Appendix A

Northwest Cary Force

Main Memorandum

DRAFT
Technical Memorandum

TO: Town of Cary
Glen Harrell, P.E.

FROM: Hazen and Sawyer, PC
Michael Wang, Frank Qiao, Todd Davis

DATE: October 25, 2010
Revised October 19, 2012

SUBJECT: Northwest Cary Force Main Diversion Evaluation
H&S Project No.: 30508-000

Introduction

Hazen and Sawyer completed an evaluation of the Northwest Cary Force Main Diversion in January 2007. In 2012 the projected wastewater flows for the Kit Creek Pump Station (KCPS) and the Morris Branch Regional Pump Station (MBRPS) were revised. This Technical Memorandum evaluates the required improvements for the Northwest Cary Force Main Diversion Project based on the revised flow projections.

Background

Currently, the West Cary Regional Pump Station (WCRPS) conveys wastewater north to the MBRPS which conveys wastewater to the KCPS, which then conveys the wastewater to either the Durham County's Triangle Wastewater Treatment Facility (WWTF) or the North Cary Water Reclamation Facility (WRF) as shown in ***Figure 1***. Once the new Western Wake Wastewater Management Facilities (WWWMF) are placed in service (currently anticipated in 2014), the wastewater collected at the KCPS and MBRPS will be conveyed south to the West Cary Regional Pump Station (WCRPS). The WCRPS will then pump the wastewater to the proposed Beaver Creek Pump Station which conveys the wastewater to the Western Wake Regional Water Reclamation Facility (WWWRF) for treatment.

The Town of Cary and Hazen and Sawyer have developed a transition plan to accomplish the redirection of flow from the three pumps stations into the WWWMF system. The redirection of flow from each of the three pump stations will occur in three phases over the course of several months, and is referred to hereinafter as the "transition period". The first phase is to redirect the WCRPS to the BCPS. The second phase is to redirect flow from the MBRPS to the WCRPS, and the third phase (referred to as "Final Status") is to redirect flow from the KCPS to the WCRPS. For the purposes of this evaluation, the transition period is assumed to be complete in the year 2015.

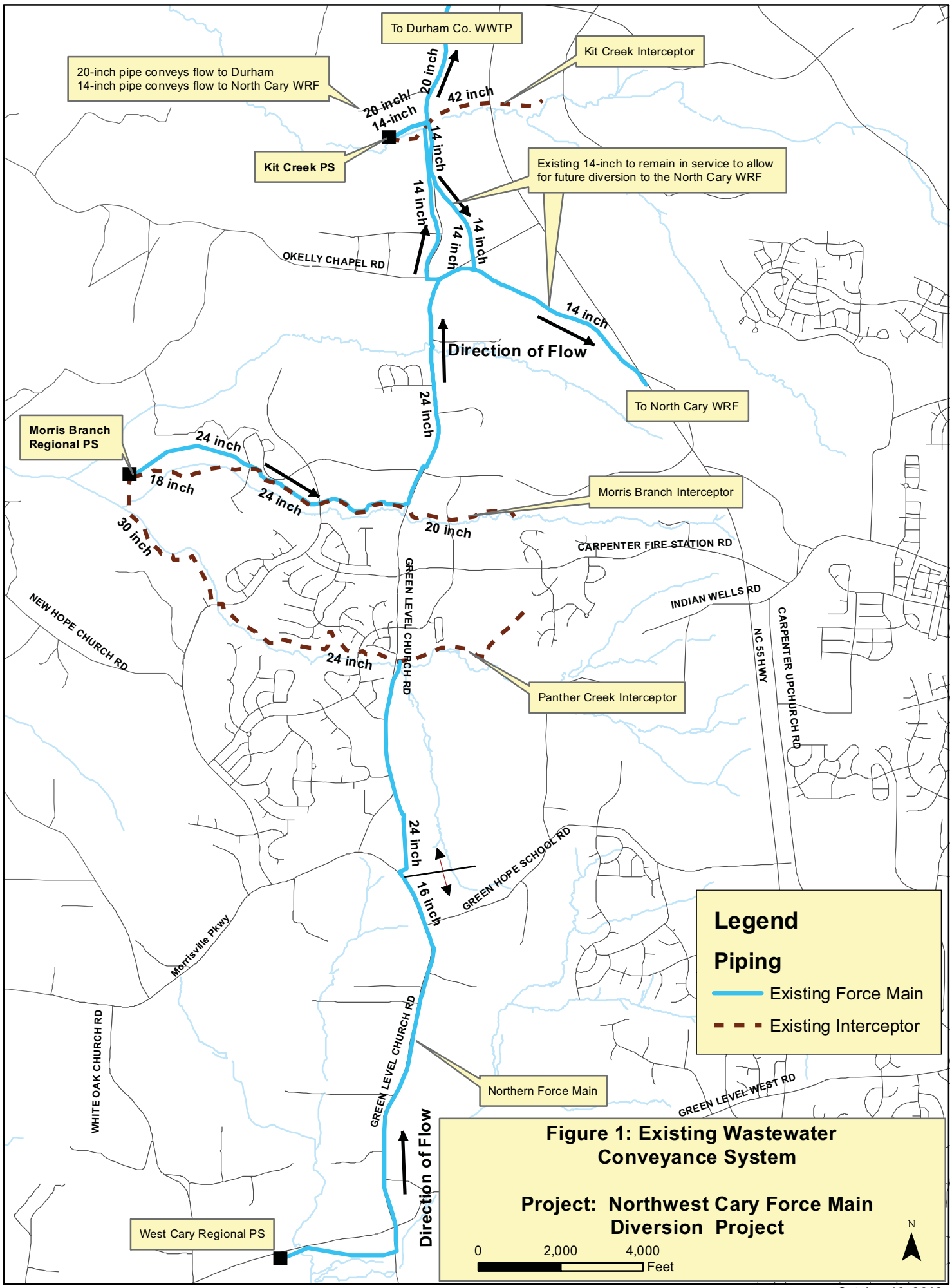
A significant portion of the current flow conveyance system force main piping can be used to convey flow to the proposed WCRPS by reversing the direction of flow through the piping. Some new sections of piping will be required to augment the existing piping system and increase the system capacity to meet projected flow rates.

The Town of Cary has authorized Hazen and Sawyer to re-evaluate the required piping system and pump station upgrades to convey flow from the KCPS and MBRPS to the WCRPS. This evaluation includes the following:

- A summary of the revised wastewater flow projections for the MBRPS and KCPS service areas, respectively.
- A hydraulic evaluation to determine the capacity of the existing pumps at the MBRPS and KCPS and the capacity of the existing force mains (based on the proposed route) to convey flow to the WCRPS.
- Preliminary sizing of pumps and force main piping to meet initial flows during the transitional period (transitioning KCPS and MBRPS to pump south to the WCRPS), the year 2030, and build-out flow conditions.
- Preliminary cost estimates for the recommended improvements for each flow condition.

During the evaluation the following assumptions were made:

- Average pipe roughness coefficient (Hazen Williams C-factor) for all existing and proposed pipes is 100.
- Force main piping was sized to provide a flow velocity of 4 to 7 feet per second (fps) at the design peak flow rate.
- Gravity sewer pipe was sized to provide flow velocities between 2.5 and 12 feet per second, and to be no more than 2/3 full at the build-out peak flow.


To Durham Co. WWTP
20-inch pipe conveys flow to Durham
14-inch pipe conveys flow to North Cary WRF
Kit Creek Interceptor
20 inch
20 inch/
14-inch
42 inch
Kit Creek PS
14 inch
Existing 14-inch to remain in service to allow
for future diversion to the North Cary WRF
14 inch
14 inch
14 inch
OKELLY CHAPEL RD
14 inch
Direction of Flow
24 inch
To North Cary WRF
Morris Branch
Regional PS
24 inch
18 inch
24 inch
Morris Branch Interceptor
20 inch
30 inch
CARPENTER FIRE STATION RD
INDIAN WELLS RD
NEW HOPE CHURCH RD
GREEN LEVEL CHURCH RD
NC 55 HWY
CARPENTER UPCHURCH RD
24 inch
Panther Creek Interceptor
24 inch
16 inch
GREEN HOPE SCHOOL RD
Morrisville Pkwy
WHITE OAK CHURCH RD
GREEN LEVEL CHURCH RD
Northern Force Main
GREEN LEVEL WEST RD
Direction of Flow
West Cary Regional PS
Legend
Piping
Existing Force Main
Existing Interceptor
Figure 1: Existing Wastewater
Conveyance System
Project: Northwest Cary Force Main
Diversion Project
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2,000
4,000
Feet
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Wastewater Flow Projections

Wastewater flow projections for the Western Cary Service Area were recently revised based on data developed as part of the ongoing wastewater master plan project. The West Cary Service Area is served by the KCPS, MBRPS, and WCRPS. ***Figure 2*** shows the portions of the West Cary service area that contribute flow to these three pump stations. The areas served by KCPS are shown as pink, MBRPS is shown as blue, and WCRPS is shown as green.

The current flows for the MBRPS and KCPS and the projected flows through build-out are summarized in ***Table 1***. A peaking factor of approximately 2.5 was applied to all projected annual average flows to project the peak hour flows for each pump station. The green values in ***Table 1*** represent flows pumped north to the Durham County WWTF while the flows in pink represent wastewater pumped south to the WWWMF. During Phase 1 of the transitional period the WCRPS flow will be pumped south to the Beaver Creek Pump Station. During this phase the influent flow to the WCRPS remains the same, while flows at both the MBRPS and KCPS decrease as they no longer repump the WCRPS flow. Phase 2 of the transitional period will redirect the MBRPS flow to the WCRPS, further decreasing the flows pumped by the KCPS. The "Final Status" is the last phase of the transitional period and will redirect flow from KCPS to the WCRPS. The WCRPS will then repump the KCPS and MBRPS so that the entire Western Service area wastewater flow is delivered to the BCPS for conveyance to the WWWRF. Both the 2011 and the 2015 wastewater flows were considered during the evaluation of the transitional period. This approach ensures that both the KCPS and MBRPS can meet the minimum hour flows associated with 2011, which are based on actual measured data, as well as the peak hour flows of 2015, which assume modest growth.

Hydraulic Evaluation

The KCPS, MBRPS, and associated force mains were evaluated based on their capacity to meet the transitional flow conditions (year 2011 min flows to year 2015 peak hourly flows), 2030 flow conditions, and build-out flow conditions as summarized in ***Table 1***. The MBRPS and KCPS combined projected peak hourly flow rate to be conveyed to the WCRPS is 8.57 mgd for 2015, 15.9 mgd for 2030, and 21.27 mgd for build-out conditions. This Technical Memorandum focuses on the conveyance systems required for flow from the KCPS and MBRPS and does not include the requirements for the expansion of the WCRPS.

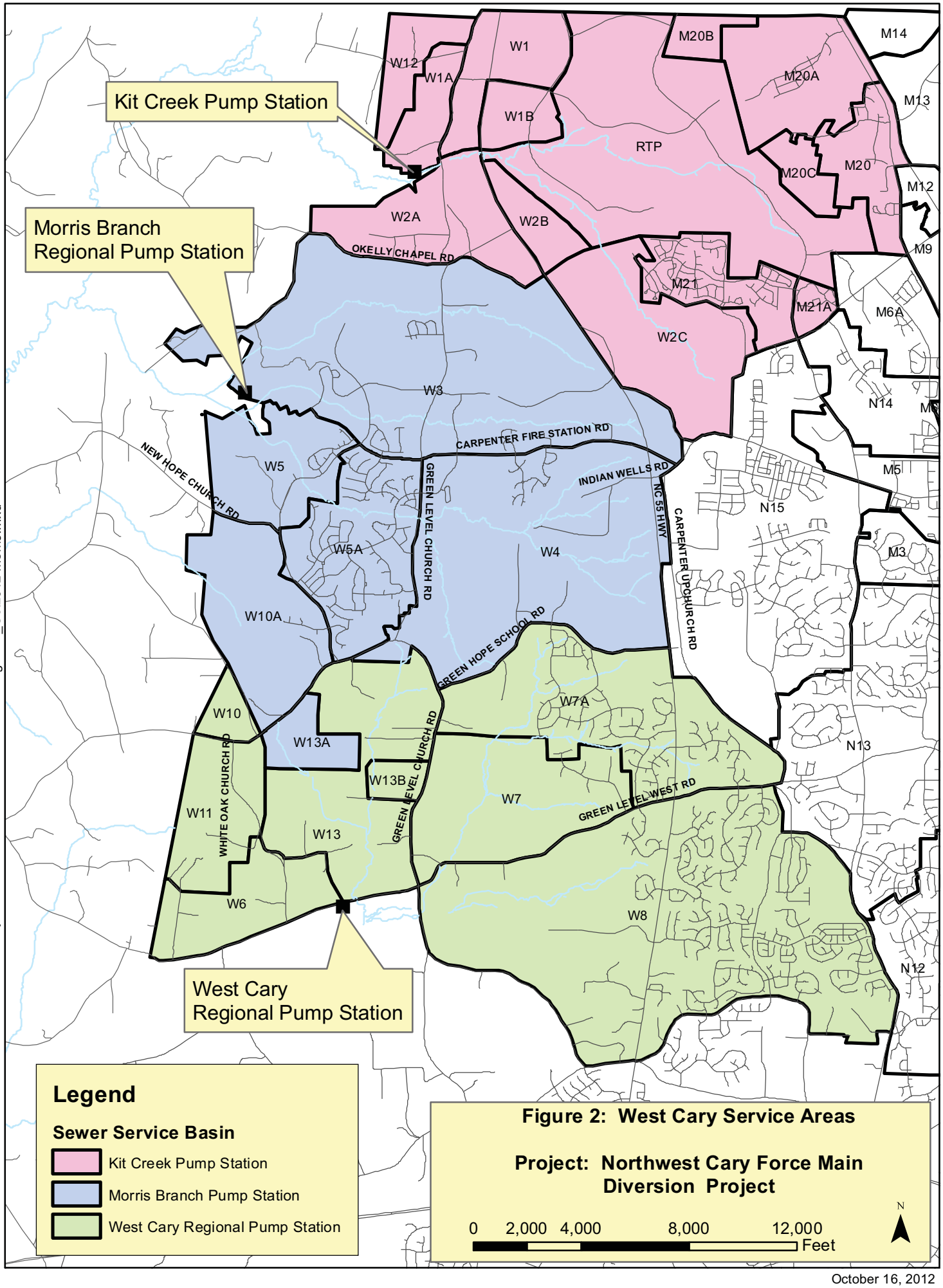
Kit Creek Pump Station
Morris Branch
Regional Pump Station
West Cary
Regional Pump Station
W12
W1A
W1
W1B
W2A
W2B
W2C
W3
W4
W5
W5A
W10A
W10
W13A
W13B
W11
W13
W6
W7
W7A
W8
RTP
M20B
M20A
M20C
M20
M14
M13
M12
M9
M21
M21A
M6A
N14
M6
M5
N15
M3
N13
N12
OKELLY CHAPEL RD
CARPENTER FIRE STATION RD
NEW HOPE CHURCH RD
GREEN LEVEL CHURCH RD
INDIAN WELLS RD
NC 55 HWY
CARPENTER UPCHURCH RD
GREEN HOPE SCHOOL RD
WHITE OAK CHURCH RD
GREEN LEVEL WEST RD
Legend
Sewer Service Basin
Kit Creek Pump Station
Morris Branch Pump Station
West Cary Regional Pump Station
Figure 2: West Cary Service Areas
Project: Northwest Cary Force Main Diversion Project
0 2,000 4,000 8,000 12,000
Feet
N
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Table 1: Existing and Projected Flows

Flow Projections for Pump Stations in the West Cary Service Area (MGD)	Year										
	2011 Pumping North	2011 Transition Phase 1	2011 Transition Phase 2	2011 Final Status	2015 Pumping North	2015 Transition Phase 1	2015 Transition Phase 2	2015 Final Status	2020	2030	Build-out
Kit Creek PS (Mininum Hourly * 0.25)	0.73	0.53	0.22	0.22	1.06	0.85	0.56	0.56	0.70	0.98	1.27
Kit Creek PS (Annual Average)	2.32	1.57	0.96	0.96	4.22	3.40	2.23	2.23	2.81	3.90	5.06
Kit Creek PS (Peak Hourly)	5.54	3.36	1.84	1.84	10.56	8.50	5.57	5.62	7.22	10.05	13.82
Morris Branch PS (Minimum Hourly *0.25)	0.51	0.31	0.31	0.31	0.50	0.29	0.29	0.29	0.42	0.58	0.70
Morris Branch PS (Average Day)	1.36	0.61	0.61	0.61	1.99	1.17	1.17	1.17	1.67	2.32	2.81
Morris Branch PS (Peak Flow)	3.70	1.52	1.52	1.52	4.98	2.92	2.92	2.95	4.17	5.85	7.45
West Cary Regional PS (Minimum Hourly *0.25)	0.20	0.20	0.51	0.73	0.21	0.21	0.50	1.06	1.37	2.31	2.89
West Cary Regional PS (Average Day)	0.75	0.75	1.36	2.32	0.82	0.82	1.99	4.22	5.47	9.23	11.57
West Cary Regional PS (Peak Flow)	2.18	2.18	3.70	5.54	2.06	2.06	4.97	10.56	13.88	24.28	30.22

Transition Phase 1: Kit Creek PS and Morris Branch PS pumping north, while West Cary Regional PS pumping south

Transition Phase 2: Kit Creek PS pumping north, Morris Branch PS, and West Cary Regional PS pumping south

Final Status: All three pump stations convey flow south

Pumping North

Pumping South

Year 2011 flows were derived from actual flow monitoring data

Pipeline Routing Summary

While a significant portion of the current flow conveyance system can be used to convey flow to the proposed WCRPS by reversing the direction of flow through the piping, two new force mains and a gravity sewer must be constructed to properly connect the system. Additional parallel force mains at select locations are required in the future to handle the projected flows. For the purpose of evaluating hydraulic capacity, the proposed piping system to the WCRPS has been divided into the following sections which are described below and illustrated on ***Figure 3***:

- KCPS Service Road– From the KCPS to the intersection of the KCPS service road and Green Level Church Road. Existing piping consists of a 1,100 LF of 20-inch and 14-inch force main. The existing 20-inch force main will be utilized when pumping south the WCRPS. Existing 14-inch force main will remain in service to allow for future diversion to the North Cary WRF.

- Section No. 1 –From the Green Level Church Road/KCPS service road intersection to the point where the KCPS and MBRPS flows combine just south of the intersection of McCrimmon Pkwy and Green Level Church Road. Existing piping consists of approximately 4,000 LF of 24-inch force main (Section No. 1A), which is currently under construction, and 5,800 LF of existing 24-inch force main (Section No. 1B).

- Section No. 2 – From the MBRPS to the point where the KCPS and MBRPS flows combine. Existing piping in this section consists of approximately 7,700 LF of 24-inch force main.

- Section No. 3 – The combined force main for the KCPS and MBRPS along Green Level Church Road. The first portion of this pipe section (Section No. 3A) consists of, approximately 3,900 LF of proposed 30-inch force main. The second portion of this pipe section (Section No. 3B) consists of approximately 5,400 LF of existing 24-inch force main.

- Section No. 4 – Gravity interceptor from the intersection of Green Level Church Road and Morrisville Pkwy to the WCRPS. Only a portion of this 11,000 LF section of gravity interceptor currently exists. The remainder of the pipe is proposed for construction within an existing utility corridor. The alignment of the proposed gravity interceptor will parallel an existing stream and be located approximately 100 feet east of the stream's top of bank.

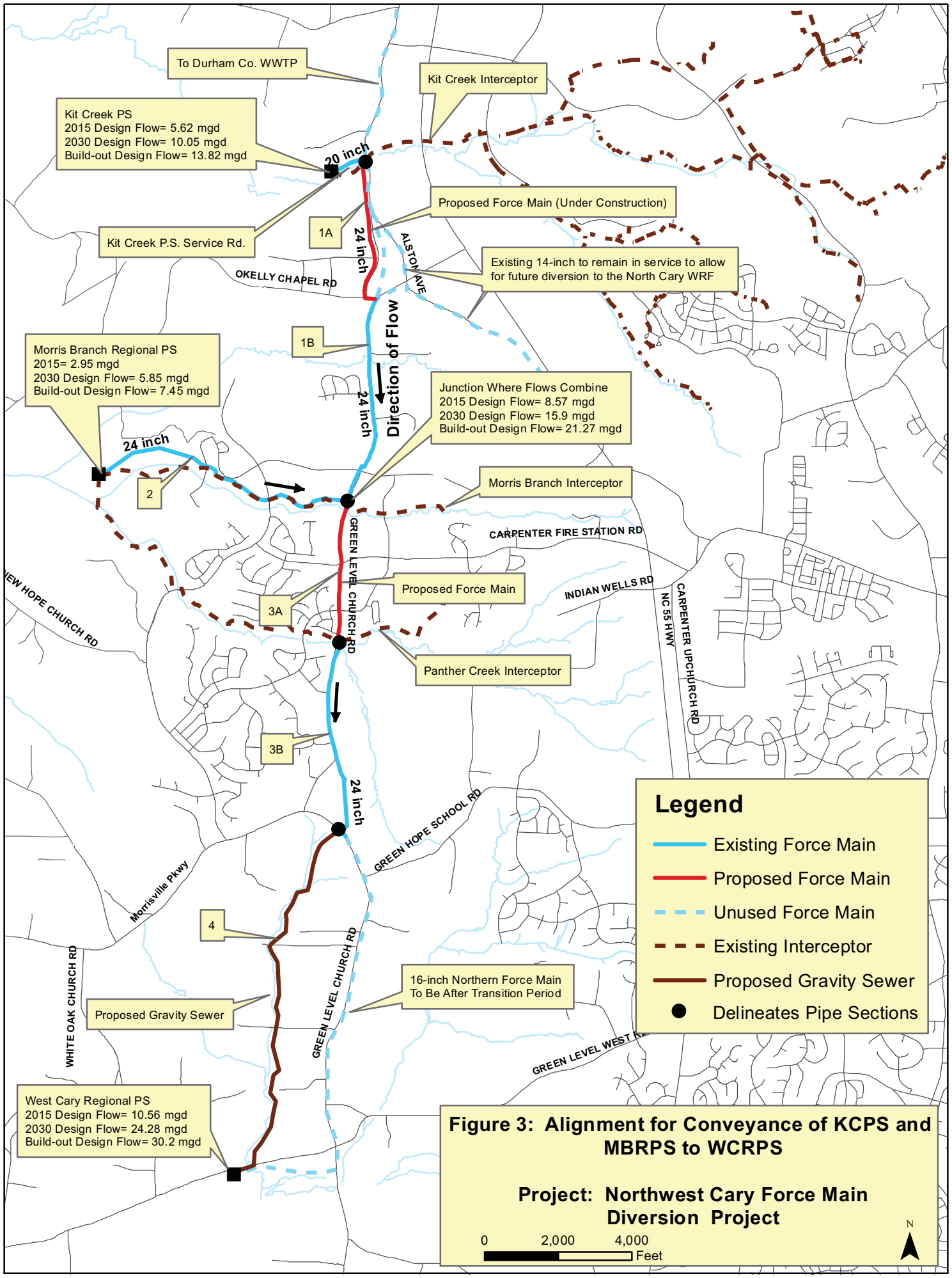

Figure 3: Alignment for Conveyance of KCPS and MBRPS to WCRPS

Project: Northwest Cary Force Main Diversion Project

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Overview of Existing Pump Stations and Force Main Piping

The KCPS currently conveys flows to the Durham County's Triangle WWTF through a 20-inch force main or alternatively to the North Cary WRF through a 14-inch force main. A summary of the existing KCPS and MBRPS pump characteristics is provided in *Table 2*.

Table 2

Existing Pumps in the KCPS and MBRPS

Item	Kit Creek PS	Morris Branch Regional PS
Required Pump Station Firm Capacity	7.57 mgd	4.16 mgd
Number of Existing Pumps	2 duty / 1 standby	2 duty
Pump Model	Flygt CP3231	Flygt CP3231
Capacity per Pump	4.5 mgd (3,140 gpm)	4.3 mgd (3,000 gpm) (1)
Total Dynamic Head (TDH) at Design Capacity	187 feet	172 feet
Pump Motor Horsepower	250 HP	185 HP
Operating Efficiency at Design Capacity	73%	72%

(1) MBRPS pumps were tested in 2010 and found to be underperforming when compared to the indicated manufacturer's point. The tested performance points were used to develop a pump curve that was used when evaluating pump station performance during and after the transitional period.

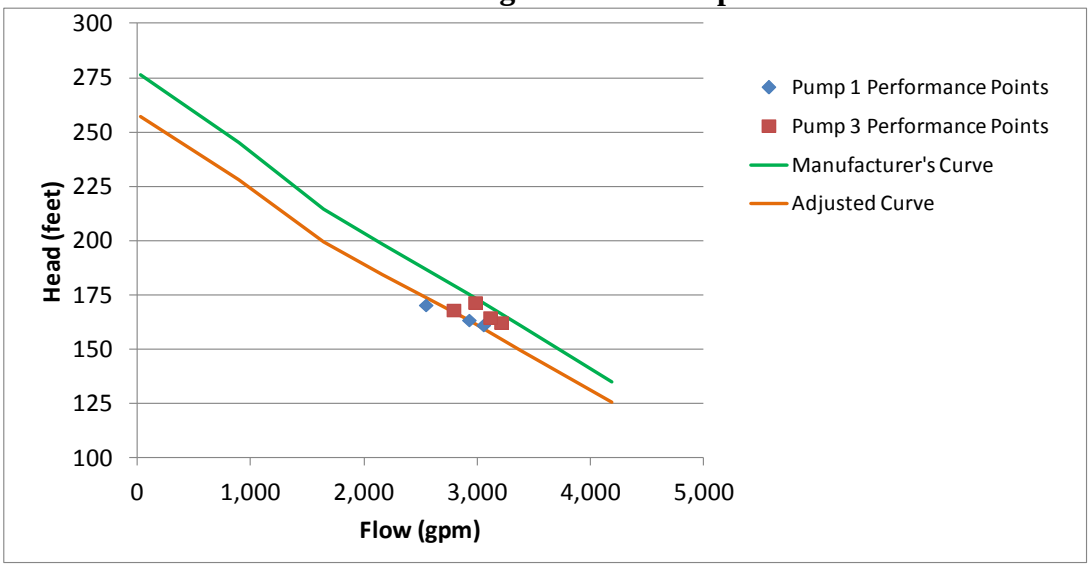
Kit Creek Pump Station

The KCPS includes three 250 HP submersible pumps with available space for one additional pump by expanding the wet well and valve vault structures. The manufacturer's pump test curves for the three existing pumps indicate each pump has a capacity of approximately 3,140 gpm at 187 feet of total dynamic head (TDH). The construction drawings indicate an average wet well operating water level elevation of 230 feet. The individual pump discharge piping and valves are 12-inch diameter. The pump discharge piping combines into a 12-inch header, which splits and conveys flow to either Durham or the North Cary WRF. When conveying flow to Durham, the 12-inch force main increases to an 18-inch flow metering section before increasing to a 20-inch force main. When conveying flow to the North Cary WRF, the 12-inch pipe enters a 12-inch flow metering section before increasing to 14-inch force main. Currently the KCPS pumps are able to meet the required firm capacity of 7.57 mgd.

Morris Branch Regional Pump Station

The MBRPS includes two 185 HP pumps with two additional pump wells available for future expansions. The manufacturer's pump test curves for the two existing pumps indicate each pump has a capacity of 3,000 gpm at 172 feet TDH. The MBRPS pumps were tested in 2010 and found to be underperforming by approximately 7%. ***Figure 4*** compares the manufacturer's pump curve to the measured performance points. The measured performance points were used to adjust the manufacturer's pump curve so more accurate pumping conditions were reflected when evaluating pump station performance during and after the transitional period. The construction drawings indicate an average wet well operating water level elevation of 218 feet. The individual pump discharge piping and valves are 18-inch diameter. The pumps discharge into a combined header that reduces to a 16-inch flow metering section then increases to a 24-inch force main. The MBRPS pumps are currently able to meet the required firm capacity of 4.16 mgd.

Figure 4
Morris Branch Regional P.S. Pump Curves



West Cary Regional Pump Station

The WCRPS is in operation with a firm capacity of 2.29 mgd. Submersible pumps located in the future bar screen facility convey flow via a 16-inch/24-inch force main that discharges into the Panther Creek Interceptor for conveyance to the MBRPS. The WCRPS will be expanded to its build-out capacity of 30.22 mgd as part of the WWWMF Influent Conveyance Project.

Overview of Proposed Conveyance System

The KCPS and the MBRPS will be utilized to convey flow to the WCRPS as shown on ***Figure 3.*** Flow will transition from pressurized flow to gravity flow near the intersection of Morrisville Pkwy and Green Level Church Road (junction of piping Section No. 3B and Section No. 4). This location serves as the control point for pump hydraulic calculations. As-built drawings indicate a top of pipe elevation of 363 feet at the control point. Based on the wet well levels in the KCPS and MBRPS of 230 feet and 218 feet, respectively, the pumps in the KCPS must overcome a static head of +/-133 feet; whereas, the pumps in the MBRPS must overcome a static head of +/-145 feet.

