

Technical Memorandum

**Phase 1 Part 2 CSO Control Plan
Wellington Avenue CSO Facility**

**Flow Isolation and Follow Up Closed Circuit
Television Inspection**

Prepared for:

City of Newport
Public Works Department
70 Halsey Street
Newport, RI 02840

Prepared by:

Earth Tech, Inc.
300 Baker Avenue, Suite 290
Concord, Massachusetts 01742-2167

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J.N. 82372

INTRODUCTION

This Flow Isolation and Follow Up Closed Circuit Television Inspection Technical Memorandum (TM) has been prepared to describe the investigation procedure used, results of the investigation, and recommendations for rehabilitation of observed defects.

DESCRIPTION OF NEWPORT SEWER SYSTEM

The city of Newport sanitary sewer system that services the priority infiltration Sewer Catchment Areas is comprised primarily of vitrified clay, asbestos cement, and polyvinyl chloride (PVC) pipe. The larger pipes and transmission sewer mains are typically larger diameter vitrified clay pipe or brick sewers, similar to the Thames Street Interceptor. The pipe size typically ranges from 8-inch to 12-inch collector lines and 15-inch or larger transmission or interceptor lines.

FLOW ISOLATION PROCEDURES

The purpose of flow isolation is to further identify segments of sewer that contribute to a system's infiltration problem. Flow isolation was conducted within the priority infiltration Catchment Areas 3, 4, and 7. The flow isolation gauging incorporated the use of portable pre-calibrated weirs placed in the downstream manhole of each line segment to record the infiltration. The upstream portion of each sewer segment was plugged when possible to obtain an infiltration reading for that segment. The flow isolation procedure is shown in Figure 1. Flow isolation is typically performed during low flow periods (e.g. 12 Am to 6 Am) to reduce the amount of service flow entering the line being measured and artificially increasing the observed flow. Observed flow are compared from one area to another by normalizing infiltration volume by the length and diameter of sewer pipe in the study or catchment area using the following sample calculation using Victoria Avenue between manholes 142-3 and 142-9:

Gallons Per Inch Diameter Mile

$$GPDIM = [Measured\ Flow\ (gpd) / Diameter\ (in.)] \times [(5,280\ feet/mile) / Pipe\ Length\ (ft)]$$

For Victoria Avenue between 142-3 and 142-9

$$(1440\ gpd / 8") \times (5,280\ ft/mi / 150\ ft) = 6,336\ GPDIM$$

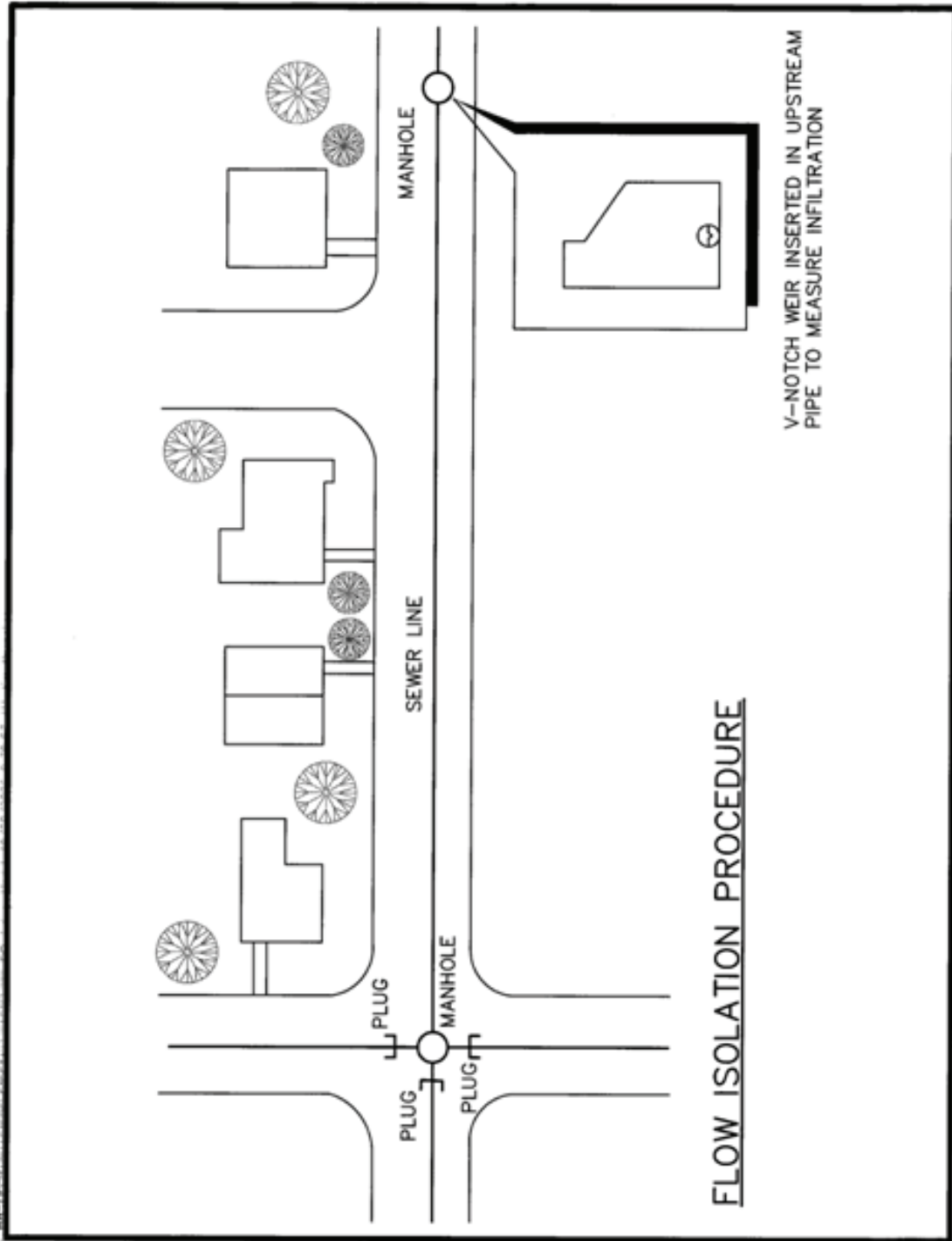


Figure 11
FLOW ISOLATION PROCEDURE
NOT TO SCALE

Flow isolation was performed between April 20, 2006 and April 28, 2006 and follow up flow isolation was performed June 13, 2006. ADS' flow isolation and instantaneous flow measurement reports are presented in Appendix A.

FLOW ISOLATION RESULTS

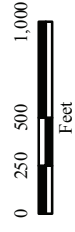
The flow isolation was performed in two segments due to concerns regarding weather and groundwater levels. The results of the flow isolation performed between April 20, 2006 and April 28, 2006 were generally lower than the infiltration flows estimated in the Phase I Part I CSO Control Plan. The results of the April 20 to April 28, 2006 flow isolation measurements are presented in Tables 1, 2, and 3 organized by Catchment Area. Figure 2 presents the locations in the priority area that were flow isolated in April 2006.

The total infiltration flow observed in the 3 priority Catchment Areas during the initial flow isolation measurement was approximately 105,120 gallons per day (gpd). It is noted that the months of March and April 2006 were extremely dry with record low precipitation. Based on the results, further flow isolation measurements were postponed. In May and June, significant wet weather occurred and flow isolation measurements were restarted and completed on June 13, 2006.

As the overall infiltration flows measured were significantly lower than the 845,962 gallons per day (gpd) of estimated in the Phase I Part 1 Report, instantaneous flow measurements were performed in June 2006 at midstream and downstream locations to observe all upstream flow to determine if infiltration flow had increased from the April low flow that was observed. All flow tributary to the locations being measured was observed as no line plug was installed upstream of the location that was being measured. The results of the supplemental flow isolation measurements are presented in Tables 4, 5, and 6. Figure 2 also presents the location of the instantaneous flow isolation locations relative to the areas that were measured in April 2006. Due to the large line sections measured, the likelihood of service flows (e.g. wastewater) is increased. Since none of the upstream sections of the sanitary sewer pipe were plugged, a small volume of visible sewage indicates that base waste water flows were present and a significant number of sump pumps were later observed upstream of the instantaneous measurement location. Therefore, it is prudent to consider the flow's recorded in the following tables as extremely conservative representations of infiltration flow.



DECEMBER 2006



Legend

- Instantaneous Flow Measurement Location (June 2006) ●
- Flow Isolation Location (April 2006) —
- Buildings ■
- Docks ■
- Roads/Parking ■
- Water ■

FIGURE 2
FLOW ISOLATION
PHASE I PART 2 CSO CONTROL PLAN

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**Table 1 – Catchment Area 3
Flow Isolation Results
April 2006**

Location	From MH	To MH	Pipe Size (IN)	Length (FT)	Measured Infiltration Flow		Measured Infiltration Rate (GPDIM)
					(GPM)	(GPD)	
Victoria Avenue	142-3	142-9	8	150	1	1,440	6,336
Webster Street	119-26	120-31	12	331	2	2,880	3,828
Webster Street	120-29	120-30	18	184	0.5	720	1,148
Narragansett Avenue	113-79	113-78	8	60	0.1	144	1,584
Lawrence Avenue	120-36	120-32	24	155	0.25	360	511
Leroy Lane	130-6	119-27	12	819	0.5	720	387
Leroy Lane	119-27	120-33	12	605	0.5	720	524
Lawrence Avenue	120-33	131-14	24	221	0.5	720	717
Lawrence Avenue	131-14	131-13	24	310	0.5	720	511
Ochre Point Avenue	EAST	131-9	6	240	3.5	5,040	18,480
Shepard Avenue	131-15	131-7	12	292	0.5	720	1,085
Shepard Avenue	131-10	131-11	8	201	0.5	720	2,364
Victoria Avenue	142-13	142-11	8	377	0.1	144	252
Spring Street	118-16	118-123	8	433	0.1	144	219
Morton Avenue	118-124	118-125	36	224	0.5	720	471
Earl Avenue	129-97	129-94	8	286	1	1,440	1,864
Vaughan Avenue	129-5	129-95	8	490	3	4,320	5,819
Vaughan Avenue	129-95	TEE	8	365	0.5	720	1,302
Weatherly Avenue ROW	140-55	140-51	8	319	0.1	144	298
Bateman Avenue	140-54	140-52	8	289	0.25	360	822
Bateman Avenue	140-52	140-53	8	169	1.75	2,520	9,841
Shepard Avenue	EAST	140-62	10	1360	0.1	144	56
Kerins Terrace	129-1	118-124.2	8	202	0.5	720	2,352
Kerins Terrace	140-63	129-1	8	225	0.5	720	2,112
Kerins Terrace	N. EAST	129-1	8	40	0.1	144	2,376
Kerins Terrace ROW	118-124.2	118-124.1	36	570	0.75	1,080	278
Kerins Terrace ROW	118-124.1	118-124	36	375	0.5	720	282
Ruggles Avenue	152-43	152-44	8	201	0.25	360	1,182
Weatherly Avenue	140-61	152-45	8	289	0.25	360	822
Ruggles Avenue	140-48.1	140-48	12	595	2.5	3,600	2,662
Ruggles Avenue	141-77	140-49	8	224	2	2,880	8,486
Ruggles Avenue	141-74	141-76	6	292	0.1	144	434
Spring Street	140-46	140-45	8	168	0.1	144	566
Carroll Avenue ROW	152-46	152-37	10	221	0.25	360	860
McCormick Road	152-36	152-37	8	251	0.25	360	947
McCormick Road	152-37	152-38	12	300	0.25	360	528
Ruggles Avenue	151-27	151-28	8	250	0.1	144	380
Florence Avenue	140-57	151-28	8	354	0.25	360	671
Ruggles Avenue	152-43.1	152-43	8	240	0.25	360	990
Shields Street	140-59	152-43	8	265	0.25	360	897
Carroll Avenue	163-67	163-66	8	225	0.25	360	1,056
Carroll Avenue	163-66	163-65	8	128	0.25	360	1,856
Carroll Avenue	163-65	163-72	8	212	0.25	360	1,121
Carroll Avenue	151-30	151-32	8	339	0.25	360	701
					28.9	40,176	

