

Prepared for
Narragansett Bay
Commission

CSO Control Facilities Phase III Reevaluation IPF: Affordability Analysis & Alternatives Costs

23 October 2014

Providence

Rumford

East Providence

Edgewood Lake

Edgewood Yacht Club

Fay Memorial Field



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Affordability analysis

Alternatives costs

Subsystem alternatives
evaluation completion

Alternatives analysis conclusion
& next steps

Alternatives Costs



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Phase II Baseline Subsystems

Design Capacity (MG)	CSO Control Solution	CSOs Controlled
0.77	035 Sewer separation	035
0.46	039 Sewer separation	039
0.42	056 Sewer separation	056
0.14	206 Sewer separation	206
5.26	Upper High & Cross St interceptor	101, 103 ←
5.74	Lower High & Cross St interceptor	101, 103, 104, 105 ←
1.91	Middle St interceptor	201, 202, 203 ←
22.27	Drop shaft 205 & conduit	101, 103, 104, 105, 201, 202, 203, 204, 205
7.21	Drop shaft 210/211 & conduit	207, 208, 209, 210, 211
3.24	Drop shaft 213 & conduit	213, 214
4.97	Pawtucket Ave interceptor	107, 220 ←
7.68	Drop shaft 217 & conduit	107, 217, 220
14.76	Drop shaft 218 & conduit	212, 215, 216, 218
0.00	No Source control	
55.16	Baseline Pawtucket tunnel	101 - 107, 201 - 205, 207 - 220
	Regulator modification	101, 107, 202, 204, 207, 208, 209, 212, 214, 215 ←

Phase II Alternatives Subsystems

Design Capacity (MG)	CSO Control Solution	CSOs Controlled
0.77	Hybrid GSI / Sewer separation	035
0.46	Hybrid GSI / Sewer separation	039
0.42	Hybrid GSI / Sewer separation	056
0.14	Parking lot stormwater tanks	206
5.26	High Street Tank	101, 103
2.12	Webbing Mills Tank	104, 105
1.26	East Street Tank (Viper VoIP Corporation)	201, 202
8.97	Front St Tank / T&D with GSI	203, 204, 205
7.21	City Hall Tank	207, 208, 209, 210, 211
3.24	Apex (or other location) Tank	213, 214
4.97	Morley Field tank, or Stub tunnel	107, 220
2.71	Tidewater Tank / T&D	217
14.02	Bucklin Point landfill tank / T&D	212, 215, 216, 218
5.41	GSI in select sewersheds ←	039, 056, 201, 202, 203, 204, 205, 206, 209, 216
0.00	Tunnel	
	Regulator modifications ←	036, 101, 107, 204, 207, 208, 212, 215

Alternatives Costs

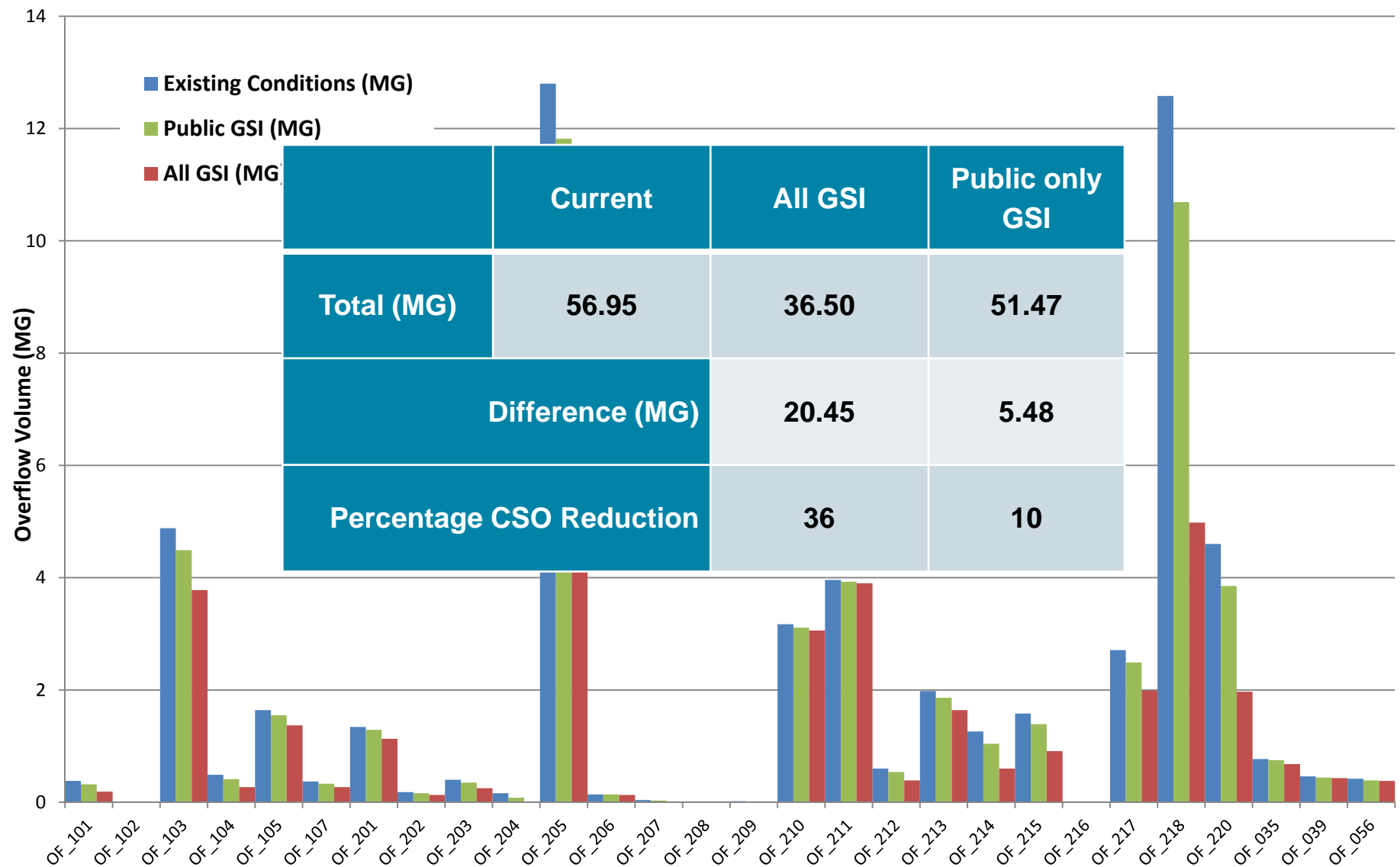
Green Stormwater Infrastructure

GSI Conceptual Designs



	GSI Technique	Design Criteria
Private	Porous Pavement & Bioretention Parking Lots	Equates to 7.2-in depth of storage
	Flat Roof (including green roof)	1.5-in rainfall storage
Public	Porous Pavement	Equates to 3.6-in depth of storage
	Tree Box Filter	Equates to 36 cu.ft storage
	Raingarden / Bumpout	Equates to 4-in depth of storage
	Dry well / infiltration catch basin	Equates to 76 cu.ft storage
	Bioswale	4-in depth of storage

Model Results – CSO reduction



Phase III CSO GSI Capital Costs

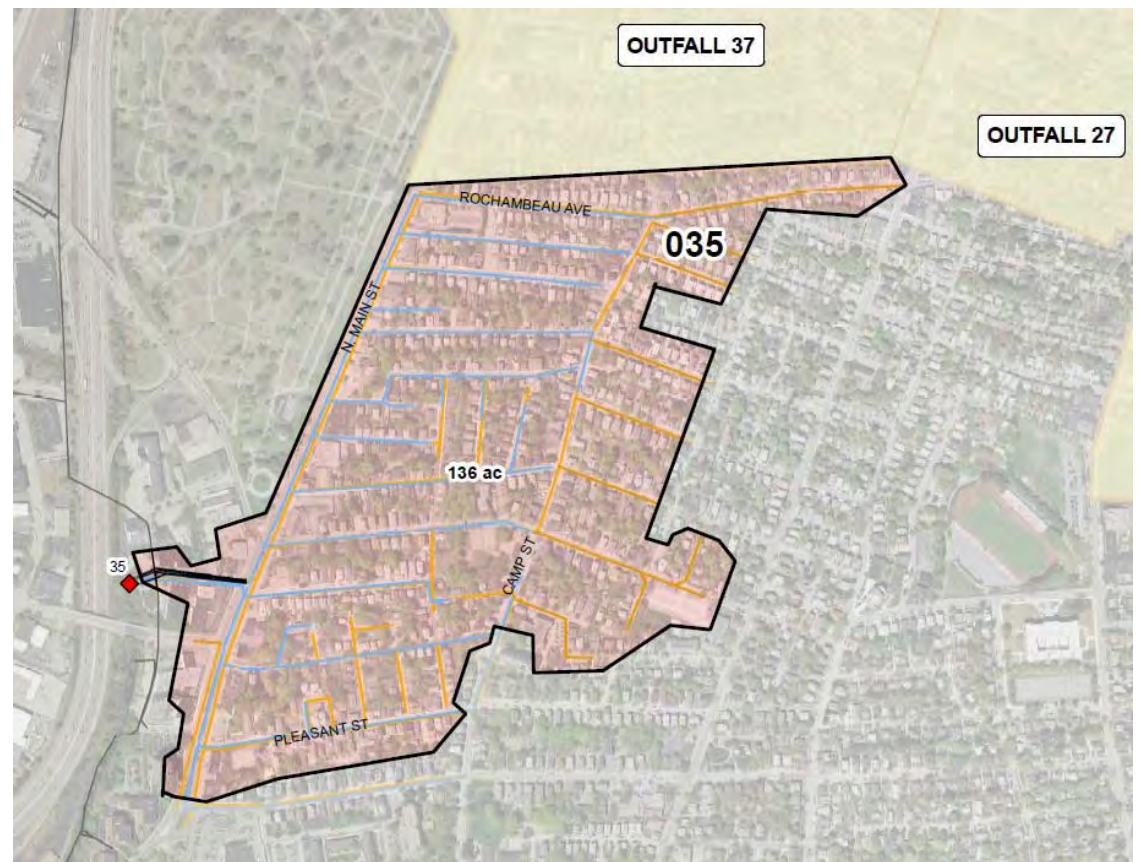
CSO Outfall	Public GSI Basin Cost (\$)	Private GSI Basin Cost (\$)	Full GSI Basin Cost (\$)	Public GSI CSO Reduction Cost (\$/gal)	Full GSI CSO Reduction Cost (\$/gal)	CSO Outfall	Public GSI Basin Cost (\$)	Private GSI Basin Cost (\$)	Full GSI Basin Cost (\$)	Public GSI CSO Reduction Cost (\$/gal)	Full GSI CSO Reduction Cost (\$/gal)
OF_101	3,825,210	3,101,522	6,926,732	54.2	33.7	OF_208	335,393	0	335,393	103.8	103.8
OF_103	20,732,777	12,103,459	32,836,236	39.8	26.4	OF_209	2,277,656	1,846,748	4,124,405	471.2	266.6
OF_104	3,341,401	2,709,244	6,050,646	42.9	30.7	OF_210	3,936,340	1,063,876	5,000,215	49.8	43.7
OF_105	3,847,256	3,119,397	6,966,653	36.6	21.6	OF_212	3,244,093	2,630,346	5,874,439	67.0	40.0
OF_106	5,269,420	4,272,502	9,541,922	19.1	13.5	OF_213	4,344,176	3,489,155	7,833,331	30.8	24.4
OF_107	10,315,705	8,364,085	18,679,789	143.8	193.7	OF_214	1,704,786	95,408	1,800,193	8.4	4.2
OF_201	2,682,238	2,174,787	4,857,025	32.2	25.0	OF_215	8,434,692	7,019,506	15,454,198	55.1	36.3
OF_202	265,223	215,045	480,268	17.0	13.3	OF_216	2,539,203	2,058,813	4,598,017	546.1	678.6
OF_203	2,502,500	2,029,054	4,531,553	58.0	27.8	OF_217	8,000,617	6,486,987	14,487,604	38.4	23.7
OF_205	64,139,831	52,005,268	116,145,099	58.9	27.5	OF_218	85,541,098	69,357,647	154,898,744	39.3	31.7
OF_206	280,113	75,706	355,819	45.4	37.9	OF_220	60,110,890	48,802,524	108,913,415	80.0	50.0
OF_207	1,250,835	1,014,191	2,265,026	162.2	97.7	Total	302,900,561	237,261,575	540,162,136	48.1	32.2

