ILLICIT CONNECTION AND ILLICIT DISCHARGE  
FIELD SCREENING AND SOURCE TRACING  
GUIDANCE MANUAL

May 2020 Revision

Prepared for  
King County  
and  
Washington State Department of Ecology

Prepared by  
Herrera Environmental Consultants, Inc.  
and  
Aspect Consulting, LLC

ILLICIT CONNECTION AND ILLICIT DISCHARGE  
FIELD SCREENING AND SOURCE TRACING  
GUIDANCE MANUAL

May 2020 Revision

Prepared for:

King County Department of Natural Resources

Stormwater Services Section

<https://kingcounty.gov/services/environment/water-and-land/stormwater.aspx>

and

Washington State Department of Ecology

Stormwater Action Monitoring Program

<https://ecology.wa.gov/Regulations-Permits/Reporting-requirements/Stormwater-monitoring/Stormwater-Action-Monitoring>

Prepared by:

Herrera Environmental Consultants, Inc.

Seattle, Washington 98121

[www.herrerainc.com](http://www.herrerainc.com)

and

Aspect Consulting, LLC

Seattle, Washington 98104

[www.aspectconsulting.com](http://www.aspectconsulting.com)

May 7, 2020

Contents

[Acknowledgements v](#_Toc39736015)

[1. Introduction 1](#_Toc39736016)

[1.1. Background and Updates 1](#_Toc39736017)

[1.2. Scope of Manual 3](#_Toc39736018)

[1.3. Manual Organization 3](#_Toc39736019)

[2. Definitions and Regulatory Requirements 5](#_Toc39736020)

[2.1. Definitions and Acronyms 5](#_Toc39736021)

[2.2. Regulatory Requirements 10](#_Toc39736022)

[3. Field Screening Methodologies 13](#_Toc39736023)

[3.1. Selecting a Field Screening Methodology 13](#_Toc39736024)

[3.2. General Guidelines 16](#_Toc39736025)

[Data Management Recommendations 16](#_Toc39736026)

[Safety Considerations 18](#_Toc39736027)

[Costs 19](#_Toc39736028)

[3.3. Field Screening Methodology Pullout Sections 20](#_Toc39736029)

[Catch Basin/Manhole Inspections 21](#_Toc39736030)

[Ditch Inspections 27](#_Toc39736031)

[Outfall Inspections 33](#_Toc39736032)

[Video Inspections 37](#_Toc39736033)

[Other Field Screening Methodologies 41](#_Toc39736034)

[4. Indicators 43](#_Toc39736035)

[4.1. Selecting an Indicator 43](#_Toc39736036)

[4.2. Selecting a Method 51](#_Toc39736037)

[Test Strips 51](#_Toc39736038)

[Test Kits 51](#_Toc39736039)

[Field Meter 51](#_Toc39736040)

[Multimeter 52](#_Toc39736041)

[Colorimeter 52](#_Toc39736042)

[Spectrophotometer 52](#_Toc39736043)

[Laboratory Analysis 52](#_Toc39736044)

[4.3. General Guidelines 53](#_Toc39736045)

[Field Quality Assurance/Quality Control 53](#_Toc39736046)

[Laboratory Analysis Quality Assurance/Quality Control 54](#_Toc39736047)

[Safety Considerations 55](#_Toc39736048)

[Costs 56](#_Toc39736049)

[4.4. Indicator Pullout Sections 56](#_Toc39736050)

[Flow 57](#_Toc39736051)

[Ammonia 63](#_Toc39736052)

[Color 69](#_Toc39736053)

[Odor 75](#_Toc39736054)

[pH 79](#_Toc39736055)

[Temperature 85](#_Toc39736056)

[Turbidity 89](#_Toc39736057)

[Visual Indicators 95](#_Toc39736058)

[Bacteria 105](#_Toc39736059)

[Chlorine and Fluoride 111](#_Toc39736060)

[Detergents/Surfactants 117](#_Toc39736061)

[Hardness 121](#_Toc39736062)

[Nitrate 125](#_Toc39736063)

[Specific Conductivity 131](#_Toc39736064)

[Total Petroleum Hydrocarbons (TPH) 135](#_Toc39736065)

[Other Indicators 139](#_Toc39736066)

[5. Source Tracing Methodologies 143](#_Toc39736067)

[5.1. Selecting a Source Tracing Methodology 143](#_Toc39736068)

[5.2. General Guidelines 146](#_Toc39736069)

[Data Management Recommendations 146](#_Toc39736070)

[Safety Considerations 147](#_Toc39736071)

[Costs 148](#_Toc39736072)

[5.3. Source Tracing Methodology Pullout Sections 148](#_Toc39736073)

[Business Inspections 149](#_Toc39736074)

[Catch Basin/Manhole Inspections 153](#_Toc39736075)

[Ditch Inspections 157](#_Toc39736076)

[Dye Testing 161](#_Toc39736077)

[Septic System Inspections 167](#_Toc39736078)

[Smoke Testing 171](#_Toc39736079)

[Vehicle/Foot Reconnaissance 177](#_Toc39736080)

[Video Inspections 181](#_Toc39736081)

[Other Source Tracing Methodologies 185](#_Toc39736082)

[6. References 187](#_Toc39736083)

[7. Index 189](#_Toc39736084)

Appendices

[Appendix A](#_Toc30007585) [Field Screening, Source Tracing, and Indicator Sampling Equipment Costs](#_Toc30007586)

[Appendix B](#_Toc30007587) [Example Field Forms](#_Toc30007588)

[Appendix C](#_Toc30007592) [Case Studies](#_Toc30007593)

[Appendix D](#_Toc30007594) [Other Resources](#_Toc30007595)

[Appendix E](#_Toc30007596) [Other Field Screening Methodologies](#_Toc30007597)

[Appendix F](#_Toc30007598) [Other Indicators](#_Toc30007599)

[Appendix G](#_Toc30007600) [Other Source Tracing Methodologies](#_Toc30007601)

Tables

[Table 1.1. Key Changes in the 2020 IC-ID Field Screening and Source Tracing Manual. 2](#_Toc30068352)

[Table 2.1. Requirements in the NPDES Municipal Stormwater Permits Related to Field Screening and Source Tracing. 11](#_Toc30068353)

[Table 2.2. Requirements in the NPDES Municipal Stormwater Permits Related to Field Screening and Source Tracing for Secondary Permittees. 12](#_Toc30068354)

[Table 3.1. Data Management Recommendations for Field Screening Methodologies. 17](#_Toc30068355)

[Table 3.2. Options for Annual Field Screening Percentage Calculation. 18](#_Toc30068356)

[Table 4.1. Primary Field Screening Indicator Observations and Follow-Up Indicator Recommendations Based on the Suspected Source of an Illicit Discharge. 49](#_Toc30068357)

[Table 5.1. Source Tracing Methodology Recommendations Based on the Suspected Source of an Illicit Discharge. 145](#_Toc30068358)

[Table 5.2. Data Management Recommendations for Source Tracing Methodologies. 147](#_Toc30068359)

Figures

[Figure 3.1. Field Screening and Source Tracing Methodology Flow Chart. 15](#_Toc30070596)

[Figure 4.1. Indicator Sampling Flow Chart (Urban Land Use). 45](#_Toc30070597)

[Figure 4.2. Indicator Sampling Flow Chart (Rural Land Use). 47](#_Toc30070598)

Acknowledgements

We would like to thank the following people who worked on the team for developing the updated 2020 manual:

* Rebecca Dugopolski, Herrera Environmental Consultants
* James Packman, Aspect Consulting
* Jeanne Dorn, King County
* John Lenth, Herrera Environmental Consultants
* Katie Wingrove, Herrera Environmental Consultants
* Brian Hite, Aspect Consulting
* Will Guyton, Aspect Consulting

We also thank the following groups that provided valuable feedback on the updated 2020 manual:

* SWG Source ID Subgroup
* APWA Stormwater Managers Committee
* NPDES Coordinators Forum, Central Puget Sound

We also thank the following people and regional forums that provided valuable input on the original 2013 manual:

* Doug Navetski, King County
* Russ Connole, Spokane County
* Tanyalee Erwin, Washington Stormwater Center
* George Iftner, Herrera Environmental Consultants
* Anneliese Sytsma, Herrera Environmental Consultants
* Regional Operations and Maintenance Program (ROADMAP)
* Eastern Washington Stormwater Coordinators Group (EWSCG)

We would also like to thank the following people for providing photos and case studies for use in the manual:

* Russell Cotton-Betteridge and Maria Stevens, City of Bellevue
* Andy Loch, City of Bothell
* Daniel Smith, City of Federal Way
* Ryean-Marie Tuomisto, City of Kirkland
* Scott McQuary, City of Redmond
* Adam Bailey, City of Seattle
* Jennifer Keune and Jeanne Dorn, King County
* Anneliese Sytsma, Christina Avolio, Dan Bennett, George Iftner, Matt Klara, and Rebecca Dugopolski, Herrera Environmental Consultants

# Introduction

## Background and Updates

This Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual (Manual) was developed to serve as guidance for municipalities in Washington State that perform field screening and source tracing to address the illicit discharge detection and elimination (IDDE) program requirements in the National Pollutant Discharge Elimination System (NPDES) Phase I and Phase II Municipal Stormwater Permit. These municipalities currently use a wide variety of field screening and source tracing methodologies to identify illicit discharges and illicit connections, with varying levels of success. The goal of this manual is to provide a single, detailed source of information that municipal staff across Washington State can use for field screening and source tracing for illicit discharges and illicit connections in their storm drainage systems. Note that when the term illicit discharge (ID) is used in this manual, it is intended to also include illicit connections (IC).

This manual was originally developed in 2013 by King County, the Washington Stormwater Center, and Herrera Environmental Consultants using funding from a Grant of Regional or Statewide Significance (Grant No. G1200467) from the Washington State Department of Ecology (Ecology). A survey of Washington permittees was conducted to determine which methodologies and indicators were being used for field screening and source tracing of illicit discharges. A literature review was also performed to gather input from national IDDE programs as well as local IDDE programs. In addition to the survey and literature review, discussions regarding methodologies and indicators were also held at the Regional Operations and Maintenance Program (ROADMAP) and Eastern Washington Stormwater Coordinators Group (EWSCG) forums.

This 2020 update was developed by Herrera Environmental Consultants and Aspect Consulting for King County using funding from Western Washington permittees. This update was overseen by the Source Identification (Source ID) subgroup of the Stormwater Work Group (SWG) which is part of the Stormwater Action Monitoring (SAM) collaborative. Ecology manages the SAM program on behalf of the municipal stormwater permittees. The 2020 update included a survey of Washington permittees and two workshops (Aspect Consulting, 2019a), a literature review (Aspect Consulting, 2019b), and a data review (Aspect Consulting, 2019c) as well as input from the Source ID subgroup. The overall structure and technical content of the 2020 manual remains largely the same as the 2013 manual; however, there are several key changes that are noted that are summarized in Table 1.1.

|  |  |  |
| --- | --- | --- |
| Table 1.1. Key Changes in the 2020 IC-ID Field Screening and Source Tracing Manual. | | |
| Section | Subsection | Summary of Change |
| 2.0 – Definitions and Regulatory Requirements | 2.1 – Definitions and Acronyms | Added new definitions (conditionally allowable discharges and discharge point). |
| 2.2 – Regulatory Requirements | Updated tables to reflect the regulatory requirements in the 2019-2024 municipal NPDES permits. |
| 3.0 – Field Screening Methodologies | 3.1 – Selecting a Field Screening Methodology | Removed distinction between piped and ditch systems to streamline flow chart. |
| 3.2 – General Guidelines | Added a table describing options for calculating percent screened (related to the municipal NPDES permit field screening tracking requirements). |
| 3.3 – Field Screening Methodology Pullout Sections | Shifted Business Inspections and Stormwater BMP Inspections to Appendix E. |
| Other Field Screening Methodologies | Added references for Automated Sampling. |
| 4.0 – Indicators | 4.1 – Selecting an Indicator | Streamlined flow charts. Removed A:P ratio and fecal coliform bacteria thresholds. Added new recommended threshold for specific conductivity. |
| 4.2 – Selecting a Method | Added a new section with generic language providing an overview of the various methods (e.g., test strips, test kits, field meters, etc.) used to evaluate indicators. Deleted this generic language from the individual indicator sections. |
| Flow, pH, Temperature, and Chlorine | Added examples of conditionally allowable discharges to Description sections. |
| Bacteria | Renamed Fecal Coliform Bacteria section as “Bacteria” and added detail for Escherichia (E.) coli and Bacteroidales DNA. Updated state water quality standards for fecal coliform bacteria. Added recommended threshold values for E. coli and Bacteroidales DNA. |
| Total Petroleum Hydrocarbons (TPH) | Moved from the Other Indicators list to the Follow-up Indicators section and added detail related to indicator sampling. Added recommended threshold value for TPH. |
| Other Indicators | Added numerous indicators to Other Indicators table. |
| 5.0 – Source Tracing Methodologies | 5.3 – Source Tracing Methodology Pullout Sections | Shifted Optical Brightener Monitoring and Sandbagging to Appendix G. Added example questions for neighboring homeowner or business owner/employee interviews. |
| Other Source Tracing Methodologies | Expanded Continuous Monitoring description. Added Optical Brightener Monitoring and Sandbagging with a link to Appendix G. |
| Appendix A | Field Screening, Source Tracing, and Indicator Sampling Equipment Costs | Updated costs and added new equipment. |
| Appendix B | Example Field Forms | Incorporated new example field forms. Removed one outdated field form. |
| Appendix E | Other Field Screening Methodologies | New appendix that includes detailed information on Business Inspections and Stormwater BMP Inspections. |
| Appendix F | Other Indicators | New appendix that includes detailed information on Potassium indicator. |
| Appendix G | Other Source Tracing Methodologies | New appendix that includes detailed information on Business Inspections and Stormwater BMP Inspections. |

## Scope of Manual

The intended audience for this manual includes local jurisdiction permit coordinators and field staff who implement illicit discharge field screening and source tracing in Washington State. Some of this guidance may also be useful for secondary permittees. This manual focuses on methodologies used for field screening a municipal separate storm sewer system (MS4) for illicit discharges as well as methodologies used for source tracing of potential illicit discharges. The most appropriate methodologies and indicators for any given jurisdiction will be determined based on their specific situation including the location and type of illicit connection or illicit discharge they are tracing, the skill set of and equipment available to their staff and/or contractors, and their priorities. This manual also identifies chemical and physical indicators that can be used to help identify illicit discharges and trace their sources.

## Manual Organization

The rest of this manual is organized into the following major sections:

* [Section 2](#_Definitions_and_Regulatory) – Definitions and Regulatory Requirements
* [Section 3](#_Field_Screening_Methodologies) – Field Screening Methodologies
* [Section 4](#_Indicators) – Indicators
* [Section 5](#_Source_Tracing_Methodologies) – Source Tracing Methodologies
* [Section 6](#_References) – References

# Definitions and Regulatory Requirements

The definitions, acronyms, and regulatory requirements for illicit connections and illicit discharges are included in this section. While most of the definitions and acronyms used here are consistent with the NPDES Municipal Stormwater permits or regulations, some are not. Users of this manual should always refer to their NPDES Municipal Stormwater permits and/or the appropriate regulations for specific definitions and requirements.

## Definitions and Acronyms

Conditionally allowable discharges – This regulatory mechanism may allow the following categories of non-stormwater discharges only if the stated conditions are met and such discharges are allowed by local codes and regulations:

* Discharges from potable water sources, including but not limited to water line flushing, hyperchlorinated water line flushing, fire hydrant system flushing, and pipeline hydrostatic test water. Planned discharges shall be dechlorinated to a total residual chlorine concentration of 0.1 parts per million (ppm) or less, pH-adjusted, if necessary, and volumetrically and velocity controlled to prevent re-suspension of sediments in the MS4.
* Discharges from lawn watering and other irrigation runoff. These discharges shall be minimized through, at a minimum, public education activities and water conservation efforts.
* Dechlorinated swimming pool, spa and hot tub discharges. The discharges shall be dechlorinated to a total residual chlorine concentration of 0.1 ppm or less, pH-adjusted and reoxygenized if necessary, and volumetrically and velocity controlled to prevent resuspension of sediments in the MS4. Discharges shall be thermally controlled to prevent an increase in temperature of the receiving water. Swimming pool cleaning wastewater and filter backwash shall not be discharged to the MS4.
* Street and sidewalk wash water, water used to control dust, and routine external building washdown that does not use detergents. The Permittee shall reduce these discharges through, at a minimum, public education activities and/or water conservation efforts. To avoid washing pollutants into the MS4, Permittees shall minimize the amount of street wash and dust control water used.
* Other non-stormwater discharges. The discharges shall be in compliance with the requirements of a pollution prevention plan reviewed by the Permittee, which addresses control of such discharges.

Continuous discharges – Discharges that occur most or all of the time. Examples of continuous illicit discharges include sewage cross‑connections or failing septic fields. Examples of continuous discharges that are not considered illicit include groundwater flows.

Discharge point – A location where stormwater leaves the Permittee’s MS4 by flowing overland to land owned by another entity, where the stormwater then infiltrates, or by infiltrating to ground from municipal stormwater facilities. Discharge points can include best management practices (BMPs) designed to infiltrate stormwater, and also underground injection wells designed to convey stormwater to the groundwater table.

Ditch system – A series of linear, shallow, and narrow excavations dug in the earth for drainage that are typically planted with grass and designed or used for collecting and conveying runoff.

Dry weather flow – Flowing water observed in a catch basin/manhole, ditch, or outfall after 48 hours without rain that can be composed of one or more of the following types of flow:

* Sanitary wastewater or human/animal waste flows are caused by sewer pipes that are illicitly connected to the MS4, failing or improperly plumbed septic systems, and improper storage of animal waste.
* Washwater flows are caused by illicit connections or improper source control from residential gray water (for example, laundry), commercial carwashes, commercial or municipal fleet washing, commercial laundry, and commercial/industrial floor washing to shop drains.
* Liquid waste refers to illegal dumping of materials such as oil, paint, and process water (for example, radiator flushing water, winemaking residue, food product residual fluids) into the MS4.
* Tap water flows can be observed in the MS4 if leaks and losses are occurring in the drinking water supply system.
* Irrigation overspray flows occur when excess potable water used for residential or commercial irrigation ends up in the MS4.
* Groundwater and spring water flows occur when the local water table rises and enters the MS4 through infrastructure cracks and joints, or where open channels or pipes intercept seeps and springs.

Field screening methodology – Techniques that are used to proactively investigate large sections of a drainage area or storm drainage system (for example, ditches, pipes, catch basins, and manholes) to determine if illicit discharges are present.

Illicit connection (IC) – An illicit connection is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as any infrastructure connection to the MS4 that is not intended, permitted, or used for collecting and conveying stormwater or non-stormwater discharges allowed as specified in the permit. Examples include sanitary sewer connections, floor drains, channels, pipelines, conduits, inlets, or outlets that are connected directly to the MS4.

Illicit discharge (ID) – An illicit discharge is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as any discharge to a MS4 that is not composed entirely of stormwater or of non-stormwater discharges allowed as specified in the permit.

Illicit Discharge Detection and Elimination (IDDE) – An ongoing program required by the NPDES Phase I and Phase II Municipal Stormwater Permits designed to prevent, detect, characterize, trace, and eliminate illicit connections and illicit discharges into the MS4.

Indicator – Water quality parameter or visual/olfactory observation used to determine the presence or absence of an illicit discharge or natural phenomenon.

Intermittent discharges – Illicit discharges that occur over a few hours per day or a few days per year. Examples of intermittent illicit discharges include cross connections between washing machines, which only discharge while they are running, to the MS4.

Land use – The type of development based on visual observations of a drainage basin or as defined by city/county/town zoning maps. For illicit discharge investigations, land use types are divided into the following classifications:

* Urban – Land that is composed of areas of intensive use with much of the land covered by buildings and paved surfaces. This category includes cities, towns, villages, commercial strip developments along major roads and highways, shopping centers, industrial and commercial complexes, and institutions.
* Rural – Development outside of designated urban areas and that are not in long-term resource use areas. This category includes agricultural and rural residential land uses and forested land uses.
* Agricultural – Land that is used primarily for the commercial production of food and fiber. This category includes cropland, pasture, orchards, groves, vineyards, nurseries, ornamental horticultural areas, confined feeding operations, livestock holding areas, farmsteads, horse farms, and farm lanes and roads.
* Commercial – Land that is used primarily for the sale of products and services. This category includes central business districts, shopping centers, office parks, public institutions, and commercial strip developments along major roads and highways.
* Industrial – Land that is used primarily for light and heavy manufacturing, distribution, and warehouse uses. This category includes design, assembly, finishing, processing, and packaging of products (light manufacturing). This category also includes steel mills, pulp and lumber mills, electric power generating stations, oil refineries and tank farms, chemical plants, and brick making plants (heavy manufacturing).
* Mining – Land that is used or was formerly used for strip mining, quarries, and gravel pits. This category includes inactive, unreclaimed, and active strip mines, quarries, borrow pits, and gravel pits until another land cover or land use has been established.
* Residential – Land that is used primarily used for housing. This category includes single family (houses, mobile homes) and multi-family (apartments, condominiums, dormitories, townhouses) development.

Municipal separate storm sewer system (MS4) – A MS4 is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as a conveyance, or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains):

* + 1. Owned or operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of wastes, stormwater, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under Section 208 of the Clean Water Act that discharges to waters of Washington State.
    2. Designed or used for collecting or conveying stormwater.
    3. Which is not a combined sewer;
    4. Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.; and
    5. Which is defined as “large” or “medium” or “small” or otherwise designated by Ecology pursuant to 40 CFR 122.26.

National Pollutant Discharge Elimination System (NPDES) – NPDES is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as the national program for issuing, modifying, revoking, and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Federal Clean Water Act, for the discharge of pollutants to surface waters of the state (waters defined as “waters of the United States” in 40 CFR Subpart 122.2 within the geographic boundaries of Washington State and “waters of the state” as defined in chapter 90.48 RCW, which includes lakes, rivers, ponds, streams, inland waters, underground waters, salt waters and all other surface waters and water courses within the jurisdiction of the State of Washington) from point sources. These permits are referred to as NPDES permits and, in Washington State, are administered by Ecology.

Outfall – An outfall is the point where an approved discharge leaves the Permittee’s MS4 and enters a surface receiving water body or surface receiving waters. Outfalls do not include pipes, tunnels, or other conveyances that connect segments of the same stream or other surface waters and are used to convey primarily surface waters (such as, culverts). This point source definition of an outfall is from the NPDES Phase I and Phase II Municipal Stormwater Permits; 40 CFR 122.2.

Permittee – A Permittee is defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as, unless otherwise noted, includes city, town, or county Permittee, port Permittee, Co-Permittee, Secondary Permittee, and New Secondary Permittee.

Piped system – A series of metal, plastic, or concrete pipes that are designed or used for collecting and conveying stormwater. Access to piped systems is provided through manholes, catch basins, and vaults. Piped systems are typical in urban areas and less typical in rural areas.

Quality Assurance/Quality Control (QA/QC) – A set of activities designed to establish and document the reliability and usability of measurement data and the routine application of measurement and statistical procedures to assess the accuracy of measurement data.

Receiving water body or receiving waters – Defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as naturally and/or reconstructed naturally occurring surface water bodies, such as creeks, streams, rivers, lakes, wetlands, estuaries, and marine waters, or groundwater, to which a MS4 discharges.

Source tracing methodology – Focused techniques that are used to investigate smaller sections of a drainage area or storm drainage system (for example, ditches or pipes) to isolate the source of a confirmed or suspected illicit discharge.

Transitory discharges – Illicit discharges that occur in response to singular events. Examples of transitory illicit discharges include vehicle accidents, spills, ruptured tanks, sewer main breaks, and illegal dumping.

Visual indicators – This manual describes the following visual indicators: deposits and staining, fish kills, floatables, sewage bacteria, structural damage, surface scum or sheen, trash and debris, and abnormal vegetation. Color, odor, and flow are listed separately from visual indicators due to their importance in illicit discharge investigations.

Water quality standards – Defined by the NPDES Phase I and Phase II Municipal Stormwater Permits as Surface Water Quality Standards, Chapter 173‑201A WAC, Ground Water Quality Standards, Chapter 173‑200 WAC, and Sediment Management Standards, Chapter 173‑204 WAC. This manual focuses on the Surface Water Quality Standards, Chapter 173‑201A WAC.

## Regulatory Requirements

Table 2.1 briefly summarizes the requirements for IC and ID field screening and source tracing in the 2019–2024 NPDES Municipal Stormwater permits (Ecology 2019a, 2019b, and 2019c). Table 2.2 briefly summarizes the requirements for IC and ID field screening and source tracing for secondary permittees. For a summary of reporting requirements for sections G3 and S4.F of these permits, refer to Ecology’s Focus on Municipal Stormwater: General Condition G3 Reporting (Ecology 2019d) and Reporting and Notification Requirements webpage <<https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Municipal-stormwater-permit-guidance/Reporting>> or more recent documentation (if available).

|  |  |  |  |
| --- | --- | --- | --- |
| Table 2.1. Requirements in the NPDES Municipal Stormwater Permits Related to Field Screening and Source Tracing. | | | |
| Category | Phase I Permit (2019-2024) | Western Washington Phase II Permit (2019-2024) | Eastern Washington Phase II Permit (2019-2024) |
| Field Screening Requirements | The program shall include implementation of a field screening methodology appropriate to the characteristics of the MS4 and water quality concerns. | | Field assessment activities, including visual inspection of outfalls, discharge points, or facilities serving priority areas during dry weather. |
| Field Screening Methodologies | Screening for illicit connections may be conducted using this updated Manual, the 2013 version of this Manual, or another methodology of comparable or improved effectiveness. | | Not specified in permit, but Permittees must develop procedures (see Field Screening Performance Measures below) |
| Business Inspections | Each Permittee shall update their source control inventory at least once every five years; 20% of these businesses and/or properties shall be inspected annually. | Each Permittee shall develop a source control inventory; 20% of these businesses and/or properties shall be inspected annually starting in 2023. | Permittee shall locate priority areas likely to have illicit discharges, including, at a minimum: evaluating land uses and associated business/industrial activities present; areas where complaints have been registered in the past; and areas with storage of large quantities of materials that could result in illicit discharges, including spills. |
| Field Screening Performance Measures | Each Permittee shall implement an ongoing field screening program of, on average, 12% of the Permittee’s known MS4 each year and track total percentage of the MS4 screened beginning August 1, 2019. | All Permittees shall complete field screening for an average of 12% of the MS4 each year and track total percentage of the MS4 screened beginning August 1, 2019. | Field assessing at least 12%, on average, of the MS4 within the Permittee’s coverage area each year to verify outfall locations and detect illicit discharges. Permittees shall track total percentage of the MS4 assessed beginning August 1, 2019. |
| Source Tracing | The program shall include procedures for tracing the source of an illicit discharge; including visual inspections, and when necessary, opening manholes, using mobile cameras, collecting and analyzing water samples, and/or other detailed inspection procedures. | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 2.2. Requirements in the NPDES Municipal Stormwater Permits Related to Field Screening and Source Tracing for Secondary Permittees. | | | | |
| Category | Phase I Permit Secondary S6.E Permittees (Port of Seattle and Port of Tacoma) (2019–2024) | Phase I Permit Secondary S6.D Permittees (2019-2024) | Western Washington Phase II Permit Secondary Permittees (2019–2024) | Eastern Washington Phase II Permit Secondary Permittees (2019–2024) |
| Field Screening Requirements | Implementation of a field screening methodology appropriate to the characteristics of the MS4 and water quality concerns. | Conduct field inspections and visually inspect for illicit discharges at all known MS4 outfalls and discharge points. | | |
| Field Screening Methodologies | Not specified in permit, but Permittees must develop procedures (see Field Screening Performance Measures below). | | | |
| Business Inspections | Each Permittee shall maintain a list of sites covered by Stormwater Pollution Prevention Plans (SWPPPs); at least 20% the listed sites shall be inspected annually. | Not specified in permit. | | |
| Field Screening Performance Measures | Each Permittee shall conduct field screening of at least 20% of the MS4 each year. | Visually inspect at least one third (on average) of all known MS4 outfalls and discharge points each year beginning no later than 2 years from the initial date of permit coverage. | | |
| Source Tracing | Implement procedures to identify and remove any illicit discharges and illicit connections. | Implement procedures to identify and remove any illicit discharges. | | |

# Field Screening Methodologies

As described in the previous section, each permittee must implement a methodology or multiple methodologies for illicit discharge field screening. The field screening methodologies summarized in this manual are listed below. Several field screening methodologies can also be used to trace the source of an illicit discharge in addition to being used for field screening. Specific information related to field screening is included in this section of the manual. Details on two additional field screening methodologies that are commonly used for other aspects of stormwater management programs, but not commonly used for field screening (Business Inspections and Stormwater BMP Inspections) are included in Appendix E. Specific information related to source tracing for these methodologies is included in [Section 5.0 – Source Tracing Methodologies](#_Source_Tracing_Methodologies).

|  |  |
| --- | --- |
| Field Screening Methodologies | Field Screening and Source Tracing Methodologies |
| * Catch basin/manhole inspections * Ditch inspections * Outfall inspections * Video inspections | * Catch basin/manhole inspections * Ditch inspections * Video inspections |

## Selecting a Field Screening Methodology

Since illicit discharge field screening is a proactive technique for detecting illicit connections and illicit discharges, the field screening methodology or methodologies should be selected based on the system type. The field screening methodologies that are included in this manual are summarized below with their applicable system type:

|  |  |
| --- | --- |
| Piped Systems | Ditch Systems |
| * Catch basin/manhole inspections * Outfall inspections * Video inspections | * Catch basin/manhole inspections * Ditch inspections * Outfall inspections |

An IDDE program manager should select one or more field screening methodologies to screen a portion of their MS4 each year. The methodology or methodologies should be selected based on what each jurisdiction determines to be the most appropriate depending on their priorities; however, some general guidelines are provided below:

* Incorporate work that is already underway: For example, if your jurisdiction is already performing business inspections (see Appendix E) as part of the NPDES municipal stormwater permit requirements (Phase I and western Washington Phase II jurisdictions) or voluntarily (either through the local source control program or as part of your stormwater management program), incorporate that field screening methodology into your IDDE program. If you are planning on conducting video inspections to assess the condition of your stormwater pipes, review the videos to look for indicators of illicit connections as well.
* Incorporate IC and ID identification into daily work activities: For example, in the course of routine public and private stormwater facility operation and maintenance (O&M) inspections, questions can be added to standard catch basin/manhole inspection forms to trigger an IDDE investigation if a color, odor, or visual indicator is observed.
* Review your storm drainage system information: Do you have 50, 500 or 5,000 outfalls? If you have fewer outfalls that cover large drainage areas, outfall inspections during dry weather may be the most cost-effective approach for your jurisdiction. Although outfall inspections may be the most cost effective, they may not result in finding all the illicit connections or illicit discharges in a drainage basin and should be combined with one or more other field screening methodologies such as business inspections (see Appendix E) or video inspections. If you have numerous outfalls, strategic catch basin/manhole inspections may be more cost effective than outfall inspections.
* Contracting out IC and ID field screening work: If sufficient staff time, equipment, or skills are not available to perform a particular field screening methodology, a private contractor can be hired to perform the work. It is important that the selected contractor has the required expertise to perform the field screening methodology and that they follow the appropriate safety protocols.

