CITY OF DEADWOOD – WATER SYSTEM MODELING – TASK 1 TECHNICAL MEMORANDUM #1 (revised)

Prepared for:
Mr. Kevin Kuchenbecker
Interim Public Works Director
City of Deadwood
108 Sherman Street
Deadwood, SD 57732

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of South Dakota.

REGISTERED PROFESSIONAL ENGINEER
REG. NO.
02.01.2023
9254
MICHAEL J. TOWEY
SOUTH DAKOTA

Michael Towey, PE	Date
Reg. No. 9254
Expiration Date: 8/31/2023
TDG Project Number: 21-042

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Introduction

Currently the City of Deadwood (DWD) has approximately 800-900 users accessing the water system. The city currently has a System Operations Manual (updated February 2010) to help guide the operation for system maintenance and emergency situations. The overall operations and descriptions listed in this manual are unchanged for many years.

Existing Model Development

The active water source for this system is through the Lead-Deadwood Sanitary District. The system includes 6 reservoirs, 11 pressure reducing valve stations, 3 booster pump stations, and miles of various sized piping and appurtenances to complete the network. The upper elevations within the network are at the Roosevelt Tank (5129 +/-) and lower elevations are in Zone 6 (4395 +/-).

The pipe network used in the water model was based on the converted Deadwood GIS data. One booster pump station is active in the model which is the Denver Street pumps that fills the Roosevelt Tank. There are multiple PRVs throughout the water system which were all set to the individual characteristics as noted in the operations manual and as measured in the field.

In order to develop an existing conditions model, each parcel was classified by the type of land use for that lot. These uses included into single family residential, commercial, parks, industrial, and multi-family land. Each lot was then given a water demand pattern that matched the land usage as determined by our review of the existing water usage data provided by city staff.

Our analysis indicates the existing water system in Deadwood is adequate for the current demands.

Proposed Model Development

A proposed conditions model was then developed to identify the effects that all of the recently proposed developments will have on the current city water system. Currently, there are 4 developments, all at various stages of fruition, that were considered in our proposed water model. These include:

- Stage Run (160 dwelling units);
- Boot Hill (298 dwelling units);
- The Ridge (264 dwelling units);
- Shirttail Gulch (existing subdivision with 28 dwelling units).

Our first option was to consider full-buildout conditions. **At full buildout, including full development of the proposed subdivisions, the Deadwood water system becomes inadequate for the additional demands.** The biggest failing point of the system is with the Denver Street booster pump stations and the storage capacity in the Roosevelt tank.

Growth in Deadwood appears to continue on the horizon. Therefore, we then created an alternate water model to estimate how much development could occur without overtaxing the current water system. Proposed conditions parameters used in the new water model were based on development criteria as listed in Section 3 of the Rapid City Infrastructure Design Criteria Manual (IDCM). *Please note, the IDCM uses very conservative estimates as compared to the city's existing demands.*

The results of our alternate model showed that significant improvements were needed after the addition of 100 new single family dwelling units. At this time, pump run time in the average day model appears within reason, runtime during peak flow times exceed normal standards and manufacturers recommendations. The use of 100 new residential buildings can be further expanded based on land use as described in our Technical Memorandum #1.

Recommendations

Effective November 30, 2022, it is our recommendation that the recommended amount of additional single family equivalent taps is estimated to be 100 connections until further evaluation can be completed. Our recommendation is based on excessive use of your pumps and other minor strains in the system. This is based on the Rapid City IDCM peak day water use per dwelling unit criteria. As each new connection is made, the water and pump usage should be monitored to confirm the modeling estimates.

It is recommended the city start developing a plan and funding source immediately for future improvements to the water system. Future improvements and recommendations are forthcoming from our firm.

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Technical Memorandum #1

Date: November 30, 2022

To: Mr. Kevin Kuchenbecker, Interim Public Works Director
City of Deadwood
108 Sherman Street
Deadwood, SD 57732

Engineer: Mr. Michael Towey, PE
Towey Design Group, Inc.
475 Villa Drive, Suite #3
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RE: Deadwood Water System Modeling – Task 1
Technical Memorandum #1

Thank you for the opportunity to allow TDG to work with the city on the very important project. Forward thinking of the city's utility needs as the city continues to grow is a huge benefit to the municipality. We believe this memorandum will address all project requirements as listed in our proposal dated 8.31.2022 and we look forward to taking the next step in this process. *Vacation rentals will be discussed in Phase 2.*

This memorandum will describe the data and assumptions used to help create the existing and proposed conditions water models and further presents the initial results of our proposed conditions water model for the City of Deadwood.

INTRODUCTION

Currently the City of Deadwood (DWD) has approximately 800-900 users accessing the water system. Deadwood currently has a slightly outdated system operations manual (updated February 2010) to help guide the operation for system maintenance and emergency situations. The overall operations and descriptions listed in this manual are unchanged. Slight differences in pressure reducing valve (PRV) settings and active PRV's have changed over the 12 years of operation, but in general the system has remained the same. A general overview of the entire system is shown on **Exhibit A**.

The active water source is from the Lead-Deadwood Sanitary District Well #1. The system includes 6 reservoirs, 11 pressure reducing valve stations, 1 booster pump station, and miles of various sized piping and appurtenances to complete the network. The upper elevations within the network are at the Roosevelt Tank (5129 +/-) and lower elevations are in Zone 6 (4395 +/-). A copy of the current City Pressure Zone Map is included as **Exhibit B**.

PROVIDED/ACQUIRED DATA FOR THE MODEL

Deadwood GIS Water Mains

City staff provided TDG with all their GIS data concerning the water system in Deadwood. Deadwood has GIS information on all existing pipes within the water system. The information includes an Object ID (number), size of pipe, and shape length, as well as if it is classified as a main line or a service line or if it is a fire hydrant lead.

Elevation Data

Water modeling efforts requires data for 2 main features, links (or pipes) and nodes (services, fire hydrant, or general demand). The GIS information provided necessary information for all the links (pipe, pipe sizes, etc.). Nodes require elevation and an estimated water demand at each node. Elevation data was acquired through the United States Geological Survey (USGS) website. The website has 0.5 - 1-meter lidar available for download for most areas located within the United States. The data set used for determining node elevations is OPR_SD_HY17_NRCS_Lidar_FURGO_2017. The project horizontal and vertical datum is set for NAD83 South Dakota North State Plane and NAVD88 (SD83-NF).

PROGRAMS USED

QGIS 3.26.3

QGIS was used to help convert city GIS data from shapefiles to linework that could be inserted into AutoCAD Civil 3D.

AutoCAD Civil 3D 2021

AutoCAD Civil 3D was used to organize the GIS data into EPANET. It was also used to set the node elevations for the EPANET model. Civil 3D also was used to create the base map for the EPANET model.

EPANET 2.2

EPANET 2.2 is the program used to model the water system network in Deadwood. It is an opensource program that calculates the pressures and head elevations of nodes and tanks based while allowing inputs from pressure reducing valves, pumps, and valves. EPANET is a great program for calculating pressures and flows within a system.

