ Thermometer
- ☐ Cooler
- ☐ Sample bottles (automated partial chemistry and microbiology)
- ☐ Cleaning supplies

Miscellaneous

- ☐ GPS/GIS data logger
- ☐ Flashlight
- ☐ Mirror (for shining into manholes)
- ☐ Marking paint
- ☐ Drainage system maps
- ☐ Emergency phone numbers
- ☐ Permit to work in MDOT ROW
- ☐ Business cards and work ID
- ☐ Corks, fishing bobbers, etc.
- ☐ Metal detector
- ☐ Shovels
- ☐ Waders
- ☐ Fluorescent dye
- ☐ Vehicle log
- ☐ Accident/incident report form
- ☐ Sunscreen and bug spray
- ☐ Hand sanitizer (waterless)
- ☐ First aid kit

Fieldwork

The preparation for initial site fieldwork is shown in **Figure 2**.

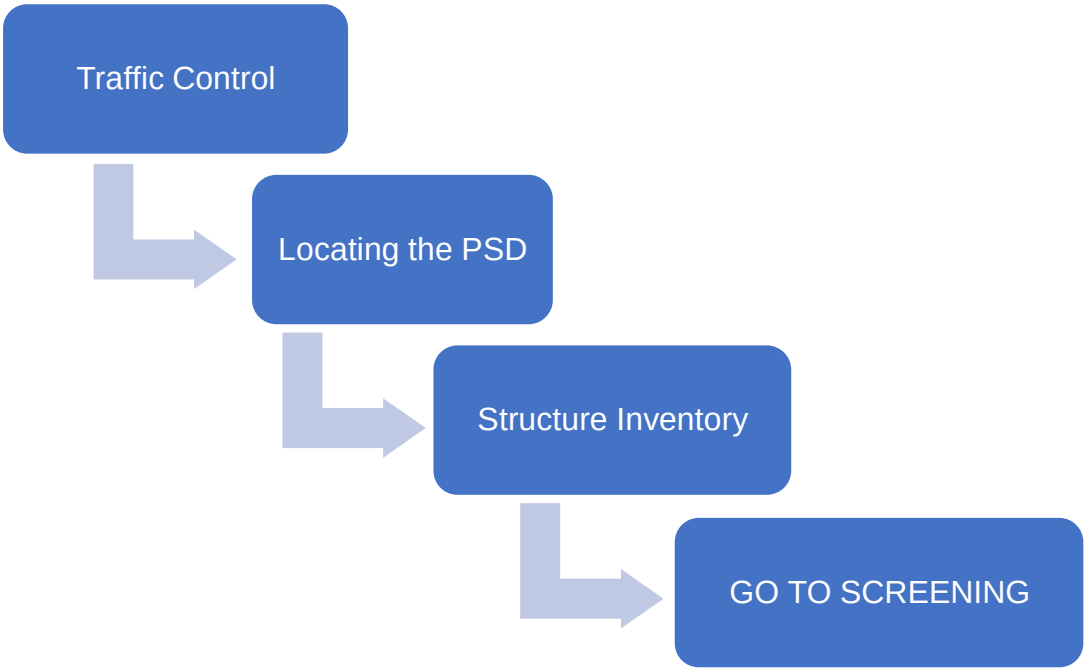


Figure 2. Fieldwork Flow Chart

Traffic Control

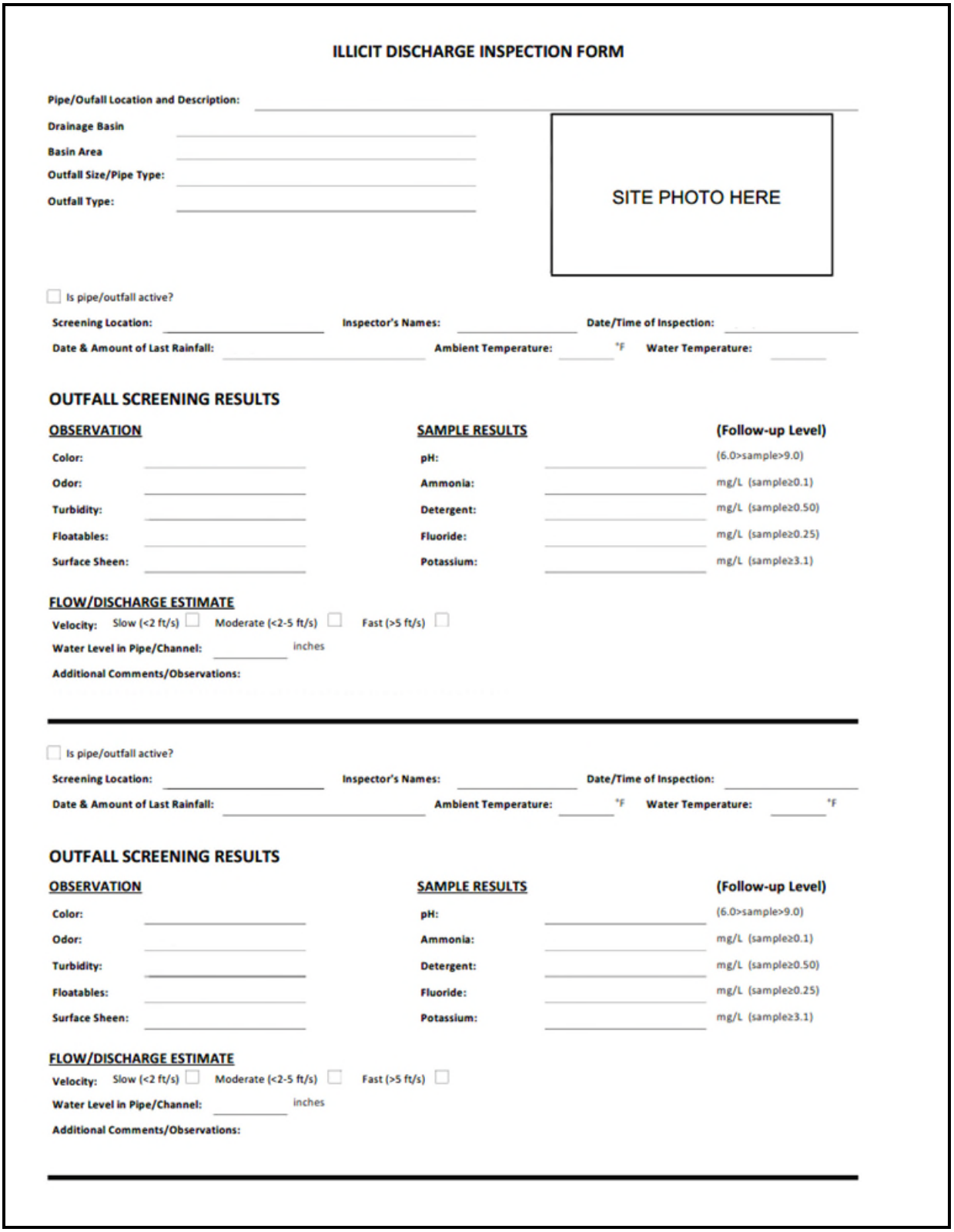
Utilize vehicles with beacons when working on or near the MDOT ROW. Contact the Transportation Service Center (TSC) permitting staff prior to accessing the site when lane closures are required to perform dry weather screenings or IDEP investigations. Set up traffic control devices as required to create a safe working environment. Work required on the MDOT ROW must follow the Michigan Manual of Uniform Traffic Control Devices.

Locating the PSD

Identify the location of the PSD or structure in the field by utilizing MDOT road plans or PSD maps, in conjunction with municipal drainage system maps. If latitude and longitude data is available, a GPS unit may be used to locate the PSD.

Structure Inventory

See Figure 3 for a sample inspection form. Using a GIS data logger is more efficient than a paper form and is highly encouraged. Ensure all known and new outfalls are added to the inventory during field inspections.



ILLICIT DISCHARGE INSPECTION FORM

Pipe/Oufall Location and Description: _____

Drainage Basin _____

Basin Area _____

Outfall Size/Pipe Type: _____

Outfall Type: _____

SITE PHOTO HERE

☐ Is pipe/outfall active?

Screening Location: _____ Inspector's Names: _____ Date/Time of Inspection: _____

Date & Amount of Last Rainfall: _____ Ambient Temperature: _____ °F Water Temperature: _____

OUTFALL SCREENING RESULTS

OBSERVATION		SAMPLE RESULTS		(Follow-up Level)
Color:		pH:		(6.0>sample>9.0)
Odor:		Ammonia:		mg/L (sample≥0.1)
Turbidity:		Detergent:		mg/L (sample≥0.50)
Floatables:		Fluoride:		mg/L (sample≥0.25)
Surface Sheen:		Potassium:		mg/L (sample≥3.1)

FLOW/DISCHARGE ESTIMATE

Velocity: Slow (<2 ft/s) ☐ Moderate (<2-5 ft/s) ☐ Fast (>5 ft/s) ☐

Water Level in Pipe/Channel: _____ inches

Additional Comments/Observations:

☐ Is pipe/outfall active?

