DESIGN ANALYSIS REPORT FOR

PUEBLO ALTO / MILE HI GSI PHASE IIIA

60% DESIGN SUBMITTAL

DRAFT

JULY 22, 2024

Prepared for:

Prepared by:

Bohannan Huston

DESIGN ANALYSIS REPORT

FOR

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Prepared for:

CITY OF ALBUQUERQUE DEPARTMENT OF MUNICIPAL DEVELOPMENT

ONE CIVIC PLAZA, ROOM 7057

ALBUQUERQUE, NM 87102

Prepared by:

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

This design analysis report presents the results of the hydrologic and hydraulic analysis of the Pueblo Alto and Mile Hi neighborhoods. The analysis was performed using a combined hydrologic and hydraulic (H & H) two-dimensional rain-on-grid model covering the subject neighborhoods. Off-site flows were included for the existing conditions analysis based on the results of previous studies completed for the area. Based on the assumption of future upstream drainage infrastructure improvements, a future conditions analysis that did not include offsite flows was also simulated. For existing and future conditions, the 2-, 10-, and 100-year return events were analyzed.

Results of the analyses were used to inform the 60% design of green stormwater infrastructure (GSI) and drainage improvements as pilot projects for the area. Proposed project elements include upsized storm drain, underground storage systems, and stormwater bumpouts. The project locations and layouts were based on maximizing available space within the City of Albuquerque's rights-of-way. No design storm is applicable for this project as the purpose, from a stormwater quality perspective, is to maximize the storage volume and infiltration capacity with various stormwater solutions as a pilot project. The proposed improvements were incorporated into the analysis to determine the anticipated level of flood reduction.

1 INTRODUCTION

Bohannan Huston, Inc. (BHI) was initially contracted by the City of Albuquerque (COA) to conceptually design green stormwater infrastructure (GSI) improvements in pilot project areas in the Pueblo Alto and Mile Hi neighborhoods of Albuquerque ("study area") (Figure 1). The Design Analysis Report (DAR) for the Conceptual Design phase was submitted to COA on December 8, 2023. Based on the results of that phase, BHI was subsequently contracted for the final design of the Pilot Projects (Phase IIIA). This report is substantially based on the previously submitted DAR with updates made where necessary to reflect changes from the Conceptual Design phase to Phase IIIA.

1.1 PHASE IIIA

Based on the findings of the Conceptual Design phase, it was determined, with input from COA, to progress the design of two pilot project areas. A feasibility assessment completed in the Conceptual Design phase included community outreach, analysis of subsurface soil conditions, and maintenance considerations for improvements. Outcomes from that feasibility assessment further informed the design elements included for Phase IIIA. The improvements selected for pilot project areas are:

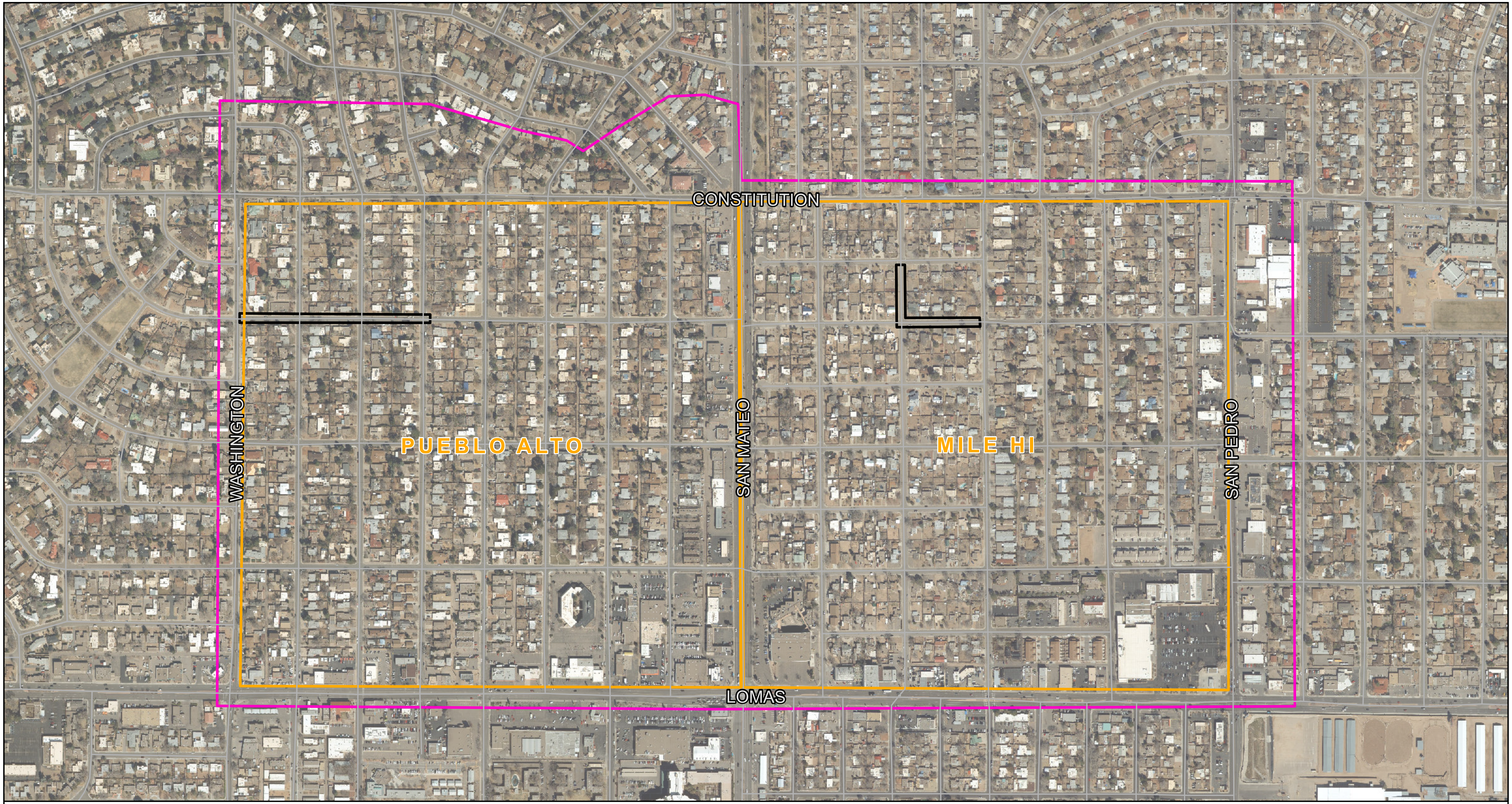
- In Pueblo Alto: on Summer Avenue (from Washington to Madison)
- In Mile Hi: on La Veta Drive (from Summer to El Encanto) and on Summer Avenue (from La Veta to Alvarado)

The design goals, as developed at the direction of COA for the pilot project areas, are not based on meeting design storm criteria but are based on maximizing storage in the project footprints and optimizing flood reduction benefits achievable from those storage facilities. Due to the limited project footprints, the flood reduction benefits are primarily realized in smaller/more frequent return events. Therefore, in alignment with these project goals, the 2- and 10-year return events were included in the analysis. The 100-year event was also included to demonstrate no adverse impacts from the project on the typical design event.

Analysis for supporting the design of the pilot projects was based on a combined hydrologic and hydraulic (H&H) two-dimensional (2D) rain-on-grid model with limits covering both neighborhoods.

The study area has historical flooding issues resulting from both local topography and inadequate drainage infrastructure. The topography of the neighborhood forces water to collect in streets and increase in depth until the curb is overtopped and private yards are flooded. Storm drains and inlets throughout the neighborhood do not have sufficient capacity to convey stormwater flows from major events away from these low areas. Additionally in the Mile Hi neighborhood, upstream runoff from the neighborhoods east of San Pedro Drive flows in the streets from east to west combining with local flows to cause significant flooding issues in the northwest quadrant of the neighborhood in the vicinity of the proposed project location.

This report summarizes the approach used to perform the H&H analyses, results of the analyses, elements and considerations of the design, and resulting impact of the proposed projects. The analysis required to evaluate the existing problem areas served as the basis for evaluating proposed solutions to be designed.



2D Model Extent
Neighborhood
Phase IIIA Project Area

N

0 250 500 1,000 Feet
1 in = 500 ft

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GSI Phase IIIA
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Figure 1
Phase IIIA Project Area

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Author: rburkhard

June 2024

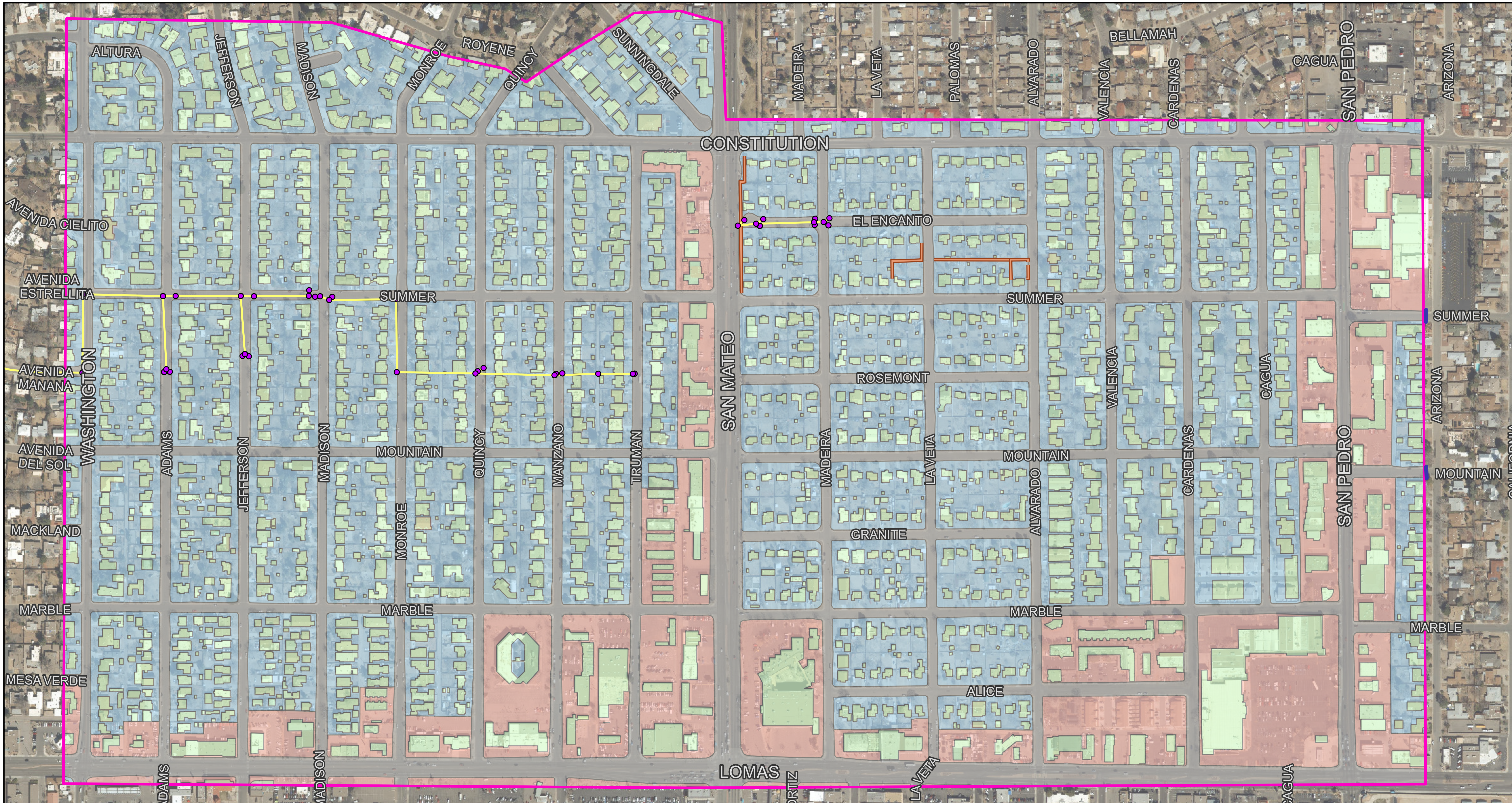
2 HYDROLOGIC AND HYDRAULIC ANALYSIS

A 2D rain-on-grid hydraulic model was developed for the area of interest using Autodesk InfoWorks ICM (v. 2024.2 Ultimate). The area of interest covers both the Mile Hi and Pueblo Alto neighborhoods. Based on the topography, the model limits were delineated beyond the neighborhood areas to capture flow paths entering and leaving the area of interest. This model used a combined approach for H&H analysis by simulating overland and storm drain flows for runoff resulting from precipitation falling on the modeling domain as well as inflows from beyond the study area. Four different analysis scenarios were included:

- **Existing Conditions**
  - Includes external inflow hydrographs further discussed in Section 2.1.5.
- **Future Conditions, No GSI Improvements**
  - Assumes future regional storage and/or storm drain improvements are constructed upstream of study area, so no external inflow hydrographs are included.
- **Proposed Conditions**
  - Includes external inflow hydrographs further discussed in Section 2.1.5.
  - Includes proposed improvements further discussed in Section 3.
- **Future Conditions, With GSI Improvements**
  - Assumes future regional storage and/or storm drain improvements are constructed upstream of study area, so no external inflow hydrographs are included.
  - Includes proposed improvements further discussed in Section 3.

2.1 MODEL INPUTS

The types of input data required for the modeled simulations are topographic data, a computational mesh, land cover areas for both H&H parameters, precipitation intensity hyetographs, inflow hydrographs, storm drain network elements, boundary conditions, and simulation parameter controls. Modeling inputs required for the analysis were delineated within the modeling domain as shown in Figure 2. The modeling inputs shown were maintained for the proposed conditions analysis with the addition of infiltration zones, mesh level zones, and storm drain network elements as discussed in Section 4.



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- Existing Node
- Existing Conduit
- Wall
- External Boundary Condition
- 2D Model Extent

Land Cover Categories
- Building Footprint
- Commercial
- Residential
- Road/Sidewalk

N

0 200 400 800 Feet

1 in = 400 ft

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Figure 2
Model Inputs

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2.1.1 TOPOGRAPHIC DATA

The basis of the 2D model is topographic data used to represent the underlying terrain. A bare earth digital elevation model (DEM) was obtained from the Mid-Region Council of Governments (MRCOG) 2018 Light Detecting and Ranging (LiDAR) project for the model basis. The data is reported to meet US Geological Survey Quality Level 2 (QL2), which has a vertical accuracy requirement of 10 cm and supports a DEM cell size of 1 m. The MRCOG 2018 dataset has known accuracy issues that vary throughout the region. To verify the accuracy within the study area, BHI performed a series of checks between the data and 39 surveyed control points. The results of those checks verify that the portion of the DEM within the study area meets QL2 requirements.

2.1.2 COMPUTATIONAL MESH

The 2D modeling domain covers the two neighborhoods between San Pedro Drive and Washington Street from east to west, and between Lomas Boulevard and Constitution Avenue from south to north. The total modeling domain is approximately 400 acres. Within the defined domain, InfoWorks ICM creates a mesh that consists of a network of triangles as defined by a minimum/maximum triangle size as well as an optional maximum height difference across individual triangles. The elevation of each triangle vertex is defined by the point at which it is spatially referenced to the DEM so that the mesh approximates the underlying terrain by representation at the triangle vertices.

The maximum triangle area used throughout the modeling domain is 300 square feet. This produced triangles with approximately 25-foot sides. To capture greater detail where required in the proposed project locations and in the street/sidewalk corridors, a maximum triangle area of 50 square feet was used. This produced triangles with approximately 10-foot sides. Additionally, breaklines were delineated at the gutter line, based on the DEM, and were used in the mesh generation to force one edge of the triangle to follow the gutter line. This resulted in a triangle face alignment with the gutter line, which better represents hydraulic conditions controlled by the curb and gutter throughout the study area.

Walls were generally not included in the computational mesh. This approach is conservative as it allows for more flows to reach streets and downstream areas, whereas including walls would retain flows to backyards. However, based on field review of modeling results, several private/backyard walls in the Mile Hi neighborhood and the wall alongside the east side of San Mateo Boulevard between Summer Avenue and Constitution Avenue were included. These walls were observed to be made of impermeable materials (i.e., cinderblock without turned blocks at the bottom to pass flows) and would re-direct/detain surface runoff. There are other impermeable walls in the neighborhood that were not included in the model, as based on preliminary modeling results, since they would not significantly obstruct or re-direct primary flow paths. Within the computational mesh, a line feature represents these walls and hydraulically controls overland flows so that no flow will pass through that location until flooding depths reach 3-feet. This depth was set based on engineering judgement and the assumption that the walls are not designed to detain significant depths of water. When flooding depths along the wall exceed 3-feet, the model assumes that the wall has failed, and it is removed from the simulation.

Building footprints from the COA 2012 dataset were used to represent building features within the model. Buildings were raised in the computational mesh by an elevation of 4-feet above the DEM. This allows for the buildings to obstruct and redirect overland flows, while precipitation that falls on buildings is generated as runoff.

2.1.3 LAND COVER

Bernalillo County parcel data was used as the basis for land cover delineation within the modeling domain. The parcels were merged such that each block was represented by a polygon feature. Each polygon was categorized as either commercial or residential. The space between the parcels was categorized as representative of the combined road and sidewalk area. Manual modifications were made to the polygon boundaries so that the road/sidewalk region is delineated at the back of sidewalk as identified from the 2020 MRCOG aerial imagery. Land cover polygons are shown in Figure 2.

2.1.3.1 *Hydrologic Parameters*

The land cover features are included as Infiltration Zones in the model and were assigned infiltration rates per Chapter 6 of the *COA Development Process Manual* (DPM) (2020). Because building footprints are being independently considered in the model, the percent impervious outlined in the *COA DPM* (2020) Table 6.2.10 were reduced as summarized in Table 1, below. The percent impervious for each category was determined through calculations of building footprints relative to overall area for representative parcels. Based on the percent impervious adjustments, the area weighted infiltration loss rate was calculated assuming that all pervious surfaces are of a condition consistent with the land treatment category “B” described in the *COA DPM* (2020) Table 6.2.9. Category “B” is defined as “Irrigated lawns, parks and golf courses with 0 to 10% slopes. As the area is fully developed there are no pervious, Category “A” areas. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes greater than 10% and less than 20%". The area weighted infiltration loss rate is also summarized in Table 1. Initial abstractions were not accounted for in the hydrologic parameter inputs in the model, as a conservative measure.

Table 1 – Land Cover Categories and Hydrologic Parameters

Category	Percent Impervious	Loss Rate (in/hr)
Residential	25%	0.623
Commercial	80%	0.166
Road/Sidewalk	100%	0.040
Building Footprints	100%	0.040

2.1.3.2 *Hydraulic Parameters*

Flow routing throughout the modeling domain is computed for each computational mesh element with the excess rainfall and external inflows being conveyed between elements. Friction losses are calculated based on the definition of roughness regions. Each roughness region is assigned a Manning's "n" value. The same land cover regions discussed in the previous section were used as the roughness regions and Manning's "n" values were assigned as outlined in Table 2, below.

Table 2 – Land Cover Categories and Hydraulic Parameters

Category	Manning's "n" Value
Residential	0.10
Commercial	0.08
Road/Sidewalk	0.017
Building Footprints	0.017

2.1.4 PRECIPITATION

The 2-, 10-, and 100-year return period, 24-hour duration precipitation events were modeled. The *COA DPM* (2020) prescribes use of the 24-hour duration precipitation (storm) event. No design storm is applicable for this project, as the purpose from a stormwater quantity perspective is to maximize the storage volume and infiltration capacity with various stormwater solutions as a pilot project. Therefore, the 2-year and 10-year events were evaluated, in addition to the typical 100-year event, to estimate the project impact on smaller and more frequent storms. The 100-year event was evaluated to demonstrate no adverse impacts as a result of the proposed projects and will be used in future phases of the design for sizing erosion protection as needed.

Point precipitation frequency estimates for these events were obtained at the centroid of the modeling domain from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server (PFDS). The NOAA Atlas 14, Volume 1, Version 5 estimates are included in Appendix A. The depths and peak intensities for the design rainfall events are summarized in Table 3, below. The project area falls in both Zones 1 and 3, as defined in the *COA DPM* (2020), with San Mateo Boulevard being the dividing line between the zones. As such, the precipitation depths and intensities used for this project fall between those listed in Table 6.2.8 of the *COA DPM* (2020) for Zones 1 and 3. The NOAA Atlas 14 values were used to generate hyetographs for the modeling.

Table 3 – Design Rainfall Depths and Peak Intensities for 24-hour Design Event

Return Period	Depth (in)	Intensity (in/hr)
2-year	1.26	0.053
10-year	1.83	0.076
100-year	2.71	0.113

Hyetographs for the design events were generated in the US Army Corps of Engineers (USACE) Hydrologic Engineering Center's Hydrologic Model System (HEC-HMS) (software v. 4.10). HEC-HMS was used to create a meteorologic model of a "Frequency Storm" with an intensity duration of 5 minutes and an intensity position of 25% for each return period. No area-reduction factor is required based on the size of the modeling domain being less than 5 square miles. Section 6-2(A)(1) of the *COA DPM* (2020) prescribes that the peak intensity be set 12-hours into the storm. However, to simultaneously time the incorporation of offsite inflows (discussed in Section 2.1.5) the peak intensity was set 6-hours into the storm using an intensity position of 25%, consistent with that reference study.

The hyetographs were extracted from the HEC-HMS results and manually entered as rainfall events in InfoWorks ICM. The intensity specified in these hyetographs is directly applied to individual elements for each computational time step, the infiltration rate is applied to the computed depth of water on the mesh element, and the excess precipitation is routed through the modeling domain.

2.1.5 EXTERNAL INFLOWS/PREVIOUS STUDIES

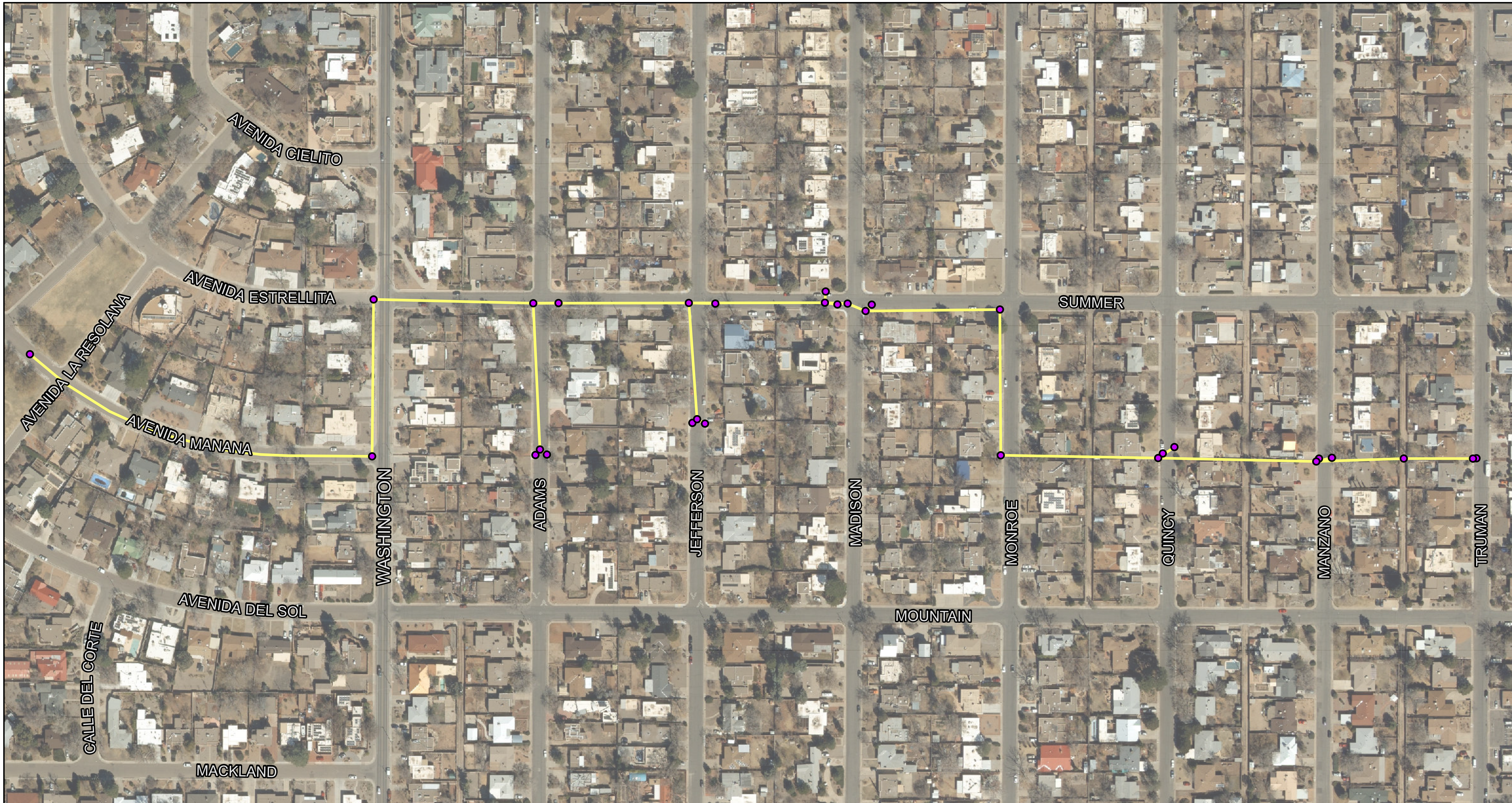
The *San Mateo to Moon Mini Drainage Management Plan* (SMMMDMP), prepared by Smith Engineering Company for AMAFCA in November 2017, included drainage analysis of a larger study area that encompasses the modeling domain delineated for this project. Applicable excerpts from the *SMMMDMP* (2017) are included in Appendix B. The existing conditions H&H analysis completed for the *SMMMDMP* (2017) identified deficiencies in the storm drain capacities in the vicinity of the study area. To account for these deficiencies in the *SMMMDMP* (2017) analysis, flow divides were used to route flows as either street flooding or through storm drains based on assumptions of controlling inlet capacity or downstream storm drain capacity. Within the HEC-HMS model created for the *SMMMDMP* (2017), diversions were used at major street intersections to divert street bypass flows and storm drain flows as determined by the analysis.

The street bypass flow junctions at the San Pedro Drive/Summer Avenue and San Pedro Drive/Mountain Road intersections were identified as the key locations of contributing overland flows upstream of the modeling domain for this project. To account for these street bypass flows, hydrographs were obtained from the existing conditions analysis results of the *SMMMDMP* (2017) and included as inflows to the modeling domain. Further discussion of the application of boundary conditions is in Section 2.1.7.

Hydraulic analysis for the *SMMMDMP* (2017) included a high-level rain-on-grid analysis of the study area in the USACE's Hydrologic Engineering Center's River Analysis System (HEC-RAS) (v. 5.0.3). The analysis included hydraulic modeling of excess precipitation applied to each subbasin with 50-foot grid cells to approximate flood depths. Subbasins did not include routing of flows between modeling domains. The level of detail of the *SMMMDMP* (2017) analysis was developed for a watershed wide master planning study with large scale subbasin analysis and is not comparable to the methods in this study. As such, no direct comparisons of results are applicable.

2.1.6 STORM DRAIN NETWORK ELEMENTS

InfoWorks ICM uses the Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM) v5.1.15s engine to compute storm drain hydraulics for the modeled scenarios. Inputs for the storm drain network require defining properties for inlets, manholes, and conduits. Only storm drain networks with direct impacts to the proposed project locations were included in the analysis (Figure 3 and Figure 4).



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- Existing Node
- Existing Conduit

N

0 100 200 400 Feet

1 in = 200 ft

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Figure 3
Existing Storm Drain Network
Pueblo Alto Neighborhood

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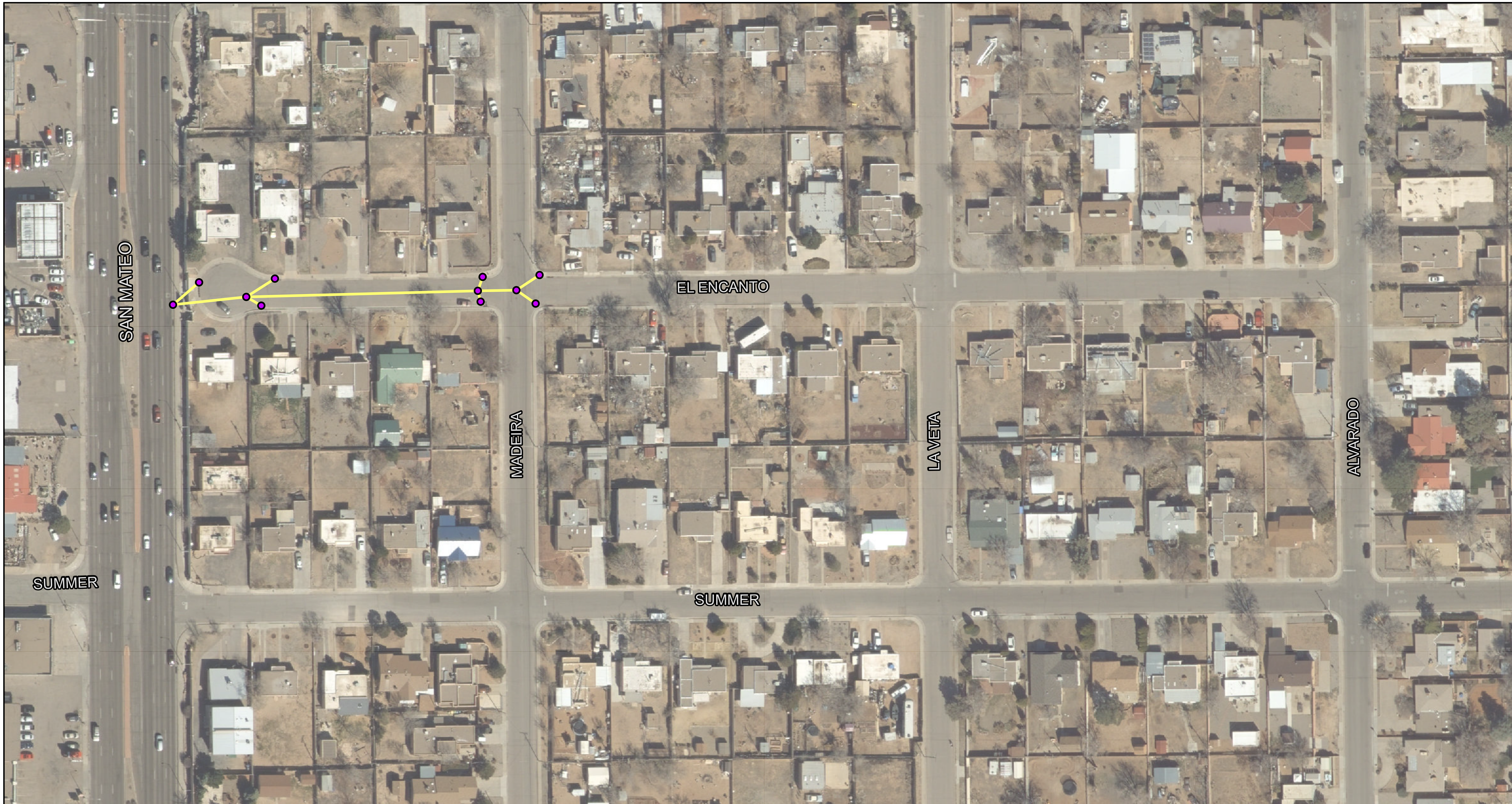
Author: rburkhard

June 2024



Existing Node
Existing Conduit

N

0 50 100 200 Feet

1 in = 100 ft

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Figure 4
Existing Storm Drain Network
Mile Hi Neighborhood

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Author: rburkhard

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Existing storm drain systems in both the Mile Hi and Pueblo Alto neighborhoods that had direct impacts on the project locations were included in the model based on preliminary model results and *SMMMDMP* (2017) conclusions. The *SMMMDMP* (2017) analysis concluded that the main interceptor storm drains within the studied area are at full capacity during “heavy rainfall events”. The San Mateo Boulevard storm drain network is included in the *SMMMDMP* (2017) analysis and was assumed to not have any additional conveyance capacity for any of the simulated events. Based on this assumption, it was not included in the model.

The storm drain network in Pueblo Alto beginning at Truman Street and continuing west and north through the neighborhood was included to the downstream storm drain network modeling domain extents at the intersection of Avenida Manana and Avenida La Rosolana, see Figure 3. The pipe sizes, materials, and invert elevations were collected during BHI’s topographic surveys of the area in November 2018, April 2023, and June 2024. At the downstream end of the modeled portion of the storm drain network, a free outfall allows for storm drain flows to leave the analyzed system. It was determined through reviewing modeling results that this outfall location, over 1,100-feet downstream of the project area and over 5-feet lower in elevation, is sufficiently removed such that boundary condition assumptions do not affect the results of the analysis at the project elements. Sensitivity analysis on setting a constant tailwater elevation at the outfall was also conducted and there was not a significant impact on the storm drain hydraulics at the project location.

The storm drain network in Mile Hi along El Encanto Place was included in the model, see Figure 4. Pipe sizes and materials were obtained from the COA storm drain GIS data. No record drawings were available for the system. Pipe inverts were set based on an assumption of a minimum of 2-feet of cover and a minimum slope of 0.5%. Inlets to the network were measured in the field and included based on DEM elevations at the inlet locations. The connection of the El Encanto Place storm drain network to the San Mateo Boulevard network was modeled as a constant tailwater elevation of 5,230 feet (the ground elevation in San Mateo where the El Encanto system connects), and it was assumed that the controlling tailwater elevation was at existing ground. Multiple analyses to determine the sensitivity of the storm drain capacity to this assumption were completed and it was determined that the assumed tailwater elevation did not have significant impact on modeling results of interest for this project.

2.1.7 BOUNDARY CONDITIONS

Inflows from upstream of the modeling domain, as discussed in Section 2.1.5, are included in the simulation by introducing the hydrographs obtained from the *SMMMDMP* (2017) HEC-HMS model results at the modeling domain boundary along a closed cross section at the applicable streets. The peak discharges from the inflow hydrographs are summarized in Table 4, below.

Table 4 – Inflow Boundary Conditions

Inflow Location	Peak Discharge (cfs)		
	2-year	10-year	100-year
Summer Avenue	17	41	93
Mountain Road	109	202	368

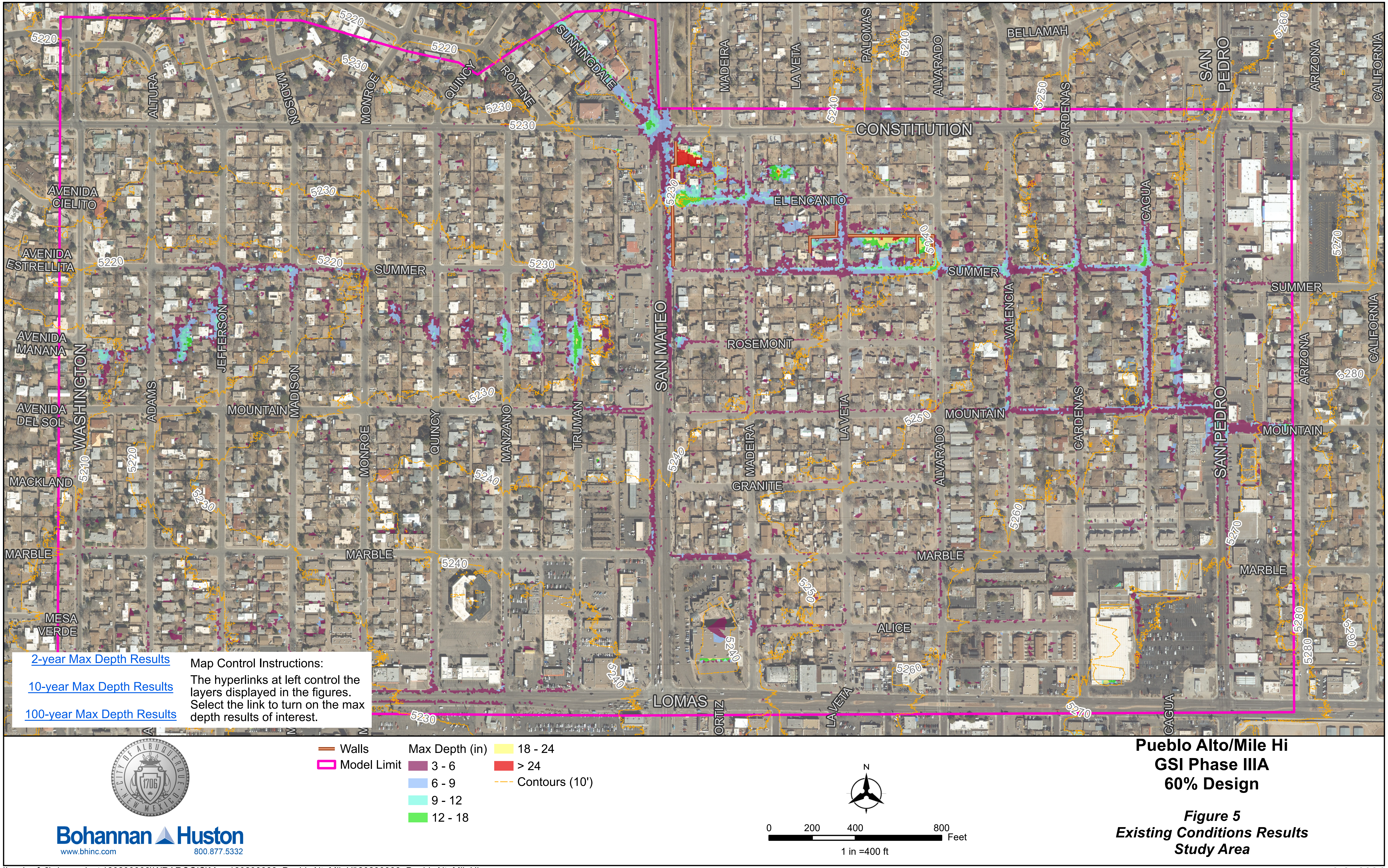
Along the boundary of the modeling domain, the simulations allow for overland flows to leave the model based on calculated normal depth at each mesh element. A rating curve relating flow rates to normal depths is calculated by the software for each mesh element along the boundary, and as the normal depth in the cell is reached, the corresponding flow rate is discharged from the modeling domain. At the modeled downstream end of the storm drain networks, the captured flows are discharged from the modeling domain.

2.1.8 SIMULATION PARAMETERS

The modeled scenarios were run for a duration of 12 hours. Computational time steps were set to 10 seconds for all simulations. The default and/or recommended values for calculation tolerances and stability controls were used.

2.2 MODEL SIMULATIONS AND RESULTS

Simulations of the 2-, 10-, and 100-year return period 24-hour duration precipitation events were included for existing and future conditions. Depth results maps for the project areas are included in Figure 5 through Figure 10. Additional modeling results are included in Appendix C.



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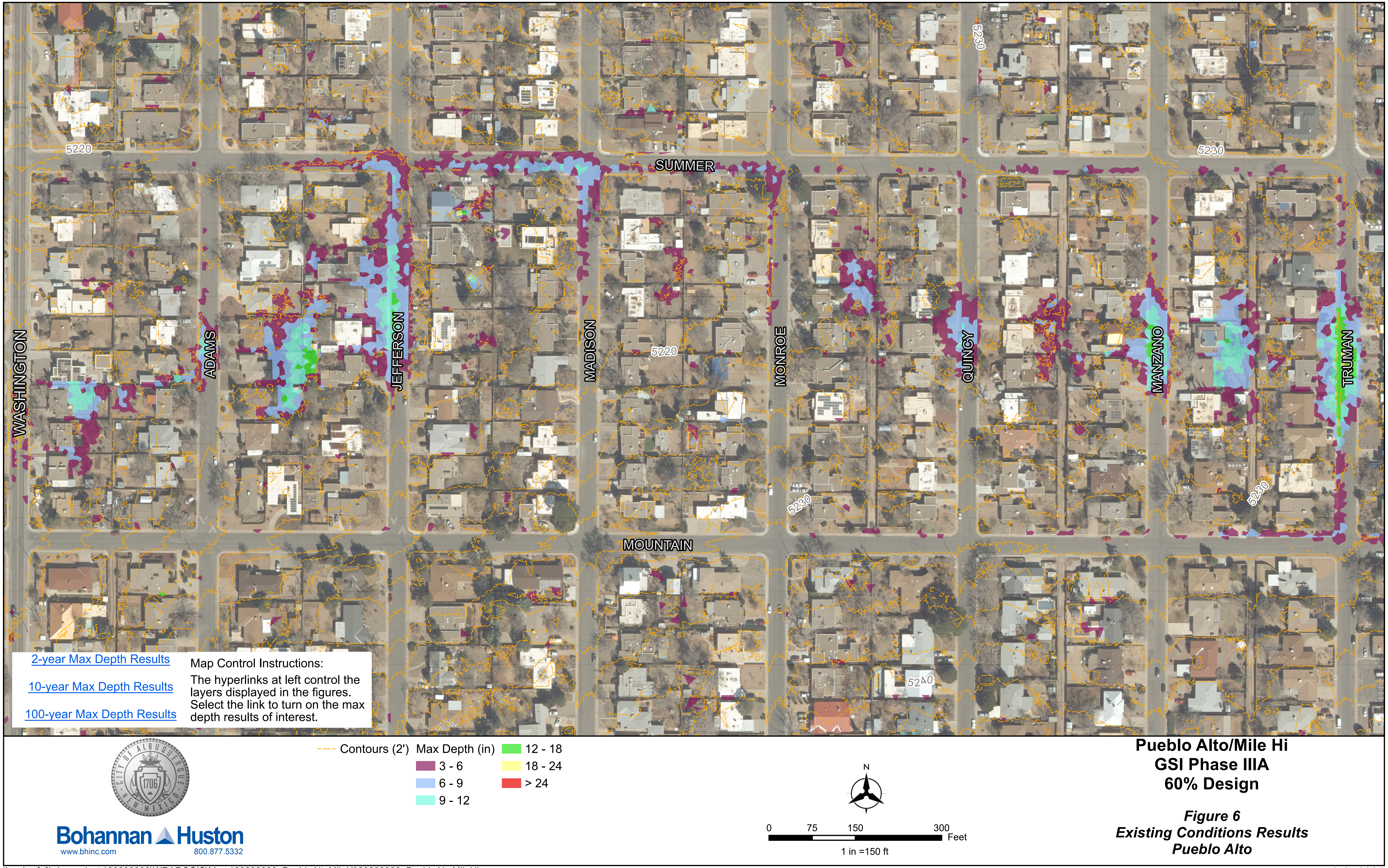

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Figure 6
Existing Conditions Results
Pueblo Alto

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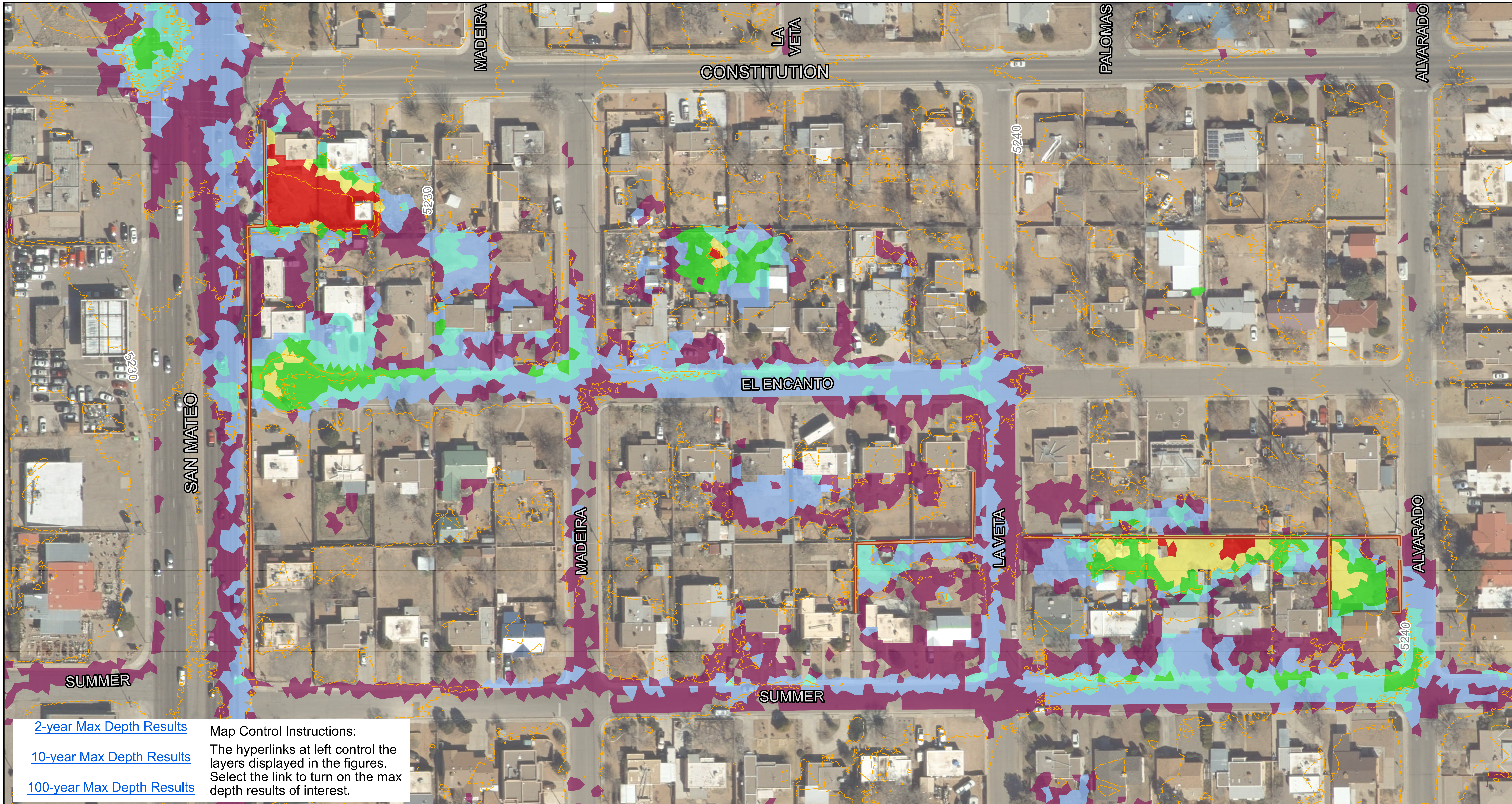

2-year Max Depth Results

10-year Max Depth Results

100-year Max Depth Results

Map Control Instructions:

The hyperlinks at left control the layers displayed in the figures. Select the link to turn on the max depth results of interest.