**Table 2 – Catchment Area 4
Flow Isolation Results
April 2006**

Location	From MH	To MH	Pipe Size (IN)	Length (FT)	Measured Infiltration Flow		Measured Infiltration Rate (GPDIM)
					(GPM)	(GPD)	
Brenton Road	SOUTH	127-49	8	120	2	2,880	15,840
Harrison Avenue	127-53	127-52	8	276	0.5	720	1,200
Chastellux Avenue	127-66	127-56	8	105	0.25	360	2,263
Halidon Avenue	116-82	116-81	8	332	0.5	720	1,431
Halidon Avenue	116-80	108-19	10	350	0.5	720	1,086
Wellington Avenue	108-19	108-18.1	10	200	0.25	360	950
Wellington Avenue	108-18.1	108-18	10	209	0.25	360	909
Wellington Avenue	109-35	109-24	15	219	0.5	720	1,157
Roseneath Avenue	117-88.1	117-95.1	8	342	0.25	360	695
Connection Street	117-95.1	117-95	8	282	0.5	720	1,685
Connection Street	WEST	117-95.1	8	180	0.25	360	1,320
Connection Street	117-95	117-107	8	388	0.25	360	612
Eastnor Road	128-84	128-77	8	259	0.2	288	734
Eastnor Road	128-78	128-77	8	247	0.25	360	962
Marchant Street	128-77	128-76	18	226	0.25	360	467
Atlantic Street	129-2	128-76	8	364	0.25	360	653
Connection Street	118-10	117-107	8	302	2	2,880	6,294
Marchant Street	117-107	117-106	12	145	0.5	720	2,185
Lucas Avenue	117-109	117-106	8	489	3	4,320	5,831
Marchant Street	117-106	117-103	12	156	0.5	720	2,031
Potter Street	118-4	117-103	8	575	2	2,880	3,306
Carey Street	118-118	118-119	8	212	1	1,440	4,483
Carey Street	118-117	118-118	8	200	1	1,440	4,752
Carey Street	EAST	118-117	8	120	2	2,880	15,840
Marchant Street	117-103	117-102	12	174	0.5	720	1,821
Stockholm Street	117-104	117-102	8	58	0.5	720	8,193
Stockholm Street	117-105	117-104	8	181	0.25	360	1,313
Stockholm Street	118-126	117-105	8	292	0.25	360	814
West Narragansett Avenue	118-3	117-100	8	557	1.5	2,160	2,559
West Narragansett Avenue	117-85.1	117-85	8	306	0.5	720	1,553
West Narragansett Avenue	117-85	117-99	8	228	1	1,440	4,168
Thames Street	NORTH	118-1	12	660	0.5	720	480
Clinton Street	117-94	117-93	10	59	0	0	0
Clinton Street	117-93	117-92	10	305	0.25	360	623
Clinton Street	117-92	117-90	10	263	0.25	360	723
Clinton Street	109-34	109-35	10	326	2	2,880	4,665
Houston Avenue	117-95	117-108	12	298	0.5	720	1,063
Houston Avenue	109-36	109-35.1A	12	257	0.5	720	1,233
Conrad Court	WEST	117-97	8	140	0.25	360	1,697
Gilles Court	117-89	117-96	8	160	0.5	720	2,970
Roseneath Avenue	117-96	109-29	10	333	0.25	360	571
Roseneath Avenue	109-29	109-32	10	335	0.25	360	567
West Narragansett Avenue	WEST	117-91	8	225	2	2,880	8,448
Total					30.7	44,208	

**Table 3 – Catchment Area 7
Flow Isolation Results
April 2006**

Location	From MH	To MH	Pipe Size (IN)	Length (FT)	Measured Infiltration Flow		Measured Infiltration Rate (GPDIM)
					(GPM)	(GPD)	
Ruggles Avenue	150-18	150-17	8	345	0.25	360	689
Old Fort Road	139-40	151-33	8	304	0.2	288	625
Ernest Street	139-31	139-30	8	71	0.1	144	1,339
Old Fort Road	139-41	139-40	8	211	0.2	288	901
Old Fort Road	139-42	139-37	8	280	0.25	360	849
Harold Street	139-36	TEE	8	46	0.75	1,080	15,496
Harold Street	SOUTH	139-36	8	150	0.1	144	634
Harold Street	139-35	139-36	8	169	0.15	216	844
Palmer Street	128-71	128-73	10	180	0.5	720	2,112
Gilroy Street	NORTH	128-71	8	375	0.15	216	380
Palmer Street	128-72	128-71	10	191	0.75	1,080	2,986
Stacey Street	139-39	128-72	8	232	0.25	360	1,024
Norman Street	139-38	139-39	8	252	0.25	360	943
Palmer Street	128-68	128-72	10	250	1.5	2,160	4,562
Palmer Street ROW	128-68.2	128-68.1	10	500	0.5	720	760
Old Fort Road	128-73	128-74	10	174	0.5	720	2,185
Old Fort Road	128-74	128-75	10	101	0.25	360	1,882
Old Fort Road	128-75	128-79.1	10	221	0.25	360	860
Bateman Avenue	129-96	128-80	8	420	0.25	360	566
Carroll Avenue	139-43	128-80	10	525	3	4,320	4,345
Florence Avenue	140-58	140-64	8	165	0.25	360	1,440
Carroll Avenue	128-79	129-3	15	337	0.5	720	752
Carroll Avenue	129-3	129-4	15	301	0.5	720	842
Harrison Avenue	128-88.1	128-88	8	292	2	2,880	6,510
Sullivan Street	127-57	127-60	8	280	1	1,440	3,394
					14.4	20,736	

**Table 4 – Catchment Area 3
Supplemental Instantaneous Flow Measurement Results
June 2006**

Location	From MH	To MH	Pipe Size (IN)	Observed Flow	
				(GPM)	(GPD)
Morton Avenue near Earl Avenue	East	118-125	28"X38"	881	1,268,640
Lawrence Ave at Sheppard Avenue	North	131-7	24	171	246,240
Lawrence Ave at Sheppard Avenue	East	131-7	12	3	4,320
Lawrence Ave at Sheppard Avenue	West	131-7	8	0.5	720
Bateman Street at Vanderbilt Avenue	West	140-52	8	3	4,320
Carroll Avenue	North	151-32	8	6	8,640
Carroll Avenue	South	151-32	8	3	4,320
McCormick Street	West	152-38	12	20	28,800
Ruggles Avenue at Shields Street	North	152-43	8	4	5,760
Ruggles Avenue at Shields Street	West	152-43	8	8	11,520

No total is provided as some measurement locations are downstream of other locations which would inflate the infiltration flow by counting flow twice.

**Table 5 – Catchment Area 4
Supplemental Instantaneous Flow Measurement Results
June 2006**

Location	From MH	To MH	Pipe Size (IN)	Observed Flow	
				(GPM)	(GPD)
Wellington Avenue at Chastellux Avenue	West	108-18	10	35	50,400
Marchant Street at Simmons Street	East	109-24.1	12	15	21,600
Marchant Street at Grafton Street	East	109-22	8	18	25,920
Wellington Avenue at Marchant Street	West	109-24	15	130	187,200
Wellington Avenue at Marchant Street	South	109-24	10	140	201,600
Wellington Avenue at Roseneath Avenue	South	109-32	10	8	11,520
Marchant Street at Connection Street	South	117-107	18	30	43,200
Marchant Street at Connection Street	West	117-107	10	35	50,400
Houston Avenue, Mid-block between Connection Street and Narragansett Avenue	South	117-108	12	6	8,640

No total is provided as some measurement locations are downstream of other locations which would inflate the infiltration flow by counting flow twice.

**Table 6– Catchment Area 7
Supplemental Instantaneous Flow Measurement Results
June 2006**

Location	From MH	To MH	Pipe Size (IN)	Observed Flow	
				(GPM)	(GPD)
Old Fort Road near Palmer Street	West	128-73	10	15	21,600
Old Fort Road near Palmer Street	South	128-73	8	11	15,840
Carroll Avenue at Harrison Avenue	West	128-79	10	30	43,200
Carroll Avenue at Bateman Avenue	South	128-80	10	20	28,800
Carroll Avenue at Bateman Avenue	East	128-80	8	2	2,880
Carroll Avenue at Atlantic Street	Southwest	129-3	15	80	115,200

No total is provided as some measurement locations are downstream of other locations which would inflate the infiltration flow by counting flow twice.

Based on the results of the two flow isolation periods, Earth Tech selected segments of sanitary sewer to perform CCTV inspection. The following pipe segments selected for inspection were based on the quantity of observed infiltration flow observed in the flow isolation. For this study, this included any individual pipe segment with approximately 1 gpm or more infiltration flow or any pipe segment with a diameter in excess of 18-inches or an infiltration rate over 4000 gallons per inch diameter mile.

Table 7
Pipe Segments Selected for CCTV Inspection

Location	From MH	To MH	Location	From MH	To MH
Atlantic Street	128-76	117-86	Lawrence Avenue	142-4	142-3
Atlantic Street	129-2	128-76	Lawrence Avenue	142-3.1	142-3
Bateman Avenue	140-53	140-52	Lawrence Avenue	131-7	142-3.1
Bateman Avenue	140-54	140-52	Leroy Avenue	119-27	120-33
Carey Street	118-118	118-117	Leroy Avenue	119-27	130-6
Carey Street	118-118	118-119	Lucas Avenue	117-106	117-109
Carey Street	118-117	STUB	Marchant Street	128-77	128-76
Carroll Avenue	151-30	151-32	McCormick Road	152-37	152-36
Carroll Avenue	163-66	163-65	McCormick Road	152-37	152-38
Carroll Avenue	163-67	163-66	Morgan Street	128-69	T-IN
Carroll Avenue	163-65	163-72	Morgan Street	128-69	128-72
Carroll Avenue	139-43	128-80	Morton Avenue Easement	118-124.2A	118-124.1
Carroll Avenue Easement	151-32	151-35	Morton Avenue Easement	118-124.2	118-124.2A
Carroll Avenue Easement	152-37	152-46	Narragansett Avenue	112-69.1	T-IN
Carroll Avenue Easement	151-35	152-47	Narragansett Avenue	112-69.1	112-68
Carroll Avenue Easement	152-46	152-47	Narragansett Avenue	112-68	113-78
Clinton Street	109-34	109-35	Narragansett Avenue	113-78	113-79
Clinton Street	117-90	109-34	Norman Street	139-39	139-38
Clinton Street	117-92	117-90	Ochre Point Avenue	131-9	131-9.1
Clinton Street	117-92	117-93	Ochre Point Avenue	131-8	131-9
Connection Street	118-10	117-107	Old Fort Road	139-37	128-73
Connection Street	117-95.1	STUB	Old Fort Road	128-75	128-74
Connection Street	117-95.1	117-95	Old Fort Road	128-73	128-74
Connection Street	117-107	117-95	Old Fort Road	128-75	128-79.1
Conrad Court	117-97	STUB	Old Fort Road	139-42	139-37
Earl Avenue	129-97	129-TEE	Palmer Street	128-72	128-68
Earl Avenue	129-94	129-STUB	Palmer Street	128-72	128-71
Florence Avenue	140-58	140-64	Potter Street	118-4	117-103
Florence Avenue	139-28	140-64	Richmond Place	139-36	STUB
Gilroy Street	128-71	STUB	Roseneath Avenue	109-29.1	109-29
Halidon Avenue	116-81	116-80	Roseneath Avenue	117-96	109-29.1
Halidon Avenue	116-82	116-81	Roseneath Avenue	109-29	109-32
Harold Street	139-36	139-TEE	Roseneath Avenue	117-97	117-96
Harold Street	139-36	139-35	Roseneath Avenue	117-97	117-98
Harrison Avenue	127-60	127-57	Ruggles Avenue	140-48	140-48.1
Harrison Avenue	128-88.1	128-88	Shepard Avenue	131-11	131-7
Houston Avenue	109-35.1A	109-35.1	Shepard Avenue	131-15	131-7
Houston Avenue	117-95	117-108	Shepard Avenue	131-10	131-11
Houston Avenue	109-35.1A	109-36	Shepard Avenue	131-8	131-15
Kerins Terrace	129-1	118-124.2	Stacey Street	139-39	128-72
Kerins Terrace Easement	129-1	140-63	Vanderbilt Avenue	140-51	140-55
Lawrence Avenue	120-36	120-32	Vaughan Avenue	129-95	129-5
Lawrence Avenue	120-32	120-33	Victoria Avenue	142-9	142-3
Lawrence Avenue	120-30	120-36	Webster Street	120-31	119-26
Lawrence Avenue	131-12	131-7	Webster Street	120-29	120-30
Lawrence Avenue	131-13	131-12	West Narragansett Avenue	117-91	STUB
Lawrence Avenue	131-14	131-13	West Narragansett Avenue	117-85	117-99
Lawrence Avenue	120-33	131-14	West Narragansett Avenue	118-3	117-100

