

Prepared for:

TOWN OF ROCKLAND, MASSACHUSETTS

SEWER SYSTEM EVALUATION SURVEY

September 2021



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BACKGROUND

On January 13, 2021, AECOM received an executed Agreement from the Town of Rockland to solicit bids and procure a subcontractor to perform infiltration/inflow (I/I) investigative field work, and to document the findings in a sewer system evaluation survey (SSES) report. The work consists of flow isolation of approximately 90% of all pipe ranging in size from 8 to 12-inch diameter and follow-up television inspection in pipes that qualify for that work; and television inspection of approximately one-third of all pipe ranging in size from 15 to 33-inch diameter. The locations of the work are further identified in the “Figures” subsection of this report.

In accordance with the Agreement, the scope of work for this project includes the following:

1. Coordinate the work between the subcontractor and the Town to perform the field work, review the results of the flow isolation for pipe sizes 8 to 12-inch diameter and identify locations that qualify for follow-up CCTV inspection, review television inspection videos and written inspection logs and identify locations where rehabilitation is warranted to remove I/I sources.
2. For each I/I source identified in item 1, identify the type of rehabilitation method and estimate the rehabilitation cost.
3. Prepare a letter report documenting the findings of the field work including a general description and summary of the work, a summary of the sewer pipeline and/or manhole defects (I/I sources), rehabilitation costs and a priority ranking of I/I sources recommended for rehabilitation.

Presented in this report are the results of the field work and recommended follow-up rehabilitation work to remove I/I sources from the sewer system.

FIGURES

The following two figures are presented in Attachment A:

- Figure 1, Field Work Locations, identifies the locations of areas that were flow isolated and the main pipeline that received television inspection as part of this study.
- Figure 2, General Location Plan of Work, identifies the locations of I/I sources recommended for rehabilitation or further investigation as described later in this report.

DATA COLLECTION

Field work performed for this project consisted of flow isolation, internal preparatory cleaning and closed-circuit television (CCTV) inspection of sewer pipelines to identify infiltration sources. These efforts are described in the text below. The field work was performed by National Water Main Cleaning Company (NWM) under subcontract to AECOM.

Flow Isolation

Between March 1, 2021 and April 9, 2021, a total of 200,451 linear feet of mainline sewer with diameter from 8 to 12-inches received flow isolation work generally between the hours of midnight and 5:00 a.m. In most locations, the upstream manhole of each manhole-to-manhole pipe segment was plugged. After installation of the plug, the flow was measured in the downstream manhole using precalibrated weirs. The measured flow during the early morning hours is considered to be infiltration.

A detailed breakdown of the results of the flow isolation work is presented in a letter report dated April 30, 2021, prepared by AECOM and submitted to the Town of Rockland. The letter report and related backup tables are included in Attachment B of this report. The letter report includes the following tables and plan:

- Table 1. Rank of Pipe Segments with Infiltration Greater than 4,000 gpd/in-mi.

- Flow Isolation Summary Tables.
- Plan showing locations of sewer segments 8 to 12-inch diameter recommended for television inspection based on flow isolation results, and locations of pipe larger than 12-inch diameter that are scheduled for CCTV inspection.

In summary, Table 1 presented in Attachment B identifies 81 pipe segments with infiltration above 3,000 gpd/inch-mile. These pipe segments, representing a total length of approximately 19,131 linear feet of main pipeline, were scheduled for television inspection. Note: as explained in the letter report dated April 30, 2021, some pipe segments with infiltration greater than 3,000 gpd/in-mi but less than 4,000 gpd/in-mi were included in the list of pipe segments scheduled for CCTV inspection.

Sewer manholes that were accessed during the flow isolation work were observed for infiltration sources. The rate of infiltration observed entering the sewer system through each manhole was estimated, and the location of each manhole infiltration source was noted in the “Comments” column of the Flow Isolation Report tables presented in Attachment B.

Presented in Table 1 is a summary of manhole defects and estimated infiltration amounts from the manholes observed to have infiltration sources during the field work. A total of 34 manholes were found to have infiltration sources. Chemical sealing is the recommended rehabilitation method for all manholes. In some manholes with more serious leaks, the addition of a cementitious liner is also recommended. The information from Table 1 was used to identify manholes which qualify for rehabilitation work as described later in this report.

Preparatory Cleaning and Internal Television Inspection

Approximately 31,541 linear feet of main pipeline was scheduled for preparatory cleaning and internal television inspection. This total represents the sum of the following:

- 19,131 linear feet of 8 to 12-inch diameter pipe that qualified for CCTV inspection based on the flow isolation results.
- 8,860 linear feet of 15 to 21-inch diameter pipe which represents approximately one-third of the total pipe length in the Town of Rockland within that pipe range.

TABLE 1. SUMMARY OF MANHOLE DEFECTS FOUND DURING FLOW ISOLATION WORK

Manhole Number	Street Name	Defect	Estimated Infiltration (gpd)	Recommended Rehabilitation
D1	North Ave.	Walls	1,400	Chemical Seal & Cementitious Liner
D133	Leisurewoods Dr.	Walls	1,400	Chemical Seal & Cementitious Liner
D144	Leisurewoods Dr.	Walls	300	Chemical Seal
E2	Plain St.	Walls	300	Chemical Seal
E5	Reed St.	Walls	300	Chemical Seal
E12	Belmont St.	Pipe Connections (PC)	300	Chemical Seal
E13	Belmont St.		300	Chemical Seal
E14	Belmont St.	Bench	300	Chemical Seal
E15	Belmont St.	Bench	300	Chemical Seal
E19	Pacific St.	Bench	300	Chemical Seal
E20	Pacific St.	Bench	300	Chemical Seal
E22	Pacific St.	Walls	300	Chemical Seal
E24	Reed St.	Walls	300	Chemical Seal
E28	Reed St.	Bench	300	Chemical Seal
E32	Taunton Ave.	Bench	300	Chemical Seal
E70	Grove St.	PC	300	Chemical Seal
H40	Park St.	Walls	300	Chemical Seal
H67	School St.	Invert & PC	2,900	Chemical Seal & Cementitious Liner
J4	Shaw Rd.	PC	150	Chemical Seal
J6	Josh Gray Rd.	Walls	400	Chemical Seal
L10	Liberty St.	Walls @ PC	1,100	Chemical Seal & Cementitious Liner
L12	Sunnybank Ave.	Wall @ PC	150	Chemical Seal
L21	Webster St.	Walls	300	Chemical Seal
L33	Everett St.	Walls	300	Chemical Seal
L61	Hingham St.	Walls	300	Chemical Seal
N113	Liberty St.	Bench	300	Chemical Seal
N115	Liberty St.	Walls	300	Chemical Seal
N143	Liberty St.	Wall @ PC	3,600	Chemical Seal & Cementitious Liner
N152	Liberty St.	Walls	300	Chemical Seal
N156	Liberty St.	PC	300	Chemical Seal
S190	Summer St.	Wall @ PC	5,000	Chemical Seal & Cementitious Liner
W7	Culver Dr.	Walls	300	Chemical Seal
W46A	Salem St.	Wall @ PC	300	Chemical Seal
W89	Brookside Rd.	Walls	1,400	Chemical Seal & Cementitious Liner
Totals	34 Manholes		24,700	

Notes:

(1) Estimated infiltration is based on a visual assessment of each infiltration source.

- 3,550 linear feet of 24 to 33-inch diameter pipe which represents approximately one-third of the total pipe length in the Town of Rockland within that pipe range.

The internal television inspection work was performed to identify specific pipeline defects or infiltration sources within a length of sewer from one manhole to another (pipe segment). Where necessary to perform the work, pipe segments were cleaned by a high-pressure jet to remove minor obstructions and to clean the pipe walls so that if defects are present they can be visually detected. Subsequently, a closed-circuit television camera, with audio, was used to inspect and record the condition of the pipe segment. The location, type and magnitude of each pipeline defect or infiltration source was documented.

