

Middletown: Impacts of Buildout on Water Resources & Traffic

Town Council, December 14, 2020

PURPOSE OF STUDY

- ▶ To evaluate impacts of projected full buildout on natural resources, particularly ground and surface water, and traffic.
- ▶ Findings to be used to inform update to the Middletown Comprehensive Plan and possible amendment to land use regulations and zoning.

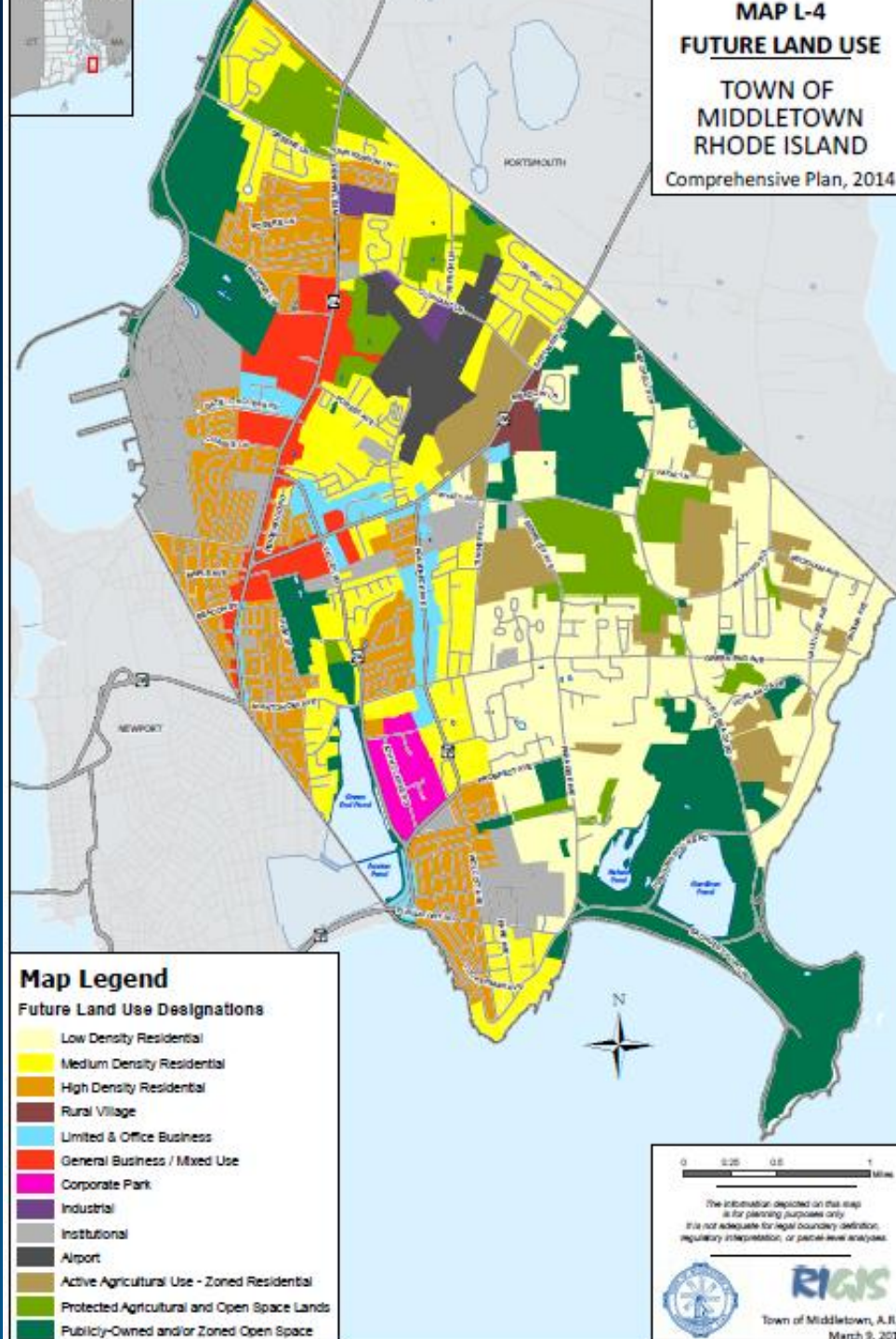
PROJECT SCOPE

- ▶ Land Development Potential (buildout)
- ▶ Evaluation of Surface Water Impacts
- ▶ Evaluation of Groundwater Impacts
- ▶ Evaluation of Traffic Impacts

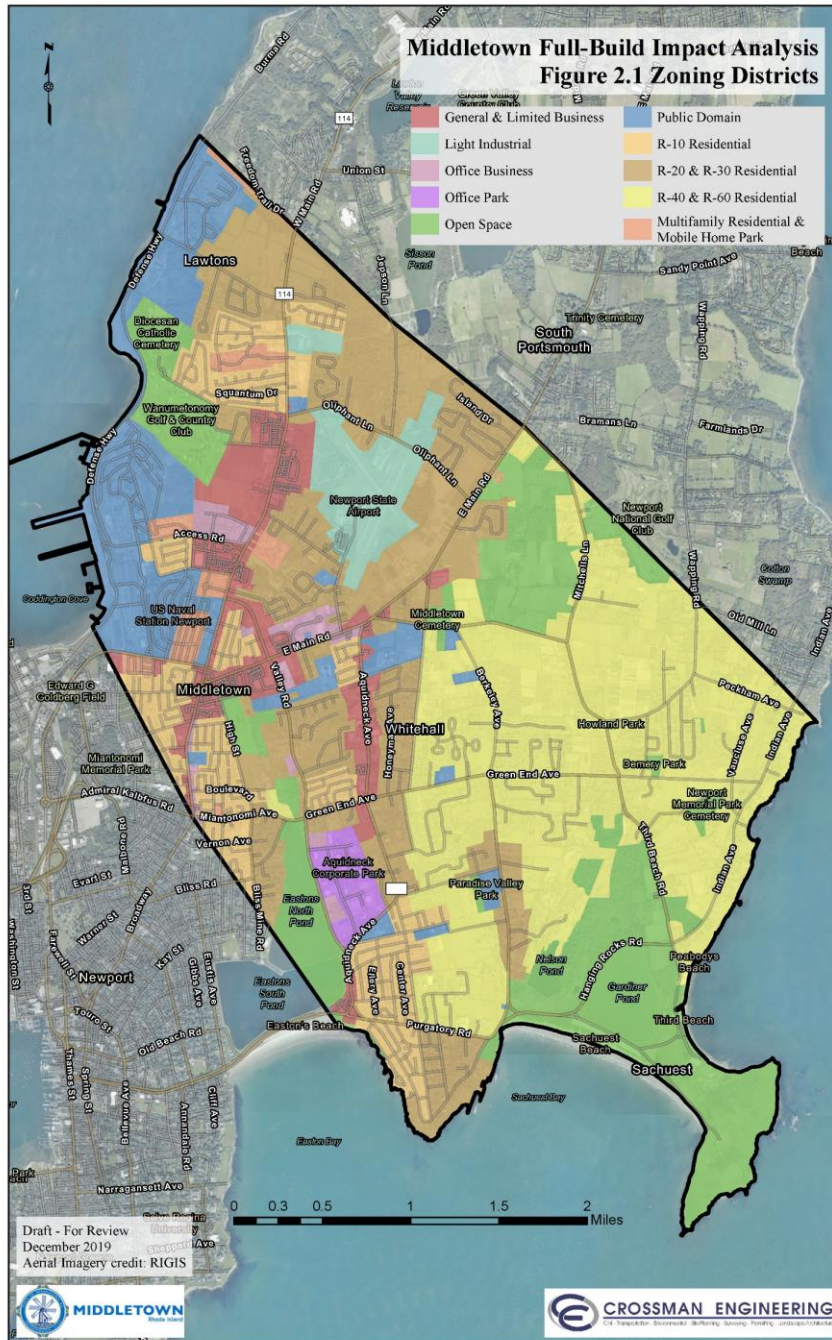
BUILDOUT METHODOLOGY

- ▶ Current Zoning
- ▶ Scenarios
 - ▶ Full Build
 - ▶ Increased Residential Lot Size (R-40 & R-60 to R-100)
 - ▶ Exclude Marginal Lots (street frontage limitations)
 - ▶ Exclude WPD Zone 1

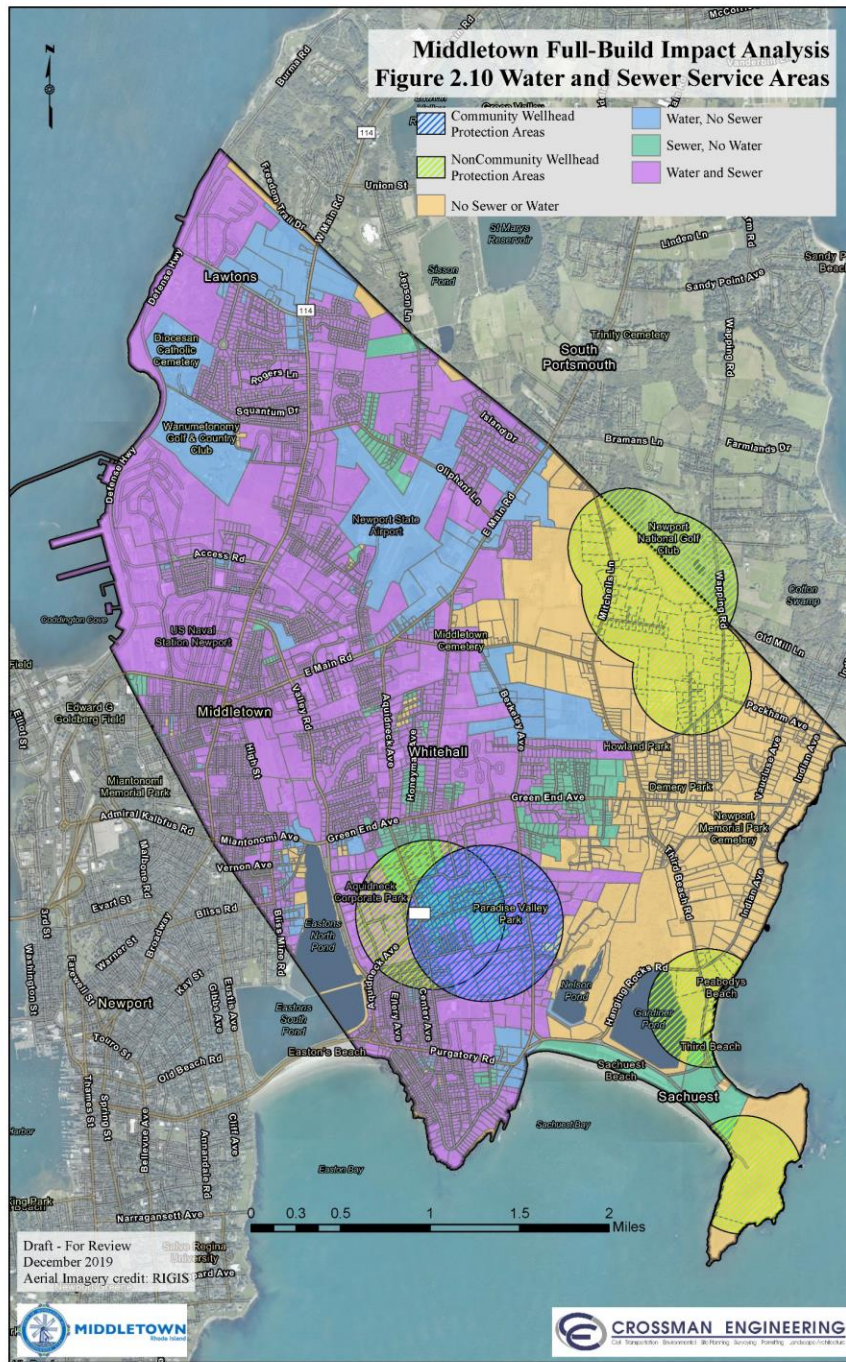
COMP PLAN FUTURE LAND USE



CURRENT ZONING



EXISTING WATER AND SEWER SERVICE AND WELLHEAD PROTECTION AREAS



FULL BUILD DETERMINATION

Residential

- Examine undeveloped land in residential zoning areas and oversized developed lots
- Exclude wetlands
- Exclude conservation easement and other conserved lands – Total 2,333 acres

Commercial

- Examine undeveloped land on commercially zoned parcels
- Exclude mapped wetlands
- No vertical “reconfiguration” of existing developments

Mixed-use

- Based on Zoning Ordinance Article 27A
- Retail space at 35% of developed space
- Residential Use at 35% of developed space, units determined at 1,000 Sq. Ft. / Unit
- Office at 30% of developed space

RESIDENTIAL FULL BUILD RESULTS

Zone	Existing Dwelling Units	Additional Dwelling Units, Full-Build	Total Dwelling Units
R-10	2,724	250	2,974
R-20	1,672	226	1,898
R-30	276	247	523
R-40	878	414	1,292
R-60	267	174	441
Mobile / Transient	89	0	89
Multifamily	1,185	0	1,185
OS ¹	6	125	131
COM ^{2, 5}	348	423	674 ⁴
P ^{3, 5}	354	57	411
Total	7,799	1,916	9,618

1 OS is Open Space; Additional Dwelling Units reflect redevelopment of Wanumetonomy Country Club

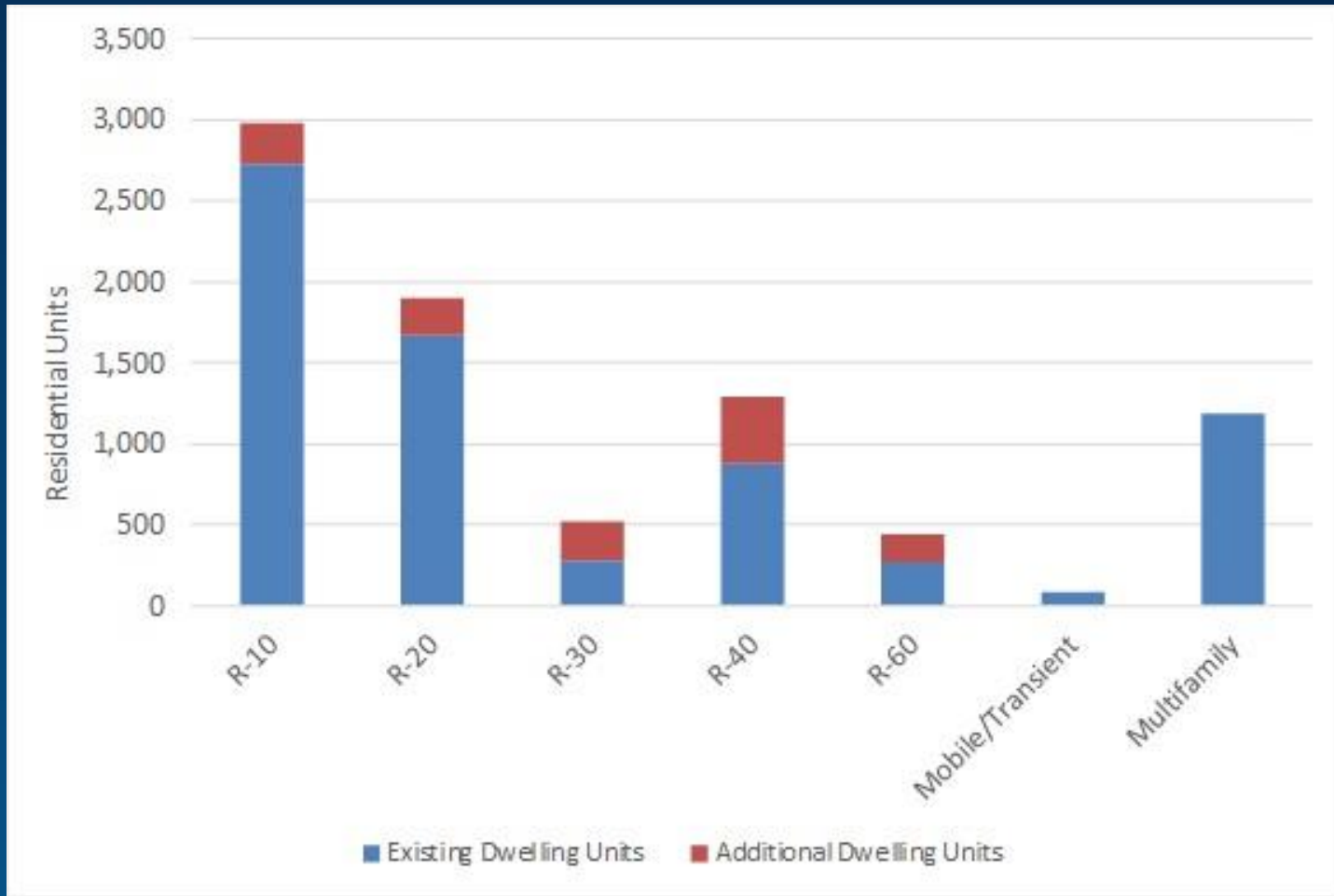
2 COM is General Business, Limited Business, Office Business, Office Park, and Light Industrial

