

EASTERN GOOCHLAND FORCE MAIN REPLACEMENT- SECTION B

Preliminary Engineering Report

.....
DECEMBER 29, 2021



PREPARED FOR

Goochland County
Public Utilities
1800 Sandy Hook Road, Suite 260
Goochland, VA 23063

PREPARED BY

Dewberry
4805 Lake Brook Dr, Ste #200
Glen Allen, VA 230
Phone: 804.823.6980
Contact: Richard Kincheloe

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EXECUTIVE SUMMARY

In 2021, Goochland County Department of Public Utilities (DPU) contracted Dewberry Engineers (Dewberry) to evaluate a recent force main rupture in the Eastern Goochland Pump Station (EGPS) system. The force main, referred to as the Eastern Goochland Force Main (EGFM), is made of 48-inch Fiberglass Reinforced Pipe (FRP) and originates at the EGPS, located at the eastern end of the Eastern Goochland Service Area along Patterson Avenue. The purpose of this Preliminary Engineering Report (PER) is to evaluate the existing force main and assess replacement alternatives, formulate a basis of design for this replacement, and perform hydraulic steady-state and transient analyses of the proposed new force main.

Force Main Replacement

The scope of the force main replacement outlined in this PER is from the EGPS located on the north side of Patterson Ave. to just south of the Randolph Square residential community. To reach an economically efficient design, both traditional open cut installation and sliplining will be used to perform the force main replacement.

A material analysis was conducted to determine the optimum pipe size and material for the new force main. HDPE was identified as an optimum material choice due to its ductile properties which make it resistant to damage from surge pressures, as well as its flexibility which makes sliplining easier. The hydraulic analyses performed in the previous TMs showed that the minimum allowable pipe size for the system was a 36-in pipe or a pipe with an equivalent inside diameter. Because of this, 42" HDPE DR-21 pipe, which has an average inside diameter of 37.76 inches was selected. To maintain a consistent design, this material was selected for the entirety of the force main replacement.

To limit community impacts and minimize construction costs, sliplining was identified as an optimum replacement method for long straight sections of the existing force main. However, the feasibility of sliplining is dependent on several key features including pull length, force main geometry, available pipe staging area, and construction access. Because of this, sliplining is not a feasible installation technique for some sections of the system. Through these more challenging sections, replacement will be performed using traditional open cut installation.

A basis of design for replacement of the 2.5 mile stretch of force main was developed by assessing the project site, existing pipe alignment, maximum pull length, and community and environmental considerations. As a result of the evaluation, the force main was divided into seven design sections.

Section 1 runs from Sta. 13+74 to Sta. 17+56 and will be replaced using open cut installation. The existing pipe alignment creates constructability challenges that make sliplining infeasible. In addition to the identification of the replacement technique for this section, relocation of a portion of this section further south to avoid conflict with existing overhead power lines was recommended.

Section 2, spanning Sta. 17+56 to Sta. 31+00, will continue to utilize open cut installation to navigate significant vertical bends in the existing force main as it crosses beneath a creek. Trenchless installation was considered a risky option for replacement of the pipe crossing the creek. To avoid the risks associated with sliplining this section, open cut installation was recommended.

Section 3 of the force main includes a relatively straight alignment. Because of this, sliplining was determined to be feasible. The section spans from the south side of the creek at Sta. 31+00 to where the existing force main crosses beneath another creek at Sta. 45+50.

Section 4 begins on the north side of the creek at Sta. 45+50. Sliplining was identified as an infeasible option for the creek crossing. Because of this, open cut installation was recommended. Open cut installation through this section will continue to Sta. 57+14 where the existing force main turns onto River Rd.

Section 5 runs along River Rd from Sta. 57+14 to Sta. 85+82, where it turns south into a utility easement. Sliplining was determined to be a feasible option for this section due to the straight existing pipe alignment. This section is longer than the calculated maximum allowable pull length for slip line installation. Because of this, excavation of an intermediate pit at Sta. 71+50 was recommended. From this pit, pipe can be staged in both directions to perform the slip line of the entire stretch of force main.

Section 6 begins where the force main turns south off River Rd at Sta. 85+82 and ends approximately 500 LF down the utility easement at Sta. 90+50. Open cut installation was recommended through this section to manage several significant vertical bends in the existing force main.

Section 7 runs down the utility easement from Sta. 90+50 south to where the existing force main is comprised of ductile iron at approximately Sta. 122+50. The force main alignment through the easement does not contain significant bends. Because of this sliplining was identified as a feasible installation method. To maintain shorter pull lengths within the allowable range, an intermediate pit was recommended to be excavated at Sta. 103+50.

As part of the basis of design, an evaluation of available construction access points was completed. As a result of this evaluation, four access points were identified. For replacement of the northern sections along Patterson Ave, the utility easement will be accessed using the West Side Engines parking lot off Patterson Ave. Two access points were identified on either end of the stretch of force main running along River Rd. These points can be used to access the easements running between Patterson Ave and River Rd and between River Rd and Randolph Square Parkway. For replacement of the stretch of force main south of Randolph Square Parkway, a construction access point was identified where the utility easement crosses Randolph Square Parkway. These four access points were determined to be sufficient for completion of the force main replacement.

Dewberry also conducted an environmental review and report of the project to identify potential environmental and archeological disturbances and impacts due to the project. The report determined that while streams and historic sites are located within the vicinity of the alignment, since this is a replacement project, any sites that could be potentially impacted would have already been previously disturbed by the initial installation of the force main. Therefore, it is recommended that a Nationwide 3 (NWP3) Preconstruction Notification (PCN) permitting package be prepared as a maintenance/repair activity. A delineation report should be included in the PCN document to confirm the status and extents of wetlands in the area that assist with permitting approval.

Hydraulic Analysis

A hydraulic analysis was completed to evaluate the response of the EGFM under both steady state and transient operating conditions. The steady state hydraulic analysis was completed to ensure flow in the proposed force main is sufficient for the current demands of EGPS. Steady state results indicate that EGPS is able to provide a flow of 17.9 MGD at the highest head operating condition, when pumping to the Henrico County outfall while Gambles Mill Pump Station is active. This is sufficient to meet the current demand of 14.1 MGD. EGPS is also able to meet the future pumping requirement of 27.1 MGD under the highest head condition, with a flow of 27.8 MGD with 5 duty pumps operating.

The transient analysis was completed to ensure pressures within the force main remain within the operable limits of the existing and proposed materials. Under the current 2 duty pump operating condition of EGPS, when undergoing a worst-case transient scenario pressure remain within the allowable surge pressures for each of the pipe materials present along the profile whether pumping to the City of Richmond or Henrico County outfalls. If Gambles Mill Pump Station is active and undergoes a transient event at the same time as EGPS, transient results are slightly worse, but still within allowable limits. With the future 5 duty pumps operating the EGFM experiences a more severe transient response than under the existing conditions. Transient pressures are within the allowable limits when pumping to the Richmond outfall, however, when the EGPS is pumping to the Henrico outfall (with or without Gambles Mill active), the EGFM experiences pressures above the 100 psi limit of the existing 48" FRP pipe. When EGPS is upgraded to include 3, 4,

and 5 duty pumps, additional transient analyses must be performed to determine the location and size of required surge mitigation devices, or the existing FRP pipe should be replaced with a pipe than can withstand higher transient pressures, such as HDPE.

Summary and Budgetary Estimates

As outlined above, replacement of the existing 48-inch FRP force main with 42" HDPE DR-21 pipe is recommended to be completed using both open-cut installation and sliplining. Based on the recommended installation method, a preliminary opinion of probable construction cost for this project was developed. It is important to note that the budgetary cost estimate was prepared to reflect current market conditions for material and installation costs associated with the current state of the COVID-19 pandemic and subsequential supply chain challenges. The cost estimate takes the state of the current market into account but based on the volatility of pricing for certain items, there is potential for long-term effects to construction costs which may affect the project cost.

The overall project costs are outlined in the table below.

| BUDGETARY COST ESTIMATE | |
|---------------------------------------------------------------|-----------------------|
| ITEM | COST |
| Section 1 (Sta. 13+74 to Sta.17+56) – Open Cut Installation | \$480,000.00 |
| Section 2 (Sta. 17+56 to Sta. 31+00) – Open Cut Installation | \$311,000.00 |
| Section 3 (Sta. 31+00 to Sta.45+50) – Slipline Installation | \$1,014,000.00 |
| Section 4 (Sta. 45+50 to Sta. 57+14) – Open Cut Installation | \$618,000.00 |
| Section 5 (Sta. 57+14 to Sta. 85+82) – Slipline Installation | \$888,000.00 |
| Section 6 (Sta. 85+82 to Sta.90+50) – Open Cut Installation | \$1,199,000.00 |
| Section 7 (Sta. 90+50 to Sta. 122+50) – Slipline Installation | \$346,000.00 |
| PROJECT SUBTOTAL COST | \$6,198,000.00 |
| Contingency (±15%) | \$929,700.00 |
| TOTAL CONSTRUCTION COST | \$7,127,700.00 |

1.0 INTRODUCTION

The Goochland County Department of Public Utilities (DPU) owns and operates the Eastern Goochland Wastewater Collection System, which consists of 56 miles of gravity sanitary sewer, 14 miles of force main, and 5 wastewater pump stations. As part of that wastewater system, DPU owns and operates the Eastern Goochland Pump Station (EGPS), which conveys wastewater through the Eastern Goochland Force Main (EGFM) to either Henrico County or the City of Richmond. The EGFM and EGPS is jointly managed by DPU and Henrico County with agreements in place for repairs, replacements, long term improvements, operation and maintenance. The EGFM system consists of over 9 miles of pipeline from the EGPS to the discharge location near the City of Richmond. The first 2.5 miles of the force main, located within Goochland County, is made up of 48-inch fiberglass reinforced plastic pipe (FRP) that was installed in 2002.

Based on the Goochland County Utility Master Plan, EGPS contains three (3) dry-pit pumps that operate at 4,500 GPM at 210 feet of head. The pump station has a total installed capacity of 13 MGD, with room for three (3) additional pumps and an ultimate firm capacity of 33 MGD.

The purpose of this PER is to evaluate replacement alternatives for the approximate 2.5 miles of pipeline constructed of FRP and recommend an approach to extend the useful life of the force main.

The first 2.5 miles of the EGPS force main is located within roadway right-of-ways and utility easements as shown in Figure 1-1 below:



Figure 1-1 – EGPS Force Main Alignment

2.0 FORCE MAIN REPLACEMENT

2.1 Introduction

The purpose of this Preliminary Engineering Report (PER) is to define the basis of design for replacement of the existing 48-inch diameter force main using both sliplining and open cut replacement techniques. Sliplining is a more cost-effective approach due to the elimination of open cut excavation, force main demolition and access requirements. However, sliplining cannot be performed where geometry of the force main system does not allow the new pipe to traverse due to bending radius restrictions. The following sections of the PER summarizes the most cost-effective approach to replacement of the force main system through a combination of sliplining and open cut replacement.

2.2 Material Analysis

There are a number of different materials that can be used to slipline including HDPE, Fusible PVC, Steel and rigid pipe materials such as ductile iron pipe (DIP) or FRP. Rigid pipe is typically used to slipline gravity sewer or other pipes where the geometry of the system between access points is straight with limited to no changes in geometry. Since the EGFM does not have existing access points and the geometry of the system varies significantly, flexible piping systems are recommended.

HDPE, Fusible PVC and Steel are all piping systems that can be used to slipline across a variety of geometry. Steel is not recommended since the EGFM conveys raw sewage and minimum bending radius requirements would make installation challenging. Fusible PVC is also not recommended because it has a thinner wall than HDPE and sliplining may cause minor damage to the pipe wall which could result in premature failure.

Therefore, HDPE was chosen as the optimum pipe material for this project. The ductile properties of HDPE make it resistant to damage from the surge pressures. HDPE is also a flexible material, making sliplining an easier and more feasible method of installation. Based on the results of the hydraulic analysis performed in the previous TMs, the minimum pipe size that was identified for the EGPS system was a 36-in pipe or a pipe with an equivalent inside diameter. Because of this, the pipe size selected for design was a 42" HDPE with a dimension ratio 21 (DR 21) in iron pipe size (IPS). A 42" HDPE DR 21 pipe has an average inside diameter of 37.76 inches and an approximate weight of 110.54 lbs/ft. The maximum recommended operating pressure for a DR 21 HDPE pipe is 100 psi. HDPE pipe can withstand occasional transient pressures much higher. These properties are important in analysis of sliplining feasibility.

The first aspect of design that needs to be determined is the maximum pull length of the selected pipe material and size. The maximum pull force that a 42" HDPE DR 21 pipe can withstand without deforming is approximately 343,000 lbs. Subsequent sections of this report include calculations for maximum pull lengths. When conducting the basis of design, this material property was taken into consideration in determining the allowable length of sliplining certain sections of force main.

2.3 Open-Cut Assessment

Sliplining is limited in its applicability due to access, pull length and geometry. Based on the existing force main system, sliplining is not feasible for the entirety of the force main. Therefore, several sections of the force main will need to be replaced using open cut installation. While open-cut installation is both more invasive and more expensive than trenchless alternatives, several constructability challenges throughout the project site make this method the only feasible option for certain segments.

Where open cut occurs, the existing force main will need to be excavated and removed, new trench bedding and backfill will be required, and new pipe will need to be installed. In order to maintain a holistic solution, the new force main will use the same pipe as the sliplining section.

2.4 Constructability

As outlined above, both traditional open-cut installation and sliplining will be used to complete the force main replacement. Constructability challenges are present in the use of both methods. Open-cut installation in areas adjacent to residential neighborhoods will create significant community impacts. Because of this, coordination in advance with the homeowners will be required. While sliplining long segments of pipe is possible, certain limitations dictate how far an individual span of sliplining can feasibly be performed without adding additional intermediate insertion pits.

The strength of the pipe material when subject to pull forces plays an important role in determining maximum sliplining pull lengths (MPL). Determining maximum pull length requires an analysis of the allowable maximum pull force for the pipe (MPF), the weight of that pipe per foot, a factor of safety and using a coefficient of friction. Based on materials properties of 42" DR-21 HDPE pipe, the following information was used to determine maximum pull length.

| | |
|------------------------------------|--------------------|
| Maximum Allowable Pull Force (MPF) | 343,000 pounds |
| Weight of Pipe (W) | 110.54 pounds/foot |
| Coefficient of Friction (CF) | 0.7 |
| Factor of Safety (FS) | 1.5 |

42" DR-21 HDPE has a maximum allowable pull length of approximately 2,900 LF as shown in Equation 2-1 below.

Equation 2-1 – Maximum Pull Length

$$MPL = \frac{\frac{MPF}{FS}}{W * CF}$$

$$MPL = \frac{\left(\frac{343,000lbs}{1.5}\right)}{\left(110.54 \frac{lbs}{ft}\right) (0.7)}$$

$$MPL = 2,964 ft$$

However, the capacity of the construction equipment also provides its own limitations as it relates to pull forces and feasible pull lengths. A longer pull length requires a larger minimum pull force capacity for the construction equipment. Therefore, although the pipe material can withstand pull lengths up to 2,900 LF, the equipment constraints further limit the feasible pull lengths. For the purpose of this analysis, a 100,000-pound maximum pull force was used for the constructability analysis. In addition, the coefficient of friction for calculating maximum pull length for constructability was considered to be 0.5. A lower coefficient of friction can be used for actual pull forces during construction based on the actual geometry of the force main. Installations where the geometry does not change, a coefficient of friction of 0.3 could be used. However, as outlined above, a coefficient of friction of 0.5 is sufficiently conservative for the construction calculations. Contractors will be responsible for supplying equipment as necessary to complete the sliplining. Using the equation for maximum pull length above, and assuming 100,000 pounds of maximum pull force based on construction equipment limitations, the maximum pull length was calculated as approximately 1,800 LF as shown in equation 2-2 below.

Equation 2-2 – Maximum Pull Length

$$MPL = \frac{MPF}{W * CF}$$

$$MPL = \frac{100,000 \text{ lbs}}{\left(110.54 \frac{\text{lbs}}{\text{ft}}\right) (0.5)}$$

$$MPL = 1,811 \text{ ft}$$

Available pipe lay down areas also provide limitations that impact the basis of design. These pipe staging limitations occur in confined areas where the utility easement makes significant turns or in residential areas where staging would require laying down pipe in homeowners’ yards or across driveways. In these situations, shorter segmental sliplining or more intermediate insertion pits may be required. All these factors were taken into consideration during development of the basis of design for the force main replacement.

Sliplining pressure piping systems (i.e. force mains) requires the pipeline to be taken out of service for the duration of construction. DPU should work with Henrico County to confirm flow can be diverted from the EGPS to the Henrico County gravity sewer system for the duration of the project of approximately twelve (12) months.

2.5 Basis of Design

A basis of design for renewing the 2.5-mile section of existing 48” diameter force main has been developed. The recommended approach accounts for limitations outlined above as well as construction limitations and risks associated with the lack of available information on the existing force main system. Locations for construction access points were determined through analysis of the project site’s environment, potential community impacts, traffic conditions, and available easement. An assessment of the geometry of the existing force main, available pipe staging area and construction accessibility was used to formulate a basis of design for the force main replacement. It should be noted that the existing geometry was based off as-built drawings and did not include review of pipe lay schedule shop drawings.

As a result of this assessment, the force main was divided into seven (7) sections based on stationing from the as-built drawings. The sections and associated installation methods are summarized in Table 2-1 and shown in Figure 2-1 below.

Table 2-1 – Force Main Replacement Section Summary

| SECTION NUMBER | STATION | INSTALLATION METHOD |
|----------------|----------------|---------------------|
| 1 | 13+74 to 17+56 | OPEN CUT |
| 2 | 17+56 to 31+00 | OPEN CUT |
| 3 | 31+00 to 45+50 | SLIPLINE |
| 4 | 45+50 to 57+14 | OPEN CUT |
| 5 | 57+14 to 85+82 | SLIPLINE |
| 6 | 85+82 to 90+50 | OPEN CUT |

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| | | |
|---|--------------------|----------|
| 7 | 90+50 to 122+50 | SLIPLINE |
|---|--------------------|----------|



Figure 2-1 – Basis of Design for Force Main Replacement

2.5.1 Force Main Section 1 (Sta. 13+74 to Sta. 17+56) – Open cut Installation

The project will start on the north side of Patterson Avenue, close to the EGPS, at Sta. 13+74. From this location, the force main crosses under Patterson Avenue through an existing steel casing pipe before it turns 90 degrees along Patterson Avenue and continues to the easement before it travels southward towards River Road. Figure 2-2 below shows the location of this section of force main.

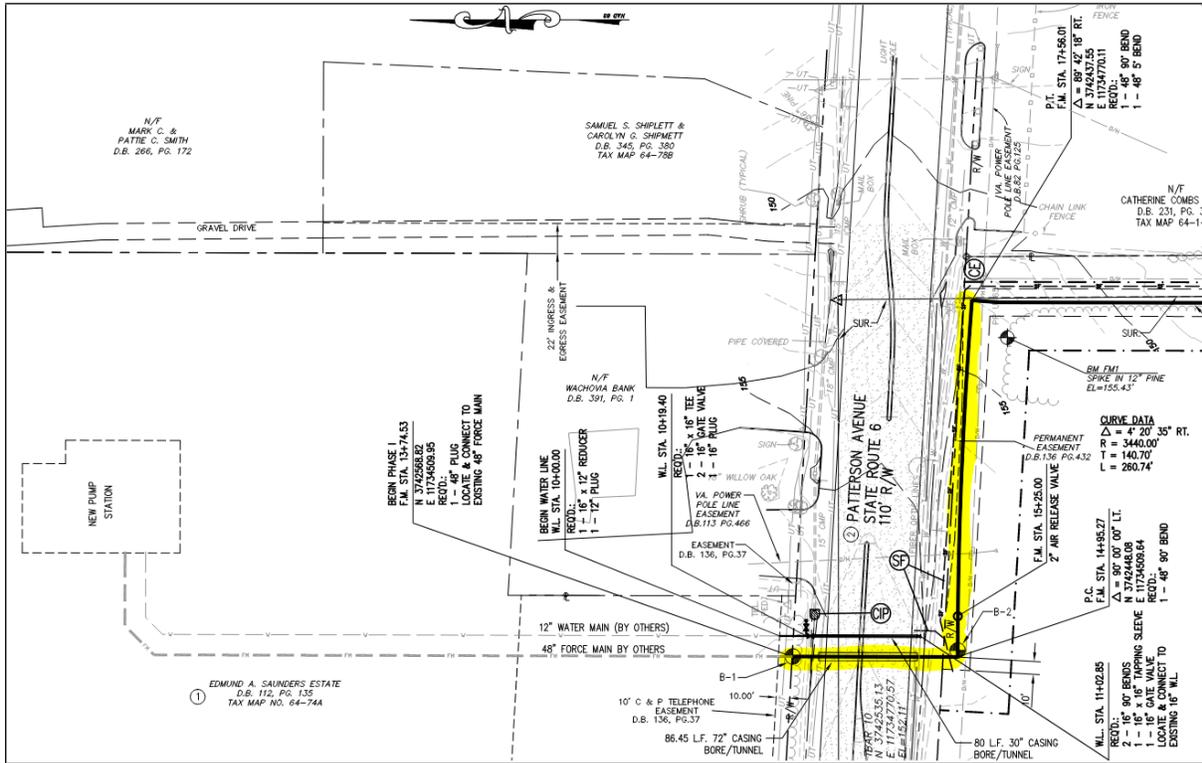


Figure 2-2 – Existing EGFM Section 1 Alignment (Highlighted)

Based on the alignment of the existing force main, including several 90-degree bends, this section of force main is recommended to be replaced using open cut installation. However, the pipe should be installed under Patterson Avenue within the existing casing or within the existing force main to eliminate the need for traffic control and open cut installation within the travel lanes.

