WithersRavenel
Our People. Your Success.

WATER DISTRIBUTION SYSTEM ANALYSIS

Goldston Gulf Sanitary District
Water Storage Tank Replacement, Contract I; Booster Pump Station, Contract II
Goldston, North Carolina

Prepared For:

Goldston Gulf Sanitary District
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November 02, 2017

Project Number: 02160168.00

Michael C. Wicker, P.E. 11/2/2017

Preparer Full Name

DocuSigned by:
Michael Wicker
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TABLE OF CONTENTS

APPENDICES

1.0 - GOLDSTON-GULF SANITARY DISTRICT PROJECT DESCRIPTION

This project will consist of the erection of a repurposed elevated storage tank for the Goldston-Gulf Sanitary District ("District") in Goldston, NC. The tank is a 250,000-gallon torus bottom, five-leg elevated water storage tank built by Caldwell in 1988. The tank is 43' in diameter with a distance of 120' to the low-water line and 145'6" to the high-water line. The tank will be erected to AWWA standards. In addition, a 350 gpm booster pump station with two (2) 25-hp pumps to replace the current booster pumps and optimize use of the new elevated storage tank will be constructed for the Goldston-Gulf Sanitary District.

2.0 - PROJECT LOCATION

The proposed site for the elevated storage tank is 563 S. Church Street, which has adequate room for a storage tank, is located at a highpoint within the District, and has close proximity to the 10-inch water line. The current water storage unit for the Goldston-Gulf Sanitary District is a 500,000-gallon standpipe which is approximately 50 years old and is past its useful life span. An inspection conducted in September 2015 by Utility Services Company, LLC noted exterior and interior coating failure, metal deterioration, structural issues, and noncompliance with current regulations. The standpipe is no longer repairable and will need to be deconstructed, hauled, and salvaged at a scrap facility. The existing tank site is not large enough to construct a new tank; therefore, the District has purchased a new site for the repurposed elevated storage tank. The repurposed elevated storage tank will require approximately 100 linear feet of 8-inch water line to connect to the existing system. In addition, a new booster pump station will be necessary to optimize use of the elevated storage tank.

The proposed site for the booster pump station is the Town of Goldston Lift Station Site located at 2699 S. Main Street in Goldston, NC. This site location has the added benefits of already being owned by the Town of Goldston with prior land use disturbance for utility construction, adequate space for the package pump station, stand-by generator and existing power and telemetry capability. The existing booster pumps are housed in a deteriorating water plant building with limited access and are pumping from a clear well in need of maintenance. A duplex packaged pump station will be utilized for this project, and approximately 150 linear feet of 6-inch suction/discharge piping will be needed to connect to the existing water line.

3.0 - SYSTEM AND POPULATION

This project will serve the Goldston-Gulf Sanitary District which operates a public water supply and distribution system (PWS No. 03-19-025) serving the Town of Goldston, the Town of Gulf, and surrounding areas in Chatham County, NC. Since 2009, the District has purchased water from the City of Sanford (PWS No. 03-53-010) up to a quantity of 0.25 MGD with a minimum purchase of 3 MG per month. A copy of the Water Purchase Agreement between Goldston-Gulf Sanitary District and the City of Sanford is attached in **Appendix A**. The current population of the District is approximately 1,250 (550 connections) and minimal growth is projected for the area for the next 40 years. This population data is summarized in **Table 1-A** and **Table 1-B**.

Table 1-A Historical Population Trends				
Year	**1997**	**2002**	**2010**	**2015**
Population, GGSD	**1,000**	**1,200**	**1,250**	**1,250**
Percent Increase		**20%**	**4%**	**0%**

Table 1-B Population Projections					
Year	**2010**	**2020**	**2030**	**2040**	**2050**
Population, GGSD	**1,250**	**1,280**	**1,290**	**1,295**	**1,300**
Percent Increase		**2%**	**1%**	**1%**	**1%**

4.0 - ELEVATED STORAGE TANK

The needed water storage tank volume was determined based on the current average daily flow (ADF) and the required fire flow storage. **Table 2** summarizes the tank volume calculations based on an ADF of 88,000 gpd and varying fire flow volumes. In summary, a 200,000-gallon storage tank allows for a fire flow volume of 500 gpm for 4 hours in addition to equalization and storage of one-half the ADF. The 250,000-gallon storage tank will provide more-than-sufficient water storage for the District, in addition to providing capacity for future system expansion if needed. The useful life of the re-furbished tank is expected to be approximately 50 years with proper maintenance; Goldston-Gulf Sanitary District has a maintenance contract with Utility Services Company, LLC.

Table 2 Elevated Water Storage Tank Volume Calculations			
Existing ADF Sold (gpd)	**58,000**	**58,000**	**58,000**
Existing ADF Purchased (gpd)	**88,000**	**88,000**	**88,000**
Fire Flow (gpm)	**500**	**500**	**500**
Duration (hr)	**4**	**2**	**1**
Fire Flow Volume (gal)	**120,000**	**60,000**	**30,000**
Equalization, 15% (gal)	**13,200**	**13,200**	**13,200**
½ Day ADF (gal)	**44,000**	**44,000**	**44,000**
Total (gal)	**177,200**	**117,200**	**87,200**
Tank Volume (gal)	**200,000**	**150,000**	**100,000**

5.0 - BOOSTER PUMP STATION

The booster pump station design was based upon the flow requirements and required head to optimize use of the new elevated storage tank, in addition to the hydraulic model described in the following sections. The selected flow was 350 gpm and the total dynamic head (TDH) was determined to be 165 feet. Two 25-hp Cornell Model 2.5 WH pumps were selected for this application and will be housed in a packaged duplex booster pump station. The pump curve for the Cornell Model 2.5 WH pump is shown in **Appendix B**. The useful life of the pumps is anticipated to be approximately 15 years with proper maintenance.

6.0 - ALTERNATIVES

Alternatives considered for the elevated storage tank included no action, rehabilitating the existing stand pipe, and abandoning the stand pipe and constructing/erecting a new/repurposed elevated storage tank. Ultimately, the current stand pipe in use is beyond repair and taking no action would continue to allow leaks and the potential for complete storage failure to occur. The use of a repurposed elevated storage tank incurs a lower cost than a new elevated storage tank of the same size, and thus was the selected alternative.

For the booster pump station, the existing clear well pumps have reached the end of their useful life and were not sized to pump to the new elevated storage tank. Additionally, the existing pumps are housed in a deteriorating water plant building with limited access and are pumping from a clear well in need of maintenance. For these reasons a new booster pump station was needed for the District. The existing site at the Goldston Water Treatment Plant and the proposed site at the Town of Goldston property were evaluated for the new package booster pump station; the Town site provided the best hydraulic improvements to the system and thus was the selected location.

7.0 - HYDRAULIC ANALYSIS PROJECT DESCRIPTION

Using Bentley's WaterGEMS, a hydraulic analysis of the District's water distribution system was conducted. **Appendix C** shows the water distribution system schematic including pipes, junctions, hydrants, tanks, reservoirs, and pumps.

