Appendix M

Meadow Glade Hydraulic Analysis

TECHNICAL MEMORANDUM

Date: August 25, 2017

To: Shawn Moore, Robin Krause

From: Craig Chambers, Dave Harms, Kranti Maturi

Subject: Meadow Glade Hydraulic Analysis

Project No: 15-10377.01

BHC performed a hydraulic modeling analysis for the Clark Regional Wastewater District to evaluate the Meadow Glade mini-basin's STEP system capacity. The analysis was performed to characterize and evaluate the available capacity of the collection system during existing and future buildout peak flow conditions. Of particular interest to the District, is a dialysis center that contributes significant flow to the southeast portion of the system. The District desires to understand the impact of the dialysis center on overall system capacity as population grows within the mini-basin from existing to buildout conditions.

Model Analysis Approach

BHC prepared a hydraulic model as part of the Clark Regional Comprehensive General Sewer Plan Update, however it did not include the Meadow Glade collection system. BHC, therefore, developed a separate, stand-alone hydraulic model for the Meadow Glade mini-basin analysis.

The analysis was performed using MIKE Urban modeling software (release 2016, SP1), by DHI. MIKE Urban software is developed specifically for modeling urban sanitary and combined sewer systems and calculates both gravity and pressure flow, surcharging in manholes, backwater effects and reversal of flow. The software operates interactively with ArcGIS.

The modeling approach for this analysis is briefly described in the following steps and is described in additional detail in the subsequent sections:

1. Import GIS background data received from the District into the model. This data is used as a basis for model development and supplemented by selected as-built drawings and field survey verification.
2. Manually enter the “nodes” and “links”. Nodes are service structures such as cleanouts, air-vac valves and pipe junctions and links are the connecting pipes.
3. Review the model for data omissions or errors using the software’s “project check” function and fix the errors.
4. Investigate characteristics of STEP system collective operations and group the STEP systems into “clusters” of pumps. Input one pump into the model representing each cluster. Input wet wells for each modeled pump.
5. Load “high-head” and “low-head” pump curves into the model.
6. Load sanitary wastewater flows for the 2016 condition, which is equivalent to 735 Equivalent Residential Units (ERUs), into the model. These flows were developed for the General Sewer Plan update effort.
7. Develop and input unitless diurnal demand curves and peaking factors for the Meadow Glade system using the actual flowmeter data received from the District.
8. Import rainfall data previously received from the District into the model.
9. Setup RDI module method to simulate inflow and infiltration (I/I) and set initial related parameter values based on I/I evaluation.
10. Perform diagnostic model runs and debug as necessary.
11. Calibrate the model to available flow monitoring and pressure data for the 2016 condition. Flow monitoring data is available for the time period between February 10, 2017 and March 2, 2017.
    a. Perform dry model runs, iteratively adjusting flow and loadings to match available data for the dry weather conditions.
    b. Perform wet weather model runs, adjusting I/I parameters to match the wet weather conditions.
12. Load sanitary wastewater flows into the model for the buildout condition, which is equivalent to 1377 ERUs. Use the same I/I parameters as the 2016 condition.
13. Perform system analysis for the buildout condition and characterize the system performance.

Model Input Parameters

Data sources

The following information was obtained from the District in developing the model for the existing Meadow Glade mini-basin system:

- GIS map including nodes and pipes (Attachment A). This data is supplemented by selected as-built drawings and field survey verification.
- Additional GIS base data including parcels, streets, zoning, and topography. This information is not provided as part of this memo.
- Meadow Glade Sub mini-basin map (See Figure 1)
- Existing flow meter and pressure meter logger locations (See Figure 1).
- Rainfall data for the SMN045 gauge that is located near the Meadow Glade mini-basin.
- STEP system/STEP tank configuration (Attachment B).
- Pump curves for high-head and low-head pumps. Anecdotal data about the location of the high- and low-head pumps (Attachment B).
- Diurnal curves for the week days and weekends that was derived from the flowmeter data provided.

Modeling of Physical System Features

The Meadow Glade mini-basin is divided into 74 “sub mini-basins”. Figure 1 consists of the sub mini-basin ID, existing connected ERUs and available for future connection ERUs.

The model includes 408 nodes. These nodes could not be imported directly from the District-provided GIS database and were therefore added manually to replicate the network in the GIS database.

The model includes 412 pipes or “links”, which were also manually added into the model and connected to associated nodes using their designated up- and downstream node attributes.

Node elevation information was obtained using the topography information provided. The type and diameter of the “links” was available in the GIS database and that information was loaded into the model. A soil cover of 3 feet above the crown of the pipe was assumed.

A pressure sustaining valve was installed near the outlet per the record drawing/as-built drawing information provided by the District, to maintain pipes in full condition and prevent air entrainment within the collection system. The Record Drawings are included as Attachment B.

Approximately 850 STEP pumps and wetwells are in the Meadow Glade mini-basin. Modeling such a large number of pumps is very time-consuming and considered unnecessary for capacity evaluation purposes. Therefore, to simplify the model for the intended use, STEP pumps and wet wells were clustered into groups at an average of 11.5 per each cluster. One STEP pump and wet well representing each cluster was input to the model. Each sub mini-basin is served by an individual cluster. Therefore, the model includes 74 pumps.

The Meadow Glade system has high-head and low-head STEP pumps. Based on the anecdotal information received from the District, the western portion of the system typically has high-head pumps. Pump capacities, pump controls and wet well configurations were defined in the model based on the pump curves and record drawings provided by the District that is included as Attachment B. Pumps were designated as constant speed pumps and generalized wetwell set points for the pumps are input to the model as identified by the District.

Model Flow Input

Peak day flows are comprised of two components: sanitary/dry weather flow (DWF) and infiltration and inflow (I/I), which are loaded separately and simulated using different model functions. Flow scenarios were created for 2016 and buildout conditions.

Dry Weather Flow

DWF flow projections for residential, commercial, and school categories were summarized in Chapter 6 of the GSP. However, population projections presented in Chapter 6 were slightly increased to estimate DWFs for this modeling effort for conservatism.

The number of existing and future residential, commercial, and school category connections that are tributary to Loggers # 1, 2 and 3 were calculated based on the location and the ERU data presented in Figure 1.

The dialysis center is represented as sub mini-basin # 97 and is located near the intersection of SW 40th Street and SW 38th CIR. Each ERU in the dialysis center is equivalent to 22 ERUs for the 2016 condition per the information received from the District. The same factor of 22 ERUs is assumed for the buildout condition. These factors are not added to the 735 ERUs and 1377 ERUs for the 2016 and buildout conditions.

The 2016 DWF was divided based on the number of connections within each category and tributary to the loggers. For example, DWF for residential category that is tributary to logger # 1. Similarly, DWF for all three categories that are tributary to loggers # 1, 2 and 3 were calculated. These DWFs were loaded into the model.

Table 1 provides information on the number of connections in 2016 and buildout DWFs per each category and tributary area. Each sub mini-basin has one flow connection in the model.

Infiltration and Inflow

Rainfall data for SMN045 gauge that is near the Meadow Glade mini-basin was obtained from the District. This rainfall data was modified into a DFS0 file format, which is compatible with the MIKE URBAN model.

Simulation of I/I in the model is accomplished using the MIKE Urban Rainfall Dependent Infiltration (RDI) module, together with the model's "Time-Area A" ("A") module to simulate infiltration. Model setup for I/I simulation is accomplished by subdividing the mini-basin into multiple "catchments" and assigning RDI and "A" module parameter values governing the response to rainfall for each catchment. Each sub mini-basin was delineated as a catchment. Each catchment discharges to a single node that is identified in the model.

I/I can be a significant component of the total wastewater flow. The I/I flow component is reflective of current conditions and that, as the STEP systems continue to age and degrade, the volume of I/I entering the system may continue to increase.

Diurnal patterns

Flowmeter data is available for the time period between February 10 and March 2, 2017. Diurnal patterns for the weekdays and weekends for the DWF were developed by normalizing dry-day flow for weekdays and weekends. Multiple days of dry weather flow were averaged to produce weekday, Saturday, and Sunday patterns at each calibration location.

Model Calibration

Model calibration is performed to ensure that the modeled collection system is an accurate representation of the mini-basin's physical system and flows. Calibration is an iterative process of adjusting model parameters that control simulated flow, until model output matches measured real world data within acceptable limits.

District maintains the following three pressure meter loggers in the mini-basin:

1. Logger # 1 located on east side of Cramer Road approximately 100 feet north of NE 183rd Street.
2. Logger # 2 located at Air Release Valve 47-639 that is located near intersection of SW 10th Avenue and 184th Street.
3. Logger # 3 located near the intersection of SW 10th Avenue and SW Eaton Street

These logger locations are shown on Figure 1.

There is one flowmeter that captures all the flow from Meadow Glade mini-basin before it is discharged into the Battleground pump station.

Calibration was performed at the three loggers (Loggers # 1, 2 and 3) and one flow meter location. The data received from the District for loggers 1 and 2 was for the time period between January 23, 2017 and March 1, 2017, for logger 3 was for the time period between December 8, 2016 and March 1, 2017 and for the flowmeter was the time period between February 10, 2017 and March 2, 2017.

Sanitary flow loaded into the model at each node is factored over the 24-hour simulation period, according to the assigned diurnal pattern. Diurnal patterns were adjusted as necessary during calibration, to account for hydraulic attenuation in the collection system and achieve a match between simulated and measured flow. DWF calibration is illustrated for loggers 1, 2, 3 and the flow meter in Figures 2 through 5. Three dry days, February 22 through 25, were selected for the dry weather calibration. The remaining days for which the measured data was available were affected by rainfall and were wet.

Total volume is also checked during model calibration, to verify that per capita rates derived in Chapter 6 of the General Sewer Plan, result in an acceptable volume match between simulated and measured flow. Total volume was within 4 percent for a slightly longer duration than the dry weather days (February 11 to February 25, 2017).

Manufacturer's pump curves were loaded into the model for the pump clusters, together with operational controls, wet well configurations and system piping information. Pump curves from the manufacturer represent the curve for one STEP pump. Pump curve sensitivity was checked by increasing it to represent more pumps in the cluster. The closest match to the actual pressure data was achieved however, by simulating one individual pump in the model. This implies that no two pumps start at the same time within a cluster. However, all flows from the area served by a cluster are processed by one pump, so the pump operates more frequently. Simulated pump discharge data was plotted versus simulated total dynamic head (TDH) downstream of the pump, (See Figure 9) to verify that pumps were operating as expected and also to check that the model was producing stable pump discharge.

After an acceptable match is achieved between simulated and measured flow and pressure for the dry weather condition, the model is calibrated to wet weather flow by applying local rainfall data and adjusting parameter values that govern the hydrologic response from the RDI and "A" modules in MIKE Urban. Parameter values were adjusted iteratively, until an acceptable pressure match was achieved at the three logger locations and flow matched the flowmeter, for the wet days. The primary calibration parameter for wet weather flow is the percentage of mini-basin area that contributes runoff to I/I flow in the pipes. It is representative of the presence of cracks and defects in the pipes for the RDI module and direct inflow to the pipes through direct connections or through manhole lids, etc. For STEP systems, I/I input to the system is limited to the upstream or suction side of each pump.

System Analysis

After model calibration and analysis for the 2016 condition was completed, an analysis was performed for the buildout DWF condition. Results for the dry weather buildout condition are illustrated on Figures 6 through 8.

The model output generated pump output summary was checked for pumps that had significant numbers of stops/starts and for pumps that had long run times. The pump representing the dialysis center STEP system was found to be one of the pumps that had significant stops/starts and long run times.

Figure 9 illustrates pump operation for the dialysis center pump. The TDH vs discharge for the buildout scenario had relatively higher TDH and lower discharge than the 2016 condition. Note that system head is measured in the piping system somewhat downstream of the pump discharge point, which is why the model output points are below and above the pump curve.

In the buildout DWF scenario, it was observed that the pumps were turning on more frequently than in the 2016 condition (See Figures 10 through 12). However, the system appeared to have capacity to handle the additional flow for the buildout condition since the wet wells were still emptying. System capacity appears adequate for the overall mini-basin for the buildout DWF scenario. System pressure was slightly higher in the buildout DWF scenario than for the existing DWF scenario.

The model was also run to determine if the system will have capacity for the buildout wet weather condition. The days prior to February 22nd and after the 25th within the time period evaluated were wet weather days. Higher rainfall (5.1 inches) that occurred on January 18, 2017 was assigned to February 21, 2017 to simulate the wet weather buildout condition using that storm event.

The system also has capacity to handle additional flow resulting from the wet weather buildout condition. Model results indicate the pumps run longer than the other scenarios but are able to keep up with inflow. Results for the wet weather condition are illustrated on Figures 10 through 12.

System pressures are illustrated in Plan view for the 2016, dry weather buildout and wet weather buildout conditions in Figures 13, 14 and 15. Pressures for the dry weather buildout scenario are approximately 5 to 10 feet of head higher than the 2016 scenario and pressures for the wet weather buildout condition are approximately 10 to 15 feet of head higher than the 2016 condition. These pressures appeared to be well within acceptable limits.

In conclusion, model results indicate that system capacity is sufficient for the 2016 and buildout conditions.