From April 20, 2021 to May 6, 2021, a total of 31,618 linear feet of municipal sewer main pipeline received internal television inspection. This length of pipeline represents the sum of 19,385 feet of pipe 8 to 12-inch diameter plus 8,739 feet of pipe 15 to 21-inch diameter plus 3,494 feet of pipe 24 to 33-inch diameter.

The results of the internal television inspections are documented in videos and corresponding television inspection logs, also identified as “NWMCC Inspection Report”, prepared by NWM. A hard copy of the television inspection logs and a thumb drive containing electronic copies of both the television inspection logs and the videos were provided separately to the Town of Rockland. The television inspection logs and the videos prepared by NWM are made a part of this report by reference.

AECOM performed a review of the television inspection videos and corresponding logs to determine the locations and types of pipeline defects, to estimate infiltration amounts associated with each defect, and to determine recommended rehabilitation methods. Presented in Table 2 is a summary of the pipeline defects identified from this study and an estimate of infiltration entering the sewer system from each defect. Recommended rehabilitation for each defect is presented separately in Tables 3 and 4, described later in this report.

TABLE 2. SUMMARY OF SEWER PIPELINE DEFECTS

Location				Pipe Information			Main Pipeline Defect Severity	Pipeline Defects				
Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in.)	Main Pipeline Defect Severity	Leak in Joint ⁽¹⁾	Cracked or Broken Pipe ⁽¹⁾	Estimated Infiltration (gpd) ⁽²⁾	Service Connection Location (Station/Orientation) ⁽³⁾	Estimated Infiltration (gpd) ⁽²⁾
Concord	C2	C1	Concord St.	300	VC	8	None				8/R 78/R 114/L 173/R	700 700 300 300
Concord	C3	C2	Concord St.	234	VC	8	Minor	100		400	117/R 130/L 187/R	1,400 300 1,400
Concord	C1	C63	Concord St.	41	RC	30	None					
Concord	C86	C1	Albion St.	348	RC	30	Minor	233		150	75/T 121/T 168/T 299/T	700 150 700 1,400
Concord	C5	C86	Albion St.	355	RC	30	Minor	136		700	80/T 120/T 215/T	300 300 700
Concord	C85	C5	Albion St.	410	RC	30	None				327/T	2,900 ⁽⁴⁾
Concord	C85	C35	Albion St.	379	RC	30	Minor	79; 90; 190		900	83/T 162/T	150 300
Concord	C7	C35	Market St.	431	RC	30	None				20/T 156/T	700 1,400
Division	D2	D1	North Ave.	252	VC	10	Minor	40	250	3,000	12/T 171/T 249/T	300 5,000 5,000
Division	D3	D2	North Ave.	160	VC	10	Minor				37/T	2,200
Division	D4	D3	North Ave.	87	VC	10	Minor	36		1,400	82/R	700
Division	D7	D6	North Ave.	230	VC	8	Minor	227 ⁽⁶⁾	218-220	2,900		
Division	D9	D8	North Ave.	180	VC	8	Minor		52; 100	2,900	46/T 79/T 143/T 160/T	700 700 700 2,200
Division	D68	D67	Union St.	291	VC	8	None				126/L	700

TABLE 2 (Continued). SUMMARY OF SEWER PIPELINE DEFECTS

Location				Pipe Information			Main Pipeline Defect Severity	Pipeline Defects				
Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in.)		Main Pipeline			Service Connections	
								Leak in Joint ⁽¹⁾	Cracked or Broken Pipe ⁽¹⁾	Estimated Infiltration (gpd) ⁽²⁾	Service Connection Location (Station/ Orientation) ⁽³⁾	Estimated Infiltration (gpd) ⁽²⁾
Division	D67	D66	Union St.	257	VC	8	None				12/L 66/R 174/L	1,400 300 1,400
Emerson	E1	M23	Easement	228	RC	18	None					
Emerson	E2	E1	Easement	267	RC	18	None					
Emerson	E3	E2	Easement	358	RC	18	None					
Emerson	E4	E3	Easement	326	RC	18	Minor	311		700	85/L	8,600
Emerson	E5	E4	Easement	301	RC	18	Minor	142		300	72/T	4,300
Emerson	E13	E12	Belmont St.	170	VC	8	None				65/L 107/R 134/L 166/R	150 400 1,400 400
Emerson	E14	E13	Belmont St.	292	VC	8	Minor	226		400	72/L 89/L	400 2,200
Emerson	E19	E18	Pacific St.	300	VC	8	Minor		71-72 ⁽⁵⁾ , 108-109 ⁽⁵⁾		226/R 228/L	700 ⁽⁷⁾ 400
Emerson	E20	E19	Pacific St.	299	VC	8	Minor	88		700	31/L 58/R 124/R 287/R	400 ⁽⁷⁾ 1,400 ⁽⁷⁾ 300 150
Emerson	E21	E22	Pacific St.	242	VC	8	None				72/L 74/R	150 300
Emerson	E24	E9	Reed St.	300	VC	8	Minor		33 ⁽⁵⁾		43/L	400
Emerson	E25	E24	Reed St.	301	VC	8	None				21/R 85/R 191/L 286/R	400 400 700 400
Emerson	E26	E25	Reed St.	300	VC	8	Moderate		215-216	2,900	45/L 134/R	700 1,400
Emerson	E30	E8	Division St.	112	VC	10	None					
Emerson	E31	E30	Taunton Ave.	253	VC	8	Minor		62 ⁽⁵⁾		154/R	700
Emerson	E32	E31	Taunton Ave.	265	VC	8		160; 256	160-161; 256-257	7,200		
Howard	H3	H2	Howard St.	201	VC	10	Minor	3; 114		4,300	8/R	150

TABLE 2 (Continued). SUMMARY OF SEWER PIPELINE DEFECTS

Location				Pipe Information			Main Pipeline Defect Severity	Pipeline Defects				
Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in.)		Main Pipeline			Service Connections	
								Leak in Joint ⁽¹⁾	Cracked or Broken Pipe ⁽¹⁾	Estimated Infiltration (gpd) ⁽²⁾	Service Connection Location (Station/ Orientation) ⁽³⁾	Estimated Infiltration (gpd) ⁽²⁾
Howard	H4	H3	Howard St.	239	VC	10	Minor	214		700	50/R 68/L 123/R 234/L	3,600 700 300 700
Howard	H6	H5	Howard St.	300	VC	8	None					
Howard	H7	H6	Howard St.	303	VC	8	Minor	99		150		
Howard	H8	H7	Howard St.	226	VC	8	Moderate	148; 158; 163	12-13; 22-23 ⁽¹⁵⁾	900	179/L	700
Howard	H9	H8	Howard St.	165	VC	8	Minor	13; 30		700	19/L 48/R	300 300
Howard	H10	H9	Howard St.	336	VC	8	Minor	90; 260		600	100/R 108/L 182/L 202/R	400 400 700 400
Howard	H13	H12	Wall St.	214	VC	8	Minor	66		700	72/L 187/R 199/L	700 2,200 ⁽⁷⁾ 2,200 ⁽⁷⁾
Howard	H14	H13	Exchange St.	45	VC	8	None					
Howard	H15	H14	Exchange St.	337	VC	8	None				23/R 124/R 187/R 209/L 252/L	700 400 400 150 300
Howard	H13	H31	Exchange St.	280	VC	8	None				87/R 171/R	2,900 ⁽⁸⁾ 1,400 ⁽⁹⁾
Howard	H31	H32	Exchange St.	348	VC	8	None				92/R 104/L 200/R 218/R 347/L 348/R	1,400 ⁽⁴⁾ 1,400 2,900 ⁽⁷⁾ 2,900 ⁽⁷⁾ 400 ⁽¹⁷⁾ 1,400 ⁽¹⁷⁾
Howard	H17	H16	Del Prete Ave.	340	VC	8	Minor	121; 264	152-153 ⁽⁵⁾	3,000	19/R 95/L 222/L	2,200 700 150