8.0 - FIRE HYDRANT TEST

WithersRavenel (WR) staff in conjunction with GGSD staff conducted several hydrant flow tests on July 26, 2017. Hydrant Test 1 was used to establish a boundary condition to simulate the available hydraulic grade line provided by the City of Sanford system. The "hydrant test" approach to establishing a dynamic hydraulic grade line is an accepted method that provides sufficiently accurate predictions of flow and pressure and involves observing the pressure at each test hydrant under two conditions. The first condition is that no hydrants are discharging water. The second condition is that nearby hydrant(s) are opened and the flow rate measured.

Appendix D contains the flow test results for the hydrant tests. **Table 3** summarizes the existing boundary condition based on the provided fire flow data.

Table 3 – Hydrant Test 1	
Hydrant Flowed	intersection of US 421 and Fayetteville Road
Flow Rate	1,000 gpm
Hydrant 1 Measuring Pressure	approximately 2,400 feet west of the intersection of US 421 and Fayetteville Road
Hydrant 1 Static Pressure	105 psi
Hydrant 1 Residual Pressure	47 psi

Utilizing the flow data, residual pressures corresponding to other flow rates at the test hydrant were computed via the fire flow equation described in "Fire Flow Testing and Marking of Hydrants", NFPA 291 and shown here for convenience.

$$Qr = Qf * \left(Hr / Hf \right)^{0.54}$$

Q_r =	Flow available at the desired residual pressure
Q_f =	Flow obtained from hydrant test
H_r =	Pressure drop to desired residual
H_f =	Pressure drop during hydrant flow test

The pressure/flow relationship at the boundary of the model was simulated in the hydraulic model using a "virtual" pump with a three-point rating curve. The two initial points of the pump curve were obtained from the hydrant flow test data; additional data points were calculated using the fire flow equation above for 20 psi residual pressure. **Appendix D** contains the simulated pump curve report used in the model.

9.0 - MODEL BOUNDARY CONDITION CALIBRATION

A hydraulic model of the water distribution system was constructed. Calibration of the model was used to verify the accuracy of the model predictions against actual data. A simulation was performed to calibrate the system under flowing hydrant conditions.

Hydrant "H-Pressure 1" corresponds to the hydrant located approximately 2,400 feet west of the intersection of US 421 and Fayetteville Road where system pressure was obtained. A static pressure of 105 psi was reported and the model also reported a pressure of 105 psi at Hydrant "H-Pressure 1". A second calibration of the model simulated the test pressure while the hydrant was flowing. Hydrant "H-Flow 1" depicts the hydrant where the flow rate was measured at the intersection of US 421 and Fayetteville Road. The results of this calibration test match that of the field test in that 1,000 gpm was withdrawn from Hydrant "H-Flow 1" while measuring a residual pressure of 47 psi at Hydrant "H-Pressure 1".

Based on the results of the calibration, the model matched actual field test data and is calibrated at the boundary condition. **Appendix E** is a summary of the modeling results showing the existing static conditions and includes the Reservoir, Pump, and Hydrant Reports. **Appendix E** is similar to **Appendix F** except it is the summary of the residual conditions with the test hydrant flowing.

10.0 - ADDITIONAL CALIBRATION

Additional calibration was achieved by utilizing Hydrant Test 2 and Hydrant Test 3. These tests were used to adjust model parameters to achieve calibration within acceptable tolerances. Parameters adjusted to achieve calibration included water demand and pipe roughness heights (ε). **Tables 4** and **5** summarize the hydrant test data for Hydrant Tests 2 and 3 respectively.

Table 4 – Hydrant Test 2	
Hydrant Flowed	approximately 2,150 feet west of the intersection of US 421 and Murchison Road
Flow Rate	650 gpm
Hydrant 1 Measuring Pressure	approximately 1,700 feet west of the intersection of US 421 and Murchison Road
Hydrant 1 Static Pressure	85 psi
Hydrant 1 Residual Pressure	40 psi

Table 5 – Hydrant Test 3	
Hydrant Flowed	approximately 1,550 feet west of the intersection of St Luke's Church Road and Horton Road
Flow Rate	530 gpm
Hydrant 1 Measuring Pressure	intersection of St Luke's Church Road and Horton Road
Hydrant 1 Static Pressure	60 psi
Hydrant 1 Residual Pressure	5 psi

Table 6 summarizes Calibration results including a comparison of field data to model results. Static pressure results generated by the model compared favorably with the static pressures observed during hydrant testing. The most useful comparison however is the pressure drop. After parameter adjustment the differences in pressure drop reported by the model were all within 10% from what was observed in the field. This was considered adequate for the purposes of this project.

Table 6 - Comparison			
	Hydrant Test 1	Hydrant Test 2	Hydrant Test 3
Field Static Pressure (psi)	105	85	60
Model Static Pressure (psi)	105	87	60
Field Residual Pressure (psi)	47	40	5
Model Residual Pressure (psi)	47	39	10
Field Pressure Drop (psi)	58	45	55
Model Pressure Drop (psi)	58	48	50
Difference Pressure Drop (psi)	0	-3	5
Difference Pressure Drop (%)	0.00%	-6.67%	9.09%

11.0 - ASSUMPTIONS

The analysis requires that some assumptions about the existing and proposed water distribution system be made. The analysis is dependent on the hydrant test which only reveals conditions at one particular moment in time. The available hydraulic grade line would of course vary and is dependent on the time it was conducted. Friction losses in pipes were calculated using the Darcy-Weisbach formula.

12.0 - PRESSURE CHANGE SUMMARY

Changing the location of the booster pump and tank will affect the system in multiple ways. Some customers will see increased pressure due to the increase in the height of the tank. However, other parts of the system will see decreased pressure as a result of relocating the booster pump from the water treatment plant to the proposed pump station site closer to Goldston. The movement of the booster pump station will effectively transfer much of the district to a different pressure zone, one tied to the City of Sanford pressure zone. The Hydraulic Grade Line (HGL) of the lower pressure zone is approximately 500-ft Mean Sea Level (MSL). The HGL of the higher-pressure zone is tied to the overflow elevation of the new tank and is 594-ft MSL. For reference the HGL of the existing system is approximately 535-ft MSL. **Appendix C** shows the two pressure zones.

In order to create these two pressure zones a PRV will be installed on the line parallel to Saint Lukes Church Road at the intersection of Saint Lukes Church Road and Henry Oldham Road.

Areas within the higher-pressure zone will see an increase of approximately 26-psi. Areas within the lower pressure zone will see a decrease of approximately 15-psi. The location was chosen in order to limit the line pressure near Gulf.

A low-pressure concern arises from relocating the booster pump. The area just south of the Town of Goldston along South Main Street on the suction side of the pump will see a dramatic decrease in pressure when the pump is operating. Currently, at 2767 South Main Street, the pressure is approximately 65-psi. Pressure will drop to approximately 30-psi with the pump in operation. A variable frequency drive will be used to limit the drop in pump suction pressure to ensure pressure will remain above 30-psi.

When taken as a whole the system will see an increase in pressure of approximately 7-psi. **Appendix G** shows a summary of the pressure as it exists, the pressure once the change is made, and the difference between the two.

