City of Struthers Sanitary Sewer Flow Monitoring Study

City of Struthers, OH

Prepared for City of Struthers
by IBI Group
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1 Executive Summary

The City of Struthers owns and operates a wastewater treatment plant called the Struthers Water Pollution Control Facility located at 530 Lowellville Road, Struthers Ohio. The plant currently receives on average 4 to 6 MGD during dry weather. In addition to the plant, Struthers has an equalization tank with six (6) cells totaling 3.7 million gallons in capacity. Each cell can hold 617,000 gallons. During large rain events, this storage volume is not enough. The treatment plant has experienced several sanitary sewer overflows reaching over ten (10) MGD. Within the duration of this two month study, a total of 15 overflows occurred during large precipitation events. Frequent large precipitation events put stress on the system, which leads to an increase in maintenance, operation costs and possible health violations due to raw sewage entering public waters. Our team worked with the City of Struthers to select ten (10) manhole locations to place flow meters during the study period. In addition, the Parshall flume data was carefully monitored to record the inflow coming from other service areas to determine their volume input in the Struthers sanitary sewer system.

Struthers sanitary sewer system consists of Vitrified Clay Pipe (VCP) and is at least 75 years old. Like any aging infrastructure, failures in the sewer line can be common and allows water from precipitation events to flow into sewer lines through improper connections (inflow) or raise the groundwater table, which can infiltrate into the sewer line (infiltration). This extra volume added from inflow and infiltration (I&I) can exceed the facility capacity to treat the wastewater, which forces untreated sewage to enter waterways. In addition, I&I can cause more wear and tear on the facility, which increases operation costs. All of these components have led to the need for conducting a Flow Monitoring Study in the City of Struthers. This study is designed to help identify and narrow down the location of the problem within the sewer system.

Table 1 is a summary of the flow monitoring results found throughout the two month study period. The ten areas are ranked in order of priority based on the magnitude of wet weather flow rates and peak factors:

Table 1: Summary of Flow Study (March 19th – May 21st)

Site ID	Average Dry Weather Base Flow Rate (GPM)	Observed Range of Wet Weather Peak Flow Rate (GPM)	Range of Peak Factor	Priority
MH H5A	292	1003-1401	3-5	1
MH F56	200	397-645	2-3	2
MH F76A	63	341-771	5-12	3
MH F69	39	96-279	4-7	4
MH G64	30	93-182	3-6	5
MH F9	76	204-223	3	6
MH G18	24	215-347	9-14	7
MH F79	25	147-211	6-8	8
MH F50	11	62-158	6-14	9
MH G56	10	89-101	9-10	10

Overall, substantial I&I has been observed along the trunk line, with various peak factors. The average peak factor observed is about 6.

The following three alternatives are suggested solutions to remediate the inflow and infiltration occurring within the system: 1) Smoke and Camera Testing 2) Remove Improper Connections to the Sewer System 3) New Flow Equalization Tank. Smoke testing and inspecting the sewers with video camera would help determine exact locations as to where inflow and infiltration is occurring within the system. Another option is to remove or disconnect improper connections to the sanitary main to prevent extra volume of water from inflow. A new larger flow equalization tank is an option to handle the additional volume during rain events.

Based on all of the data collected we recommend further smoke and camera testing of the system along with removal and disconnection of improper connections to reduce I&I during wet weather events.

2 Introduction

2.1 Purpose

The purpose of this study is to determine if there is inflow and infiltration (I&I) present in the sanitary sewer system and identify the contributing areas. To find locations, flow meters were placed in selected manholes to record the flow rate, velocity, and depth. The monitored flow and precipitation data was analyzed for potential I&I especially volume and location. I&I and other terms used in this report can be found in Appendix, Section 6.1.

2.2 Site Location

Our team worked with the City of Struthers staff to select a total of ten (10) manholes to be monitored as shown in Figure 1. These manholes along the main trunk line were carefully selected based on prior issues and minimal inflow influence from outside the system. A drainage map was also created to determine which portion of the study contributed the largest volume (Figure 2 and Figure 3).

Table 2: Summary of Manhole Locations

Site ID	Manhole ID	Diameter (inches)
Site 1	MH F50	8
Site 2	MH F56	10
Site 3	MH F69	8
Site 4	MH F76A	8
Site 5	MH F79	8
Site 6	MH G18	8
Site 7	MH G56	8
Site 8	MH G64	8
Site 9	MH H5A	12
Site 10	MH F9	10

