Prepared for

Narragansett Bay Commission

CSO Control Facilities Phase III Reevaluation Alternatives Analysis

04 September 2014

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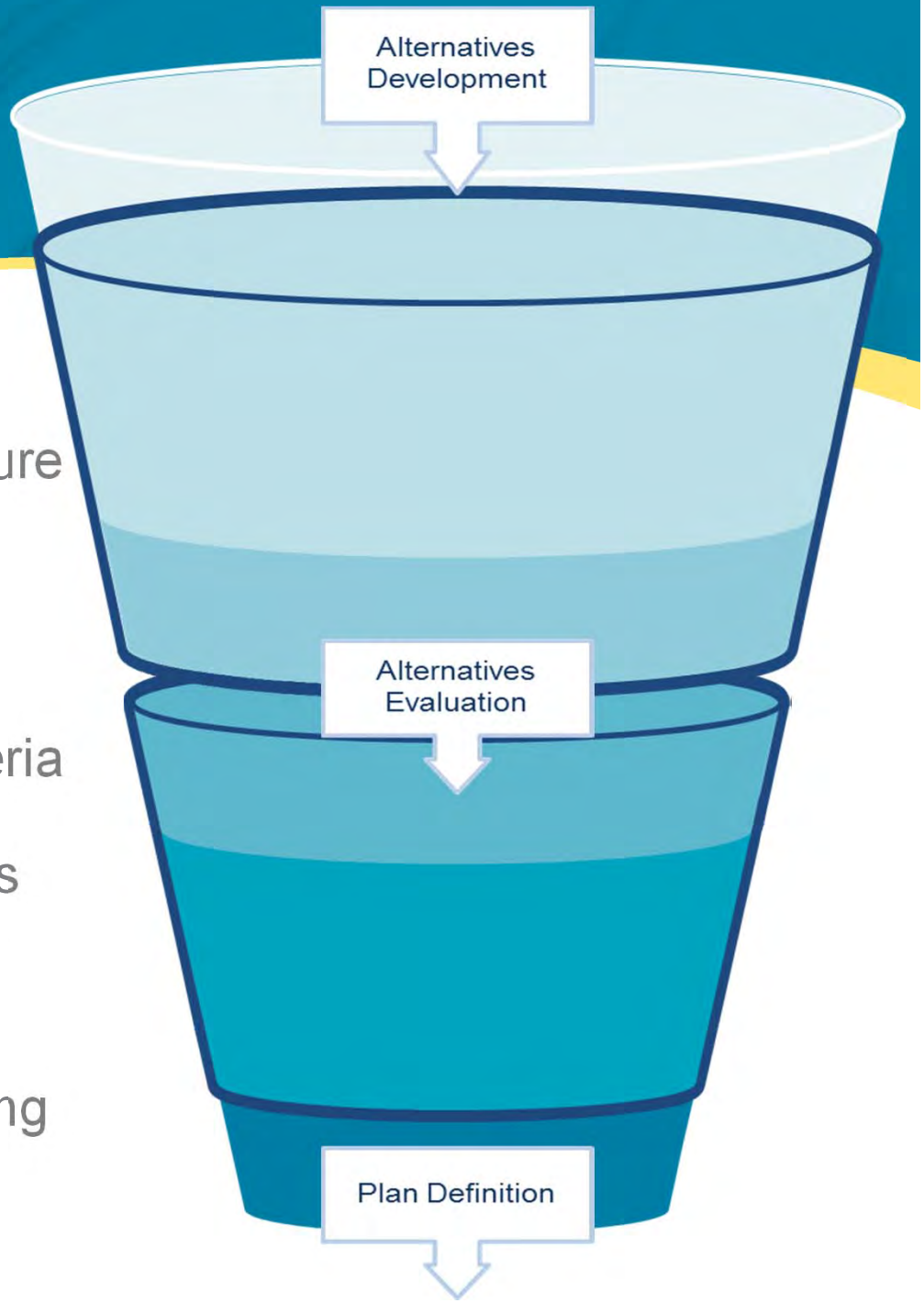
Outline

- Stakeholder process review
- Alternatives development & screening review
- Evaluation criteria
- CSO needs analysis & hydraulic model results
- Alternatives analysis: Subsystem delineations
- Alternatives evaluation by subsystem
- Alternatives analysis conclusions

Development & Evaluation Process

- Alternatives Development
  - April 10, Grey Infrastructure Focus
  - May 22, Green Infrastructure Focus
- Alternatives Evaluation
  - June 19, Evaluation Criteria Focus
  - September 4, Alternatives Analysis Workshop
- Plan Definition
  - October 23, IPF, Project Prioritization & Sequencing
  - November, Plan Finalization



Alternatives development & screening review

Evaluation criteria

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Alternatives Development & Screening

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CSO Mitigation Strategies

- Source
  - Stormwater controls
  - Green Stormwater Infrastructure (GSI)
- Pathway
  - Stormwater storage
  - Sewer separation
  - Regulator modifications
  - Interceptor relief
- Receptor
  - Treatment & discharge
  - Near surface storage
  - Deep tunnel storage

Alternatives Technical Feasibility Screening

	Source			Pathway				Receptor					
Outfall	No GSI	Public Way GSI	Full GSI	Sewer Separation	Hydraulic Control & Stormwater Storage	Regulator Modification	Interceptor Relief	Satellite Treatment & Discharge	Near Surface Storage	Wetland Treatment	Pawtucket Stub Tunnel	Pawtucket Tunnel	Main Spine Tunnel
35	✔	✔	✔	✔	✔								
36	✔	✔	✔			✔							✔
39	✔	✔	✔	✔			✔				☑		
56	✔	✔	✔	✔			✔				☑		
101	✔	✔	✔			☑			✔			✔	
103	✔	✔	✔						✔			✔	
104	✔	✔	✔						✔			✔	
105	✔	✔	✔						✔			✔	
107	✔	✔	✔			✔						✔	
201	✔	✔	✔					☑	✔			✔	
202	✔	✔	✔			☑		☑	✔			✔	
203	✔	✔	✔					☑	✔			✔	
204	✔	✔	✔					☑	✔			✔	
205	✔	✔	✔					☑	✔			✔	
206	✔	✔	✔	✔	✔	✔			✔			✔	
207	✔	✔	✔			✔			✔			✔	
208	✔	✔	✔			✔			✔			✔	
209	✔	✔	✔			✔			✔			✔	
210	✔	✔	✔						✔			✔	
211	✔	✔	✔						✔			✔	
212	✔	✔	✔			✔		☑	✔			✔	
213	✔	✔	✔						✔			✔	
214	✔	✔	✔						✔			✔	
215	✔	✔	✔			✔		☑	✔			✔	
216	✔	✔	✔			✔		☑	✔			✔	
217	✔	✔	✔					☑	✔			✔	
218	✔	✔	✔					☑	✔			✔	
220	✔	✔	✔					☑	✔		✔	✔	

Satellite Treatment & Discharge – Screening & Disinfection

- Insufficient data to confirm technical feasibility of Ultraviolet disinfection
- UV disinfection effectiveness dependent upon light transmission through water
- UV typically requires pretreatment – increases footprint, cost & operations
- Chlorination has same toxic residual & chemical handling risks noted during previous stakeholder process
- Paracetic acid is an emerging alternate disinfection technology requiring piloting and special approval
- Regulatory issues
  - Discharge limits
  - Water quality

Alternatives development & screening review

Evaluation criteria

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Alternatives analysis conclusions