Contours (2')
Walls

Max Depth (in)
- 3 - 6
- 6 - 9
- 9 - 12
- 12 - 18
- 18 - 24
- > 24

N

0 50 100 200 Feet

1 in =100 ft

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Figure 7
Existing Conditions Results
Mile Hi

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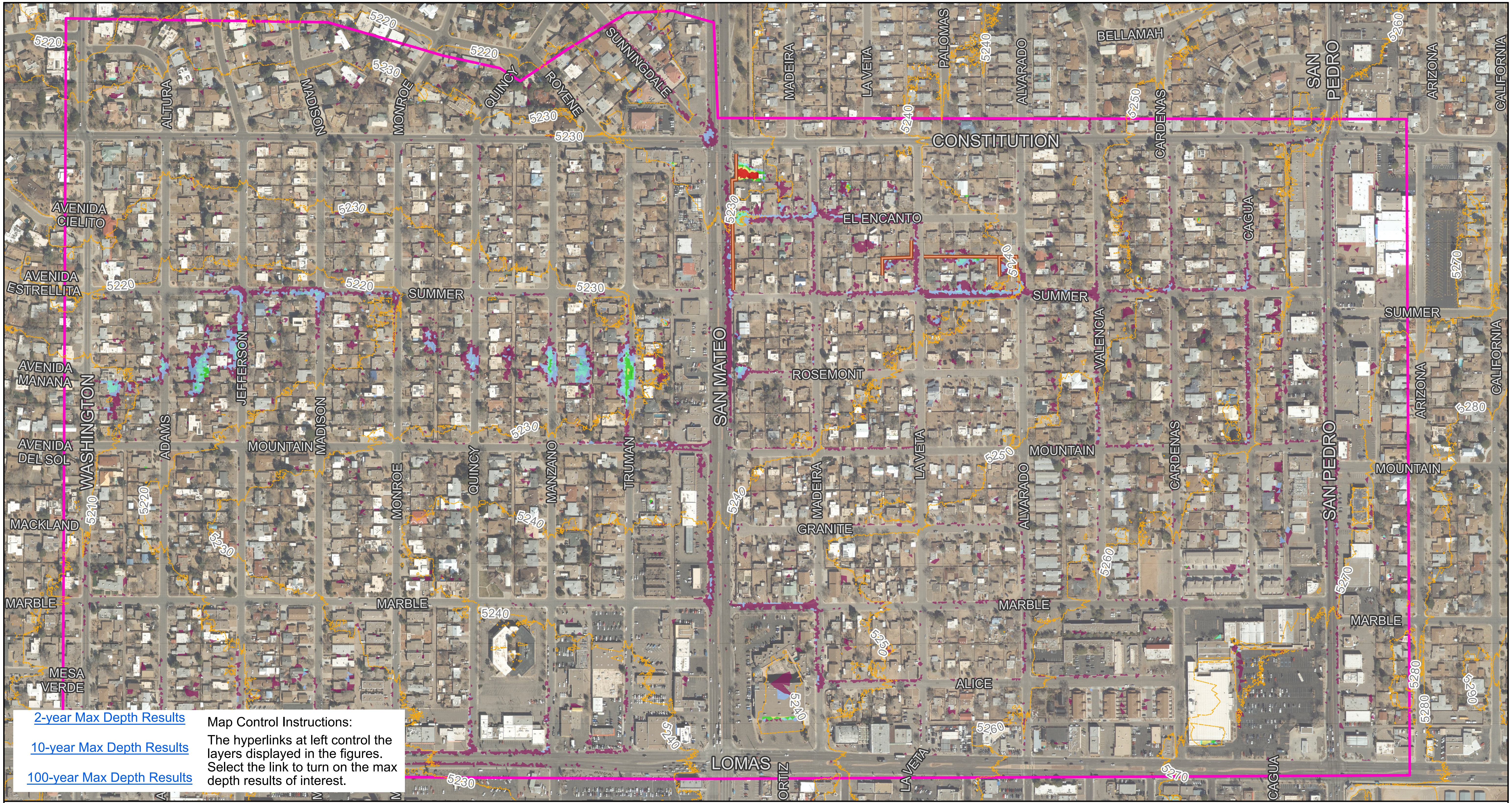

Contours (10') | Walls | Model Limit

Max Depth (in): 3 - 6 | 6 - 9 | 9 - 12 | 12 - 18 | 18 - 24 | > 24

N

0 | 200 | 400 | 800 Feet

1 in =400 ft

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Figure 8
Future Conditions Results
Study Area

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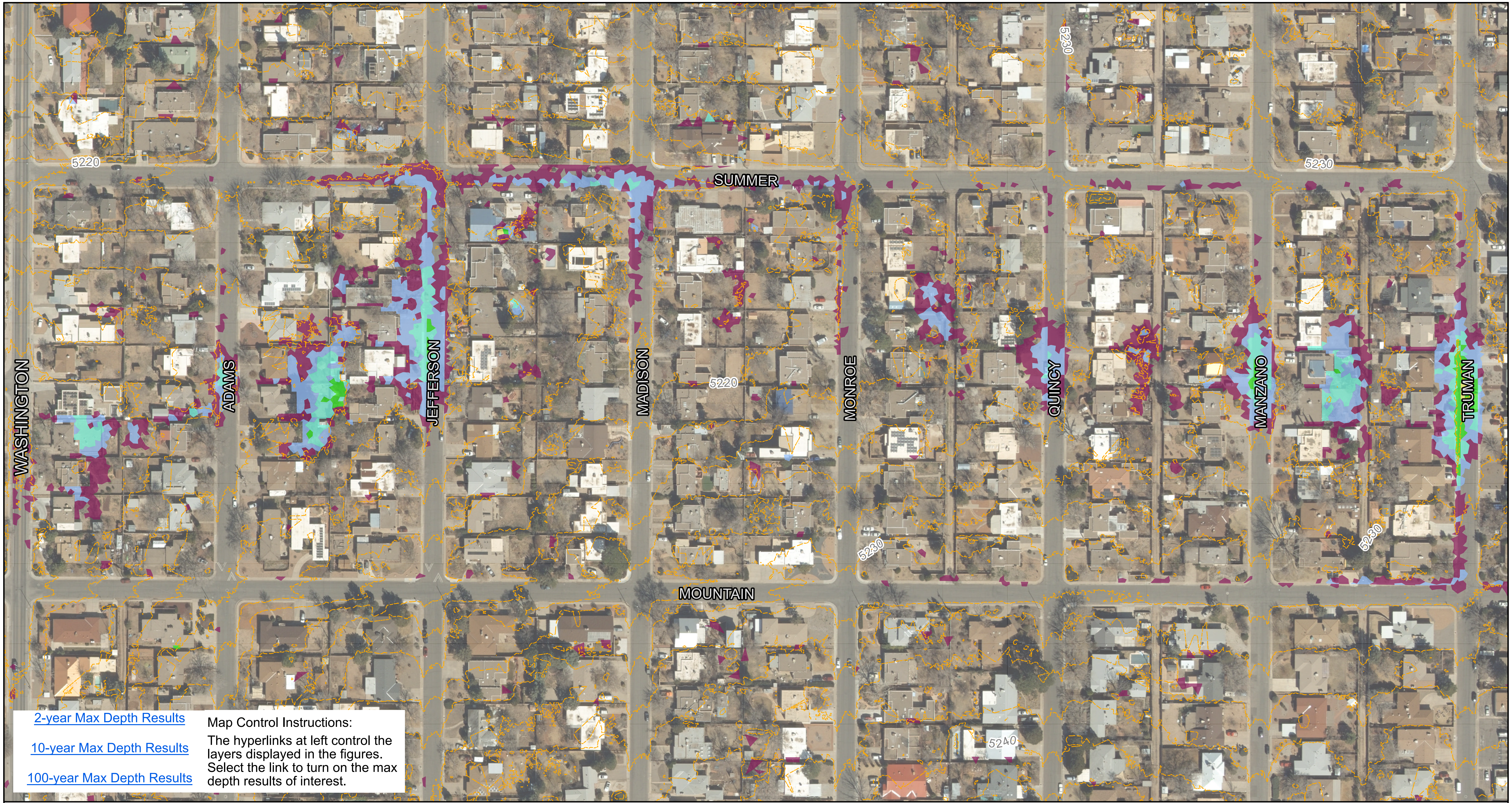

Contours (2') Max Depth (in)
3 - 6
6 - 9
9 - 12
12 - 18
18 - 24
> 24

N

0 75 150 300 Feet
1 in =150 ft

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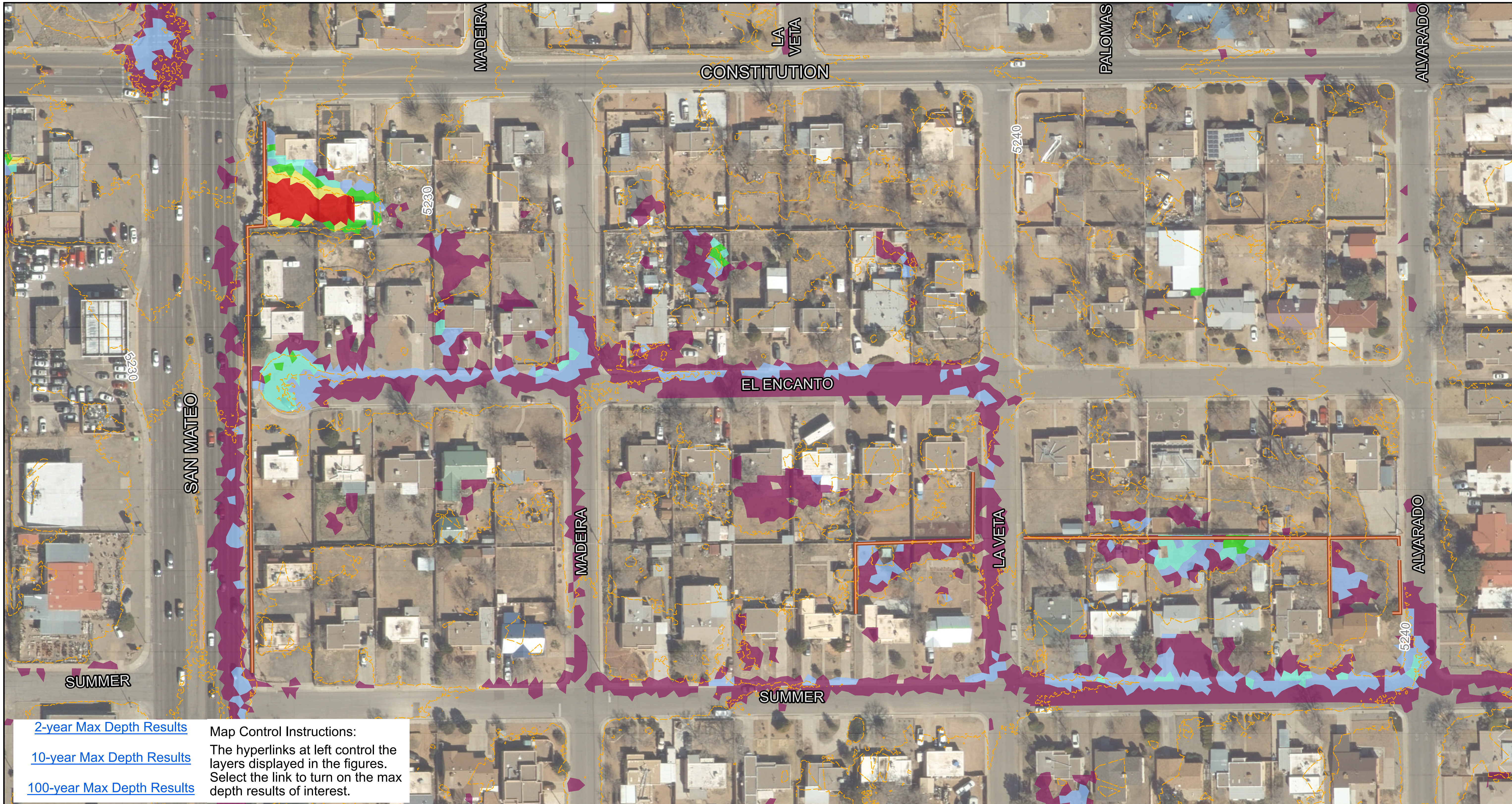
Figure 9
Future Conditions Results
Pueblo Alto



2-year Max Depth Results

10-year Max Depth Results

100-year Max Depth Results

Map Control Instructions:

The hyperlinks at left control the layers displayed in the figures. Select the link to turn on the max depth results of interest.

Contours (2') Walls

Max Depth (in)

3 - 6
6 - 9
9 - 12
12 - 18
18 - 24
>24

N

0 50 100 200 Feet

1 in =100 ft

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Figure 10 Future Conditions Results Mile Hi

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3 DESIGN

The proposed GSI and drainage improvements for the pilot project areas consist of upsizing the existing storm drain, installing underground storage chambers, and constructing stormwater bumpouts. The improvements were designed to optimize the use of the available space within existing COA rights-of-way (ROWs) for improvements within the pilot project areas. In May 2023 and April 2024, a subsurface utility survey was conducted by High Mesa Consulting Group to inform proposed improvement layouts. Quality Level (QL) D/C/B has been provided to inform the 60% design. QL D included records research and collection of first resource utility information via NM811, QL C included visual inspection of the project area and collection of visible features, and QL B included designation (line-spotting) of utilities provided by utility operators/stakeholders. QL A (potholing) will be performed by High Mesa Consulting Group prior to the 90% design.

3.1 STORMWATER BUMPOUTS

As shown in Figure 11, stormwater bumpouts are pervious areas that extend from the curb line toward the center of the roadway. Bumpouts provide a depressed area for runoff to accumulate and infiltrate, reducing stormwater volumes and peak flows downstream. They also provide water quality treatment through the collection of sediment/debris and biofiltration. The 60% design for this project includes stormwater bumpouts on one side of the road while maintaining two travel lanes.

Figure 11 – Stormwater Bumpout Details

3.2 UNDERGROUND STORAGE

Layouts for the underground storage and infiltration systems were developed to maximize the storage volume provided within the pilot project areas, while minimizing utility conflicts and ensuring the systems are constructable and maintainable. For the 60% design, concrete chambers, as designed by StormTrap, are proposed for the underground storage systems. How these systems would be connected to the existing storm drain network and to proposed inlets and the modeling approach is further discussed in Section 4.1. The underground storage systems would provide short-term (approximately 24 to 48 hours) storage of excess runoff, reducing flooding. After the peak flows pass through the existing storm drain network, the underground system would drain via infiltration and release of stored water into the storm drain network.

3.2.1 INFILTRATION ANALYSIS

A geotechnical engineering firm, Geo-Test, Inc., was hired as a subconsultant to evaluate subsurface drainage conditions in the proposed project areas. The *Geotechnical Engineering Services Report* is included as Appendix D. To support the analysis, five (5) exploratory borings were drilled to a depth of 25-feet throughout the proposed project areas. The collected soils were analyzed and a variety of soil classifications were reported, ranging from clean relatively coarse grained non-plastic sands to fine grained high plasticity clay.

The results of the geotechnical analysis were processed to determine expected infiltration rates and corresponding drain times for project features. Tables summarizing that analysis are included in Appendix D. Results of that analysis and conclusions of the geotechnical report support that the depths at which the underground storage chambers will be installed are sufficiently draining such that the detained flows will infiltrate in less than 96 hours. The recommendation of the geotechnical engineer includes removal and replacement of clayey soils with well-draining imported soils, as encountered during construction, to ensure adequate drainage.

4 DESIGN HYDROLOGIC AND HYDRAULIC MODELING

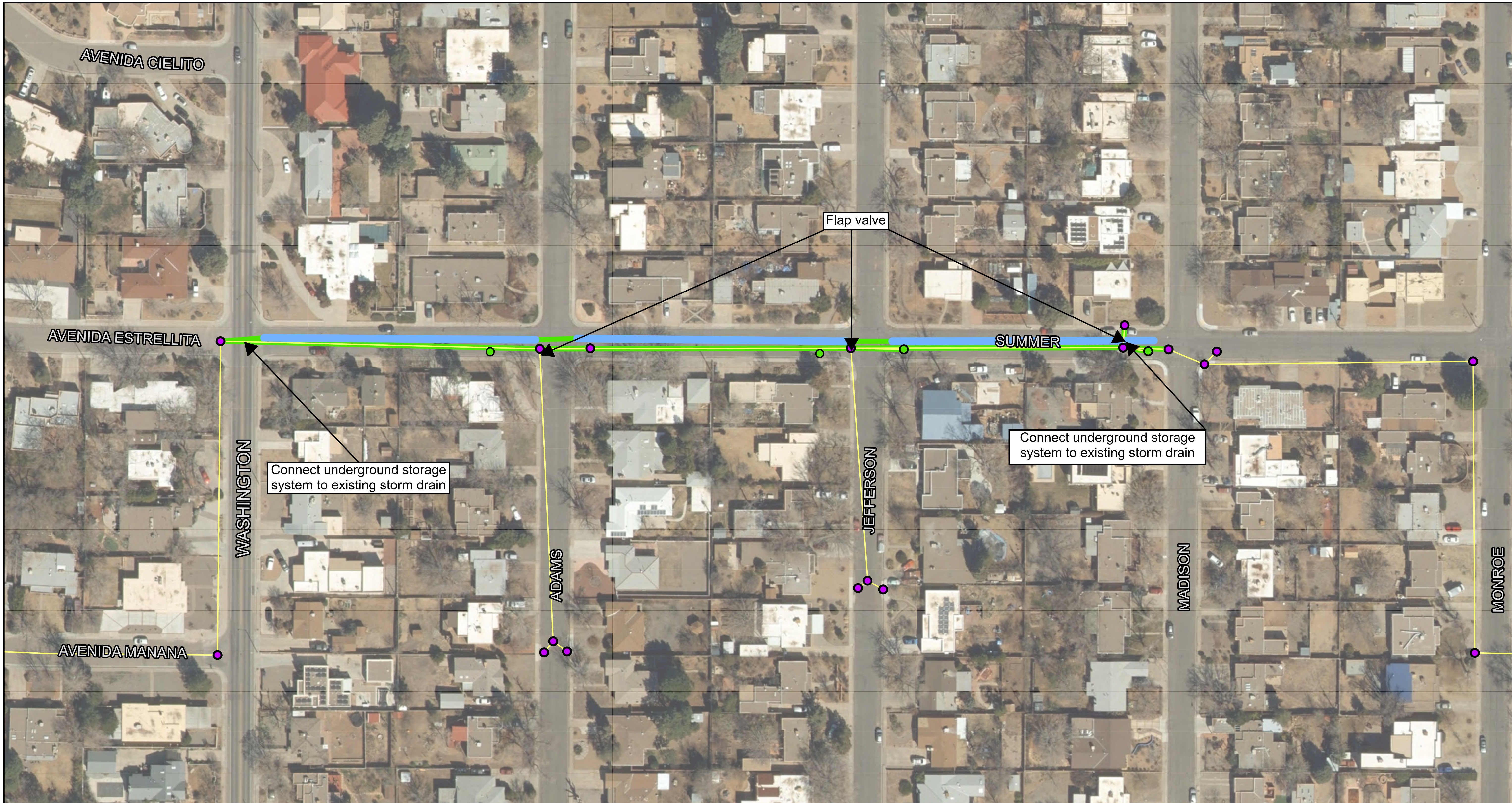
The existing and future conditions H&H models discussed in Section 2 were modified to include 60% design infrastructure discussed in Section 3.

4.1 UNDERGROUND STORAGE

The underground storage systems were included in the model as storage nodes with properties defined by a stage-storage relationship based on the calculated storage volume and the height of the system. The storage nodes are connected to the existing storm drain system and new inlets, as shown on Figure 12 and Figure 13. Existing and new inlets capture surface flows from the 2D mesh and divert runoff to the proposed underground storage system which are interconnected to disperse stormwater storage throughout the network. Further discussion of the storm drain and inlets is included in the following section.

In the Pueblo Alto area, at the intersection of Madison and Summer, a new diversion manhole will be constructed to divert flows from the existing storm drain system at low flows to the upsized downstream storm drain and excess flows to the underground storage system. As each tank fills, water is conveyed to the next downstream tank through an orifice connection in the model's storm drain network. The orifices are set at the inverts of the storage system to act as balance pipes between tanks. At the downstream end of the system, near Washington Street and Summer Avenue, a low-flow bleed pipe at the bottom of the tank and an overflow weir at the top of the tank connects the downstream-most tank back to the existing storm drain system.

The underground system in La Veta Drive receives flows from the new inlets as shown in Figure 13. These flows are diverted to the underground storage system that infiltrates the retained volume into the surrounding area.



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- Proposed Inlets
- Proposed Storm Drain
- Proposed Underground System
- Existing Node
- Existing Storm Drain

N

0 50 100 200 Feet
1 in = 100 ft

Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Figure 12
Proposed Underground System
Pueblo Alto

P:\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: eadams

July 2024

Proposed Inlets
Proposed Storm Drain
Proposed Underground System
Existing Node
Existing Storm Drain

N

0 50 100 200 Feet
1 in = 100 ft

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Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Figure 13
Proposed Underground System
Mile Hi

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Author: eadams

July 2024

4.2 STORMWATER BUMPOUTS

The stormwater bumpout footprints were included in the InfoWorks ICM modeling software to adjust mesh elevations and infiltration parameters as required to represent the bumpouts in the model. The approximate bumpout toe of slope was added to the model as a Mesh Level Zone effectively lowering the mesh elevations covered by the floor footprint by 0.75-feet. Additionally, the extents of the bumpout were set to be an infiltration zone with the same infiltration rate as the residential parcels (Table 1). No additional grading modifications to the existing terrain are included in the model at this phase in the project.

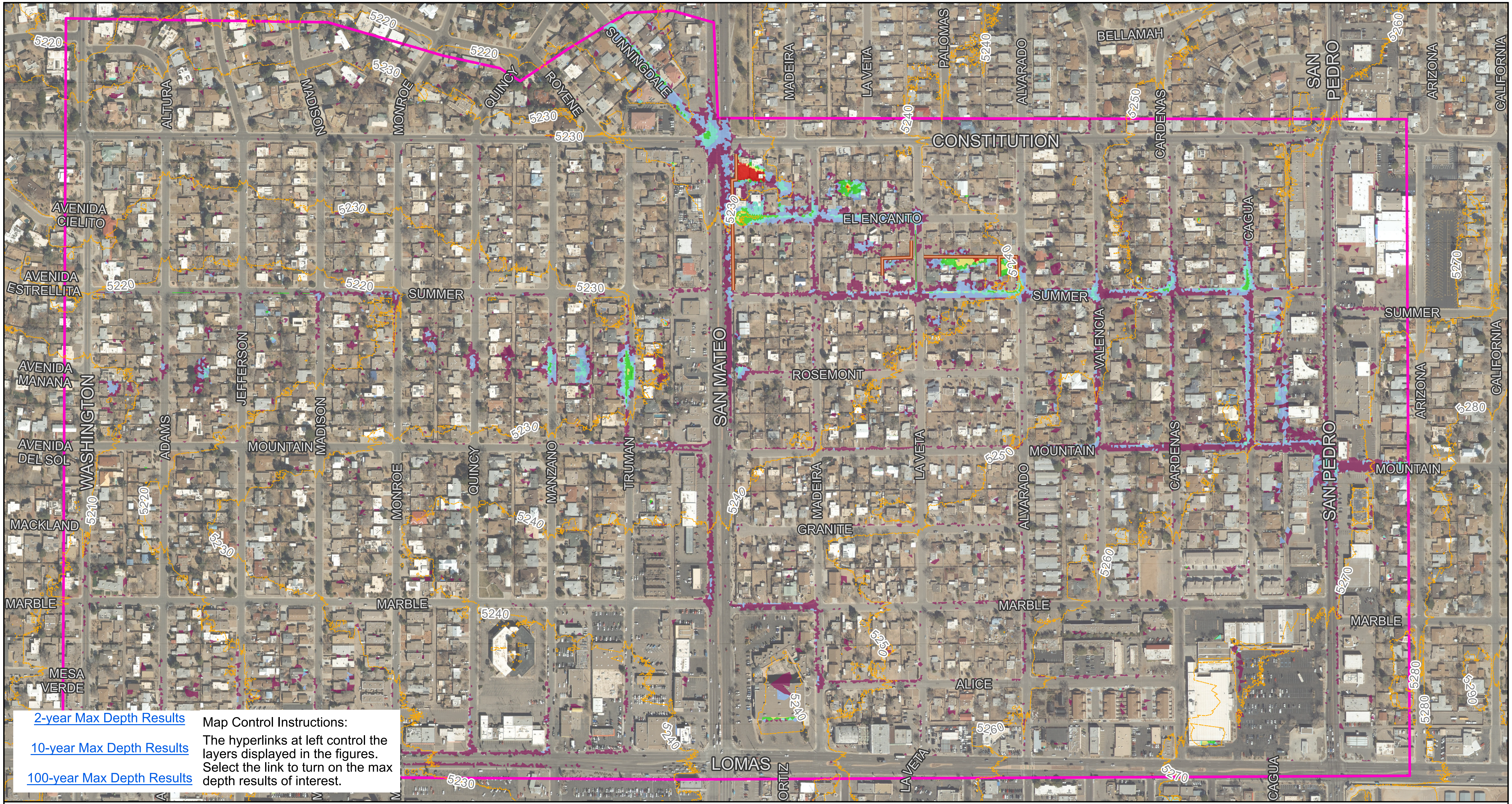
Runoff in the street enters the bumpouts at the level flush with the existing street grades at the bumpout ends, and the collected runoff is infiltrated through the defined infiltration zone. Flows collected in the bumpouts are conveyed to the proposed storm drain system where indicated in the 60% design.

4.3 STORM DRAINS AND INLETS

As discussed in the previous sections, proposed storm drains and inlets are included in the proposed conditions models where indicated in the 60% design. In the Pueblo Alto neighborhood, the upsized storm drain in Summer and new storm drain connections to the existing system are modeled in the proposed conditions storm drain network. Where the proposed network connects to the existing system, at the intersections of Summer and Adams, Summer and Jefferson, and Summer and Madison, flap gates are included in the modeled network to prevent backflow. In the Mile Hi neighborhood, the proposed storm drain and inlets were included based on the geometry and configuration of the 60% design. Proposed inlets are COA Type D standard inlets and are included in the model as inlet nodes with grate opening areas based on COA standard drawings.

4.4 RESULTS

Simulations of the 2-, 10-, and 100-year return period 24-hour duration precipitation events were included for proposed and future conditions, with proposed project improvements. Depth results maps for the project areas are included in Figure 14 through Figure 19. These figures are included as interactive PDFs in which layers can be controlled to show depth results for multiple events on the same figure using preset views. Please refer to the layer control instructions on the figure for operation instructions. Figure 20 through Figure 22 show surface flow depth reduction resulting from construction of the project when compared to the existing conditions 2-year return event. Additional modeling results maps and output are included in Appendix E.



2-year Max Depth Results

10-year Max Depth Results

100-year Max Depth Results

Map Control Instructions:
The hyperlinks at left control the layers displayed in the figures. Select the link to turn on the max depth results of interest.

Walls
Model Limit

Max Depth (in)
3 - 6
6 - 9
9 - 12
12 - 18
18 - 24
> 24
Contours (10')

N

0 200 400 800 Feet
1 in =400 ft

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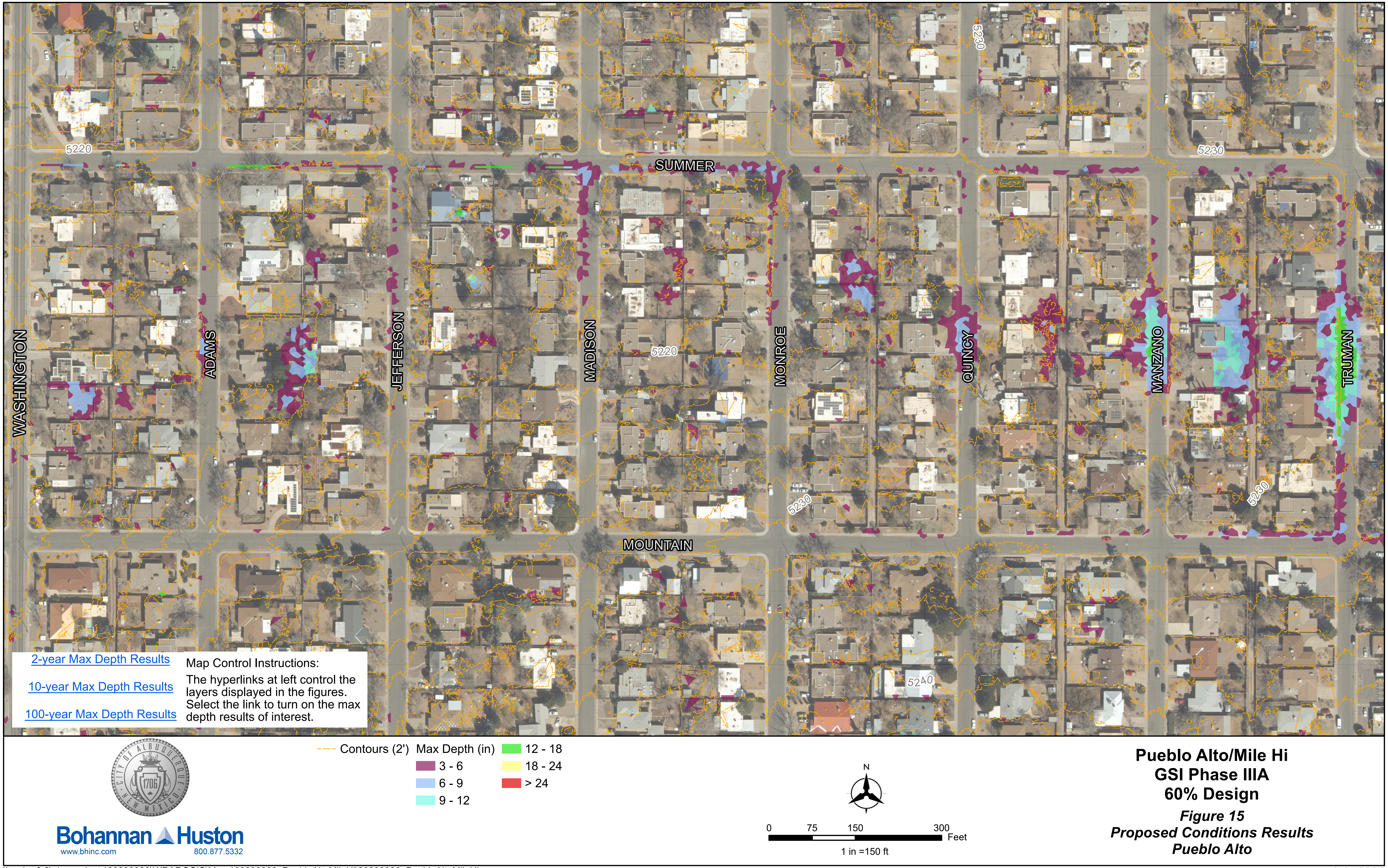
Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Figure 14
Proposed Conditions Results
Study Area

\\a-abq-fs2\abq-projects\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: rburkhard

July 2024



Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Figure 15
Proposed Conditions Results
Pueblo Alto

\\a-abq-fs2\abq-projects\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: rburkhard

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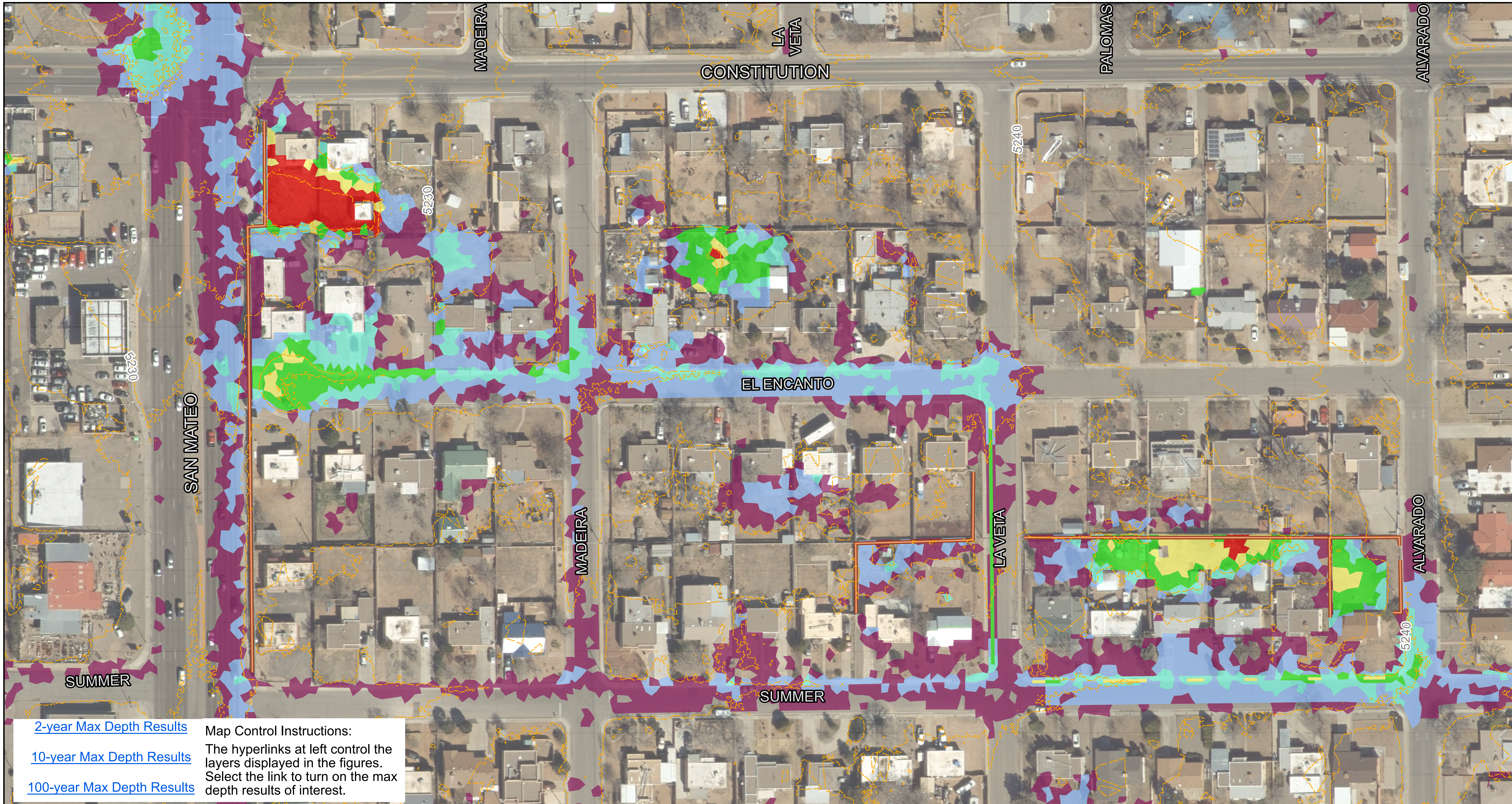

Contours (2')
Walls

Max Depth (in)

3 - 6	12 - 18
6 - 9	18 - 24
9 - 12	> 24

N

0 50 100 200 Feet

1 in =100 ft

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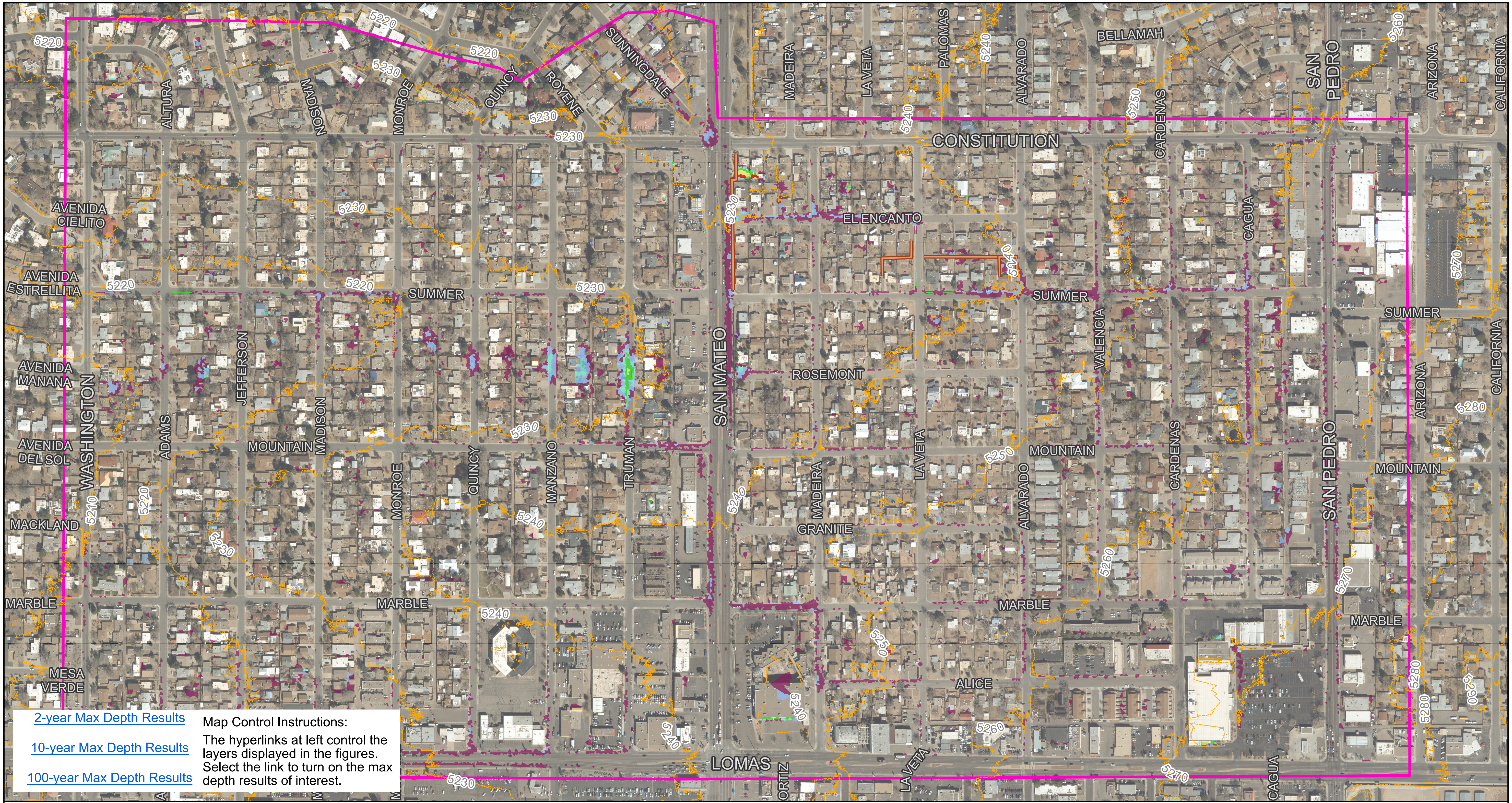
Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Figure 16
Proposed Conditions Results
Mile Hi

\\a-abq-fs2\abq-projects\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: rburkhard

July 2024



Contours (10') | Walls | Model Limit

Max Depth (in)	
3 - 6	18 - 24
6 - 9	> 24
9 - 12	
12 - 18	

N

0 200 400 800 Feet
1 in =400 ft

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Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Figure 17
Future Conditions,
with GSI improvements Results
Study Area

\\a-abq-fs2\abq-projects\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: rburkhard

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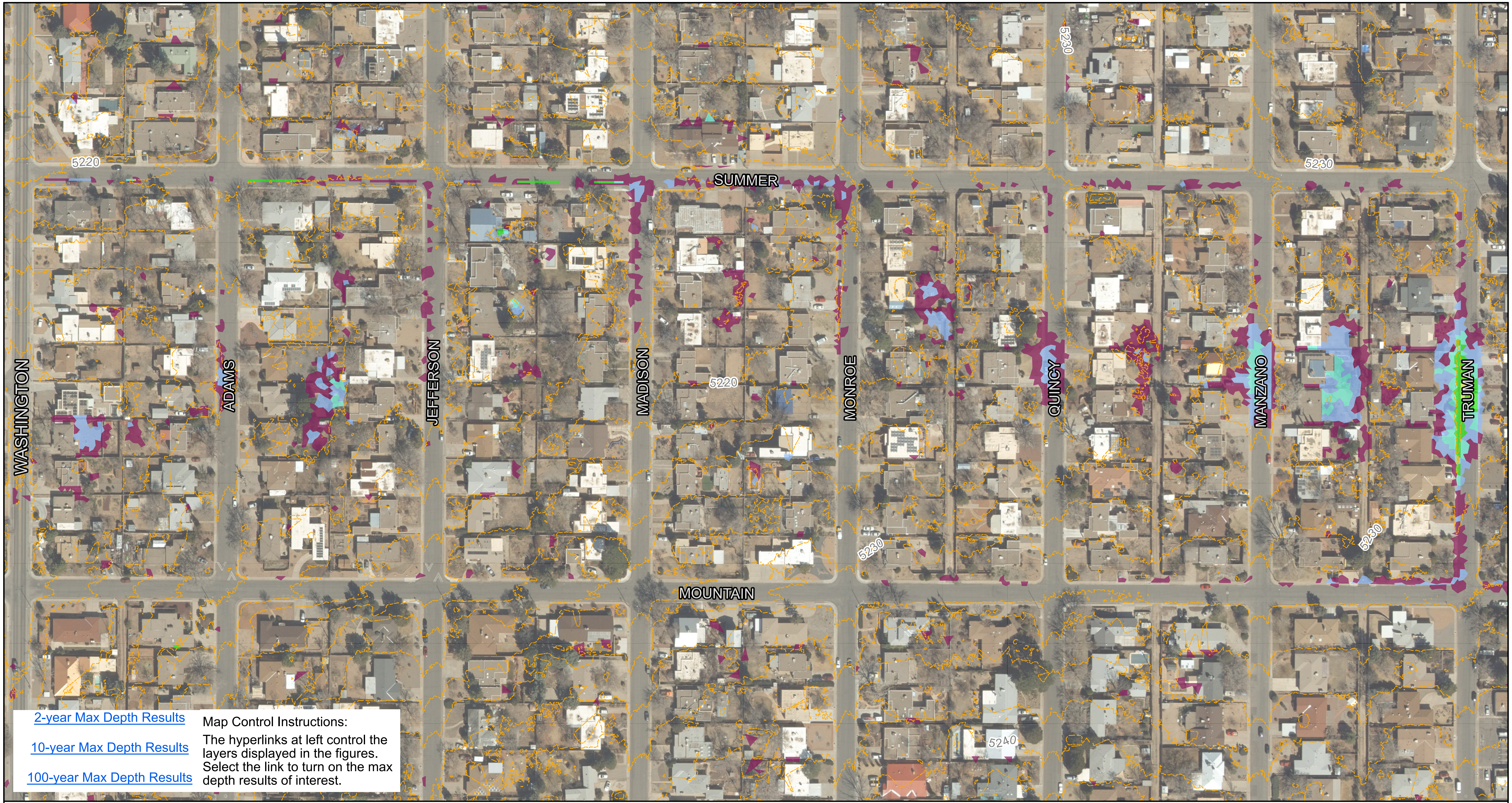

[2-year Max Depth Results]

[10-year Max Depth Results]

[100-year Max Depth Results]

Map Control Instructions:

The hyperlinks at left control the layers displayed in the figures. Select the link to turn on the max depth results of interest.