CLOSED CIRCUIT TELEVISION (CCTV) INSPECTION PROCEDURES

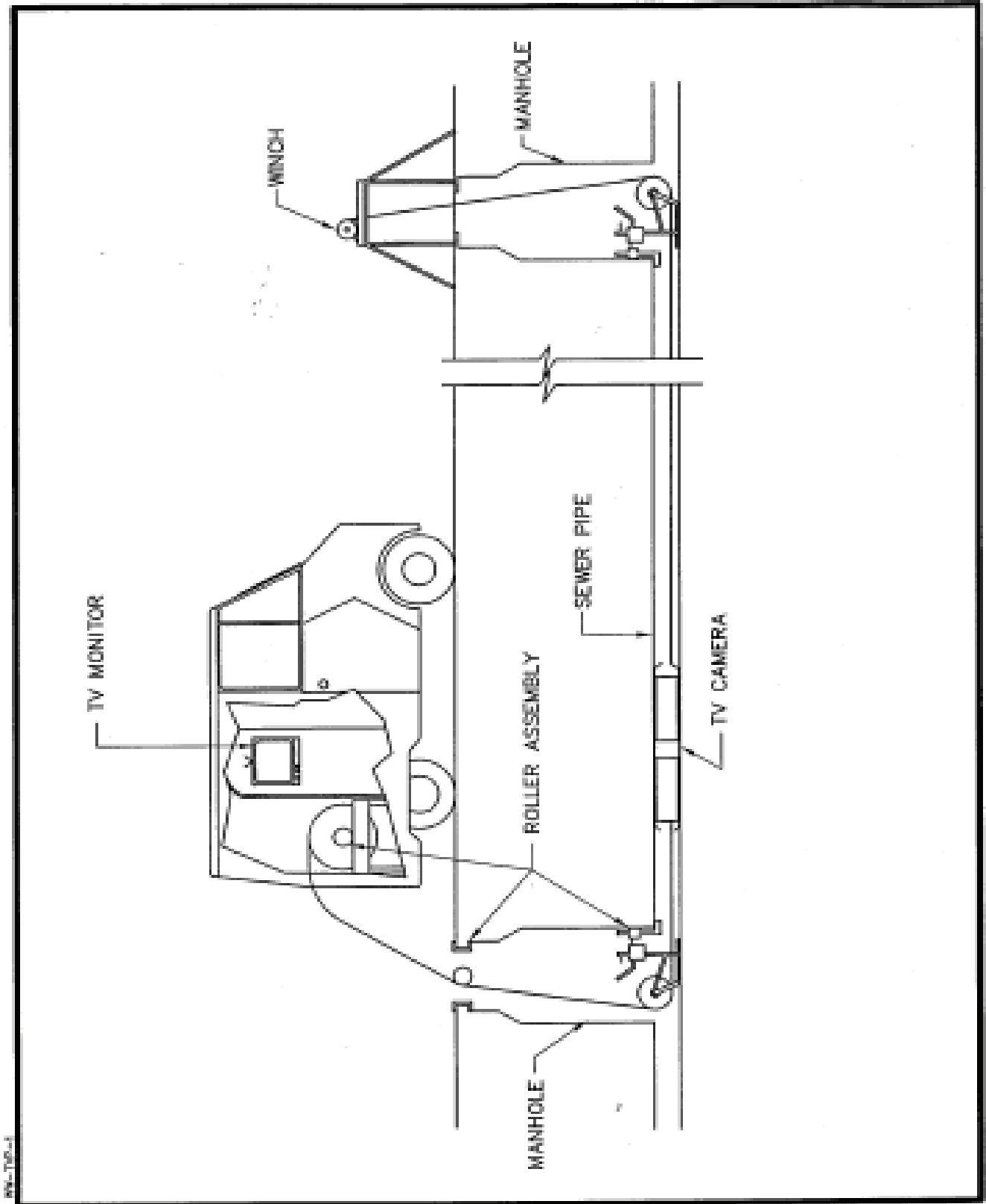
Based on the age of the system and the results of the flow isolation, the Phase I Part I CSO Control Plan included a recommendation that preparatory sewer line cleaning and internal television inspection be performed on selected segments of sanitary sewer. Television inspection allows the location of individual flow sources within these segments to be pinpointed, viewed and assessed. Television inspection was performed by ADS Environmental Services (formerly Severn Trent Pipeline Services) under subcontract to Earth Tech (ET), between May 23, 2006 and September 5, 2006.

During this procedure, the sewer pipe was first pressure cleaned to facilitate the movement of the television camera through the pipe. The camera used was a track-operated device with pan and tilt capability (Figure 3). Infiltration sources in each segment were pinpointed by viewing television footage and observing leaking joints, cracked and broken pipes, leaking services, sagging pipes, mineral deposits, etc. The television inspection determined the specific location, condition and observed the estimated flow rate of the sources of infiltration within the line sections. Television inspection also allowed the estimation of flow from running or leaking services. Appendix A presents a summary of the television inspection performed showing the length of sewer televised; the major defects encountered and the infiltration found; and the individual CCTV inspection logs documented by ADS. The locations where CCTV inspections were performed are shown on Figure 4.

CCTV INSPECTION RESULTS

Earth Tech reviewed the television inspection logs, and the following general observations were noted. For service connection information, defects, and rehabilitation recommendations by length of pipe see Tables 8 through 47. For detailed information at individual locations, see the CCTV Inspection Report logs in Appendix A:

- Given its age, the Newport sanitary sewer system is generally in fair condition.
- 593 service connections were observed. The breakdown is as follows:
 - 215 service connections in good condition
 - 143 service connections capped
 - 139 service connections with constant clear water infiltration running introducing approximately 42,000 gpd of infiltration flow
 - 10 service connections in use at the time of the inspection



ENV-TAD-1

FIGURE 3
T.V. INSPECTION PROCEDURE
NOT TO SCALE



FIGURE 4
CCTV INSPECTION LOCATIONS
PHASE I PART 2 CSO CONTROL PLAN

- Legend**
- CCTV
 - Buildings
 - Docks
 - Roads/Parking
 - Water

0 250 500 1,000
 Feet

DECEMBER 2006

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- 14 infiltration at joints contributing approximately 5,700 gallons per day
- 64 cracked pipe joints
- 2 offset joints observed in service connections
- 10 offset joints observed in sanitary sewer main line pipe
- 18 multiple crack locations in sanitary sewer main line pipe
- 1 location in the sanitary sewer main line pipe with circular cracks
- 11 longitudinal cracks in sewer main
- 7 locations with broken pipe, 3 observed as repaired, 1 heavily crack, but generally intact, and 3 observed as failing (i.e. loose or missing piece of jagged pipe)
- 7 locations with holes in pipe, 3 observed as repaired and 4 observed as not repaired
- 44 locations with mineral deposits in the service connection
- 25 locations with mineral deposits in the sewer main line pipe
- 28 sewer main line pipe segments with mineral deposits throughout the entire pipe segment
- 1 service connection with light grease
- 30 locations with dirt and debris in the service connection. Occasionally obscuring the camera's view of the service connection.
- 7 locations with light root growth in the service connection
- 28 locations with light root growth in the sewer main line pipe
- 7 pipe segments with light root growth throughout the entire pipe segment
- 2 locations with moderate root growth in the service connection
- 1 location with moderate root growth in the sanitary sewer main line pipe
- 1 location with heavy root growth in the service connection
- 3 locations with heavy root growth in the sanitary sewer main line pipe
- 6 service connections observed with a pipe sag
- 55 locations with sags in the sewer main pipe
- 2 misaligned pipe segments

OBSERVATIONS AND EVALUATIONS

Based on the observations made during the CCTV inspection of the sanitary sewer within the priority infiltration catchment areas, Earth Tech presents the following evaluations and recommendations and preliminary cost estimates to repair only the defects noted. The costs presented are only the costs to repair the defects noted and not to perform more comprehensive repairs to sanitary sewer lines that may require

additional rehabilitation. It should also be noted that many of these repairs should be combined into a larger rehabilitation project to avoid premium mobilization costs to perform a small number of repairs.

Service Connections

Service Connections in good condition or capped service connections require no action at this time. These service connections are shown in Tables 8 and 9.

Table 8 - Service Connections in Good Condition

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Narragansett Avenue	112-69.1	112-68	8	PVC	1
3	Webster Street	120-31	119-26	12	VCP	4
3	Webster Street	120-29	120-30	18	VCP	1
3	Lawrence Avenue	120-36	120-32	24	VCP	1
3	Leroy Avenue	119-27	120-33	12	VCP	3
3	Lawrence Avenue	120-30	120-36	24	VCP	1
3	Earl Avenue	129-97	129-TEE	8	VCP	1
3	Earl Avenue	129-94	129-STUB	10	VCP	4
3	Vaughan Avenue	129-95	129-5	8	VCP	7
3	Leroy Avenue	119-27	130-6	12	VCP	8
3	Lawrence Avenue	131-12	131-7	24	Brick	3
3	Lawrence Avenue	131-13	131-12	24	Brick	1
3	Lawrence Avenue	131-14	131-13	24	Brick	3
3	Lawrence Avenue	120-33	131-14	24	VCP	2
3	Ruggles Avenue	140-48	140-48.1	10	VCP	2
3	Bateman Avenue	140-54	140-52	8	VCP	3
3	Bateman Avenue	140-52	140-53	8	VCP	1
3	Vanderbilt Avenue	140-51	140-55	8	VCP	2
3	Kerins Terrace Easement	129-1	140-63	8	VCP	1
3	Lawrence Avenue	142-4	142-3	24	Brick	8
3	Lawrence Avenue	142-3.1	142-3	24	Brick	3
3	Carroll Avenue	151-30	151-32	8	VCP	7
3	McCormick Road	152-37	152-36	8	ACP	2
3	McCormick Road	152-37	152-38	12	DIP	3
3	Carroll Avenue Easement	152-37	152-46	10	VCP	1
3	Carroll Avenue	163-66	163-65	8	VCP	1
3	Carroll Avenue	163-65	163-72	8	VCP	1
4	Conrad Court	117-97	STUB	8	VCP	3
4	Roseneath Avenue	109-29.1	109-29	10	VCP	4
4	Roseneath Avenue	117-96	109-29.1	10	VCP	2
4	Roseneath Avenue	109-29	109-32	10	VCP/ACP	4
4	Clinton Street	109-34	109-35	10	VCP	1

Table 8 - Service Connections in Good Condition

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
4	Houston Avenue	109-35.1A	109-35.1	12	VCP	2
4	Houston Avenue	109-35.1A	109-36	12	VCP	1
4	Halidon Avenue	116-81	116-82	8	VCP	2
4	Clinton Street	117-92	117-90	10	VCP	2
4	Clinton Street	117-92	117-93	10	VCP	2
4	Connection Street	117-95.1	117-95	8	VCP	1
4	Roseneath Avenue	117-96	117-97	10	VCP	8
4	Roseneath Avenue	117-97	117-98	10	VCP	3
4	West Narragansett Avenue	118-3	117-100	10	VCP	12
4	Potter Street	118-4	117-103	12	VCP	3
4	Connection Street	118-10	117-107	10	VCP	7
4	Houston Avenue	117-95	117-108	12	VCP	6
4	Atlantic Street	129-2	128-76	6	VCP	1
4	Marchant Street	128-77	128-76	15	VCP	4
4	Atlantic Street	128-76	129-2	8	VCP	5
4	Carey Street	118-117	118-118	8	VCP	4
4	Carey Street	118-118	118-119	8	VCP	11
4	Carey Street	118-117	STUB	6	VCP	2
7	Gilroy Street	128-71	STUB	8	VCP	4
7	Morgan Street	128-69	T-IN	8	VCP	4
7	Palmer Street	128-72	128-71	10	VCP	3
7	Morgan Street	128-69	128-72	8	VCP	2
7	Palmer Street	128-68	128-72	10	VCP	1
7	Old Fort Road	139-37	128-73	8	VCP	6
7	Old Fort Road	128-74	128-75	10	VCP	3
7	Old Fort Road	128-73	128-74	10	VCP	4
7	Old Fort Road	128-75	128-79.1	10	VCP	2
7	Carroll Avenue	139-43	128-80	10	VCP	3
7	Harold Street	139-36	139-TEE	8	VCP	2
7	Old Fort Road	139-42	139-37	8	VCP	3
7	Norman Street	139-39	139-38	8	VCP	11
7	Florence Avenue	140-58	140-64	8	VCP	2
Total Service Connections in Good Condition						215

