City of Grand Junction Colorado
CITY MANAGER'S OFFICE

March 28, 2022

Colorado Water Conservation Board:
Finance Section
Attn: Matt Stearns, P.E.
1313 Sherman Street, Room 718
Denver, CO 80203

Dear Mr. Stearns,

Please find enclosed a Loan Feasibility Study and Loan Application for the Kannah Creek Flowline Replacement Project that the city of Grand Junction is proposing to complete in 2022. We are requesting a $3,200,000 loan for this project through the CWCB Water Project Loan Program.

Should you have any questions, please contact our Utilities Director, Randi Kim at 970-244-1429 or randik@gjcity.org.

Thank you for your consideration.

Sincerely,

Greg Caton, ICMA - CM
City Manager

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Water Project Loan Program

Projects financed by the Water Project Loan Program must align with the goals identified in Colorado's Water Plan and its measurable objectives.

Application Type

☐ Prequalification *(Attach 3 years of financial statements)* ☑ Loan Approval *(Attach Loan Feasibility Study)*

Agency/Company Information

Company / Borrower Name: City of Grand Junction

Authorized Agent &Title: Greg Caton, City Manager

Address: 250 N. Fifth Street, Grand Junction, CO 81501

Phone: (970) 244-1508	Email: gregc@gjcity.org
Organization Type: ☐ Ditch Co, ☐ District, ☑ Municipality ☐ other:	Incorporated? ☑ YES ☐ NO
County: Mesa	Number of Shares/Taps: 9,967 taps
Water District:	Avg. Water Diverted/Yr 5,300 acre-feet
Number of Shareholders/Customers Served: 30,000	Current Assessment per Share $ (Ditch Co)
Federal ID Number:	Average monthly water bill $ 25.00 (Municipality)

Contact Information

Project Representative: Randi Kim

Phone: ( )970-244-1429	Email: randik@gjcity.org

Engineer: John Eklund

Phone: ( )970-244-1558	Email: johne@gjcity.org

Attorney: Jamie Beard

Phone: ( )970-256-4032	Email: jamieb@gjcity.org

Project Information

Project Name: Kannah Creek Flow Line Replacement

Brief Description of Project: (Attach separate sheets if needed)

The Kannah Creek Flow Line is a gravity transmission main of approximately 17.5 miles and is the secondary structure that conveys raw water from Kannah Creek to the City of Grand Junction's Water Treatment Plant.

The flow line has reached the end of its useful life and needs replacement. This project will replace 3 miles of the Kannah Creek Flow Line.

Project Start Date(s) Design: January 2022 Construction: September 2022

General Location: (Attach Map of Area)

Project Costs - Round to the nearest thousand

Estimated Engineering Costs: $195,300	Estimated Construction Costs: $3,254,700
Other Costs (Describe Above): $50,000 (easements)	Estimated Total Project Costs: $3,500,000
Requested Loan Amount: $3,200,000	Requested Loan Term(10, 20, or 30 years): 20 Years

Signature

/ City Manager 3/28/22
Signature / Title Date

Return to: Finance Section Attn: Matt Stearns
1313 Sherman St #718
Denver, CO 80203
Ph. 303/866.3441
e-mail: matthew.stearns@state.co.us

Loan Feasibility Study
City of Grand Junction
Kannah Creek Flow Line

1.0 Background

1.1 Purpose

This section provides a brief overview of the project, including the type of project and amount of loan funding being requested, and a statement of what the project and study is intended to accomplish. It should describe the need for the project, the problems and opportunities to be addressed, the expectations of the study participants, and why the project is important to the borrower. It should also discuss relevant project history and identify any regulatory compliance issues that are being addressed, such as dam safety, water quality and flood control.

The Kannah Creek Flow Line is a gravity transmission main of approximately 17.5 miles and is the structure that conveys raw water from the Kannah Creek to the City of Grand Junction's Water Treatment Plant. The flow line has reached the end of its useful life and needs replacement. The City already replaced approximately a large portion of the Kannah Creek Flow Line with 20-inch PVC. This project will replace approximately 3 miles of the upper segment of the Kannah Creek Flow Line. This segment of the flow line consists of 18-inch cast iron and 20-inch steel pipe, which has reached its useful life. The estimated cost of replacement is $3.2 million. The City of Grand Junction is requesting a Water Project Loan of $3.2 million to fund the construction phase of this project. Replacement of the last segment of this supply line is intended to restore the service life of the Kannah Creek Flow Line to 100 years and increase the flow capacity to 9.8 million gallons per day.

Feasibility Study participants include the City of Grand Junction and the Colorado Water Conservation Board. City staff will serve as the Project Manager. JVA Consultants, Inc. will serve as design engineer. The City plans to bid the construction phase of the project.

1.2 Study Area Description

The study area/service area is generally the geographic area to be served by the proposed project. The study area description should include the following items:

- a. *A narrative description of the study area to include the county, the location of towns or cities, topography, and locations of major streams.*
- b. *A study area map showing each of the items above, as well as the locations of existing facilities, proposed project facilities and boundaries of lands to be served.*
- c. *Socio-economic characteristics of the study area such as population, employment and land use. For irrigation projects, the tabulation should provide a description of cropping patterns and crop yields on existing agricultural lands.*

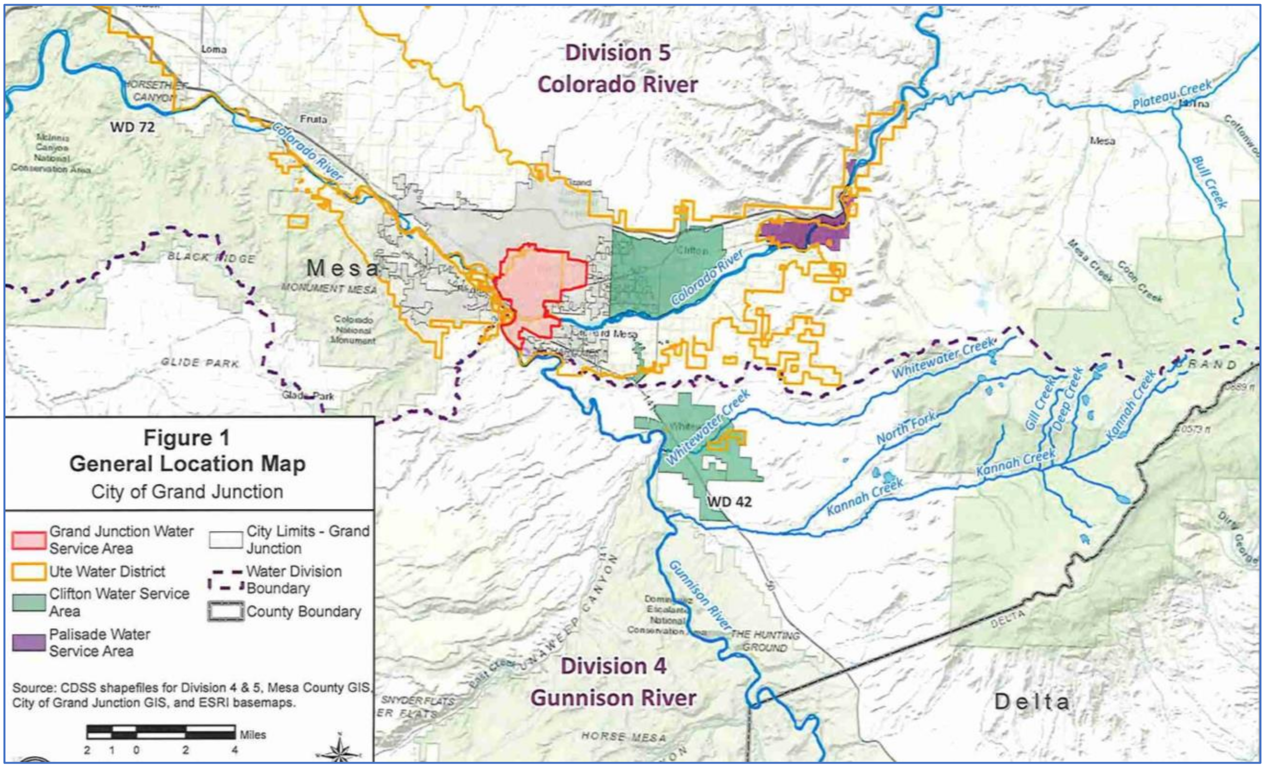
The study area encompasses the 3 miles of the Kannah Creek Flow Line near Whitewater, Mesa County, Colorado as highlighted in orange in **Figures 1 and 2**.

Figure 1 – Upper Kannah Creek Flow Line Project Location

Figure 2 – Upper Kannah Creek Flow Line Project and Interconnect Location

The project will serve the City of Grand Junction municipal water service area as shown in **Figure 3**.

Figure 3 – City of Grand Junction Water Service Area



The City of Grand Junction's water service area covers only a portion of the City of Grand Junction city limits. Other portions of the City are served by Ute Water District and Clifton Water District. The City currently serves a population of 29,500 with an average demand of 4.9 million gallons per day (mgd) and a peak demand of 9.8 mgd. Based upon water supply analysis conducted by DiNatale Water Consultants for the City of Grand Junction, the 50-year population projection for the City's service area is 49,000 in 2069 with an average demand of 6.5 mgd and a peak demand of 13.0 mgd. The City's service area includes residential, commercial, and government customers.

The City's primary reservoir is Juniata Reservoir. The primary supply line that conveys water from Juniata Reservoir to the Grand Junction Water Treatment plant is the Purdy Mesa Flow Line. The Kannah Creek Flow Line conveys water from Kannah Creek to Juniata Reservoir. It also serves as a secondary supply line to convey water directly from Kannah Creek to the Grand Junction Water Treatment Plant.

1.3 Previous Studies

To the maximum extent possible, the results of any previous studies and investigation should be utilized for the current Loan Feasibility Study. If the Loan Feasibility Study was preceded by a reconnaissance-level study, the results of the reconnaissance study should be summarized.

The following studies were completed that support the basis for design of the Purdy Mesa Flow Line Replacement project:

1. Kannah Creek Flowline Hydraulic Evaluation, Black & Veatch, April 2018. This report is included as **Appendix A**.
2. Water Supply Modeling Model Documentation and Firm Yield Determination Report, DiNatale Water Consultants, January 2019. This report is included as **Appendix B**.
3. Water Supply Analysis, DiNatale Water Consultants, July 2019. This report is included as **Appendix C**.
4. Options Assessment for the City of Grand Junction Water Supply, Burns & McDonnell, July 2020. This report is included as **Appendix D**.

2.0 Project Sponsor

Each Loan Feasibility Study should include a description of the entity (municipality, irrigation district, conservancy district, ditch company, etc.) that is sponsoring the proposed project. The project sponsor may be a public or private entity. The description should include the following:

- *a. Type of organization, official name, the year formed, and the statutes under which the entity was formed. For private entities, a copy of the Articles of Incorporation and By-laws should be appended to the report.*
- *b. For public entities, the number of customers, taps, etc. served, and current water usage, and future growth plans.*
- *c. For private entities, the number of members or shareholders and shares of stock outstanding or a description of other means of ownership, and current water delivery.*
- *d. A brief history of the sponsoring entity.*
- *e. Identification of revenue sources (existing service charges, tap fees, share assessments, etc.).*
- *f. A description of existing water supply facilities owned and/or operated by the entity.*

The City of Grand Junction is the project sponsor. The City of Grand Junction is a Colorado Home Rule municipality organized under Article XX, section 6 of the Colorado Constitution. As a Home Rule Municipality, the City adopted a Charter on September 14, 1909. The Constitution was adopted after the City Charter and Grand Junction is specifically cited in the Constitution and the City Charter is adopted and ratified by reference.

The Constitution, the Charter, the laws of the State of Colorado and the ordinances, resolutions and regulations of the City serve as "bylaws" for the conduct of City business.

The City of Grand Junction's serves a population of 29,500 with about 9,800 taps. Current average water demand is 4.9 million gallons per day (mgd) with a peak demand of 9.8 mgd. The 50-year population projection for the City's service area is 49,000 in 2069 with an average demand of 6.5 mgd and a peak demand of 13.0 mgd.

The City's Utilities Department oversees the Water Services Division which is responsible for operation and maintenance of the water supply, treatment and distribution system. Operations expenses and capital projects are funded by the Water Enterprise Fund. Revenue sources for the Water Enterprise Fund include water service charges and tap fees.

The City's water supply is the Kannah Creek watershed which covers 200 square miles on the top and west side of the Grand Mesa. The City has a number of water diversion and storage rights within this watershed including a paramount water right on the Kannah Creek and storage rights in 19 reservoirs. Water is conveyed from the City's Kannah Creek diversion structure to either the Juniata Reservoir or directly to the City's water treatment plant via the Kannah Creek Flow Line.

3.0 Water Rights

3.1 Water Availability

The Loan Feasibility Study should provide a detailed description and analysis of each water supply source to be utilized by the proposed project. (A brief description of existing sources may be adequate for projects that involve only rehabilitation of existing facilities). Each source of supply should be described in terms of location, yield, extent of development, and water rights status. Maps and schematic diagrams should be included as a part of the description.

For surface water sources, the description should include a numerical and graphical tabulation of annual flows and average monthly flows for the period of record on each stream. For groundwater sources, the source aquifer(s) and the expected yields and reliability of wells should be identified. A complete tabulation of water rights for each surface water source should also be provided to include appropriation dates, adjudication dates, status of adjudication (absolute or conditional), and amounts decreed to direct flow or to storage. For groundwater sources, the status of well permits and history of use should be provided.

For new water supply facilities or the expansion of existing facilities, an analysis of the expected yield of water supply sources should be included in the Loan Feasibility Study. The analysis should be performed in such a way as to take into account a reasonable range of variations in flow due to hydrologic and meteorological conditions as well as the operation of the water rights priority system.

The City's water supply is the Kannah Creek watershed which covers 200 square miles on the top and west side of the Grand Mesa. The City has a number of water diversion and storage rights within this watershed including a paramount water right on the Kannah Creek and storage rights in 19 reservoirs. Water is conveyed from the City's Kannah Creek diversion structure to either the Juniata Reservoir or directly to the City's water treatment plant via the Kannah Creek Flow Line.

Water Supply Modeling conducted by DiNatale Water Consultants determined a firm yield for the Kannah Creek watershed of between 5,800 and 6,275 acre-feet per year A copy of the Water Supply Modeling report is included in **Appendix B**.

3.2 Water Supply Demands

Existing and future water demands are analyzed, as well as the adequacy of water rights/existing yields, and water demand and availability are compared. Study area water demands are generally estimated for a selected planning horizon or period of time. Typically, a planning horizon should be at least as long as the CWCB loan period. Demands are estimated for the study planning horizon and compared with the yields of existing supplies. If the comparison indicates a water supply deficit at some point during the planning horizon, alternatives are formulated to meet the deficit by reducing demands or increasing supplies, or both. Alternatives are then formulated to supply water to the project service area under varying degrees of reliability.

In support of its water rights due diligence filings, DiNatale Water Consultants analyzed current and future water supply demands for a 50-year timeframe. Using the current per capita potable water demand and the projected population for 2069, the City's annual treated water demand is 8,760 acre-feet (AF) as measured as production at the water treatment plant. This is 3,460 AF more than the current (2018) potable water treatment plant production demand of 5,300 acre-feet. A copy of the Water Supply Analysis (July 2019) is included in **Appendix C**.

4.0 Project Description - Analysis of Alternatives & Selected Alternative

This section further documents the project need by assessing existing and future conditions, identifying problems and deficiencies, and formulating and evaluating potential solutions.

4.1 Analysis of Alternatives

Each study should include the formulation and evaluation of a reasonable number of alternatives for accomplishing the study objective(s). The number of alternatives will depend upon the objective and scope of the Loan Feasibility Study. Generally, a minimum of three alternatives should be presented, one of which should be the "no-action alternative." Each alternative should be described in terms of its various components (both structural and non-structural) and the manner in which the proposed facility will operate. Examples of non-structural elements are improvements in the management of developed water supplies, water transfers from existing to new uses and new or revised institutional arrangements.

Evaluation Factors - Alternatives should be evaluated to distinguish the differences between them, in accordance with evaluation factors suggested below: Project evaluation factors typically used are as follows:

a. *Outputs/yields - Project outputs are typically expressed in terms of acre-feet of water supply or in units of energy for hydropower. For municipal water supply projects, the estimated safe annual yield of the project should be given. The safe annual yield is the amount of water the project is expected to yield during each year of a critical dry period. For irrigation projects, the yield should be expressed in terms of acre-feet of water supplied to the project service area on an annual basis. The degree of reliability or firmness of a particular yield should also be given. For projects that involve the rehabilitation of existing facilities, the yield should be expressed as the incremental difference in water supply with and without the project.*
b. *Costs (capital, operations and maintenance (O & M), total annual costs and costs per unit) - A cost comparison should be made between alternatives. The cost analyses should consist of: (1) an estimate of total capital costs and total annual (O & M) and replacement costs for each alternative, and (2) a total annual cost for each alternative calculated by adding O & M to amortized capital costs, and (3) a cost per unit of project output, i.e. annual project cost per acre-foot of water delivered.*
c. *Impacts – Identifies and compares potential impacts to the man-made environment and the natural environment:*
    1. *impacts on the man-made environment – residential or commercial buildings affected; utility relocations; acreages of developed lands impacted; historical and archaeological sites impacted; impacts on outdoor recreation activities.*
    2. *impacts on the natural environment - acres of forest, grasslands, etc. to be impacted; streamflow impacts; water quality impacts; impacts on vegetation, aquatic wildlife and terrestrial wildlife; threatened and endangered species in the project area; impacts to federal land national forests, wilderness areas or other areas.*
d. *Economic analysis and feasibility - The level of economic analysis will vary from project to project, but generally will include an assessment of benefits and costs. An estimate of the number of shareholders, members, households, etc., expected to benefit from the project should be provided.*
e. *Institutional requirements – Identify and evaluate permits, court actions, contracts, agreements, etc. that are required for project implementation.*

f. *Special considerations - These are extraordinary situations likely to be encountered during design and/or construction. They may relate to special technical considerations, the need for further investigations, uncertainty or risk associated with demand projections or cost estimates, or the possibility of new technologies affecting project.*

The results of the alternatives evaluation should be described and displayed in such a manner that the differences between alternatives are apparent. The report should identify the differences between alternatives and comparative costs and should describe the process (evaluation methodology) used in selecting one of the alternatives as the preferred plan.

The purpose of this project is to provide a means for the City of Grand Junction to continue providing potable water to City customers by increasing the reliability of its secondary water supply line and increasing the capacity to meet future demands. Three alternatives were considered:

1. The no-action alternative.
2. Replace the remaining steel section of the Kannah Creek Flow Line with 20-inch PVC ($3,000,000).
3. Replace the remaining steel section of the Kannah Creek Flow Line with 24-inch PVC ($4,000,000).

Alternative No. 1 was considered unacceptable because the existing 18-inch cast iron and 20-inch steel pipe has reached its useful life.

Alternative No. 2 was selected because it is the least costly reliable alternative. This alternative provides reliability and capacity to meet current and future demands. It does not provide full capacity on peak demand days 50 years into the future. However, the City also maintain reservoir storage capacity at the water treatment plant that can be utilized to supplement water supply on peak demand days.

Alternative No. 3 was ruled out due to the additional cost for additional capacity that would only be needed on peak demand days. The City can utilize reservoir storage capacity at the water treatment plant to supplement water supply on peak demand days.

The City of Grand Junction has prepared comparative cost estimates for the project alternatives. The cost breakdown is summarized in **Tables 1** and **2**.

Table 1. Alternative 2 Cost Estimate (Selected Alternative: 20-Inch PVC)

Cost Estimate Item	Quantity	Unit	Unit Price $	Amount $
20-inch PVC	15,300	LF	$150.00	$2,295,000
General Conditions	8%	Of above		$183,600
OHP	10%	Of Above		$229,500
Subtotal				$2,708,100
Contingency	1	LS	$340,000	$270,810
Total				**$2,978,910**

Table 2. Alternative 3 Cost Estimate (Evaluated Alternative: 24-Inch PVC)

Cost Estimate Item	Quantity	Unit	Unit Price $	Amount $
24-inch PVC	15,300	LF	$200.00	$3,060,000
General Conditions	8%	Of above		$244,800
OHP	10%	Of Above		$306,000
Subtotal				$3,610,800
Contingency	1	LS	$340,000	$361,080
Total				**$3,971,880**

4.2 Selected Alternative

A detailed description of the Selected Alternative should be provided and should include the following:

a. *Project Description – A narrative description of project components and operation to indicate how the entire project will function.*
b. *Map - A map of the entire project area showing the locations of existing and proposed project components, and other features like floodplains, spillway inundation zones, etc.*
c. *Conceptual Plan/Cross-Section - Layout and cross-sections for each major structure to include dimensions and hydraulic properties. Profile and typical sections for canals and pipelines with water surface and hydraulic gradeline elevations.*
d. *Conceptual Design Features - Hydraulic, hydrologic, and structural design criteria for all proposed facilities including:*

- *Sizing criteria for all hydraulic features such as reservoirs, outlet works, canals, pipelines, pumping plants, etc. with associated energy losses where appropriate.*
- *Preliminary structural design criteria including loadings, stresses, geotechnical considerations, and assumptions used for stability analyses.*

- *Derivation of the reservoir inflow design flood with volume, peak discharge and routing through the reservoir.*
- *Spillway sizing for the inflow design flood.*
- *The number, size and operating characteristics of pumping units.*
- *Other site factors such as erosion hazard, icing and cold-weather conditions, special construction requirements, and sedimentation.*

e. Field Investigations - A description of all field investigations including the date of the investigations, type of investigations, methodology used and results. For all major structures, the Loan Feasibility Study should describe site conditions, engineering geology, geologic mapping, source and availability of construction materials, and subsurface investigations used in the design of the structure. Where geologic conditions are poor or may require intensive exploration and evaluation, a comprehensive report by a qualified engineering geologist may be necessary.

f. Right-of-Way/Land - Land and right-of-way requirements for the proposed project and a tabulation of land ownership at the site of proposed facilities.

a) The upper segment of the Kannah Creek Flowline totals 15,300 LF (approximately 3 miles). Pipe material will be C900 PVC. Standard minimum cover is 3' using standard elbows for abrupt changes in alignment.

b) Vicinity Map – please see vicinity map presented as Figure 1.

c) Conceptual plans for the pipeline can be reference in Appendix E.

d) The pipeline replacement design is based on the recommendations from two studies performed for the City of Grand Junction:
   - Kannah Creek Flowline Hydraulic Evaluation, Black & Veatch, September 2018.
   - Options Assessment for the City of Grand Junction Water Supply, Burns & McDonnell, July 2020.

   The study by Black & Veatch recommended upsizing the entire length of the Kannah Creek Flowline to 20-inches to achieve a maximum flow capacity of 9.7 mgd from Kannah Creek and 6.2 mgd from Juniata Reservoir. The study by Burns & McDonnell suggested that the selecting the 20-inch option would allow the City rely on the Kannah Creek Flowline as backup and redundancy. Pipeline hydraulics can be found in the Black and Veatch study.

e) Geotechnical investigation is forthcoming. It will be a minor part of the overall design cost since most of the land is open adjacent to existing pipe. The ground is known to be Badland and Killpack soil types that are high in stone and boulder content. Up to 6 test pits will be observed prior to final design (approximate every ½ mile along pipeline).

   The City has existing easements on private properties for the Kannah Creek Flowline with ROW 50 feet on either side of the existing pipeline (100' total width). Realignment of a portion of the pipeline to the north will require the following new easements with private property owners: Kristen Brewer (40 feet by 1,240 feet), Scenic Investments LLC (40 feet by 600 feet), and Amos Delfin Martinez and Dana Edwina Summers Revocable Living Trust (40 feet by 260 feet). The detailed cost estimate includes a ROW budget to purchase easements that are not already recorded.

4.3 Cost Estimate

Provide a detailed estimate for all capital costs of project implementation such as planning and permitting activities, engineering design, construction inspection, administrative and legal costs, land and right-of-way acquisition, relocation costs, construction costs, financing costs and an appropriate contingency factor. Detailed construction cost estimates should include a tabulation of quantities, unit costs and total costs. Allowance should be made for cost escalation expected between the date of the construction cost estimate and the award of the construction contract. For large projects with multi-year construction schedules, cost escalation during construction should also be estimated.

A cost estimate for capital project implementation for the selected alternative is presented in **Table 3**. As detailed below, the total estimate is $3,500,000. The City has been awarded a grant of $300,000 from the U.S. Bureau of Reclamation for a portion of the project. Therefore, we are requesting a CWCB Water Loan of **$3,200,000**.

Table 3. Alternative 2 Detailed Cost Estimate

Cost Estimate Item	Quantity	Unit	Unit Price $	Amount $
Mobilization	1	LS	$100,000	$100,000
Traffic Control	1	LS	$25,000	$25,000
Erosion Control	1	LS	$30,000	$30,000
20-inch PVC	15,300	LF	$150.00	$2,295,000
Slope stability	84	CY	$125.00	$10,500
Remove/replace gravel drives	574	CY	$35.00	$20,090
Asphalt t-patch	410	SF	$15.00	$6,150
Subtotal				$2,486,740
General Conditions	8%	Of above		$198,939
OHP	10%	Of Above		$248,674
Subtotal				$2,934,353
Contingency	1	LS	$340,000	$293,435
Construction Quality Assurance	1	LS	$20,000	$20,000
Engineering/Survey/Environmental	1	LS	$195,300	$195,300
Easements	1	LS	$50,000	$50,000
Total				**$3,493,089**

4.4 Implementation Schedule

Provide a project implementation schedule showing the beginning and completion dates for all activities required for project implementation such as planning studies, permits, design, contracts, land and right-of-way acquisition, financing, and construction.

The following is a project implementation schedule for the Kannah Creek Flow Line Replacement Project:

Project Activity	Start Date	Completion Date
Preliminary Design	January 2022	April 2022
Environmental/Cultural Study	March 2022	July 2022
Geotechnical Investigation	March 2022	May 2022
Survey	March 2022	April 2022
Final Design	April 2022	June 2022
Permitting	April 2022	May 2022
Easements	March 2022	July 2022
Bidding	July 2022	August 2022
Construction	September 2022	January 2023

4.5 Impacts

Provide plans for addressing impacts identified in Section 4.1.c. Also include consideration of the impact of the proposed project on local and/or regional plans for water resource development, land use, recreation, water quality management, economic development, and other social and environmental effects.

The replacement of aging transmission pipe has important several important impacts. It reduces the risk of pipe failures. This ensures more reliable and resilient delivery of water to customers, increase safety to City Staff, reduces annual maintenance and repair cost, reduces loss of water due to undetected leaks and breaks, which can cause erosion and degrade sensitive desert landscape and potentially increase sediment and air entrainment to the City of Grand Junction Water Treatment Plant.

An Inventory of Endangered or Threatened Species, Cultural and Paleontological Resources will be performed as part of the SF299 Permit Application (see Section 4.6). Any species or resource noted in the project area will be appropriately protected using methods including, but not limited to adjusting construction schedule, fencing protected sites, moving protected species, reconfiguring pipe alignment as identified in the corresponding Treatment Plans. Any fenced areas will be shown on the final Construction Plans.

4.6 Institutional Feasibility

Address institutional considerations such as actions or proceedings that must be undertaken to obtain compliance from governmental agencies, or other parties involved in design, construction and financing, to allow project implementation. They include permits, court actions, contracts, agreements, other agency approvals, etc. Coordination on the project may be required with other Department of Natural Resources Departments such as Division of Wildlife and Division of Parks.

The U.S. Corps of Engineers 404 (Dredge and Fill) Permit is generally the key approval for water diversion and storage projects. The 404 permit may trigger the U.S. Environmental Protection Agency - National Environmental Policy Act (NEPA) process, which can require an Environmental Impact Statement (EIS) or an Environmental Assessment (EA) for smaller projects.

Other typical federal, state, and local permits that could be encountered are:
- U.S. Forest Service – special use permit
- U.S. Fish and Wildlife – endangered species consultation
- U.S. Bureau of Reclamation – right-of-way/permit, lease, license agreement, easement, carriage contract,

etc.
- State Division of Water Resources – well permits, engineering plan approval
- State Water Quality Control Division – water quality
- County Commissioner approval - conditional or special use, HB 1041 activities of "state interest"

The Bureau of Land Management requires the City to submit an Application for Transportation, Utility Systems, Telecommunication and Facilities on Federal Lands and Property (SF299). While this will include environmental studies and possibly a Cultural Resource Inventory, the permit will be expedited due to the pipeline being installed prior to the aforementioned 1976 Act.

The City will also submit a Pre-Construction Notification (PCN) application to United States Army Corps of Engineers (USACE) to seek approval for the Wetlands – 404 permit with regard to the ephemeral washes and Kannah Creek that the pipeline crosses in these reaches.

5.0 Financial Feasibility Analysis

This section documents the financial feasibility of the selected alternative. It provides a detailed financial program to describe financing arrangements and the sources and uses of funds for the proposed project. It provides an analysis of the project sponsor's ability to repay all existing and projected debt service, as well as normal operating expenses. This section includes:

1. Loan Amount - Discuss total project costs, the amount of CWCB loan requested, and the term and interest rate sought.

2. Financing Sources – Identify sources of funding for the project, including how the local share will be provided. Describe each method of financing to be utilized, such as CWCB loan, loans from other agencies, bonds, etc.

3. Revenue and Expenditure Projections – Include a detailed schedule of estimated annual revenues and annual expenditures for the entire period of debt retirement. Annual revenues should be estimated and displayed for each source of funds (assessments, water sales, property taxes, etc.). Annual expenditures should be displayed for debt retirement payments to each category of debt, for operation and maintenance costs, and for payments to reserve funds. For CWCB loans, borrowers are required to accumulate the equivalent of one annual loan payment in a loan reserve fund, over the first 10 years of loan repayment. (i.e. place in reserve 10% of the annual loan payment for each of the first 10 years of the loan.) An example of a schedule of annual revenues and expenditures is provided herein, and an electronic version and an example of how to use it, are included in the CWCB website at www.cwcb.state.co.us.

4. Loan Repayment Sources - Describe sources of funds for loan repayment, such as assessments, water sales, property taxes and grants. Discuss current water rates/ assessments/fees. Feasibility studies for projects with a hydropower component should include an assessment of the potential market for the hydropower.

5. Financial Impacts – Discuss financial impacts of the project on total debt, water rates, assessments of users, and property taxes. Determine future rates needed to cover CWCB loan obligations and additional operating costs. Discuss savings or new revenues generated.

6. TABOR (Taxpayer's Bill of Rights) Issues - Provide a full discussion of TABOR issues, particularly regarding the ability to incur multi-year debt, and limits on increased tax revenues and spending. An election may be required for public entities not havingSince the status of a qualified enterprise. The *provisions of TABOR are complex and may require an attorney and/or accountant opinion.*

7. Collateral - Discuss specifics of the loan collateral or security being offered by the borrower (in accordance with CWCB Policies) to assure repayment of the CWCB loan. The type of collateral will vary based on the type of organization, and typically may include a pledge of revenues/assessments, project facilities/water rights, or real property. If real property is offered as collateral, the applicant will be required to submit supporting documentation of land values, based on current land use and including improvements financed by the CWCB, from a Colorado Certified General Appraiser. If water rights are being purchased or offered as collateral, the applicant will be required to submit a written appraisal or opinion of value from a qualified water rights appraiser supporting the purchase price and value.

8. Sponsor Creditworthiness - Provide information to be used by staff to evaluate creditworthiness and financial need (in accordance with CWCB Policies) as follows:

a) Current schedule of rates or assessments.
b) Copies of the three most recent audit reports of financial statements.
c) A current credit report, if requested.

Loan Amount
The City of Grand Junction is requesting a loan in the amount of **$3,200,000** to cover estimated project costs. The City is requesting a 20-year term at the low-income interest rate of 1.35% resulting in annual payments of $183,642. To this would be added $18,364 (10% of the annual loan payment) per year for the first 10 years to fund the loan reserve account.

Financing Sources
The City is requesting $3,200,000 in funding from the CWCB Water Project Loan. The City has been awarded a grant of $300,000 from the U.S. Bureau of Reclamation for a portion of the project.

Revenue and Expenditures Projections
The **Table 4** presents a summary of revenue and expenditures projections for the loan period. Revenue projections are based upon the assumption that the City will increase water rates by 5% annually between 2022 and 2024, 3% between 2025 and 2029, and 2% thereafter. The projected 2022 beginning balance (reserve funds) for the City's Water Enterprise is $3.3 million.

Table 4 – Revenue and Expenditure Projections

	Revenue		Expenses									
Year	Annual Revenue	Other Revenue (Loan Proceeds)	Operating Expense	Capital Expense	Existing Debt Service	CWCB Loan Reserve Fund for Purdy Mesa	Payments on CWCB $7M Loan for Purdy Mesa	CWCB Loan Reserve Fund for Carson Dam	Payments on CWCB $3M Loan for Carson Dam	CWCB Loan Reserve Fund for Kannah Creek Flowline	Payments on CWCB Loan for $3.2M Kannah Creek Flowline	Total Expenditures
2022	$9,737,287	$10,200,000*	$6,231,139	$15,599,000	$633,636							$22,463,775
2023	$10,164,582	$3,000,000**	$6,401,357	$4,383,000	$385,812	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$12,173,521
2024	$10,613,243		$6,576,265	$3,371,190	$385,811.93	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$11,336,619
2025	$10,895,898	$2,500,000**	$6,755,991	$4,300,526	$385,811.93	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$12,445,681
2026	$11,187,034		$6,940,670	$1,816,041	$385,811.93	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$10,145,875
2027	$11,486,904		$7,130,440	$1,908,523	$385,811.93	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$10,428,127
2028	$11,795,769		$7,325,441	$1,852,278	$385,811.93	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$10,566,883
2029	$12,113,901		$7,525,819	$1,897,347	$ 385,811.93	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$10,812,330
2030	$12,332,352	$10,000,000**	$7,731,725	$11,893,767	$ 263,443.04	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$20,892,287
2031	$12,555,171		$7,943,310	$1,944,580	$ 141,073.97	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$11,032,316
2032	$12,782,447		$8,160,734	$1,996,918	$ 141,073.97	$41,175	$411,751	$31,674	$316,746	$18,364	$183,642	$11,302,078
2033	$13,014,268		$8,384,159	$2,750,825	$ 141,073.97		$411,751				$183,642	$11,871,451
2034	$13,250,726		$8,613,752	$2,106,350	$ 141,073.97		$411,751				$183,642	$11,456,569
2035	$13,491,913		$8,849,684	$2,163,540	$ 141,073.97		$411,751				$183,642	$11,749,691
2036	$13,737,924		$9,092,132	$2,222,447	$ 141,073.97		$411,751				$183,642	$12,051,046
2037	$13,988,855		$9,341,278	$2,283,120	$ 49,758.90		$411,751				$183,642	$12,269,550
2038	$14,244,804		$9,597,307	$2,345,614			$411,751				$183,642	$12,538,314
2039	$14,505,873		$9,860,412	$2,409,982			$411,751				$183,642	$12,865,787
2040	$14,705,590		$10,130,790	$2,476,281			$411,751				$183,642	$13,202,464
2041	$14,908,303		$10,408,643	$2,544,570			$411,751				$183,642	$13,548,606
2042	$15,114,057		$10,694,181	$2,614,907			$411,751				$183,642	$13,904,481

*Includes $7 million CWCB loan for Purdy Mesa Flowline Project and additional $3.2 million CWCB loan for Carson Lake Dam Rehabilitation Project.

**Future anticipated loans

Loan Repayment Sources
Sources of funds for loan repayment are water service charges.

Financial Impacts
This loan of $3.2 million will increase total debt service from $15 million to $18.2 million (inclusive of Carson and Purdy Mesa loans). The City anticipates increasing water rates by 5% annually between 2022 and 2025 and then by 2% thereafter to cover CWCB loan obligations.

TABOR
Since revenues are from Water sales and not from City taxes, there are no TABOR issues associated with this project.

Collateral
Collateral for this loan consists of a pledge of Water revenues.

Sponsor Creditworthiness
The following information is included to support the City of Grand Junction's creditworthiness:

a) Current schedule of Water Rates (**Appendix F**).
b) The City's most recent Comprehensive Annual Financial Reports can be found at: https://www.gjcity.org/380/Comprehensive-Annual-Financial-Report

6.0 Conclusions and Recommendation

Provide a summary of study conclusions, and an opinion and recommendation as to the overall feasibility of the project and the feasibility of loan repayment.

In conclusion, the City has determined that the Kannah Creek Flowline Replacement project is technically feasible and repayment of the $3.2 million loan is feasible for the City's Water Enterprise Fund to repay over the 20-year loan period. City staff are recommending application of this loan through the CWCB Water Loan Program.

Appendices

A Kannah Creek Flowline Hydraulic Evaluation, Black & Veatch, September 2018

B Water Supply Modeling Model Documentation and Firm Yield Determination Report, DiNatale Water Consultants, January 2019

C Water Supply Analysis, DiNatale Water Consultants, July 2019

D Options Assessment for the City of Grand Junction Water Supply, Burns & McDonnell, July 2020.

E Conceptual Design Plans for Kannah Creek Flowline

F Water Rates Resolution (2022)

FINAL

KANNAH CREEK FLOW LINE HYDRAULIC EVALUATION

Grand Junction, Colorado

B&V PROJECT NO. 197600

PREPARED FOR

City of Grand Junction

10 SEPTEMBER 2018

BLACK & VEATCH

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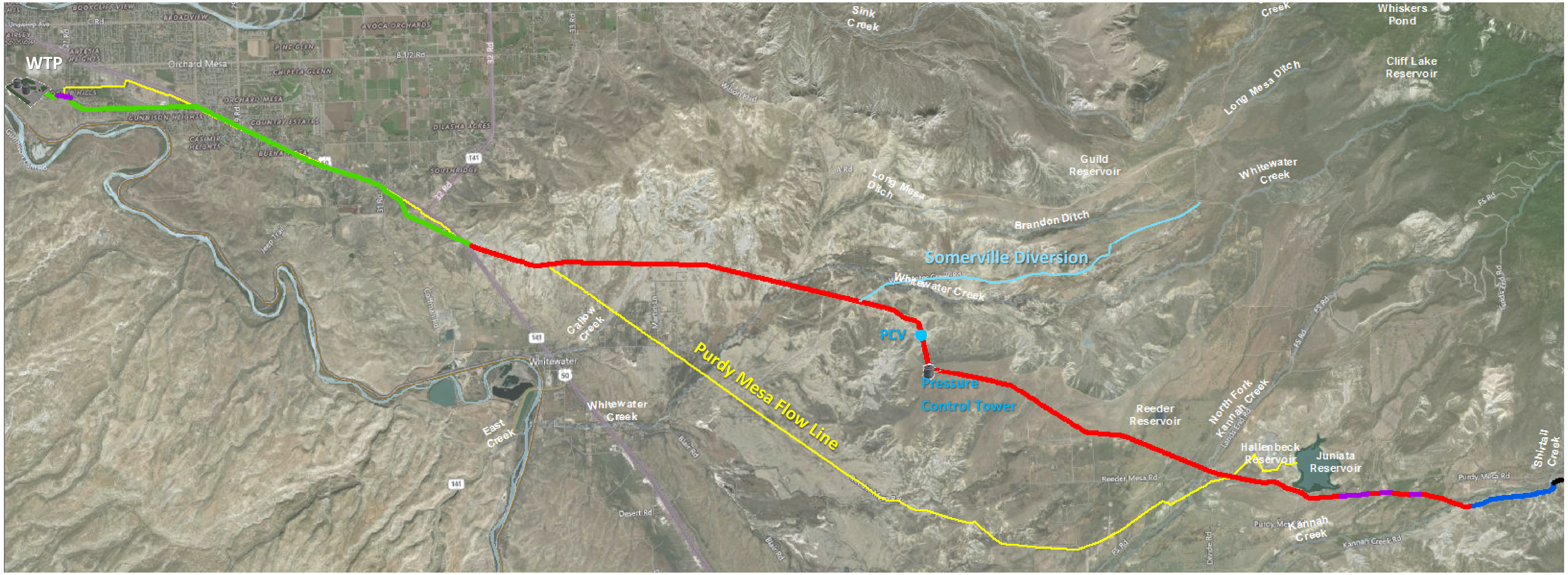
1 Introduction

The Kannah Creek Flow Line (KCFL) is a gravity transmission main of approximately 20 miles which currently conveys raw water from Kannah Creek to the Grand Junction Water Treatment Plant (WTP) in the City of Grand Junction, Colorado (City) as shown by the plan and profile in Figure 1. Currently, the KCFL provides additional capacity for carrying water to the Grand Junction WTP during the peak summer season. In the winter, the only parts of the KCFL that are used are to transfer water from Kannah Creek to Juniata Reservoir and from the Sommerville Diversion to the Grand Junction WTP. Although the KCFL has limited use during normal operating conditions, it provides critical redundancy to the Purdy Mesa Flow Line (PMFL), which is the primary raw water flow line serving Grand Junction WTP.

The KCFL consists of 12 miles of 18-inch cast iron pipe (CIP), and 5.6 miles of 20-inch steel pipe (shown in red and green, respectively), which are approaching the end of their useful life and may be in need of replacement. The KCFL also consists of an approximate total of 1 mile of newer 20-inch PVC pipe (in four segments) where replacement of the older pipes has occurred due to condition (shown in purple). There is also approximately 1 mile of newer 18-inch PVC beginning at the Kannah Creek which continues about halfway to the Juniata Reservoir Inlet (shown in blue). Figure 1 also shows the alignment of the PMFL, in yellow, which conveys raw water from Hallenbeck Reservoir to the Grand Junction WTP. Due to the age and condition of much of the KCFL, the City is considering replacement of much of the KCFL. The City currently limits flows through the pipeline to about 4 mgd, to minimize stress on the KCFL. This is less than the 7.81 cubic feet per second (cfs), or 5 million gallons per day (mgd), of paramount water rights from Kannah Creek that is generally available to the City between April and November. Winter water rights from the Kannah Creek are 3.91 cfs (2.5 mgd) if it is available. The City rarely uses water from Kannah Creek through the KCFL to the Grand Junction WTP during the winter; it is usually sent directly to the Juniata Reservoir and stored or brought to the Grand Junction WTP via the PMFL. The Somerville Diversion (shown as the cyan pipes in Figure 1) can convey a winter water right that comes from the Brandon Ditch of about 1mgd to 2 mgd to the Grand Junction WTP via the lower portion of the KCFL, but because of the difference in water needs and availability, water is not simultaneously taken from the Somerville Diversion and from Kannah Creek.

The evaluations performed for this task and documented in this memo provide an assessment of the existing capacity of the KCFL, evaluations for a staged replacement, and the future anticipated capacity through the replacement program and upon finalization of the complete replacement of the aging portions of the KCFL.



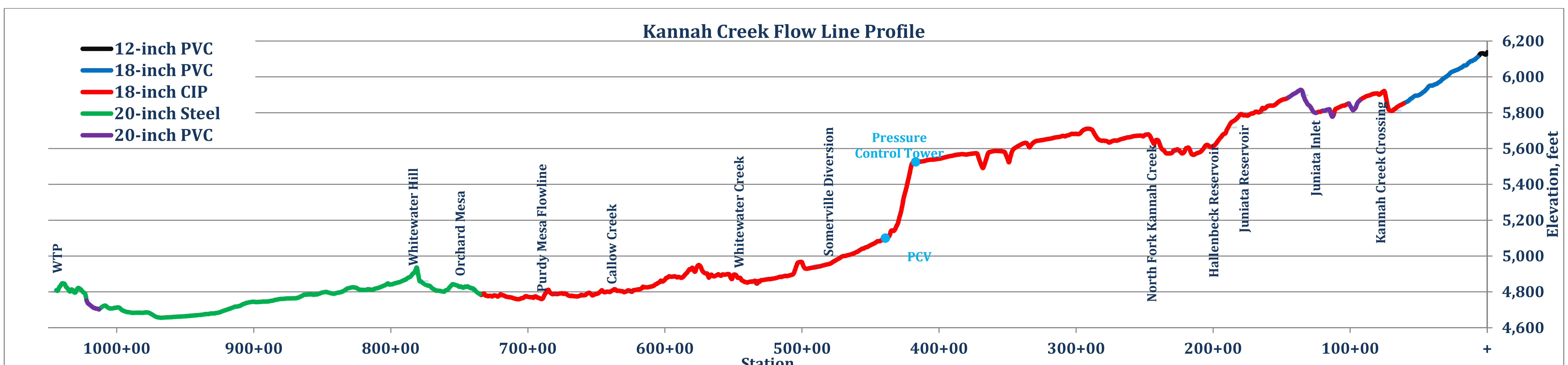


Figure 1 Kannah Creek Flow Line – Plan and Profile

2 Model Development

The initial intention was to construct a hydraulic model of the KCFL in the Bentley WaterGEMS hydraulic modeling software. As the hydraulic characteristics of the KCFL were evaluated, it was determined that a hydraulic computer model in this software would not yield usable results because the flow moves through ranges of open channel flow and pressurized flow. The WaterGEMS software is incapable of simulating accurate results with conditions where open channel flow occurs. Rather than develop a model in WaterGEMS, it was determined to build a GIS geospatial model and use this information to develop a spreadsheet model which could approximate the hydraulic grade line (HGL) and pressures that would be experienced under various flow conditions through the KCFL.

The City provided the following data sources to Black & Veatch which were used to compile the data and develop the spreadsheet model.

1. *1972 Modifications to Kannah Creek Flow Line* as-built drawings for providing the Pressure Control Tower (PCT) and Pressure Control Valve (PCV) section of the pipeline (Station 600+12 to Station 324+56)
2. *Kannah Creek Flow Line Plan & Profile (HDR), 1972* drawing
3. *Kannah Creek Flow Line Replacement, 1974* as-built drawing (only shows Somerville Diversion pipeline).
4. *Kannah Creek Flow Line Replacement December, 2001* as-built drawings
5. *2014 Water Line Replacement* as-built drawings
6. Air valve location drawings
7. GIS layer files of the pipelines

Note that there were discrepancies between the GIS data and the as-built drawings. The as-built drawing from the 1972 Modification to Kannah Creek Flow Line, item 1 in the above list, show a 450-foot section of 16-inch steel pipe between the PCV and PCT: The City's GIS shows this as an 18-inch CIP. Additionally, the Kannah Creek Flow Line Plan and Profile drawing, done in 1972, shows many sections of the 18-inch CIP shown in Figure 1 to be of various sizes and materials from CIP to steel and 20-inch to 14-inch. Data from GIS was used in the spreadsheet model and a conservative C-factor of 90 was used to account for these differences. Because these sections are already candidates for replacement, it is not a high priority for the City to identify the exact inventory that is in the ground along this 18-inch CIP shown in the GIS.

Table 1 displays a summary of the KCFL pipelines segments based on information provided by the City. This information was used to build the spreadsheet model. Because observed flow data and pressures are not available along the pipeline, the estimates for the C-factors cannot be validated through a calibration process.

Table 1 Kannah Creek Flow Line Pipe Summary

PIPE SIZE	MATERIAL	C-FACTOR	LENGTH	INSTALLATION OR REHAB YEAR (1)	DESCRIPTION
12-inch	PVC	130	500 feet 0.1 miles	Unknown	Directly at Kannah Creek
18-inch	PVC	130	5,600 feet 1.1 miles	Unknown	From intake of Kannah Creek mid-way to just east of the Kannah Creek crossing.
18-inch (1)	CIP	90	63,800 feet 12.1 miles	Unknown	From just east of the Kannah Creek crossing to the US Hwy 50
20-inch	Steel	124	30,000 feet 5.7 miles	1940	US Hwy 50 to the WTP
20-inch	PVC	130	900 feet 0.2 miles	Unknown	Small section just east of the WTP
20-inch	PVC	130	3,600 feet 0.7 miles	2014	Three sections of replacement of the 18-inch CIP at and just east of the Juniata Reservoir inlet.

(1) As-built drawings did not list the installation year for the pipeline sections.

(2) A C-factor of 90 was selected to account for the unknowns/source data deviations in the diameter and material in this section.

3 Existing Pipeline Hydraulic Analyses

The spreadsheet model of the KCFL was used to analyze the pipeline during different flow conditions and to determine the existing capacity.

3.1 PRESSURE CONTROL TOWER

The PCT at the location shown in Figure 1 is located at a high point before a steep drop in elevation along the KCFL. The likely intent for this structure was to attempt to control the flows and pressures through the steep drop in elevation. The spreadsheet model shows that the PCT does not provide control to the KCFL during any of the flow rates evaluated because of the open channel flow conditions that occur. Without pressurization of the pipeline at this location, water flows by gravity through the PCT and does not control the HGL as intended by the design. Anecdotal information from the City indicates that the PCT does not provide any control; although it is in use, it is just a passthrough facility.

3.2 PRESSURE CONTROL VALVE

Like the PCT, the PCV was likely intended to provide some control of the hydraulic conditions along the KCFL due to the sharp drop in elevation through this section of pipe. Evaluations using the spreadsheet model indicate that PCV does not provide functional control through the KCFL. City staff confirmed that the PCV is not used in the operation of the KCFL and is fully open.

3.3 CURRENT HYDRAULIC CAPACITY

Determination of the current hydraulic capacity is complicated because the capacity is based on the desire to minimize pressures to prevent pipe breaks rather than hydraulic restrictions in the pipe due to operating criteria. If pressure constraints were disregarded, the capacity of the pipeline would be approximately 8 mgd depending on the C-factors of the pipes. However, this would result in pressures of nearly 220 psi in some sections of the KCFL.

Two major factors, pipeline pressures and air entrainment, have been identified as concerns related to the hydraulic capacity of the existing flowline. Two evaluations were performed with the existing system to understand the HGL profile at flows less than 4 mgd and a second set of evaluations to determine at flows of over 4 mgd, what the pressures would be in the pipeline.

Air Entrainment:

Potential for air entrainment in the pipeline, which can lead to a variety of negative consequences including cloudy water and premature pipe wear is a concern for the KCFL. The impact of air entrainment is less noticeable in the KCFL compared to the PMFL because the PMFL generally flows directly into the Grand Junction WTP headworks where air entrainment can cause air binding in the filters. The flow through the KCFL generally discharges into the detention reservoir at the Grand Junction WTP allowing time for the entrained air to be released. City staff noted that air entrainment is generally seen at flows above 4.2 mgd. The following section notes the locations where water transitions between pressurized flow and open channel flow (*flow transition*), and these locations are candidate locations for areas where air entrainment is occurring along the pipeline.

Pipeline Pressures:

Because of the age of the pipe there is concern that high pressures would lead to pipe breaks. Pipeline breaks have led to replacement of certain sections of the 18-inch CIP near the Juniata inlet as shown in Figure 1. Until the City replaces or rehabilitates sections of the pipeline subject to high pressures, the HGL and corresponding pressures at certain flow rates is important to understand.

3.3.1 Low-Flow (4 mgd and Less) Hydraulic Profiles

The spreadsheet model was used to evaluate the HGL and pressure profile at flows less than 4 mgd, which is the City's typical operating range for the KCFL. Flow conditions for 1 mgd, 2 mgd, 3 mgd, and 4 mgd were selected to evaluate these conditions. Both the propensity for air entrainment and high pressures were evaluated through the spreadsheet model. Figure 2 and Figure 3 present the HGL and pressure profiles respectively which illustrate the conditions in the pipeline during low flows of 4 mgd or less.

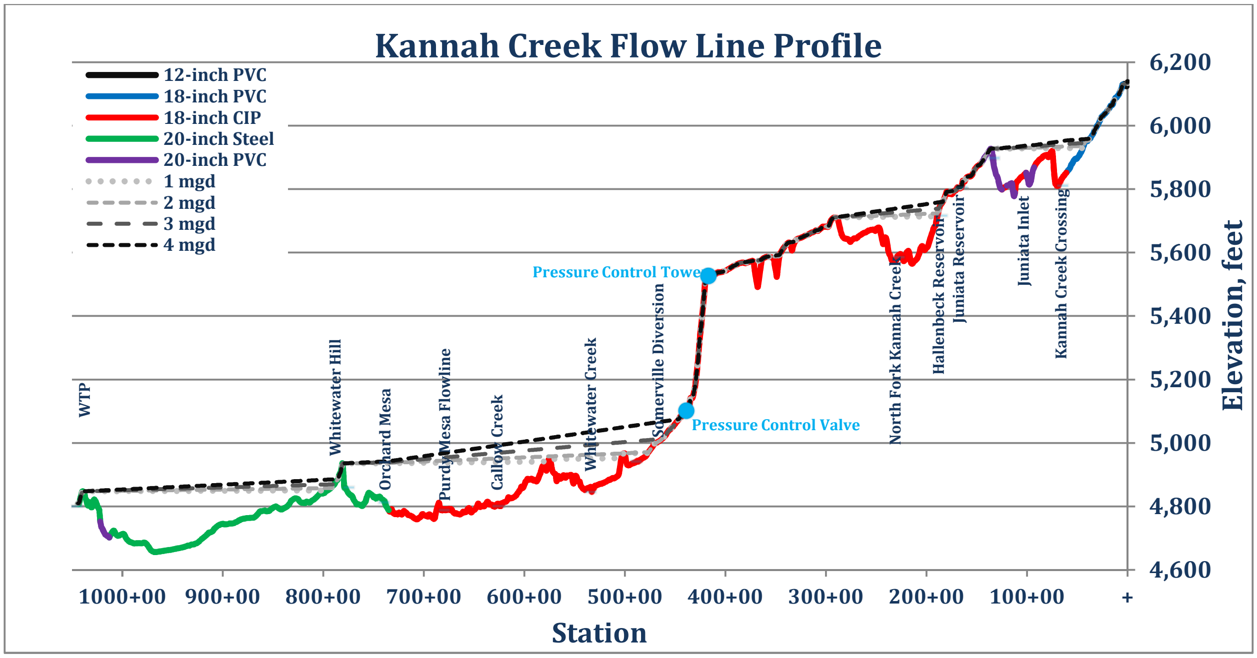


Figure 2 Existing Kannah Creek Flow Line HGL Profile (Low-Flow)

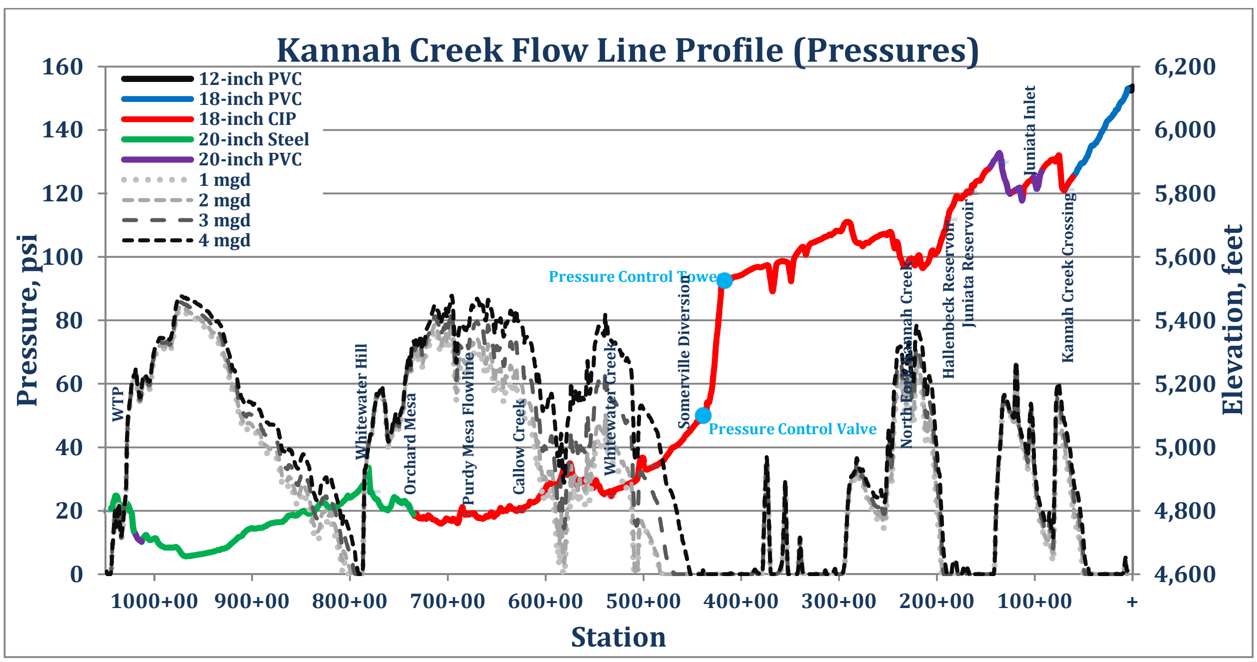


Figure 3 Existing Kannah Creek Flow Line Pressure Profile (Low-Flow)

From the spreadsheet model and the figures, pipeline velocities, maximum pressures and locations, and flow transition locations are documented in Table 2.

Table 2 Summary of Existing KCFL Conditions (Low-Flow)

FLOW CONDITION	PIPELINE VELOCITIES	MAXIMUM PRESSURE AND LOCATIONS	FLOW TRANSITION LOCATIONS (OPEN CHANNEL/CLOSED CONDUIT)
1.0 mgd	18-inch: 0.9 feet per second (fps) 20-inch: 0.7 fps	~83 psi in 20-inch steel pipe ~77 psi in 18-inch CIP near PMFL crossover ~65 psi in 18-inch CIP near North Fork Hannah Creek Crossing	1) Just east of WTP 2) 1,000 ft. west of Whitewater Hill 3) 5,000 ft. east of Callow Creek 4) 3,000 ft. east of Whitewater Creek 5) 1,500 ft. east of Somerville Diversion 6) 1,000 ft. east of Somerville Diversion 7) Both low points 5,000 ft. east of PCT 8) High point 6,000 ft. west of North Fork Hannah Creek Crossing 9) At Hallenbeck Reservoir 10) High point 1,500 feet west of Juniata Reservoir intake 11) 3,000 ft. west of Kannah Creek Crossing
2.0 mgd	18-inch: 1.8 fps 20-inch: 1.4 fps	~84 psi in 20-inch steel pipe ~79 psi in 18-inch CIP near PMFL crossover ~67 psi in 18-inch CIP near North Fork Hannah Creek Crossing	Same number and approximately the same locations as the 1.0 mgd scenario
3.0 mgd	18-inch: 2.6 fps 20-inch: 2.1 fps	~86 psi in 20-inch steel pipe ~83 psi in 18-inch CIP near PMFL crossover ~72 psi in 18-inch CIP near North Fork Hannah Creek Crossing	1) Just east of WTP 2) 800 ft. west of Whitewater Hill 3) Right at Somerville Diversion 4) Both low points 5,000 ft. east of PCT 5) High point 6,000 ft. west of North Fork Hannah Creek Crossing 6) At Hallenbeck Reservoir 7) High point 1,500 feet west of Juniata Reservoir intake 8) 3,000 ft. east of Kannah Creek Crossing
4.0 mgd	18-inch: 3.5 fps 20-inch: 2.7 fps	~88 psi in 20-inch steel pipe ~88 psi in 18-inch CIP near PMFL crossover ~82 psi in 18-inch CIP near North Fork Hannah Creek Crossing	Same number and approximately the same locations as the 3.0 mgd scenario

As can be seen from Figures 2 and 3 and Table 2, the flow regimes are similar for low-flow conditions, of 4 mgd and less. Pressures in all locations at 4 mgd or less are less than 90 psi. The major difference in low flows occurs with the number and locations of flow transitions. Flows of 3 mgd and 4 mgd experience less flow transitions, in particular the area around the Sommerville Diversion is completely pressurized.

3.3.2 High-Flow (Over 4 mgd) Hydraulic Profiles

The spreadsheet model was also used to evaluate the HGL and pressure profile at flows greater than 4 mgd. Flow conditions above 4.0 mgd for these evaluations were selected based on flows that would maintain pressure limits for a maximum pressure in the pipeline of 90 psi, 100 psi, 110 psi, and 120 psi. Figure 4 and Figure 5 present the HGL and pressure profiles, respectively, which illustrate the conditions in the pipeline at flows greater than 4 mgd.

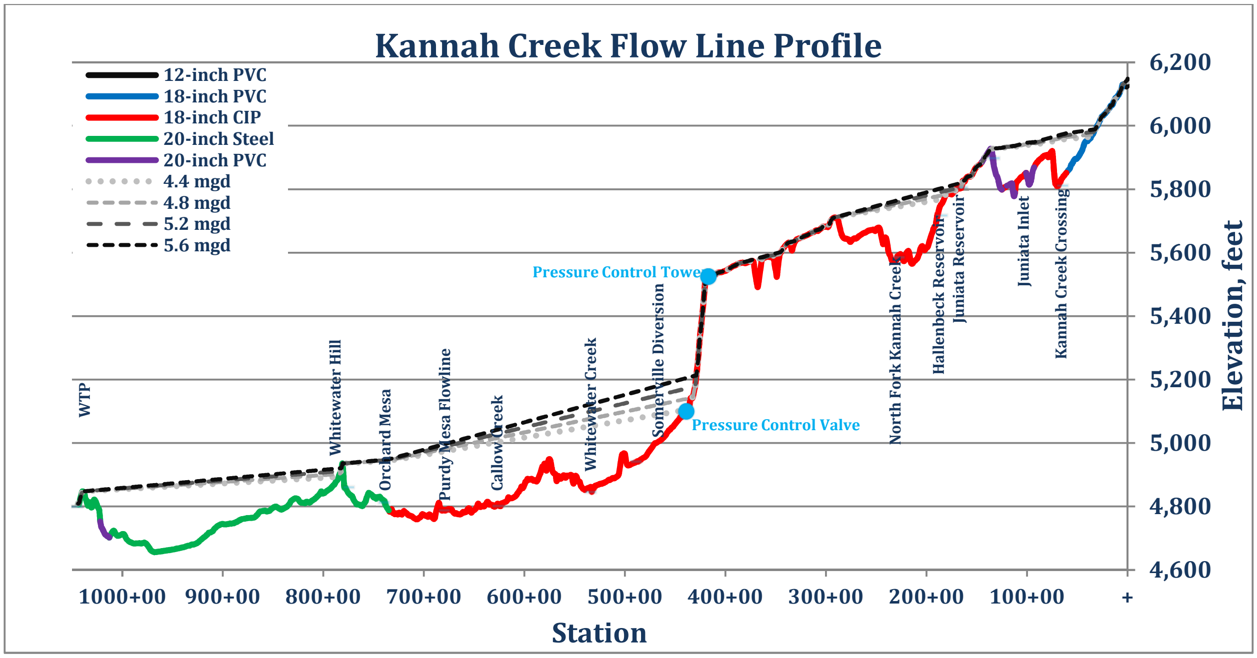


Figure 4 Existing Kannah Creek Flow Line HGL Profile (High-Flow)

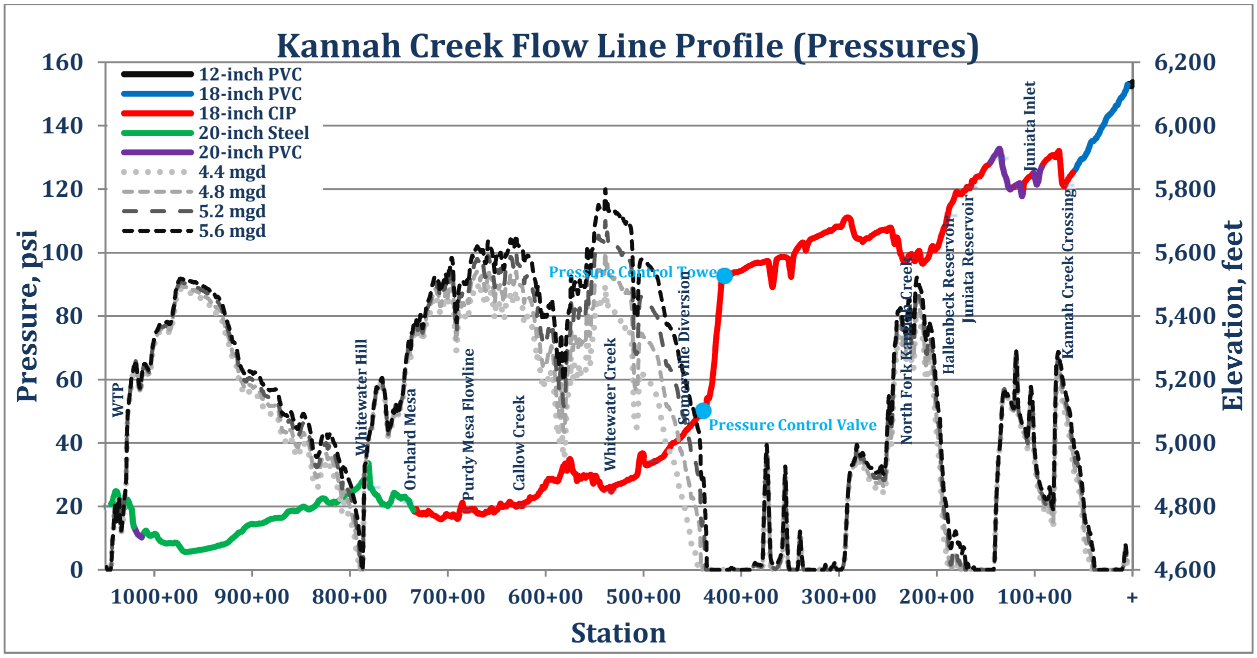


Figure 5 Existing Kannah Creek Flow Line Pressure Profile (High-Flow)

Table 3 Summary of Existing Flow Line Conditions (High-Flow)

FLOW CONDITION	PIPELINE VELOCITIES	MAXIMUM PRESSURE AND LOCATIONS	FLOW TRANSITION LOCATIONS OPEN CHANNEL/CLOSED CONDUIT)
4.4 mgd	18-inch: 3.8 fps 20-inch: 3.1 fps	~88 psi in 20-inch steel pipe ~90 psi in 18-inch CIP near PMFL crossover ~81 psi in 18-inch CIP near North Fork Hannah Creek Crossing	1) Just east of WTP 2) At Whitewater Hill 3) Just east of the PCV 4) Both low points 5,000 ft. east of PCT 5) High point 6,000 ft. west of North Fork Hannah Creek Crossing 6) Between Hallenbeck Reservoir and Juniata Reservoir 7) High point 1,500 feet west of Juniata Reservoir intake 8) 3,000 ft. east of Kannah Creek Crossing
4.8 mgd	18-inch: 4.2 fps 20-inch: 3.4 fps	~90 psi in 20-inch steel pipe ~100 psi in 18-inch CIP near PMFL crossover ~85 psi in 18-inch CIP near North Fork Hannah Creek Crossing	Same number and approximately the same locations as the 4.4 mgd scenario
5.2 mgd	18-inch: 4.6 fps 20-inch: 3.7 fps	~91 psi in 20-inch steel pipe ~110 psi in 18-inch CIP near PMFL crossover ~89 psi in 18-inch CIP near North Fork Hannah Creek Crossing	Same number and approximately the same locations as the 4.4 mgd scenario

FLOW CONDITION	PIPELINE VELOCITIES	MAXIMUM PRESSURE AND LOCATIONS	FLOW TRANSITION LOCATIONS OPEN CHANNEL/CLOSED CONDUIT)
5.6 mgd	18-inch: 4.9 fps 20-inch: 4.0 fps	~92 psi in 20-inch steel pipe ~120 psi in 18-inch CIP near PMFL crossover ~92 psi in 18-inch CIP near North Fork Hannah Creek Crossing	Same number and approximately the same locations as the 4.4 mgd scenario

A review of the results presented in Figures 4 and 5 and Table 3, shows that minor flow increases produce a large increase in maximum pressures at flows of over 4 mgd. The flow transition locations, however, are unaffected from those that are experienced at lower flows of 3 mgd or 4 mgd.

Review of the existing spreadsheet model does not provide any explanation as to why at flows of approximately 4.2 mgd or more, cloudy water is seen leaving the KCFL at the Grand Junction WTP as observed by City Staff. The cause of this cloudy water is attributed to air entrainment. Additional field testing and observations would be required to identify the cause of the air entrainment. Since the identification of the flow transition locations did not provide insight into the air entrainment issue, the locations of flow transitions for the replacement evaluations will not be identified.

4 Replacement Evaluations

Evaluations were performed using the spreadsheet model to determine the impact of replacement of certain sections of the KCFL and the phasing of the replacement projects. Iterative evaluations were performed to determine the impact of replacing certain sections of the pipeline, the sizes of the replacements, and the phasing of these replacements. Pipeline diameters used in the evaluation are interior pipe diameter. The first three replacement evaluations reviewed the impact of replacing the entire 18-inch CIP and 20-inch steel pipes in the system with a consistent diameter. Each scenario represents a different diameter; and the evaluation summarizes the ability of that diameter to meet flow, pressure, and velocity impacts of using that diameter.

For the Purdy Mesa Flowline, efforts were made to evaluate alternatives that would achieve pressurized flow through the length of the flow line. There are three primary reason that the evaluations for the KCFL do not incorporate these same pressurized flow assessments.

1. The KCFL does not flow directly into the WTP headworks and there is the ability to settle out some of the cloudy water due to air entrainment in detention.
2. The KCFL is a supplemental supply line and is used less frequently than the PMFL and conveys less supply.
3. The PMFL had two control valves downstream of its Pressure Control Tower that could be used to provide fully pressurized flow and the KCFL only has one control valve.

All the replacement alternatives evaluated assumed that additional supply above the current water rights of 7.81 cubic feet per second (cfs), or 5 million gallons per day (mgd), are being supplied from Kannah Creek. A final section in these evaluations show the maximum capacities of each replacement alternative should any supply above the current water rights of Kannah Creek be supplemented from the Juniata Reservoir instead and a replacement alternative that would improve the hydraulic capacity if water is supplemented from the Juniata Reservoir. The reason that the KCFL capacity would be different is that the Kannah Creek is at a higher HGL than the Juniata Reservoir. The ultimate capacity in the pipeline, should supplemental flow need to come through a new intake from Juniata into the KCFL, needs to consider that the minimum water surface elevation of the Juniata Reservoir of approximately 5,740 feet is 360 feet lower than the Kannah Creek grade of approximately 6,100 feet.

For replacement pipes, a C-factor of 130 was used. The replacement evaluations used flow conditions of 2 mgd, 6 mgd, 8 mgd, and 9 mgd to show the characteristics through a wide spread of flow ranges.

4.1 18-INCH REPLACEMENT

Figure 6 and Figure 7 show the HGL and pressure profile through the KCFL at flow increments of 2 mgd, 6 mgd, 8 mgd, and 9 mgd assuming a replacement diameter of 18-inches. These figures show that at flows over 6 mgd or more, the pressures downstream of the PCV increase rapidly with maximum pressures at flow rates of 9 mgd exceeding 220 psi just downstream of the existing PCV location and other areas between Whitewater Creek and Whitewater Hill nearing 200 psi. Additionally, pipeline velocities would approach 8 fps at 9 mgd, which would present a considerable risk for possible transients and could lead to reduced pipe life and pipe breaks. Replacement using 18-inch diameter pipes is not recommended if there may be a future desire to convey flows of 6 mgd or more through the KCFL. Replacement of the entire KCFL with 18-inch PVC rated for 160 psi would provide a maximum hydraulic capacity of 7.4 mgd.

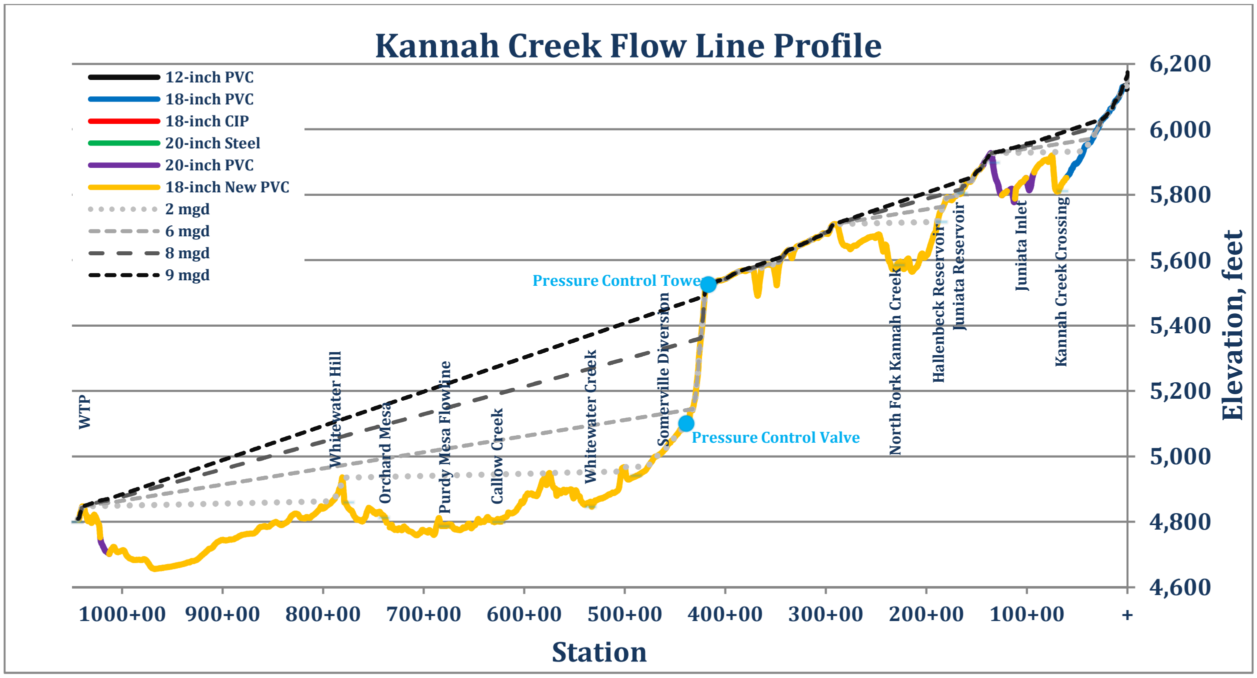


Figure 6 Kannah Creek Flow Line 18-inch Replacement HGL Profile

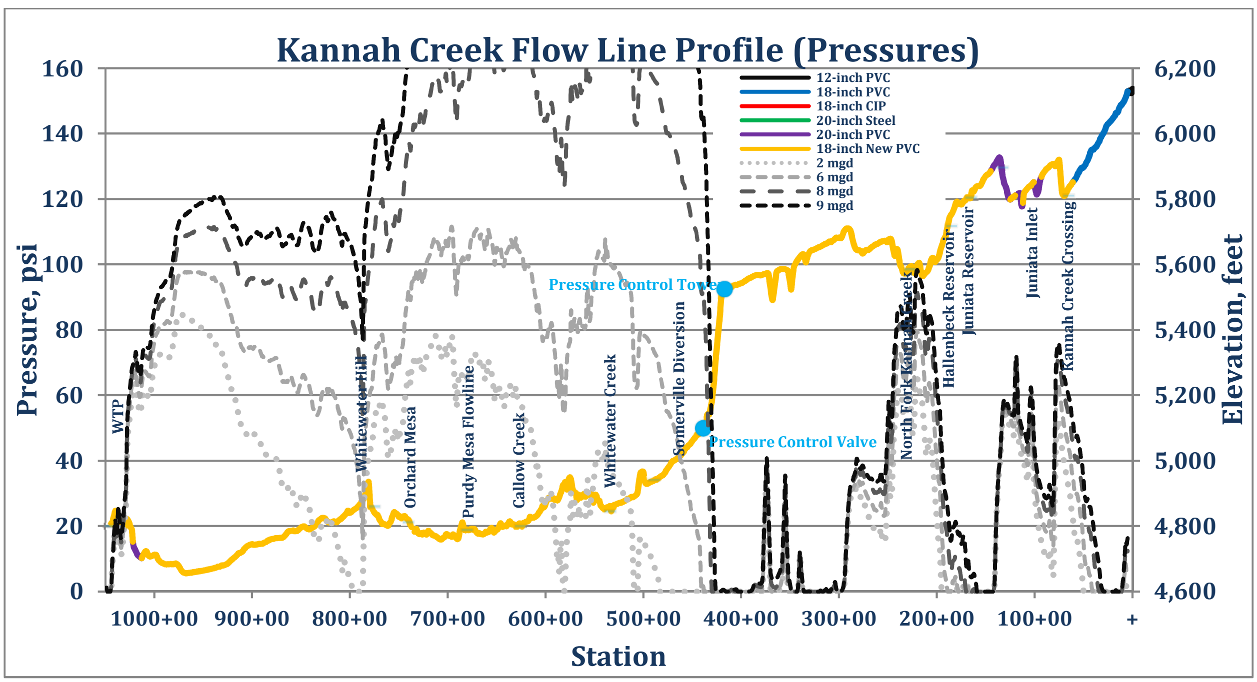


Figure 7 Kannah Creek Flow Line 18-inch Replacement Pressure Profile

4.2 20-INCH REPLACEMENT

Figure 8 and Figure 9 show the HGL and pressure profile through the KCFL at flow increments of 2 mgd, 6 mgd, 8 mgd, and 9 mgd assuming a replacement diameter of 20-inches. This size replacement provides more reasonable pressures at the higher flow rates with maximum pressures at rates of 9 mgd less than 140 psi. Velocities would also be maintained less than 6.5 fps at a flow rate of 9 mgd or less. Replacement of the entire KCFL with 20-inch PVC rated for 160 psi would provide a maximum hydraulic capacity of 9.7 mgd.

