Breakfast Hill Water Main Extension

Master Plan Supplement

April 2, 2019

Portsmouth/Greenland, NH

Drinking Water Groundwater Trust Fund Project#: DWGT-08

Submitted by:

UNDERWOOD engineers

25 Vaughan Mall
Portsmouth, New Hampshire
99 North State Street
Concord, New Hampshire

2303.00

Table of Contents

List of Tables

List of Figures

Attachments

Executive Summary

The purpose of this report is to evaluate the ability of and the improvements needed if the Portsmouth Water System was extended to the Breakfast Hill area in Greenland. The work is being done at the request of the Town of Greenland due to concerns related to groundwater contaminants around the Coakley Landfill area. The report will act as a supplement to the *2013 Portsmouth Water System Master Plan* by Tighe & Bond (2013 Master Plan). Greenland is a franchise area for Portsmouth's Water System.

The 2013 Master Plan evaluated the growth of the existing Greenland water service area, but the Breakfast Hill service area was not part of the estimated demands. This technical memorandum considers the added developed area in Greenland, which includes the following:

- ~ 785 acres
- 240 improved residential properties
- 5 improved commercial properties

Water demands added from the developed Breakfast Hill Area are as follows:

- Estimated 2018 Average Day Demands = 0.04 MGD
- Estimated 2018 Max Day Demands = 0.29 MGD

The total updated Greenland demands (included Breakfast Hill) are as follows:

- Estimated 2018 Average Day Demands = 0.20 MGD
- Estimated 2018 Max Day Demands = 0.54 MGD

Additional growth of undeveloped land was not considered in this assessment because most of the study area is developed, but all improved lots were assumed to connect. The high estimated maximum day demands are due to significant irrigation use in the area. The added demands due to the Breakfast Hill area represent approximately 0.8% increase to 2018 Portsmouth system wide average day demands (3.7% increase to 2018 Portsmouth system wide maximum day demands). Available water supply was evaluated as part of this study. The City's water sources' sustained and maximum yields were updated from the 2013 Master Plan. Assuming the findings of the 2013 T&B report are still valid, the system's current supply can meet current estimated demands.

The hydraulic model of the City's water distribution system was used to evaluate the pressure and fire flow. Three (3) distribution system pipeline scenarios were evaluated for extending water to the study area. The scenario of just looping the water main from Post Road to the City's line on Lafayette Road did not work due to limited pressure and inadequate fire flows. Similarly, the scenario of connecting to the Pease system with the higher hydraulic grade line did not work either since the demand center on Breakfast Hill was so far away, fire flows were too low, and storage was limited.

Scenario #2 would be the best option of those considered that meets the goals of providing the following:

- A minimum static pressure of 35 psi at the street. Note, the static pressure in the Breakfast Hill area at an HGL of 230 will range from 39 psi to 76 psi.
- Minimal impacts to the existing Portsmouth service areas in terms of pressure reduction or fire flow reduction.

Raising the grade line in all of Greenland would increase the pressures through Greenland by approximately 25 psi (59 feet). Higher pressures approaching 85-90 psi will be found in lower elevations of Town. Individual PRV's may be needed for those properties, but it is not anticipated to be a significant number.

This scenario includes the following:

- 9,000 feet of 12" transmission main extension from Post Road to Lafayette Road
- 28,000 feet of 8" piping to serve the neighborhoods.
- 500,000-gallon, 91-foot elevated water storage tank. One potential location is on Breakfast Hill Road on land owned by the Town of Greenland.
- New booster pump station (and PRV) near the C&J Bus Station in Pease – Alternative location at Ocean Road.
- Pease interconnection for emergency on Grafton Road (normally off). The Greenland pressure zone will match the Pease pressure zone.
- Pressure Reducing Valve on Ocean Road to allow water flow into Portsmouth.
- Upgrade to the Greenland Well Pump. Replacing the 10" main from the pump is not included.

The Pease interconnect would provide storage to be used for either zone (Pease or Greenland) in the event of an emergency. The booster pumping station would provide redundancy in the event the Greenland well is down or is off-line.

For the recommended alternative, certain areas within the City were evaluated and it was found that where fire flows decreased, they were no lower than 10% compared to existing conditions with proper management of the system. An extended time water age evaluation on Scenario #2 suggests that water age decreases in some areas of the system and increases in others. The increases and decreases depend on how the system is operated.

If Scenario #2 were to be completed, the water age of the system (and fire flow impacts) could be managed further with coordinated use of the Greenland well, new booster pumping station and controlled tank drawdowns. Additional evaluations would be needed to further confirm residual pressures and fire flows as well as look at impacts if alternative tank site and pumping station locations are considered.

The opinion of cost for all of Scenario #2 is $20.3 Million – $24.6 Million. It can be completed in phases, but at a minimum the first phase would include the backbone of the system as follows:

- 9,000 feet of 12" transmission main from Post Road to Lafayette Road
- 500,000 gallon elevated water storage tank on Breakfast Hill Road (or other location).
- New booster pump station at the C&J Bus Station site
- Pease interconnection (1,700 feet) for emergency on Grafton Road (normally off).
- Pressure Reducing Valve pit on Ocean Road
- Upgrade to the Greenland Well Pump
- Connections to properties along Breakfast Hill Road
- Individual PRV's in select locations of Greenland

Future projects will serve the abutting neighborhoods as shown in Figure #1 including the following:

- Maple Drive/Sunnyside Drive Neighborhood (63 connections)
- Coombs Farm Road/Windsor Green Road Neighborhood (25 connections)
- Stone Meadow Way/Berry Farm Lane Neighborhood (14 connections)
- September Drive/October Drive Neighborhood (26 connections)
- Falls Way Neighborhood (77 connections)

If pursued, the following is recommended as next steps in design:

- Pursue Scenario No. 2: Standalone Greenland Pressure Zone by advancing final design of Phase 1. The recommended budget (2019 dollars) for the design phase of the backbone is $610,000. This does not include the neighborhoods.
- Refine locations of booster pumping stations and tank locations.
- Additional design could be completed as part of the first project on neighborhoods that Greenland would like to serve.
- Meet with the NHDES to discuss further funding through the Trust Funds and/or Settlement Funds.
- Coordinate with Greenland for advancement of the next steps.

Due to significant up-front costs, an interim connection to the Rye Water District (RWD) was evaluated. Although not confirmed with Rye Water District, it is possible to connect the east side of the Breakfast Hill Road service area as an interim solution. In summary, this would include (see Figure 10):

- Approximately $2.5M - $3.0M to construct an extension to the service area east of the power line corridor. This includes piping only and does not include storage or supply improvements. Preliminary first phase includes:
- 4,700 LF of 12" D.I. Water Main

- 1,600 LF of 8” D.I. Water Main
- 34 properties served
- Initial findings support that this option is feasible with respect to RWD’s hydraulic grade line, water supply, storage, etc., but additional evaluation is necessary.
- Additional approval and votes from Rye and Portsmouth would be necessary.

1. Background/Purpose

The Town of Greenland (TOG) and the City of Portsmouth (COP) have agreed to cooperatively advance the preliminary design phase of a water main extension from the existing Portsmouth system to the Breakfast Hill area of Greenland. The work is being pursued based on a request of the Town of Greenland with the primary goal of mitigating the risks associated with the presence of certain contaminants in groundwater around the Coakley Landfill groundwater management zone. The municipal system would provide the potable water instead of the individual private wells.

This technical memorandum is to supplement the Portsmouth Water System Master Plan that was prepared in 2013 by Tighe & Bond. Applicable sections of the Master Plan, in which the proposed water main extension will affect will be reviewed, specifically including:

- Existing System Demands
- Existing System Supply Capacity
- Capital Improvement Recommendations for the Project

2. Proposed Service Area

2.1. Description

The proposed water main extension to the Breakfast Hill area will add approximately 245 user connections to Portsmouth's water system. 240 of the proposed user connections will be residential users. Included in the 240 connections are duplexes on Maple Drive, Maple Drive Ext., and Berry Farm Lane. Each will have two (2) connections. There are five (5) proposed commercial properties along Breakfast Hill Road. These include connections to Rolling Green Nursery, Garden of Eves Greenhouses, Breakfast Hill Golf Club, Bethany Church, and 611 Breakfast Hill Road. Commercial properties will be provided a domestic water service and a fire protection service. See Attachment "A" for limits of the study area (service area).

A summary of connections, organized by project area, is shown below in Table 1.

Table 1. Breakfast Hill Service Area – Estimated Number of Connections

Neighborhood	Streets	No. of Residential Connections	No. of Commercial Connections
Neighborhood #1	Maple Drive Maple Drive Extension Sunnyside Drive	63	-
Neighborhood #2	Coombs Farm Road Windsor Green Road	25	-
Neighborhood #3	September Drive October Drive	26	-
Neighborhood #4	Falls Way Skyview Drive Ridgecrest Drive Balsamic Circle Pinewood Circle	77	-
Neighborhood #5	Stone Meadow Way Red Oak Drive Berry Farm Lane	14	-
Neighborhood #6	Breakfast Hill Road	25	5
Neighborhood #7	Seavey Way	10	-
	Total	**240**	**5**

Notes:

1. Seavey way has existing distribution piping. Two connections will be made to the existing piping to loop the neighborhood.
2. Although not all the homes are constructed, all 10 of the Seavey Way lots are included.

2.2. Estimated Demands

Current demands for the Breakfast Hill area have been estimated as shown below in Table 2.

Table 2. Breakfast Hill Service Area – Estimated Demands

	Average Day Demand (gpd)			Max Day Demand (gpd)		
	Domestic Demand	**Irrigation Demand**	**Total Demand**	**Domestic Demand**	**Irrigation Demand**	**Total Demand**
Residential Connections	30,000	-	30,000	48,000	171,000	219,000
Breakfast Hill Golf Club	4,000	-	4,000	6,400	20,000	26,400
Garden of Eves Greenhouses	125	-	125	200	15,000	15,200
Rolling Green Nursery	375	-	375	600	15,000	15,600
611 Breakfast Hill Road	550	-	550	880	3,200	4,000
Bethany Church	925	-	925	1,200	4,300	5,500
Total	**36,000**	**-**	**36,000**	**58,000**	**228,000**	**286,000**

Notes:

1. Residential domestic demands (240 connections) are calculated using 125 gpd per connection (based on historic Portsmouth Water System usage data).
2. Residential demands include future demands for a total of ten (10) houses to be constructed on Seavey Way. Currently only two (2) are constructed.
3. Max day domestic demands use a peaking of 1.6, based on historic water usage in the Portsmouth Water System.
4. Domestic irrigation demands use a peaking factor of 5.7, based on historic irrigation trends in the Portsmouth Water System.

3. Water Demand and Water Supply

3.1. Water Demand Projections

The purpose of the tables below is to provide an update to the Portsmouth Water System Master Plan, completed by Tighe & Bond in 2013. The Master Plan projected demands to year 2030 using a 1% increase in demand per year. UE extended the original projections to year 2040, also using a 1% increase in demand per year. The original Master Plan tables summarized average day demands (ADD) and maximum month demands (MMD). In this report, maximum day demands (MDD) are summarized in place of maximum month demands to be more conservative. A peaking factor of 1.6 was used to calculate the MDD from the original ADD projections. This factor is an average from historical peaking factors from 2003 through 2011.

It should be noted that the Master Plan acknowledged the Breakfast Hill area as a potential area for expansion for the water system. However, the Master Plan's 1% growth in demand per year in Greenland does not include the projected demands for the Breakfast Hill area. Therefore, estimated demands by UE were added to the 1% per year demand increases.

3.1.1. Greenland Demands

The following tables provide projected demands in Greenland. Table 3, below, summarizes projected demands from the 2013 Master Plan and Table 4 is a revision to include estimated flows from the Breakfast Hill area.

Table 3. 2013 Master Plan – Projected Greenland Demands

Year	ADD (mgd)	MDD (mgd)
2018	0.16	0.25
2020	0.17	0.26
2025	0.18	0.27
2030	0.19	0.28
2035	0.20	0.30
2040	0.21	0.31

Table 4. Adjusted Greenland Demands with Breakfast Hill Area

Year	ADD (mgd)	MDD (mgd)
2018	0.20	0.54
2020	0.20	0.55
2025	0.22	0.58
2030	0.23	0.61
2035	0.24	0.64
2040	0.25	0.67

3.1.2. System-Wide Demands

The following tables provide projected demands for the entire Portsmouth Water System. Table 5 summarizes the demands from the 2013 Master Plan and Table 6 is a revision to include estimated flows from the Breakfast Hill area.

Table 5. 2013 Master Plan – Projected System Wide Demands

Year	ADD (mgd)	MDD (mgd)
2018	4.92	7.54
2020	5.02	7.69
2025	5.28	8.08
2030	5.55	8.49
2035	5.83	8.92
2040	6.13	9.38

Table 6. Adjusted System Wide Demands with Breakfast Hill Area

Year	ADD (mgd)	MDD (mgd)
2018	4.96	7.82
2020	5.06	7.98
2025	5.32	8.39
2030	5.59	8.81
2035	5.87	9.26
2040	6.17	9.74

3.2. Available Water Supply & Margin of Safety

3.2.1. Master Plan – Water Supply

Table 7 below summarizes, in the 2013 Master Plan sustained yield and the maximum yield for each of the Portsmouth Water System's supply sources.

Table 7. 2013 Master Plan – Sustained Yield vs. Maximum Yield of Portsmouth's Water Supply Sources (T&B 2013)

Source	Sustained Yield (mgd)	Maximum Yield (mgd)	Max vs. Sustained (mgd)
Madbury WTF	2.50	4.00	+1.50
Madbury Wells	0.93	1.21	+0.28
Greenland Well	0.66	0.71	+0.05
Portsmouth Well	0.38	0.58	+0.20
Collins Well	0.22	0.40	+0.18
Haven Well	0.77	0.77	+0.00
Smith Well	0.22	0.35	+0.13
Harrison Well	0.19	0.33	+0.14
Total	**5.87**	**8.35**	**+2.48**

3.2.2. Current Water Supply

Table 8 below summarizes the current sustained yield and the maximum yield for each of the Portsmouth Water System's supply sources. Yields were updated from the 2013 Master Plan based on correspondence with the City of Portsmouth Water Department.

Table 8. Current Sustained Yield vs. Maximum Yield of Portsmouth's Water Supply Sources (Portsmouth Water Department 2019)

Source	Sustained Yield (mgd)	Maximum Yield (mgd)	Max vs. Sustained (mgd)
Madbury WTF	2.50	4.00	+1.50
Madbury Wells	0.69	1.50	+0.81
Greenland Well	0.65	0.65	+0.00
Portsmouth Well	0.40	0.65	+0.24
Collins Well	0.29	0.40	+0.12
Haven Well	0.77	1.01	+0.24
Smith Well	0.23	0.49	+0.26
Harrison Well	0.19	0.41	+0.22
Total	**5.72**	**9.11**	**+3.39**

Notes:

1. The Haven Well in Pease is currently off-line due to PFAS contamination. A new treatment plant is currently being designed and is estimated to be built and operational in 2021 (same as initial year of proposed service extension to the Breakfast Hill service area). For this reason, the yields from the Haven Well are included in the water supply analysis.

The numbers in Table 8 vary from the numbers in Table 7. This is due to sustained and maximum yield revisions provided by the Portsmouth Water Department. In general, sustained yield capacities decreased and maximum yield capacities increased based on recent pumping and system operational trends.

3.2.3. Margin of Safety

A Margin of Safety analysis is a method to access available water supply based on average day system demands. It is standard practice to access a system's Margin of Safety with its largest source off line. It is updated here consistent with the evaluations in the 2013 Master Plan. The following tables evaluate the system's margin of safety using two (2) scenarios. In the first scenario, the system is operating at the sustained supply yield of the system. In the second scenario, the system is operating at 24 hours per day with the largest source off line (Madbury Water Treatment Facility).