Contours (2')

Max Depth (in)		
3 - 6	12 - 18	
6 - 9	18 - 24	
9 - 12	> 24	

N

0 75 150 300 Feet

1 in = 150 ft

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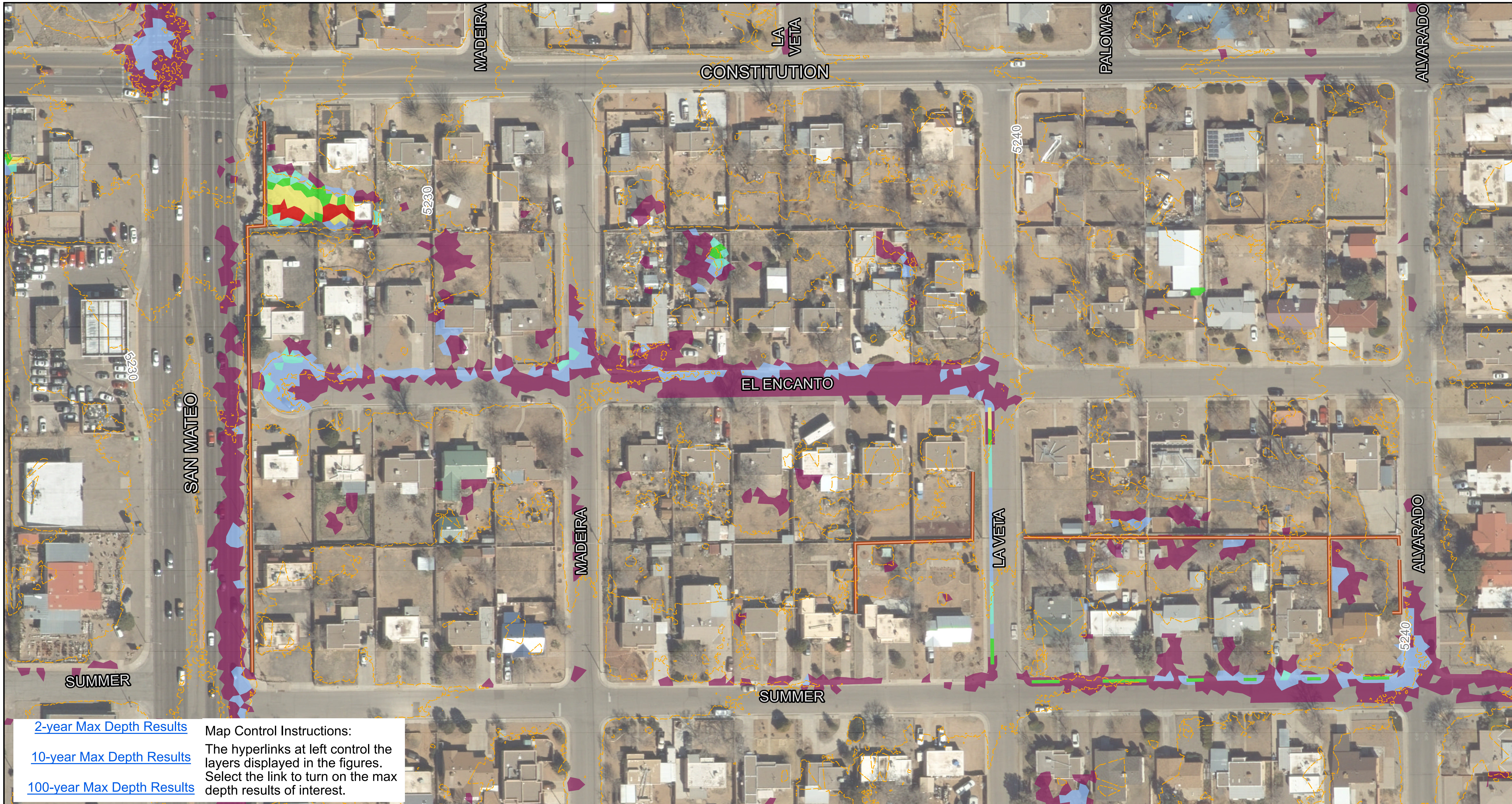
Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Figure 18
Future Conditions,
with GSI Improvements Results
Pueblo Alto

\\a-abq-fs2\abq-projects\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: rburkhard

July 2024



Contours (2')
Walls

Max Depth (in)	
3 - 6	18 - 24
6 - 9	> 24
9 - 12	
12 - 18	

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N

0 50 100 200 Feet
1 in =100 ft

Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Figure 19
Future Conditions, with GSI Improvements Results
Mile Hi

\\a-abq-fs2\abq-projects\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: rburkhard

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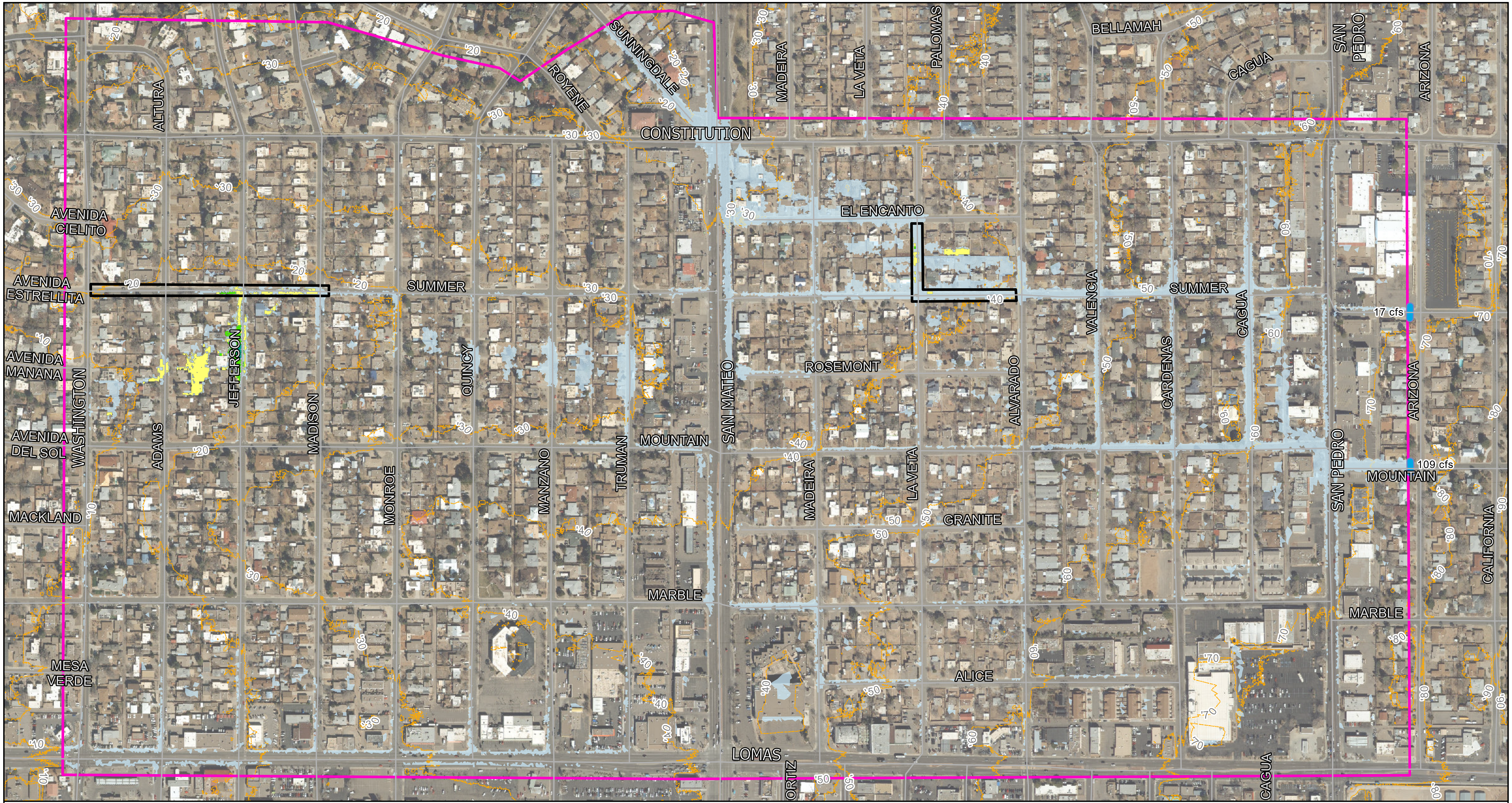

Contours (10')
Modeled Offsite Inflow Location
Proposed GSI Pilot Project Areas
Model Limits
Existing Water Depths > 3 inches

Water Depth Reduction (in)
< 3 Not Shown
3 - 6
6 - 9
> 9

0 200 400 800 Feet
1 in =400 ft

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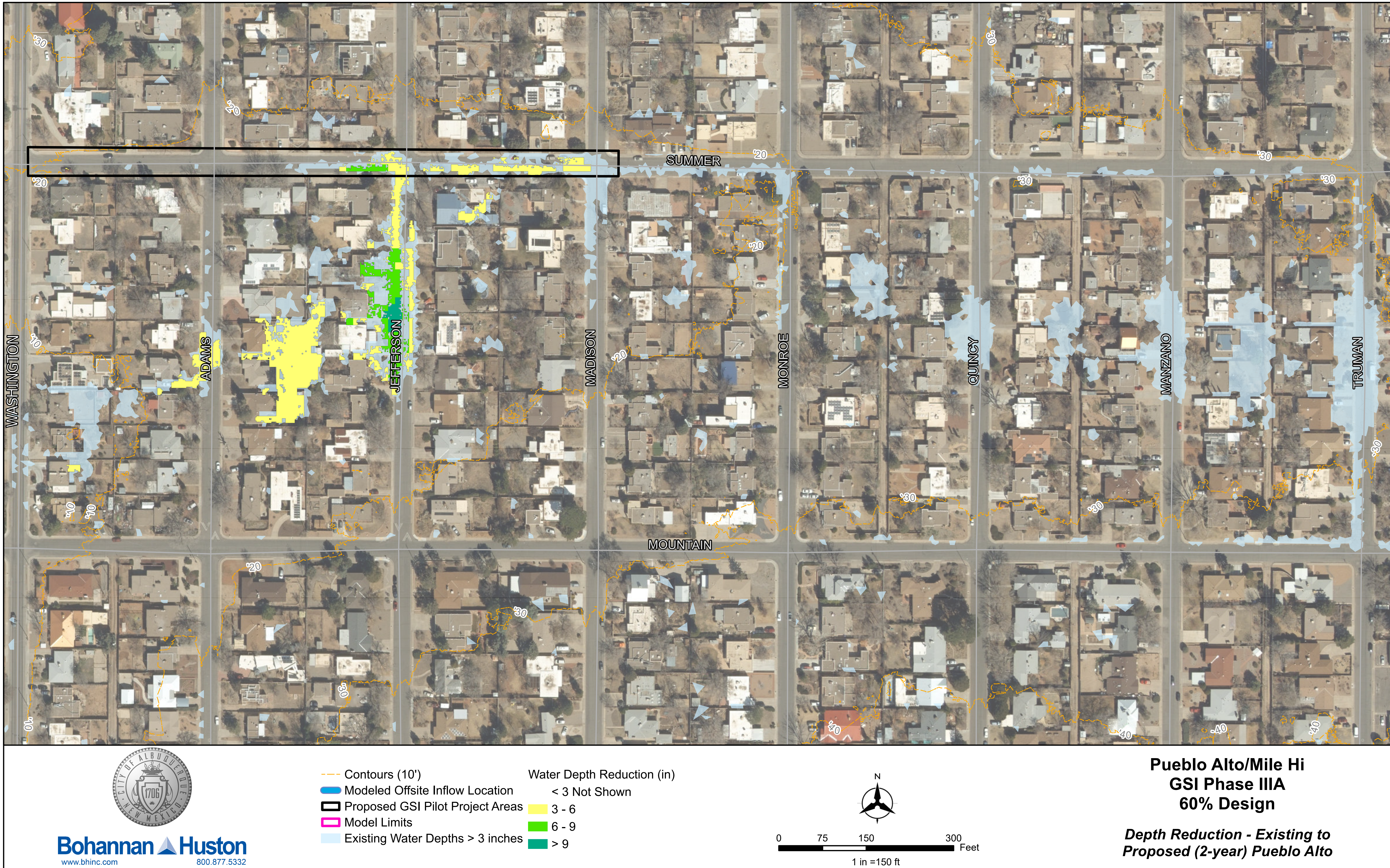
Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Depth Reduction - Existing to Proposed (2-year) Study Area

\\a-abq-fs2\ABQ-Projects\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: rburkhard

July 2024

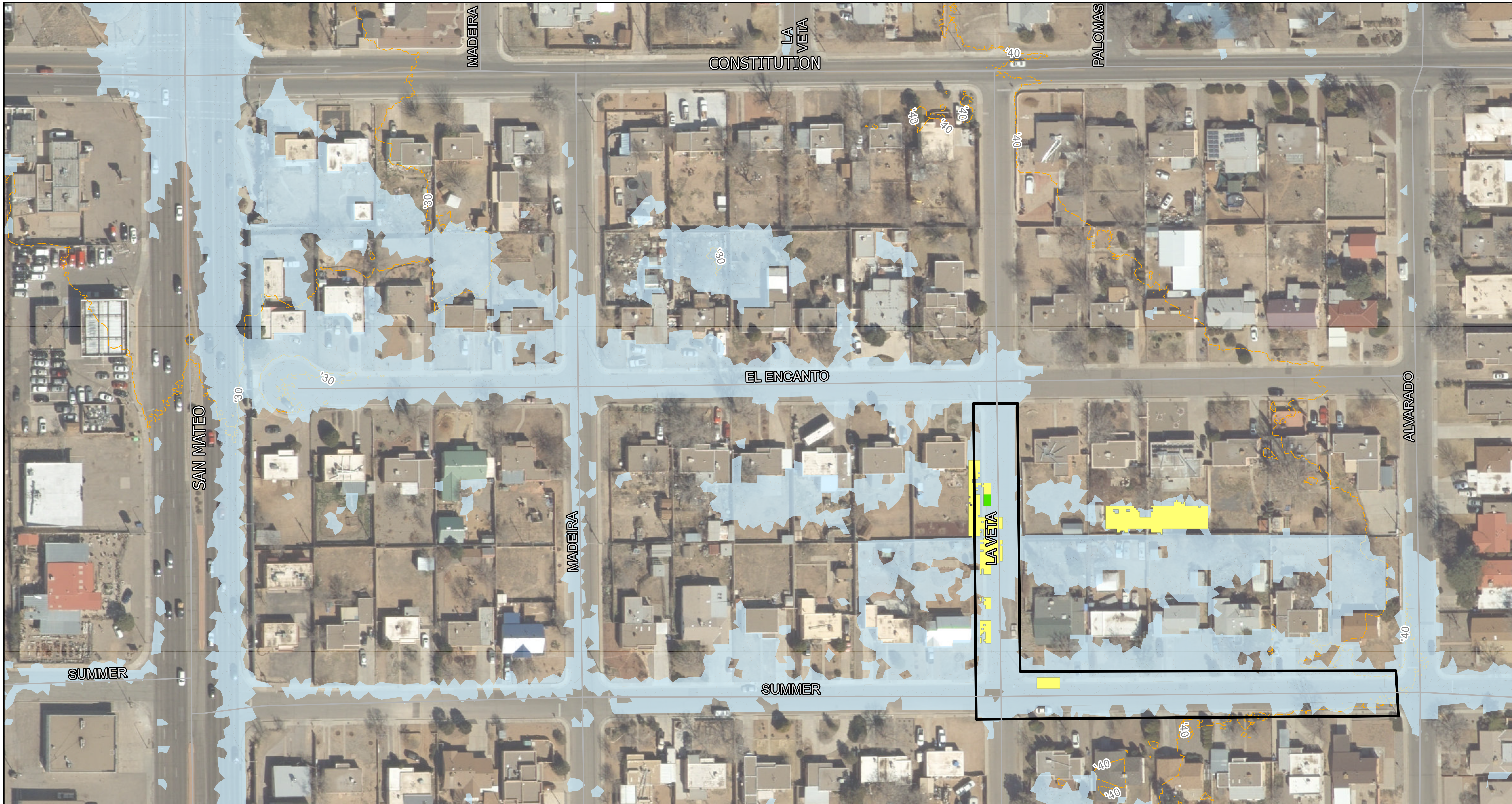


Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Depth Reduction - Existing to Proposed (2-year) Pueblo Alto

\\a-abq-fs2\ABQ-Projects\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: rburkhard

July 2024



Contours (10')
Modeled Offsite Inflow Location
Proposed GSI Pilot Project Areas
Model Limits
Existing Water Depths > 3 inches

Water Depth Reduction (in)
< 3 Not Shown
3 - 6
6 - 9
> 9

N

0 50 100 200 Feet
1 in =100 ft

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Pueblo Alto/Mile Hi
GSI Phase IIIA
60% Design

Depth Reduction - Existing to Proposed (2-year) Mile Hi

\\a-abq-fs2\ABQ-Projects\20230388\WRARCGIS\Maps\20230388_PuebloAltoMileHi\20230388_PuebloAltoMileHi.aprx
Author: rburkhard

July 2024

5 CONCLUSION

This DAR summarizes the H&H analysis completed for the Pueblo Alto/Mile Hi GSI Phase IIIA 60% Design Submittal. The proposed improvements were designed and evaluated based on this analysis. The evaluation of improvements included optimization of the proposed improvements and their connection to the existing infrastructure to maximize the available project area and flood reduction benefits. Additional modifications to the design and associated modeling will be made for the 90% design, and an updated DAR will be submitted to COA at that time.

APPENDICES

APPENDIX A – NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATE DATA

NOAA Atlas 14, Volume 1, Version 5
Location name: Albuquerque, New Mexico, USA*
Latitude: 35.0921°, Longitude: -106.5862°
Elevation: m/ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.176** (0.151-0.207)	**0.229** (0.195-0.269)	**0.307** (0.261-0.360)	**0.367** (0.311-0.429)	**0.450** (0.380-0.525)	**0.514** (0.432-0.600)	**0.582** (0.485-0.678)	**0.653** (0.541-0.760)	**0.749** (0.615-0.873)	**0.825** (0.673-0.963)
10-min	**0.269** (0.230-0.316)	**0.348** (0.297-0.409)	**0.467** (0.398-0.547)	**0.559** (0.474-0.653)	**0.685** (0.578-0.799)	**0.783** (0.657-0.913)	**0.886** (0.738-1.03)	**0.994** (0.823-1.16)	**1.14** (0.935-1.33)	**1.26** (1.02-1.47)
15-min	**0.333** (0.286-0.391)	**0.431** (0.368-0.506)	**0.579** (0.493-0.678)	**0.693** (0.587-0.810)	**0.849** (0.716-0.990)	**0.970** (0.815-1.13)	**1.10** (0.915-1.28)	**1.23** (1.02-1.44)	**1.41** (1.16-1.65)	**1.56** (1.27-1.82)
30-min	**0.449** (0.385-0.526)	**0.581** (0.495-0.682)	**0.780** (0.664-0.913)	**0.933** (0.790-1.09)	**1.14** (0.964-1.33)	**1.31** (1.10-1.52)	**1.48** (1.23-1.72)	**1.66** (1.37-1.93)	**1.90** (1.56-2.22)	**2.10** (1.71-2.45)
60-min	**0.556** (0.476-0.651)	**0.719** (0.613-0.844)	**0.965** (0.821-1.13)	**1.16** (0.978-1.35)	**1.42** (1.19-1.65)	**1.62** (1.36-1.89)	**1.83** (1.53-2.13)	**2.05** (1.70-2.39)	**2.35** (1.93-2.75)	**2.60** (2.12-3.03)
2-hr	**0.645** (0.545-0.777)	**0.826** (0.698-0.996)	**1.09** (0.921-1.32)	**1.31** (1.10-1.56)	**1.60** (1.33-1.91)	**1.84** (1.53-2.19)	**2.10** (1.72-2.49)	**2.36** (1.93-2.80)	**2.73** (2.20-3.24)	**3.03** (2.42-3.61)
3-hr	**0.687** (0.585-0.822)	**0.873** (0.741-1.04)	**1.14** (0.972-1.36)	**1.36** (1.15-1.62)	**1.66** (1.39-1.97)	**1.90** (1.59-2.25)	**2.15** (1.79-2.55)	**2.42** (1.99-2.87)	**2.80** (2.28-3.32)	**3.11** (2.51-3.69)
6-hr	**0.799** (0.685-0.950)	**1.01** (0.864-1.20)	**1.30** (1.11-1.54)	**1.53** (1.31-1.81)	**1.84** (1.56-2.17)	**2.09** (1.76-2.46)	**2.35** (1.97-2.77)	**2.61** (2.18-3.08)	**2.99** (2.47-3.51)	**3.29** (2.70-3.87)
12-hr	**0.882** (0.764-1.02)	**1.11** (0.964-1.29)	**1.41** (1.22-1.63)	**1.64** (1.42-1.90)	**1.96** (1.68-2.26)	**2.20** (1.88-2.54)	**2.46** (2.09-2.83)	**2.72** (2.30-3.14)	**3.08** (2.57-3.55)	**3.37** (2.79-3.89)
24-hr	**1.01** (0.884-1.16)	**1.26** (1.11-1.45)	**1.58** (1.39-1.81)	**1.83** (1.60-2.10)	**2.18** (1.89-2.49)	**2.44** (2.12-2.78)	**2.71** (2.35-3.09)	**2.99** (2.57-3.40)	**3.36** (2.87-3.83)	**3.66** (3.11-4.16)
2-day	**1.06** (0.930-1.20)	**1.33** (1.17-1.50)	**1.66** (1.46-1.88)	**1.92** (1.68-2.17)	**2.27** (1.99-2.56)	**2.54** (2.21-2.87)	**2.82** (2.45-3.19)	**3.11** (2.68-3.51)	**3.49** (3.00-3.95)	**3.78** (3.24-4.29)
3-day	**1.15** (1.03-1.28)	**1.43** (1.28-1.60)	**1.78** (1.59-1.98)	**2.05** (1.82-2.28)	**2.41** (2.14-2.68)	**2.69** (2.38-2.99)	**2.97** (2.62-3.31)	**3.26** (2.87-3.63)	**3.64** (3.19-4.06)	**3.94** (3.43-4.40)
4-day	**1.24** (1.13-1.36)	**1.54** (1.40-1.69)	**1.89** (1.71-2.08)	**2.17** (1.97-2.38)	**2.55** (2.30-2.80)	**2.84** (2.55-3.11)	**3.13** (2.80-3.43)	**3.42** (3.05-3.75)	**3.80** (3.38-4.18)	**4.09** (3.63-4.51)
7-day	**1.41** (1.29-1.54)	**1.76** (1.60-1.92)	**2.14** (1.95-2.34)	**2.44** (2.22-2.66)	**2.84** (2.58-3.09)	**3.14** (2.84-3.42)	**3.43** (3.10-3.75)	**3.72** (3.36-4.06)	**4.10** (3.69-4.48)	**4.38** (3.92-4.80)
10-day	**1.57** (1.43-1.71)	**1.94** (1.78-2.12)	**2.38** (2.18-2.59)	**2.72** (2.49-2.96)	**3.18** (2.91-3.45)	**3.52** (3.21-3.83)	**3.87** (3.51-4.20)	**4.21** (3.81-4.57)	**4.65** (4.19-5.06)	**4.98** (4.47-5.43)
20-day	**1.96** (1.79-2.15)	**2.44** (2.22-2.67)	**2.96** (2.70-3.24)	**3.36** (3.06-3.67)	**3.86** (3.52-4.23)	**4.23** (3.84-4.63)	**4.59** (4.16-5.01)	**4.93** (4.46-5.38)	**5.35** (4.83-5.85)	**5.66** (5.09-6.19)
30-day	**2.36** (2.15-2.56)	**2.92** (2.67-3.18)	**3.52** (3.21-3.82)	**3.96** (3.61-4.30)	**4.52** (4.11-4.90)	**4.92** (4.46-5.33)	**5.29** (4.80-5.74)	**5.65** (5.12-6.13)	**6.08** (5.50-6.60)	**6.39** (5.76-6.94)
45-day	**2.88** (2.64-3.13)	**3.57** (3.28-3.88)	**4.26** (3.90-4.63)	**4.75** (4.35-5.16)	**5.35** (4.90-5.81)	**5.76** (5.27-6.27)	**6.14** (5.62-6.68)	**6.48** (5.92-7.05)	**6.87** (6.27-7.48)	**7.12** (6.50-7.74)
60-day	**3.32** (3.04-3.61)	**4.10** (3.77-4.47)	**4.89** (4.50-5.33)	**5.46** (5.02-5.94)	**6.15** (5.65-6.69)	**6.62** (6.08-7.20)	**7.05** (6.47-7.68)	**7.44** (6.83-8.11)	**7.89** (7.24-8.61)	**8.18** (7.51-8.93)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

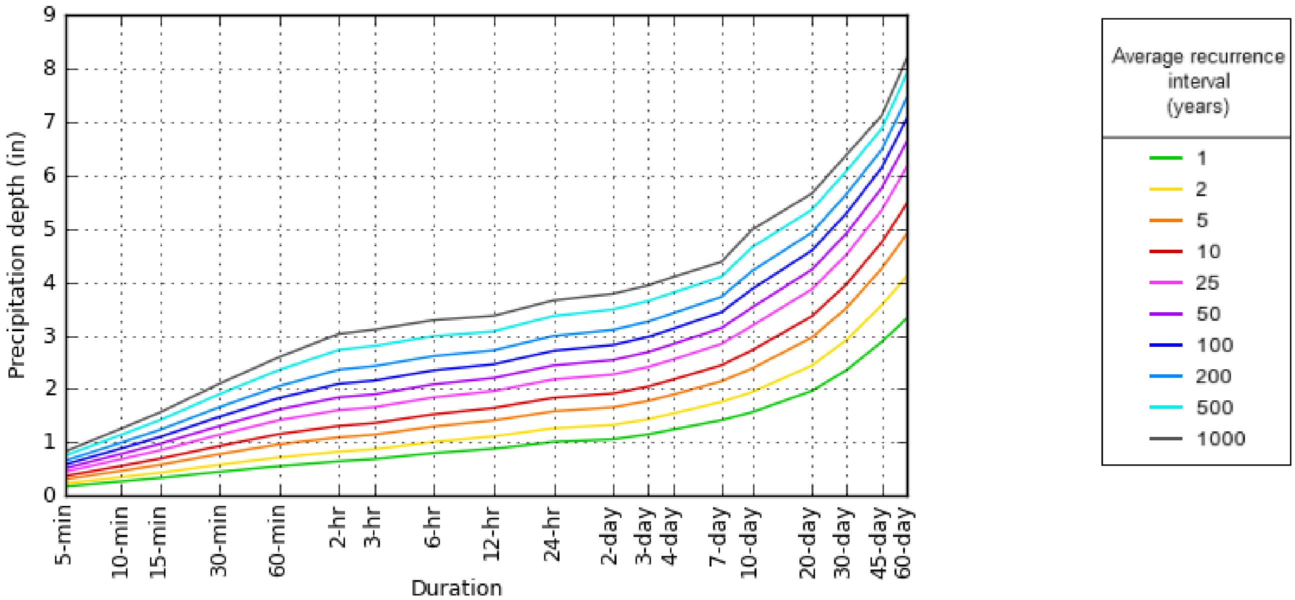
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

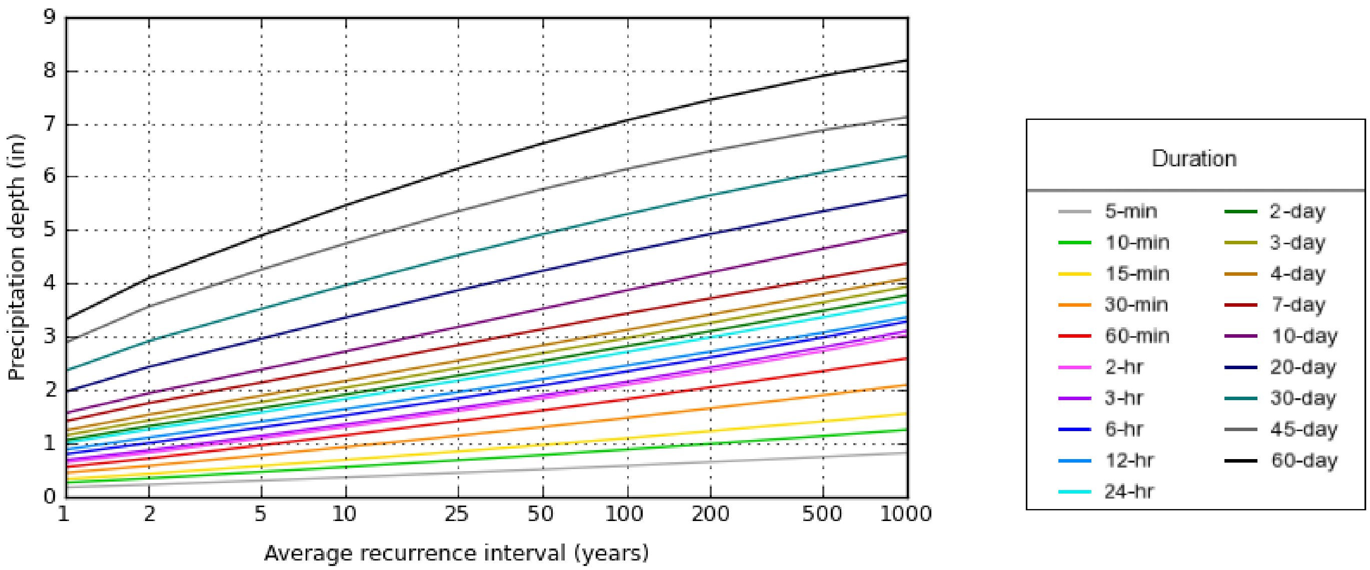
Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 35.0921°, Longitude: -106.5862°



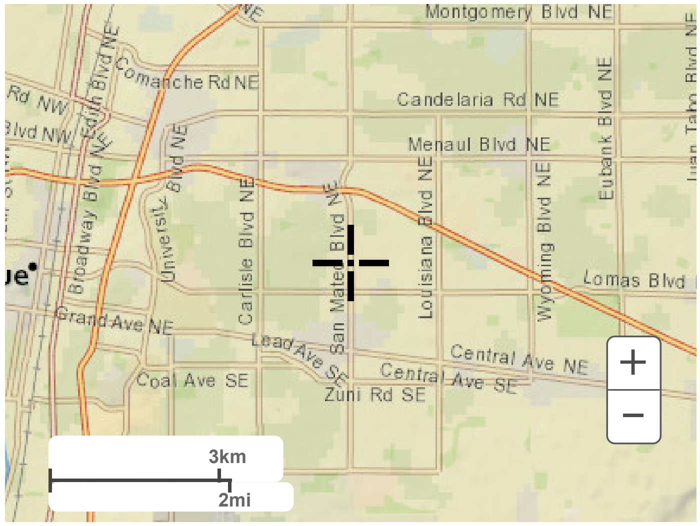


NOAA Atlas 14, Volume 1, Version 5 Created (GMT): Tue Mar 21 21:26:48 2023

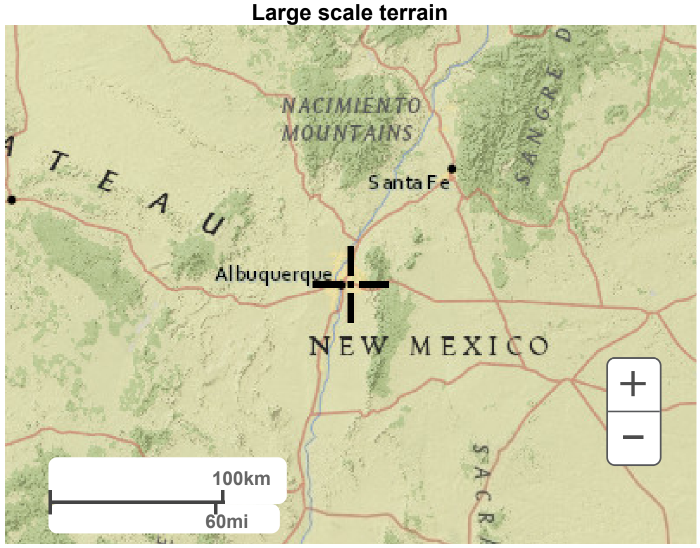
Back to Top

Maps & aerials

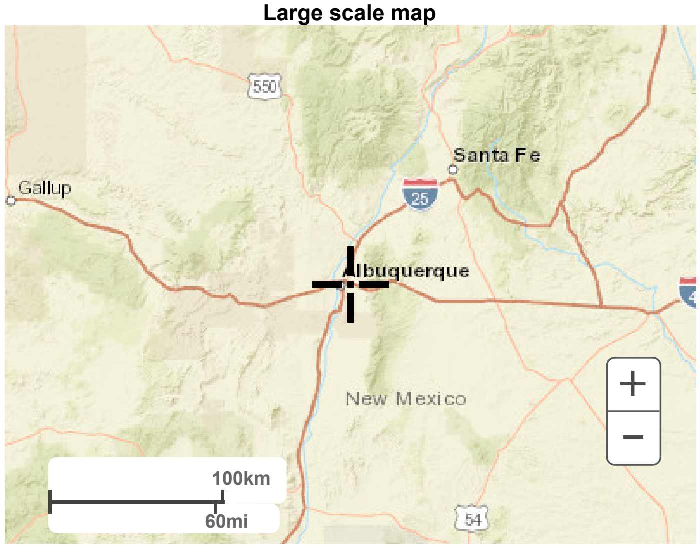
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

Back to Top

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Questions?: HDSC.Questions@noaa.gov

APPENDIX B – SAN MATEO TO MOON MINI DRAINAGE MANAGEMENT PLAN EXCERPTS

FINAL
SAN MATEO to MOON MINI

DRAINAGE MANAGEMENT PLAN

Volume 1

Prepared for:

Albuquerque Metropolitan Arroyo Flood Control Authority

AMAFCA

Prepared by:

SMITH ENGINEERING

Smith Engineering Company

November 2017

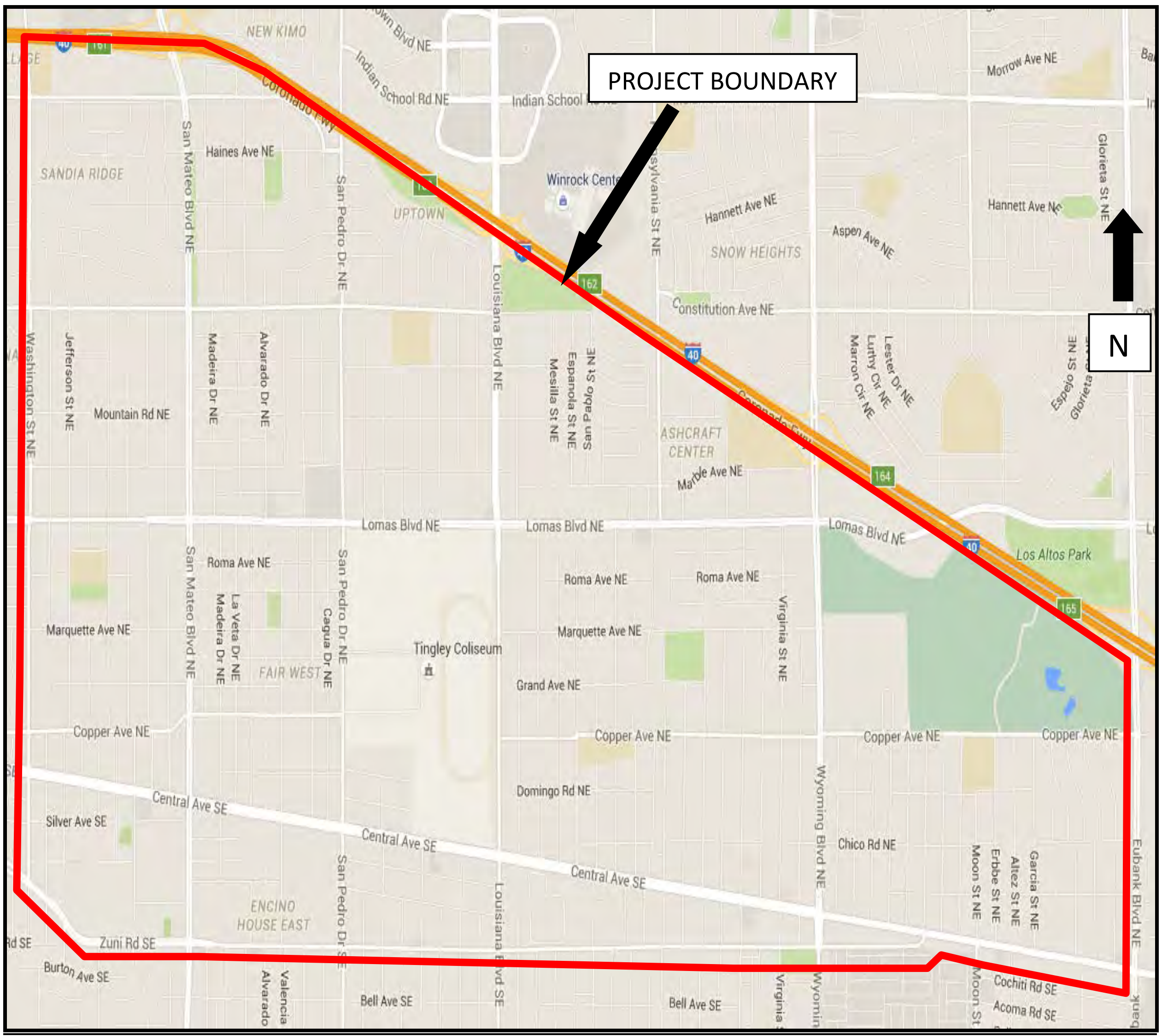
SEC Project. No. 115115

SECTION 1. GENERAL PROJECT INFORMATION

1.1 Description and Purpose of Project

The Albuquerque Metropolitan Arroyo and Flood Control Authority (AMAFCA) authorized Smith Engineering Company (Smith) to prepare a drainage management plan for the San Mateo to Moon basin. The purpose of the management plan is to analyze existing drainage conditions, determine deficiencies and develop proposed improvements. While the master plan is titled San Mateo to Moon Mini Drainage Management Plan, the true western boundary of the basin ends at Washington St. NE. This modification of the basin boundary was requested by AMAFCA. **Figure 1.0** below shows the Washington to Moon basin project vicinity map.

Figure 1.0 Washington to Moon Basin Vicinity Map



1.2 Field Observation

Smith conducted field observations to verify basin and subbasin boundaries and inspect drainage structures. **Appendix 1** contains annotated photographs.

SECTION 2. EXISTING HYDROLOGIC AND HYDRAULIC ANALYSES

2.1 Basin Description and Drainage Issues

Drainage Basin Description

The total basin area is approximately 4.5 square miles of fully developed urban land characterized by commercial and residential development and several City of Albuquerque parks. The basin has an extensive storm drain network and three detention ponds located in the Expo NM grounds. The infrastructure contains new and old systems with record drawings ranging from the 1960s to 2014. The basin generally drains from east to west. The large diameter interceptor storm drains are generally located in north-south direction streets; however, the conveyance capacity of these large diameter storm drains is limited due to the mild south to north slopes that rarely exceed 1%. Due to mild slopes, the interceptor storm drains often flow under pressure and drain at a slow rate. The east-west subbasin slopes range from 1-3% and the surface runoff drains to the interceptor storm drains faster than these storm drains can convey.

This conflict in timing of the pressure flow storm drain hydrographs and the surface hydrographs creates a significant drainage problem. Once flowing under pressure, assuming the storm drain hydraulic grade lines are at the grate elevations, these interceptor storm drains cannot capture additional surface runoff. Therefore, surface runoff accumulates as it flows west and creates flooding during heavy rainfall events. The five main interceptor storm drains that drain from south to north are listed below. The systems annotated with CW are those that convey offsite flows into the study basin from the southern adjacent Campus Wash Basin.

- Moon St. Storm Drain System
- Wyoming Blvd. Storm Drain system
- Dallas St. Storm Drain System - CW
- Alcazar St. Storm Drain System (Expo NM Storm Water Relief Phases 1&2) - CW
- San Pedro Dr. - Central Heights Storm Drain - CW
- San Mateo Blvd. Storm Drain System - CW

Figure 1.1 shows the layout of the existing storm drain network.

2.5 Hydrologic Modeling Parameters and Assumptions

2.5.1 Rainfall Distribution

The study basin is located within the USDA Natural Resources Conservation Service (NRCS) previously the Soil Conservation Service (SCS) Type II rainfall distribution area as defined by the NRCS. Please refer to **Appendix 4** for Type II boundaries.

However, AMAFCA dictated that the 25% Frequency Storm Distribution be adopted within the HEC-HMS program. It places most of the rainfall in a short period at 25% of the storm duration, or at 6-hours for a 24-hour storm.

2.5.2 Areal Reduction Factors

No areal reduction factors were necessary since the basin is less than 10 square miles.

2.5.3 Point Rainfall Data

Point rainfall data for the 2-yr., 10-yr. and 100-yr. return period storms for various durations were obtained from NOAA Atlas 14 website. **Appendix 4** contains the printouts from the NOAA Atlas 14-point rainfall data results. **Table 2.2** (**Appendix 4**) contains the point rainfall depth data.

2.5.4 Soils Data

Soils data were obtained from the NRCS Web Soil Survey website. **Appendix 4** contains the detailed soils report from the NRCS site. The soils report indicated that the predominant Hydrologic Soil Groups (HSGs) are HSG "A" and "B".

2.5.5 Runoff Curve Number Rainfall Loss Method

The SCS Runoff Curve Number (CN) method was adopted to approximate rainfall initial abstraction and infiltration losses. The CN rainfall loss method simulates initial abstraction and infiltration as a combined CN value. The NRCS **Table 2-2a** (included in **Appendix 4**) was adopted for CN selection in urban areas. Sensitivity analyses were conducted to ensure that unit peak discharges (cfs/acre) were within the range of values presented in the City of Albuquerque Development Process Manual. Results are documented in **Table 2.3.1**, **and 2.3.2** within **Appendix 4**. The following assumptions were applied to select CN values:

1. Parks were assigned a CN of 49 assuming "fair" cover conditions.

2. Impervious areas were assigned a CN of 98.

3. An average lot size of 1/8th acre was assumed after sampling average lot sizes for several homogenous residential subbasins which is conservative as a few areas have larger lot sizes.

4. Residential areas were assigned a CN of 80.

Table 2.4 (**Appendix 4**) contains the subbasin areas and CNs assigned to all land treatment types.

2.5.6 Time of Concentration (T_c), Lag Time (T_L) and Travel Time (T_T) Computations

The NRCS TR-55 T_c method was adopted. A water course may have up to three sub reaches that comprise the longest flow path. The upper overland flow reach, then a shallow concentrated flow reach followed by a channel reach. The time of concentration (T_c) for the watercourse equals the summation of travel times (T_t) from each sub-reach. **Appendix 4** contains the TR-55 description and procedures. The various reaches and their physical characteristics were determined from the topographic data and field observation. **Table 2.6** summarizes the input, calculations and T_c for all subbasins. The T_c flow paths are documented on **Figures 3.1 and 3.2** which are included digitally. There were several subbasins that were entirely pervious (grassy fields) such as those delineated on the Los Altos Golf Course south east of Lomas Blvd. & Wyoming Blvd. The parameters for these basins were changed to reflect the appropriate friction factors.

Appendix 4 contains the reference pages that describe the lag time concept and method from National Engineering Handbook, May 2015, Chapter 15. Manning's Roughness Coefficients "n" assumptions were obtained from: NRCS TR-55, by experience and by review of "n" value tables by Chow, 1959 (copies include in **Appendix 4**). The NRCS Unit Hydrograph Lag Time Method (T_L) was applied to the T_c to compute the unit hydrograph Time to Peak (T_p). Note that Lag Time = 0.6 T_c. Since this hydrologic analysis implements the use of split hydrographs (discussed in the next section) the procedure applied with subbasin T_c is discussed in the next section to set the context of discussion.

2.5.7 Split Hydrograph Method

When subbasins are relatively homogeneous in terms of land use and Runoff Curve Numbers (CNs), an areal weighted CN approach may be acceptable where CNs vary by 10 or less. When non-homogeneous land use types occur and a where CNs vary by greater than 10, the subbasin runoff is more accurately simulated with spilt hydrographs as described here. For a mixed land use subbasin such as one comprised of commercial and residential, the split hydrograph method simulates the quick response, high runoff volume, and peak rate of the impervious area and the slower response and less runoff volume and peak rate from the residential area more accurately. The split hydrograph method is even more important when the impervious part of the subbasin is near the subbasin outlet.

The original subbasin is subdivided into the impervious subbasin area and the pervious subbasin area. These subdivided subbasin hydrographs are combined to simulate the final subbasin hydrograph.

Impervious Area Assumptions and Computations for Split Hydrographs

1. Measure the impervious area.
2. Assume fast travel times for impervious areas and therefore assume a minimum T_c of 12 minutes.
3. Assume CN of 98 as prescribed by NRCS **Table 2-2a** (included in **Appendix 4**) for impervious areas.
4. The pervious part of the subbasin is assigned the computed T_c and assigned a weighted CN based on CN values presented in NRCS **Table 2-2a** (included in **Appendix 4**).
5. Simulate the pervious and impervious hydrographs and combine at a junction.

Table 2.4 (**Appendix 4**) contains the subbasin areas and CNs assigned to all land treatment types. For these subbasins the following procedure was used for T_c calculations. Typically, the computed T_c was applied to the pervious part of the subbasin while the minimum T_c of 12 minutes was applied to the impervious part of the subbasin. Several impervious subbasins were sampled for their longest flow paths. In all cases the computed T_c fell below the minimum requirement of 12 minutes primarily due to very short flow path lengths. As a result, no further T_c calculations were performed for the remaining impervious subbasins of similar size and flow path lengths. There were some instances where impervious subbasins were of large enough size that T_c computation had to be performed. These subbasins are documented on **Table 2.6** in **Appendix 4**.

2.5.8 Channel Routing

HEC-HMS channel routing experience from other urban drainage analyses has shown that with short and moderately steep routing reaches, little if any attenuation occurs by routing. Therefore, hydrographs were not routed.

2.5.9 Computation Time Increment for HEC-HMS Models

The computation increment assumed within a HEC-HMS model may make a significant difference in model peak discharge results particularly for large drainage basins. Guidance on computation intervals was found in a Digital Engineering Library (McGraw-Hill, a copy included in **Appendix 4**) and summarized here.

The computation time increment is typically based on T_c and the following equation:

$$T_c / 5 \leq \text{computation time increment} \leq T_c / 3$$

The computation time increment was selected as 4 minutes based on this inequality.

2.5.10 Campus Wash Hydrographs

Review of the Campus Wash Drainage Management Plan (2008) clearly indicated that several 100-yr. 24-hr. storm inflow hydrographs must be imported into this study. Note that the Campus Wash study only simulated the 100-yr. 24-hr. storm. **Table 2.1** (**Appendix 4**) presents a summary of the Campus Wash hydrograph inflow locations, drainage areas and hydrologic summary. The Campus Wash hydrographs inflow locations are illustrated on **Figure 2.0 and Figures 2.1 and 4.1** (included digitally).
The Campus Wash hydrographs generated with AHYMO_97 have a time to peak of about 1.6 hours for the100-year storm which creates a disparity when combining those hydrographs within

HEC-HMS that will generate hydrographs with a peak located at about 6 hours (the 25% frequency distribution for the 24-hr. storm).

Therefore, the AHYMO_97 hydrographs were shifted in time so that the peaks coincided at 6 hours to match the HEC-HMS hydrograph peaks. Hydrographs for the 2-yr. and 10-yr. storms are not available from the Campus Wash study and would be very difficult to recreate in the Campus Wash AHYMO_97 model as numerous divide hydrograph values were based on the 100-year hydrographs, and therefore this effort was beyond the scope of this study. Therefore, a procedure was developed to synthesize the 2-yr. and 10-yr. hydrographs which are included **Appendix 4.**

2.5.11 Flow Divides

Flow divides become a critical hydrologic component particularly in an urban environment that has storm drain infrastructure. This requires an accounting of the flow divide quantity and direction or outfall.

Three primary factors govern flow divides for hydrographs:

1. The total hydrograph.
2. Total inlet capacity - inlet capture capacity was assumed to be 5 cfs per inlet as recommended by AMAFCA based on experience from data accumulated over numerous study reports and design projects
3. Downstream storm drain capacity.

Once all locations of all infrastructure components are known, either inlet capacity or storm drain capacity will control the flow divide value. For example, if the hydrograph peak discharge is 30 cfs, the inlet capacity is 20 cfs and storm drain capacity is 50 cfs, the inlet capacity will govern the flow divide. All hydrograph values less than 20 cfs will be divided into the storm drain and all hydrograph values greater than 20 cfs will bypass the inlet(s) and remain as surface flow.

2.6 Existing Conditions Modeling Results

Task B summarized the deficiencies in the hydraulic capacity of the interceptor storm drains. In summary, after the Campus Wash hydrographs were imported into HEC-HMS, no capacity remained within the Dallas, Alcazar, San Pedro and San Mateo storm drains. Therefore, no surface runoff hydrographs could be diverted into these interceptor storm drains. Consequently, the surface runoff hydrographs accumulated from the east to the west. The flow accumulation across the basin was documented with analysis points and these are presented in **Figure 2.1** and **Figure 4.1** (included digitally).

Based on the existing conditions analysis, an inundation map was prepared. HEC-RAS 2D was utilized to generate inundation depths and limits for the watershed. The procedure is described in the flow chart below.

