# HILL CREEK SUBDIVISION LOW PRESSURE SEWER SYSTEM HYDRAULIC MODELING – BENTLEY SEWER GEMS

## FOR

### BOONE COUNTY REGIONAL SEWER DISTRICT

**PROJECT NO. 18688.013**

**DATE PREPARED: MARCH 2026**


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March 3, 2026

Boone County Regional Sewer District (BCRSD)
1314 N. 7th Street
Columbia, MO 65201

Re: BCRSD Bentley Sewer GEMS – Hydraulic Modeling
Hill Creek Subdivision Low Pressure Sewer System

**BACKGROUND**

Boone County Regional Sewer District (BCRSD) is a public sewer utility district located within Boone County, Missouri outside of city limits. BCRSD requested the development of a wastewater model for a specific subdivision within their collection system where they frequently experience issues, such as pump failures. Bartlett & West developed a Bentley Sewer GEMS wastewater hydraulic model in order to determine theoretical solutions to the challenges that BCRSD is facing. The following data was used for the development of the model:

- BCRSD Online ArcGIS Database – Pipeline Layout, Pipeline Sizes, Presence of Air Release Valves
- Previously Developed Reports by other engineering firms – Pump Curves for pumps present in the system currently
- Field Measurements – Location of Individual Property Grinder Pump Facilities, Elevations of top of Wet Wells of Individual Property Grinder Pump Facilities
- Record Drawings – Layout and internal elevations of Wet Well and Pump Configurations
- Publicly Available LiDAR Topographical Data – Elevations of pipelines throughout the collection system

The Hill Creek Subdivision System is a Low-Pressure Collection System, which means that each home connected to the collection system is pumped by a small grinder pump. The entire collection system is a pumped system that can experience hydraulic challenges when multiple pumps operate at the same time, especially when the elevations and the pump types vary. For this reason, much of the model required troubleshooting to occur to ensure the model was calibrated to what BCRSD staff see in the field currently, prior to making any recommendations/modifications to the system for improvements.

**CURRENT CONFIGURATION**

While Bartlett & West developed this Bentley Sewer GEMS model using available field data and known infrastructure components, it should still be considered only a tool to aid in understanding what may be happening in the field. The model is a theoretical representation and simplifies real-world operations. It should be noted that the model may not fully capture actual field performance and in-field conditions should be backchecked when evaluating the model results.

The current Hill Creek Subdivision Model has the following parameters present:

- Pumps Present (Property Connections Present): 90
  - 82 pumps are the Zoeller Progressive Cavity Grinder Pump Model 815
    - Within the Bentley Sewer GEMS model, this pump was modeled as a Multiple Point (Type 3) Pump with the following head conditions:

| Flow (gal/min) | Head (ft) |
|---|---|

| | |
|---|---|
| 5.5 | 240.00 |
| 7.0 | 200.00 |
| 8.6 | 160.00 |

- 8 pumps are the Barnes Submersible Grinder Pump Model OGP2022AUE
  - Within the model, this pump was also modeled as a Multiple Point (Type 3) Pump with the following head conditions:

| Flow (gal/min) | Head (ft) |
|---|---|
| 0 | 200 |
| 2 | 195 |
| 5 | 190 |
| 7 | 185 |
| 9 | 180 |
| 12 | 175 |
| 15 | 170 |
| 17 | 165 |
| 20 | 160 |
| 22 | 155 |
| 24 | 150 |
| 27 | 140 |
| 29 | 125 |

- Some additional aspects within the model that were key in ensuring the system was able to run and produce realistic results are listed below.
  - Initial Settings – Status (Initial) On
  - Operational Settings – Ignore On and Off Elevations? False
  - Physical Settings – Is Variable Speed Pump? False
  - Physical Settings – Update Ground Elevation from Terrain Model? False

- Wet Wells Present: 90
  - During the development of the model, field measurements were taken to determine the elevation of the top of the wet well at each property connection. This top elevation was used, along with the standard dimensions of the wet wells, which were pulled from the record drawings, to input size and elevations of the wet wells in the model. The following are the dimensions of the wet well and the elevation of the pumps within the wet wells as measurements from the existing grade shot.
  - The table below shows the physical and operational characteristics which were input into Bentley Sewer GEMS for each wet well.

| | |
|---|---|
| Pump - Elevation (Ground) | Measured in Field (GPS Unit) |
| Pump – Elevation (Invert) | 7.7 ft below grade |
| Pump – Elevation (On) | 7.1 ft below grade |
| Pump – Elevation (Off) [1] | 6.1 ft below grade |
| Wet Well – Elevation (Ground) | Measured in Field (GPS Unit) |
| Wet Well – Elevation (Base) | 7.7 ft below grade |
| Wet Well – Elevation (Minimum) | 7.7 ft below grade |
| Wet Well – Elevation (Initial) [2] | 7.7 ft below grade |
| Wet Well – Elevation (Maximum) | 4.7 ft below grade |

[1] According to the record drawings for the design of the Hill Creek Subdivision, the distance between the Pump On and Pump Off floats

was only 4-inches. When this was verified in the field by BCRSD, it was determined that the floats are approximately 12-inches apart in the field. For this reason, the elevations in the model were adjusted to reflect true field conditions.