13.0 - FIRE FLOW CHANGE SUMMARY

Fire flow capability will significantly increase for most of the higher-pressure zone due to the increase in the height of the tank. It might seem counter intuitive that the area being moved to the lower pressure zone will also see an increase in fire flow but that is the case. The reason for this is that the fire flow for this area is now dependent on the City of Sanford system and the 10-inch transmission main for fire protection. The average increase in fire protection is approximately 435-gpm while maintaining a pressure of 20-psi throughout the system. There are some areas that will not have the capability to provide a fire flow of 500-gpm while maintaining a pressure of 20-psi, but these areas cannot provide the 500 gpm fire flow under existing conditions and the available fire flow for these areas will increase. In addition, the system can provide a 250 gpm fire flow for two hours everywhere in the system without a drop in pressure below 20-psi.

On average, the system will see an increase in fire flow capability of approximately 435-gpm. This is a dramatic increase and the improvement cannot be overstated. **Appendix H** shows a summary of the available fire flow as it exists, the available fire flow once the change is made, and the difference between the two.

Appendix A

Water Purchase Agreement

STATE OF NORTH CAROLINA

COUNTY OF LEE

THIS AGREEMENT, made and entered into this the 17 day of Feb, 2009 by and between the CITY OF SANFORD, a municipal corporation chartered by the State of North Carolina, and located in Lee County, North Carolina, hereinafter referred to as "City," and the GOLDSTON GULF SANITARY DISTRICT (GGSD), a body both corporate and politic of the State of North Carolina, and located in North Carolina, hereinafter referred to as "GGSD."

WITNESSETH:

WHEREAS, City operates a water system, and presently has a surplus of treated water, and is willing to sell to GGSD a portion of said surplus water, upon the terms and conditions hereinafter set forth; and

WHEREAS, GGSD is willing to obligate itself to purchase a minimum amount of water per month and desires to purchase water from the City upon the terms and conditions set forth:

NOW, THEREFORE, in consideration of the premises, the mutual promises herein contained, and the sum of Ten Dollars, each to the other paid, the parties have mutually agreed as follows:

1. City agrees to sell to GGSD at a point of delivery located on US 421, on the south side of the Deep River, in Lee County, North Carolina, potable treated water, satisfying applicable purity standards of North Carolina Division of Environmental Health at an approximately constant, normal gravity pressure, based upon an elevated storage level of 534 feet above sea level for a twelve-inch main supply at the point of delivery, subject to reductions

or failures of pressure of supply due to main supply line breaks, power failures, floods, fire and the use of water to fight fire, earthquakes and other causes beyond the City's control for such reasonable period of time as may be necessary to restore normal service.

Upon request of GGSD and approval of the City, the City agrees to provide water to GGSD for use upon the terms and conditions herein contained.

2. City agrees to sell GGSD any amount up to a maximum of 250,000 gallons per day. On or before January first of each year, GGSD shall notify the City if GGSD would like to change the maximum daily usage, and if additional usage is requested, the provisions of this contract shall be renegotiated.

3. City shall own and maintain that section of waterline and meter, installed by GGSD from the existing water main at the intersection of Boone Trail Road (US 421) and Cumnock Road (SR 1400); then extending north on US 421 to the point of delivery at the County line located on the south side of the Deep River, as shown on the attached map.

4. City shall be under no obligation to reimburse GGSD for costs incurred by it in building the necessary interconnection from the City's water system, except as hereafter set forth.

5. GGSD agrees to pay the City the rate as stated in the attached, *City Water Rates (Exhibit A)*, for all water sold and delivered pursuant to this agreement subject to changes in said rate as hereinafter set forth or as set from time to time by the City.

6. GGSD agrees to pay the City the rate as stated in the attached, *City Water Rates (Exhibit A)*, for water reserved pursuant to this agreement subject to changes in said rate as hereinafter set forth or as set forth from time to time by the City.

7. City will bill GGSD monthly for the actual amount of water sold and delivered to it at the then applicable rate; provided, however, the City will bill and GGSD will pay for a minimum quantity of 3,000,000 (three million) gallons per month regardless of whether or not GGSD actually uses such quantity.

8. City agrees to maintain at the point of delivery, the metering equipment necessary to accurately measure the water sold and delivered to GGSD; and upon the written request of GGSD, the City will calibrate the metering equipment once in every twelve (12) month period. If such calibration does not register an error of more than two percent (2%) above or below the test reading, the meter shall be deemed to be accurate. If the meter registers an error of more than two percent (2%) above or below the test reading, then City shall adjust its bill accordingly for the previous one (1) month only. If the meter fails to register during any monthly period, then the amount of water sold and delivered during such period shall be deemed to be the average monthly quantity delivered during the preceding twelve (12) months, or whenever applicable, the total of the meters being served by the above-mentioned master meter.

8. The point of delivery of the water from the City to GGSD shall be at a point located on US 421, on the south side of the Deep River, in Lee County, North Carolina, jointly agreed upon by the parties, and as shown on plans prepared by GGSD's engineers and approved by the City of Sanford.

9. GGSD specifically agrees to the following conditions:

(a.) City shall have the absolute right, in its sole discretion, to either terminate or interrupt delivery of water to GGSD, without prior notice or an opportunity to be heard, or to take any action that the City deems necessary upon the happening of any of these events:

(i.) If GGSD shall fail to pay its monthly water on the date it is due under this agreement;

(ii.) If emergencies shall occur, including but not limited to, main supply line breaks, power failures, floods, fires, earthquakes, and other causes beyond the control of City, so as to require the use of said water elsewhere or to prevent its delivery to GGSD;

(iii.) If GGSD breaches any of the terms of this agreement.

GGSD hereby acknowledges that the foregoing rights reserved to the City are conditions precedent to the making of this contract and sale and delivery of water provided for herein.

(b.) GGSD will convey to the City line, valves, easements and right in land located in Lee County necessary to connect GGSD's system to the City's system up to and including the water meter. These will be conveyed to the City without cost and will be maintained by the City without cost to GGSD.

A meter and appropriate backflow prevention devices shall be installed by GGSD at the point of delivery to measure the transfer of water by the City to GGSD through the City's line.

(c.) GGSD shall control the water usage within the agreed consumption limits, as stated in section (2) of this agreement, with the exception that no water shall be used to serve any hazardous waste treatment facility. Violation of said terms shall constitute termination or cause interruption of delivery of water to GGSD, without prior notice or any opportunity to be heard and/or the City shall have the right to take any additional remedies, including civil action to collect the debt.

(d.) GGSD shall furnish and operate, at its own expense, adequate pumps and equipment to operate its system, and shall regulate the flow of water into its system at a uniform rate over a twenty-four (24) hour period, and shall take all reasonable precautions to avoid and prevent public health hazards in its system and in the City's.

10. The rates for water sold and delivered, as well as reservation of water quantity under this agreement, are subject to increase or decrease annually at the end of the City's fiscal year. An increase in the usage rate shall be based upon increase in the City's cost of operating its water system, including performance of this agreement. GGSD shall have the right to reject the increased rates charged by the City, whereupon City's obligation to sell and deliver water to GGSD shall end and this agreement is terminated.

