Little Cottonwood Canyon ENVIRONMENTAL IMPACT STATEMENT
S.R. 210 | Wasatch Blvd. to Alta

Draft Alternatives Development and Screening Report

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 – Wasatch Boulevard to Alta

Utah Department of Transportation

June 8, 2020

Executive Summary

This report summarizes and presents the results of the alternatives development and screening process for the Little Cottonwood Canyon Environmental Impact Statement (EIS). The study area for the transportation needs assessment used for the State Route (S.R.) 210 Project extends along S.R. 210 from its intersection with S.R. 190/Fort Union Boulevard in Cottonwood Heights, Utah, to its terminus in the town of Alta, Utah, and includes the Bypass Road.

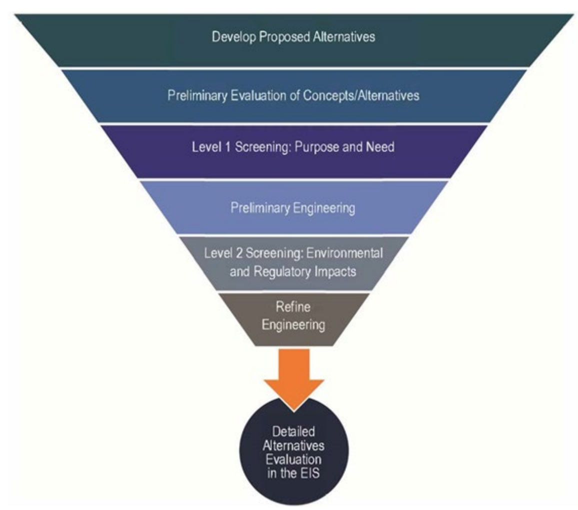
The alternatives development and screening process described in this report provided critical information about how well an alternative would satisfy the purpose of and need for the S.R. 210 Project and whether it is reasonable and practicable. The criteria used in both the first- and second-level screening analyses generated measures that allowed the Utah Department of Transportation (UDOT) to systematically and objectively identify reasonable alternatives and screen out unreasonable alternatives. The entire process took place over several months and considered agency and public input.

The environmental review, consultation, and other actions required by applicable federal environmental laws for this action are being, or have been, carried out by UDOT pursuant to 23 United States Code (USC) Section 327 and a Memorandum of Understanding dated January 17, 2017, and executed by the Federal Highway Administration and UDOT.

Results of the Screening Process

UDOT conducted a three-level screening evaluation of alternatives suggested by stakeholders and in previous studies, as shown in Figure 1-1. The evaluation started with a preliminary evaluation of alternatives to determine whether they were feasible to be considered further in Level 1 screening. If an alternative was determined to be feasible, it was further developed so that Level 1 screening could be conducted.

Figure 1-1. Screening Process Overview



Level 1 screening was based on the project purpose to substantially improve safety, reliability, and mobility on S.R. 210 from Fort Union Boulevard through the town of Alta for all users on S.R. 210. In this report, *reliability* refers to closure of S.R. 210 from avalanches and avalanche mitigation, and *mobility* refers to travel time and vehicle backups caused by congestion. The alternatives that passed Level 1 screening were then evaluated with Level 2 screening in terms of their expected impacts to the natural and built environment.

The alternatives were screened with regard to the following project purpose elements:

- **Improve mobility on S.R. 210:**
  - Mobility on Wasatch Boulevard
  - Mobility on S.R. 210 from Fort Union Boulevard to Alta
- **Improve reliability and safety on S.R. 210:**
  - Avalanche mitigation
  - Trailhead parking
  - Winter roadside parking

What are mobility and reliability?

In this report, *mobility* refers to travel time and vehicle backups caused by congestion, and *reliability* refers to closure of S.R. 210 from avalanches and avalanche mitigation.

Based on the screening process, the following alternative options (designated with square bullets) passed both Level 1 and Level 2 screening:

- **Improve mobility on S.R. 210:**
  - Mobility on Wasatch Boulevard:
    - Imbalanced-lane alternative
    - Five-lane alternative
  - Mobility on S.R. 210 from Fort Union Boulevard to Alta:
    - Enhanced bus service with no widening of S.R. 210 in Little Cottonwood Canyon (24 buses per hour during the peak period)
    - Enhanced bus service in peak-period shoulder lanes on S.R. 210 in Little Cottonwood Canyon (24 buses per hour during the peak period)
    - Gondola with enhanced bus service
- **Improve reliability and safety on S.R. 210:**
  - Avalanche mitigation:
    - Snow sheds with guiding berms
    - Snow sheds and realigned road with no guiding berms
  - Trailhead parking:
    - Trailhead parking improvements with no roadside parking within ¼ mile
    - Trailhead parking improvements with no roadside parking from canyon entrance to Snowbird Entry 1
    - No trailhead parking improvements with no roadside parking from canyon entrance to Snowbird
  - Winter roadside parking:
    - Elimination of winter roadside parking on S.R. 210 adjacent to the ski resorts

Alternatives Advanced for Further Evaluation in the Draft EIS

To conduct the analysis of the effects of the alternative options on the human and natural environment, UDOT packaged the alternative options into three main alternatives with options to ensure that each alternative met the project purpose of improving safety, reliability, and mobility. These three action alternatives presented in Table S-1.

After the impact evaluation is performed, UDOT will review the information and identify a preferred alternative in the Draft EIS from the three alternatives listed in Table S-1. The preferred alternative will include a selection of which options for each element (Wasatch Boulevard, S.R. 210, Avalanche Mitigation, Trailhead Parking, and Winter Roadside Parking) UDOT prefers.

Table S-1. Alternatives and Options To Be Evaluated in the Draft EIS

Alternative	Purpose Element and Associated Options				
	Purpose Element: Improve Mobility		Purpose Element: Improve Reliability and Safety		
	Wasatch Boulevard Options	S.R. 210 from Fort Union Boulevard to Alta Options	Avalanche Mitigation Options	Trailhead Parking Options	Winter Roadside Parking Options
Enhanced Bus Service with No Widening of S.R. 210 in Little Cottonwood Canyon Alternative	• Imbalanced-lane Alternative • Five-lane Alternative	Enhanced bus service with mobility hubs at the gravel pit[a] and 9400 South/Highland Drive • Winter point-to-point bus service from each mobility hub directly to the ski resorts[b] • 24 buses per hour in the peak hour • About 1,008 people on buses in the peak hour • 2,500 new parking spaces divided between two mobility hubs at the gravel pit and 9400 South and Highland Drive • Bus priority on Wasatch Boulevard • Tolling or other management strategies such as no single-occupant vehicles during peak periods	• Snow sheds with berms • Snow sheds and realigned road with no berms	• Trailhead parking improvements with no roadside parking within ¼ mile • Trailhead parking improvements with no roadside parking from canyon entrance to Snowbird Entry 1 • No trailhead parking improvements with no roadside parking from canyon entrance to Snowbird	• Elimination of winter roadside parking on S.R. 210 adjacent to the ski resorts
Enhanced Bus Service in Peak-period Shoulder Lanes on S.R. 210 in Little Cottonwood Canyon Alternative	• Imbalanced-lane Alternative • Five-lane Alternative	Enhanced bus service with mobility hubs at the gravel pit[a] and 9400 South/Highland Drive • Winter point-to-point bus service from each mobility hub directly to the ski resorts[b] • 24 buses per hour in the peak hour • About 1,008 people on buses in the peak hour • 2,500 new parking spaces divided between two mobility hubs at the gravel pit and 9400 South and Highland Drive • Bus priority on Wasatch Boulevard • Tolling or other management strategies such as no single-occupant vehicles during peak periods • Winter bus only peak-period shoulder lanes from the North Little Cottonwood Road/Wasatch Boulevard intersection to the Alta Bypass Road; peak-period shoulder lanes would be cyclist and pedestrian facilities in summer	• Snow sheds with berms • Snow sheds and realigned road with no berms	• Trailhead parking improvements with no roadside parking within ¼ mile • Trailhead parking improvements with no roadside parking from canyon entrance to Snowbird Entry 1 • No trailhead parking improvements with no roadside parking from canyon entrance to Snowbird	• Elimination of winter roadside parking on S.R. 210 adjacent to the ski resorts
Gondola Alternative	• Imbalanced-lane Alternative • Five-lane Alternative	Gondola from the entrance of Little Cottonwood Canyon to Alta Ski Resort • Winter gondola service starting at the gondola platform at the entrance of Little Cottonwood Canyon with stops at Snowbird ski resort and Alta ski resort only[b] • About 30 gondola cabins per hour • About 1,050 people on gondolas in the peak hour • 2,500-space parking structure at the gravel pit • Enhanced bus service from the gravel pit to the gondola loading platform at the entrance of Little Cottonwood Canyon (there would be no parking at the gondola platform) • Bus priority on Wasatch Boulevard • Tolling or other management strategies such as no single-occupant vehicles during peak periods	• None; gondola could be used when S.R. 210 is closed for avalanche mitigation, similar to existing conditions	• Trailhead parking improvements with no roadside parking within ¼ mile • Trailhead parking improvements with no roadside parking from canyon entrance to Snowbird Entry 1 • No trailhead parking improvements with no roadside parking from canyon entrance to Snowbird	• Elimination of winter roadside parking on S.R. 210 adjacent to the ski resorts

[a] The gravel pit is located on the east side of Wasatch Boulevard between 6200 South and Fort Union Boulevard.

[b] The purpose of the project is to improve winter mobility. Screening criteria did not evaluate the performance of summer service.

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Abbreviations and Acronyms

1S	mono-cable gondola system
2S	bi-cable gondola system
3S	tri-cable gondola system
AHI	avalanche hazard index
AM	morning
CFR	Code of Federal Regulations
D.A.V.E.	Dual-mode Advanced Vehicular Endeavor
EIS	Environmental Impact Statement
FHWA	Federal Highway Administration
GIS	geographic information systems
HOV	high-occupancy vehicle
i.e.	that is
I-15	Interstate 15
I-215	Interstate 215
LOS	level of service
MUTCD	*Manual on Uniform Traffic Control Devices*
NA	not applicable
NEPA	National Environmental Policy Act
NFS	National Forest System
O&M	operation and maintenance
OD	origin-destination (study)
PM	afternoon
PPSL	peak-period shoulder lane
RTP	*Wasatch Front Regional Transportation Plan*
S.R.	state route
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
Section 4(f)	Section 4(f) of the Department of Transportation Act of 1966
Section 6(f)	Section 6(f) of the Land and Water Conservation Fund Act of 1965
SPT	Little Cottonwood Canyon Sketch Planning Tool
UDOT	Utah Department of Transportation
USC	United States Code
USDA	U.S. Department of Agriculture
USDOT	United States Department of Transportation
UTA	Utah Transit Authority
WFRC	Wasatch Front Regional Council

1.0 Introduction

1.1 Report Purpose and Background Information

This summarizes and presents the results of the alternatives development and screening process for the Little Cottonwood Canyon Environmental Impact Statement (EIS). The study area for the transportation needs assessment used for the State Route (S.R.) 210 Project extends along S.R. 210 from its intersection with S.R. 190/Fort Union Boulevard in Cottonwood Heights, Utah, to its terminus in the town of Alta, Utah, and includes the Bypass Road (Figure 1-1). UDOT developed this study area to include an area that is influenced by the transportation operations in Little Cottonwood Canyon and to provide logical termini for the project. The transportation needs assessment study area is used only to determine the need for transportation solutions. Separate impact analysis areas will be developed for each environmental resource evaluated in this EIS to assess direct, indirect, and cumulative impacts to those resources.

The intersection of S.R. 210 with S.R. 190/Fort Union Boulevard was selected as the western terminus because it is the point where traffic splits between Big Cottonwood Canyon and Little Cottonwood Canyon. Traffic south of this intersection is mostly related to trips into and out of Little Cottonwood Canyon and commuter traffic on Wasatch Boulevard. The end of the paved road in Little Cottonwood Canyon was selected as the eastern terminus because this is where S.R. 210 terminates in the town of Alta at Albion Basin Road. The project does not include Albion Basin Road.

The study area also includes the S.R. 210 Bypass Road. The Bypass Road was included in the evaluation because it functions as an alternate route when S.R. 210 is closed for avalanche control.

Through the study area, S.R. 210 is designated with different street names. For clarity in this report, the following segments of S.R. 210 use the following naming conventions (shown in Figure 1-1):

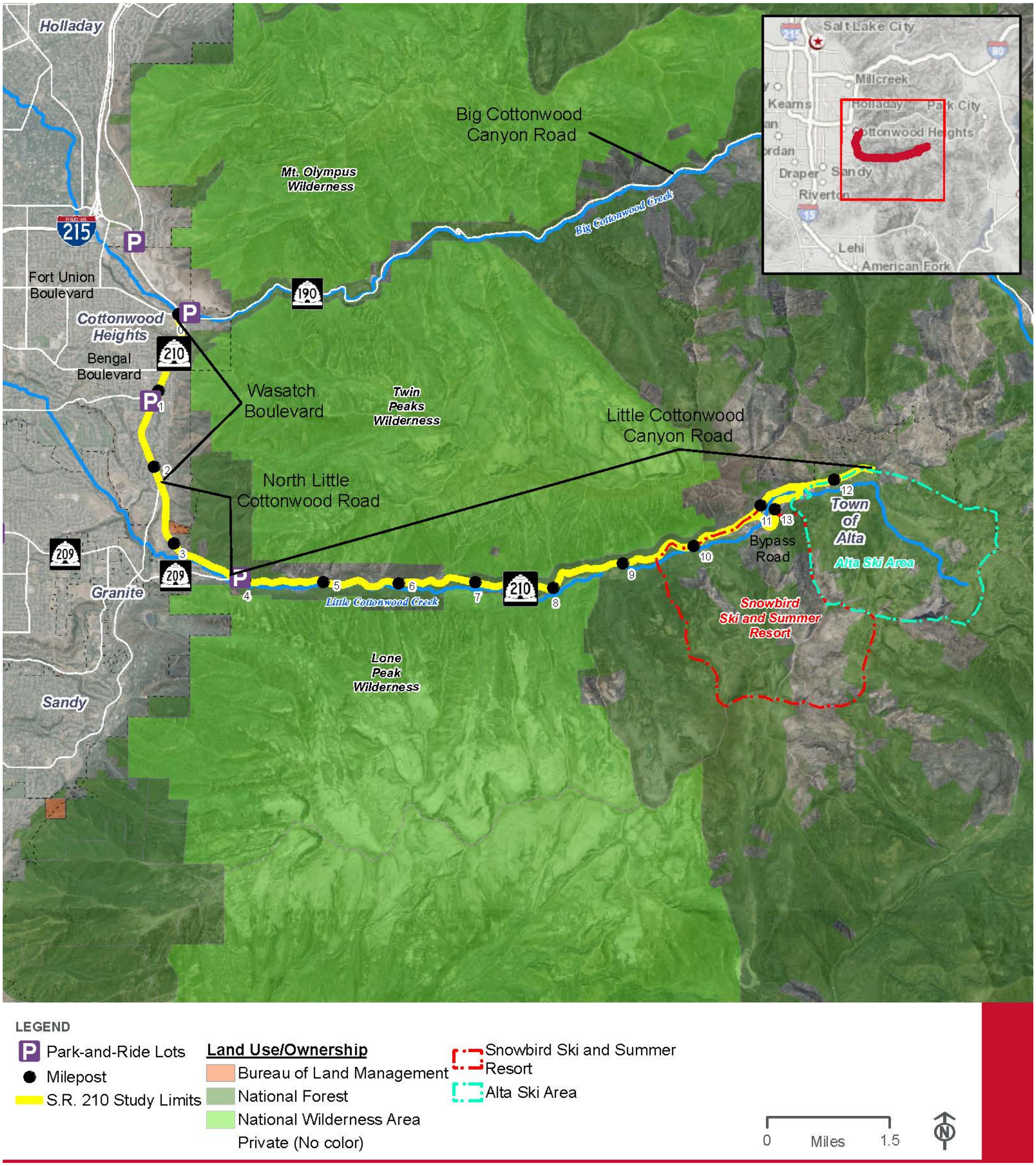
- **Wasatch Boulevard** – S.R. 210 from Fort Union Boulevard to North Little Cottonwood Road
- **North Little Cottonwood Road** – S.R. 210 from Wasatch Boulevard to the intersection with S.R. 209
- **Little Cottonwood Canyon Road** – S.R. 210 from the intersection of North Little Cottonwood Road and S.R. 209 through the town of Alta, including the Bypass Road, up to but not including Albion Basin Road

The alternatives development and screening process described in this report provided critical information about how well an alternative would satisfy the purpose and need for the S.R. 210 Project and whether it is reasonable and/or technically feasible. The criteria used in both the first- and second-level screening analyses generated measures that allowed the Utah Department of Transportation (UDOT) to systematically and objectively identify reasonable alternatives and screen out unreasonable alternatives. The entire process took place over several months and considered agency and public input.

This report provides UDOT's preliminary evaluation of the alternatives development and screening process. As UDOT receives input from the public and agencies during the EIS process, the results of this process might be modified.

The environmental review, consultation, and other actions required by applicable federal environmental laws for this action are being, or have been, carried-out by UDOT pursuant to 23 United States Code (USC) 327 and a Memorandum of Understanding dated January 17, 2017, and executed by the Federal Highway Administration (FHWA) and UDOT.

Figure 1-1. Transportation Needs Assessment Study Area for the S.R. 210 EIS



1.2 Summary of the Project Purpose and Need

The first level of screening, and the primary criterion for determining whether an alternative is reasonable and practicable, is whether the alternative reasonably meets the purpose of and need for the project. For the S.R. 210 Project, UDOT's purpose is reflected in one primary objective for S.R. 210:

- Substantially improve transportation related safety, reliability, and mobility on S.R. 210 from Fort Union Boulevard through the town of Alta for all users on S.R. 210.

The transportation needs in the study area are related primarily to traffic during peak periods, avalanche risk and avalanche control in Little Cottonwood Canyon, multiple roadside users in constrained areas, and anticipated future increases in visitation to Little Cottonwood Canyon as a result of population growth in Utah. The following deficiencies occur in the study area:

- Decreased mobility in winter during the morning (AM) and afternoon (PM) peak travel periods related to visits to ski areas, with the greatest traffic volumes on weekends and holidays and during and after snowstorms.
- Decreased mobility on Wasatch Boulevard resulting from weekday commuter traffic.
- Safety concerns associated with avalanche hazard and traffic delays caused by the current avalanche-control program in Little Cottonwood Canyon. Periodic road closures for avalanche control can cause 2-to-4-hour travel delays or longer, which can cause traffic to back up in the neighborhoods around the entrance of the canyon and often stretching to Interstate 215 (I-215).
- Limited parking at trailheads and ski areas that leads to roadside parking. The consequences of roadside parking include:
    - Reduced mobility on S.R. 210 near trailheads and at ski areas
    - Loss of shoulder area for cyclists and pedestrians, which forces them into the roadway travel lane and creates a safety concern
    - Creation of informal trailheads that contribute to erosion, mineral soil loss, the spread of invasive weeds, watershed degradation, and loss of native vegetation in the canyon
    - Damage to the pavement along the roadway edge, which causes increased soil erosion, runoff into nearby streams, and watershed degradation

What are peak periods?

Peak periods are the periods of the day with the greatest amounts of traffic. For Little Cottonwood Canyon, the winter daily peak periods are tied to the ski areas opening and closing, whereas peak summer traffic occurs in the early afternoon. Peak periods are looked at by transportation analysts when examining the need for a project.

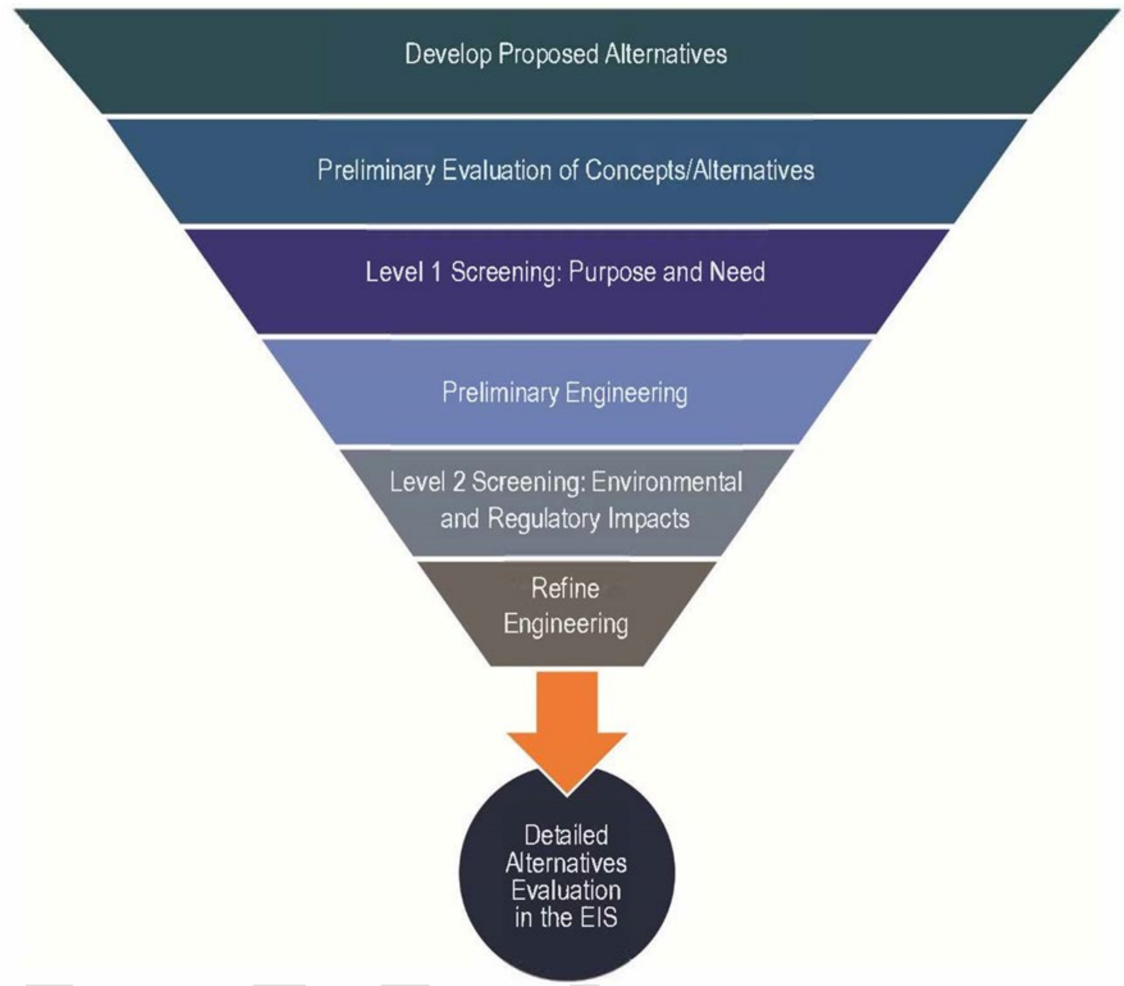
In this report, *reliability* refers to closure of S.R. 210 from avalanches and avalanche mitigation, and *mobility* refers to travel time and vehicle backups caused by congestion.

1.3 Screening Process Overview

The alternatives development and screening process consisted of the following phases (Figure 1-2):

1. Develop proposed alternatives that respond to the Purpose and Need Statement based on previous studies, public and agency input during the scoping process, and local and regional land use and transportation plans.
2. Conduct a preliminary evaluation of general concepts and/or alternatives received during the EIS scoping process to determine which concepts and/or alternatives could generally meet the project purpose, are within the scope of the EIS and EIS study area, and are technically feasible (for more information, see Section 1.3.2, Preliminary Evaluation of Concepts and Alternatives). The alternatives that were not eliminated during the preliminary evaluation were carried forward into Level 1 screening.
3. Apply initial (Level 1) screening criteria to eliminate alternatives that do not meet the purpose of and need for the project.
4. Refine alternatives that pass the Level 1 screening process.
5. Apply secondary (Level 2) screening criteria to eliminate alternatives that might meet the purpose of and need for the project but would be unreasonable alternatives for other reasons—for example, an alternative would have unreasonable impacts to the natural and human environment, would not meet regulatory requirements, or could be replaced by a less costly alternative with similar impacts to the natural and human environment.
6. Conduct preliminary engineering. The alternatives that pass Level 1 and Level 2 screening will be further developed to avoid and minimize impacts to the natural and human environment and designed to a higher level of detail before UDOT performs the detailed impact analyses for the EIS.

Figure 1-2. Overview of the Little Cottonwood Canyon EIS Alternatives Development and Screening Process



The alternatives development and screening process is designed to be dynamic throughout the EIS process. If a new alternative is developed later in the process, it will be subject to the same screening process as all of the other alternatives, as described in this report. The results of the screening process are presented in this report and will be summarized in the EIS. All proposed alternatives were developed to an equal level of detail at each screening level to allow for objective screening.

1.3.1 Development of Proposed Alternatives

The first phase in the alternatives development and screening process was identifying a list of preliminary alternatives. To be considered a preliminary alternative, an alternative had to be applicable to the study area and had to present a type of solution that could potentially meet the project's purpose and basic transportation needs. For example, an alternative had to be compatible with the area's topography, climate, and available technology and had to be potentially capable of addressing mobility, reliability, and safety challenges, especially during peak travel periods.

The preliminary alternatives were developed based on previous planning studies and through the EIS agency and public scoping process. These alternatives were developed with input from existing land use and transportation plans, the public, local municipal governments, and resource agencies. The input was collected during the EIS public scoping periods (initial scoping period March 9 to May 4, 2018, and revised scoping period March 5 to June 14, 2019), at agency scoping meetings (April 9, 2018, and April 3, 2019), and in stakeholder interviews. In addition, a report describing the screening process that would be used (*Draft Alternatives Development and Screening Methodology and Preliminary Concept Report*) was placed on the project website (on November 4, 2019) and provided to the public and cooperating and participating agencies for a 40-day public comment period. During that review period, additional alternative concepts were provided to UDOT to consider.

1.3.1.1 Previous Studies and Plans

The Little Cottonwood Canyon EIS team considered alternatives from the following previous transportation studies:

- Mountain Accord Process
- *Mountain Transportation Study Final Report* (Fehr & Peers 2012)
- *Cottonwood Heights General Plan* (City of Cottonwood Heights 2005)
- *Cottonwood Canyons Scenic Byways Corridor Management Plan* (Fehr & Peers 2008)
- *Wasatch Boulevard Master Plan* (City of Cottonwood Heights 2019)

1.3.1.2 Scoping

As discussed in the *Little Cottonwood Canyon EIS Scoping Summary Report*, during the EIS scoping process in 2018 and 2019, UDOT received more than 1,500 comments, about 100 of which suggested concepts and alternatives for UDOT to evaluate in the EIS. These 100 comments addressed alternative locations, alternative configurations, travel modes, safety, construction costs, construction methods, and logical termini. Where applicable, the Little Cottonwood Canyon EIS team incorporated the alternatives scoping comments when developing the range of preliminary alternatives. For more information, see Section 1.3.2, Preliminary Evaluation of Concepts and Alternatives.

1.3.1.3 Meetings with Stakeholders

During the development of alternatives, UDOT held numerous meetings with stakeholders to receive input on potential alternatives to consider. Meetings were held with the Salt Lake Climbers Alliance on May 1, 2019; with the Granite Community Council on April 10, 2019; and with the following city and county councils:

- City of Cottonwood Heights, April 2, 2019
- Town of Alta, April 11, 2019
- Sandy City, April 23, 3019
- Salt Lake County, June 11, 2019

Additionally, a 40-day review period (from November 4, 2019, to December 13, 2019) was provided for stakeholder comments on the preliminary alternatives development and alternatives screening criteria. During this comment period, the following meetings were held with stakeholders:

- Central Wasatch Commission, November 4, 2019
- Granite Community Council, November 6, 2019
- Save Our Canyons, November 13, 2019
- Town of Alta Council, November 13, 2019
- Cottonwood Heights residents, November 13 and 15, 2019
- Central Wasatch Commission staff, November 18, 2019
- Granite Community residents, November 18, 2019
- Salt Lake City Department of Public Utilities, November 19, 2019
- Granite Transportation Committee, November 20, 2019
- Alta, Brighton, and Snowbird Ski Resorts, December 2, 2019
- Solitude Ski Resort, December 4, 2019
- Mountainous Planning District Commission, December 5, 2019
- Sandy City staff, December 5, 2019
- Sandy City Council, December 10, 2019
- Town of Alta staff, December 10, 2019

1.3.1.4 Agency and Public Input under NEPA and SAFETEA-LU

The Little Cottonwood Canyon EIS team used several methods to involve agencies and the public during the development and screening of preliminary alternatives as required under the National Environmental Policy Act (NEPA) and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The Little Cottonwood Canyon EIS team requested agency and public input through meetings, open houses, and reviews of project materials.

SAFETEA-LU requires that the project team hold an agency scoping meeting. The initial agency scoping meeting for the Little Cottonwood Canyon EIS was held on April 9, 2018, and is described in the July 2018 *Scoping Summary Report*. Based on changes to the scope of the project, UDOT issued a revised Notice of Intent to prepare an EIS and held a second agency scoping meeting on April 3, 2019. The items that were discussed at the second meeting included the anticipated release of a new Notice of Intent identifying the need for increased capacity in Little Cottonwood Canyon; the preliminary alternatives for avalanche mitigation, improvements at trailheads, and improved mobility on Wasatch Boulevard; the purpose of and need for the project, which remained the same as presented in previous scoping activities; and alternatives screening.

The public was also asked to review and provide comments on the proposed alternatives screening methodology and criteria and on the list of preliminary alternatives. The proposed alternatives screening methodology and criteria and the preliminary list of alternatives were posted on the project website for public review between November 4 and December 13, 2019. During this comment period, about 400 comments were received. Based on those comments, UDOT made some changes to the screening criteria.

1.3.2 Preliminary Evaluation of Concepts and Alternatives

1.3.2.1 First Preliminary Evaluation of Concepts and Alternatives

During the EIS scoping process in 2018 and 2019, UDOT received more than 1,500 comments, about 100 of which suggested concepts and alternatives for UDOT to evaluate in the EIS. As part of the preliminary evaluation of concepts and alternatives, UDOT considered these suggested concepts and alternatives to determine whether they would meet project objectives, are within the project study area, are technically feasible, and are UDOT operational improvements that are in process, or are small improvements that were considered within a larger alternative. Appendix A, Preliminary Evaluation of Alternatives and Concepts, summarizes those comments and the preliminary evaluation by UDOT. The concepts and alternatives that were not eliminated as part of the preliminary evaluation were evaluated in Level 1 screening.

The preliminary evaluation of alternatives was included in the *Draft Alternatives Development and Screening Methodology and Preliminary Concept Report*, which was provided to the public and cooperating and participating agencies for a 40-day agency and public review process. About 400 comments were received on the preliminary evaluation. None of the comments generated new alternatives or concepts that were not already being evaluated.

1.3.2.2 Second Preliminary Evaluation of Concepts and Alternatives

The preliminary concepts and alternatives that came out of the first evaluation were further defined and evaluated in this report to determine whether each concept or alternative was feasible to be considered further in Level 1 screening. The preliminary concepts and alternatives were not developed in enough detail to conduct traffic modeling or have general layouts for impact evaluation. However, each one was reviewed to determine whether the concept or alternative was technically or operationally feasible, would meet the person demand requirements to meet the project purpose, or would provide less benefit compared to other similar concepts and alternatives.

For example, there are many different types of gondola systems. The preliminary evaluation determined which gondola system would best meet the travel demand, travel time, and weather conditions necessary for Little Cottonwood Canyon. The gondola system that best met the overall requirements was carried forward for Level 1 screening.

1.3.3 Level 1 Screening Process

> **What is the purpose of Level 1 screening?**
>
> The purpose of Level 1 screening is to eliminate alternatives that do not meet the purpose of and need for the project.

During the Level 1 alternatives screening phase, each of the proposed alternatives will be evaluated using criteria that identify whether the alternative reasonably meets the purpose of and need for the project.

The purpose of Level 1 screening is to eliminate alternatives that do not meet the purpose of and need for the project. Alternatives that are determined by UDOT to not meet the purpose of and need for the project are considered unreasonable for NEPA purposes, not practicable under the Clean Water Act, and not prudent under Section 4(f) of the Department of Transportation Act, and were not carried forward for further analysis in Level 2 screening. (Note that some of the resources considered under these laws were not found near the alignments of some alternatives being evaluated, so those resources were not a factor in the screening process for those alternatives.) For more information, see Section 1.4, Reasons Why an Alternative Might Be Eliminated during the Screening Process.

Initial alternatives that are not eliminated during Level 1 screening will be refined and advanced to Level 2 screening. Table 1-1 lists the Level 1 screening criteria.

Table 1-1. Level 1 Screening Criteria (Purpose and Need)

Criterion	Measure
Improve mobility in 2050	• Substantially improve peak-hour per-person (defined as the 30th-busiest hour[a]) travel times in Little Cottonwood Canyon for uphill and downhill users in 2050 compared to travel times with the No-Action Alternative in 2050. • Meet peak-hour average total person-demand on busy ski days in Little Cottonwood Canyon. • Substantially reduce vehicle backups on S.R. 210 and S.R. 209 through residential areas on busy ski days (30th-busiest day). • By 2050, meet UDOT's goal of level of service (LOS) D in the weekday AM and PM peak periods on Wasatch Boulevard.
Improve reliability and safety in 2050	• Substantially reduce the number of hours and/or days during which avalanches delay users. • Substantially reduce the avalanche hazard for roadway users. • Improve roadway safety at existing trailhead locations. • Reduce or eliminate traffic conflicts between motorized and nonmotorized transportation modes at key trailhead locations. • Reduce or eliminate roadside parking to improve the safety and operational characteristics of S.R. 210.

[a] The travel demand during the 30th-busiest hour in 2050 would be about 1,555 vehicles or about 3,260 people.

1.3.4 Level 2 Screening Process

The purpose of Level 2 screening is to identify alternatives that are practicable and reasonable and should be evaluated in detail in the EIS. During Level 2 screening, UDOT collectively evaluated the alternatives that passed Level 1 screening against key criteria that focus on the alternative's impacts to the natural and built environment, estimated project costs, logistical considerations, and technological feasibility. Table 1-2 lists the Level 2 screening criteria.

What is the purpose of Level 2 screening?

The purpose of Level 2 screening is to identify alternatives that are practicable and reasonable and should be evaluated in detail in the EIS.

The overall process for Level 2 screening was:

- Estimate the impacts of each alternative that passed Level 1 screening on key resources.
- Evaluate the alternatives for costs, logistical considerations, and technological feasibility.
- Determine whether any of the alternatives would have substantially greater impacts or costs without having substantially greater benefits in meeting the purpose of and need for the project.

Using the information gathered from Level 2 screening, UDOT determined which alternatives to study in detail in the EIS.

Estimate Impacts on Resources. Using geographic information systems (GIS) software, UDOT will estimate how each alternative that passed Level 1 screening might affect resources such as wetlands and other waters of the United States, Section 4(f) and Section 6(f) resources, critical threatened and endangered species habitat, existing and planned parks and trail systems, cultural resources, camping areas, wilderness areas, and community facilities such as schools, senior centers, fire stations, and community gathering places. The amount of impacts will be determined by overlaying the estimated right-of-way for each alternative on the GIS datasets for these resources. UDOT will use the same approach to identify the potential number of impacts to homes and businesses, potential property acquisitions, and potential community impacts.

Evaluate Alternatives for Consistency with Permitting Requirements. UDOT will evaluate the alternatives independently for their consistency with applicable permitting requirements, including consideration of whether an alternative is practicable for Clean Water Act Section 404(b)(1) purposes. If an alternative is found by UDOT to be practicable and to have less adverse impacts to the aquatic environment, it will be retained for detailed analysis in the EIS. For more information, see Section 1.4, Reasons Why an Alternative Might Be Eliminated during the Screening Process.

Compare Impacts and Costs to Benefits. UDOT will use the screening results to determine whether any of the alternatives would have substantially greater impacts or costs without having substantially greater benefits to the purpose and need. Alternatives that have the same or similar benefits to other alternatives but have substantially greater impacts or costs will be eliminated and considered unreasonable for NEPA purposes.

Table 1-2. Level 2 Screening Criteria (Impacts)

Criterion	Measure
Cost	• Alternative's cost compared to other similar alternatives that pass Level 1 screening
Consistency and compatibility with local and regional plans	• Alternative's consistency with local and regional land use and transportation plans[a] • Alternative's compliance with the Wilderness Act of 1964 and consistency with the 2003 *Revised Wasatch-Cache Forest Plan*
Compatibility with permitting requirements	• Permit requirements
Impacts related to Clean Water Act	• Acres and types of wetlands and other waters of the United States[b]
Impacts to natural resources	• Acres of floodplain • Acres of critical habitat
Impacts to the built environment	• Number and area of parks • Number of community facilities • Number of potential property acquisitions including residential and business. • Number of Section 4(f)/Section 6(f) uses[c] • Number of cultural resources (for example, historic and archaeological resources) affected

[a] This criterion is a secondary objective that will be used to measure how well an alternative meets local community desires after environmental impacts are considered and to make minor shifts to alternatives' alignments. It will not be used to determine whether an alternative is reasonable or practicable.

[b] Based on Clean Water Act requirements, an alternative with a substantially greater number of wetland impacts could be eliminated from detailed study in the EIS. UDOT will not use the criteria listed in this table to eliminate alternatives from detailed study in the EIS before considering whether the alternatives would comply with the Clean Water Act Section 401(b)(1) Guidelines. Each alternative will be evaluated individually regarding cost, existing technology and logistics before the other criteria in this table are considered. For more information, see Section 1.4.2, Clean Water Act Requirements.

[c] Based on the requirements of Section 4(f) of the Department of Transportation Act of 1966 and Section 6(f) of the Land and Water Conservation Fund Act of 1965, an alternative with substantially greater Section 4(f) or Section 6(f) impacts could be eliminated from detailed study in the EIS. For more information, see Section 1.4.3, Section 4(f) and Section 6(f) Requirements.

1.4 Reasons Why an Alternative Might Be Eliminated during the Screening Process

In addition to an alternative not meeting the project purpose (Level 1 screening), other laws and guidance can also determine whether an alternative is not reasonable, as described below.

1.4.1 Council on Environmental Quality Regulations and Guidance

According to NEPA regulations and the Council on Environmental Quality, there are three primary reasons why an alternative might be determined to be not reasonable and eliminated from further consideration.

1. The alternative does not satisfy the purpose of the project (evaluated in the Level 1 screening for the S.R. 210 Project).
2. The alternative is determined to be not practical or feasible from a technical and/or economic standpoint (evaluated in the Level 2 screening for the S.R. 210 Project).
3. The alternative substantially duplicates another alternative; that is, it is otherwise reasonable but offers little or no advantage for satisfying the project's purpose, and it has impacts and/or costs that are similar to or greater than those of other, similar alternatives (evaluated in the Level 2 screening for the S.R. 210 Project).

1.4.2 Clean Water Act Requirements

Because the area of analysis for the project might support federally regulated wetlands or other waters of the United States, UDOT will also consider the Clean Water Act *Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material* (40 Code of Federal Regulations [CFR] Part 230) and Executive Order 11990, *Protection of Wetlands*, during the alternatives development phase. The U.S. Army Corps of Engineers is responsible for determining compliance with the Section 404(b)(1) Guidelines and may permit only the least environmentally damaging practicable alternative.

The Section 404(b)(1) Guidelines state that "no discharge of dredged or fill material [to Section 404–regulated waters] shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences" [40 CFR Section 230.10(a)]. This section of the Guidelines further states that:

> 1. For the purpose of this requirement, practicable alternatives include but are not limited to:
>   i. Activities which do not involve a discharge of dredged or fill material into the waters of the United States or ocean waters;
>   ii. Discharges of dredged or fill material at other locations in waters of the United States or ocean waters[.]
> 2. An alternative is practicable if it is available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes. If it is otherwise a practicable alternative, an area not presently owned by the applicant which could reasonably be obtained, utilized, expanded, or managed in order to fulfill the basic purpose of the proposed activity may be considered.

3. Where the activity associated with a discharge which is proposed for a special aquatic site (as defined in Subpart E [of the Guidelines]) does not require access or proximity to or siting within the special aquatic site in question to fulfill its basic purpose (i.e., is not "water dependent"), practicable alternatives that do not involve special aquatic sites are presumed to be available, unless clearly demonstrated otherwise. In addition, where a discharge is proposed for a special aquatic site, all practicable alternatives to the proposed discharge which do not involve a discharge into a special aquatic site are presumed to have less adverse impact on the aquatic ecosystem, unless clearly demonstrated otherwise.

To achieve compliance with the Section 404(b)(1) Guidelines, UDOT will need to demonstrate through an evaluation of alternatives in the EIS that the alternative selected in the project's Record of Decision is the least environmentally damaging practicable alternative.

1.4.3 Section 4(f) and Section 6(f) Requirements

Section 4(f) of the Department of Transportation Act of 1966 (49 USC Section 303) applies to publicly owned parks, recreation areas, and wildlife and waterfowl refuges and publicly or privately owned significant historic properties. The requirements of Section 4(f) apply only to agencies within the U.S. Department of Transportation (USDOT)—for example, FHWA. Pursuant to 23 USC Section 327 and the NEPA Assignment Memorandum of Understanding between FHWA and UDOT dated January 17, 2017, UDOT is responsible for meeting Section 4(f) and Section 6(f) requirements.

Section 4(f) prohibits USDOT agencies from approving the use of any Section 4(f) land for a transportation project, except as follows:

- First, the USDOT agency can approve the use of a Section 4(f) only if it makes a determination that (1) there is no prudent and feasible alternative that would avoid the use of the Section 4(f) property *and* (2) the project includes all possible planning to minimize harm to that property;
- Second, if there is no feasible and prudent avoidance alternative and there are multiple remaining alternatives with Section 4(f) uses, the approved alternative would cause least overall harm in light of Section 4(f)'s preservation purpose; and
- Third, the USDOT agency can approve the use of Section 4(f) property by making a finding of *de minimis* impact for that property.

What is a *de minimis* impact?

For publicly owned public parks, recreation areas, and wildlife and waterfowl refuges, a *de minimis* impact is one that would not adversely affect the activities, features, or attributes of the property.

For historic sites, a finding of *de minimis* impact means FHWA has determined that the project would have "no adverse effect" on the historic property.

Section 6(f) of the Land and Water Conservation Act requires that the conversion of lands or facilities acquired with Land and Water Conservation Act funds be approved by the U.S. Department of the Interior. Approval requires "substitution of other recreation properties of at least equal fair market value and of reasonably equivalent usefulness and location."

Section 4(f) and Section 6(f) Criteria. An alternative that would not be available because of the severity of Section 4(f) or Section 6(f) impacts could be eliminated during Level 2 screening. To achieve compliance with the Section 4(f) regulations, UDOT will need to demonstrate through an evaluation of alternatives that either (1) the alternative selected would have a *de minimis* use of Section 4(f) resources or (2) there is no feasible and prudent alternative that would avoid the use of Section 4(f) resources, and the project includes all possible planning to minimize harm to Section 4(f) resources.

1.4.4 Wilderness Act of 1964

Little Cottonwood Canyon is in the Uinta-Wasatch-Cache National Forest. The canyon is home to two National Wilderness Areas: Twin Peaks Wilderness to the north of Little Cottonwood Canyon Road and Lone Peak Wilderness to the south. The Wilderness Act of 1964 (Public Law 88-577; 16 USC Sections 1131–1136) was established by Congress to secure for the American people of present and future generations the benefit of an enduring resource of wilderness. The Wilderness Act states that there shall be no commercial enterprise and no permanent road within any wilderness area designated by the Act and, except as necessary to meet minimum requirements for the administration of the area for the purpose of the Act (including measures required in emergencies involving the health and safety of persons within the area), there shall be no temporary road, no use of motor vehicles, motorized equipment or motorboats, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any such area.

An alternative could be eliminated because of conflicts with the Wilderness Act.

1.4.5 Appropriation of Land Owned by the United States for Highway Purposes

In Little Cottonwood Canyon, S.R. 210 crosses National Forest System (NFS)-managed land; however, UDOT does not currently have a perfected easement for the entire length of the S.R. 210 corridor on those lands. If proposed improvements would occur on NFS-managed land not already appropriated by FHWA, this action might be subject to the conditions of 23 USC Section 317, *Appropriation for Highway Purposes of Lands or Interests in Lands Owned by the United States*.

Through this appropriation process, the U.S. Secretary of Agriculture can certify that the appropriation of NFS-managed land for transportation use is contrary to the public interest or inconsistent with the purposes for which the NFS-managed land was originally reserved, or agree to the appropriation and transfer of the land to FHWA and UDOT, potentially with stipulated conditions to protect NFS-managed land. In addition, for the consideration of aerial transportation systems, UDOT will work with FHWA to determine the applicability of the use of 23 USC Section 317 for areas under such a system.

If such authorities are not applicable, UDOT might need to discuss the NEPA decision requirements of the U.S. Department of Agriculture (USDA) Forest Service, and the USDA Forest Service Special Use Permit or easement requirements, with the Forest Service to assess the authorization of such alternatives on NFS-managed land.

1.5 Consideration of Design Standards in Alternatives Development

When developing projects through the NEPA process, UDOT follows design standards for the alternatives that are developed. UDOT's standards are in place to ensure the safety of the traveling public by providing separation from roadside obstructions, providing space for vehicles to pull out of traffic in an emergency, having adequate distance to see intersections, and providing a safe place for cyclists and pedestrians. Standards are also important for roadway operations such as providing an area for storing plowed snow and conducting routine maintenance safely.

UDOT follows its design standards unless it is not reasonably possible to do so; for example, in cases where meeting one standard would cause another standard not to be met. For example, in a steep canyon, increasing the length of a road by adding more corners might reduce the roadway grade to meet grade standards, but it would not allow a sight distance standard (ability to see around corners) to be met. If the road were straightened to improve sight distance, it would reduce the length of the road and thus not meet grade standards. Additionally, UDOT might not meet clear zone standards when adding a lane if meeting the clear zone standard would cause substantial additional impacts to the natural or human environment.

What is a clear zone?

A clear zone is an unobstructed, traversable roadside area that allows a driver to stop safely or regain control of a vehicle that has left the roadway.

1.5.1 Consideration of Design Standards for Wasatch Boulevard

During the development of the project purpose and need, the design deficiencies listed in Table 1-3 on Wasatch Boulevard were mentioned by the public and verified by roadway engineers. All of the design deficiencies were addressed by using UDOT design standards for safety in developing the roadway alternatives for Wasatch Boulevard. Table 1-3 shows each design deficiency and how it was addressed by following UDOT standards.

Table 1-3. Consideration of UDOT Design Standards on Wasatch Boulevard

Design Deficiency Identified	Consideration of UDOT Design Standards
The standard shoulder width for this segment of S.R. 210 is 10 feet. The current shoulder width varies from 4 feet to 10 feet, with 4 feet being the typical width.	Alternatives were designed to meet the 10-foot design standard.
The intersection sight distance at Kings Hill Drive is insufficient.	Alternatives were designed to meet sight distance standards, which included removing some roadside obstructions and improving the curve radius at the Kings Hill Drive intersection.
The length of the deceleration lane for the center left turn at Golden Hills Avenue is substandard.	The length of the deceleration lane was increased to meet design standards.
Per UDOT's roadside design guidance, the suggested clear zone is 20 to 22 feet. There are some unprotected hazards within the clear zone including substandard barrier end treatments, trees, and steep slopes.	Alternatives were designed to meet 20- to 22-foot clear zone design standards.
95% of Wasatch Boulevard has no sidewalks or pedestrian-related facilities.	Alternatives were designed to included painted bicycle lanes in the 10-foot shoulder per UDOT design standards and include a 10-foot pedestrian trail on the east side of Wasatch Boulevard.

1.5.2 Consideration of Design Standards for S.R. 210 in Little Cottonwood Canyon

S.R. 210 in Little Cottonwood Canyon is a steep, narrow canyon road that over 6 miles climbs from an elevation of 5,400 feet at the canyon entrance to about 9,200 feet in the town of Alta. Portions of the road exceed UDOT standards for grade, sight distance (because of the winding nature of the road in the canyon), and clear zones. Table 1-4 lists the parts of S.R. 210 that do not meet design standards and how UDOT considered design standards when developing the roadway alternatives.

Table 1-4. Consideration of UDOT Design Standards on S.R. 210 in Little Cottonwood Canyon

Design Deficiency Identified	Consideration of UDOT Design Standards
The standard shoulder width for this roadway classification is 8 feet, but over 85% of this segment has shoulder widths less than 8 feet.	For alternatives that propose modifying S.R. 210 in Little Cottonwood Canyon, UDOT will meet the design standard for shoulder width (8 feet).
The stopping sight distance does not meet design guidance in several locations because trees, rocks, and steep embankments block visibility around curves. The sight distance is insufficient in the eastbound direction through the curves near mileposts 5.45, 5.60, 5.97, 6.40, and 6.67 and in the westbound direction through the curves near mileposts 10.60, 10.43, 9.50, 9.30, 8.31, 8.04, 7.95, 7.60, 6.59, 6.49, 6.30, 5.97, 5.60, 5.25, 4.80, 4.35, and 4.14.	Meeting sight distance requirements would not be reasonable throughout Little Cottonwood Canyon without extensively realigning the road. To improve sight distance around curves, UDOT would need to straighten the road, which would reduce the road length. If UDOT were to straighten the road to improve sight distance, the road grade would increase, which is already between 9% and 11% in many locations and exceeds UDOT's standard of 8%. Increasing downhill grades would reduce safety for downhill-traveling vehicles, since it would become increasingly difficult for drivers to maintain appropriate downhill speeds. Increasing uphill grades would slow vehicle traffic, thereby causing greater congestion. Overall, UDOT determined that it was not reasonable to meet UDOT's sight distance standards in Little Cottonwood Canyon because meeting sight distance standards would result in the road further exceeding grade standards.
The roadside design guidance suggests a clear zone of 14 to 16 feet. However, this segment of S.R. 210 does not meet the design guidance because it has a substantial number of unprotected hazards, with boulders, steep slopes, and trees being the majority of the hazards. The intersection sight distance is inadequate at several minor roads and parking areas at points of interest, including at the White Pine and Lisa Falls Trailheads.	Meeting clear zone design standards when making roadway improvements, such as the addition of peak-period shoulder lanes on all segments of S.R. 210, could place fill in segments of Little Cottonwood Creek, which is part of Salt Lake City's watershed. Avoiding impacts from the clear zone to the creek would require greater rock cuts into the canyon wall than what would be required for adding the peak-period shoulders only. Given the steepness of the canyon, UDOT would need to build large retaining walls with the cuts to prevent rock slides. Therefore, UDOT determined that it that was not reasonable to meet UDOT's clear zone standards on all segments of S.R. 210 in Little Cottonwood Canyon because of the additional environmental impacts the clear zones would cause in the canyon. The substandard sight distance at the Lisa Falls and White Pine Trailheads is addressed through the improved trailhead parking options considered in the EIS.
Several dedicated left-turn and right-turn lanes do not meet current standards for taper lengths and deceleration distance.	Alternatives were designed to have turn lanes that meet safety standards.

1.6 Consideration of Climate Change in Alternatives Development

Public comments provided during the EIS scoping period and the public review of the alternative screening report suggested that climate change should be considered in the development of alternatives. Specifically, public comments stated that, with the warming climate, there will be less snow and thus fewer skiers at the resorts in Little Cottonwood Canyon. The commenters stated that with fewer skiers there would not be a need to improve S.R. 210 in Little Cottonwood Canyon.

Based on the climate change literature reviewed by UDOT (see Appendix B, Little Cottonwood Canyon Alternatives and Climate Change), in 2050, the buildup of the snowpack at the canyon resorts could be delayed by 1 to 2 weeks, with little snow at Thanksgiving, and the ski season might end 1 to 2 weeks earlier. Historically, high-traffic days in the canyon have occurred from late December (typically around the Christmas holiday) through March, when the snowpack should be deep enough based on climate studies for skiing. Since most high traffic days don't occur until December and likely around the late December holiday period and end in March when snow pack should be enough to ski based on literature, climate change should not result in a need to modify alternatives that address mobility during high travel periods. In addition, sites at higher elevations (such as Snowbird and Alta ski resorts, at 7,800 feet and above) tend to be more resilient to projected changes in temperature and precipitation.

UDOT also reviewed traffic data for eastbound traffic in the canyon from the 2013 through 2018 ski seasons. These ski seasons had different yearly snow totals. During this 6-year period, there were an average of 39 travel periods per ski season with more than 1,000 vehicles in the canyon. The highest number of travel periods on S.R. 210 in Little Cottonwood Canyon with more than 1,000 vehicles (51) occurred during the 2016–2017 ski season, and the lowest number of travel periods with more than 1,000 vehicles (31) occurred during the 2014–2015 ski season. The 2014–2015 ski season had the lowest snow total of any year from the 2006–2007 ski season to the 2018–2019 ski season. Overall, the data show that, even during years with low snow totals, there are more than 30 travel periods per ski season in which the number of vehicles in the canyon exceeds 1,000 vehicles. This number (30) is only 9 below the average number for the 6-year period (39). Therefore, even with the potential for less snowfall at the resorts in the future, UDOT still expects that there would be enough heavy traffic days to justify developing alternatives that address mobility during high-travel periods.

2.0 Alternatives Development and Screening Process – Improve Mobility in 2050

Improving mobility on S.R. 210 in 2050 involves meeting two different needs: improving mobility for commuter traffic during the weekday on Wasatch Boulevard and improving mobility for the winter ski traffic on S.R. 210 along the entire corridor. The screening criteria for the weekday commuter traffic are different than for the winter ski traffic since the roadway travel demand varies by each type of traffic. Because the criteria are different, the alternatives screening process for Wasatch Boulevard in particular (see Section 2.1) was conducted separately from and prior to the alternatives screening process S.R. 210 overall (see Section 2.2). The mobility benefits provided by the Wasatch Boulevard alternatives that pass Level 1 and Level 2 screening will be considered part of the baseline conditions when evaluating how to improve mobility on S.R. 210 overall (see Section 2.2).

2.1 Improve Mobility on Wasatch Boulevard

2.1.1 Range of Alternatives

Table 2-1 lists the preliminary alternatives for improving mobility on Wasatch Boulevard that emerged from the scoping process, other public comment periods, and previous plans to be considered in the screening process for the EIS. Figure 2-1 shows the key roads and intersections discussed in this section.

To the extent practicable, when developing these alternatives, UDOT considered elements of the *Cottonwood Heights Wasatch Boulevard Master Plan Corridor Study* (City of Cottonwood Heights 2019). UDOT considered different travel modes (for example, transit, automobile, walking, and bicycling) and how they can be changed to improve transportation on the urban segment of S.R. 210 in support of the project's purpose and need.

Table 2-1. Preliminary Alternatives – Wasatch Boulevard

Alternative	Description
Mass Transit Alternative	The Mass Transit Alternative includes all current transit on Wasatch Boulevard, all future planned transit on Wasatch Boulevard in the Wasatch Front Regional Council's 2019–2050 *Wasatch Front Regional Transportation Plan*, and expanded transit proposed as part of this alternative.
Imbalanced-lane Alternative – one northbound travel lane and two southbound travel lanes (Figure 2-2)	The Imbalanced-lane Alternative includes one northbound lane from North Little Cottonwood Road to Bengal Boulevard and two southbound lanes from Bengal Boulevard to North Little Cottonwood Road. From Fort Union Boulevard to Bengal Boulevard, there would be four travel lanes, similar to existing conditions. A center two-way left-turn lane would be included from Fort Union Boulevard to North Little Cottonwood Road. At the southern end of Wasatch Boulevard, the two southbound lanes would pass through the intersection of Wasatch Boulevard and North Little Cottonwood Road and then merge down to one lane. The intersection of Kings Hill Drive with Wasatch Boulevard was evaluated both with and without a traffic signal.
Reversible Three-lane Alternative – reversible center lane (Figure 2-3)	The Reversible Three-lane Alternative would add one additional travel lane. The reversible lane would be used by northbound traffic during the morning peak period and southbound traffic during the evening peak period. During non-peak periods, the center lane would be used as a center two-way left-turn lane. The reversible lane would require lighted direction signs be placed over Wasatch Boulevard about every 1,320 feet with additional signs required at intersections and cross streets. Overall, there would be about 12 overhead signs on Wasatch Boulevard from Fort Union Boulevard to North Little Cottonwood Road. The intersection of Kings Hill Drive with Wasatch Boulevard was evaluated both with and without a traffic signal.
Five-lane Alternative (Figure 2-4)	The Five-lane Alternative would add one additional travel lane in each direction between Bengal Boulevard and North Little Cottonwood Road while maintaining a center two-way left-turn lane. At the southern end of Wasatch Boulevard, the two southbound lanes would pass through the intersection of Wasatch Boulevard and North Little Cottonwood Road and then merge down to one lane. The intersection of Kings Hill Drive with Wasatch Boulevard was evaluated both with and without a traffic signal.
Multiple Roundabouts Alternative (Figure 2-5)	The Multiple Roundabouts Alternative would add an additional travel lane in each direction, for a total of four travel lanes. It would place roundabouts at the intersections of S.R. 210 with Bengal Boulevard, 3500 East, Kings Hill Drive, and North Little Cottonwood Road. Left-turn lanes would be provided at key streets, but there would be no continuous center median.

Source: Fehr & Peers 2019

Figure 2-1. Wasatch Boulevard and Connecting Roads

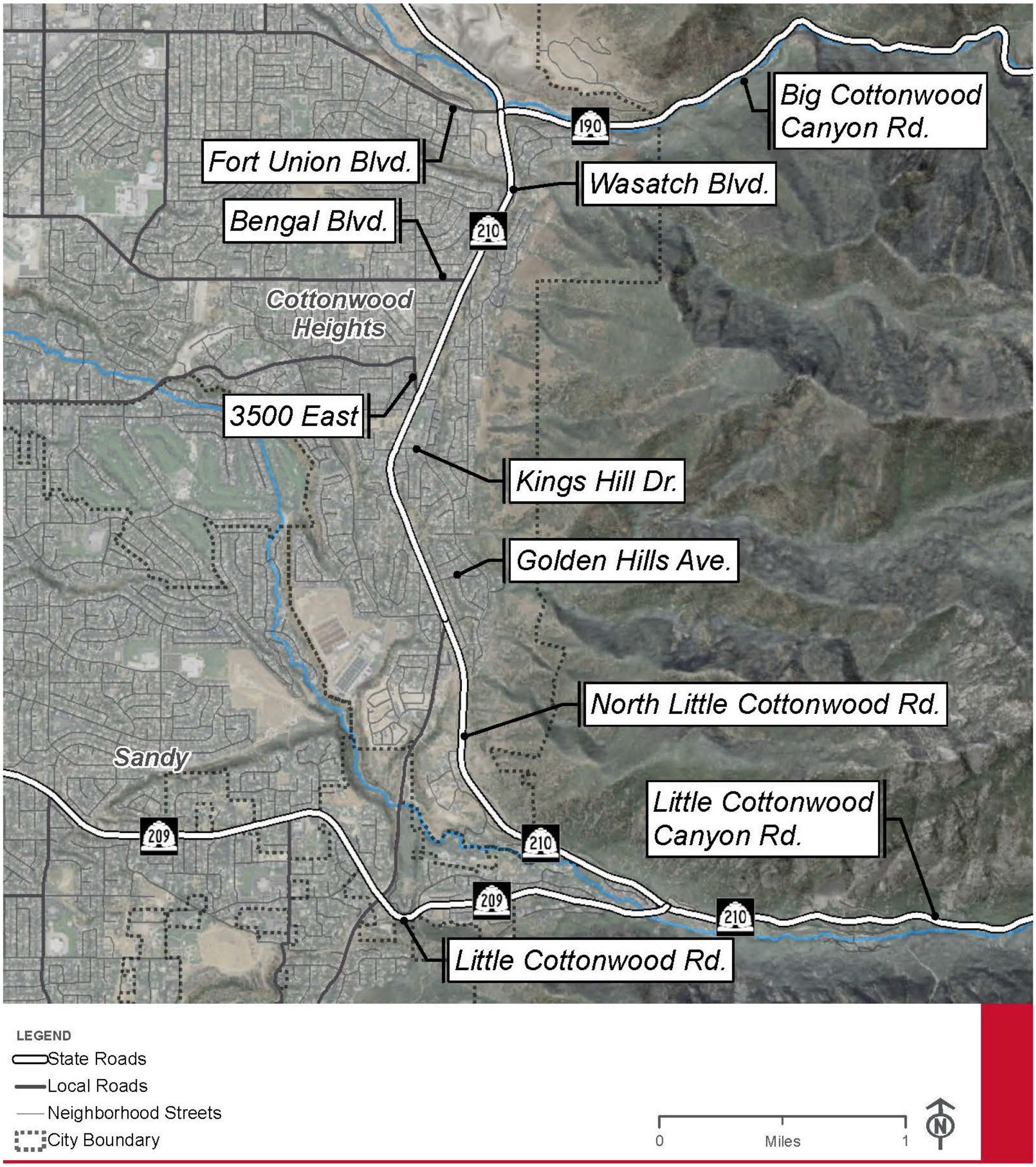


Figure 2-2. Imbalanced-lane Alternative

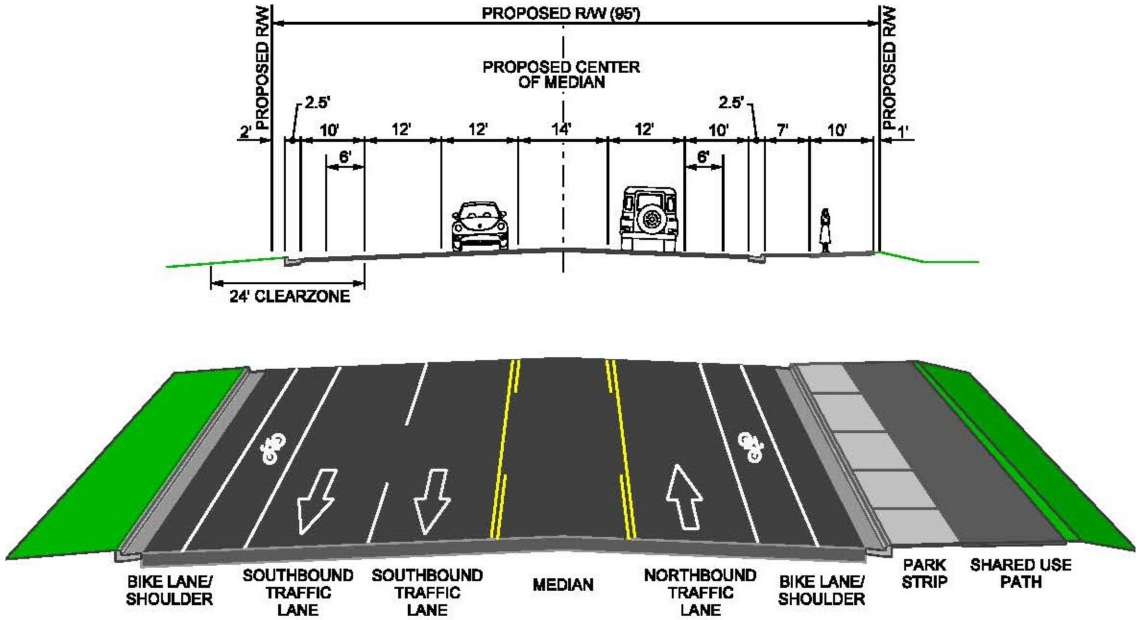


Figure 2-3. Reversible Three-lane Alternative

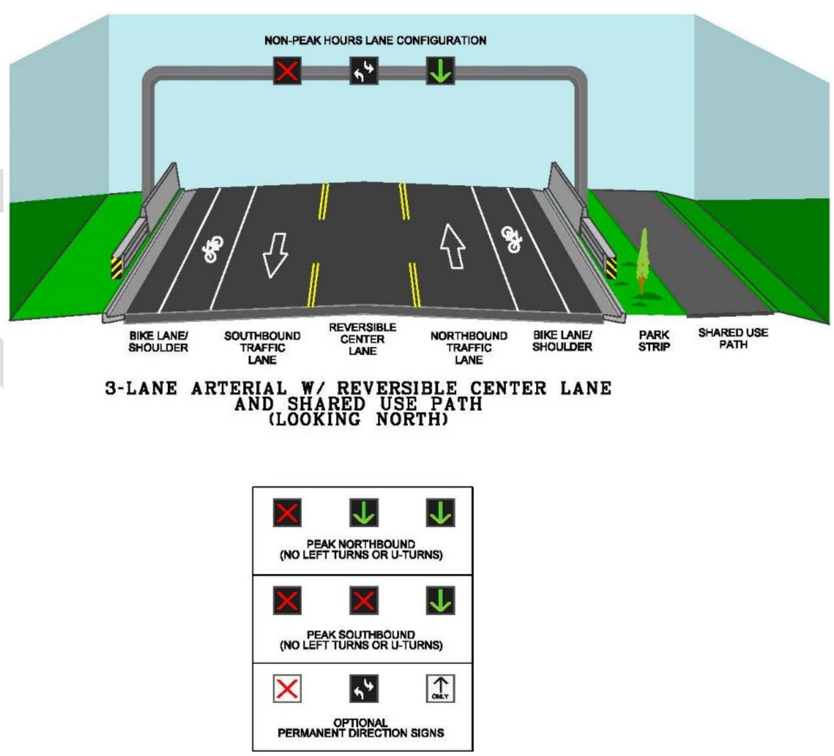


Figure 2-4. Five-lane Alternative

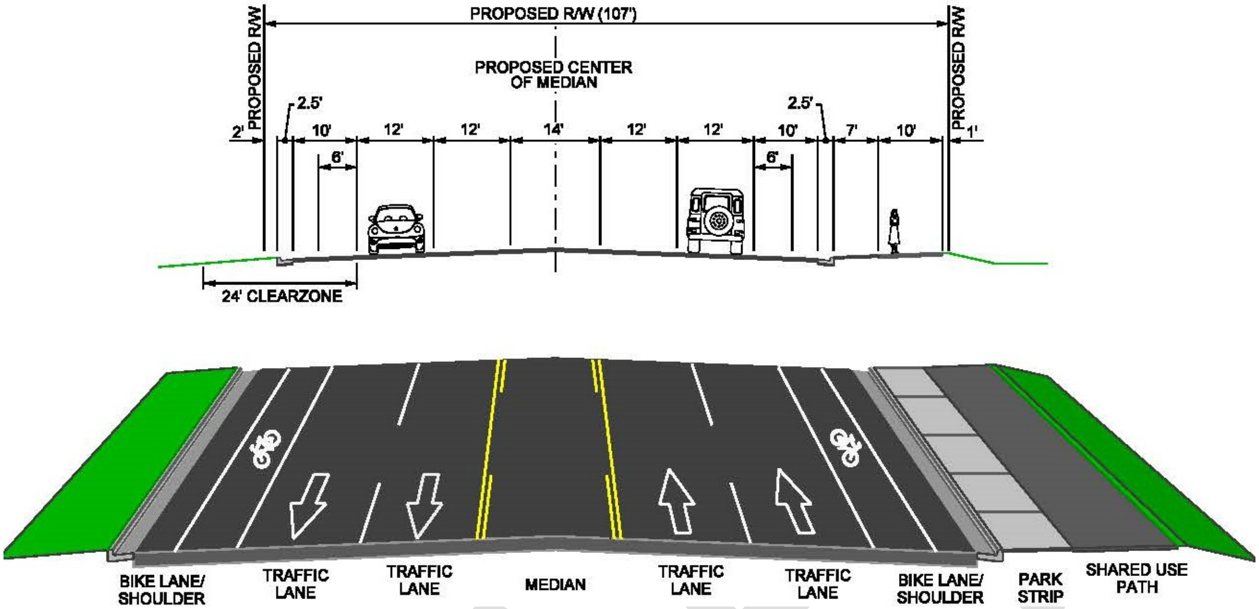
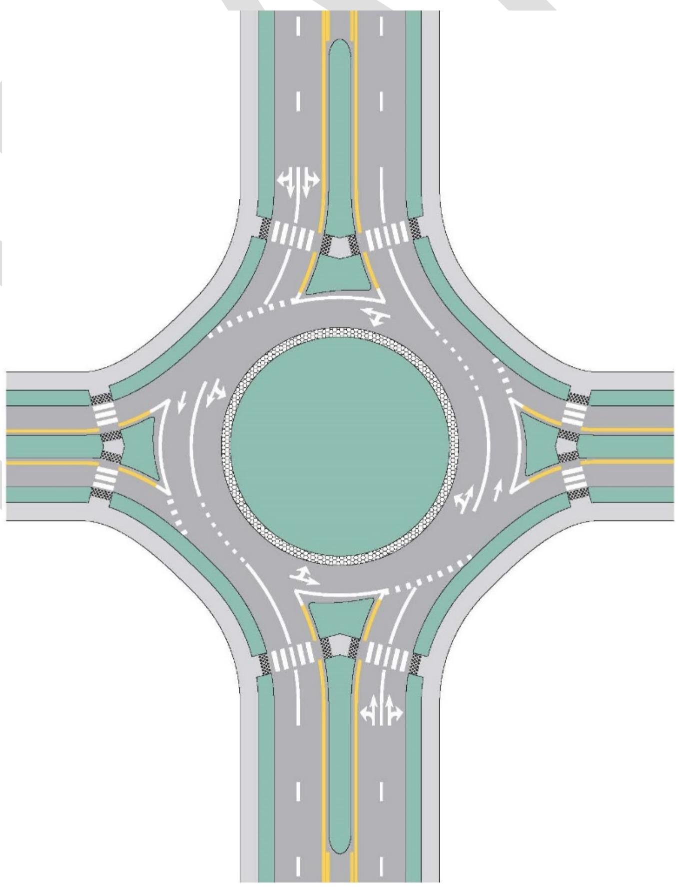


Figure 2-5. Multiple Roundabouts Alternative



2.1.2 Screening of Alternatives

As shown above in Figure 1-2, Overview of the Little Cottonwood Canyon EIS Alternatives Development and Screening Process, alternatives were screened in a three-step process consisting of a preliminary evaluation, Level 1 screening, and Level 2 screening. This section describes the three-step screening process for the five preliminary alternatives that were identified to improve mobility on Wasatch Boulevard (see Table 2-1, Preliminary Alternatives – Wasatch Boulevard, above).

2.1.2.1 Preliminary Alternatives Evaluation

The screening process included a preliminary review of each preliminary alternative in Table 2-1, Preliminary Alternatives – Wasatch Boulevard, above to determine whether it was feasible. The alternative discussed in this section was determined not to be feasible and was eliminated prior to Level 1 screening.

2.1.2.1.1 Mass Transit Alternative

During the alternatives development process, UDOT considered a mass transit alternative for commuters to alleviate weekday morning and afternoon peak traffic. Several bus routes intersect Wasatch Boulevard; however, no year-round weekday commuter bus routes run along the entire length of Wasatch Boulevard between Fort Union Boulevard and North Little Cottonwood Road. The Utah Transit Authority's (UTA) bus route 307 runs along Bengal Boulevard and along a short segment of Wasatch Boulevard near Golden Hills Park (8303 Wasatch Boulevard), while route 354 runs along Fort Union Boulevard to the intersection of Wasatch Boulevard and Fort Union Boulevard. The Cottonwood Corporate Center is the one place on Wasatch Boulevard that has a convergence of bus routes and offers a relatively high level of bus service. This area is served by routes 72 and 223, which head west and north, respectively. However, weekday ridership at these stops is still low compared to other employment centers in UTA's service area, with few stops reaching over 10 boardings per day (City of Cottonwood Heights 2019).

Even if existing bus routes were expanded to provide service farther east than what currently exists, the current low ridership on bus routes 72 and 223, coupled with low commercial densities and the predominantly single-family suburban development pattern in the project area and surrounding communities, would not easily support robust public transit.

Additionally, past transportation research has found that mass transit alternatives are efficient only in areas with a population of over 200,000 (FHWA 1987). The current population of Cottonwood Heights is less than 40,000, and the population densities in the study area's neighborhoods are low relative to the density needed for successful transit ridership. Moreover, because the traffic using Wasatch Boulevard travels to many parts of the greater Salt Lake City area, it would not be possible to provide transit service that accommodates most of the travel destinations. Because the service could not reach multiple travel destinations, it would not attract enough users to eliminate the need to improve roadway capacity on Wasatch Boulevard and intersections in 2050.

Alternative transit scenarios were modeled as part of the *Wasatch Boulevard Master Plan Corridor Study*. This study found that, in order to move people reliably through the Wasatch Boulevard corridor at acceptable levels of service, the roadway would need more vehicle capacity. The study went on to recommend adding more vehicle capacity south of Bengal Boulevard but in a way that is sensitive to and adds value to the surrounding neighborhood while prioritizing high-occupancy vehicles and future transit (City of Cottonwood Heights 2019).

The Wasatch Front Regional Council's (WFRC) 2019–2050 *Wasatch Front Regional Transportation Plan* (RTP; WFRC 2019) includes express bus service (to be implemented between 2040 and 2050) on Wasatch Boulevard running from the Little Cottonwood Canyon park-and-ride lot at the intersection of S.R. 209/S.R. 210 to I-215/3900 South, where the express bus route would connect to another express bus route heading to the University of Utah. For the analysis in this report, this express bus route on Wasatch Boulevard was considered part of the 2050 No-Action baseline conditions, which still showed congested traffic conditions on Wasatch Boulevard if no roadway capacity improvements are made.

To meet the projected traffic demand in 2050, the 2019–2050 RTP includes a combination of transit and roadway improvements on Wasatch Boulevard from Fort Union Boulevard to North Little Cottonwood Road. Because the mass transit alternative alone would not meet all of the elements of the Level 1 screening criteria, UDOT did not further consider transit-only scenarios. Since transit is included in the 2019–2050 RTP, it was assumed as part of the 2050 No-Action baseline conditions for the alternatives screening. In other words, the changes proposed as part of the roadway alternatives assume some form of transit in the future and do not preclude future transit upgrades on Wasatch Boulevard. For this reason, the overall objectives identified in the draft *Wasatch Boulevard Master Plan Corridor Study*, such as the goal to move people through the Wasatch Boulevard corridor reliably and to increase travel choices along the corridor, as well as UDOT's safety and mobility requirements, would all be addressed with any roadway alternative that is selected for this urban portion of Wasatch Boulevard.

The Mass Transit Alternative alone would not reduce congestion levels on the mainline and at the intersections of Wasatch Boulevard. For this reason, a standalone mass transit alternative for the urban section of Wasatch Boulevard was not carried forward for Level 1 screening. However, transit elements will be considered as part of all roadway alternatives evaluated in the EIS.

2.1.2.1.2 Traffic Signal at Kings Hill Drive

As part of the alternatives screening process, UDOT evaluated a traffic signal at Kings Hill Drive as part of any of the roadway action alternatives on Wasatch Boulevard. As part of the screening, UDOT conducted a traffic signal warrant study at that intersection based on the *Manual on Uniform Traffic Control Devices* (MUTCD), Chapter 4C, *Traffic Control Signal Need Studies*. The MUTCD is the law governing all traffic-control devices. It is a federal standard used by highway officials nationwide to install and maintain traffic-control devices on all streets and highways open to public travel. The MUTCD is published by FHWA under 23 CFR Part 655, Subpart F (UDOT 2011).

UDOT's review of the Kings Hill Drive intersection showed that the intersection meets the requirements for a traffic signal. However, 96% of the turning movements on Kings Hill Drive during the morning peak period are right-turning vehicles. If a dedicated right-turn lane were added on Kings Hill Drive, the signal warrant would no longer be met. There is enough room on Kings Hill Drive to stripe the road for dedicated right- and left-turn lanes without acquiring any additional right-of-way. UDOT determined that adding a traffic signal would create an off-set intersection that would not meet sight distance standards at this location, and that meeting the sight distance standards would require purchasing two homes. Therefore, UDOT decided that all of the roadway alternatives on Wasatch Boulevard would include a dedicated right- and left-turn lanes at Kings Hill Drive. Therefore, a traffic signal would not meet MUTCD warrants and was not carried forward as part of any roadway alternatives (UDOT 2018a).

2.1.2.2 Level 1 Screening

2.1.2.2.1 Level 1 Screening Alternatives

Based on UDOT's evaluation of the preliminary alternatives for improving mobility on Wasatch Boulevard, the Mass Transit Alternative and the traffic signal at Kings Hill Drive were eliminated from further consideration. The following preliminary alternatives were carried forward for Level 1 screening:

- Imbalanced-lane Alternative
- Reversible Three-lane Alternative
- Five-lane Alternative
- Multiple Roundabouts Alternative

2.1.2.2.2 Level 1 Screening Criteria

The four alternatives that were evaluated in Level 1 screening for improving mobility on Wasatch Boulevard were screened against the criterion in Table 2-2. The criterion focuses on achieving a level of service of LOS D in the morning and afternoon peak periods.

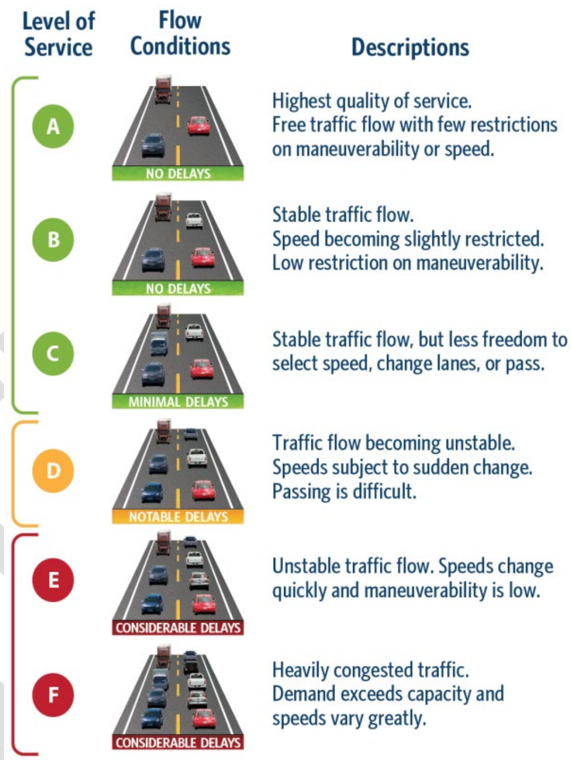
Table 2-2. Level 1 Screening Criteria – Wasatch Boulevard

Criterion	Measure
Improve mobility in 2050	• By 2050, meet UDOT's goal of LOS D in the weekday AM and PM peak periods on Wasatch Boulevard.

2.1.2.2.3 Level 1 Screening Methodology

Level of Service Goal. One of the goals in UDOT's 2018 *Strategic Direction* online report (UDOT 2018b) is to optimize mobility. To achieve this goal, proposed roadway projects are typically evaluated in terms of the road's modeled level of service. Level of service (LOS) is measure of the vehicle-carrying capacity and performance of a street, freeway, or intersection (Figure 2-6). When the capacity of a road is exceeded, the result is congestion, delay, and a poor level of service.

Figure 2-6. Levels of Service



Level of service is represented by a letter "grade" ranging from A for excellent conditions (free-flowing traffic and little delay) to F for failure conditions (extremely congested, stop-and-go traffic and excessive delay). UDOT has set a goal of maintaining roads in urban parts of the state at LOS D or better during the peak travel periods. Typically, in urban areas, LOS E and F are considered unacceptable operating conditions, and LOS A through D are considered acceptable operating conditions.

UDOT chose LOS D in the peak hour as the threshold for determining whether capacity improvements are needed on Wasatch Boulevard from Fort Union Boulevard to North Little Cottonwood Road. The peak-hour estimates are based on average annual daily traffic volumes developed through traffic counts and historical growth in traffic.

Travel Demand Modeling. Traffic conditions in the PM peak hour were analyzed using a VISSIM traffic analysis software. VISSIM includes functionality to account for the effects of delay at intersections and lane merge locations, which is common during peak conditions in the study area. When calibrating the VISSIM model, the Little Cottonwood Canyon EIS team used existing traffic data, signal timings, and geometric conditions data to ensure that the model reflected field observations. Because of the inherent randomness of stochastic micro-simulation tools, 10 VISSIM simulation runs were completed for each alternative to estimate the average delay.

As part of its regional planning, WFRC expects travel demand to increase as population increases. Salt Lake County is projected to have large increases in population, employment, and households by 2050 (Table 2-3). The increase in population would result in continued increased travel demand on all main roads in the transportation system and in Little Cottonwood Canyon. Utah County, to the south of Salt Lake County, is also projected to experience substantial growth in population, employment, and households, as shown in Table 2-3. This growth would likely contribute to increased travel demand on roads in Salt Lake County.

Table 2-3. Projected Regional Population, Employment, and Household Growth

Area	Population		Employment		Households	
	2017	2050 Projection (Percent Change from 2017)	2017	2050 Projection (Percent Change from 2017)	2017	2050 Projection (Percent Change from 2017)
Salt Lake County	1,127,117	1,531,282 (36%)	899,836	1,341,790 (49%)	394,665	606,036 (54%)
Utah County	623,706	1,297,515 (108%)	341,957	689,992 (102%)	177,092	419,678 (137%)

Source: Kem C. Gardner Policy Institute 2017

Based on historical traffic growth rates, UDOT applied a 1.1% linear annual growth rate for Wasatch Boulevard and a 0.5% linear annual growth rate for side streets and turning movements to develop the 2050 annual average daily traffic used in the travel demand modeling conducted for level 1 screening. This approach reflects the character of the land uses along Wasatch Boulevard, which are generally built out and have a low potential for more dense land use. Thus, the annual average daily traffic of 17,725 vehicles on Wasatch Boulevard in 2017 is expected by UDOT to grow to about 25,750 vehicles in 2050.

2.1.2.2.4 Level 1 Screening Results

Table 2-4 shows the level of service for S.R. 210 from Fort Union Boulevard to North Little Cottonwood Road for each of the Level 1 alternatives by roadway segment, and Table 2-5 shows the level of service by intersection. As shown in the tables, only the Imbalanced-lane and Five-lane Alternatives met the level of service criterion of LOS D for Wasatch Boulevard including the intersections.

The analysis also showed that some type of capacity improvement (additional travel lanes) is needed to meet the level of service criterion of LOS D. Additionally, only those two alternatives would substantially reduce travel time in both the AM and PM peak periods on the 2.2-mile segment of Wasatch Boulevard compared to the No-Action Alternative. With the No-Action Alternative, the Reversible Three-lane Alternative, and the Multiple Roundabouts Alternative, segments and intersections of Wasatch Boulevard would operate at an unacceptable level of service of LOS F.

Table 2-4. Wasatch Boulevard – Travel Demand Analysis by Direction and Segment in the PM Peak Hour in 2050

	Travel Time from Fort Union Blvd. to North Little Cottonwood Road (minutes)		Level of Service by Segment (Passing Criteria Are LOS A–D)			
Alternative	Northbound in AM/PM Peak Hour	Southbound in AM/PM Peak Hour	Fort Union Blvd. to Bengal Blvd.	Bengal Blvd. to 3500 East	3500 East to Kings Hill Drive	3500 East to North Little Cottonwood Road
No-Action Alternative	4:22 / 4:40	3:53 / 10:15	F	E	E	D
Imbalanced-lane Alternative	4:05 / 4:37	3:32 / 4:21	C	C	C	C
Reversible Three-lane Alternative	4:09 / 4:37	8:00 / 4:21	C	D	D	F
Five-lane Alternative	3:51 / 4:00	3:32 / 4:12	C	B	B	C
Multiple Roundabouts Alternative	6:25 / 4:43	4:32 / 10:21	F	D	C	C

Source: Fehr & Peers 2019
Green shading = Meets level of service goal of LOS D or better
Red shading = Does not meet level of service goal of LOS D

Table 2-5. Wasatch Boulevard – Travel Demand Analysis by Intersection in the AM and PM Peak Hours in 2050

Alternative	Level of Service by Intersection (Passing Criteria Are LOS A–D)									
	Fort Union Blvd./Wasatch Blvd.		Bengal Blvd./ Wasatch Blvd.		3500 East/ Wasatch Blvd.		Kings Hill Drive/ Wasatch Blvd.		North Little Cottonwood Road/Wasatch Blvd.	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
No-Action Alternative	B	F	C	F	B	E	B	F	D	C
Imbalanced-lane Alternative	C	D	C	C	A	B	C	D	C	D
Reversible Three-lane Alternative	C	D	C	C	D	B	D	D	F	D
Five-lane Alternative	C	C	B	B	A	B	B	C	C	D
Multiple Roundabouts Alternative	B	F	F	F	C	F	A	A	F	F

Source: Fehr & Peers 2019
Green shading = Meets level of service goal of LOS D or better
Red shading = Does not meet level of service goal of LOS D

Table 2-6 shows the results of the Level 1 screening analysis by alternative. As shown in the table, the **Imbalanced-lane Alternative** and the **Five-lane Alternative** met all of the Level 1 screening criteria and were therefore carried forward for Level 2 screening.

Table 2-6. Level 1 Screening Results – Wasatch Boulevard

Alternative	Level 1 Screening Criterion: Provides LOS D on Wasatch Blvd. and Intersections	Recommended for Further Analysis in Level 2 Screening
Imbalanced-lane Alternative	**Yes**	**Yes**
Reversible Three-lane Alternative	No	No
Five-lane Alternative	**Yes**	**Yes**
Multiple Roundabouts Alternative	No	No

2.1.2.3 Level 2 Screening

As a result of Level 1 screening, the Imbalanced-lane Alternative and the Five-lane Alternative were determined to meet the purpose of and need for the project and therefore were advanced into Level 2 screening.

A preliminary engineering design was developed for each of these two alternatives to determine their expected impacts according to each Level 2 criterion [Table 1-2, Level 2 Screening Criteria (Impacts), above]. Table 2-7 shows the results of Level 2 screening for the two alternatives. As shown in the table, the impacts would be similar between the Imbalanced-lane Alternative and the Five-lane Alternative.

Table 2-7. Level 2 Screening Results – Wasatch Boulevard

Impact Criterion	Unit	Alternative	
		Imbalanced-lane Alternative	Five-lane Alternative
Natural Environment[a]			
Wetlands[b]	Acres	0.65	0.65
Streams	Acres	0.03	0.03
Critical habitat	Acres	0.00	0.00
Floodplains	Acres	3.74	3.74
Impacts to wilderness areas	Acres	0.00	0.00
Built Environment[a]			
Consistency with USDA Forest Service Plan	Yes/no	Not applicable	Not applicable
Consistency with local plans	Yes/no	Yes	Yes
Recreation sites	Number	2	2
Community facilities	Number	0	0
Residential relocations	Number	1	1
Business relocations	Number	0	0
Section 4(f) properties	Number	9	9
Historic properties	Number	7	7
Cost of alternative (in 2019 dollars)	Dollars	$72 million	$76 million

[a] The acreage or number of impacts is based on a screening-level design. The actual impacts could decrease or increase based on more-detailed design conducted for the alternatives that pass Level 2 screening.

[b] The wetlands are associated with constructed stormwater-management facilities and might not be jurisdictional wetlands. The final determination of wetland jurisdiction will be made by the U.S. Army Corps of Engineers.