Conveyance System Design Criteria

The force mains will be sized to provide a flow velocity of 4 to 7 feet per second (fps) at the design peak flow rate in order to limit excessive head loss during peak flow yet maintain sufficient velocity to prevent settling of solids during average flow.
The gravity sewer section (Pipe Section No. 4) will be sized to provide flow velocities between 2.5 and 12 fps from initial startup flows to ultimate build-out flows, and to be no more than 2/3 full at the build-out peak flow.

Required Improvements to Meet Future Flow Conditions

Piping Improvements

In order to redirect the flow from the KCPS and the MBRPS to the WCRPS when the proposed WWWRF goes on line, the following improvements are required:

Immediate Piping Improvements

- Install 4,000 LF of 24-inch force main along Green Level Church Road in Section 1A (currently under construction).
- Connect existing 20-inch force main along KCPS service road to new 24-inch force main along Green Level Church Rd. in Section No. 1A.
- Install 3,900 LF of 30-inch force main in Section No. 3A.
- Install 9,800 LF of 42-inch and 1,200 LF 48-inch gravity sewer (Section No. 4).

Piping Improvements by 2030

- Install 1,100 LF of 20-inch force main parallel to the existing 20-inch force main on the KCPS service road.
- Install 5,400 LF of 24-inch force main parallel to the existing 24-inch force main in Section No. 3B.

A summary of the recommended piping improvements developed using the conveyance system design criteria is provided in ***Table 3***. The proposed piping improvements will provide the hydraulic capacity for the projected build-out flow conditions for each pump station.

Pipe segment No. 4 is a proposed gravity sewer. Approximately 1,000 LF of the lower portion of the gravity sewer has already been constructed with 48-inch pipe. Based on the existing design drawings the minimum slope of the lower portion of the gravity sewer is 0.46%. A 48-inch pipe at this slope has more than sufficient carrying capacity to manage flows through build-out. The slope of the existing terrain increases upstream of the existing 48-inch gravity sewer. Therefore, the Town has the opportunity to downsize the pipe diameter to 42-inch and still maintain a carrying capacity that that will manage flows through build-out by establishing a minimum pipe slope of 0.24%. The use of 36-inch pipe may be considered for portions of the gravity sewer where the a minimum pipe slope of 0.54% is established.

Figure 5 and ***Figure 6*** show the pipe profile and Hydraulic Grade Line (HGL) from the KCPS to the WCRPS and MBRPS to the WCRPS, respectively, for 2015, 2030, and build-out.

Table 3						
Initial Piping Improvements						
Piping Section No.	**Design Peak Flow Rate**	**Existing Pipe Size**	**Velocity at Peak Flow Rate**	**Existing Pipe Size Sufficient?**	**Proposed New Pipe**	**Revised Velocity at Peak Flow Rate**
KCPS Service Road	5.62 mgd	20-inch	4 fps	Yes	-	-
1A	5.62 mgd	24-inch	2.8 fps	Yes	-	-
1B	5.62 mgd	24-inch	2.8 fps	Yes	-	-
2	2.95 mgd	24-inch	1.5 fps	Yes	-	-
3A	8.57 mgd	30-inch	2.7 fps	Yes	-	-
3B	8.57 mgd	24-inch	4.2 fps	Yes	-	-
4	8.57 mgd	48-inch	5.5 fps @ 0.46% slope	Yes	-	-
2030 Piping Improvements						
Piping Section No.	**Design Peak Flow Rate**	**Existing Pipe Size**	**Velocity at Peak Flow Rate**	**Existing Pipe Size Sufficient?**	**Proposed New Pipe**	**Revised Velocity at Peak Flow Rate**
KPS Service Road	10.05 mgd	20-inch	7.1 fps	No	20-inch	3.6 fps
1A	10.05 mgd	24-inch	5.0 fps	Yes	-	-
1B	10.05 mgd	24-inch	5.0 fps	Yes	-	-
2	5.85 mgd	24-inch	2.9 fps	Yes	-	-
3A	15.9 mgd	30-inch	5.0 fps	Yes	-	-
3B	15.9 mgd	24-inch	7.8 fps	No	24-inch	3.9 fps
4	15.9 mgd	48-inch	6.5 fps @ 0.46% slope	Yes	-	-
Build-out Piping Improvements						
Piping Section No.	**Design Peak Flow Rate**	**Existing Pipe Size**	**Velocity at Peak Flow Rate**	**Existing Pipe Size Sufficient?**	**Proposed New Pipe**	**Revised Velocity at Peak Flow Rate**
KCPS Service Road	13.82 mgd	20-inch/ 20-inch	4.9 mgd	Yes		
1A	13.82 mgd	24-inch	6.8 fps	Yes	-	-
1B	13.82 mgd	24-inch	6.8 fps	Yes	-	-
2	7.45 mgd	24-inch	3.7 fps	Yes	-	-
3A	21.27 mgd	30-inch	6.7 fps	Yes	-	-
3B	21.27 mgd	24-inch/ 24-inch	5.2 fps	Yes	-	-
4	24 mgd	48-inch	7 fps @ 0.46% slope	Yes	-	-

Figure 5
Kit Creek P.S. Force Main Profile and HGL

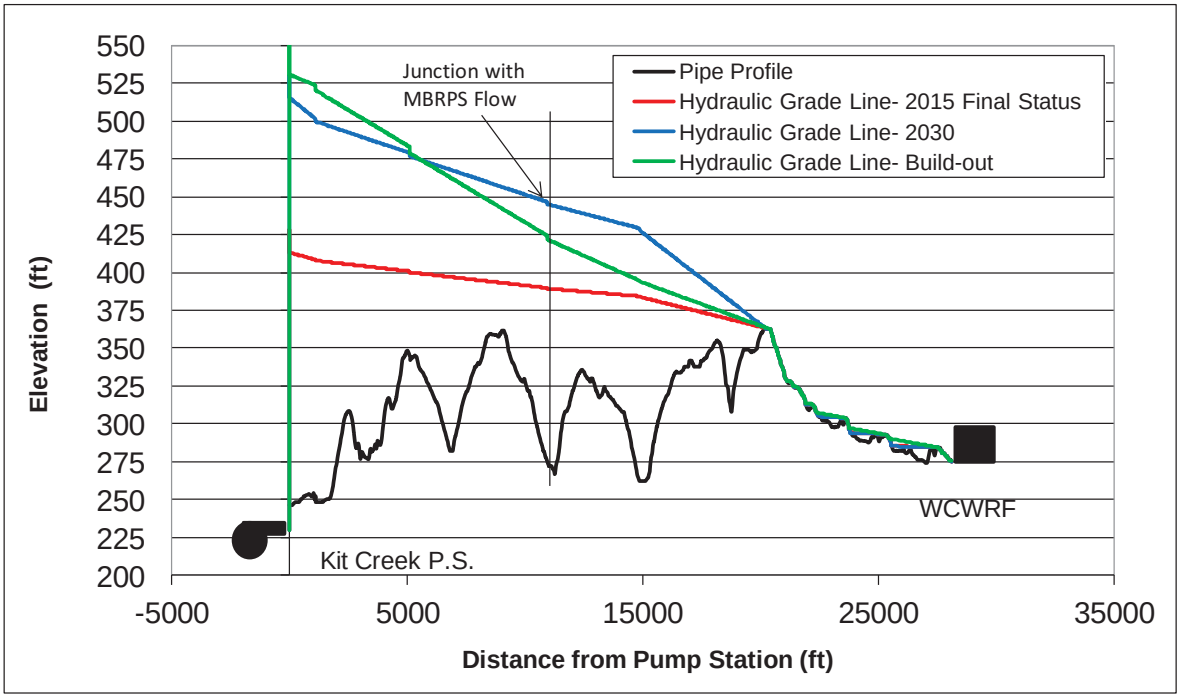
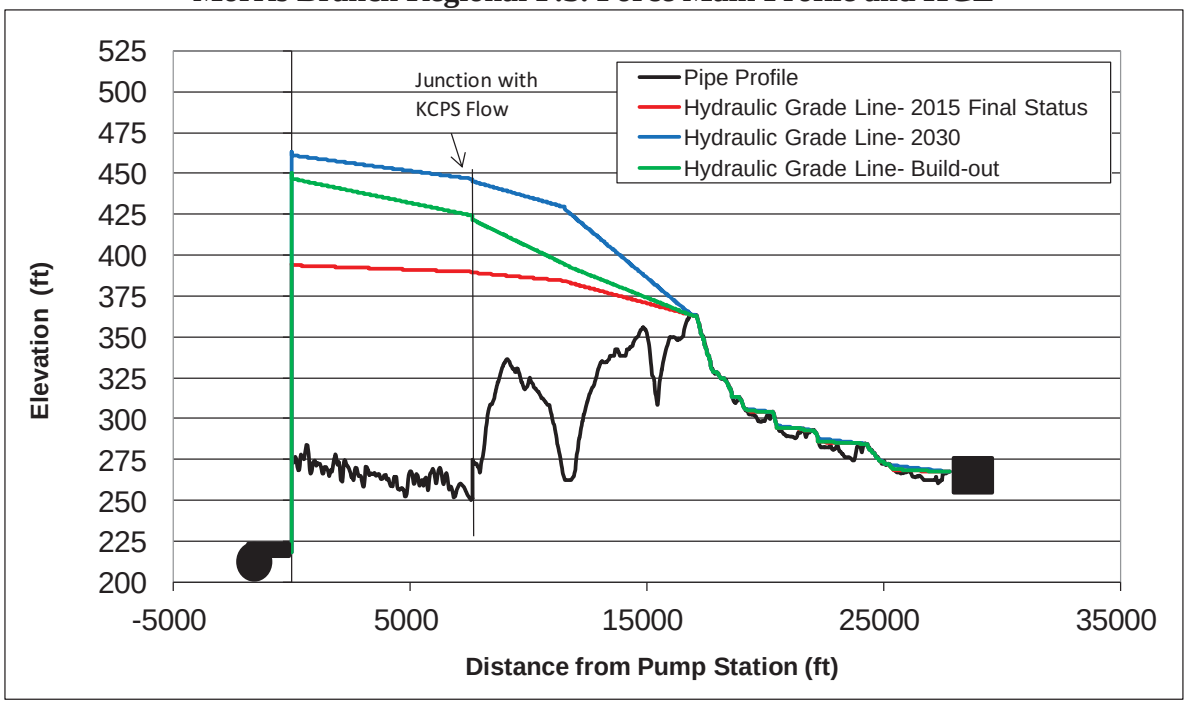


Figure 6
Morris Branch Regional P.S. Force Main Profile and HGL



Pump Station Improvements

Table 4 summarizes the pump station requirements for future conditions at the KCPS and MBRPS assuming the recommended piping improvements are implemented. The existing pumps at the KCPS and MBRPS are able to meet the flow/head conditions through the transitional period (year 2015) when wastewater at both pump stations is redirected south to the WCRPS. *Figure 7* and *Figure 8* illustrate the relationship between the system curves and pump curves for the transition period (year 2015) for the KCPS and MBRPS, respectively. The two system curves provide the flow/head range for which the pumps must be able to operate. The higher system curve (red) assumes low pipe C factors (C=100), with both pump stations running simultaneously (because they discharge to a common force main), while the lower system curve (blue) assumes higher C factors (C=120 for existing force mains, C=140 for new force mains) and only one pump station running. As illustrated in the figures the existing pumps can convey the 2015 peak hour flows. All of the pumps at both pump stations are provided with variable frequency drives (VFDs) allowing the pumping rate to be reduced to accommodate low flow periods, thereby minimizing pump cycling while maintaining sufficient pump run times.

Note: It may be beneficial for the Town to conduct pump tests at the KCPS to verify the pumps are operating close to the manufacturer's pump curves used for this evaluation, similar to the performance tests completed for the MBRPS in 2010.

The VFDs at the KCPS and MBRPS have been set by Town operational staff at 45 Hz (75%) which correlates to flow rates of roughly 2,500 gpm and 1,600 gpm, respectively. Operational experience has found that the check valves at these pump stations begin to oscillate at lower VFD frequencies. It is not clear if the check valve oscillations is a flow or pressure related issue, or perhaps a combination of both. If the oscillation issue is flow related, then the KCPS and MBRPS must maintain a minimum flow rate of 2,500 gpm and 1,600 gpm, respectively. This will result in short but acceptable pump run times (3 minutes at KCPS and 7 minutes at MBRPS) during low flow periods. Following the transition period the check valve performance should be monitored in relation to the minimum VFD settings to determine how the new pumping conditions impact performance.

Table 4		
2015- Pumping South to WCRPS		
Item	**Kit Creek PS**	**Morris Branch Regional PS**
Pump Station Firm Capacity	5.62 mgd	2.95 mgd
Number of Pumps to Provide Firm Capacity	2 duty/ 1 standby	1 duty/ 1 standby
Minimum Required Capacity per Pump	2.81 mgd (1,950 gpm)	2.95 mgd (2,050 gpm)
Approximate TDH at Design Capacity	198	176
Pump Motor Horsepower	250 HP	185 HP
Pump Efficiency at Design Capacity	67%	65%
2030 Pump Station Requirements		
Item	**Kit Creek PS**	**Morris Branch Regional PS**
Pump Station Firm Capacity	10.05 mgd	5.85 mgd
Number of Pumps to Provide Firm Capacity	3 duty / 1 standby	2 duty / 1 standby
Minimum Required Capacity per Pump	3.35 mgd (2,330 gpm)	2.93 mgd (2,030gpm)
Approximate TDH at Design Capacity	300 feet	245 feet
Pump Motor Horsepower(1)	450 HP	350 HP
Pump Efficiency at Design Capacity(1)	62%	63%
Build-out Pump Station Requirements		
Item	**Kit Creek PS**	**Morris Branch Regional PS**
Pump Station Firm Capacity	13.82 mgd	7.45 mgd
Number of Pumps to Provide Firm Capacity	3 duty / 1 standby	3 duty / 1 standby
Minimum Required Capacity per Pump	4.61 mgd (3,200 gpm)	2.48 mgd (1,725 gpm)
Approximate TDH at Design Capacity	320 feet	232 feet
Pump Motor Horsepower(1)	450 HP	350 HP
Pump Efficiency at Design Capacity(1)	69%	60%

Figure 7
2015 Kit Creek P.S. Pumping Hydraulics

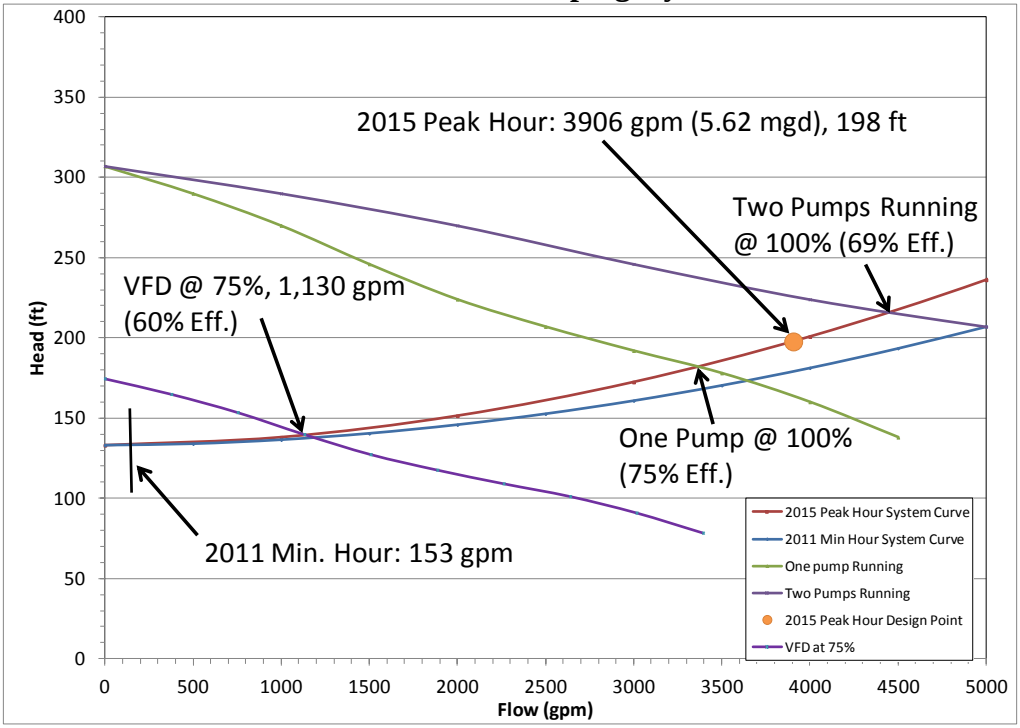
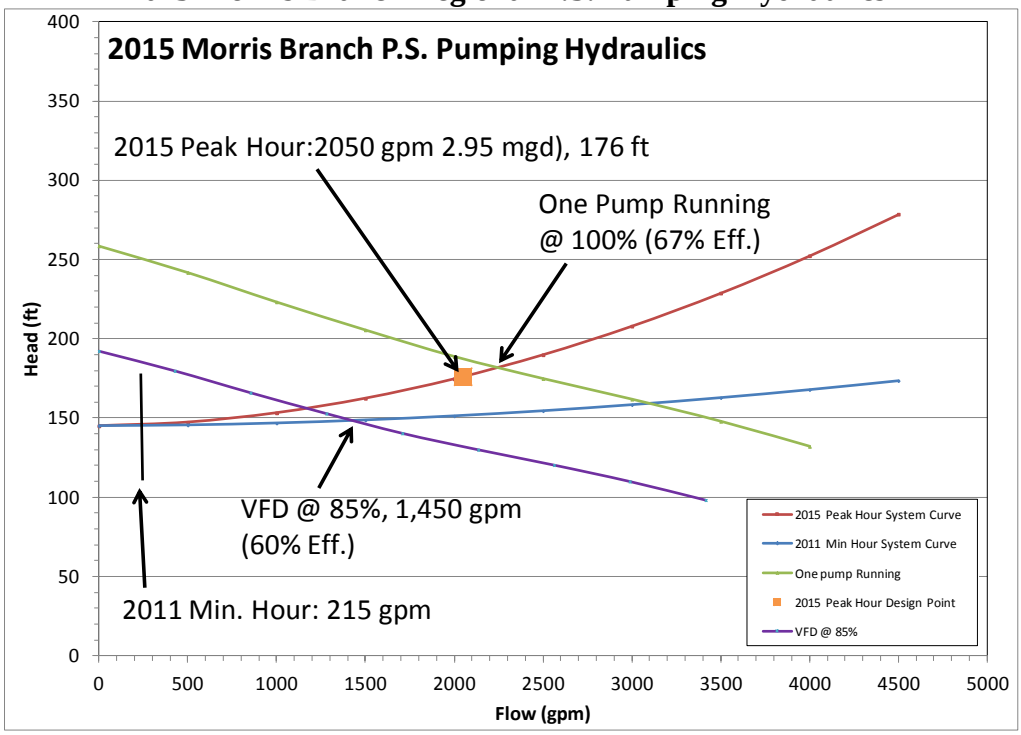


Figure 8
2015 Morris Branch Regional P.S. Pumping Hydraulics



Both the KCPS and MBRPS have capacity to meet pumping requirements for the transition period without additional modification; however, by the year 2020 modifications will be needed at both pump stations to meet projected demands. Improvements recommended by the year 2020 are designed to meet pumping requirements associated with the year 2030.

Kit Creek Pump Station Improvements

Demands for the KCPS from 2020 to the year 2030 can be met by replacing the three existing 250 HP pumps and VFD's with four new 450 HP pumps (3 duty, 1 standby) each with a rated capacity of 2,330 gpm (3.35 mgd) at 300 ft TDH. This will require the wet well be expanded to accommodate a fourth pump and the pump discharge header to be increased from 12-inch to 20-inch in diameter. The recommended pumps will provide a firm pumping capacity of 10.05 mgd in 2030 prior to installation of the 20-inch and 24-inch parallel force mains shown on ***Figure 9***. Once the parallel force mains are in service the reduced TDH will result in an increase in pump station capacity allowing the pumps to meet pumping requirements for a period beyond 2030. In order to meet the build-out design condition, the 12-inch discharge piping will need to be upsized to 16-inch pipe and the impellers on the four pumps will need to be replaced so that the pumps can convey the increased flow. The replacement pumps modeled for the KCPS are based on Flygt model CP3240.

The following is a summary of recommended KCPS improvements:

2020 Improvements

- Expand the KCPS wet well and valve vault structures to accommodate a fourth pump.
- Replace the three existing 250 HP pumps with four new 450 HP pump and VFDs. Each pump will have a rated capacity of 2,330 gpm (3.35 mgd) at 300 ft TDH.
- Replace 12-inch common header with 20-inch piping.

Build-out Improvements

- Upsize the impellers on all four 450 HP pumps to accommodate greater flows. Each pump will have a rated capacity of 3,200 gpm (4.61 mgd) at 320 ft TDH.
- Upsize pump discharge piping from 12" to 16" for each of the four pumps.

The Town may also choose to install a "jockey" pump, or low flow pump, as part of future pump station improvements that can be used during low flow periods to better match influent flow rates. Low flow pumps may help alleviate the Town's concerns in regards to odor control, increased chemical feed rates, damage to pump station check valves over time, increased energy use, and accelerated corrosion within the pipeline network, which can be a result of short run times.

Prior to the year 2020 the KCPS will require an expansion of the wet well to accommodate a fourth pump slot. All four pump slots at the KCPS will require duty pumps to meet flows in 2030. However, the fourth pump is not required for a number of years, which will allow the Town the option to install a low flow pump for a period of time until a fourth duty pump is required.

As flows continue to increase, large duty pumps will be required in all four slots to manage peak hour flows, at which point a more in-depth evaluation of low flow pumping conditions may be beneficial to help determine the need for continued low flow pumping capabilities.

Morris Branch Regional Pump Station Improvements

Demands for the MBRPS from 2020 to the year 2030 can be met by replacing the two existing 185 HP pumps and VFD's with three new 350 HP pumps (2 duty and 1 standby) each rated at a capacity of 2,030 gpm (2.93 mgd) at 245 feet TDH. The pumps will be capable of meeting the firm pumping capacity of 5.85 mgd associated with 2030 prior to constructing parallel force mains. Similar to the KCPS, once the parallel force mains are in service the reduced TDH at the pump station will result in an increase in pump station capacity allowing the pumps to meet pumping requirements for a period beyond 2030. In order to meet the build-out design condition, a fourth pump of similar size and capacity is required in the remaining pump slot. The replacement pumps for the MBRPS are based on larger pumps of Flygt model NP3231.

The following is a summary of recommended MBRPS improvements:

2020 Improvements

- Replace the two existing 185 HP pumps with three new 350 HP pumps and VFDs. Each pump will have a rated capacity of 2,030 gpm (2.93 mgd) at 245 ft TDH.

Build-out Improvements

- Install a fourth 350 HP pump and VFD (3 duty and 1 standby) that is equivalent to the pumps installed during 2020 improvements. The required capacity per pump would be 1,725 gpm (2.48 mgd) at 232 TDH.

As previously discussed concerning the KCPS, the Town may also choose to install a "jockey" pump, or low flow pump, at the MBRPS as part of future pump station improvements that can be used during low flow periods to better match influent flow rates. The Town could install a low flow pump in the existing fourth pump slot at the MBRPS as this pump slot will remain empty until flows increase beyond the capacity of the three proposed duty pumps.

As flows continue to increase, large duty pumps will be required in all four slots to manage peak hour flows, at which point a more in-depth evaluation of low flow pumping conditions may be beneficial to help determine the need for continued low flow pumping capabilities.

The recommended improvements through build-out are shown on ***Figure 9.*** The recommended pumps are sized to manage peak hour flows for the design year. The operating efficiencies for the peak hour pumping conditions shown in ***Table 4*** are lower than those that can be regularly achieved during normal operating conditions.

Appendix A includes hydraulic calculations for the force mains, gravity sewer, and the preliminary pump selections associated with each of the recommendations.

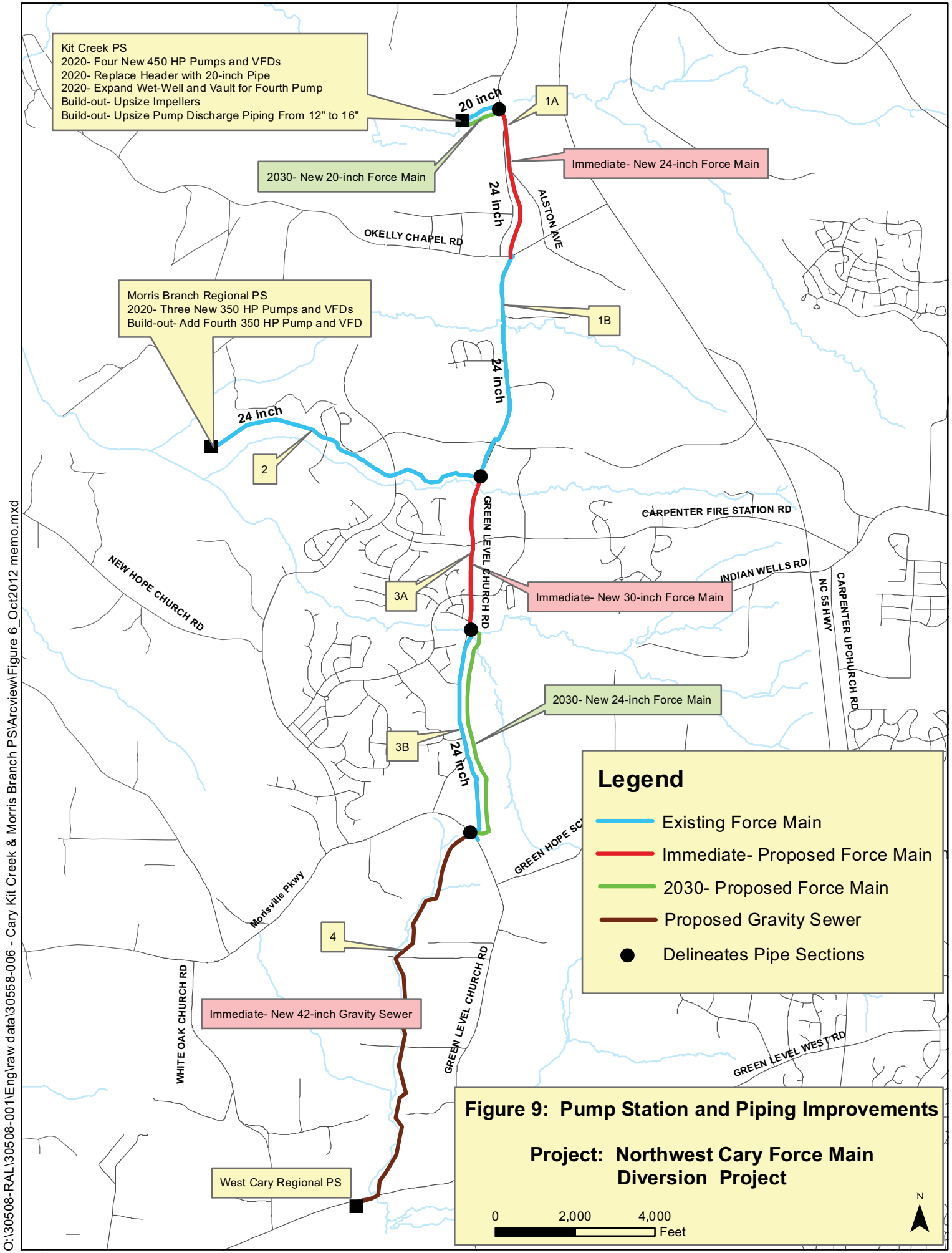

Kit Creek PS
2020- Four New 450 HP Pumps and VFDs
2020- Replace Header with 20-inch Pipe
2020- Expand Wet-Well and Vault for Fourth Pump
Build-out- Upsize Impellers
Build-out- Upsize Pump Discharge Piping From 12" to 16"
20 inch
1A
2030- New 20-inch Force Main
Immediate- New 24-inch Force Main
24 inch
ALSTON AVE
OKELLY CHAPEL RD
Morris Branch Regional PS
2020- Three New 350 HP Pumps and VFDs
Build-out- Add Fourth 350 HP Pump and VFD
1B
24 inch
24 inch
2
GREEN LEVEL CHURCH RD
CARPENTER FIRE STATION RD
NEW HOPE CHURCH RD
INDIAN WELLS RD
NC 55 HWY
CARPENTER UPCHURCH RD
3A
Immediate- New 30-inch Force Main
2030- New 24-inch Force Main
3B
24 inch
GREEN HOPE SC
Morisville Pkwy
4
WHITE OAK CHURCH RD
GREEN LEVEL CHURCH RD
Immediate- New 42-inch Gravity Sewer
GREEN LEVEL WEST RD
West Cary Regional PS
Legend
Existing Force Main
Immediate- Proposed Force Main
2030- Proposed Force Main
Proposed Gravity Sewer
Delineates Pipe Sections
Figure 9: Pump Station and Piping Improvements
Project: Northwest Cary Force Main Diversion Project
0
2,000
4,000
Feet
N
O:\30508-RAL\30508-001\Eng\raw data\30558-006 - Cary Kit Creek & Morris Branch PS\Arcview\Figure 6_Oct2012 memo.mxd
October 16, 2012

Table 5 provides a preliminary cost estimate for each phase of improvements. Detailed cost estimates are provided in *Appendix B*.