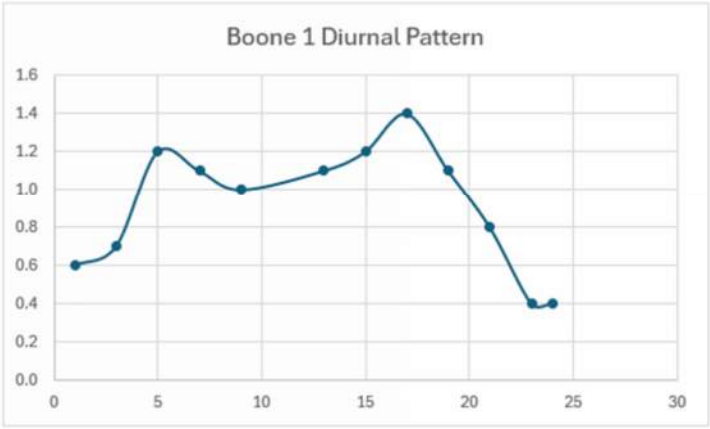
[2] When discussing the development of the model with BCRSD staff, the preliminary concept was to have the initial elevation of each of the wet wells be a random elevation between the minimum and maximum level, which would better reflect the true field conditions since all pumps will likely not operate at once. When this was inputted into the model, there were some challenges; therefore, the assumption of all of the wet wells being empty at the beginning was selected. This allowed the model to run; in order to correct for this assumption, the timeframe of the model was run for longer, so the pumps would have the time to operate independently once the wet wells filled.

- Some additional aspects within the model that were key in ensuring the system was able to run and produce realistic results are listed below.
  - Initial Settings – Is Fixed Level in Steady State? True
  - Operating Range – Operating Range Type, Elevation
  - Operating Range – Use High Alarm? False
  - Operating Range – Use Low Alarm? False
  - Physical Settings – Update Ground Elevation from Terrain Model? False
  - Physical Settings – Section? Constant Area – Circular
  - Physical Settings – Diameter? 2 ft

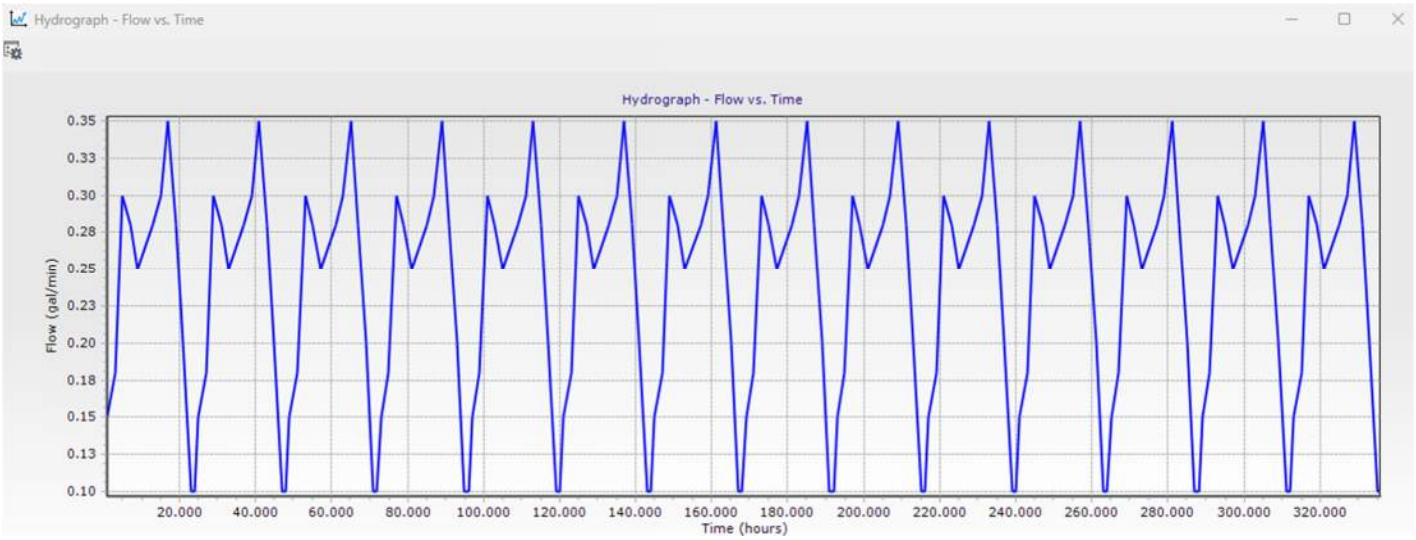
- Sanitary Loadings: BCRSD was able to provide a spreadsheet of average water usage for the various properties within the Hill Creek Subdivision. These average water usages were presented in gallons per month. Bartlett & West works with Boone County Consolidated Public Water Supply District No. 1 (Boone 1), which provides the drinking water for the Hill Creek Subdivision area. In working with Boone 1, a typical diurnal pattern of water usage was developed. This same diurnal pattern was used for the sanitary loads of each home. The diurnal pattern can be seen below.

**Diurnal Pattern for Boone 1 - from WaterGEMS**

| Factors | |
|---|---|
| Start | |
| 1 | 0.6 |
| 3 | 0.7 |
| 5 | 1.2 |
| 7 | 1.1 |
| 9 | 1.0 |
| 13 | 1.1 |
| 15 | 1.2 |
| 17 | 1.4 |
| 19 | 1.1 |
| 21 | 0.8 |
| 23 | 0.4 |
| 24 | 0.4 |



This diurnal pattern was used to develop a unit hydrograph to be used in the Bentley Sewer GEMS model. The monthly average water usage for each property was inputted to develop a flow into the wet well over each day. To ensure that the model had enough data to compute properly, a total of 14 days was input for each property. Below is an example of the hydrograph entered for one individual property; this example had an average monthly usage of 5,000 gallons.