Screening Location: _____ Inspector's Names: _____ Date/Time of Inspection: _____

Date & Amount of Last Rainfall: _____ Ambient Temperature: _____ °F Water Temperature: _____ °F

OUTFALL SCREENING RESULTS

OBSERVATION		SAMPLE RESULTS		(Follow-up Level)
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Surface Sheen:		Potassium:		mg/L (sample≥3.1)

FLOW/DISCHARGE ESTIMATE

Velocity: Slow (<2 ft/s) ☐ Moderate (<2-5 ft/s) ☐ Fast (>5 ft/s) ☐

Water Level in Pipe/Channel: _____ inches

Additional Comments/Observations:

Figure 3. Example illicit discharge inspection form

All outfalls investigated must be recorded in the MDOT outfall database. Information about the outfall including the type (pipe or ditch), receiving waterbody name, GPS coordinates, and whether it is an outfall or a point of discharge must be recorded and provided to the Stormwater Program Manager. Record only one inventory per structure. Subsequent visits will not require data collection unless the outfall has been altered.

IDEP Screening

Screening investigations on a PSD or pipe within a structure requires physical observation, calculation of flow rates, and sampling (if necessary).

Screenings may be repeated for structures if the results of previous screening suggest that an illicit connection may be present. In this scenario, a new inventory of the structure is not needed, but a new screening record must be made to show the results from that day's investigation. Record the observations, sample results, and flow measurements. The general process for IDEP screenings is shown in **Figure 4**.

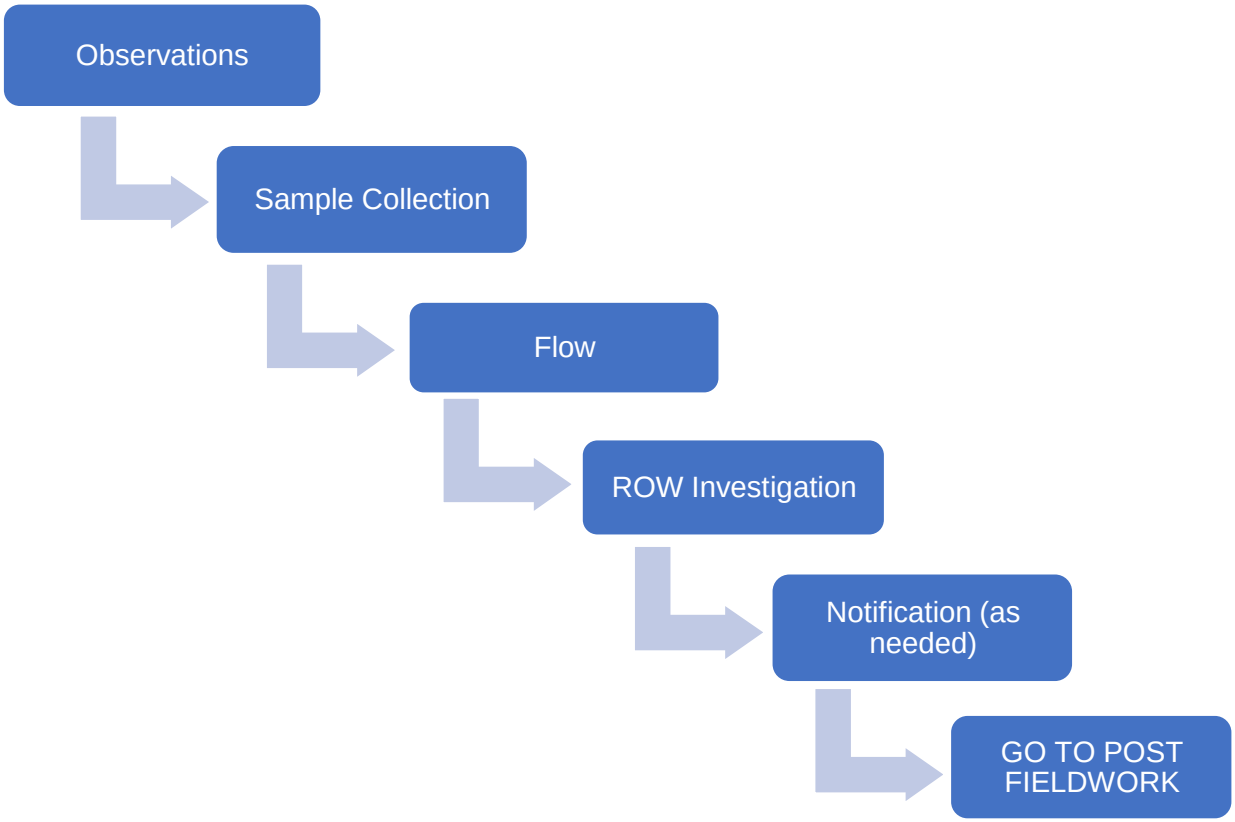


Figure 4. IDEP Screening Flow Chart

Observations

Observation of a PSD or structure condition is a critical component to determining the presence of an illicit connection to the upstream drainage system and is the first step in field screening a site. Below is a list of observations that should be made and recorded every time a structure is visited.

Naturally occurring phenomena such as algae, bacteria, bryozoans, foam, and pollen in surface waters can be confused with an illicit discharge. See the Michigan EGLE Naturally Occurring Phenomena website on how to distinguish between an illicit discharge and naturally occurring phenomena.

Dry Weather Flow

Dry weather flow is flow in the storm sewer system, even though it has not rained in several days, suggests an illicit connection or discharge, and further investigation upstream must be conducted. Dry weather flow may not indicate a problem if the flow is originating from one or more of the non-stormwater discharges listed in the introduction section of this manual. Perform a windshield survey to locate any non-stormwater discharges such as lawn irrigation, car washing, and hydrant flushing that could be the dry weather flow source.

If the initial field screening indicates that no flow is present yet there is evidence of toilet paper, staining, grease deposits, odor, or excessive plant growth, utilize the illicit connection/discharge investigation procedure (Appendix A) to identify the source of the material/odor observed.

Floatables

The occurrence of floatables at an outfall is a strong indicator of an illicit discharge/connection. Floatables can consist of a variety of items including oil sheens, sewage, and sanitary trash, such as toilet paper. If sewage and/or sanitary trash are observed in the storm sewer system, it is an indicator that a sanitary system or septic system is connected.

Odor

Strong chemical or sewage odors in a storm sewer may indicate a potential illicit connection or discharge. If odors are detected, look for other indicators including: floatables, dry weather flow, water color, and/or strains inside the manhole or pipes.

Foam

Foam can be a natural occurrence in streams and lakes, but if the foam is concentrated around a storm sewer PSD, or appears to be originating from a PSD, it is an indication of an illicit connection or discharge in that system.

Other Indicators

Other indicators, which may not be significant by themselves, can provide valuable

additional evidence to the above indicators. These indicators include color, turbidity, the existence of stains or deposits, and the occurrence of excessive vegetation at the discharge point.

Sample Collection

Use prepared sample bottles from laboratories for sampling. Collect water samples for both the chemical parameter tests and the microbiology tests and deliver to a laboratory for analysis. Keep samples refrigerated during storage prior to delivery to the lab. Microbiology tests have a maximum hold time of 24 hours between the time when the sample is collected and when the sample needs to be at the laboratory. **Table 2** summarizes the chemical parameters being tested and corresponding bottle characteristics.

NOTE: MDOT staff may not be able to collect the required samples. The Region IDEP coordinator can contact the Stormwater Program Manager to request assistance from the current stormwater program consultant for sample collection.

Table 2. Sample Parameter Information

Analyze	Test Method	Container	Preservative	Hold Time
Ammonia	EPA 350.1	500 mL plastic	1:1 H_2S0_4 preserved to pH<2	28 days
E. Coli	EPA 340.2/300	100 mL	Thiosulfate	6 hours or as soon as possible
Fluoride	LachatQuick Chem 10-109-12-2-A	500 mL plastic	None	28 days
Surfactant (Detergent)	SM 5540C	250 mL	None	2 days

Note: Sampling for E. Coli is only required when sewage floatables or odors are present.

Dry Weather Flow Sampling

When dry weather flow is observed that can't be immediately attributed to an acceptable non-stormwater discharge, collect a sample of the flow for chemical analysis. Test the samples at an analytical lab for fluoride, ammonia, and detergents. Collect field measurements of temperature and pH for each sample and record. Collect samples prior to flow measurements to ensure undisturbed samples. If the flow stream has a free fall discharge, hold the sample bottle beneath the flow stream to fill the bottle. When sampling in an open channel, manhole, or a location too dangerous to access, use a sterile disposable syringe with a pull string mounted on a grade rod or use a vacuum pump sampler to collect the sample. See Figures 4 and 5 for example sampler set ups.

Follow these steps when taking a sample with a syringe and pull string to ensure proper sampling. Secure a syringe to the end of a grade rod with the tip of the syringe below the end of the rod. Attach a string to the pull section of the syringe and remove the protective cap from the syringe. Lower the grade rod to the sample area to obtain the sample while avoiding contact of the syringe to anything other than the sample area. Do not disturb sediments when collecting the sample. Several attempts may be needed to fill the sample bottles. Cap the bottles between attempts to avoid possible cross contamination.