DEADWOOD EXISTING MODEL OVERVIEW

The overview of the model assumes the user has enough knowledge of EPANET to at least complete the tutorial of EPANET. The overview will start in the Browser window and describe some of the data and assumptions used to help create the overall model. The Network Map (locations of pipes and nodes) were imported into EPANET from AutoCAD Civil 3D. PRV's and Tanks must be "hand" inserted into the model as only links and nodes can be inserted into EPANET.

For all elevation to psi conversions, the following conversion was used. 2.31 ft of head = 1 psi.

Junctions

AutoCAD converted junctions are labeled with a "n" prefix, no prefix indicates the node was manually placed. During the AutoCAD conversion to EPANET, some of the pipes in the GIS data were not properly connected therefore some of the pipe/links needed to be edited and reconnected to the proper nodes. This is the reason some of the junction numbers are missing, it means an extra junction was added that should not have been there and has since been deleted. Node elevations were gathered from the USGS/NRCS lidar data covering the DWD, automatically imported from AutoCAD based off the lidar data.

Water Source

The program relies on a manually placed reservoir that then acts as the water source for the project inside the model. The Lead/Deadwood Sanitary District Well #1 was used as the only water source for the project. Based on discussions with city staff, this well produces much more water than is needed today. For modeling purposes, we treated the well as an unlimited water source with no restrictions or limitations. Future tasks should consider reviewing the water rights permit and verify allowable water usage within that permit.

Reservoirs

The city has 6 tanks of various shapes, sizes, and elevations located within the city water system network. Once input into the model, the nodes represent the real-life tank locations, conditions, and sizes. It should be noted that based on various SCADA settings, the city only utilizes about 80% of their available capacity. Table 1 shows the data inputs for all the existing tanks for the DWD.

Table 1: Tank ID and input data for the DWD

Tank ID	Description	Elevation (ft)	Initial Level (ft)	Minimum Level (ft)	Maximum Level (ft)	Diameter (ft)	Storage Capacity (gal)
2	Pluma Tank #2	4841.67	33	0	40	40	388,000
3	Pluma Tank #1	4841.67	33	0	40	30	208,000
15	McGovern Hill #2	4749.25	37	0	42	44	500,000
16	McGovern Hill #1	4749.25	37	0	42	40	400,000
24	Roosevelt Tank	5121.67	7*	0	16	60	340,000
51	Deadwood Hill	5095.00	13	0	19	70	550,000

*Note: Roosevelt Tank SCADA Level is set at 12-13’ however, during the calibration and validation steps, it was found that a level of 6-7’ better fits within the system. The fire hydrant test results indicate approximately 2-3 psi less from Roosevelt Tank. Depending on the time of day or status of the system (such as refilling the reservoir), variations can be expected if the reservoir was not 100% full at time of testing.

Pipes

AutoCAD converted links are labeled with a “p” prefix, no prefix indicates the link was manually placed. Some pipes in the GIS data or AutoCAD conversion were not properly converted and some of the system ended up being disconnected. Some pipe/ links needed to be edited to connect to the proper nodes. This is the reason some of the link numbers are missing. Most manually placed links are to help model valves to close and open to allow tanks and PRV's to function. The roughness for all pipes were assumed to have a Hazen-Williams coefficient of 130.

Pumps

There are 6 total pumps in the model all located in the areas described in the operations manual. The pumps on Denver Ave are active and very critical to the Zones 4, 5, 6, 7 and 8. All other pumps within the DWD water system are either not in operation, are only used for emergencies, or are seasonal (Mt. Moriah Cemetery). Only the Denver Avenue pumps are active while the model is running, if scenarios need to be ran with pumps active, they are set up in the model to allow for such scenarios.

The pumps curves on Denver Avenue were calibrated based on total pump runtime from day to day as well as total water used by Deadwood. More accurate pump curves can be found by timing the Roosevelt tank fill times throughout the day.

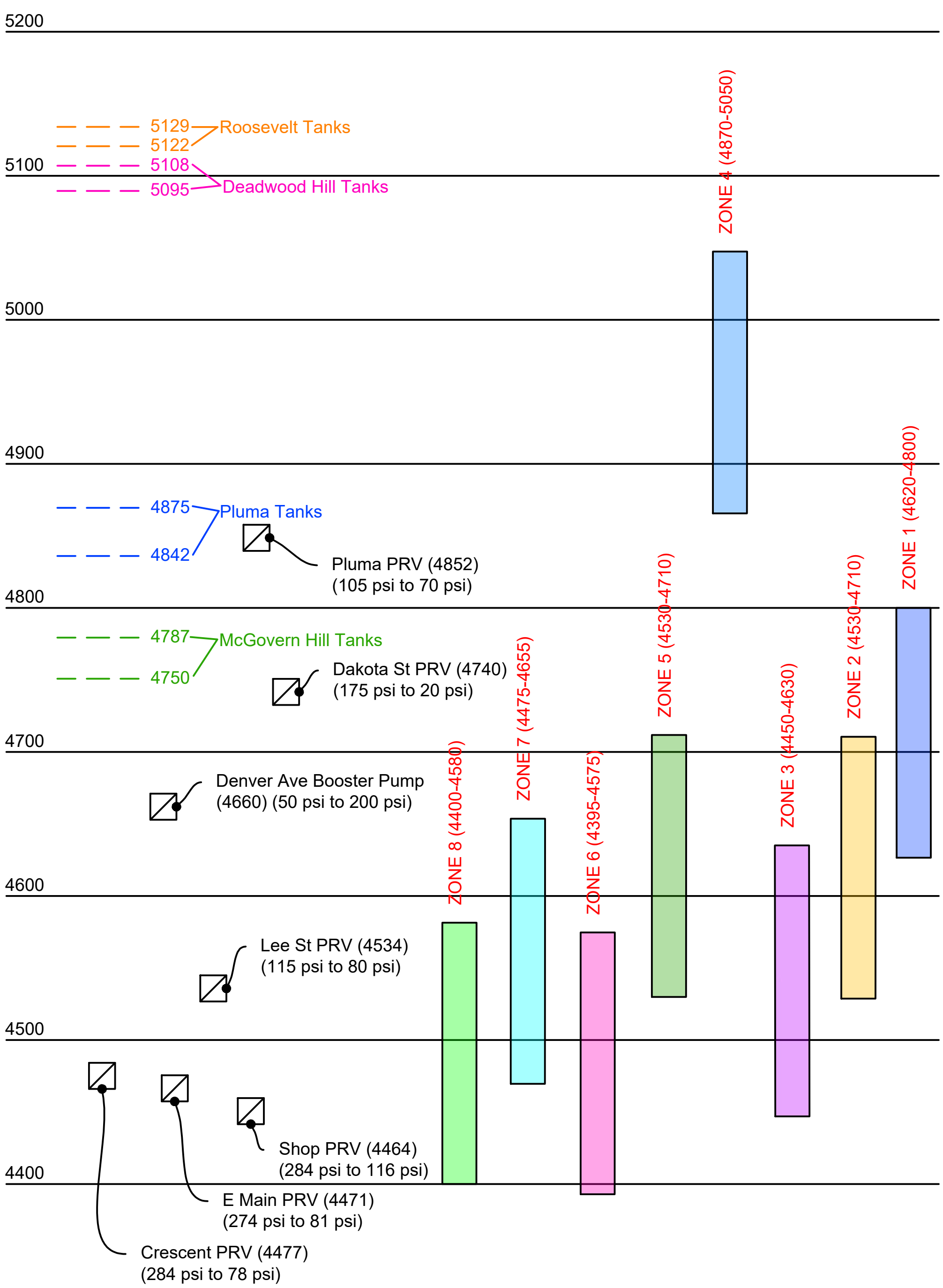
Valves

The valves list in EPANET are only for special pressure valves, this model uses Pressure Reducing Valves and General-Purpose Valves. Gate valves and control valves are incorporated into the link settings. Table 2 below shows the valve ID's and their settings within the model.