2.1.2.3.1 Level 2 Screening Results

The footprints and impact lines for the Imbalanced-lane Alternative and the Five-lane Alternative are similar, are mostly within the UDOT existing right-of-way, and, as shown above in Table 2-7above, would not have substantial differences in impacts to any of the listed resources. Because the two alternatives would have similar levels of impacts and costs, the Level 2 screening analysis did not give UDOT a reason to eliminate either alternative. In addition, based on the aquatic resources delineation (UDOT 2020) and UDOT's review of Section 4(f) and Section 6(f) resources, UDOT determined that the impacts to these resources would be the same for both alternatives, and these regulations did not provide a reason for eliminating either alternative. For these reasons, UDOT did not eliminate either the Imbalanced-lane Alternative or the Five-lane Alternative during Level 2 screening and advanced both alternatives for detailed evaluation in the EIS.

2.1.2.3.2 Alternatives Carried Forward for Further Evaluation in the EIS

The following Wasatch Boulevard alternatives were carried forward for further evaluation in the EIS and will be considered as part of the S.R. 210 mobility analysis described in Section 2.2:

- **Imbalanced-lane Alternative**
- **Five-lane Alternative**

2.2 Improve Mobility on S.R. 210 from Fort Union Boulevard to Alta

As stated in the introduction to Section 2.0, Alternatives Development and Screening Process – Improve Mobility in 2050, improving mobility on S.R. 210 in 2050 involves meeting two different needs: improving mobility on Wasatch Boulevard in particular for commuter traffic and improving mobility on S.R. 210 overall for winter ski traffic. This section looks at the latter need—improving mobility on S.R. 210 from Fort Union Boulevard to the town of Alta. The mobility benefits provided by the Wasatch Boulevard alternatives that passed Level 1 and Level 2 screening (see Section 2.1.2.3.2, Alternatives Carried Forward for Further Evaluation in the EIS) are considered part of the baseline conditions in this evaluation of improving mobility on S.R. 210 overall. Both the Imbalanced-lane and Five-lane Alternatives would provide a similar benefit (in terms of mobility improvement) for the S.R. 210 alternatives; therefore, the Imbalanced-lane Alternative was used for the analysis.

2.2.1 Range of Alternatives

The preliminary alternatives for improving mobility on S.R. 210 overall were developed based on previous planning studies and through the EIS agency and public scoping process. These alternatives were developed with input from existing land use and transportation plans, the public, local municipal governments, and resource agencies. The input was collected during the EIS public scoping periods (initial scoping period March 9 to May 4, 2018, and revised scoping period March 3 to June 14, 2019), at agency scoping meetings (April 9, 2018, and April 3, 2019), and in stakeholder interviews. In addition, a report describing the screening process that would be used (*Alternatives Development and Screening Methodology Report*) was placed on the project website (on November 4, 2019) and sent to cooperating and participating agencies for a 40-day public comment period (November 4 through December 13, 2019).

Table 2-8 lists the preliminary alternatives for improving mobility on S.R. 210 overall that emerged from the public involvement processes to be considered in the screening process for the EIS.

Table 2-8. Preliminary Alternatives – S.R. 210

Alternative	Description
Roadway Alternatives	
Double Stacking Alternative (Figure 2-7)	This alternative consists of closing the downhill lane on S.R. 210 in Little Cottonwood Canyon in the morning and the uphill lane in the afternoon to provide one-way vehicle flow during peak periods to reduce congestion.
S.R. 209 Roundabout Alternative (Figure 2-8)	This alternative consists of constructing a roundabout at the intersection of S.R. 209 and S.R. 210 to improve mobility in the canyon.
Reversible-lane Alternative with Moveable Barrier[a] (Figure 2-9)	This alternative consists of adding an additional travel lane on S.R. 210 (three travel lanes total) from the Wasatch Boulevard/North Little Cottonwood Road intersection to the ski resorts. This alternative would include a reversible middle lane to accommodate morning and evening peak traffic. A moveable barrier would direct traffic into the reversible lane. The reversible lane could be used at various times of day as an all-vehicle lane, a high-occupancy vehicle (HOV)/bus lane, and a bus-only lane.
Reversible-lane Alternative with Overhead Lane-control Signs (Figure 2-10)	This alternative consists of adding an additional travel lane on S.R. 210 (three travel lanes total) from the Wasatch Boulevard/North Little Cottonwood Road intersection to the ski resorts. This alternative would include a reversible middle lane to accommodate morning and evening peak traffic. Overhead signs would direct traffic into the reversible lane. The reversible lane could be used at various times of day as an all-vehicle lane, an HOV/bus lane, and a bus-only lane.
Peak-period Shoulder Lane Alternative – two lanes plus peak-hour shoulders[a] (Figure 2-11)	This alternative consists of one uphill lane and one downhill lane in Little Cottonwood Canyon with roadway shoulders large enough to accommodate vehicles. The shoulder lane could be used at various times of day by buses. The total width of pavement would be about the same as with the Reversible-lane Alternative with Moveable Barrier or the Reversible-lane Alternative with Overhead Lane-control Signs. The shoulders would be open to buses during peak travel times or when there is heavy congestion on S.R. 210. When not in use by buses, the shoulders would be open for emergency use and cyclists only. No parking would be allowed on the shoulders.
Transit Alternatives	
Bus-only Alternative – only buses allowed in Little Cottonwood Canyon	This alternative would increase bus service to meet the peak-hour person demand without increasing roadway capacity. The bus service assumes nonstop service from Fort Union Boulevard/Wasatch Boulevard and 9400 South/Highland Drive to the Snowbird and Alta ski resorts. This alternative assumes that buses would provide the primary vehicle transportation in Little Cottonwood Canyon, though nonresident and resort employee vehicles would be allowed. Similar to existing bus service, the bus routes would be on S.R. 210 and S.R. 209. For more information about the analysis of park-and-ride lot locations, see Section 2.2.2.2.5, Mobility Hub Alternatives. This alternative would operate from mobility hub locations that could include feeder bus routes to the mobility hub locations from areas across the Salt Lake Valley.
Enhanced Bus Service Alternative– buses and vehicles allowed in Little Cottonwood Canyon	This alternative would increase bus service to reduce vehicle use in the canyon. Vehicles would be allowed on S.R. 210 in Little Cottonwood Canyon, but transit would be incentivized through travel management strategies such as a toll or a prohibition on single-occupant vehicles. Two options were developed: one with 7.5-minute bus headways and the other with 5-minute bus headways. Similar to existing bus service, the bus routes would be on S.R. 210 and S.R. 209. For more information about the analysis of park-and-ride lot locations, see Section 2.2.2.2.5, Mobility Hub Alternatives. This alternative would operate from mobility hub locations that could include feeder bus routes to the mobility hub locations from areas across the Salt Lake Valley.

(*continued on next page*)

Table 2-8. Preliminary Alternatives – S.R. 210

Alternative	Description
Regional Shuttle Bus System Alternative	This alternative is similar to the existing UTA bus system but would use neighborhood parking areas dispersed throughout the Salt Lake Valley as pickup points for users. The system could operate with smaller vans or shuttles that would provide direct service from the pickup location to the resort. Given that there are two resorts in Little Cottonwood Canyon, such a system would require a substantial bus fleet to meet the needs of skiers across the valley.
Aerial Transit from the Salt Lake Valley Alternative	This alternative would provide aerial transit service from the Salt Lake Valley to the ski resorts in Little Cottonwood Canyon. It would use travel management strategies such as a toll or a prohibition on single-occupant vehicles to incentivize users to take the aerial transit system instead of personal vehicles. Several concepts were evaluated, including large cabin systems and new technologies such as SkyTran (magnetic levitation and propulsion system) and a detachable gondola cabin transported on a truck from park-and-ride lots that would connect into the cable system at the base of Little Cottonwood Canyon. There would be no bus service to the ski resorts with this alternative. The aerial transit would have enough person-capacity that additional roadway travel lanes would not be needed.
Rail Transit Alternative	This alternative would provide rail transit service from the Salt Lake Valley and use travel management strategies such as a toll or a prohibition on single-occupant vehicles incentivize users to take the rail transit system instead of personal vehicles. There would be no bus service to the ski resorts with this alternative. The rail service would have enough person-capacity that additional roadway travel lanes would not be needed. The rail alternative includes options to connect to UTA's existing light-rail system (TRAX).
Aerial Transit or Express Bus from Park City Alternative	This alternative would provide aerial transit or express bus service from Park City to the ski resorts in Little Cottonwood Canyon. This alternative assumes that vehicle traffic would be reduced enough that no additional roadway capacity would be needed.

[a] For more information about this alternative, see Appendix C, Draft Evaluation of Managed-lane Concepts.

2.2.2 Screening of Alternatives

2.2.2.1 Preliminary Alternatives Evaluation – Roadway Alternatives

The screening process included a preliminary review of each preliminary roadway alternative in Table 2-8 above to determine whether it was reasonable to be carried forward into Level 1 screening.

2.2.2.1.1 Double Stacking Alternative

This alternative would make S.R. 210 from the S.R. 209 intersection to Snowbird Ski Resort one way during the morning and afternoon peak periods on busy ski days. During the morning from 8 AM to 10 AM, the existing two lanes would both be uphill (eastbound) lanes, and in the afternoon from 3 PM to 5 PM, the existing two lanes would both be downhill (westbound) lanes. In the morning, all downhill traffic would be held at a gate on S.R. 210 near Snowbird Entry 1, and in the afternoon, all uphill traffic would be held at a gate on S.R. 210 at S.R. 209 west of the entrance to Little Cottonwood Canyon.

UDOT's review of traffic numbers showed that on a typical busy ski day (Sunday, January 13, 2019, was used for the analysis), about 2,081 vehicles went up the canyon in the morning between 8 AM and 10 AM and 2,309 vehicles went down the canyon between 3 PM and 5 PM. On that same day, 220 vehicles went down the canyon from 8 AM to 10 AM and 373 vehicles went up the canyon from 3 PM to 5 PM. It would not be prudent to prevent this many vehicles from traveling in the canyon during these timeframes. In the afternoon, many uphill vehicles are carrying late-afternoon skiers, residents, and workers needing to get into the canyon. In the morning, residents heading out of the canyon to appointments or hotel guests heading to the airport would be delayed.

In the morning, the line of backed-up vehicles on S.R. 210 waiting for the downhill lane to open would be about 0.6 mile long, and in the afternoon there would be about 1 mile of backed-up vehicles, split between S.R. 210 and S.R. 209. These vehicle backup lengths are based on an average vehicle length of 14 feet 7 inches (MechanicBase 2019). One of the project purposes is to minimize traffic backups in the neighborhoods along S.R. 210 and S.R. 209. Since this alternative would allow vehicles to back up into these neighborhoods, it would not meet the project purpose.

Finally, this alternative could reduce emergency vehicle response times. For example, currently, an emergency vehicle traveling up canyon in the morning can bypass heavy uphill congestion by periodically using the downhill lane because the lane is not congested. If both travel lanes were used for uphill traffic, this would limit other vehicles' ability to move out of the way of the emergency vehicle because of the narrow shoulders on S.R. 210. Figure 2-7 shows how double stacking could impede travel by emergency vehicles.

Because it would delay vehicle travel in the canyon, create long vehicle backup lengths, and potentially reduce emergency vehicle response times, the Double Stacking Alternative was determined to be not reasonable and was not carried forward into Level 1 screening.

Figure 2-7. Double Stacking Alternative

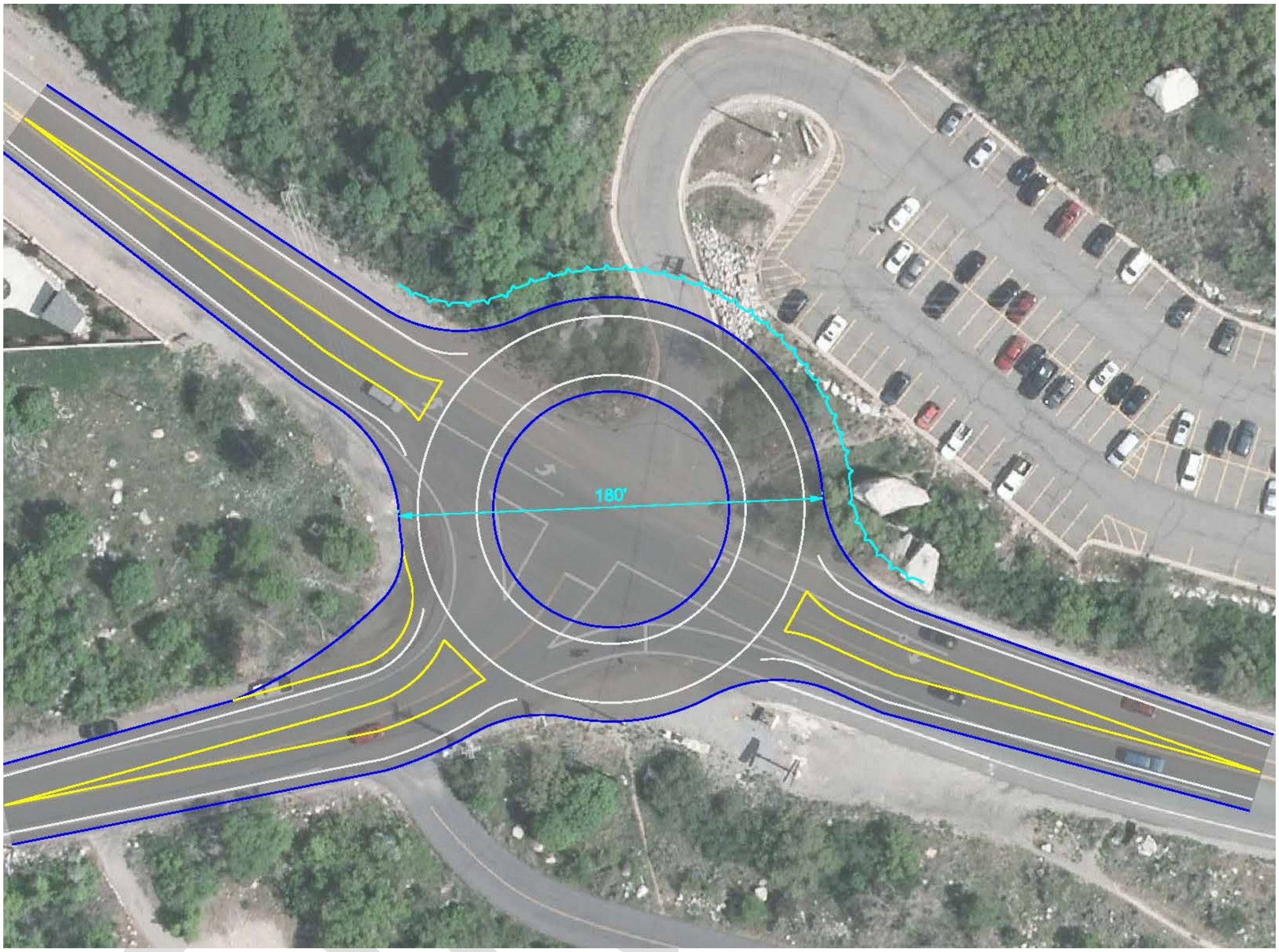
2.2.2.1.2 S.R. 209 Roundabout Alternative

This alternative would construct a roundabout at the intersection of S.R. 210 and S.R. 209 to improve the merging of traffic on these two arterial streets and thereby improve overall traffic flow. The roundabout would function similarly to the existing intersection, which has S.R. 209 merging into S.R. 210 with a merge lane. However, given the amount of traffic that heads up Little Cottonwood Canyon on S.R. 210 in the morning, it would be difficult for traffic on S.R. 209 to enter the roundabout, thereby creating vehicle backups on S.R. 209. Other potential concerns with a roundabout at this intersection based on general roundabout evaluations are as follows (NCHRP 2010):

- Vehicle slide-offs or snow that delays traffic in the canyon could routinely back up traffic into the roundabout. The successful operation of a roundabout depends on unimpeded vehicle flow on the circulatory roadway. If traffic on the circulatory roadway comes to a halt, intersection gridlock can occur.
- If S.R. 210 is operating at or near capacity, the delay could deflect all traffic entering the intersection from S.R. 209 and could introduce excessive delay.

A single-lane roundabout was designed using UDOT standards, which include accommodations for semitrailers and buses. Semitrailers frequently use S.R. 210 to deliver goods to the ski resorts. Therefore, the outer edge of the roundabout diameter would need to be about 180 feet, as shown on Figure 2-8. Overall, because of the heavy traffic during peak ski days on S.R. 210, the potential for heavy congestion at the roundabout, and the resulting vehicle backup into residential neighborhoods along S.R. 209 and S.R. 210, the S.R. 209 Roundabout Alternative was not carried forward into Level 1 screening.

Figure 2-8. S.R. 209 Roundabout Alternative



2.2.2.1.3 Managed-lane Concepts

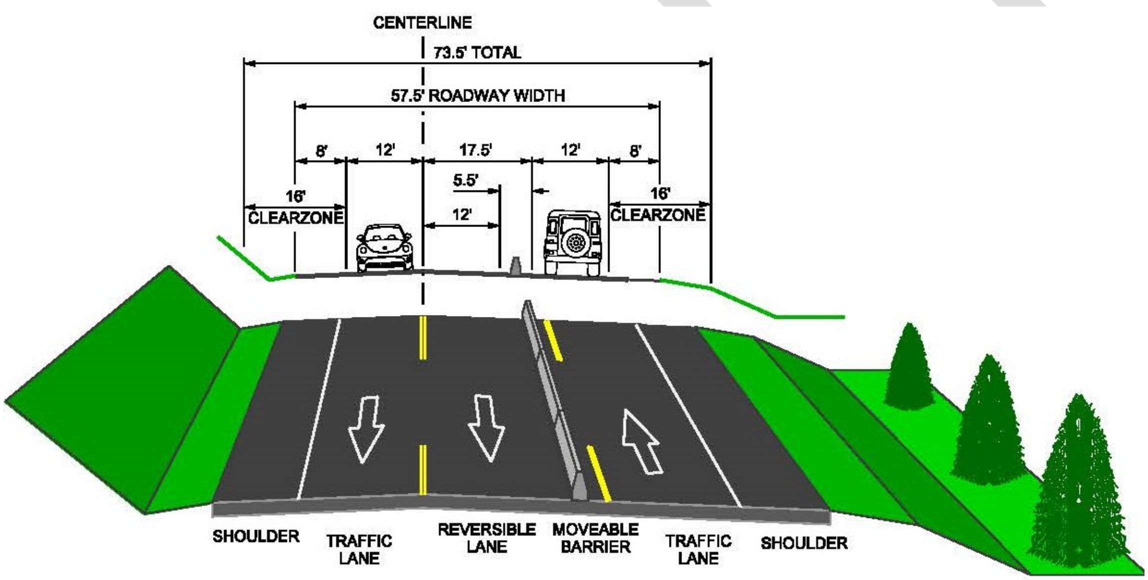
UDOT evaluated two managed-lane concepts—reversible lanes and peak-period shoulder lanes—and eliminated reversible lanes from detailed consideration in Level 1 screening. For more information, see Appendix C, Draft Evaluation of Managed-lane Concepts.

Reversible-lane Alternatives

For reversible lanes, UDOT looked at two alternatives: a moveable barrier and overhead lane-control signs.

Reversible-lane Alternative with Moveable Barrier. Reversible lanes can be implemented using moveable barrier, in which a median barrier is moved from one side of the reversible lane to the other to change the direction of traffic flow (Figure 2-9). The moveable barrier is made of short concrete segments interconnected by heavy-duty steel hinges to form a continuous wall. To move the barrier, a transfer machine lifts up each section of barrier, moves it laterally, and sets it down on the other side of the lane.

Figure 2-9. Reversible-lane Alternative with Moveable Barrier

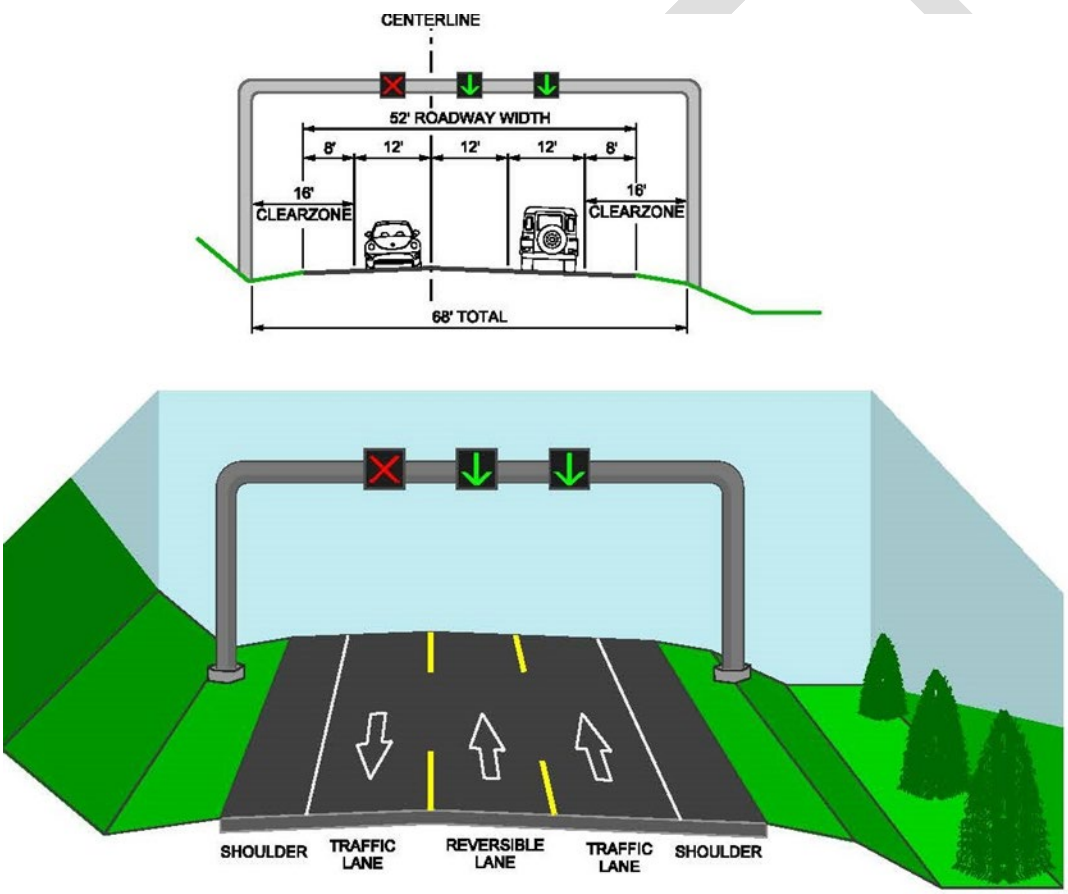


Reversible lanes with a movable barrier would require UDOT to move about 7 miles of barrier twice a day. Sometimes the barrier would need to be moved during heavy snow conditions, which would require UDOT to remove snow during the transfer process and would require a mechanism to keep the transfer machine from icing. Additionally, the barrier could be damaged if an avalanche flow hits the barrier, potentially requiring the road to be closed while the barrier is repaired.

There are other operational and safety issues as well. The barrier would limit vehicles' ability to maneuver around an accident, and a vehicle breaking down or sliding off the road could back up traffic with the barrier in place. If an accident or slide-off occurred in an area with a barrier, emergency vehicle access could also be obstructed. The barrier also has the potential to impede wildlife movement across the road. Finally, the reversible-lane transition would be complicated at intersections (S.R. 210 with S.R. 209, Snowbird Entry 1, Snowbird Entry 2, and the Bypass Road). S.R. 210 would need to be four lanes wide to accommodate turning movements, and the lane configuration might be confusing to drivers who are not familiar with the area or with moveable barriers. For these reasons, the Reversible-lane Alternative with Moveable Barrier was not carried forward into Level 1 screening.

Reversible-lane Alternative with Overhead Lane-control Signs. The other reversible-lane alternative would use overhead signs to change the direction of the traffic flow (Figure 2-10). The lane-control signs would be placed over each lane on an overhead frame (gantry), and the text on the signs could be changeable or static. To meet safety standards, the signs would be placed such that drivers would know which lanes are allowed for use at any given time. The maximum allowable spacing is 1/3 mile (UDOT 2011), with additional signs required where sight distance is limited by sharp horizontal curves. About 41 overhead signs spaced at 1/3 mile would be necessary between the intersection with S.R. 209 and the Bypass Road. This number would increase to 62 for drivers to see two overhead signs at a time.

Figure 2-10. Reversible-lane Alternative with Overhead Lane-control Signs



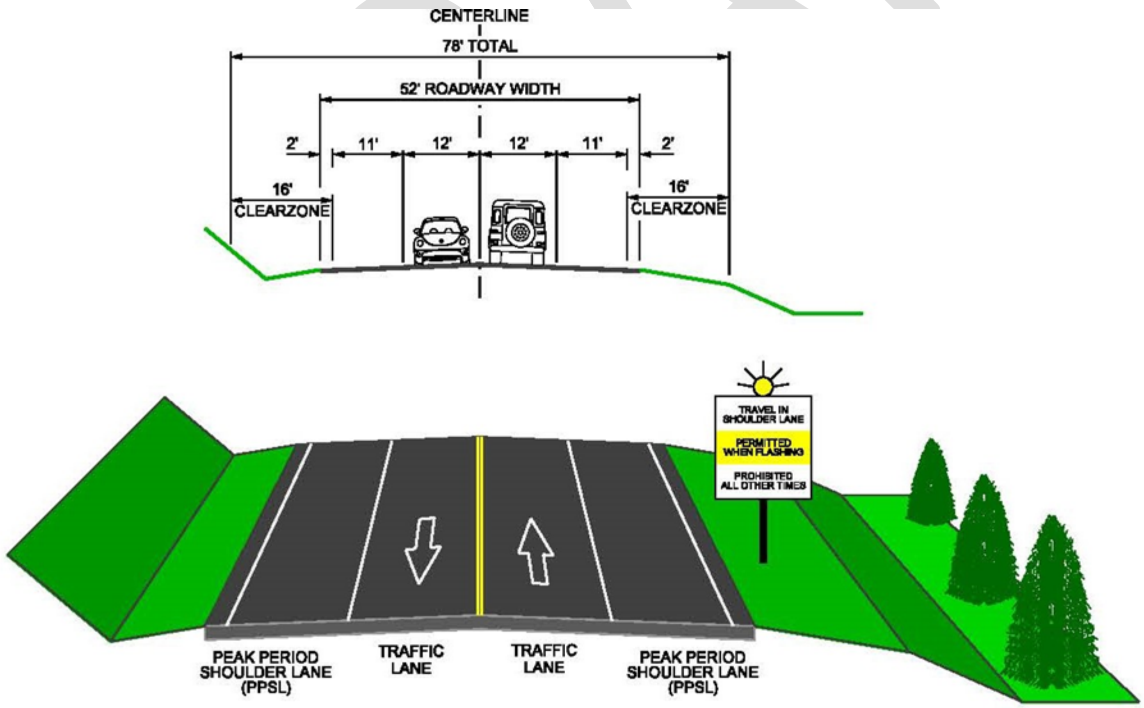
For S.R. 210, lane-control signals would indicate two lanes open to eastbound (uphill) traffic and one lane open to westbound (downhill) traffic in the morning on peak traffic days. After the peak morning traffic passed, the signal for the center lane would shift to indicate two lanes open to westbound traffic and one lane open to eastbound traffic. The visual impacts of overhead signs would be in conflict with the strategies in the *Cottonwood Canyons Scenic Byways Corridor Management Plan* for protecting scenic vistas. The reversible-lane transition is complicated at intersections (S.R. 210 with S.R. 209, Snowbird Entry 1, Snowbird Entry 2, and the Bypass Road). S.R. 210 would need to be four lanes wide to accommodate turning movements and multiple overhead lane-control signs, and the lane configuration might be confusing to drivers who are not familiar with the area. Because of the potential visual impacts and difficult vehicle transitions on S.R. 210, the Reversible-lane Alternative with Overhead Lane-control Signs was not carried forward for further consideration.

Peak-period Shoulder Lane Alternative

In addition to reversible lanes, UDOT looked at a second managed-lane concept: peak-period shoulder lanes (PPSLs). PPSLs have been implemented in various locations across the country with a constrained right-of-way to provide additional capacity and improve mobility during peak congestion without adding another lane. With PPSLs, the roadway shoulders must be wide enough and have an appropriate pavement section to handle traffic.

A clear signing plan is needed to let drivers know when the PPSLs are open and where they can enter or exit a PPSL if access is controlled. Lane-use signals are electronic message signs located next to the PPSL indicating whether it is open or closed. The recommended spacing ranges from 1/3 to 2/3 mile (CDOT 2014). In Little Cottonwood Canyon, about 27 signs in each direction (about 54 signs total) would be required on S.R. 210 between the intersection with Wasatch Boulevard and the Bypass Road assuming 1/3 mile spacing (Figure 2-11).

Figure 2-11. Peak-period Shoulder Lane Alternative



For Little Cottonwood Canyon, the PPSLs would be in use only during peak traffic periods such as holidays and weekends during the winter. During the rest of the year, the PPSLs would be closed to vehicles and open as bicycle lanes. The PPSLs would be open during the summer when bicycle use is the highest (although a PPSL could be in use during an emergency). No parking would be allowed in the PPSLs.

Results of Evaluation of Managed-lane Concepts

After eliminating the Reversible-lane Alternative with Overhead Lane-control Signs, UDOT compared the Peak-period Shoulder Lane Alternative and the Reversible-lane Alternative with Moveable Barrier. The PPSL alternative would be easier to operate because there would be no vehicle transition lanes as required by reversible lanes, and no equipment would be required to move a barrier. In addition, the PPSLs would not create a barrier to wildlife or impede vehicles that need to use the opposing travel lane to access an emergency.

Because the **Peak-period Shoulder Lane Alternative** would have a similar footprint as the Reversible-lane Alternative with Moveable Barrier with less visual impacts, less wildlife impacts, and easier operation, it was carried forward for detailed consideration in Level 1 screening, and the second reversible-lane alternative was eliminated. Table 2-9 compares the preliminary lane-configuration alternatives and shows that two alternatives would be similar.

Table 2-9. Impact Comparison for the Reversible-lane Alternative with Moveable Barrier and the Peak-period Shoulder Lane Alternative

Impact Category	Unit	Reversible-lane Alternative with Moveable Barrier	Peak-period Shoulder Lane Alternative
Natural Environment[a]			
Wetlands	Acres	0.00	0.00
Streams	Acres	0.33	0.34
Critical habitat	Acres	0.00	0.00
Floodplains	Acres	1.26	1.29
Impacts to wilderness areas	Acres	0.00	0.00
Built Environment[a]			
Consistency with USDA Forest Service Plan	Yes/no	Yes	Yes
Consistency with local plans	Yes/no	Not applicable	Not applicable
Recreation sites	Number	4	4
Community facilities	Number	0	0
Residential relocations	Number	0	0
Business relocations	Number	0	0
Section 4(f) properties	Number	9	9
Historic properties	Number	5	5
Cost of alternative in 2019 dollars	Dollars	$210 million	$211 million

[a] The acreage or number of impacts is based on a screening-level design. The actual impacts could decrease or increase based on more-detailed design conducted for the alternatives that pass Level 2 screening.

2.2.2.2 Preliminary Alternatives Evaluation – Transit Alternatives

In addition to evaluating roadway alternatives for improving mobility on S.R. 210 from Fort Union Boulevard to Alta, UDOT also evaluated the following types of transit alternatives:

- Bus
- Aerial transit
- Rail transit

2.2.2.2.1 Bus Alternatives

UDOT evaluated the following bus alternatives as preliminary alternatives for improving mobility on S.R. 210 from Fort Union Boulevard to Alta:

- Bus-only Alternative
- Enhanced Bus Service Alternative
- Regional Shuttle Bus System Alternative

Bus-only Alternative

The Bus-only Alternative would increase bus service to meet the peak-hour person-demand on S.R. 210 of about 3,200 persons without increasing roadway capacity. The bus-only service assumes nonstop service from the intersection of Fort Union Boulevard/Wasatch Boulevard and the intersection of 9400 South/ Highland Drive to the ski resorts with all other vehicles except employee, service, and residents' vehicles prohibited from using S.R. 210 in Little Cottonwood Canyon. For the Bus-only Alternative to meet the demand, the bus headways would need to be about 1.6 minutes from mobility hubs at both Fort Union Boulevard/Wasatch Boulevard (gravel pit area) and 9400 South/Highland Drive. This would equal about 75 buses per hour using UTA's current buses, which have a standing capacity of about 42 people.

UTA's current ski buses have special power, transmission, and automatic chain deployment systems designed to operate in a winter canyon environment. The engine and transmission requirements are necessary to handle the steep grades in Little Cottonwood Canyon (up to 11%), and the automatic chains are for the frequent snowfalls. Larger buses (articulated buses with a capacity of 80 persons) were considered but eliminated because of their poor operating conditions in a winter environment (for more information about articulated buses, see Appendix D, Draft Enhanced Bus Concepts).

UTA also stated that headways less than 5 minutes would be infeasible because it would require more than 5 minutes to load and unload a bus, particularly if riders were stowing and retrieving ski gear, and because a substantial number of buses would be needed to meet this short headway (UTA 2019). In addition, a bus-only alternative would require large parking structures of more than 5,000 parking stalls.

For these reasons, the Bus-only Alternative was not carried forward into Level 1 screening.

Enhanced Bus Service Alternative

What is enhanced bus service?

Enhanced bus service is typically bus service that has intersection priority and/or travels in the roadway shoulder.

Bus Service. Currently, UTA operates a winter ski bus service on fixed routes that makes intermediate stops before arriving at the ski resorts in Little Cottonwood Canyon. The Enhanced Bus Service Alternative would provide point-to-point bus service from mobility hubs to Snowbird and to Alta with no intermediate stops along the way (for more information about enhanced bus service, see Appendix D, Draft Enhanced Bus Concepts).

The purpose of point-to-point bus service with no intermediate stops is to improve the travel time and efficiency of the service. In addition, the loading and unloading time in the parking lot of the first resort in the canyon can add up to 15 minutes to the travel time to get to the second resort, thereby making bus service to the second resort less desirable. On occasion at the end of the day, buses sometimes fill up with passengers at the first resort and bypass the second resort, causing users at the second resort to wait for a later bus.

The Enhanced Bus Service Alternative looked at both 7.5-minute and 5-minute arrivals at the ski resorts. Less-frequent arrivals at the ski resorts would be similar to the existing service and would not provide enough bus capacity to meet the project purpose of substantially improving mobility. Arrivals of less than 5 minutes were considered infeasible because there would not be enough time for all riders to exit or board the bus and retrieve or stow their gear. The enhanced ski bus service would operate 7 days per week between 7 AM and 7 PM with peak service in the morning (7 AM to 10 AM) and afternoon (2 PM to 5 PM).

Table 2-10 summarizes the enhanced ski bus service. As shown, with Options A1 and A2 during the peak periods, 16 buses would travel in Little Cottonwood Canyon per hour, or a bus going up or down the canyon every 3 minutes 45 seconds. With Options B1 and B2 during the peak periods, 24 buses would travel in Little Cottonwood Canyon per hour, or a bus going up or down the canyon every 2 minutes 30 seconds. With Options A1 and B1, the buses would operate in mixed-flow traffic with other vehicles (the current roadway configuration). With Options A2 and B2, a peak-period shoulder bus lane would allow buses to have their own dedicated lane separate from personal vehicles.

Bus Routes. For Little Cottonwood Canyon, bus service would be provided from the existing park-and-ride lot at 9400 South and Highland Drive and from another proposed park-and-ride lot at the gravel pit located on the east side of Wasatch Boulevard between 6200 South and Fort Union Boulevard. For a summary of the results of an analysis of a proposed mobility hub, see Section 2.2.2.2.5, Mobility Hub Alternatives. The enhanced ski bus service would run between each of the proposed park-and-ride lots directly to one transit stop at either Snowbird or Alta.

Table 2-10. Details of Enhanced Bus Service Alternative and Options

Option	Description	Mobility Hub/Route	Days	Number of Buses per Hour	
				Peak/ Off-peak	Total Peak/ Off-peak
A1	Buses operating in mixed-flow traffic. (**No capacity added to S.R. 210 from North Little Cottonwood Road to Alta.**) Total capacity of 672 riders in the peak hour.	Gravel pit/ Wasatch Blvd.	Mon–Sun	8 / 4	16 / 8
		9400 South	Mon–Sun	8 / 4	
A2	Buses operating in a bus lane. (**Additional capacity added to S.R. 210 from North Little Cottonwood Road to Alta.**) Total capacity of 672 riders in the peak hour.	Gravel pit/ Wasatch Blvd.	Mon–Sun	8 / 4	16 / 8
		9400 South	Mon–Sun	8 / 4	
B1	Buses operating in mixed-flow traffic. (**No capacity added to S.R. 210 from North Little Cottonwood Road to Alta.**) Total capacity of 1,008 riders in the peak hour.	Gravel pit/ Wasatch Blvd.	Mon–Sun	12 / 6	24 / 12
		9400 South	Mon–Sun	12 / 6	
B2	Buses operating in a bus lane. (**Additional capacity added to S.R. 210 from North Little Cottonwood Road to Alta.**) Total capacity of 1,008 riders in the peak hour.	Gravel pit/ Wasatch Blvd.	Mon–Sun	12 / 6	24 / 12
		9400 South	Mon–Sun	12 / 6	

Bus Size. UTA's current ski buses have special power, transmission, and automatic chain deployment systems designed to operate in a winter canyon environment. The engine and transmission requirements are necessary to handle the steep grades in Little Cottonwood Canyon (up to 11%), and the automatic chains are for the frequent snowfalls. The current buses provide seating for 23 riders and standing room for an additional 19 riders, for a total capacity of 42 riders. For the analysis of enhanced bus service concepts, the total bus capacity of 42 riders was used. The current 35-foot buses are also more maneuverable in parking lots with limited space, such as the lots at the ski resorts. Larger buses such as articulated buses have a capacity of about 80 riders. However, studies have found that articulated buses are prone to jackknifing when operating in snow and ice on steep grades (for more information about articulated buses, see Appendix D, Draft Enhanced Bus Concepts). Even with tire chains, articulated buses might not be able to operate on steep grades in snow and ice as easily as nonarticulated buses can. Therefore, articulated buses were eliminated from further consideration.

Bus Technology. UTA's current ski buses are diesel-powered. For this alternatives analysis, the project team considered diesel buses, electric buses, and hybrid buses. Although electric bus technology is rapidly advancing, electric bus batteries currently have both limited range and performance issues on steep grades. Further, when electric heaters are used in cold weather, the heaters drain the batteries, limiting the range the bus can travel before needing to charge. Currently, most transit authorities heat any electric buses in their fleet using a diesel fuel heating system. Because electric bus technology is still evolving, electric buses were eliminated from consideration. This evaluation of enhanced ski bus service assumes the use of diesel buses with a total capacity of 42 riders, the same as UTA's current ski buses. If electric bus technology improves in the future, the enhanced ski bus service could use this technology. Hybrid buses could be considered as a bus option if they can be designed to meet the requirements of the steep mountain grades, maneuverability at the resorts, and chains.

Regional Shuttle Bus System Alternative

The Regional Shuttle Bus System Alternative is similar to UTA's existing bus system with park-and-ride lots, but it would use smaller parking areas dispersed throughout the Salt Lake Valley as pickup points for riders. A rider would arrive at a lot near their home at a designated time to catch a shuttle to their specific resort. Buses would likely be smaller shuttles, since the demand at each pickup location would be less than at a typical UTA park-and-ride lot. Given that there are two resorts in Little Cottonwood Canyon, such a system would require a substantial bus fleet to meet the needs of skiers across the valley.

One comment that UDOT received suggested regional transit (bus or rail) to feed a mobility hub at the base of Big Cottonwood Canyon. The commenter suggested that buses or rail from Salt Lake City could connect to the mobility hub, thereby reducing the need for recreationists to drive their vehicles to the mobility hub. The commenter suggested bus or rail down Foothill Drive and Wasatch Boulevard or rail connecting to the existing light-rail system.

> **What is a mobility hub?**
>
> A mobility hub is a location where users can transfer from their personal vehicle to a bus.

UDOT is evaluating a mobility hub (or hubs) concept for the S.R. 210 transit alternatives that would allow bus routes or other forms of transit to be located near the bases of the Cottonwood Canyons. Transit service from a mobility hub near Little Cottonwood Canyon to the ski resorts would reduce the distance of travel compared to a regional bus route starting near Salt Lake City, for example. Such transit service would therefore reduce the travel time, which would result in a more reliable service. The mobility hub would also reduce the capital and operating costs of bus service because fewer buses would be needed because the mobility hub would be located closer to Little Cottonwood Canyon which would result in shorter bus travel times. The mobility hub(s) concept is an important part of any transit alternative because it provides greater reliability in service and enough parking to accommodate the high number of potential users. Therefore, the EIS will evaluate the mobility hub(s) concept.

A regional shuttle bus system or feeder service to the mobility hub(s) from locations outside the EIS study area, such as downtown Salt Lake City, can be addressed without an EIS process by UTA adding or changing its current service routes. Also, private vendors could also develop feeder services to the mobility hub(s) locations. Without the mobility hub(s), the regional shuttle bus service would not function. For analysis in the EIS, a regional shuttle bus system was assumed to provide the same service levels as the Enhanced Bus Service Alternative, so it is not evaluated in the EIS as a separate alternative.

If an alternative with a mobility hub is selected in the EIS, UDOT would phase construction by starting with a smaller parking garage and expanding it as warranted based on demand. This phased expansion would allow UTA and private vendors to evaluate how the mobility hub(s) concept is functioning to determine the viability and type of feeder service. Considering feeder services prior to the operation of the mobility hub(s) would be speculative because it would be difficult for UTA to determine the demand and best location for feeder service without understanding the actual demand and function of the mobility hub(s) concept first.

Instead of a regional bus system, UDOT considered a rail alternative with a connection to UTA's TRAX light-rail system as part of the rail alternative. Connecting to the existing light-rail system would provide a transit connection throughout the Salt Lake Valley. The alternative being evaluated (see Section 2.2.2.2.3, Rail Transit Alternative) would connect to UTA's existing light-rail line at the Sandy Expo TRAX Station or the Midvale Fort Union TRAX Station and proceed to the ski resorts in Little Cottonwood Canyon. Some commenters suggested running the light rail down Foothill Drive and Wasatch Boulevard. UDOT selected connecting to the Sandy Expo or Midvale Fort Union stations because they would have shorter travel distances than the Foothill Drive/Wasatch Boulevard option (at least 5 miles shorter), achieve the same goal for connecting Salt Lake City light rail to the ski resorts, and have the shortest distance of new rail and thus would cost less and have fewer impacts.

Bus Alternative Selected for Level 1 Screening

Based on the above analysis, UDOT carried the **Enhanced Bus Service Alternative** forward for Level 1 screening and eliminated the Bus-only Alternative and the Regional Shuttle Bus System Alternative. UDOT selected the Enhanced Bus Service Alternative because it would provide frequent and convenient service and could be implemented. As stated in Section 2.2.2.2.1, Bus Alternatives, for the Bus-only Alternative to meet the person-demand, it would need to operate at headways of less than 5 minutes. UTA considers such short headways infeasible because riders could not board and exit the bus (and stow and retrieve their ski gear) within 5 minutes. The Regional Bus Shuttle System Alternative is not evaluated further because, once the mobility hub concept is implemented, a regional bus shuttle system could be implemented independent of the S.R. 210 Project.

2.2.2.2.2 Aerial Transit from the Salt Lake Valley Alternative

Aerial Transit Systems Evaluated

UDOT initially evaluated four types of aerial transit systems as preliminary alternatives for improving mobility on S.R. 210 from Fort Union Boulevard to Alta: aerial tramways, funifors, funitels, and gondolas. As discussed in Appendix E, Draft Aerial Transit Initial Feasibility Study, of the four systems, UDOT selected gondolas as the best alternative for Little Cottonwood Canyon because of their faster travel time and higher person-capacity.

UDOT evaluated three types of gondola systems: mono-cable (1S), bi-cable (2S), and tri-cable (3S). Table 2-11 compares these gondola systems.

Why are gondola types abbreviated 1S, 2S, and 3S?

These abbreviations come from the German word *Seil*, which means "cable," and refer to the number of cables used to propel and support the gondola cabins.

Table 2-11. Comparison of Gondola Systems

Parameter	Mono-cable (1S)[a]	Bi-cable (2S)	Tri-cable (3S)[a]
Capacity per cabin (number of people, maximum)	8 to 15	8 to 17	20 to 35
Travel speed (mph)	9 to 11	15 to 16	16 to 18
Operational wind speeds (mph)	37	43	68
Maximum capacity (approximate number of people per hour per direction)[b]	3,000	4,000	5,000
Approximate maximum tower spacing (feet)	2,300	3,000	9,000
Travel Times[c]			
Entrance of canyon to Snowbird (minutes to travel 6.5 miles)	35	26	23
Snowbird to Alta (minutes to travel 1.5 miles)	8	6	4
Total (minutes to travel 8 miles)	**44**	**32**	**27**

[a] Source: Fehr & Peers 2012

[b] The maximum hourly capacities are based on literature reviews and do not necessarily represent the gondola capacity in the Little Cottonwood Canyon setting.

[c] Travel times are calculated based on travel speeds (1S: 11 mph; 2S: 15 mph; 3S: 17 mph) and the distance between the base and terminal station.

The 1S system was eliminated from consideration because it had the lowest per-cabin capacity, had the slowest travel speeds and times, and would require the most towers. Both the 2S and 3S systems would provide reliable and safe transportation. However, the 3S provides some specific advantages including greater person-capacity, faster speeds, and greater potential tower spacing. The greater tower spacing provides more opportunity to avoid sensitive environmental areas and span avalanche paths.

Although the smaller 2S towers could have less visual impacts, UDOT would likely need to build more towers. Additionally, one disadvantage of the 2S system is that it does not have “slack carriers.” Slack carriers in the 3S system are pieces of equipment that are connected to the two support cables and that support the haul cable at all times. In a 2S system, the cabins themselves support the haul cable between the towers. Whenever the cabins are removed from the haul cable (for maintenance), the haul cable sags low. Therefore, a 2S system requires shorter distances between towers to keep the haul cable from touching the ground when the cabins are removed, and this could increase the number of towers required compared to a 3S system. Because it would have the greatest maximum capacity, fastest travel times, and greatest operational benefits (most stability in high winds), the 3S-type gondola is the most feasible gondola system for Little Cottonwood Canyon.

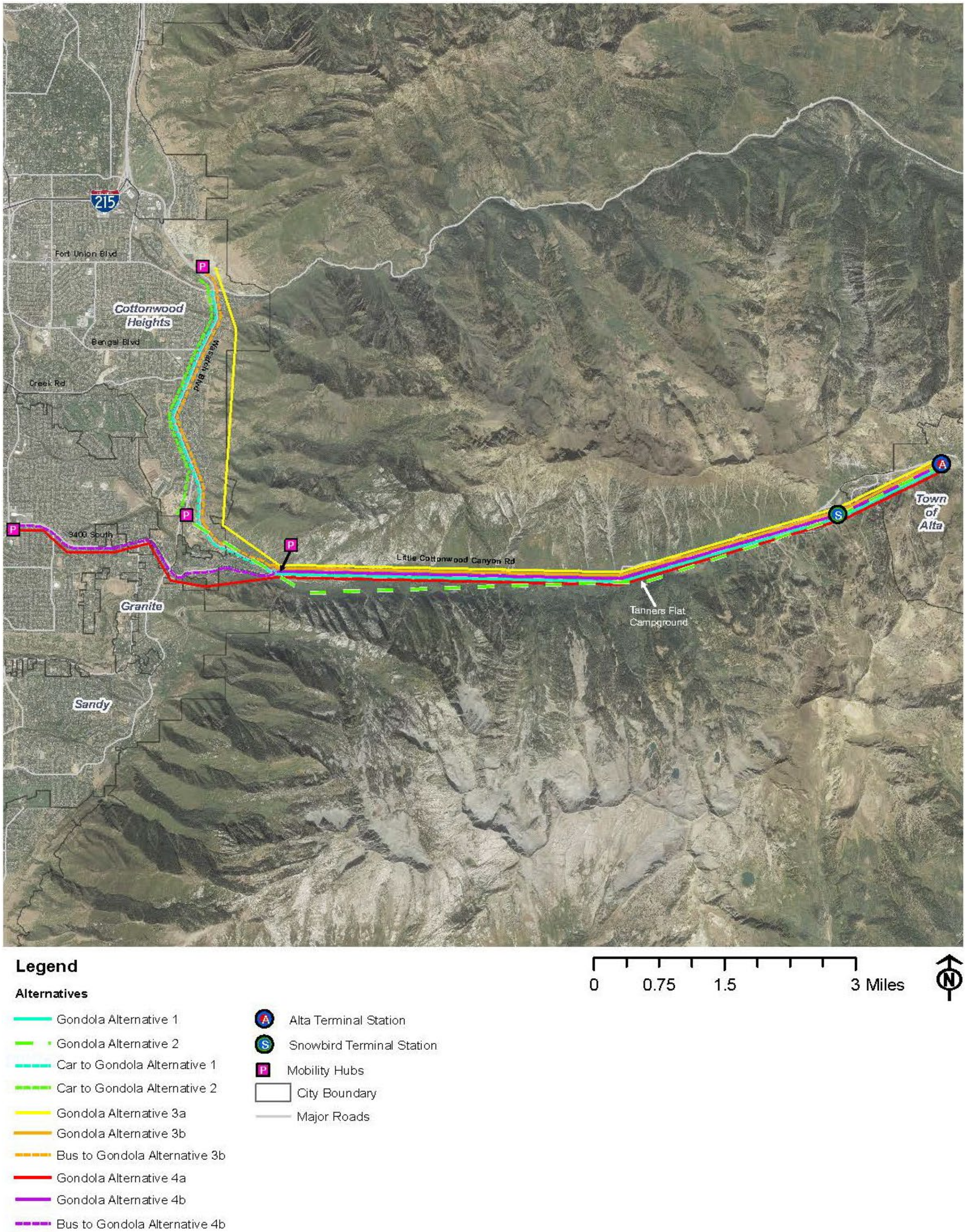
Gondola Alternatives Evaluated

Once UDOT selected the 3S-type gondola, UDOT then evaluated four alignments for the gondola from the Salt Lake Valley to Snowbird and Alta ski resorts (for more information about each alternative, see Appendix E, Draft Aerial Transit Initial Feasibility Study):

- **Gondola Alternative 1** – Expanded parking and base station at the entrance of the canyon
- **Gondola Alternative 2** – Expanded parking and base station 1 mile from the entrance of the canyon
- **Gondola Alternative 3** – Expanded parking at a mobility hub at the gravel pit (near Wasatch Boulevard and Fort Union Boulevard)
    - **Gondola Alternative 3, Option A** – A complete gondola alignment from the gravel pit mobility hub to the entrance of the canyon and continuing to the resorts
    - **Gondola Alternative 3, Option B** – A bus trip from the gravel pit mobility hub to a base station at the entrance of the canyon
- **Gondola Alternative 4** – Expanded parking at a mobility hub near 9400 South (S.R. 209) and Highland Drive
    - **Gondola Alternative 4, Option A** – A complete gondola alignment from the 9400 South/Highland Drive mobility hub to the entrance of the canyon and continuing to the resorts
    - **Gondola Alternative 4, Option B** – A bus trip from the 9400 South/Highland Drive mobility hub to a base station at the entrance of the canyon

Figure 2-12 shows the gondola alternatives that were considered.

Figure 2-12. Gondola Alternatives Evaluated



Gondola Alternatives Comparison

In addition to comparing the preliminary gondola alternatives in terms of their travel time, capital cost, and operation and maintenance (O&M) cost, UDOT also compared the alternatives in terms of feasibility criteria pertaining to the purpose of the S.R. 210 Project (improved mobility and improved neighborhood access). UDOT also included feasibility criteria pertaining to residential impacts and privacy issues, which are considerations that apply to gondolas in an urban environment. Other environmental impacts would be addressed in the EIS if a gondola alternatives is selected for detailed analysis. These additional feasibility criteria are described below, and the alternatives' ratings for these criteria are summarized in Table 2-12.

Impacts on Congestion. Improving mobility is an element of the S.R. 210 Project's purpose because traffic backs up at the intersection of S.R. 210 and S.R. 209 and clogs residential neighborhoods. In Table 2-12, impacts on traffic congestion represents the effect on the surrounding area. For example, Gondola Alternatives 1 and 2 would not change the existing travel patterns and would result in high volumes of traffic at the entrance of Little Cottonwood Canyon, so they are rated as having a high impact for this comparison criterion. In contrast, Gondola Alternative 3 would keep traffic near the existing interstate (I-215), near higher-capacity existing roads, and next to existing commercial areas, and is therefore rated as having a low impact in terms of causing traffic congestion.

Needed Roadway Improvements. This criterion qualitatively captures the degree of roadway improvements needed to provide priority travel for buses and needed infrastructure improvements near the mobility hub for efficient access to parking. Gondola Alternatives 3A and 3B are rated as having a low impact for this criterion because existing infrastructure near the gravel pit mobility hub can accommodate the expected traffic, and planned improvements to Wasatch Boulevard will help bus travel. Gondola Alternatives 1 and 2 are rated as having medium impacts because some roadway improvements would be needed near the parking garage in this more-residential area. Gondola Alternative 4B would require significant improvements from 9400 South and Highland Drive to the entrance of Little Cottonwood Canyon in order to maximize bus travel times. Therefore, Gondola Alternative 4B is rated as having a high impact for this criterion.

Residential Impacts. UDOT assumes that owners of residences directly under the gondola's airspace would need to be relocated. A low impact is assigned for this criterion for alternatives that have gondola alignments in the rural segments only (Gondola Alternatives 1, 3B, and 4B). A high impact is assigned for alternatives that have gondola alignments in the urban segments (Gondola Alternatives 3A and 4A).

Privacy Concerns. This criterion looks at the general number of homes that would be adjacent to the gondola alignment within view of gondola riders in the gondola cabin. Because the cabins would be elevated 100 to 200 feet in the air, privacy would be a concern for residents beyond the areas immediately adjacent to the gondola alignment. There is a large amount of residential development along Wasatch Boulevard and 9400 South. Like the residential impacts criterion, a low impact is assigned for this criterion for alternatives that have gondola alignments in the canyon segment only (Gondola Alternatives 1, 3B, and 4B), and a high impact is assigned for alternatives that have gondola alignments in the urban segments Gondola Alternatives 3A and 4A). For the alternatives in which the base station is located away from the entrance of Little Cottonwood Canyon, UDOT expects the public to strongly oppose these alternatives due to these privacy concerns.

When comparing these rankings, Gondola Alternative 3B has the lowest impact across the four additional feasibility criteria presented in this section. Gondola Alternative 3A is better than Gondola Alternative 1 from traffic congestion and needed roadway improvements standpoint, but implementation would be challenging because of high residential impacts and privacy concerns.

Table 2-12 summarizes all of the comparison criteria for the gondola alternatives presented in this report.

Table 2-12. Comparison of Gondola Costs, Travel Time, and Additional Feasibility Criteria

	Costs		Travel Time	Additional Feasibility Criteria[a]			
Gondola Alternative	Capital Cost (million $)	Annual O&M Cost (million $)	Total Travel Time to Alta (minutes)	Impacts on Traffic Congestion	Needed Roadway Improve-ments	Residential Impacts	Privacy Concerns
1	262.6 – 288.8	3.1 – 3.5	54	High	Medium	Low	Low
2	299.8 – 329.7	3.1 – 3.5	58	High	Medium	Medium	Medium
3A	375.6 – 413.2	4.3 – 4.8	68	Low	Low	High	High
3B[b]	312.2 – 343.4	4.1 – 4.5	62	Low	Low	Low	Low
4A	398.4 – 438.2	4.3 – 4.8	70[c]	Medium	Low	High	High
4B[b]	312.2 – 343.4	4.1 – 3.5	60[c]	Medium	High	Low	Low

[a] High impact means that the impact is greater, such as heavier congestion, greater need for roadway improvements, higher residential impacts, and greater privacy concerns. Low impact means less congestion, fewer needed roadway improvements, less residential impacts, and fewer privacy concerns.

[b] Annual O&M cost for Gondola Alternatives 3B and 4B would be about $3.8 million to $4.2 million with a modified bus schedule that has a lower hour capacity during off-peak weekend hours and weekdays.

[c] Travel time does not include a personal vehicle trip in the segment from Wasatch Boulevard and Fort Union Boulevard to a mobility hub at 9400 South and Highland Drive.

Gondola Alternative Selected for Level 1 Screening

Based on the above analysis, UDOT decided to carry **Gondola Alternative 3B** forward for Level 1 screening and to eliminate Gondola Alternatives 1, 2, 3A, 4A, and 4B. UDOT selected Gondola Alternative 3B because it would have the second-lowest overall capital cost, the fewest impacts to traffic and residential properties, and less privacy concerns. Although Gondola Alternative 4B would have a similar travel time, cost, and impacts as Gondola Alternative 3B, the parking area would be located about 3.5 miles from I-15 and about 6 miles from I-215 and would require canyon users to travel on Wasatch Boulevard or 9400 South. This route could create more traffic congestion, whereas a parking area at the gravel pit would be about 1 mile from I-215, which would result in a faster travel time because about 60% of traffic in Little Cottonwood Canyon uses I-215 and S.R. 210 to access the canyon. Gondola Alternative 4B would also need more roadway improvements to prioritize buses.

Gondola Alternative 1 would have the lowest capital cost, the lowest operational cost, and the fastest travel time; however, one of the purposes of improving mobility on S.R. 210 is to reduce traffic impacts to residential areas along S.R. 210 and S.R. 209 at the entrance to Little Cottonwood Canyon. Gondola Alternatives 1 and 2 would focus traffic on S.R. 210 and S.R. 209. These alternatives were eliminated from further study because the traffic congestion with these alternatives would be similar to existing traffic conditions, which focus peak-hour traffic to the entrance of Little Cottonwood Canyon in residential areas and restrict residents' ability to access their homes during peak ski periods. In addition, both Gondola Alternatives 1 and 2 would include building a 2,500-car multistory parking structure in a residential area, and a parking structure which would not be compatible with existing residential land uses. Gondola Alternative 2 would further cause privacy concerns since the gondola corridor would be near existing homes along S.R. 210 near the entrance to the canyon. For these reasons, Gondola Alternatives 1 and 2 were not carried forward for Level 1 screening.

Gondola Alternatives 3A and 4A had the highest capital cost, high impacts to residential properties, and most privacy concerns, and therefore were not carried forward for Level 1 screening.

In recommending Gondola Alternative 3B, UDOT realizes that scenarios with bus service that match the gondola capacity (of about 1,000 people per hour) have the higher annual operating cost and 8 minutes' more travel time than the best-performing gondola alternative (Gondola Alternative 1). UDOT determined that the traffic impacts of locating a parking garage near the entrance to Little Cottonwood Canyon with traffic congestion similar to the existing traffic conditions outweighed the additional O&M cost and travel time. In addition, bus service can be optimized to better match off-peak demands and actual ridership. The actual operating costs for Gondola Alternative 3B could be slightly lower ($3.8 million to $4.2 million) than what has been estimated in Table 2-12 above ($4.3 million to $4.8 million) with a modified bus schedule during off-peak times.

2.2.2.2.3 Rail Transit Alternative

Rail Transit Systems Evaluated

UDOT initially evaluated the following seven types of rail transit system as preliminary alternatives for improving mobility on S.R. 210 from Fort Union Boulevard to Alta:

1. Heavy/commuter rail
2. Light rail
3. Cog rail
4. Monorail
5. Maglev
6. SkyTran
7. Funiculars

Heavy/commuter rail, light rail, monorail, and maglev were eliminated from further consideration because they cannot operate on such steep grades.

SkyTran, which was suggested by a commenter, was eliminated because no technical information was provided to UDOT regarding the levitation or propulsion system or regarding the control technology needed to meter vehicles into the main-track traffic, and no test facility has been constructed. UDOT considers the technology theoretical and therefore not feasible for Little Cottonwood Canyon.

Funiculars were eliminated because the technology is not feasible to handle the high hourly rider demands in Little Cottonwood Canyon.

Finally, a commenter provided a new concept to UDOT called the Dual-mode Advanced Vehicular Endeavor, or D.A.V.E. This system uses an ordinary automobile (or light truck) adapted with a mounting device so that it can drive on the street network and then be picked up by a fixed guideway and travel above ground. Based on an internet search and a review of transportation and transit resources, UDOT did not find any examples where a D.A.V.E. concept has been implemented. The idea of dual-mode vehicles (that can operate on either roads or fixed guideways) has been previously discussed among various transit agencies, but UDOT could not find any examples where either dual-mode transit vehicles or dual-mode personal automobiles have been installed operationally. UDOT determined that the D.A.V.E concept would require a technology that does not currently exist and is not commercially or institutionally available.

Additionally, the D.A.V.E. concept would require users to either purchase new vehicles that could be used on the D.A.V.E. guideway system or purchase equipment that would allow their personal vehicles to be used with the D.A.V.E. guideway system. Neither the new vehicles nor the modification equipment are commercially available. Even if it were available, the State of Utah could not require drivers to purchase the vehicles or equipment to use the D.A.V.E. system. Because a commercially available product is not available, designing a D.A.V.E. alternative for the S.R. 210 Project would require an extensive and costly research and development process. For these reasons, the D.A.V.E. concept does not meet the logistical, technological, or economic requirements for a reasonable or practicable Little Cottonwood Canyon alternative.

As discussed in Appendix F, Draft Rail Transit Concepts Initial Feasibility Study, of the seven types of rail systems, UDOT selected **cog rail** as the best system for Little Cottonwood Canyon because it can operate on the steep grades in the canyon (up to 11%) and can be used with UTA's existing light-rail network.

Cog Rail Alternatives Evaluated

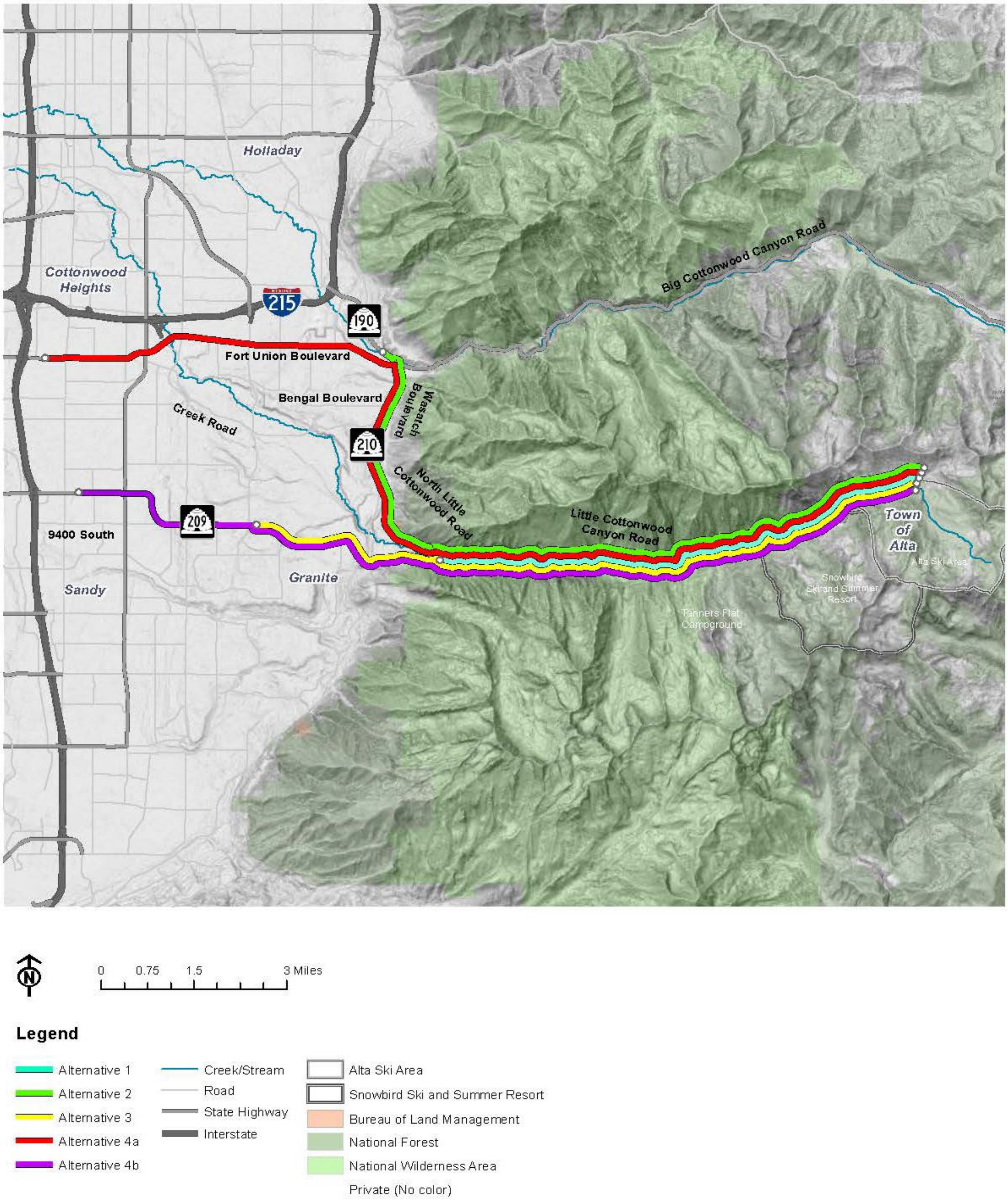
Cog rail, also called rack rail or mountain rail, is a type of light rail. Cog rail uses a third rail that is toothed or racked. Train vehicles are fitted with a cog wheel (also called a pinion wheel) that meshes with the third rail to provide additional traction. This additional traction is needed primarily for downhill travel where the added stopping power of the cog wheel is needed in addition to the adhesion forces. This design allows a train vehicle to operate on steeper grades, around 10% to 15%.

UDOT evaluated four potential alignments for cog rail from the Salt Lake Valley to the Snowbird and Alta ski resorts (for more information about each alternative, see Appendix F, Draft Rail Transit Concepts Initial Feasibility Study):

- **Cog Rail Alternative 1** – Expanded parking and rail base station at the entrance of Little Cottonwood Canyon a distance of about 8 miles to the Alta ski resort.
- **Cog Rail Alternative 2** – Expanded parking and a rail base station at a mobility hub located at the gravel pit (near Wasatch Boulevard and Fort Union Boulevard) a distance of about 12.2 miles to the Alta ski resort.
- **Cog Rail Alternative 3** – Expanded parking and a rail base station at a mobility hub near 9400 South (S.R. 209) and Highland Drive a distance of about 11.5 miles to the Alta ski resort.
- **Cog Rail Alternative 4** – UDOT also evaluated two options to connect to the existing TRAX system and avoid having to construct a large rail base station at a mobility hub with a 2,500-car parking structure. The two options for Concept 4 are:
    - **Cog Rail Alternative 4, Option A** – This option would connect a cog rail system to the existing TRAX system at the Midvale Fort Union TRAX Station (S.R. 190 and 7200 South) a distance of 18.1 miles to the Alta ski resort.
    - **Cog Rail Alternative 4, Option B** – This option would connect a cog rail system to the existing TRAX system at the Historic Sandy TRAX Station (at 9000 South and about 150 East) a distance of about 14.3 miles to the Alta ski resort.

Figure 2-13 shows the cog rail alternatives considered.

Figure 2-13. Cog Rail Alternatives



Cog Rail Alternatives Comparison

Table 2-13 compares the major feasibility criteria for the preliminary cog rail alternatives that were evaluated.

Table 2-13. Cog Rail Capital Cost, O&M Cost, and Travel Time Comparison

Cog Rail Alternative	Capital Cost (billion $)	Annual O&M Cost (million $)	Total Travel Time to Alta (minutes)
1	1.19 – 1.46	0.63	42
2	1.68 – 1.95	0.96	44
3	1.36 – 1.63	0.90	42 [a]
4A	2.09 – 2.44	1.42	54 [a,b]
4B	1.47 – 1.73	1.12	43 [a,b]

[a] Total travel times does not include any personal vehicle travel time.

[b] Total travel time does not include parking and loading times, and travel time is from the connection to UTA's TRAX system.

In addition to comparing the alternatives in terms of their travel time and capital and O&M costs, UDOT also compared the alternatives in terms of feasibility criteria pertaining to the purpose of the S.R. 210 Project (improved mobility and improved neighborhood access). UDOT also included feasibility criteria pertaining to impacts to congestion, need for roadway improvements, and expected ridership.

Impacts on Congestion. There is an existing park-and-ride lot at the entrance of Little Cottonwood Canyon at the intersection of S.R. 210 and S.R. 209. The existing lot has about 160 spaces. An expanded parking lot at or near this location, which could accommodate the assumed cog rail ridership, would require a large, multilevel parking structure. UDOT initially assumes that a 2,500-car parking structure would be required to meet the daily demand for the number transit riders entering the canyon.

Expanding the parking at the entrance to Little Cottonwood Canyon would not improve traffic congestion at the intersection of S.R. 209 and S.R. 210. A large parking structure at the base of the canyon, which would be needed with Cog Rail Alternative 1, would not improve congestion on S.R. 210 and S.R. 209 during peak arrival times. The congestion would be similar to the current conditions with traffic trying to enter the canyon. One of the purposes of the S.R. 210 Project is to reduce congestion-related access issues for residents who live at the base on the canyon (not being able to arrive at or leave their neighborhoods on peak ski days). Therefore, Cog Rail Alternative 1 would have a high impact under this criterion because it would not improve congestion.

Moving the parking and rail base station to a mobility hub located away from the entrance of the canyon (Cog Rail Alternatives 2 and 3) would benefit residents' mobility by removing some cars from the residential area. Cog Rail Alternative 2, which places the parking structure at the gravel pit and therefore closer to an interstate freeway (I-215) is better than Cog Rail Alternative 3, which is about miles from 3 miles from Interstate 15 (I-15). With Cog Rail Alternative 2, personal vehicles would travel past more residential areas to access the parking structure at the 9400 South and Highland Drive mobility hub. For train riders using their personal vehicle for the initial stages of their trip, parking for Cog Rail Alternative 4 (connections to the existing TRAX system) could be more dispersed, and Cog Rail Alternative 4 would not concentrate traffic to just one parking area.

Needed Roadway Improvements and Impacts on Travel Patterns. Implementing a cog rail line outside Little Cottonwood Canyon would require major roadway infrastructure improvements and would change travel patterns on the existing roadway network. There are many residential areas adjacent to the rail alignments outside Little Cottonwood Canyon. A center-running rail line would limit left turns out of these neighborhoods. Drivers who want to make a left-hand turn would be required to turn right, travel to a signalized intersection, and make a left U-turn or make a loop along other routes. The complicated details of the changed travel patterns through all cog rail alternative segments was not evaluated. In general, cog rail alignments that run down the center of S.R. 210 (Wasatch Boulevard), S.R. 209 (9400/9000 South), and S.R. 190 (Fort Union Boulevard) would require extensive roadway widening, would have high impacts to the existing utility infrastructure, and would change the travel patterns to and from residential and commercial areas that abut these arterial roads. Cog Rail Alternative 1 would rank as low, Cog Rail Alternatives 2 and 3 as medium, and Cog Rail Alternatives 4A and 4B as high under this criterion.

Improving Mobility and Maximizing Transit Ridership. One way to improve mobility is by providing additional transportation modes. A cog rail line would address wintertime mobility primarily by shifting a substantial portion of the future travel demand to mass transit and possibly would avoid the need to add automobile capacity in the canyon. As described in this report, UDOT's initial evaluation assumes that a percentage of the peak hourly demand could be accommodated by a cog rail system, and that all rail alternatives are essentially equal in this regard. The actual expected ridership would be based on many factors including travel time benefits and pricing.

In general, if a Little Cottonwood Canyon cog rail line were connected to UTA's existing, and expansive, light-rail network, there would be more potential riders in proximity to the existing park-and-ride lots, and this might make the transit portion of the trip attractive to more users. However, until all rail vehicles become equipped with cog equipment, riders would need to shift travel modes from standard light-rail vehicles that operate over the existing network to a cog rail vehicles that can navigate the grades in the canyon. This need to shift travel modes could reduce ridership.

Table 2-14 compares the preliminary cog rail alternatives according to the evaluation criteria.

Table 2-14. Comparison of Costs, Travel Time, and Additional Feasibility Criteria for the Preliminary Cog Rail Alternatives

	Costs		Travel Time	Additional Feasibility Criteria[a]		
Cog Rail Alternative	Capital Cost (billion $)	Annual O&M (million $)	Travel Time to Alta (minutes)	Impacts to Traffic Congestion	Roadway Improvements and Impacts on Existing Travel Patterns	Expected Ridership
1	1.2 to 1.5	0.63	42	High	Low	High
2	1.7 to 2.0	0.96	44	Low	Medium	High
3	1.4 to 1.6	0.90	42	Medium	Medium	High
4A	2.1 to 2.4	1.42	54	Low	High	Medium
4B	1.5 to 1.7	1.12	43	Low	High	Medium

[a] High impact means that the impact is greater, such as heavier congestion, a greater need for roadway improvements, or less ability to attract riders because the system is not connected to regional light rail network. Low impact means less congestion, fewer needed roadway improvements, and a greater ability to attract riders because there would be a connection to the regional light rail network.

As part of evaluating the preliminary cog rail alternatives, UDOT looked at the preliminary impacts to key resources to better understand each cog rail alternative. Table 2-15 shows the resources evaluated for Cog Rail Alternatives 1, 2, 3, and 4B.

Cog Rail Alternative 4A (cog rail from the Midvale Fort Union TRAX Station using Fort Union Boulevard and then Wasatch Boulevard) was not evaluated. The impacts from Cog Rail Alternative 4A would add to the impacts of Cog Rail Alternative 2, which would have the highest number of home acquisitions. In addition, Cog Rail Alternative 4A has the highest cost because it has the longest travel distance, but it would not provide any additional benefit to connecting to UTA's existing TRAX system compared to Cog Rail Alternative 4B.

Table 2-15. Selected Resources Evaluated for the Preliminary Cog Rail Alternatives

Impact Criterion	Unit	Alternative				
		1	2	3	4B	4A[c]
***Natural Environment*[a]**						
Wetlands[b]	Acres	0.00	0.65	0.00	0.00	Not applicable
Streams	Acres	0.19	0.22	0.19	0.19	
Floodplains	Acres	0.00	4.81	0.07	0.07	
Impacts to wilderness areas	Acres	0.00	0.00	0.00	0.00	
***Built Environment*[a]**						
Recreation sites	Number	6	6	6	7	Not applicable
Residential relocations	Number	2	63	40	48	
Business relocations	Number	0	0	0	2	
Cost of alternative in 2020 (in 2019 dollars)	Dollars (billions)	\$1.2 – \$1.5	\$1.7 – \$2.0	\$1.4 – \$1.6	\$1.5 – \$1.7	\$2.1 – \$2.4

[a] The acreage or number of impacts is based on a screening-level design. The actual impacts could decrease or increase based on more-detailed design conducted for the alternatives that pass Level 2 screening.

[b] The wetlands are associated with constructed stormwater-management facilities and might not be jurisdictional wetlands. The final determination of wetland jurisdiction will be made by the U.S. Army Corps of Engineers.

[c] Cog Rail Alternative 4A (cog rail from the Midvale Fort Union TRAX Station using Fort Union Boulevard and then Wasatch Boulevard) was not evaluated. The impacts from Cog Rail Alternative 4A would add to the impacts of Cog Rail Alternative 2, which would have the highest number of home acquisitions. In addition, Cog Rail Alternative 4A has the highest cost because it has the longest travel distance, but it would not provide any additional benefit to connecting to UTA's existing TRAX system compared to Cog Rail Alternative 4B.

Cog Rail Alternative Selected for Level 1 Screening

Based on the above analysis, UDOT carried forward **Cog Rail Alternative 4B**, cog rail connected to the existing Historic Sandy TRAX Station, for Level 1 screening. Cog Rail Alternative 4B was selected because the travel time is comparable to that of other alternatives, the alternative would have low impacts on traffic congestion, and the alternative would connect to UTA's existing light-rail network, thereby providing the opportunity for users to board the system from locations all over the Salt Lake Valley.

Comparing Cog Rail Alternative 4B to Cog Rail Alternative 2, the first alternative has a slightly lower cost (based on conceptual-level design), fewer home acquisitions, and a substantial advantage by connecting to UTA's existing light-rail network. Although Cog Rail Alternative 4B has a slightly higher cost and home acquisitions than Cog Rail Alternative 3, Cog Rail Alternative 4B has the advantage of connecting to UTA's existing light-rail network. In addition, Cog Rail Alternative 3 would require a 10-acre maintenance facility to be located near the cog rail alignment along 9400 South in a mostly residential areas, whereas Cog Rail Alternative 4B could potentially use UTA's existing maintenance facilities with some expansion.

Cog Rail Alternative 1 has the lowest costs, fastest travel times, lowest impacts to the existing roadway network, no impacts to existing travel patterns outside Little Cottonwood Canyon, and the least amount of residential impacts. However, Cog Rail Alternative 1 would require expanding the parking at the entrance to Little Cottonwood Canyon. A large parking structure at the base of the canyon, which would be needed with Cog Rail Alternative 1, would not help relieve congestion on S.R. 210 and S.R. 209 during peak arrival times. The congestion would be similar to the current conditions with traffic trying to enter the canyon. One of the purposes of improving mobility on S.R. 210 is to reduce congestion-related access issues for residents who live at the base on the canyon (not being able to arrive at or leave their neighborhoods on peak ski days). In addition Cog Rail Alternative 1 would require a parking garage that would require about 4 to 5 acres and an additional approximately 10-acre maintenance facility near the S.R. 210/S.R. 209 intersection for the cog rail in a residential area with limited land availability. Because it would not meet the project purpose of reducing congestion at the S.R. 209/S.R. 210 intersection, Cog Rail Alternative 1 was not carried forward for Level 1 screening.

2.2.2.2.4 Aerial Transit or Express Bus from Park City Alternative

As one possibility for improving mobility on S.R. 210 from Fort Union Boulevard to Alta, UDOT evaluated a preliminary alternative that would provide aerial transit or express bus service from Park City to the Snowbird and Alta ski resorts.

The Aerial Transit or Express Bus from Park City Alternative assumes that, by providing gondola or express bus service from Park City to the ski resorts in Little Cottonwood Canyon, vehicle traffic would be reduced enough that no additional roadway capacity would be needed. To evaluate this alternative, UDOT needed to determine the number of vehicles making the trip from Park City to Little Cottonwood Canyon during the peak hour. To determine the number of vehicles, UDOT conducted an origin-destination (OD) study using data from StreetLight Data. StreetLight Data is a data vendor that processes vehicle location-based data from smartphones and other navigation devices in connected cars and trucks for transportation planning purposes. OD analyses are conducted to understand travel patterns associated with trips from a given origin location to a determined destination location. For this analysis, UDOT used the StreetLight Insights web software platform (see Appendix G, Park City to Little Cottonwood Canyon Traffic Analysis).

As shown in Table 2-16, the OD data showed that between 7% and 8.5% of the morning traffic into Little Cottonwood Canyon is from Park City, or an average of 7.8% (HDR 2019a). For the mobility screening analysis to determine travel times per person, UDOT is using the 30th-busiest day in 2050 (see Section 2.2.2.3, Level 1 Screening), which is about 1,555 vehicles in the peak hour into Little Cottonwood Canyon. If a gondola or express bus system from Park City were built, on average about 121 vehicles could be eliminated from Little Cottonwood Canyon ski traffic during the peak hour, which would reduce peak-hour traffic to about 1,434 vehicles. The analysis of the 7.5-minute bus headway option showed that 1,370 vehicles per hour would back up on S.R. 210 and S.R. 209, which would be similar to backups with the No-Action Alternative. Therefore, reducing the peak-hour traffic to about 1,434 would also result in vehicle backups on S.R. 210 and S.R. 209 similar to the No-Action conditions in 2050. Because the Aerial Transit or Express Bus from Park City Alternative would cause similar vehicle backups on S.R. 210 and S.R. 209 as the 2050 No-Action Alternative, it was not carried forward for Level 1 screening.

Table 2-16. Peak Morning Traffic from Park City to Little Cottonwood Canyon

Days	Period	Percent Peak Winter Traffic (2019)	Vehicles during Peak Hour of 30th-busiest Day (2050)	
			Total Vehicles in Canyon	Estimated Vehicles from Park City
Monday–Sunday	Peak AM (7 AM–11 AM)	7.8%	1,555	121
Monday–Thursday	Peak AM (7 AM–11 AM)	8.5%	1,555	132
Friday–Sunday	Peak AM (7 AM–11 AM)	7.0%	1,555	109

2.2.2.2.5 Mobility Hub Alternatives

To support personal vehicle parking for the transit alternatives (bus, aerial transit, and rail transit), UDOT evaluated suitable locations for a mobility hub. For the transit alternatives, UDOT considered comments provided during scoping about mobility hub locations. For more information, see Appendix H, Draft Evaluation of Mobility Hub Locations.

What is a mobility hub?

A mobility hub is a location where users can transfer from a personal vehicle to a bus.

As shown in Table 2-17, UDOT evaluated 14 potential locations for a mobility hub to service Little Cottonwood Canyon. The mobility hub locations could be used for bus service directly to the ski resorts or for bus service to a train or gondola station located at the entrance to Little Cottonwood Canyon. Table 2-17 shows the results of the evaluation. Based on the alternatives screening summarized in Table 2-17 and described in Appendix H, UDOT determined that the best locations for mobility hubs were the **gravel pit on the east side of Wasatch Boulevard between 6200 South and Fort Union Boulevard** and the **UTA park-and-ride lot at 9400 South and Highland Drive**. Both locations meet the lot size and availability requirements and would provide convenient access for users and transit to Little Cottonwood Canyon. These locations were used with each bus and gondola alternative to help evaluate each transit alternative.

Table 2-17. Preliminary Screening Results – Mobility Hub Alternatives

Alternative	Screening Criteria (Green = Pass, Red = Eliminated)				
	Available[a] (Yes/No)	Convenient Access[b] (Yes/No)	Lot Size[c]	Pass Screening (Yes/No)	Notes
Little Cottonwood Canyon Park-and-Ride	Yes	Yes	1.3 acres	No	Lot size is too small to accommodate parking requirements and would result in potential traffic congestion at the S.R. 209/S.R. 210 intersection similar to existing conditions.
Big Cottonwood Canyon Park-and-Ride	Yes	Yes	1.6 acres	No	Lot size is too small to accommodate parking requirements.
9400 South/ Highland Drive Park-and-Ride	Yes	Yes	4 acres	**Yes**	**Carried forward for Level 1 Screening**
6200 South/ Wasatch Blvd. Park-and-Ride	Yes	Yes	1.6 acres	No	Lot size is too small to accommodate parking requirements Little Cottonwood Canyon.
Reams Market at 7200 South	No	Yes	500 parking stalls	No	Currently in use for commercial business. Lot would not be available.
Tree Farm off of Wasatch Blvd.	Yes	No	28.9 acres	No	The lot includes steep train that may make construction difficult. In addition, the lot would but a high level of traffic in residential area and would be located in a residential area which would not be compatible with a parking structure.
3662 North Little Cottonwood Canyon Rd	Yes	No	6.85 acres	No	Location would cause congestion on Wasatch Boulevard during peak use times in a residential area similar to current conditions. Land is between two residential subdivisions which would not be compatible with parking structure.
Swamp Lot	Yes	No	2.1 acres	No	Lot size is too small to accommodate parking requirements for Little Cottonwood Canyon.
Lower Canyon	Yes	No	6.5 acres	No	The lot would impact a heavily used Little Cottonwood Canyon hiking trail and would be immediately adjacent to Little Cottonwood Canyon Creek. Lot would result in potential traffic congestion at the S.R. 209/S.R. 210 intersection similar to existing conditions.

(*continued on next page*)

Table 2-17. Preliminary Screening Results – Mobility Hub Alternatives

Alternative	Screening Criteria (Green = Pass, Red = Eliminated)				
	Available[a] (Yes/No)	Convenient Access[b] (Yes/No)	Lot Size[c]	Pass Screening (Yes/No)	Notes
School and Church Parking Lots	No	No	Not applicable	No	Church lots would not be available on Sundays and some weekends during special events. School lots might not be available during weekdays, weekends during special events, and some holidays.
Existing Business Parking at I-215/ 6200 South	No	Yes	3,000 parking stalls	No	An agreement with the owner would need to be reached to allow use and address liability concerns. Lot might not be available on weekdays and holidays.
Gravel Pit	Yes	Yes	65 acres	**Yes**	**Carried forward for Level 1 screening**
Mall Parking – Holladay	Yes	No	48 acres	No	Area does not have convenient freeway access. Would increase transit travel times and out-of-direction travel for users.
Mall Parking – Fashion Place	No	Yes	4,900 parking stalls	No	Currently in use for commercial business and would not be available on weekdays, weekends, and holidays.

[a] The alternative must be available on weekdays, weekends, holidays, heavy snow days, and extended vacation periods (for example, the Christmas, Presidents' Day, and Easter holidays).

[b] The alternative must provide convenient access to traffic from the south end and north ends of the Salt Lake Valley, reduce out-of-direction travel, reduce potential traffic conflicts with residential traffic, and provide convenient bus access to Little Cottonwood Canyon.

[c] For new or existing mobility hub locations, the area must be 4 acres or must accommodate about 680 to 1,440 parking stalls. One or more sites could meet this need.

2.2.2.3 Level 1 Screening

2.2.2.3.1 Level 1 Screening Alternatives

Based on UDOT's evaluation of the preliminary alternatives for improving mobility on S.R. 210 from Fort Union Boulevard to Alta, the following alternatives were eliminated from further consideration and were not carried forward for Level 1 screening:

- Double Stacking Alternative
- S.R. 209 Roundabout Alternative
- Reversible-lane Alternative with Moveable Barrier
- Reversible-lane Alternative with Overhead Lane-control Signs
- Bus-only Alternative
- Regional Shuttle Bus System Alternative
- Aerial Transit or Express Bus from Park City Alternative

The alternatives that were carried forward for Level 1 screening are shown in Table 2-18. All of the alternatives in Table 2-18 include widening Wasatch Boulevard for the reasons explained in Section 2.1, Improve Mobility on Wasatch Boulevard. All of the alternatives listed in the table would need to include a toll or other travel management strategy such as a prohibition on single-occupant vehicles during peak travel periods in Little Cottonwood Canyon in order to promote transit use (bus, gondola, or rail).

Table 2-18. Level 1 Screening Alternatives – S.R. 210

Alternative	Personal Vehicles in the Peak Hour [a]	Transit Vehicles in the Peak Hour	People in Personal Vehicles in the Peak Hour	People in Transit in the Peak Hour	Total People in the Peak Hour [b]
Additional Roadway Capacity To Wasatch Boulevard with no additional capacity on S.R. 210 in Little Cottonwood Canyon Road and Increase Transit (Bus, Gondola, And Train)					
1. Enhanced Bus Service A1 – 16 buses per hour during peak period • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – One lane each direction • Transit – 16 buses per hour during peak period (every 3.45 minutes or every 7.5 minutes per resort)	1,368	16	2,585	672	3.257
2. Enhanced Bus Service B1 – 24 buses per hour during peak period • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – One lane each direction • Transit – 24 buses per hour during peak period (every 2.30 minutes or every 5 minutes to each resort)	1,190	24	2,249	1,008	3,257
3. Gondola (selected aerial transit alternative) • Wasatch Boulevard – 4 or 5 lanes • Little Cottonwood Canyon – One lane each direction • Gondola –30 gondolas (minimum) per hour during peak period (every 2 minutes)	1,190	30	2,249	1,050	3,299
4. Cog Rail (selected rail transit alternative) • Wasatch Boulevard – 4 or 5 lanes • Little Cottonwood Canyon – One lane each direction • Cog rail vehicles – 4 trains per hour during peak period (every 15 minutes)	1,190	4	2,249	1,012	3,261

(*continued on next page*)

Table 2-18. Level 1 Screening Alternatives – S.R. 210

Alternative	Personal Vehicles in the Peak Hour [a]	Transit Vehicles in the Peak Hour	People in Personal Vehicles in the Peak Hour	People in Transit in the Peak Hour	Total People in the Peak Hour [b]
Additional Roadway Capacity to Wasatch Boulevard and Peak-period Shoulder Lanes on S.R. 210 in Little Cottonwood Canyon with Bus Service					
5. Enhanced Bus Service A2 – 16 buses per hour during peak period • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – bus-only peak-period shoulder lane[c] • Transit – 16 buses per hour during peak period (every 3.45 minutes or every 7.5 minutes per resort)	1,368	16	2,585	672	3,257
6. Enhanced Bus Service B2 – 24 buses per hour during peak period • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – bus-only peak-period shoulder lane[c] • Transit – 24 buses per hour during peak period (every 2.30 minutes or every 5 minutes to each resort)	1,190	24	2,249	1,008	3,257

[a] Assumes 1.89 people per vehicle during the peak hour based on occupancy counts conducted in 2018.