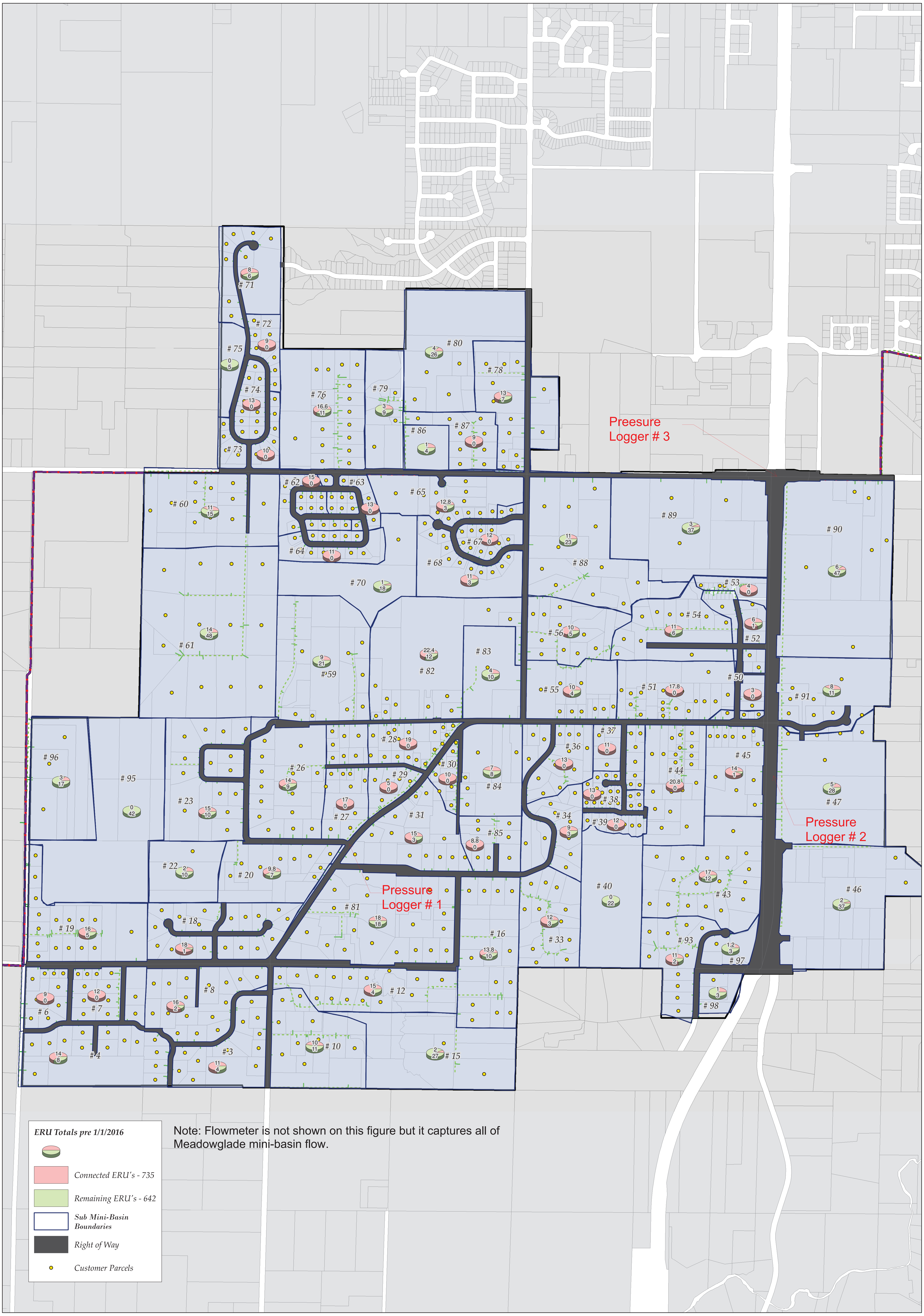
TABLES

Table 1 - Approx. 2016 DWF and Buildout Loading into the Model per Connection

Category	2016 Connections in the Model	2016 DWF Per Connection Loaded into the Model (gpd)*	Buildout Connections in the Model	Buildout DWF Per Connection Loaded into the Model (gpd)*
Residential Tributary to Logger # 1	16	2,106	16	2,998
Residential Tributary to Logger # 2 except for Dialyses Center	5	1,277	5	3,172
Residential Tributary to Logger # 2 Only from Dialyses Center	1	3,900	1	13,841
Residential Tributary to Logger # 3	25	1,993	27	3,047
Residential Tributary to Logger # 4	13	1,964	13	2,226
Commercial/Employment Tributary to Logger # 1	2	248	2	1,034
Commercial/Employment Tributary to Logger # 2			1	1,820
Commercial/Employment Tributary to Logger # 3	1	248	1	2,151
Commercial/Employment Tributary to Logger # 4	5	176	6	1,889
School Tributary to Logger # 1	1	3,132	1	3,132
School Tributary to Logger # 3	2	2,820	2	2,820

This is obtained by proportionally dividing the DWF per total ERUs in each tributary. Each mini-basin has one connection in the model.

FIGURES



CLARK REGIONAL WASTEWATER DISTRICT

Figure 1 - Meadowglade Sub Mini- Basins
Meadowglade Hydraulic Analyses
Project No. 15-10377.01

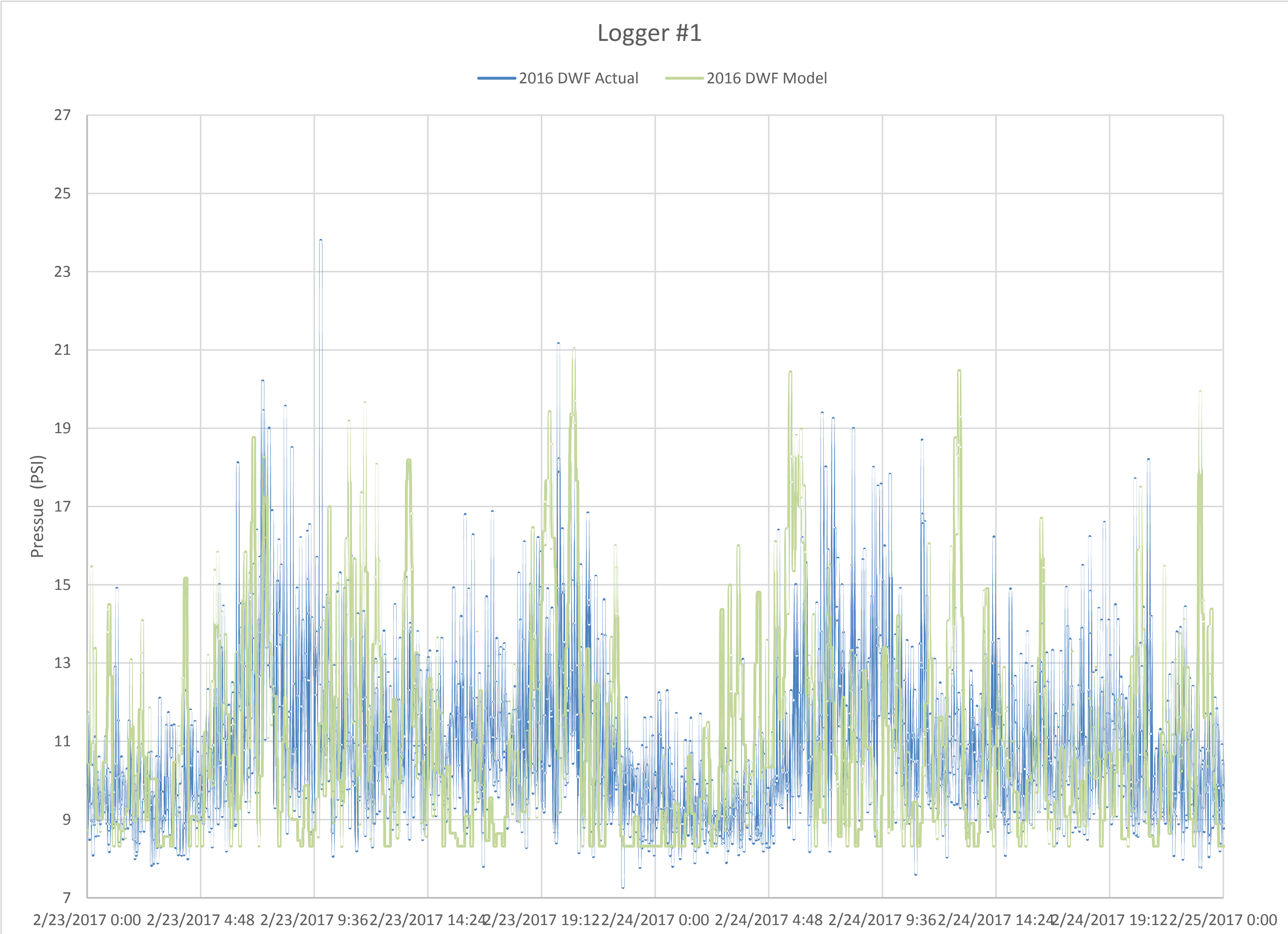


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Figure 2 - 2016 DWF Calibration at Logger # 1

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

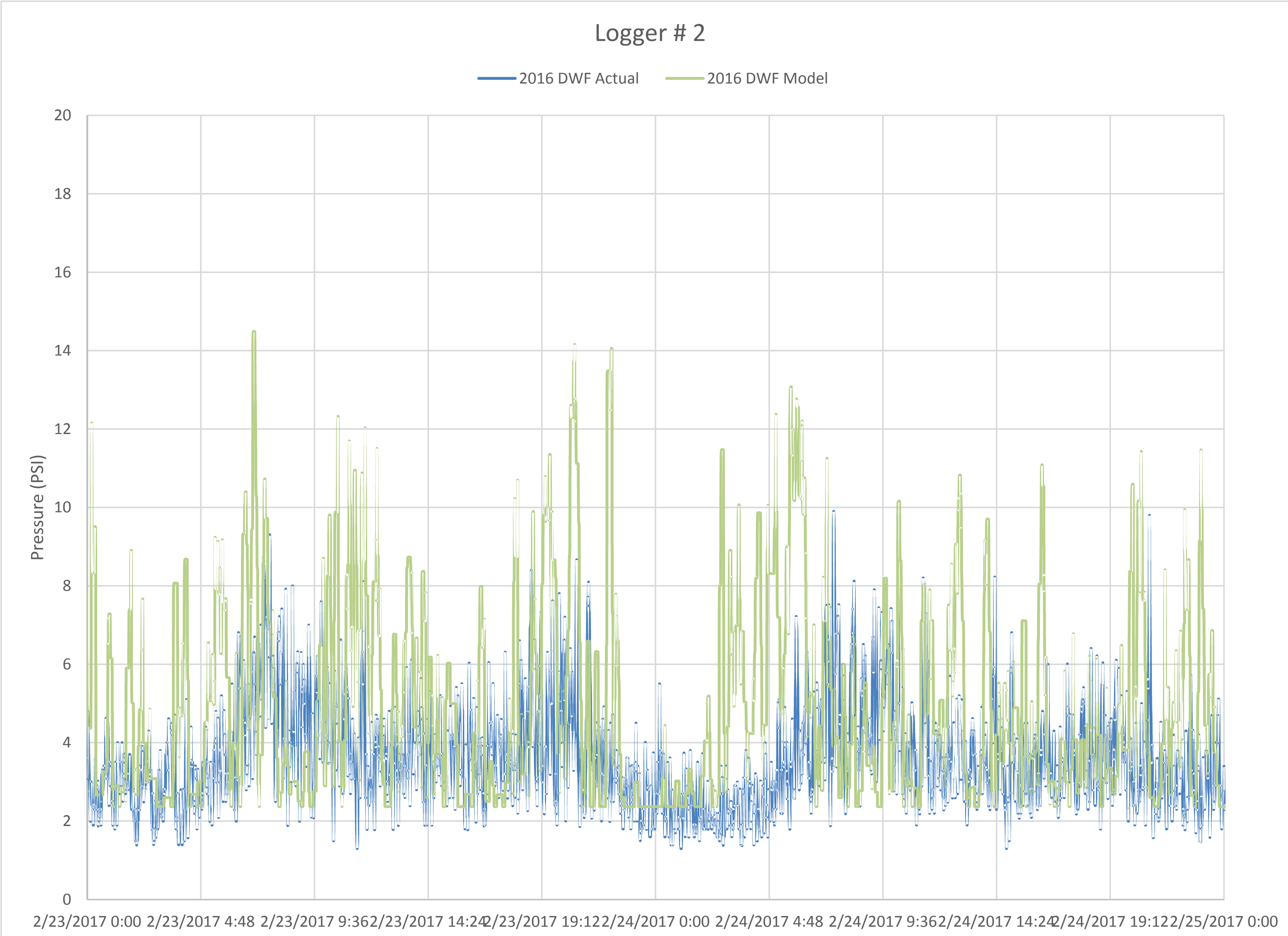

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Figure 3 - 2016 DWF Calibration at Logger # 2