11. During the term of this agreement, GGSD may extend its water system without the City's written approval. However, GGSD must get the City's written approval before extending waterlines to serve a user which would result in usage by GGSD to exceed its reserve capacity.

12. Unless sooner terminated as herein provided, this agreement shall continue in force and effect from the date of this contract for ten years, at which time, GGSD will be under no obligation to purchase water from the City. At the end of the initial ~~twenty~~ ten (10) y.e. year term, this contract shall automatically renew for additional one year terms, unless sooner terminated by giving written notice thirty days in advance to the City, PO Box 2739 Sanford NC 27330 or to GGSD PO Box 13 Goldston NC 27252.

13. City and GGSD's obligations hereunder shall be subject to such restrictions, limitations, and prohibitions as may be applicable as a result of contracts or agreements with, or lawful rules and regulations promulgated by, any State or Federal Department or agency having

jurisdiction over the City or GGSD and their operation of their respective water systems. If, as a result of this agreement, the City is required to pay back grants and loan funds heretofore received by GGSD from governmental agencies, GGSD shall, upon written demand, reimburse the City fully or completely.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be duly executed, attested by its Clerk, and its seal affixed, all by authority of its governing board, first duly given.

CITY OF SANFORD

BY Cornelia P. Olive
Mayor

ATTEST:

BY Bonnie D White
Clerk

SEAL:

GOLDSTON GULF SANITARY DISTRICT (GGSD)

BY Johnny Clark Chairman
TITLE

ATTEST:
BY Jeff Brisson
Clerk

SEAL:

EXHIBIT A

Public Works Department

CITY OF SANFORD

P. O. BOX 3729
FAX 919-774-8179

North Carolina 27331-3729

TELEPHONE 919-775-8010
or 919-775-8231

CITY WATER RATES

	PER 1000 GALLONS	PER 100 CUBIC FT
WATER	$2.02	
RESERVED CAPACITY	$25,000.00 annual/ 250,000gal/day	

Appendix B

Selected Pump Curve

Pump Data Sheet - Cornell

Company:
Name:
Date: 09/20/2017

Pump:

Size:	2.5WH	Dimensions: Suction:	3 in
Type:	Clear Liquids	Discharge:	2.5 in
Synch Speed:	3600 rpm		
Dia:	6.8125 in		
Curve:	25WH36		

Fluid:

Name:	Water		
SG:	1	Vapor Pressure:	0.256 psi a
Density:	62.4 lb/ft³	Atm Pressure:	14.7 psi a
Viscosity:	1.1 cP		
Temperature:	60 °F		

Search Criteria:

Flow:	350 US gpm	Near Miss:	---
Head:	165 ft	Static Head:	120 ft

Pump Limits:

Temperature:	250 °F	Sphere Size:	0.5 in
Wkg Pressure:	175 psi g		

Motor:

Standard:	NEMA	Size:	25 hp
Enclosure:	TEFC	Speed:	3600 rpm
Frame:	284TS		
Sizing Criteria:	Max Power on Design Curve		

Pump Selection Warnings:

None

--- Duty Point ---

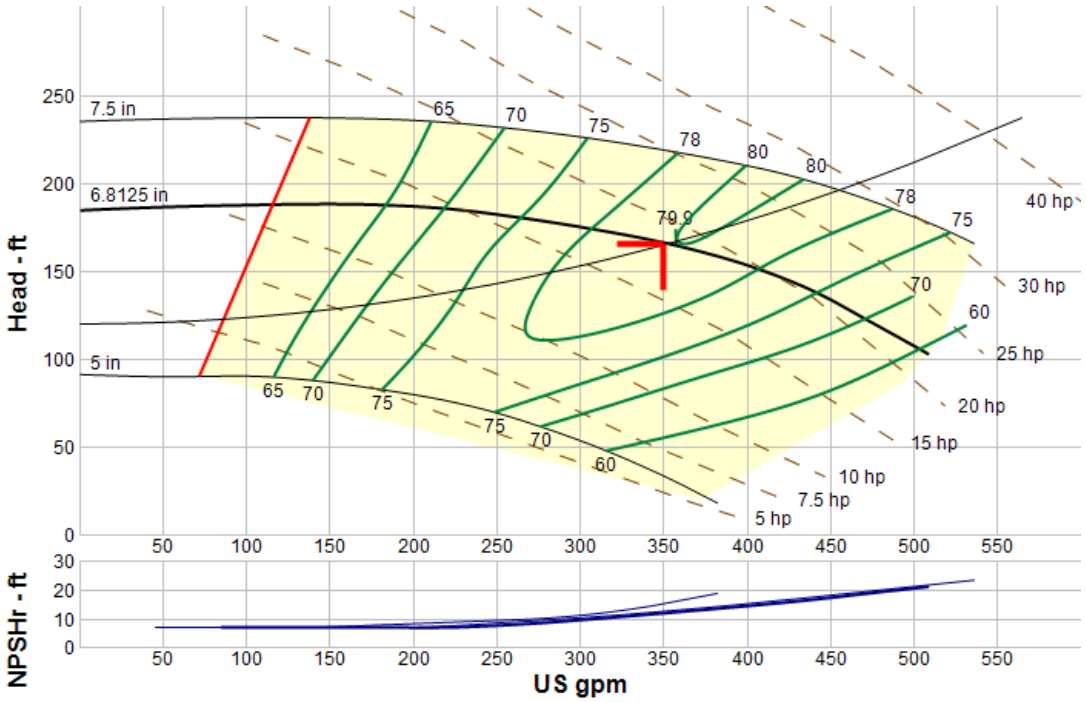
Flow:	352 US gpm
Head:	165 ft
Eff:	80%
Power:	18.4 hp
NPSHr:	12.1 ft
Speed:	3525 rpm

--- Design Curve ---

Shutoff Head:	184 ft
Shutoff dP:	79.9 psi
Min Flow:	118 US gpm
BEP:	79.9% @ 357 US gpm
NOL Power:	22.4 hp @ 503 US gpm

--- Max Curve ---

Max Power:
30.6 hp @ 536 US gpm



Performance Evaluation:

Flow	Speed	Head	Efficiency	Power	NPSHr
US gpm	rpm	ft	%	hp	ft
420	3525	146	77	20.1	15.6
350	3525	166	80	18.4	12
280	3525	178	76	16.5	8.79
210	3525	186	69	14.3	7
140	3525	187	53	12	7

Appendix C

Project Map

N
W
E
S

Color Coding Legend
Pipe Diameter (in)

- 1
- 2
- 3
- 4
- 6
- 8
- 10
- 12 Other

PRESSURE ZONE 594

PRESSURE ZONE 500

WATERS SCHOOL RD
CLAUDE HASH RD
N MAIN ST
CHATHAM AVE
HILLCREST AVE
ASHLAND DR
CYPRESS LN
COLONIAL AVE
CHURCH ST
PITTSBORO GOLDSTON RD
HILLCREST AVE
WINDSOR ST
E GOLDBAR AVE
W GOLDBAR AVE
CORAL ST
US 421
GOLDSTON GLENDON RD
ROBERTS CHAPEL CHURCH RD
S MAIN ST
PINE VIEW ACRES
ST LUKES CHURCH RD
215 HORTON RD

