BURNS McDONNELL

Broomfield Tank & Pump Station Basis of Design Report

City and County of Broomfield

Broomfield Tank & Pump Station
Project No. 121465

Revision 1
July 2022

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prepared for

City and County of Broomfield
Broomfield Tank & Pump Station
Broomfield, Colorado

Project No. 121465

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prepared by

Burns & McDonnell Engineering Company, Inc.
Centennial, CO

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1.0 INTRODUCTION

The City and County of Broomfield (CCoB) identified a need for more storage and pumping capacity in their reuse and potable distribution systems to adequately meet future demand based on modeling of the existing system. CCoB contracted with Burns & McDonnell (BMcD) to determine their water storage and pumping needs through hydraulic modeling.

BMcD completed a hydraulic technical memorandum and hydraulic modeling for the potable and reuse systems. The study concluded that two 3 million-gallon (MG) potable water tanks and a 17 million gallon per day (MGD) booster pump station will be required to match head loss with the existing Carbon Road tank. Two potable tanks are suggested as one may be taken offline in the winter when water demand is low to maintain water quality and for operational purposes. A single 4 MG reuse water tank and 6.63 MGD reuse pump station will fulfill the needs of the city and match the head loss with the existing tank. The full hydraulic report is included in Appendix A.

The new pump stations and tanks are proposed to be located in the Anthem development (Filing No. 24), on property dedicated by CCoB. Since the pump station and tanks will be located in a high-profile neighborhood, the project will require more attention to aesthetic aspects than other locations. To lessen the aesthetic impact on the surrounding neighborhood, CCoB decided to partially bury the tanks and the new pump station into the existing hill. The reuse and potable water system pump stations will be located in a singular building separated by a wall to prevent cross-contamination.

The purpose of this basis of design report (BDR) is to summarize the basic design criteria for the proposed Broomfield Booster Pump Station, Broomfield Reuse Tank, Broomfield Potable Tanks, and associated yard piping.

2.0 SITE CIVIL

2.1 APPLICABLE CODES AND CRITERIA

- American Association of State Highway and Transportation Officials (AASHTO) - Standards and Specifications
- American Concrete Institute (ACI) - Standards and Recommended Practices
- American Institute of Steel Construction (AISC) - Standards and Specifications
- American Society of Testing and Materials (ASTM) - Standards, Specifications, and Recommended Practices
- American Water Works Association (AWWA) - Standards and Specifications
- Asphalt Institute (AI) - Asphalt Handbook
- National Fire Protection Association (NFPA) - Standards
- Colorado Department of Health and Environment (CDPHE)
- State of Colorado Department of Transportation (CDOT) Road & Bridge Construction Specifications
- City and County of Broomfield Design Standards and Construction Specifications

2.2 SITE DEVELOPMENT AND LAYOUT

The proposed Broomfield Tank and Pump Station site is located east of Lowell Boulevard and north of 152nd Avenue in the City and County of Broomfield, Colorado. The proposed tank and pump station site is located near a 400' by 400' plot of land (Tract E) that CCoB currently owns. The proposed project will exceed the current tract of land owned by CCoB. The proposed site location is located adjacent to the Anthem 24 housing development, which increases the visibility of the project.

The reuse and potable water tanks are proposed to be located at the top of the hill which has a steep grade down to the pump station on the west side of the hill. The potable water tanks are proposed to be partially buried, with a slab elevation of 5440. The reuse tank is also proposed to be partially buried and has a slab elevation of 5438. In addition, the reuse tank is located on the east side of the hill; in the event of a reuse tank failure, the reuse water would flow away from the potable water tanks. The tanks would be accessed through a new gravel road that will be sized for utility truck access. There is an existing public trail in this area that will need to be closed and reconstructed with the project.

The pump station is proposed to be located near an existing parking lot on the west side of the site. The pump station finished floor elevation is expected to be approximately 5418. The pump station will be partially built into the hill to decrease the aesthetic impact to the neighborhood. Figure 2-1, below, illustrates the pump station within the existing hill.

Figure 2-1: Pump Station Elevation

The pump station will be accessed via an asphalt driveway connected to the existing parking lot roadway. A large access area in front of the pump station will be provided to allow CCoB to bring in equipment needed to service the pump station. The pump station will be surrounded by a secure fence. A preliminary site plan is included in Appendix C.

The site will be prepared and regraded as necessary around the new infrastructure. Landscaping for the project will consist of native grass reseeding for all disturbed areas not being paved or graveled for access.

2.2.1 Grading and Drainage

A topographical survey for the Broomfield Tanks and Pump Station site was completed in February 2022, the results of which can be referenced in Appendix B. The survey located existing surface features, and provided 1-foot contour elevation intervals, property and easement information, and existing buried utility information. A basic site plan was created based on the information collected in the survey, including locations for the storage tanks, pump station, and other site improvements. The site plan reflecting the proposed site layout is attached in Appendix C.

The earthwork required to excavate the locations of the three tanks and the pump station building will be extensive. Appropriate erosion control measures and best management practices (BMP) will be implemented to reduce sediment from being discharged from the site during construction. The area around the partially exposed storage tanks will be graded to provide positive drainage away from the tanks. Further design is required to determine how the increased runoff from the tanks will be routed to existing drainage pathways. The area immediately around the pump station will be paved and graded to provide positive grading away from the pump station building and convey runoff to nearby existing stormwater drainage inlets. Because the total area of disturbance exceeds 1 acre, a permit for stormwater discharge in addition to a Stormwater Management Plan (SWMP) will be required. Infrastructure required for emergency tank overflow are separate from stormwater flows and may require additional site grading and BMP installations.

The geotechnical study is in progress; the corresponding soils strength and drainage information from the report will be incorporated during detailed design.

2.3 UTILITIES

Minimal utility service will be required for the storage tank. The pump station will require a sanitary sewer connection and power. A new electrical service will be run to the new pump station, with a pad mounted service transformer located outside the facility. The sanitary sewer connection will be an extension of the existing 8” sanitary sewer located near the project site. Water for washdown in the facility will come from a tap off of the potable water pipe in the pump station; no domestic water connection will be required.

CCoB is expected to add communication fiber to the facility; however, it is not expected to be completed until after the site is constructed and fully functional. Radio communications are planned to be used in the interim.

2.4 PERMITTING

Permits will include (but are not limited to):

- Site Development Plan
- Stormwater Discharge General Permit
- Notice of Intent (NOI) for construction storm water discharge (CDPHE)
- City and County of Broomfield Building Permit
- North Metro Fire Department Inspection
- CCoB Public/Private Improvement Permit (PPIP)

3.0 PROCESS DESIGN

This section summarizes the process design for the two (2) new 3 MG potable storage tanks, one (1) 4 MG reuse storage tank, a 17 MGD capacity potable pump station, and a 6.63 MGD capacity reuse pump station. Process design includes sizing of the pump station building and storage tank, and the design of pumps, process piping (interior and yard), and pipe accessories and other appurtenances.

3.1 SYSTEM HYDRAULICS AND PUMP SIZING

An existing hydraulic model was provided by staff for both the potable system and the reuse system. BMcD updated the models to reflect the current system design. The system was modeled to meet demand for a defining emergency scenario, as outlined in the study in Appendix A. Varying conditions regarding tank levels and demand flows were modeled to determine pump station design criteria. At this time, surge modeling for the CCoB’s system and the addition of the pump station has not been performed. Once surge modeling is completed, BMcD will discuss additional surge protection devices with CCoB.

3.1.1 Potable Water System

The system curve for the Potable Water System is shown below in Figure 3-1. The curve includes the following assumptions:

- Normal maximum day and peak hour curves are based on the Carbon Road Tanks at a level of 32’ and the new tanks at 20’.
- Minimum system curves are based on the new tanks being full at 30’ and the Carbon Road Tanks being empty.
- Maximum system curves are based on the new tank being empty and the Carbon Road Tanks being full.

The Potable Water System is bounded by the 2020 max system, max day curve (in pink) and the 2038 min system, peak hour curve (in black). The 2020 system conditions are higher in required system head than the 2038 system curves because the 2020 curve represents the system as it stands today, whereas the 2038 curves include distribution system improvements that reduce overall system head loss with the increased system capacity. These improvements are shown in the North System Improvements PHD 2020-2022 Figures included as Appendix D.

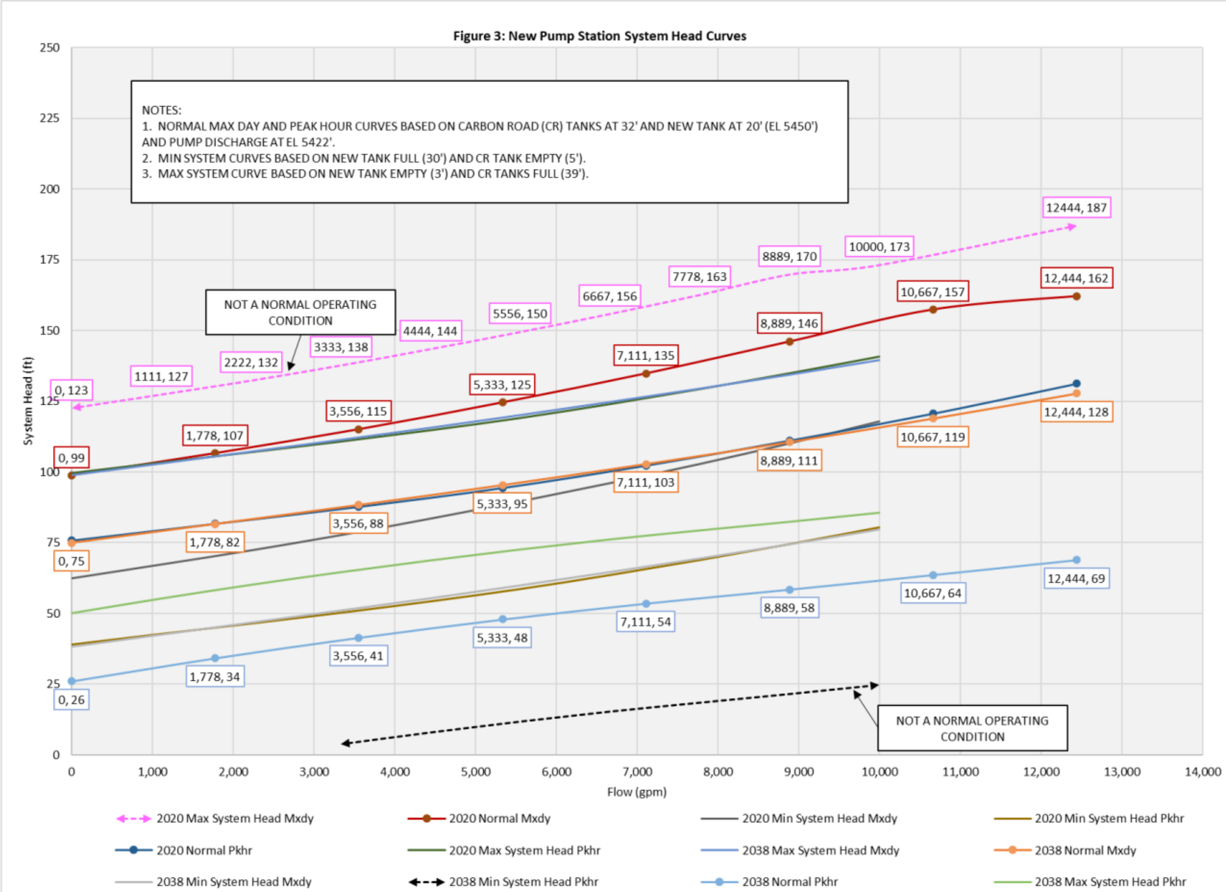


Figure 3-1: Potable Water System Curve

The maximum design conditions for the new pump station will be the 2020 max system, max day curve (in pink). This curve represents CCoB's system, without distribution system improvements, with the new tanks empty and the Carbon Road Tanks full. Although this curve is not a normal operating condition, it was selected as the maximum design condition because CCOB could decide to fill the Carbon Road Tanks during emergency scenarios (or for water quality cycling) while emptying the new tanks.

The minimum design condition will be the 2038 normal peak hour curve (in light blue). This curve represents the Carbon Road Tanks at a level of 32' and the new tanks at a level of 20'. The 2038 minimum system curve (in black) was not selected as a design point due to the improbability of this scenario occurring. The 2038 minimum system curve represents the new tank full and the Carbon Road Tanks empty. Since CCoB maintains the Carbon Road Tanks at approximately 32' at all times, this is not a likely scenario. There is also a very low probability that if the Carbon Road Tanks are empty that the new tank will be full.

In summary, the potable water pumps will be designed around a maximum flow rate of 5.67 MGD per pump and a TDH of 187’. In selecting pumps, a pump that can turn down to the 2038 normal peak hour curve will be preferred.

3.1.2 Reuse Water System

The system curve for the reuse water system is shown below in Figure 3-2. The reuse system curves were developed using the following assumptions:

- System head curve was evaluated at a pump station finished floor elevation of 5422’, with a tank water level range of 30’ for the new tanks.
- The max day average year flow rate is 16.8 MGD.
- The max day dry year flow rate is 25.2 MGD.
- The peak hour average year flow rate was 21.6 MGD.
- The peak hour dry year flow rate is 32.4 MGD.
- The demand conditions are based on model demand allocation.
- The hydraulics are influenced by the pressure reducing valves (PRV) at Sheridan Blvd and Highland Park Drive (100 psi), and the PRV at Lowell Blvd and W 136th Ave (105 psi).

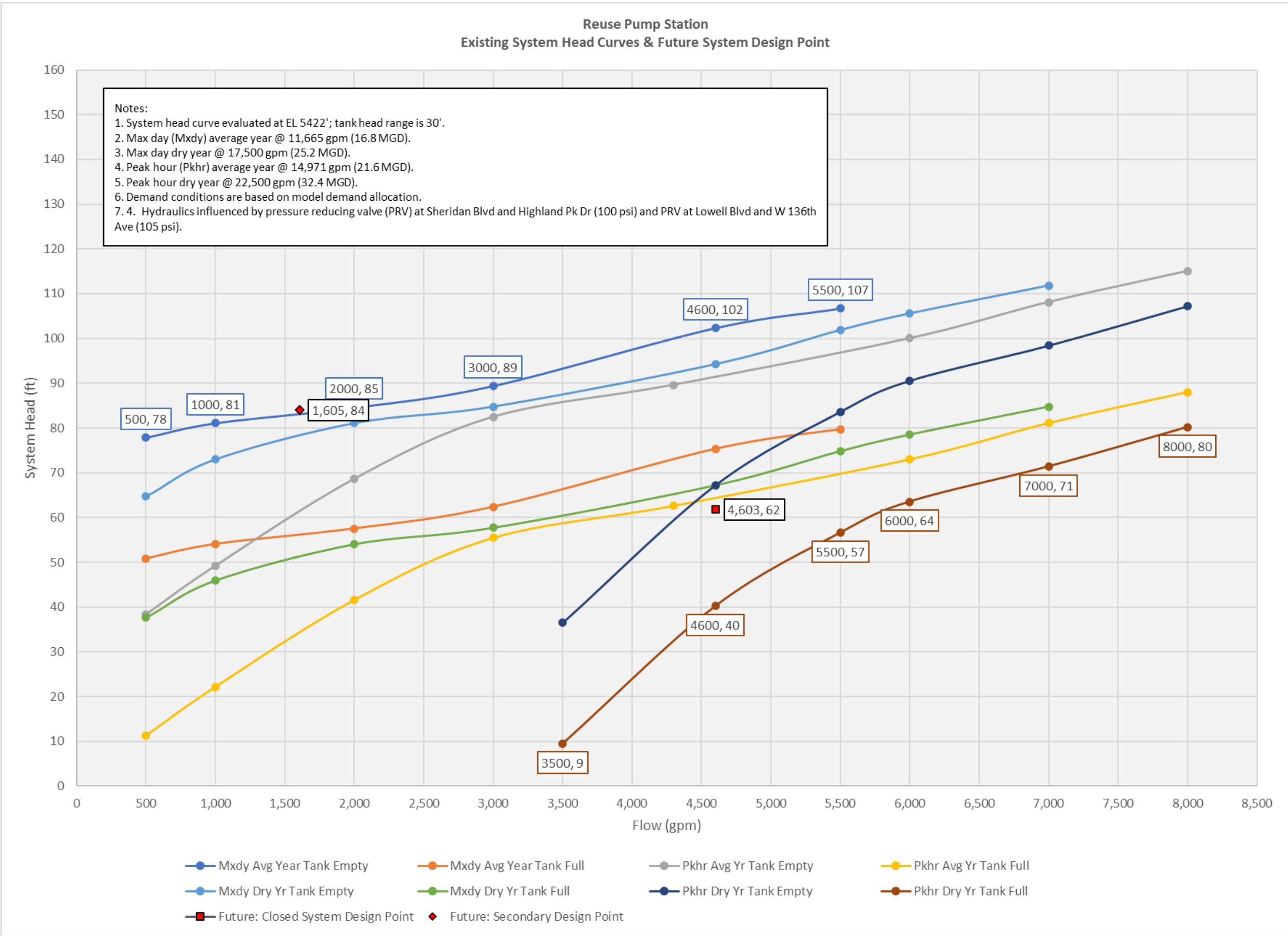


Figure 3-2: Reuse System Curve

The reuse system is currently an open system utilizing PRVs to serve the northern and southern parts of the system. In the future it will be converted to a closed system, with the new pump station only serving the northern part of the system. Since closed systems can be difficult to represent, BMcD began by modeling the existing conditions in the open system. The curves shown in Figure 3-2 represent the existing open system. The open system is bounded by the max day, average year, with empty tanks curve (royal blue) and the peak hour, dry year, tanks full curve (maroon). Once the open system was defined, BMcD approximated the two design points for the closed system. These two design points fell close to or within the envelope of the open system curves, meaning the open system curves could be used for design.