Evaluation Criteria

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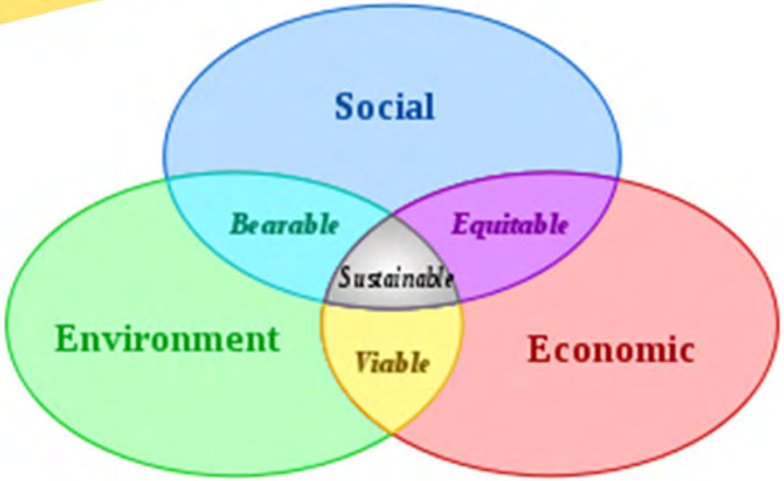
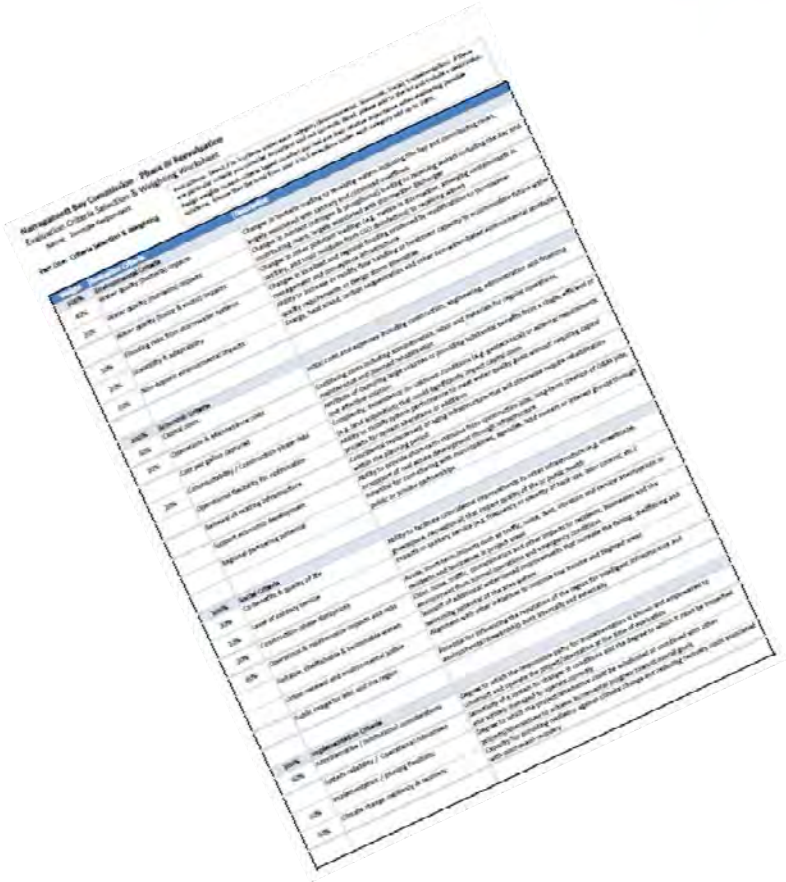
Evaluation / Prioritization Criteria





- Categories
  - Environmental
  - Economic
  - Social
  - Implementation
- Weights
  - 35%
  - 30%
  - 18%
  - 17%

Environmental Criteria

Weight	Evaluation Criteria	Description
40%	Water quality (bacteria) impacts	Changes in bacteria loading to receiving waters including the Bay and contributing rivers, largely associated with sanitary and combined overflows
20%	Flooding risks from stormwater systems	Changes in localized and regional flooding produced by modifications to stormwater management and conveyance infrastructure
20%	Water quality (nutrients) impacts	Changes in nutrient (nitrogen & phosphorus) loading to receiving waters including the Bay and contributing rivers, largely associated with stormwater discharges
20%	Scalability & adaptability	Ability to increase or modify flow handling or treatment capacity to accommodate future water quality requirements or design storm intensities
	Water quality (toxics & exotic) impacts	Changes in other pollutant loadings (e.g. metals in stormwater, emerging contaminants in sanitary, and toxic residuals from CSO disinfection) to receiving waters
	Non-Aquatic environmental impacts	Energy, heat island, carbon sequestration and other non-water-based environmental attributes

Economic Criteria

Weight	Evaluation Criteria	Description
45%	Capital costs	Initial costs and expenses including construction, engineering, administration and financing
25%	Operations & Maintenance costs	Continuing costs including administration, labor and materials for regular operations, maintenance and planned rehabilitation
10%	Constructability / Construction-phase risks	Complexity, dependency on unknown conditions (e.g. geotechnical) or external requirements (e.g. land acquisition) that could significantly impact capital costs
10%	Cost per gallon captured	Attribute of capturing large volumes or providing substantial benefits from a single, efficient or cost effective solution
10%	Operational flexibility for optimization	Ability to modify system performance to meet water quality goals without requiring capital projects for system alterations or additions
	Support economic development	Ability to provide short-term stimulus from construction jobs, long-term creation of O&M jobs, or support of real estate development through infrastructure
	Regional partnering potential	Potential for cost-sharing with municipalities, agencies, land owners or interest groups through public or private partnerships
	Renewal of existing infrastructure	Coincidental replacement of aging infrastructure that will otherwise require rehabilitation within the planning period

Social Criteria

Weight	Evaluation Criteria	Description
35%	Fishable, shellfishable & swimmable waters	Support of additional water-based improvements that increase the fishing, shellfishing and swimming potential of the area waters
25%	Co-benefits & quality of life	Ability to facilitate coincidental improvements to other infrastructure (e.g. streetscape, greenspace, recreational) that impact quality of life or public health
20%	Operations & maintenance impacts and risks	Odor, noise, traffic, contamination and other impacts to residents, businesses and the environment from normal operations and emergency conditions
20%	Construction-phase disruptions	Acute, short-term impacts such as traffic, noise, dust, vibration and service interruptions to residents and businesses in project areas
	Level of sanitary service	Impacts to sanitary service (e.g. frequency or severity of back ups, odor control, etc.)
	Urban renewal and environmental justice	Alignment with other initiatives to improve low income and blighted areas
	Public image for NBC and the region	Potential for influencing the reputation of the region for intelligent infrastructure and environmental stewardship both internally and externally

Implementation Criteria

Weight	Evaluation Criteria	Description
40%	Administrative / Institutional considerations	Degree to which the responsible party for implementation is known and empowered to construct and operate the project/alternative at the time of evaluation
30%	System reliability / Operational robustness	Sensitivity of a system to changes in conditions and the degree to which it must be inspected and actively managed to operate correctly
30%	Climate change resiliency & recovery	Capacity for providing resiliency against climate change and reducing recovery costs associated with post-event recovery
	Implementation / phasing flexibility	Degree to which the project/alternative could be subdivided or combined with other projects/alternatives to achieve incremental progress toward overall goals

Weighted Evaluation & Prioritization Criteria

- Alternatives evaluation & selection
- Program component prioritization
- IPF project prioritization

Evaluation Criteria	Weighting	Factor
Environmental Criteria	**35%**	
Water quality (bacteria) impacts	40%	14.00%
Water quality (nutrients) impacts	20%	7.00%
Flooding risks from stormwater systems	20%	7.00%
Scalability & adaptability	20%	7.00%
Economic Criteria	**30%**	
Capital costs	45%	13.50%
Operations & Maintenance costs	25%	7.50%
Constructability / Construction-phase risks	10%	3.00%
Cost per gallon captured	10%	3.00%
Operational flexibility for optimization	10%	3.00%
Social Criteria	**18%**	
Fishable, shellfishable & swimmable waters	35%	6.30%
Co-benefits & quality of life	25%	4.50%
Operations & maintenance impacts and risks	20%	3.60%
Construction-phase disruptions	20%	3.60%
Implementation Criteria	**17%**	
Administrative / Institutional considerations	40%	6.80%
System reliability / Operational robustness	30%	5.10%
Climate change resiliency & recovery	30%	5.10%

Criteria Scoring

Evaluation	Score
Advantageous	10
	9
	8
	7
	6
Neutral / No change to 2014 condition	5
	4
	3
	2
	1
Disadvantageous	0

Alternatives Evaluation & Prioritization

			203, 204, 205			056, 039	
Volume Captured:		13.37	13.37	22.01	0.88	0.88	0.88
Evaluation Criteria	**Factor**	**Drop shaft 205 & conduit**	**Front St Tank with GSI**	**Front St Screening & Disinfection**	**039 Sewer separation**	**Hybrid GSI / Sewer separation**	**West River Interceptor**
Environmental Criteria							
Water quality (bacteria) impacts	14%	10	10	5	0.5	0.5	0.5
Water quality (nutrients) impacts	7%	10	10	6	1	2	6
Flooding risks from stormwater systems	7%	5	6.5	5.0	0	3.5	6
Scalability & adaptability	7%	6	6.5	7	5	6.5	6
Economic Criteria							
Capital costs	14%						
Operations & Maintenance costs	8%	8	2	1	9	4	7
Constructability / Construction-phase risks	3%	5	2	2	1	1	2
Cost per gallon captured	3%						
Operational flexibility for optimization	3%	7	7	7	5	5.5	7
Social Criteria							
Fishable, shellfishable & swimmable waters	6%	10	10	5	0.5	0.5	0.5
Co-benefits & quality of life	5%	5	7.5	2	8	8.5	5
Operations & maintenance impacts and risks	4%	5	3	1	4	3.5	4
Construction-phase disruptions	4%	4	2.5	2	0	1.5	2
Implementation Criteria							
Administrative / Institutional considerations	7%	7	1.5	1	3	2.5	5
System reliability / Operational robustness	5%	8	2.5	1	7	5	7
Climate change resiliency & recovery	5%	7	6	7	5	5.5	6
Composite Rating & Ranking:		**6.3**	**5.1**	**3.3**	**2.7**	**2.7**	**3.6**