- In order to easily identify issues in the field and correlate the issues to the model, the property address and the monthly water usage values were listed under the Notes for each wet well.

- Air Release Valves Present: 22
  - Within the Hill Creek Subdivision system, there are several air release valves present which help to emit air from the system. The air release valves were included in the model at each location as listed on the BCRSD Online Arc GIS system. Initially, the ARVs were not included in the Bentley Sewer GEMS model, which resulted in the model having properties with negative pressure due to the vacuum condition as the pipe drains when the pumps are not running.
  - The location and presence of the ARVs was verified by BCRSD staff.

- Model Calculation and Calibration:
  - Once all of the components were inputted into the Bentley Sewer GEMS model, there were various iterations required to "troubleshoot" the model to ensure the model could compute and produce logical results. The majority of the changes occurred in the Solver Properties under the Base Calculation Options. Below are some key fields which were modified for improved results in the model.
  - Active Numerical Solver? GVF-Convex (SewerCAD)
    - The default solver is Implicit Dynamic Solver; this solver is best for gravity sewer modeling and wet-weather analysis. The solver was changed to GVF-Convex, which is best for pressure systems, more specifically low-pressure grinder pump networks. This solver runs the model by solving for gradually varied flow (GVF) under design conditions, such as peak flow.

- Time Analysis Type? EPS
  - EPS, extended period state, allows the model to run for a long period of time, rather than looking at the model at one snapshot in time. This is the desired analysis for the BCRSD modeling since the pumps operate at different intervals (due to varying influent sanitary loadings) and allows a fuller picture of the operation of the system.
- Hydraulic Time Step? 0.5 hours
  - The default hydraulic time step, which is the frequency of recalculations of the hydraulic conditions (flow, HGL, velocity), is 1 hour. This time step was lowered to 30 minutes (0.5 hours) for improved accuracy and more detailed breakdown.
- Maximum Network Traversals? 15
  - This value is the number of iterations the model performs in order to get the most accurate network results. The default of the iterations is 5, but an increase to 15 increases the number of recalculations of the hydraulic results which would increase the stability of the model and reduce oscillations in the HGLs.
- Pressure Subnetwork Accuracy? 0.10
  - This value defines how closely the pressure and flow solutions need to converge under each time step; in other words, this is a level of precision the model needs to see before continuing the calculations. Due to the complexity of this model and the low-pressure system, the model is unable to reach convergence. This value was increased in the base calculations to aid in the model reaching a closer convergence. The default value is 0.001 ft and was increased to be 0.10 ft.

**RESULTS OF CURRENT CONFIGURATION**

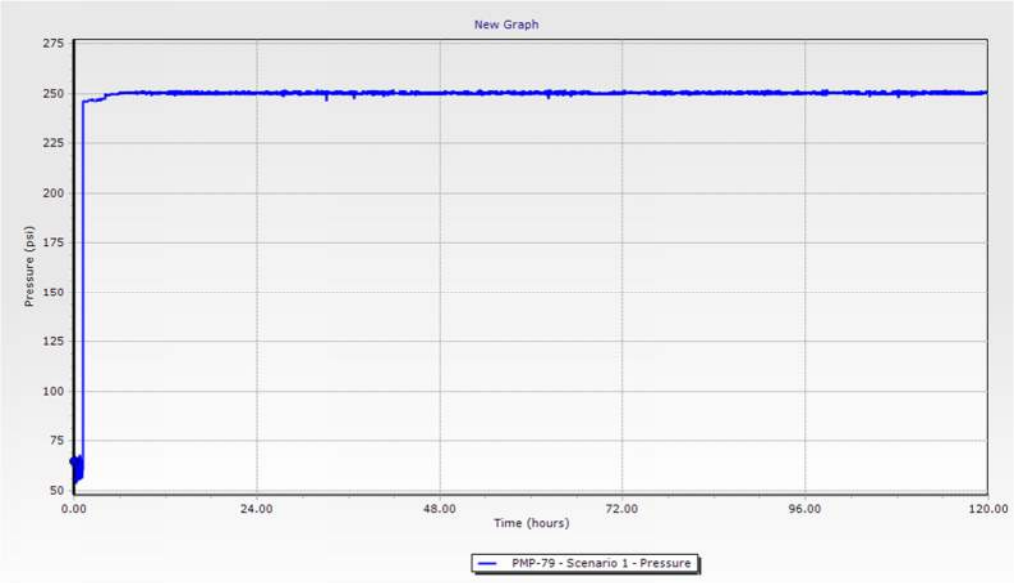
When all of the above aspects of the Hill Creek Subdivision Sewer GEMS model were inputted and the model was run, it showed that the system overall has very high pressures present. When the system was run, there appeared to be no substantial changes in pressures or flows between the time stamp of 120 hours (5 days) to 336 hours (14 days). For purposes of simplifying model and allow the system to run more efficiently, a time span of 120 hours was used for simulation.