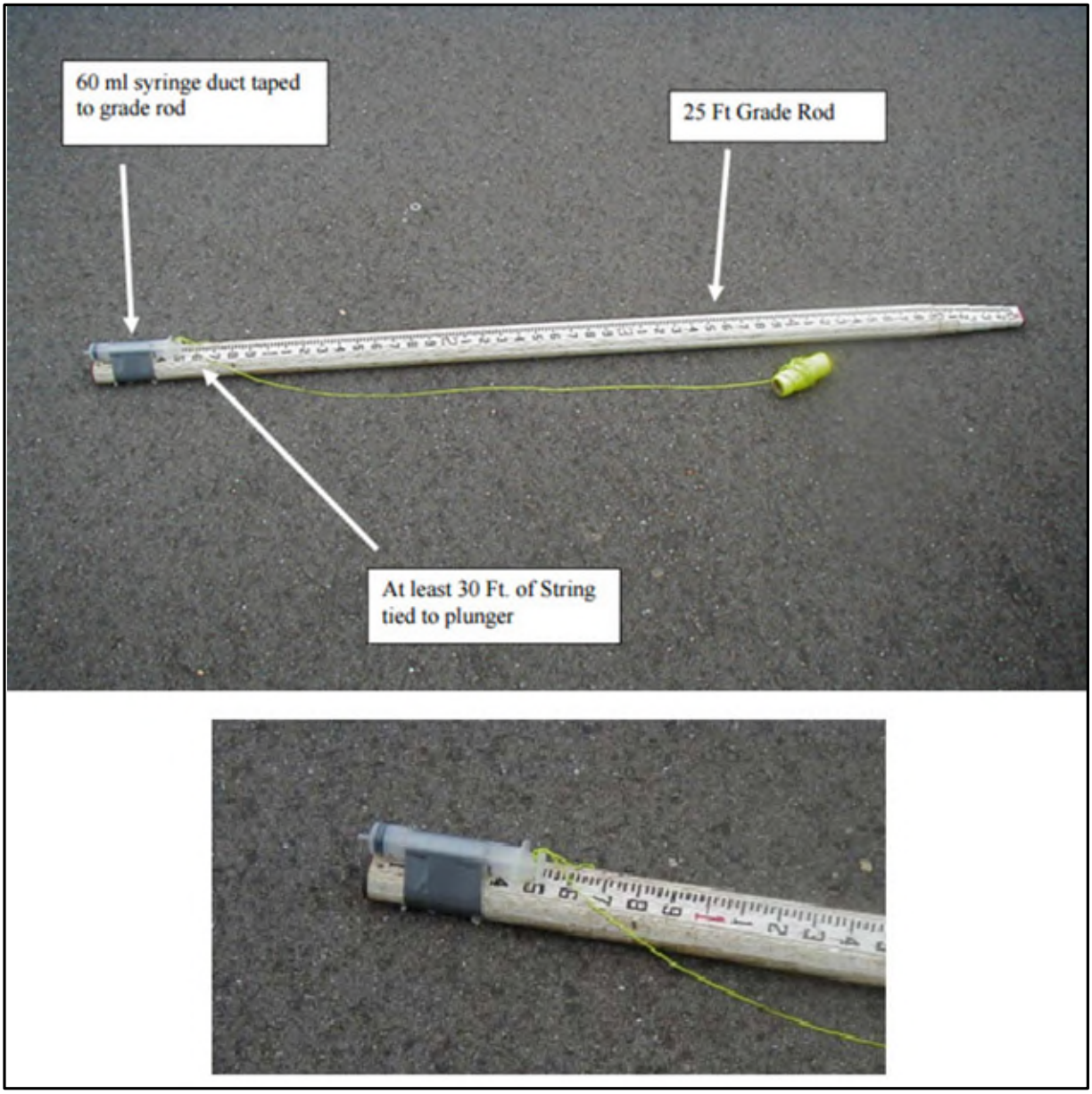


Figure 5. Example grade rod syringe sampler

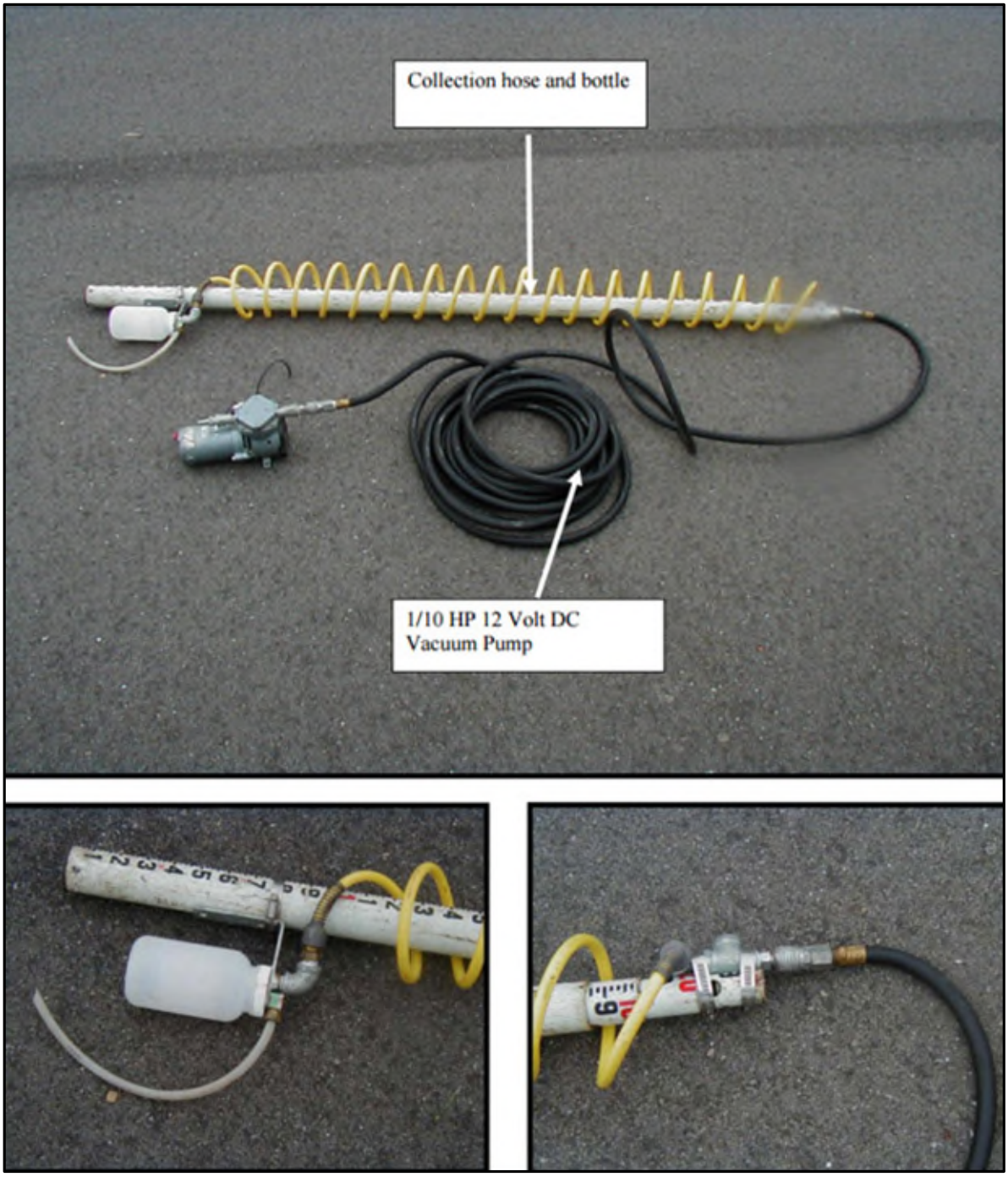


Figure 6. Example vacuum pump sampler

Vacuum pump samplers require a new clean collection bottle to collect each sample. Flush the sampler with dry weather flow from the new sample site prior to removing the contaminated bottle and collecting a new sample. The sampler is considered flushed after

250-500 ml have been collected. Remove and discard the contaminated bottle and replace with a clean sterile bottle. A new sample may be collected for laboratory analysis.

Dry weather flow may not be present at the time of inspection but there may be indicators of a possible illicit discharge/connection. Place a sandbag to block the lower part of the pipe or open channel in question to temporarily store an intermittent dry weather flow. Avoid confined space entries by securing a sandbag to a rope and lower into position. Secure the top of the rope to a manhole step or similar item for easy retrieval. **Leave sandbags in the conduit for a maximum of 1 to 2 days, and never when rain is forecasted**.

Revisit the site within 1 to 2 days looking for signs of intermittent flow, ponded water, or deposits. Conduct further investigation of the stormwater sewer system upstream until the source is isolated. This may involve repeating the sandbag method in upstream structures. Follow the sampling procedures above once the source is isolated. If the source is not identified within the MDOT ROW, follow the procedures listed in Appendix A for notifying appropriate agencies.

Use the above procedure for temporarily storing flows if there appears to be intermittent flow but there are no observations that suggest an illicit connection. Contact the TSC Construction Permit Staff to identify existing drainage connections that may be the source of the flow. Sample any collected flows to ensure they are not illicit. If the source is not identified within the MDOT ROW, follow the procedures listed in Appendix A for notifying appropriate agencies.

Three different types of samples are required for each PSD location where dry weather flow exists. Take the bacteria sample first (if required due to the presence of sanitary floatables or sewage odor) to reduce contamination followed by the chemical parameter samples. Finally, field measure the pH and temperature.

Sampling protocols recommend that the collection bottle remain sealed until ready to collect the sample and avoid contact with the inside of cap or bottle. Fill the bottle to the bottom of the neck and that each container has the correct water analysis request form attached. Samples must be refrigerated during storage prior to shipment or delivery to the lab. Complete a chain-of-custody form for samples.