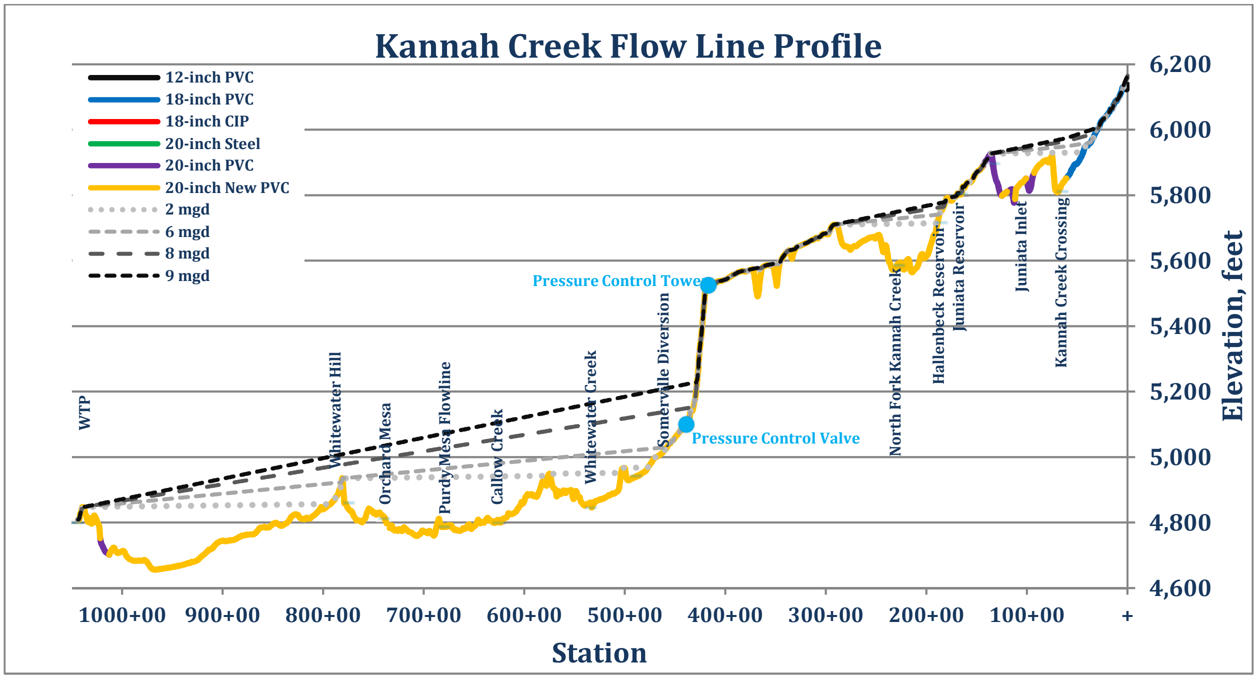


Figure 8 Kannah Creek Flow Line 20-inch Replacement HGL Profile

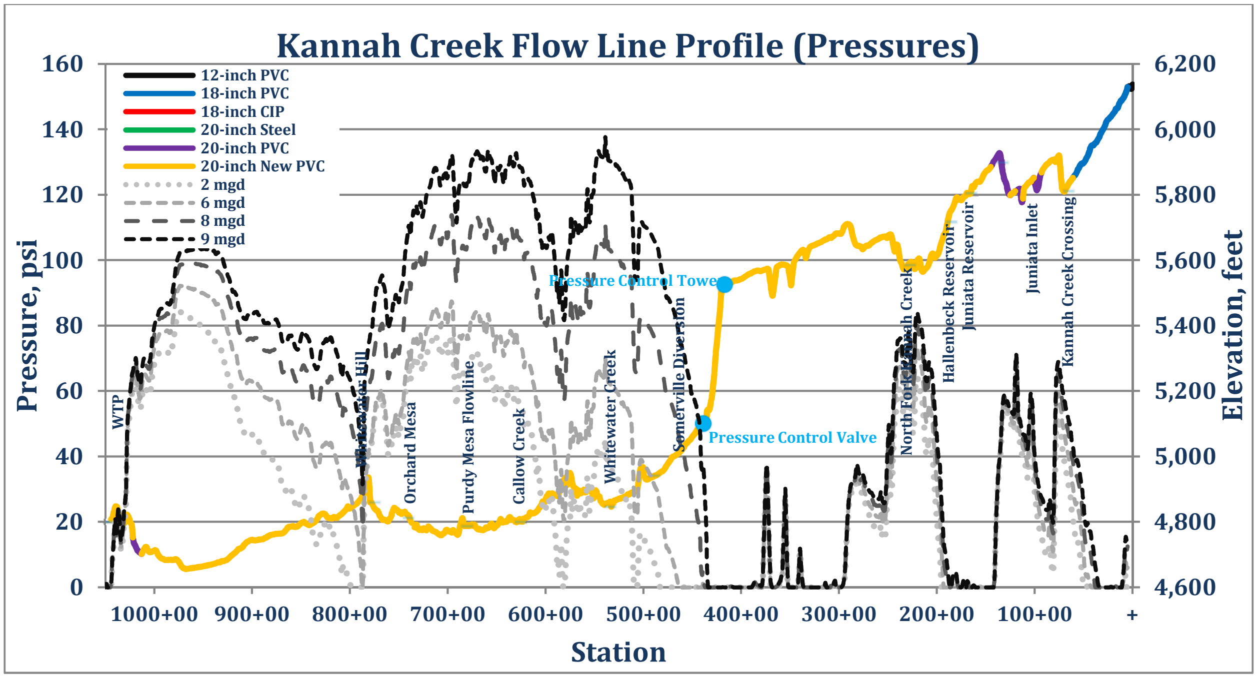


Figure 9 Kannah Creek Flow Line 20-inch Replacement Pressure Profile

4.3 24-INCH REPLACEMENT

Figure 10 and Figure 11 show the HGL and pressure profile through the KCFL at flow increments of 2 mgd, 5 mgd, 7 mgd, and 9 mgd assuming a replacement diameter of 24-inches. This pipeline size results in very little head loss through the KCFL and pressures less than 100 psi at flow rates of up to 9 mgd. Velocities would be less than 4.5 fps at a flow rate of 9 mgd through the KCFL. Replacement of the entire KCFL with 24-inch PVC rated for 160 psi would provide a maximum hydraulic capacity of 15.7 mgd.

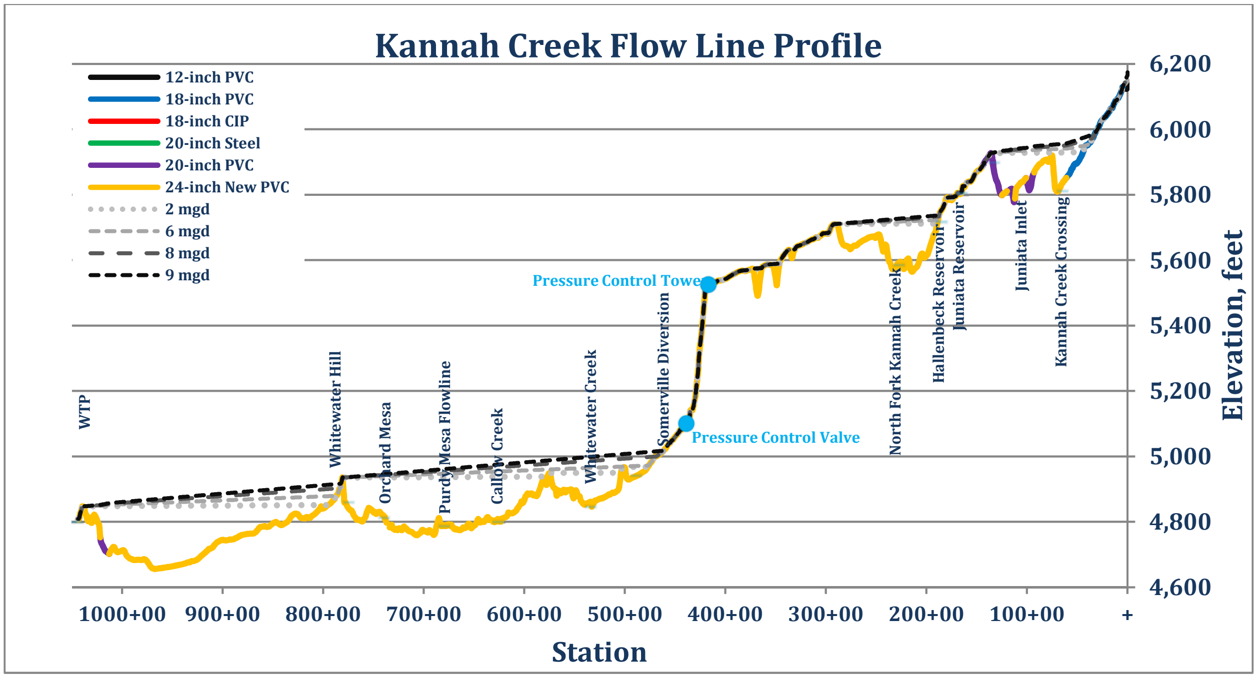


Figure 10 Kannah Creek Flow Line 24-inch Replacement HGL Profile

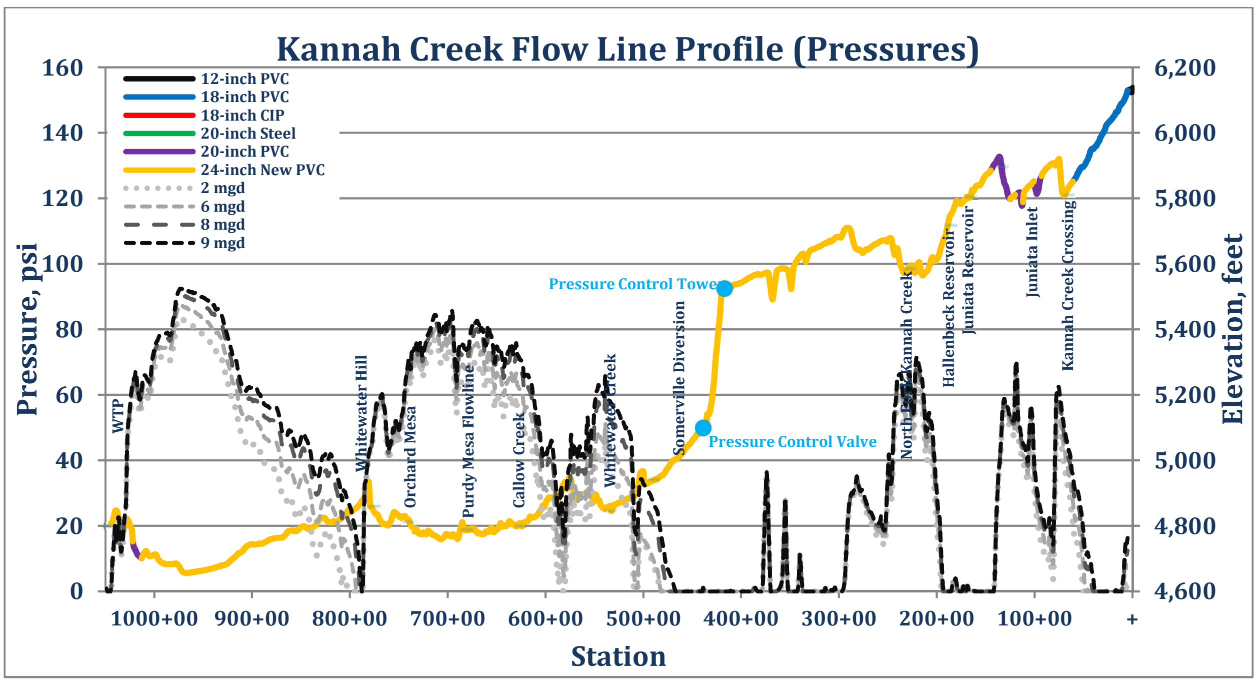


Figure 11 Kannah Creek Flow Line 24-inch Replacement Pressure Profile

4.4 PHASING OF REPLACEMENTS

Three additional evaluations of the HGL and pressure profiles were performed using the spreadsheet model to assist in determination of the phasing of replacement. The diameter of the replacements used in these evaluations was a 20-inch with a C-factor of 130. Similar to the preceding section the 20-inch diameter is an interior pipeline measurement. In the figures this pipeline is assumed to be PVC, although other pipe types would be acceptable.

4.4.1 Replacement of 18-inch Between the PCV and the 20-inch Steel Pipe

From Figure 3 and the evaluations performed in the previous section, the pipeline that experiences the highest pressures and flow constraint is the 18-inch CIP pipe from the PCV to the 20-inch steel pipe around Orchard Mesa. This area is the highest priority for replacement. Although, rehabilitation may be possible, it would further reduce the capacity of the line and limit the usefulness of the KCFL to provide redundancy for the PMFL.

The replacement of this section of pipe with 20-inch pipe, 29,000 feet or 5.5 miles, was introduced into the spreadsheet model and the four flow conditions were re-evaluated based on the flows that would maintain maximum pressures of 90 psi, 100 psi, 110 psi, and 120 psi in the existing sections of the KCFL that have not yet been replaced. Figure 12 presents the HGL profile and Figure 13 presents the pressure profile for each of those flow conditions. Replacement of this portion of the line would increase the capacity to 7.7 mgd at a maximum pressure of less than 120 psi along the existing/unreplaced sections of the KCFL.

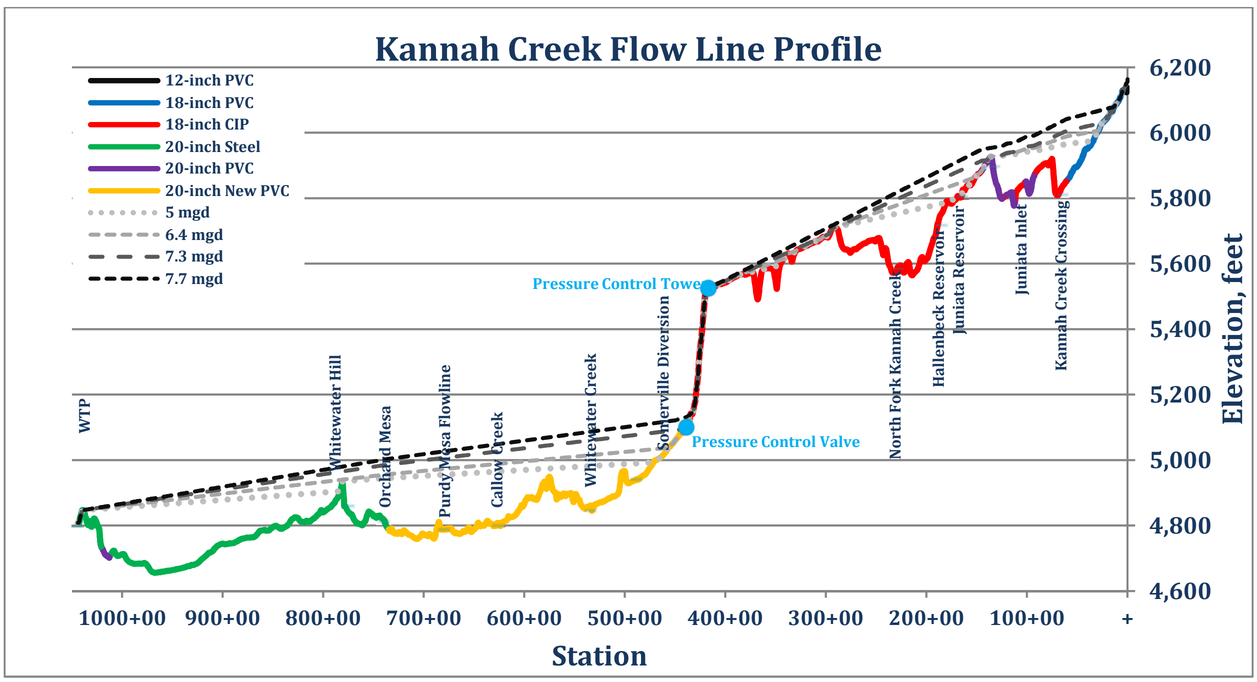


Figure 12 Kannah Creek Replacement Phasing Alternative 1 KCFL HGL Profile

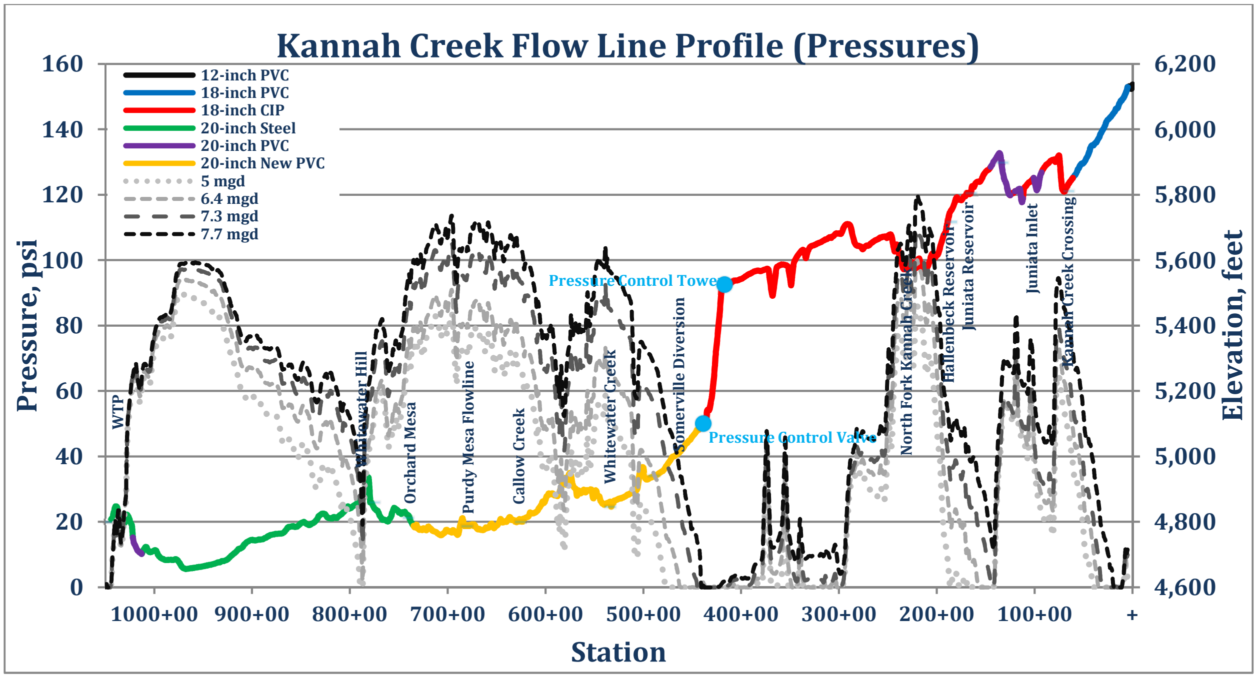


Figure 13 Kannah Creek Replacement Phasing Alternative 1 KCFL Pressure Profile

The characteristics for pressures and velocities in the Flow Line for these flow conditions are provided in Table 4.

Table 4 Kannah Creek Replacement Phasing Alternative 1 Flow Condition Summary

FLOW CONDITION	PIPELINE VELOCITIES	MAXIMUM PRESSURE AND LOCATIONS
5.0 mgd	18-inch: 4.4 fps 20-inch: 3.5 fps	~90 psi in 20-inch steel pipe ~84 psi in replacement 20-inch PVC near PMFL crossover ~86 psi in 18-inch CIP near North Fork Hannah Creek Crossing
6.4 mgd	18-inch: 5.6 fps 20-inch: 4.5fps	~94 psi in 20-inch steel pipe ~91 psi in replacement 20-inch PVC near PMFL crossover ~100 psi in 18-inch CIP near North Fork Hannah Creek Crossing
7.3 mgd	18-inch: 6.4 fps 20-inch: 5.2 fps	~97 psi in 20-inch steel pipe ~105 psi in replacement 20-inch PVC near PMFL crossover ~110 psi in 18-inch CIP near North Fork Hannah Creek Crossing
7.7 mgd	18-inch: 6.7 fps 20-inch: 5.5 fps	~99 psi in 20-inch steel pipe ~114 psi in replacement 20-inch PVC near PMFL crossover ~120 psi in 18-inch CIP near North Fork Hannah Creek Crossing

4.4.2 Replacement of All Sections of Existing 18-inch CIP

This replacement phasing option looks at completing the replacement of the entire length of 18-inch CIP from the Kannah Creek Crossing to the 20-inch steel pipe with 20-inch PVC- 63,800 feet or 12.1 miles. Figure 14 and Figure 15 provide the pipeline hydraulic profiles and Table 5 summarizes the results for this option. Replacing this portion of the line with 20-inch, would allow delivery of 9.2 mgd at a maximum pressure of less than 120 psi along the existing/unreplaced sections of the KCFL.

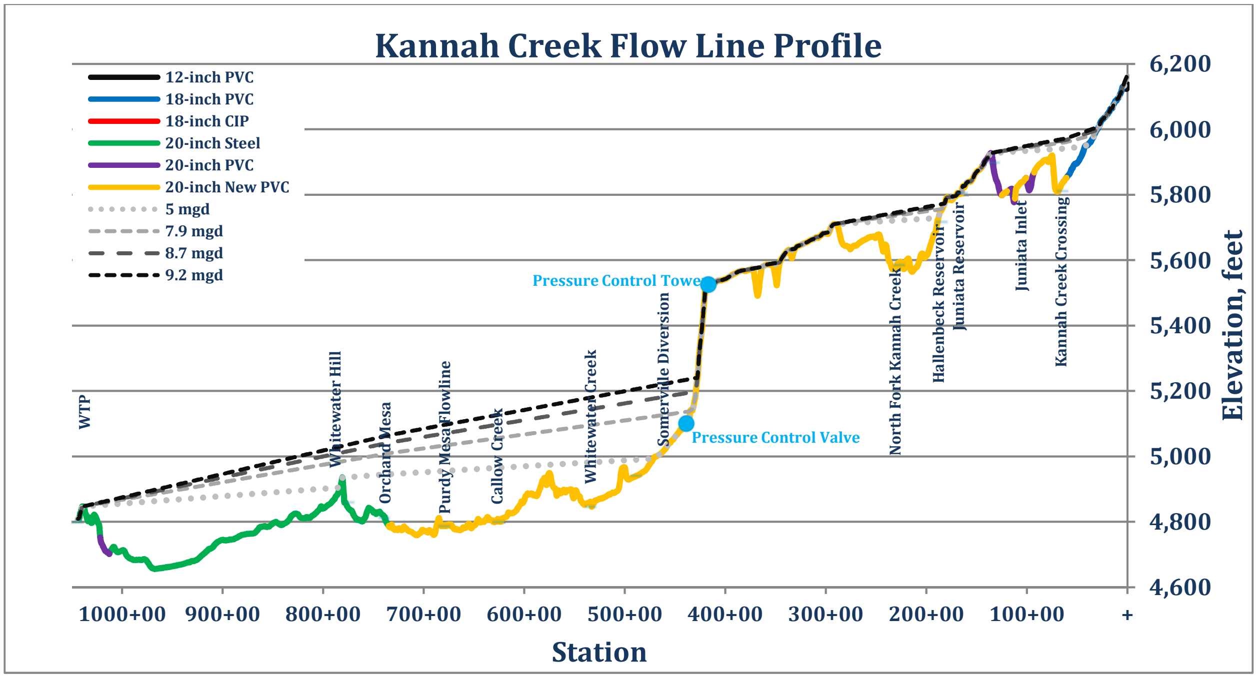


Figure 14 Kannah Creek Replacement Phasing Alternative 2 KCFL HGL Profile

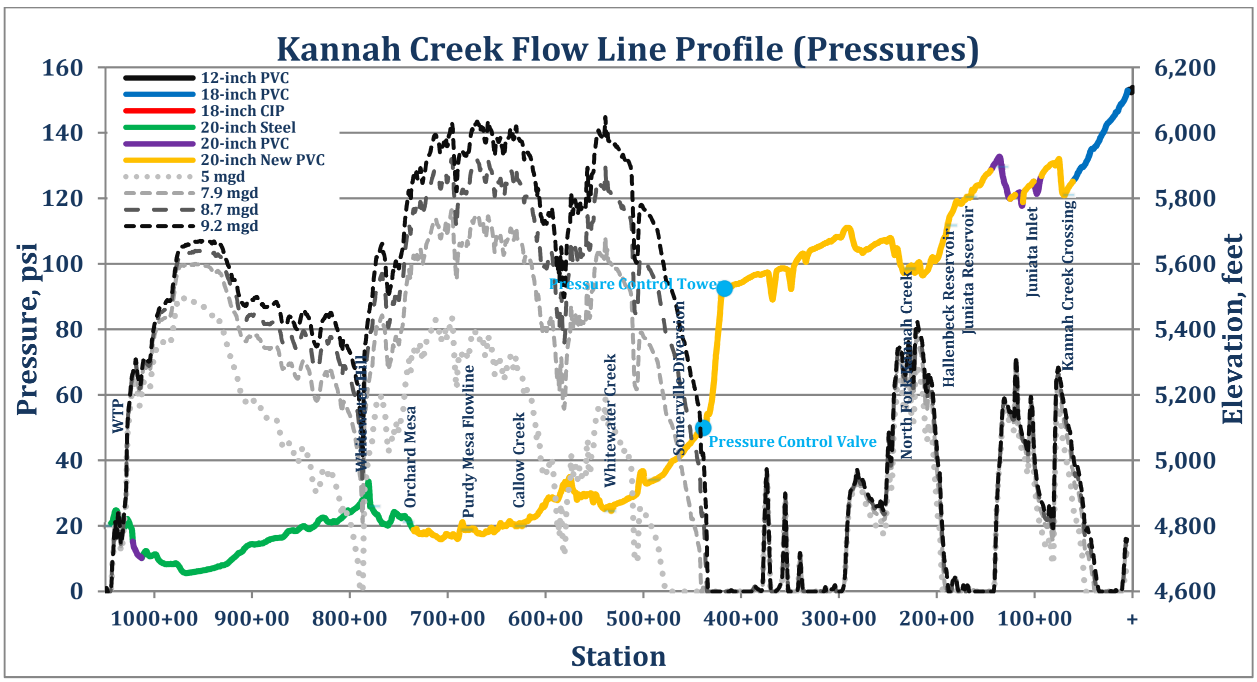


Figure 15 Kannah Creek Replacement Phasing Alternative 2 KCFL Pressure Profile

Table 5 Kannah Creek Replacement Phasing Alternative 2 Flow Condition Summary

FLOW CONDITION	PIPELINE VELOCITIES	MAXIMUM PRESSURE AND LOCATIONS
5.0 mgd	18-inch: 4.4 fps 20-inch: 3.5 fps	~90 psi in 20-inch steel pipe ~84 psi in replacement 20-inch PVC near PMFL crossover ~69 psi in replacement 20-inch PVC near North Fork Hannah Creek Crossing
7.9 mgd	18-inch: 5.6 fps 20-inch: 4.5fps	~100 psi in 20-inch steel pipe ~116 psi in replacement 20-inch PVC near PMFL crossover ~77 psi in replacement 20-inch PVC near North Fork Hannah Creek Crossing
8.7 mgd	18-inch: 6.4 fps 20-inch: 5.2 fps	~110 psi in 20-inch steel pipe ~132 psi in replacement 20-inch PVC near PMFL crossover ~80 psi in replacement 20-inch PVC near North Fork Hannah Creek Crossing
9.2 mgd	18-inch: 6.7 fps 20-inch: 5.5 fps	~120 psi in 20-inch steel pipe ~144 psi in replacement 20-inch PVC near PMFL crossover ~82 psi in replacement 20-inch PVC near North Fork Hannah Creek Crossing

4.4.3 Replacement of 18-inch CIP and 20-inch Steel Pipe Between PCV and WTP

This replacement phasing option looks at completing the replacement of the 18-inch CIP from the PCV to the 20-inch steel pipeline and then continuing the replacement of the 20-inch steel to the WTP. The replacement line would be 59,100 feet, or 11.2 miles, 20-inch pipeline. Figure 16 and Figure 17 show the hydraulic profiles and

Table 6 summarizes the results for this replacement phasing option. Replacement of this portion of the line would allow up to 7.7 mgd at a maximum pressure of less than 120 psi along existing/unreplaced sections of the KCFL.

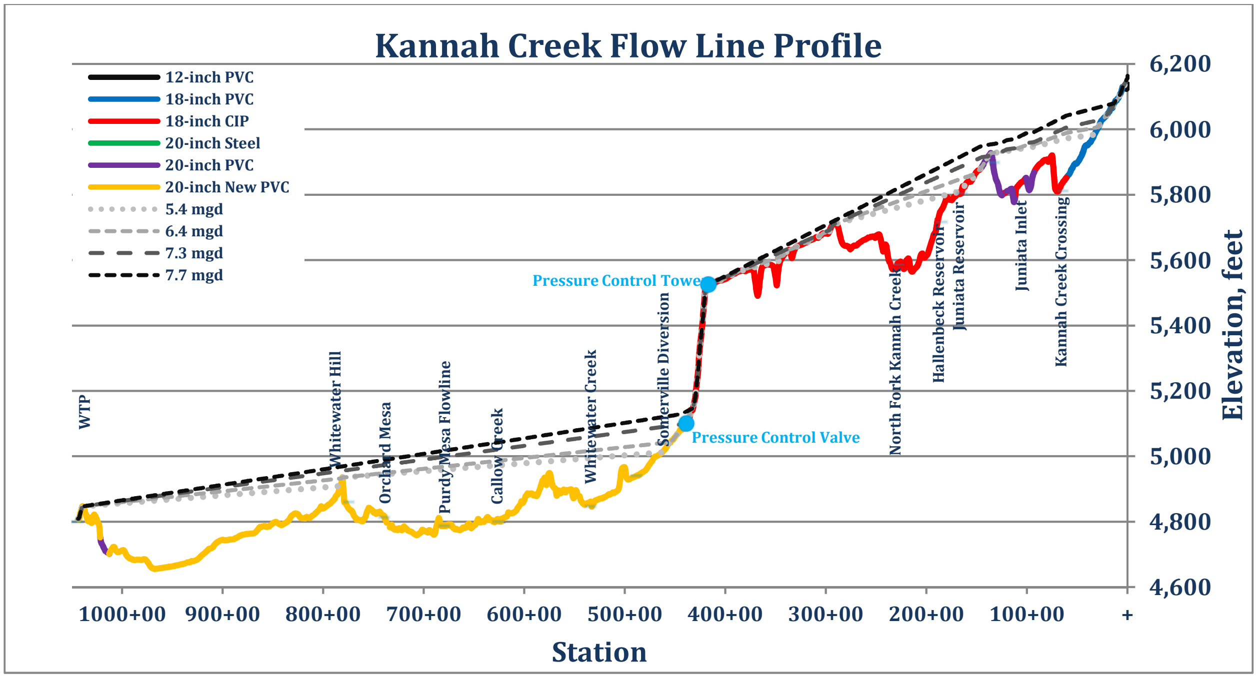


Figure 16 Kannah Creek Replacement Phasing Alternative 3 KCFL HGL Profile

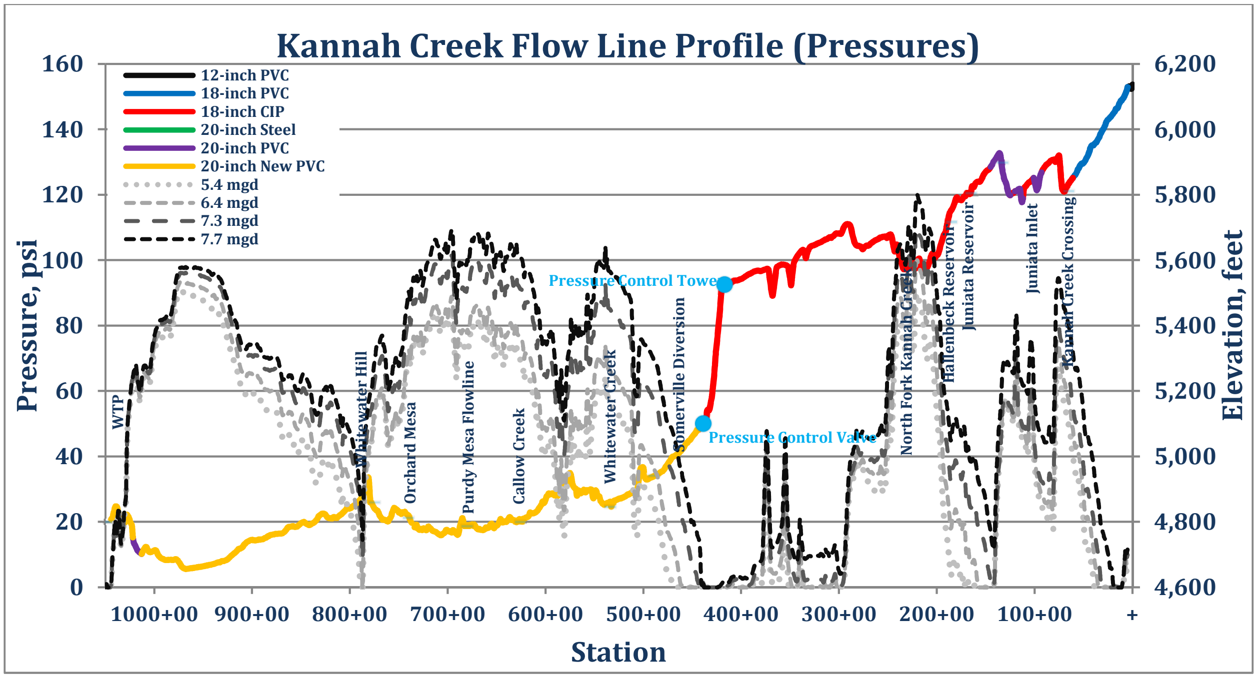


Figure 17 Kannah Creek Replacement Phasing Alternative 3 KCFL Pressure Profile

Table 6 Kannah Creek Replacement Phasing Alternative 3 Flow Condition Summary

FLOW CONDITION	PIPELINE VELOCITIES	MAXIMUM PRESSURE AND LOCATIONS
5.4 mgd	18-inch: 4.4 fps 20-inch: 3.5 fps	~90 psi in replacement 20-inch PVC ~90 psi in 18-inch PVC near North Fork Hannah Creek Crossing
6.4 mgd	18-inch: 5.6 fps 20-inch: 4.5fps	~90 psi in replacement 20-inch PVC ~100 psi in 18-inch CIP near North Fork Hannah Creek Crossing
7.3 mgd	18-inch: 6.4 fps 20-inch: 5.2 fps	~100 psi in replacement 20-inch PVC ~110 psi in 18-inch CIP near North Fork Hannah Creek Crossing
7.7 mgd	18-inch: 6.7 fps 20-inch: 5.5 fps	~110 psi in replacement 20-inch PVC ~120 psi in 18-inch CIP near North Fork Hannah Creek Crossing

4.4.4 Comparison of Replacement Alternative Phasing

The previous three sections show the evaluations of phasing alternatives for the hydraulic profile and the resulting KCFL conditions. It is evident that that the highest priority section for improvement is the 18-inch CIP between the PCV and the existing 20-inch steel pipe at Orchard Mesa, but there is little difference between replacing the 20-inch steel as the next priority or replacing the remaining 18-inch CIP as the next priority. The prioritization of replacement of these sections relates back to the maximum acceptable pressures with which the City is comfortable and the condition of the pipes in these locations that would experience high pressures. For example, if the 20-inch steel pipe is deemed more likely to experience breaks at higher pressures, it should be the second highest priority for replacement. Conversely, if the 18-inch CIP in the low-lying areas near the North Fork Kannah Creek were more of a concern, this would be the next priority for replacement. The City may want to consider condition assessment of portions of the pipeline to assist in prioritization of replacement and possible rehabilitation opportunities.

4.5 FLOW LINE CAPACITY WITH SUPPLEMENTAL FLOW FROM JUNIATA RESERVOIR

As noted in a previous section, the replacement alternatives assumed that any supplemental flow above the 7.81 cfs (5 mgd) came from Kannah Creek. It is more likely that supplemental flow above these limits would come from a new intake at the Juniata Reservoir, which would make the KCFL capacity lower than shown in the previous sections.

Using a low-water surface elevation of 5,740 feet and assuming that supplemental flow to the water rights would be supplied from Juniata Reservoir, Table 7 was developed to show the KCFL capacities for the various replacement scenarios.

Table 7 Kannah Creek Flow Line Capacity with Supplemental Flow from Juniata Reservoir

REPLACEMENT SCENARIO	DESCRIPTION	FLOW LINE CAPACITY (SUPPLEMENTAL FROM JUNIATA) [(1)]	FLOW LINE CAPACITY (SUPPLEMENTAL FROM KANNAH CREEK) [(1)]
18-inch Replacement	All 18-inch CIP and 20-steel replaced with 18-inch PVC (93,800 feet or 17.7 miles)	5.0 mgd (existing water rights)	7.4 mgd
20-inch Replacement	All 18-inch CIP and 20-steel replaced with 20-inch PVC (93,800 feet or 17.7 miles)	6.2 mgd	9.7 mgd
24-inch Replacement	All 18-inch CIP and 20-steel replaced with 24-inch PVC (93,800 feet or 17.7 miles)	Greater than 10 mgd	15.7 mgd
Phasing Alternative 1: 20-inch Replacement	18-CIP between PCV and 20-inch steel replaced with 20-inch PVC (29,000 feet or 5.5 miles)	5.0 mgd (existing water rights)	7.7 mgd
Phasing Alternative 2: 20-inch Replacement	All 18-inch CIP replaced with 20-inch PVC (63,800 feet or 12.1 miles)	6.2 mgd	9.2 mgd
Phasing Alternative 3: 20-inch Replacement	18-inch CIP and between PCV and WTP replaced with 20-inch PVC and 20-inch steel replaced with 20-inch PVC (59,100 feet, or 11.2 miles)	5.0 mgd (existing water rights)	7.7 mgd

[(1)] Capacity criteria is that for new pipe, up to 160 psi was used and existing/unreplaced pipe, up to 120 psi

Noting that the capacity restrictions if supplemental water above the existing water rights were to come from Juniata Reservoir, one final Replacement Alternative was performed. This alternative considered a 20-inch replacement of the existing 18-inch CIP between the PCV and the 20-inch steel, plus a 24-inch replacement of a 14,700-foot (2.8 miles) portion of the existing 18-inch CIP at the hill east of Juniata to the high point west of the North Fork Kannah Creek. Figure 18 and Figure 19 show the HGL profile and the pressure profile of this replacement alternative with the cyan pipe in the figure indicating where the 24-inch replacement would occur. This preferred replacement alternative and phasing would provide a capacity of 7.8 mgd maintaining a pressure of 160 psi in newly replaced pipes and a maximum pressure of 120 psi in the existing/unreplaced pipes.

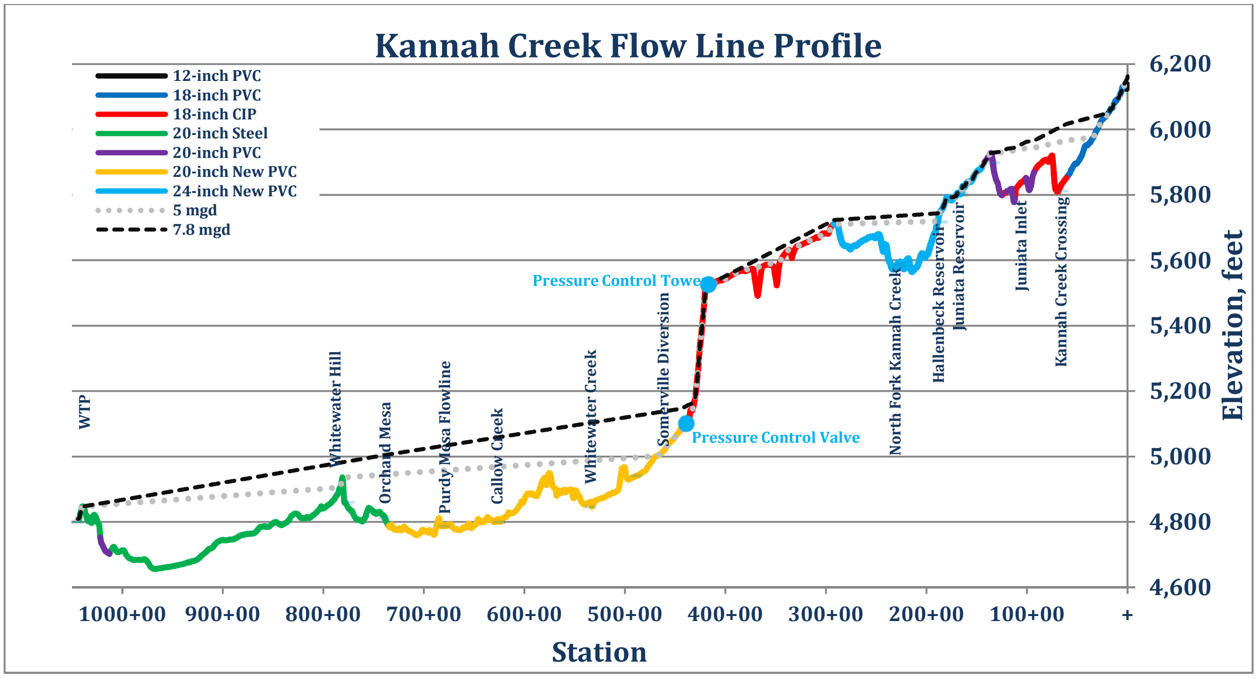


Figure 18 Kannah Creek Replacement Phasing Alternative 4 KCFL HGL Profile

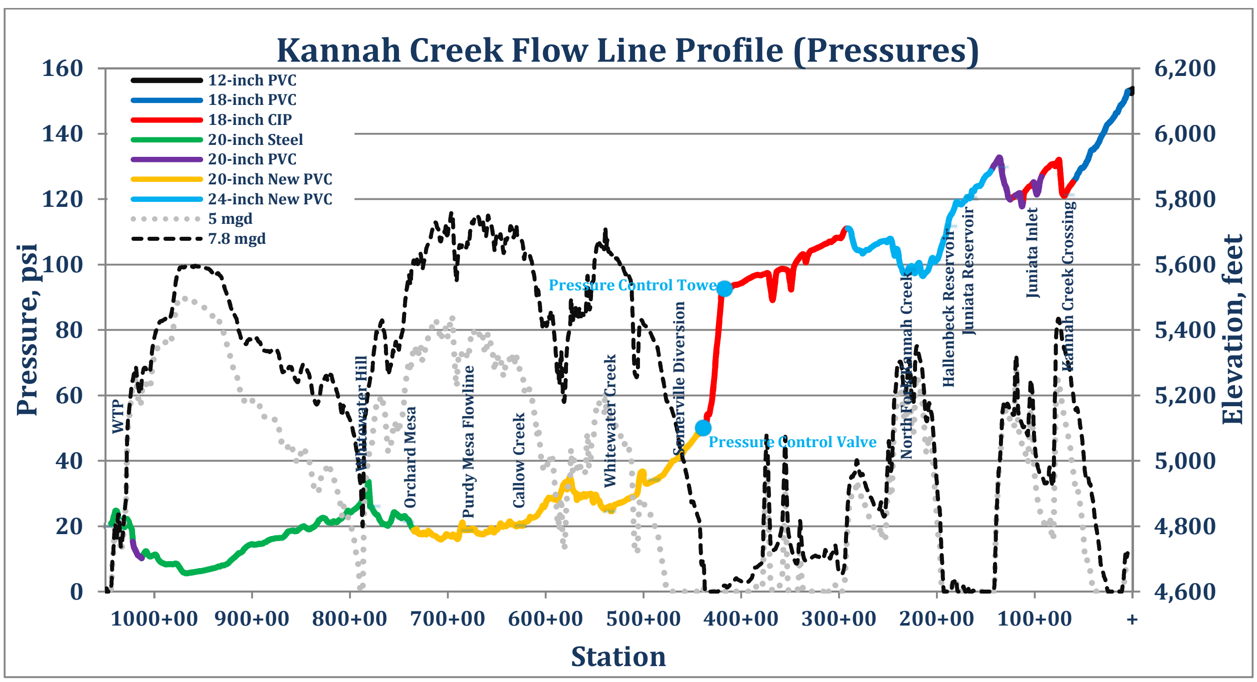


Figure 19 Kannah Creek Replacement Phasing Alternative 4 KCFL HGL Profile

5 Conclusions and Opinions of Probable Cost

The previous sections provided the KCFL capacity for existing conditions, hydraulic profiles that could be expected under various replacement alternatives, phasing evaluations of replacement alternatives, and a discussion on the KCFL capacity should supplemental flow above the existing water rights be provided from Juniata Reservoir, rather than Kannah Creek.

5.1 CONCLUSIONS

The conclusions from these evaluations are presented below:

- The PCV and PCT do not provide any hydraulic control to the existing KCFL and neither would provide control under future conditions. The City could abandon these facilities during pipeline replacement.
- Replacement of the KCFL with 18-inch inside diameter pipes will provide a capacity of 7.4 mgd at pressures in the new infrastructure of 160 psi or less.
- A 20-inch inside diameter replacement line would provide a capacity of 9.7 mgd at pressures of less than 160 psi in the KCFL unless the supplemental flow above the current Kannah Creek water rights must come out of the Juniata Reservoir. If this is the case, a maximum capacity with a 20-inch inside diameter replacement would be 6.2 mgd.
- A full 24-inch inside diameter replacement would be oversized as a replacement unless the City is considering capacities of up to 15.7 mgd in the future through the KCFL.
- The cause of air entrainment in the KCFL was not determined from these evaluations. More detailed modeling, which might include CFD modeling, or field testing would be needed to identify the cause for air entrainment. However, the cloudy water due to air entrainment coming through the KCFL has less impact than through the PMFL because of the ability to settle through detention.
- The first priority section for replacement is the 18-inch CIP from the existing PCV location to the 20-inch steel pipe.
- The next candidate section for replacement depends on the maximum pressures and conditions in the pipe sections at the 20-inch steel pipe east of the WTP and the 18-inch CIP in the low-lying areas near the North Fork Kannah Creek and how additional water above the existing water rights are going to be supplied through the KCFL.
- If supplemental flow above the existing water rights are going to come from the Juniata reservoir, the section of existing 18-inch CIP from the high point at the reservoir and the high point 6,000 feet west of the North Fork Kannah Creek (just southwest of Reeder Reservoir) should be replaced with a new 24-inch pipe. This would need to be completed in conjunction with, or following, installation of the new outlet pipe from Juniata to the KCFL.

5.2 OPINIONS OF PROBABLE CONSTRUCTION COSTS FOR HYDRAULIC IMPROVEMENTS

Estimated construction costs were developed for the four replacement improvements identified in the previous sections the three alternatives of replacing all CIP and steel with 18-inch, 20-inch, and 24-inch diameter PVC. The cost estimates included in this TM were based on estimates from the PMFL project as submitted in a separate memo in April 2008 and are considered to be Class 5, as outlined by the Association for the Advancement of Cost Engineering (AACE) Cost Estimate Classification System. Costs are based on the current design information from August 2018 with a scope development at approximately a 10% stage of design. The opinion of construction costs includes factors for construction general conditions, contingencies, engineering, and construction management. No allowance was made for irregular construction or environmental difficulties.

The estimate was based on PVC pipe at a cost of $9.00 per diameter-inch per lineal foot. These costs were roughly the average of the three sections of pipelines costed for the PMFL by backing out the cost per diameter in per lineal foot. Table 8 presents estimates for the construction costs of the various replacement alternatives provided in this memo.

Table 8 Construction Costs for Replacement Alternatives

REPLACEMENT SCENARIO	DESCRIPTION	LENGTH	CONSTRUCTION COST (1)
18-inch Replacement	All 18-inch CIP and 20-steel replaced with 18-inch PVC	93,800 feet or 17.7 miles	$28,223,000
20-inch Replacement	All 18-inch CIP and 20-steel replaced with 20-inch PVC	93,800 feet or 17.7 miles	$31,359,000
24-inch Replacement	All 18-inch CIP and 20-steel replaced with 24-inch PVC	93,800 feet or 17.7 miles	$37,631,000
Replacement Alternative 1: 20-inch Replacement	18-CIP between PCV and 20-inch steel replaced with 20-inch PVC	29,000 feet or 5.5 miles	$9,695,000
Replacement Alternative 2: 20-inch Replacement	All 18-inch CIP replaced with 20-inch PVC	63,800 feet or 12.1 miles	$21,330,000
Replacement Alternative 3: 20-inch Replacement	18-inch CIP between PCV and WTP replaced with 20-inch PVC and 20-inch steel replaced with 20-inch PVC	59,100 feet, or 11.2 miles	$19,758,000

REPLACEMENT SCENARIO	DESCRIPTION	LENGTH	CONSTRUCTION COST (1)
Replacement Alternative 4: 20-inch replacement and some 24-inch replacement	18-inch CIP between the PCV and the 20-inch steel replaced with 20-inch PVC AND 18-inch CIP at the hill east of Juniata to the high point west of the North Fork Kannah Creek replaced with 24-inch PVC	29,600 feet, or 5.6 miles 15,200 feet, or 2.8 miles, of 24-inch	$9,896,000

(1) Construction Costs include the following assumptions: $9.00 per diameter-inch per lineal foot, 5.2% subcontract mark-up, 35% construction contingency, 14% general requirement mark-up, 13% contractor mark-up, and 1.5% legal

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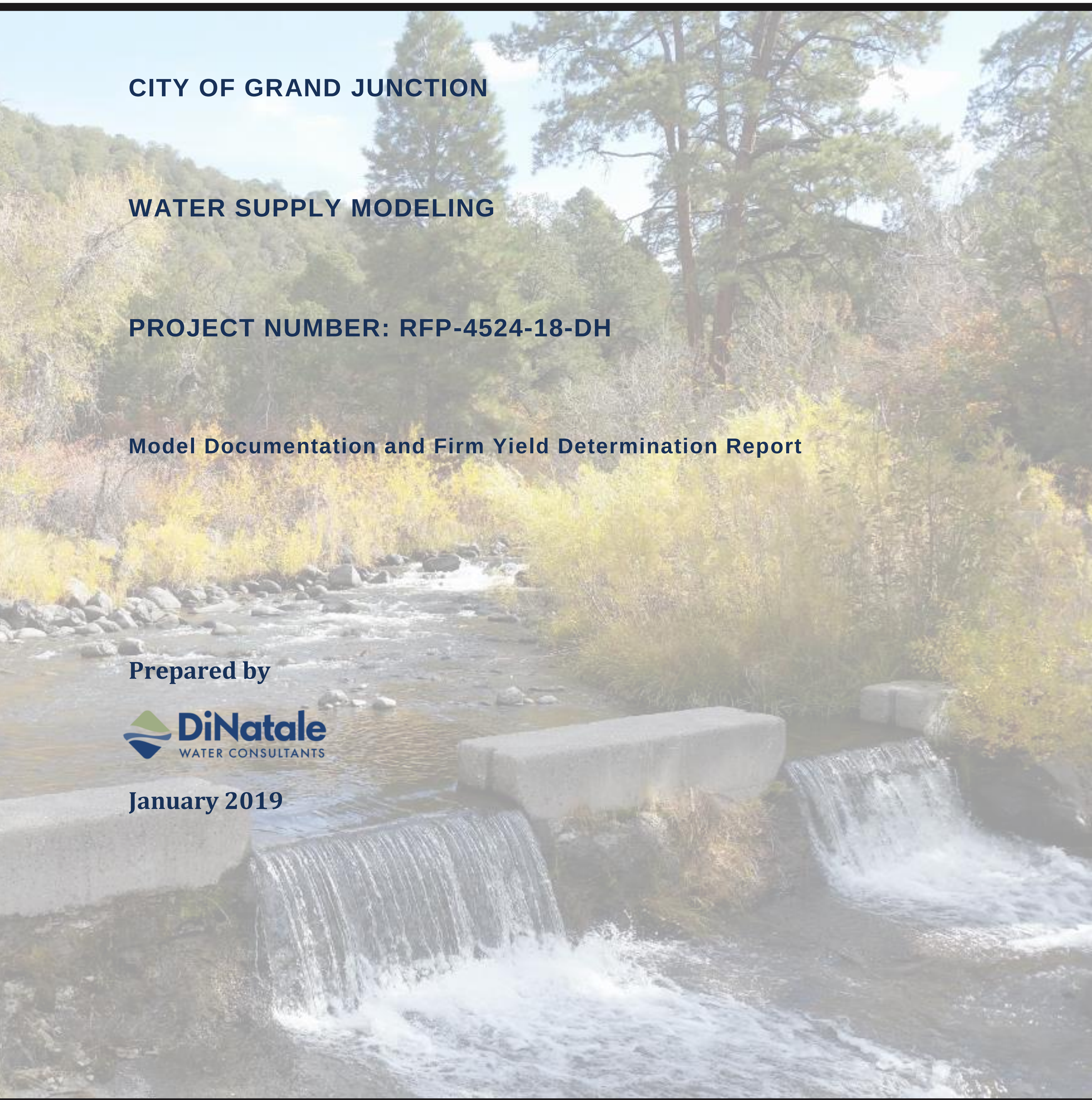

CITY OF GRAND JUNCTION

WATER SUPPLY MODELING

PROJECT NUMBER: RFP-4524-18-DH

Model Documentation and Firm Yield Determination Report

Prepared by

DiNatale
WATER CONSULTANTS

January 2019

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EXECUTIVE SUMMARY

Grand Junction contracted with DiNatale Water Consultants (DiNatale Water) to develop a hydrologic model that could determine the firm yield of the City's water supply system. In addition, specifications for the model included the ability to test a number of different future scenarios. The RiverWare software package was selected for the model development based on its flexibility in simulating a wide variety of system operations while also simulating the Colorado prior appropriation system of water rights administration.

The scope of this project included development of a baseline model that computes the system firm yield using historical hydrologic conditions (1975 through 2016) and current operational protocol. This baseline can be compared to existing demands and Grand Junction will be able to analyze and compare results of other scenarios to the existing system and current operations. The firm yield is amount of water that can be delivered through a critical drought period while maintaining at least approximately one year's supply in storage. The firm yield was tested by developing three storage-related criteria that maintain this amount of water in storage and include operational targets the City has used in its historical operations:

1) Juniata Reservoir must be at least 90% full by the end of runoff (May 1-July 1)
2) Juniata Reservoir must be at least 60% full going into winter (November 1)
3) Storage of at least 1,800 AF in Upper Reservoirs going into winter (November 1)

Figure ES-1 shows the firm yield criteria graphically along with the total reservoir capacity and the average annual demand from 2013 to 2017.

The firm yield was determined by simulating annual water demand and incrementally increasing or decreasing this demand, and determining the highest demand where all three firm yield criteria were satisfied for the entire period of record. The firm yield does not include use of Gunnison River or Colorado River supplies because these sources cannot currently be treated in the City's direct filtration water treatment plant.

The model results show that Grand Junction's current firm yield is between 5,800 and 6,275 AF per year (**Figure ES-2**). This amount includes 44 AF delivered to the Kannah Creek Water Treatment Plant and 300 AF of non-potable water used for irrigation of the cemetery and Las Colonias park. This amount does not include treatment and distribution system losses, which have been about 9% over the past decade. Deducting the Kannah Creek WTP, non-potable use, and treatment and distribution losses, the firm yield of water delivered to customer taps is between 4,960 AF and 5,400 AF per year (1,600 to 1,750 million gallons).

Model inputs were derived from observed hydrologic data and simulation of operations was based on discussions with Grand Junction staff. Due to lack of historical observed reservoir inflow data and observed evaporation data, some model inputs were estimated. Model results were tested for sensitivity to assumptions used to estimate model inputs. This sensitivity testing provides a high level of confidence that the firm yield falls within the range described above.

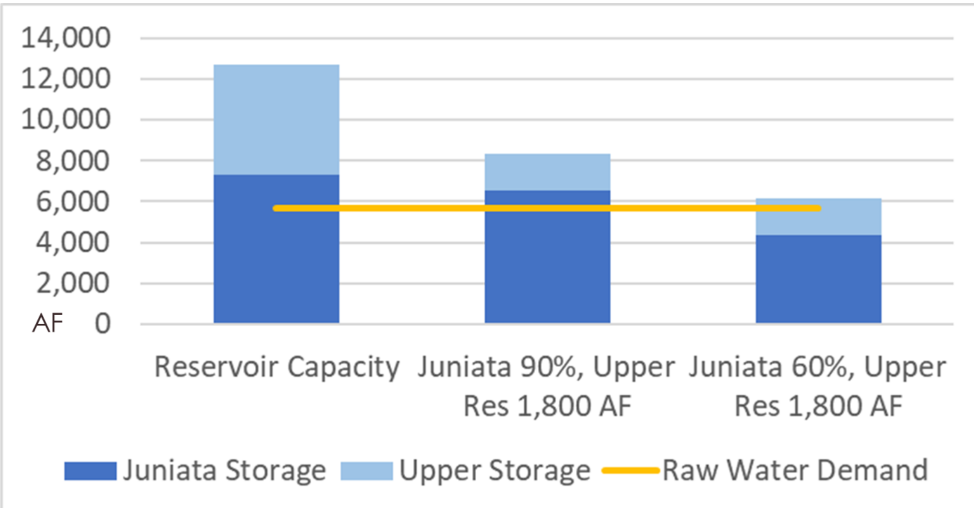

Figure ES-1. Firm yield criteria compared to full reservoir capacity and average annual raw water demand from 2013 to 2017

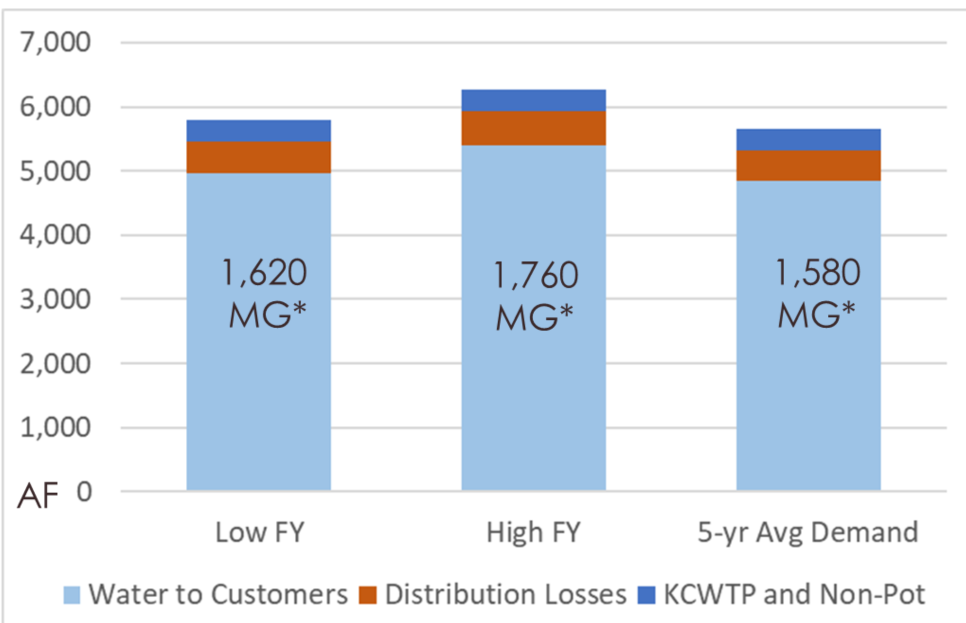

Figure ES-2. Baseline firm yield compared to five-year average annual demand (2013 to 2017)

Model Limitations and Recommendations

Hydrologic models attempt to simulate a wide range of natural phenomena that are always changing. Models by nature simplify the complex natural system to provide useful information and insight about the system. Therefore, every model has certain limitations that should be understood so that future analysis and results obtained from the model can be considered in the proper context. The following are key limitations to the current version of the RiverWare model developed for this project and associated recommendations. Additional detail and explanation for these limitations and recommendations can be found in Section 7.

1. The model was based on a repeat of historical hydrology. Future hydrology may differ from historical in terms of severity or duration of droughts.

   Recommendation A: *Consider testing various methods of hydrologic input development in addition to the percent reduction tested in Section 6.1. Examples include resequencing, more in-depth climate change considerations variations and daily-to-monthly flow considerations.*

2. System reliability criteria for the baseline RiverWare model development were based primarily on historical operating protocol and institutional knowledge. Additional evaluation of the criteria may provide additional insight into other opportunities to operate the system in a more efficient and/or reliable manner.

   Recommendation B: *Consider attempting additional outreach to regional water providers to understand other water provider system reliability criteria and assess whether such criteria would be appropriate for Grand Junction's system.*

   Recommendation C: *Consider evaluating the effect of each of its reliability criteria on firm yield. This recommendation was carried out in part as described in Section 6.1 when the Upper Reservoir criterion was relaxed for certain model runs but may also be useful for other reliability criteria.*

3. Colorado River and Gunnison River sources were not included as a source in the baseline model due to current inability to treat this water with the existing water treatment system.

   Recommendation D: *Consider evaluating potential potable and non-potable water uses for Gunnison River or Colorado River supplies, including water treatment technologies that could best serve Grand Junction.*

4. A potential Colorado River Compact call was not simulated because no such call has been placed historically. This could impact Grand Junction's reservoir water rights,

in particular the use of junior 1990's-era storage rights for municipal use in place of more senior changed agricultural water rights.

<u>Recommendation E:</u> *Consider evaluating the potential effect of the Colorado River Compact on Grand Junction's operation of junior water rights and develop a plan for operation under and maintenance of Grand Junction's more senior rights.*

5. The model simulates historical operational protocol. Different operational procedures can be tested using the RiverWare model to explore opportunities for increased efficiency and reliability. These changes can be evaluated in conjunction with firm yield criteria changes as described in item 2 and Recommendation C, above.

<u>Recommendation F:</u> *Consider evaluating operational changes that differ from historical protocol using the RiverWare model.*

1. INTRODUCTION

The City of Grand Junction provides treated and raw water to customers within its two service areas. The primary service area is located in the downtown area of Grand Junction and the second area is located near its water sources in the Kannah Creek basin and is known as the Kannah Creek service area. Other areas of the City of Grand Junction are served by the Ute Water Conservancy District (Ute Water). For the purposes of this report, references to Grand Junction mean only the water service areas of the City of Grand Junction.

Grand Junction contracted with DiNatale Water Consultants (DiNatale Water) to develop a hydrologic model that could determine the firm yield of the water supply system. In addition, specifications for the model included the ability to test a number of different future scenarios. This report documents the model developed for this purpose and presents results of the firm yield determination. Grand Junction's water supply is derived primarily from the Kannah Creek basin, located on the western side of the Grand Mesa. Grand Junction has several direct flow and storage water rights that it uses to meet the demands of its customers, as well as delivering water to ranches it owns and to other water users who lease Grand Junction's excess water in some years. Raw water is delivered from this area via two pipelines to Grand Junction's water treatment plant located on the south side of the city, near the Redlands Canal diversion dam. The pipelines are known as the Kannah Creek Flow Line and the Purdy Mesa Flow Line. A small amount of water is delivered to the Kannah Creek/Purdy Mesa water treatment plant and delivered to the Kannah Creek water service area. Grand Junction also has water rights on the Gunnison River and the Colorado River. These two sources have lower water quality and are difficult to treat with the current direct filtration process used at Grand Junction's existing facilities. A detailed water resource inventory was developed by the City of Grand Junction in early 2018 that provides additional details on the infrastructure, water rights and historical operations (2018 Water Resources Inventory; Spronk Water Engineers 2018).

The water supply model developed for this project was designed to be able to simulate other future scenarios, including the ability assess:

- which water rights are needed to meet demands under current and drought conditions
- potential operational changes at the City's reservoirs
- adequacy of emergency backup sources
- short-term operational strategies (e.g. carryover storage)
- other planning scenarios

Due to the lack of hydrologic records for some streams and reservoirs, sensitivity testing was performed on some hydrologic modeling inputs that were estimated rather than directly measured to assess the sensitivity of firm yield. Specifically, sensitivity to evaporation rates, the distribution of inflow above and below the Grand Mesa Reservoirs, as well as the total inflow above Grand Junction's point of diversion on Kannah Creek were tested. This testing is described further in Section 6.

2. MODEL SELECTION

In July 2018, DiNatale Water presented four modeling platforms to the City of Grand Junction: RiverWare, Excel spreadsheet-based model, the State of Colorado's StateMod modeling, and MODSIM. DiNatale Water facilitated a discussion with City staff regarding the advantages and disadvantages of each of the model platforms as it relates to the City's needs for the model. The City elected the RiverWare modeling platform in part due to its ability to develop custom operational rules, simulate Colorado's prior appropriation water rights administration system, and its stakeholder interface product, RiverWISE.

DiNatale Water developed the model using the schematic of the Grand Junction system produced in the 2018 Water Resources Inventory. This system schematic is reproduced in this report as **Figure 1**. The RiverWare model layout is shown as **Figure 2**. In addition to the model layout, RiverWare includes a set of operational rules that are applied to the model during each time step. These operational rules are written in the RiverWare Policy Language (RPL) and are required for running the model. The ruleset developed for the firm yield determination is described in more detail in Section 4.

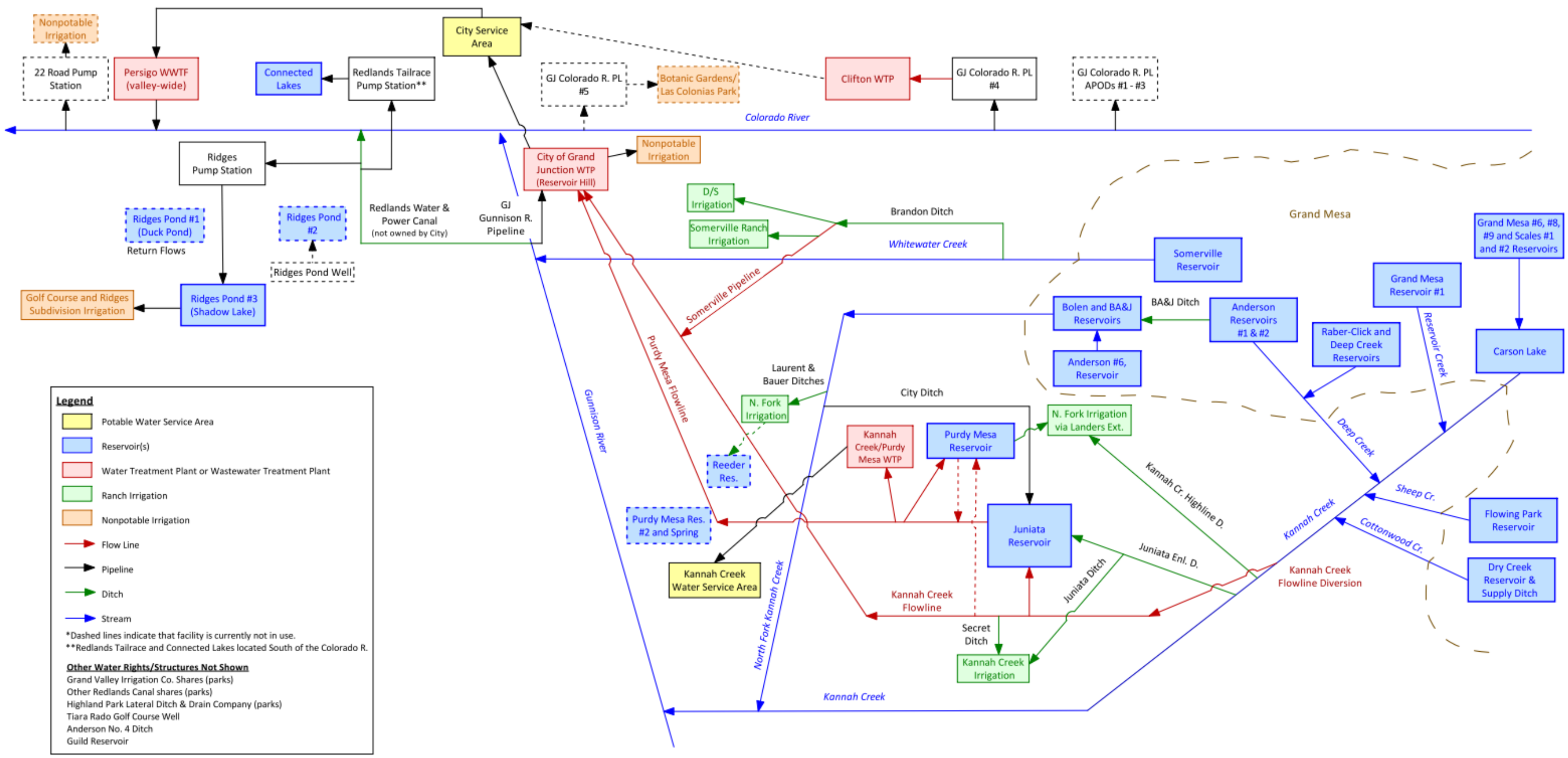

Figure 1. Schematic diagram of Grand Junction water system (from 2018 Water Resources Inventory)

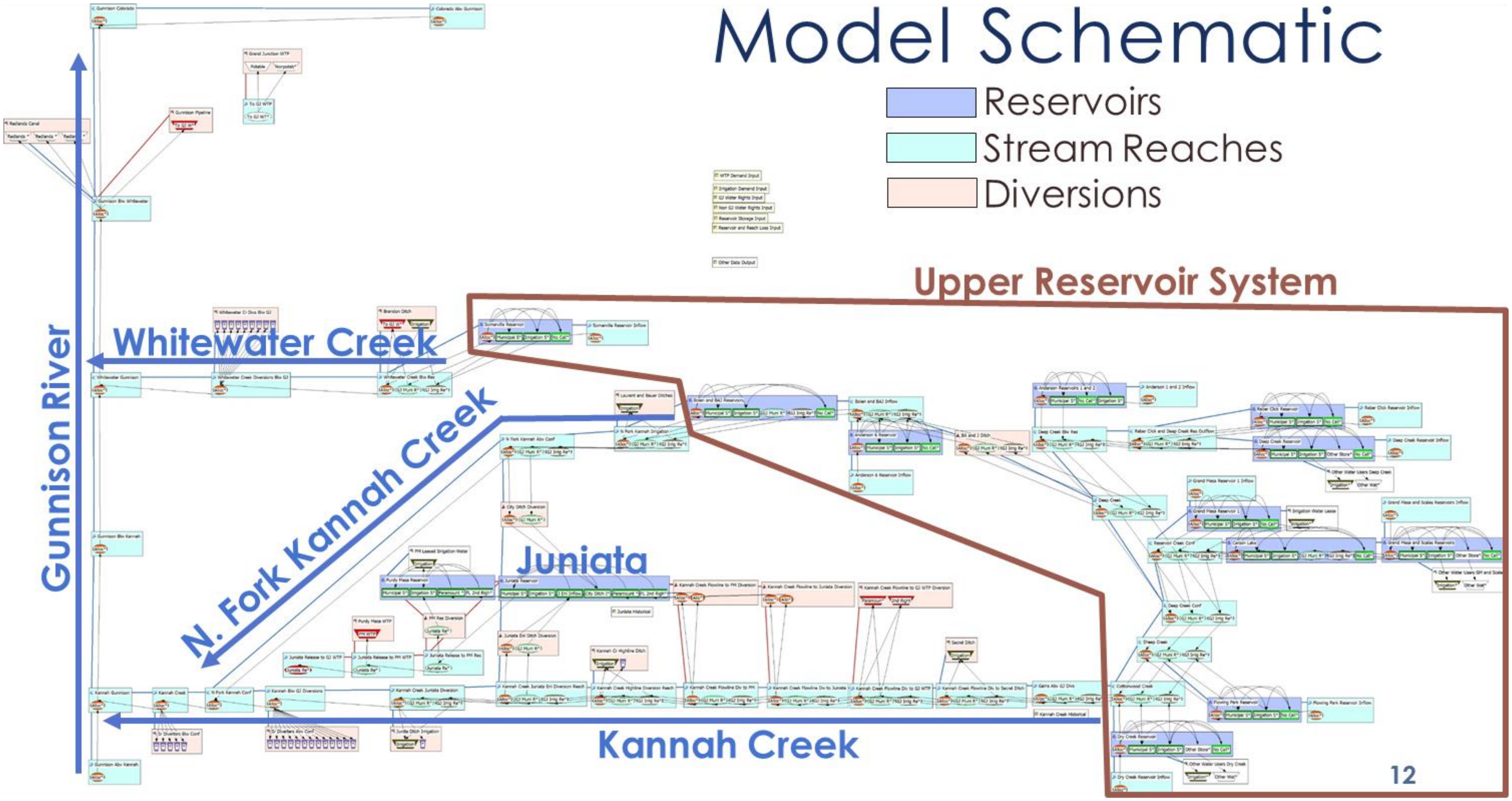

Figure 2. RiverWare model layout

3. MODEL INPUTS AND CONFIGURATION

3.1 Model Time Step and Time Period

The RiverWare model was configured with a monthly timestep from 1975 through 2016. Historical hydrology is used as a model input and current operational protocol is simulated using the historical hydrology. Historical monthly data is more readily available from reservoir records than daily data. In addition, monthly data can effectively simulate the yield of a water supply system, especially systems such as Grand Junction's that have storage facilities that can buffer some intra-month variability typically seen in daily data. From a pragmatic point of view, a monthly model is simpler to manage and modify for various scenarios simply because the amount of input and output data into and from the model is much less than a daily model.

A daily model was considered due to the frequent nature of changing river calls and fixed pipeline capacity. In addition, we discussed the possibility of Grand Junction needing a 404(b) permit from the U. S. Corps of Engineers (Corps). The Corps' regulatory process favors daily models due to its requirement to evaluate impacts to aquatic resources to issue a permit. Impacts to aquatic resources, such as fisheries and other habitat are more difficult to evaluate with monthly modeled data. Grand Junction staff indicated that it did not foresee any projects that would require a Corps permit. In addition, Grand Junction's Paramount water right is the most senior water right in the Kannah Creek basin and therefore is not susceptible to daily changing calls from other water rights. Demand and administrative calls from other water rights are generally located downstream of Grand Junction's supplies at agricultural ditches that place calls during the irrigation season. This means that although the call may change between different water rights on a daily basis during the irrigation season, the call will always be junior to the Grand Junction Paramount water right. During the winter storage filling season and during peak runoff, these downstream water rights do not typically call and Grand Junction's reservoirs will usually store during this period.

The difference between monthly and daily flow input above the Grand Junction flowline diversion was considered. Monthly input data can mask the effects of having insufficient water available on some days if the flow exceeds the diversion capacity in other days. As an example, consider a hypothetical month that had no flow available for the first half of the month, and then twice the diversion capacity available for the second half. On a monthly basis, this would show the water right fully satisfied for the entire month. But on a daily basis, only half the water could have been diverted.

Daily flows at the Grand Junction flowline diversion for 1991 through 2016 were developed as part of the 2018 Water Resources Inventory. The critical period for the firm yield modeling is 2003 and during this period the potential error introduced by daily and monthly discrepancies is approximately 10 AF. This is a relatively small potential error because at least 7.81 cfs has nearly always been available historically at the Grand Junction flowline diversion to satisfy the Paramount Right on a daily average basis, even during dry periods. As discussed in Recommendation A, analysis of more extreme drought conditions and the potential effects of climate change should further evaluate the possibility of more days within a month with less than 7.81 cfs. We understand that during the winter, flow can fall below 7.81 cfs for part of the day due to icing and freezing, but typically increases to more than 7.81 cfs later in the day as temperatures increase. This diurnal fluctuation is captured in the daily average flow evaluated above.

The time period used for the firm yield model includes several periods of dry, average, and wet years. There is significantly less hydrologic data prior to 1991 due to a lack of Kannah Creek stream gage between 1982 and 1991 along with generally sparse reservoir and diversion records. However, because 1977 is widely considered to be one of the driest water years on the West Slope, we developed model data back to that time period to evaluate system performance through that year. In addition to 1977, 2002 and into 2003 was a very dry year (Kannah Creek flows at 50% of average). At the time of writing of this report, water year 2018 is proving to be a very dry year, although the lasting effects on water supply will not be apparent until the amount of winter precipitation is known.

3.2 Stream Inflows

Stream inflows to the model were developed above the Grand Mesa reservoirs, gains to Kannah Creek between the Grand Mesa reservoirs and the Kannah Creek flowline diversion point, North Fork of Kannah Creek, Whitewater Creek, and the Gunnison River.

In general, there is only very limited data available at the Grand Mesa reservoirs. State of Colorado records available on HydroBase (the State's online hydrologic database) have infrequent data, and at times only a single record of an annual amount released or stored. Generally, the records are better since 2007, but are not sufficient to develop a long-term time series of reservoir operation records.

The 2018 Water Resources Inventory provided an estimate of average inflows to each reservoir using the USGS's StreamStats tool, which uses basin drainage area and other hydrologic factors to estimate average inflows (www.usgs.gov/media/files/streamstats-colorado). Measurements of snow-water-equivalent (SWE) are available for portions of the Grand Mesa going back to the 1970's. Both NRCS Snotel sites and the City's snow course sites were used to determine average SWE for the basin. We made an initial estimate of reservoir inflow by multiplying each year's peak SWE percent of average by the StreamStats average monthly inflow estimates. Using this data, we then compared the estimated reservoir inflow to the flow records at the Kannah Creek gage. Gains to creeks from the contributing basin below the reservoirs were similarly estimated using StreamStats data at the Kannah Creek Flowline diversion point and subtracting the estimated inflows from the contributing drainage area of each reservoir.

Using this amount as inflow to the model, we compared the simulated flow to the historical flow above Grand Junction's Kannah Creek Flowline diversion point. Historical flow at this location can be estimated prior to 1982 using the Kannah Creek Near Whitewater gage and can be estimated beginning in 1991 when the Kannah Creek at Juniata Enlarged Diversion stream gage was installed. The 2018 Water Resources Inventory computed the total flow in Kannah Creek upstream of Grand Junction's Diversions for the period from 1991 to 2016 using gage records for the Colorado Division of Water Resources (DWR) Kannah Creek at Juniata Enlarged Diversion gage station and adding in known diversions at facilities upstream of the gage. Similarly, we calculated the total flow in Kannah Creek upstream of Grand Junction's diversions prior to 1982 using the Kannah Creek near Whitewater Gage and adding in Diversions made at the Kannah Creek Flowline. This location is upstream of all major diversions on Kannah Creek except the upstream Grand Mesa reservoirs. The Kannah Creek flowline diversion point is one of the key locations where model calibration could occur. **Figure 3** is a map from the 2018 Water Resources Inventory showing this location as well as other key areas included in the modeling.

In general, using the StreamStats estimate of inflows above the Grand Mesa reservoirs and for the gains to the Kannah Creek basin below the reservoirs resulted in simulated flows that were significantly greater than the historical flows during the irrigation season at the Kannah Creek Flowline diversion point. To better fit the historical flow at the Kannah Creek Flowline diversion point, we multiplied the estimated irrigation season inflows by 52.5 percent, and further performed manual calibration to better fit monthly variations in flow. Manual calibration was necessary because the StreamStats estimates provide only an average monthly flow values that does not include any variation naturally seen in the historical flows (e.g. peak flow occurring in May in some years, but in June in others). StreamStats uses generalized watershed parameters that are generally calibrated to a region, but are not specific to the Kannah Creek watershed which necessitated the site-specific calibration to total flow volume as well as year-to-year variability.

Using the inflows described above, the simulated streamflow compares very well to the historical flow at the Kannah Creek Flowline diversion point. The simulated total volume of flow at this location over the historical period of record is within approximately 1 percent of the historical flow, well within the presumed gage error in the historical flow amount. Monthly variations do exist (**Figure 4**) in part based on the inflows using the average monthly StreamStats and also variation in historical operations of Grand Mesa reservoirs.