PROPOSE ELEVATED
STORAGE TANK LOCATION

EXISTING GROUND
STORAGE TANK LOCATION

PROPOSED BOOSTER
PUMP LOCATION

TEST 03
PRESSURE
STATIC PRESSURE: 60 PSI
RESIDUAL PRESSURE: 05 PSI

TEST 03
FLOW
530 GPM

MATCH LINE
SEE APPENDIX C-2

0 600 1200 Feet

No.	Revision	Date	By

Designer: DAM	Scale: AS NOTED
Drawn By: DAM	Date: 11/02/2017
Checked By: MCW	Job No.: 02160168.00

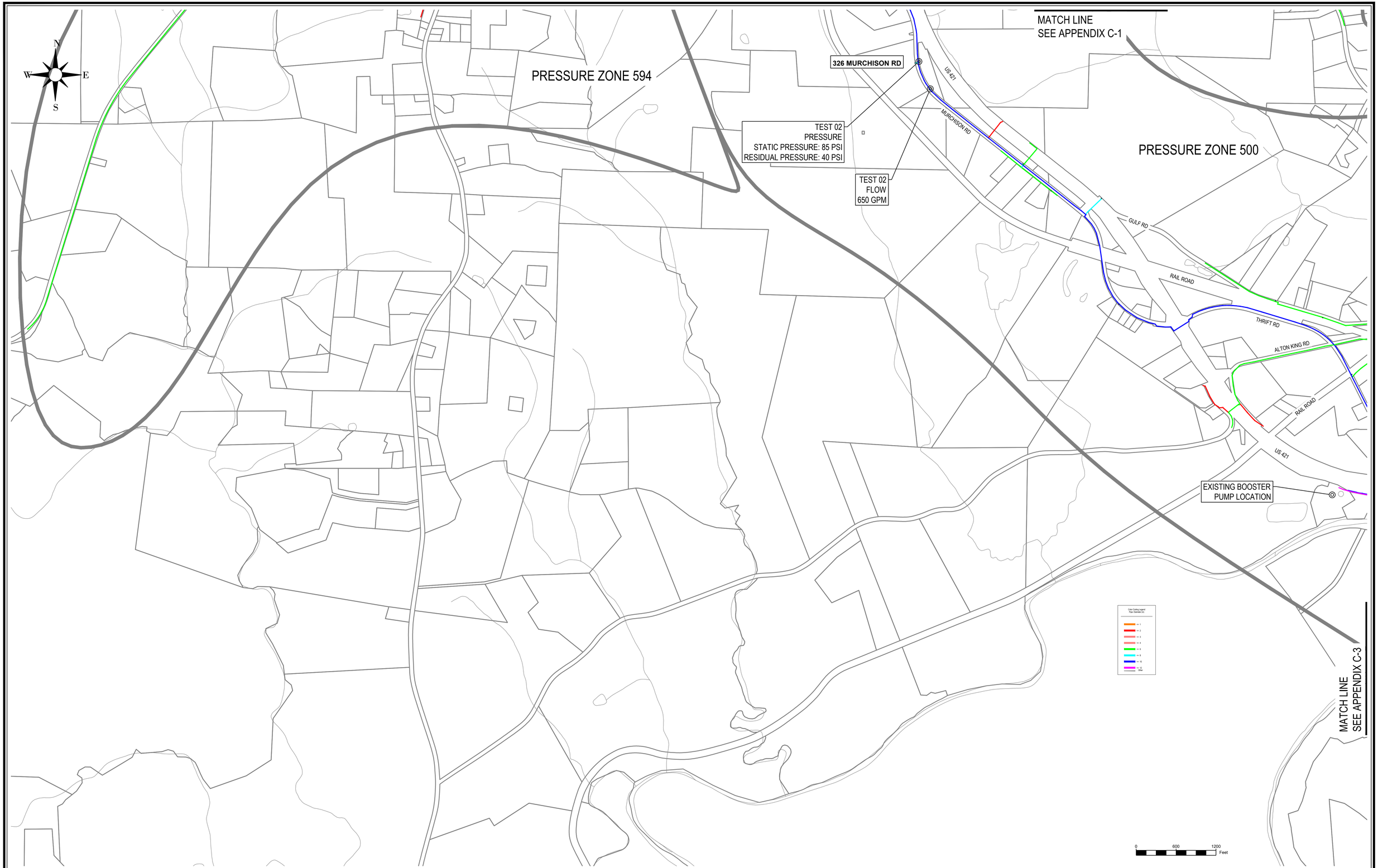
GOLDSTON GULF
WATER TANK REPLACEMENT

Chatham County — North Carolina

WATER SYSTEM MAP

WithersRavenel
Engineers | Planners | Surveyors
115 MacKenan Drive | Cary, NC 27511 | t: 919.469.3340 | license #: C-0832 | www.withersravenel.com

Sheet No.
C-1



No.	Revision	Date	By

Designer: DAM	Scale: AS NOTED
Drawn By: DAM	Date: 11/02/2017
Checked By: MCW	Job No.: 02160168.00

GOLDSTON GULF
WATER TANK REPLACEMENT

Chatham County — North Carolina

WATER SYSTEM MAP

WithersRavenel
Engineers | Planners | Surveyors
115 MacKenan Drive | Cary, NC 27511 | t: 919.469.3340 | license #: C-0832 | www.withersravenel.com

Sheet No.
C-2

PRV TO SEPARATE PRESSURE ZONES

HENRY OLDHAM RD

FAYETTEVILLE RD

GULF RD

R JORDAN RD

CLARENCE MCKEITHEN RD

TEST 01
FLOW
1,000 GPM

TEST 01
PRESSURE
STATIC PRESSURE: 105 PSI
RESIDUAL PRESSURE: 47 PSI

PRESSURE ZONE 500

MATCH LINE
SEE APPENDIX C-2

DEEP RIVER

CUMMOCK RD

US 421

Color Coding Legend
Pipe Diameter (in)

- in. 1
- in. 2
- in. 3
- in. 4
- in. 6
- in. 8
- in. 10
- in. 12
- Other

N
W
E
S

0 600 1200 Feet

K:\16\16-0160\160168-Water Storage Tank Replacement\H-H\Water Model\GIS\D Water System.dwg - Friday, November 3, 2017 9:43:38 AM - MCCLURE, DAVID

No.	Revision	Date	By

Designer: DAM	Scale: AS NOTED
Drawn By: DAM	Date: 11/02/2017
Checked By: MCW	Job No.: 02160168.00

GOLDSTON GULF
WATER TANK REPLACEMENT

Chatham County — North Carolina

WATER SYSTEM MAP

WithersRavenel
Engineers | Planners | Surveyors
115 MacKenan Drive | Cary, NC 27511 | t: 919.469.3340 | license #: C-0832 | www.withersravenel.com