The PRVs are critical to the system curves. Depending on PRV setpoints, the pump station can supply varying flow to the system.

Given the above considerations, the reuse pumps will be designed around a maximum flow rate of 3.32 MGD per pump and a TDH of 100’.

3.2 TANK AND PUMP STATION PROCESS DESIGN CRITERIA

CCoB will have three new storage tanks as outlined above. The tanks will be partially buried in a hill to reduce overall aesthetic impact to the neighborhood. The tank design criteria for the potable tanks and reuse tank are summarized below in Tables 3-1 and 3-2. Each tank will also include a globe-style fill valve to properly fill the tank.

Table 3-1: Broomfield Potable Tank Design Criteria

Component	Design Value
Storage Capacity	3.0 MG
Tank Floor Elevation	5440.0 feet
Tank Side Wall Height	32 feet
High Water Elevation	5470.0 feet
Overflow Design Flowrate	17 MGD

Table 3-2: Broomfield Reuse Tank Design Criteria

Component	Design Value
Storage Capacity	4.0 MG
Tank Floor Elevation	5438.0 feet
Tank Side Wall Height	32 feet
High Water Elevation	5468.0 feet
Overflow Design Flowrate	6.63 MGD

Pump station design criteria were developed based on the pump sizing and selection as described in Section 3.2, and are summarized in Tables 3-3 and Table 3-4. CCoB requested an increase to the Reuse system flow rate from 4300 to 4625. The new flow rate will be included in the next revision of the report.

Table 3-3: Broomfield Potable Pump Station Design Criteria

Component	Design Value
Firm Capacity	17 MGD
Number of Pumps	4 (3 + 1)
Capacity per pump	5.7 MGD
Pump Discharge Valve	Non-Slam Swing Check Valve
Pump Control Mechanism	Variable Frequency Drive
Motor Horsepower (Per Pump)	250 HP
Total Pump Station Horsepower (Excluding Redundant Pump)	750 HP

Table 3-4: Broomfield Reuse Pump Station Design Criteria

Component	Design Value
Firm Capacity	6.63 MGD
Maximum Design Point (Running out on curve)	8.82
Number of Pumps	3 (2 + 1)
Capacity per pump	3.32 MGD
Pump Discharge Valve	Non-Slam Swing Check Valve
Pump Control Mechanism	Variable Frequency Drive
Motor Horsepower (Per Pump)	75 HP
Total Pump Station Horsepower (Excluding Redundant Pump)	150 HP

3.3 PUMP STATION LAYOUT

The potable and reuse pump stations will share one common building to decrease building costs and maintenance. A preliminary layout of the facility is included in Figure 3-3, below.

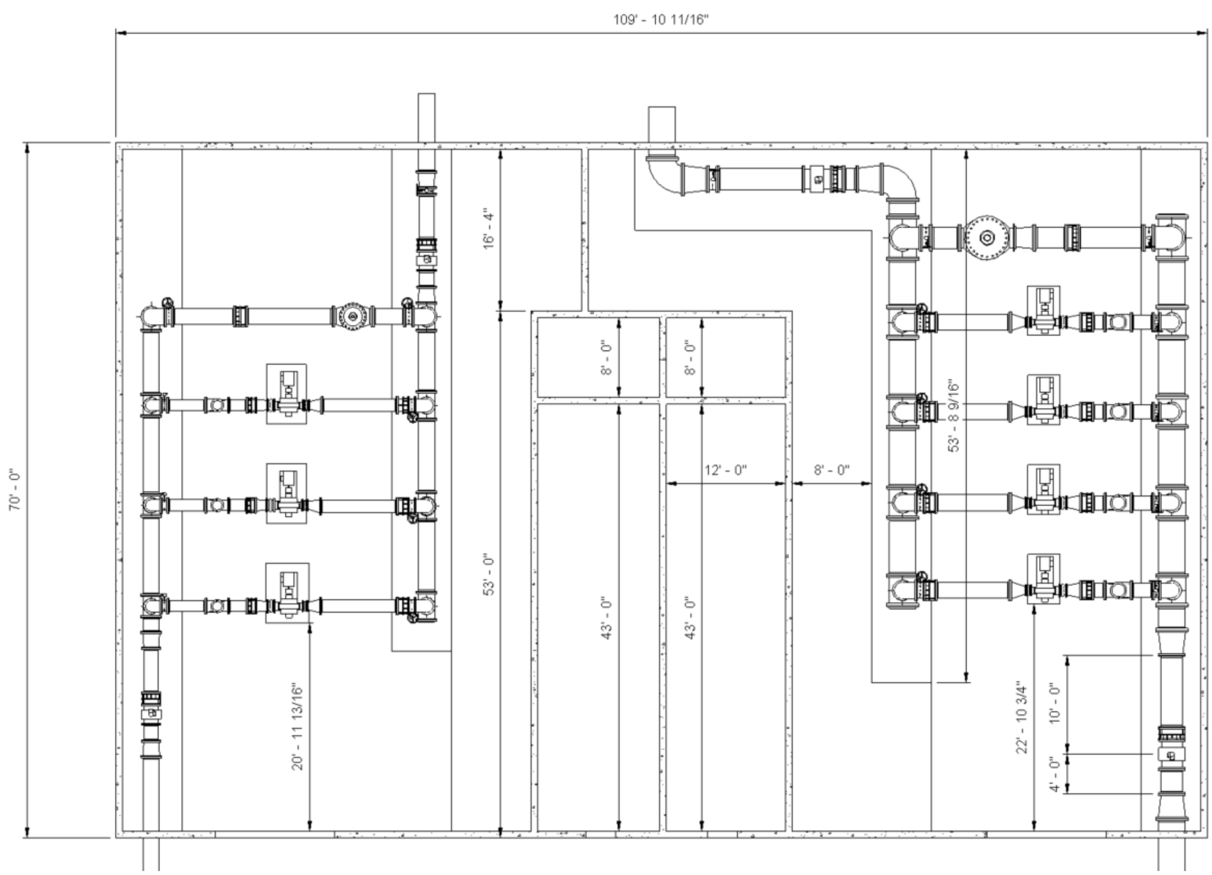


Figure 3-3: Preliminary Pump Station Layout

The facility will have a wall dividing the reuse and potable water pump stations to prevent potential cross contamination. The inlet and outlet headers for both systems will be located within trenches to increase accessibility. For maintenance purposes, there will be a bridge crane located over the pumps in both pump stations. The pumps can be pulled out with the bridge crane, set in the maintenance area in front of the pumps, and then removed through the double doors. For access to the facility, there will be man doors near the overhead doors.

The electrical room is located in the middle of the building and will be accessed through an exterior double door and a man door to each pump area. The electrical room will have windows facing the respective pump stations to facilitate communication between personnel working in the two areas.

The two pump systems have various valve and accessories for proper operation. The water will flow into the facility and pass through an isolation butterfly valve. This valve will allow CCoB to isolate the pump station for maintenance purposes. Downstream of the isolation valve is a flow meter on the header to determine the influent flow rates for each station. The water exits the top of the header pipe and flows into the individual pump inlet lines. The inlet lines are located above the finished floor. Each inlet line has an isolation butterfly valve, a dismantling joint for maintenance, and an expansion joint to prevent vibrations from being transferred from the pumps to the piping. The pump outlet lines have an expansion joint, dismantling joint, non-slam check valve, and isolation butterfly valve. The velocity on the pump discharge line is higher than the inlet lines to prevent check valve chattering. Each discharge line will also have an air/vac valve before it tees down to the header pipe. The outlet lines then elbow down into a combined discharge header located in a trench. There is a flow meter on the discharge line before it exits the building. All pipe is currently assumed to be DIP or steel. In addition to the main pump lines, there is a surge anticipator line on each side of the pump station, which opens when it senses a surge and returns water from the discharge line to the inlet. Each pump station will also include a chlorine residual analyzer to allow CCoB to monitor the chlorine levels at the pump station. The pump station will not include any provisions for increasing the chlorine residual.

4.0 ARCHITECTURAL

4.1 CODE REVIEW

This section describes the function, occupancy, classification and egress of the Broomfield Tanks and Pump Station. The proposed structures consist of an electrical building and below grade pump station.

At the time of writing for this report, CCoB has adopted the following codes:

2018 International Building Code (IBC)

2018 International Residential Code (IRC)

2018 International Fire Code (IFC)

2018 International Plumbing Code (IPC)

2018 International Mechanical Code (IMC)

2018 International Fuel Gas Code (IFGC)

2021 International Energy Conservation Code (IECC)

2020 National Electrical Code (NEC)

4.1.1 Use and Occupancy Classification – IBC Chapter 3

The pump station is classified by IBC Section 306.3 as low hazard factory industrial, Group F-2, since the processing and movement of water does not involve a significant fire hazard. The tanks are classified as utility structures, Group U.

4.1.2 Special Detailed Requirements Based on Use and Occupancy – IBC Chapter 4

There are no special detail requirements for the pump station or the tank.

4.1.3 General Building Size and Construction – IBC Chapter 5&6

This facility is constructed entirely of non-combustible building elements. Type II-B construction will be selected per IBC Table 601. The approximate size of the pump station is 7,000 square feet, which is well below the allowable area permitted by IBC Section 506. The reuse side of the structure is approximately 3,300 square feet and the potable water side of the structure is approximately 3,700 square feet.

4.1.4 Fire and Smoke Protection Features – IBC Chapters 7 & 9

Potable fire extinguishers will be provided per IBC Section 906.1 and NFPA 10. Automatic sprinkler systems are not required for Group F-2 occupancy buildings per IBC Section 903.

4.1.5 Means of Egress – IBC Chapter 10

The pump station is considered an industrial area and has a maximum floor area allowance of 100 square feet per occupant per IBC Table 1004.5. The total occupant load for the reuse side of the building is 33 persons and the occupant load for the potable water side of the building is 37 persons. A single egress door will be provided on each side of the building, which will meet the requirements of IBC Section 1005. The NEC requires electrical rooms containing equipment that has a rating greater than 1200amps and measuring over 6 feet in width to have an egress door at each end of the working space. Two egress doors will be provided in each of the electrical spaces.

4.1.6 Energy Efficiency – IBC Chapter 13

The building envelope will be designed as described in the following sections to meet the requirements of the 2018 IECC.

4.2 PUMP STATION CONSTRUCTION

4.2.1 Pump Station Exterior

The pump station will be a concrete masonry unit (CMU) block building with a flat steel framed roof. The CMU block materials will be chosen to match the existing aesthetic at the Broomfield Water Treatment Plant and Carbon Road pump station facilities. See Figure 4-1 for example colors and pattern.

Figure 4-1: Representative CMU Pattern and Colors

The City and County of Broomfield falls into Climate Zone 5B per the 2018 IECC. To meet the insulation requirements for this energy code, the exterior building walls will be constructed using cavity wall construction. Moving from the interior side to the exterior side, cavity walls will consist of 8" or 12" structural CMU block, a fluid applied air barrier, three inches of continuous rigid polyiso insulation, air space and 4" decorative CMU block. The cavity wall will have a minimum R-value of 11.4 to meet code requirements. Exterior man doors will be flush hollow metal doors with key card entry connected to the City security network. A double door will be provided on the exterior side of the electrical rooms for equipment access. Each side of the pump station will include a powered overhead door for removing equipment from the pump station.

4.2.2 Pump Station Roof

To meet energy code requirements the roof must have continuous insulation to achieve an R-value of 30. The roofing system will be an adhered EPDM roof which is constructed as follows: an underlayment layer placed over the metal deck topped by a vapor barrier followed a minimum of 5” of rigid polyiso insulation, a cover board and finally the adhered membrane layer. An example of the roofing system is shown in Figure 4-2.

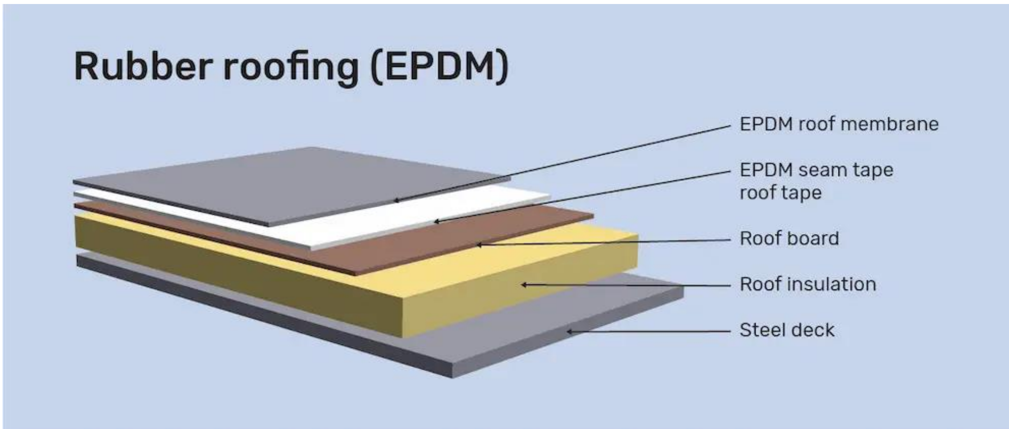


Figure 4-2: Roofing System Diagram

The walls will be capped with a light gauge steel framed mansard roof that will act as a screen wall for roof top mounted mechanical equipment. The mansard is finished with dark brown standing seam metal panels and includes an overhang beyond the face of the wall. See Figure 4-3 for an example of the mansard roof overhang. Roof access hatches will be provided to access the mechanical equipment on the roof.

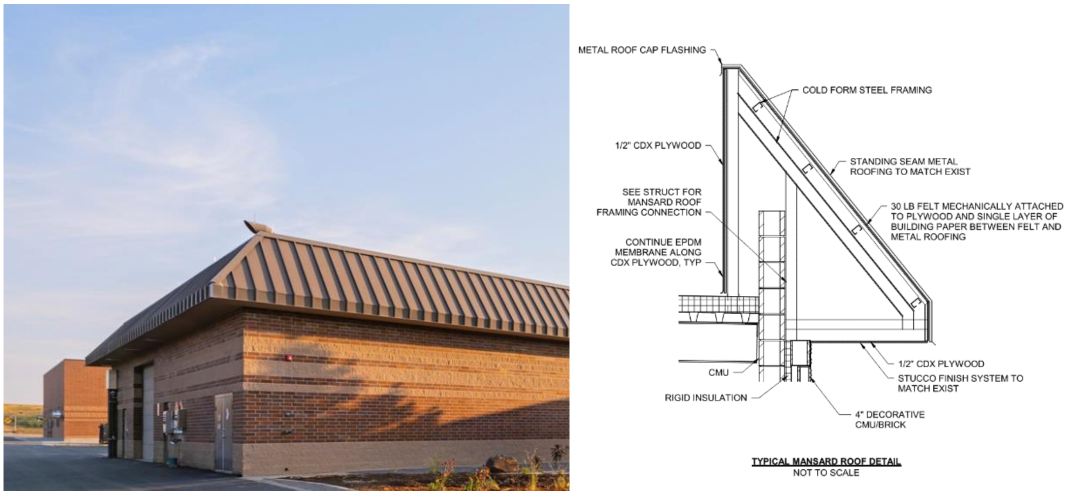


Figure 4-3: Mansard Roof Framing

4.2.3 Pump Station Interior

The pump station will be split into two separate areas. One side of the pump station will house pumps serving the potable water system. The other side of the pump station will house pumps serving the reuse system. The two sides will be separated by an 8” CMU wall to prevent cross contamination. Each side will contain an electrical room separated from pumps by an 8" CMU wall. The electrical room will have a minimum of two (2) viewing windows measuring 8-ft wide x 4-ft tall overlooking the pumping area with a separate PLC room at one end. Interior doors for the electrical and PLC rooms will be hollow metal and include a half lite viewing panel. A bridge crane sized to lift the pumps for maintenance operations will be included on each side of the pump station.

Interior finishes of the pump station building will consist of painted 8” CMU walls, natural concrete floors, painted steel roof framing and roof deck. All doors will be painted hollow metal.

5.0 STRUCTURAL

5.1 APPLICABLE CODES

In addition to codes previously listed in this report, the following codes are used for structural design of the tanks and pump station:

- American Concrete Institute Committee 350 Report, Code Requirements for Environmental Engineering Concrete Structures (ACI)
- American Concrete Institute Committee 318 Report, Building Code Requirements for Reinforced Concrete (ACI)
- American Iron and Steel Institute (AISI) S100 North American Specification for the Design of Cold-Formed Steel Structural Members
- American Institute of Steel Construction (AISC) 360 Specification for Structural Steel Buildings
- American Society of Civil Engineers (ASCE) 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures
- American Welding Society (AWS)
- Crane Manufacturers Association of America (CMAA)
- Occupational Safety and Health Administration (OSHA)
- Steel Deck Institute (SDI)
- Steel Joist Institute (SJI)

5.2 BASIS OF DESIGN LOADS

Basis of design loads are determined using ASCE 7-16 and the CCoB published amendments. The pump station will be used to provide emergency fire water under certain conditions, therefore the structure will be designed as a Risk Category IV building per ASCE 7 Table 1.5-1.

5.2.1 Wind

The Colorado Front Range Gust Map (CFRGM) and amended Recommendations for IBC 2018/ASCE 7-16 prepared by the Structural Engineering Association of Colorado (SEAC) will be used to determine wind loads for the project. Figure 1b in the CFRGM and the table for Risk Category IV buildings in the amended document return the following values:

- Ultimate Wind Speed: 125 mph (3 second Gust)
- Exposure Category: C

5.2.2 Snow

The City and County of Broomfield requires a minimum ground snow load of 30psf. However, the Colorado Design Snow Loads prepared by SEAC identifies a higher value for ground snow load that will be used.