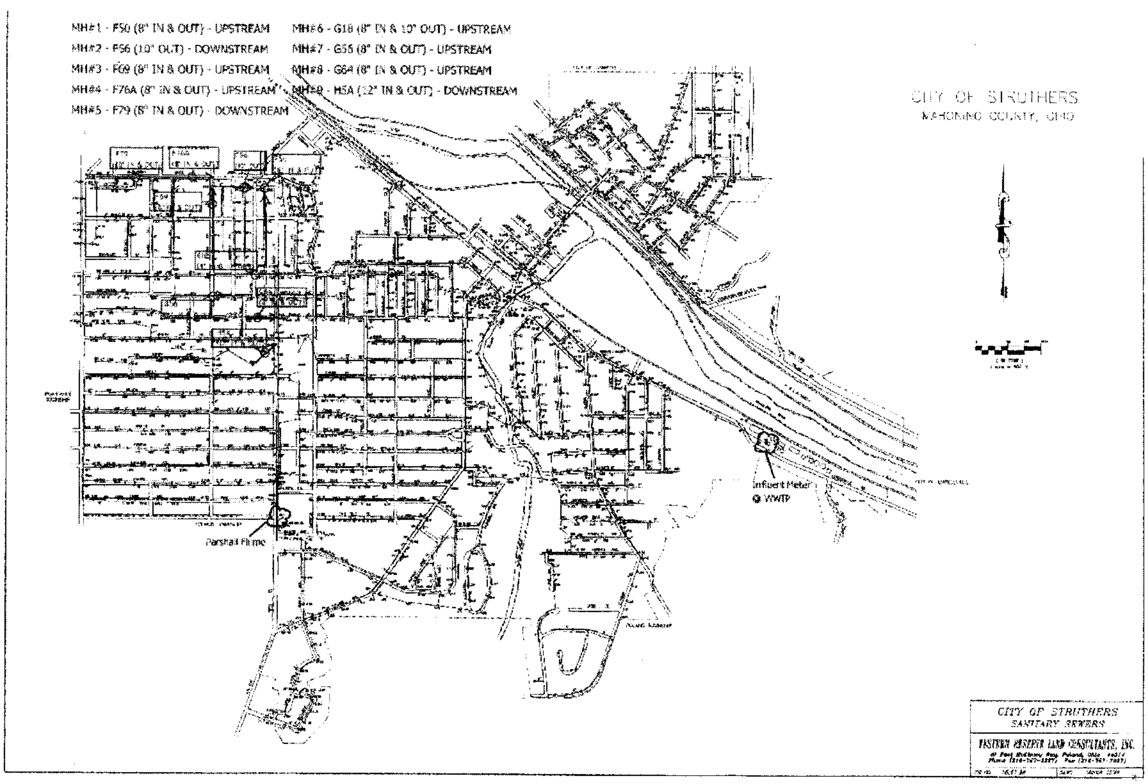


Figure 1: Location map of selected manholes to monitor – City of Struthers

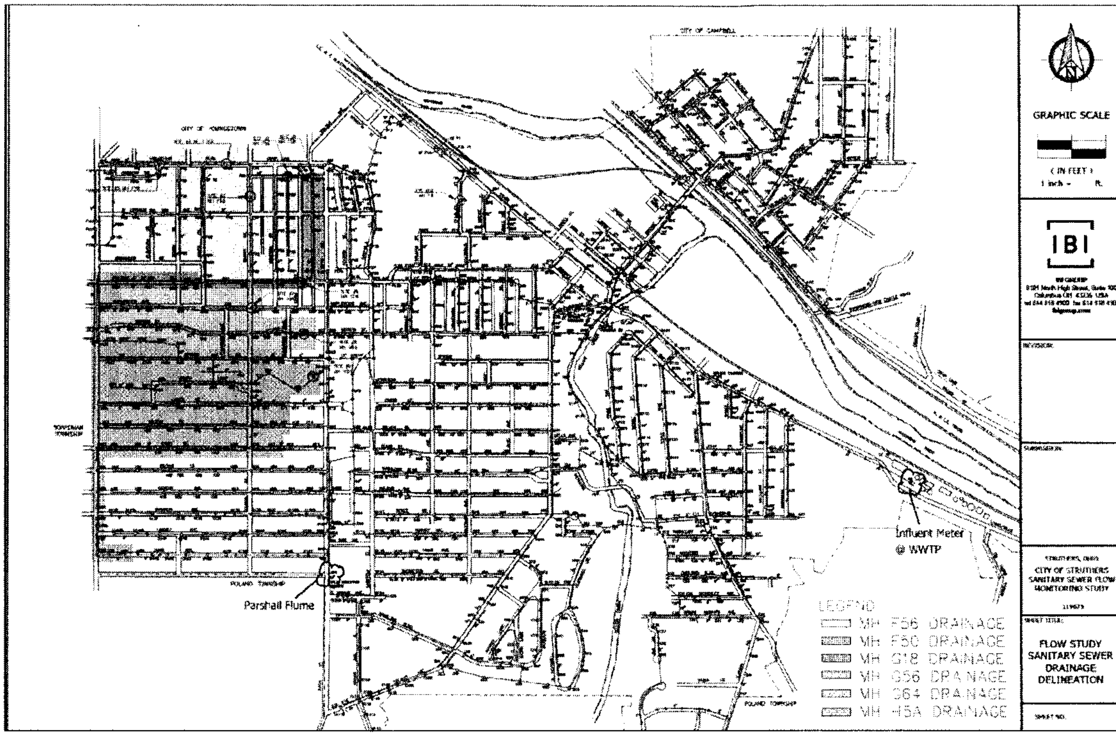


Figure 2: Overall Drainage map of selected manholes – City of Struthers

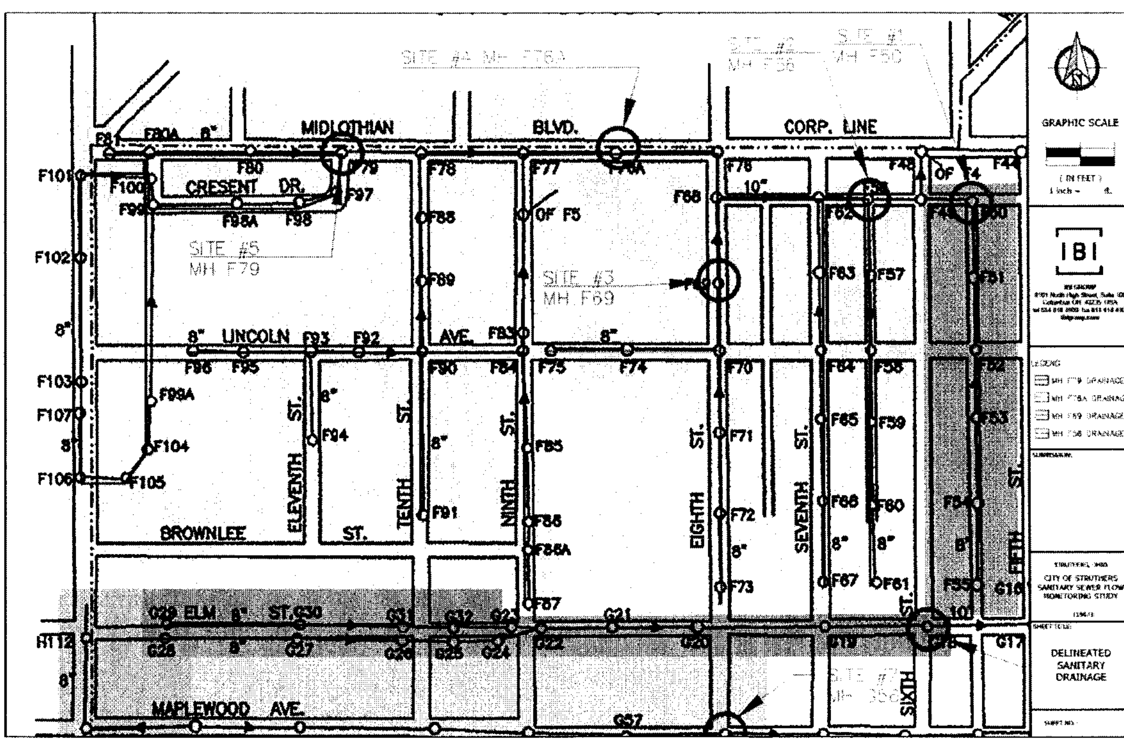


Figure 3: Drainage of MH F76, MH F76A, MH F69, and MH F56—City of Struthers

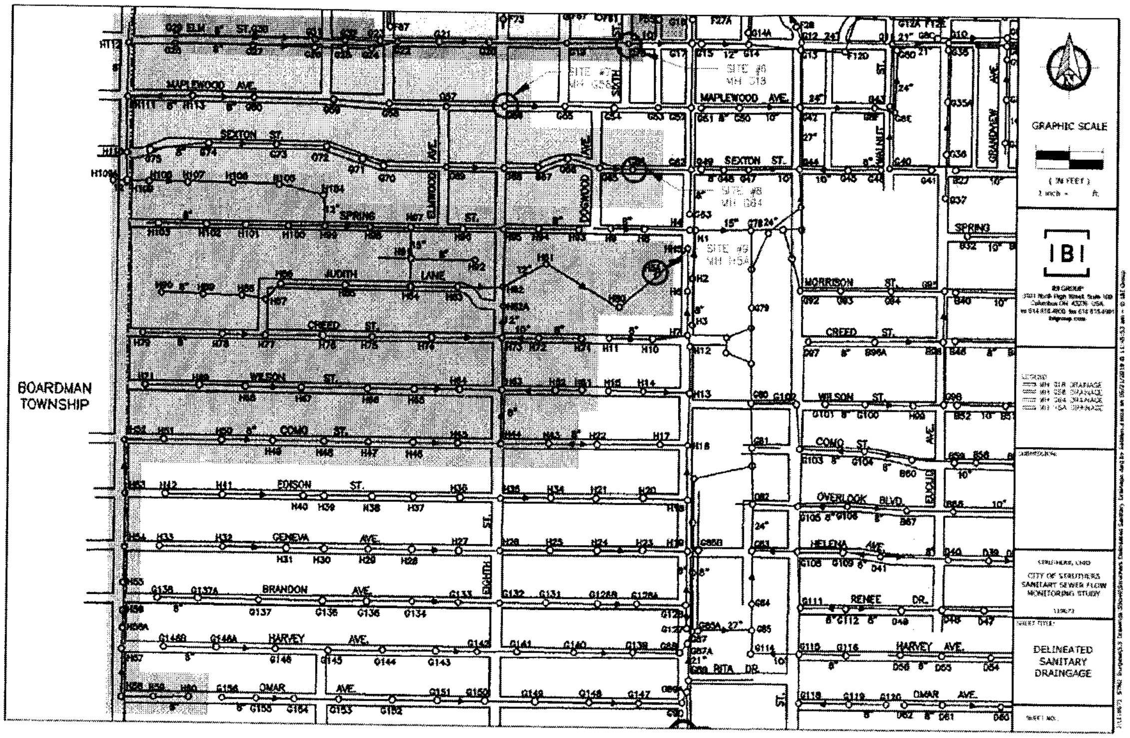


Figure 4: Drainage of MH G18, MH G56, MH G64, and MH H5A

2.3 Flow Measurements

A Mace FloPro Xci flow meter was installed in ten selected manholes from March 18th- May 21st, 2019 to record the wet and dry weather flows at five minute intervals. Information collected included: velocity, depth, current flow, and net total flow. A website, w-underground.com was used to gather hourly data on precipitation events and used to compare with the rain gauge data recorded at the Struthers Water Pollution Control Facility to ensure accuracy.

The process of installation started with securing a flow meter at the base of the invert where the direction of flow was into the manhole (Figure 5). Each meter needed to be calibrated for each manhole so accurate data could be recorded. Then as water flowed over ultrasonic Doppler sensors on the flow meter, data was stored which could be downloaded later and analyzed. This data was used to develop hydrographs and interpret the results to determine if inflow or infiltration was present within the system.

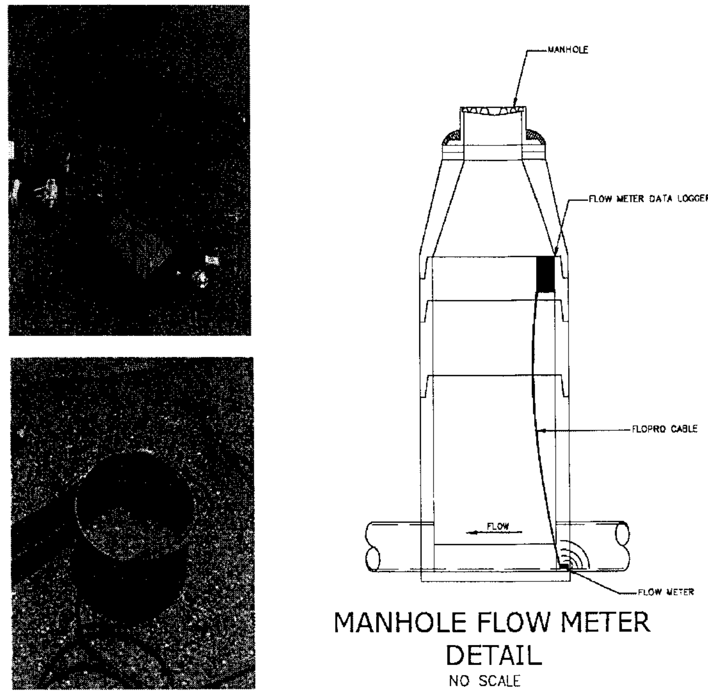


Figure 5: Top Left: flow meter data logger to store data; Bottom Left: flow meter with Doppler sensor; Right: Detail of an installed flow meter in a manhole

2.4 Site Visits and Maintenance

Multiple site visits and maintenance occurred during the course of the study. Table 3 shows a summary of the activities and resolutions:

Table 3: Site Visit / Maintenance Summary

Date	Site #	Activity
March 18, 2019	1-9	Initial installation (9 flow meters)
April 3, 2019	1-9	Downloaded data; Site #7- Corrupt memory card; Site #9- Dead Battery --> recharged
April 12, 2019	1-9	Downloaded data; Site #7: Replaced flow meter
May 3, 2019	1-9	Downloaded data; Site #2 Clogged-->Cleaned by City to remove silt and debris
May 9, 2019	1-10	Downloaded data; Relocate flow meter at Site #1 to Site #10*
May 21, 2019	1-10	Data Collection Complete; Removed the flow meters

*Site 10 was added in the latter half of the study per the City's request. The results at Site 1 were sufficient enough from the first three rain events and further monitoring at Site 1 was no longer necessary.

2.5 Rainfall Events

Using the hourly precipitation data, there were five (5) rain events recorded between the dates of March 18th- May, 21st, 2019 that collected at least a total of 0.67 inches (Table 4). The five rainfall events provided more than sufficient data to allow our team to properly analyze the system. Recording rainfall events is important for an I&I study because if a rainfall event corresponds to a peak or lag in the sanitary hydrograph, it can be interpreted as inflow or infiltration. Rainfall event data was collected from the website, w-underground.com and used to gather hourly data on precipitation events, then compared to rain gauge data recorded at the Struthers Water Pollution Control Facility (WWTP) to ensure accuracy. The website was used to obtain readings every hour vs the City rain gauge at the WWTP, which collected data daily.

Table 4- Summary of Rainfall Events

Rain Event	Dates	Duration (hours)	Total Rainfall (inches)	Intensity (inch/hour)
1	March 30 (6pm) - March 31 (4am)	12	1.21	0.10
2	April 14 (8am)- April 15 (9pm)	14	1.81	0.13
3	April 25 (7am)- April 26 (11am)	5	0.67	0.13
4	May 9 (2pm)- May 10 (6am)	18	1.08	0.06
5	May 12 (12am 11:59 pm)	24	0.85	0.04

3 Sanitary Sewer Study Results

The data set presented in each of the graphs below is from March 18th- May 20th. The flow meters were installed on March 18th. From March 18th- April 3rd, several measurements parameters, such as velocity interval and scan frequency were calibrated. The hydrographs show flow rates (blue), peak flows (labeled on blue), base flow (orange), rainfall/hour (gray), rainfall events (yellow), and total rainfall accumulation (labeled on yellow). Also, Table 5 summarizes the data found in the hydrographs for each site with percent difference between dry and wet weather events.

3.1 Site 1 (MH F50)

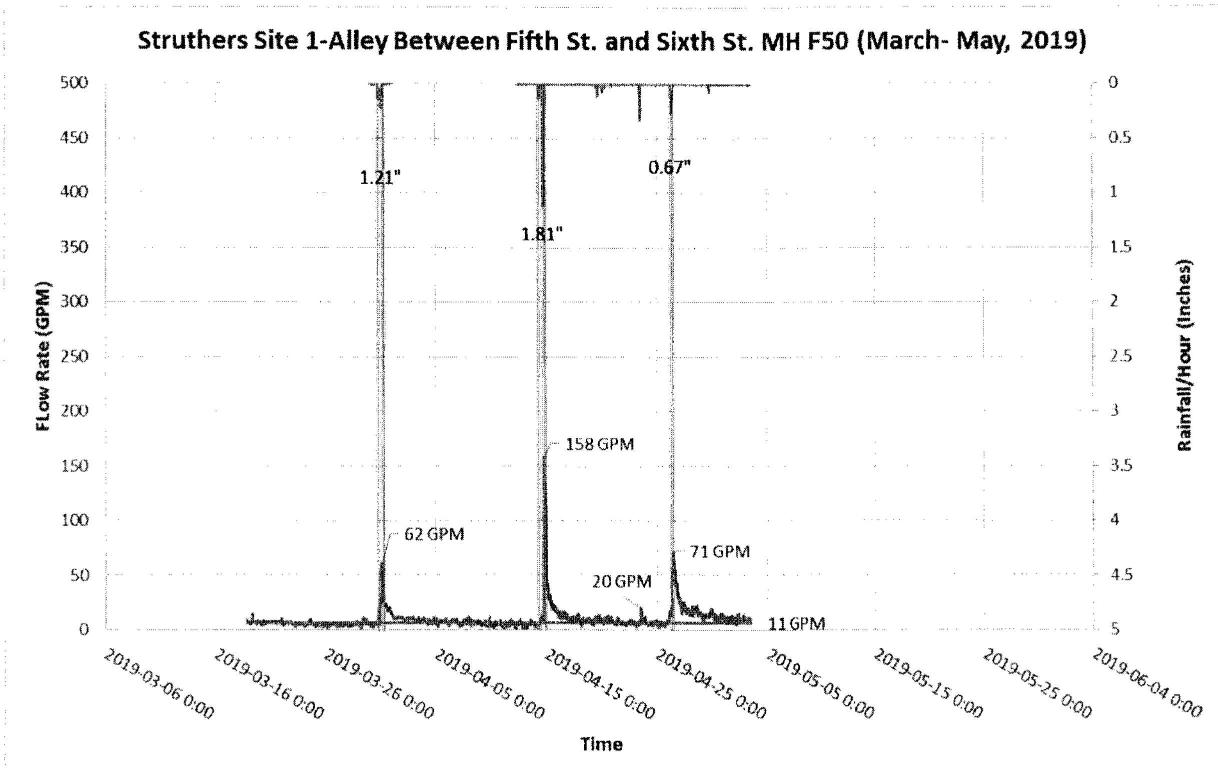


Figure 5: Site 1 Hydrograph

Site 1 observed three peak flows during three rain events indicating direct inflow. The largest peak factor observed at this site was 14. The base flow was calculated to be 11 GPM. For Site 1,data was recorded from March 18th– May 3rd. On May 3rd this flow meter was relocated to Site 10 per the City's request. The meter was relocated due to relatively low flow rates and the three rain events were sufficient to understand the nature of the site.