Alternatives Costs

Sewer Separation Areas

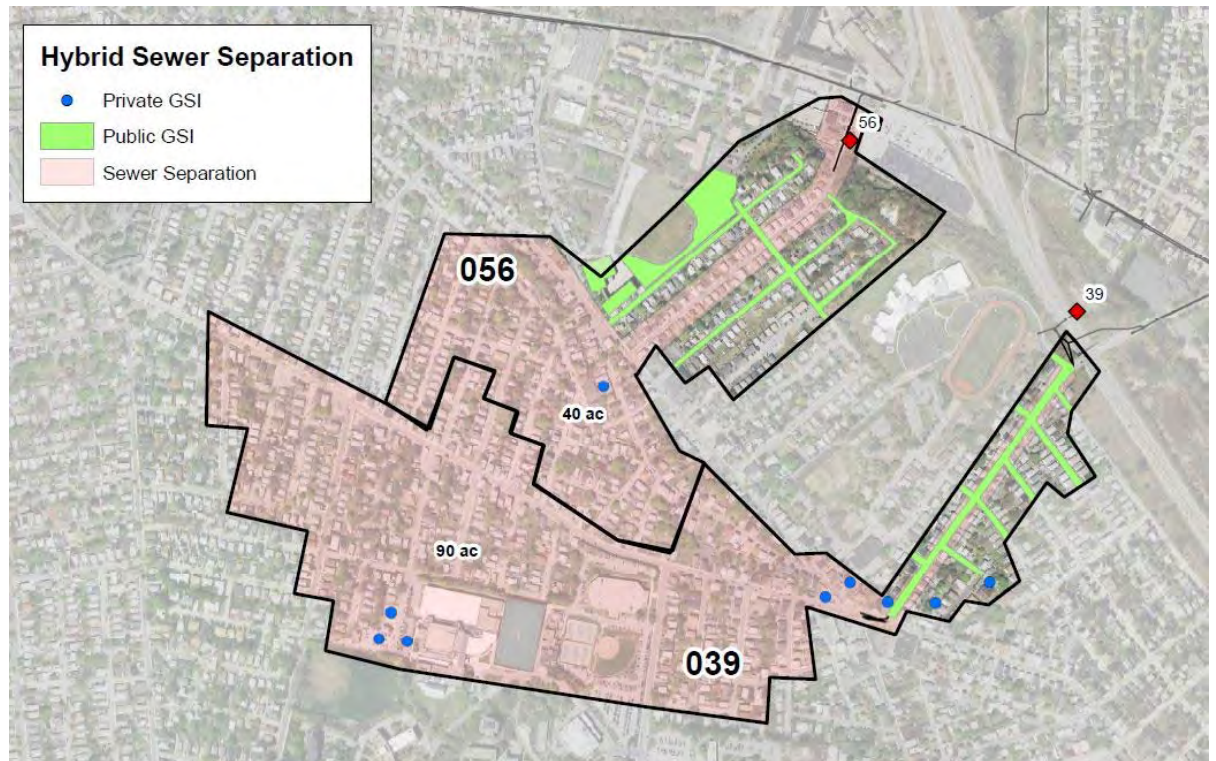
Sewer Separation Capital Costs

- Rehab / Replacement of existing pipes
- Construction of 2nd pipe network
- Water / Gas replacement
- Surface improvements
- Roadway reconstruction
- Hazardous materials allowance
- Design, construction & administration



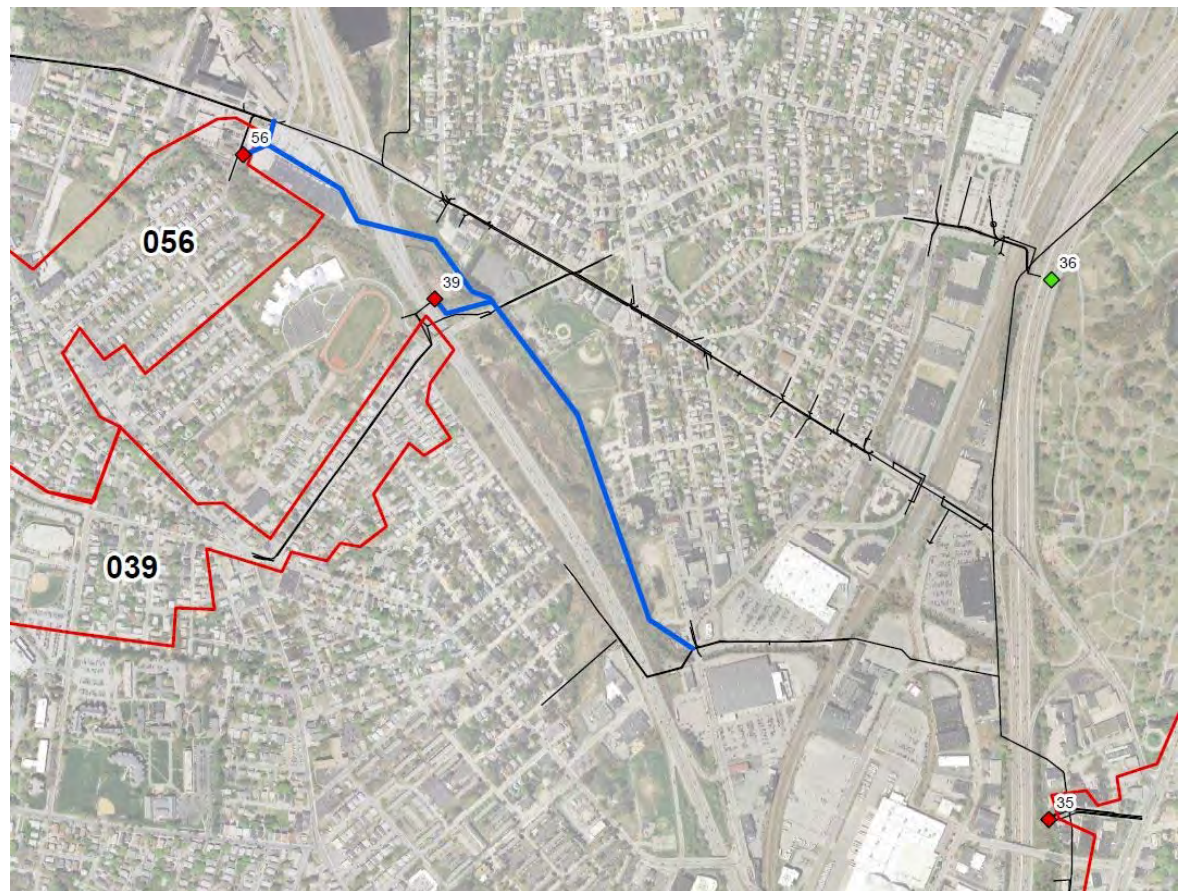
Hybrid GSI/Sewer Separation Capital Costs

- Targeted GSI
- Rehab / Replacement of existing pipes
- Construction of 2nd pipe network
- Water / Gas replacement
- Surface improvements
- Roadway reconstruction
- Hazardous materials allowance
- Design, construction & administration



West River Interceptor

- 72" dia micro-tunnel/pipe jack
- 039 056 consolidation conduits
- Charles St regulator structure
- Reconstruction of under- and over-flows to MRI
- Riverbank, park & roadway restoration
- Design, construction & administration



