City and Town of St. Albans Illicit Discharge Detection and Elimination(IDDE) Study

Final Report

Ecosystem Restoration Program
Contract #2012 ERP-1-01

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1 Introduction

A comprehensive Illicit Discharge and Detection and Elimination Study was conducted in the City and Town of St. Albans, Vermont through an Ecological Restoration Grant (#2012 ERP-1-01) funded by the Vermont Department of Environmental Conservation (DEC). The study involved a comprehensive assessment of the City and Town's existing stormwater drainage system in order to identify and eliminate non-stormwater discharges into Stevens and Rugg Brooks. Overall, sixty-five (65) outfalls in the City and thirty-seven (37) in the Town were surveyed, of which 45% had dry weather flow. Based on the survey results, illicit discharges were suspected at 24% of the outfalls. Sixteen (16) of the twenty-four (24) suspected outfalls were investigated based on priority, of which thirteen (13) were either confirmed or flagged for additional investigation as illicit discharges. Three (3) were confirmed to be natural sources of discharge and not a concern. One (1) of the previously mapped outfalls could not be found (Outfall 1), and twenty-seven (27) previously unmapped outfalls and/or surface drainage outlets were identified and mapped as a part of this study. This report presents the methods and results of the study as well as recommendations for further investigation and follow-up monitoring of outfalls with suspected illicit discharges.

1.1 Background

In 2000, the Vermont Legislature required the Department of Environmental Conservation (VTDEC) to implement a statewide program to promote detection and elimination of improper or illegal connections and discharges (Sec. 3. 10 V.S.A. § 1264 (b)(9)). Then, in 2010, St. Albans City (the City) and Town (the Town) were designated by the DEC as small MS4's to be regulated under the National Pollutant Discharge Elimination System (NPDES), due to discharges to Stevens and Rugg Brooks, both of which are listed as stormwater impaired waterways on the EPA-approved Vermont 303(d) listing. As a result of this designation, the City and Town will need to obtain coverage under the Department's General Permit 3-9014 (2012) for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems, which was signed on December 5, 2012. The final MS4 permit mandates that permittees address a number of minimum control measures, including;

- Illicit Discharge Detection and Elimination (IDDE) Program
- Storm/Sewer Geographic information System (GIS) Map (including outfalls and names of all regulated waterways)
- Non-stormwater Discharge Ordinances
- Public Education

Illicit Discharge Detection and Elimination (IDDE) is an integral component of the proposed General Permit (Part IV.G.3). The IDDE measure requires the City and Town to develop a comprehensive program to detect and eliminate non-stormwater discharges from a variety of sources. A few examples of illicit discharges include random illegal dumping activities within the impaired watersheds (ie. motor oil, fertilizers, detergents/soaps) and contamination sources such as cross connection contamination from wastewater piping systems. Detection and elimination of contaminated discharges has been shown to be a cost effective tool for the prevention of non-stormwater discharges and subsequent pollution of impaired waterways.

1.2 MS4 Storm Sewer Mapping

The City and Town have made significant steps to develop comprehensive base mapping of the stormwater and wastewater systems, as required by the MS4 permit. Within the City and Town stormwater and wastewater infrastructure, stormwater outfalls, and wastewater/stormwater subwatersheds have been mapped and imported into GIS databases by various consultants. GIS data for outfalls within the impaired boundary as previously mapped by VHB-Pioneer (VHB) contain information related to the discharge, including pipe size and material, presence of erosion or pollution, whether a discharge was flowing or not, and description of the receiving water at point of discharge. A number of additional outfalls were subsequently mapped by the ANR (2009), Forcier Aldrich (FA) (2009), and Watershed Consulting Associates (WCA) (2009-2011).

WCA merged all outfall data to one master outfall inventory including all known discharges from the City and Town. A total of 66 outfalls have been mapped for the City and 434 for the Town, including both surface channel and pipe discharges. Subwatersheds corresponding to each outfall were mapped by WCA and imported into a GIS database including important parameters such as impervious area and % impervious area. This work was completed in two separate ERP-funded studies during 2009 through 2011.

1.3 Previous IDDE Studies

A small-scale IDDE study was completed within the City in 2007 by Jeff Rouleau, Bellows Free Academy science teacher, and Karen Bates, DEC watershed coordinator. Unbleached cotton pads were deployed to 30 outfalls for a period of several days. The pads were collected and tested for optical brighteners (OB), a fluorescent white dye used in laundry detergents. The study found 5 outfalls tested positive for OB during either minimal rain or no rain periods of time, suggesting that an illicit discharge may have occurred (or is occurring) at these outfalls. A sixth outfall testing was inconclusive and the study investigators suggested further investigation to determine if an illicit discharge may also be present at this location. Overall there was good correlation between the 2007 study and the current study. Three of the outfalls that were identified as potentially illicit in the 2007 study were reconfirmed as potentially illicit in this study (Table 6). A map showing the outfalls that tested positive during this study is included in Appendix 1.

2 IDDE Study Purpose and Objectives

A comprehensive IDDE study was necessary for the City and Town to identify and eliminate illicit discharges within the stormwater drainage system, because the previous study conducted was limited in scope, and therefore, the amount of pollution being released to surface waters from illicit discharges in the urban areas of the City and Town was largely unknown.

The objective of this IDDE study was to screen outfalls in the City and Town for illicit discharges using a combination of desktop analysis, field observation, and water quality sampling techniques. Outfalls within the City and Town were screened initially for dry weather discharges and other signs of an illicit discharge. Once potential illicit discharges were discovered, more intensive sampling was conducted to confirm the presence of an illicit discharge and pinpoint the source. A confirmed illicit discharge was flagged for elimination by the City and/or Town Public Works Department. A goal of the study was also to discover any unmapped outfalls and/or corrections to the current infrastructure mapping database.

The proposed IDDE study, in general, followed the framework outlined in the "Illicit Discharge Detection and Elimination, A Guidance Manual for Program Development and Technical Assessments", by the Center for Watershed Protection (CWP) and Dr. Robert Pitt of the University of Alabama (CWP, 2004). Example data sheets and procedures included in a condensed version of the CWP manual, "Illicit Discharge Detection and Tracking Guide" (CWP 2012), was used for this study. The following tasks were completed as a part of this study:

- Initial Desktop Screening of Storm Sewer Infrastructure/Subwatersheds
- Dry Weather Outfall Survey
- GIS Database Development of Water Quality Data
- Water Quality Bracket Sampling at Suspected Outfalls
- Problem Site Investigations and Elimination
- Summary Report

2.1 Contributing Partners Roles and Responsibilities

The success of this study was as a result of collaboration between the City and Town of St. Albans Staff and Public Works Department's personnel and the WCA Project Team. Without such collaboration this project would not have been possible.

The WCA team developed the field assessment procedures, performed the dry weather outfall screening, tracked and analyzed data, and developed a GIS database of water quality information. WCA coordinated with City and Town Public Works personnel throughout the study, particularly with the completion of problem site investigations. Additionally, WCA provided recommendations for follow up investigations, monitoring, and elimination techniques, as well as this comprehensive final project report.

The City Planning Director, Chip Sawyer, assisted with coordination of the ERP grant and provided additional management assistance as needed. The City and Town Public Works Departments helped address flagged illicit discharges and provided assistance with problem site-investigations (camera & dye investigation). Additionally, the City made lab space available for WCA's use at the City Wastewater Treatment Plant (WWTP) and Plant Operators provided assistance with water quality testing and supplies.

2.2 General Study Approach

The IDDE study was conducted in general accordance with the Center of Watershed Protection Illicit Discharge Detection and Tracking Guide (CWP 2012) with the completion of the following tasks: 1) desktop assessment of storm outfalls and subwatershed delineations, 2) dry weather survey, 3) bracket water quality sampling, and 4) problem site investigations and elimination.

The basic method for the study was to screen all priority outfalls for dry weather flow, test for initial indicator water quality parameters, and then analyze the initial survey results for possible illicit discharges based on a weight of evidence approach. Suspected outfalls were then prioritized for further investigation depending on the presence and amount of elevated E. *coli* in outfall sample water, as wastewater discharge was the City and Town's primary concern. Bracket water quality testing was then conducted at suspected outfalls, using ammonia as an in indicator test, so as to isolate the source of pollution between two structures. If the sample from a catch basin or storm manhole sample had elevated ammonia, the next structure up the pipe was sampled. Sterile E.coli samples were taken if there was evidence of possible wastewater discharge (ie. odor, elevated ammonia levels, color). Further investigation of the drainage area and storm drain system (camera and dye testing) was conducted if bracket sampling was inconclusive or insufficient to identify and eliminate the source of illicit discharge. At problem sites, catch basins with submerged pipes and evidence of sediment build up were vacuumed out by the City and/or Town depending on ownership, after which follow-up sampling was conducted to detect if the water quality testing results were due to residual pollution in the catch basins or continual illicit discharges.

The general approach to the dry weather survey was to use a weight of evidence approach, involving the use of qualitative observations and quantitative data from water quality testing to make an overall assessment of the outfall discharge. Physical indicators, such as odor, color, turbidity, presence of floatables (ie. sewage, suds) and staining were initially noted and considered in combination with water testing results. The water quality parameters selected for this study were based on recommendations by Brown et al (2004). Based on years of water quality testing, certain parameters are known to indicate specific discharge types to varying degrees of certainty depending on the known likelihood that such parameter is present in the given discharge type. The results of the water quality tests were used to characterize the possible sources of discharge at each outfall based on known benchmarks for various flow types.

The complete set of indicator water quality parameters tested in this study were optical brighteners, ammonia, E.coli, fluoride, anionic surfactants (detergents), potassium, conductivity, and phosphorus. Each indicator parameter is described in Table 1 below, with the type of detectable discharge indicated (adapted from Brown et al 2004).

Table 1: Descriptions of Water Quality Indicators and Detectable Discharge Types

Parameter	Description	Types of Detectable Discharge
Optical Brighteners	-Fluorescent white dye used in laundry detergents	Wastewater/Grey water from washing activities
Ammonia	-Chemical typical of sanitary wastewater contamination if above >0.1 mg/L	Wastewater/Washwater, Industrial activities
E.coli	-Bacteria indicative of wastewater contamination	Wastewater
Fluoride	-City and Town water is fluoridated, therefore was helpful to find breaks in the City/Town water supply infrastructure	Washwater
Anionic Surfactants (detergents)	-Used to clean clothes and for use as cleansers, -Detectable if found in concentrations over 0.25 ppm	Wastewater/Washwater
Potassium	-found in wastewater (>5 ppm), and at extremely high concentrations in some industrial process water (>20 ppm)	Wastewater/Washwater, Industrial activities
Conductivity	(ie. Specific Conductance) is a measure of a solution's ability to carry an electric current, which is directly related to the concentration of ionized dissolved solids	Industrial Waste, Roadway Salt
Phosphorus	-found in wastewater, chemical waste discharges, and cleaning activities -leading source of water pollution in St. Albans bay, and the greater Lake Champlain basin	Wastewater, Chemical Discharge, runoff with fertilizers and other non-point sources

3 Methods

3.1 Desktop GIS Analysis

In 2009, as a part of a comprehensive mapping project of St. Albans City and Town, WCA delineated subwatersheds and mapped outfalls to Stevens and Rugg Brooks. GIS layers were then prepared with the infrastructure data. Aerial photographs of the area, in combination with the infrastructure data and subwatershed layers, were used to conduct a preliminary desktop assessment of illicit discharge potential (IDP). The desktop assessment was abbreviated for the City as all 66 mapped outfalls within the City were in areas with a high percentage of commercial land, and/or aging storm and wastewater infrastructure, and therefore were all categorized as a priority. The Town had a total of 434 outfalls mapped, many of which were located in areas with minimal development and/or a majority open space. The outfalls with the highest illicit discharge potential were identified for investigation as those in the most densely populated areas, primarily in the North and Southwest portions of the Town, where centralized wastewater infrastructure is located.

3.2 Dry Weather Outfall Survey

An initial screening of the prioritized outfalls was conducted during dry weather to detect non-stormwater discharges. Surveys were conducted only on days that had less than 0.1 in rainfall in the past 24 hours**.** All mapped outfalls identified for inspection were surveyed. In addition, field technicians walked stream reaches between outfalls to look for stormwater discharges that were not detected in past mapping efforts. The protocol for the outfall survey, adapted from the CWP Manual (CWP 2012), was primarily based on a combination of visual observations and field kit testing of dry-weather flow samples to determine if the outfall had a suspected illicit discharge. A copy of the field operating procedures is included in Appendix 2-1.

Field Preparation

In preparation for the outfall screening survey, field packs were prepared with equipment and supplies including items such as sterile sampling packs (7 oz. Whirl-pack©), field test kits and meters, a graduated cylinder, ice packs, portable coolers, deionized rinse water, and latex gloves. Field binders were assembled including City and Town contact information, CWP IDDE Tracking Guide, and Letters of Authorization from the City and Town for conducting the survey. An "Outfall Reconnaissance Inventory" (ORI) form prepared by the CWP was used to record data at each outfall (Appendix 2-2). Trimble-brand mapping-grade hand-held GPS devices were used in the field to have a geo-spatial record of each surveyed outfall's location. Additionally, large-scale field maps were prepared for each major section of stream that included GIS data layers of City/Town storm sewer infrastructure and road names. An example field map is included below.

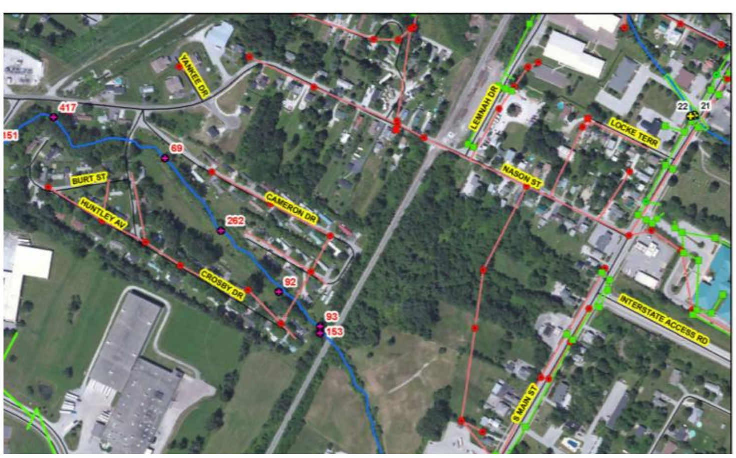

Figure 1: Example Field Map for Outfall Survey

Field Methods

The Dry Weather Survey was conducted during the week of June 4th, 2012 with one additional day on June 20th. Prior to going into the field, staff members were trained in standard field and safety procedures to ensure quality assurance and safety of field technicians throughout the survey. Two (2) teams consisting of two (2) trained field technicians worked simultaneously to conduct the survey in the most efficient method possible. The ORI form, prepared by the CWP and adapted for the purpose of this study, was used as a screening tool to record all pertinent information, from which a general discharge characterization was made as to the level of suspect; Unlikely, Potential (presence of two more indicators), Suspect (one or more with high severity), and Obvious.

At each outfall field technicians recorded the location of the outfall with the GPS, took a photo, and recorded the time/date on the ORI form. The outfall ID was then recorded on the structure with a waterproof marker numbered based on the outfall ID's assigned in the 2009 Mapping project. Outfalls that were previously unmapped were named according to the mapped outfall just upstream, in the order of appearance. For example, if two (2) outfalls were discovered after Outfall 21, the subsequent outfalls were called 21.1 and 21.2, in that order. Outfalls in the Town were differentiated from the City by adding the letter "T" before the number (ie. 'T21' versus '21').

Outfall characteristics were noted including presence and amount of flow, outfall material and size, and general drainage area landuse characteristics. For flowing outfalls, the presence of physical indicators (odor, color, turbidity, floatables, etc.) was noted, as well as a description and relative severity of the indicator (1-faint, 2-easily detected, 3-detected from a distance). Field technicians wore latex gloves when handling discharge samples for safety and to eliminate cross-contamination. The temperature and pH were measured simultaneously using a calibrated Chemetrics 1-1000 pH Double Junction Electrode Meter by placing the probe into a graduated cylinder filled with sample water until the reading was constant. Samples were collected into sterile 7 oz. Whirl-packs® by placing the bag in the line of flow, applying care to not touch the inside of the pack, and stored on ice in a portable cooler. Ammonia was also tested in the field or immediately after sample collection in the lab using a Lamotte 1200 Colorimeter test kit, according to the Nessler Method. If ammonia was over the benchmark, 0.1 mg/L, and/or there were additional physical indicators resulting in a characterization of at least "Potential", three (3) samples were collected for analysis at the WWTP lab: one for additional testing of the other water quality parameters, one for Phosphorus, and a sterile sample for E.*coli* testing.

Outfalls that looked to have had a history of intermittent discharge (ie. staining) were flagged for OBM testing. Replicate samples were collected throughout the survey for QA checks. For the outfall's at which a phosphorus sample was collected, the flow rate was measured according to three varied procedures depending on the type of outfall.

Flow rate was measured in three ways depending on the flow type; 1) Small to Medium Steady Flow, 2) Large Free-Flowing, and 3) Submerged. The **first method**, for flow type 1, involved filling a graduated cylinder or jug to a given volume while recording the time to fill the container with a stopwatch. The flow rate was computed as the ratio of volume (L)/ time (sec). For flows that were 1) too large to be measured with the above mentioned containers and 2) in free-fall, a **second method** was utilized in which the flow depth at its deepest point and the total flow width at that point were recorded. The discharge was then estimated based on an empirical formula: Discharge = 3.1 (Width)*(Depth)$^{1.5}$. A **third method** was used in the case of a submerged outfall. The width and depth of flow were measured at the lip of the outfall. Then, a ping-pong ball was dropped in the line of flow, and the time for the ball to travel a given distance was recorded. The average time of three drops was recorded as the final time estimate. Discharge was measured as Discharge= Area*Velocity, with Area equal to the (Width)*(Depth) and Velocity equal to the (Distance)/ (Avg. Time).

Lab Methods

Samples were tested in the City of St. Albans WWTP laboratory within four (4) hours of collection. Detergents, potassium, fluoride, and conductivity were tested in the lab using the equipment and methods summarized in Table 2. All analyses were conducted according to the manufacturer's instructions. Equipment was also properly calibrated based on each device's specifications.

Table 2: Equipment for In-Lab Water Quality Testing

Parameter	Testing Equipment	Method
Anionic Surfactants (Detergents)	CHEMetrics CHEMets field Kits	Methylene Blue Extraction Method
Fluoride	Hanna HI 93729 Low Range Photometer	Hanna adaptation of the EPA method 340.1 and SPADNS method
Potassium	Horiba-brand Cardy C-131 probe	Potassium Ion Electrode Method
Conductivity	Chemetrics-brand I-1200 Conductivity probe.	Chemetrics Operating Procedures

All water quality testing results were recorded on a "Sample Collection Lab Sheet", adapted from the CWP Manual (CWP 2012). A copy of the sheet is included in Appendix 2-3.

The sterile sample was used to test for E.coli and Total Coliforms, according to the US EPA approved Hach Membrane Filtration (Simultaneous Detection) Method (EPA Approved Method #10029). Positive control plates using WWTP effluent and blanks were prepared each time E.coli testing was completed for QC purposes. Sample volumes of 50 ml were used consistently. A dilution factor of 2 was applied to all raw plate counts so that results could be reported as colony forming units (cfu)/ 100 ml. Plant Operators from the City WWTP typically counted the plates so as to reduce bias in the counting process due to their lack of familiarity with the outfall ID's versus WCA field technicians.

Based on an initial screening of the water quality parameters (not including E.coli due to 24 hr time delay in results), field technicians determined whether to have the third sample tested for Total Phosphorus (TP) if the outfall was suspect. Samples were tested by Trained Personnel from the WWTP for TP according to the EPA approved ascorbic acid method using an electronic spectrophotometer (USEPA 1983).

3.3 Outfall/Bracket Water Quality Testing

Once the initial outfall screening was complete, field and lab results were entered into a comprehensive database so as to determine which outfalls met the criteria for illicit discharge classification; outfalls that had at least two (2)water quality parameter's with levels over the benchmark and/or substantial physical indicators. The benchmark values for water quality parameters used in this study were based on several independent sources, summarized in Table 3.

Table 3: Threshold Values for Water Quality Parameters

Parameter	Threshold	Source
Ammonia	0.1 mg/L	Brown et al (2004)
E. coli	77 CFU/100 ml	EPA-823-R-03-008 (2003), Vermont Freshwater Bacterial Water Quality Std.
Fluoride	0.25 mg/L	Brown et al (2004)
Detergents	0.25 mg/L	Brown et al (2004)
Potassium	5 ppm	Guidance extrapolated from Lilly and Sturm (2010)
Conductivity	1500 µs	http://www.ilmb.gov.bc.ca/risc/pubs/aquatic/interp/interp-01.htm

Note: *Threshold Values for Indicator Parameters*. Adapted from "Illicit Discharge Detection and Tracking Guide", by Center of Watershed Protection (CWP). 2012. Center of Watershed Protection (CWP).

Illicit discharges were then classified into three general flow types; wastewater, washwater, or other, with priority for investigation in that order. Samples with the presence of E.coli over the EPA maximum allowable concentration for freshwater in Vermont (77 cfu/100 ml) were marked as top priority for follow up investigation.

Bracket sampling was conducted at priority illicit discharge sites starting at the outfall and working up the drainage system (Figure 2). A "Manhole Inspection Form" was completed at each sampled structure, as well as collection of a GPS point and photo (Appendix 2-4). Structures were named based on the structure type (ie. catch basin-CB, manhole-M), outfall ID, and placement in the drainage system. For example, at Outfall 24, the first catch basin upstream from the outfall was called '24.CBA', followed by catch basin '24.CBB'. Initially, if the outfall was found to be flowing, the discharge was re-sampled and tested for ammonia in the field. A swing sampler was used to sample catch basins and manholes, by taping a whirl-pack to the end of the swing sampler. If the concentration of ammonia was elevated above the benchmark, then the next structure up the line was sampled and tested. Submerged catch basin inlets were sampled as close to the inlet as possible. Structures along the drainage line were sampled until there was a clear hotspot in ammonia levels and/or the entire line was sampled. Sterile samples were collected at suspect structures and tested for E.coli at the WWTP. Additional samples were collected and tested at the WWTP for detergents and fluoride depending on the suspect level. In the event that bracket sampling was not sufficient, or a hot spot was identified but the source of discharge was unclear, the structure was flagged for further investigation.

Figure 2: Field Technicians conducting bracket sampling at structure 24.CBA, on June 8th, 2012.

Optical Brightener Monitoring

In addition to bracket sampling, Optical Brightener Monitoring (OBM) pads were deployed at outfalls where the water quality results were inconclusive or there was no flow at the time of the survey but the presence of past discharge made the outfall suspect. OBM's consisted of an unbleached cotton pad (VWR International) encased in a wire mesh pack. The OBM was placed in the lip of the outfall and anchored in place using nylon string tied to the outfall structure. If additional support was needed, a large rock was placed in the lip of the outfall, with the OBM placed in front of the rock, lying flat in the line of flow. After 10-12 days of deployment, the OBM's were collected. OBM's were removed from the metal cage, rinsed with sample water and squeezed dry. The OBM was then placed in a labeled zip-loc bag and viewed under a fluorescent light in a dark room. The OBM was classified as a Positive, Negative, or In-conclusive hit for optical brighteners. OBM testing followed the procedure employed for the 2007-DEC study included in Appendix 2-5.

3.4 Problem Site Investigations

Outfalls flagged for further investigation based on the results of the dry-weather survey and bracket sampling were investigated using a number of techniques, so as to identify and eliminate the source of illicit discharge. The City and Town Public Works Managers were notified to gather additional information about the suspected drainage system, such as the history of structure, past contamination and/or information about nearby business owners. With assistance from the City and/or Town Public Works, the wastewater system structures suspected for possible cross-contamination were dyed using red or green Trace-a-leak Presto Dychem-brand florescent dye to detect if wastewater was directly entering the storm line. In addition to dye testing, the DPW hired Drummac Septic Service to conduct camera investigations of the drainage systems of Outfalls 43A, 34, and 11, so as to identify any unmapped infrastructure that could be the source of problem. Investigations were completed using the UEMSI Predator Advantage Mini Camera System.

4 Results

During the Dry Weather Survey, a total of 103 outfalls were assessed, including 65 in the City and 38 in the Town. At the time of the survey, 46 outfalls had dry weather flow (Table 4). Of the flowing outfalls, 15 were surface drainage discharges, while the rest were various types of pipe discharges. Additionally, there were 27 previously unmapped outfalls discovered during the Dry Weather Survey. After analysis of the physical indicators and water quality results, 24 of the total number outfalls surveyed (23%) were suspected to have illicit discharges based on the criteria outlined in Section 3.3. Figure 3 at the end of this section shows a map of the surveyed outfalls, indicating the illicit discharges. A map including just the new outfalls identified as a part of this study is included as well below (Figure 4). Results from the Dry Weather Survey are included in Appendix 3-1.

Table 4: Summary of Dry Weather Outfall Survey Results

Dry Weather Survey Results	
Total Outfalls Surveyed	103
Outfalls with Dry Weather Flow	46
Percentage with Dry Weather Flow (%)	45%
Potential Illicit Discharges Based on Survey Data	24
Potential Illicit Discharges (%)	23%

The 24 outfalls suspected to have illicit discharges based on the Dry Weather Survey were then prioritized for further investigation and bracket sampling. Follow-up investigations, including bracket sampling, were conducted at 16 of the suspected outfalls, in various degrees of detail, depending on the size and complexity of the drainage area.

Out of the 16 investigated outfalls, 13 were either confirmed or suspected to be illicit discharges. Three (3) were confirmed as not illicit and removed from the follow-up list. The outfalls that were classified as Potential from the Dry Weather Survey, but were not investigated further remain on the list of outfalls to monitor. The outfalls recommended for follow up were summarized for the Town in Table 5 and for the City in Table 6, including the confirmed or suspected source for the discharge and recommendations for investigative and/or elimination techniques, depending on the progress of the investigation. The outfalls are listed in order of priority for elimination, based on the severity of the suspected contamination. In addition, the outfalls suspected in this study were correlated to the past 2007-DEC study, showing that 3 of the 5 outfalls suspected in 2007 were suspected again in this study, and are therefore priority for elimination. Results from the Dry Weather Survey and problem site investigations for the outfalls still suspect after follow-up investigations (**boldface** outfalls in Table 5 and 6) are documented in this report below, including discussion and recommended follow-up measures for elimination of the suspected discharge. Analytical data collected during problem site investigations are included in Appendix 3-2. Additionally, an abbreviated summary log of outfall investigations is included in Appendix 4.