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

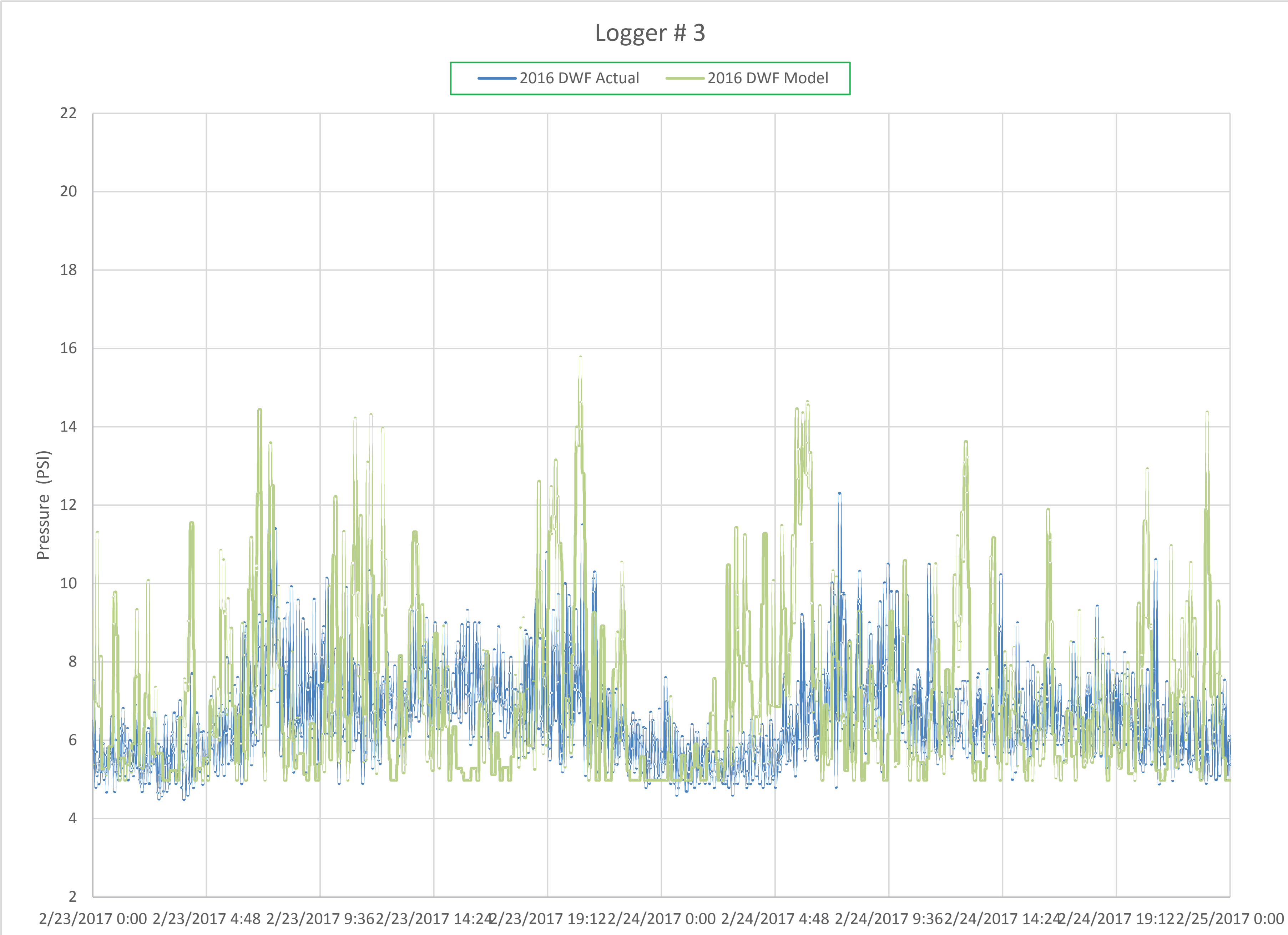

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Figure 4 - 2016 DWF Calibration at Logger # 3

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

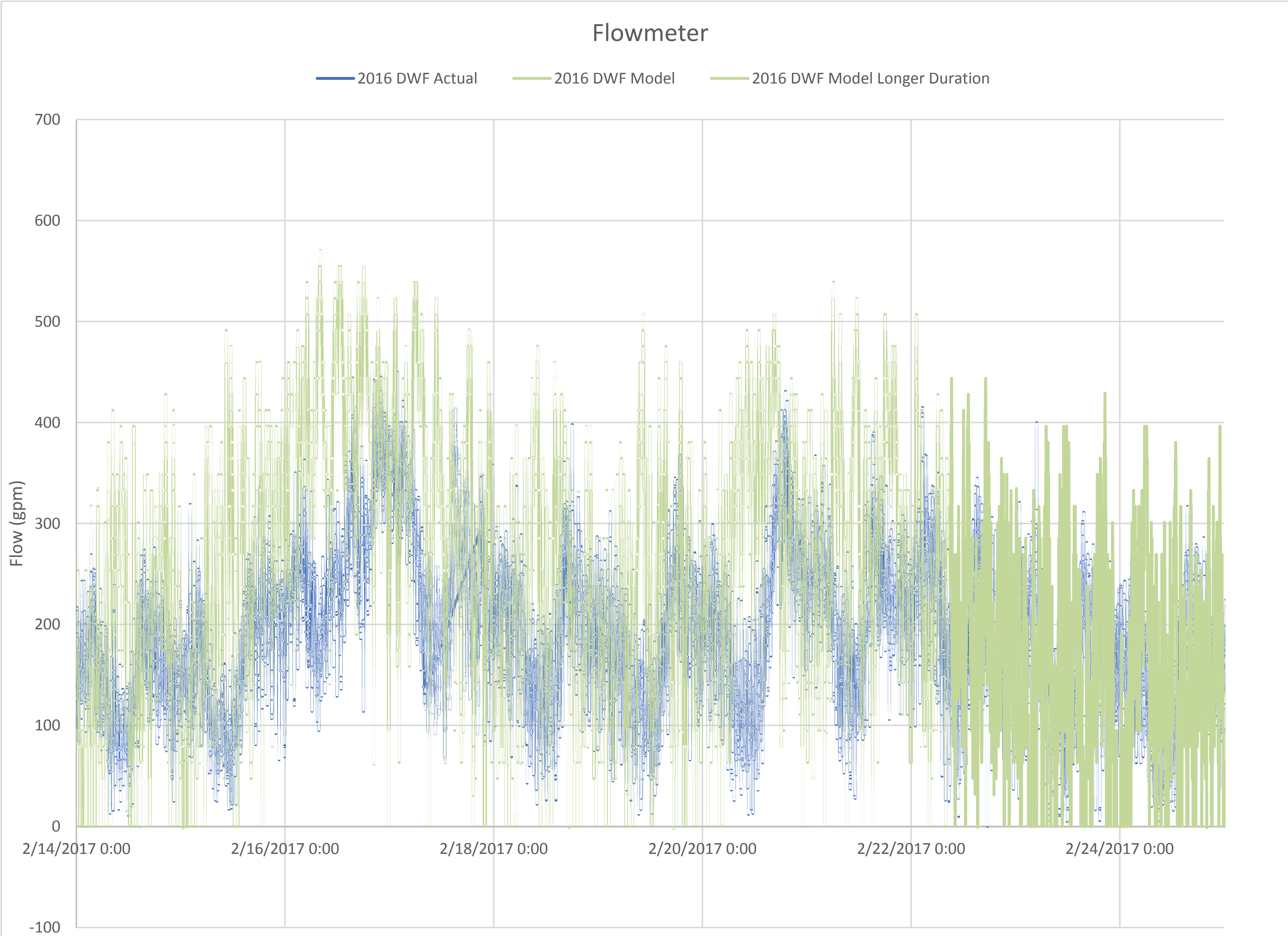

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Figure 5 - 2016 DWF Calibration at Flowmeter

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

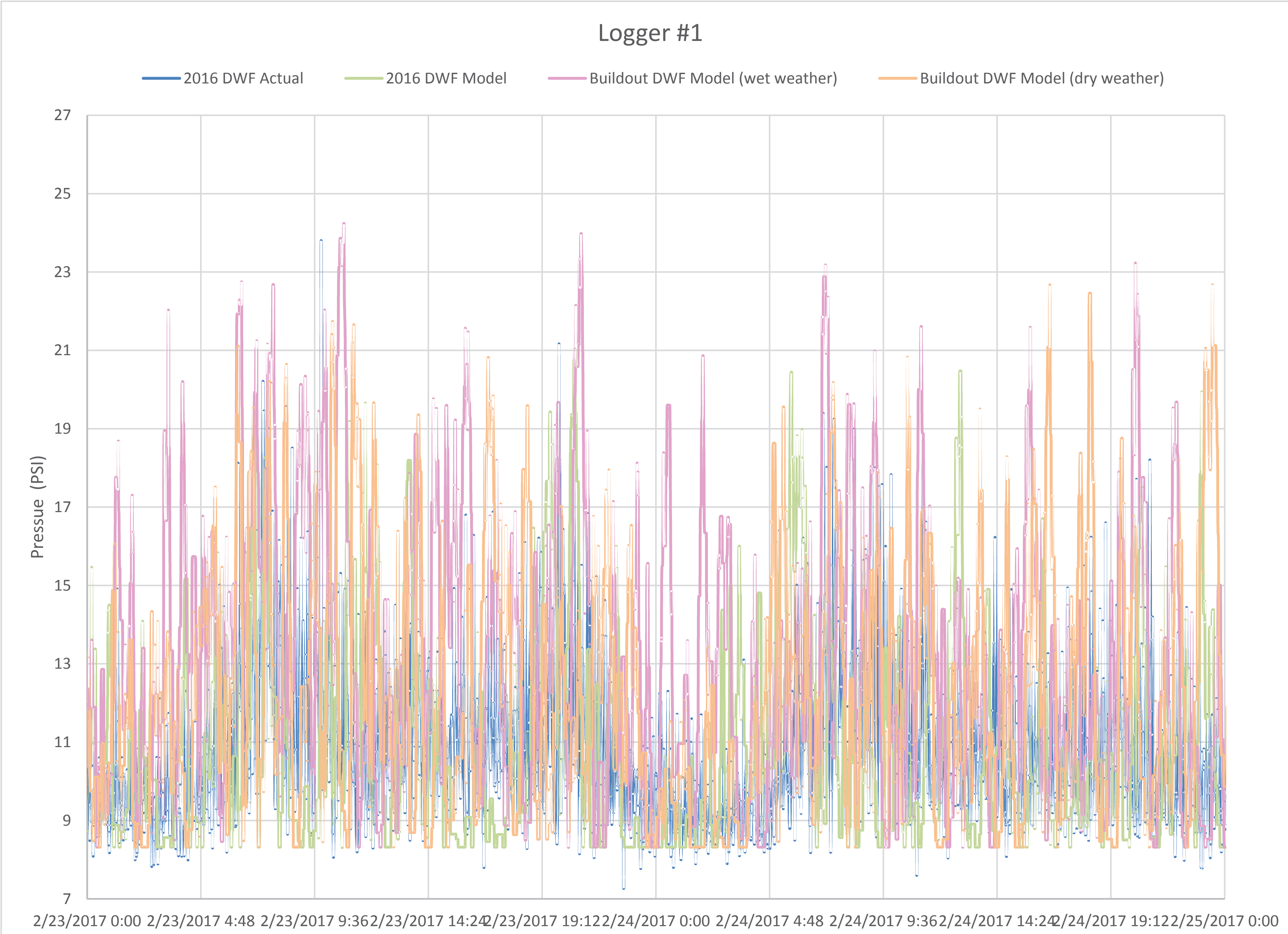

Figure 6 - Buildout DWF Logger # 1

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

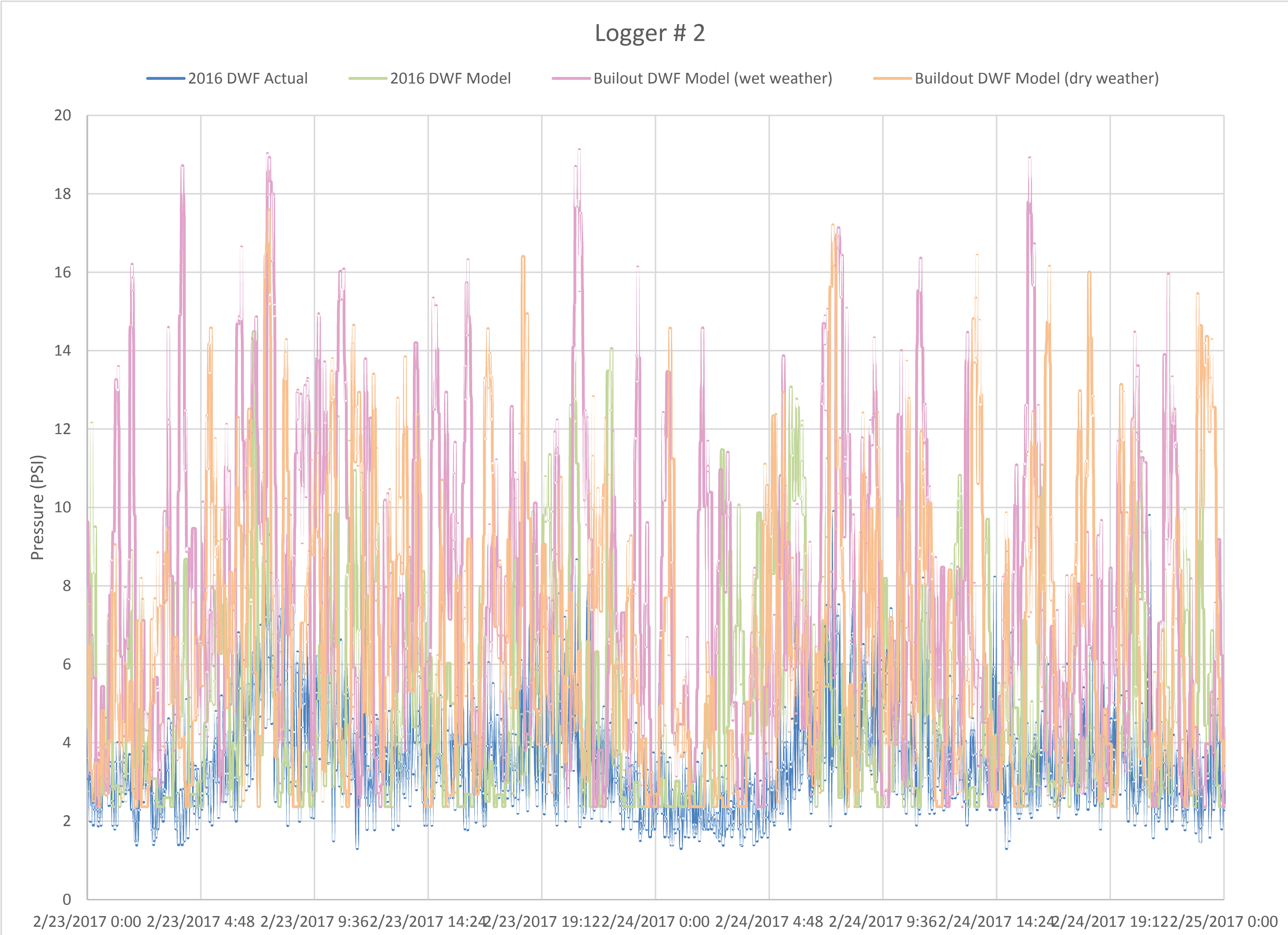

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Figure 7 - Buildout DWF Logger # 2
Meadowglade Hydraulic Analyses
Project No. 15-10377.01