Table 2: List of PRV's in Water Model

Valve ID	Description	Diameter (in)	Type	Setting (psi)	Incoming PSI (psi)	Outgoing PSI (psi)	Elevation (ft)
35	Pluma Tanks PRV	6	PRV	18	245	18	4852
40	Cutting Mine	12	PRV	50	NA	NA	4743
58	Pluma PRV	12	PRV	72	108	72	4622
61	Main Street PRV	6	PRV	60	98	NA	4560
75	Lee Street PRV	12	PRV	75	109	75	4534
79	Dakota Street PRV	6	PRV	20	169	20	4740
90	Denver Street PRV	10	PRV	47	129	NA	4660
109	Crescent Street PRV	6	PRV	78	282	78	4476
118	Shop PRV	6	PRV	115	288	115	4464
120	East Main Street PRV	10	PRV	81	275	81	4471
41	Deadwood Tank PRV	4	PRV	72	245	NA	4540
139	Pluma Orifice	6	GPV	5*	245	NA	4841

*This uses a head loss curve that represents the orifice from the Lead/ Deadwood water source that requires flow to reduce the pressure to acceptable levels. The orifice plate is located just downstream from the Lead/ Deadwood Sanitary District inflow before the Pluma tanks. This orifice plate reduces the incoming pressure from the Lead/Deadwood Sanitary District, under flow. If there is no downstream flow, the pressure will build downstream and bust pipes. This is not used under normal circumstances and is only inputted into the model for future scenarios. See Figure 1 for Elevation Graph of City Water System.



City Water System
Elevation Graph
Lawrence County
December 1st, 2022

TDG

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PRELIMINARY
FOR REVIEW ONLY

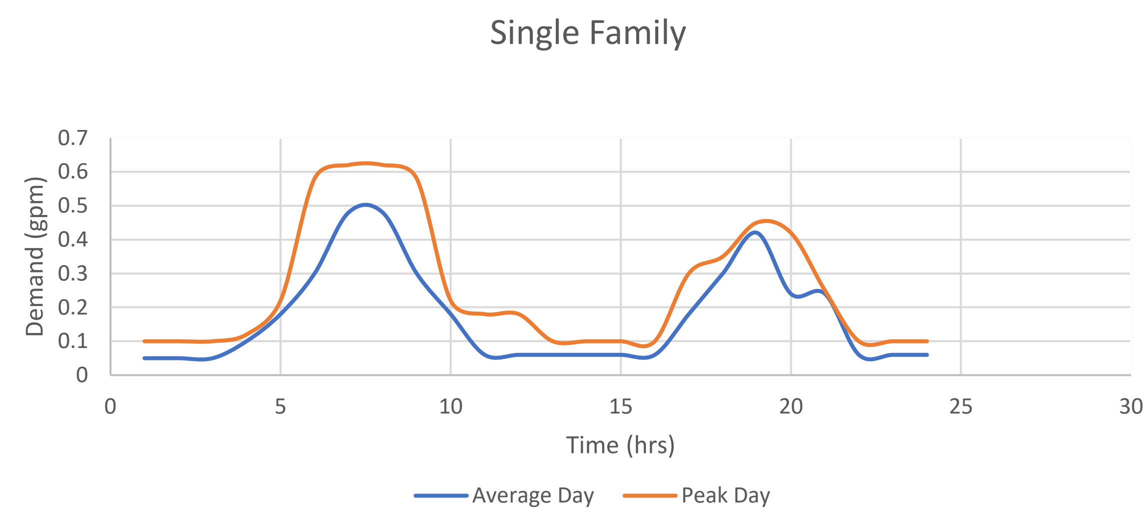
Labels

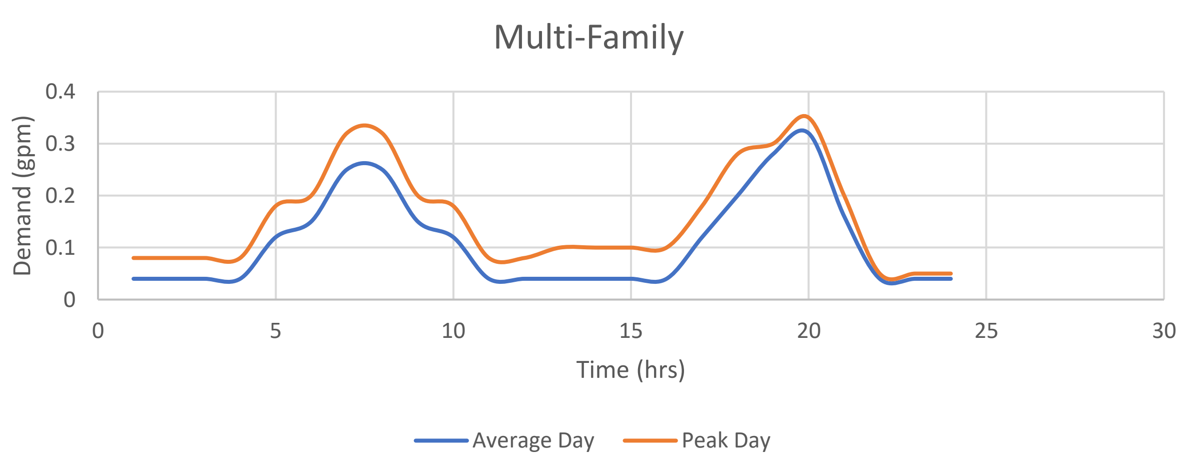
The are no labels in the model.