Table 9 - Service Connections Capped/Bricked

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Webster Street	120-31	119-26	12	VCP	2
3	Webster Street	120-29	120-30	18	VCP	1
3	Lawrence Avenue	120-36	120-32	24	VCP	1
3	Leroy Avenue	119-27	120-33	12	VCP	11
3	Leroy Avenue	119-27	130-6	12	VCP	8
3	Lawrence Avenue	131-12	131-7	24	Brick	3
3	Shepard Avenue	131-10	131-11	8	VCP	1
3	Lawrence Avenue	131-13	131-12	24	Brick	1
3	Lawrence Avenue	131-14	131-13	24	Brick	1
3	Lawrence Avenue	142-4	142-3	24	Brick	4
3	Lawrence Avenue	142-3.1	142-3	24	Brick	4
4	Connection Street	117-95.1	STUB	8	VCP	1
4	Conrad Court	117-97	STUB	8	VCP	3
4	Roseneath Avenue	109-29.1	109-29	10	VCP	4
4	Roseneath Avenue	117-96	109-29.1	10	VCP	4
4	Roseneath Avenue	109-29	109-32	10	VCP	4
4	Clinton Street	117-90	109-34	10	VCP	2
4	Houston Avenue	109-35.1A	109-35.1	12	VCP	1
4	Houston Avenue	109-35.1A	109-36	12	VCP	5
4	Atlantic Street	128-76	117-86	8	VCP	1
4	Clinton Street	117-92	117-90	10	VCP	2
4	Clinton Street	117-92	117-93	10	VCP	2
4	Connection Street	117-95.1	117-95	8	VCP	3
4	Roseneath Avenue	117-96	117-97	10	VCP	9
4	Roseneath Avenue	117-97	117-98	10	VCP	2
4	West Narragansett Avenue	118-3	117-100	10	VCP	1
4	Potter Street	118-4	117-103	12	VCP	5
4	Houston Avenue	117-95	117-108	12	VCP	4
4	Marchant Street	128-77	128-76	15	VCP	3
4	Atlantic Street	128-76	129-2	6	VCP	8
4	Carey Street	118-117	118-118	8	VCP	4
4	Carey Street	118-118	118-119	8	VCP	6
4	Carey Street	118-117	STUB	6	VCP	7
7	Morgan Street	128-69	T-IN	8	VCP	7
7	Old Fort Road	139-37	128-73	8	VCP	3
7	Carroll Avenue	139-43	128-80	10	VCP	8
7	Harrison Avenue	128-88	128-88.1	8	VCP	5
7	Norman Street	139-39	139-38	8	VCP	2
Total Service Connections Capped/Bricked						143

Service Connections Running Constant Clear Water Flow (Running Services)

139 running services were observed during the CCTV inspection in 56 segments of the sanitary sewer system presented in Table 10. Based on the visual estimation of flow from the running services as observed in the CCTV inspection by ADS, the running services contribute approximately 42,000 gpd.

Additional investigation of the sewer service would be required to isolate leaking joints or failing pipe, the following outlines the steps involved in locating and eliminating infiltration flow from the running services.

- CCTV of the service line may assist in locating damaged or leaking connections or cracked or damaged pipe in the service, but this method cannot be used where there is no access to a cleanout at the building and the service pipe connection to the mainline sewer.
- If a running service is determined to be the result of leaking joints or minor damage to the service pipe, testing and sealing joints with a mechanical packer or short liner (lining approximately 3 feet) installations can be performed. Both methods typically require that the service pipe be 6 inches in diameter or greater and require access to either end of the service. Short liners and joint sealing also typically require that the area of damage is visible to the eye or located by CCTV inspection of the service pipe.
- Lining the complete length of a sewer service pipe will eliminate leakage and provide structural strength to the service pipe. Full length lining of the service connection, requires CCTV of the service pipe and access to the service pipe at the building. Full lining is advantageous in areas where the service pipe is in congested utility corridors and excavation and bury installation methods would be difficult.
- Excavation and replacement of a service does not require CCTV or access at either end of a service pipe. Though, there is disturbance of the area in the vicinity of the excavation, the work typically lasts only a few days.

Table 10 - Service Connections Running Constant Clear Water

Catchment Area	Location	From MH	To MH	Pipe Information		Number	Estimated Flow (gpm)	Estimated Flow (gpd)
				Size (In.)	Material			
3	Kerins Terrace	129-1	118-124.2	8	VCP	3	0.73	1,051.2
3	Morton Avenue Easement	118-124.1	118-124.2A	36x24	Brick	1	1.00	2,160
3	Webster Street	120-31	119-26	12	VCP	3	1.50	2,160

Table 10 - Service Connections Running Constant Clear Water

Catchment Area	Location	From MH	To MH	Pipe Information		Number	Estimated Flow (gpm)	Estimated Flow (gpd)
				Size (In.)	Material			
3	Webster Street	120-29	120-30	18	VCP	1	0.50	720
3	Lawrence Avenue	120-36	120-32	24	VCP	1	0.50	720
3	Earl Avenue	129-94	129-STUB	10	VCP	3	0.45	648
3	Vaughan Avenue	129-95	129-5	8	VCP	10	2.38	3,427.2
3	Leroy Avenue	119-27	130-6	12	VCP	2	0.20	288
3	Shepard Avenue	131-15	131-7	12	VCP	1	0.10	144
3	Shepard Avenue	131-10	131-11	8	VCP	1	0.13	187.2
3	Lawrence Avenue	120-33	131-14	24	VCP	1	0.25	360
3	Lawrence Avenue	131-14	131-13	24	Brick	4	0.89	1,281.6
3	Bateman Street	140-54	140-52	8	VCP	1	0.13	187.2
3	Bateman Street	140-52	140-53	8	VCP	1	0.25	360
3	Vanderbilt Avenue	140-51	140-55	8	VCP	1	0.10	144
3	Kerins Terrace Easements	129-1	140-63	8	VCP	1	0.10	144
3	Lawrence Avenue	142-4	142-3	24	Brick	2	1.00	1,440
3	Lawrence Avenue	142-3.1	142-3	24	Brick	4	0.61	878.4
3	Carroll Avenue	151-30	151-32	8	VCP	1	0.25	360
3	Carroll Avenue Easement	151-32	151-35	10	VCP	1	0.10	144
3	McCormick Road	152-37	152-36	8	ACP	1	0.10	144
SUBTOTAL FOR AREA 3						44	11.27	16,948.8
4	Roseneath Avenue	109-29.1	109-29	10	VCP	1	0.10	144
4	Roseneath Avenue	109-29	109-32	10	VCP	4	0.43	619.2
4	Clinton Street	117-90	109-34	10	VCP	3	0.45	648
4	Clinton Street	109-34	109-35	10	VCP	4	1.23	1,771.2
4	Houston Avenue	109-35.1A	109-35.1	12	VCP	1	0.10	144
4	Houston Avenue	109-35.1A	109-36	12	VCP	7	0.70	1,008
4	Clinton Street	117-92	117-90	10	VCP	1	0.25	360
4	Clinton Street	117-92	117-93	10	VCP	1	0.13	187.2
4	Connection Street	117-95.1	117-95	8	VCP	8	1.50	2,160
4	Roseneath Avenue	117-96	117-97	10	VCP	6	1.03	1,483.2
4	Roseneath Avenue	117-96	109-29.1	10	VCP	1	0.10	144
4	Roseneath Avenue	117-97	117-98	10	VCP	2	0.20	288
4	Conrad Court	117-97	Stub	8	VCP	1	0.10	144
4	West Narragansett Avenue	117-85	117-99	8	VCP	2	0.20	288
4	West Narragansett Avenue	118-3	117-100	10	VCP	6	1.46	2,102.4
4	Potter Street	118-4	117-103	12	VCP	3	0.45	648
4	Connection Street	118-10	117-107	10	VCP	2	0.35	504
4	Marchant Street	128-77	128-76	15	VCP	1	0.10	144
4	Atlantic Street	128-76	129-2	6	VCP	4	0.43	619.2
4	Carey Street	118-117	118-118	8	VCP	2	0.60	864
4	Carey Street	118-118	118-119	8	VCP	5	1.15	1,656
4	Carey Street	118-117	Stub	6	VCP	5	1.08	1,555.2
SUBTOTAL FOR AREA 4						70		17,481.6

Table 10 - Service Connections Running Constant Clear Water

Catchment Area	Location	From MH	To MH	Pipe Information		Number	Estimated Flow (gpm)	Estimated Flow (gpd)
				Size (In.)	Material			
7	Morgan Street	128-69	T-IN	8	VCP	4	0.95	1,368
7	Harrison Avenue	127-60	127-57	8	VCP	1	0.50	720
7	Palmer Street	128-72	128-68	10	VCP	1	0.10	144
7	Morgan Street	128-69	128-72	8	VCP	2	0.35	504
7	Stacey Street	139-39	128-72	8	VCP	3	0.73	1,051.2
7	Old Fort Road	139-37	128-73	8	VCP	2	0.35	504
7	Old Fort Road	128-74	128-75	10	VCP	2	0.20	288
7	Old Fort Road	128-75	128-79.1	10	VCP	1	0.10	144
7	Carroll Avenue	139-43	128-80	10	VCP	1	0.10	144
7	Harrison Avenue	128-88	128-88.1	8	VCP	4	0.95	1,368
7	Harold Street	139-36	139-35	8	VCP	2	0.20	288
7	Norman Street	139-39	139-38	8	VCP	1	0.13	187.2
7	Florence Avenue	140-58	140-64	8	VCP	1	0.50	720
SUBTOTAL AREA 7						25		7,430.4
Total Service Connections Running Clear Water						139		41,860.8

Running clear water flows from service connections are assumed to be infiltration generated on private property. It should be noted that some of this flow may be generated by sump pumps connected to the sanitary sewer system. Although removal of this infiltration will positively impact the overall capacity of the sanitary sewer system, it has been determined in this phase of work that a majority of the extraneous flow to the collection system is from inflow sources.

The City should consider developing a program to coordinate repair or replacement of service connections with the private property owner. Repairs and replacement of service connections should be considered with work to be undertaken under the long term remediation recommendations outlined later in this Technical Memorandum.

Service Connections Observed In Use

Connections observed flowing sanitary sewage at the time of the CCTV inspection (Table 11) can mask infiltration flow. However, due to the small number of service connections and small volumes of flowing sewage at the time of inspection, no action is recommended at this time.

Table 11 - Service Connections Observed In Use

Catchment Area	Location	From MH	To MH	Pipe Information		
				Size (IN)	Material	Number
3	Morton Avenue Easement	118-124.1	118-124.2A	36 x 28	Brick	1
3	Earl Avenue	129-97	129-TEE	8	VCP	1
3	Earl Avenue	129-94	129-STUB	10	VCP	1
3	Leroy Avenue	119-27	130-6	12	VCP	1
3	Lawrence Avenue	142-4	142-3	24	VCP	1
3	Carroll Avenue Easement	151-35	151-47	10	VCP	1
4	Clinton Street	109-34	109-35	10	VCP	2
4	Roseneath Avenue	117-96	117-97	10	VCP	1
7	Potter Street	118-4	117-103	12	VCP	1
Total Service Connections In Use						10

Infiltration at Service Connection and Mainline Sewer Joints

Infiltration at service connections was observed at 14 locations and is presented in Table 12. Leakage at the service connection is generally a result of missing or failed mortar around the service connection pipe at the main line sewer in a break-in type connection. Repair of infiltration at a service connection can typically be repaired using a gel type sealant and a mechanical packer in smaller diameter round pipe. The individual locations will be evaluated by Earth Tech in conjunction with a pipe rehabilitation specialist, such as ADS Environmental, prior to the repair to verify that the mainline pipe and the service connection pipe are in suitable condition for this type of repair. If the pipes are in poor condition or are deteriorating, excavation and replacement of the joint with a pre-molded tee may be required. The preliminary cost to repair the leaking joints is presented in Table 13.