Baseline & Alternatives Cost Summary

	CSO Volume (MGal)	Capital Cost (\$M)	Cost / Volume (\$/gal)
Baseline Sewer Separation	1.79	\$66.82	37.33
035 Sewer separation	0.77	\$19.18	24.99
039 Sewer separation	0.46	\$24.68	53.81
056 Sewer separation	0.42	\$16.49	38.99
206 Sewer separation	0.14	\$6.47	45.92
Alternative One - Hybrid GSI / Separation	1.79	\$67.49	37.71
035 Hybrid GSI / Sewer separation	0.77	\$24.71	32.19
039 Hybrid GSI / Sewer separation	0.46	\$21.84	47.63
056 Hybrid GSI / Sewer separation	0.42	\$16.02	37.88
206 Hybrid GSI / Sewer separation	0.14	\$4.92	34.94

Baseline & Alternatives Cost Summary

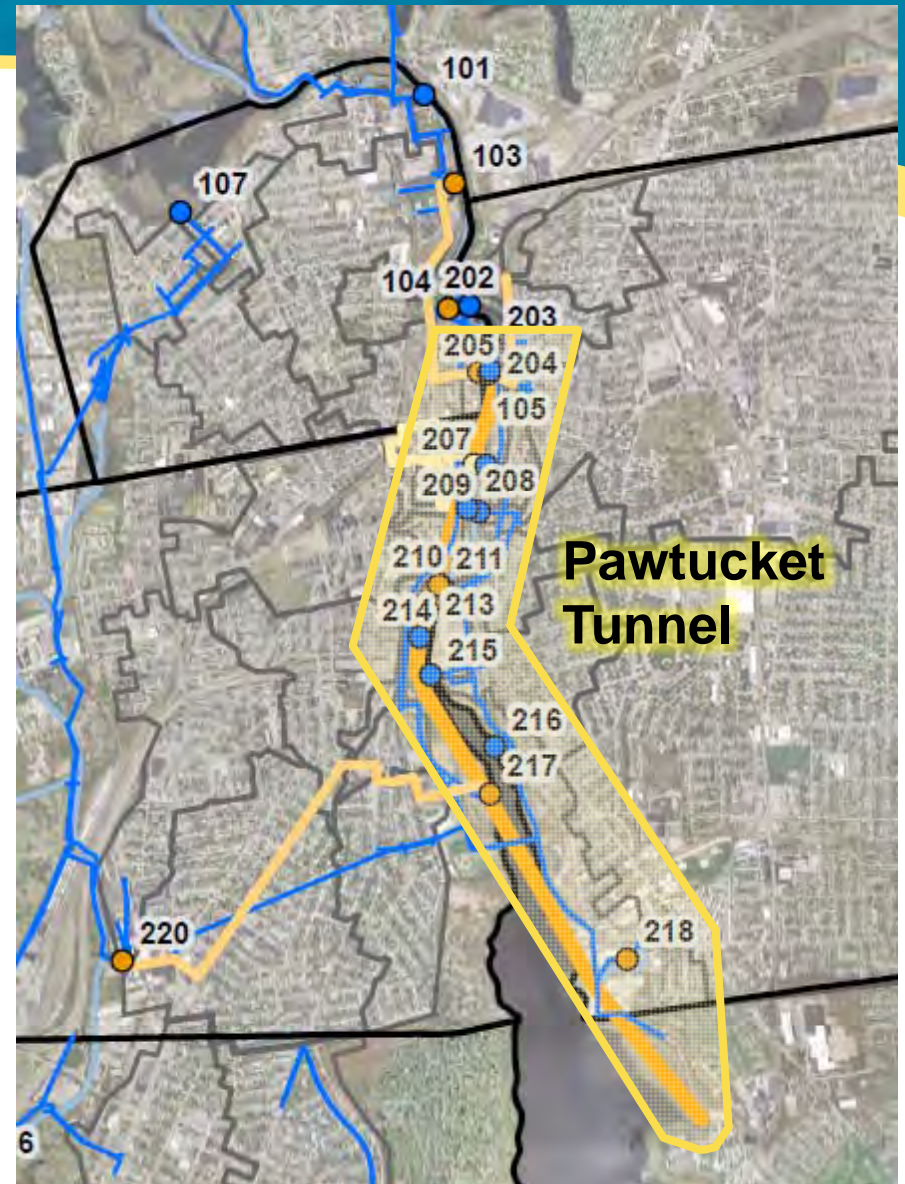
	CSO Volume (MGal)	Capital Cost (\$M)	Cost / Volume (\$/gal)
039-056 (Branch Avenue Interceptor) Alternative Two			
039/056 Sewer separation	0.88	\$41.17	46.70
039/056 Hybrid GSI / Sewer separation	0.88	\$37.86	42.95
West River Interceptor	0.88	\$34.88	39.57

Alternatives Costs

CSO Volume Storage

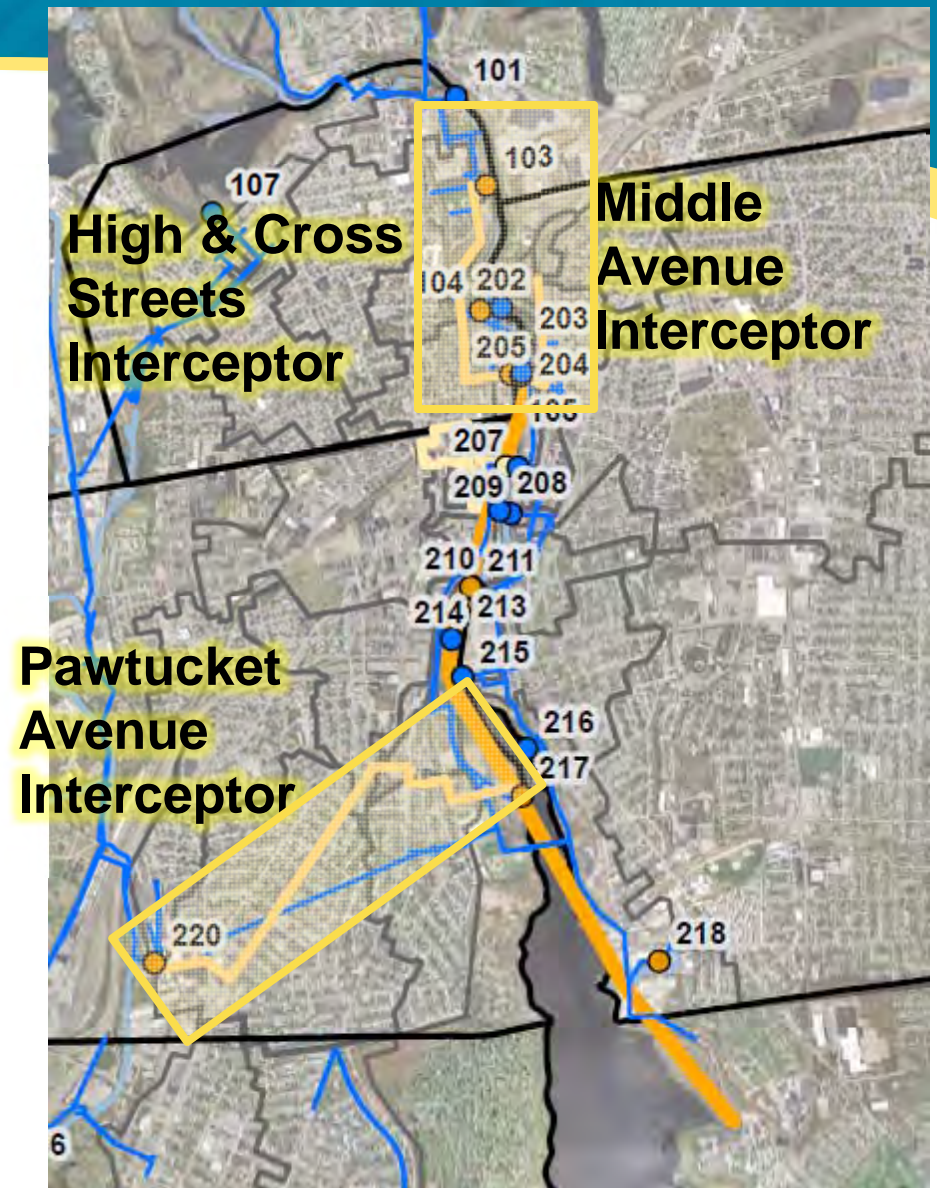
Deep Rock Tunnel

- Tunnel excavation & lining
- Pump station
- Drop shafts (5)
- Screening / approach structures
- Consolidation conduits / adits
- Surface restoration
- Design, construction & administration