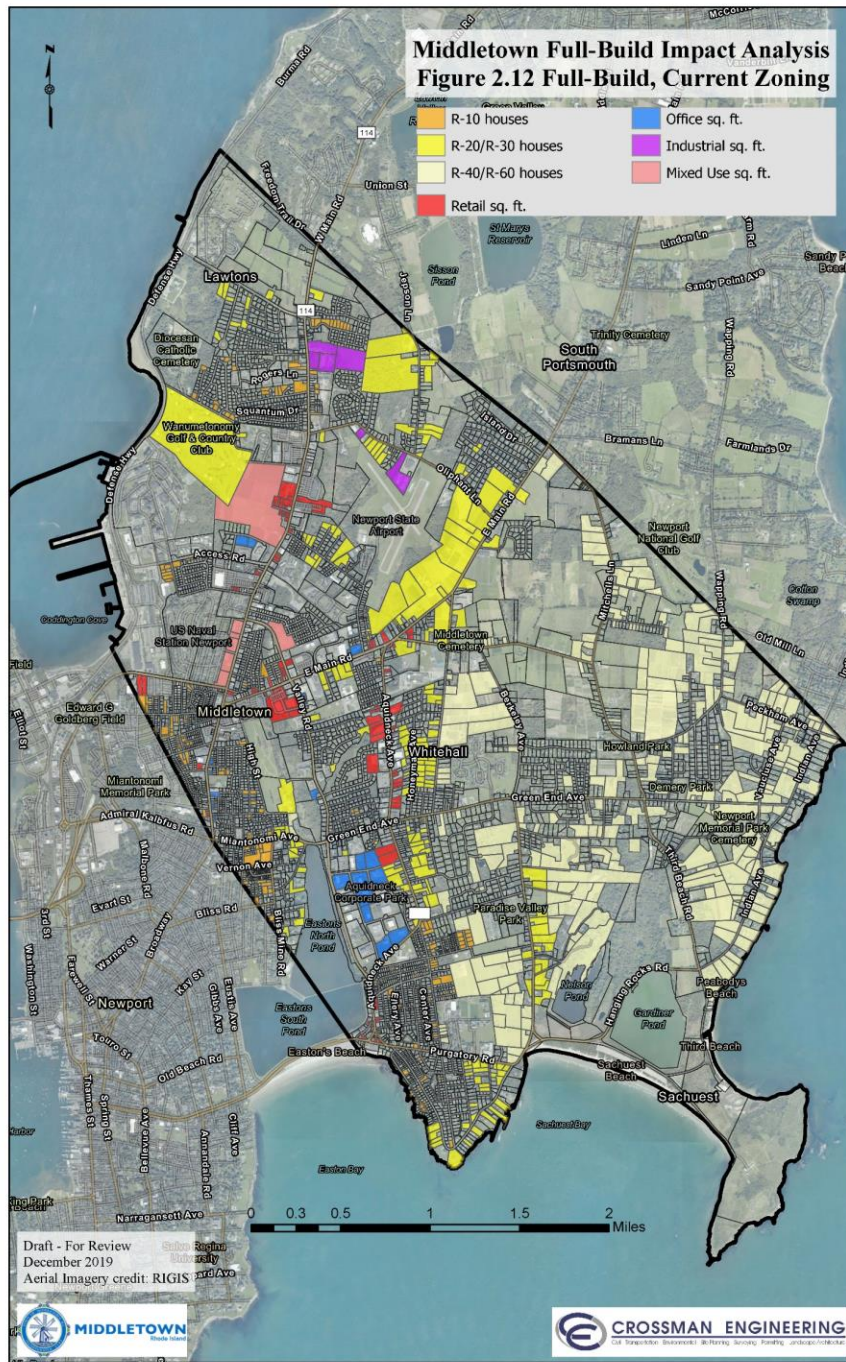
3 P is Public

4 Not a direct sum. Some existing residential units in commercial zones are converted to commercial space through build-out

5 Future development in commercial and public zones is part of mixed-use development described in Commercial full-build results section

RESIDENTIAL FULL BUILD RESULTS





RESIDENTIAL FULL BUILD RESULTS

Alternative Scenarios

	Full-Build	Exclude Marginal Lots	Re-zone R- 40/R-60 to R- 100 Zoning	Exclude Watershed Protection District 1	Implement All Alternatives
R-10	250	191 (59)	250	234 (16)	179 (71)
R-20	226	157 (69)	226	163 (63)	111 (115)
R-30	247	230 (17)	247	215 (32)	201 (46)
R-40	414	373 (41)	184 (230)	362 (52)	146 (268)
R-60	174	153 (21)	104 (70)	154 (20)	82 (92)
Mobile / Transient	0	0	0	0	0
Multifamily	0	0	0	0	0
OS	125	125	125	61 (64)	61 (64)
COM¹	423	423	423	390 (33)	390 (33)
P¹	57	57	57	57	57
Total	1,916	1,709 (207)	1,616 (300)	1,636 (280)	1,227 (689)

COMMERCIAL FULL BUILD RESULTS

Alternative Scenarios ³

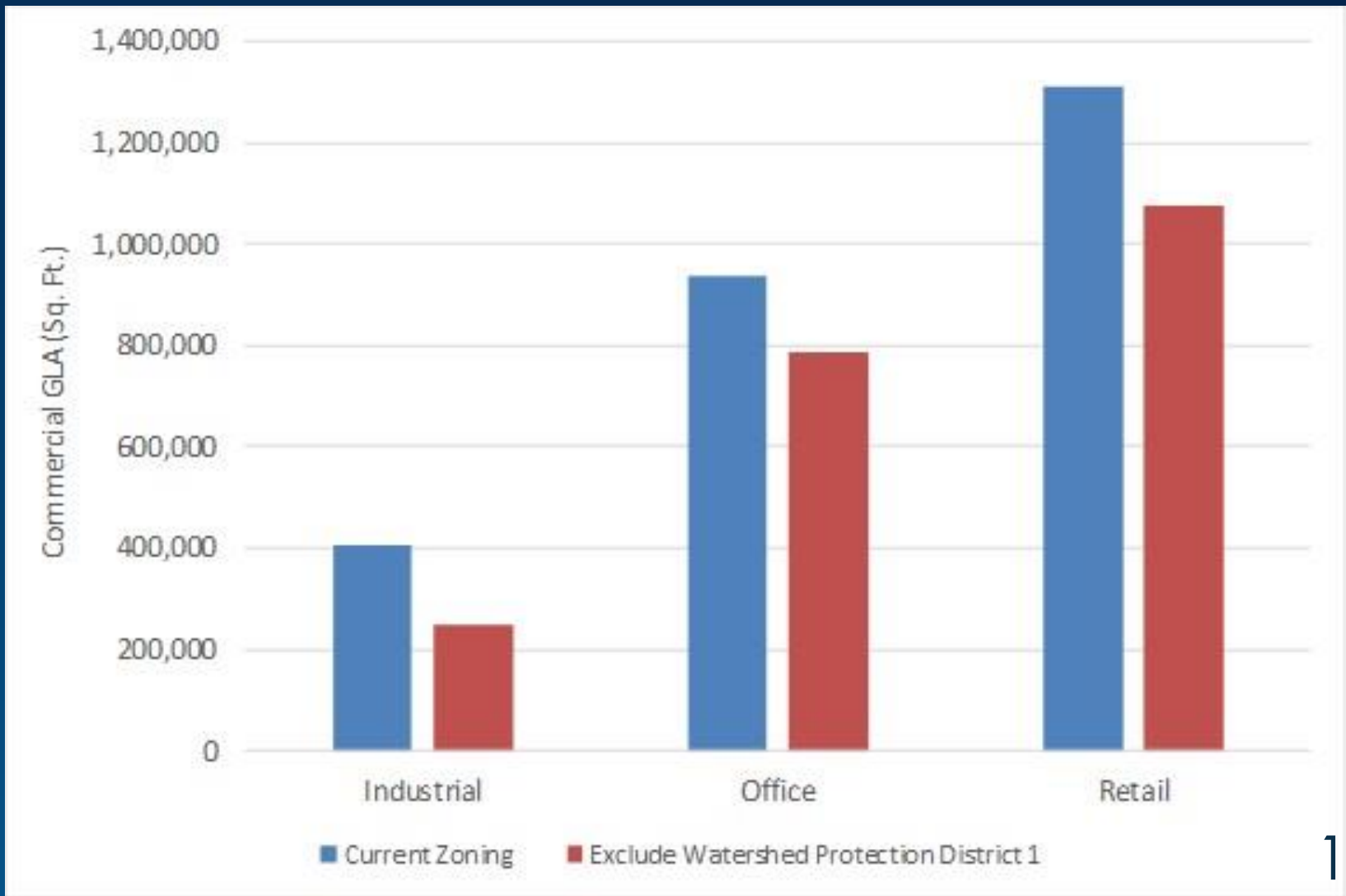
Zone ¹	Full-Build with Current Zoning	Exclude Marginal Lots ²	Re-zone R-40/R-60 to R-100 Zoning ²	Exclude Watershed Protection District 1	Implement All Alternatives ³
Industrial	406,241			249,676 (156,565)	249,676 (156,565)
Office	936,304			785,969 (150,335)	785,969 (150,335)
Retail	1,311,497			1,075,611 (235,886)	1,075,611 (235,886)
Total	2,654,042	-	-	2,111,256 (542,786)	2,111,256 (542,786)

1 Results for Residential development in mixed use category provided in Residential full-build results section.

2 Results for Exclude Marginal Lots and Re-zone R-40/R-60 to R-100 Zoning alternatives are unchanged for the Commercial full-build

3 Values in parentheses represent the reduction in additional commercial space from the full-build scenario

COMMERCIAL FULL BUILD RESULTS



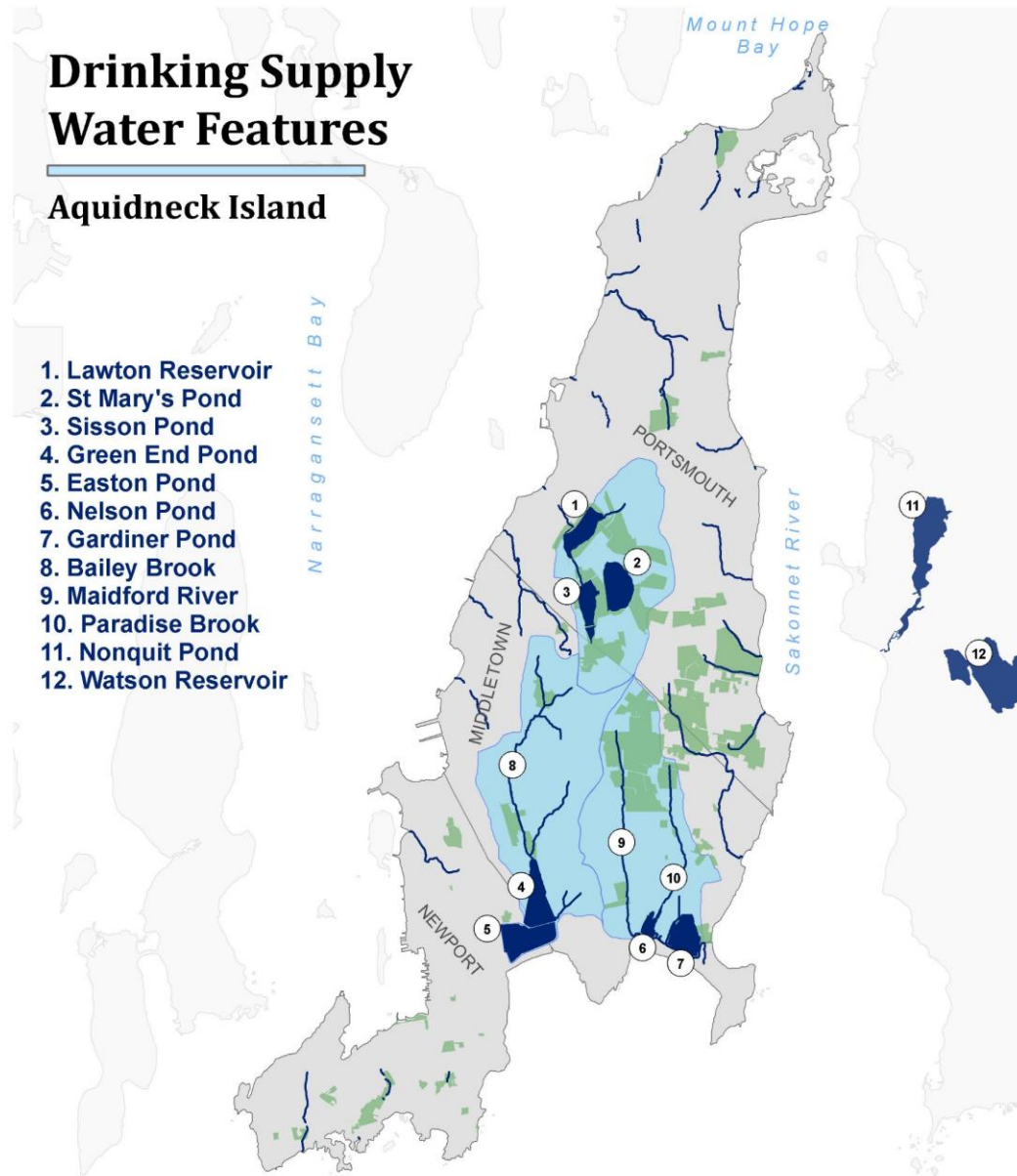
SURFACE WATER IMPACTS



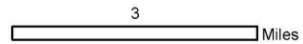
Drinking Supply Water Features

Aquidneck Island

1. Lawton Reservoir
2. St Mary's Pond
3. Sisson Pond
4. Green End Pond
5. Easton Pond
6. Nelson Pond
7. Gardiner Pond
8. Bailey Brook
9. Maidford River
10. Paradise Brook
11. Nonquit Pond
12. Watson Reservoir



- Streams
- Drinking Reservoirs
- Conserved by ALT



Sources: RIGIS Surface Water Protection Areas (edited), RIGIS 5K Streams, ALT Lands Database



SURFACE WATERSHEDS

Existing Water Quality Impairments

Waterbody

Little Creek ²

Enterococcus

Gardiner Pond (Paradise Brook; Maidford River)

Total Phosphorous (TP), Total Organic Carbon (TOC), Other flow regime alterations

Paradise Brook

Fecal Coliform (FC), Total Phosphorous, Turbidity

Nelson Pond (Paradise Brook; Maidford River)

Total Phosphorous, Total Organic Carbon, Other flow regime alterations

Maidord River, headwaters to water supply diversion

Benthic-Macroinvertebrate Bioassessments (MIB), Lead (Pb), Fecal Coliform, Total Phosphorus, Turbidity

Maidford River, water supply diversion to Hanging Rock Rd

Fecal Coliform

Baileys Brook and tributaries

Lead, Enterococcus, Total Phosphorus

North Easton Pond (Green End Pond) (Bailey's Brook)

Total Phosphorus, Chlorophyll-a (Chlor-A), Other flow regime alterations, Total Organic Carbon

South Easton Pond (Bailey's Brook)

Total Phosphorus, Total Organic Carbon

Sisson Pond (Portsmouth)

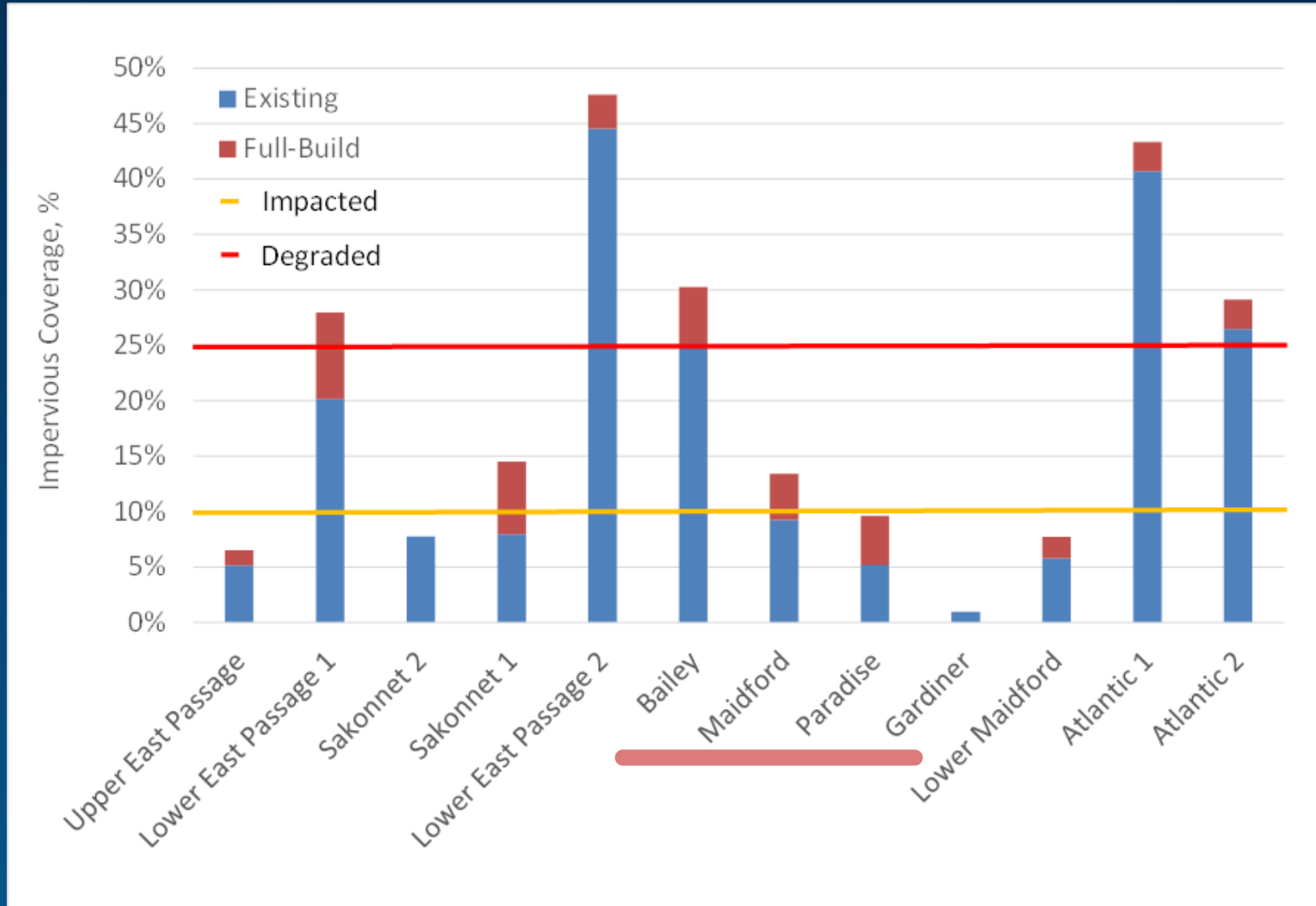
Total Phosphorus, Total Organic Carbon, Other flow regime alterations