Table 12 - Infiltration at Pipe Joints

Catchment Area	Location	From MH	To MH	Pipe Information			Length of Pipe Repair (lf)	Estimated* Infiltration (gpm)	Estimated* Infiltration (gpd)
				Size (In.)	Material	Number			
3	Kerins Terrace	129-1	118-124.2	8	VCP	2	4	0.20	288
3	Webster Street	120-31	119-26	12	VCP	2	6	0.20	288
3	Lawrence Avenue	120-32	120-33	24	VCP	1	7	1.00	1,440
4	Roseneath Avenue	109-29.1	109-29	10	VCP	2	4	0.63	907.2
4	West Narragansett Avenue	118-3	117-100	10	VCP	1	2	0.50	720
4	Marchant Street	128-77	128-76	15	VCP	1	2	0.10	144
4	Carey Street	118-117	STUB	6	VCP	2	4	1.00	1,440
7	Harrison Avenue	128-88	128-88.1	8	VCP	1	2	0.10	144
7	Harold Street	139-36	139-TEE	8	VCP	1	2	0.10	144
7	Harold Street	139-36	139-35	8	VCP	1	2	0.10	144
Total Location with Infiltration at Pipe Joints						14	35	3.93	5,659.2

* - Estimated inflow based on visual observations in the CCTV inspection by ADS

Table 13 – Estimated Cost to Repair Infiltration at Pipe Joints

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Test and Seal	Pipe in Acceptable Condition Contractor can Access to Repair Location with Equipment, cost to repair leaking joint equal sealing one length of pipe (i.e. 1 joint = 1 length of pipe)	Infiltration	\$ 30/LF	35	\$1,050
Subtotal					\$1,050
Contingency	25%	Infiltration	\$ 263	1	\$263
Engineering	15%	Infiltration	\$ 158	1	\$158
Total					\$1,470
Estimated Cost to Repair Infiltration at Service Connection Joint					\$1,500

Cracked Pipe Joints

Cracked pipe joints were observed at 64 locations and are presented in Table 14. Based on the observations during the inspection, the cracked joints generally did not appear to be leaking at the time of the inspection. Cracking in the joints of clay pipe may be a result of the installation or an early indication that the pipe is failing. Repair of the cracked joints to prevent infiltration would include a gel type sealant applied by a mechanical packer. However, if the pipe is failing, a short liner may be required to seal and structurally support the pipe segment. The city may also elect to monitor the pipe at set intervals to determine if the cracking is caused by a failure of the pipe. If the pipe is failing, a structural liner or

replacement of the pipe segment in part or in whole may be required. A preliminary cost estimate is provided below in Table 15.

Table 14 - Cracked Pipe Joints

Catchment Area	Location	From MH	To MH	Pipe Information			Length of Pipe Repair (lf)
				Size (In.)	Material	Number	
3	Kerins Terrace	129-1	118-124.2	8	VCP	2	4
3	Leroy Avenue	119-27	120-33	12	VCP	1	2
3	Vaughan Avenue	129-95	129-5	8	VCP	1	2
3	Leroy Avenue	119-27	130-6	12	VCP	1	2
3	Shepard Avenue	131-15	131-7	12	VCP	2	10
3	Kerins Terrace Easement	129-1	140-63	8	VCP	1	2
3	Carroll Avenue	163-67	163-66	8	VCP	2	4
4	Houston Avenue	109-35.1A	109-36	12	VCP	3	6
4	Connection Street	117-95.1	117-95	8	VCP	2	4
4	West Narragansett Avenue	118-3	117-100	10	VCP	13	26
7	Palmer Street	128-72	128-71	10	VCP	1	2
7	Stacey Street	139-39	128-72	8	VCP	1	2
7	Old Fort Road	139-37	128-73	8	VCP	3	6
7	Old Fort Road	128-73	128-74	10	VCP	2	4
7	Old Fort Road	128-75	128-79.1	10	VCP	1	2
7	Carroll Avenue	139-43	128-80	10	VCP	4	8
7	Old Fort Road	139-42	139-37	8	VCP	18*	36
7	Norman Street	139-39	139-38	8	VCP	1	2
7	Florence Avenue	140-58	140-64	8	VCP	5	10
Total Cracked Pipe Joints						64	98

* - This entire line segment will be replaced under Misaligned Pipe, therefore no repair is recommended under this item.

Table 15 – Estimated Cost to Repair Cracked Pipe Joints

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Test and Seal	Pipe in Acceptable Condition Contractor can Access to Repair Location with Equipment	Infiltration	\$ 30/LF	98	\$ 2,940
Short Liners (4 ft Sections)	Cracks at Joint Require Structural Support in addition to Leak Sealing, Crack is Less then 3 feet in Length	Infiltration	\$ 2,700/Ea	0	\$ 0
Subtotal					\$ 2,940
Contingency	25%	Infiltration	\$ 735	1	\$ 735
Engineering	15%	Infiltration	\$ 441	1	\$ 441
Total					\$ 4,116
Estimated Cost to Repair Cracked Pipe Joints					\$ 4,150

Offset Pipe Joints

Offset pipe joints were observed at 2 service connections and 10 locations within the sanitary sewer mainline pipe and are presented in Table 16 and 17, respectively. None of the joints appeared to be leaking at the time of the inspection. Offset joints can allow infiltration flow to enter the system during periods of high groundwater. Offset joints allow debris to become lodged and create build up in the sewer line reducing the flow area and capacity of the pipe segment. Earth Tech recommends that locations with minor offset joints be cleaned and monitored at regular intervals. Severe offset joints should be evaluated on a case by case basis to determine the infiltration potential at the joint, the current condition of the line, and the likelihood that a blockage may develop as a result of the offset joint. Severely offset joints should be replaced immediately to reduce the potential for blockages or other failure of the sanitary sewer system.

Table 16 - Offset Pipe Joints in the Service Connection

Catchment Area	Location	From MH	To MH	Pipe Information			Severity
				Size (In.)	Material	Number	
4	West Narragansett Avenue	118-3	117-100	10	VCP	1	Moderate to Severe
7	Morgan Street	128-69	T-IN	8	VCP	1	Minor
Total Offset Pipe Joints in Service Connections						2	

The City should consider developing a program to coordinate repair or replacement of service connections with the private property owner. Repairs and replacements of service connections should be performed with work to be undertaken under the long term remediation recommendations outlined later in this Technical Memorandum.

Table 17 - Offset Pipe Joints in the Sewer Main

Catchment Area	Location	From MH	To MH	Pipe Information			Length of Pipe Repair (lf)	Severity
				Size (In.)	Material	Number		
3	Kerins Terrace	129-1	118-124.2	8	VCP	1	4	Severe 3"
3	Vaughan Avenue	129-95	129-5	8	VCP	1	4	Minor
3	Vanderbilt Avenue	140-51	140-55	8	VCP	1	4	Minor 1"
3	Carroll Avenue Easement	151-35	152-47	10	VCP	1*	6	Minor 0.5"
4	West Narragansett Avenue	117-91	STUB	8	VCP	1**	4	Severe 3"

Table 17 - Offset Pipe Joints in the Sewer Main

Catchment Area	Location	Pipe Information				Number	Length of Pipe Repair (lf)	Severity
		From MH	To MH	Size (In.)	Material			
4	West Narragansett Avenue	117-99	117-85	8	VCP	1	10	Moderate 1.5"
4	Connection Street	117-95.1	117-95	8	VCP	1	4	Moderate 1"
4	Carey Street	118-117	118-118	8	VCP	1	4	Moderate 1"
7	Gilroy Street	128-71	STUB	8	VCP	1	4	Moderate 1"
7	Palmer Street	128-68	128-72	10	VCP	1	4	Moderate 1.5"
Total Offset Pipe Joints						10	38	

* - This entire line segment will be replaced under Misaligned Pipe, therefore no repair is recommended under this item.

** - This entire line segment will be replaced under Broken Pipe, therefore no repair is recommended under this item.

Table 18 - Estimated Cost to Repair Offset Main Line Pipe Joints

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Excavation and replacement of main line pipe	Pipe is in poor condition, cleaning equipment can not gain access to joint location, quantity is based on replacing 2 lengths of pipe (i.e. 2-ft joints = 4 lf pipe replacement)	Infiltration	\$ 175/LF	38	\$ 6,650
Subtotal					\$ 6,650
Contingency	25%	Infiltration	\$ 1,663	1	\$ 1,663
Engineering	15%	Infiltration	\$ 998	1	\$ 998
Total					\$ 9,310
Estimated Cost to Repair Offset Main Line Pipe Joints					\$9,400

Multiple Cracks in Service Connection Pipe/Sewer Main Pipe

Multiple cracks were observed at 18 locations, circular cracks at 1 location and longitudinal cracks were observed at 11 locations, all in the sewer main pipe, and are presented in Tables 19, 20 and 21, respectively. Multiple cracks, circular cracks and longitudinal cracks in the sewer main pipe permit infiltration flow to enter the sanitary sewer system during periods of high groundwater and may also be an indication of structural failure of the pipe. Earth Tech recommends that locations with cracked pipe segments be reevaluated with a pipe rehabilitation specialist on a case by case basis to determine the severity and extent of the cracks, overall condition of the pipe, and infiltration potential and feasibility of repairing the defect and based on the results of the reevaluation, determine the most cost effective method of remedying the defect, including chemical sealing (test and seal), a short liner in the affected area, or

excavation and replacement of the effected pipe lengths. In locations with less severe cracks and limited infiltration potential, the city may elect to continue to monitor the locations and include them in future capital improvement projects. A preliminary cost estimate to test and seal the defects is presented in Table 22.

Table 19 - Multiple Pipe Cracks in Service Connection

Catchment Area	Location	From MH	To MH	Pipe Information			Length of Pipe Repair (lf)
				Size (In.)	Material	Number	
3	Carroll Avenue Easement	151-35	152-47	10	VCP	1*	18
3	Carroll Avenue	163-67	163-66	8	VCP	2	38
3	Shepard Avenue	131-11	131-7	8	VCP	2	4
3	Shepard Avenue	131-10	131-11	8	VCP	1	2
4	West Narragansett Avenue	118-3	117-100	10	VCP	1	2
4	Marchant Street	128-77	128-76	15	VCP	1	2
4	Houston Avenue	109-35.1A	109-35.1	12	VCP	1	9
7	Morgan Street	128-69	T-IN	8	VCP	1	2
7	Palmer Street	128-72	128-71	10	VCP	1	2
7	Stacey Street	139-39	128-72	8	VCP	1	2
7	Carroll Avenue	139-43	128-80	10	VCP	1	2
7	Old Fort Road	139-42	139-37	8	VCP	4*	8
7	Florence Avenue	140-58	140-64	8	VCP	1	2
Total Service Connection with Multiple Pipe Cracks						18	67

* - This entire line segment will be replaced under Misaligned Pipe; therefore no repair will be performed under this item.

Table 20 – Circular Cracks in Sewer Main

Catchment Area	Location	From MH	To MH	Pipe Information			Length of Pipe Repair (lf)
				Size (In.)	Material	Number	
4	Carey Street	118-117	Stub	6	VCP	1	2
Total Locations with Circular Pipe Cracks						1	2

Table 21 - Longitudinal Crack in Sewer Main Pipe

Catchment Area	Location	Pipe Information					Length of Pipe Repair (lf)
		From MH	To MH	Size (In.)	Material	Number	
3	Kerins Terrace	129-1	118-124.2	8	VCP	1	2
3	Vaughan Avenue	129-95	129-5	8	VCP	1	4
3	Leroy Avenue	119-27	130-6	12	VCP	1	2
3	Shepard Avenue	131-11	131-7	8	VCP	1	4
3	Kerins Terrace Easement	129-1	140-63	8	VCP	3	15
4	Houston Avenue	109-35.1A	109-36	12	VCP	3	19
7	Old Fort Road	128-75	128-79.1	10	VCP	1	7
Total Locations with Longitudinal Pipe Cracks						11	53

Table 22 - Estimated Cost to Repair Cracks in Sewer Main

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Test and Seal	Pipe in Acceptable Structural Condition Contractor can Access to Repair Location with Equipment	Infiltration	\$ 30/LF	122	\$ 3,660
Subtotal					\$ 3,660
Contingency	25%	Infiltration	\$ 915	1	\$ 915
Engineering	15%	Infiltration	\$ 550	1	\$ 550
Total					\$ 5,125
Estimated Cost to Repair Cracks in Sewer Main Pipe					\$ 5,150

Broken Sewer Pipe

Sections of broken sewer pipe were observed at 7 locations and are presented in Table 23. Three of the sections of broken pipe appear to have been previously repaired; however, three of the locations are currently failing and one section on Stacey Street appears to have heavy cracking but is generally intact and does not appear to be collapsing or failing and the pipe is round and intact. Earth Tech recommends that the three failing broken pipe sections be excavated and replaced immediately to prevent a complete failure and a resultant blockage of the line and upstream tributary area. A short in-situ structural liner may be the most effective means to maintain the broken section of pipe that is still intact, however, additional cracked joints and multiple cracks (shown in the above tables) may indicate pipe failure. Also using short liners will result in a loss of capacity in the line section as a result of reduction in the cross-sectional area in the pipe. The pipe section on Stacey Street should be reevaluated by Earth Tech in conjunction with a pipe rehabilitation specialist to determine the feasibility of repairing the defective pipe section with a short liner and to verify that the pipe has adequate flow capacity prior to the installation of the short liner.