TABLE 2 (Continued). SUMMARY OF SEWER PIPELINE DEFECTS

Location				Pipe Information			Main Pipeline Defect Severity	Pipeline Defects				
Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in.)		Main Pipeline			Service Connections	
								Leak in Joint ⁽¹⁾	Cracked or Broken Pipe ⁽¹⁾	Estimated Infiltration (gpd) ⁽²⁾	Service Connection Location (Station/Orientation) ⁽³⁾	Estimated Infiltration (gpd) ⁽²⁾
Howard	H39	H38	Park St.	241	VC	8	Minor	129; 215		1,700	18/R 30/L 37/R 114/R 170/R 232/R	2,200 ⁽⁷⁾ 1,400 3,600 700 1,400 400
Howard	H42	H5	East Water St.	209	VC	8	Minor	80	80-81	2,200	9/L	700
Howard	H43	H42	East Water St.	215	VC	8	None					
Howard	H61	H67	School St.	321	VC	8	Minor	152	(10)	1,400	164/L 176/R	400 150 ⁽⁸⁾
Howard	H68	H67	School St.	230	VC	8	None				82/R	400
Josh Gray	J2	J1	Linwood Ter.	260	RC	15	None				168/T	700
Josh Gray	J4	J2	Shaw Rd.	223	RC	15	None				63/T 129/T	1,400 2,900
Josh Gray	J5	J4	Easement	316	RC	15	None				15/T 238/T ⁽¹¹⁾	1,400 0
Josh Gray	J6	J5	Josh Gray Dr.	220	RC	15	None				90/T 149/T	300 700
Josh Gray	J7	J6	Josh Gray Dr.	273	RC	15	Minor	126	87 ⁽⁵⁾	4,300	44/T 125/T 210/T	700 1,400 2,900 ⁽⁴⁾
Josh Gray	J7	J8	Josh Gray Dr.	262	RC	15	Minor	62; 85		1,900	29/T 89/T 131/T ⁽¹²⁾	150 700 ⁽⁴⁾ 700
Josh Gray	J9	J8	Levin Rd.	120	RC	15	None				23/R 62/R 113/L ⁽¹³⁾	1,400 ⁽⁴⁾ 1,400 0
Josh Gray	J10	J9	Levin Rd.	297	RC	15	None				42/L 190/L 234/R	300 300 2,900
Josh Gray	J11A	J10A	Levin Rd.	14	AC	10	None					
Josh Gray	J11B	J10B	Levin Rd.	14	AC	10	None					

TABLE 2 (Continued). SUMMARY OF SEWER PIPELINE DEFECTS

Location				Pipe Information			Main Pipeline Defect Severity	Pipeline Defects				
								Main Pipeline			Service Connections	
								Leak in Joint ⁽¹⁾	Cracked or Broken Pipe ⁽¹⁾	Estimated Infiltration (gpd) ⁽²⁾	Service Connection Location (Station/Orientation) ⁽³⁾	Estimated Infiltration (gpd) ⁽²⁾
Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in.)						
Josh Gray	J12	J11	Levin Rd.	290	RC	15	None		20 ⁽⁵⁾	20/L 55/R 148/R 219/L 243/R	400 300 1,400 ⁽⁴⁾ 400 400	
Josh Gray	J13	J12	Levin Rd.	234	RC	15	None			78/R 90/L 156/L 176/R	400 300 400 ⁽⁷⁾ 400 ⁽⁷⁾	
Josh Gray	J17	J16	Moncreif Rd.	301	VC	10	Minor	3; 30; 246; 256	9,000	56/L 120/L 127/R 273/L	400 400 1,400 ⁽⁴⁾ 400	
Josh Gray	J18	J17	Moncreif Rd.	287	VC	10	Minor	91; 116; 126; 152; 187	3,900	146/T 248/T	700 400	
Josh Gray	J19	J18	Moncreif Rd.	296	VC	10	None			50/T 142/T 242/T	5,800 400 400	
Josh Gray	J20	J19	Moncreif Rd.	299	VC	10	None			41/T 122/T 204/T 280/T	1,400 700 1,400 4,300	
Josh Gray	J21	J20	Moncreif Rd.	298	VC	10	None		(14)	61/T 148/T 249/T	400 1,400 400	
Josh Gray	J22	J21	Pierce Rd.	242	VC	10	None		97 ⁽⁵⁾	73/T 169/T	1,400 2,900	
Josh Gray	J23	J22	Levin Rd.	327	VC	10	None			80/T 187/T 253/T	2,900 1,400 700	
Josh Gray	J25	J23	Levin Rd.	228	VC	10	None			57/T 154/T	400 700	
Josh Gray	J25	J24	Old Market St.	88	PVC	8	None					
Josh Gray	J28	J27	Moncreif Rd.	76	VC	8	None			67/R	2,200 ⁽⁴⁾	
Josh Gray	J34	J10	Josh Gray Rd.	242	VC	8	None			80/R	700	

TABLE 2 (Continued). SUMMARY OF SEWER PIPELINE DEFECTS

Location				Pipe Information			Main Pipeline Defect Severity	Pipeline Defects				
Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in.)		Main Pipeline			Service Connections	
								Leak in Joint ⁽¹⁾	Cracked or Broken Pipe ⁽¹⁾	Estimated Infiltration (gpd) ⁽²⁾	Service Connection Location (Station/Orientation) ⁽³⁾	Estimated Infiltration (gpd) ⁽²⁾
Josh Gray	J39	J38	Moncreif Rd.	269	VC	8	None				69/R	1,400 ⁽⁴⁾
Josh Gray	J50	J13	Levin Rd.	321	PVC	8	None				75/L 170/L	2,200 1,400
Josh Gray	J51	J50	Levin Rd.	319	PVC	8	None				136/T 173/T 254/L 256/R 312/T 314/T	700 2,900 ⁽⁴⁾ 400 700 2,900 150
Josh Gray	J54	J13	Brooks Rd.	240	VC	10	Minor	29	222-223 ⁽⁵⁾	300		
Josh Gray	J55	J54	Durbeck Rd.	308	VC	8	Minor	127; 171; 186		1,300	16/R 94/L 158/L 273/L	2,900 ⁽⁷⁾ 2,200 300 700
Josh Gray	J56	J55	Durbeck Rd.	275	VC	8	Minor	84; 191; 193		6,100	21/L 101/L 124/R 176/L 193/R 270/L	1,100 700 700 2,200 700 700
Josh Gray	J59	J58	Durbeck Rd.	303	VC	8	None					
Josh Gray	J60	J59	Durbeck Rd.	219	VC	8	Minor	8; 12; 32		2,900	9/L	700
Josh Gray	J61	J54	Brooks Rd.	226	VC	8	Minor		89 ⁽⁵⁾		204/L	700
Josh Gray	J62	J61	Huggins Rd.	351	VC	8	Minor		296-297 ⁽⁵⁾		42/L	700
Josh Gray	J64	J63	Huggins Rd.	349	PVC	8	None				5/R 345/R	3,600 2,200
Liberty	L9	L8	Liberty St.	270	RC	21	Minor	61; 108; 122		3,900	20/T	700
Liberty	L10	L9	Liberty St.	261	RC	21	Minor	12		400	89/T 132/T 164/T	300 1,400 150
Liberty	L11	L10	Liberty St.	170	RC	21	None					
Liberty	L66	L11	East Water St.	131	RC	21	Minor	48; 95		300	58/T 97/T	300 300
Liberty	L12	L66	Sunnybank Ave.	251	RC	21	Minor	152		700		
Liberty	L13	L12	Sunnybank Ave.	199	RC	21	Minor	115		300		