Coddington Cove, breakwater to Coddington Point ³

Sediment Bioassays (SB) for Estuarine and Marine Waters

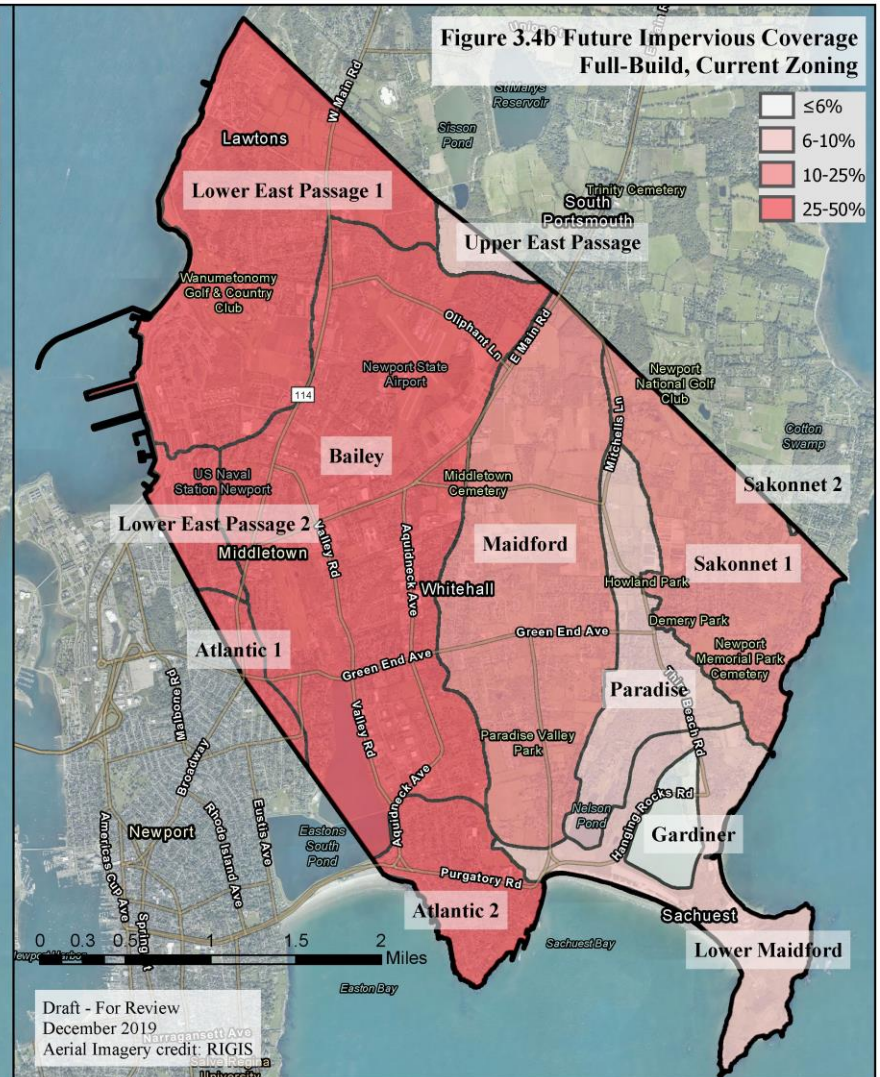
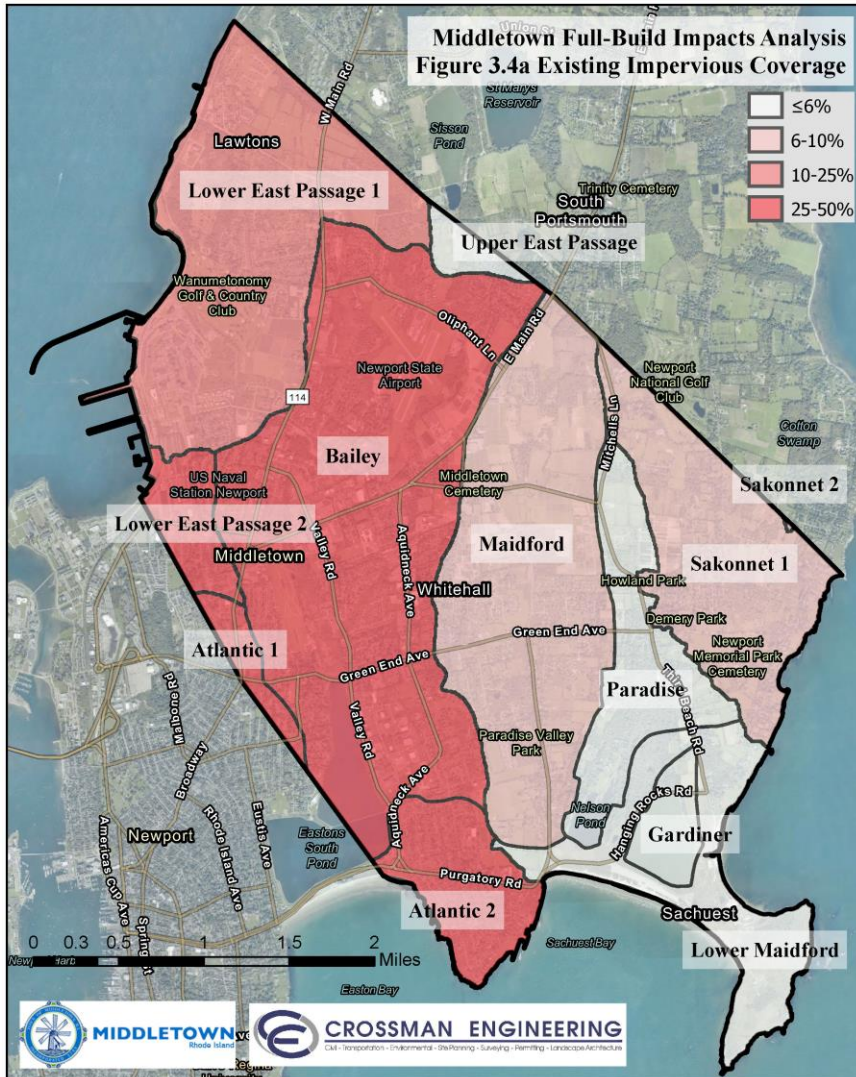
SURFACE WATER IMPACTS

