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I. History of Field Screening

From the first MS4 permit issuance in 1993, the City of Baltimore engaged in field screening as part of an Illicit Discharge Detection and Elimination (IDDE) program. The initial approach included a one-time sampling of the City's outfalls, using laboratory analysis. Given the large number of outfalls located in the City, cost in terms of personnel time and laboratory work did not correspond to a timely identification of sporadic illicit discharges. The one-time sampling did not yield information on the relative importance of the impact of the receiving waters. Even if the concentration of a pollutant from an outfall was high, the impact on the stream could be inconsequential if the outfall's flow rate were low, relative to the stream's flow. Addressing the relative impact of outfall discharges is important when the objective is to provide data for prioritizing pollutant tracking and abatement projects in a fiscally efficient and responsible way.

In the City's 1996 MS4 report, the City introduced the Stream Impact Sampling (SIS) monitoring project, conceived to address these concerns and to look at ways to more efficiently gather data so that the worst pollution problems could be attacked first. SIS monitoring was performed at locations to represent a spatially averaged condition within the stream instead of the outfalls. The locations were also selected based on access (i.e. public bridges). The analysis was still performed in the laboratory and included ammonia, nutrients, bacteria, metals, sediment and other water quality indicators.

In the City's 1998 MS4 Annual Report, the City introduced Ammonia Screening to complement the SIS program. The ability of the SIS program to track and isolate intermittent and transient contaminant sources was hampered by the time lag between sample collection and availability of laboratory results. Ammonia Screening introduced field analysis, primarily using field test kits for ammonia. Ammonia was selected as an indicator for sewage; sewage leaks and discharges were suspected as being the principal problem affecting the quality of streams. If the ammonia level at a station was 0.3 mg/l or greater, then a pollution source tracking (PST) investigation was initiated. The level of 0.3 mg/l was chosen because it was equal to the 75th percentile of the ammonia data from the historic data. As the years progressed, Ammonia Screening emerged as the primary field screening technique, while the SIS program was used for trend analysis. The sampling results of both the Ammonia Screening and AS program are posted on the City's website quarterly. Over the past 22 years, the staffing requirements, sampling locations, parameters, equipment, and technology have been added or modified to improve the Ammonia Screening program, resulting in the identification of an average of 75 sanitary-related illicit discharges per year.

II. Staffing Requirements

The City's Water Quality Monitoring and Inspection Section within the Department of Public Works consists for nine (9) field scientists, two supervisors, and one data manager. In addition to the Ammonia Screening program, SIS Program, and PST investigations, the section is responsible for the following:

- Complying with the Watershed Restoration and Stormwater Management Assessment conditions of the City's MS4 permit;
- Conducting annual biological and habitat assessments;
- Monitoring large sanitary sewer overflows (SSOs exceeding 10,000 gallons);
- Confirming abatement of SSOs;
- Compliance sampling for planned potable water discharges under the NPDES permit;
- Maintaining the City's Flood ALERT system, which includes rain and stream level gauges,
- Surface water sampling at the Quarantine Road Landfill; and
- Assisting in education and outreach efforts by DPW related to stream water quality.

The staff has a minimum education of a bachelor's degree in chemistry or biology or related field from an accredited college or university. In addition to the minimum education requirements, the staff is provided OSHA training (including confined space entry), CPR/ First Aid, and ethics training. Some staff members, assigned to perform PST investigations, are certified through the pipeline assessment certification program (PACP) through the National Association of Sewer Service Companies (NASSCO).