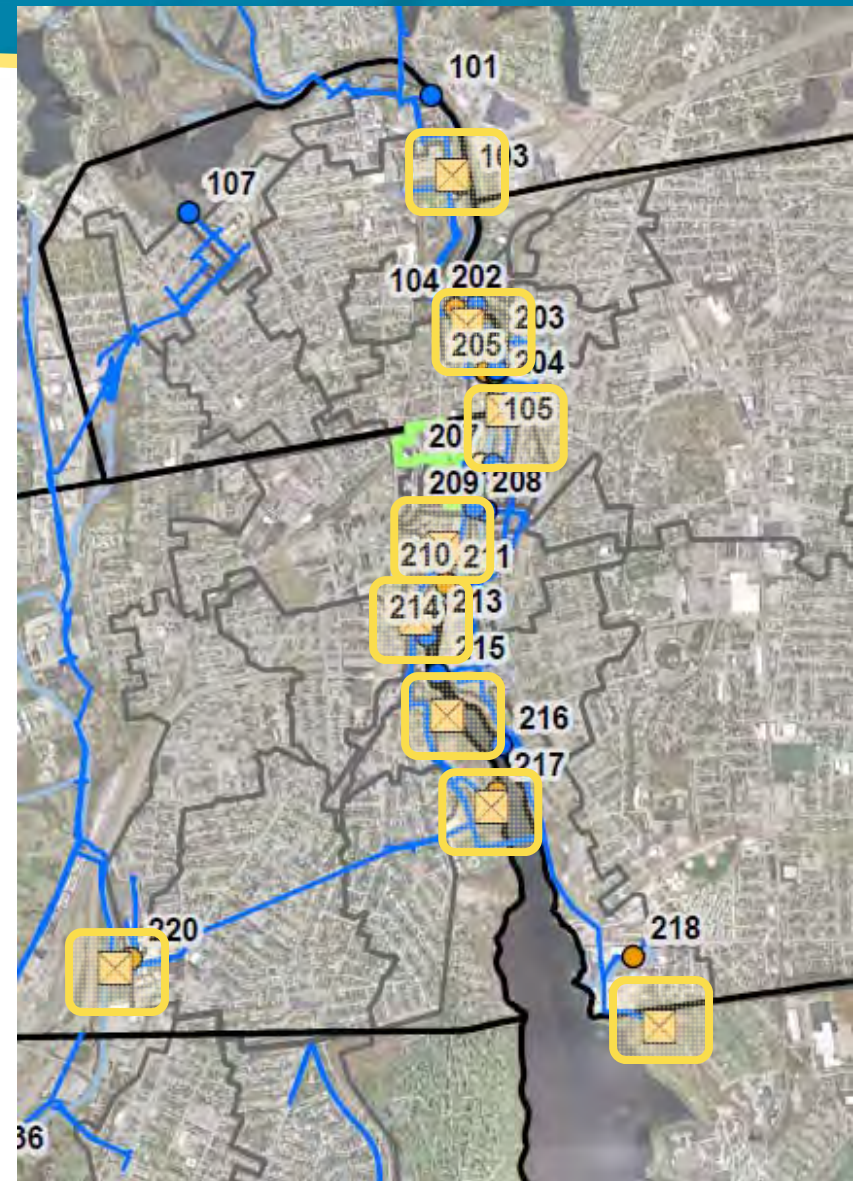
Tunnel with Interceptor Detail

- Tunnel costs PLUS
- Micro-tunneled or jacked interceptors
- Roadway & utility improvements at pits
- River crossing for High St.
- Pump station for 220

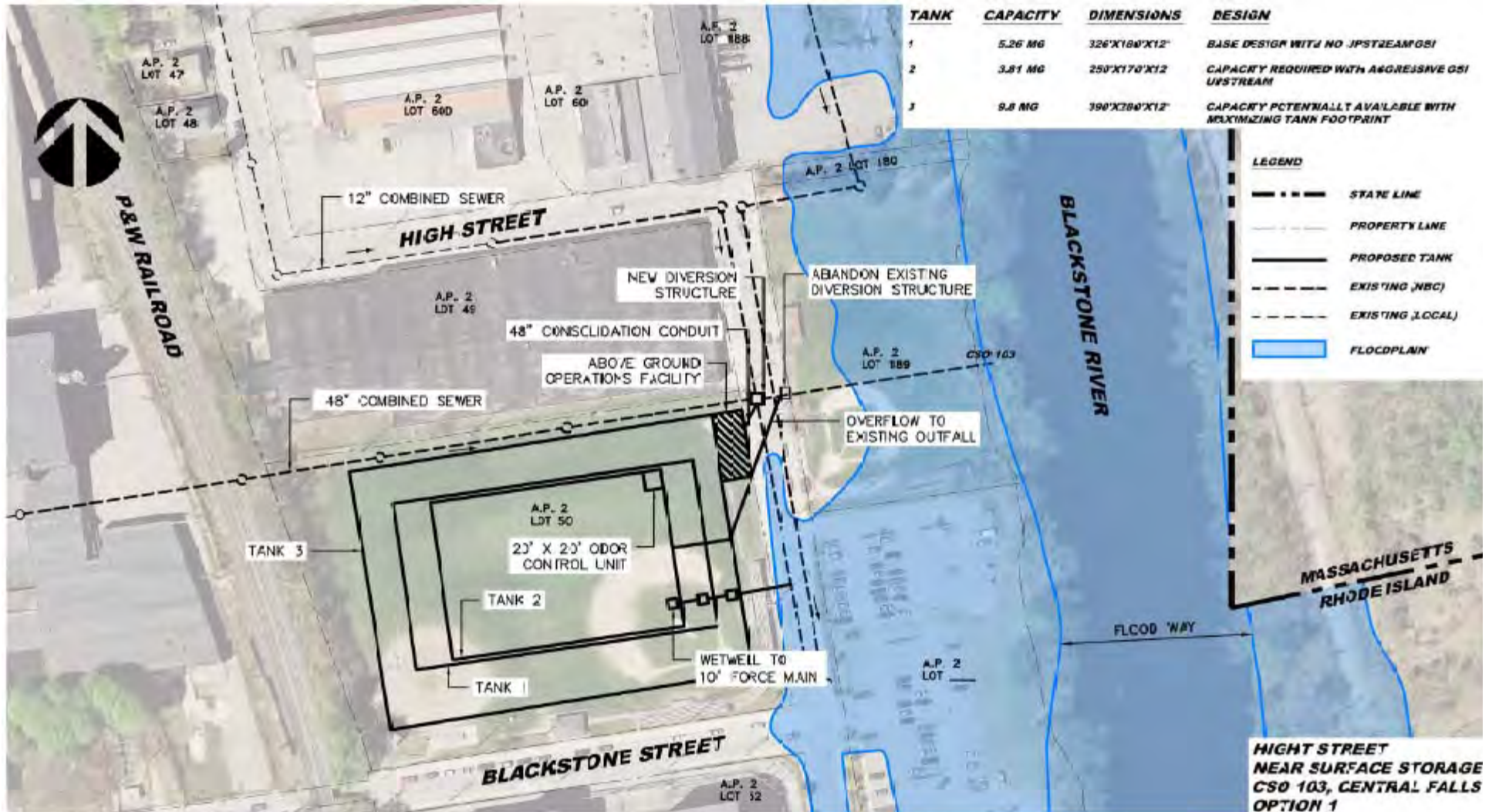


Near Surface Storage Tanks

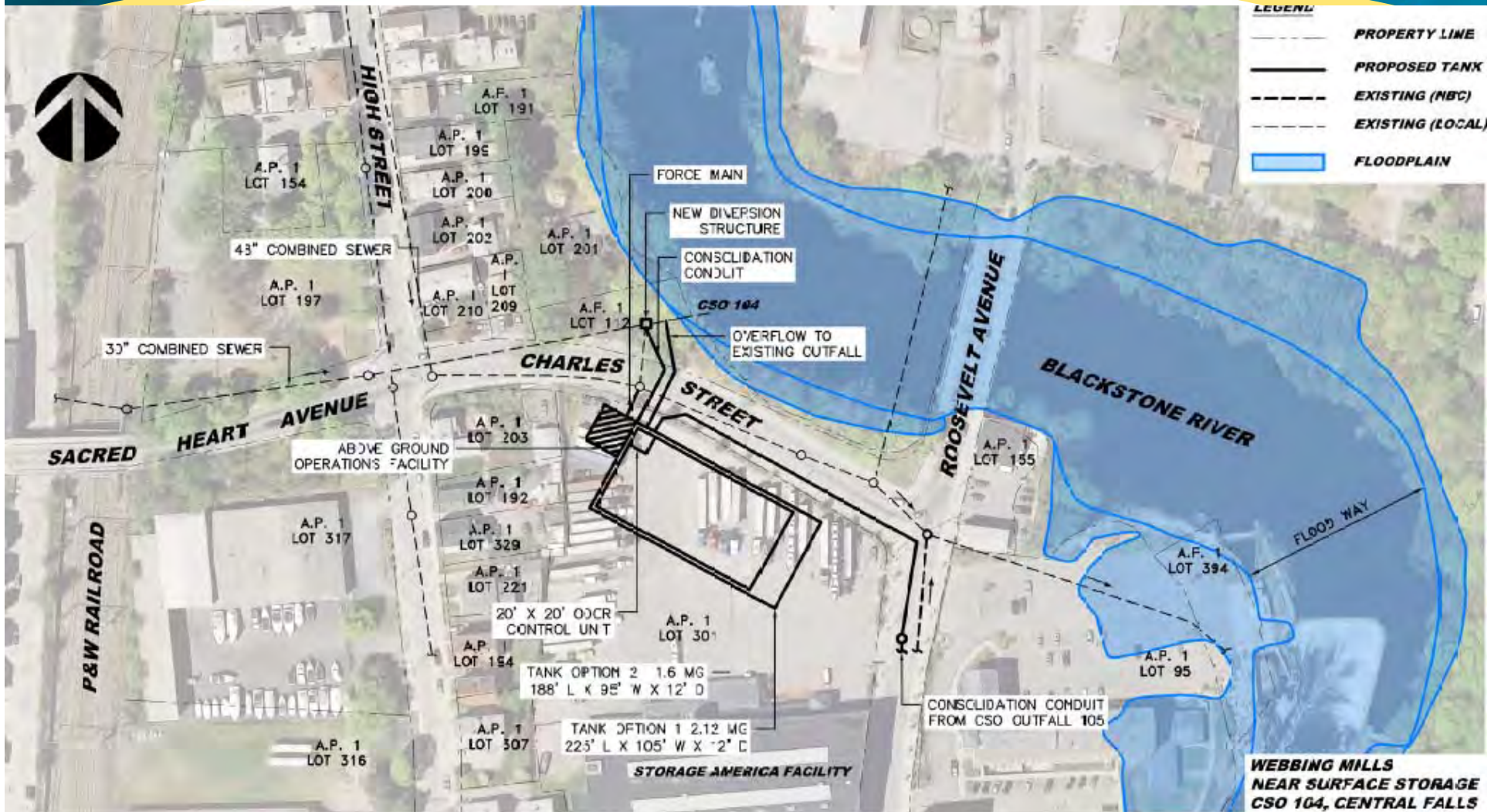
- CSO tank with odor control
- Discharge PS (influent PS for 217)
- equipment building
- Consolidation conduits
- Discharge FM
- Surface restoration
- Contaminated soil mitigation
- Public & Private GSI (Front St. Tank)
- Design, construction & administration