[b] Peak-hour person demand for any alternative would need to be equal or greater than 3,250 to meet the demand during the 30th-busiest hour in 2050.

[c] The peak-period shoulder lane would be a cyclist and pedestrian lane in the summer or would not be in use.

2.2.2.3.2 Level 1 Screening Criteria

The alternatives that were evaluated in Level 1 screening for improving mobility on S.R. 210 were evaluated against the criteria in Table 2-19. The criteria focused on improving overall mobility and reducing congestion on S.R. 210.

Table 2-19. Level 1 Screening Criteria – S.R. 210

Criterion	Measure
Improve mobility in 2050	• Substantially improve peak-hour per-person (defined as the 30th-busiest hour) travel times in Little Cottonwood Canyon for uphill and downhill users in 2050 compared to travel times with the No-Action Alternative. • Meet peak-hour average total person demand on busy ski days in Little Cottonwood Canyon. • Substantially reduce vehicle backups on S.R. 210 and S.R. 209 through residential areas on busy ski days (30th-busiest day).

2.2.2.3.3 Level 1 Screening Methodology

For more information about the methodology, see Appendix I, Draft Vehicle Mobility Analysis.

Peak Travel Hour Used in the Analysis. To determine travel times for the roadway alternatives, UDOT used a busy ski day peak hour as the design hour. A design hour is an hour with a traffic volume that represents a location-specific peak-hour value for designing the geometric and control elements of a road. This selected peak hour will allow the designed facility to accommodate traffic during most of the peak hours. The design hour is a key characteristic in estimating the expected demand for a proposed transportation facility. Typically, the hour corresponding to the 30th-highest hourly traffic volume of the year is considered as the design hour as stated by the Highway Performance Monitoring System (HPMS). In rural settings similar to S.R. 210 in Little Cottonwood Canyon, customary practice in the United States is to base highway design on the 30th-highest hour of the year. The 30th-highest hour is used because it falls in the range of subsequent highest hours that have similar traffic volumes. Even though a considerable variance is observed between the peak (highest) and 30th-highest hourly traffic volumes of a year, designing for the peak hour would not be deemed economical and feasible in many regions (FHWA 2018).

In 2017, the 30th-highest peak-hour eastbound traffic on S.R. 210 at the entrance to Little Cottonwood Canyon was 1,061 vehicles, which occurred in the morning. The 30th-highest peak-hour westbound traffic was 1,051 vehicles, which occurred in the afternoon (Fehr & Peers 2018a). To obtain 2050 30th-highest peak-hour traffic volumes, a 1.2% growth rate was applied based on historical growth rates for a 22-year period starting in 2018 and ending in 2050 (Fehr & Peers 2018b). Based on expected traffic growth and growth in regional population (see Table 2-3, Projected Regional Population, Employment, and Household Growth, above), the 30th-highest peak hour would be about 1,555 vehicles. Therefore, UDOT used the estimate of 1,555 vehicles per hour for the screening analysis to determine vehicle travel times. The 1,555 vehicles per hour was used for both uphill and downhill peak hours because traffic data from 2017 showed a similar level of travel demand during the AM and PM peak hours.

To determine the number of persons per peak hour, UDOT used the average occupancy per vehicle based on 2018 occupancy data for the peak morning hour weekend day of 1.89 occupants per vehicle and 42 occupants per bus. For buses, the current 15-minute headways from two bus routes (8 buses total per hour) was assumed. The results show that, under No-Action conditions in the peak morning hour, about

336 people would travel by bus and 2,924 would travel by car, for a total of about 3,260 people trying to enter Little Cottonwood Canyon in the peak hour on the 30th-busiest day in 2050.

Travel Time Analysis Criteria. To measure the mobility criteria to reduce travel time, UDOT used a reduction in travel time per person as the measure. This criterion would show the benefit for all users independent of traveling in a personal car or bus. For example, if a dedicated bus lane were implemented with a faster travel time for a bus than a personal vehicle, the 42 persons in the bus would have a faster travel time than the 2 people in the personal vehicle, thereby giving a greater benefit to bus service.

To provide an equal travel time comparison, common points of travel were selected for all travel modes. Travel used in the analysis was from Fort Union Boulevard and Wasatch Boulevard to the Alta Ski resort. For vehicles, the travel time would start at Fort Union Boulevard and end at the Alta ski resort. For buses and gondolas, the travel time would start at Fort Union Boulevard but would also include time to transfer from one mode to another. For the cog rail alternative, the travel time starts at the Sandy City Expo TRAX Station with no transfer times since UDOT assumed that most users would be using the existing light-rail system. Transfer mode time between parking a vehicle and transit leaving the mobility hub was assumed to be 12 minutes (Table 2-20). For example, if there was a bus parking garage at the entrance to Little Cottonwood Canyon, the total travel time would include the time to travel by vehicle from Fort Union Boulevard to the entrance of Little Cottonwood Canyon, a mode transfer time from vehicle to bus of 12 minutes, then the bus travel time to Alta.

Table 2-20. Vehicle to Transit Transfer Time Assumptions

Travel Time Description	Time in Minutes
Wait to enter parking garage	0.5
Find parking spot	1
Unload gear and put gear on (boots, jackets, helmet, etc.)	4
Fare collection	1
Walk from vehicle to transit wait area[a]	3.5
Wait for transit	2
Total transit parking and transfer time	**12**

[a] Walk speed assumed to be 3 miles per hour or 264 feet per minute. Distance from parking spot to transit wait area assumed at 900 feet for a total walk time of 3.41 minutes. Walk time rounded to 3.5 minutes.

For this analysis, the overall travel time reduction had to be substantially better that the 2050 No-Action vehicle/bus per-person travel time from Fort Union Boulevard to Alta of between 80 and 85 minutes.

Travel Time Modeling. The Little Cottonwood Canyon Sketch Planning Tool (SPT or model) is a data-driven planning tool designed for Little Cottonwood Canyon to estimate travel times in the canyon based on changes in travel demand and potential transportation improvements. The SPT is a system dynamics model. System dynamics models are applicable to systems that have many individually dynamic components which are interrelated. The SPT focuses on relationships between travel demand in Little Cottonwood Canyon, mode choice, and travel times. Each approach to the canyon and the roadway within Little Cottonwood

Canyon is programmed into the model, along with the existing number of travel lanes, and the posted speed limits (HDR 2019b).

The model begins analyzing traffic outside the canyon on S.R. 210 from the intersection with Fort Union Boulevard to the Alta ski resort. The SPT is able to adjust the overall daily travel demand for the canyon (the number of people who enter the canyon on a given day), hourly arrival times, modes of transportation used by each person, bus headways and ridership capacities, and parking lot capacities throughout the canyon.

The SPT evaluates changes to the entire study area and estimates the potential travel times. A variety of scenarios can be evaluated, including combinations of the following:

- Changing the number of travel lanes
- Changing speed limits
- Creating a transit-only (bus-only) lane
- Creating an HOV (high-occupancy vehicle) lane for buses and carpooling vehicles
- Changing the bus schedule(s) or route(s)
- Changing the mode of transportation used by each person (that is, more people carpool or take the bus)
- Changing the time of day when people arrive at or leave the canyon as a result of road closure from avalanche-control activities

For this analysis, the SPT was used to calculate travel times for vehicles and buses and the number of single occupant vehicle, high occupancy vehicle, and bus users.

Vehicle Backup into Neighborhoods Analysis Criteria. One of the screening criteria is to substantially reduce vehicle backups on S.R. 210 and S.R. 209 through residential areas on busy ski days. For this analysis, a VISSIM model was used to determine the length of vehicle backup from the S.R. 209/S.R. 210 intersection for each alternative evaluated. The analysis is based on UDOT's *Traffic Analysis Guidelines* (UDOT 2018c). The backup length criteria used in the analysis is the 95th-percentile vehicle queue, which is defined to be the vehicle queue length that has only a 5% probability of being exceeded during the analysis period. The length is measured from the stop bar of an intersection or from the beginning of a roadway bottleneck to the end of the last vehicle in the line. The screening criterion is that an alternative would substantially reduce vehicle backups compared to 2050 No-Action conditions. In 2050, the vehicle backups during the 30th-busiest design hour on S.R. 209 are projected to be past the traffic signal at 9400 South and Wasatch Boulevard, and the vehicle backups on S.R. 210 are projected to be past the traffic signal at Wasatch Boulevard and North Little Cottonwood Road.

Tolling. The analysis assumes that, to incentivize use of the Level 1 alternatives (buses, gondola, or cog rail), UDOT would need to implement a travel demand management strategy of a toll or a prohibition on single-occupant vehicles. For tolling to be effective in reducing congestion on S.R. 210 with these alternatives, the analysis assumed that the toll would be high enough that about 30% of vehicle traffic would divert to transit. Similarly, eliminating single-occupant vehicles would divert about 30% of traffic to transit.

2.2.2.3.4 Level 1 Screening Results

Table 2-21 shows the per-person travel time (Fort Union Boulevard to Alta ski resort), the S.R. 209 and S.R. 210 vehicle backup lengths, and the results of Level 1 screening for each alternative. Red cells in the table indicate performance measures that did not pass Level 1 screening. All alternatives were designed to meet the peak-hour demand of about 3,250 persons traveling eastbound on S.R. 210 and assume a widened Wasatch Boulevard. The analysis shows that all alternatives would substantially reduce travel time compared to 2050 No-action conditions; however, alternatives 1 and 5 (Enhanced Bus Service A1 and A2) would not substantially reduce vehicle backups on S.R. 209 and S.R. 210 compared to the 2050 No-Action baseline and therefore do not pass Level 1 screening. All of the other alternatives would substantially reduce travel time and backups on S.R. 209 and S.R. 210 and therefore pass Level 1 screening. Figure 2-14 shows the vehicle backups on S.R. 209 and S.R. 210 for the alternatives evaluated in Level 1 screening.

Based on the analysis, **Alternatives 2, 3, 4, and 6** passed Level 1 screening and were carried forward for Level 2 screening.

Table 2-21. Level 1 Screening Results – S.R. 210

Alternative	Personal Vehicles in Peak Hour [b]	Transit Vehicles in Peak Hour	People in Personal Vehicles in Peak Hour	People in Transit in Peak Hour	Screening Results (Red indicates does not pass and green pass)				
					Meet Peak-Hour Person Demand (total people per hour)[d]	Substantially Improve Peak-hour Travel Time per Person eastbound/westbound (minutes)[e]	Substantially Reduce Vehicle Backups at S.R. 209/S.R. 210 Intersection	Meet LOS A-D in AM and PM Weekday Peak-hour on Wasatch Blvd.	Pass Level 1 Screening Yes/No
2050 No-Action (baseline)[a] • Wasatch Boulevard – One lane each direction • Little Cottonwood Canyon – One lane each direction • Transit – 15-minute bus headways	1,547	8	2,924	336	3,260	80–85/80–85 (80–85 – vehicle and bus)	6300 + (Beyond Signals at 9400 S/Wasatch Boulevard intersection)/8500 + (Beyond Signals at Wasatch Boulevard/North Little Cottonwood Road intersection)	LOS F	N/A
Additional Roadway Capacity to Wasatch Boulevard with No Additional Capacity to S.R. 210 in Little Cottonwood Canyon and Increase Transit (Bus, Gondola, And Train)									
1. Enhanced Bus Service A1 – 16 buses per hour during peak period [c] • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – One lane each direction • Transit – 16 buses per hour during peak period (every 3.45 minutes entering the canyon or every 7.5 minutes per resort)	1,368	16	2,585	672	3.257	50–55 / 50–55 (50–55/50–55 – vehicle) (60–65/60–65 – bus)	3,400 / 8500 + (Beyond Signals at Wasatch Boulevard/North Little Cottonwood Road intersection)	LOS C/D	No
2. Enhanced Bus Service B1 – 24 buses per hour during peak period [c] • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – One lane each direction • Transit – 24 buses per hour during peak period (every 2.30 minutes entering the canyon or every 5 minutes to each resort)	1,190	24	2,249	1,008	3,257	45–50 / 45–50 (40–45/40–45 – vehicle) (50–55/50–55 – bus)	1,275/4,300	LOS C/D	Yes
3. Gondola (selected aerial transit alternative) • Wasatch Boulevard – 4 or 5 lanes • Little Cottonwood Canyon – One lane each direction • Bus to gondola at entrance of canyon –30 gondolas per hour during peak period (every 2 minutes)	1,190	30	2,249	1,050	3,299	45–50/45–50 (35–40 – vehicle) (60–65 – gondola)	350/3,050	LOS C/D	Yes
4. Cog Rail (selected rail transit alternative) • Wasatch Boulevard – 4 or 5 lanes • Little Cottonwood Canyon – One lane each direction • Double track from Historic Sandy TRAX Station to Alta • Cog vehicles – 4 per hour during peak period (every 15 minutes)	1,190	4	2,249	1,012	3,261	35–40/35–40 (35–40 – vehicle) (40–45 – train)	350/3,050	LOS C/D	Yes

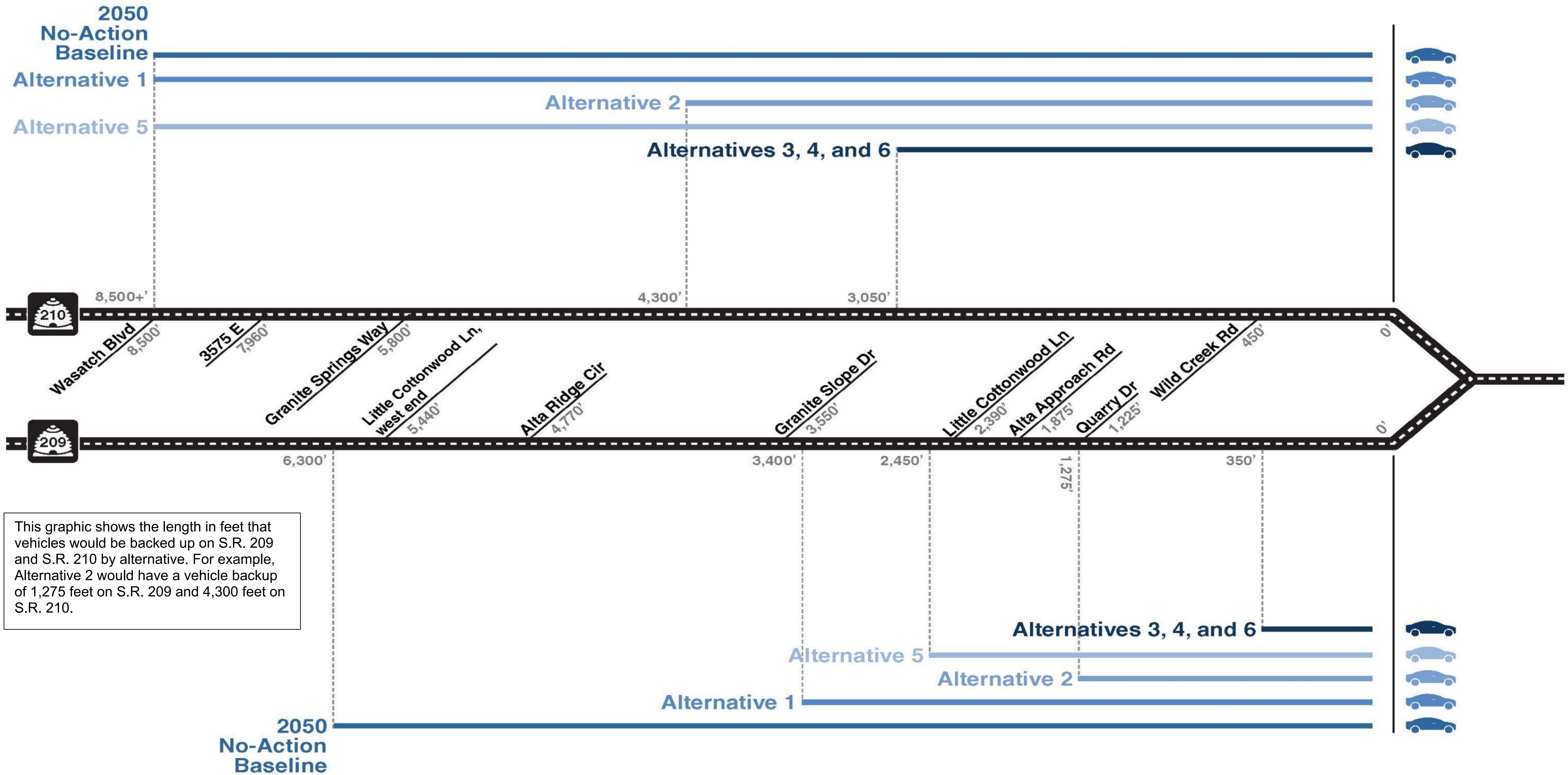
(*continued on next page*)

Table 2-21. Level 1 Screening Results – S.R. 210

Alternative	Personal Vehicles in Peak Hour[b]	Transit Vehicles in Peak Hour	People in Personal Vehicles in Peak Hour	People in Transit in Peak Hour	Screening Results (Red indicates does not pass and green pass)				
					Meet Peak-Hour Person Demand (total people per hour)[d]	Substantially Improve Peak-hour Travel Time per Person eastbound/westbound (minutes)[e]	Substantially Reduce Vehicle Backups at S.R. 209/S.R. 210 Intersection	Meet LOS A-D in AM and PM Weekday Peak-hour on Wasatch Blvd.	Pass Level 1 Screening Yes/No
Additional Roadway Capacity to Wasatch Boulevard and Peak-period Shoulder Lanes on S.R. 210 in Little Cottonwood Canyon with Bus Service									
5. Enhanced Bus Service A2 – 16 buses per hour during peak period[c] • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – bus-only peak-period shoulder lane • Transit – 16 buses per hour in peak period (every 3.45 minutes or every 7.5 minutes per resort)	1,368	16	2,585	672	3,257	45–50 / 45–50 (45–50/45–50 – vehicle) (35–40/40–45 – bus)	2,450/8500 + (Beyond Signals at Wasatch Boulevard/North Little Cottonwood Road intersection)	LOS C/D	No
6. Enhanced Bus Service B2 – 24 buses per hour during peak period[c] • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – bus-only peak-period shoulder lane • Transit – 24 buses per hour during peak period (every 2.30 minutes or every 5 minutes to each resort)	1,190	24	2,249	1,008	3,257	35–40 / 35–40 (35–40/35–40 – vehicle) (35–40/40–45 – bus)	350/3,050	LOS C/D	Yes

Red-shaded cells indicate performance measures that did not pass screening, and green-shaded cells indicate measures that passed screening.
[a] No-Action Alternative serves as baseline to compare to action alternatives and is not evaluated against screening criteria.
[b] Assumes 1.89 people per vehicle during the peak hour based on occupancy counts conducted in 2018.
[c] Assumes buses from mobility hubs at both the gravel pit and 9400 South and Highland. Bus standing capacity of 42 persons.
[d] Peak-hour person demand would need to be greater than 3,250.
[e] Travel times includes 12-minute vehicle to bus transfer time for bus and gondola alternatives. No transfer time was included for the cog rail alternative since it would connect to the existing light-rail network.

Figure 2-14. Vehicle Backup Lengths on S.R. 209 and S.R. 210 by Alternative



This graphic shows the length in feet that vehicles would be backed up on S.R. 209 and S.R. 210 by alternative. For example, Alternative 2 would have a vehicle backup of 1,275 feet on S.R. 209 and 4,300 feet on S.R. 210.

2.2.2.4 Level 2 Screening

As a result of Level 1 screening, the alternatives listed in Table 2-22 were carried forward into Level 2 screening.

Table 2-22. Level 2 Screening Alternatives – S.R. 210

Alternative	Personal Vehicles in Peak Hour [a]	Transit Vehicles in Peak Hour	People in Personal Vehicles in Peak Hour	People in Transit in Peak Hour	Total People in Peak hour [b]
Additional Roadway Capacity to Wasatch Boulevard with No Additional Capacity to S.R. 210 in Little Cottonwood Canyon and Increase Transit (Bus, Gondola, and Train)					
2. Enhanced Bus Service B1 – 24 buses per hour during peak period • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – One lane each direction • Transit – 24 buses per hour during peak period (every 2.30 minutes or every 5 minutes to each resort)	1,190	24	2,249	1,008	3,257
3. Gondola • Wasatch Boulevard – 4 or 5 lanes • Little Cottonwood Canyon – One lane each direction • Gondola –30 gondolas per hour during peak period (every 2 minutes)	1,190	30	2,249	1,050	3,299
4. Cog Rail • Wasatch Boulevard – 4 or 5 lanes • Little Cottonwood Canyon – One lane each direction • Cog vehicles – 4 per hour during peak period (every 15 minutes)	1,190	4	2,249	1,012	3,261
Additional Roadway Capacity to Wasatch Boulevard and Peak-period Shoulder Lanes on S.R. 210 in Little Cottonwood Canyon with Bus Service					
6. Enhanced Bus Service B2 – 24 buses per hour during peak period • Wasatch Boulevard – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – bus-only peak-period shoulder lane • Transit – 24 buses per hour during peak period (every 2.30 minutes or every 5 minutes to each resort)	1,190	24	2,249	1,008	3,257

[a] Assumes 1.89 people per vehicle during the peak hour based on occupancy counts conducted in 2018.

[b] Peak-hour person demand would need to be greater than 3,250.

UDOT developed a preliminary engineering design for each alternative in order to evaluate the expected impacts for each Level 2 criterion [see Table 1-2, Level 2 Screening Criteria (Impacts), above]. Table 2-23 shows the results of Level 2 screening.

Table 2-23. Level 2 Screening Results – S.R. 210

Impact Criterion	Unit	Alternative			
		2 (Enhanced Bus B1)	3 (Gondola)	4 (Cog Rail)	6 (Enhanced Bus B2)
***Natural Environment*[a]**					
Wetlands[b]	Acres	0.65	0.00	0.65	0.65
Streams	Acres	0.03	0.03	0.22	0.37
Critical habitat	Acres	0.00	0.00	0.00	0.00
Floodplains	Acres	3.74	1.83	3.81	5.03
Impacts to wilderness areas	Acres	0.00	0.00	0.00	0.00
***Built Environment*[a]**					
Consistency with USDA Forest Service Plan	Yes/no	Yes	No	No	Yes
Consistency with local plans	Yes/no	Yes	No	No	Yes
Recreation sites	Number	2	2	6	6
Community facilities	Number	0	0	0	0
Residential relocations	Number	1	1	49	1
Business relocations	Number	0	0	4	0
Section 4(f) properties	Number	9	9	37	18
Historic properties	Number	7	7	31	12
Cost of alternative in 2020[c,d]	Dollars (millions)	$280–$285	$390–$400	$1,600–$1,700	$470–$475
Annual O&M cost[e]	Dollars (millions)	$9	$4.5	$1.1	$6.2

[a] The acreage or number of impacts is based on a screening-level design. The actual impacts could decrease or increase based on more-detailed design conducted for the alternatives that pass Level 2 screening.

[b] The wetlands are associated with constructed stormwater-management facilities and might not be jurisdictional wetlands. The final determination of wetland jurisdiction will be made by the U.S. Army Corps of Engineers.

[c] Cost is in 2019 dollars.

[d] All alternative costs include widening Wasatch Boulevard and tolling infrastructure. Bus alternatives and the cog rail alternative include snow sheds. The Enhanced Bus Alternative B2 includes peak-period shoulder lanes on S.R. 210 from North Little Cottonwood Road to the Alta Bypass Road.

[e] The gondola alternative's O&M cost includes cost for enhanced bus to gondola and the gondola. Enhanced Bus Alternative B2's cost includes the bus service and the extra maintenance cost to plow the peak-period shoulder lanes.

2.2.2.4.1 Level 2 Screening Results

As shown in Table 2-23 above, the impacts to the natural environment would be similar between the alternatives evaluated in Level 2 screening. The main difference between the alternatives is related to home acquisitions, Section 4(f) impacts, historic property impacts, and cost. The cog rail alternative would have 48 more home acquisitions compared to the other alternatives, the highest Section 4(f) impacts and historic property impacts, and a cost up to 3 times greater than the other alternatives. In addition, this alternative would eliminate access to two key recreation resources in Little Cottonwood Canyon (the Gate Buttress and Lisa Falls Trailheads). Because of the high number of Section 4(f) impacts, including to important recreation sites, the cog rail alternative would not be prudent under Section 4(f). Therefore, based on the high cost and impacts to residential properties and Section 4(f) properties, UDOT eliminated the cog rail alternative from further evaluation in the EIS.

The main differences among Alternatives Enhanced Bus Alternative 2, Gondola Alternative 3, and Enhanced Bus Alternative 6 are that Alternative 6 would have the highest cost and impacts to recreational resources, historic resources, and Section 4(f) resources. However, UDOT determined that the higher cost and impacts from Alternative 6 were within a reasonable range when compared to Alternatives 2 and 3 and thus decided not to eliminate Alternative 6 in the screening process. Alternatives 2 and 3 had similar impacts and cost. Therefore, based on the Level 2 screening, UDOT determined that Alternatives 2, 3, and 6 would be considered further in the EIS and that Alternative 4 would be eliminated from further consideration.

2.2.2.4.2 Alternatives Carried Forward for Further Evaluation

The following S.R. 210 alternatives will be carried forward for further evaluation in the EIS:

- **Alternative 2 – Enhanced Bus Service B1** – 24 buses per hour during the peak period
- **Alternative 3 – Gondola**
- **Alternative 6 – Enhanced Bus Service B2** – 24 buses per hour during the peak period in peak-period, shoulder-running bus lanes

3.0 Alternatives Development and Screening Process – Improve Reliability and Safety

Improving reliability on S.R. 210 is focused on safety concerns associated with avalanche hazards and trailhead parking. Avalanche hazards cause substantial traffic delays as a result of the current avalanche-control program in Little Cottonwood Canyon. Periodic road closures for avalanche control can cause 2-to-4-hour travel delays or longer, which can cause traffic to back up in the neighborhoods at the entrance of the canyon. In turn, the reliability of vehicle travel in Little Cottonwood Canyon affects the mobility on S.R. 210.

Roadside trailhead parking on the roadway shoulder and partially on segments of the road causes safety concerns and some mobility issues because the loss of shoulder area for cyclists and pedestrians forces them into the roadway travel lane and creates a safety concern with traffic. In addition, parking along the road instead of at trailheads creates informal trailheads that contribute to erosion, mineral soil loss, the spread of invasive weeds, and loss of native vegetation in the canyon. Damage to the pavement along the roadway edge caused by roadside parking also causes increased soil erosion and runoff into nearby streams.

This section describes UDOT's evaluation of alternatives to improve reliability and safety on S.R. 210 through:

- Avalanche mitigation
- Improving trailhead parking
- Eliminating winter roadside parking

3.1 Improve Reliability and Safety through Avalanche Mitigation

3.1.1 Range of Alternatives

3.1.1.1 Active versus Passive Avalanche Mitigation Alternatives

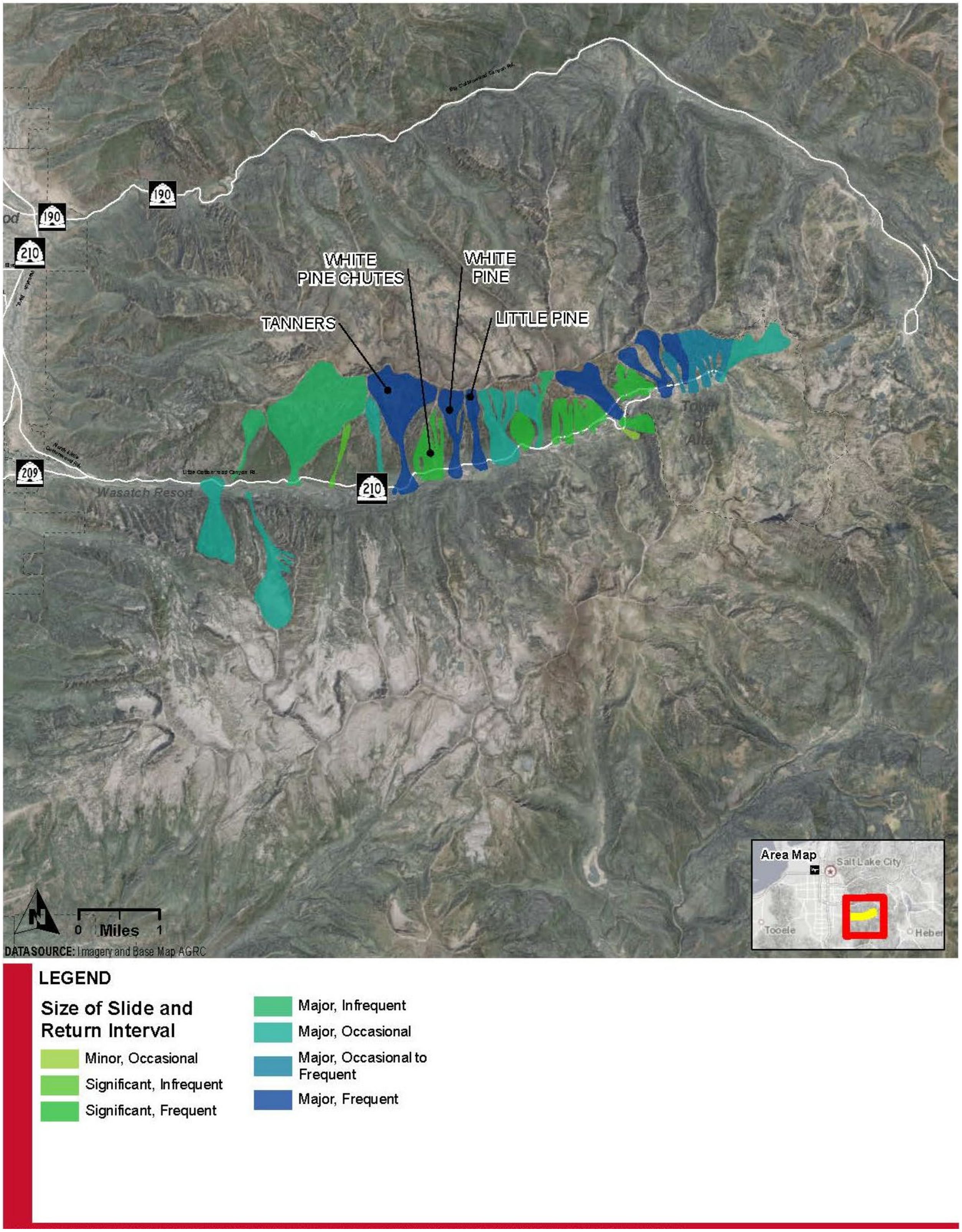
When evaluating avalanche mitigation alternatives, UDOT first considered passive and active avalanche-control measures. Active measures include blasting using artillery or explosives to create a controlled avalanche release, during which time the road is closed. UDOT currently uses active measures to control avalanches, which requires closing S.R. 210 during avalanche-control processes. Passive measures include placing snow sheds over the road, building walls to stop avalanches from impacting the road, or realigning the road outside the avalanche path. Passive measures normally do not require closing the road.

For the current analysis, one of the screening criteria for avalanche mitigation is to improve S.R. 210's reliability by substantially reducing the number of days and hours when the road is closed for avalanche mitigation and incidents. Because active measures would still require road closure during the avalanche-mitigation process (as with the existing conditions) and would not reduce the number of days or hours of closure, they were eliminated from detailed consideration. Thus, for the S.R. 210 Project, only passive measures were considered for the alternatives development and screening process. The passive avalanche mitigation alternatives considered included snow-supporting structures, snow sheds, roadway re-alignment, and deflection and stopping walls.

3.1.1.2 Avalanche Mitigation Location

The most critical avalanche paths with respect to avalanche risk in Little Cottonwood Canyon are the Tanners, White Pine Chutes, White Pine, and Little Pine avalanche paths (Figure 3-1). Therefore, the focus of the passive avalanche mitigation alternatives development process is on these avalanche paths. UDOT's active avalanche-control program in these paths consists primarily of closing the road and using artillery in a wilderness area to cause a controlled avalanche release followed by removing any snow that could impact S.R. 210. S.R. 210 is opened after the avalanche-control process is completed.

Figure 3-1. Avalanche Paths in Little Cottonwood Canyon



3.1.1.3 Avalanche Mitigation Baseline Conditions

Avalanches in Little Cottonwood Canyon present a hazard to the traveling public. Avalanche risk is measured using an avalanche hazard index (AHI), which is a numeric expression of the potential threat of an avalanche. A number of factors are combined to determine the AHI of a road, factors including snowfall abundance, terrain steepness, and traffic volume. As shown in Table 3-1, the AHI rating system characterizes risk in a range from Very Low (numerical value < 1) to Very High (numerical value > 150).

Table 3-1. Hazard Category as Defined by the Avalanche Hazard Index

Hazard Category	Avalanche Hazard Index (AHI)
Very Low	Less than 1
Low	1 to 10
Moderate	10 to 40
High	40 to 150
Very High	Greater than 150

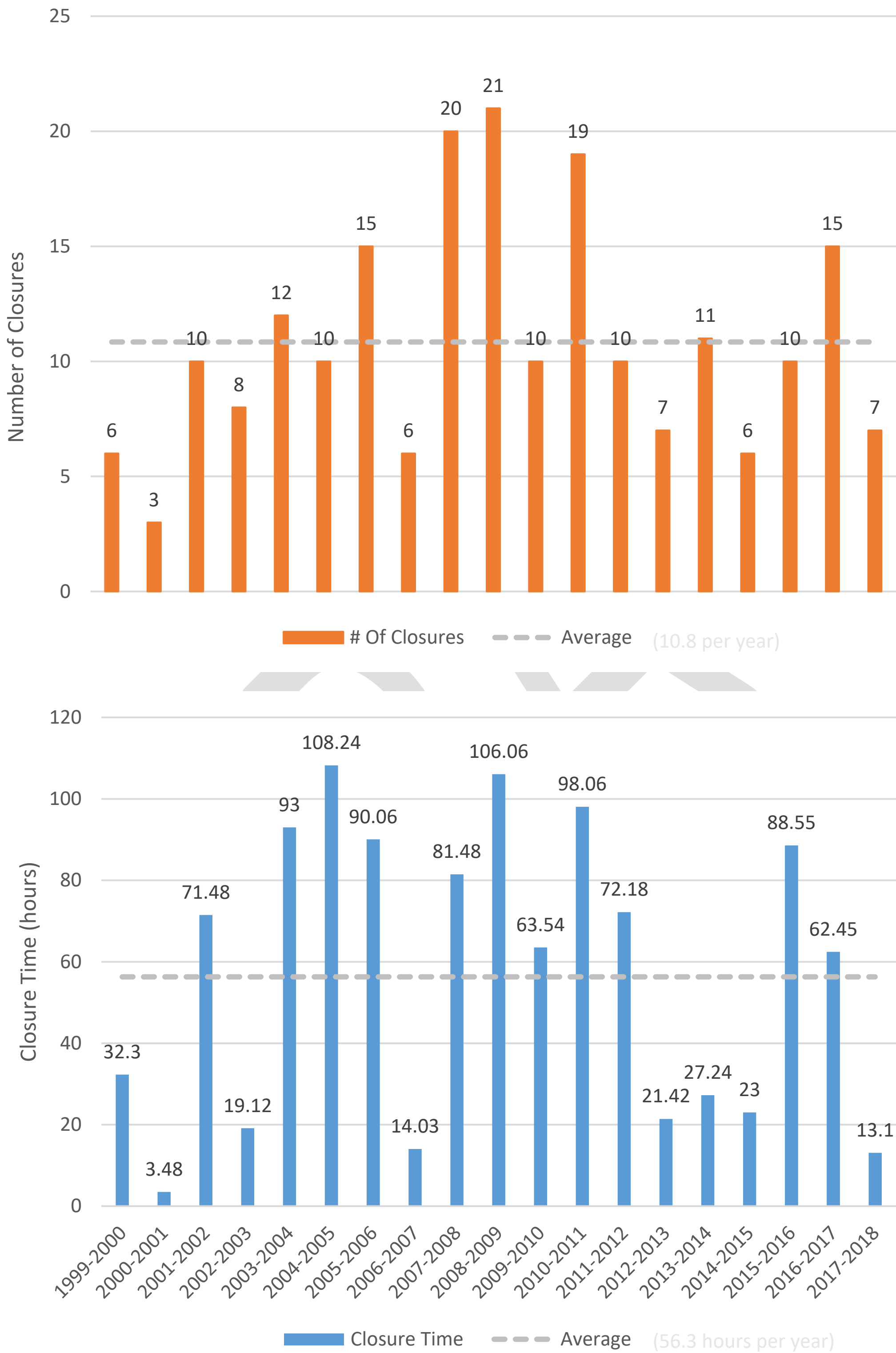
Source: Dynamic Avalanche Consulting 2018a

Little Cottonwood Canyon Road has one of the highest avalanche risks in North America based on AHI calculations without any control program (UDOT 2006). With no avalanche control and using actual traffic volumes for 2018, the AHI for Little Cottonwood Canyon is about 7,300. Using projected traffic volumes for 2050, the AHI increases to about 7,900 because increased vehicle use of S.R. 210 results in a higher risk.

With UDOT's active avalanche-control program in the canyon and the use of the Alta Bypass Road, the AHI is reduced to about 90 in 2018 and would be about 96 in 2050 (Dynamic Avalanche Consulting 2018b). The AHI with active control is still categorized as High; however, the avalanche risk is about 1% of the risk without the active control program.

Based on data recorded by UDOT, from 1999 to 2018, UDOT closed the road in Little Cottonwood Canyon an average of 10.8 days per year for part of the day to conduct avalanche control. During this period, there were an average of 56.3 hours of road closure per year, or about 5 hours of road closure per avalanche-control event (Dynamic Avalanche Consulting 2018b). The greatest number of closures between 1999 and 2018 occurred during the 2008–2009 winter season, which had 21 closure days and a total of 106 hours of closure (Figure 3-2). These closures were mostly due to controlled avalanche releases.

Figure 3-2. Number of Winter Closures and Total Closure Hours for Little Cottonwood Canyon Road (1999–2018)



3.1.1.4 Avalanche Mitigation Preliminary Alternatives

Based on public and agency input and analysis conducted by UDOT, Table 3-2 lists the preliminary alternatives that emerged from the scoping process to be considered in the avalanche mitigation screening process.

Table 3-2. Preliminary Alternatives – Avalanche Mitigation

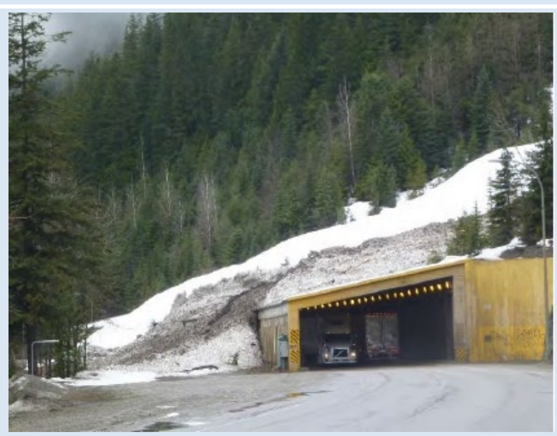
Avalanche Mitigation Alternative	Description	
Snow-supporting Structures Alternative	Snow-supporting structures are placed in the avalanche starting zone to hold the snow in place and prevent avalanches. Modern snow-supporting structures are now typically constructed using anchored wire nets, with either one single anchor point, or with supporting posts.	
Road Realignment and Bridges Alternative	S.R. 210 would be realigned to facilitate structures that would be built so that the avalanche flows could pass under the roadway to eliminate risk, or S.R. 210 would be realigned to move the road outside the avalanche path.	
Snow Sheds Alternative	Snow sheds are rigid, concrete and/or steel structures that protect a road by diverting avalanches over the top of the structure. Snow sheds mostly prevent avalanche flows from hitting a road, except in cases where they are not sufficiently long and can have the portals (open ends) overtopped.	

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Table 3-2. Preliminary Alternatives – Avalanche Mitigation

Avalanche Mitigation Alternative	Description	
Earth Berms Alternative (Stopping Dams and Diversion Berms)	Earth berms are large, earth-fill structures that are constructed in the runout zone to divert or stop avalanche flows. Berms that stop avalanches are called stopping dams, and berms that divert flow are called diversion berms. Berms are typically constructed of compacted earth, but other materials such as geotextiles and facing units (for example, gabbions, concrete blocks, or stacked rock) can be used to create a steep upslope face and reduce the amount of fill needed. The "China Wall" at the base of the White Pine path is an example of an earth-fill berm with stone facing.	
Stopping Walls Alternative	Stopping walls are constructed to stop avalanche dense flows in the runout zone typically adjacent to a highway or structure that is to be protected. Stopping walls can be reinforced concrete, concrete blocks, snow fence/catcher, and/or driven piles with cross members. Stopping walls are typically constructed where there are space restrictions; otherwise, earth-fill diversions or stopping dams tend to be more economical and can be constructed much higher.	
Reduce Traffic Flow Alternative (Bus/Gondola/Train)	This alternative includes options to reduce the vehicle use of Little Cottonwood Canyon through increased use of transit, gondola, or rail.	

3.1.2 Screening of Alternatives

This section describes the three-step screening process for evaluating alternatives to improve reliability and safety on S.R. 210 through avalanche mitigation. To screen the preliminary avalanche mitigation alternatives, UDOT conducted an initial preliminary evaluation prior to Level 1 and Level 2 screening. The purpose of the preliminary evaluation was to determine whether the preliminary alternatives are feasible for use in Little Cottonwood Canyon give the topographic features, large snow volumes, and avalanche type that occur. Following the preliminary evaluation, Level 1 and Level 2 screening was conducted.

3.1.2.1 Preliminary Alternatives Evaluation

The screening process for avalanche mitigation included a preliminary review of each alternative to determine whether the avalanche mitigation could substantially reduce the hours and days of closure caused by the type of avalanche that typically occurs in Little Cottonwood Canyon. In Little Cottonwood Canyon, the nature of the terrain (typically gullied and/or with smooth ground cover) and often dry snow characteristics result in very fast-moving, turbulent, mixed-flow avalanches, which have a basal dense flow component and a turbulent powder component. Wet flows are also common in the spring. This analysis is based on a review of the avalanche mitigation alternatives conducted by Dynamic Avalanche (Dynamic Avalanche Consulting 2018a, 2018b).

Little Cottonwood Canyon is in the Uinta-Wasatch-Cache National Forest. The canyon is home to two National Wilderness Areas: Twin Peaks Wilderness to the north of S.R. 210 and Lone Peak Wilderness to the south. The Wilderness Act does not allow permanent structures within a wilderness (for more information, see Section 1.4.4, Wilderness Act of 1964). Therefore, as part of the preliminary review of avalanche mitigation alternatives, UDOT eliminated from detailed consideration any alternative that would conflict with the Wilderness Act by requiring construction of a significant structure or fence in a wilderness area as long as there were other reasonable alternatives available that would avoid wilderness areas.

3.1.2.1.1 Snow-Supporting Structures Alternative

With this alternative, snow-supporting structures could be applied in many of the avalanche starting zone areas above Little Cottonwood Canyon. This option, however, would require the structure to be placed in a designated wilderness area, which conflicts with the Wilderness Act. In addition, the alternative would have a substantial visual impact and prevent backcountry skiing in some areas. Given the large number of avalanche starting zones, this alternative would require a substantial land area to be effective and could be used for only a few high-frequency avalanche paths. Because snow-supporting structures would need to be placed in a wilderness area and would reduce recreation activities in the area of the structure, they were not carried forward for Level 1 screening.

3.1.2.1.2 Road Realignment and Bridges Alternative

With this alternative, S.R. 210 would be realigned and bridges would be built so that avalanches would not impact the roadway. This configuration can be achieved by rerouting the roadway (away from the avalanche paths) or, in the right circumstances, spanning the avalanche paths with bridges. Although road realignment and bridges would prevent most avalanches from impacting the road, there would still be powder avalanche risk that would require UDOT to perform active avalanche control which would require some road closure.

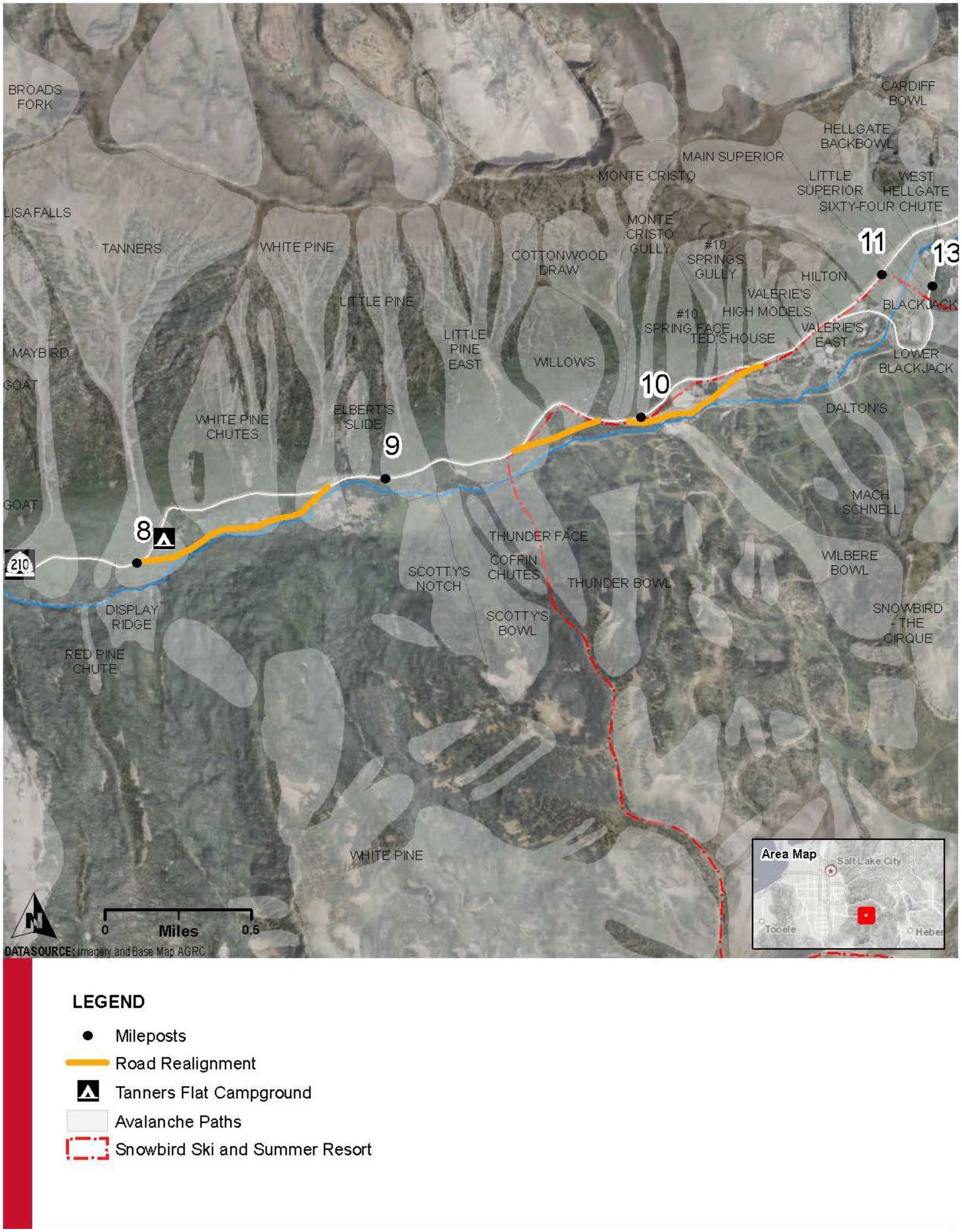
As shown in Figure 3-3, the main issue with road realignment and bridges is that the road would need to be realigned in the Tanner Flats Campground, thereby impacting this Section 4(f) resource and one of the primary campgrounds in Little Cottonwood Canyon. With the realignment, most of the camp sites would be eliminated. Additionally, the road realignment would require straightening the existing road, thereby increasing the grade from about 8% to 9.2%. Because the road realignment option would impact the Tanner Flat Campground, a Section 4(f) resource, and because other alternatives are available (snow shed alternative) that would avoid the campground, this alternative was not carried forward into Level 1 screening.

A second alignment was also suggested that would cross Little Cottonwood Creek south of the Tanners Flat Campground run on the south side of the canyon and cross the creek and reconnection with S.R. 210 before Snowbird Entry 1. This alternative was eliminated because it would cross into the Lone Peak Wilderness. The Wilderness Act states there shall be no commercial enterprise and no permanent road within any wilderness area designated by the Act.

3.1.2.1.3 Snow Sheds Alternative

Based on the preliminary evaluation, snow sheds would result in the greatest reduction in the avalanche hazard and would not impact any wilderness areas. Therefore, this alternative was carried forward into Level 1 screening. The width of the proposed snow sheds would cover the existing travel lanes in Little Cottonwood Canyon.

Figure 3-3. S.R. 210 Realignment for Avalanche Mitigation



3.1.2.1.4 Earth Berms Alternative

Berms need to be constructed high enough to either stop an avalanche flow or divert it. The height is determined by the sum of the height of snow on the ground, the height of previous deposits, the avalanche flow height, and, most importantly, the speed of the avalanche, which determines the run-up height of the avalanche flow on the berm. Avalanche flows would run up higher on a stopping dam where the dam is oriented perpendicular to the flow compared to a diversion berm, where the berm is oriented obliquely to the flow direction.

In Little Cottonwood Canyon, the nature of the terrain (typically gullied and/or with smooth ground cover) and often dry snow characteristics result in very fast-moving, turbulent, mixed-flow avalanches, which have a basal dense flow component and a turbulent powder component. Wet flows are also common in the spring. Because of the fast-moving avalanches, diversion and stopping berms need to be very high to be effective for the dense flow, and would typically be ineffective for stopping or diverting the powder component. Berm walls were not carried forward for Level 1 screening because they would not be effective for very fast-moving avalanches and would be overtopped by powder avalanche flows, which could become airborne below the berm. Diversion berms were not carried forward for Level 1 screening eliminated because the berm would divert avalanche flows to adjacent areas, which could reduce the hazard in one path and increase the risk in others, thereby not changing the overall risk.

3.1.2.1.5 Stopping Walls Alternative

The Little Cottonwood Canyon corridor was reviewed to determine areas where stopping walls would be feasible. No locations were identified where stopping walls would be completely effective. All of the paths reviewed produce fast-moving, turbulent avalanches that would simply overtop these structures, and active avalanche control would still be needed to reduce risk to acceptable levels. Therefore, stopping walls were not carried forward for Level 1 screening.

3.1.2.1.6 Reduce Traffic Flow Alternative

This avalanche mitigation alternative would use some type of mass transit option to reduce the risk of the avalanche hazard. The type of transit could include bus, train, or gondola. All options would require some form of traffic-management strategies to shift travelers onto mass transit instead of personal vehicles. The option would not fully eliminate use of S.R. 210 by vehicles, since delivery trucks and residents would still need access.

A rail or bus option would reduce the likelihood of an avalanche/vehicle encounter by reducing the number of vehicles on the road. Even under high avalanche-hazard conditions, the train or bus could be coordinated with the avalanche forecasters to minimize the probability of encounter (for example, by regulating departures as a function of avalanche control). The challenge with a road-focused option is that avalanche debris would still need to be removed from the tracks or road. Although reducing vehicles to about 1,000 cars per day could reduce the AHI to 37, it would not reduce the days or hours of closure since avalanche-control work would still need to be performed, similar to current conditions. A gondola system would eliminate most of the avalanche hazard since it would travel over the avalanche paths. During avalanche-related road closures, skiers could shift to the gondola. Therefore, a gondola system was carried forward for Level 1 screening.

3.1.2.2 Level 1 Screening

3.1.2.2.1 Level 1 Screening Alternatives

Based on UDOT's evaluation of the preliminary avalanche mitigation alternatives, the following alternatives and measure were eliminated from further consideration:

- Active avalanche-control measures
- Snow-supporting Structures Alternative
- Road Realignment and Bridges Alternative
- Earth Berms Alternative
- Stopping Walls Alternative

The following alternatives were carried forward for Level 1 screening:

- Snow Sheds Alternative
- Reduce Traffic Flow Alternative (Gondola)

3.1.2.2.2 Level 1 Screening Criteria

The alternatives that were evaluated in Level 1 screening for avalanche mitigation were evaluated against the criteria in Table 3-3. The criteria focused on reducing the number of hours and/or days when S.R. 210 is closed because of avalanche mitigation and reducing the avalanche hazard to roadway users.

Table 3-3. Level 1 Screening Criteria – Avalanche Mitigation

Criterion	Measure
Improve avalanche related roadway reliability and safety in 2050	• Substantially reduce number of hours and/or days that avalanches delay users. • Substantially reduce the avalanche hazard for roadway users.

3.1.2.2.3 Level 1 Screening Methodology

For Level 1 screening of the avalanche mitigation alternatives, UDOT hired experts in avalanche analysis and mitigation techniques to conduct the analysis. During the process, two reports were produced:

- *Little Cottonwood Canyon EIS, Snow Avalanche Hazard Baseline Condition Report* (Dynamic Avalanche Consulting 2018a)
- *Little Cottonwood Canyon EIS, Snow Avalanche Hazard Improvement Options Report* (Dynamic Avalanche Consulting 2018b)

The methods used to conduct the analysis included the following:

- Re-map avalanche paths affecting the road using high-resolution topography and images.
- Review avalanche occurrence data and historical information (written and verbal from avalanche forecasters) for avalanche history.
- Analyze avalanche magnitude and frequency.
- Conduct a field validation trip to Little Cottonwood Canyon to assess remapped avalanche paths.
- Conduct sensitivity analysis of the AHI for the current conditions that reflect a range of traffic conditions during the winter.
- Re-evaluate AHI based on the alternatives, including sensitivity analyses.
- Prepare a report that evaluates the potential reduction in AHI and reduction in closure times.

3.1.2.2.4 Level 1 Screening Results

As shown in Table 3-4, in 2050, Little Cottonwood Canyon is projected to be closed up to about 21 days and 108 hours per winter season for avalanche-mitigation work. The increase in closures is based on the greater risk with higher traffic volumes in 2050 compared to 2017. The AHI for Little Cottonwood Canyon with the current type of active avalanche-mitigation program would be an AHI of 96, or High Risk by 2050.

Table 3-4. Level 1 Screening Results – Avalanche Mitigation

Concept	Traffic (vehicles/ day)	AHI[a]	Average Days of Closures	Average Hours of Closures	Estimated Cost (2018 dollars)
Current avalanche mitigation strategies – 2018 traffic volumes	8,200	90	10.4	56.3	Not applicable
Current avalanche mitigation strategies – 2050 traffic volumes	11,300	96	10.5 to 21	56 to 108+	<$50 million
Snow shed with 2050 traffic volumes	11,300	59	4 to 6	2 to 11	$70–$90 million
Gondola with 2050 traffic volumes[b]	1,000+	37	10.5 to 21	56 to 108+	$312–$343 million

[a] AHI is the avalanche hazard index. <1 = very low; 1 to 10 = low; 10 to 40 = moderate; 40 to 150 = high; > 150 = very high
[b] Assumes vehicle traffic-management strategies implemented to increase use of gondola

As shown above in Table 3-4, both the snow shed and gondola alternatives would substantially reduce the avalanche hazard for roadway users, reducing the AHI in 2050 from 96 to 59 for the snow shed alternative and to 37 for the gondola alternative. The snow shed alternative would reduce the hazard by allowing avalanche flows to go over the road, and the gondola alternative by passing the avalanche flow under the gondola system.

The gondola alternative would require some form of congestion-management strategy to make vehicle users shift to the gondola system. However, even with a toll in place, some users including delivery truck drivers, residents, and skiers who still want to use their personal vehicles, would still use the road. Although the gondola alternative would reduce vehicle use of S.R. 210 (assuming a high user fee for vehicles), there would still need to be a substantial active avalanche-control program, similar to current conditions. Using the same avalanche-mitigation system would result in the same number of days and hours of closure as with the current active avalanche-mitigation strategies and thus would not meet the criterion of substantially reducing the number of hours and/or days when avalanches delay users. However, the gondola system would provide the opportunity for skiers to shift to the gondola when the road is closed. Therefore the gondola alternative was considered a reasonable alternative to building snow sheds. The gondola might not be able to operate during active avalanche control since it would be in the path of artillery fire. The gondola would need to be out of service only during the time artillery is in use and could immediately operate after active avalanche-control operations cease, likely early in the morning.

Although it was not a screening criterion, UDOT considered the use of artillery shells in evaluating avalanche mitigation. From 2004 to 2017, an average of 153 artillery shells per ski season were fired into the avalanche paths considered in the study area. With the gondola alternative, UDOT would still need to conduct avalanche control and artillery use similar to existing conditions. However, with the snow shed alternative, UDOT anticipates that artillery use could be reduced by 80% to about 31 artillery shells per season (Dynamic Avalanche Consulting 2019).

Because the snow shed alternative would both substantially reduce the number of days and hours of road closure and substantially reduce the avalanche hazard to roadway users, the **Snow Sheds Alternative** was carried forward for Level 2 screening along with the **Reduce Traffic Flow Alternative** (with a gondola system) (for more information about the gondola system, see Section 2.2.2.2.2, Aerial Transit from the Salt Lake Valley Alternative).

3.1.2.3 Level 2 Screening

The Snow Sheds Alternative and the Reduce Traffic Flow Alternative (with a gondola system) were carried forward for Level 2 screening.

For Level 2 screening, UDOT developed three snow shed alternatives (see Appendix J, Draft Snow Shed Concepts) and evaluated them along with Gondola Alternative 3B from the analysis of aerial transit alternatives:

- **Snow Sheds Alternative with No Berms** – two snow sheds with total length of 3,194 feet.
- **Snow Sheds Alternative with Berms** – two snow sheds with total length of 2,465 feet. Berms reduce snow shed length by guiding avalanche flows over smaller sheds. Two berms would be required for each shed, about 20 feet high and 300 feet long.
- **Snow Sheds Alternative with Realigned Road and No Berms** – two snow sheds with a total length of 3,194 feet. UDOT would realign the road to place snow sheds closer to the mountain to reduce cost of material needed to fill the gap between the mountain and snow sheds. The alternative also lessens curves to improve safety in the tunnels without substantially increasing the road grade.
- **Gondola Alternative 3B** – See Section 2.2.2.2.2, Aerial Transit from the Salt Lake Valley Alternative, for Level 2 screening information for the gondola alternative.

UDOT developed a preliminary engineering design for each alternative to determine the expected impacts for each Level 2 criterion [see Table 1-2, Level 2 Screening Criteria (Impacts), above]. Table 3-5 shows the results of Level 2 screening. For information about the Level 2 screening of the gondola alternative, see Section 2.2.2.2.2, Aerial Transit from the Salt Lake Valley Alternative.

Table 3-5. Level 2 Screening Results – Avalanche Mitigation

Impact Criterion	Unit	Alternative		
		Snow Sheds with No Berms	Snow Sheds with Berms	Snow Sheds with Realigned Road and No Berms
Natural Environment[a]				
Wetlands	Acres	0.00	0.00	0.00
Streams	Acres	0.01	0.01	0.01
Critical habitat	Acres	0.00	0.00	0.00
Floodplains	Acres	0.01	0.14	0.03
Impacts to wilderness areas	Acres	0.00	0.00	0.00
Built Environment[a]				
Consistency with USDA Forest Service Plan	Yes/no	Yes	Yes	Yes
Consistency with local plans	Yes/no	Not applicable	Not applicable	Not applicable
Recreation sites	Number	0	0	0
Community facilities	Number	0	0	0
Residential relocations	Number	0	0	0
Business relocations	Number	0	0	0
Section 4(f) properties	Number	1	1	1
Historic properties	Number	1	1	1
Cost of alternative in 2020 (in 2020 dollars)	Dollars	$89 million	$72 million	$86 million

[a] The acreage or number of impacts is based on a screening-level design. The actual impacts could decrease or increase based on more-detailed design conducted for the alternatives that pass Level 2 screening.

3.1.2.3.1 Level 2 Screening Results

As shown above in Table 3-5, the results are similar among the snow shed alternatives evaluated in Level 2 screening, with the main differences being the amount of floodplains impacted and cost. Reviewing the impact and cost information, UDOT decided to carry forward the Snow Shed with Berms Alternative because it had the least cost by $14 million as a result of the reduced snow shed length. Although the Snow Shed with Berm Alternatives would have high visual impacts, it would contribute to a reasonable range of alternatives to evaluate in further detail in the EIS.

Comparing the impacts and cost of the two snow shed alternatives without berms (Snow Sheds Alternative with No Berms and Snow Sheds Alternative with Realigned Road and No Berms) shows that the impacts would be similar, with the only difference about 0.02 acre of floodplain impact. However, between the two alternatives, the alternative with the realigned road would lessen curves in the snow sheds, which would improve driver safety, move the road slightly farther from Little Cottonwood Creek, and cost about $3 million less; therefore, UDOT selected the Snow Sheds Alternative with Realigned Road and No Berms to be evaluated further in the EIS.

Based on the Level 2 screening process for snow sheds, UDOT decided to carry forward the **Snow Sheds Alternative with Berms** and the **Snow Sheds Alternative with Realigned Road and No Berms** for detailed evaluation in the EIS. The Snow Sheds Alternative with No Berms was eliminated from further consideration. **Gondola Alternative 3B** is being carried forward for detailed evaluation in the EIS as an alternative for improving mobility on S.R. 210 from Fort Union Boulevard to Alta as well as an alternative to address avalanche mitigation.

3.1.2.3.2 Alternatives Carried Forward for Further Evaluation

The following avalanche mitigation alternatives will be carried forward for further evaluation in the EIS:

- Snow Sheds Alternative with Berms
- Snow Sheds Alternative with Realigned Road and No Berms
- Gondola Alternative 3B

3.2 Improve Reliability and Safety through Improving Trailhead Parking

Trailhead parking areas in Little Cottonwood Canyon are small and can quickly reach capacity in the summer, forcing many people to park on the side of the road and walk along or across the roadway to access trailheads, which creates a safety risk. One of the most congested parking areas is the White Pine Trailhead, located at a curve with limited sight distances and narrow shoulders, which increase safety-related risk for motorists, bicyclists, and pedestrians. Roadside parking also creates a safety hazard for cyclists and pedestrians traveling along the roadway shoulder because it narrows the area in which they can travel and requires them in some locations to use part of the travel lane to pass park vehicles. Therefore, to meet the criteria of improving safety and reducing traffic conflicts, the roadside parking would need to be eliminated as part of any alternative.

Eliminating roadside parking would improve safety by removing the need for trail users parked along S.R. 210 to walk along or cross the road in areas with limited sight distance and potentially getting struck by road traffic. Eliminating roadside parking would also remove the conflict of cyclists being forced around shoulder-parked vehicles and into the road travel lanes. Other benefits of removing roadside parking include eliminating a rut at the edge of the pavement and removing a network of “spider web” trails that promote erosion and weed infestation. Erosion caused by roadside parking can reduce water quality in Little Cottonwood Creek. Additionally, the improved parking would include enough restroom capacity to handle the number of parking spaces being proposed with each alternative. Restroom facilities would help improve water quality.

3.2.1 Range of Alternatives

UDOT developed a list of preliminary alternatives for improving reliability and safety on S.R. 210 by improving trailhead parking. UDOT gathered these alternatives from public and agency input and the following studies:

- *Cottonwood Canyons Parking Study – Existing Conditions* (Avenue Consultants 2012a)
- *Cottonwood Canyons Parking Study – Recommendations* (Avenue Consultants 2012b)

The USDA Forest Service manages in-canyon parking in Little Cottonwood Canyon per the *Revised Forest Plan Wasatch-Cache National Forest* (USDA Forest Service 2003). For the purpose of watershed protection, the plan indicates that a desired future condition in the Tri-Canyon Area (Big Cottonwood, Little Cottonwood, and Mill Creek Canyons) is to maintain the parking capacities of canyon parking areas (ski area lots, summer-use homes, and developed and dispersed recreation sites) so that parking capacity does not exceed that in year 2000 unless modification is needed for watershed protection or to facilitate mass transit. The USDA Forest Service has been using the 2012 *Cottonwood Canyons Parking Study – Existing Conditions* as the baseline for the 2000 levels since no counts were taken at that time. None of the alternatives developed by UDOT for this analysis would increase parking levels in Little Cottonwood Canyon beyond those estimated in the *Cottonwood Canyons Parking Study – Existing Conditions*. The study included both formal and informal (shoulder) parking in the capacity analysis.

3.2.1.1 Alternatives from Previous Studies

As part of a Cottonwood Canyons Parking Study, a steering committee was assembled from representatives of key stakeholder agencies including Salt Lake County, UDOT, UTA, the USDA Forest Service, Salt Lake City Watershed Planning and Restoration, and WFRC. Additionally, the City of Cottonwood Heights, Sandy City, the resorts, canyon user groups, law enforcement, and other interested parties were consulted outside of steering committee meetings regarding areas within their spheres of influence (Avenue Consultants 2012b).

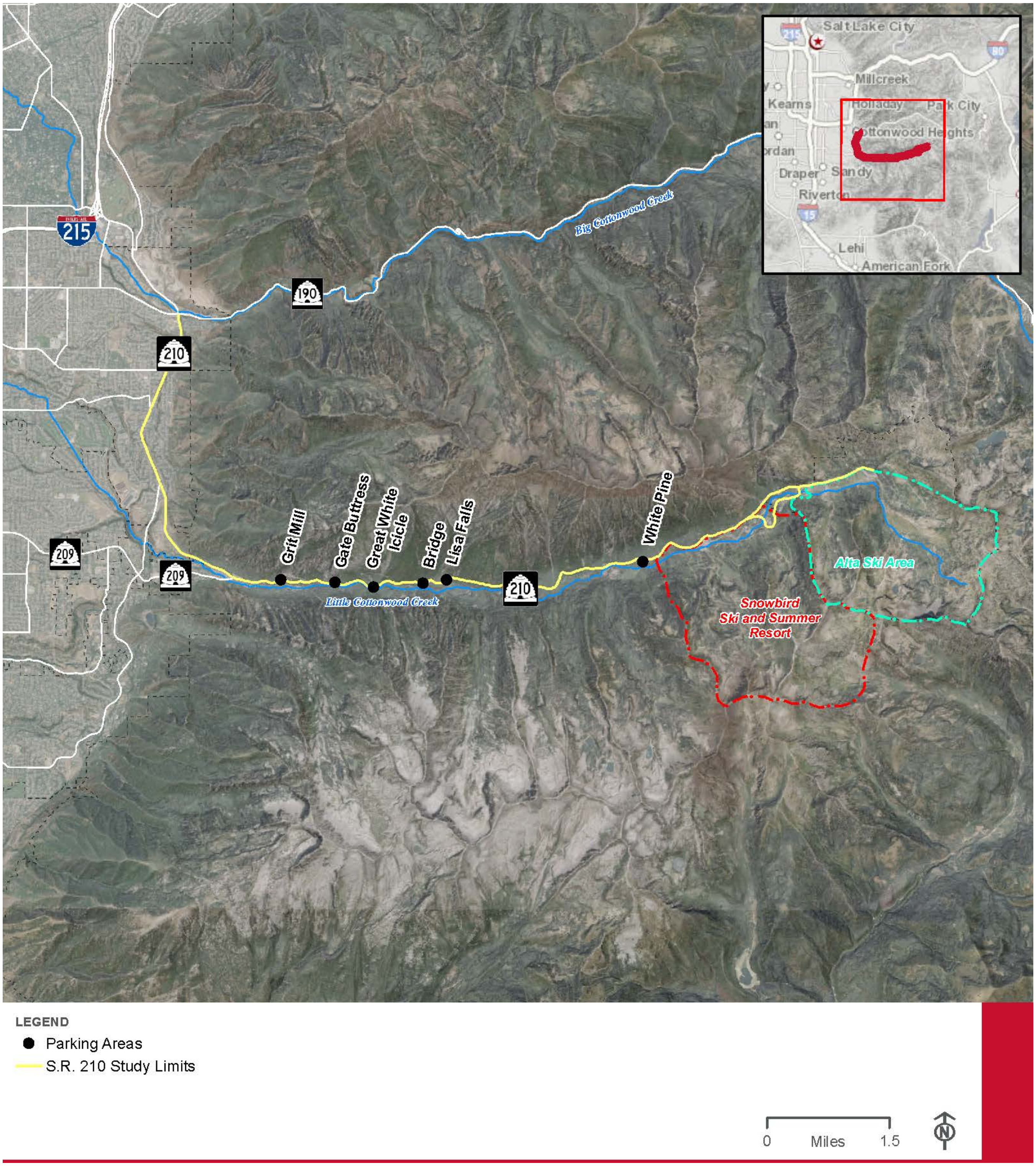
The primary purpose of the study was to identify parking needs for Big and Little Cottonwood Canyons and to develop recommendations that address those needs. The parking improvement goals of the study were safety, capacity, environmental protection, notification and wayfinding, transit support, and maintenance and enforcement. Some of the primary guiding principles included preserve the watershed, incorporate transit opportunities, enhance bicycle safety, preserve the recreational experience by limiting capacity in some areas, and ensuring no net increase in the total number of parking spaces in the canyons. To determine trailhead parking capacities, the study grouped parking within a suitable walking distance of ¼ mile of the parking at trailheads (Avenue Consultants 2012a).

The steering committee narrowed 35 candidate improvement areas down to 17 recommended locations or focus areas in both Big and Little Cottonwood Canyons. These locations included highly used locations inside the canyons, highly used locations at the entrances of the canyons, locations with opportunities for future transit or carpool expansion, and locations identified in previous studies. The focus areas in Little Cottonwood Canyon were the following (Figure 3-4):

- Grit Mill Trailhead
- Lisa Falls Trailhead
- White Pine Trailhead

The USDA Forest Service has completed the planning and environmental process for the Grit Mill parking improvements. An Environmental Assessment for the Grit Mill and Climbing Master Plan Project has been prepared (USDA Forest Service 2014), design for the parking area has been completed, and partial funding has been allocated. Once complete funding is allocated, the project will be constructed; therefore, this alternative will not be evaluated further in the Little Cottonwood Canyon EIS as an alternative.

Figure 3-4. Potential Parking Area Locations



3.2.1.2 Alternatives Suggested during Scoping

3.2.1.2.1 UDOT and USDA Forest Service Evaluation

In addition to the Lisa Falls and White Pine parking areas, UDOT worked with the USDA Forest Service to determine other potential parking locations in Little Cottonwood Canyon. UDOT's review of aerial images taken on a Saturday (June 17, 2017) showed about 10 cars parked on the shoulder of S.R. 210 in the vicinity of Lisa Falls Trailhead (about 0.3 mile down canyon from Lisa Falls) at a connecting trailhead (Bridge Trailhead) that connects to the Little Cottonwood Canyon Trail and can be used to access Lisa Falls Trailhead. Therefore, UDOT and the USDA Forest Service agreed to include the Bridge Trailhead as an alternative for trailhead parking.

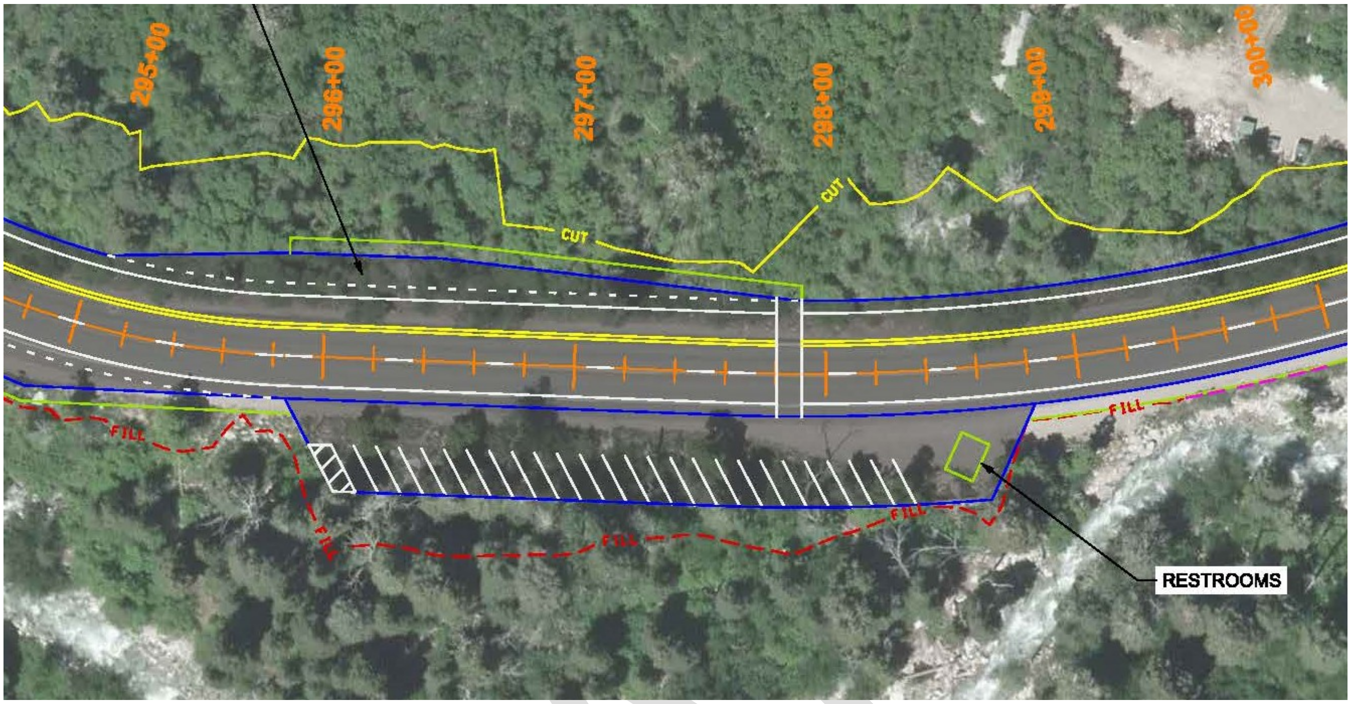
UDOT looked at existing dirt pullouts along S.R. 210 in Little Cottonwood Canyon. However, in working with the USDA Forest Service, UDOT decided not to consider the small pullouts for improvement because most do not include an area to provide parking along with restroom and water qualify best management practices or a designated trailhead with access to the forest. Plus, informal dirt pullout parking areas would not allow the USDA Forest Service to manage the use of the areas adjacent to the parking area for watershed protection.

3.2.1.2.2 Gate Buttress and Great White Icicle

During the 2019 EIS scoping period, the Salt Lake Climbers Alliance requested that Gate Buttress be considered as a parking area. The Gate Buttress is used by climbers to access boulders and climbing areas in lower Little Cottonwood Canyon. Currently there is an existing off-road dirt parking area on the north side of S.R. 210 with a capacity of about 30 vehicles. The property at the parking area is owned by the Church of Jesus Christ of Latter-day Saints and is used under an agreement with the Salt Lake Climbers Alliance. Because this is an existing informal parking area with trails connecting to climbing areas, UDOT decided to include the Gate Buttress as an alternative for trailhead parking.

Parking was also investigated for a climbing area called the Great White Icicle (Figure 3-5), which is a winter climbing area on the south side of Little Cottonwood Canyon. To minimize pedestrians crossing the road on a corner, the proposed concept was designed on the south side of S.R. 210. In this area, Little Cottonwood Creek is immediately adjacent to S.R. 210. One concern with the concept is that it could promote crossing the creek on a water pipeline on private land marked No Trespassing. Because the parking area would be within 20 feet of Little Cottonwood Creek and because the riparian corridor could be damaged during construction, this parking concept was not carried forward for Level 1 screening. Access to the Great White Icicle climbing area can be provided by the proposed Bridge Trailhead ½ mile up canyon where there is an existing bridge that crosses Little Cottonwood Creek and an existing trail on the south side of the creek that can provide access to the climbing area.

Figure 3-5. Great White Icicle Trailhead Parking Concept



3.2.1.2.3 Elimination of Roadside Parking, No Trailhead Expansion, and Summer Transit

In a meeting with Save Our Canyons on January 16, 2019, an alternative was suggested to UDOT: do not increase parking lot sizes and instead provide transit stops at the trailheads (UDOT Alternative C). If this were considered along with eliminating roadside parking, it would reduce the ability of recreational users to use personal vehicles to access trailheads beyond the existing parking lots. Based on input from Save Our Canyons, UDOT decided to evaluate an alternative that would eliminate roadside parking on S.R. 210 from S.R. 209 to Snowbird Entry 1 and would not include expansion of existing parking areas. The elimination of roadside parking from S.R. 209 to Snowbird Entry 1 and no parking expansion is different from the No-Action Alternative in that it eliminates roadside parking in Little Cottonwood Canyon in areas associated with trailhead parking.

The assumption with the alternative suggested by Save Our Canyons and other scoping comments is that UTA or a private vendor would provide supporting summer transit service to allow recreation users to access the trailheads. Currently, neither UTA nor private vendors provide summer transit services. The purpose of improving trailhead parking is to remove roadside parking conflicts between cyclists and pedestrians and vehicles parking on the road shoulder and partially in the travel lane, not to increase use at trailheads by providing summer transit service. Summer mobility was not identified as a project need; therefore, summer transit service that could improve mobility was not carried forward for Level 1 screening. Implementation of summer transit is an operational issue and can be implemented independently of the Little Cottonwood Canyon EIS process. In addition, this alternative does not preclude UTA or a private vendor from implementing a summer transit service with approval from the USDA Forest Service.

3.2.1.3 Trailhead Parking Preliminary Alternatives

Based on the *Cottonwood Canyons Parking Study – Recommendations* study and in working with the USDA Forest Service and other stakeholder input, UDOT developed the preliminary alternatives listed in Table 3-6 (see Figure 3-6 through Figure 3-9 for UDOT options). To determine the size to improve parking areas, UDOT determined the number of roadside parking spaces within ¼ mile on either side of the existing parking area that would be eliminated. A ¼-mile distance was used in the 2012 Avenue Consultants study to determine parking area capacities, and the study noted that ¼ mile was a suitable walking distance to trailhead locations (Avenue Consultants 2012a). Another study found that ¼ mile is a reasonable walking distance for parents to take children to a park location (Wolch and others 2005). Additionally, of the trailheads evaluated, the greatest roadside parking distance from the trailhead for vehicles parked on the road was observed at the White Pine Trailhead, where during peak periods vehicles were observed parking on the roadside out to about ¼ mile on either side of the trailhead.

UDOT considered one parking lot improvement alternative (Alternative A) each for the Gate Buttress and Bridge Trailheads and two alternatives (Alternatives A and B) for the Lisa Falls and White Pine Trailheads. With the improved parking lot alternatives (Alternatives A and B), UDOT considered two alternatives for roadside parking: one that would eliminate roadside parking within ¼ mile of each trailhead parking area and one that would eliminate all roadside parking from the intersection of S.R. 209/S.R. 210 to Snowbird Entry 1. Alternative C includes eliminating roadside trailhead parking related to summer use from the intersection of S.R. 209/S.R. 210 to Snowbird Entry 1 and no expansion of existing parking areas.

Table 3-6. Preliminary Alternatives – Trailhead Parking

Location	Canyon Parking Study Alternatives[a]	Alternatives A[b]	Alternatives B[b]	Alternative C
Gate Buttress	None	Proposed – 21 spaces Includes eliminating roadside parking within ¼ mile on either side of road from trailhead.	None	No parking area expansion at any trailhead, and eliminate roadside parking from the intersection of S.R. 209/S.R. 210 to Snowbird Entry 1.
Bridge Trailhead	None	Proposed – 15 spaces Includes eliminating roadside parking within ¼ mile on either side of road from trailhead. Create parking area on south side of road and include restrooms.	None	
Lisa Falls Trailhead	Proposed – 65 spaces Expand existing parking lot (20 spaces), expand Cottonwood south pullout (20 spaces), and improve shoulder parking (25 spaces).	Proposed – 41 spaces Includes eliminating roadside parking within ¼ mile on either side of road from trailhead. Expand existing parking lot and include restrooms. The number of parking spaces had to be reduced by 5 from existing conditions because the topography limits the number of parking spaces.	Proposed – 46 spaces Includes eliminating roadside parking within ¼ mile on either side of road from trailhead. Expand existing parking lot to the North of S.R. 210, realign the road on a bridge, and include restrooms.	
White Pine Trailhead	Proposed – 125 spaces Expand existing parking lot (80 spaces) and improve shoulder parking (45 spaces).	Proposed – 144 spaces Includes eliminating roadside parking within ¼ mile on either side of road from trailhead. Expand existing parking lot and provide restrooms.	Proposed – 141 spaces Includes eliminating roadside parking within ¼ mile on either side of road from trailhead. This alternative would reduce the size of the main parking by providing 25 angled parking spaces on S.R. 210. Restrooms are included in the design.	

[a] No design figures were provided as part of the Canyon Parking Study.

[b] Both options can support elimination of roadside parking within ¼ mile of the trailhead and from the intersection of S.R. 209/S.R. 210 to the entrance to Snowbird Entry 1.

Table 3-7 shows the proposed total number of parking spaces proposed with each alternative.

Table 3-7. Total Parking Spaces from S.R. 209/S.R. 210 to Snowbird Entry 1

Parking Area	Number of Parking Spaces[a]						
	Existing Parking	Canyon Parking Study Alternatives	Alternatives A		Alternatives B		Alternative C
			No Roadside Parking ¼ Mile from Trailhead	No Roadside Parking to Snowbird Entry 1	No Roadside Parking ¼ Mile from Trailhead	No Roadside Parking to Snowbird Entry 1	
Roadside parking	429	308	290	0	290	0	0
Gate Buttress	30 (in formal dirt lot)	30 (in formal dirt lot)	21	21 [b]	21	21 [b]	30 (in formal dirt lot)
Bridge Trailhead	N/A (roadside parking only)	N/A (roadside parking only)	15	15[b]	15	15 [b]	0
Lisa Falls Trailhead	17 (north and south dirt pullouts)	65	41	41	46	46	17 (north and south dirt pullouts)
White Pine Trailhead	52	125	144	144	141	141	52
Total parking spaces[a]	**528**	**528**	**511**	**221**	**513**	**223**	**99**

[a] The total number of parking spaces did not capture all of the smaller available pullouts along S.R. 210, so the total number of existing parking would be higher. The proposed Grit Mill parking area is expected to be built in 2020 and was not included as part of the analysis.

[b] There is no Option B for this trailhead. The analysis assumes that the Option A design is included in the parking space numbers.

Some of the alternatives listed above in Table 3-7 would require the use of USDA Forest Service–managed land. UDOT does not currently have a perfected easement for the entire length of S.R. 210 on those lands. If proposed improvements would occur on NFS)-managed land not already appropriated by FHWA, this action would be subject to the conditions of 23 USC Section 317, *Appropriation for Highway Purposes of Lands or Interests in Lands Owned by the United States*. Through this appropriation process, the U.S. Secretary of Agriculture can certify that the appropriation of NFS-managed land for transportation use is contrary to the public interest or inconsistent with the purposes for which the NFS-managed land was originally reserved, or agree to the appropriation and transfer of the land to FHWA and UDOT, potentially with stipulated conditions to protect NFS-managed land. In addition, any project actions proposed on NFS-managed land that would not otherwise be appropriated by FHWA might require a decision by the USDA Forest Service.