The collection system area located south of 7301 S Chimney Ridge Road and west of 1301 W Covered Bridge Road is the only area where the pressures are low. Over the 120 hour time span, the pressures in this area stayed at or below 35 psi. It should be noted that just upstream of both of these addresses are air release valves. The remainder of the system consistently is experiencing pressures between 195 psi and 258 psi. The location that is consistently the highest pressures is along Logwood Lane, where the pressures are constant around 250 psi.

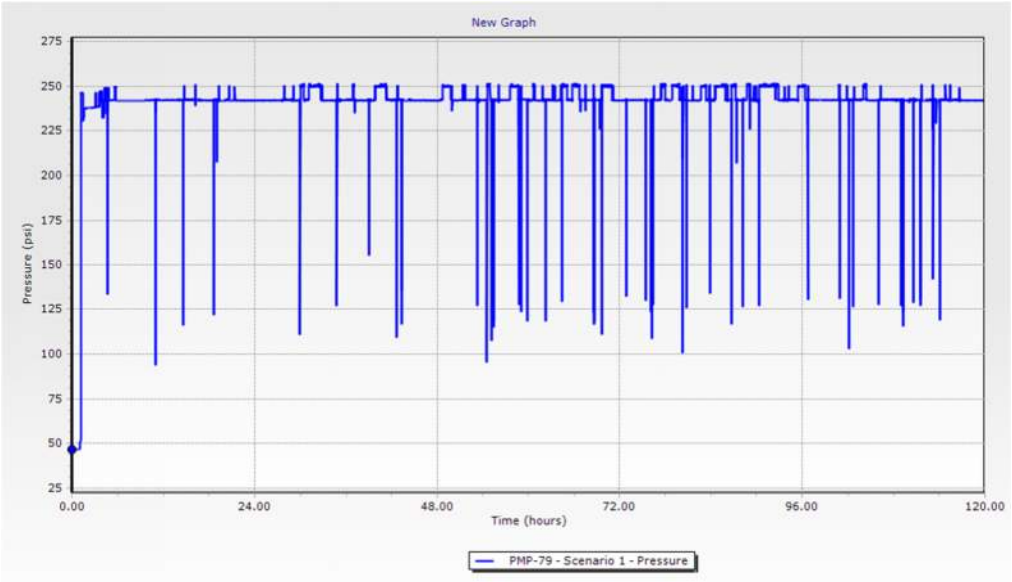
When looking at improvements that can reduce the pressures and challenges that the system is seeing, the model was modified for pipe size changes along Logwood Lane. Currently, the model has all of the pressure junctions along that line as a constant high pressure around 250 psi. When the pipe size was increased, the pressures still reached the high pressure of 250 psi, but the high pressure was not constant. Throughout the simulation, the pressures dropped to more reasonable pressures, between 100 psi and 150 psi. For ease of modifications in the model, the pipe sizes were increased from 1.720” and 2.154” in diameter to 4.420” and 4.606” in diameter. While these sizes are not traditional pipe sizes, these sizes reflect the combined pipe size of the existing pipes and a new 4.072” parallel pipe. This new parallel pipe would allow BCRSD to install a “relief” pipe to ease some of the pressures, while not requiring a few reconnection of each lateral line. The parallel line can be interconnected with the existing line in various locations, which will

result in the same simulation that the model is running. Below is a graph of the pressures at the mainline (1.72" diameter) at the end of Logwood Lane (720 W Logwood Lane) both before and after the pipe diameter was increased.

*Pressure at end of Logwood Lane with Current Pipe Sizes*




*Pressure at end of Logwood Lane with 3" Parallel Force Main Interconnected*



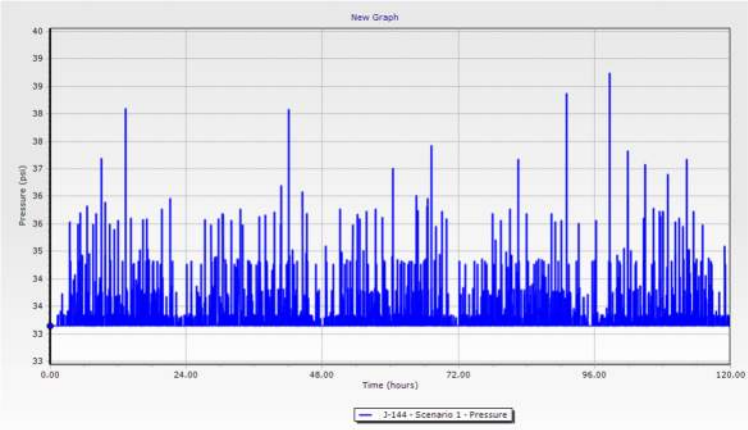

Another location where the pressures were high within the system was the upstream portion of the collection system from 901 W Covered Bridge Road. The homes along the very north side of Covered Bridge Road and the north end of Chimney Ridge Road had pressures which were consistently around 200 psi to 230 psi. Rather than paralleling this section of collection system, an air release valve was added to the model to see if this would lower the pressures. The air release valve was placed near the connection of 751 W Covered Bridge Road to the main collection line (3.166" diameter). This air release valve was able to lower the pressure in the entire northern section of the collection system. The images below show two pressure junctions in this area both before and after the addition

of an air release valve. The first pressure junction is the connection of 7301 S Chimney Ridge Road to the 3.166" force main and the second pressure junction is the connection of 7200 S Chimney Ridge Road to the 2.154" force main.