Flow Measurements

Dry weather flow rate measurements are intended to provide an estimate of the dry weather flow. If flow measurements require more than 10 to 15 minutes to perform, record a description of flow and depth measurement. Perform flow measurements after the water quality grab sample has been collected to avoid disturbing bottom sediments.

Three methods are outlined for estimating dry weather flow rates at field screening points. These methods include (1) measuring the time it takes to fill a bucket; (2) measuring area, velocity, and calculating flow as the cross-sectional area times the average velocity, and (3) measuring the

depth, width, and slope of the channel and calculating the flow based on Manning's equation. **Appendix B** describes these flow measurement methods in more detail.

Notification

If an obvious illicit connection or discharge is discovered, immediately notify the Stormwater Program Manager and the Region Resource Specialist. **If the discharge appears to be of an emergency nature, contact the Pollution Emergency Alert System (PEAS) at (800) 292-4706 to notify the EGLE of the emergency.** Contact the EGLE district Water Division staff by telephone to report the emergency whenever practical. Document the time of the call and the person contacted.

ROW Investigation

Use the windshield survey and the catch basin survey to further investigate a drainage system and provide additional detail to support an action or result listed in the screening. These surveys are primarily used to identify the source of apparently inert dry weather flow or sediment. They can be used to either support an illicit, ruled-out determination, or identify an illicit discharge.

Windshield Survey

Conduct further investigations where a PSD is observed to have dry weather flow where visual observations and lab results do not indicate an illicit discharge is present to try and locate the source of flow. Outfalls with excess sediment require additional investigation to try and locate the source of the sediment.

Investigate the drainage network looking for activities or conditions that are the source of the water or sediment. Such activities or conditions include lawn watering, car washing, fire hydrant flushing, non-contact cooling water, ground water, unswept streets, poorly maintained catch basins, broken pipes, and construction sites.

An example windshield form used to record observations of the additional investigation is shown in **Figure 7.**

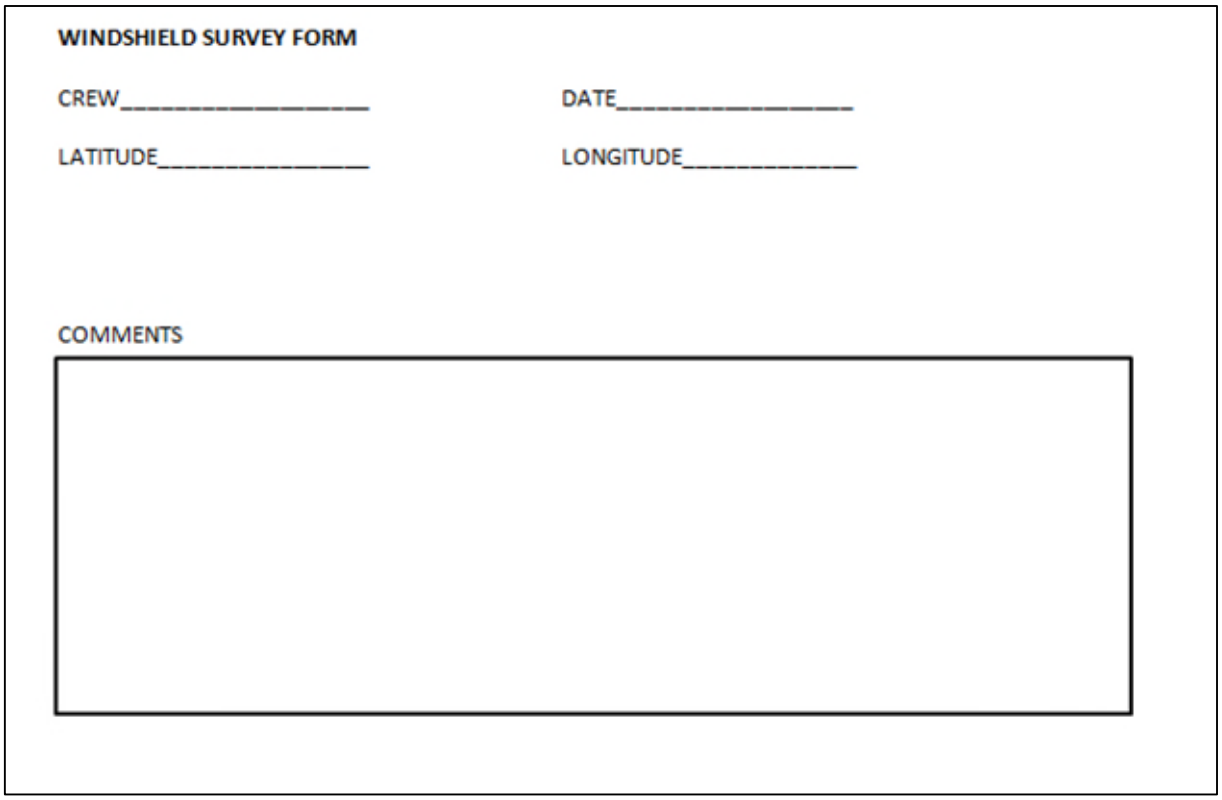


Figure 7. Windshield Survey Form

Catch Basin Survey Form

Use the sample catch basin survey form for outfalls with excess sediment (**Figure 8**). A representative number of catch basins should be surveyed throughout the drainage system to determine if the sediment observed is a result of an activity/discharge or general lack of catch basin maintenance.

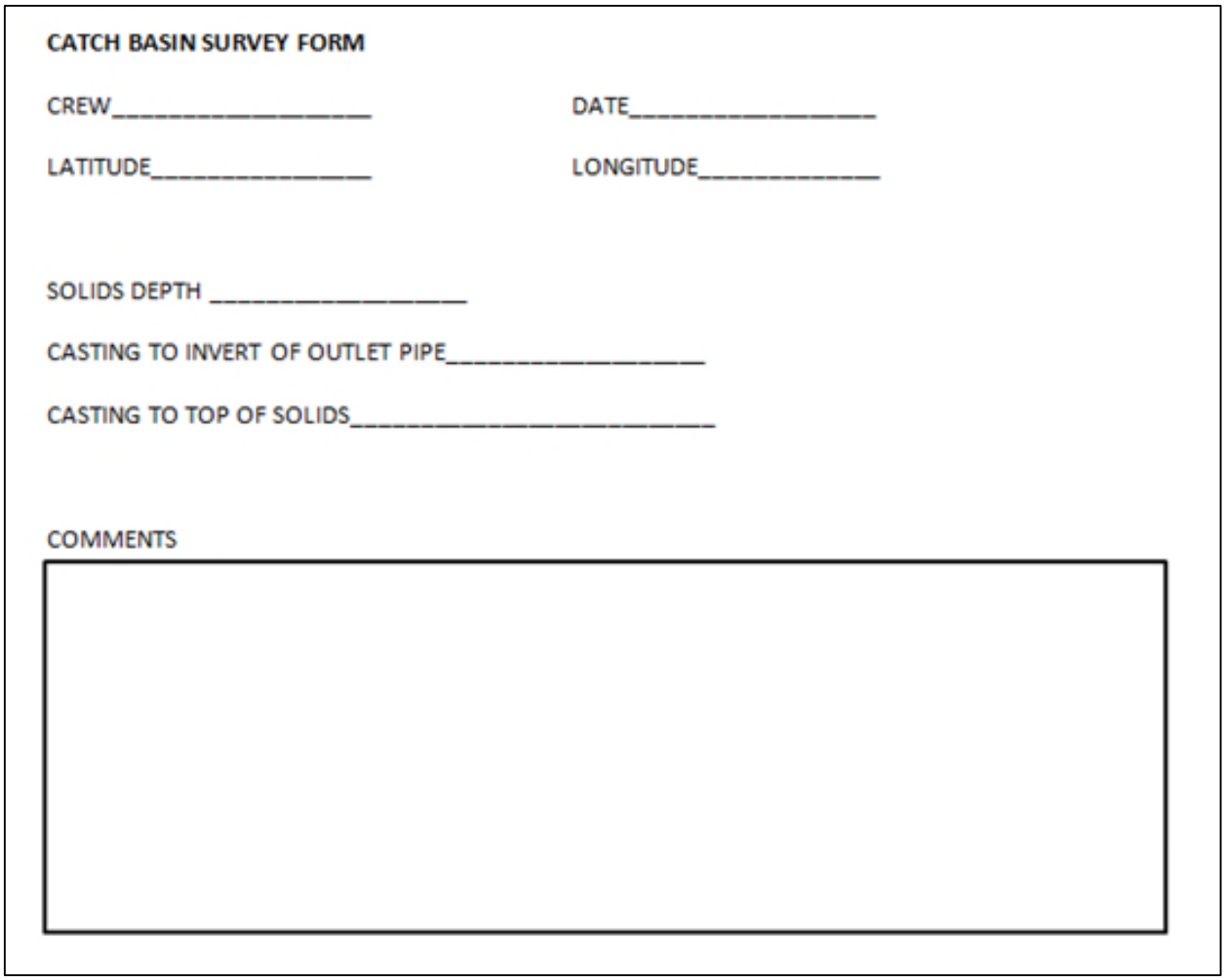


Figure 8. Catch Basin Survey Form

Post Fieldwork

The general process for the post fieldwork is shown in **Figure 9**.