Refer to the [Field Screening Methodology Pullout sections](#_Field_Screening_Methodology) for additional information on the pros and cons and applications of each methodology to select the most appropriate field screening methodologies to use for your situation. Once you have selected one or more field screening methodologies, follow the methods outlined in the [Field Screening Methodology Pullout sections](#_Field_Screening_Methodology) or modify them as appropriate to meet the unique characteristics of your jurisdiction.

Conduct the field screening during dry weather, typically defined as 48 hours or more without rainfall, if possible to narrow down the potential sources that may be present in any discharge that you observe. Follow-up investigations (using [Source Tracing Methodologies](#_Source_Tracing_Methodologies)) can be conducted during dry and/or wet weather. [Figure 3.1](#Figure31) can be used as a guide to determine the next steps in the illicit discharge identification process. If you already know which source tracing methodology that you would like to use, you can skip this flow chart.

Must fall on odd-numbered page

Figure 3.1. Field Screening and Source Tracing Methodology Flow Chart.

8.5 x 11

## General Guidelines

The following guidelines for data management recommendations, safety considerations, and costs apply to all the field screening methodologies summarized in this section.

### Data Management Recommendations

The NPDES Municipal Stormwater Permits reissued in 2019 included an updated and prescriptive reporting requirement for IDDE programs. The reporting must include information addressing 12 questions on key details of each ID incident found:

1. Jurisdiction name and permit number
2. Date incident discovered or reported
3. Date of beginning of response
4. Date of end of response
5. How was the incident discovered or reported?
6. Discharge to MS4?
7. Incident location
8. Pollutants identified
9. Source or cause
10. Source tracing approach(es) used
11. Correction/elimination methods used
12. Field notes, explanations, and/or other comments

The IDDE reporting questions and the recommended verbiage for the answers are the same for all permittees and are listed in Appendix 14 of the NPDES Phase I Municipal Stormwater Permit, Appendix 12 of the NPDES Phase II Municipal Stormwater Permit for Western Washington, and Appendix 7 of the NPDES Phase II Municipal Stormwater Permit for Eastern Washington.

Related to these reporting requirements, a spatially referenced data management system (for example, an ArcGIS geodatabase, Cartegraph, Cityworks, a Microsoft Access database, a custom database, or a combination of these) is an important component of any IDDE program. Regular updates to the system with IC/ID field screening information will reduce level of effort for annual reporting to Ecology. The information stored in the data management system should be evaluated on an annual basis at a minimum to adjust the IDDE program as needed. Table 3.1 provides a summary of the some of the information that should be tracked in relation to each field screening methodology for this purpose. This table includes basic guidance on tracking and reporting recommendations, but is not intended to provide an exhaustive list of all of the information that should be tracked for an IDDE program. If an app is used for data collection, then the scanning and recording of data recorded on a hard copy paper form can be skipped and the electronic data can be compiled directly into a spreadsheet or database.

|  |  |
| --- | --- |
| Table 3.1. Data Management Recommendations for Field Screening Methodologies. | |
| Field Screening Methodology | Tracking and Reporting Recommendations for the 2019–2024 Permits |
| Catch basin/manhole inspections | * Location of inspection (address/intersection, city, and zip or latitude/longitude) * Number of catch basins/manholes inspected * Area that drains to each catch basin/manhole * Number and types of illicit discharges or illicit connections identified (address 12 questions in the NPDES permit) * Catch basin/manhole inspection forms (or electronic database) * Digital photographs * Indicator sampling data * Follow-up sampling data * Flow data (if collected) |
| Ditch inspections | * Location of inspection (address/intersection, city, and zip or latitude/longitude) * Linear feet of ditch inspected * Area that drains to each ditch * Number and types of illicit discharges or illicit connections identified (address 12 questions in the NPDES permit) * Ditch inspection forms (or electronic database) * Digital photographs * Indicator sampling data * Follow-up sampling data * Flow data (if collected) |
| Outfall inspections | * Location of inspection (address/intersection, city, and zip or latitude/longitude) * Number of outfalls screened * Area that drains to each outfall * Number and types of illicit discharges or illicit connections identified (address 12 questions in the NPDES permit) * Outfall inspection forms (or electronic database) * Digital photographs * Indicator sampling data * Follow-up sampling data * Flow data (if collected) |
| Video inspections | * Linear feet of pipe videotaped and reviewed * Pipe network area that drains to each pipe segment * Number and types of illicit discharges or illicit connections identified (address 12 questions in the NPDES permit) * Video labeling and archiving |

Table 3.2 provides recommendations on calculating the 12 percent annual field screening requirement in the NPDES Municipal Stormwater Permits. Ecology does not specify how this percentage should be calculated but only specifies that permittees shall screen 12 percent on average of their MS4, and new permittees shall screen at least 12 percent of their MS4 by December 31, 2023. Options for determining the number, length, and area of screening locations are listed in Table 3.2. If combining multiple methodologies, either length or area should be used.

|  |  |  |  |
| --- | --- | --- | --- |
| Table 3.2. Options for Annual Field Screening Percentage Calculation. | | | |
| Field Screening Methodology | Number | Length (feet or miles) | Area (square miles) |
| Catch basin/manhole inspections | Number of catch basins/manholes inspected | Calculation metric may be applieda | Areas that drains to each catch basin/manhole |
| Ditch inspections | Not applicable | Linear feet of ditch inspected | Area that drains to each ditch |
| Outfall inspections | Number of outfalls screened | Calculation metric may be applieda | Area that drains to each outfall |
| Video inspections | Not applicable | Linear feet of pipe videotaped and reviewed | Pipe network area that drains to each pipe segment |

a A jurisdiction may be able to assign a linear metric such as 0.2 miles of linear conveyance to each catch basin or outfall for “conveyance screening purposes.”

### Safety Considerations

Safety is an important factor when conducting field screening investigations. General safety considerations include the following:

#### Manholes

* Having a field crew of at least two people.
* Properly lifting manhole covers to reduce the potential for back injuries.
* Testing for presence of flammable or toxic fumes in manholes.
* Testing for oxygen levels in manholes.
* Only entering a manhole when necessary. If entering a manhole, confined space entry training and equipment is necessary. Equipment must be in good working order and must be properly utilized whenever confined space entry is performed.

#### Surrounding Environment

* Having a field crew of at least two people.
* Being aware of the environment of the facilities field crews will enter and taking proper precautions (for example, forklifts, hazardous materials exposure, hearing, eye, and respiratory protection).
* Using appropriate traffic control equipment and clothing (for example, traffic cones and safety vests) when working in or near the road right-of-way. The Manual on Uniform Traffic Control Devices, Part 6 (Federal Highway Administration 2012) establishes flagger responsibilities and methods of operations. If the decision is made that traffic control flagging is needed, guidance provided in the “Traffic Control Flagger Certification” handbook (Evergreen Safety Council 2012) should be followed.
* Reviewing local codes for information related to private property access and confirming policies with internal managers.
* Notifying landowners and obtaining permission before accessing private property. Inspectors should be familiar with drainage system maps and private and public property lines. Inspectors should refer to the jurisdiction’s protocols for requesting access to private properties when access to private property is needed. Contact information for the private property owner should be collected at the time of inspection or prior to inspection if inspection of the property is anticipated. Follow‑up correspondence with property owners may be required.

#### Prevention

* Vaccinating field staff for Tetanus and Hepatitis B if crews will be working near metal equipment or accessing waters suspected to be contaminated with sewage discharges.
* Wearing sturdy boots or belted waders.

### Costs

Costs for representative field screening equipment and materials are summarized in Appendix A. The authors and clients or any other governmental agency referenced in this manual do not promote, endorse, or otherwise recommend any of the companies, individuals, or organizations presented in Appendix A. Rather, costs and equipment are provided for informational purposes only and do not represent a complete list of vendors or equipment.

## Field Screening Methodology Pullout Sections

Each of the following field screening methodology pullout sections contains the following information:

* Description: Field screening methodology definition
* Applications: Lists the applicable storm drainage system types (pipes and ditches), land use types (urban, rural, agricultural, commercial, industrial, mining, and residential), and weather conditions (dry and wet)
* Equipment: Checklist for field crews to determine what materials and supplies to bring to the field
* Methods: Generic standard operating procedures for conducting each field screening methodology
* Pros and cons: List of the positive and negative aspects of the field screening methodology

### Catch Basin/Manhole Inspections

#### Description

Catch basin/manhole inspections are a field screening methodology that involves removing catch basin and manhole lids and observing if flow, odor, color, or visual indicators are present during dry weather. One option for implementing catch basin/manhole inspections is to train stormwater maintenance staff on how to identify illicit discharges during routine inspections and to add tracking information regarding illicit discharges to related inspection forms. If flowing water is observed during dry weather, likely sources are groundwater inflow or an illicit discharge or connection, and the structure should be flagged for follow-up investigation. Catch basin/manhole inspections can also be used as a source tracing methodology once a suspected illicit discharge has been found to track the illicit discharge to its source (refer to [Catch Basin/Manhole Inspections](#_Catch_Basin/Manhole_Inspections) in the Source Tracing Methodologies section).

#### Applications

Catch basin/manhole inspections can be used to screen branches of the storm drainage system for illicit discharges. Catch basin/manhole inspections can be used for field screening if a larger drainage area is divided into branch or segments containing 10 to 20 structures or fewer.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Small drainage areas (20 structures or fewer) | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

The following suggested staffing and equipment apply to catch basin/manhole inspections:

* Two or more field staff
* Cell phones or 2‑way radios
* Detailed maps of the storm drainage and sanitary sewer system
* Field laptop/tablet (with charged battery) and/or clipboard, field forms (customized with line items for illicit discharge observations), and pen/pencil
* GPS unit
* Camera, phone, or other device for taking pictures (with date and time stamp)
* Dry erase board and pen for labeling catch basins or manholes (optional)
* Tape measure
* Traffic control signs and orange cones
* Confined space entry equipment (if needed)
* Various catch basin/manhole cover removal hooks and wrenches (including 7/16‑inch hexagonal Allen key for standard manhole cover bolts)
* Sledge hammer for loosening lids
* Safety equipment (for example, hard hats, work gloves, ANSI 107‑1999 labeled safety vests, steel-toe boots, ear protection, gas monitor)
* Primary field screening indicator equipment (see Flow, Ammonia, Color, Odor, pH, Temperature, Turbidity, Specific Conductivity and Visual Indicators sections)

#### Methods

The methods for conducting catch basin/manhole inspections as well as the format of the inspection form used can be modified by each jurisdiction as needed. Two general methods for conducting catch basin/manhole inspections for field screening are provided below.

***Notes:***

1) Only staff with confined space entry training should enter manholes or other confined spaces.

2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.

##### Monitoring Node Approach

|  |
| --- |
| 16 |
| Manhole inspection (Photo Credit: City of Seattle). |

1. Office Investigation:
   1. Identify pairs of staff who will work together. The buddy system is recommended for field work for health and safety reasons. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control and confined space entry needs before heading into the field. Staff should carry a current ID and business cards when conducting field work.
   2. Review GIS field maps of the drainage basin or subbasin that will be investigated.
   3. Identify the storm drainage mainline and strategic monitoring nodes/intersections where several branch lines connect to the mainline.
   4. Select monitoring nodes where field inspection and sampling, if needed, might quickly eliminate large portions of the drainage basin.
2. On‑Site Investigation:
   1. Assess nearby traffic and potential hazards to pedestrians at each catch basin/manhole to be inspected. Set up signs and cones as needed. Washington State Flagger Certification is required if placing cones in traffic; traffic flagging regulations must be followed.
   2. Check the atmosphere within the manhole structure if you suspect that explosive or toxic gases may be present. Use a gas monitor (as you would during confined space entry).
   3. Assign a unique number or identifier and record the latitude and longitude of the structure using a GPS unit if this has not previously been done.
   4. Document any visual, olfactory, or auditory indicators observed using a field notebook, customized catch basin/manhole maintenance inspection form, or a drop-down menu (for example, data dictionary) on a GPS unit.
   5. Check for dry weather flow from any of the pipes into the catch basin/manhole, and document the pipe location and direction that the flow is coming from.
      1. Collect a sample if dry weather flow is observed and record values for the other primary field screening indicators (pH, temperature, turbidity, conductivity, and ammonia). Refer to the [Indicators](#_Indicators) section for additional detailed information regarding how these samples should be collected and analyzed.
      2. Take a photograph if an illicit discharge is suspected. Optional: Use a dry erase white board next to the structure and include the date, time, structure ID, and inspector(s) initials.
      3. Trace flow using source tracing methodologies if visual indicators suggest that an illicit discharge is present.
   6. Continue to the next monitoring node and repeat steps 2a through 2e.
3. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.
4. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

##### Routine Maintenance Approach:

Revise the field form or GPS data dictionary that staff use to document routine catch basin/manhole inspections. The following fields are recommended for describing potential illicit discharges that may require follow-up investigation:

* [Color](#_Color)
* [Odor](#_Odor)
* [Turbidity](#_Turbidity)
* [Visual indicators](#_Visual_Indicators):
  + Deposits and staining
  + Fish kills
  + Floatables
  + Sewage bacteria
  + Structural damage
  + Surface scum or sheen
  + Trash and debris
  + Vegetation

Use the following steps during routine maintenance inspections:

1. Evaluate the following:
   1. Water inside of a catch basin/manhole for evidence of color, odor, turbidity, and visual indicators
   2. The condition of the structure for the following visual indicators: deposits and staining, structural damage, and vegetation
   3. The area immediately surrounding the structure for signs of visual indicators
2. Document any visual, olfactory, or auditory indicators observed using a field notebook, field form, or a drop-down menu (for example, data dictionary) on a GPS unit.
3. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Quick and inexpensive * Can eliminate branches of a storm drainage network from screening if no flow or visual indicators are present * Can test multiple storm drainage system branches that flow to a single manhole * Effective if storm drainage network is already mapped * Highly efficient if used in combination with routine catch basin/manhole inspections | * Some manholes will have flow continuously year-round due to groundwater inflow * Traffic hazards and danger to pedestrians when accessing some catch basins/manholes * Potential for toxic or flammable pollutants and hazards if confined space entry is necessary * Can be time consuming and difficult if storm drainage map is unavailable or incomplete * Less effective in wet weather than dry weather * Wet weather safety considerations for confined space entry |

### Ditch Inspections

#### Description

Inspections of ditches and similar open channels or swales can be used as a field screening methodology to help identify illicit discharges, especially in rural areas that do not have piped stormwater conveyance systems. In addition to conveying stormwater flows from the municipal separate storm drainage system, ditches also receive flows with potential illicit discharges from adjacent private property via straight pipes, swales, or seepage from failing septic systems. Ditches may also convey natural flow and can be identified by their flow patterns and historical drainage patterns:

* If a ditch only flows during storm events or periods of site discharges and/or was specifically built to convey stormwater or discharge water, then it is not typically considered to be a ditch that conveys natural flow.
* If a ditch is located in an area where there historically was a stream, then it is likely that the ditch still conveys some natural flows.

One option for implementing ditch inspections is to train stormwater maintenance staff on how to identify illicit discharges during routine maintenance and to add tracking information regarding illicit discharges to related inspection forms. Ditch inspections can also be used as a source tracing methodology once a suspected illicit discharge has been found to track the illicit discharge to its source (refer to [Ditch Inspections](#_Ditch_Inspections) in the Source Tracing Methodologies section).

#### Applications

Ditch inspections are most commonly conducted in rural areas, but can also be used in urban areas that do not have piped storm drainage systems. Ditch inspections are one of the best field screening methodologies to use in agricultural and rural residential settings with large drainage areas when performed using a combination of driving and walking.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Ditches * Large drainage areas | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

The following recommendations for staffing and equipment apply specifically to ditch inspections:

* Two field staff
* 1 to 2 vehicles
* Cell phones or 2‑way radios
* Detailed maps of the storm drainage and sanitary sewer systems
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* GPS unit (optional)
* Camera, phone, or other device for taking pictures (with date and time stamp)
* 25′ or 50′ flexible tape measure, string, or twine
* Sturdy boots or belted waders
* Safety equipment (for example, hard hats, work/leather gloves, ANSI 107‑1999 labeled safety vests)
* Machete and/or loppers
* Primary field screening indicator equipment (see Flow, Ammonia, Color, Odor, pH, Temperature, Specific Conductivity, Turbidity, and Visual Indicators sections)

#### Methods

The methods for conducting ditch inspections as well as the format of the inspection forms used can be modified by each jurisdiction as needed. Two general methods for conducting catch basin/manhole inspections for field screening are provided below.

##### Vehicle/Foot Reconnaissance Approach:

1. Identify pairs of staff who will work together. The buddy system is recommended for field work for health and safety reasons. Review the Safety Considerations in Section 3.2 of this manual. Consider property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

Notes:

1) As a general rule, do not enter private property without permission from the landowner.

1. Review GIS field maps of the drainage basin or subbasin that will be investigated.

|  |
| --- |
|  |
| Ditch inspection (Photo Credit: Herrera). |
| Cheater Pipe |
| Cheater pipe (Photo Credit: unknown). |

1. Select a driving route that includes a majority of the drainage basin or subbasin being investigated and highlights specific focus areas based on adjacent land uses that have a higher potential for illicit discharges. Driving through a drainage area can help to screen larger drainage areas that would be difficult to survey solely by foot.
2. Drive the route slowly and stop frequently to record observations and to take photographs. If two staff are present, one can record observations while the other focuses on driving.
3. Perform a walking survey at the confluence of several ditches where they come together at nodes near road intersections.
4. Record observations of the following indicators: color, odor, turbidity, visual indicators (deposits and staining, floatables, abnormal vegetation, sewage bacteria, etc.) and auditory indicators. Refer to the [Indicators](#_Indicators) section for additional detailed information regarding how to evaluate these observations.
5. Check for dry weather flow from any of the pipes into the ditch (if inspection is occurring during dry weather) and document the pipe location and direction that the flow is coming from.
6. Record observations of other items of interest such as invasive vegetation, ditch areas in need of maintenance, damaged culverts under roads, etc.
7. Document evidence of the following:
   1. Discharge locations: pipe diameter and material or ditch/channel width
      1. Cheater pipes (pipes that bypass the drain field of a septic system)
      2. Other private drainage ditches or open channels
   2. Impacting Land Uses and Activities: visual observations
      1. Pastures with grazing animals, horse and livestock corrals, and animal feed lots
      2. Adjacent landscaping
      3. Parking lots
      4. Engine/mechanical repair shops
      5. Other land uses that could generate illicit discharges, especially those with outdoor operations and activities
   3. Dump sites: approximate area, distance to ditch, and type of debris
      1. Small debris (for example, bottles, cans, and trash)
      2. Large debris (for example, shopping carts, abandoned cars, appliances, large quantities of yard waste [grass and yard clippings, piles of leaves], and/or miscellaneous pieces of junk)
      3. Trash or improvised latrines from homeless encampments
8. Record the location of each item of interest in steps 4 and 5 on a field map or using a GPS unit.
9. Take photographs of each item of interest.
10. Collect a sample if dry weather flow is present and record values for the other primary field screening indicators (pH, temperature, turbidity, specific conductivity, and ammonia). Refer to the [Indicators](#_Indicators) section for additional detailed information regarding how these samples should be collected and analyzed.
11. Trace flow using source tracing methodologies if visual indicators suggest that an illicit discharge is present.
12. Fill out a field form or use a GPS unit with drop-down menus (for example, data dictionary) to document all observations from the ditch inspection.
13. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.
14. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

##### Routine Maintenance Approach

Revise the field form or GPS data dictionary that staff use to document routine ditch inspections. The following fields are recommended for describing potential illicit discharges that may require follow-up investigation:

* [Color](#_Color)
* [Odor](#_Odor)
* [Turbidity](#_Turbidity)
* [Visual indicators](#_Visual_Indicators):
  + Deposits and staining
  + Fish kills
  + Floatables
  + Sewage bacteria
  + Structural damage
  + Surface scum or sheen
  + Trash and debris
  + Vegetation

Use the following steps during routine maintenance inspections:

1. Evaluate the following:
   1. Water floating in ditch for evidence of color, odor, turbidity, and visual indicators
   2. The condition of the ditch for the following visual indicators: deposits and staining, structural damage, and vegetation
   3. The area immediately surrounding the ditch for signs of visual or auditory indicators
2. Document any visual, olfactory, or auditory indicators observed using a field notebook, field form, or a drop-down menu (for example, data dictionary) on a GPS unit.
3. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Can be used to locate unknown outfalls and update mapping * Can quickly detect illicit connections or illicit discharges if present * Can be used to identify other issues (for example, invasive vegetation or maintenance needs) * Highly efficient if used in combination with routine ditch inspections or road maintenance activities | * Ditches can be difficult and even hazardous to access when vegetation is thick and/or when sides slopes are steep * Dense vegetation can make visual observations and finding outfalls or cheater pipes difficult * Access to ditches may be limited by permission to enter private property * Less effective in wet weather than dry weather |

### Outfall Inspections

#### Description

Outfall inspections can be used as a field screening methodology to identify illicit discharges when flow is present or when visual, olfactory, or other indicators (for example, a greasy film) are observed. Outfall inspections are best conducted during dry weather and periods of low groundwater flow, generally at least 48 to 72 hours following the last runoff-producing rainfall event. If outfalls still have flow during dry weather, the flow should be investigated further to determine if the source is groundwater inflow to the storm drainage system or an illicit discharge or illicit connection.

#### Applications

Outfall screening applies to all storm drainage system and land use types. When flow is observed in an outfall pipe, primary field screening indicator sampling should be conducted.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

The following recommendations for staffing and equipment apply specifically to outfall inspections:

* Two field staff
* Cell phones or 2‑way radios
* Detailed maps of the storm drainage and sanitary sewer systems
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* GPS unit
* Camera, phone, or other device for taking pictures (with date and time stamp)
* Dry erase board and dry erase marker for labeling outfalls
* High-powered lamps or flashlights/headlamps with batteries
* Tape measure
* Safety equipment (for example, hard hats, work gloves, ANSI 107‑1999 labeled safety vests, steel‑toe boots)

Notes:

1) Only staff with confined-space entry training should enter an outfall or other confined space.

2) As a general rule, do not enter private property without permission from the landowner.

* Primary field screening indicator equipment (see [Flow](#_Flow), [Ammonia](#_Ammonia), [Color](#_Color), [Odor](#_Odor), [pH](#_pH), [Temperature](#_Temperature), [Specific Conductivity](#_Specific_Conductivity), [Turbidity](#_Turbidity), and [Visual Indicators](#_Visual_Indicators) sections)
* Machete and/or loppers

#### Methods

The methods for conducting outfall inspections as well as the format of the inspection forms used can be modified by each jurisdiction as needed. The following general guidance is suggested for completing outfall inspections.

1. Identify pairs of staff who will work together. The buddy system is recommended for field work for health and safety reasons. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control, confined space entry needs, and property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.
2. Drive or walk to the outfall to be inspected. Refer to your storm drainage system map to determine if the outfall has been previously documented. Assign a unique number or identifier to the outfall if the outfall has not been previously documented. Note that if the outfall is not accessible, the nearest catch basin(s) upstream of the outfall can be considered to be used as ‘proxies’ for the outfall (See [Catch Basin/Manhole Inspections](#_Catch_Basin/Manhole_Inspections_1) section).

|  |
| --- |
| SDC10199 |
| Outfall inspection (Photo Credit: Herrera). |

1. Record the latitude and longitude of the outfall at the end of the pipe using a GPS unit if this has not previously been done.
2. Use a dry erase board to record down the date, time, outfall number, and inspector(s) initial. Photograph the white board next to the outfall.
3. Record the following information on an outfall inspection form or using drop-down menus (for example, data dictionary) on a GPS unit:
   1. Background Data: Receiving water, outfall ID, land use, etc.
   2. Outfall Description: location (closed pipe or open swale/ditch), material type, shape, and dimensions, and whether the outfall is submerged.
   3. Flow Measurements: (such as, quantitative characterization) for flowing outfalls only.
   4. Physical Indicators: color, odor, turbidity, and visual indicators (for example, deposits and staining, floatables, abnormal vegetation, sewage bacteria in pool below outfall, etc.). Refer to the [Indicators](#_Indicators) section for additional detailed information regarding how to evaluate these observations.
   5. Overall Outfall Characterization: unlikely illicit discharge, potential illicit discharge, obvious/likely illicit discharge
   6. Data Collection: collect a sample if dry weather flow is observed in an outfall pipe and record values for the other primary field screening indicators (pH, temperature, turbidity, and ammonia). Refer to the [Indicators](#_Indicators) section for additional detailed information regarding how these samples should be collected and analyzed.
   7. Trace flow using source tracing methodologies if visual indicators suggest that an illicit discharge is present.
4. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.
5. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Relatively quick and inexpensive * Testing at an outfall can quickly screen flows from large portions of a storm drainage basin or subbasin | * Many outfalls flow continuously year-round due to groundwater inflow * An illicit discharge may be too diluted to be detected by the time it reaches an outfall * Outfalls can be difficult to access when vegetation is thick and/or terrain is steep/rough * Access to outfalls is often limited by permission to enter private property * Less effective during wet weather than dry weather |

### Video Inspections

#### Description

Video inspections are used as a field screening methodology to assess the condition of pipes and structures over a large area of the storm drainage system. Along with this condition assessment, indicators of illicit connections or illicit discharges can be recorded that will trigger follow-up source tracing investigations in smaller sections of the storm drainage system. Video inspections can also be used as a source tracing methodology once a suspected illicit discharge has been identified to track the illicit discharge to its source (refer to [Video Inspections](#_Video_Inspections) in the Source Tracing Methodologies section).

#### Applications

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Larger diameter pipes (>3 or 4 inches) * Large drainage areas | * Rural * Urban * Commercial * Industrial * Residential | * Dry * Wet |

Video inspections are effective in large drainage areas to perform a coarse screening and assessment of the condition of pipes and structures in the storm drainage system. Sewer cameras are typically used to determine if there are cracks, leaks, or cross connections in sewer pipes. The same methodology used for televising sewer lines can be applied to storm drainage systems for screening branches of the system for illicit discharges or illicit connections. This methodology is most effective for identifying continuous or intermittent discharges or connections by working up the storm drainage system and inspecting larger mainline storm drainage pipes.

#### Equipment

Different types of video equipment are used based on the diameter of storm drainage pipe being inspected. A site visit should be conducted prior to purchasing any video inspection equipment to determine the most appropriate video camera size, material, capabilities, and accessories. Equipment specific to video inspections includes:

* Closed-Circuit Television (CCTV), capable of radial view and in color. Camera options include:
  + Mini cameras (1.5‑inch to 4‑inch diameter pipes)
  + Lateral cameras (3‑inch to 8‑inch diameter pipes)
  + Mainline crawler/tractor cameras (4‑inch to 10‑inch diameter pipes)
  + Pull cameras
* 200 to 400‑foot push reel
* Tractor or crawler unit for camera
* Skid unit for camera
* Raft for camera (if water is present in storm pipe)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Television system (truck, van, or utility trailer)
* High-powered lamps or flashlights
* Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
* Sledge hammer for loosening lids
* Safety equipment (for example, hard hats, work gloves, ANSI 107‑1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment, gas monitor)

#### Methods

Each video camera and video inspection system will have different instructions depending on its manufacturer, intended application, and capabilities. It is important to read the instructions for each component of the video inspection system closely, as equipment is expensive and potential damage to equipment should be minimized as much as possible. In general, field crews should implement the following steps during and prior to a video inspection:

1. Determine the condition of the pipe segment being tested (such as, diameter, water ponding). If excessive debris or other material in the pipe is suspected, the pipe should be cleaned prior to conducting a video inspection.
2. Select an appropriately sized camera and camera navigation system for the pipe segment (for example, tractor or crawling unit, skid unit, raft).
3. Orient the CCTV to keep the lens as close as possible to the center of the pipe.
4. Record a video with an audio voice over as the camera is guided through the pipe to document significant findings for future review and evaluation.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Pinpoints exact location of breaks, infiltration, cross connections between manhole structures * Safer than confined space entry * Does not require intrusion on members of public | * Expensive, rig including cameras, monitors, trailers and associated equipment can be expensive * Only captures continuous discharges from pipes that are not submerged * Requires field crew training to operate equipment * May require line cleaning before equipment can be used * Specialized equipment needed for smaller diameter pipes * Debris and other obstructions can block off storm drainage pipe and restrict camera usage * Less effective in wet weather than in dry weather |

### Other Field Screening Methodologies

The following field screening methodologies were not included in this manual due to the high cost of implementation and the specialized nature of these methodologies. However, IDDE program managers may want to develop and use these methodologies on a case‑by‑case basis:

|  |  |
| --- | --- |
| Other Field Screening Methodologies | Description |
| Automated Sampling | This methodology uses automated sampling equipment installed in catch basins or manholes, or near outfalls to sample intermittent flows. Laboratory testing is performed on the collected samples. Ecology (2018) has developed standard operating procedures and the USGS (2014) has developed a field manual that may be useful references when implementing automated sampling. |
| Business Inspections | Business inspections are performed to identify pollutant-generating sources at commercial, industrial, and multifamily properties and enforce implementation of required BMPs that prevent pollutants from discharging into storm drainage systems. Business inspections can also be used as a source tracing methodology. See Appendix E for more details. |
| Canine Scent Tracking | Methodology using trained dogs (for example, a canine “K‑9” unit) to perform scent tracking. |
| Infrared Color Aerial Photography | This methodology uses color as an indicator to detect changes in plant growth, differences in soil moisture content, and the presence of standing water on the ground to identify failing septic systems. |
| Infrared Thermography | This methodology uses the temperature difference of sewage as a marker to locate failing septic systems. It can be employed as a field screening methodology on a landscape scale using aerial photography systems, and also as a source tracing methodology on an in-pipe scale using video inspection systems. |
| Intensive Sampling | Intensive sampling can also be performed with automated sampling equipment or sampling conducted during base flow or storm events. |
| Sediment Trap Sampling | This methodology uses sediment traps to trace and locate sources of contamination that have adhered to storm solids and sediment (such as, polychlorinated biphenyls [PCBs] and polycyclic aromatic hydrocarbons [PAHs]). Grab samples of settled stormwater solids from catch basin/manhole sumps can also be analyzed and used to trace such sources. |
| Stormwater BMP Inspections | Stormwater BMPs include detention facilities such as ponds and vaults, stormwater treatment facilities such as stormwater wetlands and biofiltration swales, and low impact development (LID) facilities such as bioretention and permeable pavement. Stormwater maintenance staff can be trained to identify illicit discharges during routine maintenance, inspection, or repair activities. See Appendix E for more details. |
| Stream Walks | Stream walks involve walking along or wading in a stream and identifying outfall locations, indicators of potential illicit discharges, illegal dumping, and streambank erosion. This type of assessment can also be performed along the shore of a lake, pond, inlet, strait, or Puget Sound using a boat (for example, canoe, kayak, or motorboat). Stream walks are best conducted during dry weather (generally at least 48 to 72 hours following the last runoff-producing rainfall event) and after leaves have fallen (dense vegetation can make it difficult to locate outfalls and obtain accurate GPS coordinates). Local jurisdictions may have specific requirements for obtaining permission from adjacent property owners prior conducting a stream walk. |

# Indicators

Indicator sampling is a useful tool to determine the presence and potential threat to public health and the environment. Some illicit discharges are fairly obvious and have distinct colors, odors, sounds of flow or visual indicators and can be identified during field screening. Other illicit discharges, however, may not be as easy to detect using visual and olfactory observations and require additional steps to indicate what is being discharged.