The Master Plan's Margin of Safety analysis evaluated historic flow from 2003 through 2011, but did not include an analysis for projected future demands. Table 9 summarizes the system's Margin of Safety using the projected demands from the Master Plan (extended through 2040).

Table 9. 2013 Master Plan – Margin of Safety Analysis (without Breakfast Hill)

Year	Average Day Demand (MGD)	Available Water (MGD)		Margin of Safety	
		(Note 1)	(Note 2)	(Note 1)	(Note 2)
2018	4.92	5.87	1.87	1.19	0.38
2020	5.02	5.87	1.87	1.17	0.37
2025	5.28	5.87	1.87	1.11	0.35
2030	5.55	5.87	1.87	1.06	0.34
2035	5.83	5.87	1.87	1.01	0.32
2040	6.13	5.87	1.87	0.96	0.31

Notes:

1. Sustained yield based on 2013 Master Plan.
2. 24 hr/day pumping with largest source off line (Madbury WTF).

The following figure is from the 2013 Master Plan. It compares three different yield conditions with at the time (2013) current and projected 2030 average day demands.

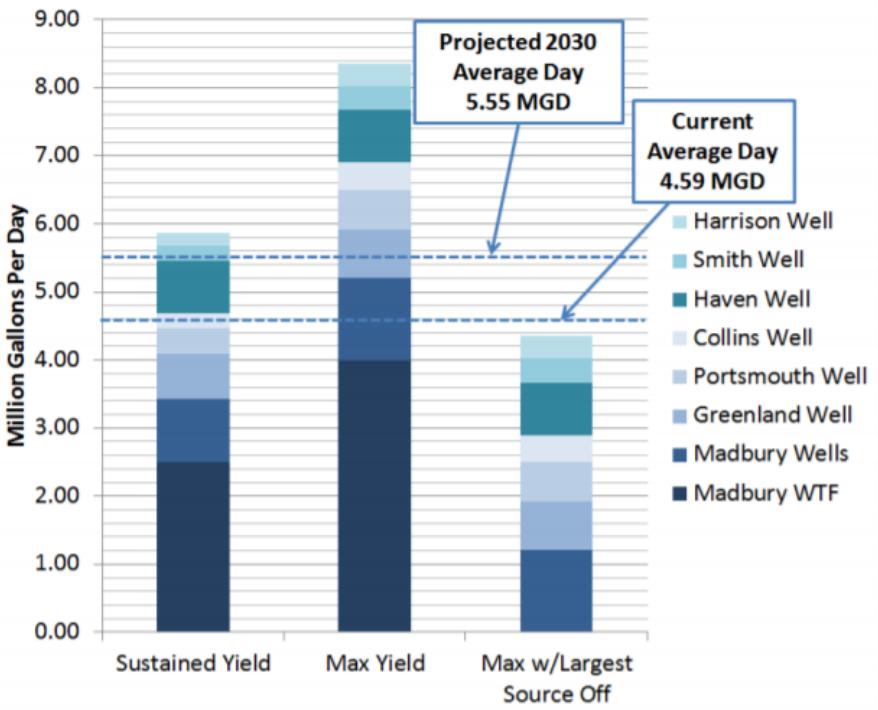


Figure A. 2013 Master Plan – Water System Supply Yield vs. Average Day Demands

Table 9 and Figure A suggest that average demands are not able to be met with the Madbury WTF off line. However, as stated in the Master Plan, it is more likely that the WTF's production would be reduced during periods of drought and that with proper management mechanisms and an emergency action plan, the system should be able to meet demands.

The Margin of Safety table above was adjusted to include current day sustained and maximum yield capacities and to include increased demands from the Breakfast Hill Road area:

Table 10. Adjusted Margin of Safety Analysis with Breakfast Hill Road Area

Year	Average Day Demand (MGD)	Available Water (MGD)		Margin of Safety	
		(Note 1)	(Note 2)	(Note 1)	(Note 2)
2018	4.96	5.72	1.72	1.15	0.35
2020	5.06	5.72	1.72	1.13	0.34
2025	5.32	5.72	1.72	1.08	0.32
2030	5.59	5.72	1.72	1.02	0.31
2035	5.88	5.72	1.72	0.97	0.29
2040	6.17	5.72	1.72	0.93	0.28

Notes:

1. Sustained yield based on information provided by Portsmouth Water Department.
2. 24 hr/day pumping with largest source off line (Madbury WTF).

The figure from the Master Plan that compares system yield with average day demand was updated as well to include the increase in demand from the Breakfast Hill Road area.

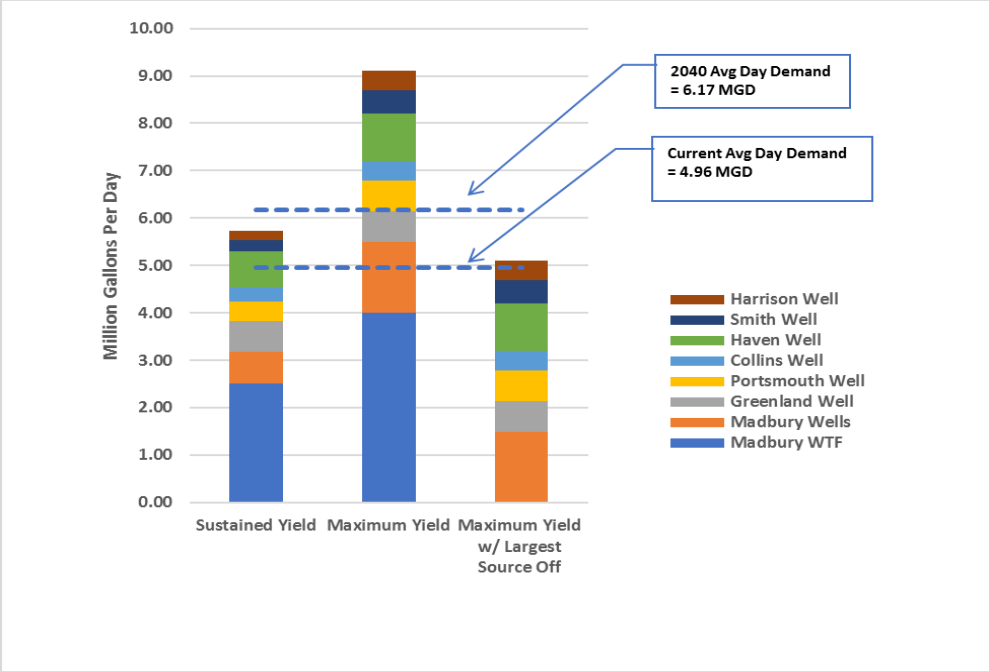


Figure B. Adjusted Water System Supply Yield vs. Average Day Demands with Breakfast Hill Road Area

Compared to Table 9 from the 2013 Master Plan, Table 10 has a smaller margin of safety after revising source supply capacities and increasing the projected demands. Compared to the 2013 Master Plan, the margin of safety, with all sources online, decreased by about 3%. With the Madbury WTF off line and 24 hours per day pumping of the other sources, the margin of safety decreased by approximately 10%. The revised Margin of Safety table and figures, like the tables and figures from the 2013 Master Plan, still support that average day demands cannot be met with the Madbury WTF off line. They further indicate that average day demands cannot be met by sustained yields around year 2035 (margin of safety < 1.0). The following excerpt is from the 2013 Master Plan:

"Note: The Weston & Sampson report noted that "sustainable yield appears to be limited by well and aquifer hydraulics," in a number of wells. They noted that with proper management, some redevelopment and possibly, replacement of a few of the wells, the output of the Portsmouth groundwater sources could likely be increased. Theoretically, they calculated that the groundwater source in the system were capable of approximately 3,335 gpm, or 4.8 mgd. This would bring the total maximum available supply of the system, together with the WTF, to nearly 10 mgd. Additionally, the Weston & Sampson report noted that the Haven Well could deliver up to 2.1 mgd based on well hydraulics. With this in mind, the City should consider the potential to install some satellite wells for backup capability."

Although the margin of safety decreased, the actual demands are well below the projected demands from the 2013 Master Plan. In fact, data provided by the City of Portsmouth Water Department suggests that, on average, the actual ADD and the actual MDD for the system was only about 93% of what the 2013 Master Plan projected.

4. Distribution System Assessment

Three (3) different scenarios were evaluated for providing Portsmouth municipal water to the Breakfast Hill service area. The scenarios are as follows:

1. Create a loop from Greenland to Lafayette Road.
2. Create a stand-alone pressure zone in Greenland.
3. Connect Greenland to the Pease pressure zone.

The Greenland portion of the water system has a history of pressure and flow deficiencies due to being on the outer edge of Portsmouth's main pressure zone and high ground elevations. The 2013 Master Plan considered similar alternatives in "Section 3 Distribution System Assessment" to mitigate these deficiencies. See Attachment "B" for a schematic of water system hydraulics with the addition of the Breakfast Hill service area.

Goals for the extension have been set to establish necessary criterion for the water system to operate effectively. They are as follows:

- Water Source Redundancy: each scenario shall have at least two (2) sources of water.
- Minimum Required Pressures:
- 35 psi under max day demands at the curb
- Fire Flows: 1,000 gpm @ 20 psi residual pressure (min.)
- Adequate Storage Capacity

4.1. Greenland Scenario No. 1: Loop between Breakfast Hill Road and Lafayette Road

Scenario No. 1 would extend Portsmouth's main pressure zone (HGL = 171 ft) to the Breakfast Hill service are.

System improvements proposed for Scenario No. 1 include:

- Extension of 12" water main from the Greenland portion of the water system on Post Road to the end of the water system on Lafayette Road in Portsmouth, creating a loop between two system endpoints (Attachment "A").
    - Proposed loop approximately 13,000 LF.
    - Quantity does not include proposed water mains within the Breakfast Hill service area neighborhoods.
- Note that the railroad corridor that intersects Ocean Road and Breakfast Hill Road was a proposed looping option to be evaluated in this report. However, due to obstacles with coordinating railroad use and the preference to stay within the road ROW, this option is considered a backup and was not evaluated further.

4.2. Greenland Scenario No. 2: Stand-Alone Greenland Pressure Zone

Scenario No. 2 would create a new pressure zone comprising of the entire Greenland area of the water system (Attachment "C"). Based on preliminary findings and evaluations, the HGL should be set equal to the Pease pressure zone HGL (230-ft), though the pressure zones will not operate as one. There will be interconnections for emergency purposes, but the main water source for the proposed Greenland pressure zone would be the Greenland Well and/or the booster pumping station by the C&J bus station.

System improvements proposed for Scenario No. 2 include:

- Extension of 12" water main from Post Road to the end of Breakfast Hill Road (approx. 9,000 LF).
    - Quantity does not include proposed water mains within the Breakfast Hill service area neighborhoods.
- Proposed 91-ft tall elevated water storage tank on the Town of Greenland owned property between the Bethany Church and the old Rye Landfill (Attachment "D").
    - Property is the highest point of elevation in the Town of Greenland.
    - Property also extends south and includes land between the Bethany Church and the Coakley Landfill.
    - Town of Greenland owned property abutting I-95 is not considered for the following reasons:
        - Poor site access for construction.
        - Site is 100' wide at the widest section and would likely require additional easements.
        - Ground elevation requires a tank approx. 130-ft tall.
- New Booster Pump Station (BPS) near the C&J Bus Station (Attachment "E").
    - The purpose of the BPS would be to pressurize water from Portsmouth's main pressure zone and to serve as a redundant water supply source in the event of a failure at the Greenland Well.
    - The proposed BPS would include a pressure reducing valve (PRV) to allow flow back into the main pressure zone at the appropriate HGL.
- Potential interconnection between the Pease pressure zone and the new Greenland pressure zone (Attachment "F").
    - Approximately 1,700 LF of 12" DI water main installed from near the intersection of Grafton Road and the Pease Golf Course access drive, along Grafton, and to the intersection of Grafton and Greenland Road.
- New PRV/meter vault on Ocean Road, within Town of Greenland R.O.W. (Attachment "G"), near the Town of Greenland/Town of Portsmouth border, to de-pressurize water flowing from the proposed new Greenland pressure zone into Portsmouth's main pressure zone.

- The Greenland Well pump would require an upgrade to pump to the increased HGL.

Two sites were evaluated for the 0.5 MG tank. The first site is a parcel of land owned by the Town of Greenland located adjacent to I-95, north of the bridge. The second site is a parcel also owned by the Town of Greenland and is on the eastern end of Breakfast Hill Road between the Bethany Church and the former Rye landfill.

4.2.1. I-95 Tank Site

The Town of Greenland owns a parcel of land adjacent to I-95 that was considered as a potential tank site (Map U-1, Lot 17). Due to the site's ground elevation, minimal space availability, and site access, a tank located on the parcel adjacent to I-95 is challenging. Based on the approximate (google Earth) ground elevation of 103-ft at the site, a tank would have to be 127-ft tall to reach the recommended HGL of 230-ft. Due to minimal space availability for consideration, a composite elevated tank would be difficult to construct. Additionally, a stand-pipe tank this tall and narrow is not desirable due to water quality concerns and usable storage issues. Further, there is poor access to the site due to the steep embankment on the north side approaching the bridge. Easements would be needed to approach through residential properties between Post Road and the site.

4.2.2. Bethany Church Access Tank Site

The Town of Greenland owns a parcel of land (Map R-1, Lot 9-B) between the Bethany Church and the former Rye landfill and it is a much larger parcel than the I-95 parcel. The property extends south-west behind the Bethany Church towards the Coakley Landfill, but the potential site for the tank is the north-western portion between the church's driveway and the former Rye landfill if there is adequate room for construction there. The site will require clearing and grubbing, but it is easily accessible from Breakfast Hill Road. If the front portion of the site is limited, the parcel has adequate space in the back. The recommended tank type is a composite elevated tank. This is the same type of tank as the Pease and Spinney Road tanks. A height of 91-ft is estimated for the HGL of 230-ft.

Figure C. Pease composite elevated tank (left) and Spinney Road composite elevated tank (right).

In summary, the Bethany Church Access Tank Site is a much more feasible site location for building a 0.5 MG water storage tank.

4.3. Greenland Scenario No. 3: Connect Greenland to Pease System

Scenario No. 3 would connect the entire Greenland area of the water system to the Pease pressure zone (HGL = 230-ft) (Attachment "H"). In this scenario, a new tank would not be constructed.

System improvements proposed for Scenario No. 3:

- Extension of 12" water main from Post Road to the end of Breakfast Hill Road (approx. 9,000 LF).
    - Quantity does not include proposed water mains within the Breakfast Hill service area neighborhoods.
- New Booster Pump Station (BPS) near the C&J Bus Station (Attachment "E").
    - The proposed BPS will act as a redundant water source for the Pease pressure zone and will provide fire flow support to the system.
    - The proposed BPS would include a pressure reducing valve (PRV) to allow flow back into the main pressure zone at the appropriate HGL.
- Interconnection between the Pease pressure zone and Greenland (Attachment "F").
    - Approximately 1,700 LF of 12" DI water main installed from near the intersection of Grafton Road and the Pease Golf Course access drive, along Grafton, and to the intersection of Grafton and Greenland Road.
- New PRV/meter vault on Ocean Road, within Town of Greenland R.O.W. (Attachment "G"), near the Town of Greenland/Town of Portsmouth border, to de-pressurize water flowing from the Pease pressure zone into Portsmouth's main pressure zone.
- The Greenland Well pump would require an upgrade to pump to the increased HGL.

5. Hydraulic Modeling

5.1. Fire Flow Evaluation

The three (3) scenarios described above were evaluated in Portsmouth's hydraulic model to determine available fire flows for each alternative. Eight (8) locations were evaluated for this study (listed below). A more detailed memorandum explaining the hydraulic modeling completed can be found in Attachment "I". Static pressures were also evaluated for each scenario based on water model elevations and proposed hydraulic grade lines for each scenario.