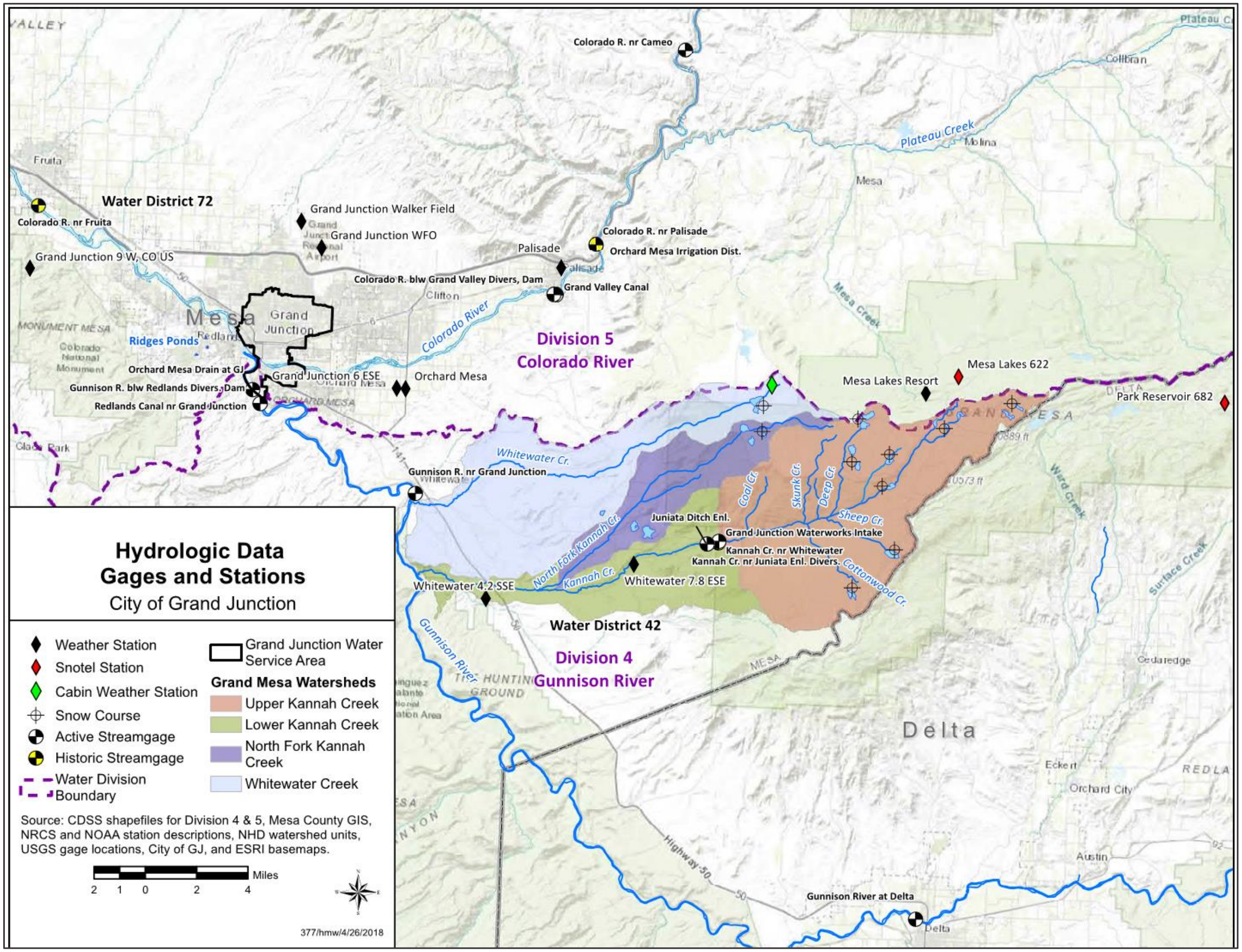

Figure 3. Map of Grand Junction water supply features (replicated from Figure 1-2 of the 2018 Water Resources Inventory)

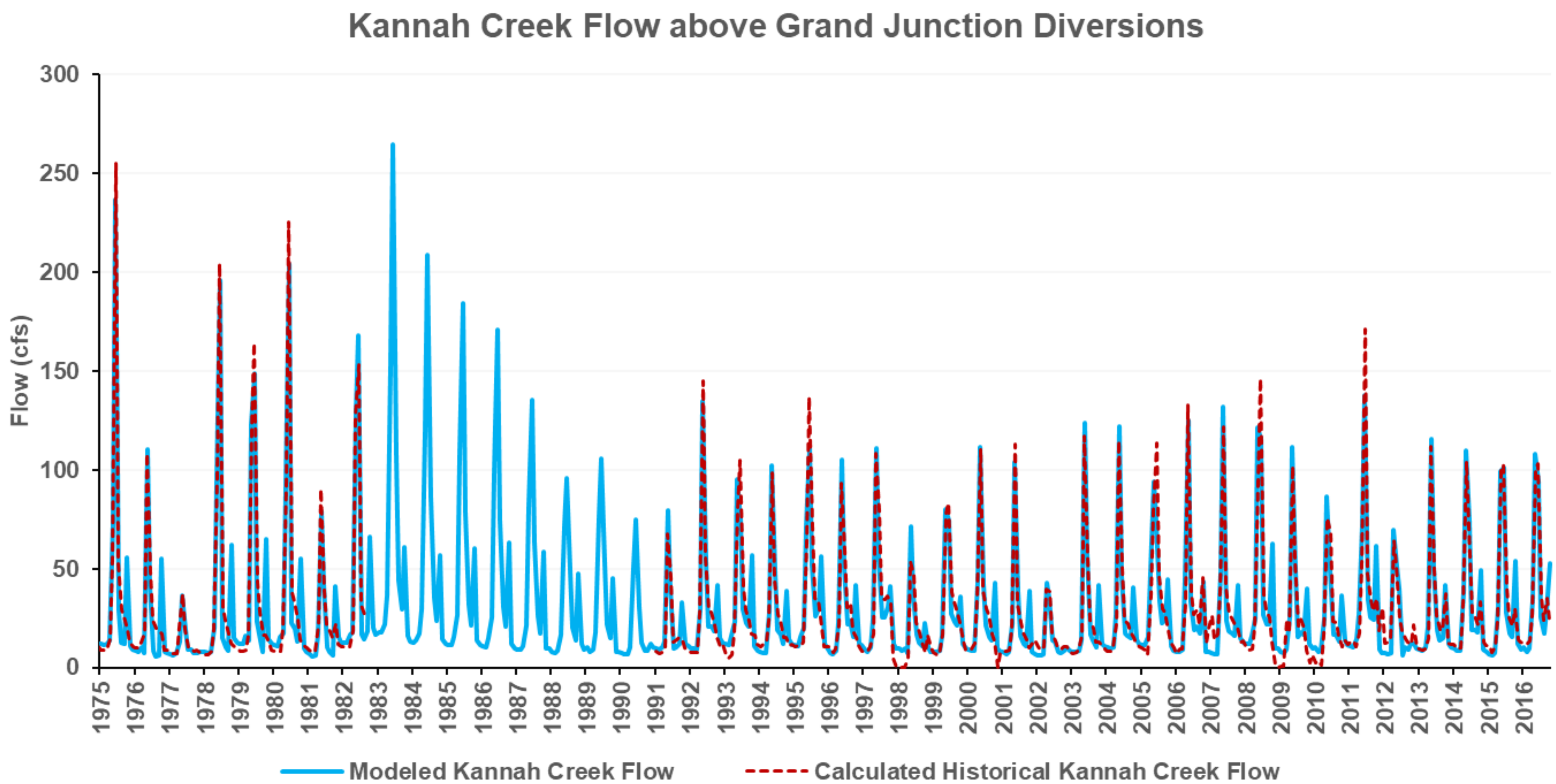

Figure 4. Historical observed flows (dashed line) and model simulated flows (solid line) at Kannah Creek above Grand Junction diversions

The coefficient of determination (R^2) between the historical and simulated flow at the Kannah Creek Flowline diversion using the calculated total flow from 1975-1982 and 1991-2016 is 0.89 (**Figure 5**), indicating a good calibration. Large differences often occur between modeled and observed flows in October because all releases from the Upper Reservoirs are modeled to occur in October, while in actual historical operations, municipal releases from the upper reservoirs appears to have occurred in other months. Our understanding is that more recent operations involve release of municipal water primarily in October, which is shown in several of the more recent years' historical flow amounts.

USGS stream gage 09152500, Gunnison River near Grand Junction, CO was used for the input inflow to the Gunnison River upstream of the Kannah Creek confluence. The Gunnison River was simulated because the Redlands Canal's senior rights can call out some of Grand Junction's water rights and could impact Grand Junction's firm yield **(Figure 3)**. For model input, we decreased the gaged Gunnison River flow by 4 percent because this gage is located downstream of both the Kannah Creek and Whitewater Creek confluence. This adjustment accounts for the additional drainage area between the actual location of the gage and the location where inflows are simulated in the model.

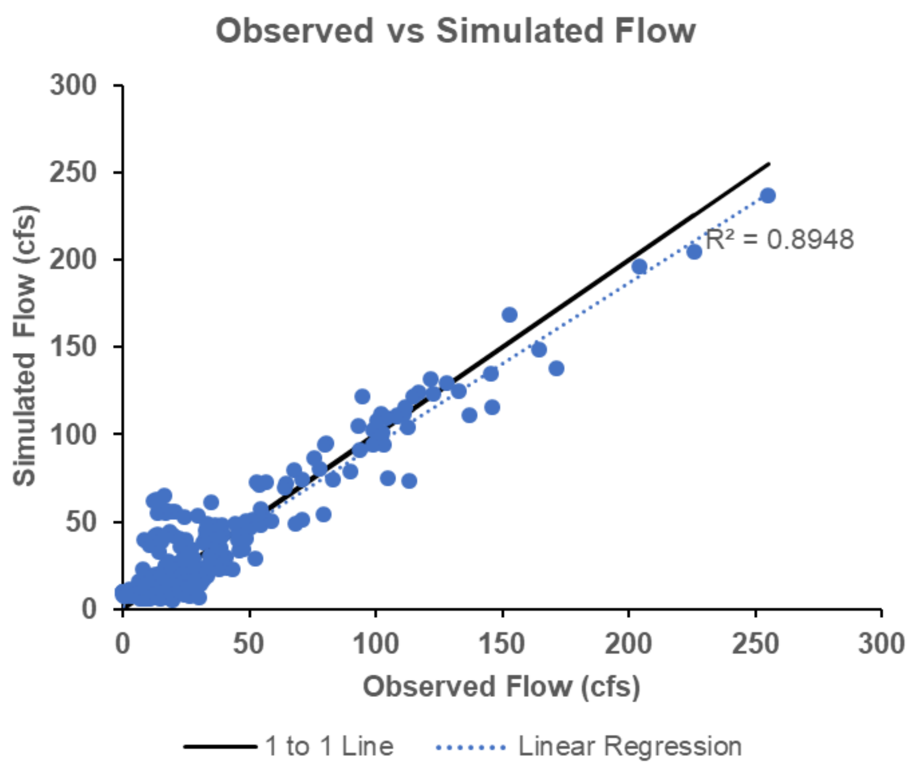

Figure 5. Observed vs simulated total Kannah Creek flow

3.3 Reservoirs

The firm yield model simulates 19 reservoirs, including 17 on the Grand Mesa, plus Juniata Reservoir and Purdy Mesa Reservoir (**Table 1**). The Grand Mesa Reservoir Nos. 6, 8, and 9 and Scales Reservoir Nos. 1 and 2 were grouped and simulated as a single reservoir due to their similar location and Grand Junction's storage ownership of 5.4% in each of these reservoirs. Anderson No. 1 and Anderson No. 2 were grouped and simulated as a single reservoir due to the similar location and Grand Junction's 100% storage in each. Bolen and Bolen, Anderson & Jacobs Reservoir No. 2 were similarly grouped into a single simulated reservoir. These reservoir groupings are indicated on **Table 1**. This grouping resulted in 13 simulated reservoir objects within the model.

Reservoir objects in the RiverWare model include both a municipal and irrigation storage accounts. Although not all reservoirs are used for irrigation or municipal use, the ability to do so was included in the model so that future modeling efforts could evaluate each reservoir in terms of value in the Grand Junction system for municipal or irrigation use. In the current modeling effort, reservoirs are simulated for either irrigation only or municipal only in the amounts shown in **Table 1**. Some reservoirs used for irrigation are partially owned by Grand Junction. These reservoirs are simulated by moving Grand Junction's pro-rata ownership into a separate Grand Junction account, while the remainder of the water is assumed to be released to other water rights owners by the end of each irrigation season

Reservoir evaporation data is input into the model in the "Reservoir and Reach Loss Input" data object. Evaporation rates are not recorded on-site at any of the Grand Junction Reservoirs and we are not aware of stage-area relationships for these reservoirs. Therefore, we developed an average annual evaporation rate in terms of a percentage of the average content of the reservoirs. Simulation of evaporation as a percent of contents is an effective method for simulating grouped reservoirs, notwithstanding the lack of observed evaporation data and stage-area relationships for these reservoirs.

The long-term average evaporation rate for Juniata Reservoir and Purdy Mesa Reservoir was determined by utilizing NOAA Technical Report NWS 33, which shows an average annual free water surface evaporation of approximately 42 inches. The surface area of Juniata Reservoir when full is approximately 155 acres, but typically reservoir levels fall during the summer months to surface area closer to approximately 130 acres. Using the average of these surface areas and applying the free water evaporation rate results in an average annual evaporation of approximately 500 AF, or about 7 percent of the typical summer contents. This same percentage was applied to Purdy Mesa Reservoir. In practice, evaporation at Purdy Mesa Reservoir as a percent of contents may be higher than Juniata Reservoir because it is shallower. However, Purdy Mesa Reservoir is not used in the determination of firm yield because it is only used to deliver water to agricultural users, and only fills after Juniata Reservoir is full. Use of the model to analyze a different use of

Purdy Mesa Reservoir should consider refining the evaporation rate to more accurately assess evaporative losses at that location.

Table 1. **Municipal and** irrigation storage in the RiverWare model

Municipal Reservoirs	Total Capacity (AF)	GJ Ownerthip (%)	GJ Capacity (AF)	Model Group
Juniata Reservoir	7,291	100%	7,291	
Bolen Reservoir	521	100%	521	a
Bolen Anderson & Jacobs Reservoir No. 2	240	100%	240	a
Anderson Reservoir No. 1	507	100%	507	b
Anderson Reservoir No. 2	595	100%	595	b
Anderson Reservoir No. 6	118	100%	118	
Raber Click Reservoir	459	100%	459	
Carson Lake	637	100%	637	
Flowing Park Reservoir	772	100%	772	
Sommerville Reservoir	973	100%	973	
Total Municipal Storage:	*12,113*		*12,113*	
Irrigation Reservoirs				
Purdy Mesa Reservoir	659	100%	659	
Deep Creek Reservoir	354	19.4%	69	
Dry Creek (Chambers) Reservoir	236	33%	78	
Grand Mesa Reservoir No. 1	559	100%	559	
Grand Mesa Reservoir No. 6	172	5.4%	9	c
Grand Mesa Reservoir No. 8	379	5.4%	20	c
Grand Mesa Reservoir No. 9	153	5.4%	8	c
Scales Lake No. 1	203	5.4%	11	c
Scales Lake No. 3	129	5.4%	7	c
Total Irrigation Storage:	*2,844*		*1,421*	

Model Group: no letter indicates reservoir simulated individually
Model Group a: Bolen Reservoir and Bolen Anderson & Jacobs Reservoir No. 2
Model Group b: Anderson Reservoir Nos. 1 and 2
Model Group c: Grand Mesa Reservoir Nos. 6, 8, 9 and Scales Lake Nos. 1 and 3
Note if Grand Junction ownership in reservoirs changes, update in the model data object "Reservoir Storage Input"

The 2018 Water Resources Inventory reported average annual evaporation from the upper reservoirs to be approximately 500 AF. This amount was confirmed by Grand Junction staff for normal years. Grand Junction's full storage capacity in of the Upper Reservoirs is approximately 5,500 AF and based on data of maximum and carry-over storage from 1999-2017, the average storage is approximately 3,150 AF. Based on the information from the 2018 Water Resources Inventory and Grand Junction staff, the long-term average evaporation as a percent of contents was estimated to be 14 percent (500 AF / (500 AF + 3,150 AF)).

While the actual evaporation rate as measured in inches of evaporation is likely lower at the Upper Reservoirs than the Lower Reservoirs (Juniata and Purdy Mesa), the Upper Reservoirs have a more surface area per unit of storage than the Lower Reservoirs. When full, the Upper Reservoirs have approximately 1 acre of surface area for every 8 AF of storage compared to a 1 acre to every 40 AF ratio at the Lower Reservoirs. The greater surface area of the Upper Reservoirs is the reason evaporation as measured as a percent of contents is higher in the Upper Reservoirs than the Lower Reservoirs.

Year-to-year variability in evaporation rates for the modeled reservoirs was simulated by multiplying the annual evaporation rate (percentage of reservoir contents as described above) by a temperature adjustment factor to increase evaporation in warmer years and decrease in cooler years. The temperature adjustment was based on summer (May to September) temperature data from the NOAA Cedaredge and Mesa Lakes weather stations. Because observed evaporation rates were not available at the Grand Mesa Reservoirs, we based the variability on observed pan evaporation rates at the Grand Junction 6 ESE weather station. The Grand Junction 6 ESE weather station has pan evaporation data going back to 1962. The Cedaredge and Mesa Lakes weather stations have different average temperatures than the Grand Junction 6 ESE station, so we evaluated the deviation from the average temperature at each station. The deviation from average was also computed for the Grand Junction 6 ESE pan evaporation rates. In the observed data, the relationship between deviation from the mean temperature and deviation from the pan generally shows higher evaporation occurs with higher temperature. Though other climatic factors drive evaporation rates as well, such as wind and relative humidity, these data are less readily available. Using this approach, the annual variability in evaporation over the model time period ranged from 0.93 to 1.14 times the long-term average.

Using the general relationship between temperature and evaporation, we used the deviation from the average temperature at the Cedaredge and Mesa Lakes stations to calculate the model input for deviation from the long-term evaporation rate for the modeled reservoirs. **Figure 6** shows the observed data (blue triangles) and the calculated evaporation variability for the model (orange circles). To be conservative for the firm yield purposes, we attempted to fit the simulated evaporation rates to more of the above-average years than the below-average years. This is apparent in **Figure 5** from the modeled data more closely aligning with years with higher observed evaporation than years with lower observed evaporation.

The annual evaporation rate, as adjusted by the temperature factor, was distributed to monthly evaporation rates (as percent of contents) using the DWR's General Administration Guidelines for Reservoirs (2016). The monthly distributions for elevations under 6,500 ft msl were used for the Lower Reservoirs, and the distributions for elevations above 6,500 ft msl were used for the Upper Reservoirs **(Table 2)**.

The firm yield results were tested for sensitivity to the variation in evaporation. Grand Junction staff reported that evaporation for the Upper Reservoirs is approximately 500 AF per year in normal years, but in 2018, losses to evaporation were significantly higher at approximately 1,000 AF. This 100% increase in evaporation relative to the average is well outside the range seen at the Grand Junction 6 ESE station **(Figure 6)** which shows a maximum evaporation rate maximum of approximately 14% above average, suggesting that seepage may have increased in 2018 or other climactic factors are present on the Grand Mesa that would cause significantly higher variability in evaporation rates than seen at the Grand Junction 6 ESE station. Additional discussion on the results of the evaporation sensitivity is provided in Section 6.2.

Table 2. Monthly evaporation distribution for reservoirs

Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<6,500 ft msl	3.0%	3.5%	5.5%	9.0%	12.0%	14.5%	15.0%	13.5%	10.0%	7.0%	4.0%	3.0%
>6,500 ft msl	1.0%	3.0%	6.0%	9.0%	12.5%	15.5%	16.0%	13.0%	11.0%	7.5%	4.0%	1.5%

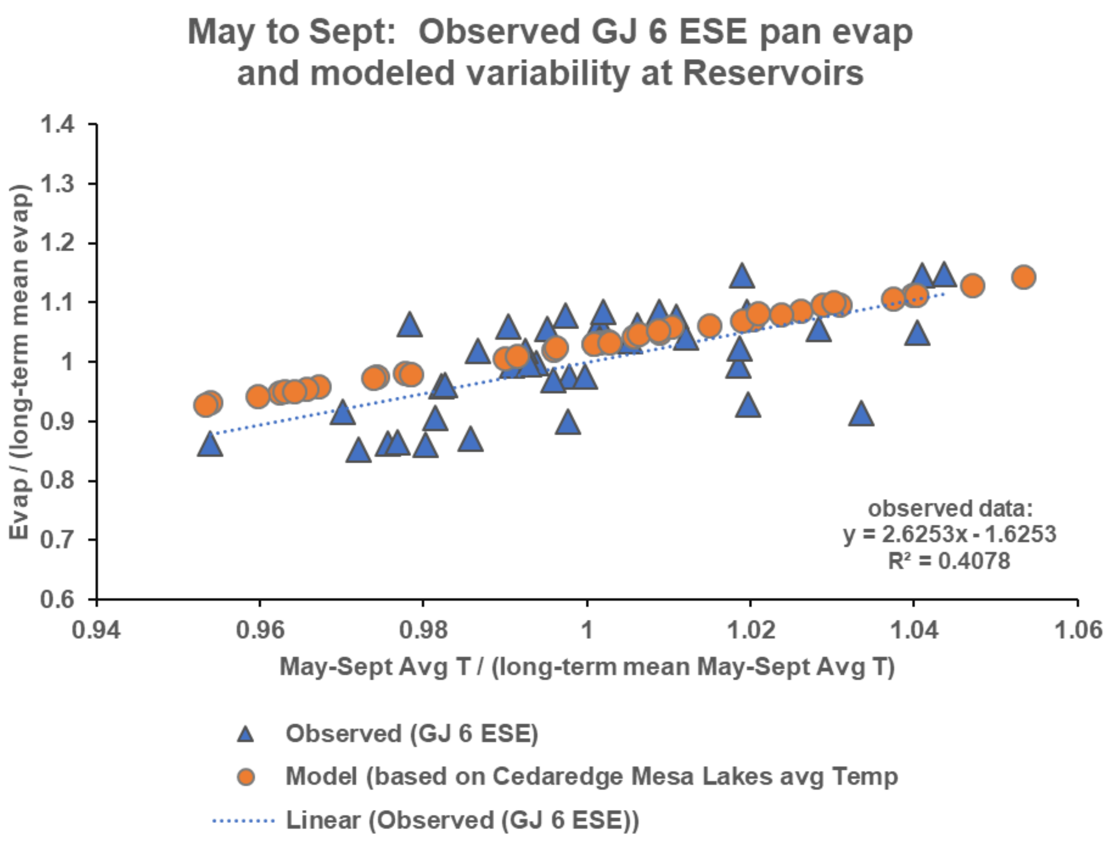

Figure 6. Observed pan evaporation at GJ 6 ESE and modeled evaporation variability

3.4 Water Rights

Direct flow water rights for both Grand Junction and non-Grand Junction water right were included in the model. Information associated with the direct flow water rights are stored within the RiverWare model in the "GJ Water Rights Input" and "Non GJ Water Rights Input" data objects. Input for each water right includes the amount of the water right for each month the water right is operated. Agricultural direct flow water rights are active April through October and are set to zero November through March. These inputs are used to set the modeled requested diversion amounts, and do not vary year by year. Actual diversions at each water right is governed by the prior appropriation system and is simulated in the RiverWare model.

Information on water rights owned by Grand Junction was obtained from the 2018 Water Resources Inventory, and HydroBase, Colorado's online hydrologic database. Information for water rights not owned by Grand Junction was obtained from HydroBase. Individual water rights were grouped into blocks based on their locations and priority dates (**Tables 3, 4 and 5**). Each block was initially given a demand equal to the total amount of the water rights during the irrigation season (April-October).

Modeled reservoirs request a diversion amount equal to the amount needed to fill the reservoir during the storage season (November-June). In the firm yield model, Upper Reservoirs that have a decreed junior (1993-1994) municipal right are operated only under this right and used only for municipal storage while reservoirs without a decreed municipal right are used for irrigation purposes (**Table 1**).

The Redlands Canal, located on the lower Gunnison River, has three water rights with appropriation dates of 1905, 1941, and 1994 for 670, 80, and 100 cfs respectively. Each of these rights has a modeled demand of the full amount year-round. In the model, the Redlands Canal can place a call on the river in dry years, as seen historically in 2002. However, based on the recent EIS for the Aspinall Unit, we understand that sufficient water will be released to Redlands to prevent a Redlands Canal call. Therefore, the firm yield was computed with the Redlands Canal water right deactivated (see also Section 5).

Because the model runs on a monthly timestep, the demands of some larger water rights were adjusted to better match their own historical diversions, and to make allocatable flow available to better match historical reservoir storage by Grand Junction. While these senior ditches may divert large flows for several days, these high flow rates will typically not be sustained throughout an entire month.

Senior diverters below the confluence of Kannah Creek and North Fork Kannah Creek include the Kannah Creek Extension Ditch, the Brown & Campion Ditch, and the Smith Irrigating Ditch. These ditches have water rights totaling 65.57 cfs with priority dates senior to most of Grand Junction's rights. The Smith Irrigating Ditch has priority no. 7 on

Kannah Creek for 19.6 cfs and the Brown & Campion Ditch has priority no. 8 for 22 cfs, totaling 41.6 cfs between the two rights. In the model, the total demand between the two rights was set to 20.8 cfs (half of the actual right) to better match the monthly maximum historical diversions at these ditches (**Figure 7**).

Similarly, we adjusted the irrigation demands at the Juniata Ditch Enlargement and the Kannah Creek Highline Ditch. Grand Junction owns a portion of the rights for each of these structures. The Grand Junction portion of the irrigation rights for the Juniata Enlarged Ditch was reduced from 114 cfs to 39 cfs (only the senior most priority) while the non-Grand Junction demands were kept at 15 cfs. The Grand Junction portion of the Kannah Creek Highline Ditch rights was reduced from 24.9 cfs to 12.45 cfs, and the non-Grand Junction portion was reduced from 43 cfs to 21.5 cfs.

To better match historical data and allow the upper reservoirs to fill, Grand Junction's direct flow irrigation rights were subordinated to the Upper Reservoirs filling. Within RiverWare, subordination works by the senior right forgoing a portion of the water that was legally and physically available for appropriation so that a junior right may take water instead. This prevents Grand Junction irrigation rights from calling out Grand Junction reservoir storage rights.

Table 3. Modeled diversion blocks on Kannah Creek below the confluence with N. Fork Kannah Creek

Kannah Creek Below Confluence with N. Fork Kannah Creek					
Structure Name	**Adjudication Date**	**Previous Adj Date**	**Appropriation Date**	**Priority Admin No.**	**Right Amount (cfs)**
Block 1 Blw Confluence					**13.62**
KANNAH CREEK EXTENSION D	07/25/1888		11/01/1884	12724	7.65
BROWN & CAMPION D	07/25/1888		11/01/1884	12724	4.21
SMITH IRRIGATING DITCH	07/25/1888		11/01/1884	12724	1.76
Block 2 Blw Confluence					**1.3**
SMITH IRRIGATING DITCH	07/25/1888		08/11/1885	13007	1.3
Block 3 Blw Confluence					**8.6**
BROWN & CAMPION D	07/25/1888		11/14/1885	13102	8.6
Block 4 Blw Confluence					**41.6**
SMITH IRRIGATING DITCH	07/25/1888		03/26/1886	13234	19.6
BROWN & CAMPION D	07/25/1888		12/16/1886	13499	22
Block 5 Blw Confluence					**0.45**
SMITH IRRIGATING DITCH	7/25/1941	8/3/1934	5/1/1920	30895.25688	0.45

Table 4. Modeled diversion blocks on Kannah Creek above the confluence with N. Fork Kannah Creek

Kannah Creek Above Confluence with N. Fork Kannah Creek					
Structure Name	**Adjudication Date**	**Previous Adj Date**	**Appropriation Date**	**Priority Admin No.**	**Right Amount (cfs)**
Block 1 Abv Confluence					**0.6**
FLORENCE H BERRY DITCH	07/25/1888		12/31/1881	11688	0.6
Block 2 Abv Confluence					**0.58**
NORTHWESTERN DITCH	07/25/1888		11/01/1884	12724	0.29
BALES WILLIAMS MORRISON	07/25/1888		11/01/1884	12724	0.29
Block 3 Abv Confluence					**4**
NORTHWESTERN DITCH	07/25/1888		08/11/1885	13007	4
Block 4 Abv Confluence					**3.57**
BOWEN PRIVATE DITCH	07/25/1888		12/03/1885	13121	3.57
Block 5 Abv Confluence					**5.47**
WASHBURN & DOWNING DIT	07/25/1888		01/21/1888	13900	2.77
BALES WILLIAMS MORRISON	07/25/1888		01/23/1888	13902	2.7
Block 6 Abv Confluence					**1.27**
COULTER DITCH	6/1/1916	7/22/1912	08/01/1889	22848.14458	0.27
VANPELT COX SEEPAGE D	6/1/1916	7/22/1912	05/01/1890	22848.14731	1
Block 7 Abv Confluence					**3.775**
FLORENCE H BERRY DITCH	6/1/1916	7/22/1912	4/25/1914	23490	1.04
BOWEN PRIVATE DITCH	7/25/1941	8/3/1934	7/28/1914	30895.23584	0.26
BOWEN PRIVATE DITCH	7/25/1941	8/3/1934	8/8/1914	30895.23595	0.72
WILLIAM H. WILLIAMS DITCH	7/25/1941	8/3/1934	8/10/1914	30895.23597	0.585
BALES WILLIAMS MORRISON	7/25/1941	8/3/1934	8/10/1914	30895.23597	
RABER DAVIS DITCH	7/25/1941	8/3/1934	9/18/1915	30895.24001	1.17
Block 8 Abv Confluence					**0.34**
RABER DAVIS DITCH	7/25/1941	8/3/1934	10/27/1921	30895.26232	0.34
Block 9 Abv Confluence					**0.75**
BLACK DITCH	7/25/1941	8/3/1934	3/15/1933	30895.30389	0.62
SULLIVAN RANCH DRAIN	7/25/1941	8/3/1934	11/15/1937	32095	0.13
Block 10 Abv Confluence					**3.07**
NORTHWESTERN DITCH	7/25/1941	8/3/1934	11/1/1939	32811	1.78
BOWEN PRIVATE DITCH	7/25/1941	8/3/1934	11/1/1939	32811	1.29
Block 11 Abv Confluence					**1**
NORTHWESTERN DITCH	7/21/1959	3/27/1944	08/11/1885	34419.13007	0.5
BOWEN PRIVATE DITCH	7/21/1959	3/27/1944	12/03/1885	34419.13121	0.5
Block 12 Abv Confluence					**8.032**
NORTHWESTERN DITCH	7/21/1959	3/27/1944	6/1/1955	38502	1.5
FLORENCE H BERRY DITCH	12/31/1971	12/31/1970	6/1/1954	44194.38137	2.166
BLACK DITCH	12/31/1971	12/31/1970	6/1/1954	44194.38137	2.166
WILLIAM H. WILLIAMS DITCH	12/31/1971	12/31/1970	6/1/1954	44194.38137	2.2
Block 13 Abv Confluence					**0.056**
GARDNER DITCH	12/31/1993	12/31/1992	2/23/1993	52284	0.036
DALTON DITCH & PUMP #2	12/31/1993	12/31/1992	12/16/1993	52580	0.02

Table 5. Modeled diversion blocks on Whitewater Creek below Grand Junction's diversions

Whitewater Creek					
Structure Name	**Adjudication Date**	**Previous Adj Date**	**Appropriation Date**	**Priority Admin No.**	**Right Amount (cfs)**
Block 1					**3**
SHROPSHIRE DITCH	7/22/1912	1/4/1911	10/01/1897	22283.17441	3
Block 2					**3.6**
ADA SUPPLY DITCH	6/1/1916	7/22/1912	10/17/1907	22848.21108	3.6
Block 3					**1**
IRA VINCENT DITCH	7/21/1959	3/27/1944	6/1/1913	34419.23162	1
Block 4					**0.5**
IRA VINCENT PETTINGELL ENl	7/21/1959	3/27/1944	8/1/1947	35641	0.5
Block 5					**5.4**
IRA VINCENT DITCH	7/21/1959	3/27/1944	5/1/1950	36645	1.15
HOLLAND WASTE WATER D	7/21/1959	3/27/1944	10/1/1950	36798	4.25
Block 6					**4.2**
ELLIOT PUMP DITCH	12/31/1973	12/31/1972	10/01/1897	44925.17441	1
WILLIAMS DITCH	12/31/1976	12/31/1975	6/1/1960	46020.40329	3
OVERHOLT PUMP STATION	12/31/1982	12/31/1981	3/29/1982	48300	0.2
Block 7					**2**
BROKEN SPOKE R C D BOYLES	12/31/1985	12/31/1984	4/1/1900	49308.18353	2
Block 8					**0.344**
KOSANKE DIVERSION NO. 2	12/31/1987	12/31/1986	12/1/1987	50373	0.2
RUSSELL DITCH	12/31/1992	12/31/1991	6/22/1992	52038	0.144
Block 9					**1.708**
NOLAND WASTE DITCH #1	12/31/1997	12/31/1996	12/31/1970	53691.44194	0.01
NOLAND WASTE DITCH #2	12/31/1997	12/31/1996	12/31/1970	53691.44194	
OSCAR DITCH	12/31/1997	12/31/1996	9/4/1997	53938	1
TERRY DITCH	12/31/1997	12/31/1996	9/4/1997	53938	
GOODFELLOW PUMP DIV	12/31/1998	12/31/1997	6/1/1998	54208	0.25
GIRIN'S PUMP STATION NO1	12/31/1999	12/31/1998	1/6/1999	54427	0.044
J. WATSON PUMP	12/31/2005	12/31/2004	7/30/2004	56613.56459	0.25
GREEN POND DIVERSION	12/31/2006	12/31/2005	6/7/1982	56978.4837	0.1
PHIPPS PUMP	12/31/2006	12/31/2005	4/18/2006	57086	0.05
DESERT OASIS SPRING	12/31/2007	12/31/2006	6/1/1970	57343.43981	0.004

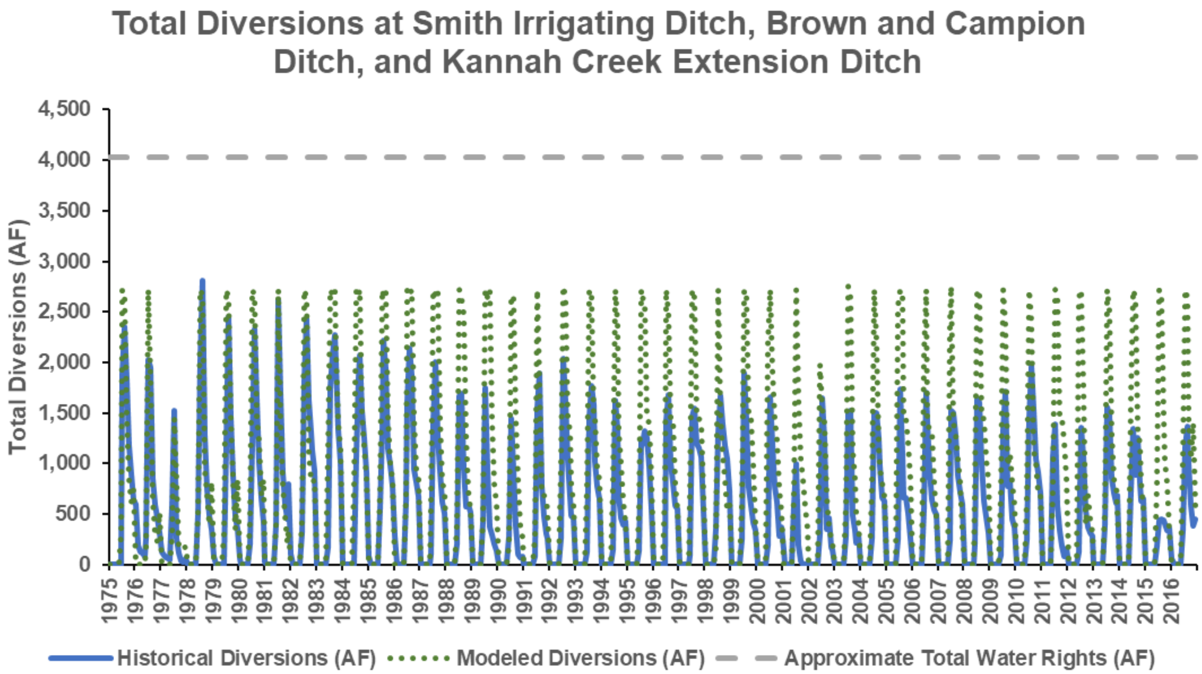

Figure 7. Historical and modeled diversions for ditches on Kannah Creek below the confluence with North Fork Kannah Creek

3.5 Conveyance Losses

The RiverWare model assesses conveyance losses to reservoir releases both as stream losses within Kannah Creek and ditch losses if delivered through a ditch. Conveyance losses are sometimes referred to as "shrink." Both stream loss and ditch loss estimates included in the model were based on conversations with Grand Junction staff. Releases from the Upper Reservoirs to Juniata Reservoir experience at 15 percent stream loss in most years and a 20 percent stream loss in dry years prior to diversion at the Kannah Creek Flowline diversion. These stream losses increase to 17 percent and 23 percent when delivered to the Juniata Ditch Enlargement diversion. In-ditch losses in the Juniata Enlargement were estimated at 30 percent in most years and 50 percent in dry years and losses in the City Ditch were estimated at 15 percent in most years and 20 percent in dry years. The higher losses in dry years were assessed in the RiverWare model when the peak SWE in the year was below 60 percent of the 1975-2016 average.

4. MODEL RULES AND OPERATIONS

The RiverWare model was configured with the RiverWare water rights solver. Use of the water rights solver requires a set of model instructions for other simulated system operations. This is accomplished using RiverWare's built-in language called RiverWare Policy Language (RPL). Model developers generate several instructions – called "rules" in RiverWare – that drive operations of the simulated river system. The rules are saved with the RiverWare model as a group called a ruleset. The ruleset provides the operational logic for the model run.

The firm yield RiverWare model contains 5 rules that run upon model initialization and the model ruleset contains 59 rules. A brief description of each rule is provided in **Appendix A**. The legal availability of water is controlled by the RiverWare water rights solver, which ensures that water rights are strictly administered within the prior appropriation system except when a water right is specifically subordinated. The ruleset is constructed to simulate the following operations if water is physically and legally available:

1) Divert the Paramount right via the Kannah Creek Flowline directly to the Grand Junction Water Treatment Plant (WTP) to meet immediate demands year-round.
    a. *Note:* In practice, Grand Junction diverts much of this water to Juniata Reservoir and concurrently releases water Juniata Reservoir to meet the immediate demands. Because this operation does not have a net effect of the mass balance of water stored in Junita Reservoir, it is modeled as a direct diversion.
2) During the winter months (November-March), divert Grand Junction's 3.91 cfs right at the Kannah Creek Flowline.
3) Store available flow under the Kannah Creek Flowline rights in excess of the immediate demand at the Grand Junction WTP in Juniata Reservoir.
4) If Juniata Reservoir is full, store water from the Kannah Creek Flowline rights in Purdy Mesa Reservoir.
5) Meet remaining GJ WTP demands via Brandon Ditch to Somerville Pipeline if Juniata storage is below 70 percent during the winter months. During the irrigation season (April-October), only divert water if storage in Juniata is Below 50 percent.
    a. *Note:* In the firm yield runs, storage in Juniata Reservoir is not allowed to go below 60 percent, so the Somerville Pipeline is never utilized during the irrigation season.
6) Meet remaining demands at the Grand Junction WTP from water stored in Juniata Reservoir via the Purdy Mesa flowline
7) Release water stored in Upper Reservoirs in excess of 2,000 AF to Juniata Reservoir in October. Stream losses are applied to these releases.

8) If Purdy Mesa Reservoir is greater than 75 percent full on April 1, lease 400 AF of irrigation water.
9) If Upper Reservoirs are greater than 90 percent full on April 1, lease 400 AF of irrigation water.
10) During irrigation season, meet irrigation demand on Grand Junction's ranches through use of irrigation direct flow rights and water stored in Upper Reservoirs and Purdy Mesa Reservoir.
11) During irrigation season, fill Juniata Reservoir from Juniata Ditch Enlargement under junior right, if available.
12) In winter, fill Juniata Reservoir from City Ditch.
13) Fill Purdy Mesa Reservoir from Juniata Reservoir overflow.
14) Fill Grand Mesa Reservoirs in winter and during peak runoff, when in priority.

The RiverWare model simulates the above operations in the order listed above. If any of the lower priority operations modify a variable that a higher priority operation depended on, RiverWare re-simulates the time step in an iterative fashion.

5. FIRM YIELD DETERMINATION

Firm yield is defined as the amount of water from a given supply that is reliably available through a defined drought condition while still maintaining defined system reliability criteria. Often, the firm yield is determined by simulating a repeat of historical hydrology and determining the maximum amount of demand that can be met through the entire historical period, including the most severe drought of that period. Firm yield runs differ from simply repeating historical operations because current demands and current operations are simulated using the historical hydrology. For example, demand for water in the Grand Junction service area has decreased since the early 2000's. The firm yield simulations do not attempt to replicate the higher demands of the early 2000's and the lower current demand. Instead, an annual demand is selected and simulated using the historical hydrology in each year and the system response is compared to the reliability criteria.

The scope of the initial firm yield model construction and firm yield development is based on current operational practices and historical hydrology. Additional testing and analysis for different scenarios and operations (as described in Section 1) can be accomplished using the RiverWare model and modifying inputs or operational rules and compared to results of the firm yield based on historical hydrology and current operational practices. The modeled historical hydrology period is from water years 1975 to 2016. Using historical hydrology is a common practice for determining the firm yield of a water supply system. However, use of historical hydrology does not consider the effects of drought for durations greater than those observed during the model period. It also does not consider the future effects on hydrology, including climate change. This means that the system could deliver less water than the firm yield should future hydrologic conditions be worse than those in the model period, or if other operations change relative to current practices.

A firm yield model run must successfully meet defined system reliability criteria. The reliability criteria used by Grand Junction were defined through the course of the project. The following criteria were used to govern a successful model run:

1) Juniata Reservoir must be at least 90% full by the end of runoff (May 1-July 1)
2) Juniata Reservoir must be at least 60% full going into winter (November 1)
3) Storage of at least 1,800 AF in Upper Reservoirs going into winter (November 1)

To determine the firm yield, we simulated the Grand Junction demand at several levels, adjusting iteratively until the maximum demand was determined and adjusted the demand at the Grand Junction WTP to the maximum amount where all of the reliability criteria are satisfied. The final firm yield amount is the sum of 300 AFY non-potable demand, 44 AFY demand at the Kannah Creek/Purdy Mesa WTP, and the iteratively adjusted demand at the Grand Junction WTP.

The annual demands used in determining the firm yield are distributed to monthly values based on historical water use in Grand Junction. The monthly distribution for potable demand is based on the total water production from 1989-2017, including water supplied to the Kannah Creek/Purdy Mesa WTP (**Table 6**). The monthly distribution for non-potable demand is based on the average usage for commercial and government irrigation from 2012-2014 (**Table 6**).

Under baseline conditions, the Grand Junction firm yield is between 5,800 AF and 6,275 AF per year. A range of values is presented due to uncertainty in some model inputs and based on the sensitivity analysis performed on key model inputs (see Section 6). This amount is the raw water delivery and does not include treatment and distribution system losses. To determine the amount of water that can be delivered to customers, any losses that occur during treatment or in the distribution system must be applied. The 2018 Water Resources Inventory indicates that treatment and distribution losses are approximately 9% over the last ten years. The firm yield of 5,800 AF to 6,275 AF, less 300 AF for non-potable use and 44 AF for the Kannah Creek WTP as delivered at customer taps is between 4,960 AF and 5,400 AF per year (1,600 to 1,750 million gallons) ((5,800 AF or 6,275 AF – 300 AF – 44 AF) * (100%-9%)).

Based on input from Water Division No. 4 Engineer, Bob Hurford, we understand that the recent environmental impact statement (EIS) currently governs operations of the Aspinall Unit (Blue Mesa Reservoir, Crystal Reservoir, and Morrow Point Reservoir), all located upstream on the Gunnison River. The EIS specifies that the Aspinall Unit will supply a sufficient amount of water to prevent a call from the Redlands Canal. Although operation of the Aspinall Unit is outside the scope of this modeling effort, we assumed that the Redlands Canal would not place a call in the future. The upper end of the range of firm yield was calculated both with and without allowing the Redlands Canal to call out Grand Junction's junior diversions for comparison purposes.

The upper range of the modeled raw water firm yield when the Redlands Canal is not allowed to place a call against Grand Junction's junior diversions and all of the above criteria are met is 6,275 AFY. In this run, the critical period occurs in spring of 2003, where Juniata is just able to meet criteria number 1 (**Figure 8**). In our opinion, this value is the most appropriate upper end of the range of current firm yield because it incorporates current operations and agreements at the Redlands Canal. However, the agreement between the Aspinall Unit operations and Redlands Canal may not be permanent.

Table 6. Potable and non-potable demand distribution

Demand	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Potable	5.3%	5.0%	5.6%	7.2%	9.9%	12.5%	13.6%	12.2%	9.9%	7.9%	5.5%	5.4%
Non-potable	0.6%	0.6%	0.8%	2.2%	10.1%	14.2%	19.8%	18.2%	15.8%	11.6%	5.1%	1.0%

When the Redlands Canal is allowed to place a call against Grand Junction's junior diversions, the upper range of the modeled firm yield decreases to 6,025 AFY. Again, in this run, the critical period occurs in spring of 2003, where Juniata is just able to meet criteria number 1 (**Figure 9**).

Figures 8 and 9 show that during the dry period, the modeled storage in Juniata does not track the historical storage well. However, this is due to the fact that the system demands were higher in the 1990's than the upper range of the current modeled firm yield. When the total system raw water demand is increased to 6,725 (as occurred in the 1990's), the modeled storage better tracks the historical data (**Figure 10**). This provides further confirmation that the model can reasonably simulate operations at different demand levels other than the firm yield amount.

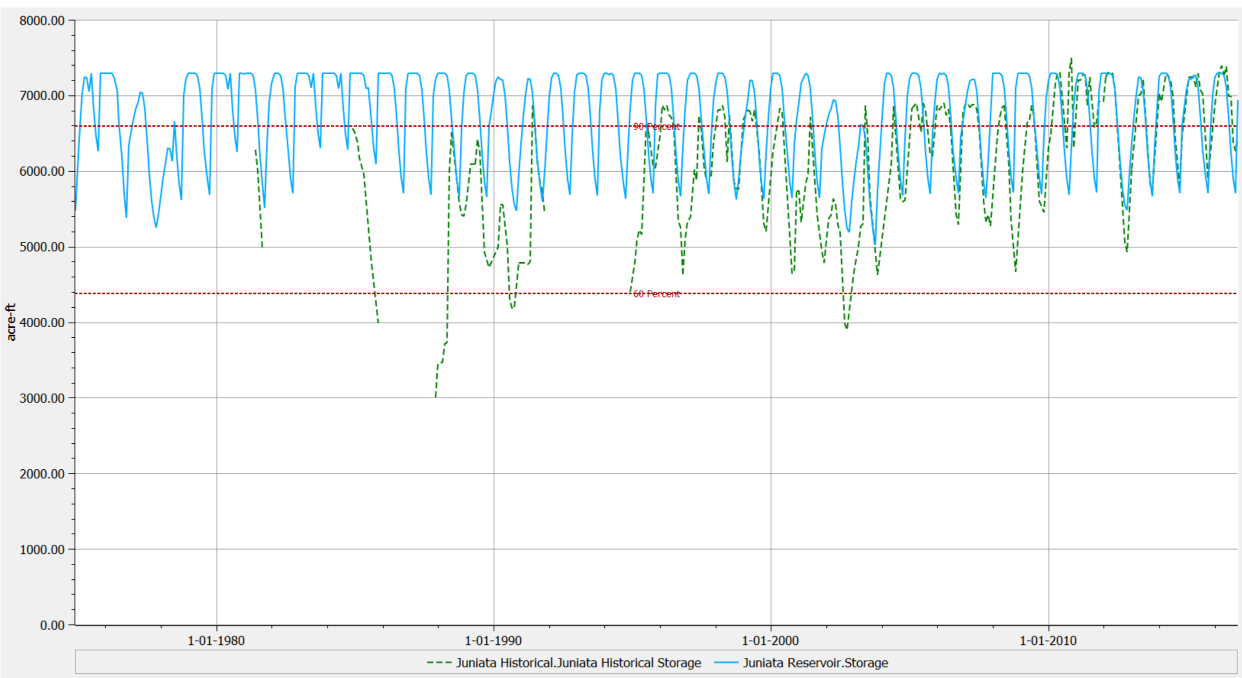

Figure 8. Modeled Juniata Reservoir storage for firm yield run not allowing Redlands Canal calls (firm yield 6,275 AF)

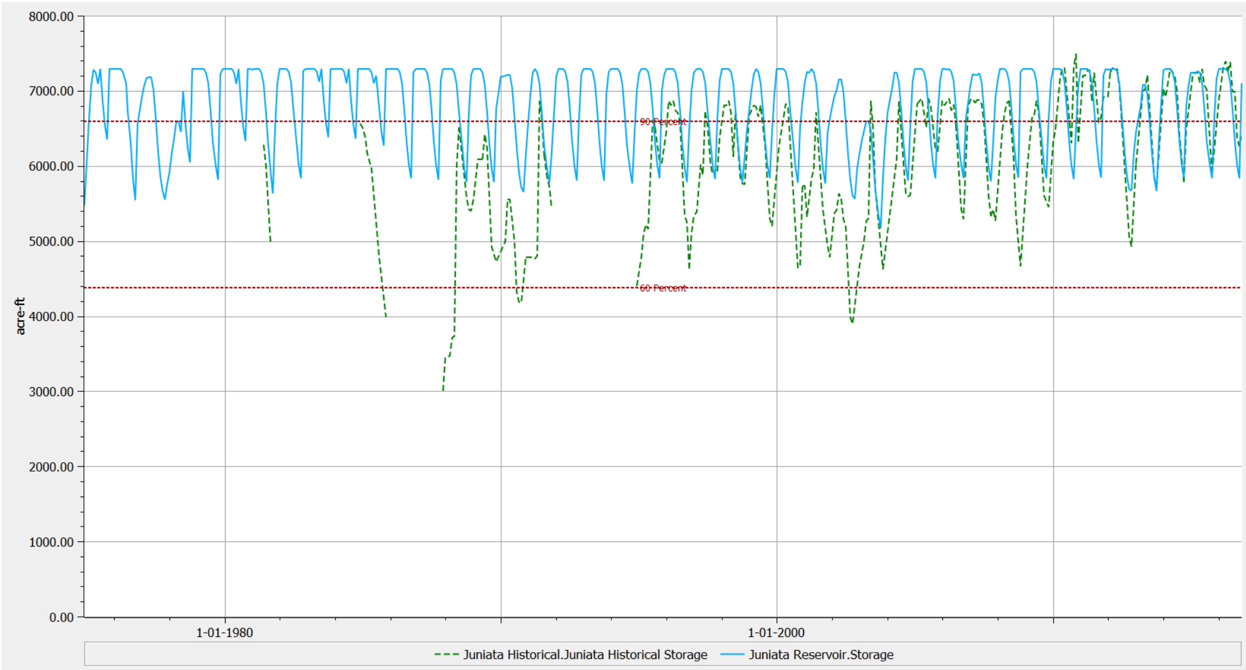

Figure 9. Modeled Juniata Reservoir storage for firm yield run allowing Redlands Canal calls (firm yield 6,025 AF)

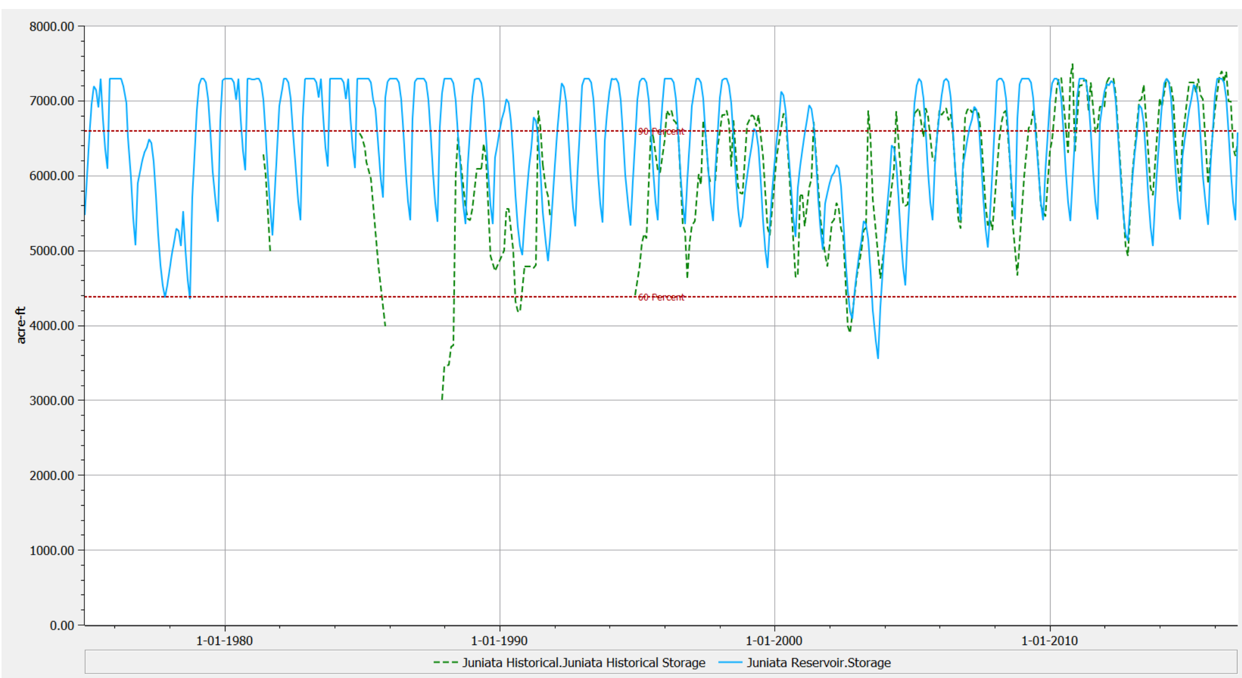

Figure 10. Modeled Juniata Reservoir storage with a total raw water demand of 6,775 AF (as occurred in the late 1990's)

6. SENSITIVITY TESTING

Lack of hydrologic data in many areas of the basin and over significant periods of time necessitated estimation of several inputs, including historical inflows to reservoirs, evaporation rates and variability, diversions at various structures, and streamflow at key locations. These inputs directly affect the firm yield of the water supply system. In our opinion, the estimates were developed with reasonable methods, and were calibrated to the extent possible to historical conditions. However, these inputs are estimates rather than measured observations.

In order to evaluate the relative impact these inputs have on the firm yield, we performed a sensitivity analysis. A sensitivity analysis involves multiple model runs where one input is systematically changed and the relative change in the input is compared to the relative change in the output. For the analysis, we tested inflows to Kannah Creek above the Grand Mesa reservoirs and evaporation rates. These two inputs were estimated due to lack of data and are the most likely inputs to have a significant impact on the firm yield.

The sensitivity testing provides the support for the range of system firm yield described in Section 5. When inputs were adjusted within a reasonable yet conservative range, the lower of the firm yield was determined to be 5,800 AF (raw water). While it is possible that the upper end of the firm yield range could increase based on the sensitivity testing (e.g. if hydrology is more favorable than was used to estimate model inputs), we do not recommend an increased amount for an upper end to the firm yield range that is higher than 6,275 AF as described in Section 5.

6.1 Inflow to Upper Reservoirs Sensitivity

Two different aspects of inflow to the Upper Reservoirs were tested: distribution of inflow above and below the Grand Mesa Reservoirs, and total flow in the Kannah Creek basin. During model input development, the total streamflow at the Kannah Creek Flowline diversion points, the simulated total flow above the Kannah Creek Flowline was within 1 percent of the historical amount (Section 3.2). However, the spatial distribution of flow originating above or below the Grand Mesa Reservoirs could not be determined from available data.

The initial inputs were developed using the distribution of inflow as estimated using the USGS StreamStats tool, which resulted in 49% of the inflow to the Kannah Creek Basin above Grand Junction's diversions simulated as inflow to the Upper Reservoirs and 51% simulated as gains below the Upper Reservoirs, but above the Kannah Creek Flowline diversion point. To evaluate the sensitivity of this distribution of inflows, we shifted a portion of the total Kannah Creek flow - as measured above Kannah Creek Flowline diversion point - above or below the Upper Reservoirs. Several runs were performed with various proportions of flow entering the system below and above the Upper Reservoirs **(Table 7)**.

Shifting the inflows so that 75% of the total Kannah Creek inflow occurs as gains to Kannah Creek below the Upper Reservoirs resulted in firm yield decreasing by 100 AF, or approximately 1.6% versus the baseline model run. On the other hand, shifting the flows so that 75% of the total Kannah Creek inflow occurs above the upper reservoirs, the firm yield showed a smaller decrease, only 25 AF. Because the firm yield criteria rely on both storage in Juniata Reservoir and storage in the Upper Reservoirs, and because model operations fill a portion of Juniata Reservoir with releases from the Upper Reservoirs, where inflows enter the reach above Grand Junction's diversion points on Kannah Creek has little impact on the firm yield, with the distribution that maximizes firm yield being approximately 50% above and 50% below the Upper Reservoirs. Therefore, the distribution of flow above and below the Upper Reservoirs is an insensitive input.

Table 7. Sensitivity to distribution of Kannah Creek inflows

Total Kannah Creek Flow Below GM Reservoirs	Total Kannah Creek Flow Above GM Reservoirs	Firm Yield (AF)	Change in Firm Yield (AF)	Failure Criteria
75%	25%	6,175	-100	Juniata 90% full summer 1978
60%	40%	6,200	-75	Juniata 90% full summer 1978
49%	51%	6,275	0	Juniata 90% full spring 2003
40%	60%	6,250	-25	Juniata 90% full spring 2003
25%	75%	6,250	-25	Juniata 90% full spring 2003

In addition to the distribution of inflow, the total inflow above the Grand Junction Flowline diversion was also tested for sensitivity in the firm yield analysis. In this analysis, we reduced the baseline inflow in all months by a specified percentage. The same reduction was applied to dry years and wet years. In contrast to the distribution of flows above and below the reservoirs, the total inflow to Kannah Creek is a sensitive input. As shown on **Table 8** and **Figure 11**, Firm yield is reduced by approximately 60% to 80% of the reduction to inflow to Kannah Creek. The model is less sensitive to smaller changes in Kannah Creek inflow than to more severe reductions, as indicated by the lower slope in Figure 10 from 2% to 15% flow reduction. In all model scenarios, the June 1978 historical month and Juniata filling to 90% criterion was the driving factor for firm yield determination.

Table 8. Sensitivity to Kannah Creek inflow reduction

Total Flow Reduction	Firm Yield (AF)	Change in Firm Yield (AF)	Change in Firm Yield (%)	Failure Criteria
2%	6,150	-125	-2%	Juniata 90% full spring 1978
5%	6,000	-275	-4%	Juniata 90% full spring 1978
10%	5,875	-400	-6%	Juniata 90% full spring 1978
15%	5,725	-550	-9%	Juniata 90% full spring 1978
25%	5,075	-1,200	-19%	Juniata 90% full spring 1978
50%	3,900	-2,375	-38%	Juniata 90% full spring 1978

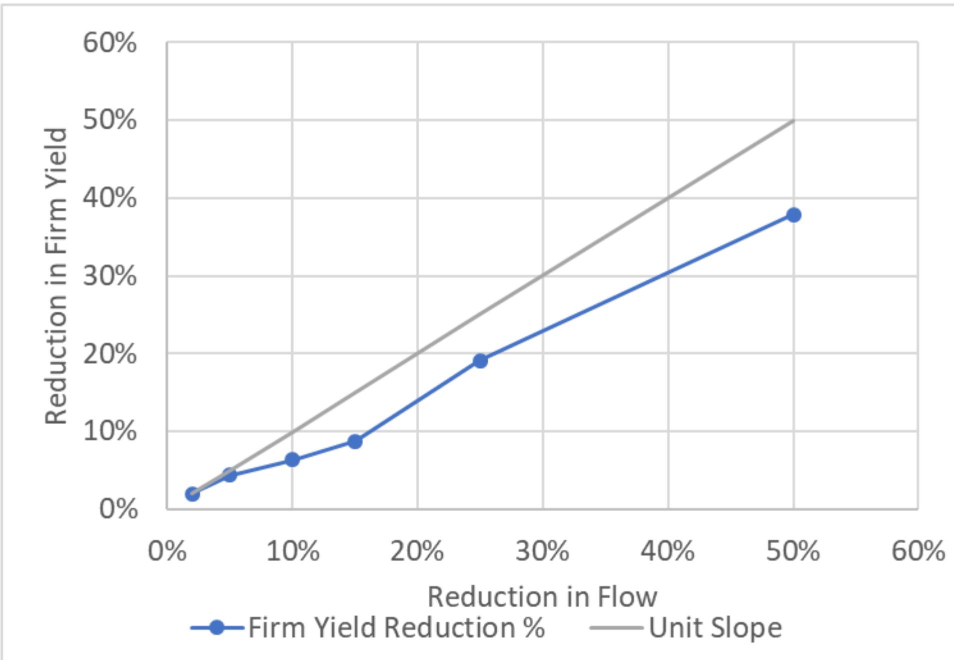

Figure 11. Percent reduction in firm yield relative to percent reduction in Kannah Creek inflow

6.2 Reservoir Evaporation Sensitivity

Based on conversations with Grand Junction staff, losses from the Upper Reservoirs average around 500 AFY and may be as much as 1,000 AFY in dry years. This variability is beyond the range seen at the Grand Junction 6 ESE weather station, which shows a maximum deviation of 14% above the average throughout the model period (see Section 3.3 and Figure 6). Additional losses to seepage in dry years or other climatic factors not seen at the Grand Junction 6 ESE station may account for some this difference.

To evaluate the effects of increased evaporation on modeled firm yield, we incrementally increased the modeled evaporation rate and variability by adjusting the parameters used to develop evaporation inputs as described in Section 3.3. This process resulted in five model runs with average annual total system evaporation ranging from approximately 1080 AF in the baseline (Upper Reservoirs and Juniata Reservoir) to 2,160 AF average annual evaporation. This process evaluated the effect on firm yield up to an approximately 100% increase from the baseline evaporation and quantified the effects on the modeled firm yield while keeping all other inputs static.

With the model targeting 2,000 AF of carry-over storage each year in the Upper Reservoirs, once the evaporation variability reaches somewhere between 30-50% over the baseline run, evaporation from the Upper Reservoirs causes them to fall below the 1,800 AF carry over criteria. This occurs due to a lack of water physically or legally available for diversion to fill the reservoirs in the preceding winter months of dry years. When this occurs, the only way to maintain 1,800 AF in the Upper Reservoirs is to go into the winter with more than the target 2,000 AF. Pursuant to the model logic, this can only occur if Juniata Reservoir is so full that there is not enough capacity to accept all the water from the Upper Reservoirs in excess of the target carryover of 2,000 AF in October, thereby keeping more than 2,000 AF in the Upper Reservoirs at the end of October. This is not a realistic scenario and is a result of strict adherence to the model logic. In addition, the parameters used to increase evaporation increase the evaporation rates in all months of the year. If evaporation rates in actuality are more consistent during the winter and the variability can be attributed to summertime evaporation rates, the increase in winter drawdown would not occur.

Therefore, we evaluated the firm yield enforcing only the Juniata fill criteria, and by not strictly enforcing the 1,800 AF Upper Reservoir carry over storage criteria. Results are shown in **Table 9** and **Figure 12.** Table 9 includes a row that shows how far below the 1,800 AF target the Upper Reservoirs fall. Increased evaporation causes a reduction in firm yield in a linear relationship at a rate of about 1 AF of firm yield per 2.3 AF of additional evaporation. **Figure 13** shows this relationship in terms of the percentage increase in evaporation compared to the percentage decrease in firm yield. This figure shows that although the firm yield decreases by 475 AF, this is a relatively small percentage reduction in comparison to the large percentage increase in evaporation needed to bring about such a reduction.

Given that Grand Junction staff have observed losses in the Upper Reservoir near 1,000 AF, it is prudent to consider this as a realistic hydrologic scenario even though observed pan evaporation rates located at the Grand Junction 6 ESE station do not suggest evaporation alone would cause this type of reservoir loss. Therefore, we consider 5,800 AF firm yield to be a reasonable lower end of the range of firm yield as described in Section 5.

Table 9. Evaporation sensitivity results

	Baseline	15% Increase over Baseline	45% Increase over Baseline	70% Increase over Baseline	90% Increase over Baseline	100% Increase over Baseline
Upper Reservoirs Average Annual Evaporation (AF)	599	696	895	1,035	1,163	1,231
Juniata Reservoir Average Annual Evaporation (AF)	481	560	686	787	886	936
Total System Average Annual Evaporation (AF)	1,080	1,256	1,581	1,822	2,049	2,167
Change in Total System Evaporation from Baseline (AF)	0	176	501	742	969	1,087
Firm Yield (AF)	6,275	6,175	6,075	5,975	5,850	5,800
Upper Reservoir minimum storage (AF)	>1,800	>1,800	1,791	1,740	1,691	1,668
Reduction in Firm Yield Relative to Baseline (AF)	0	(100)	(200)	(300)	(425)	(475)
Reduction in Firm Yield Relative to Baseline (%)	0%	-2%	-3%	-5%	-7%	-8%

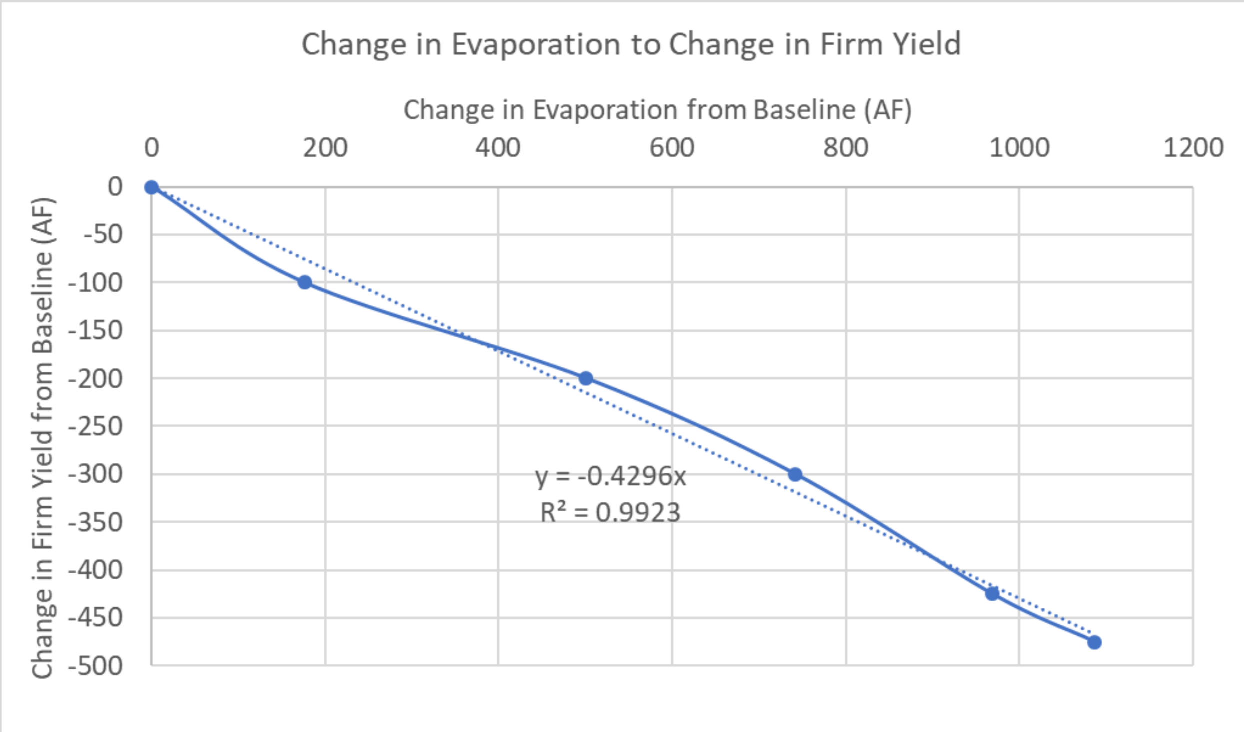

Figure 12. Change in volume of evaporation compared to change in firm yield

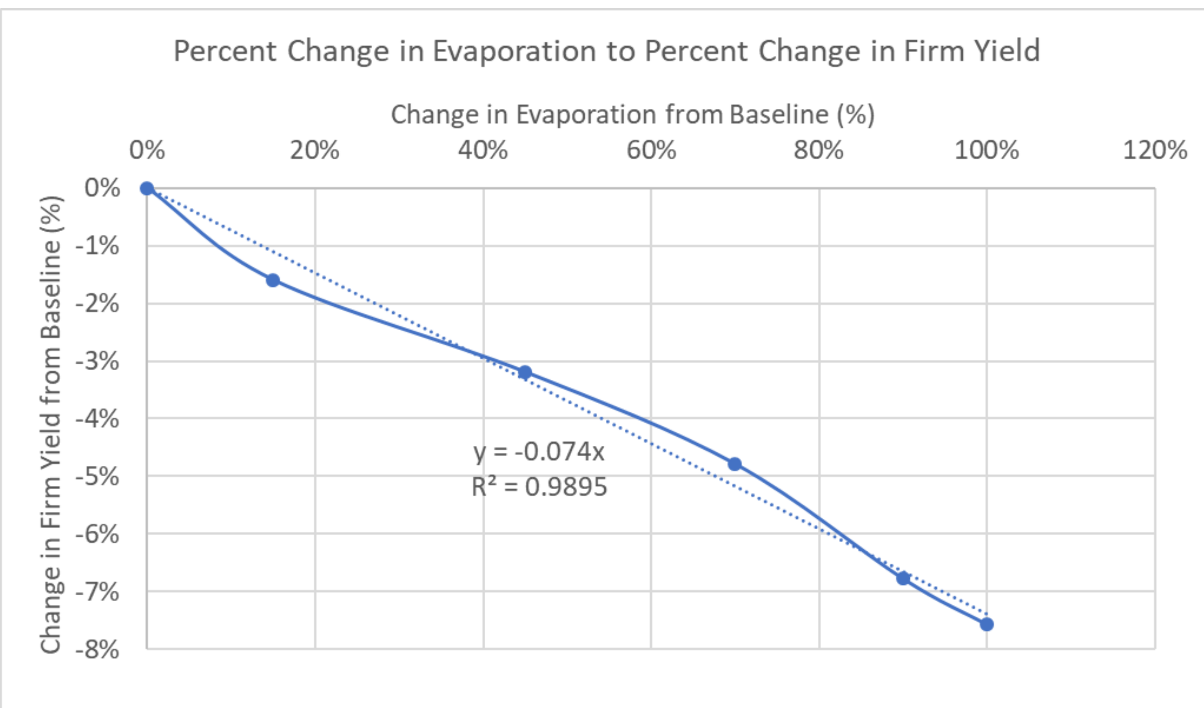

Figure 13. Percent change evaporation compared to percent change in firm yield

7. MODEL LIMITATIONS AND RECOMMENDATIONS

Natural hydrologic systems are complex and dynamic, dependent on a host of variables that cannot be fully captured in a model. The measure of the quality of a model is how useful it can be in illuminating reliability, system vulnerabilities, and testing various operational scenarios and potential changing hydrologic conditions. No matter how useful it is, every model has limitations, and users of the model should be well-versed in such limitations so that future analysis and results obtained from the model can be considered in the proper context. The following are key limitations to the current version of the RiverWare model developed for this project. For each model limitation discussed below, we provided a recommendation (denoted with a letter heading) for Grand Junction to consider for future water supply planning efforts. After the discussion on limitations, additional recommendations are provided.

1) **The firm yield model was developed with monthly historical hydrology**

   Historical hydrology is the basis for many firm yield models for water providers throughout the nation and world. For example, in Texas, water rights are only granted if the firm yield can be demonstrated through the "drought of record." Historical observations are the best predictor of future hydrological conditions. Nonetheless, the worst drought in the historical period will likely be exceeded at some point in the future. Historical gage records are rarely more than 100 years old with most records being only a few decades old. This period is relatively short when considering the length of time over which climatic events such as the Little Ice Age (ca 1400 CE), the Medieval Warm Period (ca 1000 CE) and the Roman Warm Period (ca 200 CE) have occurred.

   Use of historical hydrology means that if a more severe drought occurs than seen historically, the water supply system will not be able to deliver the firm yield and still satisfy the reliability criteria. This occurred recently in Cape Town, South Africa where an unprecedented drought began in 2015 and continues on as of the date of this report. In early 2018, Cape Town declared "Day Zero," the day on which water taps would be shut off due to lack of water. "Day Zero" was initially predicted for early April 2018. Drastic and severe water conservation measures pushed "Day Zero" out several months from the initial predicted April date. Rainfall in the winter (July – September) of 2018 appears to have alleviated the immediate threat of "Day Zero."

   The RiverWare model can be used to test a variety of different hydrologic conditions. Hydrology inputs can be altered in numerous ways to test the robustness of the firm yield computed with historical hydrology. The following are some examples:

- Rearrange historical inputs, including intentionally putting two or more known drought years in series to test reliability over a longer drought period.
- Adjust for potential climate change scenarios. Considering climate change can be accomplished from a simple percentage adjustment of relevant inputs (as was done in Section 6.1) to sophisticated methods that use down-scaled climate change global circulation model (GCM) predictions to estimate changes to historical flows.
- Stochastic methods can be used to develop hydrologic data with defined return intervals (e.g. a 1-in-100 year drought).

A) Grand Junction should consider testing variations on sequence and method of hydrologic input development. This will further its understanding of the system reliability when tested against hypothetical drought conditions that are potentially more severe than historical conditions. Additionally, as discussed above the use of monthly hydrology may have the effect of masking shortages during portions of a month with excess flow in other portions. Grand Junction should consider evaluating if the availability of water on a daily basis coincides well with monthly availability, or if adjustments to the monthly hydrology are warranted.

2) System Reliability Criteria

Grand Junction staff provided system reliability criteria primarily based on historical operating protocol and institutional knowledge. This is not necessarily a limitation because it based on years of experience operating the system. However, establishing defined system reliability criteria based on thorough system analysis can assist in providing additional technical support for the experience-based criteria or provide opportunities to modify existing criteria if appropriate.

As part of this project, we contacted several Grand Junction area water providers to inquire about reliability criteria used by other regional water providers. We received limited feedback from Ute Water Conservancy District (Ute Water) and the City of Glenwood Springs. Ute Water uses a 20% demand factor when developing its firm yield. That is, it develops a system that is able to deliver water to 120% of its anticipated demand. Ute Water did not provide other reliability criteria needed to meet that demand, such as any required storage levels. Glenwood Springs relies on two diversions points from tributaries to the Colorado River and has an emergency intake on the Roaring Fork River. It was our understanding that Glenwood Springs has not determined its system firm yield.

As a point of comparison with the Ute Water system, we simulated the Grand Junction system with demands increased by 20%. In that model run, Juniata Reservoir was nearly depleted, but water was still available in the Upper Reservoirs. Although not a perfect comparison with Ute Water, this indicates that the Grand Junction system has similar reliability characteristics as Ute Water uses.

B) Grand Junction should consider attempting additional outreach to regional water providers to understand other water provider system reliability criteria and assess whether such criteria would be appropriate for Grand Junction's system. This outreach may include water providers in other areas of Colorado or nearby states that have similar water supply system characteristics. The RiverWare model can be used to evaluate the effectiveness of any other reliability criteria.

C) Grand Junction should consider evaluating the effect of each of its reliability criteria on firm yield. Each of the reliability criteria directly affects the firm yield quantification. This recommendation was carried out in part as described in Section 6.1 when the Upper Reservoir criterion was relaxed for certain model runs, but may be useful for other of the reliability criteria. Sensitivity testing of different criteria will allow Grand Junction to weigh potential increases in risk associated with relaxing such criteria against gains in firm yield (and conversely any reduction in risk against reduction in firm yield).

Other Recommendations:

Gunnison River and Colorado River

In addition, decreed water diversions from the Colorado River and the Gunnison River were not included in the firm yield modeling. Water from these sources is vastly more plentiful than Kannah Creek but both rivers have degraded water quality especially in comparison to Kannah Creek sources. In the future, these sources could potentially be used to offset a portion of the demand from Kannah Creek sources. For example, potential opportunities for non-potable use of Gunnison River or Colorado River supplies could be evaluated and would have result in a higher firm yield for potable use from the Kannah Creek system.

D) Grand Junction should consider evaluating potential potable and non-potable water uses for Gunnison River or Colorado River supplies. This may include a water quality evaluation and/or consideration of different water treatment technologies that could best serve Grand Junction.

Colorado River Compact

The State of Colorado along with other Colorado River basin states (California, Arizona, Nevada, Utah, New Mexico, and Wyoming) have spent considerable effort evaluating the effect of a potential Colorado River Compact Call. As we understand it, water rights decreed prior to the signing of the Compact would not be subject to a call for water from downstream states, and therefore many of Grand Junction's rights would not be affected. However, Grand Junction uses junior 1993 and 1994 water right to fill many of its Upper Reservoirs.

E) *Grand Junction should consider evaluating the potential effect of the Colorado River Compact on its operation of junior water rights and develop a plan for operation under and maintenance of its more senior rights. This could include use of Aspinall Unit water as a substitute supply in the event that junior water rights are called out.*

<u>*Evaluation of Internal Operations*</u>
The model is also useful for evaluating the impacts of operational changes on the system yield. This may also be done in conjunction with modified hydrology as discussed above to evaluate how these changes may impact the system under future conditions.

F) *Grand Junction should consider evaluating operational changes that may result in an increased firm yield. These changes could include evaluating the timing of upper reservoir releases to Juniata Reservoir and forgoing the diversion of irrigation water in times of greater municipal demand.*

8. REFERENCES

Colorado Division of Water Resources. (2016, February). General Administration Guidelines for Reservoirs.

Spronk Water Engineers, Inc. (2018, April). Summary of Water Supply System, City of Grand Junction.

APPENDIX A

Note: RiverWare simulates beginning with Rule #59 first and moves to Rule #1 last.