Broken pipe sections where the pipe has failed shall be removed and replaced by open trench excavation. The repair should include the damaged section and one length of pipe upstream and downstream of the failed section. A preliminary cost estimate to repair the four broken pipe sections is shown in Table 24.

Table 23 - Broken Sewer Main Pipe

Catchment Area	Location	From MH	To MH	Pipe Information			Condition	Length of Pipe Repair (lf)
				Size (In.)	Material	Number		
3	Shepard Avenue	131-10	131-11	8	VCP	1	Repaired	0
3	Bateman Avenue	140-54	140-52	8	VCP	1	Failing	6
4	West Narragansett Avenue	117-91	Stub	8	VCP	1	Failing	226*
4	Roseneath Avenue	117-96	109-29.1	10	VCP	1	Repaired	0
4	Clinton Street	117-90	109-34	10	VCP	1	Repaired	0
7	Atlantic Street	128-76	117-86	8	VCP	1	Failing	6
7	Stacey Street	139-39	128-72	8	VCP	1	Intact	3
Total Locations with Broken Sewer Main Pipe						7		241

* - Heavily offset joints were visible through the broken pipe section; assume that entire length of stub to be replaced.

Table 24 - Estimated Cost to Replace Broken Pipe Sections

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Short Liner (Approx. 4 ft)	Suitable for damage at Stacey Street location, pipe in acceptable condition, contractor can access to repair location with equipment	Infiltration	\$ 2,700 / EA	1 (3 lf)	\$ 2,700
Excavation and Replacement Of Pipe Section	Pipe break is jagged or exhibits signs of failure, short liners can not be installed, Condition of sewer line warrants complete replacement	Infiltration	\$ 175 / LF	238	\$ 41,650
Subtotal					\$ 44,350
Contingency	25%	Infiltration	\$ 11,088	1	\$ 11,088
Engineering	15%	Infiltration	\$ 6,652	1	\$ 6,652
Total					\$62,090
Estimated Cost to Replace Broken Pipe Sections					\$ 62,100

Hole in Sewer Main Pipe

Holes in the sanitary sewer pipe were observed at 7 locations and are presented in Table 25. Three of the holes in Morgan Street appear to have been repaired. The four remaining holes should be repaired using gel type sealant and mechanical packer or in-situ structural short liner. As stated previously, using short liners will result in a loss of capacity in the line section as a result of reduction in the cross-sectional area in the pipe. Use of short liners to repair pipe sections should be evaluated by Earth Tech in conjunction with a pipe rehabilitation specialist on a case by case basis to verify that the pipe has adequate flow

capacity prior to the installation of the short liner and to determine the feasibility of using the short liner to rehabilitate the pipe section. Preliminary costs to repair the hole in the pipe are presented in Table 26.

Table25 - Hole in Sewer Main Pipe

Catchment Area	Location	From MH	To MH	Pipe Information			
				Size (In.)	Material	Number	
4	Connection Street	117-95.1	STUB	8	VCP	1	Not Repaired
4	Potter Street	118-4	117-103	12	VCP	1	Not Repaired
7	Morgan Street	128-69	T-IN	8	VCP	4	3 Repaired, 1 Not Repaired
7	Harrison Avenue	127-60	127-57	8	VCP	1	Not Repaired
Total Locations with Holes in Sewer Main Pipes						7	

Table26 – Estimated Cost to Repair Holes in the Sewer Main Pipe

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Short Liner (Approx. 4 ft)	Pipe in Acceptable Condition Contractor can Access to Repair Location with Equipment	Infiltration	\$ 2,700 / EA	4	\$10,800
Subtotal					\$10,800
Contingency	25%	Infiltration	\$ 2,700	1	\$2,700
Engineering	15%	Infiltration	\$ 1,620	1	\$1,620
Total					\$15,120
Estimated Cost to Repair Holes in the Sewer Main Pipe					\$15,200

Mineral Deposits/Grease in Service Connection

Mineral Deposits were observed in 44 service connections and at 25 isolated locations in the inspected sanitary sewer pipe and are presented in Tables 27 and 28, respectively. Mineral deposits were also noted frequently throughout entire sanitary sewer line segments. 28 sanitary sewer line segments were observed to have frequent deposits throughout the segment and are presented in Table 29. The mineral deposits observed typically ranged from minor to moderate. As they are generally not impacting flow within the interceptor or the service connection, Earth Tech recommends that remediation of mineral deposits in service connection and the sewer main pipe be completed as part of future capital improvement projects or in conjunction with other repairs on the affected lines.

Minor grease was observed at one location on Stacey Street and is presented in Table 30. Earth Tech recommends that the line be cleaned as soon as possible and the city contact the building owners to discuss

reducing the amount of grease entering the system before performance of the connection and main line sewer is degraded.

Table 27 – Mineral Deposit in Service Connection

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Lawrence Avenue	131-14	131-13	24	Brick	1
3	Lawrence Avenue	142-3.1	142-3	24	Brick	2
3	Carroll Avenue	151-35	152-47	10	VCP	1
3	McCormick Road	152-37	152-36	8	ACP	2
3	Kerins Terrace	129-1	118-124.2	8	VCP	1
4	Carey Street	118-118	118-119	8	VCP	1
4	West Narragansett	118-3	117-100	10	VCP	3
4	Roseneath Avenue	117-97	117-98	10	VCP	1
4	Roseneath Avenue	117-97	117-96	10	BVP	6
4	Roseneath Avenue	117-96	109-29.1	10	VCP	1
4	Houston Avenue	109-35.1A	109-36	12	VCP	3
4	Atlantic Street	128-76	129-2	8	VCP	6
4	Atlantic Street	128-76	117-86	8	VCP	1
4	Clinton Street	117-92	117-93	10	VCP	3
4	Clinton Street	117-90	109-34	10	VCP	2
7	Harrison Avenue	128-88.1	128-88	8	VCP	4
7	Palmer Street	128-72	128-71	10	VCP	1
7	Palmer Street	128-72	128-68	10	VCP	2
7	Morgan Street	128-69	T-IN	8	VCP	1
7	Old Fort Road	139-37	128-73	8	VCP	2
Total Service Connections with Mineral Deposits						44

Table 28 - Isolated Locations with Mineral Deposits in Sewer Main

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Sheppard Avenue	131-11	131-7	8	VCP	1
4	Marchant Street	128-77	128-76	15	VCP	4
4	Carey Street	118-117	118-118	6	VCP	1
4	West Narragansett Avenue	118-3	117-100	10	VCP	2
4	Roseneath Avenue	117-97	117-96	10	VCP	2
7	Morgan Street	128-69	128-72	8	VCP	2
7	Gilroy Street	139-36	Stub	8	VCP	1
7	Florence Avenue	139-25	140-64	8	VCP	5
7	Carroll Avenue	139-43	125-80	10	VCP	1
7	Harrison Avenue	127-60	127-57	8	VCP	3
7	Harrison Avenue	128-88.1	128-88	8	VCP	2
7	Old Fort Road	139-37	128-73	8	VCP	1
Total Locations with Mineral Deposits in the Sewer Main Pipe						25

Table 29 - Mineral Deposits Frequently Throughout the Line Segment

Catchment Area	Location	From MH	To MH	Pipe Information	
				Size (In.)	Material
3	Kerins Terrace Easement	129-1	140-63	8	VCP
3	Kerins Terrace	129-1	118-124.2	8	VCP
3	Vaughan Street	129-95	129-5	8	VCP
3	Morton Park Easement	118-124.2	118-124.2A	36 x 28	Brick
3	Morton Park Easement	128-124.2A	118-124.1	36 x 28	Brick
3	Lawrence Avenue	142-3.1	142-3	24	Brick
4	Roseneath Avenue*	117-97	117-96	10	VCP
4	Conrad Court	117-97	Stub	8	VCP
4	Roseneath Avenue	117-96	109-29.1	10	VCP
4	Roseneath Avenue	109-29.1	109-29	10	VCP
4	Roseneath Avenue	109-29	109-32	10	VCP
4	Carey Street*	118-118	118-117	8	VCP
4	Carey Street	118-118	118-19	8	VCP
4	West Narragansett Avenue*	118-3	117-100	10	VCP
4	Connection Street	117-95.1	Stub	8	VCP
4	Houston Avenue	109-35.1A	109-36	12	VCP
4	Houston Avenue	109-35.1A	109-35.1	12	VCP
4	Atlantic Street	128-76	129-2	8	VCP
4	Atlantic Street	128-76	117-86	8	VCP
7	Palmer Street	128-72	128-68	10	VCP
7	Harold Street	139-36	139-Tee	8	VCP
7	Norman Street	139-39	139-38	8	VCP
7	Stacey Street	139-39	128-72	8	VCP
7	Morgan Street	128-69	T-IN	8	VCP
7	Harold Street	139-36	139-35	8	VCP
7	Harrison Avenue*	128-88.1	128-88	8	VCP
7	Old Fort Road*	139-37	128-73	8	VCP

*-Isolated mineral deposits and pipe segments with mineral deposits throughout may coincide.

Table 30 – Light Grease in Sewer Main at Service Connection

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
7	Stacey Street	139-39	128-72	8	VCP	1
Total Service Connections with Grease Build up						1

Service Connections with Debris

30 service connections were observed to be obscured by debris at the time of the inspection. The locations are shown in Table 31. The locations typically contained a small amount of debris at the service connection and main line joint but do not appear to cause any reduction in service. Earth Tech recommends that these lines be cleaned as part of routine maintenance of the collection system.

Table 31 - Service Connection with Debris

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Lawrence Avenue	142-4	142-3	24	Brick	2
3	McCormick Road	152-37	152-38	12	DIP	2
3	Carroll Avenue	163-65	163-72	8	VCP	1
4	Roseneath Avenue	109-29.1	109-29	10	VCP	3
4	Clinton Street	117-90	109-34	10	VCP	5
4	Clinton Street	109-34	109-35	10	VCP	1
4	Houston Avenue	109-35.1A	109-36	12	VCP	1
4	West Narragansett Avenue	118-3	117-100	10	VCP	10
4	Houston Avenue	117-95	117-108	12	VCP	1
4	Marchant Street	128-77	128-76	15	VCP	1
4	Carey Street	118-118	118-119	8	VCP	2
7	Stacey Street	139-39	128-72	8	VCP	1
Total Service Connections with Debris						30

Roots

Roots were observed in service connections and in isolated locations and throughout mainline sewer pipe segments and are presented in Tables 32 through 38. Earth Tech recommends the roots be removed to mitigate impacts to flow capacity and deposition of debris and possible clogging of services. Chemical methods of root removal can be considered to prevent or limit the ability of any roots growing back. Sealing the pipe in the vicinity of the root growth after removal may also assist in preventing re-growth and prevent infiltration. However, mechanical methods of root removal may be necessary as the large quantities of root removing foam can cause problems in the biological treatment process employed at the wastewater treatment plant. Estimated costs to perform root removal are presented in Table 39 below.