Sheet No.
C-3

Appendix D

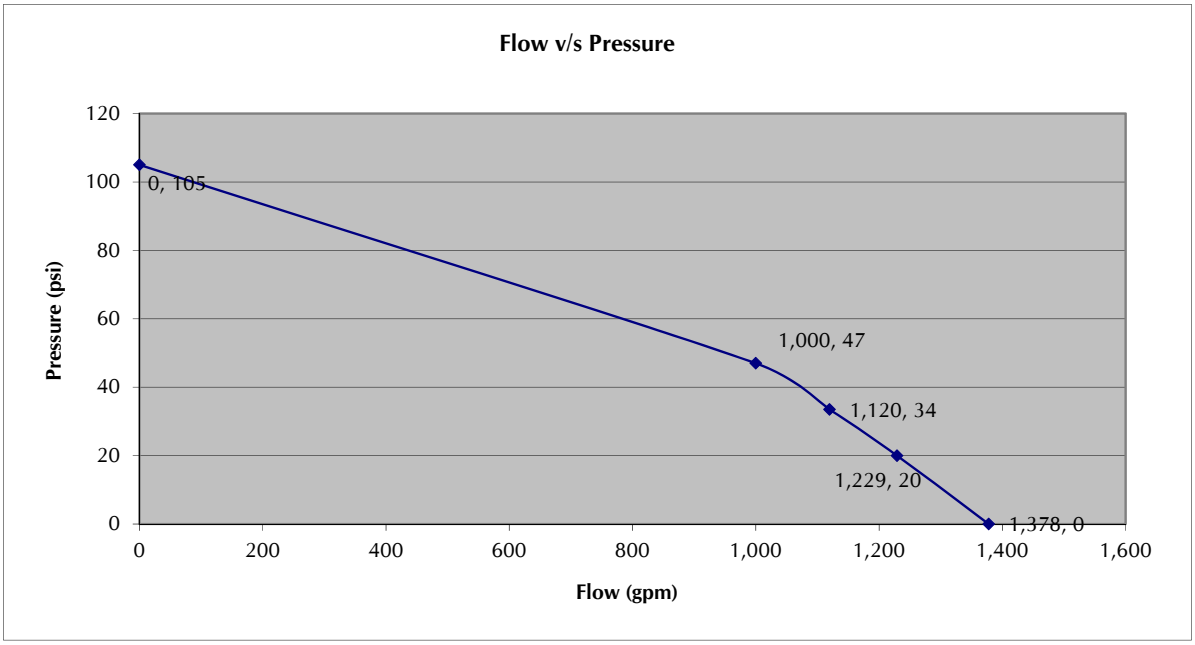
Hydrant Test & Simulated Pump Curve

FIRE FLOW TEST DATA	
Project Name	Water Storage Tank Replacement
WR Project #	02160168.00
Test Date	July 26, 2017
Test Time	9:35 AM
Flow Hydrant Location	intersection of US 421 and Fayetteville Road
Pressure Hydrant Location	approximately 2,400 feet west of the intersection of US 421 and Fayetteville Road

Flow Hydrant Coefficient	
Flow Hydrant Outlet Diameter (in)	
Test hydrant Static Pressure (psi)	105
Test Hydrant Residual Pressure (psi)	47
Nozzle 1 Observed Hydrant Flow (gpm)	1,000
Nozzle 1 Observed Hydrant Pressure (psi)	
Nozzle 1 Calculated Flow From Pressure (gpm)	0
Nozzle 2 Observed Hydrant Flow (gpm)	
Nozzle 2 Observed Hydrant Pressure (psi)	
Nozzle 2 Calculated Flow From Pressure (gpm)	0
Calculated Flow (gpm)	1,000
Pressure Drop (psi)	58

Flow/Pressure Relationship	**Flow (gpm)**	**Pressure (psi)**
	0	105
	1,000	47
	1,120	34
	1,229	20
	1,378	0

Pump Curve	**Flow (gpm)**	**Head (ft)**
	0	243
	1,000	109
	1,120	77
	1,229	46
	1,378	0



Goldston Gulf Water System

Active Scenario: Base

Pump Definition Detailed Report: Hydrant Test Simulated Pump

Element Details

ID	4693	Notes	
Label	Hydrant Test Simulated Pump		

Pump Curve

Flow (gpm)	Head (ft)
0.00	243
1,000.00	109
1,120.00	77
1,229.00	46
1,378.00	0

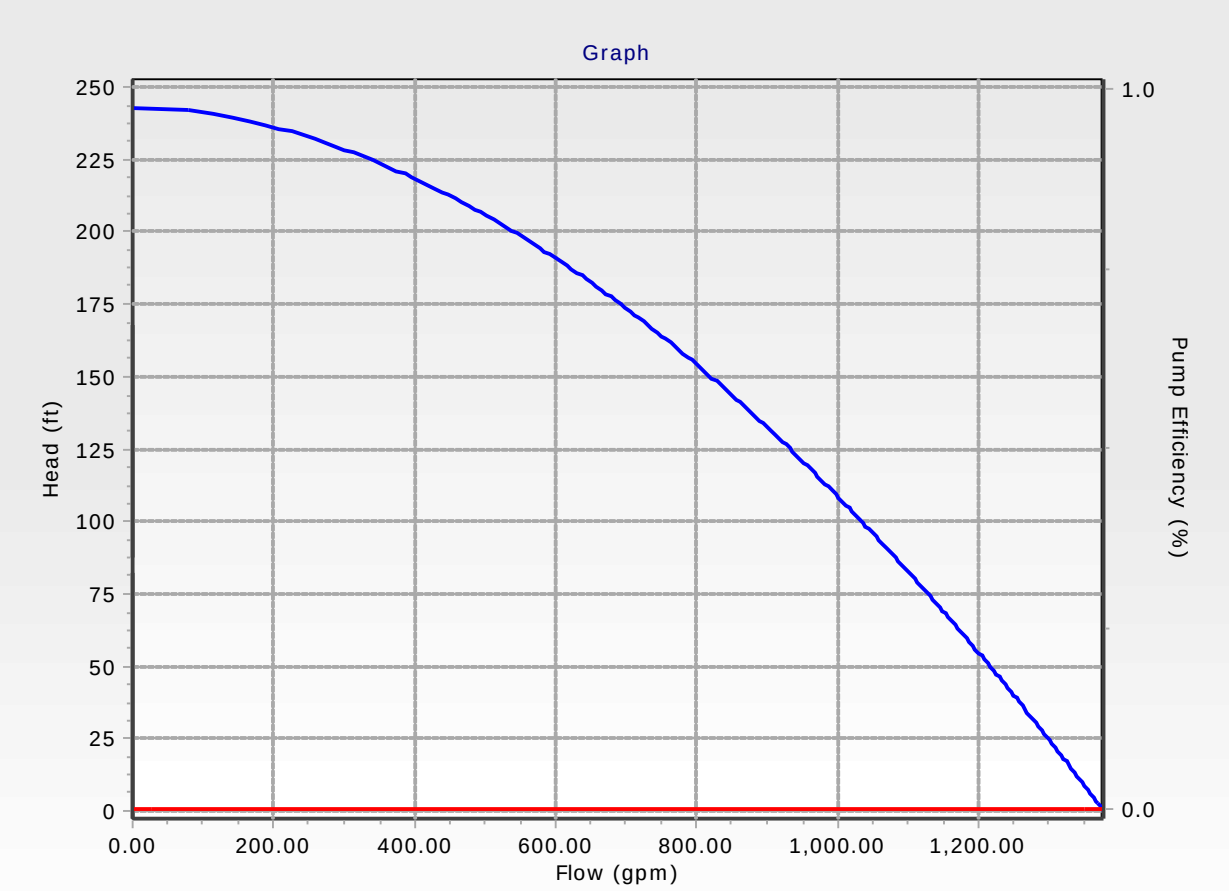
Pump Efficiency Type

Pump Efficiency Type	Best Efficiency Point	Motor Efficiency	100.0 %
BEP Efficiency	0.0 %	Is Variable Speed Drive?	False
BEP Flow	0.00 gpm		