8.1 Model Ruleset

Priority	Description
1	Sets the reservoir storage on the physical system equal to the sum of the storage in all accounts in the reservoir, allowing the object to solve
2	Sets the reservoir gain/loss on the physical system equal to the sum of the gain/loss in all accounts in the reservoir, allowing the object to solve
3	Releases a percentage of water in irrigation storage for delivery to Grand Junction Ranches
4	Diverts water from Purdy Mesa reservoir to meet the irrigation lease
5	Recalculates the amount in rule 13
6	Diverts leased irrigation water out of Grand Mesa Reservoir No. 1
7	Recalculates the amount in rule 13
8	Diverts leased irrigation water out of Deep Creek Reservoir
9	Recalculates the amount in rule 13
10	Diverts leased irrigation water out of Dry Creek Reservoir
11	Recalculates the amount in rule 13
12	Diverts leased irrigation water out of Grand Mesa and Scales Reservoirs
13	Calculates the total amount to release from Upper Reservoirs to Irrigation Leases based on user input in the "Irrigation Demand Input" data object
14	Decides whether to lease irrigation water from Purdy Mesa Reservoir if the reservoir is at least 75 percent full going into irrigation season, and lease from upper reservoirs if SWE is greater than 90%
15	Diverts water from Upper Reservoirs with partial ownership for use by non Grand Junction users
16	Diverts Upper Reservoir releases at the City Ditch
17	Diverts Upper Reservoir releases at the Juniata Enlargement Ditch
18	Sets the shrink on Upper Reservoir releases down to the City Ditch
19	Sets the shrink on Upper Reservoir releases down to the Juniata Enlargement Ditch
20	Sets the shrink on Upper Reservoir releases down to the Kannah Creek Flowline
21	Releases water from Bolen and BA&J Reservoirs per rule 33
22	Re-calculates the amount from rule 33
23	Releases water from Anderson Reservoir No 6 per rule 33
24	Re-calculates the amount from rule 33
25	Releases water from Anderson Reservoirs 1 and 2 per rule 33
26	Re-calculates the amount from rule 33

27	Releases water from Raber Click Reservoir per rule 33
28	Re-calculates the amount from rule 33
29	Releases water from Flowing Park Reservoir per rule 33
30	Re-calculates the amount from rule 33
31	Releases water from Carson Lake per rule 33
32	Sets the total release from the Upper Reservoirs to Juniata equal to the minimum of the remaining storage in Juniata and the amount in excess of the target carryover storage, taking into account reach and ditch losses
33	Calculates the amount of municipal and irrigation storage in the Upper Reservoirs
34	Divers water released from Somerville Reservoir at the Somerville Pipeline
35	Releases water from Somerville Reservoir to meet shortage at Somerville Pipeline
36	Sets the ditch losses on diversion objects based on user input in the "Reservoir and Reach Loss Input" data object
37	Recalls the RiverWare water rights solver
38	Sets the initial request at the Somerville Pipeline equal to the remaining WTP demand if Juniata storage is below 70 percent during the winter or if Juniata storage is below 25 percent during the irrigation season
39	Releases water from Juniata Reservoir to meet the remaining demands at the WTPs
40	Transfers water from all accounts in Purdy Mesa Reservoir into the irrigation account
41	Transfers water from all accounts in Juniata Reservoir into the municipal account
42	Transfers Grand Junctions pro-rata portion of water in reservoirs with shared ownership into their account
43	Sets the demand at the Kannah Creek/Purdy Mesa WTP
44	Sets the initial request at the City Ditch for delivery to Juniata Reservoir equal to the minimum of the remaining storage capacity and the input water right amount, taking into account ditch loss
45	Sets the initial request at the Juniata Enlargement Ditch for delivery to Juniata Reservoir equal to the minimum of the remaining storage capacity and the input water right amount, taking into account ditch loss
46	Calls the RiverWare water rights solver
47	Sets the initial request for the 3.91 Kannah Creek Flowline right diversion to Purdy Mesa Reservoir to the minimum of the remaining storage capacity and the amount not used for direct diversion or diversion to Juniata
48	Sets the initial request for the 3.91 Kannah Creek Flowline right diversion to Juniata Reservoir to the minimum of the remaining storage capacity and the amount not used for direct diversion
49	Sets the initial request for the 3.91 Kannah Creek Flowline right direct diversion to the WTP to the lesser of the water right input and the plant demand
50	Sets the initial request for the Paramount right diversion to Purdy Mesa Reservoir to the minimum of the remaining storage capacity and the amount not used for direct diversion or diversion to Juniata

51	Sets the initial request for the Paramount right diversion to Juniata Reservoir to the minimum of the remaining storage capacity and the amount not used for direct diversion
52	Sets the initial request for the Paramount right direct diversion to the WTP to the lesser of the water right input and the plant demand
53	Sets the gain/loss slot on each reservoir account based on the user input in the "Reservoir and Reach Loss Input" data object
54	Sets the initial diversion request at each Upper Reservoir in which Grand Junction is a partial owner from November to June equal to amount needed to fill the reservoir
55	Sets the initial diversion request at each Upper Reservoir used for irrigation storage from November to June equal to amount needed to fill the reservoir
56	Sets the initial diversion request at each Upper Reservoir used for municipal storage from November to June equal to amount needed to fill the reservoir
57	Diverts the inflow to the Grand Junction WTP to meet non-potable demand at the "Nonpotable" diversion account
58	Diverts the inflow to the Grand Junction WTP to meet potable demand at the "Potable" diversion account
59	Sets the inflow to the Grand Junction WTP reach (including non-potable use) to the sum of the diversions to the plant

8.2 Initialization Rules:

Index	Description
1	Sets the demand at the Grand Junction WTP based on user input in the "WTP Demand Input" data object
2	Sets the demand at the Kannah Creek/Purdy Mesa WTP based on user input in the "WTP Demand Input" data object
3	Sets initial values on the physical system that are required for the model to run
4	Sets initial values for reservoir storage based on user input in the "Reservoir Storage Input" data object
5	Sets the initial request for all water rights based on the user input in the "Non GJ Water Rights Input" and "GJ Water Rights Input" data objects

DiNatale
WATER CONSULTANTS

MEMORANDUM

TO: Randi Kim, Mark Ritterbush, Jamie Beard (City of Grand Junction)

FROM: Stephen Buechner, PE and Matt Bliss, PE (DiNatale Water Consultants)

SUBJECT: Water Supply Analysis in support of a finding of diligence for the Gunnison River Pipeline Water Right

DATE: July 9, 2019

Grand Junction will file an application seeking a diligence finding for its conditional water right on the Gunnison River in September 2019. The City of Grand Junction contracted DiNatale Water Consultants (DiNatale Water) to prepare a water supply analysis to support the application. The analysis evaluates Grand Junction's water demands on a 50-year planning horizon, the water supply generated by the conditional Gunnison River right and demonstrates that Grand Junction can and will use the conditional Gunnison River right.

1. GUNNISON RIVER CONDITIONAL RIGHT BACKGROUND

In July of 1959, Grand Junction obtained a conditional water right for the Grand Junction-Gunnison River Pipeline in Civil Action 8303 of the Mesa County District Court (CA8303) with an appropriation date of January 22, 1957. This water right was decreed for domestic, municipal and industrial uses in the amount of 120 cubic feet per second (cfs) of water. CA8303 granted a conditional priority to this Gunnison River Pipeline right, which means that Grand Junction must demonstrate through periodic findings of diligence that they have put this water right to a beneficial use or are working towards doing so. In the last 60 years since this adjudication, numerous diligence proceedings have been held and a total of 18.6 cfs of this 120 cfs water right has been made absolute (i.e. no longer conditional) while the remaining 101.4 cfs remains conditional.

In the most recent diligence proceeding represented by Case No. 13CW3004, the Water Division 4 Engineer's Office (Division 4) issued a letter recommending a finding of reasonable diligence for the Gunnison River Pipeline right. However, the letter contains the following statement:

> *The applicant should be aware that as this right is 54 years old and we have no record in our files of a water supply analysis addressing the elements required for a governmental entity to make a non-speculative conditional appropriation,*

> *as stated in* Pagosa Area Water and Sanitation District v. Trout Unlimited*, that this office will require such an analysis prior to recommending continued diligence in 2019. This study can include projected demand within the City of Grand Junction service area for up to a 50 year planning period pursuant to the ruling in* Pagosa Area Water and Sanitation District v. Trout Unlimited*.*

The Pagosa ruling cited in the Division Engineer's 2013 letter deals with the elements necessary for a governmental entity to make a non-speculative conditional appropriation. In that case, the Pagosa water districts were attempting to obtain a conditional water right. That case differs from the Grand Junction Gunnison River conditional water right at issue in this case because Grand Junction is not applying for a new conditional water right. Grand Junction seeks only to demonstrate diligence on an already-decreed conditional water right. Therefore, it is not clear that Grand Junction must meet the requirements laid out in the Pagosa ruling as indicated by the Division Engineer's 2013 letter, and instead must only demonstrate diligence towards completing the decreed appropriation.

The Pagosa decision discusses several "reality checks" that were built into the proposed decree for the conditional rights sought in that case. No such "reality checks" or other terms and conditions were included in the original Gunnison conditional water right decree from CA8303. A recent ruling in Water Division 1 clarified that terms and conditions cannot be added to a conditional water right decree through diligence proceedings (ruling in Case No. 15CW3065, Division 1). Therefore, addition of terms and conditions to the Gunnison decree would not be appropriate, and Grand Junction must only demonstrate diligence towards perfecting the water right and that it can and will perfect the water right. To that end, this report demonstrates the ongoing need for the water right and Grand Junction's ability to use it. In addition, the application for diligence lists several other factors that support a finding of diligence.

2. EXISTING FACILITIES

Grand Junction operates an integrated water supply system that serves a portion of the entire City of Grand Junction, primarily in the City Center area. The Gunnison River Pipeline water right can be integrated into the system and has been used in the past in the Grand Junction system. Grand Junction derives its primary water supply from the Kannah Creek watershed. Kannah Creek is a tributary to the Gunnison River approximately 20 miles southeast of the city. Water from Kannah Creek is a higher water quality than the Gunnison River, and therefore is the preferred water source for Grand Junction. Grand Junction recently completed modeling of the firm yield of its Kannah Creek water supply system.

The modeling determined that the Kannah Creek supplies can reliably deliver between 5,800 and 6,275 AF of water per year, depending on assumptions related to Grand Mesa reservoir evaporation and inflows. Of this amount, approximately 350 AF is dedicated to the Kannah Creek water treatment plant and other non-potable uses, resulting in delivery of approximately 5,450 to 5,925 AF to the existing water treatment plant through two existing pipelines, also known as flowlines. Grand Junction also has water rights on the Colorado River that are used primarily to meet some non-potable water demands.

In the past, Grand Junction has used water from the Gunnison River to meet peak summer demands and blended this water into the potable supply from the Kannah Creek flowlines. In recent years, water demand has decreased due primarily to increased water conservation efforts and Gunnison River supplies have not been required. In addition, more recent water quality standards related to turbidity make this practice more challenging with the current direct filtration water treatment process. The city is currently undertaking a water filtration study to evaluate its water treatment options for treating the Gunnison River water supply.

The Gunnison River Pipeline diversion point is constructed on the east bank of the Gunnison River at the Redlands Power Canal river check structure and diversion facility. Water is delivered from the diversion point into a wet well beneath the existing pump station. The pump station has three pump skids. On a site visit in July 2018, we observed two pumps on-site and the third pump was being repaired. The pumps currently installed have a combined capacity of 4.9 cfs and can deliver water to the Grand Junction water treatment plant through an existing 18-inch pipeline. Capacity is limited by the current installed pump sizes and in the past, larger pumps have been used to obtain the amount made absolute in previous cases.

3. FUTURE WATER DEMAND

This water supply analysis for the City includes a 50-year timeframe for evaluation of future water demands in Grand Junction.

Current Water Demand

To properly evaluate future water demands for Grand Junction, DiNatale Water first identified the City’s current water demands and the prospective changes to this demand that will occur in the coming 50 years. To quantify current water demands, DiNatale Water coordinated with City personnel to evaluate the City’s water service area and water consumption data in recent years. Grand Junction provided water usage for potable and non-potable water users located within their service area for every year from 2010-2018.

The Grand Junction Utilities Department serves a portion of the entire City of Grand Junction. Other portions of the City are served by Ute Water District and Clifton Water District. The service area for Grand Junction Utilities is shown on **Figure 1**.

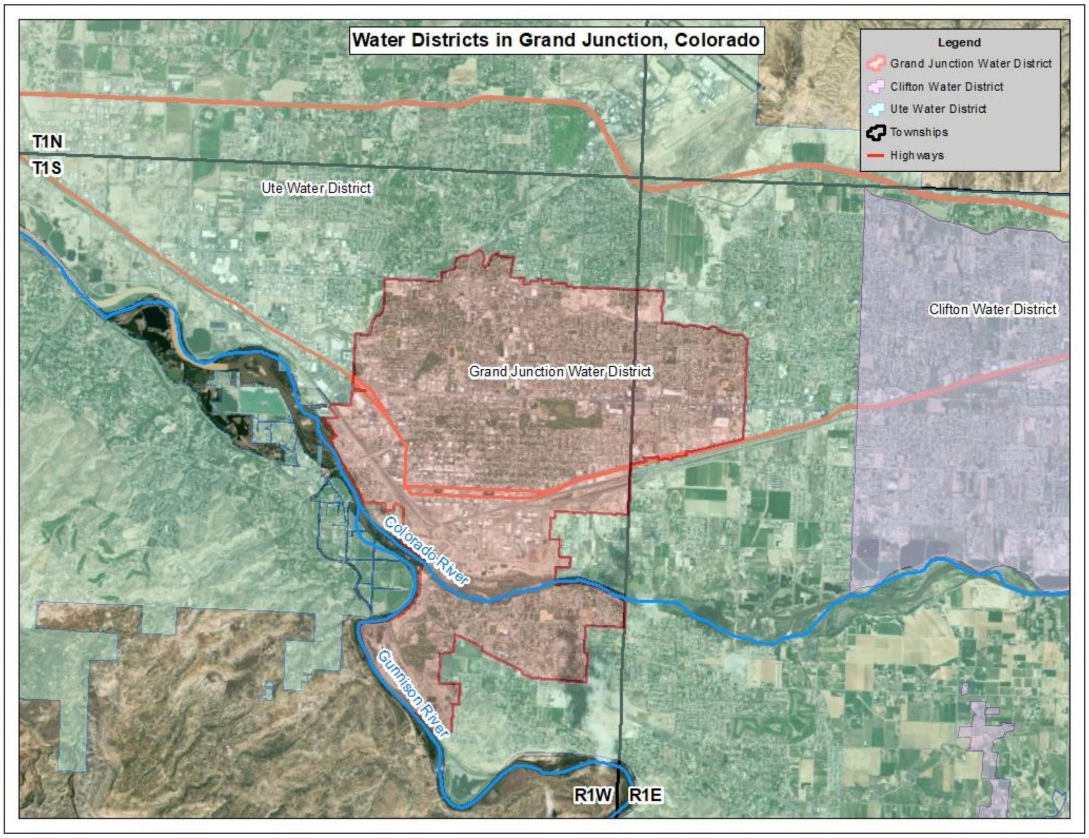

Figure 1. Water Utilities in Grand Junction, CO

The water usage data provided by the City was broken down into metered water use, raw water deliveries to a local cemetery, raw water sales to customers off the water service lines, water leased to City ranch properties, and supplemental irrigation water occasionally leased to irrigators by auction. The metered water use represents a total of all of the City's domestic water customers, all customers located off of Kannah Creek, any water the Grand Junction Parks Department uses for repayment to Ute Water District and any bulk water sales from the fill stations in the distribution system. Grand Junction also provided estimates of system loss within their distribution system. DiNatale Water totaled all of the potable and non-potable uses and applied the system losses to the appropriate metered water deliveries to identify the current annual raw water demand for the City in **Table 1** from 2010-2018.

Table 1. Grand Junction Utilities Annual Water Demands

Year	Metered Water Deliveries (AF)	System Losses (AF)	Water Treatment Plant Deliveries (AF)	Kannah Creek Deliveries* (AF)	Raw Water Deliveries** (AF)	Total Water Demand (AF)
2018	4,881	422	5,303	45	2,852	8,200
2017	4,966	425	5,391	45	5,779	11,216
2016	4,789	288	5,076	45	5,736	10,857
2015	4,534	339	4,873	45	4,991	9,910
2014	4,351	497	4,848	45	5,367	10,260
2013	4,474	583	5,057	45	4,671	9,773
2012	5,074	660	5,734	45	3,499	9,278
2011	4,690	607	5,297	45	6,857	12,199
2010	4,994	662	5,656	45	5,619	11,320
Average	4,750	498	5,248	45	5,041	10,335

**City personnel estimate 45 ac-ft/yr delivery to Kannah Creek Watershed Municipal Users*

***Includes raw water sales, supplemental irrigation leases, deliveries to cemetary and deliveries to City ranches*

Population Growth

DiNatale Water discussed future growth estimates with Grand Junction Planning Department personnel to estimate future potable water use for the City. Grand Junction's Planning Department uses a 1.4% growth rate for the City based on recent measured population growth. We applied this growth rate to the population within the Grand Junction Utility water service area using the 2010 US Census data and also to an estimate of 2017 population in the service area.

The population according to the 2010 US Census is considered to be the most accurate measurement of population within the Grand Junction service area because the census counts population at the parcel level. No census-level population counts are available for more recent years. However, Grand Junction planning staff have made population estimates through 2017 on the census tract level, which are larger than the more detailed census data. The census tracts do not exactly align with the Grand Junction water service area boundaries, so Grand Junction GIS professionals assisted DiNatale Water with estimating the population within the service areas in 2017 by scaling the tract populations based on the area of each tract within the City's Utility service area, resulting in an estimated 2017 population of approximately 29,500.

We used both the 2010 census-based population and the 2017 estimated population and projected population in 2069 using the 1.4% growth rate. Beginning with the 2010 population, the projected future population is approximately 63,000 people. Beginning with the 2017 population estimate, the future projected population is approximately 61,000 people. As a conservative measure, DiNatale Water chose to use the smaller of the two projections for estimating future demand.

Additionally, DiNatale Water opted to reduce this projected population metric as future growth within the City's water service area will be limited by the space available surrounding the current service area. The 1.4% growth rate was developed city-wide and was not limited to the water utility service area. Within the current water service area, population growth will result primarily from infill development and increasing density of land use, rather than development or new lands within the current service area. Therefore, DiNatale Water reduced the future population estimate by 20% within the current water service area in the year 2069 to be approximately 49,000.

The City Center of Grand Junction is experiencing an increase in the amount of infill development within the City's service area. Land use within the service area has become denser as parcels that historically served single family homes or were unoccupied have been developed into apartment buildings and hotels. Grand Junction Planning Department personnel provided several examples of this type of infill development where an increase in water demand is expected due to a change to the land use of the same area. DiNatale Water mapped these examples on **Figure 2**.

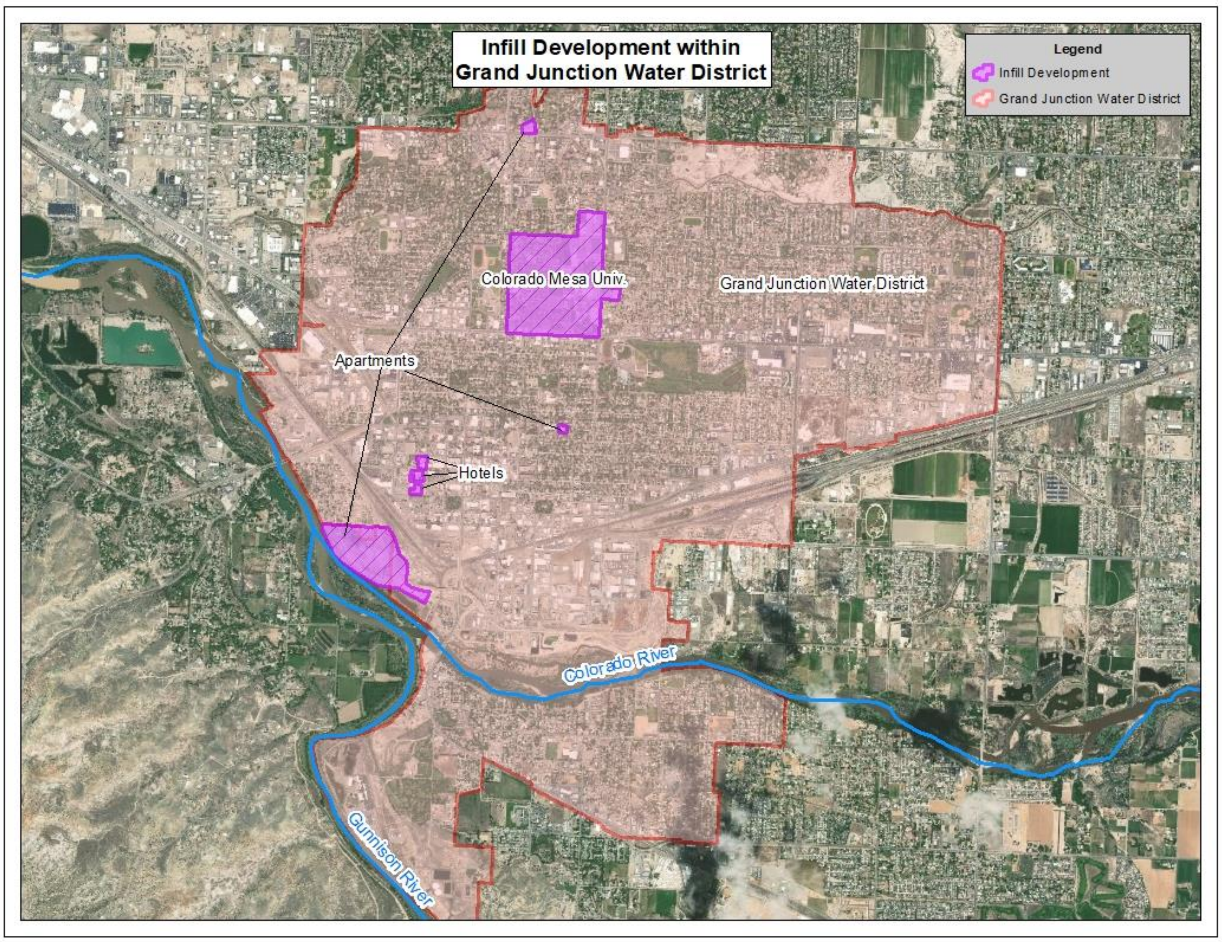

Figure 2. Examples of Infill Development Within Grand Junction Utilities Service Area

The examples provided by the City indicate that infill development is occurring and will results in higher water use within the current service area, even without an expansion of the land area of the City's water service area.

Using the current per capita potable water demand and the projected population for 2069, DiNatale Water estimates an annual treated water demand of 8,760 acre-feet (AF) as measured as production at the water treatment plant. This is 3,460 AF more than the current potable water treatment plant production demand of 5,300 acre-feet in 2018. An average annual direct flow rate of 4.77 cfs could satisfy this increased annual demand if there were no system losses and water was delivered consistently throughout the year. However, there are many other considerations one must make when delivering treated water. In order to deliver treated water to customers, additional raw water must be diverted from the stream system to account for treatment losses, distribution system losses and additional distribution considerations. In addition, water can be stored in reservoirs at higher rates when available and released at lower rates when needed. Therefore, a diversion rate from the stream system in excess of the treated water delivery rate is needed to support the water storage, treatment, and delivery processes. Further, the treated water demand varies throughout the year, with summer months requiring more water delivered to the system than winter months. This monthly variability in water use by customer class is demonstrated in **Figure 3** below, which was taken from the 2018 Water Supply Inventory.

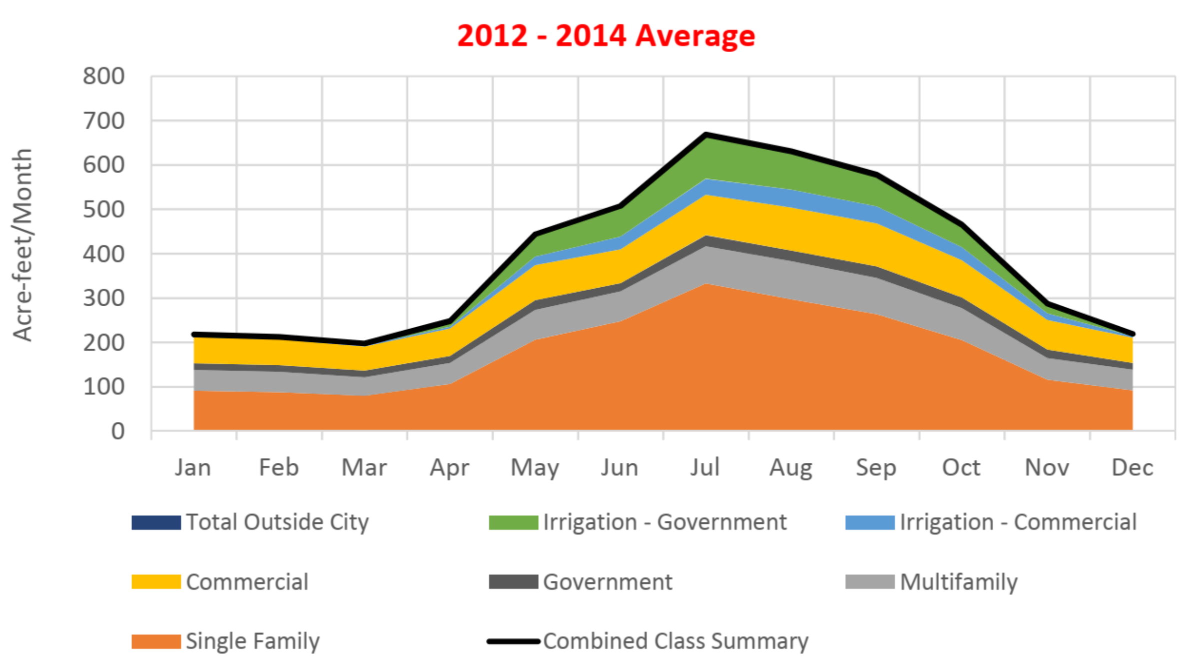

Figure 3. City of Grand Junction Water Use by Customer Class

DiNatale Water reviewed the data from the Water Supply System Summary for the City of Grand Junction and found that the month of July accounted for approximately 14% of the annual water use in recent years (2010-2017). To deliver 14% of the increased annual water demand in one month, an average monthly flow rate of 7.88 cfs would be needed.

Finally, a water treatment plant must account for daily variations in water demand. Water demands from customers can vary from day to day, and even hourly as there are greater demands in the evening hours than in the middle of the night. To account for these daily and hourly variations, DiNatale Water applied a peaking factor of 2.0. Using this peaking factor and the maximum water demand in any one month and the projected population increases expected within the Grand Junction Utilities service area, DiNatale Water estimates that potable water demands in 2069 could increase by 15.76 cfs during peak water treatment plant production. This 15.76 cfs is an estimate of the increase in water demand above and beyond the current 2018 water demands. Recent peak demand at the Grand Junction water treatment plant reached 15.11 cfs in June 2017.

Non-Potable Use

In addition to increased potable water demands for the City of Grand Junction, there are numerous opportunities for the Gunnison River Pipeline right to serve non-potable demands for the City. Non-potable use presents an opportunity for using the Gunnison River Pipeline water right because water diverted from the Gunnison River is typically lower quality than the Kannah Creek water, and may be more suitable for non-potable uses than to treat the water to potable standards. **Figure 4** shows that there are numerous parks and potential uses of non-potable water located within and near the Grand Junction Water District service area. At this time, the City has sufficient water supply from the Kannah Creek watershed and its Colorado River sources for the parks within the service area. However, as population within the service area increases, there will be additional demand for the higher quality Kannah Creek water for potable delivery, and the Gunnison River water will become an increasingly viable option for non-potable use.

The Gunnison River has relatively high levels of turbidity which can cause degradation of irrigation systems used in City parks. Grand Junction is currently exploring water treatment options for the Gunnison River. However, one method that would reduce turbidity is to store the water and allow particulates to settle out of the water. Storing the Gunnison River conditional water right prior to delivery into a non-potable irrigation season may be one of the most cost-effective means of using this water right for non-potable uses. If such a method were implemented, the high flow rate of the claimed water right would be useful to fill storage capacity quickly, but also to periodically flush the storage vessel of accumulated particulates.

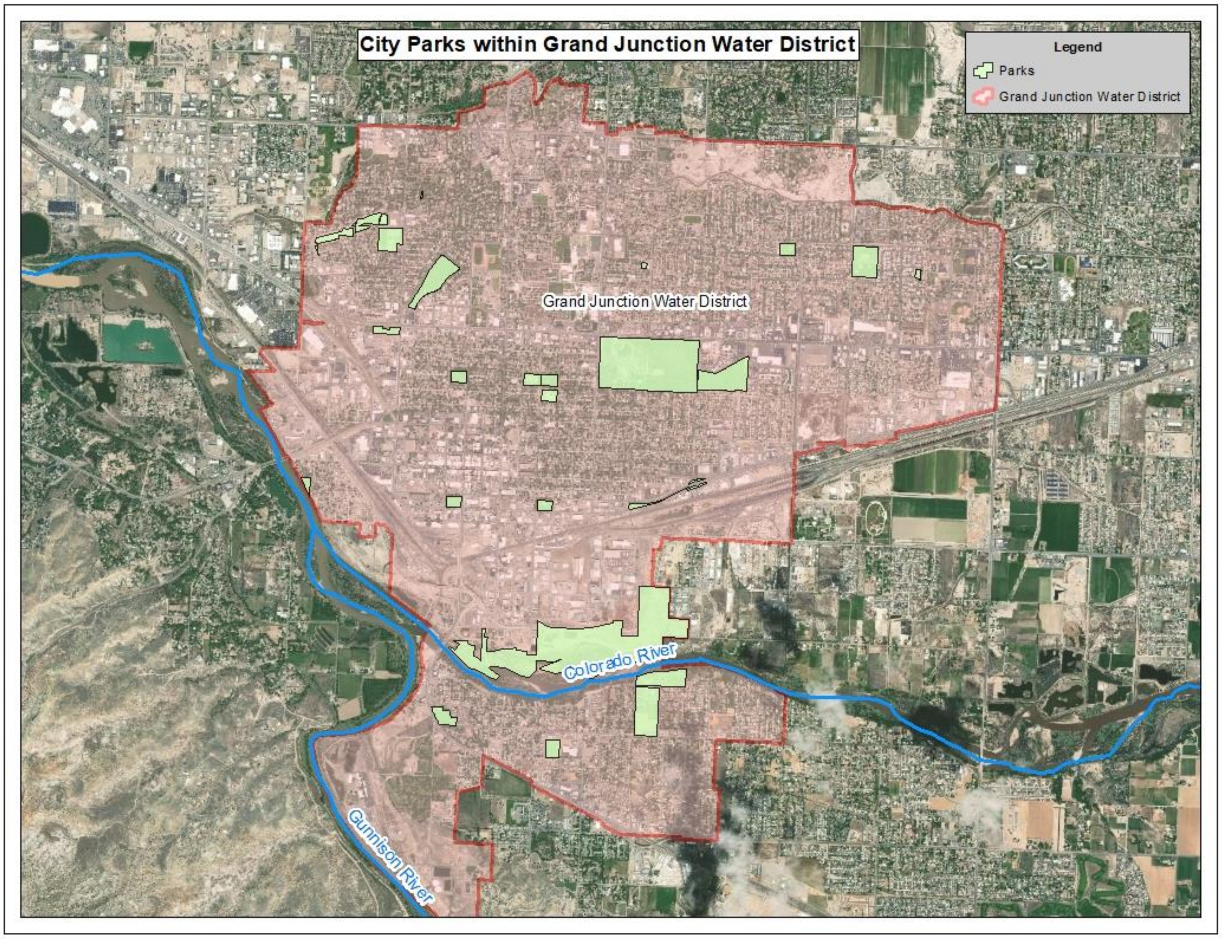

Figure 4. Parks within Grand Junction Utilities Service Area

Kannah Creek Watershed

In addition to the primary water service area within Grand Junction, the City also serves some residential users within the Kannah Creek watershed. Kannah Creek is a tributary to the Gunnison River located upstream from the Gunnison River Pipeline right diversion point and is the source of the two flow lines that serve the City's water treatment plant (Kannah Creek Flow Line and Purdy Mesa Flow Line). Therefore, additional demand within this service area will reduce the water supply from Kannah Creek available to the primary service area, increasing the potential demand on the Gunnison River water right for water within the primary service area. The current water demand for the Kannah Creek water users is relatively small (45 AF per year). Assuming a similar growth rate in this region as for Grand Junction results in a projected future demand of approximately 90 AF.

Interconnects to Other Water Utilities

Grand Junction Utilities has interconnects with both the Ute Water District and Clifton Water District for potential use in the event of drought or an emergency such as infrastructure failure. By connecting these utilities' distribution networks, the utilities provided redundancy to ensure a sufficient water supply in such conditions. This interconnectivity represents a potential demand for potable water on the Grand Junction system that exceeds demands within its service area discussed above. The ability to divert and potentially store additional water supply from the Gunnison River is important to maintain Grand Junction's ability to deliver water to neighboring districts if needed by those districts. Water stored in Grand Junction's Grand Mesa Reservoirs are delivered through the existing flowlines to the City. During peak summer months, the flowline capacity is needed for demands with the current service area. Additional water to deliver to neighboring districts therefore, could not use the flowlines from Kannah Creek. The Gunnison River pipeline is situated near the water treatment plant and could deliver such a supply.

The City entered into an agreement with the Clifton Water District that allows Grand Junction to take delivery of Clifton water, and to deliver water to Clifton through an existing pipeline that connects the two entities. The current agreement allows for a water supply of up to 4.5 million gallons per day (MGD) which is equivalent to 6.96 cfs, although additional water could be delivered in an emergency situation. The City has a verbal agreement with the Ute Water District for an emergency water supply which can be delivered through the 8 points of interconnection between the Grand Junction and Ute Water systems. Grand Junction staff report that the largest of these interconnects has a capacity of over 10 MGD, which is approximately 15 cfs.

Use within Grand Junction City Limits

In addition to emergency use through the interconnect agreements, the Gunnison River conditional right was decreed for use within the City of Grand Junction. Therefore, the water right could be used in areas outside the City water service area and used within the city limits of Grand Junction, including in areas currently served by Ute Water. While no formal discussions with Ute Water have taken place, this water source is available to supply approximately an additional 50% of the current and future projected population of the current Grand Junction Utilities water service area discussed above, which is approximately an additional population within Grand Junction city limits of 54,000 people.

Storage

Grand Junction may be able to store water under the Gunnison River Pipeline water right. Although not specifically named as a use in the original decree, storage is at times an understood use in a municipal system, such as was confirmed by the Supreme Court for the

City's Paramount Right in Kannah Creek. In addition, several of the summary of consultation documents from previous diligence proceedings indicate storage as a contemplated use for the Gunnison conditional right (e.g. Case Nos. 87CW84 and 93CW182). As discussed above, storage for non-potable uses with the current service area and within the city limits would relieve demand pressure from the potable water system as population increases. Further, the City is in the early planning stages of a potential augmentation plan to protect against potential future Colorado River compact calls, as described below that would use the Gunnison conditional water right in a local storage facility.

Colorado River Compact Protection

The City of Grand Junction is uniquely located at the mouth of the Gunnison River as well as near the Colorado River near the Colorado state boundary. Having water rights tributary to the Colorado River that are likely junior to the Colorado River Compact necessitates that the City be aware of the potential impact of a call associated with the Colorado River Compact. The possibility of a compact call under the 1922 priority of the Colorado River Compact would likely disallow use of the 1957 Gunnison River Pipeline right as well as a number of the City's additional water rights in the Kannah Creek watershed. Therefore, Grand Junction is in the initial stages of considering a plan for augmentation on the Colorado River that would involve storing flows from the Gunnison River Pipeline right when there is no compact call, and, during periods of a compact call, releasing the stored water to augment any out-of-priority depletions from other City water usage, including use of its Kannah Creek water rights. If pursued further, such an augmentation plan would need to be adjudicated in Water Court before implementation, but remains a valid and beneficial consideration for the City to use its Gunnison River Pipeline right to anticipate future Colorado River call conditions.

4. WATER SUPPLY ANALYSIS

The Gunnison River Pipeline water right was originally decreed for 120 cfs and 18.6 cfs of this right has already been made absolute. The intended infrastructure for this water right involved two parallel pipelines delivering water from the Gunnison River to the City of Grand Junction directly for use in the City's potable and non-potable water systems. DiNatale Water evaluated flows in the Gunnison River along with call records for Division 4. Since the beginning of the diligence period through the present (September 2013 through May 2019), there has not been a call in effect at the Gunnison River Pipeline diversion point and flows below the diversion point regularly exceed the claimed 120 cfs (Colorado DWR gage station GUNREDCO). Therefore, there continues to be sufficient water physically and legally available at the point of diversion.

In 2018 the City of Grand Junction developed a water supply model to determine the firm yield of its Kannah Creek water supply. The model determined the firm yield to be between 5,800 AF and 6,275 AF depending on various assumptions related to Grand Mesa reservoir evaporation and inflows. Once reduced for non-potable deliveries, and treatment and distribution system losses, this results in approximately 5,450 to 5,925 AF delivered to customer taps within the service area. When compared to Table 1, it is clear the Kannah Creek supplies are sufficient for the current potable water demand. However, as discussed in Section 3, population increases within the Grand Junction service area are projected to cause an increase in demand that will exceed the Kannah Creek firm yield, making the Gunnison River pipeline an important component in the Grand Junction system.

5. CONCLUSIONS

Based on our review of available information, DiNatale Water Consultants finds that the City of Grand Junction can and will put to beneficial use the entire 120 cfs of the Gunnison River Pipeline Right originally decreed in CA8303 based on the following:

- Future population increase projected through 2069 will approximately double within the Grand Junction Utility water service area resulting in increased water demands. Population increases will occur primarily through ongoing infill development and higher density development within the service area.
- As potable demands increase, use of the Gunnison River Pipeline water right for non-potable water will become an increasingly viable option.
- Demands in the Kannah Creek water service area will increase resulting in less Kannah Creek water available to the primary service area.
- Interconnect agreements with Clifton and Ute Water may place high demands on the Grand Junction system in the event of an emergency.
- The Gunnison River Pipeline water right is decreed for use within the entire City of Grand Junction and is not limited to the Grand Junction Utility water service area.
- The city is evaluating options to use stored Gunnison River Pipeline right water to meet non-potable uses or as a means to protect the city from potential future Colorado River Compact calls.

In addition to these reasons that show Grand Junction can and will use the Gunnison River Pipeline right, during the diligence period the city has diligently pursued completion of the appropriation through the following:

- Multiple investments in the integrated water system into which the Gunnison River Pipeline right can be delivered
- Studies and modeling regarding the city's water resources and firm yield of water rights from the Kannah Creek watershed
- This water supply analysis
- Participation in a USBR water marketing grant program
- Initial evaluation of potential uses of storage of the Gunnison River Pipeline right

Therefore, DiNatale Water finds that Grand Junction has met its burden to demonstrate it can and will develop the Gunnison River Pipeline water right and that it has been diligent in its efforts to complete the appropriation.

Options Assessment for the City of Grand Junction Water Supply

City of Grand Junction, CO

July 7, 2020

Project No. 117086

Revision 6

Options Assessment for the City of Grand Junction Water Supply

Prepared for

City of Grand Junction

Grand Junction, CO

Project No. 117086

Revision 6

7/7/2020

Prepared by

Burns & McDonnell Engineering Company, Inc.

Centennial, Colorado

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ABBREVIATIONS

Abbreviation	Term/Phrase/Name
AACE	Association of Advancement of Cost Engineering
AF	Acre Feet
BMcD	Burns & McDonnell Engineering Company, Inc.
CDPHE	Colorado Department of Public Health and Environment
cfs	Cubic Feet Per Second
CCS	Corrosion Control Study
CCT	Corrosion Control Treatment
City	City of Grand Junction
Clifton	Clifton Water District
EOPCC	Engineer's Opinion of Probable Construction Cost
gpcd	Gallons Per Capita Per Day
gpm	Gallons Per Minute
GRPS	Gunnison River Pump Station
HGL	Hydraulic Grade Line
IFC	International Fire Code
KCFL	Kannah Creek Flow Line
kWH	Kilowatt Hour
MCL	Maximum Contaminant Level
MF	Microfiltration, Membrane Filtration
mgd	Million Gallons Per Day
mg/L	Milligrams Per Liter
NF	Nanofiltration
NTU	Nephelometric Turbidity Unit
PS3	Reservoir 3 Pump Station
PMFL	Purdy Mesa Flow Line
PRV	Pressure Reducing Valve
RO	Reverse Osmosis
TDS	Total Dissolved Solids
Ute	Ute Water Conservancy District
WTP	Water Treatment Plant
ZOP	Zinc Orthophosphate

1 EXECUTIVE SUMMARY

The City of Grand Junction (City) provides potable water to its customers from its existing water treatment facility (WTP) at 244 26 1/4 Road, Grand Junction, Colorado. The primary source of raw water for the WTP is the Juniata Reservoir on the Grand Mesa through the Purdy Mesa flow line (PMFL). The Kannah Creek flow line (KCFL) runs parallel to the PMFL as a secondary supply from the Kannah Creek, also on the Grand Mesa. The KCFL experienced a series of several breaks in 2019 and is not capable of providing peak day demands.

The City contracted with Burns & McDonnell Engineering Company, Inc. (BMcD) to investigate the feasibility of alternative water supplies in the event that the PMFL is not available. The PMFL and KCFL both draw from mountain sources on the Grand Mesa. The City also has water rights to the Colorado and Gunnison Rivers, as well as an interconnection agreement with Clifton Water District. The Ute Water Conservancy District (Ute) distribution system surrounds the City with several interconnections, but there is no formal agreement.

Fourteen options were identified by the Project Team:

1. Treat Gunnison River by Lime Softening
2. Treat Gunnison River by Reverse Osmosis
3. Settle Gunnison River in the Existing Raw Water Reservoirs and Blend with Clifton
4. Settle Gunnison River in the Existing Raw Water Reservoirs and Use for Raw Water
5. Replace KCFL (24 inch)
6. Replace KCFL (20 inch)
7. Replace KCFL (24 inch) and Add Turbine
8. New WTP in Kannah Creek Watershed and Replace KCFL
9. Clifton Water Emergency Interconnect
10. Transfer Colorado River Rights to Clifton for Treatment (Full Expansion, 24 inch pipeline)
11. Transfer Colorado River Rights to Clifton for Treatment (Partial Expansion, 20 inch pipeline)
12. Route Gunnison to Clifton WTP from Current Intake
13. Purchase Treated Water from Ute (Breakpoint Chlorination)
14. Purchase Treated Water from Ute (Chloramine Conversion)

Conceptual designs were developed for each of the options to create planning-level engineer's opinion of probable construction cost (EOPCC). Estimates of operating costs were compared to purchase costs for each of the identified Options.

The analysis identified that an interconnection between the PMFL and KCFL at the Juniata Reservoir would improve redundancy by directing flow from the Juniata Reservoir and the Kannah Creek watersheds into either flowline.

The Project Team developed and evaluated the Options through a series of meetings, culminating in a Selection Workshop in January 2020. Three additional Options were added in April 2020 following a meeting with key stakeholders from the City. The Options were then re-ranked. Qualitative, non-monetary selection criteria were used to score each option, weight the criteria, rank and calculate the cost/benefit of each Option.

The Options receiving the highest weighted scores were:

1. Option 5 – Replace KCFL (24-inch)
2. Option 6 – Replace KCFL (20-inch)
3. Option 14 – Purchase Treated Water from Ute (Chloramine Conversion)
4. Option 13 – Purchase Treated Water from Ute (Breakpoint Chlorination)

The scoring indicates two types of projects will provide benefit to the City, but the nature of their benefit varies. The KCFL options provide multiple ways to access the full water rights from the Purdy Mesa. This prioritizes operational redundancy. However, the KCFL options do not provide long term resiliency for the City as a source interruption would leave the City without a water supply. In this case, the City has the option to pursue either interconnects with Clifton or Ute. The two Ute options scored higher as a mountain source with minimal capital improvements required.

2 BACKGROUND

2.1 Project Objective

The City provides potable water to its customers from its existing WTP at 244 26 1/4 Road, Grand Junction, Colorado. The primary source of raw water for the WTP is the Juniata Reservoir on Purdy Mesa through the PMFL. The KCFL runs parallel to the PMFL as a secondary supply. The KCFL experienced a series of several breaks in 2019 and is not capable of providing peak day demands.

The City contracted with BMcD to investigate the feasibility of alternative water supplies in the event that the PMFL is not available. The PMFL and KCFL both draw from the same mountain sources on the Grand Mesa. The City also has water rights to the Colorado and Gunnison Rivers, as well as an interconnection agreement with Clifton. The Ute Water Conservancy District surrounds the City and is an additional source, however, the City does not have an interconnection with Ute.

This study identifies the available water sources for the City and evaluates the associated infrastructure required to supply future peak day demands as an alternate supply to the PMFL. This study considers both redundancy (ability to provide peak day flow) and resiliency (ability to draw from alternative source waters). Monetary and non-monetary factors were used to score and rank the identified Options.

The conceptual design of the preferred option is not included in this study.

2.2 Water Sources

The following water sources are available to the City:

1. **Purdy Mesa –** The PMFL draws raw water from the Juniata Reservoir on the Grand Mesa. This high quality mountain source is the primary raw water supply for the City. The PMFL consists of approximately 18.2 miles of 18-inch steel, 20-inch steel and PVC and 24-inch PVC diameter gravity transmission main. Upgrades are proposed to replace sections that were at the end of their useful life as well as upsizing segments to 20-inch diameter to reduce air entrainment. Water rights for the PMFL are 7,459 acre-feet (AF). The 20-inch gravity transmission main has a hydraulic capacity of 9.8 mgd [1]. The existing Kannah Creek WTP draws water from both the Juniata and Hallenbeck Reservoirs to serve customers on the Kannah Creek basin. The Kannah Creek WTP has an approximate capacity of 200 gallons per minute (0.3 million gallons per day, mgd) and does not send water to the City's WTP.

2. **Kannah Creek –** The KCFL draws raw water from Kannah Creek at the City Intake, approximately 4-miles upstream from the Juniata Reservoir. The KCFL provides additional raw water to the City during the peak summer season and acts as a backup pipeline to the PMFL. During winter, the KCFL is only used to transfer water from the Kannah Creek watershed into the Juniata Reservoir. The City has 7.81 cubic feet per second (cfs) (5 mgd) of paramount water rights from Kannah Creek. The City may access an additional 3.91 cfs (2.5 mgd) of winter water rights when available. The Kannah Creek watershed can deliver up to 6,275 AF[2]. The KCFL is approximately 20-miles of 18-inch cast iron and 20-inch steel gravity transmission main. City operations limit the flow to less than 2 mgd to minimize stress on the pipeline. Extensive repairs are required on the KCFL to provide critical redundancy.

[1] Black & Veatch, Project 197600, February 2018, Draft Purdy Mesa Flow Line Hydraulic Evaluation
[2] DiNatale Water Consultants, July 9, 2019, Memorandum, Water Supply Analysis in support of a finding of diligence for the Gunnison River Pipeline Water Right

3. **Gunnison River –** The City has 120 cfs of water rights to the Gunnison River that are not being utilized (18.6 cfs absolute and 101.4 cfs conditional). The Gunnison River is a river source of variable quality, subject to swings in turbidity and has high levels of total dissolved solids (TDS). The existing water treatment plant (WTP) is not capable of treating the Gunnison River without modifications to their treatment process. The City used the Gunnison River source in the past to augment peak summer demands by blending with the Grand Mesa sources in the existing Reservoirs 3 and 4. Recent peak day demands have been met by the PMFL, making it unnecessary to use the Gunnison River source. The existing Gunnison River Pump Station (GRPS) is in poor condition with only one pump operational and is located in the flood plain. The GRPS is now only exercised periodically, with raw water blended in Reservoirs 3 and 4. The GRPS pumping capacity is approximately 6 mgd.

4. **Colorado River** – The City owns 80 cfs of water rights to the Colorado River that are not being utilized. This right was originally 120 cfs, but subsequent diligence proceedings have reduced the City's right to 80 cfs, with 20 cfs going to the Clifton and 20 cfs to the Water Development Group. The City does not have any active infrastructure to use the Colorado River source.

5. **Clifton Water District –** The City has an agreement with Clifton for seasonal water exchange. The 1998 amendment allows Clifton to supply the City with up to 250 million gallons between April and September each year (1.4 mgd average). The amendment states that the City will supply Clifton with up to 250 million gallons per day between October and March. The agreement has informally expanded over the years to allow the City to take up to 4.5 mgd of treated water from Clifton in emergency situations. Clifton treats a mix of Grand Mesa and Colorado River at its 12 mgd capacity WTP. The interconnection with Clifton is located on 29 Road, north of D Road. Water main breaks in 2019 required the City to use the Clifton interconnection. Maximum day flows up to 5.5 mgd were sustainable through the existing interconnection.

6. **Ute Water Conservancy District** – The Ute water distribution system surrounds the City's distribution system to the west, north and east, with eight points of interconnection. Ute supplies water to some customers in the municipal boundary of the City. There is no formal agreement between the City and Ute for water supply. However, there is a verbal agreement for supply in emergency conditions. The raw water source for Ute is the Plateau Creek, which is considered a high quality mountain source. Ute uses chloramines for disinfection, which are not compatible with the City's use of free chlorine. Blending of the two waters would require additional treatment.

The locations of the water sources are illustrated in Figure 1.

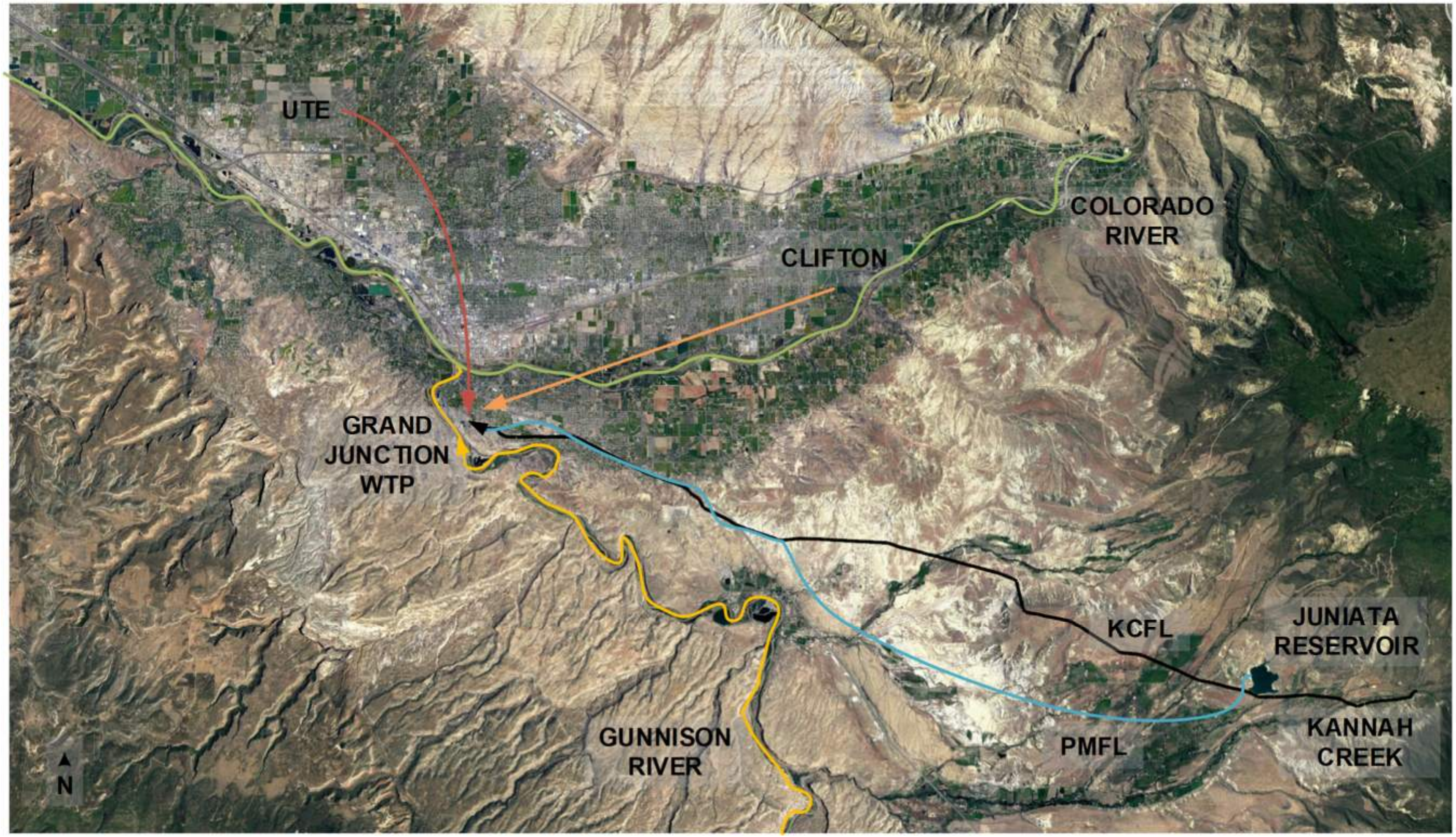

Figure 1: Map of Potential Sources for All Options

The City's available water sources are summarized in Table 1.

Table 1: Raw Water Source Summary

Source	Type	Water Rights	Current Capacity
Juniata Reservoir	Raw	7,459 AF	9.7 mgd (PMFL at 20-inch)
Kannah Creek	Raw	7.81 cfs (5 mgd) summer 11.72 cfs (7.5 mgd) winter	2 mgd[1]
Gunnison River	Raw	18.6 cfs[2] (12 MGD)	6 mgd[3]
Colorado River	Raw	80 cfs[4]	N/A
Clifton Water District[5]	Treated	4.5 mgd	5.5 mgd
Ute Water Conservancy District[6]	Treated	---	---

[1] KCFL capacity restricted by City's operations staff due to history of recent breaks, air entrainment
[2] 18.6 cfs absolute and 101.4 cfs conditional on availability (120 cfs total)
[3] Gunnison River capacity is limited by the condition and size of the existing pumps and electrical systems at the Gunnison River Pump Station
[4] Originally 120 cfs, transferred 20 cfs to Clifton and 20 cfs to Rifle
[5] The City and Clifton have an emergency interconnection agreement allowing 250 million gallons between April and September at no cost to City. Water rights are based on current agreement. Current capacity is based on the max peak daily flow through the interconnect in the summer of 2019.
[6] The City has eight emergency interconnects with the Ute but no formal interconnection agreement.

Table 2 compares the water quality of the raw water sources considered in this study.

Table 2: Raw Water Quality Comparison for Average and Maximum

Parameter	Juniata Reservoir[7] (Avg./Max.)	Kannah Creek[8] (Avg./Max.)	Gunnison River[9] (Avg./Max.)	Colorado River (Avg./Max.)
pH	7.9/8.0	8.2/8.6	8.4/8.8	8.01/8.53
Alkalinity (mg/L as $CaCO_3$)	81/83	64/91	137/188	143/260
Hardness (mg/L as $CaCO_3$)	92/95	66/90	339/492	218/316
TDS (mg/L)	86/119	62/122	530/778	517/865
Turbidity (NTU)	2.5/2.7	3.8/11.6	66/560	Unavailable
TOC (mg/L)	Unavailable	2.0/2.3	3.4/5.1	2.86/10
Fluoride (mg/L)	0.13/0.14	0.11/0.18	0.4/0.5	0.25/0.42
Chloride (mg/L)	1.0/1.1	0.42/0.75	6.5/10.6	170/408
Calcium (mg/L)	Unavailable	Unavailable	90.6/135	161/246
Sulfate (mg/L)	18.8/20.0	3.0/6.6	256/401	125/243
Selenium (mg/L)	Unavailable	Unavailable	3.4/6.5	Unavailable

[7] Source - City (based on 2016-2018 averages, unknown number of data points)
[8] Source - City (10-15 data points)
[9] Source - USGS 09152500 Gunnison River near Grand Junction, CO (38-44 data points)

2.3 Existing Water Treatment Plant

The City provides up to 9.8 mgd (peak day demand) of treated water to its and customers from its existing WTP. The rated capacity of the WTP is 16 mgd.

The WTP uses a conventional direct filtration process as shown in Figure 2. Raw water from the PMFL and KCFL enters at the Raw Water Control Vault, where it can be sent to either the contact basin or Reservoir 4. PMFL and KCFL raw water is sent to Reservoir 4 and/or Reservoir 3 during periods of poor water quality for pre-sedimentation. Water from Reservoirs 3 and 4 is recycled back to the Raw Water Control Vault from the existing Reservoir 3 Pump Station (PS3).

Raw water flows through the baffled contact basin before the gravity media filters. Filtered water flows by gravity to two 4 million gallon ground storage tanks and onto the distriubtion system. On-site sodium hypochlorite generation is used for disinfection. Backwash waste is sent to Reservoir 4 for settling before being recycled back to the Raw Water Control Vault. Residuals are disposed in a monofill on site.

Raw water from the Gunnison River is pumped from an existing intake and pump station to the 8 mg Reservoir 4. Reservoir 4 supplies raw water to the Spy Glass subdivision for irrigation from a dedicated pump station. Reservoir 4 overflows into the 15 mg Reservoir 3 and is pumped back to the Raw Water Control vault from an existing PS3. Reservoir 3 is also used to direct raw water to the nearby cemetery and Las Colonias development for irrigation purposes.

The average finished water quality can be found in Table 3.

Table 3: WTP Finished Water Quality

Parameter	Average Value
pH	8
Alkalinity	80 mg/L (as $CaCO_3$)
Hardness	88 mg/L (as $CaCO_3$)
Turbidity	0.07 NTU
Total Dissolved Solids	110 mg/L
Fluoride	0.58 mg/L
Chloride	5.8 mg/L

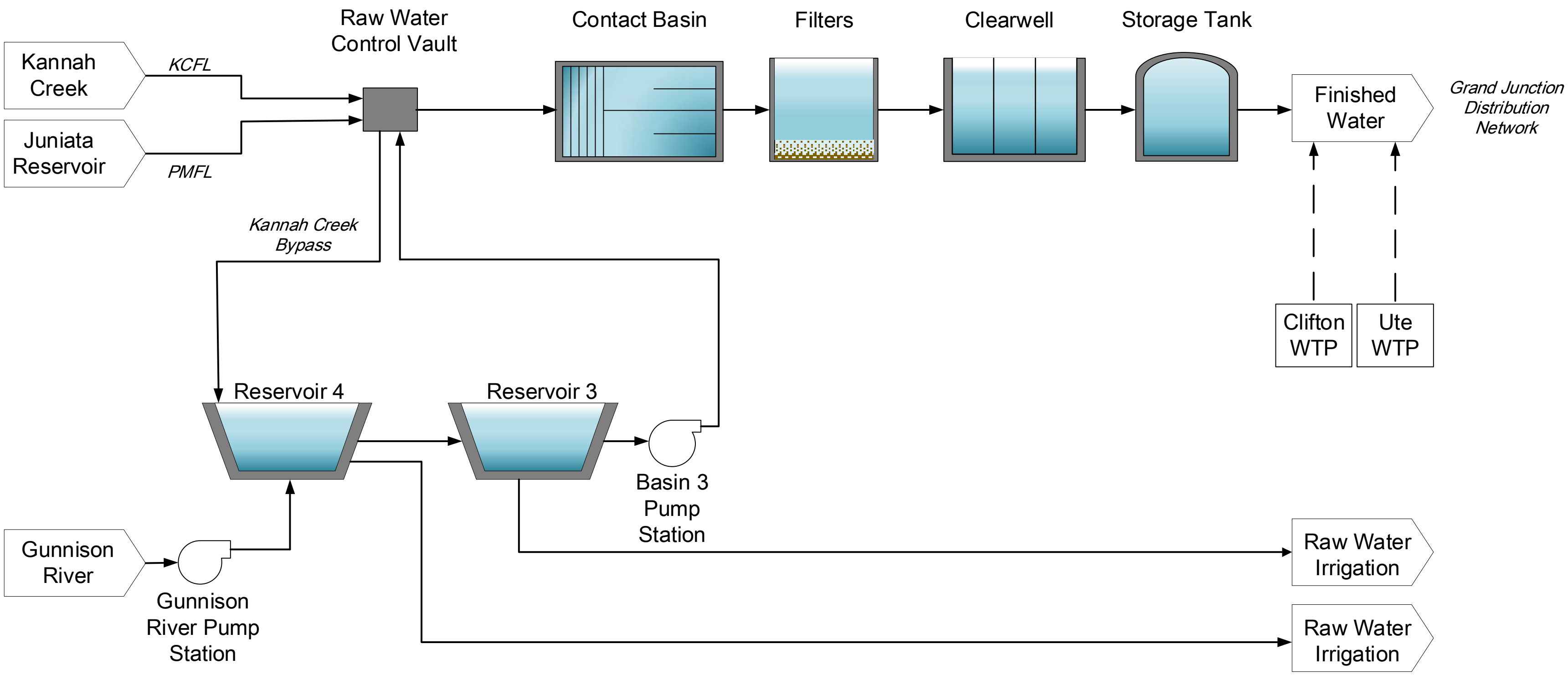

Figure 2: Existing WTP Process Flow Diagram

The City's raw water customers include the Spy Glass subdivision, the adjacent cemetery, and the City's Public Works Department for irrigation. The City has an agreement to supply the proposed and Las Colonias business park with raw water for its customers for irrigation, including a recreational amenity lake. Allocations for raw water customers are summarized in Table 4.

Table 4: Raw Water Irrigation Customer Summary

Customer	Average Flow (mgd)
Spy Glass Subdivision	0.4
Irrigation	1.0
Las Colonias	0.6
TOTAL	**2.0**

2.4 Future Water Demand

Future water demands were studied separately[3]. The future capacity of infrastructure for the purposes of this study is calculated as follows:

- Current conditions (2019):
    - Population of 29,500.
    - WTP annual production of 5,300 AF.
    - Average day demand 4.7 mgd.
    - Peak day demand 9.8 mgd.
    - Peaking factor of 2.07 (ratio of peak day to average day demand).
    - Residential demand of 88 gallons per capita per day (gpcd).

- Future conditions (2069):
    - Population of 49,000.
        - This City's Planning Department estimates an annual growth rate of 1.4%. However, the growth in the City's water service area is expected to be infill by nature, which is anticipated to result in a lower overall increase in population.
    - Population change of 19,400 .
    - Additional average day demand of 1.8 mgd (88 gpcd for new population of 19,400)
    - Future average day demand of 6.5 mgd (4.7 mgd current average day plus 1.8 mgd future average day)
    - Future peaking factor of 2.0.
        - The ratio of future peak to average day demand will be lower due to the infill nature, with less outdoor irrigation, fewer new parks, commercial or industrial users.
    - Peak day demand of 13.0 mgd.

Options considered in this study will be sized for a peak day demand of 13.0 mgd.

[3] Source – DiNatale Water Consultants, July 9, 2019, Memorandum, Water Supply Analysis in support of a finding of diligence for the Gunnison River Pipeline Water Right

2.5 Planning Goals

The options presented in the study are evaluated with their respect to their ability to provide operational redundancy, long term resiliency or both. For the purposes of discussion, the terms are defined as follows:

- **Operational Redundancy –** The ability to provide redundancy to the hydraulic capacity of the Purdy Mesa Flow Line, up to future peak day demands of 13 mgd.

- **Long Term Resiliency –** The ability to supply raw water from an alternative source in the event of a long term interruption to the City's primary source (Kannah Creek watershed and the Juniata Reservoir).

2.5.1 Operational Redundancy

This study considers which available water source has the ability to provide operational redundancy to the PMFL. The options are sized for 13 mgd future peak day demands if the PMFL is offline. PMFL outages are defined as short term events due to line breaks or periodic maintenance. Short term outages are expected to be corrected within five days.

It is anticipated that the City staff is able to repair line breaks on the PMFL within five days. The existing raw water Reservoirs 3 and 4 have up to 23 mg of storage that is available to the WTP from PS3 during short term outages (approximately 5 days of storage at current average day demands). The raw water stored in Reservoirs 3 and 4 is also available to augment flows to the WTP for Options that do not provide the future peak day demand of 13 mgd.

The KCFL provides redundancy to the PMFL from the upper Kannah Creek watershed. However, the existing KCFL is limited to only 2 mgd to limit stress on the pipeline and air entrainment. An Option considering the replacement of the KCFL will need to be sized for 13 mgd if a truly redundant pipeline is desired. However, this will require a new connection from Juniata Reservoir to the KCFL to augment KCFL flows due to the seasonal water rights from Kannah Creek (5 mgd summer and up to 7.5 mgd in the winter, when available). The redundancy provided by a replaced KCFL is only available if the Juniata Reservoir and the Kannah Creek watershed are not impacted by the same event preventing the use of the PMFL.

The City may use their existing Clifton interconnection (5.5 mgd capacity) to augment any treated water flows that the WTP is not able to produce. The use of Clifton treated water also allows the City to reserve its Grand Mesa water allocation (Juniata Reservoir and Kannah Creek), while utilizing their Colorado River rights through a water rights transfer. This is discussed in more detail in Option 10.

2.5.2 Long Term Resiliency

Long term resiliency is necessary for outages that impact the source availability of the Juniata Reservoir and the Kannah Creek watershed. A redundant pipeline to the Grand Mesa will not resolve water supply issues if the Juniata Reservoir and Kannah Creek watershed are impacted as a whole.

Events that may impact the availability of the KC watershed include runoff from wildfire, algae blooms, or drought. These events are expected to be longer term in nature and could last for a period of a few weeks to several months. Resiliency options including those drawing from alternate sources than the Grand Mesa – Gunnison River, Colorado River. or the Plateau Creek watershed (Ute).

2.6 Corrosion Control Study

Corrosion control studies (CCS) are required by both the Colorado Department of Public Health and Environment (CDPHE) and the Environmental Protection Agency's Lead and Copper Rule to evaluate and determine the optimal corrosion control treatment (CCT) for a water system. Usually a CCS is required to obtain an "optimized" designation for either an action level exceedance of lead or copper or treatment changes expected to affect corrosivity.

The City has had no action level exceedances that would normally trigger a CCS. However, a CCS is required if there is a change of the raw water source. A CCS would review the current treatment process and review other potential CCT's to comply with CDPHE and EPA requirements.

Lead and Copper Rule requirements state that a single CCT must be used at all treatment sites. Therefore, the optimal CCT for the City's entire water system must be identified from a holistic view of the City's distribution system, The optimal CCT is not for individual treatment sites and must include other finished water entry points (e.g. Clifton or Ute interconnections, if used).

Potential CCT for the City may include zinc orthophosphate (ZOP) addition, alkalinity adjustment, pH adjustment or calcium hardness adjustment. The effectiveness of CCT options must be studied over a range of conditions and water quality parameters.

This study assumes the implementation of a ZOP as the optimal CCT, which requires the City to add the corrosion control chemical at the WTP or other finished water entry points. Implementing ZOP would require the addition of chemical feed and storage equipment in a new building. Additionally, the City must consider the potential impacts ZOP will have on the Persigo Wastewater Treatment Plant, which will be subject to low phosphorous limits in the future. The implementation of ZOP could result in a significant rise in treatment costs for the Wastewater Treatment Plant.

A CCS is not part of this study but is recommended if there is a change to the City's raw water source.

3 OPTION DESCRIPTIONS

The Project Team identified the following options for providing redundancy to the PMFL, as well as resiliency to the Purdy raw water source. Table 5 lists the options that were developed as part of this study.

Table 5: Summary of Options

#	Option
1	Treat Gunnison River by Lime Softening
2	Treat Gunnison River by Reverse Osmosis
3	Settle Gunnison River in Existing Reservoirs and Blend with Clifton
4	Settle Gunnison River in Existing Reservoirs and Use for Raw Water
5	Replace Kannah Creek Flow Line (24 inch)
6	Replace Kannah Creek Flow Line (20 inch)
7	Replace Kannah Creek Flow Line (24 inch) and Add Turbine
8	New WTP in Kannah Creek Watershed
9	Clifton Water Emergency Interconnect
10	Transfer Colorado River Rights to Clifton for Treatment (Full Expansion, 24 inch pipeline)
11	Transfer Colorado River Rights to Clifton for Treatment (Partial Expansion, 20 inch pipeline)
12	Route Gunnison to Clifton WTP from Current Intake
13	Purchase Treated Water from Ute (Breakpoint Chlorination)
14	Purchase Treated Water from Ute (Chloramine Conversion)

The following sections provide a narrative of each option, list the assumptions made and present a process flow diagram.

Appendix A includes the detailed scope used to develop the EOPCC for each option.

Appendix B presents the EOPCC.

3.1 Option 1: Treat Gunnison River by Lime Softening

The City owns water rights to the Gunnison River that are not currently being utilized. The existing intake and Gunnison River Pump Station (GRPS) are only exercised periodically when raw water is sent to the WTP to blend with water in Reservoirs 3 and 4. Total dissolved solids (TDS) levels in the Gunnison River are above the secondary maximum contaminant level (MCL) of 500 mg/L. High TDS make the Gunnison River an undesirable water source, which necessitates additional treatment if used as a raw water source.

The existing intake will remain in service at its current location. The GRPS will be upgraded with new pumps, electrical and superstructure. Raw water from the Gunnison River will be pumped to Reservoir 4 to settle by gravity before it is sent to new lime softening clarifiers.

Lime softening by lime and/or soda ash addition will remove hardness by precipitation. Lime softening is assumed to the effective at reducing TDS because the Gunnison River TDS is dominated by calcium sulfate. A softened TDS goal of 200 mg/L was selected to produce water quality similar to that of Purdy Mesa. Lime silos and feed equipment, soda ash feed equipment, carbon dioxide feed equipment, solids handling and dewater systems will be included within the main building. Lime clarifiers and the chemical facilities will be located on City land to the north of Reservoir 3.

The existing Reservoir 3 Pump Station will be replaced with a new Filter Feed Pump Station to pump softened water to the existing WTP for filtration. All irrigation flows will also be routed from this pump station.

The softened Gunnison River source is significantly different in character from the current Purdy Mesa source. Therefore, a ZOP storage and dosing facility will be required on the finished at the WTP for corrosion control.

The following assumptions were used for this Option:

- Raw water source: Gunnison River via GRPS
- 13 mgd peak day demand
- KCFL will remain at current capacity as a partial backup for PMFL
- Reuse the existing intake and wet well for GRPS
- Reuse the existing pipeline from GRPS to Reservoir 3
- Lime softening process is able to reduce TDS to 200 mg/L, based on water dominated by calcium sulfate
- Lime softening effective at removing selenium present in Gunnison River
- Locate lime softening on City land north of Reservoir 3
- Treated water target to match that of Purdy Mesa (100 to 200 mg/L TDS)
- Turbidity: < 2 NTU

Figure 3 illustrates a conceptual process flow diagram for Option 1.

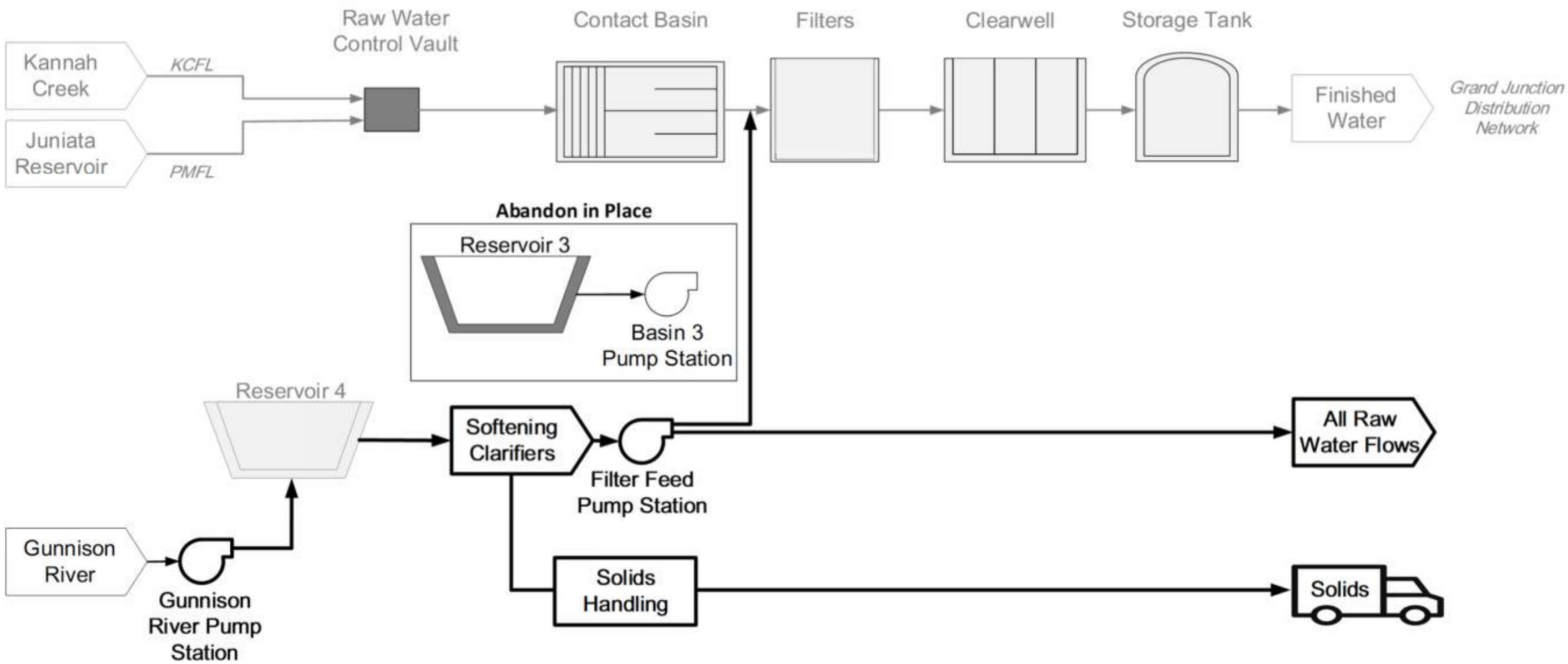

Figure 3: Process Flow Diagram for Option 1

3.2 Option 2: Treat Gunnison River by Reverse Osmosis

The high TDS of the Gunnison River may also be treated using nanofiltration (NF) or reverse osmosis (RO). A treatment goal of 100 to 200 mg/L TDS was selected to match the existing water quality supplied by the City from Purdy Mesa. This NF/RO process is similar to that used by Clifton on their Colorado River source.

The proposed treatment train consists of high pressure feed pumps, cartridge filters, RO skids, cleaning system, and chemical systems.

The existing intake will remain in service at its current location. The GRPS will be upgraded with new pumps, electrical and superstructure. Raw water from the Gunnison River will be pumped to Reservoir 4 to settle by gravity before it is sent to Reservoir 3. Reservoir 3 Pump Station pumps and electrical system will be upgraded. The settled Gunnison River water will be blended with the PMFL at the WTP contact basins and sent to filtration. A side stream flow of approximately 50% will be sent to NF/RO to remove TDS. NF/RO filtrate will be blended into the WTP filtered water to meet the TDS treatment goal.

The treated Gunnison River source is significantly different in character from the current Purdy Mesa source. Therefore, a ZOP storage and dosing facility will be required on the finished at the WTP for corrosion control.

Brine disposal is a challenge for RO facilities and will require negotiation with the CDPHE Water Quality Control Division. Disposal options include evaporation ponds, deep well injection, discharge to a wastewater treatment plant or discharge to surface water. Disposal by evaporation ponds will require a significant footprint larger than the City's existing WTP property. Therefore, deep well injection was assumed for this study because of the proximity of abandoned oil and gas wells and likelihood of CDPHE approval.

The following assumptions were used for this Option:

- Raw water source: Gunnison River via GRPS
- 13 mgd peak day demand
- KCFL will remain at current capacity as a potential backup for PMFL
- Reuse the existing intake and wet well for GRPS and PS3
- Reuse the existing pipeline from GRPS to Reservoir 3
- Locate the proposed RO system on open land to the south of the existing WTP
- Pretreatment turbidity goal: < 10 NTU
- Treated water target: < 100 mg/L TDS (to match existing source).
- Brine disposal using a high-pressure pump station and injected to four deep injection wells (10,000 to 15,000 feet).
- Suitable nearby candidates to locate and permit RO brine disposal by deep well injection

Figure 4 illustrates a conceptual process flow diagram for Option 2.

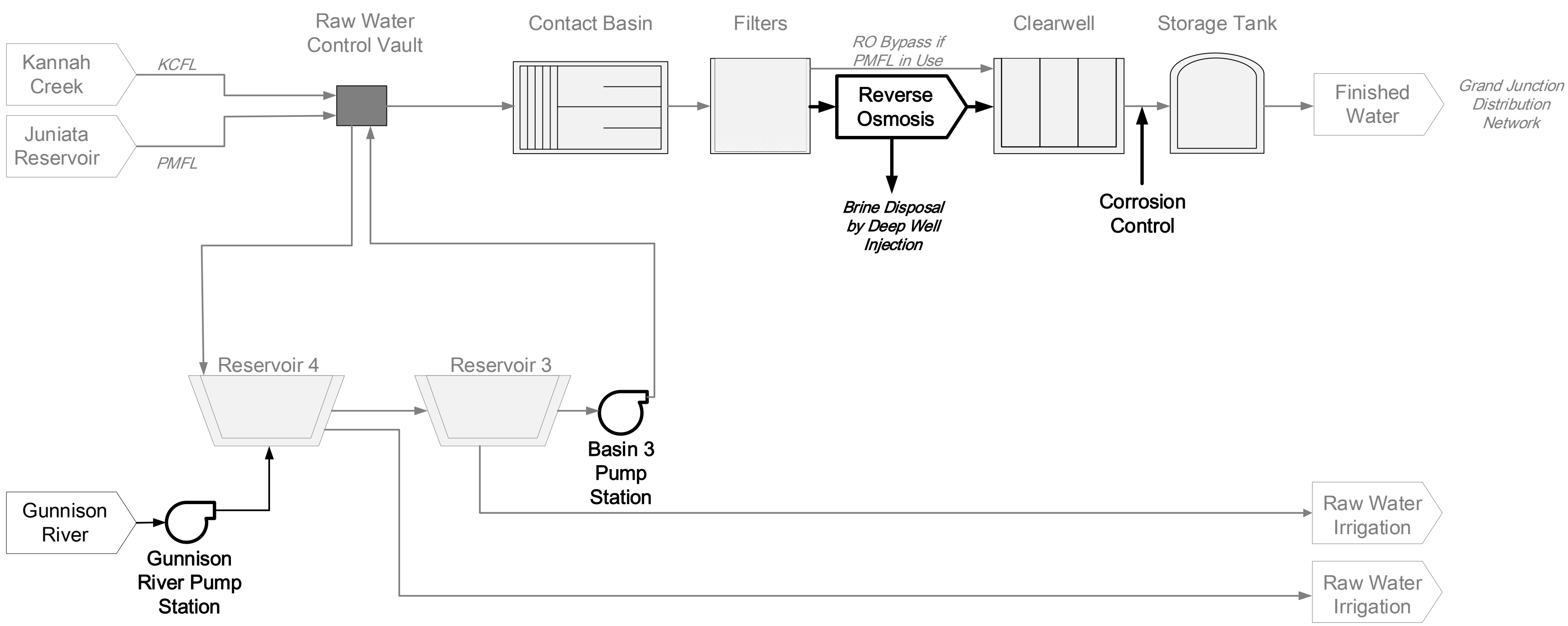

Figure 4: Process Flow Diagram for Option 2

3.3 Option 3: Settle Gunnison River in Existing Reservoirs and Blend with Clifton

This Option utilizes Gunnison River water rights by pumping to Reservoir 4 where major turbidity will be settled to less than 10 NTU. Settling in Reservoir 4 will be achieved by gravity with no mechanical modifications. Settled Gunnison River water will be pumped to the Raw Water Control Vault by a new PS3 and treated through the existing WTP.