If flow is present during dry weather, then indicator sampling or evaluation should be conducted for the primary field screening indicators listed below. These indicators were selected since they are typically quick and easy to observe or measure to determine if an exceedance of a recommended threshold is present. Recommended thresholds for the primary field screening indicators are summarized in [Figure 4.1](#Figure41) and [Figure 4.2](#Figure42) and in the indicator pullout sections. Exceedances of the recommended primary field screening indicator thresholds indicate that an illicit discharge may be present and trigger further sampling of one or more follow-up indicators listed below.

|  |  |
| --- | --- |
| Primary Field Screening Indicators | Follow-Up Indicators |
| * Ammonia * Color * Odor * pH * Temperature * Turbidity * Visual indicatorsa | * Bacteria * Chlorine * Detergents/Surfactants * Fluoride * Hardness * Nitrate * Specific conductivity * Total petroleum hydrocarbons |

a Visual indicators include floatables, debris, vegetation, deposits and staining, structural damage, sewage bacteria, surface scum or sheen, fish kills.

## Selecting an Indicator

As summarized above, the primary field screening indicators should typically be evaluated in all situations where flow is present during dry weather. Indicator sampling will typically occur using the methods specified in one of the following field screening methodology sections (see [Figure 3.1](#Figure31)):

* Catch basin/manhole inspections
* Ditch inspections
* Outfall inspections

The exact location of the indicator sampling depends on where the suspected illicit discharge was observed. If the suspected illicit discharge was observed during an outfall inspection, then indicator sampling should occur at the outfall. If exceedances are measured, successive source tracing methodologies should be conducted back up through the storm drainage network. The storm drainage network could include either pipes or ditches, which should be sampled from catch basins/manholes or from ditches.

Once a sample has been collected, the inspector should follow the [Figure 4.1](#Figure41) flow chart if indicator sampling has occurred in an urban area or the [Figure 4.2](#Figure42) flow chart if indicator sampling has occurred in a rural area. For indicators that will be analyzed in the field, the field quality assurance/quality control (QA/QC) procedures summarized in the General Guidelines section below should be followed. For indicators that will be analyzed in the lab, the laboratory QA/QC procedures summarized in the General Guidelines section below should be followed.

The flow charts provided in [Figure 4.1](#Figure41) and [Figure 4.2](#Figure42) assume that the source of illicit discharge is unknown until indicator sampling is conducted. There are certain cases; however, in which the presence of an illicit discharge can be determined based on results from the primary field screening indicators and observations of the surrounding area. In these cases, it is helpful to select an indicator or multiple indicators to confirm the suspected source of the illicit discharge. Table 4.1 lists follow-up indicators that can help to confirm the type and source of an illicit discharge based on the suspected source and primary field screening indicator observations.

In some cases, additional indicator sampling, land survey, or specialized investigation may be necessary. Refer to the [Other Indicators](#_Other_Indicators) section at the end of this section for other indicators that may be used for these cases. The case studies included in Appendix C may also provide some useful guidance in determining what the source of a potential illicit discharge may be.

If sufficient staff time, equipment, or skills are not available to perform indicator sampling, a private contractor can be hired to perform the work. It is important that the selected contractor has the required expertise to perform the indicator sampling and that they follow the appropriate safety protocols.

Must fall on odd-numbered page

Figure 4.1. Indicator Sampling Flow Chart (Urban Land Use).

11 x 17, color

This page blank for back of 11 x 17 figure

Must fall on odd-numbered page

Figure 4.2. Indicator Sampling Flow Chart (Rural Land Use).

11 x 17, color

This page blank for back of 11 x 17 figure

|  |  |  |  |
| --- | --- | --- | --- |
| Table 4.1. Primary Field Screening Indicator Observations and Follow-Up Indicator Recommendations Based on the Suspected Source of an Illicit Discharge. | | | |
| Suspected Source | Examples | Primary Field Screening Indicator Observations | Follow-Up Indicator(s) |
| Construction site runoff | * Failing erosion and sediment control BMPs | * [Color](#_Color): Tan to brown * [Turbidity](#_Turbidity): >50 NTU | * [Specific Conductivity](#_Specific_Conductivity) |
| Construction site runoff | * Concrete slurry | * [Color](#_Color): Milky white, gray * [pH](#_pH): >9 | * [Specific Conductivity](#_Specific_Conductivity) |
| Gasoline, vehicle oil, or grease | * Leaking vehicle * Oil change * Leaking storage tank * Improper material storage | * [Odor](#_Odor): petroleum * [Visual Indicators](#_Visual_Indicators):   + Surface sheen (petroleum sheen) | * [Total Petroleum Hydrocarbons](#_Total_Petroleum_Hydrocarbons) |
| Human/ animal waste | * Illicit connection * Sewage overflow * Improper disposal of animal waste * Runoff or direct discharge from homeless encampments | * [Ammonia](#_Ammonia): >1 mg/L * [Odor](#_Odor):   + Rotten egg/ hydrogen sulfide/ natural gas   + Musty * [Temperature](#_Temperature) above ambient air temperature * [Visual Indicators](#_Visual_Indicators):   + Fungus and algae (Sphaerotilus natans)   + Floatables (toilet paper, sanitary waste) | * [Bacteria](#_Bacteria) * [Nitrate](#_Nitrate) |
| Industrial process water | * Illicit connection * Overflow | * [Temperature](#_Temperature) above ambient air temperature * [Visual Indicators](#_Visual_Indicators):   + Structural damage (spalling, chipping)   + Surface sheen (petroleum sheen) | * [Hardness](#_Hardness) * [Specific Conductivity](#_Specific_Conductivity) |
| Industrial operations | * Illicit connection * Overflow * Improper material storage * Leaking storage tank * Improper waste disposal | * [Temperature](#_Temperature) above ambient air temperature * [Color](#_Color): highly variable (see Color section) * [Odor](#_Odor): highly variable (see Odor section) | * [Hardness](#_Hardness) * [Specific Conductivity](#_Specific_Conductivity) |

|  |  |  |  |
| --- | --- | --- | --- |
| Table 4.1 (continued). Primary Field Screening Indicator Observations and Follow-Up Indicator Recommendations Based on the Suspected Source of an Illicit Discharge. | | | |
| Suspected Source | Examples | Primary Field Screening Indicator Observations | Follow-Up Indicator(s) |
| Nutrient rich discharge | * Excessive irrigation * Excessive fertilization * Hydroseeding following construction | * [Visual Indicators](#_Visual_Indicators):   + Excessive vegetation   + Fungus and algae (white mat-like growth or algal blooms) | * [Nitrate](#_Nitrate) |
| Sanitary wastewater or sewage | * Illicit connection * Sewage overflow * Septic system discharge | * [Ammonia](#_Ammonia): >1 mg/L * [Color](#_Color):   + Blue green/brown green   + Black * [Odor](#_Odor): Rotten egg/ hydrogen sulfide/ natural gas * [Temperature](#_Temperature) above ambient air temperature * [Visual Indicators](#_Visual_Indicators):   + Fungus and algae (Sphaerotilus natans) * Floatables (toilet paper, sanitary waste) | * [Bacteria](#_Bacteria) * [Nitrate](#_Nitrate) |
| Tap water | * Illicit connection * Fire hydrant flushing * Swimming pool, hot tub, and spa drainage * Water main break | * [Color](#_Color): Blue green/brown green * [Odor](#_Odor): Chlorine | * [Chlorine or Fluoride](#_Chlorine_and_Fluoride) |
| Washwater | * Car washing * Pressure washing * Mobile cleaning | * [Color](#_Color):   + Blue green/brown green   + Gray to milky white * [Odor](#_Odor): Soapy/ perfume * [Temperature](#_Temperature) above ambient air temperature * [Visual Indicators](#_Visual_Indicators): Surface scum, bubbles, suds | * [Detergents/Surfactants](#_Detergents/Surfactants) * [Specific Conductivity](#_Specific_Conductivity) |

## Selecting a Method

In order to evaluate an indicator, a measurement should be taken using a test strip, test kit, field meter, multimeter, colorimeter, spectrophotometer, or collecting a sample for laboratory analysis. Some indicators may also be evaluated using visual or olfactory observations. This section provides an overview of the different methods described in each of the indicator subsections.

### Test Strips

Test strips are small pieces of paper or plastic with one or more test pads on the end of the strip. The test pads react with a water sample to cause a color change. The basic steps for using test strips include collecting a water sample, dipping the test strip in the water sample, removing the strip, and matching the color(s) that appear on the test pad to a color scale. The specific steps for using test strips vary depending on the brand of test strip being used.

### Test Kits

Test kits are typically packaged in plastic or cardboard containers and are designed to determine the concentration or quantity of an indicator. Test kits typically include reagents (such as, a substance used in a chemical analysis), sample vials (such as, to hold a given sample amount), and a user’s manual or instruction sheet. Standard solutions with known concentrations are typically used to verify that a test kit is reporting the correct results for a given indicator. Some test kits also use a water sample without the addition of a reagent as a “blank” or control sample to compare to a sample that has the reagent added.

The basic steps for using a test kit include collecting a water sample, adding one or two reagents to the water sample, waiting for a reaction to occur, and comparing the water sample to a color scale or control sample. The specific steps for using test strips vary depending on the brand of test strip being used.

### Field Meter

A field meter is an electronic instrument that operates using batteries and can be used to measure one or more water quality indicators using a probe or sensor typically attached to a cable. Field meters used for water quality sampling are typically durable and waterproof, but should be stored in a hard case lined with foam to protect the meter when not in use.

The basic steps for using field meters typically include collecting a water sample, immersing the probe or sensor attached to the field meter in the sample, and reading the value that appears on the display screen. Alternatively, some field meters can determine indicator concentrations if a small amount of the water sample is placed on the field meter sensor.

### Multimeter

A multimeter is an electronic instrument that operates using batteries and can be used to measure multiple water quality indicators using various probes or sensors. Multimeters used for water quality sampling are typically durable and waterproof, but should be stored in a hard case lined with foam to protect the meter when not in use.

The basic steps for using a multimeter typically include collecting a water sample, immersing the probe or sensor attached to the multimeter in the sample, and reading the value that appears on the display screen. The specific steps for using multimeters vary depending on the brand of multimeter being used.

### Colorimeter

A digital colorimeter is an instrument that measures the absorbance of a particular wavelength of light by a sample. The basic steps for using a colorimeter typically involves collecting a water sample, adding one or two reagents to the water sample, waiting for a reaction to occur, placing the prepared sample into the colorimeter, and comparing the prepared sample to a “blank” or control sample. Some reagents include hazardous or toxic chemicals or form hazardous or toxic byproducts when they react with a water sample that may require special handling or disposal. The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used.

### Spectrophotometer

A spectrophotometer is a digital instrument that is related to a colorimeter, but measures the transmittance or reflectance of a sample and can scan across a spectrum of wavelengths instead of focusing on a single wavelength of light. The basic steps for using a spectrophotometer typically include collecting a water sample, adding one or two reagents to the water sample, waiting for a reaction to occur, and placing the prepared sample into the spectrophotometer. The specific steps for using a colorimeter will vary depending on the brand of spectrophotometer being used. The field crew should read the user’s manual and practice using the spectrophotometer prior using it in the field to become familiar with its operation.

### Laboratory Analysis

Water samples can also be collected in the field and taken to an analytical laboratory for analysis. Laboratory analyses are typically more accurate than in field measurements, but can be more expensive and results are not available immediately. Laboratory analyses can also be less expensive than investing in a field meter, especially for infrequently used follow-up parameters. A single water sample can be analyzed for multiple indicators at an analytical laboratory; however, you should verify the required volume for each analysis in order to ensure that you collect enough sample volume in the field.

## General Guidelines

The following guidelines for field QA/QC, laboratory QA/QC, safety considerations, and costs apply to all the indicators summarized in this section.

### Field Quality Assurance/Quality Control

Basic QA/QC procedures for sample bottles, test strips, field meters, and buffers or standard solutions are summarized below.

#### Sample Bottles

Clean, sterile sample bottles should be obtained from an analytical laboratory or local wastewater treatment plant. Spare sample bottles should be carried by field personnel in case of breakage or possible contamination. Sample bottles and preservation techniques will follow Code of Federal Regulations [40 CFR 136] guidelines. Refer to the indicator pullout sections for information on recommended sample bottles.

#### Test Strips

Test strips should be stored at room temperature and should not be exposed to light when not in use. Test strips should be replaced according to the schedule specified by the manufacturer. For example, pH test strips should be replaced every 3 to 5 years.

#### Field Meters

Proper calibration is essential to obtaining accurate results. Field meters should be calibrated before heading out in the field. If the meter has been turned off for an extended period of time during the day, a calibration and battery check should be performed.

#### Buffer or Standard Solutions

Buffer or standard solutions should be labeled with the date that they were opened and replaced according to the schedule specified by the manufacturer. For example, pH buffer solutions should be replaced every 3 to 6 months once opened. Unopened pH buffer solutions can be stored for up to 2 years.

### Laboratory Analysis Quality Assurance/Quality Control

Basic QA/QC procedures for sample bottles, sample identification and labeling, chain-of-custody, sample transport, and laboratory quality control are summarized below.

#### Sample Bottles

Clean, sterile sample bottles should be obtained from an analytical laboratory or local wastewater treatment plant. Depending on what is being sampling, bottle material may be glass, polyethylene, Teflon, or other plastic. Spare sample bottles should be carried by field personnel in case of breakage or possible contamination. Sample bottles and preservation techniques will follow Code of Federal Regulations [40 CFR 136] guidelines. Refer to the indicator pullout sections for information on recommended sample bottles and contact the laboratory for specific information on bottle types, filling techniques and analyte-specific information.

##### Sample Identification and Labeling

All sample bottles will be labeled with the following information, using indelible ink and placed on dry sample bottles with labeling tape:

* Location ID
* Date of sample collection (month/day/year)
* Time of sample collection (military format)
* Sample type (grab)
* Requested analytes for lab testing

##### Chain-of-Custody

After samples have been obtained and the collection procedures properly documented, a written record of the chain-of-custody of each sample should be made. This is recommended to ensure that samples have not been tampered with or compromised in any way and to track the requested analysis for the analytical laboratory. Information necessary in the chain-of-custody includes:

* Name(s) of field personnel
* Date and time of sample collection
* Location of sample collection
* Names and signatures of field personnel and laboratory personnel handling the samples
* Laboratory analysis requested and control information (for example, duplicate or spiked samples) and any special instructions (for example, time sensitive analyses)

Sample custody will be tracked in the laboratory through the entire analytical process, and the signed chain-of-custody forms and analytical results returned to the investigator.

##### Sample Transport

Samples should be placed in a storage container (for example, cooler) in an ice bath or packed tightly with an ice substitute to keep them at 4°C (40°F) or less, and delivered to the laboratory as soon as possible.

##### Laboratory Quality Control

Accuracy of the laboratory analyses will be verified using blank analyses, duplicate analyses, laboratory control spikes and matrix spikes in accordance with the EPA methods employed. The analytical laboratory selected for the analysis will be responsible for conducting internal quality control and quality assurance measures in accordance with their own quality assurance plans.

Water quality results will be reviewed at the laboratory for errors or omissions. Laboratory quality control results will be reviewed by the laboratory to verify compliance with acceptance criteria. The laboratory will also validate the results by examining the completeness of the data package to determine whether method procedures and laboratory quality assurance procedures were followed. The review, verification, and validation by the laboratory will be documented in a case narrative that accompanies the analytical results.

### Safety Considerations

Safety is an important factor when conducting indicator sampling. Refer to the safety considerations included in the [Field Screening Methodology](#_Field_Screening_Methodologies) section. Additional safety considerations for indicator sampling include:

* Wearing nitrile gloves and safety glasses when handling samples to protect yourself from potential contaminants
* Considering the handling and disposal of hazardous test kit, colorimeter, and spectrophotometer reagents
* Determining the best method for collecting a sample (Do you need to enter a fast moving stream or river or perform confined space entry or can you collect a sample using a claw grabber or telescoping sampling pole?)

### Costs

Costs for indicator sampling equipment and materials are summarized in Appendix A. The authors do not promote, endorse, or otherwise recommend any of the companies, individuals, or organizations presented in Appendix A.

## Indicator Pullout Sections

Each of the following indicator pullout sections contains the following information:

* Description: Indicator definition.
* Applications: Lists the applicable storm drainage system types (pipes and ditches), land use types (urban, rural, agricultural, commercial, industrial, mining, and residential), and weather conditions (dry and wet).
* Equipment: Checklist for field crews to determine what materials and supplies to bring out in the field.
* Methods: Generic standard operating procedures for collecting an indicator sample for analysis using a variety of methods (for example, test strips, a test kit, a digital colorimeter, a field meter, or laboratory analysis).
* Thresholds: Recommended measurements or observations that trigger further investigation. Recommended thresholds were selected based on the values that Washington jurisdictions are currently using for IC and ID investigations as well as values that were found during the literature review. Thresholds may be modified for use based on local knowledge or observations. Surface water quality standards (if applicable) are provided for reference only and are not intended to be used as thresholds in storm drainage systems.
* Pros and cons: List of the positive and negative aspects of the indicator.
* Common sources: Lists potential sources in relation to observations of color, odor, visual indicators, or concentration of a chemical indicator (such as, high or low in comparison to the recommended threshold value).

### Flow

#### Description

Flow during dry weather is an indicator that a water source other than stormwater is flowing through the storm drainage system. The source of the flow could be groundwater or natural flow, but could also be a sanitary sewer cross-connection, potable water, or illegal dumping.

The following discharges are examples of allowable and conditionally allowable according to the NPDES Municipal Stormwater Permits:

|  |  |
| --- | --- |
| Allowable Discharges | Conditionally Allowable |
| * Diverted stream flows * Uncontaminated or rising groundwater * Foundation drains * Air conditioning condensation * Comingled irrigation and urban stormwater * Springs * Uncontaminated water from crawl space pumps * Footing drains * Flows from riparian habitats and wetlands * Flows authorized by another discharge permit * Emergency firefighting activities | * Potable water sources, such as water line testing and fire hydrant system flushing (residual chlorine of 0.1 parts per million [ppm] or less, pH adjusted if necessary, and volumetrically and velocity controlled to prevent resuspension of sediments) * Irrigation runoff, minimized through conservation efforts * Dechlorinated swimming pool, spa, and hot tub discharges (residual chlorine of 0.1 ppm or less, pH adjusted and reoxygenated if necessary, temperature controlled, and volumetrically and velocity controlled to prevent resuspension of sediments) * Street and sidewalk wash water, dust control water, and building wash water without detergents, minimized through conservation efforts |

Note: Local codes and regulations may be more restrictive than allowable and conditionally allowable discharges listed in table. Allowable and conditionally allowable discharges may require a G3 report to Ecology.

Ditches may convey natural flow and can be identified by their flow patterns and historical drainage patterns:

* If a ditch only flows during storm events or periods of site discharges and/or was specifically built to convey stormwater or discharge water, then it is not typically considered to be a ditch that conveys natural flow.
* If a ditch is located in an area where there historically was a stream or is in a known area where groundwater seeps and springs are present, then it is likely that the ditch still conveys some natural flows.

Indicator sampling should be conducted at every ditch, outfall, or manhole where dry weather flow is observed that is not attributable to groundwater, natural flow, or other allowable discharges. When no flow is present, but visual observations suggest the potential of an illicit discharge, source tracing methodologies such as sandbagging (see Appendix G) can be used to block flow to allow for indicator sampling.

#### Applications

The presence of flow is used as a trigger for primary field screening indicator sampling, and applies to all storm drainage system and land use types.

Presence of flow in a pipe, ditch, or outfall during dry weather may indicate an illicit discharge (if not attributable to groundwater or other allowable discharges), while the rate and frequency of flow can help to determine the source. Classifying the frequency of flow as continuous, intermittent, or transitory (see [Definitions and Regulatory Requirements](#_Definitions_and_Regulatory) section) can help to pinpoint specific actions that may be causing the illicit discharge.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to flow observations and/or testing includes:

* Bucket, tracing dye, or floatable item (for example, cork, orange, rubber ball, or stick)
* Alternative flow measurement device (for example, flow meter)
* Stopwatch
* Tape measure
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107‑1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders

#### Methods

Dry weather flow should be assessed qualitatively or quantitatively in the field using visual and auditory observations or quantitative measurement techniques. Although the quantitative measurement of flow is not always necessary, it can be useful for determining pollutant loading rates. Flow measurements in streams can be collected using a flow meter; however, it can often be difficult to measure the flow in a pipe with a flow meter due to the depth of a catch basin/manhole structure or shallow flow. This manual describes general procedures for two simple methods that can be used to measure flow quantitatively: the bucket method and the float method. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### Bucket Method

The bucket method requires a large enough space and water depth to accommodate a bucket or container of known volume, and is best suited for open pipes, ditches, or outfalls when the outfall is not submerged.

1. Wear nitrile gloves to protect yourself from potential contaminants.
2. Time how long it takes to fill the bucket
   1. If the bucket has incremental volume markings, hold the bucket under the flow for 1 minute.
   2. If only the total volume of the bucket is known, hold the bucket under the flow until it fills completely.
3. Calculate the flow rate (flow rate = volume of bucket/amount of time to fill the bucket).
4. Repeat steps 1 through 3 at least three times and calculate an average flow rate.
5. Record the average flow rate on your field data sheet, notebook, or field laptop/tablet.

##### Float Method

The float method requires downstream access to catch basins, manholes, ditches, or streams, and a measurable distance between the two locations. This method is therefore more appropriate for relatively short branches of the storm drainage system. One important consideration of the float method is the presence of debris or uneven substrate, which can impede the movement of the floatable material downstream. If a large amount of debris is present, consider using dye instead of a floatable object. Refer to [Dye Testing](#_Dye_Testing) and local regulations for appropriate dye testing notification procedures prior to injecting dye into the storm drainage system.

1. Wear nitrile gloves to protect yourself from potential contaminants.
2. For piped systems:
   1. Measure the distance between outfall and the first upstream catch basin or manhole.
   2. Drop floatable object (for example, cork, orange, rubber ball, or stick) or inject dye into upstream manhole and start the stopwatch.
   3. Stop timing when the object or dye reaches the outfall being investigated.
   4. Estimate the cross-sectional area of the pipe.
      1. Measure the diameter of pipe and depth of flow in pipe using a tape measure
      2. Cross-sectional area of pipe = (3.1415 x diameter of pipe2) / 4
      3. Cross-sectional area of flow = (depth of flow/diameter of pipe)2 x cross‑sectional area of pipe
3. For ditch systems:
   1. Measure a known distance of at least 20 to 30 feet upstream of the outfall being investigated, preferably with a length of 10 times the width of the ditch.
   2. Drop floatable object (for example, cork, orange, rubber ball, or stick) or inject dye into upstream manhole or in the ditch upstream of the outfall (refer to [Dye Testing](#_Dye_Testing)) and start the stopwatch.
   3. Stop timing when the object or dye reaches the outfall being investigated.
   4. Estimate the cross-sectional area of the wetted ditch section.
      1. Measure width of flow using a tape measure
      2. Measure depth of flow at three different locations along the width of the ditch. Take the average of these measurements.
      3. Cross‑sectional area = width of wetted ditch x average depth in ditch
4. Calculate the flow rate (velocity = distance/time, flow rate = velocity x cross‑sectional area).
5. Repeat procedure at least three times and calculate an average flow rate.
6. Record the average flow rate on your field data sheet, notebook, or field laptop/tablet.

##### Flow Meter Method

A flow meter is an electronic instrument that operates using batteries and can be used to measure the velocity of water using a propeller and sensor attached to the end of a wand. The velocity is read from an “indicator unit” attached to the cable. The basic steps for using a flow/velocity meter typically include taking incremental velocity measurements along the width of the stream of water. Some velocity/flow meters automatically record depths, widths, angles, and date/time, but others only record velocity measurements. With these instrument types, it is important to use a wand with measurement markings on the sides so the depth of flow can be determined. The specific steps for using velocity/flow meters vary depending on the brand of meter being used. Refer to the user’s manual with your meter for more detailed information. Velocity/flow meters are most effective in areas where the depth of flow is significant, otherwise the propeller or probe may not be submerged completely. The following steps are generally common to velocity/flow meters:

1. Check Meter: Prior to taking meter in the field, confirm that the meter is working properly and sufficient battery life is left.
2. Calibrate Meter: Manufacturers typically recommend that meter calibration be checked regularly. Refer to the user’s manual for the recalibration frequency and procedures.
3. Field Measurements:
   1. Remove sensor cap and connect wand to the Indicator control unit
   2. Place the sensor in the stream with the propeller facing into the flow
   3. Press and release the reset button to zero the display.
   4. Read the velocity, flow rate, depth, and/or time on the indicator control unit.
   5. Measure the depth of flow in this area if it is not recorded by your instrument
   6. Record the information in your field data sheet, notebook, or field laptop/tablet.
4. Meter Storage: Clean the surface of the indicator control unit with a solution designed for plastics. Wipe off the solution before storage. Store the meter and Indicator unit in a case between uses.

#### Thresholds

The following flow observation is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations.

|  |
| --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling |
| Any presence of flow during dry weather |

#### Pros and Cons

| Pros | Cons |
| --- | --- |
| * Inexpensive * Time efficient * Can help prioritize outfall investigations * Can be used to calculate pollutant loading rates | * Methods for estimating flow are not exact * Excessive debris or uneven substrate can affect movement of floatable material downstream * Bucket method is nonfunctional if end of pipe is submerged |

#### Common Sources

Flow may be associated with a variety of sources and land use types. While the presence of flow or the flow rate alone is not enough to determine the source of the potential illicit discharge, the presence of flow is a prerequisite condition for primary field screening indicator sampling. Flow measurements should be used in combination with other parameters, such as color, odor, and visual indicators. Characterization of land use can help to narrow down the potential sources of illicit discharges based on flow rate and frequency.

| Flow Frequency | Flow Rate | Potential Source |
| --- | --- | --- |
| Continuous | High flow | * Construction site dewatering * Leaking tanks and pipes * Industrial processes water * Sanitary wastewater * Septic tank effluent * Washwater |
| Low flow | * Groundwater seepage * Leaking potable water pipes |
| Intermittent | High flow | * Commercial liquid dumping * Industrial process water * Leaking tanks and pipes * Sanitary wastewater * Swimming pool, spa, or hot tub discharge * Washwater |
| Low flow | * Irrigation overflow * Household chemical discharges * Septic system cross connection * Tap water |
| Transitory | High flow | * Illegal dumping * Outdoor washing activity * Ruptured tank * Single industrial spill * Sewer break * Vehicle accident * Firefighting activities |

### Ammonia

#### Description

Ammonia (also known as ammonia nitrogen or NH3) is produced by the decomposition of plant and animal proteins and is also a main ingredient in fertilizers. The presence of ammonia in surface water usually indicates contamination from fertilizers, sanitary wastewater, or a commercial/industrial source. Trace amounts of ammonia over time can be toxic to fish and higher ammonia concentrations can result in low dissolved oxygen concentrations and fish kills.

#### Applications

Ammonia is used as a primary field screening indicator, and applies to all storm drainage system and land use types when flow is present. Ammonia concentrations may be diluted if samples are collected during wet weather.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to ammonia testing includes:

* Ammonia field test kit, ammonia test strips, or ammonia ion probe on a multimeter
* Ammonia reagent set (if ammonia field test kit is selected)
* Ammonia standard solution (if ammonia field test kit is selected)
* Laboratory grade cleaning wipes
* Tap water (for first rinse)
* Distilled water (for final rinse)
* Wash bottle (for rinsing with distilled water)
* Clean, sterile sample bottles (glass or plastic)
* Containers for waste sample water and used reagent solution
* Field laptop/tablet and/or clipboard, field forms and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Ammonia can be measured using ammonia test strips, a field test kit, an ion probe on a multimeter, or at an analytical laboratory. General procedures for each type of equipment are outlined below. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### Ammonia Test Strips

The specific steps for using test strips vary depending on the brand of test strip being used. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Remove one strip from the test strip container and replace the cap tightly.
4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.
5. Remove the strip and gently shake off any excess liquid.
6. Wait the specified amount of time for the color change to occur.
7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.
8. Record the value(s) on your field data sheet, notebook, or field laptop/tablet.
9. Dispose of sample back to source.
10. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

##### Ammonia Test Kit

The specific steps for using test kits vary depending on the brand of test kit being used. Refer to the user’s manual or instruction sheet with your test kit for more detailed information. The following steps are generally common to all test kits:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and test kit reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Follow the steps in the user’s manual included with your test kit to prepare and analyze the sample.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

##### Ammonia Ion Probe on a Multimeter

The specific steps for using multimeters vary depending on the brand of multimeter being used. Refer to the user’s manual with your multimeter for more detailed information. Note: Ion probes are available for detecting both ammonia (NH3) and ammonium (NH4); users should be careful to select the appropriate probe for measuring ammonia. The following steps are generally common to multimeters:

1. Check Meter: Prior to taking meter in the field, confirm that the meter and probes are working properly and sufficient battery life is left.
2. Probe Calibration: Manufacturers typically recommend that probes be checked at least once a year. Refer to the user’s manual for the recalibration frequency and procedures.
3. Field Measurements:
   1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
   2. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
   3. Pour some of the water sample over the probe to remove residue from the probe and avoid cross contamination of the sample.
   4. Dip the probe in the water sample. Stir gently for a few seconds. Allow up to 1 minute for the readings to stabilize.
   5. Record the ammonia concentration shown on the multimeter on your field data sheet, notebook, or field laptop/tablet.
   6. Rinse the probe with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.
   7. Dispose of sample back to source.
4. Meter Storage: Clean the surface of the probe with a laboratory grade cleaning wipe and distilled water. Wipe off the distilled water before storage. Refer to the user’s manual for specific storage recommendations.