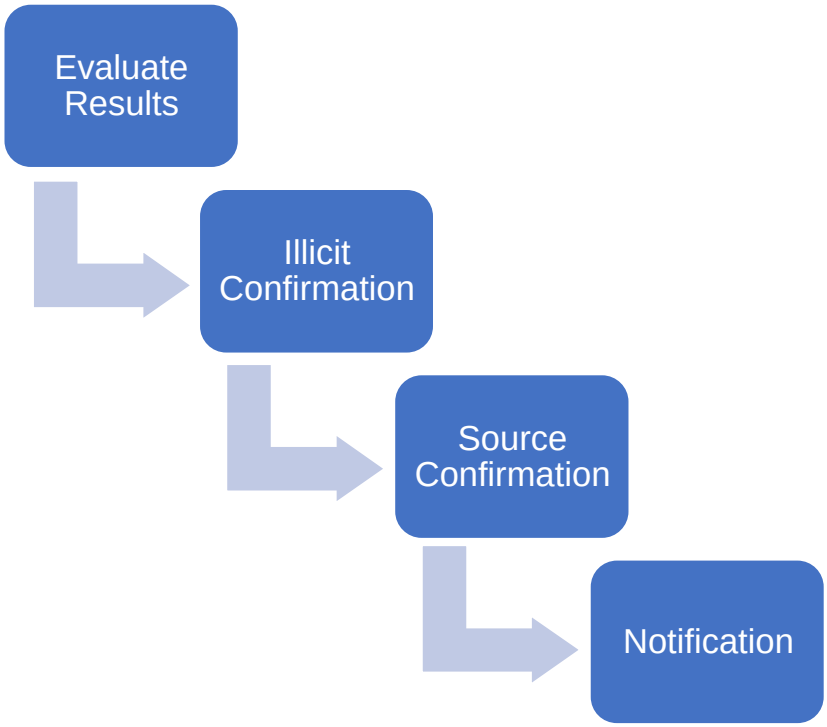


Figure 9. Post Fieldwork Flow Chart

Evaluate Results

Review the laboratory analysis to determine if an illicit discharge is present. **Table 2** shows the typical ranges for sampled parameters. Compare test results to Table 2 to see if the values would indicate a likely illicit discharge.

Table 3. Chemical parameters for illicit

Parameter	Illicit Likely	Illicit Unlikely
Bacteriological (E.Coli)	>1000 colonies/100 mL	<1000 colonies/100 mL
Surfactants (Detergents)	>0.05 mg/L	<0.05 mg/L
Ammonia	>1.0 mg/L	<1.0mg/L
Fluoride	>0.5 mg/L	<0.5 mg/L
Water Temperature *	>Air Temp and ≤ 54°	< Air Temp and ≥ 54°
pH **	>9.0 or <6.3	<9.0 or >6.3

*See discussion of variability and assumptions provided below

**The pH in stormwater is typically greater than 7.0. If the pH is less than 7.0, review other field observations for signs of an illicit connection.

Temperature can be highly variable depending on the structure type, air temperature, solar radiation, and inputs into the system. Typically, groundwater will be approximately 54 degrees. Conduct further investigation on the drainage system when sampled temperatures are below this level and air temperatures are higher than 54 degrees. Sampled water temperatures greater than ambient air temperatures also require further investigation. Investigators should be aware of or look for sources of non-contact cooling water. Water in structures exposed to sunlight may exceed outside air temperatures, which may incorrectly suggest a potential illicit. Use temperature in conjunction with observations and laboratory results to identify the presence of an illicit connection or discharge.

Illicit Confirmed?

Laboratory results confirming an illicit discharge require additional fieldwork to identify the source. **Contact the Pollution Emergency Alert System (PEAS) at (800) 292-4706 for any discharge identified either from initial observations or laboratory testing that appears to be of an emergency nature.** Contact the EGLE district Water Division Staff by telephone to report the emergency whenever practical. Document the time of the call and name of the person contacted.

Examine the upstream drainage area to locate potential sources. Use the example windshield (**Figure 7**) and catch basin survey forms (**Figure 8**) to locate potential sources within the ROW. Target and investigate key points or confluences within the drainage area using the methodology discussed in previous sections. Continue investigations until the problem is isolated between one or two stretches of pipe or private outfalls into an open ditch.

Televising or dye testing of the drainage system may be needed if above ground surveys do not locate the source of the illicit or if there are taps into the MDOT drainage system outside of a structure. Televising and dye testing can also identify any connections to the MDOT drainage system that occur outside of a structure.

A Notification of Intent must be submitted to the EGLE to obtain approval to dye test. Only dyes appearing on the Acceptable Michigan Tracer Dye List may be used. More information on tracer dye use can be found on EGLE's website.

Source Confirmed?

Follow the procedures listed in Appendix A when the source of the illicit is confirmed. These procedures describe the actions needed for notification, documenting actions, negotiating with property owners, and sources outside of the ROW. Develop a work plan for eliminating the illicit with specific timelines for corrective actions. Timelines for elimination depend on each situation.

Follow the notification/documentation procedures listed in Appendix A when either the source cannot be confirmed or if the source is known but the owner is not willing to eliminate the source.

Notification

Anyone working on behalf of MDOT that discovers a suspected illicit discharge or connection must notify the Region Resource Specialist / Region Illicit Discharge Elimination Program (IDEP) Coordinator. The IDEP Coordinator will coordinate the with the Stormwater Program Manager to develop MDOT's response. Additionally, TSC staff may be asked to assist with investigation and follow-up.

If a probable source is determined, and the owner indicates a desire to correct or eliminate the illicit, contact the property owner to begin a voluntary agreement to correct or eliminate the illicit connection/discharge. Be sure to include a timetable for when the work is to be completed. A drainage connection permit may be required if the discharge is allowable. The procedure for notifying the property owner and timeline for response is detailed in the Construction Permit Manual section 1512.71 (see Appendix A).

If the owner is unwilling to remove the illicit connection/discharge or the source is unknown and occurring outside of the MDOT ROW, notify the Stormwater Program Manager, district EGLE Water Resources Division staff, and the local health department as detailed in the Construction Permit Manual Section 1512.71. Assist EGLE and local authority staff as necessary.

Illicit Removal Confirmation

Conduct a follow up investigation to confirm that the illicit has been eliminated or obtained proper permits. Document all notifications and contacts with EGLE when the property owner is uncooperative or the discharge is outside of the ROW and can't be located. Report the final status to the Stormwater Program Manager and maintain a summary of the IDEP investigation for reporting to EGLE as part of the MS4 permit requirements.

Appendix A of G

IDEP Procedure

Taken from MDOT Construction Permits desk manual section 1512.71 (January 2020).

Illicit Connections	These connections do not have a permit to connect to the MDOT drainage system. The connection may be to an enclosed storm sewer or drainage structure or may be to an open channel (ditch). An illicit connection may be carrying predominantly stormwater, or it may be carrying non-stormwater.
Illicit Discharges	Illicit discharges occur when something other than stormwater is being conveyed to the MDOT storm system. An illicit discharge could come from a permitted drainage connection or other means.
Spills	Spills may originate from a source other than a physical connection to the MDOT drainage system. Leaking containers, overland flow of stormwater carrying polluting materials, and seepage of contaminated groundwater are all examples of spills. Spill response is detailed in the Safety and Security Administrations Emergency Response Flowchart and MDOT Procedure 10169.
Notifications	Notify the Region Resource Specialist / Region Illicit Discharge Elimination Program (IDEP) Coordinator of any complaint, discovery, or referral of a suspected ID/C The IDEP Coordinator will coordinate the response. However, TSC staff may be asked to assist with investigation and follow-up. Contact the EGLE Pollution Emergency Alerting System (PEAS) hotline at **1-800-292-4706** if a discharge appears to be of an emergency nature. Contact the district EGLE Water Division staff by telephone to report the emergency whenever practical. Document the time of call and name of the person contacted. If a municipality is involved, contact their MS4 manager to coordinate the investigation. Contact the EGLE district office,

County Drain Commissioner or the MDOT Stormwater Program manager for assistance in identifying the local MS4 manager.

Initial Investigation

This step generally involves visual inspection of the area, review of existing tap-in permits for the vicinity and general inquiries about drainage conditions and maintenance issues in the area. It may be necessary to revisit the site to confirm or rule out the presence of non-stormwater discharge.

Document visual and olfactory characteristics and arrange for sampling and laboratory analysis of the ID/C, if necessary. This analysis may help in identifying the probable source.

Videotaping the storm sewer or dye testing may be necessary to identify the source. Coordinate with the MDOT Stormwater Program manager if it is necessary to enlist the services of a consultant to complete this work.

Probable Source

In a rural area, the probable source may be apparent from a visual survey of the vicinity. In an urbanized a rea the discharge may originate from an ID/C to a third-party stormwater drainage system upstream (and off-right-of-way) of the connection to the MDOT stormwater drainage system.

Activities Outside State Highway Right-of-Way

If the initial investigation requires activities outside the state highway Right-of-Way, request permission from the property owner(s) for entry. If permission is granted, document this permission and continue the initial investigation.

If permission is <u>not</u> granted, provide written notification to EGLE District staff, and other agencies as appropriate, that an ID/C has been discovered or a complaint has been received but that the discharge originates off the state highway Right-of-Way and MDOT is unable to identify a probable source (see Letter 4). After providing written notification, document the end of the IDEP investigation and assist EGLE as needed. <u>No</u> further action is required at this time.