High Street Tank – Option A



Webbing Mills Tank



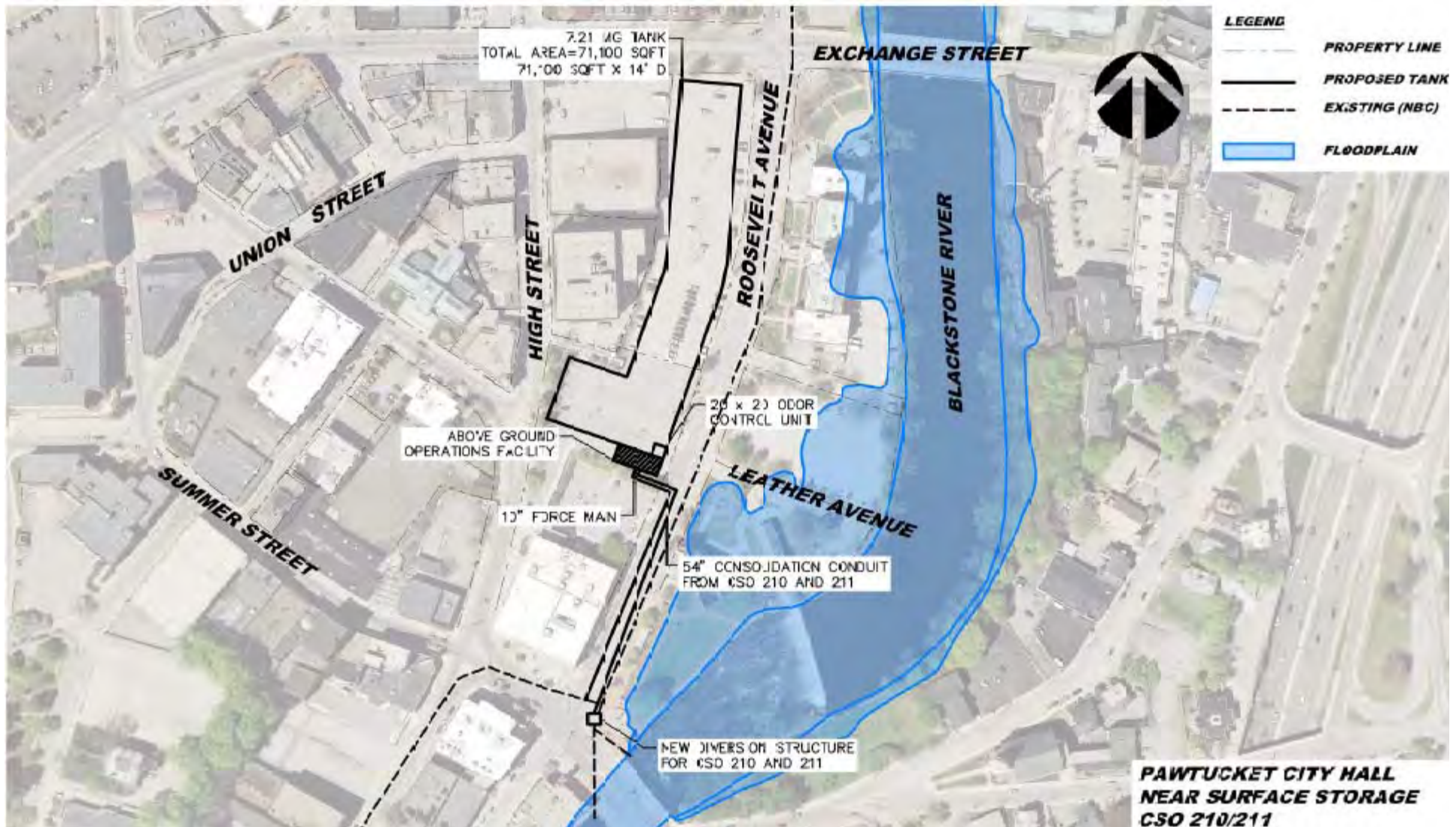
East Street Tank



Front Street Tank



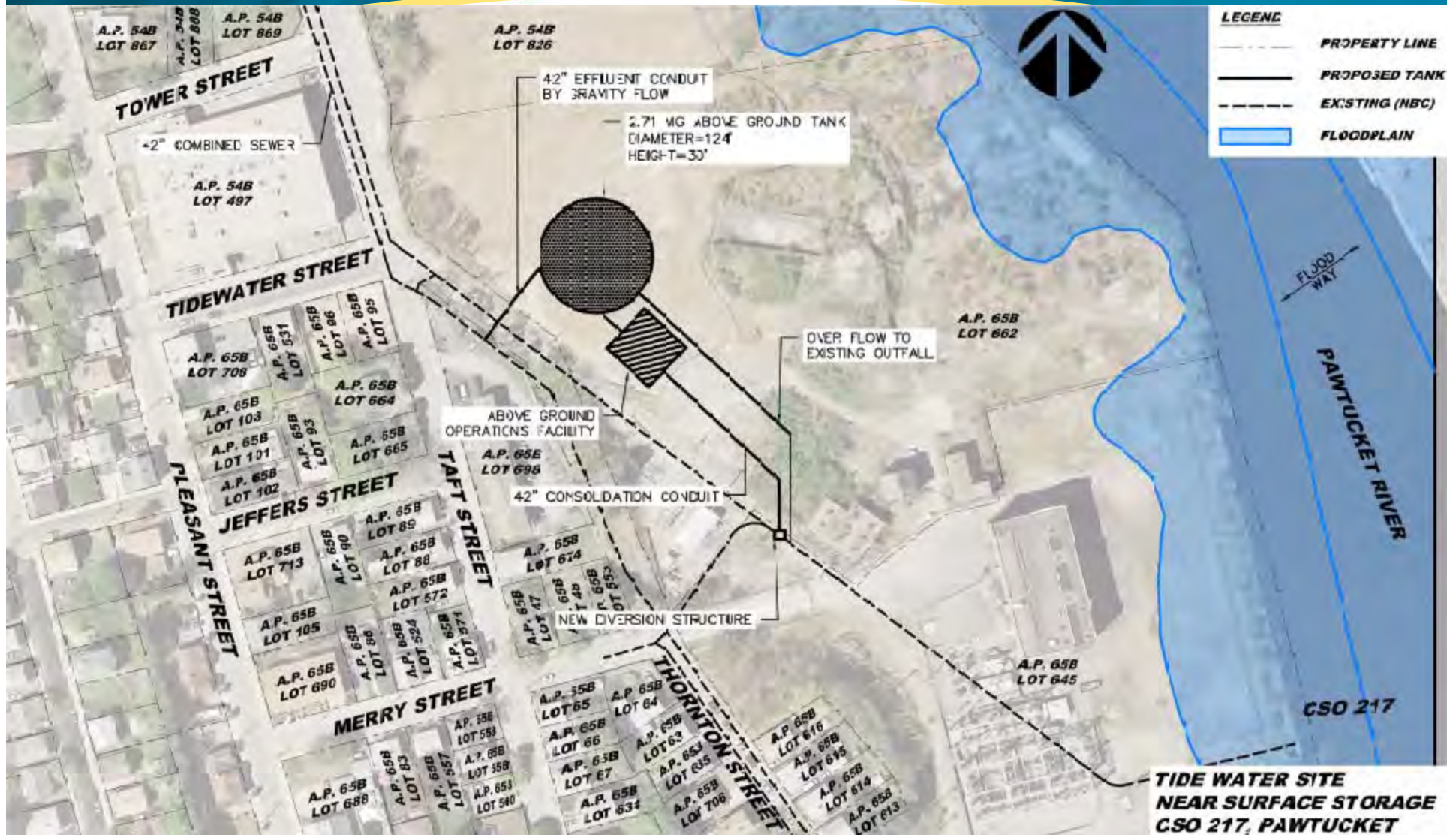
“City Hall” Tank



213 Tank



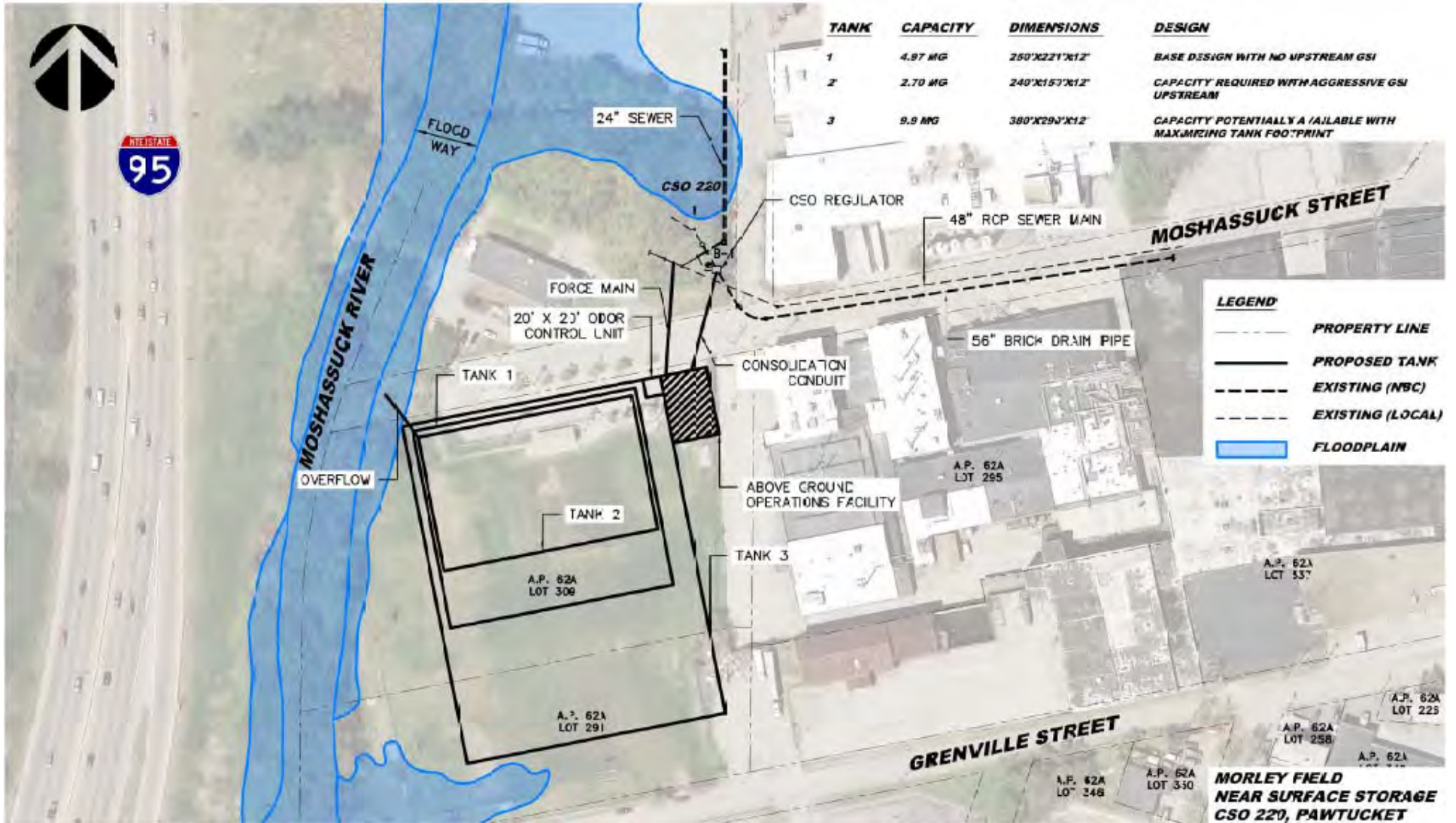
Tidewater Tank



Bucklin Point Tank



Morley Field Tank



Baseline & Alternative Cost Summary

	CSOs Controlled	CSO Volume (MGal)	Capital Cost (\$M)	Cost / Volume (\$/gal)
Baseline – Subsystems directly to Tunnel		41.29	\$445.46	10.79
Drop shaft 205 & conduit	204-205 (101-105, 201-203)	13.37	\$112.08	8.38
Drop shaft 210/211 & conduit	207-211	7.21	\$80.06	11.10
Drop shaft 213 & conduit	213-214	3.24	\$65.05	20.10
Drop shaft 217 & conduit	217 (107, 220)	2.71	\$35.64	13.15
Drop shaft 218 & conduit	212, 215, 216, 218	14.76	\$152.64	10.34
Alternative One - Near Surface Storage		41.29	\$574.48	13.91
Front St Tank with GSI	204-205 (201-203)	13.37	\$237.68	17.78
City Hall Tank	207-211	7.21	\$45.08	6.25
213 Tank	213-214	3.24	\$72.39	22.36
Tidewater Aboveground Tank	217	2.71	\$36.01	13.28
Bucklin Point Landfil Tank	212, 215, 216, 218	14.76	\$183.32	12.42

Baseline & Alternative Cost Summary

	CSOs Controled	CSO Volume (MGal)	Capital Cost (\$M)	Cost / Volume (\$/gal)
Baseline – Subsystems to Tunnel via Interceptors		13.87	\$234.60	16.91
Upper High & Cross St interceptor	101-103	5.26	\$65.44	12.45
Lower High & Cross St interceptor	104-105	2.12	\$18.35	8.64
Middle St interceptor	201-203	1.51	\$25.18	16.62
Pawtucket Ave interceptor	107, 220	4.97	\$125.63	25.26
Alternative One - Near Surface Storage		13.87	\$225.98	16.29