Table 5- Preliminary Construction Cost Summary	
Item	**Estimated Cost**
Immediate Preliminary Cost Estimate	
Piping Section No. 3A – New 30-inch Force Main, 3,900 LF	$985,000
Piping Section No. 4 – New 42-inch/48-inch Gravity Interceptor, 11,000 LF (1)	$4,787,000
Subtotal	**$5,772,000**
Contingencies @ 20%	$1,155,000
Total Cost Estimate –Immediate Improvements	**$6,927,000**
2020 Preliminary Cost Estimate	
KCPS- Expansion of Valve Vault Structures	$199,000
KCPS- Replace 250 HP Pumps with Four 450 HP Pumps and VFDs	$1,196,000
KCPS- Replace 12-inch Header with 20-inch Piping	$75,000
KCPS- Install new 12-inch Discharge Piping for Fourth Pump	$21,000
KCPS- Upgrade Electrical Equipment	$126,000
MBRPS- Replace 185 HP Pumps with Three 350 HP Pumps and VFDs	$627,000
MBRPS- Upgrade Electrical Equipment	$90,000
Subtotal	**$2,334,000**
Contingencies @ 20%	$467,000
Total Cost Estimate – 2020 Improvements	**$2,801,000**
2030 Preliminary Cost Estimate	
KCPS Service Rd. piping- New Parallel 20-inch Force Main, 1,100 LF	$185,000
Piping Section No. 3B – New Parallel 24-inch Force Main, 5,400 LF	$1,091,000
Subtotal	**$1,276,000**
Contingencies @ 20%	$256,000
Total Cost Estimate –2030 Improvements	**$1,532,000**
Build-out Preliminary Cost Estimate	
KCPS- Upsize Impellers to Accommodate Larger Flows	$29,000
KPCS- Upsize pump discharge piping from 12" to 16" pipe	$134,000
MBRPS- Install Fourth 350 HP Pump and VFD	$209,000
MBRPS- Electrical Upgrades	$28,000
Subtotal	**$400,000**
Contingencies @ 20%	$80,000
Total Cost Estimate – Build-out Improvements	**$480,000**

(1) Does not include cost of 48-inch gravity sewer that is already constructed (approximately 1,000 LF).

Contingency Pump Stations

The Town of Cary employs a pump-around strategy for a few pump stations such as Cary Park, White Oak, Fieldstone, and Lower Breckenridge, to properly manage sanitary sewer flow and mitigate the risks of surcharge/overflows in the collection system. During intensive precipitation events, the peak wet weather flow is diverted from service areas with a lack of capacity to service areas with excess capacity. Therefore, the utilization of available capacity in the existing system is maximized. After the completion of the WWWRF and the reversal of the Northwest Cary Force Main system, those four pump stations will retain dual-direction pumping capabilities for the purpose of peak wet weather management.

Summary

Currently, wastewater collected at the Kit Creek and Morris Branch Regional Pump Stations are conveyed north to either the Durham County Wastewater Treatment Facility or the North Cary WRF for treatment. In the future, these flows will be redirected south to the new WWWRF via the West Cary Regional Pump Station. To accommodate this, existing infrastructure will be reused and new infrastructure will be constructed. *Table 6* summarizes the recommended capital improvements and associated estimated construction costs for immediate conditions, year 2020, year 2030, and build-out.

The existing pump station pumps can be utilized in their existing condition transitioning from pumping north to pumping south to the West Cary Regional Pump Station. Shortly after the transitional phases are complete, upgrades will be required at both pump stations to manage flows associated with the future growth in the area.

TABLE 6								
Construction Phasing Summary								
	Immediate Improvements		**2020 Improvements**		**2030 Improvements**		**Build-Out Improvements**	
Piping Section No.								
Kit Creek Service Road	-		-		Construct parallel 20" FM		-	
1A	-		-		-		-	
1B	-		-		-		-	
2	-		-		-		-	
3A	Construct 30-inch Force Main, 3,900 LF		-		-		-	
3B	-		-		Construct parallel 24" FM		-	
4	Construct new 42"/48" Gravity Interceptor		Construct new 42"/48" Gravity Interceptor		-		-	
Pump Stations	-		-		-		-	
Kit Creek PS	-		Replace existing 250 HP pumps with four 450-HP pumps. Expand pump station structure and replace 12" header with 20" pipe		-		Upsize impellers on all four pumps to manage larger flows. Replace 12" discharge piping with 16" pipes on all pumps.	
Morris Branch Regional PS	-		Replace existing 185 HP pumps with three 350-HP pumps		-		Install a fourth 350 HP pump in remaining pump slot	
Peak Flow Capacity (mgd) to WCRPS From KCPS and MBRPS	KCPS	5.62 mgd	KCPS	7.22 mgd	KCPS	10.05 mgd	KCPS	13.82 mgd
	MBRPS	2.95 mgd	MBRPS	4.17 mgd	MBRPS	5.85 mgd	MBRPS	7.45 mgd
	Total	**8.57 mgd**	**Total**	**11.39 mgd**	**Total**	**15.90 mgd**	**Total**	**21.27 mgd**
Preliminary Cost Estimate (1)	**6,927,000**		**$2,801,000**		**$1,532,000**		**$480,000**	

(1) Cost does not include the installation of low flow pumps at the KCPS and MBRPS.

Appendix A

Hydraulic Calculations and Pump Selections

10/19/12

KCPS - Install By 2020

PERFORMANCE CURVE

PRODUCT	CP 3240 /835	TYPE	
DATE	2012-08-29	PROJECT	
CURVE NO	63-450	ISSUE	2

	1/1-LOAD	3/4-LOAD	1/2-LOAD
POWER FACTOR	0.88	0.85	0.77
EFFICIENCY	94.5 %	94.0 %	93.0 %
MOTOR DATA	---	---	---

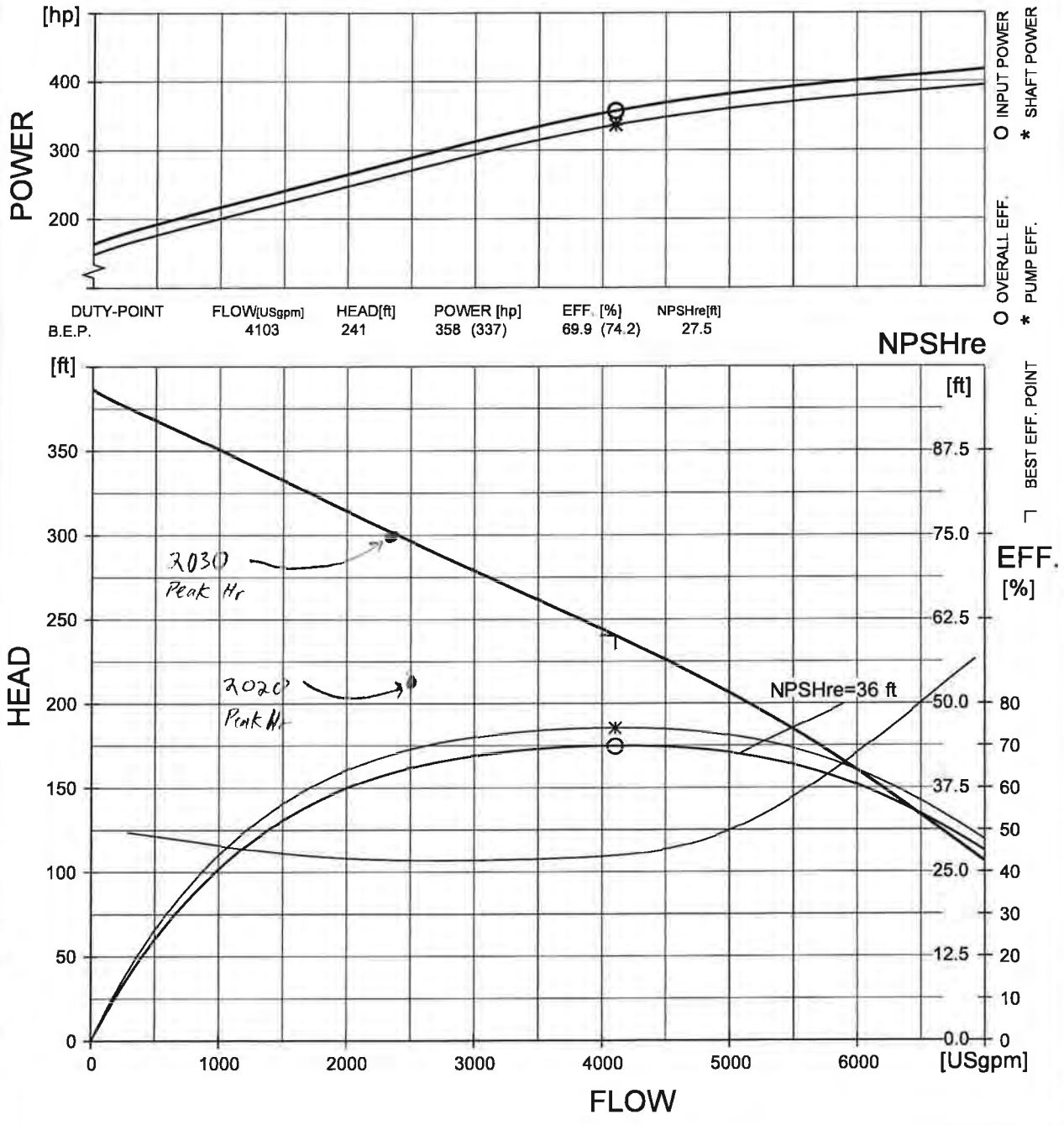
RATED POWER	455	hp
STARTING CURRENT ...	4515	A
RATED CURRENT ...	510	A
RATED SPEED	1790	rpm
TOT.MOM.OF INERTIA ...	9.0	kgm2
NO. OF BLADES	2	

IMPELLER DIAMETER	465 mm		
MOTOR #	54-52-4AA	STATOR	01D
REV	11		
FREQ.	60 Hz	PHASES	3
VOLTAGE	460 V	POLES	4
GEARTYPE	---	RATIO	---

COMMENTS

INLET/OUTLET: -/ 8 inch

IMP. THROUGHLET: 3.1 inch



DUTY-POINT	FLOW[USgpm]	HEAD[ft]	POWER [hp]	EFF. [%]	NPSHre[ft]
B.E.P.	4103	241	358 (337)	69.9 (74.2)	27.5

NPSHre = NPSH3% + min. operational margin

Performance with clear water and ambient temp 40 °C

FLYGT HI B Curve

FLYPS3.1.6.3 (20060531)

KCPS - Build-out

PERFORMANCE CURVE

PRODUCT: CP 3240 /835	TYPE:		
DATE: 2012-08-29	PROJECT:	CURVE NO: 63-450	ISSUE: 2

	1/1-LOAD	3/4-LOAD	1/2-LOAD
POWER FACTOR	0.88	0.85	0.77
EFFICIENCY	94.5 %	94.0 %	93.0 %
MOTOR DATA	---	---	---

RATED POWER	455	hp
STARTING CURRENT ...	4515	A
RATED CURRENT ...	510	A
RATED SPEED	1790	rpm
TOT.MOM.OF INERTIA ...	9.0	kgm2
NO. OF BLADES	2	

IMPELLER DIAMETER: 490 mm

MOTOR #	STATOR	REV
54-52-4AA	01D	11

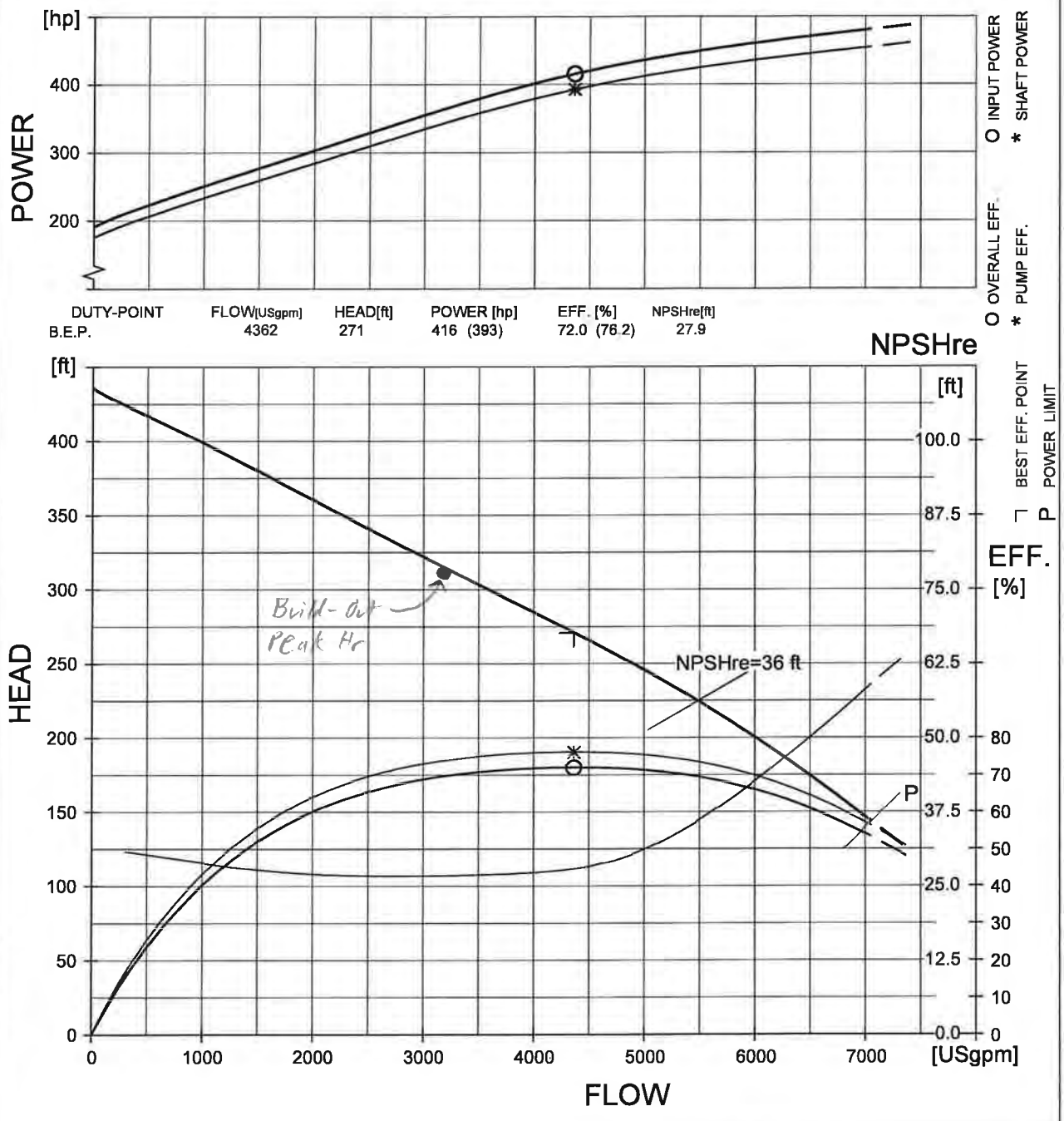
FREQ.	PHASES	VOLTAGE	POLES
60 Hz	3	460 V	4

GEARTYPE: --- RATIO: ---

COMMENTS

INLET/OUTLET: -/ 8 inch

IMP. THROUGHLET: 3.1 inch



DUTY-POINT	FLOW[USgpm]	HEAD[ft]	POWER [hp]	EFF. [%]	NPSHre[ft]
B.E.P.	4362	271	416 (393)	72.0 (76.2)	27.9

NPSHre = NPSH3% + min. operational margin

Performance with clear water and ambient temp 40 °C

FLYPS3.1.6.3 (20060531)

HI B Curve

MBRPS - Install By 2020

FLYGT

PERFORMANCE CURVE

PRODUCT	TYPE
NP 3231 /765	

DATE	PROJECT	CURVE NO	ISSUE
2012-08-28		63-470	4

	1/1-LOAD	3/4-LOAD	1/2-LOAD
POWER FACTOR	0.91	0.90	0.85
EFFICIENCY	94.0 %	94.5 %	94.5 %
MOTOR DATA	---	---	---

RATED POWER	335	hp
STARTING CURRENT ...	2155	A
RATED CURRENT ...	365	A
RATED SPEED	1775	rpm
TOT.MOM.OF INERTIA ..	3.0	kgm2
NO. OF BLADES	3	

IMPELLER DIAMETER: 410 mm

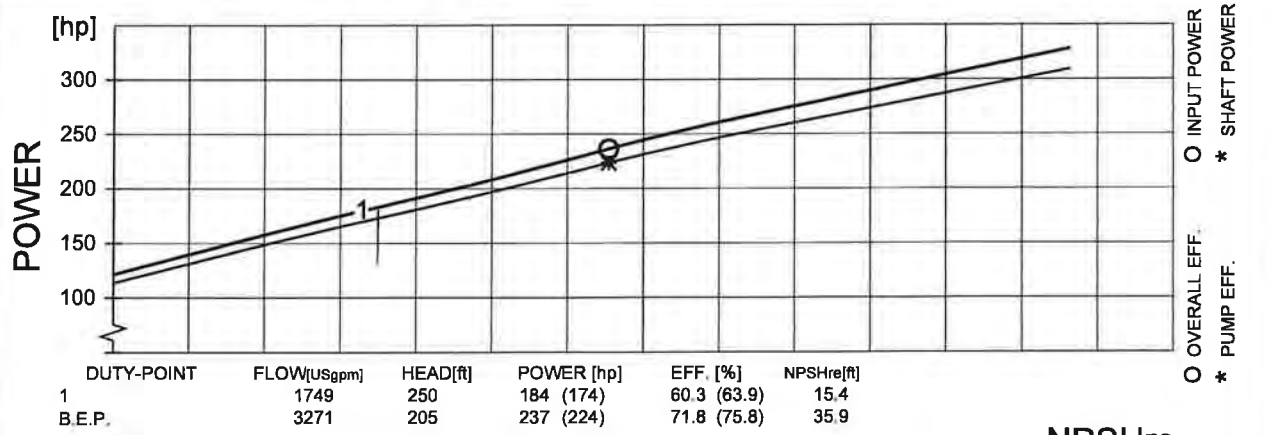
MOTOR #	STATOR	REV
43-56-4AA	06Y	11

FREQ.	PHASES	VOLTAGE	POLES
60 Hz	3	460 V	4

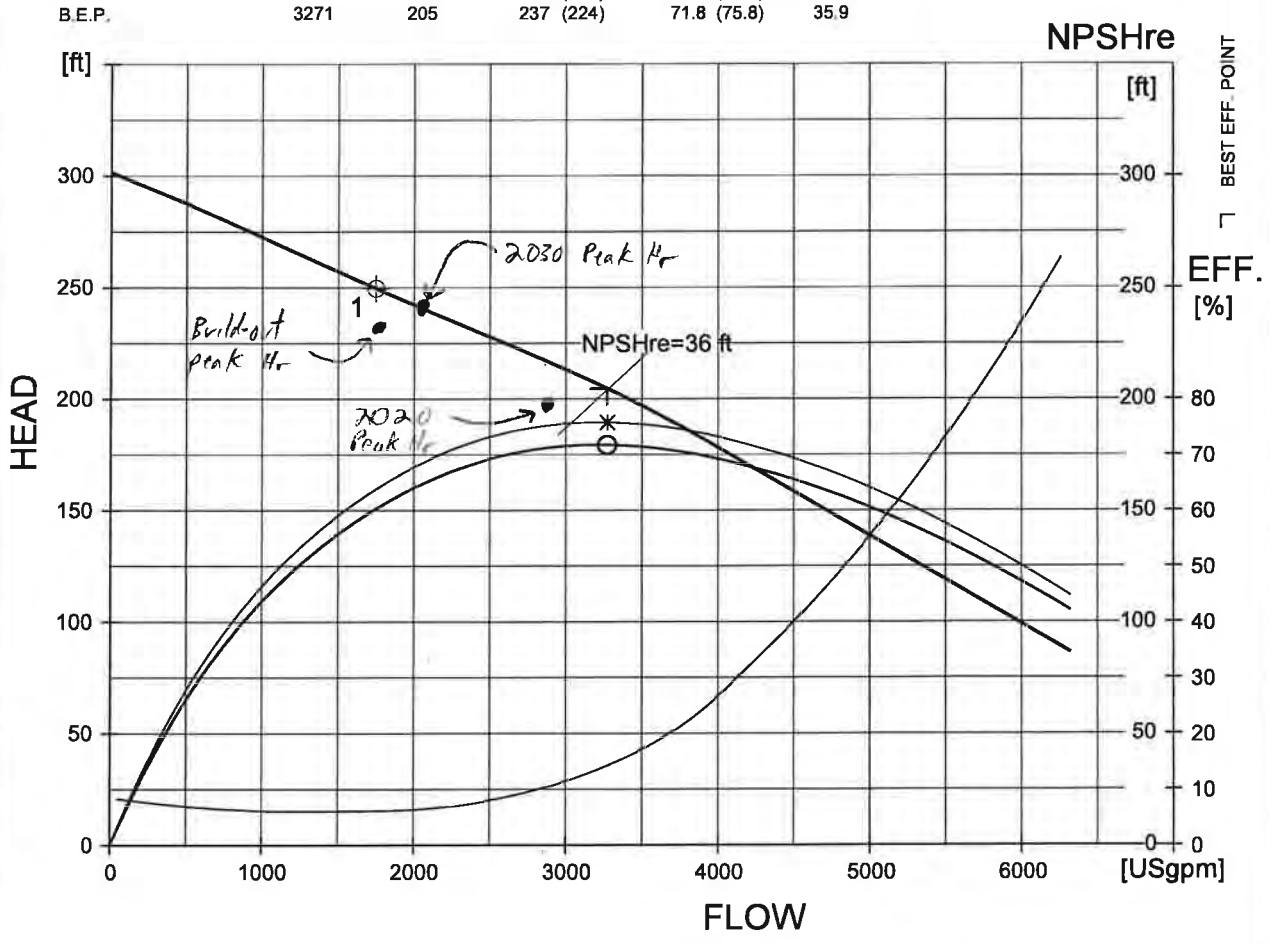
GEARTYPE	RATIO
---	---

COMMENTS

INLET/OUTLET	IMP. THROUGHLET
-/ 8 inch	---



DUTY-POINT	FLOW[USgpm]	HEAD[ft]	POWER [hp]	EFF. [%]	NPSHre[ft]
1	1749	250	184 (174)	60.3 (63.9)	15.4
B.E.P.	3271	205	237 (224)	71.8 (75.8)	35.9



NPSHre = NPSH3% + min. operational margin

Performance with clear water and ambient temp 40 °C

FLYPS3.1.6.3 (20060531)

FLYGT HI B Curve

9/6/2012
Updated June 2012- Phase 1 2015

Northwest Cary Force Main Diversion Project (2015 Flowing South)
Kit Creek P.S.

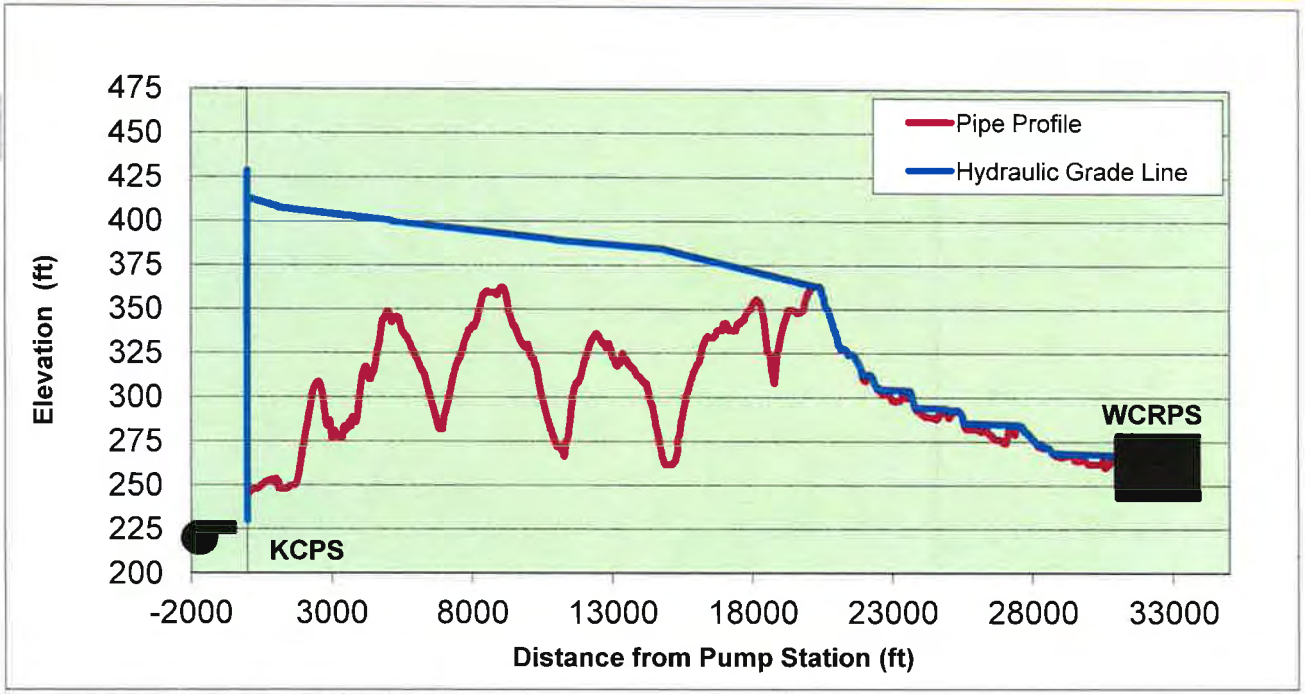
Operating Conditions

Total Pump Station Flow (mgd)	5.62
HGL at gravity junction	363
HGL at Eff PS Wetwell (ft MSL)	230

Pumping Requirements

Number of Pumps Operating	2
Flow per Pump (mgd) =	2.81
Flow per Pump (gpm) =	1953
Total Dynamic Head (ft) =	198.5
Required Hp/Pump =	131
Total Pumping HP =	261
~Force Main Detention Time (hrs)	0.04

No Pumps	PS Flow
2	5.6



Segment No.	Diam (in)	Length (ft)	H&W C	K Value	% of Total Flow	Q (mgd)	End STA	Crown Pipe	HGL Calc	Vel (fps)	Friction Loss	Form Loss	Head Loss
In Wetwell							0		230.0				
							0	246.0	428.5				
Station Loss	12	43	100	4.7	50.0%	2.8	0	246.0	425.7	5.53	0.61	2.24	2.85
Station Loss	12	45	100	4.2	100.0%	5.6	0	246.0	415.4	11.07	2.32	7.99	10.31
Station Loss	18	34	100	3.7	100.0%	5.6	0	246.0	413.8	4.92	0.24	1.39	1.63
1	20	8.77498	100	2.6	100.0%	5.6	9	246.0	413.1	3.99	0.04	0.64	0.68
2	20	3.34312	100	0	100.0%	5.6	12	246.0	413.1	3.99	0.01	0.00	0.01
3	20	2.35717	100	0	100.0%	5.6	14	246.0	413.1	3.99	0.01	0.00	0.01
4	20	24.7053	100	0	100.0%	5.6	39	246.0	412.9	3.99	0.11	0.00	0.11
5	20	21.8467	100	0	100.0%	5.6	61	246.0	412.9	3.99	0.09	0.00	0.09
6	20	19.8995	100	0	100.0%	5.6	81	246.0	412.8	3.99	0.09	0.00	0.09
7	20	2.29961	100	0	100.0%	5.6	83	246.0	412.8	3.99	0.01	0.00	0.01
8	20	44.5301	100	0	100.0%	5.6	128	246.0	412.6	3.99	0.19	0.00	0.19
9	20	46.0149	100	0	100.0%	5.6	174	247.0	412.4	3.99	0.20	0.00	0.20
10	20	18.4107	100	0	100.0%	5.6	192	247.3	412.3	3.99	0.08	0.00	0.08

9/6/2012
Updated June 2012- Phase 1 2015

Northwest Cary Force Main Diversion Project (2015 Flowing South)
Morris Branch P.S.