3.2 Site 2 (MH F56)

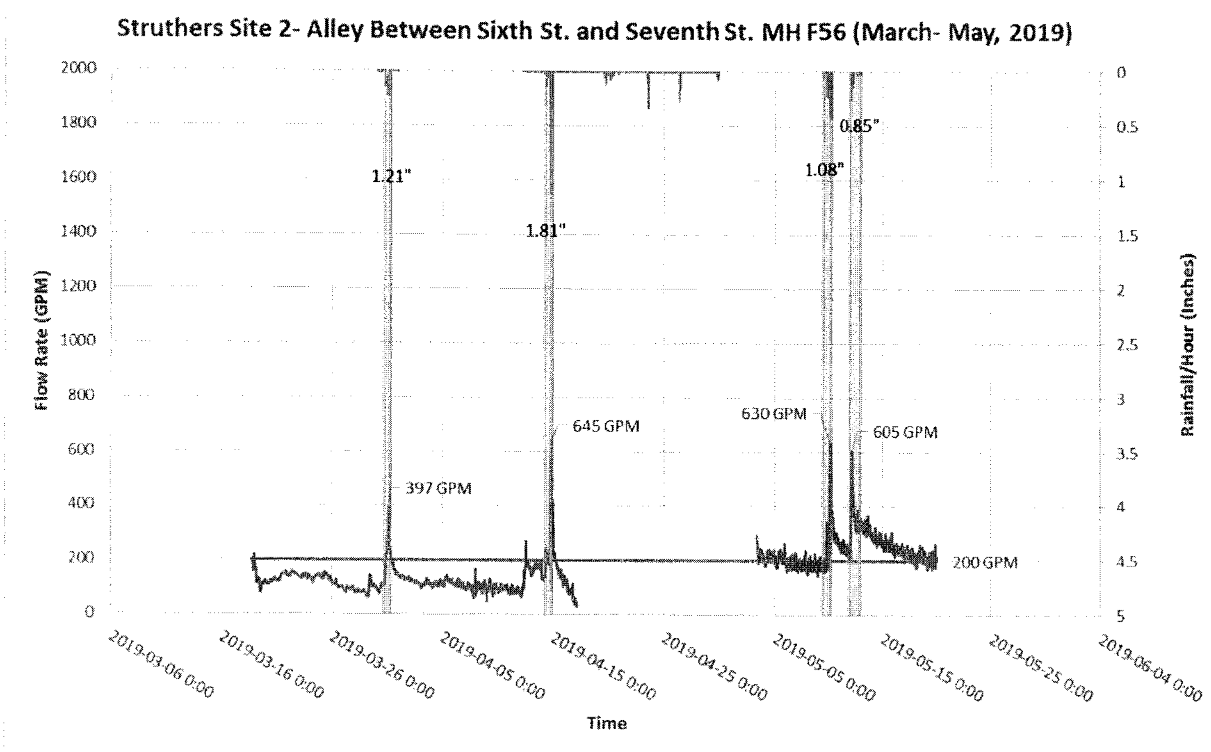


Figure 6: Site 2 Hydrograph

Spiked peaks are noticeably seen in the hydrographs during rainfall events, exemplifying direct inflow and the lag time needed to return to base flow signifying infiltration. This site observed a peak factor range of 4-6. Between April 15th and May 3rdthere was a clog within the pipe. The clog was cleared on May 3rd, no data was collected with the third rain event, but our team was able to capture data from the final two events.

3.3 Site 3 (MH F69)

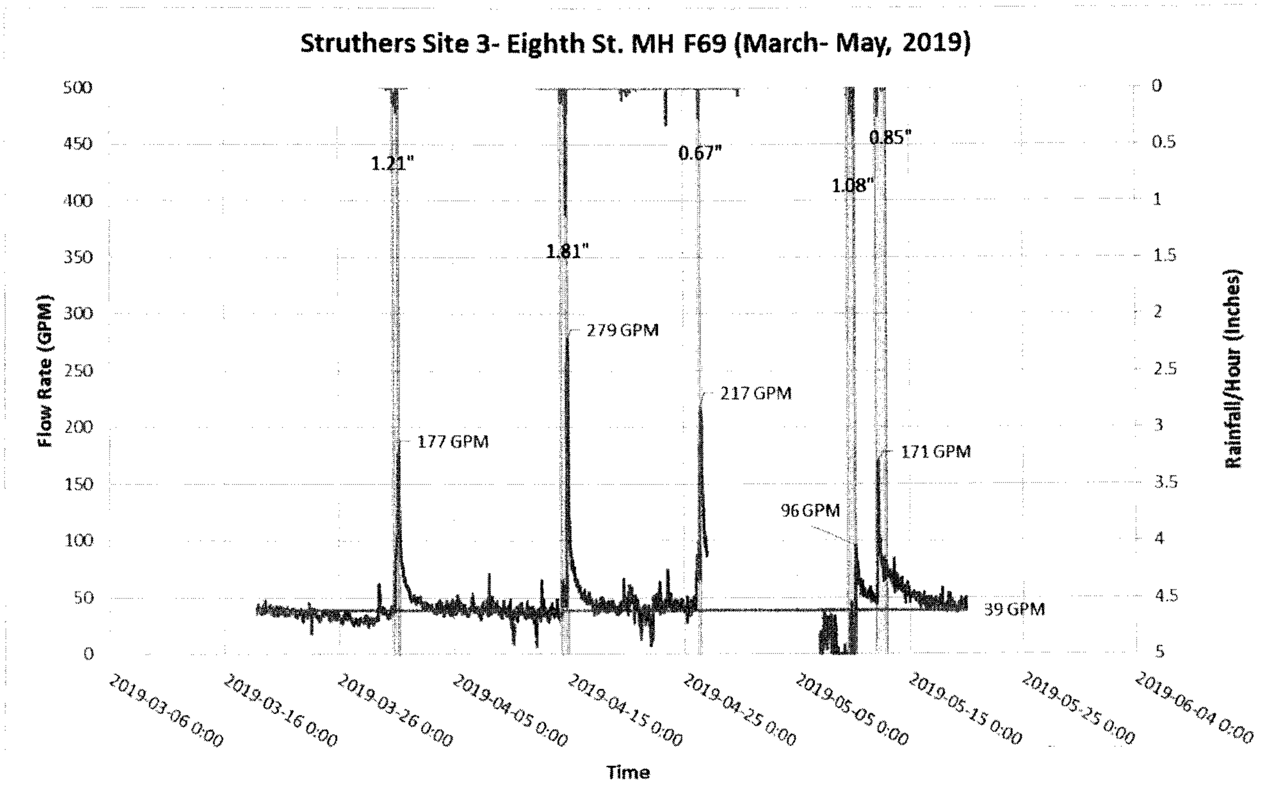


Figure 7: Site 3 Hydrograph

Site 3 observed clear indicators for inflow and infiltration during all five rain events. With the base flow at 39 GPM, the peak factor range was 4-7.There is discrepancy in the data approximately April 27- May 6 it was taken out for consistency. The reason as to why the values altered during this time frame are unknown but it appears there may have been some debris build up over the sensor causing inaccurate readings of the flow.

3.4 Site 4 (MH F76A)

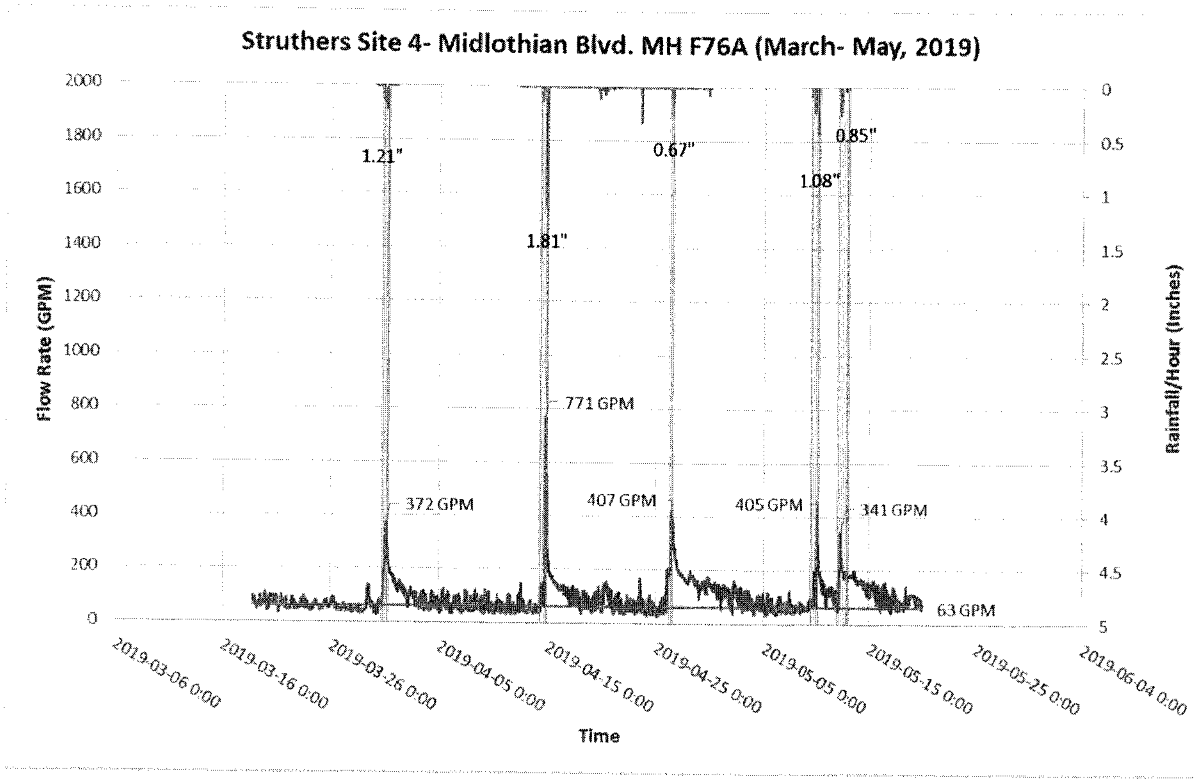


Figure 8: Site 4 Hydrograph

Site 4 shows substantial direct inflow and delayed inflow for each rainfall event that had at least 0.67 inches of accumulation. The base flow was calculated to be 63 GPM. The delayed inflow indicated rainfall induced infiltration. The peak factor range observed at Site 4 was 5-12. This suggests that there is likely improper lateral connection to the sanitary sewer line that is contributing this extra volume during rain events as well as a possible pipe failure allowing water to seep in when the water table is higher.

3.5 Site 5 (MH F79)

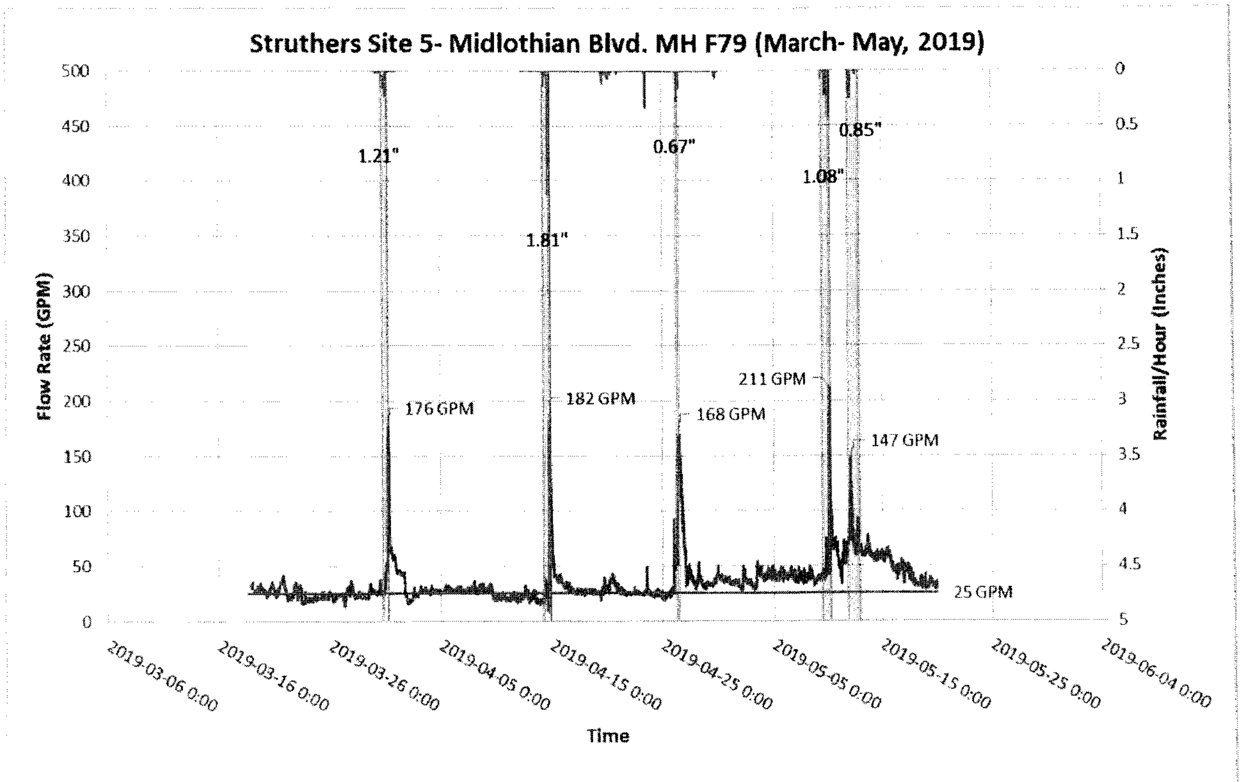


Figure 9- Site 5 Hydrograph

Site 5 exhibits a base flow of 25 GPM with a peak range of 6-8. Direct peaks are strongly correlated with each rainfall event, indicating signs of direct inflow. This could be due to improper connections of laterals to the sanitary sewer line.