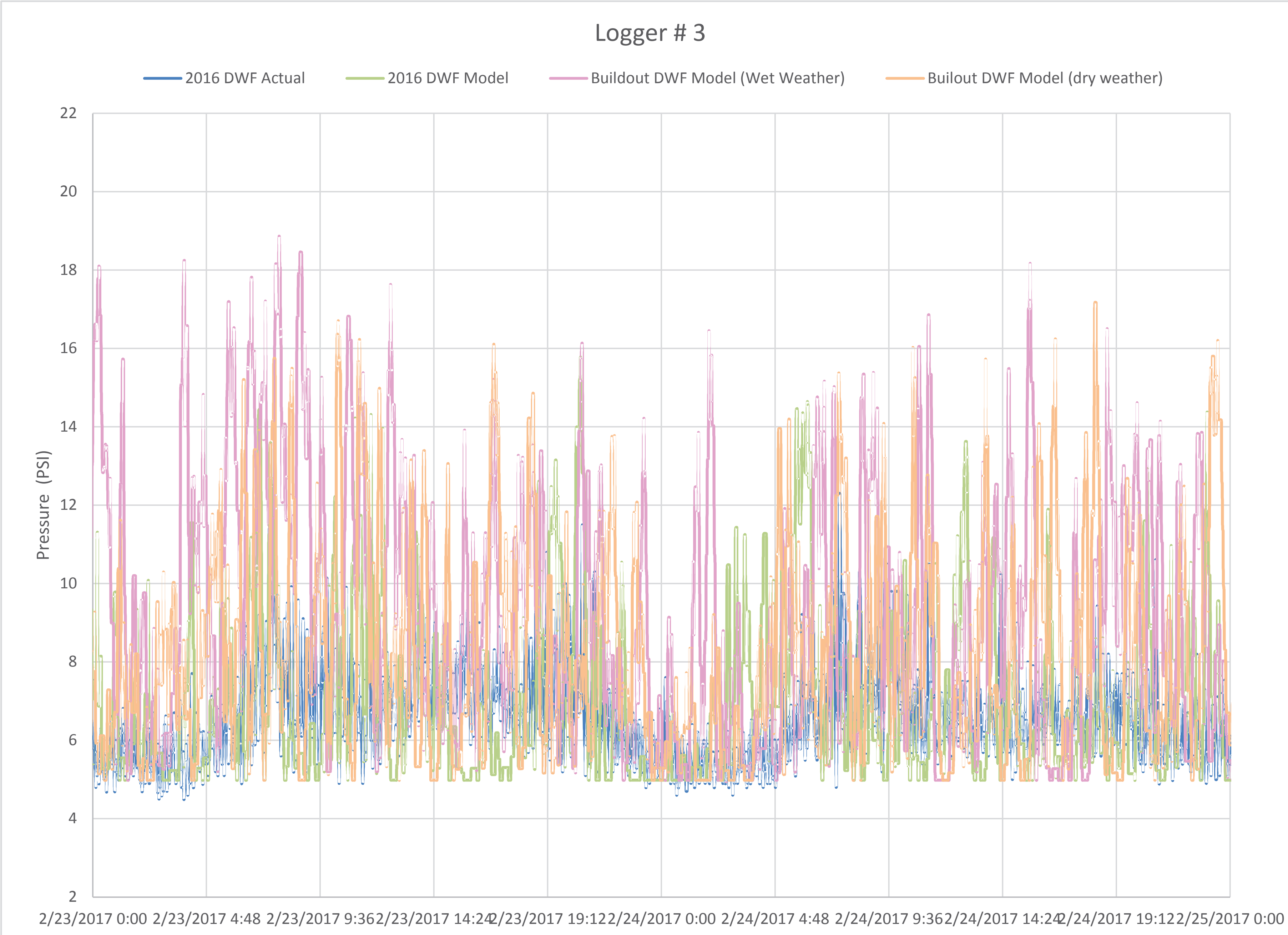

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Figure 8 - Buildout DWF Logger # 3

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

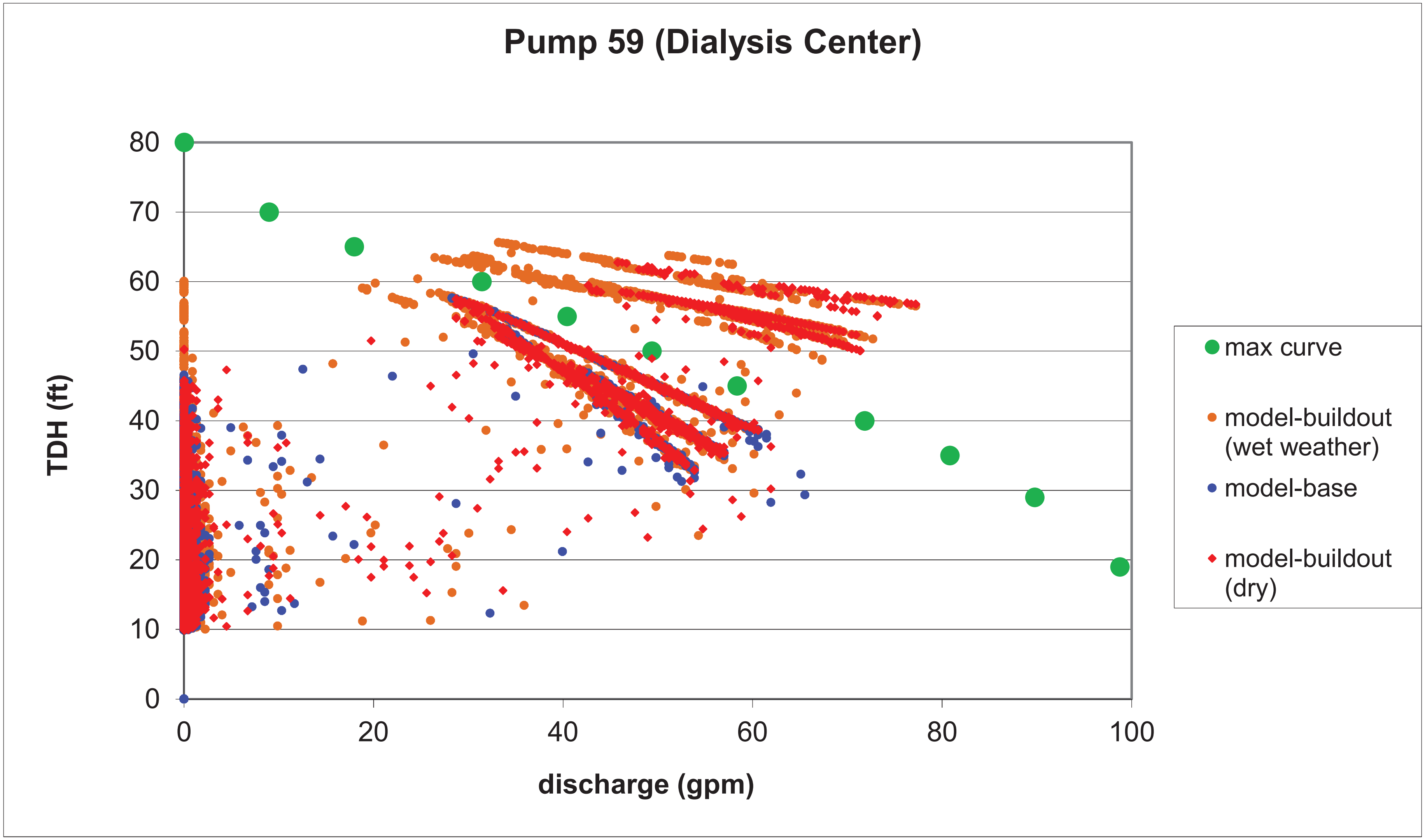
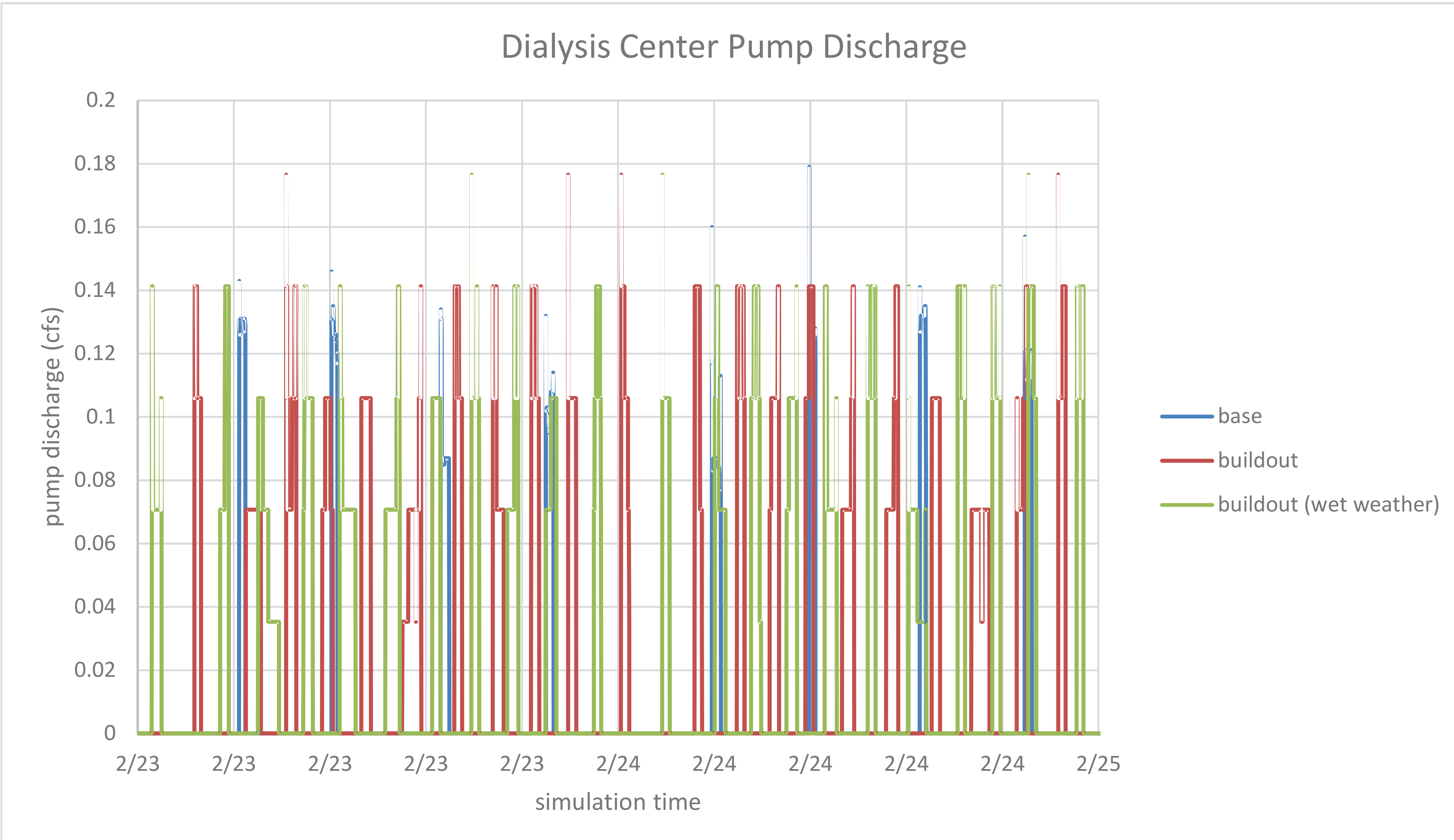


Figure 9 - TDH VS Discharge at Dialyses Center Pump
Meadowglade Hydraulic Analyses
Project No. 15-10377.01