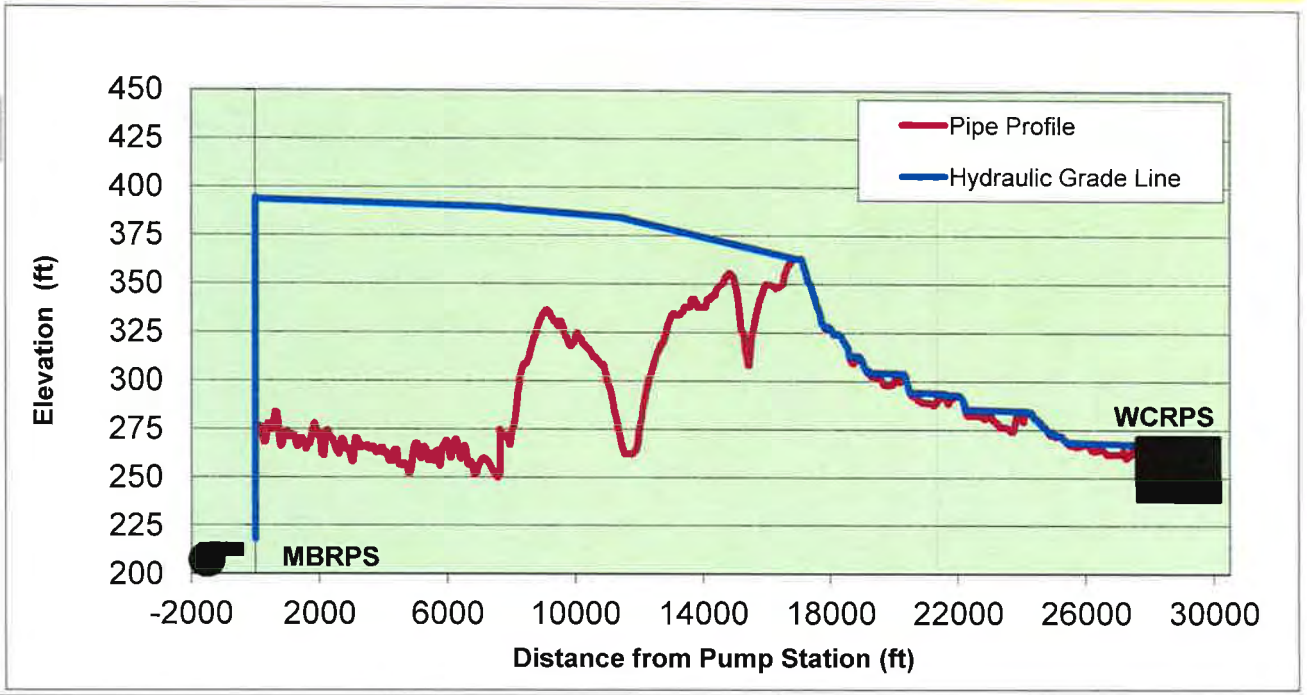
Operating Conditions

Total Pump Station Flow (mgd)	2.95
HGL at gravity junction	363
HGL at Eff PS Wetwell (ft MSL)	218

Pumping Requirements

Number of Pumps Operating	1
Flow per Pump (mgd) =	2.95
Flow per Pump (gpm) =	2050
Total Dynamic Head (ft) =	176.2
Required Hp/Pump =	122
Total Pumping HP =	122
~Force Main Detention Time (hrs)	0.06

No Pumps	PS Flow
1	3.0



Segment No.	Diam (in)	Length (ft)	H&W C	K Value	% of Total Flow	Q (mgd)	End STA	Crown Pipe	HGL Calc	Vel (fps)	Friction Loss	Form Loss	Head Loss
In Wetwell							0		218.0				
							0	274.5	394.4				
Station Loss	18	45	100	6.2	50.0%	1.5	0	274.5	394.2	1.29	0.03	0.16	0.19
Station Loss	24	40	100	0.1	100.0%	3.0	0	274.0	394.2	1.45	0.02	0.00	0.02
Station Loss	24	20	100	0.1	100.0%	3.0	0	274.0	394.2	1.45	0.01	0.00	0.01
Station Loss	16	20	100	1.1	100.0%	3.0	0	274.0	393.9	3.27	0.08	0.18	0.26
1	24	8.43774	100	4.6	100.0%	3.0	8	274.0	393.8	1.45	0.00	0.15	0.16
2	24	9.12381	100	0	100.0%	3.0	18	274.0	393.8	1.45	0.00	0.00	0.00
3	24	22.9825	100	0	100.0%	3.0	41	272.6	393.8	1.45	0.01	0.00	0.01
4	24	20.7164	100	0	100.0%	3.0	61	272.5	393.7	1.45	0.01	0.00	0.01
5	24	28.1446	100	0	100.0%	3.0	89	272.9	393.7	1.45	0.02	0.00	0.02
6	24	20.9149	100	0	100.0%	3.0	110	274.0	393.7	1.45	0.01	0.00	0.01
7	24	17.3709	100	0	100.0%	3.0	128	275.3	393.7	1.45	0.01	0.00	0.01
8	24	13.2044	100	0	100.0%	3.0	141	275.6	393.7	1.45	0.01	0.00	0.01
9	24	7.71668	100	0	100.0%	3.0	149	276.0	393.7	1.45	0.00	0.00	0.00

Northwest Cary Force Main Diversion Project (2020 Flowing South)
Kit Creek P.S.

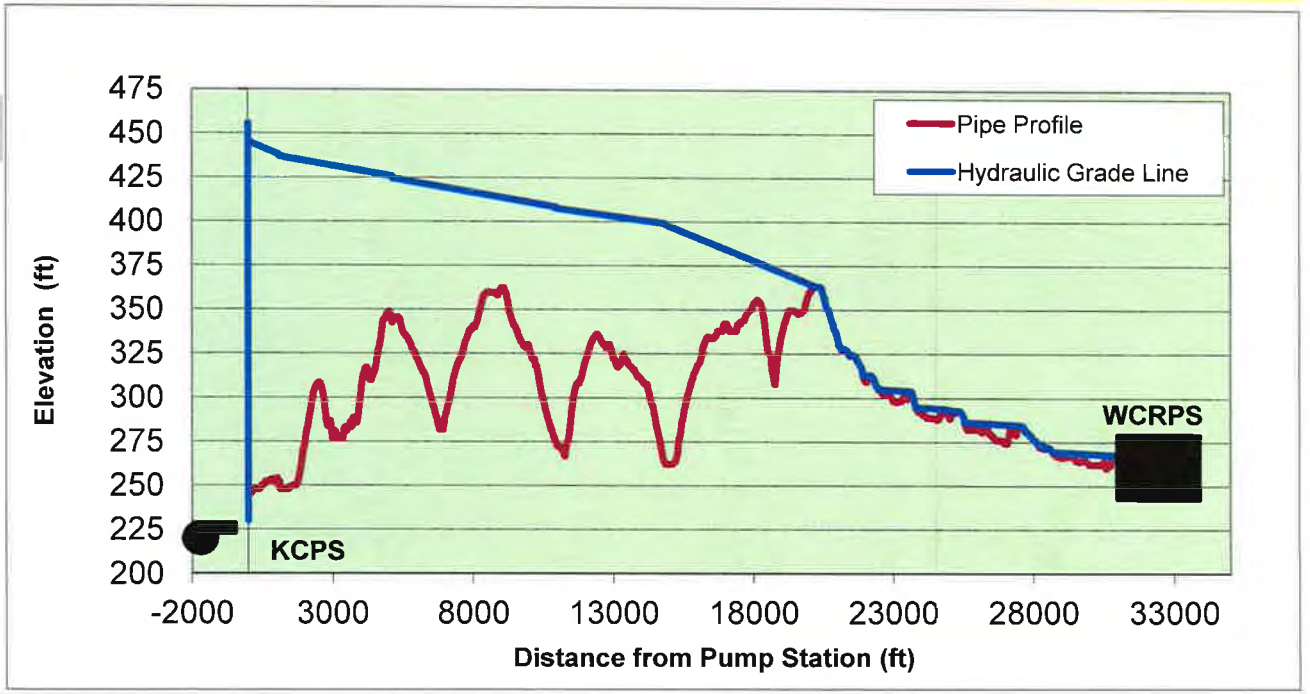
Operating Conditions

Total Pump Station Flow (mgd)	7.22
HGL at gravity junction	363
HGL at Eff PS Wetwell (ft MSL)	230

Pumping Requirements

Number of Pumps Operating	2
Flow per Pump (mgd) =	3.61
Flow per Pump (gpm) =	2509
Total Dynamic Head (ft) =	226.0
Required Hp/Pump =	191
Total Pumping HP =	382
~Force Main Detention Time (hrs)	0.03

No Pumps	PS Flow
2	7.2



Segment No.	Diam (in)	Length (ft)	H&W C	K Value	% of Total Flow	Q (mgd)	End STA	Crown Pipe	HGL Calc	Vel (fps)	Friction Loss	Form Loss	Head Loss
In Wetwell							0		230.0				
							0	246.0	456.0				
Station Loss	12	43	100	4.7	50.0%	3.6	0	246.0	451.3	7.11	0.98	3.69	4.67
Station Loss	20	45	100	4.1	100.0%	7.2	0	246.0	449.3	5.12	0.31	1.67	1.98
Station Loss	18	34	100	3.7	100.0%	7.2	0	246.0	446.6	6.32	0.39	2.30	2.68
1	20	8.77498	100	2.6	100.0%	7.2	9	246.0	445.5	5.12	0.06	1.06	1.12
2	20	3.34312	100	0	100.0%	7.2	12	246.0	445.5	5.12	0.02	0.00	0.02
3	20	2.35717	100	0	100.0%	7.2	14	246.0	445.5	5.12	0.02	0.00	0.02
4	20	24.7053	100	0	100.0%	7.2	39	246.0	445.3	5.12	0.17	0.00	0.17
5	20	21.8467	100	0	100.0%	7.2	61	246.0	445.2	5.12	0.15	0.00	0.15
6	20	19.8995	100	0	100.0%	7.2	81	246.0	445.0	5.12	0.14	0.00	0.14
7	20	2.29961	100	0	100.0%	7.2	83	246.0	445.0	5.12	0.02	0.00	0.02
8	20	44.5301	100	0	100.0%	7.2	128	246.0	444.7	5.12	0.30	0.00	0.30
9	20	46.0149	100	0	100.0%	7.2	174	247.0	444.4	5.12	0.31	0.00	0.31
10	20	18.4107	100	0	100.0%	7.2	192	247.3	444.3	5.12	0.13	0.00	0.13

Northwest Cary Force Main Diversion Project (2020 Flowing South)
Morris Branch P.S.

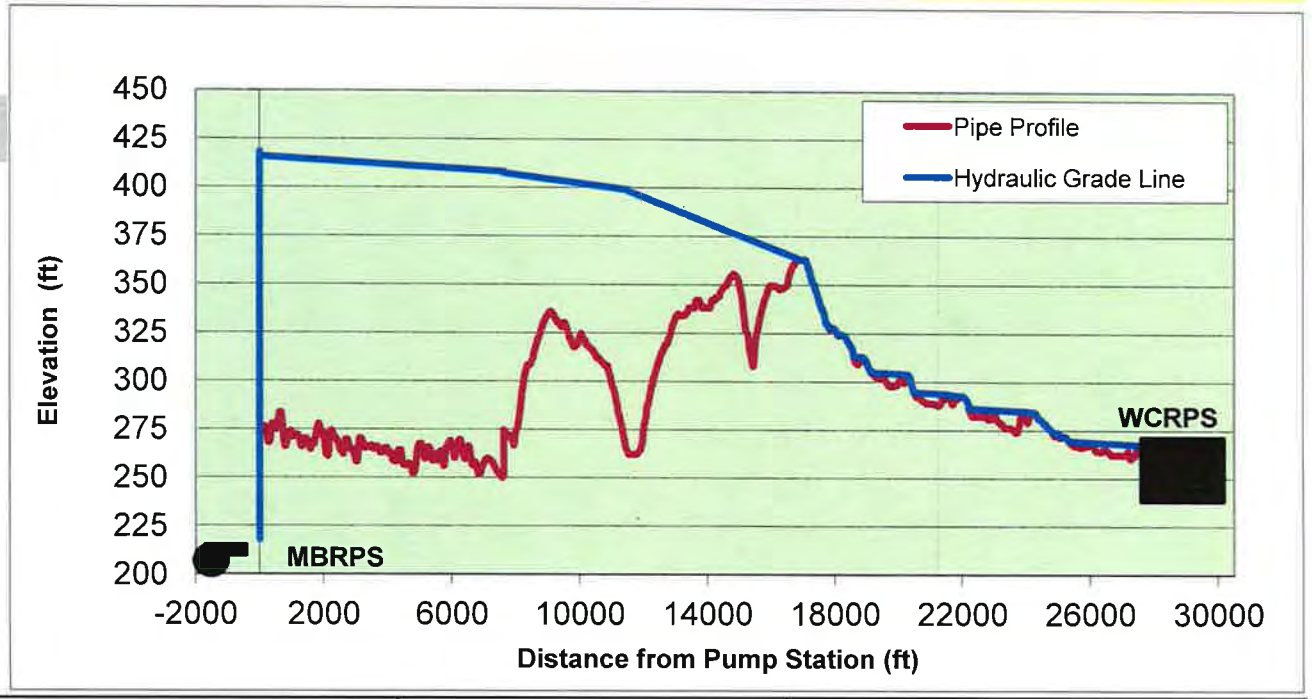
Operating Conditions

Total Pump Station Flow (mgd)	4.17
HGL at gravity junction	363
HGL at Eff PS Wetwell (ft MSL)	218

Pumping Requirements

Number of Pumps Operating	1
Flow per Pump (mgd) =	4.17
Flow per Pump (gpm) =	2898
Total Dynamic Head (ft) =	198.9
Required Hp/Pump =	194
Total Pumping HP =	194
~Force Main Detention Time (hrs)	0.04

No Pumps	PS Flow
1	4.2



Segment No.	Diam (in)	Length (ft)	H&W C	K Value	% of Total Flow	Q (mgd)	End STA	Crown Pipe	HGL Calc	Vel (fps)	Friction Loss	Form Loss	Head Loss
In Wetwell							0		218.0				
							0	274.5	418.3				
Station Loss	18	45	100	6.2	100.0%	4.2	0	274.5	416.9	3.65	0.19	1.28	1.47
Station Loss	24	40	100	0.1	100.0%	4.2	0	274.0	416.8	2.05	0.04	0.01	0.05
Station Loss	24	20	100	0.1	100.0%	4.2	0	274.0	416.8	2.05	0.02	0.01	0.03
Station Loss	16	20	100	1.1	100.0%	4.2	0	274.0	416.3	4.62	0.15	0.36	0.51
1	24	8.43774	100	4.6	100.0%	4.2	8	274.0	416.0	2.05	0.01	0.30	0.31
2	24	9.12381	100	0	100.0%	4.2	18	274.0	416.0	2.05	0.01	0.00	0.01
3	24	22.9825	100	0	100.0%	4.2	41	272.6	415.9	2.05	0.02	0.00	0.02
4	24	20.7164	100	0	100.0%	4.2	61	272.5	415.9	2.05	0.02	0.00	0.02
5	24	28.1446	100	0	100.0%	4.2	89	272.9	415.9	2.05	0.03	0.00	0.03
6	24	20.9149	100	0	100.0%	4.2	110	274.0	415.9	2.05	0.02	0.00	0.02
7	24	17.3709	100	0	100.0%	4.2	128	275.3	415.9	2.05	0.02	0.00	0.02
8	24	13.2044	100	0	100.0%	4.2	141	275.6	415.8	2.05	0.01	0.00	0.01
9	24	7.71668	100	0	100.0%	4.2	149	276.0	415.8	2.05	0.01	0.00	0.01

9/7/2012
Updated June 2012- Phase 2 2030

Northwest Cary Force Main Diversion Project (2030 Flowing South) Prior to Construction of parallel Pipes
Kit Creek P.S.

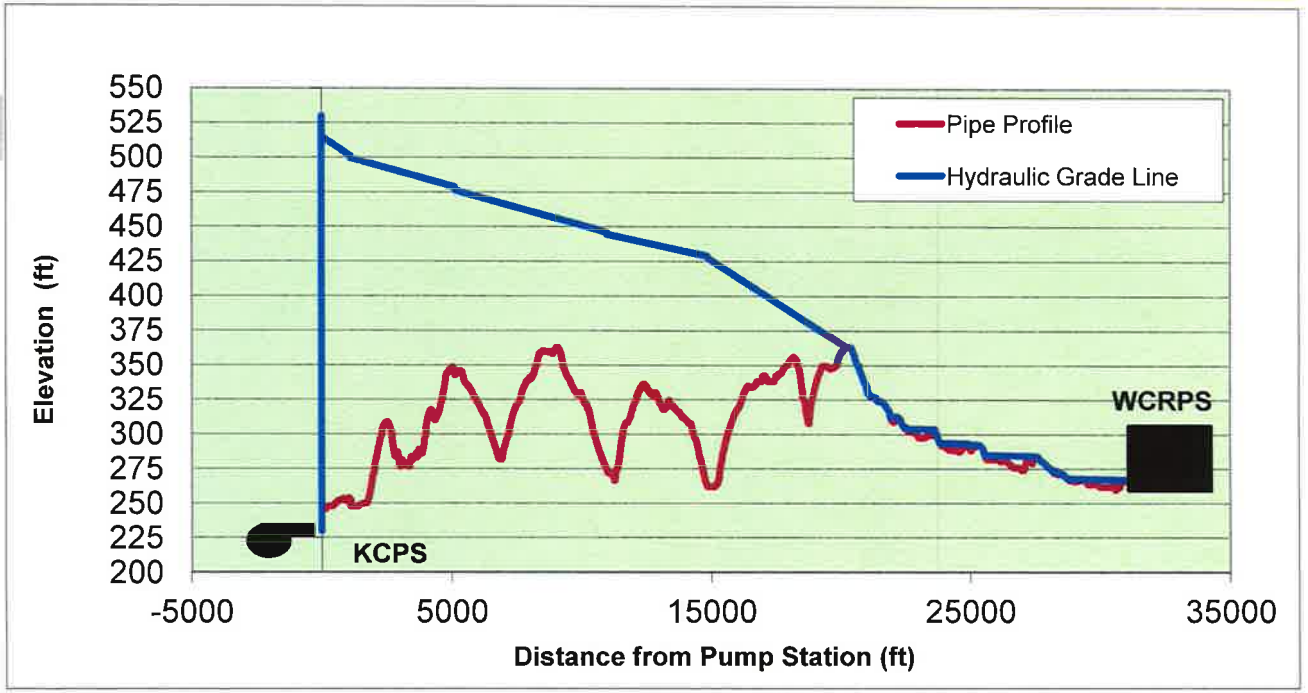
Operating Conditions

Total Pump Station Flow (mgd)	10.05
HGL at gravity junction	363
HGL at Eff PS Wetwell (ft MSL)	230

Pumping Requirements

Number of Pumps Operating	3
Flow per Pump (mgd) =	3.35
Flow per Pump (gpm) =	2328
Total Dynamic Head (ft) =	300.3
Required Hp/Pump =	236
Total Pumping HP =	707
~Force Main Detention Time (hrs)	0.02

No Pumps	PS Flow
3	6.7



Segment No.	Diam (in)	Length (ft)	H&W C	K Value	% of Total Flow	Q (mgd)	End STA	Crown Pipe	HGL Calc	Vel (fps)	Friction Loss	Form Loss	Head Loss
In Wetwell							0		230.0				
							0	246.0	530.3				
Station Loss	12	43	100	4.7	33.3%	3.3	0	246.0	526.3	6.59	0.85	3.17	4.02
Station Loss	20	45	100	4.1	100.0%	10.1	0	246.0	522.5	7.13	0.56	3.23	3.80
Station Loss	18	34	100	3.7	100.0%	10.1	0	246.0	517.4	8.80	0.71	4.45	5.16
1	20	8.77498	100	2.6	100.0%	10.1	9	246.0	515.2	7.13	0.11	2.05	2.16
2	20	3.34312	100	0	100.0%	10.1	12	246.0	515.2	7.13	0.04	0.00	0.04
3	20	2.35717	100	0	100.0%	10.1	14	246.0	515.1	7.13	0.03	0.00	0.03
4	20	24.7053	100	0	100.0%	10.1	39	246.0	514.8	7.13	0.31	0.00	0.31
5	20	21.8467	100	0	100.0%	10.1	61	246.0	514.5	7.13	0.27	0.00	0.27
6	20	19.8995	100	0	100.0%	10.1	81	246.0	514.3	7.13	0.25	0.00	0.25
7	20	2.29961	100	0	100.0%	10.1	83	246.0	514.3	7.13	0.03	0.00	0.03
8	20	44.5301	100	0	100.0%	10.1	128	246.0	513.7	7.13	0.56	0.00	0.56
9	20	46.0149	100	0	100.0%	10.1	174	247.0	513.1	7.13	0.58	0.00	0.58
10	20	18.4107	100	0	100.0%	10.1	192	247.3	512.9	7.13	0.23	0.00	0.23

Northwest Cary Force Main Diversion Project (2030 Flowing South) *Prior to Construction of Parallel Pipes*
Morris Branch P.S.

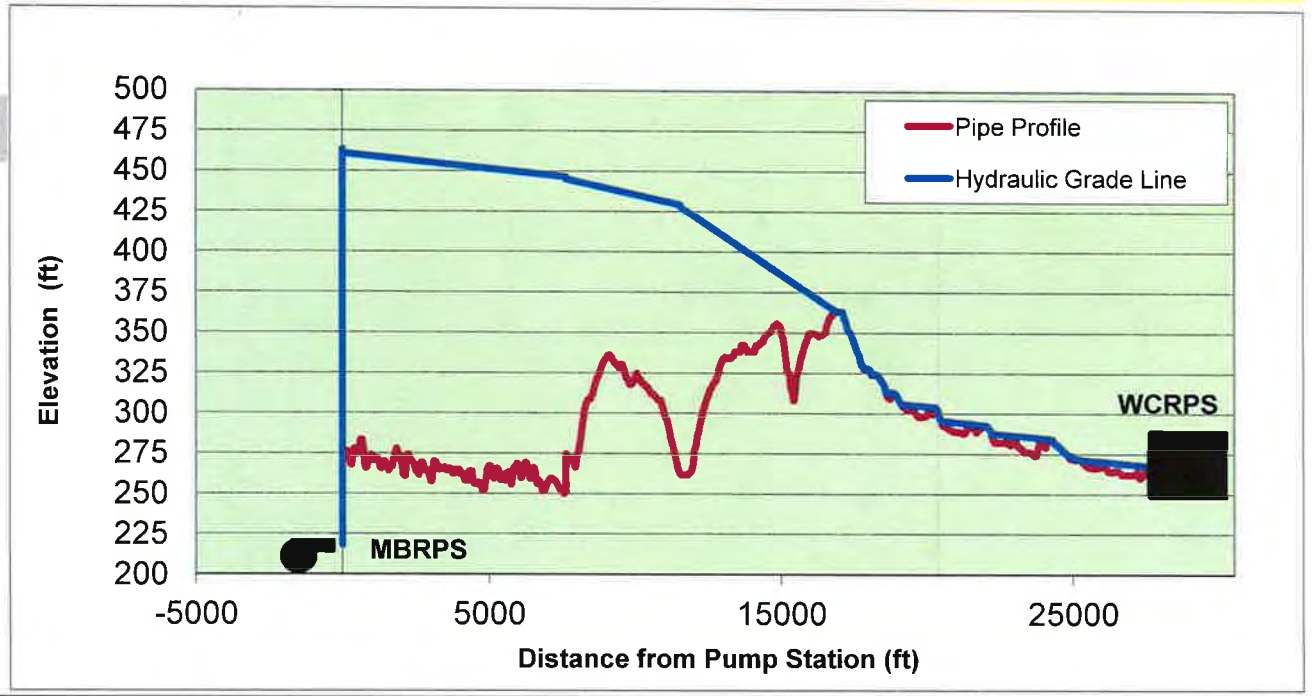
Operating Conditions

Total Pump Station Flow (mgd)	5.85
HGL at gravity junction	363
HGL at Eff PS Wetwell (ft MSL)	218

Pumping Requirements

Number of Pumps Operating	2
Flow per Pump (mgd) =	2.93
Flow per Pump (gpm) =	2033
Total Dynamic Head (ft) =	245.5
Required Hp/Pump =	168
Total Pumping HP =	336
~Force Main Detention Time (hrs)	0.03

No Pumps	PS Flow
2	3.9



Segment No.	Diam (in)	Length (ft)	H&W C	K Value	% of Total Flow	Q (mgd)	End STA	Crown Pipe	HGL Calc	Vel (fps)	Friction Loss	Form Loss	Head Loss
In Wetwell							0		218.0				
							0	274.5	463.5				
Station Loss	18	45	100	6.2	50.0%	2.9	0	274.5	462.8	2.56	0.10	0.63	0.73
Station Loss	24	40	100	0.1	100.0%	5.9	0	274.0	462.7	2.88	0.08	0.01	0.09
Station Loss	24	20	100	0.1	100.0%	5.9	0	274.0	462.6	2.88	0.04	0.01	0.05
Station Loss	16	20	100	1.1	100.0%	5.9	0	274.0	461.6	6.48	0.27	0.72	0.99
1	24	8.43774	100	4.6	100.0%	5.9	8	274.0	461.0	2.88	0.02	0.59	0.61
2	24	9.12381	100	0	100.0%	5.9	18	274.0	461.0	2.88	0.02	0.00	0.02
3	24	22.9825	100	0	100.0%	5.9	41	272.6	461.0	2.88	0.04	0.00	0.04
4	24	20.7164	100	0	100.0%	5.9	61	272.5	460.9	2.88	0.04	0.00	0.04
5	24	28.1446	100	0	100.0%	5.9	89	272.9	460.9	2.88	0.05	0.00	0.05
6	24	20.9149	100	0	100.0%	5.9	110	274.0	460.8	2.88	0.04	0.00	0.04
7	24	17.3709	100	0	100.0%	5.9	128	275.3	460.8	2.88	0.03	0.00	0.03
8	24	13.2044	100	0	100.0%	5.9	141	275.6	460.8	2.88	0.03	0.00	0.03
9	24	7.71668	100	0	100.0%	5.9	149	276.0	460.8	2.88	0.01	0.00	0.01

Northwest Cary Force Main Diversion Project (Build Out Flowing South)
Kit Creek P.S.

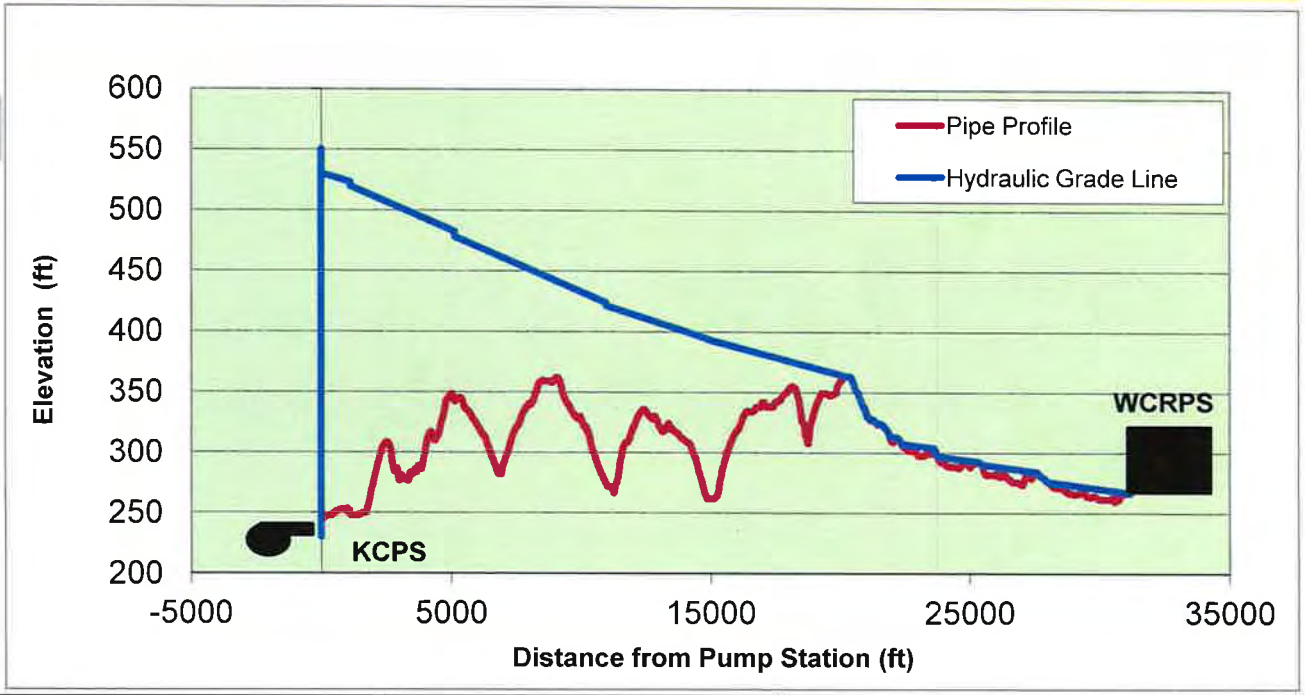
Operating Conditions

Total Pump Station Flow (mgd)	13.82
HGL at gravity junction	363
HGL at Eff PS Wetwell (ft MSL)	230

Pumping Requirements

Number of Pumps Operating	3
Flow per Pump (mgd) =	4.61
Flow per Pump (gpm) =	3202
Total Dynamic Head (ft) =	320.5
Required Hp/Pump =	346
Total Pumping HP =	1038
~Force Main Detention Time (hrs)	0.03

No Pumps	PS Flow
3	13.8



Segment No.	Diam (in)	Length (ft)	H&W C	K Value	% of Total Flow	Q (mgd)	End STA	Crown Pipe	HGL Calc	Vel (fps)	Friction Loss	Form Loss	Head Loss
In Wetwell							0		230.0				
							0	246.0	550.5				
Station Loss	16	43	100	4.7	33.3%	4.6	0	246.0	548.3	5.10	0.38	1.90	2.27
Station Loss	20	45	100	4.1	100.0%	13.8	0	246.0	541.1	9.80	1.02	6.11	7.13
Station Loss	18	34	100	3.7	100.0%	13.8	0	246.0	531.4	12.10	1.29	8.41	9.69
1	20	8.77498	100	2.6	50.0%	6.9	9	246.0	530.4	4.90	0.06	0.97	1.02
2	20	3.34312	100	0	50.0%	6.9	12	246.0	530.4	4.90	0.02	0.00	0.02
3	20	2.35717	100	0	50.0%	6.9	14	246.0	530.4	4.90	0.01	0.00	0.01
4	20	24.7053	100	0	50.0%	6.9	39	246.0	530.2	4.90	0.16	0.00	0.16
5	20	21.8467	100	0	50.0%	6.9	61	246.0	530.1	4.90	0.14	0.00	0.14
6	20	19.8995	100	0	50.0%	6.9	81	246.0	530.0	4.90	0.12	0.00	0.12
7	20	2.29961	100	0	50.0%	6.9	83	246.0	530.0	4.90	0.01	0.00	0.01
8	20	44.5301	100	0	50.0%	6.9	128	246.0	529.7	4.90	0.28	0.00	0.28
9	20	46.0149	100	0	50.0%	6.9	174	247.0	529.4	4.90	0.29	0.00	0.29
10	20	18.4107	100	0	50.0%	6.9	192	247.3	529.3	4.90	0.12	0.00	0.12

Northwest Cary Force Main Diversion Project (Build Out Flowing South)
Morris Branch P.S.