The distribution alternative goals were to provide 35 psi static pressure and 1,000 gpm of fire flow while maintaining at least 20 psi in the system. The following tables summarize the results of the hydraulic modeling based on 2040 max day demands:

Table 11. Greenland Scenario No. 1: Hydraulic Modeling Results (2040 Demands)

Location	Elevation (ft.)	Static Pressure (psi)		Available Fire Flow (gpm)	
		Existing Conditions	Proposed Conditions	Existing Conditions	Proposed Conditions
Breakfast Hill Road (Greenland)	136	N/A	15	N/A	35
Riverside Drive (Greenland)	33	60	60	1,120	150
Newington Road (Greenland)	65	46	46	230	250
Tuttle Road (Greenland)	44	55	55	980	150
Greenland Road (Portsmouth)	43	55	55	1,500	350
Lafayette Drive (Portsmouth)	42	56	56	385	40
Pannaway Manor (Portsmouth)	40	57	57	1,140	1,065
Islington Street (Portsmouth)	57	49	49	6,700	6,330

Scenario No. 1 Results

- Inadequate pressures within the Breakfast Hill Road area (below 20 psi).
- Inadequate fire flows available within the Breakfast Hill Road area.
- Generally, with the exception of Newington Road, there was a significant decrease in available fire flows observed at the evaluation points under proposed conditions.

Table 12. Greenland Scenario No. 2: Hydraulic Modeling Results (2040 Demands)

Location	Elevation (ft.)	Static Pressure (psi)		Available Fire Flow (gpm)	
		Existing Conditions	Proposed Conditions	Existing Conditions	Proposed Conditions
Breakfast Hill Road (Greenland)	136	N/A	41	N/A	6,410
Riverside Drive (Greenland)	33	60	85	1,120	1,605
Newington Road (Greenland)	65	46	71	230	450
Tuttle Road (Greenland)	44	55	81	980	1,310
Greenland Road (Portsmouth)	43	55	81	1,500	1,530
Lafayette Road (Portsmouth)	42	56	56	385	375
Pannaway Manor (Portsmouth)	40	57	57	1,140	520 (Note 2)
Islington Street (Portsmouth)	57	49	49	6,700	3,140 (Note 2)

Notes:

1. These results assume that the potential Pease connection is not open, the Greenland Well is on, and the proposed Booster Pump Station is on. Other modeling scenarios for this alternative can be found in Attachment "I".
2. When the pumps are on, there is a significant decrease in available fire flows to parts of the main pressure zone (e.g. Islington Street and Pannaway Manor) under proposed conditions because 20 psi residual pressure is reached in the Pannaway Manor area. To mitigate this the booster pump station will turn off when the low pressure threshold is reached so the fire flows compared to existing will be within 10%. See Attachment "I" for more details.

Scenario No. 2 Results

- Adequate pressures within the Breakfast Hill Road area.
- Available static pressures to existing evaluation points in Greenland pressure zone increase due to higher HGL.
- Adequate fire flows are available within the Breakfast Hill Road area.
- Increase in available fire flows to existing evaluation points in Greenland pressure zone.

Table 13. Greenland Scenario No. 3: Hydraulic Modeling Results (2040 Demands)

Location	Elevation (ft.)	Static Pressure (psi)		Elevation (ft.)	
		Existing Conditions	Proposed Conditions	Existing Conditions	Proposed Conditions
Breakfast Hill Road (Greenland)	136	N/A	41	N/A	400
Riverside Drive (Greenland)	33	60	85	1,120	985
Newington Road (Greenland)	65	46	71	230	400
Tuttle Road (Greenland)	44	55	81	980	985
Greenland Road (Portsmouth)	43	55	81	1,500	1,275
Lafayette Road (Portsmouth)	42	56	56	385	375
Pannaway Manor (Portsmouth)	40	57	57	1,140	520 (Note 2)
Islington Street (Portsmouth)	57	49	49	6,700	3,140 (Note 2)

Notes:

1. These results assume that the potential Pease connection is open, the Greenland Well is on, and the proposed Booster Pump Station is on. Other modeling scenarios for this alternative can be found in Attachment "I".
2. When the pumps are on, there is a significant decrease in available fire flows to parts of the main pressure zone (e.g. Islington Street and Pannaway Manor) under proposed conditions because 20 psi residual pressure is reached in the Pannaway Manor area. To mitigate this the booster pump station will turn off when the low pressure threshold is reached so the fire flows compared to existing will be within 10%. See Attachment "I" for more details.

Scenario No. 3 Results

- Adequate pressures within the Breakfast Hill Road area.
- Available static pressures to existing evaluation points in Greenland pressure zone increase due to higher HGL.
- Inadequate fire flows available within the Breakfast Hill Road area.
- Minimal differences in available fire flows observed for existing evaluation points in the Pease pressure zone.

In summary, Portsmouth Water System's main pressure zone in Scenario No. 1 does not have a high enough HGL to provide adequate static pressures to the Breakfast Hill area. Fire flows are also inadequate. Scenarios No. 2 and No. 3 share an HGL of 230-ft. This HGL is high enough to

provide adequate pressure to the Breakfast Hill area and also increase existing low pressures in the Greenland service area. Note that the high point on Breakfast Hill Road was used to represent the lowest available pressure in the Breakfast Hill Road service area. Raising the grade line will increase pressures in low-elevation areas of Greenland upwards of 85 to 90 psi. Static pressures are recommended to be between 35 – 80 psi. The following streets with municipal water are anticipated to have static pressures above 80 psi, thus requiring individual PRVs to reduce pressures:

- Route 33
- Riverside Dr
- Sunset Dr
- Tuttle Ln
- Bramber Valley Ln
- Anne's Ln
- Fairway Dr
- Country Club Ln
- Portsmouth Ave
- Newington Rd
- Airport Rd
- Swan Island Ln

Scenario No. 2 provides adequate fire flows of about 6,400 gpm to the Breakfast Hill Road evaluation point. This meets the study goal of fire flows greater than 1,000 gpm. Fireflows in the existing system generally remain the same in Scenario No. 2. Scenario No. 3 does not provide adequate fire flow (400 gpm) to the Breakfast Hill Road evaluation point.

5.2. Water Age

Extended Period Simulations in the water model were completed to evaluate the system's water age. Evaluation points are consistent with the locations shown above in Tables 11 through 13. A summary table for maximum water age in the system for each scenario and at each evaluation point is shown below. A more detailed analysis is provided in Attachment "I".

Table 14. Water Age Analysis Summary

Location	Existing Conditions	Scenario No. 1	Scenario No. 2	Scenario No. 3
	Max Water Age (hrs)	Max Water Age (hrs)	Max Water Age (hrs)	Max Water Age (hrs)
Breakfast Hill Road (Greenland)	N/A	331	175	175
Riverside Drive (Greenland)	87	80	220	95
Newington Road (Greenland)	350	350	380	360
Tuttle Road (Greenland)	145	140	100	145
Greenland Road (Portsmouth)	17	17	88	32
Lafayette Road (Portsmouth)	421	421	435	425
Pannaway Manor (Portsmouth)	28	28	85	38
Islington Street (Portsmouth)	15	15	40	27

Notes:

1. These results assume that the potential Pease connection is not open for Scenario No. 2.
2. High water age at Riverside Drive, Newington Road, and Tuttle Road are due to low water demands and their location on distribution spurs with no looping.

Water Age Results

Existing Conditions

- The model suggests that the Greenland service area and the end of the main pressure zone system on Lafayette Road have the highest water age.
    - Limited Lafayette Tank turnover further increases water age over time.

Scenario No. 1: Lafayette Loop

- Water age conditions improve in Greenland near the Greenland Well.
- Higher water age along Breakfast Hill Road due to low demands and connection to Lafayette Tank area.
- The model predicts a decrease in water age at all the evaluation points.

Scenario No. 2: Greenland Standalone Pressure Zone (Breakfast Hill Tank)

- The model suggests water age increases in portions of the water system and decreases in others.
- Water age can be managed with coordinated operation of the following:
    - Greenland Well
    - New booster pumping station
    - Controlled tank drawdowns

Scenario No. 3: Pease Connection

- The model predicts a decrease in water age at all the evaluation points.
- The Breakfast Hill evaluation point has experienced its lowest water age with this scenario.

In summary, based on the modeled extended period simulations, water age conditions either increased or decreased depending on the evaluation point location. For locations in Greenland that are negatively impacted, water age can likely be managed by coordinated operation of the water distribution system.

6. Storage Capacity Evaluation

6.1. Greenland Scenario No. 1: Loop between Breakfast Hill Road and Lafayette Road

The 2013 Master Plan evaluated the main pressure zone's storage capacity and recommended storage. The three tanks in the pressure zone consist of the Newington Tank (1.5 MG), the Lafayette Road Tank (2.266 MG active; 7.5 MG total), and the Spinney Road Tank (1.0 MG), combining for a total active storage capacity of 4.766 MG.

The 2013 Master Plan projects recommended storage volumes for the main pressure zone through year 2030. For the purposes of this evaluation, storage is evaluated through 2040. In the Master Plan, additional storage is evaluated at ten-year increments. To be conservative, an additional 0.5 MG of storage is assumed to be needed in the existing main pressure zone for year 2040. An adjustment for equalization (0.01 MG) and emergency storage (0.04 MG) requirements for connecting the Breakfast Hill service area to the main pressure zone are also included. It is assumed that the existing fire storage in the main pressure zone is adequate for the Breakfast Hill service area. Recommended storage for the main pressure zone is summarized below in Table 15:

Table 15. Portsmouth Main Pressure Zone Storage Recommendations

Year	2013 Master Plan Recommended Storage Volume	Adjusted Recommended Storage Volume
2011	2.223 MG	-
2020	2.678 MG	-
2030	2.991 MG	-
2040 (w/out Breakfast Hill Area)	-	3.491 MG
2040 Breakfast Hill Equalization Storage Adjustment	-	0.01 MG
2040 Breakfast Hill Emergency Storage Adjustment	-	0.04 MG
2040 Total Recommended Storage	-	**3.54 MG**

Based on the main pressure zone's storage capacity of 4.766 MG and a revised recommended storage volume of 3.54 MG in 2040, there would be a **1.23 MG storage surplus** if the Breakfast Hill area was connected to the main pressure zone with no new tanks.

6.2. Greenland Scenario No. 2: Stand-Alone Greenland Pressure Zone

Tank sizing for a standalone pressure zone in Greenland was based on storage facilities design criteria recommendations found in AWWA's Manual of Water Supply Practices: M32. The manual states that the volume of required storage is broken down into 3 primary components:

1. *Equalization Storage*: the amount of water required to meet demands in excess of the production and delivery capabilities.
2. *Fire Storage*: the amount of water required based on fire protection needs, typically determined by the Insurance Service Office (ISO).

3. *Emergency Storage*: the amount of water required during water events such as pipeline failures, equipment failures, power outages, natural disasters, etc.

Recommended storage volumes are summarized below in Table 16 for a standalone Greenland pressure zone:

Table 16. Standalone Greenland Pressure Zone Storage Requirements

Storage Component	Storage Volume	Basis
Equalization	0.06 MG	Based on 25% of 2040 Greenland average day demands (0.25 MGD).
Fire	0.27 MG	Based on 1,500 gpm fire flows for 3 hours (see Note 2).
Emergency	0.20 MG	Based on 2013 Master Plan emergency storage calculations.
Total	**0.53 MG**	

Notes:

1. Standardized tank sizing dimensions do not support the construction of a 0.53 MG water storage tank. A 0.50 MG tank is recommended for Scenario No. 2.
2. A goal for evaluating the three (3) alternatives was to provide the Breakfast Hill service area a minimum 1,000 gpm fire flow based on hydraulic evaluations. However, the fire storage component is based on 1,500 gpm fire flows which is a typical and conservative design point for estimating fire storage.

In summary, the above calculation recommends 0.53 MG of storage. However, due standard storage tank sizing per Caldwell Tanks, Inc., a **0.5 MG elevated storage tank is recommended**. This size tank will also provide improved water age conditions compared to a larger tank.

6.3. Greenland Scenario No. 3: Connect Greenland to Pease System

The 2013 Master Plan evaluated the Pease pressure zone storage capacity and recommended storage. There are two (2) tanks in the Pease zone. They are the Hobbs Hill Tank (0.6 MG) and the NHANG Tank (0.366 MG). They combine for a total storage capacity of 0.966 MG. Note that at the time the 2013 Master Plan was written the Hobbs Hill Tank had a storage capacity of 0.366 MG. It has since been replaced to store 0.6 MG of water.

The 2013 Master Plan projects recommended storage volumes for the Pease pressure zone through year 2030. For the purposes of this evaluation, storage is evaluated through 2040. In the Master Plan, additional storage is evaluated at ten-year increments. To be conservative, an additional 0.04 MG of storage is assumed to be needed in the existing Pease pressure zone for year 2040. An adjustment for equalization (0.06 MG) and emergency storage (0.20 MG) required for connecting Greenland to the Pease pressure zone are also included. It is assumed that the existing fire storage in the Pease pressure zone is adequate for extending service to

Greenland. Recommended storage for the Pease pressure zone is summarized below in Table 17:

Table 17. Pease Pressure Zone Storage Recommendations

Year	2013 Master Plan Recommended Storage Volume	Adjusted Recommended Storage Volume
2011	0.85 MG	-
2020	0.87 MG	-
2030	0.91 MG	-
2040 (w/out Breakfast Hill Area)	-	0.95 MG
2040 Greenland Equalization Storage Adjustment	-	0.06 MG
2040 Greenland Emergency Storage Adjustment	-	0.20 MG
2040 Total Recommended Storage	-	**1.21 MG**

Based on the Pease pressure zone's storage capacity of 0.966 MG and a revised recommended storage volume of 1.21 MG in 2040, there would be a **0.24 MG storage defecit** if Greenland was connected to the Pease pressure zone with no new tanks.

7. Probable Opinion of Construction Costs

After evaluation of the three (3) Greenland Scenario improvements alternatives, Scenario No. 2: Stand-Alone Greenland Pressure Zone was the only alternative that met the goals of the study, therefore only Scenario #2 costs are presented.

Probable construction costs for Greenland Scenario No. 2 have been estimated and are summarized below in Table 18:

Table 18. Greenland Scenario No. 2 Probable Opinion of Costs

Scenario	Estimated Cost Range
Greenland Scenario No. 2: Stand-Alone Greenland Pressure Zone	$20.3 M - $24.6 M

Notes:

1. A more detailed cost opinion can be found in Attachment “J”.
2. Costs do not include 12” water main installation on Lafayette Road.
3. Costs include contingency and engineering fees.

8. Project Phasing

Water main extension to the Breakfast Hill service area may be separated into multiple project phases (Attachment "K"). At a minimum, the first phase would need to include improvements to the "backbone" of the system. Water services would be provided to the curb for properties along the route of the transmission main extension down Breakfast Hill Rd. Phase 1 Improvements shall include:

- 500,000-gallon elevated water storage tank set at HGL 230-ft located at the east end of Breakfast Hill Road).
- Transmission main extension down Breakfast Hill Road from Post Road to Lafayette Road.
- Proposed booster pump station near the C&J Bus Station (Attachment "E"). Alternative pumping station location is Ocean Road.
- A connection to the Pease system for redundancy (both ways).
- Proposed PRV on Ocean Road to reduce pressure to the main pressure zone HGL.
- Improvements to the Greenland Well pump to pump to increased HGL. Consider replacing the 10" main from the well.
- Individual PRV's for properties where pressure is >80 psi.