Alternatives development & screening review

Evaluation criteria

CSO needs analysis & hydraulic model results

Alternatives analysis: Subsystem delineations

Alternatives evaluation by subsystem

Alternatives analysis conclusions

NBC Phase III Needs Analysis & Hydraulic Model

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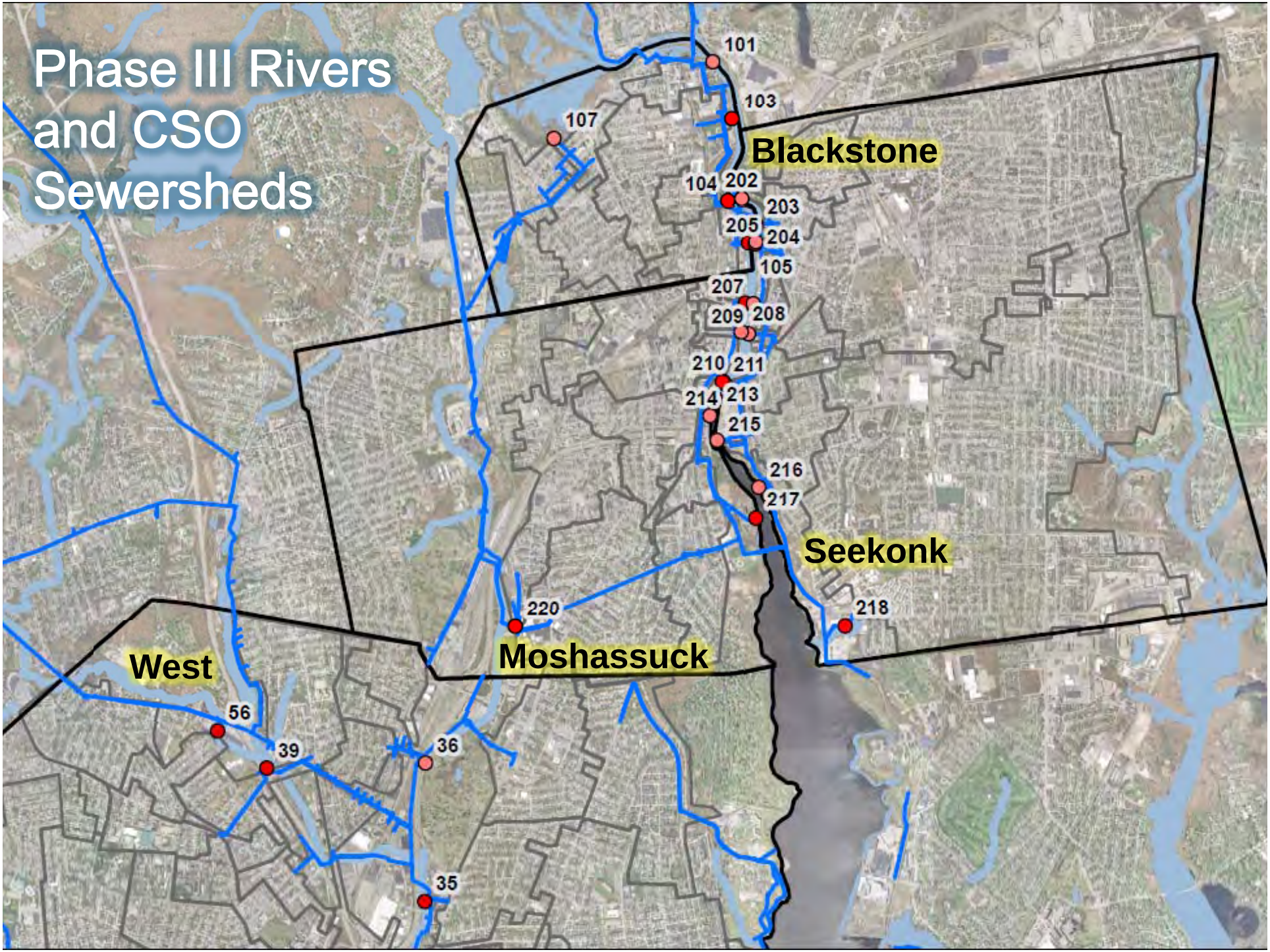

Phase III Rivers and CSO Sewersheds
101
103
107
Blackstone
104
202
203
205
204
105
207
209
208
210
211
214
213
215
216
217
Seekonk
218
220
Moshassuck
West
56
39
36
35

Developing GSI Opportunities

Step 1
- **Opportunity** - GIS based assessment of open spaces that could accommodate GSI solutions

Step 2
- **Land Use** - Review of land use to ensure current and planned uses fit in with GSI proposals

Step 3
- **Legislation** - Consideration of legislative barriers and drivers; are there and planning restrictions that would prevent the use of GSI or drivers to support their use

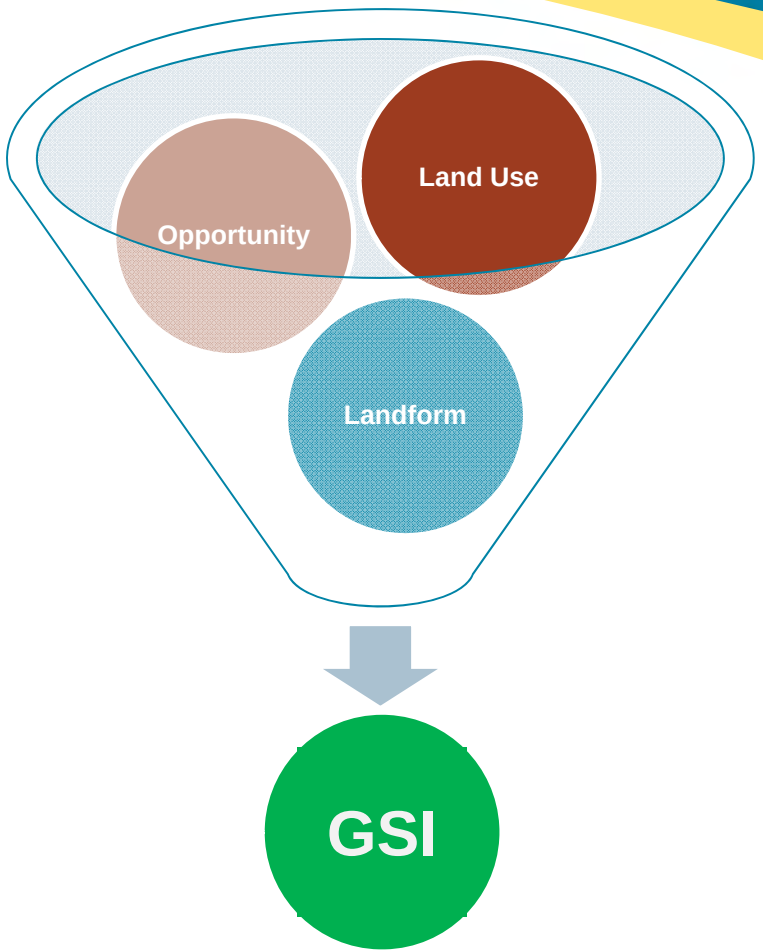
Step 4
- **Landform** - Topography and soil conditions are there any likely prohibitions on the implementation of GSI techniques

Step 5
- **Calculations** - what area could be drained by the GSI proposals and what type of land take and controls will be required to manage flows

Step 6
- **Effectiveness** - do the opportunities and calculations assessments indicate that the GSI would be an effective solution

Step 7
- **Scalability** - can the GSI be replicated at a scale that would be useful and meaningful

Step 8
- **Suitability** - do the proposals fit into the local area, community and utility needs and wishes, avoiding long term negative legacies and vulnerabilities



Developing GSI Opportunities

Step 1
- **Opportunity** – **602** Individual GSI opportunities identified across the Phase III CSO Service Area

Step 2
- **Land Use** – Following step two the number of identified opportunities reduced to **553**

Step 3
- **Legislation** - Following step three the identified opportunities remained at **553**

Step 4
- **Landform** - Following step four the number of identified opportunities reduced to **449**

Step 5
- **Calculations** - Following step five the identified opportunities remained at **449**

Step 6
- **Effectiveness** - Following step six the number of identified opportunities reduced to **349**

Step 7
- **Scalability** - Following step seven the identified opportunities remained at **349**

Step 8
- **Suitability** - Following step eight the final number of identified opportunities was **349**

