Greenville, New Hampshire

Illicit Discharge Detection & Elimination (IDDE) Investigation

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&

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1. Introduction

Greenville is a small, southern New Hampshire town with a beautiful downtown area featuring historic mill buildings situated along the Souhegan River (Figure 1). The land surface in the downtown area, near the Main Street Bridge, consists primarily of pavement and rooftops and is highly impervious. As a result, rainfall runs off downtown area surfaces rather than infiltrating into the soil. Greenville has a storm drain network that routes stormwater runoff from streets and rooftops through a set of catch basins, swales, and pipes and into the Souhegan River. This report described an illicit discharge detection study and does not include illicit discharge elimination. This report provides: (1) a description of a set of tools that has been successfully applied to conduct illicit discharge detection and elimination (IDDE) investigations (with a focus on detection) and (2) references to additional resources available to stakeholders and practitioners.

Figure 1: Aerial view of downtown Greenville, NH.

1.1. Statement of Problem

Routine monitoring conducted by the New Hampshire Department of Environmental Services (NHDES) found elevated levels of indicator bacteria in two of Greenville's storm drain outfalls. The indicator bacterium, *Escherichia coli* (*E. coli*), is used as an indicator organism because it is easily cultured and its presence in water in defined amounts indicates that sewage may be present. If sewage is present in water, pathogenic or disease-causing organisms may also be present. The presence of elevated levels of indicator bacteria in Greenville storm drain outfalls represents a potential threat to human health.

A reach of the Souhegan River immediately downstream of the Main Street bridge is on the 303(d) list of impaired waters requiring a total maximum daily load to support removal of impairment. A Statewide Bacteria TMDL has been developed for New Hampshire (NHDES 2010) and includes this impaired reach. The Souhegen reach in Greenville is assessment unit NHIMP7000609020-10 and is listed for failing to support the Designated Use of Primary Contact Recreation. The suspected source of impairment has been identified as illicit connections to the Municipal Separate Storm Sewer System (MS4). This Greenville stormdrain investigation report represents an important part of the process of removing bacteria impairment from the Souhegan River.

E. coli bacteria was measured in storm drain outfalls SGR 1825 and SGR 1840 at levels above the water quality standard of 406 counts/100ml during field surveys conducted from 2005 and 2007. These outfalls are situated immediately to the west and east of the Main Street Bridge, as shown in the photographs of Figure 2. These photographs were taken facing north and looking down Main Street. Figure 3 provides a map of the stormwater network that drains to outfalls SGR 1825 and SGR 1840. Elevated *E. coli* measurements obtained by NHDES in 2005 and 2007 at these outfalls include:

- June 23, 2005 at SGR-1825: greater than 2,000 cts/100ml
- July 6, 2005 at SGR-1840: 3,300 cts/100ml

Figure 2: Storm drain outfalls SGR 1825 (left) and SGR 1840 (right) and the Main Street Bridge

The complete set of NHDES bacteria sampling results for the 2005-2007 time period is provided in Appendix A. The presence of elevated bacteria in the Greenville storm drains is likely indicative of illicit (i.e., unlawful) sewage sources. The goal of this project was to develop an understanding of the storm drain network and to identify and remove bacteria sources.