3.6 Site 6 (MH G18)

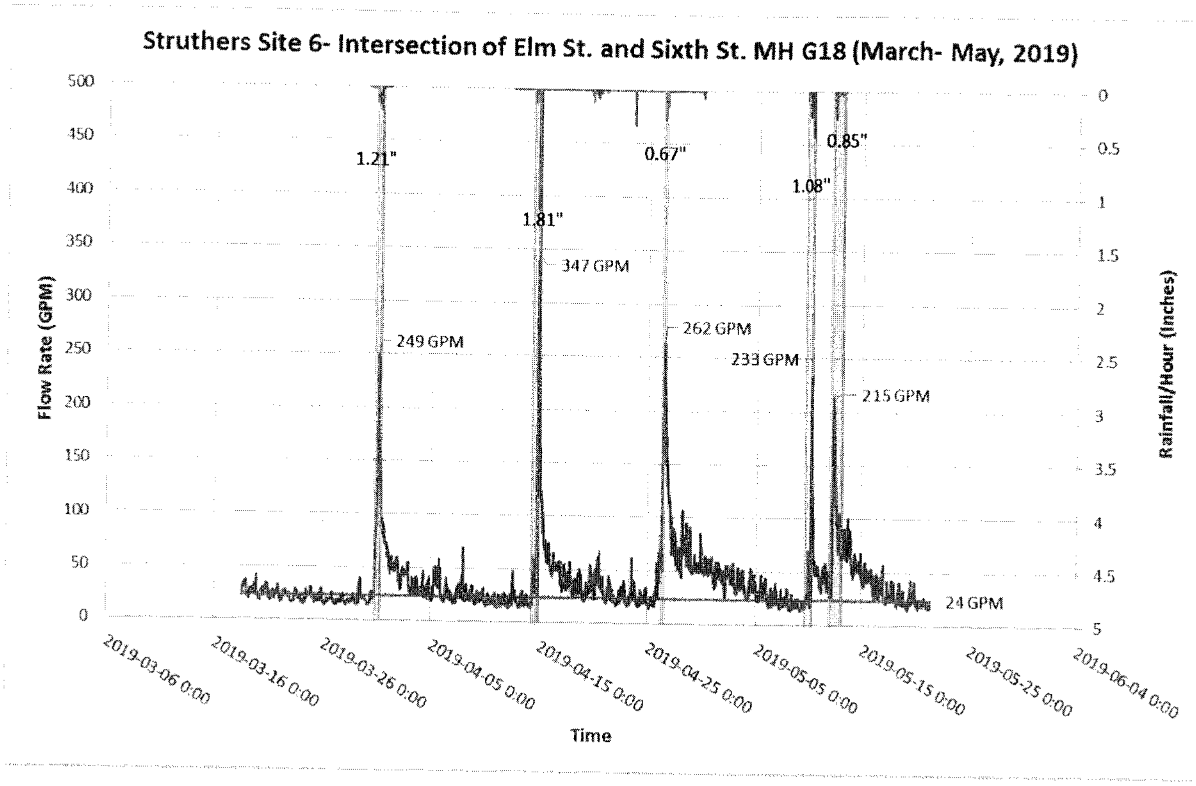


Figure 10: Site 6 Hydrograph

Site 6 has a base flow of 24 GPM with a range of peak factors between 9-14. Site 6 hydrograph also shows substantial direct inflow and rainfall induced infiltration. The sanitary sewer flow directly corresponds with rainfall events requiring several days to return to base flow.

3.7 Site 7 (MH G56)

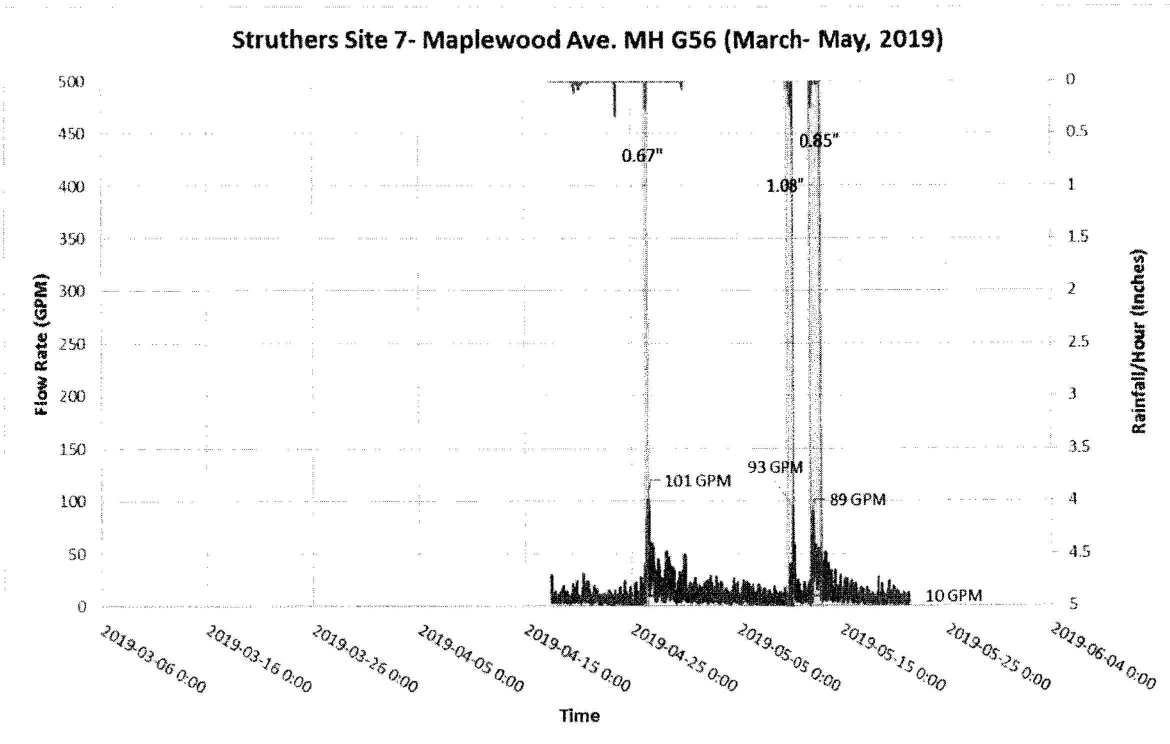


Figure 11: Site 7 Hydrograph

Site 7 observed a base flow of 10 GPM with a peak factor range 9-10. Distinct spiked peaks in flow rates were observed during the last three rainfall events. These spiked peaks signify direct inflow and the lag time to reach base flow indicates infiltration. From March 18th- April 12th there was no data being recorded due to a corrupt memory card. The memory card was replaced on April 12th.

3.8 Site 8 (MH G64)

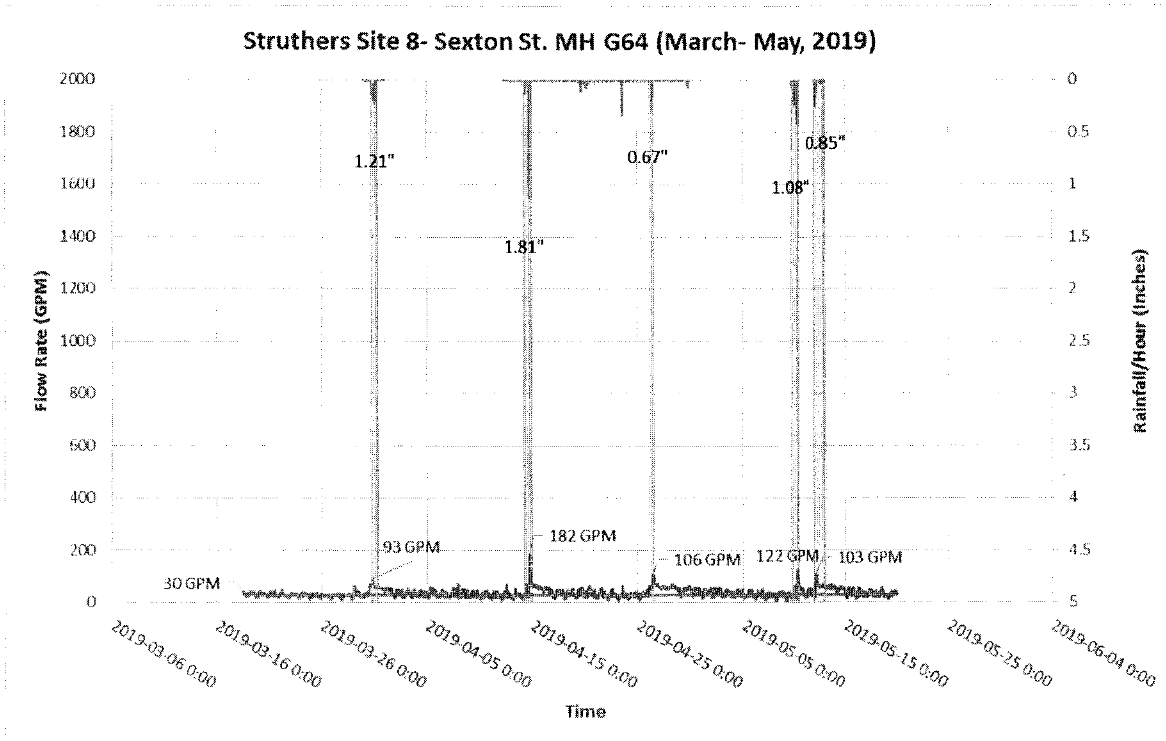


Figure 12: Site 8 Hydrograph

Site 8 observed peak hour spikes during each major rain event recorded in the 2 month study. The peak factors range from 3-6.

3.9 Site 9 (MH H5A)

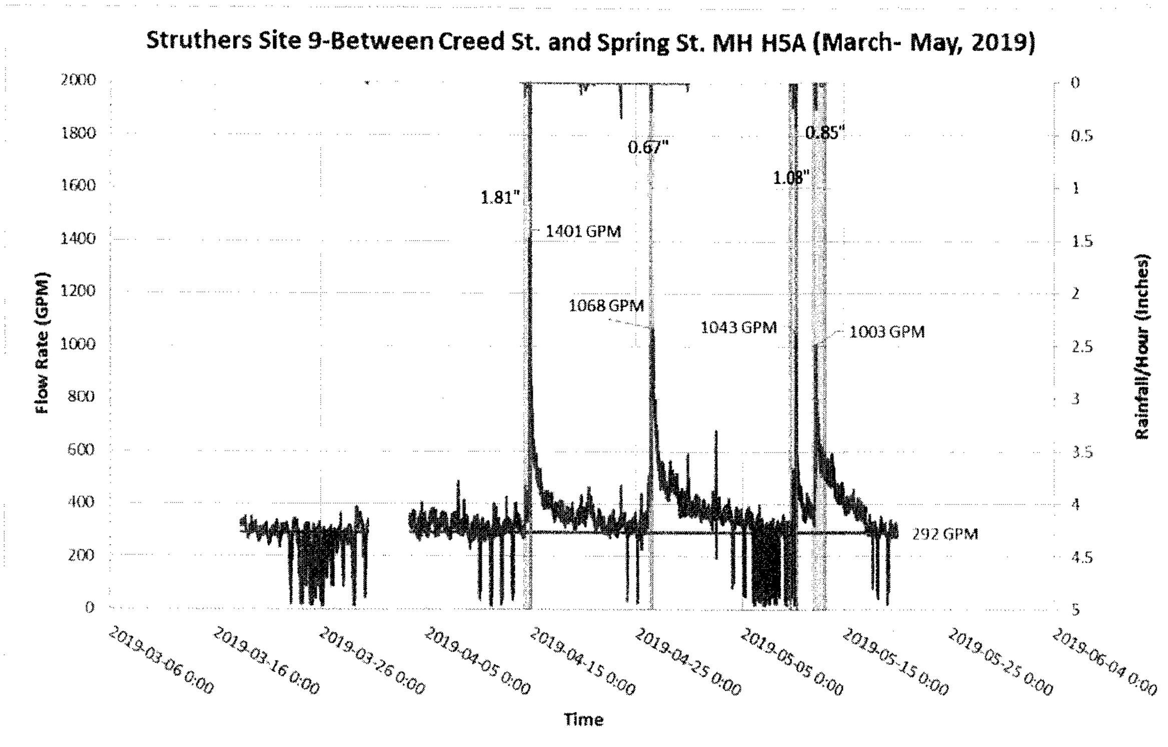


Figure 13: Site 9 Hydrograph

Site 9 shows strong signs of inflow and infiltration due to the observed peaks and lag time corresponding with each major rainfall event. The site has a base flow of 292 GPM with a peak factor of 3. The battery to store the flow meter data died March 30th and was replaced on April 3rd, therefore a gap between these dates is seen in the graph.