Table 32– Light Roots in Sewer Service Connection

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Webster Street	120-31	119-26	12	VCP	1
3	Webster Street	120-29	120-30	18	VCP	1
3	Vaughan Avenue	129-95	129-5	8	VCP	1
3	Leroy Avenue	119-27	130-6	12	VCP	1
3	Lawrence Avenue	131-14	131-13	24	Brick	1
4	Conrad Court	117-97	Stub	8	VCP	1
4	Carey Street	118-117	Stub	6	VCP	1
Total Service Connections with Light Roots						7

Table 33 - Light Roots in Sewer Main Pipe

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Kerins Terrace	129-1	118-124.2	8	VCP	1
3	Leroy Avenue	119-27	120-33	12	VCP	1
3	Vaughan Avenue	129-95	129-5	8	VCP	1
3	Lawrence Avenue	131-12	131-7	24	Brick	2
3	Ochre Point Avenue	131-9	131-9.1	12	VCP	1
3	Shepard Avenue	131-10	131-11	8	VCP	4
3	Shepard Avenue	131-8	131-15	12	VCP	4
3	Carroll Avenue	151-30	151-32	8	VCP	1
3	Carroll Avenue	163-67	163-66	8	VCP	1
3	Leroy Avenue	119-27	130-6	12	VCP	1
4	Conrad Court	117-97	STUB	8	VCP	4
4	Roseneath Avenue	109-29	109-32	10	VCP	3
7	Carroll Avenue	139-43	128-80	10	VCP	4
Total Locations with Light Roots in the Sewer Main Pipe						28

Table 34– Light Roots Throughout the Entire Sewer Main Segment

Catchment Area	Location	From MH	To MH	Pipe Information		
				Size (In.)	Material	
3	Webster Street	120-31	119-26	12	VCP	
3	Kerins Terrace Easement	129-1	140-63	8	VCP	
3	Carroll Avenue Easement	151-32	151-35	10	VCP	
3	Carroll Avenue Easements	151-35	152-47	10	VCP	
3	Vanderbilt Avenue	140-51	140-55	8	VCP	
3	Leroy Avenue	119-27	130-6	12	VCP	
7	Florence Avenue	139-28	140-64	8	VCP	
Total Pipe Segment with Light Roots Throughout						7

Table 35 - Moderate Roots in Service Connection

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
4	Conrad Court	117-97	STUB	8	VCP	1
4	Roseneath Avenue	109-29	109-32	10	VCP	1
Total Service Connections with Moderate Roots						2

Table 36 - Moderate Roots in Sewer Main

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Vanderbilt Avenue	140-51	140-55	8	VCP	1
Total Locations with Moderate Roots in the Sewer Main Pipe						1

Table 37 - Heavy Roots in Service Connection

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Roseneath Avenue	109-29	109-32	10	VCP	1
Total Service Connections with Heavy Roots						1

Table 38 – Heavy Roots in Sewer Main

Catchment Area	Location	From MH	To MH	Pipe Information		Number
				Size (In.)	Material	
3	Ochre Point Avenue	131-9	131-9.1	12	VCP	1
3	Vanderbilt Avenue	140-51	140-55	8	VCP	1
3	Kerins Terrace Easement	129-1	140-63	8	VCP	1
Total Locations with Heavy Roots in the Sewer Main Pipe						3

Table 39 – Estimated Cost To Remove Roots in the Sewer Main Pipe and Service Connections

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Mechanical Removal	Pipe in Acceptable Condition Contractor can Access to Repair Location with Equipment	Infiltration	\$ 1.50/LF	5,250	\$ 7,875
Chemical Removal	6' to 8" Pipe	Infiltration	\$ 0.75/ LF	1,520	\$ 1,140
	10" to 12" Pipe	Infiltration	\$ 1.00/LF	2,180	\$ 2,180
	Manhole (if needed)	Infiltration	\$ 85.00/EA	0	\$ 0
Subtotal					\$ 11,195
Contingency	25%	Infiltration	\$ 2,799	1	\$ 2,799
Engineering	15%	Infiltration	\$ 1,680	1	\$ 1,680
Total					\$ 15,673
Estimated Cost to Remove Roots					\$ 15,675

Pipe Sag

Sags in service connection pipe were observed at 6 locations and 55 locations in the sewer main line and are presented in Tables 33 and 34, respectively. Earth Tech recommends that all sags be removed and replaced to assure proper flow in the line segments affected and prevent collection points of sewage and other debris which may cause service interruptions and sewage backups. Each sagging pipe segment should be evaluated by Earth Tech and a pipe rehabilitation specialist to determine if the sewer line segment should be repaired or replaced in whole. This determination will be based on prioritizing each segment of the sagging pipe by the condition of the mainline pipe, location of the pipe segment and the severity of the sag in the pipe segment. The costs presented in Table 42 represent only the cost to replace the pipe sections that have sagged; the remainder of the original pipe segment will remain in place.

Table 40 –Sag in Service Connection Pipe

	LOCATION	FROM MH	TO MH	Pipe Information		Number
				Size (In.)	Material	
4	Roseneath Avenue	109-29	109-32	10	VCP	1
4	Clinton Street	109-34	109-35	10	VCP	1
4	Clinton Street	117-92	117-93	10	VCP	1
4	West Narragansett Avenue	117-85	117-99	8	VCP	1
4	Atlantic Street	129-2	128-76	6	VCP	1
7	Old Fort Road	139-37	128-73	8	VCP	1
Total Service Connections with Pipe Sags						6

The city should consider developing a program to coordinate repair or replacement of service connections with the private property owner. Repairs and replacements of service connections should be considered with work to be undertaken under the long term remediation recommendations outlined later in this Technical Memorandum.

Table 41 - Sags in Sewer Main Pipe

	LOCATION	FROM MH	TO MH	Pipe Information		Number	Length of Pipe Repair (lf)
				Size (In.)	Material		
3	Narragansett Avenue	113-78	113-79	8	PVC	1	10
3	Vaughan Avenue	129-95	129-5	8	VCP	3	37
3	Ruggles Avenue	140-48	140-48.1	10	VCP	1	44
3	Victoria Avenue	142-9	142-3	8	PVC	1	77
3	Carroll Avenue Easement	151-32	151-35	10	VCP	1	42
3	McCormick Road	152-37	152-38	12	DIP	1	187
3	Carroll Avenue Easement	151-35	152-47	10	VCP	2*	42
3	Carroll Avenue	163-67	163-66	8	VCP	1	13
3	Carroll Avenue	163-65	163-72	8	VCP	2	42
4	Roseneath Avenue	109-29	109-32	10	VCP	3	64
4	Clinton Street	117-90	109-34	10	VCP	1	146
4	Clinton Street	109-34	109-35	10	VCP	2	207
4	Houston Avenue	109-35.1A	109-35.1	12	VCP	1	27
4	Halidon Avenue	116-81	116-80	10	ACP	1**	40
4	Clinton Street	117-92	117-90	10	VCP	1	28
4	Clinton Street	117-92	117-93	10	VCP	1	39
4	Connection Street	117-107	117-95	8	VCP	1	119
4	Roseneath Avenue	117-97	117-98	10	VCP	1	8
4	West Narragansett Avenue	117-85	117-99	8	VCP	1	54
4	West Narragansett Avenue	118-3	117-100	10	VCP	5	120
4	Potter Street	118-4	117-103	12	VCP	1	30
4	Connection Street	118-10	117-107	10	VCP	3	113

Table 41 - Sags in Sewer Main Pipe

	LOCATION	FROM MH	TO MH	Pipe Information		Number	Length of Pipe Repair (lf)
				Size (In.)	Material		
4	Houston Avenue	117-95	117-108	12	VCP	1	57
7	Gilroy Street	128-71	STUB	8	VCP	2	20
7	Palmer Street	128-72	128-71	10	VCP	2	55
7	Morgan Street	128-69	128-72	8	VCP	2	67
7	Stacey Street	139-39	128-72	8	VCP	1	9
7	Palmer Street	128-68	128-72	10	VCP	2	106
7	Old Fort Road	139-37	128-73	8	VCP	1	11
7	Old Fort Road	128-73	128-74	10	VCP	2	52
7	Old Fort Road	128-75	128-79.1	10	VCP	2	36
7	Carroll Avenue	139-43	128-80	10	VCP	1	11
7	Harrison Avenue	128-88	128-88.1	8	VCP	1	16
7	Harold Street	139-36	139-TEE	8	VCP	2	40
7	Harold Street	139-36	139-35	8	VCP	1	27
Total Locations with Sags in the Sewer Main Pipe						55	

* - This entire line segment will be replaced under Misaligned Pipe, therefore no repair is recommended under this item.

Table 42 – Estimated Cost to Replace Sagging Pipe Segments

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Excavation and Replacement Of Pipe Section	Condition of sewer line warrants complete replacement of sagging section plus 1 additional pipe length on each side of the sag.	Infiltration	\$ 175 / LF	1890	\$ 330,750
Excavation and Replacement Of ACP Pipe Section	Condition of sewer line warrants complete replacement of sagging section plus 1 additional pipe length on each side of the sag, pipe is ACP, additional fee to dispose of removed pipe sections.	Infiltration	\$ 250 / LF	64	\$ 16,000
Subtotal					\$ 346,750
Contingency	25%	Infiltration	\$ 86,688	1	\$ 86,688
Engineering	15%	Infiltration	\$ 52,012	1	\$ 52,012
Total					\$ 485,450
Estimated Cost to Replace Sagging Pipe Sections					\$ 485,450

Misaligned Pipe

2 sewer main pipe segments were observed to be largely misaligned and are presented in Table 43. The misaligned sections of pipe are potential infiltration sources, prevent effective cleaning and CCTV inspection, and preclude the use of short and full liners as they can not be pulled through the line. Earth Tech recommends that the pipe sections be monitored to verify that sewage flow is uninhibited, and be replaced as part of a future capital improvement project. A preliminary cost estimate to replace the misaligned section of pipe is presented in Table 44.

Table 43 - Misalignment in Sewer Pipe

Catchment Area	Location	From MH	To MH	Pipe Information		Number	Length of Pipe Repair (lf)
				Size (In.)	Material		
3	Carroll Avenue Easement	151-35	152-47	10	VCP	1	335
7	Old Fort Road	139-42	139-37	8	VCP	1	280
Total Sewer Main Segments with Misaligned Pipe						2	615

Table 44 – Estimated Cost to Replace Misaligned Pipe Sections

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Excavation and Replacement Of Pipe Section	Pipe break is jagged or exhibits signs of failure, short liners can not be installed, Condition of sewer line warrants complete replacement	Infiltration	\$ 175 / LF	615	\$ 107,625
Subtotal					\$ 107,625
Contingency	25%	Infiltration	\$ 26,906	1	\$ 26,906
Engineering	15%	Infiltration	\$ 16,144	1	\$ 16,144
Total					\$ 150,675
Estimated Cost to Replace Misaligned Pipe Sections					\$ 150,675

Delaminated (Peeling) Pipe

A segment of asbestos cement pipe (ACP) on Halidon Avenue between manholes 116-81 and 116-80 was observed to be peeling or delaminating. The inside layer has mostly fallen away from the pipe in to the flow channel. It was not possible to determine if the material was still in the line or if it had been carried down stream. This section of pipe should be evaluated by a pipe rehabilitation specialist to determine if the pipe segment should be removed and replaced or if the approximately 55-foot section can be rehabilitated. For planning purposes, the costs presented in Table 45 assume that the pipe will be replaced in whole and will require an additional cost to dispose of the ACP.

Table 45 – Estimated Cost to Replace Peeling ACP Section

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Excavation and Replacement Of Pipe Section	Pipe will be replaced in whole, additional fee for disposal of ACP	Infiltration	\$ 250 / LF	53	\$ 13,250
Subtotal					\$ 13,250
Contingency	25%	Infiltration	\$ 3,313	1	\$ 3,313
Engineering	15%	Infiltration	\$ 1,987	1	\$ 1,987
Total					\$ 18,550
Estimated Cost to Replace Peeling ACP Section					\$ 18,550

Potter Street Stone Culvert

A section of the pipe segment on Potter Street between manholes 118-4 and 117-103 could not be fully inspected due to a change in pipe material to 20-inch by 20-inch stone box culvert. This stone culvert is not considered an acceptable conveyance for sanitary sewage, as sanitary flow can exfiltrate to the surrounding soil via open joint and ground water can infiltrate the line via the same joints. This section of stone culvert should be sliplined with PVC pipe or uncapped, filled with suitable backfill and a new section of PVC pipe installed. Based on the debris located downstream in the pipe segment, it appears that the stone culvert may be failing with pieces of stone being carried down stream causing potential blockages. Based on the CCTV inspection, it is assumed that the section that was not viewed must be replaced; however, the section of stone culvert may be shorter in length and require a more localized reconstruction. Table 46 presents the cost to reinstall 75 feet of pipe that could not be viewed.