This treatment will not impact the salinity or TDS of the water which is above the secondary maximum contaminant level (MCL) of 500 mg/L. Thus, settled water from Gunnison River will be blended with treated water from Clifton at the Raw Water Control Vault to meet the City's existing distribution system TDS. The blending of Clifton water to the Gunnison River is assumed at a 4:1 ratio to meet the finished water TDS goal.

The existing interconnection with Clifton is located on 29 Road, north of D Road. Maximum daily flows of up to 5.5 mgd were sustainable through the existing interconnection during emergency conditions in 2019. Clifton flows of 10.4 mgd are required to achieve peak day flows of 13 mgd at a 4:1 ratio with Gunnison River (2.6 mgd). The required Clifton flows of 10.4 mgd exceed the capacity of the existing interconnection. Therefore, a new pipeline will be required to bring from the Clifton WTP to the City's WTP.

The existing intake will remain in service at its current location. The GRPS will be upgraded with new pumps, electrical and superstructure . Raw water from the Gunnison River will be pumped to Reservoir 4 to settle by gravity before it is sent to the WTP from a new PS3. PS3 will be replaced due to its current condition, age, and lack of redundancy.

The treated Gunnison River source is significantly different in character from the current Purdy Mesa source. Therefore, a ZOP storage and dosing facility will be required on the finished at the WTP for corrosion control.

The following assumptions were used for this Option:

- Raw water source: Gunnison River via GRPS
- Blend with treated water from Clifton
- 13 mgd day demand
    - 2.6 mgd from Gunnison River
    - 10.4 mgd from Clifton
- KCFL will remain at current capacity as a potential backup for PMFL
- New 20-inch pipeline from Clifton to WTP (10.3 miles)
- Reuse intake and wet well for GRPS
- Reuse pipeline from GRPS to Reservoir 3
- Route GR flow to Reservoir 4 to settle by gravity
- Upgraded PS3
- Blend water 4:1
- Blending must occur before filters due to compliance point
- Turbidity: <10 NTU
- Total Dissolved Solids: 150-200 mg/L

Figure 5 below illustrates a conceptual process flow diagram for Option 3. Figure 6 shows a preliminary alignment of the pipeline from the Clifton WTP to the City's WTP.

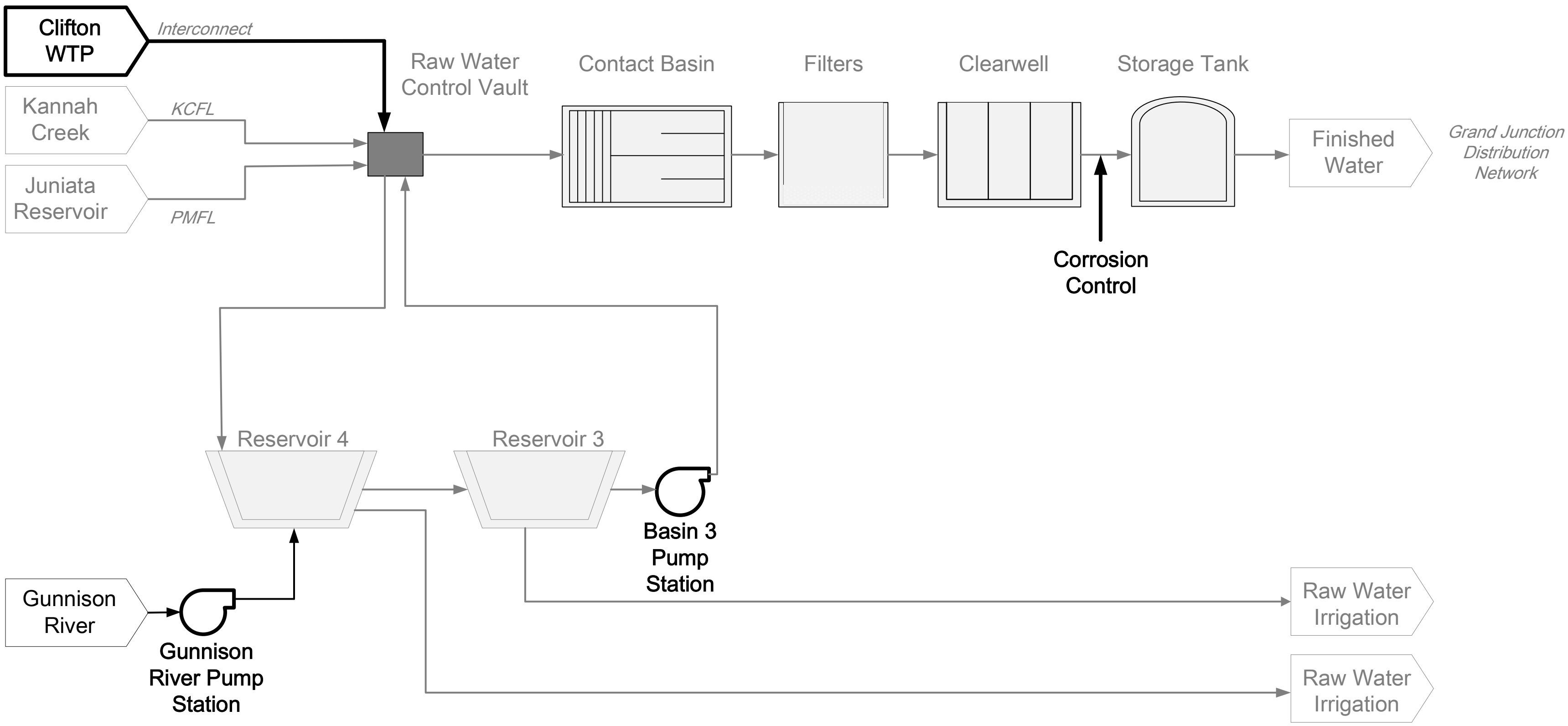

Figure 5: Process Flow Diagram for Option 3

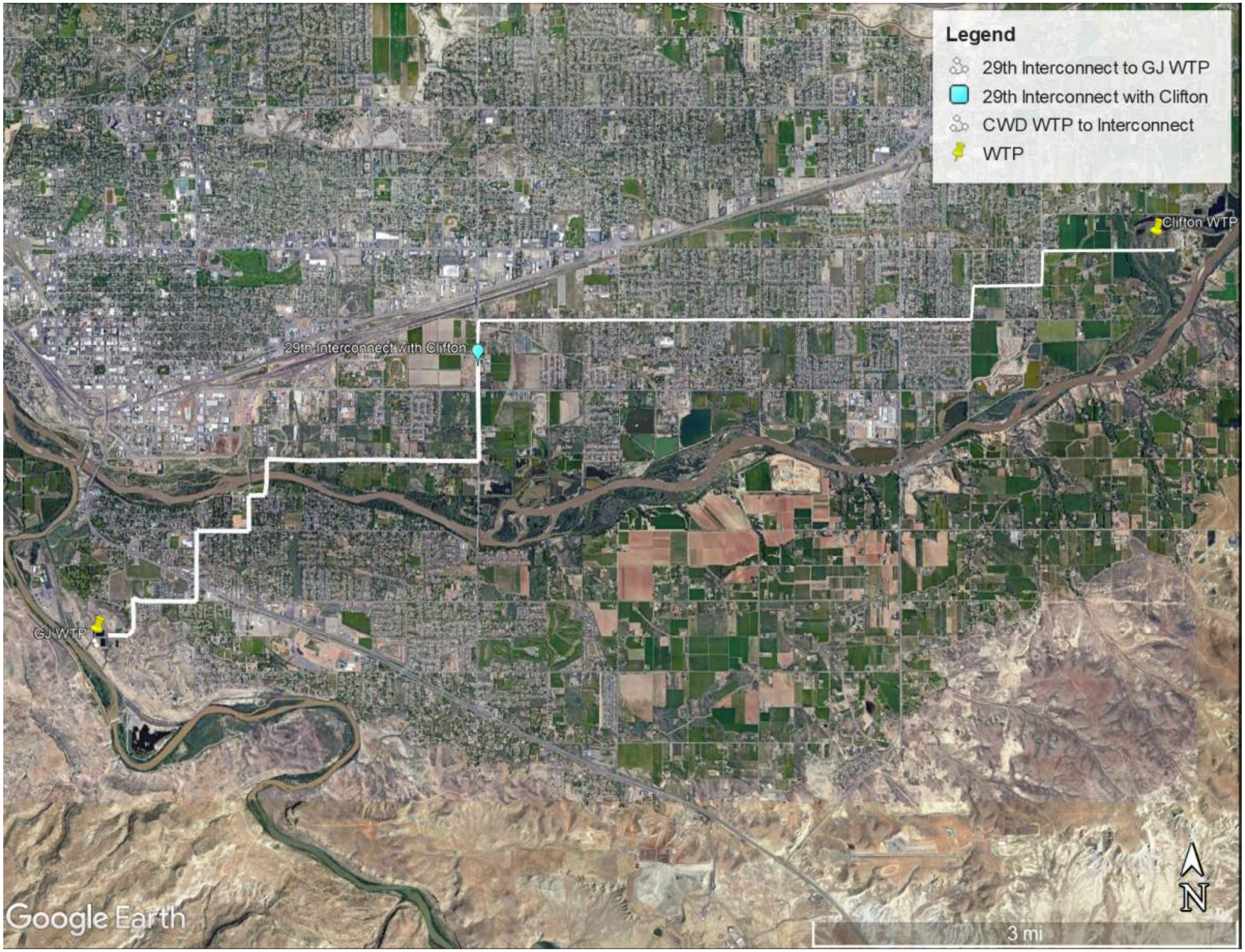

Figure 6: Preliminary Alignment for Pipeline from Clifton WTP to the City WTP

3.4 Option 4: Settle Gunnison River in Existing Reservoirs and Use for Raw Water Irrigation

This Option uses Gunnison River water rights by pumping to Reservoir 4 where major turbidity will be settled to less than 10 NTU. The Gunnison River will be used for all irrigation customers (Spy Glass Development, Las Colonias Industrial Park, and the cemetery). This reduces the total demand from the Grand Mesa source in the KCFL by dedicating all of the Kannah Creek flows for treatment at the WTP. The KCFL will be replaced but at a smaller diameter due to the 2 mgd of irrigation flows being supplied from the Gunnison River. KCFL replacement options are discussed in more detail in Option 6.

The existing intake will remain in service at its current location. The GRPS will be upgraded with new pumps, electrical and superstructure . Raw water from the Gunnison River will be pumped to Reservoir 4 to settle by gravity before it is sent to the irrigation customers. Reservoir 3 will remain as storage and settling reservoir for high turbidity events in both Grand Mesa sources.

Based on discussions with the City, this Option is not likely because the quality of settled Gunnison River water will not meet the water quality standards for the existing irrigation customers (high TDS).

The following assumptions were used for this Option:

- Raw water sources:
    - Gunnison River via GRPS
    - Kannah Creek via KCFL
- 11.7 mgd peak day flow
    - Gunnison River raw water at 2.0 mgd
    - Kannah Creek raw water of 9.7 mgd (20-inch KCFL replacement per Option 6)
- Reuse the existing intake and wet well for GRPS
- Reuse the existing pipeline from GRPS to Reservoir 3
- Route Gunnison River through Reservoir 4, settle by gravity to < 10 NTU
- Gunnison River only through Reservoirs 3 and 4 to raw water customers
- Customers do not require a higher level of treatment beyond removal of major turbidity

Figure 7 below illustrates a conceptual process flow diagram for Option 4. Figure 8 shows a preliminary alignment of the KCFL replacement.

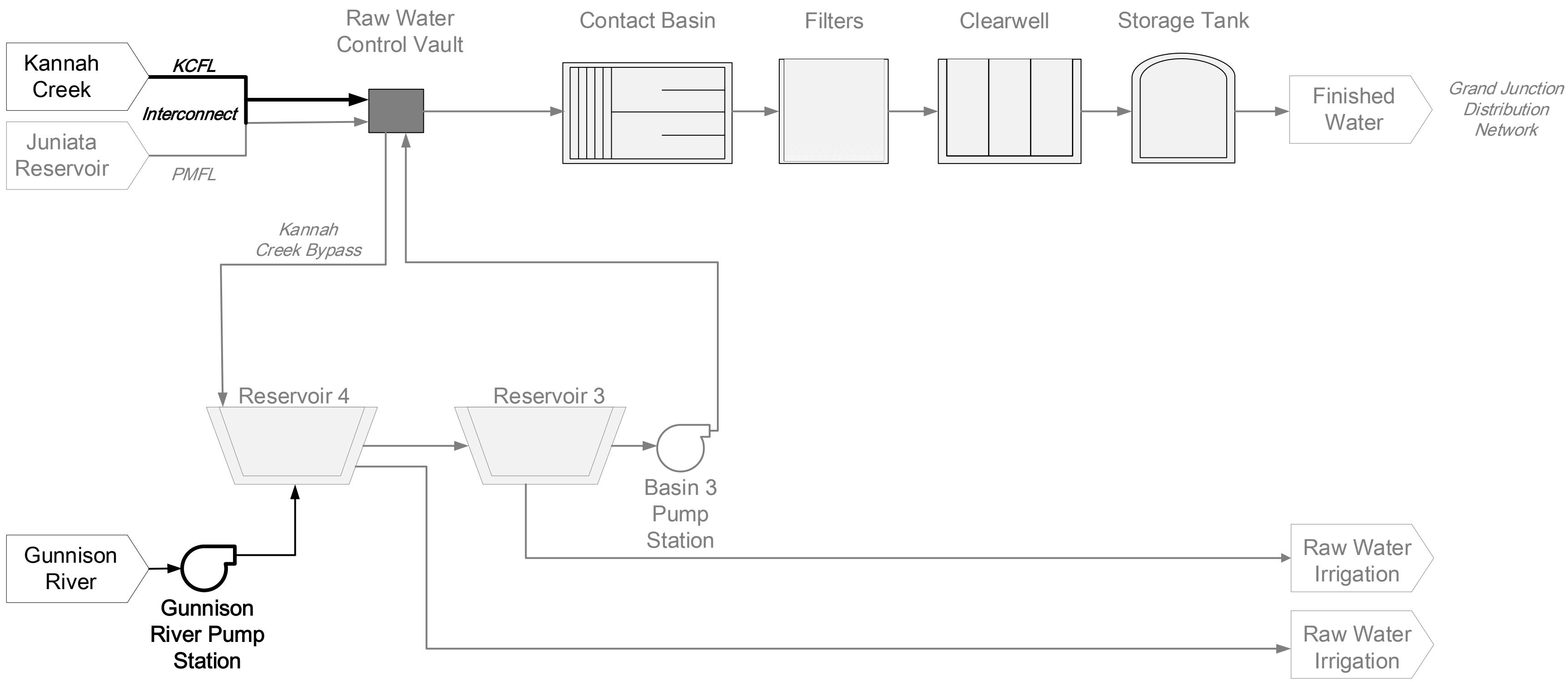

Figure 7: Process Flow Diagram for Option 4

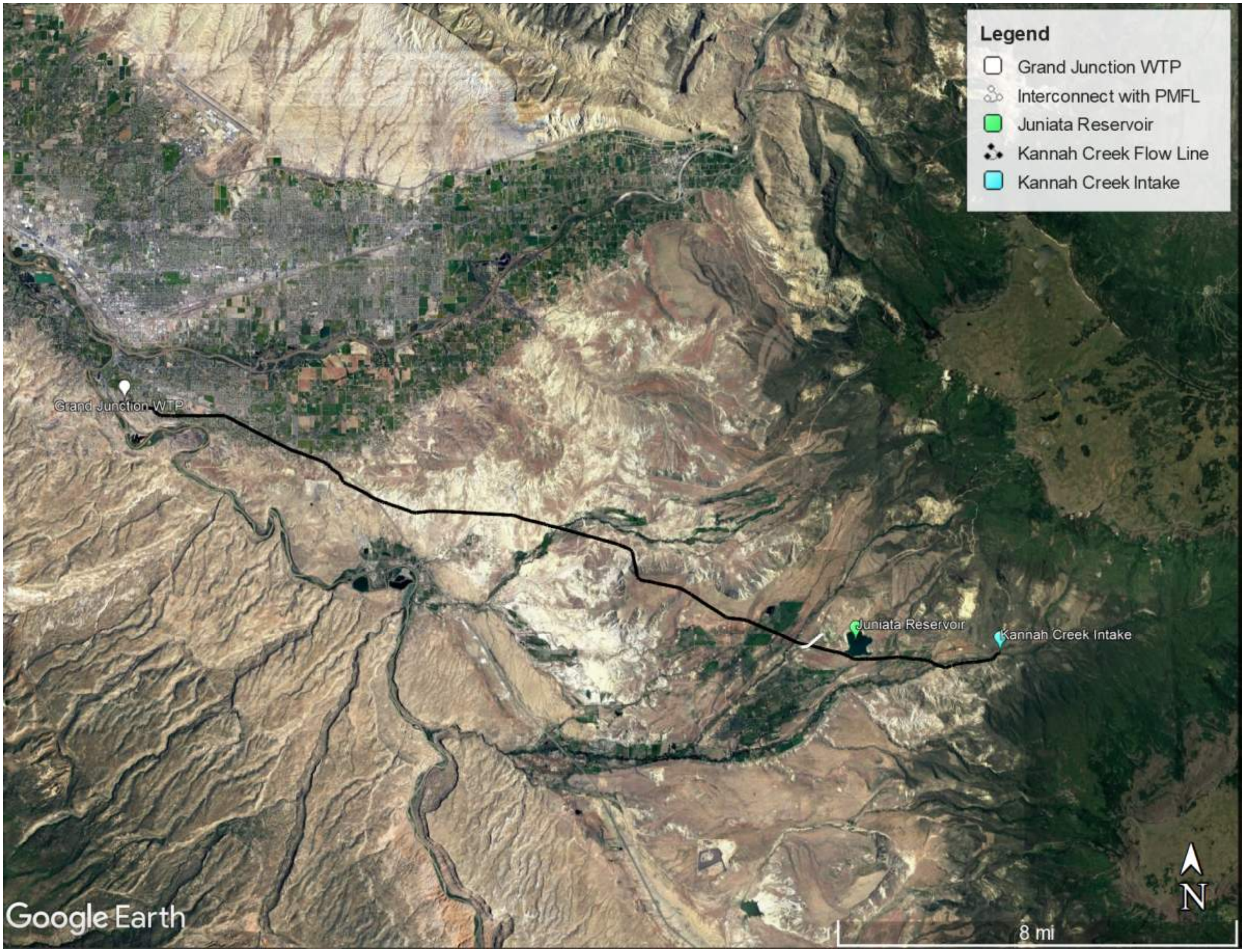

Figure 8: Preliminary Alignment for KCFL Replacement

3.5 Option 5: Replace Kannah Creek Flow Line (24 inch)

The KCFL draws raw water from Kannah Creek at the City intake, approximately 4-miles upstream from the Juniata Reservoir. The KCFL provides additional raw water to the City during the peak summer season and acts as a backup pipeline to the PMFL. During winter, the KCFL is only used to transfer water from the Kannah Creek watershed into the Juniata Reservoir.

The KCFL is approximately 20-miles of 18-inch cast iron and 20-inch steel gravity transmission main. Current City operations limit the flow to less than 2 mgd to minimize stress on the pipeline. Extensive repairs to the KCFL or a full replacement are required to provide critical redundancy.

The City has 7.81 cfs (5 mgd) of paramount water rights from Kannah Creek. The City may access an additional 3.91 cfs (2.5 mgd) of winter water rights when available. Modelling results indicate that the Kannah Creek watershed can deliver up to 6,275 AF annually, with approximately 350 AF dedicated to the Kannah Creek WTP and other non-potable uses.

An interconnect to the Juniata Reservoir is required to achieve fully redundant peak day flows to the KCFL. Juniata Reservoir water rights will augment the flow from Kannah Creek to provide peak day flow. The interconnection will allow flow from both Kannah Creek and Juniata Reservoir into either the PMFL or KCFL. The scope of the interconnection is discussed below (Section 3.5.1).

The City is planning on replacing the 4-miles of pipeline between Kannah Creek and Juniata Reservoir. Therefore, the scope of all KCFL options in this study is limited to the approximately 16-miles between Juniata Reservoir and the WTP.

Figure 9 shows the approximate pipeline elevation (blue), hydraulic grade line (red), static pressure (purple) and pipe pressure class (green). The hydraulic grade line must remain below the green line, representing the pipe pressure rating. The vertical drop in the red and purple lines represents the pressure drop at the proposed pressure reducing valve (PRV) chamber. The pipe pressure class, PRV setting, PRV location and diameter are optimized to prevent operating and static pressures from exceeding the pipe pressure class. Further optimization of pipe pressure class will occur during the concept design.

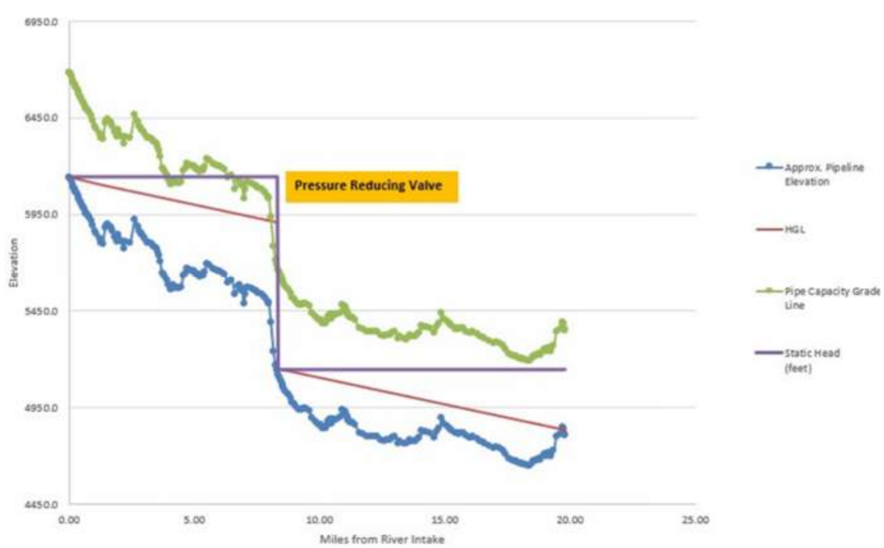

Figure 9: Hydraulic Profile of 24 inch KCFL Replacement (Option 5)

Option 5 at 24-inch diameter will convey up to 12.5 mgd. One pressure control valve is required (Figure 9). A new PRV chamber at the mesa will reduce pressures to less than the pipeline rating (235 psi). KCFL flow control will be relocated to the WTP with modulating a valve and flowmeter. KCFL flow control at Kannah Creek will be abandoned.

This Option does not change the WTP treatment processes. Kannah Creek will remain as the secondary raw water source to Purdy Mesa flow line. The Gunnison River will not be used.

The following assumptions were used for this Option:

- Raw water source:
  - Kannah Creek via KCFL
  - Augmented by Juniata Reservoir interconnection
- Capacity:
  - 12.5 mgd hydraulic capacity
    - Summer: 5 mgd from Kannah Creek plus 7.5 mgd from Juniata Reservoir
    - Winter: 7.5 mgd from Kannah Creek plus 5 mgd from Juniata Reservoir
- Add one pressure control chamber along KCFL
- Uppermost 4 miles of KCFL replacement outside scope of this project

This Option does not provide the future peak day flows of 13 mgd. Therefore, WTP flows must be augmented on peak demand days by raw water storage in Reservoirs 3 or 4 or existing distribution system storage. The interconnection with Clifton may also be used to meet peak daily flows greater than 12.5 mgd.

This Option does not provide access to an alternate water source than the PMFL.

Figure 10 below illustrates a conceptual process flow diagram for this Option. Figure 11 shows a preliminary alignment of the KCFL replacement.

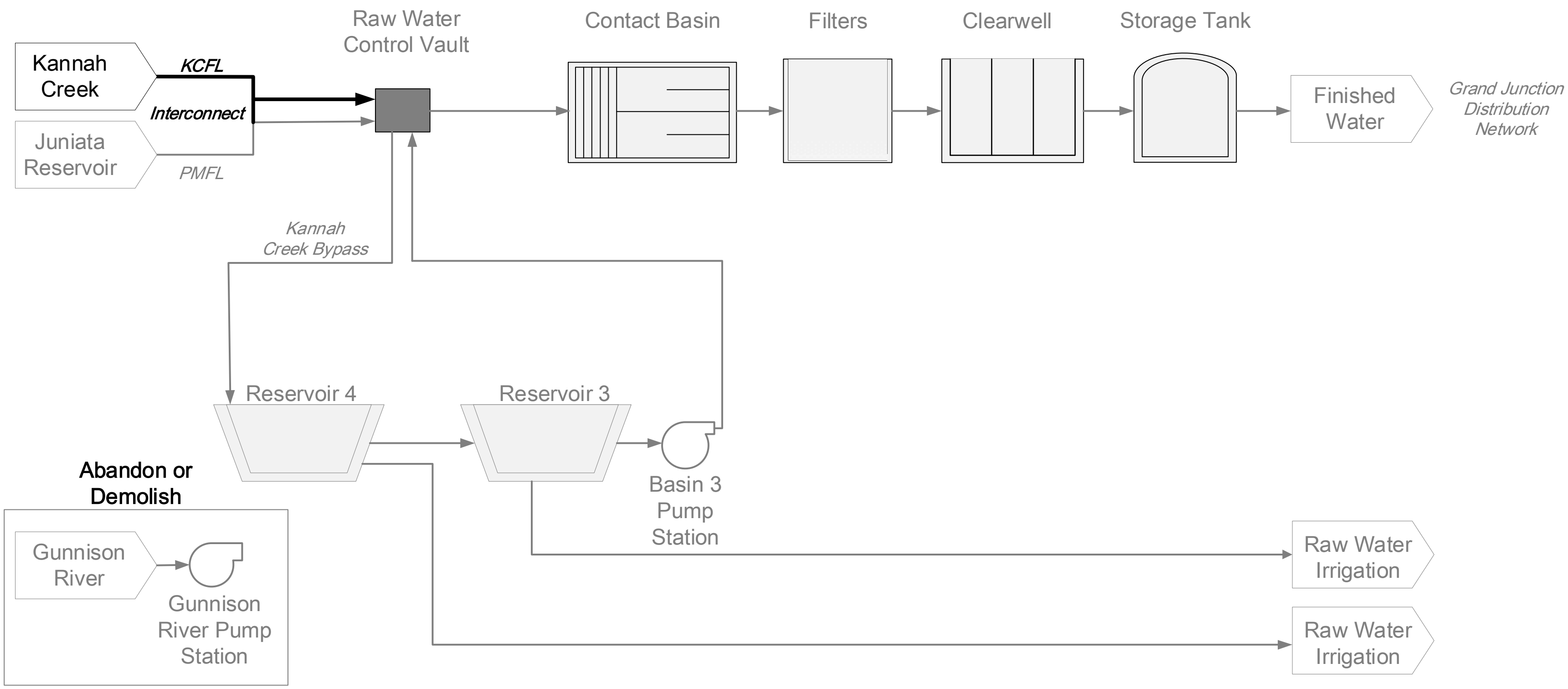

Figure 10: Process Flow Diagram for Option 5

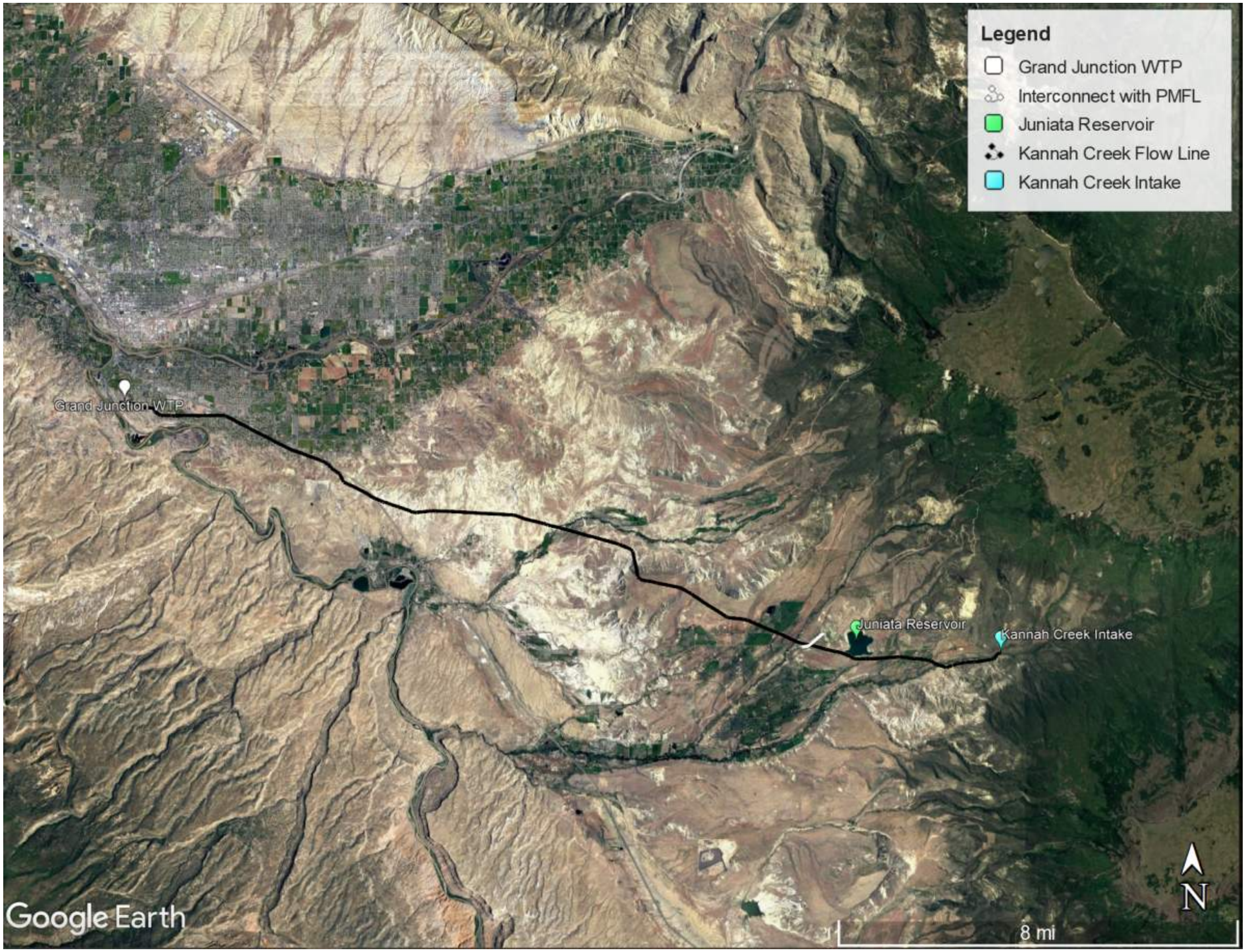

Figure 11: Preliminary Alignment for KCFL Replacement

3.5.1 Juniata Reservoir Interconnection

An interconnect to the Juniata Reservoir will be required to achieve fully redundant peak day flows to the KCFL. Juniata Reservoir water rights will augment the flow-limited, seasonal water rights from Kannah Creek to provide peak day flow. The interconnection will allow flows from both Kannah Creek and Juniata Reservoir into either the PMFL or KCFL. This improves the overall water system resiliency by allowing access to either the Juniata Reservoir or Kannah Creek watershed in either pipeline during periods of poor water quality, wildfire or algae blooms.

Control valves on the KCFL will direct flow from Kannah Creek water into the Juniata Reservoir. The existing outlet piping from Juniata Reservoir will then be sent to either the PMFL or the PMFL. Kannah Creek is at a higher elevation (approximately 6,130 feet) than Juniata Reservoir (approximately 5,760 feet). Therefore, flow control valves will isolate the portion of the KCFL upstream of the Juniata Reservoir. The interconnection will be sized to deliver the difference between the maximum hydraulic capacity of the KCFL and the seasonal water flows from Kannah Creek. The KCFL has a hydraulic capacity of 12.5 mgd at 24-inch diameter, resulting in an interconnection capacity of 7.5 mgd (5,200 gpm).

The proposed location of the Junita Reservoir Interconnection is shown in Figure 12.

Figure 12: Proposed Location of Juniata Reservoir Interconnection

Figure 13 shows a preliminary process flow diagram for the interconnection facility. The interconnection improvement is recommended regardless of which Option is selected. The interconnection will allow flows from both the Juniata Reservoir and Kannah Creek water sources through either pipeline.

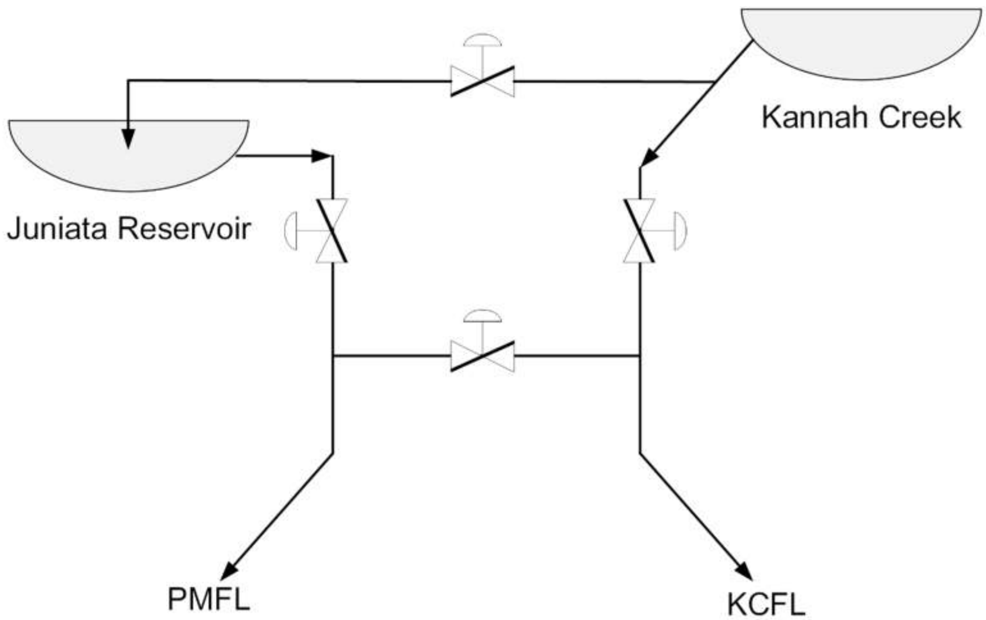

Figure 13: Process Flow Diagram for Juniata Reservoir Interconnection

3.6 Option 6: Replace Kannah Creek Flow Line (20 inch)

This Option includes the replacement of the KCFL at 20-inch diameter. Raw water is sourced from Kannah Creek, as described in Option 5. The Juniata Reservoir Interconnection (Section 3.5.1) will be required to achieve fully redundant raw water flows in either pipeline to the WTP from the Grand Mesa.

Reducing to 20-inch diameter will reduce the hydraulic capacity to 9.7 mgd. Two pressure control stations will be required. The operating pressure in the KCFL will be higher at 20-inch diameter, resulting in a higher pressure class pipe. The Option cost will be reduced at the smaller diameter KCFL.

Figure 14 shows the approximate pipeline elevation (blue), hydraulic grade line (red), static pressure (purple) and pipe pressure class (green) for both pipeline options. The hydraulic grade line must remain below the green line, representing the pipe pressure rating. The vertical drop in the red and purple lines represents the pressure drop at the proposed PRV. The pipe pressure class, PRV setting, PRV location and diameter are optimized to prevent operating and static pressures from exceeding the pipe pressure class. Further optimization of pipe pressure class will occur during the concept design.

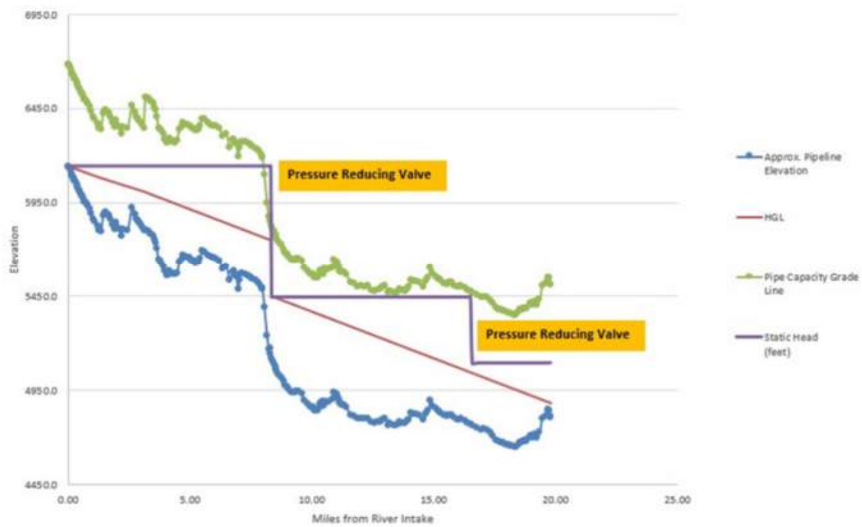

Figure 14: Hydraulic Profile of 20 inch KCFL Replacement (Option 6)

Two new PRV chambers will manage the operating pressures to the pipe rating. PVC pipe pressure class will vary along KCFL, limited either to 235 psi or 300 psi. KCFL flow control will be relocated to the WTP with modulating a valve and flowmeter. KCFL flow control at Kannah Creek will be abandoned. This option does not change the WTP treatment processes. Kannah Creek will remain as the secondary raw water source to Purdy Mesa. The Gunnison River will not be used.

The following assumptions were used for this Option:

- Raw water source:
  - Kannah Creek via KCFL
  - Augmented by Juniata Reservoir interconnection
- Capacity:
  - 9.7 mgd hydraulic capacity
    - Summer: 5 mgd from Kannah Creek plus 4.7 mgd from Juniata Reservoir
    - Winter: 7.5 mgd from Kannah Creek plus 1.2 mgd from Juniata Reservoir
- Two PRV chambers along KCFL

- Uppermost 4 miles of KCFL replacement outside scope of this project

This Option does not provide the future peak day flows of 13 mgd. Therefore, WTP flows must be augmented on peak demand days by raw water storage in Reservoirs 3 or 4 or existing distribution system storage. The interconnection with Clifton may also be used to meet peak daily flows greater than 9.7 mgd.

This Option does not provide access to an alternate water source than the PMFL.

Figure 15 below illustrates a conceptual process flow diagram for this Option. Preliminary alignment is identical to Option 5 above.

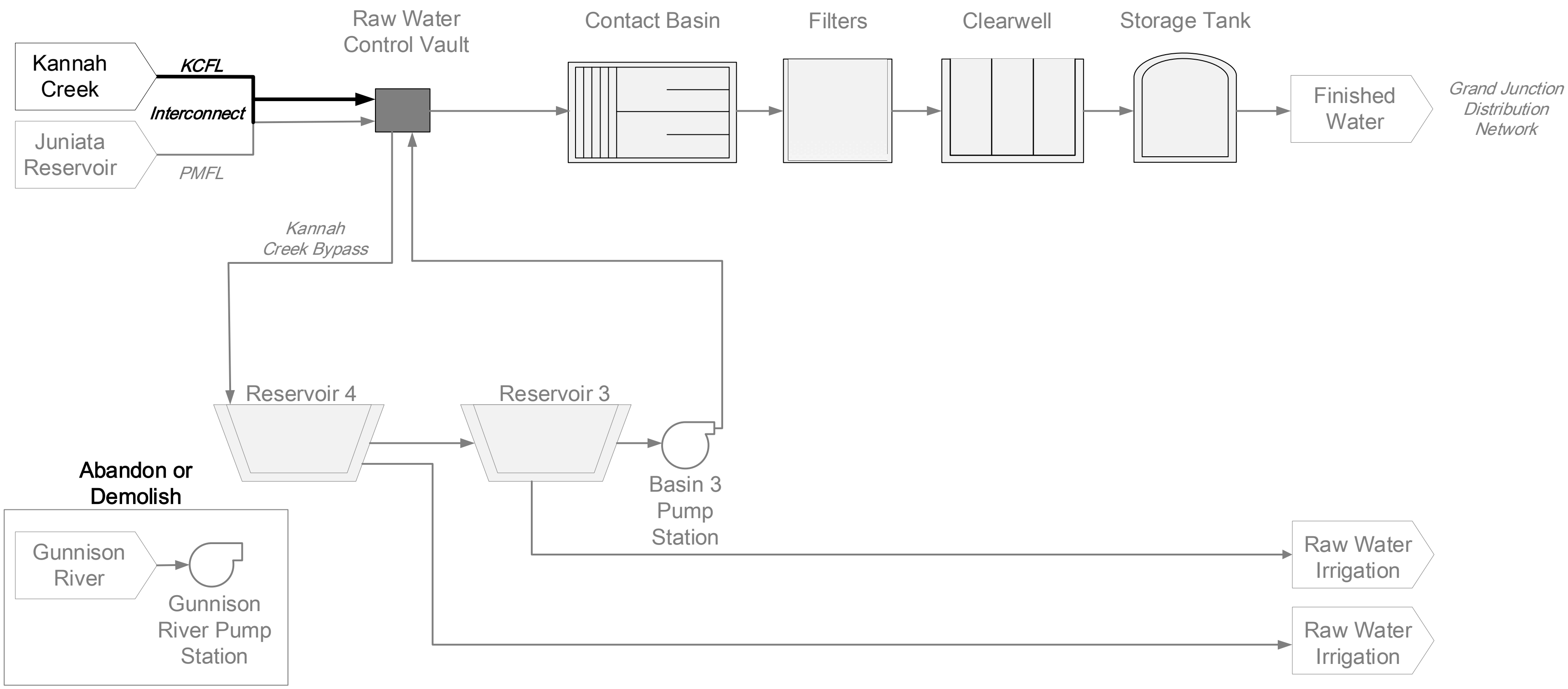

Figure 15: Process Flow Diagram for Option 6

3.7 Option 7: Replace Kannah Creek Flow Line (24 inch) and Add Turbine

This Option includes the replacement of the KCFL at 24-inch diameter. Raw water is sourced from Kannah Creek, as described in Option 5. The Juniata Reservoir Interconnection (Section 3.5.1) will be required to achieve fully redundant raw water flow to the WTP.

A new PRV chamber at the mesa will limit the pipeline pressures to less than 235 psi. A hydroelectric turbine will be installed in parallel with PRV to capture the potential energy of the high-pressure raw water. Electricity generated at the hydroelectric turbine will be transmitted overhead approximately 6 miles to the Grand Valley Power substation. Conceptual calculations indicate the potential to generate up to 3,000,000 kilowatt hours (kWH) per year (700 kW turbine), based on assumed monthly flows and available pressure.

KCFL flow control will be relocated to the WTP with modulating a valve and flowmeter. KCFL flow control at Kannah Creek will be abandoned. This Option does not change the WTP treatment processes. Kannah Creek will remain as the secondary raw water source to Purdy Mesa. The Gunnison River will not be used.

The following assumptions were used for this Option:

- Raw water source:
  - Kannah Creek via KCFL
  - Augmented by Juniata Reservoir interconnection
- Capacity:
  - 12.5 mgd hydraulic capacity
    - Summer: 5 mgd from Kannah Creek plus 7.5 mgd from Juniata Reservoir
    - Winter: 7.5 mgd from Kannah Creek plus 5 mgd from Juniata Reservoir
- Add one pressure control chamber along KCFL
- Uppermost 4 miles of KCFL replacement outside scope of this project
- Elevation change requires control valves to reduce pressure
- Transmit generated electricity to Grand Valley Power's Substation near Highway 50 and 32 Road. The capacity of this substation to receive the generated electricity must be confirmed.

This Option does not provide the future peak day flows of 13 mgd. Therefore, WTP flows must be augmented on peak demand days by raw water storage in Reservoirs 3 or 4 or existing distribution system storage. The interconnection with Clifton may also be used to meet peak daily flows greater than 12.5 mgd.

This Option does not provide access to an alternate water source than the PMFL.

Figure 16 below illustrates a conceptual process flow diagram for this Option. Figure 17 shows a preliminary alignment for the KCFL as well as preliminary turbine placement.

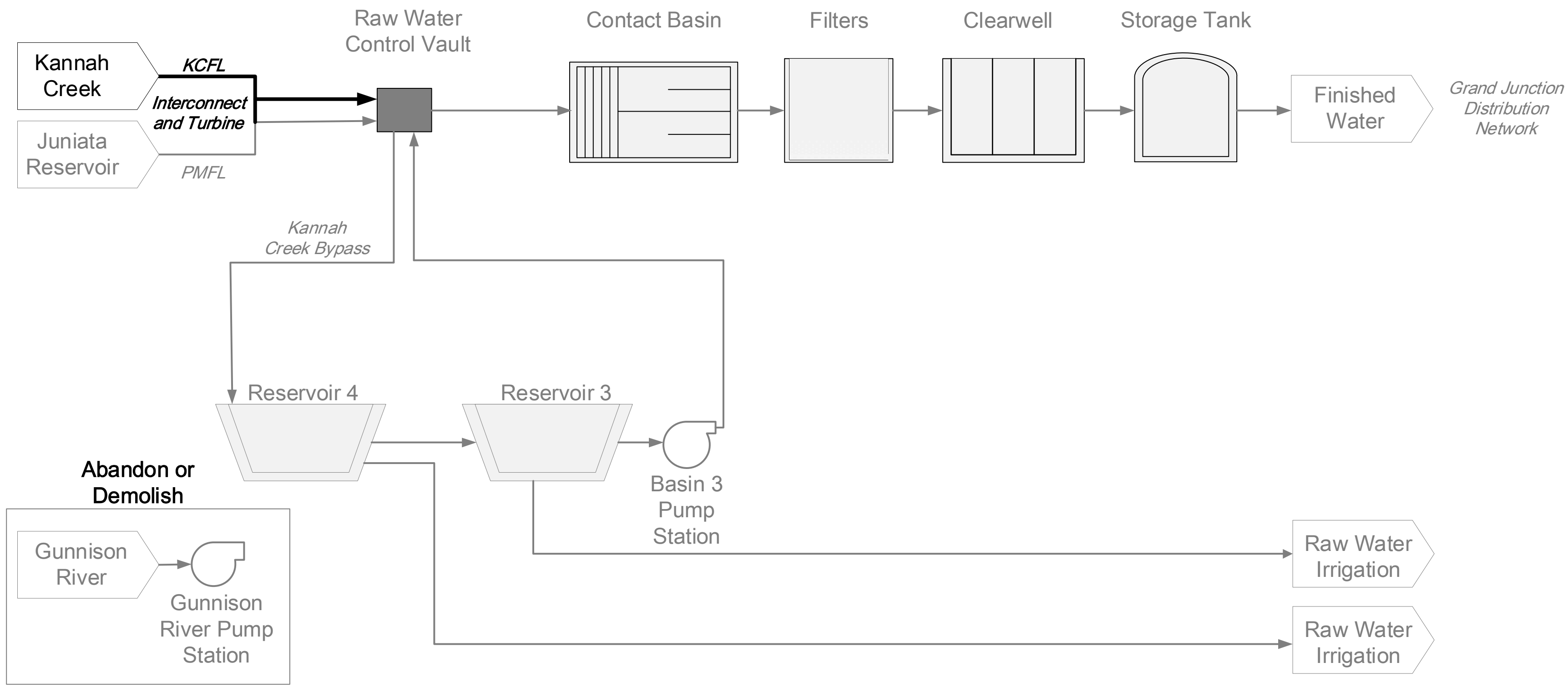

Figure 16: Process Flow Diagram for Option 7

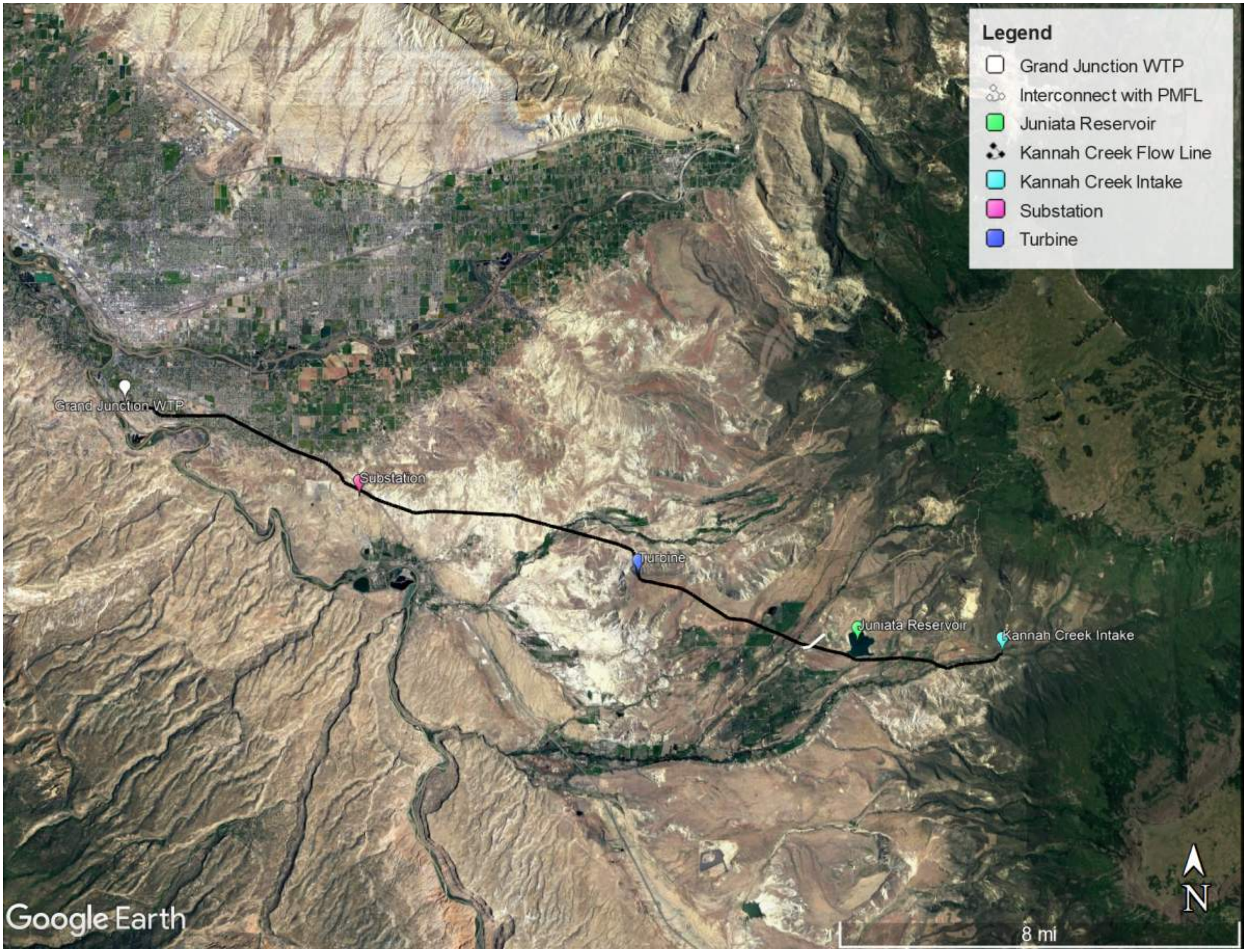

Figure 17: Preliminary Alignment for KCFL Replacement and Preliminary Turbine Placement

3.8 Option 8: New WTP in Kannah Creek Watershed

This Option includes a new WTP sized for peak day flows constructed in the Kannah Creek watershed. This new Kannah Creek WTP will utilize both Kannah Creek and Juniata Reservoir water rights. The Juniata Reservoir Interconnection (Section 3.5.1) will be required to achieve fully redundant raw water flow to the new Kannah Creek WTP.

A new Low Lift Pump Station will be constructed deliver water from either Kannah Creek or Juniata Reservoir to the new WTP. The new WTP will include conventional pretreatment, filtration, and chemical systems. Treated water will be conveyed to the distribution system via gravity through either PMFL or KCFL. The KCFL will be completely replaced with a new 24 inch pipeline (Option 5).

The new 13 mgd Kannah Creek WTP will provide treated water to the local Kannah Creek area customers and make the existing 0.3 mgd WTP redundant.

The Gunnison River will not be used but may remain operational to supply irrigation customers.

The following assumptions were used for this Option:

- Raw water source:
    - Kannah Creek via KCFL
    - Augmented by Juniata Reservoir interconnection
- Capacity:
    - 12.5 mgd (limited to hydraulic capacity of KCFL at 24-inch)
        - Summer: 5 mgd from Kannah Creek plus 7.5 mgd from Juniata Reservoir
        - Winter: 7.5 mgd from Kannah Creek plus 5 mgd from Juniata Reservoir
- Kannah Creek via interconnection and low lift pump station will be treated at new WTP
- Juniata Reservoir via low lift pump station will be treated at new WTP
- Residual pressure from the new WTP will be used to supply water directly to distribution system
- KCFL or PMFL available to convey either raw or treated water to the existing WTP for treatment or distribution
- Abandon existing 0.3 mgd WTP in place
- Add one pressure control chamber along KCFL
- Uppermost 4 miles of KCFL replacement outside scope of this project

This Option does not provide the future peak day flows of 13 mgd. Therefore, WTP flows must be augmented on peak demand days by raw water storage in Reservoirs 3 or 4 or existing distribution system storage. The interconnection with Clifton may also be used to meet peak daily flows greater than 12.5 mgd.

This Option does not provide access to an alternate water source than the PMFL.

Figure 18 below illustrates a conceptual process flow diagram for this Option. Figure 19 shows a preliminary alignment for the KCFL as well as preliminary Kannah Creek WTP location.

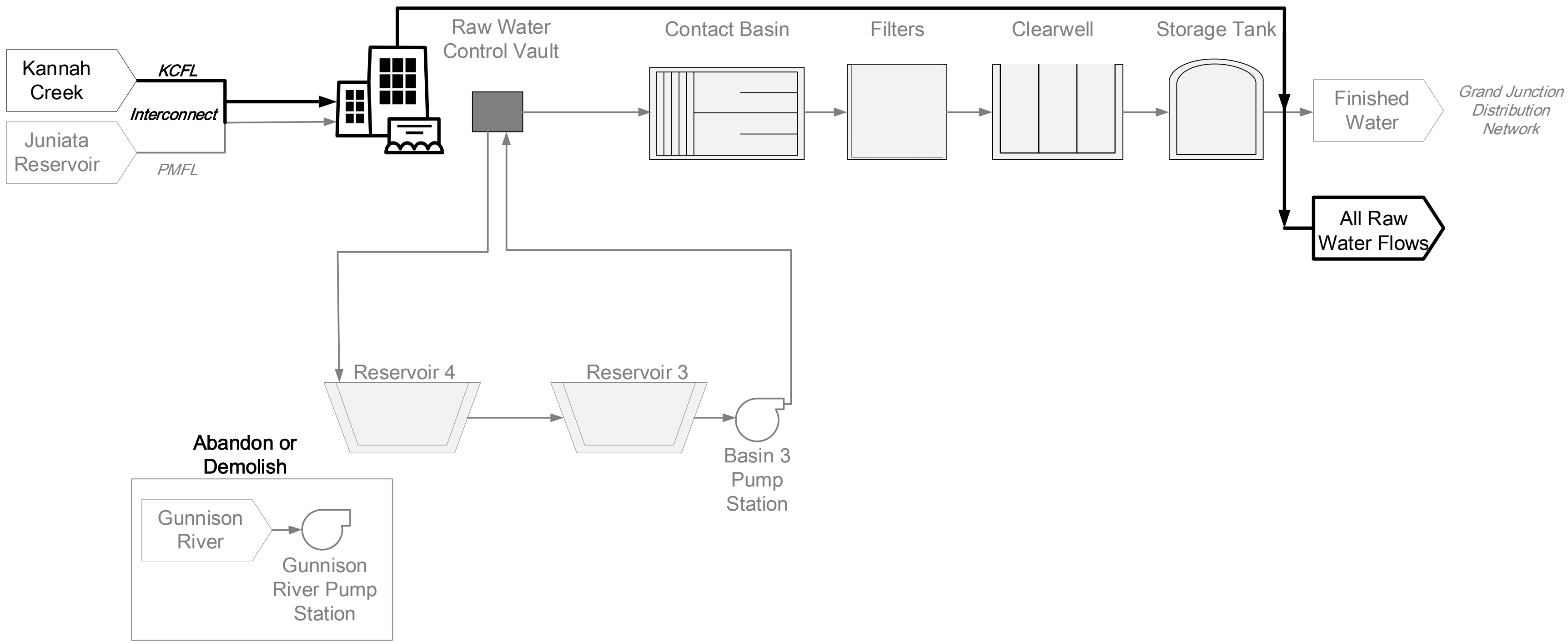

Figure 18: Process Flow Diagram for Option 8

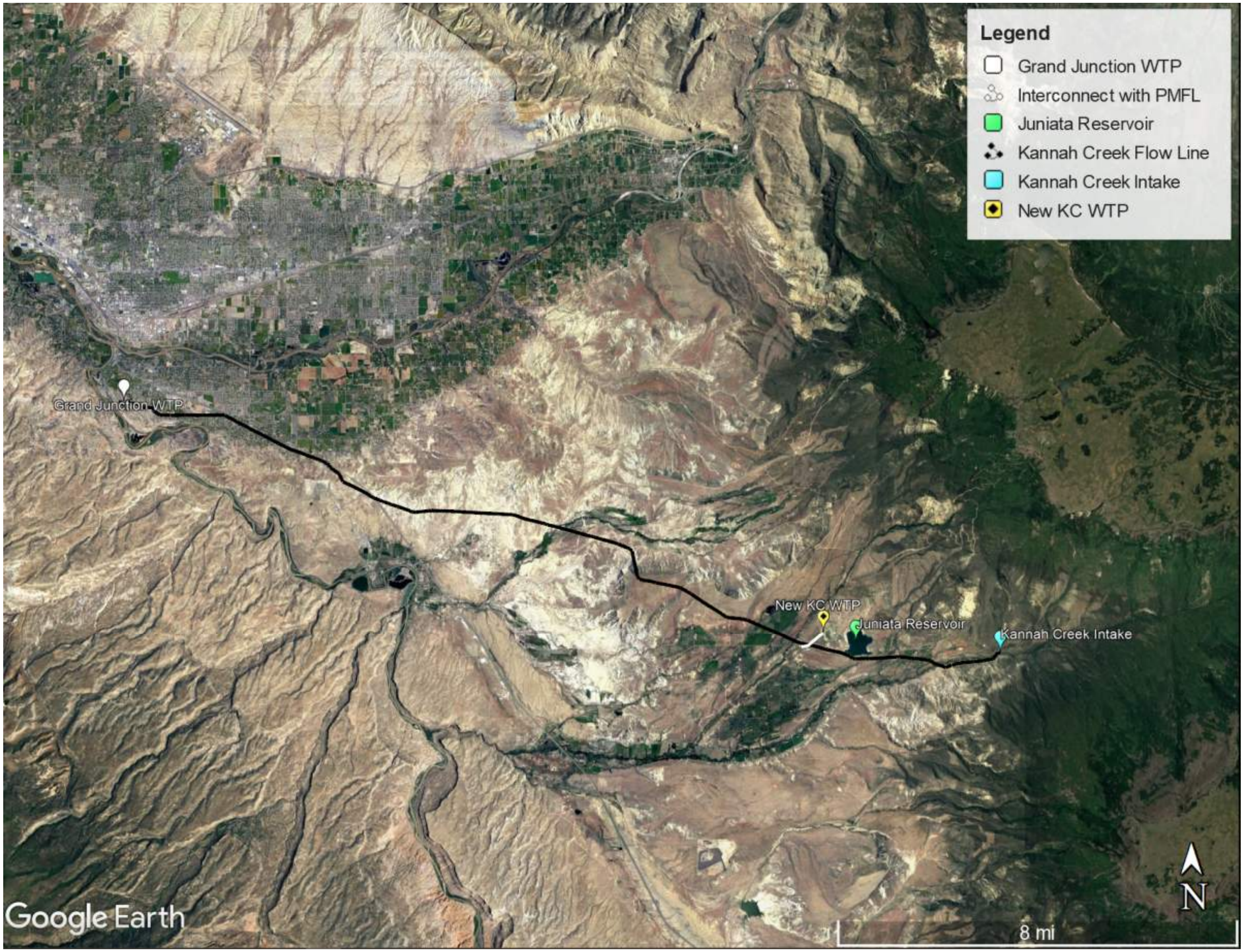

Figure 19: Preliminary Alignment for KCFL Replacement and Preliminary KC WTP Placement

3.9 Option 9: Clifton Water Emergency Interconnect

This Option is based on using the existing interconnection agreement with Clifton. The 1998 amendment allows Clifton to supply the City with up to 250 million gallons between April and September each year (1.4 mgd average). The amendment states that the City will supply Clifton with up to 250 million gallons per day between October and March. The agreement has informally expanded over the years to allow the City to take up to 4.5 mgd of treated water from Clifton in emergency situations. The Clifton interconnection on 29 Road is able to sustain flows up to 5.5 mgd.

The City will use the interconnection with Clifton in the event of a failure of the PMFL. This water would supplement the KCFL at its current capacity until complete failure of the KCFL.

The following assumptions were used for this Option:

- Raw water source: Kannah Creek via KCFL
- Treated water source: Grand Mesa and Colorado River via Clifton
- Capacity: 7.5 mgd
    - 5.5 mgd raw water from Clifton
    - 2 mgd raw water from KCFL in current condition
- KCFL will be utilized at current capacity until complete pipe failure
- Negotiate an updated agreement with Clifton
- Finished water from Clifton will be sent to the City through the existing interconnect
- Reservoirs 3 and 4 will be used to supply existing raw water irrigation customers while the PMFL is offline for repairs lasting a maximum of one week

This Option does not provide the future peak day flows of 13 mgd. Therefore, WTP flows must be augmented on peak demand days by raw water storage in Reservoirs 3 or 4 or existing distribution system storage.

The City may also consider using the Clifton interconnection agreement to preserve its water allocation on the Purdy Mesa. Clifton water may be used in non-emergency situations under the existing agreement. This approach may trigger a renegotiation of the agreement if used as a permanent, non-emergency source. Investigation of transfer, exchange, or credit of water rights to either Gunnison River or Colorado River should be explored by City but is not included in this study.

Figure 20 below illustrates a conceptual process flow diagram for this Option. This Option does not involve any capital costs, so it has been purposefully excluded from Appendices A and B.

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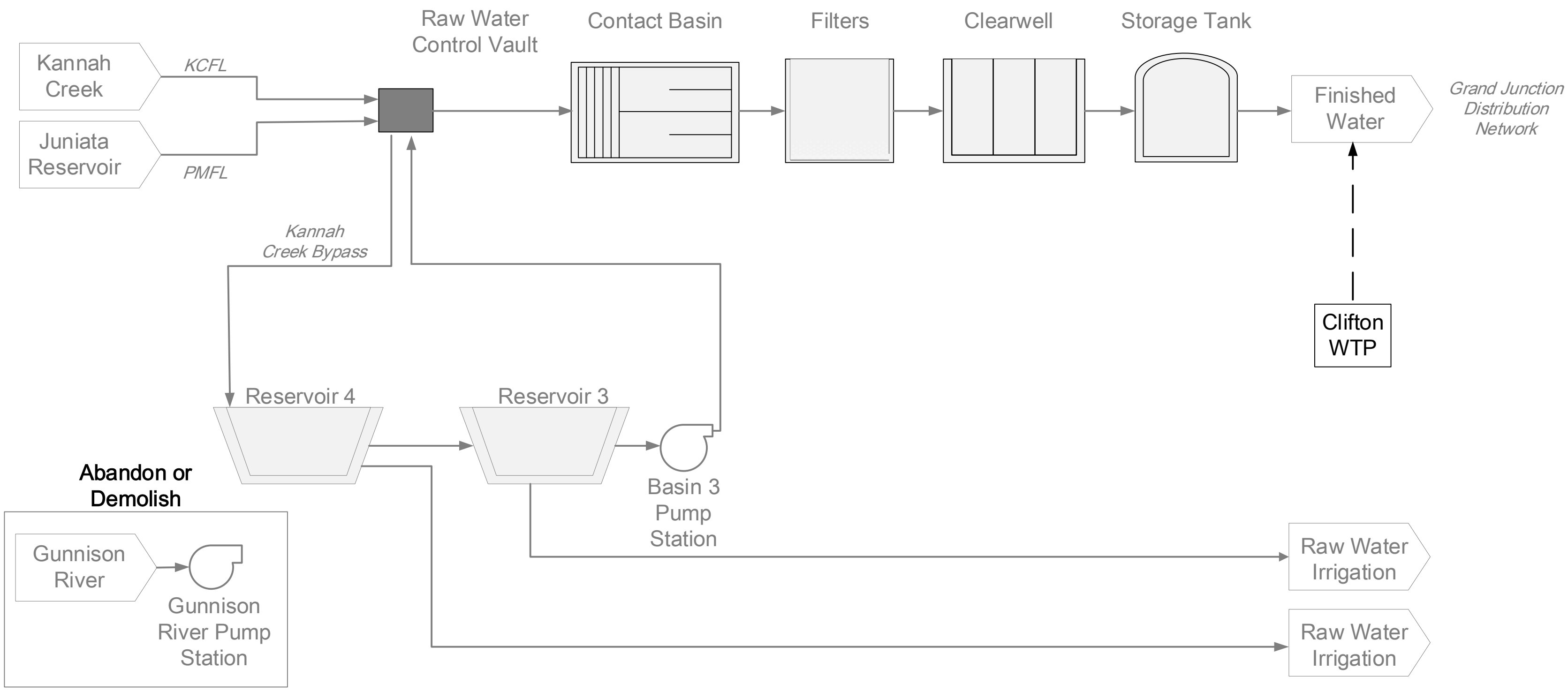

Figure 20: Process Flow Diagram for Option 9

3.10 Option 10: Transfer Colorado River Rights to Clifton for Treatment (Full Expansion, 24 inch pipeline)

The City owns 80 cfs of additional water rights to the Colorado River that are not being utilized. There is no active infrastructure that will allow the City to access its Colorado River source. This Option includes the transfer of Colorado water rights to Clifton for treatment and distribution back to the City. The Clifton WTP will be expanded to provide a fully redundant supply of 13 mgd to the City. It is anticipated that the City will contribute to the construction, operation, and maintenance of the expanded Clifton WTP.

The Clifton WTP combines membrane filtration with reverse osmosis. The treatment train is pre-sedimentation, flocculation, sedimentation and MF/UF. A portion of flow is treated by NF/RO to address high TDS in the Colorado River. The NF/RO bypass stream is blended back into the MF/UF stream.

The existing Clifton WTP has a capacity of 12 mgd, with a peak day flow of 6.3 mgd. The Clifton WTP has available space on the MF/UF and NF/RO racks for additional modules, as well as floor space in the existing buildings for additional membrane trains.

This Option is based on the expansion of the Clifton WTP to 21 mgd accommodate future peak day demands in Clifton and the City. This assumes future Clifton peak day demand of 8 mgd (30% increase), plus 13 mgd peak day demand from Grand Junction.

A new water transmission main will route treated water from the Clifton WTP to 30th Rd where existing pipe will be utilized to connect to the City's distribution network (24-inch diameter for 4 miles). This new treated water pipeline will provide flows above the 5.5 mgd capacity of the existing Clifton interconnection.

The following assumptions were used for this Option:

- Raw water source: Colorado River via Clifton WTP
- 13 mgd peak day flow
- KCFL will be abandoned in place
- Clifton will provide treatment
- Expand Clifton WTP from 12 to 21 mgd
    - 8 mgd for Clifton
    - 13 mgd for Grand Junction
- Adequate space available for Clifton WTP expansion
- CDPHE permits the expansion of the existing Clifton brine disposal ponds
- New 24-inch pipeline from Clifton to the City's distribution (4 miles)
- Reservoirs 3 and 4 will be used to supply existing raw water customers while PMFL is offline for up to one week

This Option uses the City's existing Colorado River water rights and provides access to an alternate water source than the Purdy Mesa.

Figure 21 below illustrates a conceptual process flow diagram for this Option. Figure 22 shows a preliminary alignment for the finished water pipeline from the Clifton WTP to the City's distribution system.

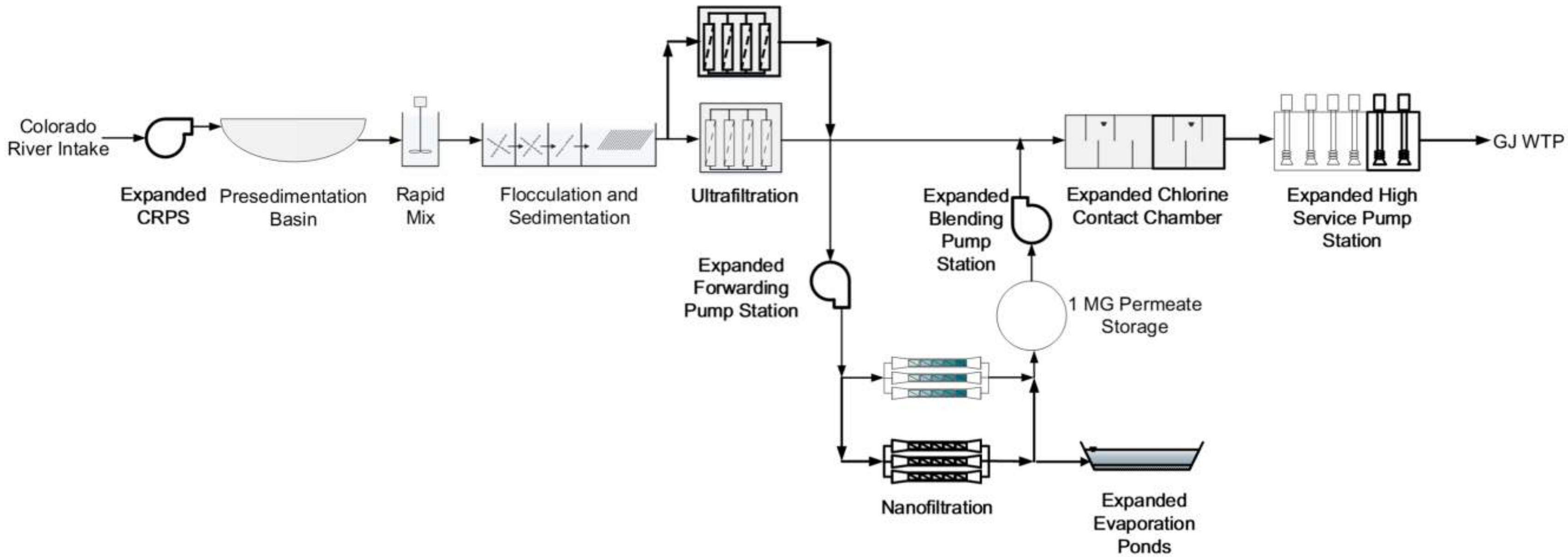

Figure 21: Process Flow Diagram for Option 10

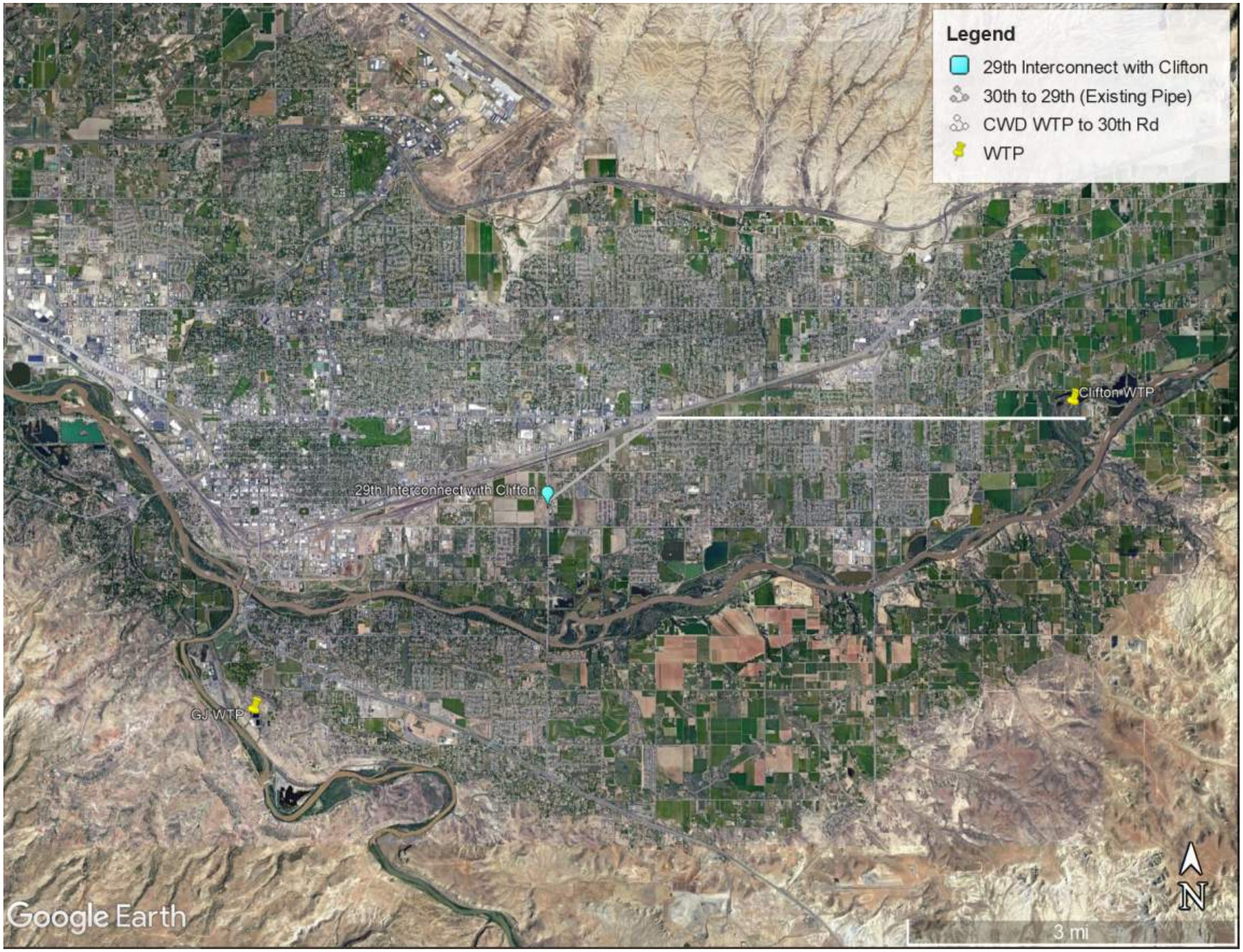

Figure 22: Preliminary Alignment for FW Transmission from CWD WTP to Grand Junction Distribution System

3.11 Option 11: Transfer Colorado River Rights to Clifton for Treatment (Partial Expansion, 20 inch pipeline)

This Option is based on an expansion of the Clifton WTP, similar to Option 10, but to a capacity of 16 mgd. This does not provide full future redundancy to the City but is a less complex and expensive expansion than the Clifton WTP expansion to 21 mgd. Clifton's pretreatment is already sized for 16 mgd, reducing the number of processes that need to be expanded. The MF/UF system will be expanded through a combination of populating existing skids with additional membrane modules, as well as adding a new MF/UF skid in the existing building space.

This Option assumes a future peak day demand of 8 mgd in Clifton (30% increase), leaving 8 mgd available for the City.

A new water transmission main will route treated water from the Clifton WTP to 30th Rd where existing pipe will be utilized to connect to the City's distribution network (20-inch diameter for 4 miles). This new treated water pipeline will provide flows above the 5.5 mgd capacity of the existing Clifton interconnection.

The following assumptions were used for this Option:

- Raw water source: Colorado River via Clifton WTP
- KCFL will be abandoned in place
- Clifton will provide treatment
- Expand Clifton WTP from 12 to 16 mgd
    - 8 mgd for Clifton
    - 8 mgd for Grand Junction
- Adequate space available for Clifton WTP expansion
- CDPHE permits the expansion of the existing Clifton brine disposal ponds
- New 20-inch pipeline from Clifton to the City's distribution (4 miles)
- Reservoirs 3 and 4 will be used to supply existing raw water customers while PMFL is offline for up to one week

This Option uses the City's existing Colorado River water rights and provides access to an alternate water source than the Purdy Mesa.

Refer to Figure 21 and Figure 22 under Option 10 for a conceptual process flow diagram and a preliminary alignment for the finished water pipeline from the Clifton WTP to the City's distribution system.

3.12 Option 12: Route Gunnison River to Clifton WTP

The City owns 120 cfs of additional water rights to the Gunnison River that are not being utilized. These rights could be transferred to Clifton for treatment at their WTP. This will require upgrades to the GRPS and a new raw water pipeline from the existing Gunnison River Intake to the Clifton WTP.

There are no significant water allocations between Clifton's Colorado River intake and the confluence of the Gunnison River. Therefore, the City could transfer part of its Colorado River rights to Clifton for treatment and replace those flows with its Gunnison River rights downstream. This avoids significant upgrades at the existing or a new Gunnison River intake, modifications to the GRPS and a raw water pipeline to the Clifton WTP.