TABLE 2 (Continued). SUMMARY OF SEWER PIPELINE DEFECTS

Location				Pipe Information			Main Pipeline Defect Severity	Pipeline Defects				
Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Pipe Information			Main Pipeline			Service Connections	
					Type	Dia. (in.)		Leak in Joint ⁽¹⁾	Cracked or Broken Pipe ⁽¹⁾	Estimated Infiltration (gpd) ⁽²⁾	Service Connection Location (Station/Orientation) ⁽³⁾	Estimated Infiltration (gpd) ⁽²⁾
Liberty	L14	L13	Sunnybank Ave.	124	RC	21	None					
Liberty	L15	L14	Sunnybank Ave.	101	RC	21	None					
Liberty	L16	L15	Sunnybank Ave.	306	RC	21	None					
Liberty	L17	L16	Sunnybank Ave.	235	RC	21	None					
Liberty	L30	L10	East Water St.	351	VC	8	Minor	141	94-95 ⁽¹⁵⁾	700	68/T 126/R 133/R 140/L 220/T	700 400 300 700 2,900
Liberty	L68	L71	East Water St.	34	AC	8	None					
JD Mem.	M1	C63	John Dunn Mem. Dr.	349	RC	24	Minor	67; 276; 298; 332		600	103/R 258/T	400 400
JD Mem.	M2	M1	John Dunn Mem. Dr.	300	RC	24	Minor	37; 115; 226		3,200	215/R	700
JD Mem.	M3	M2	John Dunn Mem. Dr.	106	RC	24	None					
JD Mem.	M4	M3	John Dunn Mem. Dr.	107	RC	24	None					
JD Mem.	M5	M4	John Dunn Mem. Dr.	178	RC	24	None					
JD Mem.	M6	M5	John Dunn Mem. Dr.	179	RC	24	None					
JD Mem.	M7	M6	John Dunn Mem. Dr.	196	RC	24	Minor	1; 34		300		
JD Mem.	M8	M7	John Dunn Mem. Dr.	115	RC	24	None				15/R	700
JD Mem.	M9	M8	John Dunn Mem. Dr.	243	RC	21	None				23/T	400
JD Mem.	M97	M9	Studley's Pond Easement	476	RC	21	None					
JD Mem.	M97	M98	Studley's Pond Easement	360	RC	21	None					
JD Mem.	M99	M98	Studley's Pond Easement	301	RC	21	None					
JD Mem.	M87	M99	Studley's Pond Easement	484	RC	21	None					
JD Mem.	M20	M87	Studley's Pond Easement	234	RC	21	Minor	6		150		
JD Mem.	M21	M20	Emerson St. Easement	213	RC	18	None					
JD Mem.	M22	M21	Emerson St. Easement	193	RC	18	None					
JD Mem.	M23	M22	Emerson St. Easement	210	RC	18	None					
JD Mem.	M25	M24	West Water St.	193	VC	8	None				23/R 98/L 177/T	400 1,400 ⁽⁴⁾ 700
-	N143	N144	Liberty St.	169	PVC	12	None				104/T	700

TABLE 2 (Continued). SUMMARY OF SEWER PIPELINE DEFECTS

Location				Pipe Information			Main Pipeline Defect Severity	Pipeline Defects				
								Main Pipeline		Service Connections		
Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in.)		Leak in Joint ⁽¹⁾	Cracked or Broken Pipe ⁽¹⁾	Estimated Infiltration (gpd) ⁽²⁾	Service Connection Location (Station/Orientation) ⁽³⁾	Estimated Infiltration (gpd) ⁽²⁾
-	N144	N147	Liberty St.	179	VC	12	Minor	36; 144; 156		4,300		
-	N284	N285	Marks St.	57	PVC	8	None					
Pond	P3	P7	Pond St.	238	AC	8	None					
Pond	P7	P10	Pond St.	102	AC	8	None					
Pond	P10	P11	Pond St.	237	AC	8	None		(16)		138/T 180/T	1,400 150
Pond	P31	P32	Old Country Way	115	PVC	8	None					
Pond	P36	P35	French Rd.	369	PVC	8	None					
Pond	P36	P37	French Rd.	80	PVC	8	None					
-	S181	S180	Summer St.	10	PVC	8	None					
-	S181	S182	Summer St.	114	PVC	8	None					
-	S190	S195	Summer St.	164	PVC	8	None					
-	S195	S196	Summer St.	242	PVC	8	None				169/T	700
-	S196	S197	Summer St.	308	PVC	8	None				177/T	700
West Water	W26	W25	North Ave.	223	PVC	12	None					
West Water	W27	W26	North Ave.	165	PVC	12	None					
West Water	W27	W28	North Ave.	86	VC	12	None					
West Water	W88	W87	Brookside Rd.	291	VC	10	None				78/T 110/T 177/T 200/T 256/T	400 2,900 3,600 1,400 400
West Water	W88	W89	Brookside Rd.	85	VC	10	None					
Total										85,450		226,500

Notes:

- (1) The number in this column is the distance in feet from the first manhole identified in the "Location" column, and represents the location of the defect.
- (2) Estimated infiltration is based upon a visual assessment of each infiltration source (pipeline defect).
- (3) The station is the distance in feet from the first manhole identified in the "Location" column. For orientation, when advancing from the first manhole identified in the "Location" column toward the second manhole, L=left side; R=right side; T=top.
- (4) Leaks visible in first joint at pipe connection between main pipeline and service connection.
- (5) Very minor crack observed with no visible infiltration. Pipe appears to be structurally sound. Rehabilitation not recommended.
- (6) Leaks visible in joint of vertical portion of drop inlet at MH D6.
- (7) Leaks visible in service connection within first few joints from the main pipeline.
- (8) Leaks entering from capped lateral about 0.5' to 1' from main pipeline.

TABLE 2 (Continued). SUMMARY OF SEWER PIPELINE DEFECTS

- (9) Lateral filled with grease or other material at the main pipeline.
- (10) Heavy debris (pieces of asphalt) observed in pipe at 314' from MH H61.
- (11) Heavy mineral deposits in service connection.
- (12) Extensive roots observed in service connection at connection with main pipeline, and protruding into main pipeline.
- (13) Yellow water (usage) entering main pipeline from this service connection. Service connection has heavy mineral deposits.
- (14) Previously installed liner at 66' from MH J21 is miss-shapen from 7 to 8 o'clock, but remains smooth and liner appears to be structurally sound.
- (15) Broken pipe. No visible infiltration.
- (16) Brick observed across sewer at 65' from MH P10.
- (17) Located in pipe stub connected to MH H32.

REHABILITATION OF INFILTRATION SOURCES ON MAIN PIPELINE AND SEWER MANHOLES

Presented in Table 3 is a summary of the proposed rehabilitation methods for the removal of the infiltration sources found in the main pipelines and sewer manholes, including estimated removable infiltration rates, rehabilitation costs and unit costs. Each rehabilitation cost represents the estimated construction cost for the noted rehabilitation method without an allowance for engineering and contingencies. With both the estimated rehabilitation cost and the estimated removable infiltration rate known, the unit cost of infiltration removed (\$/gpd) is calculated for each source by dividing the rehabilitation cost by the removable infiltration.

A cost-effectiveness analysis was performed to establish a cost-effective breakpoint for the rehabilitation of infiltration sources. The cost-effective breakpoint is a unit cost, typically presented as cost per gallon per day (gpd), whereby an infiltration source with a unit cost for removal greater than the cost-effective breakpoint is not considered cost-effective to remove.

Key items for consideration in establishing the cost-effective breakpoint include the following:

Annual transportation and treatment costs. Information was collected from the Town to estimate the annual cost to transport and treat wastewater flow. The most current information reflects an annual cost of approximately \$2,480,000 which includes costs for sewer related operation and maintenance tasks such as payment for a third party for the operation and maintenance of the wastewater treatment plant (WWTP), labor, vehicle repair and maintenance, etc.

Annual average daily flow. Based upon town records at the WWTP for the last five years (2016 through 2020), the average daily flow is approximately 2,420,000 gpd.