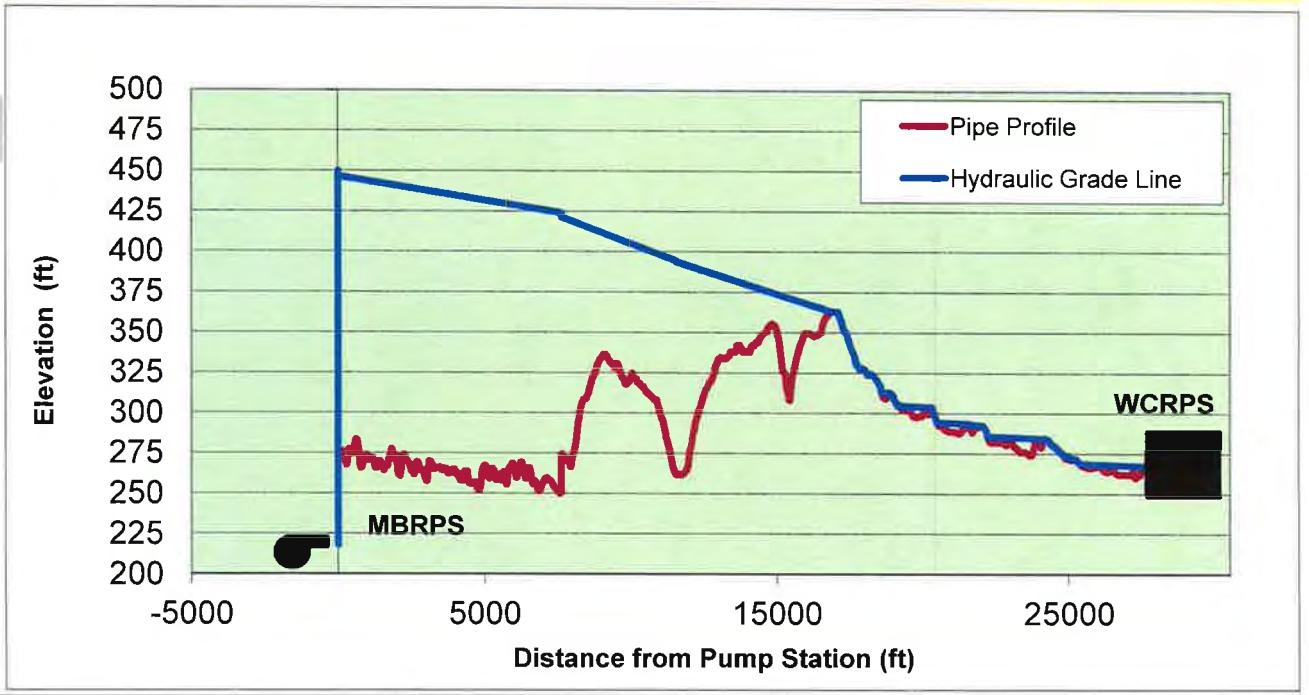
Operating Conditions

Total Pump Station Flow (mgd)	7.45
HGL at gravity junction	363
HGL at Eff PS Wetwell (ft MSL)	218

Pumping Requirements

Number of Pumps Operating	3
Flow per Pump (mgd) =	2.48
Flow per Pump (gpm) =	1726
Total Dynamic Head (ft) =	232.0
Required Hp/Pump =	135
Total Pumping HP =	405
~Force Main Detention Time (hrs)	0.02

No Pumps	PS Flow
3	7.5



Segment No.	Diam (in)	Length (ft)	H&W C	K Value	% of Total Flow	Q (mgd)	End STA	Crown Pipe	HGL Calc	Vel (fps)	Friction Loss	Form Loss	Head Loss
In Wetwell							0		218.0				
							0	274.5	450.0				
Station Loss	18	45	100	6.2	33.3%	2.5	0	274.5	449.5	2.17	0.07	0.45	0.53
Station Loss	24	40	100	0.1	66.6%	5.0	0	274.0	449.4	2.44	0.06	0.01	0.07
Station Loss	24	20	100	0.1	100.0%	7.5	0	274.0	449.3	3.67	0.06	0.02	0.08
Station Loss	16	20	100	1.1	100.0%	7.5	0	274.0	447.8	8.25	0.43	1.16	1.59
1	24	8.43774	100	4.6	100.0%	7.5	8	274.0	446.8	3.67	0.03	0.96	0.99
2	24	9.12381	100	0	100.0%	7.5	18	274.0	446.7	3.67	0.03	0.00	0.03
3	24	22.9825	100	0	100.0%	7.5	41	272.6	446.7	3.67	0.07	0.00	0.07
4	24	20.7164	100	0	100.0%	7.5	61	272.5	446.6	3.67	0.06	0.00	0.06
5	24	28.1446	100	0	100.0%	7.5	89	272.9	446.5	3.67	0.08	0.00	0.08
6	24	20.9149	100	0	100.0%	7.5	110	274.0	446.5	3.67	0.06	0.00	0.06
7	24	17.3709	100	0	100.0%	7.5	128	275.3	446.4	3.67	0.05	0.00	0.05
8	24	13.2044	100	0	100.0%	7.5	141	275.6	446.4	3.67	0.04	0.00	0.04
9	24	7.71668	100	0	100.0%	7.5	149	276.0	446.4	3.67	0.02	0.00	0.02

Kit Creek P.S.
West Cary Force Main, North Carolina
Year 2015- Peak Hour Flow
Flygt Pump Model 3231

Operating Conditions

Design System Flow, gpm	3906	HGL at High Point	363 ft
Number of Pumps Operating	2	HGL at P.S. Wetwell	230 ft
Design Flow per Pump, gpm	1953	Total Static Head	133 ft

System Data

Pipe Number	Diameter (inches)	Length (feet)	H&W C	% of Total Flow	Sum K	Velocity at Design Flow (fps)	HL at Design Flow (ft)	Kf	Km
1	12	43	100	50.0%	4.7	5.5	2.85	1.11E-02	2.96E-02
2	12	45	100	100.0%	4.1	11.1	10.11	4.21E-02	1.03E-01
3	18	34	100	100.0%	3.7	4.9	1.63	4.41E-03	1.84E-02
4	20	1113	100	100.0%	2.6	4.0	5.37	8.64E-02	8.48E-03
5	24	4012	100	100.0%	4.75	2.8	7.58	1.28E-01	7.47E-03
6	24	5823	100	100.0%	5.85	2.8	10.87	1.86E-01	9.20E-03
7	30	3905	100	152.5%	3.6	2.7	5.44	9.19E-02	5.39E-03
8	24	5368	100	152.5%	1.4	4.2	20.88	3.75E-01	5.12E-03
9									
10									

System Curve / Pump Curve

Total Flow (gpm)	System TDH (ft)	Friction Losses (ft)	Form Losses (ft)	Full Speed RPM = 1750 Pump Flow (gpm)	Full Speed RPM = 1750 TDH (ft)	Reduced Speed RPM = 1660 Pump Flow (gpm)	Reduced Speed RPM = 1660 TDH (ft)
3906	197.7	50.6	14.1	1953	197.7		
0	133.0	0.0	0.0	0	307.0	0	276.2
1000	138.0	4.1	0.9	500	290.0	474	260.9
2000	151.4	14.7	3.7	1000	270.0	949	242.9
3000	172.4	31.0	8.3	1500	246.0	1423	221.3
4000	200.7	52.9	14.8	2000	224.0	1897	201.6
5000	236.1	79.9	23.2	2500	207.0	2371	186.3
6000	278.3	111.9	33.4	3000	192.0	2846	172.8
7000	327.3	148.9	45.4	3500	178.0	3320	160.2
8000	382.9	190.6	59.3	4000	160.0	3794	144.0
9000	445.1	237.0	75.1	4500	138.0	4269	124.2
10000	513.7	288.0	92.7				

Full Speed Operating Point

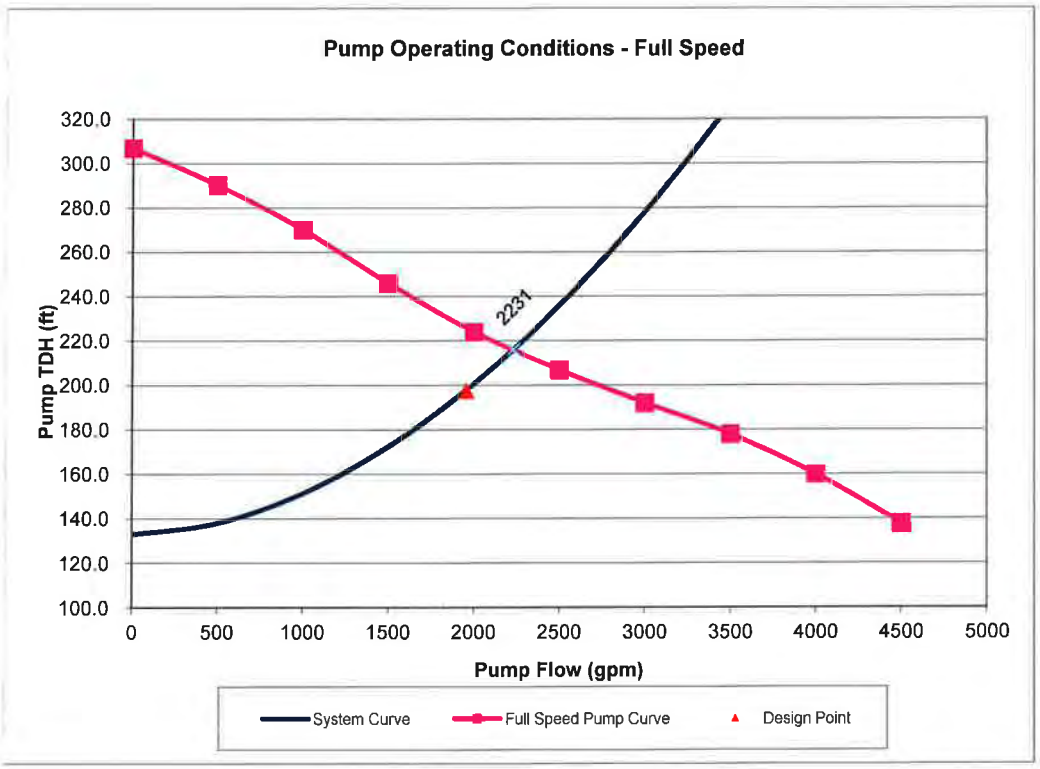
4462	216.2	64.7	18.5	2231	216.2	0.00	<<< Iterate to 0

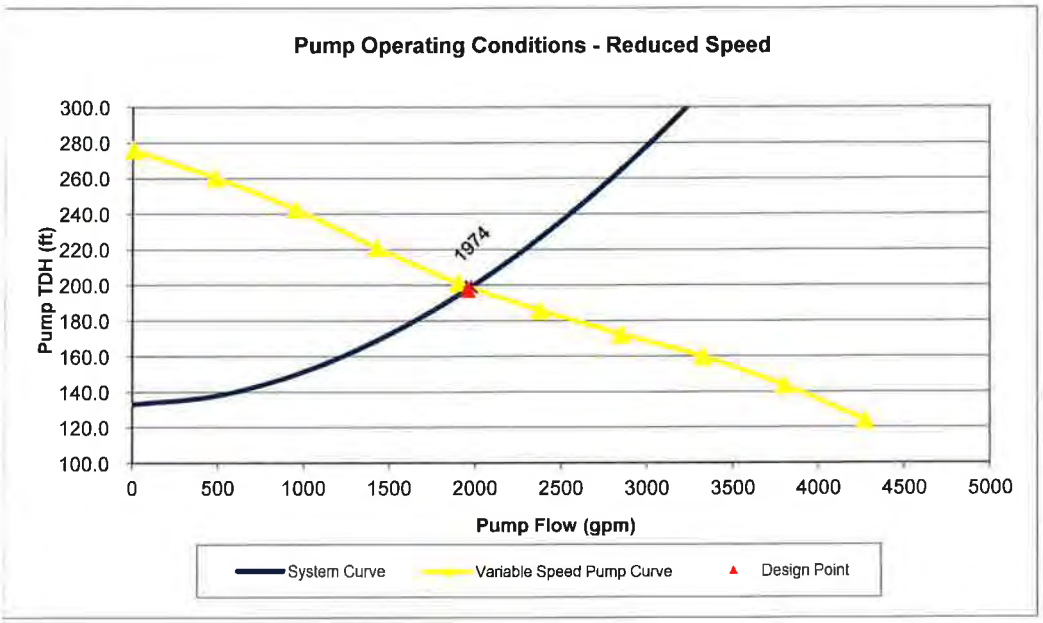
Single Click on blue cell and hit "Control + z"

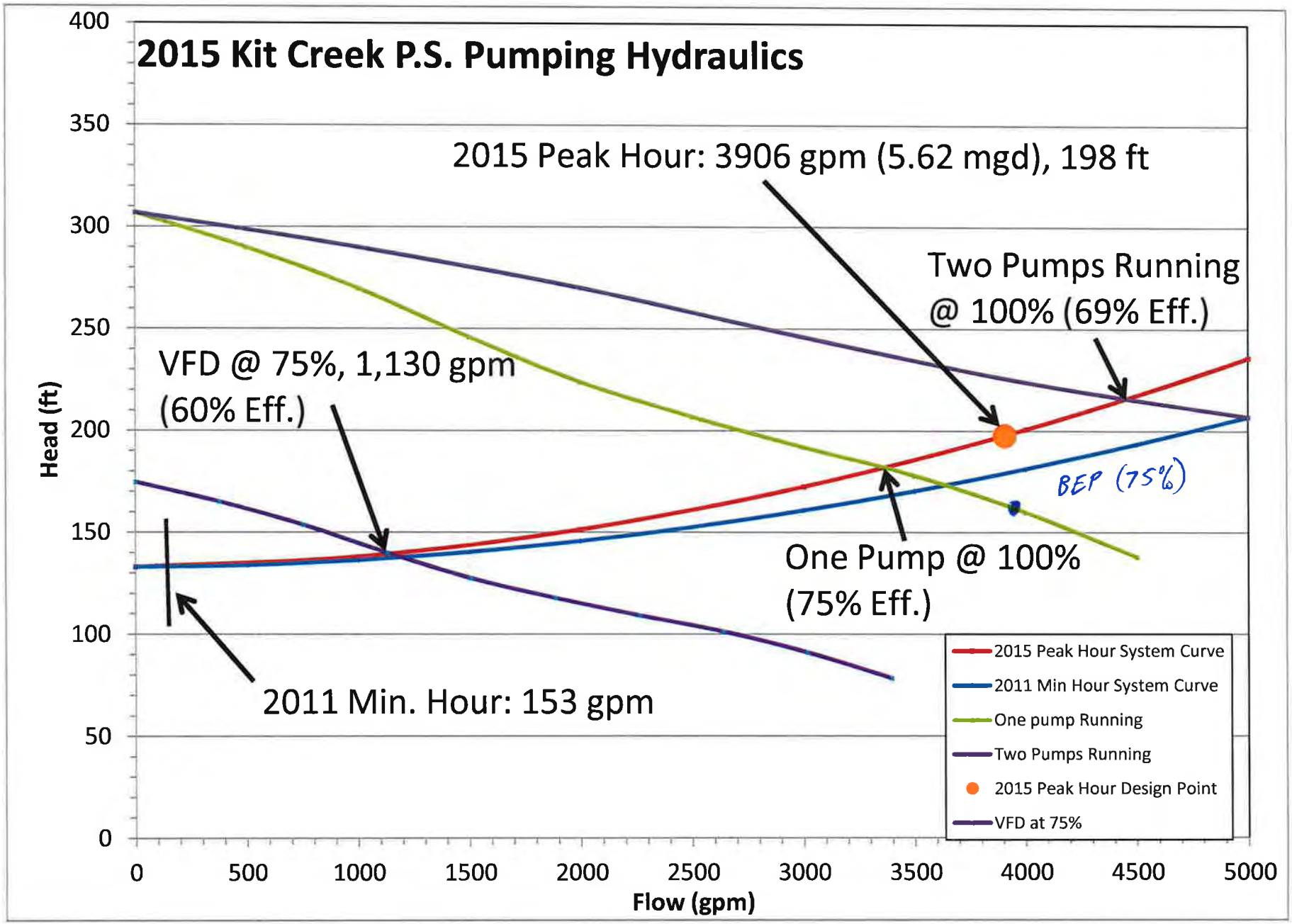
Reduced Speed Operating Point

3949	199.1	51.6	14.5	1974	199.1	0.00	<<< Check

Kit Creek P.S.
West Cary Force Main, North Carolina
Year 2015- Peak Hour Flow
Flygt Pump Model 3231






2015 Kit Creek P.S. Pumping Hydraulics
2015 Peak Hour: 3906 gpm (5.62 mgd), 198 ft
Two Pumps Running
@ 100% (69% Eff.)
VFD @ 75%, 1,130 gpm
(60% Eff.)
BEP (75%)
One Pump @ 100%
(75% Eff.)
2011 Min. Hour: 153 gpm
Head (ft)
Flow (gpm)
0
50
100
150
200
250
300
350
400
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
2015 Peak Hour System Curve
2011 Min Hour System Curve
One pump Running
Two Pumps Running
2015 Peak Hour Design Point
VFD at 75%

Morris Branch P.S.
West Cary Force Main, North Carolina
Year 2015- Peak Hour Flow
Flygt Pump Model 3231

Operating Conditions

Design System Flow, gpm	2050	HGL at High Point	363 ft
Number of Pumps Operating	1	HGL at P.S. Wetwell	218 ft
Design Flow per Pump, gpm	2050	Total Static Head	145 ft

System Data

Pipe Number	Diameter (inches)	Length (feet)	H&W C	% of Total Flow	Sum K	Velocity at Design Flow (fps)	HL at Design Flow (ft)	Kf	Km
1	18	45	100	50.0%	6.2	1.3	0.19	1.62E-03	7.71E-03
2	24	40	100	100.0%	0.1	1.5	0.02	1.28E-03	1.57E-04
3	24	20	100	100.0%	0.1	1.5	0.01	6.39E-04	1.57E-04
4	16	20	100	100.0%	1.1	3.3	0.26	4.60E-03	8.76E-03
5	24	7632	100	100.0%	4.6	1.5	4.20	2.44E-01	7.24E-03
6	30	3905	100	290.5%	3.6	2.7	5.44	3.03E-01	1.96E-02
7	24	5368	100	290.5%	1.4	4.2	20.90	1.24E+00	1.86E-02
8									
9									
10									

System Curve

Total Flow (gpm)	System TDH (ft)	Friction Losses (ft)	Form Losses (ft)
2050	176.0	29.7	1.3
0	145.0	0.0	0.0
500	147.3	2.2	0.1
1000	153.2	7.9	0.3
1500	162.4	16.7	0.7
2000	174.6	28.4	1.2
2500	189.8	42.9	1.9
3000	207.9	60.1	2.8
3500	228.8	80.0	3.8
4000	252.3	102.4	4.9
4500	278.6	127.3	6.2

Pump Curve

Full Speed RPM = 1780 Pump Flow (gpm)	Full Speed TDH (ft)	Reduced Speed RPM = 1736 Pump Flow (gpm)	Reduced Speed TDH (ft)
2050	176.0		
0	258.5	0	245.9
500	241.8	488	230.0
1000	223.2	975	212.3
1500	205.5	1463	195.5
2000	188.8	1951	179.6
2500	174.8	2438	166.3
3000	161.8	2926	153.9
3500	147.9	3413	140.6
4000	132.1	3901	125.6

Full Speed Operating Point

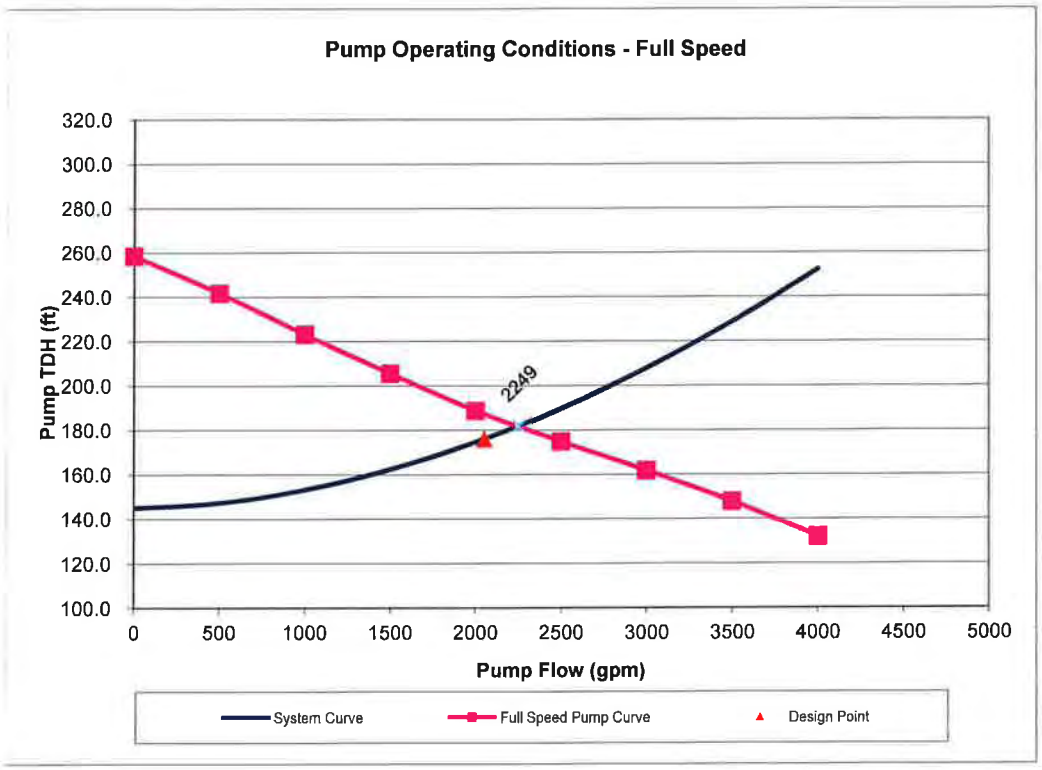
2249	181.8	35.3	1.6	2249	181.8	0.00	<<< Iterate to 0

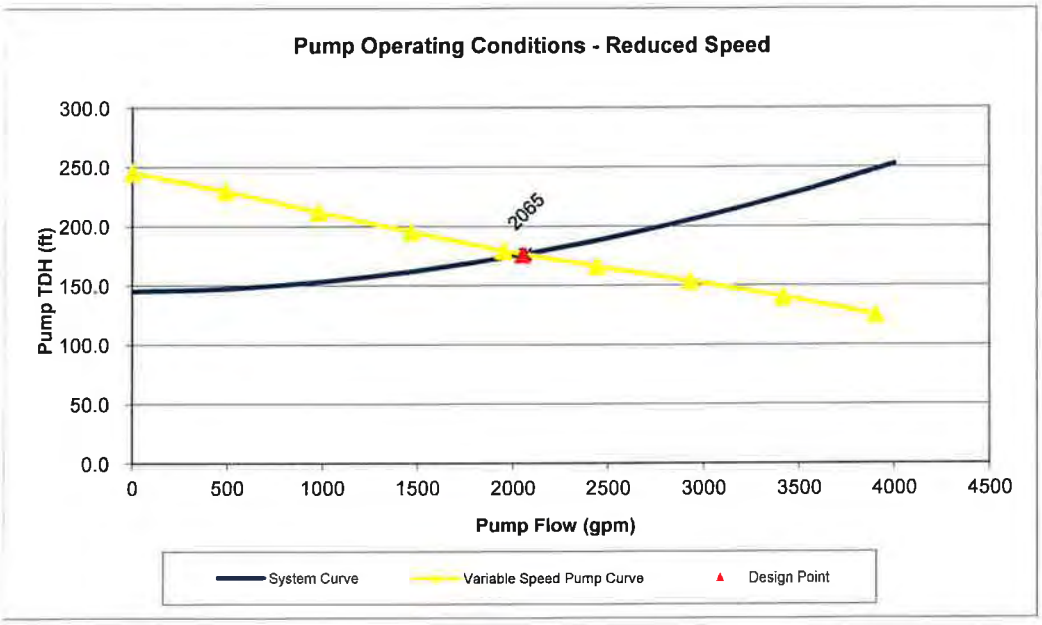
Single Click on blue cell and hit "Control + z"

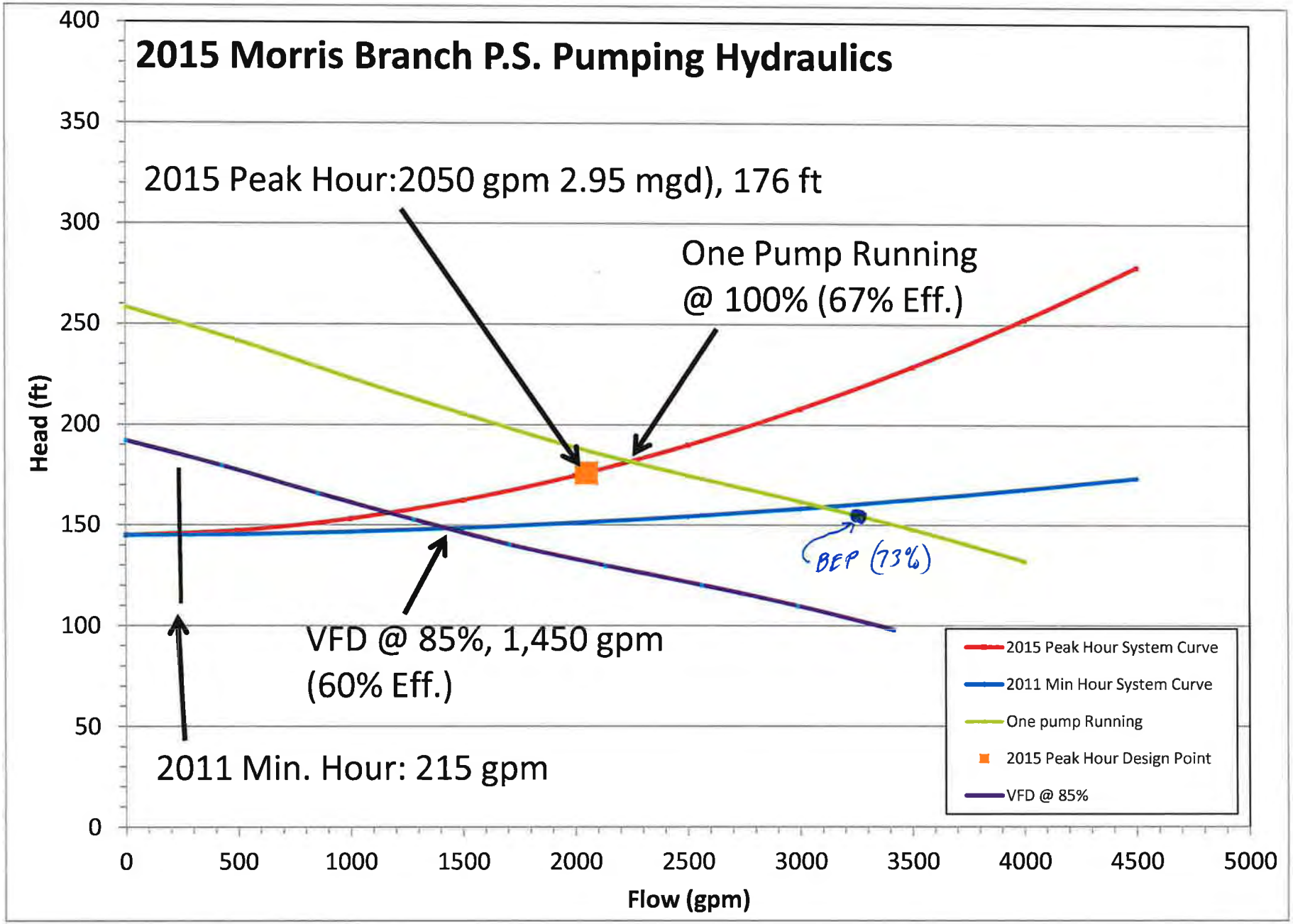
Reduced Speed Operating Point

2065	176.5	30.1	1.3	2065	176.5	0.00	<<< Check

Morris Branch P.S.
West Cary Force Main, North Carolina
Year 2015- Peak Hour Flow
Flygt Pump Model 3231