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
29	OUTFLOW FROM SAN PEDRO NORTH POND INTO CENTRAL HEIGHTS SD PLUS SD INLFOW FROM CAMPUS WASH PLUS L1.2	233	CENTRAL HEIGHTS SD AT FULL CAPACITY AT 132 CFS UNTIL SAN PEDRO AND CONSTITUTION. EXCESS OVERLFOW FROM SAN PEDRO SPILLS WEST ON ROMA AND ADDS TO BASIN 29	CENTRAL HEIGHTS STORM DRAIN SYSTEM
29.1	SURFACE OVERFLOW FROM NORTH SAN PEDRO POND PLUS BASIN 29	292	NO SD. OVERLAND BYPASS INTO BASIN 28	
30	OVERLAND BYPASS FROM AP 24 PLUS BASIN L2 AND SD INFLOW FROM SAN PEDRO PONDS	434	CENTRAL HEIGHTS SD AT FULL CAPACITY **(132 CFS*)** FROM SAN PEDRO PONDS. BYPASS ALL FLOWS OVERLAND WEST TO BASIN 27	
31	LSPN-1 PLUS SD INLFOW FROM SAN PEDRO PONDS	27	CENTRAL HEIGHTS SD AT FULL CAPACITY **(132 CFS*)** FROM SAN PEDRO PONDS. BYPASS ALL FLOWS OVERLAND WEST TO BASIN 26	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
32	OVERLAND BYPASS FROM AP 26, BASIN LSPN-2A, PLUS LSPN-2 PLUS SD INFLOW FROM SAN	369	CENTRAL HEIGHTS SD AT FULL CAPACITY **(132 CFS*)** FROM SAN PEDRO PONDS. BYPASS ALL FLOWS OVERLAND WEST TO BASIN 24	CENTRAL HEIGHTS STORM DRAIN SYSTEM
33	OVERLAND BYPASS FROM AP 27, BASIN LSPN-3A, PLUS LSPN-3, PLUS INFLOW FROM SAN	94	CENTRAL HEIGHTS SD AT FULL CAPACITY **(132 CFS*)** FROM SAN PEDRO PONDS. BYPASS ALL FLOWS OVERLAND WEST TO BASIN 19	
34	OVERLAND BYPASS FROM AP 28, BASIN LSPN-4A, PLUS LSPN-4, PLUS SD INLFOW FROM SAN PEDRO PONDS	305	CENTRAL HEIGHTS SD AT FULL CAPACITY **(132 CFS*)** FROM SAN PEDRO PONDS. BYPASS ALL FLOWS OVERLAND WEST TO BASIN 17	
35	CENTRAL HEIGHTS SD INFLOW PLUS 15 CFS FROM BASIN LSPN-5	147	OUTFALL OF CENTRAL HEIGHTS SD. INFLOW FROM LSPN-5 RESTRICTED BY INLETS	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
20	OVERLAND BYPASS FLOW FROM AP 16 PLUS BASIN 39	308	NO STORM DRAINS. SURFACE FLOW TO BASIN 38	SAN PABLO OUTFALL
20.1	OVERLAND BYPASS FROM BASIN 40 PLUS 34	113	SAN PABLO OUTFALL RESTRICTED BY OUTFALL 57 CFS PIPE CAPACITY. DIVERT 113 OVERLAND TO BASIN 32	
21	OVERLAND BYPASS FROM AP 20.1 PLUS BASIN 32	141	NO SD. BYPASS FLOWS OVERLAND TO BASIN 31	
24	OVERLAND BYPASS FLOWS FROM AP 20 PLUS BASIN 38	358	NO SD. BYPASS FLOWS OVERLAND TO BASIN L2	
25	OVERLAND BYPASS FLOWS FROM BASINS 41, 40A, 37 PLUS BASIN 36	241	NO SD. BYPASS FLOWS OVERLAND TO BASIN LSPN-2A	
26	BASIN 35	61	NO SD. BYPASS FLOWS OVERLAND TO BASIN LSPN-2A	
27	BASIN 33	28	SD INLETS PLUGGED. BYPASS FLOWS OVERLAND TO BASIN LSPN-3A	
28	OVERLAND BYPASS FROM AP 21 PLUS BASIN 31	198	SD INLETS PLUGGED. BYPASS FLOWS OVERLAND TO BASIN LSPN-4A	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN SUMMARY OF ANALYSIS POINTS FOR EXISTING CONDITIONS

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
10	OVERLAND BY PASS FROM AP 6&7 PLUS BASIN LO-1	379	DOWNSTREAM **DALLAS SD AT FULL CAPACITY DUE TO INLFOW HYDROGRAPH (274 CFS * ASSUMES PRESSURE FLOW) FROM THE CAMPUS WASH STUDY.** ALL SURFACE FLOWS AT AP 10 BYPASS OVERLAND TO LO-2 AND NOT ADDED TO COLLECTOR SD ON COPPER	DALLAS-PENNSYLVANIA STORM DRAIN SYSTEM
11	OVERLAND BY PASS FROM AP 8 PLUS BASN L3	120	SURFACE FLOW FROM L3 PLUS OVERLAND BYPASS FLOW FROM AP8. THERE ARE NO EXISTING STORM DRAINS AT AP8	
12	OVERLAND BY PASS FROM AP 9 PLUS BASIN 43 PLUS CAMPUS WASH SD INFLOW	140	ALL SURFACE FLOWS BYPASS OVERLAND TO 42 BECAUSE OF CHOKE POINT AT THE OUTFALL. **THE OUTFALL IS AT FULL CAPACITY DUE TO THE WYOMING SD DISCHARGE OF 189 CFS***	
13	BASIN 41	71	ALL SURFACE FLOWS BYPASS OVERLAND TO 40 BECAUSE OF CHOKE POINT AT THE OUTFALL CREATED BY THE WYOMING SD SYSTEM. THIS SYSTEM IS CONNECTED TO THE SAME OUTFALL MH AS THE WYOMING SYSTEM THEREFORE WYOMING SYSTEM GOVERNS WITH 189 CFS*	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN SUMMARY OF ANALYSIS POINTS FOR EXISTING CONDITIONS

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
14	OVERLAND BYPASS FROM AP 10 PLUS BASIN LO-2 PLUS CAMPUS WASH SD FLOW	468	**DALLAS SD AT FULL CAPACITY DUE TO INLFOW HYDROGRAPH (274 CFS) FROM THE CAMPUS WASH STUDY.** ALL SURFACE FLOWS AT AP 14 BYPASS OVERLAND TO LO-3	DALLAS-PENNSYLVANIA STORM DRAIN SYSTEM
15	OVERLAND FLOW FROM AP11 PLUS BASIN 45 PLUS CAMPUS WASH SD FLOW	134	**DALLAS SD AT FULL CAPACITY DUE TO INLFOW HYDROGRAPH (274 CFS) FROM THE CAMPUS WASH STUDY.** ALL SURFACE FLOWS AT AP 15 BYPASS OVERLAND TO LO-6	
16	OVERLAND FLOW FROM AP 12 PLUS BASINS 42 &44 PLUS CAMPUS WASH SD INFLOW	239	**DALLAS SD AT FULL CAPACITY DUE TO INLFOW HYDROGRAPH (274 CFS) FROM THE CAMPUS WASH STUDY.** ALL SURFACE FLOWS AT AP 14 BYPASS OVERLAND TO 20	
17	SD INFLOW FROM CAMPUS WASH	274	DALLAS SD OUTFALL	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN SUMMARY OF ANALYSIS POINTS FOR EXISTING CONDITIONS

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
6	OVERLAND BYPASS FROM AP 1, LWE-1	152	ADD 56 CFS OVERLAND BYPASS FROM AP 1 WYOMING STORM DRAIN UNDER CAPACITY. BYPASS 152 WEST OVERLAND TO LO-1	WYOMING STORM DRAIN SYSTEM
7	SD FLOW FROM AP 6, LWE-2	59	DIVERT 60 CFS FROM LWE-2 INTO WYOMING SD DUE TO GOVERNING INLET CAPACITY. BYPASS EXCESS OVERLAND TO LO-1	
8	SD FLOW FROM AP 7, LWE- 3	56	DIVERT 70 CFS FROM LWE-3 INTO WYOMING SD DUE TO GOVERNING INLET CAPACITY. BYPASS EXCESS SURFACE WEST TO L3. 189* CFS ASSUMES PRESSURE FLOW	
9	SD FLOW FROM AP 8 AND TOTAL SURFACE FLOW FROM LWE-4, M7,46	96	WYOMING SD CAPACITY RESTRICTED BY DOWNSTREAM CHOKE POINT AT OUTFALL. ALL FLOWS DIVERTED WEST OVERLAND TO 43 . **189* CFS ASSUMES PRESSURE FLOW**	
13.1	AP 6 - AP 9	---	WYOMING SD CAPACITY RESTRICTED BY DOWNSTREAM CHOKE POINT AT OUTFALL. ALL FLOWS DIVERTED WEST OVERLAND TO 43 . **189* CFS ASSUMES PRESSURE FLOW**	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN SUMMARY OF ANALYSIS POINTS FOR EXISTING CONDITIONS

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
		cfs		
1.1	M1	0	TOTAL FLOW FULLY CAPTURED AT STORM DRAIN AND ADDED TO AP 1	MOON STORM DRAIN SYSTEM
1	AP 1.1 SD FLOW , M2	56	NOT ENOUGH INLETS FOR 100% CAPTURE OF SURFACE FLOW. ADD 108 CFS OUT M2 TO SD AND 56 CFS BYPASSES WEST OVERLAND AND ADDS TO LWE-1	
2	AP 1 SD FLOW , M3A	0	TOTAL FLOW FULLY CAPTURED AT STORM DRAIN	
3	AP 2 SD FLOW, M3B	0	SURFACE FLOW FULLY CAPTURED AT STORM DRAIN	
4	AP 3 SD FLOW, M3C	0	SURFACE FLOW FULLY CAPTURED AT STORM DRAIN	
5	AP4 SD FLOW PLUS OVERLAND Q M5	0	MOON SD OUTFALL. 10 CFS RUNOFF FROM M5 DOES NOT ENTER THE SD SYSTEM. SD & SURFACE FLOWS COMBINE AT PONDING AREA BEFORE ENTERING THE I-40 CHANNEL THROUGH BOX CULVERTS	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
48	OVERLAND BYPASS FROM AP 41 PLUS BASIN 100	223	SMALL DIAMETER STORM DRAIN IN SUMMER AVE. IS SEVERELY UNDERSIZED	ADDENDUM 1 AREA
49	OVERLAND BYPASS FROM AP 40 PLUS OVERLAND BYPASS FROM AP48	649	NO STORM DRAIN AVAILABLE	
50	OVERLAND BYPASS FROM AP 36, 37, 38, 39 PLUS 101,102,103,104, & CW180	1089	BYPASS AS A RESULT OF INSUFFICIENT INLETS AND STORM DRAIN CAPACITY	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
41.1	OVERLAND FLOW FROM AP 34.1, AP 42,PLUS CAMPUS WASH SD INFLOW PLUS BASINS 9 & 16	506	SAN MATEO STORM DRAIN AT FULL CAPACITY DUE TO INFLOW CAMPUS WASH HYDROGRAPH OF 797 CFS. ASSUME SD TO BE UNDER PRESSURE AND BYPASS ALL FLOWS WEST ON CONSTITUTION	SAN MATEO STORM DRAIN SYSTEM
42	OVERLAND FLOW FROM AP 35.1, 50% OF BASINS 12&13 PLUS BASIN 14	140	SAN MATEO STORM DRAIN AT FULL CAPACITY DUE TO INFLOW CAMPUS WASH HYDROGRAPH OF 797 CFS. ASSUME SD TO BE UNDER PRESSURE. FLOWS	
43	OVERLAND BYPASS FROM BASIN 11 PLUS BASIN 10	0	SE CORNER OF INDIAN SCHOOL AND SAN MATEO. FLOW GOES OUT OF SYSTEM	
43.1	50 % OVERLAND FLOW FROM BASINS 12 & 13 PLUS 9A	60	FLOW DRAINS OUT OF SYSTEM WEST ON INDIAN SCHOOL AND OUT TO I-40 CHANNEL	
44	CAMPUS WASH SD INFLOW PLUS BASIN 8	556	SAN MATEO STORM DRAIN AT FULL CAPACITY DUE TO INFLOW CAMPUS WASH HYDROGRAPH OF 797 CFS. ASSUME SD TO BE UNDER PRESSURE.BYPASS FLOWS OVERLAND INTO BASIN 7	SAN MATEO STORM DRAIN SYSTEM ALONG SUNNINGDALE TO OUTFALL
45	OVERLAND BYPASS FLOW FROM AP 44 , CAMPUS WASH SD INFLOW PLUS BASINS 6&7	606	DIVERSION AT AP 45 IS 50 CFS BASED ON INLET CAPACITY. BYPASS EXCESS OVERLAND TO BASIN 3	
46	OVERLAND BYPASS FLOW FROM AP 45,PLUS CAMPUS WASH SD INFLOW PLUS BASINS 3,4 & 5	686	DIVERSION AT AP 45 IS 70 CFS BASED ON DOWNSTREAM PIPE CAPACITY. BYPASS EXCESS OVERLAND TO BASIN 1	
47	*OUTFALL AT I-40 CHANNEL*	1585	*OUTFALL OF SAN MATEO SD PLUS ALL EXCESS OVERLAND BYPASS FLOW DRAINS UNDER THE BRIDGE AT INDIAN SCHOOL AND SUNNINGDALE AND DRAINS TO THE NORTH END OF THE COMPLEX WHERE IT DRAINS INTO A PONDING AREA BEFORE GETTING INTO THE I-40 CHANNEL*	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN SUMMARY OF ANALYSIS POINTS FOR EXISTING CONDITIONS

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
38	OVERLAND BYPASS FLOW FROM AP 30, PLUS CAMPUS WASH SD INFLOW PLUS BASIN 27	491	SAN MATEO STORM DRAIN AT FULL CAPACITY DUE TO INFLOW CAMPUS WASH HYDROGRAPH OF 797 CFS. ASSUME SD TO BE UNDER PRESSURE AND BYPASS ALL FLOWS WEST ON LOMAS	SAN MATEO STORM DRAIN SYSTEM
39	OVERLAND BYPASS FLOW FROM AP 31.1, CAMPUS WASH SD INFLOW PLUS BASIN 25	135	SAN MATEO STORM DRAIN AT FULL CAPACITY DUE TO INFLOW CAMPUS WASH HYDROGRAPH OF 797 CFS. ASSUME SD TO BE UNDER PRESSURE AND BYPASS ALL FLOWS WEST ON MARBLE	
40	OVERLAND FLOW FROM AP 32.1 , PLUS CAMPUS WASH SD INFLOW PLUS BASINS 20, 21,22,23	466	SAN MATEO STORM DRAIN AT FULL CAPACITY DUE TO INFLOW CAMPUS WASH HYDROGRAPH OF 797 CFS. ASSUME SD TO BE UNDER PRESSURE AND BYPASS ALL FLOWS WEST ON MOUNTAIN	
41	OVERLAND FLOW FROM AP 33.1, CAMPUS WASH SD INFLOW PLUS BASIN 18	161	SAN MATEO STORM DRAIN AT FULL CAPACITY DUE TO INFLOW CAMPUS WASH HYDROGRAPH OF 797 CFS. ASSUME SD TO BE UNDER PRESSURE AND BYPASS ALL FLOWS WEST ON SUMMER	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
31.1	OVERLAND BYPASS FROM AP 31 PLUS BASIN 26	94	NO SD. BYPASS FLOWS OVERLAND TO BASIN 25	SAN MATEO STORM DRAIN SYSTEM
32.1	OVERLAND BYPASS FROM AP 32 PLUS BASIN 24	402	NO SD. BYPASS FLOWS OVERLAND TO BASIN 22	
33.1	OVERLAND BYPASS FROM AP 33 PLUS BASIN 19	128	NO SD. BYPASS FLOWS OVERLAND TO BASIN 18	
34.1	OVERLAND BYPASS FROM AP 34 PLUS BASIN 17	338	NO SD. BYPASS FLOWS OVERLAND TO BASIN 18	
35.1	OVERLAND FLOW FROM LSPN -5 PLUS BASIN 15	87	NO SD. BYPASS FLOWS OVERLAND TO BASIN 14	
35.2	BASIN 13	15	NO SD. BYPASS FLOWS OVERLAND TO BASIN 12	
36	OVERLAND AND SD INFLOW FROM CAMPUS WASH, BASIN 30 PLUS 28A	150	SAN MATEO STORM DRAIN AT FULL CAPACITY DUE TO INFLOW CAMPUS WASH HYDROGRAPH OF 797 CFS. ASSUME SD TO BE UNDER PRESSURE AND BYPASS ALL FLOWS WEST ON MARQUETTE	
37	OVERLAND BYPASS FLOW FROM AP 29.1, CAMPUS WASH SD INFLOW PLUS BASIN 28	338	SAN MATEO STORM DRAIN AT FULL CAPACITY DUE TO INFLOW CAMPUS WASH HYDROGRAPH OF 797 CFS. ASSUME SD TO BE UNDER PRESSURE AND BYPASS ALL FLOWS WEST ON ROMA	

SAN MATEO TO MOON MINI DRAINAGE MASTER PLAN SUMMARY OF ANALYSIS POINTS FOR EXISTING CONDITIONS

Analysis Point	CONTRIBUTING BASINS	OVERLAND BYPASS WEST Q (100 Yr-24Hr)	Comment	STORM DRAIN SYSTEM
18	OVERLAND BYPASS FROM AP 14 PLUS BASIN LO-3	580	ALL FLOWS BYPASS OVERLAND TO LO-4. NO EXISTING STORM DRAINS	ALCAZAR STORM DRAIN SYSTEM AND RACETRACK POND
19	OVERLAND BYPASS FLOW FROM AP 15 PLUS BASINS LO-5 & LO-6	155	DIVERT 35 CFS INTO CENTRAL HEIGHTS STORM DRAIN. DIVERSION LIMITED TO INLET CAPACITY ON MARQUETTE.BYPASS EXCESS OVERLAND TO LO-7	
22	OVERLAND BYPASS FLOW FROM AP 18 PLUS LO-4	666	CUMULATIVE OVERLAND FLOW AT COPPER & LOUISIANA UPSTREAM OF RACETRACK POND. **THE ALCAZAR SD IS AT FULL CAPACITY DUE TO CAMPUS WASH INFLOW HYDROGRAPH (412 CFS) THEREFORE NO FLOWS CAN BE ADDED INTO ALCAZAR SD FROM AP 22. CAMPUS WASH INFLOW VOLUME IS 47.3 AC-FT WHICH FILLS THE RACETRACK POND TO THE MAX**	
22.1	INFLOW HYDROGRAPH FROM CAMPUS WASH STUDY	412	90 " SD OUTFALL INTO RACETRACK POND	ALCAZAR STORM DRAIN SYSTEM AND RACETRACK POND
23	OVERLAND BYPASS FLOW FROM AP 19 PLUS LO-7	5	OVERLAND FLOW AT MARQUETTE & LOUISIANA UPSTREAM OF THE RACETRACK POND. 200 CFS CAPACITY GOVERNED BY INLETS	
23.1	SD FLOW INTO RACETRACK POND FROM AP 23	0	North ALCAZAR 66 " SD OUTFALL INTO RACETRACK POND	
23.2	LO-8	40	DIVERT 30 CFS INTO CENTRAL HEIGHTS STORM DRAIN. DIVERSION LIMITED TO INLET CAPACITY ON MARQUETTE.BYPASS EXCESS	
23T	TOTAL OVERLAND FLOW FROM AP 22, OVERLAND BYPASS FROM AP 23 AND 23.2	711	TOTAL SURFACE FLOW ALONG LOUISIANA THAT PONDS DUE TO LACK OF CAPACITY IN ALCAZAR SD AND RACE TRACK POND	

SAN MATEO TO MOON MINI DRAINAGE MANAGEMENT PLAN

FIGURE 2.1

EXISTING CONDITIONS DRAINAGE BASIN MAP

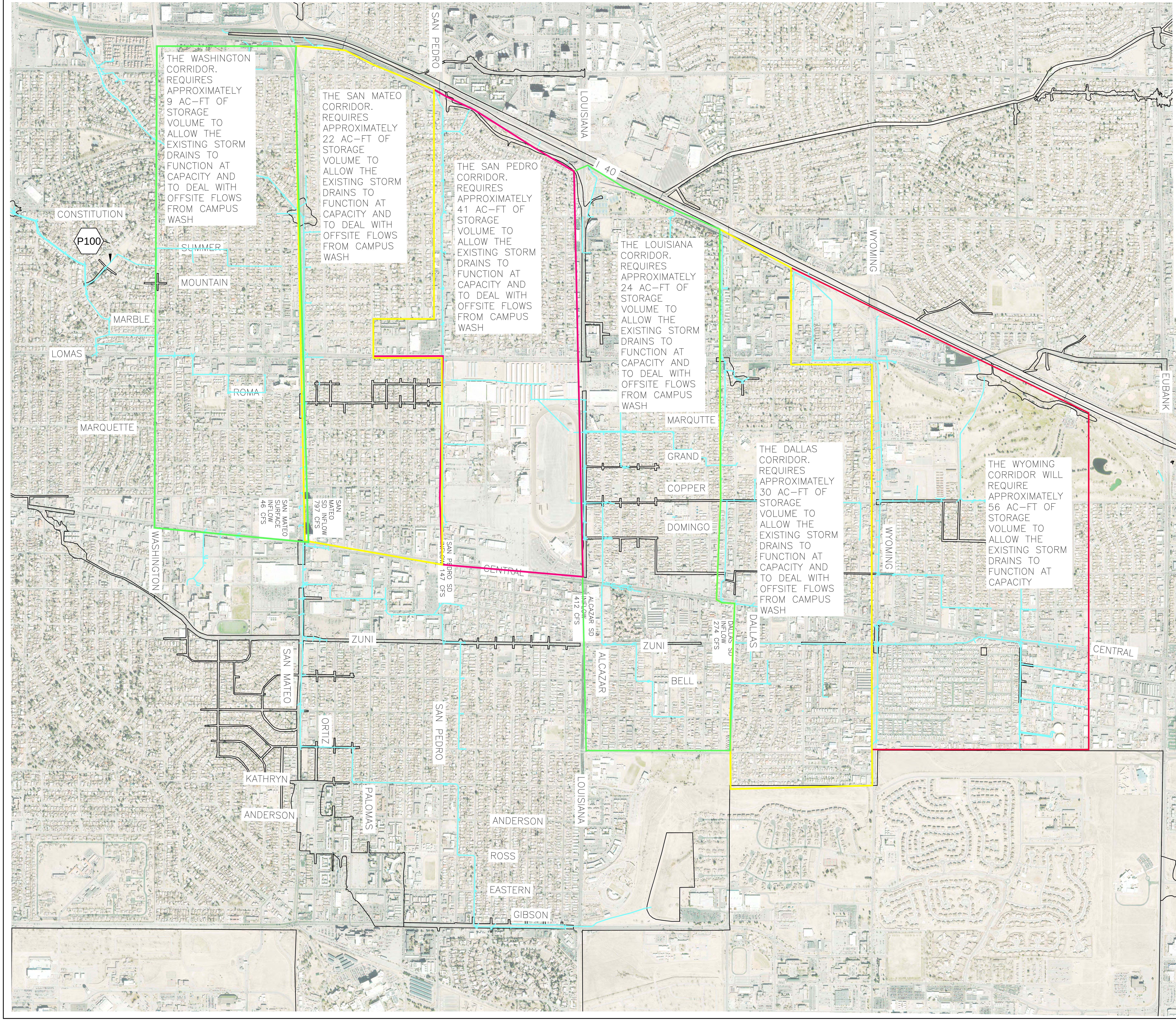
PREPARED FOR:
ALBUQUERQUE METROPOLITAN ARROYO AND FLOOD CONTROL AUTHORITY

AMAFCA

NOVEMBER, 2017

PREPARED BY:
SMITH ENGINEERING COMPANY

1989 - 2014 SMITH ENGINEERING COMPANY 25th Anniversary



LEGEND

EXISTING STORM DRAIN

BEING A FULLY DEVELOPED WATERSHED, VARIOUS CORRIDORS WERE IDENTIFIED. THESE CORRIDORS WERE DELINEATED BASED ON THE MAIN CONVEYANCE SYSTEM THAT DRAINS THE CONTRIBUTING AREA. WITHIN THE CORRIDOR, THE RECOMMENDED STORAGE WILL BE NECESSARY TO DIVERT AND DETAIN OVERLAND. THIS WILL ENABLE THE CONVEYANCE SYSTEMS TO OPERATE AT THEIR CAPACITY

NOT TO SCALE

SAN MATEO TO MOON MINI DRAINAGE MANAGEMENT PLAN

FIGURE 4.1

DRAINAGE BASIN MAP WITH POSSIBLE POND LOCATIONS

Prepared for:
Albuquerque Metropolitan Arroyo Flood Control Authority

Prepared by:
Smith Engineering Company

AMAFCA

NOVEMBER 2017

Q:\SEC---PROJECTS\115115 AMAFCA SMMMDMP\ENGINEERING\Task D - Development of Options\FIGURE 4.0A.dwg May 25, 2016 - 3:31pm Saved By: chrisn

APPENDIX C – EXISTING CONDITIONS HYDROLOGIC AND HYDRAULIC ANALYSIS RESULTS

Existing Storm Drain Layout Map

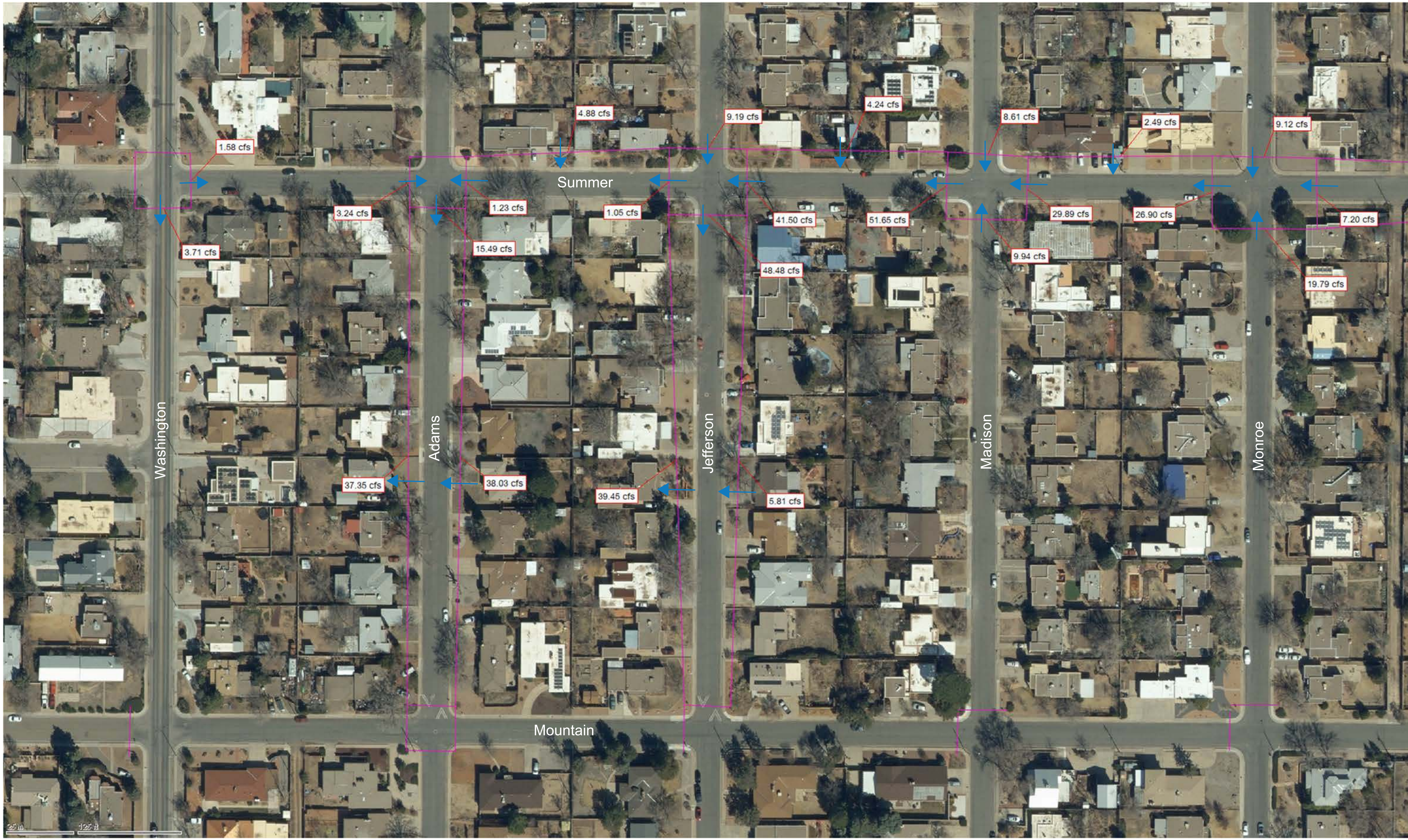
Existing Storm Drain Layout Map

Existing Conditions, No GSI 2-year Surface Peak Flows

Future Conditions, No GSI 2-year Surface Peak Flows

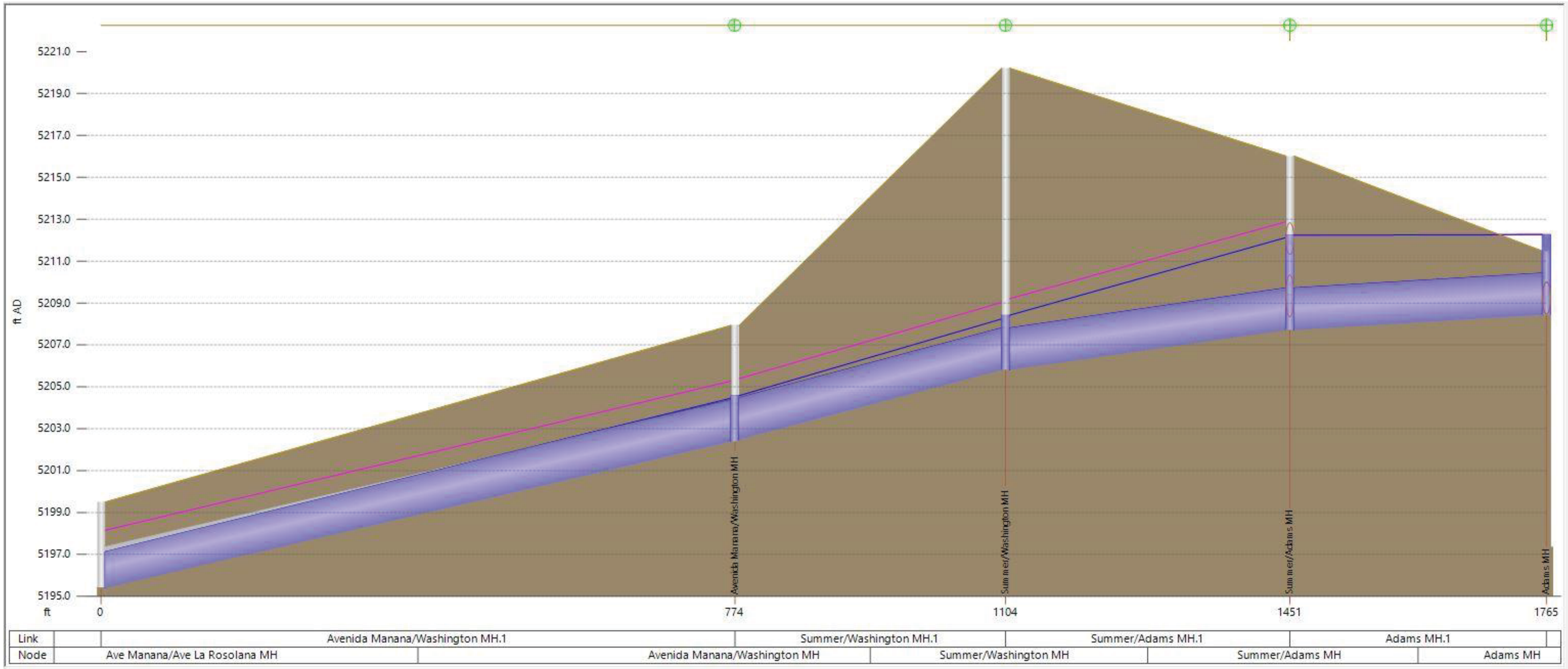
Existing Conditions, No GSI 10-year Surface Peak Flows

Future Conditions, No GSI 10-year Surface Peak Flows



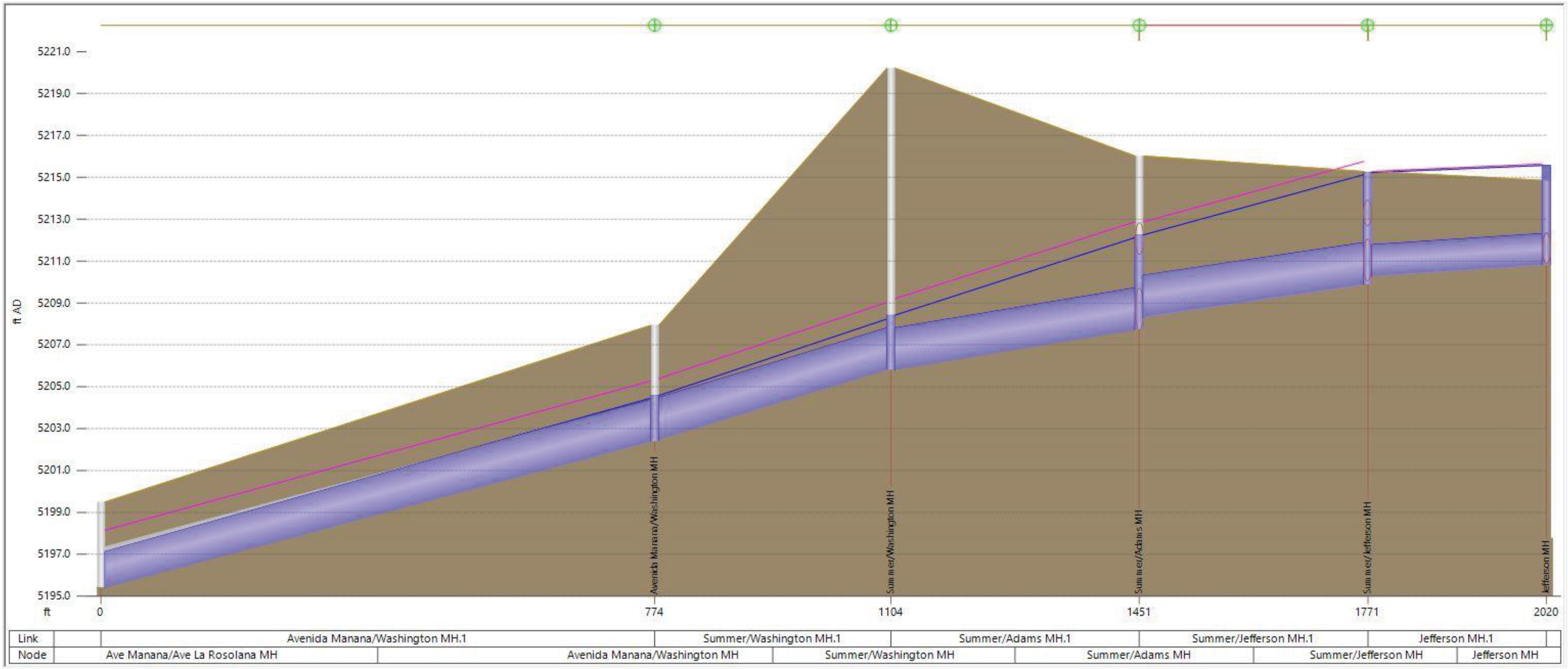
Existing Conditions, No GSI 100-year Surface Peak Flows

Future Conditions, No GSI 100-year Surface Peak Flows



Legend

- EGL
- HGL
- Ground
- Node



Legend

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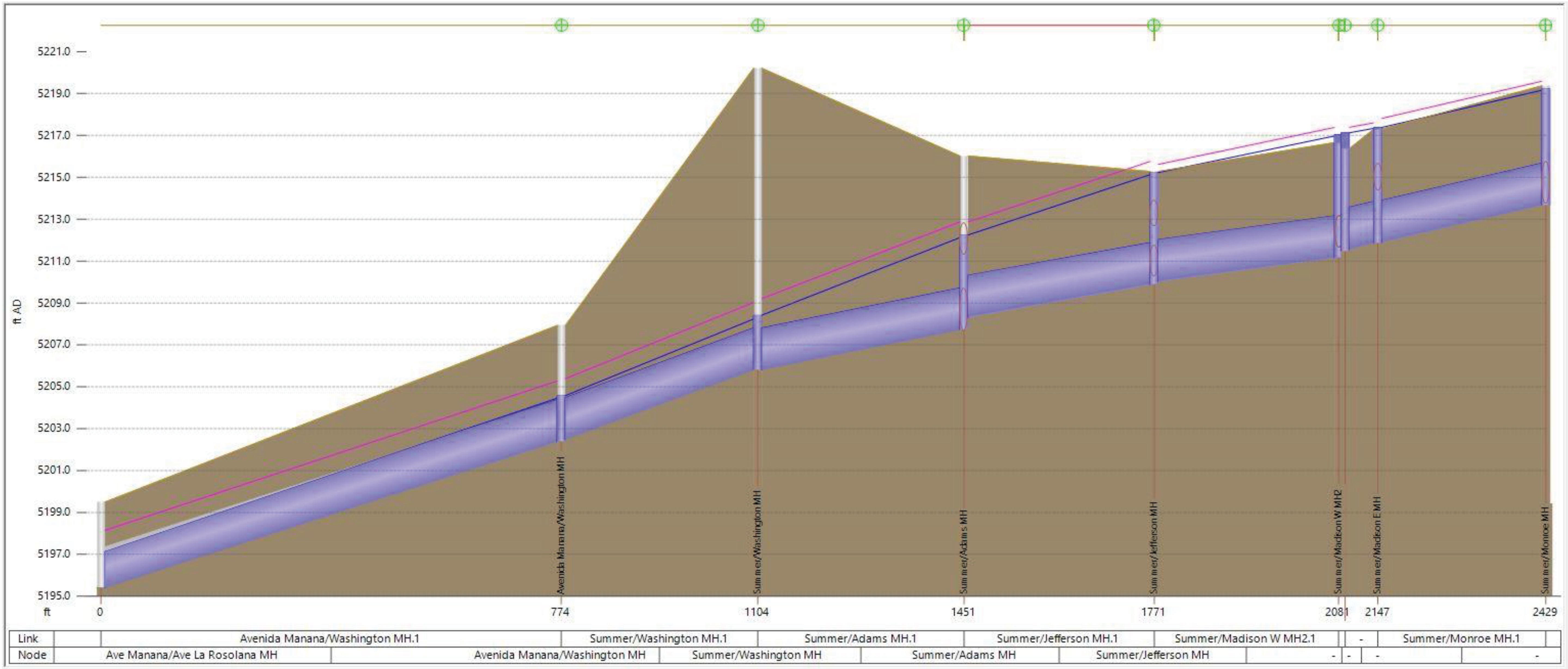
- HGL
- Ground
- Node



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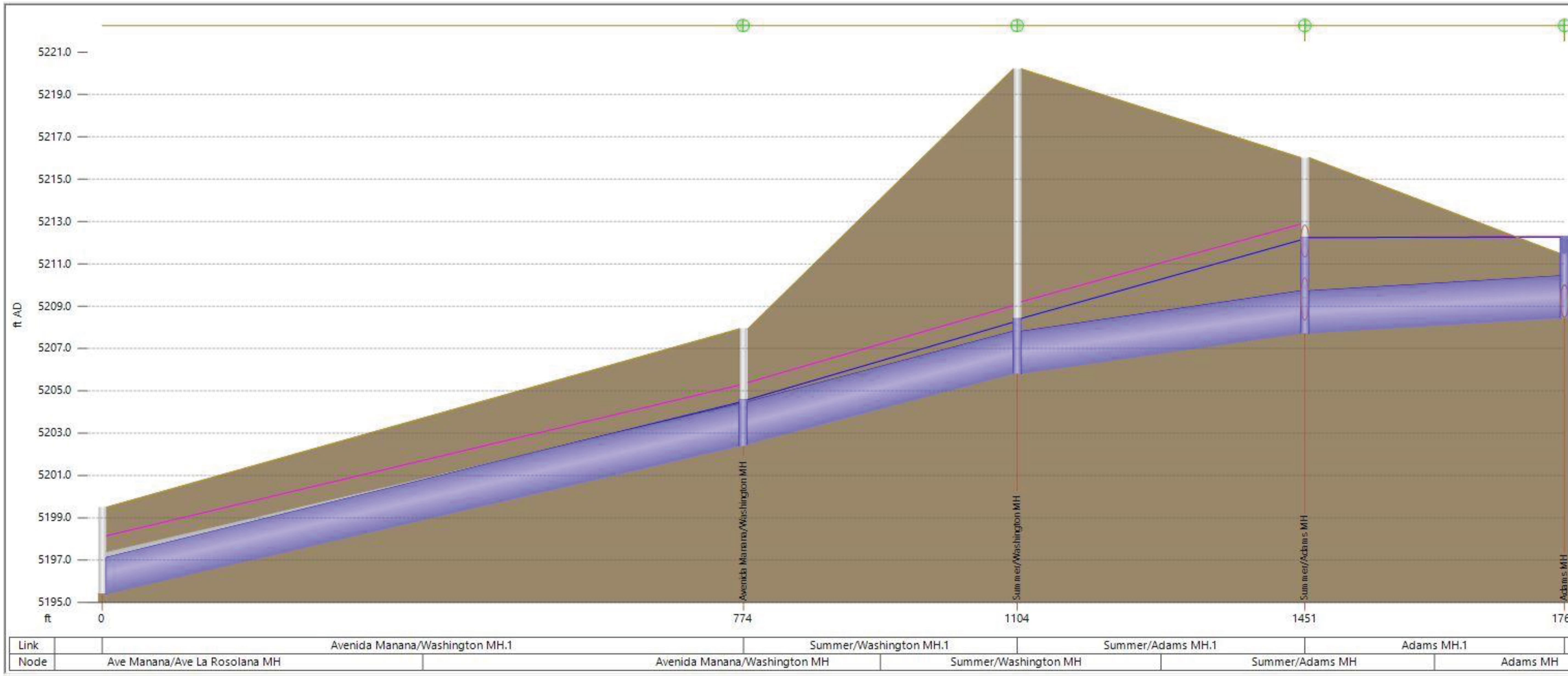
Node



Legend

- EGL
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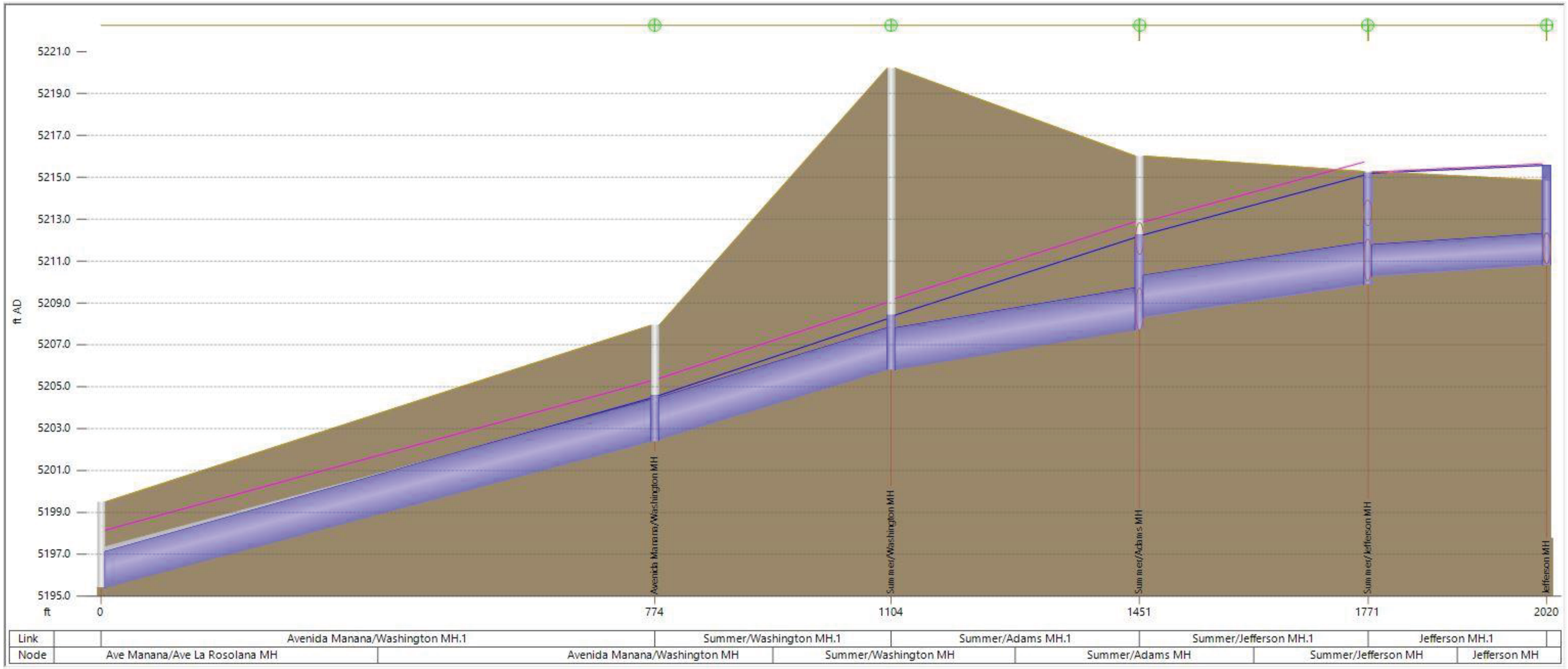
- Node



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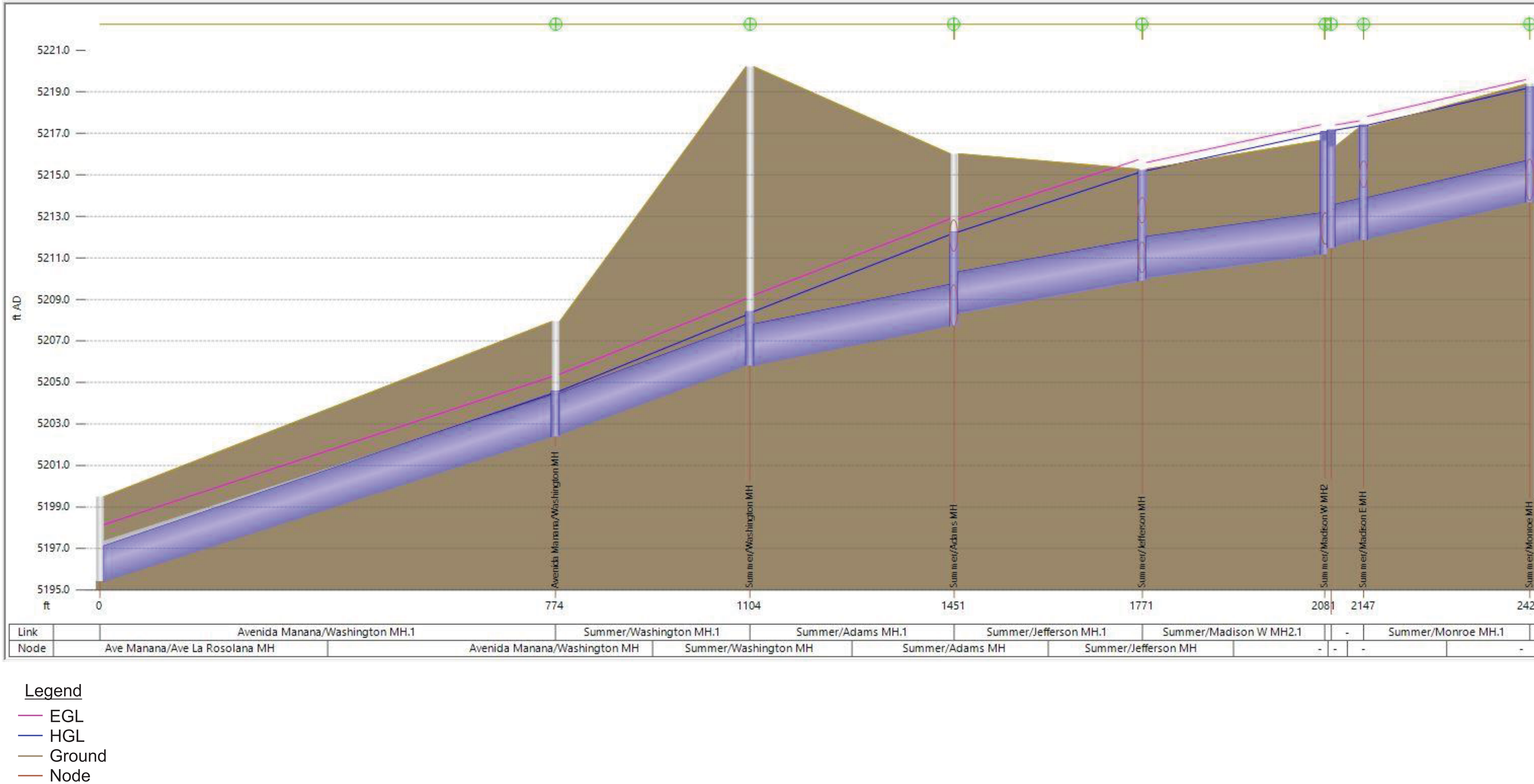
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Avenida Manana/Washington MH
Summer/Washington MH
Summer/Adams MH
Summer/Jefferson MH
Summer/Madison W MH2
Summer/Madison E MH
Summer/Monroe MH
Link
Avenida Manana/Washington MH.1
Summer/Washington MH.1
Summer/Adams MH.1
Summer/Jefferson MH.1
Summer/Madison W MH2.1
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Summer/Monroe MH.1
Node
Ave Manana/Ave La Rosolana MH
Avenida Manana/Washington MH
Summer/Washington MH
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Legend
EGL
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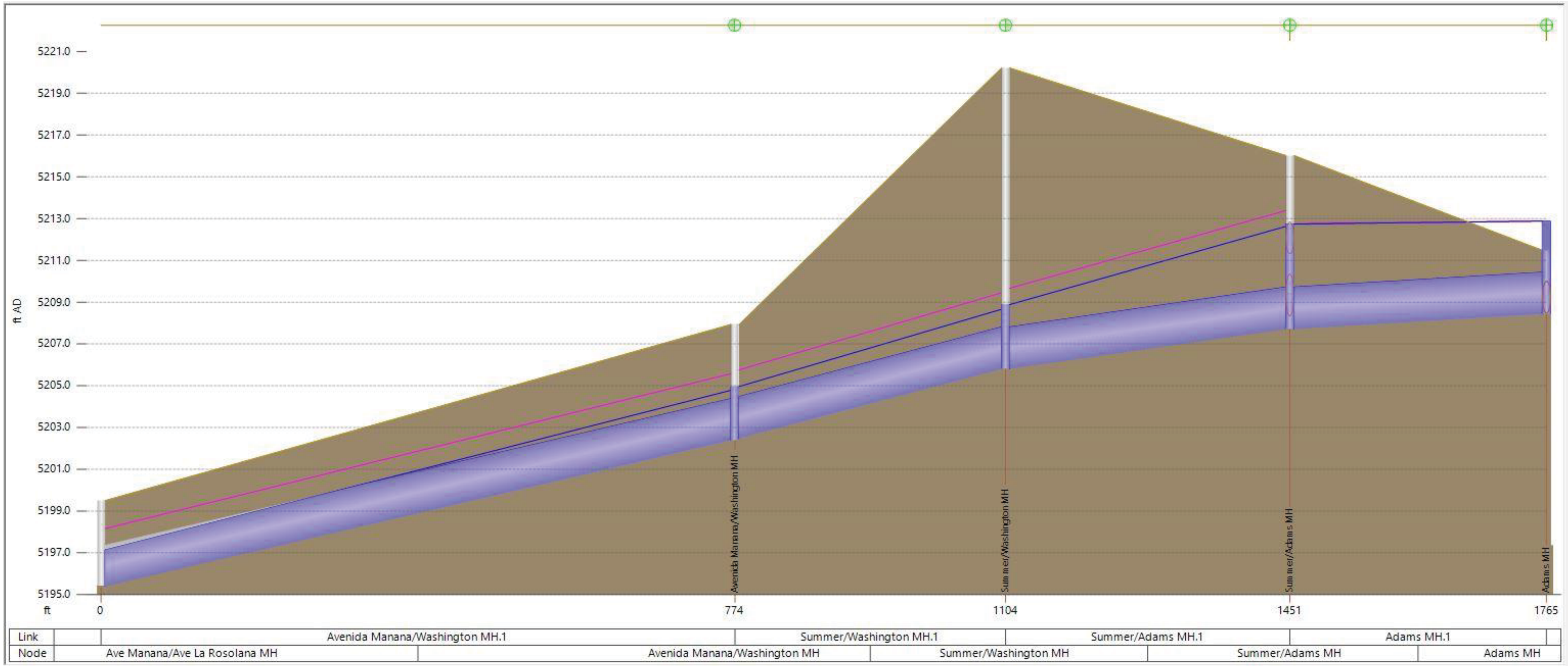