3.10 Site 10 (MH F9)

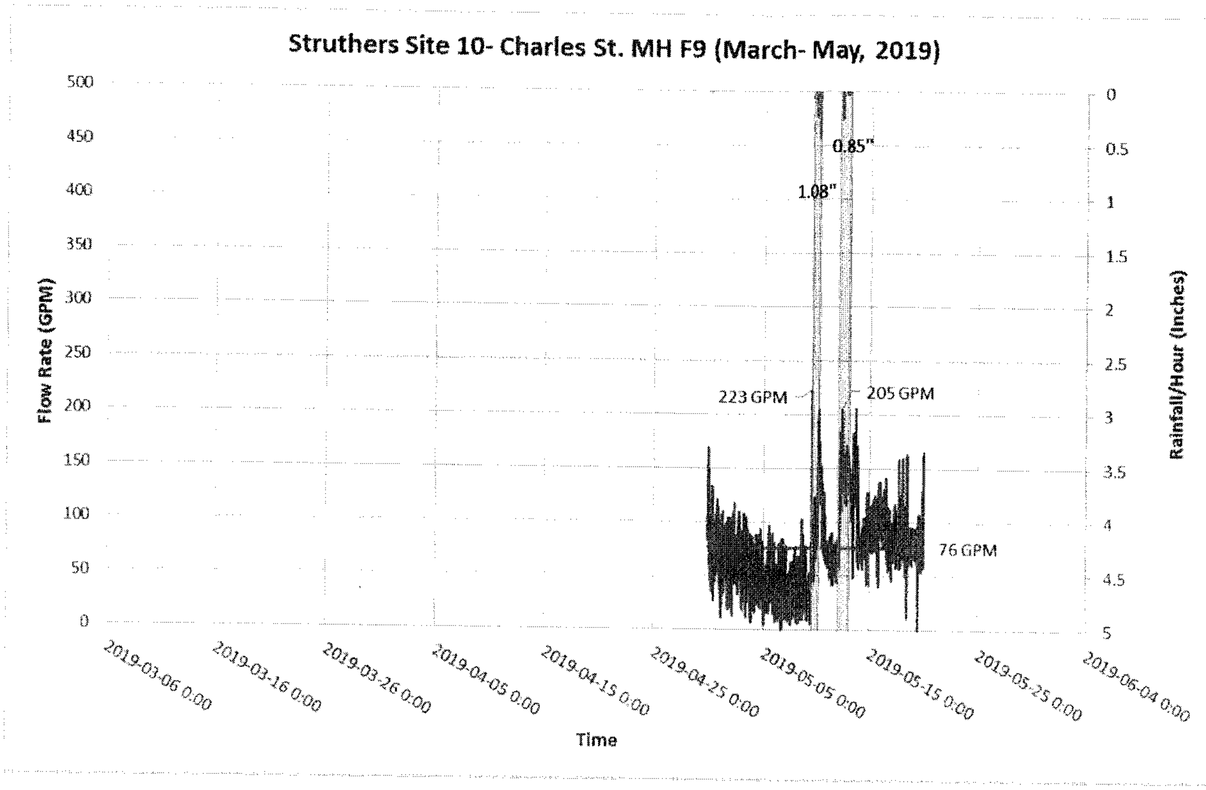


Figure 14: Site 10 Hydrograph

A flow meter was installed at Site 10 on May 9th and recorded data for the remainder of the study. Two rainfall events were captured during this time period, which observed a peak factor range of 9-10. The average base flow was 76 GPM.

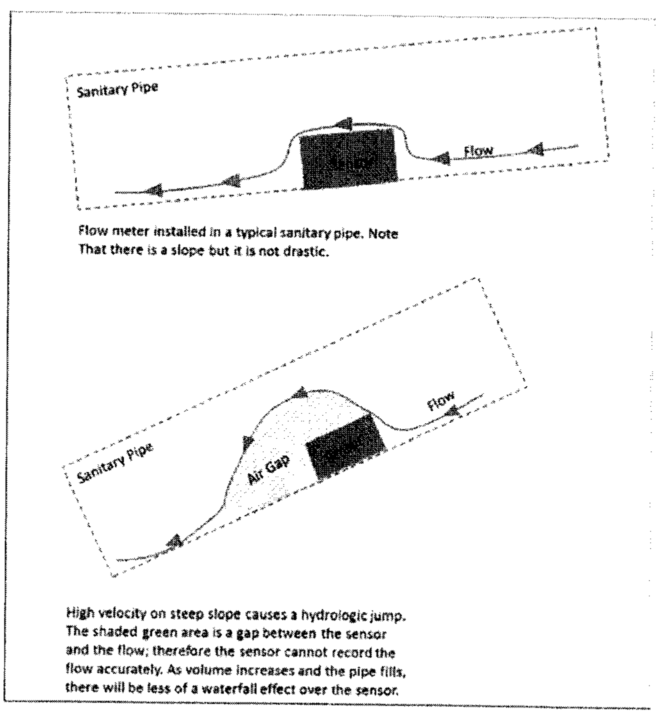


Figure 15: Detail diagram of what occurs at Site 10

This site was unique in that the pipe was fairly steep with high velocity rates so the water would skip over the flow meter (Figure 15). However, when rainfall events occur the depth of water would get deeper and the sensor would be able to collect data. To account for this site anomaly the flow meter manufacturer recommended a correction factor of 0.15, which was applied to correct for this hydrologic jump over the sensor. Nevertheless, there are signs of I&I, but further evaluation is needed to confirm flow velocity.

Table 5: Summary of Hydrographs

Site	Storm Event No.	Average Dry Weather Base Flow Rate (GPM)	Observed Wet Weather Peak Flow Rate (GPM)	Peak Factor	Dry Weather Volume	Wet Weather Volume	% Difference between Dry Weather vs Wet Weather
1	1	11	62	6	7,920	20,543	61%
	2		158	14	9,240	19,028	51%
	3		71	6	3,300	10,552	69%
	4		-	-	11,880	-	-
	5		-	-	15,840	-	-
2	1	104	397	4	74,880	180,082	58%
	2		645	6	87,360	197,576	56%
	3		-	-	31,200	88,283	65%
	4		630	6	112,320	232,350	52%
	5		605	6	149,760	494,658	70%
3	1	39	177	5	28,080	74,918	63%
	2		279	7	32,760	63,582	48%
	3		217	6	11,700	38,253	69%
	4		-	-	42,120	-	-
	5		171	4	56,160	115,621	51%
4	1	63	372	6	45,360	164,486	72%
	2		771	12	52,920	134,104	61%
	3		407	6	18,900	77,559	76%
	4		405	6	68,040	115,305	41%
	5		341	5	90,720	269,307	66%
5	1	25	176	7	18,000	50,421	64%
	2		182	7	21,000	35,391	41%
	3		168	7	7,500	30,597	75%
	4		211	8	27,000	57,889	53%
	5		147	6	36,000	108,704	67%
6	1	24	249	10	17,280	93,893	82%
	2		347	14	20,160	62,161	68%
	3		262	11	7,200	41,468	83%
	4		233	10	25,920	45,398	43%
	5		215	9	34,560	142,969	76%

Site	Storm Event No.	Average Dry Weather Base Flow Rate (GPM)	Observed Wet Weather Peak Flow Rate (GPM)	Peak Factor	Dry Weather Volume	Wet Weather Volume	% Difference between Dry Weather vs Wet Weather
7	1	10	-	-	7,200	-	-
	2		-	-	8,400	-	-
	3		101	10	3,000	16,412	82%
	4		93	9	10,800	14,017	23%
	5		89	9	14,400	54,293	73%
8	1	30	93	3	21,600	45,686	53%
	2		182	6	25,200	48,282	48%
	3		106	4	9,000	20,439	56%
	4		122	4	32,400	35,465	9%
	5		103	3	43,200	85,871	50%
9	1	292	-	-	210,240	-	-
	2		1401	5	245,280	387,517	37%
	3		1068	4	87,600	183,267	52%
	4		1043	4	315,360	351,773	10%
	5		1003	3	420,480	802,583	48%
10	1	76	-	-	54,720	-	-
	2		-	-	63,840	-	-
	3		-	-	22,800	-	-
	4		223	3	82,080	90,631	9%
	5		205	3	109,440	193,355	43%

4 Discussion

The hydrographs show the full period of the I&I study, highlighting the five (5) major rain events. The data indicates a spike in the hydrograph when the rain event occurs indicating inflow. After the spike some sites show a slow decrease or lag time to reach dry weather base flow, which indicates delayed inflow or rainfall induced infiltration. During the two month study, heavy sediment, rocks and rags were observed at several of the monitoring locations, which affected some of the site readings, but our team was still able to discern definite patterns of inflow and infiltration.

It appears that each site has inflow and infiltration occurring based on the shape of the graphs when the rainfall events occur. There is a significant amount of flow added to the sanitary sewer system. The areas that show the largest peak factor are sites with generally lower base flow rates. This can be attributed to the higher percentage of volume of rain water compared to base flow. Peak factors are important in determining the difference between base and peak flow, but to truly reduce overflows within a system, the overall volume contribution of each area is considered a higher priority. The following table below lists the priority areas of concern due to average percent increase during rain event and the amount of volume it contributes to the overall study area.

Table 6: List of Priority Drainage Sites

Priority	Site	Contribution to Total Study Area (A)	Average Percent Increase During Wet Weather (B)	Priority Factor (A*B)
1	Site 9 MH H5A	43%	37%	0.159
2	Site 2 MH F56	15%	60%	0.093
3	Site 4 MH F76A	9%	63%	0.059
4	Site 3 MH F69	6%	58%	0.033
5	Site 10 MH F9	11%	26%	0.029
6	Site 6 MH G18	4%	70%	0.025
7	Site 5 MH F79	4%	60%	0.022
8	Site 8 MH G64	4%	43%	0.019
9	Site 1 MH F50	2%	60%	0.010
10	Site 7 MH G56	1%	59%	0.009

MH H5A covers a large drainage area (150 Acres) and contributes the largest volume to the entire study area, and therefore should be considered high priority. It is important to note that MH F76A, MH F69 and MH F79 drains into MH F56. If access to MH F76A is difficult to achieve, addressing the other three manholes may alleviate the stresses in this area and reduce the volume of wet weather overflows in the sanitary sewer system. The priority factor was calculated by multiplying the contribution to the total study area and the average percent increase during wet weather.

In conclusion, based on the graphs and percent differences, it is observed that inflow is the controlling factor of this study. With most sites having a peak associated with a rain event and some duration lag time, the data strongly suggests inflow from improper connections to sanitary sewer system and delayed inflow from a rise of groundwater table that enter the system slowly through pipe failure.

5 Alternatives and Recommendations

5.1 Alternatives

Based on the findings, several alternatives were considered:

1) Smoke and Camera Testing

   It is suggested that smoke testing and video camera inspection of the trunk line be completed to determine exactly, where inflow and infiltration could be occurring. This method could help identify location of point repairs or complete replacement. An anticipated opinion of cost to complete this task was not calculated due to the availability of in house equipment (owned and operated by City staff).

2) Remove Improper Connections to the Sewer System

   Another recommendation is to remove improper connections to the sewer system such as a downspout, storm cross connection, and faulty manhole cover or frame. An anticipated opinion of cost to complete this task was not calculated due to lack of available information to complete, but it is estimated that the cost to repair a sanitary sewer line failure is $500-$700/LF for short distances. Additionally, many times these are private connections which would put the burden of the disconnect cost on the property owner.

3) New Flow EQ Tank

   To manage the excess volume entering the treatment system during rain events, another option is to build a second equalization tank to handle such events. We would recommend the City consider the installation of a 3 to 5 MG EQ tank to capture and retain additional volume during wet weather peak events. Based on the Parshall flume data, our preliminary analysis indicates that the new EQ tank can retain additional volume associated with a 2-year return storm event (1.7" total for 6 hr rain duration).

   This would be a significant capital expense and is an effort to manage the problem, not a solution to reduce or eliminate the cause of the overflows. The anticipated opinion of cost to install a 5 Million Gallon EQ Tank, not including engineering and permitting costs, would be $6.1-$9.1 Million. A project of this significance may require outside funding sources or a sewer rate increase to complete such a large project.