GSI Conceptual Designs

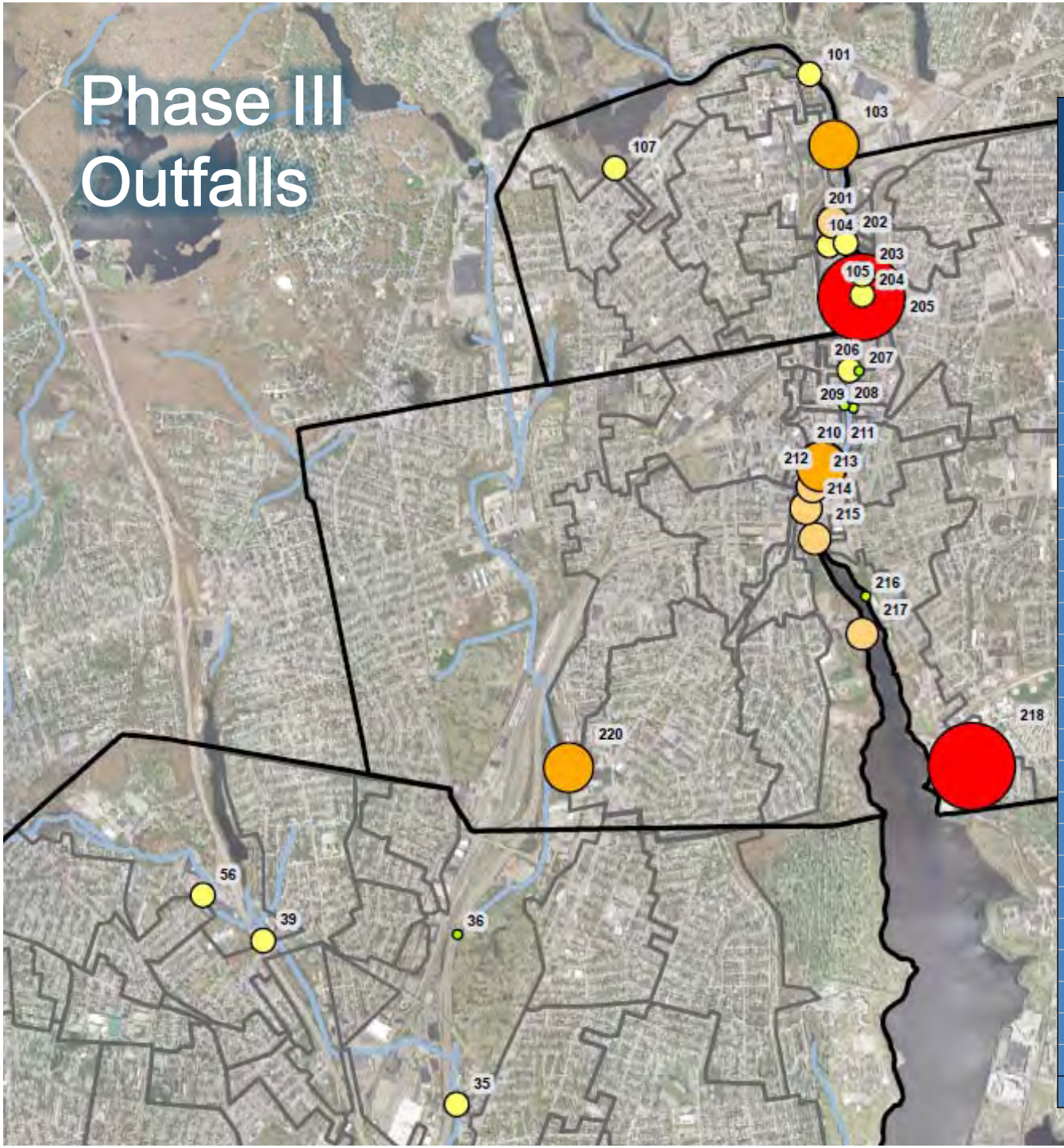
Private

1. Flat roof
2. Parking lot
3. Green space
4. Open space

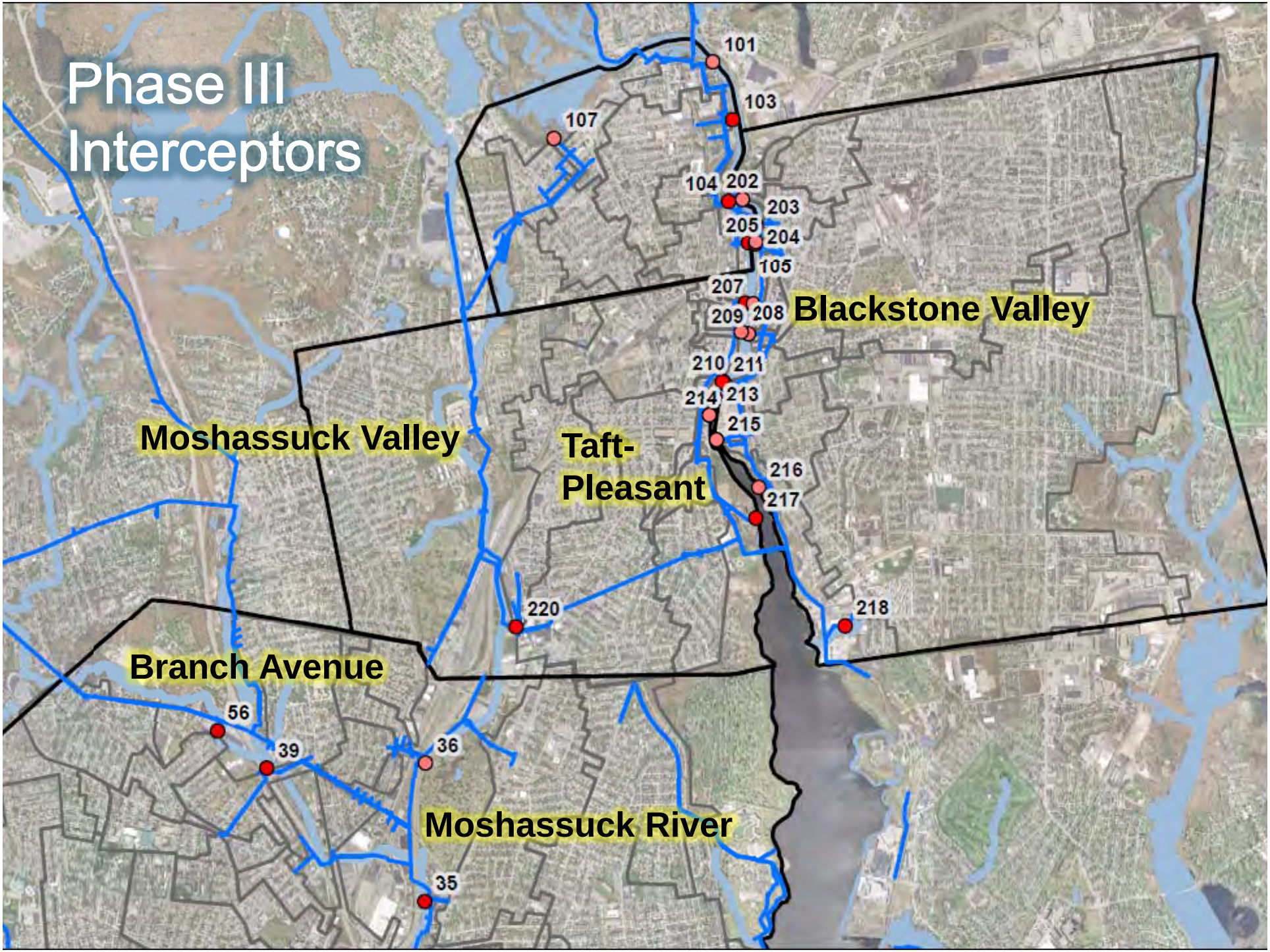
Public

5. Parking lane
6. Median
7. Green space
8. Narrow street
9. Open space

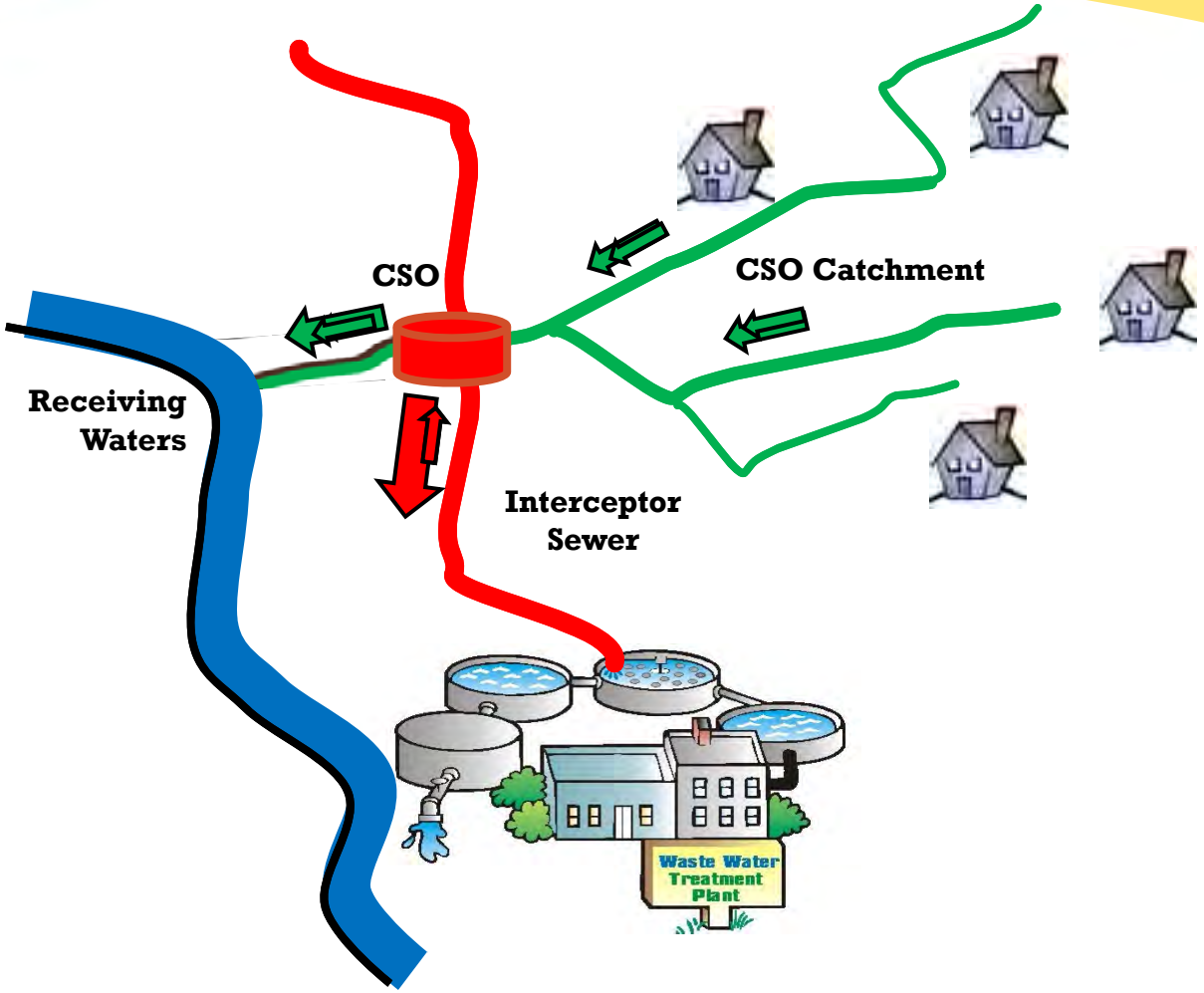
Phase III Outfalls



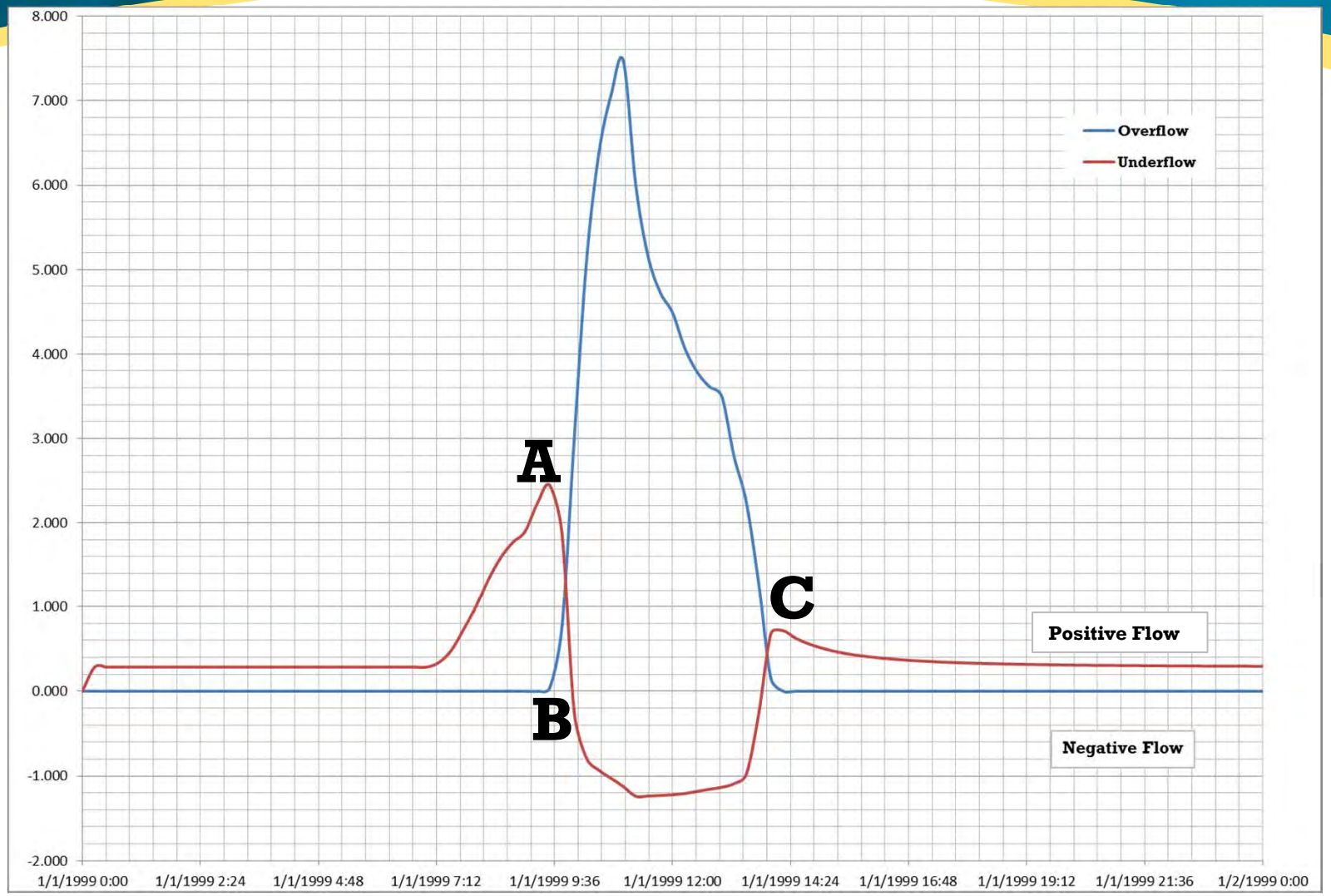
Outfall	CSO Volume (MG)		
	No Source Control	Public Way GSI	Full GSI
205	**12.81**	11.82	8.73
218	**12.58**	10.68	4.93
103	**4.88**	4.49	3.64
220	**4.60**	3.85	1.87
211	**3.96**	3.93	3.90
210	**3.17**	3.11	3.05
217	2.71	2.49	1.96
213	1.97	1.86	1.59
105	1.64	1.55	1.32
215	1.58	1.39	0.83
201	1.34	1.29	1.13
214	1.26	1.04	0.56
35	0.77	0.75	0.68
212	0.60	0.54	0.35
104	0.49	0.41	0.22
39	0.46	0.44	0.43
56	0.42	0.39	0.38
203	0.40	0.35	0.23
101	0.38	0.32	0.17
107	0.37	0.33	0.27
202	0.17	0.16	0.13
204	0.16	0.08	0.01
206	0.14	0.14	0.13
36	0.10	0.10	0.10