Table 5: Town of St. Albans-Summary of Suspected Outfalls and Follow-up Recommendations

	Outfall	Suspected Source	Investigation Technique	Elimination Technique
Investigated, Flagged for Elimination	**T16**	Trash Compactor Spillage, Illicit Floor Drain Connection	Camera investigation if feasible for small pipe	Engage Property Owner to clean CB's, Seal Trash Compactor, Monitor Spillage
	T123	Parking lot residual salt, Minor Wastewater E/I, GW Infiltration	Camera Investigation	Engage Property Owner to clean all CB's in Shopping Center Parking lot
	T149C	Residual Salt Use at Loading Dock, Illicit Floor Drain Connection	Camera Investigation	Engage Property Owner to clean loading dock CB
Suspected Not Investigated	T124	Parking Lot Salt, runoff pollution, GW Infiltration, Wastewater E/I	Bracket Sampling, Camera Investigation, *Canine SD	

***Key:** E/I= Exfiltration (E)/ Infiltration (I) of wastewater from sewer lines into stormwater system,
SD= surface drainage, GW= Groundwater
Canine SD= Canine Scent Detection; trained canines provide accurate and highly efficient tracking of illicit discharges (Environmental Canine Services, LLC)

Table 6: City of St. Albans-Summary of Suspected Outfalls and Follow-up Recommendations

	Outfall	2007 Study	Suspected Source	Investigation Technique	Elimination Technique
Confirmed Not Illicit	18		Not Illicit		
	T149A		Not Illicit		
	T149B		Not Illicit		
Investigated, Flagged for Elimination	**24**		Cleaning Solvent Dumping	Monitor Ammonia	Engage Property Owner
	26		Wastewater E/I*, GW Infiltration	Camera testing	Identify and seal leak in sewer/storm pipes
	34		Wastewater E/I	Camera/ Smoke testing	Identify and seal leak in sewer/storm pipes
	27	B011	CSO Residual (Wastewater)	Monitor CSO occurrence, clean catch basins regularly	Divert SW, reduce CSO's
	Trunkline (TL-1)		Wastewater E/I, GW Infiltration	Camera testing	Identify and seal leak in sewer/storm pipes
	43A		Car Wash Runoff, Wastewater	Camera, Canine SD*	Engage Car Wash Facility Owner
	16	B19a	Wastewater E/I, Groundwater	Bracket sampling	
	15		Fertilizers/Chemical Dumping, GW Infiltration	Canine SD*	Investigate DA for source
	11	B027	Car washing, Wastewater E/I, GW infiltration	Follow-up monitoring, Canine SD*	Engage Property Owner
Suspected from DWS, Not Investigated	37		Non-Point Phosphorus, Wastewater E/I	Bracket sampling, Canine SD*	
	38		Minor Wastewater E/I	OBM, bracket sampling, Canine SD	
	29		Washwater	Bracket sampling	
	29.1		Road salt, GW Infiltration	Bracket sampling, camera	
	40		Washwater, Road Salt	Bracket sampling	
	26.2		Intermittent SD*, Washwater	Investigate DA	
	39.1		Washwater, Road salt, GW Infiltration	Bracket sampling	
	39.2		Intermittent SD*, Washwater, Road Salt	Investigate DA	
Suspected-2007 Study	14	B017	Washwater	OBM	
	46*	B003		OBM	

***Notes:** Outfall 46 included due to a detected hit for OB's in 2007 study. However, this outfall was not included in the number of potential illicit discharges (24) as a result of this study's dry weather survey (DWS) due to lack of dry weather flow.

***Key:** E/I= Exfiltration (E)/ Infiltration (I) of wastewater from sewer lines into stormwater system,
SD= surface drainage, GW= Groundwater, OBM= Optical Brightener Monitoring Pad
Canine SD= Canine Scent Detection; trained canines provide accurate and highly efficient tracking of illicit discharges (Environmental Canine Services, LLC)

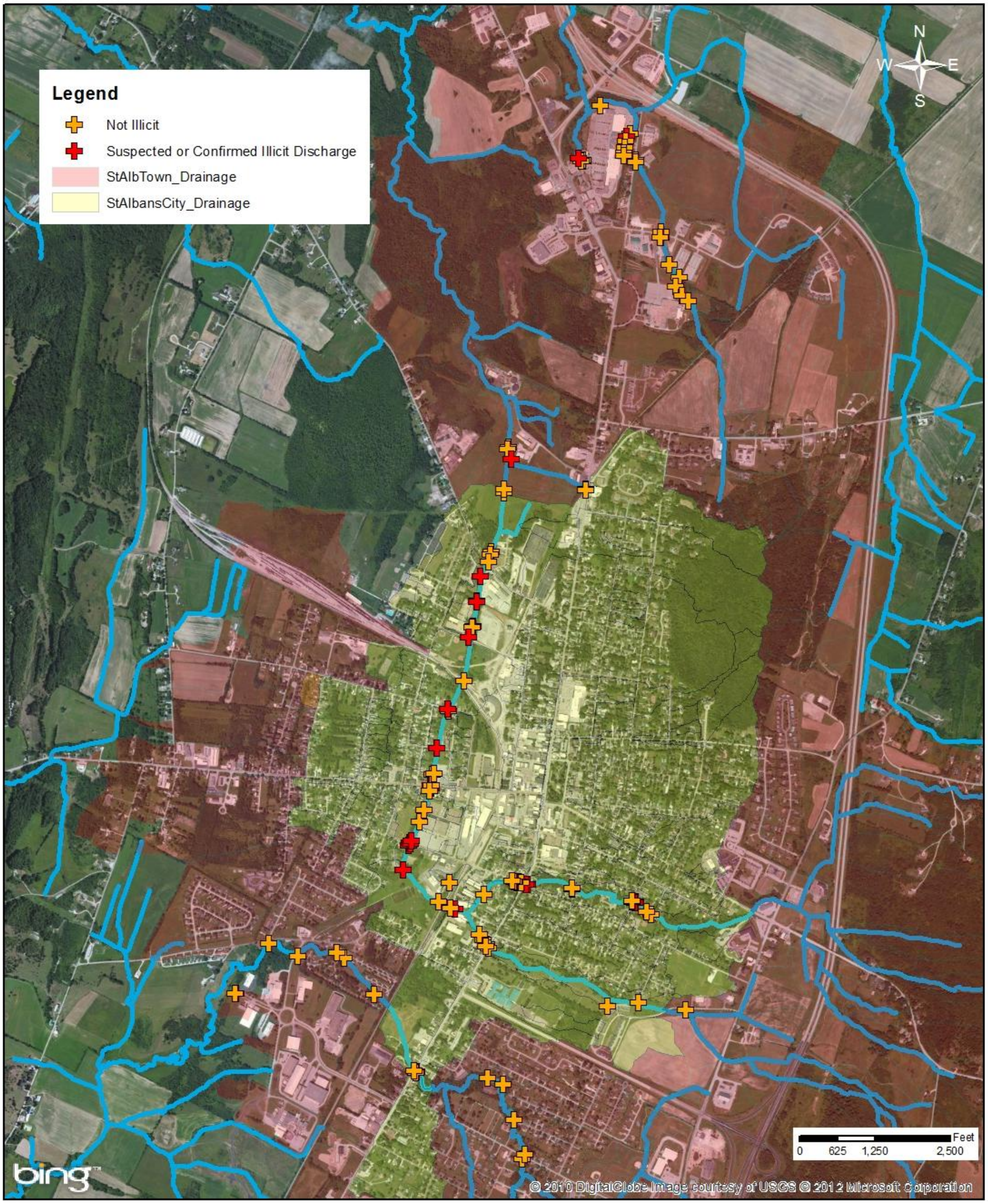

Figure 3: Outfalls Investigated During IDDE Study

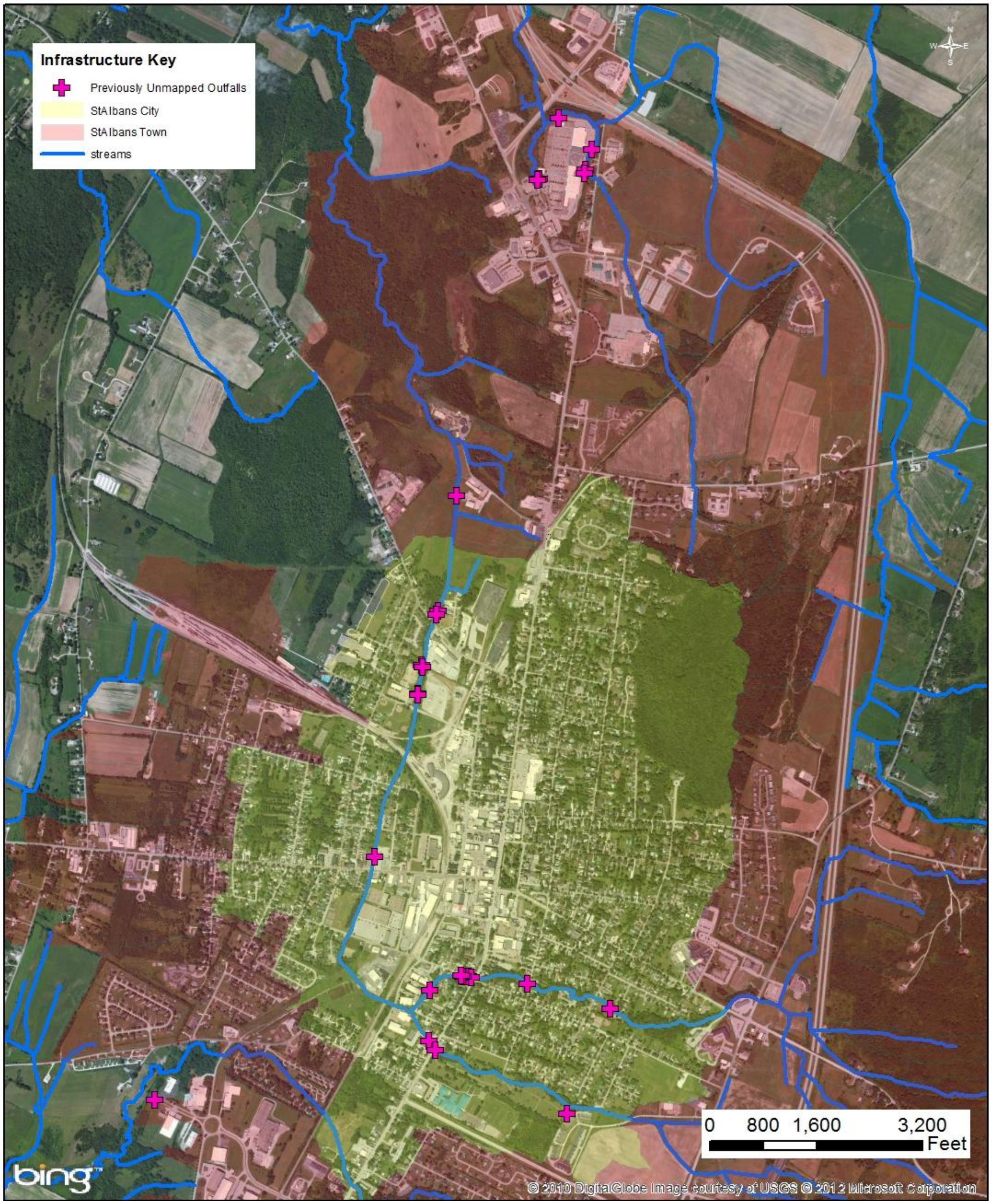

Figure 4: Previously Unmapped Outfalls Discovered During IDDE Dry Weather Survey, June 4th -8th 2012.

4.1 City of St. Albans Investigations

Outfall 24 (Maple Pro Plant, Lemnah Dr.)

Outfall 24 is an 18" corrugated metal pipe with a concrete headwall connected to a series of catch basins in the Maple Pro Facility parking lot, located on Lemnah Dr. (Figure 5). Approximately 1/8th of the pipe was submerged upon inspection, with evidence of a steady trickle of dry weather flow. The outfall was initially surveyed on June 5th, 2012 at which time substantial iron oxide staining was present in the flow line.

Figure 5: Outfall 24 on June 5th, 2012.

Field Technicians sampled the discharge and tested for all the water quality parameters detailed in Section 3 of this report. The sample water contained extremely high levels of ammonia (3.2 mg/L) and phosphorus (1.88 mg/L), suggesting a possible chemical waste discharge (Table 7). The concentration of Potassium (11 ppm) was almost twice the threshold value and there was a detectable level of detergents (0.30 ppm). Based on the analytical results, the outfall was flagged for further investigation.

Table 7: Water Quality Analysis Results for Outfall 24

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/5/2012	trickle, NM	**3.2**	0.15	**11**	**0.30**	1060	UN	**1.88**	**0.37**
6/8/2012	trickle, NM	**3.37**	NT	NT	NT	NT	NT	NT	NA
6/29/2012	trickle, NM	**2.3**	NT	NT	NT	NT	NT	NT	NA
7/13/2012	trickle, NM	0.48	NT	NT	NT	NT	NT	NT	NA
8/2/2012	trickle, NM	0.45	NT	NT	NT	NT	NT	NT	NA
8/27/2012	No Flow	NF	NF	NF	NF	NF	NF	NF	NF
10/25/2012	trickle, NM	**3.78**	NT	NT	NT	NT	NT	NT	NA
11/15/2012	trickle, NM	**2.47**	NT	NT	NT	NT	0	NT	NA

*NF- Not Sufficient Flow To Sample, NT-Not Tested, NM-Not Measured, UN= Unreadable
bold = Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection

Figure 6: Outfall 24 Drainage System

On June 8th, field technicians inspected the drainage system so as to isolate the source of contamination. The drainage system was found to differ from the existing mapping data, with the addition of two unmapped catch basins and the outfall labeled "Outfall 1" could not be found. Figure 6 (full map provided in Appendix 5-1) shows the updated drainage system, including 5 catch basins (24.CBA-24.CBE) connected to Outfall 24. Flow into the first catch basin up the line from the outfall (24.CBA) tested extremely high for ammonia (4.57 mg/L). Catch basin 24.CBD (the catch basin in the loading dock area of the facility) also tested high for ammonia (2.49 mg/L) and had a strong chemical odor (Figure 7). Catch basin 24.CBE, which doesn't receive drainage from 24.CBD and only drains the roadway had a low ammonia level of 0.27 mg/L, suggesting that the loading dock catch basin was the source of the contamination. The loading dock catch basin was found to also have 4 feet of sediment build up, therefore it was recommended to have the catch basins in the system vacuumed, particularly 24.CBD in order to detect any inflow pipes into the catch basin from the building.

Figure 7: Ammonia Testing at Loading Dock Catch Basin (24.CBD) on June 8th, 2012.

One suggestion for the contamination, due to the proximity of 24.CBD to the facility, was from past spray down of the facility floors with ammonia and phosphate based cleaning fluids resulting in residual build up of the chemical in the catch basin. Team members spoke with the Owner of the Maple Pro Facility about possible past activities. The Owner said he did not know of any cleaning activities in the vicinity of the loading dock area. However, he did mention that they had acquired the space only a year ago, and that the past occupants may have disposed of waste in the loading dock area. In addition, the system appeared to be relatively stagnant suggesting that the discharge observed at the outfall was a result of groundwater infiltration into the storm pipes and/or a slow drain of sump water from past rainfall events, and not direct continuous discharge into the system. However, the presence or lack of a floor drain needed to be confirmed.

DPW personnel cleared out the catch basins on June 21st, 2012. An inlet pipe was not found, therefore supporting the possibility of cleaning fluid contamination from washing activities near the loading dock area. Follow up monitoring of the outfall was conducted to assess if the contamination was residual waste from past dumping or current dumping activities. Monitoring results are summarized above in Table 7, which show that ammonia levels were high on June 29th (2.3 mg/L), but then declined substantially by July 13th to 0.48 mg/L. Upon observation, the amount of flow at the outfall declined throughout the summer as well, with no flow observed on August 27th, as base flow throughout the watershed decreased. In addition, the presence of excessive iron oxide was evident on June 8th, but no staining was observed on August 27th, when the outfall was dry (and base flow was low). Iron oxide is typically associated with groundwater flow, supporting the possibility of groundwater infiltration into the storm system.

On October 25th, 2012 field technicians returned to the outfall and found the flow amount to be similar to the observed flow in June, and again with substantial iron oxide build-up in the flow line. The ammonia level was found to be elevated again at 3.78 mg/L, above levels observed during the initial survey. Sump water from the loading dock catch basin, 24.CBD, was also tested and found to be elevated at 1.25 mg/L. The results suggested that new dumping activities had occurred. The outfall was again sampled on November 15th, and found to have a slightly decreased ammonia concentration of 2.47 mg/L. Flow was observed into and out of catch basins 24.CBA and CB.CBB. Sump water from both basins were sampled and found to have similar ammonia concentrations of 2.38 and 2.33 mg/L, respectively. Interestingly, sample water from the sump of the loading dock catch basin, 24.CBD, only had an ammonia concentration of 0.25 mg/L. One possible explanation for the ammonia test results is that dumping activities at 24.CBD occurred prior to October 25th, 2012 and were still actively being flushed through the system on November 15th as a result of groundwater infiltration and rainfall events.

Therefore, the overall conclusion for this site is that illicit dumping of cleaning product fluid due to cleaning activities is occurring periodically at the Maple Pro Plant, and the contamination is flushed through the system due to rainfall and groundwater infiltration.

Recommendations for further investigation and elimination of the illicit discharge are as follows:

- ✓ Speak with the Maple Pro Property Owners about the elevated ammonia levels and ask what type of cleaning products they use in their facility and about their cleaning activities, particularly if they have after-hours custodial work.

- ✓ Educate the Property Owners of the concerns of ammonia and phosphorus discharges.
- ✓ Periodically monitor the outfall for dry weather flow and test for ammonia to see if dumping activities continue.

Outfall 26 (Blooming Minds Daycare, Lemnah Dr.)

Outfall 26 is a 24" corrugated metal pipe located near Lemnah Dr. that drains a series of catch basins. Dry weather flow was observed at the outfall on June 5th, 2012. The outfall is indicated in Figure 8 below by the red arrow.

Figure 8: Outfall 26

On June 5th, 2012 the outfall was sampled from which a very high concentration of ammonia (1.96 mg/L) and Potassium (12 ppm) were detected, as summarized in Table 8. The outfall was flagged for further investigation based on the elevated analytical results.

Table 8: Water Quality Analysis Results for Outfall 26

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E.coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/5/2012	0.0003	**1.96**	0.11	**12**	0.20	960	64	**0.10**	**0.052**
6/21/2012	trickle, NM	NT	NT	NT	**0.75**	NT	NT	NT	NA
* NT-Not Tested, NM-Not Measured									
bold	Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection								

On June 21st, 2012 the drainage system was inspected using the mapped infrastructure as a guide, as mapped in Figure 9 (full map in Appendix 5-2). There was suspicion of cross-contamination from the wastewater line, as it crosses the storm line between structures 26.MA and 26.CBA. Sump water in 26.MA was tested for E.coli and found to be only 50 cfu/100ml which reduced the likelihood of a wastewater cross-contamination. The structures along the drainage line were sampled and tested for ammonia in the following order, 26.MA, 26.CBA, and 26.CBB, with ammonia concentrations increasing from 2.37, 2.65, and 3.43 mg/L, respectively.

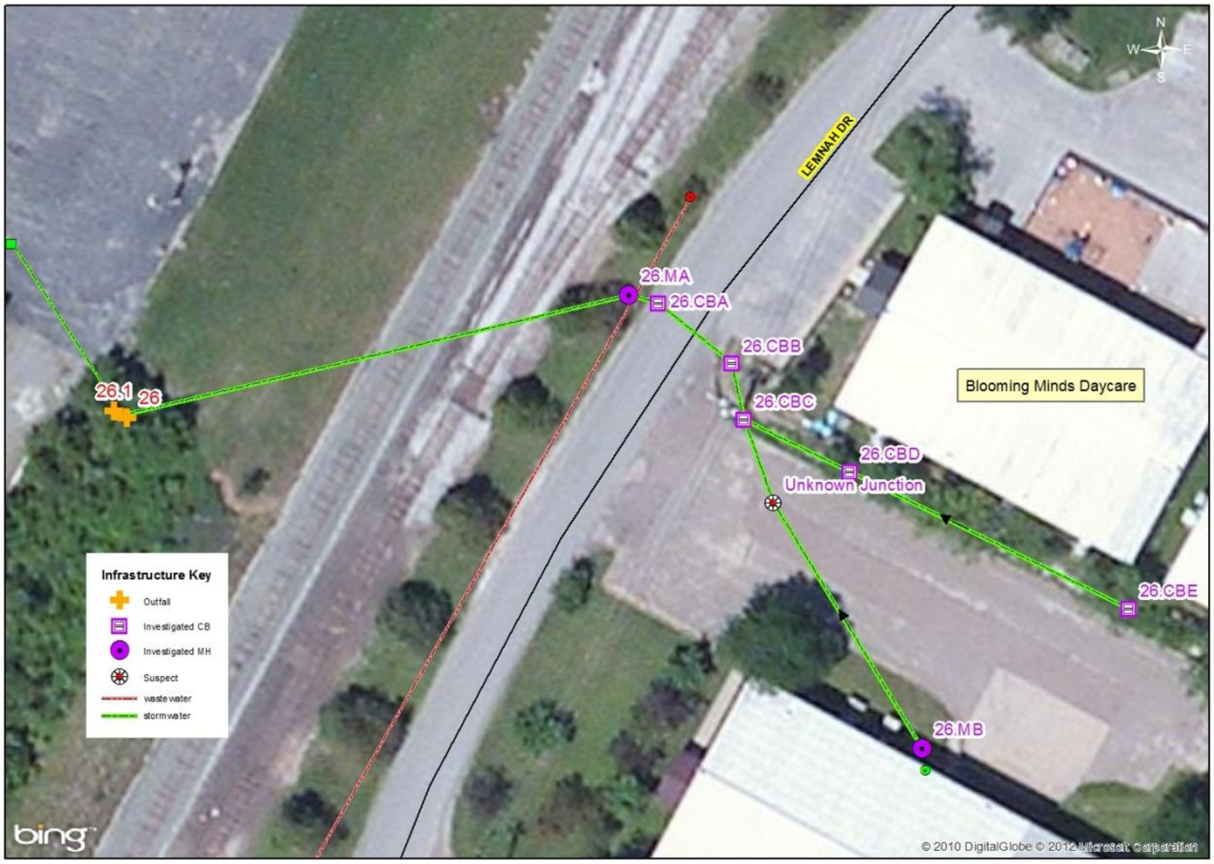

Figure 9: Outfall 26 Drainage System

All samples had detectable levels of detergents as well (0.25 mg/L). The next mapped catch basin, 26.CBC was full of sediment with no standing water, however, there appeared to be a trickle of flow into 26.CBB in the direction of 26.CBC. A manhole across the parking lot, mapped as a direct connection to 26.CBC, was sampled and only had an ammonia concentration of 0.48 mg/L, isolating the problem to 26.CBB. In 26.CBB (Figure 10) there appeared to be a submerged 4” metal pipe coming from the direction of Blooming Minds Daycare. Active flow could not be detected because the pipe was submerged. Sump water of 26.CBB was sampled for E.coli and found to have an elevated concentration of 1600 cfu/100 mL. The combination of ammonia and E.coli made the structure suspect for a wastewater discharge, although there was no trace odor of sewage. To determine if the submerged pipe was a possible illicit connection, DPW personnel dyed the sewer system at Blooming Minds. However, no dye was observed in 26.CBB.

Figure 10: Catch basin, 26.CBB, located in parking lot of Blooming Minds Daycare

It was recommended that the catch basins be cleaned so as to clear out any residual contamination and to be able to detect any pipes entering 26.CBC. The catch basins were vacuumed out by DPW Personnel on November 14th, 2012. The next day, field technicians revisited the site and discovered there was an active inflow into 26.CBC from a 6" metal pipe (26.P), but the inflow pipe did not look to be in line with 26.MB as previously mapped. The inflow appeared to be clear, but there was substantial iron oxide build up in the flow line, suggesting the possibility of groundwater infiltration. Dye was dropped into 26.MB, which had a small trickle of flow out of the pipe in the direction Blooming Minds, but was not observed at 26.CBC 30 minutes after initially placing the dye in the structure. Also, a pipe into 26.CBC from the east was discovered to be connected to a line of two unmapped catch basins (26.CBD and 26.CBE) in the ditch alongside the Daycare facility.

Additionally, on November 15th, 2012, sump water from catch basins 26.CBB, 26.CBC, 26.CBD, and 26.CBE were sampled and found to have ammonia levels of 2.74, 1.56, 1.09, and 0.15 mg/L respectively. The inflow into 26.CBC from pipe 26.P (from the direction of the parking lot) was sampled and contained a concentration of 2.58 mg/L suggesting a possible source for the high ammonia. The flow from 26.P was also tested for detergents but only had a concentration of 0.1 ppm common of natural sources. The elevated ammonia level in 26.CBD could possibly be due to back flow into the basin from 26.CBC, as the inflow pipe from 26.CBD was completely submerged. Since the catch basins were vacuumed the day before, it is likely that the source of ammonia is from an active discharge and not residual from past activity.

Samples were also tested for E.coli from 26.CBB, 26.CBD, and 26.P, all of which had 0 cfu/100ml. These results did not comply with the previous E.coli test from 26.CBB on June 21st, indicating that the E.coli on June 21st could have been from pet waste (or some other natural source) entering the catch basin, or a transient wastewater leak.

The analytical results from June 21st, were suggestive of a minor wastewater discharge into 26.CBB. In contrast, the analytical results and investigation on November 15th, suggest that the source of elevated ammonia is not from wastewater due to the low level of detergents and lack of E.coli and other physical indicators of wastewater contamination. The results were not conclusive and further investigation is needed to determine the source of elevated ammonia and presence of detergents.