In addition to the geometry, there are existing overhead powerlines over the force main on the south side of Patterson Avenue, as shown in Figure 2-3 and Figure 2-4, that will make construction in this area challenging. Therefore, it is recommended that the force main be relocated further south to avoid conflict with existing utilities. This will require easement acquisition to relocate the force main. Should easement acquisition not be practical, the force main can be installed in the existing location, but close coordination with Dominion Energy will be required to maintain safe work areas, which may include coordination of power outages to allow for work near the utility lines.

It is recommended that the new force main be constructed of 42" DR-21 HDPE and that new appurtenances be installed as necessary. During design, material transition details will be provided to transition from DIP to HDPE. In addition, final starting location for the replacement will be determined during design.



Figure 2-3 – Existing Overhead Power Lines



Figure 2-4 – Existing Overhead Power Lines

2.5.2 Force Main Section 2 (Sta. 17+56 to Sta. 31+00) – Open cut Installation

The existing force main continues within the existing sewer easement heading south from Patterson Avenue toward River Road. Approximately 1050 LF down the easement, at Sta. 28+00, the existing force main crosses beneath a creek. Figure 2-5 below shows this section of force main. There are also a number of horizontal bends on the force main in this area.

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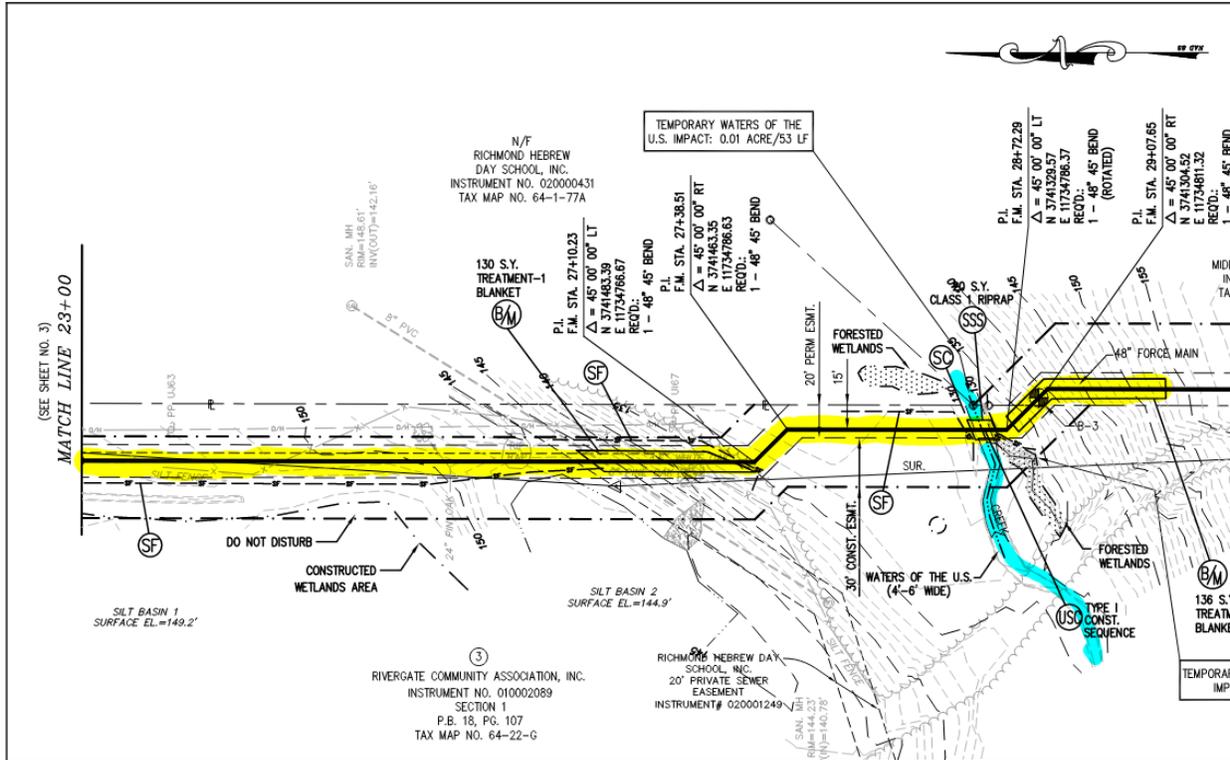


Figure 2-5- Existing EGF M Section 2 Alignment (Highlighted)

The force main profile through this section, shown in Figure 2-6 below, includes steep vertical bends as the existing force main crosses beneath the creek. As shown in the figure, no fittings or measurements of bending radii are shown or called out in the as-built drawings. These unknown variables generate risks associated with sliplining this section of force main. Because of this, open cut installation is recommended for the 42" DR-21 HDPE replacement of the section of force main running from Patterson Avenue at Sta. 17+56 to Sta. 31+00 on the south side of the creek where the force main comes up an existing hill, improving the constructability of the sliplining section.

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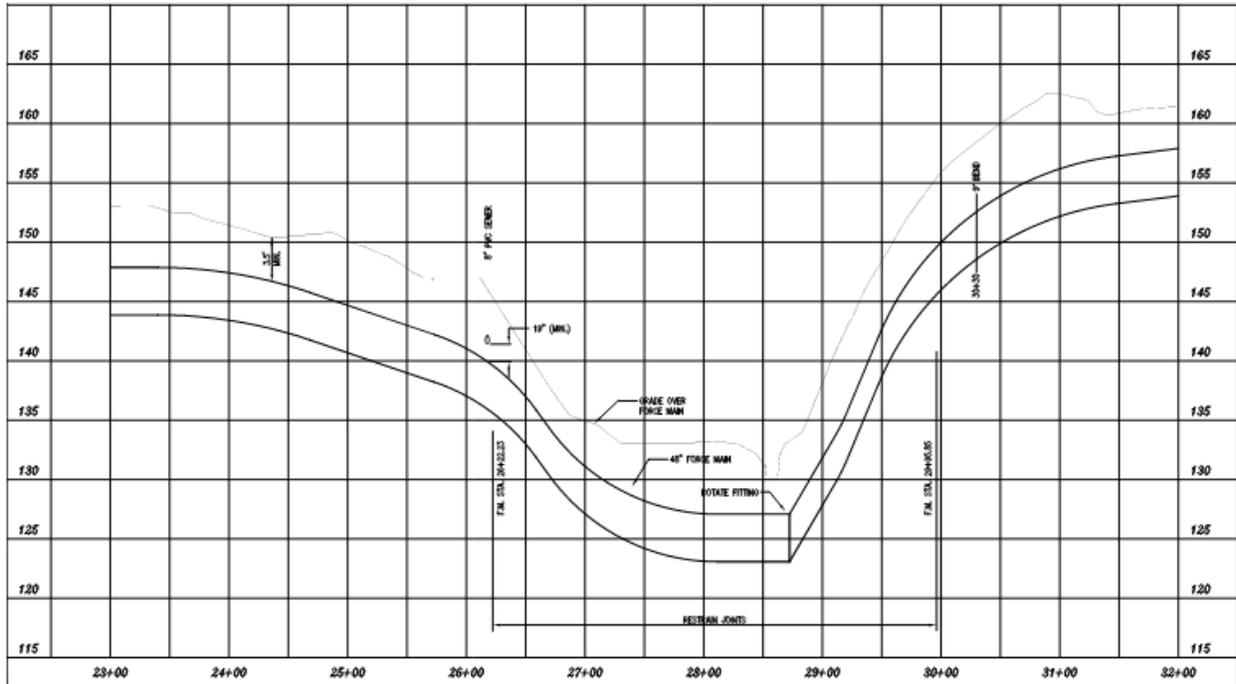


Figure 2-6 – EGFM As-Built Profile View (Sta. 23+00 to Sta. 32+00)

2.5.3 Force Main Section 3 (Sta. 31+00 to Sta. 45+50) – Slip line Installation

On the south side of the creek at Sta. 31+00, the force main is parallel to the Wickham Glen Residential Subdivision, behind a number of homes. Figure 2-7 below shows this section of force main.

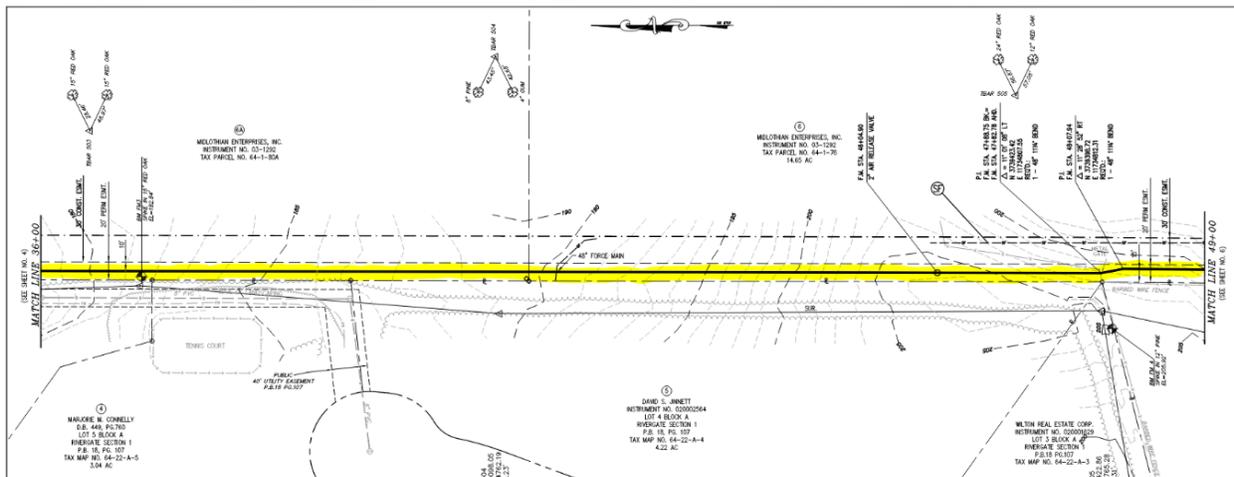


Figure 2-7 – Existing EGFM Section 3 Alignment (Highlighted)

It should be noted that the as-built drawings show easements prior to the development of the subdivision and construction of single family homes. Based on the existing conditions, the force main easements are located in the backyards of the existing homes. However, the location of the force main and easements relative to the existing homes and site features (i.e. fences, landscaping, etc...) is unknown. Therefore, it

is recommended that survey be performed in this area during design to evaluate the level of impact to the homeowners.

The alignment of the existing force main is relatively straight, with no significant vertical or horizontal bends. The geometry of the pipe alignment allows for trenchless installation via sliplining. Sliplining this section of force main will minimize impacts to homeowners by reducing the amount of open cut construction that will occur. Because of this, sliplining is recommended for installation of the section of force main replacement from the south side of the creek at Sta. 31+00 to Sta. 45+50, where the existing force main approaches another creek crossing.

To perform the sliplining through this section, an insertion pit at Sta. 45+50 and a receiving pit at Sta. 31+00 will be excavated. Approximately 1150 LF of pipe staging area is available south of the insertion pit. Because this section of replacement requires 1450 LF of staging area, continuous sliplining for the entire length of pipe is not feasible. Therefore, segmental sliplining is required to perform the installation, meaning that the pipe will be winched into place and then additional pipe will be fused during the installation. This causes a challenge with installation because once the pipe stops for additional fusing, the winch will need to overcome frictional forces with a stopped pipe. Winching will be performed from the receiving pit as pipe is fused south of the location.

2.5.4 Force Main Section 4 (Sta. 45+50 to Sta. 57+14) – Open cut Installation

As the existing force main continues southward along the easement, it crosses beneath another creek located at Sta. 52+00. The pipe profile, shown in Figure 2-8, includes significant vertical bends beginning at Sta. 46+00 as it approaches and crosses beneath the creek. The as-built drawings do not include a lay schedule or information about pipe fittings or bending radius. In addition to the risks associated with trenchless installation due to the vertical alignment, a 90-degree horizontal bend at Sta. 57+14 at the south end of the utility easement, as the existing force main turns onto River Road, makes sliplining through this section challenging. Based on the geometry of the existing force main, open cut installation is recommended for the section of force main spanning from the north side of the creek at Sta. 45+50 to the turn onto River Road at Sta. 57+14. Figure 2-9 shows the alignment of this section of force main.

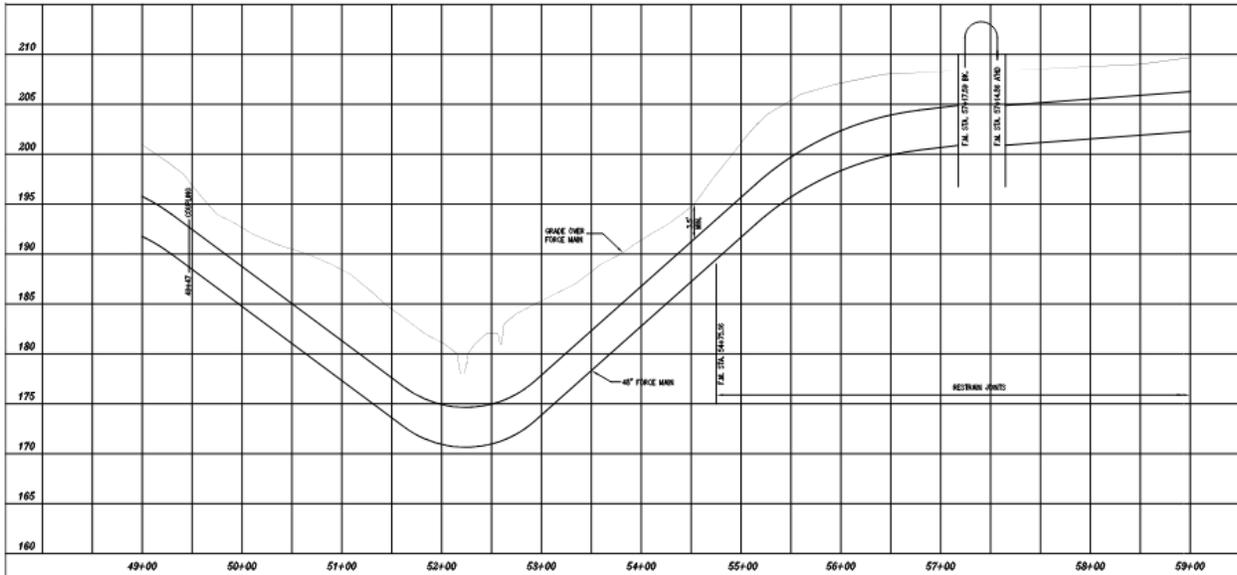


Figure 2-8 – EGFM As-Built Profile View (Sta. 49+00 to Sta. 59+00)

EASTERN GOOCHLAND FORCE MAIN REPLACEMENT
SECTION B (YR010520) PER

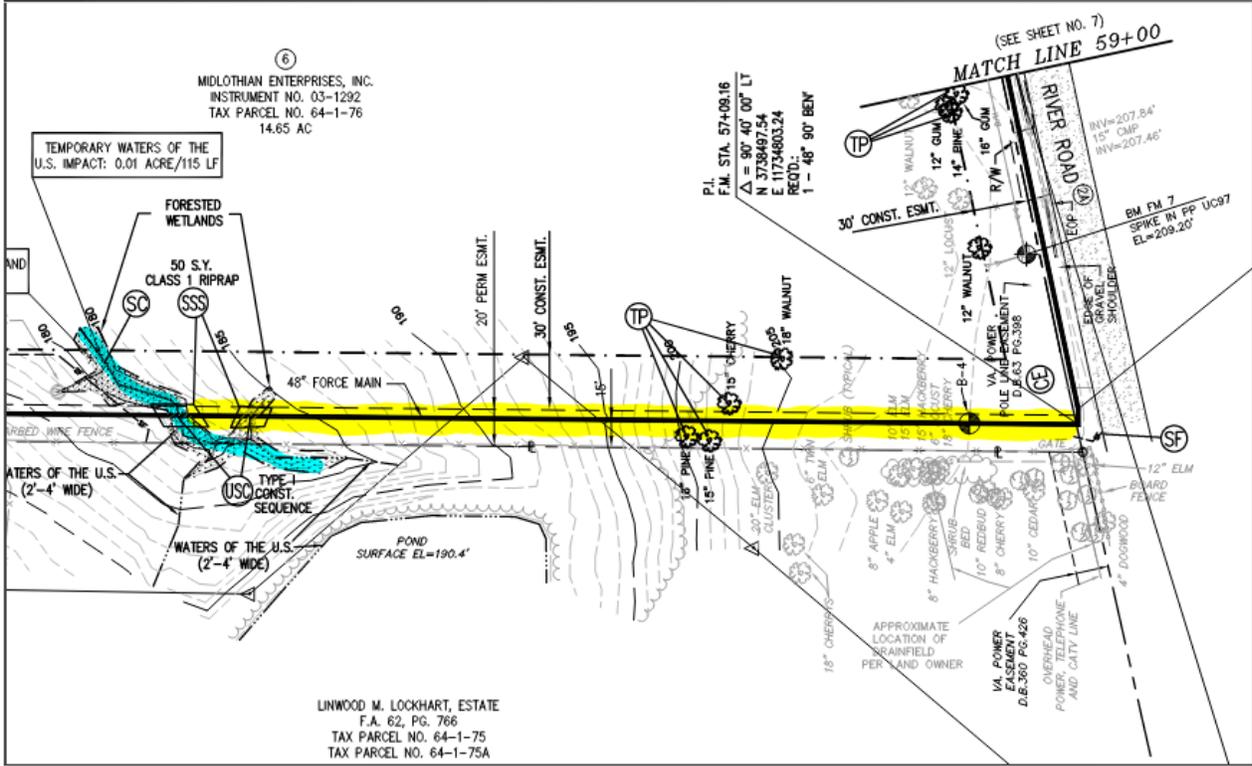
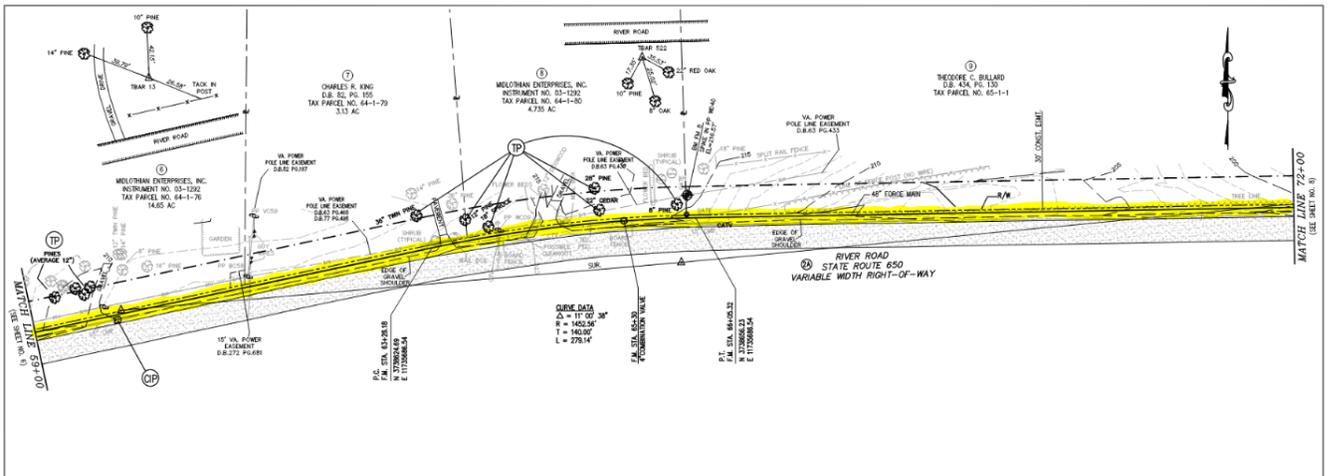


Figure 2-9 – Existing EGFM Section 4 Alignment (Highlighted)

2.5.5 Force Main Section 5 (Sta. 57+14 to Sta. 85+82) – Slip line Installation

The existing force main has a 90-degree bend and runs east parallel to River Road in an easement on the north side of the road from Sta. 57+14 to Sta. 85+82, before turning 90 degrees to cross beneath River Road heading southward. The pipe's alignment along River Road does not include significant vertical or horizontal bends. Because of this, sliplining is considered feasible and is the recommended installation method for this section of the force main replacement. This section's alignment is shown in Figure 2-10 below.