Impervious Coverage with Full Build



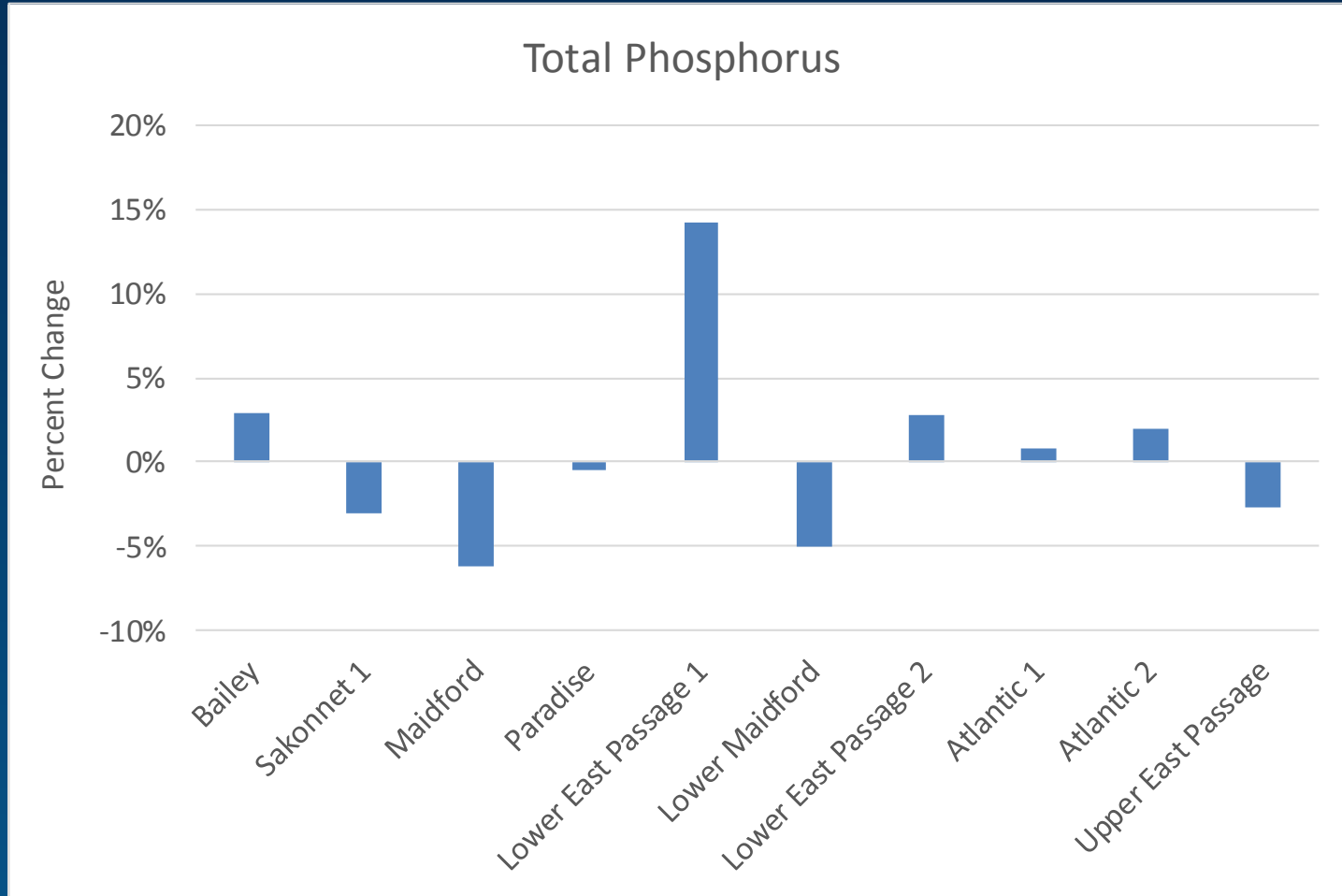
SURFACE WATER IMPACTS

Impervious Coverage Full Build



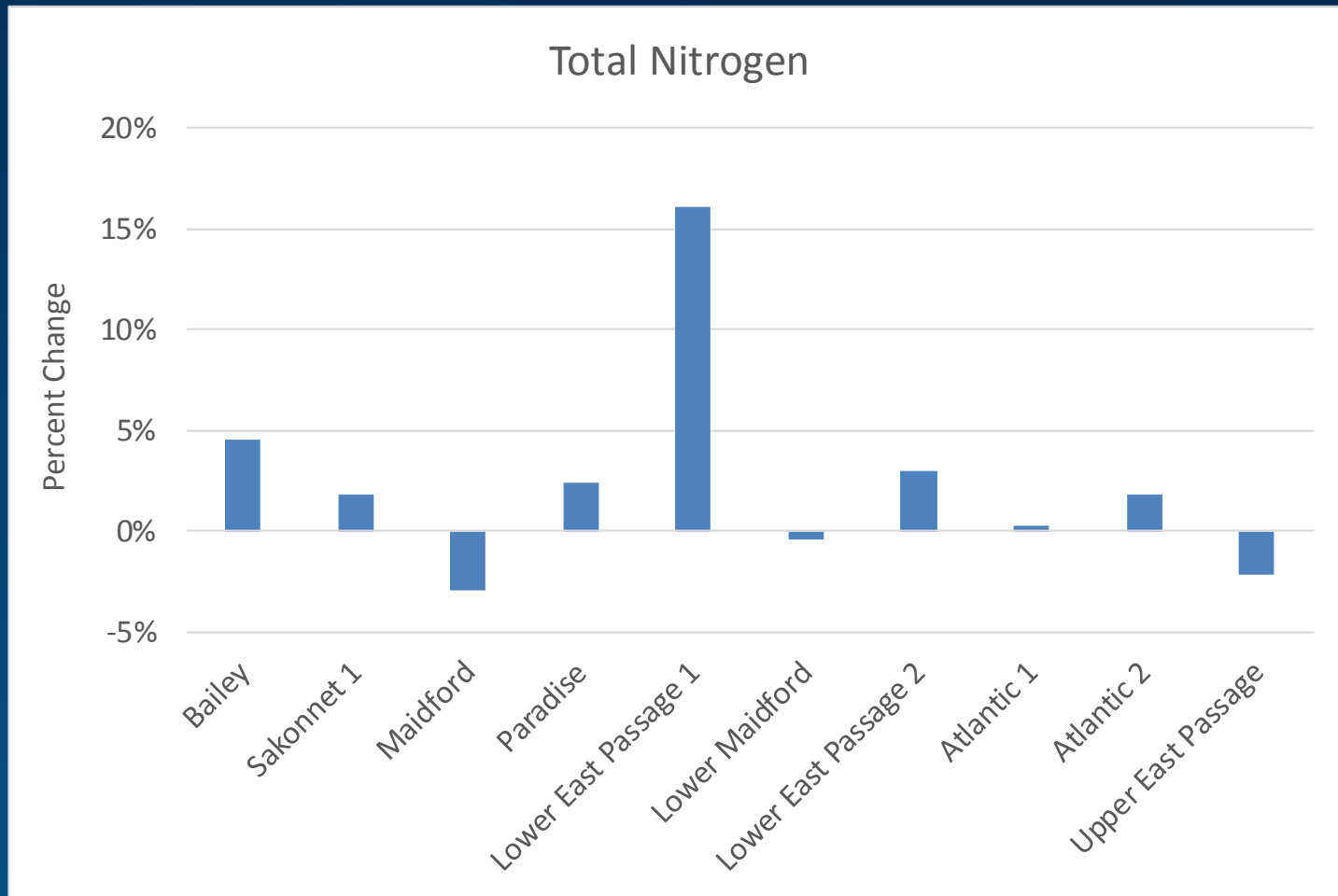
SURFACE WATER IMPACTS

Pollutant Loading Impacts



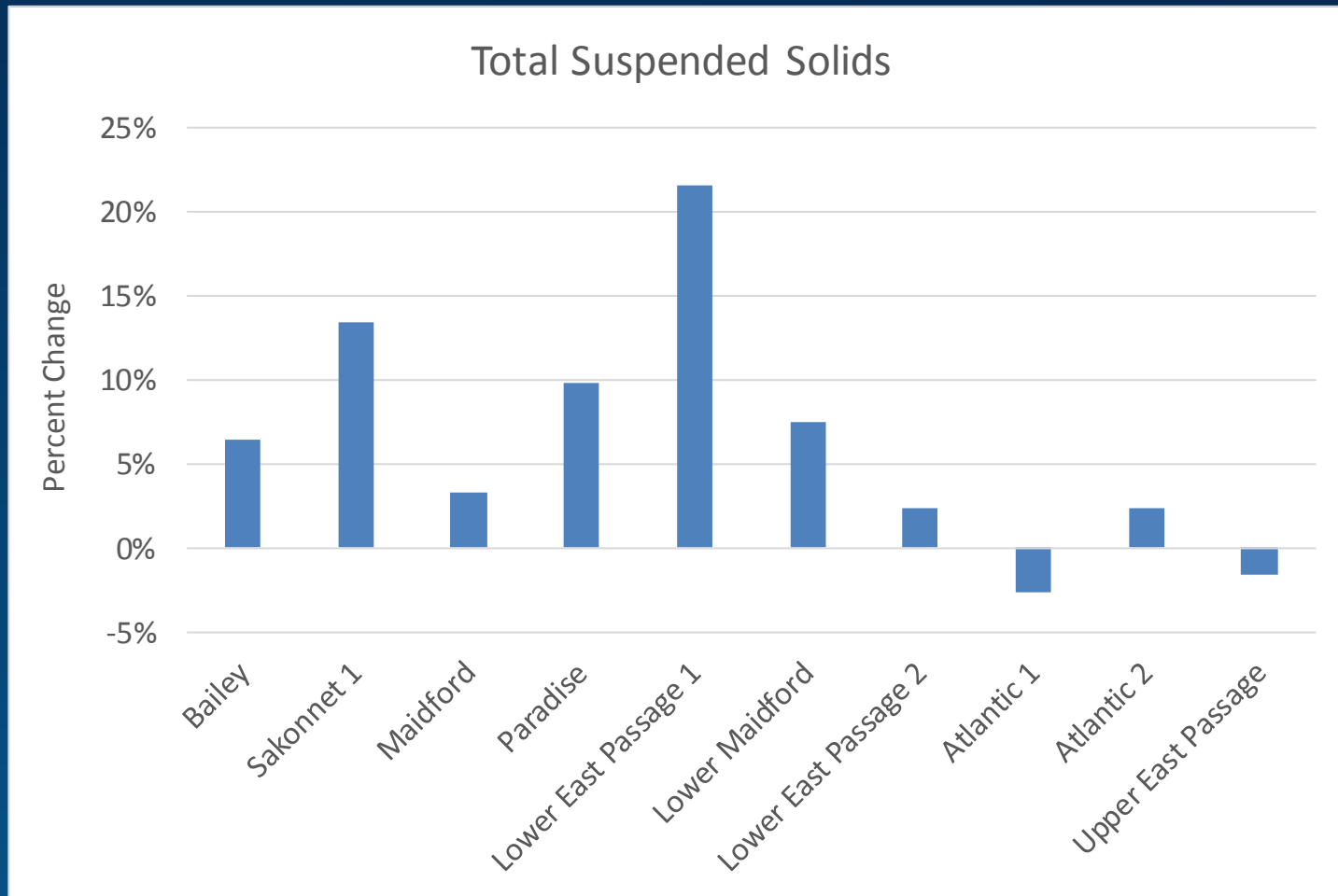
SURFACE WATER IMPACTS

Pollutant Loading Impacts



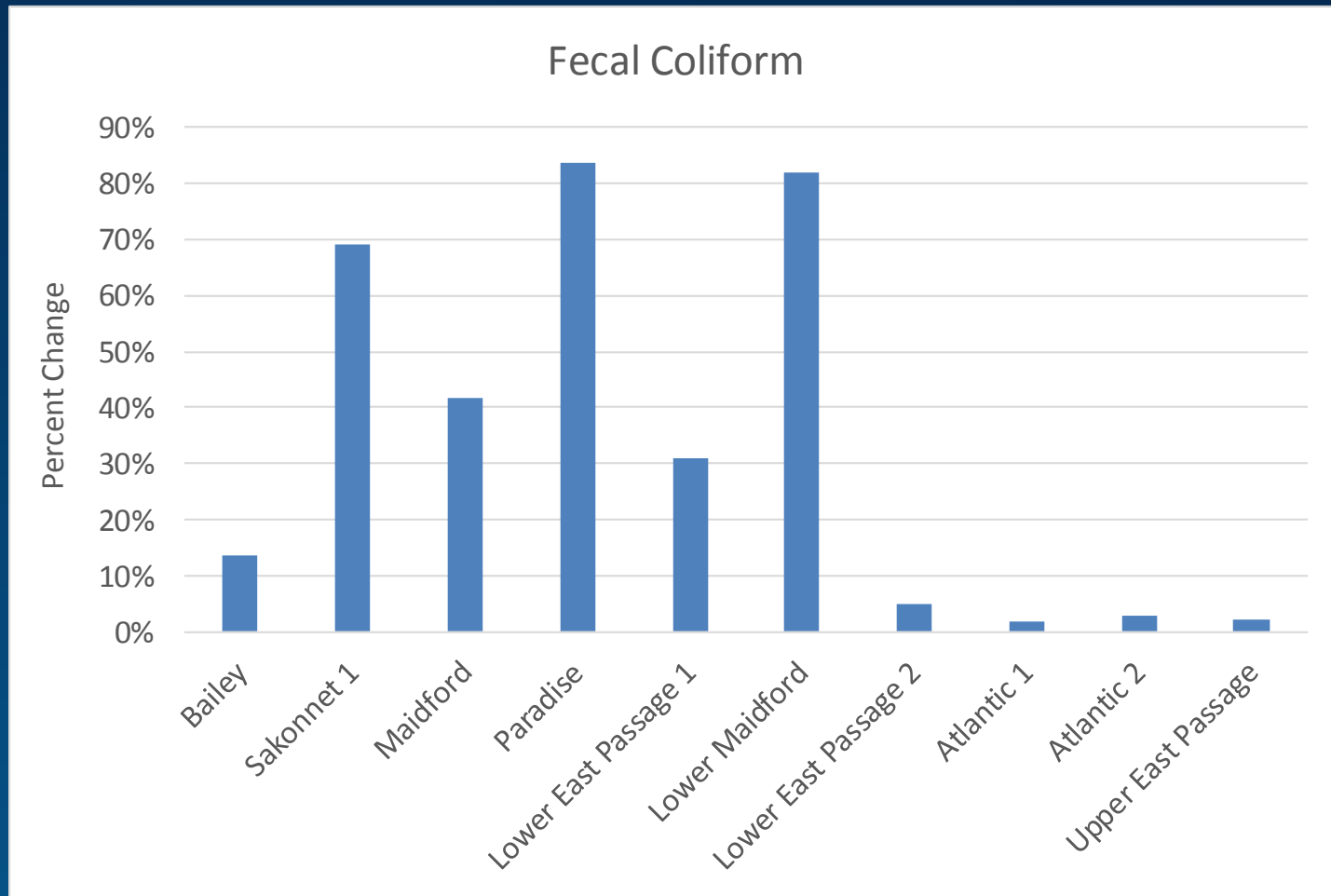
SURFACE WATER IMPACTS

Pollutant Loading Impacts



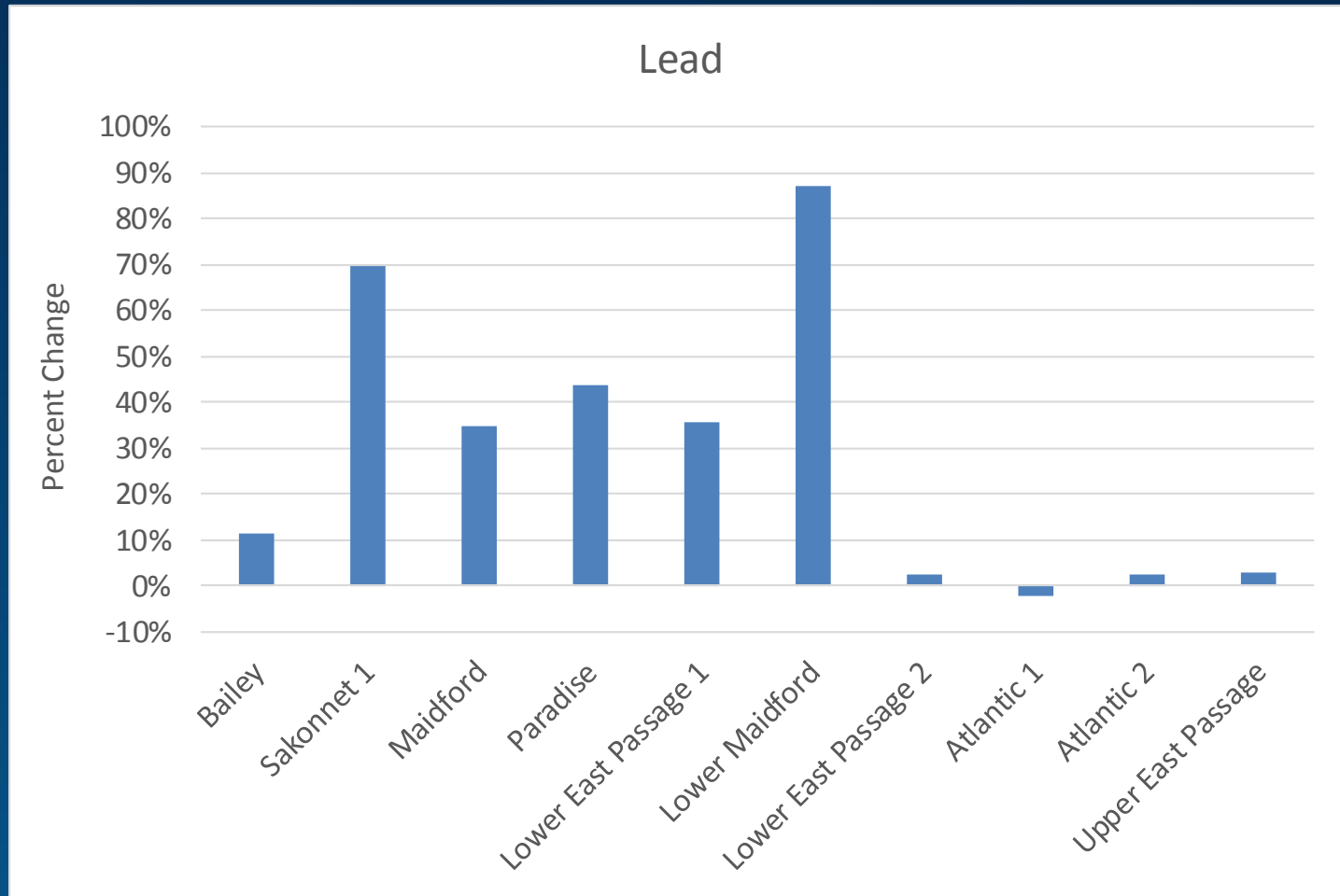
SURFACE WATER IMPACTS

Pollutant Loading Impacts



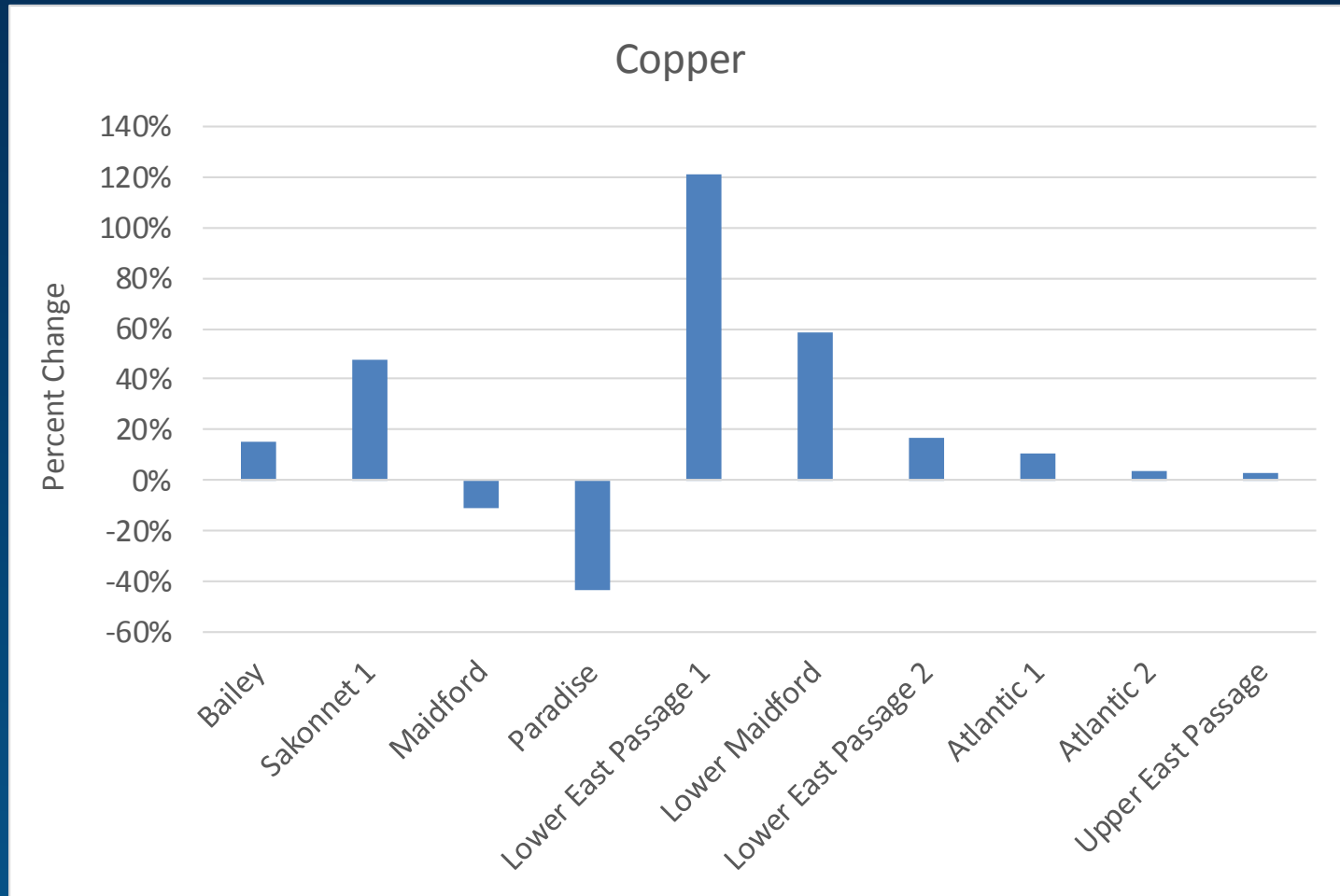
SURFACE WATER IMPACTS

Pollutant Loading Impacts



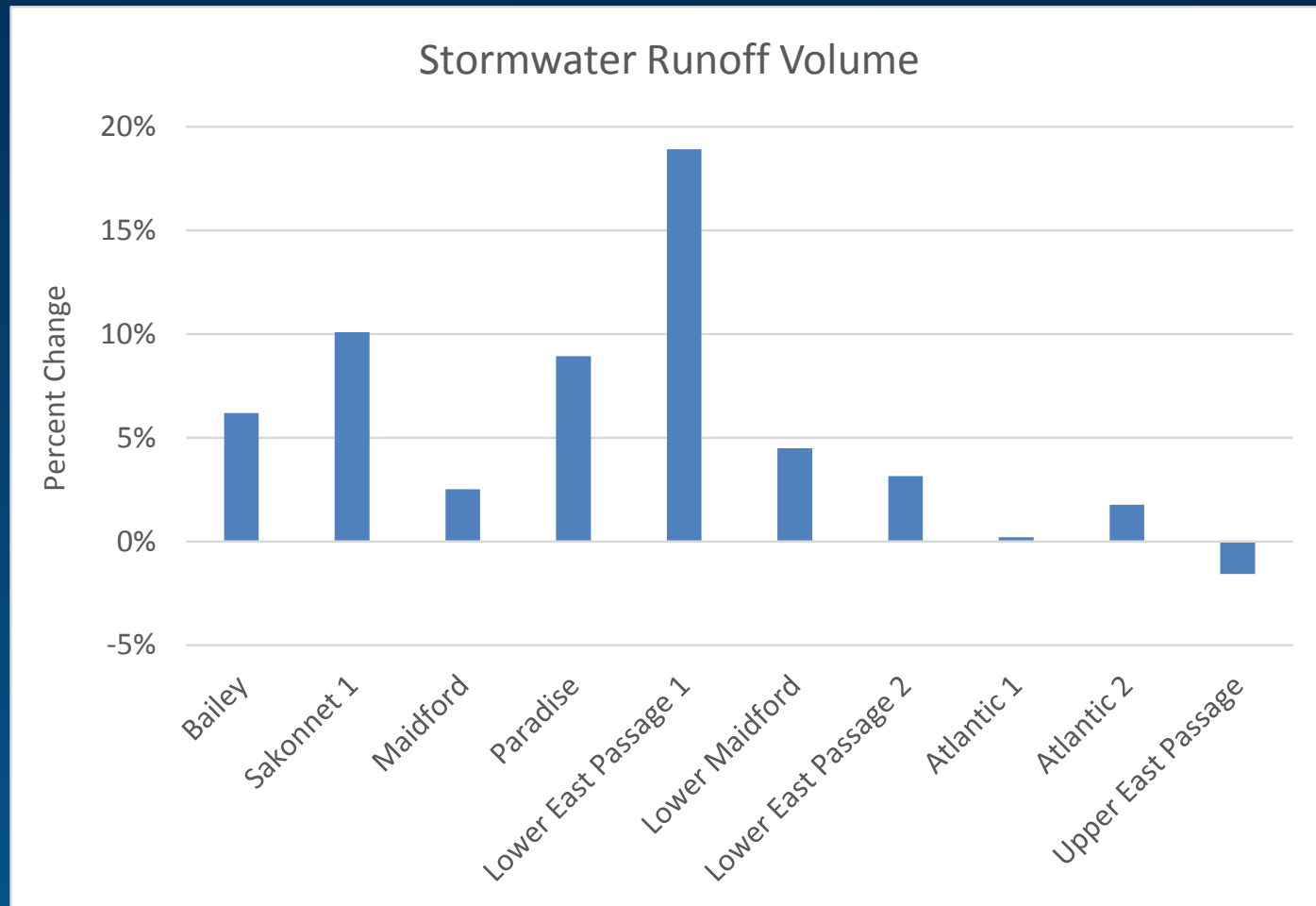
SURFACE WATER IMPACTS

Pollutant Loading Impacts



SURFACE WATER IMPACTS

Pollutant Loading Impacts – Change in Runoff



SURFACE WATER IMPACTS

Recommendations

1. Encourage low impact development (LID) development strategies
2. Update the Town Stormwater Ordinance to mitigate pollutants of concern for each watershed
3. Promote source reduction (stormwater recharge/infiltration) strategies for new development
4. Establish a Fertilizer Nutrient Control Ordinance
5. Establish routine water quality testing of Town stormwater systems. Identify and address contamination sources
6. Identify streams and waterways that experience erosion (sediment transport) for permanent stabilization projects
7. Retrofit existing stormwater systems
8. Expand public educational measures
9. Evaluate the feasibility of establishing a Town Stormwater Utility