The required upgrades after the transfer of water rights become the same as those proposed in Option 10. Options 10 and 12 result in the same scope of work (Clifton WTP expansion and finished water piping from Clifton to the City).

3.13 Blending of Free Chlorine and Chloraminated Sources

Options 13 and 14 are based utilizing the existing interconnections between the City and Ute. Ute uses chloramines for disinfection, which are not compatible with the City's use of free chlorine. Blending of the two waters would require additional treatment.

Blending of chlorinated and chloraminated water is generally not recommended due to the potential to lose chlorine residual. The ratio of chlorine to ammonia (Cl_2:NH_4-N) changes in an uncontrolled manner when free chlorine sources are blended with chloraminated sources. This can lead to a lowering of the disinfectant residuals to unsafe levels and create aesthetically unpleasing water.

Options for blending free chlorine and chloraminated sources include:

- Breakpoint Chlorination. Convert chloraminated water to free chlorine by adding sodium hypochlorite.
- Ammoniate the Chlorinated Water. Convert all water to chloramines by adding ammonia after free chlorine injection.
- Isolate Disinfectants. Separate or partition portions or zones of the distribution system to accommodate Ute's chloraminated water while some zones continue with the City's treated water from the KCFL source.
- Controlled Blending. Blend sources directly at each interconnect with the injection of chorine to convert to free chlorine residual. This option must include extensive controls to verify that free and total chlorine residuals will remain at acceptable levels. This may cause taste and odor issues if dichloramines form in the system. This option assumes use of some treated water from the City is available in the distribution system.
- Emergency Utilization. Utilize interconnects to blend Ute water as-is only in the event of emergency. This option is not recommended due to the inherent water quality risks.

Breakpoint chlorination (Option 13) and ammoniating of chlorinated water (Option 14) are discussed in the following sections.

3.14 Option 13: Purchase Treated Water from Ute (Breakpoint Chlorination)

The City has eight emergency interconnects in their water distribution network with Ute. Currently, the interconnects are not used due to the differing disinfection regimes (free chlorine at the City, chloramines at Ute).

The Linden Vault at Highway 50 and Linden Avenue is the closest Ute interconnect to the WTP at less than one mile away. Ute water enters the Linden Vault in an 18-inch pipe at approximately 200 psi. This is adequate pressure to deliver treated Ute water to the WTP in a new 24-inch pipeline from the Linden Vault.

A breakpoint chlorination station will be installed at the WTP to receive Ute treated water and convert chloramines to free chlorine. below. The City's existing sodium hypochlorite system will be expanded to accommodate the Ute flows and the higher free chlorine dose needed to destroy the chloramines. Sodium hypochlorite will be dosed in-line via a mixer past breakpoint concentrations to match the free chlorine residual required by the City.

Breakpoint chlorination (Figure 23) will remove the chloramines from the Ute treated water and convert to a free chlorine residual that matches the treated water in the City's distribution system. Breakpoint adjusted Ute water will be blended with the City's treated water in the existing storage tanks.

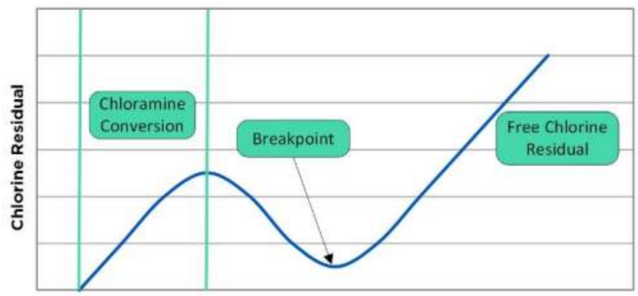

Figure 23: Breakpoint Chlorination Curve

Extensive pilot testing on the two source waters will be required to determine feasibility of blending Ute treated water with the City's water. A corrosion control/blending study is also recommended to determine the outcomes of the proposed break point chlorination design parameters across the City's distribution system.

A monitoring program must be implemented during episodes of blending Ute water. A monitoring program must monitor total chlorine, monochloramine, free ammonia, and free chlorine in the blended water to prevent issues with maintaining the chlorine residual and avoiding nitrification in the distribution network. This monitoring program will help the City verify that the water has reached and exceeded breakpoint chlorination, and that the ammonia has been removed. Nitrification action plans are also required for systems blending free and chloraminated water.

Note that the City's distribution system may encounter elevated concentrations of disinfection byproducts (DBPs) due to the additional chlorine required for breakpoint chlorination.

Pilot testing, blending studies, monitoring programs and nitrification action plans are not included in the scope of this study.

The following assumptions were used for this Option:

- Raw water source: Plateau Creek via Ute
- Adequate water rights and capacity in Ute raw water source to supply both Ute and the City's future needs
- 13 mgd peak day flow

- Single interconnection with Ute at Linden Vault
- Adequate pressure (200 psi) at Linden Vault to avoid re-pumping to the City's WTP
- Expand City's on-site sodium hypochlorite system for breakpoint chlorine doses
- Sufficient space for sodium hypochlorite tanks and pumps in existing chemical rooms (no building expansion)
- Must conduct CCS to understand the impact of using Ute water in the City's distribution system

This Option provides access to an alternate water source than the Purdy Mesa.

Figure 24 below illustrates a conceptual process flow diagram for this Option. Figure 25 shows a preliminary alignment for the raw water pipeline from the Linden Vault to the WTP.

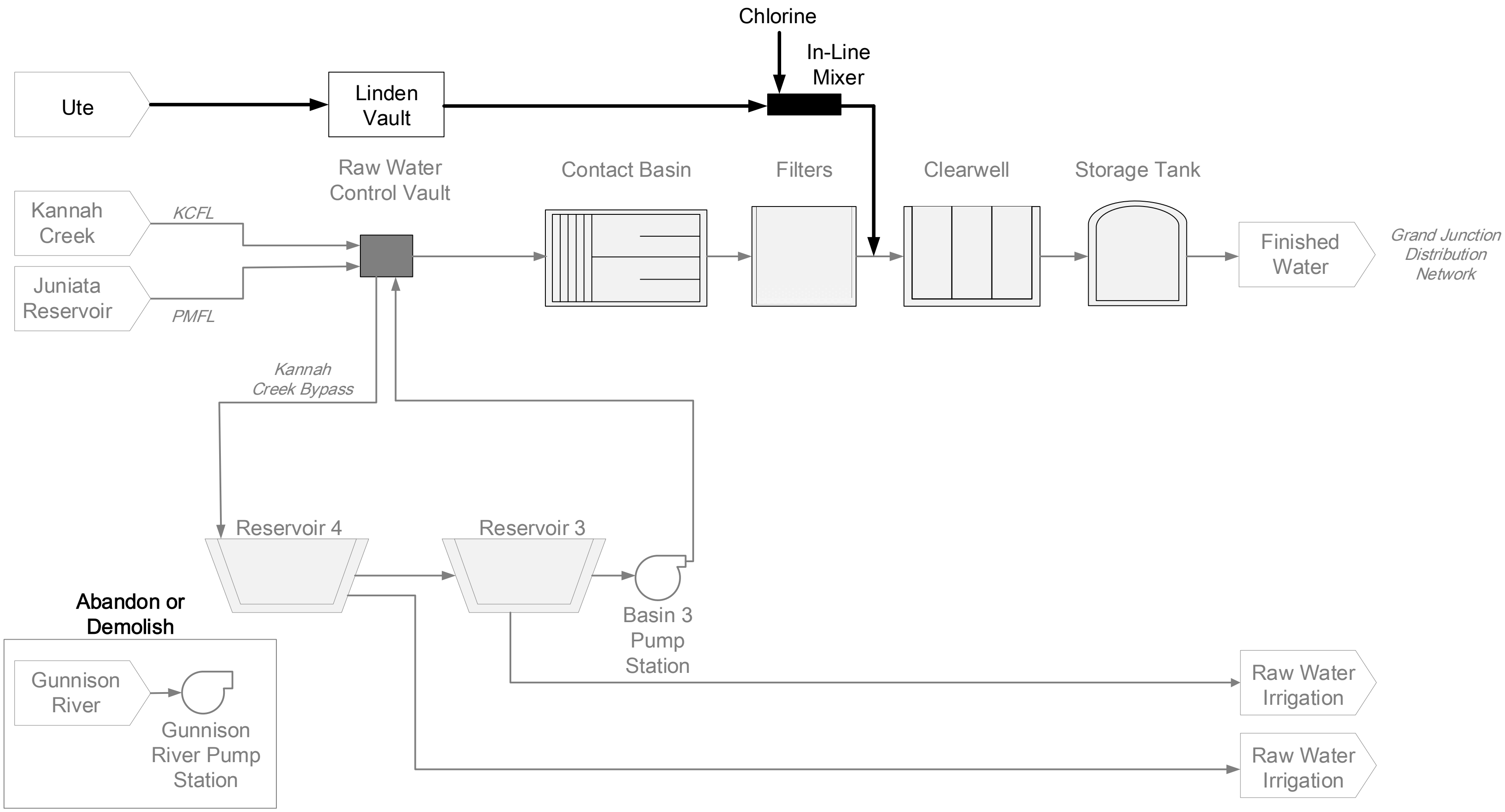

Figure 24: Process Flow Diagram for Option 14

Figure 25: Preliminary Alignment of Pipeline from Linden Vault to GJ WT

3.15 Option 14: Purchase Treated Water from Ute (Chloramine Conversion)

This Option includes the conversion of City water to chloramines instead of free chlorine. This allows the City to directly utilize any of the eight interconnects with Ute without needing to pump the water to the plant for breakpoint chlorination. It is assumed that the City will utilize the Linden and Riverside Vaults with modifications for flow control. Unlike breakpoint chlorination, this would be a permanent change to WTP operations, not just utilized when utilizing Ute water.

A liquid ammonia sulfate dosing system will be added to the WTP to convert free chlorine into chloramines. This will require a building expansion.

The use of chloramines will result with lower free chlorine levels in the distribution system, which will contribute to lower levels of DBP.

The following assumptions were used for this Option:

- Raw water source: Plateau Creek via Ute
- Adequate water rights and capacity in Ute raw water source to supply both Ute and the City's future needs
- 13 mgd peak day flow
- Two interconnects with Ute at the Linden and Riverside Vaults
- New 700 square foot liquid ammonia sulfate building at WTP
- Adequate pressure to avoid re-pumping to the City's distribution network
- Must conduct CCS to understand the impact of using Ute water in the City's distribution system

This Option provides access to an alternate water source than the Purdy Mesa.

Converting the City to chloramines will make the disinfection regime incompatible with Clifton, who use free chlorine. This may require renegotiation with Clifton on the interconnection agreement that is based on seasonal flow swapping between the City and Clifton.

Figure 26 shows a map of the top six interconnects the City has with Ute.

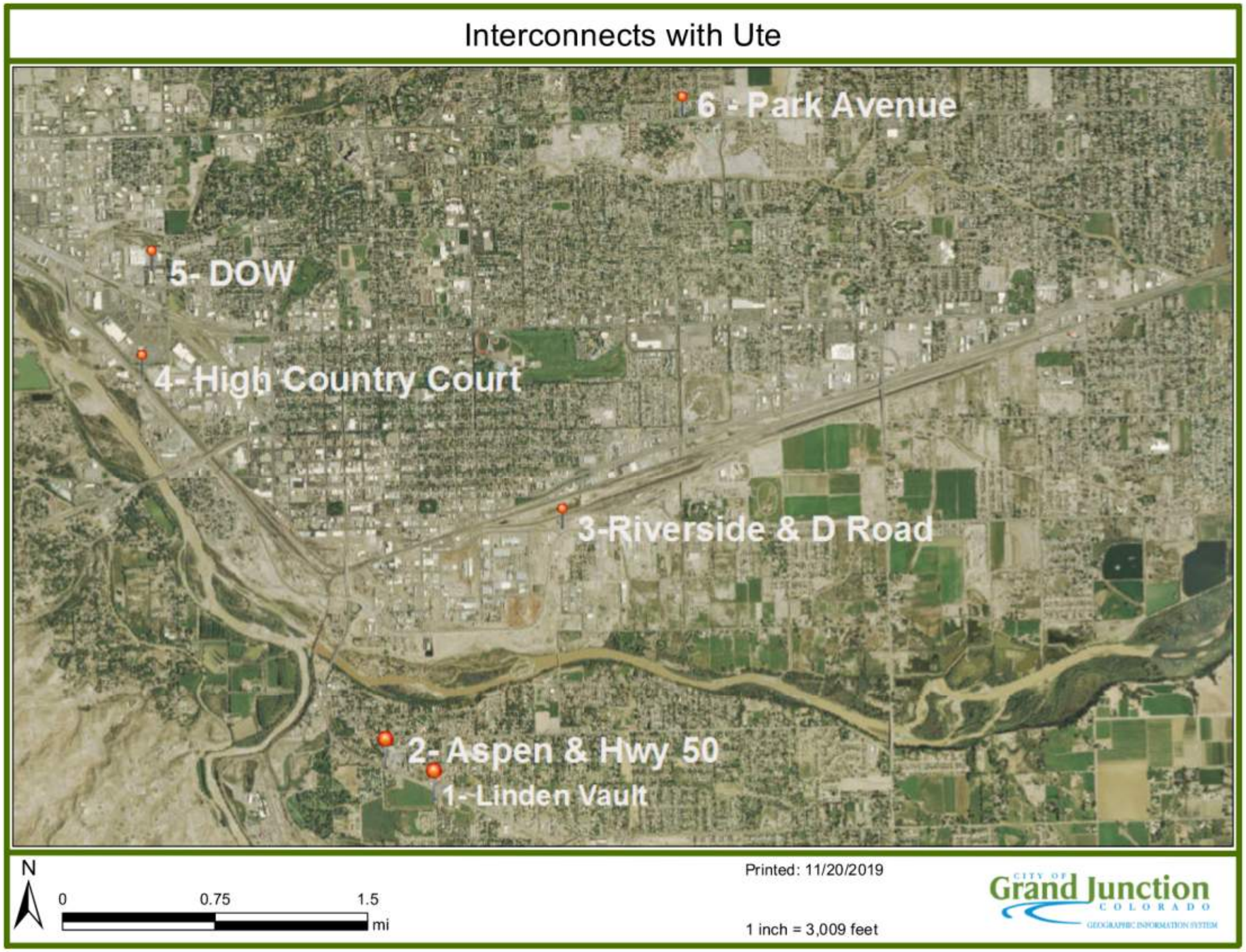

Figure 26: Map of Top Six Interconnects with Ute

4 OPTIONS SUMMARY

4.1 Hydraulic Capacity

Not all Options considered provide a fully redundant supply of 13 mgd flow. Therefore, combinations of sources were used within specific Options to achieve the 13 mgd future peak day flows. Option 9 (Clifton Emergency Interconnect) does not provide full redundancy but is included as an emergency option only. Table 6 summarizes the source, conveyance, and maximum flow of each option.

Table 6: Option Flow Composition

	Option	Source	Conveyance	Flow (mgd)
1	Treat Gunnison by Lime Softening	Gunnison River	GRPS	13.0
2	Treat Gunnison by Reverse Osmosis	Gunnison River	GRPS	13.0
3	Settle Gunnison in Existing Reservoirs and Blend with Clifton	Gunnison River Colorado River	GRPS Clifton	13.0
4	Settle Gunnison in Existing Reservoirs and Use for Raw Water	Gunnison River Kannah Creek	GRPS KCFL	11.7
5	Replace KCFL (24 inch)	Kannah Creek	KCFL	12.5
6	Replace KCFL (20 inch)	Kannah Creek	KCFL	9.7
7	Replace KCFL (24 inch) and Add Turbine	Kannah Creek	KCFL	12.5
8	New WTP in Kannah Creek Watershed	Kannah Creek	KCFL	12.5
9	Clifton Water Emergency Interconnect	Colorado River Kannah Creek	Clifton KCFL	7.5
10	Transfer Colorado Water Rights to Clifton for Treatment (Full Expansion, 24 inch)	Colorado River	Clifton	13.0
11	Transfer Colorado Water Rights to Clifton for Treatment (Partial Expansion, 20 inch)	Colorado River	Clifton	8.0
12	Route Gunnison to Clifton WTP	Colorado River (Same as Option 10)	Clifton	13.0
13	Purchase Treated Water from Ute (Breakpoint Chlorination)	Grand Mesa	Ute	13.0
14	Purchase Treated Water from Ute (Chloramine Conversion)	Grand Mesa	Ute	13.0

Figure 27 illustrates the combination of sources for each Option and their respective hydraulic capacities. Flows must be augmented on peak demand days by either raw water storage in Reservoirs 3 or 4 or the City's existing treated water storage reservoirs. The 5.5 mgd capacity interconnection with Clifton may also be used to augment Options which do not provide 13 mgd.

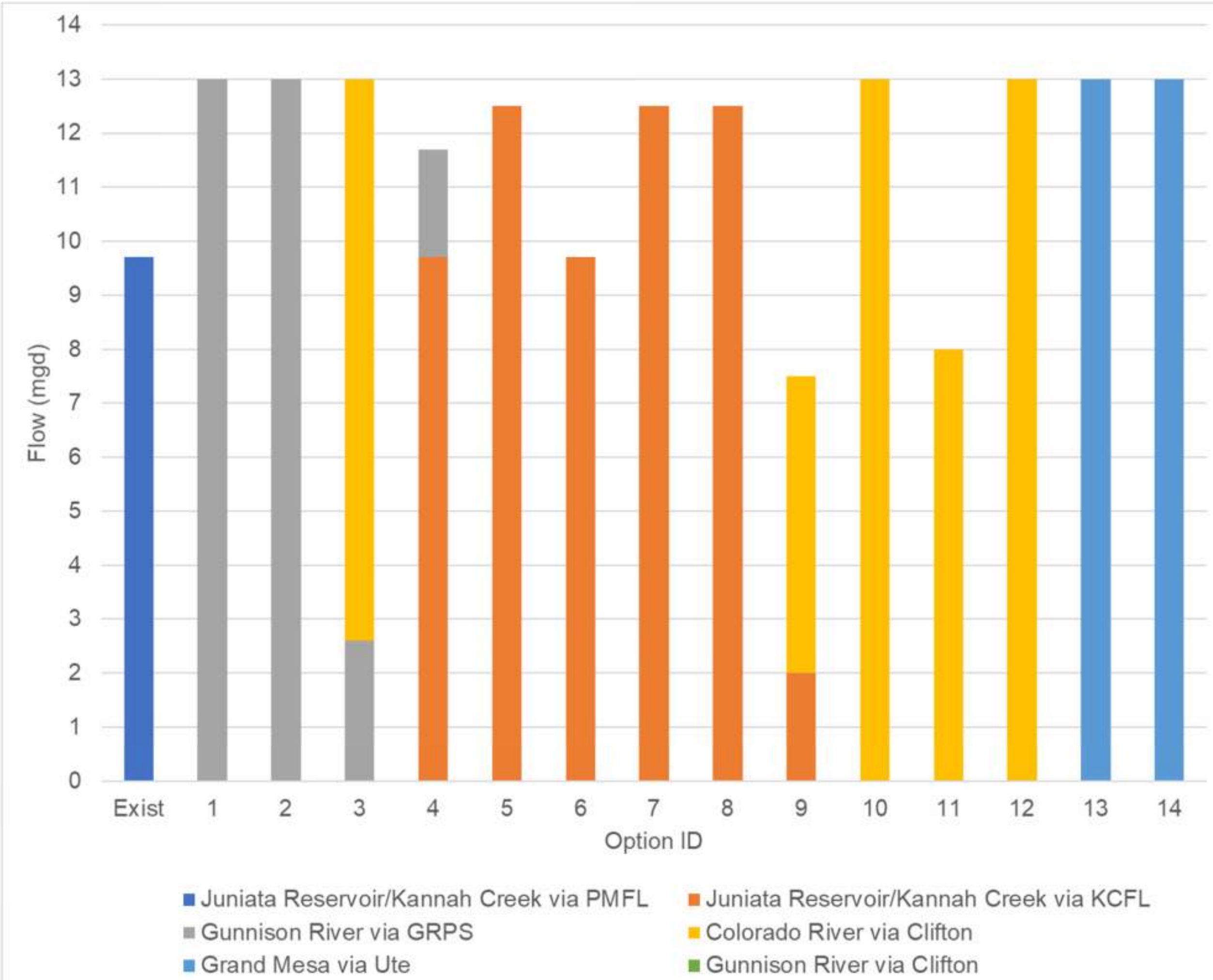

Figure 27: Hydraulic Capacity by Option

4.1.1 Treated Water Storage

The City has two 4 mg ground storage tanks at the WTP site (8 mg total). There is no treated water storage in the distribution system. Treated water storage capacity is determined through engineering studies to assess domestic demands and fire flows. Generally, water storage tanks provide:

- Peak balancing storage for instantaneous demands greater than the WTP production rate,
- Fire flows, and
- Emergency storage.

Current and future peak day demands are discussed in Section 2.4.

Fire flows in Grand Junction are based on the 2000 edition of the International Fire Code (IFC). Fire flow rates are determined by the size of the building, its use, and type of construction. Fire flows range from a minimum of 1,500 gpm for single family dwellings to 8,000 gpm for large buildings per Table B105.1 of the IFC. An assumed fire flow of 6,000 gpm is used in this study, which represents a Type 1A building of over 300,000 square feet. A duration of 4 hours required for fire flows of 6,000 gpm.

Emergency storage is available to serve customers in the event of a watermain break or service interruption at the WTP. Emergency storage may be reduced if there is sufficient capacity in the source water supply and the WTP with standby power to meet peak demands. Excess capacity may lead to water quality deterioration.

Table 7: Grand Junction Treated Water Storage

Component	Design Criteria	Flow / Volume	Volume
Peak balancing	25% of maximum day demand	13 mgd	3.3 mg
Fire flow	Table B105.1 IFC, 2000	6,000 gpm for 4 hours	1.4 mg
Emergency storage	15% of average day flow	6.5 mgd	1.0 mg
		Recommended treated water storage (future)	5.7 mg
		Actual treated water storage	8.0 mg
		Spare treated water storage (future)	2.3 mg

Table 7 indicates the City has spare storage available in the existing treated water storage tanks. This volume is available for short term operational issues, such as line breaks in the PMFL or KCFL or periodic maintenance at the WTP. The contributes to the City's goal of operational redundancy. This equates to approximately 30 hours of treated water supply at the current average day demand of 4.7 mgd, while maintaining the recommended fire flow and emergency storage volumes in the tanks. The available treated water storage is augmented by the up to 23 mg of raw water storage in Reservoirs 3 and 4 (approximately 5 days of storage at current average day demands).

Further engineering analysis and modeling is recommended to assess the benefit of additional treated water storage in the distribution system, its potential volume and location. Potential sites may require land acquisition and may modify the operating pressures due to the tank elevation. Additional water storage may impact water quality due to a longer water age.

4.2 Cost Comparison

4.2.1 Engineer's Opinion of Probable Construction Costs

EOPCC were completed in accordance with the Association for the Advancement of Cost Engineering (AACE) Class 4 definition. Class 4 EOPCC are prepared to evaluate and compare the options presented in Section 2. Class 4 EOPCC are generally developed with limited information and subsequently vary in their accuracy. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval.

Class 4 EOPCC are typically based on 1% to 15% complete design development, comprising at a minimum of:

- Plant capacity,
- Block schematics,
- Process flow diagrams (PFDs) for main process systems,
- Preliminary equipment lists, and
- Pipeline diameter and initial routing.

The expected accuracy range is -15% to -30% below and +20% to +50% above. Vendor quotes were sought and gross unit costs/ratios from past projects were used to develop the estimates in this study.

Contingency values range from 10 to 30% based on the level of detail known for each option. Major scope items and EOPCC for each option are presented in Appendices A and B, respectively. A summary of each option including EOPCC and construction cost per gallon of capacity can be found in Table 8.

The estimates, analyses, and recommendations contained in this analysis are based on professional experience, qualifications, and judgment. BMcD has no control over weather; cost and availability of labor, material, and equipment; labor productivity; energy or commodity pricing; demand or usage; population demographics; market conditions; changes in technology; and other economic or political factors affecting such estimates, analyses, and recommendations. Therefore, BMcD makes no guarantee or warranty (actual, expressed, or implied) that actual results will not vary, perhaps significantly, from the estimates, analyses, and recommendations contained herein.

4.2.2 Escalation

The EOPCC presented in this study are based on 2020 dollars at the time of issue. The use of the costs presented in this study should be escalated if used for future purposes to reflect changes in labor, material, and equipment. Local cost data or published cost indices should be consulted to determine an appropriate cost escalation factor.

Table 8: Summary of EOPCC

	Option	EOPCC	Capital Cost/Gal	Notes
1	Treat Gunnison by Lime Softening	$41,900,000	$3.22/gal	$15,300,000 Lime Softening $10,600,000 Solids Handling
2	Treat Gunnison by Reverse Osmosis	$70,900,000	$5.45/gal	$28,800,000 RO Treatment $42,100,000 Brine Disposal
3	Settle Gunnison in Existing Reservoirs and Blend with Clifton	$18,100,000	$1.39/gal	
4	Settle Gunnison in Existing Reservoirs and Use for Raw Water	$23,300,000	$1.99/gal	11.7 mgd
5	Replace KCFL (24 inch)	$27,900,000	$2.23/gal	12.5 mgd
6	Replace KCFL (20 inch)	$23,000,000	$2.32/gal	9.7 mgd
7	Replace KCFL (24 inch) and Add Turbine	$39,200,000	$3.14/gal	$28,000,000 Pipeline $1,500,000 Turbine plus $7,300,000 Electrical Transmission
8	New WTP in Kannah Creek Watershed	$59,400,000	$4.75/gal	$20,300,000 WTP $28,200,000 Pipeline
9	Clifton Water Emergency Interconnect	N/A	N/A	7.5 mgd
10	Transfer Colorado Water Rights to Clifton for Treatment (Full Expansion, 24 inch)	$44,600,000	$3.43/gal	$37,300,000 Clifton WTP expansion with evap. ponds $7,300,000 Pipeline
11	Transfer Colorado Water Rights to Clifton for Treatment (Partial Expansion, 20 inch)	$25,300,000	$3.16/gal	$19,400,000 Clifton WTP expansion with evap. ponds $5,900,000 Pipeline
12	Route Gunnison to Clifton WTP	$44,600,000	$4.31/gal	Same as Option 10
13	Purchase Treated Water from Ute (Breakpoint Chlorination)	$3,300,000	$0.25/gal	Excluding CCS, blending study, monitoring costs
14	Purchase Treated Water from Ute (Chloramine Conversion)	$3,500,000	$0.27/gal	Excluding CCS, blending study, monitoring costs

4.2.3 Operating Costs

Operations and maintenance (O&M) costs were developed under the following assumptions:

- Operating costs are based on one month use of the alternate source at current peak day flow (9.8 mgd). This value was chosen to compare to current baseline O&M costs. If option provides less than 9.8 mgd, cost is based on the lower value.
- O&M costs include chemical and electricity usage
- O&M costs exclude consumables and labor
- Treatment costs based on typical cost per 1,000 gallon (kgal) from white paper research:
    - $0.50/kgal for lime softening
    - $1.00/kgal for reverse osmosis
- Gunnison River Options
    - $35,000 pumping cost for 9.8 mgd
    - $5,000 pumping cost for 2 mgd (Option 4)
- O&M cost equivalent for KCFL is equivalent to the existing PMFL ($88,000/month)
- O&M cost for new Kannah Creek WTP (Option 8) equivalent to existing WTP
- Hydro-turbine operating costs
    - Power generation estimated 370 psi available head at average flow of 5.3 mgd
    - Turbine efficiency 73%
    - Energy cost savings of $0.034/kWh
    - Electrical demand charge savings vary seasonally between $18 and $23 per kW
- Clifton Interconnect Options
    - Purchase cost of treated water includes O&M cost (e.g. pump costs from CWD)
    - Current agreement of $0.30/kgal treated water between the City and CWD may need to be renegotiated
- Ute Interconnect Options
    - Purchase cost of treated includes O&M cost (e.g. pump costs from Ute)
    - No current agreement for treated water.
    - City and Ute to negotiate bulk purchase agreement.
        - Ute water rates as published on the City’s website.
        - Assumed Ute’s cost to supply water is their Tier 2 rate of $3.70/kgal
        - Assumed purchase cost of Tier 3 rate of $4.20/kgal for purposes of this study.

A comparison of the O&M costs versus the bulk water purchase costs is shown in Table 9.

Table 9: Summary of Purchase and Operating Costs by Month

	Option	Purchase Cost	O&M Cost	Total Cost
1	Treat Gunnison by Lime Softening	NA	$233,000	$233,000
2	Treat Gunnison by Reverse Osmosis	NA	$379,000	$379,000
3	Settle Gunnison in Existing Reservoirs and Blend with Clifton	$70,000	$93,000	$163,000
4	Settle Gunnison in Existing Reservoirs and Use for Raw Water	NA	$93,000	$93,000
5	Replace KCFL (24 inch)	NA	$88,000	$88,000
6	Replace KCFL (20 inch)	NA	$88,000	$88,000
7	Replace KCFL (24 inch) and Add Turbine	NA	$71,000	$71,000
8	New WTP in Kannah Creek Watershed	NA	$88,000	$88,000
9	Clifton Water Emergency Interconnect	$50,000	$18,000	$68,000
10	Transfer Colorado Water Rights to Clifton for Treatment (Full Expansion, 24 inch)	$88,000	NA	$88,000
11	Transfer Colorado Water Rights to Clifton for Treatment (Partial Expansion, 20 inch)	$72,000	NA	$72,000
12	Route Gunnison to Clifton WTP	$88,000	NA	$88,000
13	Purchase Treated Water from Ute (Breakpoint Chlorination)	$1,222,000	$30,000	$1,252,000
14	Purchase Treated Water from Ute (Chloramine Conversion)	$1,222,000	$30,000	$1,252,000

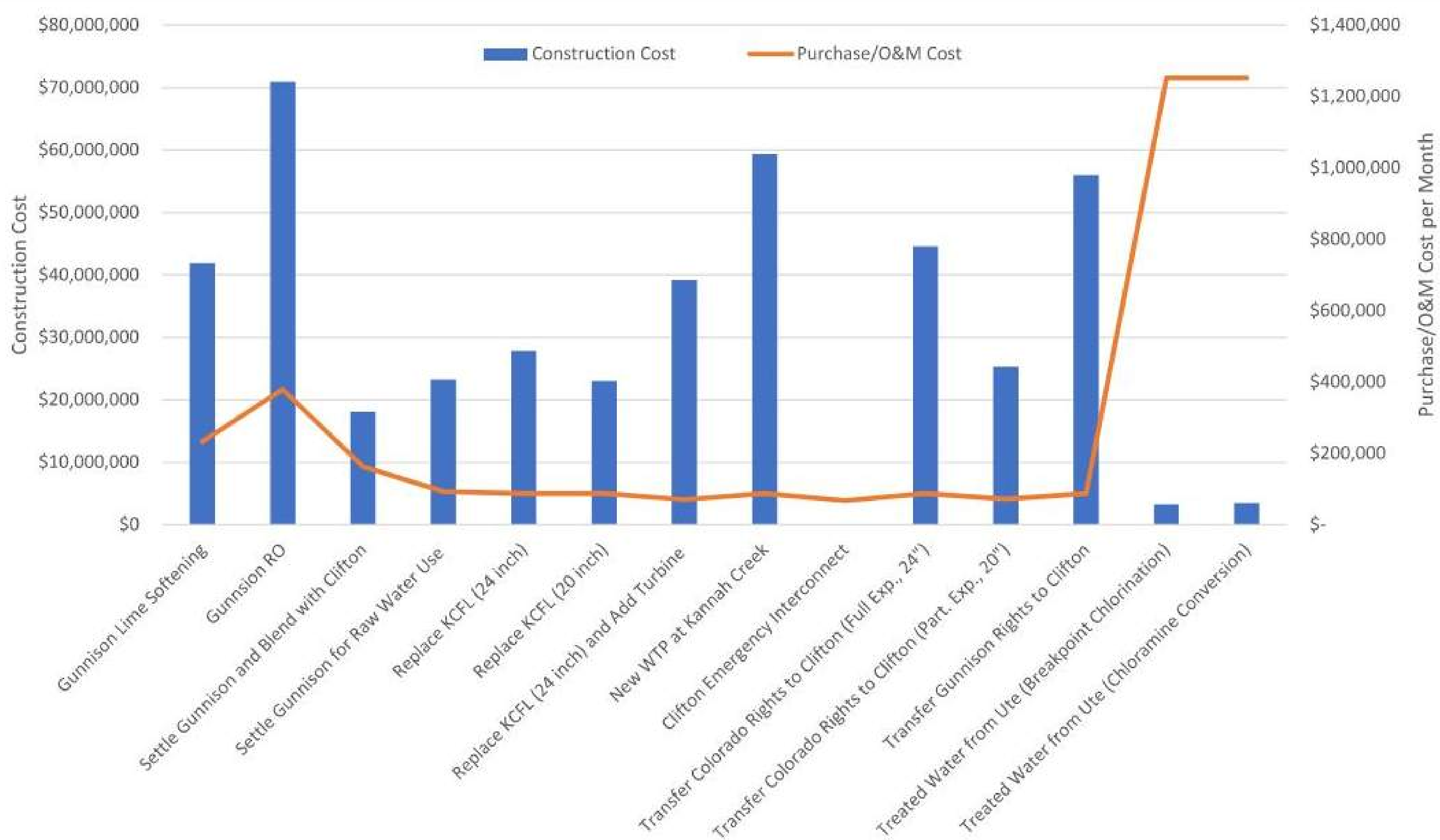

Figure 28: Comparison of Construction and O&M Costs

5 EVALUATION

The Project Team held a series of meetings in order to develop the Options for alternative water supplies. A Selection Workshop was held in January 2020 to evaluate the identified Options and select the preferred Option for conceptual design. The Project Team included the Utilities Director, Water Services Manager, Water Operations, Water Distribution, Asset Management and BMcD. The results of this initial Selection Workshop are document in Appendix C.

Three additional Options were added in April 2020 following a meeting with key stakeholders from the City. The Options were then re-ranked using a qualitative, non-monetary selection criteria. The results of the second evaluation are presented in the following sections.

5.1 Initial Screening

The following options are recommended for disqualification from the evaluation for the reasons presented in Table 9.

Table 10: Disqualified Options

	Option	Reason
2	Treat Gunnison by Reverse Osmosis	High capital cost to treat Gunnison River Option 1 (lime softening) provides lower cost of treatment
4	Settle Gunnison in Existing Reservoirs and Use for Raw Water	Does not provide acceptable water quality for raw water irrigation
7	Replace KCFL (24 inch) and Add Turbine	Feasibility not confirmed with Grand Valley Power. Potential energy production of turbine does not pay for extensive electrical upgrades
8	New WTP in Kannah Creek Watershed	High capital cost for new facility New WTP is redundant to the existing WTP KCFL update required to deliver water to City
9	Clifton Water Emergency Interconnect	Does not provide a fully redundant alternative Capacity well less than future peak day demand of 13 mgd
12	Route Gunnison to Clifton WTP	High infrastructure cost to send Gunnison River to Clifton replaced by water transfer Transfer City's Colorado River rights to Clifton and replace with City's Gunnison River allocation at confluence Becomes same as Option 10

Table 11: Options Evaluated by Project Team

#	Option
1	Treat Gunnison River by Lime Softening
3	Settle Gunnison River in Existing Reservoirs and Blend with Clifton
5	Replace Kannah Creek Flow Line (24 inch)
6	Replace Kannah Creek Flow Line (20 inch)
10	Transfer Colorado River Rights to Clifton for Treatment (Full Expansion, 24 inch)
11	Transfer Colorado River Rights to Clifton for Treatment (Partial Expansion, 20 inch)
13	Purchase Treated Water from Ute (Breakpoint Chlorination)
14	Purchase Treated Water from Ute (Chloramine Conversion)

5.2 Scoring of Options

A multi-step process was used to evaluate the technical, qualitative, and monetary criteria of each option. The first step involved developing the non-monetary criteria and then ranking the criteria in a Workshop with the Project Team. The selected criteria are shown in Table 12.

Table 12: Selection Criteria

Criteria Category	Description
Operational Redundancy	Ability to provide full redundancy of up to 13 mgd to the Purdy Mesa flowline. Options scoring high in this category can provide full redundancy to Purdy Mesa flowline without concern over water rights. Low scoring options do not provide the full capacity of 13 mgd.
Raw Water Quality	Measure of the raw water quality of the source water(s) included within the option. Options scoring high in this category mean the sources have water quality similar to Purdy Mesa. Low scoring options have poor source water quality.
Finished Water Quality	Measure of the anticipated finished water quality as a result of the treatment associated with the option. Options scoring high in this category mean the treatment is expected to produce finished water similar or better than the current WTP. This criteria also considers the satisfaction of raw water customers.
Long Term Resiliency	Ability to supply raw water from an alternative source in the event of a long term interruption to the City's primary source (Juniata Reservoir and Kannah Creek watershed).
Complexity of Sources	Evaluates the number of sources required to provide a fully-redundant capacity and the complexity to operate multiple sources. Options scoring high in this category only require one source to create redundancy.
Ease of Operations	Evaluates the complexity of operations and maintenance, number of treatment process steps and units and chemical dosing systems associated with the option. Options scoring high in this category apply operating procedures similar or less complex than the current WTP.
Public Perception	Evaluates the public perception to the alternate water source. Public opinion prefers elevated sources, considered pristine mountain source. Less favorable view of using river sources.

The second step ranked the non-monetary criteria used a paired comparison to identify the weighting for each criterion (Table 13). Each criteria were paired against the other criteria, with the criteria of higher importance being preferred. The alphanumeric identification of the preferred criteria is recorded in Table 13 (e.g. B). Then the degree to which the criteria was preferred were scored on their relative importance on a scale of 1 to 3, with 3 as a high importance. The numeric score of the preferred criteria is recorded in Table 13 (e.g. 2), resulting in a paired score (e.g. B2).

Table 13: Weighted Criteria

DEVELOP CRITERIA & WEIGHTED MATRIX										
ITEM	CRITERIA	RELATIVE IMPORTANCE							SCORE	NORMALIZED
A	Operational Redundancy	A	A 3	A 3	A 1	A 1	A 2	A 1	11	2.9
B	Raw Water Quality		B	C 3	D 2	B 2	B 1	G 3	3	0.8
C	Finished Water Quality			C	D 2	C 1	C 2	C 1	7	1.8
D	Long Term Resiliency				D	D 1	F 1	G 2	5	1.3
E	Complexity of Sources					E	E 3	G 2	3	0.8
F	Ease of Operations						F	G 1	1	0.3
G	Public Perception							G	8	2.1
Directions: For each pair, select the more important criteria. Then choose a relative importance between 1-3 (3 as high importance).									38	10

Next, the Project Team scored each Option against the criteria on a scale of 1 to 5, with 5 being high (Table 14).

Table 14: Scored Options

SCORE OPTIONS								
Option	Operational Redundancy	Raw Water Quality	Finished Water Quality	Long Term Resiliency	Complexity of Sources	Ease of Operations	Public Perception	Total
Option 1: Treat GR by Lime Softening	5	1	2	5	1	1	1	16
Option 3: Blend GR with Clifton	5	2	1	5	1	2	2	18
Option 5: 24" KCFL	5	5	5	2	5	5	5	32
Option 6: 20" KCFL	5	5	5	2	5	4	5	31
Option 10: Transfer Add. CR to Clifton, Full Ex., 24 in	5	1	3	5	2	3	3	22
Option 11: Transfer Add. CR to Clifton, Part. Ex., 20 in	3	1	3	5	2	3	3	20
Option 13: Purchase Treated Ute Water, Breakpoint Chlor.	5	4	4	4	4	4	4	29
Option 14: Purchase Treated Ute Water, Chloramines	5	4	5	3	4	3	4	28
Directions: Score each option for each criteria between 1-5 (5 is high).								

The weighting criteria was then applied to the scores to establish a weighted score (Table 15).

Table 15: Weighted Scored Options

WEIGHT SCORED OPTIONS								
Option	Operational Redundancy	Raw Water Quality	Finished Water Quality	Long Term Resiliency	Complexity of Sources	Ease of Operations	Public Perception	Total
Option 1: Treat GR by Lime Softening	55	3	14	25	3	1	8	109
Option 3: Blend GR with Clifton	55	6	7	25	3	2	16	114
Option 5: 24" KCFL	55	15	35	10	15	5	40	175
Option 6: 20" KCFL	55	15	35	10	15	4	40	174
Option 10: Transfer Add. CR to Clifton, Full Ex., 24 in	55	3	21	25	6	3	24	137
Option 11: Transfer Add. CR to Clifton, Part. Ex., 20 in	33	3	21	25	6	3	24	115
Option 13: Purchase Treated Ute Water, Breakpoint Chlor.	55	12	28	20	12	4	32	163
Option 14: Purchase Treated Ute Water, Chloramines	55	12	35	15	12	3	32	164
Directions: Table autopopulates based on weight of criteria and scored options.								

High Score	Option 5: 24" KCFL

The Options were then ranked by their weighted score and compared against the EOPCC (Table 16). The cost/benefit for each Option was calculated by dividing the EOPCC by the weighted score. A low cost/benefit indicates a favorable Option, with more benefit achieved at a lower cost investment.

Table 16: Comparison of EOPCC and Weighted Score

Comparison of EOPCC and Weighted Score			
Option	EOPCC	Weighted Score	Cost/Benefit
Option 5: 24" KCFL	$ 27,900,000	175	$ 159,000
Option 6: 20" KCFL	$ 22,200,000	174	$ 128,000
Option 14: Purchase Treated Ute Water, Chloramines	$ 3,500,000	164	$ 21,000
Option 13: Purchase Treated Ute Water, Breakpoint Chlor.	$ 3,300,000	163	$ 20,000
Option 10: Transfer Add. CR to Clifton, Full Ex., 24 in	$ 44,600,000	137	$ 326,000
Option 11: Transfer Add. CR to Clifton, Part. Ex., 20 in	$ 25,300,000	115	$ 220,000
Option 3: Blend GR with Clifton	$ 18,100,000	114	$ 159,000
Option 1: Treat GR by Lime Softening	$ 41,900,000	109	$ 384,000

Figure 29 presents the relative benefit of the evaluated Options against their EOPCC.

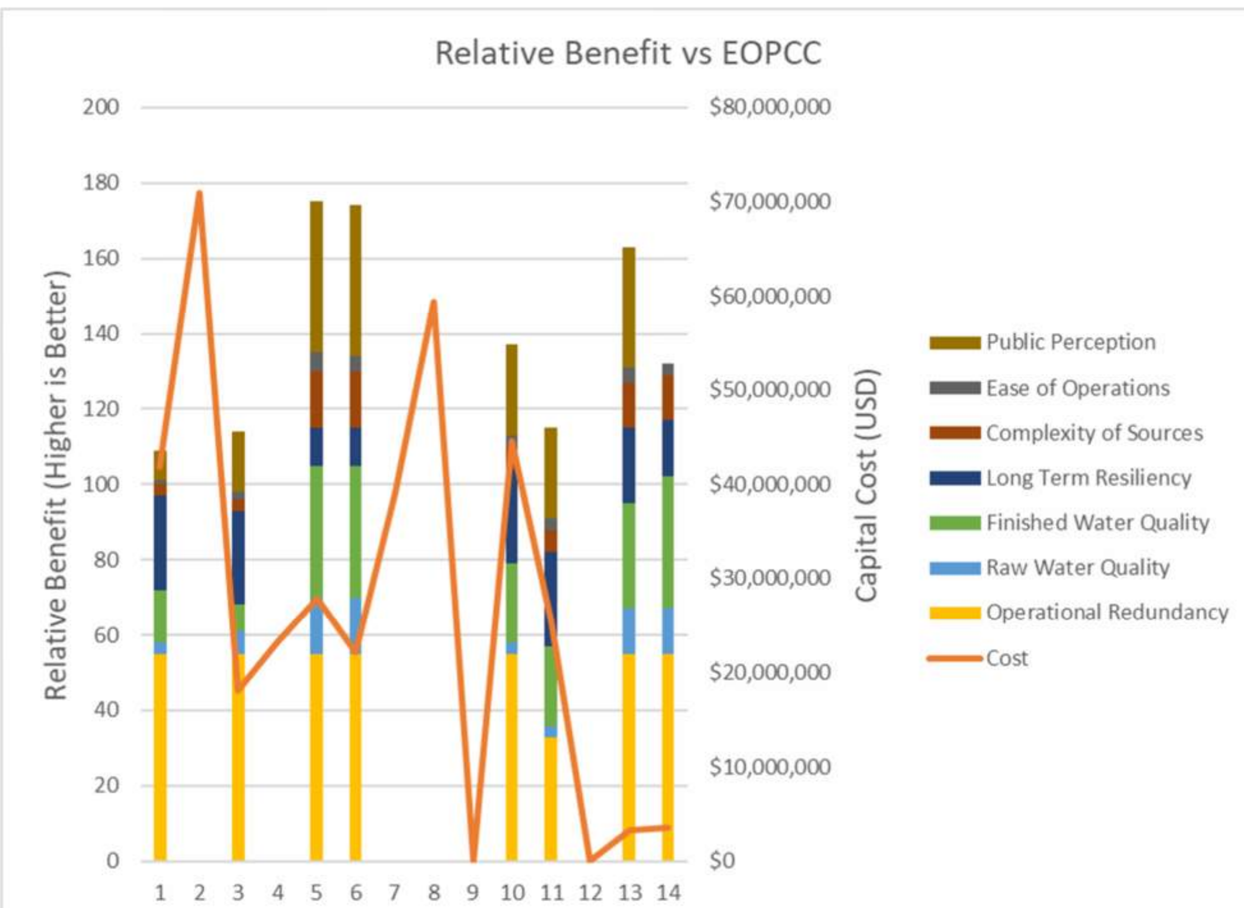

Figure 29: Relative Benefit of Each Option

Figure 30 presents the relative cost/benefit for each Option.

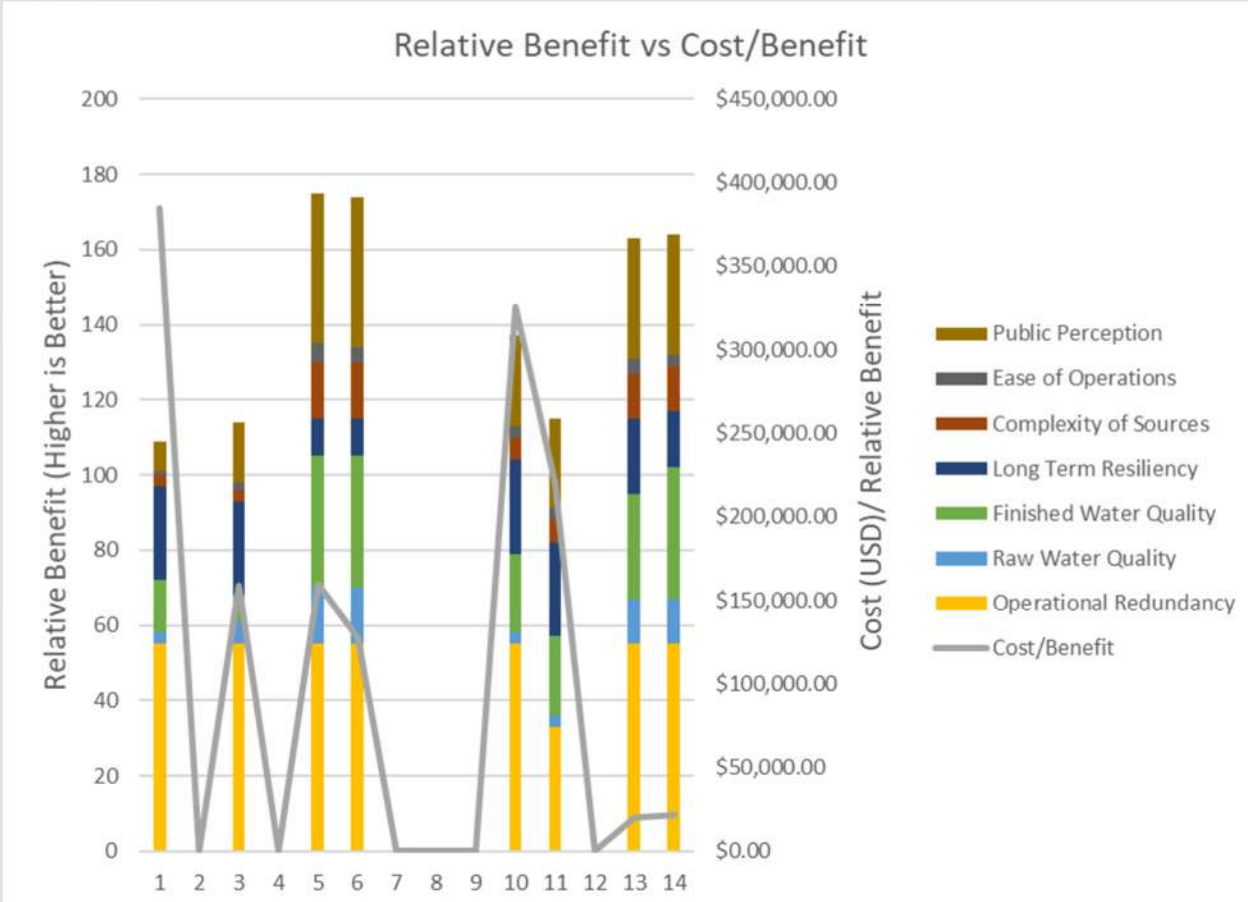

Figure 30: Relative Cost/Benefit of Each Option

The Options were also compared against the operating costs (Table 17). The cost/benefit for each Option was calculated by dividing the EOPCC by the weighted score. A low cost/benefit indicates a favorable Option, with more benefit achieved at a lower cost investment.

Table 17: Comparison of Operating Cost and Weighted Score

Comparison of Monthly Operating Cost and Weighted Score			
Option	Monthly Op. Cost	Weighted Score	Op. Cost/Benefit
Option 5: 24" KCFL	$ 88,000	175	$ 500
Option 6: 20" KCFL	$ 88,000	174	$ 510
Option 14: Purchase Treated Ute Water, Chloramines	$ 1,252,000	164	$ 7,630
Option 13: Purchase Treated Ute Water, Breakpoint Chlor.	$ 1,252,000	163	$ 7,680
Option 10: Transfer Add. CR to Clifton, Full Ex., 24 in	$ 88,000	137	$ 640
Option 11: Transfer Add. CR to Clifton, Part. Ex., 20 in	$ 72,000	115	$ 630
Option 3: Blend GR with Clifton	$ 163,000	114	$ 1,430
Option 1: Treat GR by Lime Softening	$ 233,000	109	$ 2,140

Figure 31 presents the relative benefit of the evaluated Options against their monthly operating cost.

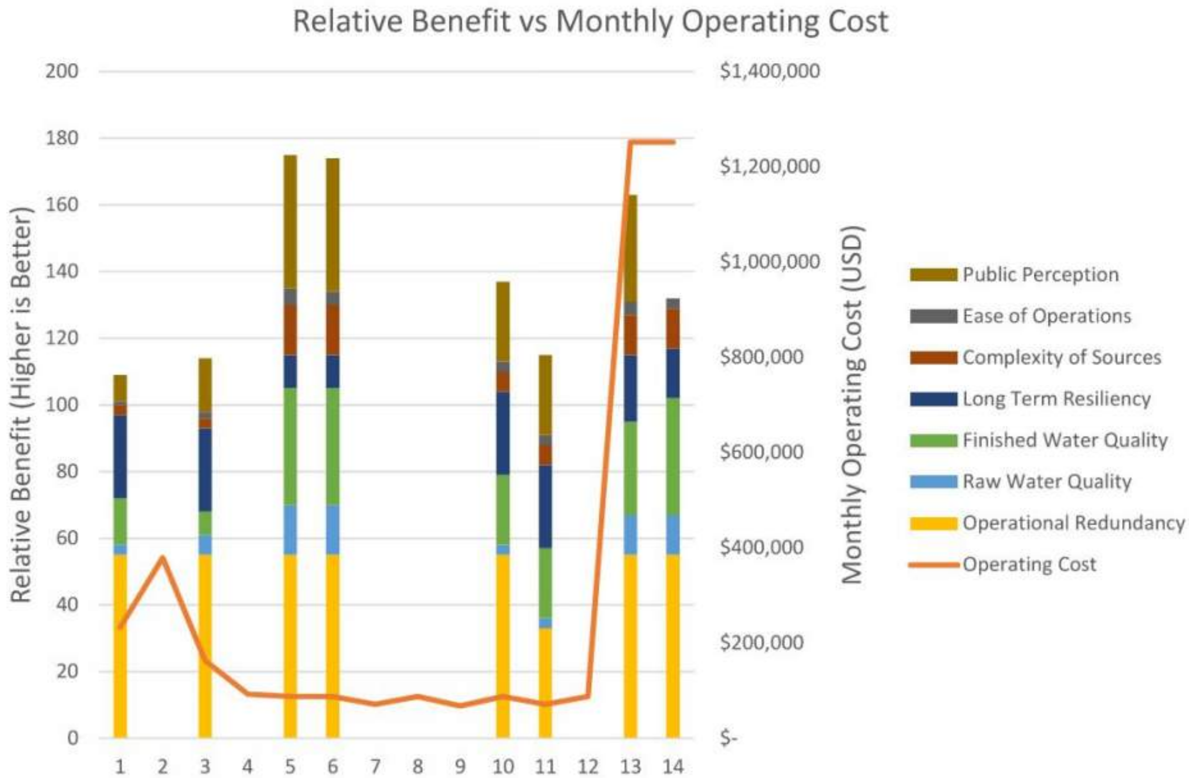

Figure 31: Relative Benefit of Each Option vs Monthly Operating Cost

Figure 32 presents the relative cost/benefit for each Option.

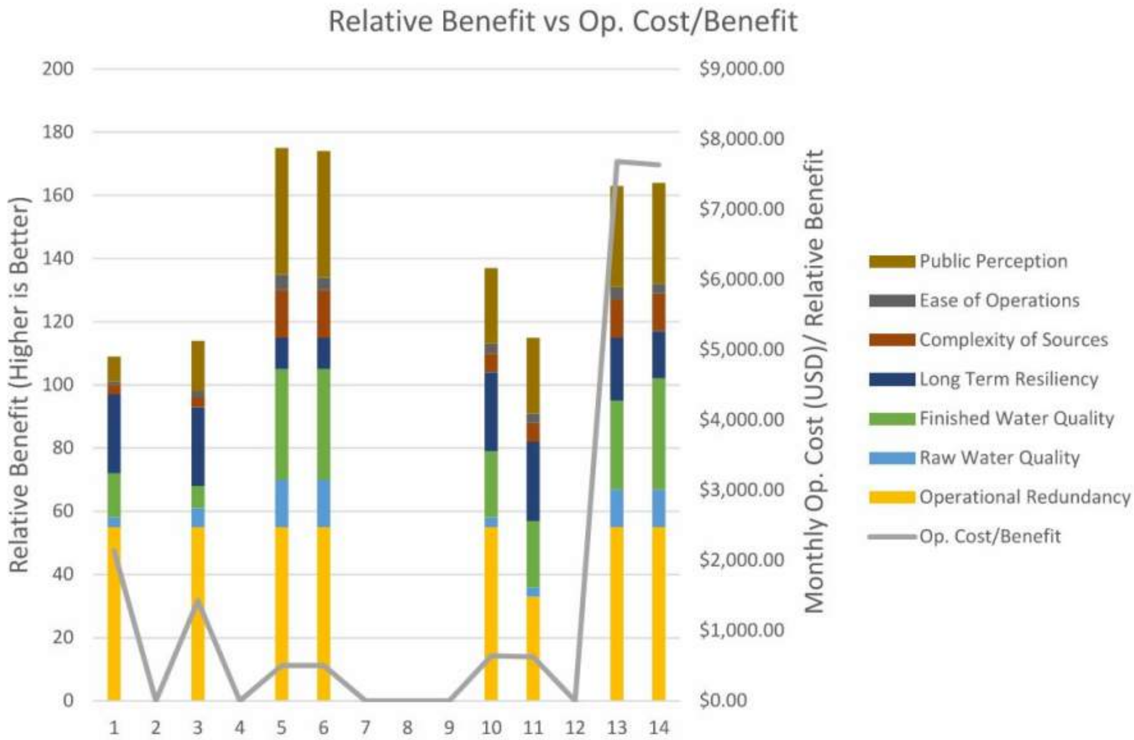

Figure 32: Relative Operating Cost/Benefit of Each Option

Options receiving high weighted scores include the both KCFL replacement Options (Option 5 and 6) and both Ute Options (Option 14 and 15). Option 14 has the lowest cost/benefit ratio for construction cost, while Option 5 has the lowest cost/benefit ratio for operating costs.

6 CONCLUSIONS

6.1 Scoring Results

Table 18 summarizes the Options that received the highest weighted scores.

Table 18: Highest Weighted Scores

#	Option	Weighted Score	Primary Criteria
5	Replace Kannah Creek Flow Line (24 inch)	175	Operational Redundancy
6	Replace Kannah Creek Flow Line (20 inch)	174	Operation Redundancy
13	Purchase Treated Water from Ute (Breakpoint Chlorination)	164	Long Term Resiliency
14	Purchase Treated Water from Ute (Chloramine Conversion)	163	Long Term Resiliency

The scoring indicates two types of projects will provide benefit to the City, but the nature of their benefit differs. The KCFL options provide multiple ways to access the full water rights from the Purdy Mesa. This prioritizes operational redundancy. However, the KCFL options do not provide long term resiliency for the City as a source interruption would leave the City without a water supply. In this case, the City has the option to pursue either interconnects with Clifton or Ute. The two Ute options scored higher as a mountain source with minimal capital improvements required.

6.1.1 Operational Redundancy – KCFL Replacement

The two KCFL Options scored very similarly, with high scores across all criteria. A new KCFL will provide operational redundancy to the PMFL but does not provide long term resiliency. Raw and Finished Water Quality from a replaced KCFL will be similar to the current conditions because it will draw from the same Juniata Reservoir and Kannah Creek sources. This fact contributed to the high score for Complexity of Sources by remaining consistent with current operational practices. Public Perception is expected to remain favorable for continuing with the higher quality mountain sources accessed from the KCFL. Some regulatory challenges are anticipated related to right of way and easement access along the KCFL pipeline route. The 24-inch Option scored higher in Ease of Operation due to only one PRV chamber when compared with two PRV chambers on the 20-inch Option.

The two KCFL Options received high weighted scores, with the 24-inch Option (175 points) slightly higher than the 20-inch Option (174 points) because of the higher complexity of operating two PRV chambers on the 20-inch pipeline. The hydraulic capacity of the 20-inch Option (9.5 mgd) does not supply the future peak day demand of 13 mgd. The 24-inch Option received the highest weighted score and provides a greater hydraulic capacity than the 20-inch Option. The City retains their independence and control of its water supply with both KCFL Options. The cost/benefit of the 24-inch Option was \$159,000 per weighted score point for construction cost, while the op. cost/benefit was \$500 per weighted score point.

6.1.2 Long Term Resiliency – Ute Interconnection

The two Ute Options also scored high across all criteria, however, operational challenges associated with the blending of the two sources affected the Complexity of Sources and Ease of Operations scores. Further study and a CCS are recommended before the blending of Ute waters into the City's distribution system. This will involve review and approvals by CDPHE before implementation. Public Perception is expected to be favorable with Ute's mountain source in comparison to Clifton's river source. The Ute Options will be implemented at a much lower construction cost when compared with other Options, resulting in a significantly lower cost/benefit ratio.

An interconnection agreement with Ute must be negotiated to confirm bulk water purchase costs before the financial impact of this Option are fully understood. The Ute Option will increase the City's reliance on another government entity for its back-up supply, but it also provides both operational redundancy and long term resiliency where the KCFL options do not. However, Option 14 would result in a loss in the ability to trade water with Clifton easily.

The Ute Options warrant further investigation if the City is interested in pursuing a lower cost Option ($3,300,000/$3,500,000) with a relatively high weighted score (164/163 points) to increase long term resiliency. This Option resulted in a lower cost/benefit score ($21,000/$20,000 per weighted score point) due to its low estimated construction cost. However, these Options also resulted in a significantly higher op. cost/benefit score ($7,630/$7,680 per weighted score point). The Ute Options will require dependence on another government agency and the City will not be providing their own water. The bulk water purchase cost, future Ute water demands, and water quality studies (corrosion control and disinfection by-products) require additional investigation.

6.1.3 Other Options

Treatment Options using the Gunnison River at the City's WTP or the Colorado River at Clifton's WTP did not score well in Finished Water Quality, Complexity of Sources, and Public Perception. Additionally, these Options had comparatively high cost/benefit ratios due to their high construction and operating costs.

6.2 Recommendations

It is recommended to implement the following:

1. Implement either KCFL Option for operational redundancy from the Purdy Mesa source. Consider the benefit of 20 or 24-inch diameter pipeline against the overall project cost.

2. Investigate the feasibility of a Ute interconnection for long term resiliency. Start preliminary discussions with Ute on the terms and bulk purchase cost in a formal interconnection agreement. Determine the City's preference for break-point chlorination of Ute treated water at the WTP or conversion of the City to chlormamines to facilitate multiple Ute interconnection in the distribution system.

3. Start the design and construction of the Juniata Reservoir Interconnect to create access to both the Juniata Reservoir and the Kannah Creek watersheds from either the PMFL or KCFL, regardless of which Option is selected.

APPENDIX A – DETAILED SCOPE BY OPTION

Option 1: Treat Gunnison River by Lime Softening	
Gunnison River Pump Station Improvements	Five vertical turbine pumps (4 duty, 1 standby) • Rated for 2,246 gpm @ 250 foot TDH • Maximum speed of 1800 RPM • 200 HP Motor, VFD • Oil lubricated enclosed line shaft, bowl assembly, inlet strainer • Up to 20 foot setting depth • Fabricated steel discharge head with single mechanical seal • Fitted into existing wet well Pump Station Building • Demolish existing above grade building • Raise floor above floodplain • 20 foot by 20 foot masonry building with steel roof • Replace electrical systems
Lime Softening Clarifiers, Dewatering Systems, and Building	Three softening clarifiers (2 duty, 1 standby) • 3470 gpm/clarifier • 0.75 to 1 gpm/sf • 76 foot diameter • Coated Steel Basins • Lime slurry feed silo • Carbon dioxide feed • Soda ash feed Dewatering Systems • Belt filter presses • Solids feed pumps and conveyors Chemical Feed and Solids Handling Building • 75 foot by 75 foot masonry building with steel roof
Filter Feed Pump Station	Filter Feed Pumps: • Five vertical turbine pumps (4 duty, 1 standby) • Rated for 2,246 gpm @ 30 foot TDH • Maximum speed of 1200 RPM • 30 HP Motor, VFD • Oil lubricated enclosed line shaft, bowl assembly, inlet strainer • Up to 20 foot setting depth • Fabricated steel discharge head with single mechanical seal Pump Station • New concrete wet well • 30 foot by 30 foot masonry building near PS3
Disclaimer: Equipment selections are based on representative projects in Colorado and engineers' experience. The information presented is intended to provide sizing in order to estimate costs.	

Option 2: Treat Gunnison River by Reverse Osmosis	
Gunnison River Pump Station Improvements	Five vertical turbine pumps (4 duty, 1 standby) • Rated for 2,246 gpm @ 250 foot TDH • Maximum speed of 1800 RPM • 200 HP Motor, VFD • Include an oil lubricated enclosed line shaft, bowl assembly, inlet strainer • Up to 20 foot setting depth • Fabricated steel discharge head with single mechanical seal • Fitted into existing wet well Pump Station Building • Demolish existing building • Raise floor above floodplain • 20 foot by 20 foot masonry building with steel roof
Reservoir 3 Pumps	Reservoir 3 Pumps: Five vertical turbine pumps (4 duty, 1 standby) • Rated for 2,778 gpm @ 30 foot TDH • Maximum speed of 1200 RPM • 30 HP Motor, VFD • Include an oil lubricated enclosed line shaft, bowl assembly, inlet strainer • Up to 20 foot setting depth • Fabricated steel discharge head with single mechanical seal • Fitted into existing wet well Pump Station • New concrete wet well • 30 foot by 30 foot masonry building near PS3
Reverse Osmosis System, Brine Disposal System, and Building	13 MGD, Six Train Reverse Osmosis System • 1800 gpm (each train) permeate flow • 85% system design recovery • Includes cartridge filters, RO high pressure pumps, RO skids, interstage booster pumps, system instruments, CIP system, feed tank Brine Disposal System • Four duty, one redundant deep injection wells • Estimated injection rate is 300 to500 gpm, assumed 300 gpm • Pipeline from brine pump station to wells, estimated 14 miles based on minimum distance to reach outside of town limits and minimum of 1 mile between wells Building • Concrete masonry with steel roof • Assumed 75 foot by 100 foot

Option 3: Settle Gunnison River in Existing Reservoirs and Blend with Clifton	
Gunnison River Pump Station Improvements	Three vertical turbine pumps (2 duty, 1 standby) • Rated for 1,042 gpm @ 250 foot TDH • Maximum speed of 1200 RPM • 100 HP Motor, VFD • Include an oil lubricated encased line shaft, bowl assembly, inlet strainer • Up to 10’ setting depth • Fabricated steel discharge head with single mechanical seal • Fitted into existing wet well Pump Station Building • Demolish existing above grade building • Raise floor above floodplain • 20’x20’ masonry building with steel roof • Replace electrical systems
Reservoir 3 Pumps	Reservoir 3 Pumps: Five vertical turbine pumps (4 duty, 1 standby) • Rated for 2,778 gpm @ 30 foot TDH • Maximum speed of 1200 RPM • 30 HP Motor, VFD • Include an oil lubricated enclosed line shaft, bowl assembly, inlet strainer • Up to 20 foot setting depth • Fabricated steel discharge head with single mechanical seal • Fitted into existing wet well Pump Station • New concrete wet well • 30 foot by 30 foot masonry building near PS3
Pipeline	• Alignment from Clifton WTP to City’s WTP • 10.25 mile, 20 inch diameter pipeline • Open-Cut Installation • Utilize existing pedestrian bridge on Colorado River

Option 4: Settle Gunnison River in Existing Reservoirs and Use for Raw Water Irrigation	
Gunnison River Pump Station Improvements	Three vertical turbine pumps (2 duty, 1 standby) • Rated for 1,042 gpm @ 250 foot TDH • Maximum speed of 1200 RPM • 100 HP Motor, VFD • Include an oil lubricated encased line shaft, bowl assembly, inlet strainer • Up to 20 foot setting depth • Fabricated steel discharge head with single mechanical seal • Fitted into existing wet well Pump Station Building • Demolish existing above grade building • Raise floor above floodplain • 20 foot by 20 foot masonry building with steel roof • Replace electrical systems
Pipeline	• KCFL replacement • 16 mile, 24 inch diameter pipeline • Open-Cut Installation • New interconnect with PMFL near Juniata Reservoir

Option 5: Replace Kannah Creek Flow Line (24 inch)	
Pipeline	• KCFL replacement • 16 mile, 24 inch diameter pipeline • DR18 PRV, 235 psi rated • Open-Cut Installation • New Juniata Reservoir Interconnection with PMFL • New PRV chamber near toe of mesa to maintain pressures over Whitewater Hill

Option 6: Replace Kannah Creek Flow Line (20 inch)	
Pipeline	• KCFL replacement • 16 mile, 20 inch diameter pipeline • DR18 PVC, 235 psi rated upstream • DR14 PVC, 300 psi rated upstream • Open-Cut Installation • New Juniata Reservoir Interconnection with PMFL • Two new PRV chamber to control pressures to the pipe pressure rating along the KCFL

Option 7: Replace Kannah Creek Flow Line (24 inch) and Add Turbine	
Turbine	• 700 kW running year round • Locate at 1,000 foot hydraulic grade drop at PRV station • Sell generated electricity back to grid (Grand Valley Power) • Must confirm capacity of substation to receive the generated electricity • Route to nearest substation approximately 6 miles through overhead wire
Pipeline	• KCFL replacement • 16 mile, 24 inch diameter pipeline • DR18 PRV, 235 psi rated • Open-Cut Installation • New Juniata Reservoir Interconnection with PMFL • New PRV chamber near toe of mesa to maintain pressures over Whitewater Hill

Option 8: New WTP in Kannah Creek Watershed	
Water Treatment Plant	• Raw Water Intake • Low Lift Pump Station • Flocculation and Sedimentation • Media Filters • Chemical Systems
Pipeline	• KCFL replacement • 16 mile, 24 inch diameter pipeline • Open-Cut Installation • New interconnect with Purdy Mesa near Juniata Reservoir

Option 9: Purchase Clifton Water (Intentionally Omitted, No Construction Scope)

Option 10: Transfer Colorado River Rights to Clifton for Treatment (Full Expansion, 24 inch)	

Clifton WTP Plant Modifications	• No modifications to the existing Clifton intake on the Colorado River
	• Two new raw water pumps at 4,250 gpm
	• No modifications to existing raw water settling pond
	• One new pretreatment train sized for 8 mgd
	  o New rapid mix
	  o Four stage flocculation
	  o Inclined plate settlers
	  o Solids collection system
	• Microfiltration system expansion from 12 to 21 mgd
	  o Three new MF feed pumps at 2,380 gpm
	  o One new MF feed strainer
	  o Three new MF racks
	  o Populate spare 15% in existing 8 MF racks
	  o No changes to existing clean in place, blower or air compressor
	  o Fit inside existing building (space available)
	• Nanofiltration system expansion from 2.4 to 4.2 mgd
	  o Two new NF feed pumps
	  o Five new dual media filters
	  o Four new cartridge filters
	  o Three new NF racks
	• Expand chlorine contact tank from 68,000 to 120,000 gallons
	• Two new high service pumps
	• Expand evaporation ponds by 50 acres

Pipeline from Clifton to 30th Rd	• 4 mile, 24 inch diameter pipeline • Open-Cut Installation • See map of estimated alignment in Figure 22

Option 11: Transfer Colorado River Rights to Clifton for Treatment (Partial Expansion, 20 inch)	

Clifton WTP Plant Modifications	• No modifications to the existing Clifton intake on the Colorado River
	• One new raw water pumps at 4,250 gpm
	• No modifications to existing raw water settling pond
	• No new pretreatment train sized for 8 mgd
	• Microfiltration system expansion from 12 to 16 mgd
	  o Two new MF feed pumps at 2,380 gpm
	  o One new MF feed strainer
	  o One new MF racks
	  o Populate spare 15% in existing 8 MF racks
	  o No changes to existing clean in place, blower or air compressor
	  o Fit inside existing building (space available)
	• Nanofiltration system expansion from 2.4 to 3.6 mgd
	  o One new NF feed pumps
	  o Three new dual media filters
	  o Two new cartridge filters
	  o Two new NF racks
	• Expand chlorine contact tank
	• One new high service pumps
	• Expand evaporation ponds by 35 acres

Pipeline from Clifton to 30th Rd	• 4 mile, 20 inch diameter pipeline • Open-Cut Installation • See map of estimated alignment in Figure 22

Option 12: Route Gunnison to Clifton WTP from Current Intake (Same as Option 10)

Option 13: Purchase Treated Water from Ute (Breakpoint Chlorination)	
Pipeline from Linden Vault to WTP	• 1 mile, 24 inch diameter pipeline • Open-Cut Installation
Breakpoint Chlorination Station	• In-line mixer • Injection quill • Chemical feed pumps • FRP storage tanks • Expand existing on-site sodium hypochlorite generation system • Chemical feed and misc. internal piping. • No building expansion

Option 14: Purchase Treated Water from Ute (Chloramine Conversion)	
Vault Modifications	• Modifications for flow control
Chloramine Conversion	• In-line mixer • Injection quill • Chemical feed pumps • FRP storage tanks • LAS system • Chemical feed and misc. internal piping. • 700 sq ft building expansion

APPENDIX B – EOPCC WORKSHEETS

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 03/16/2020
Made by - MAL
Checked by - KK
AACE Class 4 Estimate[1]

Option 1: Treat Gunnison River by Lime Softening

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment and Materials							
Gunnison River Pumps	5	3.3	MGD	$125,000	$625,000	1.3	$812,500
Softening Clarifiers, Dewatering Systems[2]	3	5	MGD	$1/gal	$13,000,000	1.3	$16,900,000
Post-Clarifier Pumps	5	3.3	MGD	$50,000	$250,000	1.3	$325,000
Corrosion Control System	1			$100,000	$100,000	1.3	$130,000
Chemical Systems	3			$100,000	$300,000	1.3	$390,000
TOTAL EQUIPMENT					$14,275,000	IE=	$18,557,500
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
GR Pump Station Building	1	400	sq ft	$ 750	$300,000	1	$300,000
Floor Demolition					$50,000	1	$50,000
New Raised Floor					$100,000	1	$100,000
Filter Feed PS Building	1	900	sq ft	$ 750	$675,000	1	$675,000
							$0
Misc. Civil & Structural (Including Yard Piping)					% of IE	5%	$927,875
Electrical					% of IE	12%	$2,226,900
Instrumentation					% of IE	4%	$742,300
TOTAL UNMARKED UP COST							$23,579,575
GENERAL REQUIREMENTS					% of Above	8%	$1,886,400
CONTRACTOR O&P					% of Above	10%	$2,546,600
TOTAL CONSTRUCTION COST							$28,012,575
DESIGN & CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$4,201,900
CONTINGENCY[3]					% of Above	30%	$9,664,300
TOTAL WITH CONTINGENCY							$41,900,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2- Estimate for softening clarifiers and dewatering systems includes price of Dewatering and Chemical Feed Building. One clarifier is redundant, and unit cost is based on gallons of treated water.
3 - Contingency of 30% based on limited design development.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 03/16/2020
Made by - MAL
Checked by - KK
AACE Class 4 Estimate[1]

Option 2: Treat Gunnison River by Reverse Osmosis

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment and Materials							
Gunnison River Pumps	5	3.3	MGD	$125,000	$625,000	1.3	$812,500
Reservoir 3 Pumps	5	3.3	MGD	$50,000	$250,000	1.3	$325,000
Reverse Osmosis	1	13	MGD	$6,000,000	$6,000,000	1.3	$7,800,000
Chemical Systems	5			$100,000	$500,000	1.3	$650,000
Sulfuric Acid							
Anti-Scalant							
High pH Cleaner							
Low pH Cleaner							
Corrosion Control							
RO Feed Tank	1			$200,000	$200,000	1.3	$260,000
TOTAL EQUIPMENT					$7,575,000	IE=	$9,847,500
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
RO Building	1	6,750	sq ft	$ 500	$3,375,000	1	$3,375,000
GR Pump Station Building	1	400	sq ft	$ 750	$300,000	1	$300,000
Floor Demolition					$50,000	1	$50,000
New Raised Floor					$100,000	1	$100,000
Basin 3 Pump Station Building	1	900	sq ft	$ 750	$675,000	1	$675,000
Misc. Civil & Structural (Including Yard Piping)					% of IE	1%	$98,475
Electrical					% of IE	12%	$1,181,700
Instrumentation					% of IE	6%	$590,850
TOTAL UNMARKED UP COST							$16,218,525
GENERAL REQUIREMENTS					% of Above	8%	$1,297,500
CONTRACTOR O&P					% of Above	10%	$1,751,600
TOTAL CONSTRUCTION COST							$19,267,625
ENGINEERING					% of Above	15%	$2,890,100
CONTINGENCY[2]					% of Above	30%	$6,647,300
TOTAL WITH CONTINGENCY							$28,805,025
BRINE DISPOSAL	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Pipeline to Injection Sites[3]	1	73,920	LF	$100	$7,392,000	1.3	$9,609,600
Deep Injection Wells[4]	5			$5,000,000	$25,000,000	1.3	$32,500,000
BRINE DISPOSAL COST							$42,109,600
TOTAL COST							$70,900,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - Contigency of 30% based on limited design development.
3 - Pipeline estimate of 14 miles based on minimum distance to reach outside of town limits and minimum of 1 mile between wells. Actual length could be significantly greater depending on distance of wells from town.
4 - Estimate of five wells based on minimum pumping rate of 300 gpm/well and need for one redundant well.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 03/16/2020
Made by - MAL
Checked by - KK
AACE Class 4 Estimate[1]

Option 3: Settle Gunnison River and Blend with Clifton

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment and Materials							
Gunnison River Pumps	3			$50,000	$150,000	1.3	$195,000
Chemical Systems for Corrosion	1			$100,000	$100,000	1.3	$130,000
Post-Clarifier Pumps	5	3.3	MGD	$50,000	$250,000	1.3	$325,000
Pipeline from CWD WTP to GJ WTP	54,120	20	in	$200.00	$10,824,000	1	$10,824,000
						IE[2]=	$650,000.00
TOTAL EQUIPMENT					$11,324,000		$11,474,000
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
GR Pump Station Building	1	400	sq ft	$750/sq ft	$300,000	1	$300,000
Floor Demolition					$50,000	1	$50,000
New Raised Floor					$100,000	1	$100,000
PS 3 Building	1	900	sq ft	$ 750	$675,000	1	$675,000
Misc. Civil & Structural (Including Yard Piping)					% of IE	4%	$26,000
Electrical					% of IE	12%	$78,000
Instrumentation					% of IE	4%	$26,000
TOTAL UNMARKED UP COST							$12,729,000
GENERAL REQUIREMENTS					% of Above[3]	8%	$152,400
CONTRACTOR O&P					% of Above[3]	10%	$205,700
TOTAL CONSTRUCTION COST							$13,087,100
ENGINEERING					% of Above	15%	$1,963,100
CONTINGENCY[4]					% of Above	20%	$3,010,000
TOTAL WITH CONTINGENCY							$18,100,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - IE only includes major equipment and does not include other materials such as pipeline.
3 -General Requirements and Contractor O&P included in pipeline estimate, so pipeline cost has been excluded from % of Above to prevent double counting.
4 - Contigency of 20% based on uncertainty involved with routing pipeline through city.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 03/16/2020
Made by - MAL
Checked by -KK
AACE Class 4 Estimate[1]