The probable construction costs for Greenland Scenario No. 2 – Phase 1 is estimated to range between **$11.8M - $13.6M**. A more detailed cost opinion for Phase 1 Improvements can be found in Attachment "J". If the final design of the "backbone" were to be pursued, a design budget of $610,000 is recommended (2019 dollars). This does not include design services within the neighborhood.

Later phases will provide water distribution improvements to the neighborhoods off Breakfast Hill Rd. Connection to the existing Seavey Way water distribution could be included in the first phase of construction.

9. Interim Rye Water District (RWD) Connection

9.1. RWD: Background

Although not part of the scope of work, due to substantial initial costs for extending Portsmouth's water system to the Breakfast Hill service area, an interim connection to Rye Water District was also considered. Existing water infrastructure from Rye's water tank to the Bethany Church and Seavey Way make it potentially possible to expand the RWD system from Seavey Way to portions of the Breakfast Hill Road area. The extension from Rye would be designed/built to accommodate a future conversion to Portsmouth's water system. For purposes of this evaluation, this option was limited to the east side of the PSNH easement to Lafayette Road.

The City of Portsmouth has a wholesale water agreement with the RWD to buy water at a wholesale rate to provide service to Bethany Church and the properties on Seavey Way, which are Greenland properties and Portsmouth's water franchise area. Improvements to provide water service to the eastern side of the Breakfast Hill service area would require a revision of the existing wholesale agreement and a vote by The Rye Water District Commissioners as well as an approval by Portsmouth's City Council.

9.2. RWD: Supply, Demand, Storage Capacities

To consider the potential of this option, information from previous reports and correspondence with Rye Water District staff was collected. Based on the information available, it is likely that the RWD can provide supply water to a small portion of the area. However, a complete evaluation is recommended prior to pursuing further. This evaluation shall include, but not limited by, evaluations for water demand, water supply capacities, storage capacities, water age analyses, and hydraulic modeling. Below is a summary of our initial findings.

9.3. RWD: Hydraulic Grade Line/Pressures Evaluation

The Rye Water District operates two (2) pressure zones. The pressure zone that would serve Breakfast Hill Road has an HGL of 252-ft, which is the high-pressure zone. Based on the range of elevations within the Breakfast Hill service area, this grade line provides adequate pressures for water service. The range of estimated pressures are tabulated below in Table 19:

Table 19. Rye Water District Pressure Evaluation

Area	Low Elevation (ft.)	High Pressure (PSI)	High Elevation (ft.)	Low Pressure (ft.)
Breakfast Hill Road	71	75	140	45
Neighborhoods	54	83	100	63

9.4. RWD: Probable Opinion of Construction Costs

Assuming this option includes expansion from the Seavey Way neighborhood to the PSNH easement (Attachment "L"), the following improvements would be needed:

- 4,700 LF of 12" D.I. Water Main
    - From power line west of golf course to Lafayette Road
- 1,600 LF of 8" D.I. Water Main
    - Stone Meadow Way
    - Red Oak Drive
    - Berry Farm Lane
- 34 properties served

Probable opinions of costs for distribution improvements to extend water to the expanded wholesale area shown in Attachment "L" is estimated to range between $2.5M and $3.0M. Costs include contingency and engineering fees, but do not include storage or treatment improvements, if necessary.

10.Public Meetings

As part of the work to develop this report, public meetings were held. Below summarizes the two meetings that were held as of the issuing of this report (See Appendix "M" for the presentation materials).

10.1. City of Portsmouth City Council Meeting – January 7th, 2019

Underwood Engineers, Inc. attended the 7:00 P.M. January 7th, 2019 Portsmouth City Council meeting at Portsmouth City Hall to present a PowerPoint project status update and preliminary findings. Items presented included:

- Description of the Breakfast Hill service area and its projected demands
- Description of the alternatives considered and the most feasible option (Scenario No. 2)
- Opinion of cost for Scenario No. 2
- Opinion of cost for the "backbone" phase of the project
- Brief description of a possible interim connection to Rye Water District

10.2. Town of Greenland Board of Selectmen Meeting – January 21st, 2019

Underwood Engineers, Inc. also attended the 7:00 P.M. January 21st, 2019 Town of Greenland Board of Selectman meeting at the Greenland Town Offices to also present a project status update and preliminary findings. The same PowerPoint presented at the Portsmouth City Council meeting was also presented to the Greenland Board of Selectmen.

11.Conclusions

11.1. Demands and Supply

- The Breakfast Hill service area consists of 245 improved properties (240 residential and 5 commercial).
- Greenland demands will be higher than projected in the 2013 Master Plan due to the expansion to the Breakfast Hill service area, which was not considered in the 2013 report.
- 2040 Average Day Demands increase from 0.21 MGD to 0.25 MGD.
- 2040 Max Day Demands increase from 0.31 MGD to 0.67 MGD. Irrigation flows are included.
- Overall City estimated projected demands from the 2013 Master Plan have not been met according to historic demand data. The Breakfast Hill area demands would not exceed the original 2013 projections.
- Present day supply in Portsmouth is adequate to meet the Breakfast Hill Area demands. However, as recommended in the 2013 Master Plan, satellite wells shall be considered for meeting future demands.

11.2. Storage

- Additional storage is needed to supply the Greenland area if it is going to be on its own pressure zone (Scenario No. 2). A 500,000-gallon tank is proposed.
- The Pease storage tanks would provide the proper HGL, but do not have enough capacity to serve Greenland (Scenario No. 3) including Breakfast Hill and a possible connection to Newington.
- Portsmouth main pressure zone would have adequate storage, but the hydraulic grade line is not adequate because pressures would be too low on Breakfast Hill Road (see below).
- Note, with proper set points, the PRV's used in Scenario #2 can be set to assist with fire flows such that the main pressure zone has access to the storage tank.

11.3. Hydraulic Grade Line

- Portsmouth's main pressure zone hydraulic grade line (171-ft) does not provide adequate pressures to serve all of the Breakfast Hill service area (Scenario No. 1). Just looping the transmission main from Post Road to Lafayette Road will not provide adequate supply/pressure.
- Due to hydraulic limitations, a new tank is needed in Greenland to maintain and improve available fire flow and pressure in the area.
- Raising the hydraulic grade line to 230-ft, equal to Pease's pressure zone, will provide adequate static pressures to the Greenland service (study) area, including the Breakfast Hill service area.

- An increased hydraulic grade line in Greenland would increase pressures in all of Greenland.
- A pumping station is recommended to serve the increased pressure zone in addition to the Greenland Well.

11.4. Water Modeling

- The hydraulic model of the City's water distribution system was used to evaluate the pressure and fire flow. Scenario #2 was the option of those considered that meets the goals of providing the following:
    - A minimum static pressure of 35 psi at the street. Note, the static pressure in the Breakfast Hill service area with an HGL of 230 will range from 39 psi to 76 psi.
    - Minimal impacts to the existing Portsmouth service areas in terms of pressure reduction or fire flow reduction. Note that this is dependent on whether the proposed booster pump station is running. See Attachment "I" for more details.

Compared to existing conditions, an extended time water age evaluation on Scenario #2 suggests that water age would decrease in some areas of the system and increase in others. Water age of the system could be managed with coordinated use of the Greenland Well, new booster pumping station and controlled tank drawdowns.

11.5. Phasing

- It is possible to phase the Breakfast Hill Area improvements
- At a minimum, the "backbone" of the system would need to be completed as Phase 1.
- Neighborhood projects can be completed in any order after that.

11.6. Opinion of Cost

- Scenario No. 2 is estimated to cost between $20.3M and 24.6M.
- Phase 1 (backbone) is estimated to cost between $11.2M and $13.6M. If pursued, it is recommended that a budget for the design phase portion of the backbone would be $610,000.

11.7. Rye Water District Interim Connection

- Due to high costs of extending Portsmouth water, an interim solution of expanding the Rye Water District wholesale agreement was considered for a portion of the Breakfast Hill area.
- Under the RWD's high pressure zone, HGL = 252-ft, static pressures would range from 45 psi to 83 psi within the Breakfast Hill service area.

- This option was considered for a portion of the Breakfast Hill area extending from Seavey Way to the PSNH easement. This includes:
    - 4,700 LF of 12” D.I. Water Main
    - 1,600 LF of 8” D.I. Water Main
    - 34 properties served
- Probable opinion of costs ranges from $2.5M and $3.0M for distribution piping. This does not include costs for any storage and supply improvement, if needed.
- This option was only considered in a very preliminary way. Although it appears feasible, additional study and coordination with RWD is needed if this option is pursued further.

12.Recommendations

Based on the evaluation above, if municipal water is to be provided to the Breakfast Hill Area by the Portsmouth system, the following is recommended:

- Greenland Scenario No. 2 - Standalone Greenland Pressure Zone provides the best long-term solution. Phase 1 Improvements would include:
    - 500,000-gallon elevated water storage tank set at HGL 230-ft located at the east end of Breakfast Hill Road).
    - Transmission main extension down Breakfast Hill Road from Post Road to Lafayette Road.
    - Proposed booster pumping station near the C&J Bus Station. Alternative pumping station location is Ocean Road.
    - A connection to the Pease system for redundancy.
    - Proposed pressure reducing valve (PRV) on Ocean Road to reduce pressure to the main pressure zone HGL.
    - Improvements to the Greenland Well pump to pump to increased hydraulic grade line. Consider replacing the 10" main from the well.
    - The recommended budget for the design of this phase is $610,000.
- Advance final design of the Phase 1 improvements and the neighborhoods that Greenland would like serve.
    - Phase 1 Final design budget is recommended at $610,000.
    - Neighborhood design fees can be provided upon request.
    - As part of the design phase work, evaluate the potential for an interim solution that would serve a portion of the Breakfast Hill area from the Rye Water District. Additional budget would be needed depending on the scope.
- Additional evaluation is recommended to optimize the design and operation of the system to manage water quality and fire flows.
    - Consider alternative pumping station location, i.e., Ocean Road.
    - Potential loop (future) from Breakfast Hill Road to the City system on Lafayette Road (~4,000 feet).
- Later phases shall include water main distribution improvements to the neighborhoods off of Breakfast Hill Road.
    - Maple Drive/Sunnyside Drive Neighborhood (6,000 LF of pipe, 63 connections)
    - Coombs Farm Road/Windsor Green Road Neighborhood (2,500 LF of pipe, 25 connections)
    - Stone Meadow Way/Berry Farm Lane Neighborhood (1,600 LF of pipe, 14 connections)

- September Drive/October Drive Neighborhood (4,100 LF of pipe, 26 connections)
- Falls Way Neighborhood (12,400 LF of pipe, 77 connections)

TOWN OF STRATHAM
TOWN OF GREENLAND

POST RD. (RT. 151)

I-95 INTERSTATE

CITY OF PORTSMOUTH
TOWN OF GREENLAND

OCEAN RD

TOWN OF GREENLAND

BREAKFAST HILL RD.

TOWN OF RYE

LAFAYETTE ROAD ROUTE 1

CITY OF PORTSMOUTH
TOWN OF RYE

LAFAYETTE LOOP
TO CITY LINE

N

POST RD. (RT. 151)

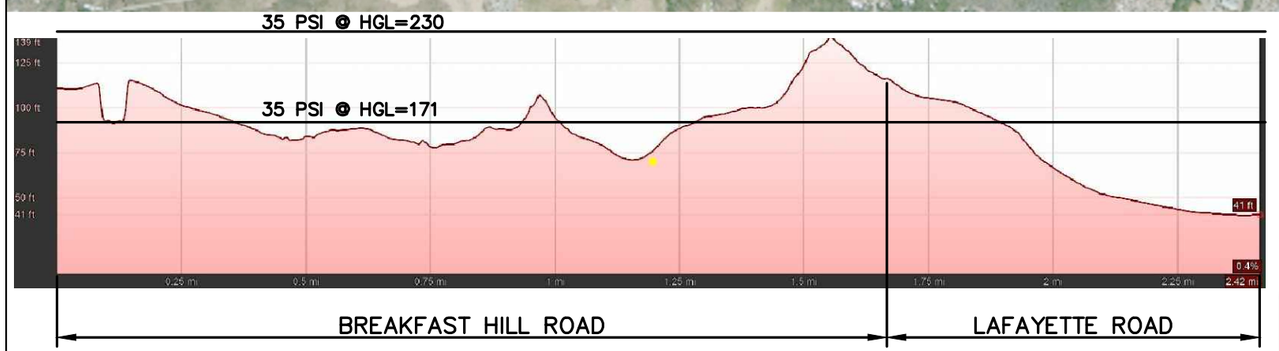
TOWN OF
GREENLAND
TOWN OF
NORTH HAMPTON

I-95 INTERSTATE

LEGEND:

EXISTING WATER SYSTEM
PROPOSED WATER
BREAKFAST HILL ROAD
SERVICE AREA

1800 0 1800
SCALE: 1 INCH = 1800FT.