##### Ammonia Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
2. Rinse the clean, sterile sample container bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.
3. Fill the bottle completely to the top after the third rinse.
4. Label the bottle with the sample location, date, and time.
5. Keep the samples at 4°C (40°F) or less by placing them in an ice-filled cooler.
6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 28 days of sample collection.

#### Thresholds

The following ammonia level is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does have surface water quality standards for ammonia; however, the standard varies with pH, temperature, and the presence/absence of salmonids (see [WAC 173‑201A‑240](https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-240)).

|  |  |
| --- | --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling | State Water Quality Standards a |
| >1.0 mg/L | Fresh water: varies with pH, temperature, and presence/absence of salmonids  Marine water: 0.233 mg/L (acute), 0.035 mg/L (chronic) |

a Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Good indicator of sanitary sewage * Test strips are easy to use * Field test kits are relatively easy to use | * Must take additional measures to account for interferences with saltwater, chlorine, iron, sulfides, and hardness * Concentrations may be too low to measure and may be diluted if samples are collected during wet weather * Cannot distinguish between human and non‑human sources (pets or wildlife) * Aqueous ammonia volatilizes to ammonia gas at the air/water interface when pH >9.0 * Field test kits are sensitive to contamination * Need to properly dispose of reagents if using an ammonia test kit * Some reagents used with the field test kits are harmful if swallowed, inhaled, or absorbed through skin and may also cause eye, skin, or respiratory tract irritation * Ammonia may be present if irrigation water is comingled with stormwater |

#### Common Sources

High concentrations of ammonia can be caused by the following sources:

|  |
| --- |
| High Ammonia |
| * Application of fertilizer, pesticides, or manure * Industrial or commercial liquid wastes (including petroleum refining and chemical industries, synthetic fibers and dyes, and pharmaceuticals) * Runoff or direct discharge from homeless encampments * Sanitary wastewater * Septic system discharge * Washwater |

### Color

#### Description

The color of water is influenced by the presence or absence of substances such as metallic salts, organic matter, dissolved or suspended materials. Color can indicate when stormwater has been contaminated by an illicit discharge or illicit connection, but not all illicit discharges will have a color. Color is assessed qualitatively by field staff using simple visual observations. Polluted stormwater often exhibits colors similar to the dissolved chemicals or materials that caused the contamination. Field staff should be aware that natural phenomena, as well as tracing dyes, can discolor stormwater, and may not be associated with an illicit discharge (see examples in Common Sources section).

#### Applications

Color is used as a primary field screening indicator, and applies to all storm drainage system and land use types.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to color observations and/or testing includes:

* Clean, sterile sample bottles (clear glass or plastic)
* Color test kit (optional)
* Tap water (if using color test kit)
* Distilled water (if using color test kit)
* Field laptop/tablet and/or clipboard, field forms and pen/pencil
* Plain white paper or dry erase board (optional)
* Safety equipment (for example, hard hats, ANSI 107‑1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)
* Camera, phone, or other device for taking pictures (with date and time stamp)

#### Methods

Color is typically assessed qualitatively in the field using visual observations of how severely a sample is discolored. Qualitative color observations (for example, brown, reddish brown, light green, etc.) are subjective and depend on the inspector. Color can also be assessed quantitatively in the field using a color test kit and reagents, but this method is generally unnecessary and not recommended unless documenting stormwater pollution related to a specific site is needed to support a code enforcement action. General procedures for these two methods of assessing color are outlined below. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### Visual Observations

1. Wear nitrile gloves to protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either clear glass or plastic using a claw grabber or telescoping sampling pole. Avoid collecting sediment with the water sample.
3. Raise the sample up to a natural light source to observe the color and how severely the sample is discolored. Place the sample against a plain white piece of paper or dry erase board (or similar neutral background) if available. Consider taking a photograph to document the color. If a second inspector is available, have them verify your observations and/or record their own observations since color can be subjective. (Note: Depth, sediment accumulation, aquatic plant growth, and weather conditions can influence your perception of the color. Do not try to assess the color by looking into a catch basin, manhole, or water body.)
4. Write “NA” (not applicable) on your field data sheet, notebook, or field laptop/tablet, if no color was observed.
5. Record the color if one was observed, and its intensity or severity (for example, 1 – low, 2 – moderate, or 3 – high) on your field data sheet, notebook, or field laptop/tablet. A low color severity is assigned when there is a faint color in a sample bottle; moderate severity is assigned when a color is clearly visible in a sample bottle; and high severity is used when a strong discoloration is clearly visible in the water in a flowing stream, ditch, or outfall.

##### Color Test Kit

The specific steps for using test kits vary depending on the brand of test kit being used. Refer to the user’s manual or instruction sheet with your test kit for more detailed information. The following steps are generally common to all test kits:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and test kit reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Follow the steps in the user’s manual included with your test kit to prepare and analyze the sample.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

#### Thresholds

The following color observations are recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for color.

|  |
| --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling |
| Any discoloration not attributed to natural phenomena (refer to examples in Common Sources section) |

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Quick and inexpensive * Fairly easy to track through a drainage system | * May be difficult or impossible for staff who are color blind * May be difficult to assess at night or without a good source of natural light * Can be subjective—one person’s gray may be another person’s off-white. Use of color standards is important. * Not all illicit discharges will have a color that can be traced |

#### Common Sources

Colors may be associated with a variety of sources and land use types. Examples of potential illicit discharges and natural phenomena (that are not considered illicit discharges) are provided below in two separate tables.

##### Potential Illicit Discharges

| Color | Potential Sources | Photo Examples |
| --- | --- | --- |
| Tan to brown | * Construction site runoff * Sediment from soil erosion (sometimes a natural phenomenon) * See Natural Phenomena table for other potential sources | Sediment2  Sediment (Photo Credit: City of Federal Way) |
| Brown to reddish brown | * Decomposing food or meat products * Grain mill products * Paint * Rusting metal * Stone, clay, glass, and concrete product manufacturing * See Natural Phenomena table for other potential sources | DSCN0481  Grocery store compactor leakage (Photo Credit: City of Redmond) |
| Brown to black | * Automotive dealers, garden or building product suppliers * Bakery products, fats and oils * Decomposing food or dumpster liquids from restaurants * Metals, rubber, wood chemicals, and plastics manufacturing * Paint * Ink from paper and cardboard manufacturing | Restaurant Grease2  Restaurant grease (Photo Credit: City of Federal Way) |
| Black | * Paint * Septic wastewater * Sulfuric acid * Turnover of oxygen depleted water * Oil * Fabric dye | Black illicit discharge_oil_credit King County  Oil (Photo Credit: King County) |
| Gray to milky white | * Concrete washwater * Dairy products * Drywall compound * Grease * Lime (limestone) * Paint * Phosphate fertilizer manufacturing * Washwater from commercial/industrial or domestic sources | P5130017  Latex paint (Photo Credit: King County) |
| Orange-red | * Iron deposits * Paint * Tracing dye * See Natural Phenomena table for other potential sources | Most orange-red discharges are related to natural iron bacteria  (see Natural Phenomena table) |
| Dark red or purple | * Blood from meat packing/processing facilities * Diesel fuel or hydraulic fluid * Fabric dye * Heating oil * Paint * Paper ink | Heating oil discharge  (Photo Credit: City of Kirkland) |
| Blue green/brown green | * Algae blooms (sometimes a natural phenomenon) * Fertilizer runoff * Paint * Portable toilet waste * Sewage * Tracing dye * Vehicle wash water * See Natural Phenomena table for other potential sources | PA270035  Paint (Photo Credit: City of Redmond) |
| Yellow to bright green | * Algae blooms (sometimes a natural phenomenon) * Chlorine chemical manufacturing * Paint * Radiator fluid (anti-freeze) * Tracing dye * See Natural Phenomena table for other potential sources | Radiator Fluid  Radiator fluid  (Photo Credit: City of Federal Way) |

#### Natural Phenomena (not illicit discharges)

| Color | Potential Sources | Photo Examples |
| --- | --- | --- |
| Tan to brown | Sediment from natural soil erosion | None provided |
| Brown to reddish brown | Naturally occurring tannins and lignins caused by the decomposition of organic matter; can cause water to look brown or tea-colored | None provided |
| Orange-red | Iron bacteria can produce orange-red deposits or staining | iron bacteria  Iron bacteria (Photo Credit: Herrera) |
| Blue green/ brown green | Algae blooms | Peabody Creek 015  Brown green algae growth (Photo Credit: Herrera) |
| Yellow to bright green | Algae blooms | Non toxic Filamentous algae bloom  Non-toxic filamentous algae bloom (Photo Credit: City of Federal Way) |

### Odor

#### Description

Odor can often indicate when stormwater has been contaminated by an illicit discharge or illicit connection since clean stormwater typically has no odor. However, not all illicit discharges will have an odor to trace. Odor is typically assessed qualitatively by field staff using their sense of smell. Polluted stormwater can exhibit odors similar to the dissolved chemicals or materials that caused the contamination.

#### Applications

Odor is used as a primary field screening indicator, and applies to all storm drainage system and land use types.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to odor observations include:

* Clean, sterile sample bottles (glass or plastic)
* Field laptop/tablet and/or clipboard, field forms and pen/pencil
* Safety equipment (for example hard hats, ANSI 107-1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Odor should be assessed qualitatively in the field using your nose to determine if a water sample has a distinct smell. Odor observations are subjective and may include descriptions such as a petroleum, sewage, or chemical odor. Odor observations are typically documented by describing the intensity or severity of odor based on a scale of 1 to 3 (faint, moderate, or strong). A faint odor is barely noticeable, a moderate odor is easily detectable, and a strong odor can be detected from several feet away. General procedures for assessing odor are outlined below. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

1. Wear nitrile gloves to protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic using a claw grabber or telescoping sampling pole. Avoid collecting sediment with the water sample.
3. Wave your hand across the water sample (instead of smelling it directly) to determine if there is a distinct odor.
4. Write “NA” (not applicable) on your field data sheet, notebook, or field laptop/tablet, if no odor was detected.
5. Record the odor (for example, petroleum, musty, acrid) if one was detected, and its intensity or severity (for example, 1, 2, or 3) on your field data sheet, notebook, or field laptop/tablet. If a second inspector is available, have them verify your observations and/or record their own observations since odor can be subjective.

#### Thresholds

The following odor observations are recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for odor.

|  |
| --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling |
| Any odor (refer to examples in Common Sources section) |

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Quick and inexpensive * Typically fairly easy to track through a drainage system | * The sense of smell of field staff may become desensitized over the course of a shift, limiting their ability to detect odors * Variability between field staff’s senses of smell can make comparisons difficult * Difficult to assess under certain conditions (for example very windy or rainy) * Not all illicit discharges will have an odor that can be traced * Inhalation of hazardous or toxic substances may be a safety consideration |

#### Common Sources

Odors may be associated with a variety of sources and land use types. Some examples are provided below:

| Odor | Potential Sources |
| --- | --- |
| Musty | * Partially treated sewage * Livestock waste * Algae |
| Rotten egg | * Raw sewage * Sulfuric acid * Anaerobic stagnant water in pipes, ditches, or wetlands * Decomposing organic matter * Rubber and plastics manufacturing |
| Rotten, spoiled, and/or rancid | * Restaurant food waste * Leaking dumpster * Dead fish/animals |
| Foul, rotten, and/or fecal | * Raw sewage |
| Natural gas | * Natural gas leak |
| Chlorine | * Broken drinking water line * Swimming pool, spa, or hot tub flushing * Wastewater treatment plant discharge * Industrial discharge * Rubber and plastics manufacturing |
| Sharp, acrid, and/or pungent | * Chemicals, pesticides, antifreeze, or solvents * Paper or associated products manufacturing |
| Soapy and/or perfumy | * Commercial or home laundry or dry cleaner discharge * Commercial or charity car wash |
| Pungent sweet, fruity, and/or musty | * Grain mill products * Soaps, detergents, and cleaning products * Phosphate fertilizers * Commercial or charity car wash |
| Beer or wine, alcohol, and/or yeasty | * Beverage production at wineries, breweries, or distilleries |
| Fishy | * Decaying algae |
| Petroleum and/or gasoline | * Oil spill or leak * Vehicle maintenance facilities * Petroleum refining |

### pH

#### Description

pH measures the hydrogen ion activity on a scale from 1 to 14. Water with a pH below 7.0 is acidic and water with a pH above 7.0 is alkaline or basic. pH values that are lower than 6.5 or higher than 8.5 may be harmful to fish and other aquatic organisms. A low pH can cause heavy metals to leach out of stream sediments, resulting in an increase in dissolved metals concentrations. A high pH can produce a toxic environment, in which ammonia becomes more poisonous to aquatic organisms.

The following discharges are examples of allowable and conditionally allowable according to the NPDES Municipal Stormwater Permits:

|  |  |
| --- | --- |
| Allowable Discharges | Conditionally Allowable |
| * Flows authorized by another discharge permit | * Potable water sources, such as water line testing and fire hydrant system flushing (residual chlorine of 0.1 parts per million [ppm] or less, pH adjusted if necessary, and volumetrically and velocity controlled to prevent resuspension of sediments) * Dechlorinated swimming pool, spa, and hot tub discharges (residual chlorine of 0.1 ppm or less, pH adjusted if necessary, temperature controlled, and volumetrically and velocity controlled to prevent resuspension of sediments) |

Note: Local codes and regulations may be more restrictive than allowable and conditionally allowable discharges listed in table. Allowable and conditionally allowable discharges may require a G3 report to Ecology.

#### Applications

pH is used as a primary field screening indicator, and applies to all storm drainage system and land use types.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to pH testing includes:

* pH meter or pH test strips
* Buffer solutions (pH = 4.01, 7.00, and 10.01; if using a meter)
* pH electrode storage solution (or pH 4.01 buffer; if using a meter)
* Laboratory grade cleaning wipes
* Tap water (for first rinse)
* Distilled water (for final rinse)
* Wash bottle (for rinsing)
* Clean, sterile sample bottles (glass or plastic)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107‑1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

pH can be measured using either a field meter or test strips. General procedures for each type of equipment are outlined below. Refer to the user’s manual with your field meter or the container holding your test strips for more detailed information. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### pH Field Meter

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user’s manual with your field meter for more detailed information. The following steps are generally common to pH field meters:

1. Check Meter: Prior to taking meter in the field, confirm that the meter and probe are working properly, storage solution is present in the probe cap, and sufficient battery life is left. It is normal to see potassium chloride (KCl) crystals around the cap. They are easily removed when rinsing the probe will distilled water.
2. Calibrate Meter: Proper calibration is essential to obtaining accurate results. Field meters should be calibrated before heading out in the field. If the meter has been turned off for an extended period during the day, a calibration check should be performed.
   1. Remove the storage cap from the pH probe, rinse with distilled water, and remove excess moisture with a laboratory grade cleaning wipe.
   2. Choose a set of buffer solutions. If the field samples to be analyzed are expected to be slightly acidic (samples from wetlands for example), calibrate with pH 4.01 and pH 7.00 buffer solutions. If samples may be basic (samples associated with concrete for example), calibrate with pH 7.00 and pH 10.01 buffers.
   3. Pour pH 7.00 buffer solution into a clean sample bottle. Rinse the probe tips with the buffer solution. Next, submerge the probe in the solution so that approximately 1.5 inches of the probe is submerged. If the meter has a temperature probe as well as a pH probe, submerge both probes in the buffer solution. Gently stir for a few seconds.
   4. Confirm the first buffer value.
   5. Pour pH 4.01 or 10.01 buffer solution into a second clean sample bottle. Remove the probe from the first buffer solution. Rinse the probe tips with distilled water, remove excess water with a laboratory grade cleaning wipe, and rinse the probe tips with the second buffer solution. Submerge the probe in the second buffer solution and gently stir for a few seconds. If the meter has a temperature probe as well as a pH probe, submerge both probes in the buffer solution.
   6. Confirm the second buffer value.
   7. Dispose of buffer solutions appropriately
3. Field Measurements:
   1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
   2. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic; avoid collecting sediment with the water sample.
   3. Pour some of the water sample over the pH probe to remove residue from the probe and avoid cross contamination of the sample.
   4. Dip the probe in the water sample. If the meter has a temperature probe as well as a pH probe, submerge both probes in the water sample. Stir gently for a few seconds. Allow up to 2 minutes for the probes to adjust to the sample temperature and the readings to stabilize.
   5. Record the pH value shown on the meter on your field data sheet, notebook, or field laptop/tablet.
   6. Rinse the probe tips with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.
   7. Dispose of sample back to source
4. Meter Storage: Cover the sensor on the pH probe with the protective cap (partially filled with storage solution or pH 4.01 buffer), turn off pH meter, and place it back in its protective case. Storing the pH probe in distilled water can damage it by causing the ions in the pH probe to leach out. Buffer solutions should be replaced every 3 to 6 months once opened (unopened buffer solutions can be stored for up to 2 years).

##### pH Test Strips

The specific steps for using test strips (defined in Section 4.2) vary depending on the brand of test strip being used. Test strips that are specific to pH are recommended; 5‑in‑1 test strips typically do not have a wide enough pH range for illicit discharge detection. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves and safety glasses to avoid sample contamination and protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Remove one strip from the test strip container and replace the cap tightly.
4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.
5. Remove the strip and gently shake off any excess liquid.
6. Wait the specified amount of time for the color change to occur.
7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.
8. Record the value(s) on your field data sheet, notebook, or field laptop/tablet.
9. Dispose of sample back to source.
10. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

#### Thresholds

The following pH levels are recommended for triggering further investigation and additional indicator sampling. These thresholds may be modified for use based on local knowledge or observations. Washington State water quality standards for pH in fresh and marine water are designated for protection of fish spawning, rearing, and migration habitats and the general aquatic environment.

|  |  |
| --- | --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling | State Water Quality Standards a |
| pH <5 or >9 | Fresh water: pH <6.5 or >8.5 Marine water: pH <7 or >8.5 |

a Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Test strips are inexpensive and easy to use * Field meters are slightly more expensive than test strips, but can provide more accurate results | * Not useful in determining presence of sanitary wastewater * Not conclusive by itself but it can identify potential illicit discharges that merit follow-up investigations using more effective indicators * Test strips must be kept dry and should be replaced after 3 to 5 years * Test strips can detect extreme pH levels, but are not as accurate as field meters in determining an exact pH value * Field meters require routine calibration and proper storage * Buffer solutions must be replaced frequently; bottles last for 2 years if they are unopened and 3 to 6 months if they have been opened * Proper buffer solution disposal needed |

#### Common Sources

Low and high pH values can be caused by the following sources:

| Low pHa,b,c | High pHa,b,c |
| --- | --- |
| * Dairy products * Fabricators * Fertilizers and pesticides * Metal finishers * Pharmaceutical manufacturers * Resin producing companies * Wineries | * Disinfectants and sanitizer * Latex paint * Metal plating and steel mills * Poured or recycled concrete, cement, mortars, and other Portland cement or lime-containing construction materials * Rubber or plastic producers * Soaps and detergents |

a Brewery effluent typically contains spent grains, waste yeast, spent hops, and grit and the pH can range from 3 to 12, resulting in either a low, high, or even a neutral pH. Other indicators such as color, odor, and floatables may be more useful than pH for determining if brewery effluent is an illicit discharge.

b Textile mills can either have a high or low pH. Other indicators such as color and odor may be more useful than pH for determining if textile mill waste is an illicit discharge.

c pH of sediments can vary depending on the pH of source soils.

|  |  |  |  |
| --- | --- | --- | --- |
| Increasing Acidity | 0 |  |  |
| 1 | Battery acid | Acid rain = 1 to 5 |
| 2 | Lemon juice |  |
| 3 | Vinegar |  |
| 4 | Beer and wine |  |
| 5 |  | Precipitation = 5 to 6 |
| 6 | Milk | Streams and stormwater = 6.5 to 8.5 |
| Neutral | 7 |  | Pure water = 7.0 |
| Increasing Alkalinity | 8 |  | Seawater = 8.3 |
| 9 |  |  |
| 10 |  |  |
| 11 | Ammonia |  |
| 12 | Soapy water |  |
| 13 | Bleach, oven cleaner |  |
| 14 | Drain cleaner, caustic soda |  |

### Temperature

#### Description

Temperature extremes can threaten the health and survival of fish and other aquatic species in many life stages including embryonic development, juvenile growth, and adult migration. Water temperature can be useful in identifying contamination by sanitary wastewater or industrial cooling water. Household and commercial sewage produces heat due to microbial activity during anaerobic decomposition, while industrial cooling water is heated as it is circulated through heat exchangers. Water temperature measurements are typically the most useful for IDDE when indicator sampling is being conducted during cold weather and temperature differences can be significant.

The following discharges are examples of allowable and conditionally allowable according to the NPDES Municipal Stormwater Permits:

|  |  |
| --- | --- |
| Allowable Discharges | Conditionally Allowable |
| * Flows authorized by another discharge permit * Emergency firefighting activities | * Dechlorinated swimming pool, spa, and hot tub discharges (residual chlorine of 0.1 ppm or less, pH adjusted if necessary, temperature controlled, and volume controlled) |

Note: Local codes and regulations may be more restrictive than allowable and conditionally allowable discharges listed in table. Allowable and conditionally allowable discharges may require a G3 report to Ecology.

#### Applications

Temperature is used as a primary field screening indicator, and applies to all storm drainage system and land use types.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to temperature testing includes:

* Temperature probe or other temperature measuring device
* Laboratory grade cleaning wipes
* Tap water (for first rinse)
* Distilled water (for final rinse)
* Wash bottle (for rinsing with distilled water)
* Clean, sterile sample bottles (glass or plastic)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example hard hats, ANSI 107‑1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Temperature can be measured using a temperature probe (often included with a pH meter or multimeter). A standard thermometer or a continuous water temperature data logger can also be used as an alternative to a temperature probe (methods not provided in this section). Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user’s manual with your field meter for more detailed information. The following steps are generally common to temperature probes:

1. Check Meter: Prior to taking meter in the field, confirm that the meter and probe are working properly and sufficient battery life is left.
2. Probe Calibration: Manufacturers typically recommend that temperature probes be recalibrated at least once a year.
3. Field Measurements:
   1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
   2. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
   3. Pour some of the water sample over the temperature probe to remove residue from the probe and avoid cross contamination of the sample. Note: temperature should be measured as soon as possible after the sample has been collected.
   4. Dip the probe in the water sample and stir gently for a few seconds. Allow up to 1 minute for the probe to adjust to the sample temperature and the readings to stabilize.
   5. Record the temperature value shown on the meter on your field data sheet, notebook, or field laptop/tablet.
   6. Rinse the probe tips with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.
   7. Dispose of sample back to source.

#### Thresholds

The following temperature level is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State water quality standards for temperature in fresh water and marine environments are designated for protection of fish spawning, rearing, and migration habitats and the general aquatic environment. The fresh water quality standard depends on the aquatic life use category and ranges from a 7‑day maximum value of 12 to 20 degrees Celsius depending on the fish species that use the receiving water. The marine water quality standard depends on the aquatic life use category and ranges from a 1‑day maximum value of 13 to 22 degrees Celsius depending on the fish species that use the receiving water. Refer to [WAC 173‑201A‑200](https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-200) for further information on fresh water criteria and [WAC 173‑201A‑210](https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-210) for further information on marine water criteria.

|  |  |
| --- | --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling | State Water Quality Standardsa |
| Above ambient air temperature | Fresh water: 12°C (53.6°F) to 20°C (68°F) 7-day maximum (depends on aquatic life use category)  Marine water: 13°C (55.4°F) to 22°C (71.6°F) 1‑day maximum (depends on aquatic life use category) |

a Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| Inexpensive (if included with pH field meter or multimeter)  Easy to measure | Most useful in cold weather when temperature difference is significant from the likely higher temperatures of illicit discharges |

#### Common Sources

Lower or higher temperature values, relative to ambient, can be caused by the following sources:

|  |  |
| --- | --- |
| Lower Temperature | Higher Temperature |
| * Large pond or lake discharge (not an illicit discharge) located in a cool climate * Groundwater (not typically an illicit discharge) * Cold storage facility discharge | * Small pond or lake (not an illicit discharge) located in a warm climate * Industrial cooling water * Sanitary wastewater * Potable water sources |

### Turbidity

#### Description

Turbidity is a measure of how transparent or clear water is based on the amount of sediment or suspended particulates. Large amounts of suspended material can affect fish growth and survival by impairing their vision, gill function, and affecting egg and larval development. Higher turbidity can also increase temperature and thereby decrease dissolved oxygen concentrations in water bodies, affecting the growth of both aquatic animals and plants. High turbidity in water can be contributed to many different sources including soil erosion, construction activities, sanitary wastewater, excessive algal growth, or industrial processes.

#### Applications

Turbidity is used as a primary field screening indicator and applies to all storm drainage system and land use types. For purposes of illicit connection and illicit discharge field screening, turbidity assessments can be based on visual observations, using a turbidity meter, or using a turbidity tube. However, for source tracing, code enforcement and other site-specific issues, quantitative turbidity measurements may be either required by regulatory agencies and/or useful; turbidity meters or turbidity tubes will be needed in these instances.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Equipment specific to turbidity testing includes:

* Turbidity meter or turbidity tube
* Turbidity standard solutions (for turbidity meter)
* Laboratory grade cleaning wipes (for turbidity meter)
* Tap water (for first rinse when using turbidity meter)
* Distilled water (for final rinse when using turbidity meter)
* Wash bottle (for rinsing with distilled water when using turbidity meter)
* Sheet of white paper or a white binder (when using turbidity tube)
* Clean, sterile sample bottles (clear glass or plastic)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Turbidity can be measured qualitatively using visual observation or quantitatively using a turbidity meter. It is important to understand the difference between turbidity and color if relying on visual observations. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### Visual Observations

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect a field sample in a clear, clean, sterile sample bottle made of either clear glass or plastic. Avoid collecting sediment with the water sample.
3. Hold the sample bottle up to a light source and visually observe how easily light is able to penetrate through the sample bottle. Do not confuse the turbidity (cloudiness) of the water with its color (tint or intensity of color observed).
4. Assign a turbidity severity ranking (1 = slight cloudiness, 2 = cloudy, and 3 = opaque) and record this on your field data sheet, notebook, or field laptop/tablet.
5. Dispose of sample back to source.

##### Turbidity Meter

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user’s manual with your field meter for more detailed information. The following steps are generally common to turbidity field meters:

1. Check Meter: Prior to taking meter in the field, confirm that the meter is working properly and sufficient battery life is left.
2. Calibration Check: Check that the meter is reading properly by using a standard turbidity solution at the beginning of each use. Turbidity field meters should also be calibrated according to the manufacturer’s instructions once every 3 months.
   1. Wipe the outside of the sample vial with a laboratory grade cleaning wipe to remove fingerprints.
   2. Insert the sample vial with the standard solution into the turbidity meter, close the lid, and take a reading. Do not hold the meter while making measurements.
   3. Record the turbidity value shown on the meter on your field data sheet, notebook, or field laptop/tablet.
   4. Repeat steps a through c with a second standard every 3 months. Performing a single point calibration is sufficient once a day before use.
3. Field Measurements:
   1. Place the turbidity meter on a level, stationary surface.
   2. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
   3. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
   4. Remove the cap from a sample vial and triple rinse the vial with the water sample.
   5. Fill the sample vial to the fill line and place the cap back on the vial.
   6. Wipe the outside of the sample vial with a laboratory grade cleaning wipe to remove fingerprints.
   7. Insert the sample vial into the turbidity meter, close the lid, and take a reading. Do not hold the meter while making measurements.
   8. Record the turbidity value shown on the meter on your field data sheet, notebook, or field laptop/tablet.
   9. Dispose of sample back to source.
4. Meter Storage: Close sample compartment lid to prevent dust and dirt from entering.

##### Turbidity Tube

A turbidity tube (also known as a transparency tube or Secchi tube) is a transparent tube that is typically 60 to 120 centimeters long with a Secchi disk (black and white symbol) at the bottom of the tube. Some turbidity tubes have a valve at the bottom of the tube and others do not.