Therefore, the following next steps are recommended:

- ✓ Camera the inlet pipe into 26.CBC from the direction of the parking lot, to detect if there is an unmapped structure or connection under the parking lot. This appears to be the active source of dry weather flow into the drainage system and therefore prime for further investigation.

Outfall 27 (Lower Welden St.)

Outfall 27 is a 24" concrete pipe located along Lower Welden St. (Figure 11). The outfall was halfway submerged, with a steady flow evident. The pool in front of the outfall appeared turbid, with sediment build up within the pipe.

Figure 11: Outfall 27 on June 6th, 2012.

Samples were collected from inside the pipe in the center of the flow line and tested according to the methods previously outlined. Results from water quality testing are summarized in Table 9 below. One of the samples was tested for ammonia in the field, and found to have an elevated ammonia concentration of 0.98 mg/L. Discharge had a detectable level of detergents (0.40 ppm) and a high E.coli concentration of 1000 cfu/100mL. Due to the steady flow, large drainage area and elevated phosphorus concentration, the phosphorus loading estimation was high at 6.27 lb/yr. The analytical data for the outfall were indicative of a possible wastewater discharge, and therefore warranted further investigation.

Table 9: Water Quality Analysis Results for Outfall 27

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/6/2012	0.014	**0.96**	0.13	2	**0.40**	450	**1000**	**0.22**	**6.27**
6/21/2012	steady, NM	NT	NT	NT	0.3	NT	NT	NT	NA
11/15/2012	trickle, NM	0.23	NT	NT	0.1	NT	**900**	NT	NA
* NT-Not Tested, NM-Not Measured									
bold	Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection								

The team spoke with the DPW about the possibility of a wastewater leak, and it was discovered that the intersection of S. Elm St. and Lower Welden St. is a low point in the wastewater system, and has a history of combined sewer overflows (CSOs). The sewer manhole is located in the middle of the intersection, and there is a catch basin, marked as 27.CBA in Figure 12 (full map in Appendix 5-3) connected to the storm system of outfall 27 directly North East of the manhole. On June 21st, 2012, the sump of this catch basin appeared stagnant and turbid. The sump water was sampled and testing revealed an exceedingly high concentration of ammonia (3.18 mg/L) and very high detergents (2.0 ppm). The testing results suggest that the catch basin 27.CBA and therefore the rest of the storm line contains residual wastewater from recent CSOs. It was recommended that the DPW clean all catch basins within the drainage system of

Figure 12: Outfall 27 Problem Site Investigation

Outfall 27. The catch basins were cleaned on November 14th, 2012. The following day samples were tested from the outfall, and revealed a low level of ammonia (0.23 mg/L) and detergents (0.1 mg/L). However, the E.coli concentration was still well above the benchmark (900 cfu/100ml) and similar to the previous test on June 6th, 2012. The elevated E.coli concentration could be due to animal waste near the vicinity of the outfall, since the outfall pipe was submerged, and or residual in the storm system from past CSO occurrence.

In order to address the continual occurrence of CSOs, implementation of stormwater BMP's in the watershed is recommended, so as to reduce stormwater flows entering the system. The CSOs are contributing a large point source of E.coli and phosphorus to Steven's Brook via the outfall, and therefore need to be minimized.

Follow up measures are recommended as follows:

- ✓ Document history of CSOs and set up regular cleaning schedule of catch basins near the intersection of Lower Welden St. and S. Elm St., as well as a mandate to clean catch basins after all CSO events.

- ✓ Continue to evaluate and implement stormwater/wastewater separation projects, as well as green infrastructure projects in the City to reduce stormwater entering the sewer system during large rainfall events and promote groundwater infiltration.

Outfall 34 (La Salle St.)

Outfall 34 is a 34"concrete outfall located along Lasalle St that drains a large primarily residential drainage network (Figure 13). On June 6th, the outfall was observed to be partially submerged with a substantial amount of sediment build up in the bottom of the pipe, and a slow moving flow through the pipe. There was also an easily detectable odor of sulfide.

Figure 13: Outfall 34 on June 6th, 2012

The outfall was sampled and tested on June 6th, 2012 revealing slightly elevated levels of ammonia (0.39 mg/L) and high E.coli (800 cfu/100ml), as summarized in Table 10. While the phosphorus concentration was not noticeably high, the moderate flow rate resulted in a substantial annual phosphorus loading estimate of 4.6 lb/yr. The water quality results suggested a possible diluted wastewater source and or chemical waste disposal somewhere further up in the drainage system.

Table 10: Water Quality Analysis Results for Outfall 34

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/6/2012	0.013	**0.39**	0	**6**	0.1	1100	**880**	**0.18**	**4.6**
bold	Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection								

The drainage network for outfall 34 was investigated on June 30th, starting with the catch basins along La Salle St, as mapped in Figure 14 (full map in Appendix 5-4). The first catch basin at the intersection of Lasalle and Spruce contained an ammonia concentration of 0.53 mg/L, but a minor E.coli concentration of 78 cfu/100ml. Sump water in the next catch basin in the line contained an ammonia level of 0.6 mg/L and a slightly higher E.coli concentration of 186 cfu/100ml. Inlet pipes were submerged in both catch basins so an active dry weather flow was not detectable. The manhole (34.MA) along the main stormline connected to outfall 34, located at the end of Lasalle St. was inspected and appeared to have a small flow from the south and no flow from the north along N. Elm St., therefore concluding that the source was likely coming from the south. Sump water from the manhole contained an ammonia concentration of 0.4 mg/L and a high level of E.coli (748 cfu/100 ml).

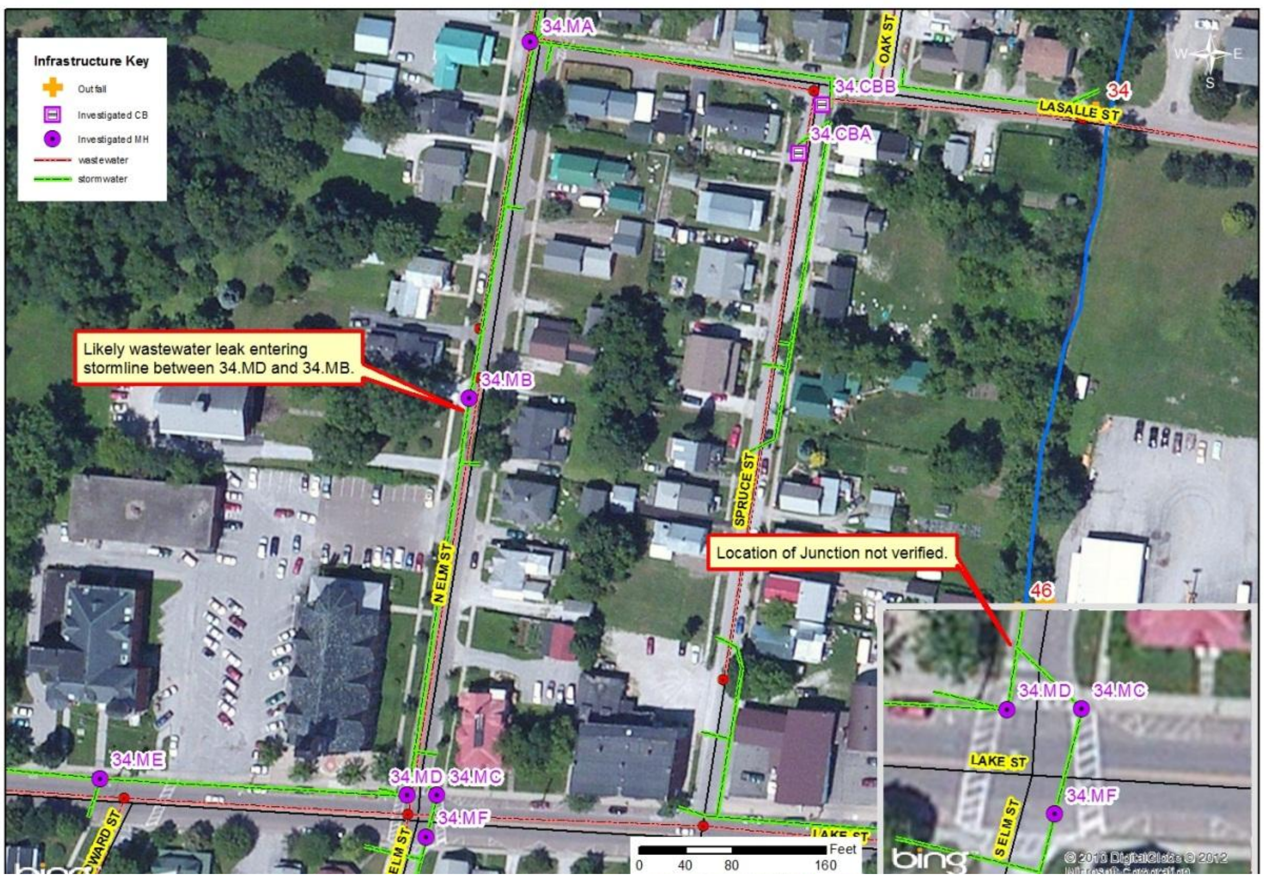

Figure 14: Outfall 34 Problem Site Investigation

Investigation of the drainage area was resumed on August 2nd, 2012. Initially, the next manhole (34.MB) in the system along N. Elm St. was inspected and observed to have a trickle from the south in the direction of 34.MA. The flow was sampled and found to have an exceedingly high ammonia concentration of 1.77 mg/L, and a detectable level of detergents (0.25 ppm), suggesting the possibility of a nearby wastewater cross-contamination. Based on the map, the next manhole in the system, was 34.MD, however, no active flow was observed and no outlet pipe was visible. There was a small puddle of water in the sump and a detectable odor of sulfide, which made the structure suspect for a wastewater connection. The next manhole (34.MC), located in the Northeast corner of Lake St./N. Elm St., was mapped to directly connect to 34.MD. However, upon inspection a steady flow was observed exiting the pipe at an angle in the direction of the center of N. Elm St., not toward 34.MD. Sample water from the manhole contained a decreased ammonia concentration of 0.57 mg/L. Detergents were detected in the sample at a level of 0.50 mg/L. However, the sample turned green upon testing, instead of the usual shade of blue. According to the manufacturer of the detergents kit (CHEMetrics), samples have been reported to turn green as a result of inference from chlorides (road salt). In several cases, when chlorides were removed from the sample water, detergents were not detected. There is a strong likelihood the sample from 34.MC contained chlorides from roadway runoff, and therefore it can be concluded that the detergents detection of 0.50 mg/L was a false positive reading. Based on the inspection results the source of ammonia and E.coli likely entered the system somewhere between 34.MC and 34.MB.

To further investigate the system, on August 6th, 2012, Drummac Septic Service conducted a camera investigation of 34.MD. Two (2) inlet pipes (12" and 9") were detected from the west side of the manhole, and an outlet pipe was confirmed in the direction of N. Elm St. A connection to 34.MC was not found, indicating that 34.MD connects directly to the main storm line along N. Elm St.

Field technicians conducted follow-up monitoring on October 25th, 2012 at 34.MB and observed a steady flow from the south. Sample water had an elevated but slightly reduced concentration of 0.57 mg/L than on the previous visit. A slight flow from the east was observed in structure 34.MD, unlike on the previous visits, and had an ammonia concentration (0.04 mg/L) similar to natural waters. In addition flow was observed in 34.MC, with an ammonia concentration of 0.19 mg/L. These results were consistent with the previous investigations, confirming that there is a suspected wastewater leak entering the storm system somewhere between Lake St. and 34.MB.

Further investigation is recommended as follows:

- ✓ During dry weather, camera the drainage line starting from manhole 34.MB and moving toward structure 34.MD to detect any sources of inflow into the pipe, and to confirm the connection between 34.MB and 34.MD. The source is likely a minor wastewater leak somewhere between these two structures.

Outfall 37 (Pearl St.)

Outfall 37 is a concrete elliptical shaped pipe on Pearl St. that is connected to a large drainage network (Figure 15). Dry weather flow from the outfall was estimated to be approximately 0.14 cfs on June 6th, 2012.

Figure 15: Outfall 37

The outfall was sampled in the middle of the flow line at the entrance of the pipe. Samples were tested and found to have a slightly elevated level of ammonia (0.32 mg/L) and a detectable concentration of detergents (0.25 ppm). The phosphorus concentration at the outfall was not substantial (0.03 mg/L), the flow estimate was large due to the size of the pipe, resulting in a substantial annual phosphorus loading estimation of 8.3 lb/yr. This estimate is likely over estimated, and based on one (1) grab sample from one (1) day, and therefore is not necessarily an accurate measure of the annual phosphorus loading. A summary of water quality testing results is included in Table 11.

Table 11: Water Quality Analysis Results for Outfall 37

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/6/2012	0.14	**0.32**	0.03	4	**0.25**	880	176	**0.03**	**8.3**
bold	Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection								

The drainage area was not investigated further due to time constraints, and the large size of the drainage area (Figure 16 - full map in Appendix 5-5). While the loading estimate may not be accurate, the estimate does demonstrate that this outfall may contribute a substantial amount of phosphorus on an annual basis. Due to the potential contribution of phosphorus pollution to

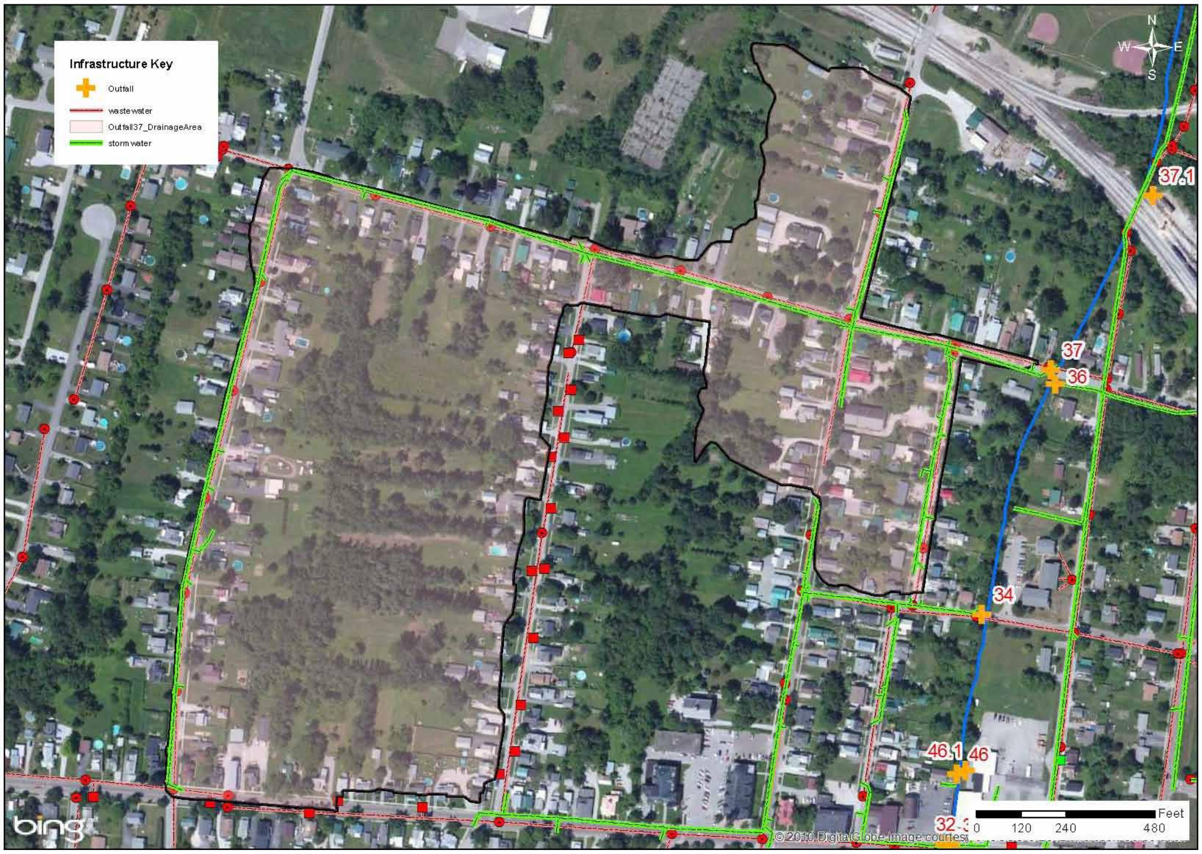

Figure 16: Outfall 37 Drainage Area

St. Albans Bay, this outfall was flagged for further investigation. The relatively low hits for ammonia, detergents, and phosphorus at the outfall indicate that the source may be much farther up in the system and as a result, is substantially diluted. The source of phosphorus may be a result of a combination of small discharges from lawn fertilizers, pet waste, and other phosphorus pollution sources.

The recommendations for further investigation are as follows:

- ✓ Due to the large size of the drainage area, the recommended investigation approach is to split the network into segments, and test manholes and/or catch basins at strategic locations within the system. A desktop assessment of the drainage area is recommended prior to investigation in the field, so as to identify any obvious possible sources of contamination.

Outfall 43A (Rewes Dr.)

Outfall 43A is a 24” corrugated metal pipe located across Main Street from the St. Albans Messenger. The outfall was surveyed on June 7th, 2012 from which a trickle of flow was present. Figure 17 below, taken on October 25th, 2012, depicts the buildup of sediment in the pipe that was present on the initial survey.

Figure 17: Outfall 43A on October 25th, 2012

Field technicians sampled the discharge and detected a slightly elevated level of ammonia (0.3 mg/L) and a phosphorus level (0.05 mg/L) above the acceptable limit (Table 12). The E.coli test revealed a concentration that was "Too Numerous to Count" (TNTC), which means the density of colony growth on the plate was too high to distinguish individual colonies. The flow was not sufficient to take a flow rate measurement, and therefore a phosphorus loading rate was not estimated. Field Technicians returned on June 29th, 2012 and observed a trickle of flow. Discharge was sampled and found to have an elevated E.coli concentration again of 1848 cfu/100ml; well above the allowable level in VT impaired freshwaters (77 E.coli cfu/100ml). At all later dates, the outfall was observed to be dry. The results of the initial survey and E.coli test warranted further investigation of the outfall.

Table 12: Water Quality Analysis Results for Outfall 43A

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/7/2012	trickle, NM	**0.3**	0	3	0.15	850	**TNTC**	**0.05**	NA
6/29/2012	trickle, NM	NT	NT	NT	NT	NT	**1848**	NT	NA
7/13/2012	No Flow	NF	NF	NF	NF	NF	NF	NF	NF
8/6/2012	No Flow	NF	NF	NF	NF	NF	NF	NF	NF
8/16/2012	No Flow	NF	NF	NF	NF	NF	NF	NF	NF
8/27/2012	No Flow	NF	NF	NF	NF	NF	NF	NF	NF

*NF- Not Sufficient Flow To Sample, NT-Not Tested, NM-Not Measured, TNTC- Too Numerous To Count
bold = Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection

The drainage system investigation began with an inspection of the next mapped structure up the line from the outfall; catch basin 43.CBA as marked in Figure 18 (full map provided in Appendix 5-6). On June 21st, 2012 water from the sump of catch basin (43A.CBA) was tested for

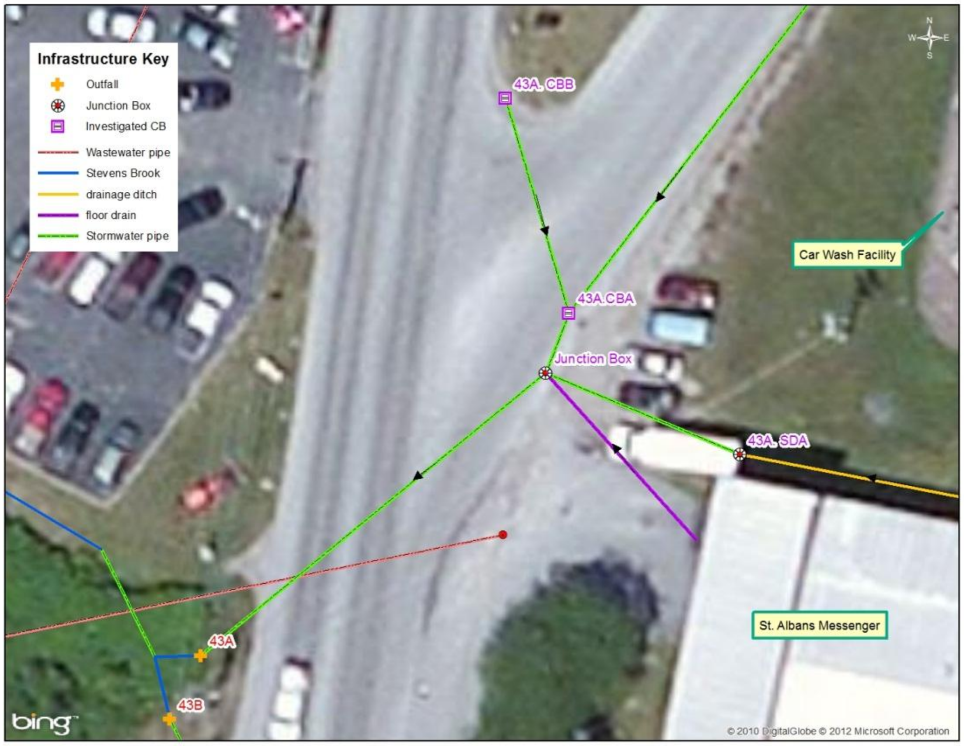

Figure 18: Outfall 43A Drainage Area

ammonia and found to have a very high concentration (3.56 mg/L). Sample water also tested high for detergents (0.75 mg/L). To trace the source of E.coli, the sump water was also tested for E.coli, but found to contain only a concentration of 2 cfu/100ml. The high ammonia and detergents levels were suggested to be as a result of runoff from a Car Wash facility up the hill from the catch basin. The source of the high E.coli level was still not confirmed.

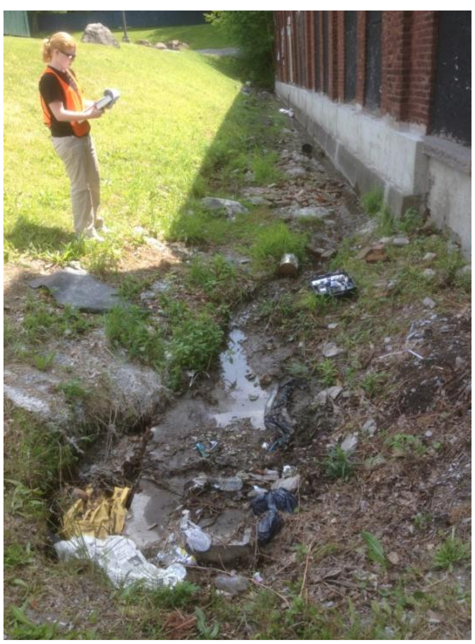

Figure 19: Surface drainage ditch adjacent to St. Albans Messenger:

A surface drainage ditch adjacent to the St. Albans Messenger was suspect due to the direction of flow toward the outfall and presence of active flow on June 21st, 2012 (Figure 19). Drainage was sampled and found to have a slightly elevated level of ammonia (0.48 mg/L), but much less than the catch basin. The ditch appeared to have a drain in the direction of the outfall, but not in the direction of the catch basin, which was the only mapped structure tied to the outfall. Therefore, the presence of an additional connection under the road was suggested for further investigation. After speaking with the Town and City Director's of Public Works, it was suggested that the surface drainage ditch could be fed by discharges or contaminated groundwater from further up in the drainage system, where many residences are on individual septic systems. In addition, the ditch is open with easy exposure to animal waste, which could also explain the high level of E.coli.

Due to the presence of a sewer line across the mapped storm line and the elevated E.coli level, there was a concern of a wastewater cross-contamination as mapped in Figure 18. To address the above issues, the City DPW assisted with the site investigation on several accounts. First, on July 13th, 2012 DPW personnel dyed the St. Albans Messenger sewer system. No dye was observed at the outfall, decreasing the likelihood of a direct cross-contamination. Then, on August 8th, 2012, Drummac Septic Service conducted a camera investigation of the drainage system starting at 43A.CBA and moving down the pipe toward the outfall. A concrete junction box was discovered approximately 9 feet down the pipe, with an outlet to the outfall and two inlet pipes; one in the direction of the St. Albans Messenger and another in the direction of the surface ditch. No active discharges into the junction box were observed but there was pooled water in the sump of the junction box.

To further refute the possibility of a slow or intermittent leak of wastewater, an optical brightener monitoring (OBM) pad was deployed on August 6th, 2012. The OBM pad was collected 10 days later, and found to be full of sediment. Three days of substantial rainfall occurred 4 days after deployment of the OBM, negating dry weather flow detection. In addition, sedimentation of OBM's is known to interfere with optical brightener detection (Guenther 2010), and therefore a new OBM was deployed on August 16th, 2012. The OBM was collected 12 days later on August 27th, 2012 after a period of only trace rainfall, and tested Negative for optical brighteners. The OBM test provides evidence that a wastewater leak is unlikely, therefore suggesting some other source for the elevated E.coli levels.

The lack of flow on four subsequent visits on July 13th, August 6th, August 16th, and August 27th, as base flow reduced substantially throughout the watershed, suggests that the observed flow on June 7th and June 21st came from residual water in the junction box sump from past runoff events and/or discharge from the surface drainage ditch.

As a result of the above findings it was concluded that the flow sampled on June 7th, 2012 was as a result of flow from the surface drainage ditch, but the detected contamination came from a combination of sources; ammonia, detergents, and phosphorus in runoff from the Car Wash Facility, and E.coli and/or phosphorus from groundwater flow contaminated by leaking septic systems and and/or animal waste droppings in the exposed ditch.

In addition, plastic bags of pet waste were observed on several accounts around the headwall of the outfall. It appears this is a common place for people (or one person who frequently passes the site) to illegally dispose of pet waste. Educational signage placed on the concrete headwall is suggested to discourage this activity, as improper disposal of pet waste is a non-point source of phosphorus and E.coli pollution.

The following next steps are recommended for further investigation of this outfall and elimination of the illicit discharge sources:

- ✓ Engage the Car Wash Facility Owners about proper containment of all runoff from their site to avoid contamination entering 43A.CBA.

- ✓ Clear sediment out of the outfall pipe, as the sediment is a source of contamination.