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- EGL
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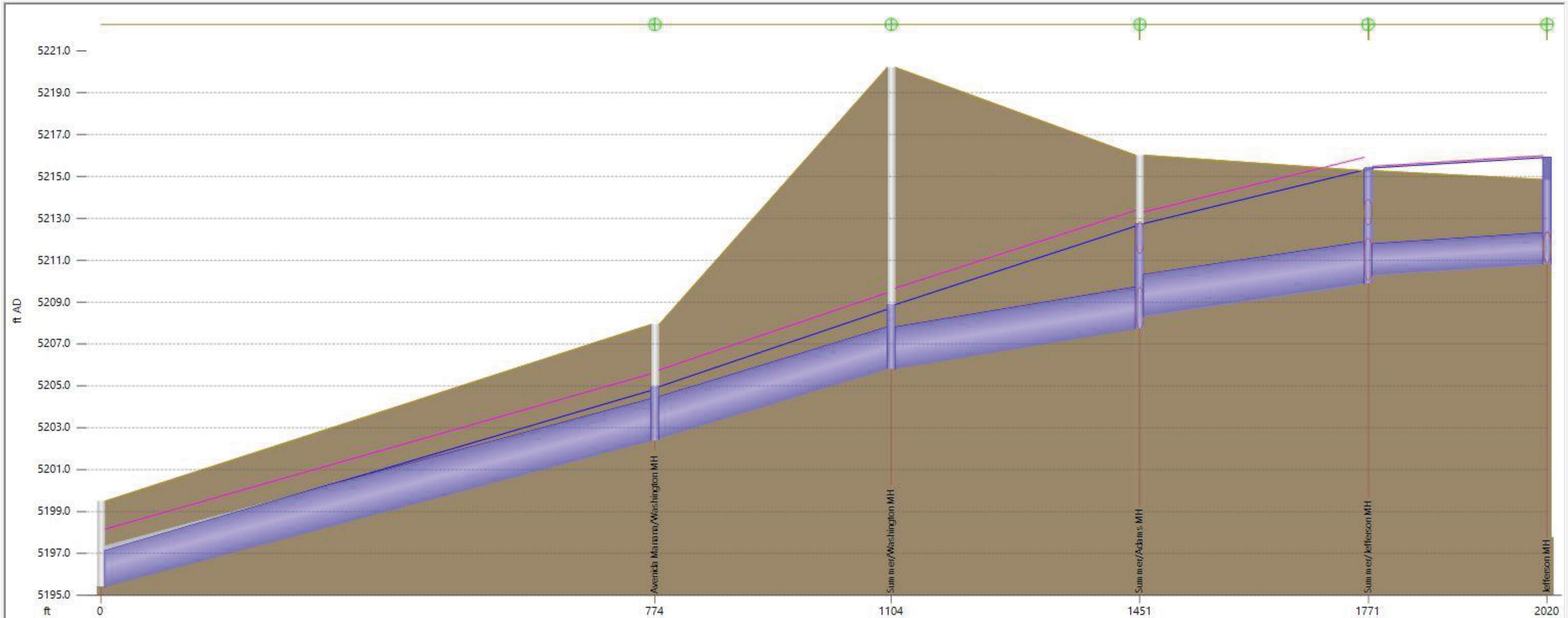

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Node	Ave Manana/Ave La Rosolana MH	Avenida Manana/Washington MH	Summer/Washington MH	Summer/Adams MH	Summer/Jefferson MH	Jefferson MH

Legend
- EGL
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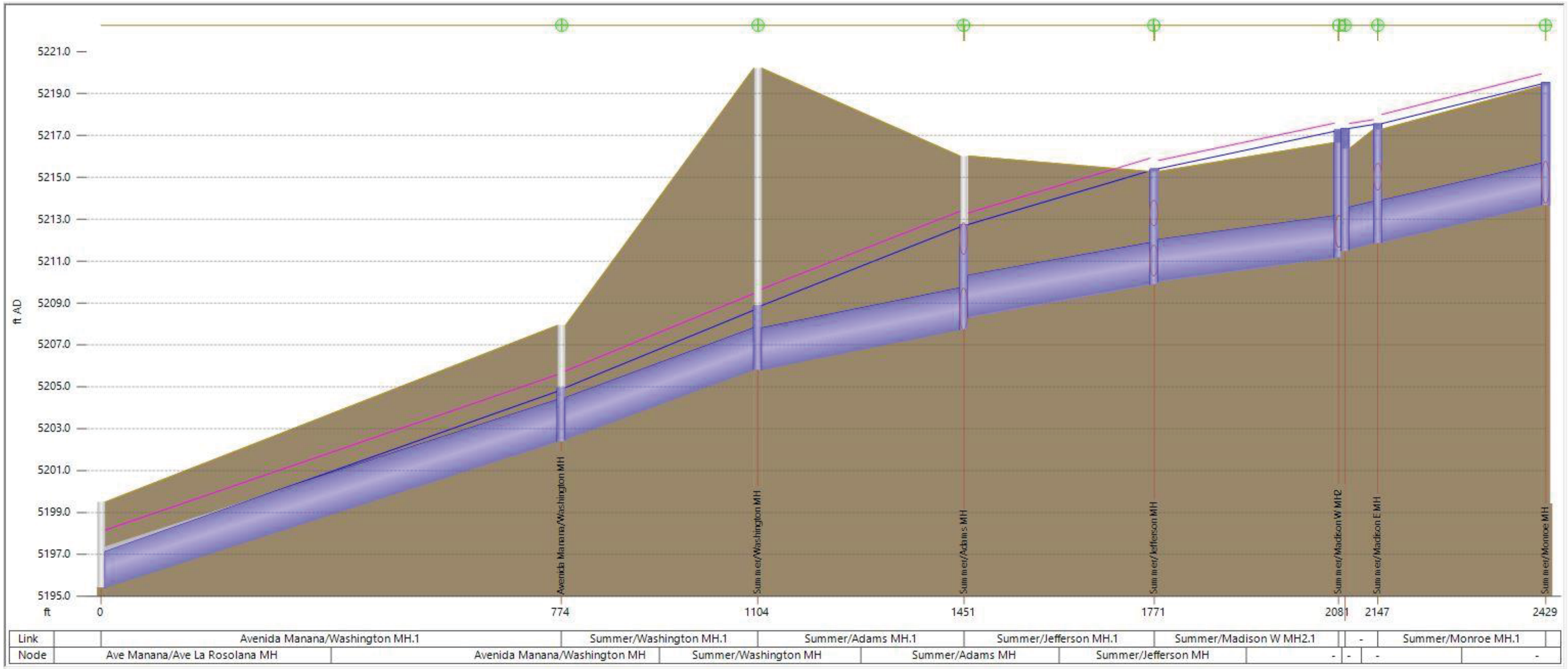
- Node



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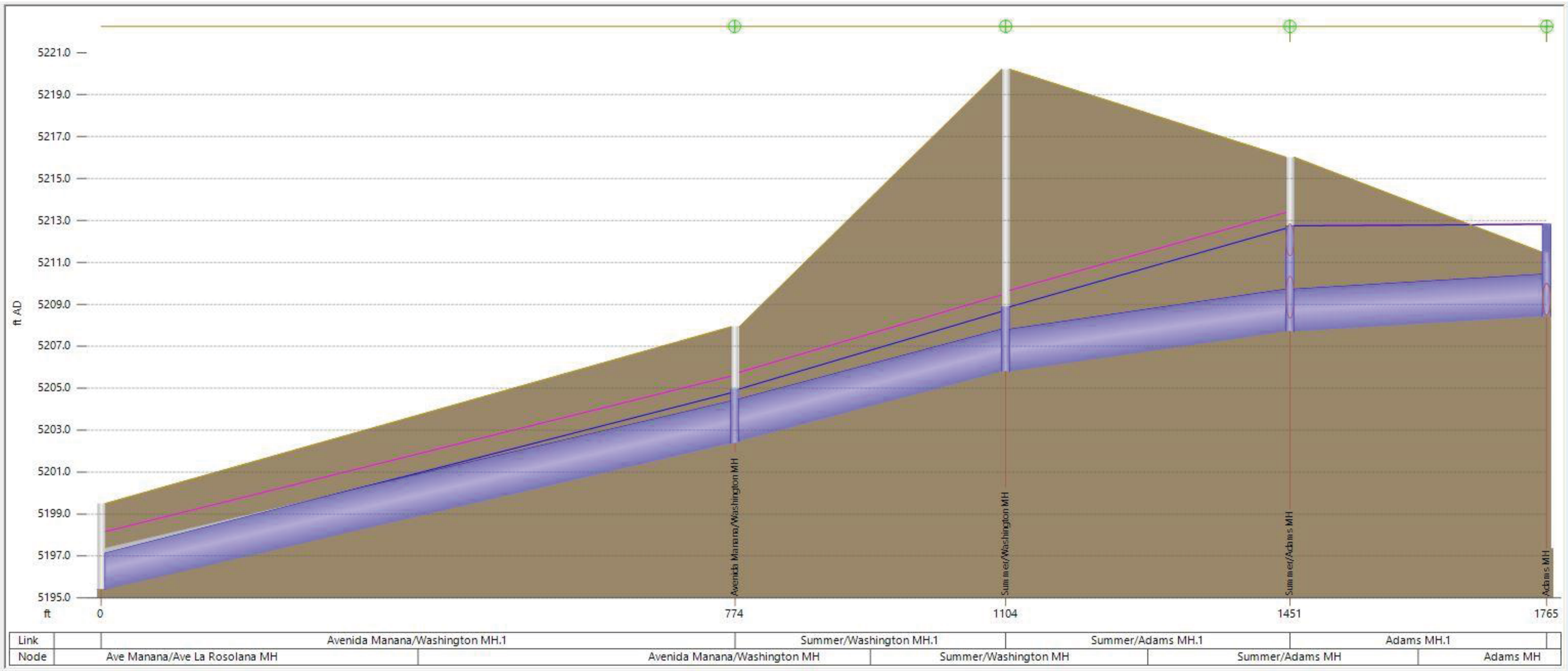

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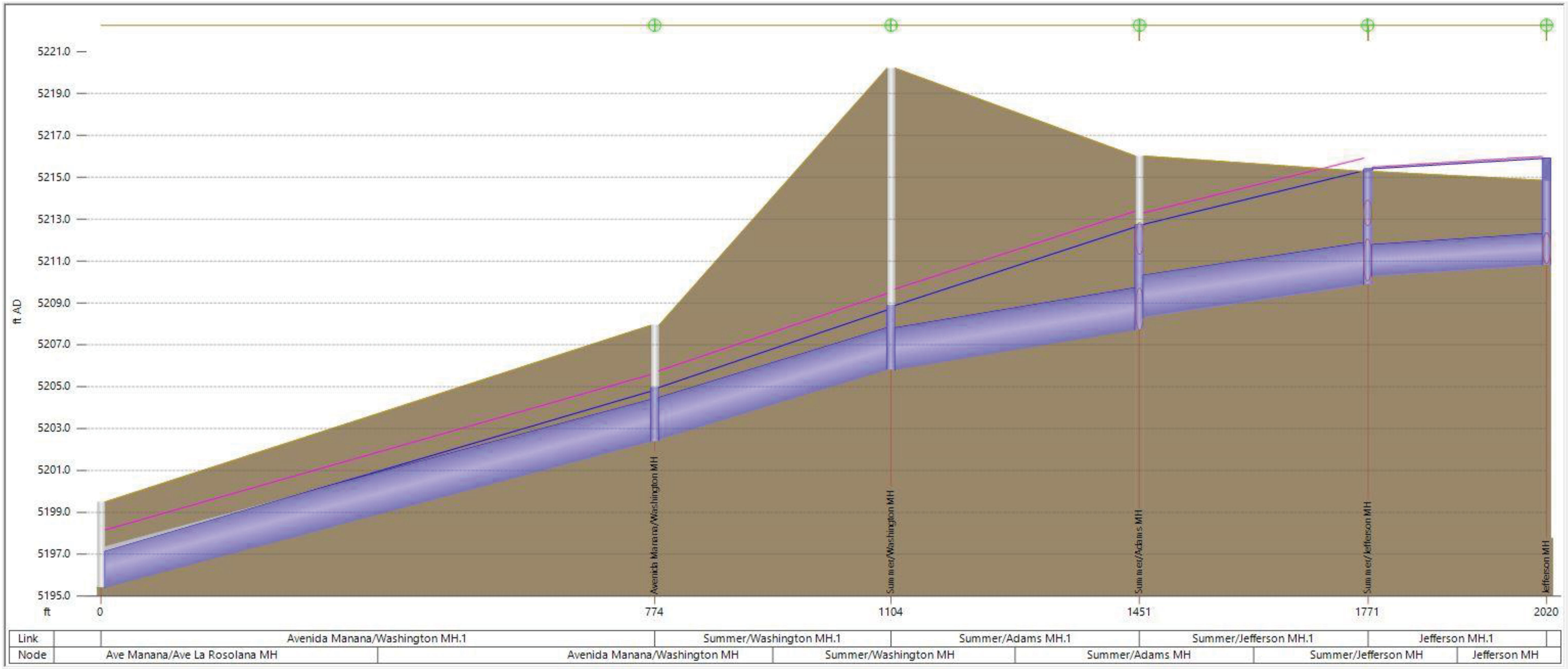

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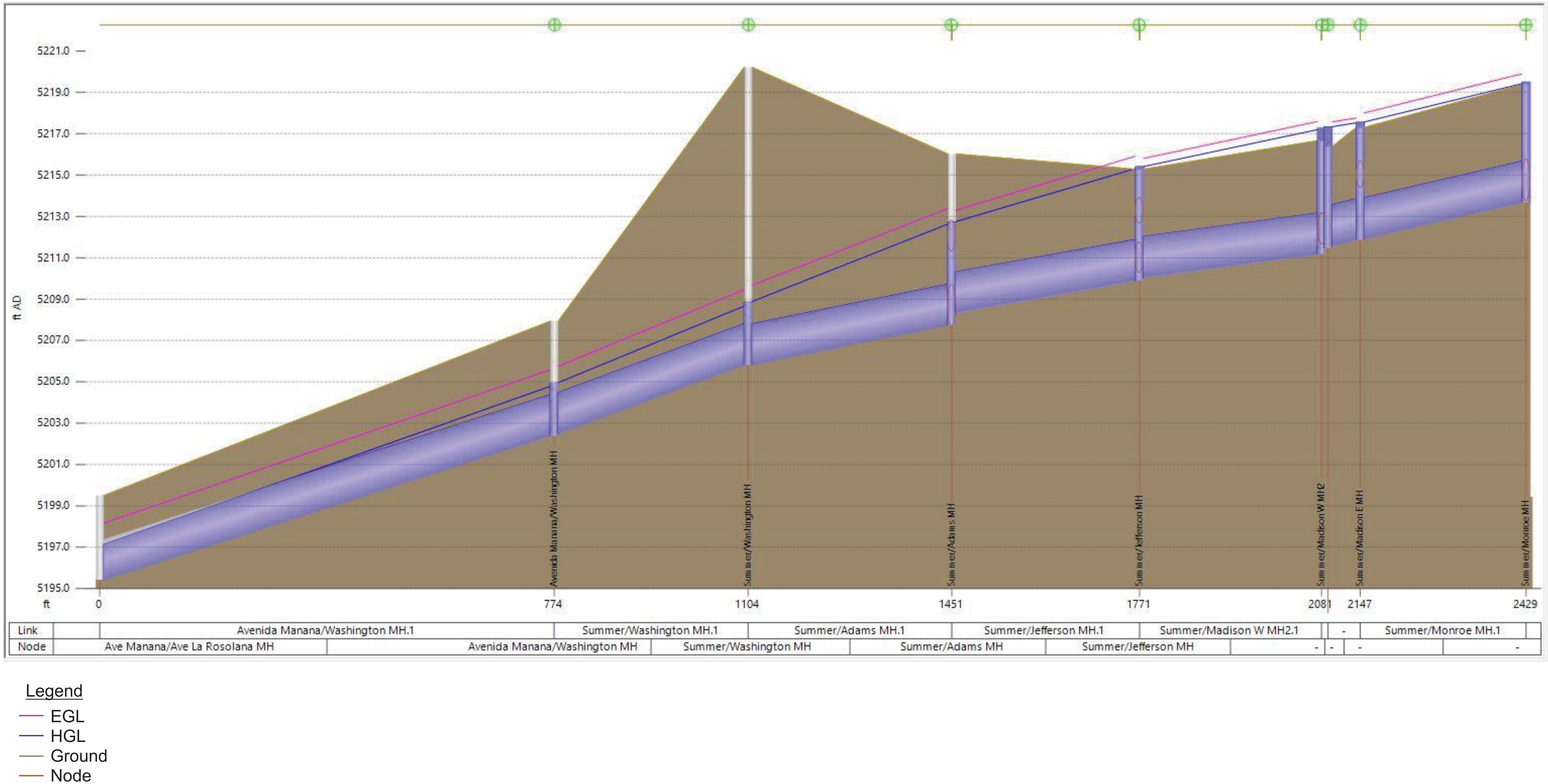

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Avenida Manana/Washington MH
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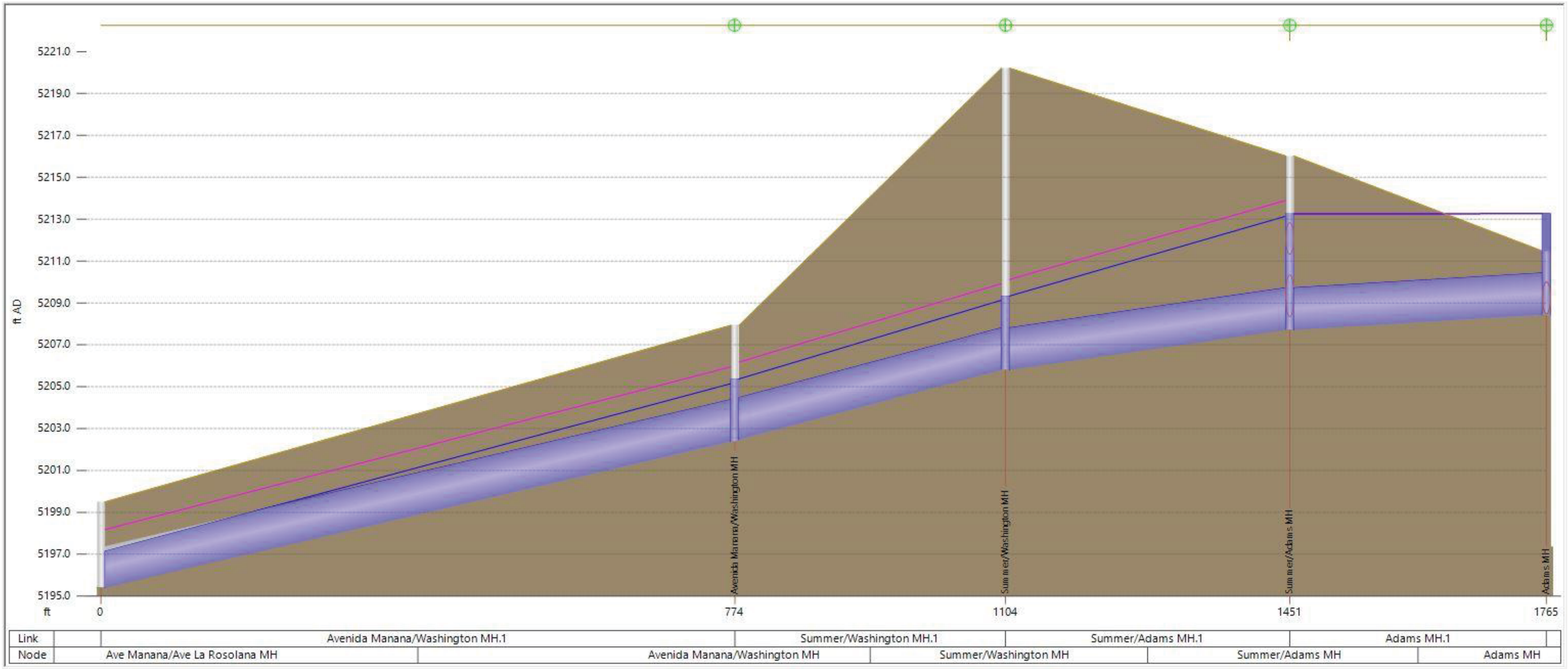

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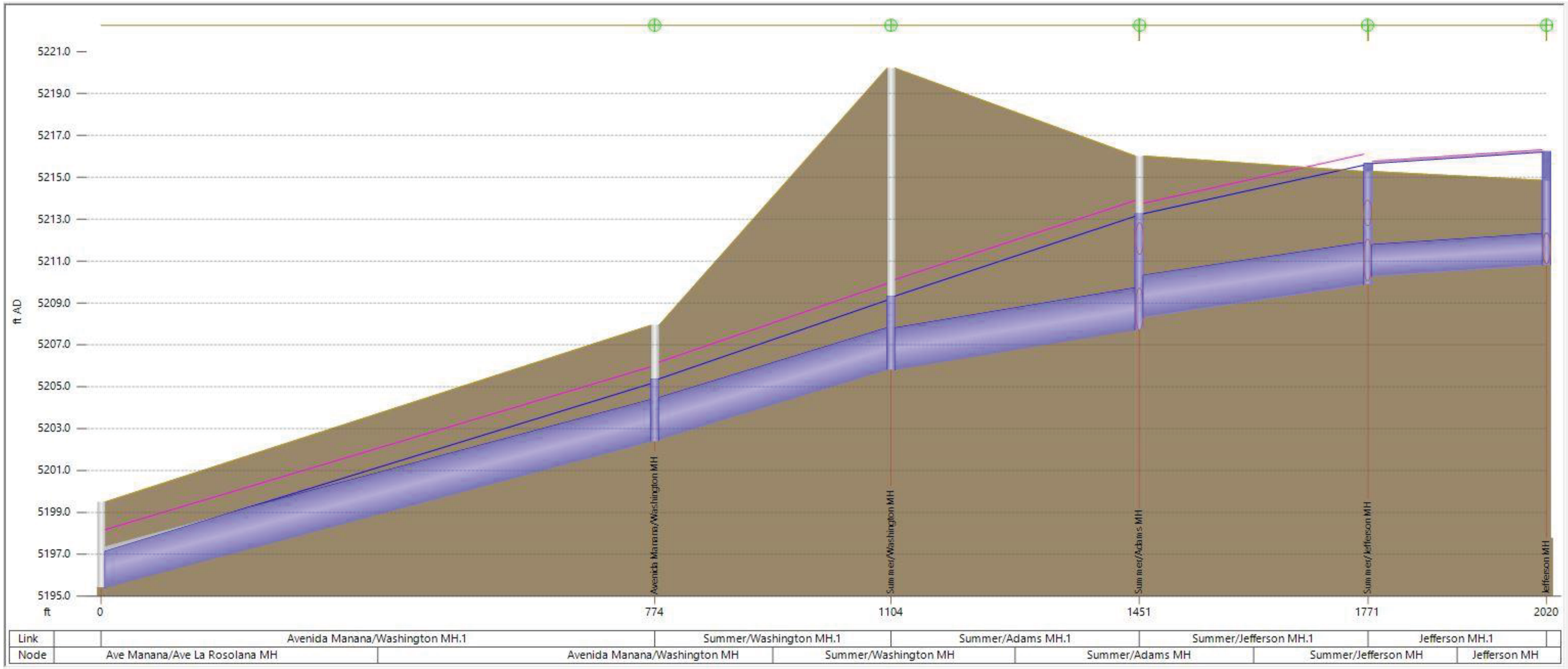

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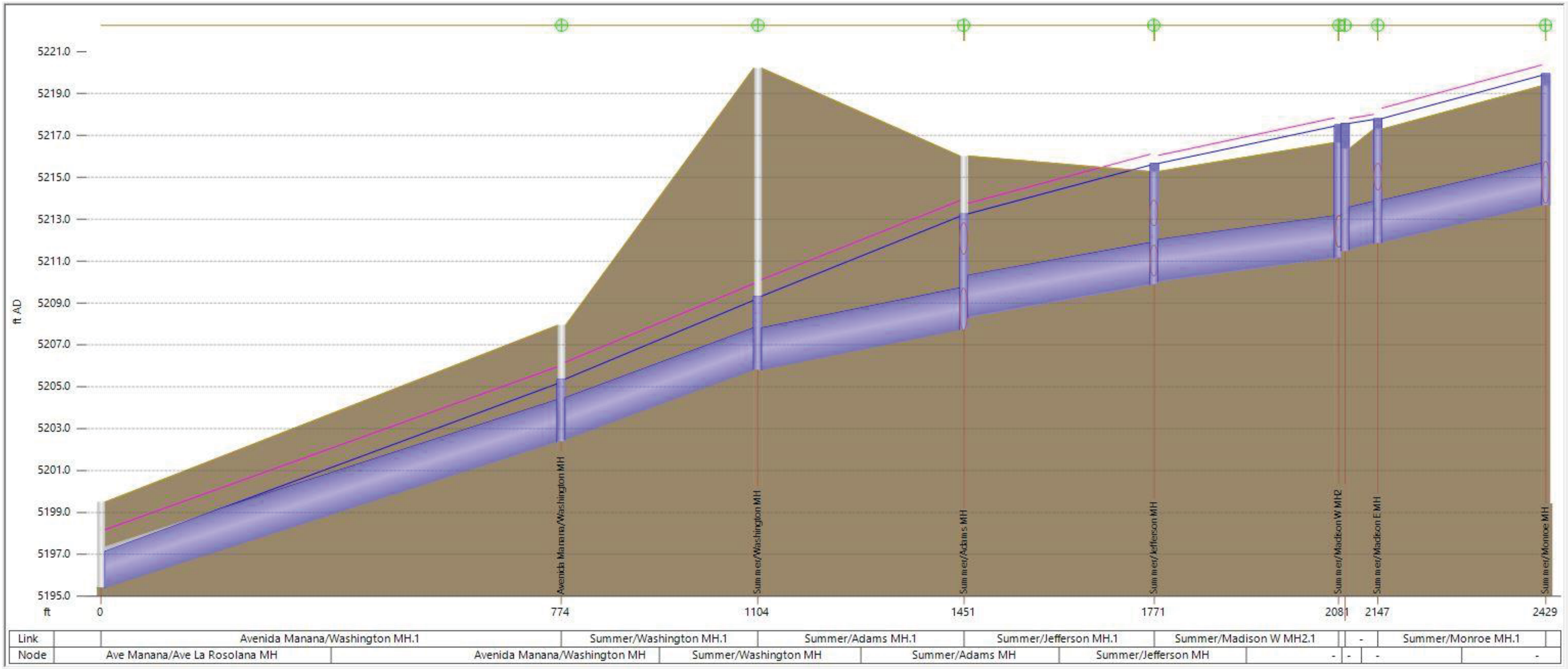

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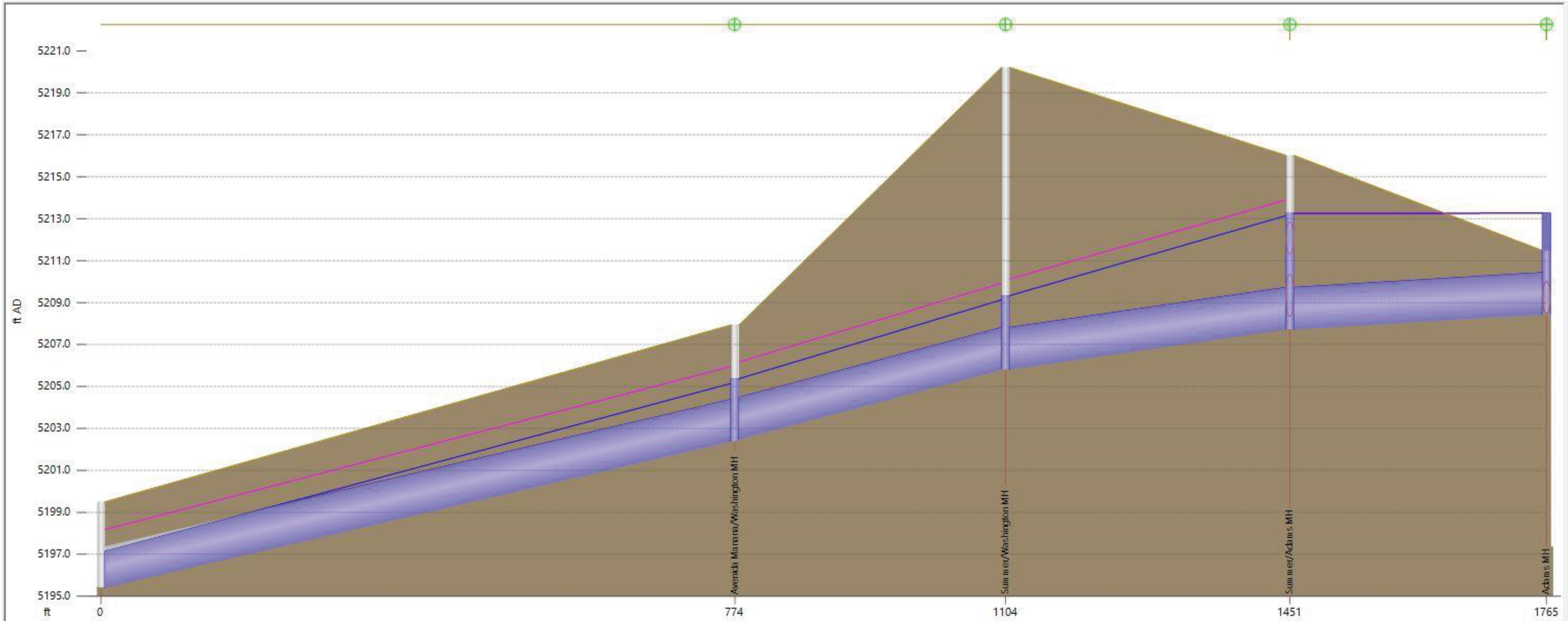

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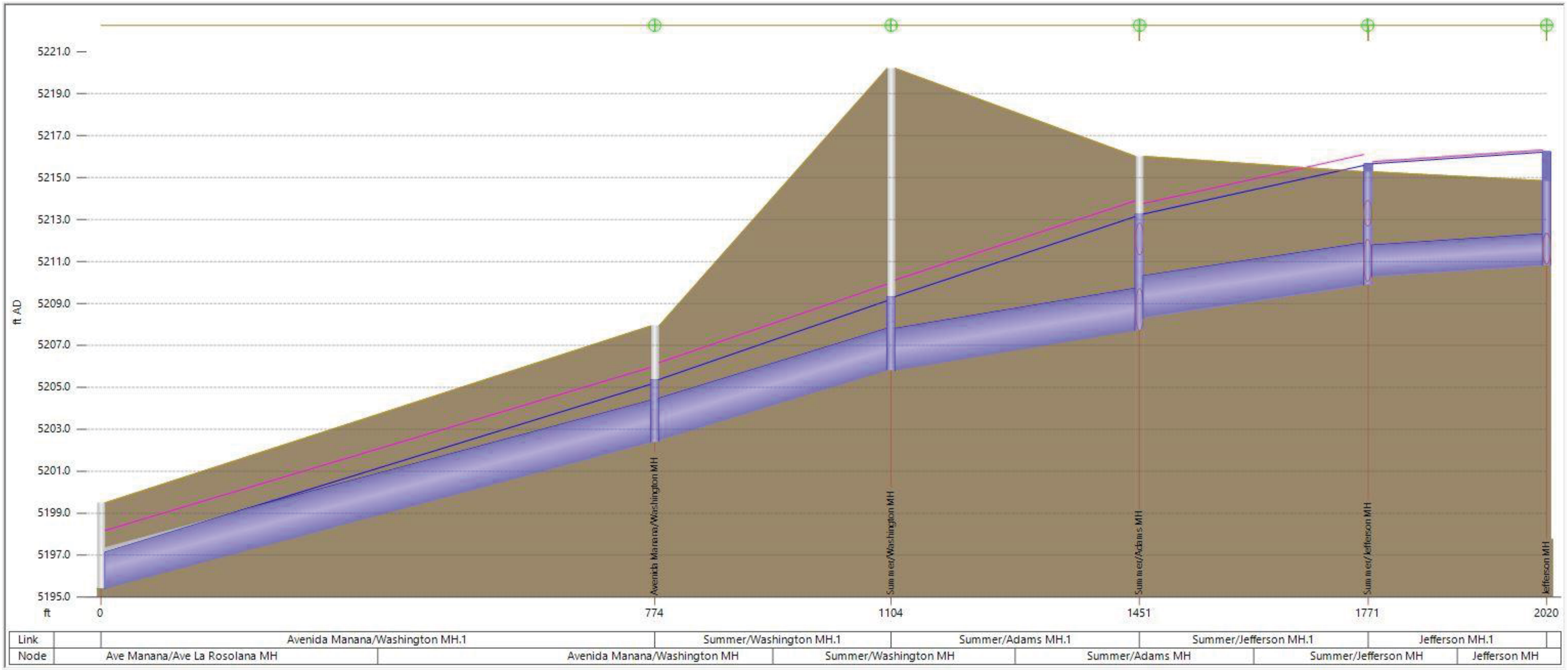
Node	Ave Manana/Ave La Rosolana MH	Avenida Manana/Washington MH	Summer/Washington MH	Summer/Adams MH	Adams MH

Legend

- EGL
- HGL
- Ground
- Node



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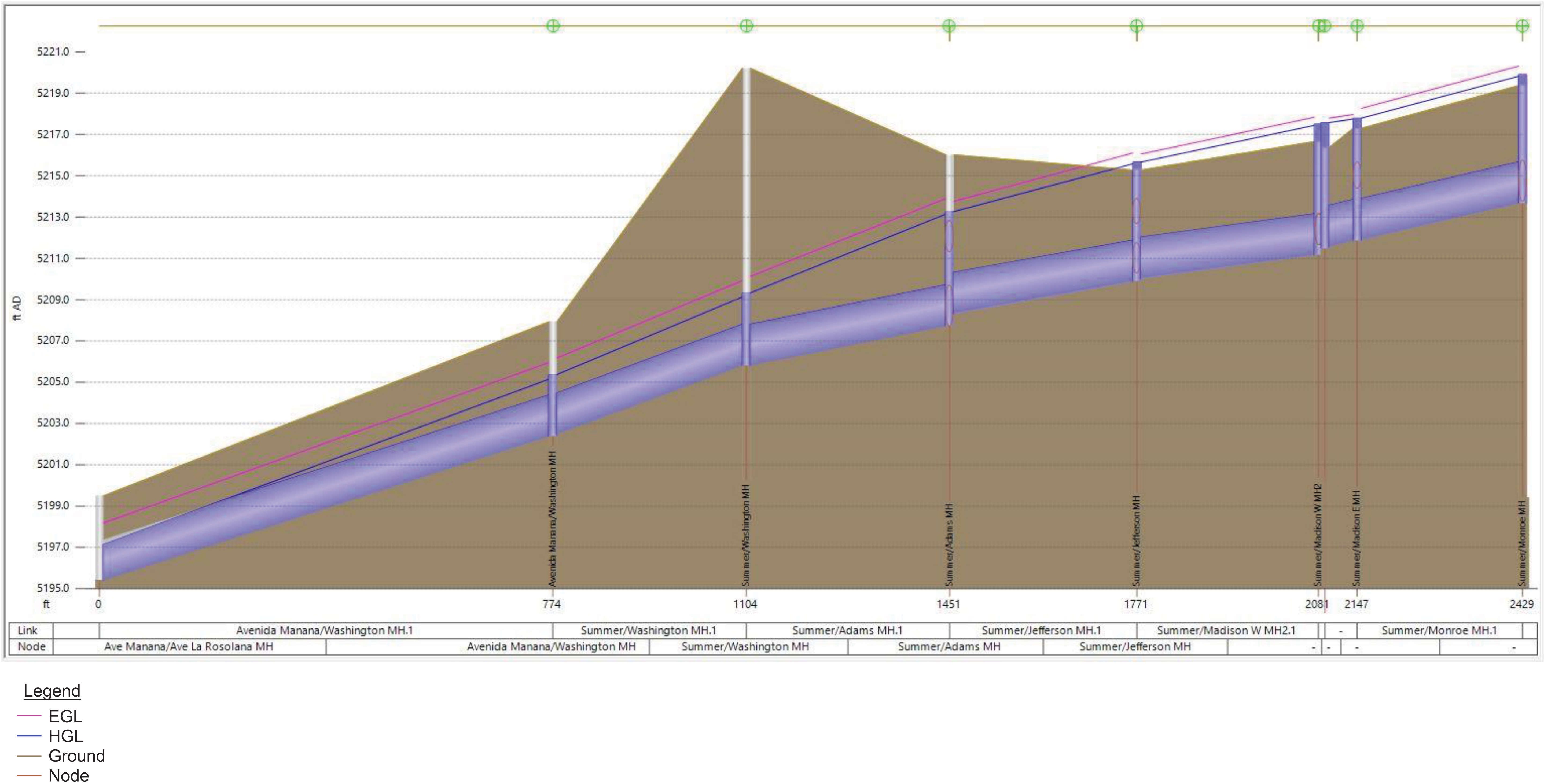

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Summer/Madison W MH2.1
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Summer/Monroe MH.1
Node
Ave Manana/Ave La Rosolana MH
Avenida Manana/Washington MH
Summer/Washington MH
Summer/Adams MH
Summer/Jefferson MH
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Legend
EGL
HGL
Ground
Node

	Intercepted flow (cfs)*						Surcharged flow (cfs)					
	100-yr		10-yr		2-yr		100-yr		10-yr		2-yr	
Node ID (Inlets Only)	ExCon	FtCon	ExCon	FtCon	ExCon	FtCon	ExCon	FtCon	ExCon	FtCon	ExCon	FtCon
Adams E	4.8	5.2	4.8	4.4	2.9	2.8	0.1	0.1	0.1	0.1	0.1	0.0
Adams W	6.9	7.3	7.2	8.0	6.0	6.0	3.7	3.7	2.1	2.1	2.8	1.1
El Encanto Cul De Sac E	22.0	20.7	20.7	19.3	19.7	15.3	0.1	0.1	0.1	0.1	0.1	0.1
El Encanto Cul De Sac N	11.5	11.4	11.3	10.7	10.8	10.0	0.0	0.0	0.0	0.0	0.0	0.0
El Encanto Cul De Sac S	3.7	-7.0	-4.0	-3.8	-4.1	-3.6	3.6	7.0	4.0	3.8	4.1	3.6
El Encanto/Madiera NE	8.8	8.5	8.4	8.2	8.5	3.5	0.0	0.0	0.1	0.1	0.0	0.0
El Encanto/Madiera SE	12.0	9.5	11.8	2.8	3.0	0.9	0.0	0.1	0.0	0.1	0.1	0.1
El Encanto/Madiera SW	-5.6	-5.4	-5.5	-1.7	-2.1	0.0	5.6	5.4	5.5	1.7	2.1	0.0
El Encanto/MadieraNW	17.6	22.0	20.8	19.8	20.8	16.5	0.4	0.1	0.1	0.1	0.1	0.1
Jefferson E	3.7	5.6	3.9	3.8	-2.2	-2.3	2.4	2.4	2.4	2.5	2.2	2.3
Jefferson W	9.9	9.5	10.3	10.1	7.4	7.9	0.0	0.0	0.0	0.0	0.0	0.0
Manzano E	5.7	5.6	6.5	6.1	4.7	5.0	0.0	0.0	0.0	0.0	0.0	0.0
Manzano W	7.2	7.0	6.5	8.6	6.2	6.2	0.0	0.0	0.0	0.0	0.0	0.0
Quincy E	6.0	5.4	6.2	5.8	3.7	4.5	0.0	0.0	1.5	0.0	0.0	0.0
Qunicy W	11.2	9.9	10.2	10.6	6.3	3.9	1.6	1.9	5.4	3.4	1.4	3.5
Summer/Adams SE	5.9	5.9	2.5	2.5	1.1	1.1	0.1	0.0	0.1	0.1	0.1	0.1
Summer/Jefferson SE	-4.6	4.4	-5.0	5.6	5.5	3.8	4.6	2.5	5.0	5.5	4.7	1.5
Summer/Madison NW	5.1	5.1	5.7	5.1	6.0	5.9	0.0	0.0	0.0	0.0	0.0	0.1
Summer/Madison SE	-5.8	-5.7	-4.9	-4.9	-3.9	-4.2	5.8	5.7	4.9	4.9	3.9	4.2
Summer/Madison SW	5.8	5.2	6.8	7.1	6.1	6.2	2.6	2.6	5.4	5.9	3.5	5.2
Summer/Manzano Inlet	17.3	13.3	7.4	4.9	2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Truman	13.5	13.4	14.1	14.1	13.6	13.7	0.0	0.0	0.0	0.0	0.0	0.0
Truman/Manzano Alley	-3.1	-3.1	-2.8	-2.8	-1.9	-1.9	3.1	3.1	2.8	2.8	1.9	1.9

* Flow from 2D zone is "net" flow

APPENDIX D – GEOTECHNICAL REPORT

GEO-TEST

GEOTECHNICAL ENGINEERING SERVICES REPORT NO. 1-40405

PUEBLO ALTO / MILE HI GREEN STORMWATER INFILTRATION PILOT PROJECT CONCEPT DESIGN

SUPPLEMENTAL INVESTIGATION

ALBUQUERQUE, NEW MEXICO

GEO-TEST, INC.
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FAX (505) 857-0803

2805-A LAS VEGAS CT.
LAS CRUCES,
NEW MEXICO
88007
(575) 526-6260
FAX (575) 523-1660

PREPARED FOR:

BOHANNAN HUSTON, INC.

GEO-TEST

June 26, 2024
Job No. 1-40405

Bohannan Huston, Inc.
7500 Jefferson St. NE
Albuquerque, NM 87109

ATTN: Vince Steiner, PE

RE: Geotechnical Engineering Services Report
Pueblo Alto/Mile Hi Green Stormwater Infiltration
Pilot Project Concept Design
Supplemental Investigation
Albuquerque, New Mexico

Dear Mr. Steiner:

Submitted herein is the Geotechnical Engineering Services Report for the above-referenced project. The report contains the results of our field investigation, laboratory testing, and supplemental drainage information and recommendations to be used in conjunction with the Geotechnical Engineering Services Report 1-30314 dated July 20, 2023 previously provided by this firm.

It has been a pleasure to serve you on this project. If you should have any questions, please contact this office.

Respectfully submitted:
GEO-TEST, INC.

PATRICK R. WHORTON
NEW MEXICO
26342
PROFESSIONAL ENGINEER

Patrick R. Whorton, PE

Reviewed By:

Patrick J. Byres, PE

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Table of Contents

GEO-TEST

INTRODUCTION

This report presents the results of our supplemental geotechnical engineering services investigation performed by this firm for the proposed Pueblo Alto / Mile Hi Green Stormwater Infiltration Pilot Project Concept Design project in Albuquerque, New Mexico.

The objectives of this investigation were to:

1) Evaluate the nature and engineering properties of the subsurface soils underlying the site.

2) Provide supplemental subsurface drainage data and design recommendations to be used in conjunction with the Geotechnical Engineering Services Report 1-30314 dated July 20, 2023 previously provided by this firm.

The investigation includes subsurface exploration, selected soil sampling, laboratory testing of the samples, performing an engineering analysis and preparation of this report.

PROPOSED CONSTRUCTION

It is understood that the project will investigate the feasibility of improvements to storm water drainage within the two subject neighborhoods to include subsurface drainage systems within the existing roadways. A previous investigation was performed by this firm as detailed in geotechnical report number 1-30314. This supplemental investigation was conducted to gather additional subsurface data relative to infiltration and the hydraulic conductivity of subsurface soils at two refined locations within the greater project area previously explored, Summer Ave. between Washington St. and Madison St. and between La Veta Dr. and Alvarado Dr. It is understood that two stormwater collection systems will be installed in these areas as well as La Veta Dr. between El Encanto Ave. and Summer Ave. The first system consists of shallow infiltration ‘bump-outs’ which are small detention ponds to be constructed adjacent to the existing curb line within the existing roadways. The second system will be a below grade storage system consisting of an 84 inch diameter corrugated metal pipe bearing 9 to 13 feet below street elevation designed to store and infiltrate stormwater into deeper subsurface soils.

Should project details vary significantly from those outlined above, this firm should be notified for review and possible revision of the recommendations contained herein.

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FIELD EXPLORATION

Five (5) borings will be drilled to a depth of 25 feet below existing site grades on Summer Ave., one (1) between Washington St. and Adams St., two (2) between Adams St. and Jefferson St. and two (2) between La Veta Dr. and Alvarado Dr. Locations of the borings are shown on the attached Boring Location Maps, Figures 1 & 2. The soils encountered in the borings were continuously examined, visually classified and logged during the drilling operation. The boring logs are presented in a following section of this report. Drilling was accomplished using a truck mounted drill rig equipped with 3.25 inch inside diameter hollow stem auger. Subsurface soils were sampled at five foot intervals or less utilizing an open tube split barrel sampler driven by a standard penetration test hammer.