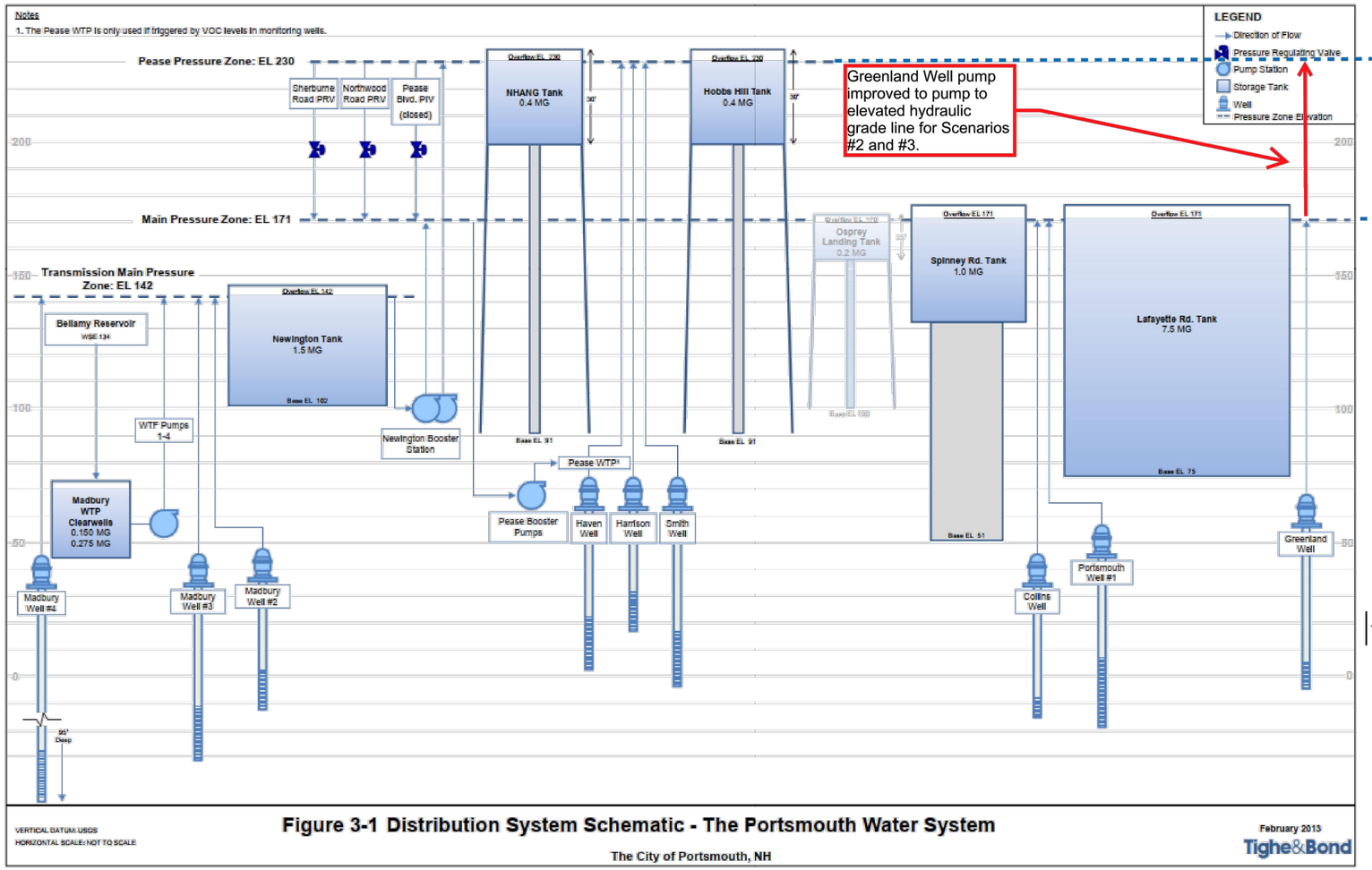


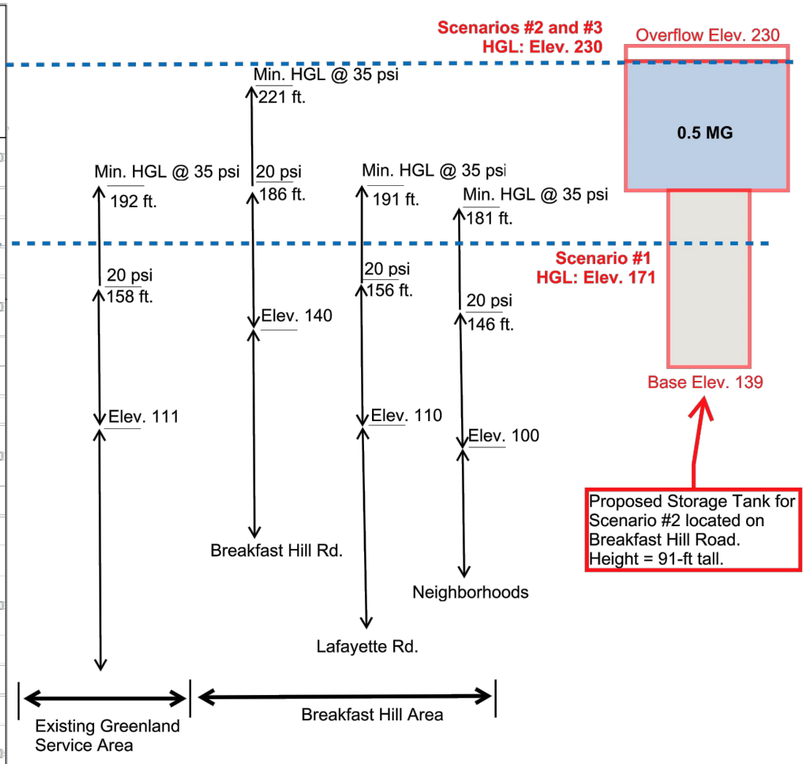
PROFILE

(NOT TO SCALE)

DATE MAR 2019 PROJECT 2303	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	ATTACHMENT "A" – SCENARIO #1 BREAKFAST HILL AREA WATER MAIN EXTENSION TOWN OF GREENLAND, NH	FIG. 1

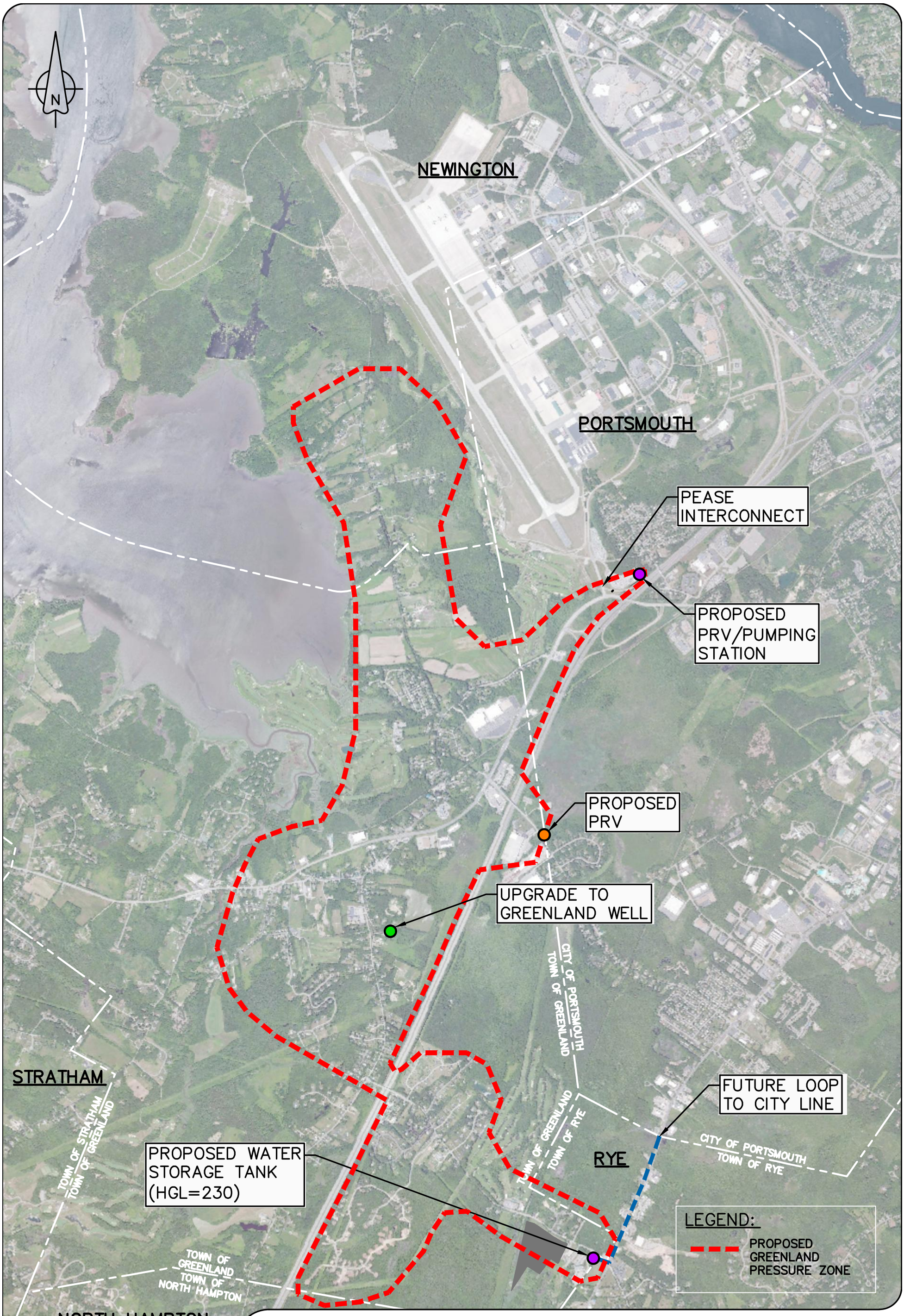
H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 2-19.dwg, 2303 FIG 1-, 3/18/2019 5:12:20 PM, mah





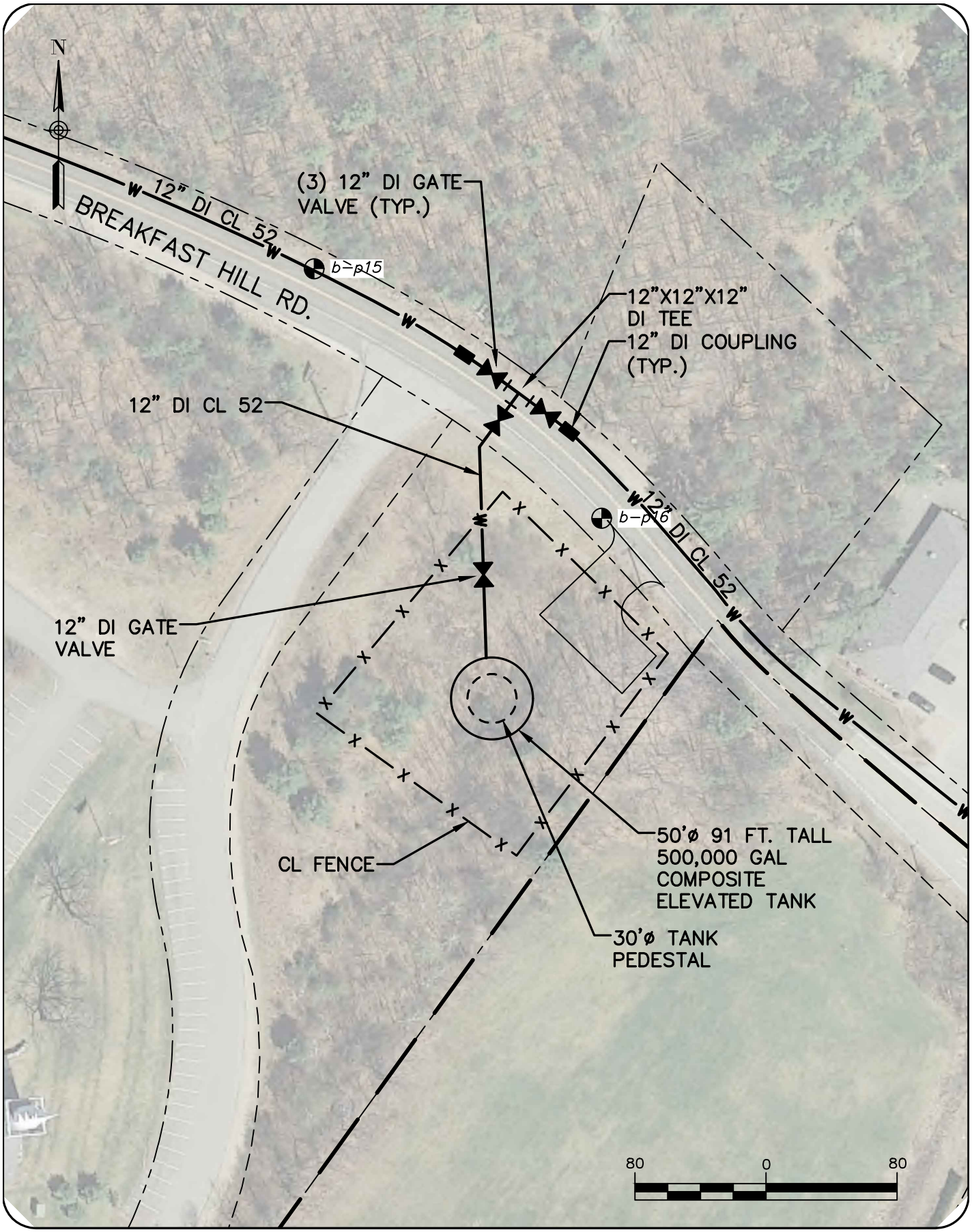
DATE MAR 2019	UNDERWOOD engineers	ATT. "B"– SYSTEM HYDRAULICS BREAKFAST HILL AREA WATER MAIN EXTENSION TOWN OF GREENLAND, NH	FIG. 2
PROJECT 2303	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603–436–6192 Fax. 603–431–4733		

H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 2-19.dwg, 2303 FIG 2-, 3/18/2019 4:21:02 PM, mah



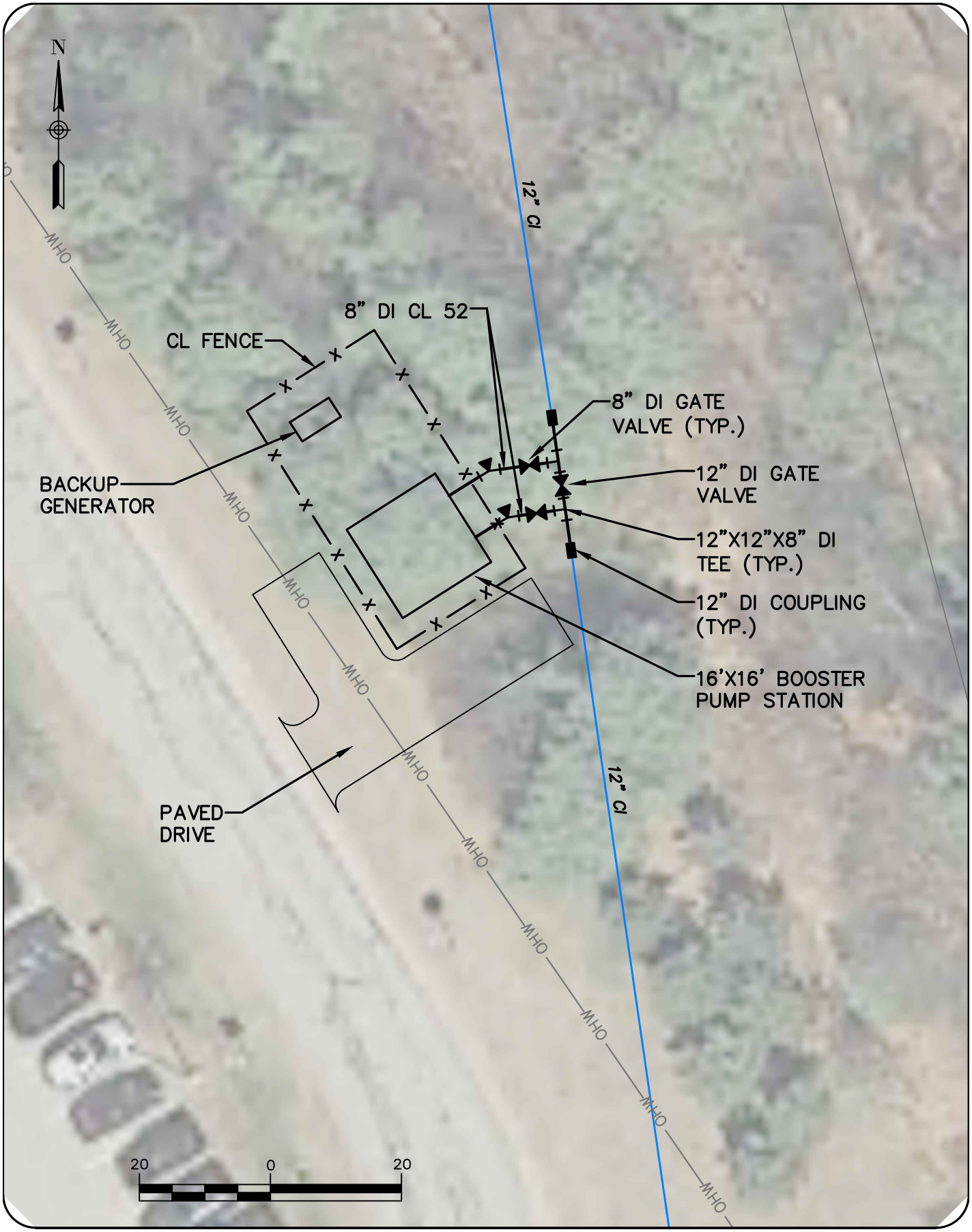
DATE MAR 2019 PROJECT 2303	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	ATTACHMENT "C" – SCENARIO #2 BREAKFAST HILL AREA WATER MAIN EXTENSION TOWN OF GREENLAND, NH
		FIG. 3

H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 3-19.dwg, 2303 FIG 3-, 3/20/2019 3:34:05 PM, mah