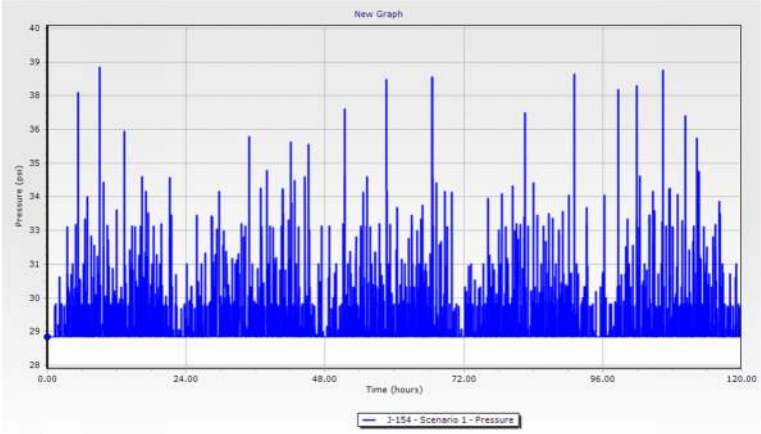
*7301 S Chimney Ridge Road Before ARV*


*7200 S Chimney Ridge Road Before ARV*


*7301 S Chimney Ridge Road After ARV*



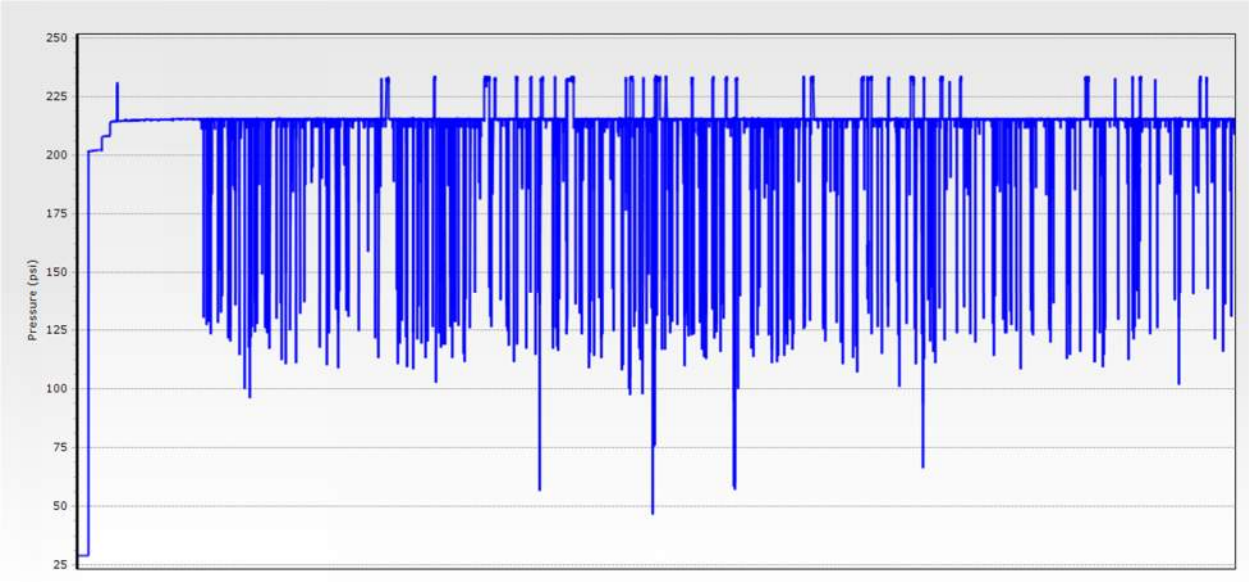

*7200 S Chimney Ridge Road After ARV*




A final key location where the pressures were exceeding the desired pressures was the south end of Cave Creek Road. The last several homes along this road are all connected to a 1.720" diameter force main. Similar to the other locations, the model was modified to try and lower these pressures. Both of the methods above were implemented to reduce the pressures seen. The existing stretch of 1.720" force main was increased to 3.604" diameter force main, which allowed less pressure on the pipe and an additional air release valve was added to the system. The 3.604" diameter pipe is representing a parallel 3.166" pipe being installed in this area. The air release valve was added to the highest point in this area, which is between 7801 S Cave Creek Road and 7800 S Cave Creek Road. While these improvements did not completely drop the pressures across the entire simulation, it allowed the pressure to be substantially lowered at various times throughout the model running. The graphs of a pressure junction in this area, upstream of the ARV, can be seen below. These graphs are both before and after both of the improvements.