- ✓ Periodically monitor the surface drainage ditch in times of dry weather and sample discharge for E.coli. If levels are consistently high, assess area for source of animal waste disposal. If animal waste disposal is not evident, further investigation of the drainage area for septic system contamination may be necessary.

- ✓ Conduct further camera, dye, and /or smoke testing to determine the origin of the pipe originating in the direction of the St. Albans Messenger and discharging into the junction box underneath the roadway.

Outfall 16 (Upper Welden/Main St.)

One June 5th, outfall 16 was observed to have a substantial amount of dry weather flow (Figure 20-Left). Outfall 16 is a 30" concrete pipe that exits from the side of the culvert (looking downstream) at the intersection of Upper Welden St. and Main St (Figure 20-Right). The outfall drains a large commercial and residential area, North of the intersection, including runoff from Main St.

Figure 20: Left **- Outfall 16 on June 5th, 2012,** Right**- Side View of Outfall 16 Looking Through Culvert Under Upper Welden St./Main St.**

The outfall was sampled and found to have elevated levels of ammonia, fluoride, potassium, and detergents as summarized in Table 13. The conductivity and E.coli levels were also elevated. While the phosphorus concentration was low, the outfall had a moderate flow present at the time of sampling, and therefore the estimated annual loading rate was substantial (2.78 lb/yr).

Table 13: Water Quality Analysis Results for Outfall 16

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/5/2012	0.035	**0.22**	**0.31**	**8**	**0.5**	**2700**	**504**	0.04	**2.78**
8/2/2012	Trickle, NM	NT	NT	NT	NT	NT	NT	NT	NA
8/6/2012	No Flow	NF	NF	NF	NF	NF	NF	NF	NA
8/16/2012	Moderate, NM	NF	NF	NF	NF	NF	NF	NF	NA

* NM-Not Measured, NT-Not Tested

bold Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection

While the discharge had elevated levels of all water quality parameters, none of the individual parameters were extremely high compared to the benchmarks. In addition, there were no physical indicators, like odor or discoloration of the water indicating a direct wastewater and or washwater discharge.

On August 2nd, 2012 three catch basins, 16.CBA, 16.CBB, and 16. CBC, located along Main St. directly up the line from Outfall 16, were inspected Figure 21 (see full map of drainage area in Appendix 5-7). The outfall at the time had only a trickle of flow, as opposed to the flow observed on June 5th, 2012. A small trickle was evident leaving the first structure from the outfall (catch basin 16.CBA). The flow was sampled and found to have an ammonia concentration of 0.23 mg/L, which was similar to that observed at the outfall. The next structure, 16.CBB had standing water with both inlet and outlet pipes submerged. The next catch basin in the system, 16.CBC, located across the street was dry and therefore determined to not be a source for the discharge. The investigation was discontinued due to time constraints.

Figure 21: Outfall 16 Problem Site Investigation

The reduced flow, and conversely the dry weather flow, at the outfall and in the catch basins indicates a correlation to groundwater flow, which was reduced in the area due to an extended period of 8 days with less than 0.1” rainfall prior to August 2nd (NOAA 2012). The outfall was observed to have no flow four days later, on August 6th, 2012, after a continued dry spell. Then, when the outfall was observed on August 16th, after two days of over 0.75” rainfall (NOAA 2012), there was once again substantial flow observed at the outfall. Therefore, the contamination observed in the discharge on June 5th, may have been due to a combination of non-point sources picked up in stormwater runoff released slowly from pooled water in catch basins. Groundwater is likely infiltrating into the storm system due to aging pipes, and therefore flushing contaminates through the system during times of elevated baseflow. In addition, there is a chance that during times of heavy rainfall the wastewater system is overwhelmed causing wastewater to leak from pipes within the drainage area and into aging stormwater pipes.

The water quality data and large drainage area which results in an increased chance of exposure to wastewater cross-contamination suggest that there may be several minor wastewater leaks further in the system that are diluted by the time the discharge reaches the outfall. The conductivity is most likely a result of residual road salt build up in catch basins, particularly those located along Main St. Some possible sources of the phosphorus could be from small wastewater leaks or non-point sources throughout the drainage area.

The recommended follow up items are:

- ✓ Continue to investigate the drainage area during times of extended dry weather using a bracket sampling approach to pinpoint sources of contamination higher up in the subwatershed.

- ✓ As source areas are better defined, conduct camera investigation, smoke and/or dye testing to eliminate illicit sources.

Outfall 15 (Upper Welden/Main St.)

Outfall 15 was investigated after an initial suspicion of an intermittent illicit discharge (Figure 22) due to a low hit for ammonia, and high level of potassium (18 ppm), as summarized in Table 14.

Figure 22: Outfall 15 on June 5th, 2012.

Table 14: Water Quality Analysis Results for Outfall 15

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/5/2012	0.0003	**0.21**	0.1	**18**	0.1	1280	2	NT	NA
8/27/2012	0.00001	NT	NT	NT	NT	NT	NT	**0.12**	0.0025

* NT-Not Tested

bold Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection

An Optical Brightener Monitoring Pad (OBM) was deployed for 12 days, from August 16th – 27th 2012. The OBM had a False Positive reading due to the presence of specks of dust that appeared to be optical brighteners, but were determined to be from contamination of the OBM after collection. The pipe was found to have a large crack about 10 ft from the outlet. The pipe and the fact that thepipe exits from the side of a steep slope, suggests that the dry weather flow was a result of groundwater infiltration (Figure 23). Due to the presence of high potassium and phosphorus levels in discharge from Outfall 15 but a lack of optical brighteners, the discharge was determined to be groundwater infiltration into the pipe contaminated by non-point source pollution from the use of fertilizers in the drainage area Figure 24 (see full map in Appendix 5-8).

Figure 23: View Looking up Outfall 15 on August 27th, 2012 (Disconnection in pipe visible 10 ft up pipe from outfall)

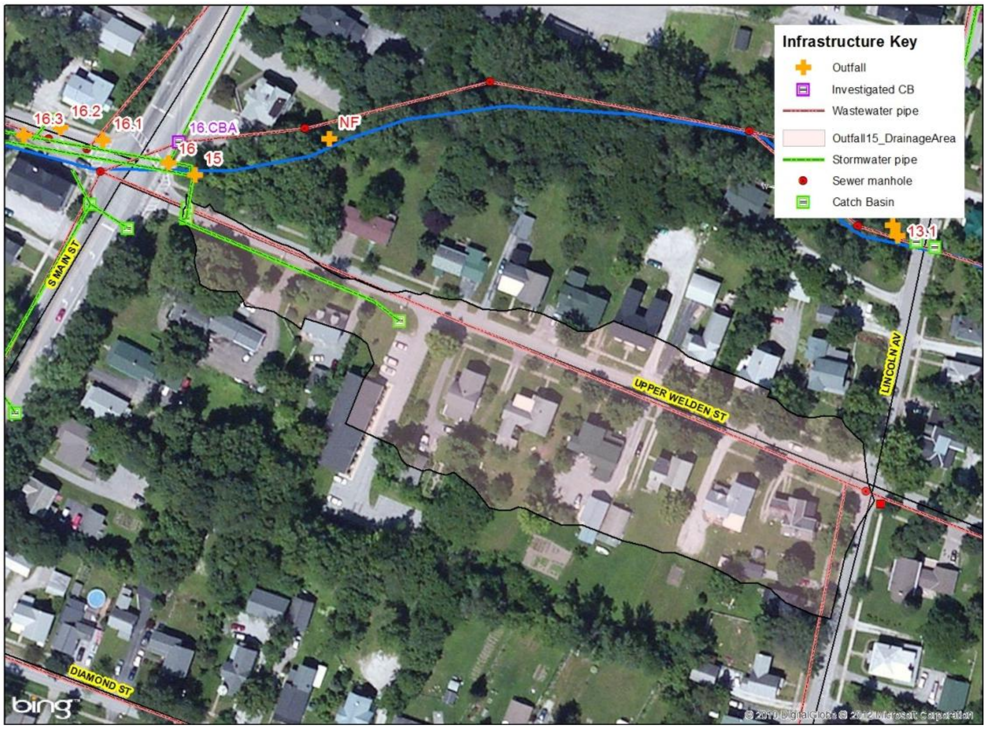

Figure 24: Outfall 15 Drainage Area

Outfall 11 (Barlow St.)

On June 4th, 2012 Outfall 11 was surveyed, and found to have about 0.005 cfs of flow (Figure 25). The outfall pipe, a 10" pvc pipe, appeared to exit out of the side of the stream bank. No other structures up the pipe could be located, suggesting the pipe was a floor or foundation drain. The pipe had brown-green bentic growth in the flow line and a very slight sulfide odor. The water was clear upon sampling.

Figure 25: Outfall 11 on June 4th, 2012

Water quality testing revealed a slightly elevated concentration of ammonia (0.25 mg/L) and elevated detergents level of 0.6 ppm (Table 15). In addition, the E.coli level (200 cfu/ 100ml) was above the benchmark. The outfall tested positive for optical brighteners in the previous (2007) study as well. The combination of results suggested a minor wastewater and/or washwater leak.

Table 15: Water Quality Analysis Results for Outfall 11

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/4/2012	0.005	**0.25**	0.16	2	**0.6**	1190	**200**	0.05	0.50
6/20/2012	trickle, NM	**0.27**	NT	NT	**0.25**	NT	NT	NT	NA
8/6/2012	trickle, NM	NT	NT	NT	NT	NT	NT	NT	NA
NT-Not Tested, NM-Not Measured									
bold	Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection								

On August 8th, 2012 Drummac Septic Service conducted a camera investigation of the pipe, and found that the pipe only extended about 10 feet into the side of the bank (Figure 26-full map provided in Appendix 5-9). The pipe appeared to be an underdrain for the bank, but was not connected to any other pipeline. The following investigation results suggested the source of the elevated parameters was groundwater contamination from a minor wastewater leak or spilled washwater and/or fertilizer onto the lawn above the outfall pipe. The presence of detergents is not natural, indicating that there had been past washing activities and/or an intermittent septic leak in the area of the outfall.

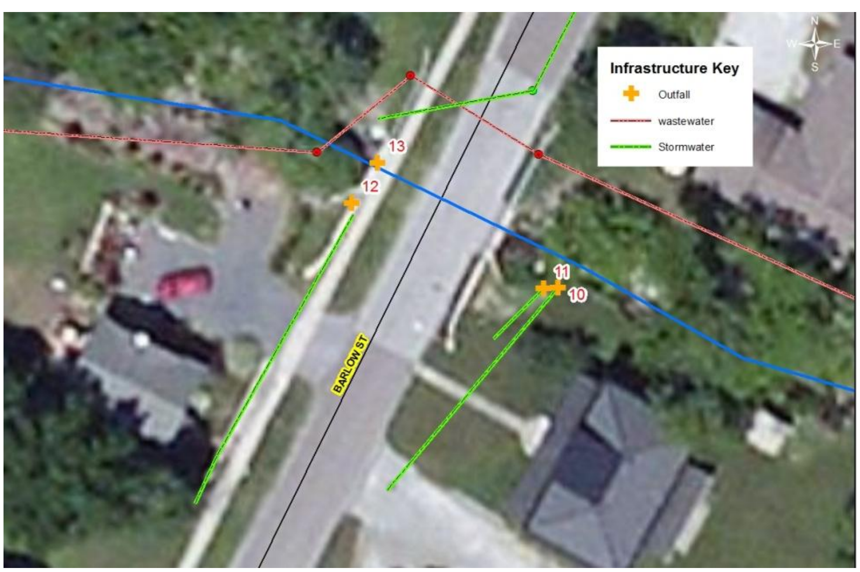

Figure 26: Outfall 11 Drainage System

The recommended follow up items include:

- ✓ The outfall should be re sampled to detect if detergents and/or ammonia levels change drastically.
- ✓ A microbial source tracking sample could be collected at the outfall to confirm the source of bacteria present.
- ✓ The configuration of lateral sewer lines serving the residences in the area should be mapped. Potential lateral sources should be further investigated by dye, smoke, or camera investigations.

4.2 Town of St. Albans Investigations

Outfall T16 (Hannafords Store)

Outfall T16 is a 15" HPDE drainage pipe that connects to a catch basin located in the loading dock area behind Hannafords Store, within the Highgate Shopping Center (Figure 28-see full map in Appendix 5-10). On June 6th, outfall T16 was surveyed and found to have approximately 0.0001 cfs of dry weather flow (Figure 27). Benthic growth and discoloration were present in the flow line suggesting a possible illicit discharge.

Figure 27: Outfall T16 on June 7th, 2012.

Figure 28: Outfall T16 Drainage System

Sample water was then tested and found to contain elevated levels of ammonia, fluoride, potassium, detergents, conductivity, and E.coli (Table 16). Of particular concern was the elevated level of E.coli which was Too Numerous To Count (TNTC), indicating an unsafe concentration of E.coli in discharge to the outfall. The conductivity level at 4500 µs was also of concern as it was elevated well above the benchmark to levels often found in industrial waste discharge. The outfall was flagged as a priority site for further investigation due to the combination of elevated levels of *all* water quality parameters and the presence of physical indicators.

Table 16: Water Quality Analysis Results for Outfall T16

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/7/2012	0.0001	**1.38**	**0.5**	**13**	**0.75**	**4500**	**TNTC**	**0.07**	0.018
6/26/2012	present, NM	NT	NT	NT	NT	NT	**1203**	NT	NA
*NF- Not Sufficient Flow To Sample, NT-Not Tested, NM-Not Measured TNTC- Too Numerous To Count **bold** = Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection									

Field Technicians conducted bracket sampling within the drainage system on June 8th, 2012. An ammonia level of > 5.0 mg/L (above measureable limits of La Motte Colorimeter) was detected in sump water of catch basin T16.CBA, located in the Hannaford loading dock area. A small pvc pipe could be seen under the water surface in the direction of the Hannafords Building, but discharge could not be confirmed because the pipe was submerged. The next structure up the drainage line had ammonia levels of only 0.46 mg/L, bracketing the source to T16.CBA. On June 21st, field technicians returned to the site and observed dry weather flow at the outfall as well as evidence of a seepage stream from the industrial trash compactor located just up gradient from T16.CBA, suggesting a possible source for the elevated WQ indicator levels (Figure 29). However, the waste stream was dry and did not explain the presence of dry weather flow.

Figure 29: T16.CBA, located in Hannaford Loading Dock. Seepage from trash compactor evident on June 21st, 2012.

On June 25th, 2012, Public Works personnel dyed the sewer system in Hannafords to identify potential floor drain connections. No dye was observed at the outfall. Sample water at the outfall and within the stream just up from the outfall were tested for E.coli at the VT Department of Health Laboratory, according to the SM 9223B-QT method. The outfall had 1203 MPN/100ml of E.coli, while the stream had 727 MPN/100ml. The elevated E.coli levels tested 18 days apart and continual presence of dry weather discharge indicated there was either a continuous illicit discharge or residual contamination in the catch basin sump with discharge into the basin from a clean source.

Field Technicians then spoke with the Town Director of Public Works, about cleaning the catch basin to see if there was flow from the small pvc pipe, and possibly using a camera up the line to identify the source of the discharge. The catch basin is privately-owned and therefore the Town needed to engage the property owner, to have the owner clean the catch basin and eliminate the source.

The recommended follow up items include:

- ✓ Engage the Property Owner and educate them about the illicit discharge issue.
- ✓ Clean catch basin and verify if there is flow from the small pvc inlet drain.
- ✓ Identify source of inflow into catch basin. Sample inflow for WQ parameters (particularly E.coli and Ammonia) and compare to WQ levels in catch basin sump (T16.CBA) so as to isolate source of contamination to the trash compactor spillage.

- ✓ Work with property owner to stop spillage from trash compactor and clean loading dock area regularly with approved cleaning chemicals.

Outfall T123 (Highgate Shopping Center)

Outfall T123 is a discharge pipe for a series of catch basins located within the Highgate Shopping Center Parking lot as mapped in Figure 30 (see full map in Appendix 5-11).

Figure 30: Outfall T123 Drainage System

The outfall is an 18" corrugated metal pipe that appears to be in disrepair as displayed in Figure 31 below.

Figure 31: Outfall T123 on June 7th, 2012.

On June 7th, 2012 the outfall was surveyed and appeared to have approximately 0.0003 cft/s of dry weather flow. The pool appeared to by turbid and green algae growth was evident at the lip of the outfall. Sample water exhibited elevated levels of all WQ parameters with the exception of E.coli which had 0 cfu/100ml (Table 17). The detergents level was five (5) times greater than the threshold value and the conductivity level (9500 µS) was the highest measured in this study, at a level characteristic of industrial activity and/or substantial road salt runoff. The initial dry weather survey made this outfall highly suspect for illicit discharge.

Table 17: Water Quality Analysis Results for Outfall T123

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
6/7/2012	0.0003	**0.68**	**0.31**	**13**	**1.25**	**9500**	0	**0.08**	0.043
6/8/2012	present, NM	**0.80**	NT	NT	NT	NT	NT	NT	NT
8/6/2012	No Flow	NF	NF	NF	NF	NF	NF	NF	NF
8/27/2012	No Flow	NF	NF	NF	NF	NF	NF	NF	NF

*NF- Not Sufficient Flow To Sample, NT-Not Tested, NM-Not Measured
bold = Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection

The outfall was re-inspected the following day on June 8th, 2012. Dry weather flow was observed and sampled again for Ammonia revealing an elevated level of 0.80 mg/L, consistent with the previous day's testing results. Field technicians inspected the drainage system displayed in Figure 30 and found a slight trickle entering the outlet pipe of the first catch basin (T123.CBA) up the line. The basin had two inlet pipes; one from the south that had a slight trickle and one pipe from the north parallel to the roadway with no flow. The catch basin (T123.CBB) connected to the southern pipe was full of sediment and no standing water was visible. It is possible there was water within the pores of the sediment resulting in a slow trickle into basin T123.CBA. The next catch basin up the line from T123.CBC was also inspected and found to be full of sediment.

The low flow and presence of sediment in the parking lot basins suggested the cause of the high conductivity to be from residual road salt within the basins flushing through the system, with eventual discharge at the outfall. The flow at the outfall could have been residual from past rain events due to the sediment in the basins hindering flow through the system.

The elevated levels of detergents and fluoride were concerning and not directly suggestive of parking lot runoff. Other possible sources of contamination could have been from an illicit floor drain connection to one of the neighboring businesses. However, when the outfall was re-inspected on August 6th, 2012 and 21 days later on August 27th, 2012, no flow was observed on either occasion, suggesting that the low flow observed on June 8th, 2012 may have been a result of runoff from past rain events.

The recommended next steps are as follows:

- ✓ Work with adjacent property owners (Thai House) to investigate if there is a floor drain in the building that may connect to the outfall pipe, and dye any floor drains to see if there is cross-contamination occurring.
- ✓ Engage Property Owner to clear sediment out of parking lot catch basins.
- ✓ Work with Property Owner on Road Salt Mitigation Plan. The level of conductivity (which is related to salinity) observed at the outfall nearly two (2) months after the last application of road salt (April to June) was substantial, indicating a need to clean the catch basins more frequently and to reduce the overall amount of salt applied in the parking lot.

Outfall T149C (Industrial Park)

Outfall T149C is a drainage outlet for a catch basin (T149.CBA) located in the loading dock of the nearest industrial building (occupant unknown). The outfall is located at the end of Industrial Park Extended Road, within the St. Albans Industrial Park as marked in Figure 32 (Full map in Appendix 5-12). On June 20th, 2012 dry weather flow was observed coming from the 15" HDPE outfall pipe (Figure 33).

Figure 32: Outfall T149C Drainage System

Figure 33: Outfall T149C; Slight trickle observed on June 20th, 2012.

One the same day, sample water was collected and tested for all WQ parameters, with the exception of Phosphorus (Table 18). Levels of ammonia (0.38mg/L) and detergents (0.30 ppm) exceeded the known benchmarks for natural waters. Of most concern was the high conductivity level, characteristic of industrial activity discharge and/or road salt runoff.

Table 18: Water Quality Analysis Results for Outfall T149C

Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)
6/20/2012	trickle, NM	**0.38**	0.02	3	**0.30**	**4100**	2	NT
8/27/2012	No flow	NF	NF	NF	NF	NF	NF	NF
*NF- Not Sufficient Flow To Sample, NT-Not Tested, NM-Not Measured **bold** = Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection								

The outfall was re-inspected on August 27th, 2012 at which time no dry weather flow was present, but there was evidence of past flow due to staining in the flow line. The catch basin T149.CBA was inspected, and discovered to have an identical 15" HDPE pipe out of the basin in the direction of the outfall. There appeared to be a small pvc pipe entering the basin from the direction of the building but no flow was present. The sump was full of clear water up to about 2" below the invert of the outlet pipe. From the above mentioned observations and water quality analysis it can be concluded that the sump of the catch basin may have residual salt build up from use at the loading dock area during winter months. The dry weather flow observed on June 20th, 2012 could have been as a result of past rainfall filling the basin, causing a slow trickle from the basin to the outfall. Another possibility is the small PVC pipe within the basin is connected to a floor drain within the building with periodic discharges, explaining the high conductivity and presence of detergents.

The following next steps are recommended to identify and eliminate the illicit discharge:

- ✓ Sample the catch basin sump for conductivity.
- ✓ Clean catch basin and resample several days after cleaning.
- ✓ An OBM could be deployed within the lip of the small pvc pipe to detect any intermittent illicit discharge into the basin if the catch basin sump is still contaminated after cleaning.

4.3 Trunkline Investigation (TL-1)

The outfall from the City abandoned wastewater pipe (hereinafter called the "trunk line"), located near the City WWTP, was fully submerged upon inspection on June 7th, 2012. Therefore, to assess if there was potential illicit discharge entering Steven's Brook from the trunk tine, the first structure (TL-1) up the pipe was surveyed as a part of the initial Dry Weather Survey (Figure 34-full map provided in Appendix 5-13). The inlet pipe to manhole TL-1 was submerged in standing water. The sump water was sampled, and found to contain slightly elevated levels of ammonia (0.48 mg/L), fluoride (0.43 mg/L), and conductivity (1550 µS), as well as a detectable concentration of detergents (0.25 ppm) (summarized in Table 19). Phosphorus was tested for and found to be high at 1.6 mg/L. Based on the Dry Weather Survey results, there was suspicion of a possible wastewater and or chemical waste discharge further up the trunk line, and it was flagged for further investigation.

Table 19: Water Quality Analysis Results for Investigation of Outfall TL-1 and the Trunk line

Structure ID	Date	Flow Estimate (cfs)	Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/yr)
TL-1	6/7/2012	submerged, NM	**0.48**	**0.43**	5	**0.25**	**1550**	1	**1.6**	NA
TL-3	10/25/2012	moderate, NM	**1.46**	0.08	NT	**0.25**	NT	**92**	NT	NA
TL-4	10/25/2012	trickle, NM	**1.72**	0.12	NT	**0.5**	NT	**372**	NT	NA
TL-5	10/25/2012	moderate, NM	**1.58**	INF	NT	0.1	NT	**600**	NT	NA
TL-6	10/25/2012	moderate,NM	**1.47**	0.17	NT	0.1	NT	**TNTC**	NT	NA
TL-6	11/15/2012	moderate,NM	**1.44**	INF	NT	**0.5**	NT	0	NT	NA
TL-7	11/15/2012	moderate,NM	NT	**0.26**	NT	NT	NT	0	NT	NA
TL-8	11/15/2012	moderate,NM	NT	INF	NT	0.1	NT	2	NT	NA

*NT-Not Tested, NM-Not Measured, TNTC- Too Numerous To Count, INF- Interference from Iron > 10.0mg/L in Sample

bold Over The Accepted Threshold Value (Benchmark) For Illicit Discharge Detection

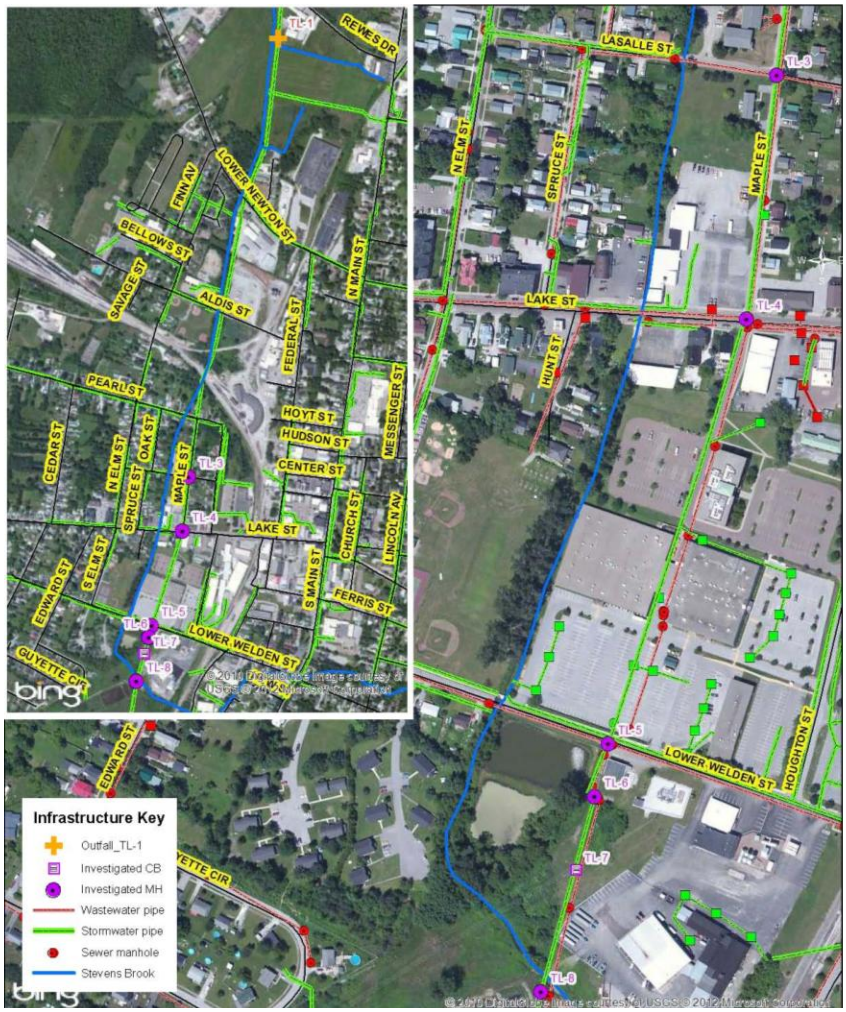

Figure 34: Trunkline Investigation

Investigation of the trunk line began on October 25th, 2012 at structure TL-3, as marked in Figure 34 and working up the pipe. The manhole (TL-3) was suspect given that a wastewater pipe crosses through the structure (Figure 35). Upon inspection, there appeared to be a buildup of iron oxide along the wastewater pipe and the sump of the basin, as well as thick brownish-orange foam. There was a steady flow visible from the partially submerged inflow pipe. In addition, a strong petroleum odor was evident. After mentioning this issue to DPW personnel, they noted that petroleum based manufacturing activities had historically occurred in the adjacent lot, and that the site had been a known source of groundwater contamination. Samples were collected at the inlet pipe, and revealed a high concentration of ammonia (1.46 mg/L) and a detectable level of detergents (0.25 ppm). E.coli was also elevated above the VT water quality standard for fresh waters, at 92 cfu/100 ml.