III. Location Selection

Initially, seventeen (17) sites were screened each week as part of the Ammonia Screening program. By FY 2016, there were forty-four (44) primary locations. Thirty-three (33) of these locations are also part of the SIS program. The locations were a combination of outfall and in-stream sampling locations. The outfall sampling locations were large-diameter outfalls with consistent base flow (i.e. piped streams). The in-stream sampling locations were selected based on access (public-owned land) and relative location to the discharge from several outfalls to be evaluated at one time. In FY 2016, the City added another 44 supplemental locations, which were sampled on at least a monthly frequency. The total distribution of Ammonia Screening sampling locations is as follows:

- 10 within the storm drain system
- 23 at outfalls
- 55 within non-tidal streams

The City's storm drain system includes over 1,700 outfalls; 350 of which are considered as major. Although the outfall locations only account for a small portion of the total outfalls, the drainage areas of the sampling locations comprise of the majority of the City. The sampling locations are evaluated every 5 years to ensure that the sampling locations prompt PST investigations.

IV. Sampling parameters and equipment

The name Ammonia Screening is a slight misnomer, since there are several chemical analyses performed. YSI water quality sondes are used for water temperature, dissolved oxygen, specific conductivity and pH. Hach portable colorimeters are used for nitrogen-ammonia and chlorine analysis. Observations of color/ cloudiness, odor, and change in discharge rate are also recorded.

A. Ammonia-nitrogen

Ammonia-nitrogen is used as the primary indicator of municipal wastewater. Ammonia nitrogen is typically around 30 milligrams per liter (mg/l) in municipal wastewater and can often be below 0.01 mg/l in surface waters. DPW established its assessment threshold value (ATV) at 0.3 mg/l for initiating PST investigations relevant to sewage from most sampling locations. The 0.3 mg/l ATV is based on data collected in the City streams and not an arbitrary number; the value was selected based on actual water quality data. The level 0.3 mg/l was equal to the 75th percentile of the ammonia data from the monthly Stream Impact Sampling (SIS) program between 1996 and 1998 at 17 locations. This threshold is also representative of surface waters polluted by wastewater in a ratio of 1 to 100 parts. The thresholds to

The ATV is used as a guide, not specific criteria. In some instances, if an ammonia nitrogen measurement is less than the ATV, but still above the average historic data for that monitoring location, a PST investigation may be started, especially if other physical indicators are observed. Conversely, if the ammonia nitrogen measurement of a monitoring location is elevated due to interference then a PST investigation may not be warranted.

B. Enterococcus

When elevated ammonia nitrogen measurements continue during a PST investigation but the entry location / discharge point within the stormwater system cannot be narrowed and there are no other physical indications of sewage, then a sample may be collected for an enterococci bacteria count. The sample is obtained within the stormwater system where the highest ammonia-nitrogen readings are measured; it is not obtained at the in-stream locations. The enterococci bacteria count is only used to verify if the elevated ammonia nitrogen measurement is sewage-related or the result of interference. If sewage is present, the enterococci bacteria count would be expected to be greater than 1,500 MPN/ml, based on historic SIS data for the City, however, the site-specific historic data would also be considered. This value is not an assessment threshold value and it is unrelated to the criteria for recreation use in COMAR. All field and laboratory analysis related to a specific PST investigation are recorded in the database.

C. Optical Brighteners

In FY 2017, the City assisted Ridges to Reef on an illicit discharge project, supported by the Chesapeake Bay Trust Watershed Assistance Grant. The purpose of the project was to test new equipment in the field, specifically a Turner Designs Aquafluor handheld fluorometer that could test for optical brighteners. Blue Water Baltimore also supported the project. The proposed equipment was used along with current methodologies used as part of the Ammonia Screening program. Results by all users were compiled and it was determined that the results of the flourometer could be used as a supplemental indicator of illicit discharges, especially when there are possible water chemistry interferences with the ammonia nitrogen test. The project resulted in the donation of the equipment to DPW.

D. Microbial Source Tracking

The City initiated Microbial Source Tracking (MST) DNA analysis in an effort to supplement the existing chemical indicators used to track wastewater contamination in the streams and storm drain systems.

The analyses were performed by Dr. Wolf Pecher through a contract between the City and the University of Baltimore. The sampling events were conducted so that samples were batched in groups of 8. The samples were analyzed for the number of human and canine DNA markers as well as a percent sewage equivalent. The percent sewage equivalent was a comparison of the number of human markers from a sample to the number of human markers found in wastewater samples taken from the influent at the Back River Wastewater Treatment Plant.