Transient (Physical)

Inertia (Pump and Motor)	0.000 lb·ft²	Specific Speed	SI=25, US=1280
Speed (Full)	0 rpm	Reverse Spin Allowed?	True

Goldston Gulf Water System
Active Scenario: Base
Pump Definition Detailed Report: Hydrant Test Simulated Pump



Appendix E

Calibration
Static Pressure

Goldston Gulf Water System

Active Scenario: Hydrant Test Static

FlexTable: Reservoirs

Label	Elevation (ft)	Flow (Out net) (gpm)	Hydraulic Grade (ft)
R-1	254	1.00	254

Goldston Gulf Water System

Active Scenario: Hydrant Test Static

FlexTable: Pumps

Label	Elevation (ft)	Pump Definition	Hydraulic Grade (Suction) (ft)	Hydraulic Grade (Discharge) (ft)	Flow (Total) (gpm)	Pump Head (ft)
Simulated Pump	253	Hydrant Test Simulated Pump	254	497	1.00	243

Goldston Gulf Water System

Active Scenario: Hydrant Test Static

FlexTable: Hydrants

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
H-Pressure 1	254	0.00	497	105
H-Flow 1	222	0.00	497	119

Appendix F

Calibration
Residual Pressure

Goldston Gulf Water System

Active Scenario: Hydrant Test 1 Residual

FlexTable: Reservoirs

Label	Elevation (ft)	Flow (Out net) (gpm)	Hydraulic Grade (ft)
R-1	254	1,001.00	254

Goldston Gulf Water System

Active Scenario: Hydrant Test 1 Residual

FlexTable: Pumps

Label	Elevation (ft)	Pump Definition	Hydraulic Grade (Suction) (ft)	Hydraulic Grade (Discharge) (ft)	Flow (Total) (gpm)	Pump Head (ft)
Simulated Pump	253	Hydrant Test Simulated Pump	254	362	1,001.00	108

Goldston Gulf Water System

Active Scenario: Hydrant Test 1 Residual

FlexTable: Hydrants

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
H-Pressure 1	254	0.00	362	47
H-Flow 1	222	1,000.00	342	52

Appendix G

Pressure Comparison

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Appendix G - Pressure Comparison			
Scenario	Average Day - Booster Pump Off		
	Existing	Pump in Goldston	Change
Label	Pressure (psi)	Pressure (psi)	Pressure (psi)
J-3	25	46	21
J-4	26	48	22
J-5	28	49	21
J-6	33	54	21
J-7	31	53	22
J-8	32	54	22
J-9	32	54	22
J-10	32	54	22
J-11	32	54	22
J-12	32	54	22
J-13	33	55	22
J-14	33	55	22
J-15	36	58	22
J-16	33	55	22
J-17	34	55	21
J-18	32	54	22
J-19	37	58	21
J-20	34	56	22
J-21	39	61	22
J-22	35	57	22
J-23	35	57	22
J-24	35	57	22
J-25	35	57	22
J-26	35	57	22
J-27	35	57	22
J-28	36	57	21
J-29	38	59	21
J-30	39	60	21
J-31	38	59	21
J-32	38	60	22
J-33	38	60	22
J-34	39	60	21
J-35	38	60	22
J-36	39	61	22
J-37	39	61	22
J-38	41	63	22
J-39	41	63	22
J-40	41	63	22
J-41	41	63	22
J-42	42	63	21
J-43	42	64	22
J-44	43	64	21
J-45	42	63	21
J-46	43	65	22
J-47	43	65	22
J-48	46	68	22
J-49	43	65	22
J-50	42	64	22
J-51	44	66	22
J-52	42	64	22
J-53	43	65	22

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Appendix G - Pressure Comparison			
Scenario	Average Day - Booster Pump Off		
	Existing	Pump in Goldston	Change
Label	Pressure (psi)	Pressure (psi)	Pressure (psi)
J-54	44	66	22
J-55	44	66	22
J-56	44	66	22
J-57	45	67	22
J-58	43	65	22
J-59	45	66	21
J-60	45	67	22
J-61	45	66	21
J-62	44	65	21
J-63	45	67	22
J-64	46	67	21
J-65	47	69	22
J-66	47	68	21
J-67	48	70	22
J-68	47	69	22
J-69	47	69	22
J-70	48	69	21
J-71	47	69	22
J-72	47	68	21
J-73	47	69	22
J-74	47	69	22
J-75	48	69	21
J-76	48	70	22
J-77	48	69	21
J-78	49	70	21
J-79	50	71	21
J-80	50	72	22
J-81	50	71	21
J-82	52	74	22
J-83	51	72	21
J-84	51	72	21
J-85	52	73	21
J-86	48	70	22
J-87	52	74	22
J-88	52	74	22
J-89	54	75	21
J-90	55	77	22
J-91	56	78	22
J-92	55	77	22
J-93	57	79	22
J-94	57	79	22
J-95	59	81	22
J-96	59	81	22
J-97	60	81	21
J-98	60	82	22
J-99	62	84	22
J-100	63	50	(13)
J-101	64	86	22
J-102	65	87	22
J-103	65	52	(13)
J-104	67	88	21

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Appendix G - Pressure Comparison			
Scenario	Average Day - Booster Pump Off		
	Existing	Pump in Goldston	Change
Label	Pressure (psi)	Pressure (psi)	Pressure (psi)
J-105	66	53	(13)
J-106	69	90	21
J-107	70	56	(14)
J-108	70	57	(13)
J-109	70	92	22
J-110	70	57	(13)
J-111	72	58	(14)
J-112	71	58	(13)
J-113	75	61	(14)
J-114	74	61	(13)
J-115	75	97	22
J-116	71	57	(14)
J-117	88	109	21
J-118	92	79	(13)
J-119	96	83	(13)
J-120	97	119	22
J-121	97	119	22
J-122	99	86	(13)
J-123	98	84	(14)
J-124	98	85	(13)
J-125	102	89	(13)
J-126	100	87	(13)
J-127	103	90	(13)
J-128	109	96	(13)
J-129	103	90	(13)
J-130	104	125	21
J-131	104	126	22
J-132	48	70	22
J-133	105	127	22
J-134	62	83	21
J-135	107	94	(13)
J-136	31	53	22
J-137	106	93	(13)
J-138	49	70	21
J-139	107	93	(14)
J-140	31	52	21
J-141	106	93	(13)
J-142	44	66	22
J-143	108	94	(14)
J-144	38	60	22
J-145	102	89	(13)
J-146	38	60	22
J-148	20	42	22
J-149	108	94	(14)
J-150	115	102	(13)
J-152	110	97	(13)
J-153	113	113	-
J-154	106	92	(14)
J-155	126	113	(13)
J-158	109	96	(13)
J-160	109	95	(14)