LABORATORY TESTING

Selected samples were tested in the laboratory to determine certain engineering properties of the soils. Moisture contents were determined to evaluate the various soil deposits with depth. The results of these tests are shown on the boring logs.

Sieve analysis and Atterberg limits tests were performed to aid in soil classification. Constant head permeability testing was also performed on select undisturbed brass tube samples to determine hydraulic conductivity. The results of these tests are presented in the Summary of Laboratory Results and on the individual test reports presented in a following section of this report.

SURFACE CONDITIONS

The two subject neighborhoods are located near the intersection of San Mateo Blvd. and Constitution Ave. and are fully developed residential neighborhoods populated with single family homes. The subject streets where this investigation was conducted are two lane residential roadways paved with 6 to 8 inches of asphalt.

SUBSURFACE SOIL CONDITIONS

The subsurface soil profile encountered at the Boring 11 location consisted of a surficial layer of medium plasticity moderately firm clayey sand which was encountered directly beneath the existing pavement section and extended to a depth of 6 feet below surface grade where loose non-plastic silty sand with gravel was encountered and extended to a depth of 9 feet below surface grade where medium dense to dense non-plastic poorly graded sand was encountered and extended to the full depth explored.

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The subsurface soil profile at the Boring 12 location consisted of a surficial layer of soft to very soft medium plasticity clayey sand which was encountered directly beneath the existing pavement and extended to a depth of 9 feet below surface grade where medium dense non-plastic poorly graded sand with silt was encountered and extended to the full depth explored.

The subsurface profile at the Boring 13 location consisted of a surficial layer of moderately firm to firm medium plasticity clayey sand which was encountered directly beneath the existing pavement and extended to a depth of 18 feet below surface grade where medium dense non-plastic poorly graded sand with silt was encountered and extended to the full depth explored.

The subsurface profile at the Boring 14 location consisted of a surficial layer of soft low plasticity clayey sand which was encountered directly beneath the existing pavement and extended to a depth of 7 feet below existing surface grade where loose non-plastic poorly graded sand with silt was encountered and extended to a depth of 12 feet below surface grade where medium dense to dense non-plastic poorly graded sand was encountered and extended to the full depth explored.

The subsurface profile at the Boring 15 location consisted of very soft medium plasticity clayey sand which was encountered directly below the existing pavement and extended to a depth of 4 feet below surface grade where very loose non-plastic silty sand was encountered and extended to a depth of 7 feet below surface grade. Below the silty sand layer, soft medium plasticity clayey sand was encountered and extended to a depth of 9 feet below surface grade where medium dense to dense non-plastic poorly graded sand was encountered and extended to the full depth explored.

No free groundwater was encountered in the borings and soil moisture contents were relatively low throughout the extent of the borings with the exception of the higher plasticity soils where moisture contents were generally found to be elevated.

CONCLUSIONS AND RECOMMENDATIONS

As discussed in report 1-30314, the subsurface soils beneath the site consisted primarily of 5 soils types as follows:

1) Non-plastic Well and Poorly Graded (clean) Sands

2) Non-plastic Silty Sand

3) Low Plasticity Silty, Clayey Sand, Sandy Clay and Clayey Sand

4) Medium Plasticity Clayey Sand

5) Medium to High Plasticity Clay

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The results of this investigation as well as data collected from Borings 3, 4, 9 and 10 from the 1-30314 investigation show that both the Pueblo Alto section located between Washington and Madison as well as the Mile Hi section between La Vita and Alvarado have a subsurface profile consisting of low to medium plasticity silty, clayey sand and clayey sand which is present below the existing pavement and extends to depths of 6 to 11 feet below surface grade. These are Type 3 and 4 soils as listed above and discussed in the 1-30314 report. Below the Type 3 and 4 soils, non-plastic silty sand and poorly graded sand was encountered and extended to the full depth explored. These soils would be Type 1 and 2 soils as listed above and discussed in the 1-30314 report.

The hydraulic conductivity of the near surface Type 3 and 4 soils is on the order of 10^{-4} to 10^{-5} cm/s while the deeper Type 1 and 2 soils have a hydraulic conductivity on the order of 10^{-2} to 10^{-3} cm/s. This indicates that these soils are generally permeable and may be valid for use in a subsurface drainage system, but also indicates that the near surface soils will drain at a slower rate than the deeper soils which may present issues with surface drainage.

The presence of the near surface clayey soils encountered throughout the areas explored may not be ideal for the use of the proposed 'bump out' infiltration system as the 'bump out' collectors have a relatively small surface areas for infiltration and combined with the relatively slow drainage capacity of the near surface soils, may not be able to provide the required drainage capacity, however, the suitability of these soils should ultimately be determined by the project civil engineer. If required, French drains could be installed within the 'bump outs' to such a depth as to access the deeper clean sands in order to facilitate drainage.

In contrast to the relatively slow draining near surface soils, the deeper non-plastic sands will drain at a greater rate such that the below grade corrugated metal pipe infiltrators would likely be more feasible way of utilizing subsurface drainage than surface infiltrators. Given that the proposed subsurface infiltrators will bear 9 to 13 feet below surface grade and the depth to the deeper well-draining soils was found to be between 6 and 11 feet below surface grade, the infiltrators may be installed directly into these soils in most areas. In some areas, clayey soils may still be present at infiltration elevation which may require additional excavation to remove in order to provide consistent well-draining for infiltration. These removed soils should then be replaced with a 'clean' fill such as concrete sand which would have similar drainage characteristics as the native sand.

In the tables below the deeper well-draining sand is referred to as the "Drainage Layer". The depth to this layer and the measured hydraulic conductivity of the layer specific to that location as well as the measured conductivity of the surface soils are presented on the Boring Logs and laboratory test reports included in a later section of this report and are summarized on the tables below.

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Pueblo Alto Section

Boring	Depth to Drainage Layer (ft)	Drainage Conductivity (cm/s)	Surface Conductivity (cm/s)
3	11	$1.48x10^{-2}$	$3.09x10^{-5}$
11	6	$3.95x10^{-2}$	$3.88x10^{-4}$
12	9	$2.39x10^{-2}$	$2.83x10^{-4}$
13	9	$2.52x10^{-3}$	$3.39x10^{-4}$
4	9	Not Determined	Not Determined

Mile Hi Section

Boring	Depth to Drainage Layer (ft)	Drainage Conductivity (cm/s)	Surface Conductivity (cm/s)
9	11	$6.01x10^{-2}$	$7.02x10^{-4}$
10	6	Not Determined	$5.21x10^{-5}$
14	7	$2.22x10^{-2}$	$3.82x10^{-4}$
15	9	$5.07x10^{-2}$	$3.07x10^{-6}$

In conclusion, the subsurface soils encountered as part of our investigation of the subject areas of the greater project were found to be permeable soils, although the near surface clayey soils have a significantly lower hydraulic conductivity than the deeper ‘clean’ sands and may not be able to provide the required drainage capacity, as determined by the project civil engineer. The deep ‘Drainage Layer’ sand will work well for infiltration but may require the removal and replacement of clayey soils, as encountered, with well-draining imported soils.

Based on standard penetration testing performed as part of this investigation, the deeper Drainage Layer is composed of medium dense to dense sands. These soils at the observed density will be generally resistant to settlement given a significant increase in moisture content, as will occur with the proposed infiltration system(s), however, these soils will not be immune to settlement such that it is recommended that this firm review the final design once the configuration and anticipated flows into the subsurface soils have been determined in order to assess any potential settlement which may occur beneath the proposed infiltrators. It should also be noted that the investigation conducted by this firm explored soils beneath the existing City of Albuquerque streets. Subsurface soils supporting private residences along the road were not investigated such that the presence of loose soils susceptible to excessive settlement may be present in these areas and could result in future settlement and potential damage to these private structures if significantly wetted. Therefore, it is recommended that the amount of lateral infiltration be accounted for to limit and/or prevent the excessive wetting of foundation supporting soils along the roadways to within 10 feet of existing foundations.

GEO-TEST

This report has been prepared to aid in the evaluation of this site and to assist in the design of this project. It is recommended that the geotechnical engineer be provided the opportunity to review the final design drawings and specifications in order to determine whether the recommendations in this report are applicable to the final design. Review of the final design drawings and specifications should be noted in writing by the geotechnical engineer.

CLOSURE

Our conclusions, recommendations and opinions presented herein are:

1) Based upon our evaluation and interpretation of the findings of the field and laboratory program.

2) Based upon an interpolation of soil conditions between and beyond the explorations.

3) Subject to confirmation of the conditions encountered during construction.

4) Based upon the assumption that sufficient observation will be provided during construction.

5) Prepared in accordance with generally accepted professional geotechnical engineering principles and practice.

This report has been prepared for the sole use of Bohannan Huston, Inc. specifically to aid in the design of the proposed Pueblo Alto / Mile Hi Green Stormwater Infiltration Pilot Project Concept Design project in Albuquerque, New Mexico, and not for use by any third parties without consent.

We make no other warranty, either expressed or implied. Any person using this report for bidding or construction purposes should perform such independent investigation as they deem necessary to satisfy themselves as to the surface and subsurface conditions to be encountered and the procedures to be used in the performance of work on this project. If conditions encountered during construction appear to be different than indicated by this report, this office should be notified.

All soil samples will be discarded 60 days after the date of this report unless we receive a specific request to retain the samples for a longer period of time.

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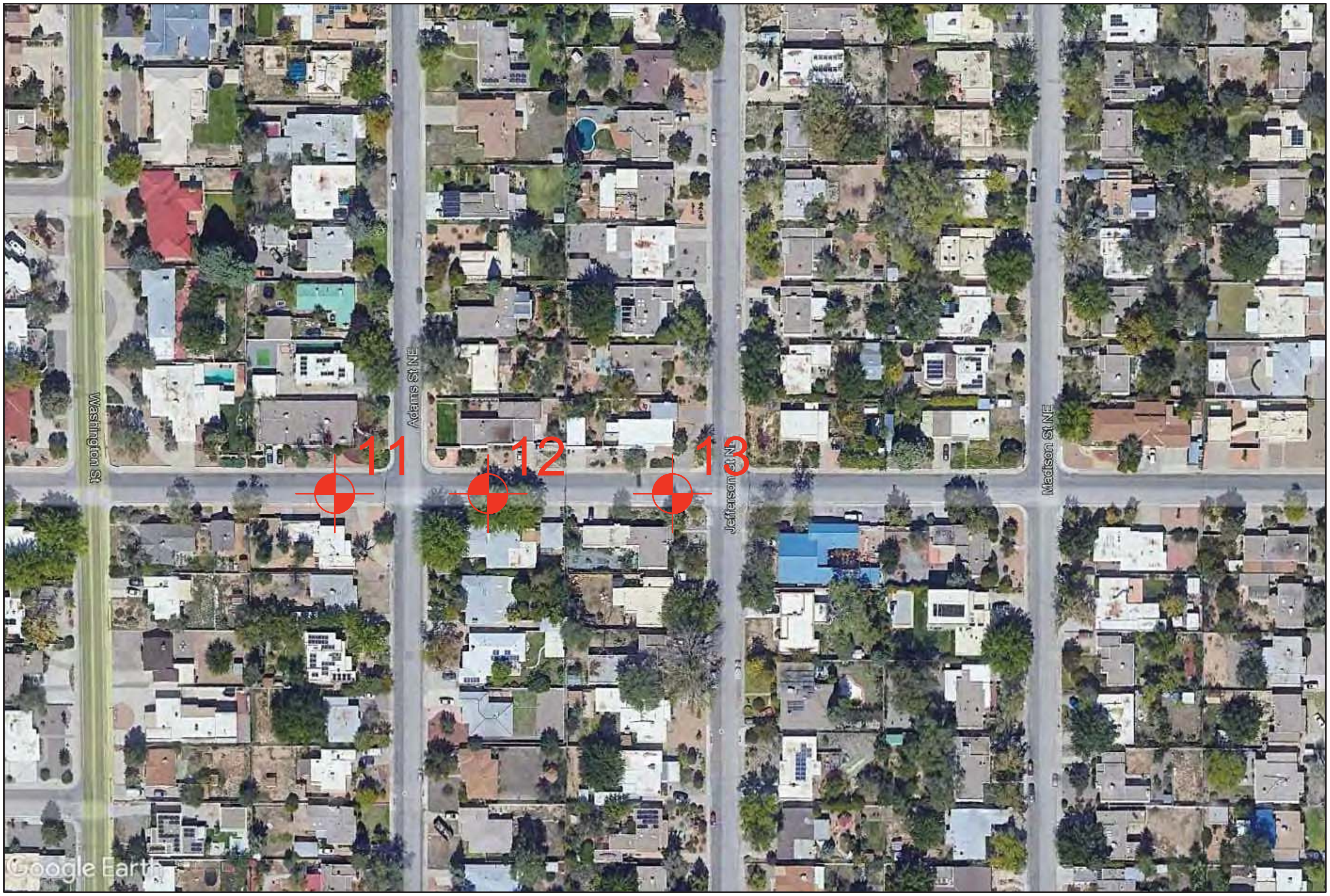
BORING LOCATION MAP



Pueblo Alto / Mile Hi Stormwater Infiltration
Albuquerque, New Mexico
Job No. 1-40405

Figure 1

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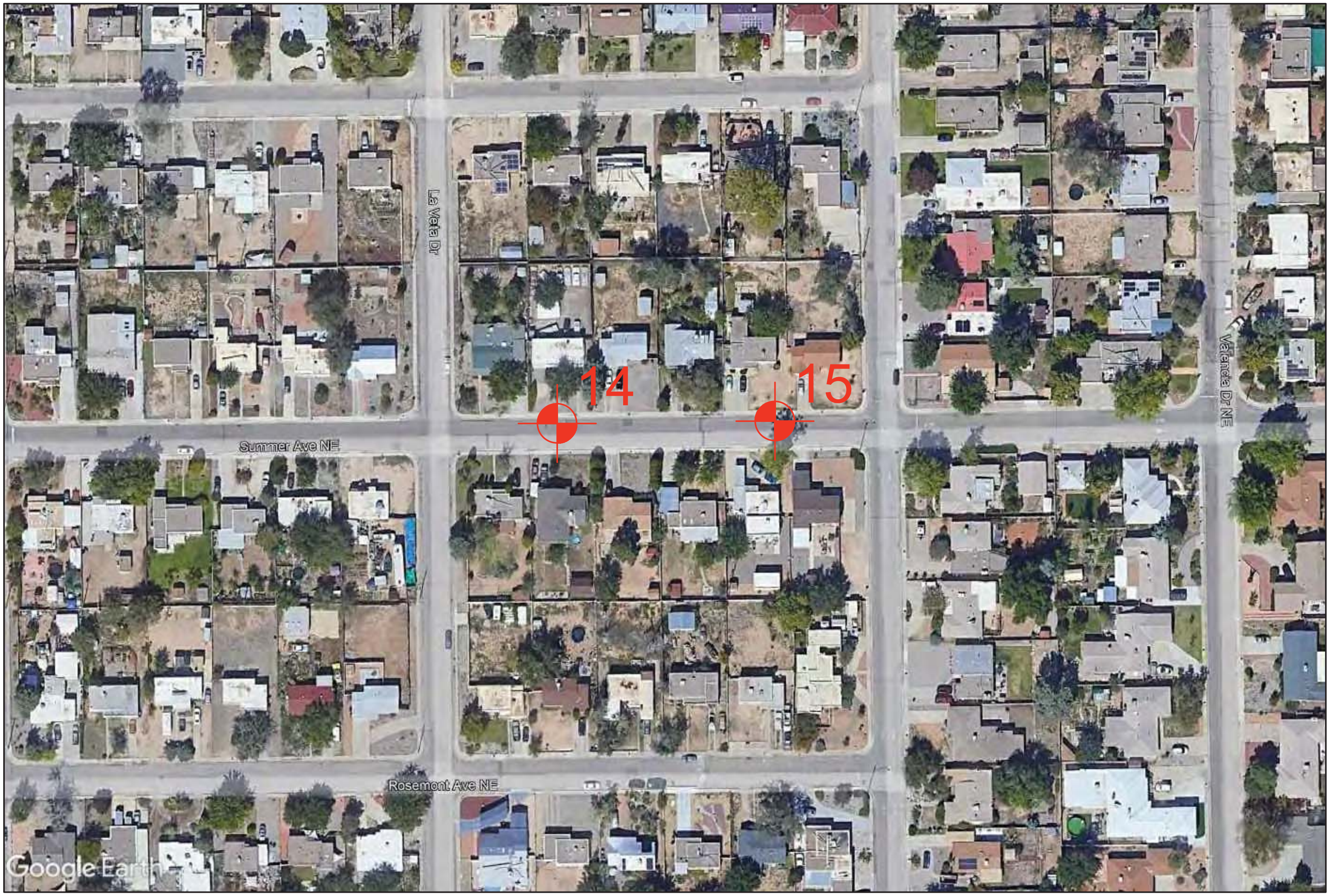
GEOTECHNICAL ENGINEERING
AND MATERIAL TESTING

BORING LOCATION MAP



Pueblo Alto / Mile Hi Stormwater Infiltration
Albuquerque, New Mexico
Job No. 1-40405

Figure 2

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GEO-TEST
GEOTECHNICAL ENGINEERING
AND MATERIAL TESTING

GEO-TEST

Project: Pueblo Alto/Mile Hi Stormwater Supplemental
Date: 05/08/2024 Project No: 1-40405
Elevation: Type: 3.25" ID HSA

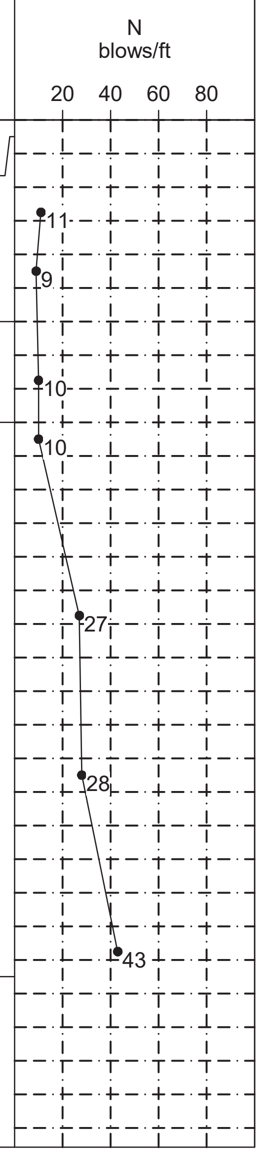
LOG OF TEST BORINGS

NO: 11

GROUNDWATER DEPTH

During Drilling: none After 24 Hours:

DEPTH (Ft)	LOG	SAMPLE INTERVAL	TYPE	N. BLOWS/FT	MOISTURE %	DRY DENSITY (pcf)	USC	DESCRIPTION
0–0.5							AC	4 inches ASPHALT with 2 inches CHIP SEAL
0.5–6			SS	3-5-6 11	10		SC	CLAYEY SAND with GRAVEL, medium plasticity, moderately firm, moist, brown
5			UD	4-5 9	13	110		
6–9			SS	1-4-6 10	6		SM	SILTY SAND with GRAVEL, non-plastic, loose, slightly moist, brown
10			UD	5-5 10	7		SP	POORLY GRADED SAND, non-plastic, medium dense to dense, moist, gray
15			SS	6-13-14 27	6			
20			UD	10-18 28	6	90		
25			SS	9-16-27 43	6			
25.5–30								Stopped Auger @ 24 feet Stopped Sampler @ 25.5 feet



LEGEND

SS - Split Spoon
AC - Auger Cuttings
UD/SL - Undisturbed Sleeve
AMSL - Above Mean Sea Level
CS - Continuous Sampler
UD - Undisturbed
ST - Shelby Tube

Stratification lines represent approximate boundaries between soil types. Transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to factors other than those present at the time measurments were made.

GEO-TEST

Project: Pueblo Alto/Mile Hi Stormwater Supplemental
Date: 05/08/2024 Project No: 1-40405
Elevation: Type: 3.25" ID HSA

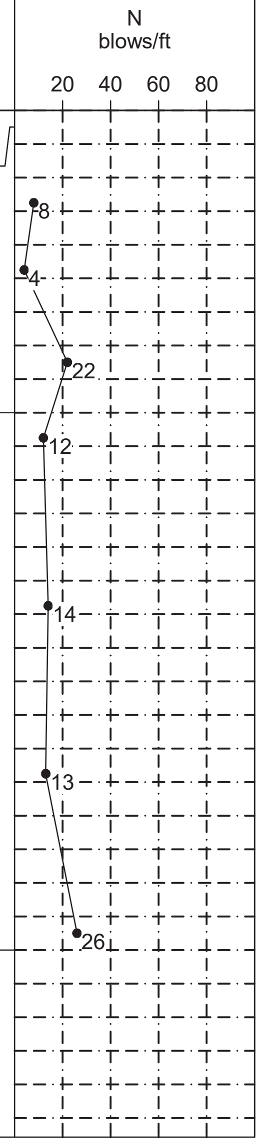
LOG OF TEST BORINGS

NO: 12

GROUNDWATER DEPTH

During Drilling: none After 24 Hours:

DEPTH (Ft)	LOG	SAMPLE INTERVAL	TYPE	N. BLOWS/FT	MOISTURE %	DRY DENSITY (pcf)	USC	DESCRIPTION
0–0.5							AC	4 inches ASPHALT with 2 inches CHIP SEAL
0.5–9			SS	3-4-4 8	6		SC	CLAYEY SAND with GRAVEL, medium plasticity, very soft to firm, slightly moist to moist, brown
5			SS	3-2-2 4	10			
			UD	9-13 22	5	102		
10			SS	6-7-5 12	6		SP-SM	POORLY GRADED SAND with SILT, non-plastic, medium dense, slightly moist to dry, gray
15			SS	4-7-7 14	6			
20			SS	4-6-7 13	3			
25			UD	16-10 26	2	110		
25–30								Stopped Auger @ 24 feet Stopped Sampler @ 25 feet



LEGEND

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GEO-TEST

Project: Pueblo Alto/Mile Hi Stormwater Supplemental
Date: 05/08/2024 Project No: 1-40405
Elevation: Type: 3.25" ID HSA

LOG OF TEST BORINGS

GROUNDWATER DEPTH

NO: 13

During Drilling: none After 24 Hours:

DEPTH (Ft)	SAMPLE INTERVAL	TYPE	N. BLOWS/FT	MOISTURE %	DRY DENSITY (pcf)	USC	DESCRIPTION	N blows/ft
0						AC	4.5 inches ASPHALT with 2 inches CHIP SEAL	
		SS	5-10-9 19	9		SC	CLAYEY SAND, medium plasticity, moderately firm to firm, moist, brown	19
5		UD	6-7 13	8	121			13
		SS	10-12-13 25	9				25
10		SS	6-7-7 14	8		SP-SM	POORLY GRADED SAND with SILT, non-plastic, medium dense, moist to dry, brown	14
15		UD	5-11 16	4	111			16
20		SS	7-9-10 19	2		SP	POORLY GRADED SAND, non-plastic, medium dense, dry, gray	19
25		SS	7-8-6 14	3				14
							Stopped Auger @ 24 feet Stopped Sampler @ 25.5 feet	
30								

LEGEND

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GEO-TEST

Project: Pueblo Alto/Mile Hi Stormwater Supplemental
Date: 05/08/2024 | Project No: 1-40405
Elevation: | Type: 3.25" ID HSA

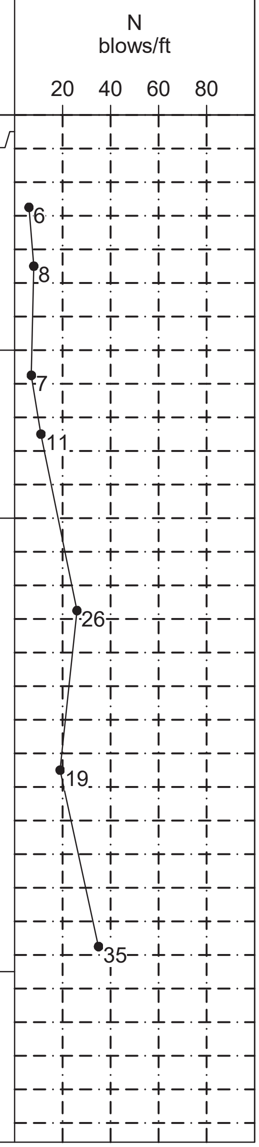
LOG OF TEST BORINGS

NO: 14

GROUNDWATER DEPTH

During Drilling: none | After 24 Hours:

DEPTH (Ft)	LOG	SAMPLE INTERVAL	TYPE	N. BLOWS/FT	MOISTURE %	DRY DENSITY (pcf)	USC	DESCRIPTION
0–0.25							AC	3 inches ASPHALT
~3			SS	3-2-4 6	9		SC	CLAYEY SAND, low plasticity, soft, moist to slightly moist, dark brown
5			UD	5-3 8	8	113		
~8			SS	3-3-4 7	5		SP-SM	POORLY GRADED SAND with SILT, non-plastic, loose, dry, light brown
10			UD	4-7 11	2	107		
15			SS	5-12-14 26	2		SP	POORLY GRADED SAND, non-plastic, medium dense to dense, dry, gray
20			UD	11-8 19	2			
25			SS	13-18-17 35	11			
								Stopped Auger @ 24 feet Stopped Sampler @ 25.5 feet



LEGEND

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GEO-TEST

Project:	Pueblo Alto/Mile Hi Stormwater Supplemental
Date:	05/08/2024
Project No:	1-40405
Elevation:	
Type:	3.25" ID HSA

LOG OF TEST BORINGS

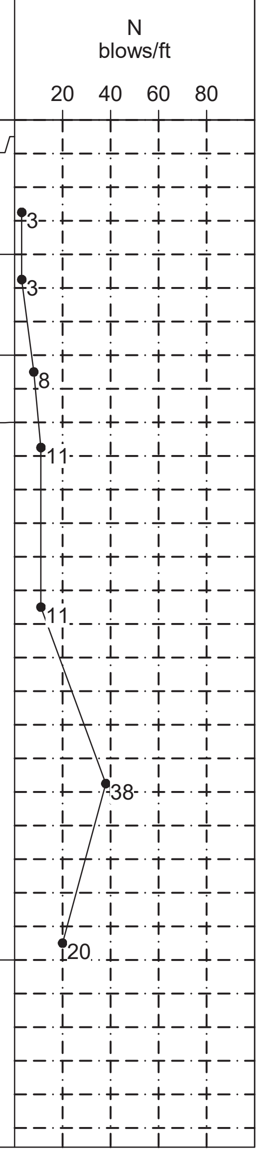
NO: 15

GROUNDWATER DEPTH

During Drilling: none

After 24 Hours:

Depth (Ft)	Sample Type	N. Blows/Ft	Moisture %	Dry Density (pcf)	USC	Description (Subsurface Profile)
0					AC	4 inches ASPHALT
2.5–4	SS	2-1-2 3	6		SC	CLAYEY SAND, medium plasticity, very soft, dry, brown
4–5.5	SS	2-2-1 3	4		SM	SILTY SAND, non-plastic, very loose, dry, brown
7–8	UD	3-5 8	8	108	SC	CLAYEY SAND, medium plasticity, soft, slightly moist, light brown
9–10.5	SS	3-5-6 11	3		SP	POORLY GRADED SAND, non-plastic, medium dense to dense, dry, gray
14–15	UD	4-7 11	3		SP	
19–20.5	SS	6-17-21 38	2		SP	
24–25	UD	5-15 20	5	94	SP	
25						Stopped Auger @ 24 feet Stopped Sampler @ 25 feet



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UD/SL - Undisturbed Sleeve
AMSL - Above Mean Sea Level
CS - Continuous Sampler
UD - Undisturbed
ST - Shelby Tube

Stratification lines represent approximate boundaries between soil types. Transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to factors other than those present at the time measurments were made.

SUMMARY OF LABORATORY RESULTS

						SIEVE ANALYSIS PERCENT PASSING											
TEST HOLE	DEPTH (FEET)	UNIFIED CLASS	(%) MOIST	LL	PI	NO 200	NO 100	NO 40	NO 10	NO 4	3/8"	1/2"	3/4"	1"	1 1/2"	2"	4"
11	3.0		10.4														
11	5.0	SC	13.4	31	16	32	52	65	78	82	86	88	96	100			
11	8.0	SM	6.2	NP	NP	15	28	44	66	72	75	83	85	100			
11	10.0	SP	7.1	NP	NP	4	10	43	94	99	100						
11	15.0		6.1														
11	20.0	SP	5.6	NP	NP	4	8	52	98	100							
11	25.0		6.1														
12	3.0		6.0														
12	5.0		9.7														
12	8.0	SC	5.0	26	11	31	58	77	94	97	99	100					
12	10.0		5.9														
12	15.0	SP-SM	5.7	NP	NP	12	24	46	82	88	94	97	100				
12	20.0		2.9														
12	25.0	SP-SM	2.4	NP	NP	10	21	47	86	93	97	98	100				
13	3.0		9.2														
13	5.0	SC	7.9	26	12	32	58	76	96	99	100						
13	8.0		9.3														
13	10.0	SC	7.8	29	15	33	62	81	96	98	99	99	100				
13	15.0	SC	4.4	22	9	27	54	77	96	99	100						

GEO-TEST

LL = LIQUID LIMIT
PI = PLASTICITY INDEX
NP = NON PLASTIC or NO VALUE

Project: Pueblo Alto/Mile Hi Stormwater Supplemental

Location: Albuquerque, NM

Number: 1-40405

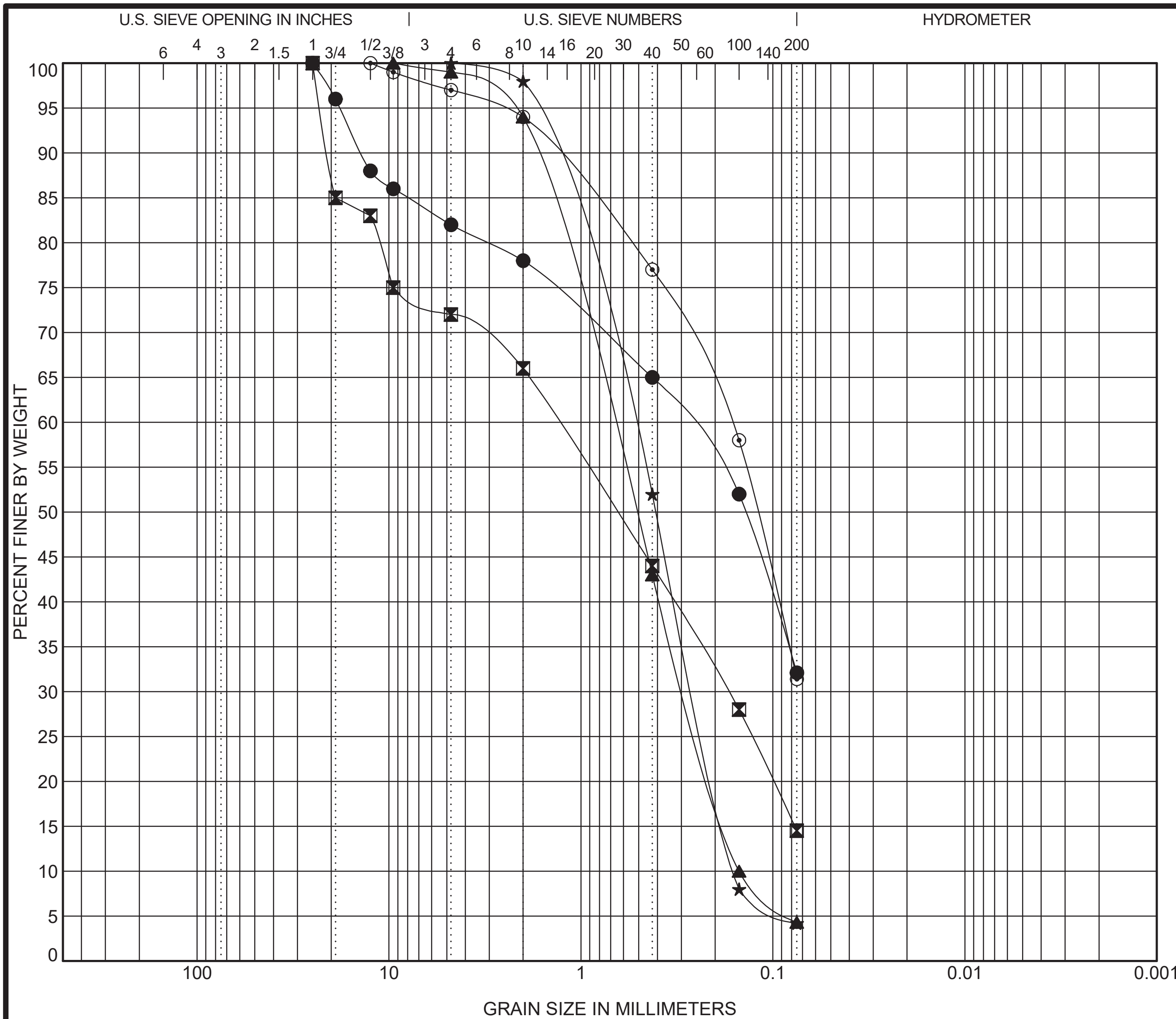
SUMMARY OF LABORATORY RESULTS

						SIEVE ANALYSIS PERCENT PASSING											
TEST HOLE	DEPTH (FEET)	UNIFIED CLASS	(%) MOIST	LL	PI	NO 200	NO 100	NO 40	NO 10	NO 4	3/8"	1/2"	3/4"	1"	1 1/2"	2"	4"
13	20.0		2.1														
13	25.0		2.9														
14	3.0	SC	8.5	24	10	31	55	73	92	97	100						
14	5.0	SC	7.9	24	10	30	51	75	84	91	97	100					
14	8.0		4.9														
14	10.0	SP-SM	1.9	NP	NP	7	14	37	73	86	97	98	100				
14	15.0		2.5														
14	20.0	SP	2.2	NP	NP	3	6	51	98	100							
14	25.0		10.7														
15	3.0		6.1														
15	5.0		3.9														
15	8.0	SC	8.4	27	12	41	59	75	93	96	99	100					
15	10.0		2.7														
15	15.0	SP	2.9	NP	NP	4	8	38	90	96	100						
15	20.0		2.2														
15	25.0	SP	5.3	NP	NP	2	6	41	85	90	96	98	100				

GEO-TEST

LL = LIQUID LIMIT
PI = PLASTICITY INDEX
NP = NON PLASTIC or NO VALUE

Project: Pueblo Alto/Mile Hi Stormwater Supplemental
Location: Albuquerque, NM
Number: 1-40405



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	11	5.0	**CLAYEY SAND with GRAVEL(SC)**	31	15	16		
⧗	11	8.0	**SILTY SAND with GRAVEL(SM)**	NP	NP	NP		
▲	11	10.0	**POORLY GRADED SAND(SP)**	NP	NP	NP	0.74	4.75
★	11	20.0	**POORLY GRADED SAND(SP)**	NP	NP	NP	0.73	3.54
⊙	12	8.0	**CLAYEY SAND(SC)**	26	15	11		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	11	5.0	25	0.285			18.0	49.9	32.1	
⧗	11	8.0	25	1.311	0.171		28.0	57.5	14.5	
▲	11	10.0	9.5	0.712	0.282	0.15	1.0	94.7	4.3	
★	11	20.0	4.75	0.556	0.252	0.157	0.0	95.8	4.2	
⊙	12	8.0	12.5	0.167			3.0	65.6	31.4	

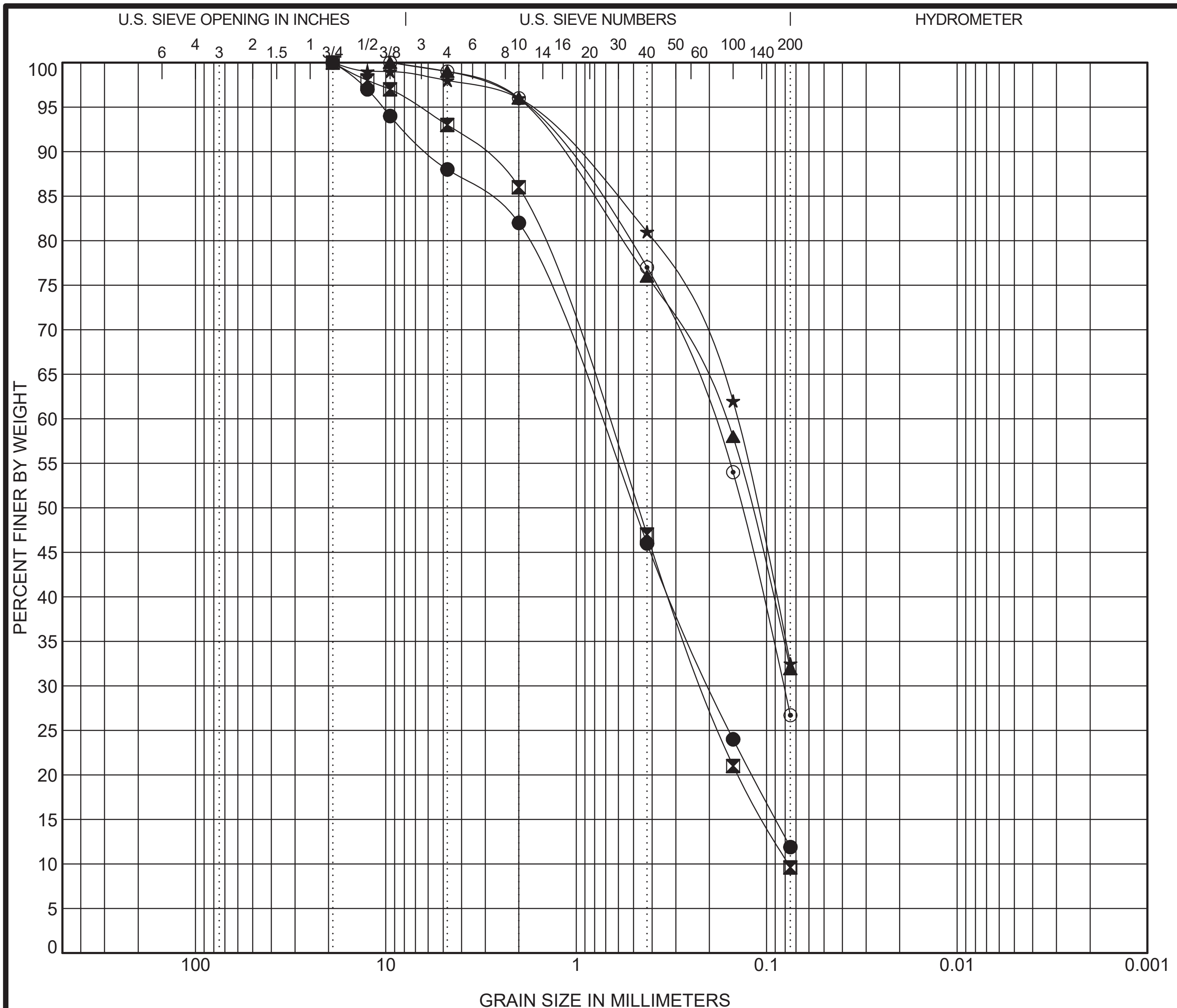
GEO-TEST

GRAIN SIZE DISTRIBUTION

Project: Pueblo Alto/Mile Hi Stormwater Supplemental

Location: Albuquerque, NM

Number: 1-40405



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	12	15.0	**POORLY GRADED SAND with SILT(SP-SM)**	NP	NP	NP	0.76	11.54
⊠	12	25.0	**POORLY GRADED SAND with SILT(SP-SM)**	NP	NP	NP	0.85	9.27
▲	13	5.0	**CLAYEY SAND(SC)**	26	14	12		
★	13	10.0	**CLAYEY SAND(SC)**	29	14	15		
⊙	13	15.0	**CLAYEY SAND(SC)**	22	13	9		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	12	15.0	19	0.776	0.199		12.0	76.1	11.9	
⊠	12	25.0	19	0.712	0.215	0.077	7.0	83.4	9.6	
▲	13	5.0	9.5	0.168			1.0	67.1	31.9	
★	13	10.0	19	0.143			2.0	65.5	32.5	
⊙	13	15.0	9.5	0.197	0.082		1.0	72.3	26.7	

US GRAIN SIZE 1-40405.GPJ GEO TEST.GDT 6/26/24

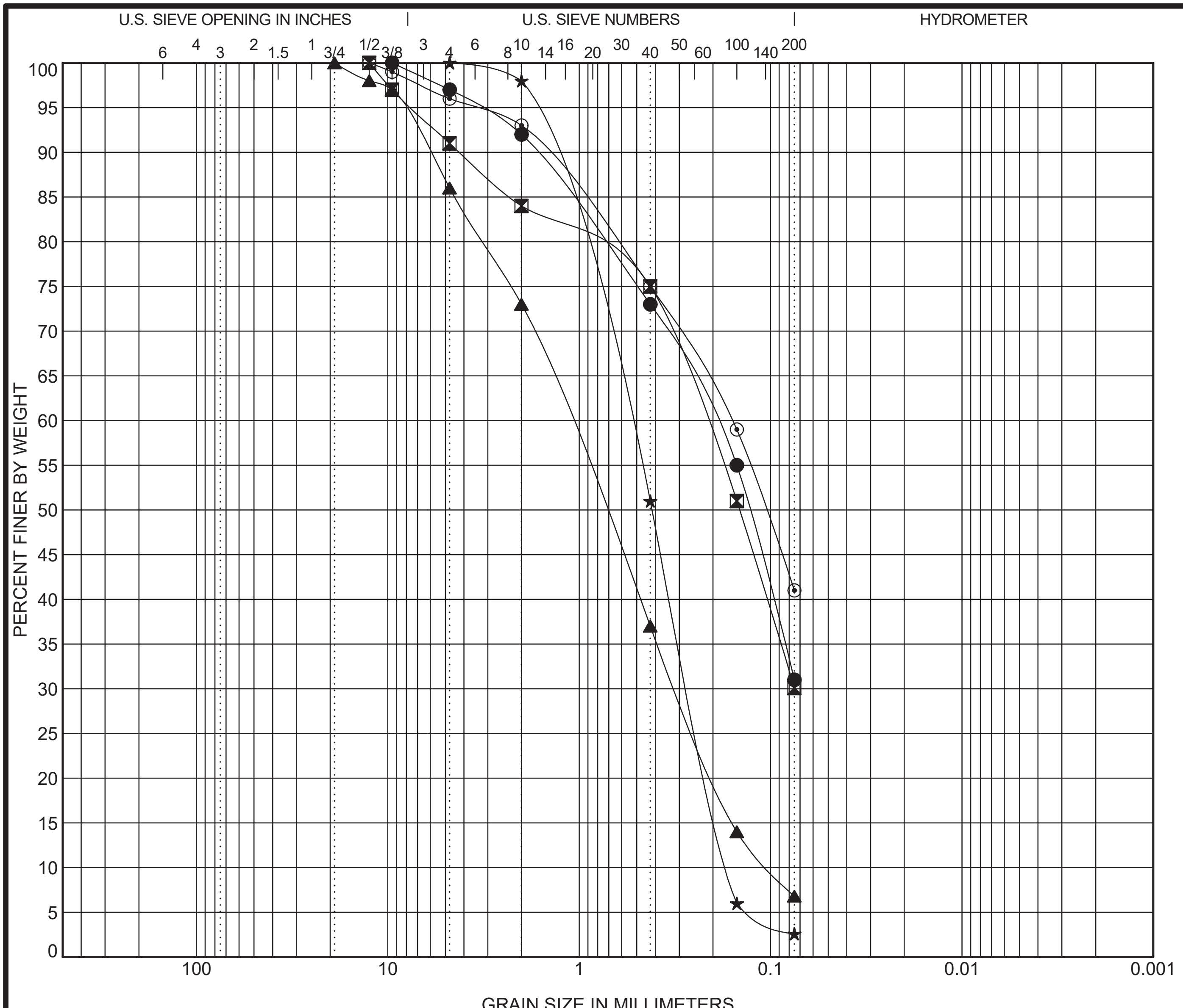
GEO-TEST

GRAIN SIZE DISTRIBUTION

Project: Pueblo Alto/Mile Hi Stormwater Supplemental

Location: Albuquerque, NM

Number: 1-40405



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	**14**	**3.0**	**CLAYEY SAND(SC)**	**24**	**14**	**10**		
⧗	**14**	**5.0**	**CLAYEY SAND(SC)**	**24**	**14**	**10**		
▲	**14**	**10.0**	**POORLY GRADED SAND with SILT(SP-SM)**	**NP**	**NP**	**NP**	**0.82**	**11.20**
★	**14**	**20.0**	**POORLY GRADED SAND(SP)**	**NP**	**NP**	**NP**	**0.73**	**3.47**
⊙	**15**	**8.0**	**CLAYEY SAND(SC)**	**27**	**15**	**12**		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**14**	**3.0**	**9.5**	**0.2**			**3.0**	**66.0**	**31.0**	
⧗	**14**	**5.0**	**12.5**	**0.222**			**9.0**	**60.9**	**30.1**	
▲	**14**	**10.0**	**19**	**1.143**	**0.31**	**0.102**	**14.0**	**79.2**	**6.8**	
★	**14**	**20.0**	**4.75**	**0.572**	**0.261**	**0.165**	**0.0**	**97.4**	**2.6**	
⊙	**15**	**8.0**	**12.5**	**0.16**			**4.0**	**55.0**	**41.0**	

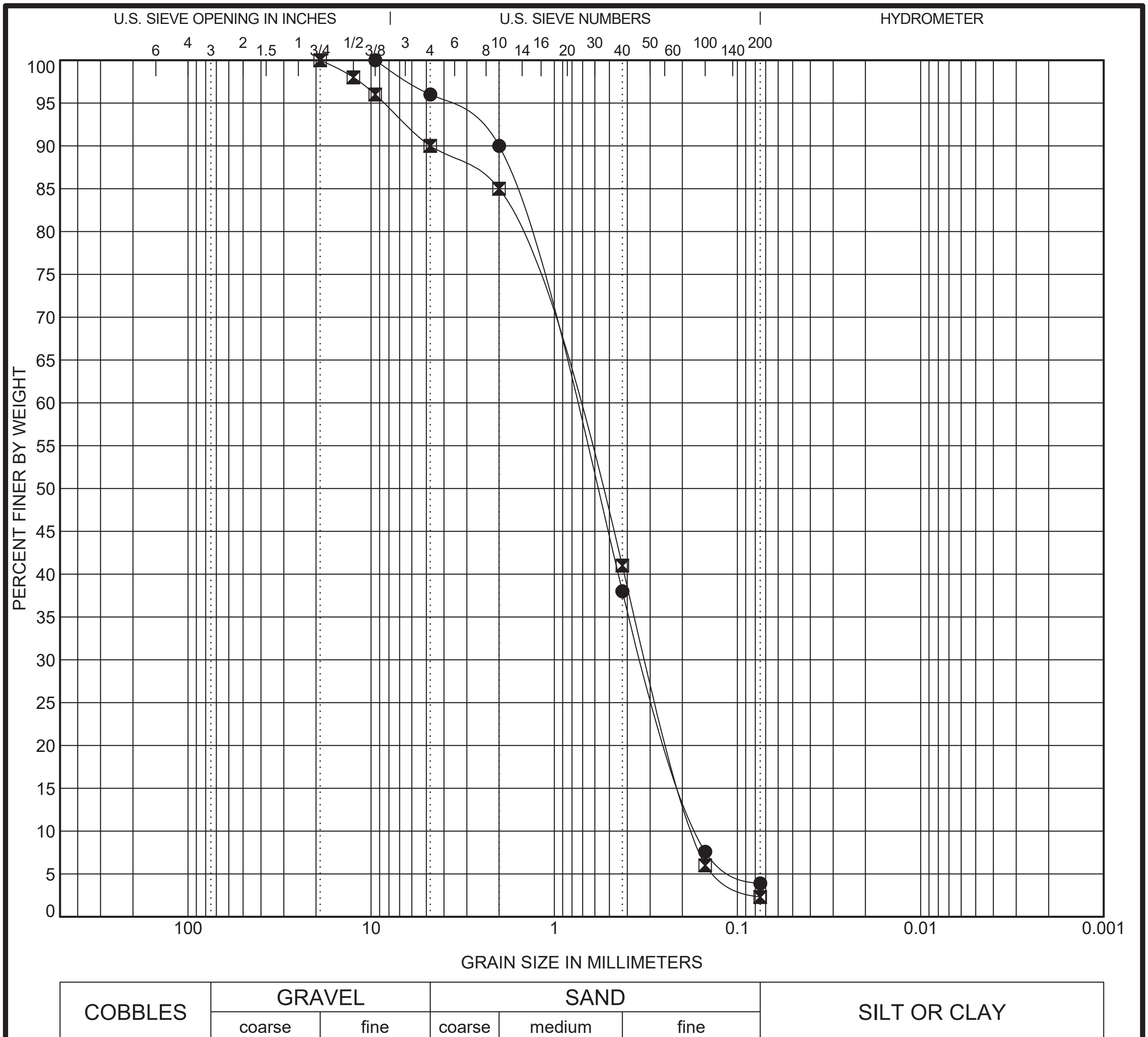
GEO-TEST

GRAIN SIZE DISTRIBUTION

Project: Pueblo Alto/Mile Hi Stormwater Supplemental

Location: Albuquerque, NM

Number: 1-40405



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	**15**	**15.0**	**POORLY GRADED SAND(SP)**	**NP**	**NP**	**NP**	**0.78**	**5.03**
⊠	**15**	**25.0**	**POORLY GRADED SAND(SP)**	**NP**	**NP**	**NP**	**0.67**	**4.91**