Negotiating with the Owner	If the owner indicates a desire to correct or eliminate the ID/C in a manner that will prevent its reconnection or resumption, agree on a timetable for this work. If excavation or other work within state highway Right-of-Way is required, a permit shall be obtained before such work may commence. See Individual Permit Process, Procedure 1502.01.
Illicit Connection on State Highway Right-of-Way	Perform a determination of Right-of-Way ownership (fee in-lieu, easement, etc.) to determine MDOT enforcement responsibilities. If the connection to the stormwater drainage system is on state owned Right-of-Way and there is no tap-in permit on file, one of the following actions is required: 1. Issue a retroactive tap-in permit, if the existence of an illicit discharge from the connection can be ruled out and the tap is allowable under the CPM guidelines. 2. Issue a "Notice and Order to Remove Encroachment" (Form 2217), if the existence of an illicit discharge from the connection cannot be ruled out or the connection is not allowable.
Notifying EGLE	Explain that an ID/C has been confirmed from a probable source off the state highway Right-of-Way. Describe actions taken to obtain voluntary compliance by the owner. Include copies of the first and second notice letters along with any additional information such as drainage maps or laboratory test results. See Letter 4.
Documenting Actions	If the owner submits written documentation describing the actions taken and correction of the ID/C is completed, provide a copy of the documentation to the Stormwater Program manager that the ID/C has been resolved. If a EGLE referral is made, provide a copy of the documentation to the Stormwater Program manager and assist the EGLE as needed. No further action is required at this time.

Letter 1

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

GRETCHEN WHITMER
GOVERNOR

PAUL C. AJEGBA
DIRECTOR

Date

CERTIFIED LETTER
RETURN RECEIPT REQUESTED

Name, Title
Address
City, State Zip Code

Dear Property Owner:

The Michigan Department of Transportation (MDOT) is currently investigating its storm sewer system within **{enter name of jurisdiction}**. Information gathered during this investigation indicates that an illicit discharge/connection is originating from your property and entering into MDOT's storm sewer system. Attached to this letter is a Notice and Order to Remove Encroachment and additional information describing the illicit discharge/connection.

The Federal Clean Water Act and Part 31, Water Resources Protection of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended and regulations promulgated pursuant to these statutes mandate that only clean stormwater or potable water can be discharged to a system that discharges to the waters of the State. Your property could be illegally connected to or discharging pollutants to MDOT's storm sewer system in violation of these laws and in violation of the Highways Obstructions and Encroachments Act, 1925 PA 368.

The attached Notice and Order directs that you remove this encroachment within 30 days after receipt of this letter. By **{insert date}** you must provide documentation to this office describing what actions you have taken to resolve this matter. If you are unable to remove this encroachment within that time, you must provide information to this office by **{insert date}**, describing the specific steps and schedule by which you will remove this encroachment. By copy of this letter we are notifying the Michigan Department of Environment, Great Lakes, and Energy (EGLE) and **{insert name of municipal jurisdiction and local health department if appropriate}** of this information.

Please contact **{fill in name and phone}** if you have any questions.

Sincerely,

TSC Manager or Region Engineer

Attachments

Cc: Local health department
Local municipality
EGLE Water Division District Supervisor (if not addressee)
MDOT Stormwater Program Manager
Region Stormwater Coordinator

Letter 2

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

PAUL C. AJEGBA
DIRECTOR

Date

CERTIFIED LETTER
RETURN RECEIPT REQUESTED

Name, Title
Address
City, State Zip Code

Dear Property Owner:

On **{date}** I sent you a letter indicating that the Michigan Department of Transportation (MDOT) is currently investigating its storm sewer system within **{enter name of jurisdiction**}. That letter also informed you that information gathered during the course of this investigation indicates that an illicit discharge/connection is originating from your property and entering into MDOT's storm sewer system. Attached to that letter was a Notice and Order to Remove Encroachment and additional information describing the illicit discharge/connection. My **{date}** letter required that you either remove the illicit discharge/connection by **{date}** or respond by **{date}** describing what actions you were going to take to eliminate this discharge/connection. To date we have not received a response from you to that letter **(or response indicated that you would not take actions to adequately resolve this matter)**.

MDOT is required by its National Pollutant Discharge Elimination System permit for the discharge of its stormwater to take enforcement actions to eliminate all illicit discharges/connections to its storm sewer system. The purpose of this letter is to inform you that if you do not remove the discharge/connection described in my **{date}** letter by **{insert date}**, MDOT will refer this matter for appropriate enforcement actions to eliminate this illicit connection/discharge to MDOT's storm sewer system.

By **{insert date}** you must provide documentation to this office describing what actions you have taken to resolve this matter. **{if within MDOT ROW insert the following: If you do not resolve this matter by this date, we will refer this matter to the Department of Attorney General to initiate appropriate enforcement actions to remove this illicit connection/discharge.}** By copy of this letter we are notifying the Michigan Department of Environment, Great Lakes and Energy (EGLE) and **{insert name of municipal jurisdiction and local health department if appropriate}** of this information.

Please contact **{fill in name and phone}** if you have any questions.

Sincerely,

TSC Manager or Region Engineer

Attachments

Cc: Local health department
Local municipality
EGLE Water Division District Supervisor (if not addressee)
MDOT Stormwater Program Manager
Region Stormwater Coordinator

Letter 3

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

PAUL C. AJEGBA
DIRECTOR

Date

CERTIFIED LETTER
RETURN RECEIPT REQUESTED

Name, Water Division District Supervisor
Department of Environmental Quality
Address
City, State Zip Code

Dear **{enter name of supervisor}**:

The Michigan Department of Transportation (MDOT) is currently investigating its storm sewer system within **{enter name of jurisdiction}**. Information gathered during the course of this investigation indicates that an illicit discharge/connection is originating from property adjacent to MDOT's right of way and entering into MDOT's storm sewer system. MDOT lacks legal authority to enter onto properties outside of MDOT's right of way and has been unable to obtain voluntary permission from adjacent property owners for MDOT to conduct investigations on these properties. As a result, MDOT is unable to investigate this possible illicit discharge/connection as required under our National Pollution Discharge Elimination System (NPDES) stormwater discharge permit.

This letter is to request your assistance in obtaining legal access for MDOT to complete the investigation described above. Attached to this letter is information describing the properties to which access is needed and the potential scope of investigatory activities MDOT or its consultant may need to undertake under such access. If Michigan Department of Environment, Great Lakes, and Energy (EGLE) is not able to obtain access to enable MDOT to conduct these investigations, MDOT will refer all further follow up actions for this potential illicit discharge or connection to the EGLE or appropriate local jurisdiction.

Please contact me at **{insert phone/e-mail}** to inform me of the status of this request or if you have any questions.

Sincerely,

TSC Manager or Region Engineer

Attachments

Cc: Local health department
Local municipality
TSC Manager/Region Engineer
MDOT Stormwater Program Manager
Region Stormwater Coordinator

Letter 4

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

GRETCHEN WHITMER
GOVERNOR

PAUL C. AJEGBA
DIRECTOR

Date

CERTIFIED LETTER
RETURN RECEIPT REQUESTED

Name, EGLE Water Division District Supervisor
EGLE and/or local jurisdiction as appropriate
Address
City, State Zip Code

Dear **{enter name of supervisor}**:

As part of the Michigan Department of Transportation's (MDOT) efforts to investigate its storm sewer system within **{enter name of jurisdiction},** we have identified potentially illicit connections/discharges to our storm sewer system. **(*Pick one of the following as appropriate*)**

Neither MDOT nor the Michigan Department of Environment, Great Lakes, and Energy (EGLE) have been able to gain permission to access properties outside of state highway Right-of-Way. As a result, we are not able to complete an investigation of the potential illicit connections/discharges to determine who may be responsible for it or take action to have it eliminated.

o r

Attached to this letter are copies of two certified letters and Orders to Remove Encroachment that were sent to the property owners that we identified as potentially responsible for these connections/discharges. To date this party has {not responded/failed to remedy the illicit connection or discharge}.

MDOT is required by its National Pollutant Discharge Elimination System (NPDES) permit for the discharge of its stormwater to take enforcement actions to eliminate all illicit discharges/connections to its storm sewer system. The purpose of this letter is to inform you that because the illicit connection or discharge exists outside of state highway Right-of-Way, **{insert if appropriate – and MDOT has been unable to obtain access to off the right of way properties over which MDOT lacks jurisdiction to enable proper investigation}** MDOT lacks the legal authority to take enforcement action against the offending party to remedy this matter. Therefore, by this letter, we are referring this matter to your

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

GRETCHEN WHITMER
GOVERNOR

PAUL C. AJEGBA
DIRECTOR

agency and requesting that you use legal authority available to you to eliminate the identified illicit discharge/connection to MDOT's stormwater system.

Please contact **{insert name and phone/e-mail}** if you have any questions or need additional information.