- Ground Snow Load: 40 psf per SEAC Document
- Roof Snow Load: 30 psf minimum per CCoB code amendments
- Importance Factor: 1.20

5.2.3 Frost Penetration

- 36 inches minimum per CCoB code amendments

5.2.4 Seismic

- Site class: D (Default assumed until Geotech obtained)
- Spectral response coefficients:
  - Short Period (S_{DS}): 0.217
  - One-second Period (S_{D1}): 0.092
- Seismic design category: C
- Equivalent Lateral Force Procedure

5.2.5 Live Loads

- Floor: 250 psf (Heavy Manufacturing use per ASCE 7 Table
- Stairs, Walkways and Platforms: 100psf uniform, 300lbs concentrated

5.3 STRUCTURAL DESIGN

5.3.1 Foundations

Based on previous projects for the CCoB located in the area we expect the underlying soils to be expansive clays and claystone bedrock. Therefore, the pump station and tank foundations will be cast-in-place concrete. Retaining walls and other site structures that can tolerate higher settlements will be constructed using spread footing type foundations.

5.3.2 Superstructure

The pump station building will be constructed using reinforced CMU block and cast-in-place reinforced concrete walls where portions of the structure double as retaining walls. The roof structure will be either hot rolled structural steel shapes or open web steel joists, with a metal deck steel diaphragm.

5.3.3 Miscellaneous Structural Design

Both sides of the pump station will require a bridge crane used for transporting pumps, motors and other equipment around the space for maintenance and replacement. The bridge crane will be a 3-Ton single girder, underhung crane. The crane rails will be supported from the roof structural members. All crane design will be performed in accordance with ASCE 7 and the CMAA Specification No. 74.

5.4 MATERIALS

5.4.1 Concrete

Concrete used for the project will meet the following properties:

- Minimum 28-day compressive strength
  - Cast-In-Place: 4,500 psi
  - Shotcrete: 4,500 psi
- Cement: Type I/II conforming to ASTM C150
- Maximum Water/Cement Ratio: 0.45
- Aggregate: Sound, well graded, with maximum size of 1-inch, conforming to ASTM C33
- Air Content: 4.5% to 7.5%
- Slump: 5”±1”
- Reinforcing Steel:
  - Bars: ASTM A615, Grade 60
  - Welded Wire Fabric (WWF): ASTM A185
  - Prestressing Strands: ASTM A416

5.4.2 Structural Concrete Masonry Units (CMU)

Structural CMU used on the project will meet the following properties:

- Medium or Light Weight Masonry Units conforming to ASTM C90
- Mortar ASTM 270 Type S
- Minimum Compressive Strength (f'_m): 2,000 psi
- Grout: ASTM C476 with an 8” to 11” slump

5.4.3 Structural Steel

Structural steel used on the project, including open web steel joists, will be painted carbon steel. Steel will meet the following properties:

- Structural Wide Flange and Tee Shapes: ASTM A992, Grade 50

- Structural Tubes: ASTM A500, Grade B
- Structural Pipe: ASTM A53, Grade B or ASTM A500, Grade B (t > 0.625”)
- Plates, Bars and other Structural Shapes: ASTM A36
- Connections:
  - High Strength Bolts: ASTM A325
  - Common Bolts: ASTM A307
  - Anchor Bolts: ASTM F1554 Grade 36

5.4.4 Grating and Guardrail/Handrail

Grating within the pump station and inside the tanks will be pultruded fiber reinforced polymer (FRP) I-bar grating. Grating used on the exterior of the tanks will be rectangular aluminum bar grating with a serrated surface.

Guardrails, ladders, and handrail in the pump station and on the exterior of the tanks will be aluminum. Guardrail, ladders, and handrail within the tanks will be FRP.

6.0 MECHANICAL

6.1 BUILDING CODE

The following codes and standards shall govern the Broomfield Tank and Pump Station Project's mechanical design:

- International Building Code (IBC), 2018 Edition.
- International Mechanical Code (IMC), 2018 Edition.
- International Plumbing Code (IPC), 2018 Edition.
- International Fuel Gas Code (IFGC), 2018 Edition.
- International Energy Conservation Code (IECC), 2021 Edition.
- The National Electrical Code, 2017 Edition.
- Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities.
- Sheet Metal Contractors National Association (SMACNA)
- American Industrial Hygiene Association (AIHA)
- American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) standards.
- American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) standard 90.1-2010.
- Occupational Safety and Health Administration (OSHA)

6.2 DESIGN CONDITIONS

- Outside design conditions for this projected were obtained from ASHRAE 90.1-2010 and IECC 2015. The climatic data used for this project will be from Denver, CO due to close proximity.

Location:	Broomfield, Colorado
Elevation:	5,418 ft
Cooling Design (0.4%) Temperature:	91.2 deg F (dry bulb) / 60.6 deg F (wet bulb)
Heating Design (99.6%) Temperature:	-1.5 deg F
Climate Zone:	5B

- Indoor design data:

Table 6-1: Pump Station Indoor Mechanical Design Data

Space	Summer	Winter
Electrical Room	72 deg F	60 deg F
Pump Room	85 deg F	60 deg F

6.3 DESIGN ASSUMPTIONS

The facility will require capacity to tie in 3/4” domestic water and a minimum of 2” sanitary connection.

6.4 HVAC

- The electrical rooms will be heated and cooled with a packaged roof top unit. The unit will utilize a direct expansion (DX) cooling coil with minimal electric heat for emergency heat to maintain space temperature setpoints.
- The pump rooms will be heated and cooled with a packaged roof top unit. The unit will utilize a direct expansion (DX) cooling coil with electric heat to maintain space temperature setpoints.

6.5 PLUMBING

- The domestic water will tap into potable water piping within facility, coordinate with process piping for proper location.
- The facility will be provided with a water meter and backflow preventer.
- The electrical rooms will not have any plumbing fixtures, domestic water or sanitary sewer.
- The pump station is intended to be provided with domestic water service for two hose bibs, and two sump pumps with at least 4 floor drains each to be discharged to the sanitary sewer.
- Route 4” sanitary sewer piping to connect into new 8” piping in yard.

6.6 FIRE PROTECTION

- Facility will be II-B construction that is single occupancy, fire sprinklers will not be required for this facility.
- Fire extinguishers will be provided per section 906 of the fire code.

7.0 ELECTRICAL

7.1 DESIGN CRITERIA

The basis of electrical design is developed using industry publications, codes, and standard industry practice. All components and materials used on site and in panels will be furnished and installed following NEC, and NFPA 70E, new and free of defects using UL recognized components. All electrical equipment, motors, panels, switchboards, motor control centers and cables will be UL Listed and fabricated following NEMA standards. All Equipment conductor termination will be UL listed for 75C. All Equipment and Materials will be identified and labeled with permanent labels, to indicate design intent. All Work will include Source Limitations: To the fullest extent possible, provide products of the same kind from a single source matching equipment already in use at the City and familiar to maintenance staff.

The following are the applicable publications for the Broomfield Tanks and Pump Station project:

- International Building Code, Latest Adopted Edition.
- International Energy Conservation Code (IECC), Latest Adopted Edition.
- National Fire Protection Association (NFPA)
    - 30 – Flammable and Combustible Liquid Code, Latest Adopted Edition.
    - 70 – National Electrical Code (NEC), Latest Adopted Edition.

Applicable recommendations and standards from the following organizations will be included in the electrical design:

- American Society for Testing and Materials (ASTM)
- National Electrical Contractors Association (NECA)
- National Electrical Testing Association (NETA)
- National Fire Protection Association (NFPA)
- Institute of Electrical and Electronic Engineers (IEEE)
- Illuminating Engineering Society of North America (IES), Lighting Handbook
- Underwriters Laboratory (UL)

7.2 UTILITY POWER AND METERING

Electric power will be provided by United Power and is expected to be secondary metered, meaning the transformer will be owned and maintained by the utility and everything downstream is customer owned and maintained. We expect working with the utility to provide service to both sides of the pump station, double tapping the utility transformer to feed two separate meters – one for each side of the pump station.

7.3 PROPOSED POWER DISTRIBUTION SYSTEM

As mentioned above, the pad mount utility transformer will supply 480 volt, 3-phase power to two separate utility meters. Beyond the utility meters, each pump station would be arranged as follows.

Power will be fed to a NEMA 3R exterior mounted service entrance main circuit breaker, serving as the main disconnect. The main breaker will feed a main switchboard configured in a main-tie-tie-main (MTTM) fashion to allow flexibility in feeding loads during maintenance operations allowing one side of the switchboard to be fully de-energized for maintenance purposes while running the pump stations on the other energized side. One of these mains will be fed from the utility side, and the other will be fed from a standby generator. The incoming breakers in this switchboard will be electrically operated, draw-out type. An energy reduction maintenance switch located on the main switchboard will be connected to the service entrance breaker to reduce the available arc flash energy. From the main switchboard, feeds from each side of the tie breakers will be routed to a motor control center (MCC) with a kirk-key interlock arrangement configured in a MTTM fashion splitting up the motors. The ties are included on the MCCs to allow maintenance and operators the ability to partially run the pump station from either source at any time, by taking one-half of the lineup out of service and still operate on the other half; pumping will be reduced to capacity. Non MTTM arrangements will not allow such pump station operation during maintenance periods requiring completely deenergizing equipment.

7.4 BACKUP POWER SYSTEM

One hundred percent of the pump station loads will be backed up via a permanently installed diesel generators. The generators will be located outside the pump station building in weatherproof enclosures with sound attenuation meeting the City and County of Broomfield’s Municipal Code. Each of the generators will be provided with a sub-base fuel tank capable of 48 hours operation. The generator serving the booster pump station will likely be sized at approximately 1250kW, whereas the generator serving the reuse pump station will likely be sized at approximately 300kW

7.5 TRANSFER SWTICH

A transfer switch will not be necessary as part of the design described in the “Proposed Power Distribution System” paragraph above. The breakers in the main switchboards will be configured to allow auto-transfer operations between the utility source and the generator source.

7.6 POWER METERING

The main switchboards will be provided with customer metering on both incoming feeds – utility and generator. This will allow for data to be relayed to the SCADA system and at the equipment for readings such as, but not limited to, voltage, current, kW, kWh, kVA, kVAh, power factor, frequency, harmonics.

7.7 VOLTAGE CLASSIFICATIONS

System voltages for electrical equipment will be divided as follows:

Motor loads 1/2 hp and smaller	120V, single phase
Motor loads 3/4 hp and higher	480V, three phase
Lighting	120V, single phase
General purpose receptacles	120V, single phase

7.8 VARIABLE FREQUENCY DRIVE (VFD) MOTOR CONTROLLERS

VFDs will be provided as 18-Pulse units with isolation transformers matching other City installations to facilitate ease in maintenance for staff. Basis of design equipment will be Eaton. VFDs will have Ethernet communications connected to the PLC control network for performance monitoring and control. The drives will also have hardwired discrete signal monitoring and control for Remote/Local, run, and alarm statuses.

7.9 DISCONNECTS

Each load will be installed with a local disconnecting switch for maintenance in accordance with the NEC; including HVAC, any process skids and across the line full-voltage motor starters. Motors controlled by variable frequency drives will not be installed with a local disconnecting switch: These installations will use the NEC exception for a local disconnect, requiring the Town implement a strict lockout tagout procedure locking out these motors from the MCC when performing any work on the associated equipment. E-stop push button stations will be placed near the motors.

7.10 TRANSFORMERS

Transformers serving non-process, building loads will be dry-type transformers. Based on preliminary layout, there should be adequate space for floor mounting these transformers; however, if space becomes limited, then wall mount brackets will be used to conserve floor space.

7.11 PANELBOARDS

Distribution panelboards will be provided for each pump station to serve their respective building spaces to provide power to heating loads, and any other 480 volt needs that arise. Distribution panelboards will be 480/277 VAC, three-phase, 3-wire, unless single phase 277-volt loads are required.

Lighting panelboards will be provided for each pump station to serve their respective building spaces to provide power to lights, receptacles, 120VAC instruments, control panels. Lighting panelboards will be 208/120 VAC, three-phase, 4-wire.

7.12 LIGHTING

Lighting will be LED fixtures to meet the recommended illumination levels listed in the Illuminating Engineering Society (IES) Lighting Handbook. Process areas will have illumination levels of 30 foot candles (fc). The pump station electrical building will have illumination levels of 50 foot candles (fc).

Interior light fixtures will be surface or pendant mount LED fixtures.

Emergency and exit lighting will be self-contained battery backup units powered from lighting panel branch circuits. Emergency lights and exit signs will have LED lamps.

Exterior light fixtures at doorways and egress pathways will also be LED. Exterior site lighting will be LED fixtures. All exterior lighting will be photo controlled and motion detected.

7.13 RECEPTACLES

General purpose receptacles will be NEMA 5-20R, 120-volt, single phase, two pole, three wire, ground fault circuit interrupter (GFCI) type provided throughout the facility. Receptacles will be installed 48-inches from the floor. While-in-Use covers shall be provided for exterior GFCI receptacles. The number of receptacles on one branch circuit will be limited to six (6) maximum for the new construction.

7.14 WIRING METHODS

Conduit raceways will be used throughout the pump station, rather than basing the design on cable tray installation. Much of the conduit system is expected to be below the floor, especially between electrical distribution equipment, to the motor loads, and between the PLCs and the related MCCs.

7.15 UNDERGROUND DUCT BANKS

Red concrete reinforced underground duck bank will be installed between the building, main breaker, and the utility transformer. All underground electrical will be installed with tracing wire and marking tape.

7.16 WIRING IDENTIFICATION

All wires and cables will have a unique identification marker using a heat shrink sleeve type cable marker. In addition to the cable marker feeder and branch circuit, color coding will be as follows:

208Y/120V	480Y/277V

Black	Phase A	Brown
Red	Phase B	Orange
Blue	Phase C	Yellow
White	Neutral	Gray
Green	Ground	Green

7.17 VOLTAGE DROP

Voltage drop calculations will be performed. However, with the short runs involved, there will likely be no need to increase wise sizes on the 480V system for voltage drop reasons. There may be a need to increase wire size on the receptacle circuits; this will be evaluated during subsequent design.

7.18 GROUNDING & LIGHTNING PROTECTION

The grounding system will provide a method to establish an equal potential reference for metallic objects to reduce shock hazards to personnel. All conduits will have a green equipment grounding conductor and not rely on the conduit as a grounding path. The power distribution service entrance equipment, all major electrical equipment inside the pump station electrical building, reinforcing steel in concrete foundations and metallic water piping where present will be bonded to ground rods.

A lightning protection system including air terminals, down conductors, and connection to the building's ground system is included.

7.19 SURGE PROTECTION

The surge protection system will be designed around a modular components approach. Surge protection devices will be installed on the 480V distribution system and the 120V level for critical loads. Surge protective devices (SPD) will be provided on the service-entrance switchboard, motor control centers, and panelboards. Additional SPD devices will be provided for critical process control PLCs and computer workstations.

7.20 UNINTERRUPTIBLE POWER SYSTEMS (UPS)

An uninterruptible power system (UPS) will be used to supply power to the new PLC processors in the pump station. The UPS will provide power to the PLC processors when utility power is momentarily interrupted.

7.21 CARD ACCESS, SITE SECURITY, & SURVEILLANCE

The building will be provided with a card access system compatible with the City's existing card access infrastructure. Card access units will be placed at each exterior door, as well as on the vehicle entrance gate at the site entrance.

Doors and access hatches will be provided with door contacts tied into the PLC system and SCADA to notify the City of intrusion at the pump station.

Additionally, surveillance cameras will be placed throughout the pump station and the building exterior

8.0 INSTRUMENTATION AND CONTROL

8.1 DESIGN CRITERIA

The basis of instrumentation and control system design is developed using industry standard practices, codes, and publications. All work performed shall be in accordance with the following applicable codes and standards:

The following codes shall govern the WTP expansion instrumentation design:

- NFPA 30 – Flammable and Combustible Liquid Code 2018 Edition.
- NFPA 400 (HMC) - Hazardous Material Code 2018 Edition.
- National Fire Protection Association (NFPA), 70 - National Electrical Code (NEC) 2017 Edition.

Applicable recommendations and standards from the following organizations will be included in the electrical design:

- American Society for Testing and Materials (ASTM)
- Cyber Security & Infrastructure Security Agency (CISA)
- ISA International (ISA)
- National Electrical Manufacturers Association (NEMA)
- National Institute of Standards and Technology (NIST)
- Underwriters Laboratory (UL)

8.2 MEASURING UNITS

Measurement	Units
Conductivity	uS/cm, micro ohms per centimeter
Differential	psi, inches water, feet water
Flow liquid	million gallons per day (mgd)
Level	percent, inches, feet
pH	Hydrogen ion concentration (0 to 14)
Pressure	psig, psia, feet of water
Residual Chlorine	milligrams per liter (mg/l)
Speed	percent, rpm
Temperature	degrees Fahrenheit
Weight	pounds, tons

8.3 INSTRUMENT NOMENCLATURE

Instrument identification will comply with ISA S5.1 and ISA S5.3 as shown in detail on the piping and instrumentation diagram (P&ID) Legend and Symbols Sheet. P&IDs will have the instrument tag numbers, plus symbols indicating the function of the instrument. Each instrument will have a unique tag number.

8.4 CONTROL SYSTEM

The pump station control system will consist of programmable logic controllers (PLC) communicating over an Ethernet network. The pump station control system will communicate with the City's existing SCADA system via radio network. The new control system will monitor all tank and pump instruments and control the station's pumps and valves. Local controls will be provided at a human machine interface (HMI) on the front of the PLC panels.

All critical control functions shall be able to be performed locally at the VFD via hand switches though hardwired controls in the event of a PLC, network or I/O failure. Critical interlocks, where necessary, will not be able to be bypassed via hand mode operation.

8.5 INSTRUMENT LOCATION AND ACCESSIBILITY

All instruments will be in accessible locations for visibility, maintenance and calibration.