Option 4: Settle Gunnison River and Use for Raw Water Supply

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment							
Gunnison River Pumps	3	1.5	MGD	$50,000	$150,000	1.3	$195,000
Control Valve and Valve House	1			$325,000	$325,000	1	$325,000
Interconnect between PMFL and KCFL	1			$250,000	$250,000	1	$250,000
KCFL Replacement	84,480	20	in	$200	$16,896,000	1	$16,896,000
						IE[2]=	$520,000
TOTAL EQUIPMENT					$17,621,000		$17,666,000
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
GR Pump Station Building	1	400	sq ft	$750/sq ft	$300,000	1	$300,000
Floor Demolition					$50,000	1	$50,000
New Raised Floor					$100,000	1	$100,000
Misc. Civil & Structural (Including Yard Piping)					% of IE	4%	$20,800
Electrical					% of IE	12%	$62,400
Instrumentation					% of IE	4%	$20,800
TOTAL UNMARKED UP COST							$18,220,000
GENERAL REQUIREMENTS					% of Above[3]	8%	$85,900
CONTRACTOR O&P					% of Above[3]	10%	$116,000
TOTAL CONSTRUCTION COST							$18,421,900
DESIGN & CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$2,763,300
CONTINGENCY[4]					% of Above	10%	$2,118,500
TOTAL WITH CONTINGENCY							$23,300,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - IE only includes major equipment and does not include other materials such as pipeline.
3 -General Requirements and Contractor O&P included in pipeline estimate, so pipeline cost has been excluded from % of Above to prevent double counting.
4 - Contigency of 10% based on higher level of detail in pipeline estimates.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 03/16/2020
Made by - MAL
Checked by - KK
AACE Class 4 Estimate[1]

Option 5: Replace Kannah Creek Pipeline (24 in) and Install New Interconnect

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment							
Control Valve and Valve House	1			$350,000	$350,000	1	$350,000
Interconnect between PMFL and KCFL	1			$500,000	$500,000	1	$500,000
KCFL Replacement	84,480	24	in	$250	$21,120,000	1	$21,120,000
						IE[2]=	$350,000
TOTAL EQUIPMENT					$21,970,000		$21,970,000
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
Misc. Civil & Structural (Including Yard Piping)					% of IE	0%	
Electrical					% of IE	0%	
Instrumentation					% of IE	0%	
TOTAL UNMARKED UP COST							$21,970,000
GENERAL REQUIREMENTS					% of Above[3]	8%	$28,000
CONTRACTOR O&P					% of Above[3]	10%	$37,800
TOTAL CONSTRUCTION COST							$22,035,800
DESIGN AND CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$3,305,400
CONTINGENCY[4]					% of Above	10%	$2,534,100
TOTAL WITH CONTINGENCY							$27,900,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - IE only includes major equipment and does not include other materials such as pipeline.
3 -General Requirements and Contractor O&P included in pipeline estimate, so pipeline cost has been excluded from % of Above to prevent double counting.
4 - Contigency of 10% based on higher level of detail in pipeline estimates.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 03/16/2020
Made by - MAL
Checked by - KK
AACE Class 4 Estimate[1]

Option 6: Replace Kannah Creek Pipeline (20 in) and Install New Interconnect

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment							
Control Valve and Valve House	2			$325,000	$650,000	1	$650,000
Interconnect between PMFL and KCFL	1			$500,000	$500,000	1	$500,000
KCFL Replacement	84,480	20	in	$200	$16,896,000	1	$16,896,000
						IE[2]=	$650,000
TOTAL EQUIPMENT					$18,046,000		$18,046,000
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
Misc. Civil & Structural (Including Yard Piping)					% of IE	0%	
Electrical					% of IE	0%	
Instrumentation					% of IE	0%	
TOTAL UNMARKED UP COST							$18,046,000
GENERAL REQUIREMENTS					% of Above[3]	8%	$52,000
CONTRACTOR O&P					% of Above[3]	10%	$70,200
TOTAL CONSTRUCTION COST							$18,168,200
DESIGN AND CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$2,725,200
CONTINGENCY[4]					% of Above	10%	$2,089,300
TOTAL WITH CONTINGENCY							$23,000,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - IE only includes major equipment and does not include other materials such as pipeline.
3 -General Requirements and Contractor O&P included in pipeline estimate, so pipeline cost has been excluded from % of Above to prevent double counting.
4 - Contigency of 10% based on higher level of detail in pipeline estimates.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 03/16/2020
Made by - MAL
Checked by - KK
AACE Class 4 Estimate[1]

Option 7: Replace Kannah Creek Pipeline, Install New Interconnect and Add Turbine

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment							
Hydro Turbine Equipment	1			$600,000	$600,000	1	$600,000
Electrical Distribution Line[2]	1	34320	ft	$160/LF	$5,500,000	1	$5,500,000
Control Valve and Valve House	1			$350,000	$350,000	1	$350,000
Interconnect between PMFL and KCFL	1			$500,000	$500,000	1	$500,000
KCFL Replacement	84,480	24	in	$250	$21,120,000	1	$21,120,000
						IE[3]=	$6,450,000
TOTAL EQUIPMENT					$28,070,000		$28,070,000
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
Turbine Building	1	1000	sq ft	$500	$500,000	1	$500,000
Misc. Civil & Structural (Including Yard Piping)					% of IE	4%	$258,000
Electrical					% of IE	6%	$387,000
Instrumentation					% of IE	4%	$258,000
TOTAL UNMARKED UP COST							$29,473,000
GENERAL REQUIREMENTS					% of Above[4]	8%	$628,200
CONTRACTOR O&P					% of Above[4]	10%	$848,100
TOTAL CONSTRUCTION COST							$30,949,300
DESIGN AND CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$4,642,400
CONTINGENCY[5]					% of Above	10%	$3,559,200
TOTAL WITH CONTINGENCY							$39,200,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - Electrical distribution line cost estimate does not include environmental, permitting, or right of way acquisition costs.
3 - IE only includes major equipment and does not include other materials such as pipeline.
4 -General Requirements and Contractor O&P included in pipeline estimate, so pipeline cost has been excluded from % of Above to prevent double counting.
5 - Contigency of 10% based on higher level of detail in pipeline estimates.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 03/16/2020
Made by - MAL
Checked by - KK
AACE Class 4 Estimate[1]

Option 8: New Water Treatment Plant in Kannah Creek Watershed

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment							
Raw water intake					$500,000	1.3	$650,000
Raw water pumps	4	3.3	MGD	$100,000	$400,000	1.3	$520,000
Floc/Sed	1			$1,235,000	$1,235,000	1.3	$1,605,500
Media Filters	1			$1,300,000	$1,300,000	1.3	$1,690,000
Chemical Systems	5			$100,000	$500,000	1.3	$650,000
Control Valve and Valve House	1			$350,000	$350,000	1	$350,000
Interconnect between PMFL and KCFL	1			$500,000	$500,000	1	$500,000
KCFL Replacement	84,480	24	in	$250	$21,120,000	1	$21,120,000
Misc. Internal Piping					% of IE	15%	$819,800
						IE[2]=	$5,465,500
TOTAL EQUIPMENT					$25,905,000		$27,905,300
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
WTP Building	1	13,000	sq ft	$750	$9,750,000	1	$9,750,000
Abandon ex WTP in place					$100,000	1	$100,000
Misc. Civil & Structural (Including Yard Piping)					% of IE	15%	$819,800
Electrical					% of IE	12%	$655,900
Instrumentation					% of IE	5%	$273,300
TOTAL UNMARKED UP COST							$39,504,300
GENERAL REQUIREMENTS					% of Above[3]	8%	$3,160,300
CONTRACTOR O&P					% of Above[3]	10%	$4,266,500
TOTAL CONSTRUCTION COST							$46,931,100
DESIGN & CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$7,039,700
CONTINGENCY[4]					% of Above	10%	$5,397,100
TOTAL WITH CONTINGENCY							$59,400,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - IE only includes major equipment and does not include other materials such as pipeline.
3 -General Requirements and Contractor O&P included in pipeline estimate, so pipeline cost has been excluded from % of Above to prevent double counting.
4 - Contigency of 10% based on higher level of detail in pipeline estimates.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 06/09/2020
Made by - MAL
Checked by - BDP
AACE Class 4 Estimate[1]

Option 10: Exchange Colorado River Rights with Clifton for Emergency Supply (Full Expansion, 24 inch)

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment							
Colorado River Intake Modifications					$0.00	1	$0.00
Raw water pumps	2	6.1	MGD	$100,000	$200,000	1.3	$260,000
Rapid Mix	1			$50,000	$50,000	1.3	$65,000
4 stage floc, inclined plates, solids collect	1			$500,000	$500,000	1.3	$650,000
MF Feed Pumps	3	3.4	MGD	$60,000	$180,000	1.3	$234,000
MF Feed Strainers	1	8.2	MGD	$30,000	$30,000	1.3	$39,000
Microfiltration/Ultrafiltration Racks	3	2	MGD	$600,000	$1,800,000	1.3	$2,340,000
Nanofiltration Racks	3	0.6	MGD	$800,000	$2,400,000	1.3	$3,120,000
RO Feed Pumps	2	1.7	MGD	$40,000	$80,000	1.3	$104,000
RO Dual Media Filters	5	0.4	MGD	$25,000	$125,000	1.3	$162,500
RO Cartridge Filters	4	0.8	MGD	$25,000	$100,000	1.3	$130,000
Chemical Systems	7			$50,000	$350,000	1.3	$455,000
Evaporation Ponds - Class A Impoundment	50	1	acre	$129,000	$6,450,000	1.3	$8,385,000
High Service Pumps	2			$150,000	$300,000	1.3	$390,000
Pipeline from CWD WTP to 30th Rd	21,120	24	inch	$250	$5,280,000	1	$5,280,000
Misc. Internal Piping					% of IE	15%	$1,192,400
						IE[2]=	$7,949,500
TOTAL EQUIPMENT					$17,845,000		$22,806,900
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
Pretreatment Building	1	3,031	sq ft	$500	$1,515,520	1.3	$1,970,176
Main Process Building			sq ft		$0	1.3	$0
NF/RO Building			sq ft		$0	1.3	$0
CCC Expansion	1700	1	sq ft	$500	$850,000	1.3	$1,105,000
Misc. Civil & Structural (Including Yard Piping)					% of IE	10%	$795,000
Electrical					% of IE	12%	$953,900
Instrumentation					% of IE	5%	$397,500
TOTAL UNMARKED UP COST							$28,028,476
GENERAL REQUIREMENTS					% of Above[3]	8%	$1,819,900
CONTRACTOR O&P					% of Above[3]	10%	$2,456,800
TOTAL CONSTRUCTION COST							$32,305,176
DESIGN & CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$4,845,800
CONTINGENCY[4]					% of Above	20%	$7,430,200
TOTAL WITH CONTINGENCY							$44,600,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - IE only includes major equipment and does not include other materials such as pipeline or evaporation ponds.
3 -General Requirements and Contractor O&P included in pipeline estimate, so pipeline cost has been excluded from % of Above to prevent double counting.
4 - Contigency of 20% based on uncertainty of Clifton expansion.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 06/18/2020
Made by - MAL
Checked by - BDP
AACE Class 4 Estimate[1]

Option 11: Exchange Colorado River Rights with Clifton for Emergency Supply (Partial Expansion, 20 inch)

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment							
Colorado River Intake Modifications					$0.00	1	$0.00
Raw water pumps	1	6.1	MGD	$100,000	$100,000	1.3	$130,000
Rapid Mix					$0	1	$0
4 stage floc, inclined plates, solids collect					$0	1	$0
MF Feed Pumps	2	3.4	MGD	$60,000	$120,000	1.3	$156,000
MF Feed Strainers	1	4.1	MGD	$30,000	$30,000	1.3	$39,000
Microfiltration/Ultrafiltration Racks	1	2	MGD	$600,000	$600,000	1.3	$780,000
Nanofiltration Racks	2	0.6	MGD	$800,000	$1,600,000	1.3	$2,080,000
RO Feed Pumps	1	1.7	MGD	$40,000	$40,000	1.3	$52,000
RO Dual Media Filters	3	0.4	MGD	$25,000	$75,000	1.3	$97,500
RO Cartridge Filters	2	0.8	MGD	$25,000	$50,000	1.3	$65,000
Chemical Systems	7			$30,000	$210,000	1.3	$273,000
Evaporation Ponds - Class A Impoundment	35	1	acre	$129,000	$4,515,000	1.3	$5,869,500
High Service Pumps	1			$150,000	$150,000	1.3	$195,000
Pipeline from CWD WTP to 30th Rd	21,120	20	inch	$200	$4,224,000	1	$4,224,000
gall					% of IE	15%	$580,100
						IE[2]=	$3,867,500
TOTAL EQUIPMENT					$11,714,000		$14,541,100
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
Pretreatment Building			sq ft		$0	1.3	$0
Main Process Building			sq ft		$0	1.3	$0
NF/RO Building			sq ft		$0	1.3	$0
CCC Expansion	755	1	sq ft	$500	$377,500	1.3	$490,750
Misc. Civil & Structural (Including Yard Piping)					% of IE	10%	$386,800
Electrical					% of IE	12%	$464,100
Instrumentation					% of IE	5%	$193,400
TOTAL UNMARKED UP COST							$16,076,150
GENERAL REQUIREMENTS					% of Above[3]	8%	$948,200
CONTRACTOR O&P					% of Above[3]	10%	$1,280,000
TOTAL CONSTRUCTION COST							$18,304,350
DESIGN & CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$2,745,700
CONTINGENCY[4]					% of Above	20%	$4,210,000
TOTAL WITH CONTINGENCY							$25,300,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - IE only includes major equipment and does not include other materials such as pipeline or evaporation ponds.
3 -General Requirements and Contractor O&P included in pipeline estimate, so pipeline cost has been excluded from % of Above to prevent double counting.
4 - Contigency of 20% based on uncertainty of Clifton expansion.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 06/18/2020
Made by - MAL
Checked by - BDP
AACE Class 4 Estimate[1]

Option 13: Purchase Treated Water from Ute (Break Point Chlorinate)

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment							
Linden Vault Modifications	1			$400,000	$400,000	1.3	$520,000
Pipeline to GJ WTP	4,066	24	inch	$250	$1,016,400	1	$1,016,400
Mixer	1			$9,000	$9,000	1.3	$11,700
Injection Quill	1			$5,000	$5,000	1.3	$6,500
Chemical Feed Pumps	2			$11,000	$22,000	1.3	$28,600
FRP Storage Tanks	2	5000	gal	$56,000	$112,000	1.3	$145,600
Chemical Feed Piping	1			$8,000	$8,000	1.3	$10,400
Sodium Hypochlorite System Expansion	1			$130,000	$130,000	1.3	$169,000
Misc. Internal Piping	1				% of IE	40%	$81,120
						IE[2]=	$202,800
TOTAL EQUIPMENT					$1,702,400		$1,989,320
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
Misc. Civil & Structural (Including Yard Piping)					% of IE	3%	$6,084
Electrical					% of IE	17%	$34,476
Instrumentation					% of IE	5%	$10,140
TOTAL UNMARKED UP COST							$2,040,020
GENERAL REQUIREMENTS					% of Above[3]	8%	$81,900
CONTRACTOR O&P					% of Above[3]	10%	$110,600
TOTAL CONSTRUCTION COST							$2,232,520
DESIGN & CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$334,900
CONTINGENCY[4]					% of Above	30%	$770,200
TOTAL WITH CONTINGENCY							$3,300,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - IE only includes major equipment and does not include other materials such as pipeline.
3 -General Requirements and Contractor O&P included in pipeline estimate, so pipeline cost has been excluded from % of Above to prevent double counting.
4 - Contigency of 30% based on uncertainty of routing through plant.

Client - City of Grand Junction
Project Number - 117086
Description - Construction Cost Option Breakdown

Date - 06/09/2020
Made by - MAL
Checked by - BDP
AACE Class 4 Estimate[1]

Option 14: Purchase Treated Water from Ute (Chloramine Conversion)

Line Item Description	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor	Installed Cost
Major Equipment							
Linden and Riverside Vault Modifications	2			$400,000	$800,000	1.3	$1,040,000
Mixer	1			$9,000	$9,000	1.3	$11,700
Injection Quill	1			$5,000	$5,000	1.3	$6,500
Chemical Feed Pumps	2			$11,000	$22,000	1.3	$28,600
FRP Storage Tanks	2	5000	gal	$56,000	$112,000	1.3	$145,600
Chemical Feed Piping	1			$8,000	$8,000	1.3	$10,400
LAS System	1			$100,000	$100,000	1.3	$130,000
Misc. Internal Piping	1				% of IE	40%	$81,120
						IE[2]=	$202,800
TOTAL EQUIPMENT					$1,056,000		$1,453,920
MISC. SUB-CONTRACTORS	No.	Size ea.	Units	Unit Purchased Cost	Purchased Cost	Installation Factor or Complexity	Installed Cost
Building Expansion	1	700	sq ft	$500	$350,000	1.3	$455,000
Misc. Civil & Structural (Including Yard Piping)					% of IE	3%	$6,084
Electrical					% of IE	17%	$34,476
Instrumentation					% of IE	5%	$10,140
TOTAL UNMARKED UP COST							$1,959,620
GENERAL REQUIREMENTS					% of Above	8%	$156,800
CONTRACTOR O&P					% of Above	10%	$211,600
TOTAL CONSTRUCTION COST							$2,328,020
DESIGN & CONSTRUCTION PHASE ENG. SERVICES					% of Above	15%	$349,200
CONTINGENCY[3]					% of Above	30%	$803,200
TOTAL WITH CONTINGENCY							$3,500,000

Notes:
1- AACE Class 4 Estimates are used for feasibility studies. The expected accuracy range is -15% to -30% on the low end, and +20% to +50% on the high end.
2 - IE only includes major equipment and does not include other materials such as pipeline.
3 - Contigency of 30% based on uncertainty of routing through plant.

APPENDIX C – INITIAL WORKSHOP SCORING

Initial Screening

The following options are recommended for disqualification from the evaluation for the reasons presented in Table 1.

Table1: Disqualified Options

	Option	Reason
2	Treat Gunnison by Reverse Osmosis	High capital cost to treat Gunnison River Option 1 (lime softening) provides lower cost of treatment
4	Settle Gunnison in Existing Reservoirs and Use for Raw Water	Does not provide acceptable water quality for raw water irrigation
7	Replace KCFL (24 inch) and Add Turbine	Feasibility not confirmed with Grand Valley Power. Potential energy production of turbine does not pay for extensive electrical upgrades
8	New WTP in Kannah Creek Watershed	High capital cost for new facility New WTP is redundant to the existing WTP KCFL update required to deliver water to City
9	Clifton Water Emergency Interconnect	Does not provide a fully redundant alternative Capacity well less than future peak day demand of 13 mgd
11	Route Gunnison to Clifton WTP	High infrastructure cost to send Gunnison River to Clifton replaced by water transfer Transfer City's Colorado River rights to Clifton and replace with City's Gunnison River allocation at confluence Becomes same as Option 10

Table 2: Options Evaluated by Project Team

#	Option
1	Treat Gunnison River by Lime Softening
3	Settle Gunnison River in Existing Reservoirs and Blend with Clifton
5	Replace Kannah Creek Flow Line (24 inch)
6	Replace Kannah Creek Flow Line (20 inch)
10	Transfer Colorado River Rights to Clifton for Treatment
12	Purchase Treated Water from Ute

Selection Workshop

A multi-step process was used to evaluate the technical, qualitative and monetary criteria of each option. The first step involved developing the non-monetary criteria and then ranking the criteria in a Workshop with the Project Team. The selected criteria are shown in Table 3.

Table 3: Selection Criteria

Criteria Category	Description
Redundancy	Ability to provide full redundancy to the Purdy Mesa flowline. Options scoring high in this category can provide full redundancy to Purdy Mesa flowline without concern over water rights. Low scoring options do not provide the full capacity of 13 mgd.
Raw Water Quality	Measure of the raw water quality of the source water(s) included within the option. Options scoring high in this category mean the sources have water quality similar to Purdy Mesa. Low scoring options have poor source water quality.
Finished Water Quality	Measure of the anticipated finished water quality as a result of the treatment associated with the option. Options scoring high in this category mean the treatment is expected to produce finished water similar or better than the current WTP. This criteria also considers the satisfaction of raw water customers.
Regulatory Challenges	Evaluates the likelihood of permitting-related challenges associated with the option, including but not limited to, CDPHE permits and land easements. Options scoring high in this category require little to no permitting.
Complexity of Sources	Evaluates the number of sources required to provide a fully-redundant capacity and the complexity to operate multiple sources. Options scoring high in this category only require one source to create redundancy.
Ease of Operations	Evaluates the complexity of operations and maintenance, number of treatment process steps and units and chemical dosing systems associated with the option. Options scoring high in this category apply operating procedures similar or less complex than the current WTP.
Public Perception	Evaluates the public perception to the alternate water source. Public opinion prefers elevated sources, considered pristine mountain source. Less favorable view of using river sources

The second step ranked the non-monetary criteria used a paired comparison to identify the weighting for each criterion (Table 4). Each criteria were paired against the other criteria, with the criteria of higher importance being preferred. The alphanumeric identification of the preferred criteria is recorded in Table 4(e.g. B). Then the degree to which the criteria was preferred were scored on their relative importance on a scale of 1 to 3, with 3 as a high importance. The numeric score of the preferred criteria is recorded in Table 4(e.g. 2), resulting in a paired score (e.g. B2).

Table 4: Weighted Criteria

DEVELOP CRITERIA & WEIGHTED MATRIX										
ITEM	CRITERIA	RELATIVE IMPORTANCE							SCORE	NORMALIZED
A	Redundancy	A	A 3	A 3	A 2	A 1	A 2	A 1	12	3
B	Raw Water Quality		B	C 3	B 1	B 2	B 1	G 3	4	1
C	Finished Water Quality			C	C 3	C 1	C 2	C 1	10	2
D	Regulatory Challenges				D	E 3	F 3	G 3	0	0
E	Complexity of Sources					E	E 3	G 2	6	1
F	Ease of Operations						F	G 1	3	1
G	Public Perception							G	9	2
Directions: For each pair, select the more important criteria. Then choose a relative importance between 1-3 (3 as high importance).									44	10

Next, the Project Team scored each Option against the criteria on a scale of 1 to 5, with 5 being high (Table 5).

Table 5: Scored Options

SCORED OPTIONS								
Option	Redundancy	Raw Water Quality	Finished Water Quality	Regulatory Challenges	Complexity of Sources	Ease of Operations	Public Perception	Total
Option 1: Treat GR by Lime Softening	5	1	2	3	1	1	1	14
Option 3: Blend GR with Clifton	5	2	1	3	1	2	2	16
Option 5: 24" KCFL	5	5	5	4	5	5	5	34
Option 6: 20" KCFL	5	5	5	4	5	4	5	28
Option 10: Transfer Add. CR to Clifton	5	1	3	4	2	3	3	21
Option 12: Purchase Treated Ute Water	5	4	4	4	4	4	4	29
Directions: Score each option for each criteria between 1-5 (5 is high).								

The weighting criteria was then applied to the scores to establish a weighted score (Table 6).

Table 6: Weighted Scored Options

WEIGHTED SCORES								
Option	Redundancy	Raw Water Quality	Finished Water Quality	Regulatory Challenges	Complexity of Sources	Ease of Operations	Public Perception	Total
Option 1: Treat GR by Lime Softening	60	4	20	0	6	3	9	102
Option 3: Blend GR with Clifton	60	8	10	0	6	6	18	108
Option 5: 24" KCFL	60	20	50	0	30	15	45	220
Option 6: 20" KCFL	60	20	50	0	30	12	45	217
Option 10: Transfer Add. CR to Clifton	60	4	30	0	12	9	27	142
Option 12: Purchase Treated Ute Water	60	16	40	0	24	12	36	188
Directions: Table autopopulates based on weight of criteria and scored options.								

High Score	Option 5: 24" KCFL

The Options were then ranked by their weighted score and compared against the EOPCC (Table 7). The cost/benefit for each Option was calculated by dividing the EOPCC by the weighted score. A low cost/benefit indicates a favorable Option, with more benefit achieved at a lower cost investment.

Table 7: Comparison of EOPCC and Weighted Score

Comparison of EOPCC and Weighted Score			
Option	EOPCC	Weighted Score	Cost/Benefit
Option 5: 24" KCFL	$ 27,900,000	220	$ 127,000
Option 6: 20" KCFL	$ 23,000,000	217	$ 106,000
Option 12: Purchase Treated Ute Water	$ 3,300,000	188	$ 18,000
Option 10: Transfer Add. CR to Clifton	$ 56,000,000	142	$ 394,000
Option 3: Blend GR with Clifton	$ 18,100,000	108	$ 168,000
Option 1: Treat GR by Lime Softening	$ 41,900,000	102	$ 411,000

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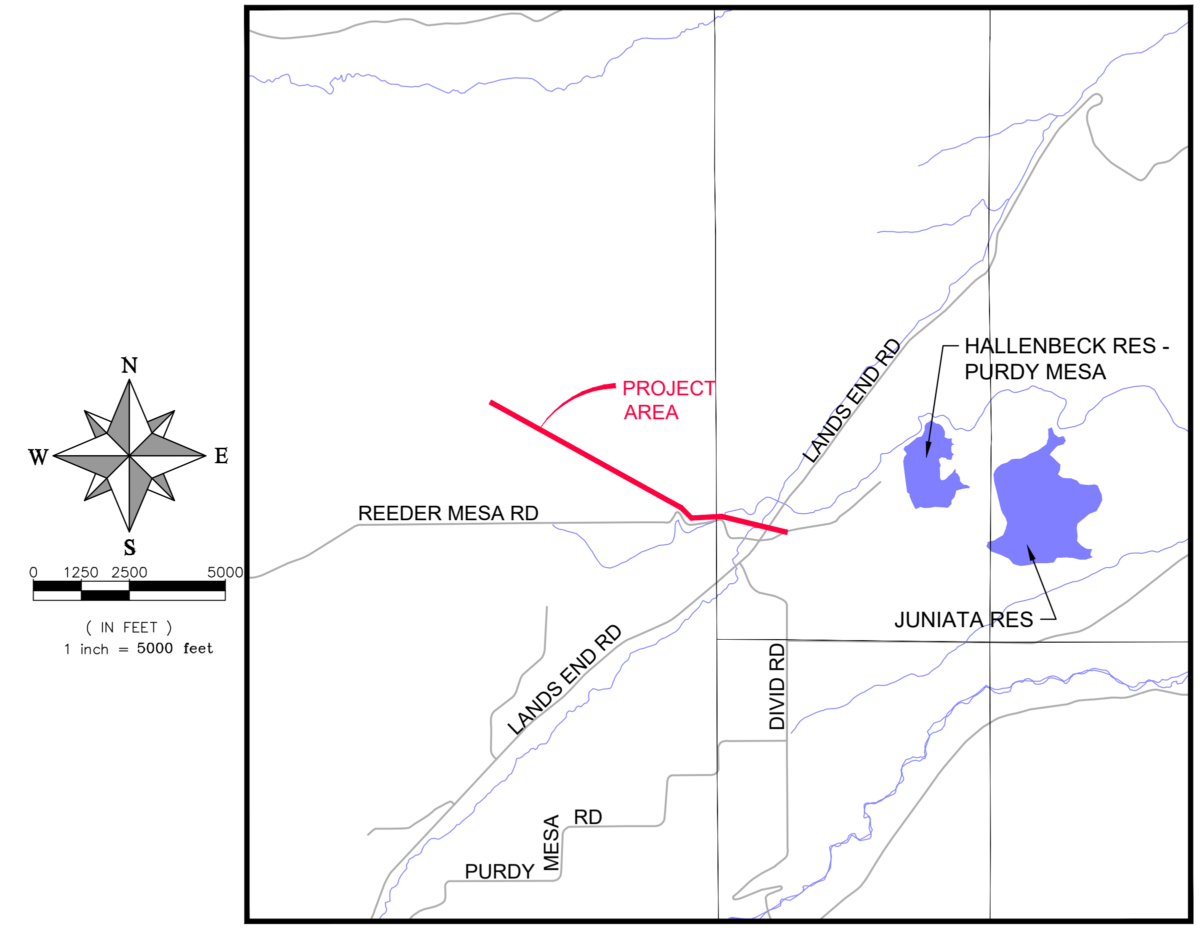
9785 Maroon Circle
Centennial, CO 80112
O 303 721-9292
www.burnsmcd.com

2021 KANNAH CREEK REALIGNMENT
FEBRUARY, 2021

VICINITY MAP



UTILITIES AND AGENCIES

AGENCY	NAME	POSITION	ROLE	MAILING ADDRESS	STREET ADDRESS	CITY, STATE	VOICE–WK	FAX
CITY OF GRAND JUNCTION	JOHN EKLUND	PROJECT ENGINEER	PROJECT ENGINEER	333 WEST AVE BLDG C	333 WEST AVE BLDG C	GRAND JCT., CO 81501	(970) 244–1558	(970) 256–4022
CITY OF GRAND JUNCTION	LEE COOPER	PROJECT ENGINEER	SANITARY SEWER	333 WEST AVE BLDG C	333 WEST AVE BLDG C	GRAND JCT., CO 81501	(970) 256–4155	(970) 256–4022
SPECTRUM	JEFF VALDEZ	MANAGER	CABLE TV	2502 FORESIGHT CIRCLE	2502 FORESIGHT CIRCLE	GRAND JCT., CO 81504	(970) 245–8750	(970) 245–6803
CENTURYLINK	CHRIS JOHNSON	ENGINEER	TELEPHONE	2524 BLICHMANN AVE	2524 BLICHMANN AVE	GRAND JCT., CO 81504	(970) 244–4311	(970) 240–4349
XCEL	SARAH DARRICAU	UNIT MANAGER	GAS	2538 BLICHMANN AVE	2538 BLICHMANN AVE	GRAND JCT., CO 81506	(970) 244–2656	(970) 244–2656
GRAND VALLEY POWER	MARK SHAFFER			845 22 RD	845 22 RD	GRAND JCT., CO 81505	(970) 260–8179	

PROJECT NO. ________________

NOTE: NOTIFY AFFECTED UTILITY VENDOR 48 HOURS PRIOR TO EXCAVATIONS THAT WILL EXPOSE UTILITY LINES. THE COVER SHEET WILL HAVE A LISTING OF UTILITY VENDORS AND TELEPHONE NUMBERS.

	DESCRIPTION	DATE
REVISION △		
REVISION △		
REVISION △		
REVISION △		

CITY OF Grand Junction COLORADO

Public Works
Engineering Division

811 Know what's below. Call before you dig.

DRAWING STATUS:
- PROGRESS
- FINAL CONSTRUCTION DRAWINGS
- ASBUILT

DESIGNED BY:
JOHN EKLUND, PROJECT ENGINEER 2021

REVIEWED BY:
TRENT C. PRALL, PUBLIC WORKS DIRECTOR 2021

AUTHORIZED FOR CONSTRUCTION
TRENT C. PRALL, PUBLIC WORKS DIRECTOR 2021

ACCEPTED AS CONSTRUCTED
JOHN EKLUND, PROJECT ENGINEER 2021

2021 KANNAH CREEK REALIGNMENT, FEBRUARY, 2021

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ABBREVIATIONS

AASHTO	AMERICAN ASSOCIATION OF STATE HIGHWAY & TRANSPORTATION OFFICIALS
ABC	AGGREGATE BASE COURSE
AC	ASBESTOS CEMENT
AP	ANGLE POINT
ASB	ANCHORED STRAW BALES
ASP	ALUMINIZED STEEL PIPE
ASTM	AMERICAN SOCIETY FOR TESTING MATERIALS
AWWA	AMERICAN WATER WORKS ASSOCIATION
BC	BACK OF CURB
BF	BUTTERFLY VALVE
BOW	BACK OF WALK
BCR	BEGIN CURB RETURN
BOT	BOTTOM
BSWMP	BETTER STORM WATER MANAGEMENT PRACTICES
CH	CHORD
CAP	CORRUGATED ALUMINUM PIPE
CDOT	COLORADO DEPARTMENT OF TRANSPORTATION
CI	CAST IRON
C,G,& SW	CURB, GUTTER & SIDEWALK
℄	CENTER LINE
CL	CLEAR
CMP	CORRUGATED METAL PIPE
CO	CLEAN OUT
COMB	COMBINATION (AS IN STORM SEWER AND SANITARY SEWER)
CONC	CONCRETE
CSM	CITY SURVEY MONUMENT
CSP	CORRUGATED STEEL PIPE
CU	COPPER
DI	DUCTILE IRON
DWY	DRIVEWAY
E	ELECTRIC
ECR	END CURB RETURN
EG	EDGE OF GUTTER
EL	ELEVATION
EP	EDGE OF PAVEMENT
EX	EXISTING
FB	FULL BODY
FC	FACE OF CURB
FG	FINISHED GRADE
℄	FLOW LINE
FL	FLANGE
FM	FORCE MAIN
FO	FIBER OPTICS
FS	FAR SIDE
FTG	FOOTING
G	GAS
GB	GRADE BREAK
GM	GAS METER
GV	GATE VALVE
HBP	HOT BITUMINOUS PAVEMENT
HDPE	HIGH DENSITY POLYETHYLENE
INV	INVERT
IRR	IRRIGATION
L	LENGTH OF ARC
LC	LONG CHORD
LF	LINEAR FEET
LL	LONG ARC
LS	SHORT ARC
LT	LEFT
MB	MAILBOX
MCSM	MESA COUNTY SURVEY MONUMENT
MH	MANHOLE
MJ	MECHANICAL JOINT
MW	MILL WRAP
N/A	NOT APPLICABLE
NIC	NOT IN CONTRACT
NOP	NO ONE PERSON
NRCP	NON-REINFORMATIONRCED CONCRETE PIPE
NS	NEAR SIDE
NTS	NOT TO SCALE
OHP	OVERHEAD POWER
OHT	OVERHEAD TELEPHONE
PC	POINT OF CURVATURE
PCC	POINT OF COMPOUND CURVATURE
PE	POLYETHYLENE
PERF	PERFORATED
PI	POINT OF INTERSECTION
PIP	PLASTIC IRRIGATION PIPE
POC	POINT ON CURVE
POT	POINT ON TANGENT
PR	PROPOSED
PRC	POINT OF REVERSE CURVATURE
PT	POINT OF TANGENCY
PVC	POLYVINYL CHLORIDE
R	RADIUS
RCP	REINFORMATIONRCED CONCRETE PIPE
REQ'D	REQUIRED
RG	RESTRAINED GLANDS
RL	LONG RADIUS
ROW	RIGHT OF WAY
RP	RADIUS POINT
RR	RAIL ROAD
RS	SHORT RADIUS
RT	RIGHT
S	SLOPE
SAN	SANITARY
SC	SHORT CHORD
SCD	STANDARD CONTRACT DOCUMENTS
SCH	SCHEDULE
SF	SILT FENCE
SL	SECTION LINE
SSRB	STANDARD SPECIFICATIONS FOR ROAD & BRIDGE CONSTRUCTION
SSUU	STANDARD SPECIFICATIONS FOR CONSTRUCTION OF UNDERGROUND UTILITIES
STA	STATION
STL	STEEL
STM	STORM
T	TELEPHONE
TAN	LENGTH OF TANGENT
TC	TOP OF CURB
TH	TEST HOLE
TV	TELEVISION
(TYP)	TYPICAL
UU	UNDERGROUND UTILITIES
VC	VERTICAL CURVE
VCP	VITRIFIED CLAY PIPE
VPC	VERTICAL POINT OF CURVATURE
VPCC	VERTICAL POINT OF COMPOUND CURVATURE
VPRC	VERTICAL POINT OF REVERSE CURVATURE
VPI	VERTICAL POINT OF INTERSECTION
VPT	VERTICAL POINT OF TANGENCY
W	WATER
△	DELTA ANGLE

LEGEND

- BSWMP DRAINAGE BASIN BOUNDARY
- BSWMP ANCHORED STRAW BALES — ASB ASB ASB ASB ASB ASB ASB
- BSWMP SILT FENCE — SF SF SF SF SF SF SF
- BUILDING
- CONCRETE CURB AND GUTTER — 2' CURB AND GUTTER
- CONCRETE CURB,GUTTER, & SIDEWALK — 7' C, G, & SW
- CONCRETE DITCH — CONCRETE
- CONCRETE SIDEWALK — 4' SW
- CULVERT — 18" RCP
- EARTH DITCH — EARTH EARTH EARTH
- EDGE OF GRAVEL
- EDGE OF PAVEMENT
- FENCE (BARBED WIRE)
- FENCE (CHAIN LINK)
- FENCE (IRON)
- FENCE (PLASTIC)
- FENCE (TEMPORARY CONSTRUCTION)
- FENCE (WOOD)
- FENCE (WOVEN WIRE)
- GUARD RAIL
- HATCHING: INDICATES ASPHALT REMOVAL
- HATCHING: INDICATES CONCRETE REMOVAL
- HATCHING: INDICATES STAGING AREA — STAGING AREA
- LINE (CENTER OF IMPROVEMENTS) — CENTERLINE
- LINE (CITY LIMITS) — CITY LIMITS
- LINE (CONTROL) — CONTROL LINE
- LINE (EASEMENT)
- LINE (MONUMENT/SECTION) — MONUMENT/SECTION LINE
- LINE (PROPERTY)
- LINE (RIGHT OF WAY)
- MATCH LINE — MATCH LINE SEE SHEET NO ?
- PIPE (IRRIGATION) — 4" IRR
- PIPE (SIPHON) — 4" SIPHON
- PROPOSED CONCRETE CURB AND GUTTER
- PROPOSED CONCRETE CURB,GUTTER,& SIDEWALK
- PROPOSED CONCRETE SIDEWALK
- PROPOSED "WET" UTILITIES (CONSTRUCTION NOTE WILL INDICATE TYPE, SIZE, AND MATERIAL OF NEW MAIN) — 8" PVC SANITARY SEWER

ALL PROPOSED FEATURES NOT SHOWN IN LEGEND WILL BE SHOWN THE SAME AS THEIR EXISTING COUNTERPART, BUT INDICATED BY BOLDER LINETYPE

- RAIL ROAD
- RETAINING WALL — 1' RETAINING WALL
- STRIPING (CONTINUOUS WHITE) — WHITE
- STRIPING (DASHED WHITE) — WHITE
- STRIPING (CONTINUOUS YELLOW) — YELLOW
- STRIPING (DASHED YELLOW) — YELLOW
- TOP OF SLOPE — 4570 4580
- CONTOUR LINES (SHOWN BETWEEN TOP & TOE)
- TOE OF SLOPE — 4570
- TRAFFIC DETECTOR LOOP
- UTILITY LINE (ABANDON) (THIS CASE A WATER LINE) — W (ABANDON) 8" W
- UTILITY LINE (CABLE TV) — TV TV
- UTILITY LINE (ELECTRIC) — E E
- UTILITY LINE (FIBER OPTIC) — FO QWEST FO
- UTILITY LINE (GAS) — G 1 1/4" MW G
- UTILITY LINE (HIGH VOLTAGE OVERHEAD POWER) — HVOHP
- UTILITY LINE (OVERHEAD POWER) — OHP
- UTILITY LINE (OVERHEAD TELEPHONE) — OHT
- UTILITY LINE (SANITARY SEWER) — 8" SAN
- UTILITY LINE (SANITARY SEWER FORCE MAIN) — 8" FM
- UTILITY LINE (SANITARY SEWER SERVICE)
- UTILITY LINE (STORM SEWER) — 8" STM
- UTILITY LINE (STORM SEWER, PERFORATED) — 6" PERF
- UTILITY LINE (STORM/SANITARY SEWER SEWER COMBINATION) — 18" COMB
- UTILITY LINE (TELEPHONE) — T T
- UTILITY LINE (WATER) — W 8" W

SYMBOLS

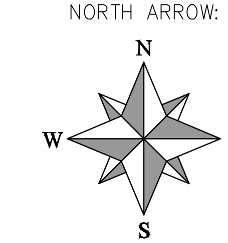
- BENCH MARK
- CATCH BASIN
- CLEAN OUT
- CURB STOP
- FIRE HYDRANT
- GUY WIRE ANCHOR
- HEADGATE
- IRRIGATION PUMP
- MAILBOX
- MANHOLE (ELECTRIC)
- MANHOLE (GAS)
- MANHOLE (SANITARY/STORM)
- MANHOLE (TELEPHONE)
- MANHOLE (TV)
- MANHOLE (WATER)
- METER (GAS)
- METER (WATER)
- PEDESTAL (TELEPHONE)
- PEDESTAL (TV)
- PROPERTY PIN
- PULL BOX
- REDUCER FITTING
- SIGN OR POST (SIGN TYPE NOTED) — STOP
- SPRINKLER HEAD
- STREET LIGHT
- SURVEY MONUMENT (CITY) — CSM
- SURVEY MONUMENT (TYPE NOTED) — MCSM
- TEST HOLE — TH #1
- TRAFFIC PAINT MARKING
- TRAFFIC SIGNAL POLE AND MAST ARM
- UTILITY POLE
- VALVE (GAS)
- VALVE (IRRIGATION)
- VALVE (WATER)
- VEGETATION (HEDGE OR BUSH)
- VEGETATION (TREE STUMP)
- VEGETATION (TREE) (CALIPER SIZE NOTED)
- WATER HYDRANT
- WEIR
- YARD LIGHT

BAR SCALE:

0 5 10 20

(IN FEET)
1 inch = 20 feet

NORTH ARROW:



DESCRIPTION	DATE
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REVISION △	

PROJECT NO. ____
DRAWN BY JCS DATE 4-02
DESIGNED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

SCALES: PLAN & PROFILE

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CITY OF GRAND JUNCTION
STANDARD ABBREVIATIONS, LEGEND, AND SYMBOLS

2

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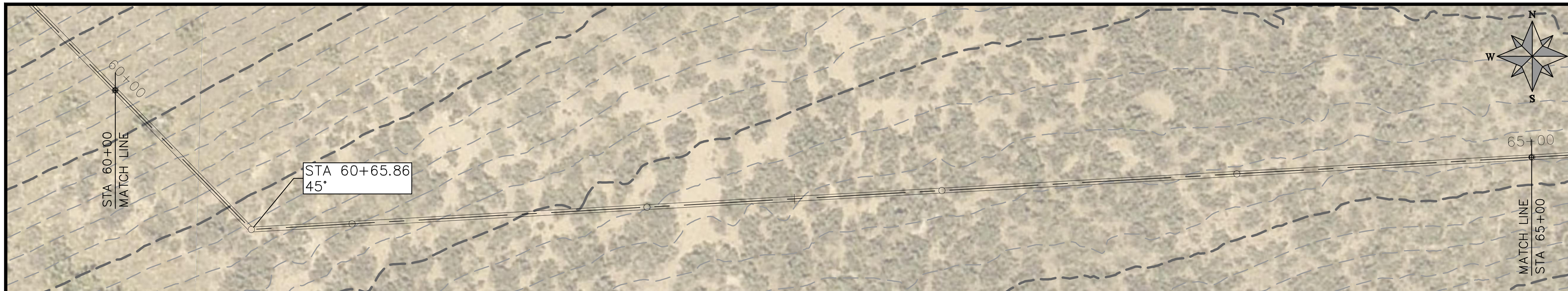

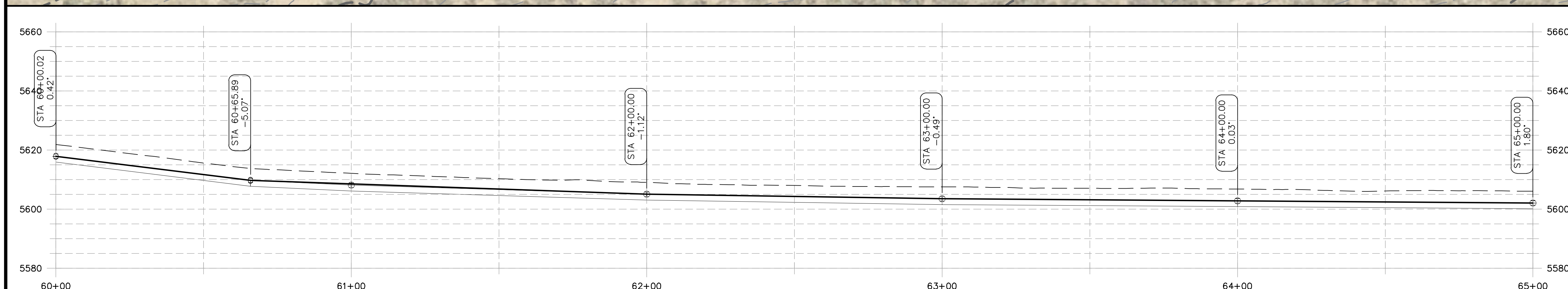

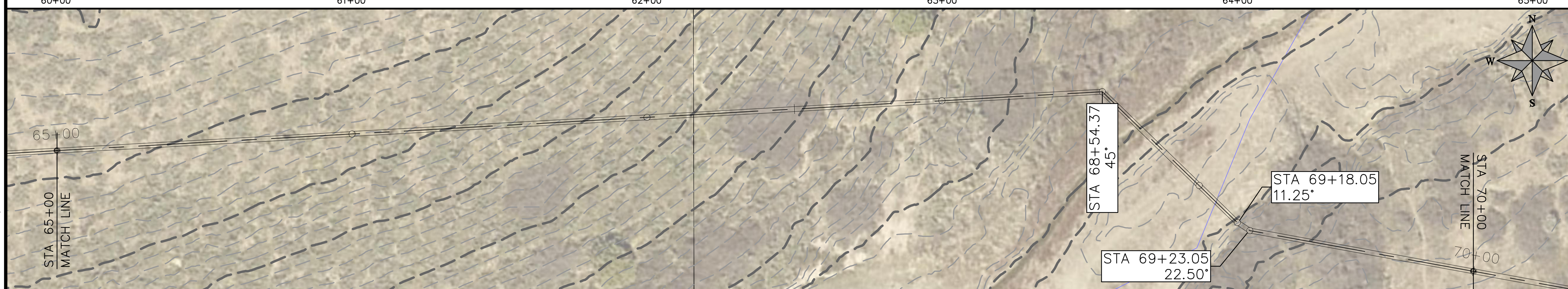

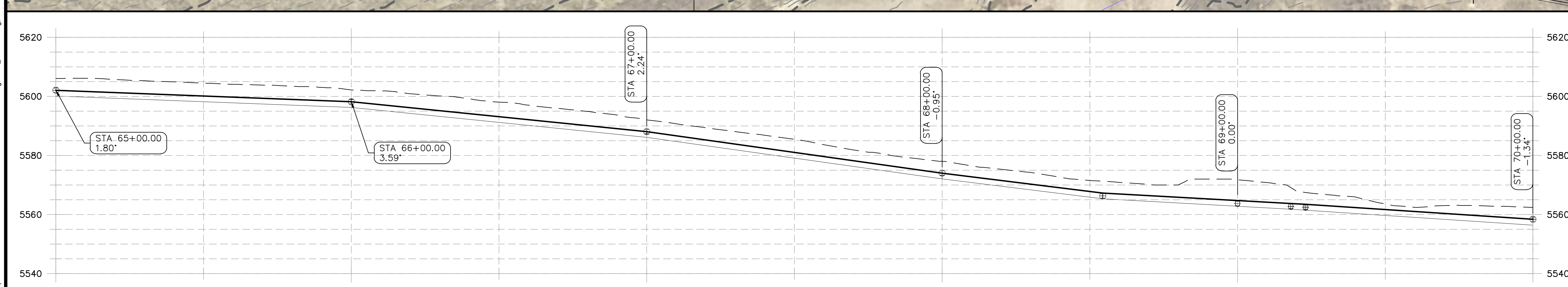

COORDINATES SHOWN IN MCLCS:MESA COUNTY LOCAL COORDINATES SYSTEM

CONSTRUCTION NOTES

(1) 202 – REMOVAL OF ASPHALT MAT. CUT AND REMOVE ASPHALT AS SHOWN. (INDICATED BY DOT HATCH PATTERN)

(400) 102.7/108.2 – 20" C900 WATER MAIN PIPE (DR-18). INCLUDES TYPE A BEDDING AND HAUNCHING MATERIAL AND BACKFILL OF TRENCH WITH NATIVE MATERIALS MEETING 103.16 EARTH BACKFILL MATERIAL.

(446) ROAD CROSSING.

(663) 304 – AGGREGATE BASE COURSE (CLASS 6) (6" THICK)

(677) 401.08 – HOT BITUMINOUS PAVEMENT (4" THICK) (GRADING SX, BINDER GRADE PG 64-22) (TWO 2" LIFTS)

NOTE
DESIGN HAS BEEN BASED ON:
-AVERAGE 3 ft BURY DEPTH
-ASSUMPTION OF 1.5° DEFLECTION IN PIPE JOINT

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DESCRIPTION	DATE
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REVISION △	–
REVISION △	–
REVISION △	–

PROJECT NO. F000610
DRAWN BY HMC DATE 2021
DESIGNED BY JAE DATE 2021
CHECKED BY JAE DATE 2021
APPROVED BY JAE DATE 2021

SCALES: PLAN & PROFILE
HORIZONTAL: 1" = 40'
0 10 20 40
VERTICAL: 1" = 5'
0 1.25 2.5 20

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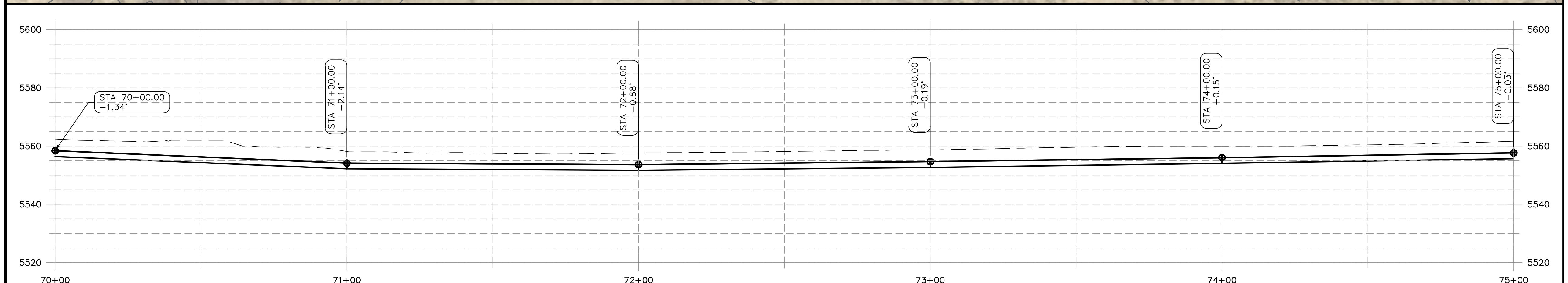
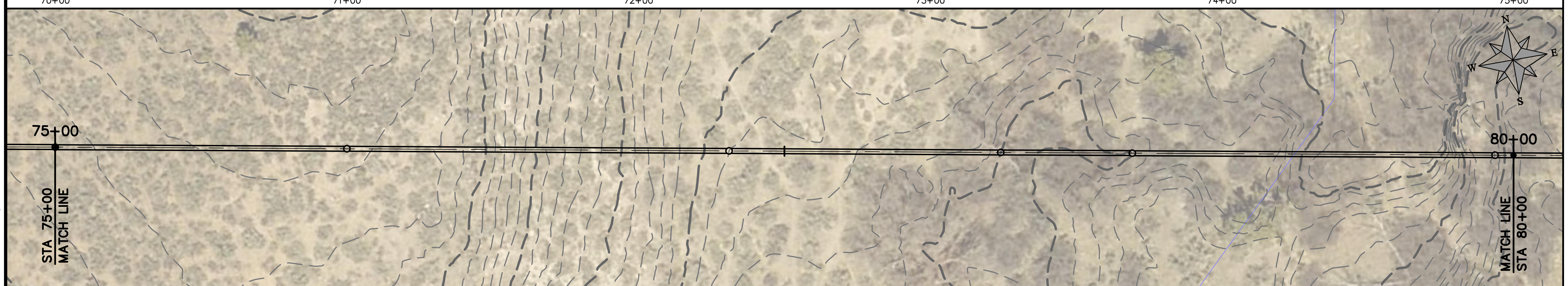
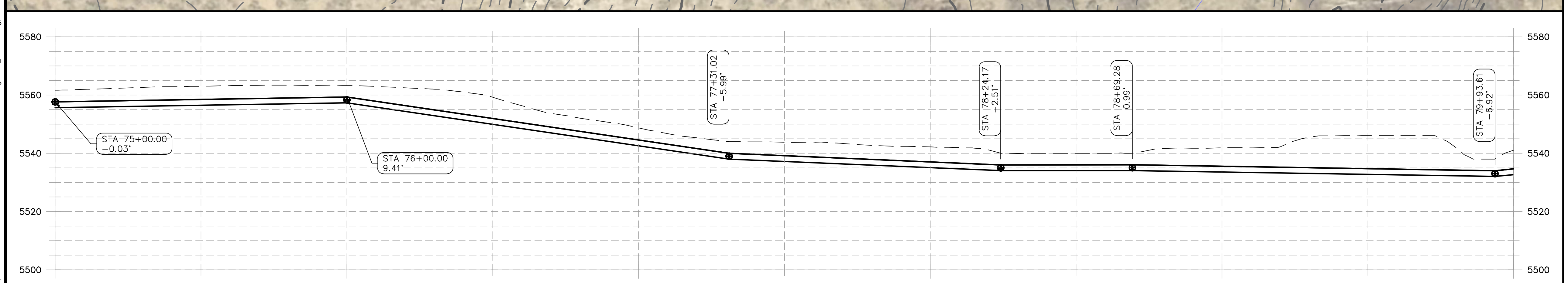
2021 KANNAH CREEK REALIGNMENT
PLAN AND PROFILE
STA 60+00 TO STA 70+00







COORDINATES SHOWN IN MCLCS:MESA COUNTY LOCAL COORDINATES SYSTEM

CONSTRUCTION NOTES

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446. ROAD CROSSING.
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677. 401.08 – HOT BITUMINOUS PAVEMENT (4" THICK) (GRADING SX, BINDER GRADE PG 64-22) (TWO 2" LIFTS)

NOTE
DESIGN HAS BEEN BASED ON:
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-ASSUMPTION OF 1.5° DEFLECTION IN PIPE JOINT

DESCRIPTION	DATE
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REVISION △	–
REVISION △	–
REVISION △	–

PROJECT NO. F000610
DRAWN BY HMC DATE 2021
DESIGNED BY JAE DATE 2021
CHECKED BY JAE DATE 2021
APPROVED BY JAE DATE 2021

SCALES: PLAN & PROFILE
HORIZONTAL: 1" = 40'
0 10 20 40
VERTICAL: 1" = 5'
0 1.25 2.5 20

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2021 KANNAH CREEK REALIGNMENT
PLAN AND PROFILE
STA 70+00 TO STA 80+00

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COORDINATES SHOWN IN MCLCS:MESA COUNTY LOCAL COORDINATES SYSTEM

CONSTRUCTION NOTES

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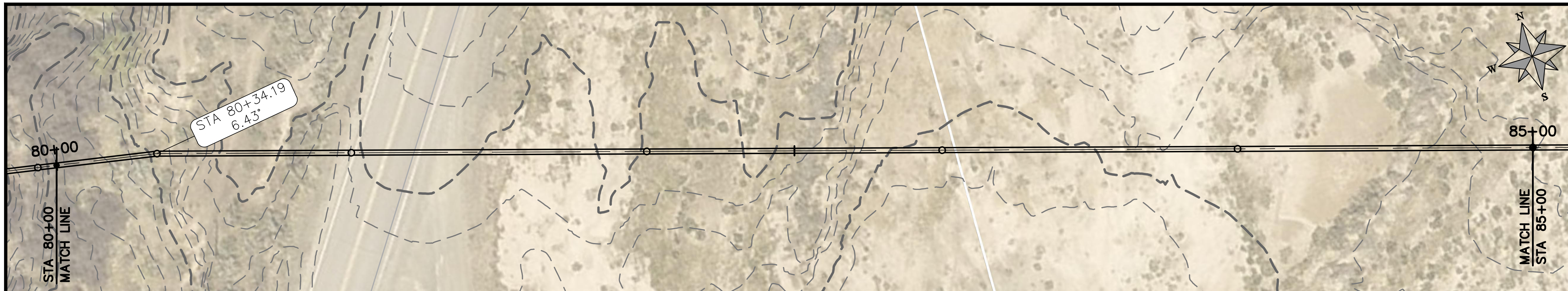
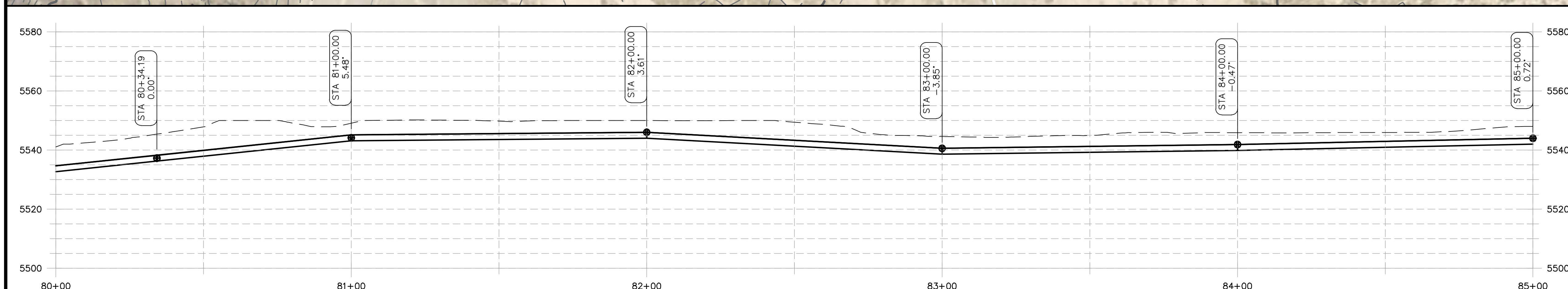
(400) 102.7/108.2 – 20" C900 WATER MAIN PIPE (DR-18). INCLUDES TYPE A BEDDING AND HAUNCHING MATERIAL AND BACKFILL OF TRENCH WITH NATIVE MATERIALS MEETING 103.16 EARTH BACKFILL MATERIAL.

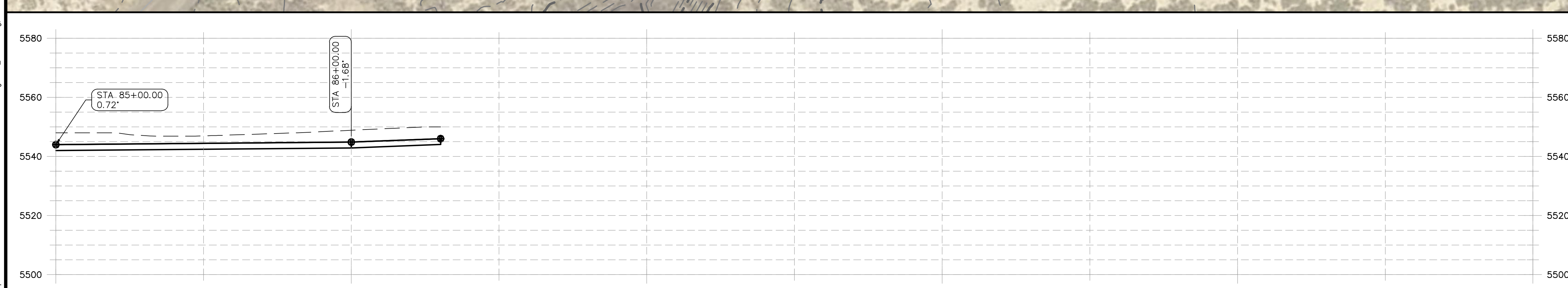
(446) ROAD CROSSING.

(663) 304 – AGGREGATE BASE COURSE (CLASS 6) (6" THICK)

(677) 401.08 – HOT BITUMINOUS PAVEMENT (4" THICK) (GRADING SX, BINDER GRADE PG 64-22) (TWO 2" LIFTS)







NOTE
DESIGN HAS BEEN BASED ON:
-AVERAGE 3 ft BURY DEPTH
-ASSUMPTION OF 1.5° DEFLECTION IN PIPE JOINT

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	DESCRIPTION	DATE
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REVISION △		–
REVISION △		–

PROJECT NO. F000610
DRAWN BY HMC DATE 2021
DESIGNED BY JAE DATE 2021
CHECKED BY JAE DATE 2021
APPROVED BY JAE DATE 2021

SCALES: PLAN & PROFILE
HORIZONTAL: 1" = 40'
0 10 20 40
VERTICAL: 1" = 5'
0 1.25 2.5 20

CITY OF Grand Junction COLORADO

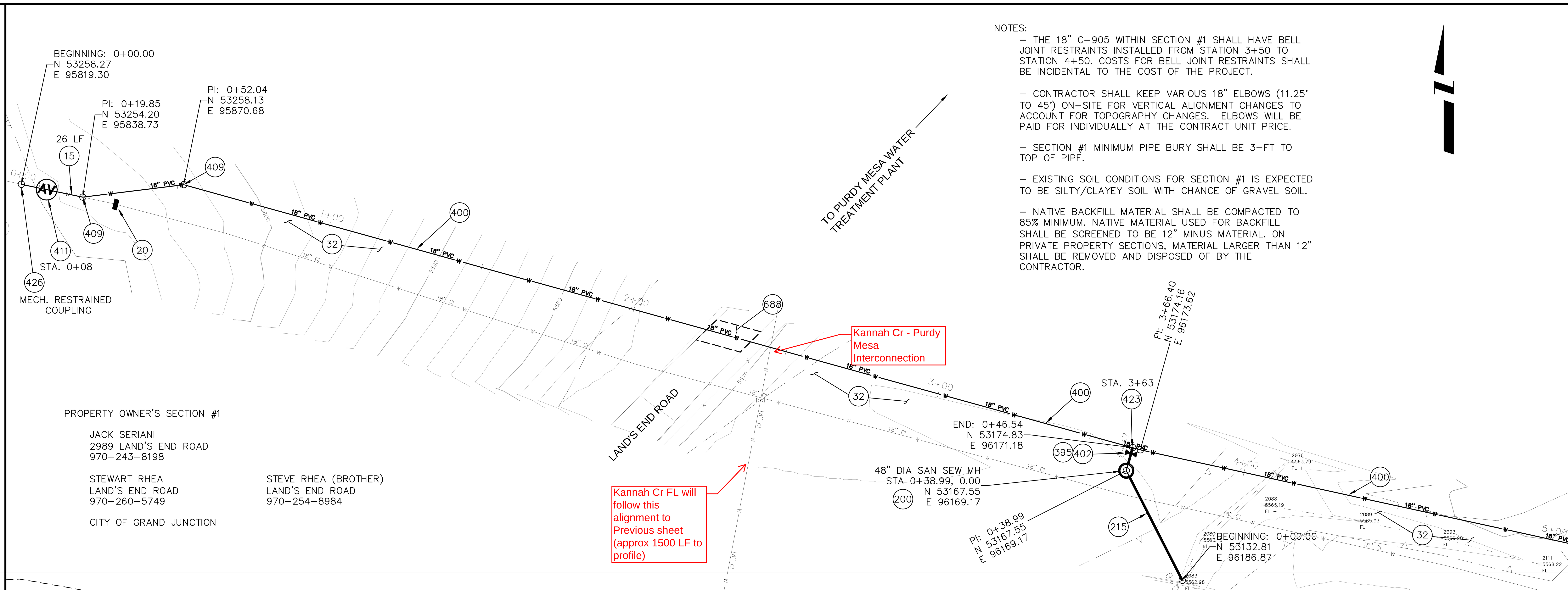
PUBLIC WORKS
ENGINEERING DIVISION

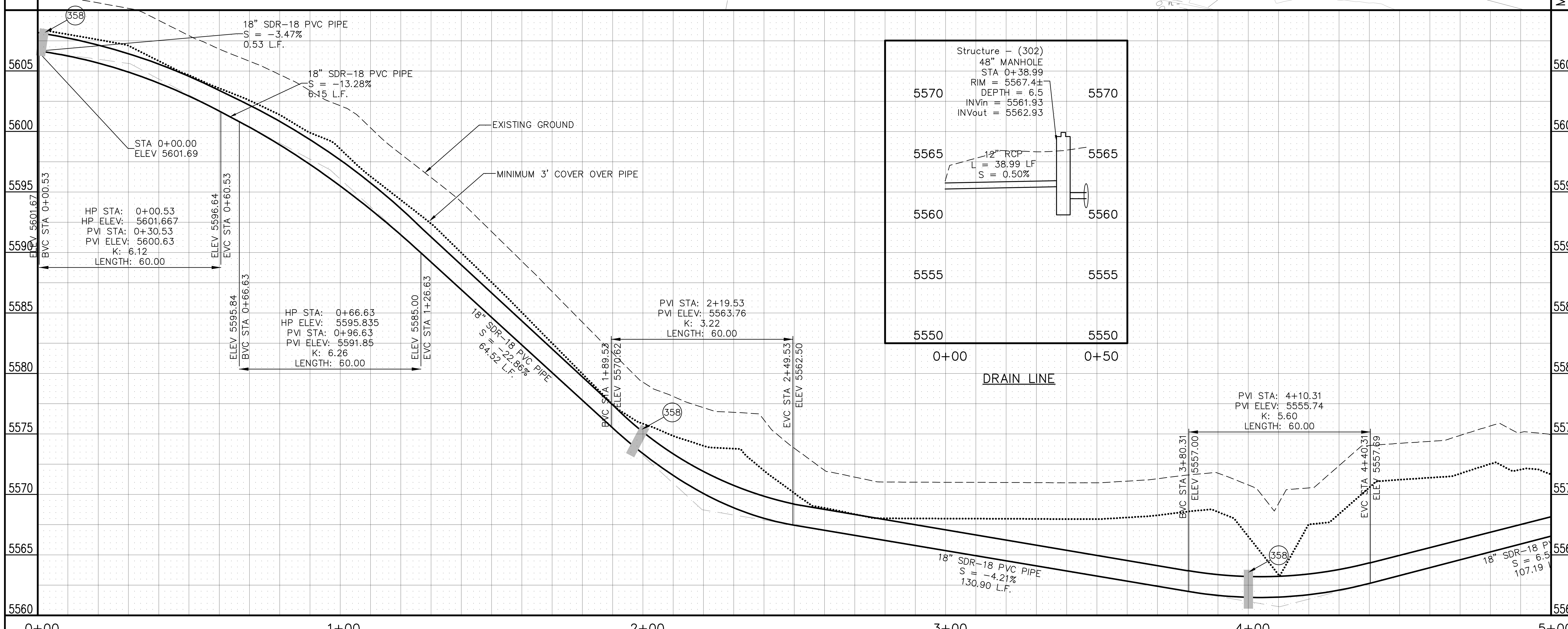
2021 KANNAH CREEK REALIGNMENT
PLAN AND PROFILE
STA 80+00 TO STA 90+00

PROJECT NO. 301-F000605

NOTES:

- THE 18" C-905 WITHIN SECTION #1 SHALL HAVE BELL JOINT RESTRAINTS INSTALLED FROM STATION 3+50 TO STATION 4+50. COSTS FOR BELL JOINT RESTRAINTS SHALL BE INCIDENTAL TO THE COST OF THE PROJECT.
- CONTRACTOR SHALL KEEP VARIOUS 18" ELBOWS (11.25° TO 45°) ON-SITE FOR VERTICAL ALIGNMENT CHANGES TO ACCOUNT FOR TOPOGRAPHY CHANGES. ELBOWS WILL BE PAID FOR INDIVIDUALLY AT THE CONTRACT UNIT PRICE.
- SECTION #1 MINIMUM PIPE BURY SHALL BE 3-FT TO TOP OF PIPE.
- EXISTING SOIL CONDITIONS FOR SECTION #1 IS EXPECTED TO BE SILTY/CLAYEY SOIL WITH CHANCE OF GRAVEL SOIL.
- NATIVE BACKFILL MATERIAL SHALL BE COMPACTED TO 85% MINIMUM. NATIVE MATERIAL USED FOR BACKFILL SHALL BE SCREENED TO BE 12" MINUS MATERIAL. ON PRIVATE PROPERTY SECTIONS, MATERIAL LARGER THAN 12" SHALL BE REMOVED AND DISPOSED OF BY THE CONTRACTOR.





CONSTRUCTION NOTES

(15) 202 - REMOVAL OF PIPE AS SHOWN. (SIZE AND TYPE AS SHOWN ON PLAN)

(20) 202 - ABANDON PIPE. ABANDON BY PLUGGING REMAINING ENDS WITH CONCRETE.

(32) 201 - CLEARING AND GRUBBING (NATIVE VEGETATION CONSISTS OF SAGEBRUSH, GRASSES, SCRUB OAK BUSHES, TAMARISK, ETC., TREES SHOWN INDIVIDUALLY FOR REMOVAL)

(102) 210 - RESET FENCE. (HEIGHT AND MATERIAL AS SHOW ON PLAN)

(200) 102.11/108.5 - ENERGY DISSIPATING MANHOLE (48" I.D.) (INCLUDES CONNECTION OF ADJACENT PIPE LINES) (SEE DETAIL THIS SHEET FOR DIMENSIONS AND ELEVATIONS)

(215) 102.10/108.2 - 12" STORM DRAIN PIPE (RCP). INCLUDES TYPE A BEDDING AND HAUNCHING MATERIAL AND BACKFILL OF TRENCH WITH NATIVE MATERIALS MEETING 103.16 EARTH BACKFILL MATERIAL.

(358) 103 - CLAY CUT-OFF WALL (INCIDENTAL TO WATER INSTALLATION PAY ITEM)

(395) 102.7/108.2 - 6" WATER MAIN PIPE (SDR-18 PVC). INCLUDES TYPE A BEDDING AND HAUNCHING MATERIAL AND BACKFILL OF TRENCH WITH NATIVE MATERIALS MEETING 103.16 EARTH BACKFILL MATERIAL.

(400) 102.7/108.2 - 18" WATER MAIN PIPE (SDR-18 PVC). INCLUDES TYPE A BEDDING AND HAUNCHING MATERIAL AND BACKFILL OF TRENCH WITH NATIVE MATERIALS MEETING 103.16 EARTH BACKFILL MATERIAL.

(402) 102.8b/108.3 - 6" GATE VALVE (INCLUDES 2' WIDE CONCRETE COLLAR, 6" THICK)

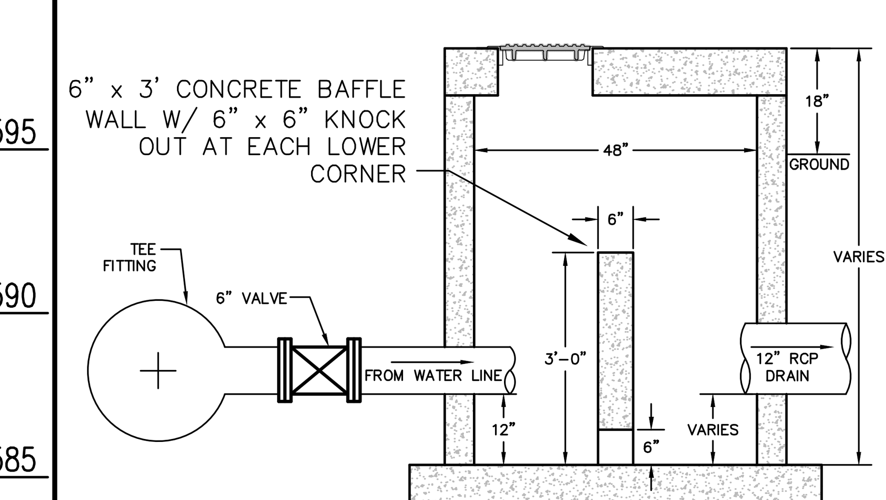
(409) 102.8/108.3 - 18", 22.5° ELBOW

(411) 102.8g/102.8h/108.3 - 6" COMBINATION AIR VALVE AND 60" DIA. CONCRETE VAULT (PER CITY DETAIL W-11)

(423) 102.8/108.3 - 18" x 6" TEE

(426) CONNECT TO EXISTING WATER PIPE/VALVE/FITTING. THE CONTRACT UNIT PRICE FOR WATER PIPE SHALL INCLUDE THE COST OF CONNECTION TO EXISTING PIPELINE USING A MECHANICALLY RESTRAINED COUPLING. DEPTH OF EXISTING WATER LINE ESTIMATED TO BE 2' TO 4' DEEP. CONTRACTOR SHALL FIELD VERIFY DEPTH OF EXISTING PIPE PRIOR TO CONSTRUCTION OF NEW WATER LINE.

(688) RESTORE GRAVEL ROADWAY SURFACE. IF ADDITIONAL GRAVEL IS NEEDED, THE COST AND PLACEMENT WILL NOT BE PAID FOR SEPARATELY, BUT SHALL BE INCLUDED IN THE COST OF THE PROJECT. (APPROXIMATE DIMENSIONS = 13' x 10')



DRAIN LINE MANHOLE DETAIL - SECTION #1

NOTE:

THE TABLE BELOW IS TO BE USED BY THE CONTRACTOR FOR RESTRAINING THE FLOW LINE PIPE ON EACH SIDE OF AN ELBOW. EBAA IRON'S RESTRAINT CALCULATOR WAS USED TO DETERMINE THE RESTRAINED LENGTHS.

PIPE SIZE	BEND ∠	BURY DEPTH	TEST PRESSURE	LENGTH OF RESTRAINED PIPE
18"	11.25°	3'-0"	300 PSI	14 FEET
18"	22.5°	3'-0"	300 PSI	26 FEET
18"	45°	3'-0"	300 PSI	56 FEET
24"	11.25°	2'-0"	300 PSI	22 FEET
24"	22.5°	2'-0"	300 PSI	44 FEET
24"	45°	2'-0"	300 PSI	91 FEET

DESCRIPTION	DATE
REVISION △	-
REVISION △	-
REVISION △	-
REVISION △	-

DRAWN BY JAH DATE 1/2013
DESIGNED BY ALC DATE 1/2013
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

SCALES: PLAN HORIZONTAL 0 5 10 20; PROFILE HORIZONTAL 0 5 10 20, VERTICAL 0 2.5 5

CITY OF Grand Junction COLORADO

PUBLIC WORKS AND PLANNING ENGINEERING DIVISION

2013 WATER LINE REPLACEMENT
SECTION #1 - FLOW LINE PLAN AND PROFILE
STA 0+00 TO STA 5+00

5

PROJECT NO. 301-F000605

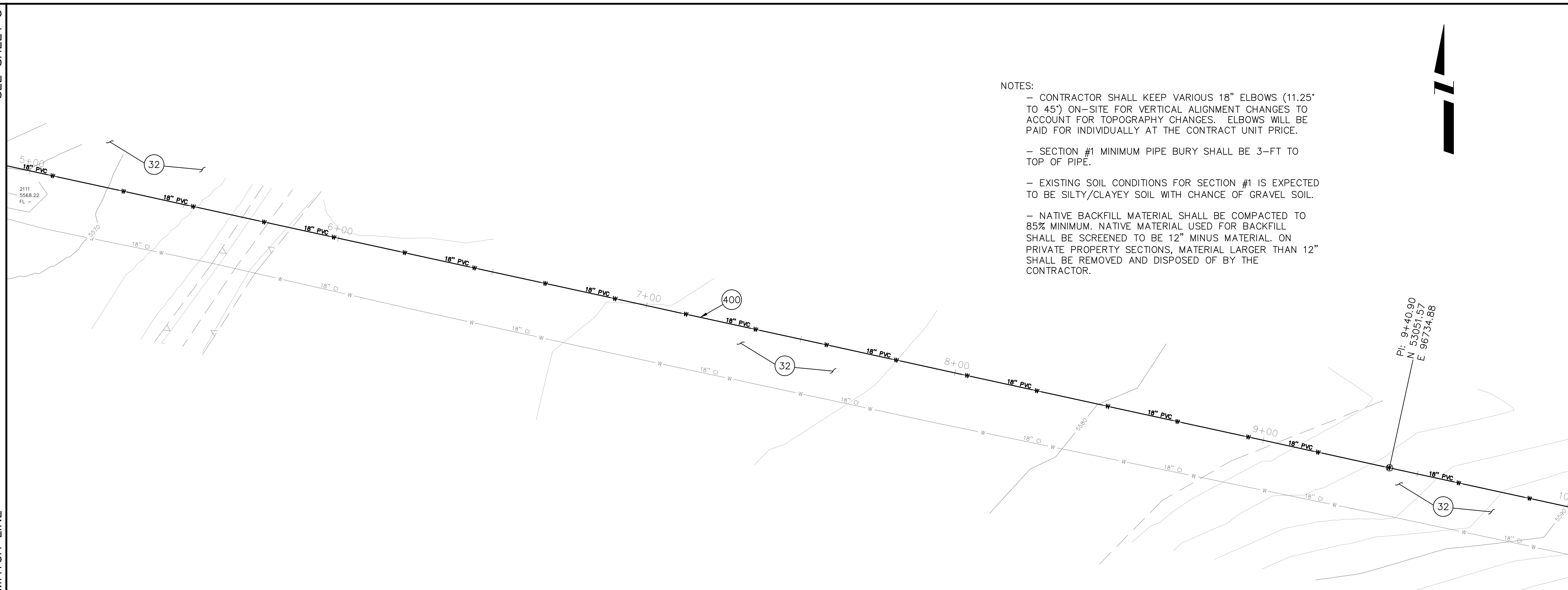
CONSTRUCTION NOTES

(358) 103 – CLAY CUT-OFF WALL (INCIDENTAL TO WATER INSTALLATION PAY ITEM)

(400) 102.7/108.2 – 18" WATER MAIN PIPE (SDR-18 PVC). INCLUDES TYPE A BEDDING AND HAUNCHING MATERIAL AND BACKFILL OF TRENCH WITH NATIVE MATERIALS MEETING 103.16 EARTH BACKFILL MATERIAL.