5.2 Recommendations

After a thorough review of the potential options we believe the City should pursue a combination of Options 1 and 2. It is recommended that manholes at Site 2 and Site 9 be checked for signs of I&I. Site 2 is located in an alley and Site 9 in a creek, both locations suspect failure in either the pipe or manhole. Report findings to us and based on the findings and priorities, begin camera/smoke testing. The implementation of a smoke testing and camera program will allow the city to more precisely locate anticipated improper or illegal connections as well as more accurately determine areas requiring repair and/or replacement. This step would be relatively inexpensive due to the availability of in house equipment but would require an increase in labor effort to complete. Additionally a disconnection procedure to remove illegal connection would need to be put in place or enforced.

There are several Federal and State funding sources available to help assist in covering the cost of this project. With the assistance of a qualified funding consultant, communities can be assisted in the time-consuming and laborious task of applying for grants.

While there is no guarantee of funding this project with outside grants or loans over the last 4 years IBI Group's full time funding specialist has helped secure an average of $20 million dollars a year in third party assistance for a variety of projects. Additionally IBI has assisted communities with obtaining funds for similar wastewater projects. Below are several sources and the possible funding timeline which the City of Struthers may consider for this project.

Federal Funding

- Community Development Block Grant
  - Approximately $20.4 million is the average annually split among Ohio counties for infrastructure improvements such as streets and utilities. Counties typically fund 3 to 4 projects up to $50,000. To be eligible for this grant, the project benefit area must be at least 51% Low to Moderate Income (LMI) households. The City of Struthers 2019 LMI is currently listed at 48.20%. A door-to-door income survey would need to be conducted to confirm the current income of the benefit area.
- CDBG Water and Sewer Grant Program
  - LMI eligibility required. Grants are available on a competitive basis up to $750,000, at a $1 to $1 (other funds) ratio for projects benefiting at least 51% LMI households. Related projects must address health and safety related issues at plant or within collection/distribution systems. Plans must be complete and PTI must be obtained. An additional $100,000 may be obtained to fund tap fees and household laterals for LMI households.

State Funding

- Ohio Public Works Commission
  - Nominations due Fall 2019. This is a grant/loan program for assisting communities with road, bridges, and water and sewer projects. Financing is available in the form of grants and loans with varying interest rates. Grants may pay up to 50% of water or sewer project costs for new projects and up to 90% for repair or replacement projects. Loans may fund up to 100% of total project costs at 0% interest. The Loan Assistance is a grant that pays for the interest on

a public or private loan during the construction period plus one year. Readiness to proceed helps you to obtain more points, so having plans completed and a PTI obtained is recommended.

- Ohio Water Pollution Control Loan Fund (WPCLF) (Ohio EPA)
    - Provides financial and technical assistance to private or public applicants for the planning, design, and construction of a wide variety of projects to protect and improve the quality of Ohio's rivers, streams, lakes and other water resources. Struthers would be eligible for a 30 year loan at 1.78% interest.
- Ohio Water Development Authority (OWDA)
    - Financing is available in the form of loans that have an interest rate determined by adding 50 basis points to the average of the "Bond Buyers" 20-Bond Index interest rate every three months. The loan has a term of 5 to 30 years. To date, all eligible applicants have been funded. Struthers would be eligible for a loan for 30 years at 2.58% interest.
- Appalachian Regional Commission (ARC)
    - Funding is in the form of supplemental grants up to $250,000. Struthers is located in Mahoning County and is considered an ARC Transitional county. Projects within this county are eligible for maximum 50% of total project cost in grant funding. Eastgate Regional Council administers this program and applications are due in May.

6 Appendices

6.1 Estimating Inflow and Infiltration

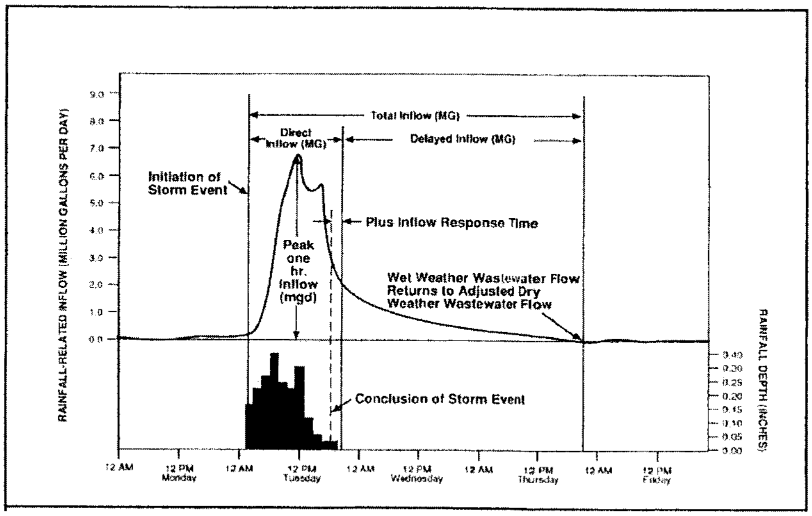


Diagram from US EPA Water Infrastructure Outreach (June 2014):
Hydrograph helps visualize inflow as the response to wet weather flow (from Mass DEP 1993)

Common Sources of Inflow and Infiltration:

Inflow	Infiltration
Roof Drain Connection	Broken House Lateral
Connected Foundation Drain	Root Intrusion into Lateral
Uncapped Cleanout	Faulty Lateral Connection
Faulty Manhole Cover or Frame	Cracked of Broken Sewer Pipe
Storm Cross Connection	Deteriorated manhole

Definitions:

Base Sanitary Flow (BSF)

- The portion of wastewater which includes domestic, commercial, institutional and industrial sewer and specifically exclude infiltration and inflow.

Delayed Inflow Volume

- The portion of total inflow which is generated from indirect connections to the collection system or connections which produce inflow after a significant time delay from the beginning of a storm. Delayed inflow sources include: sump pumps, foundation drains, indirect sewer/drain cross-connections, etc. Rainfall- induced infiltration cannot be distinguished from delayed inflow and is therefore included as part of delayed inflow. Delayed inflow sources have a gradual impact on the collection system and flow decreases gradually upon conclusion of the rainfall event and after peak inflow caused by direct connections.

Direct Inflow Volume

- The portion of total inflow volume, which is from direct connections to the collection system such as catch basins, roof leaders, manhole covers, etc. These inflow sources allow stormwater runoff to rapidly impact the collection system.

Dry Weather Flow (DWF)

- All flow in a sewer (includes sanitary flow and infiltration) except that caused directly by rainfall. Measured during a period of extended dry weather (7 to 14 days) and seasonally high groundwater.

Hydrograph

- A graph showing stage (the height of a water surface above an established datum plane), flow, velocity, or other property of water with respect to time.

Infiltration

- Water other than sanitary wastewater that enters a sewer system from the ground through defective pipes, pipe joints, connections, or manholes.

Inflow

- Water other than sanitary wastewater that enters a sewer system from sources such as roof leaders, cellar/foundation drains, yard drains, area drains, drains from springs, and swampy area, manhole covers, cross connections between storm sewers and sanitary sewers, and catch basins.

Inflow Volume

- The total volume of inflow from a single storm event including both direct and delayed inflow. Total inflow is the area between the storm event hydrograph and the dry weather hydrograph.

Peak Factor

- The ratio of peak hourly flow to average daily flow.

Rainfall-Induced Infiltration

- The short-term increase in infiltration which is the result of a rain event. Rainfall- induced infiltration is a portion of delayed inflow.

Wet Weather Flow

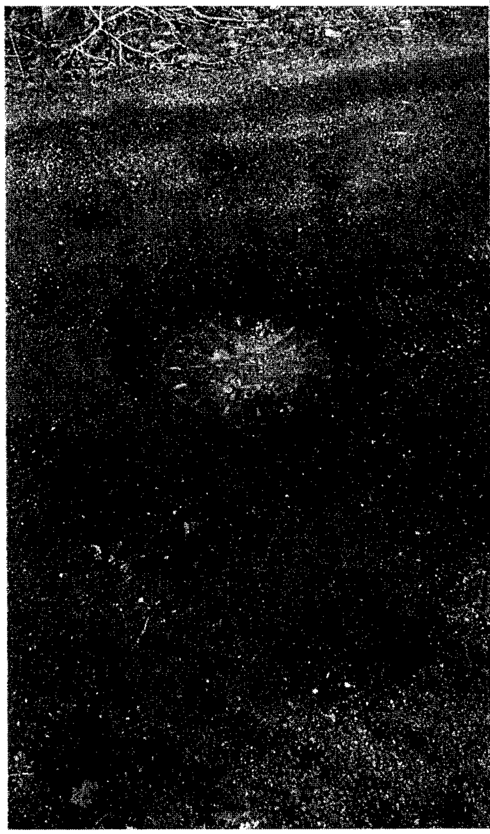
- The highest daily flow during and immediately after a significant storm evet. Includes sanitary flow, infiltration and inflow.

(Note: these definitions are pulled from US EPA Water Infrastructure Outreach)

6.2 Manhole Pictures (Site 1-10)

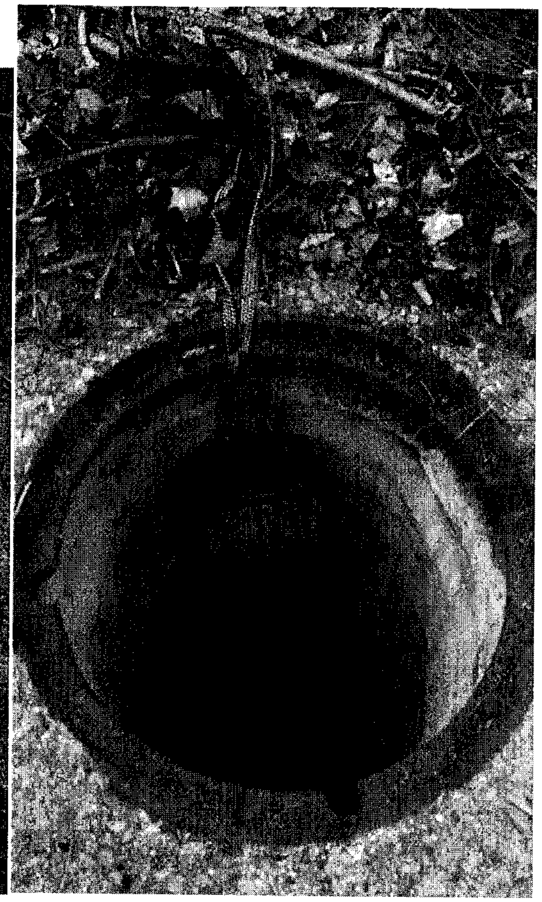
Struthers Manhole Installation Pictures

Site 1 (MH F50)



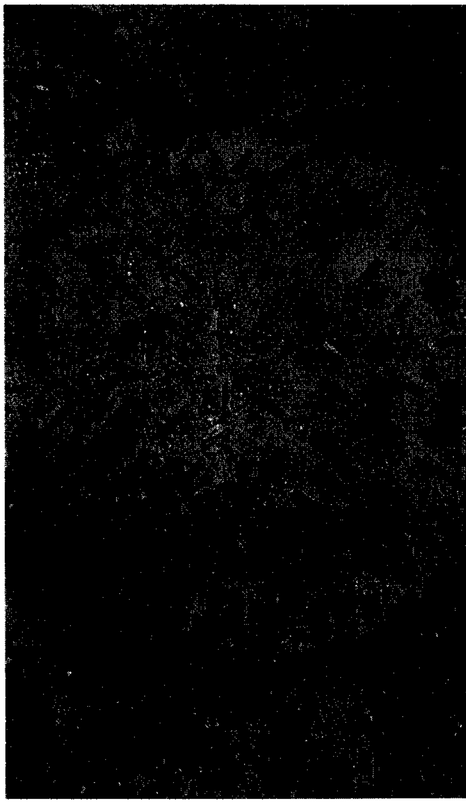
Struthers Manhole Installation Pictures

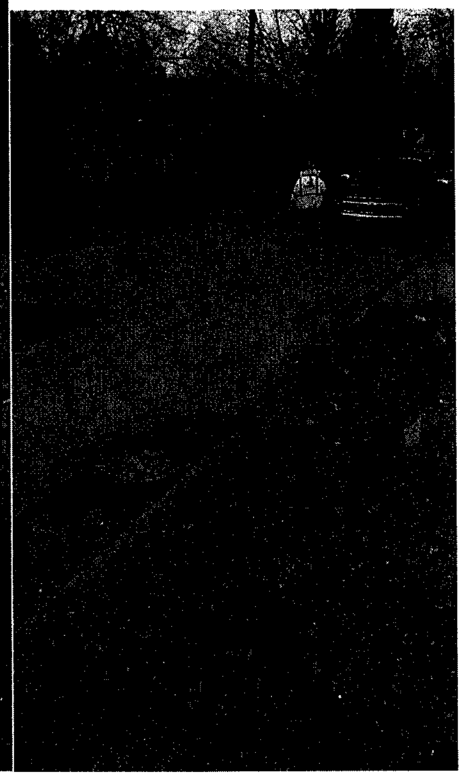
Site 2 (MH F56)