Figure 3-6. Gate Buttress Trailhead Alternative A

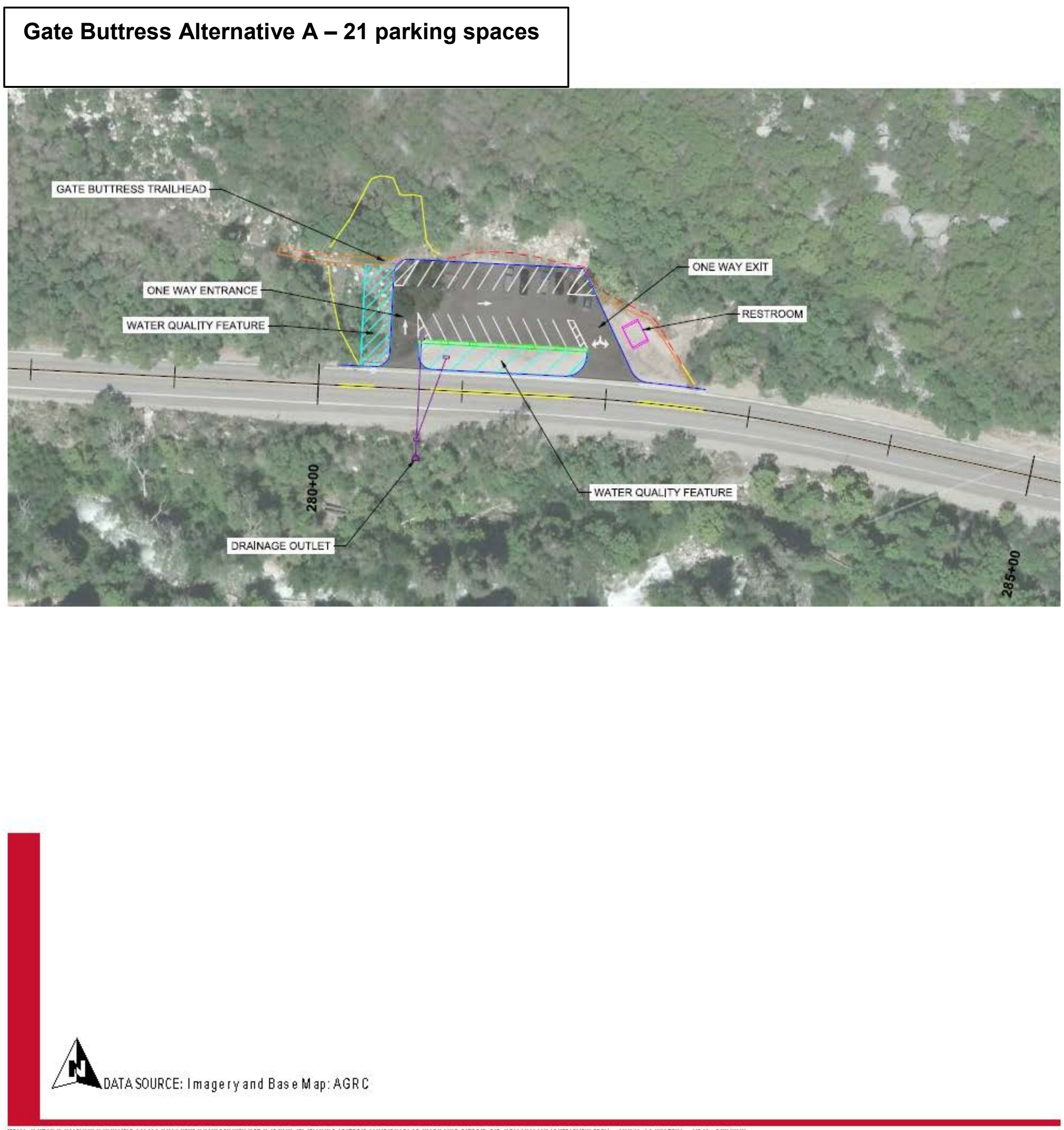
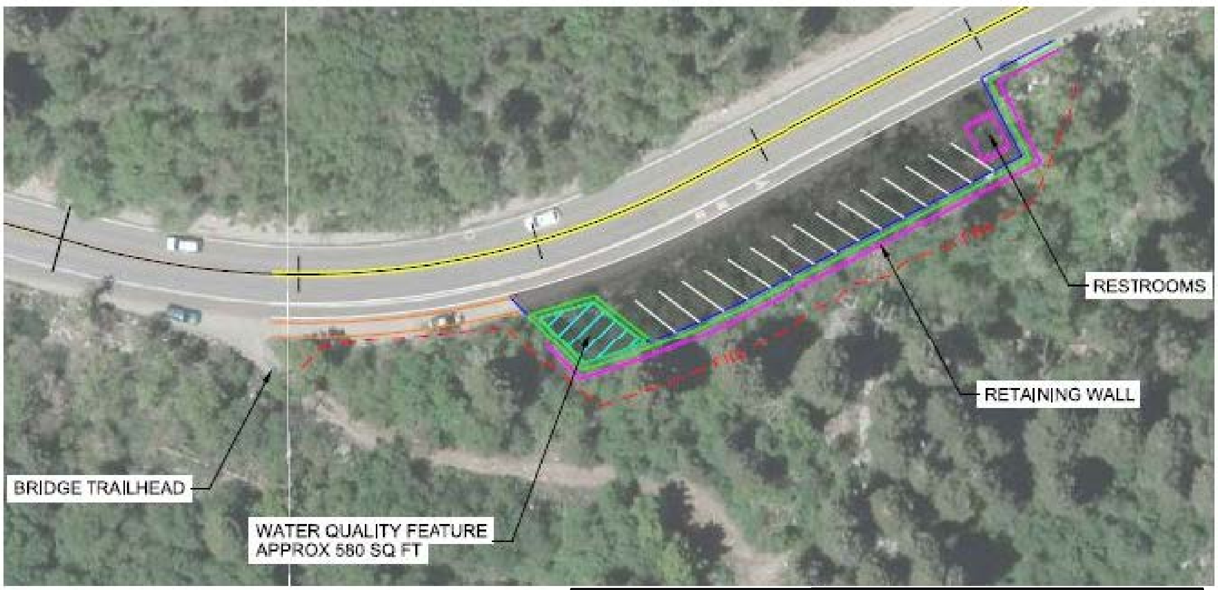


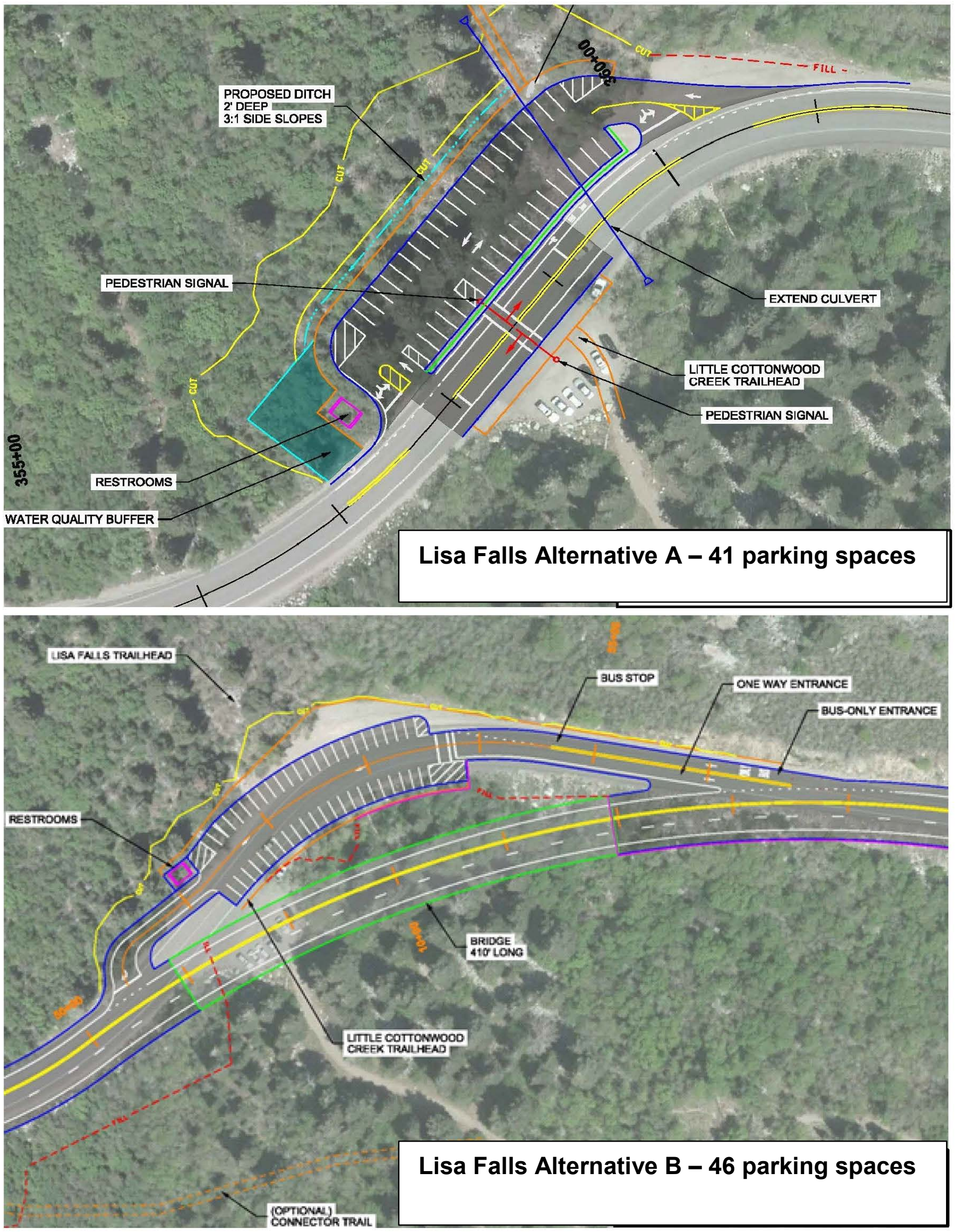
Figure 3-7. Bridge Trailhead Alternative A



Bridge Trailhead Alternative A – 15 parking spaces

DATA SOURCE: Imagery and Base Map: AGRC

Figure 3-8. Lisa Falls Trailhead Alternatives A and B



DATA SOURCE: Imagery and Base Map: AGRC

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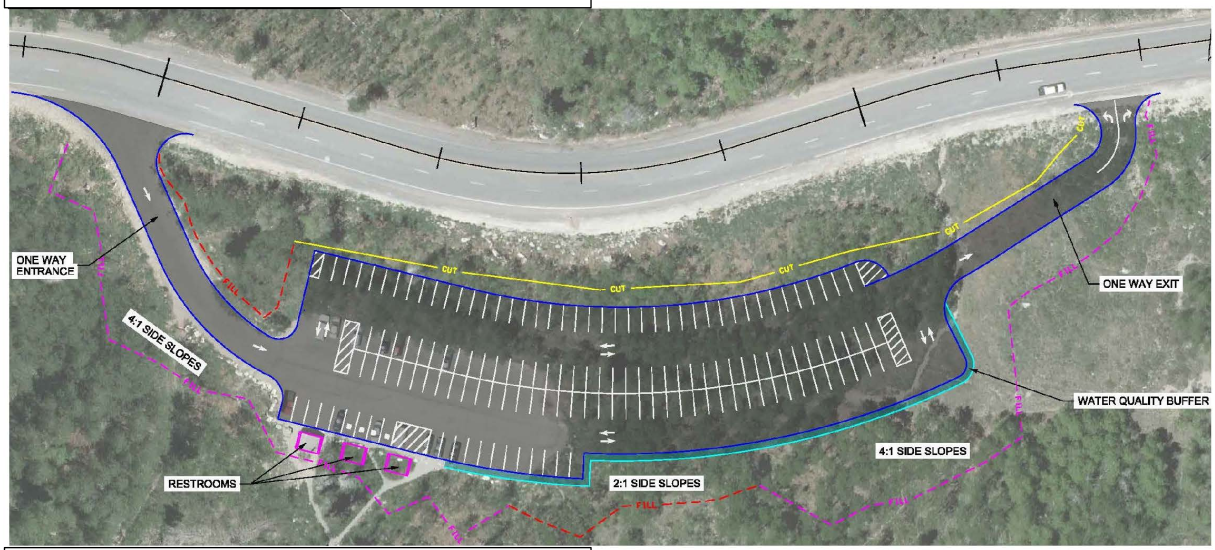
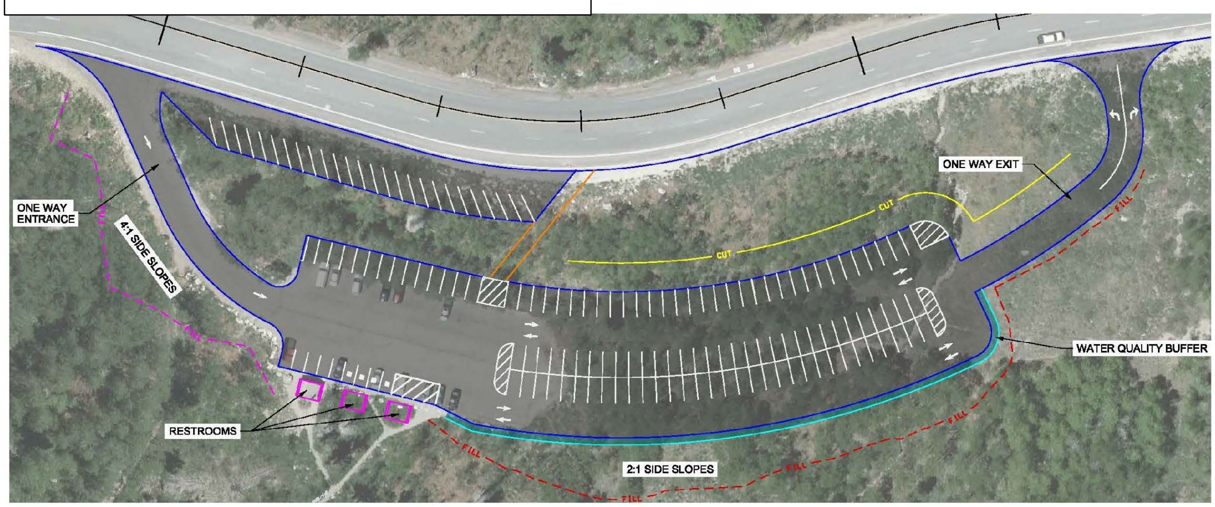
Figure 3-9. White Pine Trailhead Alternatives A and B

White Pine Alternative A – 144 parking spaces



White Pine Alternative B – 141 parking spaces



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3.2.2 Screening of Alternatives

3.2.2.1 Level 1 Screening

3.2.2.1.1 Level 1 Screening Criteria

The four alternatives that were evaluated in Level 1 screening for improving trailhead parking were screened against the criterion in Table 3-8. The criterion focuses on reducing conflicts at existing trailheads, improving safety, and maintaining or reducing existing parking levels.

Table 3-8. Level 1 Screening Criteria – Trailhead Parking

Criterion	Measure
Improve reliability and safety in 2050	• Improve safety at existing trailhead locations. • Reduce or eliminate traffic conflicts between motorized and nonmotorized transportation modes at existing trailhead locations. • Reduce or eliminate roadside parking to improve the safety and operational characteristics of S.R. 210.

3.2.2.1.2 Level 1 Screening Results

Table 3-9 shows the results of Level 1 screening for the trailhead parking alternatives. As shown in the table, all of the Alternative A trailhead alternatives, White Pine Alternative B, and Alternative C (no parking improvements and eliminate roadside parking) passed Level 1 screening. Red-shaded cells in the table are those alternatives that did not pass the Level 1 screening criteria. The A and B Alternatives that passed screening could include eliminating roadside parking within ¼ mile of the improved trailhead parking or eliminating all roadside parking from the S.R. 209/S.R. 210 intersection to Snowbird Entry 1 along with the improved trailhead parking.

Table 3-9. Level 1 Screening Results – Trailhead Parking

Alternative	Level 1 Screening Criteria: Improve Safety	Level 1 Screening Criteria: Reduce Traffic Conflicts	Level 1 Screening Criteria: Reduce or Eliminate Roadside Parking to Improve Safety and Operations	Recommended for Further Analysis in Level 2 Screening?	Notes
No-Action Alternative	No	No	No	No	
Canyon Parking Study Alternatives					
Gate Buttress	**Not applicable**	**Not applicable**	**Not applicable**	**Not applicable**	Not included in Canyon Parking Study
Bridge Trailhead	**Not applicable**	**Not applicable**	**Not applicable**	**Not applicable**	Not included in Canyon Parking Study
Lisa Falls Trailhead	No	No	**Yes**	No	Alternative includes shoulder parking thus would not substantial reduce conflicts or improve safety for pedestrian and bicyclist. Parking spaces increase existing levels.
White Pine Trailhead	No	No	**Yes**	No	Alternative includes shoulder parking thus would not substantial reduce conflicts or improve safety for pedestrian and bicyclist. Parking spaces increase existing levels.
Alternative A					
Gate Buttress	**Yes**	**Yes**	**Yes**	**Yes**	
Bridge Trailhead	**Yes**	**Yes**	**Yes**	**Yes**	
Lisa Falls Trailhead	**Yes**	**Yes**	**Yes**	**Yes**	
White Pine Trailhead	**Yes**	**Yes**	**Yes**	**Yes**	
Alternative B					
Lisa Falls Trailhead	**Yes**	**Yes**	**Yes**	**No**	The concept was eliminated because it would require a 475-foot bridge structure that would increase cost by about $15 million over Alternative A. In addition, the concept would require greater environmental impacts along S.R. 210 with the realigned road.
White Pine Trailhead	**Yes**	**Yes**	**Yes**	**Yes**	
Alternative C					
Gate Buttress, Bridge, Lisa Falls, and White Pine Trailheads	**Yes**	**Yes**	**Yes**	**Yes**	

[a] Alternatives A and B include eliminating roadside parking within ¼ mile of each trailhead and eliminating roadside parking from S.R. 209/S.R. 210 to Snowbird Entry 1.

3.2.2.2 Level 2 Screening

As a result of Level 1 screening, UDOT determined that all of the Alternative A trailhead alternatives, White Pine Alternative B, and Alternative C (no parking improvements and eliminate roadside parking) would meet the purpose of the project and therefore were carried forward for Level 2 screening.

UDOT determined a preliminary engineering design for each alternative to determine the expected impacts for each Level 2 criterion [see Table 1-2, Level 2 Screening Criteria (Impacts), above]. Table 3-10 shows the results of Level 2 screening.

Table 3-10. Level 2 Screening Results – Trailhead Parking

Impact Criterion	Unit	Alternative					
		Gate Buttress A	Bridge Trailhead A	Lisa Falls A	White Pine A	White Pine B	C – No Parking Improvements
Natural Environment[a]							
Wetlands	Acres	0	0	0	0	0	0
Streams	Acres	0	0	0.04	0.03	0.03	0
Critical habitat	Acres	0	0	0	0	0	0
Floodplains	Acres	0	0	0	0	0	0
Impacts to wilderness areas	Acres	0	0	0	0	0	0
Built Environment[a]							
Consistency with USDA Forest Service Plan	Yes/no	Yes	Yes	Yes	Yes	Yes	Yes
Consistency with local plans	Yes/no	NA	NA	NA	NA	NA	NA
Recreation sites	Number	0	0	0	0	0	0
Community facilities	Number	0	0	0	0	0	0
Residential relocations	Number	0	0	0	0	0	0
Business relocations	Number	0	0	0	0	0	0
Section 4(f) properties	Number	0	0	0	1	1	0
Historic properties	Number	0	0	0	0	0	0
Cost of alternative in 2019 (in 2019 dollars)	Dollars (millions)	$0.83	$1.4	$2.3	$2.2	$2.9	$0

[a] The acreage or number of impacts is based on a screening-level design. The actual impacts could decrease or increase based on more-detailed design conducted for the alternatives that pass Level 2 screening.

3.2.2.2.1 Level 2 Screening Results

For the trailhead improvement alternatives, only the White Pine trailhead had two alternatives that passed Level 1 screening: Alternatives A and B. Based on the evaluation, both White Pine Alternative A and Alternative B would have similar impacts and cost. However, UDOT decided to eliminate Alternative B because of its slightly higher cost ($700,000 more) and because it would have about 25 parking spaces on S.R. 210 which would require parked vehicles to back onto S.R. 210 causing a potential safety conflict due to cyclists and vehicles traveling in the eastbound travel lane. Alternative C (no parking improvements and eliminate roadside parking) would have no cost or impacts associated with the alternative and therefore passed Level 2 screening.

All of the **Alternative A** trailhead alternatives and **Alternative C** (no parking improvements and eliminate roadside parking) passed Level 2 screening and will be further evaluated in detail in the Draft EIS. The trailhead parking A alternatives have two options: eliminating roadside parking within ¼ mile of the improved trailhead parking and eliminating all roadside parking from S.R. 209/S.R. 210 intersection to Snowbird Entry 1 along with the improved trailhead parking.

3.2.2.2.2 Alternatives Carried Forward for Further Evaluation

The following trailhead alternatives will be carried forward for further evaluation in the EIS:

- **Alternative A Trailhead Parking Improvements with No Roadside Parking within ¼ Mile**
- **Alternative A Trailhead Parking Improvements with No Roadside Parking from Canyon Entrance to Snowbird Entry 1**
- **Alternative C No Trailhead Parking Improvements with No Roadside Parking from Canyon Entrance to Snowbird**

3.3 Improve Reliability and Safety through Eliminating Winter Roadside Parking

Parking on the shoulder of S.R. 210 adjacent to the Snowbird and Alta ski resorts is a common occurrence since the ski resorts do not have enough parking lot capacity to handle the demand. Roadside parking during the winter can also increase congestion as the travel lane widths are reduced and vehicles slow down as they move through the area. The roadside parking also causes safety concerns with pedestrian-vehicle conflicts as skiers walk along the road to access the resorts. The reduced lane widths also make snow plowing difficult, since the parking limits snow storage and the ability for plow drivers to maneuver through traffic. Additionally, vehicles parked on the south side of S.R. 210 make U-turns in the road when exiting in the afternoon, slowing cars heading out of the canyon, which further reduces mobility. The purposes of reducing or eliminating roadside parking on S.R. 210 would be to improve pedestrian and vehicle safety, improve winter plowing operations by removing vehicles parking on the road shoulders, and reduce travel time.

All of the S.R. 210 mobility alternatives that passed the screening process (see Section 2.2, Improve Mobility on S.R. 210 from Fort Union Boulevard to Alta) would provide additional parking in the Salt Lake Valley and an alternate form of transportation than a private vehicle. Eliminating roadside parking adjacent to the ski resorts is an operational issue that UDOT could implement outside the NEPA process. If UDOT decides to eliminate roadside parking, there would be enough parking with the alternatives being evaluated in the Salt Lake Valley to accommodate resort users. By eliminating roadside parking, fewer private vehicles would use S.R. 210 in Little Cottonwood Canyon, which would improve overall mobility. Eliminating roadside parking adjacent to the ski areas will be a component of the alternatives evaluated in detail in the EIS.

4.0 Alternatives Advanced for Further Evaluation in the Draft EIS

4.1 Results of the Screening Process

UDOT conducted a screening evaluation of alternatives suggested by stakeholders and in previous studies. The evaluation started with Level 1 screening based on the project's purpose to substantially improve safety, reliability, and mobility on S.R. 210 from Fort Union Boulevard through the town of Alta for all users on S.R. 210. The alternatives that passed Level 1 screening were then evaluated with Level 2 screening in terms of their expected impacts to the natural and built environment.

The alternatives were screened with regard to the following project purpose elements:

- **Improve mobility on S.R. 210:**
  - Mobility on Wasatch Boulevard
  - Mobility on S.R. 210 from Fort Union Boulevard to Alta
- **Improve reliability and safety on S.R. 210:**
  - Avalanche mitigation
  - Trailhead parking
  - Winter roadside parking

Based on the screening process, the following alternative options (designated with square bullets) passed both Level 1 and Level 2 screening:

- **Improve mobility on S.R. 210:**
  - Mobility on Wasatch Boulevard:
    - Imbalanced-lane alternative
    - Five-lane alternative
  - Mobility on S.R. 210 from Fort Union Boulevard to Alta:
    - Enhanced bus service with no widening of S.R. 210 in Little Cottonwood Canyon (24 buses per hour during the peak period)
    - Enhanced bus service in peak-period shoulder lanes on S.R. 210 in Little Cottonwood Canyon (24 buses per hour during the peak period)
    - Canyon gondola with enhanced bus service
- **Improve reliability and safety on S.R. 210:**
  - Avalanche mitigation:
    - Snow sheds with guiding berms
    - Snow sheds and realigned road with no guiding berms
  - Trailhead parking:
    - Trailhead parking improvements with no roadside parking within ¼ mile
    - Trailhead parking improvements with no roadside parking from canyon entrance to Snowbird Entry 1
    - No trailhead parking improvements with no roadside parking from canyon entrance to Snowbird
  - Winter roadside parking:
    - Elimination of winter roadside parking on S.R. 210 adjacent to the ski resorts

4.2 Alternatives Advanced for Further Evaluation in the Draft EIS

To conduct the analysis of the effects of the alternatives on the human and natural environment, UDOT packaged the alternative options into three main alternatives with options to ensure each that alternative met the project purpose of improving safety, reliability, and mobility. These three action alternatives presented in Table 4-1.

After the impact evaluation is performed, UDOT will review the information and identify a preferred alternative in the Draft EIS from the three alternatives listed in Table 4-1. The preferred alternative will include a selection of which options for each element (Wasatch Boulevard, S.R. 210, Avalanche Mitigation, Trailhead Parking, and Winter Roadside Parking) UDOT prefers.

Table 4-1. Alternatives and Options To Be Evaluated in the Draft EIS

Alternative	Purpose Element and Associated Options				
	Purpose Element: Improve Mobility		Purpose Element: Improve Reliability and Safety		
	Wasatch Boulevard Options	S.R. 210 from Fort Union Boulevard to Alta Options	Avalanche Mitigation Options	Trailhead Parking Options	Winter Roadside Parking Options
Enhanced Bus Service with No Widening of S.R. 210 in Little Cottonwood Canyon Alternative	• Imbalanced-lane Alternative • Five-lane Alternative	Enhanced bus service with mobility hubs at the gravel pit[a] and 9400 South/Highland Drive • Winter point-to-point bus service from each mobility hub directly to the ski resorts[b] • 24 buses per hour in the peak hour • About 1,008 people on buses in the peak hour • 2,500 new parking spaces divided between two mobility hubs at the gravel pit and 9400 South and Highland Drive • Bus priority on Wasatch Boulevard • Tolling or other management strategies such as no single-occupant vehicles during peak periods	• Snow sheds with berms • Snow sheds and realigned road with no berms	• Trailhead parking improvements with no roadside parking within ¼ mile • Trailhead parking improvements with no roadside parking from canyon entrance to Snowbird Entry 1 • No trailhead parking improvements with no roadside parking from canyon entrance to Snowbird	• Elimination of winter roadside parking on S.R. 210 adjacent to the ski resorts
Enhanced Bus Service in Peak-period Shoulder Lanes on S.R. 210 in Little Cottonwood Canyon Alternative	• Imbalanced-lane Alternative • Five-lane Alternative	Enhanced bus service with mobility hubs at the gravel pit[a] and 9400 South/Highland Drive • Winter point-to-point bus service from each mobility hub directly to the ski resorts[b] • 24 buses per hour in the peak hour • About 1,008 people on buses in the peak hour • 2,500 new parking spaces divided between two mobility hubs at the gravel pit and 9400 South and Highland Drive • Bus priority on Wasatch Boulevard • Tolling or other management strategies such as no single-occupant vehicles during peak periods • Winter bus only peak-period shoulder lanes from the North Little Cottonwood Road/Wasatch Boulevard intersection to the Alta Bypass Road; peak-period shoulder lanes would be cyclist and pedestrian facilities in summer	• Snow sheds with berms • Snow sheds and realigned road with no berms	• Trailhead parking improvements with no roadside parking within ¼ mile • Trailhead parking improvements with no roadside parking from canyon entrance to Snowbird Entry 1 • No trailhead parking improvements with no roadside parking from canyon entrance to Snowbird	• Elimination of winter roadside parking on S.R. 210 adjacent to the ski resorts
Gondola Alternative	• Imbalanced-lane Alternative • Five-lane Alternative	Gondola from the entrance of Little Cottonwood Canyon to Alta Ski Resort • Winter gondola service starting at the gondola platform at the entrance of Little Cottonwood Canyon with stops at Snowbird ski resort and Alta ski resort only[b] • About 30 gondola cabins per hour • About 1,050 people on gondolas in the peak hour • 2,500-space parking structure at the gravel pit • Enhanced bus service from the gravel pit to the gondola loading platform at the entrance of Little Cottonwood Canyon (there would be no parking at the gondola platform) • Bus priority on Wasatch Boulevard • Tolling or other management strategies such as no single-occupant vehicles during peak periods	• None; gondola could be used when S.R. 210 is closed for avalanche mitigation, similar to existing conditions	• Trailhead parking improvements with no roadside parking within ¼ mile • Trailhead parking improvements with no roadside parking from canyon entrance to Snowbird Entry 1 • No trailhead parking improvements with no roadside parking from canyon entrance to Snowbird	• Elimination of winter roadside parking on S.R. 210 adjacent to the ski resorts

[a] The gravel pit is located on the east side of Wasatch Boulevard between 6200 South and Fort Union Boulevard.
[b] The purpose of the project is to improve winter mobility. Screening criteria did not evaluate the performance of summer service.

5.0 Draft EIS Considerations

UDOT will further refine the action alternatives described in Section 4.0, Alternatives Advanced for Further Evaluation in the Draft EIS, through preliminary engineering before detailed impact analyses begin for the EIS. This preliminary engineering will include details such as horizontal and vertical alignments, potential transit stations or mode transfer locations, and potential drainage designs. Each alternative will be designed to a similar level of detail.

During the preliminary engineering process, UDOT will try to minimize impacts to the human and natural environments. Once the preliminary design work is complete, more-detailed impact analyses will be performed to identify and compare the expected effects of each of the alternatives at an equal level of detail as required under NEPA.

Because the alternatives will undergo a more rigorous engineering design and more-detailed impact analyses, the impact numbers for the alternatives as presented in the Draft EIS will likely vary (positively or negatively) from what has been presented in the Level 2 screening process.

The screening process is designed to be dynamic throughout the EIS process. If a new alternative or refinement of an alternative is developed or arises later in the process, it will be subject to the same screening process as all of the other alternatives.

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APPENDIX A

Preliminary Evaluation of Alternatives and Concepts

Table A-1. Preliminary Evaluation of Alternatives/Concepts Suggested during EIS Scoping Periods

Suggested Alternative	Part of No-Action/ Baseline	Reason for Not Including in the Proposed Alternatives				Evaluated Further in Level 1 Screening	Considered as Part of Alternative Design, Environmental Analysis, and/or Potential Mitigation	Additional Information
		Does Not Meet Project Objectives	Outside the EIS Study Area	Outside the Scope of the EIS	Technically and/or Feasibly Prohibitive			
Wasatch Boulevard								
Consider pedestrian overpasses or tunnels.							✓	Will be part of road improvements alternatives.
Add pedestrian warning lights at crosswalks.							✓	UDOT will look at pedestrian and bicycle safety as part of road improvements.
Reduce speed limits.				✓				Speed limits are a UDOT operational issue considered in accordance with state code outside NEPA. Reduced speed limits would not change the results of the roadway capacity analysis.
Don't widen Wasatch Boulevard.	✓							
Add bus-only lane.						✓		Transit-only alternatives will be considered.
Consider safety and neighborhood access. Improve intersections.							✓	Will be part of road improvements alternatives.
Add traffic signal at Kings Hill Drive.						✓		
Improve sight distance at Kings Hill Drive.							✓	Will be part of road improvements alternatives.
Add separate bicycle/pedestrian trail.							✓	Will be part of road improvements alternatives.
Improve Highland Drive to provide alternate route.	✓							Included in Phase 2 of the 2019–2050 WFRC RTP to widen Highland Drive to five lanes from 9800 South to the Draper city limits. Travel demand modeling showed that, even with Highland Drive improvements, there would be a need to improve Wasatch Boulevard.
Add bicycle lanes and improve bicycle safety.							✓	Will be part of road improvements alternatives.
Widen Wasatch Boulevard.						✓		
Provide roundabouts.						✓		
Put through traffic in a tunnel to I-215.					✓			Alternative eliminated. Cost of 3-mile tunnel would be about $2.5 billion[a]. In addition, it would require extensively reworking the existing road network to accommodate entrance and exit points.
Avalanche Mitigation								
Current system is sufficient.	✓							
Install more remote-activation systems.		✓						More remote-activation active systems would not reduce the number closure days or hours of closure since the road would still need to be closed during activation.
Add snow sheds.						✓		
Use bridges to go over avalanche paths.						✓		
Reduce the number of vehicles (provide more transit).						✓		Transit alternatives would reduce vehicle use.
Avalanche control should start early.		✓		✓				This is a UDOT operational consideration. UDOT currently conducts avalanche control at the earliest possible time. This alternative would not reduce the amount of road closure.

Table A-1. Preliminary Evaluation of Alternatives/Concepts Suggested during EIS Scoping Periods

Suggested Alternative	Part of No-Action/ Baseline	Reason for Not Including in the Proposed Alternatives				Evaluated Further in Level 1 Screening	Considered as Part of Alternative Design, Environmental Analysis, and/or Potential Mitigation	Additional Information
		Does Not Meet Project Objectives	Outside the EIS Study Area	Outside the Scope of the EIS	Technically and/or Feasibly Prohibitive			
Mobility/Capacity								
Build transit hubs at gravel pit and 9400 South.						✓		
Provide parking for cars waiting to enter Little Cottonwood Canyon.						✓		Considered as part of the transit alternative to reduce vehicle use and avalanche mitigation to reduce closure and eliminate backup both of which reduce the number of vehicles waiting to enter Little Cottonwood Canyon.
Eliminate roadside parking at ski resorts.						✓		
Increase road capacity (three and four lanes).						✓		
Don't expand road capacity.	✓							
Consider reversible lanes.						✓		
Add a dedicated travel lane for Alta.						✓		Considered in reversible lane and widen road alternatives. If alternatives provide enough roadway capacity, there would be no need for a dedicated lane.
Add more pullouts for slow vehicles.		✓					✓	Concept will be included as part of adding capacity. Slow vehicle pull outs for buses would substantially increase travel time making buses less feasible. Does not meet project objective of improving mobility for all users (including transit users)
Build a longer merge lane at S.R. 209/S.R. 210.						✓		
Don't build a merge lane at S.R. 209/S.R. 210, and reduce speed limits.	✓			✓				Reducing speed limits is a UDOT operational consideration. Reducing speed limits would not change the need for mobility improvements.
Add a traffic signal at S.R. 209/S.R. 210.				✓				UDOT is currently making safety improvements to this intersection outside the EIS process for immediate implementation.
Restrict larger vehicles during peak periods.						✓		Transit and tolling options are being considered to reduce overall vehicle use.
Allow buses only.						✓		
Add bicycle lanes.							✓	Will be considered as part of road improvement alternatives.
Limit the number of vehicles.						✓		
Eliminate single-occupant vehicles.						✓		Will be considered as part of transit and tolling alternatives.
Provide transit priority.							✓	Will be considered as part of road improvement alternatives.
No vehicle waiting at base of canyon.						✓		Part of screening criteria to reduce vehicle waiting at base of canyon. Considered under all alternatives.
Road should be one way during AM and PM peak periods.						✓		
Provide police escorts for traffic.				✓				Operational consideration that can be implemented outside the EIS process. Would still need to have large wait areas for cars to be platooned up canyon.
Provide more smaller shuttles and fewer big buses.						✓		Feasibility of transit alternatives will be considered. Size of buses to accommodate demand will be managed by UTA outside the EIS process.
Free or discounted transit.				✓				Managed by UTA outside the EIS process.

Table A-1. Preliminary Evaluation of Alternatives/Concepts Suggested during EIS Scoping Periods

Suggested Alternative	Part of No-Action/ Baseline	Reason for Not Including in the Proposed Alternatives				Evaluated Further in Level 1 Screening	Considered as Part of Alternative Design, Environmental Analysis, and/or Potential Mitigation	Additional Information
		Does Not Meet Project Objectives	Outside the EIS Study Area	Outside the Scope of the EIS	Technically and/or Feasibly Prohibitive			
Consider ride-share programs.	✓			✓				Rider-share companies currently exist along with ride-share apps. UDOT can accommodate ride-share areas but would not provide a system under which ride-sharing would operate.
Direct bus service to ski resorts (no stops).						✓		
Train and/or light rail.						✓		
Gondola from the Salt Lake Valley.						✓		
Gondola from Park City.						✓		
Give buses priority when leaving parking areas and on the road.							✓	Will be considered as part of transit alternatives.
Bus priority at signalized intersections.							✓	Will be considered as part of Wasatch Boulevard alternatives.
Bus-only reversible lane in Little Cottonwood Canyon.						✓		
Add bicycle trail by paving Temple Quarry/Little Cottonwood Creek Trail.				✓				The trail is managed and maintained by USDA Forest Service and would require a separate NEPA action.
Provide tunnels at strategic locations to ease traffic flow, mainly at ski resorts.							✓	
Open Emma Mine Tunnel between Little Cottonwood Canyon and Big Cottonwood Canyon to disperse traffic.		✓		✓				Tunnels between Little Cottonwood Canyon and Big Cottonwood Canyon are not necessary to meet the objectives of improving mobility in Little Cottonwood Canyon.
Trailhead Parking								
No additional parking at trailheads.						✓		
Charge fee for parking at trailheads.		✓		✓				UDOT does not have ability to charge for parking at trailheads. USDA Forest Service would be responsible for implementing a recreational fee program.
Expand trailhead parking with restrooms.						✓		
Allow roadside parking in Little Cottonwood Canyon near trailheads.						✓		
Add parking at Grit Mill.				✓				Project is partially funded, and USDA Forest Service has conducted the NEPA process.
Improve parking at Gate Buttress.						✓		
No parking at Lisa Falls.	✓							
Tolling								
No tolls.	✓							
Toll single-occupant vehicles only.						✓		
Toll all nontransit vehicles.						✓		
Toll based on number of occupants.						✓		

Table A-1. Preliminary Evaluation of Alternatives/Concepts Suggested during EIS Scoping Periods

Suggested Alternative	Part of No-Action/ Baseline	Reason for Not Including in the Proposed Alternatives				Evaluated Further in Level 1 Screening	Considered as Part of Alternative Design, Environmental Analysis, and/or Potential Mitigation	Additional Information
		Does Not Meet Project Objectives	Outside the EIS Study Area	Outside the Scope of the EIS	Technically and/or Feasibly Prohibitive			
Reduce toll for low-income populations.							✓	Environmental justice and equity will be evaluated in the EIS.
Dynamic tolling based on time of day and occupants.						✓		
Tolling revenue should go back into canyon.				✓				The state legislature and the Utah Transportation Commission would decide how tolling revenue would be spent.
Other								
Fire suppression in snow sheds should be nontoxic with no release into Little Cottonwood Creek.							✓	
Snow sheds should provide room for a train.							✓	Will be considered as part of snow shed alternatives design.
Provide avalanche protection for Tanner Flats.		✓						UDOT has analyzed the avalanche paths that have the greatest effect on road closure. The Tanner Flats avalanche path was determined not to warrant protection.
Charge fee for resort parking and/or reserved parking.				✓				UDOT does not have the authority to require private businesses to charge fees for parking.
Add parking at base of canyon.						✓		Will be considered as part of transit alternatives.
Open parking at 3900 South/Wasatch Boulevard.						✓		Transit alternatives evaluated in the EIS will be evaluated to determine the capacity of parking. UTA can determine routes and park-and-ride locations without the need for a NEPA analysis.
Allow parking at Reams strip mall at 7200 South.						✓		Transit alternatives evaluated in the EIS will be evaluated to determine the capacity of parking. UTA can determine routes and park-and-ride locations without the need for a NEPA analysis.
Ski areas should build parking structures.						✓		
Build parking structure at the tree farm.						✓		
Don't expand parking at Little Cottonwood Canyon park-and-ride lot.						✓		The transit and road alternatives will look at options that could include additional parking.
Expand parking at the swamp lot.						✓		The transit and road alternatives will look at options that could include additional parking.
Use school and church parking lots for bus park-and-ride lots.						✓		UDOT and UTA will develop alternatives to meet the project's purpose and will consider parking as part of the alternative design that best promotes efficient bus use.
Parking should be underground or limited to two levels.							✓	
Include rumble strips and box dots to protect cyclists.							✓	Road alternatives will consider meeting cyclist safety standards.
Improve high-tee intersections at Alta and Snowbird.				✓				UDOT is currently looking at improving these intersections as part of safety improvements.
Eliminate "right on red" at S.R. 209 and Old Wasatch Boulevard.	✓		✓					S.R. 209 is not part of the scope of the EIS.
Add guard rail in Little Cottonwood Canyon.							✓	UDOT will meet safety design standards for the alternatives considered.
Reduce travel on Albion Basin Road.				✓				Albion Basin Road is not part of S.R. 210.
Preregister vehicles for winter use and provide a fast pass.				✓				This is an operational program that would require state legislative approval. It would not require a NEPA analysis.

Table A-1. Preliminary Evaluation of Alternatives/Concepts Suggested during EIS Scoping Periods

Suggested Alternative	Part of No-Action/ Baseline	Reason for Not Including in the Proposed Alternatives				Evaluated Further in Level 1 Screening	Considered as Part of Alternative Design, Environmental Analysis, and/or Potential Mitigation	Additional Information
		Does Not Meet Project Objectives	Outside the EIS Study Area	Outside the Scope of the EIS	Technically and/or Feasibly Prohibitive			
Provide electric buses.							✓	Operational requirement that can be determined by UTA based on technical feasibility. Does not need to be part of the NEPA decision.
To encourage transit use provide ski lockers and improved stops bus stop locations. Include amenities at bus stops such as lift ticket purchasing and heating.							✓	Will be considered part of transit alternatives.
Increase fines for ill-equipped vehicles or improve monitoring.		✓		✓				This is a state enforcement consideration and does not require a NEPA analysis.
Improve traffic condition communications.	✓			✓				UDOT is currently improving canyon communications to address safety and mobility.
Work with car rental companies regarding the types of vehicles allowed in the canyon.				✓				UDOT does not have the authority to change how car rental companies operate.
Plow trailhead parking.		✓						Plowing trailheads does not meet the project purpose of improving mobility.
Provide e-bicycle rentals in summer.		✓		✓				Summer mobility is not part of the project purpose.
Provide black ice warning system.							✓	Safety improvements will be considered as part of roadway alternatives.
Restrict development in Little Cottonwood Canyon.				✓				UDOT does not have the authority to limit development. Local government agencies are responsible to implement zoning.
Allow access to Snowbird from American Fork Canyon.				✓				This alternative is being considered by Snowbird Ski Resort across its private land and is an economic decision by a private company.
No IKON pass use at ski resorts.				✓				UDOT does not have the authority to limit IKON passes.
Ski resorts should incentivize people to stay longer and stagger skiers exiting parking lots.				✓				UDOT does not have the authority to implement how a private business operates.
No bicycles on the road.		✓						Eliminating bicycles is not required to meet the project's objectives.
Add more snow plows.							✓	
Replace bridge at Wasatch Resort.		✓		✓				Wasatch Resort is a private development and road outside the authority of UDOT.
Address summer use.						✓		Summer trailhead parking is being considered in the EIS. Mobility improvements during the summer are not needed to meet project's objectives.
Use technology to reduce vehicle use.							✓	UDOT will consider the latest available technology when developing alternatives.
Add parking at Temple Quarry Trail.		✓						UDOT and UTA will develop alternatives to meet the project's purpose and will consider parking as part of the alternative design that best promotes efficient bus use.

Table A-1. Preliminary Evaluation of Alternatives/Concepts Suggested during EIS Scoping Periods

Suggested Alternative	Part of No-Action/ Baseline	Reason for Not Including in the Proposed Alternatives				Evaluated Further in Level 1 Screening	Considered as Part of Alternative Design, Environmental Analysis, and/or Potential Mitigation	Additional Information
		Does Not Meet Project Objectives	Outside the EIS Study Area	Outside the Scope of the EIS	Technically and/or Feasibly Prohibitive			
Add parking at S.R. 210/Wasatch Boulevard.							✓	UDOT and UTA will develop alternatives to meet the project's purpose and will consider parking as part of the alternative design that best promotes efficient bus use.
Provide electric charging stations at park-and-ride lots.							✓	

AM = morning; EIS = Environmental Impact Statement; I-215 = Interstate 215; NEPA = National Environmental Policy Act; PM = afternoon; RTP = *Wasatch Front Regional Transportation Plan*; S.R. = State Route; UDOT = Utah Department of Transportation; USDA = United States Department of Agriculture; UTA = Utah Transit Authority; WFRC = Wasatch Front Regional Council

[a] In 2012, the cost estimate for the Alaskan Way Viaduct tunnel in the state of Washington was $1.35 billion for the 9,100-foot tunnel, or about $148,352 per linear foot. This cost includes all elements to construct the Alaskan Way Viaduct tunnel. The LCC team used cost index inflation rates from the *Engineering News-Record* to escalate the 2012 construction cost estimate to 2018 values. Based on this cost escalation, the 2018 cost would be about $165,000 per linear foot.

APPENDIX B

Little Cottonwood Canyon Alternatives and Climate Change

Memo

Date:	Friday, January 03, 2020
Project:	Little Cottonwood Canyon EIS
To:	UDOT
From:	HDR
Subject:	**Little Cottonwood Canyon Alternatives and Climate Change**

Climate variability and climate change has and will continue to have an effect on the snow and avalanche regime in Little Cottonwood Canyon. Many studies have identified widespread declines in historical snowpack amounts in western North America over the last 30 to 50 years (for example, see Mote et al. 2005; Hamlet et al. 2005; Mote 2006), and these changes have been linked to warming trends and increasing elevations at which freezing temperatures occur. About half of recent changes in the western U.S. snowpack have been attributed to anthropogenic (human-caused) effects (Pierce et al. 2008). Future projections of the snowpack, expressed in terms of snow water equivalent, point to widespread losses across the western United States (for example, see Pierce and Cayan 2012). Research that specifically considers the Wasatch Range is consistent with the findings across the western United States showing a decrease in historical and future projected snowpacks.

For the Wasatch Range specifically, there will likely be increased variability in the snowpack as a result of the jet stream moving north. In addition, although annual precipitation amounts will remain unchanged or increase slightly (depending on the model and future scenario examined), the proportion of rain to snow will increase (Strong 2013; Scalzitti et al. 2016). This reduction in the snowpack would be driven by increasing air temperatures and, on average, will result in substantially decreased snowpack depths by the middle and end of the 21st century.

These projected changes in the snowpack could affect avalanches and ski resorts in Little Cottonwood Canyon. Although there are no conclusive studies to provide specific changes, these changes in temperatures and precipitation could result in a shorter avalanche and ski seasons that start later in winter and end earlier in spring. It is also likely that the wet snow season could start earlier in the winter. This reduction in season length could reduce the frequency and potential magnitude of avalanches in Little Cottonwood Canyon. Despite this likely average reduction in avalanche frequency and magnitude, climate change has been linked to increases in extreme events and increased variability in precipitation, so infrequent larger events should still be considered possible.

A study by Lazar and Williams (2010) analyzed climate change effects for Wasatch Range ski areas. This study found that, by 2050, climate change is predicted to have a substantial effect on snow coverage and snow depth. The authors found that the snowpack could build up enough to support skiing 1 to 2 weeks later, and snow could begin to melt at the base of the resorts 1 to 2 weeks earlier. There might be little snow by Thanksgiving, and mid-winter snow depths could be 20% to 40% less than what has occurred historically.

These studies clearly point to both changes in the inter-annual variability of the snowpack and to long-term reductions of the snowpack in the Wasatch Range. These climate variability and change issues should be considered for any future structural avalanche mitigation. By 2050, skiing spring break might be difficult at lower elevations (Lazar and Williams 2010).

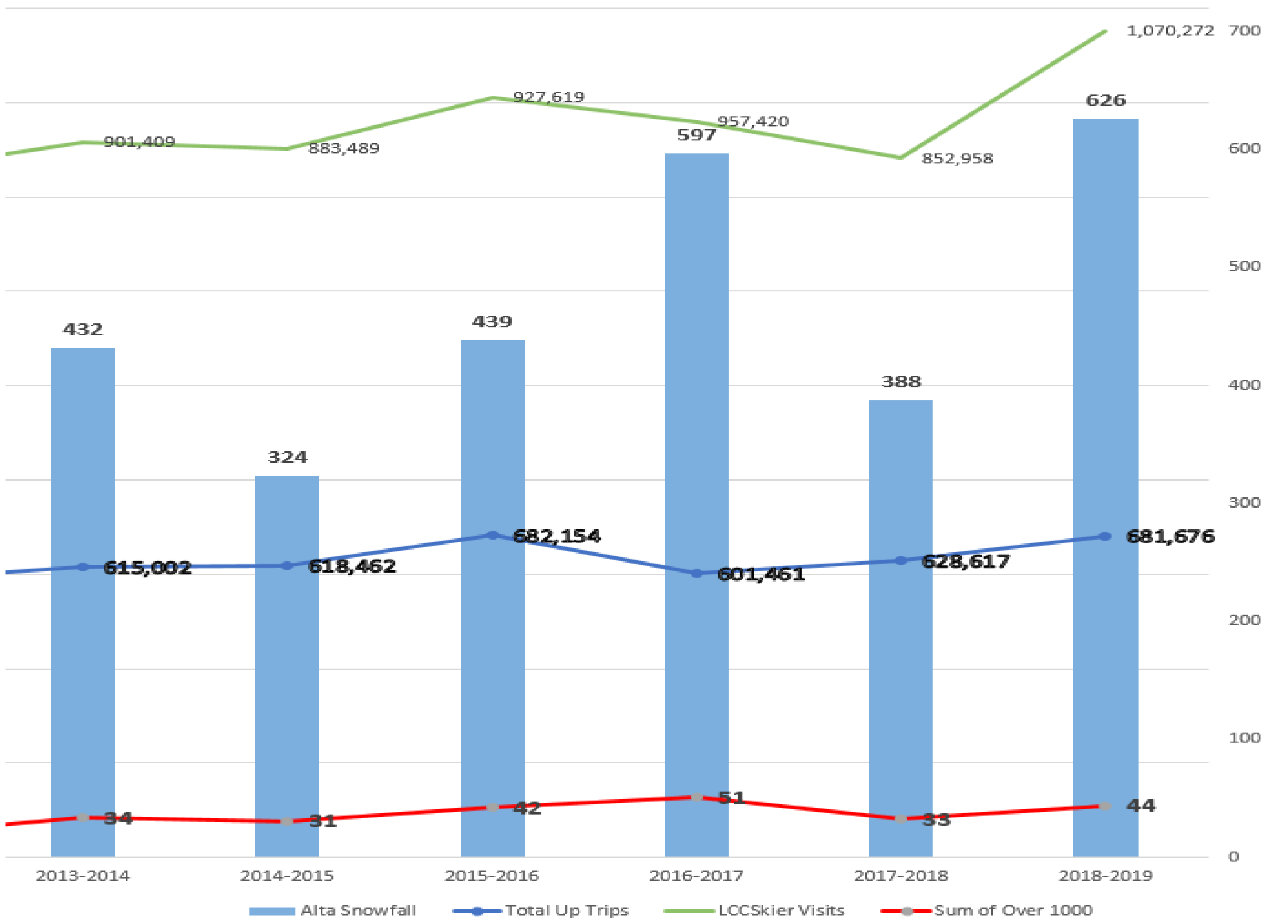
Another study (Wobus et al. 2017) found considerable variability at all levels with regard to the effects of climate change on skier days, particularly with respect to the spatial distribution of impacts. In general, sites at higher elevations (such as the Rocky Mountains and Sierras) tend to be more resilient to projected changes in temperature and precipitation. The study found that, under all scenarios of climate change that were modeled, by 2050 the number of skiing visits would be similar to current levels or would increase along with population growth.

With regard to the Little Cottonwood Canyon EIS, the Utah Department of Transportation (UDOT) considered how climate change might affect its development of alternatives for the EIS. UDOT reviewed traffic data from Little Cottonwood Canyon during the winter season (November to April) of 2018. According to the traffic data, during the winter season of 2018, there were 72 1-hour periods with more than 800 vehicles in the canyon. Nearly all (68) of the 1-hour periods with more than 800 vehicles occurred from December through the end of March. November had no 1-hour periods with more than 800 vehicles, and April had 4.

Based on the climate change literature, in 2050, the buildup of the snowpack at the canyon resorts could be delayed by 1 to 2 weeks, with little snow at Thanksgiving, and the ski season might end 1 to 2 weeks earlier. Historically, high-traffic days in the canyon have occurred from late December (typically around the Christmas holiday) through March, when the snowpack should be deep enough based on climate studies for skiing. Since most high traffic days don't occur until December and likely around the late December holiday period and end in March when snow pack should be enough to ski based on literature, climate change should not result in a need to modify alternatives that address mobility during high travel periods. In addition, sites at higher elevations (such as Snowbird and Alta ski resorts -7,800 feet and above) tend to be more resilient to projected changes in temperature and precipitation.

UDOT also reviewed traffic data for eastbound traffic in the canyon from the 2013 through 2018 ski seasons. These ski seasons had different yearly snow totals. During this 6-year period, there were an average of 39 travel periods per ski season with more than 1,000 vehicles in the canyon. As shown in the graph below, the highest number of travel periods on S.R. 210 in Little Cottonwood Canyon with more than 1,000 vehicles (51) occurred during the 2016–2017 ski season, and the lowest number of travel periods with more than 1,000 vehicles (31) occurred during the 2014–2015 ski season. The 2014–2015 ski season had the lowest snow total of any year from the 2006–2007 ski season to the 2018–2019 ski season. Overall, the data show that, even during years with low snow totals, there are more than 30 travel periods per ski season in which the number of vehicles in the canyon exceeds 1,000 vehicles. This number (30) is only 9 below the average number for the 6-year period (39). Therefore, even with the potential for less snowfall at the resorts in the future, UDOT still expects that there would be enough heavy traffic days to justify developing alternatives that address mobility during high-travel periods.

Graph 1. Number of Eastbound Travel Periods over 1,000 from 2013–2014 to 2018–2019



Graph notes:

- Total snowfall in inches for Alta Ski resort.
- Total up trips are up canyon trips (eastbound) for winter season in Little Cottonwood Canyon.
- LCC skier visits is the total number of skiers (Snowbird and Alta ski resorts) on S.R. 210 in Little Cottonwood Canyon for the winter season.
- Sum of over 1,000 is the number of up canyon (eastbound) hours that exceed 1,000 vehicles in the hour on S.R 210 in Little Cottonwood Canyon.

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APPENDIX C

Draft Evaluation of Managed-lane Concepts

Little Cottonwood Canyon ENVIRONMENTAL IMPACT STATEMENT
S.R. 210 | Wasatch Blvd. to Alta

Draft Evaluation of Managed-lane Concepts

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 - Wasatch Boulevard to Alta

Lead agency:
Utah Department of Transportation

April 3, 2020

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Acronyms and Abbreviations

EIS	Environmental Impact Statement
LED	light-emitting diode
MP	milepost
mph	miles per hour
PPSL	peak-period shoulder lane
S.R.	state route
UDOT	Utah Department of Transportation

1.0 Introduction

The purpose of this report is to summarize the Utah Department of Transportation's (UDOT) evaluation of managed lane concepts for State Route (S.R.) 210 in Little Cottonwood Canyon as part of the Little Cottonwood Canyon Project. This report provides information that UDOT will use during the alternatives development and screening process, which will evaluate how well managed-lane concepts would satisfy the purpose of the Little Cottonwood Canyon Environmental Impact Statement (EIS). The EIS identifies five primary objectives, one of which is to improve overall mobility on S.R. 210 from Wasatch Boulevard through the town of Alta. Managed lanes are being considered for a portion of the EIS study area to add roadway capacity and improve mobility.

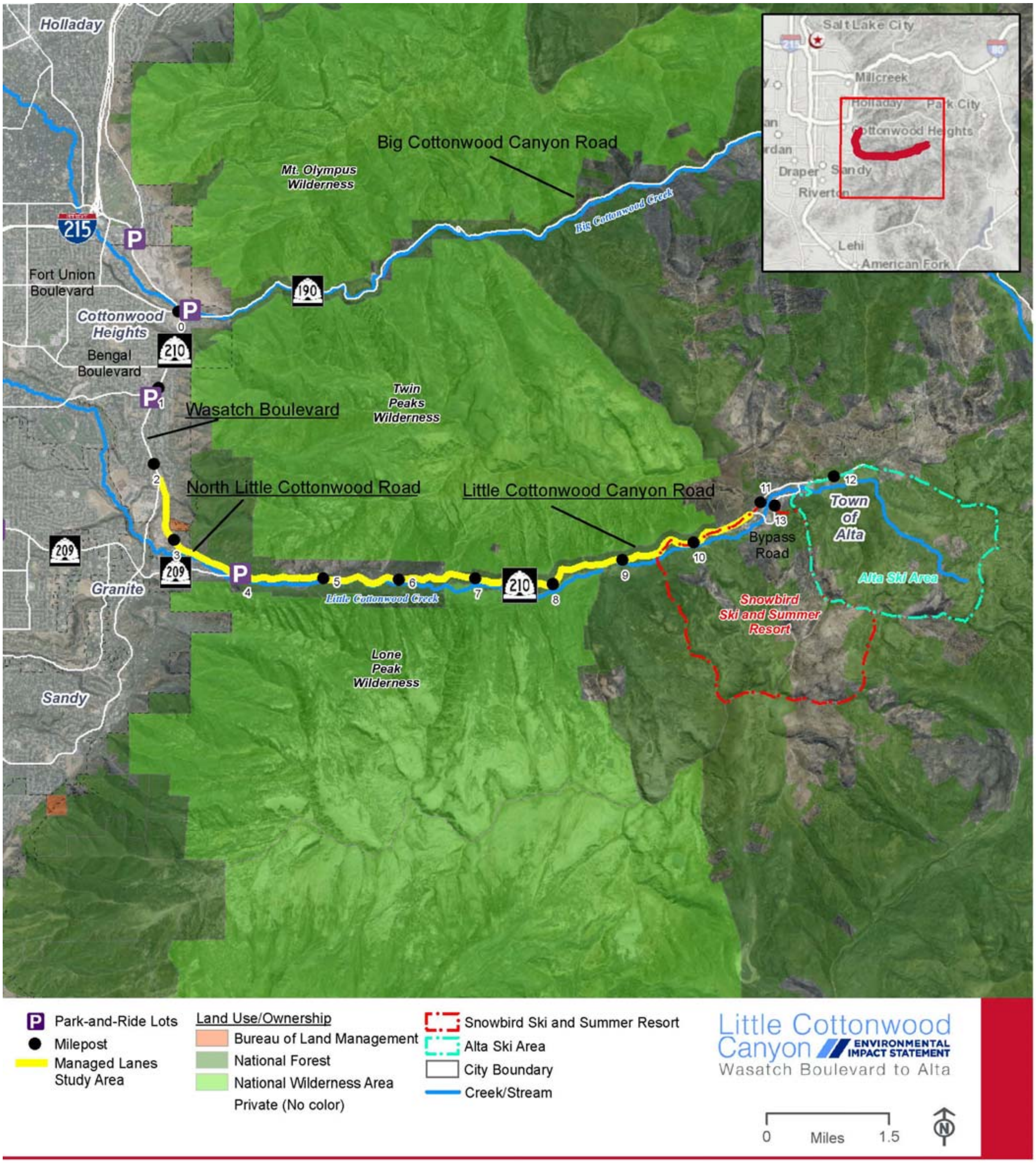
1.1 Study Area for Managed Lanes

The study area for the EIS extends along S.R. 210 from its intersection with Fort Union Boulevard (S.R. 190, at milepost [MP] 0.0) to the town of Alta (MP 12.5). Through the EIS study area, S.R. 210 is designated with different street names.

- **Wasatch Boulevard** – S.R. 210 from Fort Union Boulevard (S.R. 190; MP 0.0) to North Little Cottonwood Road (MP 2.2)
- **North Little Cottonwood Road** – S.R. 210 from Wasatch Boulevard (MP 2.2) to the intersection with S.R. 209 (MP 3.8)
- **Little Cottonwood Canyon Road** – S.R. 210 from the intersection of North Little Cottonwood Road and S.R. 209 (MP 3.8) to the town of Alta (MP 12.5)

The study area for managed lanes does not include Wasatch Boulevard but does include North Little Cottonwood Road and a portion of Little Cottonwood Canyon Road. The study area for managed lanes extends about 8.6 miles on S.R. 210 from the intersection with Wasatch Boulevard (MP 2.2) to the Bypass Road (MP 10.8). UDOT selected the intersection with Wasatch Boulevard as the starting point because S.R. 210 transitions from urban to rural at this location. The lower end of the Bypass Road (Snowbird Entry 4) was selected as the ending point because the need for additional traffic capacity decreases after vehicles headed for Snowbird resort exit S.R. 210. Figure 1-1 shows the study area for managed lanes.

Figure 1-1. Study Area for Managed Lanes



1.2 Traffic Operations

What is travel demand?

Travel demand is the expected number of transportation trips in an area. Travel demand can be met by various modes of travel, such as automobile, bus, aerial transit, carpooling, and bicycling.

Traffic operations on S.R. 210 in Little Cottonwood Canyon are characterized by traffic congestion and decreased mobility in the winter. These issues are related primarily to avalanche control and visits to ski areas, with the greatest traffic volumes occurring on weekends and holidays and during and after snowstorms. Peak traffic is directional, with heavy traffic going up canyon (eastbound) in the morning and down canyon (westbound) in the evening.

The population in Salt Lake County is projected to increase by 36% by 2050 (Kem C. Gardner Policy Institute 2017). UDOT expects this increase in population to cause increased travel demand in Little Cottonwood Canyon through 2050.

1.3 Roadway Context

S.R. 210 is generally a two-lane road (one travel lane in each direction), but there are passing lanes in three locations:

- Westbound from about MP 7.7 to MP 8.1 (near Tanner's Flat Campground)
- Eastbound from about MP 8.6 to MP 9.4 (near White Pine trailhead)
- Westbound from about MP 9.6 to MP 9.9 (near Snowbird Entry 1)

The path of S.R. 210 in the canyon is steep and windy due to the canyon terrain. The roadway grade exceeds 8% for 40% to 50% of S.R. 210's length in the canyon, and the maximum grade is 11%. The sight distance for drivers is limited because trees and steep embankments block visibility around curves.

Little Cottonwood Canyon receives heavy snow in the winter; the average snowfall at the Alta Guard Station is about 500 inches (more than 41 feet) per year (Utah Avalanche Center 2019). S.R. 210 in the canyon is threatened by 35 major avalanche paths, and an average of 33 avalanche flows hit the road annually (UDOT 2006). UDOT is responsible for t operating and maintaining S.R. 210 in the canyon, including removing snow and controlling avalanches.

S.R. 210 in Little Cottonwood Canyon is a designated scenic byway. The *Cottonwood Canyons Scenic Byways Corridor Management Plan* (UDOT 2008) describes strategies for protecting scenic vistas along this byway. It recommends a scenery management plan and a signage plan to manage detracting uses, minimize clutter, and establish a protocol for approving new signs along the byway.

2.0 Reversible-lane Concepts

Reversible lanes can move traffic in either direction. They can be used when there is a heavy directional split in traffic (that is, heavy traffic in one direction in the morning and in the opposite direction in the evening) to minimize the overall number of lanes needed, thereby minimizing impacts to the surrounding environment.

What are reversible lanes?

Reversible lanes move traffic in alternating directions during different periods of the day. They can be used where there is heavy traffic in one direction in the morning and in the opposite direction in the evening.

To implement a reversible lane on S.R. 210, UDOT would need to widen S.R. 210 to add a third lane. The reversible lane would be open to eastbound traffic during the morning peak period and westbound traffic during the evening peak period on peak traffic days (weekends during the ski season, holidays, and special events). Traffic traveling in different directions can be physically separated by a moveable barrier or directed to the appropriate lane by overhead lane-control signals or signs.

2.1.1 Moveable Barrier

Reversible lanes can be implemented using a moveable barrier, in which a median barrier is moved from one side of the reversible lane to the other to change the direction of traffic. The moveable barrier is made of short segments of concrete connected by heavy-duty steel hinges to form a continuous wall. To move the barrier, a transfer machine lifts up each segment of barrier, moves it sideways, and sets it back down on the other side of the reversible lane (Figure 2-1).

Figure 2-1. Moveable Barrier and Transfer Machine

A moveable barrier system is used for reversible lanes in several locations in the United States including high-occupancy vehicle lanes on Interstate 93 in Boston, Interstate 30 in Dallas, and Interstate 15 in San Diego.

Considerations for S.R. 210

The intersection where S.R. 209 merges into S.R. 210 (at MP 3.8, where North Little Cottonwood Road becomes Little Cottonwood Canyon Road) is a key intersection with respect to travel demand. S.R. 210 is the main route to Little Cottonwood Canyon from the north, and S.R. 209 is the main route to the canyon from the south. About 40% of the canyon traffic enters or exits the canyon on S.R. 209.

When inbound traffic backs up during the morning peak, the main bottleneck is on North Little Cottonwood Road entering the canyon. During the evening peak, the bottleneck is at the ski resorts at the top of Little Cottonwood Canyon Road heading outbound. The outbound PM travel demand on North Little Cottonwood Road is less where S.R. 209 splits off at MP 3.8. As a result, there is a greater need for additional southbound/eastbound lanes than for additional westbound/northbound lanes on North Little Cottonwood Road.

The reversible-lane concepts discussed in this report assume three travel lanes on S.R. 210 all the way from the intersection with Wasatch Boulevard (MP 2.2) to the Bypass Road (MP 10.8). However, on North Little Cottonwood Road (MP 2.2 to MP 3.8), the lanes would not be reversible. In this segment, there would be two southbound/eastbound lanes and one westbound/northbound lane at all times. On Little Cottonwood Canyon Road from the intersection with S.R. 209 (MP 3.8) to the Bypass Road (MP 10.8), the center lane would be reversible for 7.0 miles.

Figure 2-2 shows the typical section for reversible lanes with a moveable barrier on Little Cottonwood Canyon Road. UDOT would widen the road to include three travel lanes and two 8-foot-wide shoulders. The two outer travel lanes would be 12 feet wide, and the center reversible lane would be 17.5 feet wide. The moveable barrier would be 1.5 feet wide and would require a 2-foot-wide shy distance from the travel lane on each side, resulting in an additional 5.5 feet of pavement needed for the moveable barrier. The total pavement width would be 57.5 feet. The clear zone would be measured from the edge of the lane for a total roadway width of 73.5 feet.

What is a shy distance?

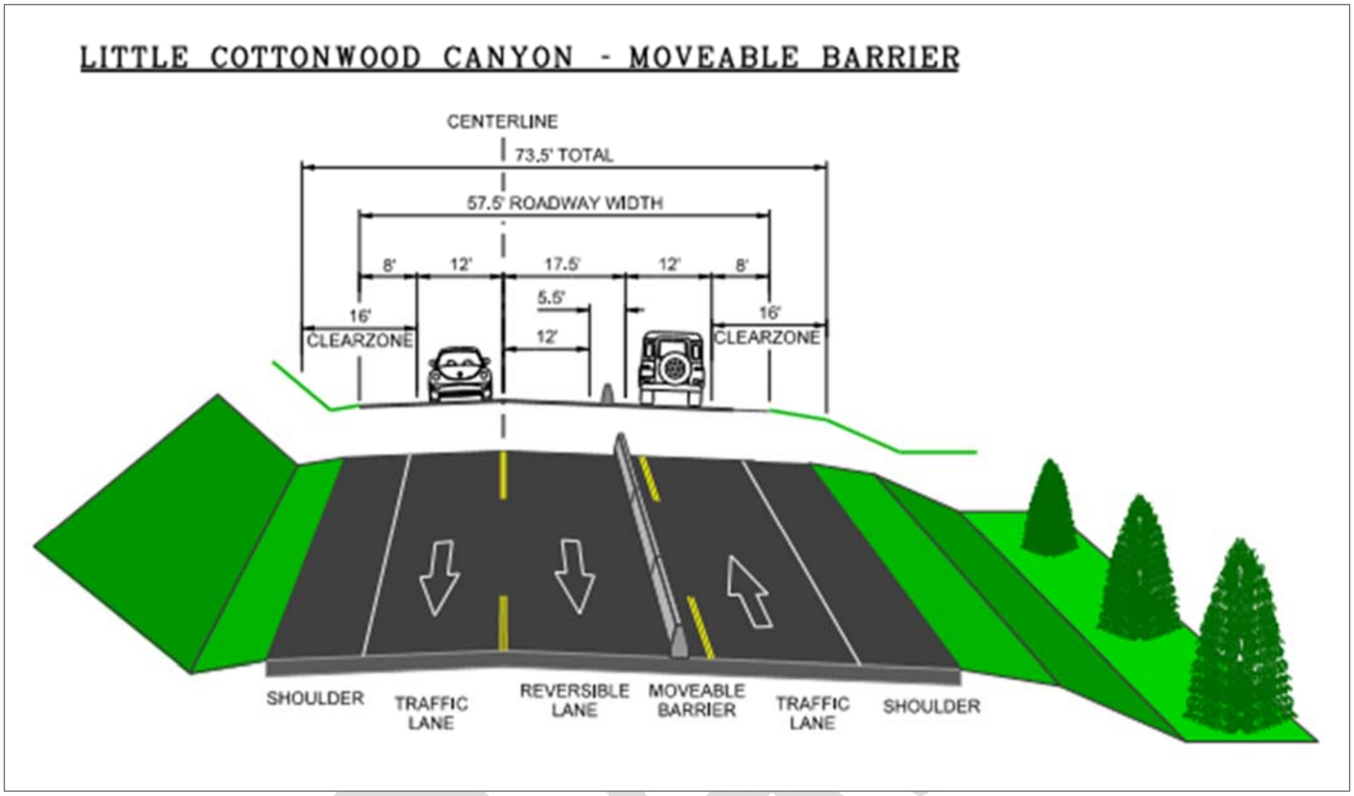
Shy distance is the space needed between a travel lane and a barrier so that a typical driver will not shift out of the center of the lane or reduce speed.

The barrier would be moved on peak traffic days only (weekends during the ski season, holidays, and special events). UDOT would place the barrier to provide two eastbound lanes and one westbound lane in the morning. After the peak morning traffic passed, the barrier would be moved to provide two westbound lanes and one eastbound lane for the evening peak traffic. After the evening peak traffic passed, the barrier would be moved back to the morning position to be ready for the next day.

On off-peak days, the barrier could be left in place with two eastbound lanes and one westbound lane. During the summer, the barrier could be placed to provide one eastbound lane, one westbound lane, and a protected bicycle lane on the south side of the road.

A heated storage facility for the transfer machine would be needed near the west end of the barrier at the mouth of the canyon, and a second facility might be needed near the east end of the barrier at the Bypass Road.

Figure 2-2. Typical Section with Moveable Barrier



The windy curves and steep grades on Little Cottonwood Canyon Road do not prevent using moveable barriers, but they would influence the transfer speed and cost of a barrier. On grades up to 8%, the maximum speed at which a barrier can be transferred from one side of the reversible lane to the other is 8 miles per hour (mph), but this speed decreases with steeper grades. Transferring a barrier from the inside of a curve to the outside changes the radius and length of the barrier. For larger-radius curves, the hinges can compensate for the change in length. For tighter curves, this option would require variable-length barriers with special operating restrictions and hardware.

The minimum radius to transfer a barrier across a 12-foot-wide lane without special operating restrictions and hardware is 1,000 feet. As the number of tight curves increases, transfer speeds drop and costs increase. Considering the steep grades and tight curves in Little Cottonwood Canyon, the transfer speed could drop to 5 mph or slower. At 5 mph, it would take about 1.4 hours (1 hour 25 minutes) to transfer 7.0 miles of barrier from the intersection with S.R. 109 to the Bypass Road once the transfer machine was in place.

There are 10 connecting roads or driveways and an additional eight informal parking areas on Little Cottonwood Canyon Road between the intersection with S.R. 209 and the Bypass Road. Gaps or breaks in the barrier would be necessary to allow vehicles to access these areas from either direction. In order to meet safety standards, crash cushions would be required at each end of the barrier. Anchorless liquid-filled crash cushions could be transferred with the barrier.

According to representatives for moveable barrier systems, the technology can be used even with 24 inches of snowfall in one day or 500 inches of snowfall over a season (Ferguson 2019a). A snow-removal plan would be required for implementation. During snow events, it would be necessary to remove snow before moving the barrier. Given that an average of 33 avalanche flows hit Little Cottonwood Canyon Road each year, moveable barriers could be hit. There is no information available regarding avalanche flows hitting moveable barriers, but semitrucks have hit them and pushed them out of place. If the barriers and hinges are not damaged, the transfer machine can pull the barriers back into place. If the barriers are damaged, the road needs to be closed while the barriers are replaced (Ferguson 2019a).

Clear signing would be critical where the road transitions to reversible lanes. Overhead reversible-lane control signs or signals would be needed in the transition areas. West of the S.R. 209 intersection, there would be two eastbound lanes and one westbound lane on S.R. 210 at all times. The transition would be straightforward during the morning peak, since there would also be two eastbound lanes and one westbound lane on S.R. 210 east of the intersection (Figure 2-3). However, during the evening peak, the center lane would reverse direction. The eastbound center lane (west of the intersection) could either merge right to continue traveling through the intersection or turn left into the adjacent park-and-ride lot. The westbound center lane (east of the intersection) could either merge right to continue traveling through the intersection or turn left onto S.R. 209. Figure 2-4 shows the transition to reversible lanes at S.R. 209 during the evening peak.

Figure 2-3. Transition to Reversible Lane at S.R. 209 – Morning Peak

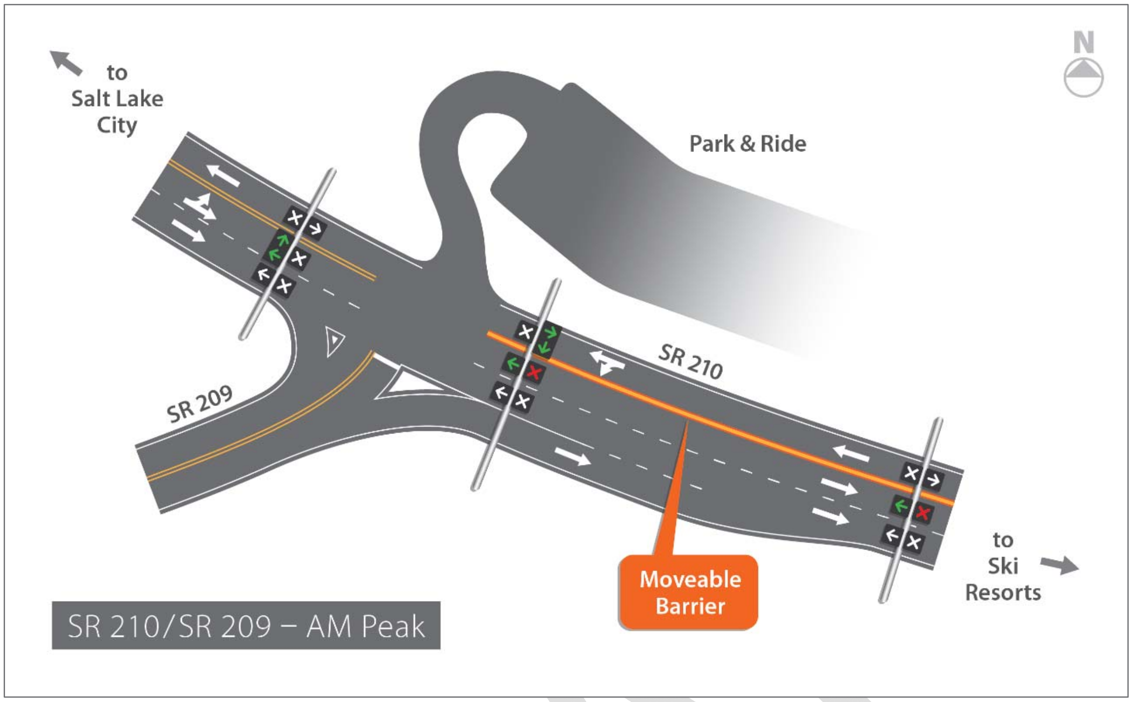
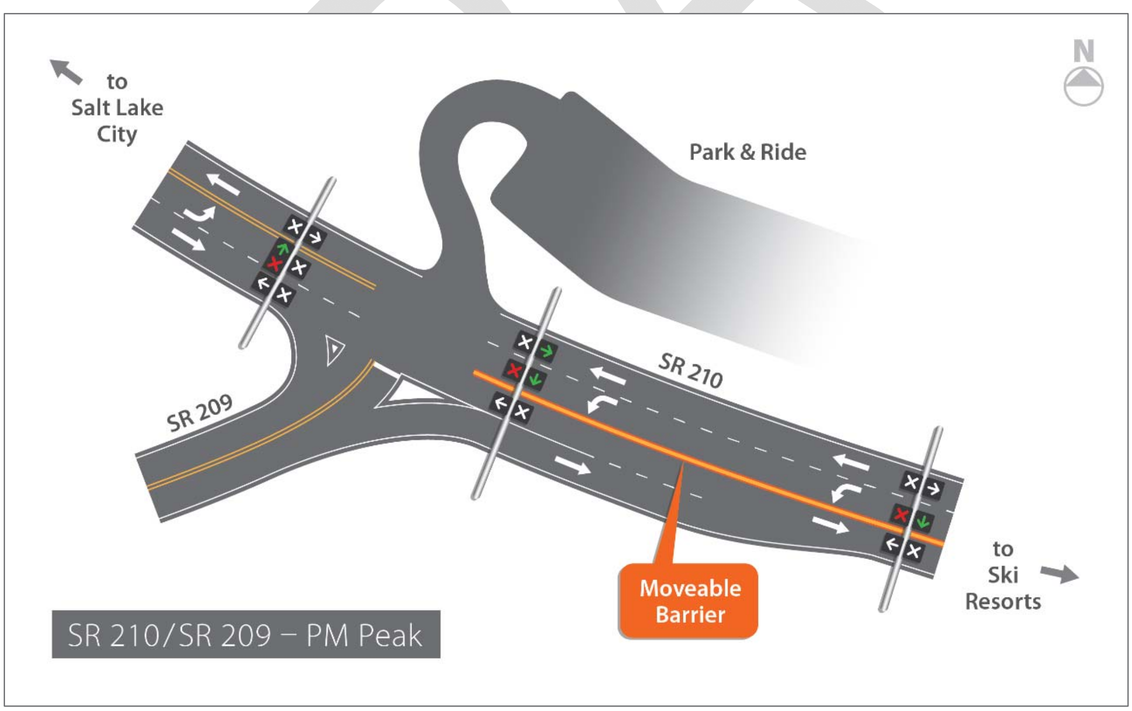


Figure 2-4. Transition to Reversible Lane at S.R. 209 – Evening Peak



East of the Bypass Road, there would be one travel lane in each direction at all times. At the Bypass Road intersection, there would be four lanes total (one lane in each direction, one dedicated right-turn lane onto the Bypass Road, and one receiving lane for left turns onto Little Cottonwood Canyon Road). West of the Bypass Road, there would be one eastbound lane and one westbound lane at all times, plus the center lane that would transition between eastbound and westbound travel.

During the morning peak, the center lane would be open to eastbound traffic. Figure 2-5 shows the transition at the Bypass Road during the morning peak. During the evening peak, the center lane would be open to westbound traffic. Vehicles turning left from the Bypass Road could continue down the canyon in the center lane. Figure 2-6 shows the transition to reversible lanes at the Bypass Road during the evening peak. It would be necessary to have a transition similar to what is shown in Figure 2-5 and Figure 2-6 at each location where there is a high-T intersection with reversible lanes. However, reversible-lane control signs or signals would be needed on both sides of the intersection.

What is a high-T intersection?

A high-T intersection is a three-way intersection with a barrier or curb that separates traffic moving straight through the intersection from the traffic turning left onto the main road.

A median barrier would reduce the risk of crossover accidents and vehicles sliding into oncoming traffic when the roads are icy. However, if a vehicle breaks down or crashes in the single lane, the median barrier could make it more difficult for an emergency response vehicle to assist. Also, it would be more difficult for traffic to detour around accidents or disabled vehicles.

Median barriers affect the movements and mortality of a wide range of wildlife, from large to small animals. Barriers can increase the number of wildlife deaths and decrease wildlife movements across the road (Caltrans 2006).

Figure 2-5. Transition to Reversible Lane at Bypass Road – Morning Peak

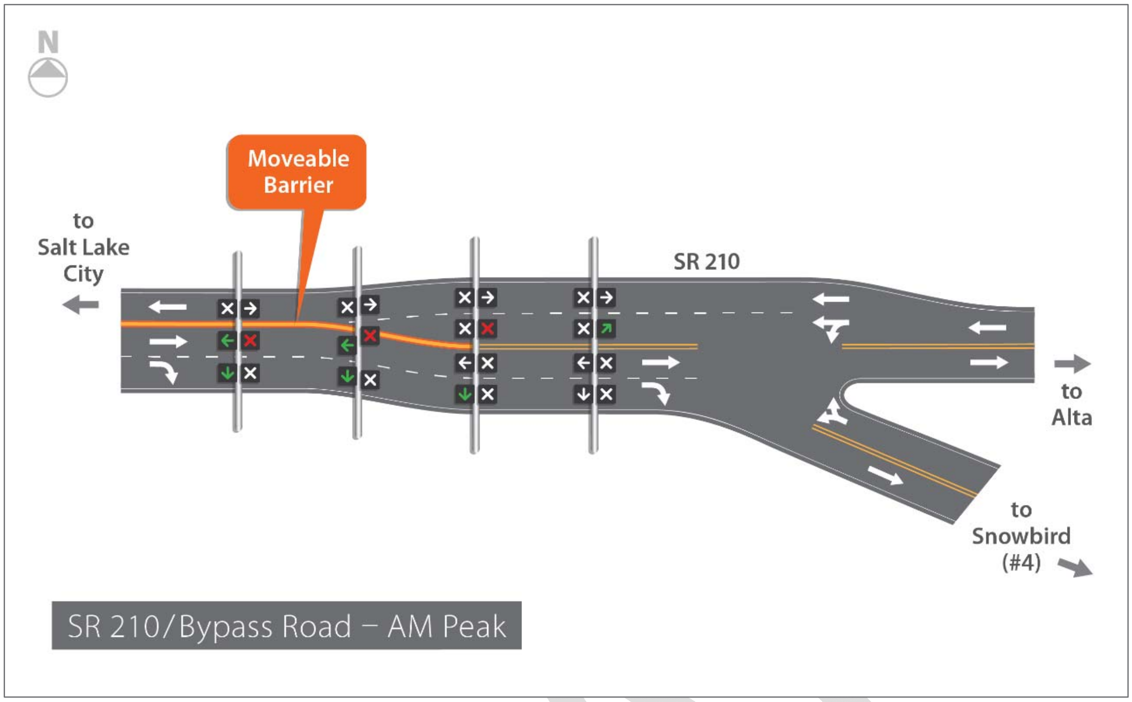
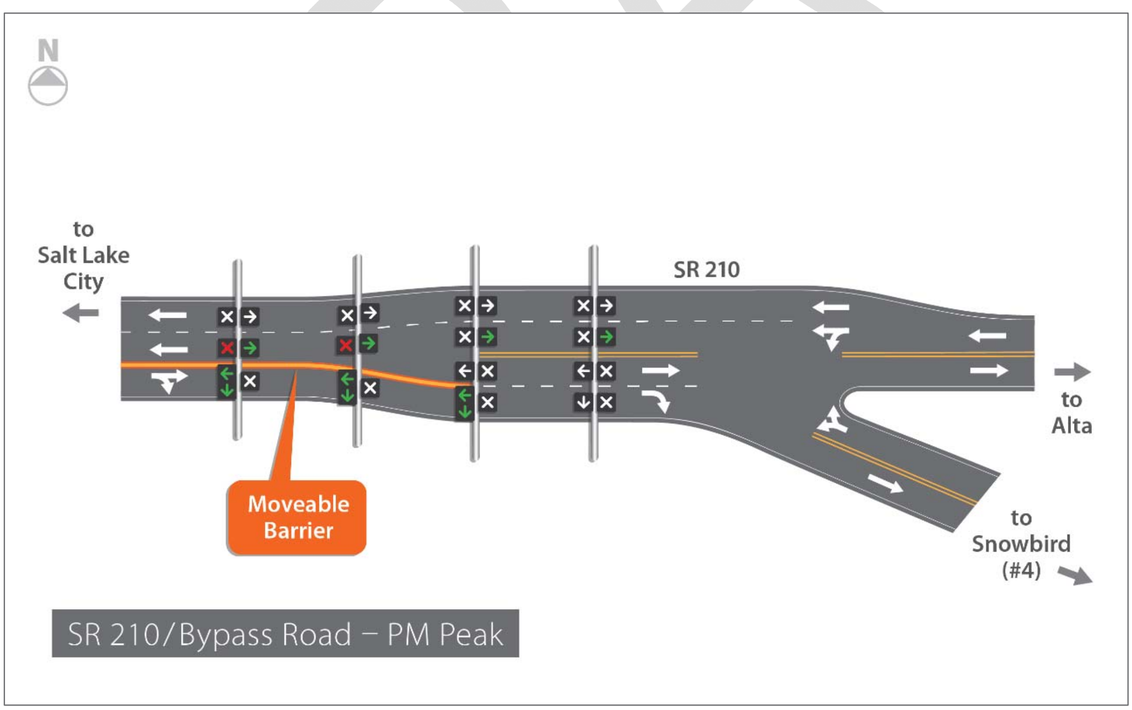


Figure 2-6. Transition to Reversible Lane at Bypass Road – Evening Peak



2.1.2 Reversible-lane Control Signals and Signs

Reversible lanes can be implemented without a barrier using lane-control signs to change the direction of traffic. The lane-control signs are placed over each lane on an overhead horizontal pole (gantry) and can be changeable (Figure 2-7) or static (Figure 2-8).

UDOT constructed reversible lanes with changeable lane-control signals on 5400 South in Salt Lake County in 2013. The road has seven lanes, three of which are reversible. Gantry spacing was typically based on the drivers' line of sight and a requirement that drivers should be able to see at least two gantries at any time. Typically, this resulted in a spacing of 500 to 700 feet (Guebert and others 2010). Figure 2-7 shows changeable lane-control signals on 5400 South.

Figure 2-7. Changeable Lane-control Signals

Photo credit: Hartmann 2012

UDOT might determine through an engineering study that physical barriers or changeable lane-control signals are not necessary and that the reversible lane can be controlled by static overhead lane-control signs. Figure 2-8 shows an example of a static lane-control sign (UDOT 2011).

Figure 2-8. Static Lane-control Sign

Reversing the flow of traffic can be controlled with pavement markings and static lane-control signs when the following conditions are met:

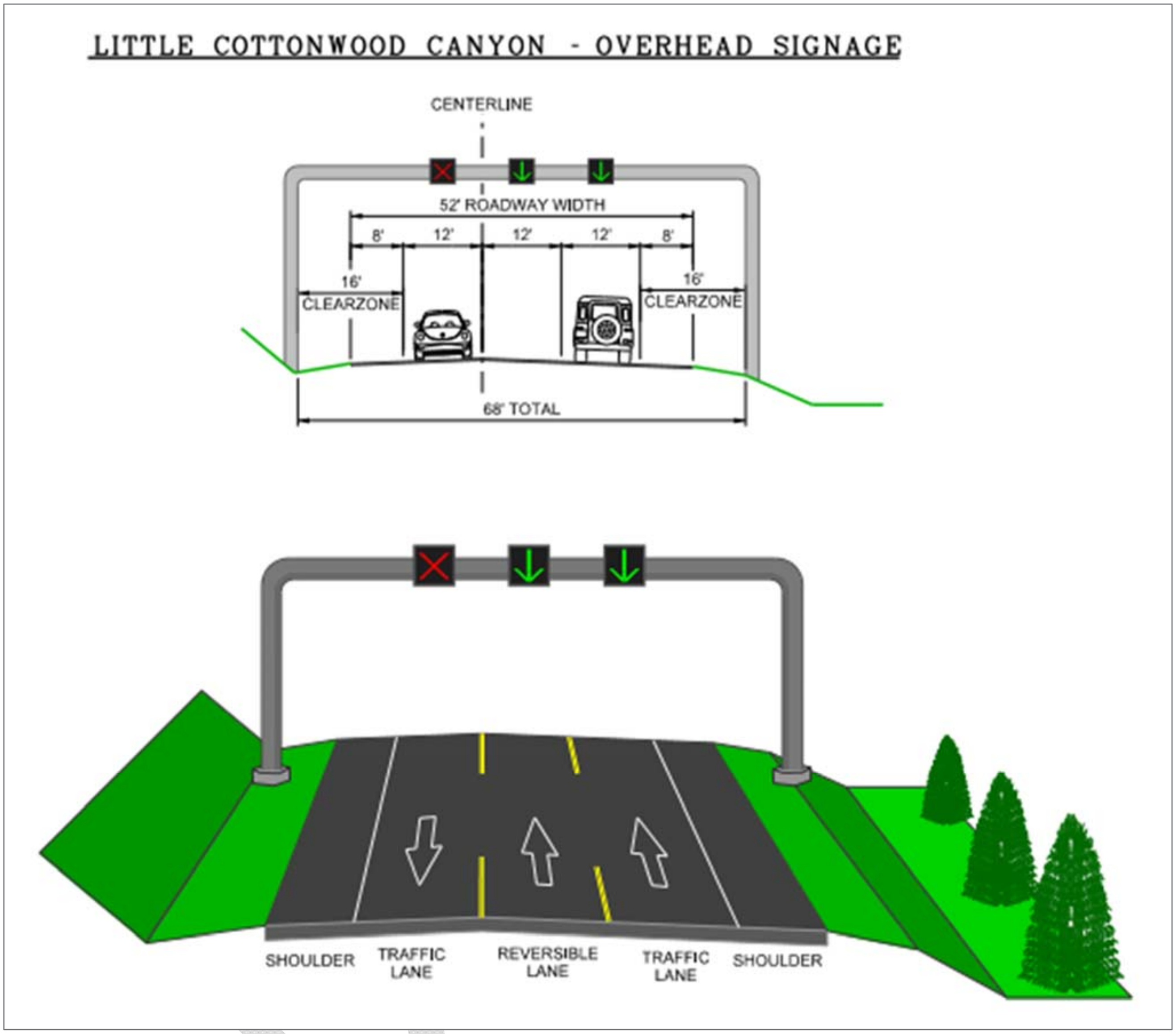
- Only one lane is being reversed,
- An engineering study indicates that the use of reversible lane-control signs alone would result in an acceptable level of safety and efficiency, and
- There are no unusual or complex operations in the reversible-lane pattern (UDOT 2011).