1. Place the turbidity tube on a level, stationary surface. It may be helpful to place a sheet of white paper or a white binder underneath the tube.
2. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
3. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
4. Pour the field sample into the turbidity tube gradually until the Secchi disk (black and white symbol) at the bottom of the tube is no longer visible. Some turbidity tubes have a valve at the bottom, so you can fill the tube and then slowly let the water out of the bottom until the Secchi disk marking at the bottom of the tube just becomes visible.
5. Read the gradation (marking) on the turbidity tube corresponding to the height of the sample in the tube.
6. Convert the height (in centimeters) to nephelometric turbidity units (NTU) using the following table (based on tube length of 60 centimeters). Alternatively, turbidity can be calculated using the following equation and the tube depth (in centimeters):

Turbidity (NTU) = 2198.1 \* (Tube Depth^(-1.2765))

1. Dispose of sample back to source.

|  |  |
| --- | --- |
| Distance from the Bottom of the Turbidity Tube (centimeters) | Nephelometric Turbidity Units (NTU) |
| <6 | >250 |
| 10 | 116 |
| 15 | 69 |
| 20 | 48 |
| 25 | 36 |
| 30 | 29 |
| 35 | 23 |
| 40 | 20 |
| 45 | 17 |
| 50 | 15 |
| 55 | 13 |
| >60 | <12 |

Source: Ecology (2005)

#### Thresholds

The following turbidity level is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State water quality standards for turbidity in fresh water and marine environments are designated for protection of fish spawning, rearing, and migration habitats and the general aquatic environment. Turbidity units of measurement are mostly commonly expressed as nephelometric turbidity units (NTU). The fresh and marine water quality standards depends on the aquatic life use category and range from 5 to 10 NTU above background levels (when background levels are 50 NTU or less) or a 10 to 20 percent increase (when background levels are more than 50 NTU) depending on the fish species that use the receiving water. Background levels are measured up-gradient or outside the area of influence of the discharge. Refer to [WAC 173‑201A‑200](https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-200) for further information on fresh water criteria and [WAC 173‑201A‑210](https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-210) for further information on marine water criteria. The Construction Stormwater General Permit also includes a benchmark value of 25 NTU (or 33 centimeters) and a phone reporting trigger value of 250 NTU (or 6 centimeters).

|  |  |
| --- | --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling | State Water Quality Standardsa |
| All land use types: >50 NTU, 19 centimeters, or visible/cloudy/opaque | Fresh and marine water: 5 to 10 NTU above background when background is ≤50 NTU; or 10 to 20% above background if background is >50 NTU |

a Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Taking note of the composition of the turbidity (for example, soil particles, algae, plankton, microbes, sewage, industrial waste) may help to identify the source * Readings taken using a turbidity meter or turbidity tube can be useful for code enforcement | * Cannot identify whether multiple sources are present * Qualitative visual observations and turbidity tube measurements can be somewhat subjective * No single turbidity meter works well for all turbidity levels * The detailed (3‑point) calibration of turbidity meters once every 3 months can be time consuming * Regional variations in soil properties may affect the readings turbidity meter readings and the correlation between NTU and centimeters * Turbidity tube results can be imprecise for water column depths of 6 centimeters or less |

#### Common Sources

High turbidity can be caused by the following sources:

| High Turbidity | |
| --- | --- |
| * Chemical manufacturing processes (for example, inorganic pigments, plastic and synthetic materials, pharmaceuticals, soaps and detergents, paints and varnishes, wood chemicals, and petroleum refining) * Coal steam electric power processes * Construction activities * Industrial washwater * Landscaping activities * Leaking underground storage tanks * Metal fabrication processes * Sanitary wastewater * Soil erosion * Stone/tile cutting * Textile mill discharges * Waste products from different food processing industries (for example, meat, dairy, vegetable, grains, oil, or bakeries) | Pic 130  A turbid discharge was observed to a catch basin (see above photo). The source was identified as a failed temporary erosion and sediment control swale overflowing to the slope above the rockery (see photo below). The contractor employed Baker Tanks and pumps to eliminate the turbid flows.  Photo Credits: Russell Cotton-Betteridge (City of Bellevue) |
| Pic 035 |

### Visual Indicators

#### Description

Visual indicators other than color, odor, and flow can often indicate when stormwater has been contaminated by an illicit discharge or illicit connection; however, not all illicit discharges will have visual indicators. Visual indicators are assessed qualitatively by field staff using simple visual observations. The following visual indicators are described in this section:

|  |  |
| --- | --- |
| Visual Indicator | Description |
| Abnormal vegetation | Excessive vegetation or dead vegetation near an outfall can indicate an illicit discharge. |
| Algae, bacteria, and fungus | *Sphaerotilus natans* is a white or grayish bacterial growth that can be found in flowing sewage.. Whitish mat-like growth can also occur in stormwater systems and is a combination of fungus, algae, and organic debris. Brownish algae growth can also occur in natural systems. |
| Deposits and staining | Deposits and staining are coatings that remain on the streambank or on the outfall structure after a non-stormwater discharge has ceased. |
| Fish kills | Fish kills are the number of dead fish observed in a stream or other water body where an illicit discharge is suspected. |
| Floatables | Floatables can include animal fats, food products, oils, solvents, sawdust, foams, packing materials, fuel, fecal matter, and toilet paper. |
| Structural damage | Structural damage such as pitting or spalling of concrete outfall structures can be caused by abnormal pH from an industrial discharge. |
| Surface film | Surface film can include pollen. |
| Surface scum | Surface scum can include bubbles, soap suds or natural foaming. |
| Surface sheen | Surface sheen can include petroleum or organic sheens. |
| Trash and debris | Trash and debris are typically listed as a prohibited discharge in illicit discharge codes and ordinances; however, tracking and enforcement can be difficult. Excessive amounts of trash and debris can indicate that illegal dumping is occurring, which may involve other pollutants. |

#### Applications

Visual indicators are used for primary field screening, and apply to all storm drainage system and land use types.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to visual indicator observation includes:

* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Camera, phone, or other device for taking pictures (with date and time stamp)
* Safety equipment (for example, hard hats, ANSI 107‑1999 labeled safety vests)

#### Methods

Visual indicators should be assessed qualitatively in the field using visual observations. Visual observations are subjective and may include descriptions such as toilet paper, petroleum sheen, suds, or dead fish. These observations are also typically documented either by noting their absence or presence and using a severity index of 1 to 3 (few/slight, many/moderate, or numerous/obvious) if observed. The descriptions documented will depend on the format of data forms used. General procedures for assessing visual observations are outlined below. Specific observations for sewage bacteria and surface scum or sheen are also highlighted below. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

1. Observe the condition of the water surface, flowing water, outfall or catch basin/manhole structure integrity, and the surrounding area.
2. Write “NA” (not applicable) on your field data sheet, notebook, or field laptop/tablet, if no visual indicators were observed.
3. Record the visual indicators if any were present, and the presence or severity (for example, 1, 2, or 3) on your field data sheet, notebook, or field laptop/tablet.
4. Take a photograph to document the visual observations.

##### Algae, Bacteria, and Fungus Observations

Record observations of the type of algae, bacteria, and fungus growing based on color and flow:

1. White or grayish growth in flowing water is typically Sphaerotilus natans, a bacterium that can be found in flowing water and in sewage and wastewater treatment plants (see photo example in Common Sources section). It “breaks up into nothing” when touched with a stick. This growth disappears quickly after sewage discharge is eliminated.
2. Dried white mat‑like growth residue is typically a combination of fungus, algae, organics, and detritus and is a dry, thin coating on solid surfaces (see photo example in Common Sources section).
3. Green or brown algae growth is typically a natural phenomenon, but can sometimes indicate an elevated level of nutrients. Green algae (Cladophora and Rhizoclonium) form long, coarse filaments in flowing water and can also form thick mats if excessive nutrients are present. Lighter green algae (Spirogyra or watersilk) feels silky and is typically found in still or stagnant water. Brown algae is formed by masses of diatoms that grow on rocks, sand, plant roots, and other surfaces and typically feels slimy when touched.
4. Algae blooms are extensive areas of tiny algae, or phytoplankton, accumulated on the surface of a water body. They typically are caused by elevated levels of nutrients in fresh or marine waters, and can be either a natural occurrence or illicit discharge related. Colors of algae blooms include red, orange green, yellow, or brown. These blooms are most common during the spring and summer when temperatures rise, and increased sunlight allows the algae to photosynthesize more rapidly near the surface of the water body. Most algae blooms are harmless, but some blooms, called Harmful Algae Blooms (or HABs), can be harmful or toxic if ingested. Note: Illicit discharges are one source of excessive nutrients that may cause an algae bloom; however, many other factors such as stormwater runoff and overland flow are also possible sources.

##### Surface Scum Observations

Record observations of the type of surface scum based on color:

1. Bubbles or suds from a washwater discharge contain a rainbow-like sheen on the surface of the bubbles; refer to [Detergents/Surfactants](#_Detergents/Surfactants_1) section for additional indicator testing.
2. Natural foaming results from the natural die-off of aquatic plants that release oils. Natural foam often has a partial brownish tint and can include organic debris.
3. Fats, grease, and oils

##### Surface Sheen Observations

Record observations of the type of surface sheen based on color and the “pencil test” (tapping the surface of the sheen with a pencil or a stick).

1. Petroleum sheen typically has an iridescent rainbow pattern (see photo example in Common Sources section) and does not separate when disturbed by poking; when pencil or stick is removed, petroleum sheen will quickly coalesce.
2. Organic sheen is a natural phenomenon that that occurs when bacteria create oil-like iridescent films when they attach themselves to the water surface. Sunlight bounces off the films, giving them an oily appearance (see photo example in Common Sources section). Organic sheens separate into plates or sheets on the surface of still water when disturbed by poking. When the pencil or stick is removed, organic sheens typically do not coalesce quickly. Organic sheens will often be accompanied by organic or rusty looking water.

#### Thresholds

The following visual indicator observations are recommended for triggering further investigation and additional indicator sampling. These thresholds may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for visual indicators. Trash and debris are typically listed as a prohibited discharge in illicit discharge codes and ordinances.

|  |
| --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling |
| Any visual indicator not attributed to natural phenomena (refer to examples in Common Sources section) |

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Quick and inexpensive * Fairly easy to track through a drainage system | * Sometimes conclusive by itself, but often requires follow-up investigation using more effective indicators |

#### Common Sources

Visual indicators may be associated with a variety of sources and land use types. Natural phenomena that are not considered illicit discharges and do not need to be traced are provided below.

##### Potential Illicit Discharges

| Visual Indicator | Potential Sources | Photo Examples |
| --- | --- | --- |
| Abnormal vegetation | * Excessive nutrients (lush vegetation growth during dry weather) * Stormwater pollutant toxic to vegetation (dead vegetation with adjacent healthy vegetation) | Dead vegetation (Photo Credit: City of Seattle) |
| Deposits and staining | * Black or gray staining from a sanitary source * Dark staining from petroleum hydrocarbons * Orange-red staining from iron bacteria * Powdery residues from chemicals * See Natural Phenomena table for other potential sources | Stained outfall pipe (Photo Credit: Herrera) |
| Fish kills | * Pesticides * Pollutant toxic to aquatic organisms * See Natural Phenomena table for other potential sources | Fish kill photo_photo credit King County  Fish kill (Photo Credit: King County) |
| Floatables (toilet paper, other sanitary waste) | * Sewage discharge * Wind-blown surface litter | DSCN0213  Toilet paper and floatables in catch basin. Illicit connection was confirmed by dye testing. (Photo Credit: City of Redmond) |
| Floatables (food waste) | * Restaurants and dumpsters, warehouses, grocery stores * Roadside fruit stands, commercial fruit processing facilities * Mobile food vendors | p7020002  Soybeans spilled at warehouse (Photo Credit: City of Bellevue) |
| Algae, bacteria, and fungus (Sphaerotilus natans) | Sewage discharge | A close up of a tree  Description automatically generated  White growth, likely Sphaerotilus natans, from a failing septic system drain field. High E. coli and human waste-related DNA confirmed the illicit discharge. (Photo Credit: King County) |
| Algae, bacteria, and fungus (white mat-like growth residue) | Excessive nutrients | Dried white mat-like growth residue on dry substrate of a stormwater pond (Photo Credit: King County) |
| Algae, bacteria, and fungus (algae blooms) | Excessive nutrients | Algae bloom (Photo Credit: Herrera) |
| Structural damage (spalling, chipping) | * Corrosive discharges from industrial or commercial sites * Natural deterioration associated with old infrastructure (not considered to be from an illicit discharge) | 2012-08-10_Norwood Village Park (37-2) (4)Structural damage of old infrastructure (Photo Credit: Herrera) |
| Surface sheen (petroleum sheen) | * Gasoline, diesel fuel, motor oil * Lubricating oil or hydraulic oil from construction equipment * Heating oil from underground or aboveground storage tanks | IMGP5101  Petroleum sheen (Photo Credit: Herrera) |
| Surface scum (bubbles or suds) | Washwater containing detergents or soaps | IMG_3756  Washwater (Photo Credit: Herrera) |
| Surface scum (fats, grease, and oils) | Fats, grease, and oils from food waste, mobile food vendors, or restaurants | Restaurant Grease  Restaurant grease (Photo Credit: City of Federal Way) |
| Trash and debris | * Illegal dumping * Wind-blown litter | P2270088  Cigarette butts in a catch basin (Photo Credit: City of Redmond) |

##### Natural Phenomena

| Visual Indicator | Potential Sources | Photo Examples |
| --- | --- | --- |
| Algae, bacteria, and fungus (green or brown algae growth) | Algae or diatom growth | Peabody Creek 015  Brown green algae growth (Photo Credit: Herrera) |
| Algae, bacteria, and fungus (algae blooms) | Algae blooms | Non toxic Filamentous algae bloom  Non-toxic filamentous algae bloom (Photo Credit: City of Federal Way) |
| Deposits and staining | Iron oxidizing bacteria can produce orange-red deposits or staining | IMG_0373  Iron bacteria (Photo Credit: Herrera) |
| Fish kills | Die off due to low oxygen levels or high temperatures | Fish Kill  Fish kill (Photo Credit: City of Federal Way) |
| Surface film (pollen) | Pollen from pine, cedar, and oak can form a yellow, brown, or black film on the surface (especially in ponds or slow-moving water) | None provided |
| Surface sheen (organic) | Iron oxidizing bacteria can produce an organic sheen (typically found in standing or stagnant waters) | IMG_0132  Organic sheen (Photo Credit: Herrera) |
| Surface scum (natural foaming) | Natural foam from organic matter decomposition (can increase after storm events and collect along shorelines or streambanks) | 20121010_152400  Natural foaming (Photo Credit: Herrera) |

### Bacteria

#### Description

There are four types of bacterial indicators addressed in this manual:

* Fecal coliform bacteria
* E. coli bacteria (a subset of fecal coliform bacteria)
* Bacteroidales DNA
* Enterococci

Fecal coliform bacteria and E. coli bacteria have been typically-used as indicators of fecal contamination of stormwater and natural waters, as they are present in the fecal waste of warm-blooded animals, including humans. A relatively elevated test result for fecal coliform bacteria or E. coli bacteria may indicate an illicit discharge or illicit connection associated with sewage or a failing septic system. However, it may indicate waste related to large domestic animals (such as cows, llamas, etc.), pets, or wild animals. Fecal coliform bacteria and E. coli bacteria are both tested using a culture (growth) analysis that is typically performed in a laboratory setting.

Bacteroidales DNA can be tested by quantitative polymerase chain reaction (qPCR), which is not a culture (growth) analysis but rather a method related to cloning and counting DNA fragments. This method is one of the most common techniques used in Microbial Source Tracking (MST), also called bacterial or fecal source tracking. Bacteroidales tests have been successfully used to track down and identify confirmed or suspected sources of human waste and other kinds of animal waste. DNA biomarkers specific to humans and a few other animal groups, such as ruminants (such as sheep, goats, and cows) and dogs, may be analyzed in a laboratory setting.

Enterococci are a subgroup of the fecal streptococci, indicate the presence of fecal contamination by warm-blooded animals, and are not known to multiply in the environment like fecal coliform bacteria. There is a Washington State surface water quality standard for enterococcus bacteria, but only in marine waters. This bacterial indicator is not commonly used in fresh water.

#### Applications

Bacteria are used as follow-up indicators, and apply to all storm drainage system and land use types.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to bacteria sampling includes:

* Clean, sterile sample bottles (usually amber glass or plastic with sodium thiosulfate preservative provided by the laboratory, unless using Coliscan© Easygel©)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders (if needed)
* Claw grabber or telescoping sampling pole (if needed for collecting samples)
* Coliscan© Easygel© supplies and equipment (nutrient bottles, pipettes, and pipette tips for field; Petri dishes and poultry egg incubator for office)

#### Methods

Bacteria by culture methods can be measured using Coliscan© Easygel© (Easygel©) or to an analytical laboratory for analysis. General sample collection and handling procedures are outlined below. Easygel© nutrient bottles should be stored in a freezer at ‑18°C (0°F) until use. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional information pertaining to interpreting results.

##### Coliscan© Easygel© Sampling and Culturing Method

The Easygel© method can be used to sample water and measure E. coli bacteria. The following steps should be followed:

1. Remove the frozen Easygel© nutrient bottles from the storage freezer the night before the sampling day and thaw them at room temperature overnight. (Note: If this step is forgotten, the bottles may be thawed by placing them in a pocket or on a warm vehicle dashboard).
2. Wear nitrile gloves in the field to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the Easygel© nutrient bottle or cap.
3. Pipette the sample (typically 5 mL) directly from the flowing water or from a sampling container, such as a ladle or bailer. When pipetting from a bailer, rinse it three times with the water being sampled (e.g., from a stormwater ditch or catch basin, or a stream) before collecting the sample to be sure that only the flowing water is being sampled. Make sure to empty the rinse water either downstream or away from your sampling location, to not disturb streambed or other bottom sediments.
4. Pipette the aliquot of sample directly into the Easygel© nutrient bottle.
5. Tightly screw the lid back on the Easygel© nutrient bottle.
6. Keep the samples (now in the Easygel© nutrient bottles) at 4°C (40°F) by placing them in an ice-filled cooler; return them to the office within 6 hours of sampling.
7. Record all information, including date, time, sample location name, and any relevant information on a paper field form or digitally.
8. Label the tops of the Easygel© Petri dishes with appropriate sample names back in the office, using a permanent marker.
9. Transfer the samples (contained in the Easygel© nutrient bottles) carefully to the bottom plates of the Petri dishes.
10. Ensure that the nutrient/sample mix is distributed evenly on the Petri dish bottom; typically just by pouring carefully.
11. Place the labeled Petri dish tops onto the dishes, and place them into an incubator, being careful not to slosh or disrupt them. The gel in the bottom of the dishes will solidify in about an hour.
12. If an incubator is available, incubate at 95ºF (35ºC) for 24 hours. If an incubator is not available, incubate at room temperature for 48 hours. Note: An incubator is recommended for improved control, temperature consistency, and faster incubation.
13. Remove Petri dishes from incubator (if applicable).
14. Inspect the Petri dish.
    1. Count all the easily-seen dark blue or dark purple-blue colonies on Petri dishes to quantify E. coli bacteria present.
    2. Disregard light blue-green, red or pink colonies or irregularly shaped, light-colored growths. Disregard any “pinprick” size colonies. However, if in serious doubt as to whether a colony color is “blue,” “purple‑blue,” or “blue‑green,” it is acceptable to err on the side of caution and count “ambiguous” colonies as E. coli bacteria.
    3. Report the results in terms of colony forming units (CFU) per 100 mL of water. Multiply the plate count by the appropriate multiplier to obtain E. coli bacteria CFU/100 mL. For example, for 5 mL sample aliquots, the multiplier is 20.
    4. Photograph the plates, typically with a completed plate count template, for documentation and for future reference if needed.
    5. Dispose Easygel© bottles by throwing them directly into the trash.
    6. Disinfect the bottom plates of the Petri dishes by placing them into a sink, pouring straight bleach or a 50/50 bleach/water mix into them, letting them sit for 5 minutes, carefully draining them, bagging them into a plastic bag, and placing the bag in the trash.

##### Bacteria Laboratory Analysis (Culture Methods and qPCR DNA)

Laboratory analysis can be used for fecal coliform and E. coli bacteria culture analyses and qPCR DNA analyses. The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves in the field to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the bottle or the lid
2. Label the bottle with the sample location, date, and time. (It is easier to label the bottle before sampling, since it is dry.)
3. Directly fill a sterile sample bottle (typically 500 or 1000 ml in size) from the flow and tightly replace the screw-top cap. (If using a sampling device such as a ladle or bailer to obtain the sample, be sure to pre‑rinse the bailer three times with the water being sampled. Be sure to empty rinse water downstream of the sampling location, to not disturb bottom sediments.)
4. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.
5. Record all information, including date, time, sample location name, and any relevant information on paper field form or digitally.
6. Follow the laboratory’s chain-of-custody procedures. Submit samples to the laboratory within 6 hours of sample collection. The samples must be analyzed within 24 hours of sample collection.

#### Thresholds

The following bacteria concentrations are recommended for triggering further investigation and additional indicator sampling. Thresholds may be modified for use based on local knowledge or observations. Fecal coliform bacteria and E. coli bacteria are typically reported in colony forming units per 100 milliliters (CFU/100 mL). DNA is reported in gene copies/mL.

Fecal coliform bacteria (FC) has a fresh water surface water quality standard in Washington state; however, it will be phased out by the end of 2020. Many streams and rivers in Washington are listed on Ecology’s 303(d) list for fecal coliform bacteria impairment or have had a fecal coliform total maximum daily load (TMDL) imposed on them due to reported exceedances of the state fecal coliform bacteria standard. At time of manual writing, it remains to be seen exactly how these fecal coliform bacteria impairments and TMDLs will be addressed by the state due to the switch to the fresh water E. coli bacteria standard (below). For saltwater, fecal coliform bacteria will continue to be used to regulate marine shellfish harvesting. Refer to [WAC 173‑201A‑200](https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-200) for further information on fresh water criteria and [WAC 173‑201A‑210](https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-210) for further information on marine water criteria.

E. coli bacteria has a fresh water surface water quality standard adopted in February 2019 and will be phasing out the use of fecal coliform bacteria as a surface water quality indicator for fresh water by the end of 2020. Refer to [WAC 173-201A-200](https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-200) for further information on fresh water criteria.

Enterococcus bacteria has a marine water surface water quality standard in Washington state. This bacterial indicator is not commonly used in fresh water.

There are no regulatory standards for Bacteroidales DNA.

|  |  |  |  |
| --- | --- | --- | --- |
| Type of Bacteria | Recommended Range for Further Investigation and Indicator Sampling b | State Water Quality Standards a | |
| Geometric Mean | Single Value |
| E. coli | 300 to 1,000 CFU/100 mL | 100 CFU/100 mL | 320 CFU/100 mL |
| Fecal coliform | 500 to 1,200 CFU/100 mL | 100 CFU/100 mL (fresh water)  14 CFU/100 mL (marine water) | 200 CFU/100 mL (fresh water)  43 CFU/100 mL (marine water) |
| Bacteroidales DNA | Varies by biomarker, extract volume, and analysis method. Confirm recommended threshold value with analytical laboratory used. | Not applicable | Not applicable |
| Enterococcusc | 500 to 1,000 CFU/100 mL | 30 CFU/100 mL  (marine water) | 110 CFU/100 mL  (marine water) |

a Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems.

bBacterial results are highly context specific. Results can be influenced by factors such as weather, seasonality, antecedent dry or wet periods, and sampling location characteristics (for example, land use, presence of septic systems, formal or informal drainage, etc.). For this reason, relative ranges may be more useful than an absolute threshold. For a sampling event that occurs at multiple sites on the same day, an illicit discharge may have occurred if one site has significantly higher results.

cThis bacterial indicator applies to marine water and is not commonly used in fresh water.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Possible indicator of fecal waste pollution sources * Fecal coliform and E. coli bacteria culture methods are fairly inexpensive * Easy sampling techniques * Fecal coliform laboratory analysis can often be performed for free or low cost by a City/County wastewater treatment plant | * Samples must be transported to the laboratory within 6 hours * Minimum of 24‑hour wait time for results from laboratory analysis and Coliscan© Easygel© analysis * Sterile sample handing procedures necessary * Results may be ambiguous |

#### Common Sources

High bacteria values can be caused by the following sources:

|  |  |
| --- | --- |
| High Bacteria (human sources) | High Bacteria (animal sources) |
| * Illicit sanitary sewer to stormwater drainage system cross-connections * Failing septic systems discharging to stormwater drainage systems or natural waters * Leaking sanitary sewer mainlines or side sewers * Municipal wastewater treatment plant effluent discharges * Runoff or direct discharge from homeless encampments | * Pets * Livestock (for example, manure storage, manure application, entering unfenced waterbodies) * Mammals and other wildlife (for example, larger populations in parks, traveling through animal migration zones) * Birds (for example, waterfowl in stormwater ponds, bird roosting areas) |

### Chlorine and Fluoride

#### Description

Chlorine and fluoride are both added to most potable water supplies in Washington State; notable exceptions include areas served by private wells. Residual chlorine in potable water supply systems is typically present at concentrations around 1.0 milligram per liter (mg/L). Fluoride is added to potable water to improve dental hygiene, typically at concentrations ranging from 0.8 to 1.35 mg/L. Most jurisdictions test for either chlorine or fluoride depending on factors such as whether potable water is chlorinated or fluoridated in their area, staff experience testing for these indicators, and whether locally elevated concentrations of fluoride occur naturally in groundwater.

The following discharges are examples of allowable and conditionally allowable according to the NPDES Municipal Stormwater Permits:

|  |  |
| --- | --- |
| Allowable Discharges | Conditionally Allowable |
| * Emergency firefighting activities | * Potable water sources, such as pipeline testing and fire hydrant system flushing (residual chlorine of 0.1 parts per million [ppm] or less, pH adjusted if necessary, and volume controlled) * Dechlorinated swimming pool, spa, and hot tub discharges (residual chlorine of 0.1 ppm or less, pH adjusted if necessary, temperature controlled, and volume controlled) |

Note: Local codes and regulations may be more restrictive than allowable and conditionally allowable discharges listed in table. Allowable and conditionally allowable discharges may require a G3 report to Ecology.

#### Applications

Chlorine or fluoride are used as follow-up indicators, and apply to piped storm drainage systems in urban, commercial, industrial, and residential land use types. Concentrations may be diluted if samples are collected during wet weather. These indicators are not useful in areas that do not chlorinate or fluoridate potable water.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes | * Urban * Commercial * Industrial * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to chlorine or fluoride testing includes:

* Chlorine test strips, test kit, or digital colorimeter
* Chlorine reagent (if using chlorine test kit or digital colorimeter)
* Fluoride test kit, field meter, or digital colorimeter
* Fluoride standard solution (if using fluoride field meter)
* Fluoride reagent (if using fluoride field meter or digital colorimeter)
* Laboratory grade cleaning wipes
* Tap water (for first rinse)
* Distilled water (for final rinse)
* Clean, sterile sample bottles (glass preferred since plastic bottles may have a large chlorine demand)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Chlorine can be measured using test strips, a test kit, or a digital colorimeter. Fluoride can be measured using a field meter or a digital colorimeter. General procedures for each type of equipment are outlined below. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### Total Chlorine Using Test Strips

The specific steps for using test strips (defined in Section 4.2) vary depending on the brand of test strip being used. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Remove one strip from the test strip container and replace the cap tightly.
4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.
5. Remove the strip and gently shake off any excess liquid.
6. Wait the specified amount of time for the color change to occur.
7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.
8. Record the value(s) on your field data sheet, notebook, or field laptop/tablet.
9. Dispose of sample back to source.
10. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

##### Total Chlorine Using a Test Kit

The specific steps for using test kits (defined in Section 4.2) vary depending on the brand of test kit being used. Refer to the user’s manual or instruction sheet with your test kit for more detailed information. The following steps are generally common to all test kits:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and test kit reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Follow the steps in the user’s manual included with your test kit to prepare and analyze the sample, and for proper hazardous material disposal, if needed.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

##### Total Chlorine Using a Digital Colorimeter

Samples are prepared for total chlorine analysis using a digital colorimeter (defined in Section 4.2) by using a N, N‑diethyl-p-phenylenediamine (DPD) reagent either contained in a powder pillow or an ampoule. The DPD reagent is not known to be hazardous; however, if samples are treated with sodium arsenite for manganese or chromium interferences, this substance is known to be toxic and corrosive. The final solution will contain arsenic in sufficient concentrations to be regulated as a hazardous waste under the Resource Conservation and Recovery Act (RCRA). Refer to the Safety Data Sheet (SDS) for safe handling and disposal instructions.

The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used. Refer to the user’s manual with your colorimeter for more detailed information. The following steps are generally common to all colorimeters:

1. Wear nitrile gloves and safety glasses to avoid sample contamination and protect yourself from potential contaminants and colorimeter reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Follow the steps in the user’s manual included with your colorimeter to prepare and analyze the sample.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

##### Fluoride Field Meter

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user’s manual with your field meter for more detailed information. The following steps are generally common to fluoride field meters:

1. Prepare Meter: Prior to taking meter in the field, confirm that the meter and electrode sensor are working properly, water is present in the electrode sensor cap, and sufficient battery life is left.
2. Calibrate Meter: Proper calibration is essential to obtaining accurate results. Field meters should be calibrated before each new measurement batch or if more than 12 hours has elapsed since the last calibration.
   1. Pour 15 to 30 milliliters (mL) of fluoride standard solution into sample cup
   2. Rinse the electrode sensor with distilled water, wipe with laboratory grade cleaning wipe, and place into fluoride standard solution
   3. Wait for the reading to stabilize (should take approximately 30 seconds)
3. Field Measurements:
   1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
   2. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
   3. Pour some of the water sample over the electrode sensor and then dip the sensor in the water sample to remove residue from the probe and avoid cross contamination of the sample.
   4. Stir gently for a few seconds. Allow up to 1 minute for the readings to stabilize.
   5. Record the value shown on the meter on your field data sheet, notebook, or field laptop/tablet.
   6. Rinse the electrode sensor with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.
4. Meter Storage: Wipe the sensor with a laboratory grade cleaning wipe. Store the electrode sensor in distilled water. Replace protective caps. The fluoride sensor will need to be replaced once the automatic calibration no longer sufficiently calibrates the meter. Standard solutions should be replaced every 6 to 12 months once opened (unopened standard solutions can be stored for up to 2 years).

##### Fluoride Using a Digital Colorimeter

Samples are prepared for fluoride analysis using a digital colorimeter (defined in Section 4.2) by using a sodium 2‑(parasulfophenylazo)‑1,8‑dihydroxy‑3,6‑naphthalene disulfonate (SPADNS) reagent either contained in a powder pillow or an ampoule. The SPADNS reagent contains sodium arsenite and is known to be toxic and corrosive. The final solution will contain arsenic in sufficient concentrations to be regulated as a hazardous waste under RCRA. Refer to the SDS for safe handling and disposal instructions.

The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used. Refer to the user’s manual with your colorimeter for more detailed information. The following steps are generally common to all colorimeters:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and colorimeter reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
3. Follow the steps in the user’s manual included with your colorimeter to prepare and analyze the sample.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

#### Thresholds

The following threshold for total chlorine and fluoride is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does have state water quality standards for chlorine, but does not have surface water quality standards for fluoride; however, a discharge is considered to be illicit by the Municipal Stormwater NPDES Permits if the chlorine concentration is greater than 0.1 mg/L.

|  |  |
| --- | --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling | State Water Quality Standardsa |
| >0.3 mg/L total chlorine or fluoride | Fresh water: 19 mg/L (acute), 11 mg/L (chronic)  Marine water: 13 mg/L (acute), 7.5 mg/L (chronic) |

a Surface water quality standards are provided for reference only and are not intended to be used as thresholds in storm drainage systems

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Chlorine testing is quick and easy * Fluoride can be a good indicator of tap water discharges or leaks and illicit connections, in areas that are known to be served by fluoridated domestic water supplies * Fluoride testing using the meter is quick and easy | * Chlorine is a poor indicator for sanitary wastewater because it quickly combines with organic compounds. * Chlorine quickly off-gases, so is a negative test result does not guarantee the water is not due to an illicit tap water discharge * The reagents used in the chlorine test kit and with the fluoride colorimeter are hazardous wastes that must be disposed of properly * Fluoride testing is not useful in areas with high concentrations naturally occurring in groundwater, or in areas that are not served by fluoridated domestic water |

#### Common Sources

High concentrations of chlorine or fluoride can be caused by the following sources:

|  |  |  |
| --- | --- | --- |
| Chlorine | Fluoride | Chlorine or Fluoride |
| * Laundries * Paper mills * Pesticide manufacturing * Textile bleaching | * Ceramic plants * Chemical manufacturing * Fertilizer manufacturing * Glass etching * Gas and coke manufacturing * Metal refining * Transistor manufacturing | * Broken drinking water line * Commercial/industrial liquid waste * Fire hydrant flushing water * Irrigation water (in urban areas with potable water) * Swimming pool, spa, or hot tub flushing * Washwater |

### Detergents/Surfactants

#### Description

Surfactants are a main component of laundry detergents and dishwashing soaps that help remove dirt, food, and stains by reducing the surface tension of water. Surfactants are often referred to as “detergents” because of the analytical method used to detect them. Surfactants are often accompanied by suds observed on the water surface. A field test for surfactants can help distinguish between an illicit discharge and natural foam caused by the decomposition of organic matter.