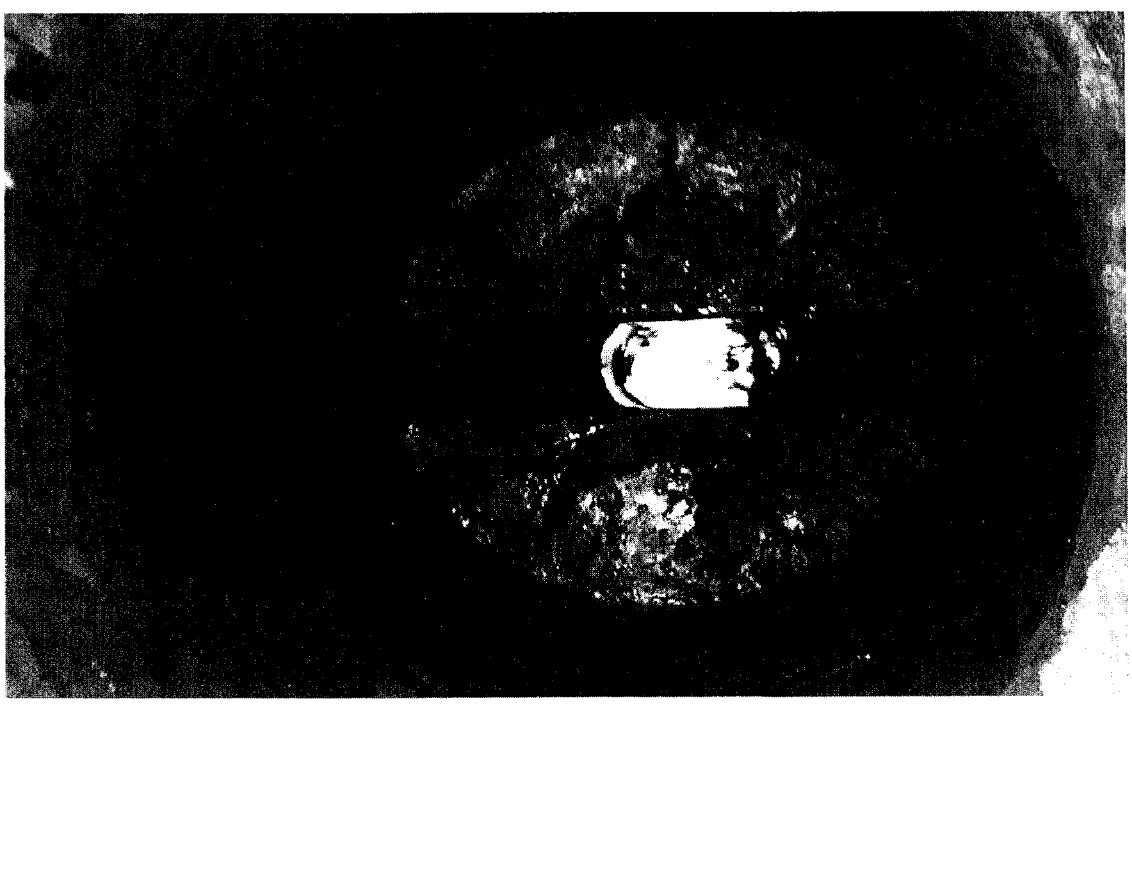


Struthers Manhole Installation Pictures

Site 3 (MH F69)

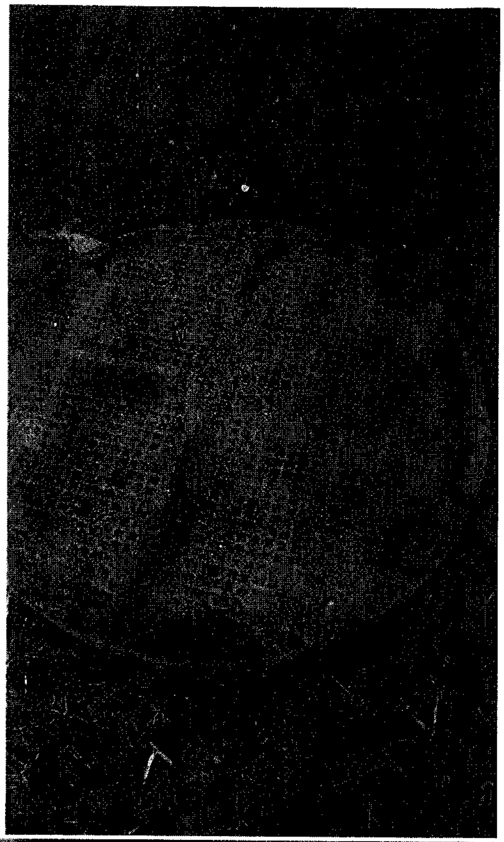


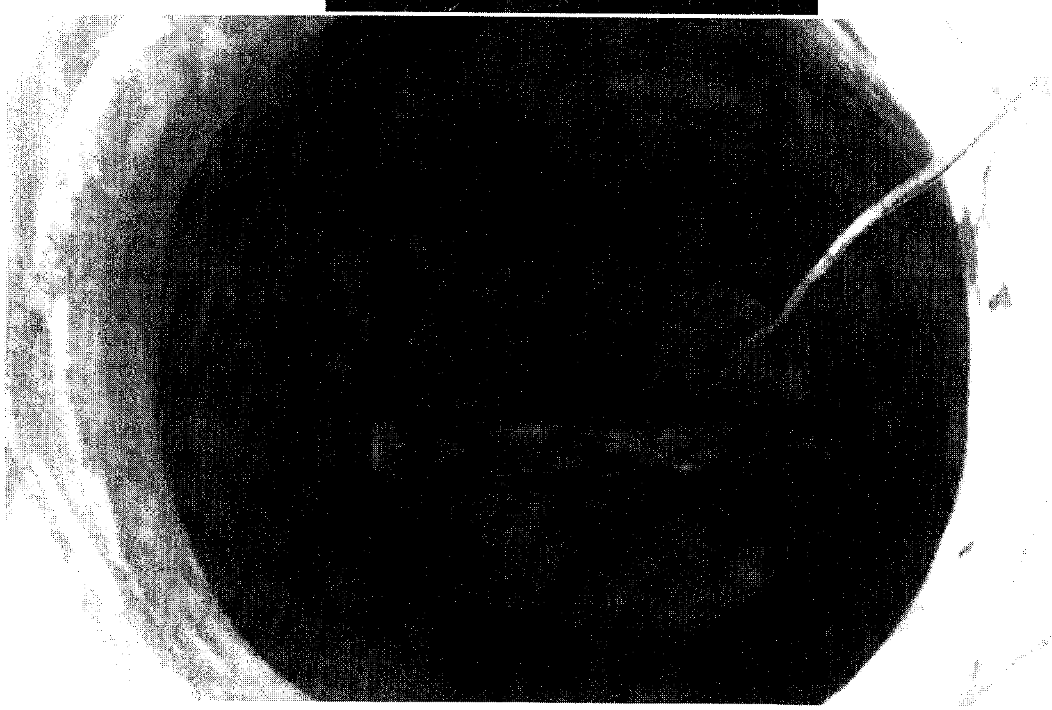




Struthers Manhole Installation Pictures

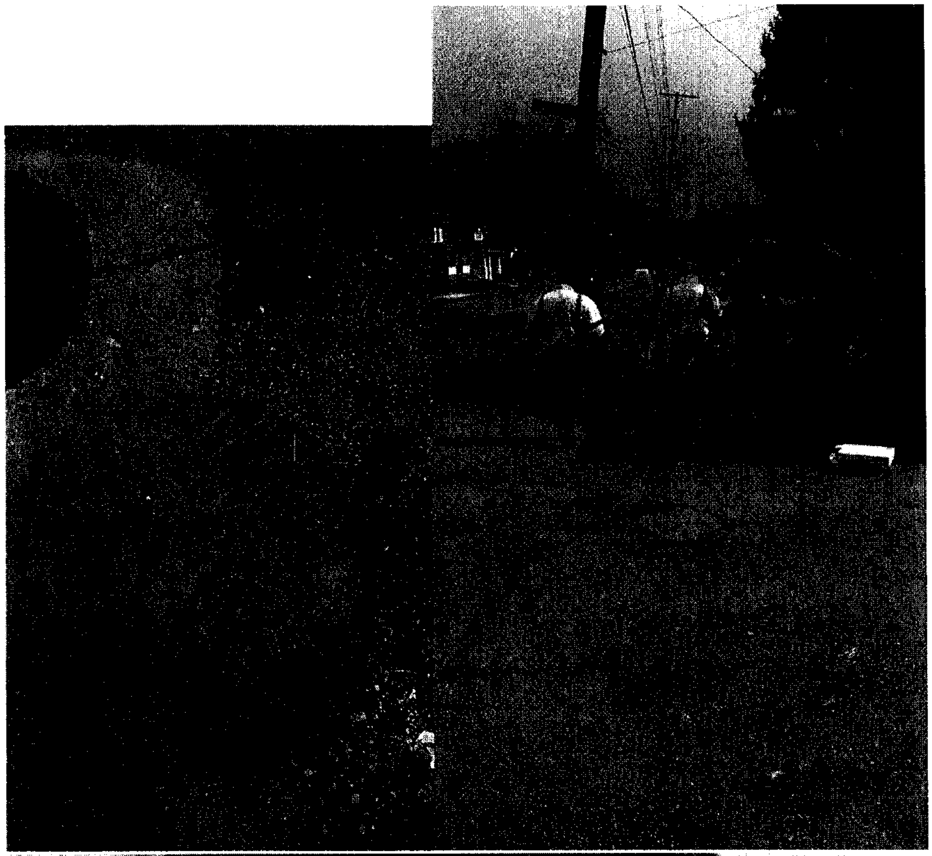
Site 4 (MH F76A)

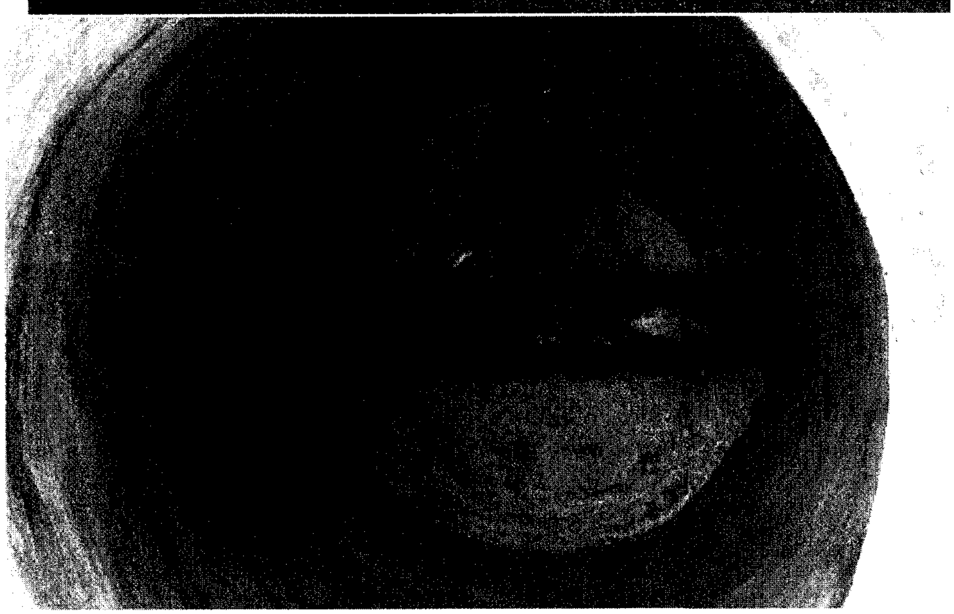




Struthers Manhole Installation Pictures

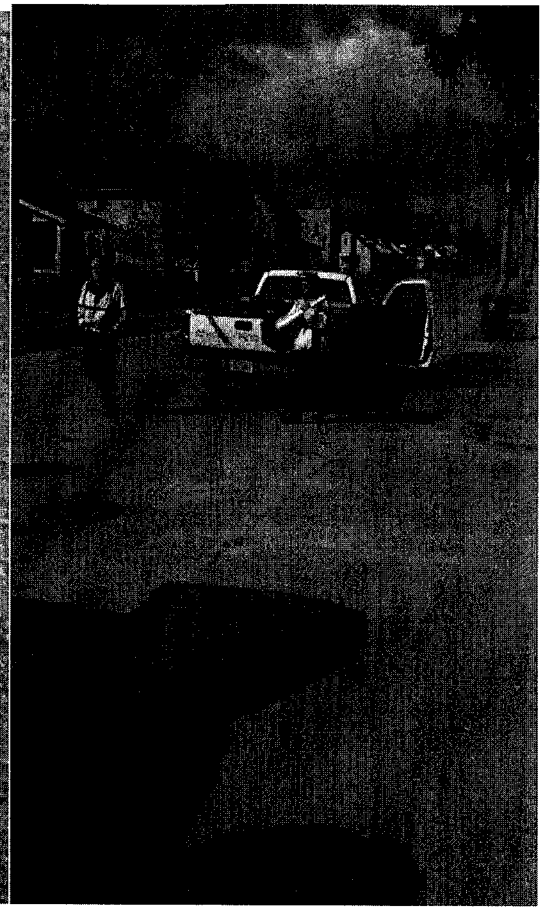
Site 5 (MH F79)