CONSULTANTS

Figure 10 - Pump Discharge at Dialyses Center

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

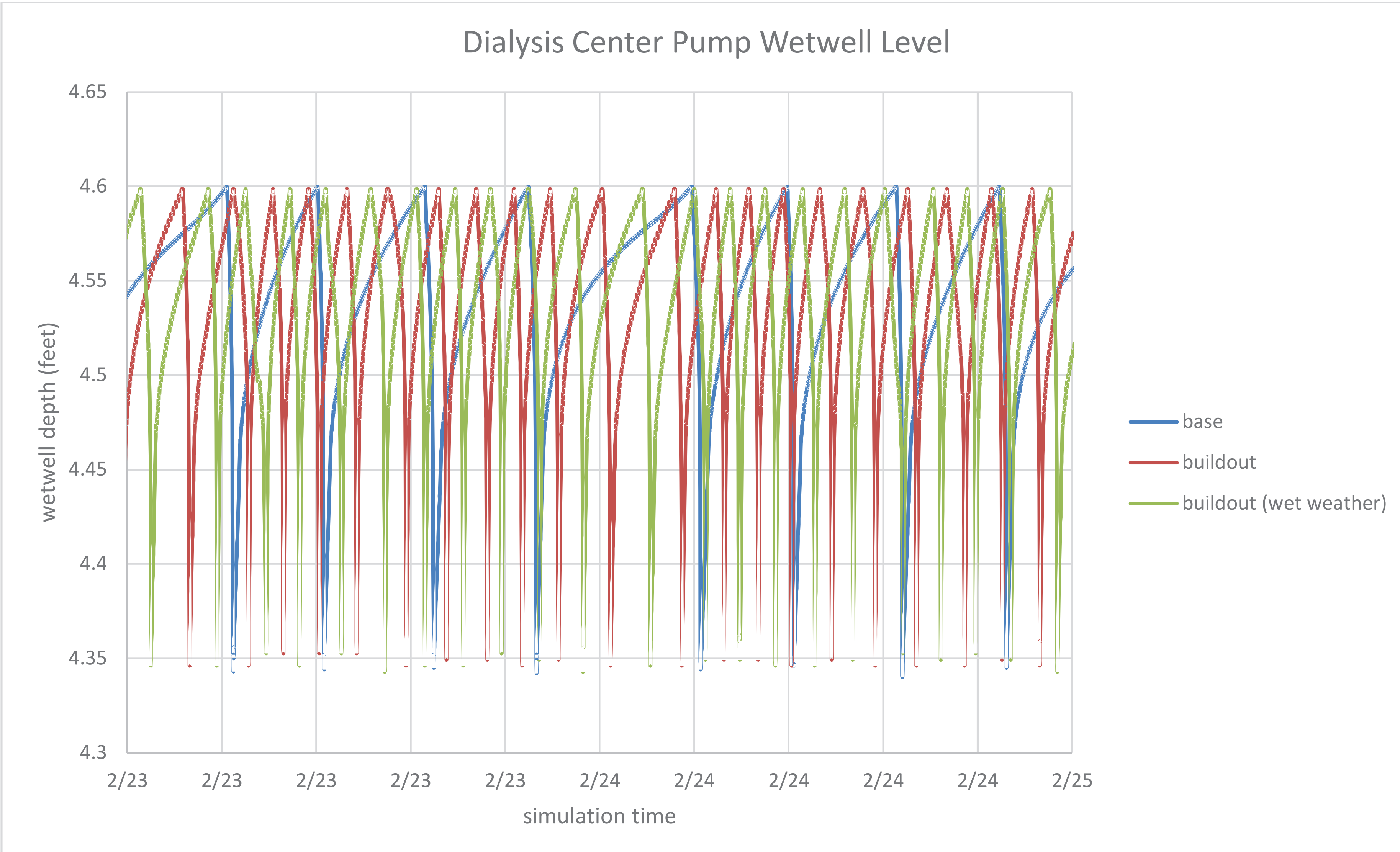


Figure 11 - Wetwell Level at Dialyses Center

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

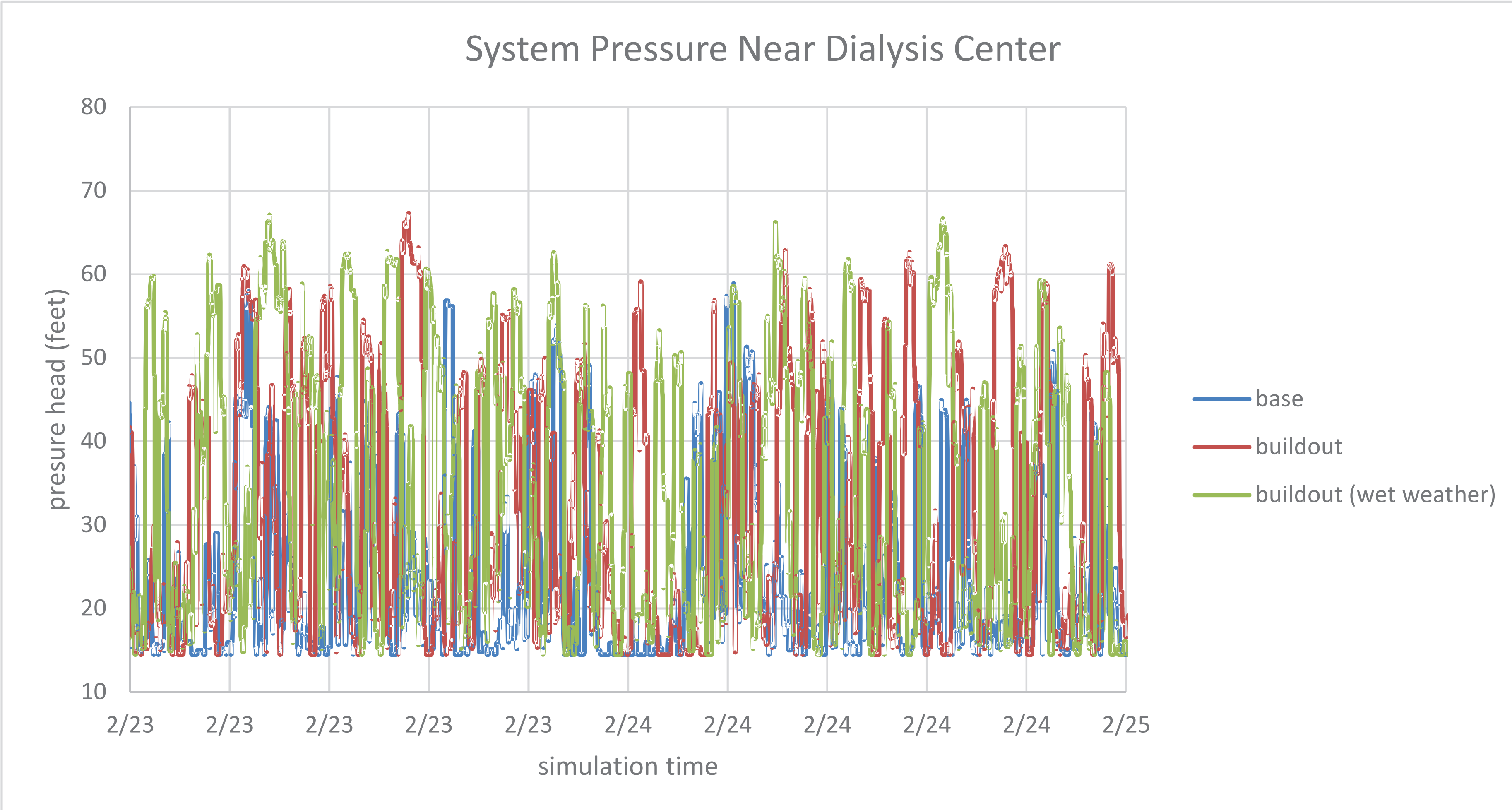


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Figure 12 - System Pressure Near Dialyses Center
Meadowglade Hydraulic Analyses
Project No. 15-10377.01

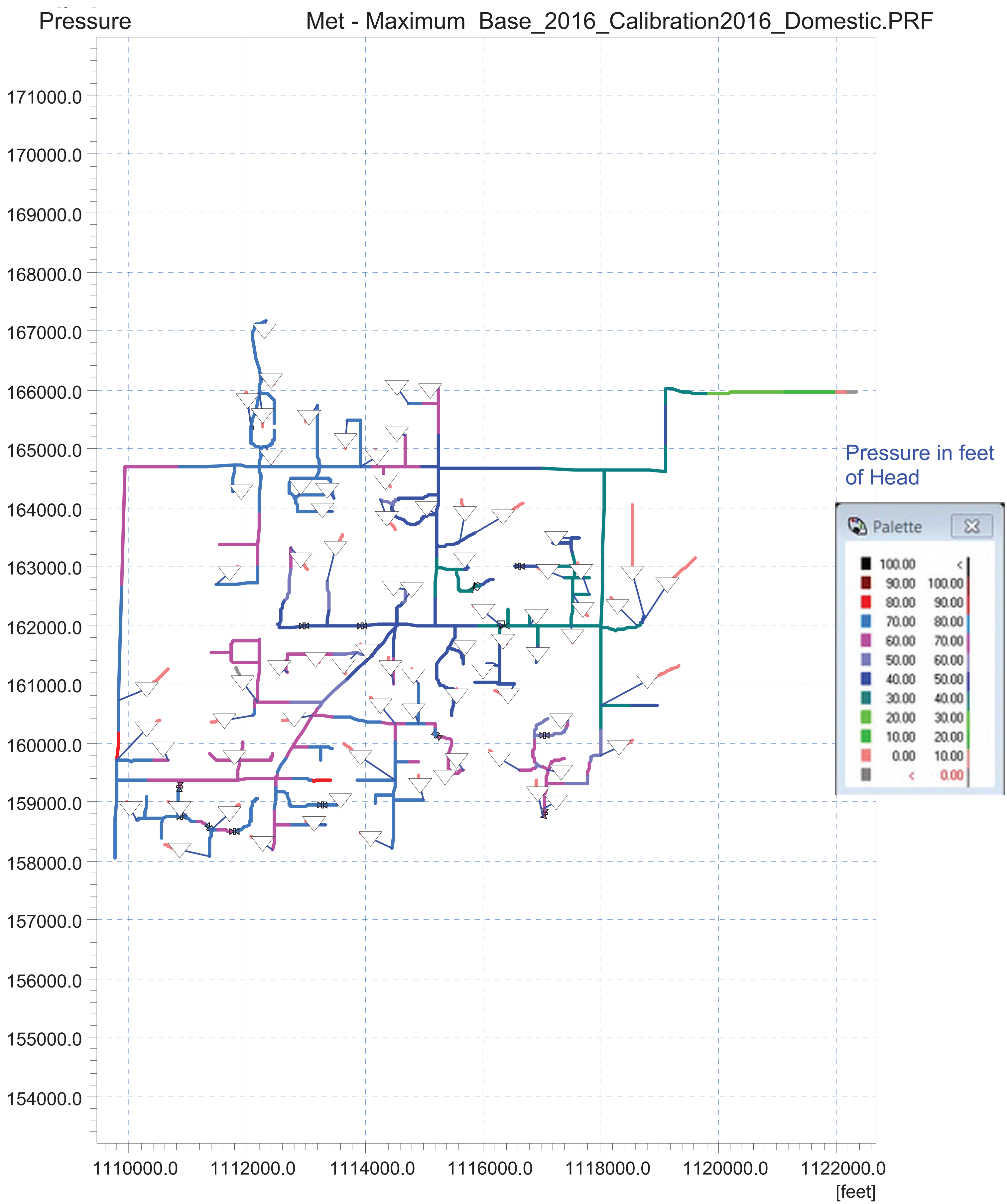

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Figure 13 - Overall Pressures - 2016 condition

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

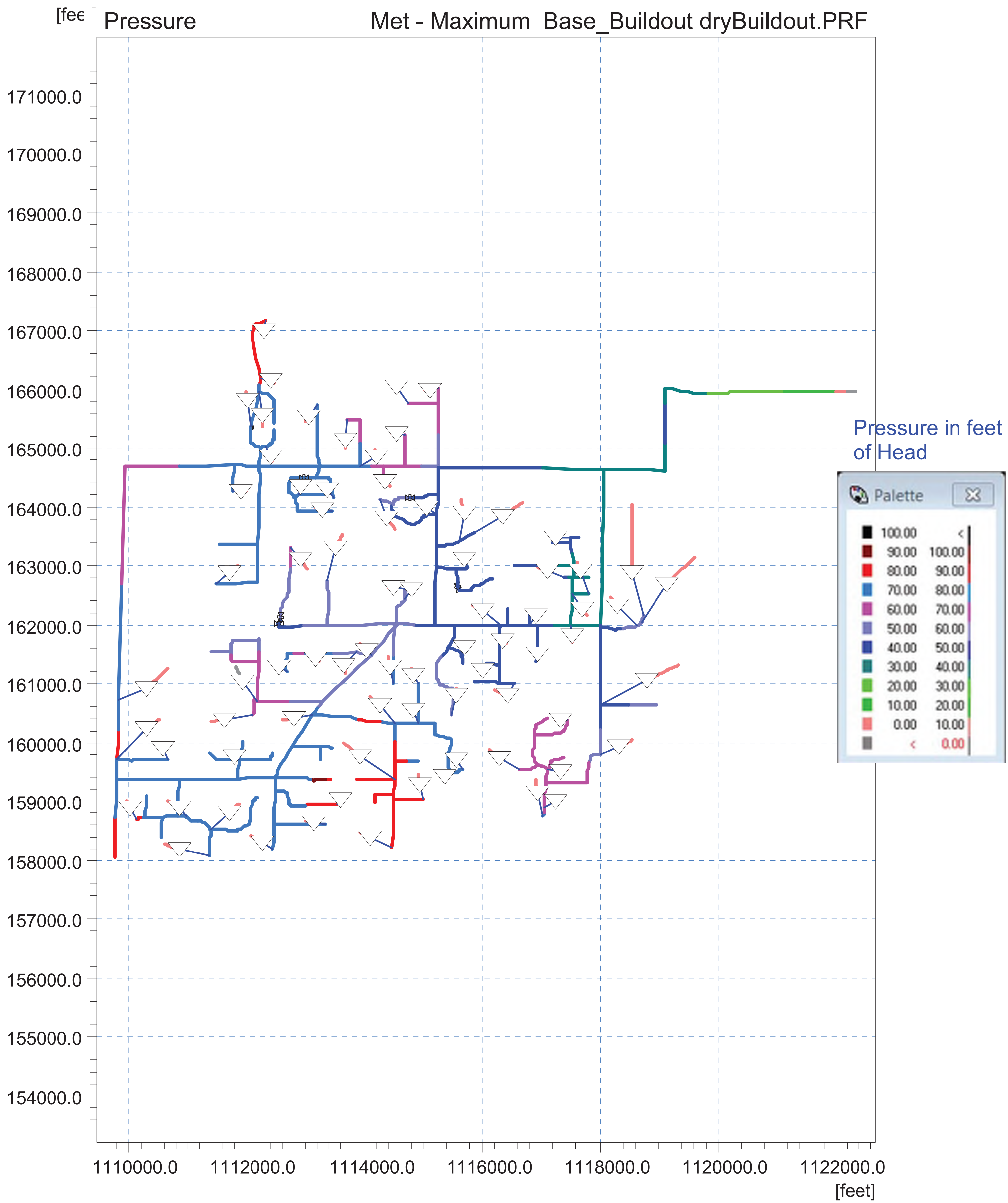

Figure 14 - Overall Pressures - Buildout (Dry Weather)