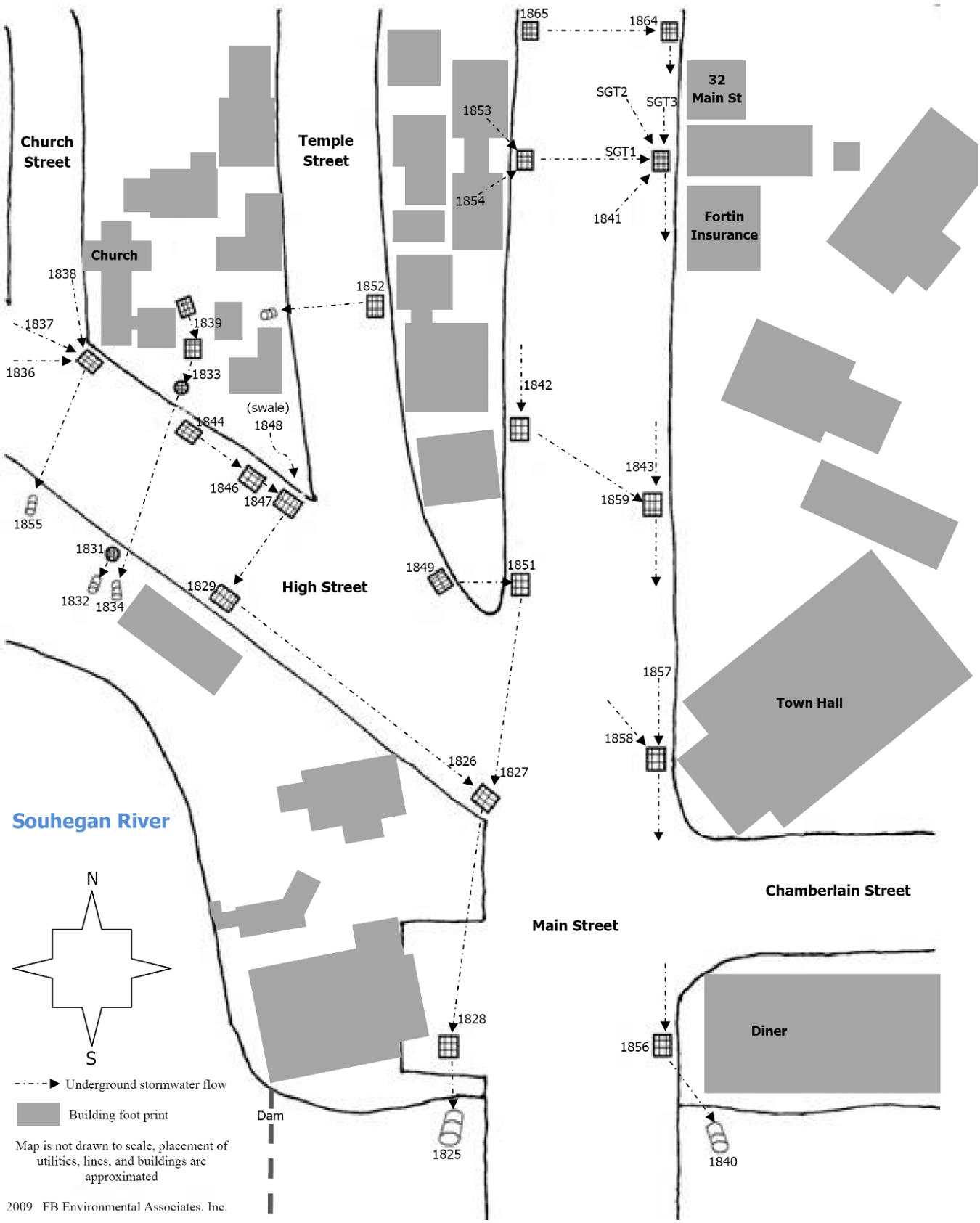


Figure 3: Map of the stormwater network that drains to outfalls SGR 1825 and SGR 1840.

The approach applied in conducting this investigation was to begin at the outfall, where the presence of excess bacteria was known to exist, and to work upgradient in the system to identify and isolate source(s) of bacteria. Locating illicit wastewater discharges is often challenging, given that they can occur out of sight, in confined areas, and may involve unmapped infrastructure. However, there are several tools and methods that can help narrow in on—and ultimately pinpoint—these unseen sources of water quality pollution. Several investigative tools were selected and applied, as described below (with relevant sections indicated parenthetically).

- Storm drain network reconnaissance, inventory and mapping (Section 2);
- Bracket sampling; bacteria sampling to bracket bacteria source locations (Section 2);
- Optical brightener surveys (Section 3);
- Television surveys (Section 4); and
- Research and consultation with Department of Public Works and Sewer & Water Department personnel.

A discussion of results and a set of recommendations are provided in Section 5. It is hoped that others will find this report useful as an example of the methods and work involved with identifying illicit connections.

2. Bracket Sampling for Bacteria Sources

Bracketed bacteria sampling is conducted to locate the source(s) of bacteria entering a storm drain and is conducted by sampling upgradient and downgradient of potential sources to “bracket” (or isolate) pollutant source locations. Bracket testing can help determine the geographic extent of illicit discharge problems. Testing may also reveal that elevated bacteria levels are spread throughout a stormwater system. Although this situation may seem to frustrate the immediate goal of pinpointing a single location, it is useful in determining the geographic scope of the problem, and avoiding too narrow a focus.