EASTERN GOOCHLAND FORCE MAIN REPLACEMENT
SECTION B (YR010520) PER

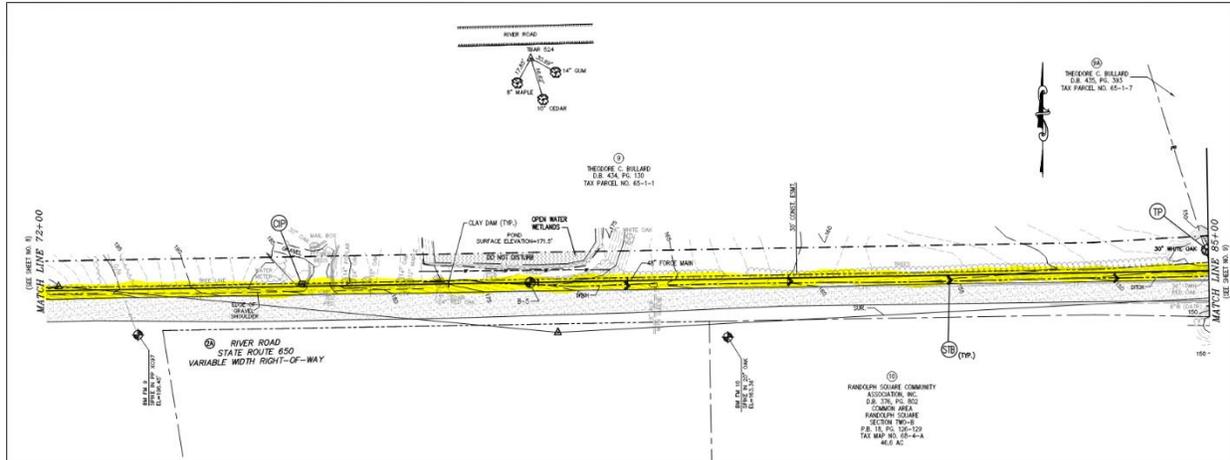


Figure 2-10 – Existing EGFM Section 5 Alignment (Highlighted)

In order to perform the slip line installation, receiving pits located at either end of the stretch of force main at Sta. 57+14 and 85+82 will need to be excavated. In addition, due to the length of this installation, and limitations of the construction equipment and pipe, an intermediate insertion pit will be required to install the new force main. This intermediate pit is recommended to be excavated at Sta. 71+50, to provide ample staging area to the east and west of the insertion pit in order to perform sliplining in both directions and minimize pull stresses on the pipe. Winching will be performed from the receiving pits at either end of the stretch of force main. Figure 2-11 below shows the location of the insertion pits and available pipe staging area for sliplining in both directions.



Figure 2-11 – River Road Available Pipe Staging Area

The majority of the force main running along River Road is located in a swale in front of a private residential property. The existing force main crosses a driveway directly connecting the property to River Road, shown in Figure 2-12. Because of this, staging of long pipe lengths may create an impact on this property owner since pipe would be staged across the driveway during installation of the western half of this stretch of force main, obstructing the owner's access to their property. However, an existing path on the western end of the property, shown in Figure 2-13, that is wide enough to provide temporary access to compact vehicles, may provide the owner with feasible access to the property during installation of the western half of this stretch of force main. When sliplining in the opposite direction, the driveway will be available for access. Coordination with the property owner will be required prior to construction.



Figure 2-12 – Existing Property Driveway



Figure 2-13 – Proposed Temporary Access Road

2.5.6 Force Main Section 6 (Sta. 85+82 to Sta. 90+50) – Open cut Installation

The existing force main turns 90-degrees and crosses beneath River Road through an existing 72" steel casing pipe before running down an easement on the south side of River Road. A horizontal bend 200 LF down the easement at Sta. 88+50 and a lack of pipe lay down area create constructability challenges for trenchless installation. The horizontal alignment of the pipe through this section is shown in Figure 2-14. In addition to these geometric properties, the vertical pipe alignment as the force main crosses River Road, shown in Figure 2-15, also includes a significant vertical bend, making sliplining difficult. Because of these geometric properties in the existing pipe, open cut installation is recommended for the force main replacement from Sta. 85+82 to Sta. 89+00. The new force main will be installed under River Road within the existing casing or within the existing force main to eliminate the need for traffic control and open cut installation within the travel lanes.

EASTERN GOOCHLAND FORCE MAIN REPLACEMENT
SECTION B (YR010520) PER

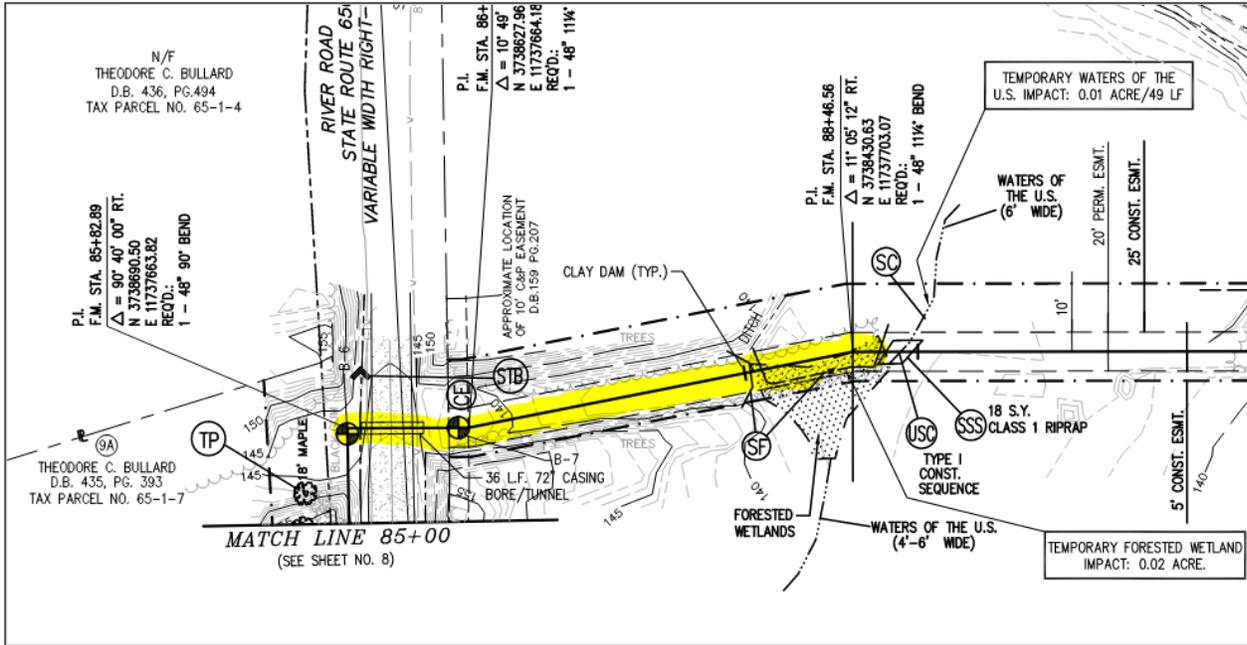


Figure 2-14 – Existing EGFM Section 6 Alignment

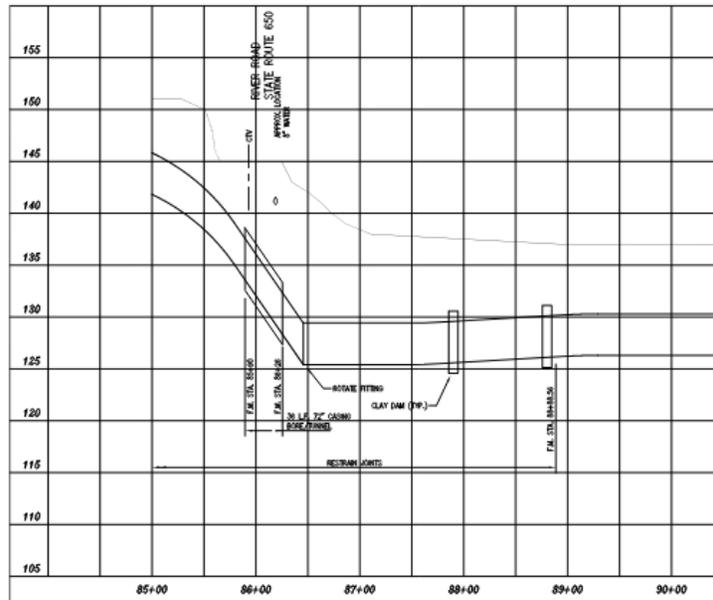
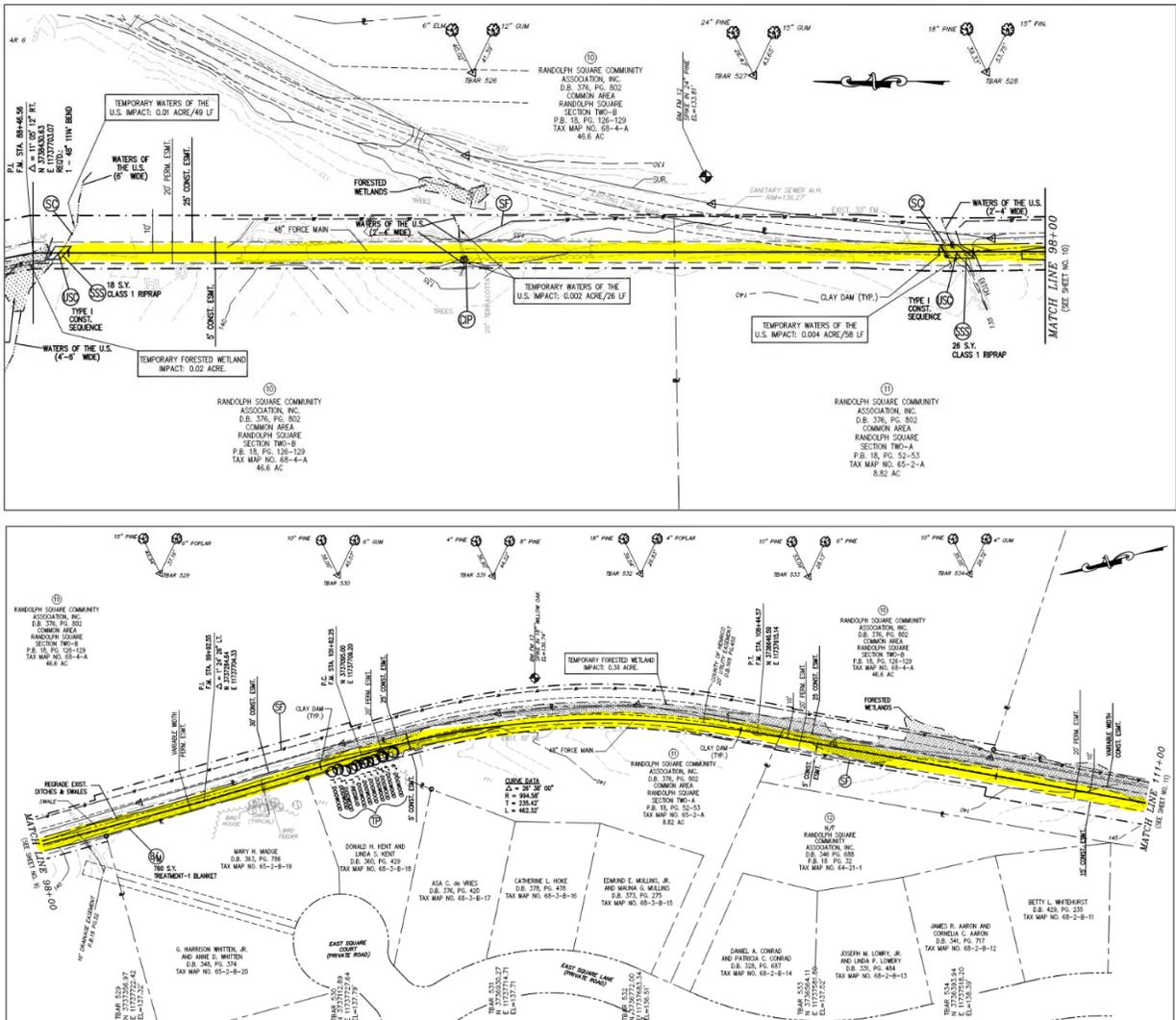


Figure 2-15 – EGFM As-Built Profile View (Sta. 85+00 to Sta. 90+50)

From Sta. 87+50 to Sta. 89+00, the easement is crowded by encroaching overgrown bamboo from the nearby forested wetlands. The bamboo will need to be cleared in order to maintain the required easement width to accommodate proper mobility of construction equipment. Coordination with the Randolph Square Community HOA is recommended.

2.5.7 Force Main Section 7 (Sta. 90+50 to Sta. 122+50) – Slip line Installation

The existing force main continues south down the easement, running parallel to Tuckahoe Creek and the Randolph Square Residential Community. At Sta. 115+50, the force main crosses beneath Randolph Square Parkway through an existing 60" bore pipe. From this location, the force main runs down a utility easement on the south side of Randolph Square Parkway for approximately 500 LF where it ties into an existing 48" ductile iron force main. The pipe alignment through the easement is relatively straight with no significant vertical or horizontal bends, making sliplining a feasible installation option. In addition to this, the utility easement in which the existing force main is located is visible from the backyards of numerous homeowners within the Randolph Square Community. Sliplining is an optimal installation method through this section as it avoids much of the significant community impact that open cut installation would generate. Because of this, sliplining is recommended for the force main replacement from Sta. 89+00 to Sta. 122+50, where the line ties into the existing 48" ductile iron force main. This section of force main is shown in Figure 2-16 below.



EASTERN GOOCHLAND FORCE MAIN REPLACEMENT
SECTION B (YR010520) PER

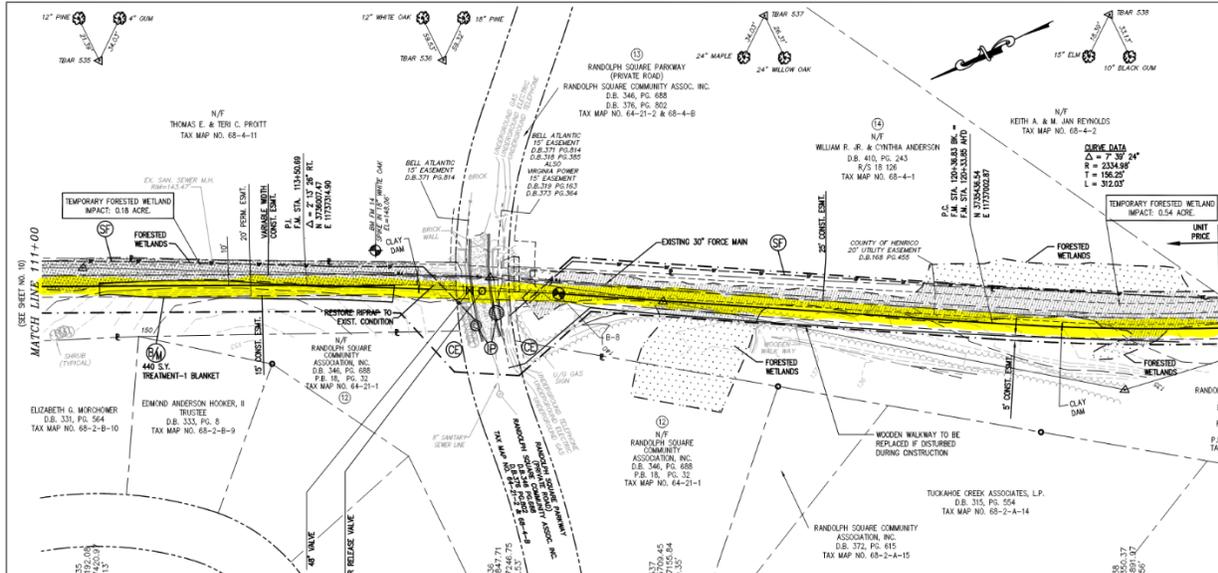


Figure 2-16 – Existing EGFM Section 7 Alignment

Pits are recommended to be constructed on either end of the section of force main replacement at Sta. 89+00 and Sta. 122+50. An intermediate receiving pit on the north side of Randolph Square Parkway at Sta. 103+50 is recommended to maintain shorter pipe staging and manage a slight horizontal bend in the utility easement as well as minimize pulling forces. This pit will be used as an insertion pit to perform the slip line northward and will be used as a receiving pit to perform winching for the sliplining of the force main southward.

Additional Considerations

Environmental and archeological impacts also contribute constructability challenges to the project. An environmental review and report of the project area, attached in Appendix A, was conducted to determine the extent of impact caused by the project and identify proper mitigation processes. The report recommended that wetland information and preliminary construction plans be utilized to prepare a Nationwide 3 (NWP3) Preconstruction Notification (PCN) package. This package will include information on the amounts and types of state and federal waters and wetlands proposed to be impacted and the construction details of the pipeline crossing of wetlands or streams within the alignment. The report further advised that the project avoid permanent impacts to existing stream crossings or wetlands as these would require mitigation. Mitigation for jurisdictional features should not be necessary since these impacts were determined to be temporary. The report also evaluated the risk of impact on archeological resources. Two previously recognized archeological resources were identified as sites over which the project alignment overlaps (The Tuckahoe and James River Railroad) and two other cultural resources (Lockhart House and Saint Mary’s Episcopal Church) along which the alignment passes were also identified. However, given that the project involves force main replacement, prior disturbance of these sites was assumed. The report anticipated that any archeological resources on these sites along the alignment have been previously disturbed from the original construction of the pipeline and that the replacement project will not generate further impacts.

A key consideration of design is the identification of construction access points. Four points across the scope of the project were identified as access points for construction equipment. These four points will be used to access all sections of the project and perform the entirety of the force main replacement. Force main replacement of sections 1 and 2 will be performed utilizing Patterson Avenue as a construction access point. The easement on the south side of Patterson Avenue can be accessed through the West Side Engines parking lot off Patterson Avenue just east of the easement. This access point will only be used for construction in this easement up through Sta. 31+00. In an effort to avoid impacts to the creek at Sta.

28+00, construction equipment should not cross over the creek. Figure 2-17 shows the Patterson Avenue construction access point.



Figure 2-17 – FM Sections 1 & 2 Patterson Road Access

Replacement of the force main in the remainder of the easement (sections 3 and 4) should be performed, utilizing a construction access point located at the southern end of the utility easement where it connects with River Road. Temporary stream crossing will be required to move equipment across the creek at Sta. 52+00 with minimum environmental impact. The access point off River Road will also be used to access the easement running along the north side of River Road to perform replacement of section 5 of the existing force main. This access point is shown in Figure 2-18 below.



Figure 2-18 – FM Sections 3,4 & 5 River Road Construction Access

For construction of the force main between River Road and Randolph Square Parkway, construction access is available at the location where River Road meets the utility easement running parallel to the Randolph Square Community, shown in Figure 2-19. Due to the steep slope of the easement south of River Road and the need to transport heavy equipment and material to the project site, equipment may require access

through Randolph Square Parkway.



Figure 2-19 – FM Section 6 & 7 River Road Construction Access

Replacement of the remainder of the force main located south of Randolph Square Parkway will be performed utilizing Randolph Square Parkway to access the easement. Figure 2-20 below shows the location of this access point.



Figure 2-20 – FM Section 7 Randolph Square Parkway Construction Access

3.0 SYSTEM HYDRAULICS

3.1 Hydraulic Overview

Dewberry completed a hydraulic analysis of the Eastern Goochland Force Main with the proposed 42" DR-21 HDPE pipe. This analysis was completed to ensure that the pressures within the force main remain within acceptable operating parameters under steady state and transient hydraulic scenarios. The model includes geometry for East Goochland Pump Station and the EGFM, the Henrico-owned Gambles Mill Pump Station and Force Main, and the Maple Avenue Force Main.