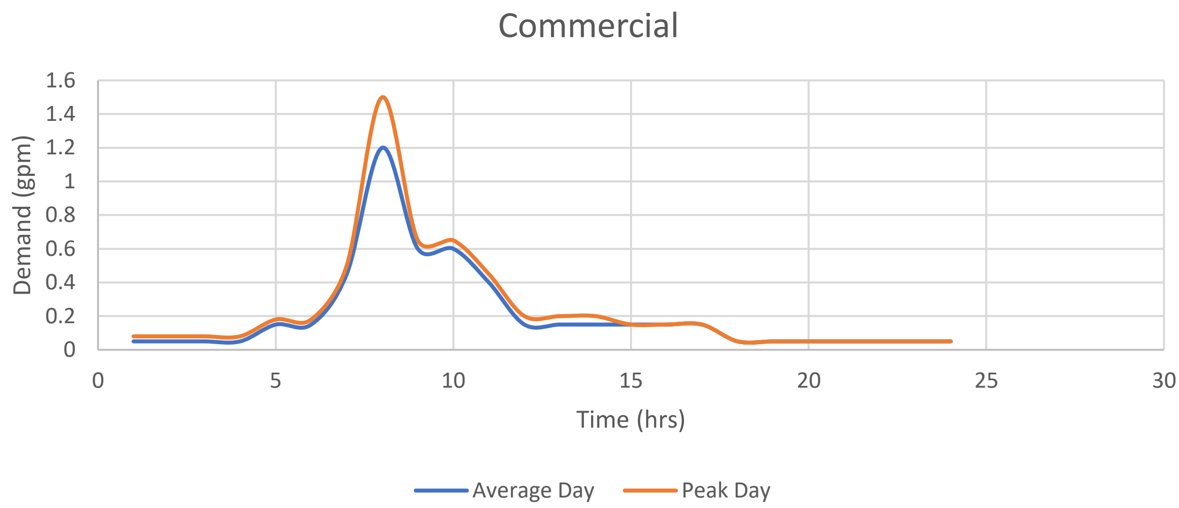
Patterns

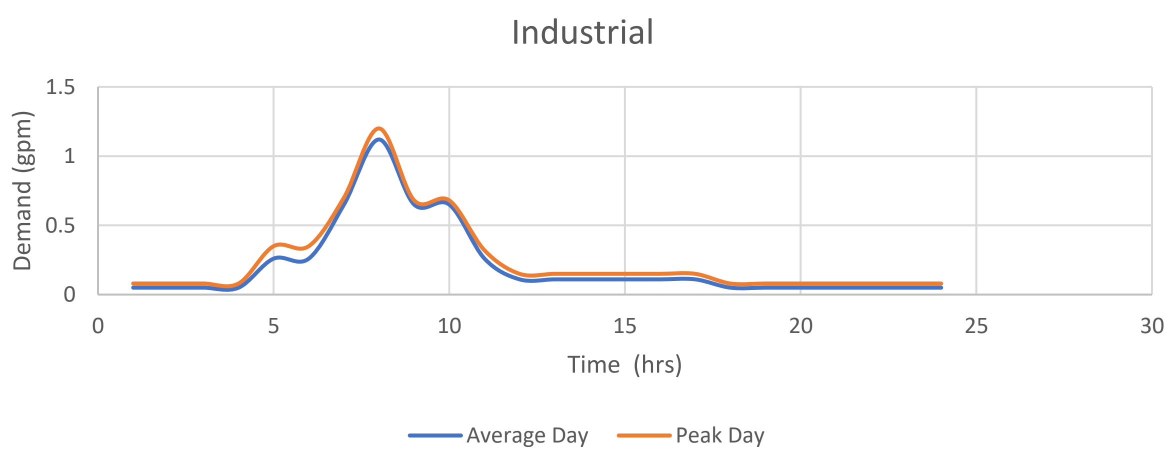
Patterns are used to create demand for each node within the model. Each node was looked at and assigned a single-family dwelling unit, commercial acreage, open space/ industrial acreage, or multi-family/ hotel rooms value. The base demands represent a dwelling unit count or acreage associated with each node. The designated pattern determines the gpm/dwelling unit or gpm/acre depending on what the node is classified as.

Residential nodes use Pattern 1. Commercial nodes use Pattern 2. Industrial/ Park nodes use Pattern 3. Hotel/ Multi-family use Pattern 1.1. Fire flow nodes given a base demand can use Pattern 4 or no specified pattern. Pattern 4 is a constant multiplier of 1 therefore base demand = actual demand.









The patterns were calibrated to the average day water usage for Deadwood, as well as the peak day water usage for Deadwood. The model has patterns for the average day usage and the peak day usage. EPANET allows the user to specify variable demands for each pattern. This model separated the average day demands into hourly demands that peak in the morning and evenings and a steady average day demand for each node. The same was done for peak day demands. Two patterns are available to use for average and peak days. The average and peak day demands were further separated into residential, commercial, industrial, and multi-family residential demands. The figures below show each pattern available for the model.

The single-family average day demand equals 0.17 gpm per dwelling unit, the peak day equals 0.25 gpm per dwelling unit. The commercial average day demand equals 0.21 gpm per acre, the peak day equals 0.24 gpm per acre. The industrial average day demand equals 0.21 gpm per acre, the peak day equals 0.25 gpm per acre. The multi-family average day demand equals 0.11 gpm per dwelling unit, the peak day equals 0.16 gpm per dwelling unit. Since hotels are included in the multi-family category adjusting this pattern can create large demands or largely decrease demands on the Deadwood system.

Curves

The water model consists of 5 curves. 4 curves are estimated pump curves. All pumps use a specified curve defining an additional head or pressure depending on a specified flow. Denver Avenue pumps were estimated by pump runtime data, other pumps were estimated by the specifications given in the operations manual and finding a similar pump and using that pump curve, normal operation of the DWD water system only use the Denver Avenue pumps. The other pumps are only modeled for the option to look at scenarios that require those pumps. There was no calibration or validation for the non-critical pumps because no pressure data was available to calibrate the pumps.

Note: The next phase of this project should include acquiring actual curve data for all pumps within the water system. Actual curve data should be incorporated and verified into the final model.

Controls

The controls in EPANET are text-based code that the program reads. The code can activate pumps, close links and much more, this model only activates pumps and closes links using the "simple" and "rule-based" controls. There are 6 "simple" controls that control the elevation of the Pluma tanks and a link that mimics the altitude valve located on East Main Street.

The "Rule-based" controls allows less simple rules to be done on links and nodes. Rules 1-2 also help control the Pluma Tanks. Rules 3-6 are set to work the Denver Avenue pumps, since there is no way to alternate pumps in EPANET each Denver Avenue pump works for half the day, thus the need for 4 rules to work the pumps. Rule 1 and Rule 3 are described in detail below, the other rules and simple controls are very similar.

RULE 1	
IF TANK 3 LEVEL BELOW 30.5	Tank 3 is Pluma tank #1, if the level in the tank is below 30.5 then move to the next line.
OR TANK 2 LEVEL BELOW 30.5	Tank 2 is Pluma tank #2, if the level in the tank is below 30.5 then move to the next line.
THEN LINK 33 STATUS IS OPEN	Since line 1 is IF and line 2 is OR if either line is true then Link 33 will be open. Rule 2 closes the link.
RULE 3	
IF TANK 24 LEVEL BELOW 6	Tank 24 is Roosevelt Tank, if it is below level 6, move onto the next line.
AND SYSTEM CLOCKTIME >= 12 AM	If the time is greater than 12am and...
AND SYSTEM CLOCKTIME < 12 PM	If the time is less than 12pm then...
THEN PUMP 85 STATUS IS OPEN	If all above is true then the pump will open. Rules 3-6 determine if the pumps need to be closed or open, since there are 2 pumps that run half the time.

Options

Hydraulics: The flow units for the model is in gallons per minute (gpm), the head loss formula is the Hazen-Williams equation. The accuracy of the model is set to 0.01 (psi and gpm) the remainder of the hydraulic options are default.