Static lane-control signs would not give UDOT flexibility in implementing reversible lanes based on weather, holidays, and special events.

Considerations for S.R. 210

Figure 2-9 shows the typical section for reversible lanes with a changeable lane-control signal on Little Cottonwood Canyon Road. The road would be widened to include three 12-foot-wide travel lanes and two 8-foot-wide shoulders. The total pavement width would be 52 feet. The overhead gantry would span the clear zone for a total roadway width of 68 feet.

Figure 2-9. Typical Section with Lane-control Signal



For S.R. 210, lane-control signals would indicate that two lanes are open to eastbound traffic and one lane is open to westbound traffic during the morning peak on peak traffic days. After the peak morning traffic passed, the signal for the center lane would shift to indicate that two lanes are open to westbound traffic and one lane is open to eastbound traffic.

The overhead gantries should be placed such that the driver has a definite indication of the lanes specifically reserved for use at any given time. The maximum allowable spacing is 1/3 mile (UDOT 2011), with additional gantries recommended where sight distance is limited by sharp horizontal curves. About 41 overhead gantries spaced at 1/3 mile would be needed on S.R. 210 between the intersection with S.R. 209 and the Bypass Road. This number would increase to 62 if UDOT wanted drivers to see two gantries at a time.

The visual impacts of overhead gantries would need to be evaluated considering the strategies for protecting scenic vistas in the *Cottonwood Canyons Scenic Byways Corridor Management Plan*. Figure 2-10 shows an example of what an overhead gantry might look like in Little Cottonwood Canyon. Given the scenic nature of Little Cottonwood Canyon, gantries would detract from the scenic canyon.

Figure 2-10. Simulation of Overhead Gantry in Little Cottonwood Canyon

The transition to reversible lanes with lane-control signals would be similar to what was discussed for the moveable barrier in Section 2.1.1. Because drivers might be confused by reversible lanes that are controlled by overhead signals, drivers would need to be educated. During periods of peak traffic, drivers would likely be a combination of locals and out-of-state tourists.

Reversible lanes would not impede wildlife movement or increase the number of wildlife deaths. However, the overhead lights could attract or confuse birds.

2.1.3 Other Reversible-lane Technologies

UDOT also considered other reversible-lane technologies: electroluminescent paint, in-pavement light-emitting diode (LED) markers, retractable bollards, and barriers on each side of the reversible lane. However, UDOT does not consider these technologies feasible for Little Cottonwood Canyon, as described below.

Considerations for S.R. 210

Electroluminescent Paint. Electroluminescent paint lights up when an electric current passes through it. By using this paint, it might be possible to change the pavement markings (roadway striping) from a dashed white line to a solid yellow line to indicate the allowed lane use. However, this technology is still in the early stages of development (Arvind 2015). UDOT does not consider this technology feasible for Little Cottonwood Canyon because the technology is not yet available and the paint would not be visible when covered by snow.

In-pavement LED Markers. In-pavement LED markers are currently used to illuminate crosswalks and delineate ramps and curves. With the addition of intelligent features, they could be used to indicate directional traffic flow by turning the lights on or off. Implementing LED markers would require them to be controlled remotely, reliably, and dynamically. The LED markers would need to be closely spaced so that they would collectively emit enough light to be seen during the daytime. This close spacing could produce an uncomfortable ride for drivers and passengers because vehicles might pass over multiple markers while changing lanes (Arvind 2015). UDOT does not consider this technology feasible in Little Cottonwood Canyon because the markings would not be visible when covered by snow.

Retractable Bollards. Retractable bollards are vertical posts that can be extended above the pavement to act as a barrier or retracted below the pavement to remove the barrier. They are commonly used in parking and pedestrian areas. Implementing retractable bollards for reversible lanes would require UDOT to modify the bollard design to withstand impacts from vehicles traveling at high speeds. UDOT would also need to easily extend and retract multiple bollards and control the bollard operations remotely (Arvind 2015). UDOT does not consider this technology feasible in Little Cottonwood Canyon because the technology is not currently available and because snow and ice could interfere with retracting the bollards.

Barrier on Each Side. UDOT considered using a reversible lane in the center of S.R. 210 with a permanent barrier on each side of the lane. This reversible lane would be open to eastbound traffic during the morning peak and westbound traffic during the evening peak. UDOT does not consider this option feasible in Little Cottonwood Canyon because the reversible lane could not be plowed. UDOT’s maintenance crews need 10 to 15 feet of clear space on the right side of the roadway for storing snow.

3.0 Peak-period Shoulder Lane Concept

A peak-period shoulder lane (PPSL) is an upgraded shoulder that functions as a travel lane during periods of peak congestion. During non-peak times, it functions as a shoulder.

PPSLs are a way to provide additional traffic capacity within a constrained right-of-way and improve mobility during periods of peak congestion without adding another lane. The shoulders must be wide enough and have an appropriate pavement section to handle traffic. In the event of an emergency or blocking vehicle, the PPSL is closed until the lane is cleared.

What is a peak period shoulder lane?

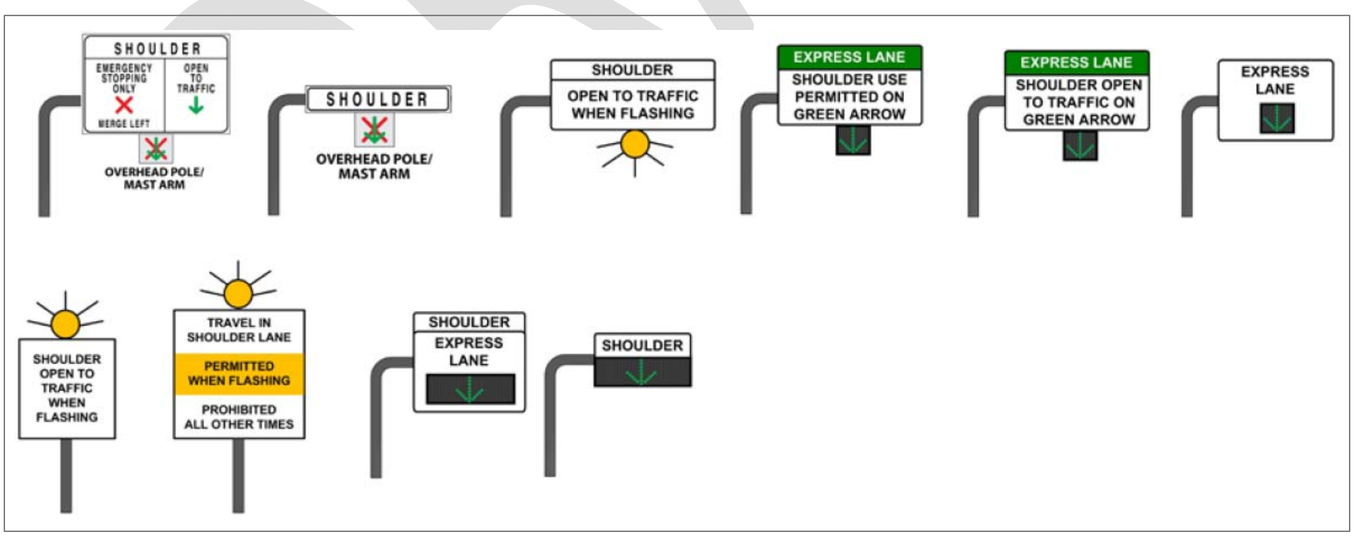
A peak period shoulder lane (PPSL) is an upgraded shoulder that functions as a travel lane during periods of peak congestion. During non-peak times, it functions as a shoulder.

PPSLs are used in several locations in Europe and the United States including on Interstate 35 West in Minnesota, Interstate 405 and U.S. Highway 2 in Washington State, and Interstate 70 in Colorado. European agencies have realized safety and mobility benefits as a result of PPSL projects (CDOT 2014).

PPSLs rely on various technology. Dynamic message signs inform motorists whether the PPSL is open to traffic. Closed-circuit television (CCTV) cameras ensure that the lane is clear of vehicles, snow, and debris and monitors the flow of traffic when the lane is operational. If an incident occurs while the PPSL is open, UDOT's Traffic Operations Center would communicate with emergency responders to assist with crashes or disabled vehicles and use variable message signs to notify the travelling public that the PPSL is closed.

A clear signing plan is needed to let drivers know when the PPSL is open and, if access to the lane is controlled, where they can enter and exit the lane. Lane-use signals are located next to the PPSL to indicate whether it is open or closed (Figure 3-1).

Figure 3-1. Examples of Lane-use Signals for PPSLs



Considerations for S.R. 210

The PPSL concepts in this report would be implemented on S.R. 210 for 8.6 miles from the intersection with Wasatch Boulevard (MP 2.2) to the Bypass Road (MP 10.8). Figure 3-2 shows the typical section for PPSLs in Little Cottonwood Canyon. S.R. 210 would be widened to include two 12-foot-wide travel lanes and two 11-foot-wide shoulders with 2 feet of pavement beyond the shoulder stripe. The total pavement width would be 50 feet. The clear zone would be measured from the edge of the PPSL for a total roadway width of 78 feet.

The PPSLs would be open to eastbound traffic during the morning peak and open to westbound traffic during the evening peak on peak traffic days (weekends during the ski season, holidays, and special events). The PPSLs could be open to general-purpose traffic without restrictions, or they could be limited to buses only. The transition areas at the beginning and end of each PPSL would be fairly straightforward. Lane-use signals would alert drivers as to whether the PPSL is open or closed. When the lane is closed, drivers would merge back into the general-purpose lane.

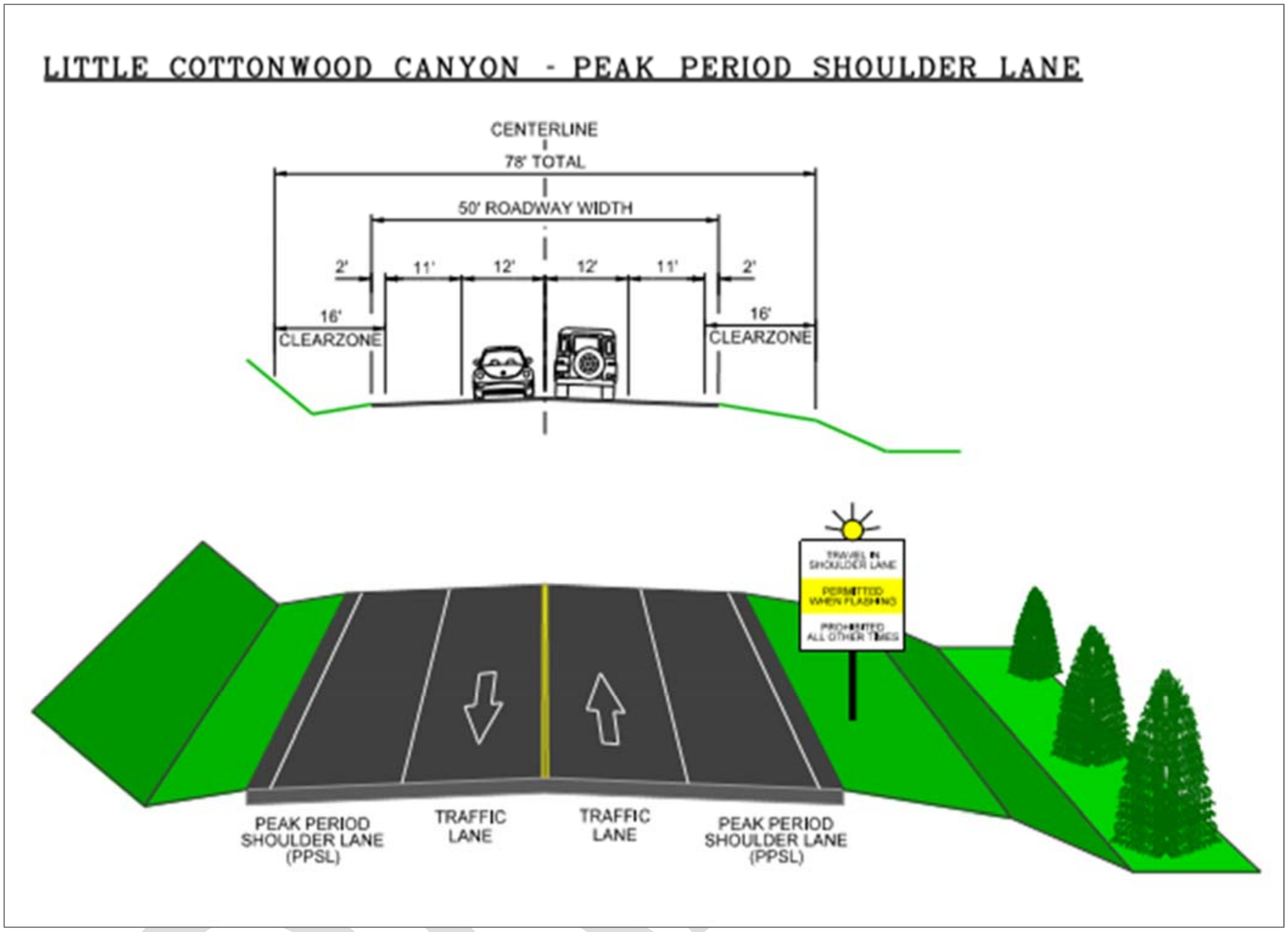
North Little Cottonwood Road currently has signed and striped bicycle lanes. These bicycle lanes would cause conflicts between cyclists and vehicles when the PPSL is open, and these conflicts would need to be resolved. However, the PPSL would generally be open when bicycle use is low (that is, during the winter).

Lane-use signals would be placed so that drivers have a clear indication whether the PPSL is open. The recommended spacing ranges from 1/3 to 2/3 mile (CDOT 2014). About 27 signs spaced at 1/3 mile (about 54 signs total) would be required on S.R. 210 in each direction between the intersection with Wasatch Boulevard and the Bypass Road. The signs would be evaluated considering the strategies in the *Cottonwood Canyons Scenic Byways Corridor Management Plan* for protecting scenic vistas. Compared to lane-control signs and signals for reversible lanes, the lane-use signals for PPSLs would be less intrusive because they would be placed adjacent to the shoulders, not over every lane.

Vehicles using the open PPSL would have only a 2-foot-wide outside shoulder; however, the clear zone (recovery area for errant vehicles) would be 16 feet wide. The existing shoulder on S.R. 210 is 2 feet wide in some locations. The closed PPSL could provide enough space to keep bicycles out of the travel lanes, especially on tight curves with poor sight distance.

There is a risk that drivers would use the PPSL when the lane is closed to pass slow-moving vehicles. This could cause problems, especially in the summer when there could be heavy bicycle traffic in the PPSL. Enforcement would be necessary to keep drivers from using the PPSLs when the lanes are not open. The presence of the PPSL would not allow roadside parking on S.R. 210 at any time of year. The PPSL concept would not impede wildlife movement or increase the number of wildlife deaths.

Figure 3-2. Typical Section with Peak-period Shoulder Lane



4.0 Comparison of Concepts

Table 4-1 provides a high-level comparison of the reversible-lane and PPSL concepts. A reversible lane with a moveable barrier would cost more and would require a greater level of effort for ongoing operation and maintenance than the other concepts; however, it would have lower visual impacts because fewer signs and signals would be required. A reversible lane with lane-control signs (or signals) and PPSLs would each cost less than a reversible lane with a moveable barrier and would require a lower level of effort for ongoing operation and maintenance. However, these concepts would have larger visual impacts. A reversible lane with lane-control signs (or signals) would have larger visual impacts than PPSLs.

Table 4-1. Comparison of Managed-lane Concepts

Managed-lane Concept	Cost	Level of Effort Required for Operation and Maintenance	Visual Impacts	Wildlife Impacts	Safety Considerations
Reversible Lane with Moveable Barrier	$15 million for 7.0 miles of barrier, transfer machine, crash cushions, and training for UDOT personnel (Ferguson 2019b, 2019c)	High • Mobilization and operation of transfer machine • Snow plowing considerations • Repair of avalanche-damaged barriers • Monitoring by UDOT Traffic Operations Center	Moderate • Crash cushions at each end of the barrier	Moderate • Barrier would impede wildlife movement and increase the number of wildlife deaths	• Reduces potential for crossover accidents. • Limits ability for vehicles to go around vehicle accidents or breakdowns. • Limits ability of emergency responders to access an accident location with the barrier in place. • Could accommodate roadside parking. • 8-foot-wide shoulder for summer use by cyclists.
Reversible Lane with Lane-control Signs or Signals	$14 million for 62 signs or signals (overhead signs or signals across all lanes)	Low • Monitoring by UDOT Traffic Operations Center	High • About 62 lane-control signs or signals across all lanes	Low • Overhead signals could attract or confuse birds	• Risk of driver confusion. Many drivers would be from out of state and not familiar with the roadway. • Could accommodate roadside parking. • 8-foot-wide shoulder for summer use by cyclists.
Peak-period Shoulder Lanes (PPSL)	$6.5 million for 54 signals on shoulder or $14 million for overhead signals	Low • Monitoring by UDOT Traffic Operations Center	Moderate • About 54 lane-use signals adjacent to shoulders	Low	• Provides wide, 11-foot uphill and downhill bicycle lane for summer use. • Possible enforcement issues with drivers using the wide shoulder lanes when they are not open. • No roadside parking allowed.

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APPENDIX D

Draft Enhanced Bus Concepts

Little Cottonwood Canyon ENVIRONMENTAL IMPACT STATEMENT
S.R. 210 | Wasatch Blvd. to Alta

Draft Enhanced Bus Concepts

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 - Wasatch Boulevard to Alta

Utah Transit Authority
Utah Department of Transportation

April 3, 2020

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1.0 Introduction

The purpose of this technical report is to analyze enhanced bus service for Little Cottonwood Canyon to support enhanced winter transit service. This report also provides information that the Utah Department of Transportation (UDOT) will use during the alternatives development and screening process for the Little Cottonwood Canyon Environmental Impact Statement (EIS), which will evaluate how well the bus concepts described in this report would satisfy the purpose of and need for the Little Cottonwood Canyon Project.

During the winter, Little Cottonwood Canyon experience increase travel for winter recreation to two resorts. By 2050, winter recreation and overall travel demand is expected to increase on State Route (S.R.) 210, which will result in reduced mobility. By 2050, the population in Salt Lake County is expected to increase by 36% and Utah County by 108%.

The purpose of the winter transit concepts presented in this report is to reduce personal vehicle use on S.R. 210 by having people going to the resorts use bus service instead of personal vehicles to improve overall mobility. See Sections 4.0 for more information about the transit service being proposed. For Little Cottonwood Canyon, this report looks at providing a peak-hour bus capacity that can accommodate up to 1,008 people per hour. The capacity of 1,008 people per hour is the maximum capacity of bus service assuming 5-minute headways to each resort. Headways less than 5 minutes would be difficult when considering the time to load and unload buses with the equipment required for skiing.

For each concept, direct service to each resort is assumed. For example, a bus leaving a transit hub would go directly to the Alta resort without stopping at Snowbird. The purpose of the direct service is to make the bus service more attractive to all users. Currently, when a bus stops at the Snowbird resort first, this adds about 15 minutes to the travel time to the Alta resort. In addition, at the end of the day, buses fill up with passengers at the Snowbird resort first, making it difficult for Alta users to find space on the bus. A survey conducted by the Utah Transit Authority (UTA) in March 2019 of 333 bus users in Little Cottonwood Canyon found that 16.5% of those using the bus service were going to Alta resort and 45.6% were going to Snowbird resort (UTA 2019). The purpose of the point-to-point service is to make bus service more attractive to users of each resort.

Summer transit is not be considered in this report. UTA can implement summer transit if a need is identified in the future.

2.0 Existing Bus Service

2.1 Little Cottonwood Canyon

Existing transit service in Little Cottonwood Canyon includes two UTA bus routes (953 and 994) that provide ski bus service during the winter season. UTA ski bus service to Alta and Snowbird resorts typically begins on or around December 1 and operates until early April. The service runs all day from two routes with 15-minute frequency during peak hours, or a capacity of about 336 riders per hour (see Section 3.1 for passenger-carrying assumptions). UTA's bus service provides connections to TRAX, FrontRunner, and Route 220 (a UTA route that serves the University of Utah and downtown Salt Lake City), offering frequent all-day access to people from downtown Salt Lake City and throughout the region.

At the resorts, the number of stops (three at Snowbird and two at Alta) and circulation in resort lots accounts for 15 minutes of scheduled travel time along a route with no congestion. In addition, buses are subject to the same roadway congestion as other vehicles, which does not provide an incentive for using transit. The slower time for transit travel makes it unattractive to many users.

The cash fare for the ski bus is $4.50 each way. The cost of any bus, TRAX, or FrontRunner ticket counts for partial credit toward a ski bus fare, so riders pay only once, even if they transfer. The cost of the ski bus service is free to resort season pass holders (the cost of the bus ride is subsidized by the resort).

The Route 953 ski bus operates between Midvale Fort Union TRAX Station and Snowbird/Alta with 15 to 30-minute service during peak hours along with several midday trips. The Route 994 ski bus operates between Historic Sandy TRAX Station and Snowbird/Alta with 15-minute service during the peak hours and 30-minute service during the midday. The Route 953 ski bus also operates one daily trip during the summer to serve employees at Snowbird. The existing transit service is shown in Table 1 and Figure 1.

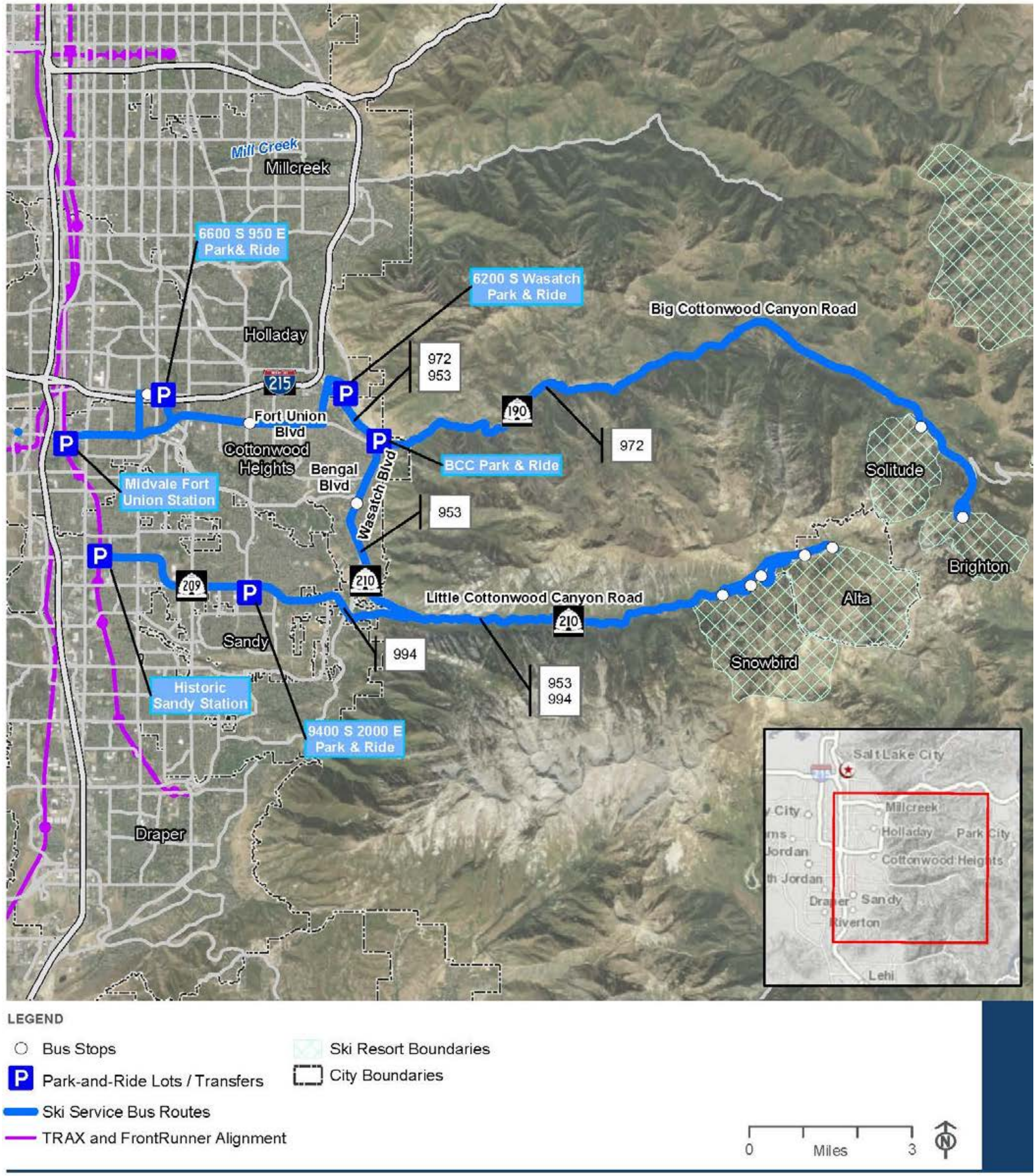
Table 1. Existing Bus Service in Little Cottonwood Canyon

Route	Description	Winter	Summer
953	Midvale Fort Union Station to Snowbird/Alta	15–30 minute service during peak hours, with additional midday trips	1 trip in each direction (up and down canyon) per day
994	Historic Sandy Station to Snowbird/Alta	15–30 minute service	None

Source: UTA 2018a

A survey conducted by UTA in March 2019 of 333 bus users in Little Cottonwood Canyon found that about 60% of ski bus passengers were season pass holders or employees,18% paid as they boarded (cash, mobile application, or FAREPAY cards), and 5% paid by SuperPass. This indicates that the average ski bus rider is either a resort employee or a dedicated resident skier (UTA 2019). Data from the Ski Utah survey (presented in Mountain Accord 2015) show that about 7% of the visitors to the ski areas in Big and Little Cottonwood Canyons use public transit, whereas 78% use a private or rental vehicle.

Figure 1. Existing Transit Service in Little Cottonwood Canyon



3.0 Assumptions Made for the Enhanced Bus Service Concepts

The project team made the following assumptions when developing the enhanced bus service concepts that are analyzed in this report.

3.1 Bus Capacity and Technology Type

Size. UTA's current ski buses have special power, transmission, and automatic chain deployment systems designed to operate in a winter canyon environment. The engine and transmission requirements are necessary to handle the steep grades in Little Cottonwood Canyon (up to 11%), and the automatic chains are for the frequent snowfalls. The current buses provide seating for 23 riders and standing room for an additional 19 riders, for a total capacity of 42 riders. For the analysis of enhanced bus service concepts, the total bus capacity of 42 riders was used.

Figure 2. Articulated Bus

Transit buses are typically 35 feet long. Replacing the 35-foot buses currently used in the canyons with 60-foot articulated buses (see Figure 2) would allow UTA to carry more riders without hiring more operators. Larger buses such as articulated buses have a capacity of about 80 riders. However, studies have found that articulated buses are prone to jackknifing when operating in snow and ice on steep grades (Nelson/Nygaard Consulting Associates, Inc. 2017). Even with tire chains, articulated buses might not be able to operate on steep grades in snow and ice as easily as nonarticulated buses can. Therefore, articulated buses were eliminated from consideration in this concepts analysis.

Technology. UTA's current ski buses are diesel powered. For this concepts analysis, the project team considered diesel buses, electric buses, and hybrid buses.

Although electric bus technology is rapidly advancing, electric bus batteries currently have both limited range and performance issues on steep grades. Further, when primary electric heaters are used in cold weather, the heaters drain the batteries, limiting the range the bus can travel before needing to charge. (Currently, most transit authorities heat any electric buses in their fleet using a diesel fuel heating system.)

Because electric bus technology is still evolving, electric buses were eliminated from consideration when this report was written. This concepts analysis assumes the use of diesel buses with a total capacity of 42 riders, the same as UTA's current ski buses. If electric bus technology improves in the future, UTA might add electric buses to its ski bus fleet.

Hybrid buses could be considered by UTA as a bus option if they can be designed to meet the requirements of the steep mountain grades, maneuverability at the resorts, and chains.

3.2 Bus Routes

To optimize bus travel time to be competitive with personal vehicles, the project team assumed point-to-point service from an origin point to the resorts with no intermediate stops along the way. The reason for point-to-point service is that the loading and unloading time in the parking lot of the first resort in the canyon can add up to 15 minutes to the travel time to get to the second resort, thereby making bus service to the second resort less desirable. In addition, at the end of the day, buses sometimes fill up with passengers at the first resort and bypass the second resort, causing users at the second resort to wait for a later bus.

For Little Cottonwood Canyon, bus service would be provided from the existing park-and-ride lot at 9400 South and Highland Drive and from another proposed park-and-ride lot at the gravel pit located on the east side of Wasatch Boulevard between 6200 South and Fort Union Boulevard. See the technical memorandum *Evaluation of Transit Hub Locations in Big and Little Cottonwood Canyons* (UDOT 2019) for more information regarding the proposed park-and-ride lots and Section 4.2, Valley Transit Hubs, below for a summary of the results of an analysis of a proposed transit hub. The enhanced ski bus service would run between each of the proposed park-and-ride lots directly to one transit stop each at either Snowbird or Alta. Riders on the bus to Alta would not need to stop at Snowbird first, since separate buses would run directly to each resort.

4.0 Enhanced Bus Service Concepts for Little Cottonwood Canyon

> **What is mixed-flow traffic?**
>
> In mixed-flow traffic, automobiles and buses operate in the same travel lanes.

For Little Cottonwood Canyon, the following four enhanced bus service concepts are being considered. The four concepts described in this report will provide data to support the bus transit alternatives being considered in the Little Cottonwood Canyon Environmental Impact Statement. Note that the ridership for each concept in the year 2050 is the bus capacity per hour, not the predicted number of riders. For each concept, the buses would be staged to go directly to Snowbird or Alta from either the gravel pit or the existing UTA park-and-ride at 9400 South and Highland Drive. Bus service for the mobility concepts described in this report would be provided from 7 AM to 7 PM. UTA would also extend a less-frequent service outside these hours for night skiing and resort employees.

- **Concept A1:**
  - **Roadway** – Mixed flow (No new roadway capacity in Little Cottonwood Canyon. Bus in same traffic flow as personal vehicles). Transit priority from Fort Union Boulevard to the S.R. 209/S.R. 210 intersection.
  - **Number of transit hubs** – 2 (gravel pit, 9400 South and Highland Drive).
  - **Peak-travel bus headway/route:**
    - Gravel pit to Alta – 4 buses per hour (1 bus every 15 minutes)
    - Gravel pit to Snowbird – 4 buses per hour (1 bus every 15 minutes)
    - 9400 South/Highland Drive to Alta – 4 buses per hour (1 bus every 15 minutes)
    - 9400 South/Highland Drive to Snowbird – 4 buses per hour (1 bus every 15 minutes)
  - **Total bus peak-hour resort capacity** – 8 buses per resort × 42 riders for an hourly capacity of 336 per resort.
  - **Total concept peak-hour bus capacity** – Capacity of 672 riders per hour.
- **Concept A2:**
  - **Roadway** – Bus lane (new bus lane capacity added starting at Wasatch Boulevard and North Little Cottonwood Road; bus operates in its own lane separate from personal vehicles or shared with high-occupancy vehicles). Bus might operate in a striped peak-hour shoulder lane. Transit priority from Fort Union Boulevard to the S.R. 209/S.R. 210 intersection.
  - **Number of transit hubs** – 2 (gravel pit, 9400 South and Highland Drive).
  - **Peak-travel bus headway/route:**
    - Gravel pit to Alta – 4 buses per hour (1 bus every 15 minutes)
    - Gravel pit to Snowbird – 4 buses per hour (1 bus every 15 minutes)
    - 9400 South/Highland Drive to Alta – 4 buses per hour (1 bus every 15 minutes)
    - 9400 South/Highland Drive to Snowbird – 4 buses per hour (1 bus every 15 minutes)
  - **Total bus peak-hour resort capacity** – 8 buses per resort × 42 riders for an hourly capacity of 336 per resort.
  - **Total concept peak-hour bus capacity** – Capacity of 672 riders per hour.

- **Concept B1:**
  - **Roadway** – Mixed flow (no new roadway capacity in Little Cottonwood Canyon; bus in same traffic flow as personal vehicles). Transit priority from Fort Union Boulevard to the S.R. 209/S.R. 210 intersection.
  - **Number of transit hubs** – 2 (gravel pit, 9400 South and Highland Drive).
  - **Peak-travel bus headway/route:**
    - Gravel pit to Alta – 6 buses per hour (1 bus every 10 minutes)
    - Gravel pit to Snowbird – 6 buses per hour (1 bus every 10 minutes)
    - 9400 South/Highland Drive to Alta – 6 buses per hour (1 bus every 10 minutes)
    - 9400 South/Highland Drive to Snowbird – 6 buses per hour (1 bus every 10 minutes)
  - **Total bus peak-hour resort capacity** – 12 buses per resort × 42 riders for an hourly capacity of 504 per resort.
  - **Total concept peak-hour bus capacity** – Capacity of 1,008 riders per hour.
- **Concept B2:**
  - **Roadway** – Bus lane (new bus lane capacity added starting at Wasatch Boulevard and North Little Cottonwood Road; bus operates in its own lane separate from personal vehicles or shared with high-occupancy vehicles). Bus lane might operate in a striped peak-hour shoulder lane instead of a dedicated separate traffic lane. Transit priority from Fort Union Boulevard to the S.R. 209/S.R. 210 intersection.
  - **Number of transit hubs** – 2 (gravel pit, 9400 South and Highland Drive).
  - **Peak-travel bus headway/route:**
    - Gravel pit to Alta – 6 buses per hour (1 bus every 10 minutes)
    - Gravel pit to Snowbird – 6 buses per hour (1 bus every 10 minutes)
    - 9400 South/Highland Drive to Alta – 6 buses per hour (1 bus every 10 minutes)
    - 9400 South/Highland Drive to Snowbird – 6 buses per hour (1 bus every 10 minutes)
  - **Total bus peak-hour resort capacity** – 12 buses per resort × 42 riders for an hourly capacity of 504 per resort.
  - **Total concept peak-hour bus capacity** – Capacity of 1,008 riders per hour.

The bus technology, transit hub locations and amenities, transit priority, and resort transit stops would be common to all four concepts. The alignment configuration would be common to the A1 and B1 (mixed-flow) concepts and common to the A2 and B2 (bus lane) concepts. The headways, and consequently the operating and capital costs, would be different, as discussed in Section 4.4.1, Operating Cost, and Section 4.4.2, Capital Cost.

4.1 Hours of Operation and Headways

The enhanced bus service would operate 7 days per week between 7 AM and 7 PM. As shown in Table 3, during the morning (7 AM to 10 AM) and afternoon (2 PM to 5 PM) peak hours, a bus would leave from each transit hub to Snowbird or Alta every 10 minutes. A bus would leave every 20 minutes during off-peak hours.

For each concept, a travel demand model was used to determine travel times assuming a reduced number of personal vehicles as more recreationists use buses. With more recreationists using buses, the analysis of the enhanced bus concepts showed that bus service during the peak hours would reduce per-person travel time and meet the ridership capacity for the concepts developed. Headways less than 5 minutes were considered infeasible because there would not be enough time for all riders to exit or board the bus and retrieve or stow their gear.

The travel time in 2050 with enhanced bus service is projected to be 24 to 64 minutes under dry road conditions, depending on the concept, from the valley transit hub to the resort stop. Travel time for each bus was assumed to be the speed limit in the valley and 30 miles per hour in Little Cottonwood Canyon where steep grades slow bus speeds.

Concepts A2 and B2 (with the dedicated bus lane) would have the fastest travel time: 24 minutes from the gravel pit transit hub to Alta. Travel time was calculated to Alta, so the travel time to Snowbird would be slightly less. The Alta stop would be about 1.5 miles past the Snowbird stop. Assuming a bus speed average of around 20 miles per hour (mph), it would be about 4 minutes faster to travel to Snowbird on the road. So, the fastest trip to Snowbird would be about 20 minutes. Note that a direct route to each resort was assumed to reduce travel time to the second resort. Although there would be only a 4-minute road travel time difference between Snowbird and Alta if the same bus were to stop at Snowbird first, it would add 15 minutes to the Alta travel time because the Alta passengers would have to wait for the bus to travel through the Snowbird area and unload or load passengers first.

Table 3 shows the enhanced bus travel times for Little Cottonwood Canyon in 2050 for each concept. For reference, in 2050 under no-build conditions (no increase in bus service and no change in roadway capacity), the travel time for the ski bus without the enhanced bus service would be 80 to 85 minutes between Fort Union Boulevard and Alta and 105 to 110 minutes from 9400 South to Alta.

The reason for the different travel times between concepts with the same road configuration (for example, A1 and B1) is that the greater number of buses with the B1 concept would result in fewer personal vehicles on the road and thus less roadway congestion and faster travel times.

Table 2. Operating Details for Little Cottonwood Canyon Concepts in 2050

Concept	Description	Transit Hub/Route	Days	Frequency to Each Ski Resort Peak/Off Peak (minutes)	Travel Time (minutes)
A1	Buses operating in mixed-flow traffic. (No capacity added to S.R. 210 from North Little Cottonwood Road through the town of Alta.). Total concept capacity of 672 in peak hour.	Gravel pit/ Wasatch Blvd	Mon–Sun	15/30	52
		9400 South	Mon–Sun	15/30	64
A2	Buses operating in a bus lane. (Additional capacity added to S.R. 210 from North Little Cottonwood Road through the town of Alta.). Total concept capacity of 672 in peak hour.	Gravel pit/ Wasatch Blvd	Mon–Sun	15/30	24
		9400 South	Mon–Sun	15/30	36
B1	Buses operating in mixed-flow traffic. (No capacity added to S.R. 210 from North Little Cottonwood Road through the town of Alta.). Total concept capacity of 1,008 in peak hour.	Gravel pit/ Wasatch Blvd	Mon–Sun	10/20	42
		9400 South	Mon–Sun	10/20	52
B2	Buses operating in a bus lane. (Additional capacity added to S.R. 210 from North Little Cottonwood Road through the town of Alta.). Total concept capacity of 1,008 in peak hour.	Gravel pit/ Wasatch Blvd	Mon–Sun	10/20	24
		9400 South	Mon– Sun	10/20	34

The analysis in this table is based on the following assumptions:

- Ski bus capacity: 42 passengers.
- Operating plan: Mon–Sun, 12 hours/day, 6-hour peak (7:00–10:00 AM and 2:00–5:00 PM).
- Travel time was calculated from Fort Union Blvd./Wasatch Blvd. to Alta Ski Resort. The roadway travel time to Snowbird was assumed to be about 4 minutes shorter (does not account for buses stopping at Snowbird first).
- Travel times for B1 and B2 are faster than for A1 and A2 because more users would be using bus service and there would be fewer personal vehicle on the road and thus overall less congestion and faster travel times.

4.2 Valley Transit Hubs

As described in the technical report *Evaluation of Transit Hub Locations in Big and Little Cottonwood Canyons* (UDOT 2019), the project team determined that two valley transit hubs would be required to meet the bus ridership demand for both concepts. The proposed transit hubs would be located at the Wasatch Boulevard gravel pit and the current UTA park-and-ride lot at 9400 South and Highland Drive. The transit hubs would include amenities including shelters, lighting and seating at passenger waiting areas, enhanced fare collection (such as prepaid or smart card technologies), real-time service information, and security features.

4.3 Transit Priority

Transit signal priority (TSP) treatment of transit vehicles (such as buses) gives them priority when they approach a traffic signal. With TSP, sensors on traffic signals detect approaching buses and extend the duration of a green signal or shorten the duration of a red signal as the bus approaches the intersection. All four enhanced bus concepts assume transit priority at all traffic signals between the transit hubs and base of Little Cottonwood Canyon. There would be three traffic signals with transit priority along 9400 South and four traffic signals with transit priority along Wasatch Boulevard.

The project team assumed that any travel time benefit from TSP would be greatest at traffic signals with bus-only travel lanes (that is, along Wasatch Boulevard where buses could operate in the shoulder during peak hours). In areas where the buses would travel in mixed-flow traffic (along 9400 South or along Wasatch Boulevard when the buses are not operating in the shoulders), there would be little travel time savings for the buses because the bus would be moving with the rest of traffic.

4.4 Ski Resort Transit Stops

Buses would travel directly between the two valley transit hubs to either Snowbird or Alta. The locations of the ski resort transit stops have not been determined, but there would be one transit stop at each resort. The transit stops would be designed to handle peak-hour arrivals and departures. The stops would be developed to minimize conflicts with vehicle traffic and parking at the resorts to improve safety and to help buses stay on schedule.

4.4.1 Operating Cost

Table 4 lists the operating cost per revenue hour for Little Cottonwood Canyon concepts. Concepts A1 and A2 have lower operating cost because the bus service is less frequent compared to B1 and B2. Appendix A, Operation and Capital Cost, provides more information about the cost assumptions.

Table 3. Winter Operating Cost per Revenue-Hour for Little Cottonwood Canyon Concepts

Concept	Route	Bus Travel Time (minutes)	Cost per Revenue-Hour ($)	Days	Frequency Peak/ Off-Peak (minutes)		Trips both Directions	Days	Operating Cost ($)
A1: Two lanes, bus and vehicle, and 7.5-minute headways	S.R. 210 Fort Union – Snowbird	48	112.63	Mon–Sun	15	30	72	140	1,563,073
	S.R. 210 Fort Union – Alta	52	112.63	Mon–Sun	15	30	72	140	1,652,726
	S.R. 209 Highland – Snowbird	60	112.63	Mon–Sun	15	30	72	140	2,026,927
	S.R. 209 Highland – Alta	64	112.63	Mon–Sun	15	30	72	140	2,116,579
								Total winter operating cost	7,359,305
B1: Two lanes, bus and vehicle, and 5-minute headways	S.R. 210 Fort Union – Snowbird	38	112.63	Mon–Sun	10	20	108	140	1,886,602
	S.R. 210 Fort Union – Alta	42	112.63	Mon–Sun	10	20	108	140	2,069,805
	S.R. 209 Highland – Snowbird	48	112.63	Mon–Sun	10	20	108	140	2,490,782
	S.R. 209 Highland – Alta	52	112.63	Mon–Sun	10	20	108	140	2,625,260
								Total winter operating cost	9,072,448
A2: Three lanes, with bus-only lane, and 7.5-minute headways	S.R. 210 Fort Union – Snowbird	20	112.63	Mon–Sun	15	30	72	140	789,332
	S.R. 210 Fort Union – Alta	24	112.63	Mon–Sun	15	30	72	140	878,985
	S.R. 209 Highland – Snowbird	32	112.63	Mon–Sun	15	30	72	140	1,139,497
	S.R. 209 Highland – Alta	36	112.63	Mon–Sun	15	30	72	140	1,294,116
								Total winter operating cost	4,101,930
B2: Three lanes, with bus-only lane, and 5-minute headways	S.R. 210 Fort Union – Snowbird	20	112.63	Mon–Sun	10	20	108	140	1,135,274
	S.R. 210 Fort Union – Alta	24	112.63	Mon–Sun	10	20	108	140	1,318,477
	S.R. 209 Highland – Snowbird	30	112.63	Mon–Sun	10	20	108	140	1,625,764
	S.R. 209 Highland – Alta	34	112.63	Mon–Sun	10	20	108	140	1,825,209
								Total winter operating cost	5,904,724

4.4.2 Capital Cost

Table 5 lists the capital cost per concept for Little Cottonwood Canyon. Capital costs are fixed, one-time expenses incurred for the purchase of land, buildings, roadway improvements, and equipment used for a project. The capital costs for each concept include bus stops, parking lots, TSP equipment, bus maintenance and storage facilities, fare collection and communications equipment, buses, snow sheds, and road widening (Concepts A2 and B2).

The capital cost was determined for each bus route for each concept—Snowbird and Alta from the gravel pit transit hub and Snowbird and Alta from the 9400 South transit hub, since the routes have a different number of signalized intersections and maintenance and storage facility needs and locations. The capital cost for each of the four routes under each concept was then combined to produce the total capital cost for each concept (A1, A2, B1, and B2). As shown, the concepts that include the addition of a bus lane on S.R. 210 in Little Cottonwood Canyon (Concepts A2 and B2) have the highest capital cost. These concepts also have the fastest bus travel times. Appendix A, Operation and Capital Cost, provides more information about the cost assumptions.

Table 4. Winter Capital Cost for Little Cottonwood Canyon Concepts

Item	2019 Unit Cost	Unit	A1							
			Quantity				Amount			
Roadway										
Bus lane	$211,000,000	Lump Sum	0				$0			
Stops										
Stops at terminal	$500,000	Per stop	4				$2,000,000			
Park-and-Rides										
Parking (Gravel Pit and 9400 S)	$36,000,000	Lump Sum	1				$36,000,000			
Parking (Gravel Pit and 9400 S)	$52,000,000	Lump Sum	0				$0			
Transit Speed and Reliability										
Queue jumps	$250,000	Per intersection	6				$1,500,000			
Transit signal priority (Intersection)	$75,000	Per intersection	6				$450,000			
Systems										
Fare collection (Ticket vending machine)	$50,000	Per TVM	8				$400,000			
Fare collection (Tap machine)	$5,000	Per tap	8				$40,000			
Communications	$100,000	Lump Sum	1				$100,000			
Other										
Snow Sheds	$72,000,000	Lump Sum	1				$72,000,000			
Subtotal							**$112,490,000**			
			Gravel Pit - Snowbird		**Gravel Pit - Alta**		**9400 South - Snowbird**		**9400 South - Alta**	
			Quantity	**Amount**	**Quantity**	**Amount**	**Quantity**	**Amount**	**Quantity**	**Amount**
Support Facilities										
Light maintenance and storage facility	$850,000	Per vehicle	10	$8,500,000	10	$8,500,000	12	$10,200,000	12	$10,200,000
Subtotal			**$37,400,000**							
Vehicles										
Ski bus	$530,000	Per vehicle	10	$5,300,000	10	$5,300,000	12	$6,360,000	12	$6,360,000
Transit signal priority (Bus)	$25,000	Per bus	10	$250,000	10	$250,000	12	$300,000	12	$300,000
Subtotal			**$24,420,000**							
Total										**$174,310,000**

(*continued on next page*)

Table 5. Winter Capital Cost for Little Cottonwood Canyon Concepts (*continued*)

Item	2019 Unit Cost	Unit	A2							
			Quantity				Amount			
Roadway										
Bus lane	$211,000,000	Lump Sum	1				$211,000,000			
Stops										
Stops at terminal	$500,000	Per stop	4				$2,000,000			
Park-and-Rides										
Parking (Gravel Pit and 9400 S)	$36,000,000	Lump Sum	1				$36,000,000			
Parking (Gravel Pit and 9400 S)	$52,000,000	Lump Sum	0				$0			
Transit Speed and Reliability										
Queue jumps	$250,000	Per intersection	6				$1,500,000			
Transit signal priority (Intersection)	$75,000	Per intersection	6				$450,000			
Systems										
Fare collection (Ticket vending machine)	$50,000	Per TVM	8				$400,000			
Fare collection (Tap machine)	$5,000	Per tap	8				$40,000			
Communications	$100,000	Lump Sum	1				$100,000			
Other										
Snow Sheds	$72,000,000	Lump Sum	1				$72,000,000			
Subtotal							**$323,490,000**			
			Gravel Pit - Snowbird		**Gravel Pit - Alta**		**9400 South - Snowbird**		**9400 South - Alta**	
			Quantity	**Amount**	**Quantity**	**Amount**	**Quantity**	**Amount**	**Quantity**	**Amount**
Support Facilities										
Light maintenance and storage facility	$850,000	Per vehicle	5	$4,250,000	5	$4,250,000	6	$5,100,000	8	$6,800,000
Subtotal			**$20,400,000**							
Vehicles										
Ski bus	$530,000	Per vehicle	5	$2,650,000	5	$2,650,000	6	$3,180,000	8	$4,240,000
Transit signal priority (Bus)	$25,000	Per bus	5	$125,000	5	$125,000	6	$150,000	8	$200,000
Subtotal			**$13,320,000**							
Total										**$357,210,000**

(*continued on next page*)

Table 5. Winter Capital Cost for Little Cottonwood Canyon Concepts (*continued*)

Item	2019 Unit Cost	Unit	B1							
			Quantity				Amount			
Roadway										
Bus lane	$211,000,000	Lump Sum	0				$0			
Stops										
Stops at terminal	$500,000	Per stop	4				$2,000,000			
Park-and-Rides										
Parking (Gravel Pit and 9400 S)	$36,000,000	Lump Sum	0				$0			
Parking (Gravel Pit and 9400 S)	$52,000,000	Lump Sum	1				$52,000,000			
Transit Speed and Reliability										
Queue jumps	$250,000	Per intersection	6				$1,500,000			
Transit signal priority (Intersection)	$75,000	Per intersection	6				$450,000			
Systems										
Fare collection (Ticket vending machine)	$50,000	Per TVM	8				$400,000			
Fare collection (Tap machine)	$5,000	Per tap	8				$40,000			
Communications	$100,000	Lump Sum	1				$100,000			
Other										
Snow Sheds	$72,000,000	Lump Sum	1				$72,000,000			
Subtotal							**$128,490,000**			
			Gravel Pit - Snowbird		Gravel Pit - Alta		9400 South - Snowbird		9400 South - Alta	
			Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Support Facilities										
Light maintenance and storage facility	$850,000	Per vehicle	11	$9,350,000	12	$10,200,000	15	$12,750,000	15	$12,750,000
Subtotal			**$45,050,000**							
Vehicles										
Ski bus	$530,000	Per vehicle	11	$5,830,000	12	$6,360,000	15	$7,950,000	15	$7,950,000
Transit signal priority (Bus)	$25,000	Per bus	11	$275,000	12	$300,000	15	$375,000	15	$375,000
Subtotal			**$29,415,000**							
Total										**$202,955,000**

(*continued on next page*)

Table 5. Winter Capital Cost for Little Cottonwood Canyon Concepts (*continued*)

Item	2019 Unit Cost	Unit	B2							
			Quantity				Amount			
Roadway										
Bus lane	$211,000,000	Lump Sum	1				$211,000,000			
Stops										
Stops at terminal	$500,000	Per stop	4				$2,000,000			
Park-and-Rides										
Parking (Gravel Pit and 9400 S)	$36,000,000	Lump Sum	0				$0			
Parking (Gravel Pit and 9400 S)	$52,000,000	Lump Sum	1				$52,000,000			
Transit Speed and Reliability										
Queue jumps	$250,000	Per intersection	6				$1,500,000			
Transit signal priority (Intersection)	$75,000	Per intersection	6				$450,000			
Systems										
Fare collection (Ticket vending machine)	$50,000	Per TVM	8				$400,000			
Fare collection (Tap machine)	$5,000	Per tap	8				$40,000			
Communications	$100,000	Lump Sum	1				$100,000			
Other										
Snow Sheds	$72,000,000	Lump Sum	1				$72,000,000			
Subtotal							**$339,490,000**			
			Gravel Pit - Snowbird		Gravel Pit - Alta		9400 South - Snowbird		9400 South - Alta	
			Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Support Facilities										
Light maintenance and storage facility	$850,000	Per vehicle	6	$5,100,000	8	$6,800,000	9	$7,650,000	10	$8,500,000
Subtotal			**$28,050,000**							
Vehicles										
Ski bus	$530,000	Per vehicle	6	$3,180,000	8	$4,240,000	9	$4,770,000	10	$5,300,000
Transit signal priority (Bus)	$25,000	Per bus	6	$150,000	8	$200,000	9	$225,000	10	$250,000
Subtotal			**$18,315,000**							
Total										**$385,855,000**

5.0 References

Mountain Accord

2015 Big Cottonwood Canyon and Little Cottonwood Canyon Visitation (2015) Based on UDOT Vehicle Counts and Assumed Occupancy.

Nelson/Nygaard Consulting Associates, Inc.

2017 Whatcom Transit Authority 2017 Strategic Plan. April 1.

[UDOT] Utah Department of Transportation

2019 Evaluation of Transit Hub Locations in Big and Little Cottonwood Canyons. October 17.

[UTA] Utah Transit Authority

2018a Ski Bus Service. April.

2018b Email communication between Mary DeLoretto, UTA, and Vince Izzo, HDR, regarding transit payment type for the 2017–2018 ski season. May 9.

2019 Salt Lake Ski Service Survey Based on 333 Samples. March.

Appendix A. Operation and Capital Cost

Little Cottonwood Canyon - Transit Alternatives
Draft Operating Cost

Cost per Mile Methodology

Alternative	Route	Miles	Cost per Rev Mile	Days	Peak Frequency	Off-Peak Frequency	Trips	Days	Revenue Operating Cost			Deadhead Operating Cost	Total Operating Cost
A1	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	15	30	72	140	$949,133			$373,901	$1,323,034
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	15	30	72	140	$1,121,702			$373,901	$1,495,603
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	15	30	72	140	$862,848			$539,280	$1,402,128
	9400 South - Alta	12.0	$8.56	Mon-Sun	15	30	72	140	$1,035,418			$539,280	$1,574,698
									$3,969,101			**$1,826,362**	**$5,795,463**
A2	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	15	30	72	140	$949,133			$186,951	$1,136,084
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	15	30	72	140	$1,121,702			$186,951	$1,308,653
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	15	30	72	140	$862,848			$251,664	$1,114,512
	9400 South - Alta	12.0	$8.56	Mon-Sun	15	30	72	140	$1,035,418			$323,568	$1,358,986
									$3,969,101			**$949,134**	**$4,918,235**
B1	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	10	20	108	140	$1,423,699			$405,060	$1,828,759
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	10	20	108	140	$1,682,554			$467,376	$2,149,930
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	10	20	108	140	$1,294,272			$647,136	$1,941,408
	9400 South - Alta	12.0	$8.56	Mon-Sun	10	20	108	140	$1,553,126			$647,136	$2,200,262
									$5,953,651			**$2,166,708**	**$8,120,359**
B2	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	10	20	108	140	$1,423,699			$218,109	$1,641,808
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	10	20	108	140	$1,682,554			$280,426	$1,962,980
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	10	20	108	140	$1,294,272			$359,520	$1,653,792
	9400 South - Alta	12.0	$8.56	Mon-Sun	10	20	108	140	$1,553,126			$431,424	$1,984,550
									$4,400,525			**$1,289,479**	**$5,690,004**

Cost per Revenue Hour Methodology

Alternative	Route	Travel Time	Cost per Rev Hour	Days	Peak Frequency	Off-Peak Frequency	Trips	Days	Revenue Operating Cost	Load/Unload Operating Cost	Layover Operating Cost	Deadhead Operating Cost	Total Operating Cost
A1	Gravel Pit - Snowbird	48	$116.01	Mon-Sun	15	30	72	140	$935,505	$194,897	$140,326	$292,346	$1,563,073
	Gravel Pit - Alta	52	$116.01	Mon-Sun	15	30	72	140	$1,013,463	$194,897	$152,020	$292,346	$1,652,726
	9400 South - Snowbird	60	$116.01	Mon-Sun	15	30	72	140	$1,169,381	$194,897	$175,407	$487,242	$2,026,927
	9400 South - Alta	64	$116.01	Mon-Sun	15	30	72	140	$1,247,340	$194,897	$187,101	$487,242	$2,116,579
									$4,365,688	**$779,587**	**$654,853**	**$1,559,176**	**$7,359,305**
A2	Gravel Pit - Snowbird	20	$116.01	Mon-Sun	15	30	72	140	$389,794	$194,897	$58,469	$146,173	$789,332
	Gravel Pit - Alta	24	$116.01	Mon-Sun	15	30	72	140	$467,752	$194,897	$70,163	$146,173	$878,985
	9400 South - Snowbird	32	$116.01	Mon-Sun	15	30	72	140	$623,670	$194,897	$93,550	$227,380	$1,139,497
	9400 South - Alta	36	$116.01	Mon-Sun	15	30	72	140	$701,628	$194,897	$105,244	$292,346	$1,294,116
									$2,182,844	**$779,587**	**$327,427**	**$812,072**	**$4,101,930**
B1	Gravel Pit - Snowbird	38	$116.01	Mon-Sun	10	20	108	140	$1,110,912	$292,345	$166,637	$316,708	$1,886,602
	Gravel Pit - Alta	42	$116.01	Mon-Sun	10	20	108	140	$1,227,850	$292,345	$184,177	$365,432	$2,069,805
	9400 South - Snowbird	48	$116.01	Mon-Sun	10	20	108	140	$1,403,257	$292,345	$210,489	$584,691	$2,490,782
	9400 South - Alta	52	$116.01	Mon-Sun	10	20	108	140	$1,520,195	$292,345	$228,029	$584,691	$2,625,260
									$5,262,214	**$1,169,381**	**$789,332**	**$1,851,522**	**$9,072,448**
B2	Gravel Pit - Snowbird	20	$116.01	Mon-Sun	10	20	108	140	$584,690	$292,345	$87,704	$170,535	$1,135,274
	Gravel Pit - Alta	24	$116.01	Mon-Sun	10	20	108	140	$701,628	$292,345	$105,244	$219,259	$1,318,477
	9400 South - Snowbird	30	$116.01	Mon-Sun	10	20	108	140	$877,036	$292,345	$131,555	$324,828	$1,625,764
	9400 South - Alta	34	$116.01	Mon-Sun	10	20	108	140	$993,974	$292,345	$149,096	$389,794	$1,825,209
									$3,157,328	**$1,169,381**	**$473,599**	**$1,104,416**	**$5,904,724**

Assumptions

Operating Plan
  Seasonal: 140 days (20 weeks)
  Mon-Sun: 12 hours (7am-7pm), 6 hour peak (7am-10am, 2pm-5pm)
Loading/Unloading: Assumes 5 minutes each for total of 10 minutes
Layover: Assumes 15% of revenue operating cost

Source	**2018**	**3%**	**2019**
Cost per Revenue Mile is from NTD 2018, then inflated by 3% for 2019	$8.31	$0.25	$8.56
Cost per Revenue Hour is from NTD 2018, then inflated by 3% for 2019	$112.63	$3.38	$116.01

Little Cottonwood Canyon - Transit Alternatives
Draft Operating Cost

Cost per Mile Methodology **Trip Table**

					Peak				Off-Peak				Total Trips	
Alternative	Route	Miles	Cost per Rev Mile	Days	Peak Frequency	Hours	Trips per Hour	Trips	Off-Peak Frequency	Hours	Trips per Hour	Trips	One-Way	Both Directions
A1	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	9400 South - Alta	12.0	$8.56	Mon-Sun	15	6	4	24	30	6	2	12	36	72
A2	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	9400 South - Alta	12.0	$8.56	Mon-Sun	15	6	4	24	30	6	2	12	36	72
B1	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	9400 South - Alta	12.0	$8.56	Mon-Sun	10	6	6	36	20	6	3	18	54	108
B2	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	9400 South - Alta	12.0	$8.56	Mon-Sun	10	6	6	36	20	6	3	18	54	108

Cost per Revenue Hour Methodology **Trip Table**

					Peak				Off-Peak				Total Trips	
Alternative	Route	Travel Time	Cost per Rev Hour	Days	Peak Frequency	Hours	Trips per Hour	Trips	Off-Peak Frequency	Hours	Trips per Hour	Trips	One-Way	Both Directions
A1	Gravel Pit - Snowbird	48	$116.01	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	Gravel Pit - Alta	52	$116.01	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	9400 South - Snowbird	60	$116.01	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	9400 South - Alta	64	$116.01	Mon-Sun	15	6	4	24	30	6	2	12	36	72
A2	Gravel Pit - Snowbird	20	$116.01	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	Gravel Pit - Alta	24	$116.01	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	9400 South - Snowbird	32	$116.01	Mon-Sun	15	6	4	24	30	6	2	12	36	72
	9400 South - Alta	36	$116.01	Mon-Sun	15	6	4	24	30	6	2	12	36	72
B1	Gravel Pit - Snowbird	38	$116.01	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	Gravel Pit - Alta	42	$116.01	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	9400 South - Snowbird	48	$116.01	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	9400 South - Alta	52	$116.01	Mon-Sun	10	6	6	36	20	6	3	18	54	108
B2	Gravel Pit - Snowbird	20	$116.01	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	Gravel Pit - Alta	24	$116.01	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	9400 South - Snowbird	30	$116.01	Mon-Sun	10	6	6	36	20	6	3	18	54	108
	9400 South - Alta	34	$116.01	Mon-Sun	10	6	6	36	20	6	3	18	54	108

Assumptions

Operating Plan
  Seasonal: 140 days (20 weeks)
  Mon-Sun: 12 hours (7am-7pm), 6 hour peak (7am-10am, 2pm-5pm)
Loading/Unloading: Assumes 5 minutes each for total of 10 minutes
Layover: Assumes 15% of revenue operating cost

Source

  Cost per Revenue Mile is from NTD 2018, then inflated by 3% for 2019
  Cost per Revenue Hour is from NTD 2018, then inflated by 3% for 2019

Little Cottonwood Canyon - Transit Alternatives
Draft Operating Cost

Cost per Mile Methodology — **Deadhead Calculation**

Alternative	Route	Miles	Cost per Rev Mile	Days	Total Minutes	Peak Frequency	Peak Pullout	Off-Peak Return	Deadhead Trips/Day	Deadhead Miles/Trip	Deadhead Miles/Day	Deadhead Cost
A1	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	120	15	8	4	24	13	312	$373,901
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	120	15	8	4	24	13	312	$373,901
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	150	15	10	5	30	15	450	$539,280
	9400 South - Alta	12.0	$8.56	Mon-Sun	150	15	10	5	30	15	450	$539,280
A2	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	60	15	4	2	12	13	156	$186,951
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	60	15	4	2	12	13	156	$186,951
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	75	15	5	2	14	15	210	$251,664
	9400 South - Alta	12.0	$8.56	Mon-Sun	90	15	6	3	18	15	270	$323,568
B1	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	90	10	9	4	26	13	338	$405,060
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	100	10	10	5	30	13	390	$467,376
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	120	10	12	6	36	15	540	$647,136
	9400 South - Alta	12.0	$8.56	Mon-Sun	120	10	12	6	36	15	540	$647,136
B2	Gravel Pit - Snowbird	11.0	$8.56	Mon-Sun	50	10	5	2	14	13	182	$218,109
	Gravel Pit - Alta	13.0	$8.56	Mon-Sun	60	10	6	3	18	13	234	$280,426
	9400 South - Snowbird	10.0	$8.56	Mon-Sun	70	10	7	3	20	15	300	$359,520
	9400 South - Alta	12.0	$8.56	Mon-Sun	80	10	8	4	24	15	360	$431,424

Cost per Revenue Hour Methodology — **Deadhead Calculation**

Alternative	Route	Travel Time	Cost per Rev Hour	Days	Total Minutes	Peak Frequency	Peak Pullout	Off-Peak Return	Deadhead Trips/Day	Deadhead Hour/Trip	Deadhead Hour/Day	Deadhead Cost
A1	Gravel Pit - Snowbird	48	$116.01	Mon-Sun	120	15	8	4	24	0.75	18	$292,346
	Gravel Pit - Alta	52	$116.01	Mon-Sun	120	15	8	4	24	0.75	18	$292,346
	9400 South - Snowbird	60	$116.01	Mon-Sun	150	15	10	5	30	1	30	$487,242
	9400 South - Alta	64	$116.01	Mon-Sun	150	15	10	5	30	1	30	$487,242
A2	Gravel Pit - Snowbird	20	$116.01	Mon-Sun	60	15	4	2	12	0.75	9	$146,173
	Gravel Pit - Alta	24	$116.01	Mon-Sun	60	15	4	2	12	0.75	9	$146,173
	9400 South - Snowbird	32	$116.01	Mon-Sun	75	15	5	2	14	1	14	$227,380
	9400 South - Alta	36	$116.01	Mon-Sun	90	15	6	3	18	1	18	$292,346
B1	Gravel Pit - Snowbird	38	$116.01	Mon-Sun	90	10	9	4	26	0.75	20	$316,708
	Gravel Pit - Alta	42	$116.01	Mon-Sun	100	10	10	5	30	0.75	23	$365,432
	9400 South - Snowbird	48	$116.01	Mon-Sun	120	10	12	6	36	1	36	$584,691
	9400 South - Alta	52	$116.01	Mon-Sun	120	10	12	6	36	1	36	$584,691
B2	Gravel Pit - Snowbird	20	$116.01	Mon-Sun	50	10	5	2	14	0.75	11	$170,535
	Gravel Pit - Alta	24	$116.01	Mon-Sun	60	10	6	3	18	0.75	14	$219,259
	9400 South - Snowbird	30	$116.01	Mon-Sun	70	10	7	3	20	1	20	$324,828
	9400 South - Alta	34	$116.01	Mon-Sun	80	10	8	4	24	1	24	$389,794

Assumptions
Operating Plan
  Seasonal: 140 days (20 weeks)
  Mon-Sun: 12 hours (7am-7pm), 6 hour peak (7am-10am, 2pm-5pm)
Loading/Unloading: Assumes 5 minutes each for total of 10 minutes
Layover: Assumes 15% of revenue operating cost

Source
  Cost per Revenue Mile is from NTD 2018, then inflated by 3% for 2019
  Cost per Revenue Hour is from NTD 2018, then inflated by 3% for 2019

Deadhead calculation provided by UTA
Assumptions

Deadhead	Miles	Hours
SR-201 Fort Union	13	0.75
SR-209 Highland	15	1

<u>Deadhead Costs Calculation, based on miles</u>
Deadhead Trips/Day = [(Peak Pullout)*2 + (Off-Peak Return)*2]
Deadhead Miles/Day = (Deadhead Trips/Day) * (Deadhead Mile/Trip)

<u>Deadhead Costs Calculation, based on hours</u>
Deadhead Trips/Day = [(Peak Pullout)*2 + (Off-Peak Return)*2]
Deadhead Hours/Day = (Deadhead Trips/Day) * (Deadhead Hour/Trip)
Deadhead Costs = (Deadhead Hour/Day) * (Costs/Hour) * (Days/Year)

Little Cottonwood Canyon - Transit Alternatives
Draft Fleet Estimate

Alternative	Route	Peak Frequency	One-way (minutes)	Roundtrip (minutes)	Layover (minutes)	Total (minutes)	Fleet	Spare	Total
A1	Gravel Pit - Snowbird	15	48	96	14	120	8	2	10
	Gravel Pit - Alta	15	52	104	16	120	8	2	10
	9400 South - Snowbird	15	60	120	18	150	10	2	12
	9400 South - Alta	15	64	128	19	150	10	2	12
	Subtotal								**44**
A2	Gravel Pit - Snowbird	15	20	40	6	60	4	1	5
	Gravel Pit - Alta	15	24	48	7	60	4	1	5
	9400 South - Snowbird	15	32	64	10	75	5	1	6
	9400 South - Alta	15	36	72	11	90	6	2	8
	Subtotal								**24**
B1	Gravel Pit - Snowbird	10	38	76	11	90	9	2	11
	Gravel Pit - Alta	10	42	84	13	100	10	2	12
	9400 South - Snowbird	10	48	96	14	120	12	3	15
	9400 South - Alta	10	52	104	16	120	12	3	15
	Subtotal								**53**
B2	Gravel Pit - Snowbird	10	20	40	6	50	5	1	6
	Gravel Pit - Alta	10	24	48	7	60	6	2	8
	9400 South - Snowbird	10	30	60	9	70	7	2	9
	9400 South - Alta	10	34	68	10	80	8	2	10
	Subtotal								**33**

Assumptions

Layover	15%
Spare Ratio	20%

Fleet estimate based on peak vehicle requirement

APPENDIX E

Draft Aerial Transit Initial Feasibility Study

Little Cottonwood Canyon ENVIRONMENTAL IMPACT STATEMENT
S.R. 210 | Wasatch Blvd. to Alta

Draft Aerial Transit Concepts Initial Feasibility Study

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 - Wasatch Boulevard to Alta

Lead agency:
Utah Department of Transportation

April 3, 2020

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Acronyms and Abbreviations

1S	one-cable gondola system
2S	two-cable gondola system
3S	three-cable gondola system
ATS	aerial transit system
EIS	Environmental Impact Statement
fps	feet per second
I-215	Interstate 215
mph	miles per hour
NA	not applicable
O&M	operation and maintenance (cost)
S.R.	state route
SANDAG	San Diego Association of Governments
UDOT	Utah Department of Transportation
USDA	United States Department of Agriculture
UTA	Utah Transit Authority

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1.0 Introduction

The purpose of this report is to summarize the Utah Department of Transportation's (UDOT) evaluation and other considerations regarding constructing and operating an aerial transit system (ATS; also called a cableway, ropeway, or tramway) as part of the S.R. 210 Project. This report provides information that UDOT will use during the alternatives development and screening process for the Little Cottonwood Canyon Environmental Impact Statement (EIS), which will evaluate how well the ATS concepts described in this report would satisfy the purpose of the Project.

What is the purpose of this report?

The purpose of this report is to summarize UDOT's evaluation of and recommendations regarding the feasibility of constructing and operating an aerial transit system as part of the Little Cottonwood Canyon Project.

The goal of this report is to define the ATS technology that is most feasible for the needs of Little Cottonwood Canyon. The information in this report will be used to compare the most feasible ATS concepts with other non-ATS concepts considered to address the purpose of the project.

1.1 Aerial Transit Systems

Modern ATSs were developed to move skiers to the tops of ski slopes. ATSs can consist of permanently fixed or detachable cabins that are attached to steel cables and that travel above ground. ATS technologies include aerial tramways, Funifors, Funitels, and gondolas. See Section 2.0, Types of Aerial Transit Systems, for descriptions of these different technologies. The popularity of these systems as a form of urban mass transit is growing throughout the world because they can reliably move a substantial number of people between destinations.

The benefits of ATSs include reduced right-of way needs in densely developed areas compared to other types of transit that use an exclusive right-of-way, the ability to navigate difficult terrain (climb steep hills or span waterways), and lower costs compared to some other types of transit (commuter rail or light rail for example). The limitations of ATSs include a reduced number of stations compared to other types of transit, the need for straight alignment segments, relatively low speeds, and a limited ability to add capacity once an ATS is constructed. See Section 4.0, General Considerations for Implementing a 3S Gondola System, for more information regarding the unique engineering and operational considerations of the recommended type of ATS.

1.2 Description of the Study Area

Little Cottonwood Canyon is in the Uinta-Wasatch-Cache National Forest, which is on the eastern edge of the Salt Lake City metropolitan area located in Salt Lake County. Salt Lake County has a population of about 1.12 million. The canyon is home to two ski resorts, Alta and Snowbird, and includes parts of two National Wilderness Areas: Twin Peaks Wilderness to the north and Lone Peak Wilderness to the south. Winter recreation activities include skiing at the resorts, backcountry skiing, snowshoeing, and ice climbing. In the summer, the resorts offer abundant recreation opportunities, and land administered by the U.S. Department of Agriculture (USDA) Forest Service is used extensively for hiking, cycling, rock climbing, fishing, camping, and picnicking.

The transportation needs assessment study area used for the Little Cottonwood Canyon Project extends along State Route (S.R.) 210 from its intersection with S.R. 190/Fort Union Boulevard in Cottonwood Heights, Utah, to its terminus in the town of Alta, Utah, and includes the Bypass Road. UDOT developed the study area to include an area that is influenced by the transportation operations in Little Cottonwood Canyon and to provide logical termini for the project. Traffic south of the S.R. 190/Fort Union Boulevard intersection is mostly related to trips into and out of Little Cottonwood Canyon and commuter traffic on Wasatch Boulevard.

Through the transportation needs assessment study area, S.R. 210 is designated with different street names. For clarity in the EIS process, the following segments of S.R. 210 use the following naming conventions (shown in Figure 1):

- **Wasatch Boulevard** – S.R. 210 from about Fort Union Boulevard to North Little Cottonwood Road
- **North Little Cottonwood Road** – S.R. 210 from Wasatch Boulevard to the intersection with S.R. 209
- **Little Cottonwood Canyon Road** – S.R. 210 from the intersection of North Little Cottonwood Road and S.R. 209 through the town of Alta, including the Bypass Road, up to but not including Albion Basin Road

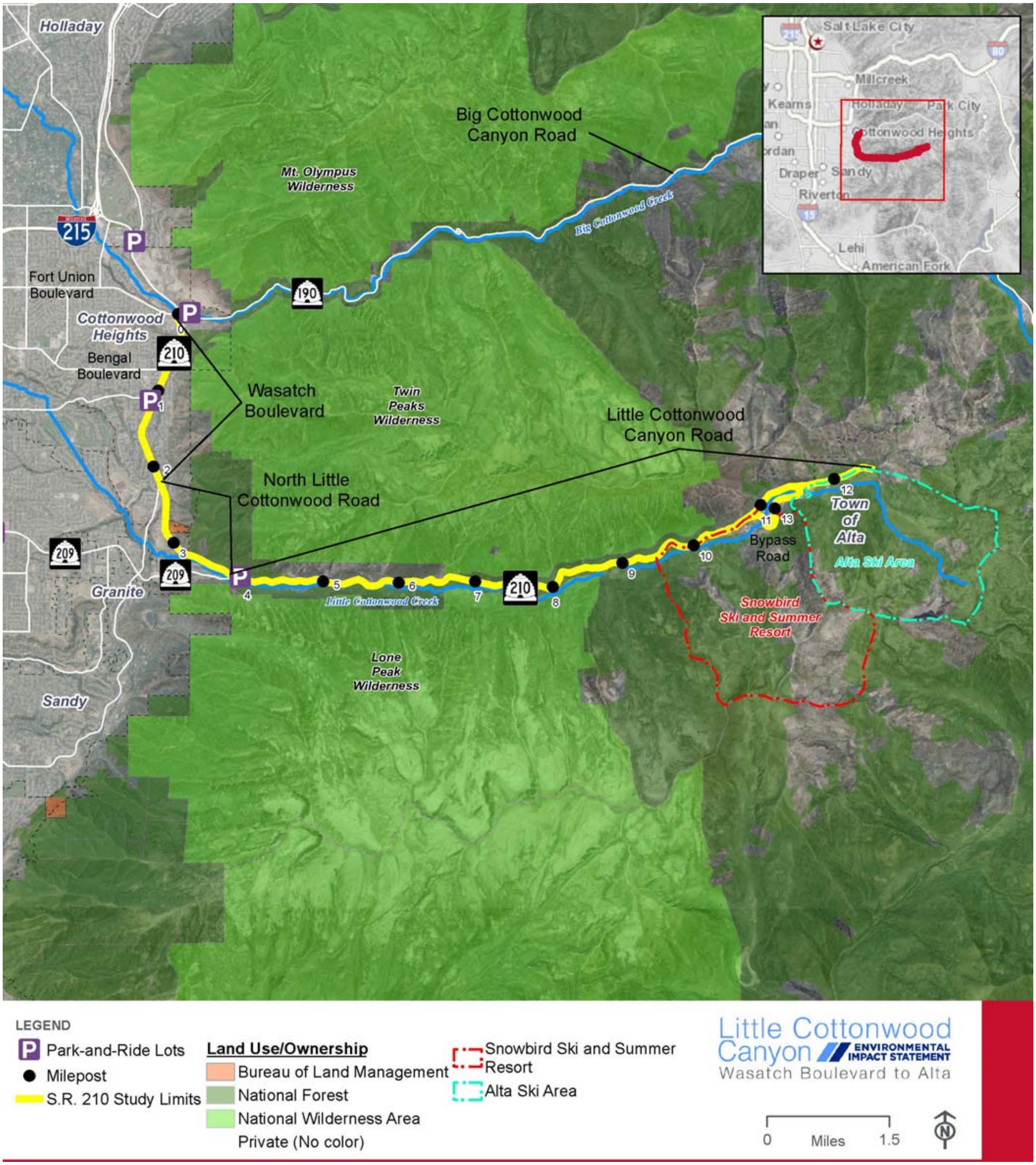
In this report, ATSs are being proposed mainly to address heavy skier use in winter and the related traffic congestion on North Little Cottonwood Road and Little Cottonwood Canyon Road. For this ATS feasibility analysis only, the study area also includes S.R. 209 (9400 South) in Sandy, Utah.

1.3 Previous Analysis

Several previous studies have analyzed the current and future transportation needs for Big and Little Cottonwood Canyons. In 2012, Salt Lake County and its study partners—UDOT, the Utah Transit Authority (UTA), Salt Lake City, the Wasatch Front Regional Council, and the USDA Forest Service—developed a range of short- and long-term transportation solutions. The *Mountain Transportation Study* (Fehr and Peers 2012) recommended evaluating the range of alternatives in an EIS.

In the years before the current EIS process was initiated, UDOT, UTA, and other agencies and planning organizations conducted studies of congestion, parking, transit use, and avalanche impacts in Little Cottonwood Canyon and on S.R. 210. Numerous studies were conducted as part of a process known as the Mountain Accord. The Mountain Accord developed a plan for preserving the central Wasatch Mountains (which include Little Cottonwood Canyon) including short- and long-term transportation options. Both of these studies (the *Mountain Transportation Study* and the Mountain Accord) identified ATSs as one of many potential transportation concepts that should be explored in greater detail under an EIS framework.

Figure 1. Transportation Needs Assessment Study Area for the Little Cottonwood Canyon EIS



2.0 Types of Aerial Transit Systems

There are several different types of ATS, each of which has unique characteristics in terms of the mechanics of its cabling, its capacity, its speed, and the maximum practical spacing of its towers. The feasibility of each type depends on the specific application for which it is used. Section 2.0 describes four types of ATS: aerial tramways, Funifors, Funitels, and gondolas.

In this report, the term *terminal station* refers to the first and last stations on a passenger's route. Passengers board and disembark the ATS cabins at the terminal stations. The *base station* is the terminal station at the bottom of the canyon, and a *destination station* is a terminal station at the top of the canyon. An ATS can also include *angle stations*, which are needed to adjust the horizontal direction of the cabin; passengers remain in the cabin as it passes through an angle station.

2.1 Aerial Tramways

Photo credit: Georgeclerk

With aerial tramways, cabins are permanently fixed to the cable system that hauls the cabins. This means that a tramway cabin must shuttle back and forth between origin and destination points using the same cable. Typically, two cabins are operationally connected: as one cabin moves uphill, the other moves downhill. Snowbird Resort's tram is an example.

The capacity (people per hour per direction) of an aerial tramway is a function of the cabin capacity (up to 150 to 200 people per cabin), the travel speed, and the distance between the origin and destination. These systems have high speeds and good capacity for short distances. However, because cabins are fixed to the haul cable and the cabin shuttles back and forth, one-way capacity becomes limited for long distances. The maximum spacing of terminal stations for tramways was not determined for this analysis. Several separate segments might be required in the canyon.

Aerial tramways have speeds of about 22 miles per hour (mph)[1,2] If aerial tramways are operationally feasible, the total travel time at about 22 mph from the mouth of Little Cottonwood Canyon to a terminal station between Snowbird and Alta (a total distance of 8 miles) would be about 30 minutes. When loading and unloading times are included, the tramway system could make just one round trip per hour per cabin. Assuming that two tramway cabins are implemented, the total capacity would be about 300 to 400 people per hour per direction. Because of its limited capacity, this type of ATS is not feasible for Little Cottonwood Canyon.

1 http://www.gobytram.com/about

2 https://liftblog.com/2016/10/28/at-45-years-snowbirds-tram-still-soars

2.2 Funifors

Photo credit: Doppelmayr

Funifors are similar to aerial tramways in that the cabins are fixed to a haul cable. Funifors ride on two guide cables for additional stability during high winds. Like tramways, Funifors travel from origin to destination and back. Unlike tramways, the haul rope and cabins of this system can operate independently with separate drives. Funifors have speeds of about 22 mph. The capacity is about 60 passengers per cabin.[3]

Like tramways, Funifors have operational limitations for large distances between terminal stations. At 22 mph, and assuming an 8-mile route and including loading and unloading times, a Funifor system would make one round trip per hour per cabin. Assuming that two 60-passenger cabins are implemented, the total capacity would be about 120 people per hour. Because of its limited capacity, this type of ATS is not feasible to address the mobility needs of Little Cottonwood Canyon.

2.3 Funitels

Photo credit: Jarin047

Funitels use detachable cabins that attach to two haul cables. The haul cables (which is actually one continuous, looped cable) circulate between terminal stations so that the cables are paired, and the same cable pair transitions from up to down so that the weight of the cabins heading downhill assists with lifting cabins uphill. Cabins are slowed down through the terminal stations for passenger loading and unloading. Therefore, different cabin propulsion systems are used within the terminal stations. Funitels have speeds of about 13 mph.[4] Cabins are typically sized for 18 (seated) to 24 (standing) people.

Because the cabins circulate between terminal stations and do not run back and forth like aerial tramways or Funifors, a Funitel system's cabins arrive more frequently, and the total capacity is about 3,200 to 4,000 people per hour. Funitels are stable in higher winds. According to the *Mountain Transportation Study* (Fehr and Peers 2012), Funitels are mechanically complex and have long evacuation times. Funitels are more energy-intensive and need more maintenance, and are therefore more expensive to operate and maintain (CH2M 2018). Funitels also require shorter tower spacing than do three-cable gondolas, which are described in Section 2.4.3, Tri-cable Gondola (3S). Because of these reasons, UDOT selected gondolas over Funitels for more detailed analysis in this initial feasibility report.

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3 https://www.doppelmayr.com/en/products/funifor/

4 https://www.doppelmayr.com/en/products/funitel/

2.4 Gondolas

Gondola cabins have detachable grips. Cabins are detached and slowed at the terminal stations for loading and unloading passengers. A main haul cable circulates between two stations. Like for Funitels, these stations have their own propulsion systems that slow the cabins for unloading and loading or, in the case of angle stations, for changing direction, and then gradually increase the speed of the cabin to match the speed of the haul cables. The main differences between the gondola systems are their speeds, wind stability, and maximum feasible tower spacing. UDOT evaluated three types of gondolas for the EIS—mono-cable (1S), bi-cable (2S), and tri-cable (3S)—which are described below.

Why are gondola types abbreviated 1S, 2S, and 3S?

These abbreviations come from the German word *Seil*, which means “cable,” and refer to the number of cables used to propel and support the gondola cabins.

2.4.1 Mono-cable Gondola (1S)

Mono-cable gondolas use a single cable for both propulsion and support. This means that the cable that pulls the cabins is also the cable that supports the cabins. Compared to other gondola systems, 1S gondolas have smaller towers, and the towers are typically spaced shorter distances apart (up to about 2,300 feet) to support the weight of the cable and cabins. They operate at maximum speeds of about 11 mph (Fehr and Peers 2012). The travel time for the 8-mile trip from the mouth of the canyon to Alta would be about 44 minutes.

Because the gondolas are supported by just one cable, mono-cable systems are most susceptible to being shut down during high winds.

Photo credit: FilippoBacci

2.4.2 Bi-cable Gondola (2S)

Another type of gondola is the bi-cable gondola. In addition to the main haul cable, a bi-cable gondola has one stationary cable that helps support the cabins. Because of the added stability provided by the second cable, 2S gondolas can operate slightly faster (5 to 6 mph) than 1S gondolas. The maximum distance between towers can be longer for 2S gondolas compared to 1S gondolas. At a speed of 15 mph, the total travel time for the 8-mile trip from the mouth of the canyon to Alta would be about 32 minutes.

Photo credit: Magnus Manske

2.4.3 Tri-cable Gondola (3S)

A third type of gondola is a tri-cable gondola system. This system has two fixed-support cables and one circulating haul cable connected to the cabins. The main benefits of 3S gondolas are faster speeds, the potential to increase the tower spacing up to about 9,000 feet,[5] a greater number of passengers per cabin (up to 35 per cabin, standing), a high capacity (up to about 5,000 people per hour per direction), and greater wind stability than 1S and 2S gondolas. At 17 mph, the total travel time for the 8-mile trip from the mouth of the canyon to Alta would be about 27 minutes.

Photo credit: clickflashphotos

2.5 Other Systems

What is scoping?

Scoping is an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action.

During the scoping period for the EIS, UDOT received several comments regarding ATSs and the infrastructure required to make these systems useful. (For more information, see Section 4.3, Base Station Parking Considerations). One comment asked UDOT to evaluate a transit concept that is a hybrid bus-ATS.

The comment first stated that a multilevel parking garage at the mouth of Little Cottonwood Canyon was not feasible and would be met with strong opposition because of concerns with neighborhood traffic congestion. The commenter also stated that a parking structure located away from the mouth of the canyon would require an ATS alignment that strung the cable over large residential areas, which would also be met with strong opposition. Therefore, the commenter asked UDOT to evaluate a hybrid bus-ATS, which can be generally described as follows:

- Build a large parking structure away from the mouth of the canyon, build a bus-ATS base station at the mouth of the canyon, and build an ATS in the canyon.
- In the morning, passengers would board a large ATS cabin at the parking structure. The cabin would be attached to an over-the-road, electronically powered “transporter” vehicle that would be used to move the loaded cabin to the base station. The transporter could eventually be an autonomous vehicle. This over-the-road cabin would function as a bus to transport passengers from the parking structure to the base station.
- At the base station, the cabin would be detached from the transporter’s chassis, the same cabin would be attached to the ATS’s cable system, and passengers would continue up the canyon via the ATS.
- The transporter would then pick up the empty cabin and return it to the parking structure, where more people would board and the cycle would continue.
- In the evening, the process would be reversed, with passengers coming down the canyon via the ATS and the loaded cabins being moved via the transporter vehicle from the base station to the parking structure.

5 https://www.leitner-ropeways.com/fileadmin/user_upload/Tricable_gondola_lifts.pdf

The main benefit of this proposal is that it could eliminate the need for passengers to change transit modes. They would remain in the same cabin from when they boarded at the parking structure to their destination. However, UDOT is not aware that a similar technology exists. The size, cabin capacity, and weight of each loaded cabin was not provided by the commenter. UDOT cannot determine the system's mechanical needs (cable strength, detaching mechanisms, and power) and operational performance (number of people per hour). Because no similar system exists to prove the concept, it is not considered reasonable for detailed analysis in the EIS.

3.0 Selection of ATS Technology

Because of their travel speed and hourly capacity, gondola systems are the most feasible ATS for Little Cottonwood Canyon (for more information, see Section 2.4, Gondolas). Table 1 summarizes the different parameters for the three gondola systems (1S, 2S, and 3S) that were evaluated in this report.

Table 1. Comparison of Gondola Systems

Parameter	Mono-cable (1S)[a]	Bi-cable (2S)	Tri-cable (3S)[a]
Capacity per cabin (number of people, maximum)	8 to 15	8 to 17	20 to 35
Travel speed (mph)	9 to 11	15 to 16	16 to 18
Operational wind speeds (mph)	37	43	68
Maximum capacity (approximate number of people per hour per direction)[b]	3,000	4,000	5,000
Approximate maximum tower spacing (feet)	2,300	3,000	9,000
Travel Times[c]			
Mouth of canyon to Snowbird (minutes to travel 6.5 miles)	35	26	23
Snowbird to Alta (minutes to travel 1.5 miles)	8	6	4
Total (minutes to travel 8 miles)	44	32	27

[a] Source: Fehr and Peers 2012

[b] The maximum hourly capacities are based on literature reviews and do not necessarily represent gondola capacity needed in the Little Cottonwood Canyon setting.

[c] Travel times are calculated based on travel speeds (1S: 11 mph; 2S: 15 mph; 3S: 17 mph) and the distance between the base and terminal stations.