Using a 20-year planning period and an interest rate of 4 percent, the present worth of the transportation and treatment cost is approximately \$33,704,000. The cost-effective breakpoint is established by dividing the present worth of the transportation and treatment cost by the average daily flow at the WWTP:

TABLE 3. MAIN PIPELINE AND MANHOLES – SUMMARY TABLE OF INFILTRATION SOURCES, REHABILITATION METHODS AND COSTS

Location				Pipe Information			Heavy Cleaning	Main Pipeline Recommended Rehabilitation Method			Removable Infiltration (gpd) ⁽¹⁾	Rehabilitation Cost (\$) ⁽²⁾	Unit Cost (\$/gpd)		
Rank	Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Type		Dia. (in.)	Joint Test & Seal	Grout Spot Repair				Structural Spot Repair	Manhole Chemical Seal
1	Josh Gray	J17	J16	Moncrief Rd.	301	VC	10	X					4,500	2,300	0.51
2	Howard	H67	-	School St.							X ⁽³⁾		2,900	1,600	0.55
3	-	S190	-	Summer St.							X ⁽³⁾		5,000	2,800	0.56
4	-	N143	-	Liberty St.							X ⁽³⁾		3,600	2,400	0.67
5	Josh Gray	J56	J55	Durbeck Rd.	275	VC	8	X					3,050	2,100	0.69
6	-	N144	N147	Liberty St.	179	VC	12	X					2,150	1,500	0.70
7	Howard	H3	H2	Howard St.	201	VC	10	X					2,150	1,600	0.74
8	Division	D4	D3	North Ave.	87	VC	10	X					700	700	1.00
9	Division	D133	-	Leisurewoods Dr.							X ⁽³⁾		1,400	1,400	1.00
10	Josh Gray	J7	J6	Josh Gray Dr.	273	RC	15	X					2,150	2,200	1.02
11	Josh Gray	J18	J17	Moncrief Rd.	287	VC	10	X					1,950	2,200	1.13
12	Josh Gray	J60	J59	Durbeck Rd.	219	VC	8	X					1,450	1,700	1.17
13	Liberty	L9	L8	Liberty St.	270	RC	21	X					1,950	2,700	1.39
14	Division	D1	-	North Ave.							X ⁽³⁾		1,400	2,200	1.57
15	West Water	W89	-	Brookside Rd.							X ⁽³⁾		1,400	2,400	1.71
16	Emerson	E26	E25	Reed St.	300	VC	8			215-216			1,450	2,500	1.72
17	Howard	H17	H16	Del Prete Ave.	340	VC	8	X					1,500	2,600	1.73
18	Josh Gray	J6	-	Josh Gray Rd.							X		400	700	1.75
19	Emerson	E32	E31	Taunton Ave.	265	VC	8	X		160-161; 256-257			3,600	7,000	1.94
20	Howard	H39	H38	Park St.	241	VC	8	X					850	1,800	2.12
21	JD Mem.	M2	M1	JD Mem. Dr.	300	RC	24	X					1,600	3,500	2.19
22	Howard	H42	H5	East Water St.	209	VC	8			80-81			1,100	2,500	2.27
23	Division	D144	-	Leisurewoods Dr.							X		300	700	2.33
24	Emerson	E2	-	Plain St.							X		300	700	2.33
25	Emerson	E5	-	Reed St.							X		300	700	2.33
26	Emerson	E12	-	Belmont St.							X		300	700	2.33
27	Emerson	E13	-	Belmont St.							X		300	700	2.33
28	Emerson	E14	-	Belmont St.							X		300	700	2.33
29	Emerson	E15	-	Belmont St.							X		300	700	2.33
30	Emerson	E19	-	Pacific St.							X		300	700	2.33
31	Emerson	E20	-	Pacific St.							X		300	700	2.33
32	Emerson	E22	-	Pacific St.							X		300	700	2.33

TABLE 3 (Continued). MAIN PIPELINE AND MANHOLES – SUMMARY TABLE OF INFILTRATION SOURCES, REHABILITATION METHODS AND COSTS

Location				Pipe Information			Heavy Cleaning	Main Pipeline Recommended Rehabilitation Method			Manhole Chemical Seal	Removable Infiltration (gpd) ⁽¹⁾	Rehabilitation Cost (\$) ⁽²⁾	Unit Cost (\$/gpd)
Rank	Sewer Subbasin	From MH	To MH	Street Name	Length (ft)	Type		Dia. (in.)	Joint Test & Seal	Grout Spot Repair				
33	Emerson	E24	-	Reed St.							X	300	700	2.33
34	Emerson	E28	-	Reed St.							X	300	700	2.33
35	Emerson	E22	-	Taunton Ave.							X	300	700	2.33
36	Emerson	E70	-	Grove St.							X	300	700	2.33
37	Howard	H40	-	Park St.							X	300	700	2.33
38	Liberty	L21	-	Webster St.							X	300	700	2.33
39	Liberty	L33	-	Everett St.							X	300	700	2.33
40	Liberty	L61	-	Hingham St.							X	300	700	2.33
41	-	N113	-	Liberty St.							X	300	700	2.33
42	-	N115	-	Liberty St.							X	300	700	2.33
43	-	N152	-	Liberty St.							X	300	700	2.33
44	-	N156	-	Liberty St.							X	300	700	2.33
45	West Water	W7	-	Culver Dr.							X	300	700	2.33
46	West Water	W46A	-	Salem St.							X	300	700	2.33
47	Liberty	L10	-	Liberty St.							X ⁽³⁾	1,100	3,000	2.73
48	Josh Gray	J7	J8	Josh Gray Dr.	262	RC	15		X ⁽⁴⁾			950	2,600	2.74
49	Division	D7	D6	North Ave.	230	VC	8		X ⁽⁵⁾	218-220		1,450	4,500	3.10
50	Division	D2	D1	North Ave.	252	VC	10		X	250		1,500	4,700	3.13
51	Howard	H61	H67	School St.	321	VC	8	314 ⁽⁶⁾	X			700	2,400	3.43
52	Division	D9	D8	North Ave.	180	VC	8			52; 100		1,450	5,000	3.45
53	Josh Gray	J55	J54	Durbeck Rd.	308	VC	8		X			650	2,300	3.54
54	Howard	H9	H8	Howard St.	165	VC	8		X			350	1,300	3.71
55	Howard	H13	H12	Wall St.	214	VC	8		X			350	1,600	4.57
56	Josh Gray	J4	-	Shaw Rd.							X	150	700	4.67
57	Liberty	L12	-	Sunnybank Ave.							X	150	700	4.67
58	Howard	H4	H3	Howard St.	239	VC	10		X			350	1,800	5.14
59	Emerson	E20	E19	Pacific St.	299	VC	8		X			350	2,300	6.57
60	Liberty	L12	L66	Sunnybank Ave.	251	RC	21		X			350	2,500	7.14
61	Howard	H10	H9	Howard St.	336	VC	8		X			300	2,500	8.33
62	Emerson	E4	E3	Easement	326	RC	18		X			350	3,000	8.57
63	Liberty	L66	L11	East Water St.	131	RC	21		X			150	1,300	8.67
64	Concord	C3	C2	Concord St.	234	VC	8		X			200	1,800	9.00
65	Emerson	E14	E13	Belmont St.	292	VC	8		X			200	2,200	11.00
66	Howard	H8	H7	Howard St.	226	VC	8		X	12-13		450	5,000	11.11
67	Josh Gray	J54	J13	Brooks Rd.	240	VC	10		X			150	1,800	12.00

TABLE 3 (Continued). MAIN PIPELINE AND MANHOLES – SUMMARY TABLE OF INFILTRATION SOURCES, REHABILITATION METHODS AND COSTS

Rank	Sewer Subbasin	Location			Pipe Information			Heavy Cleaning	Main Pipeline Recommended Rehabilitation Method			Manhole Chemical Seal	Removable Infiltration (gpd) ⁽¹⁾	Rehabilitation Cost (\$) ⁽²⁾	Unit Cost (\$/gpd)
		From MH	To MH	Street Name	Length (ft)	Type	Dia. (in.)		Joint Test & Seal	Grout Spot Repair	Structural Spot Repair				
68	Concord	C85	C35	Albion St.	379	RC	30		X				450	5,700	12.67
69	Liberty	L10	L9	Liberty St.	261	RC	21		X				200	2,600	13.00
70	Liberty	L13	L12	Sunnybank Ave.	199	RC	21		X				150	2,000	13.33
71	JD Mem.	M1	C63	JD Mem. Dr.	349	RC	24		X				300	4,000	13.33
72	Concord	C5	C86	Albion St.	355	RC	30		X				350	5,300	15.14
73	JD Mem.	M7	M6	JD Mem. Dr.	196	RC	24		X				150	2,300	15.33
74	Liberty	L30	L10	East Water St.	351	VC	8		X		94.95		350	6,000	17.14
75	Emerson	E5	E4	Easement	301	RC	18		X				150	2,700	18.00
76	Howard	H7	H6	Howard St.	303	VC	8		X				75	2,300	30.67
77	JD Mem.	M20	M87	Studley's Pond Easement	234	RC	21		X				75	2,400	32.00
78	Concord	C86	C1	Albion St.	348	RC	30		X				75	5,200	69.33
Total													67,425	160,700	