8.6 SIGNAL TYPES AND RANGES

Instrument or Device	Electronic Signal
(Pressure, Flow) Transmitter	4-20mAdc
Thermocouple	0-80 mV
RTDs	100-1000 ohms
Relay contacts	120VAC, 60 Hz
Solenoids	120VAC, 60 Hz
Shutdown circuits	120VAC, 60 Hz
Local controllers	120VAC, 60 Hz
Control valves	120VAC, 60 Hz
Remote operated valves	120VAC, 60 Hz
Pressure Relief Valves	120VAC, 60Hz

8.7 FIELD INSTRUMENTATION

Design and selection of appropriate field instrumentation should include the proper metallurgy of wetted parts for treated water service, compatibility with the pump station control system, high reliability, ease of maintenance, and good vendor support. All field transmitters should provide local indication and should be capable of remote calibration checks (smart transmitters).

8.8 INSTRUMENT AND I/O LISTS

Schedules for instruments and I/O signals will be provided. The I/O list will itemize all input/output PLC signals. The I/O list will include the descriptions, instrument types, signal types, and measurement ranges to be used during startup, checkout and commissioning of the facility.

The instrument list will summarize all field instruments provided by the system integrator and shipped lose instruments provided by specific system vendors.

8.9 INSTRUMENT WIRING PACKAGES

Instrument wiring shall be segregated physically and installed in separate cables, conduits, junction boxes, and routing based upon the following categories (signal levels):

- 120 VAC 60 Hz signal wiring
- 4-20 mAdc signal wiring
- Digital pulse circuit wiring
- Analyzer wiring
- RTD signals

These criteria also apply to control panels having levels of instrument signals. The same separation is required. It is important to note that most of today's plant-wide control systems communicate through a data highway with signals that are immune to most plant electrical interference.

Control wiring will use #14 AWG THWN/THHN, single conductor, stranded and multi-conductor 2, 3, 4, 5, 7, 12 conductor #14 AWG with overall PVC jacket. Color-coding will follow ICEA S-61-402, Appendix K, Method 1, Table K-2 (white or green not used) or as directed per COL color code standards.

Instrumentation wiring will use #16, AWG twisted, shielded pair, 600V, PVC jacket for 4-20mA analog signals.

8.10 GROUNDING

The instrumentation and control systems shall have a separate ground network that is connected to the same point as the power grounding network at the ground rod level. Grounding shall be provided as follows:

- DC Circuits: The system common shall be grounded to the instrument main panel or rack ground bus.
- Thermocouples: All thermocouple junctions shall be grounded type.
- Cable Shields: The grounding point of cable shields shall be at main control room ground bus.
- Control Room Ground Bus: Each control room rack shall have a 1/8" thick by 2" wide copper ground bus insulated from the rack with an insulated copper cable to the instrument ground system.

8.11 PROCESS ALARM SYSTEMS

Process alarms will be subdivided into three (3) classifications:

- Trouble Alarms
- Pre-Shutdown Alarms
- Shutdown Alarms

Trouble alarms and pre-shutdowns alarms will be displayed on the operator's console and will require an operator reset for acknowledgment. The shutdown alarm will be configured in a first-out sequence to assist in diagnostics.

8.12 EMERGENCY POWER REQUIREMENTS

In the event of a momentary or sustained power failure of the main electrical power supply system, the plant instrumentation and controls must continue to function for a sufficient length of time to achieve stable process conditions. The PLC and HMI systems will be connected to the UPS to ensure the continuation of the control system in the event of a power interruption. No analyzers, instruments or motors will be connected to the UPS.

8.13 INSTRUMENTATION AND CONTROL PROJECT DOCUMENTATION

The project documentation shall follow generally accepted industry practices, ISA standards, and shall be suitable for this facility. A list of minimum requirements includes the following:

- The instrumentation and control design basis
- The automation and control system philosophy
- Control system architecture

- Instrument and control system specifications
- I&C drawings
- P&ID drawings
- Instrument index
- Configuration and programming guides
- Installation, calibration, and start-up guidelines
- Software documentation
- Vendor selection and purchase documents
- Operating procedures

APPENDIX A – DISTRIBUTION SYSTEM STORAGE AND PUMPING MEMORANDUM (BMCD)

Memorandum

Date: December 2, 2021

To: Ronda Jo Ackerman Alford
CIP Project Manager
City and County of Broomfield, Colorado

From: Nikole Rachelson, Project Manager
Emily Huth, Interim Project Manager
Ryan Scott, Project Engineer

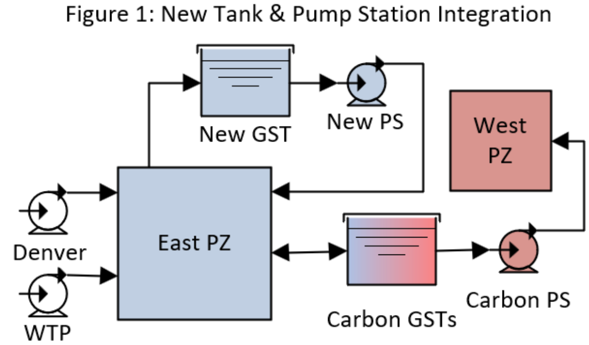
Subject: Broomfield Tanks Project
Draft Basis of Design Memorandum – Distribution System Storage and Pumping
Burns & McDonnell Project No. 135303

This basis of design memorandum details the sizing recommendations for storage and pumping in the City of Broomfield's (City) water distribution system. The location of this facility is northeast of the intersection at W 152nd Ave and Lowell Blvd in the East Pressure Zone (PZ) and includes ground storage and a pump station. The City's hydraulic model is used to evaluate storage and pumping hydraulics to support facility design needs.

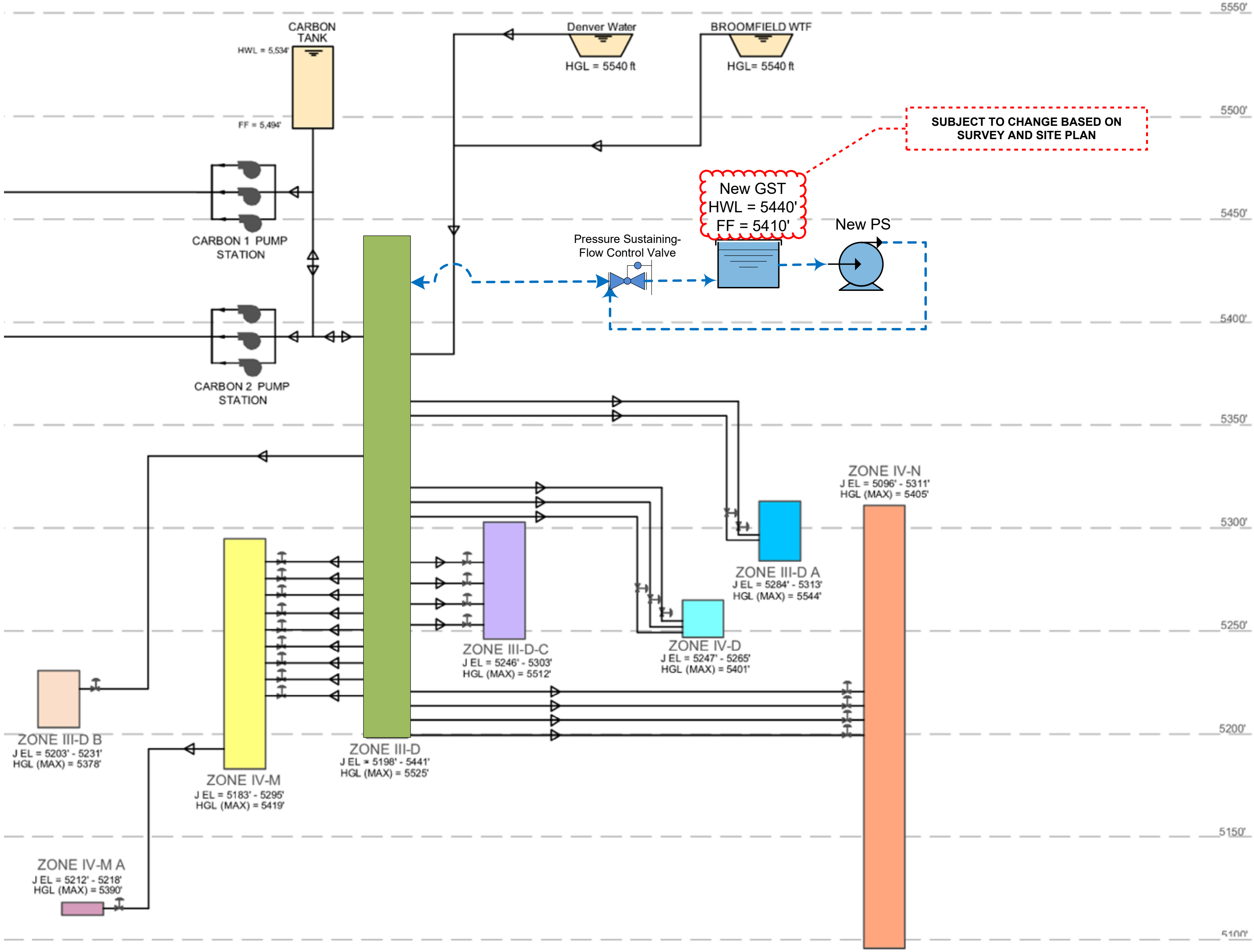
SYSTEM DESCRIPTION

The City's water distribution system is supplied by the Broomfield Water Treatment Plant (WTP) with a current capacity of 26.0 million gallons per day (MGD) and a connection with Denver Water with a supply of up to 10.0 MGD. Both sources supply customer demands the East PZ and fill the Carbon Rd tanks which includes two 3.1 million gallon (MG) ground storage tanks. The Carbon Rd tanks can supply East PZ when the hydraulic gradient allows and supply the Carbon Rd pump station which, effectively, supplies the West PZ. The ability to back feed the East PZ and supply the needs of the West PZ via the Carbon Rd pump station results in a shared storage condition between the PZs. The new ground storage tank(s) and pump station will be situated in the East PZ and operate in parallel with the WTP, supply from Denver Water, and Carbon Rd ground storage. The arrangement of these facilities is illustrated in Figure 1 and 1.1.

Figure 1: New Tank & Pump Station Integration



Note: Not all facilities shown in West PZ for clarity.



Notes:
1. Dashed blue connecting lines, new GST, and new PS added to figure; all other figure data prepared by others.

BURNS McDONNELL

CITY AND COUNTY OF BROOMFIELD COLORADO

Figure 1.1

New Ground Storage Tank & Pump Station Network Arrangement

SYSTEM DEMAND AND SHARED STORAGE

The hydraulic model, prepared by others, includes existing and projected maximum day and peak hour (on the maximum day) water demands in the East and West PZs. A summary of these demands is listed in Table 1.

Table 1: Water Demand Summary by Pressure Zone

Year	Maximum Day (MGD)			Peak Hour (MGD)			Peak Hour Factor
	East	West	Total	East	West	Total	
Existing	16.2	11.2	27.4	30.9	21.2	52.1	1.90
2022	19.1	12.2	31.3	36.3	23.3	59.6	1.90
2030	28.2	13.1	41.4	53.8	24.8	78.6	1.90
2038	30.5	13.1	43.6	58.1	24.8	82.8	1.90

The East PZ includes, by far, the most opportunity for future growth and, as such, is represented in the demand projections. The East PZ maximum day demand is projected to increase from 16.2 MGD to 30.5 MGD whereas the West PZ is projected to increase from 11.2 MGD to 13.1 MGD over the same planning period. Sizing new storage in the East PZ is, in part, dependent on the shared storage allocation in the Carbon Rd tanks. The volumetric allocation of shared storage in the Carbon Rd tanks is based on the respective maximum day demands in each PZ. A summary of the storage allocation in each PZ is listed in Table 2.

Table 2: Storage Summary

Ground Storage	Capacity (MG)	Allocation (MG)	
		East Demand 16.2 MGD	West Demand 11.2 MGD
Carbon Rd 1	3.1	1.8	1.3
Carbon Rd 2	3.1	1.8	1.2
Airport	3.0	--	3.0
Interlocken	7.8	--	7.8
Total	17.0	3.7	13.2

The shared storage allocation in the Carbon Rd tanks for the East PZ increases through the planning period as the maximum day demand projection increases, which also results in a commensurate decline of shared storage in the Carbon Rd tanks for the West PZ. The City can expect greater turnover in the Carbon Rd tanks due to increases in East PZ demand and from longer run times at Carbon Rd pump station needed to replenish storage in the West PZ because it will be relied upon for more peaking supply. A summary of the shared storage allocation for the demand projection in each planning period is listed in Table 3.

Table 3: Carbon Rd Shared Storage Allocation (MG)

Year	Total	East	West
Existing	17.0	3.7	13.2
2022	17.0	3.8	13.2
2030	17.0	4.2	12.7
2038	17.0	4.3	12.6

For the purposes of this storage evaluation, the following assumptions are made:

- Any potable water storage capacity at the WTP is for WTP process needs and not considered distribution storage. This is a conservative approach that places the pumping burden to the new pump station in lieu of the WTP high service pump station (HSPS).
- New storage in the East PZ is sized for the demand projection in the East PZ; though possible via the Carbon Rd tanks and pump station, it is not sized to supplement West PZ storage needs. This is a conservative approach with respect to water quality. Holding storage in the East PZ for the West PZ requires larger storage and its volumetric usage likely secondary to the turnover requirements of storage in the West PZ.
- The shared storage allocation in the Carbon Rd tanks is termed effective for the East PZ; these tanks are considered high elevation ground storage and can provide the level of service requirement for minimum pressure and fire flow at the nearest customer connection.
- The volume of new ground storage tanks in the East PZ is termed effective storage with backup power for firm capacity pumping.

DIURNAL ANALYSIS AND EQUALIZATION STORAGE

Diurnal patterns represent changes in water demand over the course of a day, reflecting times when the City's customers are using more water or less water than the average for that day. The average demand for a day, or 24-hour period, is represented at 100 percent. Equalization demands refer to periods when the diurnal pattern is above 100 percent and represents the amount of storage needed when demand exceeds the supply.

The diurnal analysis includes the seven 24-hour periods between 7/25/2021 and 7/31/2021 which spans the maximum day demand for the year at approximately 24 MGD (total system, East PZ plus West PZ). The diurnal pattern for the East PZ is calculated from a mass balance of metered and measured flow contributions, from which the equalization factor is determined. A summary of the East PZ diurnal analysis results and mass balance equation for East pressure zone demand is listed in Table 4.

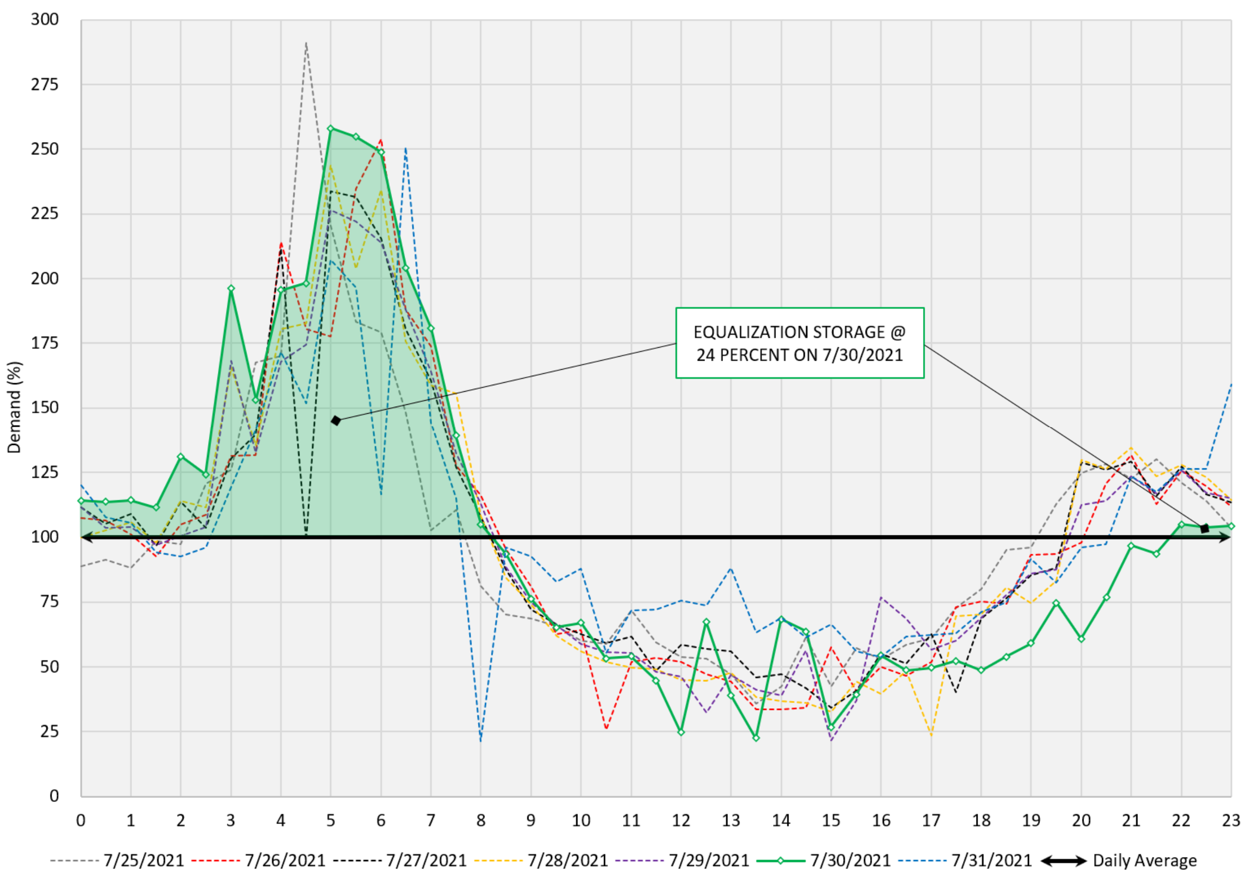
Table 4: East Pressure Zone Diurnal Results

Date	Demand[1]		Equalization Storage (%)
	(MGD)	(gpm)	
7/25/2021	13.30	9,235	19
7/26/2021	14.32	9,944	20
7/27/2021	13.63	9,464	20
7/28/2021	14.62	10,153	22
7/29/2021	13.90	9,650	20
7/30/2021	13.38	9,294	24
7/31/2021	8.42	5,844	17

Notes:
1. Demand = WTP flow + Denver Water flow - (CR pump station flow - CR tank level delta).
2. CR = Carbon Rd; CR tank level delta measured between 1-hour intervals and tank geometry.