High Street Tank	101-103	5.26	\$63.51	12.08
Webbing Mills Tank	104-105	2.12	\$50.15	23.60
East Street Tank	201-203	1.51	\$45.41	29.98
Morley Field Tank	107, 220	4.97	\$66.90	13.45

Baseline & Alternative Cost Summary

	CSOs Controlled	CSO Volume (MGal)	Capital Cost (\$M)	Cost / Volume (\$/gal)
Baseline Pawtucket Tunnel with Interceptors				
Pawtucket Ave interceptor	107, 220	4.97	\$125.63	25.26
Alternative One - Near Surface Storage				
Morley Field Tank	107, 220	4.97	\$66.90	13.45
220 Alternative Two				
220 Stub Tunnel	107, 220	4.97	\$93.00	18.70

Screening & Disinfection Cost Summary

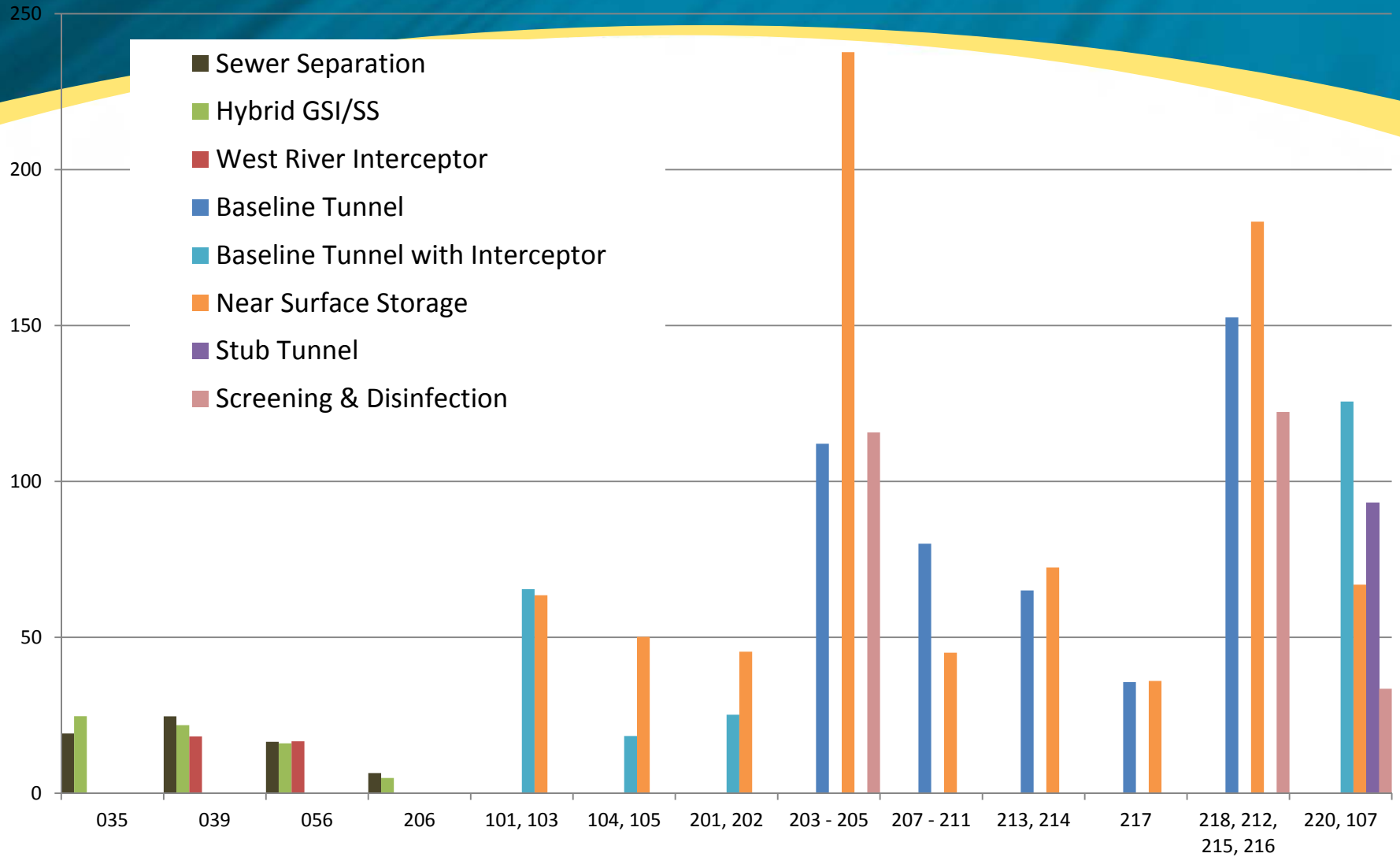
	CSOs Controlled	CSO Volume (MGal)	Capital Cost (\$M)	Cost / Volume (\$/gal)
Baseline Pawtucket Tunnel		33.11	\$390.34	11.79
Drop shaft 205 & conduit	204-205 (101-105, 201-203)	13.37	\$112.08	8.38
Drop shaft 218 & conduit	212, 215, 216, 218	14.76	\$152.64	10.34
Pawtucket Ave interceptor	107, 220	4.97	\$125.63	25.26
Alternative One - Near Surface Storage		33.11	\$487.89	14.74
Front St Tank with GSI	204-205 (201-203)	13.37	\$237.68	17.78
Bucklin Point Landfil Tank	212, 215, 216, 218	14.76	\$183.32	12.42
Morley Field Tank	107, 220	4.97	\$66.90	13.45
Screening & Disinfection Alternative		33.11	\$271.53	8.20
OF 205 Screening & Disinfection	201-205	13.37	\$115.74	8.66
OF 218 Screening & Disinfection	212, 215, 216, 218	14.76	\$122.29	8.28
OF 220 Screening & Disinfection	107, 220	4.97	\$33.51	6.74

- 2 log reduction in bacteria
- Requires permitting
- Requires study
- **Considered interim solution**