*Pressure along S Cave Creek Road with Current Pipe Sizes and no ARV*

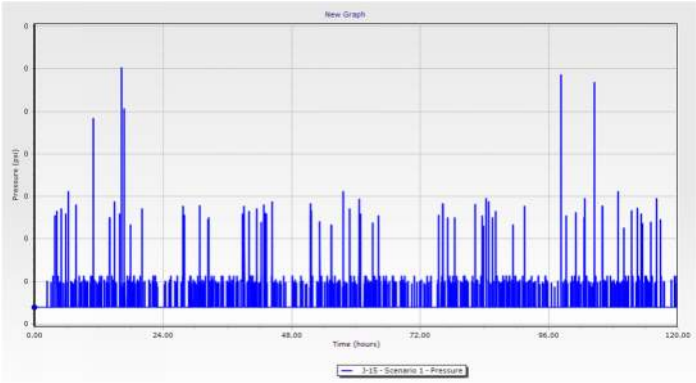

*Pressure along S Cave Creek Road with Parallel Pipe and additional ARV*



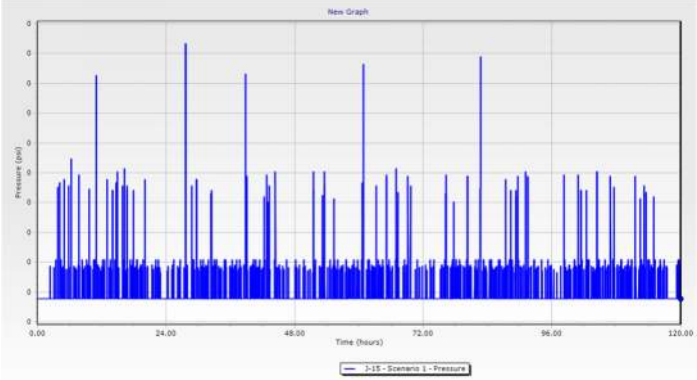

In the August 2014 report developed for this low pressure system completed by HDR, there was a recommendation of the upsizing of existing pipeline within the system to reduce the pressures. It was recommended by HDR to upsize the existing pipeline along Covered Bridge Road/Chimney Road from the 4" branch to Ridge Run. Similar to the scenarios above, the existing pipe was modeled with an internal diameter of 5.158", which would be the combined sizes if the existing 3" pipeline was paralleled by a new 4" pipeline. The total length of pipeline that was previously recommended to be replaced was approximately 1,465'. On the original plans for the Hill Creek subdivision, this section would be Line 1 from Station 58+38 to 73+09. When this update was inputted into the model, it was found that the increased pipe size had no substantial effect on the pressures seen within the system. Neither the upstream nor downstream pressure nodes of this improvement

showed a drop in pressures. Below are some graphics showing the upstream and downstream junctions of the improvements, both before and after the pipe was upsized.