2015 Morris Branch P.S. Pumping Hydraulics
2015 Peak Hour:2050 gpm 2.95 mgd), 176 ft
One Pump Running
@ 100% (67% Eff.)
BEP (73%)
VFD @ 85%, 1,450 gpm
(60% Eff.)
2011 Min. Hour: 215 gpm
Head (ft)
Flow (gpm)
0
50
100
150
200
250
300
350
400
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
2015 Peak Hour System Curve
2011 Min Hour System Curve
One pump Running
2015 Peak Hour Design Point
VFD @ 85%

Kit Creek P.S.
West Cary Force Main, North Carolina
Year 2020- Peak Hour Flow
Flygt Pump Model 3240

Operating Conditions

Design System Flow, gpm	5017.9	HGL at High Point	363 ft
Number of Pumps Operating	2	HGL at P.S. Wetwell	230 ft
Design Flow per Pump, gpm	2509	Total Static Head	133 ft

System Data

Pipe Number	Diameter (inches)	Length (feet)	H&W C	% of Total Flow	Sum K	Velocity at Design Flow (fps)	HL at Design Flow (ft)	Kf	Km
1	12	43	100	50.0%	4.7	7.1	4.66	1.11E-02	2.96E-02
2	20	45	100	100.0%	4.1	5.1	1.97	3.49E-03	1.34E-02
3	18	34	100	100.0%	3.7	6.3	2.68	4.41E-03	1.84E-02
4	20	1113	100	100.0%	2.6	5.1	8.57	8.64E-02	8.48E-03
5	24	4012	100	100.0%	4.75	3.6	12.08	1.28E-01	7.47E-03
6	24	5823	100	100.0%	5.85	3.6	17.33	1.86E-01	9.20E-03
7	30	3905	100	157.8%	3.6	3.6	9.24	9.79E-02	5.78E-03
8	24	5368	100	157.8%	1.4	5.6	35.39	3.99E-01	5.48E-03
9									
10									

System Curve

Total Flow (gpm)	System TDH (ft)	Friction Losses (ft)	Form Losses (ft)
5017.9	224.9	79.7	12.2
0	133.0	0.0	0.0
2000	149.5	14.5	1.9
4000	193.2	52.4	7.8
6000	261.4	111.0	17.5
8000	353.0	188.9	31.0
10000	467.0	285.5	48.5
12000	602.8	400.0	69.8
14000	760.1	532.0	95.1
16000	938.2	681.1	124.2
18000	1137.0	846.9	157.1
20000	1356.2	1029.2	194.0

Pump Curve

Full Speed RPM = 1790 Pump Flow (gpm)	Full Speed RPM = 1790 TDH (ft)	Reduced Speed RPM = 1600 Pump Flow (gpm)	Reduced Speed RPM = 1600 TDH (ft)
2509	226.0		
0	387.0	0	309.2
1000	350.0	894	279.6
2000	315.0	1788	251.7
3000	279.0	2682	222.9
4000	245.0	3575	195.7
5000	206.0	4469	164.6
6000	162.0	5363	129.4
7000	106.0	6257	84.7
8000			
9000			

Full Speed Operating Point

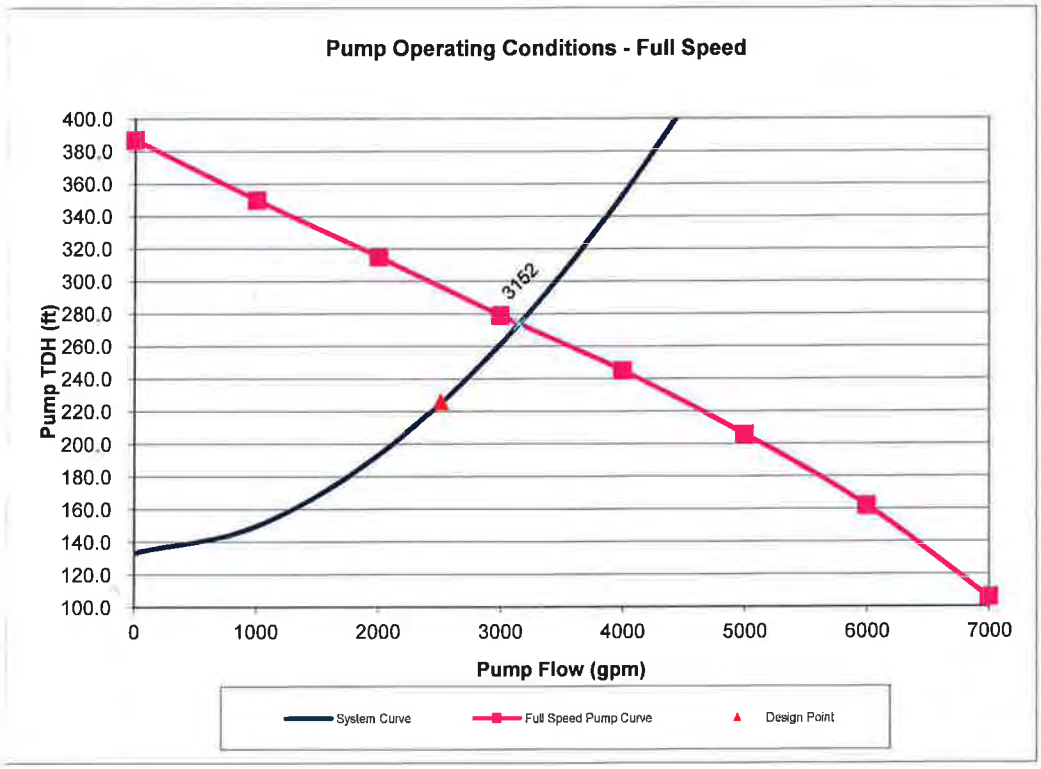
6304	273.8	121.6	19.3	3152	273.8	0.00	<<< Iterate to 0

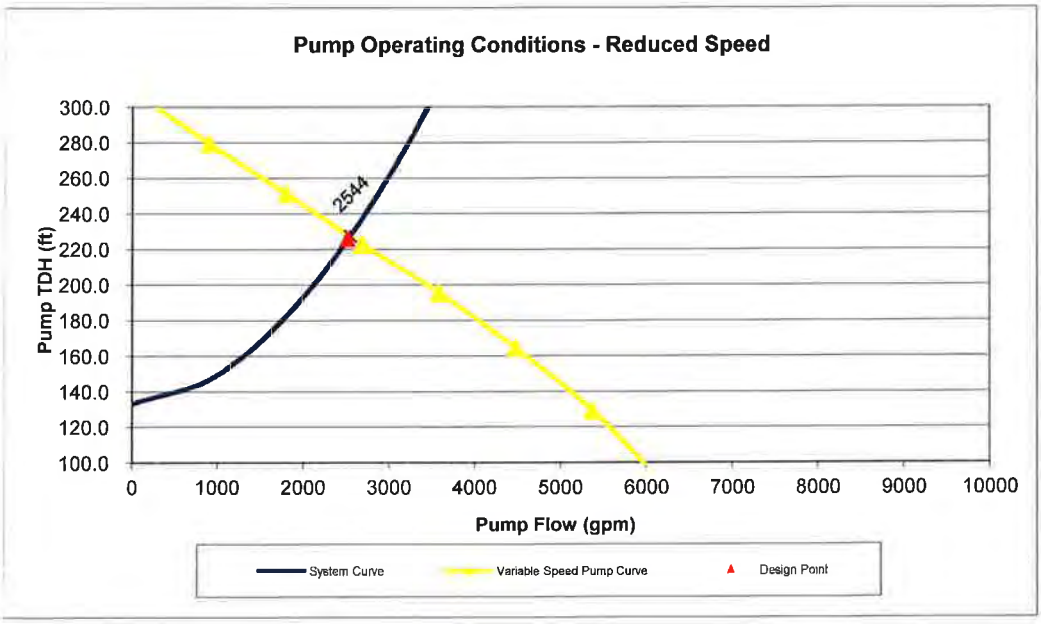
Single Click on blue cell and hit "Control + z"

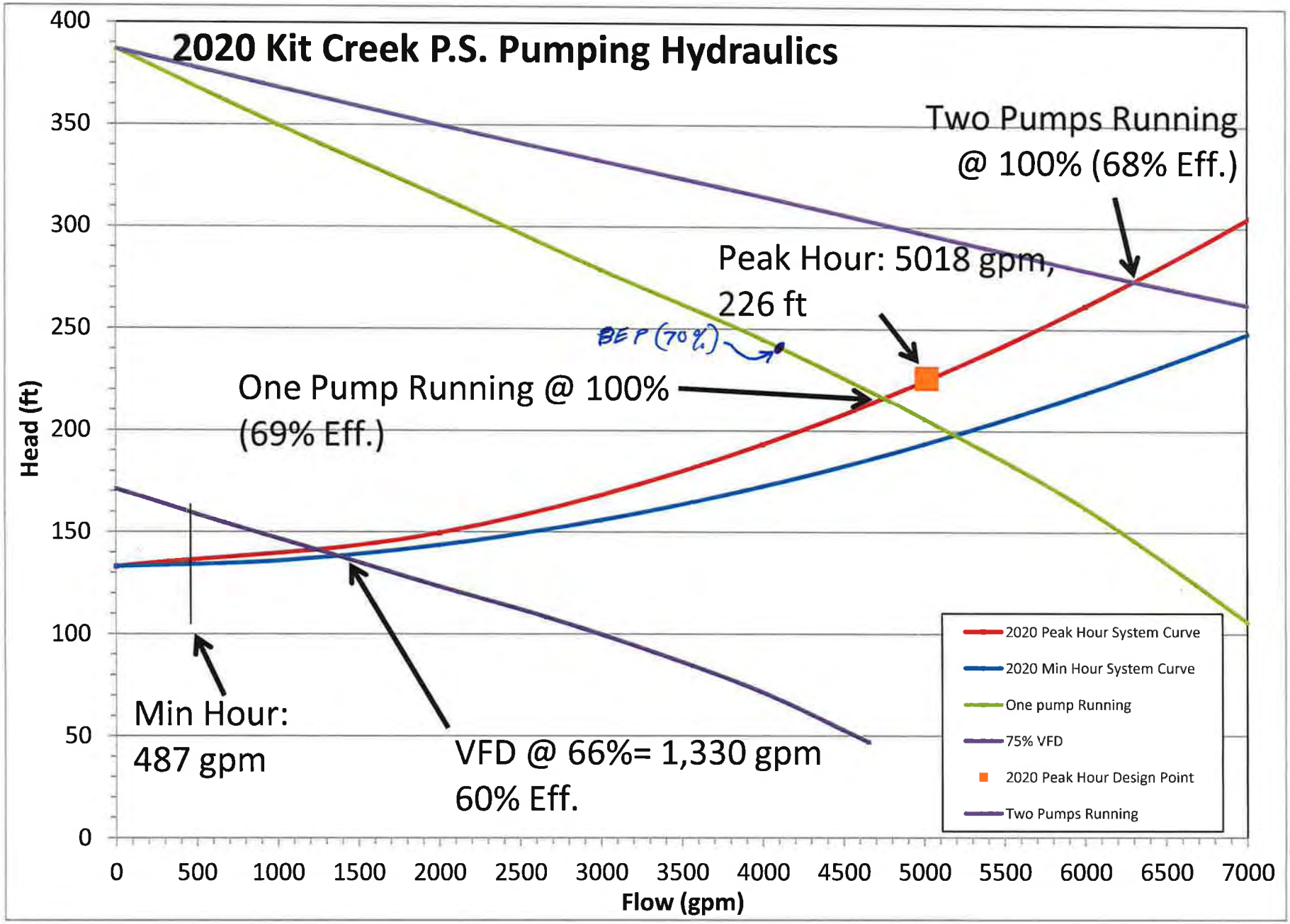
Reduced Speed Operating Point

5088	227.3	81.8	12.6	2544	227.3	0.00	<<< Check

Kit Creek P.S.
West Cary Force Main, North Carolina
Year 2020- Peak Hour Flow
Flygt Pump Model 3240






2020 Kit Creek P.S. Pumping Hydraulics
Two Pumps Running
@ 100% (68% Eff.)
Peak Hour: 5018 gpm,
226 ft
BEP (70%)
One Pump Running @ 100%
(69% Eff.)
Min Hour:
487 gpm
VFD @ 66%= 1,330 gpm
60% Eff.
Head (ft)
Flow (gpm)
0
50
100
150
200
250
300
350
400
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
2020 Peak Hour System Curve
2020 Min Hour System Curve
One pump Running
75% VFD
2020 Peak Hour Design Point
Two Pumps Running

Morris Branch P.S.
West Cary Force Main, North Carolina
Year 2020- Peak Hour Flow
Flygt Pump Model 3231

Operating Conditions

Design System Flow, gpm	2898.2	HGL at High Point	363 ft
Number of Pumps Operating	1	HGL at P.S. Wetwell	218 ft
Design Flow per Pump, gpm	2898	Total Static Head	145 ft

System Data

Pipe Number	Diameter (inches)	Length (feet)	H&W C	% of Total Flow	Sum K	Velocity at Design Flow (fps)	HL at Design Flow (ft)	Kf	Km
1	18	45	100	100.0%	6.2	3.7	1.47	5.84E-03	3.08E-02
2	24	40	100	100.0%	0.1	2.1	0.05	1.28E-03	1.57E-04
3	24	20	100	100.0%	0.1	2.1	0.03	6.39E-04	1.57E-04
4	16	20	100	100.0%	1.1	4.6	0.51	4.60E-03	8.76E-03
5	24	7632	100	100.0%	4.6	2.1	7.98	2.44E-01	7.24E-03
6	30	3905	100	273.1%	3.6	3.6	9.24	2.70E-01	1.73E-02
7	24	5368	100	273.1%	1.4	5.6	35.40	1.10E+00	1.64E-02
8									
9									
10									

System Curve / Pump Curve

Total Flow (gpm)	System TDH (ft)	Friction Losses (ft)	Form Losses (ft)	Full Speed RPM = 1775 Pump Flow (gpm)	Full Speed RPM = 1775 TDH (ft)	Reduced Speed RPM = 1720 Pump Flow (gpm)	Reduced Speed RPM = 1720 TDH (ft)
2898.2	199.7	51.3	3.4	2898	199.7		
0	145.0	0.0	0.0	0	302.0	0	283.6
500	147.1	2.0	0.1	500	287.0	485	269.5
1000	152.6	7.2	0.4	1000	273.0	969	256.3
1500	161.1	15.2	0.9	1500	258.0	1454	242.3
2000	172.4	25.8	1.6	2000	242.0	1938	227.2
2500	186.5	39.0	2.5	2500	226.0	2423	212.2
3000	203.3	54.7	3.6	3000	213.0	2907	200.0
3500	222.7	72.7	4.9	3500	197.0	3392	185.0
4000	244.5	93.1	6.4	4000	177.0	3876	166.2
4500	268.9	115.8	8.1	4500	160.0	4361	150.2
5000	295.7	140.7	10.0	5000	140.0	4845	131.5
5500	325.0	167.8	12.1	5500	121.0	5330	113.6
6000	356.6	197.2	14.4	6000	99.0	5814	93.0

Full Speed Operating Point

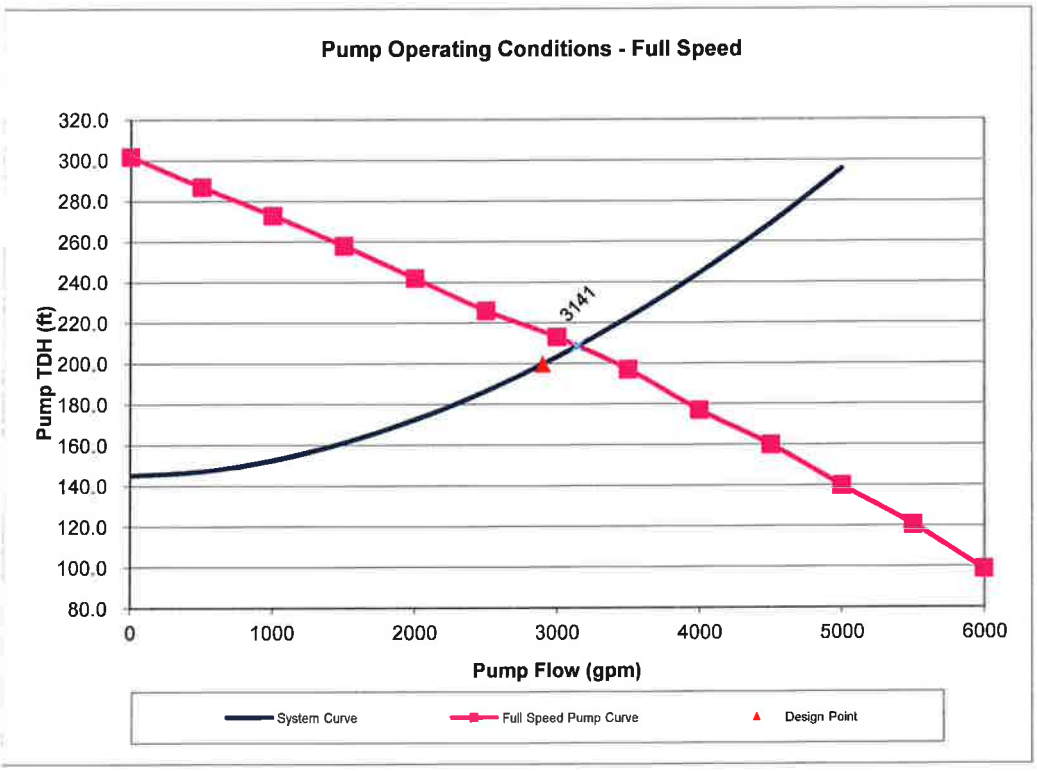
3141	208.5	59.5	4.0	3141	208.5	0.00	<<< Iterate to 0

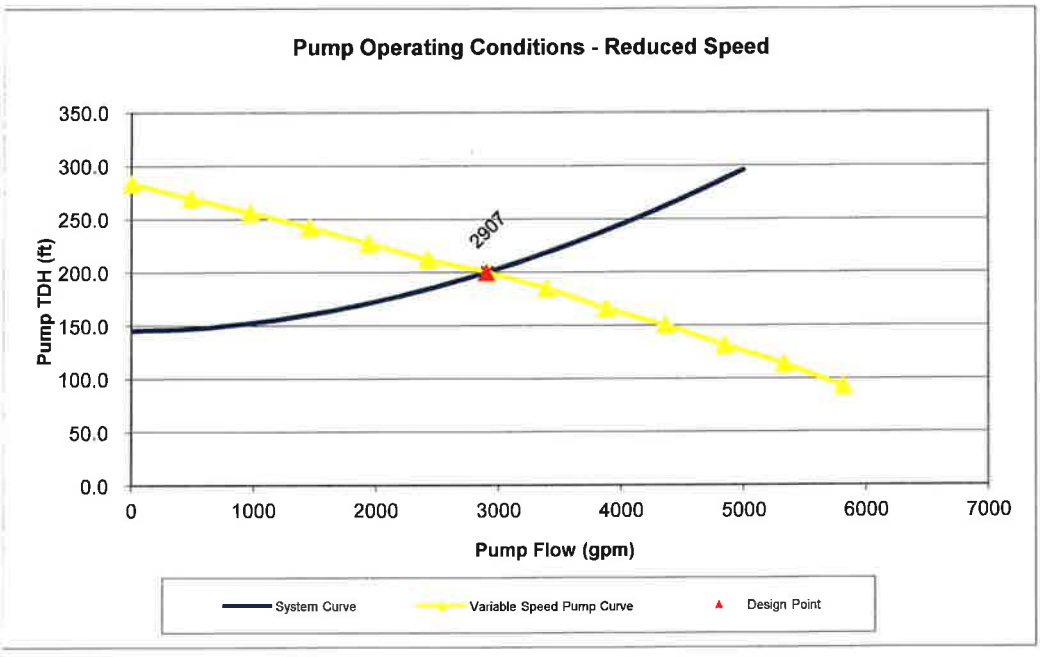
Single Click on blue cell and hit "Control + z"

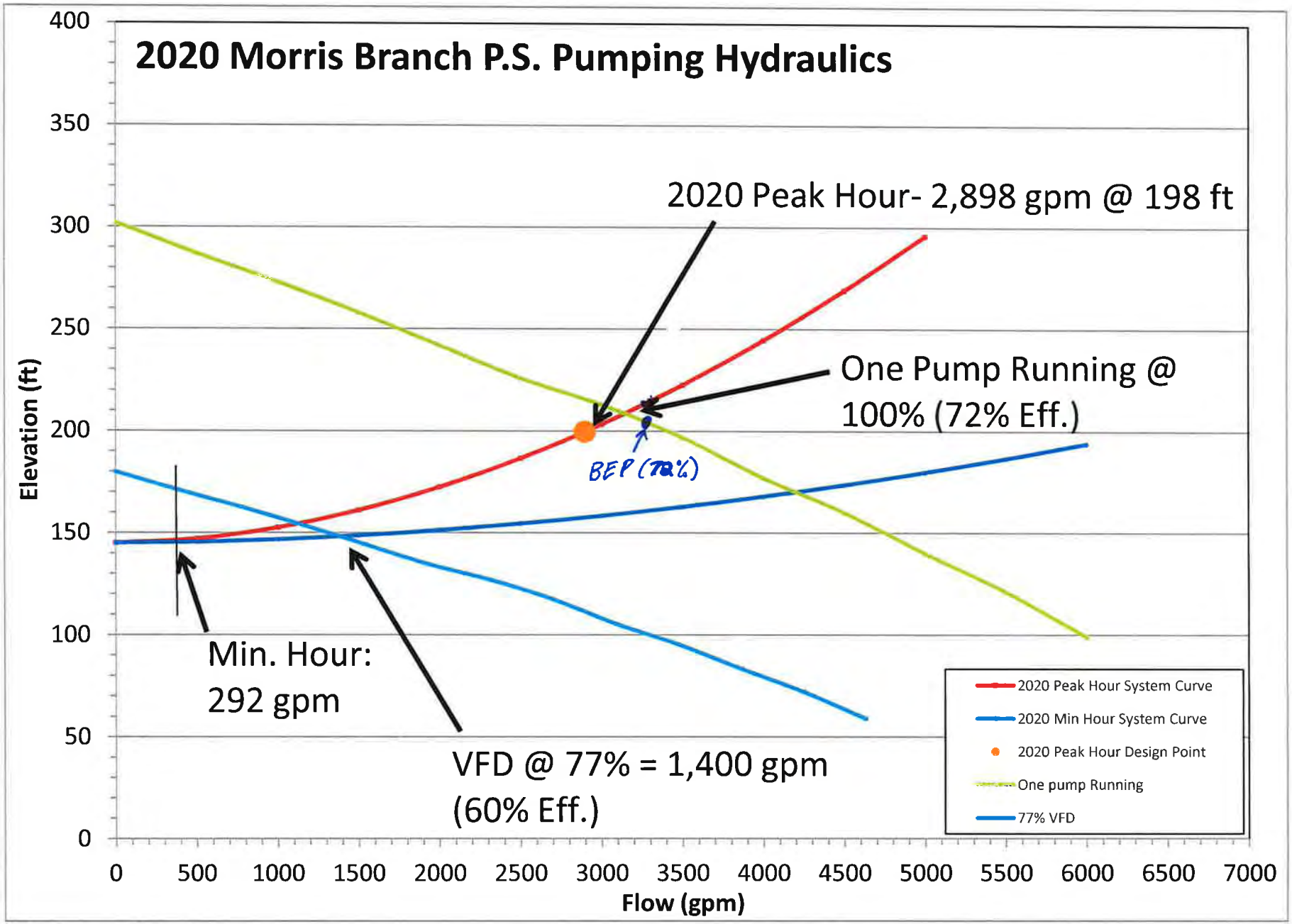
Reduced Speed Operating Point

2907	200.0	51.6	3.4	2907	200.0	0.00	<<< Check

Morris Branch P.S.
West Cary Force Main, North Carolina
Year 2020- Peak Hour Flow
Flygt Pump Model 3231






2020 Morris Branch P.S. Pumping Hydraulics
2020 Peak Hour- 2,898 gpm @ 198 ft
One Pump Running @ 100% (72% Eff.)
BEP (72%)
Min. Hour: 292 gpm
VFD @ 77% = 1,400 gpm (60% Eff.)
2020 Peak Hour System Curve
2020 Min Hour System Curve
2020 Peak Hour Design Point
One pump Running
77% VFD
Elevation (ft)
Flow (gpm)
0
50
100
150
200
250
300
350
400
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000

Kit Creek P.S.
West Cary Force Main, North Carolina
Year 2030- Peak Hour Flow
Flygt Pump Model 3240

Operating Conditions

Design System Flow, gpm	6984.8	HGL at High Point	363 ft
Number of Pumps Operating	3	HGL at P.S. Wetwell	230 ft
Design Flow per Pump, gpm	2328	Total Static Head	133 ft

System Data

Pipe Number	Diameter (inches)	Length (feet)	H&W C	% of Total Flow	Sum K	Velocity at Design Flow (fps)	HL at Design Flow (ft)	Kf	Km
1	12	43	100	33.3%	4.7	6.6	4.02	5.24E-03	1.31E-02
2	20	45	100	100.0%	4.1	7.1	3.80	3.49E-03	1.34E-02
3	18	34	100	100.0%	3.7	8.8	5.16	4.41E-03	1.84E-02
4	20	1113	100	100.0%	2.6	7.1	15.91	8.64E-02	8.48E-03
5	24	4012	100	100.0%	4.75	5.0	22.36	1.28E-01	7.47E-03
6	24	5823	100	100.0%	5.85	5.0	32.05	1.86E-01	9.20E-03
7	30	3905	100	158.2%	3.6	5.0	17.18	9.84E-02	5.81E-03
8	24	5368	100	158.2%	1.4	7.8	65.63	4.01E-01	5.51E-03
9									
10									

System Curve

Total Flow (gpm)	System TDH (ft)	Friction Losses (ft)	Form Losses (ft)
6984.8	299.1	146.4	19.7
0	133.0	0.0	0.0
3000	167.3	30.7	3.6
6000	258.1	110.5	14.5
9000	399.7	234.0	32.7
12000	589.6	398.5	58.1
15000	825.9	602.1	90.8
18000	1107.4	843.6	130.8
21000	1433.0	1122.0	178.0
24000	1801.9	1436.4	232.5
27000	2213.4	1786.1	294.2
30000	2666.8	2170.5	363.3
33000	3161.6	2589.1	439.5
36000	3697.4	3041.3	523.1

Pump Curve

Full Speed RPM = 1790 Pump Flow (gpm)	Full Speed RPM = 1790 TDH (ft)	Reduced Speed RPM = 1790 Pump Flow (gpm)	Reduced Speed RPM = 1790 TDH (ft)
2328	298.8		
0	387.0	0	387.0
1000	350.0	1000	350.0
2000	315.0	2000	315.0
3000	279.0	3000	279.0
4000	245.0	4000	245.0
5000	206.0	5000	206.0
6000	162.0	6000	162.0
7000	106.0	7000	106.0
8000			
9000			
10000			
11000			
12000			