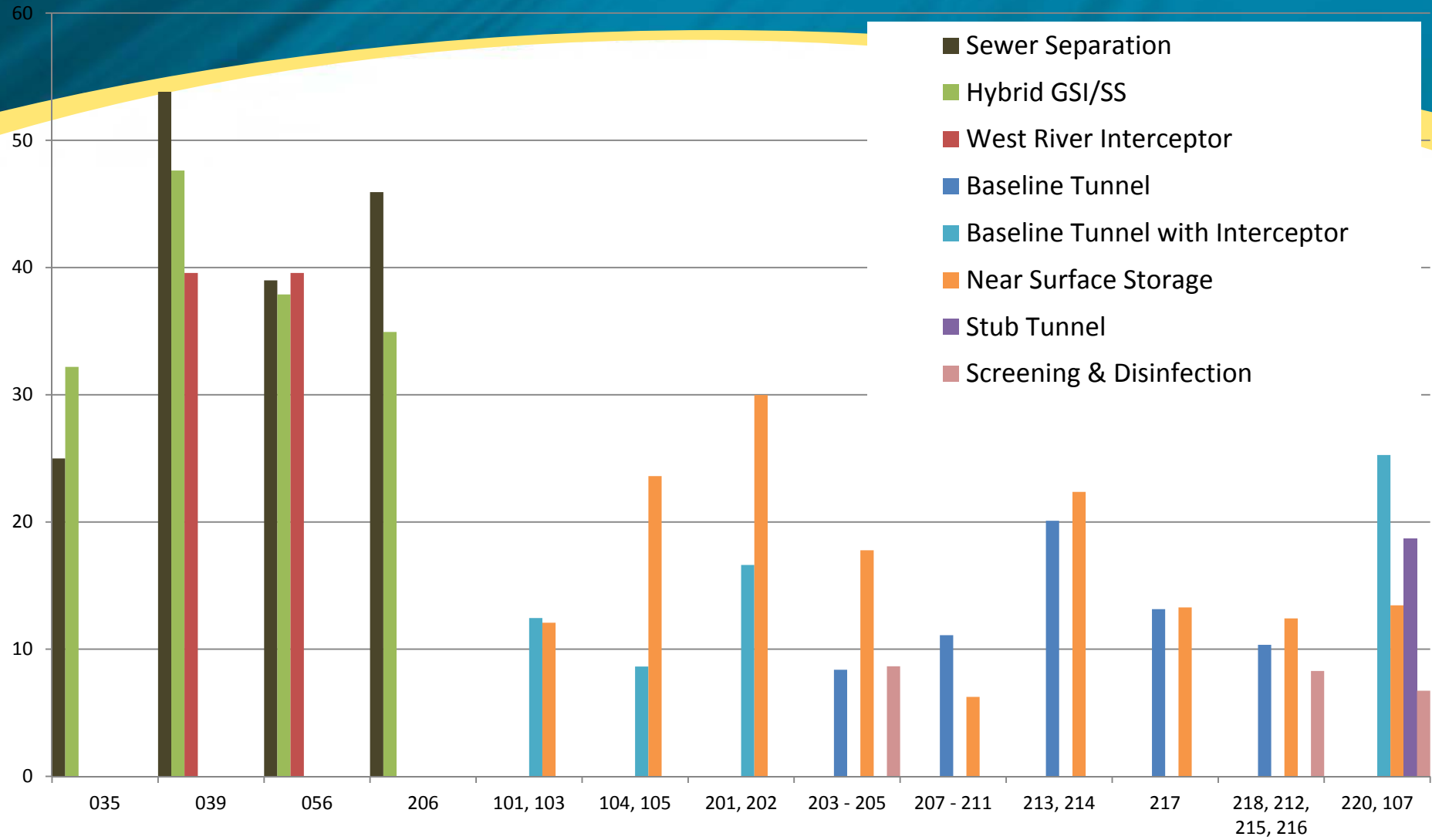
Alternatives Costs

Subsystem Costs & Cost per Gallon Summaries

Subsystem Costs Summary



Cost per Gallon Summary



Alternatives Costs

Operations & Maintenance Costs

Baseline O&M Costs

Technology	System	Quantity	Unit	Unit Cost (\$/yr)	Cost (\$/yr)
Deep-Rock Tunnel	Pawtucket	51	MG	\$8,500	\$433,500
Interceptor	BPSA	6,300	LF	\$2.30	\$14,490
Interceptor	CSO 220	8,200	LF	\$2.30	\$18,860
Sewer Separation	CSO 035, 039, 056, 206	100,000	LF	\$0.23	\$23,000
Regulator Modifications	12 CSOs	12	EA	n/a*	n/a*
Total =					\$489,850

* O&M for regulator modifications is included in the respective tunnel, interceptor, separation O&M cost.

Alternatives O&M Costs

Technology	Subsystem	Quantity	Unit	Cost (\$/yr)
Hybrid Separation	CSO 035, plus stormwater tank	40,120	LF	\$16,400
Hybrid Separation	CSO 039	22620	LF	\$5,200
Hybrid Separation	CSO 056	11820	LF	\$2,700
Hybrid Separation	CSO 206, plus stormwater tank	2215	LF	\$7,700
Near-Surface Storage	CSO 103 - High Street Tank	5.26	MG	\$120,100
Near-Surface Storage	CSO 104 - Webbing Mills Tank	2.12	MG	\$87,900
Near-Surface Storage	CSO 201 - East Street Tank	1.30	MG	\$79,600
Near-Surface Storage	CSO 205 - Front St Tank / T&D with GSI	10.10	MG	\$179,600
Near-Surface Storage	CSO 210/211 - City Hall Tank	7.21	MG	\$140,000
Near-Surface Storage	CSO 213/214 - Tank	3.24	MG	\$99,400
Near-Surface Storage	CSO 220 - Morley Field tank	4.97	MG	\$117,100
Near-Surface Storage	CSO 217 - Tidewater Tank	2.71	MG	\$94,000
Near-Surface Storage	CSO 218 - Bucklin Point landfill tank	14.76	MG	\$227,300
GSI in select areas	GSI in select sewersheds	69,589,791	\$	\$1,392,000
Regulator Mod's	12 CSOs	12	EA	\$50,000
Total =				\$2,619,000

*** GSI O&M costs = 2% of construction cost for Public Way GSI. Includes labor & equipment for cleaning, plus materials for replacement

Treatment O&M Costs

	O&M Cost (\$/yr)
OF 205 Screening & Disinfection	\$942,000
OF 218 Screening & Disinfection	\$688,330
OF 220 Screening & Disinfection	\$423,985

- More complex to operate & maintain than tanks or tunnels
- Chemical & power costs
- Cleaning of screens, disposal of materials
- Maintenance of disinfection equipment

Affordability analysis

Alternatives costs

**Subsystem alternatives
evaluation completion**

Alternatives analysis conclusion
& next steps

Subsystem Alternatives Analysis Completion



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039-056 Subsystem

- Recommended Alternative: **West River Interceptor**
 - ✓ Capital cost
 - ✓ Operational flexibility
 - ✓ Reliability
- Eliminated Alternative: **Sewer Separation**
 - Construction-phase disruptions
 - Flooding risks
 - Discharge of nutrients
- Eliminated Alternative: **Hybrid GSI / Sewer Separation**
 - Similar to Sewer Separation
 - ✓ Co-benefits
 - Administrative / Institutional considerations

035 Subsystem

- Recommended Alternative: **Sewer Separation**
 - ✓ Capital cost – existing 2 pipe system
 - ✓ Reliability
 - Construction-phase disruptions
 - Flooding risks
 - Discharge of nutrients
- Eliminated Alternative: Hybrid GSI / Sewer Separation
 - ✓ Co-benefits
 - Administrative / Institutional considerations

206 Subsystem

- Recommended Alternative: **Hybrid GSI / Sewer Separation**
 - ✓ Capital cost
 - ✓ Co-benefits
 - ✓ Operational flexibility
 - Construction-phase disruptions
- Eliminated Alternative: **Sewer Separation**
 - ✓ Reliability
 - ✓ Administrative / Institutional considerations
 - Flooding risks
 - Discharge of nutrients

201-205 Subsystem

- Recommended Alternative: **Pawtucket Tunnel & Middle Street Interceptor**
 - ✓ Capital cost
 - ✓ O&M cost
 - ✓ Administrative / Institutional considerations
 - ✓ System reliability / Operational robustness
- Eliminated Alternative: **Front Street & East Street Tanks**
 - Constructability / Construction-phase risks
 - Construction phase disruptions
 - Operations & maintenance impacts and risks
- Potential Interim Alternative: **Front Street Screening & Disinfection**
 - ✓ Provide interim water quality improvements
 - Construction- & Operations-phase disruptions – difficult site
 - No recoverable assets once long-term solution implemented
 - Requires study and permitting effort

207-211 Subsystem

➤ Recommended Alternative: **Pawtucket Tunnel**

- ✓ O&M cost
- ✓ Administrative / Institutional considerations
- ✓ System reliability / Operational robustness

➤ Eliminated Alternative: **City Hall Tank**

- ✓ Capital cost
- Constructability / Construction-phase risks
- Construction phase disruptions
- Operations & maintenance impacts and risks

213-214 Subsystem

- Recommended Alternative: **Pawtucket Tunnel**
 - ✓ Capital cost
 - ✓ O&M cost
 - ✓ Administrative / Institutional considerations
 - ✓ System reliability / Operational robustness
- Eliminated Alternative: **213 Tank**
 - Construction phase disruptions
 - Operations & maintenance impacts and risks

217 Subsystem

➤ Recommended Alternative: **Pawtucket Tunnel**

- ✓ O&M cost
- ✓ Administrative / Institutional considerations
- ✓ System reliability / Operational robustness

➤ Eliminated Alternative: **Tidewater Aboveground Tank**

- Constructability / Construction-phase risks
- Construction phase disruptions
- Operations & maintenance impacts and risks

212, 215, 216, 218 Subsystem

➤ Recommended Alternative: **Pawtucket Tunnel**

- ✓ Capital cost
- ✓ O&M cost
- ✓ Administrative / Institutional considerations
- ✓ System reliability / Operational robustness

➤ Eliminated Alternative: **Bucklin Point Landfill Tank**

- Constructability / Construction-phase risks
- Construction phase disruptions
- Operations & maintenance impacts and risks

➤ Potential Interim Alternative: Route to BPWWTF Wet Weather Facility

- ✓ Provide interim water quality improvements
- ❖ Consolidation conduit moves drop shaft closer to BPWWTF
- Requires study and permitting effort