Three (3) reference sites were included to evaluate the MST DNA analysis. An outfall sampling site with historically low ammonia nitrogen and enterococci bacteria values resulted in only 9 copies of a human marker in 1 ml and 0.00% sewage equivalent. An outfall sampling site with a known (and soon eliminated) small wastewater infiltration up stream was sampled, and resulted in a value of 2.61% sewage equivalent. This site prompted the use of 1% sewage equivalent as the threshold for continuing an investigation- since a known trace amount of sewage was detected at just over 2.5%. An additional reference site with a moderate known level of wastewater contamination was submitted, and the resulting value was 9.59% sewage equivalent.

MST analysis was primarily used during PST investigations where high levels of the primary wastewater indicators (ammonia nitrogen and bacteria) were found, but various investigative techniques were exhausted (dye testing, CCTV of pipelines, visual inspection, and historical mapping review) and yielded no sanitary sewer sources. If the samples contained a high number of human markers and a sewage equivalent greater than 1%, the investigation would remain open for further monitoring and investigation. If the number of human markers was low and the sewage equivalent was less than 1%, the investigation was discontinued. Between FY 2017 to 2019, 14 of the 20 PST investigations were discontinued due to the sewage equivalent value being less than 1%. Due to the cost and minimum sampling requirements, this methodology was most appropriate to discontinue a PST investigation than to serve as a primary IDD method.

E. PST Investigations

Phase I PST investigations proceed upstream from the sampling location to the likely outfall source and through the storm sewer system. In addition to ammonia-nitrogen measurements, PST investigations include the following:

- Area reconnaissance at the ground surface level to identify potential sources of the high nitrogen-ammonia readings, such as surface discharge from other utilities, sump pump discharges, or dog parks

- Observations of the flow within the storm sewer system either by confined entry (person) or use of a camera device. Observations should be related to changes in the flow rate, flow content (color/ odor/floatable debris), the conditions of the storm drain structures locations of inflow and infiltration into the storm sewer system.

- Observations of the flow in nearby sanitary sewer pipes from the ground level/ top of manhole. Observations should be related to the flow rate, surcharge conditions due to an obstruction within the system and visual defects in the system causing possible exfiltration.

- Dye tests performed within public sanitary system. If clean-outs are available in the sanitary laterals or if the property owner provides access, dye tests may be performed to determine if sanitary service laterals are the source of the illicit discharge. Different dye colors may be used as a part of the investigation; appropriate notifications to the public are required. Baltimore City has developed different methods for introducing dye, such as a dye tea bag and a dye diffuser.

- Review of previous PST investigations within the drainage area of the outfall, as shown in the PST investigation application.

- Review of recent or on-going construction activities and / or recent SSO reports.

V. Technology

The accuracy and timeliness of a PST investigation is dependent on data availability. When the City initiated the IDDE program in the mid-1990's, information on the 2,000+ miles of sanitary and stormwater pipe networks was only available on hard copy maps. All field data was recorded on hard copy field forms. In 2003, the City digitized these maps into a GIS-based system, but the information was only available at the office. In 2008, the City developed a PST Investigation application, which included the GIS information (2003) and a computer-based data entry and retention system. The application was used on laptop computers (notebooks) and the data was downloaded in the office. Then in 2015, the PST Investigation application was updated and made available to tablets (i.e. IPads), allowing for real-time data transfer. The application also linked to the City's most recent GIS information. The use of tablets also allowed the staff to access other systems such as 3-1-1 service requests and SSO reporting. In 2020, a tablet application was developed for the Ammonia Screening program, allowing staff to provide real-time, remote data entry and access to historic data. Both of these applications eliminated the potential for error due to data transfer from paper forms to electronic database, and allowed for easy transfer of data between team members.