The equalization factor is quantified as the area under the diurnal pattern and above 100 percent (average day demand). The diurnal pattern for each of the days included in the diurnal analysis is illustrated in Figure 2; the green area for the 7/30/2021 diurnal pattern represents an equalization storage factor of 24 percent and is used in the storage sizing requirement. Equalization storage is one of many factors in determining storage sizing requirements and is discussed in further detail in the following section.

Figure 2: East Pressure Zone Diurnal Patterns



<u>STORAGE SIZING REQUIREMENTS</u>

The total effective storage in the East PZ can be used for equalization demands, fire flow requirements, and emergency reserve. Allocations for each of these components are quantified to determine the storage needs in the East PZ.

- Minimum Storage Requirement:
  - Equalization storage is required to make-up the difference between the amount of water demanded by customer consumption and the rate at which the water is supplied to the system from the WTP and Denver Water. The equalization storage factor is 24 percent of the maximum day demand and determined by a diurnal analysis of the East PZ. As projected demands increase during the planning period the equalization storage requirement increases.
  - Fire storage is required for fire flow requirements and is governed by the types of customer facilities in the distribution system. A review by City staff of the

maximum fire flow requirement for customers in the East PZ is 3,500 gpm for 3 hours and is equivalent to a volume of 0.63 MG.

- Emergency Reserve:
  - Emergency storage is a discretionary quantity designated by the City and represents any reserve in excess of the minimum storage requirement. Emergency storage also represents a storage surplus. A storage deficit is any amount less than the minimum storage requirement (equalization plus fire).
- Total Storage Determination:
  - Minimum storage requirement plus any amount designated for emergency storage.

EAST PZ STORAGE ANALYSIS RESULT

The current effective storage is 3.69 MG which is the shared storage allocation for the East PZ held in the Carbon Rd tanks. The fire storage requirement is 0.63 MG. The equalization storage requirement is 3.89 MG and based on the current East PZ maximum day demand of 16.2 MGD and an equalization storage factor of 24 percent. The minimum storage requirement is 4.52 MG for fire and equalization needs; this results in a storage deficit of approximately 0.83 MG. These results are summarized in Table 5.

Table 5: Storage Analysis - East Pressure Zone (Existing)

Component	Quantity	Comments
Maximum Day Demand (MGD)	16.20	From model, existing system, East PZ
Available Storage (MG)	3.69	Shared storage allocation from CR tanks
Effective Storage (MG)	3.69	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	3.89	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	4.52	Fire + Equalization
Storage Analysis Result (MG)	**-0.83**	**Deficit**

Note:
1. LOS = level of service.

The storage deficit indicated above needs perspective as historically, under normal conditions, the distribution system and its customers have been adequately served by the distribution system, supply sources, and storage/pumping facilities. The deficit above is meant to suggest that any demand greater than the maximum day demand and fire flow requirement that is not supplied by the Carbon Rd tanks would have to be supplemented by additional pumping capacity from the WTP, emergency connections, or additional supply capacity from Denver Water.

The storage analysis for the East PZ based on the projected maximum day demand of 30.5 MGD, the commensurate escalation in shared storage at CR tanks, the same fire flow and equalization storage requirements, results in a storage deficit (-) of approximately -3.6 MG through the planning period; therefore, the minimum storage sizing recommendation is 4.0 MG which would include an emergency reserve of approximately 0.4 MG through the end of the planning period.

STORAGE SENSTIVITY ANALYSIS

Quantifying the projected storage deficit is the first step in characterizing sizing options available to the City under these conditions, stated assumptions, and impacts of varying emergency reserves. As indicated in the previous section, a new 4.0 MG storage tank in the East PZ results in a storage surplus, or emergency reserve, of 0.4 MG through the end of the planning period (Year 2038). Under projected maximum day demands, this reserve could supply the East PZ for approximately 0.3 hrs. Similarly, under projected average day demands, a 0.4 MG emergency reserve could supply the East PZ for 7.0 hours and includes the extra diurnal equalization capacity.

This sensitivity analysis with a new 4.0 MG tank (or 4.0 MG of new storage in multiple tanks) is listed in Tables 6.a, 6.b, 6.c, and 6.d. Storage sizing options for 5.0 MG and 6.0 MG are listed in Tables 7.a-7.d and 8.a-8.d, respectively.

PUMP STATION CAPACITY SIZING

The pump station capacity is sized to deliver projected equalization demands and fire flow requirements of the East PZ. Pump station capacity expansions are directly impacted by anticipated WTP capacity expansions. City staff confirmed assumptions, prepared by others, for the timing of anticipated capacity expansions which are governed by system demands. The timing and/or demand projections associated with the WTP capacity expansions are summarized below:

- Current WTP capacity at 26.0 MGD.
- Current Denver Water capacity at 10.0 MGD (constant).
- WTP capacity expansion to 32 MGD:
    - Before year 2030 or before East PZ demands reach 28.2 MGD and 53.8 MGD for maximum day and peak hour respectively.
- WTP capacity expansion to 38 MGD:
    - Before year 2038 or before East PZ demands reach 30.5 MGD and 58.1 MGD for maximum day and peak hour respectively.

The pump station is sized to deliver the difference between the total supply capacity (WTP plus Denver Water) and the peak hour demand in the East PZ plus the fire flow requirement. This results in a pump station capacity expansion in stages beginning at 6.0 MGD, increasing to 12.0 MGD, and buildout firm capacity at 17.0 MGD. Sizing and staging recommendations for the new pump station is summarized in Table 9

Table 6.a: Existing System Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	16.20	From model
Available Storage (MG)	7.69	Carbon Rd Allocation + 4.0 MG New Tank
Effective Storage (MG)	7.69	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	3.89	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	4.52	Fire + Equalization
Storage Analysis Result (MG)	**3.17**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**4.7**	**On Max Day Demand (16.2 MGD)**
Emergency Storage Duration (hr)	**16.2**	**On Average Day Demand (6.5 MGD)**

Table 7.a: Existing System Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	16.20	From model
Available Storage (MG)	8.69	Carbon Rd Allocation + 5.0 MG New Tank
Effective Storage (MG)	8.69	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	3.89	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	4.52	Fire + Equalization
Storage Analysis Result (MG)	**4.17**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**6.2**	**On Max Day Demand (16.20)**
Emergency Storage Duration (hr)	**19.4**	**On Average Day Demand (6.5 MGD)**

8.a: Existing System Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	16.20	From model
Available Storage (MG)	9.69	Carbon Rd Allocation + 6.0 MG New Tank
Effective Storage (MG)	9.69	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	3.89	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	4.52	Fire + Equalization
Storage Analysis Result (MG)	**5.17**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**7.7**	**On Max Day Demand (16.2 MGD)**
Emergency Storage Duration (hr)	**22.5**	**On Average Day Demand (6.5 MGD)**

Table 6.b: Year 2022 Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	19.10	From model
Available Storage (MG)	7.79	Carbon Rd Allocation + 4.0 MG New Tank
Effective Storage (MG)	7.79	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	4.58	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	5.21	Fire + Equalization
Storage Analysis Result (MG)	**2.58**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**3.2**	**On Max Day Demand (19.1 MGD)**
Emergency Storage Duration (hr)	**13.2**	**On Average Day Demand (7.6 MGD)**

Table 7.bYear 2022 Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	19.10	From model
Available Storage (MG)	8.79	Carbon Rd Allocation + 5.0 MG New Tank
Effective Storage (MG)	8.79	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	4.58	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	5.21	Fire + Equalization
Storage Analysis Result (MG)	**3.58**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**4.5**	**On Max Day Demand (19.1 MGD)**
Emergency Storage Duration (hr)	**15.8**	**On Average Day Demand (7.6 MGD)**

Table 8.b: Year 2022 Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	19.10	From model
Available Storage (MG)	9.79	Carbon Rd Allocation + 6.0 MG New Tank
Effective Storage (MG)	9.79	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	4.58	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	5.21	Fire + Equalization
Storage Analysis Result (MG)	**4.58**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**5.8**	**On Max Day Demand (19.1 MGD)**
Emergency Storage Duration (hr)	**18.5**	**On Average Day Demand (7.6 MGD)**

Table 6.c: Year 2030 Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	28.20	From model
Available Storage (MG)	8.25	Carbon Rd Allocation + 4.0 MG New Tank
Effective Storage (MG)	8.25	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	6.77	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	7.40	Fire + Equalization
Storage Analysis Result (MG)	**0.85**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**0.7**	**On Max Day Demand (28.2 MGD)**
Emergency Storage Duration (hr)	**7.9**	**On Average Day Demand (11.3 MGD)**

Table 7.c: Year 2030 Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	28.20	From model
Available Storage (MG)	9.25	Carbon Rd Allocation + 5.0 MG New Tank
Effective Storage (MG)	9.25	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	6.77	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	7.40	Fire + Equalization
Storage Analysis Result (MG)	**1.85**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**1.6**	**On Max Day Demand (28.2 MGD)**
Emergency Storage Duration (hr)	**9.7**	**On Average Day Demand (11.3 MGD)**

Table 8.c: Year 2030 Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	28.20	From model
Available Storage (MG)	10.25	Carbon Rd Allocation + 6.0 MG New Tank
Effective Storage (MG)	10.25	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	6.77	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	7.40	Fire + Equalization
Storage Analysis Result (MG)	**2.85**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**2.4**	**On Max Day Demand (28.2 MGD)**
Emergency Storage Duration (hr)	**11.5**	**On Average Day Demand (11.3 MGD)**

Table 6.d: Year 2038 Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	30.50	From model
Available Storage (MG)	8.35	Carbon Rd Allocation + 4.0 MG New Tank
Effective Storage (MG)	8.35	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	7.32	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	7.95	Fire + Equalization
Storage Analysis Result (MG)	**0.40**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**0.3**	**On Max Day Demand (30.5 MGD)**
Emergency Storage Duration (hr)	**7.0**	**On Average Day Demand (12.2 MGD)**

Table 7.d: Year 2038 Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	30.50	From model
Available Storage (MG)	9.35	Carbon Rd Allocation + 5.0 MG New Tank
Effective Storage (MG)	9.35	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	7.32	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	7.95	Fire + Equalization
Storage Analysis Result (MG)	**1.40**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**1.1**	**On Max Day Demand (30.5 MGD)**
Emergency Storage Duration (hr)	**8.7**	**On Average Day Demand (12.2 MGD)**

Table 8.d: Year 2038 Storage Analysis - East Pressure Zone

Component	Quantity	Comments
Maximum Day Demand (MGD)	30.50	From model
Available Storage (MG)	10.35	Carbon Rd Allocation + 6.0 MG New Tank
Effective Storage (MG)	10.35	Effective (meets LOS pressure & fire)
Fire Flow Requirement (MG)	0.63	3,500 gpm for 3 hours
Equalization Storage Requirement (MG)	7.32	Equalization factor at 24 percent
Minimum Storage Requirement (MG)	7.95	Fire + Equalization
Storage Analysis Result (MG)	**2.40**	**Surplus = Emergency Storage Reserve**
Emergency Storage Duration (hr)	**1.9**	**On Max Day Demand (30.5 MGD)**
Emergency Storage Duration (hr)	**10.3**	**On Average Day Demand (12.2 MGD)**

Table 9: Pump Station Sizing (MGD)

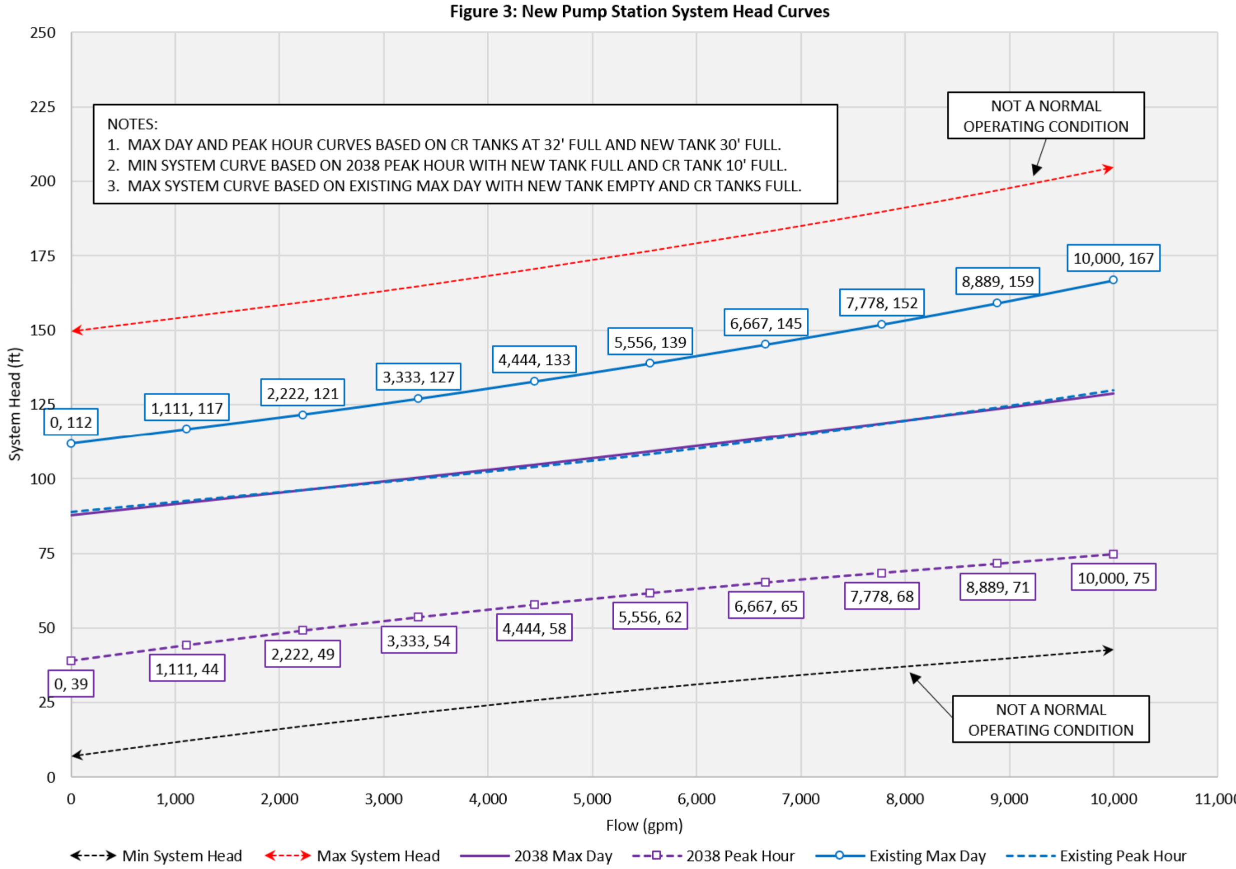
Planning Period	Supply			Peak Hour Demand[1]	Pumping Capacity			
	WTP	Denver H2O	Total		Capacity[2]	Fire Flow[3]	Total	Staging
Existing	26.0	10.0	36.0	30.9	-5.1	5.0	-0.1	6.0
2022	26.0	10.0	36.0	36.3	0.3	5.0	5.3	12.0
2030	32.0	10.0	42.0	53.8	11.8	5.0	16.8	17.0
2038	38.0	10.0	48.0	58.1	10.1	5.0	15.1	17.0

Notes:

1. Peak hour demand in the East PZ.
2. Pumping capacity is the difference between total supply capacity and peak hour demand.
3. 5.0 MGD is equivalent to 3,500 gpm; maximum fire flow requirement in the East PZ.

The hydraulic model is used to develop system head curves for the new pump station. System head curves are a graphical representation of the head required to deliver a given flow through the pump and into the distribution system for varying static head conditions on both the suction and discharge side of the pump. The static head conditions imposed on the pump station are created by the suction head from the ground storage tank between empty and full and the head range of Carbon Rd ground storage tanks situated on the discharge side of the new pump. Pump operating conditions are defined at intersection points of the system head curves and the pump curves. The range of system head curves under existing and projected maximum day and peak hour demands is illustrated in Figure 3.

Figure 3: New Pump Station System Head Curves



After individual pump flow conditions have been sized for the pump station capacity staging plan indicated previously in Table 9, the model should be update with the manufacturer published pump curves to confirm operating conditions of the pumps under the demand conditions and suction/discharge static head conditions for normal system operation.

ADDITIONAL CONSIDERATIONS

In addition to quantifying the equalization storage factor for the East PZ, the diurnal analysis also captures peak hour and minimum hour factors for each day evaluated. The peak hour factor applied in the model and the demand projections is 1.90 and less than those calculated in the diurnal analysis. This is important because the pump station capacity sizing (both flow and head) is based on the peak hour demand projections. A summary of the peak hour factors captured in the diurnal analysis for the East PZ are listed in Table 10.

If the peaking factors calculated from the diurnal analysis persist in the future as the maximum day demand escalates from the highly anticipated growth opportunities in northeast Broomfield (in the East PZ), then the City should start identifying and procuring available land for additional ground storage and pumping (assuming elevated storage is not feasible due to topography, level of service, customer opinion/perception, etc.) to meet higher system demands than those currently projected.