Quality: EPANET has the capability to model contaminates that spill within the water system, the model has not been set up for water quality options.

Reactions: Another option related to quality; the model has not been set up for water quality options.

Times: The model is currently set up to run for 96 hours with a time step of 15 minutes. The reporting time step is 30 minutes with the start time at 72 hours. All those can be changed to longer runtimes and longer reporting times in the Options -> Times from the Browser window.

Energy: EPANET can model pump costs based on price, patterns, and demands; the model has not been set up for energy options.

CALIBRATION AND VALIDATION

The documents used for calibration were from the daily checks data. The daily checks data include daily data including inflow and outflow pressures at all the PRV's.

Calibration Values

PRV Name	Model (psi)	Low (psi)	High (psi)	Model (psi)
Pluma PRV In	105	104	109	107
Pluma PRV Out	70	69	71	72*
Lee PRV In	115	114	115	109
Lee PRV Out	75	74	75	75
Shop PRV In	284	284	285	282
Shop PRV Out	116	112	118	115
Crescent PRV In	284	284	285	277
Crescent PRV Out	78	78	79	78
Lo Main PRV In	274	272	274	279
Lo Main PRV Out	81	81	83	81
Dakota PRV In**	175	174	176	165
Dakota PRV Out	20	19	21	20
Denver Ave In	50	48	52	47
Denver Ave Out	200	200	202	202

*PRV out setting set at 72 psi to closely match McGovern Tanks elevations

**The elevation is listed as 4740 in operations manual contour data elevation is estimated to be 4730

Calibration was done under average day steady demand conditions. Most differences in pressure can be accounted for in elevation differences between actual and DEM elevations, real world demand conditions and assumed model demands.

Validation Values

Validation results are shown below. Note most of the residual pressures are within approximately 3-6 psi and is usually lower than the measured residual pressure. This allows for a more conservative model showing the absolute low value that can be experienced on the water system. The validation pressures between the measured values and modeled values vary significantly more than the calibration results. This error can be accounted for a couple of reasons.

- The first condition is the system state at the time of the test (i.e. was the tank at 100% full, 50% full, or in process of filling or being drained). All the fire hydrant tests were done on different days at different times. It is almost impossible to know the exact usage during the fire flow tests or the state of the system at the time of the tests.

- Another reason could be the use of measuring and flow hydrants, a fire hydrant test requires 2 hydrants, both should be close to each other and preferably the same elevation. Due to topography, this can be impossible for some fire hydrants and can cause significant error in the test for modeling purposes as in some cases the pressure hydrant is lower than the flow hydrant resulting in a higher pressure in the measured test than what the model shows, or vice versa.

Fire Hydrant #	Fire Hydrant	Static Pressure	Residual Pressure	Model Static Pressure	Model Residual Pressure
15	Comfort Inn North	106	85	103	88
74	25 Taylor - Top of Taylor	69	48	57	48
94	820 Main Street	94	76	86	79
114	250 Main Street	90	61	78	73
125	100 Pinecrest/N. Park	98	86	89	80
160	476 Williams Street	95	78	85	81
46	37 Sherman/ Pioneer	124	107	110	107
67	66 Lincoln	41	33	44	24

PROPOSED MODEL

A proposed model was developed to observe what effects the proposed developments would have on the city water system. Three new subdivisions have been proposed within or adjacent to the city. These include Stage Run Subdivision, The Ridge, and Boot Hill Estates. Other local subdivisions have inquired about connecting to the city's water supply also such as Shirttail Gulch. **Exhibit C** shows the approximate locations of these subdivisions in relation to the city and their water supply. All new subdivisions in the proposed model were given pattern numbers of 1.3 to allow for the use of more conservative demands for new subdivisions, the following data used the single-family demand use from the existing model.

Stage Run Subdivision

The Stage Run subdivision consists of a proposed ±160 dwelling units for single family and multi-family land uses. The multi-family water usage was assumed as proposed single family demand usage, this was done as a more conservative approach. A portion of this subdivision's elevation is higher than the Roosevelt tank elevation, meaning a booster pump will be required to serve a portion of this subdivision.

Stage Run connects to Zone 4 and is fed by the Deadwood Hill tank, the Deadwood Hill tank is fed by the Roosevelt tank and the Denver Street booster pumps. Every lot that is added as part of Stage Run subdivision will increase demand on the Denver Street pumps and the Roosevelt tank.

Boot Hill Subdivision

The Boot Hill subdivision consists of a proposed ±298 dwelling units for single family and multi-family land uses. The multi-family water usage was assumed as proposed single-family demand usage, this was done as a more conservative approach. The proposed model has Boot Hill in Zone 7. This zone is a little low in pressure for the majority of the subdivision therefore, a booster pump will be required to keep acceptable pressures in the higher elevations.

Boot Hill subdivision is proposed to connect to Zone 7. Zone 7 feeds off of the Roosevelt tank with a PRV. Every lot and residence that is added as part of Boot Hill subdivision will require water from the Roosevelt tank and affect the Denver Street Booster pumps.

The Ridge Subdivision

The Ridge subdivision consists of a proposed ±264 dwelling units for both single family and multi-family residential land uses, in the first 3 phases of development. More lots are shown on the master plan for the future phases and true lot counts may not be accurate. This includes both single family and multi-family lots. The multi-family water usage was assumed as proposed single-family demand usage, this was used as a more conservative approach. The Ridge is proposing to connect into the city water system off of Highway 14A in the Zone 4 pressure zone, a PRV will be required for this subdivision.

The Ridge subdivision connects to Zone 4 which is fed by the Deadwood Hill tank. The immediate water usage will affect the Deadwood Hill water tank. The Deadwood Hill tank is fed by the Roosevelt tank and the Denver Street pumps. This causes more stress on the daily usage on the Denver Street pumps with each lot and dwelling unit added to The Ridge subdivision.

Shirttail Gulch

Shirttail Gulch is an existing subdivision located about a mile east of the existing Deadwood water system. Shirttail Gulch has approximately 28 dwelling units all currently served by ground water wells. The impacts of adding this sub-division to the water system is less than the impacts than the other subdivisions at full build out, however 28 dwelling is still water usage. With elevations ranging from 4570' and 4760', a booster pump or new tank will be required to serve this subdivision.

Shirttail Gulch is proposed to have access from either Zone 8 or Zone 4. Connection from Zone 8 will require booster pumps, connection from Zone 4 will require high pressure pipe and PRV's. Both zones are either directly fed or indirectly fed by the Roosevelt tank and Denver Street pumps and the added lots will increase demand on the Denver Street pumps and the storage in the Roosevelt tank.

EXISTING TO PROPOSED MODELS

Four scenarios were done to compare the existing model to the "Full Buildout" proposed model. "Full Buildout" indicates Stage Run, Boot Hill, and The Ridge are implemented into the model. Additional scenarios can be run within the model however, this report will cover the scenario listed above. The following demand patterns were looked at for the system, Average Day, Peak Day, Steady Average Day, Steady Peak Day. Where average and peak day includes variable demand patterns closely representing what the system can see on the average and peak days, and steady average and peak days where there are constant demands on nodes throughout the day.