Table 46 – Estimated Cost to Replace Potter Street Stone Culvert

Item	Assumption	Source	Unit Cost	Quantity	Estimated Cost
Excavation and Replacement Of Pipe Section	Section of pipe not viewed will be replaced in whole, additional work will be required to remove stone for salvage or disposal	Infiltration	\$ 200/ LF	75	\$ 15,000
Subtotal					\$ 15,000
Contingency	25%	Infiltration	\$ 3,750	1	\$ 3,750
Engineering	15%	Infiltration	\$ 2,250	1	\$ 2,250
Total					\$ 21,000
Estimated Cost to Replace Potter Street Stone Culvert					\$ 21,000

Morton Park Easement Brick Sewer

The brick sewer that extends through Morton Park from Kerins Terrace to Morton Avenue and the Thames Street Interceptor appears to be in fair condition with considerable leaking brick and mineral deposits, which may indicate additional leakage during periods of high groundwater. Rehabilitation of this pipe segment would likely be similar to the short and long term rehabilitation methods recommended in the Thames Street Interceptor CCTV Inspection Technical Memorandum, including manned entry of the brick sewer to repair a poor connection between the service connections and the mainline sewer; replace or seal minor damage to the service connection pipe; clean mineral deposits, clean debris not cleared by standard cleaning methods such as water jet cleaning or use of a clamshell bucket, remove and seal root intrusions, remove mineral deposits, repoint and seal leaking bricks and replace missing bricks, and seal, repoint, and repair any visible damage not viewed in the CCTV inspection footage due to flow in the sewer at the time of the inspections. The

interceptor can then be prepared to accept an in-situ structural liner. During the CCTV inspection, the inspection technician estimated total line infiltration at approximately 11 gallons per minute or approximately 16,000 gallons per day.

The grate type manhole covers that currently permit storm water to enter the sanitary system at Morton Park should also be removed or sealed. Re-routing of the storm water flows at Morton Park will be reviewed under Phase 1 Part 3.

Rehabilitation of the sewer system would include the following minor rehabilitation tasks:

- Repair of leaking service connections/poor connections between service connections and mainline sewers, protruding services, and joint repair.
- Repair of broken and/or cracked pipes observed in service connections or main line sewer pipes.
- Removal of mineral deposits in service connections and main line sewer pipes.
- Sealing of joints.
- Repair of leaking bricks or lining within the Morton Park sewer easement

The rehabilitation or removal and replacement of pipe segments would require the installation of a sewage bypass pumping system to redirect flows around areas of work. Based on the costs of recent similarly sized projects with comparable flows to the Morton Park brick sewer, the estimated bypass pumping costs are \$1,800 to \$2,500 per day.

As part of the City's long term system-wide operation and maintenance, rehabilitation consisting of lining the Morton Park sanitary sewer is recommended and based on the following assumptions:

- Rehabilitation procedures are based on the physical condition of the system and service connections as encountered in the CCTV inspection,
- No plans exist to replace the sections of the sanitary sewer system in part or in whole where defects were observed.

The preliminary cost estimate to repair and line the interceptor and for bypass pumping is shown in Table 47 below.

Table 47 - Long Term Rehabilitation Recommendations – Morton Park Brick Sewer

Item	Assumption	Unit Cost	Quantity	Estimated Cost
Minor repairs and lining	Bypass pump setup is feasible; Pipe segments will not be replaced in whole.	\$500/LF	700	\$350,000
Bypass Pumping of Flows around Work Area	Suitable location for equipment, suction and discharge can be located.	\$2,500/day	30	\$75,000
Subtotal				\$425,000
Contingency	25%	\$106,250	1	\$106,250
Engineering	15%	\$63,750	1	\$63,750
Total				\$595,000
Estimated Cost to Rehabilitate Morton Park Brick Sewer				\$600,000

REHABILITATION RECOMMENDATIONS

Based on the results of the CCTV inspection, the sanitary sewer system is generally in fair condition with defects that require immediate rehabilitation work. Therefore, Earth Tech has prepared the following short term and long term recommendations for rehabilitation of the sanitary sewer system in the priority inflow and infiltration catchment areas.

Short Term Rehabilitation Recommendations

Earth Tech recommends that the City of Newport perform the following short term investigation and rehabilitation tasks based on priority:

Priority 1 – High

The following defects have been assigned a high priority as they are currently degrading the systems performance, allowing infiltration flow, or are will likely contribute to a failure of service in the sanitary sewage collection system if not addressed. A summary of preliminary costs to remedy high priority defects in the pipe segments observed in the CCTV inspection is presented in Table 46.

- Replace segments of misaligned sewer mainline pipe. The estimated cost to replace the approximately 615 LF of misaligned segments of sewer pipe at \$175 per LF is \$150,675, including engineering costs and contingency.

- Replacement of sewer main pipe segments with severe sags. The estimated cost to replace approximately 1890 LF of sagging segments of pipe at approximately \$175 per LF and 64 LF of sagging ACP with additional handling and disposal costs of \$250 per LF is \$485,450, including engineering costs and contingency.
- Replacement of segments of pipes with offset joints. The estimated cost to replace 38 LF of pipe segments with offset joints at approximately \$175 per LF is \$9,400, including engineering and contingency.
- Repair of broken pipe at two locations, replacement of the entire stub at West Narragansett Avenue and lining of the broken pipe on Stacey Street. The estimated cost to repair the three failing pipe sections by excavation and replacement methods at \$175 per LF and to short line the broken pipe on Stacey Street at \$2,700 is approximately \$62,100, including engineering and contingency.
- Repair of four locations where pipe segments with holes in the mainline sewer pipe. The estimated cost to repair holes using short liners in the sewer mainline pipe at \$2,700 each is approximately \$15,150, including engineering and contingency.
- Remove roots from the locations indicated within this TM by chemical or mechanical methods. Perform isolated pipe sealing in conjunction with joint sealing, if required. The estimated cost to remove roots by chemical and mechanical methods from approximately 9000 LF of mainline sewer pipe is \$15,675, including engineering and contingency.
- Replace section of asbestos cement pipe segment on Halidon Avenue. Dispose of ACP using approved procedures for handling and disposal. The estimated cost to remove and replace the 53 LF of ACP sewer pipe at \$250 per LF is \$18,550, including engineering and contingency.
- Install PVC sewer pipe in the Potter Street stone culvert to eliminate leakage of sanitary sewer flows and infiltration of groundwater. The unit price of \$200 per LF includes the preparation or removal of the stone culvert and the PVC installation. The estimated cost to install the PVC sewer within the stone culvert is \$21,000, including engineering and contingency.

**Table 48 - Order Of Magnitude Cost Estimate
High Priority Rehabilitation Recommendations**

Item	Source	Assumption	Unit Cost	Quantity	Estimated Cost
Replacement of misaligned pipe segments	Table 44	Pipe segments will be replaced in whole	\$175/LF	615	\$ 107,625
Replacement of sagging sewer main	Table 42	Only sagging section to be replaced	\$175/LF	1,890	\$ 330,750
		Only sagging section to be replaced, additional fees to handle and dispose of ACP pipe	\$250/LF	64	\$ 16,000
Replacement of sections of Pipe with offset joints	Table 18	Joint and 2 lengths of pipe to be replaced	\$175/LF	38	\$ 6,650
Replacement of broken/damaged pipe sections	Table 24	Replacement of 2 locations in part, West Narragansett stub in whole, using remove and replace methods	\$175/LF	238	\$ 41,650
		4-foot short liner to reinforce damaged section	\$2,700/ea	1	\$ 2,700
Repair of holes in sewer pipe sections	Table 26	4-foot short liner to reinforce damaged section	\$2,700/ea	4	\$ 10,800
Root removal	Table 39	Using chemical methods to help prevent re-growth 6- to 8-inch diameter pipe	\$0.75/LF	1,520	\$ 1,140
		Using chemical methods to help prevent re-growth 10 - to 12-inch diameter pipe	\$1.00/LF	2,180	\$ 2,180
		Mechanical root removal for isolated locations or large diameter pipes	\$ 1.50/LF	5,250	\$ 7,875
Replacement of ACP pipe	Table 45	Pipe will be replaced in whole, additional fee for disposal of ACP	\$ 250/LF	53	\$ 13,250
Replacement of Potter Street Stone Culvert	Table 46	Section of pipe not viewed will be replaced in whole, additional work will be required to remove stone for salvage or disposal	\$ 200/LF	75	\$ 15,000
Subtotal					\$555,620
Contingency		25%	\$ 138,905	1	\$ 138,905
Engineering		15%	\$ 83,343	1	\$ 83,343
Total					\$ 777,868
Estimated Cost for High Priority Repairs					\$ 778,000

Priority 2 - Moderate

- Develop a program to coordinate and remedy service connections with various defects including running clear water, service connections with offset joints, and service connections with sags.

As service connections defects are generally a cause of private infiltration sources, it is assumed that costs to remedy service connections defects will be borne by the property owner.

Priority 3 – Low

The following repairs have been assigned a low priority as no or very little infiltration flow was noted at these locations and repairs would not be cost effective at this time. It should be noted that cracking in pipe sections may be a sign of structural failure of the pipe section. Failure of the pipe may cause interruption of service and would require immediate repair, therefore, the city should address these section as part of their sanitary sewer system and road paving capital improvement plans as addressed in the long term rehabilitation recommendations in the next section. A summary of estimated costs to remedy the low priority defects is presented in Table 49.

- Repair of leaking joints between the service connection and mainline sewer pipe. The estimated cost to seal the leaking joints is \$ 1,500, including engineering and contingency.
- Sealing of cracked pipe joints in the mainline sewer pipe. The estimate cost to test and seal cracked joints is \$ 4,150, including engineering and contingency.
- Testing and sealing of locations in the main line sewer pipe with multiple cracks, circular cracks, and longitudinal cracks. The estimated cost to repair cracked the cracked locations is \$ 5,150, including engineering and contingency.

**Table 49 - Order Of Magnitude Cost Estimate
Low Priority Rehabilitation Recommendations**

Item	Assumption	Unit Cost	Quantity	Estimated Cost
Testing and sealing of leaking joints	Table Contractor can access repair location, pipe is in suitable condition for the repair, pipe is structurally sound	\$ 30/LF	38	\$ 1,050
Testing and sealing of cracked pipe joints	Table Contractor can access repair location, pipe is in suitable condition for the repair, pipe is structurally sound	\$ 30/LF	98	\$ 2,940
Testing and sealing of cracks in main line sewer pipe	Table Contractor can access repair location, pipe is in suitable condition for the repair, pipe is structurally sound	\$ 30/LF	122	\$ 3,660
Subtotal				\$ 7,650
Contingency	25%	\$ 1,912	1	\$ 1,912
Engineering	15%	\$ 1,148	1	\$ 1,148
Total				\$ 10,710
Estimated Cost for High Priority Repairs				\$ 10,800

Long Term Rehabilitation Recommendations

As noted above, the sanitary sewer collection system is generally in fair condition with defects that require rehabilitation work based on the CCTV inspection performed by ADS Environmental Services. As indicated by the many isolated locations with defects that should be remedied immediately or in the near future to avoid failure of service, which are noted in the section above, we conclude that other portions of the clay pipes throughout the collection system may be entering the end of their useful service life.

The city should continue to perform CCTV inspection of other areas of the city. The CCTV inspection results present herein represents 5.7% of Newport's approximately 417,500 LF of sanitary sewer pipe. Based on the age of the system in those areas, the City should anticipate finding similar conditions throughout the city as those observed in this limited CCTV inspection. This program should also include annual preventative maintenance on the system to extend the service life of the existing system and planning and/or replacement of pipe that has reached the end its useful service life.

Based on the age of the sanitary sewer system and the general condition of the primarily vitrified clay pipe system, the city of Newport should develop a plan to systematically replace the aging vitrified clay and asbestos cement sewer pipe with PVC pipe and brick manholes with pre-cast concrete manholes to maintain service, to extend the service life of the collection system, and to eliminate infiltration. This plan should be coordinated with other utility and roadway capital improvement projects to minimize construction costs and disruption.

Conclusion

Earth Tech recommends that the City address in Phase 2 the recommended high priority rehabilitation that was identified in the Flow Isolation/CCTV Technical Memorandum including broken pipes, sagging pipes, pipes with holes, and pipes exhibiting other signs of imminent failure or detriment to the operation of the collection system. The low and medium priority rehabilitation should be addressed during future capital improvement projects and collection system operation and maintenance. The estimated cost for the design of the high priority rehabilitation and the preliminary construction cost is \$778,000 as presented in Table 48. The construction cost is a planning level estimate and will be refined upon completion of the design.