Table 10: East Pressure Zone Peaking Factors

Date	Demand (MGD)	Equalization Storage (%)	Peaking Factor
7/25/2021	13.30	19	2.91
7/26/2021	14.32	20	2.54
7/27/2021	13.63	20	2.34
7/28/2021	14.62	22	2.44
7/29/2021	13.90	20	2.26
7/30/2021	13.38	24	2.58
7/31/2021	8.42	17	2.51

It is equally important to note that if peaking demands are considerably higher in the future than projected, spreading system storage and pumping capability to more than one location in the East PZ significantly improves distribution system resiliency, provides a degree of operational redundancy that the City has never had, and improves the overall level of service to the City's customers. While it does add more utility assets that are accompanied with upfront capital and long-term operation and maintenance costs, the ability to pump ground storage into the East PZ from multiple locations significantly increases service resiliency and limits single point of failure opportunities.

These benefits also cascade to the West PZ because its supply source is effectively the Carbon Rd ground storage tanks. In an emergency situation where the WTP capacity is lessened or Denver Water cannot deliver the full contractual 10.0 MGD capacity (issues could be low pressure, significant water main break, emergency service to neighboring customers that impacts supply to the City, etc.), storage and pumping in multiple areas can help offset lost capacities in the short term or as long as the storage can supply the demand in the East PZ and capacity needs (by volume) at Carbon Rd ground storage tanks.

RS

Attachments: Diurnal calculations, Existing Hydraulic Grade Line Schematic by Others used in Figure 1.1

cc: Jeff Ruger (City)
Rick Bednar (City)
Katie Allen (City)
Matt Deaver (City)

APPENDIX B – SURVEY (ENCOMPASS)

TOPOGRAPHIC SURVEY

TRACT B, BROOMFIELD, CO
SITUATED IN THE SW 1/4 AND NW 1/4 OF SECTION 8,
TOWNSHIP 1 SOUTH, RANGE 68 WEST OF THE 6TH P.M.,
BROOMFIELD, COLORADO

SURVEYOR'S NOTES:

1. THIS SURVEY DOES NOT CONSTITUTE A TITLE SEARCH BY ENCOMPASS SERVICES, LLC TO DETERMINE OWNERSHIP OR EASEMENTS OF RECORD. FOR ALL INFORMATION REGARDING EASEMENTS, RIGHTS-OF-WAY, AND TITLE OF RECORD, ENCOMPASS SERVICES, LLC RELIED UPON A PUBLIC RECORDS SEARCH ONLY. ENCOMPASS SERVICES, LLC HAS NOT RESEARCHED OR SHOWN ANY OTHER EASEMENTS, RIGHTS-OF-WAY, VARIANCES, AND OR AGREEMENTS OF RECORD EXCEPT AS SHOWN HEREON.

2. UTILITIES SHOWN HEREON ARE FROM VISIBLE FIELD INFORMATION AND UTILITY LOCATES PROVIDED BY ENCOMPASS SERVICES, LLC. ENCOMPASS SERVICES, LLC DOES NOT GUARANTEE THESE LOCATIONS OR THAT THE UTILITIES SHOWN HEREON COMPRISE ALL UTILITIES IN THIS AREA, EITHER IN SERVICE OR ABANDONED. FOR THE EXACT LOCATION OF ALL UNDERGROUND UTILITIES, CONTACT THE UTILITY NOTIFICATION CENTER OF COLORADO AND THE APPROPRIATE UTILITY COMPANY PRIOR TO EXCAVATION AND OR CONSTRUCTION.:

   QUALITY LEVEL A (QL-A)
   PRECISE HORIZONTAL AND VERTICAL LOCATION OF UTILITIES BY ACTUAL EXPOSURE AND SUBSEQUENT MEASUREMENT OR SURVEY AT A SPECIFIC POINT REFERENCED TO THE SURVEY DATUM. (INCLUDES QL-B, QL-C AND QL-D EFFORTS)

   QUALITY LEVEL B (QL-B)
   APPLICATION OF APPROPRIATE SURFACE GEOPHYSICAL METHODS E.G. ELECTROMAGNETIC PIPE LOCATOR, SEWER SONDE, GPR, OPTICAL METHODS, ETC. TO DETERMINE THE APPROXIMATE HORIZONTAL LOCATION ONLY OF SUBSURFACE UTILITIES TO INCLUDE SUBSEQUENT MEASUREMENT OR SURVEY AT A SPECIFIC POINT REFERENCED TO THE SURVEY DATUM. (INCLUDES QL-C AND QL-D EFFORTS)

   QUALITY LEVEL C (QL-C)
   SURVEYING ABOVE-GROUND UTILITY FEATURES ONLY AND CORRELATING THIS INFORMATION TO EXISTING FACILITY RECORDS, MAPS AND OR ORAL RECOLLECTIONS. (INCLUDES QL-D EFFORTS)

   QUALITY LEVEL D (QL-D)
   INFORMATION DERIVED FROM EXISTING FACILITY RECORDS, MAPS AND OR ORAL RECOLLECTIONS.

3. PROJECT COORDINATES ARE NAD83(11) COLORADO STATE PLANE CENTRAL ZONE (502)

4. ALL ELEVATIONS SHOWN HEREON ARE RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) AND BASED UPON STATIC OBSERVATION AND NGS OPUS SOLUTION SUPPLEMENTED W/ GEOID MODEL 2018.

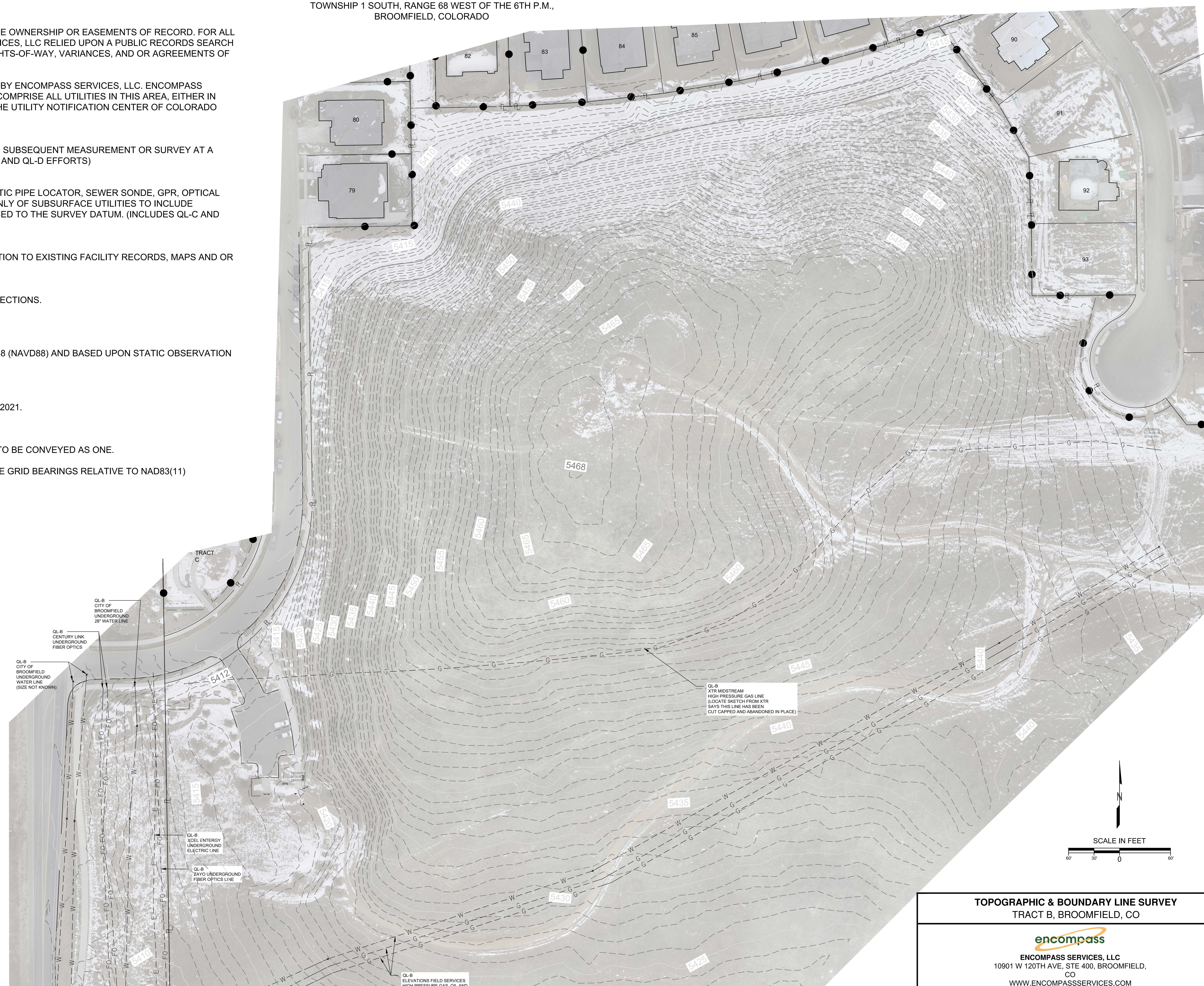
5. THE LINEAR UNITS FOR THIS SURVEY ARE US SURVEY FEET ($^{1200}/_{3937}$ METERS).

6. THE FIELD SURVEY FOR THIS TOPOGRAPHIC AND BOUNDARY SURVEY WAS PERFORMED NOVEMBER 2021.

7. THE AERIAL IMAGERY SHOWN HEREON WAS ACQUIRED ON NOVEMBER 4, 2021.

8. THIS IS NOT A LAND SURVEY PLAT, IMPROVEMENT SURVEY PLAT, OR SUBDIVISION PLAT AND IS NOT TO BE CONVEYED AS ONE.

9. THE BASIS OF BEARINGS FOR THIS SURVEY, MONUMENTED AND DESCRIBED AS SHOWN HEREON, ARE GRID BEARINGS RELATIVE TO NAD83(11) COLORADO STATE PLANE, CENTRAL ZONE, GRID COORDINATE SYSTEM.



	FOUND SECTION CORNER AS NOTED
WC	FOUND WITNESS CORNER AS NOTED
PP	FOUND PROPERTY CORNER AS NOTED
	SET PRIMARY CONTROL POINT AS NOTED
	SET AERIAL CONTROL FLIGHT PANELS
	SIGN (SINGLE POST)
	SIGN (DOUBLE POST)
	PARK BENCH
	FIRE HYDRANT
	FIBER OPTICS RISER
	SECTION LINE
	TRACT B PROPERTY LINE
	SUBDIVISION LOT LINE
	PLATTED EASEMENT AS NOTED
— FO —	UNDERGROUND FIBER OPTIC LINE
— E —	UNDERGROUND ELECTRIC LINE
— G —	UNDERGROUND HIGH PRESSURE GAS LINE
— W —	UNDERGROUND WATER LINE
	WOOD FENCE
	EXISTING MINOR CONTOUR (1' INTERVAL)
	EXISTING MAJOR CONTOUR (5' INTERVAL)