104-105 Subsystem

- Recommended Alternative: **Pawtucket Tunnel & Lower High & Cross Street Interceptor**
 - ✓ Capital cost
 - ✓ O&M cost
 - ✓ Administrative / Institutional considerations
 - ✓ System reliability / Operational robustness
- Eliminated Alternative: **Webbing Mills Tank**
 - Constructability / Construction-phase risks
 - Construction phase disruptions
 - Operations & maintenance impacts and risks

101-103 Subsystem

- Recommended Alternative: **Pawtucket Tunnel & Upper High & Cross Street Interceptor**
 - ✓ O&M cost
 - ✓ Administrative / Institutional considerations
 - ✓ System reliability / Operational robustness
- Eliminated Alternative: **High Street Tank**
 - Constructability / Construction-phase risks
 - Construction phase disruptions
 - Operations & maintenance impacts and risks

107-220 Subsystem

- Recommended Alternative: 220 Stub Tunnel
 - ✓ O&M cost
 - ✓ Administrative / Institutional considerations
 - ✓ System reliability / Operational robustness (including BAI relief)
- Potential Alternative: Morley Field Tank
 - ✓ Capital cost
 - Construction phase disruptions
 - Operations & maintenance impacts and risks
- Eliminated Alternative: Pawtucket Avenue Interceptor to Tunnel
 - Capital cost
 - Constructability / Construction-phase risks, Construction phase disruptions
- Potential Interim Alternative: Morley Field Screening & Disinfection
 - ✓ Provide interim water quality improvements
 - Construction- & Operations-phase disruptions – requires relocation of field
 - No recoverable assets once long-term solution implemented
 - Requires study and permitting effort

GSI Prioritization

- GSI for system optimization (capital & operational)
 - ✓ 101, 201-202, 206-209, 216, 217
- GSI for early, cost effective water quality gains
 - ✓ 103, 203-205, 213, 214, 215, 218
- Poor opportunity / effectiveness GSI
 - 035, 056, 104, 107, 210, 211, 220

Affordability analysis
Alternatives costs
Subsystem alternatives
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conclusion & next steps

Subsystem Alternatives Analysis Conclusion & Next Steps



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Subsystem Alternatives Analysis Conclusion

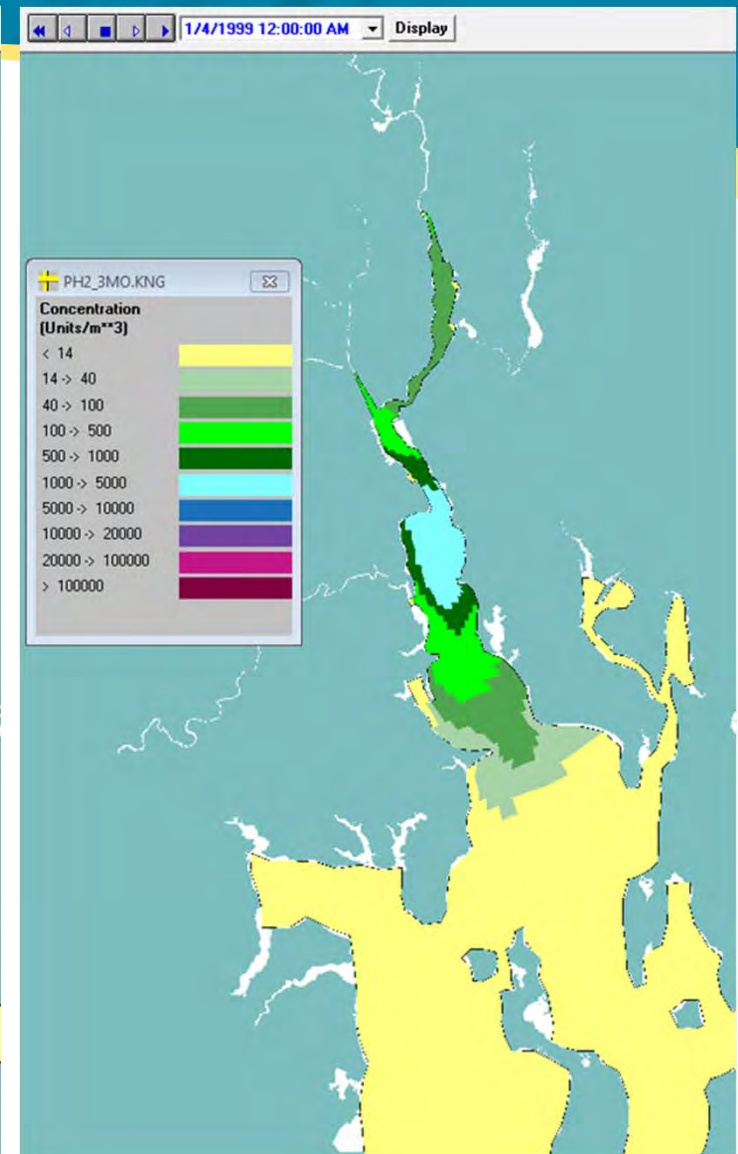
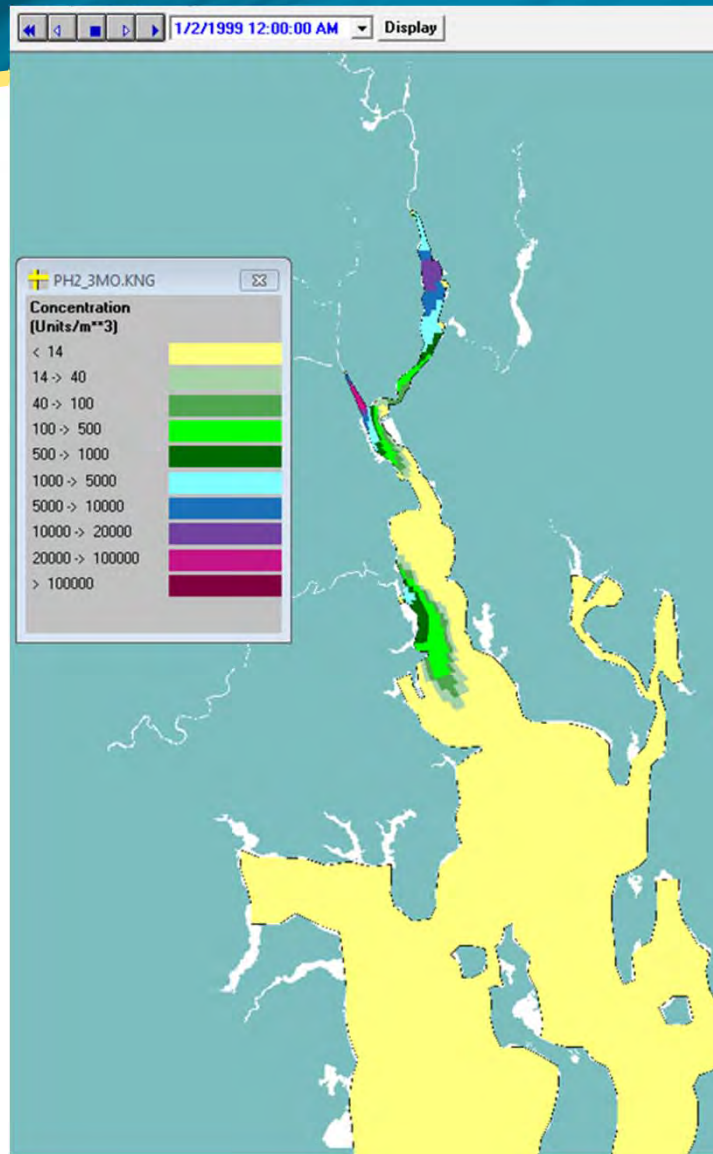
CSO Control Solution	CSOs Controlled
Revised Phase III Components	
Components Requiring Additional Evaluation	
Interim Water Quality Improvement Projects for Consideration	

Subsystem Alternatives Analysis Conclusion

CSO Control Solution	CSOs Controlled
Revised Phase III Components	
035 Sewer separation (limited scope, existing dual pipe system)	035
West River Interceptor	039, 056
206 Hybrid GSI / sewer separation	206
Pawtucket Tunnel via drop shafts & consolidation conduits	204, 205, 210, 211, 213, 214, 217
Middle Street Interceptor to Pawtucket Tunnel via Drop Shaft 205	201-203
High & Cross Street Interceptor to Pawtucket Tunnel via DShaft 205	101 - 105
Regulator modifications facilitated by interceptor relief via Pawtucket Tunnel	101, 107, 202-204, 207-209, 212, 215, 216, (036)
GSI for system optimization (capital & operational)	101, 201-202, 206-209, 217
GSI for early, cost effective water quality gains	103, 203-205, 213, 214, 215, 218
Components Requiring Additional Evaluation	
220/MVI Stub Tunnel	107, 220 (BAI system)
Morley Field CSO Storage Tank	107, 220
Interim Water Quality Improvement Projects for Consideration	
Morley Field screening & disinfection	107, 220
Bucklin Point wet weather facilities	218 (212, 215, 216)

Water Quality Analysis

- Sensitivity analysis
 - All Phase III
 - Just 205 thru 218
 - Just 220
 - Just 218 to BPWWTF



Develop & Analyze Scenarios

- Subsystem alternatives analysis yielded system components
- Preliminary prioritization based on evaluation/prioritization criteria (triple bottom line costs/benefits) informed by water quality analysis
- Affordability may prohibit construction of highest priority projects (i.e. Pawtucket Tunnel)
- Outstanding questions:
 - Given affordability, what projects should be done first
 - Which is the better option: Morley Field Tank or Stub Tunnel
 - Given interceptor relief from tunnel, where can GSI optimize system design
 - Can interim disinfection projects provide water quality improvements and are they worth the cost
- Next steps: Develop & analyze scenarios to test those questions

Next Meeting

13 November 2014, 9:00AM

**Alternative Phase III Scenarios
Review, Project Prioritization
& Recommended Plan Finalization**