Notes:

- (1) Infiltration rates shown are estimated removable infiltration rates. It was assumed that recommended rehabilitation work would remove 100 percent of the infiltration entering the system through manhole walls and bases and 50 percent of infiltration through main pipelines.
- (2) Rehabilitation costs do not include an allowance for engineering and contingencies.
- (3) Recommended rehabilitation includes chemical seal and installation of cementitious liner.
- (4) Root removal required at 130' from MH J7.
- (5) Recommended rehabilitation is for testing and sealing joints in drop connection at MH D6.
- (6) Heavy debris (pieces of asphalt) observed in pipe at 314' from MH 61. Pipe cleaning is recommended.

General Notes:

- A. Refer to Tables 1 and 2 for detailed breakdown of manhole defects and pipeline defects, respectively.
- B. The number noted in the "Spot Repair" columns or the "Heavy Cleaning" column is the distance in feet from the first manhole identified in "Location" column, and represents the location of recommended pipe spot repair or heavy cleaning.

$$\frac{\text{Present worth of transportation and treatment cost}}{\text{Average daily flow}} = \frac{\$33,704,000}{2,420,000 \text{ gpd}} = \$13.93/\text{gpd}$$

This means that any infiltration source with a unit cost for removal equal to or less than \$13.93 per gallon per day is considered cost-effective to remove. An infiltration source with a unit cost for removal greater than \$13.93 per gallon per day is not considered cost-effective to remove.

Table 3 includes a priority ranking of infiltration sources from the lowest unit cost to the highest unit cost. We recommend that all infiltration sources with a unit cost for removal equal to or less than \$13.93 be rehabilitated. In applying this criteria to Table 3, a total of approximately 66,200 gpd of infiltration can be cost-effectively removed from the main pipelines and manholes by rehabilitating 71 infiltration sources at an estimated construction cost of \$134,500.

REHABILITATION OF INFILTRATION SOURCES ON SERVICE CONNECTIONS

The results of the television inspection and flow isolation work show a significant amount of infiltration entering the sewer system through lateral service connections. In fact, as shown in the “Total” row at the bottom of Table 2, the estimated infiltration entering the sewer system from service connections within the sewers that were televised is substantially greater than the estimated infiltration entering the sewer system from the main pipeline (226,500 gpd versus 85,450 gpd, respectively). Evidence of infiltration from service connections was noted by the following methods:

- During the television inspection work, the camera used to inspect the main pipeline had the pan and tilt capability to peer directly into the incoming service connection. In many locations, the resulting video clearly shows the locations of leaks in joints within the first few pipe lengths of the service connection.
- Service connections noted to be running with a constant flow of clear water over a period of several minutes.

There are four typical methods to rehabilitate a service connection to remove infiltration sources, as described below. The estimated costs presented below are construction costs and do not include an allowance for engineering and contingencies.

- a. Joint Test and Seal.** This work is typically performed by inserting joint testing and sealing equipment into the service connection from the main pipeline. Joints and pipe cracks in the service connection are then chemically grouted in a manner similar to that used in the main pipeline. During this work, it is often difficult for the equipment to negotiate the pipe bends commonly installed on service connections and the extent of work is generally limited to short distances of up to 20 feet from the main pipeline. The estimated cost to test and seal the joints in a service connection as referenced above is approximately \$3,000 per connection.
- b. Excavate and Replace.** The service connection may be excavated and replaced from the face of the dwelling to the main pipeline in the street. The cost of this work will vary depending upon the length of the service connection, the depth of pipe, the need for dewatering of groundwater in the pipe trench, the extent of above ground reinstatement work that would need to be performed to improved lawns and shrubbery, sidewalk and pavement replacement in the main road, and traffic control. A typical cost for replacement of a service connection 55 feet long may approach \$10,000 per service connection, if the service connection is connected to the main pipeline through a wye branch.

If a service connection is connected to the main pipeline through a chimney, as defined later in this report, the estimated cost to excavate and replace the chimney and 10 feet of main pipeline (5 feet each side of chimney) is approximately \$10,000 per chimney. Thus, the total cost to excavate and replace a service connection connected to a chimney is approximately \$20,000, being the sum of \$10,000 for the service connection plus \$10,000 for the chimney and 10 feet of main pipeline.

- c. Pipe Lining Through Wye Branch Connection.** There are several trenchless technologies available for installing a cured-in-place lateral liner into the existing service connection between the house and the main pipeline. The lining is typically installed from the main pipeline into the wye branch of the lateral and consists of a one-piece product affixed to the walls of the lateral pipe and at the junction within the main pipeline. This method of rehabilitation eliminates the joints between the main pipeline and the service connection, and along the service connection to the termination of the liner typically at the cleanout near the house. Depending upon the number of bends that exist in the lateral, a lateral liner can be installed up to 100 feet into the lateral from the main pipeline. A typical cost for service connection lining is approximately \$6,500 per connection, assuming an average service connection length of 55 feet. This cost is estimated using a cost of \$4,500 for the first 30 feet of liner from the main pipeline, plus \$55 per linear foot of liner beyond the first 30 feet from the main pipeline, plus \$600 for CCTV inspection of the new liner roughly a year after completion to confirm no defects.
- d. Pipe Lining with Chimney Connection.** Some service connections connect to the main pipeline through a chimney instead of a wye branch. A chimney is a vertical pipe that extends upward from the main pipeline and connects to the service connection at the top of the chimney with a 90 degree “tee” fitting. The tee fitting may connect to either one or two lateral service connections at the top. Where a chimney exists, installation of a continuous liner between the main pipeline and the lateral service connection to the cleanout of the house is not possible because the equipment is usually not capable of navigating the 90 degree bend at the top of the chimney. Instead, current technology allows for the bottom two feet of the chimney to be sealed from the main pipeline including the key connection between the chimney with the main pipeline where infiltration is commonly found; and a liner is installed in the service connection from the cleanout near the house to the top of the chimney at the main pipeline. Under this procedure, the service connection is lined and a portion of the chimney is sealed, but the length of chimney greater than 2 feet from the main pipeline remains unsealed. For example, if a chimney vertical dimension is 5 feet, only the bottom 2 feet of the chimney would be sealed and the remaining top 3 feet of the chimney would not be sealed.

Where one service connection is connected to the top of a chimney, a typical estimated cost for service connection liner with the bottom 2 feet of chimney seal is approximately \$10,100 per connection, assuming an average service connection length of 55 feet. This cost is estimated using a unit rate of \$100 per linear foot of liner installed from cleanout to the main pipeline (\$5,500) plus \$2,500 for the bottom 2 feet of the chimney to be sealed at the main pipeline, plus \$1,500 for work at the cleanout near the house from where the liner will be installed, plus \$600 for CCTV inspection of the new liner through the cleanout roughly a year after completion to confirm no defects.

Where two service connections are connected to the top of the chimney, a typical estimated cost for two service connection liners with a chimney seal is approximately \$17,700 using the same unit rates identified above.

As shown above, joint testing and sealing is the least expensive method for rehabilitating a service connection. However, joint testing and sealing is not recommended for rehabilitation of a service connection because of the limited length (approximately 20 feet) that joint testing and sealing can be performed from the main pipeline. The 20 feet length is approximately one-third of the total length of a typical service connection. If only the first 20 feet of the service connection is sealed, there is a potential for infiltration to migrate to the joints along the service connection that are left unsealed.