Ambient bacteria data are collected during both wet and dry conditions to estimate the bacteria levels from all contributing sources because many sources of bacteria are diffuse and intermittent (rather than flowing from an identifiable pipe on a regular basis). High levels of bacteria during dry conditions indicate the presence of direct wastewater discharges, or contamination from groundwater leachate (from agriculture, leaking sewer pipes, illicit connections to stormdrains), from recreational activities (swimmers and boaters), or from wildlife (including birds). High levels of bacteria during wet conditions (rainfall) indicate contamination from wildlife and domesticated animals (including pets), stormwater runoff (including municipal separate storm systems or MS4s), or discharges from combined sewer overflows (CSOs).

Storm drain system reconnaissance and mapping was conducted prior to bracket sampling. Reconnaissance and mapping served to develop an understanding of storm drain connectivity and to identify potential sources to address during the bracket sampling surveys. A set of reconnaissance and bracketed bacteria sampling surveys was conducted in the Greenville storm drain network in 2008. A chronology of these surveys is provided below:

1. April 4 – Greenville stormdrain reconnaissance survey (day 1)
2. April 10 – Greenville stormdrain reconnaissance survey (day 2)
3. May 8 – Stakeholder meeting and Greenville storm drain tour
4. May 14 – Greenville stormdrain network connectivity and bacteria sampling survey #1
5. June 16 – Bacteria sampling survey #2
6. June 17 - Bacteria sampling survey #3
7. July 1 – Bacteria sampling survey #4
8. July 8 – Bacteria sampling survey #5

A description of these surveys is described below.

2.1. Storm Drain System Reconnaissance and Mapping

Storm drain reconnaissance and mapping was conducted by lifting drain covers and catch basin grates and observing the pipes connected to each junction. The survey was conducted beginning at the outfall on the Souhegan River and moving upgradient. At each junction, a sketch was made and a detailed description of pipe size, material, and flow amount and direction was logged. The outfall end of each pipe was given an identification number (e.g., SGR-1843) and its location recorded using a geographical positions system (GPS) unit. Moving up the system, a map of the storm drain system was completed. Figure 4 provides photographs taking during a storm drain mapping survey. Storm drain system mapping was conducted by Steve Landry and Jeff Marcoux of NHDES and Ken Hickey of FB Environmental Associates.

Figure 3 above provides a map of the town center with drainage patterns and sampling locations indicated. This figure is based on the storm drain mapping surveys and provided sampling locations to support the bracketed bacteria sampling surveys.

Figure 4: Storm drain mapping photos.

2.2. Bacteria Sampling Results

A set of sampling locations was identified to support the goal of bracketing the location of bacteria sources. Ideally, sampling would be conducted upgradient and downgradient of each potential source. In this manner, the bacteria sampling results will provide insights to the location of sources. Historic (2005-2007) bacteria data were also considered in designing the 2008 sampling program.

A total of five sampling surveys were conducted and the results are presented in Table 1. All samples were delivered to the NHDES Laboratory Services Unit in Concord and were analyzed following the DES outfall sampling standard operating procedures. The cost per sample analyzed for *E. coli* bacteria was

$20. Figure 5 provides a rainfall record for the summer of 2008 with sampling dates indicated to place the results in context relative to weather conditions. The sampling location identification numbers in the map correspond to the ID numbers in the table (the "SGR" prefix was excluded in the map). Review of Greenville field sampling data yield the following observations:

- Exceedances of the bacteria water quality standard (*E.* coli >406 cts/100 ml) were found throughout the study area;
- 5 out of 6 sites sampled on June 17 exceeded bacteria water quality standards, the maximum was >20,000 cts/100 ml and was measured in 3 of the 5 locations. These highest bacteria counts occurred after a large rainfall event (0.65" in previous 4 days) in samples taken from both High Street and Main Street locations; and
- Bacteria counts tended to increase during wet weather conditions.

The bracketed bacteria sampling program identified sources along Main Street and along High Street for further evaluation.

Table 1: 2008 bacteria data summary.