The mono-cable (1S) system was eliminated from consideration because it would have the lowest per-cabin passenger capacity, would have the slowest travel speeds and times, and would require the most towers. Both the bi-cable (2S) and tri-cable (3S) systems would provide reliable and safe transportation. However, the 3S system would provide some specific advantages including greater person-capacity, more cabin options, faster speeds, and greater potential tower spacing. The greater tower spacing would offer the most flexibility to help avoid sensitive environmental areas.

Although the smaller 2S towers could have less visual impacts, UDOT would likely need to build more towers. Additionally, one disadvantage of the 2S system is that it does not have "slack carriers." Slack carriers in the 3S system are pieces of equipment that are connected to the two support cables and that support the haul cable at all times. These slack carriers are shown on the left side of the photograph in Section 2.4.3, Tri-cable Gondola (3S). In a 2S system, the cabins themselves support the haul cable between the towers. Whenever the cabins are removed from the haul cable (for maintenance), the haul cable sags low. Therefore, a 2S system requires shorter distances between towers to keep the haul cable from touching the ground when the cabins are removed, and this could increase the number of towers required compared to a 3S system.

Because it would have the greatest maximum passenger capacity, the fastest travel times, the greatest operational benefits (most stability in high winds), and the most opportunity to avoid environmental resources, the 3S-type gondola is the most feasible gondola system for Little Cottonwood Canyon. This selection of gondola technology matches the conclusion of previous studies (Fehr and Peers 2012; Mountain Accord 2017).

4.0 General Considerations for Implementing a 3S Gondola System

Section 4.0 presents the fundamental engineering and operational considerations for 3S gondola systems as well as considerations for parking at the base station. UDOT will compare ATSs to other concepts in a separate report or in the EIS.

4.1 Engineering Considerations

Section 4.1 describes some of the fundamental engineering considerations for 3S gondolas.

4.1.1 Stations

Gondolas work best as a point-to-point, or station-to-station, service. The cabins on the haul cable travel at 17 mph, or 25 feet per second (fps). In order to facilitate passenger loading and unloading, cabins are detached from the haul cables at terminal stations, are slowed gradually, and traverse the station platforms at slower speeds (about 1 fps). Therefore, adding intermediate stations would slow the overall travel time for the passengers who are traveling between the terminal stations.

Station spacing is a function of overall passenger capacity, the elevation gains, and the resulting power needs of the gondola. The *Mountain Transportation Study* (Fehr and Peers 2012) assumed 3,000 passengers per hour and assumed that two intermediate stations would be needed to turn corners and to supply the overall power needs of the conceptual system evaluated in that study. A conceptual 3S gondola alignment developed for UDOT by Leitner-Poma in 2018 assumed 4,000 passengers per hour and needed one intermediate angle station (see Section 4.1.2 below). This conceptual alignment placed the base station farther into the canyon.

Because some passengers would disembark at Snowbird, a smaller system (1S or 2S gondola, or another ATS) could be used from Snowbird to Alta. Passengers would be required to disembark from one ATS and board another. The details of the capacity and optimal system for the last segment of the trip are not included in this preliminary feasibility analysis.

4.1.2 Alignment

Gondolas require straight alignment segments between stations because gondolas can only turn at only very small angles. A maximum 7-degree deflection can be made at towers,[6] so angle stations are needed to turn sharper angles. Cabins are also detached and slowed as they approach an angle station. Cabins traverse through the angle station with a separate propulsion system (and therefore the angle station also needs to be powered), and then cabins are accelerated before being reconnected to the full-speed haul cable for the next alignment segment. The haul cable circulates between a base station and either a destination station or an angle station. Because passengers are not loading and unloading, the cabins might be able to pass through an angle station at speeds higher than 1 fps. Depending on the exact alignment in Little Cottonwood Canyon, one or two intermediate angle stations would be needed to move the cabins to the top of the canyon.

4.1.3 Towers

The tower spacing depends on the topography under the alignment, the elevation gain needed in each segment, and the vertical clearance required from obstacles (including snow and avalanche flows) below the alignment. The weights of the loaded gondola cabins and cables cause the line to sag between towers. To maintain vertical clearance requirements,[7] towers would be between 150 and 200 feet tall. Towers would be spaced between 2,000 and 3,500 feet apart on average. The towers could be placed outside avalanche flow paths, and multiple avalanche flow paths could potentially be spanned between towers.

4.1.4 Right-of-Way

Gondola stations and towers require a dedicated right-of-way or airspace. For the alignment segments between stations, an exclusive undeveloped airspace is preferred to avoid impacts to private property or the need for easements. The gondola airspace could feasibly be shared with the right-of-way of another public transportation facility or located over public land. However, if the airspace is within a wilderness area, special authorization from the USDA Forest Service would be needed.

The width of the airspace depends on the gondola manufacturer's equipment specifications, which define the required lateral spacing between cabins, as well as on a minimum outside clearance standard of 5 feet on each side of the gondola.[8] For example, a 40-foot-wide gondola would need a 50-foot-wide right-of-way. In addition, because of privacy concerns, UDOT expects heavy opposition from any private property owners living adjacent to the exclusive gondola airspace in residential areas.

[6] Notes from a meeting with UDOT and Doppelmayr, May 23, 2018.

[7] Vertical clearance requirements are defined in American National Standard Institute B77.1-2017. The maximum height of an avalanche was not considered in the requirements for vertical clearance and approximate tower heights.

[8] Horizontal spacing and airspace clearance requirements are defined in American National Standard Institute B77.1-2017. The final airspace requirement would need to include a swing distance, which is a function of tower spacing and was not considered when determining approximate right-of-way needs.

4.2 Operational Considerations

Section 4.2 describes some of the fundamental operational considerations of 3S gondolas.

4.2.1 Operational Capacity and Demand

As shown above in Table 1, Comparison of Gondola Systems, 3S gondolas have a maximum capacity of about 5,000 people per hour, or about 83 people per minute. Assuming a cabin capacity of 35 people per cabin, a cabin would have to arrive at a terminal station about every 25 seconds, on average. However, because of the long travel time (at least 27 minutes), some passengers would likely prefer to sit. The seated capacity is about 25 people per cabin. At a 25-to-30-second arrival frequency (or "headway"), the actual hourly capacity would be closer 3,000 to 4,000 people per hour. Top speeds would be about 17 to 18 mph. In addition, the time required for a cabin to traverse the terminal station platforms needs to take into account that passengers would be carrying ski or snowboard equipment and other supplies and might be walking with or carrying children.

The actual number of gondola users per hour might be different from the overall operational capacity. The actual anticipated demand, or ridership, depends on many factors. A demand analysis was outside the scope of the initial ATS evaluation presented in this report. UDOT expects the maximum hourly demand to occur during the winter months and on weekends and holidays when skiers and snowboarders are traveling to the resorts at the top of Little Cottonwood Canyon.

What is travel demand?

Travel demand is the expected number of transportation trips in an area. Travel demand can be met by various modes of travel, such as automobile, bus, light rail, carpooling, bicycling, and ATS or a combination of modes.

The expected peak period of travel demand on S.R. 210 in 2050, as measured by the number of vehicles currently using the road, is between 7:00 AM and 10:00 AM. The current free-flow capacity of the road is about 1,100 vehicles or fewer per hour, but this capacity analysis uses a peak-period demand number of about 1,555 vehicles per hour (which assumes an average busy ski weekend). Transportation analysts often look at the 30th-busiest hour on a road over the course of a year when determining the future travel demand on the road. For S.R. 210 in 2050, the 30th-busiest-hour roadway demand would be about 3,200 people per hour. A gondola could accommodate this level of *hourly* demand. However, the actual anticipated ridership of a gondola system, measured as the percentage of gondola users compared to the overall number of people accessing Little Cottonwood Canyon in the peak hour, was not evaluated in this report. In order to compare transit concepts (aerial transit, bus, and train) equally, UDOT assumed a similar peak-hour ridership of about 1,000 people for each.

4.2.2 Time Required for Shifting Transit Modes

Without a direct transit connection to the base station, the gondola system would require a large parking area where riders would park their personal vehicles (or disembark from another transit mode or rideshare), walk to the cabin loading platform, and board a cabin. These transfers take time. If parking is separated from the base station, additional walking time or some form of transit (people-mover or buses) would be needed to transport passengers from the parking area to the base station. When there is an additional shift in transit mode, riders would experience additional waiting and transfer times. These times are considered in

Section 5.0, Parking, Base Station, and Gondola Alignment Scenarios, which explores approximate travel times for different parking and base station scenarios.

4.2.3 Staffing

The "per-shift" staffing requirement for gondolas would be between 15 and 17 people.[9] The staffing requirements at the parking structure are likely 2 to 3 people. Staff positions include supervisors, operators, gondola platform attendants, parking attendants, administrative personnel, mechanics, and electricians.

4.2.4 Emergency Evaluation

The terminal stations and angle stations would need to be equipped with backup power to allow emergency evacuations. Diesel generators could be used to supply this power. An evacuation access would also be needed to each station. Therefore, it is preferable to locate stations closer to existing roads. Bridges would be needed if stations are sited on the south side of Little Cottonwood Creek. At a minimum, pedestrian access would be required at each tower, and each tower would be supplied with tools and equipment to fix a problem if it were to occur at a tower. Evacuation times would depend on the distance between each pair of stations.

4.2.5 Cooling and Heating

Gondola cabins are not typically air-conditioned. Heating and cooling all of the cabins would require high-voltage electrical power. Cabins could contain rechargeable batteries to power low-voltage lighting and intercom systems. However, providing the power needed to run heating or cooling units during transit would require installing high-voltage power lines with the gondola-carrying and hauling cables, which is not feasible.

4.3 Base Station Parking Considerations

Section 4.3 describes some of the fundamental considerations for parking at the gondola base station.

A large parking area would be needed near the base station. The required or anticipated ridership will inform the parking requirements, but these requirements were not considered in this report. This report presents general scenarios for parking locations because the locations of the parking area and base station are fundamental considerations for the feasibility of a gondola.

As described in Section 4.1, Engineering Considerations, straight alignment segments are required between stations. If the base station is located farther outside the canyon, it becomes more challenging to design a minimum number of straight segments because of the presence of residential neighborhoods. If intermediate stations (including possibly angle stations) are required, travel times between terminal stations would be greater because of the overall distance between the terminal stations and because cabins would need to decelerate to pass through the intermediate stations at a slower speed than the haul cable and then accelerate to match the speed of the haul cable.

[9] Numbers for the Mountain Village Gondola in Telluride, Colorado, reported in the *Aerial Cable Transit Feasibility Study, Final Report* (Jacobs Engineering Group 2016).

Currently, the existing park-and-ride lots near the mouths of Big and Little Cottonwood Canyons are heavily used, especially during the winter. These lots operate at capacity most winter weekend days. There is parking away from the mouths of the canyons along the existing bus routes; however, these parking lots are heavily utilized during periods of peak winter demand. Because canyon users typically want the shortest travel time, transit riders tend to drive to the mouth of a canyon and take the ski bus up the canyon for the last segment of their trip. The same general principles would apply to gondola use.

Section 5.0 below presents various parking options and the resulting gondola alignment that would be needed. Several scenarios are presented to capture various options for accessing the base station from potential parking location.

5.0 Parking, Base Station, and Gondola Alignment Scenarios

Section 5.0 presents alternative parking lot and base station locations and describes the resulting gondola alignments. Several scenarios are presented in this section. Some scenarios include an expanded parking area and a base station at the same location. Other scenarios separate the parking area from the base station and assume that canyon users take a bus between the parking area and the base station. The different scenarios and options analyzed are:

- **Scenario 1** – Expanded parking and base station at the mouth of the canyon
- **Scenario 2** – Expanded parking and base station 1 mile from the mouth of the canyon
- **Scenario 3** – Expanded parking at a mobility hub at the gravel pit (near Wasatch Boulevard and Fort Union Boulevard)
  - **Scenario 3, Option A** – A complete gondola alignment from the gravel pit mobility hub to the mouth of the canyon and continuing to the resorts
  - **Scenario 3, Option B** – A bus trip from the gravel pit mobility hub to a base station at the mouth of the canyon
- **Scenario 4** – Expanded parking at a mobility hub near 9400 South (S.R. 209) and Highland Drive
  - **Scenario 4, Option A** – A complete gondola alignment from the 9400 South/Highland Drive mobility hub to the mouth of the canyon and continuing to the resorts
  - **Scenario 4, Option B** – A bus trip from the 9400 South/Highland Drive mobility hub to a base station at the mouth of the canyon

The remainder of Section 5.0 describes these scenarios in more detail, presents calculations of the approximate travel times, and presents approximate cost estimates. Also see Appendix A, Travel Time Calculations, for the travel time assumptions and calculations. See Appendix B, Aerial Transit Cost Estimates, for rough order-of-magnitude cost estimates.

5.1 Scenario 1 – Expanded Parking and Base Station at the Mouth of the Canyon

5.1.1 Parking Location and Gondola Alignment

There is an existing park-and-ride lot at the mouth of Little Cottonwood Canyon at the intersection of S.R. 210 and S.R. 209. The existing lot has about 160 spaces. An expanded parking lot at or near this location, which could accommodate the assumed high gondola ridership, would require a large, multilevel parking structure. In order to compare transit concepts (bus, gondola, and train) equally, UDOT assumed a similar peak-hour ridership of about 1,000 people and a peak daily ridership of about 5,200. This level of ridership for Little Cottonwood Canyon would require a parking structure of about 2,500 cars.

Some members of the public are opposed to expanding the parking lot at the base of Little Cottonwood Canyon because vehicle traffic during peak times causes traffic congestion in the area and restricts residents' ability to access their neighborhoods. A large parking structure at the base of the canyon would not help relieve congestion on S.R. 210 and S.R. 209 during peak arrival times. The mobility conditions with Scenario 1 would be similar to the current conditions with traffic trying to enter the canyon. The purpose of the Little Cottonwood Canyon Project is to reduce congestion-related access issues for residents who live at the base on the canyon (that is, not being able to enter or leave their neighborhoods during peak ski days) and to improve overall mobility.

This location for expanded parking and a base station has benefits with respect to the resulting gondola alignment. A 4-mile-long, straight gondola segment could begin at this base station location and extend to the area around Tanners Flat. At Tanners Flat, one angle station could be used to turn the alignment northeast and direct the alignment toward Snowbird. The second straight segment would run for about 2.5 miles from the angle station at Tanners Flat to Snowbird, and a third, 1½-mile segment would then connect Snowbird to Alta.

5.1.2 Travel Time

The approximate gondola travel time from a base station at the existing park-and-ride lot at the mouth of the canyon to Snowbird would be about 24 minutes (6.5 miles at 17 mph equals 23 minutes, plus 1 minute to pass through the angle station). This does not include the time it would take a gondola user to park their car (or shift from another transit mode or rideshare), walk to the base station, and wait to board the gondola cabin. For gondola riders continuing to Alta, an additional distance of about 1½ miles, the additional travel time would be about 9 minutes, which consists of a 3½-minute gondola transfer time plus a 5½-minute gondola ride.

What would be the total travel time to Snowbird and Alta with Scenario 1?

With Scenario 1, the total travel time would be about 44 minutes to Snowbird and about 54 minutes to Alta.

To calculate the total travel time for canyon users and to compare this travel time to that of other transportation modes (car, train, or bus), UDOT estimated the total travel time to reach the top of Little Cottonwood Canyon from a starting point at the intersection of Fort Union Boulevard and Wasatch Boulevard. This is the predominant route for users of the canyon. This scenario assumes an expanded parking area near the existing park-and-ride lot and assumes that gondola riders would access the parking area via automobile.

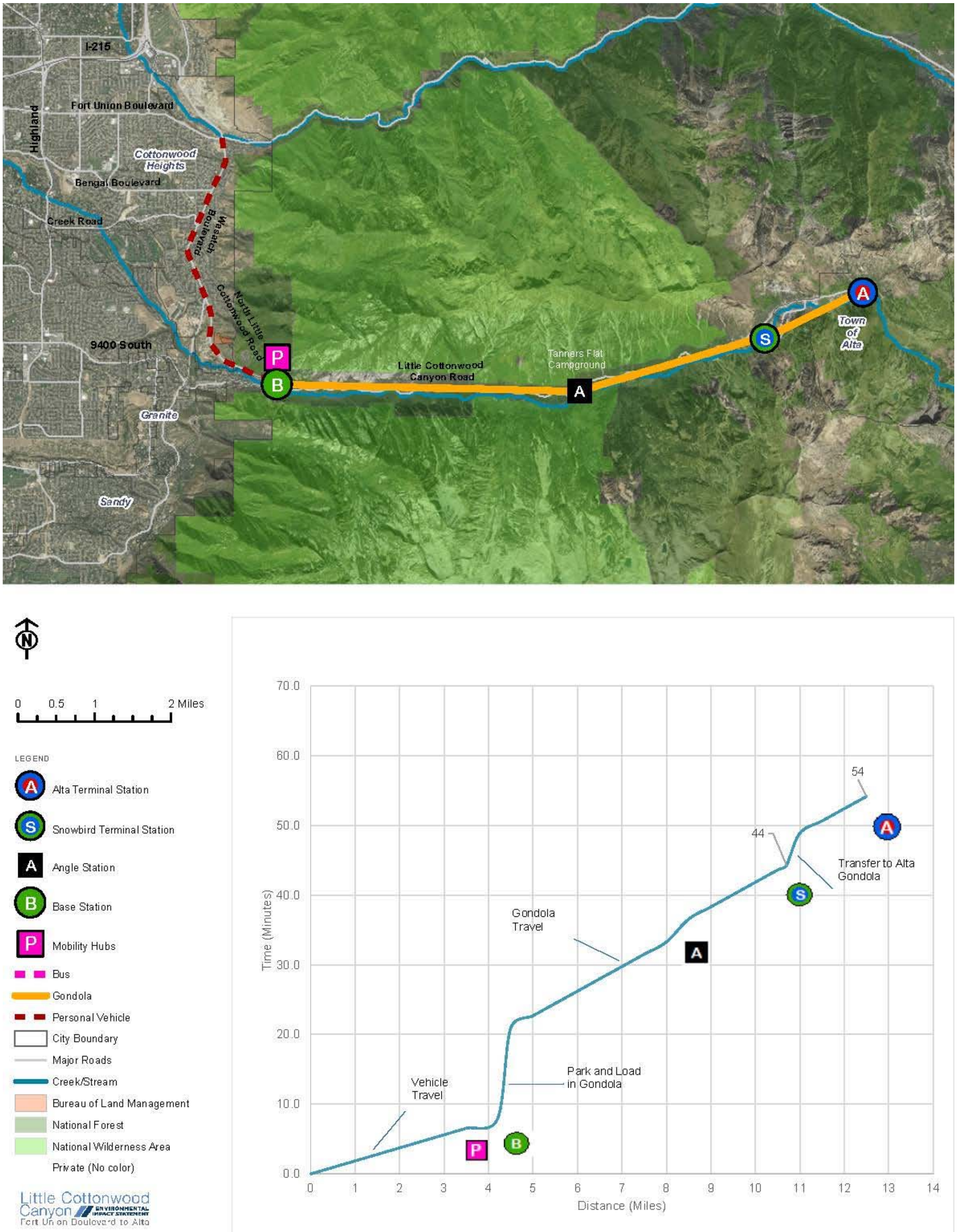
The estimated vehicle travel time in 2050 along Wasatch Boulevard is about 8 minutes from Fort Union Boulevard to the mouth of Little Cottonwood Canyon. This travel time assumes that Wasatch Boulevard has been expanded to accommodate the projected travel demand in 2050. With about 500 vehicles trying to park at the expanded park-and-ride lot or new parking structure at the intersection of S.R. 209 and S.R. 210 during the peak period, there could likely be some congestion at the intersection. However, this analysis assumes that the intersection of S.R. 210 and S.R. 209 can be improved, that vehicles can access the area efficiently, and that vehicles would not back up onto S.R. 210 or neighborhood streets.

UDOT added 12 minutes to the initial 8-minute segment time to account for the time to drive into the parking structure, park a vehicle, unload gear, walk to the gondola loading area, pay for a fare, board the gondola cabin, and depart the base station.[10] Adding the 24-minute gondola ride, the resulting total travel time is about **44 minutes to Snowbird**. Assuming a 3.5-minute mode shift to a separate gondola system and a 1½-mile, 5½-minute ride on the gondola to Alta, the total travel time for Scenario 1 would be about **54 minutes to Alta**.

Figure 2 shows a map with the locations of the major components that make up this scenario. Note that the starting point for travel under this scenario is the intersection of Fort Union Boulevard and Wasatch Boulevard. Scenario 1 includes a personal vehicle trip (a dashed red line in the figure) from this starting point to the base station at the mouth of the canyon. Then the remaining segments are a gondola trip (solid orange line) from the base station through an angle station and on to the resorts. Figure 2 also presents a graph, which is a cumulative travel time chart for each segment. The horizontal axis on the graph represents the distance from the starting point to a gondola system component (base station, angle station, or terminal station), and the vertical axis is the travel time from the starting point to that component.

[10] These additional 12 minutes consist of the following times and activities: 0.5 minute to wait in the line of vehicles at the parking garage, 1 minute to find a parking spot, 4 minutes to unload gear, 3.5 minutes to walk to the gondola loading area (assumed to be a 900-foot distance at a 3-mph pace), 1 minute to pay for a fare, and 2 minutes waiting in line to board the gondola cabin.

Figure 2. Scenario 1 Map and Travel Time Graph



5.1.3 Cost Estimate

Capital Cost

The capital cost for Scenario 1 was established by estimating the costs for the different gondola components needed to load passengers and reach the terminal stations. These are rough order-of-magnitude costs and are for comparison purposes only. The scenario components include the following:

- **Lift System.** The cost estimate for gondola cabling, cabins, and towers uses an assumed cost per mile of about $18 million.[11]
- **Terminal Stations.** The cost estimate for the base and destination stations uses a cost per station for power equipment, emergency backup power, gondola controls, sensors, loading platforms, and mechanical equipment. UDOT estimated these costs to be about $11 million per terminal station.
- **Resort Interface for Terminal Stations.** Required terminal station infrastructure, or "resort interface," costs are included to address utilities, site civil works, and building enclosure needs. UDOT estimated these costs to be about $6 million per terminal station.
- **Angle Station.** No loading or unloading of passengers occurs at angle stations (unless emergency evacuation is needed). However, the angle stations require power and equipment to decelerate and maneuver the detached cabins slowly through the angle station. The approximate cost for angle stations and their required infrastructure was assumed to be about 60% of the terminal station cost (to account for utilities and civil work), or about $10.2 million total.
- **Parking.** The cost estimate for the parking structure uses a per-space average of about $64.77 per square foot.[12] Assuming a 2,500-car parking structure, the total cost for this structure would be about $52 million.

It is important to note that right-of-way costs and costs to relocate existing infrastructure are *not* included in these rough order-of-magnitude costs.

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[11] Gondola lift system costs include costs for mechanical equipment, cabins, and towers. Component costs were estimated from costs presented in the *Mountain Transportation Study* (Fehr and Peers 2012), which were based on the constructed cost of the Whistler-Blackcomb Peak-to-Peak 3S Gondola in 2012. Total costs were broken down to the various components using percentages of the total and were inflated by 1.31 representing the difference between the ENR Construction Index 2012 and May 2019 dollars. UDOT also reviewed the *Aerial Cable Transit Feasibility Study* (Jacobs Engineering Group 2016) commissioned by the Miami-Dade Metropolitan Planning Organization in Florida, the *Sorrento Valley Skyway Feasibility Study* (WSP/Parsons Brinkerhoff 2017), and the *San Diego Bay to Balboa Park Skyway Feasibility Study* (Parsons Brinkerhoff and others 2015), the latter two of which were commissioned by the San Diego Association of Governments, to determine approximate gondola lift system and station costs, including required site infrastructure. In addition, Leitner-Poma (2018) provided a budgetary cost for a gondola lift system from the mouth of Little Cottonwood Canyon 6.5 miles to Snowbird. UDOT used these references to determine the terminal costs, terminal infrastructure costs, and per-mile gondola system cost (mechanical systems, towers, and cabins), as well as annual operation and maintenance costs.

[12] The per-parking-spot, planning-level capital cost estimate for a parking structure was provided to UDOT by its parking consultant, DESMAN Corporation.

Adding these component costs for Scenario 1 produces a total estimated cost of about $262,600,000 to $288,860,000, with the high estimate including an additional 10% contingency. Table 2 provides a breakdown of the capital cost. Also see Appendix B, Aerial Transit Cost Estimates.

Table 2. Scenario 1 Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	8.3 miles	18,000,000	149,400,000
Terminal stations	3 stations	11,000,000	33,000,000
Resort interface for terminal stations	3 stations	6,000,000	18,000,000
Angle station	1 station	10,200,000	10,200,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Total Low Estimate			262,600,000
Contingency (10% of low estimate)	—	—	26,260,000
Total High Estimate			288,860,000

Annual O&M Cost

Annual operation and maintenance (O&M) costs include labor, annual contribution of funds to a capital replacement reserve account to pay for periodic major capital replacements and refurbishments, and miscellaneous costs for maintaining the gondola system. These miscellaneous costs include spare system parts, tools, and consumables (lubricants); staff uniforms and vehicles; and power to run the motors and monitoring equipment.

The annual O&M costs are discussed below. For more information, see Appendix B, Aerial Transit Cost Estimates.

- **Operating Assumptions.** UDOT assumes that the gondola would operate for about 140 days in the winter months between 7:00 AM and 7:00 PM. A gondola system would be a large investment, and UDOT or private operator would want to maximize its use and collect as much in fares as possible to pay for the gondola's capital investment and operation. (A market assessment and determination of the potential annual ridership was outside the scope of the initial ATS evaluation presented in this report.) With the above inputs, the gondola would operate for 1,680 hours per year under every scenario.
- **Labor Costs.** As described in Section 4.2.3, Staffing, operating the gondola requires several different categories of labor. Staffing estimates for the conceptual Little Cottonwood Canyon gondola were based on staffing numbers provided in aerial transit feasibility reports commissioned by the Miami-Dade Metropolitan Planning Organization (Jacobs Engineering Group 2016) and by the San Diego Association of Governments (SANDAG) (Parsons Brinkerhoff and others 2015). An experienced gondola manufacturer, Doppelmayr USA, Inc., participated in the latter study. According to these studies, the per-shift staffing needs for the Scenario 1 gondola are 18 people: 2 managers, 1 electrician, 1 mechanic, 3 operators, 10 parking and platform attendants, and 1 administrative support person. UDOT scaled these staffing numbers for the longer gondola alignments

(Scenarios 3 and 4). The total labor needs and costs were determined by estimating the total labor needs for the annual operating hours (1,680 hours) and applying a burdened hourly rate for each labor category. The total annual labor cost is estimated to be about $1,476,000 for Scenario 1.

- **Major Equipment Replacement Reserves.** Moving gondola system components (cables, motors, and grips) wear and therefore have a finite life. They would need to be replaced near the end of their useful life (about 15 years). In addition, gondola cabins need to be refurbished about every 20 years. UDOT used the SANDAG report from 2015 (Parsons Brinkerhoff and others 2015) as the basis for determining replacement costs and useful life. UDOT calculated a per-mile cost from that study (which evaluated a 2.5-mile 1S gondola) and applied a per-mile replacement cost to the length of the Scenario 1 alignment (8.3 miles) to determine the replacement cost for Scenario 1. Based on this calculation, about $453,000 would need to be set aside annually to establish a fund to replace the system components and refurbish cabins for Scenario 1.
- **Miscellaneous Costs.** These costs include spare parts, lubricants, insurance, annual cable and gondola system inspections, staff vehicles, tools, and other “soft” operating costs. These miscellaneous O&M costs are estimated to total about $990,000 annually for Scenario 1.
- **Energy Costs.** Electricity is needed to power the haul cable motors, the mechanical components in each station, and the monitoring and communication equipment as well as lights and fire and life safety systems at the stations. A conceptual design produced by Leitner-Poma (2018) determined that two 550-horsepower motors would be needed to operate a lift system between the base station at the mouth of Little Cottonwood Canyon and Snowbird. UDOT assumed that a third motor would be needed to operate the segment between Snowbird and Alta. At the assumed operating hours and at a cost of $0.0819 per-kilowatt-hour, the total energy cost is estimated to be about $227,000 annually for Scenario 1.

Table 3 provides a breakdown of annual O&M costs for Scenario 1 by category and a total rough order-of-magnitude annual cost. The total annual O&M cost for Scenario 1 is estimated at about $3,144,000 to $3,458,400.

Table 3. Scenario 1 Annual O&M Cost Estimate

O&M Category	Annual Cost ($)
Labor costs	1,476,000
Major equipment replacement reserves	453,000
Miscellaneous costs	990,000
Energy costs	227,000
Subtotal[a]	3,144,000
Contingency (10%)	314,400
Total	3,458,400

[a] Also see Appendix B, Aerial Transit Cost Estimates. Numbers might not match exactly due to rounding.

5.2 Scenario 2 – Expanded Parking and Base Station 1 to 1½ Miles from the Mouth of the Canyon

5.2.1 Parking Location and Gondola Alignment

The steep slopes around the existing park-and-ride lot at the mouth of Little Cottonwood Canyon might limit the size of a new parking structure. In addition, S.R. 210 and S.R. 209 merge at this location, which causes traffic to back up. Therefore, a large parking structure at the location identified in Scenario 1 might not provide any congestion-reduction benefits. Because of these constraints, the *Mountain Transportation Study* (Fehr and Peers 2012) explored a conceptual parking structure and base station located about 1 to 1½ miles northwest of the existing Little Cottonwood Canyon park-and-ride lot along the west side of S.R. 210. UDOT also evaluated this scenario for the EIS.

Given the location of the parking structure and base station with Scenario 2, the gondola alignment would extend in a 1 to 1½-mile straight segment that crosses S.R. 210 twice and runs to an angle station southwest of the Wasatch Resorts and south of Little Cottonwood Creek. The second straight segment would run south of the Wasatch Resorts, traveling about 4 miles to a second angle station near Tanners Flat. This alignment also places the second angle station south of the creek near Tanners Flat. (This angle station could be moved north of the creek to avoid a long access road and bridge, but alternate locations were not evaluated for this report.) From Tanners Flat, a third straight segment would run about 2 miles to Snowbird. The fourth straight segment would connect Snowbird to Alta, a distance of about 1½ miles.

The base station for Scenario 2 would be in between two residential areas. The first straight segment would run along the east side of S.R. 210 along the foothills. The second straight segment would run past the Wasatch Resorts. Privacy issues would be a concern with this segment. At least one (and maybe two) angle stations would be located south of the creek and would require a maintenance road, a bridge over the creek, and base and emergency power.

5.2.2 Travel Time

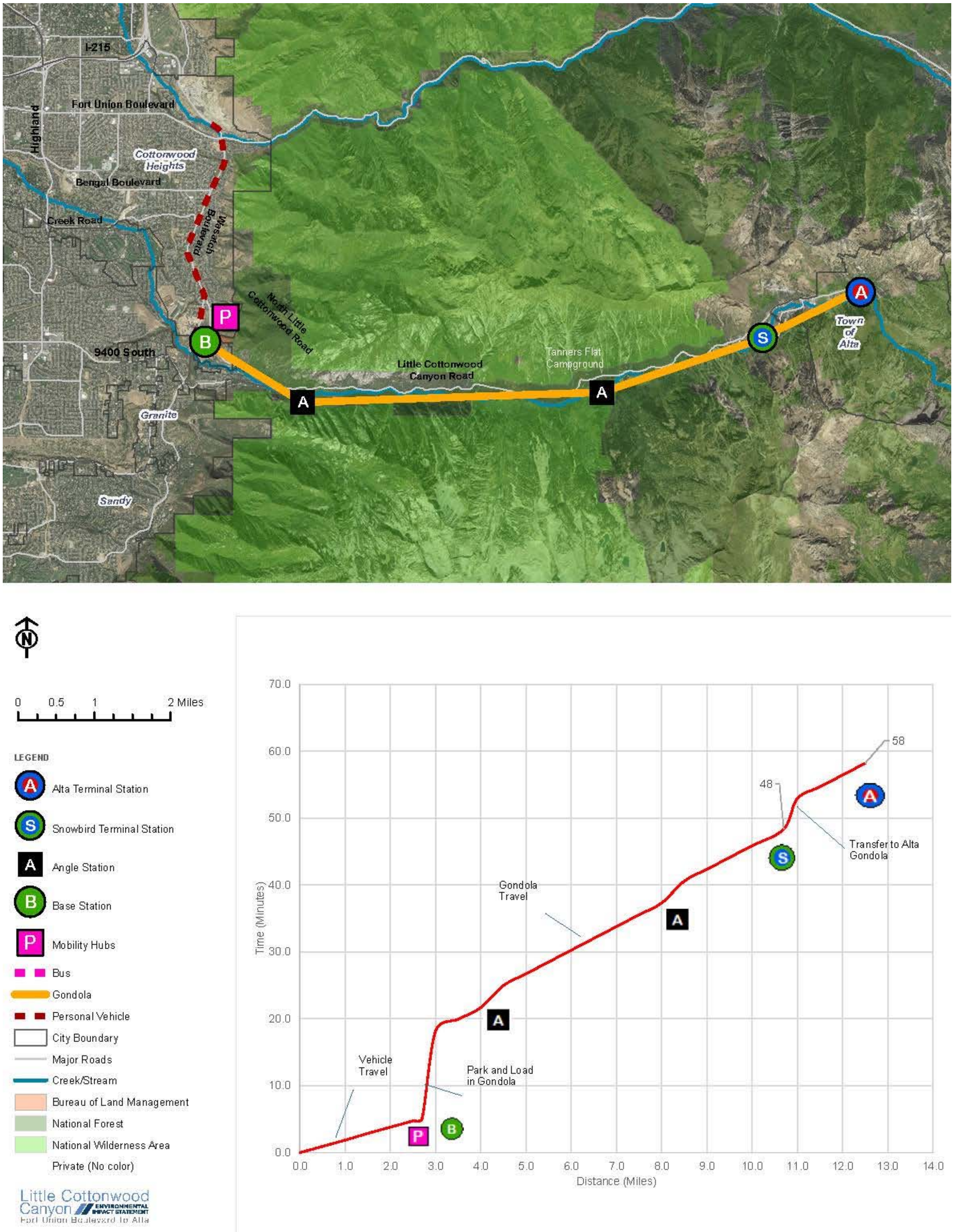
The additional 1½-mile gondola segment from Snowbird to Alta would add about 7 minutes to the gondola travel time (6 minutes plus 1 minute to go through the additional angle station). The resulting gondola travel time from the parking structure and base station would be about 31 minutes to Snowbird and about 40 minutes to Alta.

In terms of the overall travel time from the intersection of Fort Union Boulevard and Wasatch Boulevard, the vehicle travel time would be slightly reduced (from about 8 to 5 minutes) compared to Scenario 1. Adding the time for a rider to park their car, walk to the gondola platform, and board the gondola cabin, the total travel time would be about **48 minutes to Snowbird** and, with the transfer to a separate gondola system for the last segment, **about 58 minutes to Alta** (Figure 3).

What would be the total travel time to Snowbird and Alta with Scenario 2?

With Scenario 2, the total travel time would be about 48 minutes to Snowbird and about 58 minutes to Alta.

Figure 3. Scenario 2 Map and Travel Time Graph



5.2.3 Cost Estimate

Capital Cost

The total estimated capital cost for Scenario 2 is about $299,800,000 to $329,780,000. A cost breakdown is provided in Table 4. The higher cost ($40,900,000) compared to Scenario 1 can be attributed to the 1 to 1½-mile longer total length and the need for an additional angle station.

Table 4. Scenario 2 Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	9.8 miles	18,000,000	176,400,000
Terminal stations	3 stations	11,000,000	33,000,000
Resort interface for terminal stations	3 stations	6,000,000	18,000,000
Angle stations	2 stations	10,200,000	20,400,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Total Low Estimate			299,800,000
Contingency (10% of low estimate)	—	—	29,980,000
Total High Estimate			329,780,000

Annual O&M Cost

The O&M cost for Scenario 2 would be essentially the same as for Scenario 1. A similar number of staff would be needed. The miscellaneous costs and power costs would be about the same. More gondola cabins would be needed for the extra length of this alignment, and, compared to Scenario 1, more cabins would eventually need to be refurbished. However, the difference in the major equipment replacement reserves would be negligible. Therefore, the total O&M cost for Scenario 2 is also estimated at about $3.1 million to $3.5 million.

5.3 Scenario 3 – Gravel Pit Mobility Hub

5.3.1 Parking Location and Gondola Alignment

This scenario would place a parking structure at a site of an aggregate (gravel) mining operation that is just east of Wasatch Boulevard and north of Fort Union Boulevard near the mouth of Big Cottonwood Canyon. The parking structure would allow this location to function as a “mobility hub” from which users could take various transit options.

A main benefit of this location is that it would take cars away from the mouth of Little Cottonwood Canyon, which is where S.R. 210 and S.R. 209 merge and where traffic congestion is heavy during the current winter AM peak period. This location is near Interstate 215 (I-215) and would not add traffic to a residential area. Another benefit of this location as a mobility hub is that it could serve transit users traveling to either Big Cottonwood Canyon or Little Cottonwood Canyon, as well as serve weekday commuters in the future as UTA and UDOT explore long-term transit options for this part of the Salt Lake Valley. Parking could also be developed in conjunction with a future commercial or mixed-use development in the area. UDOT has coordinated with the City of Cottonwood Heights regarding this possibility.

For canyon users originating from the north part of the Salt Lake Valley (north of Fort Union Boulevard), this mobility hub would be on their route. However, canyon users who originate from south of 9400 South (S.R. 209) would need to bypass Little Cottonwood Canyon and drive about 3 more miles north to this mobility hub before boarding the gondola.

Two options were explored for accessing the gondola under Scenario 3.

- With **Option A (Complete Gondola Alignment)**, users would board the gondola at a base station at the mobility hub at the gravel pit and then transfer to a second gondola system at a second base station at the mouth of Little Cottonwood Canyon. This would be a complete gondola alignment (no bus service) that begins in the urban environment.
- With **Option B (Express Bus to Gondola Alignment)**, users would take an express bus from the mobility hub at the gravel pit to a base station at the mouth of Little Cottonwood Canyon.

These Scenario 3 options are described in greater detail below.

Scenario 3A – Complete Gondola Alignment

With Scenario 3A (Figure 4 on page 25), the gondola alignment that would connect the mobility hub at the gravel pit to Little Cottonwood Canyon would be very challenging. There are existing homes on both sides of Wasatch Boulevard. The *Mountain Transportation Study* (Fehr and Peers 2012) explored two alignments that would connect a base station at the mobility hub to a base station at the mouth of Little Cottonwood Canyon.

The alignment that appears to have the least impacts to the current residential areas would run south from the gravel pit, fly over homes along the east side of Wasatch Boulevard for about 1 mile (likely requiring the acquisition of at least 10 to 15 residences), and include an angle station in Ferguson Canyon. From there, the gondola alignment would skirt the western edge of USDA Forest Service land for about 3 miles to the mouth of the canyon. This segment of the gondola alignment would run past existing homes east of Wasatch Boulevard. Two angle stations would likely be needed in the urban segment. From the mouth of the canyon, the gondola alignment would be similar to that for Scenario 1.

Scenario 3B – Express Bus to Gondola Alignment

With Scenario 3B (Figure 5 on page 27), gondola users would park their vehicle at the gravel pit mobility hub and then travel via express bus from the mobility hub to a base station at the mouth of Little Cottonwood Canyon. This option would avoid siting a large parking area at the mouth of Little Cottonwood Canyon, would keep traffic away from residential areas, and would avoid a difficult gondola alignment that would run through or adjacent to residential areas. However, gondola users would need to change travel modes twice: from vehicle to bus and then from bus to gondola for the trip up the canyon.

In general, a “one-seat ride” (either vehicle or transit) is most preferable to users. One mode shift, or a “two-seat ride,” is less desirable but is still acceptable to many users as evidenced by the use of the existing park-and-ride lots and ski bus service. Shifting travel modes twice, or a “three-seat ride,” would likely be unpopular but could be acceptable to some users if the travel time were shorter than with other available options. If resort parking becomes more limited in the future, or if future policy decisions limit automobile use in the canyon and buses are given priority in traffic, a vehicle-to-bus-to-gondola trip could be a reasonable scenario. Considering the difficulty in establishing an acceptable gondola alignment between the canyons, UDOT evaluated the travel times and the cost of Scenario 3B as it considers and compares all feasible and reasonable concepts to evaluate in detail in the EIS.

5.3.2 Travel Time

Scenario 3A – Complete Gondola Alignment

Scenario 3A involves a complete gondola trip from the starting point (the intersection of Wasatch Boulevard and Fort Union Boulevard) to the ski resorts, a total distance of about 12.5 miles. The travel time considerations for this gondola scenario (parking, walking, and gondola loading times) are the same as those described in Section 5.1.2, Travel Time.

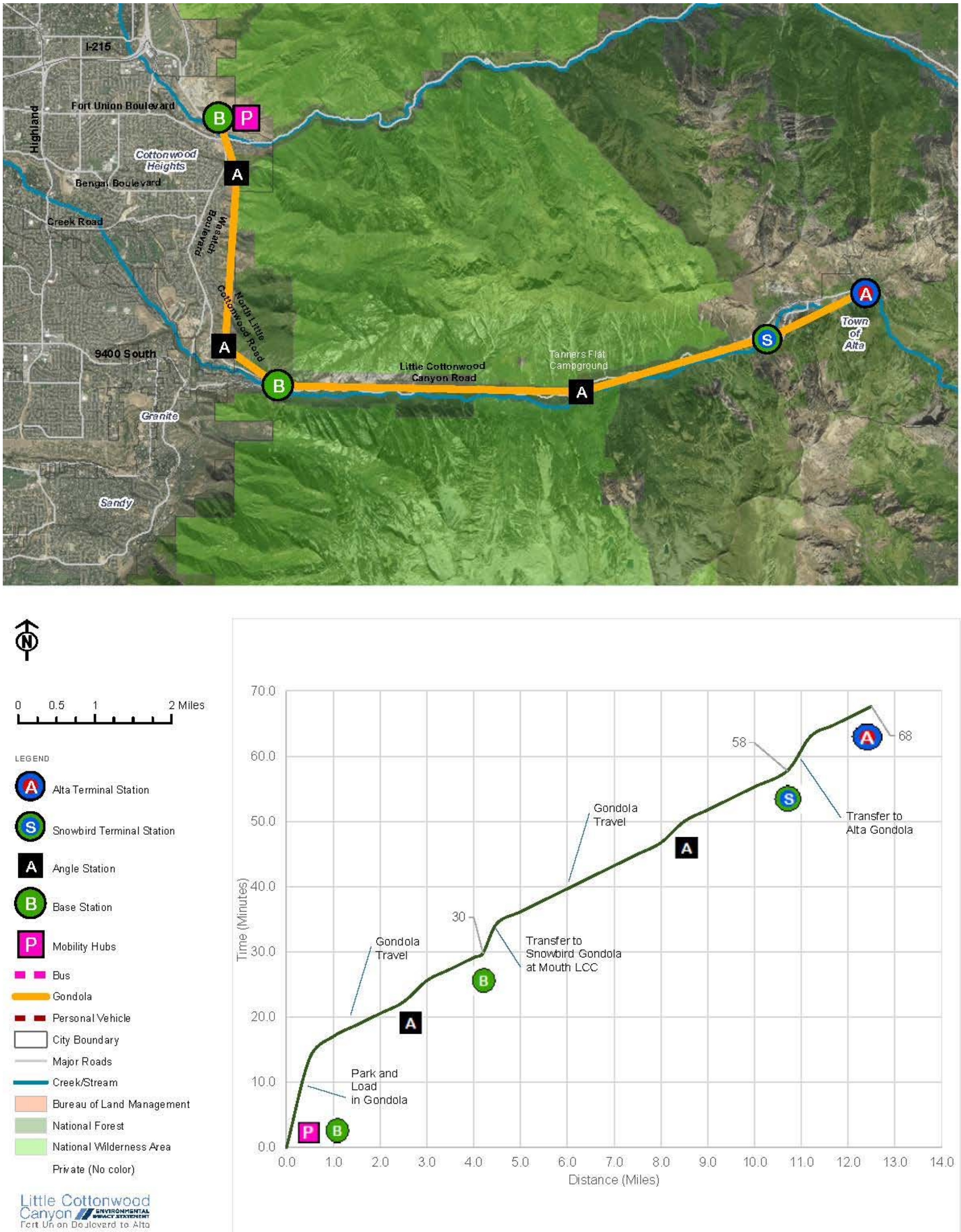
What would be the total travel time to Snowbird and Alta with Scenario 3A?

With Scenario 3A, the total travel time would be about 58 minutes to Snowbird and about 68 minutes to Alta.

Previous studies theorized that a different type of gondola could be used to connect Big and Little Cottonwood Canyons, and UDOT believes it is unlikely that one operationally connected cabling system could be used for this length of gondola system with its several angle stations. Therefore, to be conservative, UDOT has assumed that users would transfer from one gondola system to another at the mouth of Little Cottonwood Canyon.

The travel time for accessing and traveling in a gondola from the start point to the mouth of Little Cottonwood Canyon would be about 30 minutes. Adding the gondola transfer time (3.5 minutes) and the gondola travel time from the mouth of the canyon to the resorts results in a total travel time of about **58 minutes to Snowbird** and about **68 minutes to Alta** (Figure 4). The travel time for this scenario is about 14 minutes longer than with Scenario 1 (parking and base station at the mouth of Little Cottonwood Canyon).

Figure 4. Scenario 3A Map and Travel Time Graph



Scenario 3B – Express Bus to Gondola Alignment

With Scenario 3B, gondola riders would park their vehicles at the gravel pit mobility hub, take an express bus for 4.2 miles to a base station at the mouth of the canyon, and then transfer to a gondola.

Whereas the gondola system would offer nearly constant service (a gondola cabin would arrive about every 30 seconds), the express buses would arrive at a longer intervals, and the wait time for a bus could be longer than for a gondola. UDOT assumed that Scenario 3B would use articulated buses with a capacity of about 60 people per bus. These buses could be electric and would have three loading doors.

UDOT assumed a bus wait time of 2 minutes. Therefore, the assumed parking, walking, and waiting time at the starting point is about 12 minutes.

With Scenario 3B, the segment of the trip between the starting point and the mouth of the canyon would be about 25 minutes, about 5 minutes faster than with the complete gondola alignment (Scenario 3A). The assumed speed of the bus (20 mph[13]) is faster than the assumed speed of the gondola (17 mph[14]). Adding the 3.5-minute bus-to-gondola transfer time at the base station at the mouth of the canyon and the gondola travel time, the total travel time with this option would be about **53 minutes to Snowbird** and about **62 minutes to Alta** (Figure 5).

What would be the total travel time to Snowbird and Alta with Scenario 3B?

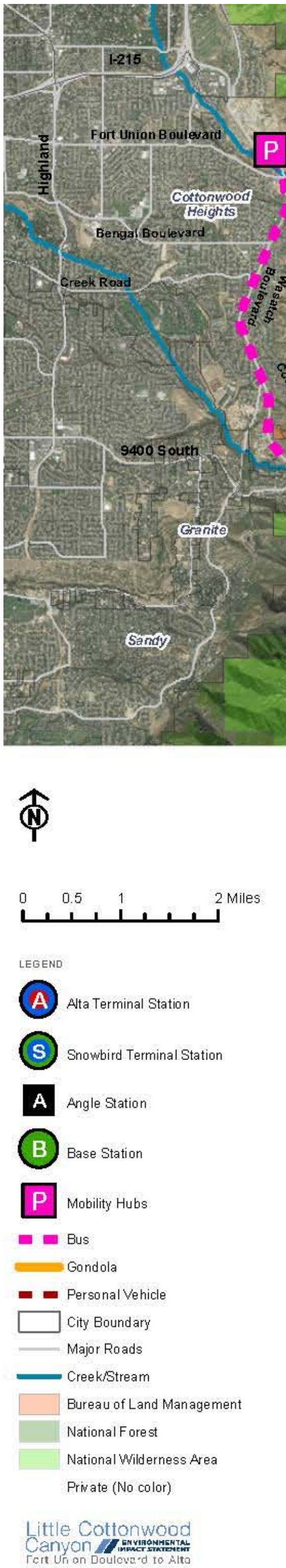
With Scenario 3B, the total travel time would be about 53 minutes to Snowbird and about 62 minutes to Alta.

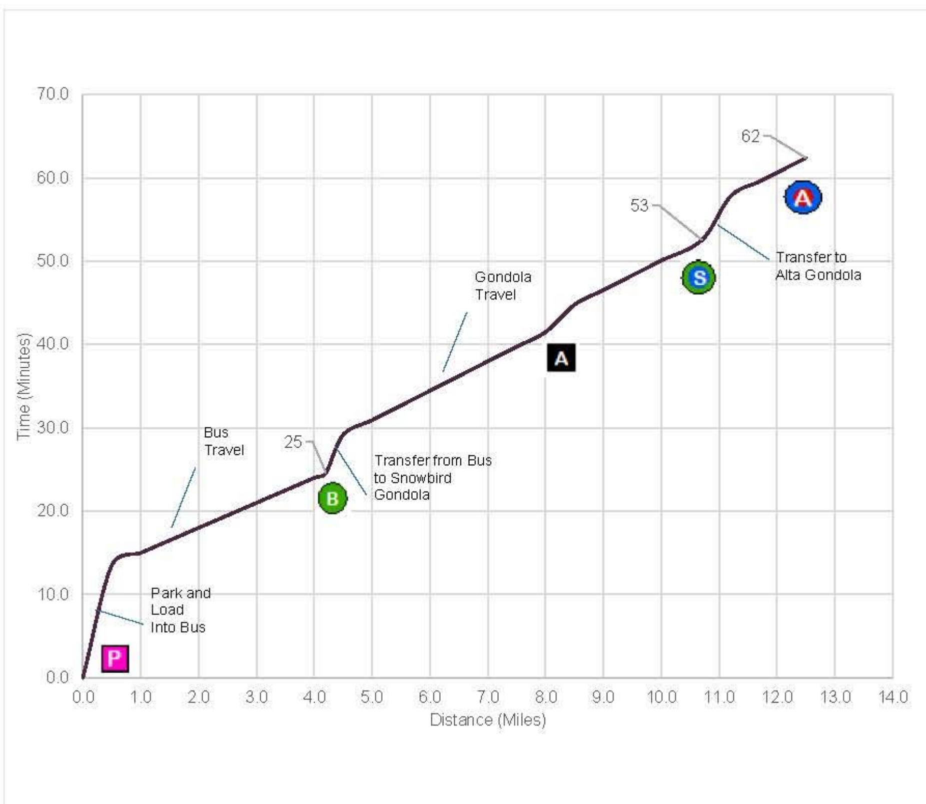
What is an articulated bus?

An articulated bus is an extended bus in which two or more sections are linked with pivoting joints to accommodate more passengers while still allowing the bus to maneuver.

[13] Operating bus speed is assumed to be equivalent to bus rapid transit operating in an urban area (20 mph).
[14] Gondola operating speed is taken from the *Mountain Transportation Study* (Fehr and Peers 2012).

Figure 5. Scenario 3B Map and Travel Time Graph





5.3.3 Cost Estimate

Scenario 3A – Complete Gondola Alignment

Capital Cost

Scenario 3A includes the same general components as Scenarios 1 and 2. However, this gondola alignment would need two more angle stations than Scenario 1 and one more angle station than Scenario 2. The length of the gondola alignment would be about 12.5 miles, 4.2 miles longer than with Scenario 1. UDOT also assumes that a gondola system transfer at the mouth of the canyon would be needed, requiring another base station (four terminal stations total) for this scenario. Table 5 provides the breakdown of capital costs. Note that these costs do not include right-of-way or property acquisition costs.

Table 5. Scenario 3A Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	12.5 miles	18,000,000	225,000,000
Terminal stations	4 stations	11,000,000	44,000,000
Resort interface for terminal stations	4 stations	6,000,000	24,000,000
Angle stations	3 stations	10,200,000	30,600,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Total Low Estimate			375,600,000
Contingency (10% of low estimate)	—	—	37,560,000
Total High Estimate			413,160,000

Annual O&M Cost

The additional gondola system segment (base station to the mouth of the canyon) would lead to additional O&M costs. These additional considerations are as follows.

- **Labor Costs.** UDOT scaled up Scenario 1's per-shift staffing needs to arrive at the staffing needs for the Scenario 3A gondola system. The staffing needs for Scenario 3A would be about 22 positions per shift: 1 administrative professional, 2 managers, 1 electrician, 2 mechanics, 4 operators, and 12 parking and platform attendants. The total labor cost for Scenario 3A would be about $1,816,000, which is about $340,000 more than for Scenario 1 or 2.
- **Major Equipment Replacement Reserves.** UDOT used a per-mile replacement cost that was calculated for Scenario 1 and applied it to Scenario 3A (with an alignment of 12.5 miles). Two additional motors (five total) would be needed for this scenario. About $673,000 would need to be set aside annually to establish a fund to replace the major system components and refurbish cabins for Scenario 3A. This is about 49% more than for Scenario 1 or 2.
- **Miscellaneous Costs.** Similar to the method used to calculate equipment replacement and refurbishment costs, miscellaneous annual costs were calculated using a per-mile unit cost. UDOT estimated the annual miscellaneous costs for Scenario 3A by adding 49% to the miscellaneous

costs for Scenarios 1 and 2 (which have about the same miscellaneous costs). A total of about $1,469,000 would need to be budgeted for this cost item for Scenario 3A.

- **Energy Costs.** Assuming that Scenario 3A would have five motors and the same operating hours as Scenarios 1 and 2, the energy costs of Scenario 3A would be about $378,000 per year.

Table 6 provides a breakdown of annual O&M costs for Scenario 3A by category and a total rough order-of-magnitude annual cost. This 12.5-mile gondola would cost about $4,337,000 to $4,770,700 annually to operate and maintain.

Table 6. Scenario 3A Annual O&M Cost Estimate

O&M Category	Annual Cost ($)
Labor costs	1,816,000
Major equipment replacement reserves	673,000
Miscellaneous costs	1,469,000
Energy costs	378,000
Subtotal[a]	4,337,000
Contingency (10%)	433,700
Total[a]	4,770,700

[a] Also see Appendix B, Aerial Transit Cost Estimates. Numbers might not match exactly due to rounding

Scenario 3B – Express Bus to Gondola Alignment

Capital Cost

The gondola system for Scenario 3B is the same as for Scenario 1. This option replaces Scenario 3A's gondola alignment through the initial urban segments with express bus service and adds the capital cost of these buses.

UDOT assumed that articulated buses could be used to transport people from the parking area at the gravel pit to the base station at the mouth of Little Cottonwood Canyon. These articulated buses have a higher capacity per bus (60 people maximum) compared to regular buses and ski buses (which have a maximum capacity of about 42 people). Assuming that a bus can make two round trips per hour, each articulated bus could transport 120 people per hour. If 1,000 people per hour need to be moved, about 8 buses would be required. Adding a 20% "spare ratio" to account for breakdowns and maintenance needs, this option would require 10 buses total. At about $1,100,000 per articulated bus, the total capital cost for buses would be about $11,000,000.

The cost estimate in Table 7 also includes a budgetary number of $10 million for improving shoulders to allow the buses to use them during times of heavy traffic, for adding "queue jump" lanes and traffic signal priority systems that would allow buses to get to the front of the line at intersections, and for building a maintenance and bus storage facility near the parking area.

Table 7 summarizes the breakdown of capital costs for Scenario 3B. The capital cost of this scenario is about $94 million less than the cost of Scenario 3A.

Table 7. Scenario 3B Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	8.3 miles	18,000,000	149,400,000
Terminal stations	3 stations	11,000,000	33,000,000
Resort interface for terminal stations	3 stations	6,000,000	18,000,000
Angle station	1 station	10,200,000	10,200,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Enhanced bus service	1 lump sum	21,000,000	21,000,000
Total Low Estimate			283,600,000
Contingency (10% of low estimate)	—	—	28,360,000
Total High Estimate			311,960,000

Annual O&M Cost

This gondola alignment and parking scenario would include O&M costs for both gondola and bus. The gondola O&M cost would be the same as that for Scenario 1, which would be about $3.5 million annually.

As described in the previous section for capital cost, about 10 buses would be needed to accommodate the same hourly capacity as was assumed for the gondola (1,000 people per hour). Assuming that each bus can make two round trips each hour between the gravel pit mobility hub and the gondola base station at the mouth of Little Cottonwood Canyon, which are 4.2 miles apart, about 840 bus-fleet miles per day would be driven. If the buses operate at the same times as the gondola (12 hours per day for 140 days), about 11,760 miles would be driven per year. Using an operating expense per vehicle revenue mile of $7.88 per mile, the total annual O&M cost for buses would be about $927,000 ($1,020,000 including a 10% contingency) (UTA 2019).

Table 8 presents the estimated total annual O&M cost for Scenario 3B. This 8.3-mile gondola alignment with three terminal stations and with express bus service transporting users to the base terminal at the mouth of the canyon would cost about $4.5 million annually to maintain and operate.

Table 8. Scenario 3B Annual O&M Cost Estimate

O&M Category	Annual Cost ($)
Labor costs	1,476,000
Major equipment replacement reserves	453,000
Miscellaneous costs	990,000
Energy costs	227,000
Gondola Subtotal	3,146,000
Bus O&M	927,000
Subtotal	4,073,000
Contingency (10%)	470,000
Total[a]	4,543,000

[a] Also see Appendix B, Aerial Transit Cost Estimates. Numbers might not match exactly due to rounding.

Bus service can be more easily optimized than can gondola service to accommodate the actual hourly demand. The number of buses arriving per hour can be adjusted, whereas the number of gondola cabins arriving per hour is fixed. UDOT created a modified bus schedule for Scenario 3B (Table 9) to account for the difference in expected transit demands between winter weekend (including Fridays) peak and off-peak hours and winter weekday demands.

With the modified schedule, maximum bus operations (3 to 4-minute frequency or headways) would occur for about 6 hours per day for 60 weekend days (including Fridays) per year. The bus capacity during peak hours would be about 1,000 people per hour. The bus frequency would be reduced to a 15-minute headway for the remaining 6 hours of weekend operating times. During the winter weekdays, UDOT assumes that there would be 30-minute bus headways between the gravel pit mobility hub and the base gondola station at the mouth of Little Cottonwood Canyon.

Table 9. Modified Bus Schedule for Scenario 3B

Schedule	Hours of Operation	Frequency (minutes)	Trips per Hour	Trips per Day	Days of Operation	Total Trips
Winter weekends, peak hours Friday–Sunday 7–10 AM and 3–6 PM	6	3	20	120	60	7,200
Winter weekends, off-peak hours Friday–Sunday 10 AM–3 PM and 6–7 PM	6	15	4	24	60	1,440
Winter weekdays, all hours Monday–Thursday 7 AM–7 PM	12	30	2	24	80	1,920
Total Trips						10,560

Table 9 above shows the estimated total number of bus trips per year (10,560) with Scenario 3B. The one-way distance between the gravel pit mobility hub and the base gondola station is about 4.2 miles (8.4 miles round trip). Given an estimated 10,560 annual bus trips, about 88,704 fleet-miles per year would be traveled. Using an operating expense per vehicle revenue mile of $7.88 per mile, the total annual O&M cost for buses with this scenario would be about $699,000. As shown in Table 10, the O&M cost for Scenario 3B with a modified bus schedule would be about $3.8 million to $4.2 million annually. Optimizing the hourly bus service to the gondola would save about $0.3 million annually.

Table 10. Scenario 3B (with Modified Bus Schedule) Annual O&M Cost Estimate

O&M Category	Annual Cost ($)
Labor costs	1,476,000
Major equipment replacement reserves	453,000
Miscellaneous costs	990,000
Energy costs	227,000
Gondola Subtotal	3,146,000
Bus O&M	699,000
Subtotal	3,845,000
Contingency (10%)	384,000
Total[a]	4,229,500

[a] Also see Appendix B, Aerial Transit Cost Estimates. Numbers might not match exactly due to rounding.

5.4 Scenario 4 – 9400 South and Highland Drive Mobility Hub

5.4.1 Parking Location and Gondola Alignment

Another scenario for implementing a mobility hub would be expanding parking near the existing park-and-ride lot at 9400 South (S.R. 209) and Highland Drive. Although this area is outside the EIS transportation needs assessment study area, UDOT wanted to evaluate the potential merits of gondola use in Little Cottonwood Canyon, and this is one feasible possibility for a mobility hub. A benefit of this site for a mobility hub is that parking itself would be near existing commercial developments and away from both residential areas and the junction of S.R. 210 and S.R. 209 at the mouth of the canyon.

For canyon users traveling from the south, this mobility hub, which would be about 3.5 miles from Interstate 15, would be on their route. However, canyon users traveling from the north would need to drive about 6 miles farther south from I-215 to reach this parking location.

As with Scenario 3, two options were explored for accessing the gondola under Scenario 4.

- With **Option A (Complete Gondola Alignment)**, users would board the gondola at a base station at the mobility hub at 9400 South and Highland Drive and then transfer to a second gondola system at a second base station at the mouth of Little Cottonwood Canyon. This would be a complete gondola alignment (no bus service) that begins in the urban environment.
- With **Option B (Express Bus to Gondola Alignment)**, users would take an express bus from the mobility hub at 9400 South and Highland Drive to a base station at the mouth of Little Cottonwood Canyon.

These Scenario 4 options are described in greater detail below.

Scenario 4A – Complete Gondola Alignment

With Scenario 4A (Figure 6 on page 35), a gondola alignment from the 9400 South mobility hub would run 3½ miles to the mouth of Little Cottonwood Canyon. This would be a very challenging alignment because of the narrow roadway and adjacent residential areas. The area along 9400 South from just east of Highland Drive to the mouth of the canyon has dense residential development. 9400 South is currently four lanes (two lanes in each direction) near the potential mobility hub but transitions to two lanes about ¾ mile east of the mobility hub, at about 2350 East, and is only two lanes from there to the intersection of 9400 South and S.R. 210 at the mouth of Little Cottonwood Canyon. A gondola alignment would need to follow 9400 South for the entire segment to avoid major residential impacts. Only at 9400 South and Wasatch Boulevard could the gondola alignment divert from the road to run south of residential neighborhoods to the mouth of the canyon.

At least six angle stations would be needed to reach the base station at the mouth of Little Cottonwood Canyon. Having six angle stations would slow the average speed of the gondola significantly. UDOT assumes that users would transfer to a second gondola system at the mouth of the canyon because it is unlikely that one continuous-haul cabling system could connect the gondola system for the entire 11.5 miles.

Scenario 4B – Express Bus to Gondola Alignment

With Scenario 4B (Figure 7 on page 37), express bus service using articulated buses would connect gondola riders from the 9400 South mobility hub to a base station at the mouth of Little Cottonwood Canyon (similar to Scenario 3B). Gondola riders would need to change travel modes twice: from vehicle to bus and then from bus to gondola for the trip up the canyon.

5.4.2 Travel Time

Scenario 4A – Complete Gondola Alignment

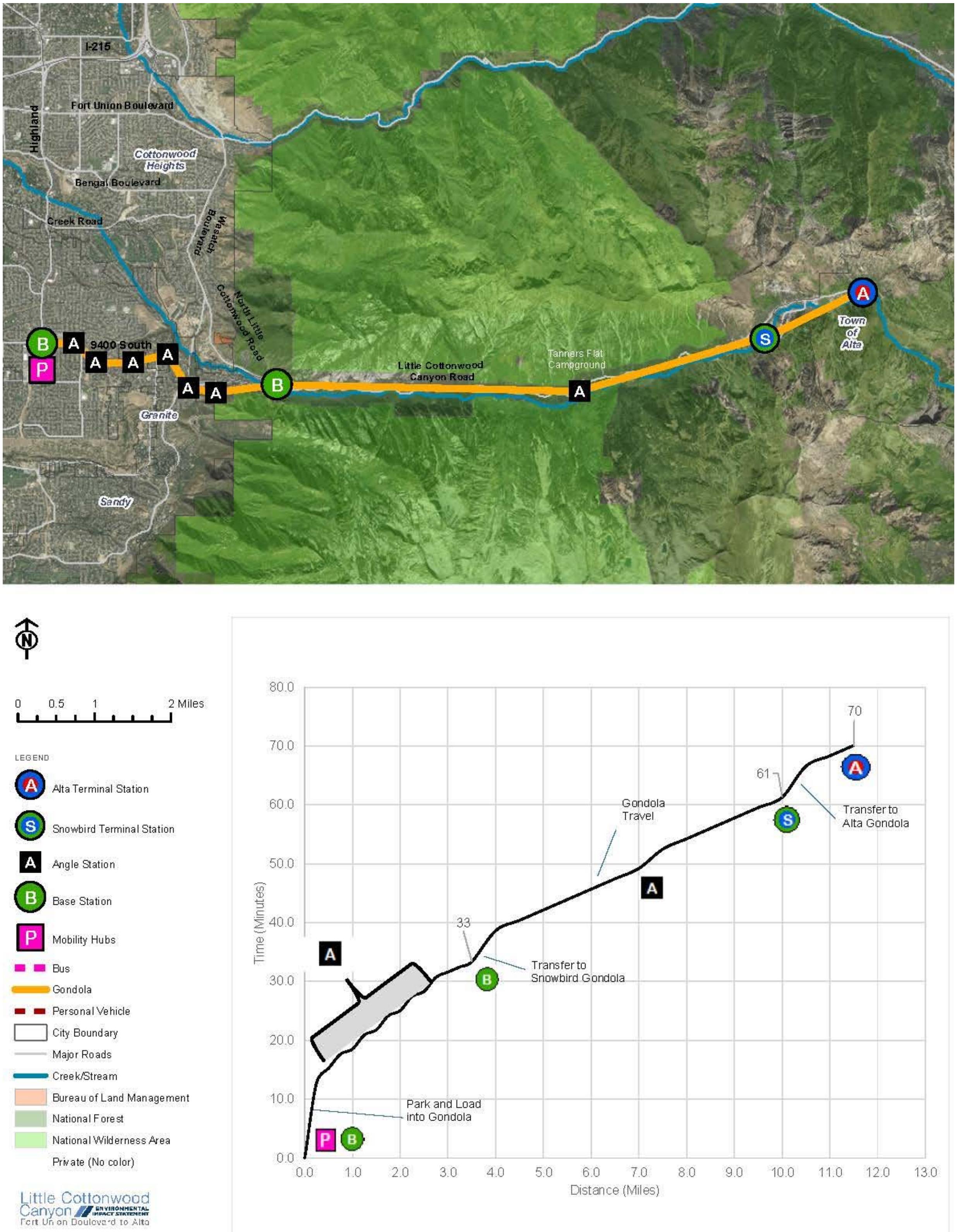
With Scenario 4A, it would take a gondola rider about 33 minutes to get from 9400 South and Highland Drive to the mouth of the canyon considering parking, walking, gondola loading times, and time to pass through the angle stations. The total travel time would be about **61 minutes to Snowbird** and about **70 minutes to Alta** (Figure 6).

Note that this travel time does not include the travel time from the starting point, Wasatch Boulevard and Fort Union Boulevard. Therefore, a comparison to Scenarios 1, 2, and 3 is not appropriate.

What would be the total travel time to Snowbird and Alta with Scenario 4A?

With Scenario 4A, the total travel time would be about 61 minutes to Snowbird and about 70 minutes to Alta.

Figure 6. Scenario 4A Map and Travel Time Graph



Scenario 4B – Express Bus to Gondola Alignment

With Scenario 4B, it would take a bus rider about 23 minutes to get from 9400 South and Highland Drive to the mouth of the canyon considering parking, walking, bus loading times, and bus travel times. Note that this calculation used an average assumed speed of 20 mph. 9400 South is only two lanes for much of segment between Highland Drive and the intersection with S.R. 210, and there are many homes on both sides of the road. Shoulder and intersection improvements alone might not effective for maintaining the assumed speed of the articulated buses during heavy traffic.

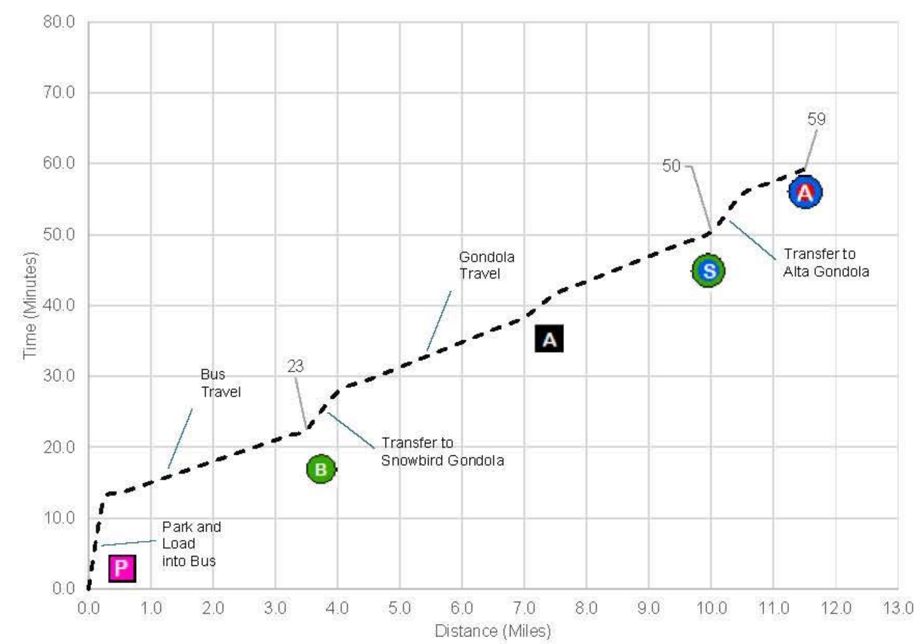
What would be the total travel time to Snowbird and Alta with Scenario 4B?

With Scenario 4B, the total travel time would be about 50 minutes to Snowbird and about 60 minutes to Alta.

Including the transfer from bus to gondola, the total travel time would be about **50 minutes to Snowbird** and about **59 minutes to Alta** (Figure 7). However, if buses are operating on a two-lane 9400 South in mixed traffic (both personal vehicles and buses), slower average speeds are expected.

Note that this travel time does not include the travel time from the starting point, Wasatch Boulevard and Fort Union Boulevard. Therefore, a direct comparison to Scenarios 1, 2, and 3 is not appropriate.

Figure 7. Scenario 4B Map and Travel Time Graph



5.4.3 Cost Estimate

Scenario 4A – Complete Gondola Alignment

Capital Cost

Scenario 4A would be a complete gondola alignment from 9400 South and Highland Drive to the mouth of the canyon. UDOT has assumed a mode shift (from bus to gondola) at the mouth of the canyon requiring four total terminal stations and seven total angle stations. The total length of the alignment would be 11.5 miles. The rough order-of-magnitude capital cost estimate is broken down by component in Table 11. The total capital cost would be about $438,240,000. Note that this cost does not include right-of-way costs, residential relocation costs, or costs to relocate existing infrastructure.

Table 11. Scenario 4A Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	11.5 miles	18,000,000	207,000,000
Terminal stations	4 stations	11,000,000	44,000,000
Resort interface for terminal stations	4 stations	6,000,000	24,000,000
Angle stations	7 stations	10,200,000	71,400,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Enhanced bus service capital	1 lump sum	NA	NA
Total Low Estimate			398,400,000
Contingency (10% of low estimate)	—	—	39,840,000
Total High Estimate			438,240,000

Annual O&M Cost

The annual O&M cost for Scenario 4A would be similar to that for Scenario 3A. Scenario 4A has a slightly shorter gondola alignment than does Scenario 3A. Using the per-mile unit cost for some of the gondola O&M categories would result in a slightly lower cost for Scenario 4A. However, the additional angle stations and equipment for Scenario 4A would likely more than offset the annual O&M cost savings of this shorter gondola alignment. UDOT estimates that the total rough order-of-magnitude cost to operate Scenario 4A would be about $$4,337,000 to $4,770,700 annually.

Scenario 4B – Express Bus to Gondola Alignment

Capital Cost

Table 12 presents the rough order-of-magnitude capital cost for Scenario 4B. This scenario uses the same bus capital assumptions as for Scenario 3B. Using buses to move people to the mouth of Little Cottonwood Canyon would cost about $126 million less than would using a gondola over the same distance.

Table 12. Scenario 4B Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	8.3 miles	18,000,000	149,400,000
Terminal stations	3 stations	11,000,000	33,000,000
Resort interface for terminal stations	3 stations	6,000,000	18,000,000
Angle station	1 station	10,200,000	10,200,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Enhanced bus service capital	1 lump sum	21,000,000	21,000,000
Total Low Estimate			283,600,000
Contingency (10% of low estimate)	—	—	28,360,000
Total High Estimate			311,960,000

Annual O&M Cost

The annual O&M cost for Scenario 4B would be similar to that for Scenario 3B. UDOT assumes that the same number of buses would be needed to transport passengers from the 9400 South and Highland Drive mobility hub to the mouth of the canyon. Major roadway improvements to 9400 South, which are not included in this scenario, would be required to help buses operate along this route. Scenario 4B would have a total rough order-of-magnitude O&M cost of about $4,073,000 to $4,543,000 annually.

Assuming the same modified bus schedule and capacity shown in Table 9 for Scenario 3B, UDOT estimates that the rough order-of-magnitude O&M cost for Scenario 4B would be about $3.8 million to $4.2 million annually.

6.0 Comparison of Concepts

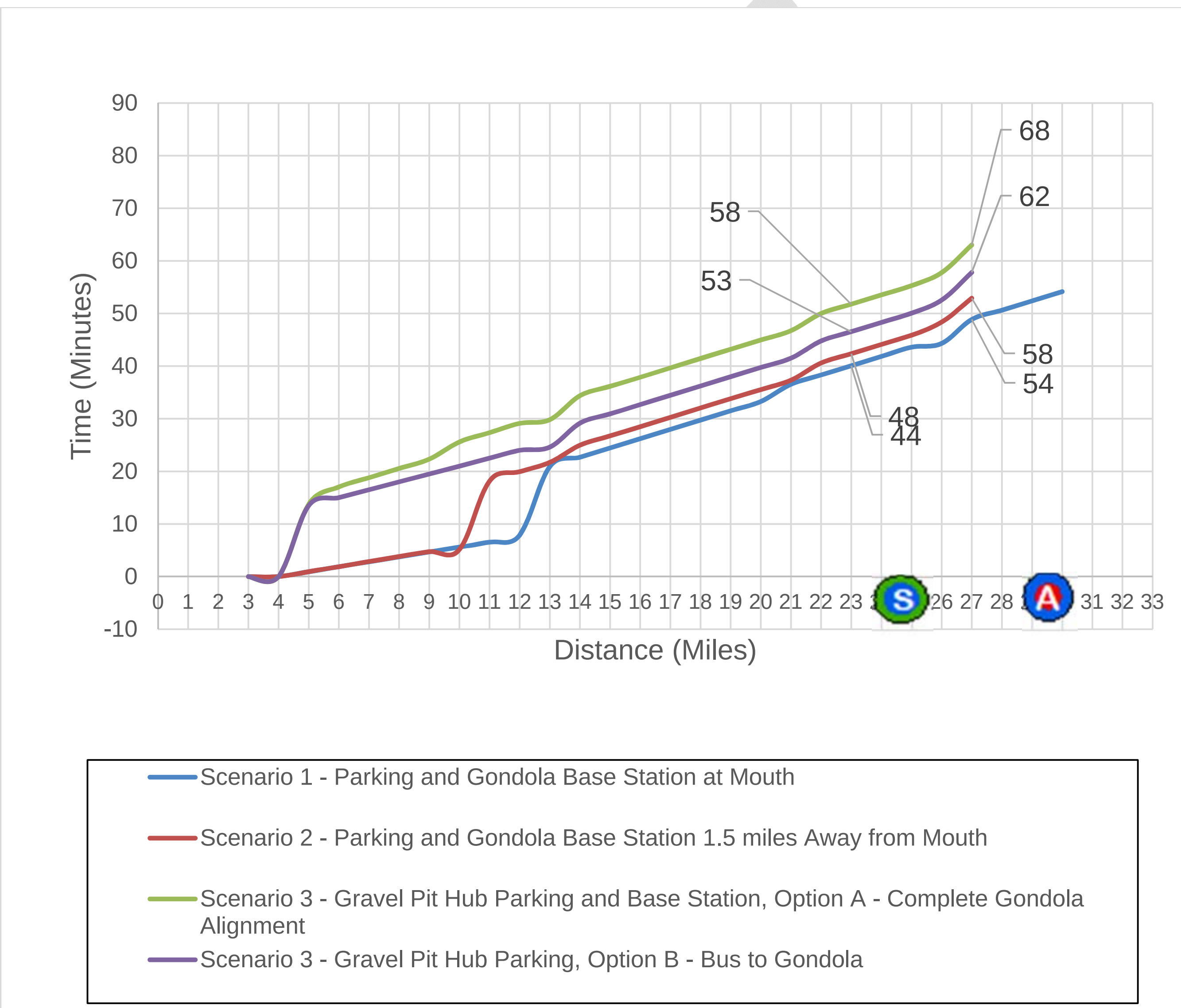
Taking into account the details of each scenario as described in Section 5.0, Parking, Base Station, and Gondola Alignment , UDOT compared the scenarios using the major initial feasibility criteria of travel time and capital and O&M costs. UDOT also compared the scenarios using the additional feasibility criteria of the purpose of the Little Cottonwood Canyon Project as well as specific considerations that apply to gondolas in an urban environment.

6.1 Comparisons Using the Major Feasibility Criteria

6.1.1 Travel Time

Figure 8 compares the cumulative travel times for scenarios that use or parallel Wasatch Boulevard. Figure 8 also shows the total estimated travel times from Fort Union Boulevard to Snowbird and Alta for Scenarios 1, 2, 3A, and 3B.

Figure 8. Travel Time Comparison for Scenarios 1, 2, 3A, and 3B



With the assumptions used in this initial feasibility study, the fastest overall travel times to the resorts in a gondola would occur with an expanded parking area and base station near the mouth of Little Cottonwood Canyon. Moving the parking away from the canyon, to Wasatch Boulevard and Fort Union Boulevard or to the mouth of Big Cottonwood Canyon, would add about 9 to 14 minutes to the total travel time.

Figure 9 presents a cumulative travel time graph for the 9400 South and Highland Drive mobility hub scenarios (Scenarios 4A and 4B). If roadway and bus operating conditions could allow a 20-mph average bus speed, Scenario 4B would result in faster travel times than would a complete gondola alignment from this mobility hub.

Figure 9. Travel Time Comparison for Scenarios 4A and 4B

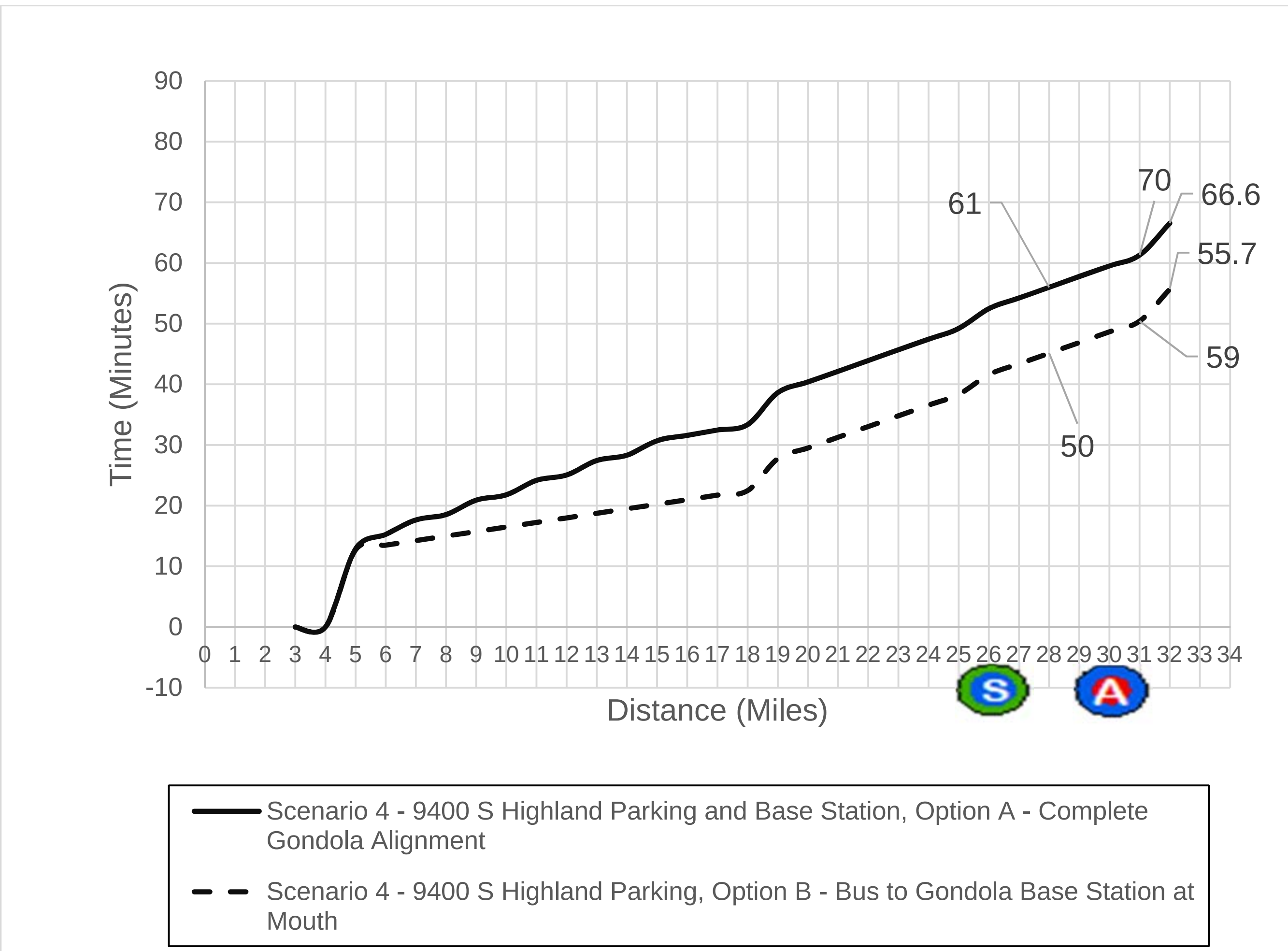


Table 13 summarizes the gondola segments and travel times for the scenarios presented in Section 5.0, Parking, Base Station, and Gondola Alignment Scenarios.

Table 13. Gondola Travel Time Comparison

Scenario	Bus Segment (miles)	Gondola Segment (miles)	Travel Time to Snowbird (minutes)	Travel Time to Alta (minutes)
1	0.0	8.3	44	54
2	0.0	9.8	48	58
3A	0.0	12.5	58	68
3B	4.2	8.3	53	62
4A	0.0	11.5	61[a]	70[a]
4B	3.5	8.3	50[a]	59[a]

[a] Travel time does not include a personal vehicle trip in the segment from Wasatch Boulevard and Fort Union Boulevard to a mobility hub at 9400 South and Highland Drive.

The travel time for Scenario 3A would be about 14 minutes longer than for Scenario 1, which would place both the parking structure and the base station at the mouth of the canyon. The travel time for Scenario 3B would be about 8 minutes longer than for Scenario 1. Scenario 3A would have travel times 6 minutes longer than Scenario 3B. Using express, high-capacity buses from the gravel pit mobility hub (Scenario 3B), travel times would be about 8 minutes longer compared to personal vehicle travel and gondola transit in the canyon (Scenario 1).

6.1.2 Capital and Annual O&M Costs

Table 14 presents a comparison of the capital and annual O&M costs for each scenario.

Table 14. Gondola Capital and Annual O&M Cost Comparison

In millions of dollars

Scenario	Capital Cost	Annual O&M Cost	
		With Original Bus Schedule	With Modified Hourly Bus Schedule
1	262.6 – 288.6	3.1 – 3.5	NA
2	299.8 – 329.7	3.1 – 3.5	NA
3A	375.6 – 413.2	4.3 – 4.8	NA
3B	312.2 – 343.4	4.1 – 4.5	3.8 – 4.2
4A	398.4 – 438.2	4.3 – 4.8	NA
4B	312.2 – 343.4	4.1 – 4.5	3.8 – 4.2

The biggest capital cost drivers are the length of the gondola alignment and the need for more terminal and angle stations (and their required infrastructure). Comparing Scenario 1 to Scenario 3A, it would cost about $124 million more to construct a gondola alignment running from the mobility hub at the gravel pit to a base station at the mouth of Little Cottonwood Canyon than to construct a parking structure and base station at the mouth of the canyon.

Constructing a parking structure at the mouth of Little Cottonwood Canyon might not be feasible for several reasons: it might cause traffic delays at the intersection of S.R. 210 and S.R. 209, there might not be enough space to construct a parking facility at the base of the canyon, it might cause traffic congestion for residents entering and leaving their neighborhoods, and there might be public opposition. If constructing a parking structure at the mouth of the canyon is not feasible, it might be more cost-effective from a capital cost perspective to use buses to access the gondola base station at the mouth of the canyon for passenger loading and unloading. This approach would also result in shorter overall travel times.

Comparing the Scenario 3 options, Scenario 3A would cost about $101.2 million more to construct (capital cost) than would Scenario 3B. Scenario 3B ($4.5 million) would also have slightly lower O&M costs than would Scenario 3A ($4.8 million) if buses were used in the urban segments. Other scenarios that use only a gondola would have annual O&M costs of about $3.5 million (Scenarios 1 and 2) to $4.8 million (Scenario 3A).

Comparing the Scenario 4 options, using buses in the urban segment of 9400 South (Scenario 4B) could save about 11 minutes of travel time compared to a complete gondola alignment (Scenario 4A). In addition, Scenario 4A would cost almost $126 million more than Scenario 4B. More analysis would be required in order to more accurately determine the roadway, shoulder, and intersection improvements needed to maintain the assumed bus speeds with Scenario 4B. The O&M costs to operate both the gondola system and a bus fleet with Scenario 4B would be about $4.5 million compared to $4.8 million annually for Scenario 4A, which is a gondola-only option.

The annual O&M costs would comparable (at about $3.8 million to $4.8 million annually) for all scenarios (3A, 3B, 4A, and 4B) where parking would be located away from the mouth of Little Cottonwood Canyon. Annual O&M cost might be slightly lower, about $0.6 million, if the bus schedule were optimized to better match the expected hourly demand.

6.2 Comparisons Using Additional Feasibility Criteria

In addition to comparing the scenarios in terms of their travel time and capital and O&M costs (Section 6.1), UDOT also compared the scenarios in terms of feasibility criteria pertaining to the purpose of the Little Cottonwood Canyon Project (improved mobility and improved neighborhood access). UDOT also included feasibility criteria pertaining to residential impacts and privacy issues, which are considerations that apply to gondolas in an urban environment. Other environmental impacts would be addressed in the EIS if a gondola concept is selected for detailed analysis. These additional feasibility criteria are described below, and the scenarios' ratings for these criteria are summarized in Table 15.