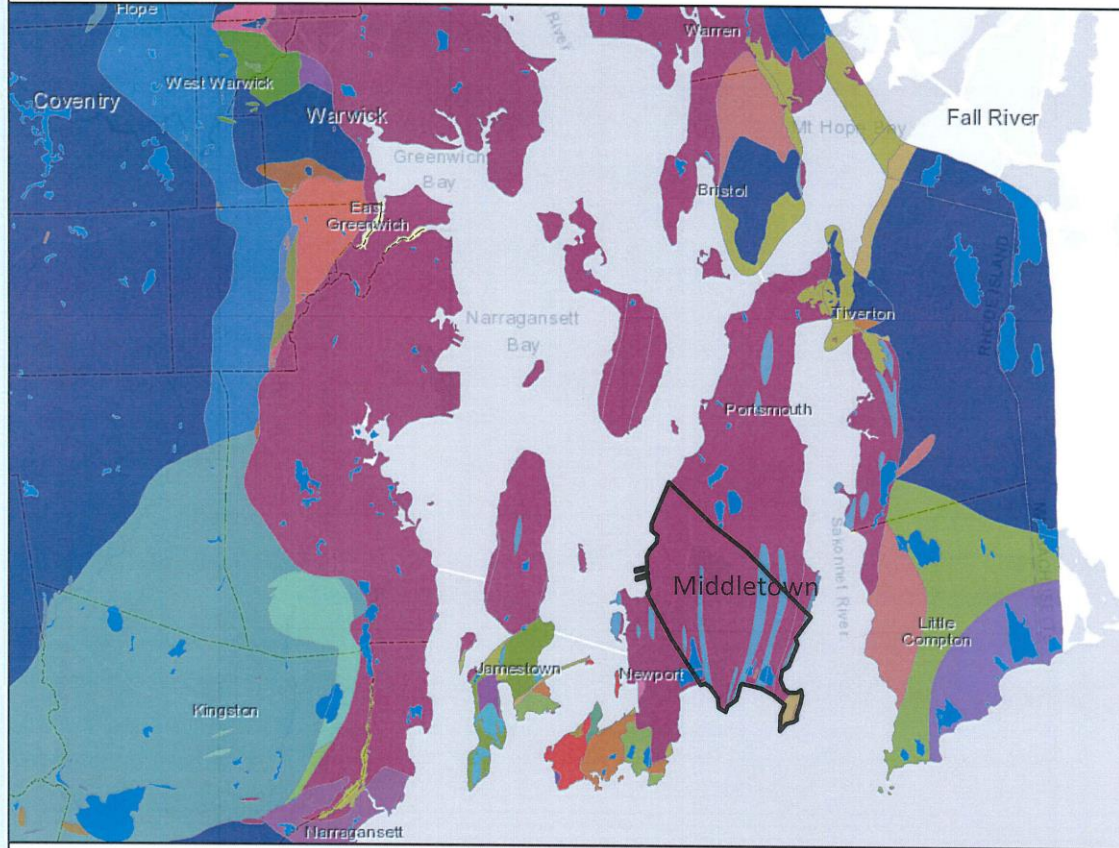
GROUNDWATER IMPACTS



GROUNDWATER RESOURCES

Figure 4.1 Bedrock Geology for eastern Rhode Island

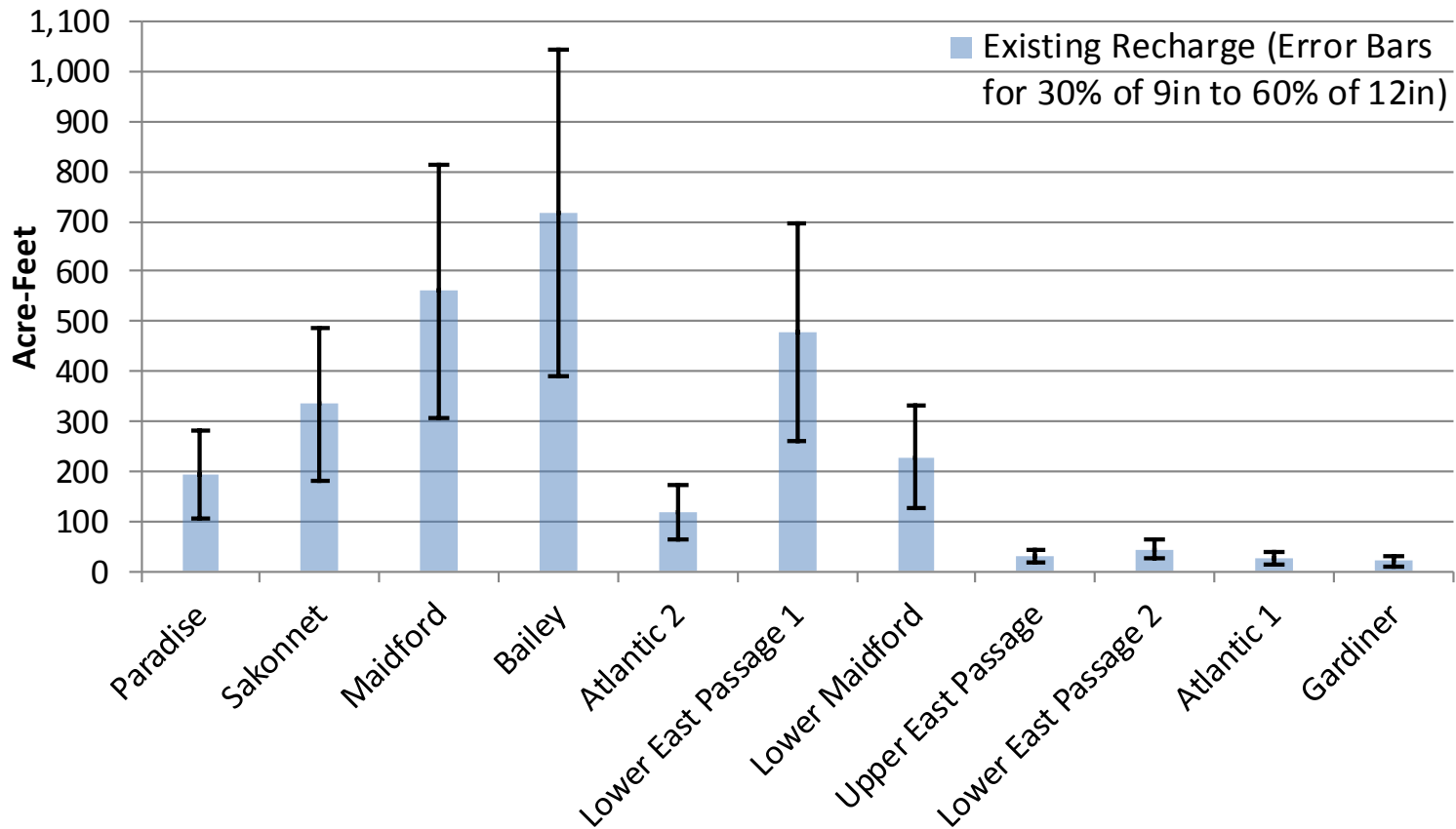
- RI Bedrock Geology (0)**
- Absalona Formation
 - Dedham Granite
 - Dighton Conglomerate
 - Dutch Island Harbor Formation
 - East Passage Formation
 - FRESH WATER
 - Fort Adams Formation
 - Hoppin Formation
 - Jamestown Formation
 - Jamestown Formation + Fort Burnside Formation
 - Mamacokie Formation
 - NO BEDROCK UNIT EXPOSED
 - Newport Neck Formation
 - Nipsachuck Formation
 - Pirate Cove Formation + Jamestown Formation
 - Plainfield Formation
 - Pondville Conglomerate
 - Price Neck Formation
 - Purgatory Conglomerate ←
 - Raritan Formation
 - Rhode Island formation ←
 - Rope Ferry Gneiss
 - SALT WATER
 - Sachseut Arkose
 - Wamsutta Formation
 - Woonasquatucket Formation
 - alkali-feldspar gneiss
 - alkali-feldspar granite of Cumberland
 - augen granite gneiss
 - cumberlandite
 - diabase
 - diorite/gabbro
 - epidote and biotite schist
 - felsic volcanoclastic rocks
 - fine-grained granite
 - gabbro/diorite
 - granite
 - granite gneiss
 - granodiorite
 - greenstone, amphibolite, serpentinite
 - leucocratic granite
 - mafic/intermediate gneiss
 - mafic/intermediate rock
 - metaclastic rock, undivided
 - mica schist
 - minette dike rocks
 - monchiquite
 - monzonite/monzodiorite
 - porphyritic granite
 - quartzite
 - rhyolite
 - undifferentiated rock
 - vein quartz
 - volcanoclastic rocks



1:288,895
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 Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user

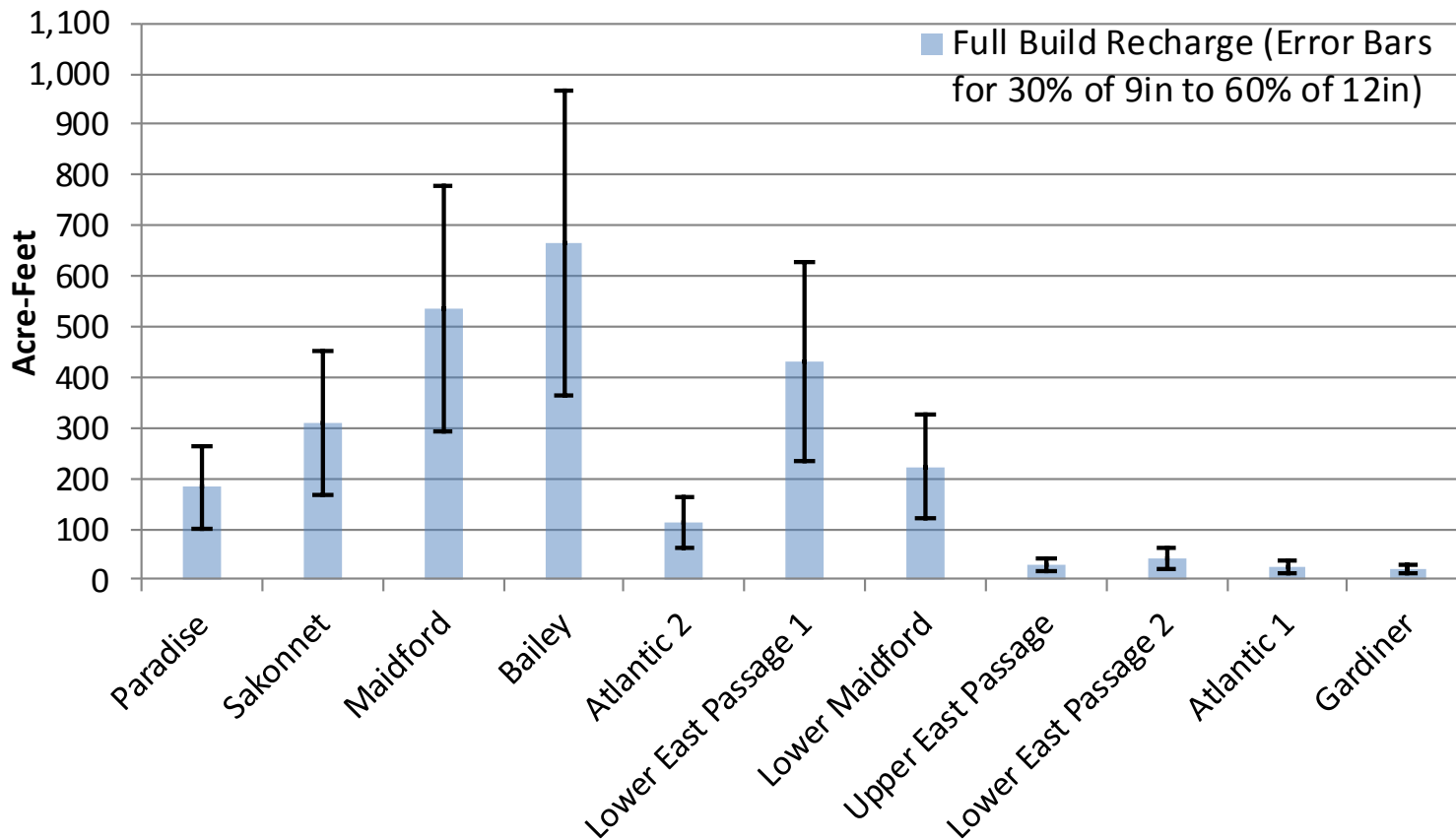
GROUNDWATER RESOURCES

Bedrock Annual Recharge (Existing)

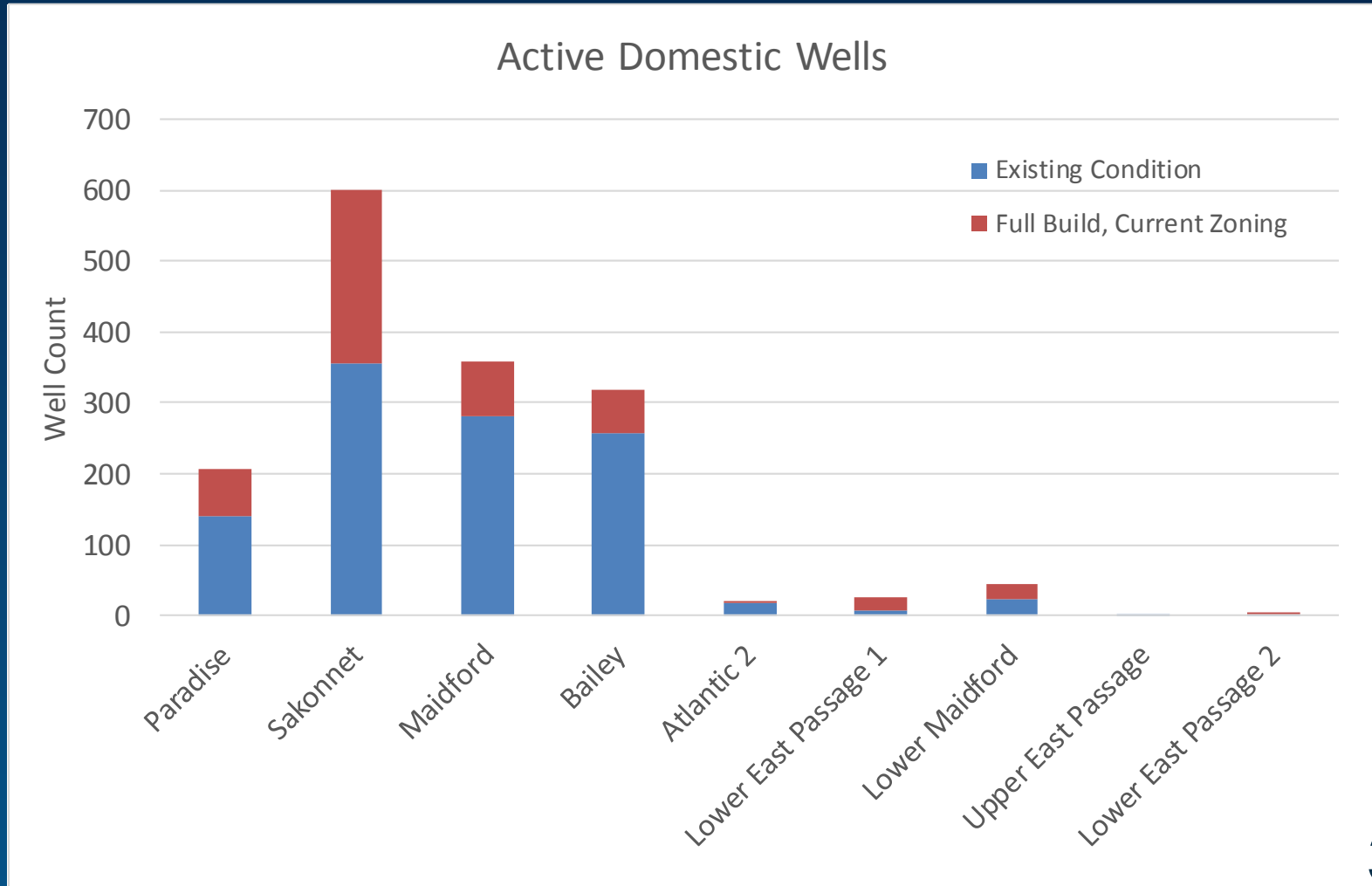


GROUNDWATER IMPACTS

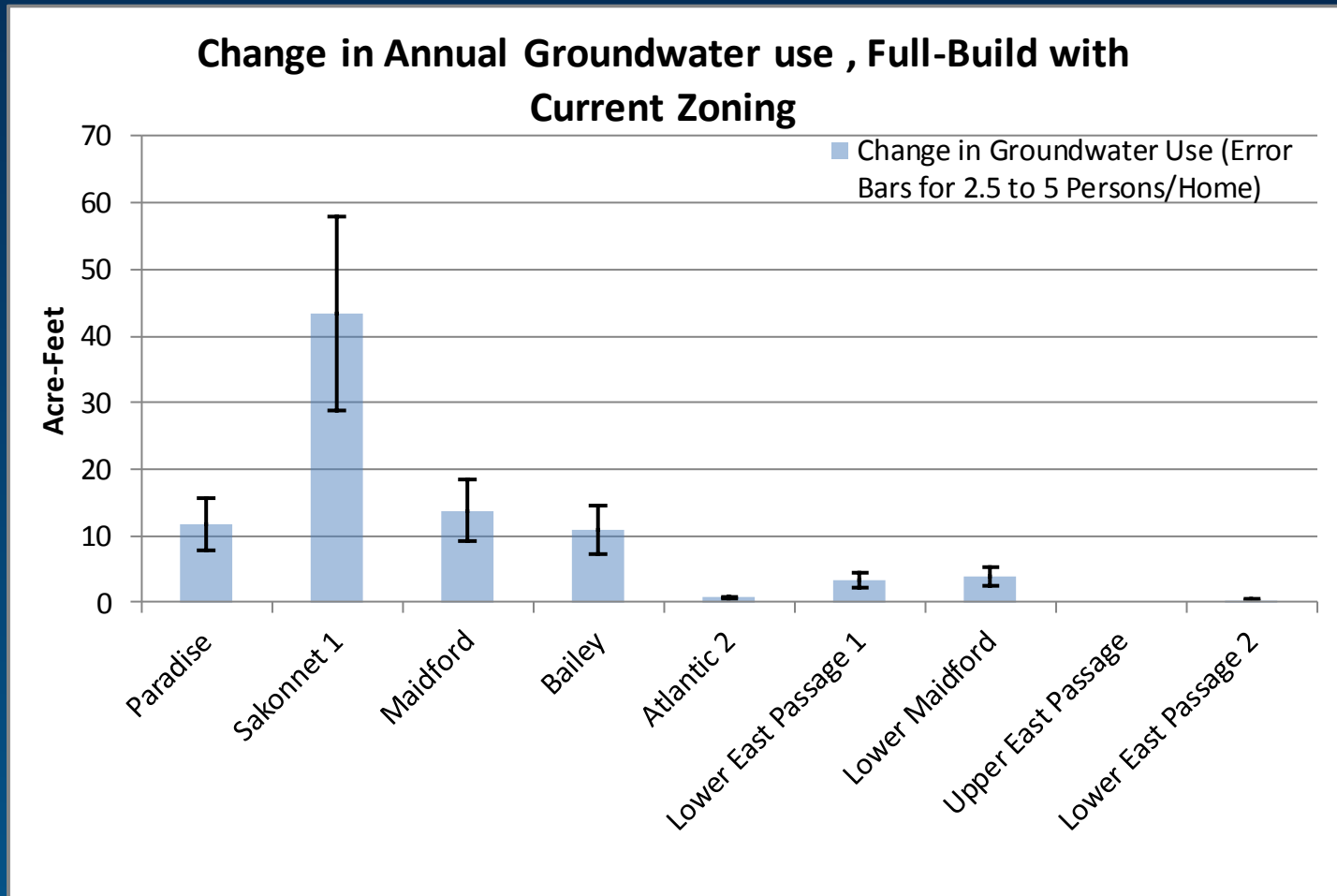
Bedrock Annual Recharge (Full-Build, Current Zoning)