At full buildout, it was found that the Deadwood water system is inadequate. This assumed the calibrated water usage of Deadwood (0.17gpm per dwelling unit average day and 0.25 gpm per dwelling unit for peak day scenarios) for the proposed subdivisions.

There were 8 elements compared for each scenario, Pipe 9 (outlet pipe from Pluma Tanks), Node 2 (Pluma Tank #2), Node 16 (McGovern Tanks), Pipe 16 (Inlet pipe into Roosevelt Tank), Node 24 (Roosevelt Tank), Pipe p719 (Outlet pipe from Roosevelt Tank), Pipe 128 (Inlet into Deadwood Hill Tank), Node 51 (Deadwood Hill Tank). Pipes were looked at to determine daily volume, and tanks were looked at to determine daily water levels.

Average Day

The existing model was calibrated to use about 485,000 gallons a day, at full buildout with the 4 subdivisions included into the model, the average daily usage increased to 667,000 gallons.

- The Pluma tanks are modeled to fill to 33' and start filling at 30.5'. This assumes the water source can supply up to 3000 gpm through the incoming pipes.
- The McGovern tanks have slightly lower levels in the proposed model and can be seen in the appendix.
- The amount of water pumped into the Roosevelt tank is approximately 139,000 gallons, while the pump (Denver Street pumps) runs an average of 7.5 hours a day during existing conditions. The proposed model shows pumping into the Roosevelt tank at 317,000 gallons, while the Denver Street Pumps runs an average of 17 hours. The Roosevelt Tank in the proposed model shows larger dips in elevation through the day.
- The Deadwood Hill tank for the existing model uses 73,000 gallons, the proposed model Deadwood Hill tank uses 97,000 gallons. The Deadwood Hill tank is set to fill to 13' and start filling at 12' of elevation and both the existing and proposed model can keep the elevation within the range.

Peak Day

The existing model was calibrated to use about 700,000 gallons a day, at full buildout with the 4 subdivisions the average daily usage increased to 950,000 gallons.

- The Pluma tanks can retain the 30.5' to 33' elevation level.
- The McGovern tanks show a slight drop in elevation in the proposed model.
- The peak day existing model pump approximately 203,000 gallons per a day through the Denver Street pumps and have an estimated run time of 11 hours, the proposed model pumps approximately 454,000 gallons a day and runs for 24 hours a day, while the Roosevelt tanks slowly empty. The Roosevelt tank levels can be seen on the peak day models.
- The Deadwood Hill Tank used less gallons from the existing model to the proposed model, this is because there is so much demand from the other subdivisions that the tank is not that high of a priority for the system. Therefore, more infrastructure must be added to the Deadwood water system, as the system is showing signs of failure on multiple peak days.

CITY OF DEADWOOD WATER SYSTEM ALLOWABLE DEVELOPMENT

The existing water system is sized appropriately for the existing conditions. At full buildout, including full development of the proposed subdivisions, the Deadwood water system becomes inadequate for the additional demands. The biggest failing point of the system is with the Denver Street pumps and the storage capacity of the Roosevelt tank which feeds zone 4, 5, 6, 7, and 8 and all new zones. Increasing the demand on this tank will eventually cause it to draw down during peak hours and peak days.

The Denver Street booster pump fills the Roosevelt Tank. As demand is placed on the Roosevelt Tanks, the volume of water booster increases also. The following table estimates theoretical run time periods (2-day average) of the existing pumps based on additional new single family dwelling units:

Estimated Runtime of Denver Avenue Booster Pump (hrs)						
Additional SFD (units)	Average Day Runtime	Peak Day Runtime		Additional SFD (units)	Average Day Runtime	Peak Day Runtime
10	6.50	12.25		110	11.25	23.00
20	8.25	12.75		120	10.75	23.00
30	8.50	14.75		130	11.25	23.00
40	8.50	15.75		140	11.75	23.00
50	8.50	16.50		150	12.25	23.25
60	9.50	18.25		160	13.00	23.25
70	9.75	19.75		170	12.50	23.25
80	9.50	21.00		180	13.25	23.25
90	10.00	22.75		190	13.50	23.25*
100	11.00	23.00		200	14.00	23.25*

* Denotes negative pressures and emptying tanks for these runs.

The goal of this section is to determine the allowable number of lots that can be added to the Deadwood water system. Therefore, future demands were taken from design criteria shown in Rapid City standards for proposed water usage. The assumed water usage table can be found in Section 3.9.2.1 in the Rapid City Infrastructure Criteria Manual 2012 Edition. The model assumes only single-family residential water usages, a conversion table for allowable multi-family and commercial areas will be provided later in the document. The table is shown below.

WATER USE CRITERIA			
Land Use	**Average Day**	**Peak Day**	**Peak Hour**
Residential Single Family*	0.4 gpm/du	1.8 gpm/du	4.0 gpm/du
Residential multi family	0.3 gpm/du	1.3 gpm/du	3.0 gpm/du
Commercial office/retail	0.8 gpm/ac	3.2 gpm/ac	6.4 gpm/ac
Industrial	0.8 gpm/ac	3.2 gpm/ac	25.6 gpm/ac**

gpm = gallons per minute

du = dwelling unit (house, apartment, hotel/motel room, camp site, etc.)

ac = acre

* Duplexes for the purpose of determining water use shall be considered as two residential single-family units.

** Recommended value to be utilized in the absence of site-specific engineering criteria / analysis.

Recommended Allowable Additional Lots to the DWD Water System

Four developments were looked at for the city water system, with all four developments, at full build out additional infrastructure for the water system is needed. The construction and timelines of each development start and finish dates is unclear. Since each development in the proposed model require water from Zone 4, recommended total number of lots will be a total number of additional lots, instead of dividing the lots by each development. **As of 11/30/2022, the recommended allowable number of new additional Single Family Dwelling Units is 100, until further evaluation can be completed.**

This was found by applying the peak RCIDCM flows until the Denver Street pumps ran for 24 hours (peak day) a day while keeping the Roosevelt and Deadwood Hill Tanks full. This was found by adding additional demands to the proposed model until the Roosevelt tank volume equaled the modeled average day volume plus 25% of the peak day demand volume. Note these are based on 100 proposed single family dwelling unit water usages, a combination of multi-family, commercial, and industrial may be mixed into the 100 allowable dwelling units at the following conversions.

Single Family Conversions**	
Single Family	1
Multi-Family	0.75
Commercial	2*Acre
Industrial	2*Acre

**Based off Rapid City IDCM proposed water average day demands

As an example, a total of 133 multi-family units may be added to the system or a total of 50 acres of commercial property may be added.

Use of localized booster pumps/PRV's may be required for each new development to provide adequate pressure and should be analyzed on a case-by-case basis. After 100 single family dwelling units have been added to Zone 4, the Denver Street pumps will start running 24 hours according to the RCIDCM peak flows. Then with additional lots connected to Zone 4 system starts having emergency water storage issues.