3.1.1 Data Acquisition and Model Development

The EGPS and the EGFM were modeled in Bentley WaterGEMS CONNECT Edition and Bentley Hammer CONNECT Edition. WaterGEMS was used to set up the model geometry and complete the steady state hydraulic analysis, and Hammer was used to complete the transient hydraulic analysis. To accurately model the pump station and force main, several record drawing sets for EGPS, the EGFM, Gambles Mill Pump Station, Gambles Mill Force Main and Maple Avenue Force Main were used. Previous reports on the EGFM were referenced as well. All references are listed below:

1. R. Stuart Royer & Associates, Inc., Timmons (2002), "Goochland County, Virginia Eastern Goochland Pump Station, Addendums Incorporated", Record Drawings, 04/07.
2. R. Stuart Royer & Associates, Inc., Timmons (2003), "Goochland County, Virginia Goochland/Henrico Regional Force Main Project Phase I", Record Drawings, 8/29/06.
3. R. Stuart Royer & Associates, Inc., Timmons (2003), "Goochland County, Virginia Goochland/Henrico Regional Force Main Project Phase II", Record Drawings, 8/30/06.
4. R. Stuart Royer & Associates, Inc., Timmons (2003), "Goochland County, Virginia Goochland/Henrico Regional Force Main Project Phase III", Record Drawings, 8/31/06.
5. R. Stuart Royer & Associates, Inc., Timmons (2003), "Goochland County, Virginia Goochland/Henrico Regional Force Main Project Phase IV", Record Drawings, 9/5/06.
6. Draper Aden Associates (2003), "County of Henrico, Virginia, Department of Public Utilities, Maple Avenue 30" Force Main", Record Drawings, 4/5/07.
7. Wiss, Janney, Elstner Associates, Inc., "Pressure Test on 48 in. Diameter Flowtite Glass-Fiber Reinforced Polymer (FRP) Pipe Manufactured by Amitech USA, Ltd.", July 22, 2005.
8. Dewberry Engineers, Inc., "Eastern Goochland Pump Station and Force Main Transient Analysis", October 13, 2014.
9. Brown and Caldwell, "Goochland-Henrico Regional Force Main Evaluation", February 13, 2019.

In addition to the above resources, cutsheets for the pumps in both EGPS and Gambles Mill Pump Station were acquired through coordination with their respective Owners and used to create an accurate model. Pump curves used in the model are provided in Appendix B. The basic operating conditions of the model are shown in Table 3-1.

Table 3-1 – Model Parameters

| EASTERN GOOCHLAND PUMP STATION | | | |
|--------------------------------------------------------------------|------------------------------------------|-------------------------------------------|---------------------|
| Parameter | Value | | |
| Number of Pumps, Duty/Standby | 2/1 | | |
| Pump Design Point, gpm / Head, feet | 4,583/210 | | |
| Motor Horsepower, each | 469 | | |
| Pump/Motor Inertia, each, lb-ft | 405 | | |
| EASTERN GOOCHLAND PUMP STATION PIPING | | | |
| Parameter | Value | | |
| Pipe Material | Flanged DI | | |
| Total Length, ft (Profile) | 100 | | |
| Diameter, in | Varies from 12 to 42 | | |
| Pressure Class | Thickness Class 53 | | |
| Wave speed, ft/s | Various | | |
| EASTERN GOOCHLAND FORCE MAIN | | | |
| Parameter | Value | Value | Value |
| Pipe Material | FRP | MJ DI | HDPE |
| Nominal Diameter, in | 48 | 48 | 42 |
| Inner Diameter, in | 49.11 | 49.04 | 37.76 |
| Steady State Hazen Williams Roughness Coefficient | 120 | 120 | 120 |
| Transient Hazen Williams Roughness Coefficient | 150 | 150 | 150 |
| Pressure Class | CL100 | Thickness Class 53 | DR-21 |
| Model Stations | I-131+90 to III-106+70 | I-0+00 to I-14+95 I-122+50 to I-131+90 | I-14+95 to I-122+50 |
| Length, ft. | 36,070 | 2,435 | 10,755 |
| Wave speed, ft/s | 1,744 | 3,616 | 893 |
| EGPS HYDRAULIC BOUNDARY CONDITIONS | | | |
| Parameter | Value | | |
| Wet Well WSELs ⁽¹⁾ , max/min elev | 119.50/114.00 | | |
| Richmond Force Main High Point, invert elev | 253.00 | | |
| Henrico Force Main High Point, invert elev | 268.00 | | |
| Pump Station Static Lifts to Richmond ⁽²⁾ , max/min, ft | 133.50/139.00 | | |
| Pump Station Static Lifts to Henrico ⁽²⁾ , max/min, ft | 148.50/154.00 | | |
| (1) | WSEL = Water surface elevation | | |
| (2) | Discharge elevation – Wet well elevation | | |

3.1.2 System Curve

A system curve for EGPS was generated along with 1, 2, 3, and 5 duty pump curves for the existing EMU pumps for EGPS pumping to the City of Richmond outfall. The system curve and the pump curves for the different duty pump scenarios are shown in Figure 3-1.

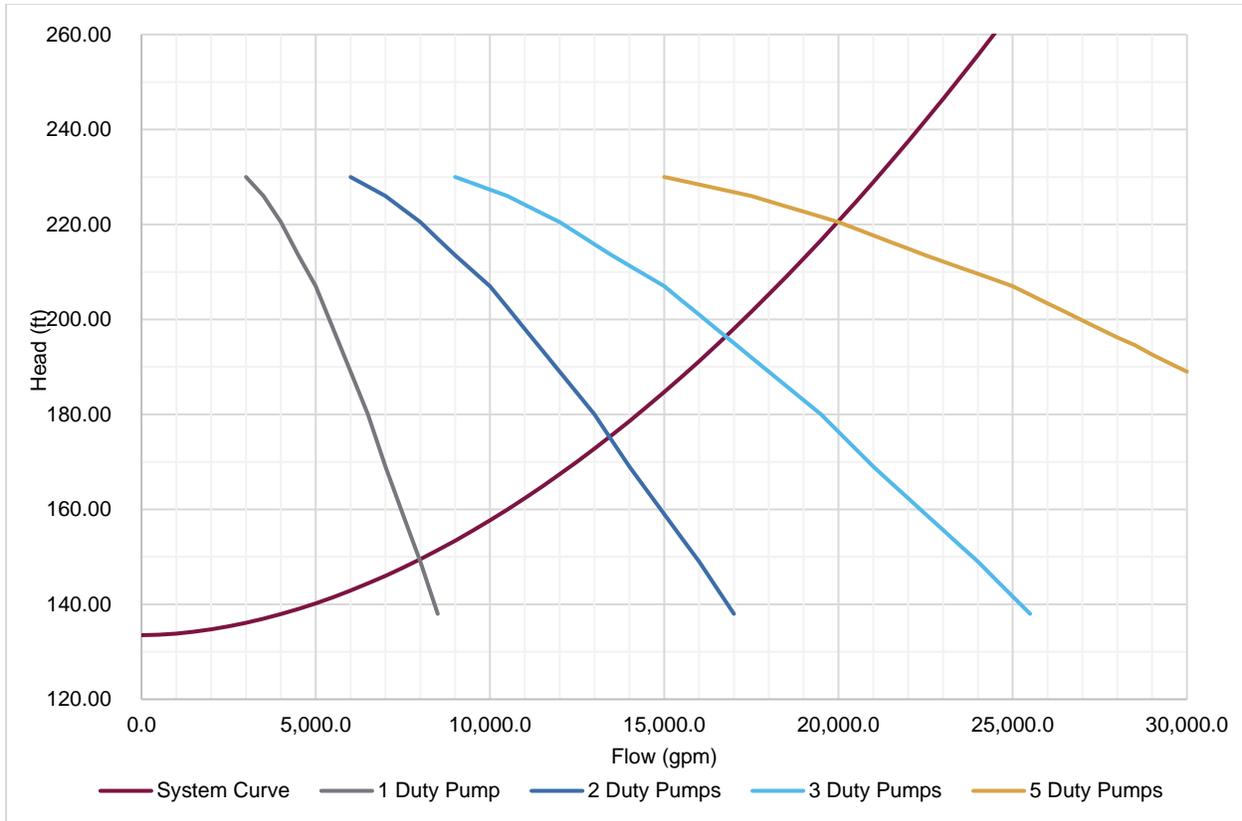


Figure 3-1 – Single Pump System Curves

The point where the pump and system curves intersect represents the firm capacity of the pump station. Based on the calculated system curves, the duty point of each pump and the station's firm capacity are shown in Table 3-2.

Table 3-2 – EGPS Firm Capacity

| OPERATING SCENARIO | FLOW PER PUMP (GPM) | HEAD (FT) | TOTAL FLOW (GPM) | TOTAL FLOW (MGD) |
|-------------------------|---------------------|-----------|------------------|------------------|
| Existing (2 Duty Pumps) | 6,800 | 174 | 13,600 | 19.6 |
| Future (3 Duty Pumps) | 5,600 | 196 | 16,800 | 24.2 |
| Future (5 Duty Pumps) | 4,000 | 220 | 20,000 | 28.8 |

The projected capacity of EGPS is provided in Table 3-3.

Table 3-3 – EGPS Projected Capacity

| YEAR | AVERAGE DAILY FLOW (MGD) | PEAK FACTOR | PEAK HOUR FLOW (MGD) | HENRICO PEAK HOUR FLOW (MGD) | TOTAL REQUIRED CAPACITY (MGD) |
|------|--------------------------|-------------|----------------------|------------------------------|-------------------------------|
| 2020 | 0.42 | 2.5 | 1.06 | 13.0 | 14.06 |
| 2045 | 5.64 | 2.5 | 14.09 | 13.0 | 27.09 |

With the proposed 42” HDPE force main section installed, EGPS will be able to meet both existing and future demand requirements, provided the station is upgraded to include more pumps and assuming that flow from Henrico does not increase beyond the current maximum flow of 13.0 MGD.

3.2 Steady State Analysis

A steady state hydraulic model was completed to confirm flow rate, steady state pressures, and hydraulic grade of the force main under normal operating conditions. Several scenarios were set up to accurately model the different operating conditions of the EGFM.

Six (6) steady state scenarios were completed as part of this model, each representing a different operating condition for the EGFM. Scenario S1.1 involved EGPS pumping through the EGFM to the Richmond City outfall on Cary Street Rd. Scenario S1.2 involved EGPS pumping through the EGFM and the Maple Avenue Force Main to the Henrico County outfall on Maple Ave. Scenario S1.3 involved the same conditions as S1.2, but with the addition of the Henrico-owned Gambles Mill Pump Station actively pumping to the Henrico outfall through the Gambles Mill and Maple Avenue Force Mains. S2.1, S2.2, and S2.3 follow the geometries of S1.1, S1.2, and S1.3 respectively, but operate under the future pump station condition with 5 duty pumps. These scenarios are summarized in Table 3-4.

Table 3-4 – Steady State Analysis Scenarios

| SCENARIO | ANALYSIS TYPE | NUMBER OF DUTY PUMPS | OUTFALL | GAMBLES MILL |
|----------|---------------|----------------------|----------|--------------|
| S1.1 | Steady State | 2 | Richmond | Inactive |
| S1.2 | Steady State | 2 | Henrico | Inactive |
| S1.3 | Steady State | 2 | Henrico | Active |
| S2.1 | Steady State | 5 | Richmond | Inactive |
| S2.2 | Steady State | 5 | Henrico | Inactive |
| S2.3 | Steady State | 5 | Henrico | Active |

For each scenario, the steady state pressure within the force main, the pump station capacity, and total dynamic head (TDH) are noted in the summaries below.

3.2.1 Scenario S1.1

Under Scenario S1.1 EGPS pumps through the EGFM to the City of Richmond outfall located on Cary Street Rd. With the existing 2 duty pumps operating, the firm capacity of EGPS when pumping to Richmond is 13,808 gpm, or 6,904 gpm per pump at 172 TDH. This is a total capacity of roughly 20.0 MGD. Pressures in the force main range from 0 psi to 72 psi. The profile and hydraulic grade for the EGFM from EGPS to the Richmond outfall is shown in Figure 3-2.

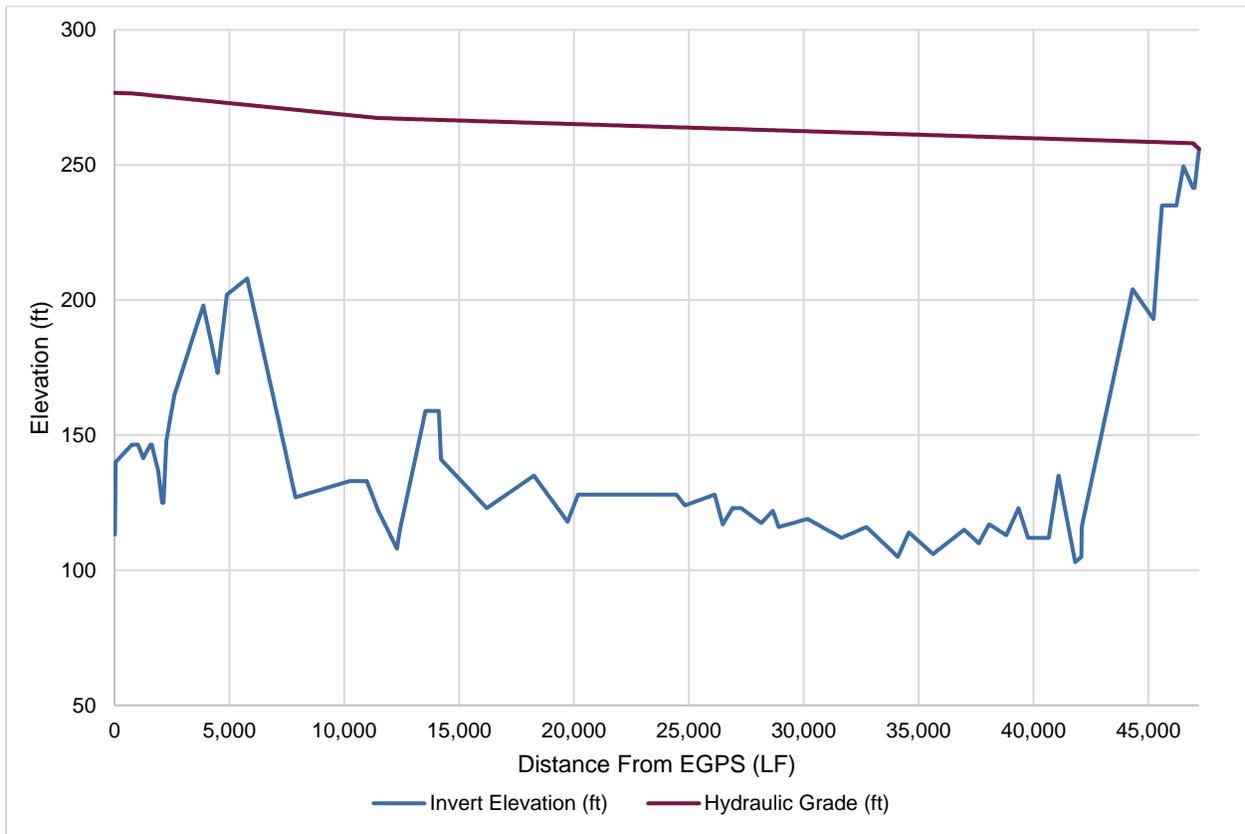


Figure 3-2 – Scenario S1.1 EGFM Hydraulic Grade

3.2.2 Scenario S1.2

Under Scenario S1.2 EGPS pumps through the EGFM to the Henrico County outfall on Maple Ave. With the existing 2 duty pumps operating, the firm capacity of EGPS when pumping to Henrico is 12,738 gpm, or 6,369 gpm per pump at 183 TDH. This is a total capacity of roughly 18.5 MGD, a slight decrease from S1.1 due to a slightly larger TDH when pumping to Henrico. Pressures in the force main range from 0 psi to 77 psi. The profile and hydraulic grade of the EGFM from EGPS to the high point on the Maple Avenue Force Main is shown in Figure 3-3.

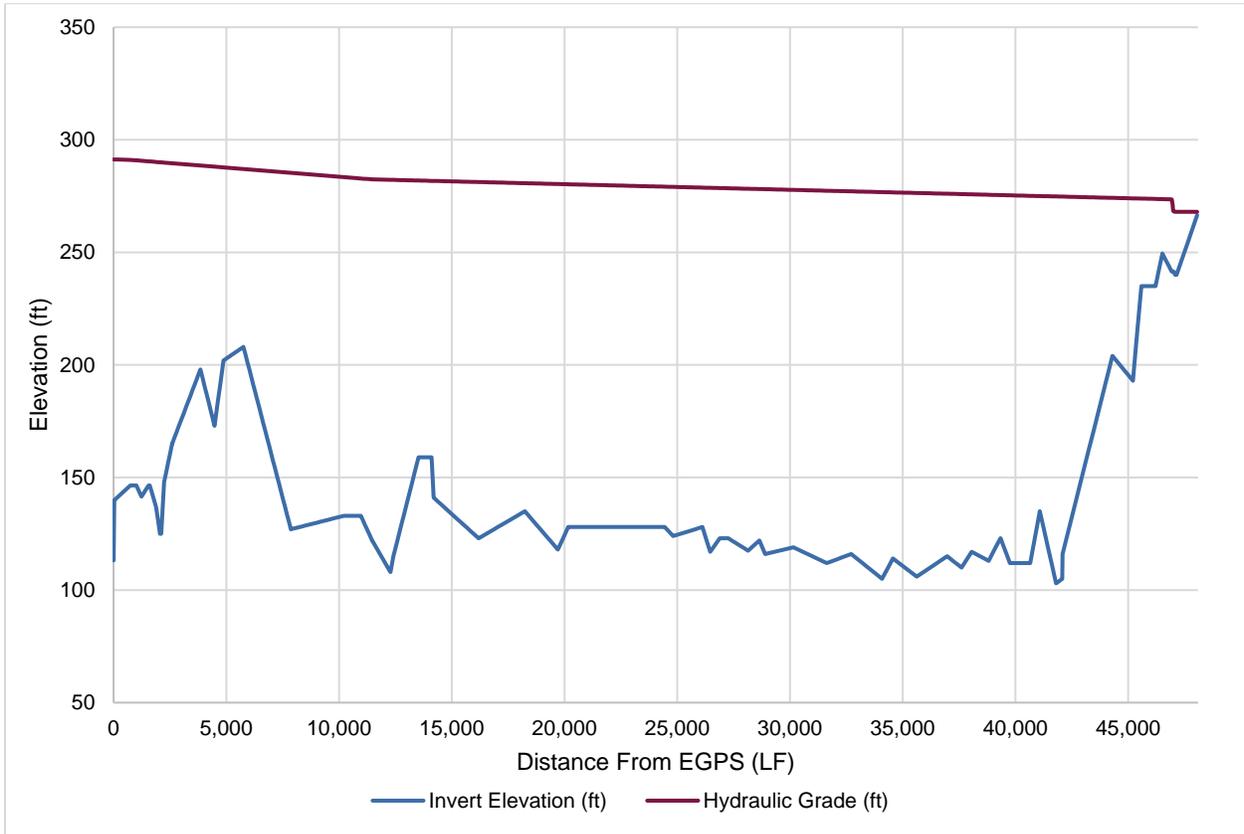


Figure 3-3 – Scenario S1.2 EGFM Hydraulic Grade

3.2.3 Scenario S1.3

Under Scenario S1.3 EGPS pumps through the EGFM to the Henrico County outfall on Maple Ave, with the Gambles Mill Pump Station pumping to the Henrico outfall at the same time. With the existing 2 duty pumps operating, the firm capacity of EGPS when pumping to Henrico is 12,414 gpm, or 6,207 gpm per pump at 183 TDH. This is a capacity of roughly 17.9 MGD, a further decrease from S1.2 due to the additional head losses caused by the increased flow through the Maple Avenue Force Main. Pressures in the force main range from 0 psi to 79 psi. The profile and hydraulic grade of the EGFM from EGPS to the high point on the Maple Avenue Force Main is shown in Figure 3-4.