GROUNDWATER IMPACTS



GROUNDWATER IMPACTS



GROUNDWATER IMPACTS

Groundwater Budget

Future estimated recharge 1,400 to 3,740 acre-feet

Future estimated domestic well water use 190 to 370 acre-feet

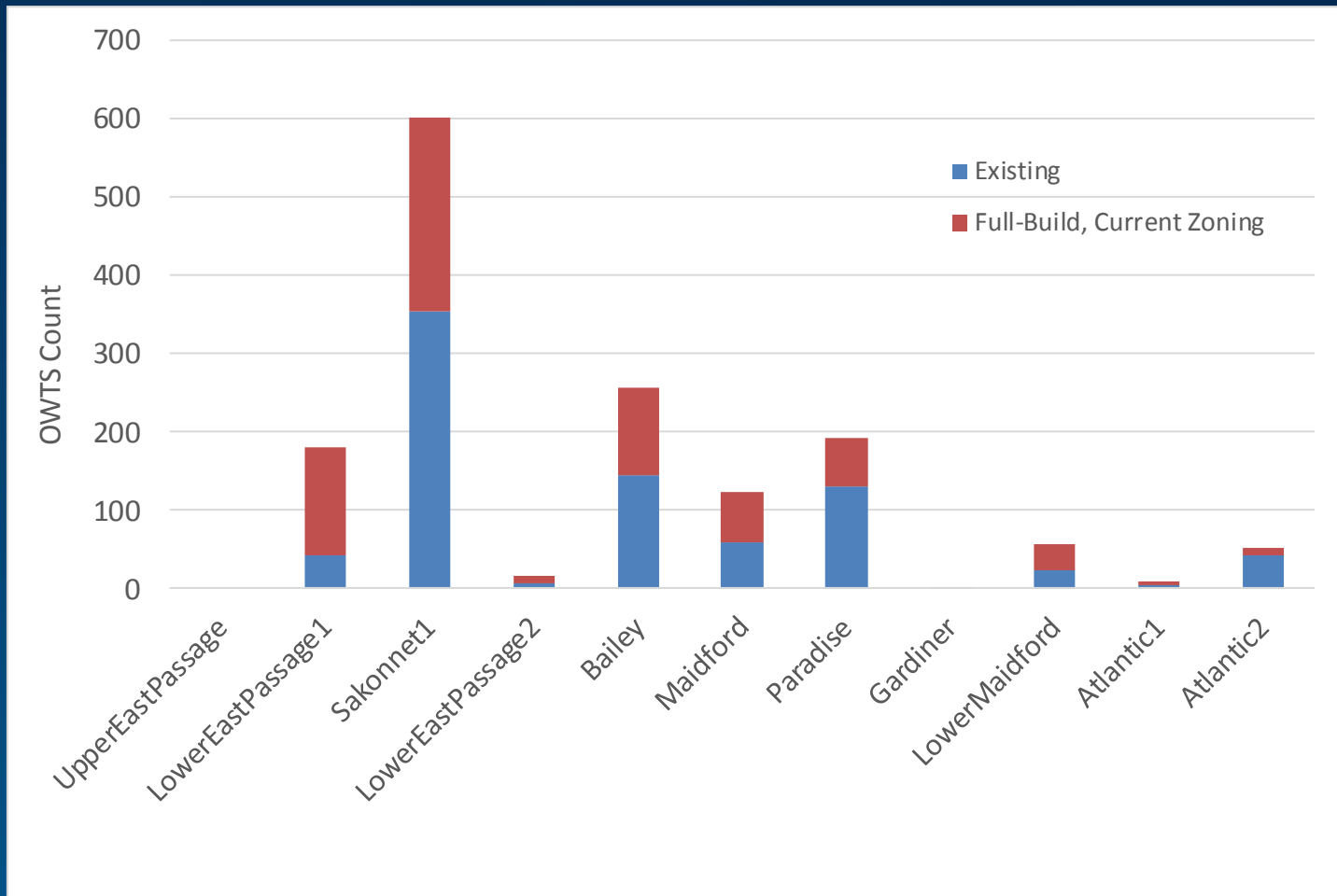
Note: Not all recharge is available due to fissure network.

*Excludes Irrigation and other non-domestic water uses

*Seasonal variability in water table may create temporal shortfalls in water supply

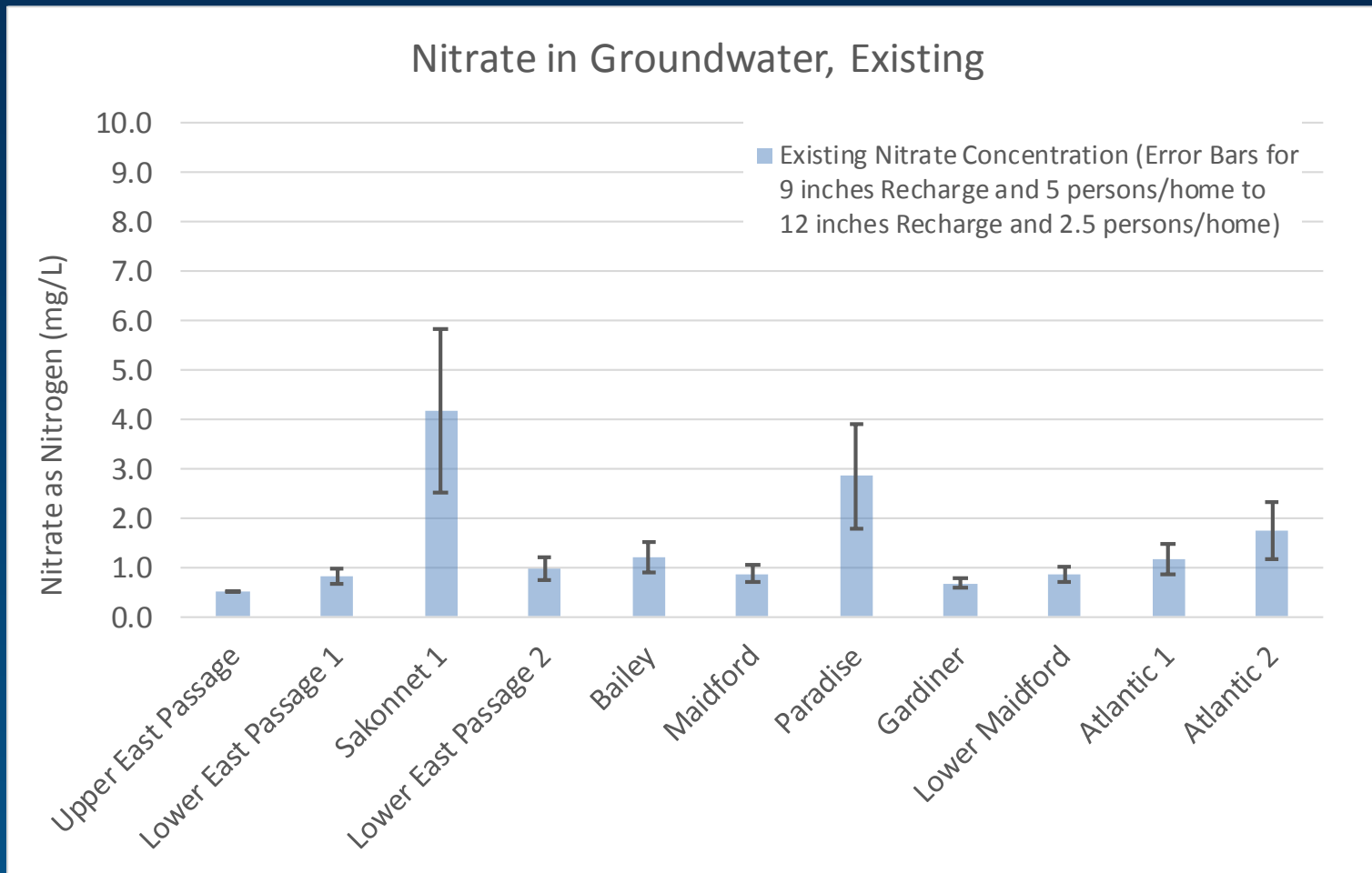
GROUNDWATER IMPACTS

Groundwater Quality – On-site Wastewater Treatment Systems



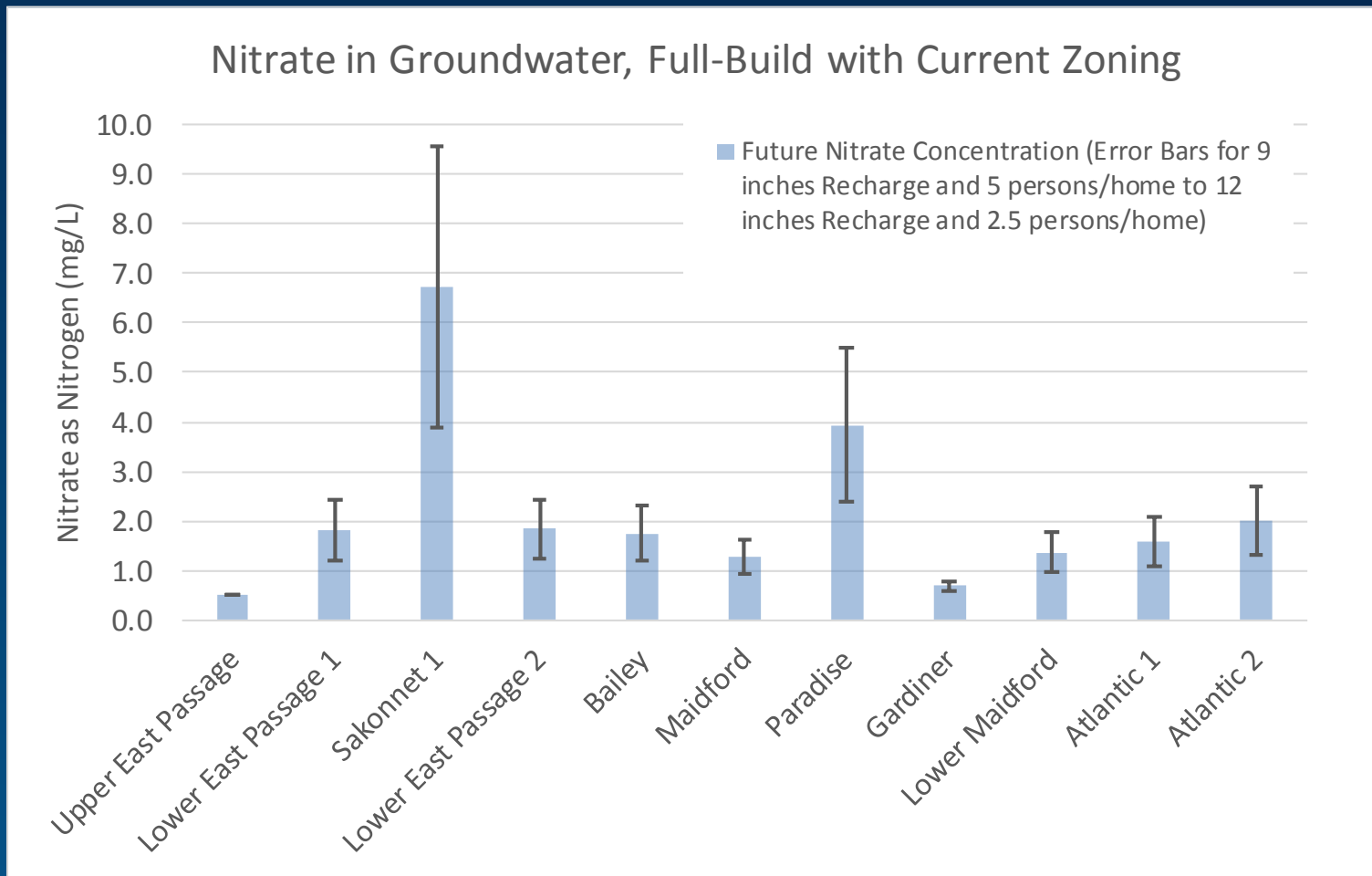
GROUNDWATER IMPACTS

Groundwater Quality



GROUNDWATER IMPACTS

Groundwater Quality



GROUNDWATER IMPACTS

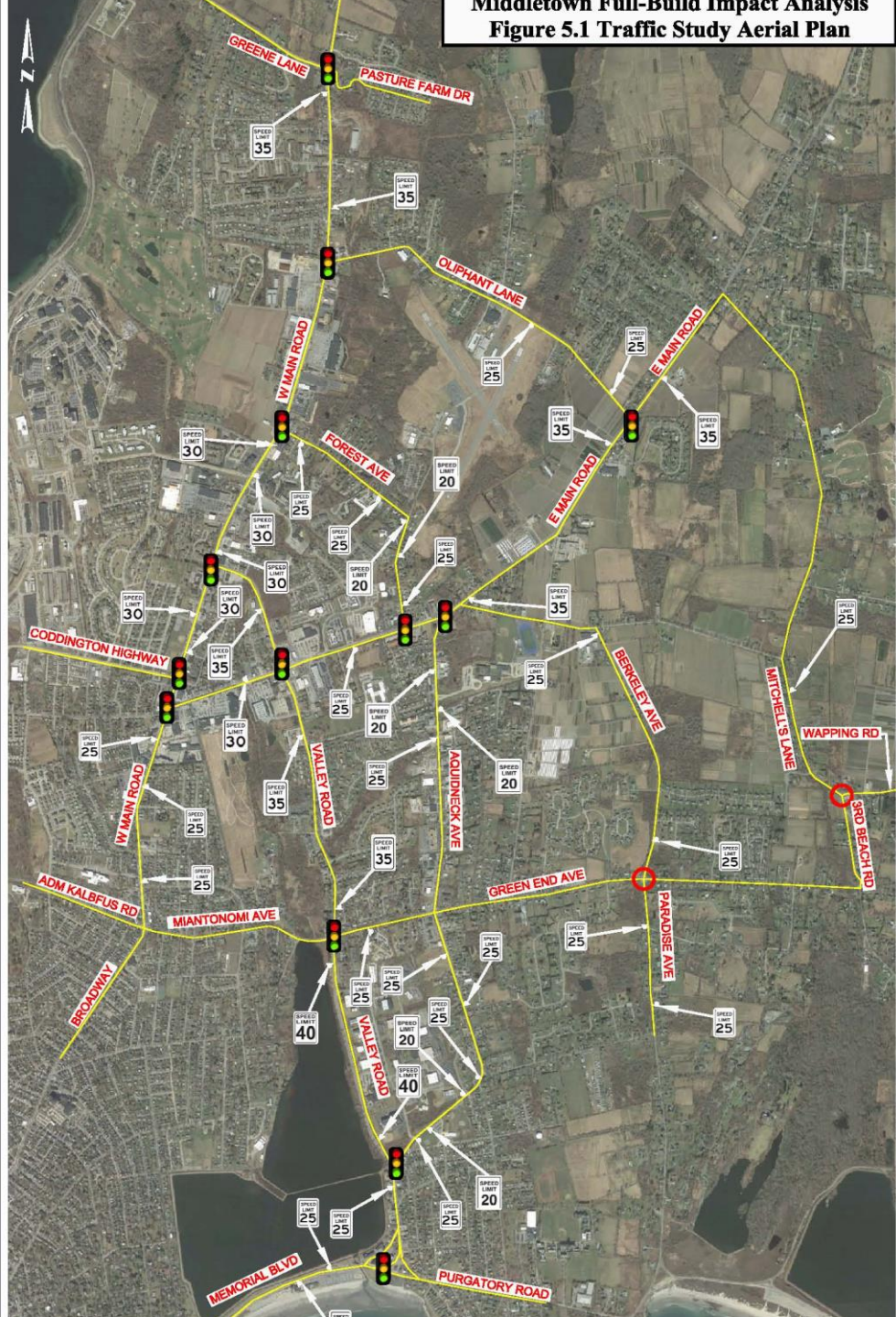
Recommendations

1. Minimize the granting of waivers to the Town's Stormwater Standards
2. Recharge standard, used in calculating the conceptual water budget, should be revised to address climate change
3. The Recharge Standard should be revised to address diminished performance of systems over time
4. Consider the installation of a series of groundwater monitoring wells throughout the Town to monitor groundwater levels, quality and trends.
5. Survey homes with on-site wells to collect well data and identify supply issues
6. Encourage testing of private wells by homeowners and retain data in a Town database for future groundwater evaluations
7. Develop an OWTS educational program for residents to ensure proper maintenance
8. Consider enacting an Onsite Wastewater Management Ordinance
9. Evaluate minimum lot size and other dimensional requirements for new parcels with OWTS and/or wells based upon number of bedrooms, water use, soil conditions and daily sanitary flow rate, particularly in conservation style developments
10. Perform town-wide groundwater quality testing to document conditions and needs for public water extensions
11. Review historical records of OWTS failures or need for repair to assess future needs for public sewer extensions