#### Applications

A surfactants test is used as a follow-up indicator and applies to all storm drainage system and land use types. Concentrations may be diluted if samples are collected during wet weather.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to surfactants testing includes:

* Surfactant test kit or colorimeter
* Clean, sterile sample bottles (amber glass bottle for test kits and colorimeters, glass or plastic for laboratory analysis)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107‑1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Surfactants can be measured using a field test kit, colorimeter or at an analytical laboratory. General procedures for each type of equipment are outlined below. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### Surfactant Test Kit

Surfactant test kits (defined in Section 4.2) typically use a methylene blue extraction method. Tests typically take 3 to 5 minutes per sample. Detergents in the sample react with methylene blue to form a blue complex that is directly related to the concentration of “methylene blue active substances” present in the sample. Surfactant test kits typically contain chloroform and sulfuric acid, which are both known to be toxic. Chloroform is also a possible carcinogen to humans and animals and sulfuric acid is harmful to aquatic organisms. Refer to the Safety Data Sheet (SDS) for safe handling and disposal instructions. The shelf life of a surfactant test kit is typically 8 months.

The specific steps for using test kits vary depending on the brand of test kit being used. Refer to the user’s manual or instruction sheet with your test kit for more detailed information. The following steps are generally common to all test kits:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and test kit reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of glass. Avoid collecting sediment with the water sample.
3. Follow the steps in the user’s manual included with your test kit to prepare and analyze the sample.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

##### Surfactants Using a Digital Colorimeter

Samples are prepared for detergent/surfactant analysis using a digital colorimeter (defined in Section 4.2) by the Crystal Violet method. One of the steps in this method involves adding benzene. Benzene should only be used in a well-ventilated area. Benzene solutions are regulated as a hazardous waste under the Resource Conservation and Recovery Act (RCRA). Refer to the SDS for safe handling and disposal instructions. It should be noted that detergent/surfactant digital colorimeters are prone to false positive results, in which the test indicates slight contamination where none is actually present. To account for this tendency, a sample with no detergent/surfactant contamination can be tested with the detergent/ surfactant colorimeter and the resulting color can serve as a basis for correcting any false positive results.

The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used. Refer to the user’s manual with your colorimeter for more detailed information. The following steps are generally common to all colorimeters:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and colorimeter reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle. Avoid collecting sediment with the water sample.
3. Follow the steps in the user’s manual included with your colorimeter to prepare and analyze the sample.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

##### Surfactants Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
2. Rinse the clean, sterile sample container bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.
3. Fill the bottle completely to the top after the third rinse.
4. Label the bottle with the sample location, date, and time.
5. Keep the samples at 4°C (40°F) by placing them in an ice‑filled cooler.
6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 48 hours.

#### Thresholds

The following surfactant level is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for surfactants.

|  |
| --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling |
| >0.25 mg/L |

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Results can clearly indicate an illicit discharge or illicit connection * Generally more reliable than testing for detergents using boron or optical brightener monitoring traps | * Preparing samples for analysis in the field can be time consuming * The reagents used in the test kit and colorimeter are a hazardous waste that must be disposed of properly * False positive results may occur when using the test kit (from passing the tip of the test ampoule through the methylene blue solution), but should only have a slight blue tinge and are typically less than the recommended threshold value |

#### Common Sources

High concentrations of surfactants can be caused by the following sources:

|  |
| --- |
| High Surfactants |
| * Washwater (residential) * Commercial laundry facilities * Firefighting foam * Washwater from temporary (charity care washes) or fixed-facility car washes (commercial car washes, rental car facilities, and auto dealerships) * Washwater from mobile cleaning businesses (carpet cleaning or floor cleaning) * Sewage from a broken sewer line or illicit connection * Septage from a failing septic system |

### Hardness

#### Description

Hardness is a measurement of the dissolved mineral content (primarily calcium and magnesium) of water. Hard water contains a high mineral content and soft water contains a low mineral content. In areas where hardness levels are elevated due to local geology, hardness can help distinguish between natural groundwater flows and tap water. Tap water is typically “soft” with a low hardness. Very high or low hardness values can also be associated with certain industrial discharges. High hardness values can increase or decrease the toxicity of metals in runoff, depending on the aquatic species that is exposed. Natural sources of hardness include limestone (which introduces calcium into percolating groundwater) and dolomite (which introduces magnesium).

#### Applications

Hardness is used as a follow-up indicator that applies to piped storm drainage systems, urban areas, and commercial/industrial land uses.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes | * Urban * Commercial * Mining * Industrial | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to hardness sampling includes:

* Hardness test strips or hardness test kit (if a field method is selected)
* Hardness buffer solution(s) (if a field method is selected)
* Clean, sterile sample bottles (glass or plastic)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Hardness can be measured using test strips, a test kit, or at an analytical laboratory. General procedures for each type of equipment are outlined below. If shallow groundwater is suspected as a source, you should also test for elevated pH above 8.5. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### Hardness Test Strips

The increments of hardness that correspond to a color on the color scale differ depending on the type of test strip used. Generally, a test strip with more increments will provide more accurate results. Hardness is typically measured in milligrams per liter (mg/L) as calcium carbonate (CaCO3). Test strips with large measuring ranges (0 to 1,000 mg/L) use larger increments, and while they are useful for obtaining an approximation of water hardness, their accuracy is compromised by the larger increments. Test strips with small measuring ranges (0 to 425 mg/L) can provide more accurate results, and can be used after the hardness of the water sample has been narrowed down to a smaller range.

The specific steps for using test strips (defined in Section 4.2) vary depending on the brand of test strip being used. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
3. Remove one strip from the test strip container and replace the cap tightly.
4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.
5. Remove the strip and gently shake off any excess liquid.
6. Wait the specified amount of time for the color change to occur.
7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.
8. Record the value on your field data sheet, notebook, or field laptop/tablet.
9. Dispose of sample back to source.
10. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

##### Hardness Test Kit

The specific steps for using test kits (defined in Section 4.2) vary depending on the brand of test kit being used. Refer to the user’s manual or instruction sheet with your test kit for more detailed information.

Hardness test kits are available, but include hazardous reagents and involve a complicated series of steps. Hardness tests are best performed in the field using test strips or in a laboratory (either using a test kit or at an approved analytical laboratory).

##### Hardness Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
2. Rinse the clean, sterile sample bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.
3. Fill the bottle completely to the top after the third rinse.
4. Label the bottle with the sample location, date, and time.
5. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.
6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 6 months of sample collection.

#### Thresholds

The following hardness concentrations are recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for hardness; however, the toxicity of several heavy metals (for example, copper, lead, zinc) is hardness dependent and uses a conversion factor based on the measured hardness ([WAC 173-201A-240](https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-240)).

|  |
| --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling |
| Commercial/Industrial only: Hardness ≤10 mg/L as CaCO3 or ≥1,000 mg/L as CaCO3 |

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Hardness test strips are quick and easy to use and can confirm extremely low or high concentrations | * Not conclusive by itself but it can identify potential illicit discharges that merit follow-up investigations using more effective indicators * Hardness test strips are not as accurate as the other test methods listed * Presence of metals can interfere with hardness tests and result in false positive tests results |

#### Common Sources

Very low and high hardness values can be caused by the following sources:

|  |  |
| --- | --- |
| Low Hardness (≤10 mg/L as CaCO3) | High Hardness (≥1,000 mg/L as CaCO3) |
| * Radiator flushing | * Industrial plating baths |

Other sources such as sewage, septage, laundry washwater, car washwater, tap water, groundwater, and landscaping irrigation water are considered to be soft or moderately hard (typically in the range of 40 to 70 mg/L as CaCO3) and are difficult to identify using a hardness test. If a water sample has high hardness and high specific conductivity, it is possible that the presence of metals has interfered with the hardness measurement, and a sample should be submitted to a laboratory for individual laboratory analyses of these parameters.

For reference to what is typically considered soft and hard water, the following table provides these classifications:

|  |  |  |
| --- | --- | --- |
| Hardness Concentration (mg/L as CaCO3) | Classification | Natural Source |
| 0 to 60 | Soft | Erosion from mineral-poor soil (e.g., glacial deposits) |
| 61 to 120 | Moderately hard |  |
| 121 to 180 | Hard |  |
| >180 | Very hard | Erosion from mineral-rich soil (e.g., limestone, dolomite) |

### Nitrate

#### Description

Nitrate (NO3‑) (often expressed as nitrate+nitrite nitrogen, or NO3‑ plus NO2‑) is a concern in fresh water because it may contribute to an overabundant growth of aquatic plants and to a decline in diversity of the biological community.

#### Applications

Nitrate is used as a follow-up indicator, and applies to all storm drainage system and land use types. Concentrations may be diluted if samples are collected during wet weather.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to nitrate sampling includes:

* Nitrate test strips, nitrate ion probe on multimeter, or spectrophotometer (if a field method is selected)
* Clean, sterile sample bottles (glass or plastic)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107‑1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Nitrate can be measured using test strips, a digital colorimeter, a nitrate ion probe on a multimeter, or at an analytical laboratory. General procedures for each method are outlined below. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### Nitrate and Nitrite Test Strips

The specific steps for using test strips (defined in Section 4.2) vary depending on the brand of test strip being used. Refer to the container holding your test strips for more detailed information. The following steps are generally common to all test strips:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
3. Remove one strip from the test strip container and replace the cap tightly.
4. Dip the strip into your sample and move back and forth for the specified amount of time. Make sure that the test pad(s) are always submerged.
5. Remove the strip and gently shake off any excess liquid.
6. Wait the specified amount of time for the color change to occur.
7. Match the color(s) on the test pad(s) as closely as possible to the color scale on the test strip container.
8. Record the value on your field data sheet, notebook, or field laptop/tablet.
9. Store test strips at room temperature and avoid exposure to light when not in use. Replace test strips after 3 to 5 years.

##### Nitrate Ion Probe on a Multimeter

The specific steps for using multimeters (defined in Section 4.2) vary depending on the brand of multimeter being used. Refer to the user’s manual with your multimeter for more detailed information. The following steps are generally common to multimeters:

1. Check Meter: Prior to taking meter in the field, confirm that the meter and probes are working properly and sufficient battery life is left.
2. Probe Calibration: Manufacturers typically recommend that probes be checked at least once a year. Refer to the user’s manual for the recalibration frequency and procedures.
3. Field Measurements:
   1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
   2. Collect a field sample in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
   3. Pour some of the water sample over the probe to remove residue from the probe and avoid cross contamination of the sample.
   4. Dip the probe in the water sample. Stir gently for a few seconds. Allow up to 1 minute for the probe to adjust to the sample temperature and the readings to stabilize.
   5. Record the nitrate concentration shown on the meter on your field data sheet, notebook, or field laptop/tablet.
   6. Rinse the probe with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.
   7. Dispose of sample back to source.
4. Meter Storage: Clean the surface of the probe with a laboratory grade cleaning wipe and distilled water. Wipe off the distilled water before storage. Refer to the user’s manual for specific storage recommendations.

##### Nitrate Using a Spectrophotometer

Samples are prepared for nitrate analysis using a spectrophotometer (defined in Section 4.2) by using a reagent typically contained in a power pillow. Suspended matter and debris in a sample can interfere with spectrophotometer results, and should be removed prior to testing using filtration. Refer to the user’s manual with your spectrophotometer for more detailed information. The following steps are generally common to collecting and preparing a sample for a spectrophotometer,:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
3. Follow the steps in the user’s manual included with your spectrophotometer to prepare and analyze the sample.
4. Record the value on your field data sheet, notebook, or field laptop/tablet.

##### Nitrate and Nitrite Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
2. Rinse the clean, sterile sample bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.
3. Fill the bottle completely to the top after the third rinse.
4. Label the bottle with the sample location, date, and time.
5. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.
6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 28 days of sample collection.

##### Nitrate Using a Digital Colorimeter

Samples are prepared for nitrate analysis using a digital colorimeter (defined in Section 4.2) by using either a NitraVer5 reagent either contained in a powder pillow or an ampoule. The NitraVer5 reagent contains cadmium in sufficient concentrations to be regulated as a hazardous waste under the Resource Conservation and Recovery Act (RCRA). Refer to the Safety Data Sheet (SDS) for safe handling and disposal instructions.

The specific steps for using a colorimeter will vary depending on the brand of colorimeter being used. Refer to the user’s manual with your colorimeter for more detailed information. The following steps are generally common to all colorimeters:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants and colorimeter reagents.
2. Collect the sample to be analyzed in a clean, sterile sample bottle made of either glass or plastic. Avoid collecting sediment with the water sample.
3. Follow the steps in the user’s manual included with your colorimeter to prepare and analyze the sample.
4. Record the value for nitrate on your field data sheet, notebook, or field laptop/tablet.

#### Thresholds

The following nitrate and nitrite concentrations are recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for nitrate. Nitrate is typically measured in milligrams per liter (mg/L).

|  |
| --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling |
| >1 mg/L |

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Nitrate and nitrite test strips are quick and easy to use and can confirm extremely low or high concentrations | * Not conclusive by itself but it can identify potential illicit discharges that merit follow-up investigations using more effective indicators * Test strips are not as accurate as the other test methods listed for nitrate and nitrite * The reagents used in the colorimeter are a hazardous waste that must be disposed of properly * Nitrate may be present if irrigation water is comingled with stormwater |

#### Common Sources

High nitrate and high nitrite values can be caused by the following sources:

|  |  |
| --- | --- |
| High Nitrate | High Nitrite |
| * Biological waste in agricultural runoff * Compost * Fertilizer in irrigation runoff * Fertilizer in residential irrigation overspray * Runoff from nurseries and garden supply stores | * Corrosion inhibitors in industrial process and cooling water * Preservatives in food |

### Specific Conductivity

#### Description

Specific conductivity, also referred to as specific conductance, is a measure of how well water can conduct an electrical current based on ionic activity and content. Specific conductivity is an indicator of dissolved solids from potential pollutant sources such as sewage and washwater, and can help distinguish groundwater from illicit discharges and identify commercial/ industrial liquid waste if used in combination with another parameter such as [Hardness](#_Hardness), [Turbidity](#_Turbidity), or [Detergents/Surfactants](#_Detergents/Surfactants_1). Specific conductivity can also be used in combination with caffeine or pharmaceuticals (see Other Indicators) to indicate sanitary wastewater.

#### Applications

Specific conductivity is used as a follow-up indicator, and applies primarily to piped storm drainage systems in urban, commercial, and industrial land use types when flow is present. As an indicator, specific conductivity depends on whether concentrations are elevated in “natural” or clean waters. For example, seawater naturally has a high specific conductivity due to its high concentration of ionic constituents (salt). For this reason, specific conductivity testing is not recommended for detecting illicit discharges in marine outfalls or areas near marine waters.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes | * Urban * Commercial * Mining * Industrial | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to specific conductivity sampling includes:

* Conductivity meter (if field meter is used)
* Conductivity standard solutions (if field meter is used)
* Thermometer (if field meter is used)
* Laboratory grade cleaning wipes (if field meter is used)
* Tap water (for first rinse)
* Distilled water (for final rinse)
* Wash bottle (for rinsing with distilled water)
* Clean, sterile sample bottles (glass or plastic)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107‑1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Specific conductivity can be measured using a conductivity field meter or at an analytical laboratory. General procedures for using a field meter and collecting a sample for laboratory analysis are outlined below. Refer to the user’s manual with your field meter for more detailed information. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### Specific Conductivity Field Meter

The specific steps for using field meters (defined in Section 4.2) vary depending on the brand of field meter being used. Refer to the user’s manual with your field meter for more detailed information. The following steps are generally common to specific conductivity field meters:

1. Check Meter: Prior to taking meter in the field, confirm that the meter and probe are working properly and sufficient battery life is left.
2. Calibrate Meter:
   1. Verify the meter’s internal temperature sensor against a thermometer and note any differences.
   2. Rinse probe with distilled water and blot dry with a laboratory grade cleaning wipe.
   3. Immerse the probe in the first standard solution and calibrate; follow with additional standards if appropriate (rinsing with distilled water between each standard).
   4. Record post calibration readings and recalibrate if necessary.
3. Field Measurements:
   1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants.
   2. Collect a field sample in a clean, sterile sample bottle made of glass or plastic. Avoid collecting sediment with the water sample.
   3. Immerse the probe in the sample (or place a drop of the sample on the sensor) and allow the meter to stabilize.
   4. Record the temperature and the conductivity value shown on the meter on your field data sheet, notebook, or field laptop/tablet. If the meter does not automatically compensate for temperature, it is important to document the temperature so that the appropriate adjustments can be made.
   5. Rinse the probe with distilled water and dry with a laboratory grade cleaning wipe between each reading and before storage.
4. Meter Storage: Rinse the conductivity sensor with clean water after each use. To clean to conductivity sensor, dip the sensor in a foaming acid tile cleaner and agitate for 2 to 3 minutes. Use a small nylon brush to remove any contaminants from the inside of the electrode chamber. Repeat above steps until sensor is completely clean, then rinse with distilled water. Store in the meter storage chamber.

###### Specific Conductivity Laboratory Analysis

The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle.
2. Rinse the clean, sterile sample bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.
3. Fill the bottle completely to the top after the third rinse.
4. Label the bottle with the sample location, date, and time.
5. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.
6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 28 days of sample collection.

#### Thresholds

The following specific conductivity concentration is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Background specific conductivity concentrations can vary and are strongly influenced by local geology, ambient temperature, and dilution from stormwater runoff. Washington State does not have surface water quality standards for specific conductivity, but drinking water standards for specific conductivity in Washington State are set at > 700 microsiemens per centimeter (µS/cm).

|  |
| --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling |
| >500 µS/cm |

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Easy and quick measurements | * Naturally occurring * Ineffective in saline waters * High specific conductivity may be present if irrigation water is comingled with stormwater * Moderately elevated specific conductivity (400‑500 µS/cm) may not necessarily indicate an illicit discharge; additional indicator sampling may be needed to verify the source |

#### Common Sources

High specific conductivity can be caused by the following sources:

|  |  |
| --- | --- |
| High Specific Conductivity (Industrial/Commercial) | High Specific Conductivity (Residential) |
| * Commercial/industrial waste * Plating bath water * Radiator flushing water * Food manufacturing * Wood products * Shallow groundwater | * Sanitary wastewater * Washwater (laundry) * Washwater (vehicle) * Shallow groundwater |

Low specific conductivity could result from the presence of tap water or spring water.

### Total Petroleum Hydrocarbons (TPH)

#### Description

Total petroleum hydrocarbons (TPH) is a term that is used to describe a family of several hundred chemical compounds, primarily composed of hydrogen and carbon (hydrocarbons), that originate from crude oil. Some of the chemicals found in TPH include benzene, toluene, xylene, hexane, naphthalene, and fluorene. In Washington, the analytical laboratory analysis (NWTPH) groups these compounds into Dx (motor oil and diesel) and Gx (gasoline) fractions. The Dx fraction includes jet fuels, kerosene, diesel oils, hydraulic fluids, mineral oils, lubricating oils, and fuel oils. The Gx fraction includes aviation and automotive gasolines, mineral spirits, Stoddard solvent, and naphtha.

#### Applications

TPH is used as a follow-up indicator and applies to applies to all storm drainage system and land use types.

|  |  |  |
| --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet |

#### Equipment

Refer to the equipment list in the [Field Screening Methodology](#_Field_Screening_Methodologies) section for the methodology you have selected. Equipment specific to TPH sampling includes:

* Clean, sterile sample bottles (typically amber glass)
* Field laptop/tablet and/or clipboard, field forms and pen/pencil
* Safety equipment (for example, hard hats, ANSI 107-1999 labeled safety vests)
* Nitrile gloves
* Sturdy boots or belted waders
* Claw grabber or telescoping sampling pole (for collecting samples)

#### Methods

Laboratory analysis is recommended for TPH detection. General procedures for collecting a sample for laboratory analysis are outlined below. Field test kits may also be available for screening for presence or absence of TPH in the field; however, since the authors of this manual did not have direct experience using field test kits for TPH detection (or oil screening), they were not added to this manual for this update. Refer to [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42) for additional indicator sampling after obtaining results.

##### TPH Laboratory Analysis

TPH samples are typically submitted to an analytical laboratory for analysis. A single water sample can be analyzed for multiple indicators at an analytical laboratory; however, you should verify the required volume for each analysis in order to ensure that you collect enough sample volume in the field. The following steps should be followed to collect samples for laboratory analyses:

1. Wear nitrile gloves to avoid sample contamination and protect yourself from potential contaminants. Do not touch the inside of the lid or bottle. For TPH samples, glass bottles are required (TPH will stick to the sides of plastic bottles).
2. Label the bottle with the sample location, date, and time. It is easier to pre-mark a dry bottle prior to sample collection.
3. Rinse the clean, sterile sample bottle three times with sample water before collecting the sample. Make sure to empty the sample water either downstream or away from your sampling location to avoid stirring up sediment and to avoid collecting sediment with your water sample.
4. Fill the bottle completely to the top after the third rinse.
5. Keep the samples at 4°C (40°F) by placing them in an ice-filled cooler.
6. Fill out a chain-of-custody form and submit to a laboratory. The samples must be analyzed within 14 days of sample collection (or within 7 days if unpreserved).

#### Thresholds

The following TPH concentration is recommended for triggering further investigation and additional indicator sampling. This threshold may be modified for use based on local knowledge or observations. Washington State does not have surface water quality standards for TPH, but does have surface water quality standards for some of the components of TPH (for example, benzene). The state has developed Model Toxics Control Act (MTCA) cleanup values for TPH present in groundwater. TPH measurements are measured in units of milligrams per liter (mg/L).

|  |
| --- |
| Recommended Threshold for Further Investigation and Additional Indicator Sampling |
| 1 mg/L (Dx or Gx) |

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Laboratory analysis is relatively inexpensive * Test result should be unambiguous | * Wait time for results from laboratory analysis * Laboratory analysis does not distinguish between the various types of hydrocarbons * Field test kit does not provide a TPH concentration, just the presence or absence of TPH |

#### Common Sources

High TPH can be caused by the following sources:

|  |
| --- |
| High TPH |
| * Heating oil leaks from underground or aboveground storage tanks * Leaking vehicles and equipment * Leaking construction equipment * Leaks from improper fuel storage containers (tanks, drums, etc.) * Service stations * Engine or automobile repair shops * Automotive dealerships * Municipal garages * Washing down or degreasing vehicles and equipment * Abandoned or converted service station fuel tanks * Fleet operators (e.g., taxicab and vehicle rental companies) * Industrial plants, including refineries, terminals, and bulk plants * Airports * Pipelines * Abandoned oil and gas wells * Pesticides |

### Other Indicators

The following indicators are not described in detail in this manual, but may be used for specialized investigations on a case‑by‑case basis. Recommended threshold values (or ranges) are included if they were specified in the references reviewed for the literature review for this project, but were not available for all indicators.

| Other Indicators | Description | Recommended Threshold Value |
| --- | --- | --- |
| Alkalinity | Alkalinity is a measure of the buffering capacity (ability to neutralize acids and bases) of a water body. It can be used along with pH, hardness, temperature, and conductivity, as an indicator of an industrial wash water discharge. | NG |
| Biochemical oxygen demand (BOD) | BOD is a measure of the amount of oxygen required or consumed for the microbiological decomposition (oxidation) of organic material in water. High BOD values may indicate industrial, domestic, or agricultural sources of organic matter, which may cause low dissolved oxygen levels. It is often used in combination with COD. | >30 mg/Li |
| Boron | Boron is added as a water softener to washing powders and detergents and may indicate sewage or washwater discharges. It can also be added to swimming pools (in the form of borate) to stabilize pH. | >0.35 mg/L for wastewater or washwatera,b,c  <0.35 mg/L for tap or irrigation waterb,c |
| Caffeine | Caffeine can be used to indicate the presence of sanitary sewage. Caffeine is best used in combination with other indicators such as pharmaceuticals, specific conductivity, and temperature. Lower values of specific conductivity in water that tests positive for caffeine may indicate dilution of the water being tested and highlight the need for further investigation moving upstream. | NG |
| Chemical oxygen demand (COD) | COD is a measure of the amount of oxygen required or consumed for the microbiological decomposition (oxidation) of organic material in water. High COD values may indicate residual food and beverage waste from cans and bottles, antifreeze, or emulsified oils, which may cause low dissolved oxygen levels. It is often used in combination with BOD. | >120 mg/Li |
| Dissolved oxygen (DO) | DO is an important parameter for salmonids and other aquatic organisms. Low dissolved oxygen levels can be harmful to larval life stages and respiration of juveniles and adults. DO depends on local hydraulic conditions affecting the oxygenation of the discharge. For this reason, DO is not a widely useful indicator for illicit discharges. | <6 mg/Ld |
| Fecal sterols | Fecal sterols have been used as chemical indicators of fecal pollution in many parts of the world. The primary sterol found in human feces is coprostanol. Fecal sterols can be used to indicate the presence of sanitary sewage, but are not specific to human waste. They are best used in combination with other fecal indicators if confirmation of human fecal pollution is desired. | NG |
| Fluorescence | Fluorescence is an analytical technique that can identify a wide range of organic compounds. Optical brighteners use fluorescence by changing the reflective wavelength of material exposed to brightener chemicals, which are often used in laundry detergents to make fabrics appear whiter or brighter. In addition to portable optical brightener pads for in-situ detection (see Appendix G), portable fluorometers can also be used to detect brighteners in water samples. Some fluorometers have multiple “channels” that can be used to detect different wavelength ranges to indicate a range of organic compounds, turbidity, cyanobacteria, chlorophyll a, toxicity to cellular organisms, as well as detecting dye used for dye testing (see Section 5). | NG |
| Glycol | Glycol or ethylene glycol is the main component of automotive antifreeze. It can also be found in hydraulic brake fluids, deicing solutions, stamp pad ink, ballpoint pens, and print shops. Ethylene glycol is used to make some plastics and textiles. | >0.5 mg/Le  >1.5 mg/Lf  >5 mg/Ld |
| Metals | Metals are inorganic substances that occur naturally. Typical metals measured as water quality parameters include copper, lead, and zinc. At higher concentrations copper can become toxic to aquatic life. At low concentrations, copper can negatively affect olfaction in salmonids that plays a key role in species recognition, migration, reproduction, and predator avoidance. | >0.025 mg/L (copper)g  >0.1 mg/L (copper)h  >0.1 mg/L (lead)e  >0.2 mg/L (nickel)e |
| Pharmaceuticals | Pharmaceuticals, such as colfibric acid, aspirin, ibuprofen, steroids, and illegal drugs, can be used to indicate the presence of sanitary sewage. Pharmaceuticals are best used in combination with caffeine and specific conductivity. | NG |
| Phenol | Phenols are organic compounds that are produced for various industrial processes. Phenol is also produced by the natural degradation of organic wastes including benzene. Phenols are can be toxic to both humans and aquatic organisms. Sources of phenol include cleaning compounds, coal tar, wastewater from manufacturing (resins, plastics, fibers, adhesives, iron, steel, aluminum, leather, rubber), effluents from synthetic fuel manufacturing, paper pulp mills, and wood treatment facilities. Phenol can also be found in wastewater treatment plant effluent and sewage overflows. | >0.1 mg/Lg  >1.0 mg/Lh |
| Phosphate | Phosphate (or phosphorus) is a concern in fresh water because high levels can lead to accelerated plant growth, algal blooms, low dissolved oxygen, decreases in aquatic diversity, and eutrophication. | >0.5 mg/Le  >1.5 mg/Ld  ≥5.0 mg/Lf |
| Potassium | Potassium is a naturally occurring element that can be found widely in the environment and in natural waters. High concentrations of potassium are found in sewage and commercial/industrial discharges. See Appendix F for more detail on this indicator. | >5 mg/L |
| Orthophosphate | Orthophosphate (also known as soluble reactive phosphorus or SRP) is an inorganic fraction of phosphorus that is produced by natural processes, but also can be measured in municipal sewage. Additional sources of orthophosphate are similar to those for phosphate such as septic system failure, animal waste, decaying vegetation and animals, and fertilizer runoff. | NG |
| Oxygen stable isotopes | Naturally occurring oxygen is composed of three stable isotopes: 16O, 17O, and 18O. Oxygen stable isotopes are used to identify major sources of water such as drinking water and groundwater. | NG |
| Salinity | Salinity is the saltiness or dissolved inorganic salt content of water. The Pacific Ocean has an average salinity of 34 parts per thousand (ppt) compared to 29 ppt in Puget Sound. | NG |
| Semi-volatile organic compounds (SVOCs) | SVOCs are used and produced in the manufacturing industry (for example, in plastic, pharmaceutical and pesticide manufacturing) | NG |
| Tannins and lignins | Tannins and lignins are released during the decomposition of wood and tend to make water look dark brown or tea-colored. | NG |
| Total dissolved solids (TDS) | Total dissolved solids reflect the amount of dissolved material in water and strongly affect conductivity; most often used to detect industrial discharges. | NG |
| Total Kjeldahl nitrogen (TKN) | TKN is a combination of organically bound nitrogen and ammonia. TKN can be used as an indicator of pollution from industrial sources and municipal sewage. | >3 mg/Ld |
| Toxicity screening tests | Toxicity screening tests are short-term tests performed in a laboratory to assess the relative toxicity of a water sample to a selected test organism. | NG |

CFU/100 mL = colony forming units per 100 milliliters

mg/L = milligrams per liter

MPN/100 mL = most probable number per 100 milliliters

NG = no guidance provided in literature review

a Source: CWP (2004)

b Source: Lower Charles River (2004)

c Source: Snohomish County (2010)

d Source: King County (2011)

e Source: North Central Texas (2011)

f Source: Kitsap County (2011)

g Source: Lake County (2009)

h Source: Wayne County (1996)

I Source: Grand Island, Nebraska (2016)

# Source Tracing Methodologies

Once a potential illicit discharge has been detected using one or more of the field screening methodologies (Section 3 of this manual) and/or identified by one or more indicator tests (Section 4 of this manual), a source tracing methodology can be used to locate the source of the illicit discharge. Source tracing methodologies can also be utilized to respond to referrals through the IDDE/spill hotline, citizen complaints, or staff reports. The source tracing methodologies that are included in Section 5 of this manual are summarized below with their applicable system type:

|  |  |
| --- | --- |
| Piped Systems | Ditch Systems |
| * Business inspections * Catch basin/manhole inspections * Dye testing * Septic system inspections * Smoke testing * Vehicle/Foot Reconnaissance * Video inspections | * Business inspections * Catch basin/manhole inspections * Ditch inspections * Septic system inspections * Vehicle/Foot Reconnaissance |

## Selecting a Source Tracing Methodology

[Figure 3.1](#Figure31) shows the process of selecting a source tracing methodology for the following situations:

* Flow is not present, but visual/olfactory observations suggested a potential illicit discharge
* Flow is present, indicator sampling suggested a potential illicit discharge, and the investigator has access to the property where the illicit discharge is suspected to be originating from
* Flow is present, indicator sampling suggested a potential illicit discharge, and the investigator does not have access to the property where the illicit discharge suspected to be originating from

An IDDE program manager should select the most appropriate source tracing methodology depending on the location and type of illicit connection or illicit discharge that they are tracing, and the skill set of their staff and/or contractors. The methodology or methodologies should be selected based on what each jurisdiction determines to be the most appropriate; however, some general guidelines are provided below and in Table 5.1:

* Equipment and staff availability: Is an illicit connection suspected based on the indicators observed and measured? Do your staff frequently perform dye testing, smoke testing, or have access to video inspection equipment to conduct a video inspection?
* Weather: Most source tracing methodologies can be performed in dry or wet weather; however, video inspections tend to work better in dry weather. Sandbagging and optical brightener traps (see Appendix G) are also installed during dry weather if visual and/or olfactory observations suggest an illicit discharge, but no flow is present.
* Drainage area size: Most source tracing methodologies are easier to conduct on a small drainage area. Follow-up business inspections (see Appendix E) are typically performed if the source of an illicit connection or illicit discharge has been narrowed down to a few businesses or properties. Dye testing and septic system investigations are more cost effective if the potential area has been narrowed down to less than 10 properties.
* Coordination and investigation: If your City/County has a business inspection program, follow-up with them to find out the results of past business inspections on properties where a suspected illicit connection or illicit discharge may have been identified. The inspectors may also assist with follow-up source tracing inspections and/or enforcement actions. Contact your local health department to find out the results of past septic system inspections and coordinate with them to inspect properties where failing septic fields are suspected. Consult planning/development departments for recent permit activities (such as, building, plumbing, side sewer permits) that may require follow up investigations.
* Contracting out IC and ID source tracing: If sufficient staff time, equipment, or skills are not available to perform a particular source tracing methodology, a private contractor or another jurisdiction can be hired to perform the work. It is important that the selected contractor or jurisdiction has the required expertise to perform the source tracing methodology and that they follow the appropriate safety protocols.

|  |  |  |
| --- | --- | --- |
| Table 5.1. Source Tracing Methodology Recommendations Based on the Suspected Source of an Illicit Discharge. | | |
| Suspected Source | Examples | Recommended Source Tracing Methodologies |
| Cleaning chemicals | * Improper material storage * Improper waste disposal | * Business inspections * Vehicle/foot reconnaissance |
| Construction site runoff | * Failing erosion and sediment control BMPs * Concrete slurry * Oil sheen from leaking equipment or spills of fuel | * Catch basin/manhole inspections * Vehicle/foot reconnaissance * Video inspections |
| Gasoline, vehicle oil, or grease | * Leaking vehicle * Oil change * Leaking storage tank * Improper material storage | * Catch basin/manhole inspections * Vehicle/foot reconnaissance |
| Human/animal waste | * Illicit connection * Sewage overflow * Improper disposal of animal waste * Runoff or direct discharge from homeless encampment | * Catch basin/manhole inspections * Septic system investigation * Vehicle/foot reconnaissance |
| Industrial operations | * Illicit connection * Overflow * Improper material storage * Leaking storage tank * Improper waste disposal | * Catch basin/manhole inspections * Vehicle/foot reconnaissance * Video inspections |
| Industrial process water | * Illicit connection * Overflow | * Catch basin/manhole inspections * Vehicle/foot reconnaissance * Video inspections |
| Nutrient rich discharge | * Excessive irrigation * Excessive fertilization * Hydroseeding following construction | * Ditch inspections * Vehicle/foot reconnaissance |
| Sanitary wastewater or sewage | * Illicit connection * Sewage overflow * Septic system discharge | * Catch basin/manhole inspections * Dye testing * Smoke testing * Vehicle/foot reconnaissance * Video inspections |
| Tap water | * Illicit connection * Fire hydrant flushing * Swimming pool, hot tub, and spa drainage * Pressure washing for cleaning, paint removal, or stripping * Water main break | * Catch basin/manhole inspections * Ditch inspections * Vehicle/foot reconnaissance |
| Washwater | * Car washing * Pressure washing * Mobile cleaning | * Business inspections * Catch basin/manhole inspections * Vehicle/foot reconnaissance |

## General Guidelines

The following guidelines for data management recommendations, safety considerations, and costs apply to all the source tracing methodologies summarized in this section.