Figure 35: TL-3 Storm Manhole on October 25th, 2012.

The next structure (TL-4), located at Maple/Lake St. appeared to have a slow flow through the basin. There was an apparent sheen on the surface, as well as foam. There was a rusty tinge to the water, upon sampling. The ammonia level was again elevated at 1.72 mg/L. Detergents and E.coli were elevated and above the previous structure's samples, at 0.5 ppm, and 372 cfu/100ml, respectively.

On the next cross street (Lower Welden St.), structure TL-5, was suspect due to a wastewater pipe crossing through the structure (Figure 36 below), as was the case for TL-3. The inflow pipe to the structure was partially submerged, and flow was evident. Sample water had a pronounced rusty tinge. The ammonia concentration was 1.58 mg/L. While the detergents level was below the benchmark (0.1 ppm), the E.coli concentration was high at 600 cfu/100ml. Fluoride could not be measured due to interference from a high amount of iron in the sample resulting in an erroneous negative reading.

Figure 36: Structure TL-5 on October 25th, 2012.

The next structure, TL-6, was investigated and found to have a slow but steady flow from a partially submerged pipe. The water was clear upon sampling, but there was slight iron oxide staining on the sump of the basin, similar to the other structures. The ammonia concentration was elevated at 1.47 mg/L, and again like the previous structure, detergents were low (0.1 ppm). In contrast, the E.coli concentration was much greater at “Too Numerous To Count (TNTC)”. The presence of high E.coli and elevated ammonia suggested that there was some source of wastewater discharge further up the system.

On November 14th, 2012, DPW personnel dyed the top of the wastewater line that runs parallel to the trunk line, starting at the Briarwood Trailer Park. Manholes along the storm trunk line (TL-8 through TL-5) were inspected for dye. Dye was not detected in any of the manholes. Since a clear source was not identified and the water quality results were suspect, TL-6 and the rest of the structures along the trunk line were sampled on November 15th, 2012.

TL-6 was re-tested and found to have variable results from the October 25th sample. The ammonia concentration of 1.44 mg/L, was nearly the same. The detergents level was higher than the previous sample and above the benchmark, at 0.5 ppm. The biggest difference, however was the E.coli concentration, which was 0 cfu/100 ml, unlike that last sample which had TNTC. This indicates there is some transient source of E.coli entering the system.

The next structure, TL-7, is a catch basin that appeared to connect directly to the trunk line. However, all pipes were submerged upon inspection and the water was turbid, so the exact connection is unknown. There was a strong odor of sulfide coming from the basin, and the sump water appeared yellowish when sampled. In the process of testing the sample for ammonia, the bulb in the Lamotte Colorimeter burned out. However, the reagents were added to the sample, revealing qualitative evidence for an exceptionally high ammonia concentration based on the deep golden yellow color (Figure 37). The E.coli test revealed 0 cfu/100 ml. The high ammonia and lack of E.coli suggest the possibility of an ammonia-based chemical spill.

Figure 37: Reacted Samples from TL-7
Indicates High Concentration of Ammonia (> 5.0 mg/L)

A steady flow through the next manhole (TL-8) was observed, with a substantial build up of iron oxide in the flow line. Inside the basin there is an elevated ledge (about 5 feet from the bottom of the basin) that had a buildup of sewage waste (toilet paper, etc) providing evidence of past sewer overflows into the basin. While ammonia could not be tested due to the burned out bulb, the reagents were added, and revealed a yellow color, indicating an elevated concentration of ammonia. Detergents were low (0.1 ppm) and iron in the sample interfered with the fluoride reading. There was only a 2 cfu/100ml in the sample water, similar to the other structures sampled in the system.

In general, the inflow pipes within the trunk line structures were deep (5-15 ft) increasing the possibility of the pipe placement at or below the groundwater table. Additionally, there is a likelihood of groundwater infiltration into the trunk line, due to the consistent presence of iron oxide in the trunk line structures (excluding TL-7 which is thought to be connected off from the main line).

While the sampling results had several inconsistencies, the detectable presence of detergents and substantial E.coli concentration detected in TL-6 on October 25th, 2012 indicates that there is most likely a diluted wastewater leak entering the trunk line somewhere up the pipe from TL-6. Furthermore, the presence of substantial flow through the system during dry weather suggests that there are likely cracks and leaks in the aging pipe, particularly between T-6 and the last manhole in the trunk line, beyond T-8, since the greatest flow was observed in TL-8. As a recommended next step in the investigation, the depth of the wastewater pipeline in close proximity to TL-8 and TL-7 should be compared to the inverts of the trunk line. It has been found that low-level wastewater leaks are most likely in areas where the sewer pipes are above the storm pipes and both are below the groundwater table (Holden et al. 2011).
The recommended next steps are as follows:

- ✓ Conduct a camera or smoke investigation from TL-6 up the trunk line to better identify sources of cross contamination.

- ✓ Clean catch basin TL-7 and verify the connection to the trunk line. Conduct follow up sampling from the basin to detect if ammonia levels are still elevated.

5 Overall Study Conclusions

Through this study, at least 12 confirmed or suspected illicit discharges were identified and flagged for elimination. An additional 9 outfalls were classified as a potential concern, and are recommended for investigation. Sources of illicit discharges were detected including diluted wastewater contamination, washwater, cleaning supplies dumping, road salt pollution, and trash compactor waste. Overall we found only very limited blatant signs of illicit discharge. The majority of the illicit detection was done through water quality analysis.

A total of 22.6 lb/yr (11.1 kg/yr) of Total Phosphorus was estimated to enter Stevens and Rugg Brook due to illicit discharges from stormwater outfalls (Table 20). The total loading estimate comes from only a few outfalls, with significantly higher individual loading estimates than the others, including outfalls 34, 27, 16, and 37. The loading estimates were based on one grab sample and were highly dependent on the flow rate, implying that these calculated values are only estimates of total loading.

Table 20: Annual Phosphorus Loading Estimates from Suspected Illicit Discharges

Outfall	Flow Rate, cfs	Total Phosphorus (TP), mg/L	TP Annual Loading, lb/yr
City Outfalls			
24	NM	1.88	NA
26	0.0003	0.10	0.05
34	0.013	0.18	**4.6**
27	0.014	0.22	**6.3**
Trunk line (TL-1)	NM	1.60	NA
43A	NM	0.05	NA
16	0.035	0.04	**2.8**
15	0.00001	0.12	0.003
11	0.005	0.05	0.50
37	0.14	0.03	**8.3**
38	0.0007	NT	NA
29	NM	0.08	NA
29.1	0.0005	0.1	0.10
40	0.0065	NT	NA
26.2	NM	0.26	NA
39.1	NM	0.06	NA

Outfall	Flow Rate, cfs	Total Phosphorus (TP), mg/L	TP Annual Loading, lb/yr
City Outfalls Continued			
39.2	NM	0.09	NA
14	0.035	NT	NA
Town Outfalls			
T16	0.0001	0.07	0.018
T123	0.0003	0.08	0.043
T149C	0.0001	NT	NA
T124	0.010	NT	NA
	TOTAL Annual TP Loading (lb/yr) =		**22.6**
* NM- Not sufficient flow to measure, NT- Not Tested, NA- Not Available, **Boldface**= Outfalls Investigated for Illicit Discharge Source			

The water quality parameters selected allowed for the distinction between several types of illicit discharges. E.coli samples proved to be variable, and therefore collecting multiple samples, possibly at different times of day to get an average concentration, may have offered a more representative measurement. Camera investigations facilitated the identification several updates to the City and Town storm sewer mapping, including an unknown junction box at outfall 43A and an incorrect connection between catch basins 34.CBC, 34.CBD, and 34.CBB. Dye testing helped to rule out possible direct wastewater cross-contamination. However, at a few sites minor and/or slow wastewater leaks are suspected that would be identified more effectively using a continuous monitoring probe with a low detection limit for diluted dye (Holden 2011).

Canine scent detection could be a very useful and cost-effective strategy for making progress on all of the follow up investigation work presented in this report. The project team has been in contact with Environmental Canine Services (ECS), LLC of Vermontville, MI, a firm that specializes in using canine scent detection for identifying illicit discharges. These trained canines have been shown to be accurate and highly efficient for tracking illicit discharges. If an ECS team could be hired in conjunction with other projects in the Northeast, there could be substantial cost savings for the service. The canine tracking could be used in conjunction with other advanced investigation techniques including dye, camera, and smoke testing. A Phase II study is recommended to further investigate problem areas to eliminate the most impacting illicit discharges.

6 References

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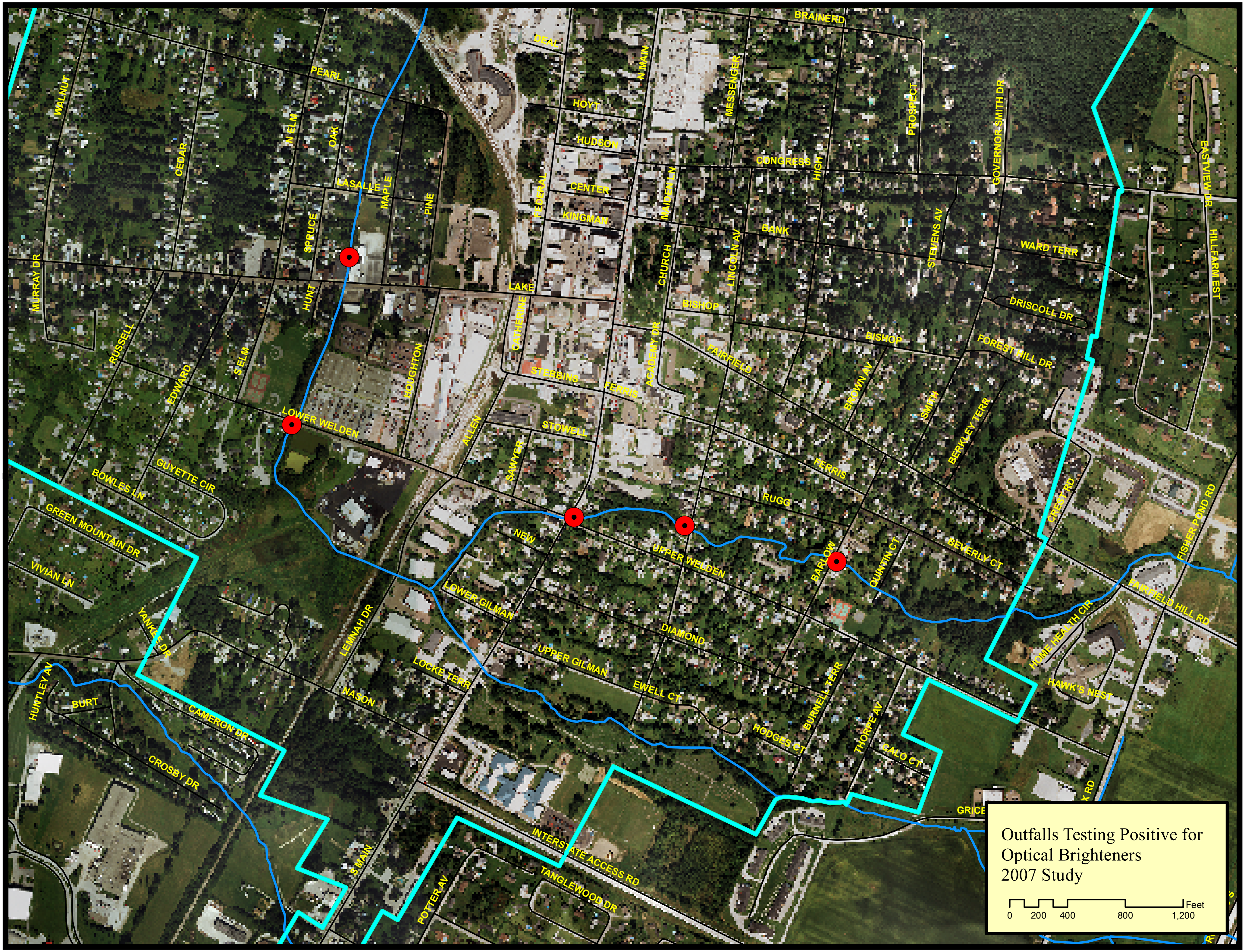
Appendices

APPENDIX 1

2007 VT DEC Outfall Study Map


Outfalls Testing Positive for
Optical Brighteners
2007 Study
Feet
0 200 400 800 1,200
BRAINERD
DEAL
PEARL
WALNUT
N MAIN
MESSENGER
PROSPECT
GOVERNOR SMITH DR
HOYT
HUDSON
N ELM
OAK
CEDAR
CONGRESS
HIGH
EASTVIEW DR
LASALLE
MAPLE
PINE
FEDERAL
CENTER
MAIDEN LN
KINGMAN
BANK
STEVENS AV
HILLFARM EST
SPRUCE
WARD TERR
MURRAY DR
CHURCH
LINCOLN AV
LAKE
HUNT
BISHOP
DRISCOLL DR
CATHERINE
ACADEMY DR
RUSSELL
S ELM
HOUGHTON
FAIRFIELD
FOREST HILL DR
STEBBINS
FERRIS
BROWN AV
EDWARD
SMITH
BERKLEY TERR
LOWER WELDEN
ALLEN
STOWELL
SAWYER
GUYETTE CIR
BOWLES LN
RUGG
CREST RD
GREEN MOUNTAIN DR
NEW
UPPER WELDEN
BARLOW
QUINTIN CT
BEVERLY CT
FISHER POND RD
VIVIAN LN
LOWER GILMAN
FAIRFIELD HILL RD
HOME HEALTH CIR
YANKEE DR
LEMNAH DR
DIAMOND
UPPER GILMAN
HUNTLEY AV
BURT
LOCKE TERR
EWELL CT
BURNELL TERR
HAWK'S NEST
NASON
CAMERON DR
HODGES CT
THORPE AV
CALO CT
CROSBY DR
GRICE
S MAIN
INTERSTATE ACCESS RD
TANGLEWOOD DR
POTTER AV

APPENDIX 2

IDDE Operating Procedures and Forms

APPENDIX 2-1

Dry Weather Survey Procedures

IDDE Dry Weather Survey Operating Procedures

[Pages 15-16 adapted from "Illicit Discharge Detection and Tracking Guide", by Center of Watershed Protection (CWP). 2012. Center of Watershed Protection (CWP).]

The primary field screening tool is the Outfall Reconnaissance Inventory (ORI) form, which is provided in Appendix 2 and described fully in Brown et al. (2004). The basic procedure at each outfall is to take a picture of the outfall and, collect GPS coordinates, and label the outfall with waterproof marking stick in a prominent location such as the outfall headwall.

Next, an ORI form is completed, which includes recording a description of the outfall (e.g., pipe material, diameter), a description of physical indicators of potential illicit discharges for both flowing and non-flowing outfalls and the results of flow and water quality measurements taken at flowing outfalls.

Sample Collection:

If the outfall has dry weather flow, four samples should be collected: one for field-analysis of ammonia; one for lab analysis including fluoride, potassium and detergents; one for total phosphorus; and one for E.coli.

The procedure for collecting a water sample is as follows:

1. Put on gloves;
2. When possible, sample the flow directly in a clean sterilized plastic Whirl-pack®;
3. Be sure to rinse the sampling container once with flow from the sample water for conditioning;
4. If a dipper, bailer, bucket or other device is used to collect a sample, be sure that they are conditioned with the flow prior to final collection as well;
5. Sample packs are to be labeled with the appropriate outfall ID, date of collection, and sample collector initials using a water-proof marker;
6. Collect replicates as specified, if needed; and
7. Put samples for lab in cooler with ice.

Field Testing:

Measure the Temperature and pH of the discharge by first rinsing a graduated cylinder with sample water. Then, fill the graduate cylinder with sample water until the electrode probe can be fully immersed in the sample. Record the temperature and pH on the ORI form.

Next, conduct the ammonia test following the instructions provided by the manufacturer of the test kit. Record the results on the ORI form. Be sure to rinse probes/cuvets with distilled water after sample analysis.

Flow Rate Measurement:

Lastly, measure the flow rate at all flowing outfalls. Flow measurements can be difficult to accurately collect in certain situations, for example, when the flow is too large or too little to collect with the chosen container. As such, three methods are presented and are listed in priority preference:

Method 1**:** Utilizing a graduated milk jug marked at 1 Liter and a stopwatch record the amount of time required to fill the jug to 1 Liter. Ensure you are capturing the entire flow. When the flow is only a trickle, use a smaller volume container and follow the same method. The following equation is used to calculate flow: **Discharge = Volume filled (cu. ft.) x Time (sec).** For pipes that are discharging larger volumes where it is not be possible to capture the volume in a graduated container, see Method 2.

Method 2: This method should only be used with a free-flowing outfall (i.e. water drops out of the pipe and falls to the stream channel) and when the depth of flow is relatively uniform. Utilizing a tape measure, record the flow depth in the pipe at the deepest point (thalweg) and the total flow width. Then use the following equation: **Discharge= 3.1 x wetted width (ft) x flow depth (ft) ^1.5**

Method 3: Using a tape measure record the width of the flow. Next measure and record the depth of the flow. Using a measuring tape, ping pong ball, and stop watch, record the length of time it takes to travel a known distance and. Repeat velocity measurement 3-5 times and average the results. Then use the following equations to calculate the flow rate and record the results on the ORI form:
Area= Wetted width (ft) x flow depth (ft)
Velocity= Length of ping pong ball run (ft) / Time (sec)
Discharge= Area x Velocity

Lab Testing:

Test samples for conductivity, fluoride, detergents, and potassium. Record results of lab analysis on the Sample Collection Lab Sheet (Appendix 2-3).

All samples collected for external lab analysis should be preserved as specified by the lab for the parameter of interest. See Standard Methods for the Examination of Water and Wastewater for more information about sample collection and sample preservation: http://www.standardmethods.org/. Bacteria samples are to be processed within 6 hours of collection and incubated at the appropriate temperature and for the necessary length of time as indicated by the bacteria plate manufacturer.

Follow up:

All outfalls with a confirmed illicit discharge will require a drainage area investigation. If the outfall is determined to have a potential illicit discharge based on physical indicators, but samples do not exceed established water quality thresholds, the outfall should be re-visited two additional times during the permit cycle to determine if an intermittent discharge may be present. Ideally, one re-visit will occur on a different day of the week than the original visit and/or at a different time of day.

APPENDIX 2-2

Dry Weather Survey ("Outfall Reconnaissance Inventory") Field Sheet

(CWP 2012)

OUTFALL RECONNAISSANCE INVENTORY/ SAMPLE COLLECTION FIELD SHEET

Section 1: Background Data

Subwatershed:		Outfall ID:	
Today's date:		Time (Military):	
Investigators:		Form completed by:	
Temperature (°F):	Rainfall (in.): Last 24 hours: Last 48 hours:		
Latitude:	Longitude:	GPS Unit:	GPS LMK #:
Camera:		Photo #s:	

Land Use in Drainage Area (Check all that apply):

☐ Industrial ☐ Ultra-Urban Residential ☐ Commercial ☐ Open Space ☐ Suburban Residential ☐ Institutional

Other: ____ Known Industries: ____

Notes (e.g., origin of outfall, if known):

Section 2: Outfall Description

LOCATION	MATERIAL		SHAPE		DIMENSIONS (IN.)	SUBMERGED
☐ **Closed Pipe**	☐ RCP	☐ CMP	☐ Circular	☐ Single	Diameter, circular: _____	In Water: ☐ No ☐ Partially* ☐ Fully*
	☐ PVC	☐ HDPE	☐ Elliptical	☐ Double	Box: h - _____ w - _____	
☐ **Manhole**	☐ Steel		☐ Box	☐ Triple	Elliptical: h - _____ w - _____	With Sediment: ☐ No ☐ Partially ☐ Fully
	☐ Other: __________		☐ Other: _____	☐ Other: _____		
☐ **Open drainage**	☐ Concrete	☐ rip-rap ☐ Earthen	☐ Trapezoid	☐ Other:__________	Depth: _____	Bottom Width: __________
	☐ Other: __________		☐ Parabolic		Top Width: _____	
☐ **In-Stream**	**Complete Stream Discharge form**					
Flow Present?	☐ **Yes**	☐ **No**	***If No, Skip to Section 5***	**Flow Description** ☐ **Trickle**	☐ **Moderate**	☐ **Substantial**

Section 3: Quantitative Characterization

FIELD DATA FOR FLOWING OUTFALLS				
PARAMETER		**RESULT**	**UNIT**	**EQUIPMENT**
☐Flow #1	Volume		Liter	Bottle
	Time to fill		Sec	Stopwatch
☐Flow #2 (only for free-flowing outfalls)	Flow depth		In	Tape measure
	Wetted width		ft	Tape measure
☐Flow #3	Flow width	__________' __________"	Ft, In	Tape measure
	Flow depth		In	Tape measure
	Time of travel (avg)	1._________2. _________3._________	Sec	Stop watch
	Measured length	__________' __________"	Ft, In	Tape measure
Ammonia			mg/L	Specific ion probe Type:
Temperature			ºF	--
pH				--

Outfall Reconnaissance Inventory Field Sheet

Section 4: Physical Indicators for Flowing Outfalls Only

Are Any Physical Indicators Present in the flow? ☐ Yes ☐ No *(If No, Skip to Section 5)*

INDICATOR	CHECK if Present	DESCRIPTION	RELATIVE SEVERITY INDEX (1-3)		
Odor	☐	☐ Sewage ☐ Rancid/sour ☐ Petroleum/gas ☐ Sulfide ☐ Other:	☐ 1 – Faint	☐ 2 – Easily detected	☐ 3 – Noticeable from a distance
Color	☐	☐ Clear ☐ Brown ☐ Gray ☐ Yellow ☐ Green ☐ Orange ☐ Red ☐Other:	☐ 1 – Faint colors in sample bottle	☐ 2 – Clearly visible in sample bottle	☐ 3 – Clearly visible in outfall flow
Turbidity	☐	See severity	☐ 1 – Slight cloudiness	☐ 2 – Cloudy	☐ 3 – Opaque
Floatables -Does Not Include Trash!!	☐	☐ Sewage (Toilet Paper, etc.) ☐ Suds ☐ Petroleum (oil sheen) ☐ Other:	☐ 1 – Few/slight; origin not obvious	☐ 2 – Some; indications of origin (e.g., possible suds or oil sheen)	☐ 3 - Some; origin clear (e.g., obvious oil sheen, suds, or floating sanitary materials)

Section 5: Physical Indicators for Both Flowing and Non-Flowing Outfalls

Are physical indicators that are not related to flow present? ☐ Yes ☐ No *(If No, Skip to Section 6)*

INDICATOR	CHECK if Present	DESCRIPTION	COMMENTS
Outfall Damage	☐	☐ Spalling, Cracking or Chipping ☐ Peeling Paint ☐ Corrosion	
Deposits/Stains	☐	☐ Oily ☐ Flow Line ☐ Paint ☐ Other:	
Abnormal Vegetation	☐	☐ Excessive ☐ Inhibited	
Poor pool quality	☐	☐ Odors ☐ Colors ☐ Floatables ☐ Oil Sheen ☐ Suds ☐ Excessive Algae ☐ Other:	
Pipe benthic growth	☐	☐ Brown ☐ Orange ☐ Green ☐ Other:	

Section 6: Overall Outfall Characterization

☐ Unlikely ☐ Potential (presence of two or more indicators) ☐ Suspect (one or more indicators with a severity of 3) ☐ Obvious

Section 7: Data Collection

1. External lab sample? ☐ Yes ☐ No	2. Internal lab sample? ☐ Yes ☐ No	3. Sterile sample for bacteria analysis? ☐ Yes ☐ No
4. Sample(s) collected from: ☐ Flow ☐ Pool	5. Duplicate collected? ☐ Yes ☐ No	*If yes, check appropriate:* ☐ External lab ☐ Internal lab ☐ Sterile

Section 8: Any Non-Illicit Discharge Concerns (e.g., trash or needed infrastructure repairs) or other Notes?