TOPOGRAPHIC & BOUNDARY LINE SURVEY
TRACT B, BROOMFIELD, CO

encompass

ENCOMPASS SERVICES, LLC
10901 W 120TH AVE, STE 400, BROOMFIELD, CO
WWW.ENCOMPASSSERVICES.COM
PH: 303.955.6080

SCALE: 1" = 60'	DATE: 02-04-2022	COUNTY: BROOMFIELD	SHEET
DWG NO.: 63499_EES_SRVY_GRID.dwg		REV: 0	1 OF 1

APPENDIX C – SITE PLAN

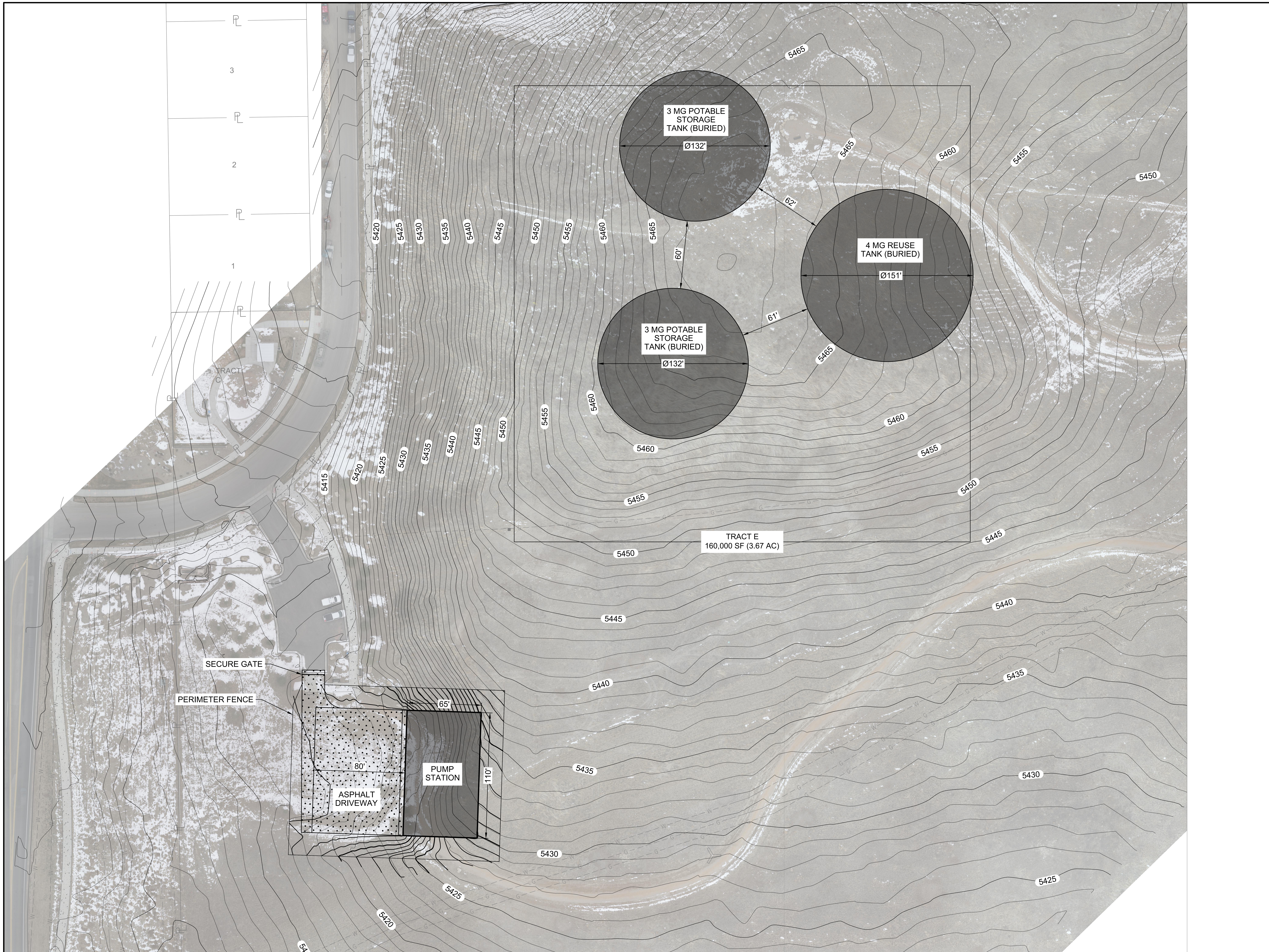


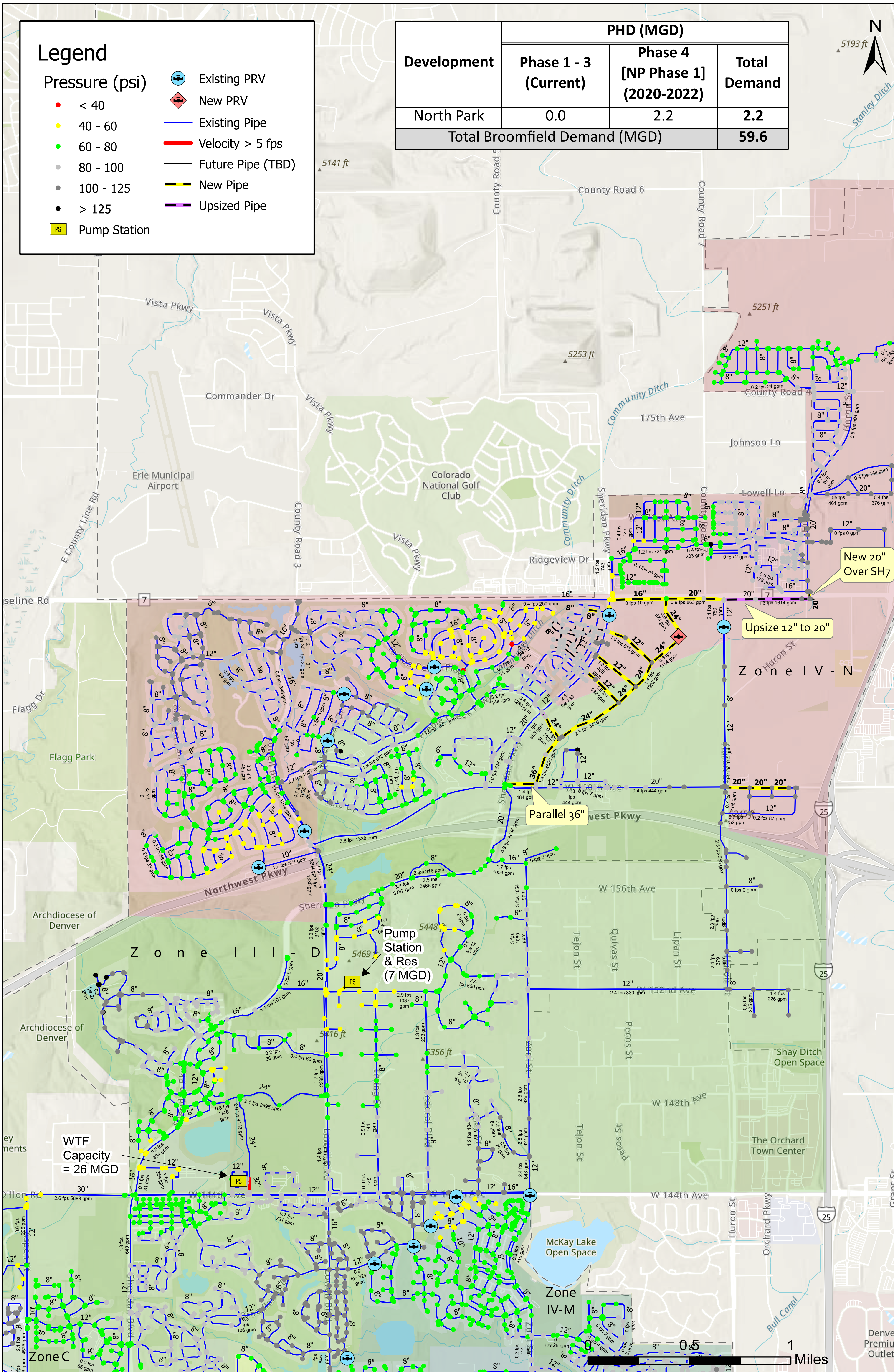
EXHIBIT:
BROOMFIELD TANKS AND PUMP STATION
CONCEPTUAL SITE PLAN

PROJECT NO. 135303

BURNS McDONNELL

CITY AND COUNTY OF BROOMFIELD COLORADO

APPENDIX D – NORTH SYSTEM IMPROVEMENTS PHD 2020-2022 FIGURES



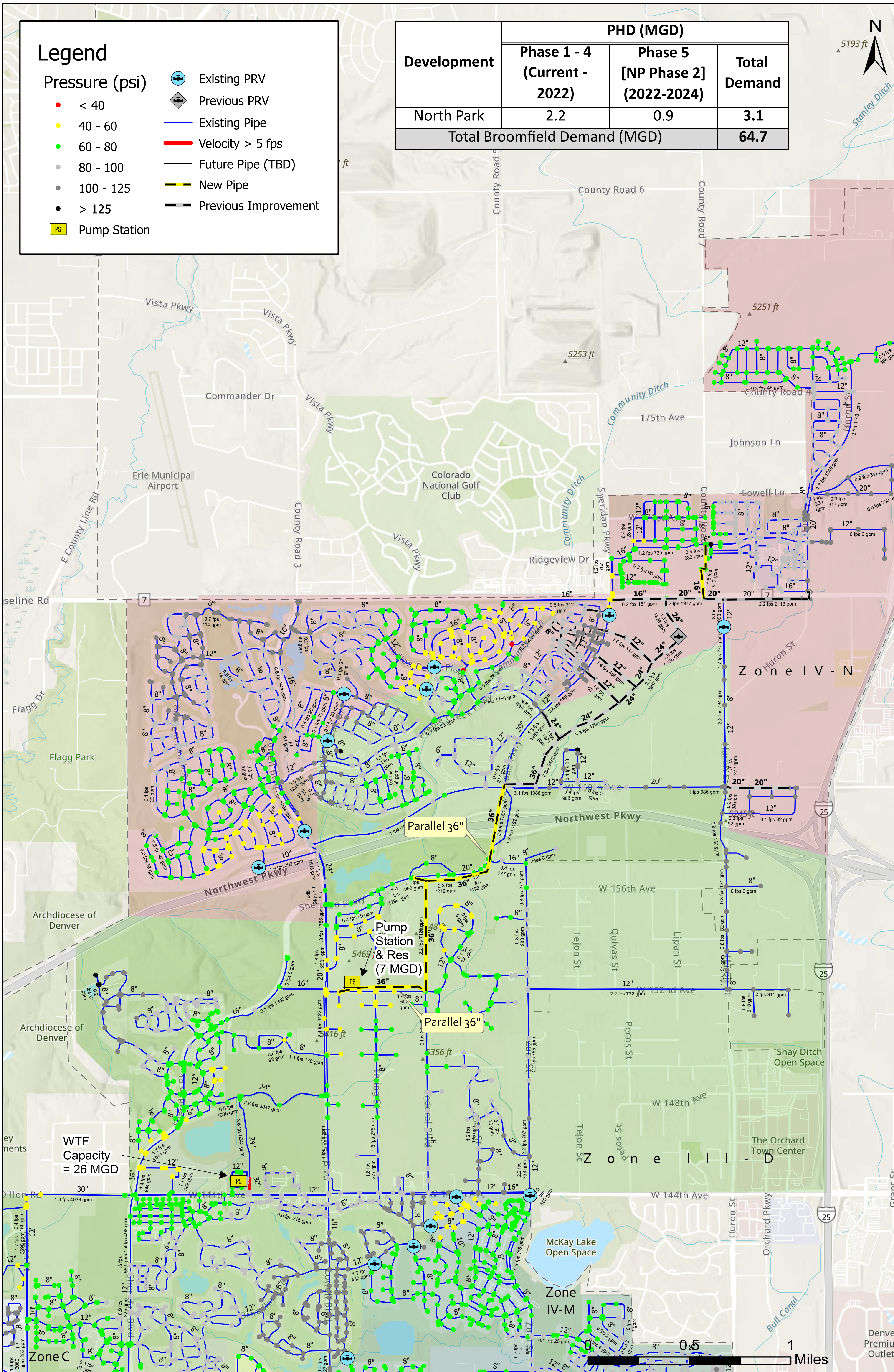
Development	PHD (MGD)		
	Phase 1 - 3 (Current)	Phase 4 [NP Phase 1] (2020-2022)	Total Demand
North Park	0.0	2.2	**2.2**
Total Broomfield Demand (MGD)			**59.6**

City and County of Broomfield

ARCADIS

North System Improvements PHD 2020 - 2022

Figure 4.1



Development	PHD (MGD)		
	Phase 1 - 4 (Current - 2022)	Phase 5 [NP Phase 2] (2022-2024)	Total Demand
North Park	2.2	0.9	**3.1**
Total Broomfield Demand (MGD)			**64.7**

City and County of Broomfield

ARCADIS

North System Improvements PHD 2022 - 2024

Figure 5.1

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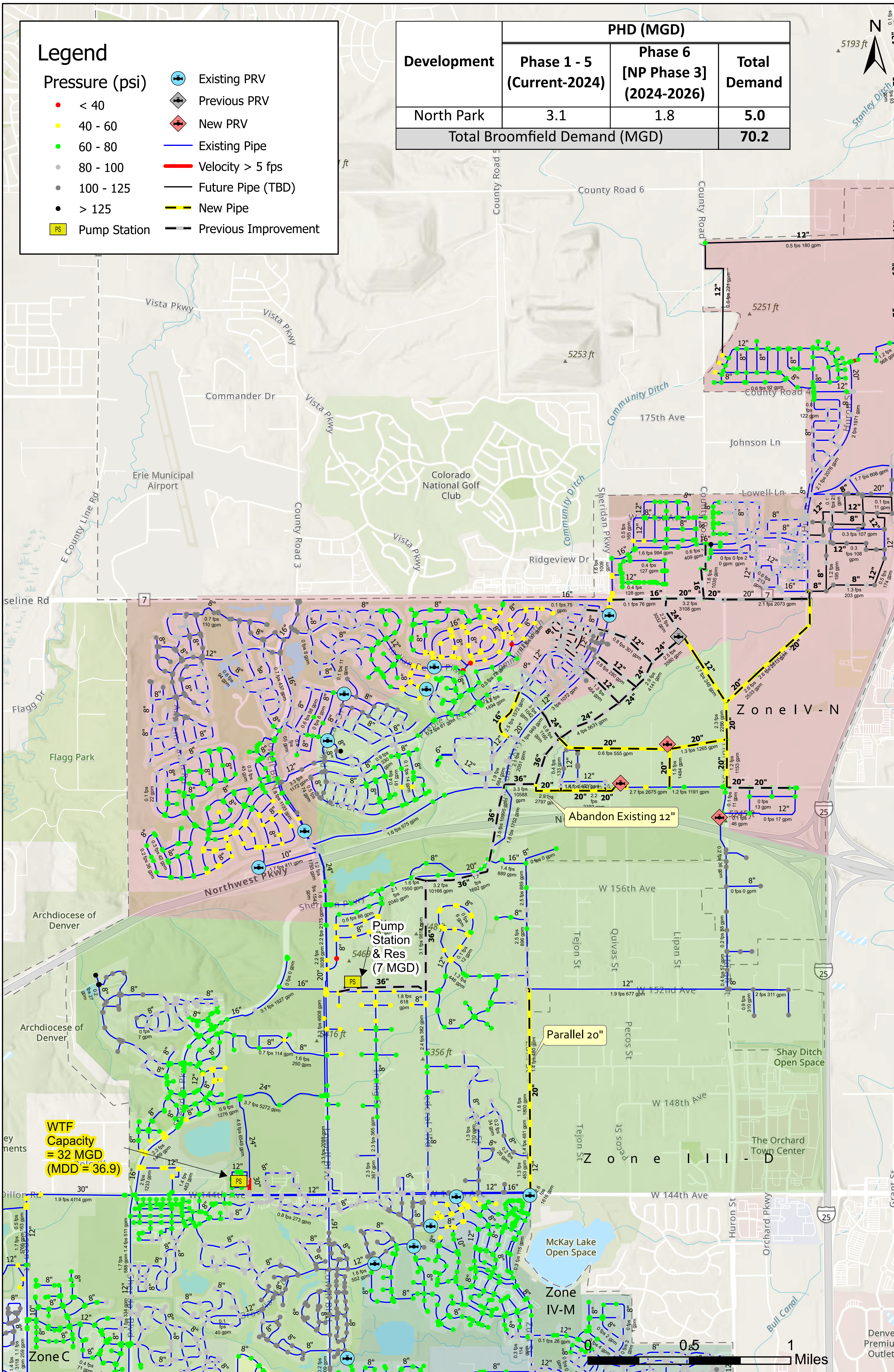

Development	PHD (MGD)		
	Phase 1 - 5 (Current-2024)	Phase 6 [NP Phase 3] (2024-2026)	Total Demand
North Park	3.1	1.8	**5.0**
Total Broomfield Demand (MGD)			**70.2**

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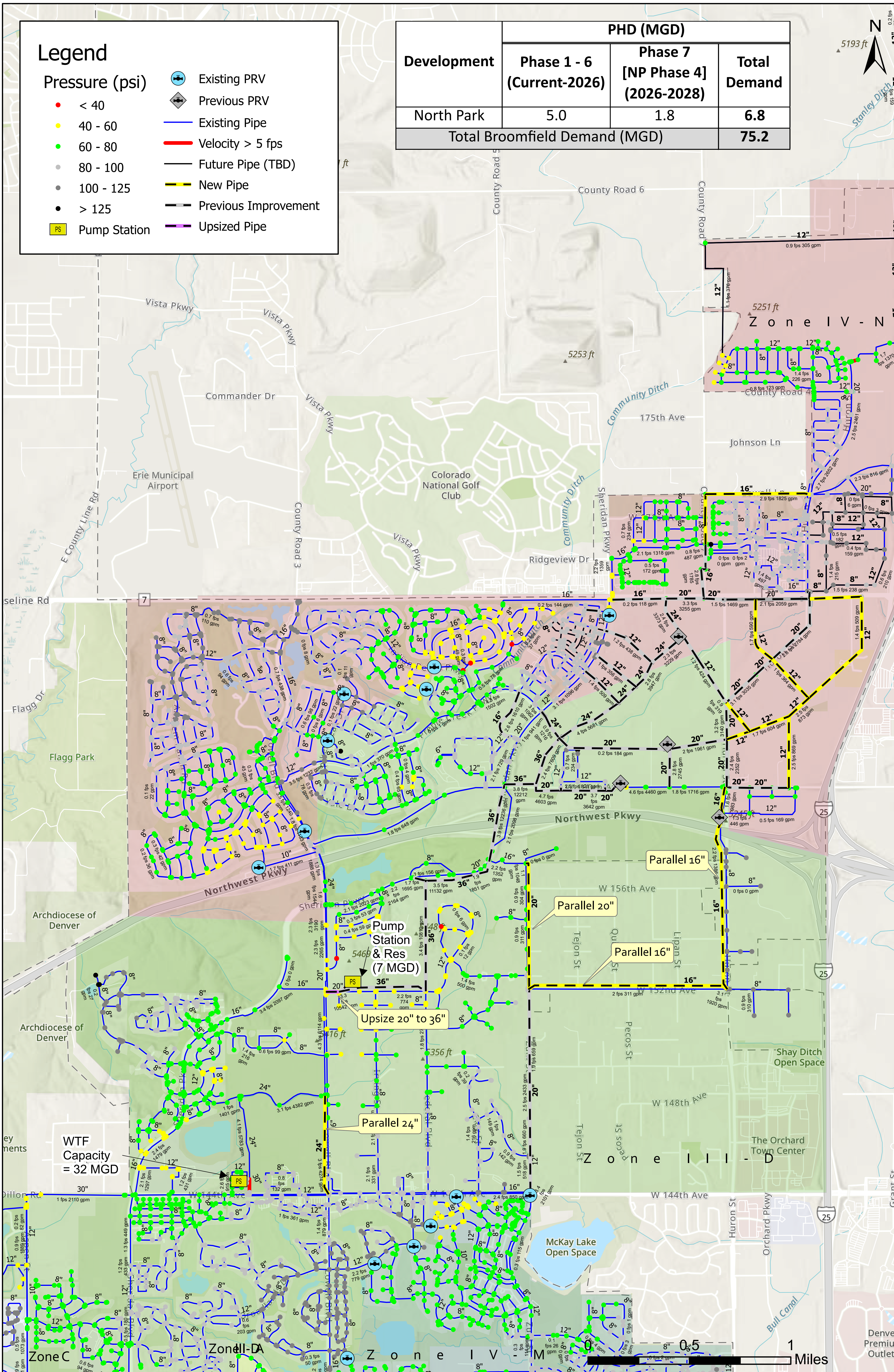
Service Layer Credits: World Topographic Map: City and County of Broomfield, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA; World Hillshade: Esri, NASA, NGA, USGS, FEMA

City and County of Broomfield

ARCADIS

North System Improvements PHD 2024 - 2026

Figure 6.1



Development	PHD (MGD) Phase 1 - 6 (Current-2026)	Phase 7 [NP Phase 4] (2026-2028)	Total Demand
North Park	5.0	1.8	**6.8**
Total Broomfield Demand (MGD)			**75.2**

City and County of Broomfield

ARCADIS

North System Improvements PHD 2026 - 2028

Figure 7.1

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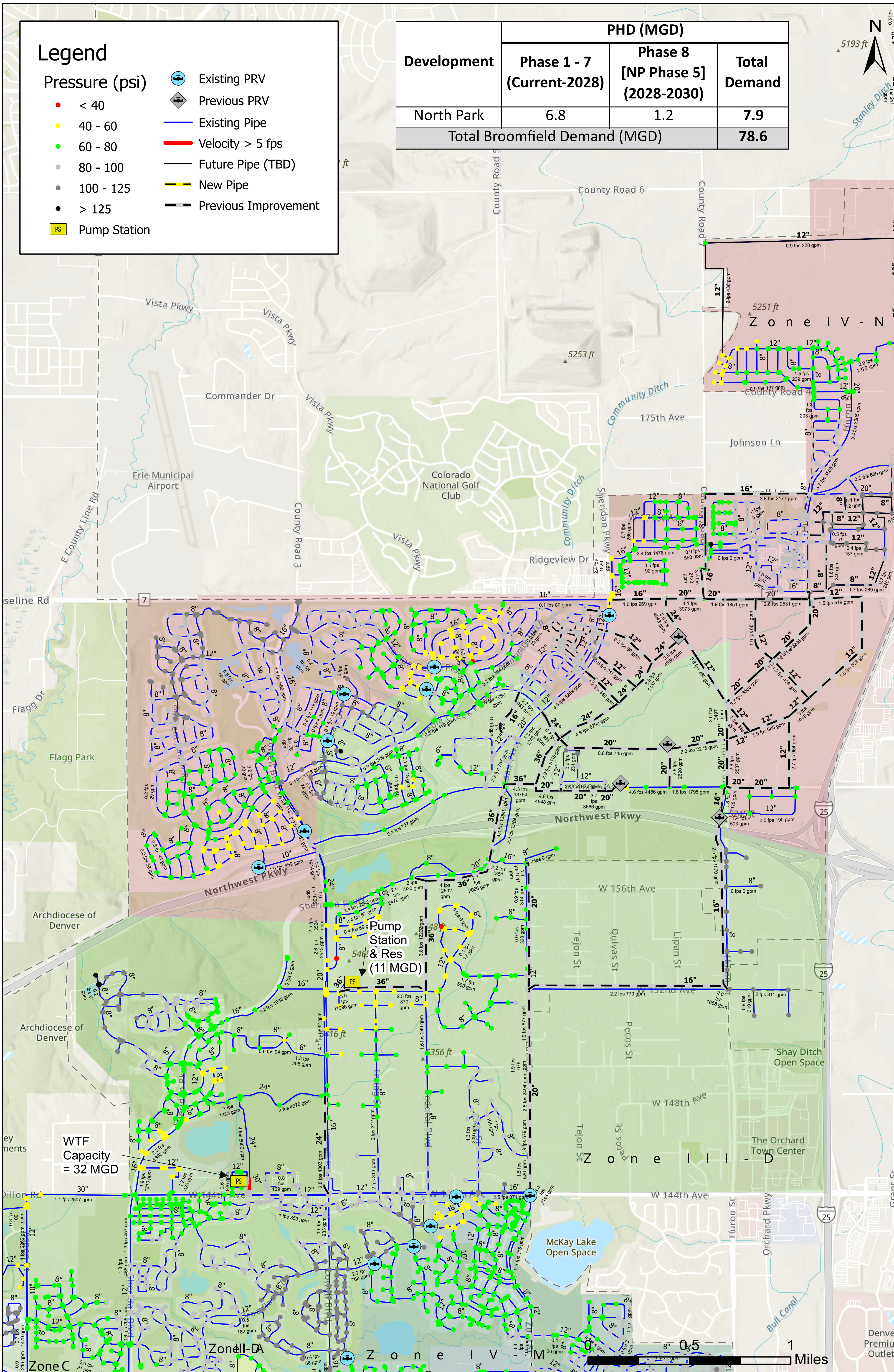