Sampling Location	Description	*E. Coli Analysis Results (counts/100 ml)* *Date of Sampling Event (2008)*				
		May 14	**June 16**	**June 17**	**July 1**	**July 8**
Upper High St.						
SGR-1830	outfall	100	20			
High St.						
SGR-1837	Church St.	100				
SGR-1839	Church parking lot	100				
SGR-1826	High St.		520	>20,000		
SGR-1827	Temple St.	100	130	30		
SGR-1825	west outfall to Souhegan R.	100	200	>20,000	30	<10
Main St.						
SGR-1853	from Main St. apartment	50			<10	
SGR-1854	from Main St. apartment	100				
SGR-1842	Main St. west side	100				
SGR-1859	Main St. west to east		120	>20,000	10	
SGR-1843	Main St. Library		110	3,600	400	
SGR-1840	east outfall to Souhegan R.	1,000	400	1,900	100	20
Wet Weather Status:		**No**	**Yes**	**Yes**	**Yes**	**No**
rainfall in inches prior to sampling:						
24 hrs (>0.1")		**0**	**0.17+**	**0.48**	**0.19**	**0**
48 hrs (>0.25")		**0**	**0.17+**	**0.65**	**0.38**	**0**
96 hrs (>2.0")		**0**	**0.17+**	**0.65**	**0.71**	**0.13**

Water Quality Standard to Bacteria

E. coli bacteria is an indicator of bacteria pollution that can be harmful to human health. The New Hampshire water quality standards for E. coli (in freshwater Class B waters that are not designated beaches) are:

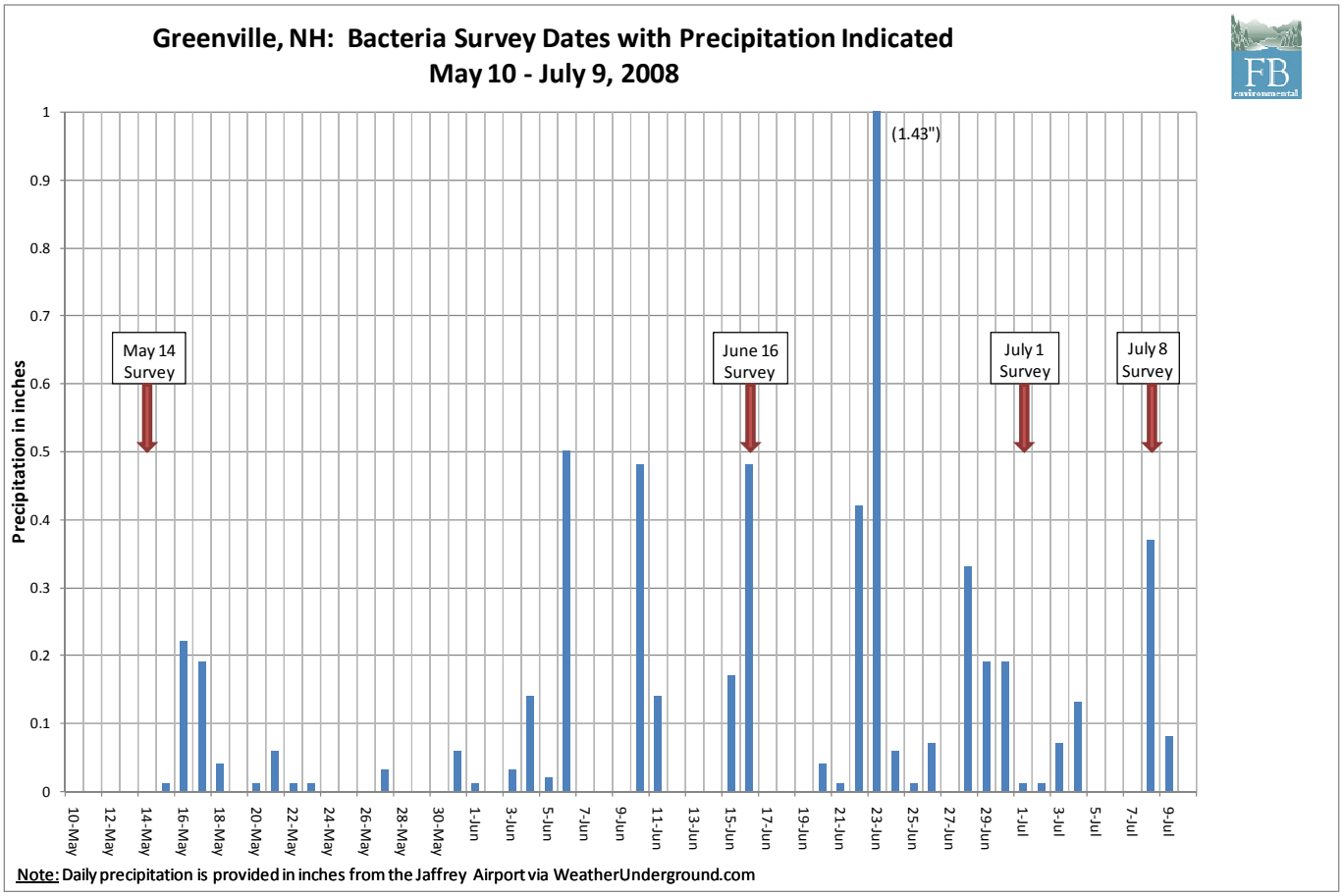
Maximum for a single sample: 406 counts/100 mL, unless naturally occurring