APPENDIX 2-3

Sample Collection Sheet

(CWP 2012)

Subwatershed:			Outfall ID:	
Today's date:			Duplicate? (yes/no):	
Form completed by:				
PARAMETER	**RESULT**		**UNIT**	**EQUIPMENT**
Fluoride			mg/L	Photometer
Potassium			ppm	Compact ion meter
Detergents			ppm	Chemets kits
Conductivity			µS	Conductivity probe
Bacteria	***Count***	***Dilution (1:1 or 1:100)***		
Red w/ gas			CFUs	Petrifilm plate
Blue w/ gas			CFUs	Petrifilm plate

Subwatershed:			Outfall ID:	
Today's date:			Duplicate? (yes/no):	
Form completed by:				
PARAMETER	**RESULT**		**UNIT**	**EQUIPMENT**
Fluoride			mg/L	Photometer
Potassium			ppm	Compact ion meter
Detergents			ppm	Chemets kits
Conductivity			µS	Conductivity probe
Bacteria	***Count***	***Dilution (1:1 or 1:100)***		
Red w/ gas			CFUs	Petrifilm plate
Blue w/ gas			CFUs	Petrifilm plate

Subwatershed:			Outfall ID:	
Today's date:			Duplicate? (yes/no):	
Form completed by:				
PARAMETER	**RESULT**		**UNIT**	**EQUIPMENT**
Fluoride			mg/L	Photometer
Potassium			ppm	Compact ion meter
Detergents			ppm	Chemets kits
Conductivity			µS	Conductivity probe
Bacteria	***Count***	***Dilution (1:1 or 1:100)***		
Red w/ gas			CFUs	Petrifilm plate
Blue w/ gas			CFUs	Petrifilm plate

APPENDIX 2-4

Manhole and Catch Basin Investigation Field Sheet

(CWP 2012)

MANHOLE INSPECTION FORM

Section 1: Background Data

Today's date:	Time (Military):	Subwatershed:	Outfall ID:
Investigators:	Form completed by:	Temperature (°F):	
Camera:	Photo #s:	Rainfall (in.): Last 24 hours:	Last 48 hours:
Latitude:	Longitude:	GPS Unit:	GPS LMK #:

Land Use in Drainage Area (Check all that apply):

☐ Industrial ☐ Ultra-Urban Residential ☐ Commercial ☐ Open Space ☐ Suburban Residential ☐ Institutional

Other: ____ Known Industries: ____

Section 2: Manhole Description

STANDING WATER?	OBSTRUCTIONS	FLOATABLES	ODOR	FLOW PRESENT?
☐ Yes ☐ No **Color of Water:** ☐ **Clear** ☐ **Cloudy** ☐ **Other**___________	**Blockages?** ☐ **Yes** ☐ **No** **Sediment?** ☐ **Yes** ☐ **No** Percent of pipe filled: ____________%	☐ None ☐ Sewage ☐ Oily Sheen ☐ Foam ☐ Other: _____	☐ None ☐ Sewage ☐ Petroleum/gas ☐ Sulfide ☐ Other: __________	☐ **Yes** ☐ **No** **Velocity:** ☐ **Trickle** ☐ **Moderate** ☐ **Substantial** **Color of Flow:** ☐ **Clear** ☐ Other: __________ ☐ **Cloudy** ☐ **Suspended Solids** **Depth of Flow: ____________________________in** **Width of Flow: ____________________________in** **Approx flow velocity ______________________ft/s**

Section 3: Field Testing

FIELD DATA FOR FLOWING OUTFALLS			
PARAMETER	**RESULT**	**UNIT**	**EQUIPMENT**
Ammonia		mg/L	Colorimeter
Temperature		ºF	--
pH			--
Potassium		Ppm	Ion probe
Detergents		Ppm	Chemets kits
Fluoride		Mg/L	Photometer
Conductivity		µS	Conductivity probe

Section 4: Sample Collection

1. External lab sample? ☐ Yes ☐ No
2. Internal lab sample? ☐ Yes ☐ No
3. Sterile sample for bacteria analysis? ☐ Yes ☐ No
4. Duplicate collected? ☐ Yes ☐ No *If yes, check appropriate:* ☐ External lab ☐ Internal lab ☐ Sterile

APPENDIX 2-5

Optical Brightener Monitoring Methods

Excerpt from DEC Outfall Study *"Detection of Non Stormwater Discharges To Stevens Brook within the City of St. Albans"* (DEC 2007)

Detection of Non-Stormwater Discharges
To Stevens Brook within the City of St. Albans City

INTRODUCTION

Background

Stevens Brook, a tributary to St. Albans Bay, is included in Vermont's 2006 List of Impaired surface waters for stormwater runoff. The density of impervious surfaces in St. Albans City is the main reason for the impairment as the majority of the stormwater from these surfaces is collected and discharged into Stevens Brook. Another possible source of urban pollutants may be illicit discharges through the stormwater drainage system of residential and commercial wastewater.

Illicit discharges enter the stormwater drainage system through either direct connections or indirect connections. The following examples were taken from the Friends of the Winooski River, *Detection and Elimination of Non-Stormwater Discharges to the Streams of the City of Barre*, March 2007:

Examples of **direct connections** include:

- Wastewater piping either mistakenly or deliberately connected to the stormdrain system.
- A shop floor drain that is connected to the stormdrain system.
- A cross-connection between the sanitary sewer and stormdrain system.

Examples of **indirect connections** include:

- Infiltration into the stormdrain system from a leaking sanitary sewer line.
- Infiltration or surface discharge into the stormdrain system from a failed septic system.
- A spill flowing to a catchbasin.
- Materials (*e.g.*, paint or used oil) dumped directly into a catchbasin.

Recently, St. Albans city's stormwater drainage to Stevens Brook was mapped (see attached maps). In addition, the mapping also identified private outfall pipes that may include foundation drains, stormwater drainage systems on private properties or possibly relict wastewater pipes.

One method for identifying illicit discharges is optical brightener testing. Optical brighteners, a fluorescent white dye used in laundry detergents, can be identified in stormwater discharges and can therefore be used to identify potential contamination from residential or commercial wastewater. In 2007, a Bellows Free Academy science teacher, Jeff Rouleau, worked with DEC watershed coordinator, Karen Bates, to develop and conduct an optical brightener survey of the mapped outfalls to Stevens Brook within St. Albans city.

METHODS

The survey was conducted at three different times during the spring, summer and fall of 2007. Two surveys were conducted with students from two of Mr. Rouleau's high school science classes. The first class tested in late May 2007, the second class repeated the test in early November 2007. Mr. Rouleau and Ms. Bates also repeated the tests in mid-July 2007.

Thirty stormwater outfalls in the city were tested. The stormwater outfalls were identified using a map and pictures obtained from the Northwest Regional Planning Commission (see attached map). All mapped outfalls within city limits on the Stevens were tested except for B029, which could not be found. B007 and B008 were dropped after the first survey because of restricted access. Outfall B0019 included four, not one outfall as mapped, and each was tested.

At each outfall, an unbleached cotton pad (VWR, International, Inc.) inserted into a packet of stapled plastic pet screen netting was attached to a rock with monofilament line. The line was wrapped around the rock and placed in an outfall pipe or a small stream. The packets were deployed for a period of about five days, including a weekend. More specifically: in May, the samples were inserted on the 17th and 18th and removed on the 21^{st} and the 22; in July, the samples were inserted on the 20^{th} and removed on the 23^{rd}; and in November the samples were inserted on the 8^{th} and removed on the 12^{th}.

After each sample was retrieved, the pad was rinsed in the sample water, squeezed "dry" and then placed flat in a plastic sandwich bag. The bag was labeled on the outside with the station number. No replicates were taken. Besides laundry detergents, metal particles, bleached materials, cotton dust, or paper products may also cause positive results. The project participants took care to make sure that the unbleached cotton pads were not exposed to these contaminants via aerial deposition or by physical contact.

<u>Optical brightener analysis</u>

The packets were hung on a line in a dark room with clothes pins. A pad was considered positive for wastewater contamination when a hand-held, long wave fluorescent (UVA or "black") light[1] showed florescence on the hanging pad (Table 1). Specs of florescence were assumed to indicate contamination by flecks of dust, and were not included as a positive showing.

[1] 115V-60Hz UV light with range 254 - 364 nm purchased from VWR International, P/N 95-0017-09

Table 1 Positive optical brightener results from three surveys of stormwater outfalls in St. Albans City

Positive results	Location/ownership	May 2007 (minimal rain)	July 2007 (no rain)	November 2007 (no rain)	Remarks
B003	North of Lake Street/private	X			Pad was black and oily first survey and dry the second and third survey
B011	Lower Weldon St./public	X		X*	
B017	Lincoln Ave./public		X	X*	
B019a (First culvert under road on north side as heading down stream.	Main St. culvert/public		X	X*	Second survey: Pad was black and flow present. Flow was present during third survey as well.
B027	Barlow St./private			X*	

Discussion and Results

Cotton pads collected from the following outfalls showed positive for optical brighteners (Table 1):

- B003, private pipe that drains from parking lot of Beverage Mart on Lake Street.
- B0011, city-owned pipe off Lower Weldon Street
- B017, city-owned pipe off Lincoln St.
- B019a, city-owned outfall off Main St.
- B027, private pipe off Barlow St.

To reduce the chances of picking up contamination due to cracked wastewater pipes, only the first survey was completed during a period of high ground water. The other two surveys were conducted during the drier periods of the year (July and November) when the ground water table was more likely to be below the pipes.

The decreased stormwater flows in July and November due to drier soils and a lower ground water table may have had more of an impact on the results. Both B017 and B019a outfalls only showed positive during the later two surveys as reduced flows may have increased optical brightener concentrations to a detectable level. Both of these outfalls probably drain the older section of the city where old pipes and past day practices are most likely responsible for the contamination. Both outlets were flowing in July and November despite the dry weather, also suggesting that residential wastewater may be contributing to the flows. Further study is required.

The city has already identified the problem at B011 and an engineering study is currently underway.

The only positive result for B003 may be due to the discontinuation of throwing wash water down a storm drain after word of the sampling results for that particular outlet spread. The only positive result for B027 may be due to a connection with one residence and irregular discharge such as wastewater from a washing machine.

Although, the following sites were negative for optical brightener, they may warrant additional testing for wastewater contamination for the following reasons: B027's pad may have been too soiled to show the florescence. Both B022 and B023 outfalls were flowing in November despite the dry weather and the excessive flow may reduce optical brightener concentrations below detection levels.

B004 was questionable for florescence in November and should also be tested again.

APPENDIX 3

IDDE Study Data Summary Tables

APPENDIX 3-1

Dry Weather Survey Data

St. Albans IDDE Dry Weather Survey Results
ERP Contract # 2012 ERP-1-01
December 13th, 2012- Revised 9/8/14 by JS Submitted to JP

Date	Investigator	Outfall_ID	Pipe diameter (in)	Photo #,time stamp	Dry Weather Flow (Y/N)	Notes	Flow (cfs)	Water Temperature (C)	pH	Field Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Ammonia/ Potassium ratio	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/cf)	TP (lb/yr)
6/4/2012	JS,LL,SS	8	6	1	N														
6/4/2012	JS,LL,SS	8.1	4	2-3	N														
6/4/2012	JS,LL,SS	10	6	4	N														
6/4/2012	JS,LL,SS	11	10	5	Y	1-sewage/storm, brown benthic growth	0.0050			0.25	0.16	2	0.125	0.60	1190	200	0.05	3.1E-06	0.50
6/4/2012	JS,LL,SS	12	15	6	N														
6/4/2012	JS,LL,SS	13	26	7-8	Y	1-Chlorine Odor	0.0589			0	0.38	1	0.000	0.00	210	0			
6/4/2012	JS,LL,SS	13.1	8	10	Y	trickle				0		6	0.000	0.30	1460	6			
6/4/2012	JS,LL,SS	14		11-13	Y	algae growth in flow line	0.0353			0	0.55	3	0.000	0.20	950	44			
6/5/2012	AT, JS	6	8	10:57	N		NM			0.02									
6/5/2012	AT, JS	6.1	8	12:03	Y	sediment deposit and algae growth in flowline	0.0002												
6/5/2012	AT, JS	T47	15	10:43	N														
6/5/2012	LL,SS	15	15	14	Y	2-chemical odor, deposits in flowline	0.0003	15.6	8.16	0.21	0.1	18	0.012	0.10	1280	2	0.12	7.5E-06	0.07
6/5/2012	LL,SS	16	30	15-17	Y		0.0353	15.6	7.83	0.22	0.31	8	0.028	0.50	2700	504	0.04	2.5E-06	2.78
6/5/2012	LL,SS	16.1	15	18	N														
6/5/2012	LL,SS	16.2	24	19	N														
6/5/2012	LL,SS	16.3	14	20	N														
6/5/2012	LL,SS	23	20	21	N														
6/5/2012	LL,SS	23.1	8	22	N														
6/5/2012	LL,SS	23.2	20	23	N														
6/5/2012	AT,SS	23.3	10	13:37	N	iron staining													
6/5/2012	AT,SS	24	18	14:04	Y	2-orange color, iron staining in flow line		NA	7.36	3.2	0.15	11	0.291	0.30	1060		1.88		
6/5/2012	AT,SS	26.3	open draina	14:21	N														
6/5/2012	AT,SS	26.1	12	14:44	N														
6/5/2012	AT,SS	26	24	14:44	Y	1-gray color, pool turbid/gray, semi-crushed pipe	0.0003	NA	7.48	1.96	0.11	12	0.163	0.20	960	64	0.10	6.2E-06	0.05
6/5/2012	AT,SS	25	18	14:51	N														
6/6/2012	AT,JS	26.2	open draina	9:48	Y	surface drainage from wetland, iron staining		NA	NA	0.62	0.45	3	0.207	0.40	460		0.26	1.6E-05	
6/6/2012	AT,JS	27	24	10:16	Y		0.0145	NA	7.6	0.96	0.13	2	0.480	0.40	450	1000	0.22	1.4E-05	6.27
6/6/2012	AT,JS	28	15	10:38	N														
6/6/2012	AT,JS	29	36	10:40	Y	sediment deposits, 1-turbid, oil sheen	NM	NA	7.51	0.23	0.18	4	0.058	0.50	1380	250	0.08	5E-06	
6/6/2012	AT,JS	29.1	15	11:10	Y	sediment deposits, 1-turbid, oil sheen	0.0005	NA	7.44	0.11	0.2	2	0.055	0.75	3000		0.10	6.2E-06	0.10
6/6/2012	AT,JS	29.2	8	11:17	Y	rooftop drain, clean so no lab samples taken	NM	NA	8.01	0.16									
6/6/2012	AT,JS	29.3	open draina	11:32	Y	good spot for retrofit													
6/6/2012	AT,JS	29.4	10	11:41	N	appears abandoned													
6/6/2012	AT,LL	30	12	39	N	under culvert													
6/6/2012	AT,LL	31	18	no pic	N	under culvert													
6/6/2012	LL,SS	20.1	12	24-27	N														
6/6/2012	LL,SS	21	24	28,31	Y		0.0041	18.6	8.27	0.15	0.23	3	0.050	0.20	880				
6/6/2012	LL,SS	22	24	32	Y		0.0244	16.8	7.97	0.17	0.24	2	0.085	0.20	1350				
6/6/2012	LL,SS	22.1	13	10:39	N														
6/6/2012	LL,SS	22.2	48x129 (Str	11:00	Stream	in stream sample at outlet to underground culvert	0.3629	16.3	8.12	0.21	0.14	0	#DIV/0!	0.75	620		0.03	1.9E-06	21.43
6/6/2012	SS,AT	T392	open draina	no pic	N														
6/6/2012	SS,AT	T21	open draina	13:32	N														
6/6/2012	SS,AT	T21.1	4	13:35	Y	submerged, looks like foundation drain													
6/6/2012	SS,AT	44	36	13:47	N		0.1903	NA	8.08	0.05	0.09	1	0.050	0.10	480	44			
6/6/2012	SS,AT	44.2	12	14:41	N	filled with sediment													
6/6/2012	SS,AT	44.3	4	14:54	Y	only a trickle	NM	NA	7.42	0.17	0.05	0	#DIV/0!	0.10	1100	6			
6/6/2012	SS,AT	42	48	14:57	N	pipe benthic growth	0.1620	NA	7.96	0.17	0.14	2	0.085	0.10	1170	24			
6/6/2012	SS,AT	40	24	15:19	Y		0.0065	NA	7.55	0.52	0.09	4	0.130	0.20	1270	14			
6/6/2012	SS,AT	39.1	open draina	15:37	Y			NA	7.7	0.41	0.17	0		0.10	960	176	0.06	3.7E-06	

St. Albans IDDE Dry Weather Survey Results
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December 13th, 2012- Revised 9/8/14 by JS Submitted to JP

Date	Investigator	Outfall_ID	Pipe diameter (in)	Photo #,time stamp	Dry Weather Flow (Y/N)	Notes	Flow (cfs)	Water Temperature (C)	pH	Field Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Ammonia/ Potassium ratio	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/cf)	TP (lb/yr)
6/6/2012	SS,AT	39	15	15:53	N														
6/6/2012	SS,AT	39.3	open draina	15:56	Y														
6/6/2012	SS,AT	39.4	open draina	15:57	Y														
6/6/2012	JS, LL	32	12	40	N	submerged, full of sediment													
6/6/2012	JS, LL	33	14	0:00	N														
6/6/2012	JS, LL	34	34	44	Y	partialy submerged, 2-sulfide odor,	0.0129	18.4	7.42	0.39	0	6	0.065	0.10	1100	880	0.18	1.1E-05	4.56
6/6/2012	JS, LL	36	10	46,47	Y	1-turbidity, totally submerged	0.3035	17.7	7.28	0.19	0.2	4	0.048	0.40	1920	38			
6/6/2012	JS, LL	37	elliptical	47	Y		0.1406	19.2	7.95	0.32	0.03	4	0.080	0.25	880	176	0.03	1.9E-06	8.30
6/6/2012	JS, LL	37.1	8	no pic	N														
6/6/2012	JS, LL	46	8	42	N														
6/6/2012	JS, LL	46.1	15	no pic	N	unmapped, possibly abandoned													
6/6/2012	JS, LL	38	28	49	Y	1-sulfide smell, 2-turbid, poor pool quality	0.0007	NA	NA	0.33	0.03	2	0.165	0.25	720	88			
6/7/2012	AT, SS	TL-1	couldn't tell	10:11	Y		NM	NA	7.33	0.48	0.43	5	0.096	0.25	1550	1	1.60	1E-04	
6/7/2012	AT, SS	43A	24	10:43	Y		NM	NA	8.01	0.3	0	3	0.100	0.15	850	1848	0.05	3.1E-06	
6/7/2012	AT, SS	43B	24	10:56	Y	clay	0.0101	NA	8.04	0.07	0.06	2	0.035	0.10	820	32			
6/7/2012	AT, SS	T10	open draina	12:54	Y			NA	7.45	0.24	0.18	2	0.120	0.10	990				
6/7/2012	AT, SS	T9	open draina	13:05	Y														
6/7/2012	AT, SS	T119	open draina	13:06	Y			NA	7.5	0.25	0.27	2	0.125	0.10	1570				
6/7/2012	AT, SS	T213	open draina	13:13	Y														
6/7/2012	AT, SS	T215	18	13:25	Y	sediment deposits in flowline	0.0067	NA	7.15	0.24	0.07	2	0.120	0.10	810				
6/7/2012	AT, SS	T214	12	13:25	N														
6/7/2012	AT, SS	T235	12	13:52	N														
6/7/2012	AT, SS	T232	10	13:56	Y	flow may be from flushed hydrants	0.0051	NA	NA	0.15	0.55	2	0.075	0.00	280	112			
6/7/2012	AT, SS	T13	open draina	no pic	Y														
6/7/2012	AT, SS	T157	open draina	15:06	Y														
6/7/2012	JS, LL	T123	18	50, 51	Y	1-turbid, metal strippedoutfall, poor pool quality	0.0003	19.3	7.41	0.68	0.31	13	0.052	1.25	9500	0	0.08	5E-06	0.04
6/7/2012	JS, LL	T123.1	4	52	N	located next to 123													
6/7/2012	JS, LL	T123.2	18	53	N	crushed pipe, possibly abandoned													
6/7/2012	JS, LL	T124	24	54,55	Y	turbid pool, sediment in flow line	0.0970	17.1	7.56	0.43	0.43	5	0.086	0.30	3000	32			
6/7/2012	JS, LL	T124.1	12	56	N														
6/7/2012	JS, LL	T17.1	13	62	N	possibly roof													
6/7/2012	JS, LL	T15	18	no pic	N														
6/7/2012	JS, LL	T14	8	66,65	N														
6/7/2012	JS, LL	T14.1	8	no pic	N														
6/7/2012	JS, LL	T14.2	8	68	N														
6/7/2012	JS, LL	T16	15	63	Y	good site for OB pad	0.0001	22.2	7.1	1.38	0.50	13	0.106	0.75	4500	2000	0.07	4.4E-06	0.02
6/8/2012	AT, SS	T53	open draina	11:31	Y					0.13									
6/8/2012	AT, SS	T197	open draina	no pic	Y														
6/8/2012	AT, SS	T255	15	12:03	Y	corrosion, deposits in flowline	NM	NA	7.53	0.14	0.07	1	0.140	0.10	890				
6/8/2012	AT, SS	T257	open draina	12:18	Y		0.0261	NA	7.8	0.01									
6/8/2012	AT, SS	T71	24	12:35	Y		0.0187	NA	8.14	0.14	0.19	2	0.070	0.10	940				
6/8/2012	AT, SS	19	24	13:03	Y	iron staining in flowline	0.0049	NA	7.96	0.1	0.19	2	0.050	0.10	690				
6/20/2012	AT, JS	20	15	10:20	N	Bricks and debris in pipe													
6/20/2012	AT, JS	18	38	10:21	Y	sediment deposits in flowline	0.0186	NA	8.12	0.18	0.17	4	0.045	0.25	530	12	0.02		
6/20/2012	AT, JS	T69	open draina	10:56	N														
6/20/2012	AT, JS	T92	open draina	10:43	N														
6/20/2012	AT, JS	T417	open draina	11:03	N														
6/20/2012	AT, JS	T151	open draina	11:25	N														
6/20/2012	AT, JS	T267	30	11:48	Y	1-must odor, brown/green algae, brown foam	0.1095	NA	NA	0.14	0	1	0.140	0.20	870	12			
6/20/2012	AT, JS	T149A	30	12:35	Y		0.0218	NA	8.05	0.25	0.11	1	0.250	0.20	990	378	0.02	1.2E-06	0.86
6/20/2012	AT, JS	T149B	4	12:16	Y	green/brown pipe benthic growth	0.0043	NA	7.99	0.25	0	1	0.250	0.10	1540	0			
6/20/2012	AT, JS	T149C	15	12:30	Y	deposits in flowline			8.12	0.38	0.02	3	0.127	0.30	4100	2			
6/7/2012	AT, SS	T234	open draina	no pic	N														
8/6/2012	JS	29	*sample not processed				moderate												

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Date	Investigator	Outfall_ID	Pipe diameter (in)	Photo #,time stamp	Dry Weather Flow (Y/N)	Notes	Flow (cfs)	Water Temperature (C)	pH	Field Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	Ammonia/ Potassium ratio	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)	TP (mg/L)	TP (lb/cf)	TP (lb/yr)
6/6/2012	SS,AT	39.2	open drainage		Y			NA	7.7	0.24	0.25	2	0.120	0.10	1160	476	0.09	5.6E-06	
8/6/2012	JS	18	*sample not processed				0.0186					0		0.50		226			
8/6/2012	JS	WWTP Tap	faucet				faucet				0.54								
5/29/2012	AT,JS	S-Stevens	30' upstream of 16							0.04		1	0.040						
5/29/2012	AT,JS	S-Rugg	near Knights of Columbus							0.02		1	0.020						
5/29/2012	AT,JS	GW	bathroom sink-Tap from Bedrock well				town office bth sink			1.25		1	1.250						
8/6/2012	JS	S27	10' upstream of 27				trickle, low flow			0.48	0.69	0	#DIV/0!	0.10		822			
8/6/2012	JS	S16	20' upstream of 16				moderate flow			0.1	0.72	0	#DIV/0!	0.00		208			
8/27/2012	JS	T267					0.0008										0.015	9.4E-07	0.02
8/27/2012	JS	T149B					0.0011										0.010	6.2E-07	0.02
8/27/2012	JS	15					0.0000										0.120	7.5E-06	0.00
8/27/2012	JS	S16.2					0.0002										0.010	6.2E-07	0.00
8/27/2012	JS	29					0.0032										0.01	6.2E-07	0.06
8/27/2012	JS	18					0.0026										0.02	1.2E-06	0.10

APPENDIX 3-2

IDDE Problem Site Investigations Data

St. Albans IDDE Problem Site Investigations Results
ERP Contract # 2012 ERP-1-01
December 13th, 2012

						Indicator Parameters						
Date	**Investigator**	**Outfall_ID**	**Pipe diameter (in)**	**Note**	**Flow**	**Field Ammonia (mg/L)**	**Fluoride (mg/L)**	**Potassium (ppm)**	***Ammonia/ Potassium ratio***	**Detergents (ppm)**	**Conductivity (µS)**	**E. coli (CFU/100 ml)**
Bracket Sampling and Investigation												
6/8/2012	AT, SS	T16.CBA	CB	investigation		>5.0						
6/8/2012	AT, SS	T16.CBB	CB	investigation		0.46						
6/8/2012	AT, JS, LL, SS	24	outfall	investigation		3.37						
6/8/2012	AT,JS, LL, SS	24.CBA	CB	investigation		4.57						
6/8/2012	AT, JS, LL,SS	(Loading dock)	CB	investigation		2.49						
6/8/2012	AT, JS, LL,SS	24.CBE	CB	investigation		0.27						
6/8/2012	LL, JS	T123	outfall	investigation		0.8						
6/8/2012	LL, JS	T123.CBA	CB	investigation		0.54						
6/8/2012	LL, JS	T123.CBB	CB	investigation								
6/20/2012	AT, JS	11	outfall	investigation	moderate flow	0.27						
6/21/2012	AT, JS	43A	outfall	investigation	trickle							
6/21/2012	AT, JS	43A.CBA	CB	investigation	trickle	3.56				0.75		2
6/21/2012	AT, JS	43A.SDA	SD	investigation	trickle	0.43						
6/29/2012	AT, JS	43A	outfall	investigation	trickle							1848
6/21/2012	AT, JS	26	outfall	investigation	slight trickle					0.75		
6/21/2012	AT, JS	26.CBA	CB	investigation	standing water	2.65				0.25		
6/21/2012	AT, JS	26.MA	MH	investigation	standing water	2.37				0.25		50
6/21/2012	AT, JS	26.CBB	CB	investigation	standing water	3.43				0.25		1600
6/21/2012	AT, JS	26.MB	MH	investigation	standing water	0.48				0.10		
6/21/2012	AT, JS	27	outfall	investigation	flow					0.30		
6/21/2012	AT, JS	27.CBA	CB	investigation	standing water	3.16				2.00		
6/21/2012	AT, JS	34.MA	MH	investigation	standing water	0.4						748
6/21/2012	AT, JS	34.CBA	CB	investigation	standing water	0.53						78
6/21/2012	AT, JS	34.CBB	CB	investigation	standing water	0.6						186
6/26/2012	DPW	T16	outfall	DPW-investigation	N/A							1203
6/26/2012	DPW	S16	upstream of T16	DPW-investigation	N/A							727
6/29/2012	AT, JS	24	outfall	Follow-up	trickle	2.3						
7/13/2012	JS	26.CBB	CB	investigation-dye	standing water							
7/13/2012	JS	24	outfall	Follow-up	trickle	0.48						
7/13/2012	JS	43A	outfall	investigation-dye	dry							
8/2/2012	AT, JS	24	outfall	Follow-up	trickle	0.45						
8/2/2012	AT, JS	34.MB	MH	investigation	trickle from southern i	1.77		1	1.770	0.25		
8/2/2012	AT, JS	34.MC	MH	investigation	steady flow from south	0.08		0	#DIV/0!	0.50		
8/2/2012	AT, JS	34.MD	MH	investigation	dry-no flow							
8/2/2012	AT, JS	16.CBA	CB	investigation	trickle	0.23		1	0.230			
8/2/2012	AT, JS	16.CBB	CB	investigation	no flow, standing water							
8/2/2012	AT, JS	16.CBC	CB		no flow, dry							
8/6/2012	JS	T16	outfall	investigation	moderate flow							
8/6/2012	JS, DPW	43A	outfall	investigation-camer	no flow							