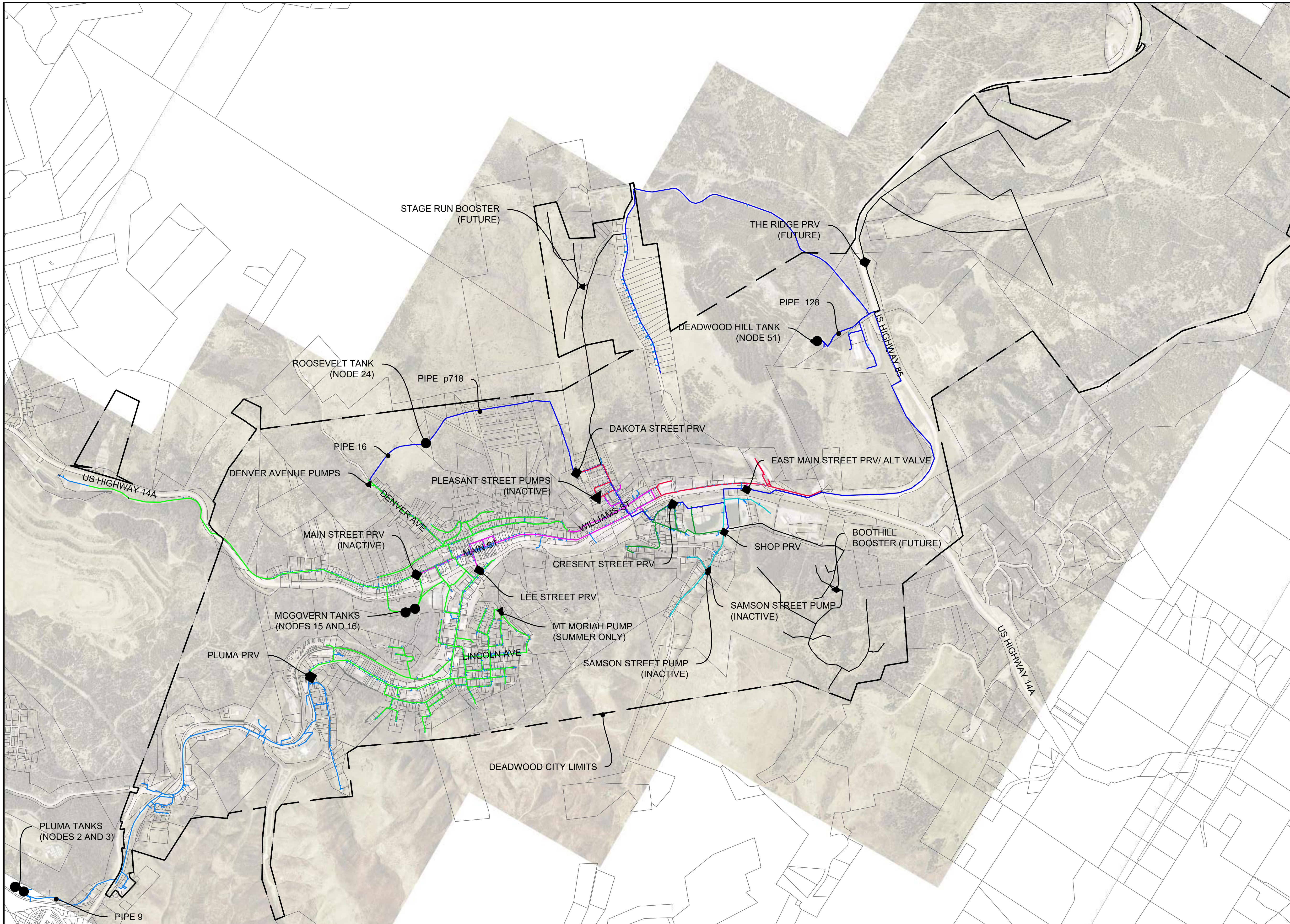
FUTURE PROJECT REQUIREMENTS

The existing water system is sized appropriately for the existing conditions. At full buildout, incorporating the proposed new developments, the Deadwood water system becomes inadequate for the additional demands. Additional points have been made throughout this technical memorandum for the next phase of this project. This includes reviewing water rights to verify adequate supply, incorporating the demands from the other booster pumps in the system, and determining what improvements provide most benefit to the city.

The next phase of this project should include:

- Verification of current water rights.
- Updating model with all booster pumps and existing conditions.
- Incorporation of current open booster pumps.
- Incorporate classification and develop requirements concerning short-term rentals.
- Preliminary development of proposed improvements required.

A final phase of this project may include a water facility plan to be reviewed and approved by SDDANR.



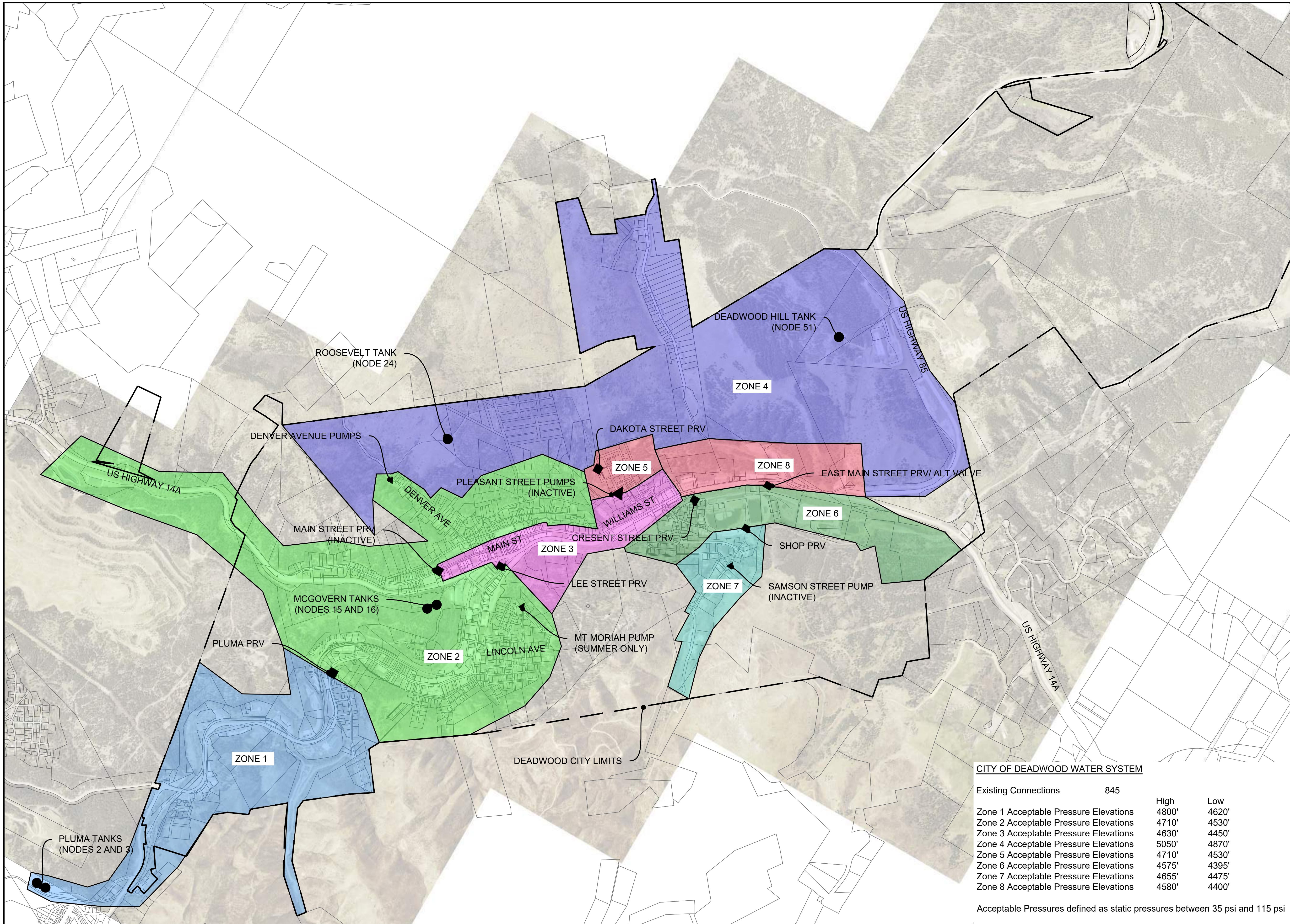
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
ZONE 7
ZONE 8
RESERVOIR
PRV/ ALT VALVE
PUMP