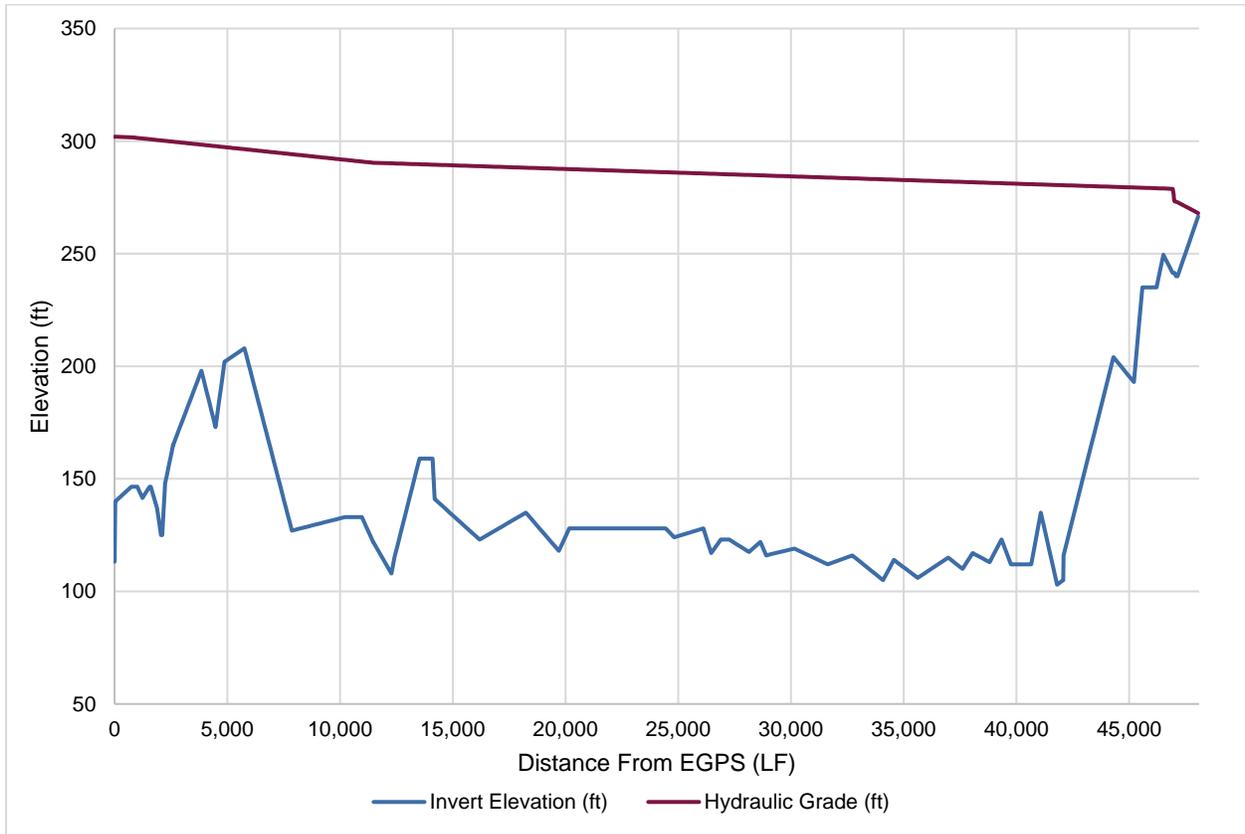


Figure 3-4 – Scenario S1.3 EGFM Hydraulic Grade

3.2.4 Scenario S2.1

Scenario S2.1 follows the force main geometry of S1.1, but with 5 duty pumps actively pumping from EGPS to the Richmond outfall. With the future 5 duty pumps operating, the firm capacity of EGPS when pumping to Richmond is 22,144 gpm, or 4,429 gpm per pump at 213 TDH. This is a capacity of roughly 31.9 MGD. Pressures in the force main range from 0 psi to 82 psi. Figure 3-5 shows the difference in pressure between the S1.1 and S2.1.

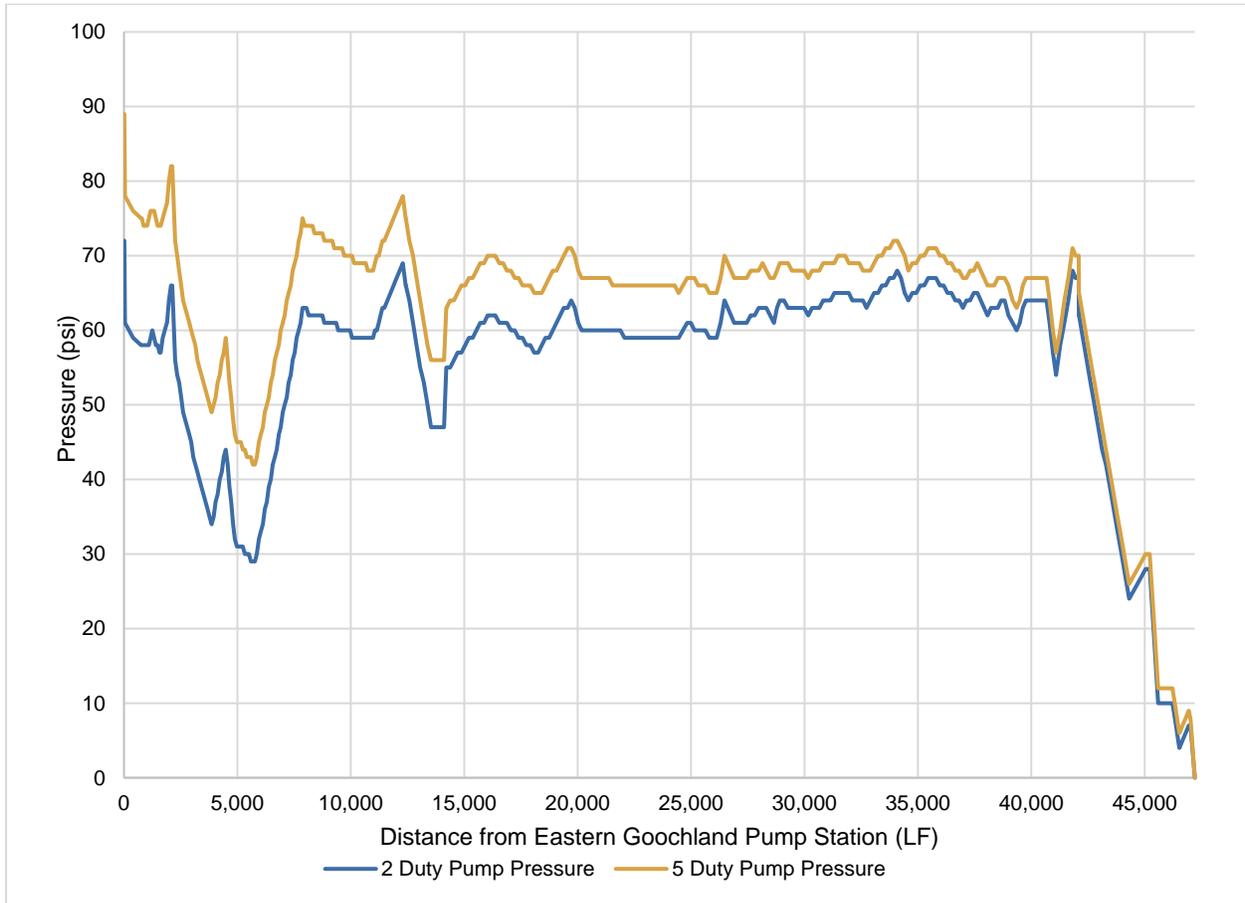


Figure 3-5 – Scenario S1.1 and S2.1 EGFM Steady State Pressures

3.2.5 Scenario S2.2

Scenario S2.2 follows the force main geometry of S1.2, but with 5 duty pumps actively pumping from EGPS to the Henrico outfall. With the future 5 duty pumps operating, the firm capacity of EGPS when pumping to Henrico is 19,944 gpm, or 3,989 gpm per pump at 223 TDH. This is a capacity of roughly 28.7 MGD. Pressures in the force main range from 0 psi to 88 psi. Figure 3-6 shows the difference in pressure between the S1.2 and S2.2.

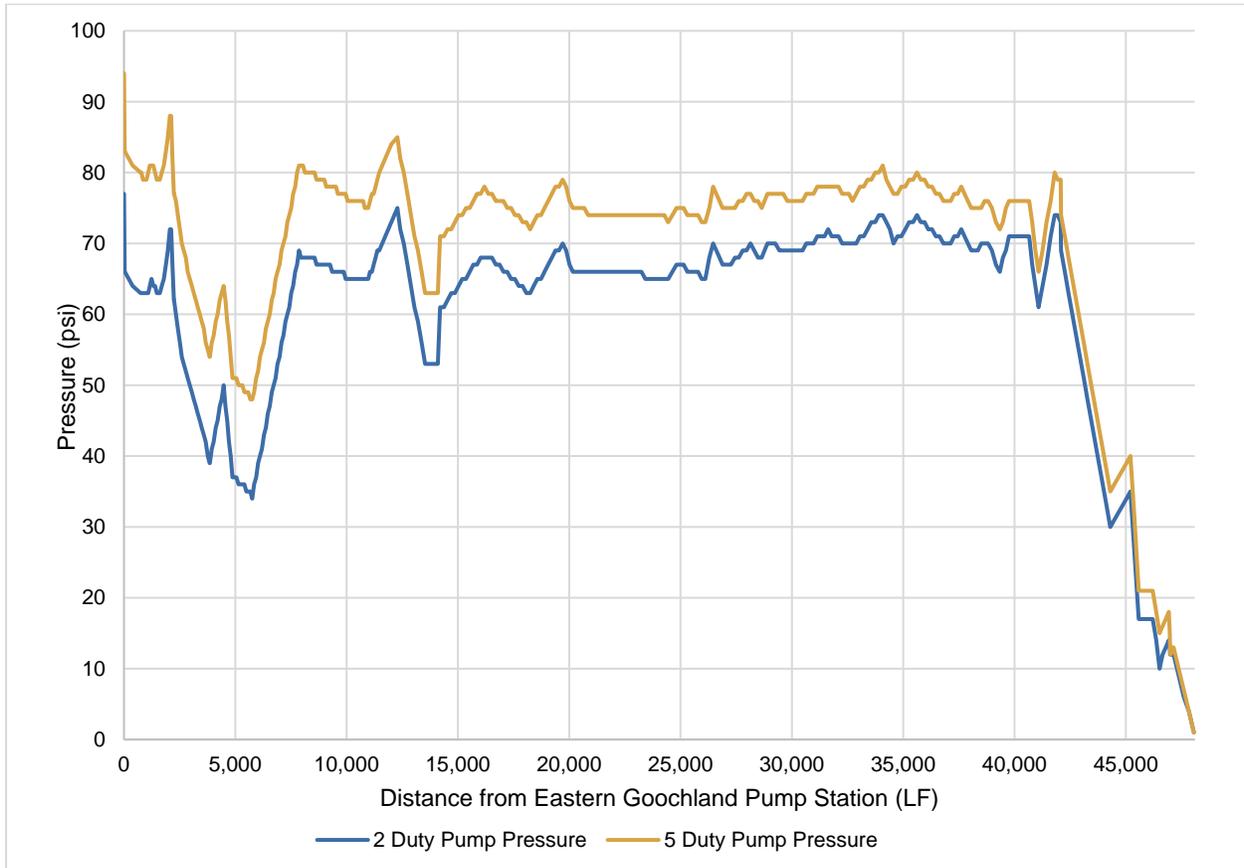


Figure 3-6 – Scenario S2.1 and S2.2 EGFM Steady State Pressures

3.2.6 Scenario S2.3

Scenario S2.3 follows the force main geometry of S1.3, but with 5 duty pumps actively pumping from EGPS to the Henrico outfall concurrently with Gambles Mill Pump Station. With the future 5 duty pumps operating, the firm capacity of EGPS when pumping to Henrico with Gambles Mill is 19,319 gpm, or 3,864 gpm per pump at 225 TDH. This is a capacity of roughly 27.8 MGD. Pressures in the force main range from 0 psi to 89 psi. Figure 3-7 shows the difference in pressure between the S1.3 and S2.3.

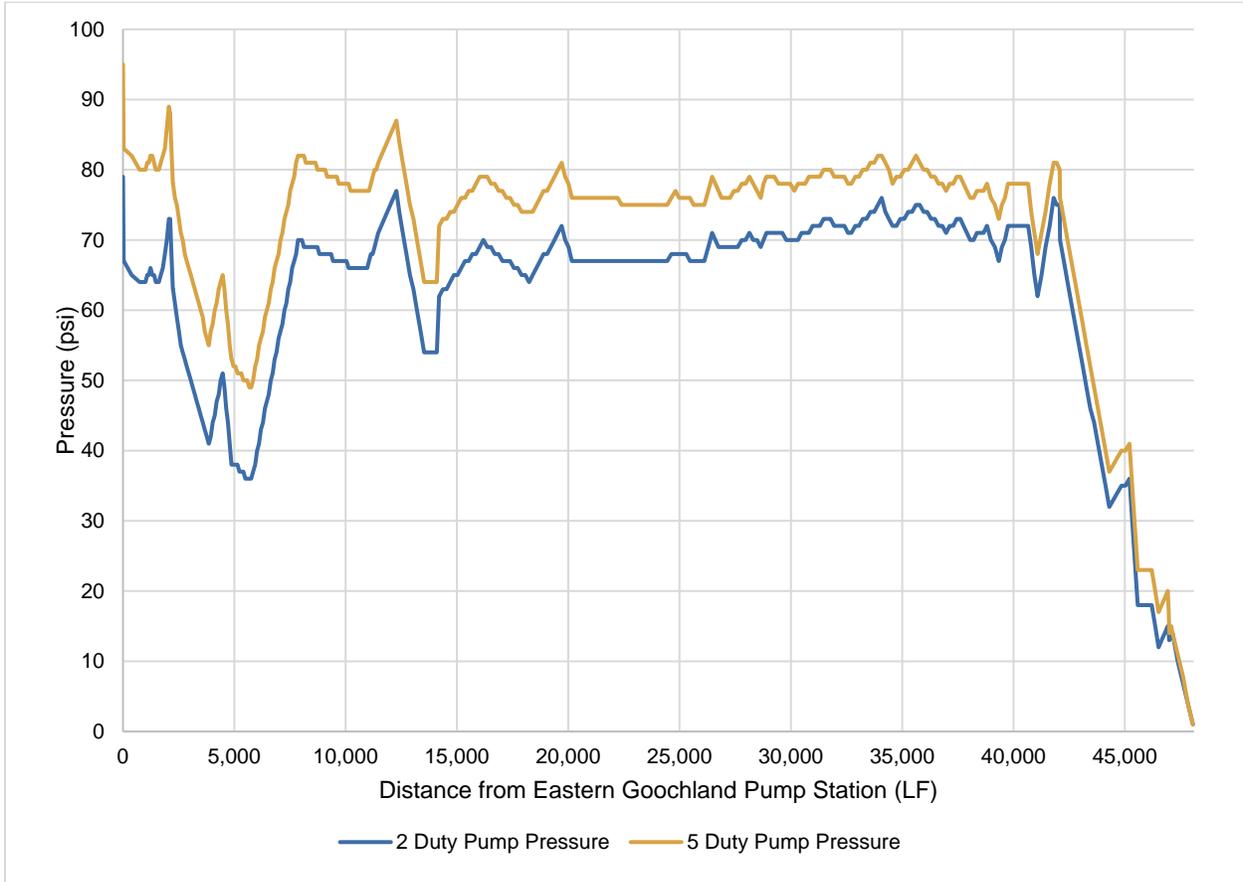


Figure 3-7 – Scenario S1.3 and S2.3 EGFM Steady State Pressures

3.2.7 Steady State Analysis Results

The results of the steady state analysis are shown in Table 3-5.

Table 3-5 – Steady State Analysis Results

| SCENARIO | FLOW PER PUMP (GPM) | TOTAL DYNAMIC HEAD (FT) | TOTAL CAPACITY (GPM) | TOTAL CAPACITY (MGD) |
|----------|---------------------|-------------------------|----------------------|----------------------|
| S1.1 | 6,904 | 172 | 13,808 | 20.0 |
| S1.2 | 6,369 | 183 | 12,738 | 18.4 |
| S1.3 | 6,207 | 186 | 12,414 | 17.9 |
| S2.1 | 4,429 | 213 | 22,144 | 31.9 |
| S2.2 | 3,989 | 223 | 19,944 | 28.7 |
| S2.3 | 3,864 | 225 | 19,319 | 27.8 |

Under each existing pump station scenario, the pump station and force main operate as expected. With the current 2 duty pump configuration of EGPS, the required capacity of the pump station of 14.1 MGD is met

despite the increase in head caused by the smaller diameter of the proposed 42” HDPE pipe. When EGPS is upgraded to 5 duty pumps, it can provide 27.8 MGD of flow at the highest head condition, exceeding the projected 27.1 MGD requirement for the pump station.

3.3 Transient Analysis

A hydraulic transient analysis was completed on the EGFM to ensure that transient velocities and pressures remain within the operating limits of the existing and proposed piping. Should the transient pressures in the force main be outside the operable range, additional surge mitigation devices will be required to reduce the transient response. A pump station trip transient scenario was set up, along with six (6) different physical scenarios to match those in the steady state analysis. A pump station trip when all duty pumps are running at 100% speed and the wet well is at its maximum level typically represents the worst-case transient event for pump stations. Scenarios that can cause this are total power loss to the pump station or simultaneous emergency stop of all duty pumps. These conditions create the highest steady state flow velocity in the force main and will result in the maximum transient event in the system.

For the purposes of this transient analysis, a Hazen Williams C value of 150 was applied to all pipes in the system. According to the Plastic Pipe Institute (PPI) polyethylene pipe typically has a C value of 150 to 155. FRP pipe has also been tested and shown to have a C value of 150 to 160. Cement lined DIP has been tested by the Ductile Iron Pipe Research Association (DIPRA) and results indicate C values up to 150 to 157. In practice, roughness coefficients for DI pipe can range from 110 to 150 however, a high C value such as 150 helps to simulate a worst-case transient event because it enables higher flow velocities.

Table 3-6 displays the minimum and maximum allowable transient pressures for each of the pipe types within the EGFM. These values are based on manufacturer data and published literature on the pipe materials.

Table 3-6 – Allowable Surge Pressures

| CRITERIA | PIPE TYPE | | | |
|----------------------------------|----------------------|-------------------------------|----------|------------|
| | Flanged Ductile Iron | Mechanical Joint Ductile Iron | FRP | DR-21 HDPE |
| Maximum Allowable Surge Pressure | 660 psig | 660 psig | 100 psig | 200 psig |
| Minimum Allowable Surge Pressure | -10 psig | -10 psig | -7 psig | -10 psig |

Maximum and minimum velocity is not dependent on pipe material. The maximum allowable velocity is 10.0 ft/s and the minimum allowable velocity is 2.0 ft/s. Both existing and proposed force main materials are evaluated to ensure these limits are not exceeded.

In each scenario, all existing devices that may contribute to surge mitigation are modeled on each force main. There are 23 air valve locations located along the EGFM alignment, 8 valves on Phase 1, 8 valves on Phase 2, and 7 valves on Phase 3. Existing valves include both 2-inch and 4-inch combination air release/vacuum breaker valves. Each valve functions as both an air release valve and a vacuum breaker valve with an anti-surge orifice. The station point, assumed make/model, and size of each air valve are shown in Table 3-7.

Table 3-7 – Existing EGFM Air Valves

| EASTERN GOOCHLAND FORCE MAIN PHASE 1 | | | |
|-----------------------------------------------------------|-----------------------|-----------------------|---------------------|
| STATION | AIR VALVE SIZE | MAKE AND MODEL | NO OF VALVES |
| 15+25 | 2 | ARI D-020 | 1 |
| 22+98 | 2 | ARI D-020 | 1 |
| 46+05 | 4 | Vent-O-Mat RGX II | 2 |
| 56+50 | 4 | Vent-O-Mat RGX II | 2 |
| 65+30 | 4 | Vent-O-Mat RGX II | 2 |
| 115+20 | 2 | ARI D-020 | 1 |
| 148+29 | 4 | Vent-O-Mat RGX II | 1 |
| 189+46 | 2 | ARI D-020 | 1 |
| EASTERN GOOCHLAND FORCE MAIN PHASE 2 | | | |
| STATION | AIR VALVE SIZE | MAKE AND MODEL | NO OF VALVES |
| 10+75 | 2 | ARI D-020 | 1 |
| 53+67 | 2 | ARI D-020 | 1 |
| 69+70 | 2 | ARI D-020 | 1 |
| 78+00 | 2 | ARI D-020 | 1 |
| 94+60 | 2 | ARI D-020 | 1 |
| 109+79 | 2 | ARI D-020 | 1 |
| 135+42 | 2 | ARI D-020 | 1 |
| 153+93 | 2 | ARI D-020 | 1 |
| EASTERN GOOCHLAND FORCE MAIN PHASE 3⁽¹⁾ | | | |
| STATION | AIR VALVE SIZE | MAKE AND MODEL | NO OF VALVES |
| 10+54 | 2 | ARI D-020 | 1 |
| 20+80 | 2 | ARI D-020 | 1 |
| 33+35 | 2 | ARI D-020 | 1 |
| 50+69 | 2 | ARI D-020 | 1 |
| 82+98 | 2 | ARI D-020 | 1 |
| 93+00 | 4 | Vent-O-Mat RGX II | 2 |
| 102+80 | 4 | Vent-O-Mat RGX II | 1 |

(1) According to the 2019 Brown and Caldwell report there is an additional valve at station 42+50 of phase 3. Evidence of this valve cannot be found elsewhere, and it was excluded from the model.

Additionally, a 3-inch combination air release/vacuum breaker valve is located immediately upstream of the control valve on the 18" DI pipe for flow going to the Maple Avenue Force Main towards the Henrico outfall. All existing air valves are assumed to be in service and good working condition on both the existing and proposed sections of the force main. Existing valves are assumed to be reused or replaced in-kind on the proposed HDPE sections of the force main. Two (2) surge relief valves are present and modeled in the Eastern Goochland Pump Station. The valves have open pressure set points of 110 psi and 120 psi. Valve locations along EGPS profile are shown in Figure 3-8.