SEE SHEET 5 — MATCH LINE

SEE SHEET 7 — MATCH LINE



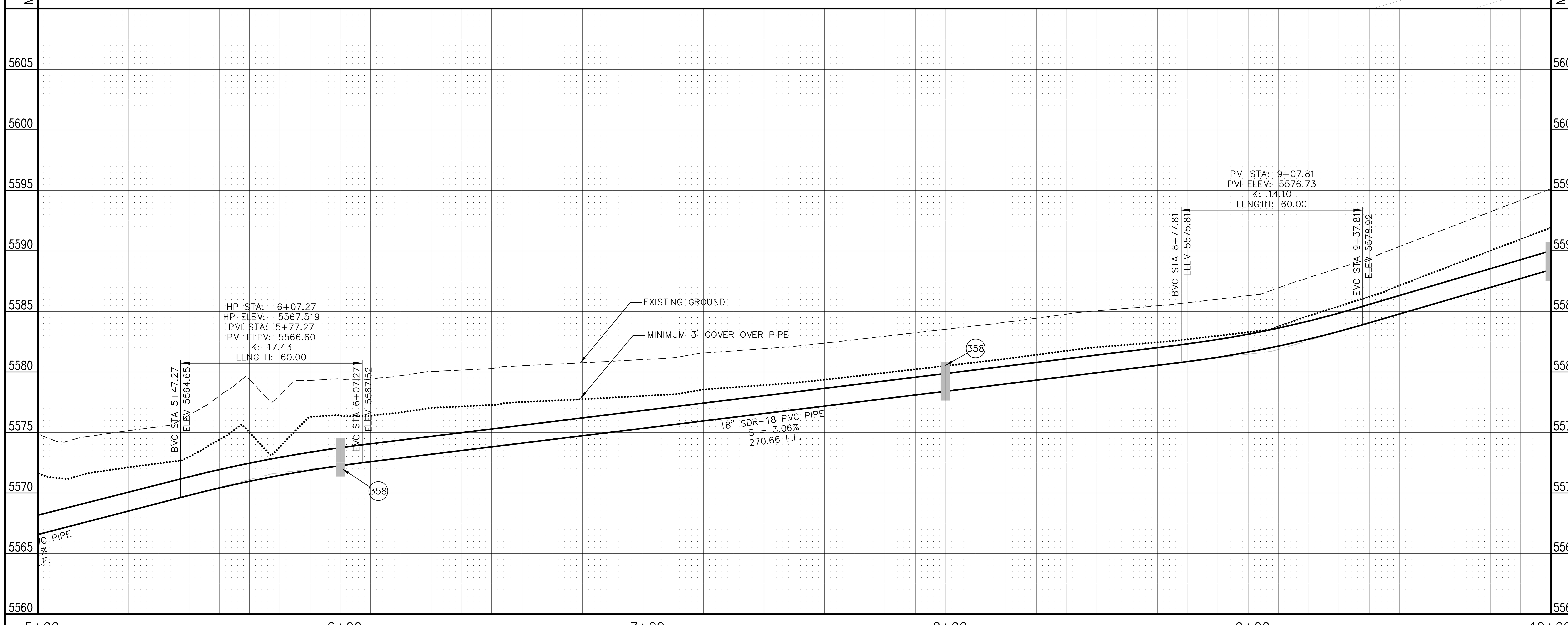
NOTES:

– CONTRACTOR SHALL KEEP VARIOUS 18" ELBOWS (11.25° TO 45°) ON-SITE FOR VERTICAL ALIGNMENT CHANGES TO ACCOUNT FOR TOPOGRAPHY CHANGES. ELBOWS WILL BE PAID FOR INDIVIDUALLY AT THE CONTRACT UNIT PRICE.

– SECTION #1 MINIMUM PIPE BURY SHALL BE 3-FT TO TOP OF PIPE.

– EXISTING SOIL CONDITIONS FOR SECTION #1 IS EXPECTED TO BE SILTY/CLAYEY SOIL WITH CHANCE OF GRAVEL SOIL.

– NATIVE BACKFILL MATERIAL SHALL BE COMPACTED TO 85% MINIMUM. NATIVE MATERIAL USED FOR BACKFILL SHALL BE SCREENED TO BE 12" MINUS MATERIAL. ON PRIVATE PROPERTY SECTIONS, MATERIAL LARGER THAN 12" SHALL BE REMOVED AND DISPOSED OF BY THE CONTRACTOR.



DESCRIPTION	DATE
REVISION 1	
REVISION 2	
REVISION 3	
REVISION 4	

DRAWN BY JAH DATE 1/2013
DESIGNED BY ALC DATE 1/2013
CHECKED BY ______ DATE ______
APPROVED BY ______ DATE ______

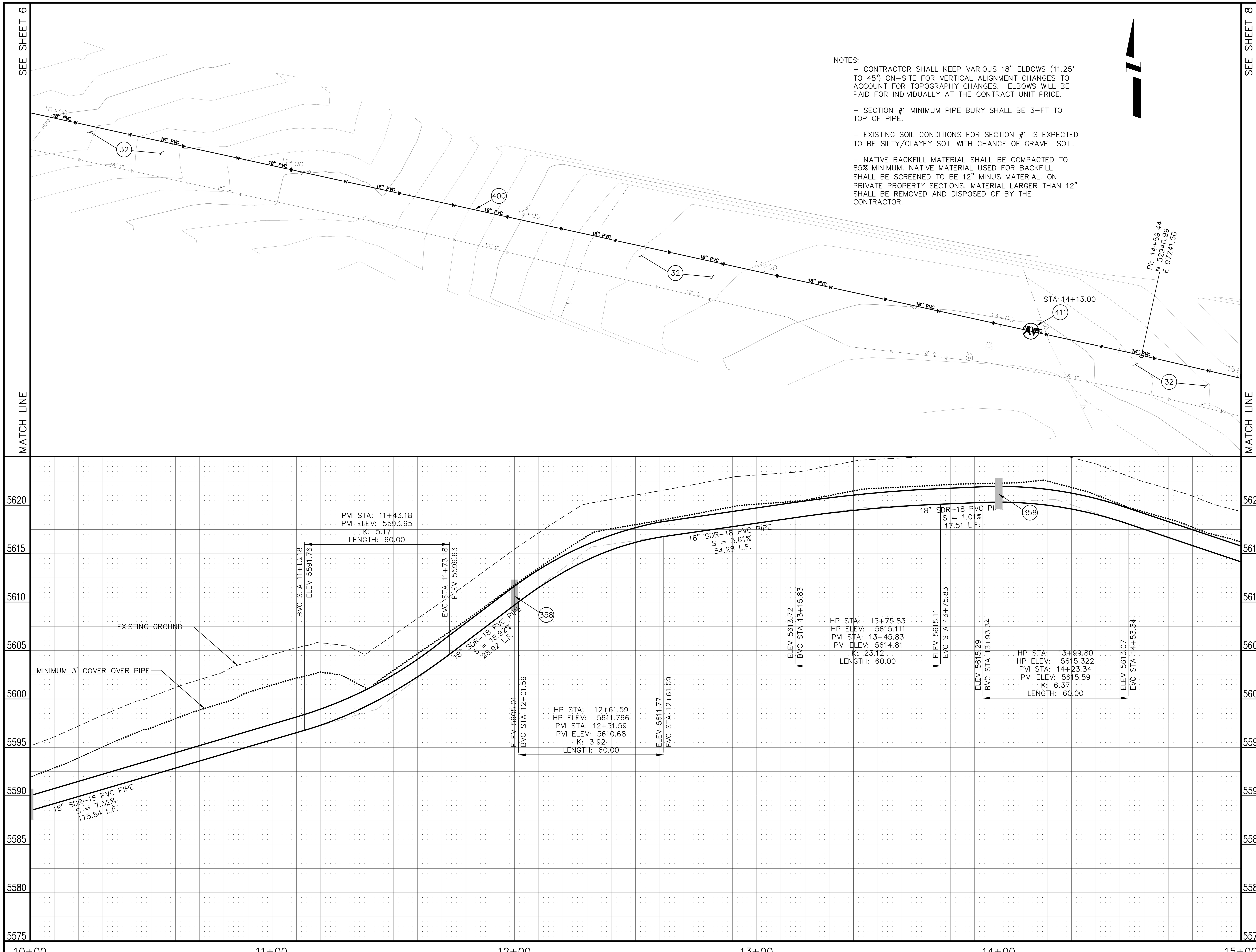
SCALES: PLAN — HORIZONTAL 0 5 10 20; PROFILE — HORIZONTAL 0 5 10 20, VERTICAL 0 2.5 5

CITY OF Grand Junction COLORADO

PUBLIC WORKS AND PLANNING ENGINEERING DIVISION

2013 WATER LINE REPLACEMENT
SECTION #1 – FLOW LINE PLAN AND PROFILE
STA 5+00 TO STA 10+00

6



NOTES:
- CONTRACTOR SHALL KEEP VARIOUS 18" ELBOWS (11.25° TO 45°) ON-SITE FOR VERTICAL ALIGNMENT CHANGES TO ACCOUNT FOR TOPOGRAPHY CHANGES. ELBOWS WILL BE PAID FOR INDIVIDUALLY AT THE CONTRACT UNIT PRICE.
- SECTION #1 MINIMUM PIPE BURY SHALL BE 3-FT TO TOP OF PIPE.
- EXISTING SOIL CONDITIONS FOR SECTION #1 IS EXPECTED TO BE SILTY/CLAYEY SOIL WITH CHANCE OF GRAVEL SOIL.
- NATIVE BACKFILL MATERIAL SHALL BE COMPACTED TO 85% MINIMUM. NATIVE MATERIAL USED FOR BACKFILL SHALL BE SCREENED TO BE 12" MINUS MATERIAL. ON PRIVATE PROPERTY SECTIONS, MATERIAL LARGER THAN 12" SHALL BE REMOVED AND DISPOSED OF BY THE CONTRACTOR.

PROJECT NO. 301-F000605

CONSTRUCTION NOTES

(358) 103 – CLAY CUT-OFF WALL (INCIDENTAL TO WATER INSTALLATION PAY ITEM)

(400) 102.7/108.2 – 18" WATER MAIN PIPE (SDR-18 PVC). INCLUDES TYPE A BEDDING AND HAUNCHING MATERIAL AND BACKFILL OF TRENCH WITH NATIVE MATERIALS MEETING 103.16 EARTH BACKFILL MATERIAL.

(411) 102.8g/102.8h/108.3 – 6" COMBINATION AIR VALVE AND 60" DIA. CONCRETE VAULT (PER CITY DETAIL W-11)

DESCRIPTION	DATE
REVISION △	–
REVISION △	–
REVISION △	–
REVISION △	–

DRAWN BY JAH DATE 1/2013
DESIGNED BY ALC DATE 1/2013
CHECKED BY DATE
APPROVED BY DATE

SCALES: PLAN HORIZONTAL 0 5 10 20; PROFILE HORIZONTAL 0 5 10 20; VERTICAL 0 2.5 5

CITY OF Grand Junction COLORADO

PUBLIC WORKS AND PLANNING ENGINEERING DIVISION

2013 WATER LINE REPLACEMENT
SECTION #1 – FLOW LINE PLAN AND PROFILE
STA 10+00 TO STA 15+00

7

PROJECT NO. 301-F000605

SEE SHEET 7

MATCH LINE

NOTES:
- CONTRACTOR SHALL KEEP VARIOUS 18" ELBOWS (11.25° TO 45°) ON-SITE FOR VERTICAL ALIGNMENT CHANGES TO ACCOUNT FOR TOPOGRAPHY CHANGES. ELBOWS WILL BE PAID FOR INDIVIDUALLY AT THE CONTRACT UNIT PRICE.
- SECTION #1 MINIMUM PIPE BURY SHALL BE 3-FT TO TOP OF PIPE.
- EXISTING SOIL CONDITIONS FOR SECTION #1 IS EXPECTED TO BE SILTY/CLAYEY SOIL WITH CHANCE OF GRAVEL SOIL.
- NATIVE BACKFILL MATERIAL SHALL BE COMPACTED TO 85% MINIMUM. NATIVE MATERIAL USED FOR BACKFILL SHALL BE SCREENED TO BE 12" MINUS MATERIAL. ON PRIVATE PROPERTY SECTIONS, MATERIAL LARGER THAN 12" SHALL BE REMOVED AND DISPOSED OF BY THE CONTRACTOR.

CONSTRUCTION NOTES

(15) 202 – REMOVAL OF PIPE AS SHOWN. (SIZE AND TYPE AS SHOWN ON PLAN)

(20) 202 – ABANDON PIPE. ABANDON BY PLUGGING REMAINING ENDS WITH CONCRETE.

(102) 210 – RESET FENCE. (4 FT ± HIGH BARBED WIRE FENCE WITH WOODEN POSTS)

(358) 103 – CLAY CUT-OFF WALL (INCIDENTAL TO WATER INSTALLATION PAY ITEM)

(400) 102.7/108.2 – 18" WATER MAIN PIPE (SDR-18 PVC). INCLUDES TYPE A BEDDING AND HAUNCHING MATERIAL AND BACKFILL OF TRENCH WITH NATIVE MATERIALS MEETING 103.16 EARTH BACKFILL MATERIAL.

(402) 102.8b/108.3 – 6" GATE VALVE

(403) 102.8b/108.3 – 18" BUTTERFLY VALVE (FL x FL)

(409) 102.8/108.3 – 18", 22.5° ELBOW

(418) 102.7/108.3 – 6" FLANGED END CAP (ATTACH TO VALVE)

(419) 102.7/108.3 – 18", FLANGED COUPLING ADAPTER (EPOXY)

CONSTRUCTION NOTES

(423) 102.8/108.3 – 18" x 6" TEE

(425) 102.8/108.3 – 18" x 18" TEE

(426) CONNECT TO EXISTING WATER PIPE/VALVE/FITTING. THE CONTRACT UNIT PRICE FOR WATER PIPE SHALL INCLUDE THE COST OF CONNECTION TO EXISTING PIPELINE USING A MECHANICALLY RESTRAINED COUPLING. DEPTH OF EXISTING WATER LINE ESTIMATED TO BE 2' TO 4' DEEP. CONTRACTOR SHALL FIELD VERIFY DEPTH OF EXISTING PIPE PRIOR TO CONSTRUCTION OF NEW WATER LINE.

(432) 102.8h/108.5 – 72" DIA. CONCRETE BUTTERFLY VALVE VAULT (CONTRACTOR SHALL POSITION CONCRETE COVER SO THE CAST IRON MANHOLE LID IS POSITIONED OVER THE VALVE NUT FOR OPERATION) (6' INSIDE HEIGHT)

DESCRIPTION	DATE
REVISION △	–
REVISION △	–
REVISION △	–
REVISION △	–

DRAWN BY JAH DATE 1/2013
DESIGNED BY ALC DATE 1/2013
CHECKED BY ______ DATE ______
APPROVED BY ______ DATE ______

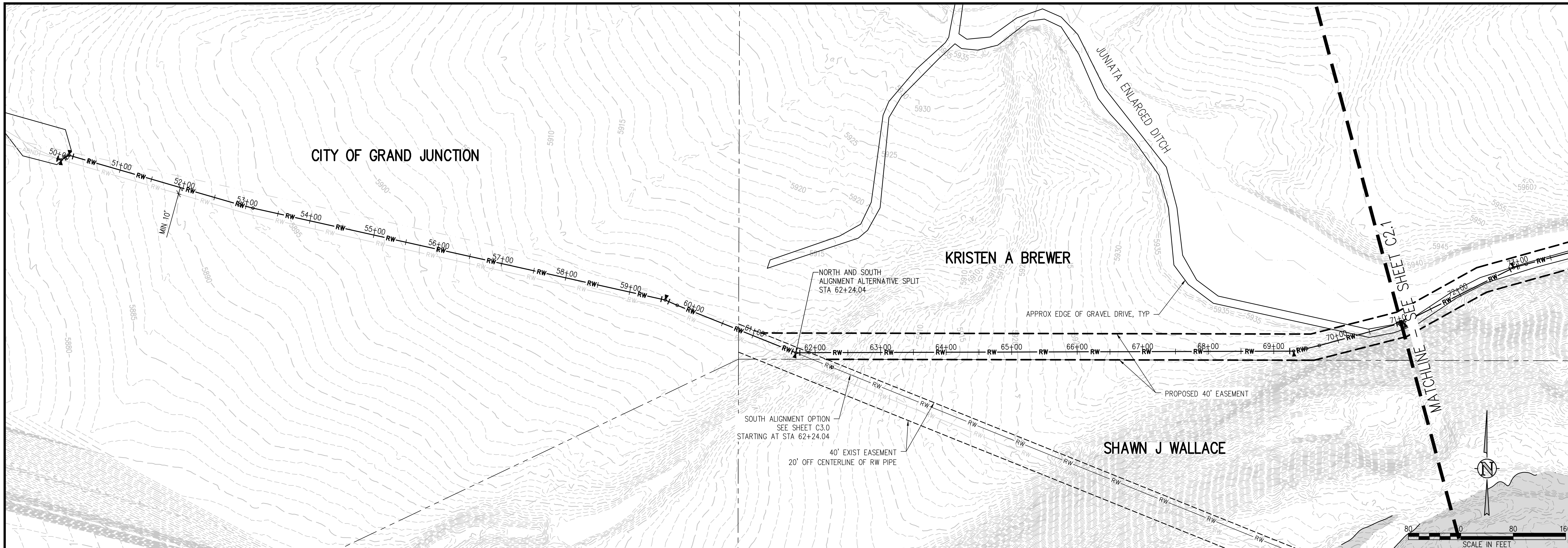
SCALES: PLAN HORIZONTAL 0 5 10 20; PROFILE HORIZONTAL 0 5 10 20; VERTICAL 0 2.5 5

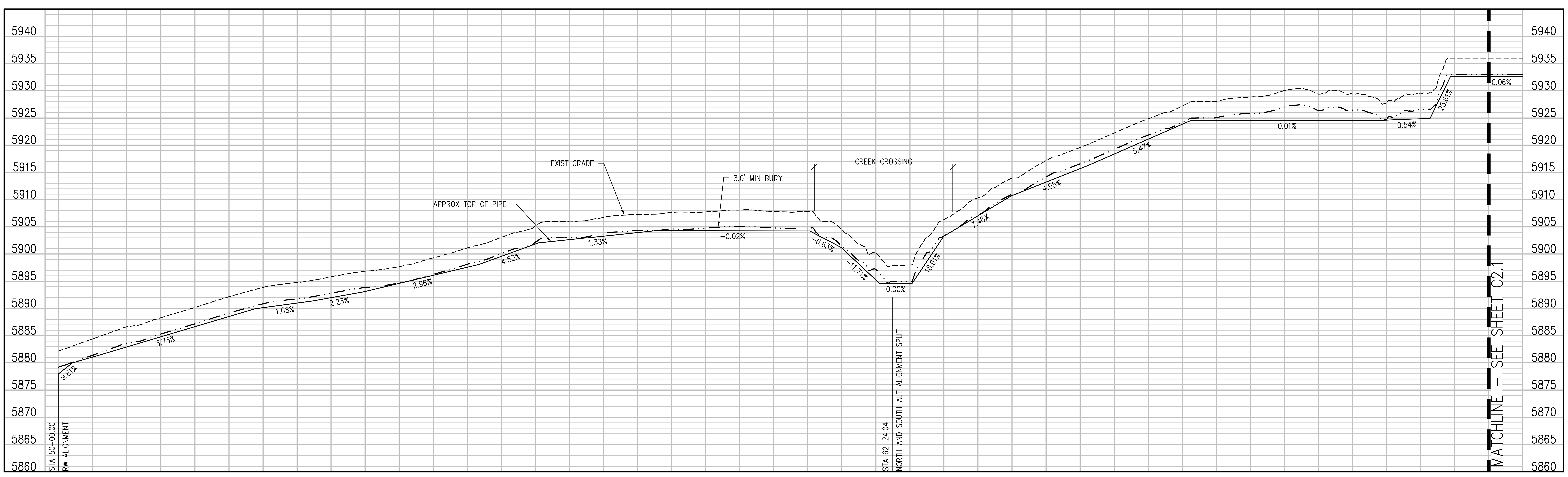
CITY OF Grand Junction COLORADO

PUBLIC WORKS AND PLANNING ENGINEERING DIVISION

2013 WATER LINE REPLACEMENT
SECTION #1 – FLOW LINE PLAN AND PROFILE
STA 15+00 TO STA 20+57.82

8





NORTH ALIGNMENT PROFILE

SCALE: 1"=80' HORIZ
1"=10' VERT

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NO.	DATE	DES'D	DWN	REVISION DESCRIPTION

DESIGNED BY:	LAL
DRAWN BY:	LAL
CHECKED BY:	JJM
JOB #:	1071.11e
DATE:	OCTOBER 2021

CITY OF GRAND JUNCTION
KANNAH CREEK RAW WATERLINE
PRELIMINARY ALIGNMENT ALT ANALYSIS

RAW WATERLINE ALIGNMENT
AND NORTH ALIGNMENT

SHEET NO.

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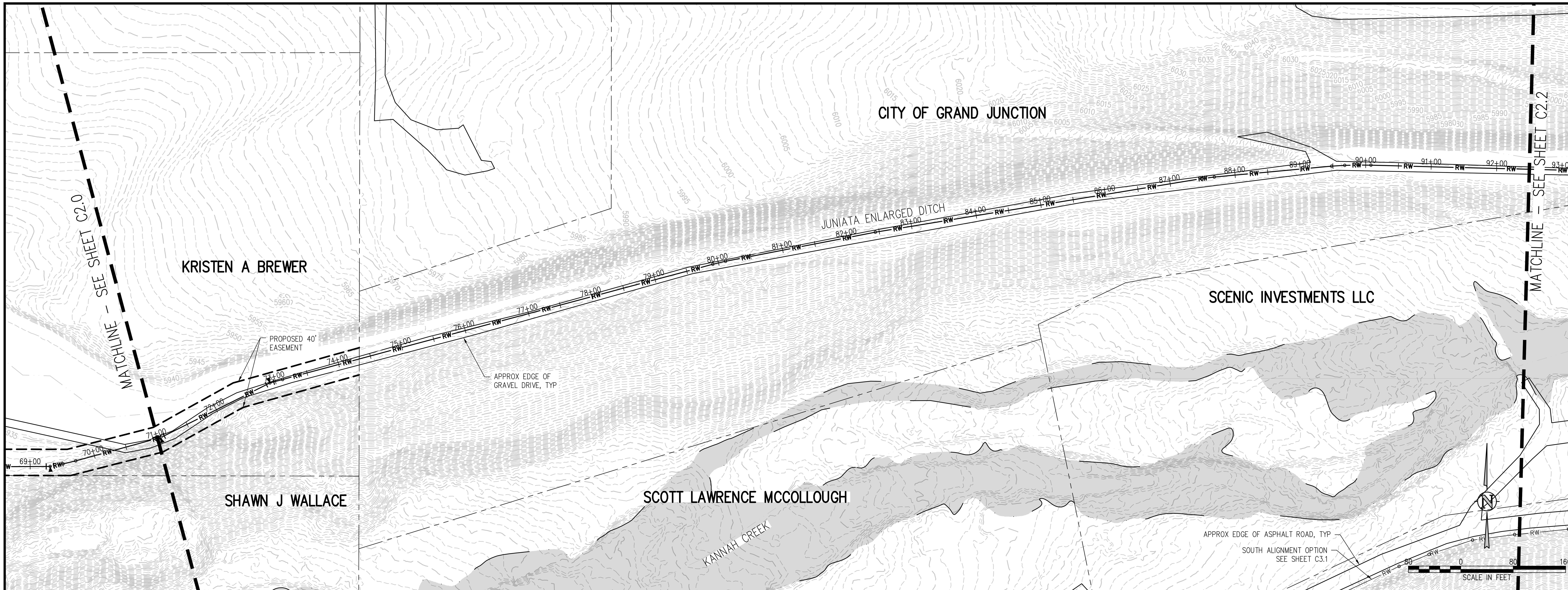

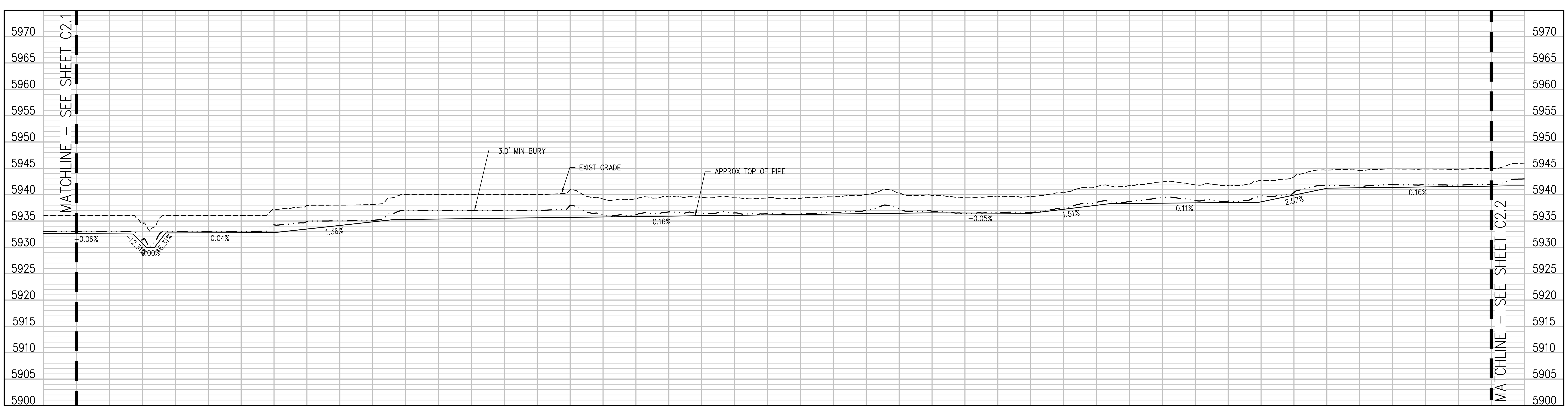

NORTH ALIGNMENT PROFILE

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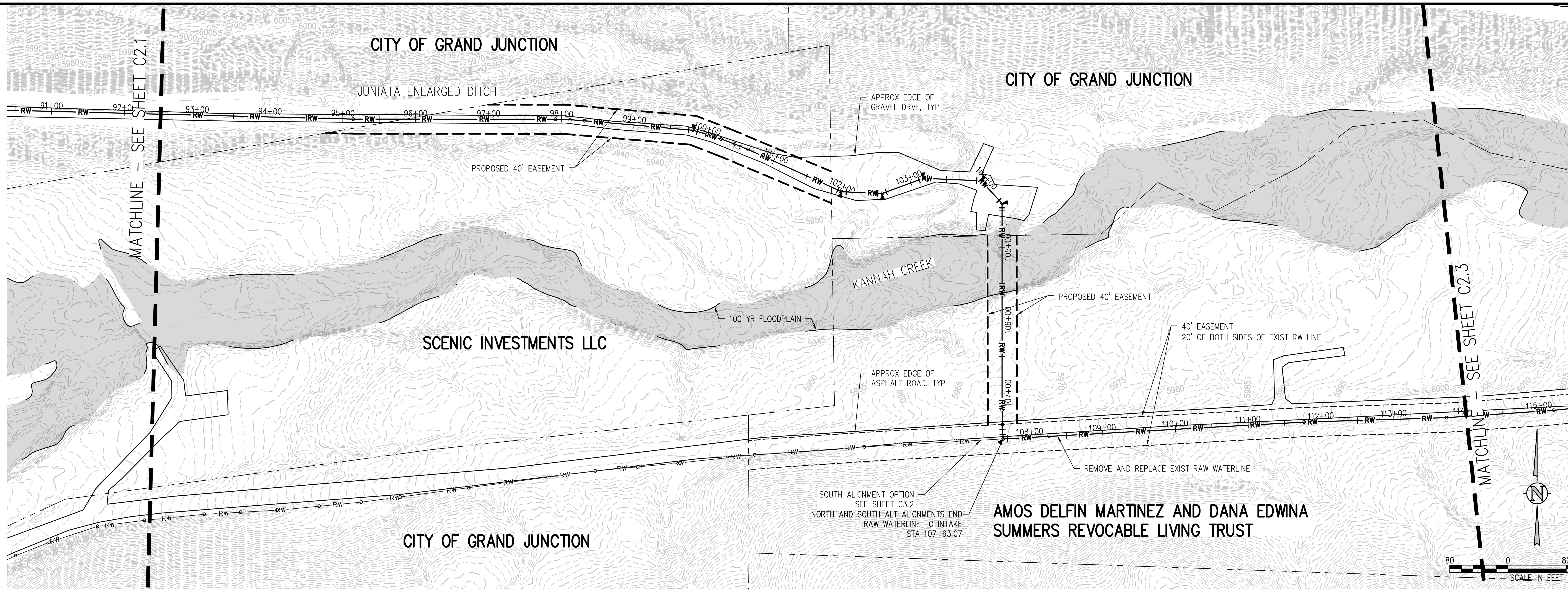
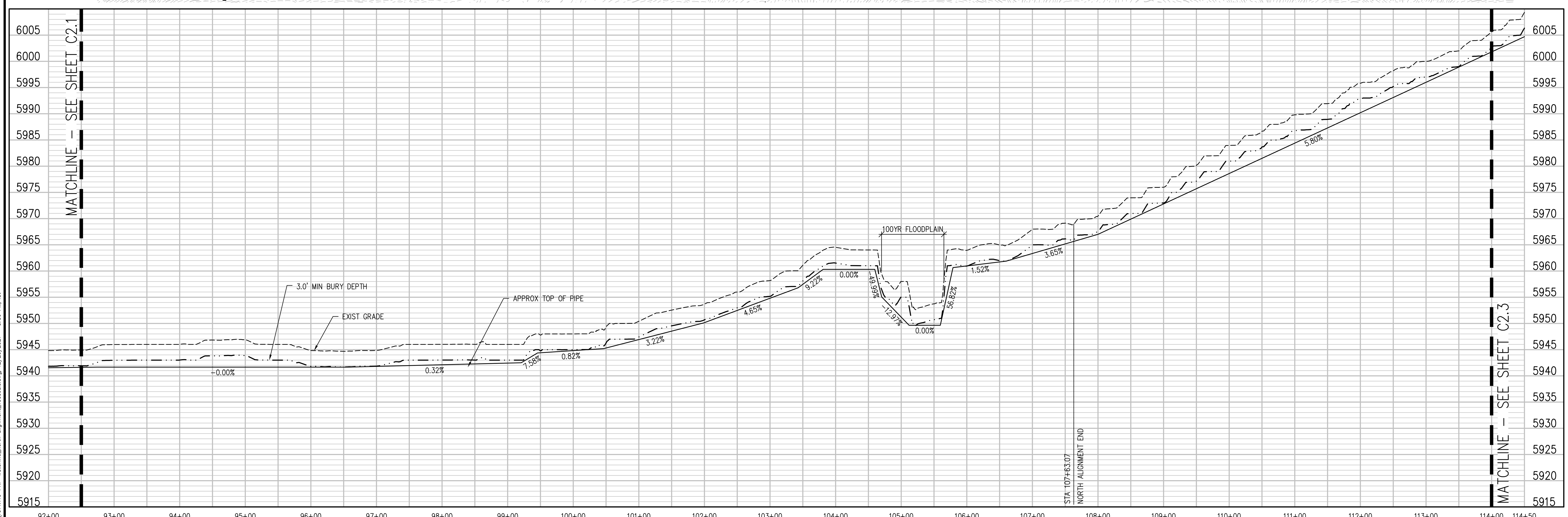
JOB #: 1071.11e
DATE: DECEMBER 2021

CITY OF GRAND JUNCTION
KANNAH CREEK RAW WATERLINE
PRELIMINARY ALIGNMENT ALT ANALYSIS

NORTH ALIGNMENT

SHEET NO.
C2.1





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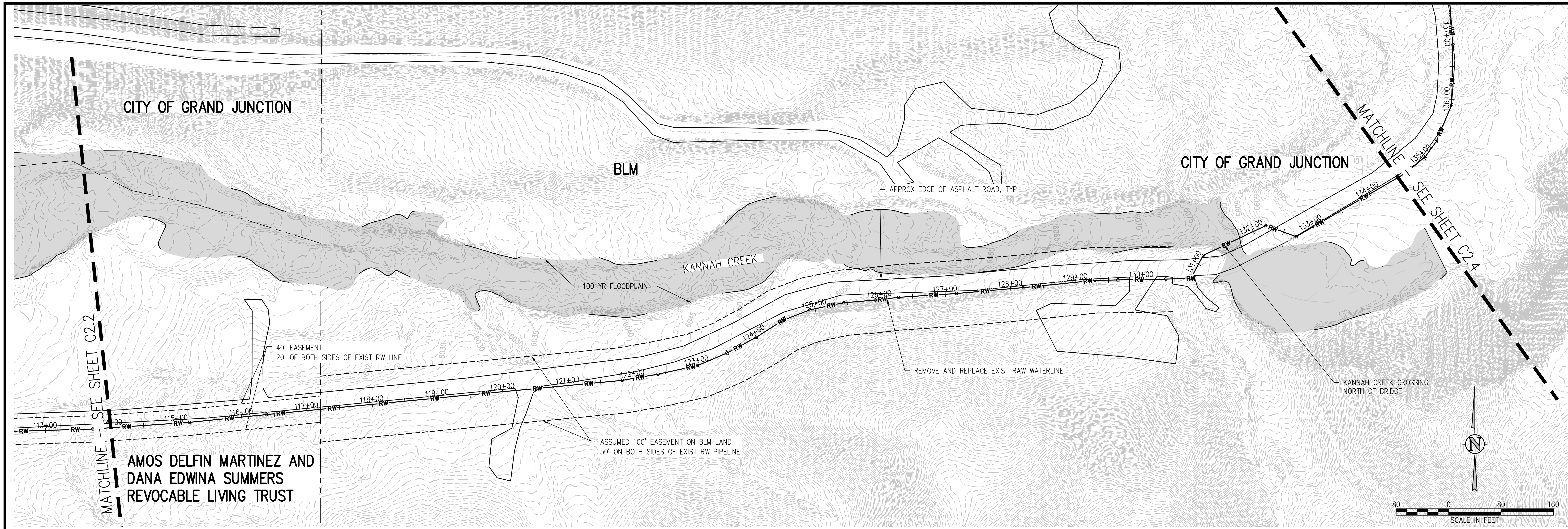
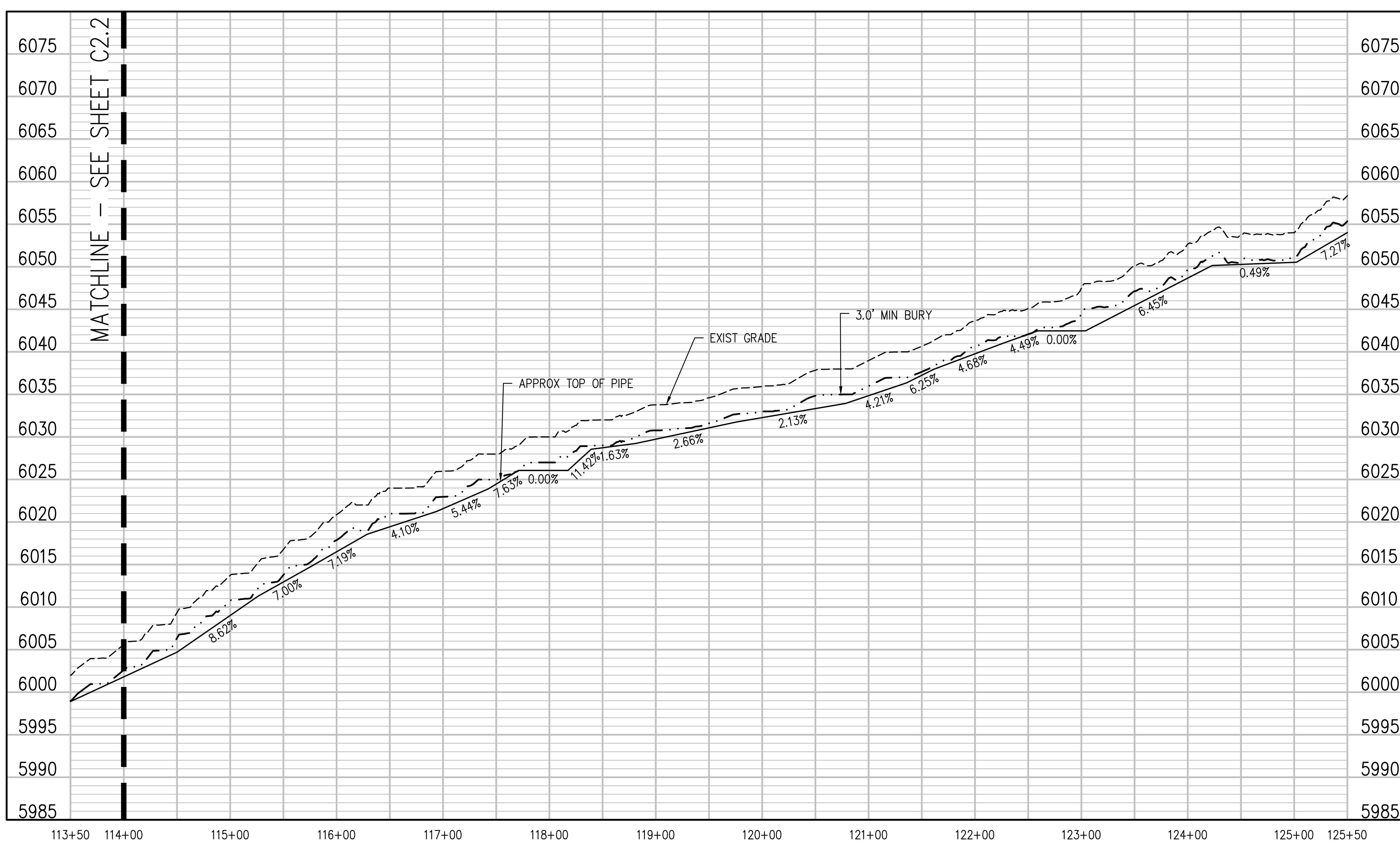
CITY OF GRAND JUNCTION
KANNAH CREEK RAW WATERLINE
PRELIMINARY ALIGNMENT ALT ANALYSIS

NORTH ALIGNMENT
AND RAW WATERLINE TO INTAKE

SHEET NO.
C2.2





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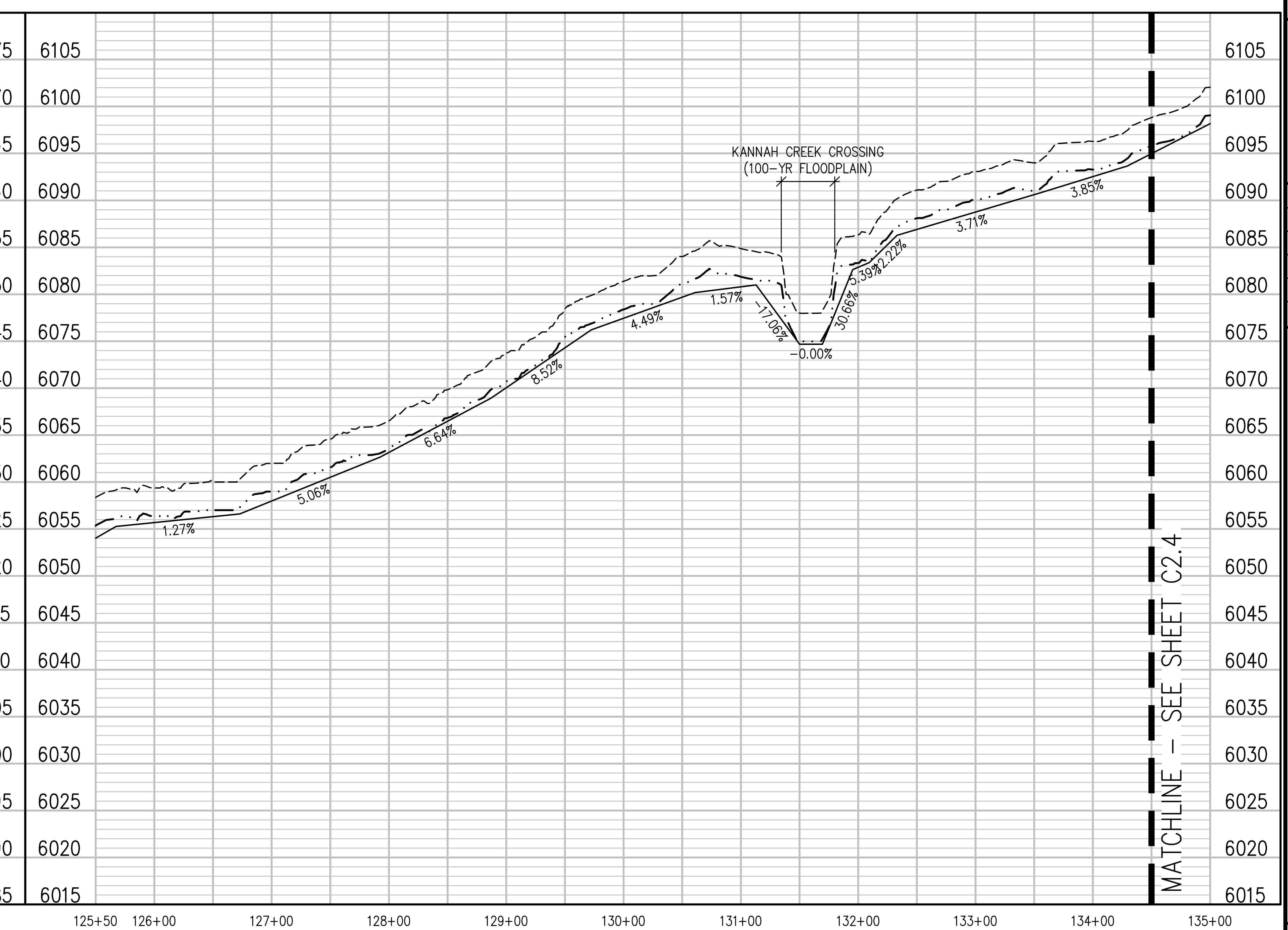

NORTH ALIGNMENT PROFILE

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1"=10' VERT

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CITY OF GRAND JUNCTION
KANNAH CREEK RAW WATERLINE
PRELIMINARY ALIGNMENT ALT ANALYSIS

RAW WATERLINE TO INTAKE

SHEET NO.
C2.3

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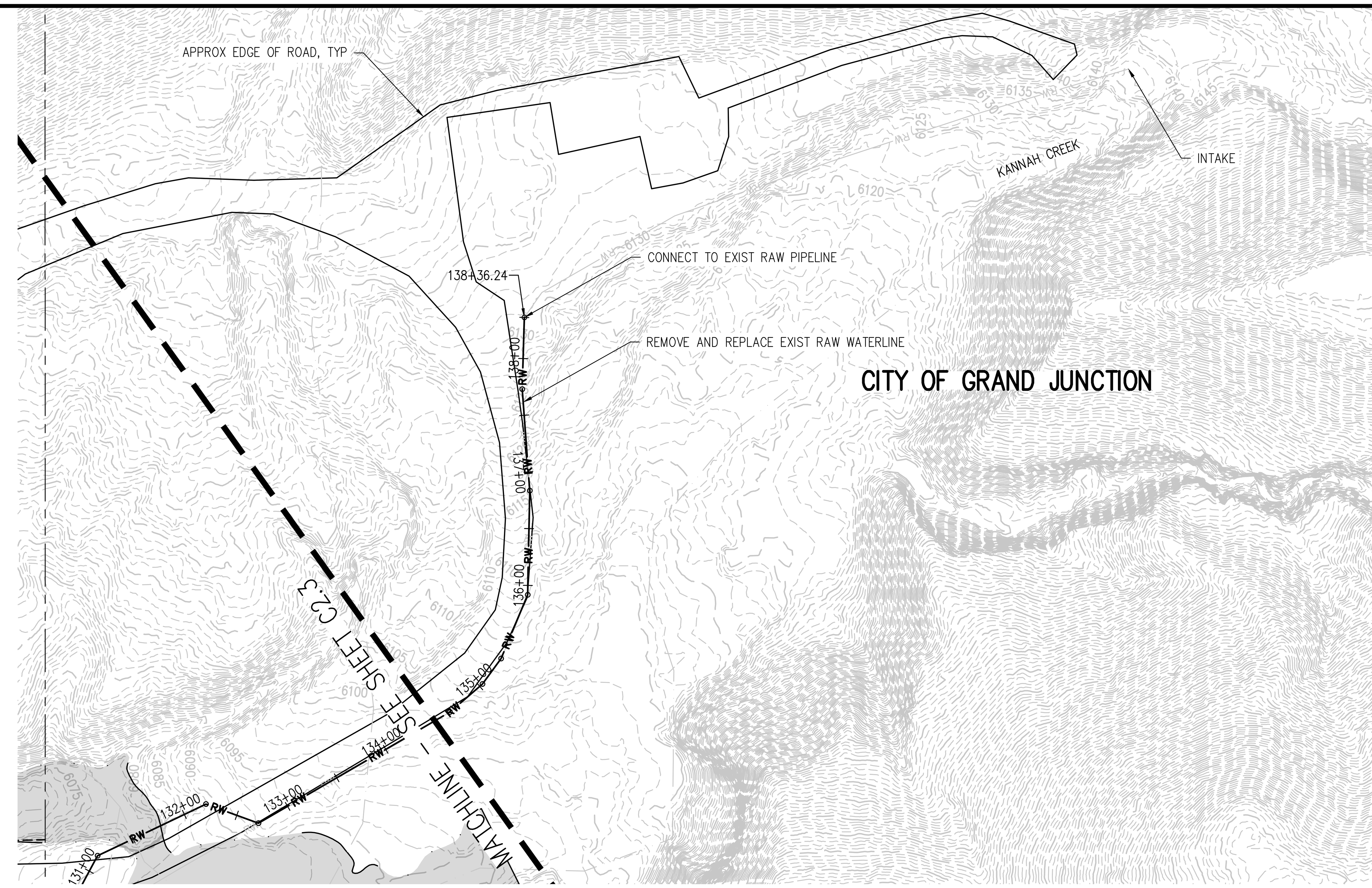

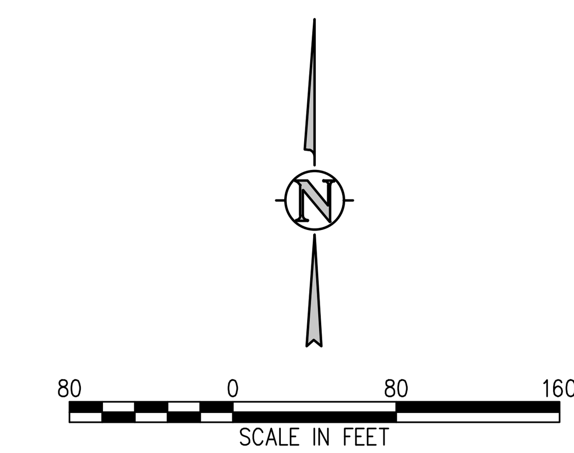

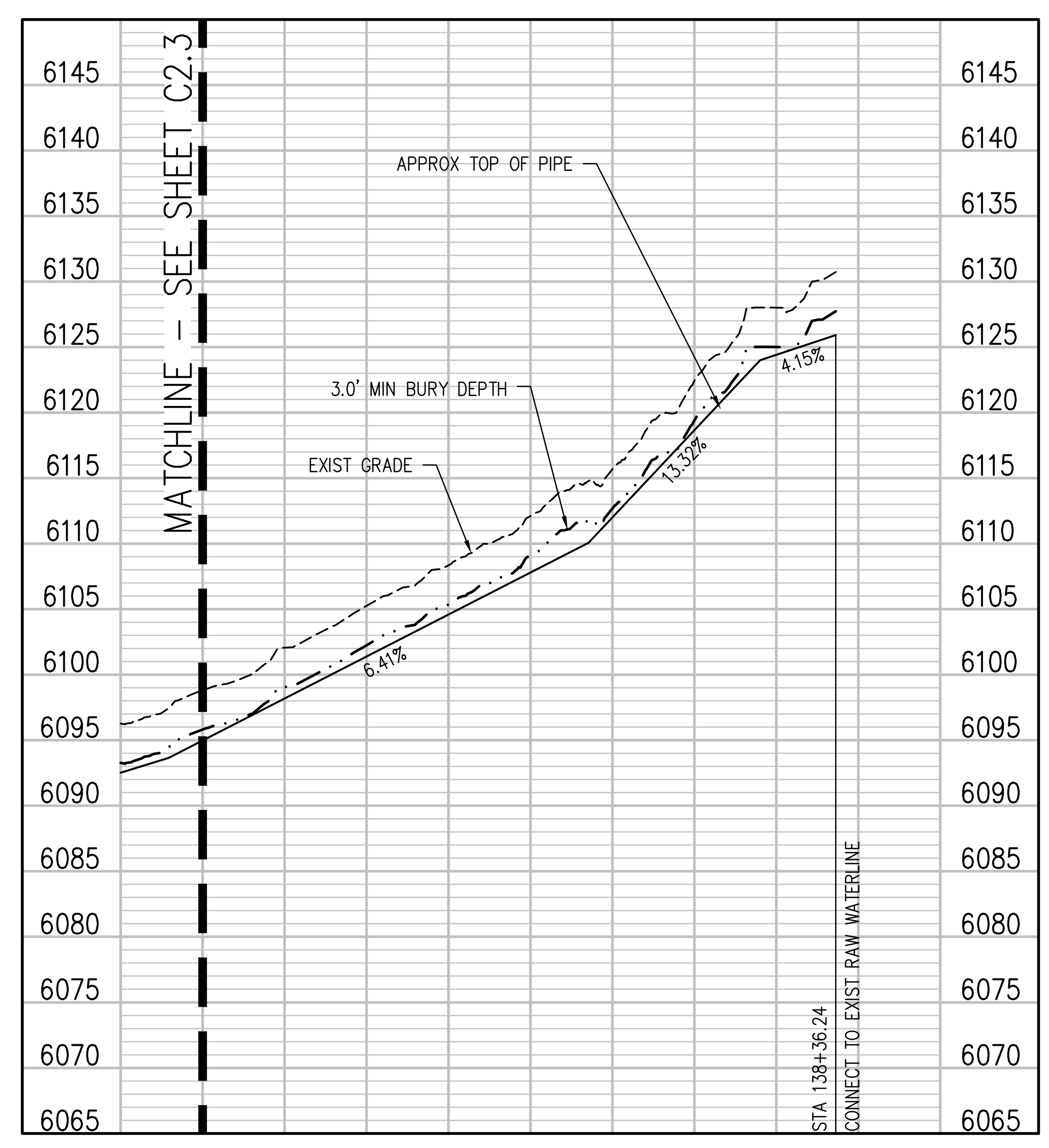

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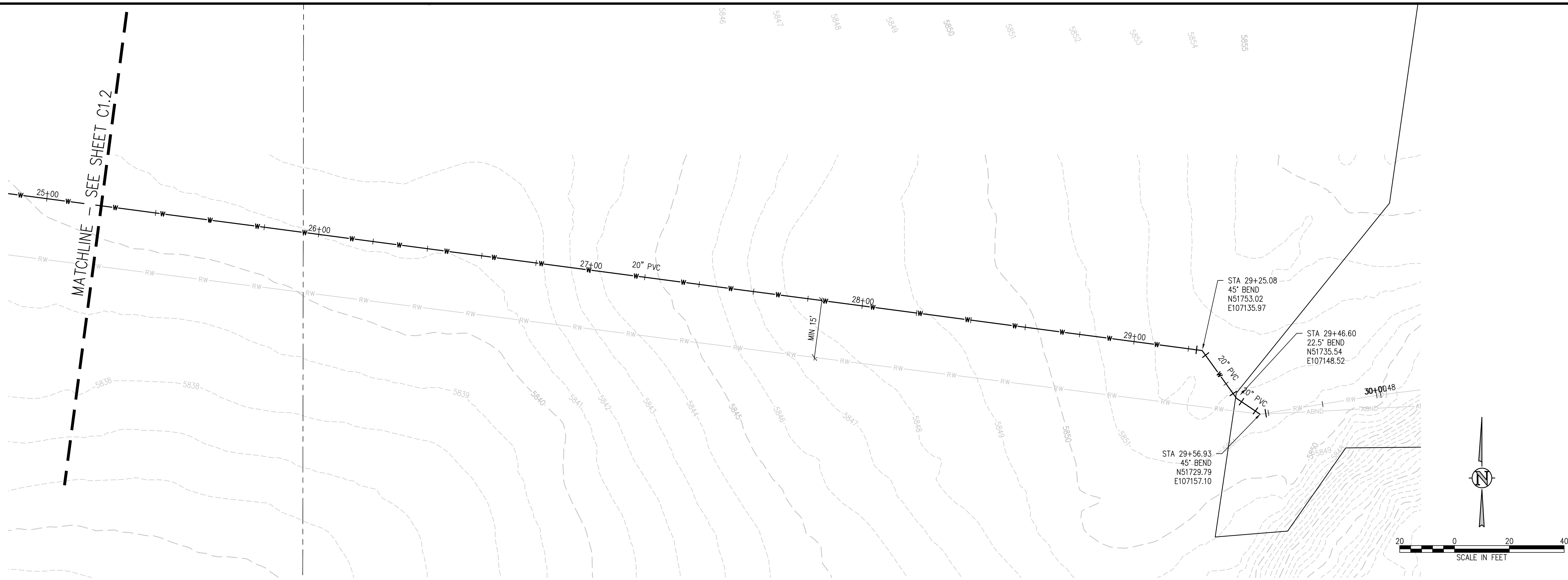
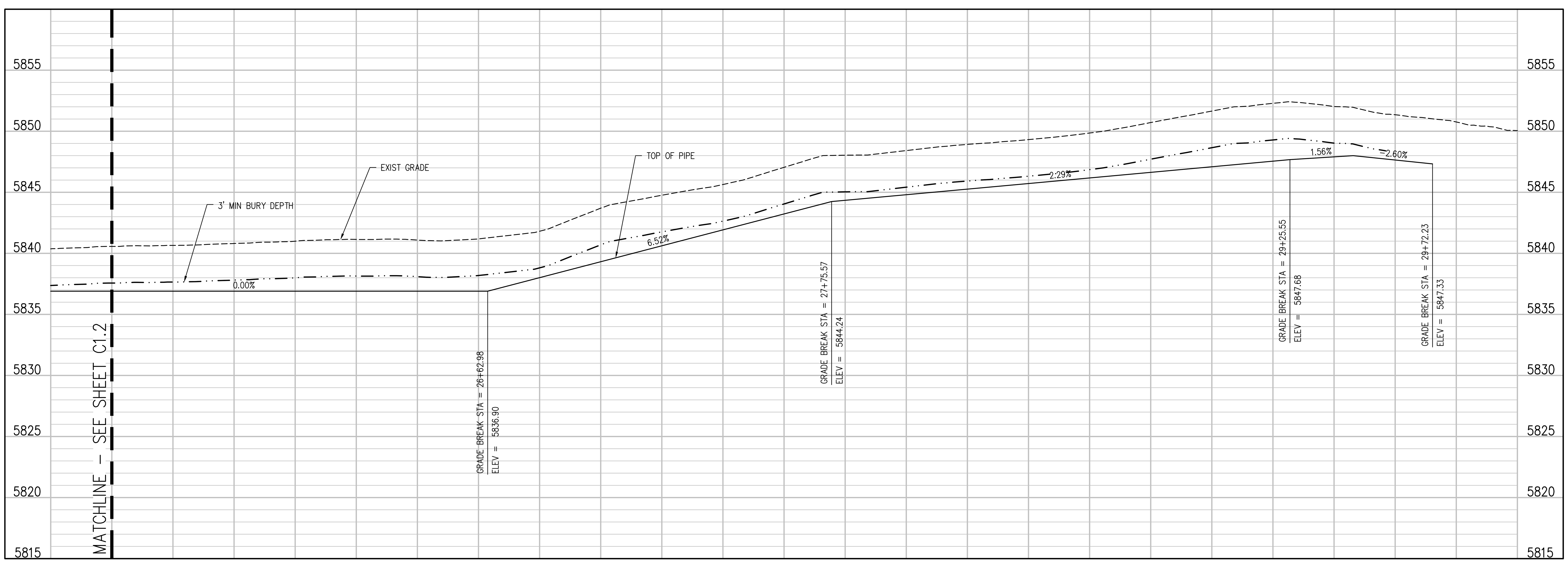
CITY OF GRAND JUNCTION
KANNAH CREEK RAW WATERLINE
PRELIMINARY ALIGNMENT ALT ANALYSIS

RAW WATERLINE TO INTAKE

SHEET NO.
C2.4





WATERLINE 20+00 to 30+00 PROFILE

SCALE: 1"=20' HORIZ
1"=5' VERT

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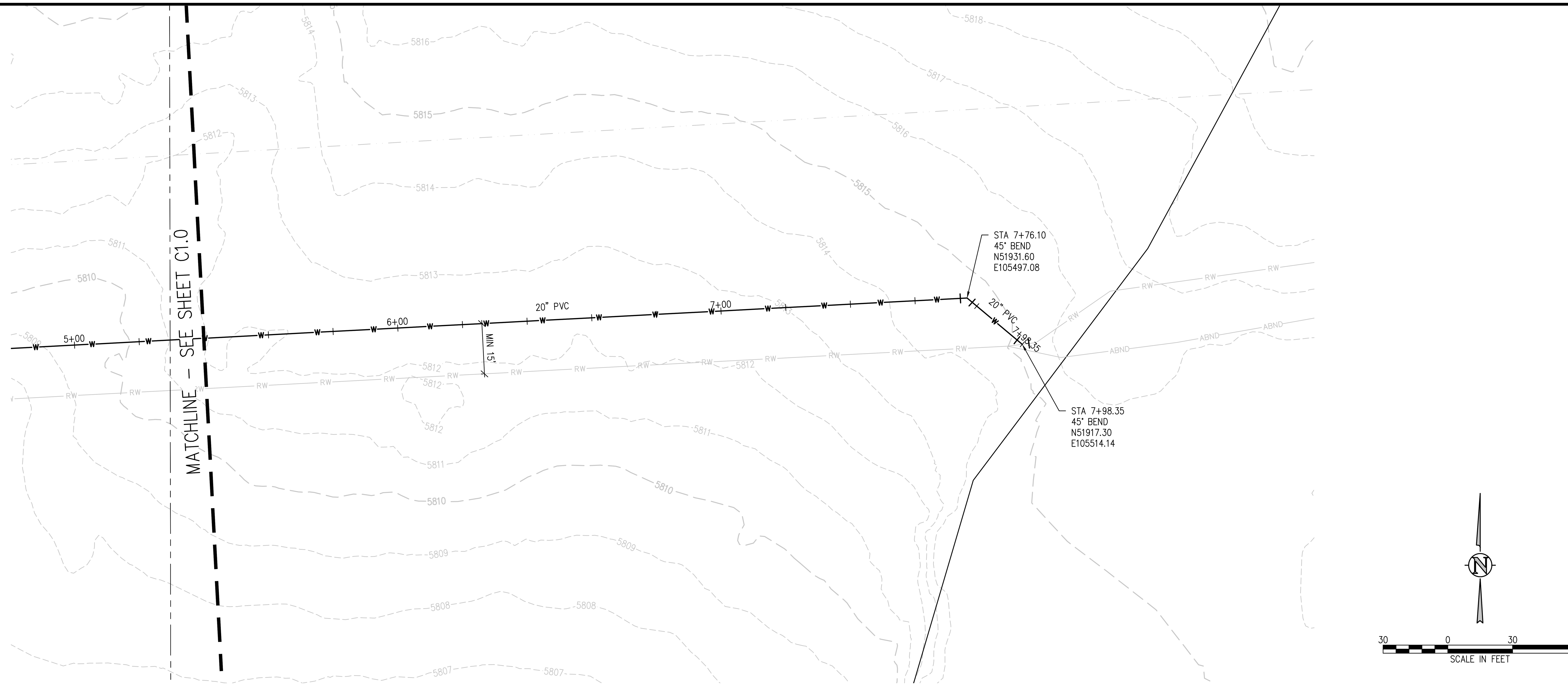
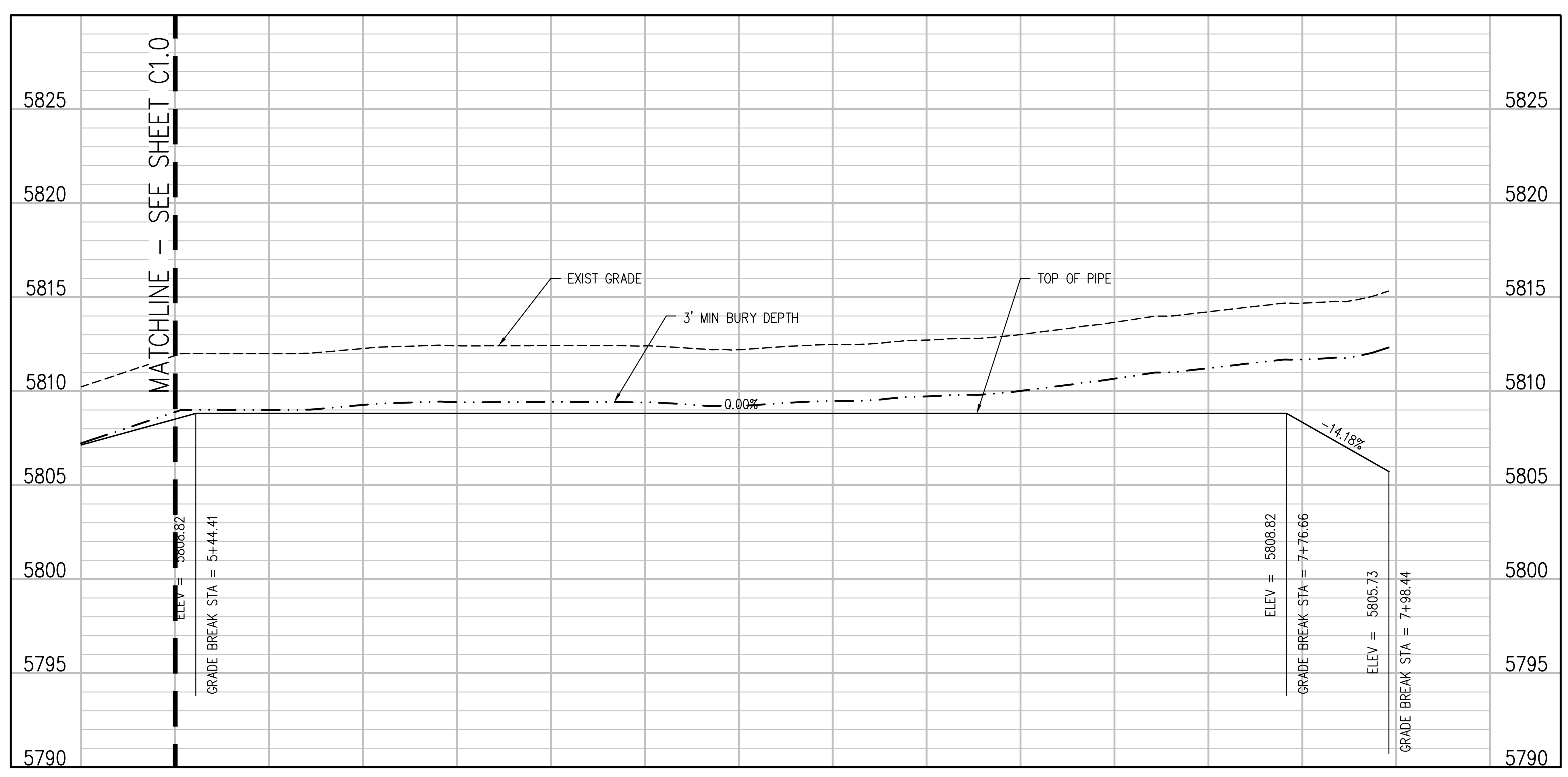
CITY OF GRAND JUNCTION
KANNAH CREEK RAW WATERLINE
PRELIMINARY ALIGNMENT ALT ANALYSIS

WATERLINE 20+00 TO 30+00
PLAN AND PROFILE

SHEET NO.
C1.3





WATERLINE 00+00 to 10+00 PROFILE

SCALE: 1"=20' HORIZ
1"=5' VERT

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CITY OF GRAND JUNCTION
KANNAH CREEK RAW WATERLINE
PRELIMINARY ALIGNMENT ALT ANALYSIS

WATERLINE 00+00 TO 10+00
PLAN AND PROFILE

SHEET NO.
C1.1

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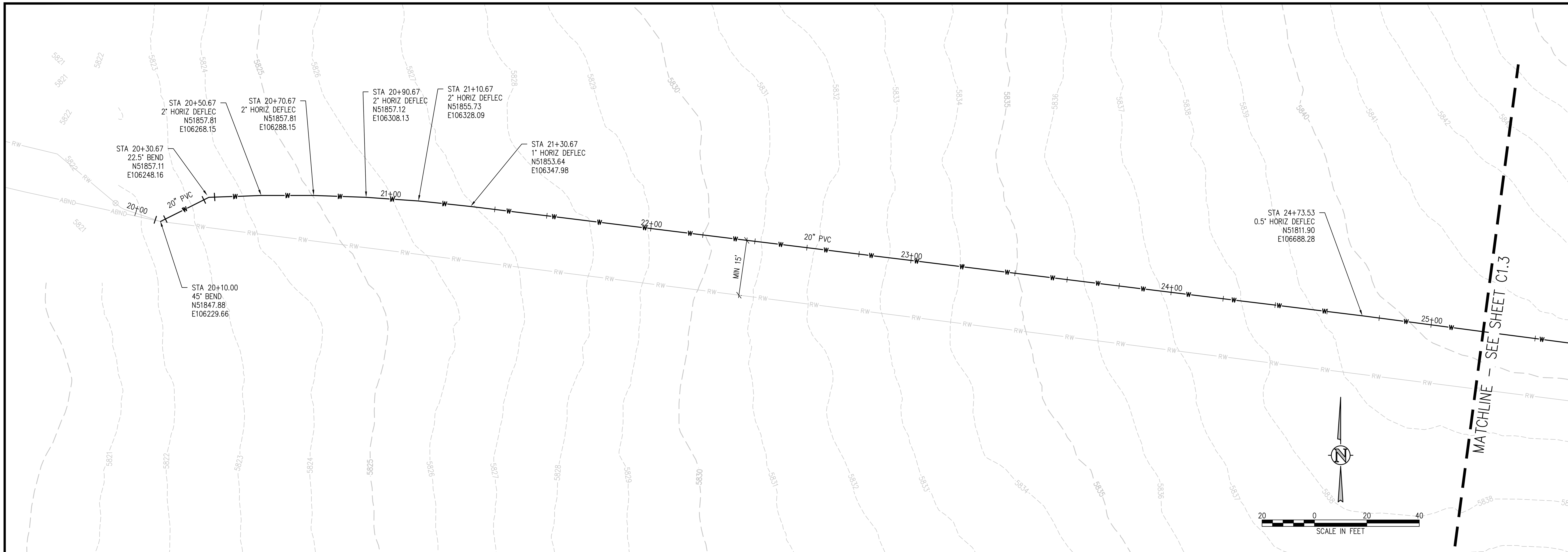

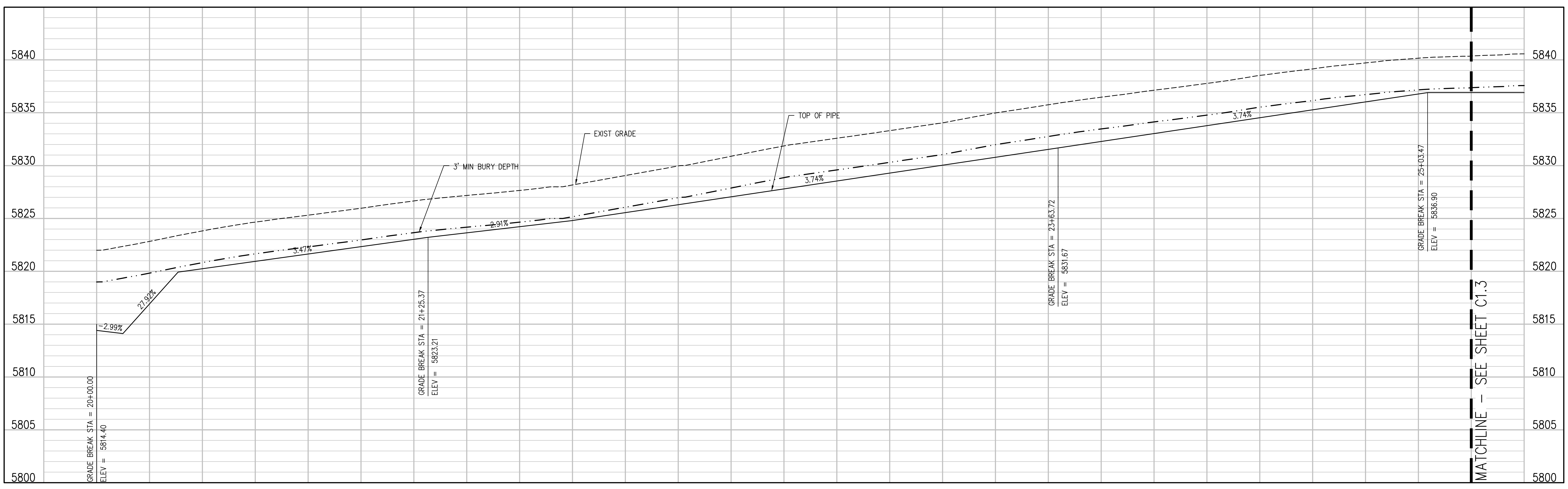

WATERLINE 20+00 to 30+00 PROFILE

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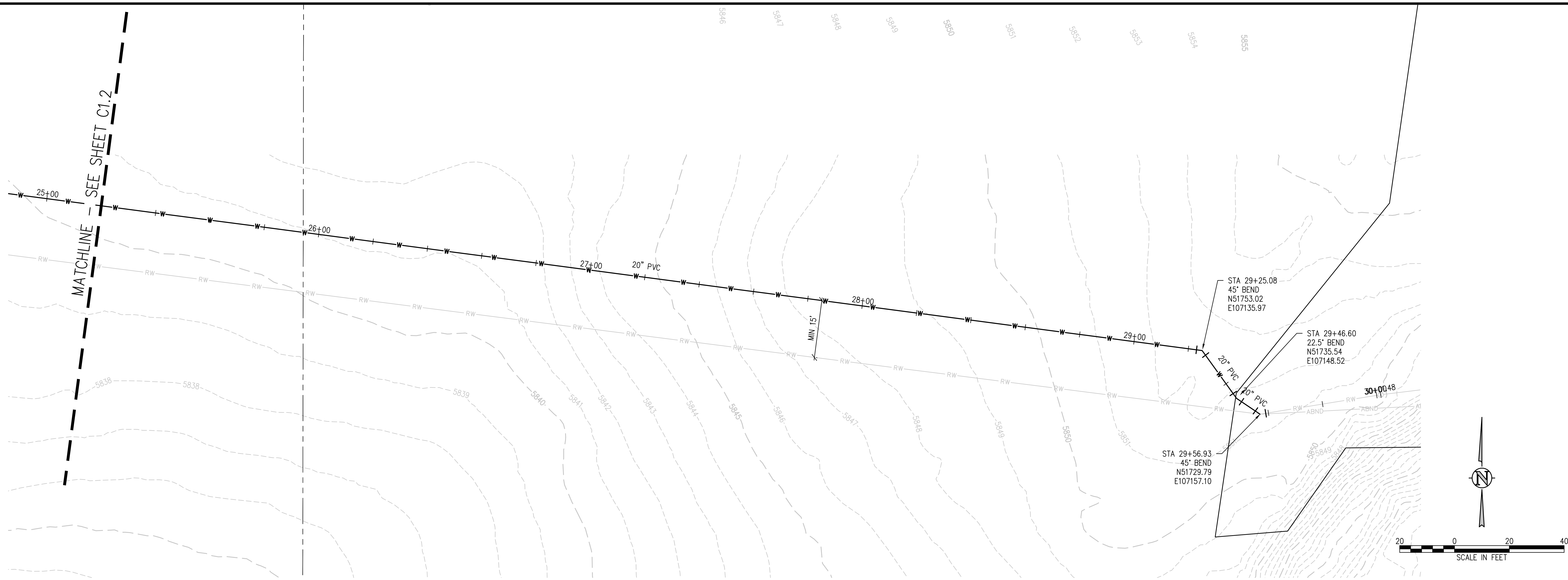
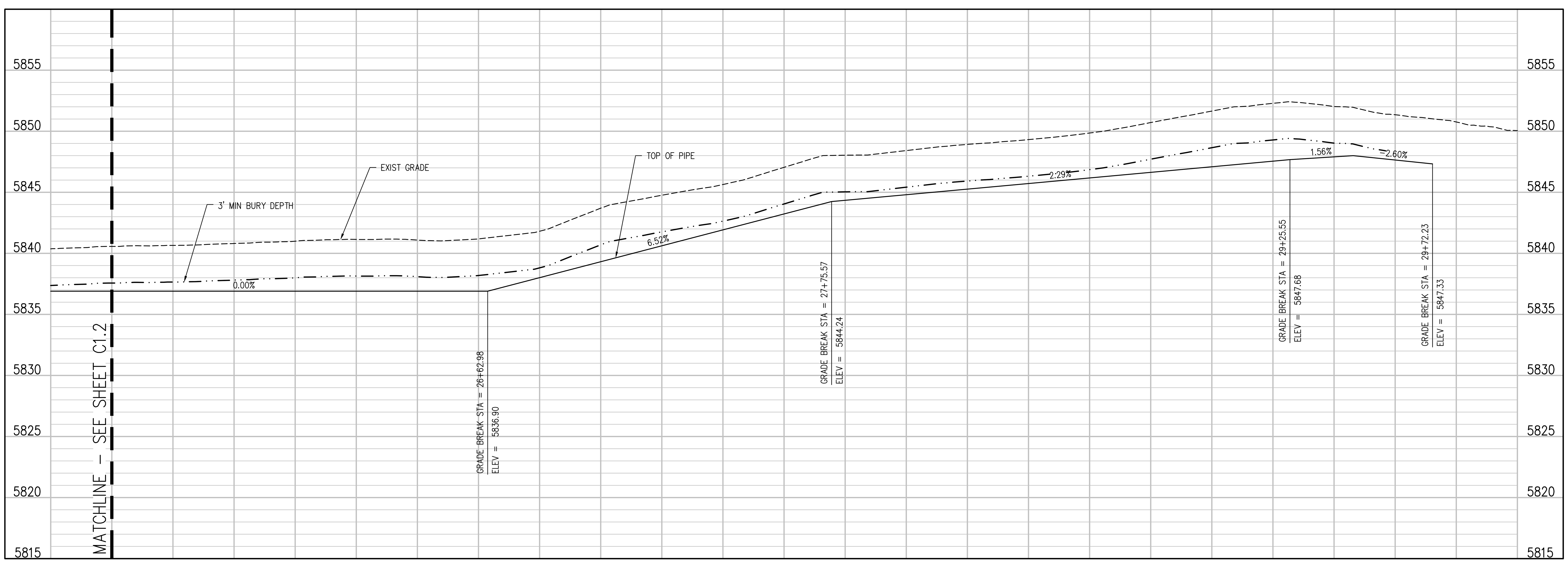
CITY OF GRAND JUNCTION
KANNAH CREEK RAW WATERLINE
PRELIMINARY ALIGNMENT ALT ANALYSIS

WATERLINE 20+00 TO 30+00
PLAN AND PROFILE

SHEET NO.
C1.2





WATERLINE 20+00 to 30+00 PROFILE

SCALE: 1"=20' HORIZ
1"=5' VERT

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CITY OF GRAND JUNCTION
KANNAH CREEK RAW WATERLINE
PRELIMINARY ALIGNMENT ALT ANALYSIS

WATERLINE 20+00 TO 30+00
PLAN AND PROFILE

SHEET NO.
C1.3

CITY OF GRAND JUNCTION, COLORADO

RESOLUTION NO. 96-21

A RESOLUTION ADOPTING RATES, FEES, AND CHARGES FOR WATER, WASTEWATER AND SOLID WASTE UTILITIES

Recitals:

The City of Grand Junction establishes rates, fees, and charges for Water, Wastewater, and Solid Waste services, and by this resolution, the City Council establishes these rates, fees, and charges to implement decisions made in the long-term financial plans.

Now, therefore, be it resolved that:

Effective January 1, 2022, rates for Water, Wastewater, and Solid Waste utility services change according to the following schedule:

Water Rates			
City Water System Monthly Service Charge	**2021**	**2022 Proposed**	**Change**
0 - 3,000 Gallons	$ 20.94	$ 21.34	$ 0.40
3,000 – 10,000 Gallons (per 1,000)	$ 3.24	$ 3.47	$ 0.23
10,000 - 20,000 Gallons (per 1,000)	$ 3.84	$ 4.11	$ 0.27
> 20,000 Gallons (per 1,000)	$ 4.48	$ 4.79	$ 0.31
Kannah Creek Water System			
0 - 3,000 Gallons	$ 47.15	$ 48.09	$ 0.94
3,000 – 10,000 Gallons (per 1,000)	$ 5.00	$ 5.35	$ 0.35
10,000 – 20,000 Gallons (per 1,000)	$ 6.15	$ 6.58	$ 0.43
> 20,000 Gallons (per 1,000)	$ 7.15	$ 7.65	$ 0.50
City & Kannah Creek Water System			
Administrative Fees			
Availability Fee (Monthly)	$ 14.10	$ 14.38	$ 0.28
Ridges Irrigation System			
Single Family	$ 19.72	$ 20.71	$ 0.99
Multiple Family (per unit)	$ 14.11	$ 14.82	$ 0.71
Bulk Water (Fill Stations)			
Per 1,000 Gallons	$ 7.80	$ 8.20	$ 0.40

Wastewater Rates			
201 Sewer System	**2021**	**2022 Proposed**	**Change**
Monthly Service Charge	$ 22.85	$ 23.31	$ 0.46

Wastewater Fees			
Description	2021	2022 Proposed	Change
Plant Investment Fee	$ 5,067.00	$ 5,219.00	$ 152.00
Trunk Line Extension Fee			
Developer			
1 unit/acre	$ 1,332.00	$ 1,359.00	$ 27.00
>1-3 units/acre	$ 1,200.00	$ 1,224.00	$ 24.00
>3 units/acre	$ 888.00	$ 906.00	$ 18.00
Builder			
1 unit/acre	$ 3,108.00	$ 3,170.00	$ 62.00
>1-3 units/acre	$ 2,662.00	$ 2,715.00	$ 53.00
>3 units/acre	$ 1,775.00	$ 1,811.00	$ 36.00

Solid Waste Rates			
Automated Monthly Container Prices	2021	2022 Proposed	Change
1-64 Gallon Container	$ 13.00	$ 13.25	$ .25
1-96 Gallon Container	$ 18.00	$ 18.25	$ .25
2-64 Gallon Container	$ 22.00	$ 22.55	$ .55
1-64, 1-96 Gallon Container	$ 26.00	$ 26.65	$ .65
2-96 Gallon Container	$ 30.00	$ 30.75	$ .75
Commercial Monthly Dumpster Prices			
1-2 Cubic Yard - Pick-Up 1 Time Per Week	$ 74.38	$ 74.38	$ 1.62
1-4 Cubic Yard - Pick-Up 1 Time Per Week	$ 120.48	$ 123.25	$ 2.77
1-6 Cubic Yard - Pick-Up 1 Time Per Week	$ 163.01	$ 167.00	$ 3.99
1-8 Cubic Yard - Pick-Up 1 Time Per Week	$ 205.01	$ 210.00	$ 4.99

PASSED and ADOPTED this 1st day of December 2021.

President of the Council

CITY OF GRAND JUNCTION COLORADO

Attest:

City Clerk