Maximum for a geometric mean: 126 counts/100mL, unless naturally occurring

Note 1: Weather data obtained from the Jaffrey Airport via WeatherUnderground.com. Jaffrey Airport is located approximately 10 miles from the Greenville study area.

Note 2: Red color is used to indicate exceedances of the single sample standard and orange is used to indicate an single measurement above the geometric mean standard.

Figure 5: Rainfall record for the summer of 2008 with sampling dates indicated.



3. Optical Brightener Surveys

Optical brighteners are chemicals that are added to most laundry detergents. Their presence in stormwater is often an indication that domestic wastewater is present. The method for detecting these chemicals is called an optical brightener (OB) monitoring trap, and is simple and inexpensive. An OBM trap consists of a swatch of untreated, unbleached cotton firmly fixed into the flow of a storm drain or stream using a small cage or PVC pipe and weights or monofilament (Figure 6). It can take several days for the cotton fibers to accumulate enough optical brighteners to be detected, so deployment times are typically 3 to 7 days. Once the swatch has been retrieved, a black light or a fluorometer is used to check for fluorescence.

Optical brighteners are easy to use, but they have a few drawbacks. Certain natural substances in the environment, such as humic and fulvic acids, can mimic the fluorescence of laundry detergent optical brighteners (Alhajjar et al. 1990). Furthermore, a black light is effective only when the there are very high concentrations of optical brighteners in the water, approximately equal to full strength effluent from a washing machine (Brown, et al., 2004). Optical brightener concentrations in septic tank effluent, however, do not visibly fluoresce, and require the use of a fluorometer (Hagedorn, et al. 2005). Analysis with a fluorometer is more expensive and is typically done by a trained technician.

Optical brighteners traps were deployed in the Greenville stormdrains to support identification of household waste sources. These sources are illicit and should not be connected to the storm drains. Household sources are also likely to include a sewage and harmful bacteria component and should be removed. Figure 6 provide photographs of the OB deployment process. OB pads were placed in netting and deployed using monofilament fishing line (30 lb) to anchor them into specified pipes. The end of the line was then tied to the storm drain cover to enable retrieval.

An OB survey conducted from September 12 to 19 found optical brighteners at location 1843, along Main Street upgradient of Town Hall (Figure 3). Sampling locations 1859, crossing Main Street did not have OB present in the sample. Also, locations 1854 and 1853, located on the other (western) side of Main Street were negative for OBs. The September OB survey findings suggest residential or commercial source(s) along the east side of Main Street upgradient of Town Hall (and sampling location 1843). The OB survey was successful in homing in on potential bacteria sources.

Figure 6: Optical brightener survey photos.