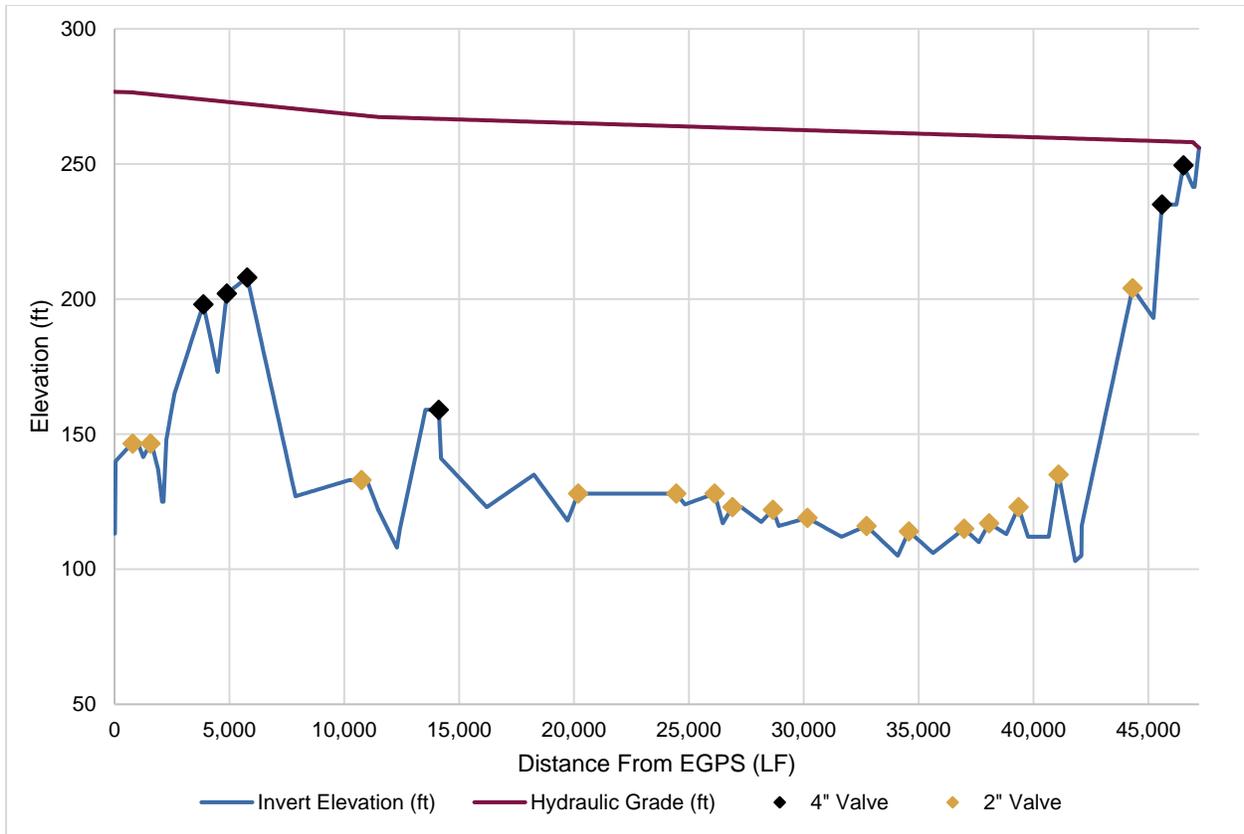


Figure 3-8 – Air Valve Locations

In addition to the existing valves on the EGFM, existing air and vacuum valves on the Gambles Mill and Maple Avenue Force Mains were modeled. The locations and further details for these air valves are shown in Table 3-8.

Table 3-8 – Gambles Mill and Maple Avenue Air Valves

| GAMBLES MILL FORCE MAIN | | |
|-------------------------|----------------|--------------|
| STATION | AIR VALVE SIZE | NO OF VALVES |
| 809+89 | 4 | 1 |
| 797+97 | 4 | 1 |
| MAPLE AVENUE FORCE MAIN | | |
| STATION | AIR VALVE SIZE | NO OF VALVES |
| 20+48 | 4 | 1 |
| 46+40 | 4 | 1 |

The make and model of the air valves on the Maple Avenue and Gambles Mill force mains is unknown. For the purposes of the transient analysis, air valve orifice size was assumed to be the same as the valves on the EGFM.

3.3.1 Pump Station Trip/Power Failure

Six (6) physical scenarios were modeled under the pump station trip scenario to encompass the different operating conditions of EGPS and the EGFM. These scenarios are summarized in Table 3-9.

Table 3-9 – Transient Analysis Scenarios

| SCENARIO | ANALYSIS TYPE | NUMBER OF DUTY PUMPS | OUTFALL | GAMBLES MILL |
|----------|---------------|----------------------|----------|--------------|
| S3.1 | Transient | 2 | Richmond | Inactive |
| S3.2 | Transient | 2 | Henrico | Inactive |
| S3.3 | Transient | 2 | Henrico | Active |
| S4.1 | Transient | 5 | Richmond | Inactive |
| S4.2 | Transient | 5 | Henrico | Inactive |
| S4.3 | Transient | 5 | Henrico | Active |

3.3.2 Scenario S3.1

Under scenario S3.1, EGPS pumps through the EGFM to the City of Richmond outfall located on Cary Street Rd. The pressure profile in this section represents the entire EGFM, and the DI pipe leading up to the outfall. The maximum and minimum transient pressures within the proposed HDPE pipe are 91 psi and -2 psi, respectively. Both the maximum and minimum pressures are within the acceptable operating range of DR-21 HDPE pipe. The velocity through the 42" HDPE pipe is 4.16 ft/s. In the existing FRP pipe, the maximum and minimum pressures are 94 psi and -2 psi, respectively. Both pressures are within acceptable operating levels for the FRP pipe. The velocity through the 48" FRP pipe is 2.46 ft/s. The transient pressures for this scenario are shown in Figure 3-9.

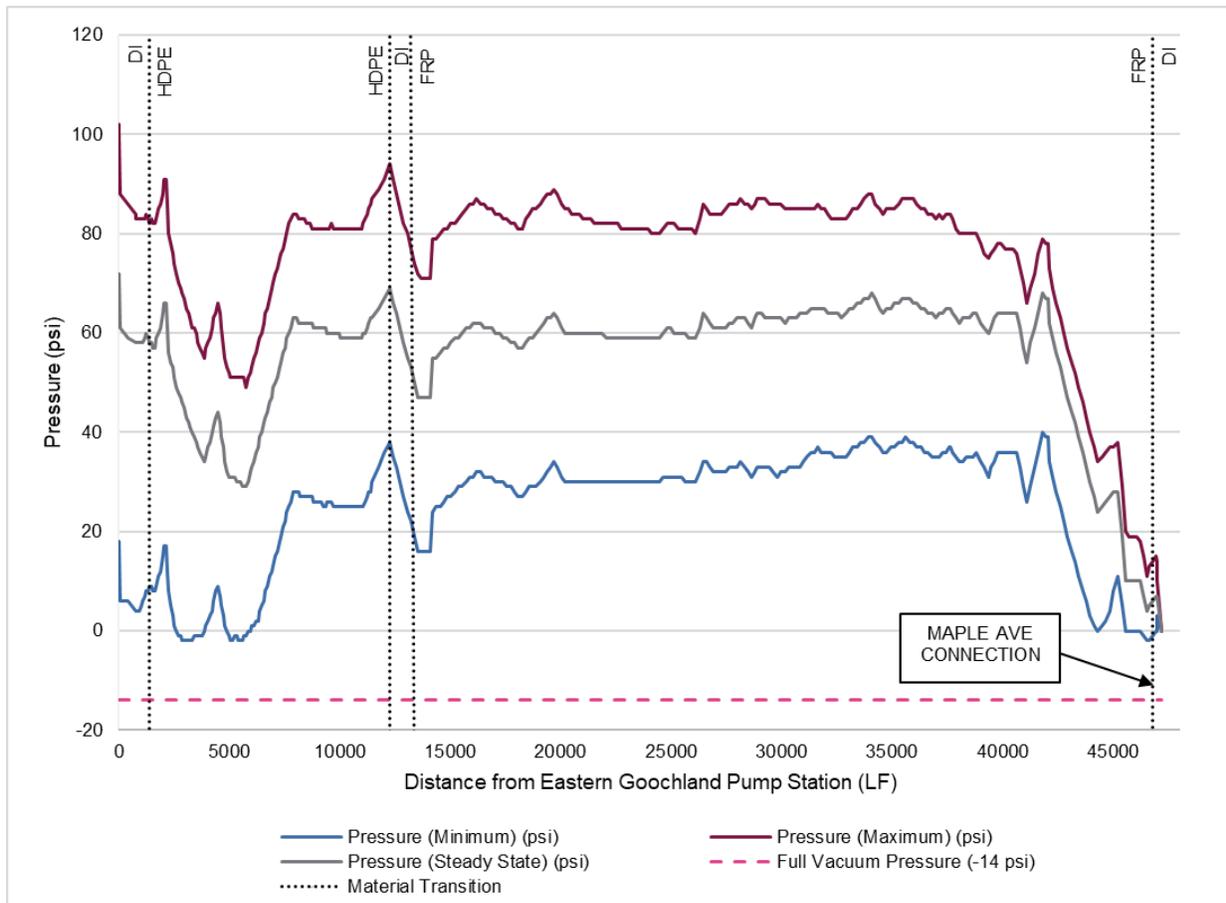


Figure 3-9 – Scenario S3.1 Transient Pressures

3.3.3 Scenario S3.2

In scenarios S3.2 and S3.3, the transient analysis focuses on EGPS, as well as a section of the Maple Avenue Force Main up to the high point of 268' at station 20+48. The transient effects of the pump trip do not propagate beyond this point, as the wave does not propagate beyond the controlling high point of the force main. Pressure profiles displayed in these sections represent the entire EGFM and the length of the Maple Avenue Force Main up to the high point. The maximum and minimum transient pressures within the proposed HDPE pipe are 88 psi and -2 psi, respectively. Both the maximum and minimum pressures are within the acceptable operating range of DR-21 HDPE pipe. The velocity through the 42" HDPE pipe is 3.83 ft/s. In the existing FRP pipe of the force main, the maximum and minimum pressures are 98 psi and -2 psi, respectively. The maximum pressure of 98 psi occurs at station 131+60 of the EGFM phase 1. While this pressure is slightly below the 100 psi maximum allowable surge pressure of FRP pipe, a change in operating conditions, such as the addition of a third duty pump, could cause pressure at this point to rise above acceptable levels. The velocity through the 48" FRP pipe is 2.27 ft/s. Pressures briefly dip to -5 in the 18" ductile iron portion of the force main where the control valve is located. The transient pressures for this scenario are shown in Figure 3-10.

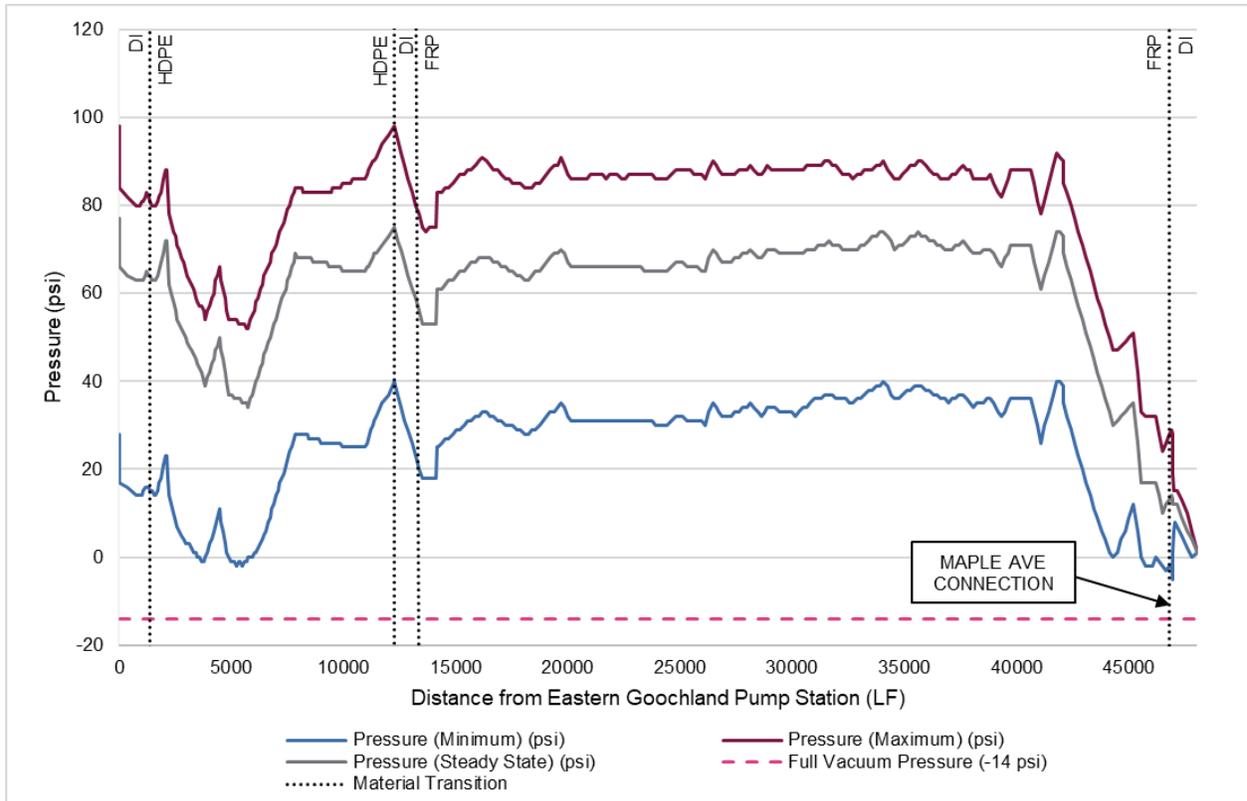


Figure 3-10 – Scenario S3.2 Transient Pressures

3.3.4 Scenario S3.3

Scenario S3.3 follows the same force main geometry as S3.2, but with the addition of the Gambles Mill Pump Station undergoing a pump trip transient event at the same time that EGPS undergoes a pump trip. Results of this scenario closely follow that of S3.2. The maximum and minimum transient pressures within the proposed HDPE pipe are 90 psi and -2 psi, respectively. Both the maximum and minimum pressures are within the acceptable operating range of DR-21 HDPE pipe. The velocity through the 42" HDPE pipe is 3.76 ft/s. In the existing FRP pipe of the force main, the maximum and minimum pressures are 93 psi and -2 psi, respectively. The velocity through the 48" FRP pipe is 2.22 ft/s. The transient pressures for this scenario are shown in Figure 3-11.

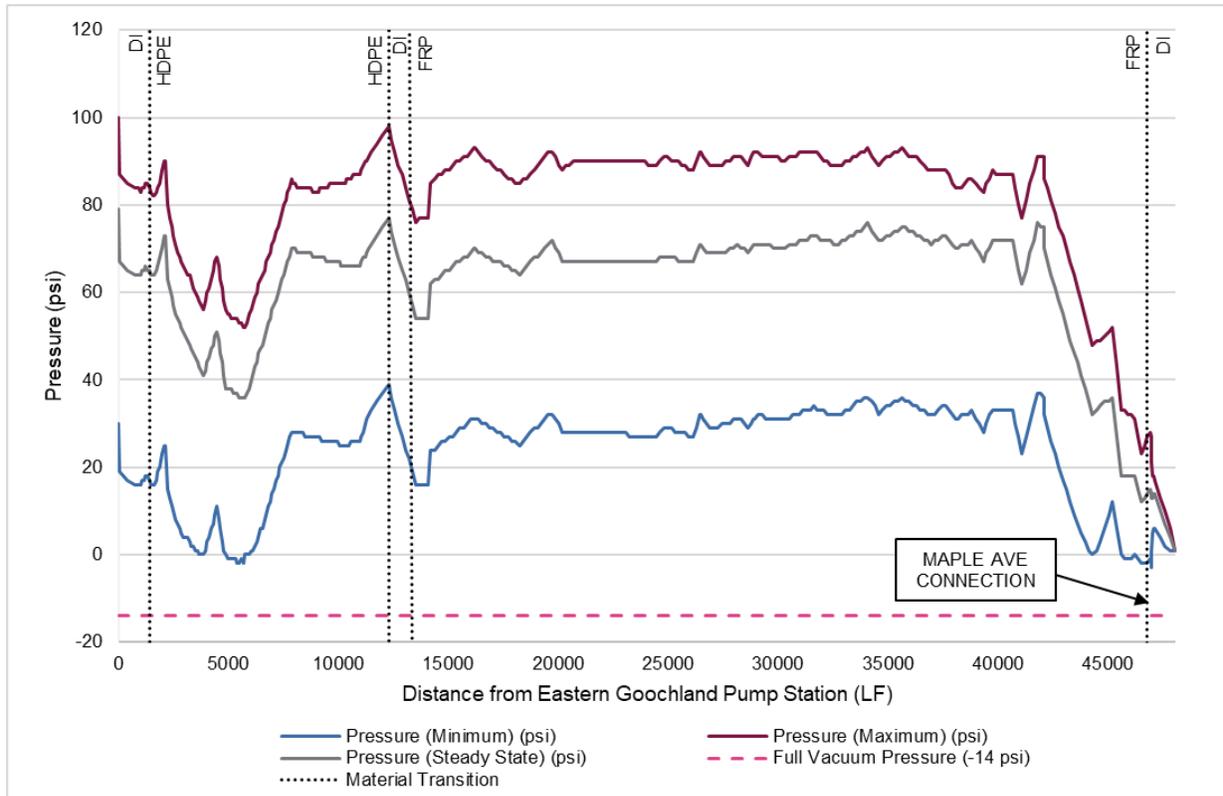


Figure 3-11 – Scenario S3.3 Transient Pressures

3.3.5 Scenario 4.1

Under scenario S4.1, EGPS pumps with 5 pumps through the EGFM to the City of Richmond outfall located on Cary Street Rd. The maximum and minimum transient pressures within the proposed HDPE pipe are 90 psi and -8 psi, respectively. Despite the more extreme minimum transient pressure when compared to the existing 2-pump scenario, both the maximum and minimum pressures are within the acceptable operating range of DR-21 HDPE pipe. The velocity through the 42" HDPE pipe is 7.05 ft/s. In the existing FRP pipe of the force main, the maximum and minimum pressures are 95 psi and -3 psi, respectively. Both pressures are within acceptable operating levels for the FRP pipe. The velocity through the 48" FRP pipe is 4.17 ft/s. The transient pressures for this scenario are shown in Figure 3-12.