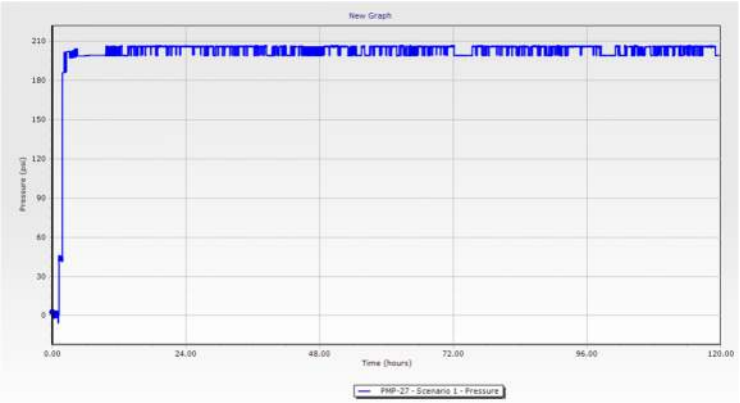
*Downstream Before Improvements*



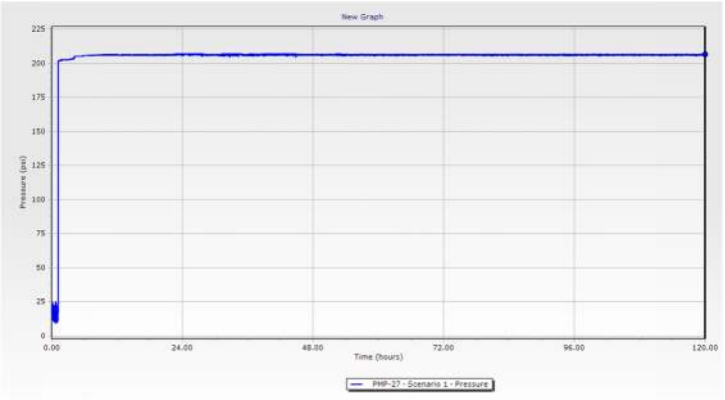

*Downstream After Improvements*




*Upstream Before Improvements*




*Upstream After Improvements*

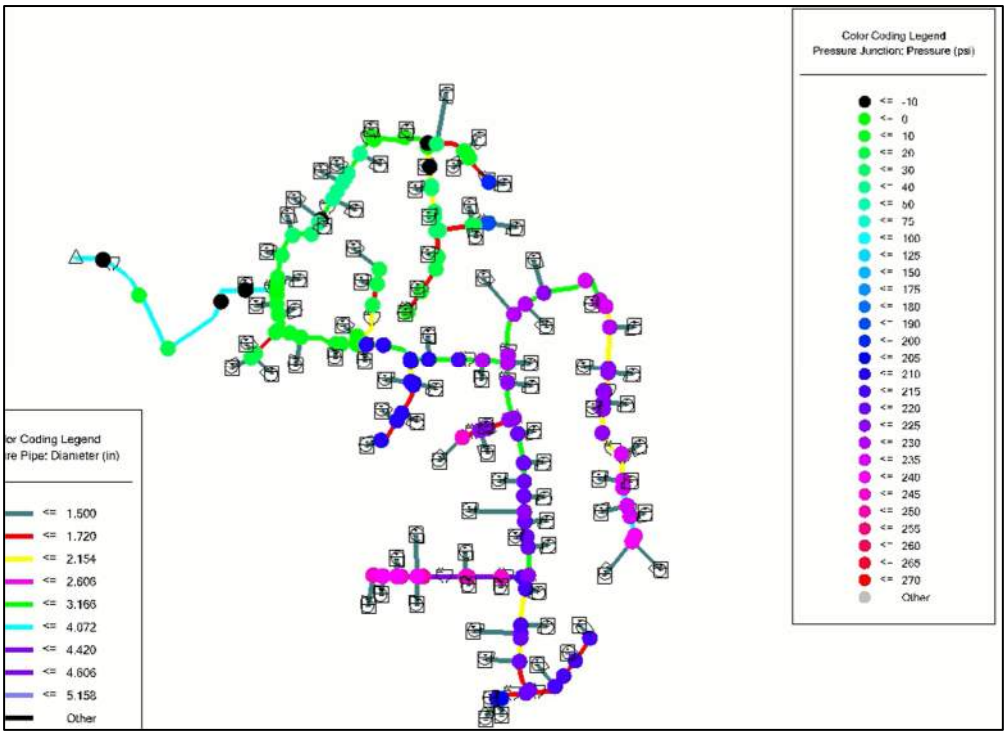



These results show that this previously recommended improvement, when inputted into the model, does not show enough results to warrant BCRSD pursuing this improvement. There are other locations with other improvements that the model shows are more valuable.

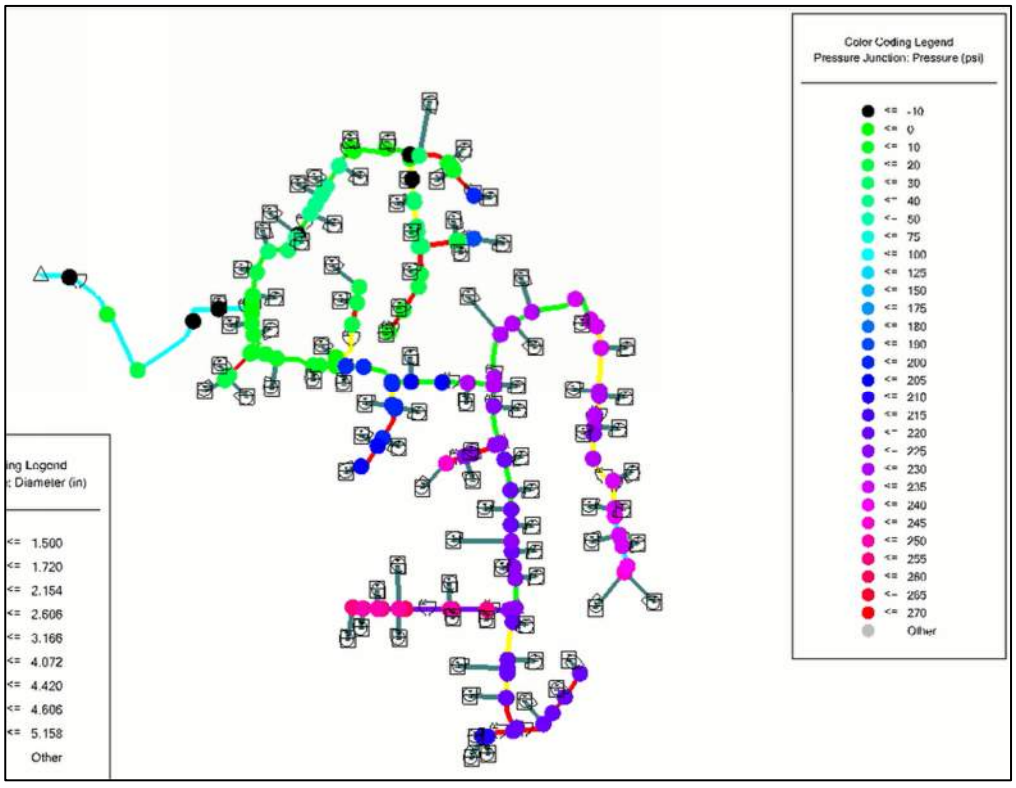
Thus far, all of the modifications to the current collection system have been within the collection system itself (i.e. pipelines, air release valves, etc.). Another aspect of pressure within the system, which may be the most influential, is the actual pumps themselves. As stated previously, there are currently two types of pumps present in the system, Barnes and Zoeller. The model was adjusted to reflect the installation of all Zoeller pumps and then all Barnes pumps. Unfortunately, this simulation will not be able to be reflected in this report by use of a graph, since it will be affecting the entire system as a whole. When the model was run in its current state, with 82 Zoeller pumps and 8 Barnes pumps, the maximum pressure within the system over the entire simulation time period was noted as 257 psi. When the system was modified to reflect only Zoeller pumps present within the Hill Creek collection system, the maximum pressure within the system was noted at 257 psi again. While this may seem unusual, this benefit of switching pumps may have affected some of the connections and pressure junctions, but it is evident that it did not effect all of them. The same pressure junctions which are experiencing high pressure today would experience the same high pressure if all of the pumps were switched to Zoeller. However, when all of the pumps were switched to Barnes, the maximum pressure seen throughout the system over the entire simulation time period was 173 psi. This shows a substantial

drop in pressure across the system. This can also be seen in the snips of the model, which are included below.