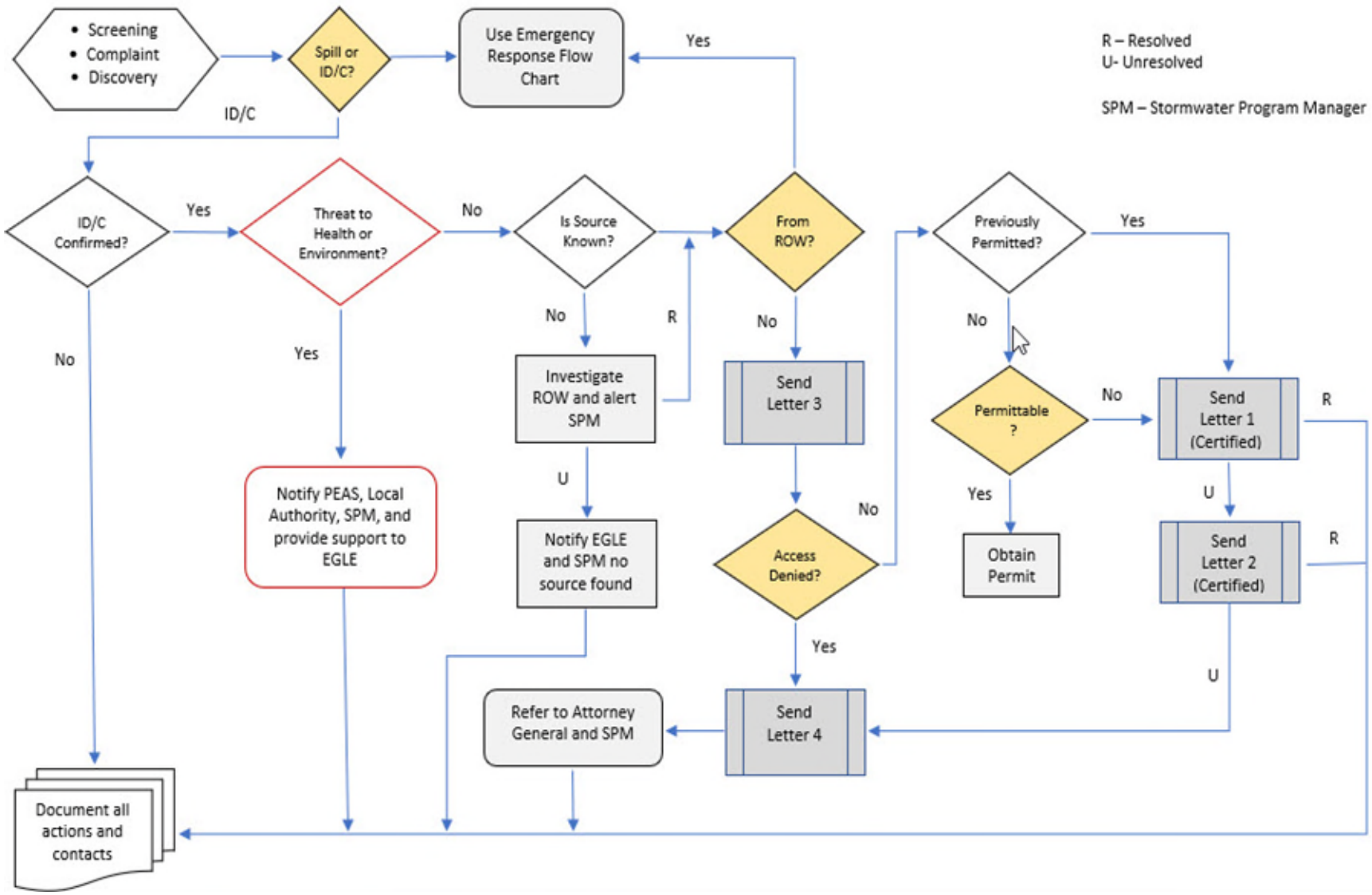
Sincerely,

TSC Manager or Region Engineer

Attachments

Cc: Property owner(s) in question
Local health department
Local municipality
EGLE Water Division District Supervisor (if not addressee)
MDOT Stormwater Program Manager
Region Stormwater Coordinator

MDOT Illicit Discharge/Connection Removal Workflow



Letter 1: To property owner – include Form 2217 (Notice and Order to Remove Encroachment).
Letter 2: To property owner – second notice.
Letter 3: To EGLE Water Division district staff requesting assistance with obtaining property access.
Letter 4: To EGLE Water Division and local authority reporting illicit connection off MDOT ROW.

Appendix B of G

Flow Measurement Methods

Bucket Method

This method is typically limited to locations where there is free fall of water at the discharge point. The free fall must be high enough and concentrated along a narrow area so that a calibrated container can be positioned to collect the flow.

Equipment Needed:

1. Wide mouthed container(s) (bucket) graduated in known volume increments.
2. Stopwatch.

Procedure:

1. Place container under flow discharge point so that entire flow is collected.
2. Measure the time it takes to fill the bucket to a known volume.
3. Record the time duration and the volume.
4. Repeat Steps 1 through 3 at least once. Repeat steps at least twice if the results vary by more than 20 percent.
5. Calculate the average time.
6. Compute the flow rate as follows: (Calculations to be done in the office). Q = V/t where: Q = flow rate V = volume t = time required
7. Convert the calculated flow rate to gallons per second.

Area/Velocity Method

The second method for estimating flow requires channel measurements. The cross-sectional area of the flowing water and velocity must be estimated. Use this method to estimate flow rates in pipes or channels where a significant, measurable, or steady velocity is observed and cross-sectional measurements can be readily obtained. Open channel measurements will rely on estimates of a top and bottom width. Perform velocity measurements using floats and a stopwatch.

Equipment Needed:

1. Depth Measurement Rod.
2. Tape Measure.
3. Float(s). These might include corks, fishing bobbers, wooden sticks, sticks and leaves, Cheerios, orange peel, or popcorn. If the float is not recoverable, then only objects that are non-objectionable in streams should be used.
4. Stopwatch.

Procedure:

1. Locate a relatively uniform section of the channel/pipe between 3 to 10 feet long.
2. Mark off a known length of the channel/pipe using available objects, such as rocks or sticks. If the site is at a manhole, the diameter (typically 4 feet) of the manhole can be used as the travel length. If the PSD location is at the end of a pipe and the PSD is

accessible, a yardstick can be placed into the pipe or measure the length of a pipe section with a tape measure or folding ruler.

3. Use the stopwatch to measure the time required in seconds for a float to travel the marked off distance. If conditions are windy, it is desirable to have a float that is partially submerged. The float can be inserted upstream and timed as it passes the starting point. This technique may not be applicable if swirls or eddies are observed or if the flow depth is not very deep.
4. Repeat step No. 3 at least twice. Perform two additional measurements if the original measurements vary by more than 20 percent. Average the measurements after dropping outliers.
5. Measure the cross-sectional area of the discharge. For flow in a pipe, measure the depth of flow and the size of the pipe (if the pipe is other than round, sufficient measurements are needed to fully describe the shape of the pipe). Measure the depth of flow, bottom width of the channel, and the width of the channel at the flow surface for natural channels.
6. Calculate the cross-sectional area of the flow. Use Table 4 or the following equations for partially filled circular pipes.
    - Rectangular pipes: area = width * depth
    - Trapezoidal channels: area = (top width + bottom width)/2 * depth
    - Circular pipes:

$$A = \frac{d^2}{4}(\theta - \sin(\theta) * \cos(\theta))$$

$$\theta = cos^{-1}\left(1 - \frac{2y}{D}\right) * \frac{\pi}{180}$$

where: A = Area
D = Diameter of pipe
y = Depth of flow

7. Calculate the flow rate and express the result in units of gallons per minute. Flow = Area * Velocity

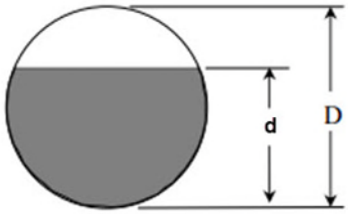
Table 4. Flow area of partially filled round pipe