Meadowglade Hydraulic Analyses

Project No. 15-10377.01

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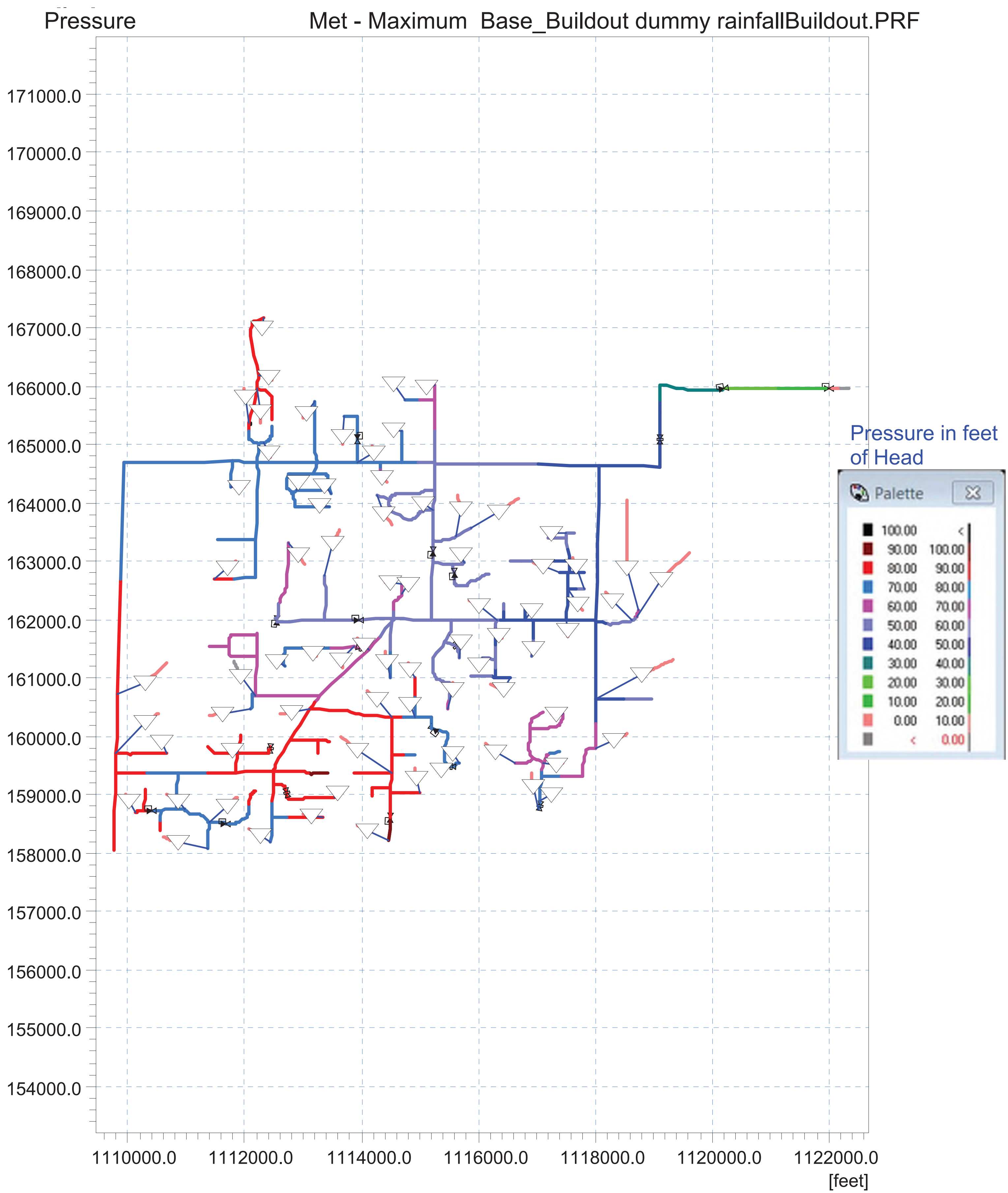


Figure 15 - Overall Pressures - Buildout (Wet Weather)

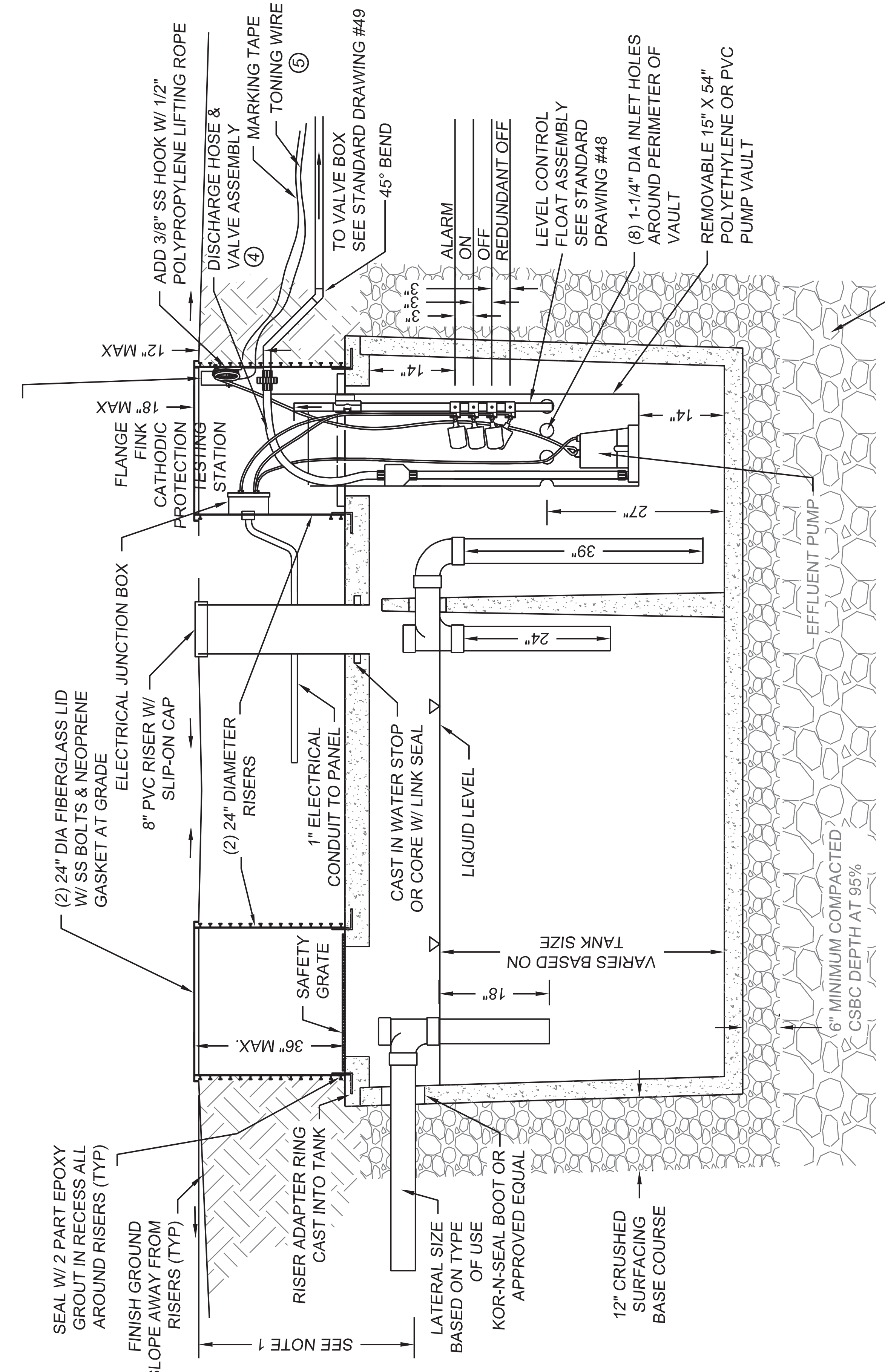
Meadowglade Hydraulic Analyses

Project No. 15-10377.01

ATTACHMENT A

ATTACHMENT A
GIS MAP
SOURCE: CLARK REGIONAL WASTEWATER DISTRICT

ATTACHMENT B



NOTES:

1. FIELD LOCATE EXISTING BUILDING SEWER & SET TANK ELEVATION TO DRAIN BUILDING SEWER AT MIN 1/4" PER FOOT. MAX DEPTH AS NEEDED TO LIMIT RISER DEPTH TO 3'.
2. SEE TYPICAL GRINDER / S.T.E.P. SITE PLAN DRAWING FOR APPROXIMATE TANK & PANEL LOCATIONS.
3. MIN SIZE SHALL BE 1500 GAL. LARGER TANKS MAY BE REQUIRED BASED ON USE. FLOW CALCULATIONS MAY BE REQUIRED.
4. DISCHARGE HOSE AND VALVE ASSEMBLY BY ORENCO MODEL # HV125CM
5. COIL 3' OF TONING WIRE INTO SIDE OR RISER.

CLARK REGIONAL WASTEWATER DISTRICT

S.T.E.P.