St. Albans IDDE Problem Site Investigations Results
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December 13th, 2012

Date	Investigator	Outfall_ID	Pipe diameter (in)	Note	Flow	Field Ammonia (mg/L)	Fluoride (mg/L)	Potassium (ppm)	*Ammonia/ Potassium ratio*	Detergents (ppm)	Conductivity (µS)	E. coli (CFU/100 ml)
Bracket Sampling and Investigation												
8/6/2012	JS, DPW	34.ME	MH	investigation-camer	small pool in sump, no flow							
8/6/2012	JS, DPW	11	outfall	investigation-camer	trickle							
8/6/2012	JS	24	outfall-pool	Follow-up	outfall-dry, sampled po	0.32						
8/6/2012	JS	24	outfall-stream	Follow-up	sampled stream infron	0.52						
8/6/2012	JS	43A	outfall	deploy OBM	no flow							
8/6/2012	JS	T123	outfall	deploy OBM	no flow							
8/6/2012	JS	15	outfall	deploy OBM	no flow							
8/6/2012	JS	16	outfall	deploy OBM	no flow							
8/16/2012	JS	43A	outfall	collect OBM, deploy	no flow							
8/16/2012	JS	15	outfall	collect OBM, deploy	no flow							
8/16/2012	JS	16	outfall	OBM confirmed lost	moderate flow							
8/27/2012	JS	43A	outfall	collect OBM	no flow							
8/27/2012	JS	T123	outfall	collect OBM	no flow							
8/27/2012	JS	15	outfall	collect OBM	trickle							
10/25/2012	AT,JS	34.MB	MH	investigation	steady flow from south	0.57						
10/25/2012	AT,JS	34.MF	MH	investigation	no flow (evidence of p	N/A						
10/25/2012	AT. JS	34.ME	MH	investigation	slight flow from East (l	0.04						
10/25/2012	AT,JS	34.MC	MH	investigation	slight flow	0.19						
10/25/2012	AT,JS	24	outfall	investigation	moderate flow	3.78						
10/25/2012	AT,JS	24.CBD	CB	investigation	stagnant	1.25						
10/25/2012	AT,JS	TL-3	MH	investigation	moderate flow	1.46	0.08			0.25		92
10/25/2012	AT,JS	TL-4	MH	investigation	slow trickle	1.72	0.12			0.50		372
10/25/2012	AT,JS	TL-5	MH	investigation	moderate flow	1.58	"ERR"			0.10		600
10/25/2012	AT,JS	TL-6	MH	investigation	moderate flow	1.47	0.17			0.10		TNTC
11/15/2012	AT,JS	TL-8	MH	investigation	moderate flow	Bulb Burned	"ERR"			0.50		0
11/15/2012	AT,JS	TL-7	MH	investigation	moderate flow	Bulb Burned	0.26					0
11/15/2012	AT,JS	TL-6	MH	investigation	moderate flow	1.44	"ERR"			0.10		2
11/15/2012	AT,JS	27	outfall	investigation	stagnant	0.23						900
11/15/2012	AT,JS	24	outfall	investigation	flow	2.47						0
11/15/2012	AT,JS	24.CBA	CB	investigation	trickle	2.38						0
11/15/2012	AT,JS	24.CBB	CB	investigation	trickle	2.33						0
11/15/2012	AT,JS	24.CBD	CB	investigation	stagnant	0.25						N/A
11/15/2012	AT,JS	26.CBB	CB	investigation	submerged	2.74						0
11/15/2012	AT,JS	26.CBC	CB	investigation	slow trickle from 26.P	1.56						
11/15/2012	AT,JS	26.CBD	CB	investigation	stagnant	1.09						0
11/15/2012	AT,JS	26.CBE	CB	investigation	stagnant	0.15						
11/15/2012	AT,JS	26.P	Pipe In	investigation	slow trickle into 26.CB	2.58	0.1			0.10		0
11/15/2012	AT,JS	26.MB	MH	investigation	pooled water	N/A						

APPENDIX 4

Investigations Summary Log

St. Albans IDDE Study
Investigation Log Summary (as of 12-13-12)

WATERSHED CONSULTING ASSOCIATES, LLC

Key:		**Follow-Up Priority Ranking**
(blue)	Priority Sites	HIGH (red)
(black outline)	Confirmed Source	MED (orange)
OBM :Optical Brightener Test		LOW (yellow)

City of St. Albans

ID	Recommended Follow-up Priority Ranking	2007 Survey Hits for Illicit Discharge	ID Source (s)	Follow-up Completed	Recommended Action	Discussion
24 (Maple Pro Industries, Lemnah Dr.)	HIGH		Residual CLEANING SOLVENT Dumping/ GW Contamination	Sampled all CB's in system, follow-up sampling June-Nov, Vac'ed CB's	*Follow up sampling of ammonia and retest for phosphorus at outfall	**June* : Elevated Ammonia, Phosphorus indicative of residual from dumping of cleaning solvent in loading dock CB **November:* Elevated Ammonia at outfall, not at Loading dock indicative of posbile GW contamination and/or flush of recent illicit discharge of solvent (test for phosphorus for confirmation)
26 (Blooming Minds Day-care, Lemnah Dr.)	HIGH		WASTE water/ Animal Waste/ GW Contamination	Vac'ed CB's, Dyed sewer at Blooming minds (no hit), investigated all CB's	Camera pipe into 26.CBC for unmapped junction under parking lot	***26.CBB:** High E.coli and Ammonia hits on 6/21 indicative of wastewater, however, on 11/15 high ammonia but E.coli of 0 cfu/100ml suggest the E.coli on 6/21 may have been from animal waste that entered CB. *Dyed 26.MH but didn't see dye in 26.CBC, indicating there may be a junction under pavement south of Blooming Minds. Pipe inlet to 26.CBC from under parking lot had trickle with elevated ammonia, no E.coli. Need to conduct follow-up sampling.
27 (South/West side-Lower Welden St.)	HIGH	B011	Residual WASTE water/ Source of (P)	Vac'ed CB's, Sampled CB's at intersection of Lower Welden/S. Elm St.	Review history of CSO's and conduct sampling after future CSO's	*Residual contamination from combined sewer overflows (CSO's). *Large drainage area and elevated phosphorus at outfall (0.22 mg/l) results in substanial estimated phosphorus loading (**6.27lb/yr**). *Long-tem solution would be to reduce occurance of CSO's by alleviating sewer system (ie. divert stormwater from the sewer system through implementation of stormwater BMP's).
34 (LaSalle St.)	HIGH		WASTE water/ Source of (P)	Camera'ed up line along Lake St. at Lake/N.Elm for possible laterals, Worked up pipe	Camera stormline on N. Elm starting at 34.MB toward Lake St. for cracks/laterals, Vac CB's along N. Elm St.	Steady flow and elevated phosphorus at outfall (0.18mg/L) results in a substantial estimated phosphorus loading **(4.5lb/yr).** Bracketted possible source for elevated phosphorus and ammonia between Lake St. and LaSalle (no flow from Spruce St). Sample at storm manhole (34.MB) between Lake and Lasalle was indicative of a low hit for wastewater.
37 (Westside-Pearl St.	HIGH		Non-Point Source (P)		Vac CB's within drainage area, work up pipe	Large drainage area and steady flow with phosphorus in sample at outfall (0.03 mg/l) resulted in a significant estimated phosphorus loading **(8.3 lb/yr).**
TL-1 (just up pipe from WWTP)	HIGH		WASTEwater/ Animal Waste/ GW contamination	Dyed sewer line starting at Briar Wood Trailer park (no hits in storm trunkline). Sampled manholes along trunkline.	Follow-up sampling of storm manholes from diversion structure to Lower Welden St., Vac CB located in grass area up trunkline from Lower Welden st.	Sample at end of trunkline (TL-1) had elevated phosphorus (1.6 mg/l), ammonia, fluoride, detergents, and conductivity suggesting possible wastewater discharge to the trunkline. Storm manholes from LaSalle to the diversion structure were sampled. All had elevated ammonia, detergents, and E.coli ranging from 92 to TNTC cfu/100ml. E.coli samples on 11/15 were all 0 cfu/100ml (past rain could have flushed out E.coli resulting in lower counts).
43A (Rewes Dr.)	MED		CAR Wash runoff, PET Waste, WASTEwater	Dyed sewer at St.Albans Messenger, Camera'ed line, Deployed OBM (no hit)	Clean out pipeline (up from outfall), install signage ("Do Not Dispose of Pet Waste"), Talk to Car Wash owners	Intermittant flow, sediment build up in outlet of outfall pipe. Found three pet waste bags dropped near outfall which may have contributed to high E.coli count in sample. Elevated ammonia in CB just at base of hill from Car Wash indicates possible disharge from car wash activities.

City of St. Albans Continued						
Outfall	**Recommended Follow-up Priority Ranking**	**2007 Survey Hits for Illicit Discharge**	**ID Source (s)**	**Follow-up Completed**	**Recommended Action**	**Discussion**
16 (Northside-Main St./ Upper Welden)		B19a	Non-Point source	No flow in three CB's directly up pipe at time of visit	large area-continue to work up pipe, redeploy OBM	High conductivity and presence of fluoride and detergents indicate non-point source pollution (road salt, possible break in WW line farther up in system)
14 (Lincoln Ave.)		B017	Non-Point Source/ City Water		Re-sample for ammonia and fluoride, redeploy OBM	Positive hit of optical brighteners in 2007 made this outfall suspect. Discharge from this study only had a hit for fluoride, so it could be due to a minor city waterline leak. All other indicators were low.
11 (Barlow St.)		B027	GW infiltration, CAR Wash runoff	Camera'ed line, dyed sewer of adjacent home, investigated basement	Monitor outfall for detergents	*Presence of detergents and ammonia suggest infiltration from lawn in front of home on Barlow St. *Pipe appears to be an underdrain for the bank that was installed when the bank was extended toward the stream
26.2 (Cul-de-sac off Lower Welden St.)			WASH Water	No flow on 8/27 (no E.coli sample)	intermittent, check area for other sources	Open drainage (no pipe), possible washwater from homes (high flouride, detectable detergents)
29 (North/ Eastside-Lower Weldon)			Non-Point Source		Vac CB's, work up pipe, look for car washing/laundry discharge	Hits for detergents from possible car washig activities and/or possible sump pump discharge, Hit for conductivty from road salt.
29.1 (Homeland Security lot underdrain)			ROAD SALT/ Runoff	No flow on 8/27 (no E.coli sample)	*Recommend reduction of salt usage given direct discharge to stream	Homeland Security parking lot underdrain: Hit for detergents and conductivity (3000 us/cm) indicative of possible car washing activities and road salt application
46 (North of Lake St.)		B003	WASH water		Deploy OBM	Possible floor drain of Beverage Mart on Lake Street. Not flowing at the time of investigation. Positive OBM hit during 2007 Survey. Deploy OBM in dry weather.
39.2 (Past crossing of Aldis St.)			Non-Point Source		Investigate drainage area for possible washwater source	Intermittant open drainage. Hit for E.coli suggestive of animal waste source. Low hits for flouride and conductivity indicate non-point source pollution.
38 (Aldis St.)			Non-Point Source/ NATURAL		work up pipe	Low hits for ammonia and detergents indicates possible dilution of non-point source pollution and/or natural source pollution
39.1 (North of Aldis St.)			Non-Point Source/ NATURAL		work up pipe	Low hits for ammonia and conductivty indicates possible dilution of non-point source pollution and or natural source pollution
40 (Four Wind Apts)			Non-Point Source/ NATURAL		work up pipe	Low hits for ammonia and conductivty indicates possible dilution of non-point source pollution and or natural source pollution
15 (Southside-Main St./Upper Welden)			Non Point Source (P), Groundwater	False Positive hit on OBM	Redeploy OBM	False positive OBM hits, high level of Potassium (18 ppm) and phosphorus was above allowable limit (0.12 mg/L) suggesting the source of flow could be groundwater with non-point sources of potassium and phosporus from fertilizers used further up in the drainge system.
18 (S. Main St. from South)	Not Illicit		Non-Point Source(base flow with roadway/ag runoff	Worked up pipe: Slight flow in all CB's along S Main St.	Work top-down along stormline (start at top of hill-Parson Ave/S.Main)	Long stormline of CB's with several foundation drains, and large grass field at top of hill up the line from outfall that could supply baseflow with minor amount of non-point pollution from agriculture runoff

Town of St. Albans						
ID	**Recommended Follow-up Priority Ranking**	**2007 Survey Hits for Illicit Discharge**	**ID Source (s)**	**Follow-up Completed**	**Recommended Action**	**Discussion**
T16 (Behind Hannaford's Store)			WASHwater/ GARBAGE COMPACTOR SPILLAGE	Follow up E.coli sampling at outfall and stream, investigated CB's up pipe, dyed sewer in Hannaford (no hit)	Vac loading dock CB, investigate undocumented pipe (possible floor drain), educate about stopping spillage from compactor	High hits for E.coli, ammonia, fluoride, detergents, conductivity, and phosphorus indicate that there is a point-source discharge entering the drainage system. There was evidence of a stream of spillage from the trach compactor, which may be the cause of the high E.coli (disposed meat). A small pipe could be seen in the CB at the loading dock, which could be a floor drain from inside the store. The Town will speak with the Owners about this issue.
T123 (Highgate Shopping Plaza by TD Bank)			ROAD SALT Runoff/ WASH Water	Follow-up sampling, deployed OBM (no hits-interference from heavy rainfall while deployed)	Repair outfall pipe, Vac CB's in parking lot, possible floor drain connection from Thai House restaurant	Highgate Shopping Center; road salt and sediment build up in CB's throughout parking area. Presence of detergents and fluoride indicate there may be a floor drain connection from Thai House. Its recommended that the outfall be monitored for possible discharges.
T149C (Industrial Park Rd.)			ROAD SALT /Industrical Activity Discharge	Worked up pipe-loading dock CB appears to be connected to outfall	Vac loading dock CB (possible residual salt), Investigate pipe into Loading dock CB	*Trickle from 15" HDPE, high conductivity (HDPE pipe in Loading dock CB same type as outfall 149C). *High Conductivity indicative of residual road salt in CB at loading dock, or industrial activity discharge into CB.
T124 (Highgate Shopping Plaza near KFC)			ROAD SALT Runoff		Vac CB's along drainage line, work up pipe to identify if there are any point-source disharges	Low hits for ammonia, fluoride, and detergents and a very high conductivity (3000 us/cm), suggest that this discharge may be the result of groundwaterilfiltration into the stormline, contaminated by residual road salt and non-poiint source pollution in parking lot catch basins.
T149B (Industrial Park Rd.)	Not Illicit		Roof/ Foundation Drain Runoff		Investigate if outfall pipe is roof or foundation drain	Appears to be a roof or foundation drain (couldn't' see where outfall pipe connects).
T149A (Industrial Park Rd.)	Not Illicit		NATURAL SOURCE E.COLI			Outfall connected to open ditch along Industrial Park Rd. Trickle at oufall. Open channel offers easy access for animals (suggested source of E.coli in sample).

Town of St. Albans Continued						
T149C (Industrial Park Rd.)			ROAD SALT /Industrical Activity Discharge	Worked up pipe-loading dock CB appears to be connected to outfall	Vac loading dock CB (possible residual salt), Investigate pipe into Loading dock CB	*Trickle from 15" HDPE, high conductivity (HDPE pipe in Loading dock CB same type as outfall 149C). *High Conductivity indicative of residual road salt in CB at loading dock, or industrial activity discharge into CB.
T124 (Highgate Shopping Plaza near KFC)			ROAD SALT Runoff		Vac CB's along drainage line, work up pipe to identify if there are any point-source disharges	Low hits for ammonia, fluoride, and detergents and a very high conductivity (3000 us/cm), suggest that this discharge may be the result of groundwaterilfiltration into the stormline, contaminated by residual road salt and non-poiint source pollution in parking lot catch basins.
T149B (Industrial Park Rd.)	Not Illicit		Roof/ Foundation Drain Runoff		Investigate if outfall pipe is roof or foundation drain	Appears to be a roof or foundation drain (couldn't' see where outfall pipe connects).
T149A (Industrial Park Rd.)	Not Illicit		NATURAL SOURCE E.COLI			Outfall connected to open ditch along Industrial Park Rd. Trickle at oufall. Open channel offers easy access for animals (suggested source of E.coli in sample).