207	0.04	0.03	0.01
209	0.02	0.01	0.00
208	0.01	0.01	0.01
216	0.01	0.00	0.00
Volume Controlled:		**10%**	**34%**


Phase III
Interceptors
101
103
107
104
202
203
205
204
105
207
209
208
Blackstone Valley
210
211
214
213
215
Moshassuck Valley
Taft-
Pleasant
216
217
220
218
Branch Avenue
56
39
36
Moshassuck River
35

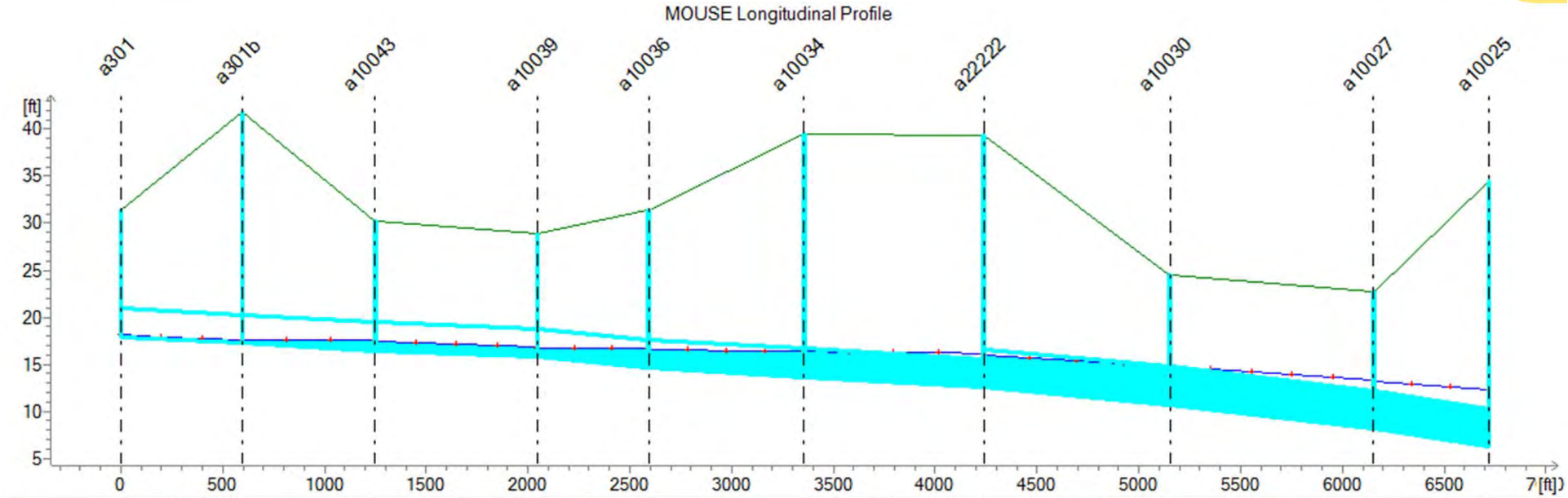
Catchment-driven vs. Interceptor-driven



CSO Overflow / Underflow the balancing act



Branch Avenue Interceptor - Hydraulics



Link ID	a1043b	a1043	a1036	a1036b	a1033	a1033b	a1030	a1027	a1025		
Link Diameter	3.0000						4.0000				
Shaft ID	a301	a301b	a10043	a10039	a10036	a10034	a22222	a10030	a10027	.....	
Shaft Diameter	4.0000										
Ground Level	31.35	41.75	30.15	28.95	31.35	39.45	39.35	24.45	22.75	34.55	
Invert Level	17.95	17.25	16.45	15.75	14.65	13.65	12.60	10.75	8.15	6.21	
Link Slope	0.12		0.09	0.20	0.13	0.12	0.20	0.26	0.34		