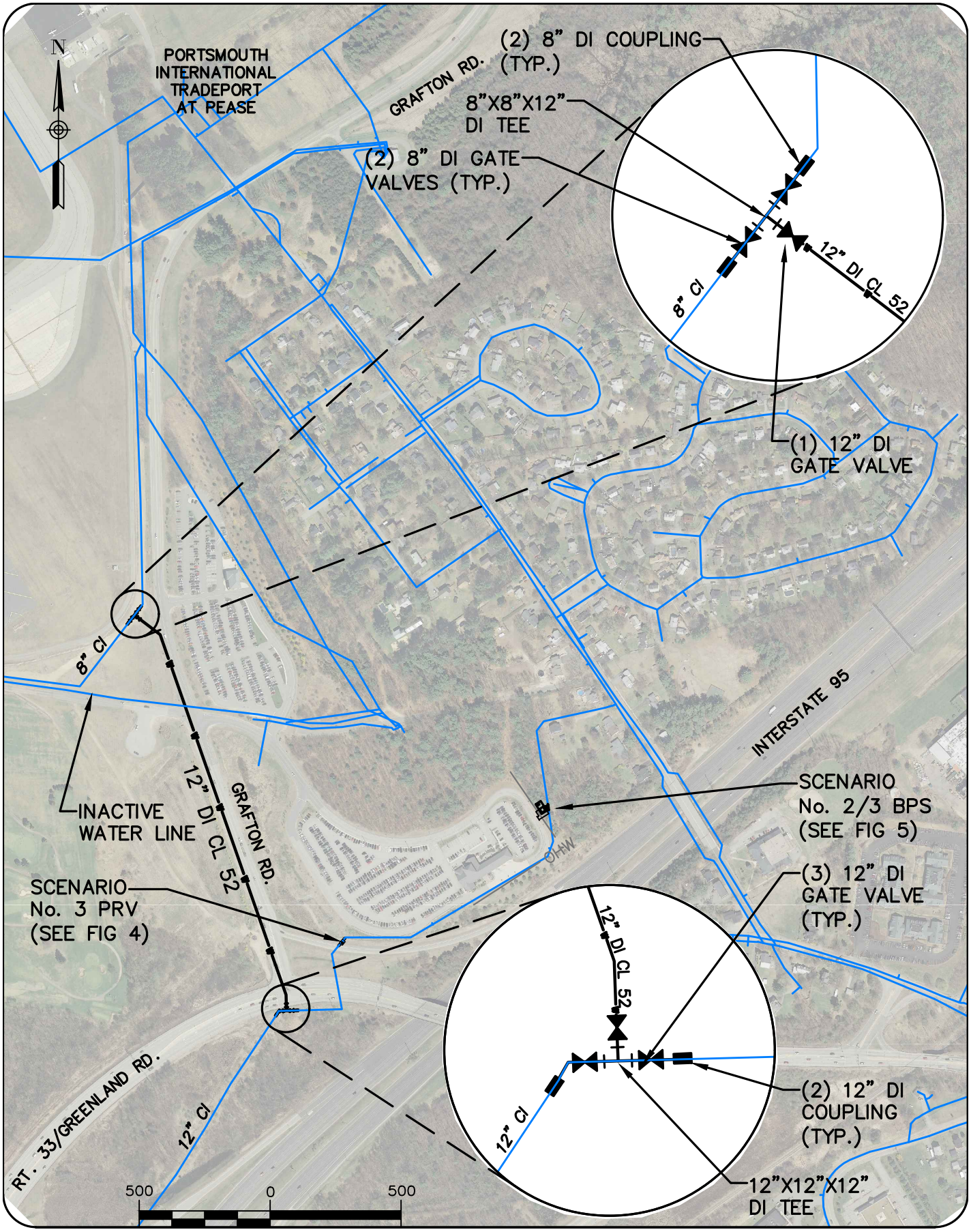
DATE MAR 2019 PROJECT 2303	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	ATTACHMENT "D" SCENARIO No. 2 - CONCEPTUAL TANK SITE PLAN TOWN OF GREENLAND GREENLAND, NEW HAMPSHIRE	FIG. 4

H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 2-19.dwg, 2303 FIG 4-, 3/18/2019 4:21:43 PM, mah



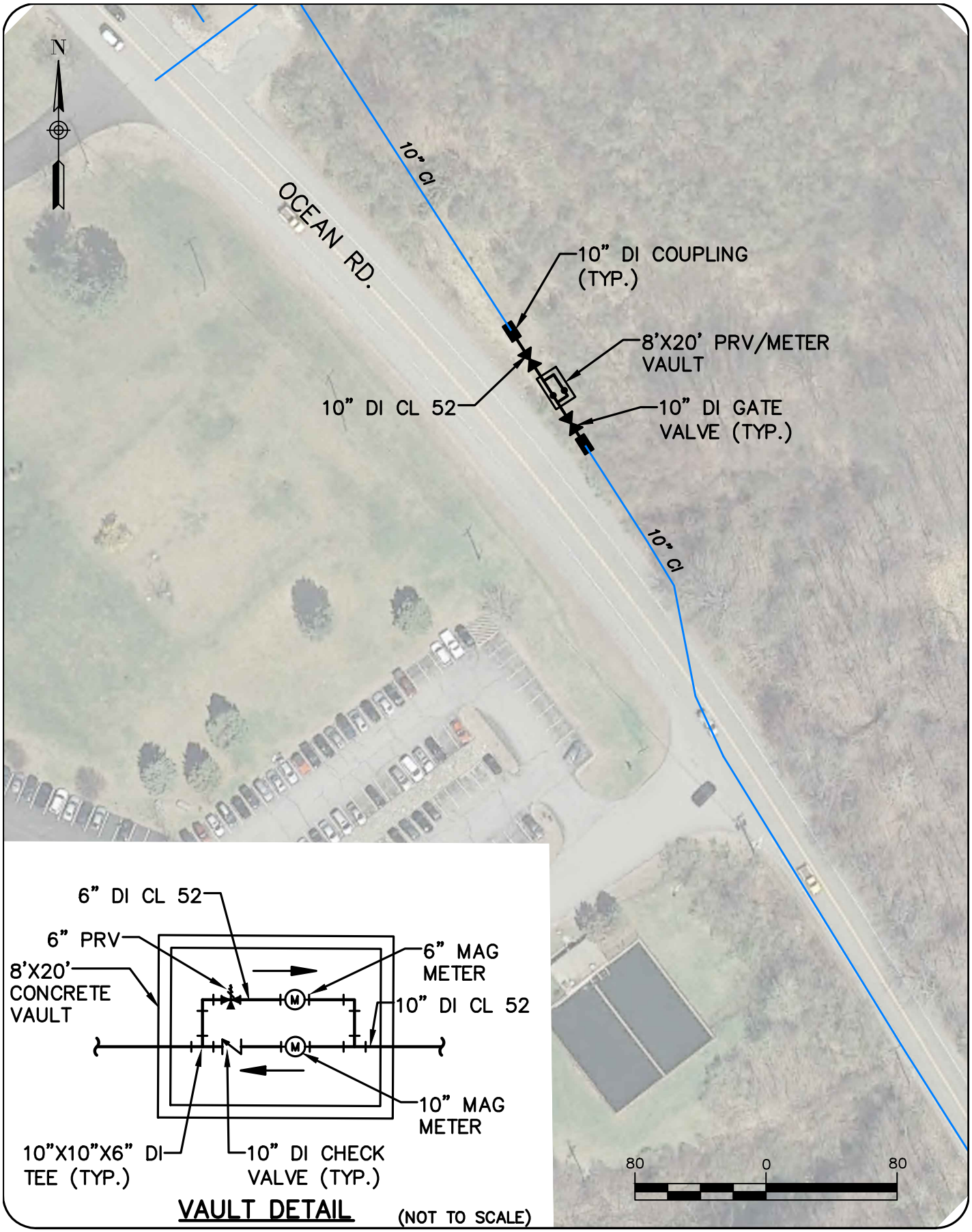
DATE		ATTACHMENT "E"	FIG.
MAR 2019	UNDERWOOD engineers	SCENARIO No. 2/3 – CONCEPTUAL BPS SITE PLAN	5
PROJECT 2303	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603–436–6192 Fax. 603–431–4733	TOWN OF GREENLAND GREENLAND, NEW HAMPSHIRE	

H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 3-19.dwg, 2303 FIG 5- (2), 3/20/2019 3:19:46 PM, mah



DATE MAR 2019 PROJECT 2303	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	ATTACHMENT "F" SCENARIO No. 2/3 – PEASE INTERCONNECT TOWN OF GREENLAND GREENLAND, NEW HAMPSHIRE	FIG. 6

H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 3-19.dwg, 2303 FIG 6-, 3/20/2019 3:33:02 PM, mah

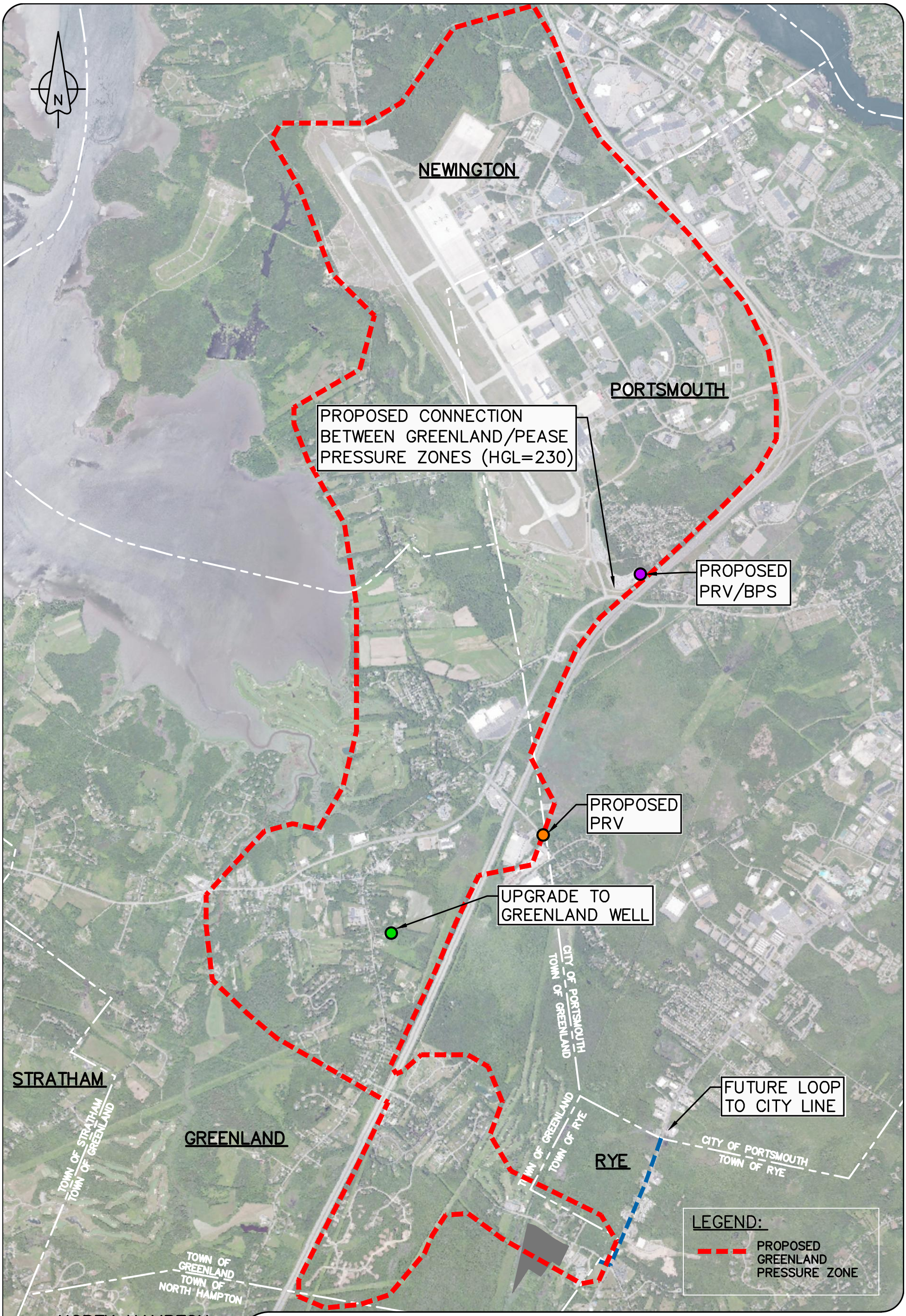


VAULT DETAIL

(NOT TO SCALE)

DATE MAR 2019 PROJECT 2303	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	ATTACHMENT "G" SCENARIO No. 2/3-OCEAN ROAD. PRV/METER VAULT TOWN OF GREENLAND GREENLAND, NEW HAMPSHIRE	FIG. 7

H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 2-19.dwg, 2303 FIG 7., 3/18/2019 4:23:30 PM, mah



DATE MAR 2019 PROJECT 2303	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	ATTACHMENT "H" – SCENARIO No. 3 BREAKFAST HILL AREA WATER MAIN EXTENSION TOWN OF GREENLAND, NH	FIG. 8

H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 3-19.dwg, 2303 FIG 8-, 3/20/2019 3:32:23 PM, mah

Attachment "I"

UNDERWOOD engineers

25 Vaughan Mall
Portsmouth, NH, 03801-4012
Tel: 603-436-6192 Fax: 603-431-4733

Technical Memorandum

To: UE Project File (#2303)

From: Keith Pratt, P.E. and Erik Nichols, E.I.T.

Date: March 25, 2019

Subject: Breakfast Hill Service Area Hydraulic Model Evaluation

1. BACKGROUND

The City of Portsmouth's (City) 2013 Water Master Plan, developed by Tighe & Bond, identified fire flow and water age deficiencies within portions of the City's water distribution system including within the Town of Greenland. The Town of Greenland is interested in extending the water system to include Breakfast Hill Road and provide municipal water to the residential and commercial users in the area.

The City has tasked Underwood Engineers (UE) to evaluate system improvements and impacts that would be needed to provide municipal service to the Breakfast Hill Area using the City's existing hydraulic water model maintained by Weston and Sampson. The model includes both steady-state and extended time period scenarios.

2. REVIEW OF EXISTING INFORMATION

The following information was used during the evaluation:

- Existing water model in Infowater (Innovyze) provided by Weston and Sampson
- Water system GIS, provided by Weston and Sampson
- City of Portsmouth's Water Master Plan (Tighe & Bond, 2013)
- Tax Map information to develop average day and max day demands based on users.
- ISO Reports provided by the City
- Discussions with City Staff

3. UPDATING THE EXISTING WATER MODEL

Based on our review of the above information, UE made the following updates to the model to incorporate the Breakfast Hill Service Area:

Calibration

Calibrating the City's existing hydraulic was not part of this scope of work and the water model provided is assumed to be up to date. To confirm, UE ran existing conditions within the model

and found results were consistent with the predicted available fire flows and water age values within the 2013 Water Master Plan.

Demands

Underwood Engineers updated the demands within the model based on the projected demands from the Water Master Plan, and estimated demands within the Breakfast Hill Service Area:

- **2018 Average Day Demands (ADD) = 4.96 MGD**
  Note: The City's existing model used an ADD of 4.22 MGD. A multiplier was used to increase the ADD to the 4.92 MGD 2018 projections in the Water Master Plan plus the Breakfast Hill Service area to a predicted amount of 4.96 MGD.
- **2018 Max Day Demands (MDD) = 8.75 MGD**
  Note: The model's existing MDD was greater than the projected MDD identified in the City's Master Plan (8.46 MGD vs. 7.82 MGD). UE used the higher value and added the Breakfast Hill Service Area, to reach the 2018 predicted MDD of 8.75 MGD.
- **2040 Max Day Demands (MDD) = 9.74 MGD**
  Note: A multiplier was applied to the 2018 MDD in order to meet the projected 2040 MDD.