APPENDIX 5

Problem Site Investigation Figures

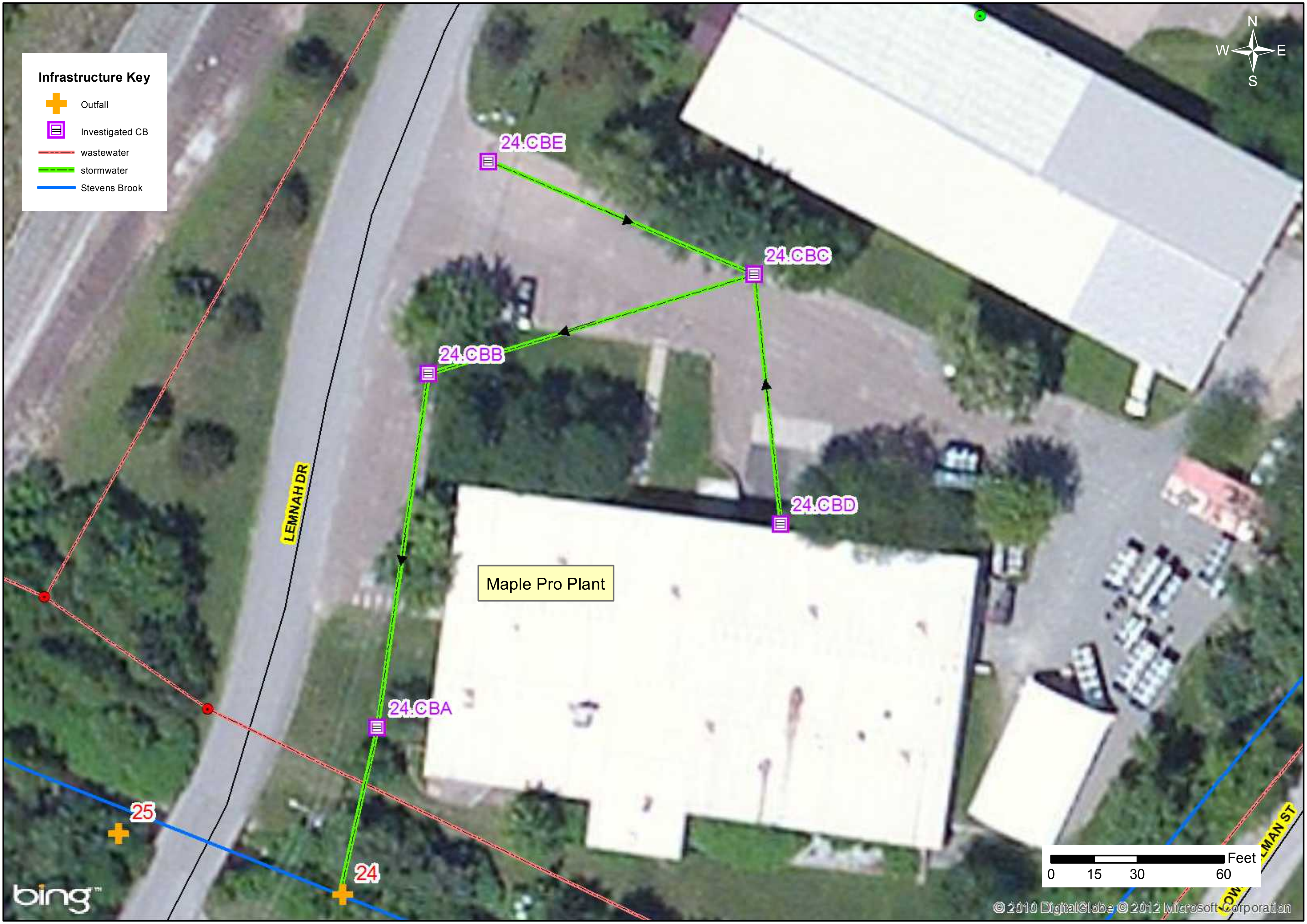

Figure 5-1: Problem Site Investigation for Outfall 24

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

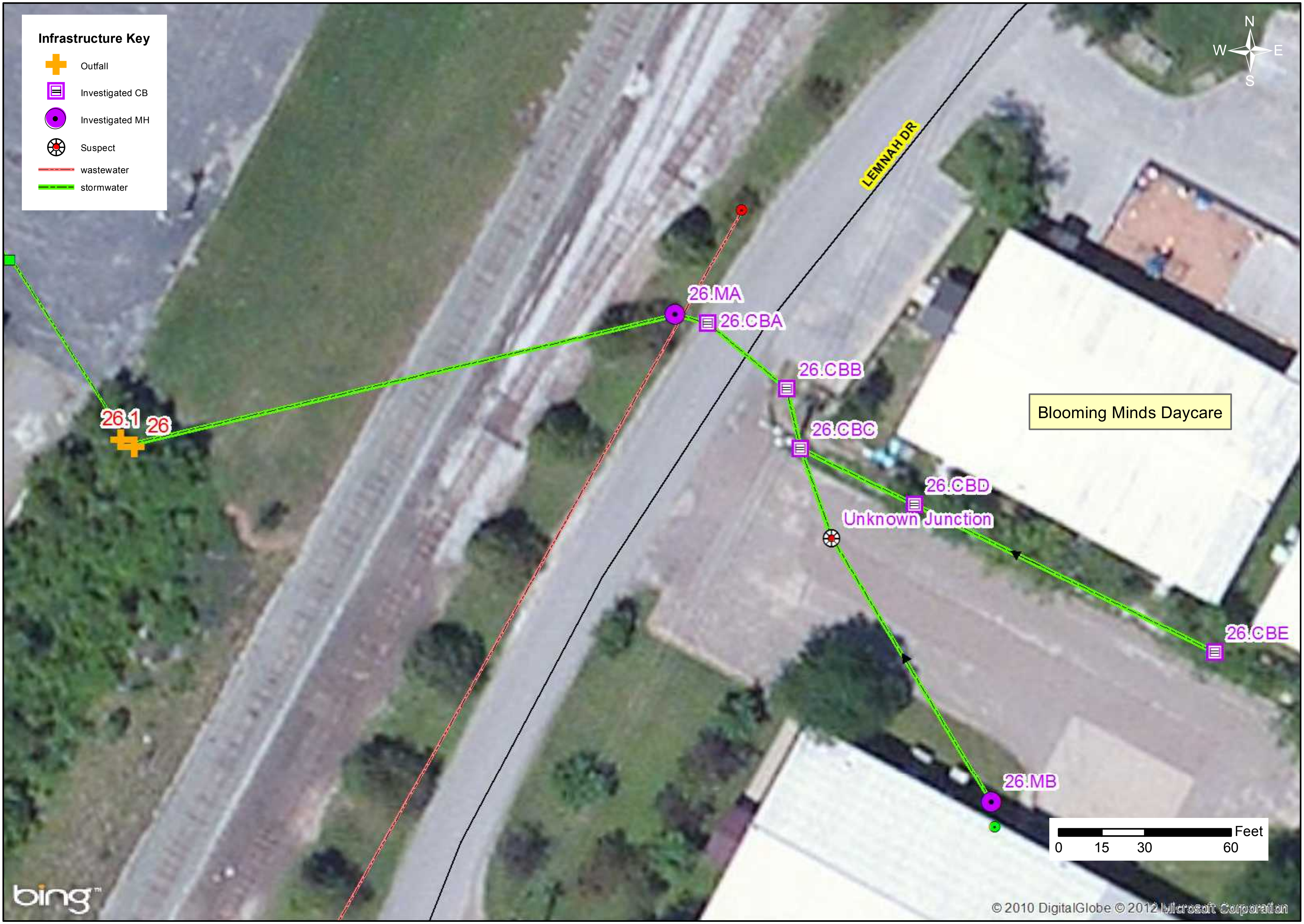

Figure 5-2: Problem Site Investigation for Outfall 26

WATERSHED CONSULTING ASSOCIATES, LLC

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

Figure 5-3: Problem Site Investigation for Outfall 27

Watershed Consulting Associates, LLC

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

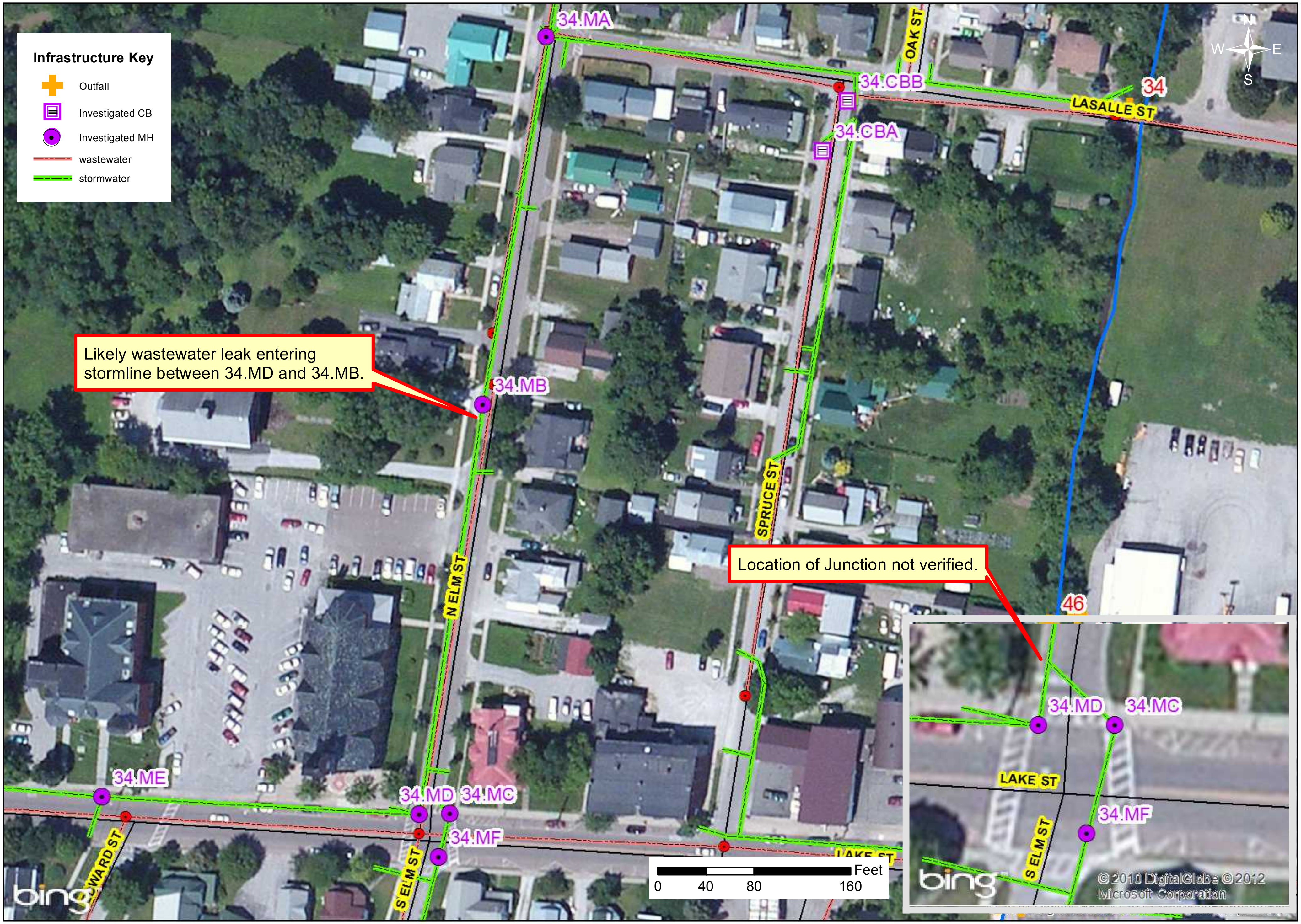

Figure 5-4: Problem Site Investigation for Outfall 34

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

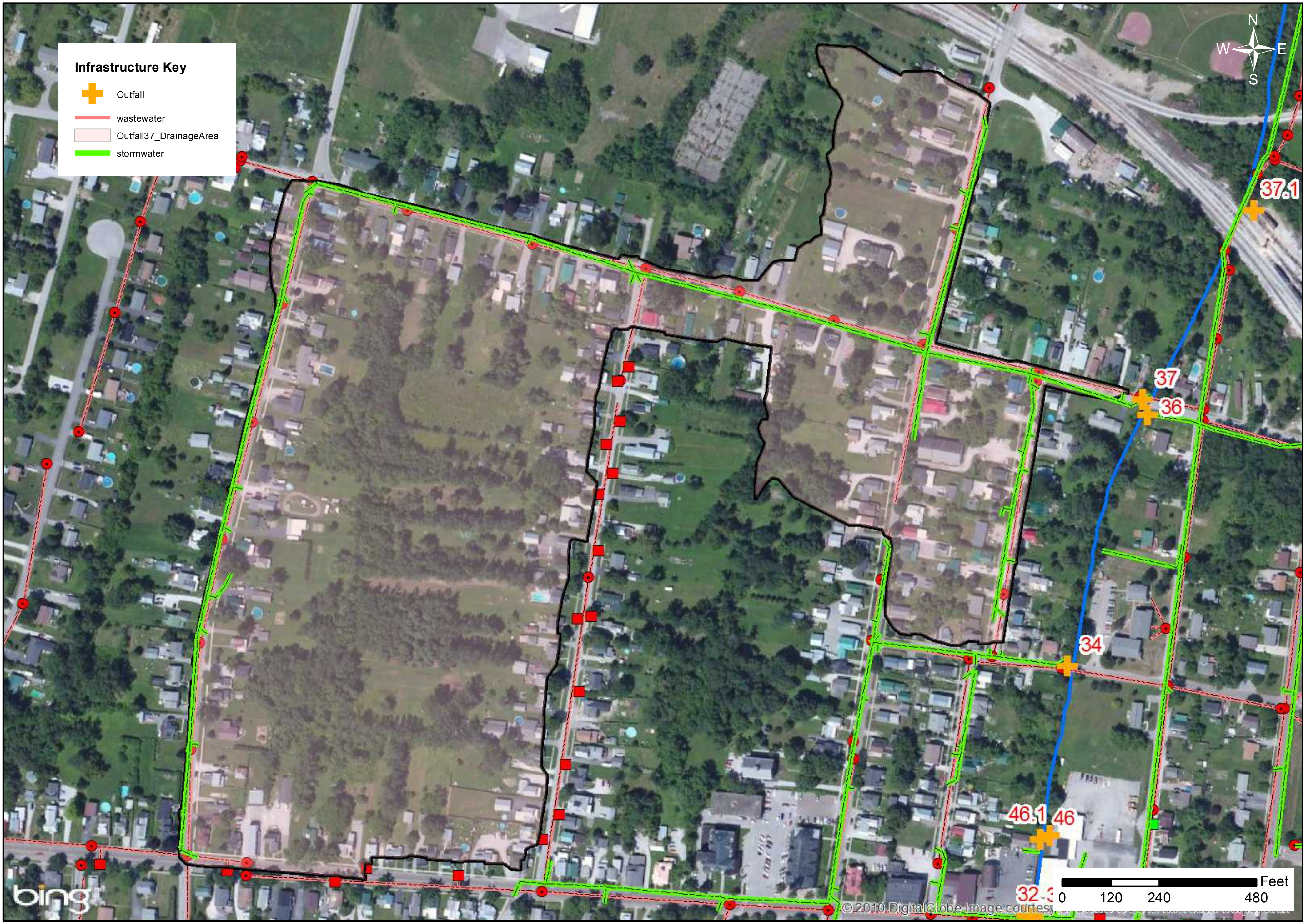

Figure 5-5: Drainage Area for Outfall 37

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

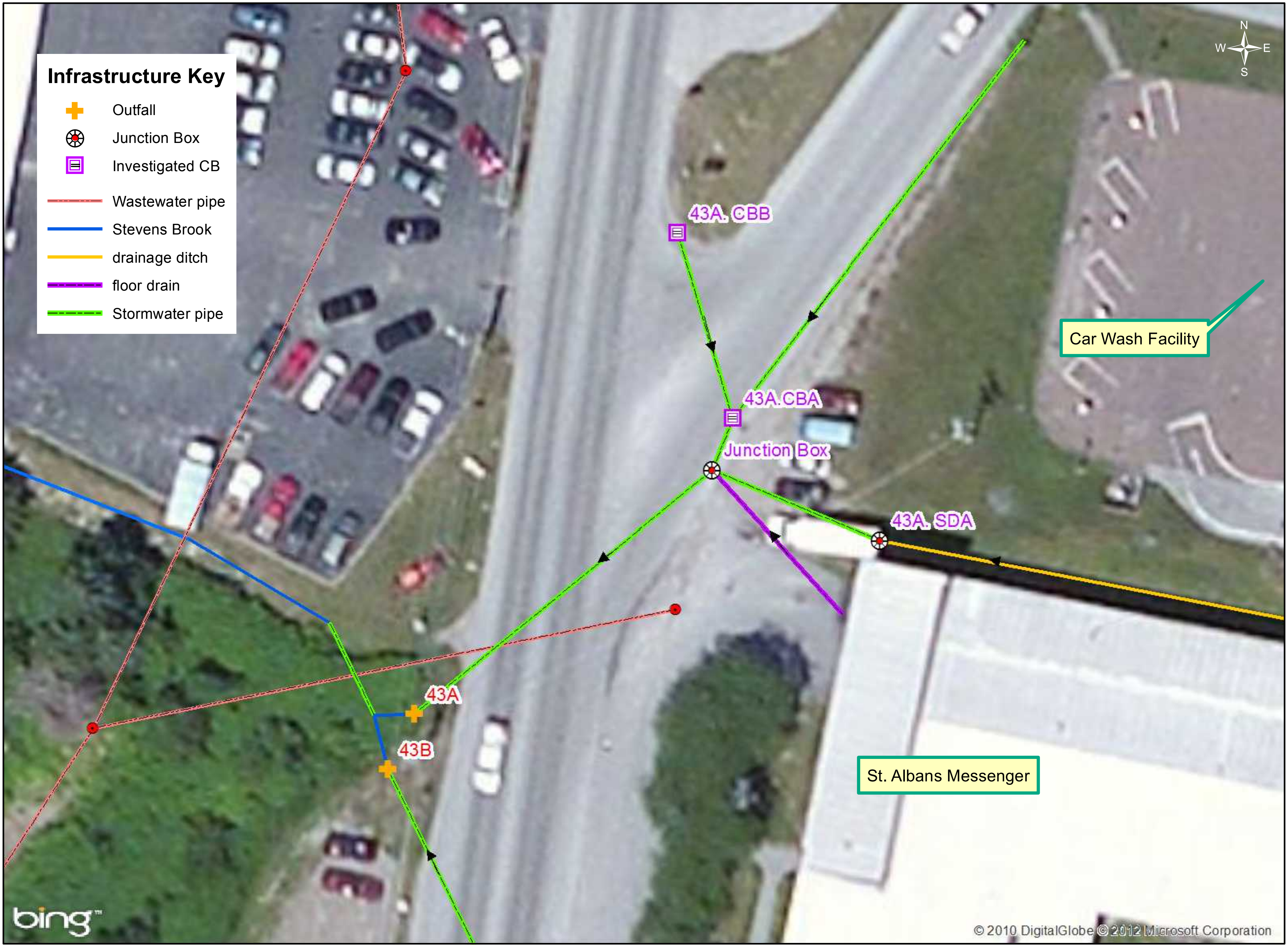

Figure 5-6: Drainage Area for Outfall 43A

Infrastructure data provided by ANR, FAA, and WCA, 2009. Revisions to infrastructure completed by WCA, 2012.

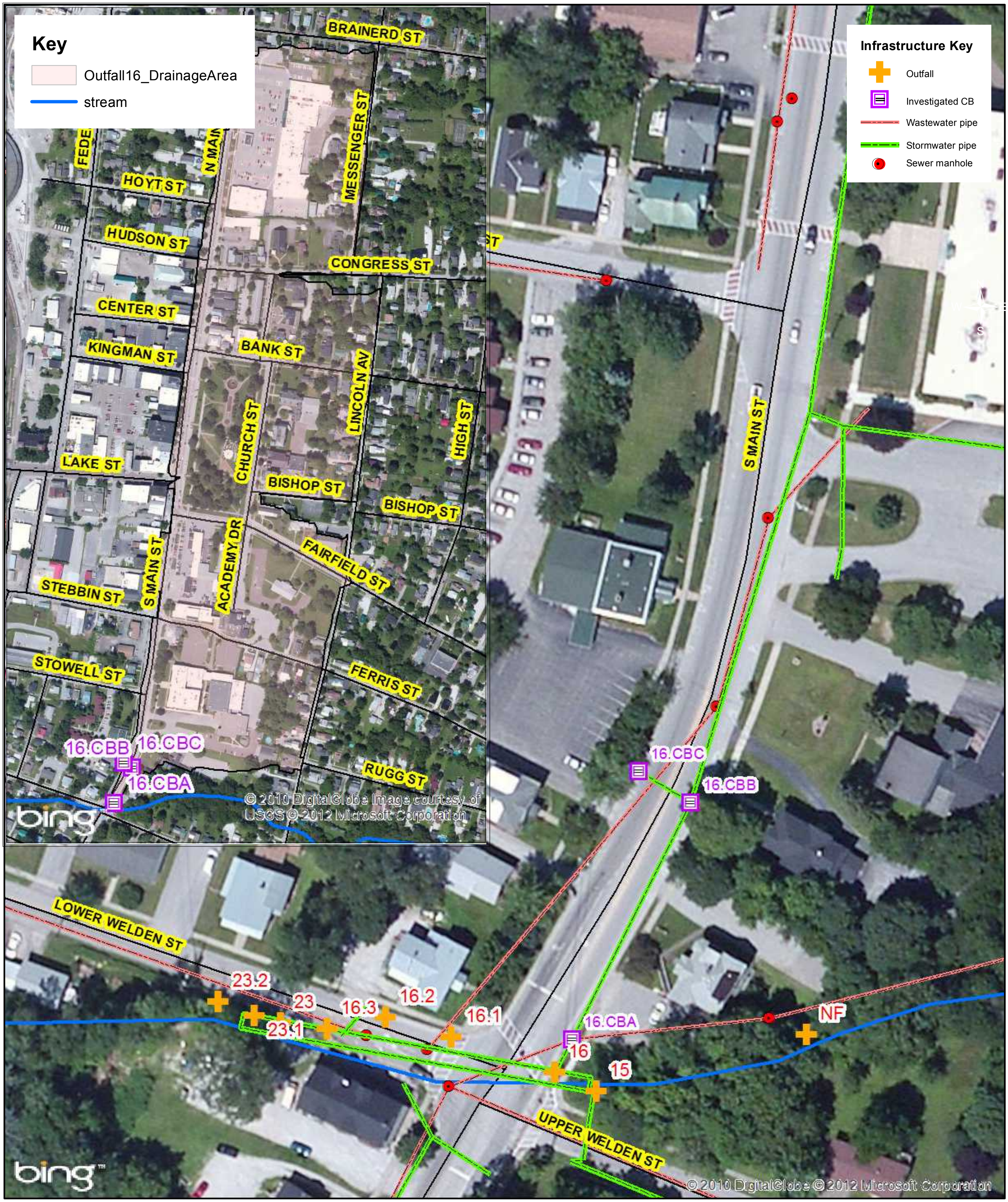

Figure 5-7: Problem Site Investigation for Outfall 16

WATERSHED CONSULTING ASSOCIATES, LLC

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

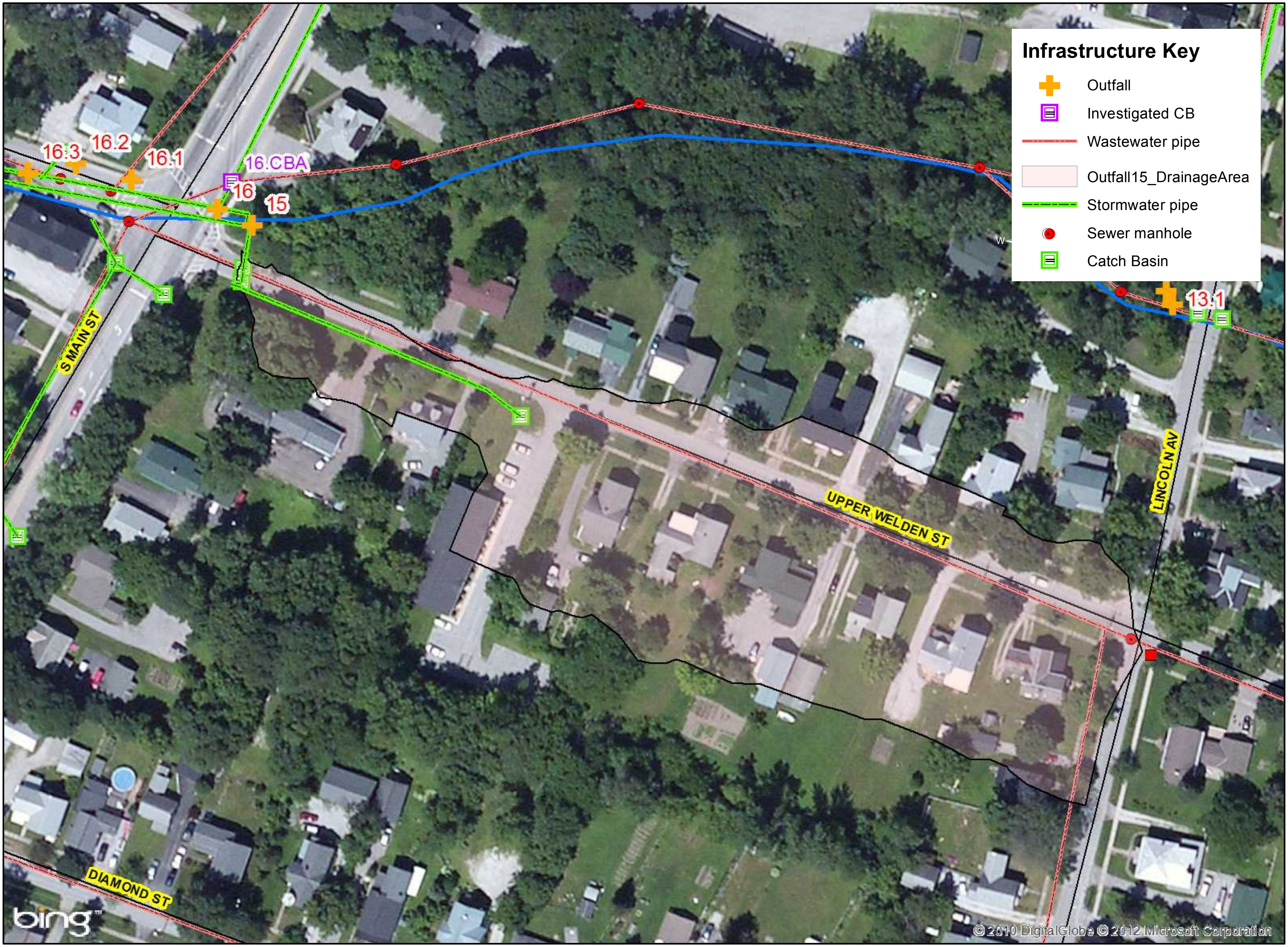

Figure 5-8: Drainage Area for Outfall 15

Watershed Consulting Associates, LLC

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

Figure 5-9: Drainage Area for Outfall 11

WATERSHED CONSULTING ASSOCIATES, LLC

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

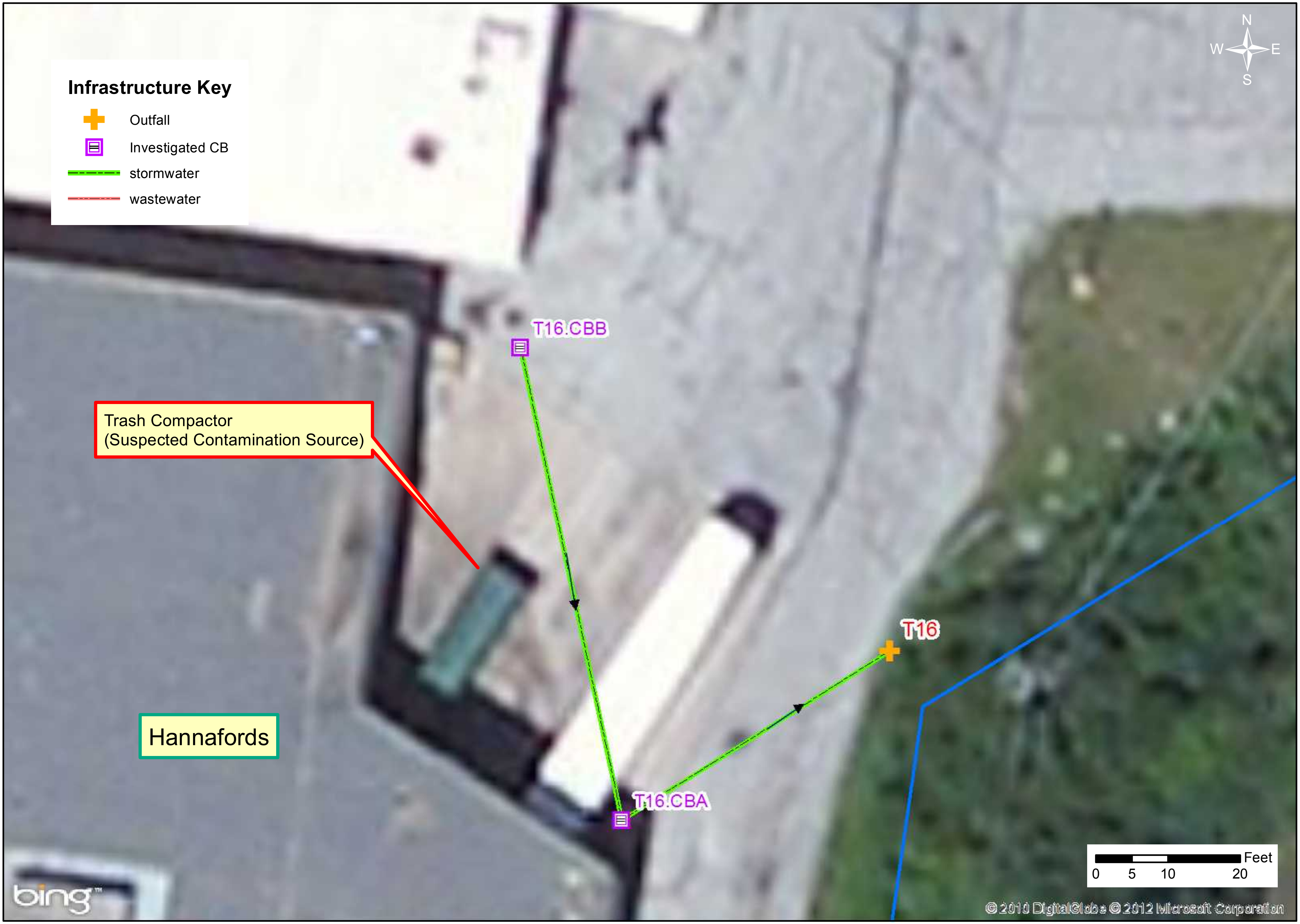

Figure 5-10: Problem Site Investigation for Outfall T16

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

Figure 5-11: Problem Site Investigation for Outfall T123

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

Figure 5-12: Problem Site Investigation for Outfall T149C

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.

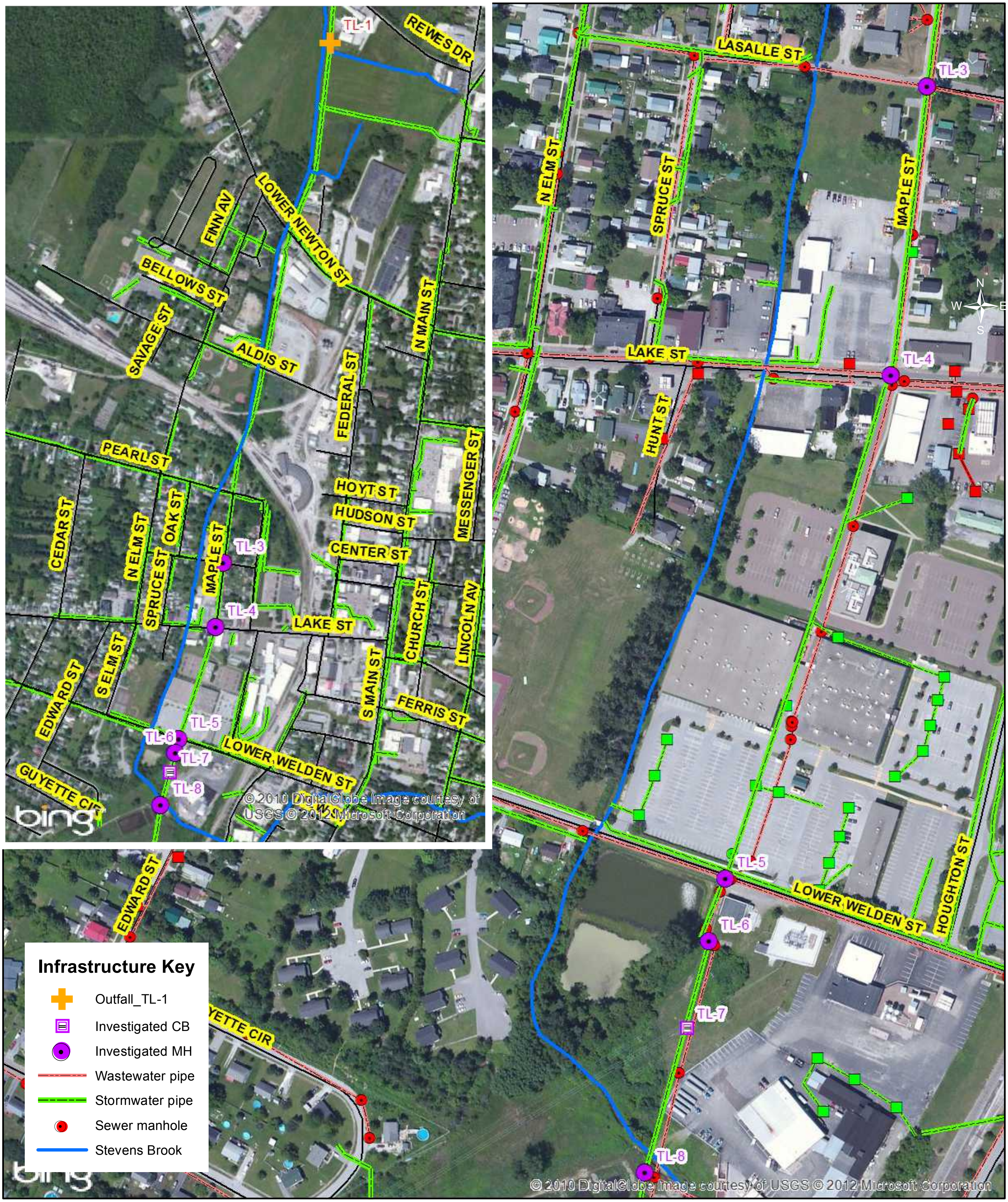

Figure 5-13: Problem Site Investigation of Trunk line

WATERSHED CONSULTING ASSOCIATES, LLC

Infrastructure data provided by ANR, FAA, and WCA, 2009.
Revisions to infrastructure completed by WCA, 2012.