Water Depth (feet)	Pipe Diameter (inches)										
	8	12	15	18	24	30	36	42	48	54	60
	Partial Area (square feet)										
0.05	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
0.10	0.03	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.08	0.09	0.09
0.15	0.06	0.07	0.08	0.09	0.11	0.12	0.13	0.14	0.15	0.16	0.17
0.20	0.09	0.11	0.13	0.14	0.16	0.18	0.20	0.22	0.23	0.25	0.26
0.25	0.12	0.15	0.17	0.19	0.23	0.26	0.28	0.31	0.33	0.35	0.37
0.30	0.15	0.20	0.23	0.25	0.30	0.33	0.38	0.40	0.43	0.46	0.48
0.40	0.22	0.29	0.34	0.38	0.45	0.51	0.56	0.61	0.65	0.70	0.74
0.50	0.28	0.39	0.46	0.52	0.61	0.70	0.77	0.84	0.91	0.97	1.02
0.60	0.33	0.49	0.58	0.66	0.79	0.91	1.00	1.10	1.18	1.26	1.33
0.70	0.35	0.59	0.71	0.81	0.98	1.13	1.25	1.37	1.48	1.58	1.67
0.80		0.67	0.83	0.96	1.17	1.35	1.51	1.66	1.79	1.91	2.03
0.90		0.74	0.95	1.11	1.37	1.59	1.78	1.96	2.12	2.26	2.40
1.00		0.79	1.05	1.25	1.57	1.83	2.06	2.27	2.46	2.63	2.80
1.10			1.14	1.39	1.77	2.08	2.35	2.59	2.81	3.01	3.20
1.20			1.21	1.52	1.97	2.33	2.64	2.92	3.17	3.40	3.62
1.30			1.23	1.63	2.16	2.58	2.94	3.25	3.54	3.81	4.06
1.40				1.72	2.35	2.83	3.23	3.59	3.92	4.22	4.50
1.50				1.77	2.53	3.08	3.53	3.94	4.30	4.64	4.95
1.60					2.69	3.32	3.83	4.29	4.69	5.07	5.42
1.70					2.85	3.55	4.13	4.64	5.09	5.50	5.89
1.80					2.98	3.78	4.43	4.99	5.48	5.94	6.36
1.90					3.08	4.00	4.72	5.33	5.88	6.38	6.85
2.00					3.14	4.21	5.01	5.68	6.28	6.83	7.33
2.10						4.40	5.29	6.03	6.68	7.28	7.83
2.20						4.58	5.56	6.37	7.08	7.73	8.32
2.30						4.72	5.82	6.70	7.48	8.18	8.82
2.40						4.84	6.06	7.03	7.87	8.63	9.32
2.50						4.91	6.30	7.35	8.26	9.07	9.82
2.60							6.51	7.66	8.65	9.52	10.32
2.70							6.70	7.96	9.02	9.96	10.82
2.80							6.87	8.25	9.40	10.40	11.31
2.90							7.00	8.52	9.76	10.84	11.81
3.00							7.07	8.78	10.11	11.26	12.30
3.10								9.01	10.45	11.68	12.79
3.20								9.22	10.78	12.10	13.27
3.30								9.40	11.09	12.50	13.75
3.40								9.54	11.38	12.90	14.22
3.50								9.62	11.66	13.27	14.68
3.60									11.91	13.64	15.13
3.70									12.14	13.99	15.58
3.80									12.33	14.33	16.01
3.90									12.48	14.64	16.43
4.00									12.57	14.94	16.84
4.10										15.21	17.23

4.20										15.45	17.61
4.30										15.65	17.96
4.40										15.82	18.30
4.50										15.90	18.61
4.60											18.90
4.70											19.15
4.80											19.37
4.90											19.54
5.00											19.63

Table 5. Area and hydraulic radius for various flow depths

d/D	Area/D^2	Hyd. Rad./D	d/D	Area/D^2	Hyd. Rad./D	d/D	Area/D^2	Hyd. Rad./D
0.01	0.0013	0.0066	**0.36**	0.2546	0.1978	**0.71**	0.5964	0.2973
0.02	0.0037	0.0132	**0.37**	0.2642	0.2020	**0.72**	0.6054	0.2984
0.03	0.0069	0.0197	**0.38**	0.2739	0.2061	**0.73**	0.6143	0.2995
0.04	0.0105	0.0262	**0.39**	0.2836	0.2102	**0.74**	0.6231	0.3006
0.05	0.0147	0.0326	**0.40**	0.2934	0.2142	**0.75**	0.6318	0.3017
0.06	0.0192	0.0389	**0.41**	0.3032	0.2181	**0.76**	0.6404	0.3025
0.07	0.0242	0.0451	**0.42**	0.3130	0.2220	**0.77**	0.6489	0.3032
0.08	0.0294	0.0513	**0.43**	0.3229	0.2257	**0.78**	0.6573	0.3037
0.09	0.0350	0.0574	**0.44**	0.3328	0.2294	**0.79**	0.6655	0.3040
0.10	0.0409	0.0635	**0.45**	0.3428	0.2331	**0.80**	0.6736	0.3042
0.11	0.0470	0.0695	**0.46**	0.3527	0.2366	**0.81**	0.6815	0.3044
0.12	0.0534	0.0754	**0.47**	0.3627	0.2400	**0.82**	0.6893	0.3043
0.13	0.0600	0.0813	**0.48**	0.3727	0.2434	**0.83**	0.6969	0.3041
0.14	0.0688	0.0871	**0.49**	0.3827	0.2467	**0.84**	0.7043	0.3038
0.15	0.0739	0.0929	**0.50**	0.3927	0.2500	**0.85**	0.7115	0.3033
0.16	0.0811	0.0986	**0.51**	0.4027	0.2531	**0.86**	0.7186	0.3026
0.17	0.0885	0.1042	**0.52**	0.4127	0.2561	**0.87**	0.7254	0.3017
0.18	0.0961	0.1097	**0.53**	0.4227	0.2591	**0.88**	0.7320	0.3008
0.19	0.1039	0.1152	**0.54**	0.4327	0.2620	**0.89**	0.7384	.02996
0.20	0.1118	0.1206	**0.55**	0.4426	0.2649	**0.90**	0.7445	.02980
0.21	0.1199	0.1259	**0.56**	0.4526	0.2676	**0.91**	0.7504	0.2963
0.22	0.1281	0.1312	**0.57**	0.4625	0.2703	**0.92**	0.7560	0.2944
0.23	0.1365	0.1364	**0.58**	0.4723	0.2728	**0.93**	0.7612	0.2922
0.24	0.1449	0.1416	**0.59**	0.4822	0.2753	**0.94**	0.7662	0.2896
0.25	0.1535	0.1466	**0.60**	0.4920	0.2776	**0.95**	0.7707	0.2864
0.26	0.1623	0.1516	**0.61**	0.5014	0.2797	**0.96**	0.7749	0.2830
0.27	0.1711	0.1566	**0.62**	0.5115	0.2818	**0.97**	0.7785	0.2787
0.28	0.1800	0.1614	**0.63**	0.5212	0.2839	**0.98**	0.7816	0.2735
0.29	0.1890	0.1662	**0.64**	0.5308	0.2860	**0.99**	0.7841	0.2665
0.30	0.1982	0.1709	**0.65**	0.5404	0.2881	**1.00**	0.7854	0.2500
0.31	0.2074	0.1755	**0.66**	0.5499	0.2899			
0.32	0.2167	0.1801	**0.67**	0.5594	0.2917			
0.33	0.2260	0.1848	**0.68**	0.5687	0.2935			
0.34	0.2355	0.1891	**0.69**	0.5780	0.2950			
0.35	0.2450	0.1935	**0.70**	0.5872	0.2962			



Manning's Equation

Use Manning's equation to provide an estimate of the flow rate without velocity measurements. Manning's equation requires measurements of the channel cross-section, depth of flow, and slope of the channel, and a roughness coefficient, n, must be estimated. Use it where the cross-section of the channel or pipe is uniform, the slope and roughness of the channel can be estimated, and where flow discharges freely with no backwater or impoundment due to a downstream condition. Slope of the channel is taken from as-builts or recent survey.

Equipment Needed:

1. Tape measure and/or depth measuring rod.

Procedure:

1. Obtain measurements to calculate the cross-sectional area of the discharge. For flow in a pipe, measure the depth of flow and the size of the pipe (if the pipe is other than round, sufficient measurements are needed to fully describe the shape of the pipe). For flow in a natural channel, measure the depth of flow, the bottom width of the channel, and the width of the channel at the flow surface.
1. Additional observations should include information to determine Manning's roughness coefficient (Tables 4 and 5). If possible, photographs should be taken of channel to help select the Manning roughness coefficients.
2. Calculate flows using the Manning equation. The Manning equation is:

$$Q = \frac{c}{n} * (A^{\frac{5}{3}} / P_w^{\frac{2}{3}}) * \sqrt{S}$$

Table 5 provides area and hydraulic radius (A/P_W) values for partially full circular conduits. Use the following area and wetted perimeter equations for natural channels:

Rectangular Channels:

$$A = by$$

$$P_{w=}\, b + 2y$$

Trapezoid Channels:

$$A = \frac{y(b+B)}{2}$$

$$P_w = b + 2\sqrt{y^2 + \left(\frac{B-b}{2}\right)^2}$$

Where:

Q = Flow (ft^3/s)
C = 1.0 for m^3/s, 1.49 for ft^3/s
n = Manning's roughness coefficient
A =Area of flow (ft^2)
P_w = Wetted perimeter (ft)
S = Slope (ft/ft)
y = Depth of water (ft)
d = Diameter (ft)
b = Bottom width (ft)
B = Top width of water surface (ft)

Table 6. Typical channel lining Manning's roughness coefficients

Lining Category	Lining Type	Manning's n		
		Maximum	Typical	Minimum
Rigid	Concrete	0.015	0.013	0.011
	Grouted riprap	0.040	0.030	0.028
	Stone masonry	0.042	0.032	0.030
	Soil element	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare soil	0.025	0.020	0.016
	Rock cut	0.045	0.035	0.025
Rolled Erosion Control Product (RECP)	Open-weave textile	0.028	0.025	0.022
	Erosion control blanket	0.045	0.035	0.028
	Turf reinforcement mat	0.036	0.030	0.024

Kilgore, R.T. and Cotton, G.K., 2005. **Design of Roadside Channels with Flexible Linings**

Table 7. Typical range of Manning's coefficient (n) for channels and pipes

Conduit Material	Manning's n*
Closed conduits	
Concrete	0.010 – 0.015
Corrugated metal	0.011 – 0.037
Cast iron	0.012 – 0.015
Clay	0.013 – 0.014
Plastic (smooth)	0.009 – 0.015
Plastic (corrugated)	0.012 – 0.016
Natural channels (minor streams, top width at flood stage <100 ft (30m))	
Fairly regular section	0.025 – 0.050
Irregular section with pools	0.040 – 0.150

* Lower values are for well-constructed and maintained pipes and channels.