Scenarios

Underwood Engineers created three (3) scenarios to provide municipal water to the Breakfast Hill Service Area:

- **Scenario No. 1: Loop between Breakfast Hill Road and Lafayette Road**
  - Added approximately 9,000 LF of 12" DI Pipe (C=100) on Breakfast Hill Road from the existing pipe located on Post Road to the end of the service area on Lafayette Road.
  - Connect the Breakfast Hill Service Area to the existing water system limit on Lafayette Road with approximately 3,800 LF of 12" DI Pipe (C=100).
  - Breakfast Hill stays within the Portsmouth Main Pressure Zone

- **Scenario No. 2: Greenland Standalone Pressure Zone (Breakfast Hill Tank)**
  - Greenland becomes its own pressure zone (HGL = 230-ft.), equal to the Pease pressure zone
  - A booster pumping station for emergency supply from the Portsmouth Main Pressure Zone to the Greenland Pressure Zone.
  - Added approximately 9,000 LF of 12" DI Pipe (C=100) on Breakfast Hill Road from the existing pipe located on Post Road to the end of the service area on Lafayette Road.
  - New elevated water storage tank on Breakfast Hill Road
    - Volume: 500,000-gal
    - HGL: 230-ft (Initial setting @ 225-ft)
  - Pease interconnection on Grafton Road (normally off)
  - Pressure Reducing Valve on Ocean Road and Greenland Road to maintain an upstream (Greenland) pressure of 77 psi.

- Upgrade to the Greenland Well Pump with possible replacement of the existing 10" pipe from the well (Design point 400 gpm @ 280 TDH).
    - Design/modeling results do not include replacing the pipe

- **Scenario No. 3: Greenland Pease Connection**
    - Connect Greenland to the Pease Pressure Zone with approximately 1,700 LF of 12" Pipe from Greenland Road to the existing 8" pipe within the Pease Pressure Zone on Grafton Road.
    - Added approximately 9,000 LF of 12" DI Pipe (C=100) on Breakfast Hill Road from the existing pipe located on Post Road to the end of the service area on Lafayette Road.
    - Pressure Reducing Valve on Ocean Road and Greenland Road to maintain an upstream (Greenland) pressure of 77 psi.
    - Booster pumping station for emergency supply from the Portsmouth Main Pressure Zone into the Greenland Pease Pressure Zone.
    - Pressure Reducing Valve on Ocean Road
    - Upgrade to the Greenland Well Pump with possible replacement of the existing 10" pipe from the well (Design point 400 gpm @ 280 TDH).
        - Design/modeling results do not include replacing the pipe

4. AVAILABLE FIRE FLOW ANALYSIS

UE incorporated each scenario noted above to evaluate the available fire flows at six (8) different locations across the municipal water system as shown in Figure 1 (Attached). The following system settings were used during the fire flow evaluation:

- 2018 MDD = 8.75 MGD
- 2040 MDD = 9.73 MGD
- Time evaluation @ 0.0 hrs
- Greenland Well On
- Madbury Wells 3 & 4 On
- Portsmouth Well Off
- Collins Well Off
- Smith Well Off
- NHANG Tank = 223'
- Hobbs Hill Tank = 223'
- Lafayette Tank = 160'
- Newington Tank = 135'
- Spinney Road Tank = 162'
- New Greenland Tank = 225'

Available fire flows were evaluated at 2018 MDD and 2040 MDD. Tables 1 and 2 below show the available fire flows for each scenario:

Table 1: Available Fire Flows at 2018 MDD

		Scenario No. 1	Scenario No. 2		Scenario No. 3
		Lafayette Loop Connection (HGL = 161 ft)	New Greenland Standalone Pressure Zone (Breakfast Hill Tank, HGL= 230 ft)	Greenland Tank and Booster Pumping Station (500 gpm, HGL = 230)	Connection To Pease Pressure Zone (HGL = 230 ft), with 500 gpm Fire Pump
Location	**Available Fire Flow (gpm)**	**Available Fire Flow (gpm)**	**Available Fire Flow (gpm)**	**Available Fire Flow (gpm)**	**Available Fire Flow (gpm)**
Breakfast Hill Road (Greenland)	N/A	65	5,670	6,225	420
Riverside Drive (Greenland)	1,120	350	1,460	1,585	1,045
Newington Road (Greenland)	230	255	275	450	400
Tuttle Road (Greenland)	980	345	1,080	1,295	1,050
Greenland Road	1,500	550	1,690	1,515	1,350
Lafayette Road (Portsmouth)	385	115	390	380	380
Pannaway Manor (Portsmouth)	1,140	1,075	1,160	690	690
Islington Street (Portsmouth)	6,700	6,330	6,720	3,885	3,885

Note 1: The available fire flows stated above maintain a minimum residual pressure of 20 psi across the entire system.
Note 2: It should be noted that the drops in available fire flow on Islington Street for Scenarios 2 and 3 are due to the Booster Pumping Station's impacts to the residual pressures within the Portsmouth Main Pressure Zone.

Table 2: Available Fire Flows at 2040 MDD

	Scenario No. 1		Scenario No. 2		Scenario No. 3
		Lafayette Loop Connection (HGL = 161 ft)	New Greenland Standalone Pressure Zone (Breakfast Hill Tank, HGL= 230 ft)	Greenland Tank and Booster Pumping Station (500 gpm, HGL = 230)	Connection To Pease Pressure Zone (HGL = 230 ft), with 500 gpm Fire Pump
Location	**Available Fire Flow (gpm)**	**Available Fire Flow (gpm)**	**Available Fire Flow (gpm)**	**Available Fire Flow (gpm)**	**Available Fire Flow (gpm)**
Breakfast Hill Road (Greenland)	N/A	35	6,100	6,410	400
Riverside Drive (Greenland)	1,120	150	1,150	1,605	985
Newington Road (Greenland)	230	250	370	450	400
Tuttle Road (Greenland)	980	150	1,040	1,310	985
Greenland Road	1,500	350	975	1,530	1,275
Lafayette Road (Portsmouth)	385	40	375	375	375
Pannaway Manor (Portsmouth)	1,140	1,065	1,065	520	520
Islington Street (Portsmouth)	6,700	6,330	6,330	3,140	3,140

Note 1: The available fire flows stated above maintain a minimum residual pressure of 20 psi across the entire system.
Note 2: It should be noted that the drops in available fire flow on Islington Street for Scenarios 2 and 3 are due to the Booster Pumping Station's impacts to the residual pressures within the Portsmouth Main Pressure Zone.

As shown in Tables 1 and 2 above, the only scenario that provides significant fire flows to the Greenland portion of the distribution system while maintaining a minimum residual pressure of 20 psi is Scenario No. 2: Greenland Pressure Zone (Breakfast Hill Tank). The Portsmouth Main Pressure Zone (HGL 171') in Scenario No. 1 does not provide sufficient fire flows to the Breakfast Hill Area (Elevation ~ 142'). Scenario No. 3 also does not provide sufficient fire flows to the Breakfast Hill Area.

5. EXTENDED PERIOD SIMULATION (WATER AGE)

The existing model provided by Weston & Sampson was previously calibrated for Extended Period Simulations with demand patterns in place for different sectors of the City's system (e.g. Portsmouth Main, Pease Industrial, Golf Courses, etc.). The existing patterns used for the Greenland demands within the model were applied to the estimated Breakfast Hill demands.

Existing Conditions

UE used the compared the existing model with the water age results (@ 200 hrs) to the results within the 2013 Water Master Plan. The existing conditions matched fairly closely with a majority of the Master Plan results (specifically the Portsmouth Main Pressure Zone). The results show that portions within the Pease Pressure Zone, the Lafayette Tank Area, experience higher peaks of water age during the 200-hour evaluation. These may be attributed to possible system changes since the 2013 evaluation, model updates since 2013, or longer extended period simulation run times. It should be noted that the water age within the Lafayette Tank did not stabilize and continued to increase with time. This is most likely due to low turnover within the tank.

With the estimated increase for the 2018 ADD (4.96 MGD), portions of the system's max water age improved. Specifically, the areas located around the City's wells and within Greenland, while the impact to the rest of the City's water age appeared to be minor. Figure 2 attached identifies the predicted water age for existing conditions. A water age calibration is recommended to confirm the models results.

Breakfast Hill Service Scenarios

Figures 3 through 5 show the max water ages predicted by the model for each scenario over a 500-hour simulation. 500-hours was used for these evaluations, due to the predicted time it would take for the new Greenland Tank to stabilize. Table 3 below identifies the max water age for each scenario at the evaluation points identified during the fire flow analysis:

Table 3: Max Water Age at Evaluation Points

		Scenario No. 1	Scenario No. 2	Scenario No. 3
	Existing Conditions	Lafayette Loop Connection (HGL = 161 ft)	New Greenland Standalone Pressure Zone (Breakfast Hill Tank, HGL= 230 ft)	Connection To Pease Pressure Zone (HGL = 230 ft), No Pump
Location	**Max Water Age (hrs)**	**Max Water Age (hrs)**	**Max Water Age (hrs)**	**Max Water Age (hrs)**
Breakfast Hill Road (Greenland)	N/A	331	175	175
Riverside Drive* (Greenland)	87	80	220	95
Newington Road* (Greenland)	350	350	380	360
Tuttle Road* (Greenland)	145	140	100	145
Greenland Road	17	17	88	32
Lafayette Road (Portsmouth)	421	421	435	425
Pannaway Manor (Portsmouth)	28	28	85	38
Islington Street (Portsmouth)	15	15	40	27

***High water age in these points are due to low water demands and their location on distribution spurs with no looping.

The addition of a water storage tank (Scenario 2) on Breakfast Hill Road is needed to provide adequate fire flows within the existing Greenland portion of the system and on Breakfast Hill Road and is recommended. This tank as shown in Table 3 above and in Figure 4 increases the water age within some of the areas in Greenland. UE evaluated additional control settings for Scenario No. 2 to determine whether improvements to the system's water age could be made. These evaluations included an alternative with a Lafayette Loop Connection (and PRV) to supply portions of Lafayette Road from the Greenland Tank and a separate alternative with a booster pump located on Ocean Road (no Lafayette Loop) to induce greater demand within the Portsmouth System and pump water into Greenland. The Lafayette alternative did not significantly improve the water age within either Portsmouth or Greenland and was not further evaluated. The Ocean Road booster pump alternative increased the max water age within a majority of Greenland and did not make significant improvements to the Portsmouth system's water age.

UE also evaluated the impact to system water age of placing the new Greenland Tank at the Greenland Well site. Placing the tank closer to the water source did lower the system's water age within Greenland. However, the lower elevation of this site compared to the Breakfast Hill location would not provide the needed fire flows due to the lower HGL. Since these alternatives did not improve the max water age near the Lafayette Tank, the initial system improvements for Scenario No. 2, as described above, are recommended. It should be noted that with Scenario 2, water age could be further managed through PRV settings and pump settings to allow more water from the Greenland Well into the main pressure zone.

6. CONCLUSIONS

Underwood Engineers offers the following conclusions based on the above findings:

Available Fire Flows

- Greenland currently has low available fire flows within their portion of the distribution system.
- Scenario No. 1: Lafayette Loop
    - Cannot provide enough available fire flows or adequate pressures due to the low HGL (171') compared to the Breakfast Hill Area (Ground Elevation ~ 142').
- Scenario No. 2: Greenland Standalone Pressure Zone (Breakfast Hill Tank)
    - Provides adequate (> 35 psi) static pressure to the Breakfast Hill Area.
    - Increases the available fire flows to the majority of the Greenland portion of the distribution system.
    - Available fire flows within the City of Portsmouth do not decrease by more than 10% with proper system operation (i.e. booster pumping station is off).
- Scenario No. 3: Pease Connection
    - Provides adequate (> 35 psi) static pressure to the Breakfast Hill Area.
    - Does not significantly improve available fire flows over existing conditions.

Water Age Analysis

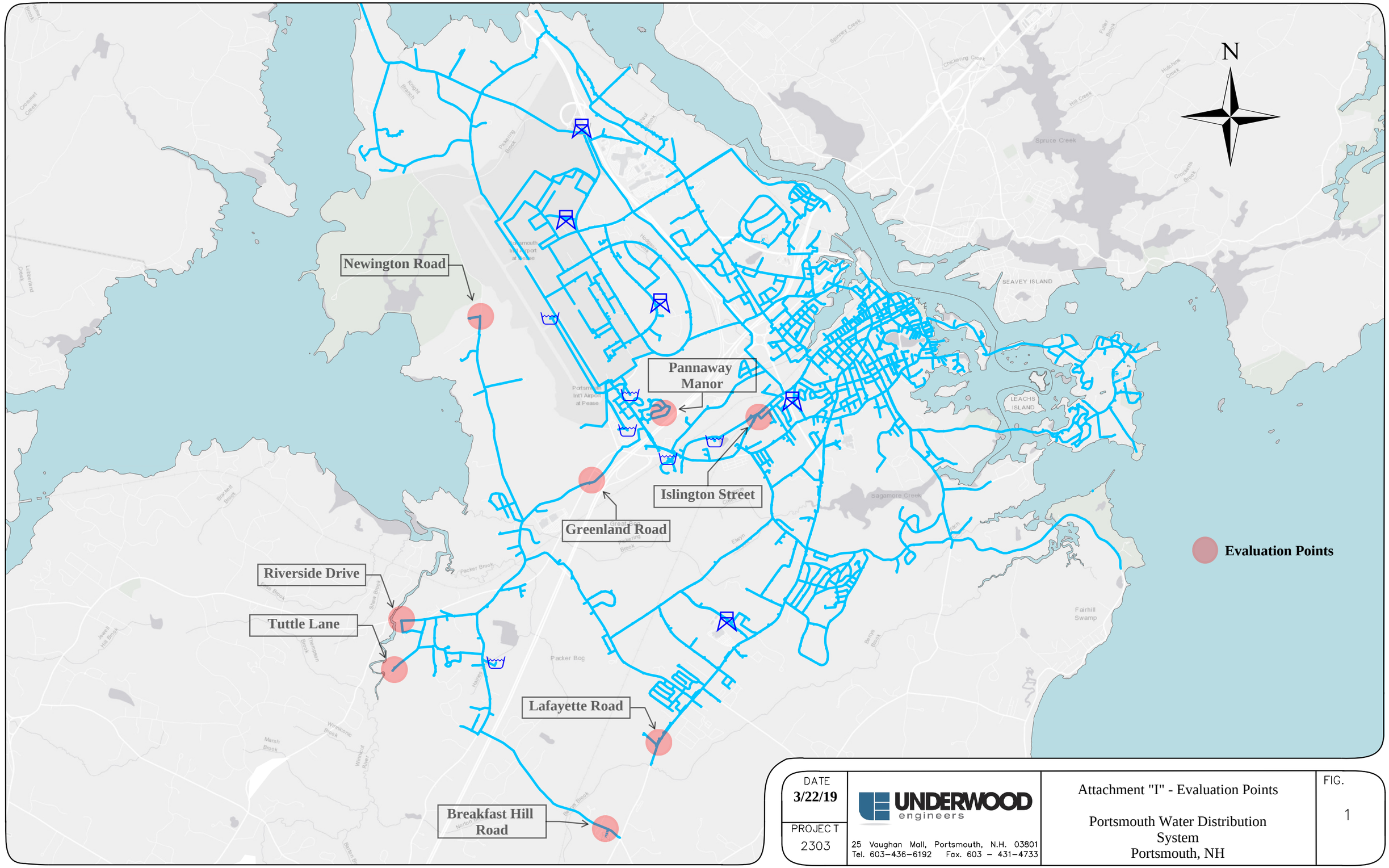
- Existing Conditions
    - The water model predicts that the age of water is greater in areas around the Lafayette Tank and the Pease Pressure Zone than previously predicted in the 2013 Water Master Plan.
    - Water age continues to increase over time within the Lafayette Tank due to low turnover.
- Scenario 1: Lafayette Loop
    - Water age conditions improve within the Greenland portion of the system near the Greenland Well.
    - Water age is greater than 300 hours along Breakfast Hill Road due to low demands and connection to the Lafayette Tank Area.
- Scenario 2: Greenland Standalone Pressure Zone (Breakfast Hill Tank)
    - Water age increases within the system due to the addition of the water storage tank on Breakfast Hill Road.