Development	PHD (MGD)		
	Phase 1 - 7 (Current-2028)	Phase 8 [NP Phase 5] (2028-2030)	Total Demand
North Park	6.8	1.2	**7.9**
Total Broomfield Demand (MGD)			**78.6**

City and County of Broomfield

ARCADIS

North System Improvements PHD 2028 - 2030

Figure 8.1

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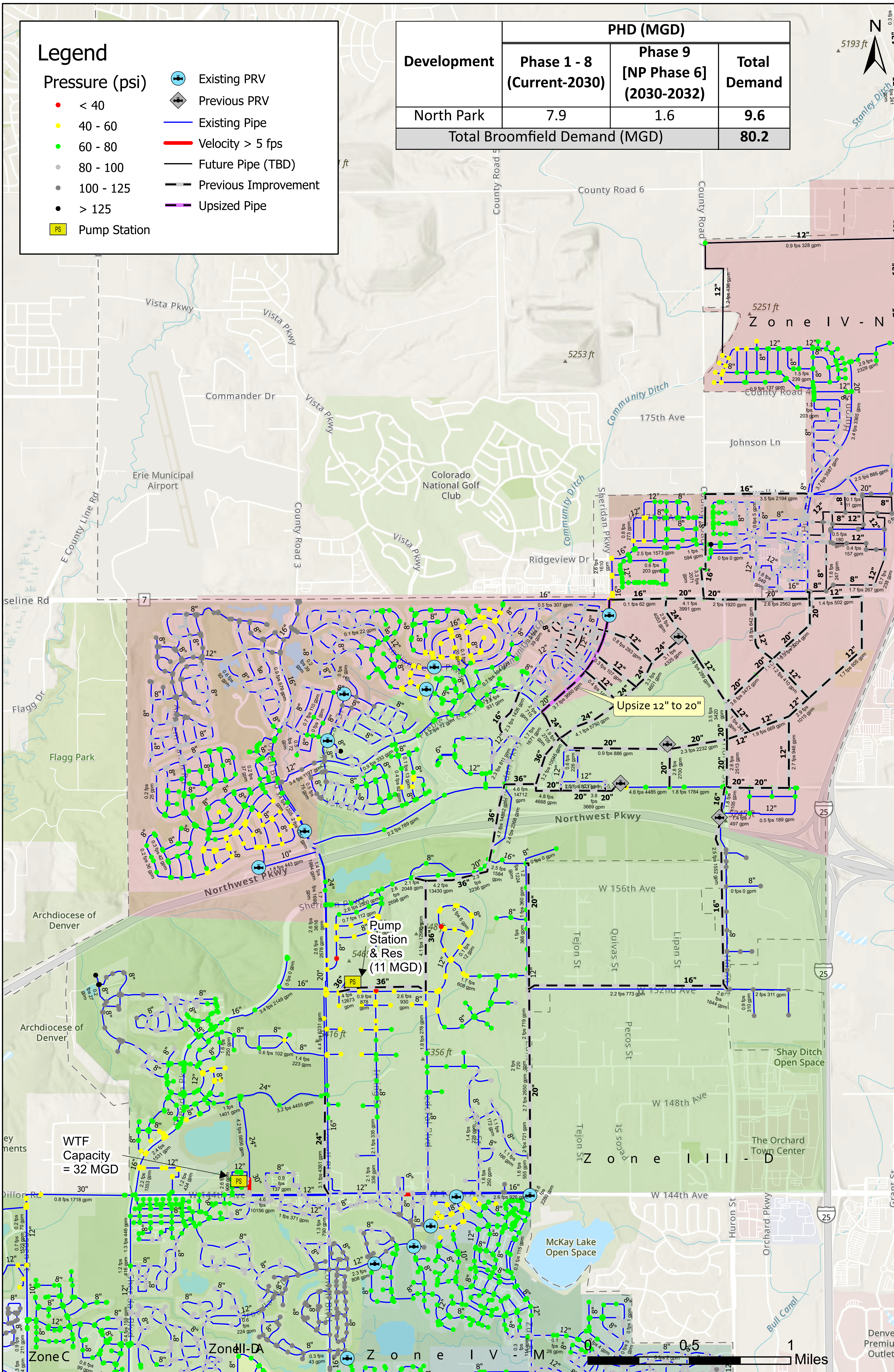

Development	PHD (MGD)		
	Phase 1 - 8 (Current-2030)	Phase 9 [NP Phase 6] (2030-2032)	Total Demand
North Park	7.9	1.6	**9.6**
Total Broomfield Demand (MGD)			**80.2**

City and County of Broomfield

ARCADIS

North System Improvements PHD 2030 - 2032

Figure 9.1

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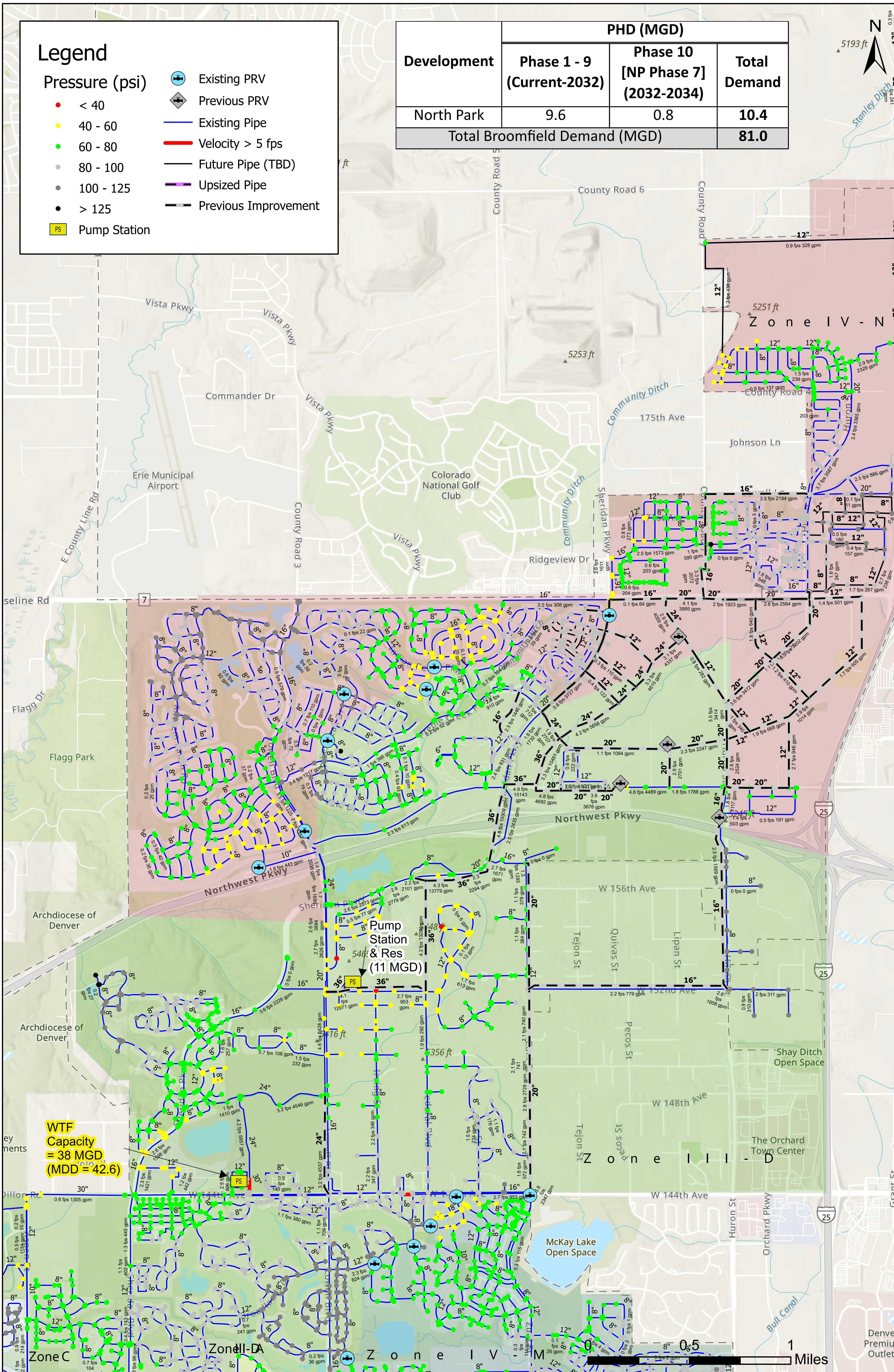
Service Layer Credits: World Topographic Map: City and County of Broomfield, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA; World Hillshade: Esri, NASA, NGA, USGS, FEMA



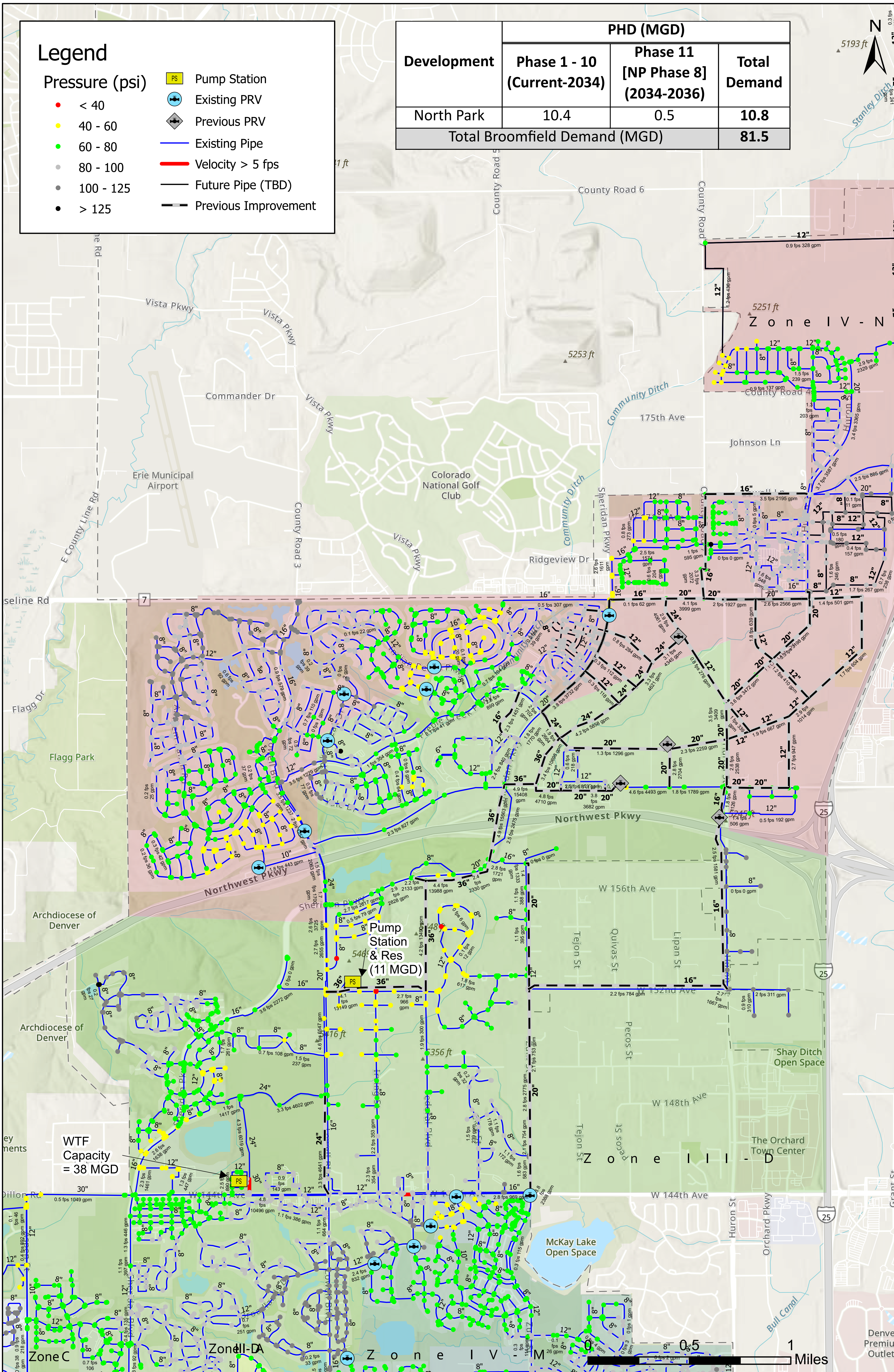
Development	PHD (MGD)		
	Phase 1 - 9 (Current-2032)	Phase 10 [NP Phase 7] (2032-2034)	Total Demand
North Park	9.6	0.8	**10.4**
Total Broomfield Demand (MGD)			**81.0**

City and County of Broomfield

ARCADIS

North System Improvements PHD 2032 - 2034

Figure 10.1



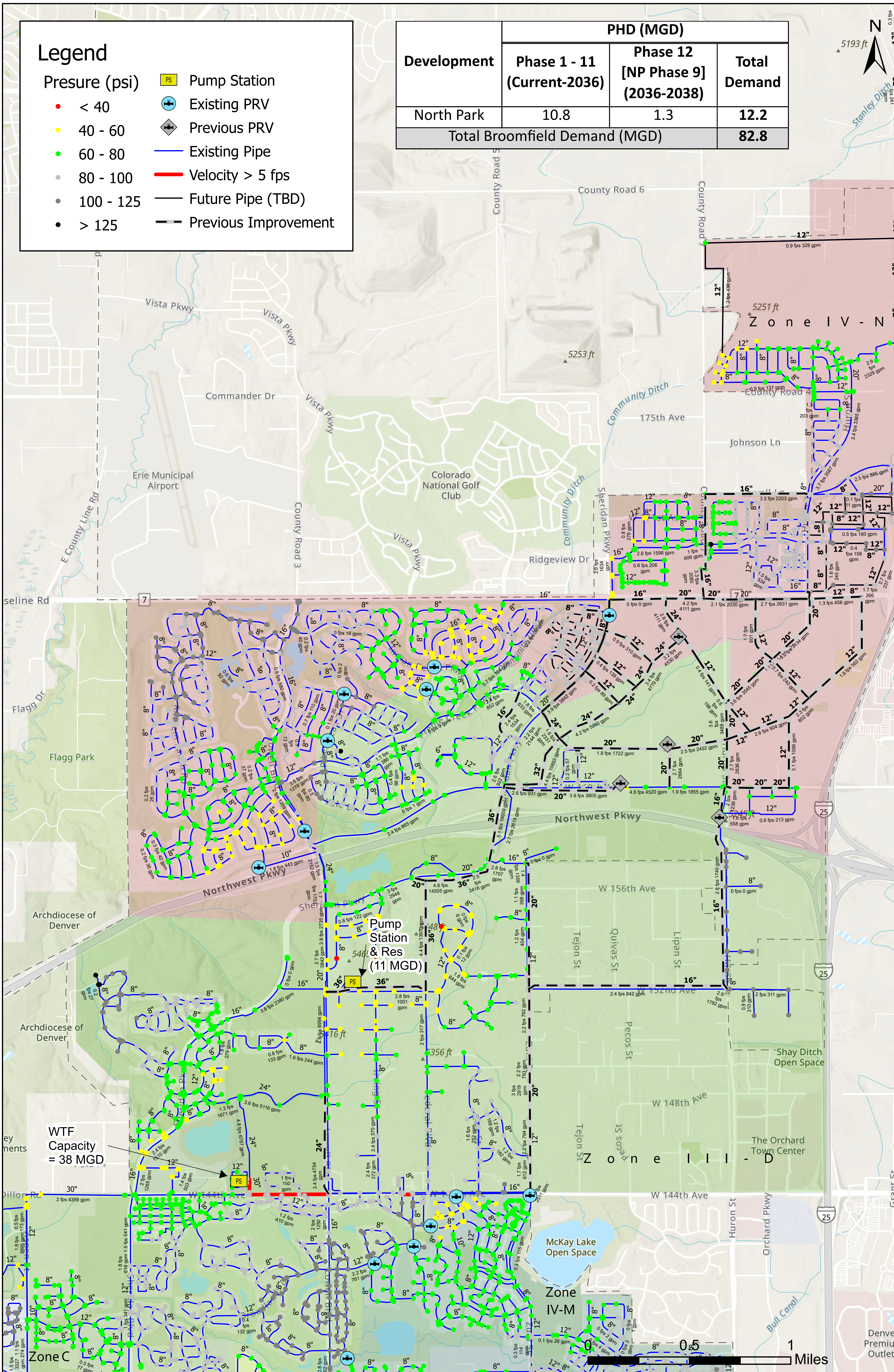
Development	PHD (MGD)		
	Phase 1 - 10 (Current-2034)	Phase 11 [NP Phase 8] (2034-2036)	Total Demand
North Park	10.4	0.5	**10.8**
Total Broomfield Demand (MGD)			**81.5**

City and County of Broomfield

ARCADIS

North System Improvements PHD 2034 - 2036

Figure 11.1



Development	PHD (MGD)		
	Phase 1 - 11 (Current-2036)	Phase 12 [NP Phase 9] (2036-2038)	Total Demand
North Park	10.8	1.3	**12.2**
Total Broomfield Demand (MGD)			**82.8**

City and County of Broomfield

ARCADIS

North System Improvements PHD 2036 - 2038

Figure 12.1

City: Broomfield, CO Created By: bchenevey C:\Users\bchenevey\OneDrive - ARCADIS\Documents\ArcGIS\Packages\Broomfield_Updated_ImpMaps_4204d5\p20\Broomfield Updated Improvement Maps.aprx 4/15/2021 12:36 PM
Service Layer Credits: World Topographic Map: City and County of Broomfield, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA; World Hillshade: Esri, NASA, NGA, USGS, FEMA

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