Full Speed Operating Point

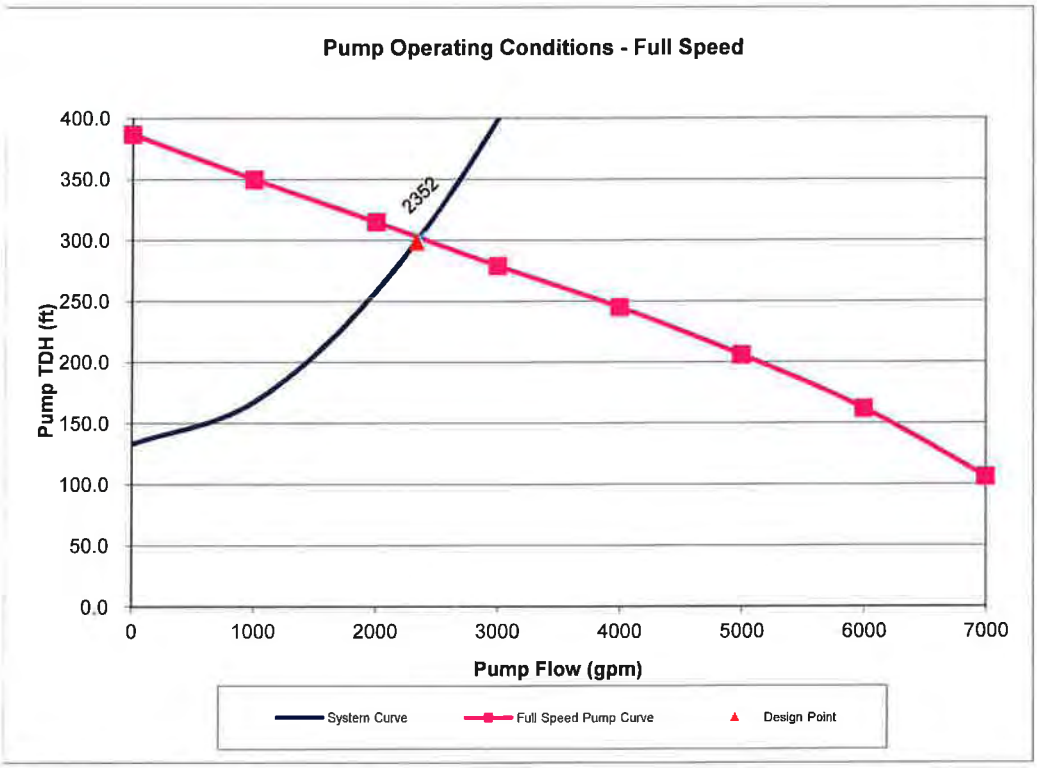
7057	302.3	149.2	20.1	2352	302.3	0.00	<<< Iterate to 0

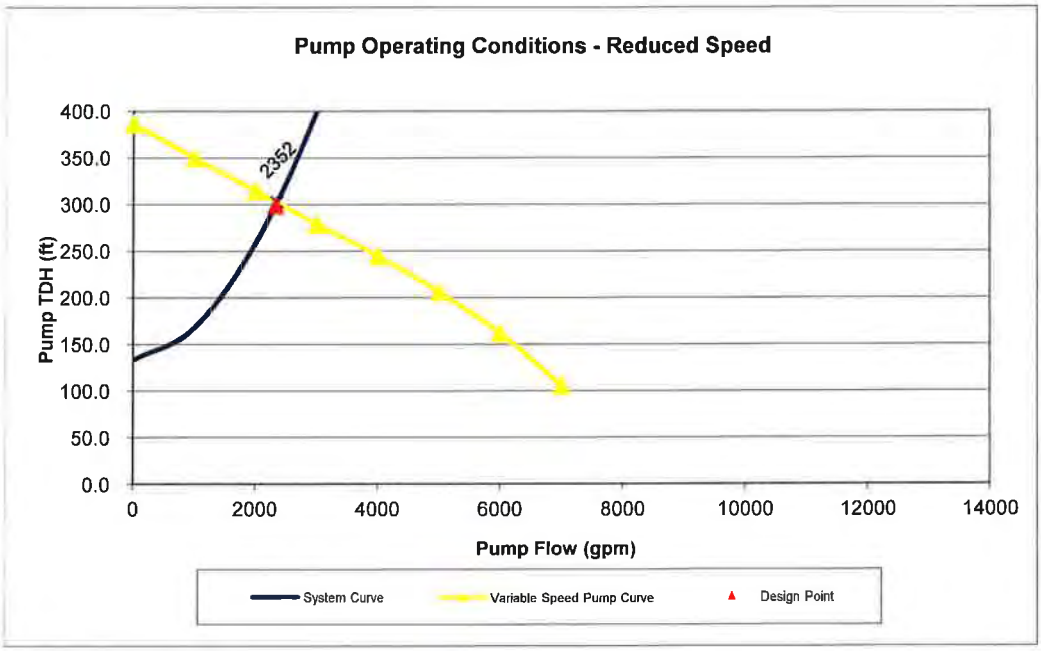
Single Click on blue cell and hit "Control + z"

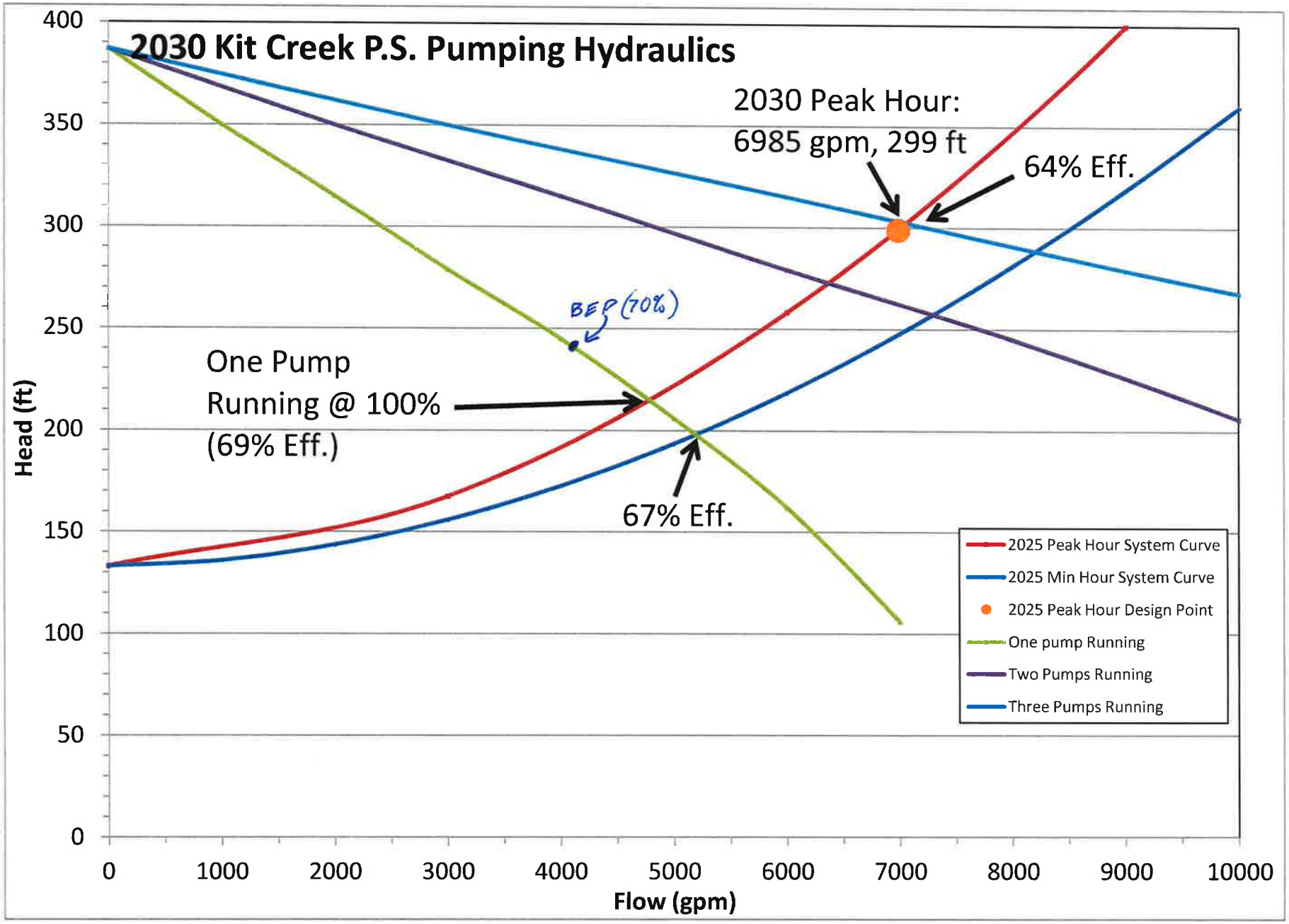
Reduced Speed Operating Point

7057	302.3	149.2	20.1	2352	302.3	0.00	<<< Check

Kit Creek P.S.
West Cary Force Main, North Carolina
Year 2030- Peak Hour Flow
Flygt Pump Model 3240







O:\30508-RAL\30508-001\Eng\raw data\30558-006 - Cary Kit Creek & Morris Branch PS\Revised Evaluation 2012\Kit Creek Pump Calcs.- Hydraulics- 2030- Before parallel pipes constructed

Last Updated 9/6/2012

Morris Branch P.S.
West Cary Force Main, North Carolina
Year 2030- Peak Hour Flow
Flygt Pump Model 3231

Operating Conditions

Design System Flow, gpm	4065.8	HGL at High Point	363 ft
Number of Pumps Operating	2	HGL at P.S. Wetwell	218 ft
Design Flow per Pump, gpm	2033	Total Static Head	145 ft

System Data

Pipe Number	Diameter (inches)	Length (feet)	H&W C	% of Total Flow	Sum K	Velocity at Design Flow (fps)	HL at Design Flow (ft)	Kf	Km
1	18	45	100	50.0%	6.2	2.6	0.73	1.62E-03	7.71E-03
2	24	40	100	100.0%	0.1	2.9	0.09	1.28E-03	1.57E-04
3	24	20	100	100.0%	0.1	2.9	0.05	6.39E-04	1.57E-04
4	16	20	100	100.0%	1.1	6.5	0.99	4.60E-03	8.76E-03
5	24	7632	100	100.0%	4.6	2.9	14.96	2.44E-01	7.24E-03
6	30	3905	100	271.8%	3.6	5.0	17.20	2.68E-01	1.71E-02
7	24	5368	100	271.8%	1.4	7.8	65.71	1.09E+00	1.63E-02
8									
9									
10									

System Curve / Pump Curve

Total Flow (gpm)	System TDH (ft)	Friction Losses (ft)	Form Losses (ft)	Full Speed RPM = 1775 Pump Flow (gpm)	Full Speed RPM = 1775 TDH (ft)	Reduced Speed RPM = 1775 Pump Flow (gpm)	Reduced Speed RPM = 1775 TDH (ft)
4065.8	244.7	95.0	4.7	2033	244.7		
0	145.0	0.0	0.0	0	302.0	0	302.0
1000	152.4	7.1	0.3	500	287.0	500	287.0
2000	171.7	25.6	1.1	1000	273.0	1000	273.0
3000	201.7	54.1	2.6	1500	258.0	1500	258.0
4000	241.7	92.2	4.6	2000	242.0	2000	242.0
5000	291.4	139.3	7.1	2500	226.0	2500	226.0
6000	350.4	195.2	10.3	3000	213.0	3000	213.0
7000	418.6	259.6	14.0	3500	197.0	3500	197.0
8000	495.6	332.4	18.2	4000	177.0	4000	177.0
9000	581.3	413.3	23.1	4500	160.0	4500	160.0
10000	675.7	502.2	28.5	5000	140.0	5000	140.0
11000	778.5	599.0	34.5	5500	121.0	5500	121.0
12000	889.7	703.7	41.0	6000	99.0	6000	99.0

Full Speed Operating Point

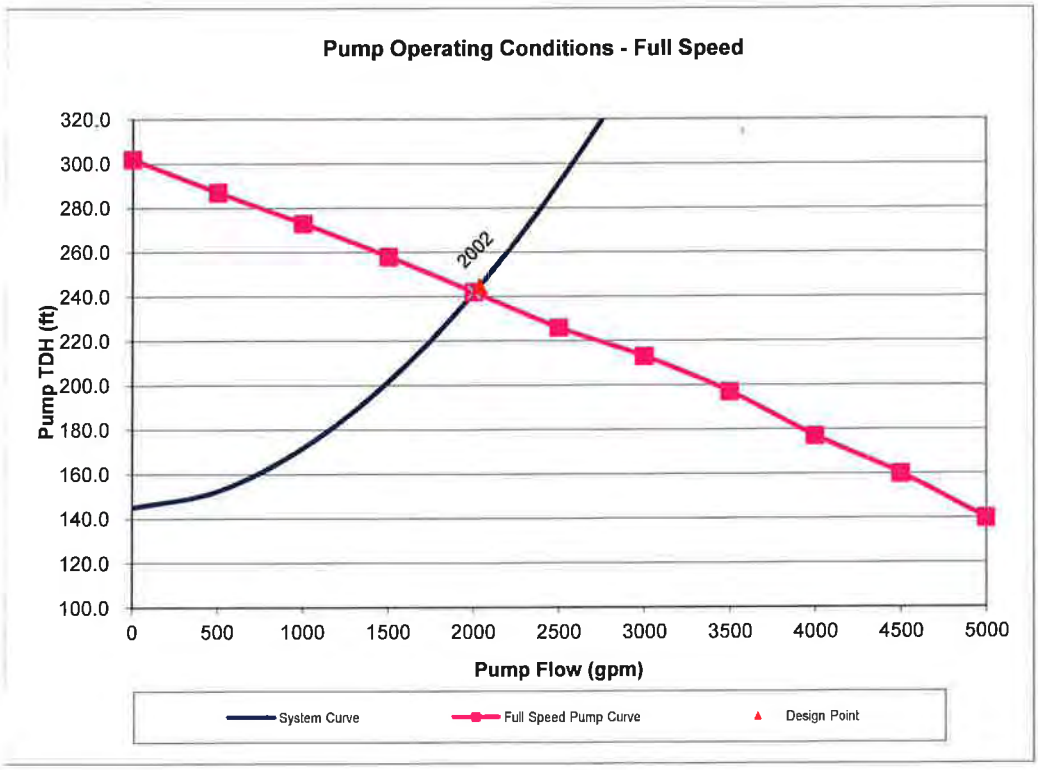
4004	241.9	92.4	4.6	2002	241.9	0.00	<<< Iterate to 0

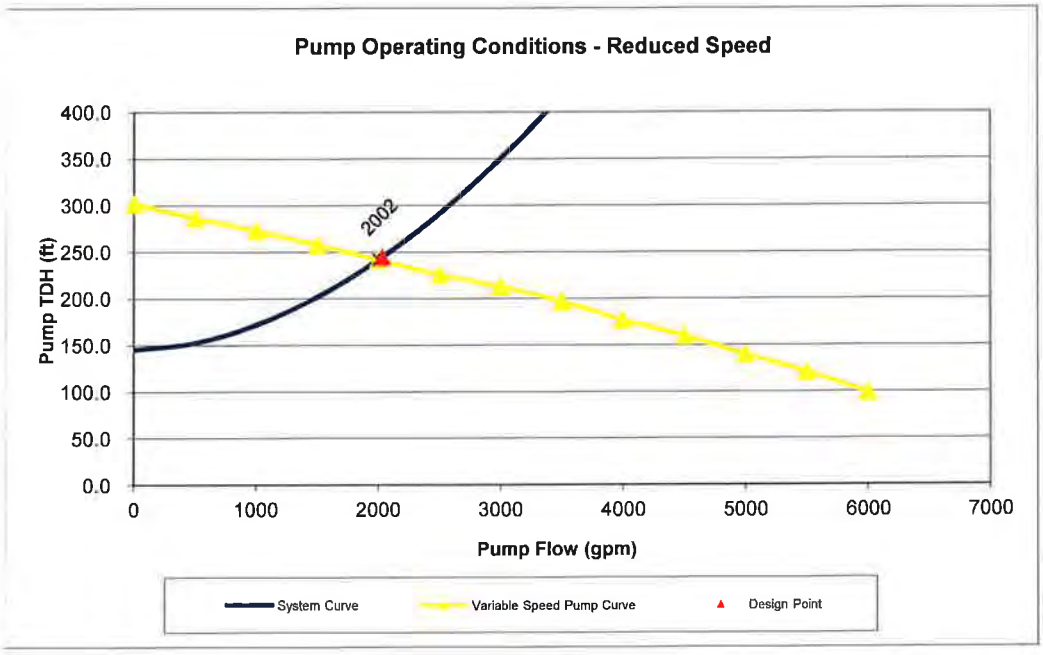
Single Click on blue cell and hit "Control + z"

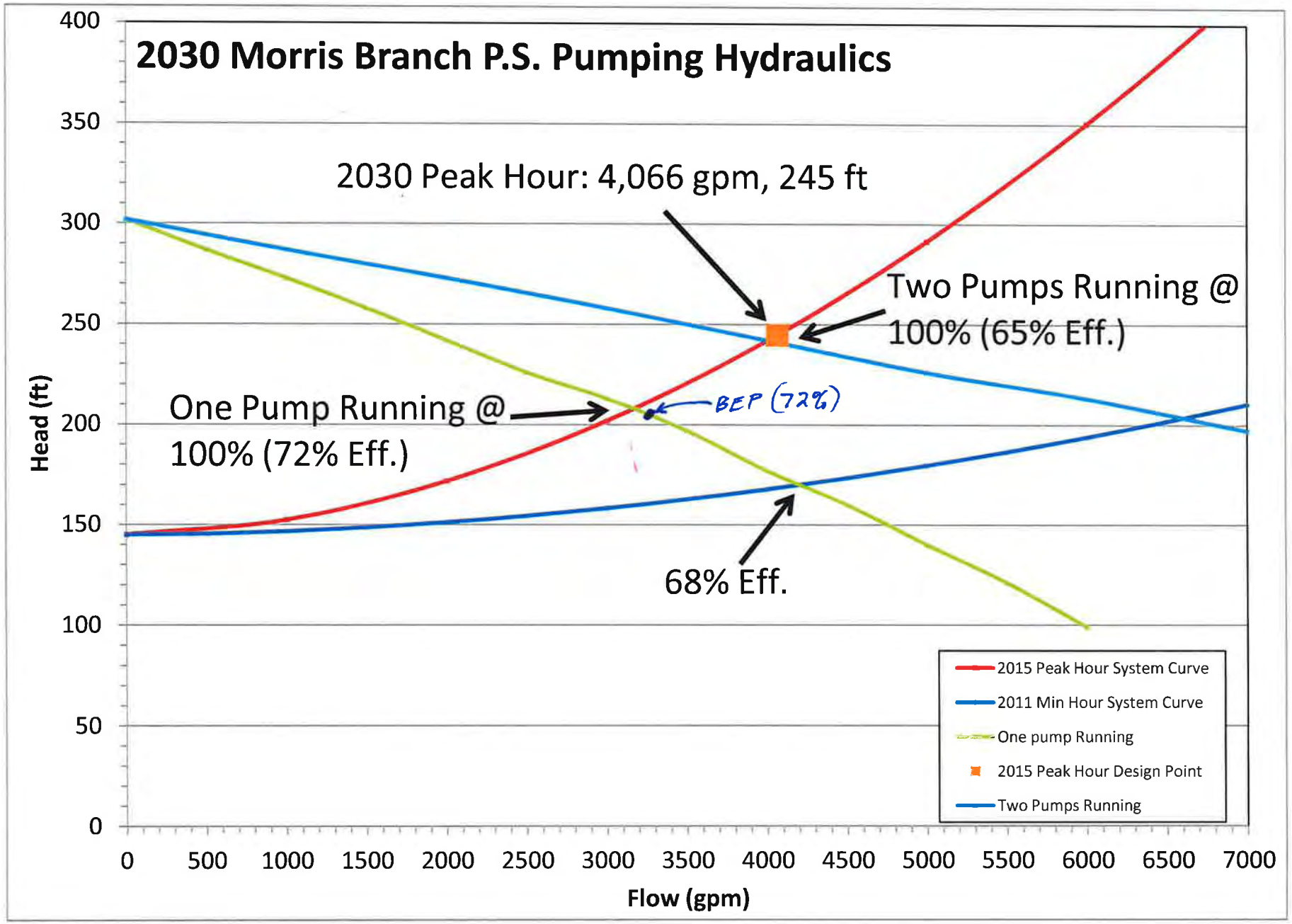
Reduced Speed Operating Point

4004	241.9	92.4	4.6	2002	241.9	0.00	<<< Check

Morris Branch P.S.
West Cary Force Main, North Carolina
Year 2030- Peak Hour Flow
Flygt Pump Model 3231






2030 Morris Branch P.S. Pumping Hydraulics
2030 Peak Hour: 4,066 gpm, 245 ft
Two Pumps Running @
100% (65% Eff.)
One Pump Running @
100% (72% Eff.)
BEP (72%)
68% Eff.
Head (ft)
Flow (gpm)
400
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
2015 Peak Hour System Curve
2011 Min Hour System Curve
One pump Running
2015 Peak Hour Design Point
Two Pumps Running

Kit Creek P.S.
West Cary Force Main, North Carolina
Build Out- Peak Hour Flow
Flygt Pump Model 3240

Operating Conditions

Design System Flow, gpm	9604.9	HGL at High Point	363 ft
Number of Pumps Operating	3	HGL at P.S. Wetwell	230 ft
Design Flow per Pump, gpm	3202	Total Static Head	133 ft

System Data

Pipe Number	Diameter (inches)	Length (feet)	H&W C	% of Total Flow	Sum K	Velocity at Design Flow (fps)	HL at Design Flow (ft)	Kf	Km
1	16	43	100	33.0%	4.7	5.1	2.23	1.27E-03	4.08E-03
2	20	45	100	100.0%	4.1	9.8	7.13	3.49E-03	1.34E-02
3	18	34	100	100.0%	3.7	12.1	9.69	4.41E-03	1.84E-02
4	20	1113	100	50.0%	2.6	4.9	7.89	2.39E-02	2.12E-03
5	24	4012	100	100.0%	4.75	6.8	40.47	1.28E-01	7.47E-03
6	24	5823	100	100.0%	5.85	6.8	57.98	1.86E-01	9.20E-03
7	30	3905	100	153.9%	3.6	6.7	29.54	9.35E-02	5.49E-03
8	24	5368	100	77.0%	1.4	5.2	31.14	1.06E-01	1.31E-03
9									
10									

System Curve / Pump Curve

Total Flow (gpm)	System TDH (ft)	Friction Losses (ft)	Form Losses (ft)	Full Speed RPM = 1790 Pump Flow (gpm)	Full Speed RPM = 1790 TDH (ft)	Reduced Speed RPM = 1790 Pump Flow (gpm)	Reduced Speed RPM = 1790 TDH (ft)
9604.9	319.1	158.0	28.1	3202	319.0		
0	133.0	0.0	0.0	0	437.0	0	437.0
3000	154.1	18.3	2.7	1000	399.0	1000	399.0
6000	210.1	66.1	11.0	2000	362.0	2000	362.0
9000	297.7	140.0	24.7	3000	323.0	3000	323.0
12000	415.3	238.5	43.9	4000	285.0	4000	285.0
15000	561.9	360.3	68.6	5000	247.0	5000	247.0
18000	736.6	504.9	98.8	6000	200.0	6000	200.0
21000	938.9	671.5	134.4	7000	147.0	7000	147.0
24000	1168.2	859.6	175.6	8000			
27000	1424.1	1068.9	222.2	9000			
30000	1706.3	1299.0	274.3	10000			
33000	2014.4	1549.4	331.9	11000			
36000	2348.1	1820.0	395.0	12000			

Full Speed Operating Point

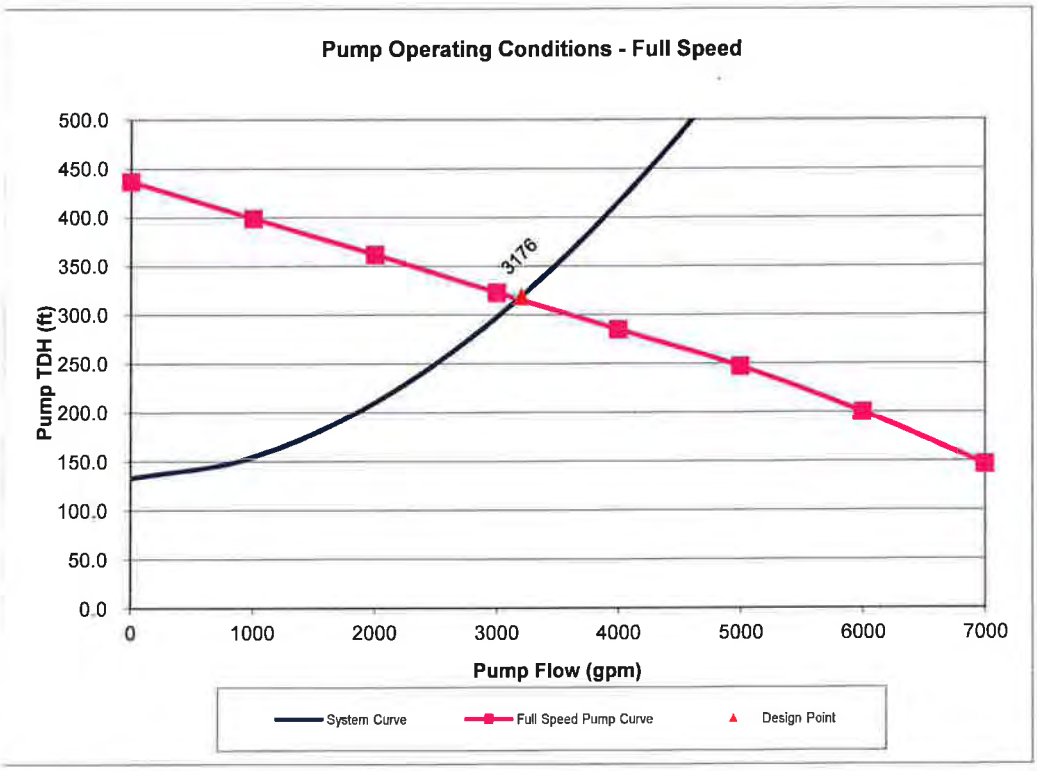
9528	316.3	155.6	27.7	3176	316.3	0.00	<<< Iterate to 0

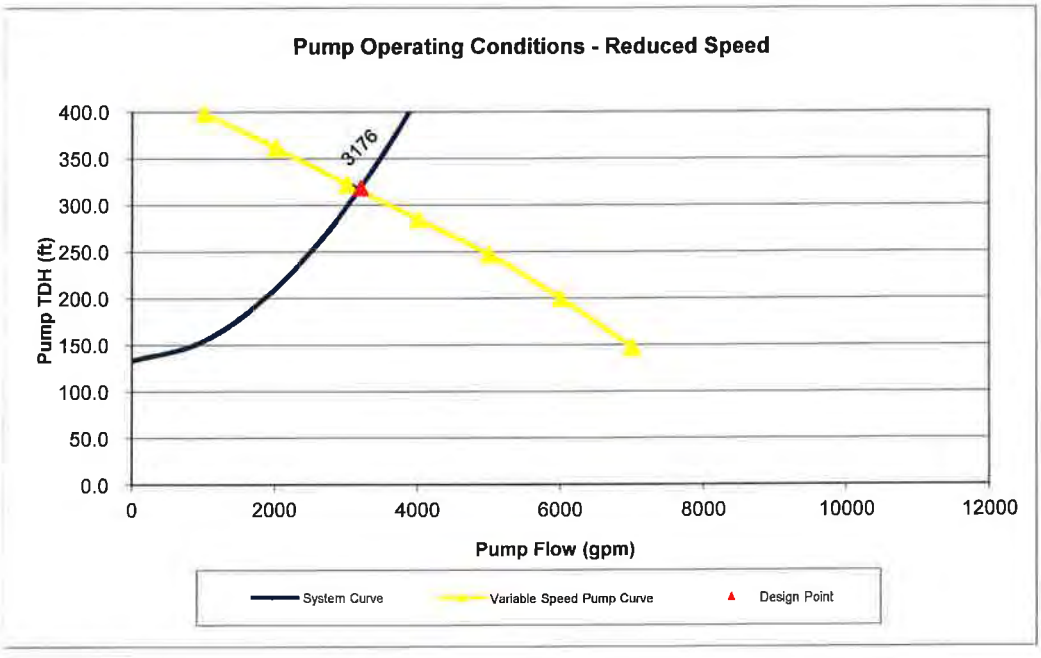
Single Click on blue cell and hit "Control + z"