- Water age can be managed through valve and pump settings to improve conditions along Breakfast Hill Road.
- Scenario 3: Pease Connection
  - Breakfast Hill Road water age is at its lowest.

7. RECOMMENDATIONS

UE offers the following recommendations:

- Proceed with planning for Scenario 2: Greenland Standalone Pressure Zone and a new water storage tank on Breakfast Hill Road in order to improve the fire flows and pressures within the Greenland portion of the system.
- Evaluate additional system controls within the model to promote faster turnover within the recommended Breakfast Hill Tank to lower water age within the system.
- Perform water age calibration evaluations to confirm model results during final design.
- Confirm results with City's consultant.



DATE **3/22/19**	UNDERWOOD engineers	Attachment "I" - Evaluation Points	FIG. 1
PROJECT 2303	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603 - 431-4733	Portsmouth Water Distribution System Portsmouth, NH	

N

Legend

Pipe

MAX_QUAL

- less than 15.00
- 15.00 ~ 30.00
- 30.00 ~ 100.00
- 100.00 ~ 200.00
- 200.00 ~ 500.00

DATE 3/22/2019	UNDERWOOD engineers	Water Age Analysis Existing Conditions (2018 ADD) Portsmouth, NH	FIG. 2
PROJECT 2303	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603 - 431-4733		

N

SEAVEY ISLAND

LEACHS ISLAND

Portsmouth Int'l Airport at Pease

Great Bog

Packer Bog

Spruce Creek

Sagamore Creek

Fairhill Swamp

Legend

Pipe

MAX_QUAL

- less than 15.00
- 15.00 ~ 30.00
- 30.00 ~ 100.00
- 100.00 ~ 200.00
- 200.00 ~ 500.00

DATE **3/22/19**	UNDERWOOD engineers	Water Age Analysis Scenario No. 1 Lafayette Loop Portsmouth, NH	FIG. 3
PROJECT 2303	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603 - 431-4733		

N

SEAVEY ISLAND

LEACHS ISLAND

Portsmouth Int'l Airport at Pease

Great Bog

Packer Bog

Spruce Creek

Sagamore Creek

Fairhill Swamp

Legend

Pipe

MAX_QUAL

- less than 15.00
- 15.00 ~ 30.00
- 30.00 ~ 100.00
- 100.00 ~ 200.00
- 200.00 ~ 500.00

DATE 12/11/18 PROJECT 2303	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603 - 431-4733	Water Age Analysis Scenario No. 2 Greenland Standalone PZ Portsmouth, NH	FIG. 4

N

Legend

Pipe

MAX_QUAL

- less than 15.00
- 15.00 ~ 30.00
- 30.00 ~ 100.00
- 100.00 ~ 200.00
- 200.00 ~ 500.00

DATE 12/11/18	UNDERWOOD engineers	Water Age Analysis Scenario No. 3 Pease Connection Portsmouth, NH	FIG. 5
PROJECT 2303	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603 - 431-4733		

Attachment "J"

Breakfast Hill Area Water Main Extension

Opinion of Costs

2/22/2019

Item	Scenario No. 2	Scenario No. 2 - Phase 1
8" Water Main (27,500 LF)	$ 6.19 Million	$ - Million
12" Water Main (10,600 LF)	$ 2.86 Million	$ 2.86 Million
I-95 Bridge Crossing	$ 0.50 Million	$ 0.50 Million
Rock Removal	$ 0.45 Million	$ 0.45 Million
0.5 Million Gal. Tank	$ 2.00 Million	$ 2.00 Million
Booster Pump Station	$ 1.00 Million	$ 1.00 Million
PRV/Meter Vault	$ 0.30 Million	$ 0.30 Million
Greenland Well Pump	$ 0.10 Million	$ 0.10 Million
SCADA Improvements	$ 0.10 Million	$ 0.10 Million
Subtotal	**$13.50 Million**	**$ 7.31 Million**
Contingency (25%)	$ 3.37 Million	$ 1.83 Million
Engineering (20%)	$ 2.70 Million	$ 1.46 Million
Subtotal	$19.57 Million	$ 10.60 Million
2018 Dollars Total (Rounded)	$ 20.0 Million	$ 11.0 Million
Range - Low (-5%)	$ 19.0 Million	$ 10.5 Million
Range - High (15%)	$ 23.0 Million	$ 12.7 Million
2020 Dollars Total	**$ 21.4 Million**	**$ 11.8 Million**
Range - Low (-5%)	**$ 20.3 Million**	**$ 11.2 Million**
Range - High (15%)	**$ 24.6 Million**	**$ 13.6 Million**

Notes

1. Pipe quantity includes costs for the Pease Interconnect.
2. 2020 dollars assume an inflation rate of (3.5% per year).

PHASE 1 IMPROVEMENTS ALSO INCLUDE:
- PRV ON OCEAN ROAD
- BOOSTER PUMP STATION
- PEASE INTERCONNECT

NOTE: LATER PHASES WILL INCLUDE WATER MAIN DISTRIBUTION IMPROVEMENTS TO THE LABELED NEIGHBORHOODS.

APPROX. LOCATION GREENLAND WELL

PHASE 1: GREENLAND WELL IMPROVEMENT

NEIGHBORHOOD #2 COOMBS FARM ROAD & WINDSOR GREEN ROAD

NEIGHBORHOOD #1 SUNNYSIDE DRIVE & MAPLE DRIVE

INTERSTATE 95 BRIDGE CROSSING

NEIGHBORHOOD #3 SEPTEMBER DRIVE

PHASE 1 IMPROVEMENTS

NEIGHBORHOOD #4 FALLS WAY

NEIGHBORHOOD #5 STONE MEADOW WAY & BERRY FARM ROAD

PHASE 1: ELEVATED STORAGE TANK

NEIGHBORHOOD #7 SEAVEY WAY

FORMER RYE LANDFILL

NEIGHBORHOOD #6 BREAKFAST HILL ROAD & LAFAYETTE ROAD

FORMER COAKLEY LANDFILL

GROUNDWATER MANAGEMENT ZONE

POST RD. (RT. 151)

I-95 INTERSTATE

BREAKFAST HILL RD.

LAFAYETTE ROAD

ROUTE 1

OCEAN RD

CITY OF PORTSMOUTH
TOWN OF GREENLAND

TOWN OF GREENLAND
TOWN OF RYE

CITY OF PORTSMOUTH
TOWN OF RYE

TOWN OF GREENLAND
TOWN OF NORTH HAMPTON

LEGEND:

- EXISTING CITY OF PORTSMOUTH WATER
- MAIN PROPOSED WATER MAIN EXTENSION

NOTES:
1. FOR THE PURPOSES OF THIS EVALUATION, A 12" WATER MAIN WAS ASSUMED FOR BREAKFAST HILL ROAD. THE NEIGHBORHOOD AREA IS ASSUMED TO BE 8".

2000 0 2000
SCALE: 1 INCH = 2000FT.

DATE MAR 2019 PROJECT 2303	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	ATTACHMENT "K" BREAKFAST HILL AREA PORTSMOUTH WATER MAIN EXTENSION TOWN OF GREENLAND, NH	FIG. 9

H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 2-19.dwg, 2303 FIG 9-, 3/18/2019 5:07:36 PM, mah

POST RD. (RT. 151)

I-95 INTERSTATE

TOWN OF STRATHAM
TOWN OF GREENLAND

POST RD. (RT. 151)

TOWN OF GREENLAND
TOWN OF NORTH HAMPTON

I-95 INTERSTATE

CITY OF PORTSMOUTH
TOWN OF GREENLAND

OCEAN RD

BREAKFAST HILL RD.

TOWN OF GREENLAND

TOWN OF RYE

LAFAYETTE ROAD

ROUTE 1

CITY OF PORTSMOUTH
TOWN OF RYE

POSSIBLE EXPANDED WHOLESALE AREA

EXISTING WHOLESALE AREA

N

LEGEND:

- EXISTING WATER SYSTEM
- PROPOSED WATER
- BREAKFAST HILL ROAD SERVICE AREA
- EXISTING WHOLESALE AREA
- POSSIBLE EXPANDED WHOLESALE AREA

1800 0 1800

SCALE: 1 INCH = 1800FT.

PROFILE

(NOT TO SCALE)

DATE MAR 2019 PROJECT 2303	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	ATTACHMENT "L" – INTERIM RWD CONNECTION BREAKFAST HILL AREA WATER MAIN EXTENSION TOWN OF GREENLAND, NH	FIG. 10

H:\Real Numbers\Portsmouth\2303-Portsmouth Breafast Hill Water Main Hydraulic\Drawings\2303 Interconnect Figures 2-19.dwg, 2303 FIG 10-, 3/18/2019 5:06:28 PM, mah

Attachment "M"

Introductions

- Underwood Engineers, Inc.
  - Keith Pratt, PE, President
  - Tim Noble, EIT, Project Engineer
- City of Portsmouth Water Department
  - Brian Goetz, Deputy Director of Public Works

UNDERWOOD engineers

Breakfast Hill Road Area Water Main Extension City of Portsmouth, NH

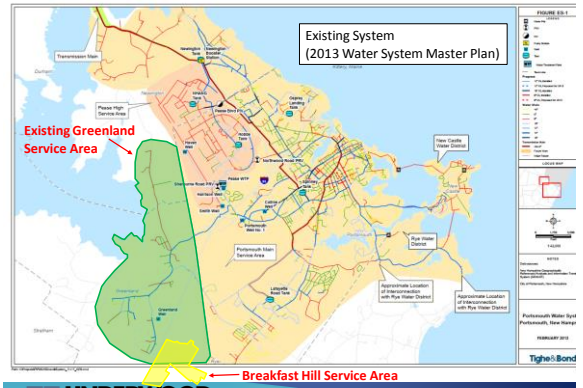
January 7th, 2019

UNDERWOOD engineers

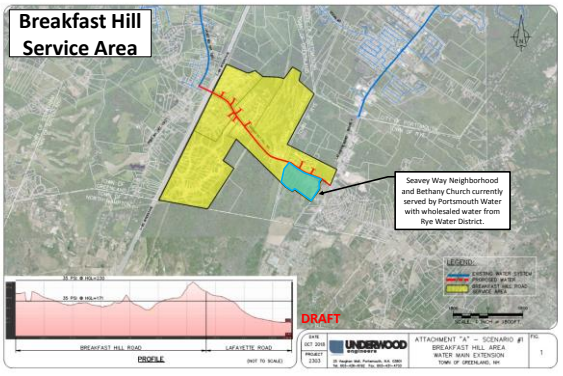
Purpose

- Evaluate water system improvements to extend municipal water service to area in Greenland not currently served by Portsmouth's water system.
- Funding provided by NHDES Trust Fund Grant

UNDERWOOD engineers



UNDERWOOD engineers



UNDERWOOD engineers

Breakfast Hill Service Area

Neighborhood	Streets	No. of Residential Connections	No. of Commercial Connections
Neighborhood #1	Maple Drive Maple Drive Extension Sunnyside Drive Coombs Farm Road	63	-
Neighborhood #5	Red Oak Drive Berry Farm Lane	14	-
Neighborhood #6	Breakfast Hill Road	25	5
Neighborhood #7	Seavey Way	10	-
	Total	**240**	**5**

Notes:
1. Seavey way has existing distribution piping. Two connections will be made to the existing piping to loop the neighborhood.

17 Streets (40,000 feet)
240 residential units
5 commercial lots (1 golf course)

UNDERWOOD engineers

Breakfast Hill Area Estimated Demands

	Average Day Demand (gpd)			Max Day Demand (gpd)		
	Domestic Demand	Irrigation Demand	Total Demand	Domestic Demand	Irrigation Demand	Total Demand
Residential Connections	30,000	-	30,000	48,000	171,000	219,000
Breakfast Hill Golf	4,000	-	4,000	6,400	20,000	26,400
Breakfast Hill Road						
Bethany Church	750	-	750	1,200	4,275	5,475
Total	35,800	-	35,800	57,280	228,410	285,690

Average Day Demand: 35,800 GPD
Max Day Demand: 286,000 GPD

Notes:
1. Residential domestic demands (240 connection) are calculated using 125 gpd per connection (based on historic Portsmouth Water System usage data).
2. Residential demands include future demands for a total of ten (10) houses to be constructed on Seavey Way. Currently only two (2) are constructed.
3. Max day domestic demands use a peaking of 1.6, based on historic water usage in the Portsmouth Water System.
4. Irrigation demands use a peaking factor of 5.7, based on historic irrigation trends in the Portsmouth Water System.

UNDERWOOD engineers

7

Average Day Demand Increases

	Existing ADD (MGD)	Adjusted ADD (MGD)	% Increase
Portsmouth – System Wide	4.92	4.96	0.8%

Maximum Day Demand Increases

	Existing MDD (MGD)	Adjusted MDD (MGD)	% Increase
Portsmouth – System Wide	7.54	7.82	3.7%

Note:

Demands represent increases compared to 2018 estimated demands from the 2013 Master Plan.

UNDERWOOD engineers

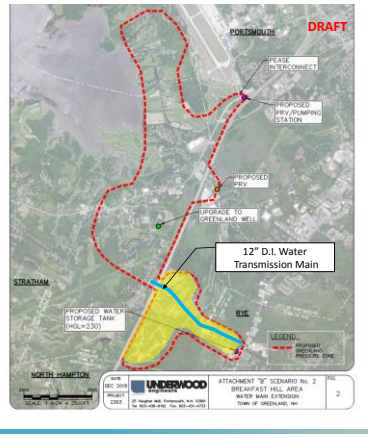
8

Alternative Conclusions

	Available Storage	System Pressures	Fire Flows
Scenario No. 1: Loop	✓	X	X
Scenario No. 2: Greenland Tank	✓	✓	✓
Scenario No. 3: Connect to Pease	X	✓	X

UNDERWOOD engineers

9



UNDERWOOD engineers

10

Opinion of Costs – All Phases

Scenario	Estimated Cost Range
Greenland Scenario No. 1: Loop between Breakfast Hill Road and Lafayette Road	$14.2 M - $19.0 M
Greenland Scenario No. 2: Stand-Alone	$18.5 M - $24.6 M

Scenario No. 2: $18.5M - $24.6M
Approx. $85,000 +/- per property

Notes:
1. [illegible]
2. Scenarios No. 2 and No. 3 do not include 12" water main installation on Lafayette Road.
3. Costs include contingency and engineering fees.

UNDERWOOD engineers

11

Project Phasing

- Project can be phased
- 1st Phase: Water System "Backbone"
- Later Phases: Neighborhoods

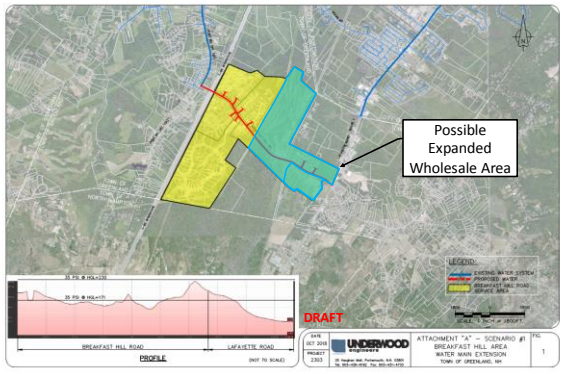
UNDERWOOD engineers

12

Interim Option: Rye Connection

- Extend Rye Water District service beyond Bethany Church/Seavey Way to portions of Breakfast Hill service area
  - Would require a revision/vote to revise the current agreement the City has with Rye Water District
- Lower up-front cost to provide water service
- Accommodates future conversion to Portsmouth's water system

UNDERWOOD engineers



UNDERWOOD engineers

Questions?

UNDERWOOD engineers