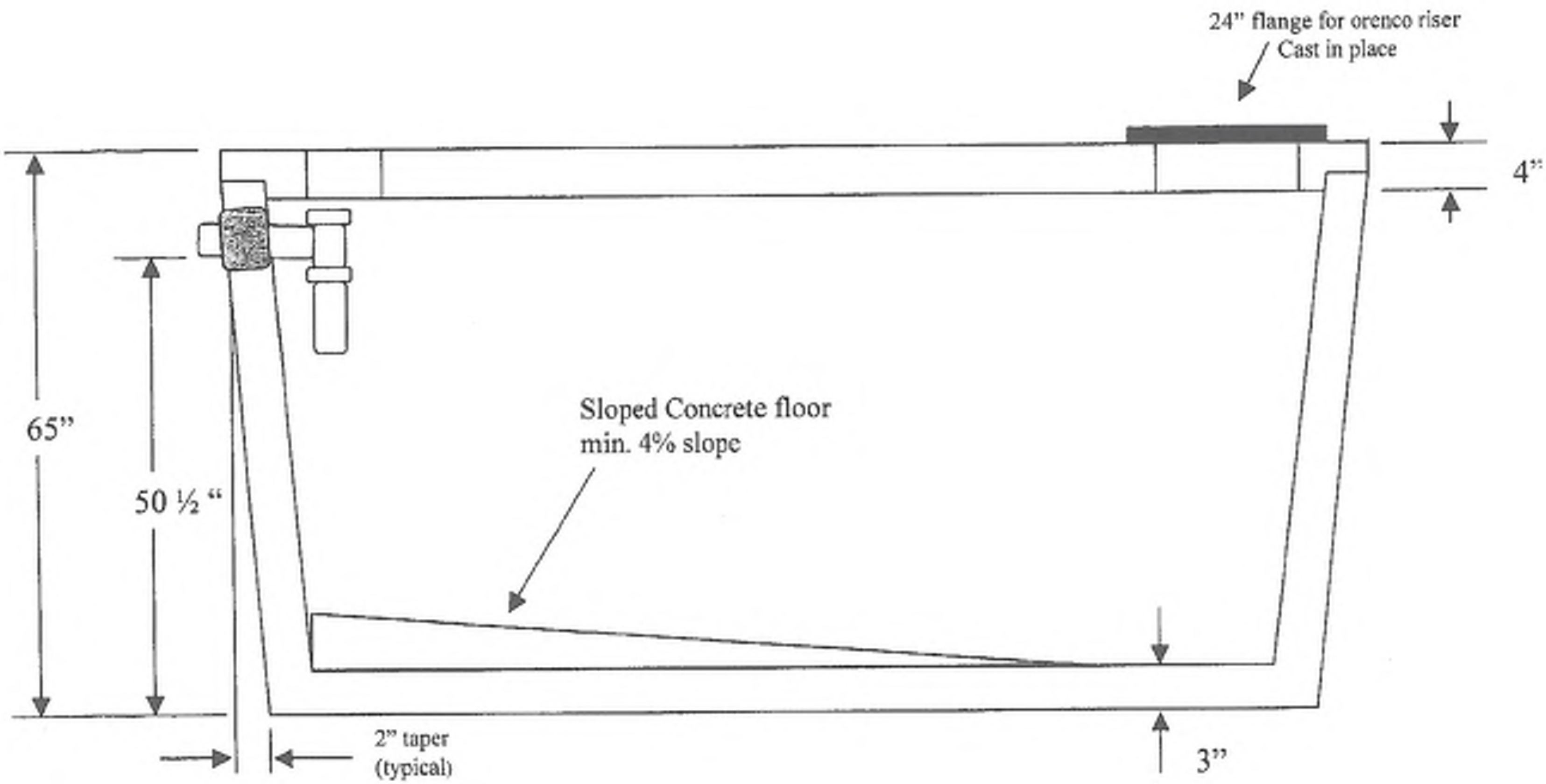
RESIDENTIAL CONCRETE S.T.E.P. TANK

STANDARD DRAWING

45

APPROVED: APR 2010

1000 Gallon Grinder Tank

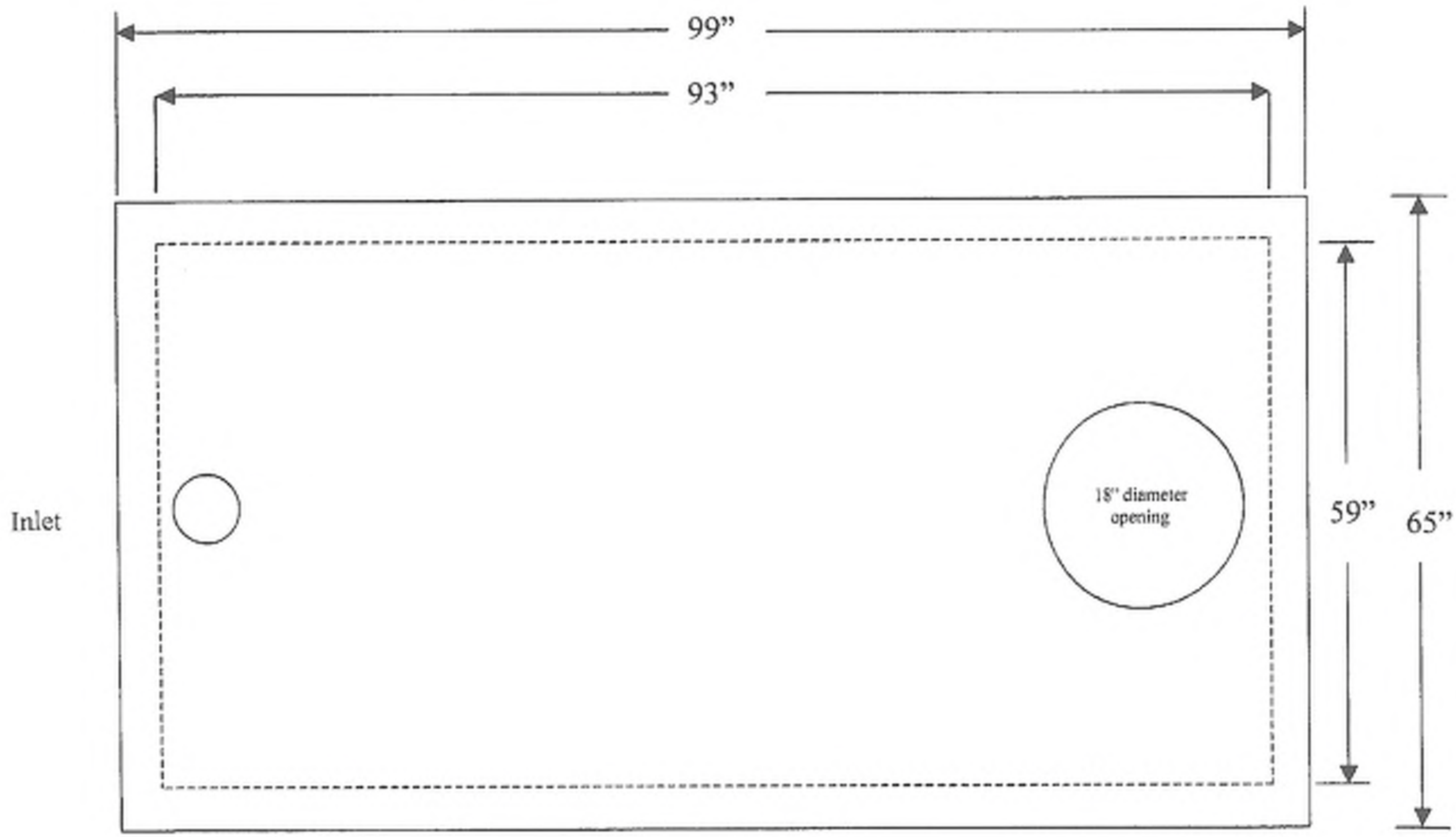


D & K
Concrete Products
15008 N.E. 15th Ave
Vancouver, Wa 98685
(360) 573-4020

Side view

Note: Grinder tanks are seal coated inside and out.

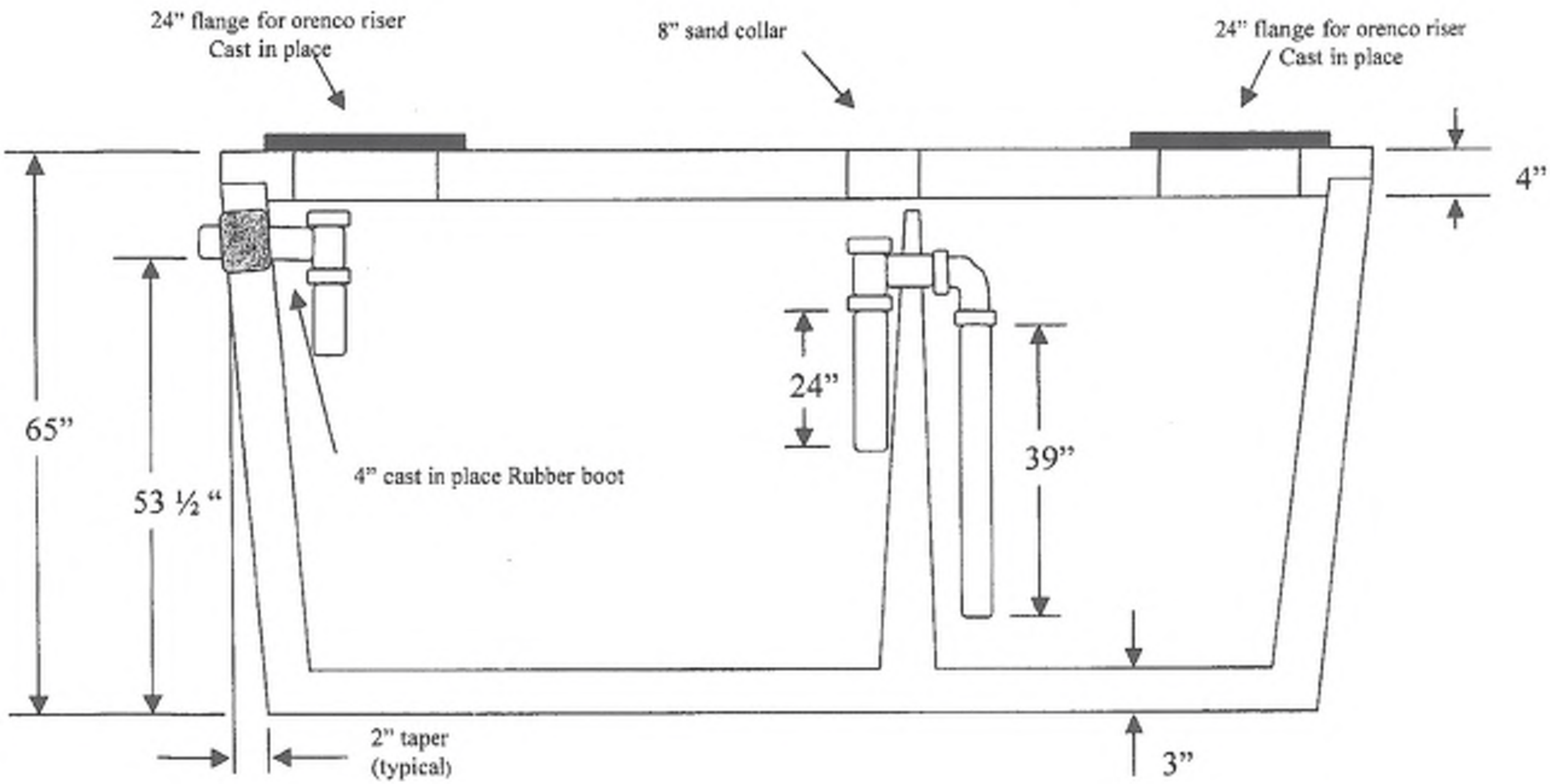
1000 Gallon Grinder Tank



D & K
Concrete Products
15008 N.E. 15th Ave
Vancouver, Wa 98685
(360) 573-4020

Top View

1500 Gallon 2/C Pump, STEP or MG

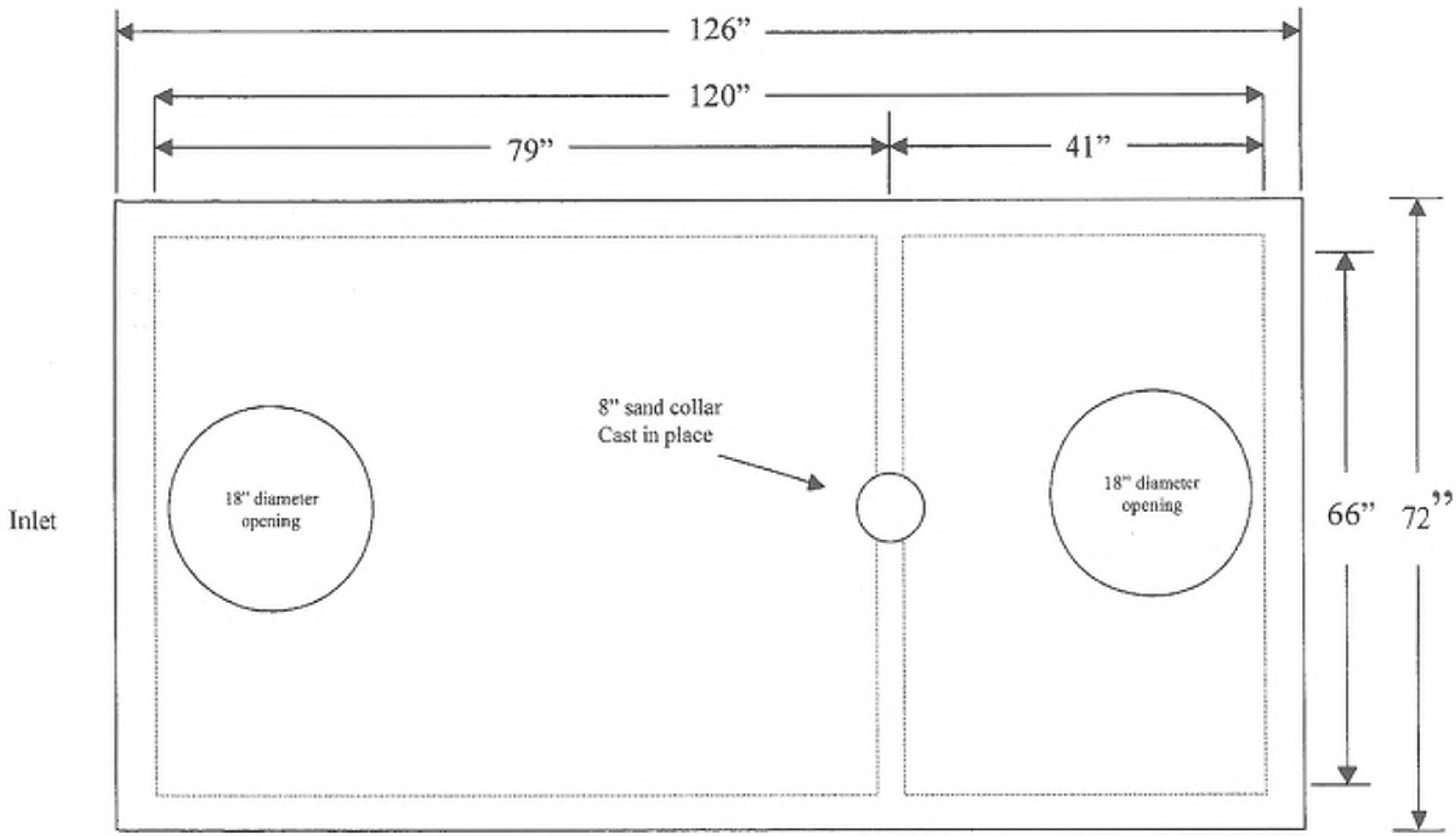


D & K
Concrete Products
15008 N.E. 15th Ave
Vancouver, Wa 98685
(360) 573-4020

Side view

Note: Step tanks and Meadow Glade tanks are seal coated inside and outside.

1500 Gallon 2/C Pump, STEP or MG



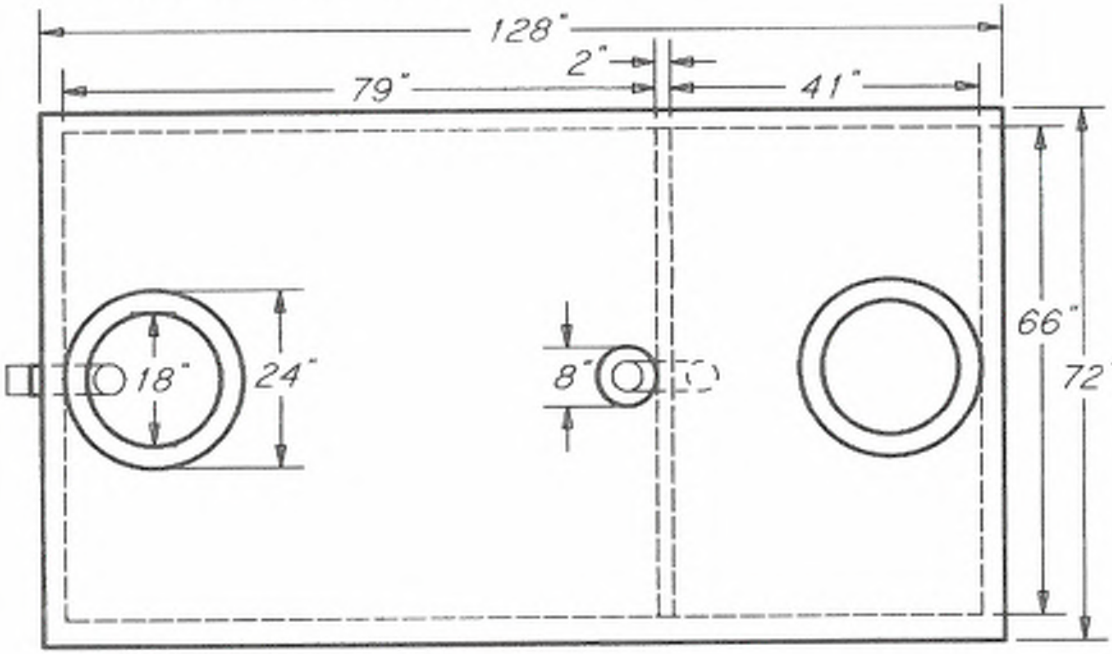
D & K
Concrete Products
15008 N.E. 15th Ave
Vancouver, Wa 98685
(360) 573-4020