EXHIBIT A
CITY OF DEADWOOD WATER SYSTEM OVERVIEW MAP
LAWRENCE COUNTY
DECEMBER 1ST, 2022

TDG
Towey Design Group
475 Villa Drive, Suite #3
Box Elder, SD 57719
605.600.3758

800' 400' 0 800' 1600'
SCALE: 1"= 1600'

PRELIMINARY FOR REVIEW ONLY



CITY OF DEADWOOD WATER SYSTEM

Existing Connections 845

	High	Low
Zone 1 Acceptable Pressure Elevations	4800'	4620'
Zone 2 Acceptable Pressure Elevations	4710'	4530'
Zone 3 Acceptable Pressure Elevations	4630'	4450'
Zone 4 Acceptable Pressure Elevations	5050'	4870'
Zone 5 Acceptable Pressure Elevations	4710'	4530'
Zone 6 Acceptable Pressure Elevations	4575'	4395'
Zone 7 Acceptable Pressure Elevations	4655'	4475'
Zone 8 Acceptable Pressure Elevations	4580'	4400'

Acceptable Pressures defined as static pressures between 35 psi and 115 psi

ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
ZONE 7
ZONE 8
RESERVOIR
PRV/ ALT VALVE
PUMP

EXHIBIT B
CITY OF DEADWOOD CURRENT PRESSURE ZONE MAP
LAWRENCE COUNTY
DECEMBER 1ST, 2022

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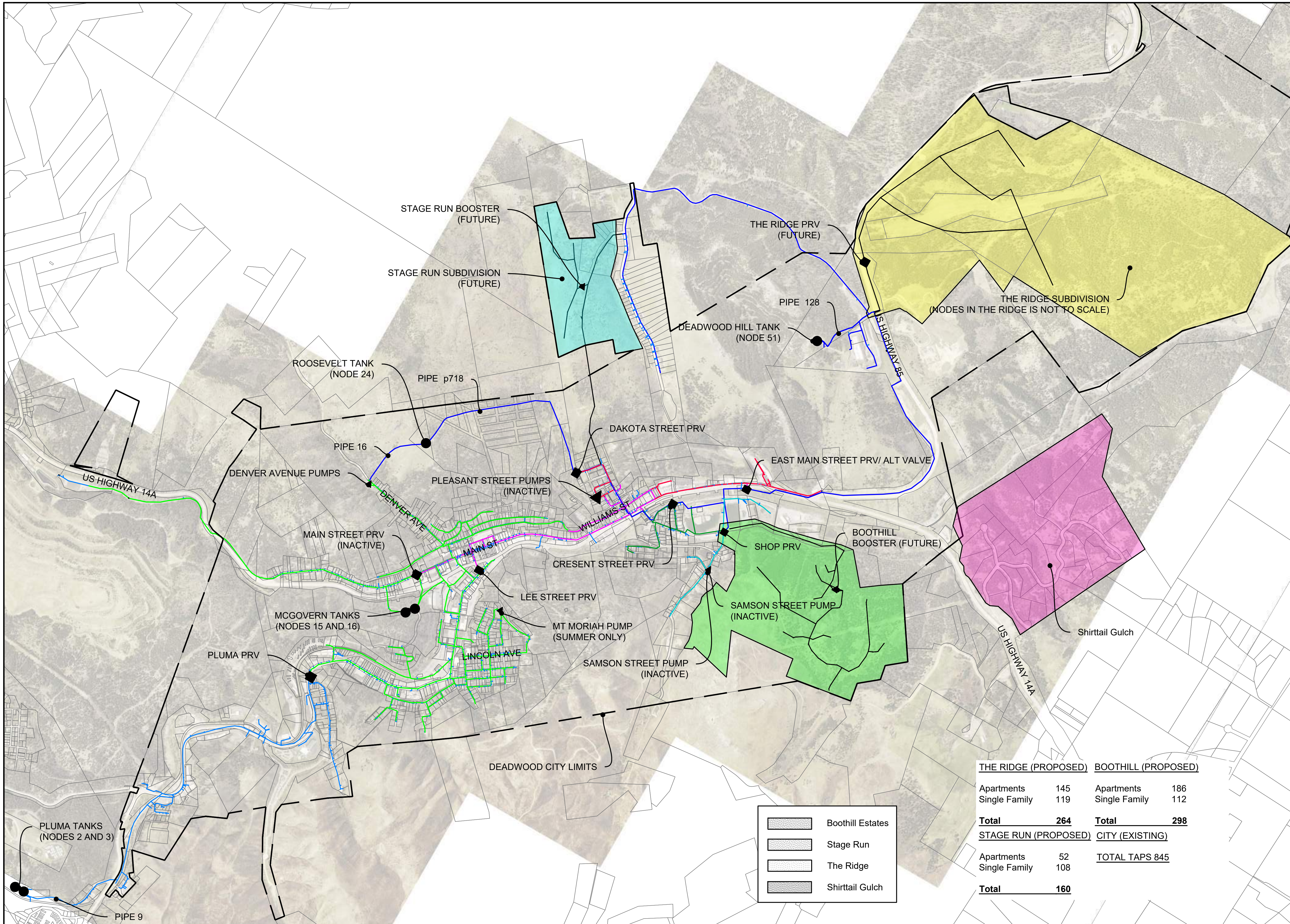
800' 400' 0 800' 1600'
SCALE: 1"= 1600'

PRELIMINARY FOR REVIEW ONLY



THE RIDGE (PROPOSED)		BOOTHILL (PROPOSED)	
Apartments	145	Apartments	186
Single Family	119	Single Family	112
Total	**264**	**Total**	**298**

STAGE RUN (PROPOSED)		CITY (EXISTING)
Apartments	52	TOTAL TAPS 845
Single Family	108	
Total	**160**	

EXHIBIT C
CITY OF DEADWOOD WATER SYSTEM OVERVIEW MAP w/ PROPOSED SUBDIVISIONS
LAWRENCE COUNTY
DECEMBER 1ST, 2022

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PRELIMINARY FOR REVIEW ONLY