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**15**	**15.0**	**9.5**	**0.818**	**0.323**	**0.163**	**4.0**	**92.1**	**3.9**	
⊠	**15**	**25.0**	**19**	**0.83**	**0.306**	**0.169**	**10.0**	**87.7**	**2.3**	

GEO-TEST

GRAIN SIZE DISTRIBUTION

Project: Pueblo Alto/Mile Hi Stormwater Supplemental

Location: Albuquerque, NM

Number: 1-40405

Rigid Wall Constant Head
Remold Permeability

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 11
Sample Depth:	5 feet
Soil Description:	Clayey Sand (SC)
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	210.6	grams	Weight of Sample:	660.6	grams
Apartus Weight + Soil:	871.2	grams	Weight of Sample:	1.456349	lb
Mold Diameter:	6.187	cm	Mold Area:	30.06423	cm^2
Pipe Diameter:	1.27	cm	Pipe Area:	1.266769	cm^2
Length of Sample	10.99	cm	Area Factor:	0.042135	
Pressure Head Applied 1psi = 70.34 cm:	0	cm	Volume of Sample:	330.4059	cm^3
Can #:			Volume of Sample:	0.011668	ft^3
Wet Weight:	183	grams	**Unit Weight:**	**124.8**	**lb/ft^3**
Dry Weight:	161.4	grams	**Moisture Content:**	**13.4**	**%**
			Dry Unit Weight:	**110.1**	**lb/ft^3**

Time	Trial 1		Trial 2		Trial 3	
Hour	0		0		0	
Minute	26		25		24	
Second	37		32		47	
Total (hr)	0.443611		0.425556		0.413056	
h_0	65	cm	65	cm	65	cm
h_1	10	cm	10	cm	10	cm
$Head_0$	75.99	cm	75.99	cm	75.99	cm
$Head_1$	20.99	cm	20.99	cm	20.99	cm
Ks (cm/hour)	1.34	cm/hr	1.40	cm/hr	1.44	cm/hr
Ks (cm/sec)	3.73E-04	cm/s	3.89E-04	cm/s	4.01E-04	cm/s

Saturated Hydraulic Conductivity, $K_{s:}$ **1.40 cm/hr**

Saturated Hydraulic Conductivity, K_s: **3.88E-04 cm/s**

Rigid Wall Constant Head
Remold Permeability

GEO-TEST

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 11
Sample Depth:	20 feet
Soil Description:	Poorly Graded Sand
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	204.7	grams	Weight of Sample:	501.2	grams
Apparartus Weight + Soil:	705.9	grams	Weight of Sample:	1.104938	lb
Mold Diameter:	6.195	cm	Mold Area:	30.14203	cm^2
Pipe Diameter:	1.27	cm	Pipe Area:	1.266769	cm^2
Length of Sample	10.9	cm	Area Factor:	0.042027	
Pressure Head Applied 1psi = 70.34 cm:	0	cm	Volume of Sample:	328.5481	cm^3
Can #:			Volume of Sample:	0.011603	ft^3
Wet Weight:	169.7	grams	**Unit Weight:**	**95.2**	**lb/ft^3**
Dry Weight:	160.7	grams	**Moisture Content:**	**5.6**	**%**
			Dry Unit Weight:	**90.2**	**lb/ft^3**

Time	Trial 1		Trial 2		Trial 3	
Hour	0		0		0	
Minute	26		0		0	
Second	10		10		10	
Total (hr)	0.436111		0.002778		0.002778	
h_0	65	cm	65	cm	65	cm
h_1	10	cm	10	cm	10	cm
$Head_0$	75.9	cm	75.9	cm	75.9	cm
$Head_1$	20.9	cm	20.9	cm	20.9	cm
Ks (cm/hour)	1.35	cm/hr	212.68	cm/hr	212.68	cm/hr
Ks (cm/sec)	3.76E-04	cm/s	5.91E-02	cm/s	5.91E-02	cm/s

Saturated Hydraulic Conductivity, K_{s}: **142.24 cm/hr**

Saturated Hydraulic Conductivity, K_s: **3.95E-02 cm/s**

Rigid Wall Constant Head
Remold Permeability

GEO-TEST

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 12
Sample Depth:	7.5 feet
Soil Description:	Clayey Sand (SC)
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	211.9	grams	Weight of Sample:	572.2	grams
Apparartus Weight + Soil:	784.1	grams	Weight of Sample:	1.261464	lb
Mold Diameter:	6.195	cm	Mold Area:	30.14203	cm^2
Pipe Diameter:	1.27	cm	Pipe Area:	1.266769	cm^2
Length of Sample	11.05	cm	Area Factor:	0.042027	
Pressure Head Applied 1psi = 70.34 cm:	0	cm	Volume of Sample:	333.0694	cm^3
Can #:			Volume of Sample:	0.011762	ft^3
Wet Weight:	135.4	grams	**Unit Weight:**	**107.2**	**lb/ft^3**
Dry Weight:	128.9	grams	**Moisture Content:**	**5.0**	**%**
			Dry Unit Weight:	**102.1**	**lb/ft^3**

Time	Trial 1		Trial 2		Trial 3	
Hour	0		0		0	
Minute	36		34		34	
Second	16		45		22	
Total (hr)	0.604444		0.579167		0.572778	
h_0	65	cm	65	cm	65	cm
h_1	10	cm	10	cm	10	cm
$Head_0$	76.05	cm	76.05	cm	76.05	cm
$Head_1$	21.05	cm	21.05	cm	21.05	cm
Ks (cm/hour)	0.99	cm/hr	1.03	cm/hr	1.04	cm/hr
Ks (cm/sec)	2.74E-04	cm/s	2.86E-04	cm/s	2.89E-04	cm/s

Saturated Hydraulic Conductivity, $K_{s:}$ **1.02 cm/hr**

Saturated Hydraulic Conductivity, K_s: **2.83E-04 cm/s**

Rigid Wall Constant Head
Remold Permeability

GEO-TEST

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 12
Sample Depth:	25 feet
Soil Description:	Poorly Graded Sand
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	215.4	grams	Weight of Sample:	747.8	grams
Apparartus Weight + Soil:	963.2	grams	Weight of Sample:	1.648589	lb
Mold Diameter:	6.195	cm	Mold Area:	30.14203	cm^2
Pipe Diameter:	1.27	cm	Pipe Area:	1.266769	cm^2
Length of Sample	13.71	cm	Area Factor:	0.042027	
Pressure Head Applied 1psi = 70.34 cm:	0	cm	Volume of Sample:	413.2472	cm^3
Can #:			Volume of Sample:	0.014594	ft^3
Wet Weight:	230.1	grams	**Unit Weight:**	**113.0**	**lb/ft^3**
Dry Weight:	223.1	grams	**Moisture Content:**	**3.1**	**%**
			Dry Unit Weight:	**109.5**	**lb/ft^3**

Time	Trial 1		Trial 2		Trial 3	
Hour	0		0		0	
Minute	0		0		0	
Second	31		28		28	
Total (hr)	0.008611		0.007778		0.007778	
h_0	65	cm	65	cm	65	cm
h_1	10	cm	10	cm	10	cm
$Head_0$	78.71	cm	78.71	cm	78.71	cm
$Head_1$	23.71	cm	23.71	cm	23.71	cm
Ks (cm/hour)	80.29	cm/hr	88.89	cm/hr	88.89	cm/hr
Ks (cm/sec)	2.23E-02	cm/s	2.47E-02	cm/s	2.47E-02	cm/s

Saturated Hydraulic Conductivity, $K_{s:}$ **86.02 cm/hr**

Saturated Hydraulic Conductivity, K_s: **2.39E-02 cm/s**

Rigid Wall Constant Head Remold Permeability

GEO-TEST

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 13
Sample Depth:	5 feet
Soil Description:	Clayey Sand (SC)
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	205.5 grams		Weight of Sample:	725.6	grams
Apparartus Weight + Soil:	931.1 grams		Weight of Sample:	1.599647	lb
Mold Diameter:	6.187 cm		Mold Area:	30.06423	cm^2
Pipe Diameter:	1.27 cm		Pipe Area:	1.266769	cm^2
Length of Sample	11.54 cm		Area Factor:	0.042135	
Pressure Head Applied 1psi = 70.34 cm:	0 cm		Volume of Sample:	346.9412	cm^3
Can #:			Volume of Sample:	0.012252	ft^3
Wet Weight:	220.5 grams		**Unit Weight:**	**130.6**	**lb/ft^3**
Dry Weight:	204.3 grams		**Moisture Content:**	**7.9**	**%**
			Dry Unit Weight:	**121.0**	**lb/ft^3**

Time	Trial 1	Trial 2	Trial 3
Hour	0	0	0
Minute	28	31	30
Second	55	22	45
Total (hr)	0.481944	0.522778	0.5125
h_0	65 cm	65 cm	65 cm
h_1	10 cm	10 cm	10 cm
$Head_0$	76.54 cm	76.54 cm	76.54 cm
$Head_1$	21.54 cm	21.54 cm	21.54 cm
Ks (cm/hour)	1.28 cm/hr	1.18 cm/hr	1.20 cm/hr
Ks (cm/sec)	3.55E-04 cm/s	3.28E-04 cm/s	3.34E-04 cm/s

Saturated Hydraulic Conductivity, $K_{s:}$ **1.22 cm/hr**

Saturated Hydraulic Conductivity, K_s: **3.39E-04 cm/s**

Rigid Wall Constant Head
Remold Permeability

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 13
Sample Depth:	15 feet
Soil Description:	Poorly Graded Sand with Silt (SP-SM)
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	212.9	grams	Weight of Sample:	601.4	grams
Apparartus Weight + Soil:	814.3	grams	Weight of Sample:	1.325838	lb
Mold Diameter:	6.193	cm	Mold Area:	30.12257	cm^2
Pipe Diameter:	1.27	cm	Pipe Area:	1.266769	cm^2
Length of Sample	10.81	cm	Area Factor:	0.042054	
Pressure Head Applied 1psi = 70.34 cm:	0	cm	Volume of Sample:	325.625	cm^3
Can #:			Volume of Sample:	0.011499	ft^3
Wet Weight:	226.4	grams	**Unit Weight:**	**115.3**	**lb/ft^3**
Dry Weight:	216.8	grams	**Moisture Content:**	**4.4**	**%**
			Dry Unit Weight:	**110.4**	**lb/ft^3**

Time	Trial 1		Trial 2		Trial 3	
Hour	0		0		0	
Minute	3		3		3	
Second	56		54		51	
Total (hr)	0.065556		0.065		0.064167	
h_0	65	cm	65	cm	65	cm
h_1	10	cm	10	cm	10	cm
$Head_0$	75.81	cm	75.81	cm	75.81	cm
$Head_1$	20.81	cm	20.81	cm	20.81	cm
Ks (cm/hour)	8.97	cm/hr	9.04	cm/hr	9.16	cm/hr
Ks (cm/sec)	2.49E-03	cm/s	2.51E-03	cm/s	2.54E-03	cm/s

Saturated Hydraulic Conductivity, $K_{s:}$ **9.06 cm/hr**

Saturated Hydraulic Conductivity, K_s: **2.52E-03 cm/s**

Rigid Wall Constant Head
Remold Permeability

GEO-TEST

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 14
Sample Depth:	5 feet
Soil Description:	Clayey Sand (SC)
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	209.3	grams	Weight of Sample:	647.6	grams
Apartus Weight + Soil:	856.9	grams	Weight of Sample:	1.42769	lb
Mold Diameter:	6.195	cm	Mold Area:	30.14203	cm^2
Pipe Diameter:	1.27	cm	Pipe Area:	1.266769	cm^2
Length of Sample	11.05	cm	Area Factor:	0.042027	
Pressure Head Applied 1psi = 70.34 cm:	0	cm	Volume of Sample:	333.0694	cm^3
Can #:			Volume of Sample:	0.011762	ft^3
Wet Weight:	234.1	grams	**Unit Weight:**	**121.4**	**lb/ft^3**
Dry Weight:	216.9	grams	**Moisture Content:**	**7.9**	**%**
			Dry Unit Weight:	**112.5**	**lb/ft^3**

Time	Trial 1		Trial 2		Trial 3	
Hour	0		0		0	
Minute	25		26		25	
Second	54		32		43	
Total (hr)	0.431667		0.442222		0.428611	
h_0	65	cm	65	cm	65	cm
h_1	10	cm	10	cm	10	cm
$Head_0$	76.05	cm	76.05	cm	76.05	cm
$Head_1$	21.05	cm	21.05	cm	21.05	cm
Ks (cm/hour)	1.38	cm/hr	1.35	cm/hr	1.39	cm/hr
Ks (cm/sec)	3.84E-04	cm/s	3.75E-04	cm/s	3.87E-04	cm/s

Saturated Hydraulic Conductivity, $K_{s:}$ **1.37 cm/hr**

Saturated Hydraulic Conductivity, K_s: **3.82E-04 cm/s**

Rigid Wall Constant Head
Remold Permeability

GEO-TEST

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 14
Sample Depth:	10 feet
Soil Description:	Poorly Graded Sand with Silt (SP-SM)
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	207.9	grams	Weight of Sample:	581.4	grams
Apparartus Weight + Soil:	789.3	grams	Weight of Sample:	1.281746	lb
Mold Diameter:	6.182	cm	Mold Area:	30.01566	cm^2
Pipe Diameter:	1.27	cm	Pipe Area:	1.266769	cm^2
Length of Sample	11.08	cm	Area Factor:	0.042204	
Pressure Head Applied 1psi = 70.34 cm:	0	cm	Volume of Sample:	332.5735	cm^3
Can #:			Volume of Sample:	0.011745	ft^3
Wet Weight:	192.3	grams	**Unit Weight:**	**109.1**	**lb/ft^3**
Dry Weight:	188.8	grams	**Moisture Content:**	**1.9**	**%**
			Dry Unit Weight:	**107.1**	**lb/ft^3**

Time	Trial 1		Trial 2		Trial 3	
Hour	0		0		0	
Minute	0		0		0	
Second	27		27		27	
Total (hr)	0.0075		0.0075		0.0075	
h_0	65	cm	65	cm	65	cm
h_1	10	cm	10	cm	10	cm
$Head_0$	76.08	cm	76.08	cm	76.08	cm
$Head_1$	21.08	cm	21.08	cm	21.08	cm
Ks (cm/hour)	80.02	cm/hr	80.02	cm/hr	80.02	cm/hr
Ks (cm/sec)	2.22E-02	cm/s	2.22E-02	cm/s	2.22E-02	cm/s

Saturated Hydraulic Conductivity, $K_{s:}$ **80.02 cm/hr**

Saturated Hydraulic Conductivity, K_s: **2.22E-02 cm/s**

Rigid Wall Constant Head Remold Permeability

GEO-TEST

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 15
Sample Depth:	8 feet
Soil Description:	Clayey Sand (SC)
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	211.8	grams	Weight of Sample:	595.4	grams
Apartus Weight + Soil:	807.2	grams	Weight of Sample:	1.31261	lb
Mold Diameter:	6.18	cm	Mold Area:	29.99624	cm^2
Pipe Diameter:	1.27	cm	Pipe Area:	1.266769	cm^2
Length of Sample	10.56	cm	Area Factor:	0.042231	
Pressure Head Applied 1psi = 70.34 cm:	1406.8	cm	Volume of Sample:	316.7603	cm^3
Can #:			Volume of Sample:	0.011186	ft^3
Wet Weight:	203.3	grams	**Unit Weight:**	**117.3**	**lb/ft^3**
Dry Weight:	187.5	grams	**Moisture Content:**	**8.4**	**%**
			Dry Unit Weight:	**108.2**	**lb/ft^3**

Time	Trial 1		Trial 2		Trial 3	
Hour	1		1		1	
Minute	29		34		31	
Second	6		18		10	
Total (hr)	1.485		1.571667		1.519444	
h_0	65	cm	65	cm	65	cm
h_1	10	cm	10	cm	10	cm
$Head_0$	1482.36	cm	1482.36	cm	1482.36	cm
$Head_1$	1427.36	cm	1427.36	cm	1427.36	cm
Ks (cm/hour)	0.01	cm/hr	0.01	cm/hr	0.01	cm/hr
Ks (cm/sec)	3.15E-06	cm/s	2.98E-06	cm/s	3.08E-06	cm/s

Saturated Hydraulic Conductivity, $K_{S:}$	**0.01 cm/hr**
Saturated Hydraulic Conductivity, K_S:	**3.07E-06 cm/s**

Rigid Wall Constant Head
Remold Permeability

GEO-TEST

Project:	Pueblo Alto / Mile Hi Stormwater Infiltration
Job #:	1-40405
Boring/Location:	Boring 15
Sample Depth:	25 feet
Soil Description:	Poorly Graded Sand (SP)
Remolded to:	In-Situ Tube Sample

Aparatus Weight Empty:	211.5	grams	Weight of Sample:	532.9	grams
Apparartus Weight + Soil:	744.4	grams	Weight of Sample:	1.174824	lb
Mold Diameter:	6.177	cm	Mold Area:	29.96713	cm^2
Pipe Diameter:	1.27	cm	Pipe Area:	1.266769	cm^2
Length of Sample	11.28	cm	Area Factor:	0.042272	
Pressure Head Applied 1psi = 70.34 cm:	0	cm	Volume of Sample:	338.0292	cm^3
Can #:			Volume of Sample:	0.011937	ft^3
Wet Weight:	171.7	grams	**Unit Weight:**	**98.4**	**lb/ft^3**
Dry Weight:	163.1	grams	**Moisture Content:**	**5.3**	**%**
			Dry Unit Weight:	**93.5**	**lb/ft^3**

Time	Trial 1		Trial 2		Trial 3	
Hour	0		0		0	
Minute	0		0		0	
Second	12		12		12	
Total (hr)	0.003333		0.003333		0.003333	
h_0	65	cm	65	cm	65	cm
h_1	10	cm	10	cm	10	cm
$Head_0$	76.28	cm	76.28	cm	76.28	cm
$Head_1$	21.28	cm	21.28	cm	21.28	cm
Ks (cm/hour)	182.62	cm/hr	182.62	cm/hr	182.62	cm/hr
Ks (cm/sec)	5.07E-02	cm/s	5.07E-02	cm/s	5.07E-02	cm/s

Saturated Hydraulic Conductivity, $K_{S:}$ **182.62 cm/hr**

Saturated Hydraulic Conductivity, K_s: **5.07E-02 cm/s**

Attachment 1

BOHANNAN HUSTON, INC.

SUBCONSULTANT QUALITY VERIFICATION FORM

Subconsultant must provide a signed copy of this form with each deliverable specified in the contract or the deliverable will not be accepted. A copy of Subconsultant's internal QA/QC review should be kept and may be requested by Bohannan Huston, Inc. for audit purposes.

This form must be signed by Subconsultant's Quality Reviewer.

Project Name: CABQ Pueblo Alto Mile Hi GSI Pilot Project

Bohannan Huston Project Number: 20230388

Deliverable Description: Supplemental Geotechnical Report

I, Patrick R. Whorton, PE, warrant and represent that the project deliverable described above and attached to this form was developed in accordance with the project scope of work, and is fully in compliance with the specifications or requirements. All elements relating to the quality of the deliverable were verified in accordance with the requirements of my firm's internal quality management/quality assurance system.

Signature: ______________________ Date: 6/26/2024
(by QC Reviewer)

Subconsultant: Geo-Test, Inc.

Infiltration/Draw-Down Analysis

Project Name: Pueblo Alto/Mile Hi Phase IIIA
BHI Project No.: 20230388
Prepared By: ELA
Date: 7/9/2024

	Location in Relation to Tank	Depth to Drainage Layer (feet)	Infiltration Rate (in./hr)	Maximum Depth Based on Drain Time 48 hours (feet)	Maximum Depth Based on Drain Time 96 hours (feet)	Time to Drain 6" (bumpout) (min / hr)	Time to Drain 7' 2" (tank) (hr / d)
Boring 3 (PA)	Adams-Washington W	11	10.5	42.0	83.9	36 / 0.6	8.2 / 0.3
Boring 11 (PA)	Adams-Washington E	6	28.0	112.0	223.9	12 / 0.2	3.1 / 0.1
Boring 12 (PA)	Jefferson-Adams W	9	16.9	67.7	135.5	24 / 0.4	5.1 / 0.2
Boring 13 (PA)	Jefferson-Adams E	9	1.8	7.1	14.3	204 / 3.4	48.2 / 2
Boring 4 (PA)	Madison-Jefferson	9	Not Calculated	-	-	-	-
Boring 9 (MH)	LaVeta N	11	42.6	170.4	340.7	6 / 0.1	2 / 0.1
Boring 10 (MH)	N/A	6	Not Calculated	-	-	-	-
Boring 14 (MH)	LaVeta S	7	15.7	62.9	125.9	24 / 0.4	5.5 / 0.2
Boring 15 (MH)	N/A	9	35.9	143.7	287.4	12 / 0.2	2.4 / 0.1

Notes:

1. \\a-abq-fs2\projects\20230388\Archive\Received\GeoTest\2024.06.26-Supplemental geotech report\Geo-Test Report 1-40405 Pueblo Alto Mile Hi Supplemental.pdf

APPENDIX E – PROPOSED CONDITIONS HYDRAULIC ANALYSIS RESULTS

Proposed Storm Drain Layout Map

Proposed Storm Drain Layout Map

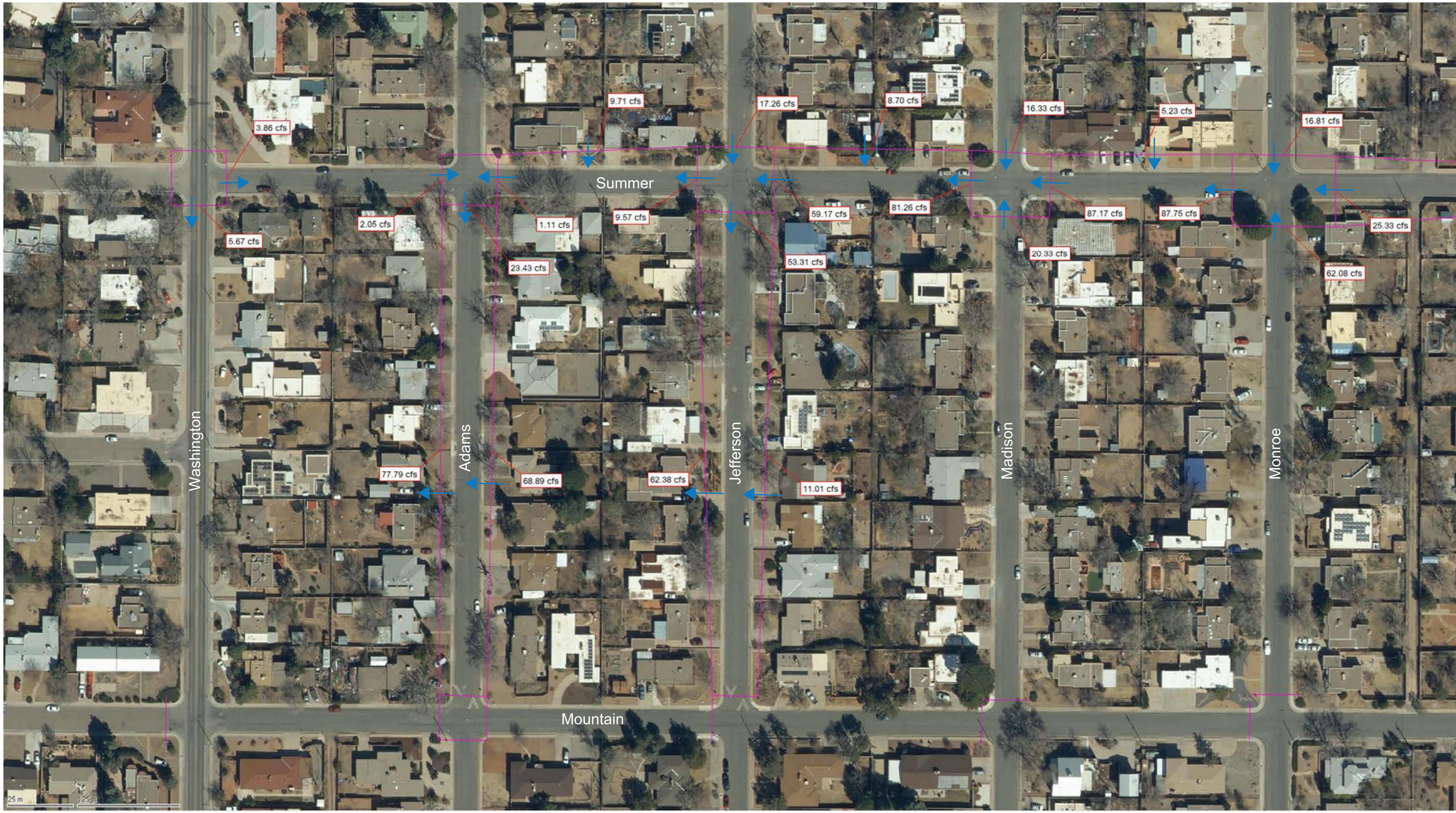
Proposed Conditions 2-year Surface Peak Flows

Future Conditions, With GSI 2-year Surface Peak Flows

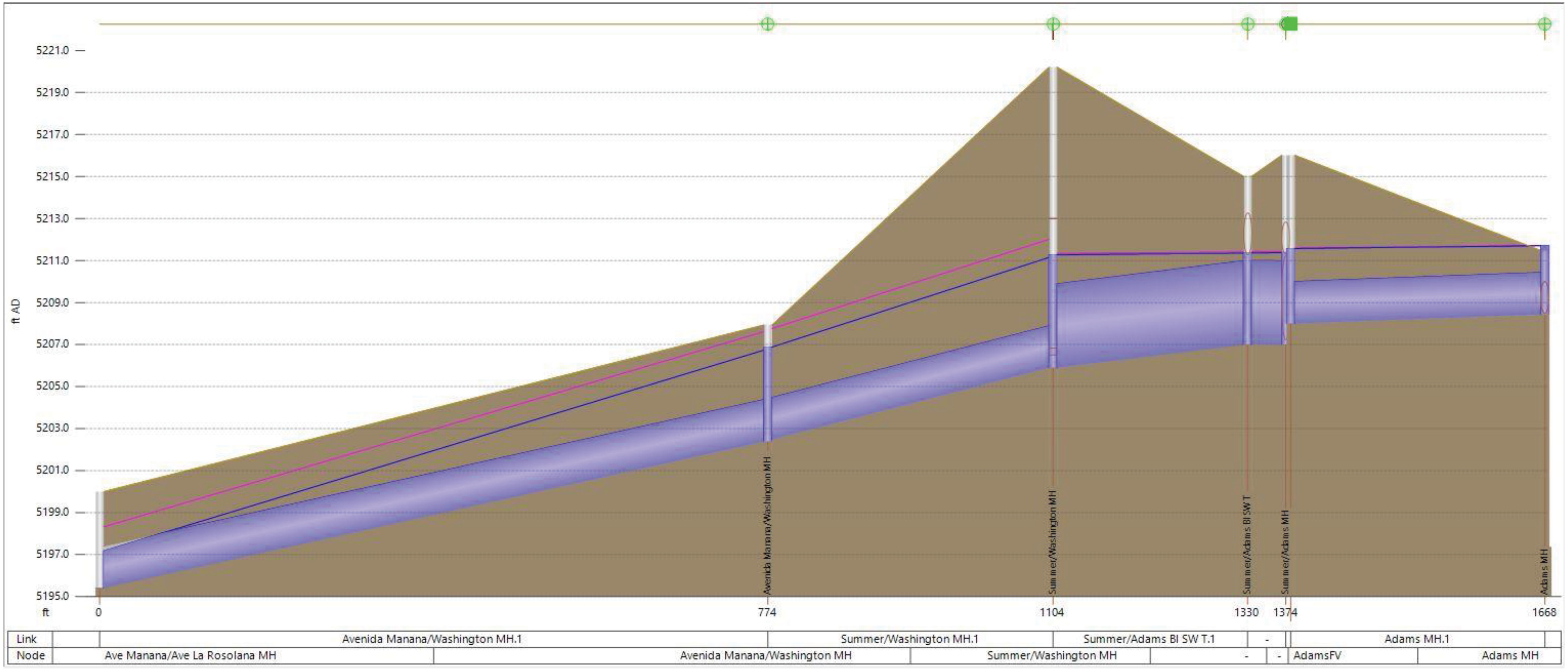
Proposed Conditions 10-year Surface Peak Flows

Future Conditions, With GSI 10-year Surface Peak Flows

Proposed Conditions 100-year Surface Peak Flows



Future Conditions, With GSI 100-year Surface Peak Flows



Legend

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- Ground
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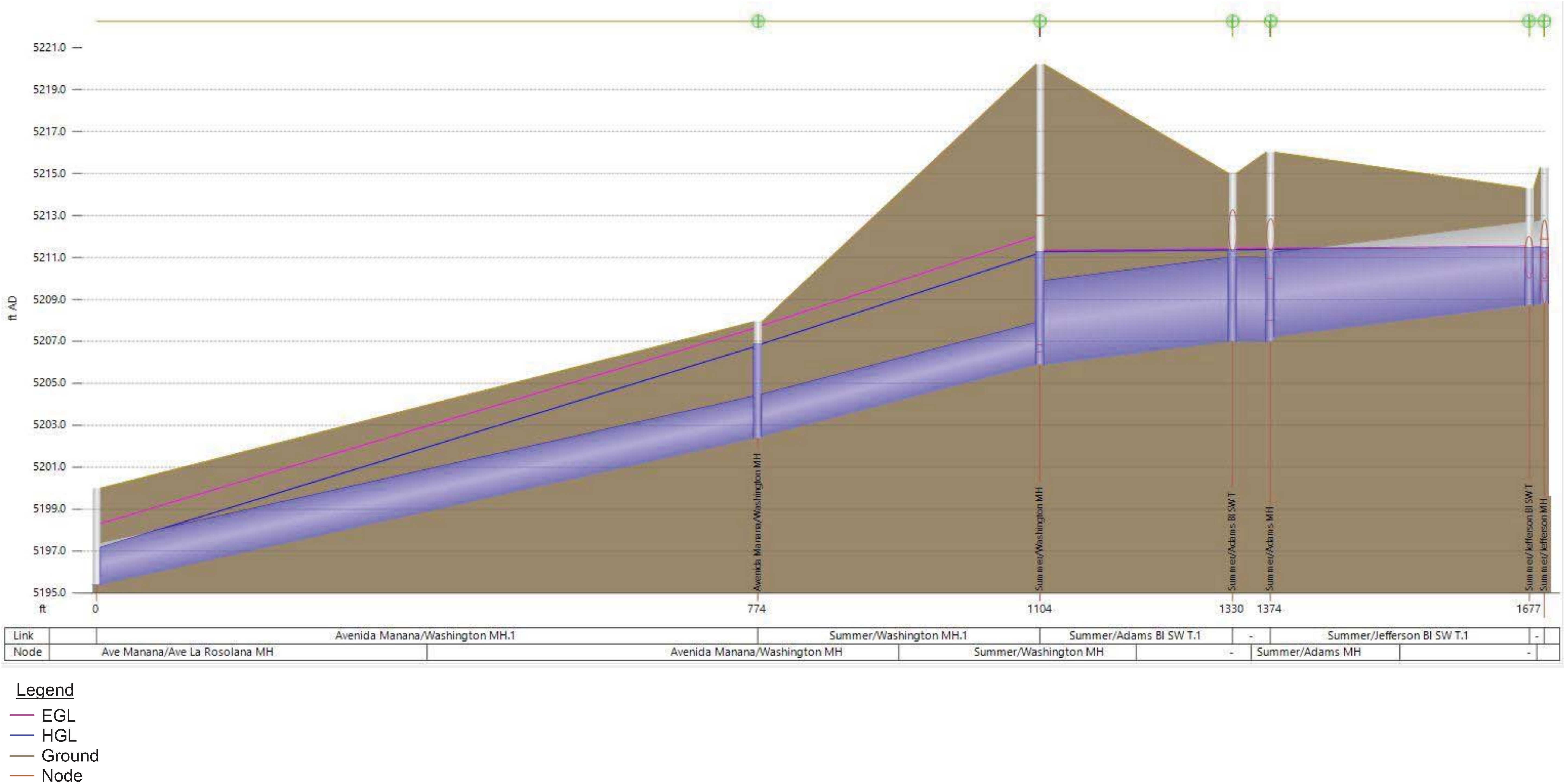
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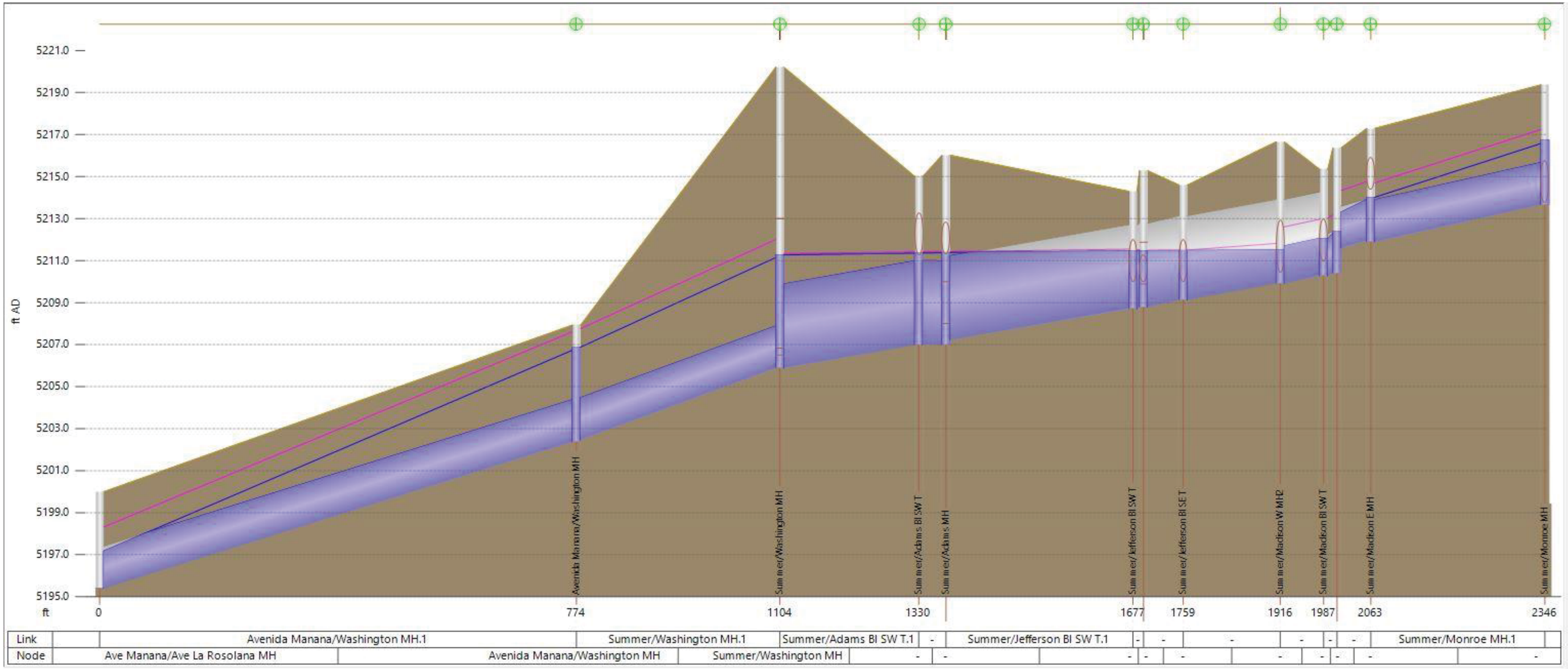

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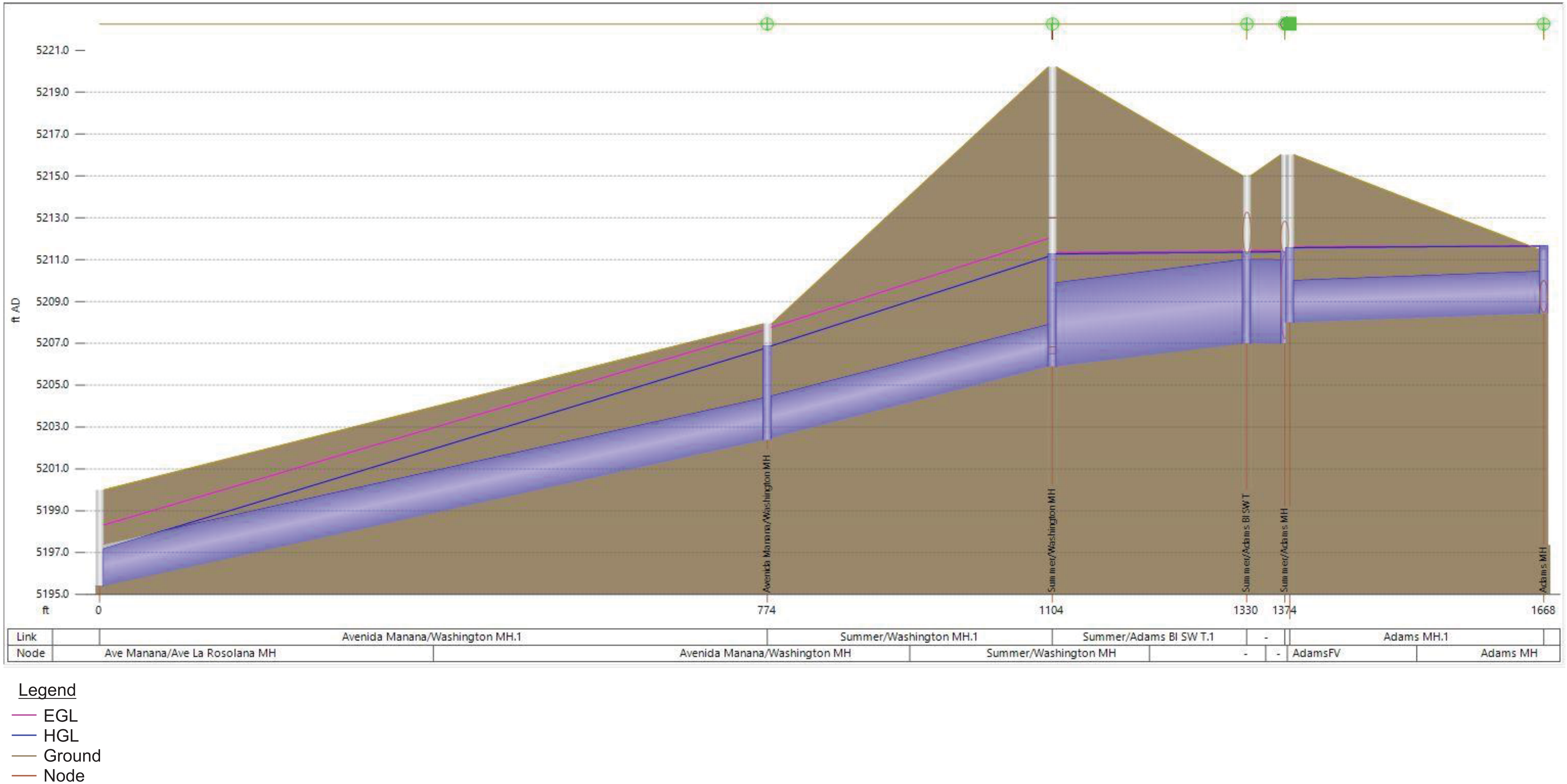

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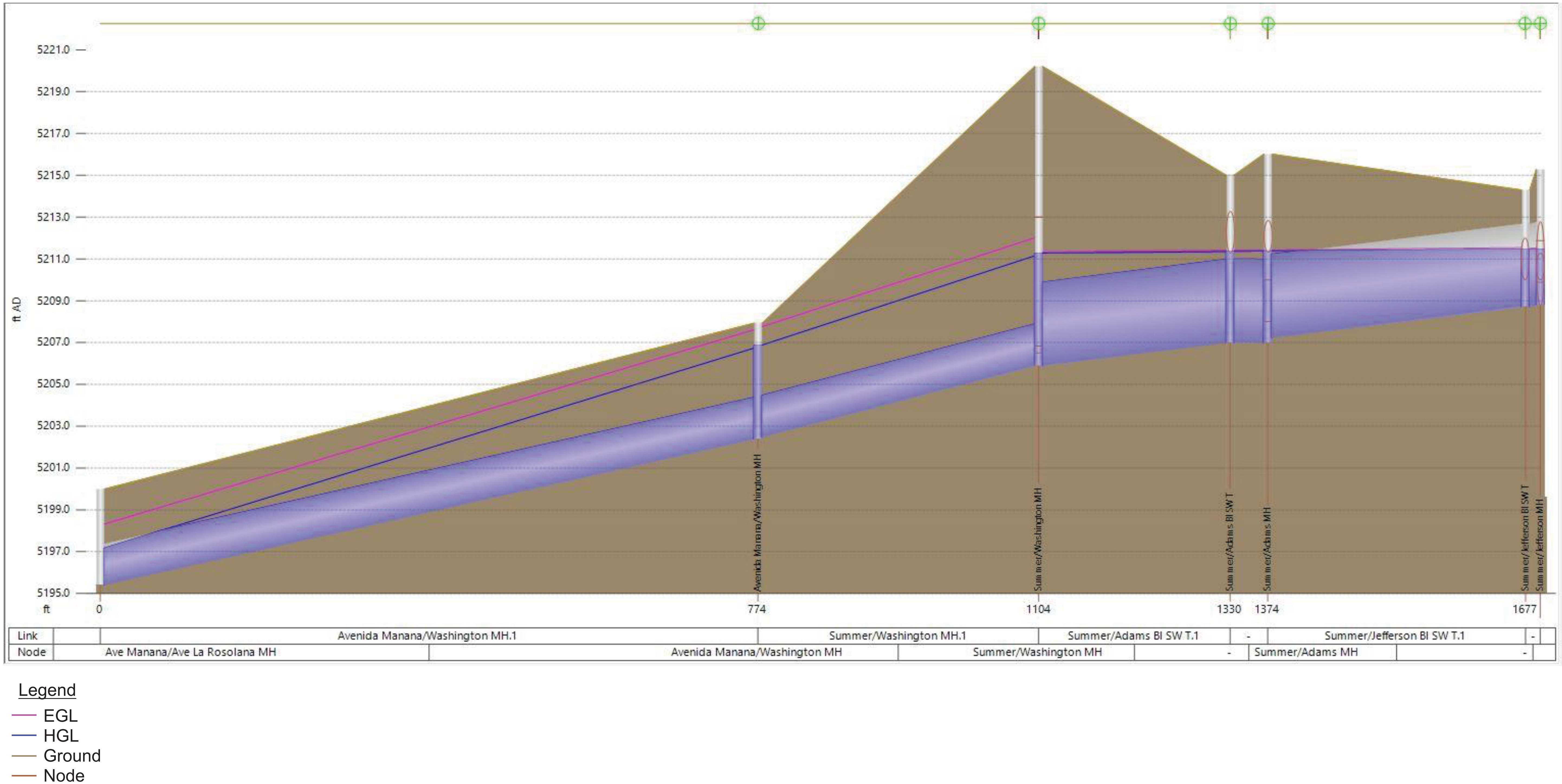
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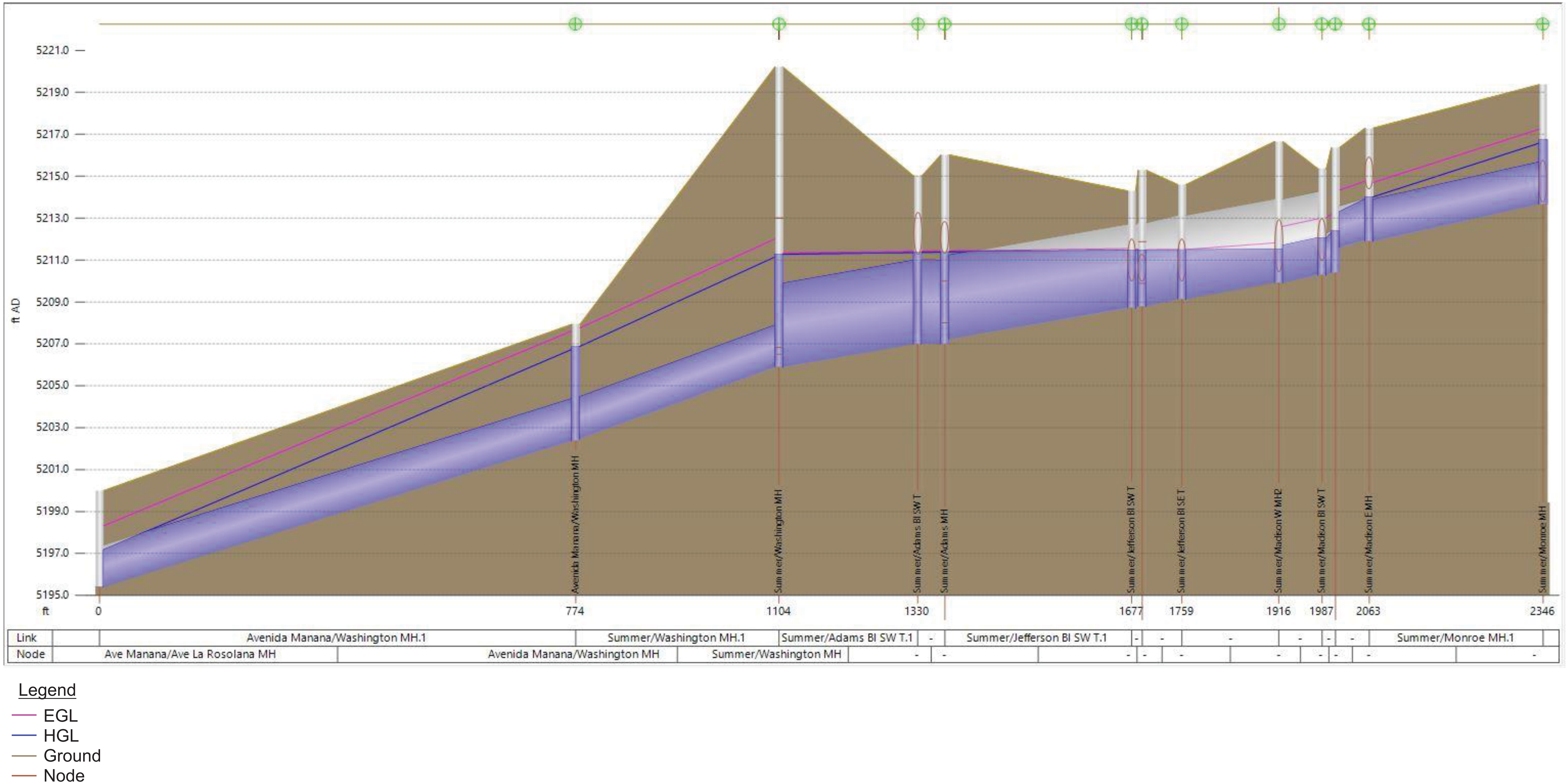