4. Video Survey

Closed-circuit TV systems mounted to manually fed cable on a small remote-controlled vehicle can be used to explore via video a storm drain network. As the vehicle is pushed or drawn through the storm drain system, lights illuminate the pipe walls, and the camera records all sides of the system either by use of a wide angle lens or by rotating. The entire system, including TV monitors, cables, camera, lights, and remote-controlled vehicle is usually contained in a single truck or van. The advantage to this method is that it is non-intrusive, avoiding the need to access homes and businesses. Systems are relatively expensive, but some public utilities or municipalities may already have appropriate equipment. Intermittent illicit discharges which are not flowing when the camera passes will probably be missed. (Brown, et al., 2004)

Two video surveys were conducted in the Greenville storm drain system. These surveys were made possible by Carla Mary (Woodard Curran), project manager of the Greenville Wastewater & Water Department and her staff. Carla Mary volunteered to conduct the video survey in support of this project. The video surveys were conducted during the fall of 2008. The first survey was conducted along High Street between sampling locations 1829 and 1826 (Figure 3). The second survey was conducted along Main Street upgradient of sampling location 1843. Figure 7 provides photographs of the video surveys.

Unfortunately, the video surveys were only partially successful due to technical difficulties in moving the camera through the pipes. Several minor observations such as cracks in the piping, accumulations of fungal matting, and turbid pools of water were made, but no pollution sources were found. A motorized or more sophisticated video transport vehicle would likely have greater success in pinpointing sources of illicit sanitary discharges within downtown Greenville.

Figure 7: Video survey photos.

5. Summary and Recommendations

The Greenville illicit discharge detection investigation resulted in identification of the east side of Main Street north of Town Hall as a pollution source area. Several buildings in that area, including 32 Main Street, should be tested for illicit connections. NHDES staff plan to re-visit Greenville stormdrain network in 2010 to conduct tests to support precise identification of Main Street pollution sources. These tests will likely include dye testing or smoke testing individual buildings to determine connectivity to the storm drain network. Each of these techniques is described briefly below.

Dye Testing

Introducing non-toxic dye into building waste pipes is a straightforward and inexpensive method of testing for illicit discharges. If the dye appears in a stormwater pipe or a stream, an illicit discharge is confirmed. Such testing should be carefully planned in order to obtain full benefit. Factors to consider include choice of dye, protocol for requesting access to homes and businesses, which fixtures to test, where and how to observe stormwater and/or surface waters, and whether or not a fluorometer will be used to detect the dye. This method typically requires a crew of two or three people, with one person observing the stormdrain outfall or stream and another observing the next down stream sewer manhole. A limited area of ten or fewer buildings at a time is ideal (Brown, et al., 2004).

Dye testing at 32 Main Street and several adjacent buildings along Main Street is recommended to pinpoint illicit connections in that area. Coordination with municipal sewer and water departments may be necessary to run surveillance within the target area to confirm illicit cross connections. Alerting fire and police prior to dye testing is also recommended in case calls are received from the public.

Smoke Tests

Smoke can be blown into a stormwater system using a smoke candle or “liquid smoke” and a blower to test for connectivity to wastewater systems. Adjacent manholes and catch basins are usually blocked using sandbags, inflatable balls, or stoppers. Observers look for smoke rising from plumbing or septic system vents, which would indicate a connection between the building’s plumbing and the storm drain network. Smoke may also be seen rising through cracks in pavement, roof drains, or foundations.

Smoke used is non-toxic, but extensive communication with residents and public safety officers, including fire and police departments, prior to conducing smoke tests is important. This method is potentially useful when access into buildings is not feasible, and when pipes are too small for video testing (Brown, et al., 2004). Smoke testing should be considered if dye testing in the study area is not successful.

6. References

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APPENDIX A: Greenville, NH Historical Bacteria Data

Stationid	Startdate	E. coli (cts/100ml)
SGR-1825	6/23/2005	>2000
SGR-1830	6/23/2005	20
SGR-1870	6/27/2005	TNTC
SGR-1890	6/27/2005	20
SGR-1825	7/6/2005	500
SGR-1840	7/6/2005	3300
SGR-1870	7/6/2005	80
SGR-1826	7/6/2005	TNTC
SGR-1827	7/6/2005	<10
SGR-1841	7/6/2005	70
SGR-1871	7/6/2005	20
SGR-1872	7/6/2005	<5
SGR-1873	7/6/2005	<10
SGR-1825	7/12/2005	40
SGR-1841	7/12/2005	9
SGR-1842	7/12/2005	<10
SGR-1843	7/12/2005	>5400
SGR-1825	8/4/2005	490
SGR-1845	8/4/2005	<10
SGR-1830	8/1/2007	130
SGR-1840	8/1/2007	>230
SGR-1843	8/15/2007	38000