TRAFFIC IMPACTS



Middletown Full-Build Impact Analysis
Figure 5.1 Traffic Study Aerial Plan

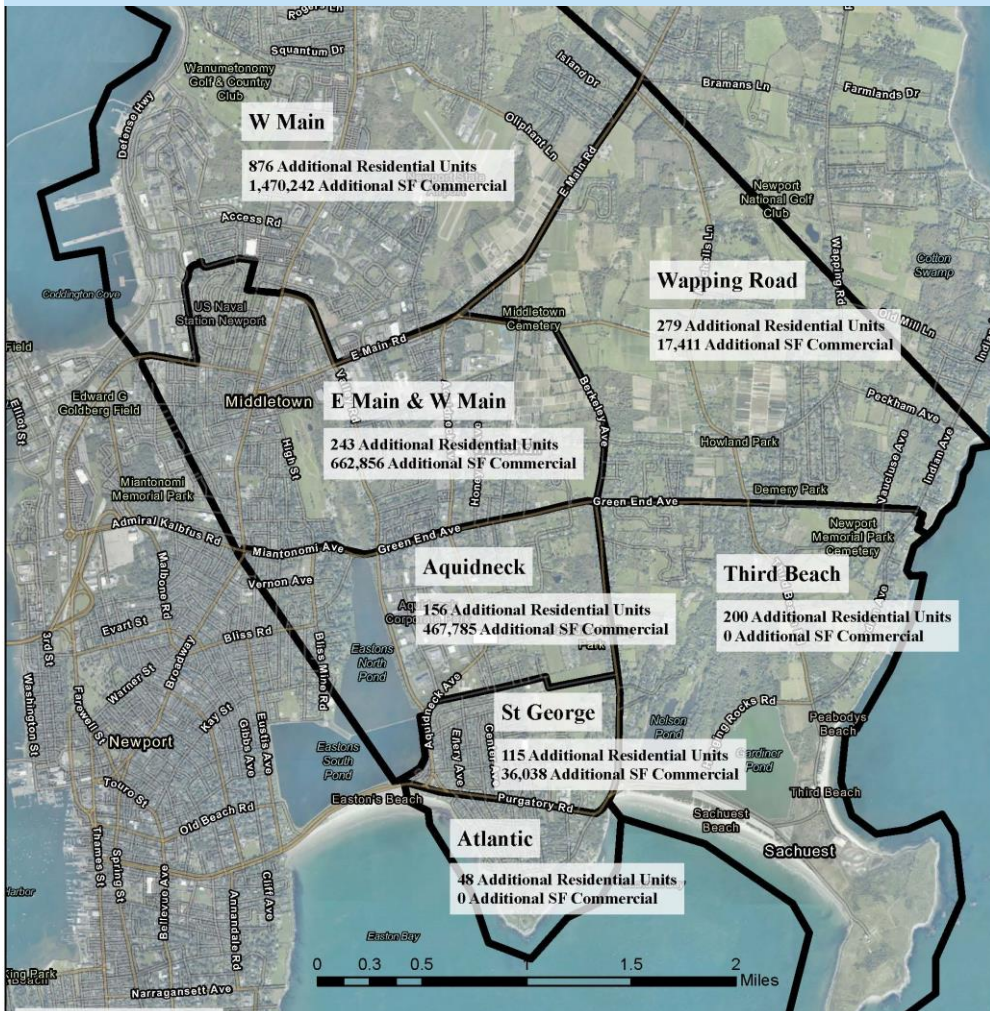


EXISTING CONDITIONS

- Study area includes 15 intersections determined to be most impacted by full build-out development
- Weekday am & pm peak hour turning movement counts collected at each intersection from 7-9 am and 4-6 pm in June 2019
- Weekday am & pm peak hours analyzed: 8-9 am and 4:15-5:15 pm

Middletown Full-Build Impact Analysis
Figure 5.2a Build-Out per Traffic Areas,
Full-Build with Current Zoning

	W Main	E.Main/ W.Main	Aquidneck	St George	Wapping	Third Beach	Atlantic	Total
Residential (# of units)	452	186	156	115	279	200	48	1436
Industrial	406,241	0	0	0	0	0	0	406,241
Mixed Use	1,210,142	161,577	0	0	0	0	0	1,371,719
Office Park	0	0	378,220	0	0	0	0	378,220
Office/ Business	76,784	69,786	0	0	0	0	0	146,570
Retail	200,625	488,045	89,565	36,038	17,411	0	0	831,684



THE PROPOSED FULL BUILD-OUT CONSISTS OF THE FOLLOWING DEVELOPMENTS:

- 1,436 UNITS - RESIDENTIAL (SINGLE-UNIT HOUSES) UNITS
- 406,241 SF - INDUSTRIAL
- 1,371,719 SF - MIXED USE
- 378,220 SF - OFFICE PARK
- 146,570 SF - OFFICE SPACE
- 831,684 SF – RETAIL

PROPOSED TRIP GENERATION

Peak hour vehicle trip generation estimates for the proposed development were calculated using ITE trip generation.

Estimated trip generation for the additional development:

	AM PEAK HOUR TRIPS*			PM PEAK HOUR TRIPS*		
	TOTAL	ENTERING	EXITING	TOTAL	ENTERING	EXITING
RESIDENTIAL	1,063	266	797	1,422	896	526
INDUSTRIAL	164	133	31	164	34	130
MIXED USE	1,102	624	478	2,516	1,081	1,435
OFFICE PARK	152	123	29	152	32	120
OFFICE / BUSINESS	172	148	24	170	27	143
RETAIL	782	485	297	3,169	1,521	1,648
TOTAL TRIPS	3,435	1,779	1,656	7,593	3,591	4,002

*IT SHOULD BE NOTED THAT NOT ALL TRIPS GENERATED WILL BE DISTRIBUTED ALONG THE STUDY AREA STREETS ANALYZED FOR CAPACITY

PROPOSED TRIP DISTRIBUTION / ROUTE ASSIGNMENT

Middletown



Number of working residents aged 16+: 7,999
 Percentage of residents who work in hometown: 35.6%
 Number of workers aged 16+: 11,207
 Percentage of workers who live in hometown: 25.4%
 Number of households: 6,832
 Median household income: \$65,799
 Number of families: 4,412
 Median family income: \$81,628
 Annual unemployment rate: 3.9%
 Percentage of residents aged 25+ with HS diploma/equivalency or higher: 92.3%
 Percentage of residents aged 25+ with Bachelors degree or higher: 41.4%

Where Middletown Residents Work

	Total	7,999	100.0%
Newport, RI	3,194	39.9%	
Middletown, RI	2,844	35.6%	
Portsmouth, RI	353	4.4%	
Providence, RI	196	2.5%	
North Kingstown, RI	115	1.4%	
South Kingstown, RI	108	1.4%	
Bristol, RI	99	1.2%	
Warwick, RI	68	0.9%	
Fall River, MA	57	0.7%	
Exeter, RI	56	0.7%	
Pawtucket, RI	52	0.7%	
Tiverton, RI	48	0.6%	
Jamestown, RI	46	0.6%	
Cranston, RI	43	0.5%	
East Greenwich, RI	42	0.5%	
Dartmouth, MA	35	0.4%	
East Providence, RI	32	0.4%	
Sandwich, MA	32	0.4%	
Westerly, RI	32	0.4%	
West Milwaukee, WI	30	0.4%	
Other Communities	517	6.5%	

Middletown Residents Work in the State of:

	Total	7,999	100.0%
Rhode Island	7,445	93.1%	
Massachusetts	385	4.8%	
Connecticut	14	0.2%	
Other State/Country	155	1.9%	
Total	7,999	100.0%	

Where Middletown Workers Live

	Total	11,207	100.0%
Middletown, RI	2,844	25.4%	
Newport, RI	1,565	14.0%	
Portsmouth, RI	1,552	13.8%	
Tiverton, RI	743	6.6%	
Bristol, RI	604	5.4%	
Fall River, MA	557	5.0%	
North Kingstown, RI	397	3.5%	
Warwick, RI	249	2.2%	
South Kingstown, RI	217	1.9%	
Cranston, RI	181	1.6%	
Warren, RI	175	1.6%	
Jamestown, RI	159	1.4%	
Johnston, RI	134	1.2%	
Narragansett, RI	133	1.2%	
Dartmouth, MA	118	1.1%	
Exeter, RI	115	1.0%	
Providence, RI	106	0.9%	
East Providence, RI	74	0.7%	
North Attleborough, MA	69	0.6%	
New Bedford, MA	63	0.6%	
Other Communities	1,152	10.3%	

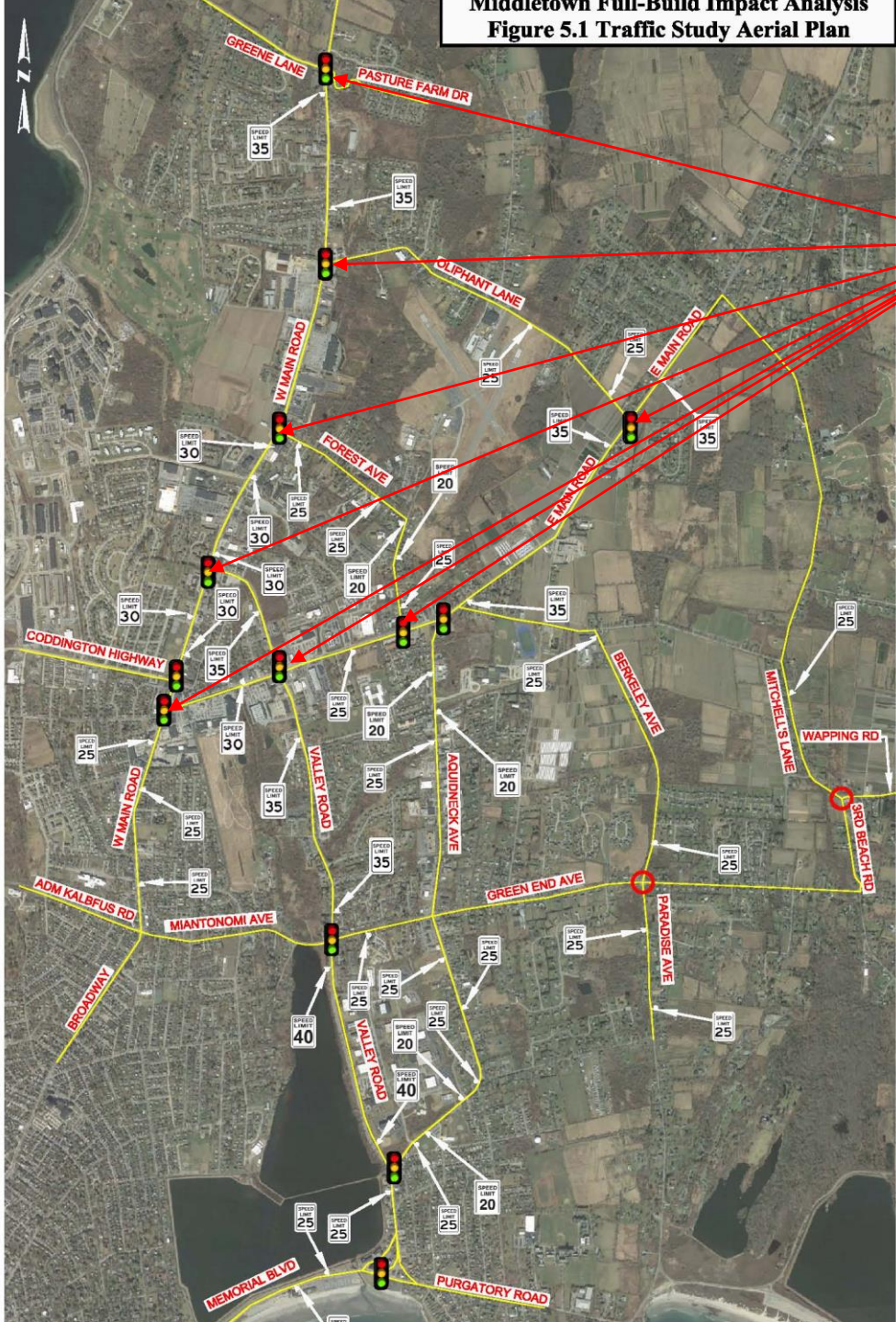
Middletown Workers Live in the State of:

	Total	11,207	100.0%
Rhode Island	9,821	87.6%	
Massachusetts	1,133	10.1%	
Connecticut	182	1.6%	
Other State/Country	71	0.6%	
Total	11,207	100.0%	

The proposed distribution of site generated traffic is based on:

- EXISTING TRAFFIC PATTERNS
- CENSUS DATA FROM 2011-2015
 - WHERE MIDDLETOWN RESIDENTS WORK – FOR RESIDENTIAL & RETAIL
 - WHERE MIDDLETOWN WORKERS LIVE – FOR OFFICE, BUSINESS & INDUSTRIAL

Middletown Full-Build Impact Analysis
Figure 5.1 Traffic Study Aerial Plan



RECOMMENDATIONS

1. Optimizing the signal timings will provide some level of improvement but more significant mitigations will be needed in the future to improve capacity such as change in signal phasing, re-striping, road widening and conversion to roundabout:

- WEST MAIN RD / GREENE LN / PASTURE FARM DR
- WEST MAIN RD / OLIPHANT LN
- WEST MAIN RD / FOREST AVE
- WEST MAIN RD / VALLEY RD
- WEST MAIN RD / EAST MAIN RD
- EAST MAIN RD / OLIPHANT LN
- EAST MAIN RD / FOREST AVE / RAMADA DRIVE
- EAST MAIN RD / VALLEY RD

TRAFFIC RECOMMENDATIONS

2. Rockwood Rd (32' to 23.5' wide) could possibly be re-stripped with 11' travel lanes and minimal shoulder to provide a left/thru and thru/right lane for a short distance to commercial driveway curb cut. This may provide some delay and queue improvement.
3. Slightly extend the striping for the right lane turn pocket on Aquidneck Ave at east main rd. Since the Aquidneck Ave NB LT/thru lane carries a small amount of traffic compared to the right lane, re-striping the left/thru as a left/thru/right general use lane may improve capacity for this approach.
4. For Green End Ave at Valley Rd, it appears that using the dedicated eastbound right turn lane as a right/thru lane may provide some improvement to capacity eastbound.
5. There are already plans to reconstruct the signalized intersection of Aquidneck Ave/Valley Road to a single lane roundabout. Analysis shows that the proposed roundabout will provide much improved los for the future full buildout conditions.
6. In the future the town may want to analyze and consider the option of a roundabout to replace the signal at Aquidneck Ave/Purgatory Road/Memorial Blvd.
7. For future mitigation, a proposed roundabout should be considered at Green End Ave/Berkeley Ave/Paradise Ave. Analysis shows that the intersection would function very well as a roundabout.
8. The LOS at Third Beach Road/Mitchell's Lane/Wapping Road remains very good for future conditions. Should traffic conditions change, the town may want to consider the option of a roundabout in the future.

SUMMARY OF FINDINGS



FINDINGS - BUILDOUT

- Full buildout for undeveloped, underdeveloped, and redeveloped lots, results in 1,916 new residences, and 2.6 million square feet of new commercial space (including mixed use developments).
- Possible strategies to reduce the impacts of full buildout include:
 - Limit development of marginal lots
 - Rezone R-40 & R-60 to R-100
 - Prohibit development in Watershed Protection District Zone 1 areas

FINDINGS – SURFACE WATER

- Current surface water is already considered impaired, and will continue to degrade without remediation even if no further development occurs.
- Buildout of any amount will worsen the current impairment in most watersheds, with impacts differing in both amount and polluting constituents.
- In areas currently dominated by undeveloped agricultural land, buildout is expected to improve the impairment situation by eliminating this major source of pollutants.
- The recommended strategies to reduce impacts of full buildout introduce mostly small, though in some cases significant, improvements.

FINDINGS- GROUNDWATER

- Groundwater environment characterized by a layer of soil over bedrock, with most wells relying on bedrock water.
- Groundwater recharge, including bedrock recharge, is significantly greater than water usage even with full buildout.
- The biggest factors for a successful well are access to bedrock fissures and depth of well.
- Wells should be drilled to a depth of 500 ft; much shallower wells are susceptible to going dry during low rainfall seasons, with or without buildout.

FINDINGS- TRAFFIC

- Traffic volumes on the west side of town are problematic even before any further development.
- Full buildout noticeably worsens traffic on the west side of town, and introduces some problem areas on the east side of town.
- The recommended strategies to reduce impacts of full buildout introduce mostly small improvements:
 - Timing of traffic signals
 - Widening certain lanes or roadways
 - Adding/lengthening turning lanes and introducing signals
 - Installing roundabouts at certain intersections.