- **Impacts to Congestion.** Improving mobility is an element of the Little Cottonwood Canyon Project's purpose because traffic backs up at the intersection of S.R. 210 and S.R. 209 and clogs residential neighborhoods. In Table 15, impacts to traffic congestion represent the effect on the surrounding area. For example, Scenarios 1 and 2 would not change the existing travel patterns and so are rated as having a high impact for this comparison criterion. In contrast, Scenario 3 would keep traffic near the existing interstate (I-215), near higher-capacity existing roads, and next to existing commercial areas, and is therefore rated as having a low impact.
- **Needed Roadway Improvements.** This criterion qualitatively captures the degree of roadway improvements needed to provide priority travel for buses and needed infrastructure improvements near the mobility hub for efficient access to parking. Scenarios 3A and 3B are rated as having a low impact for this criterion because existing infrastructure near the gravel pit mobility hub can accommodate the expected traffic, and planned improvements to Wasatch Boulevard will help bus travel. Scenarios 1 and 2 are rated as having medium impacts because some roadway improvements would be needed near the parking structure in this more-residential area. Scenario 4B would require significant improvements from 9400 South and Highland Drive to the mouth of the canyon in order to maximize bus travel times. Therefore, Scenario 4B is rated as having a high impact for this criterion.
- **Residential Impacts.** UDOT assumes that owners of residences directly under the gondola's airspace would need to be relocated. A low impact is assigned for this criterion for scenarios that have gondola alignments in the rural segments only (Scenarios 1, 3B, and 4B). A high impact is assigned for scenarios that have gondola alignments in the urban segments (Scenarios 3A and 4A).
- **Privacy Concerns.** This criterion looks at the general number of homes that would be adjacent to the gondola alignment within view of gondola riders in the gondola cabin. Because the cabins would be elevated 100 to 200 feet in the air, privacy would be a concern for residents beyond the areas immediately adjacent to the gondola alignment. There is a large amount of residential development along Wasatch Boulevard and 9400 South. Like the residential impacts criterion, a low impact is assigned for this criterion for scenarios that have gondola alignments in the rural segments only (Scenarios 1, 3B, and 4B), and a high impact is assigned for scenarios that have gondola alignments in the urban segments (Scenarios 3A and 4A). For the scenarios in which the base station is located away from the mouth of Little Cottonwood Canyon, UDOT expects the public to strongly oppose these scenarios due to these privacy concerns.

Table 15. Comparison of Additional Feasibility Criteria

Scenario	Impacts on Traffic Congestion	Needed Roadway Improvements	Residential Impacts	Privacy Concerns
1	High	Medium	Low	Low
2	High	Medium	Medium	Medium
3A	Low	Low	High	High
3B	Low	Low	Low	Low
4A	Medium	Low	High	High
4B	Medium	High	Low	Low

Comparing these rankings, Scenario 3B has the lowest impact across the four additional feasibility criteria presented in this section. Scenario 3A is better than Scenario 1 from the standpoints of traffic congestion and needed roadway improvements, but implementing Scenario 3A would be challenging because of potentially high residential impacts and privacy concerns.

Table 16 summarizes all of the comparison criteria for the scenarios presented in this report.

Table 16. Comparison of Costs, Travel Times, and Additional Feasibility Criteria

Scenario	Capital Cost (million $)	Annual O&M Cost (million $)	Total Travel Time to Alta (minutes)	Impacts on Traffic Congestion	Needed Roadway Improve-ments	Residential Impacts	Privacy Concerns
1	262.6 – 288.6	3.1 – 3.5	54	High	Medium	Low	Low
2	299.8 – 329.7	3.1 – 3.5	58	High	Medium	Medium	Medium
3A	375.6 – 413.2	4.3 – 4.8	68	Low	Low	High	High
3B[a]	312.2 – 343.4	4.1 – 4.5	62	Low	Low	Low	Low
4A	398.4 – 438.2	4.3 – 4.8	70[b]	Medium	Low	High	High
4B[a]	312.2 – 343.4	4.1 – 3.5	59[b]	Medium	High	Low	Low

[a] Annual O&M cost for Scenarios 3B and 4B would be about $3.8 million to $4.2 million with a modified bus schedule (see Table 9).

[b] Travel time does not include a personal vehicle trip in the segment from Wasatch Boulevard and Fort Union Boulevard to a mobility hub at 9400 South and Highland Drive.

6.3 Considerations for Implementing ATS in Little Cottonwood Canyon

General engineering and operational considerations were provided in Section 4.0, General Considerations for Implementing a 3S Gondola System. Additional implementation considerations include the following:

- Peak demand periods occur for about 2 or 3 hours during the winter in the morning and evening (4 to 6 hours total) over about 68 weekend days and holidays. For the majority of the winter season, the gondola could be operating at less than maximum capacity. Canyon visitors might not use the gondola as frequently during off-peak times and on weekdays, when there is generally less congestion and adequate parking available, because gondolas would have longer travel times to the resorts compared to automobiles.
- Gondolas would have a limited ability to serve dispersed summer recreation in the canyon. In order to maintain reasonable travel times for the long gondola ride during the highest demand periods (winter weekends), few intermediate terminals and few turns (requiring angle stations) should be added to the gondola alignment. For the long distances needed to reach the resorts (8 to 12 miles), gondola cabins need to stay on the haul cable as much as possible. Adding stations at trailheads for summer use (when peak-hour demands are lower) would slow the gondola during times of peak demand.
- The scenarios were sized to accommodate the peak-hour total travel demand (about 1,000 people per hour). Bus service can be adjusted to better match expected hourly ridership by adjusting the days of the week and the times of the day when services are provided. This would save some O&M costs. Gondolas, on the other hand, need to be designed to handle the higher hourly demands so that they are attractive to riders during these periods. However, gondola operations cannot be easily adjusted during lower-demand periods, so the O&M costs for gondolas are fixed unless the gondola is shut down.
- The annual ridership of a gondola system, measured as a percentage of total trips in the canyon, would be low without other traffic-demand-management tools (such as tolling) or an overall policy to significantly restrict personal vehicles in the canyon. The resulting gondola fare needed to pay back the capital cost and fund operating expenses was not determined for this initial feasibility study. UDOT is conducting an analysis to understand canyon users' willingness to pay for transit service versus the value of their time (ridership elasticity) and will apply those findings in the ongoing alternatives evaluation process for the EIS.

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APPENDIX F

Draft Rail Transit Concepts Initial Feasibility Study

Little Cottonwood Canyon ENVIRONMENTAL IMPACT STATEMENT
S.R. 210 | Wasatch Blvd. to Alta

Draft Rail Transit Concepts Initial Feasibility Study

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 - Wasatch Boulevard to Alta

Lead agency:
Utah Department of Transportation

April 3, 2020

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Appendixes

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1.0 Introduction

What is the purpose of this report?

The purpose of this report is to summarize UDOT's evaluation of constructing and operating a conceptual rail transit system as part of the Little Cottonwood Canyon Project.

The purpose of this report is to summarize the Utah Department of Transportation's (UDOT) evaluation of constructing and operating a conceptual rail transit system as part of the Little Cottonwood Canyon Project. This report provides information that UDOT will use during the alternatives development and screening process for the Little Cottonwood Canyon Environmental Impact Statement (EIS), which will evaluate how well the rail transit concepts described in this report would satisfy the purpose of and need for the Little Cottonwood Canyon Project.

The goal of this report is to define the rail technology that is most feasible for the needs of Little Cottonwood Canyon. The report also presents approximate travel times and costs for different rail alignment concepts to address future mobility needs of visitors to Little Cottonwood Canyon. The information in this report will be used to compare the most feasible rail technology and conceptual alignments with other mobility modes (aerial transit, buses, and/or roadway improvements) that are being considered to address the purpose of the project.

1.1 Description of the Study Area

Little Cottonwood Canyon is in the Uinta-Wasatch-Cache National Forest, which is on the eastern edge of the Salt Lake City metropolitan area located in Salt Lake County. Salt Lake County has a population of about 1.12 million. The canyon is home to two internationally recognized ski resorts, Snowbird Resort and Alta Ski Area, and includes parts of two National Wilderness Areas: Twin Peaks Wilderness to the north and Lone Peak Wilderness to the south. Winter recreation activities include skiing at the resorts, backcountry skiing, snowshoeing, and ice climbing. In the summer, the resorts offer abundant recreation opportunities, and land administered by the U.S. Department of Agriculture Forest Service is used extensively for hiking, cycling, rock climbing, fishing, camping, and picnicking.

The EIS study area used for the Little Cottonwood Canyon Project extends along State Route (S.R.) 210 from its intersection with S.R. 190/Fort Union Boulevard in Cottonwood Heights, Utah, to its terminus in the town of Alta, Utah, and includes the Bypass Road. UDOT developed the study area to include an area that is influenced by the transportation operations in Little Cottonwood Canyon. Traffic south of this intersection is mostly related to trips into and out of Little Cottonwood Canyon and commuter traffic on Wasatch Boulevard.

Through EIS study area, S.R. 210 is designated with different street names. For clarity in the EIS process, the following segments of S.R. 210 use the following naming conventions (shown in Figure 1):

- **Wasatch Boulevard** – S.R. 210 from Fort Union Boulevard to North Little Cottonwood Road
- **North Little Cottonwood Road** – S.R. 210 from Wasatch Boulevard to the intersection with S.R. 209
- **Little Cottonwood Canyon Road** – S.R. 210 from the intersection of North Little Cottonwood Road and S.R. 209 through the town of Alta, including the Bypass Road up to but not including Albion Basin Road

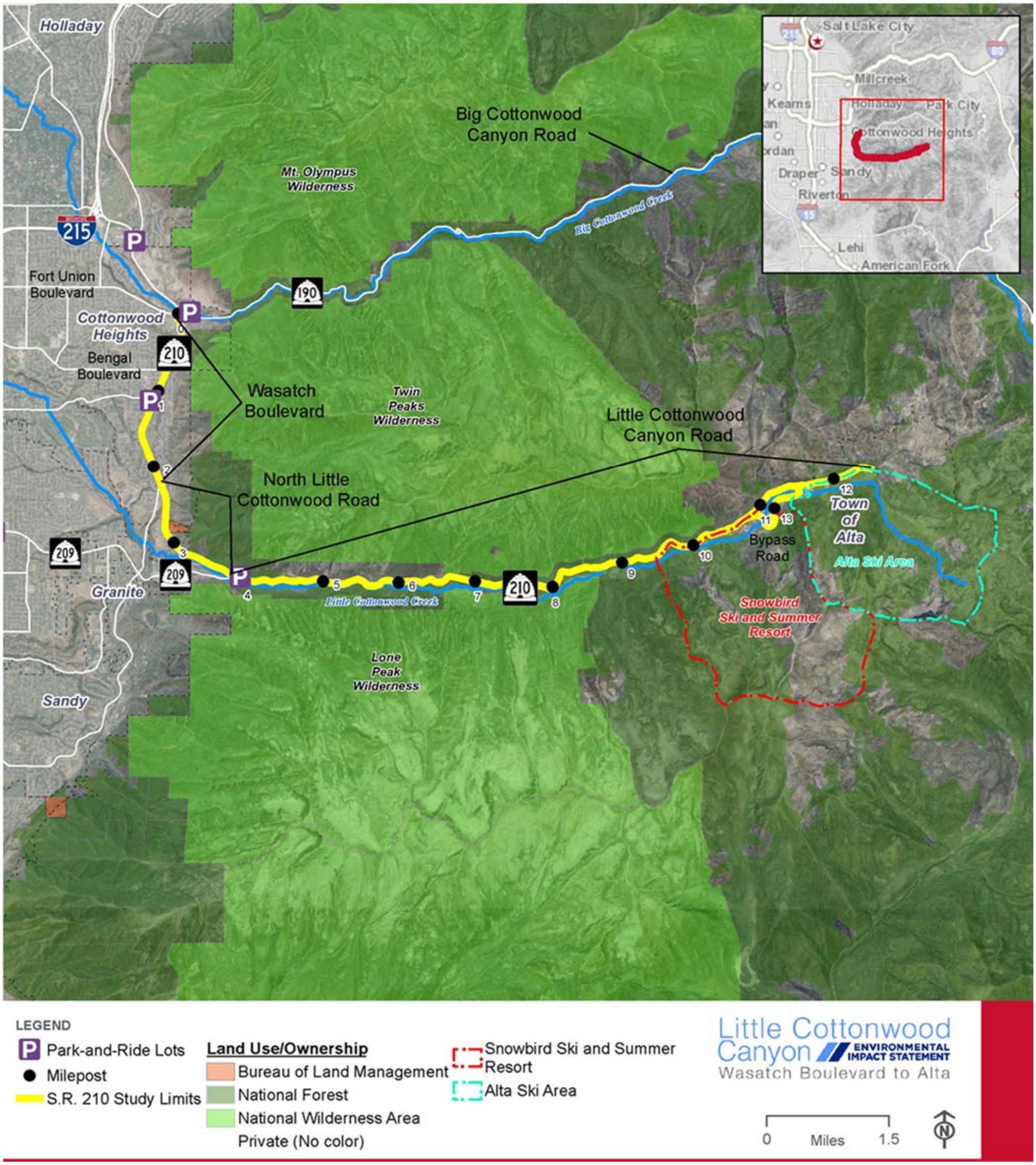
In the EIS, mobility modes are being evaluated to address skier use in winter and the related traffic congestion on North Little Cottonwood Road and Little Cottonwood Canyon Road. For this rail transit feasibility analysis only, the study area also includes S.R. 209 (9400 South and 9000 South) in Sandy, Utah. The S.R. 209 travel corridor is another potential route for a rail line into Little Cottonwood Canyon.

1.2 Previous Analysis

Several previous studies have analyzed the current and future transportation needs for Big and Little Cottonwood Canyons. In 2012, Salt Lake County and its study partners—UDOT, the Utah Transit Authority (UTA), Salt Lake City, the Wasatch Front Regional Council, and the U.S. Department of Agriculture Forest Service—developed a range of potential short- and long-term transportation solutions. The *Mountain Transportation Study* (Fehr and Peers 2012) recommended evaluating a range of different alternatives in an EIS.

In the years before the current EIS process was initiated, UDOT, UTA, and other agencies and planning organizations conducted studies of congestion, parking, transit use, and avalanche impacts in Little Cottonwood Canyon and on S.R. 210. Numerous studies were conducted as part of a process known as the Mountain Accord (Mountain Accord 2017). The Mountain Accord developed a plan for preserving the central Wasatch Mountains (which include Little Cottonwood Canyon) including short- and long-term transportation options. Both of these studies (the *Mountain Transportation Study* and the Mountain Accord) identified rail transit as one of many potential mobility concepts that should be explored, in greater detail, under an EIS framework.

Figure 1. Study Area for the Little Cottonwood Canyon EIS



2.0 Types of Rail Transit Systems

There are several different types of rail transit technologies, each of which has unique characteristics in terms of its passenger capacity, maximum operating speed, and engineering standards. The feasibility of each type depends on the specific application for which it is being evaluated. This section describes the types of rail transit concepts evaluated: heavy rail/commuter rail, light rail, cog rail, monorail, maglev, SkyTran, and funiculars.

2.1 Heavy Rail/Commuter Rail

Heavy rail/commuter rail generally consists of electric or self-propelled diesel locomotives pulling passenger cars. They usually operate in a densely developed urban environment or between major metropolitan areas. In dense urban environments, this type of rail service is often associated with subways, although many rail lines may be at-grade or elevated. In most instances, tracks run in dedicated corridors, without many grade crossings and physically isolated from adjacent properties by fences or other barriers. Stations are usually large to accommodate the large number of riders. Long spacing between stations and short dwell times (stops at stations) are desirable to minimize overall trip times and reduce fleet size. UTA's FrontRunner is an example of commuter rail.

To minimize capital costs, commuter rail is often operated over tracks that are part of the general freight rail system. For this reason, the rolling stock, signal equipment, and operating practices must be in accordance with all applicable government (for example, state and Federal Railroad Administration) regulations and standards developed by the American Railway Engineering and Maintenance-of-Way Association (AREMA) and the Association of American Railroads. Commuter rail operations, including associated terminals and operations and maintenance facilities (OMF), therefore require railroad-type rolling stock, larger curve radii, low maximum grades (less than about 4% is preferred), and signaling systems compatible with mainline railroad practice.

Heavy rail is not feasible for Little Cottonwood Canyon. Typical locomotive power (diesel-electric locomotives) is not adequate to climb the steep grades in the canyon, which are over 10%.

2.2 Light Rail

Light rail transit is a mode of transit service that is a successor to streetcars, tramways, and trolleys. It operates passenger rail vehicles individually (or in short, usually two- or three-vehicle trains) on fixed rails in right-of-way that is often separated from other traffic for much of its alignment. Light rail vehicles are typically driven electrically with power being drawn from an overhead electric line (overhead contact system, or OCS) via a pantograph. Running speeds are up to about 55 miles per hour (mph) depending on the alignment. UTA's TRAX is an example of light rail.

The key characteristic of light rail transit is its ability to operate on city streets without large station facilities and in mixed traffic (that is, within the same alignment as automobiles). Desirable maximum grades are also about 4%, though absolute maximum grades for ballast track of about 6% are acceptable for short distances. This flat vertical grade is needed because light rail transit (similar to commuter rail) typically uses an adhesion rail system in which power is applied by the electric motors to steel wheels to steel rails and the frictional forces drive the train forward. Adhesion is the most common type of rail system in the United States.

Light rail is not feasible for Little Cottonwood Canyon because more traction would be needed to navigate grades steeper than 6%. Little Cottonwood Canyon has grades over 10% in many sections of the canyon.

2.3 Cog Rail

Cog rail, also called rack rail or mountain rail, is a type of light rail. Cog rail uses a third rail that is toothed or racked. Train vehicles are fitted with a cog wheel (also called a pinion wheel) that meshes with the third rail to provide additional traction. This additional traction is needed primarily for downhill travel where the added stopping power of the cog wheel is needed in addition to the adhesion forces. This design allows a train vehicle to operate on steeper grades, around 10% to 15%. Maximum running speeds are similar to light rail (55 mph) when the cog is not engaged. However, in alignments with many curves or where vehicles operate in mixed traffic, slower speeds are used. In addition, when descending steep grades and the cog wheel is engaged, slower speeds (18 to 20 mph) are required for safe operation.

Cog rail vehicles are electric and powered by an OCS using catenary wire and a pantograph on the vehicle. Just like light rail, power collected by the pantograph is conveyed to electric motors on each set of trucks (or "bogies") on a vehicle so that traction power can be distributed over the rail vehicle or train. See Figure 5 on page 18.

2.4 Monorail

Monorail is an above-ground, fixed-guideway transit system with vehicles similar to those in a light rail system. Monorail can provide an hourly capacity at 5,000 persons and can travel at speeds greater than 50 mph. With few exceptions, monorail systems use rubber tires for traction. Aside from the elevated guideway, this is the main technological difference between monorail and traditional rail. Although rubber traction on steel rails is used on at least one monorail system (Aerobus), most systems with rubber tires run on concrete surfaces. In this regard, most monorail vehicles run more like road vehicles than railway trains. Theoretically, rubber-tired traction can overcome gradients of more than 15%, but currently the steepest gradient on which a monorail is operating is 10% in Japan (Atkins 2015).

A monorail system would operate similarly to the train concept being considered for Little Cottonwood Canyon but would have the primary disadvantage of not being compatible with the existing transit network, whereas a cog rail system could operate on the existing light rail transit network and use the same maintenance facilities. For the monorail to work in Little Cottonwood Canyon, it would require two fixed guideways to meet the per-person hourly capacity requirements and would require a separate maintenance facility. The required footprint would be similar to a cog rail system since it would require a separate structure for each guideway to provide safety redundancy if the support structure is struck by a major avalanche or canyon rock slide. Additionally, the monorail could not operate during active avalanche-mitigation periods because of the potential for an avalanche powder blast or an avalanche to damage the system. Because the monorail is elevated, it would be difficult to place the monorail track inside a snow shed. The columns to support an elevated track could be hardened to allow the main avalanche slide should go underneath the monorail system.

The monorail system would operate similarly to a cog rail system for moving people and would require a similar footprint to operate but would not be compatible with the existing light rail network to provide regionally connectivity, and would not be able to operate during avalanche mitigation. Therefore, UDOT decided not to evaluate the monorail further but to evaluate the cog rail system as a similar concept.

2.5 Maglev

Maglev (derived from *magnetic levitation*) is a type of monorail system that uses two sets of magnets or electromagnets—one set to repel and push the train up off the track, and another set to move the “floating train” ahead at high speed, taking advantage of the lack of friction. The goal of maglev is to obtain high train speeds. Along certain medium-range routes (usually 200 to 400 miles), maglev can compete favorably with high-speed rail and airplanes (Wikipedia 2019).

At the high, desirable speeds, the maglev track should have few horizontal and vertical curves. Maglev technology is not as feasible as other rail types for steep grades and sharp curves, such as those in Little Cottonwood Canyon. The minimum radius of curvature for high-speed operation is 5 to 10 miles, and the maximum grade is about 4% (USDOT and FRA 2018). Therefore, maglev is not recommended for further study in this report.

2.6 SkyTran

UDOT received a comment during the project scoping period to consider SkyTran as a solution for Little Cottonwood Canyon. According to the information provided to UDOT, SkyTran appears to be similar to maglev; it uses “magnetic wings” and a “spiral drive” to propel individual cars, which hold one to two people.[1] The individual SkyTran vehicles run along a main, elevated track and then diverge from the main track to a parallel track to access small stations that can be chosen by the rider. Individual vehicles can, therefore, bypass stops if riders do not need to board or disembark. When leaving a station, the vehicle would re-enter the main track where there is a gap between other vehicles, similar to ramp metering on a freeway.

What is scoping?

Scoping is an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action.

No technical information was provided to UDOT regarding the levitation or propulsion system or regarding the control technology needed to meter vehicles into the main-track traffic, and no test facility has been constructed. UDOT considers this technology theoretical and therefore not feasible for Little Cottonwood Canyon.

2.7 Funiculars

Funicular railways typically use two rail vehicles that rest on tracks and are pulled up a steep slope by a cable-wench system. The vehicles are permanently attached to the cables. They move synchronously—while one vehicle is ascending, the other is descending on the track to provide a counterbalance and to help lift the other vehicle. They have capacity limitations (in terms of passengers per hour) for long distances because one vehicle would need to make a complete round trip before it could pick up more passengers.

This technology is not feasible to handle the high hourly rider demands in Little Cottonwood Canyon and is therefore not evaluated further in this report.

[1] The commenter directed UDOT to review the technology on two websites: https://vimeo.com/253517920 and https://www.skytran.com/system.

3.0 Selection of the Most Feasible Rail Technology and Track Configuration

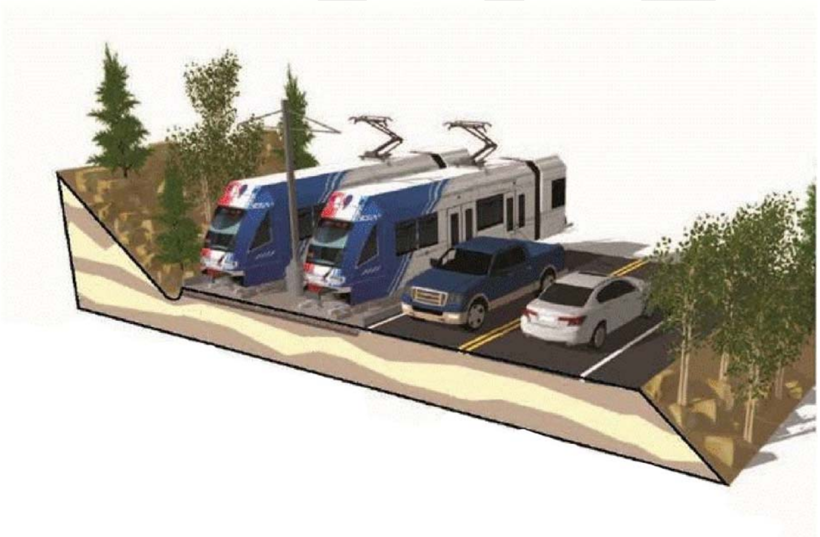
Because the grades in Little Cottonwood Canyon average 10% to 12%, and because a canyon alignment would have tight curves, a cog rail system is the most technically feasible fixed-rail transit concept for Little Cottonwood Canyon.

What is the most technically feasible rail technology for Little Cottonwood Canyon?

A cog rail system is the most technically feasible rail transit technology for the canyon.

Previous studies (Fehr and Peers 2012; Mountain Accord 2017) concluded that a cog rail line in the canyon would likely follow the existing Little Cottonwood Canyon Road because the wilderness areas[2] and Little Cottonwood Creek[3] (an important water source to Salt Lake City) constrain alignments outside the existing road corridor. Alternative alignments might exist, but, for this preliminary evaluation, UDOT assumes that the cog rail line would run along the north side of Little Cottonwood Canyon Road. Figure 2 presents a conceptual cross-section of Little Cottonwood Canyon Road.

Figure 2. Conceptual Cross-section for a Cog Rail Line along Little Cottonwood Canyon Road



[2] The Wilderness Act states there shall be no commercial enterprise and no permanent road within any Wilderness Area designated by the Act and, except as necessary to meet minimum requirements for the administration of the area for the purpose of the Act (including measures required in emergencies involving the health and safety of persons within the area), there shall be no temporary road, no use of motor vehicles, motorized equipment or motorboats, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any such area

[3] The 2003 *Revised Forest Plan Wasatch-Cache National Forest* notes that because of streams and riparian areas relatively high value and small proportion of the landscape, development outside already developed areas within these prescription is to be avoided by 300 feet on either side.

4.0 General Considerations for Implementing a Cog Rail System

This section presents some of the fundamental engineering and operational assumptions of a conceptual cog rail system for Little Cottonwood Canyon as well as considerations for parking at a rail base station. UDOT will compare the selected rail concept(s) to other mobility concepts (aerial transit, bus, and/or roadway expansion) in a separate report or in the EIS.

4.1 Operational Capacity and Demand

What is travel demand?

Travel demand is the expected number of transportation trips in an area. Travel demand can be met by various modes of travel, such as automobile, bus, rail, carpooling, bicycling, aerial transit, or a combination of modes.

The expected peak period of travel demand on S.R. 210 in 2050, as measured by the number of cars currently using the road, is between 7:00 AM and 10:00 AM. The current free-flow capacity of the road is about 1,100 cars per hour. Transportation analysts often look at the 30th-busiest hour on a road over the course of a year when determining the future travel demand on the road. For S.R. 210 in 2050, the 30th-busiest-hour roadway demand would be about 1,555 vehicles or about 3,200 people per hour. For a rail system to accommodate this high level of hourly demand (3,200 people), rail vehicles would need to arrive very frequently. Assuming a maximum capacity of 253 people[4] per rail vehicle and about 10 rail vehicles per hour, or a 5-minute frequency (or "headway") would be required to meet this demand. If rail vehicles could be connected to form a two-vehicle, 506-passenger train "consist," about 5 trains per hour (10-minute headways) would be required.

The actual number of riders per hour would vary from the maximum operational capacity during various times of the day and seasonally. The actual anticipated ridership depends on many factors, and a detailed demand analysis was outside the scope of the initial rail feasibility evaluation presented in this report. The maximum hourly demands occur during the winter months and on weekends (Friday, Saturday, and Sunday) when skiers and snowboarders are traveling to the resorts at the top of Little Cottonwood Canyon. This initial feasibility analysis used a peak-hour ridership of about 1,000 people. This hourly capacity was used to compare other transit concepts (gondola and bus) for Little Cottonwood Canyon. The peak daily ridership of about 5,200 people was used to estimate the required parking structure size, which is about 2,500 cars.

With the assumed travel demand of 1,000 people per hour, at 15-minute headways (4 vehicles per hour), and one cog-rail vehicle (253 passengers per vehicle), the hourly capacity would be about 1,012 people. The actual capacity per rail vehicle might be lower considering that train riders would be carrying gear (skis or snowboards, helmets, boots, and extra clothing). The capital cost estimates presented later in this report vary the per-vehicle capacity to determine a range of potentially required cog rail vehicles that would be needed to accommodate the peak-hour demand. The total number of cog rail vehicles needed to serve the

[4] Maximum capacity of Stadler 129829 cog rail vehicle with 106 seated passengers and assuming 147 standees. Email November 4, 2019. The number of standees is based on four riders per square meter of floor space, or one person in a 19-by-19-inch-square space.

hourly demands is also function of the round-trip travel times (which depends on the length of track and the assumed travel speed). These factors are described in Section 5.0, Rail Concepts Evaluation, for the various rail alignment concepts.

4.2 Connectivity with the Existing Light Rail System

One key consideration for a cog rail system serving Little Cottonwood Canyon is whether to connect it to UTA's existing TRAX light rail system or build a separate cog rail system to serve the canyon exclusively. With a connection to the existing TRAX system, passengers could embark from dispersed origins such as existing TRAX stations (with existing surface parking areas) or from the Salt Lake City International Airport, downtown Salt Lake City, or other commercial or residential areas (where there are stations but not dedicated park-and-ride lots).

4.2.1 Considerations for Parking

Parking might need be expanded at one or more of the existing TRAX stations to accommodate peak winter rider demands. However, this initial concept feasibility report does not analyze the parking availability at existing TRAX station park-and-ride lots during times of peak travel demand in Little Cottonwood Canyon (winter weekends, Fridays, Saturdays, and Sundays). The result of connecting a cog rail system to the existing TRAX system would be longer rail infrastructure and more cog rail vehicles to serve the peak-hour demands at acceptable headways.

The other general option would be to construct a cog rail line to serve users of Little Cottonwood Canyon only. This would require building a large parking area near the same location as the rail base station (the train station at the base of the canyon). UDOT's feasibility evaluations of other transit concepts (expanded bus and gondola aerial transit) have assumed that a large, 2,500-car parking structure would be located at a new "mobility hub" constructed at one of three locations: (1) at the mouth of the canyon, (2) at the gravel pit at the intersection of Wasatch Boulevard and Fort Union Boulevard near the mouth of Big Cottonwood Canyon, or (3) near the existing park-and-ride lot at the intersection of 9400 South and Highland Drive.

Section 4.2.4, Rail Base Station, Parking Options, and Resulting Rail Alignment, describes the concepts for either connecting a cog rail system to the existing TRAX system or building a dedicated rail base station with its required parking and operation and maintenance facility.

4.2.2 Operations and Maintenance Facility

If the cog rail system serving Little Cottonwood Canyon were not connected to UTA's existing TRAX system, a stand-alone cog rail operation and maintenance facility (OMF) would be required somewhere near the cog rail alignment. The OMF would be needed to operate the new rail system. The OMF would include the communications systems, train control rooms, areas to store track and right-of-way maintenance equipment, rail vehicle storage areas, and maintenance garages, as well as the necessary employee support facilities (offices, conference rooms, and restrooms). The preliminary estimate for the site size for OMF buildings, rail and support vehicle maneuvering and storage, onsite parking, and roads is about 10½ acres.[5] If the Little

[5] The preliminary OMF size is based on the building needs to operate the system and support staff and the site needs to maneuver, store, and maintain about 14 new cog rail vehicles.

Cottonwood Canyon rail system were to connect to UTA's existing TRAX system, UTA might also need to expand UTA's existing OMF to accommodate the addition of cog rail vehicles to UTA's fleet. A lower level of capital costs is assumed for this option.

4.2.3 Operating Assumptions

UDOT assumes that the cog rail system would provide 12 hours per day of winter service to the resorts in Little Cottonwood Canyon. Summer service is not required to meet the mobility requirements evaluated in the EIS and therefore was not evaluated in this preliminary feasibility study. In urban areas, UTA could use the track alignment to operate a light rail system year-round for weekday commuters. However, addressing weekday commuter demand on all of S.R. 209 and S.R. 210 is not part of the purpose of and need for the Little Cottonwood Canyon Project, and these corridors are outside the EIS study area. Rail transit along these routes are being evaluated in this report only as a way to provide potential connection points for a cog rail concept for Little Cottonwood Canyon. According to the Wasatch Front Regional Council's (WFRC) *Wasatch Front Regional Transportation Plan* (RTP) for 2019–2050, the potential transit ridership in these corridors does not justify transit investments at the level that can be provided by light-rail-type modes.

Table 1 presents the schedule assumptions for about 1,000 people per hour peak capacity and scaled back at other times during the winter season. This service schedule is considered in the annual operating cost estimates for each concept in Section 5.0, Rail Concepts Evaluation.

Table 1. Operating Schedule

Schedule	Schedule Details	Hours of Operation (hours)	Headway (minutes)	Trips per Hour	Maximum Hourly Capacity (passengers)
Winter peak days, peak hours	Friday–Sunday (7:00–10:00 AM and 3:00–6:00 PM)	6	15	4	1,012
Winter peak days, off-peak hours	Friday–Sunday (10:00 AM–3:00 PM and 6:00–7:00 PM)	6	30	2	506
Winter weekdays	Monday–Thursday (7:00 AM–7:00 PM)	12	30	2	506

4.2.4 Rail Base Station, Parking Options, and Resulting Rail Alignment

If a cog rail system is not connected to the existing TRAX system, a 2,500 stall parking area would be needed near the rail base station. General parking location options are presented in this report because the location of the parking area and rail base station is a fundamental consideration for the resulting alignment and the feasibility of a cog rail concept for Little Cottonwood Canyon.

Currently, the existing park-and-ride lots near the mouths of Big and Little Cottonwood Canyons are heavily used, especially during the winter. These lots operate at capacity most winter weekend days. There is parking away from the mouths of the canyons along the existing ski bus routes; however, these park-and-ride lots are heavily utilized during periods of peak winter demand. Because canyon users typically want the shortest travel time, transit riders tend to drive to the mouth of a canyon and take the ski bus up the canyon for the last segment of their trip However, when the existing park-and-ride lots reach capacity, some *potential* transit users bypass the lots and drive their vehicle up the canyons. Other canyon users will consider a shift in travel modes (from car to transit) as less desirable for various reasons and would rather drive their vehicle up the canyon.

Several parking locations have been explored by UDOT in this report to help expand ridership. The combination of the base parking lot and rail base station (or existing TRAX connection) and the resulting cog rail alignment define the following concepts evaluated in this report:

- **Concept 1** – Expanded parking and a rail base station at the mouth of Little Cottonwood Canyon. The resulting cog rail concept would run for about **8 miles** up the Little Cottonwood Canyon Road segment of the study area. UDOT assumes stations, in addition to the rail base station, at Snowbird Resort and Alta Ski Area. Preliminary design plans for Concept 1 are included in Appendix B1, Preliminary Design Plans for Segment 1 – Little Cottonwood Canyon.
- **Concept 2** – Expanded parking and a rail base station at a mobility hub located at the gravel pit (near Wasatch Boulevard and Fort Union Boulevard). UDOT assumes two train stations in the canyon (at Snowbird Resort and Alta Ski Area). This concept would have a cog rail alignment of about **12.2 miles**. Preliminary design plans for the canyon segment of Concept 2 are included in Appendix B1, Preliminary Design Plans for Segment 1 – Little Cottonwood Canyon. Preliminary design plans for the Wasatch Boulevard segment of Concept 2 are included in Appendix B2, Preliminary Design Plans for Segment 2 – Gravel Pit to Mouth of Little Cottonwood Canyon.
- **Concept 3** – Expanded parking and a rail base station at a mobility hub near 9400 South (S.R. 209) and Highland Drive. UDOT assumes two train stations in the canyon (at Snowbird Resort and Alta Ski Area). This concept would have a cog rail alignment of about **11.5 miles**. Preliminary design plans for the canyon segment of Concept 3 are included in Appendix B1, Preliminary Design Plans for Segment 1 – Little Cottonwood Canyon. Preliminary design plans for the segment of Concept 3 outside the canyon are included in Appendix B3, Preliminary Design Plans for Segment 3 – 9400 South and Highland Drive to Mouth of Little Cottonwood Canyon.
- **Concept 4** – UDOT also evaluated two options to connect to the existing TRAX system and avoid having to construct a large rail base station at a mobility hub with a 2,500-car parking structure and a large stand-alone OMF near the alignment. The two options for Concept 4 are:
    - **Concept 4, Option A** – This option would connect a cog rail system to the existing TRAX system at the Midvale Fort Union TRAX Station. The resulting cog rail concept would run east along Fort Union Boulevard (S.R. 190 and 7200 South) for about 5.9 miles to Wasatch Boulevard. The alignment would then run south along Wasatch Boulevard and North Little Cottonwood Road (S.R. 210) for about 4.2 miles to the mouth of Little Cottonwood Canyon. UDOT assumes three intermediate train stations along Fort Union Boulevard and one intermediate train stations along Wasatch Boulevard. Adding the 8-mile canyon alignment, the total length of this option is about **18.1 miles**. Preliminary design plans for the canyon segment of Concept 4A are included in Appendix B1, Preliminary Design Plans for Segment 1 – Little Cottonwood Canyon. Preliminary design plans for the segment of Concept 4A from the gravel pit to the mouth of the canyon are provided in Appendix B2, Preliminary Design Plans for Segment 2 – Gravel Pit to Mouth of Little Cottonwood Canyon. No conceptual design plans were prepared

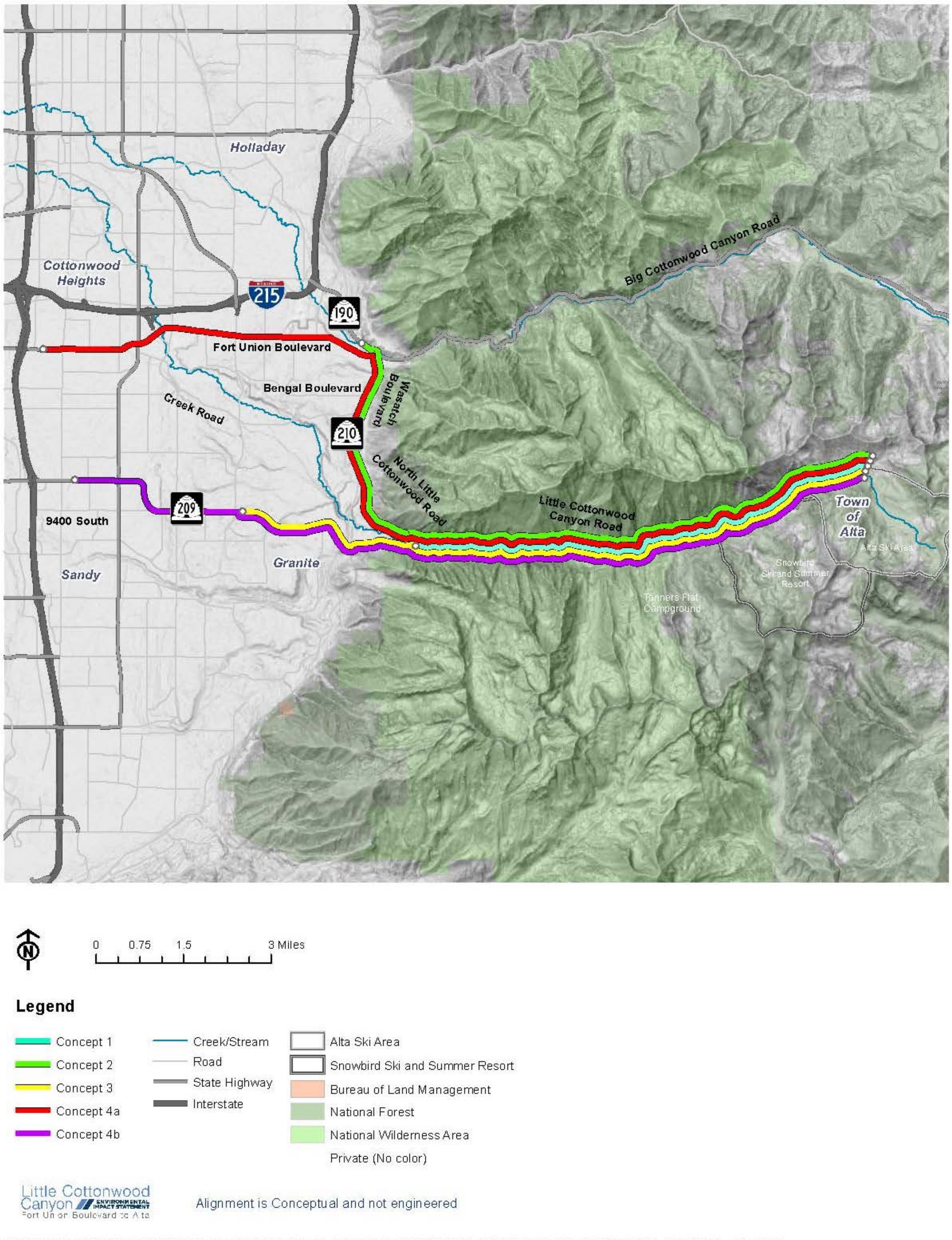
for this initial feasibility study for the segment of this concept between the Midvale Fort Union TRAX Station and the gravel pit mobility hub.

- **Concept 4, Option B** – This option would connect a cog rail system to the existing TRAX system at the Historic Sandy TRAX Station (at 9000 South and about 150 East). The resulting cog rail alignment would run east along 9000 South and 9400 South (S.R. 209) for about 6.3 miles to the mouth of Little Cottonwood Canyon. UDOT assumes three intermediate train stations somewhere along S.R. 209.[6] Adding the 8-mile canyon alignment, the total length of this option is about **14.3 miles**. Preliminary design plans for the canyon segment of Concept 4B are included in Appendix B1, Preliminary Design Plans for Segment 1 – Little Cottonwood Canyon. Preliminary design plans for the segment of Concept 4A outside the canyon are included in Appendix B3, Preliminary Design Plans for Segment 3 – 9400 South and Highland Drive to Mouth of Little Cottonwood Canyon, and Appendix B4, Preliminary Design Plans for Segment 4 – Historic Sandy TRAX Station 9400 South and Highland Drive.

Figure 3 shows the routes of these concepts. For details, see Section 5.0, Rail Concepts Evaluation.

[6] The assumed intermediate train stations are for travel time calculations only. UDOT's conceptual design for Concept 4A and 4B did not determine locations for these stations.

Figure 3. Rail Concept Overview



4.3 Right-of-way Considerations

The *Manual on Uniform Traffic Control Devices*, published by the Federal Highway Administration, defines the standards used by road managers nationwide to install and maintain traffic-control devices on all public streets, highways, bikeways, and private roads open to public travel. This manual groups rail transit right-of-way (ROW) into the following three types (FHWA 2009).

- **Exclusive rail ROW.** An exclusive ROW is completely grade-separated and protected by a fence or other traffic barrier. Motor vehicles, pedestrians, and bicycles are physically prohibited within the entire length of the ROW. The existing UTA TRAX system does not have any completely exclusive alignments because most street crossings are at grade. If a third rail at ground level is used to supply power to electric cars, a completely exclusive ROW is required.[7] (For more information, see Section 4.4, Typical Cross-section.) In general, higher rail speeds can be achieved when the ROW is totally protected from vehicle and pedestrian access.
- **Semi-exclusive ROW.** Semi-exclusive alignments are in a separate ROW or along a street or railroad right-of-way where motor vehicles, pedestrians, and bicycles have limited access and are directed to cross at designated locations only. Most of UTA's TRAX system is along semi-exclusive alignments with mostly at-grade street crossings. With semi-exclusive ROW, overhead contact wire systems (catenary) are required to prevent pedestrians or trespassers from contacting an electrified wire.[8]
- **Non-exclusive (mixed-use) ROW.** A mixed-use ROW is an alignment in which rail operates in mixed traffic with all types of road users (cars and pedestrians). This type includes streets, transit malls, and pedestrian malls where the ROW is shared with other uses. UTA's TRAX system from 1200 South to 900 South and along North Temple in Salt Lake City are examples of a mixed-use alignment. These use overhead contact systems and, because they operate in mixed traffic, the rail vehicles travel at slower speeds than they could in exclusive or semi-exclusive ROWs.

A cog rail system for Little Cottonwood Canyon would use a semi-exclusive ROW. More-detailed engineering design and analysis would be needed to determine which type of ROW is needed in various segments of an alignment as well as any ROW protection measures that should be implemented.

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7 AREMA Section 2.6.11, *Electric Traction Characteristics*

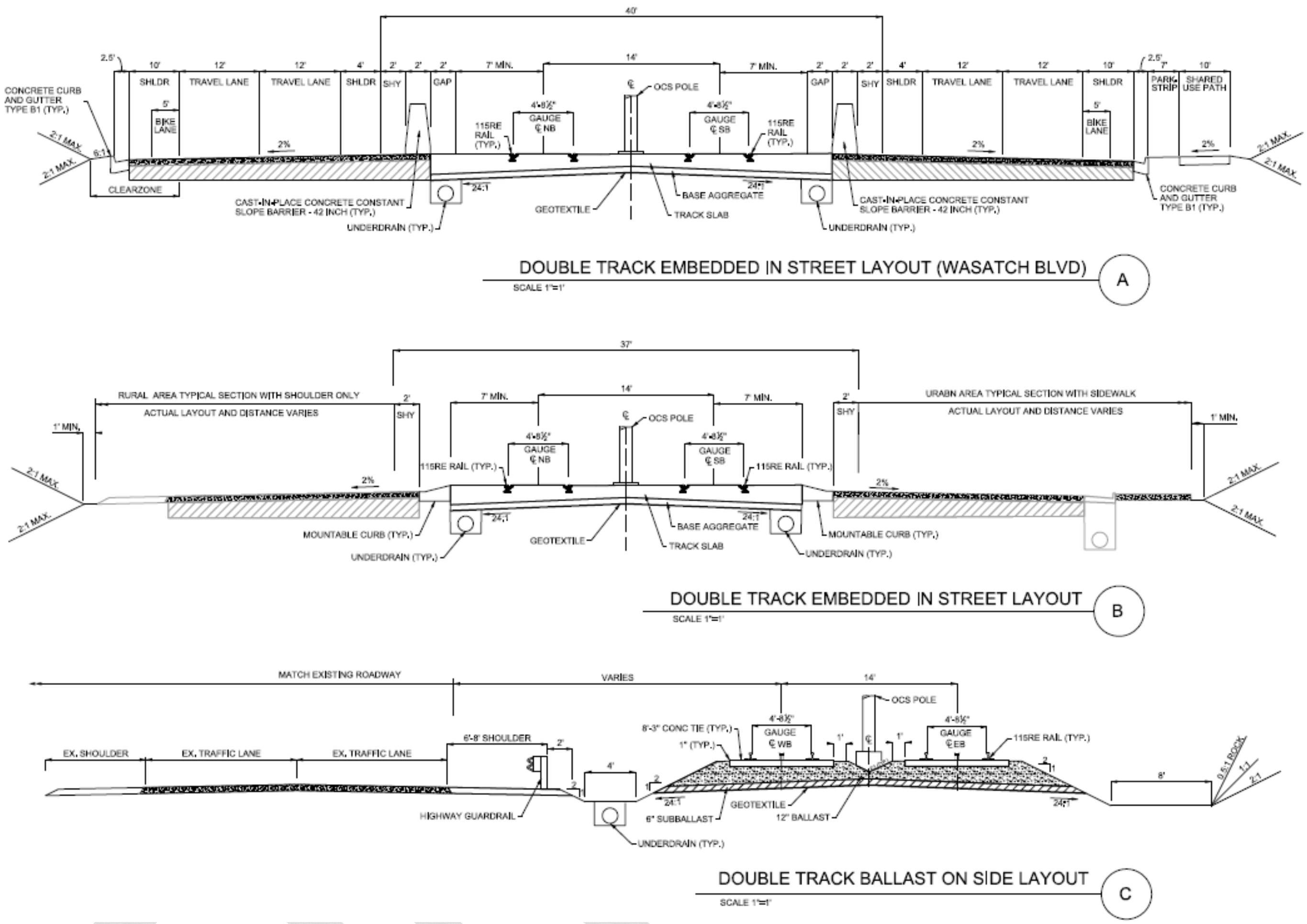
8 AREMA Section 2.6.10.2, *Dedicated Grade-level Right-of-Way*

4.4 Typical Cross-section

Figure 4 presents typical cross-sections for a conceptual cog rail alignments serving Little Cottonwood Canyon. These typical sections are generally categorized as one of two types: embedded track and ballasted track.

- **Embedded Track.** Typical Sections A and B in Figure 4 show the rail alignment in semi-exclusive ROW where the track would be embedded in pavement and running down the center of a street. This section would be used for cog rail segments outside the canyon. As shown for Typical Sections A and B, the center-running rail would be about 37 to 40 feet wide, and roadway widening would be required. Typical Section A shows a barrier between the travel lanes and the cog rail tracks. This typical section would be used in areas where there are higher road speed limits. Typical Section A would likely be used for Concept 2 along Wasatch Boulevard. Where slower speeds allow a more compact rail cross-section, Typical Section B could be used. Because the 9400 South segment between Highland Drive and S.R. 210 has a narrow, two-lane ROW and because several homes abut the street, Concept 3 uses Typical Section B, and this section was assumed for the entire length of this concept as well as for Concept 4B. More design would be needed to define areas where these or other cross-sections are applicable.
- **Ballasted Track.** Typical Section C in Figure 4 shows the rail on ballasted track in semi-exclusive ROW running adjacent to the road. This cross-section would be used in the canyon. The space between the tracks and the roadway would vary depending on the location of the tracks relative to the roadway. Cog rail alignments require greater minimum curve radius, which is a function of design speeds, compared to the roadway curves in Little Cottonwood Canyon. Therefore, the cog rail alignment would not exactly parallel the existing roadway alignment, and the separation distance would vary in different segments of the canyon as the rail alignment diverges from the road. An 8-foot-wide ditch between the rail ballast and the mountain side is included to manage stormwater runoff from the mountains side, to allow space to store snow removed from the tracks, and to collect fallen rocks.

Figure 4. Typical Cross-sections



4.5 Traction Power

Electric vehicles are the current industry and UTA standard. Power for vehicles can be provided via OCS or a third rail. A third rail would require an exclusive ROW to protect the public from the electrical hazard. An exclusive ROW could be achieved with fences, elevating the rail line on a structure, or placing it inside an enclosure or tunnel. National Fire Protection Association standards would apply to fixed-guideway transit and passenger rail systems.[9] If the track is elevated or in a tunnel, additional fire and life safety design criteria would apply; these ventilation or emergency egress elements are not considered in this report.

What is a third rail?

A third rail is an electrified rail adjacent to tracks at the same elevation as the tracks.

For this initial evaluation, UDOT assumes that traction power would be provided to the rail with an OCS, as with the existing TRAX system. An electrified third rail was eliminated because the need to totally enclose the ROW would limit pedestrian and wildlife access across the tracks in Little Cottonwood Canyon, affecting recreation and wildlife corridors. As a basic description of OCS, an electrical wire is suspended between OCS support poles, which forms the catenary. A pantograph, which is mounted on the top of the cars, collects the current and distributes it to the electric motor. Figure 5 shows the OCS poles between two sets of track and the pantograph on top of the light rail vehicle.

Figure 5. Example OCS and Pantograph

Substations would be needed to convert grid power, which is alternating current (AC), to the direct current (DC)-powered traction motors. The capacity of the existing, buried power line along Little Cottonwood

[9] NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems*, 2017

Canyon Road was not evaluated. UDOT assumes that a separate, dedicated power system would be needed for a Little Cottonwood Canyon cog rail concept. The proposed cog rail system would need about 24 megawatts of power from the utility network. UDOT also did not investigate the existing power capacity in the area for this initial feasibility report.

4.6 Avalanche Protections

One primary objective for the Little Cottonwood Canyon EIS is to address the reliability of the Little Cottonwood Canyon Road corridor and substantially reduce the number of days and hours that the canyon is closed for avalanche mitigation and incidents. With the use of an OCS and an alignment along the north side of Little Cottonwood Canyon Road, UDOT assumes that the electrical components and the cog rail line would need to be protected by running the rail inside snow sheds through some of the more critical avalanche paths at a minimum. In order to more completely define cog rail concepts, and to generate rough-order-of-magnitude cost ranges, UDOT estimated potential snow shed lengths to protect the rail line and passengers in the canyon segments for all concepts

Dynamic Avalanche Consulting, LLC (Dynamic), assessed the avalanche hazards in Little Cottonwood Canyon in 2018. Dynamic's evaluation defined risks (based on traffic) and return periods (annual, 3-year, 10-year, and 30-year, for example) and then ranked avalanche paths that warrant mitigation to reduce risks and maintain mobility in the canyon. The top-ranked paths, in terms of risk,[10] are White Pine, Superior, Little Superior, White Pine Chutes 1, Little Pine, White Pine Chutes 2 and 4, East Hellgate, and White Pines Chutes 3 (Dynamic 2019).

What is return frequency?

Return frequency is average time, in years, between avalanches, whether triggered naturally or artificially through active mitigation, that have reached the road in each avalanche path.

Using these nine paths as a baseline, UDOT evaluated the approximate return frequency of adjacent paths to determine the preliminary lengths of snow sheds that would be needed to protect the cog rail OCS and track from avalanches. Longer snow sheds might be needed, compared to snow sheds for the road, because the effects of an avalanche (main slide and powder blast) on a cog rail line's power system would be greater than the effects of an avalanche on the road. The road would simply be covered by snow and could be cleared relatively easy, whereas it might take crews more time (possibly days) to repair or reconstruct the cog rail's power-delivery system.

Table 2 presents the conceptual lengths of snow shed that would be needed to protect a cog rail system. UDOT estimated the minimum mid-canyon and upper canyon snow sheds lengths by assuming that continuous snow sheds are needed to protect the rail line through the most significant, higher-return-period, avalanche paths. UDOT also extended these minimum snow shed lengths to cover more paths, pending more-detailed risk analysis, in order to determine a rough order-of-magnitude cost range for an added level of protection. For example, at a minimum, the mid-canyon segment has six of the top risk-ranked paths where a cog rail would need to include snow sheds (see the first column of Table 2). A snow shed that is at least 0.91 mile long would be required in this location. The Little Pine East avalanche path, which has a 10-year return period, is east of these six paths, and the Maybird path, which also has a 10-year return period, is west of these six paths. If additional protection is required, the mid-canyon snow shed would be extended

[10] Risks were assessed using Avalanche Hazard Index methods that considers all avalanche paths, frequency of events, and the anticipated traffic on S.R. 210 in Little Cottonwood Canyon.

(see the second column of Table 2). Under an extended mid-canyon snow sheds scenario, UDOT estimates that a continuous, 2.11-mile-long snow shed could be needed to protect the rail line in this section of the canyon. Similarly, between 1.23 and 1.73 miles of snow shed might be needed to protect the cog rail system in the upper portions of the canyon (see the third and fourth columns of Table 2).

Table 2. Assumed Minimum and Extended Snow Sheds

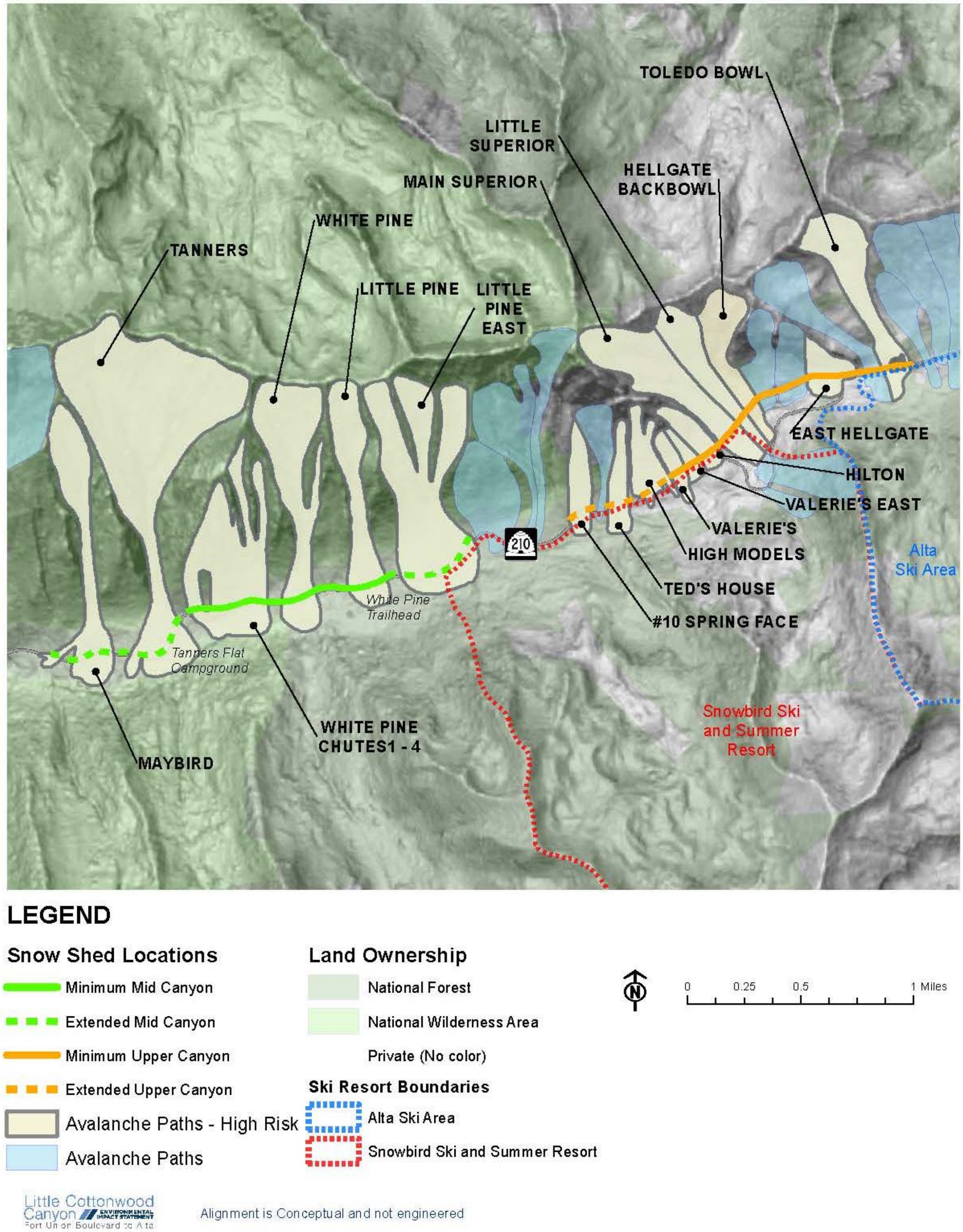
Minimum Mid-Canyon Snow Shed	Extended Mid-Canyon Snow Shed	Minimum Upper Canyon Snow Shed	Extended Upper Canyon Snow Shed
	Little Pine East	Toledo Bowl/Reds	Toledo Bowl/Reds
Little Pine	Little Pine	East Hell Gate	East Hell Gate
White Pine	White Pine	Little Superior	Little Superior
White Pine Chutes 1	White Pine Chutes 1	Superior	Superior
White Pine Chutes 2	White Pine Chutes 2	Hilton	Hilton
White Pine Chutes 3	White Pine Chutes 3	Valarie's East	Valarie's East
White Pine Chutes 4	White Pine Chutes 4	Valarie's	Valarie's
	Tanners		High Models
	Maybird		Ted's House
			#10 Springs Face
Length 0.91 mile	Length 2.11 miles	Length 1.23 miles	Length 1.73 miles
Minimum length for mid- and upper-canyon snow sheds[a]			2.14 miles
Extended length for mid- and upper-canyon snow sheds[b]			3.84 miles
Maximum conceptual length[c]			7.50 miles

[a] Sum of minimum mid-canyon and minimum upper-canyon snow sheds.
[b] Sum of extended mid-canyon and extended upper-canyon snow sheds.
[c] Maximum theoretical length of snow shed to cover a cog rail line from Mormon Slide to Toledo Bowl avalanche paths.

Figure 6 shows the approximate limits of the minimum and extended mid-canyon and upper canyon snow sheds. For a low-end range, UDOT estimates that about 2.14 miles of snow shed would be needed (0.91 mile in the mid-canyon section and 1.23 miles in the upper-canyon segment) to protect the cog rail infrastructure. If more of the cog rail line needs to be protected below some of the other higher-frequency avalanche paths, UDOT estimates that about 3.84 miles (2.11 miles in the mid-canyon section plus 1.73 miles in the upper-canyon section) of snow shed would be needed. If, based on more thorough risk and cost-benefit analysis, complete protection for the cog rail line is necessary, up to about 7.5 miles of snow shed could be needed. A more thorough risk analysis would be needed to fully define the necessary protections. See Section 5.0, Rail Concepts Evaluation for capital costs.

UDOT conducted a risk analysis (measured as the Avalanche Hazard Index, or AHI) for Little Cottonwood Canyon Road for the current (2018) and 2050 roadway traffic conditions. Incorporating a fixed-rail-transit concept would result a different AHI (considering both the road and rail). However, this preliminary analysis did not include AHI calculations for a rail line nor required, or feasible, mitigation needed to adequately reduce the AHI (if the AHI is high) with changes in the transportation system.

Figure 6. Potential Cog Rail Snow Sheds



4.7 Travel Time Assumptions

Travel time is a function of track length and average train speed. The maximum grade, track curvature, and ROW type all affect the maximum train speeds in various segments of the cog rail line. For this initial analysis, UDOT assumes an average speed of 25 mph for all rail segments (both cog and adhesion).

Without a direct transit connection, the cog rail concept would require a large parking area where riders would park their personal vehicles, walk to the train-loading platform, and wait for and board a train. These transfers take time. If parking is separated from the base rail station, additional walking time or some form of transit (people-mover or buses) would be needed to transport passengers from the parking area to the rail base station. In the travel time calculations that follow, UDOT added 12 minutes to the travel time to account for this transfer.[11]

Dwell time is the time during which a train is stopped at a station to allow passengers to embark and disembark the rail vehicles. UDOT assumes a 2-minute dwell time at each station. These times are considered in Section 5.0, Rail Concepts Evaluation, which explores approximate travel times for different parking and rail base station concepts.

5.0 Rail Concepts Evaluation

5.1 Concept 1 – Expanded Parking and Rail Base Station at the Mouth of Little Cottonwood Canyon

There is an existing park-and-ride lot at the mouth of Little Cottonwood Canyon at the intersection of S.R. 210 and S.R. 209. The existing lot has about 160 spaces. An expanded parking lot at or near this location, which could accommodate the assumed ridership, would require a large, multilevel parking structure. In order to compare transit concepts (bus, gondola, and train) equally, UDOT assumed a similar peak-hour ridership of about 1,000 people and a peak daily ridership of about 5,200. This level of ridership for Little Cottonwood Canyon would require a parking structure of about 2,500 cars.

Some members of the public are opposed to expanding the parking at this location because vehicle traffic during peak times creates traffic congestion in the area and restricts residents' mobility. A large parking structure at the base of the canyon would not help relieve congestion on S.R. 210 and S.R. 209 during peak arrival times. The congestion would be similar to the current conditions with traffic trying to enter the canyon. One of the purposes of the Little Cottonwood Canyon Project is to reduce congestion-related access issues for residents who live at the base on the canyon (that is, not being able to arrive at or leave their neighborhoods on peak ski days). However, this location for expanded parking and a rail base station has benefits with respect to the resulting rail alignment. The length of a cog rail line would be about 6.5 miles to Snowbird and another 1.5 miles to Alta, or about 8 miles total (Figure 7). UDOT prepared a preliminary design for Concept 1 (see Appendix B1, Preliminary Design Plan for Segment 1 – Little Cottonwood Canyon). The preliminary design used Typical Section C from Figure 4. The preliminary design plans do not include the snow sheds.

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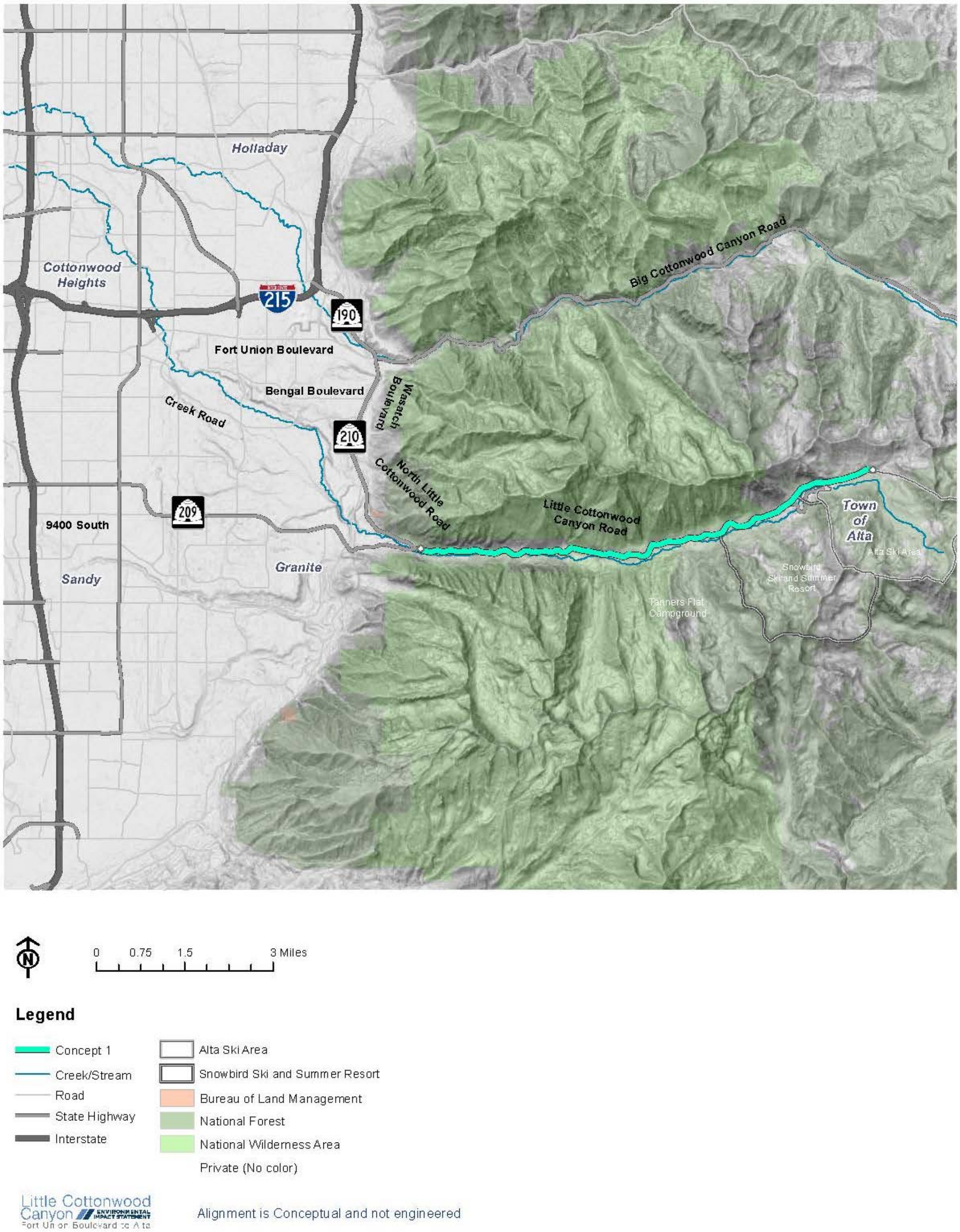
[11] These additional 12 minutes consist of the following times and activities: 0.5 minute to wait in the line of vehicles at the parking garage, 1 minute to find a parking spot, 4 minutes to unload gear, 3.5 minutes to walk to the train platform (assumed to be a 900-foot distance at a 3-mph pace), 1 minute to pay for a fare, and 2 minutes waiting in line to board the train.

Figure 7. Concept 1 Alignment



5.1.1 Travel Times

The travel time for Concept 1 includes personal vehicle travel time from Fort Union Boulevard to the mouth of Little Cottonwood Canyon; the time for a rider to park a vehicle, unload gear, walk to the loading platform, pay for a fare, board the train, and depart the rail base station; and the travel time from the rail base station to the resorts.

The estimated personal vehicle travel time along Wasatch Boulevard in 2050 is about 8 minutes from Fort Union Boulevard to the mouth of Little Cottonwood Canyon. This travel time assumes that Wasatch Boulevard has been expanded to accommodate the projected travel demand in 2050. With about 1,500 vehicles per hour trying to park at the expanded park-and-ride structure at the intersection of S.R. 209 and S.R. 210 during the peak hours, there could likely be some congestion at the intersection. However, this preliminary analysis assumes that the intersection of S.R. 210 and S.R. 209 can be improved such that vehicles can access the parking structure efficiently and that vehicles would not back up onto S.R. 210 or neighborhood streets.

UDOT added 12 minutes to the initial segment time to account for the time to park a personal vehicle, unload gear, walk to the train loading area, pay for a fare, board the train, and depart the rail base station. At an average speed of 25 miles per hour, the travel time to Snowbird would be about 16 minutes. With a 2-minute dwell time at a Snowbird station and a 1.5-mile, 4-minute train ride, the travel time to Alta would be another 6 minutes. The total travel time for Concept 1 would be about **36 minutes to Snowbird** and about **42 minutes to Alta** (Table 3).

Table 3. Travel Times for Concept 1

Segment Start	Segment End	Travel Mode	Rail Segment Length (miles)	Time, One-Way (minutes, rounded)
Fort Union Boulevard	Parking lot at rail base station	Drive	—	8
Parking lot	Departure from rail base station	Walk	—	12
Rail base station	Snowbird station	Rail	6.5	16
Snowbird station	Alta station	Rail	1.5	6
Total			8.0	42

5.1.2 Costs

Capital Cost

Capital costs include rolling stock (rail vehicles), track infrastructure (guideway, embedded track or ballast track and switches), civil site work (cuts and fills, structures, retaining walls, and storm drains), OCS, traction-power substations, station platforms, and utility relocations.[12] Costs in each segment of the cog rail concept would vary depending on the need for ROW, earthwork quantities, and the need for structural support elements (retaining walls or bridges). UDOT prepared preliminary engineering plans to conceptually define the cog rail Concept 1. ROW are not included.

Table 4 presents a rough order-of-magnitude cost for a cog rail line running about 8 miles from the mouth of Little Cottonwood Canyon to Alta. A cost range is presented by adjusting the number of rail vehicles that would be needed to serve the peak hour (5 to 8 vehicles), by providing a range of costs for a stand-alone OMF (variable size and location), and by assuming different lengths of snow sheds (2.14 to 3.84 miles).

Table 4. Concept 1, Capital Cost Range

Element	Component Cost ($million, 2019$)	
	Low Range	High Range
Guideway and track elements	130.0	130.0
Stations and terminals (base, Snowbird, Alta)	4.2	4.2
Site work (utilities and roadways)	15.1	15.1
Systems (controls, communications, and power supply/distribution)	202.5	202.5
Professional services (engineering, construction admin., legal, startup)	236.3	236.3
Contingencies (about 20%)	150.8	150.8
Cog rail vehicles [a]	55.6	88.8
Cog rail subtotal	794.5	827.7
Operation and maintenance facility [b]	60.0	75.3
Parking structure [c]	52.0	52.0
Snow sheds [d]	282.5	506.9
Total	1,189	1,461.9

[a] Five (low range) to eight (high range) cog rail vehicles would be needed for this concept depending on the actual per-vehicle capacity. A per-vehicle cost of about $11.1 million (2019$, Stadler 2019) was used in the estimate.

[b] Initial OMF sized to operate and maintain up to 14 cog rail vehicles at an estimated cost of about $75.3 million. The OMF cost was scaled for the low range to account for the potential for building a smaller OMF with this concept.

[c] Assumed parking structure sized for 2,500 cars for both the high and low ranges.

[d] Snow shed lengths of 2.14 miles (low range) and 3.84 miles (high range) were used. Snow shed unit cost is about $25,000 per linear foot based on a conceptually designed three-travel-lane snow shed.

[12] Not an exhaustive list.

The total estimated cost range for the design and construction of the cog rail system for Little Cottonwood Canyon only (Concept 1) would be about $795 million to $828 million. The approximately 10.5-acre OMF would cost about $60 million to $75.3 million. Assuming a 2,500-car parking structure at about $20,800 per parking space, the parking structure would cost about $52 million.[13] Snow sheds would cost about 25,000 per linear foot of snow shed or about $282.5 million to $506.9 million total, depending on the final snow shed lengths needed. A capital cost summary for Concept 1 is included in Appendix A. **The total estimated cost range for cog rail Concept 1 is about $1.19 billion to $1.46 billion.**

O&M Cost

To estimate operation and maintenance (O&M) costs, UDOT used a cost-per-mile methodology. UDOT assumes that cog rail train operations could be adjusted to more closely match actual expected ridership demands, which would vary by time of day and day of the week in the winter and seasonally. Operating assumptions are described in Section 4.2.3, Operating Assumptions. With those operating assumptions, UDOT estimated the total number of train trips per year and total number of miles traveled by rail vehicles. Table 5 presents the estimated total number of train trips (4,080) into Little Cottonwood Canyon per year under the assumed operating schedule.

Table 5. Number of Train Trips per Year into Little Cottonwood Canyon

Schedule	Hours of Operation	Trips per Hour[a]	Trips per Day	Days of Operation	Total Trips per Year
Winter peak hours	6	4	24	60	1,440
Winter off-peak hours	6	2	12	60	720
Winter weekdays	12	2	24	80	1,920
Total					4,080

Given the 8-mile one-way distance and the 16-mile round trip from the mouth of Little Cottonwood Canyon to Alta, the total miles traveled by cog rail vehicles would be about 65,280 miles annually. At $9.61 per vehicle revenue-mile (UTA 2018, p. 120), the total estimated annual O&M cost for Concept 1 is about **$628,000**.

[13] The per-parking-spot, planning-level capital cost estimate for a parking structure was provided to UDOT by its parking consultant, DESMAN Corporation.

5.2 Concept 2 – Expanded Parking and Rail Base Station at a Gravel Pit Mobility Hub

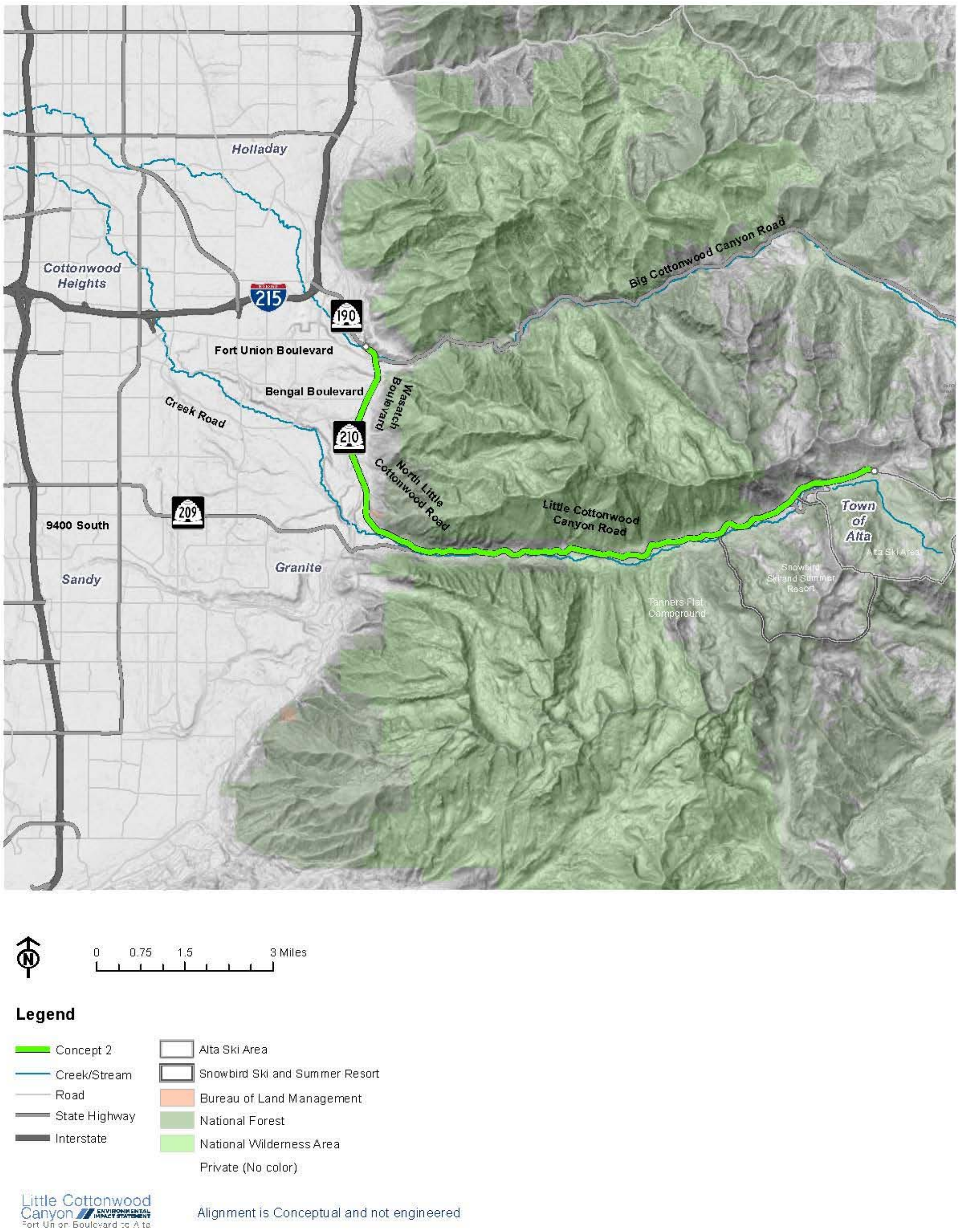
Because of the public opposition to an expanded parking lot and a parking structure in the residential areas around the mouth of Little Cottonwood Canyon, UDOT explored options to construct a large parking structure away from the mouth of the canyon. One option would place a large parking structure at a site of an aggregate (gravel) mining operation located just east of Wasatch Boulevard and north of Fort Union Boulevard near the mouth of Big Cottonwood Canyon. The parking structure would allow this location to function as a “mobility hub” from which users could take various transit options.

A main benefit of this location is that it would take cars away from the mouth of Little Cottonwood Canyon, which is where S.R. 210 and S.R. 209 merge and where traffic congestion is heavy during the current winter morning peak period. This location is near Interstate 215 (I-215) and would not add traffic to a residential area. Another benefit of this location as a mobility hub is that it could serve transit users traveling to either Big Cottonwood Canyon or Little Cottonwood Canyon, as well as serve weekday commuters in the future as UTA and UDOT explore long-term transit options for this part of the Salt Lake Valley. Parking could also be developed in conjunction with a future commercial or mixed-use development in the area.

For canyon users originating from the north part of the Salt Lake Valley (north of Fort Union Boulevard), this mobility hub would be on their route. However, canyon users who originate from south of 9400 South (S.R. 209) would need to bypass Little Cottonwood Canyon and drive about 3 more miles north to this mobility hub before boarding a cog rail vehicle.

See Figure 8 for the general route of Concept 2. The resulting train alignment would be about 12.2 miles. UDOT assumes that the double-track cog line would follow the same general alignment as S.R. 210—running in the center of Wasatch Boulevard, turning onto North Little Cottonwood Road, and then running along the north side of Little Cottonwood Canyon Road to the ski resorts. Conceptual design plans are shown in Appendix B2, Preliminary Plans for Segment 1 – Little Cottonwood Canyon, and Appendix B2, Preliminary Plans for Segment 2 – Gravel Pit to Mouth of Little Cottonwood Canyon.

Figure 8. Concept 2 Alignment



5.2.1 Travel Times

The urban segments of this concept alignment have flatter grades and wider curves than in Little Cottonwood Canyon. However, UDOT assumes that the maximum 25-mph speed in the canyon dictates the travel speed of cog rail vehicles along all segments of the route and in all directions for this concept. Note that the travel time begins at the gravel pit mobility hub near Fort Union Boulevard.

Table 6 presents the travel time for each segment and the total travel time for Concept 2. The total travel time is about **38 minutes to Snowbird** and about **44 minutes to Alta**. Note that, besides the base, Snowbird, and Alta stations, no intermediate train stations are assumed with this concept.

Table 6. Travel Times for Concept 2

Segment Start	Segment End	Travel Mode	Rail Segment Length (miles)	Time, One-Way (minutes, rounded)
Fort Union Boulevard	Parking lot at the rail base station at gravel pit mobility hub	Drive	—	Not applicable
Parking lot	Departure from rail base station	Walk	—	12
Rail base station	Mouth of Little Cottonwood Canyon	Rail	4.2	10
Mouth of Little Cottonwood Canyon	Snowbird station	Rail	6.5	16
Snowbird station	Alta station	Rail	1.5	6
Total			12.2	44

5.2.2 Costs

Capital Cost

Table 7 presents a rough order-of-magnitude cost for Concept 2, a cog rail line running about 12 miles from the gravel pit mobility hub at the intersection of Fort Union Boulevard and Wasatch Boulevard to Alta. The cost estimate for Concept 2 includes the planned roadway improvements to Wasatch Boulevard as well as a new bridge over Big Cottonwood Canyon creek. A cost range is presented by adjusting the number of rail vehicles that might be needed to serve the peak hour (6 to 9 vehicles), by providing a range of costs for a stand-alone OMF ($60 million to $75 million), and by assuming different lengths of snow sheds (2.14 to 3.84 miles).

Table 7. Concept 2, Capital Cost Range

Element	Component Cost ($million, 2019$)	
	Low Range	High Range
Guideway and track elements	167.4	167.4
Stations and terminals	4.2	4.2
Site work (utilities and roadways)	233.2	233.2
Systems (controls, communications, and power supply/distribution)	319.7	319.7
Professional Services (engineering, construction admin., legal, startup)	261.2	261.2
Contingencies (about 20%)	233.1	233.1
Cog rail vehicles [a]	66.7	100.0
Cog rail subtotal	1,285.5	1,318.8
Operation and maintenance facility [b]	60.0	75.3
Parking structure [c]	52.0	52.0
Snow sheds [d]	282.5	506.9
Total	1,680.0	1,953.0

[a] Six (low range) to nine (high range) cog rail vehicles would be needed for this concept depending on the actual per-vehicle capacity. A per-vehicle cost of about $11.1 million (Stadler 2019) was used in the estimate.

[b] Initial OMF sized to operate and maintain up to 14 cog rail vehicles at an estimated cost of about $75.3 million. The OMF cost was scaled for the low range to account for the potential for building a smaller OMF with this concept.

[c] Assumed parking structure sized for 2,500 cars for both the high and low ranges.

[d] Snow shed lengths of 2.14 miles (low range) and 3.84 miles (high range) were used. Snow shed unit cost is about $25,000 per linear foot based on a conceptually designed three-travel-lane snow shed.

The total estimated cost range for the design and construction of the cog rail system with a parking structure at the gravel pit mobility hub and tracks running in the center of Wasatch Boulevard and into Little Cottonwood Canyon (Concept 2) would be about $1,285 million to $1,319 million. The approximately 10.5-acre OMF would cost about $60 million to $75.3 million. Assuming a 2,500-car parking structure at about $20,800 per parking space, the parking structure would cost about $52 million. Snow sheds, if needed to protect the cog rail OCS, would cost about 25,000 per linear foot of snow shed or about $282.5 million to $506.9 million total, depending on the final snow shed lengths needed. A capital cost summary for Concept 2 is included in Appendix A. **The total estimated cost range for cog rail Concept 2 is about $1.68 billion to $1.95 billion.**

O&M Cost

Concept 2 would have the same schedule and annual number of trips into Little Cottonwood Canyon as would Concept 1 (4,080 trips per year). Because Concept 2 is longer (24.4 miles round trip) than Concept 1 (16 miles round trip), the cog rail vehicle fleet would travel more miles per year with Concept 2. The total miles traveled by cog rail cars would be about 99,552 miles. At $9.61 per vehicle revenue-mile, the total estimated annual O&M cost for Concept 2 is about **$957,000**.

5.3 Concept 3 – Expanded Parking and Rail Base Station at a 9400 South and Highland Mobility Hub

Another concept would be to place a large parking structure near an existing park-and-ride lot at 9400 South and Highland Drive. The parking structure would allow this location to function as a mobility hub. This concept would also benefit mobility by removing cars from the mouth of Little Cottonwood Canyon, which is where S.R. 210 and S.R. 209 merge and where traffic congestion is heavy during the current winter morning peak period. UDOT assumes that a rail alignment can follow 9400 South to the mouth of Little Cottonwood Canyon and the north side of Little Cottonwood Canyon Road. See Figure 9 for the general route of Concept 3. The resulting cog rail alignment would be about 11.5 miles long. UDOT assumes that this concept would also require a double-track line for all segments. See Appendix B1, Preliminary Design Plans for Segment 1 – Little Cottonwood, and Appendix B3, Preliminary Design Plans for Segment 3 – 9400 South and Highland Drive to Mouth of Little Cottonwood Canyon, for the preliminary design plans for the canyon segment and the segment between 9400 South and Highland and the mouth of Little Cottonwood Canyon, respectively.

5.3.1 Travel Times

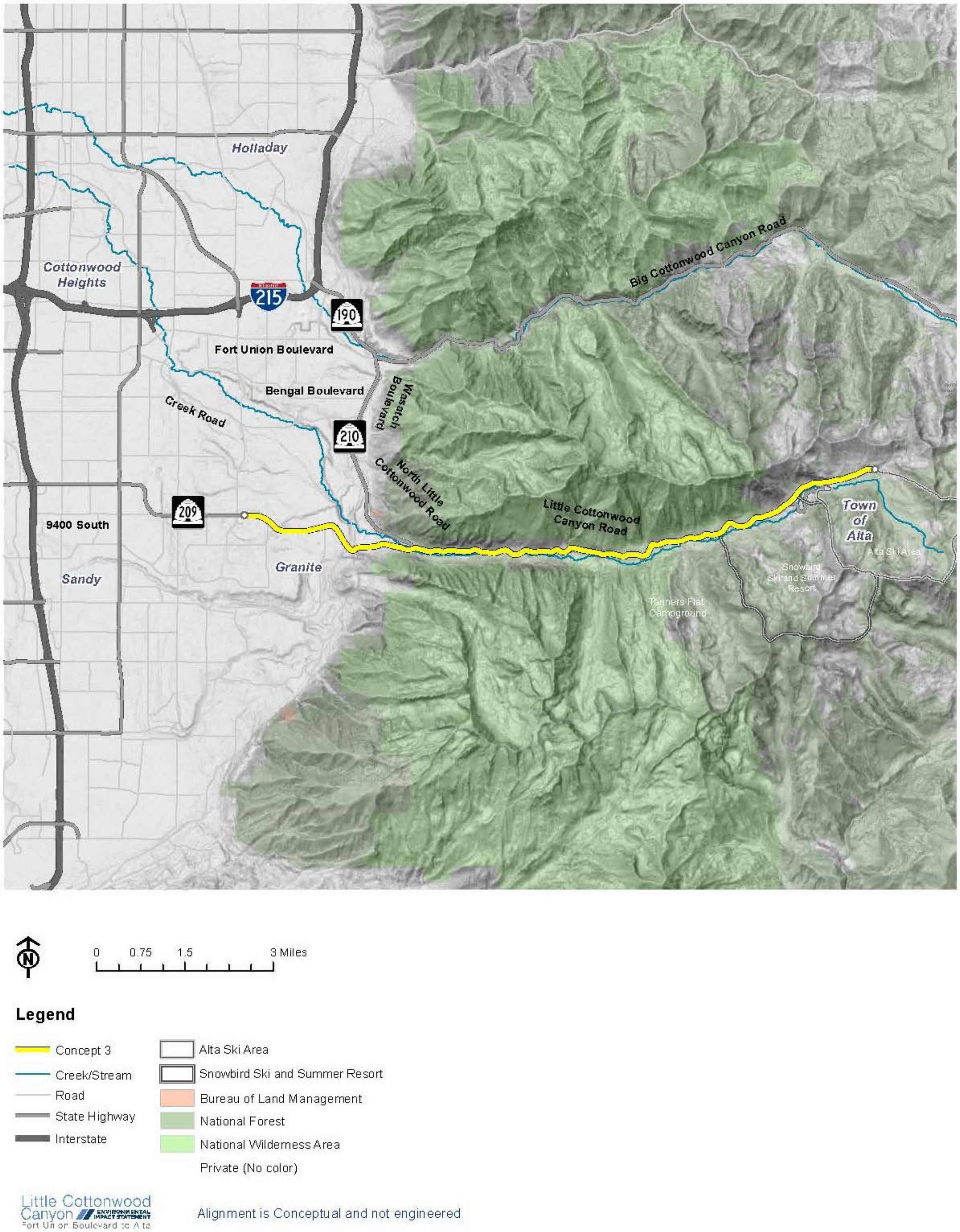
For Concept 3, the travel time in a cog rail train would be about **36 minutes to Snowbird** and about **42 minutes to Alta**. Note that, besides the base, Snowbird, and Alta stations, no intermediate train stations are assumed with this initial concept. Table 8 presents the travel time for each segment and the total travel time for Concept 3.