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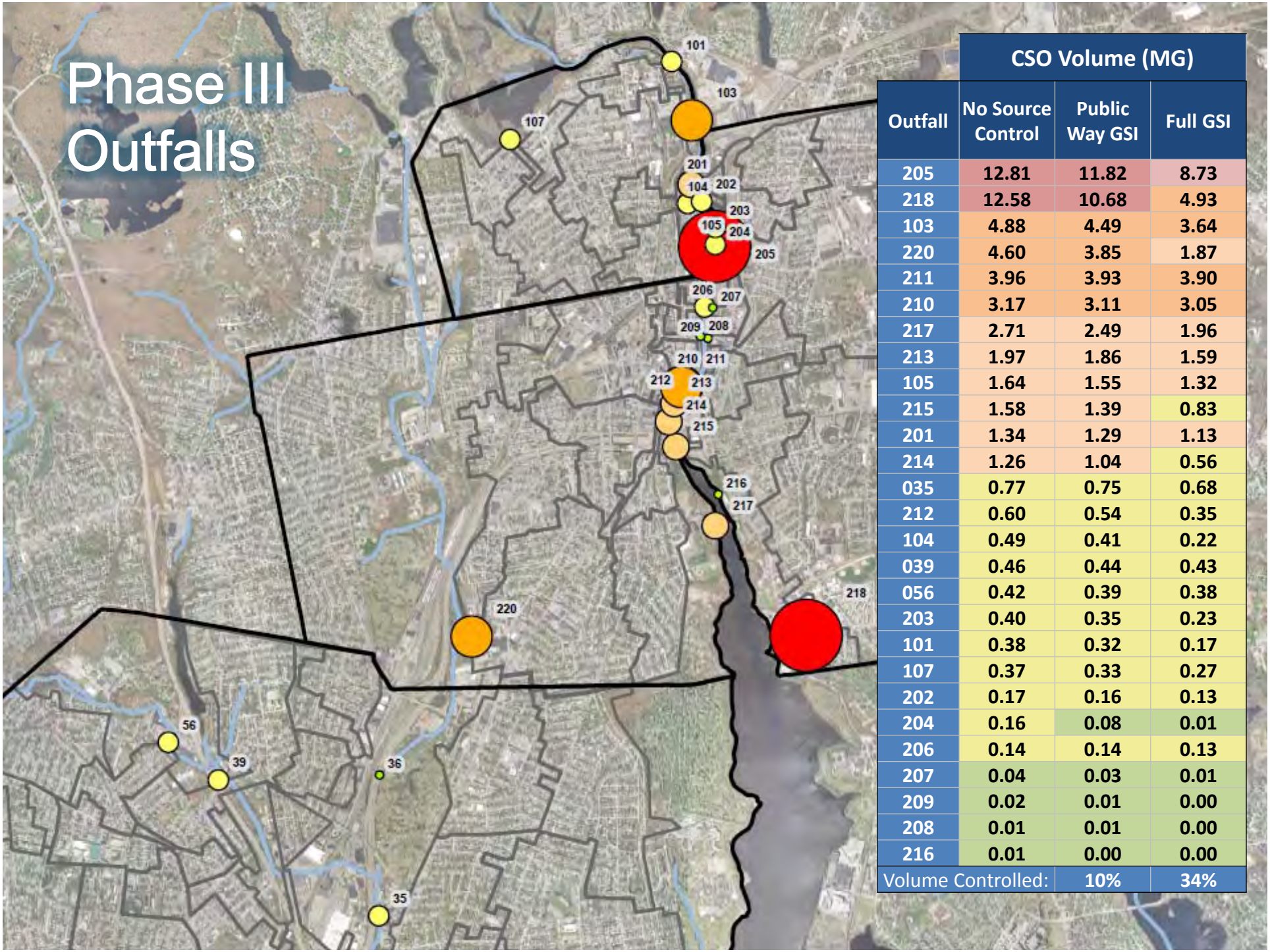
Phase III Outfalls



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211	3.96	3.93	3.90
210	3.17	3.11	3.05
217	2.71	2.49	1.96
213	1.97	1.86	1.59
105	1.64	1.55	1.32
215	1.58	1.39	0.83
201	1.34	1.29	1.13
214	1.26	1.04	0.56
035	0.77	0.75	0.68
212	0.60	0.54	0.35
104	0.49	0.41	0.22
039	0.46	0.44	0.43
056	0.42	0.39	0.38
203	0.40	0.35	0.23
101	0.38	0.32	0.17
107	0.37	0.33	0.27
202	0.17	0.16	0.13
204	0.16	0.08	0.01
206	0.14	0.14	0.13
207	0.04	0.03	0.01
209	0.02	0.01	0.00
208	0.01	0.01	0.00
216	0.01	0.00	0.00
Volume Controlled:		10%	34%

Incorporating GSI into Phase III

- GSI could eliminate CSOs 209 and 216
- All other outfalls require an accompanying grey solution
- Three major roles for GSI
  - Reduce the design capacity of grey infrastructure where site constraints are limiting (Part of today's alternatives analysis)
  - Optimize the design of the selected grey infrastructure alternatives based on a cost-benefit analysis (Part of October's plan refinement)
  - Provide additional control and flexibility in the future (Part of adaptive management for future designs and plan modification)

Alternatives development & screening review
Evaluation criteria
CSO needs analysis & hydraulic model results
Alternatives analysis: Subsystem delineations
Alternatives evaluation by subsystem
Alternatives analysis conclusions

Alternatives Analysis: Subsystem Delineation

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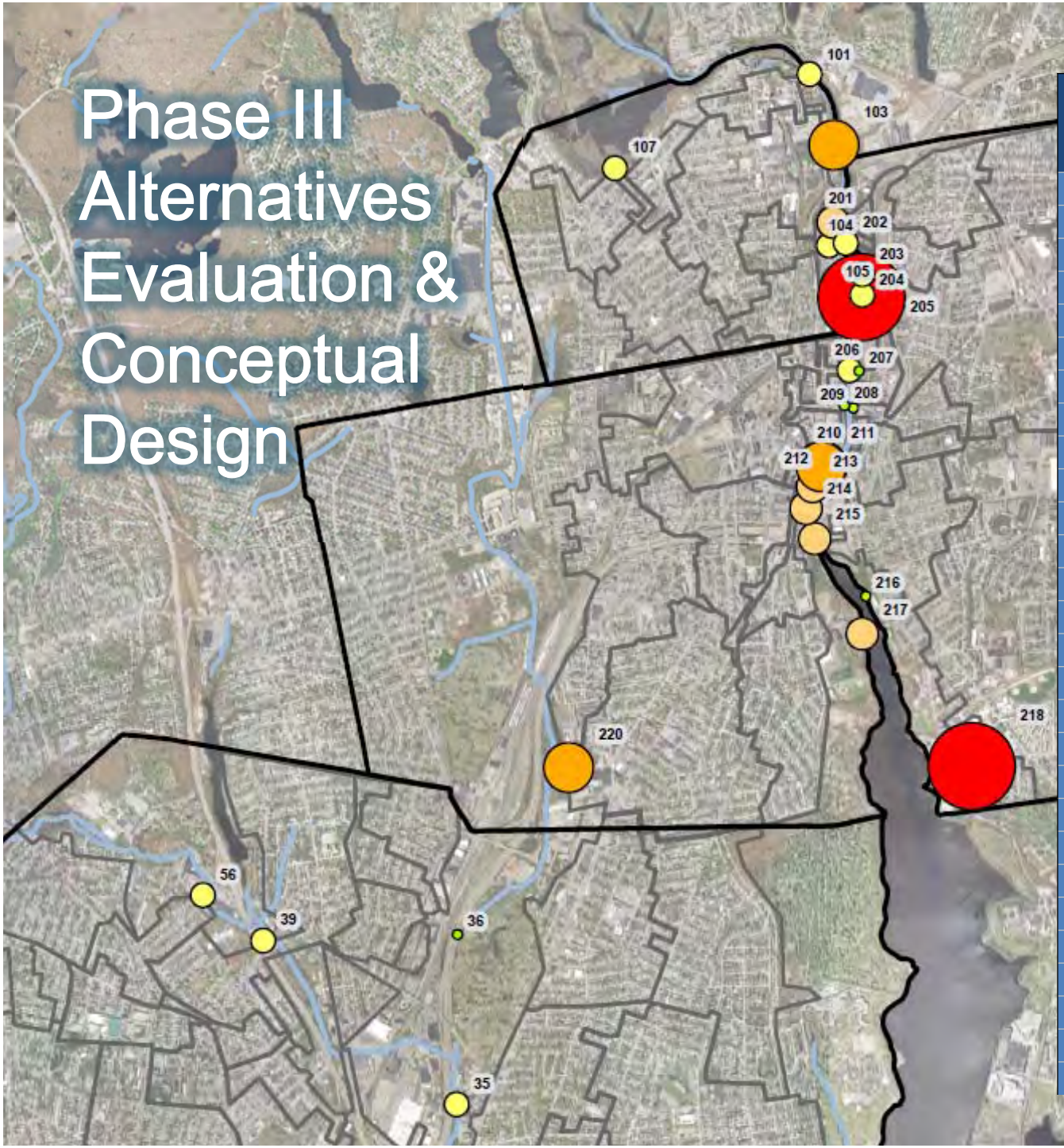
Phase III Alternatives Evaluation & Conceptual Design