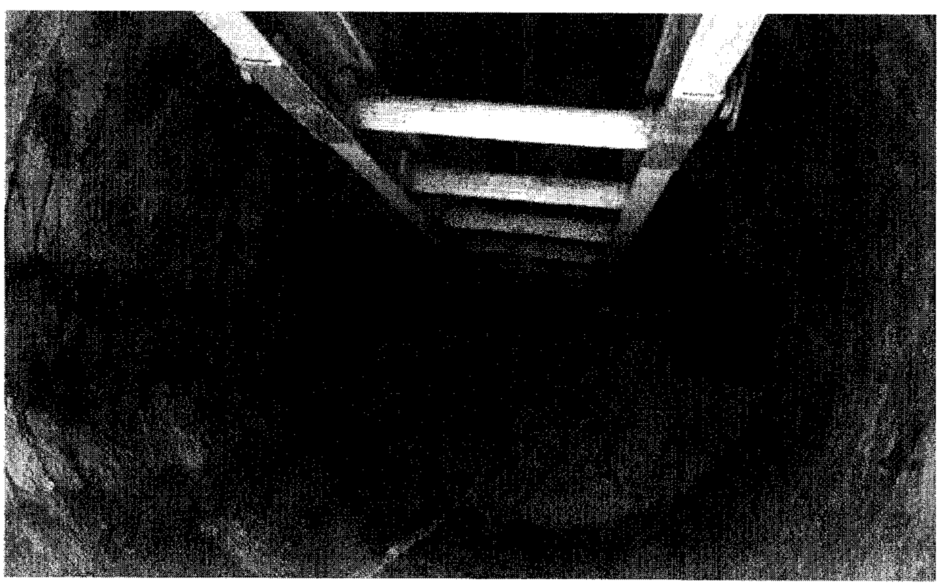




Struthers Manhole Installation Pictures

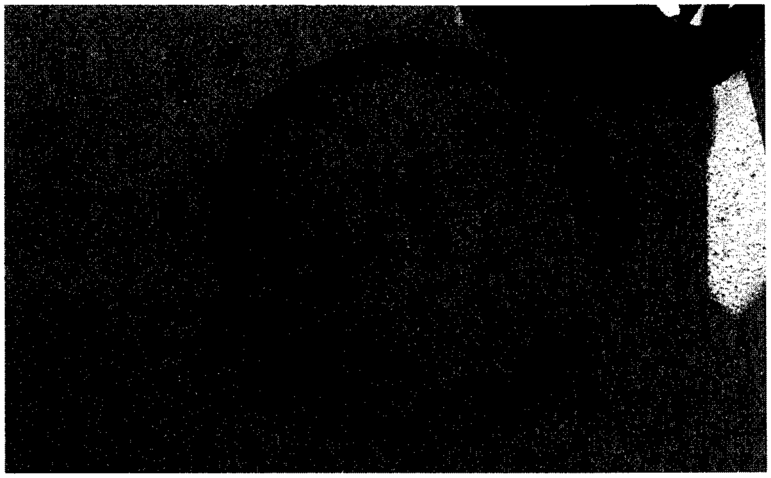
Site 6 (MH G18)

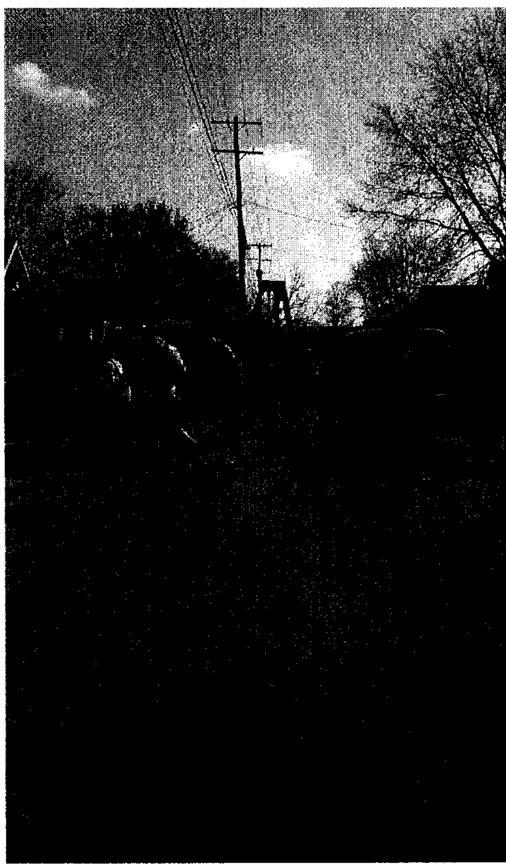


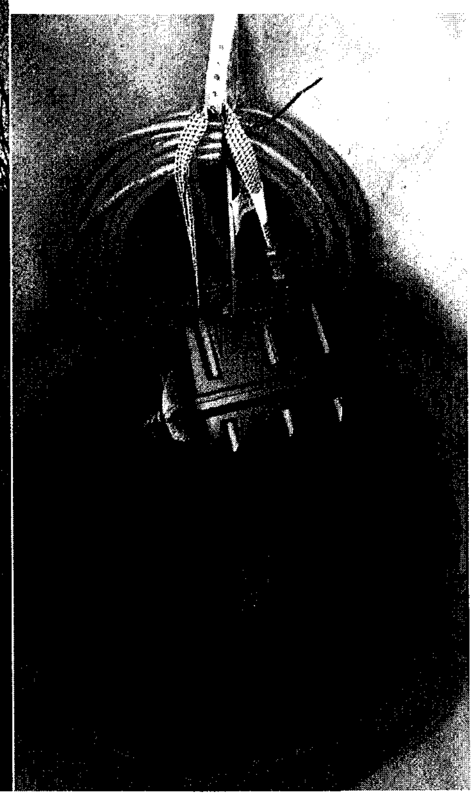


Struthers Manhole Installation Pictures

Site 7 (MH G56)







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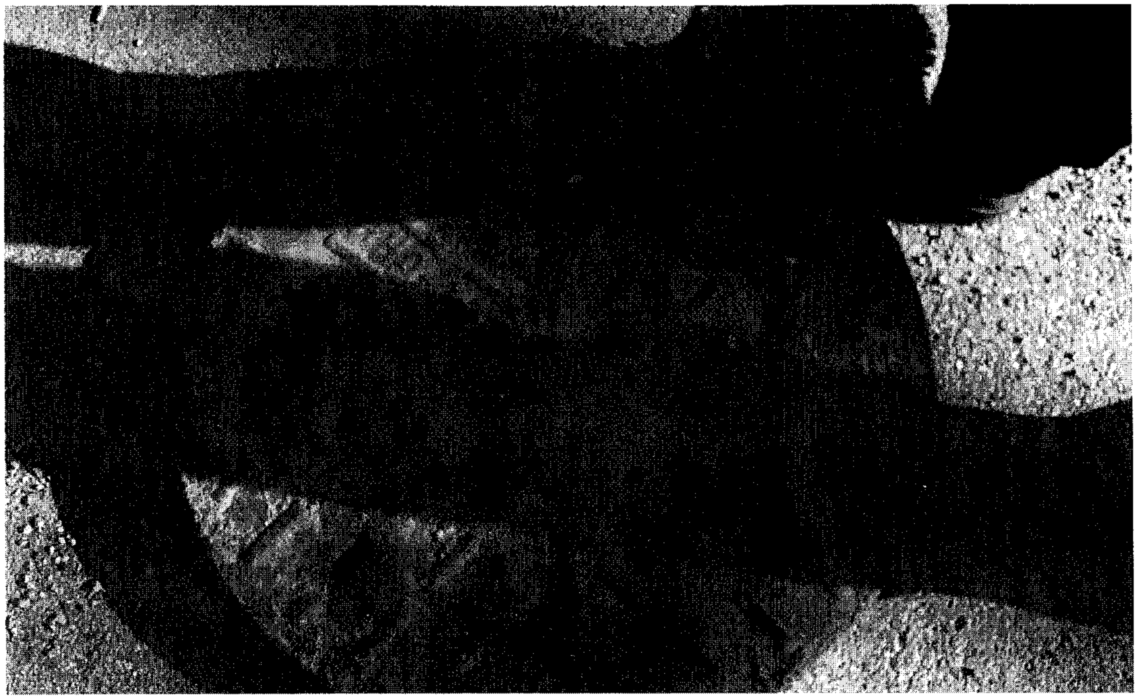
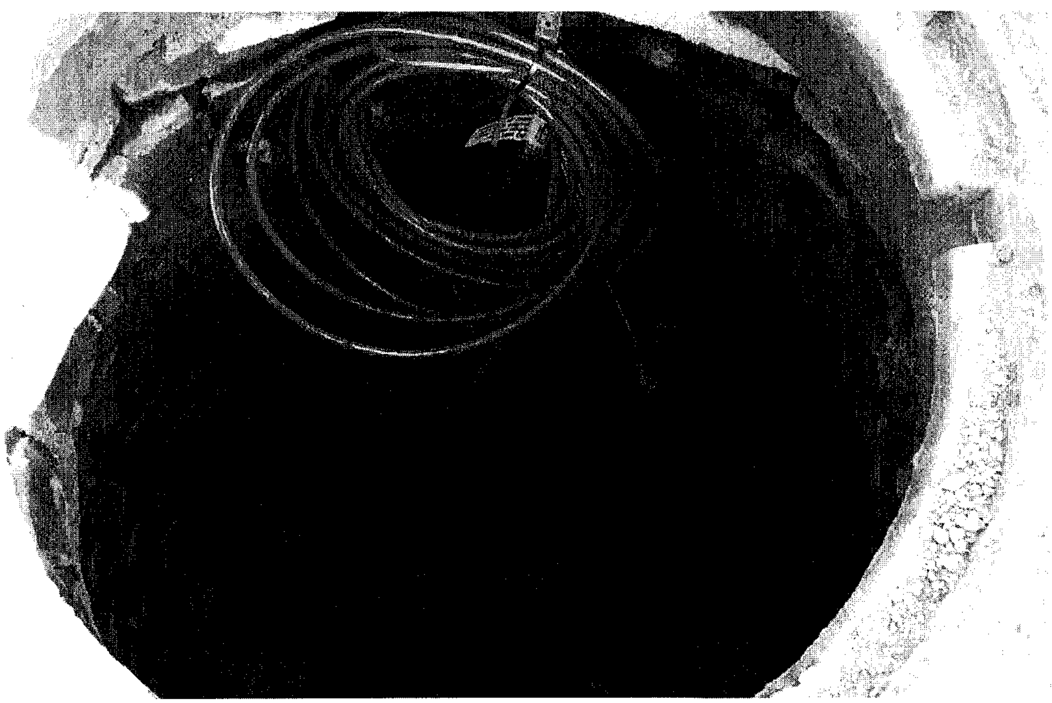
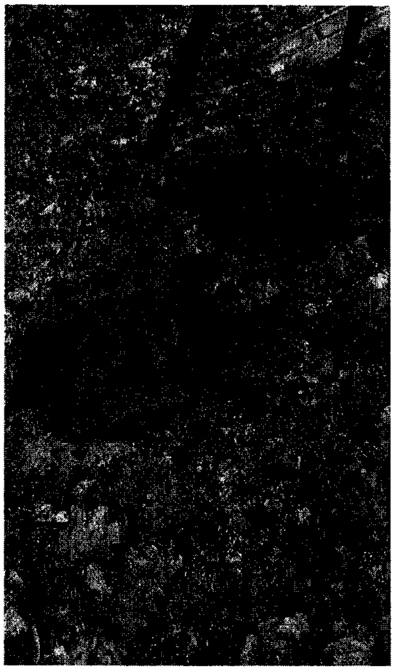




Struthers Manhole Installation Pictures

Site 9 (MH H5A)



Struthers Manhole Installation Pictures

Site 10 (MH F9)