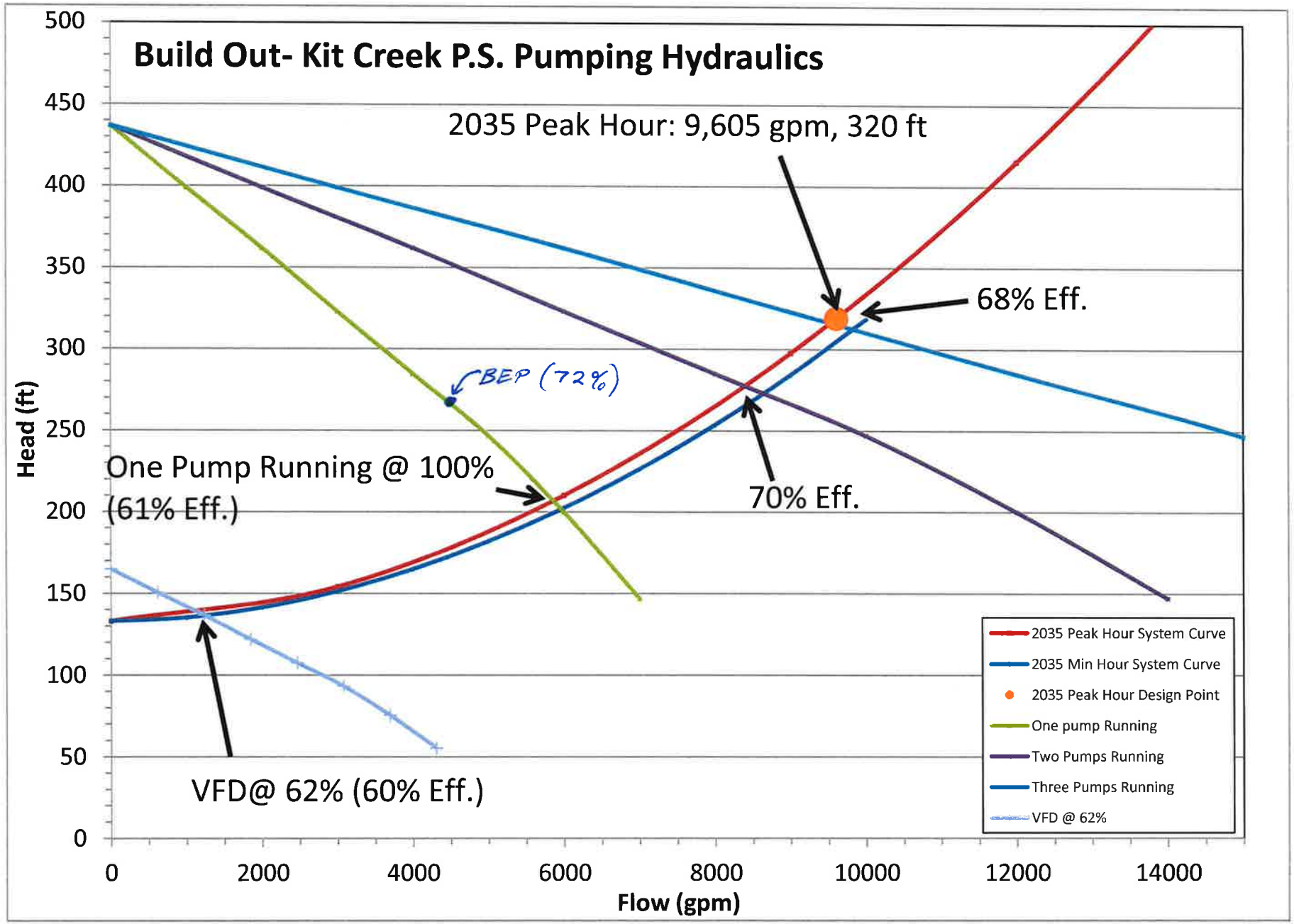
Reduced Speed Operating Point

9528	316.3	155.6	27.7	3176	316.3	0.00	<<< Check

Kit Creek P.S.
West Cary Force Main, North Carolina
Build Out- Peak Hour Flow
Flygt Pump Model 3240







O:\30508-RAL\30508-001\Eng\raw data\30558-006 - Cary Kit Creek & Morris Branch PS\Revised Evaluation 2012\Kit Creek Pump Calcs.- Hydraulics- Build Out

Last Updated 9/11/2012

Morris Branch P.S.
West Cary Force Main, North Carolina
Build Out- Peak Hour Flow
Flygt Pump Model 3231

Operating Conditions

Design System Flow, gpm	5177.8	HGL at High Point	363 ft
Number of Pumps Operating	3	HGL at P.S. Wetwell	218 ft
Design Flow per Pump, gpm	1726	Total Static Head	145 ft

System Data

Pipe Number	Diameter (inches)	Length (feet)	H&W C	% of Total Flow	Sum K	Velocity at Design Flow (fps)	HL at Design Flow (ft)	Kf	Km
1	18	45	100	33.3%	6.2	2.2	0.52	7.62E-04	3.42E-03
2	24	40	100	66.6%	0.1	2.4	0.06	6.02E-04	6.98E-05
3	24	20	100	100.0%	0.1	3.7	0.08	6.39E-04	1.57E-04
4	16	20	100	100.0%	1.1	8.3	1.59	4.60E-03	8.76E-03
5	24	7632	100	100.0%	4.6	3.7	23.43	2.44E-01	7.24E-03
6	30	3905	100	285.5%	3.6	6.7	29.57	2.94E-01	1.89E-02
7	24	5368	100	142.8%	1.4	5.2	31.17	3.32E-01	4.49E-03
8									
9									
10									

System Curve / Pump Curve

Total Flow (gpm)	System TDH (ft)	Friction Losses (ft)	Form Losses (ft)	Full Speed RPM = 1775 Pump Flow (gpm)	Full Speed RPM = 1775 TDH (ft)	Reduced Speed RPM = 1710 Pump Flow (gpm)	Reduced Speed RPM = 1710 TDH (ft)
5177.8	231.4	80.7	5.7	1726	231.4		
0	145.0	0.0	0.0	0	302.0	0	280.3
1500	153.6	8.2	0.5	500	287.0	482	266.4
3000	176.3	29.4	1.9	1000	273.0	963	253.4
4500	211.6	62.3	4.3	1500	258.0	1445	239.5
6000	258.7	106.0	7.7	2000	242.0	1927	224.6
7500	317.2	160.2	12.0	2500	226.0	2408	209.8
9000	386.7	224.4	17.3	3000	213.0	2890	197.7
10500	467.0	298.5	23.5	3500	197.0	3372	182.8
12000	557.9	382.1	30.7	4000	177.0	3854	164.3
13500	659.1	475.2	38.9	4500	160.0	4335	148.5
15000	770.5	577.4	48.0	5000	140.0	4817	129.9
16500	891.9	688.8	58.1	5500	121.0	5299	112.3
18000	1023.3	809.1	69.2	6000	99.0	5780	91.9

Full Speed Operating Point

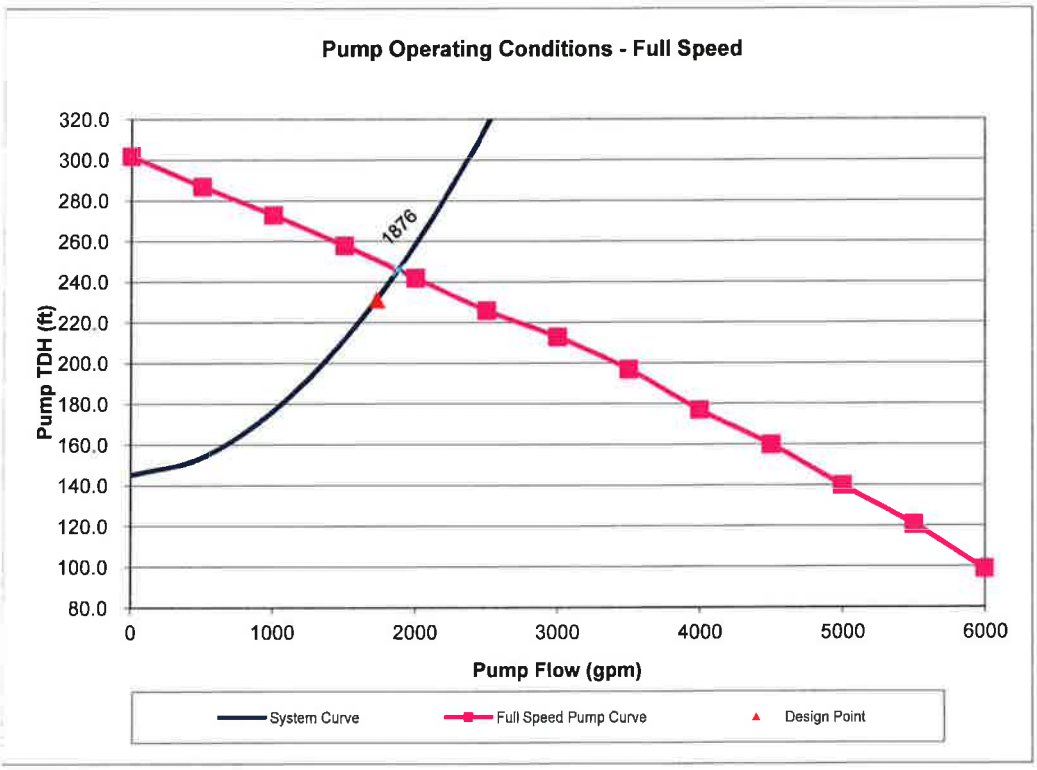
5629	246.0	94.2	6.8	1876	246.0	0.00	<<< Iterate to 0

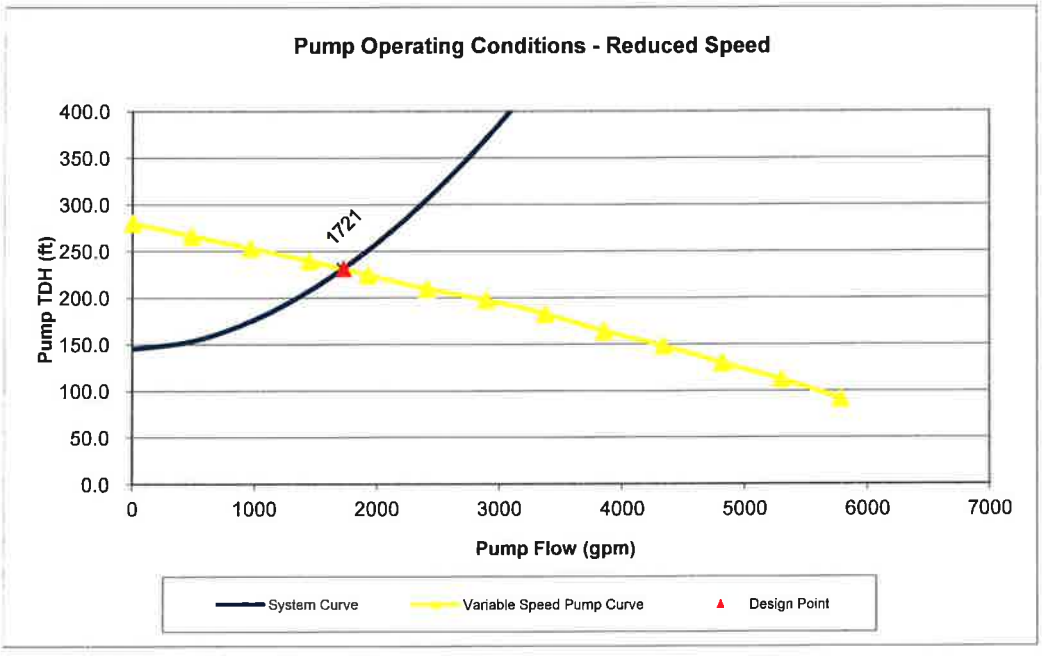
Single Click on blue cell and hit "Control + z"

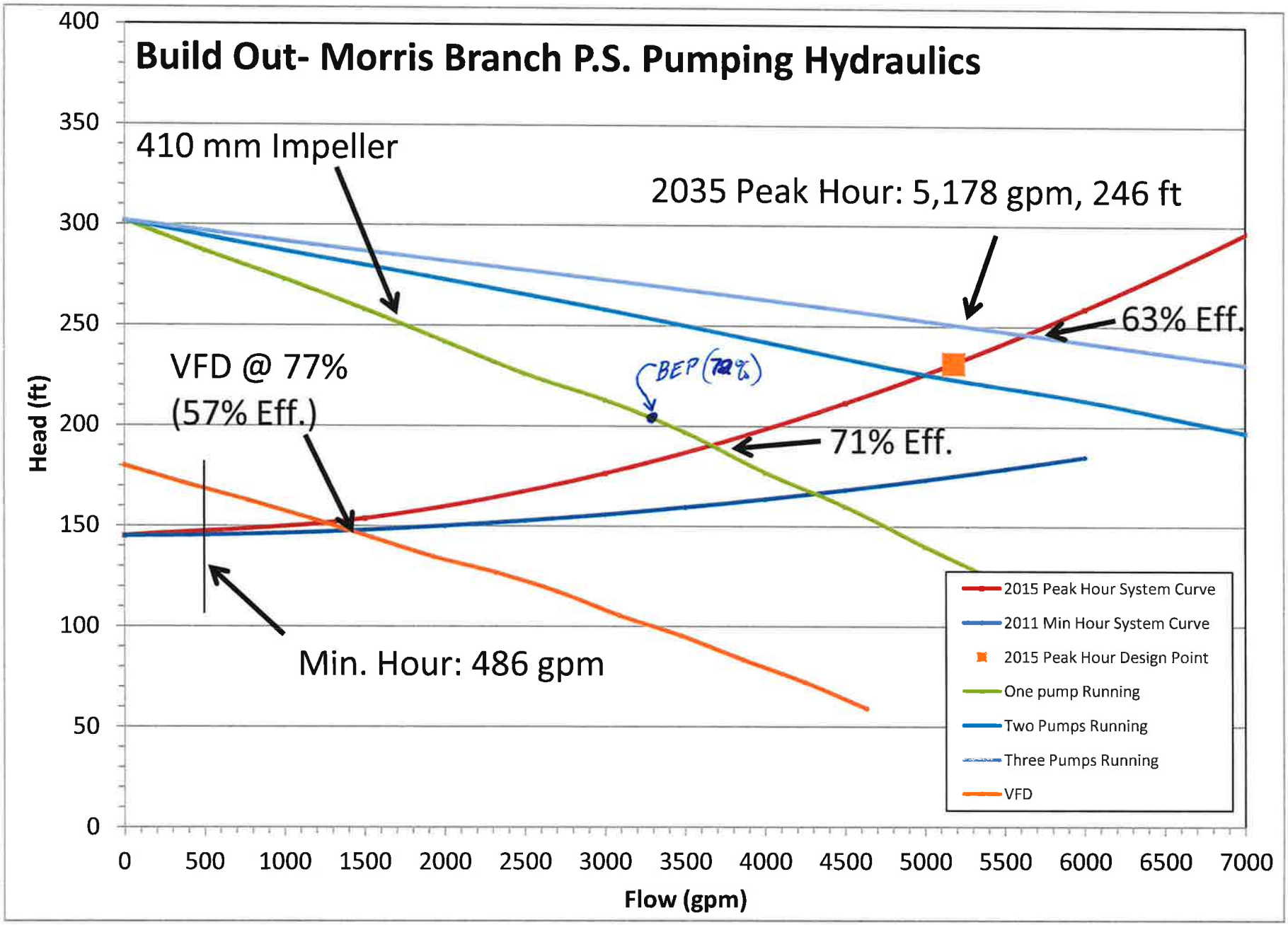
Reduced Speed Operating Point

5162	231.0	80.3	5.7	1721	231.0	0.00	<<< Check

Morris Branch P.S.
West Cary Force Main, North Carolina
Build Out- Peak Hour Flow
Flygt Pump Model 3231






Build Out- Morris Branch P.S. Pumping Hydraulics
410 mm Impeller
2035 Peak Hour: 5,178 gpm, 246 ft
63% Eff.
VFD @ 77%
(57% Eff.)
BEP (72%)
71% Eff.
Min. Hour: 486 gpm
Head (ft)
Flow (gpm)
0
50
100
150
200
250
300
350
400
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
2015 Peak Hour System Curve
2011 Min Hour System Curve
2015 Peak Hour Design Point
One pump Running
Two Pumps Running
Three Pumps Running
VFD

GRAVITY PIPE FLOW CALCULATIONS FOR 36-INCH GRAVITY SEWER

48-inch Gravity Sewer		PIPE DIA	48		AVG Q=	7.87 MGD	Pipe length= 11000
PROJECT NO.:	30508	SLOPE	0.0046	FT/FT	PEAK Q=	24.00 MGD	Required Drop 50.6 ft
DATE: 9/6/2012		PIPE n	0.0135				
					AVG Q=	5509 GPM	6
CALCs. BASED ON Q=1.486/n x AR2/3 X S1/2					PEAK Q=	16800 GPM	10
CFS / 1.547 = MGD VEL=Q/A							

d/D RATIO	PIPE-AF (SQ FT)	WET PER	HYD R	SLOPE %	FLOW (CFS)	FLOW (MGD)	GPM	VEL	DEPTH (INCHES)		
0.02	0.059	1.120	0.040	0.46%	0.05	0.03	24	0.89	0.96		1
0.04	0.176	1.600	0.104	0.46%	0.29	0.19	132	1.68	1.92		2
0.08	0.464	2.280	0.204	0.46%	1.21	0.78	545	2.61	3.84		3
0.12	0.848	2.840	0.300	0.46%	2.86	1.85	1284	3.37	5.76		4
0.17	1.424	3.400	0.416	0.46%	5.96	3.85	2675	4.18	8.02		5
0.21	1.920	3.800	0.504	0.46%	9.12	5.89	4094	4.75	9.98	**AVERAGE**	6
0.25	2.400	4.200	0.588	0.46%	12.62	8.16	5666	5.26	12.00		7
0.29	3.040	4.560	0.664	0.46%	17.32	11.20	7776	5.70	13.99		8
0.33	3.680	4.880	0.740	0.46%	22.52	14.56	10111	6.12	15.98		9
0.38	4.320	5.340	0.824	0.46%	28.38	18.35	12742	6.57	18.00	**PEAK**	10
0.46	5.600	5.960	0.948	0.46%	40.36	26.09	18119	7.21	21.98		11
0.50	6.240	6.280	1.000	0.46%	46.59	30.11	20914	7.47	24.00		12
0.54	6.880	6.600	1.048	0.46%	52.98	34.25	23783	7.70	26.02		13
0.58	7.520	6.920	1.092	0.46%	59.50	38.46	26711	7.91	27.98		14
0.63	8.320	7.320	1.136	0.46%	67.57	43.68	30333	8.12	30.00		15
0.67	8.960	7.680	1.168	0.46%	74.11	47.91	33271	8.27	32.02		16
0.71	9.600	8.000	1.192	0.46%	80.48	52.02	36129	8.38	33.98		17
0.75	10.080	8.360	1.208	0.46%	85.25	55.11	38271	8.46	36.00		18
0.79	10.560	8.760	1.216	0.46%	89.70	57.98	40269	8.49	38.02		19
0.83	11.200	9.160	1.216	0.46%	95.13	61.50	42709	8.49	39.98		20
0.88	11.680	9.720	1.204	0.46%	98.56	63.71	44249	8.44	42.00		21
0.92	12.160	10.280	1.176	0.46%	101.03	65.31	45357	8.31	44.02		22
0.96	12.320	10.960	1.132	0.46%	99.82	64.52	44812	8.10	45.98		23
1.00	12.560	12.560	1.000	0.46%	93.77	60.61	42095	7.47	48.00		24

2/3 pipe depth
32

48" can convey peak flow @ less than ½ full.
(slope = 0.46%)

GRAVITY PIPE FLOW CALCULATIONS FOR 36-INCH GRAVITY SEWER

42-inch Gravity Sewer		PIPE DIA	42		AVG Q=	7.87 MGD	Pipe length= 11000
PROJECT NO.:	30508	SLOPE	0.0024	FT/FT	PEAK Q=	24.00 MGD	Required Drop 26.4 ft
DATE: 9/6/2012		PIPE n	0.0135				
					AVG Q=	5509 GPM	9
CALCs. BASED ON Q=1.486/n x AR2/3 X S1/2					PEAK Q=	16800 GPM	15
CFS / 1.547 = MGD VEL=Q/A							

d/D RATIO	PIPE-AF (SQ FT)	WET PER	HYD R	SLOPE %	FLOW (CFS)	FLOW (MGD)	GPM	VEL	DEPTH (INCHES)		
0.02	0.045	0.980	0.035	0.24%	0.03	0.02	12	0.59	0.84		1
0.04	0.135	1.400	0.091	0.24%	0.15	0.10	67	1.11	1.68		2
0.08	0.355	1.995	0.179	0.24%	0.61	0.40	276	1.73	3.36		3
0.12	0.649	2.485	0.263	0.24%	1.45	0.94	650	2.23	5.04		4
0.17	1.090	2.975	0.364	0.24%	3.02	1.95	1355	2.77	7.01		5
0.21	1.470	3.325	0.441	0.24%	4.62	2.99	2073	3.14	8.74		6
0.25	1.838	3.675	0.515	0.24%	6.39	4.13	2869	3.48	10.50		7
0.29	2.328	3.990	0.581	0.24%	8.77	5.67	3937	3.77	12.24		8
0.33	2.818	4.270	0.648	0.24%	11.40	7.37	5120	4.05	13.99	**AVERAGE**	9
0.38	3.308	4.672	0.721	0.24%	14.37	9.29	6452	4.35	15.75		10
0.46	4.288	5.215	0.830	0.24%	20.44	13.21	9175	4.77	19.24		11
0.50	4.778	5.495	0.875	0.24%	23.59	15.25	10590	4.94	21.00		12
0.54	5.268	5.775	0.917	0.24%	26.83	17.34	12043	5.09	22.76		13
0.58	5.758	6.055	0.956	0.24%	30.13	19.48	13526	5.23	24.49		14
0.63	6.370	6.405	0.994	0.24%	34.21	22.12	15360	5.37	26.25	**PEAK**	15
0.67	6.860	6.720	1.022	0.24%	37.53	24.26	16847	5.47	28.01		16
0.71	7.350	7.000	1.043	0.24%	40.75	26.34	18295	5.54	29.74		17
0.75	7.718	7.315	1.057	0.24%	43.17	27.90	19379	5.59	31.50		18
0.79	8.085	7.665	1.064	0.24%	45.42	29.36	20391	5.62	33.26		19
0.83	8.575	8.015	1.064	0.24%	48.17	31.14	21627	5.62	34.99		20
0.88	8.943	8.505	1.054	0.24%	49.91	32.26	22406	5.58	36.75		21
0.92	9.310	8.995	1.029	0.24%	51.16	33.07	22968	5.50	38.51		22
0.96	9.433	9.590	0.991	0.24%	50.55	32.67	22692	5.36	40.24		23
1.00	9.616	10.990	0.875	0.24%	47.48	30.69	21316	4.94	42.00		24

2/3 pipe depth
28

42" can convey peak flow @ 2/3 full.
(0.24% slope)

GRAVITY PIPE FLOW CALCULATIONS FOR 36-INCH GRAVITY SEWER

36-inch Gravity Sewer		PIPE DIA	36		AVG Q=	7.87 MGD	Pipe length= 11000
PROJECT NO.:	30508	SLOPE	0.0054	FT/FT	PEAK Q=	24.00 MGD	Required Drop 59.4 ft
DATE: 9/10/2012		PIPE n	0.0135				
					AVG Q=	5509 GPM	9
CALCs. BASED ON Q=1.486/n x AR2/3 X S1/2					PEAK Q=	16800 GPM	16
CFS / 1.547 = MGD VEL=Q/A							

d/D RATIO	PIPE-AF (SQ FT)	WET PER	HYD R	SLOPE %	FLOW (CFS)	FLOW (MGD)	GPM	VEL	DEPTH (INCHES)		
0.02	0.033	0.840	0.030	0.54%	0.03	0.02	12	0.80	0.72		1
0.04	0.099	1.200	0.078	0.54%	0.15	0.10	67	1.50	1.44		2
0.08	0.261	1.710	0.153	0.54%	0.61	0.40	275	2.34	2.88		3
0.12	0.477	2.130	0.225	0.54%	1.44	0.93	647	3.02	4.32		4
0.17	0.801	2.550	0.312	0.54%	3.00	1.94	1348	3.75	6.01		5
0.21	1.080	2.850	0.378	0.54%	4.60	2.97	2064	4.26	7.49		6
0.25	1.350	3.150	0.441	0.54%	6.36	4.11	2856	4.71	9.00		7
0.29	1.710	3.420	0.498	0.54%	8.73	5.64	3920	5.11	10.49		8
0.33	2.070	3.660	0.555	0.54%	11.35	7.34	5096	5.48	11.99	**AVERAGE**	9
0.38	2.430	4.005	0.618	0.54%	14.31	9.25	6423	5.89	13.50		10
0.46	3.150	4.470	0.711	0.54%	20.34	13.15	9133	6.46	16.49		11
0.50	3.510	4.710	0.750	0.54%	23.48	15.18	10542	6.69	18.00		12
0.54	3.870	4.950	0.786	0.54%	26.70	17.26	11988	6.90	19.51		13
0.58	4.230	5.190	0.819	0.54%	29.99	19.39	13464	7.09	20.99		14
0.63	4.680	5.490	0.852	0.54%	34.06	22.02	15290	7.28	22.50		15
0.67	5.040	5.760	0.876	0.54%	37.36	24.15	16771	7.41	24.01	**PEAK**	16
0.71	5.400	6.000	0.894	0.54%	40.57	26.22	18211	7.51	25.49		17
0.75	5.670	6.270	0.906	0.54%	42.97	27.78	19291	7.58	27.00		18
0.79	5.940	6.570	0.912	0.54%	45.21	29.23	20298	7.61	28.51		19
0.83	6.300	6.870	0.912	0.54%	47.95	31.00	21528	7.61	29.99		20
0.88	6.570	7.290	0.903	0.54%	49.68	32.12	22304	7.56	31.50		21
0.92	6.840	7.710	0.882	0.54%	50.93	32.92	22863	7.45	33.01		22
0.96	6.930	8.220	0.849	0.54%	50.31	32.52	22588	7.26	34.49		23
1.00	7.065	9.420	0.750	0.54%	47.26	30.55	21219	6.69	36.00		24

2/3 pipe depth
24

36" can convey peak flow @ 2/3 ft.
(0.54% slope)

Appendix B

Supporting Cost Details for Table 5 of the Memorandum

Northwest Cary Force Main Diversion Evaluation- Preliminary Cost Estimate- September 2012

Immediate Improvement Costs

	Quantity	Units	Unit cost	Material	Labor	Total cost
Force Main Piping						
Piping Section No. 3A – New 30-inch Force Main	3,900	LF	$185	$721,500	$216,450	$937,950
5% Misc Valves		LS	-	-	-	$46,898
Piping Section No. 4 – New 42-inch Gravity Interceptor	9,000	LF	$356	$3,204,000	$961,200	$4,165,200
2% Misc Valves		LS	-	-	-	$83,304
Piping Section No. 4 – New 48-inch Gravity Interceptor	1,000	LF	$406	$406,000	$121,800	$527,800
2% Misc Valves		LS	-	-	-	$10,556
Sub Total						**$5,771,708**

2020 Improvement Costs

	Quantity	Units	Unit cost	Material	Labor	Total cost
Kit Creek Pump Station						
Installation of Valve Vault Structure		LS	$198,000			$198,000
12" 90 Deg Elbow (FL)	1	EA	$975	$975	$293	$1,268
12" DIP (FL)	45	LF	$111	$4,995	$1,499	$6,494
12" Swing Check	1	EA	$6,000	$6,000	$1,800	$7,800
12" Plug Valve	1	EA	$5,000	$5,000	$1,500	$6,500
20" DIP	60	LF	$185	$11,100	$3,330	$14,430
20" 90 Deg Elbow (MJ)	3	EA	$2,040	$6,120	$1,836	$7,956
20" X 12" Tee (FL)	4	EA	$2,055	$8,220	$2,466	$10,686
20" Plug Valve	4	EA	$8,000	$32,000	$9,600	$41,600
450 hp Pumps	4	EA	$128,638	$514,550	$51,455	$566,005
VFD's	4	EA	$157,500	$630,000	-	$630,000
Lighting		LS	$5,000	-	-	$5,000
Electrical Distribution Equipment		LS	$100,000	-	-	$100,000
Electrical Misc at 20%		LS	$21,000	-	-	$21,000
Sub Total						**$1,616,738**
Morris Branch Regional Pump Station						
350 hp Pumps	3	EA	$78,750	$236,250	$23,625	$259,875
VFD's	3	EA	$122,500	$367,500	-	$367,500
Lighting		LS	$5,000	-	-	$5,000
Electrical Distribution Equipment		LS	$70,000	-	-	$70,000
Electrical Misc		LS	$15,000	-	-	$15,000
Sub Total						**$717,375**
2020 Improvement Cost						**$2,334,113**

2030 Improvements

	Quantity	Units	Unit cost	Mat. Cost	Installation	Total cost
Force Main Piping						
Kit Creek Service Rd. Piping Section – New 20-inch Force Main	1,100	LF	$123	$135,300	$40,590	$175,890
5% Misc Valves		LS	-	-	-	$8,795
Piping Section No. 3B – New 24-inch Force Main	5,400	LF	$148	$799,200	$239,760	$1,038,960
5% Misc Valves		LS	-	-	-	$51,948
Sub Total						**$1,275,593**
2030 Improvement Cost						**$1,275,593**

Build-out Improvements

	Quantity	Units	Unit cost	Mat. Cost	Installation	Total cost
Kit Creek Pump Station						
Upsize impellers for 450 hp pumps	4	EA	$6,000	$24,000	$4,800	$28,800
16" DIP (FL)	180	LF	$148	$26,640	$7,992	$34,632
16" 90 Deg Elbow (FL)	4	EA	$1,515	$6,060	$1,818	$7,878
20" X 16" Tee	4	EA	$2,520	$10,080	$3,024	$13,104
16" Swing Check	4	EA	$7,000	$28,000	$8,400	$36,400
16" Plug Valve	4	EA	$8,000	$32,000	$9,600	$41,600
Sub Total						**$162,414**
Morris Branch Regional Pump Station						
350 hp pumps	1	EA	$78,750	$78,750	$7,875	$86,625
VFD's	1	EA	$122,500	$122,500	-	$122,500
Electrical Distribution Equipment		LS	$23,333	-	-	$23,333
Electrical Misc		LS	$4,667	-	-	$4,667
Sub Total						**$237,125**
Build-out Improvement Cost						**$399,539**

Total Cost **$9,780,952**