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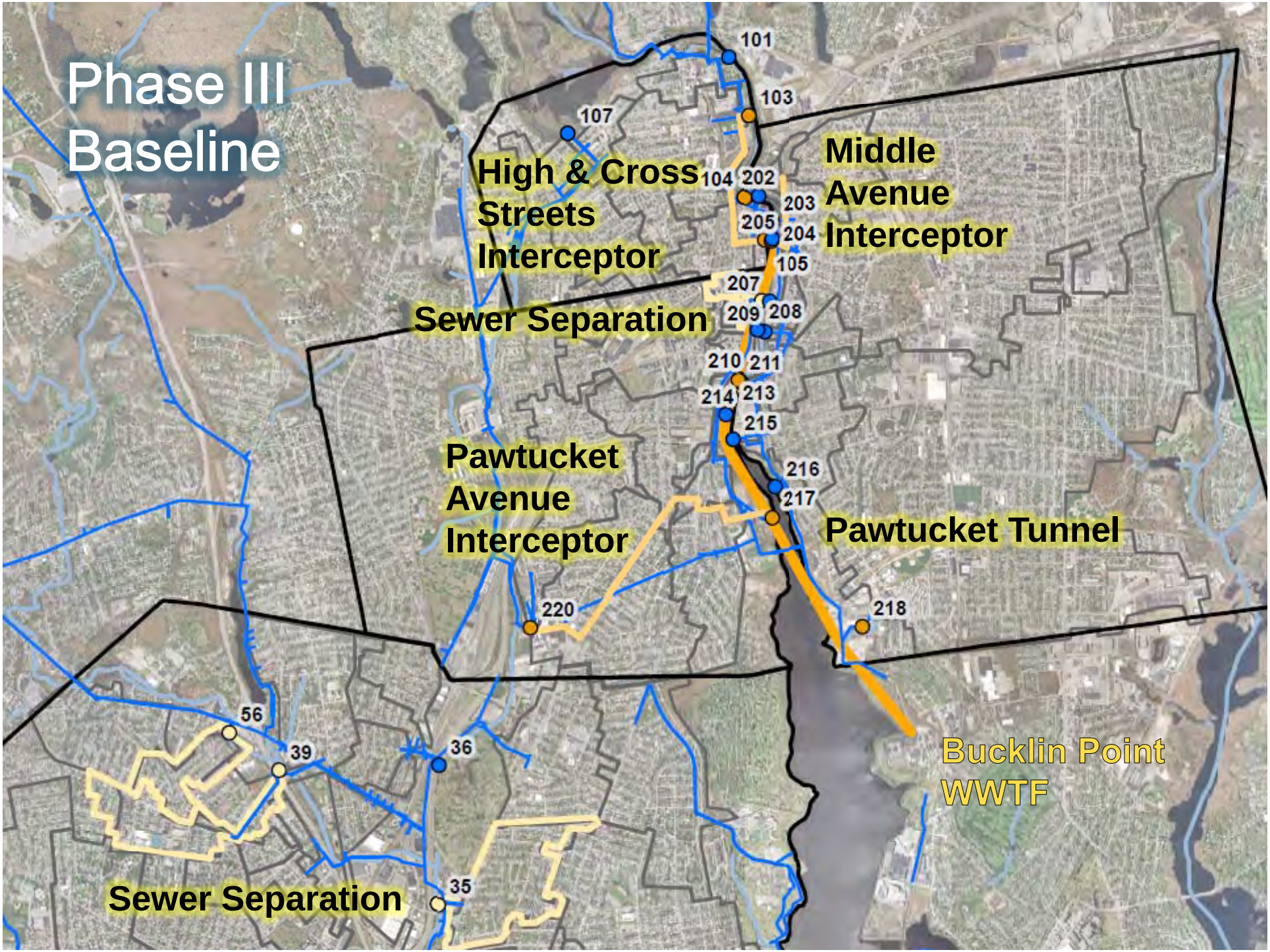
36	0.10	0.10	0.10
39	0.46	0.44	0.43
56	0.42	0.39	0.38
101	0.38	0.32	0.17
103	**4.88**	4.49	3.64
104	0.49	0.41	0.22
105	1.64	1.55	1.32
107	0.37	0.33	0.27
201	1.34	1.29	1.13
202	0.17	0.16	0.13
203	0.40	0.35	0.23
204	0.16	0.08	0.01
205	**12.81**	11.82	8.73
206	0.14	0.14	0.13
207	0.04	0.03	0.01
208	0.01	0.01	0.01
209	0.02	0.01	0.00
210	**3.17**	3.11	3.05
211	**3.96**	3.93	3.90
212	0.60	0.54	0.35
213	1.97	1.86	1.59
214	1.26	1.04	0.56
215	1.58	1.39	0.83
216	0.01	0.00	0.00
217	2.71	2.49	1.96
218	**12.58**	10.68	4.93
220	**4.60**	3.85	1.87


Phase III
Baseline
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103
107
High & Cross
Streets
Interceptor
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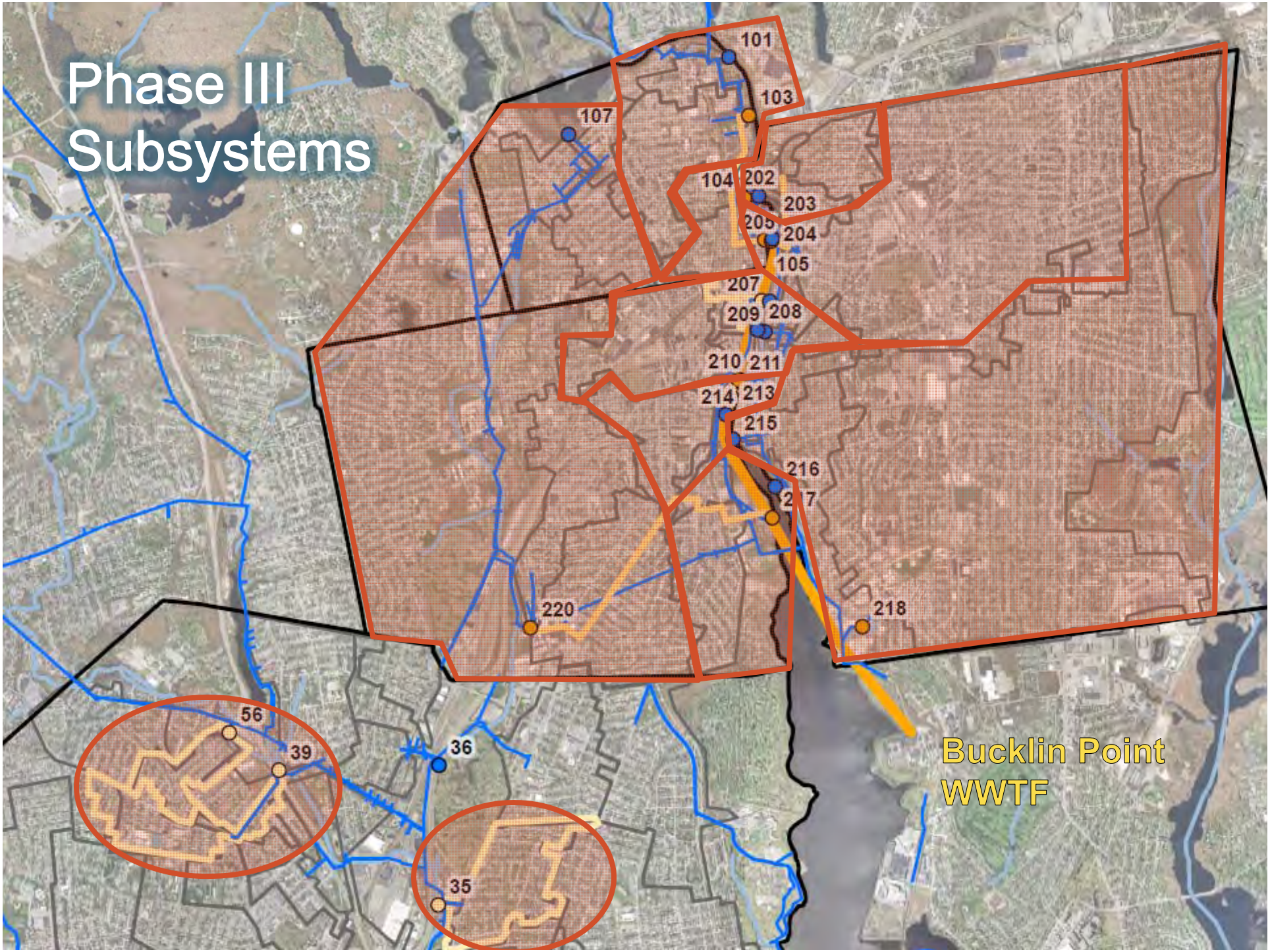
202
203
205
204
Middle
Avenue
Interceptor
105
207
Sewer Separation
209
208
210
211
214
213
215
Pawtucket
Avenue
Interceptor
216
217
Pawtucket Tunnel
220
218
56
39
36
Bucklin Point
WWTF
Sewer Separation
35