### Data Management Recommendations

The NPDES Municipal Stormwater Permits reissued in 2019 included an updated and prescriptive reporting requirement for IDDE programs. The reporting must include information addressing 12 questions on key details of each ID incident found. Information required includes location of the ID incident, response dates, how the incident was reported, if the discharge reached the MS4, what pollutants were identified, what the source was and was source tracing approaches were used, and what correction and elimination methods were used. The IDDE reporting questions are the same for all permittees and are listed in Appendix 14 of the NPDES Phase I Municipal Stormwater Permit, Appendix 12 of the NPDES Phase II Municipal Stormwater Permit for Western Washington, and Appendix 7 of the NPDES Phase II Municipal Stormwater Permit for Eastern Washington.

Related to these reporting requirements, a spatially referenced data management system (for example, ArcGIS geodatabase, Cartegraph, CityWorks, Microsoft Access database, or a specialized database) is an important component of any IDDE program. Regular updates to the system with IC/ID field screening information will reduce level of effort for submission to Ecology. The information stored in the data management system should be evaluated on an annual basis at a minimum to adjust the IDDE program as needed. Table 5.2 provides a summary of the some of the information that should be tracked in relation to each source tracing methodology for this purpose. This table includes basic guidance on tracking and reporting recommendations, but is not intended to provide an exhaustive list of all of the information that should be tracked for an IDDE program.

|  |  |
| --- | --- |
| Table 5.2. Data Management Recommendations for Source Tracing Methodologies. | |
| Source Tracing Methodology | Tracking and Reporting Recommendations |
| Business inspections | * Location of inspection * Parcel size * Business contact information * Number and types of illicit discharges or illicit connections identified * Number and types of BMPs in use to manage or treat runoff or process water * Business inspection forms * Digital photographs |
| Catch basin/manhole inspections | * Location of inspection * Number of catch basins/manholes inspected * Number and types of illicit discharges or illicit connections identified * Catch basin/manhole inspection forms * Digital photographs * Indicator sampling data * Follow-up sampling data * Flow data (if collected) |
| Dye testing | * Property owner contact information * Number and types of fixtures tested * Number and types of illicit discharges or illicit connections identified * Detailed sketch or map of facility showing fixtures tested * Dye testing forms * Dye color used * Digital photographs |
| Septic system inspections | * Property owner contact information * Number of inspections conducted * Number and type of retrofit recommendations made * Septic system investigation forms * Follow-up inspection/code enforcement |
| Smoke testing | * Length of storm drainage pipe network or drainage basin area * Number and types of illicit discharges or illicit connections identified |
| Video inspections | * Linear feet of pipe videotaped and reviewed * Number and types of illicit discharges or illicit connections identified * Video labeling and archiving |
| Vehicle/foot reconnaissance | * Location of survey * Length of roadway driven * Approximate size of drainage basin observed * Number and types of illicit discharges or illicit connections identified * Digital photographs |

### Safety Considerations

Safety is an important factor when conducting source tracing investigations. Refer to the general safety considerations summarized previously in [Section 3 – Field Screening Methodologies](#_Field_Screening_Methodologies).

### Costs

Costs for representative source tracing equipment and materials are summarized in Appendix A. The authors do not promote, endorse, or otherwise recommend any of the companies, individuals, or organizations presented in Appendix A.

## Source Tracing Methodology Pullout Sections

Each of the following source tracing methodology pullout sections is organized in the same format as the field screening methodologies and contains the following information:

* Description: Source tracing methodology definition
* Applications: Lists the applicable storm drainage system types (pipes and ditches), land use types (urban, rural, agricultural, commercial, industrial, mining, residential), weather conditions (dry and wet), and complementary source tracing methodologies
* Equipment: Checklist for field crews to determine what materials and supplies to bring out in the field
* Methods: Generic standard operating procedures for conducting the source tracing methodology
* Pros and cons: List of the positive and negative aspects of the source tracing methodology

### Business Inspections

#### Description

Business inspections can be used as a source tracing methodology once field screening has identified the presence of an illicit discharge, and the illicit discharge is suspected to be originating at a business or private property. When used for source tracing, business inspections will require a detailed investigation of potential cross connections and illicit discharge sources from materials stored and used at a business or private property.

#### Applications

Business inspections can be used for source tracing once the likely source of an illicit discharge has been narrowed down to a small drainage area (a few businesses or private properties).

|  |  |  |  |
| --- | --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions | Complementary Source Tracing Methodologies |
| * Pipes * Ditches | * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet | * Catch Basin/Manhole Inspections * Dye Testing * Septic System Inspections * Smoke Testing * Video Inspections |

#### Equipment

Equipment specific to business inspections includes:

* Local stormwater code or manual
* Best Management Practices (BMP) handouts and outreach materials (brochures, posters, etc.)
* Camera, phone, or other device for taking pictures (with date and time stamp)
* Site plans (if available)
* Maps of sanitary and storm drainage systems
* Facility/property owner contact information
* Various catch basin/manhole hooks and wrenches (including hexagonal Allen key) (for both types of inspections)
* Sledge hammer for loosening lids
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, eye protection, work gloves, ANSI 107‑1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment)
* Equipment for other source tracing methodologies to be used

#### Methods

Field crews should implement the following steps during business inspections for source tracing:

1. In-office Investigation:
   1. Review storm drainage and sanitary sewer maps to identify lateral sewer connections and access points including building sanitary sewer as-built drawings.
   2. Review results of previous investigations.
   3. Communicate with the site owner to gather information about the types of activities that occur on site.
2. Onsite investigation:

***Notes:***

1) As a general rule, do not enter private property without permission from the business owner.

* 1. Notify the property owner if required according to jurisdiction protocols (for example, using a notification letter).
  2. Walk and discuss site operations and BMPs in use with a property owner, manager, or other representative familiar with the site.
  3. Investigate material storage areas and handling and storage practices if hazardous or polluting materials are found on site.
  4. Ensure that there are no connections or discharges to the storm drainage system that contain anything other than stormwater. Check for dry weather flow in downstream catch basins/manholes or stormwater BMPs.
     1. Check to see if there are floor drains in any work areas on the site. If so, determine whether polluting fluids could enter the drain, and if the drain discharges to the sanitary sewer or storm system. [Catch Basin/Manhole Inspections](#_Catch_Basin/Manhole_Inspections), [Dye Testing](#_Dye_Testing), [Septic System Inspections](#_Septic_System_Inspections), [Smoke Testing](#_Smoke_Testing), or [Video Inspections](#_Video_Inspections) can be used to verify that floor drains and other indoor plumbing connections are not connected to the storm drainage system.
  5. Record any issues observed in field data sheet, notebook, or field laptop/tablet.

1. Conduct a second round of indicator sampling using [Catch Basin/Manhole Inspections](#_Catch_Basin/Manhole_Inspections), [Ditch Inspections](#_Ditch_Inspections), or Outfall Inspections to confirm initial results if business inspection does not lead to the source of the discharge.
2. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Can be used in combination with other source tracing methodologies to confirm drainage connections * Can be used as a public education and outreach tool to help prevent future illicit discharges * Effective during wet and dry weather * Can be combined with other NPDES permit requirements to reduce overall number of inspections | * Coordination with property owner, site visits, communication after the site visit, and follow-up can be time consuming * Private property access can be difficult if the property owner is not responding to notification letters or calls * Follow up source tracing methodologies may have limited effectiveness in wet weather |

### Catch Basin/Manhole Inspections

#### Description

Catch basin/manhole inspections can be used as a source tracing methodology once a suspected illicit discharge has been found to track the illicit discharge to its source. Catch basin/manhole inspections can be used any time of year when attempting to trace an illicit discharge back to a source.

#### Applications

Catch basin/manhole inspections can be used to trace a specific illicit discharge that was observed or reported back to its source. This methodology is most effective in urban environments with piped systems for source tracing when the likely source of an illicit discharge has been narrowed down to a small drainage area (20 structures or fewer).

|  |  |  |  |
| --- | --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions | Complementary Source Tracing Methodologies |
| * Pipes | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet | * Dye Testing * Smoke Testing * Video Inspections |

#### Equipment

The following suggested staffing and equipment apply to catch basin/manhole inspections:

* 2 field staff
* Cell phones or 2‑way radios
* Detailed maps of the storm drainage and sanitary sewer system
* Field laptop/tablet and/or clipboard, field forms (customized with line items for IDDE observations), and pen/pencil
* GPS unit
* Camera, phone, or other device for taking pictures (with date and time stamp)
* Dry erase board and pen for labeling catch basins or manholes (optional)
* Tape measure
* Traffic control signs and orange cones
* Confined space entry equipment (if needed)
* Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
* Sledge hammer for loosening lids
* Safety equipment (for example, hard hats, work gloves, ANSI 107‑1999 labeled safety vests, ear protection, steel-toe boots, gas monitor)
* Follow-up indicator sampling equipment (see [Flow](#_Flow), [Ammonia](#_Ammonia), [Specific Conductivity](#_Specific_Conductivity), [Color](#_Color), [Odor](#_Odor), [pH](#_pH), [Temperature](#_Temperature), and [Visual Indicators](#_Visual_Indicators) sections)

#### Methods

The methods for conducting catch basin/manhole inspections as well as the format of the inspection form used can be modified by each jurisdiction as needed. The general methods for conducting catch basin/manhole inspections for source tracing are provided below.

Notes:

1) Only staff with confined space entry training should enter manholes or other confined spaces.

2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.

1. Review maps and active construction permits to determine the area of the drainage basin where the illicit discharge might be originating from.
2. Select monitoring nodes where field sampling might quickly eliminate large portions of the drainage basin from further sampling while tracing the illicit discharge to its source.
3. Assess nearby traffic and potential hazards to pedestrians at each catch basin/manhole to be inspected. Review the Safety Considerations in Section 3.2 of this manual. Set up signs and cones as needed. Washington State Flagger Certification is required if placing cones in traffic; traffic flagging regulations must be followed.
4. Check the atmosphere within the manhole structure if you suspect that explosive or toxic gases may be present. Use a gas monitor (as you would during confined space entry).
5. Assign a unique number or identifier and record the latitude and longitude of the structure using a GPS unit if this has not previously been done.
6. Document any visual or olfactory indicators observed using a field notebook, customized catch basin/manhole maintenance inspection form, or a drop‑down menu (for example, data dictionary) on a GPS unit.
7. Collect a sample if dry weather flow is observed and record values for follow-up field screening indicators selected based on [Figure 4.1](#Figure41) and [Figure 4.2](#Figure42). Refer to the [Indicators](#_Indicators) section for additional detailed information regarding how these samples should be collected and analyzed.
8. Take a photograph if visual indicators are present. Optional: Use a dry erase white board next to the structure and include the date, time, structure ID, and inspector(s) initials.
9. Continue to the next monitoring node and repeat steps 3 through 8.
10. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.
11. Conduct a second round of indicator sampling to confirm initial results if catch basin/ manhole inspection does not lead to the source of the discharge.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Quick and inexpensive * Can test multiple storm drainage system branches that flow to a single manhole * Effective if storm drainage network is already mapped | * Some manholes will have flow continuously year round due to groundwater inflow * Traffic hazards and danger to pedestrians when accessing some catch basins/manholes * Potential for toxic or flammable pollutants and hazards if confined space entry is necessary * Can be time consuming and difficult if storm drainage map is unavailable or incomplete * Less effective in wet weather than dry weather * Wet weather safety considerations for confined space entry |

### Ditch Inspections

#### Description

Inspections of ditches and similar open channels or swales can help identify the source of illicit discharges, especially in rural areas that do not have piped stormwater conveyance systems. In addition to conveying stormwater flows from the municipal separate storm drainage system, ditches also receive flows with potential illicit discharges from adjacent private property via straight pipes, swales, or seepage from failing septic systems. Ditches may also convey natural flow and can be identified by their flow patterns and historical drainage patterns:

* If a ditch only flows during storm events or periods of site discharges and/or was specifically built to convey stormwater or discharge water, then it is not typically considered to be a ditch that conveys natural flow.
* If a ditch is located in an area where there historically was a stream, then it is likely that the ditch still conveys some natural flows.

#### Applications

Ditch inspections are most commonly conducted in rural areas, but can also be used in urban areas without piped storm drainage systems. Ditch inspections can be used in smaller drainage areas (up to two adjacent properties or at a road intersection where one or more ditches intersect) for source tracing.

|  |  |  |  |
| --- | --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions | Complementary Source Tracing Methodologies |
| * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet | * Septic System Inspections * Vehicle/Foot Reconnaissance |

#### Equipment

The following recommendations for staffing and equipment apply specifically to ditch inspections:

* 2 field staff
* 1 to 2 vehicles
* Cell phones or 2‑way radios
* Detailed maps of the storm drainage and sanitary sewer systems
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* GPS unit (optional)
* Camera, phone, or other device for taking pictures (with date and time stamp)
* 25’ or 50’ flexible tape measure, string, or twine
* Sturdy boots or belted waders
* Safety equipment (for example, hard hats, work gloves, ANSI 107-1999 labeled safety vests, ear protection)
* Sledge hammer for loosening lids
* Machete and/or loppers
* Follow-up indicator sampling equipment (see [Indicators](#_Indicators) section)

#### Methods

The methods for conducting ditch inspections as well as the format of the inspection forms used can be modified by each jurisdiction as needed. The following general guidance is recommended for completing ditch inspections.

1. Identify pairs of staff who will work together. The buddy system is recommended for field work for health and safety reasons. Review the Safety Considerations in Section 3.2 of this manual. Consider property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

Notes:

1) As a general rule, do not enter private property without permission from the landowner.

1. Review GIS field maps of the properties or road intersections that will be investigated. Review active construction permits in the vicinity of the inspection area.
2. Walk along a ditch that is being inspected. It may be helpful to inspect the confluence of several ditches where they come together at nodes near road intersections.
3. Collect a sample if dry weather flow is observed and record values for follow-up indicators selected based on [Figure 4.1](#Figure41) or [Figure 4.2](#Figure42). Refer to the [Indicators](#_Indicators) section for additional detailed information regarding how these samples should be collected and analyzed.

|  |
| --- |
|  |
| Ditch inspection (Photo Credit: Herrera). |
| Cheater Pipe |
| Cheater pipe (Photo Credit: Herrera). |

1. Document evidence of the following:
   1. Discharge Locations:
      1. Cheater pipes (pipes that bypass the drain field of a septic system)
      2. Other private drainage ditches or open channels
   2. Impacting Land Uses and Activities: visual observations
      1. Horse corrals and animal feed lots
      2. Landscaping adjacent to ditches
      3. Parking lots
      4. Pastures with grazing animals adjacent to a ditch
      5. Other land uses that could generate illicit discharges
   3. Dump Sites: approximate area, distance to ditch, and type of debris
      1. Small debris (for example, bottles, cans, and trash)
      2. Large debris (for example, shopping carts, abandoned cars, appliances, large quantities of yard waste [grass and yard clippings, piles of leaves], and/or miscellaneous pieces of junk)
      3. Trash or improvised latrines from homeless encampments
2. Record the location of each item of interest in step 5 on a field map or using a GPS unit.
3. Take photographs of each item of interest.
4. Fill out a field form or use a GPS unit with drop-down menus (for example, data dictionary) to document all observations from the ditch inspection.
5. Follow internal notification procedures to ensure proper reporting to other agencies and appropriate timely follow up if an illicit discharge is identified.
6. Return to the office and make sure that documentation from the field work is completed and downloaded. This includes hardcopy field forms, photographs, GPS data, and storm drainage system mapping updates delivered to GIS staff.
7. Conduct a second round of indicator sampling to confirm initial results if ditch inspection does not lead to the source of the discharge.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Can be used to locate unknown outfalls and update mapping * Effective in wet weather as well as dry weather | * Ditches can be difficult and even hazardous to access when vegetation is thick and/or when sides slopes are steep * Dense vegetation can make visual observations and finding outfalls or cheater pipes difficult * Access to ditches may be limited by permission to enter private property |

### Dye Testing

#### Description

Dye testing is a source tracing methodology typically used to pinpoint or isolate illicit connections in a smaller section of the storm drainage system, and may include testing the storm drainage system or plumbing fixtures at an individual facility. Dye testing is typically performed on all plumbing fixtures within a building (such as, sinks, toilets, and floor drains) using colored dyes. Dye is available in liquid, powder, strip, wax cakes and donuts, and tablet forms. The most commonly used color is fluorescent yellow-green; other colors include fluorescent red, orange, blue, and violet. Any dyes used for surface water testing must be non-toxic and biodegradable. Fluorescent dyes are easily detected with field fluorometer.

#### Applications

Dye testing is the most effective in small drainage areas (fewer than 10 properties). It is typically used once the likely source of an illicit discharge has been narrowed down to a few houses or businesses. This methodology is most effective for identifying continuous or intermittent discharges or connections. As an in-pipe methodology, dye testing can be complemented with the use of other in-pipe methodologies as noted in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions | Complementary Source Tracing Methodologies |
| * Pipes | * Urban * Commercial * Industrial * Residential | * Dry * Wet | * Catch Basin/Manhole Inspections * Smoke Testing * Video Inspections |

#### Equipment

Equipment specific to dye testing includes:

* 2 or more staff
* 2‑way radios or cell phones
* Dye (multiple colors; liquid powder, strip, wax, or tablet form)
* High-powered lamps or flashlights
* Field fluorometer with a rhodamine sensor (optional)
* Hose (optional)
* Camera, phone, or other device for taking pictures (with date and time stamp)
* Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
* Sledge hammer for loosening lids
* Activated charcoal packets (optional)
* Site utility plan (if available)
* Maps of storm drainage and sanitary sewer systems
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Facility/property owner contact information
* Safety equipment (for example, hard hats, work gloves, ANSI 107‑1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment, gas monitor)

#### Methods

##### Prior to Testing

Field crews should implement the following steps prior to dye testing:

1. Review storm drain and sanitary sewer maps to identify lateral sewer connections and access points including building sanitary sewer as-built drawings.
2. Notify property owners to obtain permission to enter home/facility at least 2 weeks prior to dye testing. Provide the following information:
   1. Date(s) that dye testing will occur
   2. Reason for dye testing
   3. Numbers to call regarding any questions related to the dye testing
3. Notify agencies to avoid wasted efforts should the dye testing result in complaints or reports of discoloration in the receiving water body. The following agencies should be notified regarding when and where dye testing will be occurring, dye color(s) being used, and which water body the dye may end up in:
   1. The agency responsible for operating the sewage system (either the local sewer district or the local public health department)
   2. City and/or County water quality or Public Works staff and/or spill hotline
   3. The Washington State Department of Ecology spill hotline
   4. Any other agency that could be involved in spill reporting and clean-up (for example, City/County Roads Maintenance Division)
4. Obtain a site utility plan (if available) and identify fixtures that will be tested.
5. Identify form of dye (such as, tablets, liquid, strips, powder, wax cakes, wax donuts) that will be used.

##### During Testing

Field crews should implement the following steps during dye testing:

1. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control, confined space entry needs, and property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

Notes:

1) Only staff with confined space entry training should enter manholes or other confined spaces.

2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.

3) As a general rule, do not enter private property without permission from the landowner.

1. Designate field staff positions (such as, dye tester and field verifier) and follow the steps outlined below:
   1. Field verifier: Select the closest sanitary sewer manhole for visual observations. Follow the field procedure for removal of manhole covers found in the [Catch Basin/Manhole Inspections](#_Catch_Basin/Manhole_Inspections_1) methodology. Monitor the manhole for toxic or flammable fumes before removing the lid completely.
   2. Dye tester: Flush or wash dye down the fixture or manhole being tested and then contact the field verifier using a 2‑way radio or cell phone. A different dye color should be used for each fixture and structure being tested. If dye tablets are being used, they can be dissolved before use in the fixture by being placed in a partially-filled water bottle and shaken. Use two tablets per bottle per dye test. Approximate dosages for several forms of dye are provided below. Refer to the instructions from the dye manufacturer for specific dosage information.

| Form of Dye | Approximate Dosage |
| --- | --- |
| Liquid | 1 oz per 500 gallons |
| Powder | 1 lb per 16,000 gallons |
| Strips | 1 strip per 500 gallons (or per toilet) |
| Wax cake | 1 cake per up to 3,600 gallons (Bright Dyes) |
| Wax cone | 1 cone per up to 12,000 gallons (Bright Dyes) |
| Wax donuts | 1 donut per 8,000 gallons (Norlab)  1 donut per up to 93,000 gallons (Bright Dyes) |
| Tablets | 2 tablets per test |

Record the time the dye was introduced to the fixture on the site utility plan or a dye testing field form.

Notes:

Dye tests typically last 20 to 30 minutes, but can last over an hour if sumps are present in the storm drainage system.

|  |
| --- |
| 6 |
| Dye test from a home thought to be illicitly connected to the storm drainage system (Photo Credit: City of Seattle). |

* + 1. Residential: Flush dye down the toilet. Flush quickly and repeatedly to prevent staining. Run a nearby sink/bathtub for 5 to 10 minutes to ensure the dye is washed to the monitored sanitary manhole. Alternatively, dye can be placed in the sewer cleanout for the house and washed down using a hose connected to a nearby hose bib. Note that the dye may need to be flushed for up to 1 hour if sumps are present in the storm drainage system.
    2. Commercial and Industrial: Flush dye down a restroom toilet, janitor’s sink, and floor drains. Flush quickly and repeatedly with water to prevent staining. Run a nearby sink for 5 to 10 minutes to ensure that dye is washed down to the monitored sanitary manhole. Note that the dye may need to be flushed for up to 1 hour if sumps are present in the storm drainage system.
    3. Sanitary Sewer: Choose a sanitary manhole upstream of the stormwater outfall or upstream of where the sanitary sewer line crosses the storm drain line
  1. Field verifier: Use a high-powered lamp or flashlight or field fluorometer with a rhodamine sensor to check if the dye appears; take photographs if possible. If dye appears in the sanitary sewer manhole, immediately call the dye tester to relay this information and the time the dye was observed. This is a correct sanitary sewer connection. The dye tester should note the correct connection and immediately move on to the next dye test location.
  2. Field verifier: If no dye is detected in the sanitary sewer manhole after 15 minutes of continuous water flow to the fixture, either an illicit sewage-to-stormwater connection may be present, or the fixture may be connected to another sanitary sewer main.
  3. Field verifier: Attempt to locate the dye by checking downgradient storm drains or outfalls for the presence of dye, determining if the sewer line is clogged, and verifying that the facility is not connected to a septic system or to another sewer main. The fixture may need an additional round of dye testing conducted, since the dye may have already passed through the stormwater conveyance section by the time the field verifier checks it. Make sure to use a different dye color and document the time of the second dye test.
     1. For dark light conditions where it may be hard to see the dye, it is recommended to use fluorescent dye with a field fluorometer to verify the presence of dye.
     2. If dye does not surface in the storm drain after two or more dye tests at the same fixture, or if the field staff cannot wait for the dye to surface, secure activated charcoal packets any place where dye is expected to surface. Leave the activated charcoal packets in place for a week or two, then retrieve and analyze. Activated charcoal packets can be disposed of in the garbage or recharged for future use. Use of activated charcoal packets for dye testing may require additional training.
  4. Dye tester: Record the date, time, dye color, and the fixtures that were tested on a site utility plan (if available) or develop a detailed sketch of the facility with this information.

1. Verify that all water has been turned off after testing fixtures and all manholes have been closed. Collect all testing equipment.
2. Notify the property owner(s) of the results of the dye testing
3. Conduct a second round of indicator sampling to confirm initial results if dye test does not lead to the source of the discharge.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Dye is water soluble, biodegradable, stable, and has low toxicity * Dye is inexpensive * Effectively locates specific illicit connections * Quick (typically 20‑30 minutes per test) * Easy to implement and to train staff to implement | * May be difficult to gain access to some properties * Time consuming in low flow conditions * May require follow up site visit if flow is too low at the time of the dye test * Can be difficult to see dye in high flow or turbid conditions * Requires notifying local public health and state water quality staff * Less effective during wet weather than dry weather |

Pros and cons of various forms and colors of dye include the following:

| Form/Color of Dye | Pros | Cons |
| --- | --- | --- |
| Liquid | * Disperses quickly * Easy to use * Works well with moderate to large volumes of water (>20,000 gallons) * Input can be metered | * Potential for spilling and staining ground, equipment, and clothing. |
| Powder | * Works well with moderate to large volumes of water (>50,000 gallons) * Can be premixed in 5-gallon pails of water prior to usage in high wind environments and indoors | * Messier than liquid and strips, especially in high wind environments and indoors * Not effective unless dissolved completely * Moderate rate of dispersion |
| Strips | * Less cumbersome than liquid dye * Ideal for cold weather applications (will not freeze) * Ideal for indoor applications (nothing to spill) * Provides a measured dosage (individually packaged) | * Multiple strips may need to be used in a larger volume of flow |
| Wax cakes or donuts | * Works well with moderate to large volumes of water (20,000-50,000 gallons) * Can be suspended in water from a line, string, or mesh bag | * Slow to moderate rate of dispersion (approximately 3 to 5 hours) |
| Tablets | * Dissolves quickly (3 to 5 minutes) * Can release dye over a longer period of time than some of the other forms of dye * Works well with small volumes of water (<20,000 gallons) | * May need to be dissolved in a small amount of water prior to use |
| Yellow-green | * Typically provides the greatest contrast in murky water * Easier to see than non-fluorescent blue dye * Typically takes 2 to 3 days to degrade/fade | * Can be difficult to see in sunlight |
| Red | * Easier to see than yellow-green dye if large amounts of algae are present * Easier to see than non-fluorescent blue dye | * Typically takes 5 to 7 days to degrade/fade |
| Orange | * Easier to see than yellow-green dye if large amounts of algae are present * Easier to see than non-fluorescent blue dye | * Can be difficult to see if water contains significant amounts of naturally occurring orange or brown substances, such as iron bacteria or tannins |
| Blue | * Best used in high-light environments and in clear water * Color may be more aesthetically acceptable to the public than fluorescent dyes | * Typically takes 2 to 3 weeks to degrade/fade * Not as readily visible in dark water and against dark background, such as metal pipes. |
| Violet | * Best used in high-light environments and in clear water * Color may be more aesthetically acceptable to the public than fluorescent dyes | * Not as readily visible in dark water and against dark background, such as metal pipes. |

### Septic System Inspections

#### Description

Septic system inspections are a source tracing methodology that can be used to detect failing septic systems and locate illicit discharges in drainage basins with elevated concentrations of  bacteria or nutrients. Failing septic systems produce an illicit discharge of sanitary wastewater, commonly called septage, through a breakout at the ground surface from a septic drain field or a straight pipe discharge (cheater pipe) where a property owner has intentionally bypassed the drain field of a septic system.