Appendix G - Pressure Comparison			
Scenario	Average Day - Booster Pump Off		
	Existing	Pump in Goldston	Change
Label	Pressure (psi)	Pressure (psi)	Pressure (psi)
J-161	106	93	(13)
J-162	108	95	(13)
J-163	109	96	(13)
J-164	110	97	(13)
J-165	109	96	(13)
J-166	110	97	(13)
J-167	109	95	(14)
J-168	109	96	(13)
J-169	111	98	(13)
J-170	111	98	(13)
J-171	111	133	22
J-172	111	98	(13)
J-173	111	98	(13)
J-174	111	98	(13)
J-175	111	98	(13)
J-176	105	105	-
J-177	111	98	(13)
J-178	108	94	(14)
J-179	112	98	(14)
J-180	107	94	(13)
J-181	113	99	(14)
J-182	114	100	(14)
J-183	114	101	(13)
J-184	114	101	(13)
J-185	114	101	(13)
J-186	115	101	(14)
J-187	115	102	(13)
J-188	116	102	(14)
J-189	114	101	(13)
J-190	116	103	(13)
J-191	117	104	(13)
J-192	118	105	(13)
J-193	118	105	(13)
J-194	119	105	(14)
J-195	119	106	(13)
J-197	119	119	-
J-199	117	103	(14)
J-200	118	105	(13)
J-201	126	113	(13)
J-202	120	107	(13)
J-203	112	112	-
J-204	121	108	(13)
J-205	121	108	(13)
J-206	121	107	(14)
J-207	121	108	(13)
J-208	121	108	(13)
J-209	121	108	(13)
J-210	118	105	(13)
J-211	128	115	(13)
J-212	129	116	(13)
J-222	105	105	-

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Appendix G - Pressure Comparison			
Scenario	Average Day - Booster Pump Off		
	Existing	Pump in Goldston	Change
Label	Pressure (psi)	Pressure (psi)	Pressure (psi)
J-227	92	79	(13)
J-228	118	105	(13)
J-229	118	105	(13)
J-230	118	104	(14)
J-231	122	109	(13)
J-232	116	103	(13)
J-233	111	98	(13)
J-234	123	110	(13)
J-235	121	108	(13)
J-236	108	95	(13)
J-237	112	99	(13)
J-238	108	94	(14)
J-239	114	101	(13)
J-240	113	100	(13)
J-241	121	107	(14)
J-242	113	100	(13)
J-243	104	91	(13)
J-244	99	121	22
J-245	113	100	(13)
J-246	102	88	(14)
J-247	98	85	(13)
J-248	102	88	(14)
J-249	100	87	(13)
J-250	104	90	(14)
J-251	103	89	(14)
J-252	56	78	22
J-253	59	81	22
J-254	60	82	22
J-255	87	73	(14)
J-256	87	73	(14)
J-257	69	55	(14)
J-258	44	66	22
J-259	42	64	22
J-260	68	90	22
J-261	54	76	22
J-262	52	74	22
J-263	52	74	22
J-264	56	78	22
J-265	51	72	21
J-266	47	69	22
J-267	44	65	21
J-268	41	63	22
J-269	48	69	21
J-270	48	69	21
J-271	35	57	22
J-272	33	54	21
J-273	31	53	22
J-274	41	63	22
J-275	43	65	22
J-276	43	65	22
J-277	48	70	22

Appendix G - Pressure Comparison			
Scenario	Average Day - Booster Pump Off		
	Existing	Pump in Goldston	Change
Label	Pressure (psi)	Pressure (psi)	Pressure (psi)
J-278	44	66	22
J-279	50	71	21
J-280	39	61	22
J-281	43	65	22
J-282	52	74	22
J-283	38	59	21
Average	**73**	**80**	**7**

Appendix H

Fire Flow Comparison

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Appendix H - Fire Flow Comparison			
Scenario	Average Day		
	Existing	Pump in Goldston	Change
Label	Fire Flow (Available) (gpm)	Fire Flow (Available) (gpm)	Fire Flow (Available) (gpm)
H-8	313	701	387
H-817	315	771	456
H-883	313	697	383
H-886	313	695	381
H-888	313	695	382
H-889	313	694	381
H-890	313	694	381
H-891	313	693	380
H-892	313	673	359
H-894	313	429	116
H-895	313	372	59
H-896	313	358	44
H-897	313	324	11
H-898	313	691	378
H-899	313	689	375
H-900	313	685	372
H-902	313	675	362
H-903	313	667	353
H-904	313	667	354
H-905	313	667	354
H-906	313	607	294
H-909	313	618	304
H-910	314	600	286
H-911	314	587	274
H-912	314	587	274
H-913	314	556	242
H-915	314	565	252
H-916	314	530	216
H-917	314	506	192
H-918	314	881	567
H-919	314	881	566
H-920	315	881	566
H-921	1,543	2,200	657
H-922	1,642	1,598	(44)
H-923	607	805	198
H-924	703	5,035	4,331
H-925	604	1,556	952
H-926	565	817	252
H-927	539	1,681	1,142
H-928	523	1,604	1,081
H-929	520	1,671	1,151
H-930	436	1,289	853
H-931	410	1,156	747
H-933	475	1,442	967
H-934	427	1,255	829
H-935	372	1,058	686
H-936	428	1,257	829
H-937	504	1,527	1,023
H-938	551	1,690	1,140
H-939	826	1,810	983
H-940	315	881	566

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Appendix H - Fire Flow Comparison			
Scenario	Average Day		
	Existing	Pump in Goldston	Change
Label	Fire Flow (Available) (gpm)	Fire Flow (Available) (gpm)	Fire Flow (Available) (gpm)
H-941	315	882	567
H-942	316	883	567
H-943	319	892	573
H-944	320	892	572
H-946	305	773	468
H-947	231	615	384
H-948	244	653	409
H-950	259	598	339
H-951	260	647	387
H-952	269	652	383
H-953	309	856	547
H-954	292	761	468
H-955	281	699	418
H-956	302	706	404
H-957	306	403	97
H-959	275	670	395
H-960	270	499	228
H-961	246	399	153
H-962	223	363	139
H-963	225	364	140
H-964	225	364	139
H-965	270	468	198
H-966	270	419	148
H-967	314	878	564
H-968	312	870	557
H-1768	307	379	72
H-1770	257	668	411
H-1777	310	368	58
H-1778	312	517	205
H-1779	308	342	34
H-1877	308	330	22
H-Flow 1	1,228	701	(527)
H-Flow 2	314	569	256
H-Flow 3	309	368	59
H-Pressure 1	1,224	751	(473)
H-Pressure 2	314	565	252
H-Pressure 3	308	368	60
Average	**392**	**827**	**435**