Phase III
Subsystems
101
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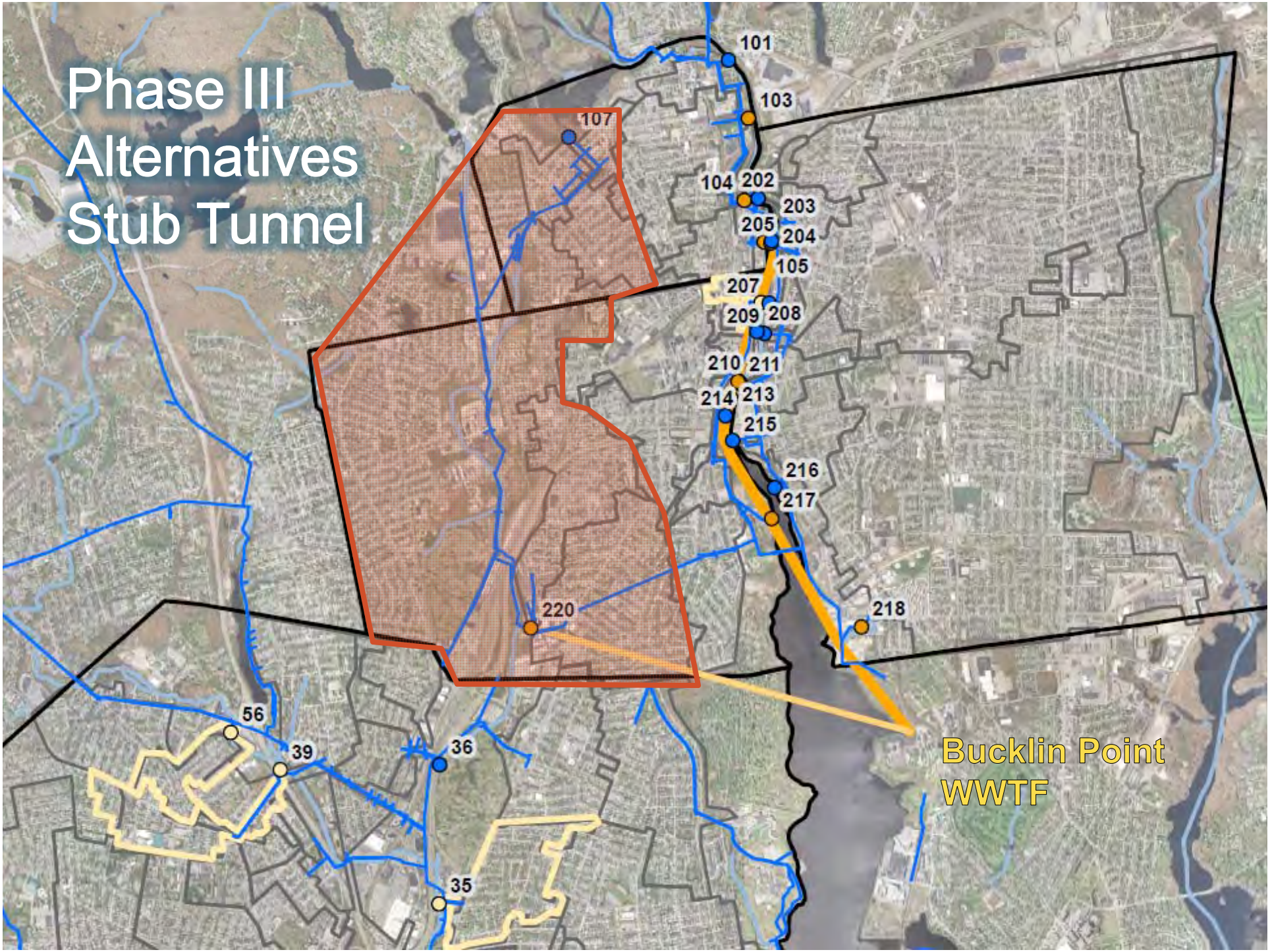
Bucklin Point
WWTF


Phase III
Alternatives
Stub Tunnel
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103
107
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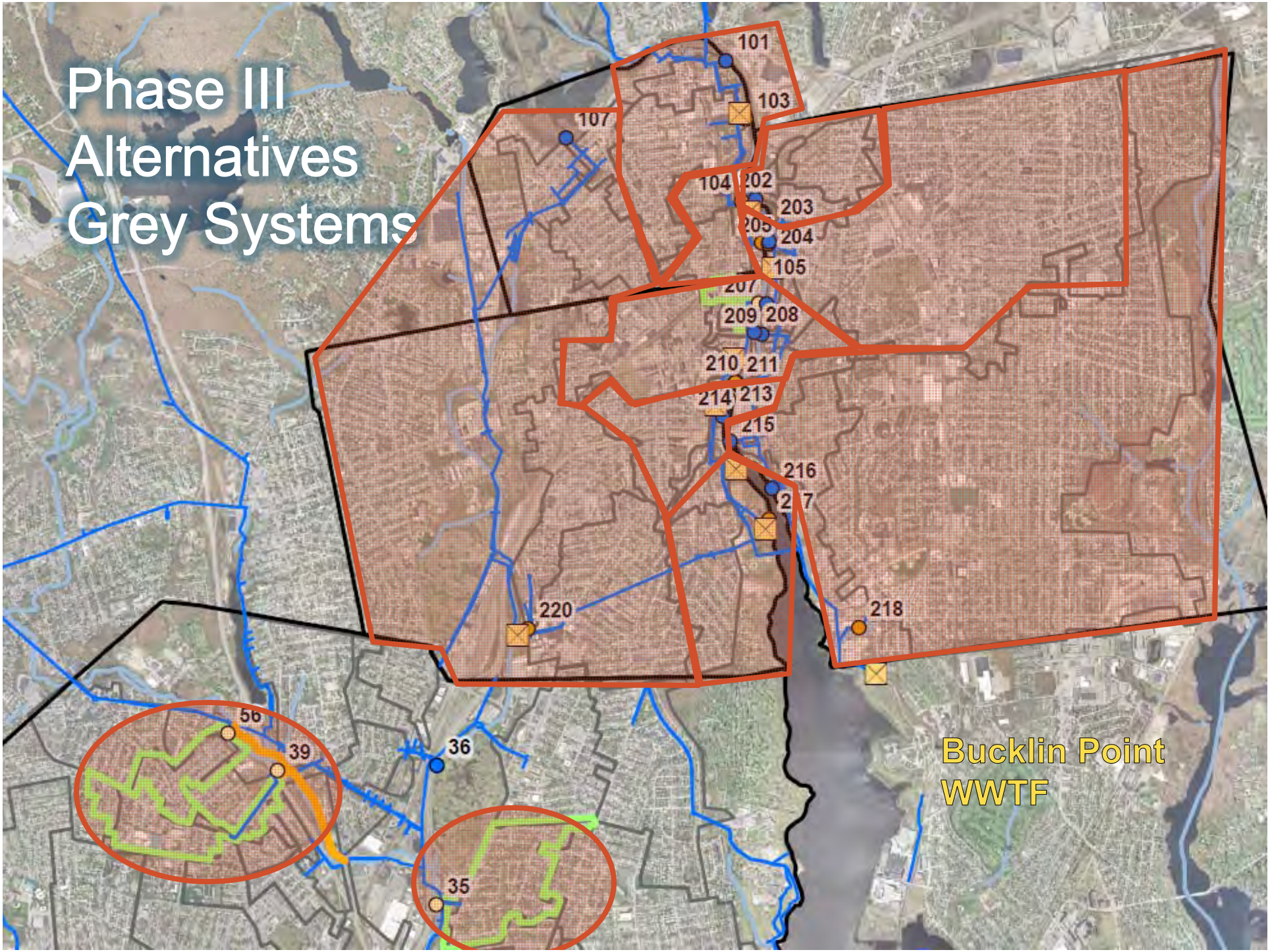
Bucklin Point
WWTF


Phase III
Alternatives
Grey Systems
101
103
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Bucklin Point
WWTF

Phase III 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
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 III 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 landfil 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

After the Break…
Subsystem Alternatives Evaluation

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