The recommended method for rehabilitating service connections is pipe lining, which eliminates joints between the main pipeline to the terminus of the liner at the cleanout near the house. During the initial stages of the rehabilitation work, television inspection of each service connection should be performed to confirm if the service connection is an appropriate candidate for pipe lining or if another rehabilitation method is appropriate, based on the nature and location of the pipe defects and leaks, and the location of bends in the pipe.

Presented in Table 4 is a summary of the lateral service connections with infiltration sources identified during the field work and the related rehabilitation costs. Only the service connections with estimated infiltration amounts of 1,000 gpd or greater are shown in the table.

TABLE 4. LATERAL SERVICE CONNECTIONS – SUMMARY TABLE OF INFILTRATION SOURCES AND REHABILITATION COSTS

General Location			Main Pipeline Information			Lateral Service Connection Information						
From MH	To MH	Service Connection Address or Street Name	Length (feet)	Type	Diameter (inches)	Location (1)	Orientation (2)	Approx. Chimney Height (feet)	Chimney Service Connections (3)	Estimated Infiltration (gpd)	Estimated Rehabilitation Cost (\$)(4)	Unit Cost (\$/gpd)
C3	C2	41 Concord St. 47 Concord St.	234	VC	8	117 187	R R			1,400 1,400	6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾	4.64 4.64
C86	C1	142 Albion St. & 80 Concord St.	348	RC	30	299	T	2.7	2	1,400	17,700 ⁽¹³⁾	12.64
C85	C5	71 & 72 Albion St.	410	RC	30	327	T	4.9	2	2,900 ⁽⁵⁾	17,700 ⁽¹³⁾	6.10
C7	C35	323/325 Market St.	431	RC	30	156	T	4.0	1	1,400	10,100 ⁽¹⁴⁾	7.21
D2	D1	177 & 180 North Ave. 169/171 North Ave.	252	VC	10	171 249	T T	3.2 4.7	2 1	5,000 5,000	17,700 ⁽¹³⁾ 10,100 ⁽¹⁴⁾	3.54 2.02
D3	D2	203 North Ave.	160	VC	10	37	T	4.3	1	2,200	10,100 ⁽¹⁴⁾	4.59
D9	D8	305 North Ave.	180	VC	8	160	T ⁽¹⁰⁾			2,200	6,500 ⁽¹²⁾	2.95
D67	D66	466 Union St. 482 Union St.	257	VC	8	12 174	L L			1,400 1,400	6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾	4.64 4.64
E4	E3	Connection from Memorial Park School	326	RC	18	85	L ⁽¹¹⁾			8,600	(11)	-
E5	E4	210 & Lot W-56 & 13 Reed St.	301	RC	18	72	T	4.9	2	4,300	17,700 ⁽¹³⁾	4.12
E13	E12	134 Belmont St.	170	VC	8	134	L			1,400	6,500 ⁽¹²⁾	4.64
E14	E13	102 Belmont St.	292	VC	8	89	L			2,200	6,500 ⁽¹²⁾	2.95
E20	E19	71 Pacific St.	299	VC	8	58	R			1,400 ⁽⁶⁾	6,500 ⁽¹²⁾	4.64
E26	E25	71 Reed St.	300	VC	8	134	R			1,400	6,500 ⁽¹²⁾	4.64
H4	H3	196 Howard St.	239	VC	10	50	R			3,600	6,500 ⁽¹²⁾	1.81
H13	H12	28 Wall St. 27 Wall St.	214	VC	8	187 199	R L			2,200 ⁽⁶⁾ 2,200 ⁽⁶⁾	6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾	2.95 2.95
H13	H31	Across from 104 Exchange St. Across from 114 Exchange St.	280	VC	8	87 171	R R			2,900 ⁽⁷⁾ 1,400 ⁽⁸⁾	6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾	2.24 4.64
H31	H32	127 Exchange St. 138 Exchange St. 139 Exchange St. 145 Exchange St. 153 Exchange St.	348	VC	8	92 104 200 218 348	R L R R R			1,400 ⁽⁵⁾ 1,400 2,900 ⁽⁶⁾ 2,900 ⁽⁶⁾ 1,400 ⁽⁹⁾	6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾	4.64 4.64 2.24 2.24 4.64

**TABLE 4 (Continued). LATERAL SERVICE CONNECTIONS – SUMMARY TABLE OF INFILTRATION
SOURCES AND REHABILITATION COSTS**

General Location			Main Pipeline Information				Lateral Service Connection Information					
From MH	To MH	Service Connection Address or Street Name	Length (feet)	Type	Diameter (inches)	Location (1)	Orientation (2)	Approx. Chimney Height (feet)	Chimney Service Connections (3)	Estimated Infiltration (gpd)	Estimated Rehabilitation Cost (\$)(4)	Unit Cost (\$/gpd)
H17	H16	37 Christine Ave.	340	VC	8	19	R			2,200	6,500 ⁽¹²⁾	2.95
H39	H38	57 Park St.	241	VC	8	18	R			2,200 ⁽⁶⁾	6,500 ⁽¹²⁾	2.95
		58/56 Park St.				30	L			1,400	6,500 ⁽¹²⁾	4.64
		65 Park St.				37	R			3,600	6,500 ⁽¹²⁾	1.81
		75/73 Park St.				170	R			1,400	6,500 ⁽¹²⁾	4.64
J4	J2	Shaw Rd. "lots"	223	RC	15	63	T	6.2	2	1,400	17,700 ⁽¹³⁾	12.64
		16 & 32 Linwood Ter.				129	T	6.2	2	2,900	17,700 ⁽¹³⁾	6.10
J5	J4	38 & 43 Josh Gray Rd.	316	RC	15	15	T	6.4	2	1,400	17,700 ⁽¹³⁾	12.64
J7	J6	20 & 19 Josh Gray Rd.	273	RC	15	125	T	3.1	2	1,400	17,700 ⁽¹³⁾	12.64
		24 & 23 Josh Gray Rd.				210	T	4.1	2	2,900 ⁽⁵⁾	17,700 ⁽¹³⁾	6.10
J9	J8	307 Levin Rd.	120	RC	15	23	R			1,400 ⁽⁵⁾	6,500 ⁽¹²⁾	4.64
		5 Josh Gray Rd.				62	R			1,400	6,500 ⁽¹²⁾	4.64
J10	J9	299 Levin Rd.	297	RC	15	234	R			2,900	6,500 ⁽¹²⁾	2.24
J12	J11	265 Levin Rd.	290	RC	15	148	R			1,400 ⁽⁵⁾	6,500 ⁽¹²⁾	4.64
J17	J16	139 Moncrief Rd.	301	VC	10	127	R			1,400 ⁽⁵⁾	6,500 ⁽¹²⁾	4.64
J19	J18	123 & 122 Moncrief Rd.	296	VC	10	50	T	6.1	2	5,800	17,700 ⁽¹³⁾	3.05
J20	J19	91 & 90 Moncrief Rd.	299	VC	10	41	T	4.2	2	1,400	17,700 ⁽¹³⁾	12.64
		107 & 104 Moncrief Rd.				204	T	4.4	2	1,400	17,700 ⁽¹³⁾	12.64
		115 & 114 Moncrief Rd.				280	T	4.4	2	4,300	17,700 ⁽¹³⁾	4.12
J21	J20	74 & 73 Moncrief Rd.	298	VC	10	148	T	4.2	2	1,400	17,700 ⁽¹³⁾	12.64
J22	J21	61 Levin Rd.	242	VC	10	73	T	4.2	1	1,400	10,100 ⁽¹⁴⁾	7.21
		64 Moncrief Rd. & 6 Pierce Rd.				169	T	4.3	2	2,900	17,700 ⁽¹³⁾	6.10
J23	J22	30 & 27 Levin Rd.	327	VC	10	80	T	4.3	2	2,900	17,700 ⁽¹³⁾	6.10
		38 & 37 Levin Rd.				187	T	4.2	2	1,400	17,700 ⁽¹³⁾	12.64
J28	J27	21 Moncrief Rd.	76	VC	8	67	R			2,200 ⁽⁵⁾	6,500 ⁽¹²⁾	2.95
J39	J38	263 Moncrief Rd.	269	VC	8	69	R			1,400 ⁽⁵⁾	6,500 ⁽¹²⁾	4.64
J50	J13	208 Levin Rd.	321	PVC	8	75	L			2,200	6,500 ⁽¹²⁾	2.95
		216 Levin Rd.				170	L			1,400	6,500 ⁽¹²⁾	4.64
J51	J50	185 Levin Rd.	319	PVC	8	173	T ⁽¹⁰⁾			2,900 ⁽⁵⁾	6,500 ⁽¹²⁾	2.24
		138 Levin Rd.				312	T ⁽¹⁰⁾			2,900	6,500 ⁽¹²⁾	2.24
J55	J54	193 Durbeck Rd.	308	VC	8	16	R			2,900 ⁽⁶⁾	6,500 ⁽¹²⁾	2.24
		204 Durbeck Rd.				94	L			2,200	6,500 ⁽¹²⁾	2.24