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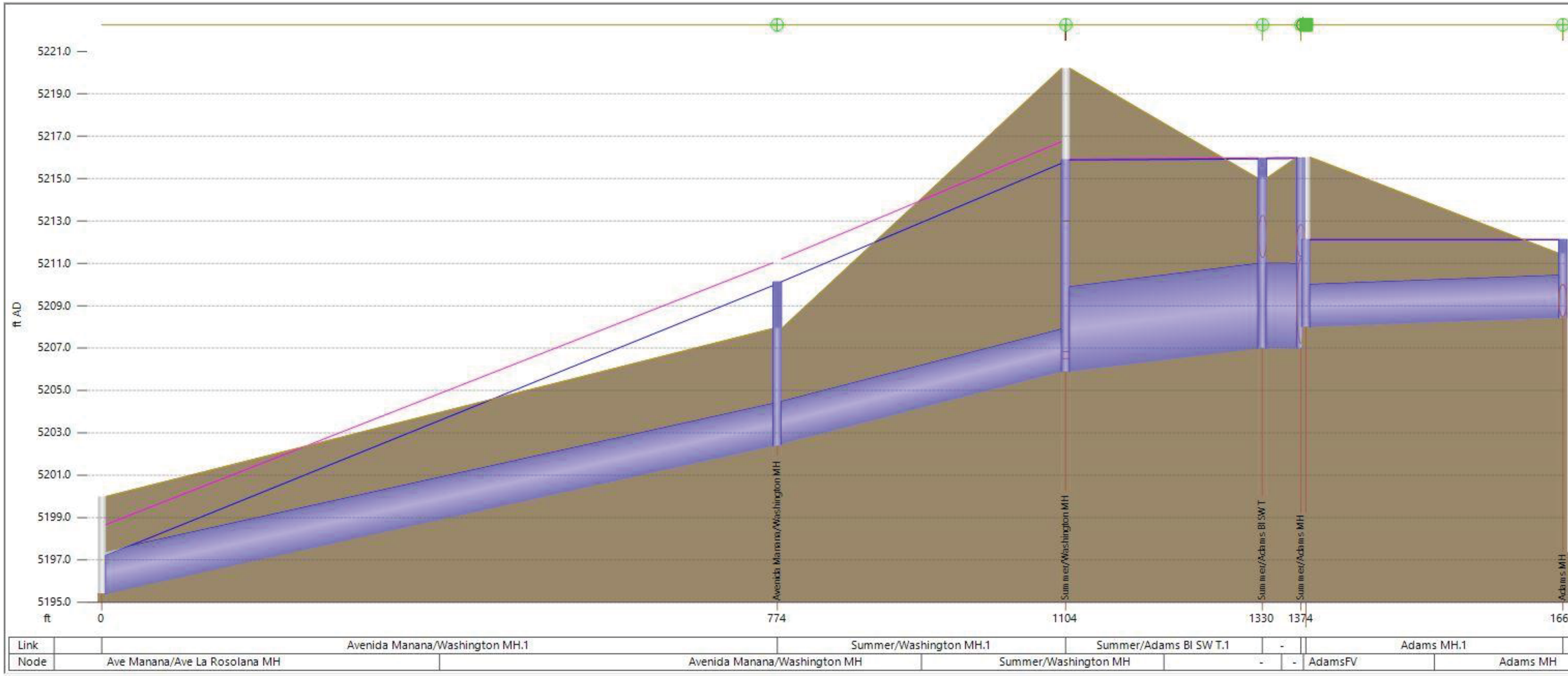

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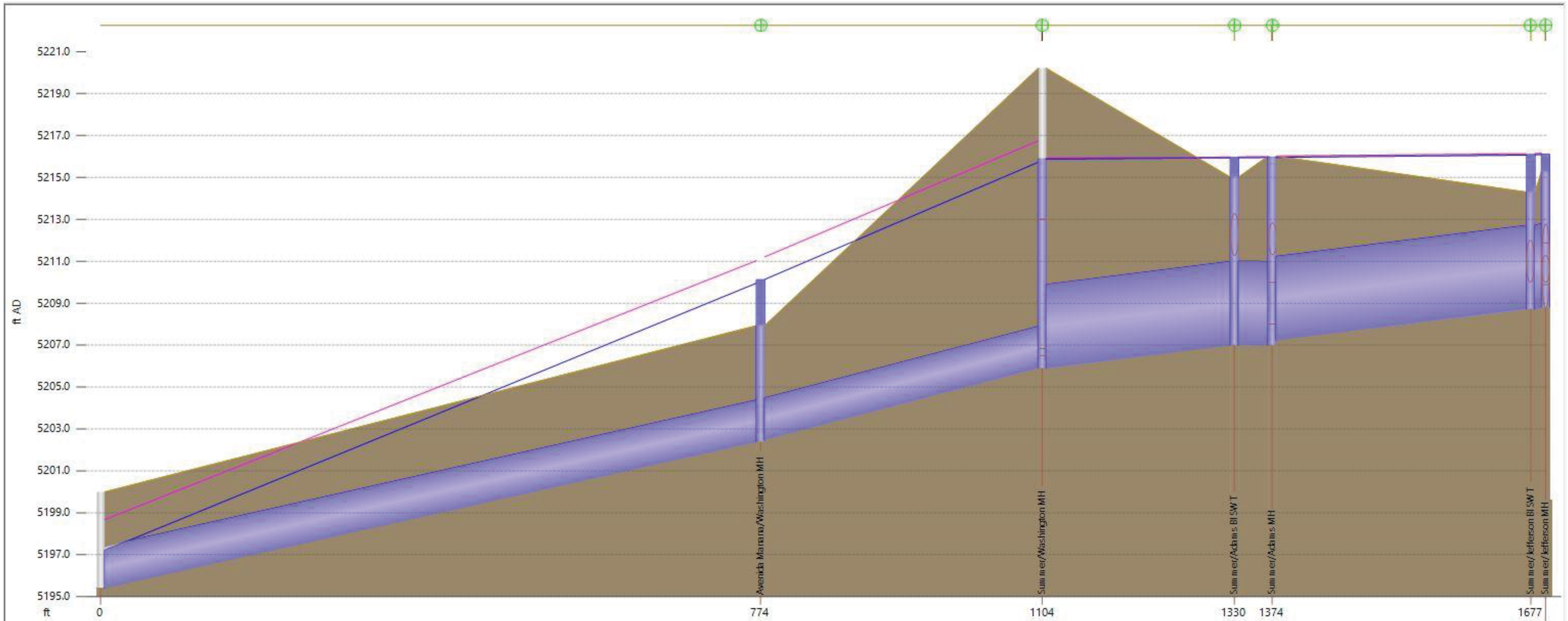

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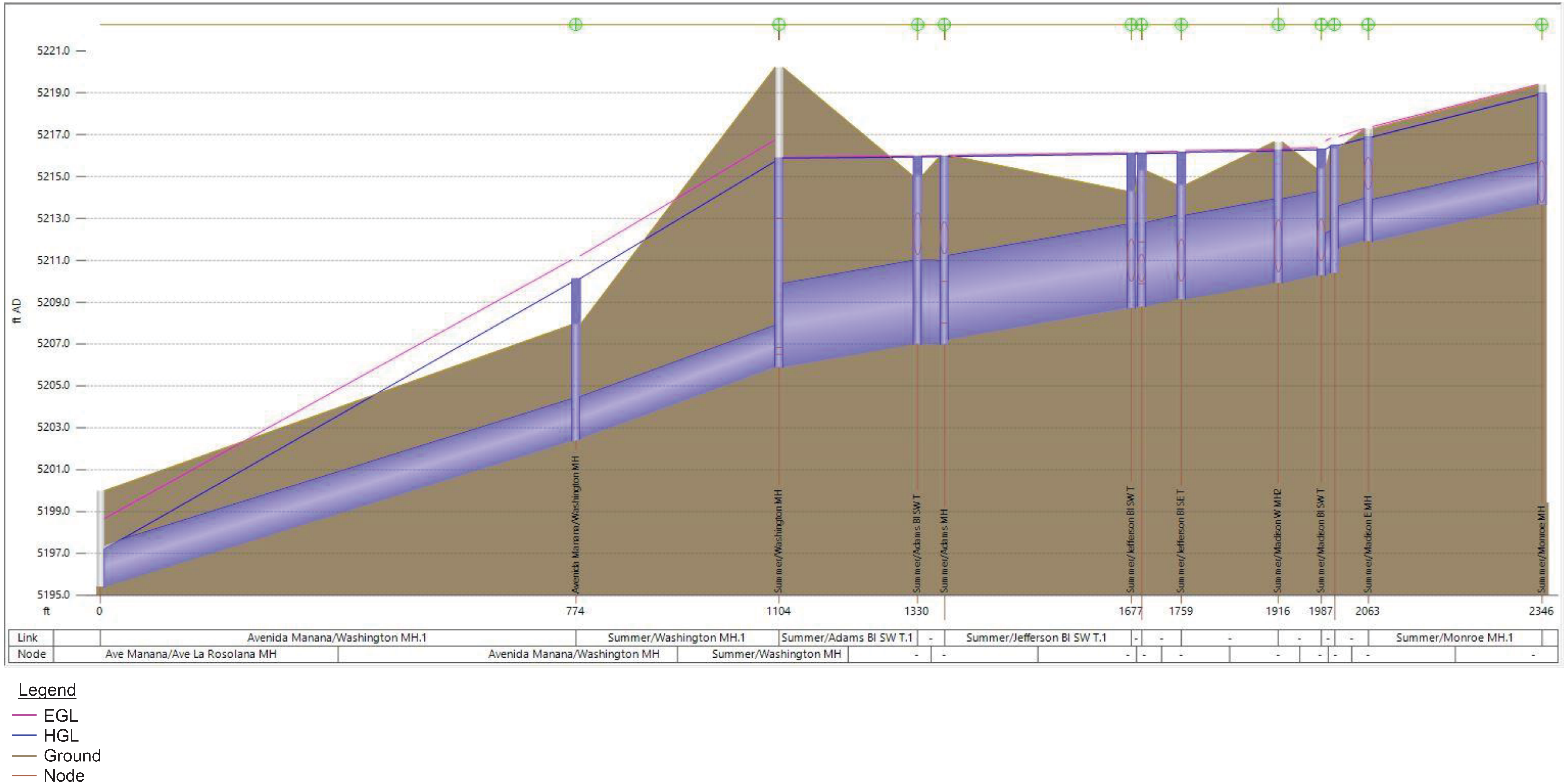

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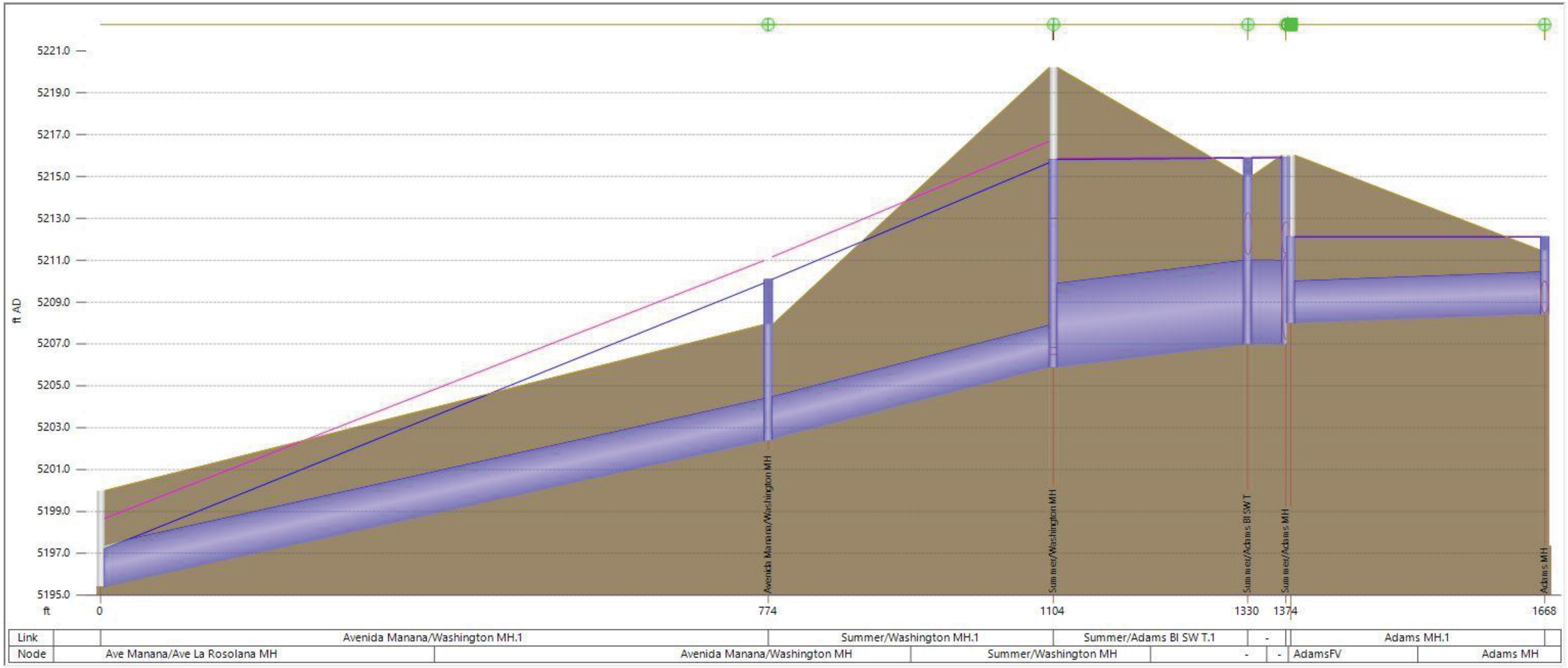

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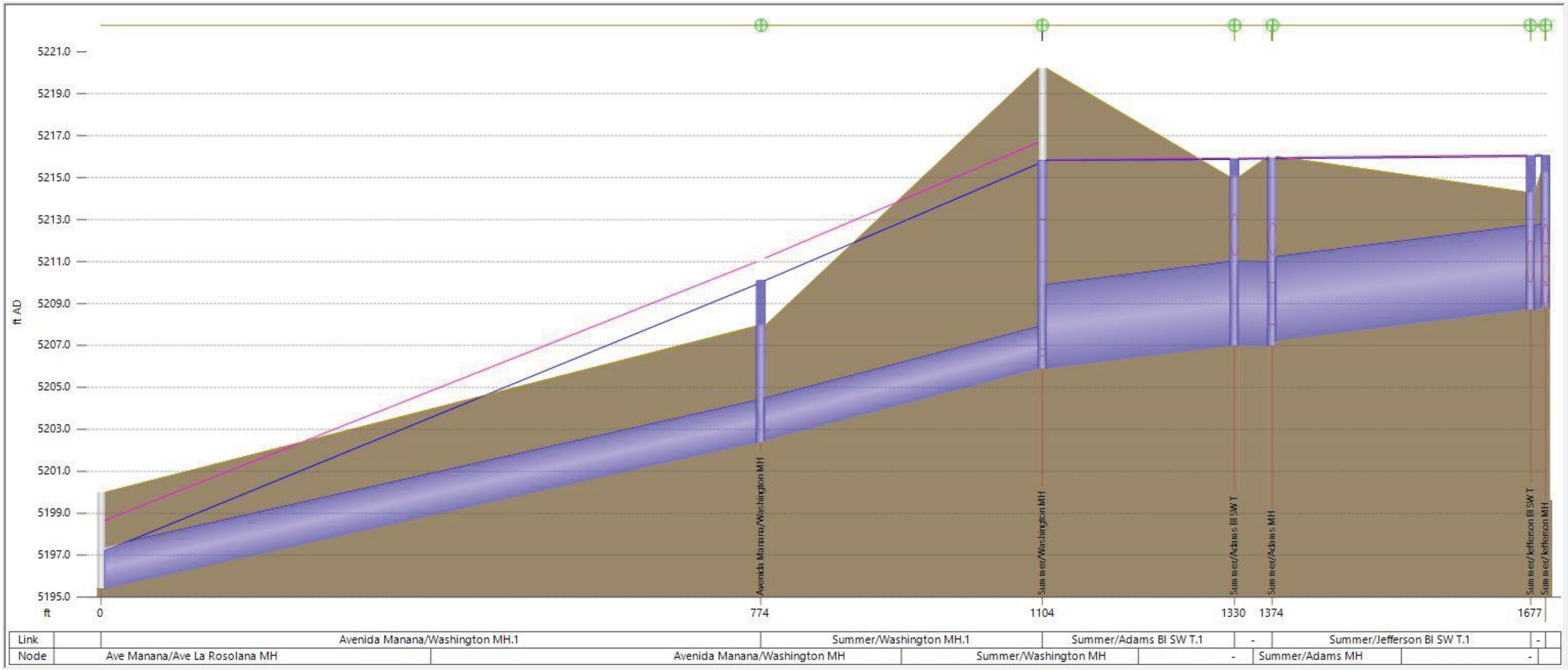

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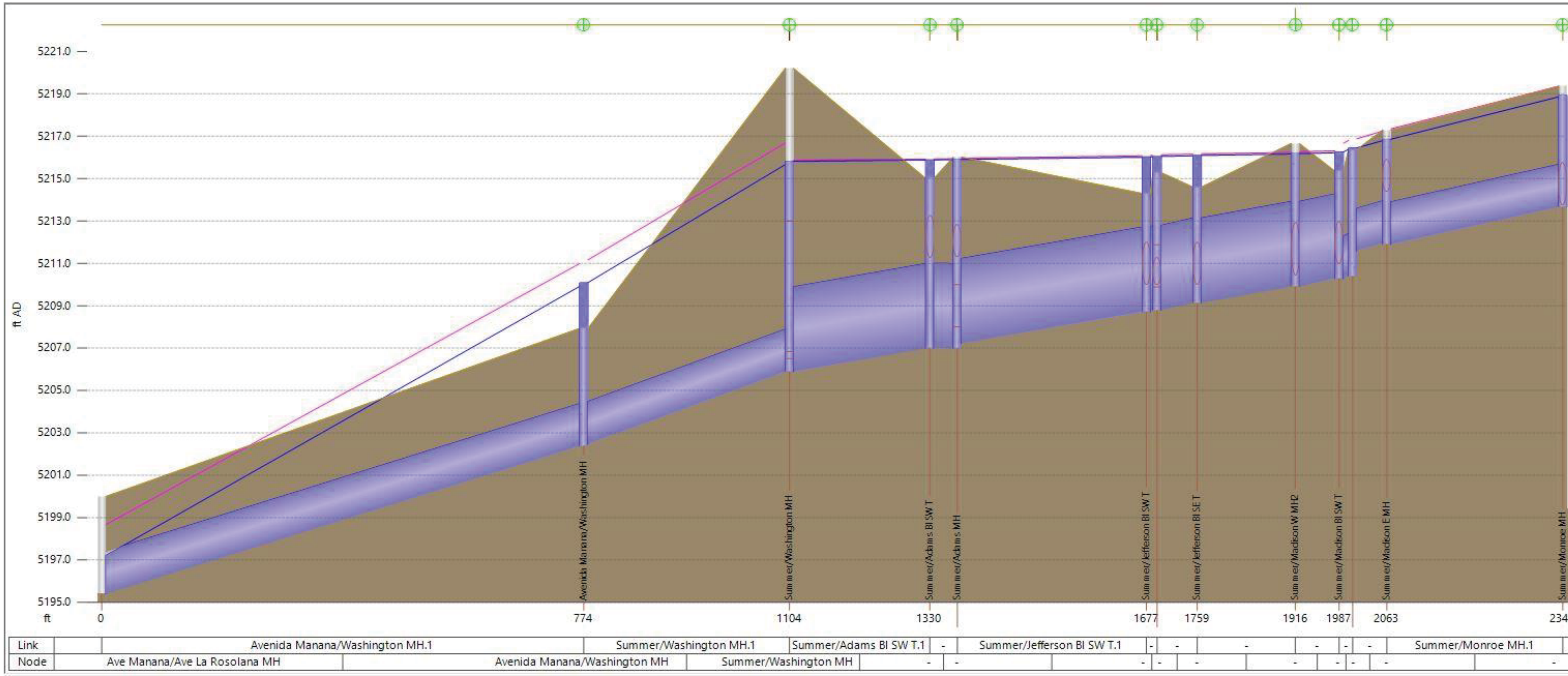

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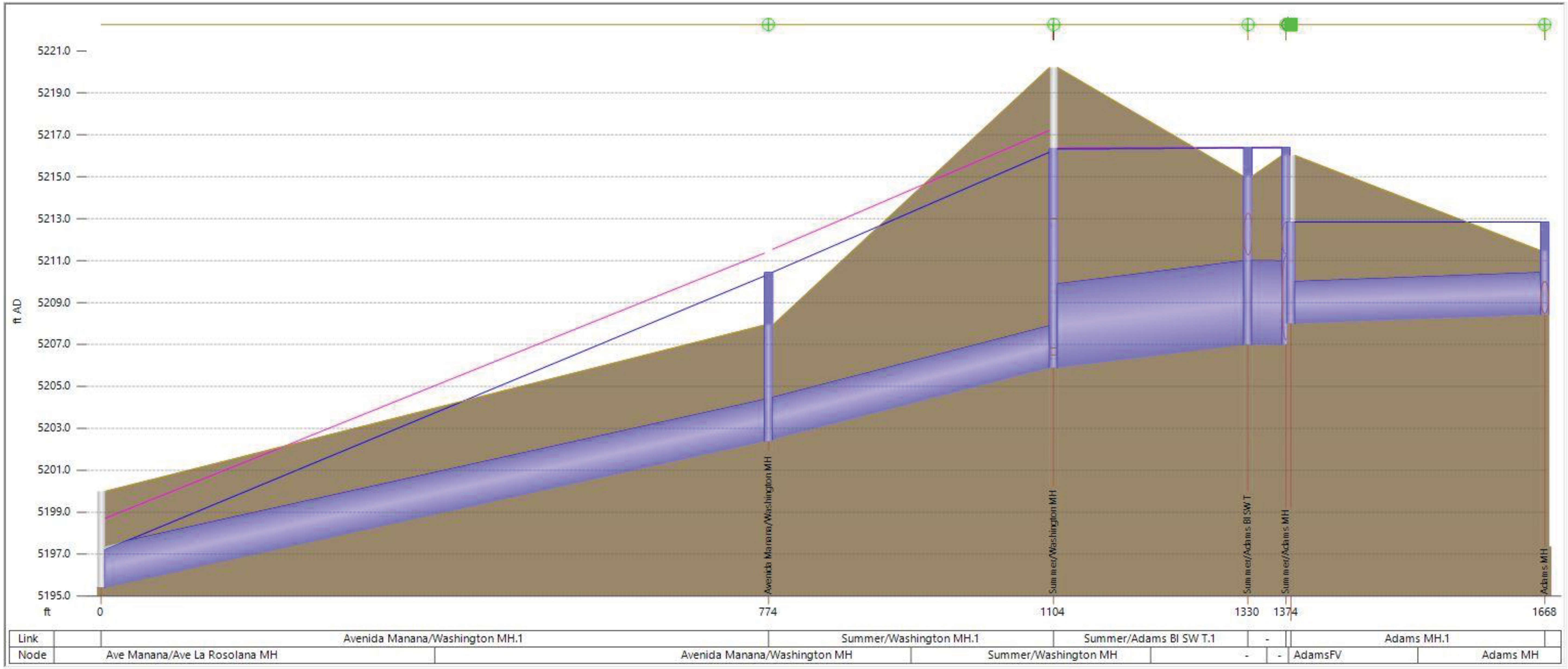

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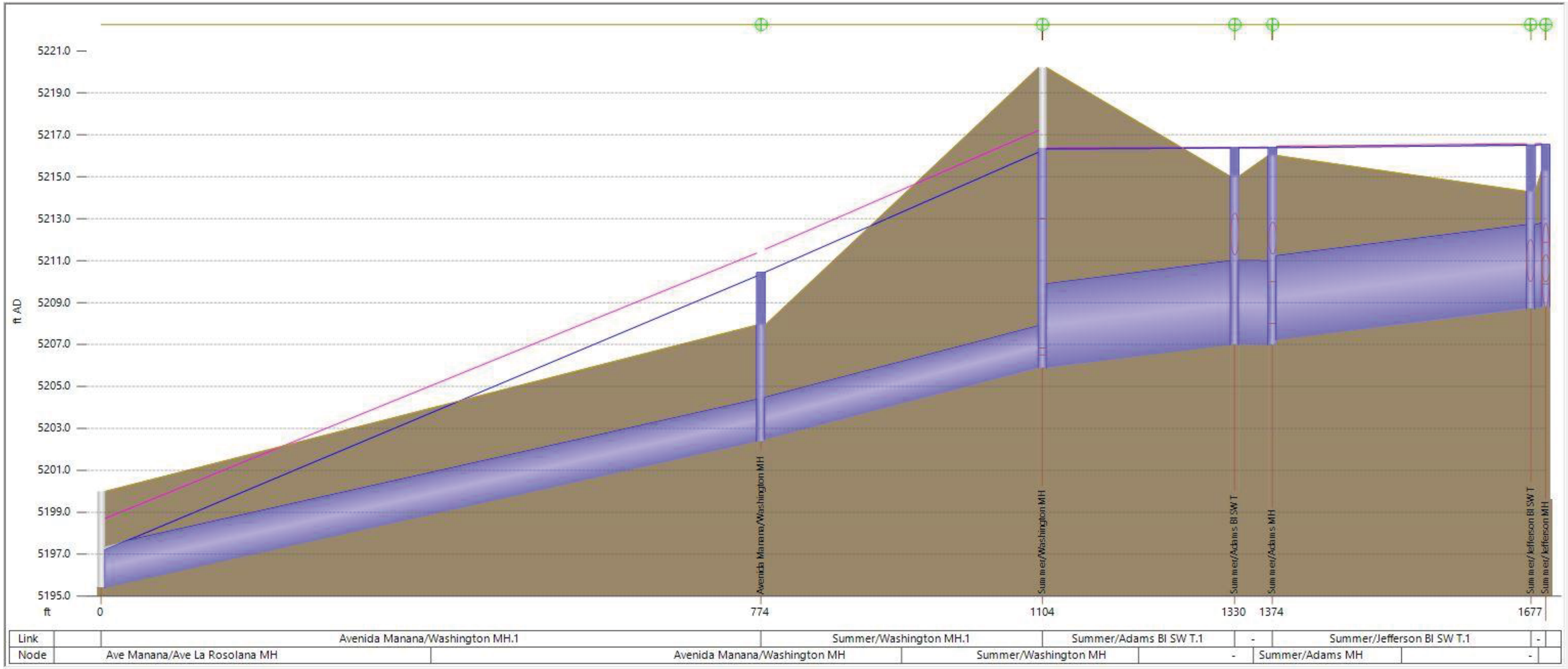

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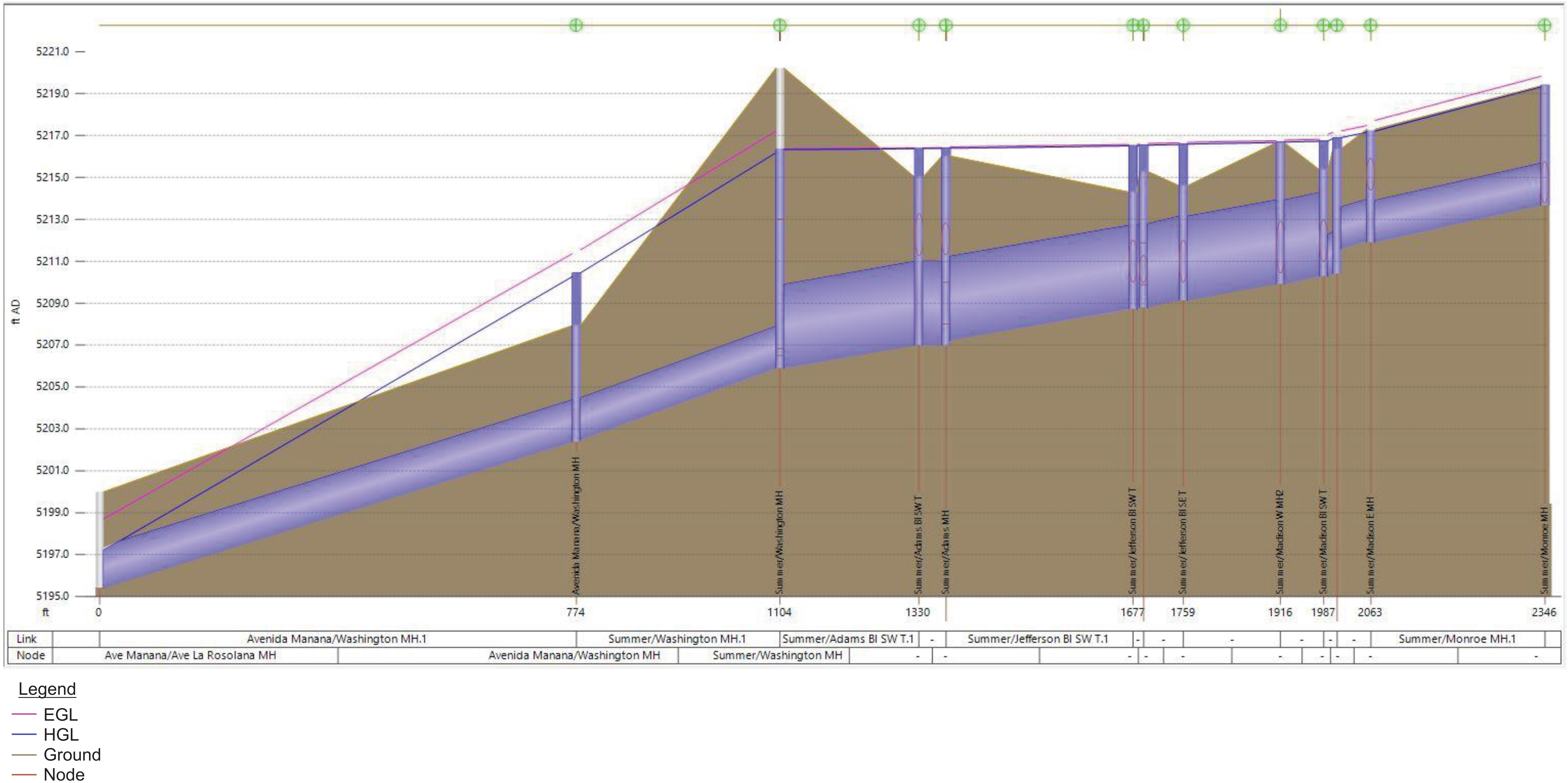

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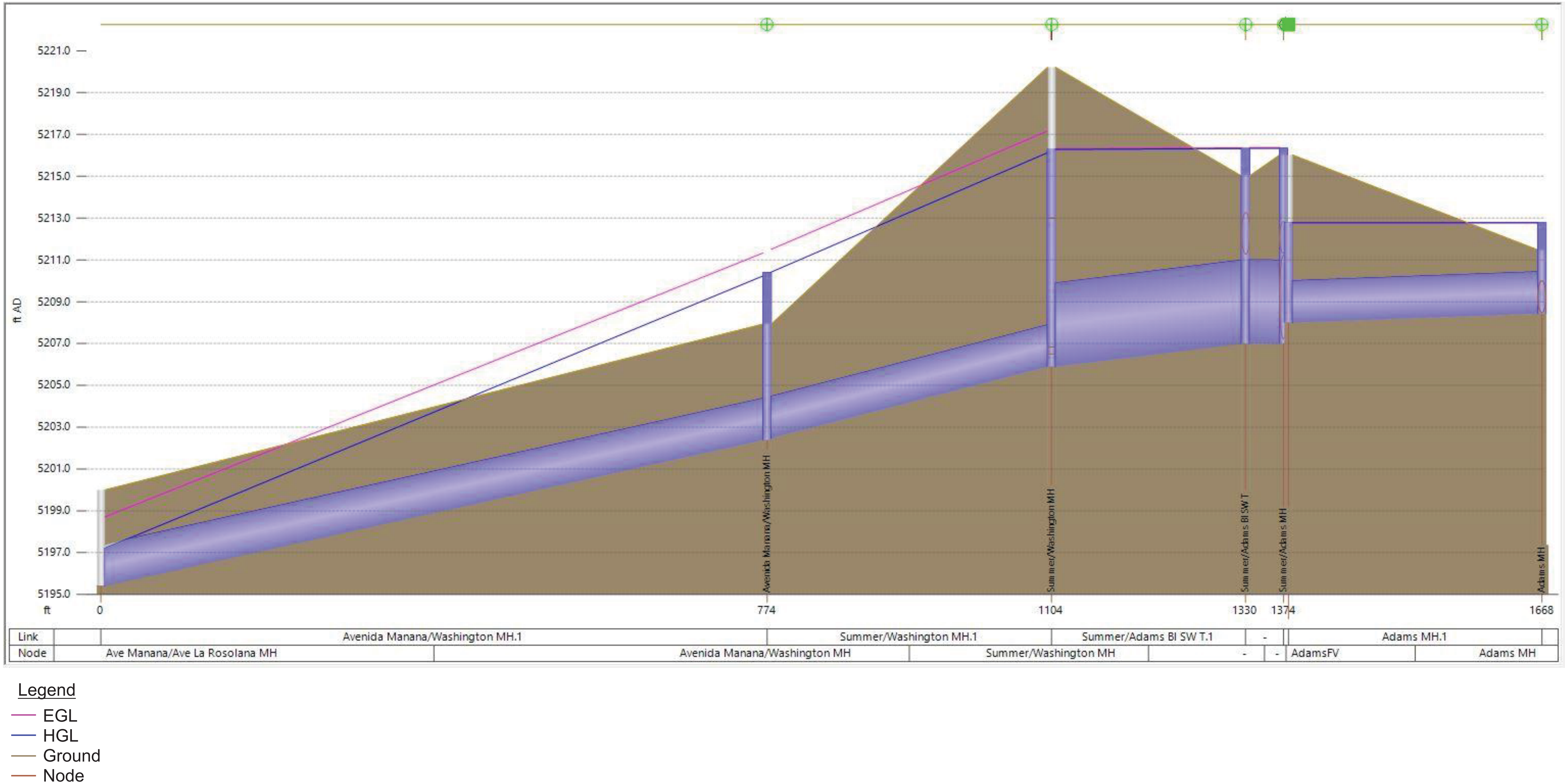

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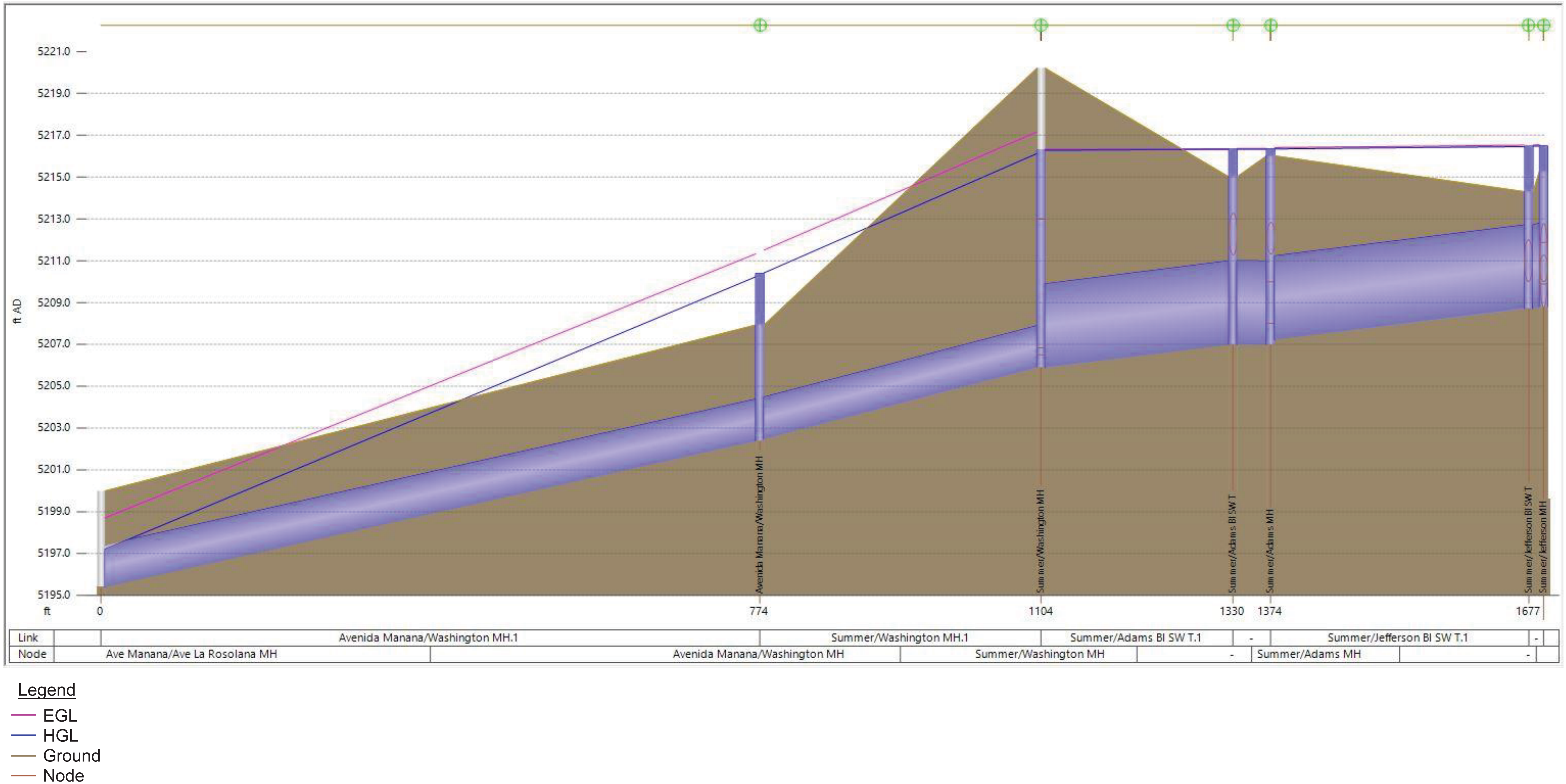
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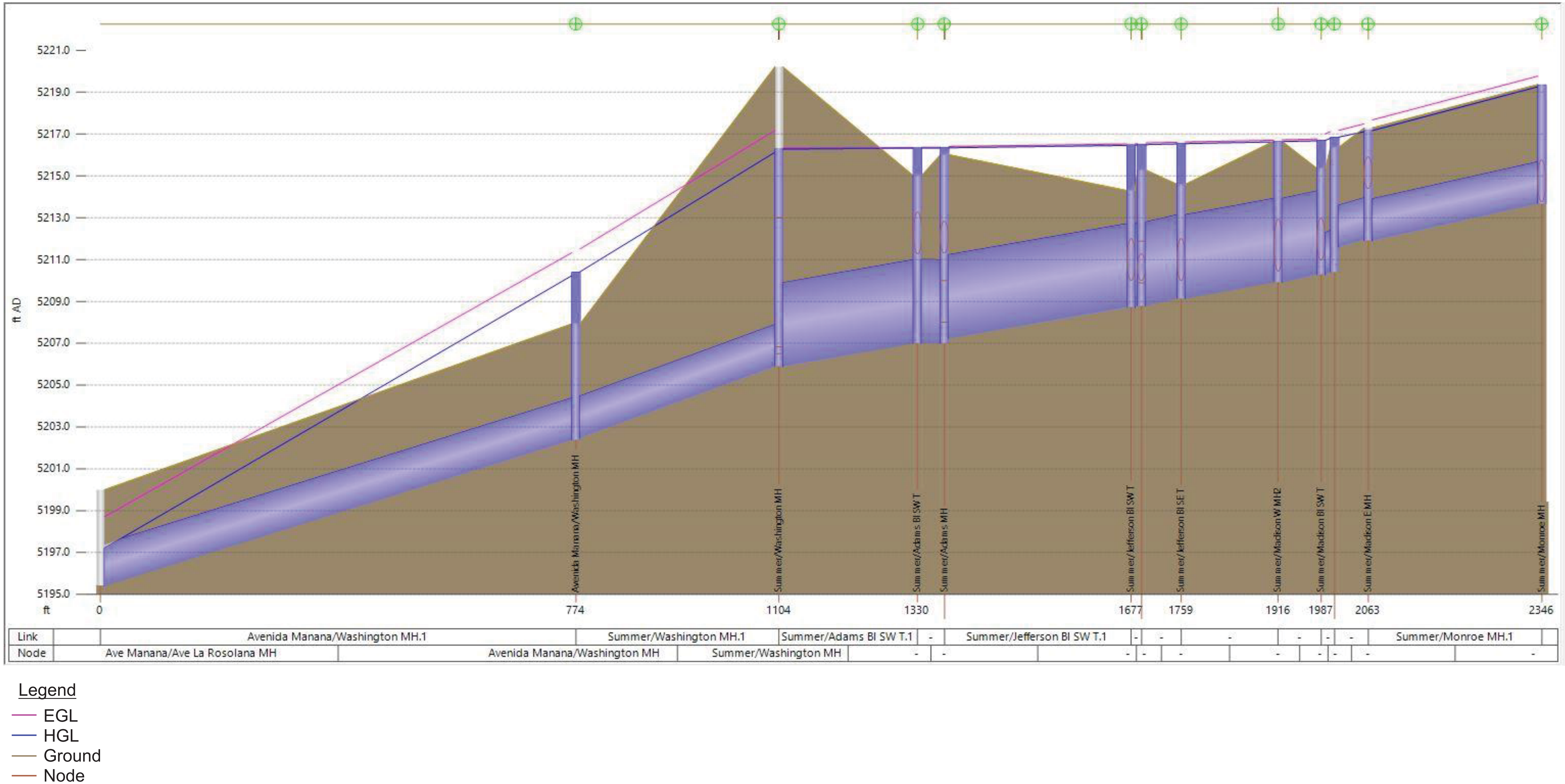
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	Intercepted flow (cfs)*						Surcharged flow (cfs)					
	100-yr		10-yr		2-yr		100-yr		10-yr		2-yr	
Node ID (Inlets Only)	ExCon	FtCon	ExCon	FtCon	ExCon	FtCon	ExCon	FtCon	ExCon	FtCon	ExCon	FtCon
Truman	13.1	13.9	14.0	14.0	13.9	13.6	0.0	0.0	0.0	0.0	0.0	0.0
Truman/Manzano Alley	-2.3	-2.3	-2.1	-2.1	1.9	2.2	2.3	2.3	2.1	2.1	1.3	1.3
Manzano E	6.5	6.2	7.1	8.8	5.8	6.0	0.0	0.0	0.0	0.0	0.0	0.0
Manzano W	6.7	6.2	7.3	8.7	6.6	6.8	0.0	0.0	0.0	0.0	0.0	0.0
Quincy E	8.0	5.4	7.6	5.1	3.2	3.2	0.6	0.0	0.0	0.0	0.0	0.0
Qunicy W	10.2	9.6	10.8	10.5	3.9	4.1	3.0	3.0	2.6	2.6	1.2	0.6
Summer/Madison SE	5.3	6.7	4.0	3.7	1.8	1.8	4.1	3.9	1.7	1.2	0.0	0.0
Summer/Madison NW	12.8	11.7	4.9	4.9	0.4	0.4	0.1	0.0	0.1	0.1	0.1	0.0
Summer/Madison SW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Summer/Jefferson SE	8.4	8.5	-4.3	-4.2	-0.1	-0.1	5.3	5.2	4.3	4.2	0.1	0.1
Summer/Adams SE	-8.3	-8.1	-7.7	-3.8	0.9	0.9	8.3	8.1	7.7	3.8	0.1	0.1
Jefferson E	4.5	-4.4	-3.9	-3.9	-0.1	-0.1	4.4	4.4	3.9	3.9	0.1	0.1
Jefferson W	10.1	10.1	10.3	10.3	5.6	5.6	0.0	0.0	0.0	0.0	0.0	0.0
Adams E	6.8	7.3	7.0	7.1	6.1	6.1	0.1	0.1	0.1	0.1	0.1	0.1
Adams W	-11.0	8.6	9.0	8.9	-7.3	6.7	11.0	6.6	5.8	5.8	7.3	4.3
El Encanto/Madiera NE	8.1	8.6	9.0	8.4	8.0	3.1	0.0	0.0	0.1	0.1	0.0	0.0
El Encanto/Madiera SE	9.5	12.1	11.5	2.5	2.8	0.6	0.1	0.1	0.1	0.1	0.0	0.0
El Encanto/MadieraNW	22.1	19.7	20.7	20.1	14.4	9.3	0.1	0.1	0.9	0.1	0.1	0.1
El Encanto/Madiera SW	-4.1	-5.0	-5.3	-0.8	-1.2	0.0	4.1	5.0	5.3	0.8	1.2	0.0
El Encanto Cul De Sac N	11.6	11.5	11.5	10.7	10.8	9.9	0.0	0.0	0.0	0.0	0.0	0.0
El Encanto Cul De Sac S	-4.7	-6.2	-9.1	-4.2	-4.7	-2.5	4.7	6.2	9.1	4.2	4.7	2.5
El Encanto Cul De Sac E	22.7	21.3	22.2	19.0	19.7	9.8	0.1	0.1	0.1	0.1	0.1	0.1
La Veta - South	5.1	20.6	13.9	18.2	17.0	-3.9	4.1	4.0	4.2	3.7	3.9	3.9
SummerEast1	17.9	22.1	19.9	20.4	20.3	12.9	0.0	0.0	0.0	0.0	0.0	0.0
SummerEast2	15.7	16.1	19.1	15.7	15.6	15.8	0.8	0.7	0.0	0.0	0.0	0.0
SummerEast3	20.0	20.1	19.9	20.3	20.1	20.0	0.0	0.0	0.0	0.0	0.0	0.0
La Veta - North	-16.4	20.7	-16.6	16.9	-16.2	-15.0	16.4	16.8	16.6	15.9	16.2	15.0
Summer/Adams BI SW	6.1	6.1	3.7	3.7	1.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0
Summer/Jefferson BI SW	22.4	22.4	13.9	13.9	5.3	5.3	0.0	0.0	1.5	1.3	0.0	0.0
Summer/Jefferson BI SE	19.0	19.1	14.1	14.1	3.2	3.2	0.0	0.0	0.7	0.8	0.0	0.0
Summer/Madison BI SW	24.6	24.6	22.1	22.1	18.2	18.2	0.0	0.0	0.0	0.0	0.0	0.0

* Flow from 2D zone is "net" flow