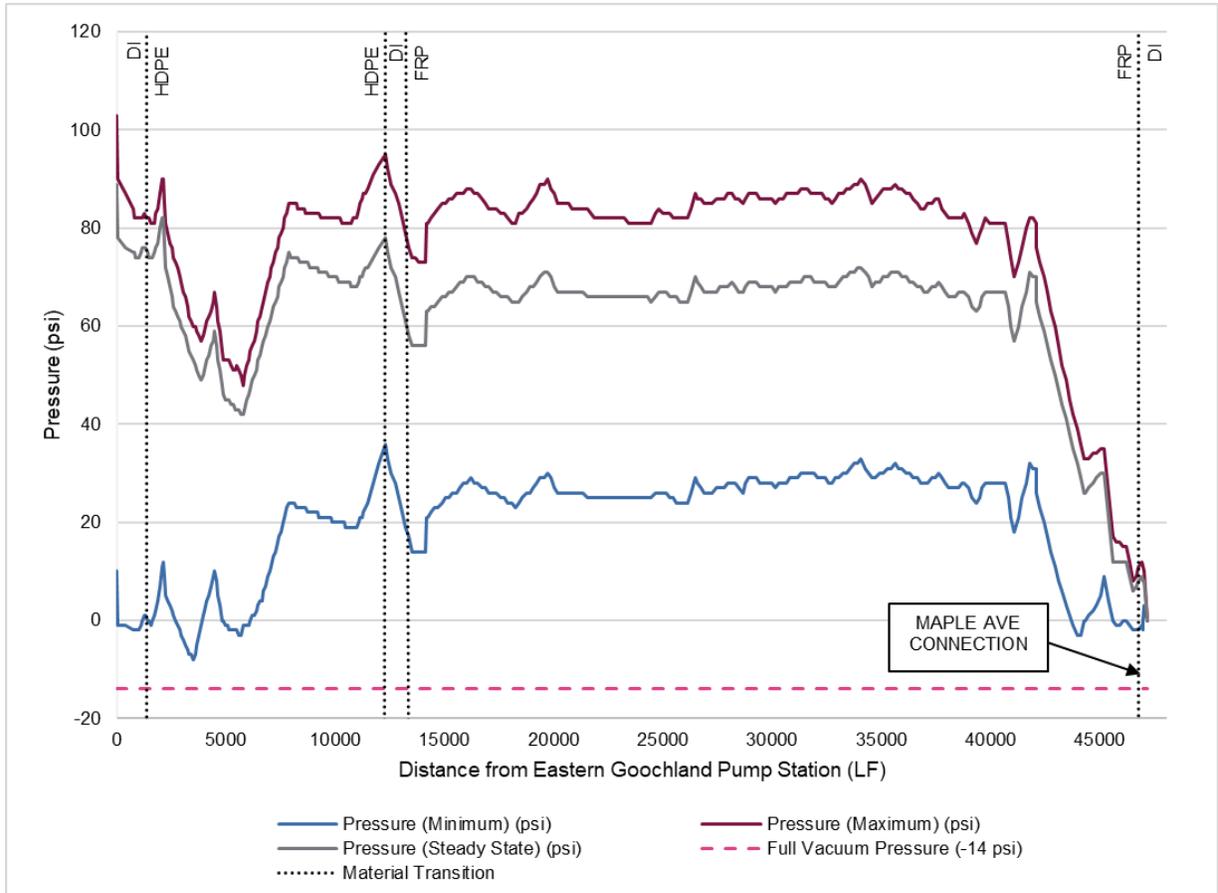


Figure 3-12 – Scenario S4.1 Transient Pressures

3.3.6 Scenario S4.2

In scenario S4.2 the future 5 duty pumps at EGPS pump through the EGFM to the Henrico outfall. The maximum and minimum transient pressures within the proposed HDPE pipe are 94 psi and -2 psi, respectively. Like with S4.1, transient results are more extreme under the 5-pump scenario than the 2-pump scenario; however, both the maximum and minimum pressures remain within the acceptable operating range of DR-21 HDPE pipe. The velocity through the 42" HDPE pipe is 6.36 ft/s. In the existing FRP pipe, the maximum and minimum pressures are 102 psi and -4 psi, respectively. The maximum transient pressure of 103 psi at phase 2 station 149+00 is above the rated maximum pressure of the FRP pipe. Additional surge mitigation at this location may be required to prevent pipe breaks around this location. Additionally, transient pressures reach the maximum pressure of 100 psi at two other locations: phase 1 station 131+60 and from phase 2 stations 166+07 to 169+45. A change in operating conditions could cause pressure to rise above the maximum pressure at either of these locations. The velocity through the 48" FRP pipe is 3.76 ft/s.

Similar to S3.2, pressures briefly dip lower, to -8 psi in S4.2, in the 18" ductile iron portion of the force main where the control valve is located. This is still above the minimum transient pressure of ductile iron pipe. The transient pressures for this scenario are shown in Figure 3-13.

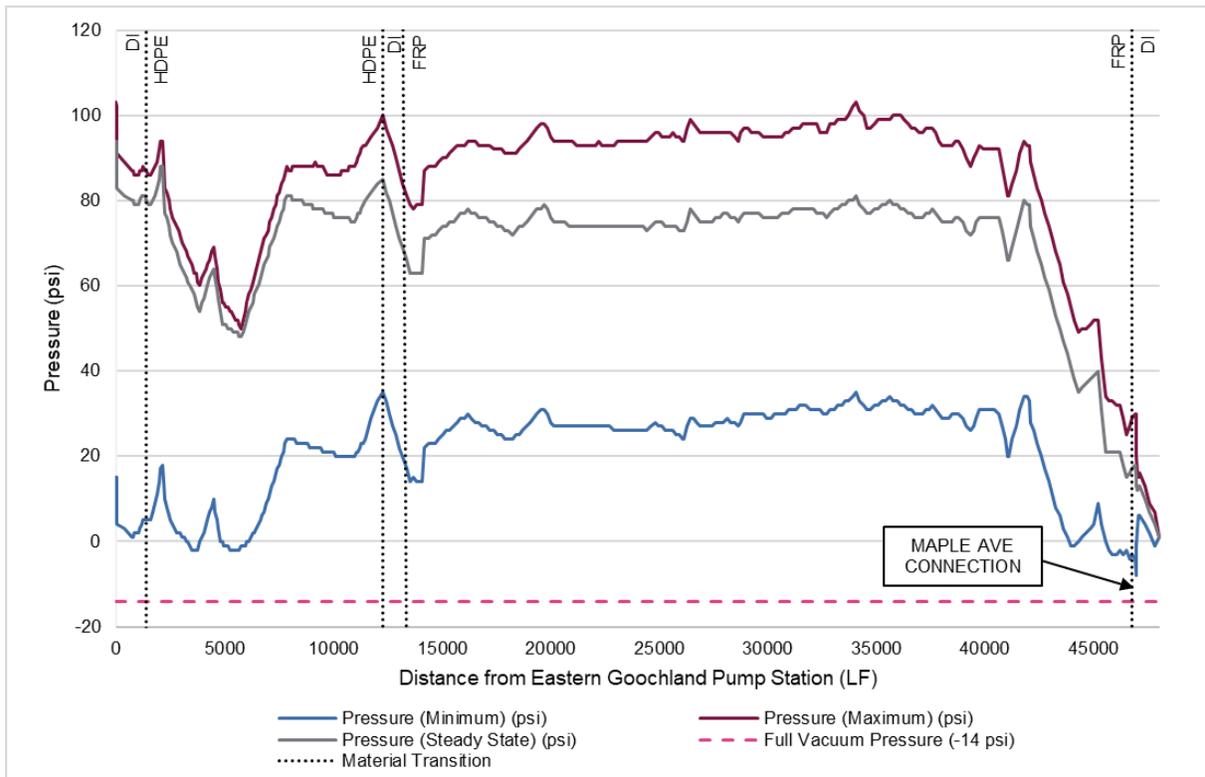


Figure 3-13 – Scenario S4.2 Transient Pressures

3.3.7 Scenario S4.3

Scenario S4.3 follows the same force main geometry as S4.2, with the addition of the Gambles Mill Pump Station undergoing a simultaneous pump trip. The maximum and minimum transient pressures within the proposed HDPE pipe are 97 psi and -3 psi, respectively. Both the maximum and minimum pressures are within the acceptable operating range of DR-21 HDPE pipe. The velocity through the 42" HDPE pipe is 6.21 ft/s. In the existing FRP pipe, the maximum and minimum pressures are 103 psi and -3 psi, respectively. The maximum pressure of 101 psi occurs at phase 2 stations 73+75 and 149+00. The 101 psi maximum at station 149+00 occurs along a length of force main, roughly from phase 2 station 142+00 to station 153+31, where pressures remain above 100 psi. Should a transient event occur, these points would be the most likely location for a break to occur. Additional surge mitigation to lessen the effects of a transient event is recommended. Transient pressures reach 100 psi at two other points along the FRP force main: phase 1 stations 131+60 and 204+00. The velocity through the 48" FRP pipe is 3.67 ft/s. The transient pressures for this scenario are shown in Figure 3-14.

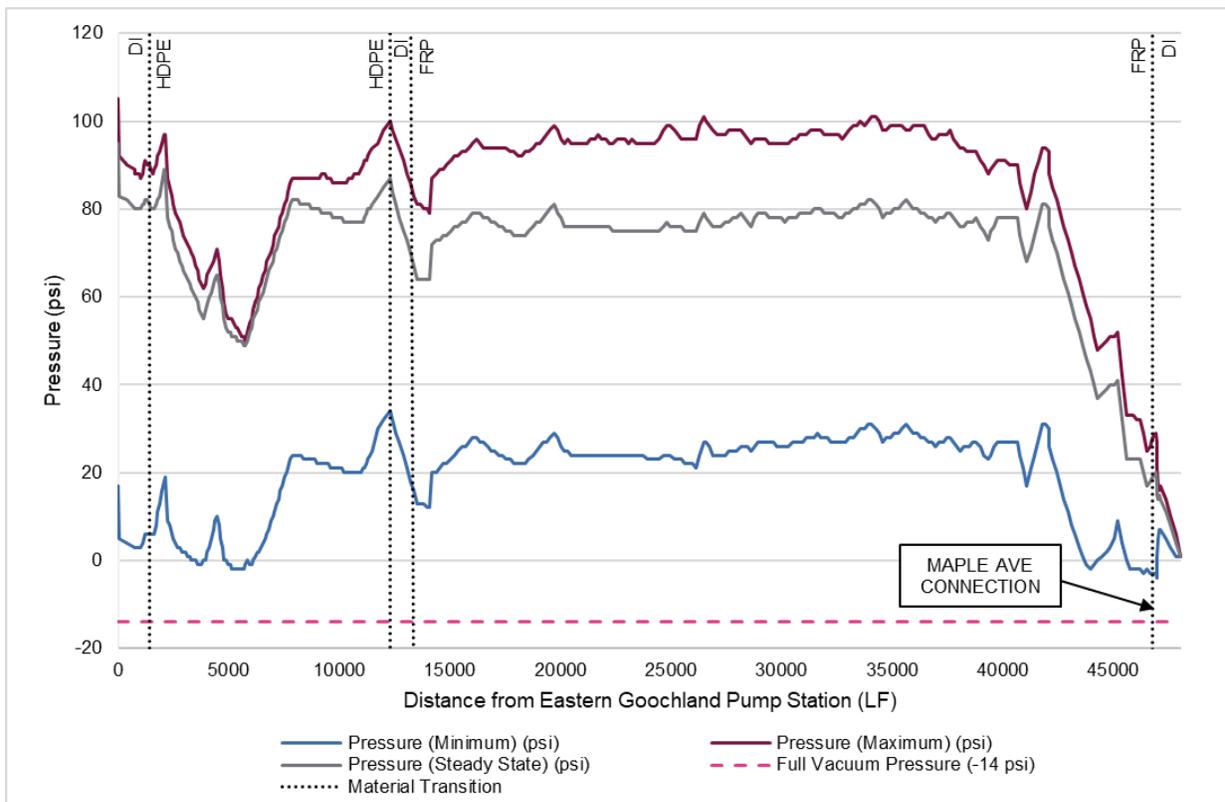


Figure 3-14 – Scenario S4.3 Transient Pressures

EGPS will be upgraded in phases with 3 and 4 duty pumps being used prior to the final 5 duty pump condition. S4.3 was modified to run using 3 and 4 duty pumps to determine whether pressures rise above 100 psi in the FRP force main at the intermediate phases. When 4 duty pumps are active, the transient pressure rises to 100 psi at phase 1 station 131+60. When 3 duty pumps are active at EGPS, transient pressure rises to 102 psi at one point, phase 2 station 149+00. When the County completes upgrades to EGPS to include a third and then a fourth duty pump to provide additional capacity, either additional surge mitigation along the FRP portion of the force main or further replacement of FRP sections with HDPE pipe will be required to ensure that transient pressures remain within allowable levels.

In addition, the pressure setpoints of the existing surge relief valves may be lowered so that the valves open at 100 psi rather than 110 psi and 120 psi. This lowered setpoint allows the valve to open in this

scenario, which helps to mitigate the transient response. This change alone, however, does not provide a large enough effect on the transient response to bring all pressures below the 100 psi limit in the FRP pipe and additional mitigation as discussed above would still be required.

3.3.8 Transient Analysis Results

The results of the transient hydraulic analysis are shown in Table 3-10.

Table 3-10 – Transient Analysis Results

| SCENARIO | 42" HDPE VELOCITY (FT/S) | HDPE MAX PRESSURE (PSI) | HDPE MIN PRESSURE (PSI) | 48" FRP VELOCITY (FT/S) | FRP MAX PRESSURE (PSI) | FRP MIN PRESSURE (PSI) |
|----------|--------------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|------------------------------|
| S3.1 | 4.16 | 91 | -2 | 2.46 | 94 | -3 |
| S3.2 | 3.83 | 88 | -1 | 2.27 | 98 | -2 |
| S3.3 | 3.76 | 90 | -2 | 2.22 | 93 | -2 |
| S4.1 | 7.05 | 90 | -8 | 4.17 | 95 | -3 |
| S4.2 | 6.36 | 94 | -2 | 3.76 | 103 | -4 |
| S4.3 | 6.21 | 97 | -3 | 3.67 | 101 | -3 |

At the pump station’s current pumping capacity, the transient pressures within the force main remain within the maximum and minimum allowable pressures for both the existing and proposed piping. When pumping to the Henrico outfall, with or without Gambles Mill active, transient results are slightly more severe than when pumping to the Richmond outfall. Flow velocities remain within the allowable limits throughout the force main for each existing scenario.

Due to the projected increase in demand in the service area, the County plans to eventually upgrade the pump station to include 5 duty pumps. At this future operating condition, transient pressures remain within allowable limits when EGPS is pumping to the City of Richmond outfall. However, when EGPS is pumping to the Henrico County outfall, whether Gambles Mill Pump Station is active or inactive, transient pressures rise above the acceptable limit of 100 psi for the FRP pipe at several locations. Additionally, for earlier phases of the EGPS expansion when there are 3 or 4 duty pumps, Gambles Mill Pump Station is active, and both pump stations trip, transient pressures in the force main exceed the allowable limit. Should the County expand EGPS in the future to meet projected demands, additional surge mitigation where the maximum pressure exceeds the allowable pressure or rehabilitation of the force main involving a change in material would likely be required. Flow velocities remain within allowable limits throughout the force main under each future scenario.

The following is recommended to ensure the long-term reliability of the EGFM

- Ensure all existing combination air/vacuum valves remain in service, are in good condition, or are replaced in-kind along the EGFM after the proposed HDPE pipe is installed.
- When EGPS is upgraded to include 3 duty pumps, perform a detailed transient evaluation to determine the location of any additional surge mitigation devices required to further reduce transient pressure or areas of force main that require replacement with materials that have a transient pressure rating greater than the transient pressures in the system, such as HDPE.
- Complete the same detailed analysis for the 4 and 5 duty pump upgrades to the pump station, if necessary.

4.0 PROJECT SUMMARY

4.1 Overview of Recommended Project

In summary, the recommended approach for renewing the existing EGFM system is through a combination of open cut installation and sliplining. The new force main will be a 42-inch IPS DR-21 HDPE pipe that will replace the existing 48-inch FRP force main that is currently failing. Based on the hydraulic analysis, the new force main will be able to meet the performance requirements for the existing conditions and potential future flows.

A summary approach drawing has been developed and is attached as Appendix C showing locations and approximate distances for open cut installation and slipline installation.

4.2 Project Cost

A preliminary opinion of probable construction cost has been developed based on the recommended approach. It should be noted that due to a number of factors, including inflation, COVID-19 and supply chain challenges, construction costs have been recently volatile. The cost estimate has been developed using the most up to date industry standards and cost approximations based on regional history.

The overall project includes the replacement of approximately 11,000 LF of force main. A budgetary cost estimate for this project is approximately \$7.1 million, including a 15% contingency. This estimate does not include costs associated with land acquisition, engineering, survey or legal fees. It also does not include permit fees or other costs associated with project approvals.

This estimate carries standard costs for property/site restoration such as seeding and sodding. Based on a field walkthrough and review of available as-built and GIS data, it is anticipated that the existing force main and easements are located close to, and on, residential properties. Based on the available data, the impact to these properties is unknown. However, it is anticipated that the majority of the work will be completed within existing easements. Should decorative landscaping, fencing or other improvements exist in the easements, additional cost may be realized associated with restoration.

Lastly, a potential significant cost factor that is not included in this estimate is bypass pumping. As outlined above, the influent sewer to the EGPS allows flow to be diverted from the EGPS to the Henrico County gravity sewer system. It is assumed that flow will be diverted through gravity flow control within the existing system by DPU and Henrico County and no mechanical bypass would be required by the Contractor. The flow diversion will need to be in place for the duration of construction, approximately twelve (12) months.

Table 4-1 – Budgetary Cost Estimate

| OPINION OF PROBABLE CONSTRUCTION COST | | | | |
|--------------------------------------------|----------|------|--------------|---------------------|
| GENERAL ITEMS | | | | |
| LINE ITEM | QUANTITY | UNIT | UNIT COST | EXTENSION |
| Mobilization/Demobilization | 1 | LS | \$75,000.00 | \$75,000.00 |
| Site Restoration | 5 | AC | \$22,500.00 | \$122,500.00 |
| Construction Access, Clearing and Grubbing | 1 | LS | \$165,000.00 | \$165,000.00 |
| Maintenance of Traffic and Traffic Control | 1 | LS | \$42,500.00 | \$42,500.00 |
| Force Main Testing and Commissioning | 1 | LS | \$85,000.00 | \$85,000.00 |
| <i>General Items Subtotal:</i> | | | | <i>\$480,000.00</i> |

| SECTION 1 (STA. 13+74 TO STA. 17+56) – OPEN CUT INSTALLATION | | | | |
|---------------------------------------------------------------------|----------|------|-------------|-----------------------|
| LINE ITEM | QUANTITY | UNIT | UNIT COST | EXTENSION |
| Furnish 42" HDPE DR-21 Force Main | 400 | LF | \$245.00 | \$98,000.00 |
| 2" ARV with Precast Structure and Valve | 1 | EA | \$15,000.00 | \$15,000.00 |
| Excavation | 711 | CY | \$75.00 | \$53,325.00 |
| Pipe Cleaning, Removal, Disposal and | 400 | LF | \$155.00 | \$62,000.00 |
| Pipe Bedding, Backfill and Compaction | 711 | CY | \$60.00 | \$42,667.00 |
| Fusion Weld and Install 42" HDPE DR-21 Force | 400 | LF | \$100.00 | \$40,000.00 |
| <i>General Items Subtotal:</i> | | | | \$311,000.00 |
| SECTION 2 (STA. 17+56 TO STA. 31+00) – OPEN CUT INSTALLATION | | | | |
| LINE ITEM | QUANTITY | UNIT | UNIT COST | EXTENSION |
| Furnish 42" HDPE DR-21 Force Main | 1,350 | LF | \$245.00 | \$330,750.00 |
| 2" ARV with Precast Structure and Valve | 1 | EA | \$15,000.00 | \$15,000.00 |
| Excavation | 2,400 | CY | \$75.00 | \$180,000.00 |
| Pipe Cleaning, Removal, Disposal and | 1,350 | LF | \$155.00 | \$209,250.00 |
| Pipe Bedding, Backfill and Compaction | 2,400 | CY | \$60.00 | \$144,000.00 |
| Fusion Weld and Install 42" HDPE DR-21 Force | 1,350 | LF | \$100.00 | \$135,000.00 |
| <i>General Items Subtotal:</i> | | | | \$1,014,000.00 |
| SECTION 3 (STA. 31+00 TO STA. 45+50) – SLIPLINE INSTALLATION | | | | |
| LINE ITEM | QUANTITY | UNIT | UNIT COST | EXTENSION |
| Furnish 42" HDPE DR-21 Force Main | 1,450 | LF | \$245.00 | \$355,250.00 |
| 2" ARV with Precast Structure and Valve | 1 | EA | \$15,000.00 | \$15,000.00 |
| Excavation of Insertion/Winching Pits | 2 | EA | \$11,500.00 | \$23,000.00 |
| Fusion Weld and Install 42" HDPE DR-21 Force | 1,450 | LF | \$75.00 | \$108,750.00 |
| Annular Space Grouting | 1,450 | LF | \$80.00 | \$116,000.00 |
| <i>General Items Subtotal:</i> | | | | \$618,000.00 |
| SECTION 4 (STA. 45+50 TO STA. 57+14) – OPEN CUT INSTALLATION | | | | |
| LINE ITEM | QUANTITY | UNIT | UNIT COST | EXTENSION |
| Furnish 42" HDPE DR-21 Force Main | 1,200 | LF | \$245.00 | \$294,000.00 |
| Excavation | 2,133 | CY | \$75.00 | \$160,000.00 |
| Pipe Cleaning, Removal, Disposal and | 1,200 | LF | \$155.00 | \$186,000.00 |
| Pipe Bedding, Backfill and Compaction | 2,133 | CY | \$60.00 | \$127,980.00 |
| Fusion Weld and Install 42" HDPE DR-21 Force | 1,200 | LF | \$100.00 | \$120,000.00 |
| <i>General Items Subtotal:</i> | | | | \$888,000.00 |
| SECTION 5 (STA. 57+14 TO STA. 85+82) – SLIPLINE INSTALLATION | | | | |
| LINE ITEM | QUANTITY | UNIT | UNIT COST | EXTENSION |
| Furnish 42" HDPE DR-21 Force Main | 2,868 | LF | \$245.00 | \$702,660.00 |
| 4" Combination Valve & Manhole | 1 | EA | \$17,500.00 | \$17,500.00 |
| Excavation of Insertion/Winching Pits | 3 | EA | \$11,500.00 | \$34,500.00 |
| Fusion Weld and Install 42" HDPE DR-21 Force | 2,868 | LF | \$75.00 | \$215,100.00 |
| Annular Space Grouting | 2,868 | LF | \$80.00 | \$229,440.00 |
| <i>General Items Subtotal:</i> | | | | \$1,199,000.00 |
| SECTION 6 (STA. 85+82 TO STA. 90+50) – OPEN CUT INSTALLATION | | | | |
| LINE ITEM | QUANTITY | UNIT | UNIT COST | EXTENSION |
| Furnish 42" HDPE DR-21 Force Main | 468 | LF | \$245.00 | \$114,660.00 |
| Excavation | 832 | CY | \$75.00 | \$62,400.00 |
| Pipe Cleaning, Removal, Disposal and | 468 | LF | \$155.00 | \$72,540.00 |
| Pipe Bedding, Backfill and Compaction | 832 | CY | \$60.00 | \$49,920.00 |
| Fusion Weld and Install 42" HDPE DR-21 Force | 468 | LF | \$100.00 | \$46,800.00 |
| <i>General Items Subtotal:</i> | | | | \$346,000.00 |
| | | | | |
| | | | | |

| SECTION 7 (STA. 90+50 TO STA. 122+50) – SLIPLINE INSTALLATION | | | | |
|----------------------------------------------------------------------|----------|------|-------------|-----------------------|
| LINE ITEM | QUANTITY | UNIT | UNIT COST | EXTENSION |
| Furnish 42" HDPE DR-21 Force Main | 3,200 | LF | \$245.00 | \$784,000.00 |
| 2" ARV with Precast Structure and Valve | 1 | EA | \$15,000.00 | \$15,000.00 |
| Excavation of Insertion/Winching Pits | 3 | EA | \$11,500.00 | \$34,500.00 |
| Fusion Weld and Install 42" HDPE DR-21 Force | 3,200 | LF | \$75.00 | \$240,000.00 |
| New Mainline Valve Installation | 1 | EA | \$12,500.00 | \$12,500.00 |
| Annular Space Grouting | 3,200 | LF | \$80.00 | \$256,000.00 |
| <i>General Items Subtotal:</i> | | | | \$1,342,000.00 |
| PROJECT SUBTOTAL COST | | | | \$6,198,000.00 |
| Contingency (±15%) | | | | \$929,700.00 |
| TOTAL CONSTRUCTION COST | | | | \$7,127,700.00 |