TABLE 4 (Continued). LATERAL SERVICE CONNECTIONS – SUMMARY TABLE OF INFILTRATION SOURCES AND REHABILITATION COSTS

General Location			Main Pipeline Information				Lateral Service Connection Information					
From MH	To MH	Service Connection Address or Street Name	Length (feet)	Type	Diameter (inches)	Location (1)	Orientation (2)	Approx. Chimney Height (feet)	Chimney Service Connections (3)	Estimated Infiltration (gpd)	Estimated Rehabilitation Cost (\$ (4)	Unit Cost (\$/gpd)
J56	J55	172 Durbeck Rd. 188 Durbeck Rd.	275	VC	8	21 176	L L			1,100 2,200	6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾	5.91 2.95
J64	J63	65 Huggins Rd. 101 Huggins Rd.	349	PVC	8	5 345	R R			3,600 2,200	6,500 ⁽¹²⁾ 6,500 ⁽¹²⁾	1.81 2.95
L10	L9	225 East Water St.	261	RC	21	132	T	4.3	1	1,400	10,100 ⁽¹⁴⁾	7.21
L30	L10	222 East Water St.	351	VC	8	220	T	3.0	1	2,900	10,100 ⁽¹⁴⁾	3.48
M25	M24	232 West Water St.	193	VC	8	98	L			1,400 ⁽⁵⁾	6,500 ⁽¹²⁾	4.64
P10	P11	154R Pond St.	237	AC	8	138	T	8.6	1	1,400	10,100 ⁽¹⁴⁾	7.21
W88	W87	60 Brookside Rd. 69 Brookside Rd. 70 Brookside Rd.	291	VC	10	110 177 200	T T T	2.6 2.4 2.4	1 1 1	2,900 3,600 1,400	10,100 ⁽¹⁴⁾ 10,100 ⁽¹⁴⁾ 10,100 ⁽¹⁴⁾	3.48 2.81 7.21
Total										161,700	674,900	

Notes:

- (1) The number noted in the "Location" column is the distance in feet from the first manhole identified in the "General Location" column.
- (2) When advancing from the first manhole identified in the "General Location" column toward the second manhole, L = left side; R = right side; T = top.
- (3) Number in column indicates number of lateral service connections that are connected to the top of chimney.
- (4) Rehabilitation costs do not include an allowance for engineering and contingencies.
- (5) Leaks visible in first joint at pipe connection between main pipeline and chimney.
- (6) Leaks visible in service connection within first few joints from the main pipeline.
- (7) Leaks entering from capped lateral about .5' to 1' from main pipeline.
- (8) Lateral filled with grease or other material at the main pipeline.
- (9) Located in pipe stub connected to MH H32.
- (10) One LSC connection at top of main pipeline, but not a chimney.
- (11) Approximate 300' long service connection (6" & 8" VC pipe) extending to Memorial Park School, consisting of approximately 5 pipe segments. Internal CCTV inspection of the 300 LF of pipe is recommended in order to confirm if any subsequent rehabilitation work is needed.
- (12) Estimated rehabilitation cost is for lining the LSC from the main pipeline to the cleanout near house.
- (13) Estimated rehabilitation cost is for sealing the bottom 2 feet of chimney at the main pipeline and for lining each of the two LSC's from cleanout at each house to the top of the chimney at the main pipeline.
- (14) Estimated rehabilitation cost is for sealing the bottom 2 feet of chimney at the main pipeline and for lining the LSC from the cleanout at house to the top of the chimney at the main pipeline.

The rehabilitation costs represent the estimated construction costs without an allowance for engineering and contingencies.

A review of Table 4 shows the following types of lateral service connections:

- A total of 40 service connections are shown to be connecting to the main pipeline either from the left or the right, identified as “L” or “R” respectively, in the orientation column. These service connections are typically connected to the side of the main pipeline through a wye branch at an angle not greater than 45 degrees.
- A total of 30 service connections are shown to connect to the main pipeline from the top, identified as “T” in the orientation column. Three of these service connections are connected to the main pipeline from the top through a wye branch and the other 27 are connected to the main pipeline through a chimney. Table 4 identifies the number of service connections connected to each chimney and the approximate height of each chimney. As shown in Table 4, 10 chimneys connect to one service connection at the top of the chimney, and 17 chimneys connect to two service connections at the top of the chimney.

The locations of the service connections with infiltration listed in Table 4 were reviewed. If service connections for adjacent houses are found to exhibit high infiltration rates, this is an indication that the general area may have high groundwater and defective service connections, and the most effective way to reduce the infiltration is to rehabilitate all of the service connections in that area. A group of 9 service connections listed in Table 4 recommended for rehabilitation is clustered along Exchange Street and Wall Street between manhole Nos. H32 and H12. Another group of 9 service connections is clustered along Moncrief Road and Levin Road between manhole Nos. J18 and J23.

Table 4 includes a column showing the unit cost (\$/gpd), representing the estimated rehabilitation cost divided by the estimated infiltration removed for each infiltration source. For estimating the unit cost, we assume the recommended rehabilitation method will remove all the

estimated infiltration in the service connection. As derived earlier in this report, an infiltration source with a unit cost for removal equal to or less than \$13.93 per gallon per day is considered cost-effective to remove. In applying this criteria to Table 4, a total of approximately 153,100 gpd of infiltration can be cost-effectively removed from the lateral service connections and chimneys by rehabilitating 69 infiltration sources at an estimated construction cost of approximately \$674,900.

SUMMARY

The field work performed as part of this study identified 78 infiltration sources in sewer manholes and main pipelines. These sources contribute an estimated 67,500 gpd of removable infiltration. The field work also identified 69 service connections with estimated infiltration amounts equal to or greater than 1,000 gpd each. These service connections contribute an estimated 153,100 gpd of infiltration to the sewer system.

A cost-effectiveness analysis was performed, and 140 infiltration sources contributing a total of approximately 219,300 gpd of infiltration were determined to be cost-effective to remove. The total construction cost of this rehabilitation effort is estimated at \$809,400, representing the sum of approximately \$134,500 to rehabilitate manholes and main pipeline plus approximately \$674,900 to rehabilitate lateral service connections.

We recommend that the infiltration sources which were determined to be cost-effective to remove be rehabilitated.

During the television inspection work between manhole Nos. E4 and E3 (easement for 18-inch pipe off Reed Street), a pipe connection thought to be a service connection was found to have significant infiltration of approximately 8,600 gpd. A subsequent review of available plans in this area shows that the pipe connection is actually an approximate 300 feet long service connection consisting of about 5 pipe segments (6-inch and 8-inch vitrified clay pipe) extending to the Memorial Park School. We recommend the 5 pipe segments receive follow-up CCTV

inspection during a high groundwater period to determine the pipe condition and location of any infiltration sources.

ATTACHMENT A

- Figure 1 Field Work Locations
- Figure 2 General Location Plan of Work

ATTACHMENT B

AECOM Letter Report Dated April 30, 2021 Documenting Flow Isolation Results and
Recommendations for Television Inspection