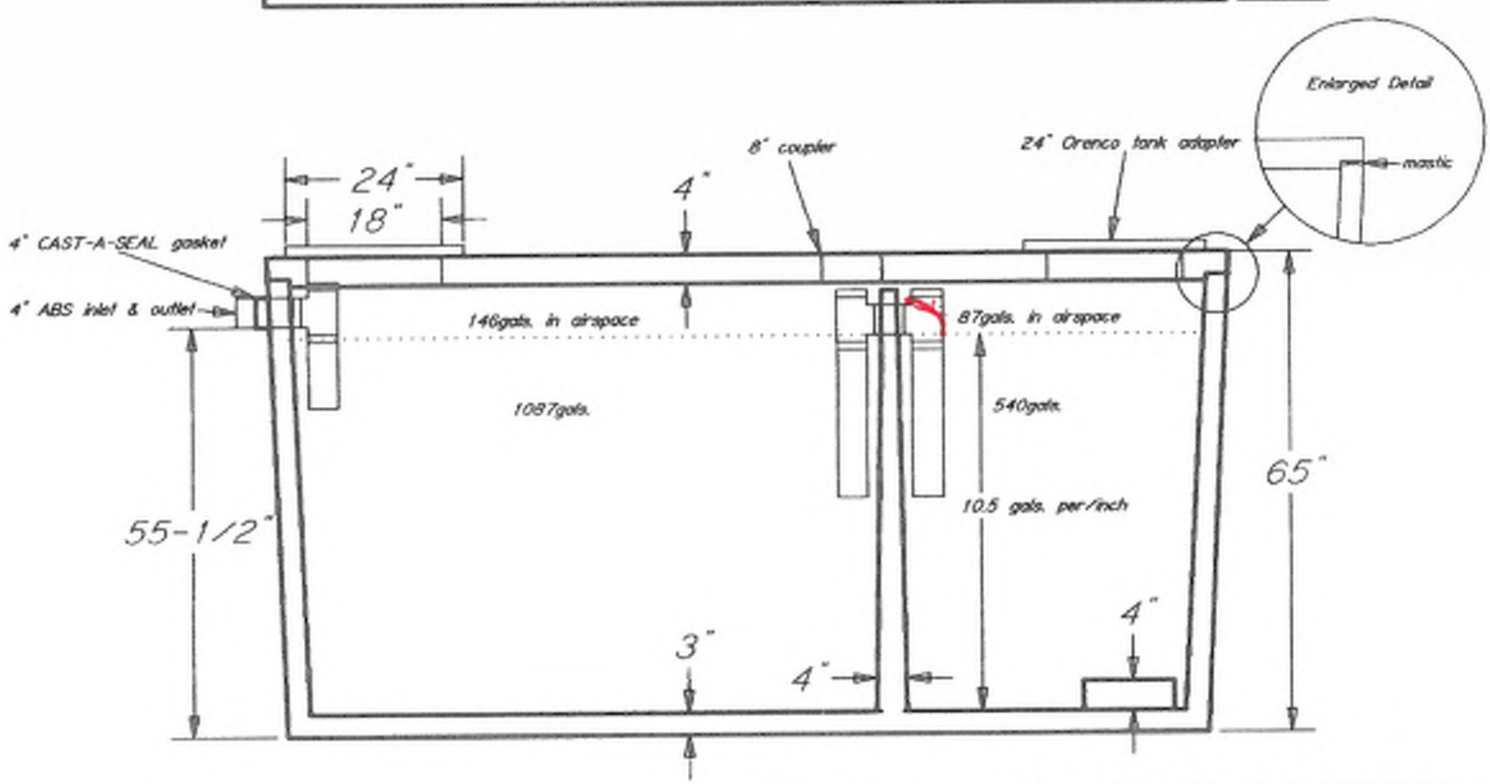
Top View

Sound Placement Services LLC
(360)274-7675

1500 Gal. STEP

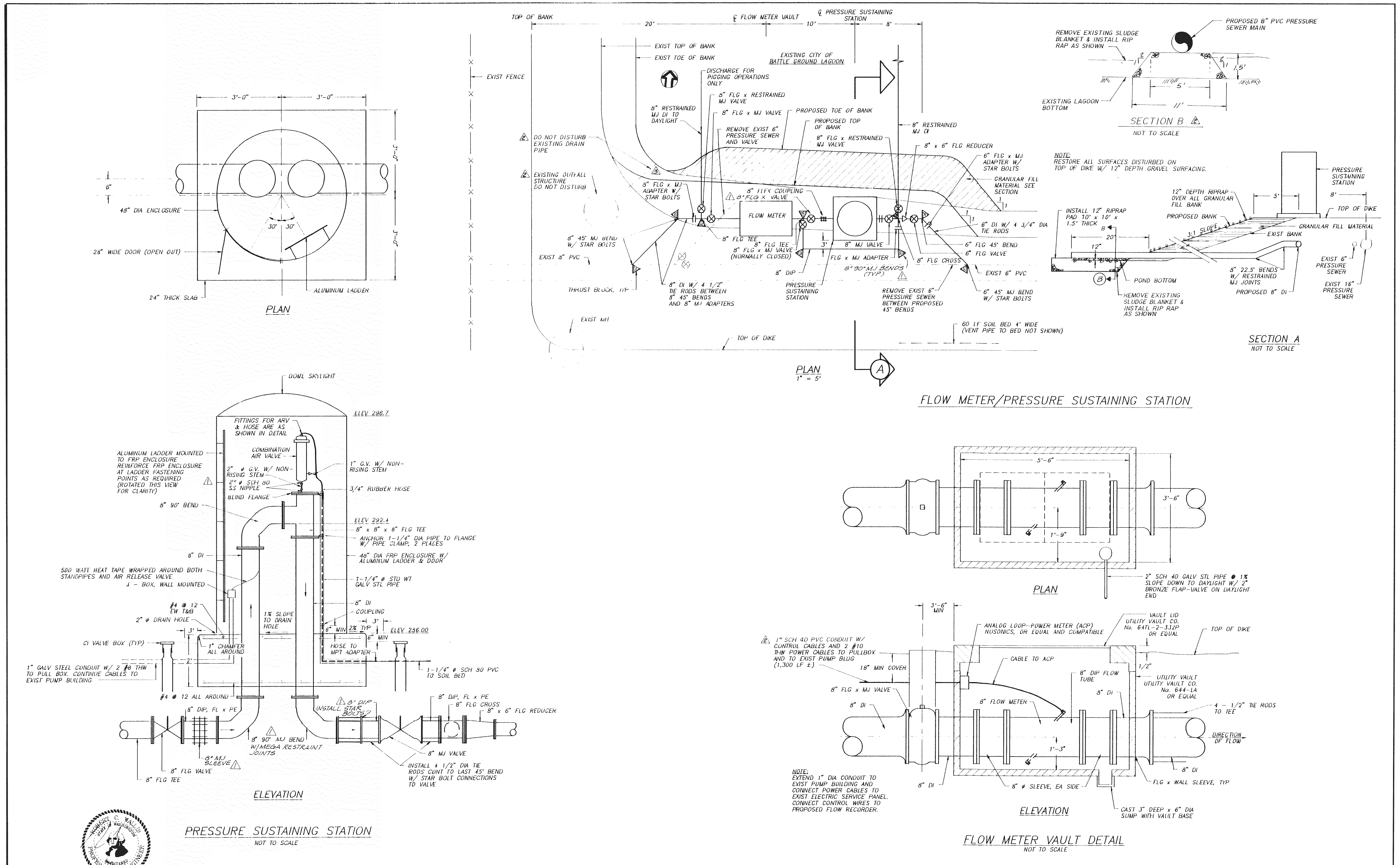
Notes:
1) Tank is coated with a cement based waterproof masonary sealer
2) 2' - 8" SCH40 pipe with cap provided
3) Optional 30" Orenco tank adapter available upon request





Order # 1500STEP

Approx. weight 12,000lbs.



NO.	REVISION	BY	DATE
1	REVISED FITTINGS AS NOTED	PAO	10/8/98
2	REVISIONS AS NOTED	KDH	4/29/93
3	REVISED DIKE EXTENSION	KDH	4/29/93

WALLIS ENGINEERING

PROJECT NO. 337

DATE DECEMBER 1991

CLARK COUNTY DEPARTMENT OF PUBLIC WORKS

MEADOW GLADE PRESSURE SEWER SYSTEM

STANDARD DETAILS – FLOW METERING / PRESSURE SUSTAINING STATION

DRAWING NO. A47

SHEET NO. 47 OF 50

Goulds 3885 Series Submersible Effluent Pumps

- **All cast-iron construction**
- **Runs dry without harm**

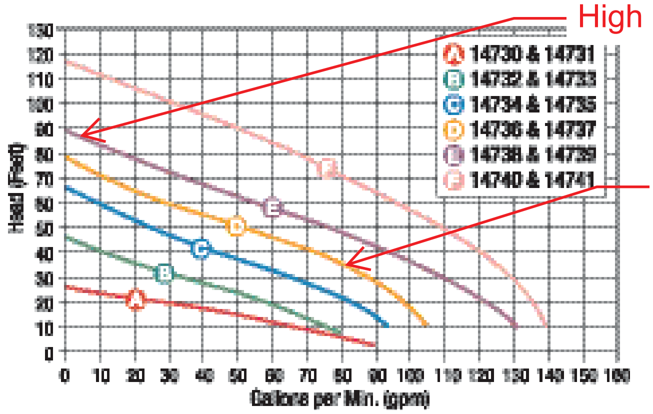
These 2" submersible effluent pumps are built tough for long life. All models have a cast-iron housing with cast-iron impeller mounted on a stainless steel shaft. Upper and lower bearings are heavy-duty ball bearings. Silicon carbide seals are standard on all models.

Higher head and double-seal models are available as special order. Contact USABlueBook for more information.

Shipping: Additional shipping fees may apply. Select models ship motor freight. Contact USABlueBook for more information.

Pump type:	submersible effluent pump
Solids handling:	3/4" spherical max
Construction:	cast iron housing, volute & impeller, SS shaft & fittings, Buna-N elastomers
Impeller:	semi-open with back pump out vanes, dynamically balanced
Bearings:	upper & lower single-row ball, oil lubricated
Seal:	single mechanical silicon carbide, Buna-N elastomers
Motor:	capacitor start*, oil-filled, thermal overload protection**
Max liquid temp:	104°F
Discharge:	2" vertical NPT(F)
Cord:	20'L (16/3 or 14/3*** on 1-phase, 14/4 on 3-phase)
Approvals:	UL, CSA, ISO 9001 registered

***1-phase motors.** ****3-phase motors require external overloads in panel.**
*****16/3 (1/3 & 1/2) includes 3-prong plug, all others have bare leads.**



MODEL	HP	VOLTS†	PH	AMPS	WT (LBS)	STOCK #	EACH
WE0311L	1/3	115	1	9.8	56	**14730**	**$ 589.95**
WE0312L	1/3	230	1	5.5	56	**14731**	**609.95**
WE0511H	1/2	115	1	14.5	60	**14732**	**764.95**
WE0512H	1/2	230	1	7.3	60	**14733**	**779.95**
WE0712H	3/4	230	1	10.0	70	**14734**	**959.95**
WE0732H	3/4	230	3	5.4	70	**14735**	**959.95**
WE1012H	1	230	1	8.1	70	**14736**	**1,009.95**
WE1032H	1	230	3	7.0	70	**14737**	**1,009.95**
WE1512H	1 1/2	230	1	15.7	80	**14738**	**1,169.95**
WE1532H	1 1/2	230	3	9.2	80	**14739**	**1,169.95**
WE2012H	2	230	1	18.0	83	**14740**	**1,349.95**
WE2032H	2	230	3	11.6	83	**14741**	**1,319.95**

†Alternate voltages available. Contact USABlueBook for more information.

GOULDS WATER TECHNOLOGY a xylem brand

Goulds 3885 Series Submersible High-Head Effluent Pumps

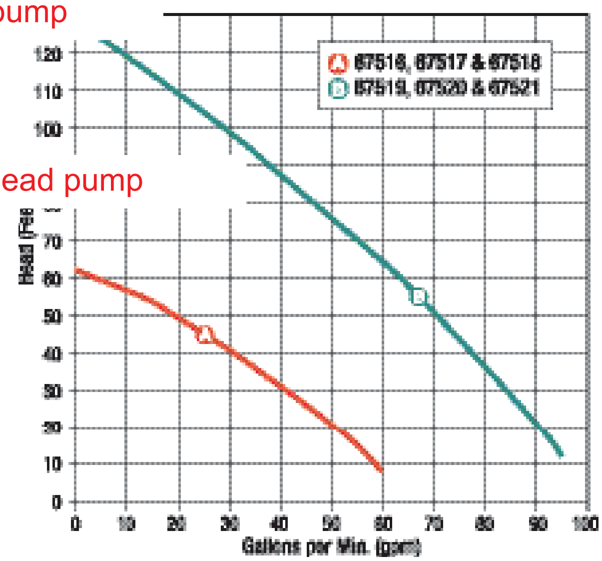
- **All cast-iron construction**
- **Runs dry without harm**

These 2" submersible effluent pumps are built tough for long life. Cast-iron housing with cast-iron impeller, mounted on a SS shaft. Upper and lower bearings are heavy-duty ball bearings. Silicon carbide seals. Choose from 1/2 hp and 1-1/2 hp models.

Shipping: Additional shipping fees may apply. Select models ship motor freight. Contact USABlueBook for more information.

Pump type:	submersible effluent pump
Solids handling:	3/4" spherical max
Construction:	cast-iron housing, volute & impeller; SS shaft & fittings; Buna-N elastomers
Impeller:	semi-open with back pump-out vanes, dynamically balanced
Bearings:	upper & lower single-row ball, oil lubricated
Seal:	single mechanical silicon carbide, Buna-N elastomers
Motor:	oil-filled, capacitor start (1 phase only), thermal overload protection (1 phase only*)
Max liquid temp:	104°F
Discharge:	2" vertical NPT(F)
Cord:	20'L
Approvals:	UL, CSA, ISO 9001 registered

***3-phase motors require external overloads in panel.**



MODEL	HP	VOLTS†	PH	AMP	WT (LBS)	STOCK #	EACH
WE0511HH	1/2	115	1	14.5	60	**67516**	**$ 764.95**
WE0512HH	1/2	230	1	7.3	60	**67517**	**782.95**
WE0532HH	1/2	230	3	3.6	60	**67518**	**869.95**
WE1512HH	1 1/2	230	1	15.7	80	**67519**	**1,169.95**
WE1532HH	1 1/2	230	3	9.2	80	**67520**	**1,169.95**
WE1534HH	1 1/2	460	3	4.6	80	**67521**	**1,169.95**

†Alternate voltages available. Contact USABlueBook for more information.

Not sure which pump you need? We can help.

ATTACHMENT B
PUMP CURVES