4.3 Project Schedule

Based on the approach outlined above, the following project schedule has been developed:

| <u>TASK</u> | <u>COMPLETION DATE</u> |
|--------------------------------------------------------------------------------|------------------------|
| Preliminary Field Engineering NTP | 0 Weeks |
| Preliminary Field Engineering (Property Boundary Survey and Utility Locations) | 6 Weeks |
| Engineering Design NTP | 6 Weeks |
| 60% Design Submission | 12 Weeks |
| Review and Comment Period | 14 Weeks |
| 90% Design Submission | 20 Weeks |
| Review and Comment Period | 22 Weeks |
| Final Design Submission | 26 Weeks |
| Invitation for Bid | 30 Weeks |
| Bid Phase and Receipt of Bid | 36 Weeks |
| Issue Contractor Notice to Proceed | 40 Weeks |
| Construction Start | 44 Weeks |
| Construction Substantially Complete (Pressure Testing Acceptance) | 96 Weeks |
| Final Completion (Site Restoration, Final Walkthrough, Punch List) | 100 Weeks |

Appendix A

Environmental Report

Wetlands Determination/Delineation

It is anticipated that the following tasks will be required:

- Wetland assessment and field delineation – Jurisdictional waters of the U. S. including wetlands will be delineated and/or reconfirmed as appropriate along the entire project corridor (for a width of approximately sixty feet) per the 1987 U. S. Army Corps of Engineers (USACE) Wetland Delineation Manual and the Eastern Mountain Piedmont Regional Supplement, as well as the most current Waters of the U. S. and State definitions. Given recent regulatory definition changes from the EPA and guidance from DEQ, it is assumed DEQ will review and provide a finding on the “Waters of the State” during a joint site visit with the Corps. Field work will commence once access to the parcels are gained and the preliminary project corridor(s) is identified.
- Preparing, submitting and obtaining a jurisdictional determination – A Delineation Report will be prepared and included in the PCN document to confirm the current status and extents of the wetland areas and assist with permitting approvals. Confirming wetland locations will also assist in identifying where contractors must apply protection and restoration measures.

Meetings with agency representatives on-site will be coordinated, as necessary, for field verification of wetland features during the permitting process verification process.

Nationwide 3 Pre-Construction Notification (PCN) Permitting/Documentation

It is anticipated that wetland information and preliminary construction plans will be utilized to prepare a Nationwide 3 (NWP3) Preconstruction Notification (PCN) package for the project. The PCN package will include general information about the applicant, the amounts and types of state and federal waters and wetlands proposed to be impacted, and construction details of the pipeline crossing of wetlands and/or streams within the alignment. The application will evaluate the proposed project corridor to ensure the project meets all relevant General and Regional conditions for the NWP3, including conditions relating to Cultural Resources, Threatened and Endangered Species, and regulated Floodplains.

The project should avoid and minimize permanent and temporary impacts to existing stream crossings and wetland areas. It should be noted that permanent impacts to wetlands, particularly forested wetlands, may require mitigation.

A plan to address potential inadvertent impacts caused by boring activities under wetlands (e.g. inadvertent returns) along the project corridor will be prepared to supplement the PCN package.

As the anticipated impacts to jurisdictional features will be temporary, mitigation is not expected to be necessary. Should it be determined that the project requires compensatory mitigation, the costs of any necessary compensatory mitigation and banking coordination are excluded from this scope.

- Review Existing Threatened and Endangered species registers – Federal and State databases will be reviewed and an official response will be requested from Virginia Department of Conservation and Recreation Division of Natural Heritage (VDCR-NH), Virginia Department of Wildlife Resources (DWR), and the U.S. Fish and Wildlife Service (USFWS) to assess the projects potential to impact documented populations of threatened and endangered species (T&E) along the alignment. Should it be determined that any additional studies or surveys are required to comply with the NWP3 regional conditions, they are excluded from this scope and will be addressed under a separate task order.

- Cultural Resources – The project alignment overlaps with two previously identified archaeological resources (The Tuckahoe and James River Railroad and the adjacent railroad site) that are unevaluated for inclusion on the National Register of Historic Places (NRHP). The alignment also passes adjacent to two previously identified architectural resources: the Lockhart House, which has been determined not eligible for NRHP listing, and the Saint Mary’s Episcopal Church, which is eligible for listing. Two previous Phase I Cultural Resource surveys have been conducted within the alignment including one that encompasses the majority of the southern portion of the project corridor where the alignment overlaps with the Tuckahoe and James River Railroad site.

Given the project involves the replacement of an existent force main and given the prior disturbance from existing roads and developments along the proposed alignments, it is anticipated that archaeological resources along the alignment have been previously disturbed and potential undocumented artifacts are not anticipated to be adversely impacted by the proposed project.

In addition, because the project involves the repair of the existing force main it is not anticipated to include above-ground structures, eligible or potentially eligible architectural resources adjacent to the alignment should not be adversely affected by the project. Consultation with VDHR is recommended before and during the PCN review process to assess Section 106 resource concerns and the potential need for further studies or survey.

Should it be determined that additional studies or surveys are necessary to comply with regional or general conditions of the NWP3 relating to Section 106 requirements, they are excluded from this scope and will be addressed under a separate task order.

Noted Exclusions:

- Note 1: Regulated Floodplains – Portions of the project alignment fall within FEMA Flood Zones. As the project is not proposing temporary or permanent structures within the flood zones and is not anticipated to result in a change in elevation within the project area, floodplain studies are excluded from the scope of work and if determined necessary will be addressed under a separate task order. The location of regulated floodplains within the project area will be identified via FEMA’s National Flood Hazard Layer viewer for the NWP3 submittal.

- Note 2: Regulated Dams – The alignment runs adjacent to one regulated dam (the Rivergate Lake Dam) and within the dam break inundation zone for the aforementioned dam. In accordance with VAC § 10.1-606.3, plan reviews for the project must be evaluated by DCR for

the potential to impact the spillway design flood standards. Confirmation of the regulatory status of additional impoundments and ponds adjacent to the alignment should be established as well. No excavation adjacent to dams is anticipated necessary; dam evaluation and DCR submittals are excluded from this scope of work.

- Note 3: Geotechnical Investigations - It is assumed that if geotechnical investigations are necessary for the project, they can be conducted outside of jurisdictional areas and will not require separate permit authorization. Only one permit submittal is included in this task. Should geotechnical investigations require temporary or permanent impacts to jurisdictional waters of the U. S. and State, a separate scope of work will be submitted for that permitting.

- Note 4: Nationwide Permit Renewals - It is assumed that this project will be contracted prior to the expiration date for the USACE Nationwide Permit #3 (3/18/2022 or earlier dependent on USACE reauthorization reviews) and that all work associated with the project can be completed prior to the allowed expiration date for all work (12 months after permit expiration). If either of these deadlines cannot be met, the project will be required to apply for a new permit and subject to the permit conditions of the renewed/amended NWP3 or equivalent Nationwide permit as determined during the reauthorization process. These permitting tasks are excluded from this scope and will be addressed under a separate task order as necessary.

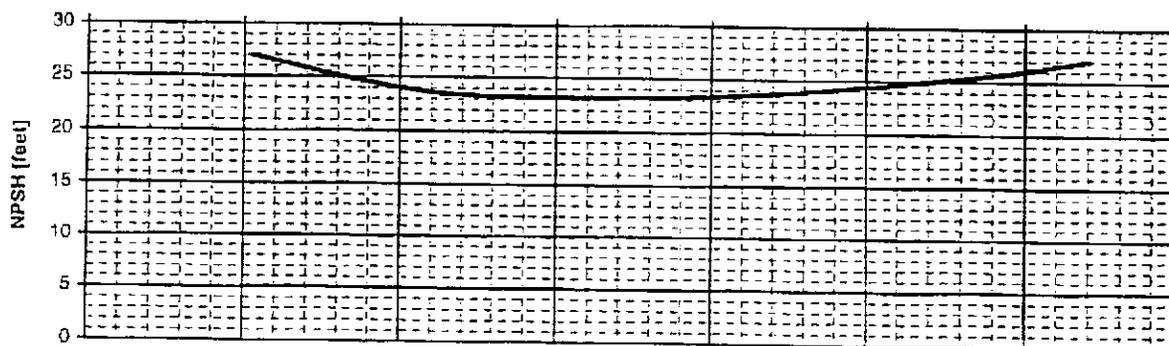
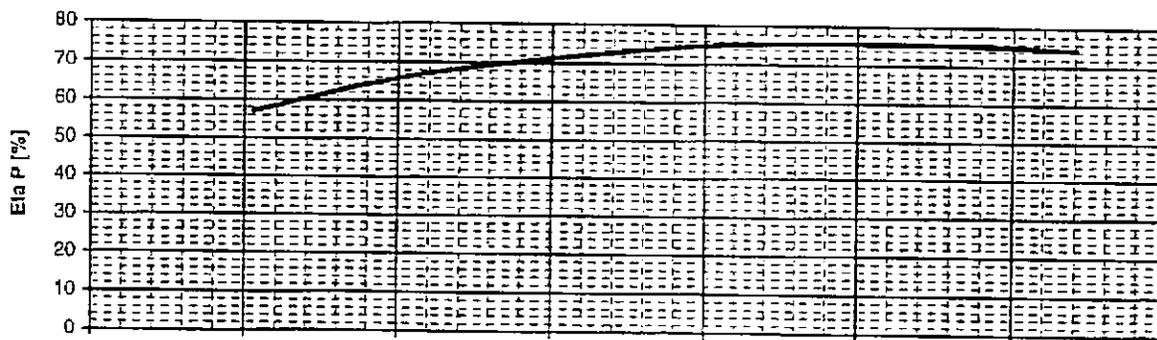
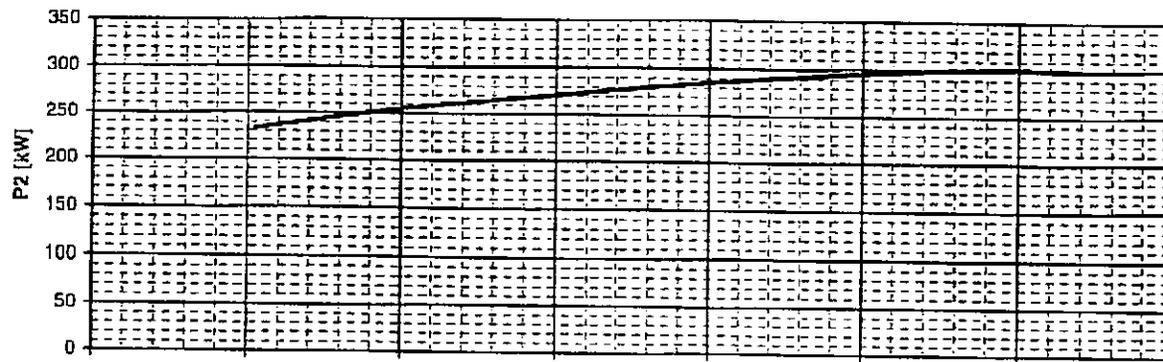
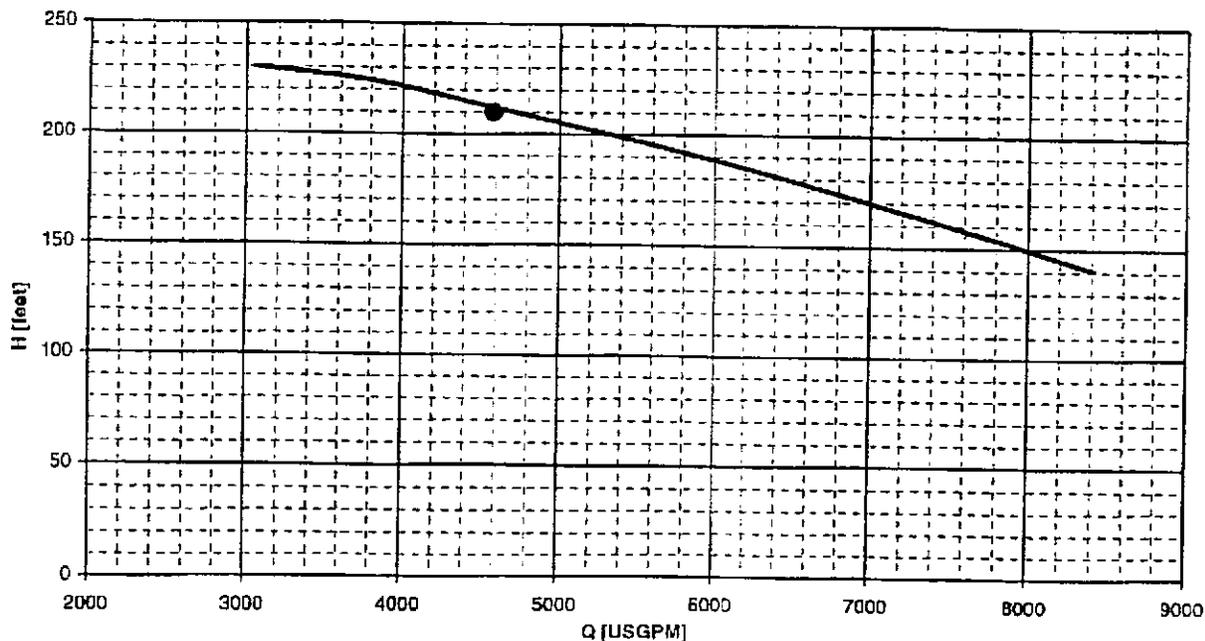
| Agency | Permit/Approval Type | Project Requirement | Action/Report/Application |
|------------------------------------------------|----------------------------------------------------|----------------------------------------------------------|-------------------------------------------------------------|
| U.S. Army Corps of Engineers | PJD/JD Reconfirmation | Identify/Confirm Jurisdictional Features Along Alignment | Delineation (Reconfirmation) and Delineation Report |
| U.S. Army Corps of Engineers | Nationwide Permit 3 (CWA Section 404/10) | Permitting Impacts to Jurisdictional Waters | Pre-Construction Notification |
| Virginia Dept. of Environmental Quality | Virginia Water Protection Permit (CWA Section 401) | Permitting Impacts to State Jurisdictional Waters | Permitted with above Pre-Construction Notification |
| Goochland County | Virginia Stormwater Management Program Permit | TBD: Necessary if land disturbances >1 acre | VSMP Application/Approved SWPPP including Approved ESC Plan |
| Goochland County | Additional Permits (TBD by Final Design) | As Determined in Final Design | Applicable Goochland County Applications |

Appendix B

Pump Curves

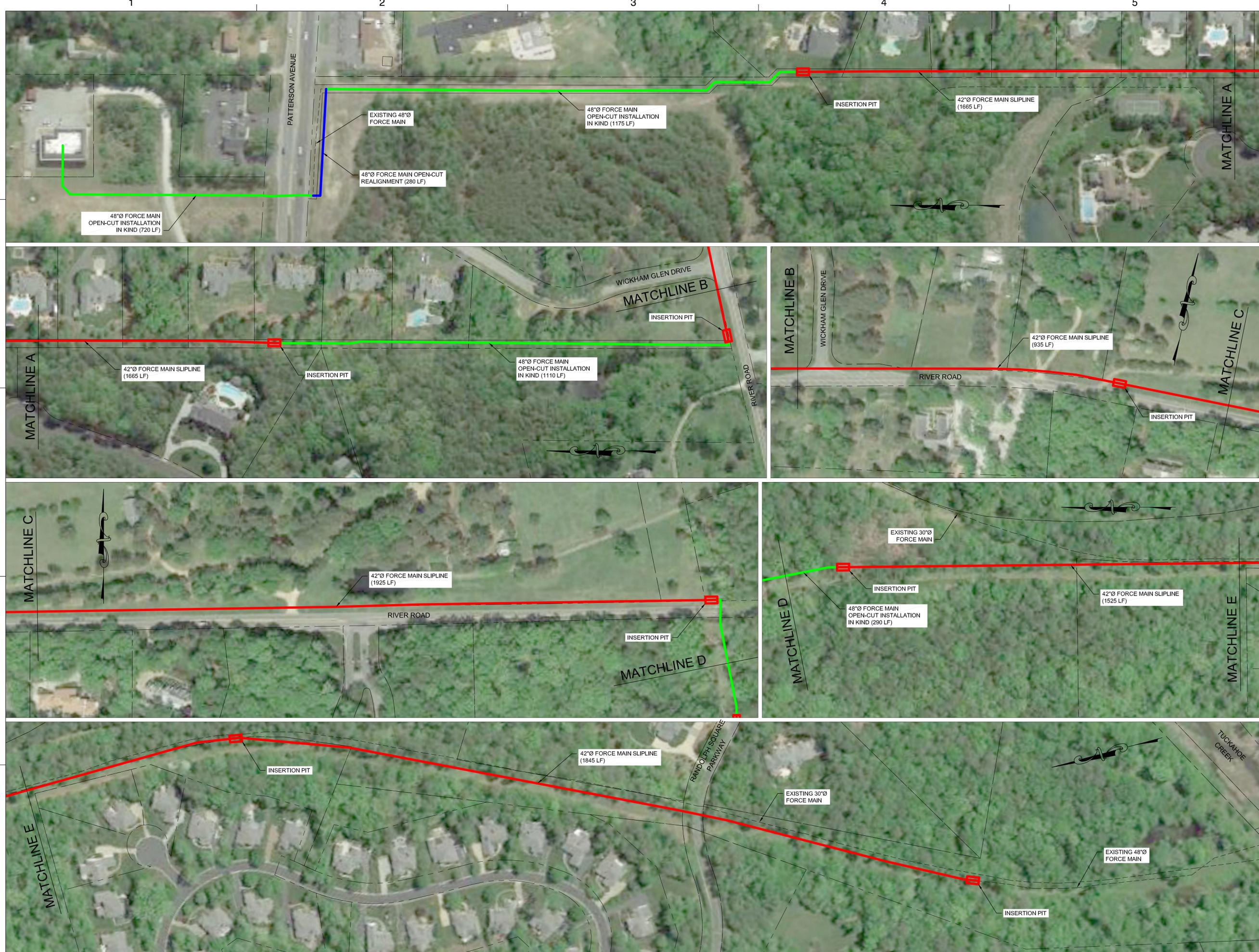
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Appendix C

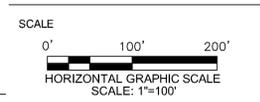
Basis of Design Summary Approach Drawing



**GOOCHLAND / HENRICO
 REGIONAL FORCE MAIN
 REHABILITATION PROJECT**
 GOOCHLAND COUNTY
 HENRICO COUNTY
 GOOCHLAND & HENRICO COUNTY, VIRGINIA

SEAL

KEY PLAN



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**OVERALL PROJECT
 APPROACH**

PROJECT NO. 50142563

FIG 1

SHEET NO.