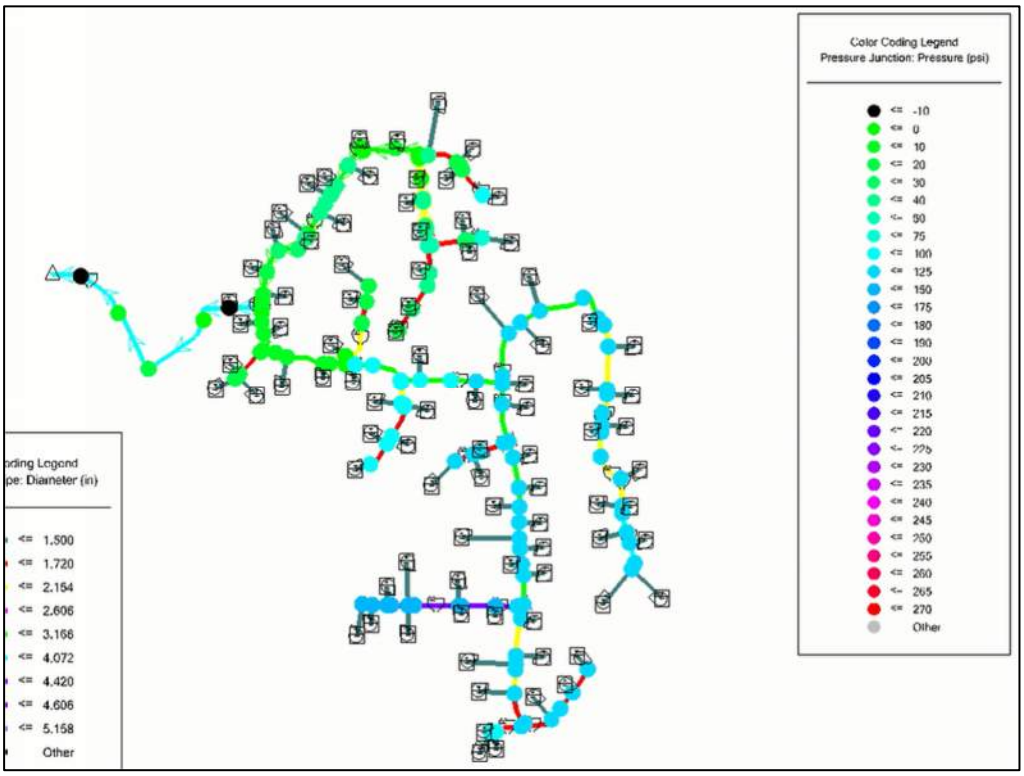
*Current Pump Scenario at Hour 32*




*Pump Scenario at Hour 32 with all Zoeller Pumps*



*Pump Scenario at Hour 32 with all Barnes Pumps*




**<u>SUMMARY OF RECOMMENDATIONS</u>**

After all of these modifications and possible improvements were modeled in the Bentley Sewer GEMS hydraulic model, there are several recommendations that can be made for BCRSD to move forward with in order to improve the performance of the Hill Creek Subdivision Low Pressure Sewer System. Below is a summary of the recommendations from this report, as well as the anticipated results as an outcome of the improvement.

- <u>Logwood Lane Parallel Pipe:</u> Install new 4" PR200 SDR21 PVC pipe paralleling existing 1.5" force main and 2" force main for a total of approximately 1,210 ft. The new 4" force main should be interconnected to the existing force mains intermittently to ensure both pipes are handling the flows.
    - This would lower the average pressures of the eight (8) homes along Logwood Lane from approximately 250 psi to between 100 and 150 psi.
- <u>751 W Covered Bridge Road ARV:</u> Install an Air Release Valve (ARV) just downstream of the connection of 751 W Covered Bridge Road to the 3" force main. ARV to be installed along 3" force main.
    - This would lower the pressures of all homes (total of 19 homes) located upstream, and including, 7301 S Chimney Ridge Road. The pressures of this entire area drop from 200-230 psi to approximately 40 psi.
- <u>Cave Creek Road Parallel Pipe and ARV:</u> Install new 3" PR200 SDR21 PVC pipe paralleling existing 1.5" force main for a total of approximately 490 ft and install an Air Release Valve (ARV) between 7800 S Cave Creek Road and 7801 S Cave Creek Road. The new 3" force main should be interconnected to the existing force mains intermittently to ensure both pipes are handling the flows.
    - This would lower the average pressures of the six (6) homes along the 1.5" force main along S Cave Creek Road from approximately 220 psi to approximately 175 psi.

- Pump Replacement: Replace all of the existing Zoeller Pumps with Barnes Pumps. Barnes Pumps to be installed are to be Barnes 1.25" NPT Upgrade Core Submersible Grinder Pumps with Model OGP2022AUE. The pump curve should match the following parameters of Flow (GPM)/Head (ft):

| Flow (gpm) | Head (ft) |
|---|---|
| 0 | 200 |
| 2 | 195 |
| 5 | 190 |
| 7 | 185 |
| 9 | 180 |
| 12 | 175 |
| 15 | 170 |
| 17 | 165 |
| 20 | 160 |
| 22 | 155 |
| 24 | 150 |
| 27 | 140 |
| 29 | 125 |

  - This will lower the overall pressures throughout the system from approximately 250-260 psi to a maximum pressure of 173 psi.