#### Applications

Septic system inspections are most commonly performed in rural areas, but also in some urban settings where homes are not connected to the sanitary sewer system. Detailed system inspections are often performed by County health department inspectors or private contractors, but City staff may conduct homeowner interviews or yard inspections. Some jurisdictions may have developed Pollution Identification and Correction (PIC) programs and Onsite Sewage System (OSS) Monitoring and Maintenance programs that refer to local regulations and authorities to address pollution caused by on-site septic systems. PIC Programs can help a jurisdiction prioritize and address water quality problem areas by educating owners and residents regarding proper septic system maintenance and corrective actions. Septic system inspections are the most effective for IDDE in small drainage areas (less than 10 properties) once the likely source of an illicit discharge has been narrowed down to a few houses or businesses. This methodology is most effective for identifying intermittent discharges or connections.

|  |  |  |  |
| --- | --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions | Complementary Source Tracing Methodologies |
| * Ditches | * Rural * Urban * Commercial * Industrial * Residential | * Dry * Wet | * Ditch Inspections * Dye Testing * Smoke Testing * Vehicle/Foot Reconnaissance |

#### Equipment

Equipment specific to septic system inspections includes:

* 1 or 2 staff
* Camera, phone, or other device for taking pictures (with date and time stamp)
* Nitrile gloves
* Site plans (if available)
* Maps of nearby natural drainage systems
* Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
* Sledge hammer for loosening lids
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, work gloves, ANSI 107‑1999 labeled safety vests, steel‑toe boots, ear protection, safety glasses, traffic control equipment, gas monitor)

#### Methods

Four methods used to identify failing septic systems include: 1) homeowner interview and yard inspection, 2) detailed system inspection, and 3) canine scent tracking. Each method is briefly summarized below.

##### Homeowner Interview and Yard Inspection

Notes:

1) As a general rule, do not enter private property without permission from the landowner.

The table below provides example questions for conducting a homeowner interview and questions that can be used as part of a checklist for performing a yard inspection. Appendix B also includes example septic system survey forms and questions. If property access is granted by the homeowner, both sets of questions can be used during the same site visit. It is helpful to compare the system capacity against water usage for the entire household to determine if the system may be overloaded. Typical water usage rates range from 50 to 100 gallons per day per person and a septic tank should be large enough to hold 2 days’ worth of wastewater.

| Homeowner Interview Questions | Yard Inspection Checklist Questions |
| --- | --- |
| How many years old is the septic system? | Is there visible liquid on the ground surface above the drain field (for example, surface breakouts)? |
| What is the septic tank capacity? | Are any obvious pipes installed to bypass a failing drain field? |
| When was the system last cleaned or maintained? | Are there wet, soft spots, sewage odors, lush green grass, or dead grass in the yard near the drain field? |
| Do the drains in the house empty slowly or not at all? Do toilets back up frequently? | Are any cars, boats, or other heavy objects located over the drain field that could crush lateral pipes? |
| How many people live at the residence? | Are there any cave-ins or exposed system components? |
| Is the septic tank effluent piped so it drains to a roadside ditch, storm drain, stream, or farm drain tile? | Is there an algae bloom or excessive weed growth in an adjacent ditch or stream? |
| How many water-using machines do you have in your home (for example, washing machine, garbage disposal, dish washer, water softener, whirlpool tub)? | How many feet away from the drain field is the shore of a lake, stream, and/or stormwater ditch? |
| Do you have a sump pump that discharges to the septic system? | Have elevated levels of fecal coliform bacteria (or other bacterial indicators) been detected downstream from the home or in a nearby ditch and/or stream? |
| Do you have roof drains or floor drains that discharge to the septic system? | Are the maintenance holes accessible? |

##### Detailed System Inspection

|  |
| --- |
|  |
| Components of a standard septic system that would be inspected during a detailed system inspection. |

Homeowners can hire a certified professional to inspect their septic system if they notice odors, backups, or their system is not functioning properly. A typical inspection includes checking the integrity of the entire septic system to observe any leaks, broken pipes, or blockages. An inspection also includes measuring the depth of solids, estimating the distance to surface water and groundwater, and [Dye Testing](#_Dye_Testing) the system.

##### Canine Scent Tracking

Some jurisdictions in the United States use trained dogs to detect septage and surfactants in illicit discharges from failing septic systems. The dogs are typically trained as puppies and most dogs can learn to differentiate between fecal waste from animals versus from humans.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Homeowner interviews and yard inspections are inexpensive and easy to perform * The results of interviews and inspections can often identify obvious illicit discharges * Using trained dogs, if available, can quickly and accurately identify an illicit discharge * Effective in wet weather as well as dry weather | * Homeowner interviews may be inconclusive if the homeowner is not knowledgeable about their septic system * Site-specific inspections require permission to access a property * A detailed system inspection can be expensive and time consuming to perform * Trained dogs are expensive to either contract with or to keep on hand. |

### Smoke Testing

#### Description

Smoke testing is a source tracing methodology that involves forcing a non-toxic, artificially-created smoke through a storm drainage system using a smoke blower or fan to find leaks and illicit connections to the system. Plumes of smoke will form where leaks or connections are present. Smoke testing has been used historically to identify areas of inflow or infiltration into the sanitary sewer system; however, its application to IDDE investigations of the storm drainage system is relatively new. While smoke testing can determine the source of direct discharges and connections, it is ineffective in identifying any indirect discharges to the storm system, such as spills or dumping.

#### Applications

Smoke testing is most effective when the illicit discharge has been isolated to a small drainage area (the upper reaches of the storm drainage network). It is useful when pipe diameters are too small for video inspections and gaining access to multiple properties makes dye testing an infeasible option. This methodology can be used to identify continuous, intermittent, or transitory discharges or connections.

|  |  |  |  |
| --- | --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions | Complementary Source Tracing Methodologies |
| * Pipes | * Urban * Commercial * Industrial * Residential | * Dry * Wet | * Business Inspections * Catch Basin/Manhole Inspections * Dye Testing * Vehicle/Foot Reconnaissance * Video Inspections |

#### Equipment

Equipment specific to smoke testing includes:

* 2 or more staff
* Smoke source (smoke candle or liquid smoke)
* Smoke blower or fan (smoke candle blower or liquid smoke blower)
* Sewer plugs (sandbags or expandable plugs)
* Bucket and rope (if using smoke candle)
* Camera, phone, or other device for taking pictures (with date and time stamp)
* Handheld video camera (for documenting test, including views of all homes/businesses in range of test)
* Nitrile gloves
* Site plans (if available)
* Maps of storm drainage and sanitary sewer system
* Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)

|  |
| --- |
|  |
| Smoke testing engine and liquid smoke in place during smoke test (Photo Credit: City of Seattle). |

* Sledge hammer for loosening lids
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Safety equipment (for example, hard hats, work gloves, ANSI 107‑1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment, gas monitor)

#### Methods

##### Prior to Testing

|  |
| --- |
| smoke testing |
| Smoke test reveals connections to the storm drainage system (Photo Credit: City of Federal Way). |
|  |
| Different colored smoke candles used in a manhole (Photo Credit: Herrera). |

Field crews should implement the following steps prior to smoke testing.

1. Notify the public by letter at least 2 weeks prior to smoke testing. Provide the following information:
   1. Date(s) that smoke testing will occur
   2. Reason for smoke testing
   3. Methods to prevent smoke from entering homes
   4. Action to take if smoke enters homes
   5. Numbers to call and relay any health concerns regarding smoke testing
2. Notify the local fire and police departments of smoke testing at least 1 week before testing to warn them of potential calls from the public.
3. Remind the fire and police departments of smoke testing again on the day of testing; personnel from these departments may wish to be present at the smoke test.
4. Notify the public by door hanger notice the day or two prior to actual smoke test. Door-to-door visits by staff with pictures of smoke testing can also help to prepare the public, especially in neighborhoods where English is not the primary language. Provide same information specified above and included on the initial notification letter.
5. Conduct a second round of indicator sampling to confirm initial results if smoke testing does not lead to the source of the discharge.

##### During Testing

Field crews should implement the following steps during smoke testing.

1. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control, confined space entry needs, and property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.

Notes:

1) Only staff with confined space entry training should enter manholes or other confined spaces.

2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.

3) As a general rule, do not enter private property without permission from the landowner.

1. Identify type of smoke (such as, smoke candle, liquid smoke) and type of blower (such as, smoke candle blower or liquid smoke blower) that will be used
2. Open the catch basin or manhole that leads to the branch of the storm drainage system suspected of an illicit connection
3. Seal off all storm drainage branches except one branch by using sandbags. See Sandbagging methodology (Appendix G) for more information on sandbag placement.
4. Set up the smoke blower by pointing it into the open catch basin or manhole
5. Designate field staff positions (such as, smoke tester and field verifier) and follow the steps outlined below:
   1. Field Verifier: Turn on the smoke blower.
   2. Smoke Tester: If using a smoke candle, light the candle and lower the it into the open catch basin using a bucket and aim the smoke candle blower into the open catch basin or manhole.
   3. Smoke Tester: If using liquid smoke, inject liquid smoke into the hot exhaust of the liquid smoke blower and aim blower into the open catch basin or manhole.
   4. Field Verifier: Observe the surrounding area for smoke escaping from leaks, internal plumbing fixtures, or sewers.
   5. Field Verifier: Document any visual evidence of smoke using a field notebook, customized smoke testing form, or using a drop-down menu (for example, data dictionary) on a GPS unit. Differentiate the source of smoke on building exteriors and roof tops. Smoke from gutters and downspouts indicate normal stormwater connections. Smoke from a soil stack (plumbing vent), floor drains, sinks, or interior plumbing fixtures indicates an illicit connection.
6. Conduct a second round of indicator testing to confirm initial results if smoke testing does not lead to the source of the discharge.

Additional considerations for smoke testing include:

* Online postings, community meetings, and news reports can be an effective way of notifying the public.
* Smoke escaping from floor drains, sinks or other plumbing fixtures inside buildings or from exterior soil stacks (plumbing vents that typically extend above the building roof) are indications of illicit sewer‑to‑stormwater conveyance connections. Note that many plumbing connections will have water standing in their P‑traps (fitting outside the U‑bend); this water typically prevents smoke from entering the fixture from the stormwater system if there is an illicit connection. However, neglected floor, sink or shower drains may have dried out P‑traps that will allow smoke to pass through. A toilet with a bad wax ring may allow smoke to enter the house if an illicit connection is present. Exterior soil stacks (plumbing vents) should allow smoke to pass if an illicit connection is present.
* Smoke leaving gutters and downspouts of houses/businesses are indications of normal downspout‑to‑stormwater conveyance system connections and are not evidence of illicit connections. It is also normal for smoke to escape from storm drainage manholes, catch basins, or any structure intended for storm drainage conveyance.
* Smoke blowers can weigh up to 100 pounds.
* Any smoke testing equipment purchased for IDDE purposes can also be used to evaluate maintenance needs and check for leaks or damage of sanitary sewers or storm drainage pipes.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Useful for finding cross connections from the sanitary sewer system * Can be used to verify mapping * Can identify other underground sources caused by storm drainage damage * Quick (about 30 minutes) * Inexpensive * Effective in wet weather as well as dry weather | * Must notify public in advance (2 weeks recommended) prior to smoke testing * More effective in inflow and infiltration investigations for sanitary sewer systems than in detecting illicit connections to storm drainage system * May cause irritation of respiratory passages * Not effective in identifying indirect discharges |

Pros and cons of various forms of smoke include the following:

|  |  |  |
| --- | --- | --- |
| Form of Smoke | Pros | Cons |
| Liquid | * Easier to control than smoke candles * No shelf life * Less expensive to run per minute of smoke * Produces smoke for 45 to 60 minutes | * Not as visible as smoke candles * Does not travel as far as smoke candles * Petroleum-based oil * Requires a liquid smoke blower or liquid smoke conversion kit on a smoke candle blower |
| Candles | * Produces a denser smoke than the liquid form * Less expensive equipment than the liquid form * Compact * Can be biodegradable * Can be daisy-chained to lengthen tests (for example, 6, 9, or 12 minutes of smoke) | * Should be stored in a dry location * Has a shelf life of 1 to 2 years * Only generates smoke for approximately 3 minutes |

### Vehicle/Foot Reconnaissance

#### Description

Vehicle/foot reconnaissance is a source tracing methodology that can be used during dry or wet weather when attempting to trace an illicit discharge back to a source.

This methodology is most effective when used after a field screening methodology has narrowed down the drainage area to a smaller area or properties suspect of illicit discharge or illicit connections. As a source tracing methodology, foot reconnaissance relies on walking and investigating specific areas identified in the screening process.

#### Applications

Vehicle/foot reconnaissance is the most effective as a source tracing methodology in small drainage areas (a few businesses or properties) where the field crew is familiar with surrounding business operations. Vehicle/foot reconnaissance is typically followed by another source tracing methodology to confirm the source of any suspected illicit discharges.

|  |  |  |  |
| --- | --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions | Complementary Source Tracing Methodologies |
| * Pipes * Ditches | * Rural * Urban * Agricultural * Commercial * Industrial * Mining * Residential | * Dry * Wet | * Catch Basin/Manhole Inspections * Ditch Inspections * Dye Testing * Septic System Inspections * Smoke Testing * Video Inspections |

#### Equipment

Equipment specific to vehicle/foot reconnaissance include:

* Vehicle
* Camera, phone, or other device for taking pictures (with date and time stamp)
* GPS unit
* Detailed maps of the storm drainage and sanitary sewer systems
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil

#### Methods

Field crews should implement the following steps during a vehicle/foot reconnaissance survey.

1. Review maps and active construction permits to determine the area of the drainage basin where the illicit discharge might be originating from.
2. Walk by the businesses suspected in the drainage area for obvious illicit connections or discharges.
3. Document any visual, olfactory, or auditory indicators observed using a field notebook, customized vehicle/foot reconnaissance form, or using a drop-down menu (such as a data dictionary) on a GPS unit. Take photographs of potential sources of illicit discharges at businesses and residences in the drainage basin.
4. Interview neighboring homeowners or business owners/employees regarding their observations. Homeowner interviews can be conducted when the source of the illicit connection or illicit discharge is suspected to be originating in a residential area. On sites where property access has not been granted or the property owner is reluctant to talk, surrounding homeowners or business owners/employees can often be a good source of information. The table below provides example questions for conducting an interview with a neighboring homeowner or business owner/employee.

| Neighboring Homeowner Interview Questions | Neighboring Business Owner/Employee Questions |
| --- | --- |
| Have you noticed any illegal dumping or improper storage of construction materials and household hazardous waste in your neighborhood? | Have you noticed any illegal dumping or improper storage of materials and hazardous waste at [the adjacent business]? |
| Have you noticed any issues with overfertilizing or overwatering in your neighborhood? | Have you noticed any issues with overfertilizing or overwatering at [the adjacent business]? |
| Have you noticed any leaking vehicles, garbage, or yard waste management problems in your neighborhood? | Have you noticed any issues with disposal of trash or dumping of oil, cleaning fluids, or other potentially toxic materials at adjacent businesses? |
| Have you observed any mobile contractors working in your neighborhood recently? | Are you aware of a new owner or new employees at [the adjacent business]? |
| Have you observed any new construction or remodeling occurring in your neighborhood recently? | Have you observed any new construction or remodeling occurring at [the adjacent business] recently? |

1. Follow up with [Dye Testing](#_Dye_Testing), [Smoke Testing](#_Smoke_Testing), or [Video Inspections](#_Video_Inspections) for obvious discharges that match the discharge downstream (for example gasoline discharge from a gas station; soapy discharge from a charity car wash or Laundromat).
2. Collect a sample using the methods outlined in the [Catch Basin/Manhole Inspections](#_Catch_Basin/Manhole_Inspections) or [Ditch Inspections](#_Ditch_Inspections) if the specific connection is not clear.
3. Conduct a second round of indicator sampling to confirm initial results using [Catch Basin/Manhole Inspections](#_Catch_Basin/Manhole_Inspections), [Ditch Inspections](#_Ditch_Inspections), or Outfall Inspections if vehicle/foot reconnaissance does not lead to the source of the discharge.

#### Pros and Cons

|  |  |
| --- | --- |
| Pros | Cons |
| * Can quickly identify and direct resources to cleaning up illicit discharges if the potential source has been isolated to a few businesses * Uses existing staff and experienced field crews * Low cost * Can identify compounded discharges (for example, illegal paint dumping and pressure washing) * Can be combined with temporary mitigation measures (for example, sandbagging) | * Not very precise or conclusive by itself * Detects only the obvious illicit discharges * Always requires follow up with another source tracing methodology * Only useful if the discharge has unique characteristics that pertain to directly certain business activities * Limited usefulness for detecting illicit discharges in piped systems |

### Video Inspections

#### Description

Video inspections are typically used as a source tracing methodology when looking for an illicit connection (typically a sanitary sewer) between two manhole structures or along an isolated segment of the storm drainage system. Video inspections are performed using a sewer inspection camera to record activity and condition of the storm drainage system segment. Video inspections provide documentation of actively flowing illicit connections, grease buildup, and other deposits or conditions caused by illicit discharges. They are particularly helpful when an illicit connection from the sanitary sewer system is suspected in a smaller reach of the storm drainage system or when used to inspect potential cross connections from a single business. Video inspections can be used in smaller sections of a piped storm drainage system to identify the source of an illicit discharge or illicit connection after indicator sampling has triggered a follow-up investigation.

|  |  |  |  |
| --- | --- | --- | --- |
| Storm Drainage System Types | Land Use Types | Weather Conditions | Complementary Source Tracing Methodologies |
| * Larger diameter pipes (>3 or 4 inches) | * Rural * Urban * Commercial * Industrial * Residential | * Dry * Wet | * Business Inspections * Catch Basin/Manhole Inspections * Dye Testing * Smoke Testing |

#### Applications

Video inspections are the most effective in small drainage areas (section of the storm drainage system that flows to a single node) or at a single business and are typically used once the likely source of an illicit discharge has been narrowed down and when access to property is limited. This methodology is most effective for identifying continuous or intermittent discharges or connections. If an illicit discharge is suspected in a smaller reach of a piped system but the pipe diameter is too small for a video camera, [Smoke Testing](#_Smoke_Testing) or [Dye Testing](#_Dye_Testing) should be considered as alternative source tracing methodologies.

#### Equipment

Different types of video equipment are used based on the diameter of storm drainage pipe being inspected. A site visit should be conducted prior to purchasing any video inspection equipment to determine the most appropriate video camera size, material, capabilities, and accessories. Equipment specific to video inspections includes:

* Closed‑Circuit Television (CCTV), capable of radial view and in color. Camera options include:
  + Mini cameras (1.5‑inch‑ to 4‑inch‑diameter pipes)
  + Lateral cameras (3‑inch‑ to 8‑inch‑diameter pipes)
  + Mainline crawler/tractor cameras (4‑inch‑ to 10‑inch‑diameter pipes)
* 200‑to 400‑foot push reel
* Tractor or crawler unit for camera
* Skid unit for camera
* Raft for camera (if water is present in storm pipe)
* Field laptop/tablet and/or clipboard, field forms, and pen/pencil
* Television system (truck, van, or utility trailer)
* High-powered lamps or flashlights
* Various catch basin/manhole hooks and wrenches (including hexagonal Allen key)
* Sledge hammer for loosening lids
* Safety equipment (for example, hard hats, work gloves, ANSI 107‑1999 labeled safety vests, ear protection, steel-toe boots, traffic control equipment, gas monitor)

#### Methods

Each video camera and video inspection system will have different instructions depending on its manufacturer, intended application, and capabilities. It is important to read the instructions for each component of the video inspection system closely, as equipment is expensive and potential damage to equipment should be minimized as much as possible. In general, field crews should implement the following steps during and prior to a video inspection:

Notes:

1) Only staff with confined space entry training should enter manholes or other confined spaces.

2) Use traffic control and orange cones near catch basins/manholes to protect you and pedestrians from harm.

3) As a general rule, do not enter private property without permission from the landowner.

1. Review the Safety Considerations in Section 3.2 of this manual. Consider traffic control, confined space entry needs, and property access before heading into the field. Staff should carry a current ID and business cards when conducting field work.
2. Determine the condition of the pipe segment being tested (such as, diameter, water ponding). If excessive debris or other material in the pipe is suspected, the pipe should be cleaned prior to conducting a video inspection.
3. Select an appropriately sized camera and camera navigation system for the pipe segment (for example, tractor or crawling unit, skid unit, raft). For smaller areas and pipes to single businesses, a smaller camera (mini camera) is recommended.
4. Orient the CCTV to keep the lens as close as possible to the center of the pipe.
5. Record a video with an audio voice over as the camera is guided through the pipe to document significant findings for future review and evaluation.
6. Follow the potential illicit discharge or connection up the storm drainage system using system maps
7. Notify the business or property owner of connection if a potential illicit discharge or connection is found.
8. Conduct a second round of indicator sampling using [Catch Basin/Manhole Inspections](#_Catch_Basin/Manhole_Inspections), [Ditch Inspections,](#_Ditch_Inspections) or Outfall Inspections to confirm initial results if video inspection does not lead to the source of the discharge.

#### Pros and Cons

| Pros | Cons |
| --- | --- |
| * Pinpoints exact location of breaks, infiltration, cross connections between manhole structures * Safer than confined space entry * Does not require intrusion on members of public | * Expensive, rig including cameras, monitors, trailers and associated equipment can be expensive * Only captures continuous discharges from pipes that are not submerged * Requires field crew training to operate equipment * May require line cleaning before equipment can be used * Specialized equipment needed for smaller diameter pipes * Debris and other obstructions can block off storm drainage pipe and restrict camera usage * Less effective in wet weather than in dry weather |

### Other Source Tracing Methodologies

The following source tracing methodologies are included in this manual with brief descriptions for reference and alternatives. Many of these have high cost of implementation and a specialized nature of the investigation, but can be researched by the investigator for usefulness and used on a case-by-case basis:

| Other Source Tracing Methodologies | Description |
| --- | --- |
| Continuous Monitoring | This methodology can be used to track intermittent or unpredictable illicit discharges such as sewer cross connections, draining storage tanks, and swimming pools as well as to capture the variability in discharges over time. In this context, continuous monitoring refers to water quality monitoring using unattended, preprogrammed automated instruments (such as a sonde, cold flush technology, or data loggers) in catch basins, manholes, and/ or outfalls to measure temperature, pH, specific conductivity, and/or dissolved oxygen, among other parameters. The results can complement automated sampling and help to determine if a location has an illicit connection or illicit discharge or if further indicator testing is needed. With cellular, satellite, or another telemetry connection, data from continuous monitoring can be viewed in real-time (or near real-time) if an instrument is programmed to send data to a cloud-based network platform. |
| Optical Brightener Monitoring | Optical brighteners are fluorescent white dyes that are used in laundry soaps and detergents to enhance the appearance of fabric and paper. Optical brightener monitoring involves anchoring an absorbent pad in a pipe, catch basin, manhole, or inlet to capture intermittent dry weather flows to determine if detergents are present. See Appendix G for details. |
| Pressure Testing | Pressure testing can be helpful in limited circumstances where a leak or break is suspected in a pressured pipe, such as a water or irrigation pipe, that could be contributing to dry weather (and wet weather) flow in a storm drainage pipe. |
| Sandbagging | Sandbagging is used to catch intermittent discharges by sealing off flow in the storm drain, followed by sampling. In addition to sandbags, other materials (for example, beach balls, expandable plugs, or caulk dams) can be used to block flow. See Appendix G for details. |

# References

Aspect Consulting. 2019a. Technical memo: IC-ID Feedback Workshops and Survey, Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual Update. May.

Aspect Consulting. 2019b. Technical memo: IC-ID Literature Review, Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual Update. June.

Aspect Consulting. 2019c. Technical memo: IDDE Data Review, Illicit Connection and Illicit Discharge Field Screening and Source Tracing Guidance Manual Update. August.

CWP. 2004. Illicit Discharge Detection and Elimination – A Guidance Manual for Program Development and Technical Assessments. Center for Watershed Protection, Ellicott City, Maryland. October.

Ecology. 2005. Stormwater Quality Survey of Western Washington Construction Sites, 2003-2005. Publication 05-03-028. Prepared by the Washington State Department of Ecology. August.

Ecology. 2018. Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring. Publication No. 18-10-024. Prepared by the Washington State Department of Ecology. July.

Ecology. 2019a. Phase I Municipal Stormwater Permit, effective date August 1, 2019. Prepared by the Washington State Department of Ecology.

Ecology. 2019b. Western Washington Phase II Municipal Stormwater Permit, effective August 1, 2019. Prepared by the Washington State Department of Ecology.

Ecology. 2019c. Eastern Washington Phase II Municipal Stormwater Permit, effective August 1, 2019. Prepared by the Washington State Department of Ecology.

Ecology. 2019d. Focus on Municipal Stormwater: General Condition G3 Reporting. Publication No. 07-10-089 (revised November 2019). Prepared by the Washington State Department of Ecology Water Quality Program. November.

Evergreen Safety Council. 2012. Traffic Control Flagger Certification Handbook, Fourth Edition. Prepared by the Evergreen Safety Council of Seattle, Washington.

Federal Highway Administration. 2012. Manual on Uniform Traffic Control Devices for Streets and Highways. 2009 edition (including Revision 1 dated May 2012 and Revision 2 dated May 2012). May.

King County. 2011. King County Dry Weather Outfall Reconnaissance Inventory (ORI) Standard Operating Procedures (SOP). SOP ID No. 2011-01. Prepared by King County Department of Natural Resources and Parks, Water and Land Resources Division, Stormwater Services Section. January.

Kitsap County. 2011. Illicit Discharge Detection and Elimination Program Summary Report 2000–2010: A Comparison of Outfall Screening, Reporting, and Inspection Programs. Prepared by Kitsap County Department of Public Works Surface and Stormwater Management Program, Kitsap County, Washington. July.

Lake County. 2009. Stormwater Management Program Plan. Prepared by The Lake County Stormwater Management Commission, The Village of Mundelein, and Bleck Engineering Company, Inc. April 20.

Lower Charles River. 2004. Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol. November.

North Central Texas. 2011. Illicit Discharge Detection & Elimination (IDDE) Field Investigation Guide.

Pitt, R. 2001. Methods for Detection of Inappropriate Discharges to Storm Drainage Systems Background Literature and Summary of Findings. November.

Snohomish County. 2010. Dry Weather Outfall Screening Manual. Prepared by Snohomish County Public Works, Surface Water Management Division, Snohomish County, Washington.

USGS. 2014. National Field Manual for the Collection of Water Quality Data (Chapter A2: Selection of Equipment for Water Sampling). Prepared by the United States Geological Survey. April.

Wayne County. 1996. Summary of Illicit Connection Detection Programs in Michigan Technical Memorandum. Prepared by the Rouge River Project, Wayne County, Michigan. February 19.

# Index

|  |  |  |  |
| --- | --- | --- | --- |
| **Suspected Source** | **Primary Field Screening Indicator(s)** | **Follow-Up Indicator(s)** | **Recommended Source Tracing Methodologies** |
| Cleaning chemicals | [Odor](#_Odor) | [Detergents/ Surfactants](#_Detergents/Surfactants) | * [Business inspections](#_Business_Inspections) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) |
| Construction site runoff | * [Color](#_Color) * [pH](#_pH) * [Turbidity](#_Turbidity) | [Specific Conductivity](#_Specific_Conductivity) | * [Catch basin/manhole inspections](#_Catch_Basin/Manhole_Inspections) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) * [Video inspections](#_Video_Inspections) |
| Gasoline, vehicle oil, or grease | * [Odor](#_Odor) * [Visual Indicators](#_Visual_Indicators) | [Total Petroleum Hydrocarbons](#_Total_Petroleum_Hydrocarbons) | * [Catch basin/manhole inspections](#_Catch_Basin/Manhole_Inspections) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) |
| Human/animal waste | * [Ammonia](#_Ammonia) * [Odor](#_Odor) * [Temperature](#_Temperature) * [Visual Indicators](#_Visual_Indicators) | * [Bacteria](#_Bacteria) * [Nitrate](#_Nitrate) | * [Catch basin/manhole inspections](#_Catch_Basin/Manhole_Inspections) * [Septic system investigation](#_Septic_System_Inspections) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) |
| Industrial operations | * [Color](#_Color) * [Odor](#_Odor) * [Temperature](#_Temperature) | * [Hardness](#_Hardness) * [Specific Conductivity](#_Specific_Conductivity) | * [Catch basin/manhole inspections](#_Catch_Basin/Manhole_Inspections) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) * [Video inspections](#_Video_Inspections) |
| Industrial process water | * [Temperature](#_Temperature) * [Visual Indicators](#_Visual_Indicators) | * [Hardness](#_Hardness) * [Specific Conductivity](#_Specific_Conductivity) | * [Catch basin/manhole inspections](#_Catch_Basin/Manhole_Inspections) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) * [Video inspections](#_Video_Inspections) |
| Nutrient‑rich discharge | [Visual Indicators](#_Visual_Indicators) | [Nitrate](#_Nitrate) | * [Ditch inspections](#_Ditch_Inspections) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) |
| Sanitary wastewater or sewage | * [Ammonia](#_Ammonia) * [Color](#_Color) * [Odor](#_Odor) * [Temperature](#_Temperature) * [Visual Indicators](#_Visual_Indicators) | * [Bacteria](#_Bacteria) * [Nitrate](#_Nitrate) | * [Catch basin/manhole inspections](#_Catch_Basin/Manhole_Inspections) * [Dye testing](#_Dye_Testing) * [Smoke testing](#_Smoke_Testing) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) * [Video inspections](#_Video_Inspections) |
| Tap water | * [Color](#_Color) * [Odor](#_Odor) | [Chlorine or Fluoride](#_Chlorine_and_Fluoride) | * [Catch basin/manhole inspections](#_Catch_Basin/Manhole_Inspections) * [Ditch inspections](#_Ditch_Inspections) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) |
| Washwater | * [Color](#_Color) * [Odor](#_Odor) * [Temperature](#_Temperature) * [Visual Indicators](#_Visual_Indicators) | * [Detergents Surfactants](#_Detergents/Surfactants_1) * [Specific Conductivity](#_Specific_Conductivity) | * [Business inspections](#_Business_Inspections) * [Catch basin/manhole inspections](#_Catch_Basin/Manhole_Inspections) * [Vehicle/foot reconnaissance](#_Vehicle/Foot_Reconnaissance) |

Appendix A

Field Screening, Source Tracing, and Indicator Sampling Equipment Costs

Appendix B

Example Field Forms

Field Screening Methodologies

Source Tracing Methodologies

Indicators

Appendix C

Case Studies

Appendix D

Other Resources

Appendix E

Other Field Screening Methodologies

Appendix F

Other Indicators

Appendix G

Other Source Tracing Methodologies