NEXT STEPS

- ▶ Presentation to Town Council
- ▶ PB Subcommittee to prioritize recommendations
- ▶ Identify specific policies and actions based on recommendations
- ▶ Report back to the Town Council
- ▶ Incorporate policies and actions into Comp Plan, regulations, and project priorities

Appendix:

Intersection Level of Service Data

Table 5.8A- Signalized Level-Of-Service Analysis Summary

Location	Movement	2019 Existing			Build			Build Alternative		
		v/c	Delay	LOS	v/c	Delay	LOS	v/c	Delay	LOS
AM PEAK HOUR										
W. Main Rd / Greene Ln / Pasture Farm Dr	OVERALL	0.56	17.5	B	0.84	54.9	D	0.79	42.3	D
Greene Ln	EB	0.10	38.5	D	0.20	38.3	D	0.18	38.3	D
Pasture Farm Dr	WB	0.49	41.9	D	0.52	42.1	D	0.52	42.1	D
W. Main Rd (RI 114)	NE	0.29	3.6	A	0.52	22.4	C	0.48	20.2	C
W. Main Rd (RI 114)	SE	0.74	23.3	C	1.10	78.6	E	1.04	57.5	E
W. Main Rd / Oliphant Ln	OVERALL	0.70	15.7	B	1.07	92.7	F	0.99	64.1	E
Oliphant Ln	WB	0.68	29.8	C	0.75	42.1	D	0.74	42.1	D
W. Main Rd (RI 114)	NE	0.61	16.4	B	1.03	68.4	E	0.97	49.2	D
W. Main Rd (RI 114)	SE	0.70	13.3	B	1.17	117.2	F	1.07	77.6	E
W. Main Rd / Forest Ave	OVERALL	0.82	20.1	C	1.23	121.2	F	1.15	96.6	F
Forest Ave	WB	0.74	44.9	D	0.83	50.5	D	0.82	48.9	D
W. Main Rd (RI 114)	NE	0.58	16.4	B	0.88	31.9	C	0.83	29.8	C
W. Main Rd (RI 114)	SE	0.84	18.1	B	1.35	191.5	F	1.26	148.0	F
W. Main Rd / Valley Rd	OVERALL	0.65	13.0	B	1.05	28.6	C	0.99	22.7	C
Valley Rd	WB	0.52	19.4	B	0.83	30.2	C	0.78	26.6	C
W. Main Rd (RI 114)	NE	0.67	20.8	C	0.96	40.1	D	0.91	33.2	C
W. Main Rd (RI 114)	SE	0.64	5.4	A	1.08	19.7	B	1.02	13.8	B
W. Main Rd / Coddington Hwy	OVERALL	0.51	28.2	C	0.65	31.8	C	0.63	30.3	C
Coddington Hwy	EB	0.70	43.7	D	0.86	49.1	D	0.83	47.2	D
Rockwood Rd	WB	0.25	56.1	E	0.25	56.1	E	0.25	56.1	E
W. Main Rd (RI 114)	NE	0.61	26.3	C	0.62	28.4	C	0.62	25.9	C
W. Main Rd (RI 114)	SE	0.41	18.9	B	0.58	23.1	C	0.55	22.3	C
W. Main Rd / E. Main Rd	OVERALL	0.63	34.1	C	0.82	43.0	D	0.78	38.8	D
E. Main Rd	EB	0.57	55.7	E	0.57	55.7	E	0.57	55.7	E
E. Main Rd (RI 138)	WB	0.70	49.4	D	0.66	43.8	D	0.66	44.7	D
W. Main Rd (RI 114)	NE	0.59	28.1	C	0.96	54.4	D	0.89	44.2	D
W. Main Rd (RI 114)	SE	0.72	25.9	C	0.82	25.0	C	0.81	24.3	C
E. Main Rd / Oliphant Ln	OVERALL	0.79	26.6	C	1.01	111.2	F	0.97	91.8	F
E. Main Rd (RI 138)	NE	0.50	6.3	A	0.61	8.9	A	0.59	8.4	A
E. Main Rd (RI 138)	SE	0.98	35.3	D	1.33	176.9	F	1.26	144.1	F
Oliphant Ln	SE	0.42	29.0	C	0.74	37.8	D	0.69	34.5	C
Hotel Driveway	NW	0.04	26.6	C	0.04	24.1	C	0.04	24.6	C
E. Main Rd / Aquidneck Ave	OVERALL	0.75	17.9	B	0.87	26.6	C	0.85	24.1	C
E. Main Rd (RI 138)	EB	0.72	26.3	C	0.87	32.7	C	0.85	30.4	C
E. Main Rd (RI 138)	WB	0.78	11.4	B	0.95	23.3	C	0.92	20.1	C
Aquidneck Ave	NE	0.57	31.3	C	0.60	30.2	C	0.60	30.6	C
Plaza / Bank	SB	0.12	29.3	C	0.10	27.8	C	0.11	28.2	C

Location	Movement	2019 Existing			Build			Build Alternative		
		v/c	Delay	LOS	v/c	Delay	LOS	v/c	Delay	LOS
AM PEAK HOUR										
E. Main Rd / Forest Ave / Ramada	OVERALL	0.72	21.2	C	0.84	35.1	D	0.81	31.1	C
E. Main Rd (RI 138)	EB	0.36	8.5	A	0.43	12.5	B	0.42	14.7	B
E. Main Rd (RI 138)	WB	0.71	17.6	B	0.79	18.3	B	0.78	16.9	B
Hotel Driveway	NB	0.04	24.7	C	0.04	25.7	C	0.04	25.4	C
Forest Ave	SB	0.87	53.0	D	1.14	130.1	F	1.08	107.2	F
E. Main Rd / Valley Rd	OVERALL	0.69	28.1	C	0.86	34.4	C	0.83	33.0	C
E. Main Rd (RI 138)	EB	0.58	26.7	C	0.79	35.2	D	0.75	33.1	C
E. Main Rd (RI 138)	WB	0.86	21.1	C	0.94	26.6	C	0.95	27.6	C
Valley Rd	NB	0.65	35.8	D	0.87	43.5	D	0.81	38.8	D
Valley Rd	SB	0.71	37.1	D	0.75	37.8	D	0.73	36.9	D
Green End Ave / Valley Rd	OVERALL	0.66	25.7	C	0.87	37.2	D	0.83	34.2	C
Green End Ave	EB	0.48	20.8	C	0.73	27.8	C	0.67	26.4	C
Green End Ave	WB	0.64	33.5	C	0.90	53.5	D	0.86	47.4	D
Valley Rd	NB	0.57	17.6	B	0.77	24.5	C	0.73	22.8	C
Valley Rd	SB	0.74	33.7	C	0.91	48.8	D	0.87	44.7	D
Aquidneck Ave / Valley Rd	OVERALL	0.79	14.3	B	PROPOSED ROUNDABOUT*			PROPOSED ROUNDABOUT*		
Aquidneck Ave	WB	0.80	16.0	B	0.70	17.0	C	0.67	15.0	B/C
Aquidneck Ave	NB	0.79	15.9	B	0.61	10.0	A/B	0.58	10.0	A/B
Valley Rd	SE	0.60	9.9	A	0.63	15.0	B/C	0.60	14.0	B
Aquidneck Ave / Valley Rd (w/SIGNAL)	OVERALL	0.79	14.3	B	0.92	25.8	C	0.90	22.8	C
Aquidneck Ave	WB	0.80	16.0	B	0.90	24.0	C	0.88	21.6	C
Aquidneck Ave	NB	0.79	15.9	B	0.94	30.4	C	0.92	27.4	C
Valley Rd	SE	0.60	9.9	A	0.92	21.7	C	0.86	17.9	B
Aquidneck Ave / Purgatory Rd	OVERALL	0.60	9.4	A	0.75	14.0	B	0.73	13.2	B
Aquidneck Ave	SB	0.63	8.7	A	0.80	15.0	B	0.78	13.8	B
Memorial Blvd	NW	0.48	17.4	B	0.62	21.6	C	0.59	20.6	C
Purgatory Rd	NE	0.64	8.0	A	0.76	10.9	B	0.74	10.4	B

*Proposed roundabout at Aquidneck Avenue / Valley Road follows unsignalized LOS criteria

Table 5.8B- Signalized Level-Of-Service Analysis Summary

Location	Movement	2019 Existing			Build			Build Alternative		
		v/c	Delay	LOS	v/c	Delay	LOS	v/c	Delay	LOS
PM PEAK HOUR										
W. Main Rd / Greene Ln / Pasture Farm Dr	OVERALL	0.70	21.8	C	1.47	297.9	F	1.36	242.0	F
Greene Ln	EB	0.67	39.8	D	0.69	39.7	D	0.68	39.6	D
Pasture Farm Dr	WB	0.01	31.9	C	0.02	31.4	C	0.02	31.4	C
W. Main Rd (RI 114)	NB	0.71	19.6	B	1.53	276.5	F	1.41	224.5	F
W. Main Rd (RI 114)	SB	0.69	21.1	C	1.73	355.5	F	1.58	290.0	F
W. Main Rd / Oliphant Ln	OVERALL	0.95	44.2	D	1.54	273.7	F	1.44	226.3	F
Oliphant Ln	WB	0.96	89.4	F	1.46	270.4	F	1.38	236.5	F
W. Main Rd (RI 114)	NB	1.00	49.4	D	1.58	296.0	F	1.49	252.2	F
W. Main Rd (RI 114)	SB	0.73	26.2	C	1.44	241.9	F	1.32	186.6	F
W. Main Rd / Forest Ave	OVERALL	0.94	40.6	D	1.52	325.1	F	1.41	269.3	F
Forest Ave	WB	0.72	44.5	D	0.86	53.7	D	0.83	50.9	D
W. Main Rd (RI 114)	NB	1.05	58.3	E	1.69	337.4	F	1.58	288.4	F
W. Main Rd (RI 114)	SB	0.85	15.6	B	1.73	347.6	F	1.57	276.7	F
W. Main Rd / Valley Rd	OVERALL	0.90	19.3	B	1.83	151.6	F	1.67	121.1	F
Valley Rd	WB	0.83	33.3	C	1.55	260.6	F	1.43	211.2	F
W. Main Rd (RI 114)	NB	0.83	24.6	C	1.28	155.5	F	1.21	121.8	F
W. Main Rd (RI 114)	SB	0.87	10.7	B	1.83	112.7	F	1.67	90.8	F
W. Main Rd / Coddington Hwy	OVERALL	0.66	32.4	C	0.98	107.5	F	0.91	81.6	F
Coddington Hwy	EB	0.72	44.7	D	1.02	74.3	E	0.96	63.3	E
Rockwood Rd	WB	0.52	54.8	D	0.52	54.8	D	0.52	54.8	D
W. Main Rd (RI 114)	NB	0.53	20.2	C	0.55	22.1	C	0.55	22.1	C
W. Main Rd (RI 114)	SB	0.77	34.2	C	1.34	163.2	F	1.24	120.4	F
W. Main Rd / E. Main Rd	OVERALL	0.73	40.6	D	1.05	122.0	F	1.00	103.0	F
E. Main Rd	EB	0.64	56.7	E	0.64	56.7	E	0.64	56.7	E
E. Main Rd (RI 138)	WB	0.69	48.1	D	0.67	42.8	D	0.66	43.0	D
W. Main Rd (RI 114)	NB	0.75	36.0	D	1.40	223.9	F	1.31	186.5	F
W. Main Rd (RI 114)	SB	0.83	37.6	D	1.20	66.6	E	1.09	53.8	D
E. Main Rd / Oliphant Ln	OVERALL	0.89	30.9	C	1.27	174.0	F	1.20	145.0	F
E. Main Rd (RI 138)	NB	0.95	24.7	C	1.38	189.6	F	1.30	156.8	F
E. Main Rd (RI 138)	SB	0.93	42.3	D	1.33	180.6	F	1.26	152.5	F
Oliphant Ln	SE	0.63	32.3	C	0.97	70.2	E	0.92	57.4	E
Hotel Driveway	NW	0.05	25.2	C	0.04	21.9	C	0.04	22.2	C
E. Main Rd / Aquidneck Ave	OVERALL	0.86	30.8	C	1.35	120.7	F	1.26	100.0	F
E. Main Rd (RI 138)	EB	1.00	40.9	D	1.26	141.5	F	1.22	122.0	F
E. Main Rd (RI 138)	WB	0.67	12.7	B	1.44	108.8	F	1.35	90.4	F
Aquidneck Ave	NB	0.84	37.6	D	1.23	116.6	F	1.14	90.7	F
Plaza / Bank	SB	0.14	22.0	C	0.12	18.1	B	0.11	18.1	B

Location	Movement	2019 Existing			Build			Build Alternative		
		v/c	Delay	LOS	v/c	Delay	LOS	v/c	Delay	LOS
PM PEAK HOUR										
E. Main Rd / Forest Ave / Ramada	OVERALL	0.71	21.1	C	0.97	30.7	C	0.93	27.6	C
E. Main Rd (RI 138)	EB	0.63	17.6	B	0.92	21.8	C	0.88	20.0	B
E. Main Rd (RI 138)	WB	0.55	12.1	B	0.73	16.1	B	0.70	13.9	B
Hotel Driveway	NB	0.08	23.7	C	0.08	23.0	C	0.08	23.0	C
Forest Ave	SB	0.90	54.9	D	1.08	101.4	F	1.05	90.8	F
E. Main Rd / Valley Rd	OVERALL	0.77	38.0	D	1.15	180.3	F	1.08	150.1	F
E. Main Rd (RI 138)	EB	0.71	31.1	C	0.88	38.6	D	0.86	37.1	D
E. Main Rd (RI 138)	WB	0.81	36.7	D	1.12	57.0	E	1.06	52.1	D
Valley Rd	NB	0.78	40.5	D	1.88	372.5	F	1.72	308.1	F
Valley Rd	SB	0.85	45.3	D	1.44	208.2	F	1.35	171.4	F
Green End Ave / Valley Rd	OVERALL	1.00	45.5	D	1.64	210.7	F	1.56	187.9	F
Green End Ave	EB	0.77	26.1	C	1.17	74.7	E	1.14	62.9	E
Green End Ave	WB	0.79	41.3	D	1.23	155.3	F	1.15	125.8	F
Valley Rd	NB	1.19	71.8	E	1.98	229.4	F	1.91	208.0	F
Valley Rd	SB	0.74	36.6	D	1.76	390.0	F	1.69	357.8	F
Aquidneck Ave / Valley Rd	OVERALL	0.74	12.1	B	PROPOSED ROUNDABOUT*		PROPOSED ROUNDABOUT*			
Aquidneck Ave	WB	0.68	14.2	B	0.71	18.0	C	0.64	15.0	B/C
Aquidneck Ave	NB	0.78	13.4	B	0.90	26.0	D	0.84	20.0	C
Valley Rd	SE	0.66	8.6	A	0.90	34.0	D	0.83	24.0	C
Aquidneck Ave / Valley Rd (w/SIGNAL)	OVERALL	0.74	12.1	B	1.15	91.8	F	1.08	71.6	E
Aquidneck Ave	WB	0.68	14.2	B	0.85	19.5	B	0.81	17.8	B
Aquidneck Ave	NB	0.78	13.4	B	1.30	158.3	F	1.21	120.1	F
Valley Rd	SE	0.66	8.6	A	1.36	59.6	E	1.27	48.6	D
Aquidneck Ave / Purgatory Rd	OVERALL	0.71	8.6	A	0.98	49.3	D	0.93	32.8	C
Aquidneck Ave	SB	0.51	5.2	A	1.02	47.1	D	0.93	26.5	C
Memorial Blvd	NW	0.62	26.7	C	0.62	24.1	C	0.61	24.1	C
Purgatory Rd	NE	0.73	7.6	A	1.09	55.8	E	1.03	39.1	D

*Proposed roundabout at Aquidneck Avenue / Valley Road follows unsignalized LOS criteria

Table 5.9 - Unsignalized Level-Of-Service Analysis Summary

Location	Movement	2019 Existing			Build			Build Alternative		
		w/c	Delay	LOS	w/c	Delay	LOS	w/c	Delay	LOS
AM PEAK HOUR										
Green End Ave / Berkeley Ave / Paradise Ave										
Green End Ave	EB	0.02	1.2	A	0.03	1.2	A	0.03	1.2	A
Green End Ave	WB	0.05	2.4	A	0.06	1.9	A	0.05	2.0	A
Paradise Ave	NB	0.35	18.6	C	0.80	60.1	F	0.70	44.5	E
Berkeley Ave	SB	0.37	17.5	C	0.52	26.8	D	0.50	24.8	C
Green End Ave / Berkeley Ave / Paradise Ave										
PROPOSED ROUNDABOUT*										
Green End Ave	EB				0.27	6.0	A	0.26	6.0	A
Green End Ave	WB				0.34	7.0	A	0.32	6.0	A
Paradise Ave	NB				0.19	5.0	A	0.17	5.0	A
Berkeley Ave	SB				0.19	6.0	A	0.19	6.0	A
Third Beach Rd / Mitchell's Ln / Wapping Rd										
Wapping Rd	WB	0.07	5.4	A	0.10	5.4	A	0.09	5.4	A
Third Beach Rd	NB	0.21	11.6	B	0.31	13.9	B	0.29	13.5	B
Mitchell's Ln	SE	0.09	0.0	A	0.10	0.0	A	0.10	0.0	A
PM PEAK HOUR										
Green End Ave / Berkeley Ave / Paradise Ave										
Green End Ave	EB	0.04	1.5	A	0.04	1.3	A	0.04	1.3	A
Green End Ave	WB	0.03	1.6	A	0.04	1.4	A	0.04	1.4	A
Paradise Ave	NB	0.50	21.7	C	1.02	108.2	F	0.90	73.2	F
Berkeley Ave	SB	0.40	21.1	C	0.77	60.4	F	0.70	47.7	E
Green End Ave / Berkeley Ave / Paradise Ave										
PROPOSED ROUNDABOUT*										
Green End Ave	EB				0.42	7.0	A	0.39	7.0	A
Green End Ave	WB				0.31	6.0	A	0.29	6.0	A
Paradise Ave	NB				0.29	7.0	A	0.27	7.0	A
Berkeley Ave	SB				0.18	6.0	A	0.17	5.0	A
Third Beach Rd / Mitchell's Ln / Wapping Rd										
Wapping Rd	WB	0.05	4.3	A	0.08	4.5	A	0.07	4.4	A
Third Beach Rd	NB	0.22	11.3	B	0.34	13.3	B	0.32	12.9	B
Mitchell's Ln	SE	0.12	0.0	A	0.16	0.0	A	0.15	0.0	A

*Proposed roundabout at Green End Ave / Berkeley Ave / Paradise Ave follows unsignalized LOS criteria