Table 8. Travel Times for Concept 3

Segment Start	Segment End	Travel Mode	Rail Segment Length (miles)	Time, One-Way (minutes, rounded)
Fort Union Boulevard	Parking lot at rail base station at 9400 South and Highland Drive mobility hub	Drive	—	Not applicable
Parking lot	Departure from rail base station	Walk	—	12
Rail base station	Mouth of Little Cottonwood Canyon	Rail	3.5	8
Mouth of Little Cottonwood Canyon	Snowbird station	Rail	6.5	16
Snowbird station	Alta station	Rail	1.5	6
Total			11.5	42

Note that the drive time in a personal vehicle from Fort Union Boulevard along Wasatch Boulevard was not included in the travel time for this concept. With this concept, UDOT assumes that some train riders would adjust their route to use Interstate 15 (I-15) and S.R. 209 (9000/9400 South) as opposed to I-215 and Wasatch Boulevard. Therefore, Wasatch Boulevard might not be the predominant route for transit riders to this mobility hub serving Little Cottonwood Canyon under Concept 3.

Figure 9. Concept 3 Alignment



5.3.2 Costs

Capital Cost

Table 9 presents a rough order-of-magnitude cost for Concept 3, a cog rail line running about 11.5 miles from 9400 South and Highland Drive mobility hub to Alta. A cost range is presented by adjusting the number of rail vehicles that might be needed to serve the peak hour (6 to 9 vehicles), by providing a range of costs for a stand-alone OMF, and by assuming different lengths of snow sheds (2.14 to 3.84 miles).

Table 9. Concept 3, Capital Cost Range

Element	Component Cost ($million, 2019$)	
	Low Range	High Range
Guideway and track elements	157.4	157.4
Stations and terminals	4.2	4.2
Site work (utilities and roadways)	40.8	40.8
Systems (controls, communications, and power supply/distribution)	280.2	280.2
Professional services (engineering, construction admin., legal, startup)	236.3	236.3
Contingencies (about 20%)	178.8	178.8
Cog rail vehicles [a]	66.7	100.0
Cog rail subtotal	964.4	997.7
Operation and maintenance facility [b]	60.0	75.3
Parking structure [c]	52	52
Snow sheds [d]	282.5	506.9
Total	1,358.9	1,631.9

[a] Six (low range) to nine (high range) cog rail vehicles would be needed for this concept depending on the actual per-vehicle capacity. A per-vehicle cost of about $11.1 million (Stadler 2019) was used in the estimate.

[b] Initial OMF sized to operate and maintain up to 14 cog rail vehicles at an estimated cost of about $75.3 million. The OMF cost was scaled for the low range to account for the potential for building a smaller OMF with this concept.

[c] Assumed parking structure sized for 2,500 cars for both the high and low ranges.

[d] Snow shed lengths of 2.14 miles (low range) and 3.84 miles (high range) were used. Snow shed unit cost is about $25,000 per linear foot based on a conceptually designed three-travel-lane snow shed.

The total estimated cost range for the design and construction of the cog rail system with a parking structure at a 9400 South and Highland Drive mobility hub and tracks running in the center of S.R. 210 and into Little Cottonwood Canyon (Concept 3) would be about $964 million to $998 million. The approximately 10.5-acre OMF would cost about $60 million to $75.3 million. Assuming a 2,500-car parking structure at about $20,800 per parking space, the parking structure would cost about $52 million. Snow sheds, if needed to protect the cog rail OCS, would cost about 25,000 per linear foot of snow shed or about $282.5 million to $506.9 million total, depending on the final snow shed lengths needed. A capital cost summary for Concept 3 is included in Appendix A. **The total estimated cost range for cog rail Concept 3 is about $1.36 billion to $1.63 billion.**

O&M Cost

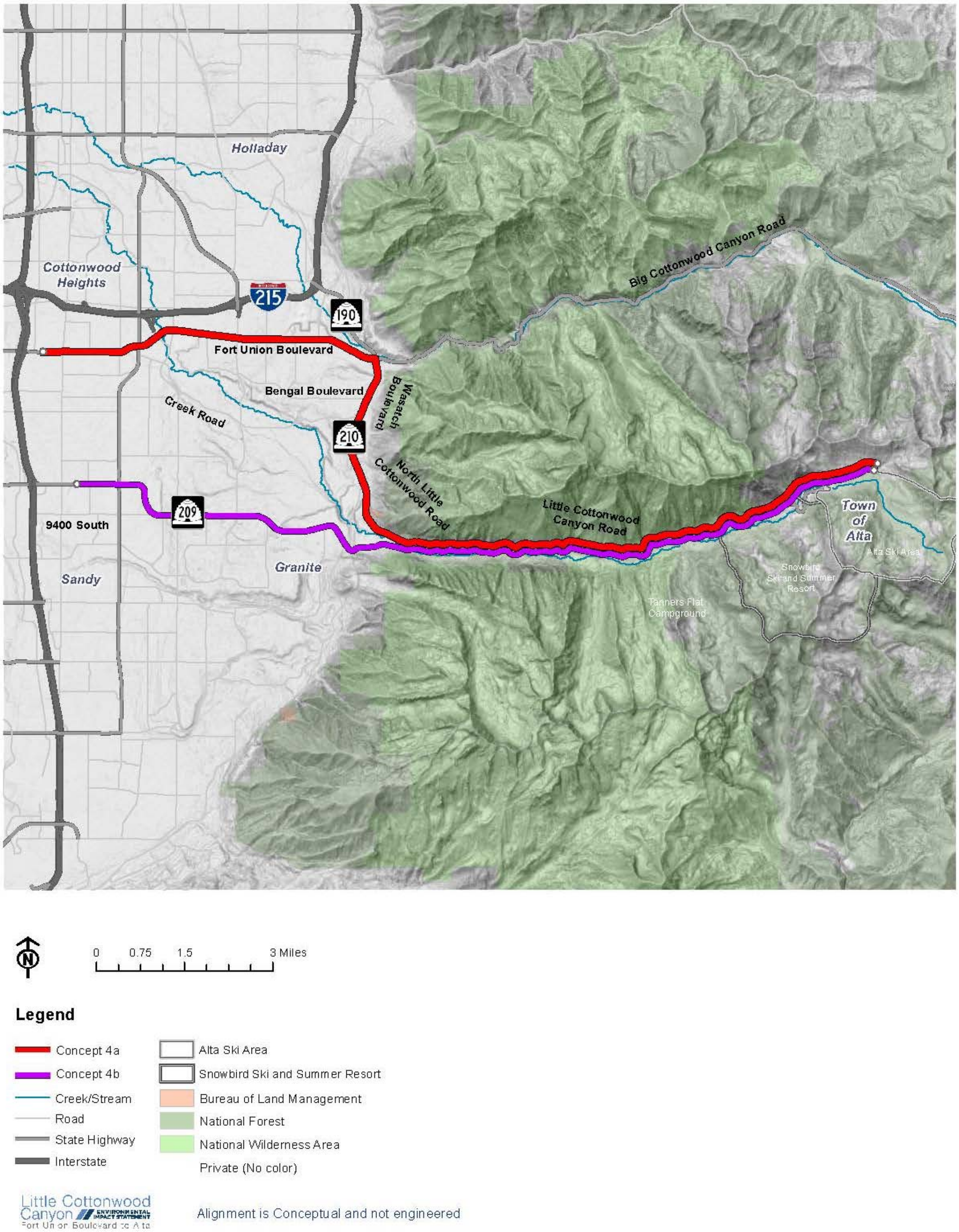
Concept 3 would have the same schedule and annual number of trips into Little Cottonwood Canyon as would Concept 1 (4,080 trips per year). With Concept 3, the total miles traveled by cog rail cars would be about 93,840 miles. At $9.61 per vehicle revenue-mile, the total estimated annual O&M cost for Concept 3 is about **$902,000**.

5.4 Concept 4 – Connection to the Existing TRAX System

UDOT evaluated two options to connect a Little Cottonwood Canyon cog rail line to UTA's existing TRAX system (see Figure 10). These options were consider to avoid the need to construct a large parking structure and reduced the need for a large (10.5-acre) stand-alone OMF to operate and service rail vehicles.

- **Concept 4, Option A** would connect to the existing TRAX system at the Midvale Fort Union TRAX Station near I-15 and Fort Union Boulevard (7200 South). The resulting conceptual rail alignment would run for about 5.9 miles east along Fort Union Boulevard to Wasatch Boulevard and then turn south and run for about 4.2 miles along Wasatch Boulevard to the mouth of Little Cottonwood Canyon. Adding the 8-mile segment in Little Cottonwood Canyon, the total length of this option would be about **18.1 miles**. See Appendix B1, Preliminary Design Plans for Segment 1 – Little Cottonwood, and Appendix B2, Preliminary Design Plans for Segment 2 – Gravel Pit to Mouth of Little Cottonwood Canyon, for the preliminary design plans for the canyon segment and segment between the gravel pit and the mouth of Little Cottonwood Canyon, respectively, which make up Concept 4A. No preliminary design plans were prepared for the Concept 4A segment between the Fort Union Boulevard TRAX Station and the gravel pit.
- **Concept 4, Option B** would connect to the existing TRAX system at the Historic Sandy Station near about 150 East and 9000 South. From the Historic Sandy TRAX Station, the resulting conceptual rail alignment would east run for about 6.3 miles along S.R. 209 (9000 south and 9400 South) to the mouth of Little Cottonwood Canyon. Adding the 8-mile segment in Little Cottonwood Canyon, the total length of this option would be about **14.3 miles**. See Appendix B1, Preliminary Design Plans for Segment 1 – Little Cottonwood, Appendix B3, Preliminary Design Plans for Segment 3 – 9400 South and Highland Drive to Mouth of Little Cottonwood Canyon, and Appendix B4, Preliminary Design Plans for Segment 4 – Historic Sandy TRAX Station 9400 South and Highland Drive, for the preliminary design plans for Concept 4B.

Figure 10. Concept 4A and 4B Alignments



5.4.1 Travel Times

Concept 4A – TRAX Connection at Midvale Fort Union Station

As described in Section 4.2.3, Operating Assumptions, connecting a Little Cottonwood Canyon cog rail line to UTA's existing TRAX system could also serve weekday commuter traffic. Although this is not part of the purpose of and need for the Little Cottonwood Canyon Project, if such a rail line were constructed to serve the needs of Little Cottonwood Canyon, it could also serve weekday commuters.

For travel time calculations, UDOT assumes that four intermediate stations would be built somewhere along the alignment of Concept 4A: three stations along Fort Union Boulevard and one station along Wasatch Boulevard. No specific station locations were identified for this preliminary feasibility study. A station dwell time of 2 minutes was assigned to each of these stations. UDOT also assumed that the TRAX vehicles could be equipped to use the cog rail line, so riders would not need to transfer at the mouth of the canyon. Note that driving or parking times were not included in the travel time calculations for Concept 4A.

Table 10 presents the travel time for Concept 4A, which is an 18.1-mile-long line. UDOT used the 25-mile-per-hour cog rail speed for all segments. Assuming that a rider embarks at the TRAX Midvale Fort Union TRAX Station, the total travel time would be about **48 minutes to Snowbird** and about **54 minutes to Alta**.

Table 10. Travel Times for Concept 4A

Segment Start	Segment End	Travel Mode	Rail Segment Length (miles)	Time, One-Way (minutes, rounded)
Midvale Fort Union TRAX Station	Wasatch Boulevard and Fort Union Boulevard	Rail	5.9	20
Wasatch Boulevard and Fort Union Boulevard	Mouth of Little Cottonwood Canyon	Rail	4.2	12
Mouth of Little Cottonwood Canyon	Snowbird station	Rail	6.5	16
Snowbird station	Alta station	Rail	1.5	6
Total			18.1	54

Concept 4B – TRAX Connection at Historic Sandy Station

UDOT assumed that Concept 4B would include three intermediate stations somewhere along 9000 South and 9400 South (S.R. 209). Table 11 presents the travel time for Scenario 4B, which is a 14.3-mile-long rail line. UDOT used the 25-mile-per-hour speed for all segments and a 2-minute dwell time at each station. UDOT also assumed that riders would not need to transfer to a cog rail vehicle at mouth of the canyon. Note that driving or parking times were not included in the travel time calculations for Concept 4B. Travel times for passengers that start at the Historic Sandy TRAX Station would be about **37 minutes to Snowbird** and about **43 minutes to Alta**.

Table 11. Travel Times for Concept 4B

Segment Start	Segment End	Travel Mode	Rail Segment Length (miles)	Time, One-Way (minutes, rounded)
Historic Sandy TRAX Station	Mouth of Little Cottonwood Canyon	Rail	6.3	21
Mouth of Little Cottonwood Canyon	Snowbird station	Rail	6.5	16
Snowbird station	Alta station	Rail	1.5	6
Total			14.3	43

5.4.2 Costs

Capital Cost

In order to generate conceptual construction quantities and rough order-of-magnitude cost estimates, UDOT prepare conceptual design plans for cog rail Concept 4B. Concept 4B, which would include a new rail line down S.R. 209, would be the shortest connection (about 3.8 miles shorter than Concept 4A) to the existing UTA light rail system. It would also have faster travel times (11 minutes faster) as measured from the connection points (either Midvale Fort Union or Historic Sandy TRAX Stations). The total cost for the urban segment of Concept 4A from UTA's Midvale Fort Union TRAX Station to the gravel pit mobility hub were estimated by applying a per-mile cost ($85 million to $100 million per mile) to the additional length, and adding that cost to the cost of Concept 2 (gravel pit mobility hub to Alta). A cost summary for Concept 2 is included in Appendix A.

Table 12 presents rough order-of-magnitude capital cost estimates for Concept 4A.

Table 12. Concept 4A, Capital Cost Range

Element	Component Cost ($million, 2019$)	
	Low Range	High Range
Concept 2 cost estimate range	1,284.6	1,317.9
5.9 miles of rail in urban setting ($85 million to $100 million per mile)	501.5	590.0
Cog rail subtotal	1,786.1	1,907.9
Operation and maintenance facility [b]	25.1	25.1
Parking structure [c]	0	0
Snow sheds [d]	282.5	506.9
Total	2,093.7	2,439.9

[a] Nine (low range) to 12 (high range) cog rail vehicles would be needed depending on the actual per-vehicle capacity. A per-vehicle cost of about $11.1 million (Stadler 2019) was used in the estimate.

[b] Because the cog rail system would connect to the existing UTA light rail system, a stand-alone OMF would not be needed for this concept. An allocation of $25.1 million is included in the cost estimate to account for expanding the existing OMF.

[c] A large parking structure would not be needed for this concept.

[d] Snow shed lengths of 2.14 miles (low range) and 3.84 miles (high range) were used. Snow shed unit cost is about $25,000 per linear foot based on a conceptually designed three-travel-lane snow shed.

The total estimated cost range for designing and constructing a cog rail system that connects to the Midvale Fort Union TRAX Station and runs about 18.1 miles to Alta is about $1.8 million to $1.9 billion. This cost does not include any parking structures or expanding existing park-and-ride lots. UDOT allocated $25.1 million for expanding UTA's existing OMF to accommodate the 9 to 12 additional cog rail vehicles needed for this concept. Snow sheds would cost about $282.5 million to $506.9 million total, depending on the final snow shed lengths needed. **The total estimated cost range for cog rail Concept 4A is about $2.09 billion to $2.44 billion.**

As mentioned in Section 5.4, Concept 4 – Connection to the Existing TRAX System, UDOT prepared a concept deign for Concept 4B. Table 13 presents rough order-of-magnitude capital cost estimates for Concept 4B.

Table 13. Concept 4B, Capital Cost Range

Element	Component Cost ($million, 2019$) Low Range	High Range
Guideway and track elements	180.6	180.6
Stations and terminals	4.2	4.2
Site work (utilities and roadways)	67.7	67.7
Systems (controls, communications, and power supply/distribution)	369.8	369.8
Professional services (engineering, construction admin., legal, startup)	236.3	236.3
Contingencies (about 20%)	203.4	203.4
Cog rail vehicles [a]	100.0	133.3
Cog rail subtotal	1,162.0	1,195.3
Operation and maintenance facility [b]	25.1	25.1
Parking structure [c]	—	—
Snow sheds [d]	282.5	506.9
Total	1,469.6	1,727.3

[a] Nine (low range) to 12 (high range) cog rail vehicles would be needed depending on the actual per-vehicle capacity. A per-vehicle cost of about $11.1 million (Stadler 2019) was used in the estimate.

[b] Because the cog rail system would connect to the existing UTA light rail system, a stand-alone OMF would not be needed for this concept. An allocation of $25.1 million is included in the cost estimate to account for expanding the existing OMF.

[c] A large parking structure would not be needed for this concept.

[d] Snow shed lengths of 2.14 miles (low range) and 3.84 miles (high range) were used. Snow shed unit cost is about $25,000 per linear foot based on a conceptually designed three-travel-lane snow shed.

The total estimated cost range for designing and constructing a rail system that connects to the Historic Sandy TRAX Station and runs for about 14.3 miles to Alta is about $1.21 million to $1.24 billion. This cost does not include any parking structures or expanding existing park-and-ride lots. UDOT allocated $25.1 million for expanding UTA's existing OMF to accommodate the 9 to 12 additional cog rail vehicles needed for this concept. Snow sheds would cost about $282.5 million to $506.9 million total, depending on the final snow shed lengths needed. A capital cost summary for Concept 4B is included in Appendix A. **The total estimated cost range for cog rail Concept 4B is about $1.74 billion to $1.77 billion.**

O&M Cost

Given the 36.2-mile round trip with Concept 4A and the 28.6-mile round trip with Concept 4B, the total miles traveled by cog rail vehicles would be 147,696 miles with Concept 4A and 116,688 miles with Concept 4B. At $9.61 per vehicle revenue-mile, the total estimated annual O&M costs would be about **$1,420,000** for Concept 4A and about **$1,122,000** for Concept 4B.

6.0 Comparison of Cog Rail Concepts

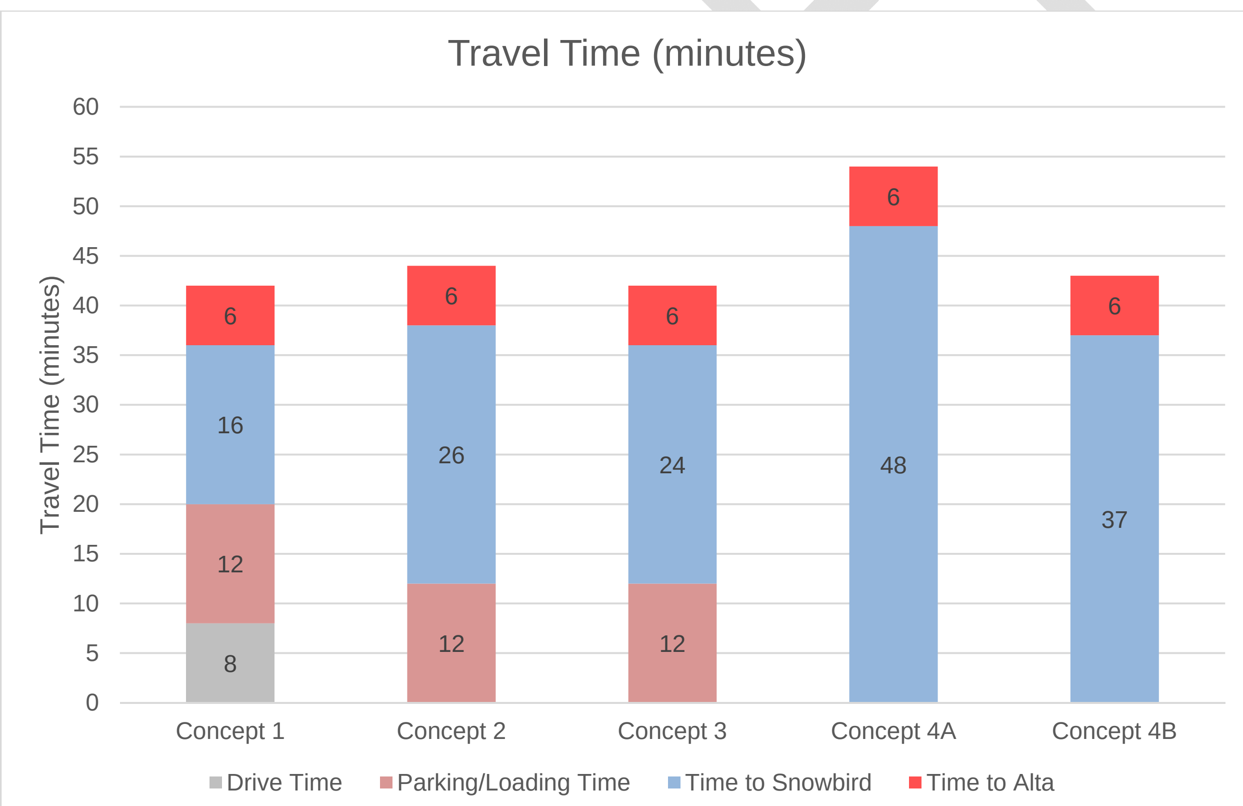
Taking into account the details of each scenario as described in Section 5.0, Rail Concepts Evaluation, UDOT compared the scenarios using the major initial feasibility criteria of travel time and capital and O&M costs. UDOT also compared the scenarios using the additional feasibility criterion of the purpose of the Little Cottonwood Canyon Project as well as specific considerations that apply to implementation of cog rail.

6.1 Rail Concept Comparisons Using the Major Feasibility Criteria

6.1.1 Travel Times

Figure 11 compares the estimated travel times for the rail concepts evaluated in this preliminary rail feasibility study.

Figure 11. Travel Time Comparisons



With the assumptions used in this initial feasibility study, the fastest overall travel times to the resorts in a cog rail train would occur with an expanded parking area and rail base station near the mouth of Little Cottonwood Canyon (Concept 1 with a travel time of about 42 minutes). Concept 1 includes 8 minutes of travel time in personal vehicle, which is the modeled travel time along Wasatch Boulevard with planned roadway improvements from Fort Union Boulevard to the base train station. Moving the parking away from the canyon, to Wasatch Boulevard and Fort Union Boulevard or to 9400 South and Highland Drive mobility hubs, would have similar total travel times (44 minutes for Concept 2 and 42 minutes for Concept 3). The 8-minute car ride with Concept 1 would be replaced with a 10-minute train ride with Concept 2. Note that the drive time in a personal vehicle was not included in Concept 3 since train riders' initial travel patterns could shift away from Wasatch Boulevard.

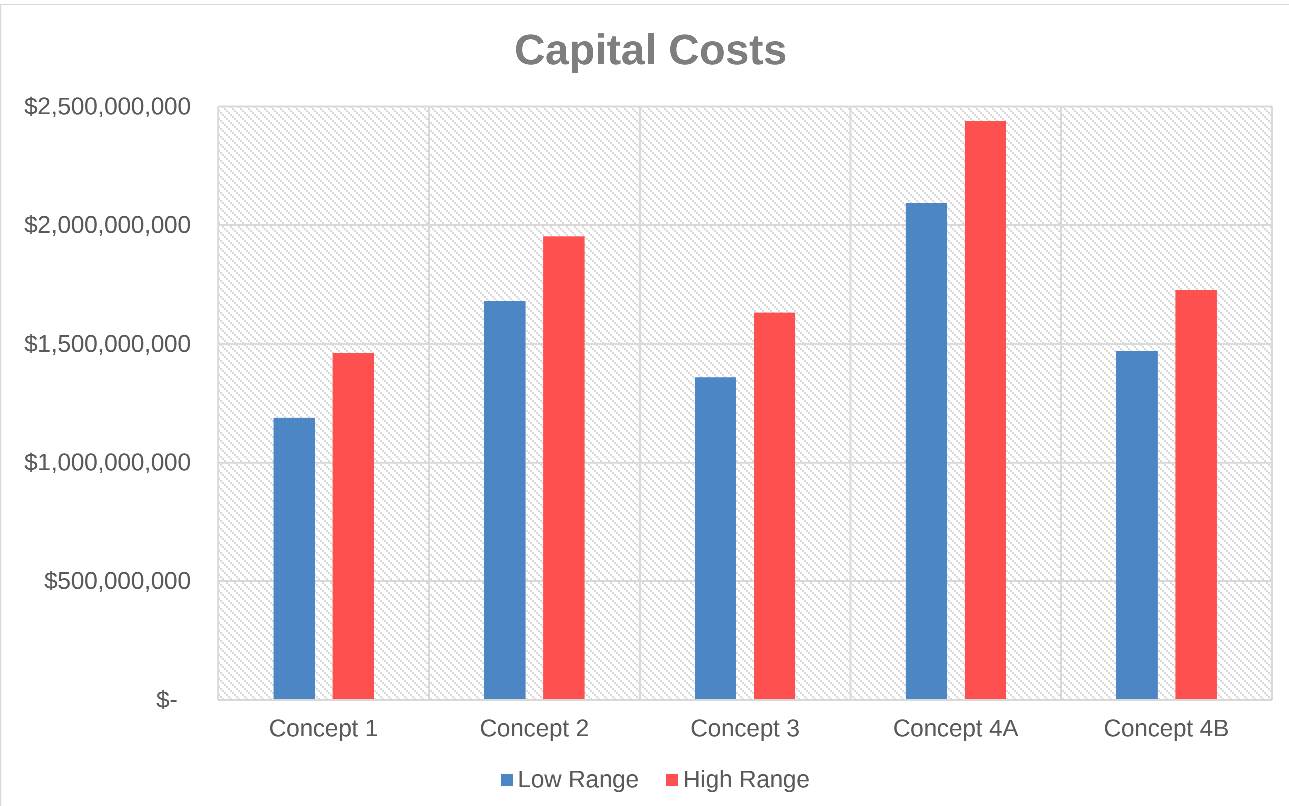
Connecting a Little Cottonwood Canyon cog rail to the existing TRAX system would result in travel times of 43 to 54 minutes from the assumed connection points (Historic Sandy or Midvale Fort Union TRAX Stations). These concepts would be 2 to 12 minutes longer than Concept 1. However, the travel times for Concepts 4A and 4B do not include any personal vehicle travel time nor any parking and loading times. With the concepts that connect to the existing light rail systems, travel times would be longer for riders embarking from TRAX stations located north or south of these connection points. Passengers embarking from intermediate stations along the Little Cottonwood Canyon cog rail line between the connection point and the mouth of Little Cottonwood Canyon would experience shorter travel times.

6.1.2 Capital and O&M Costs

Capital Costs

Figure 12 compares the estimated low- and high-range, capital costs for the cog rail concepts evaluated in this initial feasibility report.

Figure 12. Capital Cost Comparison



The least expensive concept, Concept 1 with a parking structure and a base rail station at the mouth of Little Cottonwood Canyon, would cost about $1.19 billion to about $1.46 billion. In addition to the track, power systems, rail vehicles, parking, and OMF, a major capital cost consideration is the need for snow sheds to protect the cog rail track and OCS from avalanches. Because an electrified third rail at ground level is not feasible, OCS would be needed, and the OCS would need to be protected to avoid long shut-down periods and to maintain reliable operations. These snow sheds, however, add considerable capital cost (an additional $300 million to $500 million total) from what might be typical for a new light rail or cog rail system.

Using a mobility hub that is located away from the mouth of the Little Cottonwood Canyon would require more infrastructure and more cog rail vehicles to serve peak-hour users. Capital costs for Concepts 2 and 3 are estimated to be between about $1.36 billion (low range for Concept 3) and about $1.95 billion (high range for Concept 2), or $170 million to $490 million more than Concept 1. Note that the capital cost for

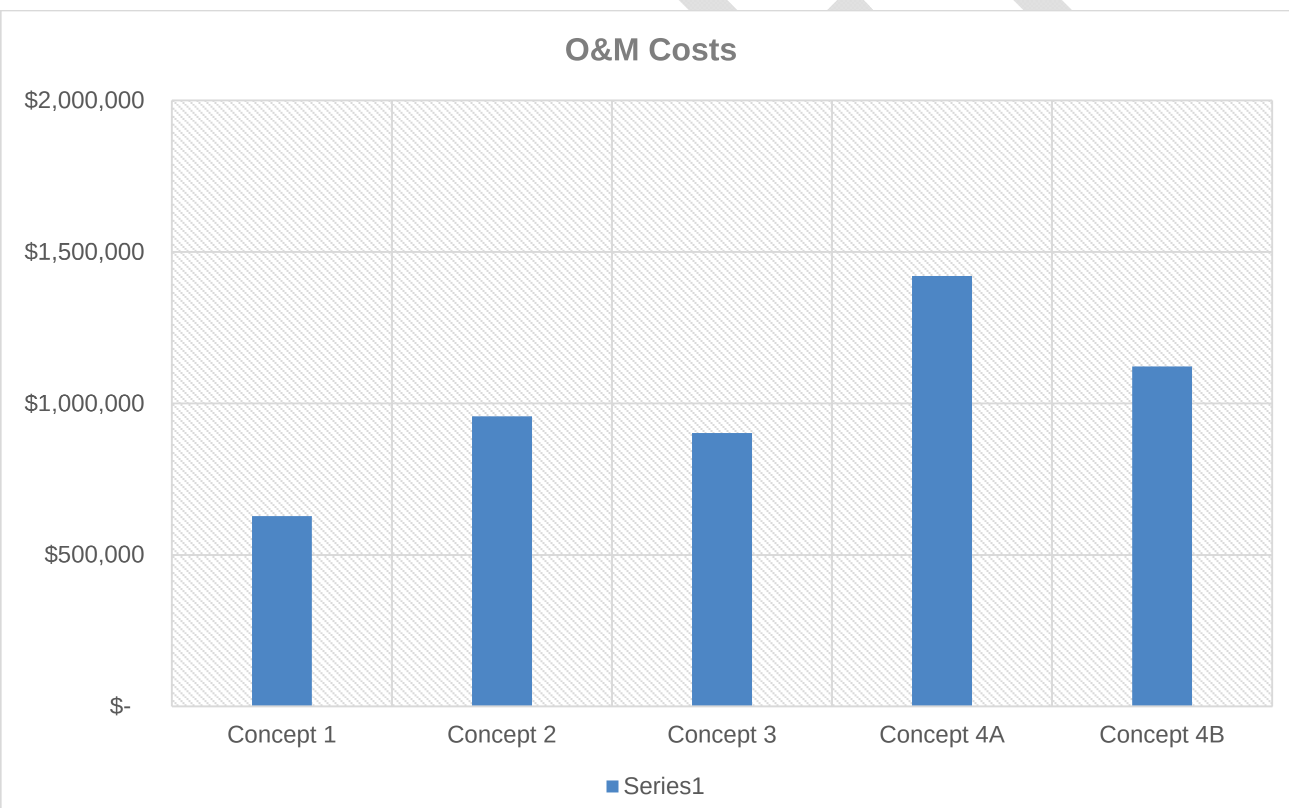
Concept 2 accounts for the planned roadway improvements to Wasatch Boulevard, which are needed to serve projected weekday commuter traffic.

The estimated cost of light rail line in an urban environment is about $100 million per mile. The per-mile cost offsets the avoided cost of a large parking structure ($52 million) and a large stand-alone OMF ($60 million to $75 million), which would not be required for Concepts 4A and 4B. Connecting a Little Cottonwood Canyon cog rail line to the existing TRAX system would cost about $1.7 billion to $2.4 billion (high range), or at least $260 million to more than $978 million more than Concept 1.

O&M Costs

O&M cost was determined by calculating the total miles travel annually by the cog rail vehicles and applying a per-mile unit operating cost. Figure 13 shows the approximate O&M costs for the cog rail concepts evaluated in this report. O&M costs would range from about $0.63 million to $1.4 million annually for winter service for the various concepts evaluated in this report.

Figure 13. O&M Cost Comparison



Concepts with parking near the mouth of Little Cottonwood Canyon or at mobility hubs would cost about $0.63 million to more than $0.96 million annually to operate rail vehicles and maintain the rolling stock and infrastructure. Annual O&M costs for concepts that connect to the existing light rail system would be $1.12 million to $1.42 million. Because it is shortest route, Concept 1 would have the lowest O&M cost.

6.1.3 Comparison of Major Feasibility Criteria

Table 14 compares the major feasibility criteria for the cog rail concepts evaluated in this initial feasibility report.

Table 14. Cog Rail Capital Cost, O&M Cost, and Travel Time Comparison

Concept	Capital Cost (billion $)	Annual O&M Cost (million $)	Total Travel Time to Alta (minutes)
1	1.19 to 1.46	0.63	42
2	1.68 to 1.95	0.96	44
3	1.36 to 1.63	0.90	42 [a]
4A	2.09 to 2.44	1.42	54 [a,b]
4B	1.47 to 1.73	1.12	43 [a,b]

[a] Total travel times does not include any personal vehicle travel time.

[b] Total travel time does not include parking and loading times

6.2 Rail Concept Comparisons Using Additional Feasibility Criteria

In addition to comparing the scenarios in terms of their travel time and capital and O&M costs (Section 6.1, Rail Concept Comparisons Using the Major Feasibility Criteria), UDOT compared the rail concepts in terms of additional feasibility criteria pertaining to the purpose of the Little Cottonwood Canyon Project (improved mobility and improved neighborhood access or reduced congestion). UDOT included additional criteria pertaining to transportation reliability and changes to travel patterns, which are considerations that apply to rail transit in an urban environment. Other environmental impacts would be addressed in the EIS if a cog rail concept is selected for detailed analysis. These additional feasibility criteria are described below, and the scenarios' ratings for these criteria are summarized in Section 6.2.6, Summary of Rail Concept Comparisons Using Additional Feasibility Criteria.

6.2.1 Impacts to Congestion

There is an existing park-and-ride lot at the mouth of Little Cottonwood Canyon at the intersection of S.R. 210 and S.R. 209. The existing lot has about 160 spaces. An expanded parking lot at or near this location, which could accommodate the assumed cog rail ridership, would require a large, multilevel parking structure. UDOT initially assumes that a 2,500-car parking structure would be required to meet the daily demand for the number transit riders entering the canyon.

Some members of the public are strongly opposed to expanding the parking lot at this location because traffic during peak times creates traffic congestion in the area and restricts residents' mobility. A large parking structure at the base of the canyon, which would be needed with Concept 1, would not help relieve congestion on S.R. 210 and S.R. 209 during peak arrival times. The congestion would be similar to the current conditions with traffic trying to enter the canyon. One of the purposes of the Little Cottonwood Canyon Project is to reduce congestion-related access issues for residents who live at the base on the canyon (not being able to arrive at or leave their neighborhoods on peak ski days). Therefore, Concept 1 would have a high impact under this criterion.

Moving the parking and rail base station to a mobility hub located away from the mouth of the canyon (Concepts 2 and 3) would benefit residents' mobility by removing some cars from the residential area. Concept 2, which places the parking structure at the gravel pit and therefore closer to an interstate freeway (I-215) is better than Concept 3, which is about miles from 3 miles from I-15. With Concept 2, personal vehicles would travel past more residential areas to access the parking structure at the 9400 South and Highland Drive mobility hub. For train riders using their personal vehicle for the initial stages of their trip, parking for Concept 4 could be more dispersed, and Concept 4 would not concentrate traffic to just one parking area.

6.2.2 Needed Roadway Improvements and Impacts to Travel Patterns

Implementing a cog rail line outside Little Cottonwood Canyon would require major roadway infrastructure improvements and would change travel patterns on the existing roadway network. There are many residential areas adjacent to the rail alignments outside Little Cottonwood Canyon. A center-running rail line would limit left turns out of these neighborhoods. Drivers who want to make a left-hand turn would be required to turn right, travel to a signalized intersection, and make a left U-turn or make a loop along other routes. The complicated details of the changed travel patterns through all cog rail concepts segments was not evaluated in this initial feasibility report. In general, cog rail concepts that run down the center of S.R. 210 (Wasatch Boulevard), S.R. 209 (9400/9000 South), and S.R. 190 (Fort Union Boulevard) would require extensive roadway widening, would have high impacts to the existing utility infrastructure, and would substantially change the travel patterns to and from residential and commercial areas that abut these arterial roads. Concept 1 would rank as low, Concepts 2 and 3 as medium, and Concepts 4A and 4B as high under this criterion.

6.2.3 Potential Residential Impacts

Concept 1, which runs on the north side S.R. 210, would require the acquisition of a few homes that are located in the upper portions of the canyon. Compared to other concepts, Concept 1 would score low on the residential impacts criterion. Several residential areas surround the mouth of Little Cottonwood Canyon. Cog rail concepts outside the canyon have a high potential to affect residents and will result in several property acquisitions. The preliminary design for Concept 2 assumes a wider typical cross-section because the concept includes improvements to Wasatch Boulevard. Concept 2 (and 4A, which has the same Wasatch Boulevard segment as Concept 2) has a higher potential for property acquisitions. The design for Concepts 3 and 4B would reconstruct the same number of travel lanes as exist now. These concepts have a medium rank for the potential to affect residential areas.

6.2.4 Improving Mobility and Maximizing Transit Ridership

One way to improve mobility is by providing additional transportation modes. A cog rail line would address wintertime mobility primarily by shifting a substantial portion of the future travel demand to mass transit and possibly would avoid the need to add automobile capacity in the canyon. As described in this report, UDOT's initial evaluation assumes that a percentage of the peak hourly demand could be accommodated by a cog rail system, and that all rail concepts are essentially equal in this regard. The actual expected ridership would be based on many factors including travel time benefits and pricing, which was not estimated in this conceptual feasibility report.

In general, a “one-seat ride” (either vehicle or transit) is most preferable to users. One mode shift, or a “two-seat ride,” is less desirable but is still acceptable to many users as evidenced by the use of the existing park-and-ride lots and the popularity of ski bus service. If a Little Cottonwood Canyon cog rail line were connected to UTA’s existing, and expansive, light rail network, there would be more potential riders in proximity to the existing park-and-ride lots, and this might make the transit portion of the trip attractive to more users. However, until all rail vehicles become equipped with cog equipment, riders would need to shift travel modes from standard light rail vehicles that operate over the existing network to a cog rail vehicles that can navigate the grades in the canyon. Shifting travel modes twice (from car to light rail to cog rail), or a “three-seat ride,” would likely be unpopular but could be acceptable to some users if the travel time were shorter than with other available options or if it were less expensive. If resort parking becomes more limited in the future, or if future policy decisions limit automobile use in the canyon, a longer train ride could be a reasonable scenario.

The annual transit ridership, measured as a percentage of total trips in the canyon, would be low without other traffic demand management tools (such as tolling) or an overall policy to substantially restrict personal vehicles in the canyon. The resulting fare needed to pay back a portion of the cog rail’s capital cost and help fund operating expenses was not determined for this initial feasibility study. UDOT is conducting an analysis to understand canyon users’ willingness to pay for transit service versus the value of their time (“ridership elasticity”) and will apply those findings in the ongoing alternatives-evaluation process for the EIS. The biggest cost driver is the length of the rail infrastructure, which affects both initial capital costs and annual O&M costs. Moving the rail base station to mobility hubs located away from the mouth of Little Cottonwood Canyon (Concepts 2 and 3, which would cost between $1.95 billion and $1.6 billion, respectively) would cost about $170 million to $492 million more (up to about 34% more) than would a rail base station at the mouth of the canyon (Concept 1, which would cost about $1.18 billion to 1.46 billion). The additional infrastructure would tend to increase the fare required to pay back the initial capital cost, if the intent is to require users to pay back some of the costs.

6.2.5 Avalanche Closure Risks

An additional mobility consideration is the reliability of the transportation system given the unique characteristics of the Little Cottonwood Canyon transportation corridor. The current avalanche-control program in Little Cottonwood Canyon causes the road to be closed periodically for avalanche control and can cause 2-to-4-hour travel delays or longer. This causes traffic to back up in the neighborhoods at the entrance of the canyon.

As described in Section 4.6, Avalanche Protections, UDOT initially assumes that snow sheds in would be needed for cog rail concepts as passive avalanche-control measures. UDOT estimated that between 2.14 and 3.84 miles of snow sheds would be needed to protect the track and OCS from avalanches with all concepts. If the entire cog rail OCS needs to be protected in all avalanche paths in the canyon, up to 7.5 miles of snow sheds might be required. Placing snow sheds in these paths to protect the cog rail track and OCS from avalanches would also make a cog rail system reliable compared to the existing road and could significantly reduce closure times (currently about 56.3 hours of road closure per year), which are needed for the active avalanche-control measures (primarily artillery) currently being used. However, these come at a high cost, as explained in Section 5.0, Rail Concept Evaluation. All cog rail concepts are equivalent for this criterion.

6.2.6 Summary of Rail Concept Comparisons Using Additional Feasibility Criteria

Table 15 shows a comparison of evaluation criteria presented in this initial feasibility report.

Table 15. Comparison of Costs, Travel Times, and Additional Feasibility Criteria

Concept	Capital Cost (billion $)	Annual O&M (million $)	Travel Time to Alta (minutes)	Impacts to Traffic Congestion	Roadway Improvements and Impacts on Existing Travel Patterns	Potential Residential Impacts	Expected Ridership
1	1.19 to 1.46	0.63	42	High	Low	Low	High
2	1.68 to 1.95	0.96	44	Low	Medium	High	High
3	1.36 to 1.63	0.90	42	Medium	Medium	Medium	High
4A	2.09 to 2.44	1.42	54	Low	High	High	Medium
4B	1.47 to 1.73	1.12	43	Low	High	Medium	Medium

Comparing these rankings, Concept 1 has the lowest costs, fastest travel times, lowest impacts to the existing roadway network, no impacts to existing travel patterns outside Little Cottonwood Canyon, and the least amount of residential impacts. However, Concept 1 does not relieve congestion to residential areas at the mouth of the canyon during times of peak winter demand. Relieving congestion by moving the parking and base cog rail station from the mouth of the canyon comes at a high cost due to the additional rail infrastructure and the need for roadway reconstruction. Moving the parking also introduces other impacts; the impacts to residential areas increase, and the cog rail line running in the center of travel lanes would change area travel patterns.

UDOT will use this information during the alternatives development and screening process for the Little Cottonwood Canyon EIS, which will evaluate how well the rail transit concepts described in this report would satisfy the purpose of and need for the Little Cottonwood Canyon Project. The information in this report will be used to compare the most feasible rail technology and conceptual alignments with other mobility modes (aerial transit, buses, and/or roadway improvements) that are being considered to address the purpose of the project. UDOT would prepared more-refined engineering design for the rail concept(s) if one or more are carried forward for a detailed analysis in the EIS. After that more-refined engineering design is complete, more-accurate costs and impact estimates could be provided.

7.0 References

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APPENDIX A

Cost Estimates

			LCC - Cog Rail Concept Concept 1 - LCC Mouth to Alta		
SCC	SCC Sub	Item #	Item Description	YoE	Subtotal YoE
10			GUIDEWAY & TRACK ELEMENTS (Route Miles)		$129,953,623
	10.05		Guideway: Earthwork		$99,113,043
	10.10		Track: Embedded		$0
	10.11		Track: Ballasted		$28,521,739
	10.12		Track: Special (switches, turnouts)		$2,318,841
20			STATIONS, STOPS, TERMINALS, INTERMODAL (number)		$4,173,913
	20.01		At-grade station, stop, shelter, mall, terminal, platform		$4,173,913
	20.06		Automobile parking multi-story structure		$0
30			SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS		$75,362,319
	30.03		Heavy Maintenance Facility		$75,362,319
40			SITEWORK & SPECIAL CONDITIONS		$15,055,652
	40.01		Demolition, Clearing, Earthwork		$2,747,826
	40.02		Site Utilities, Utility Relocation		$7,327,536
	40.03		Additional Projects / Locations		$0
	40.04		Environmental mitigation, e.g. wetlands, historic/archeologic, parks		$1,831,884
	40.05		Curb, Sidewalk, Guardrail		$1,188,406
	40.06		Pedestrian / bike access and accommodation, landscaping		$686,957
	40.07		Roadway Work		$1,273,043
	40.08		Temporary Facilities and other indirect costs during construction		$0
50			SYSTEMS		$202,453,426
	50.01		Train control and signals		$16,115,942
	50.02		Traffic signals and crossing protection		$765,217
	50.03		Traction power supply: substations		$153,977,322
	50.04		Traction power distribution: catenary system		$16,864,510
	50.05		Communications		$8,701,449
	50.06		Fare collection system and equipment		$231,884
	50.07		Central Control		$5,797,101
60			ROW, LAND, EXISTING IMPROVEMENTS		$0
	60.01		Purchase or lease of real estate		$0
	60.02		Relocation of existing households and businesses		$0
70			VEHICLES (number)		$88,888,889
	70.01		Cog Rail Vehicles		$88,888,889
80			PROFESSIONAL SERVICES (applies to Cats. 10-50)		$236,302,244
	80.01		Preliminary Engineering		$22,867,287
	80.02		Final Design		$60,979,433
	80.03		Project Management for Design and Construction		$45,734,575
	80.04		Construction Administration & Management		$48,992,020
	80.05		Professional Liability and other Non-Construction Insurance		$8,165,337
	80.06		Legal; Permits; Review Fees by other agencies, cities, etc.		$16,330,673
	80.07		Surveys, Testing, Investigation, Inspection		$16,330,673
	80.08		Start up		$16,902,247
90			UNALLOCATED CONTINGENCY		$150,438,013
100			FINANCE CHARGES		*YoE Total*
	Segment Totals (10-100)				$902,628,080

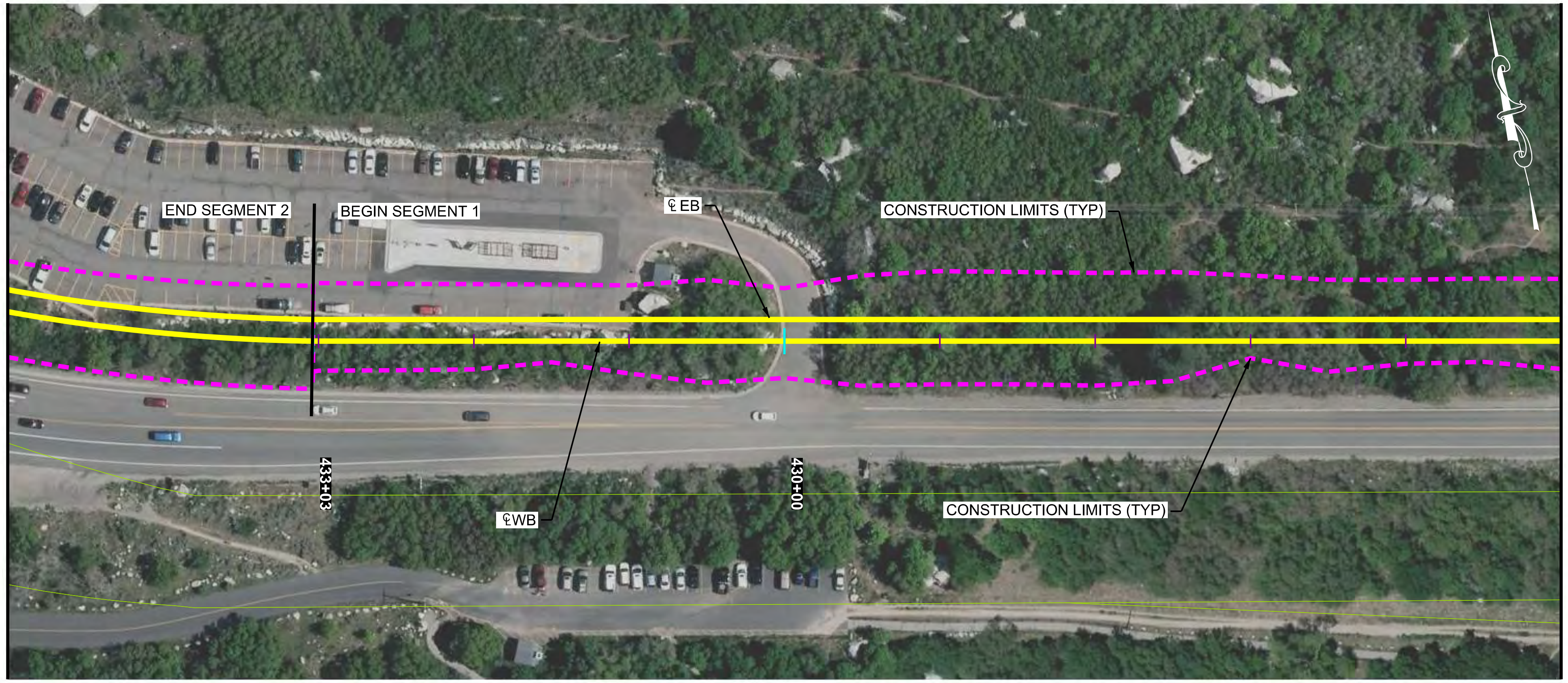
			LCC - Cog Rail Concept Concept 2 - Gravel Pit to Alta		
SCC	SCC Sub	Item #	Item Description	YoE	Subtotal YoE
10			GUIDEWAY & TRACK ELEMENTS (Route Miles)		$167,411,710
	10.05		Guideway: Earthwork		$99,576,812
	10.10		Track: Embedded		$36,414,609
	10.11		Track: Ballasted		$28,521,739
	10.12		Track: Special (switches, turnouts)		$2,898,551
20			STATIONS, STOPS, TERMINALS, INTERMODAL (number)		$4,173,913
	20.01		At-grade station, stop, shelter, mall, terminal, platform		$4,173,913
	20.06		Automobile parking multi-story structure		$0
30			SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS		$75,362,319
	30.03		Heavy Maintenance Facility		$75,362,319
40			SITEWORK & SPECIAL CONDITIONS		$233,155,100
	40.01		Demolition, Clearing, Earthwork		$8,255,072
	40.02		Site Utilities, Utility Relocation		$27,617,391
	40.03		Additional Projects / Locations		$0
	40.04		Environmental mitigation, e.g. wetlands, historic/archeologic, parks		$2,991,304
	40.05		Curb, Sidewalk, Guardrail		$10,985,863
	40.06		Pedestrian / bike access and accommodation, landscaping		$1,846,377
	40.07		Roadway Work		$77,787,729
	40.08		Temporary Facilities and other indirect costs during construction		$103,671,363
50			SYSTEMS		$319,716,586
	50.01		Train control and signals		$25,043,478
	50.02		Traffic signals and crossing protection		$3,826,087
	50.03		Traction power supply: substations		$239,937,623
	50.04		Traction power distribution: catenary system		$30,671,716
	50.05		Communications		$14,208,696
	50.06		Fare collection system and equipment		$231,884
	50.07		Central Control		$5,797,101
60			ROW, LAND, EXISTING IMPROVEMENTS		$0
	60.01		Purchase or lease of real estate		$0
	60.02		Relocation of existing households and businesses		$0
70			VEHICLES (number)		$100,000,000
	70.01		Cog Rail Vehicles		$100,000,000
80			PROFESSIONAL SERVICES (applies to Cats. 10-50)		$261,185,696
	80.01		Preliminary Engineering		$25,275,293
	80.02		Final Design		$67,400,780
	80.03		Project Management for Design and Construction		$50,550,585
	80.04		Construction Administration & Management		$54,151,051
	80.05		Professional Liability and other Non-Construction Insurance		$9,025,175
	80.06		Legal; Permits; Review Fees by other agencies, cities, etc.		$18,050,350
	80.07		Surveys, Testing, Investigation, Inspection		$18,050,350
	80.08		Start up		$18,682,112
90			UNALLOCATED CONTINGENCY		$232,201,065
100			FINANCE CHARGES		*YoE Total*
	Segment Totals (10-100)				$1,393,206,389

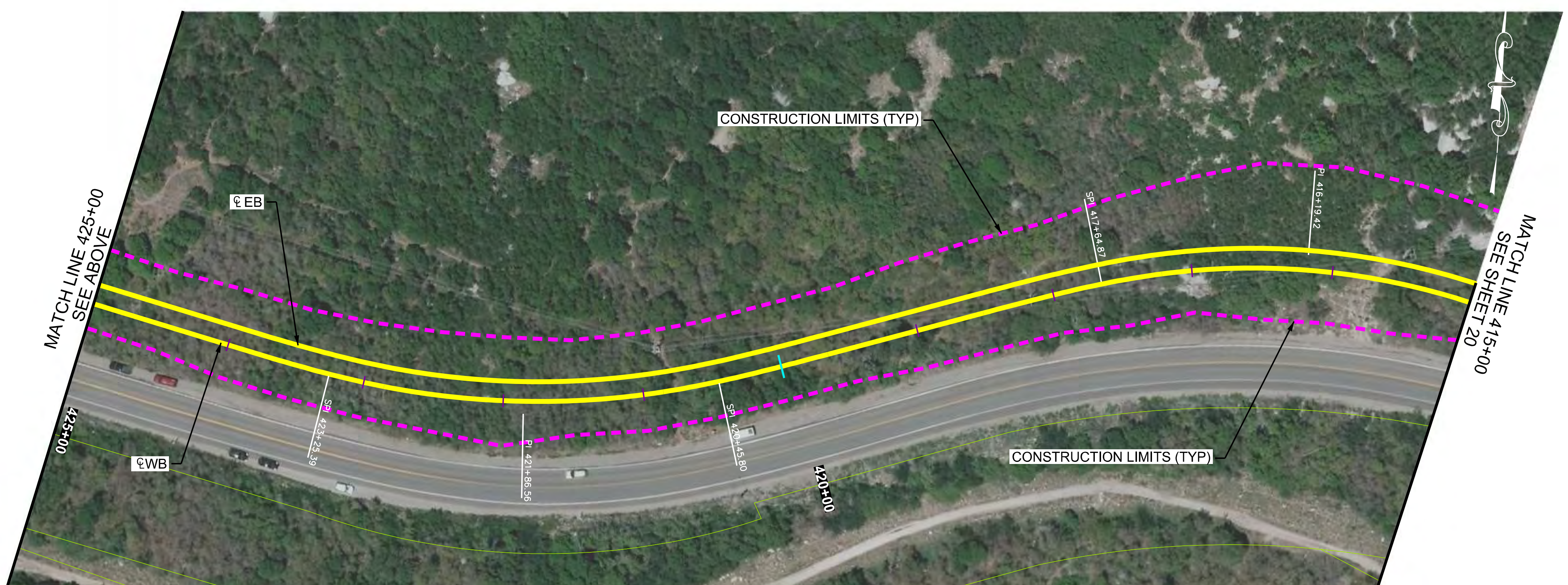
			LCC - Cog Rail Concept		
			Concept 3 - 9400/Highland to Alta		
SCC	**SCC Sub**	**Item #**	**Item Description**	**YoE**	**Subtotal YoE**
10			**GUIDEWAY & TRACK ELEMENTS (Route Miles)**		**$157,431,884**
	10.05		Guideway: Earthwork		**$99,576,812**
	10.10		Track: Embedded		**$26,434,783**
	10.11		Track: Ballasted		**$28,521,739**
	10.12		Track: Special (switches, turnouts)		**$2,898,551**
20			**STATIONS, STOPS, TERMINALS, INTERMODAL (number)**		**$4,173,913**
	20.01		At-grade station, stop, shelter, mall, terminal, platform		**$4,173,913**
	20.06		Automobile parking multi-story structure		**$0**
30			**SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS**		**$75,362,319**
	30.03		Heavy Maintenance Facility		**$75,362,319**
40			**SITEWORK & SPECIAL CONDITIONS**		**$40,879,305**
	40.01		Demolition, Clearing, Earthwork		**$6,602,899**
	40.02		Site Utilities, Utility Relocation		**$15,849,275**
	40.03		Additional Projects / Locations		**$0**
	40.04		Environmental mitigation, e.g. wetlands, historic/archeologic, parks		**$2,643,478**
	40.05		Curb, Sidewalk, Guardrail		**$1,985,971**
	40.06		Pedestrian / bike access and accommodation, landscaping		**$1,701,449**
	40.07		Roadway Work		**$12,096,232**
	40.08		Temporary Facilities and other indirect costs during construction		**$0**
50			**SYSTEMS**		**$280,195,525**
	50.01		Train control and signals		**$25,043,478**
	50.02		Traffic signals and crossing protection		**$3,849,275**
	50.03		Traction power supply: substations		**$205,939,757**
	50.04		Traction power distribution: catenary system		**$26,777,507**
	50.05		Communications		**$12,556,522**
	50.06		Fare collection system and equipment		**$231,884**
	50.07		Central Control		**$5,797,101**
60			**ROW, LAND, EXISTING IMPROVEMENTS**		**$0**
	60.01		Purchase or lease of real estate		**$0**
	60.02		Relocation of existing households and businesses		**$0**
70			**VEHICLES (number)**		**$100,000,000**
	70.01		Cog Rail Vehicles		**$100,000,000**
80			**PROFESSIONAL SERVICES (applies to Cats. 10-50)**		**$236,302,244**
	80.01		Preliminary Engineering		**$22,867,287**
	80.02		Final Design		**$60,979,433**
	80.03		Project Management for Design and Construction		**$45,734,575**
	80.04		Construction Administration & Management		**$48,992,020**
	80.05		Professional Liability and other Non-Construction Insurance		**$8,165,337**
	80.06		Legal; Permits; Review Fees by other agencies, cities, etc.		**$16,330,673**
	80.07		Surveys, Testing, Investigation, Inspection		**$16,330,673**
	80.08		Start up		**$16,902,247**
90			**UNALLOCATED CONTINGENCY**		**$178,869,038**
100			**FINANCE CHARGES**		***YoE Total***
	Segment Totals (10-100)				**$1,073,214,227**

			LCC - Cog Rail Concept Concept 4B - Sandy Trax to Alta		
SCC	SCC Sub	Item #	Item Description	YoE	Subtotal YoE
10			GUIDEWAY & TRACK ELEMENTS (Route Miles)		$180,620,290
	10.05		Guideway: Earthwork		$100,040,580
	10.10		Track: Embedded		$48,000,000
	10.11		Track: Ballasted		$28,521,739
	10.12		Track: Special (switches, turnouts)		$4,057,971
20			STATIONS, STOPS, TERMINALS, INTERMODAL (number)		$4,173,913
	20.01		At-grade station, stop, shelter, mall, terminal, platform		$4,173,913
	20.06		Automobile parking multi-story structure		$0
30			SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS		$25,120,773
	30.03		Heavy Maintenance Facility		$25,120,773
40			SITEWORK & SPECIAL CONDITIONS		$67,678,145
	40.01		Demolition, Clearing, Earthwork		$9,797,101
	40.02		Site Utilities, Utility Relocation		$22,910,145
	40.03		Additional Projects / Locations		$0
	40.04		Environmental mitigation, e.g. wetlands, historic/archeologic, parks		$3,315,942
	40.05		Curb, Sidewalk, Guardrail		$3,670,029
	40.06		Pedestrian / bike access and accommodation, landscaping		$2,542,029
	40.07		Roadway Work		$25,442,899
	40.08		Temporary Facilities and other indirect costs during construction		$0
50			SYSTEMS		$369,873,310
	50.01		Train control and signals		$32,869,565
	50.02		Traffic signals and crossing protection		$6,168,116
	50.03		Traction power supply: substations		$273,925,194
	50.04		Traction power distribution: catenary system		$35,130,725
	50.05		Communications		$15,750,725
	50.06		Fare collection system and equipment		$231,884
	50.07		Central Control		$5,797,101
60			ROW, LAND, EXISTING IMPROVEMENTS		$0
	60.01		Purchase or lease of real estate		$0
	60.02		Relocation of existing households and businesses		$0
70			VEHICLES (number)		$133,333,333
	70.01		Cog Rail Vehicles		$133,333,333
80			PROFESSIONAL SERVICES (applies to Cats. 10-50)		$236,302,244
	80.01		Preliminary Engineering		$22,867,287
	80.02		Final Design		$60,979,433
	80.03		Project Management for Design and Construction		$45,734,575
	80.04		Construction Administration & Management		$48,992,020
	80.05		Professional Liability and other Non-Construction Insurance		$8,165,337
	80.06		Legal; Permits; Review Fees by other agencies, cities, etc.		$16,330,673
	80.07		Surveys, Testing, Investigation, Inspection		$16,330,673
	80.08		Start up		$16,902,247
90			UNALLOCATED CONTINGENCY		$203,420,402
100			FINANCE CHARGES		*YoE Total*
	Segment Totals (10-100)				$1,220,522,410

APPENDIX B1

Preliminary Design Plans for Segment 1 – Little Cottonwood





REVISIONS

NO.	DATE	APPROVED BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION

HDR

DRAWN BY

QC CHECKED BY

APPROVED

PROFESSIONAL ENGINEER

DATE

PROJECT: LITTLE COTTONWOOD CANYON EIS

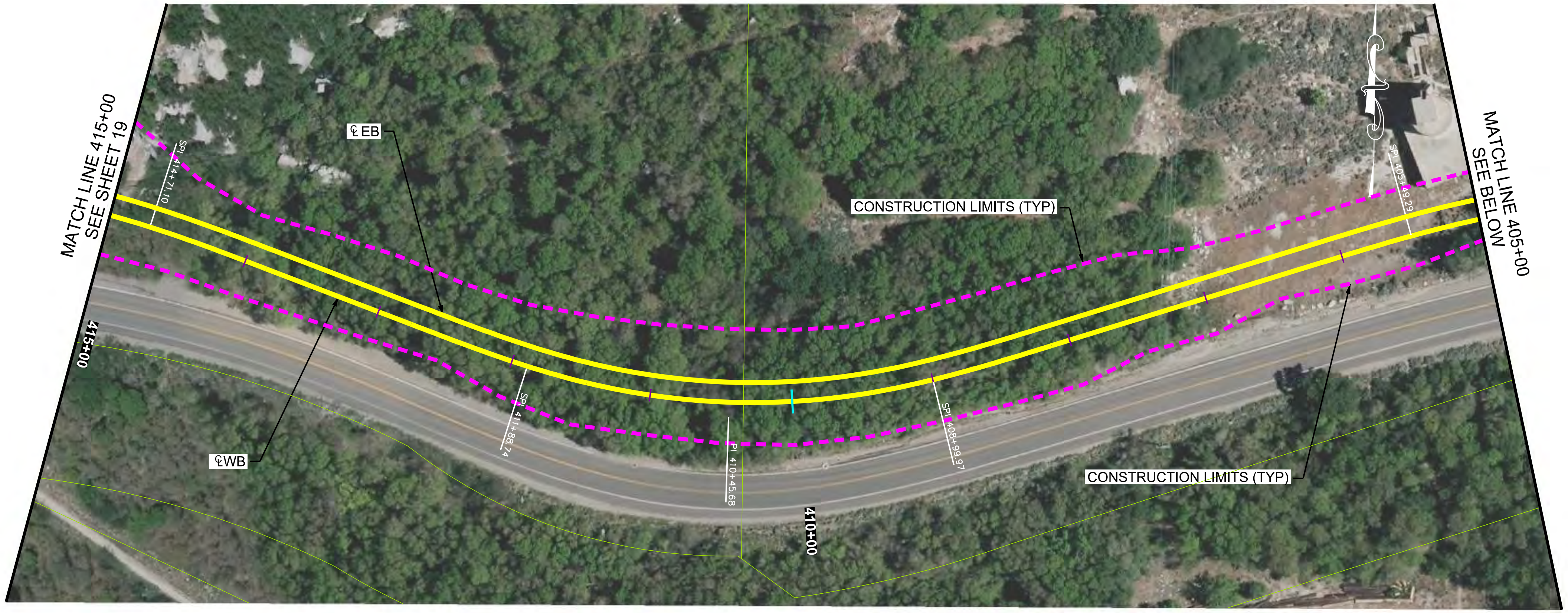
COG RAIL SEGMENT 1

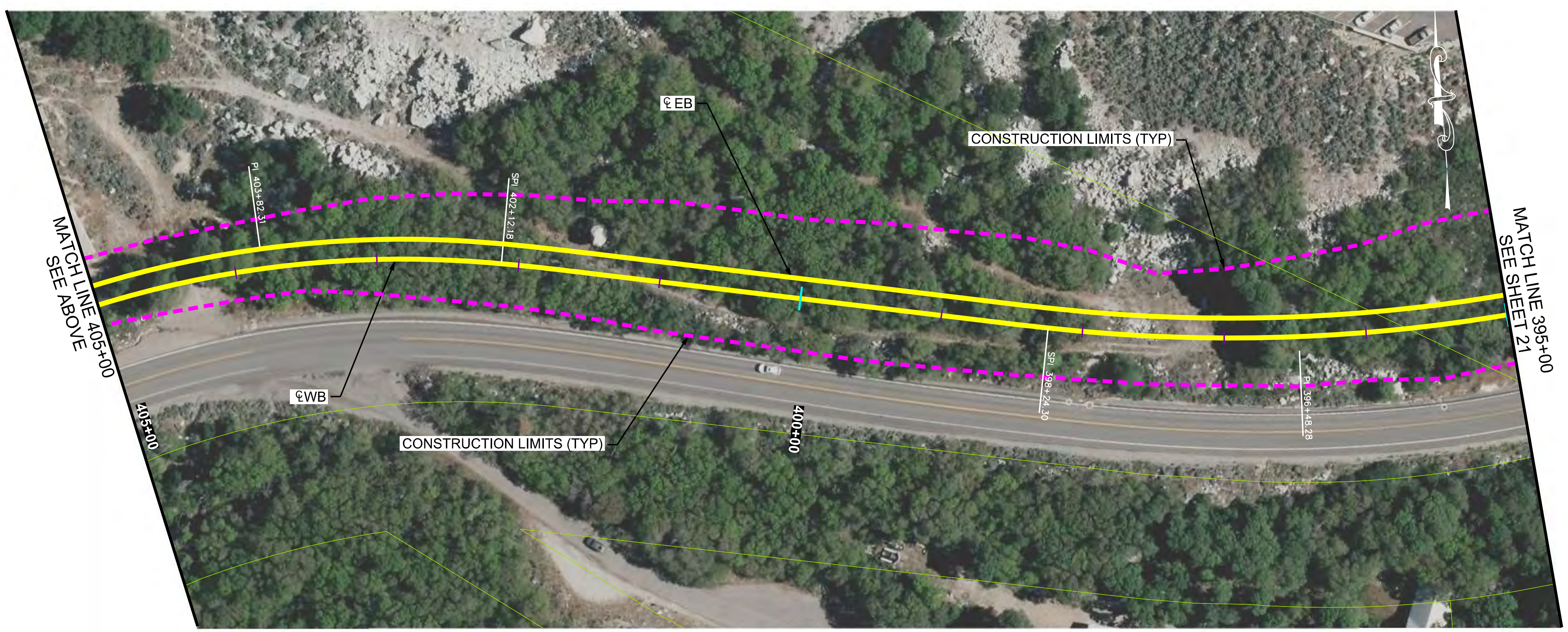
PIN 16092

PROJECT NUMBER XXXX

SHEET NO. 19

2/17/2020





REVISIONS			
NO.	DATE	APPROVED BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION

HDR

DRAWN BY

QC CHECKED BY

DATE

APPROVED

PROFESSIONAL ENGINEER

PROJECT: LITTLE COTTONWOOD CANYON EIS

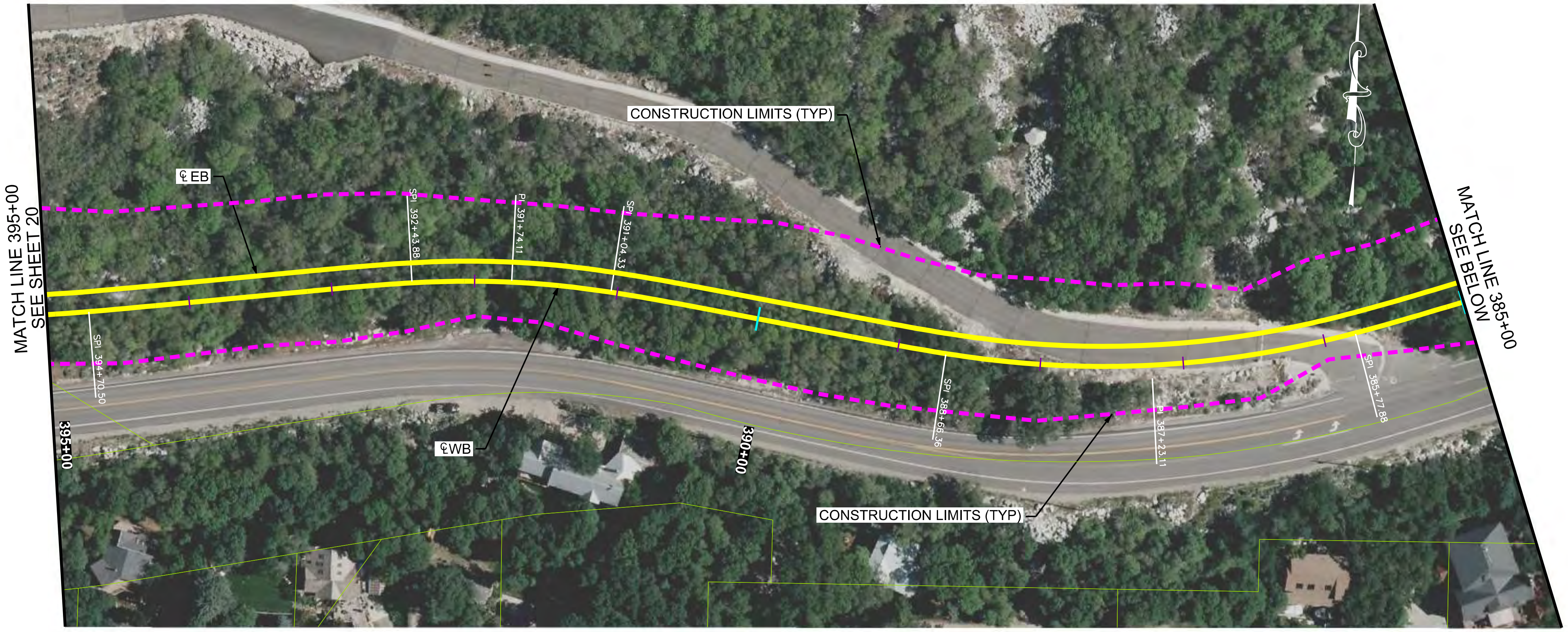
COG RAIL SEGMENT 1

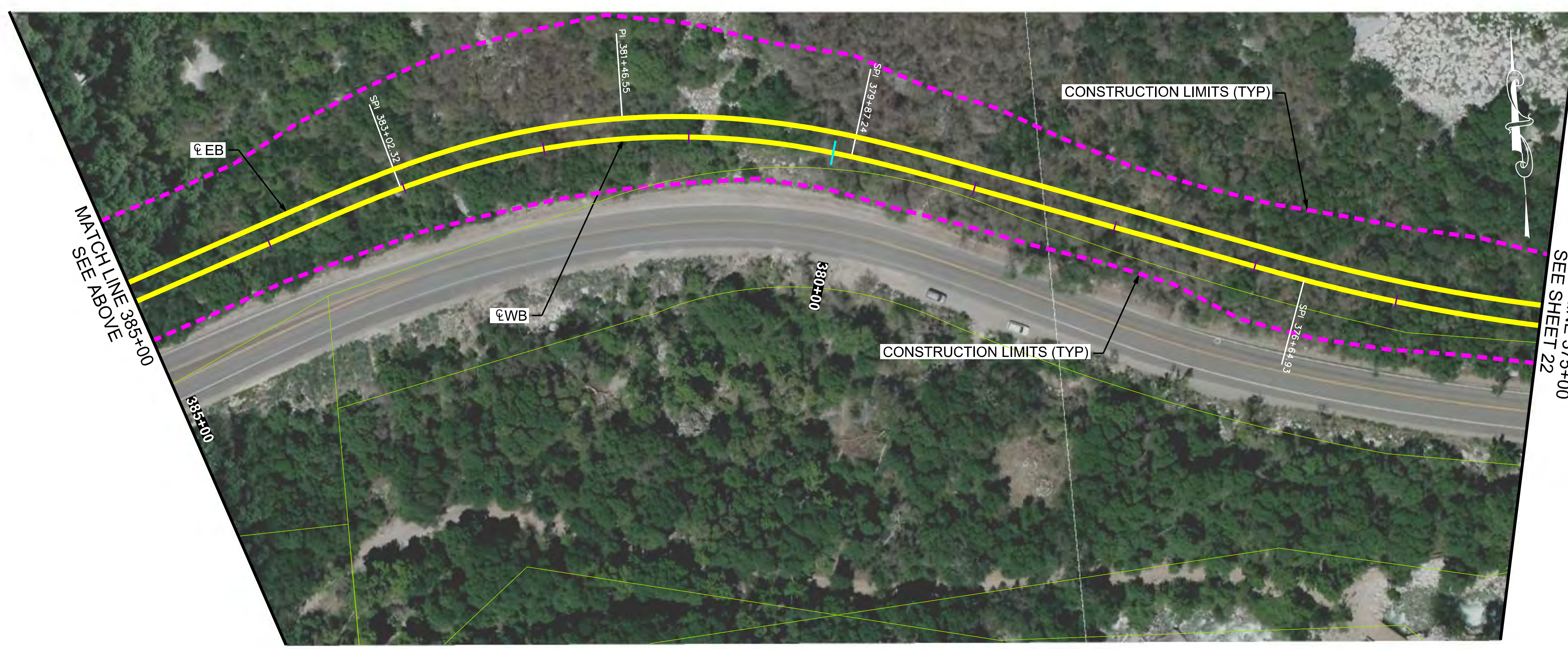
PIN 16092

PROJECT NUMBER: XXXX

SHEET NO. 20

2/17/2020





REVISIONS

NO.	DATE	APPROVED BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION

HDR

DRAWN BY

QC CHECKED BY

APPROVED

PROFESSIONAL ENGINEER　　DATE

PROJECT: LITTLE COTTONWOOD CANYON EIS
COG RAIL SEGMENT 1

PIN 16092

PROJECT NUMBER: XXXX

SHEET NO. 21

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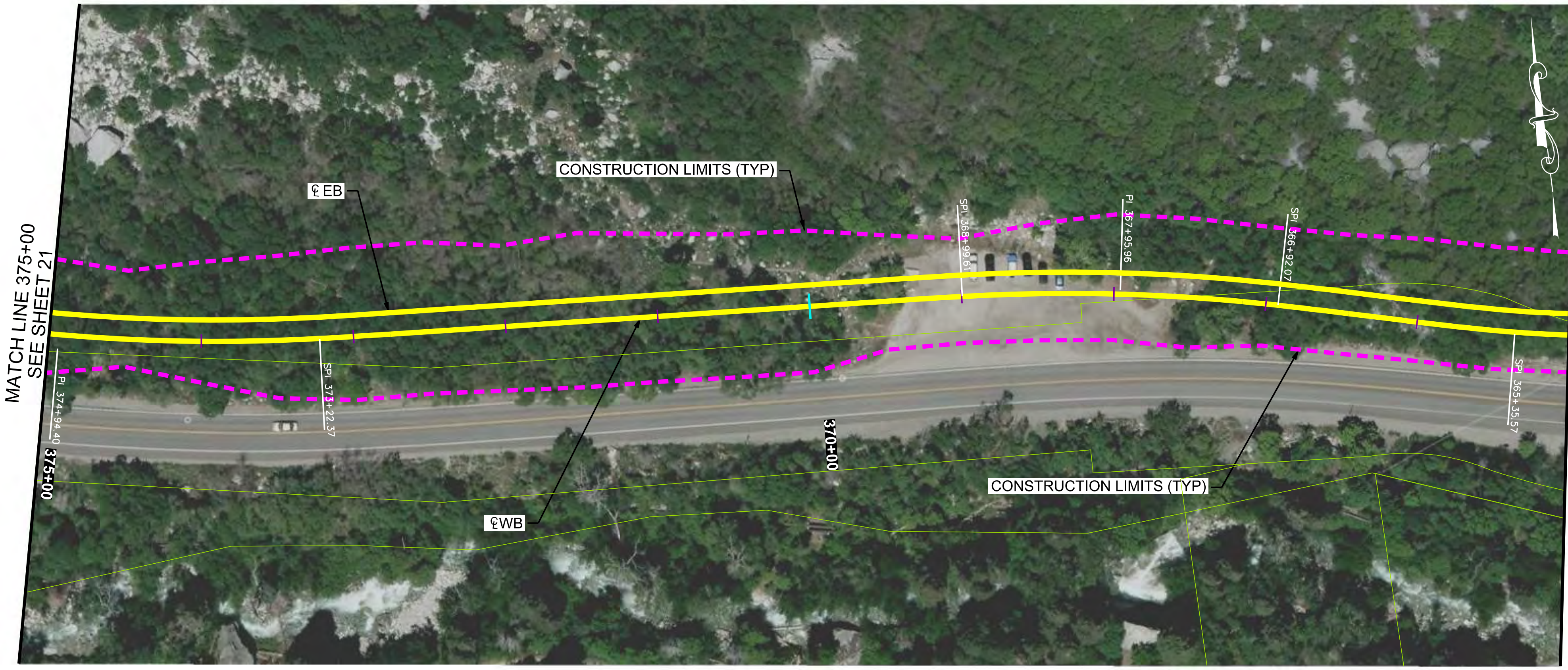

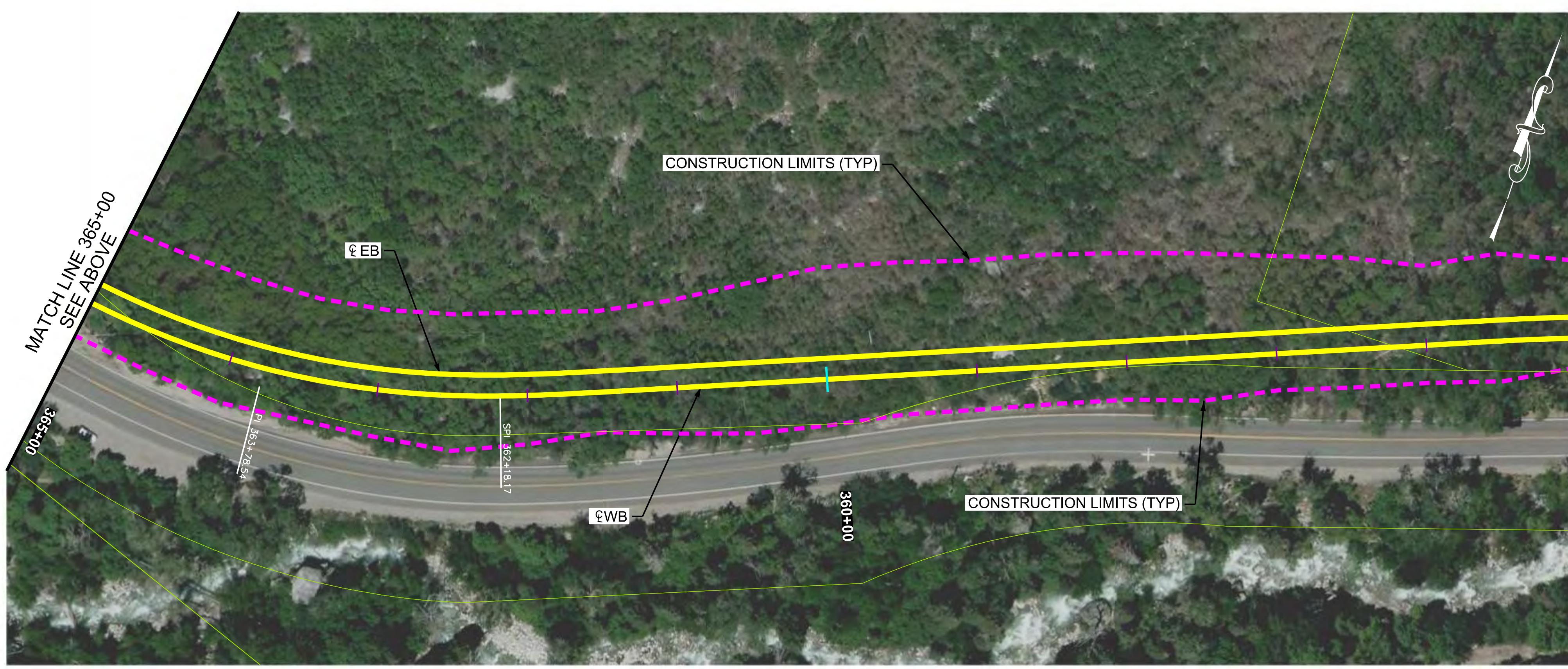

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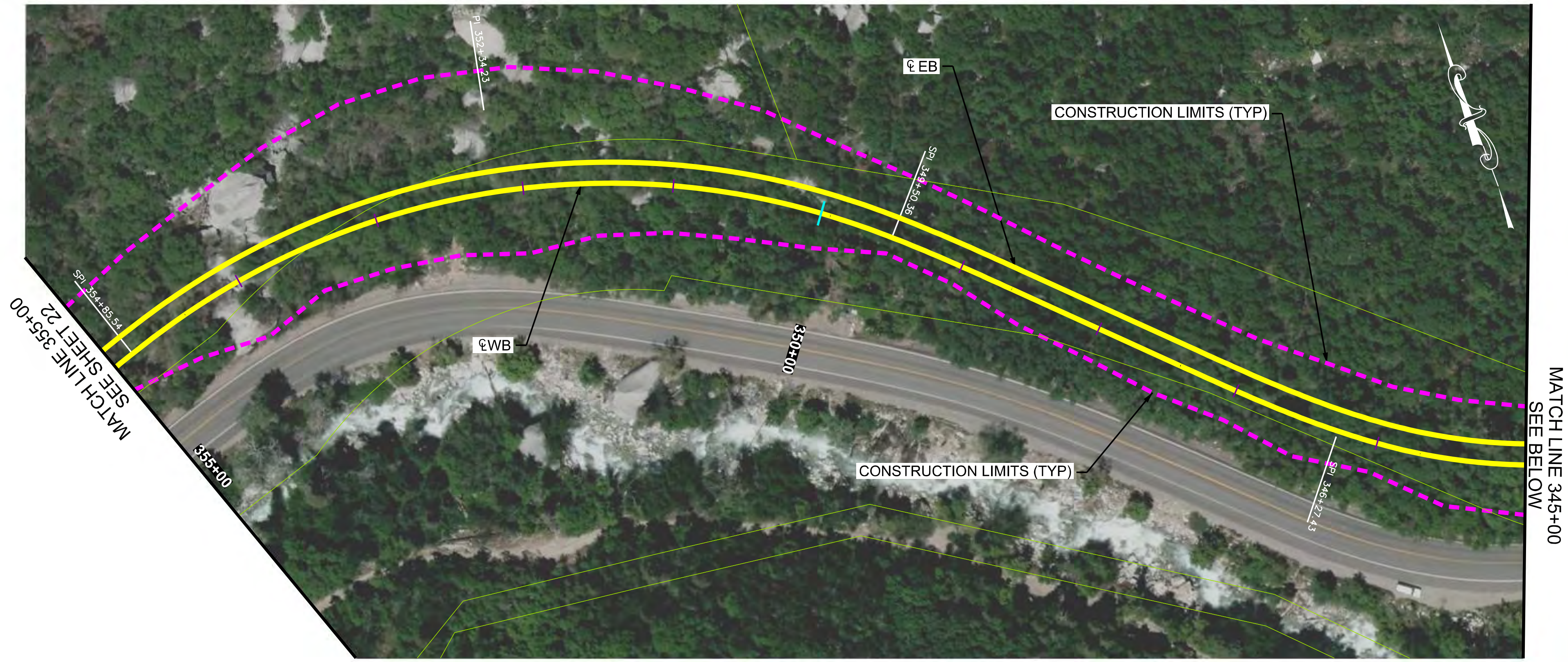
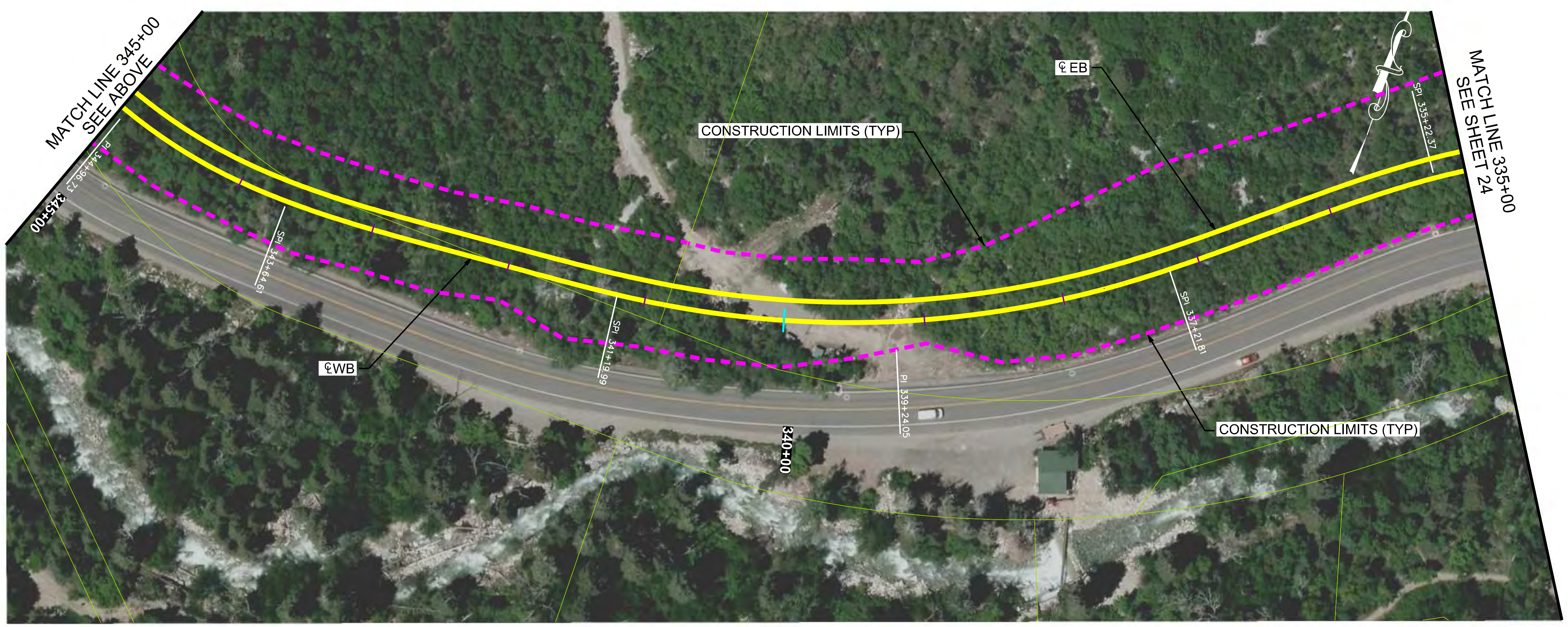
COG RAIL SEGMENT 1

PROJECT NUMBER: XXXX

PIN: 16092

SHEET NO. 22





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COG RAIL SEGMENT 1

PROJECT NUMBER: XXXX

PIN: 16092

SHEET NO. 23

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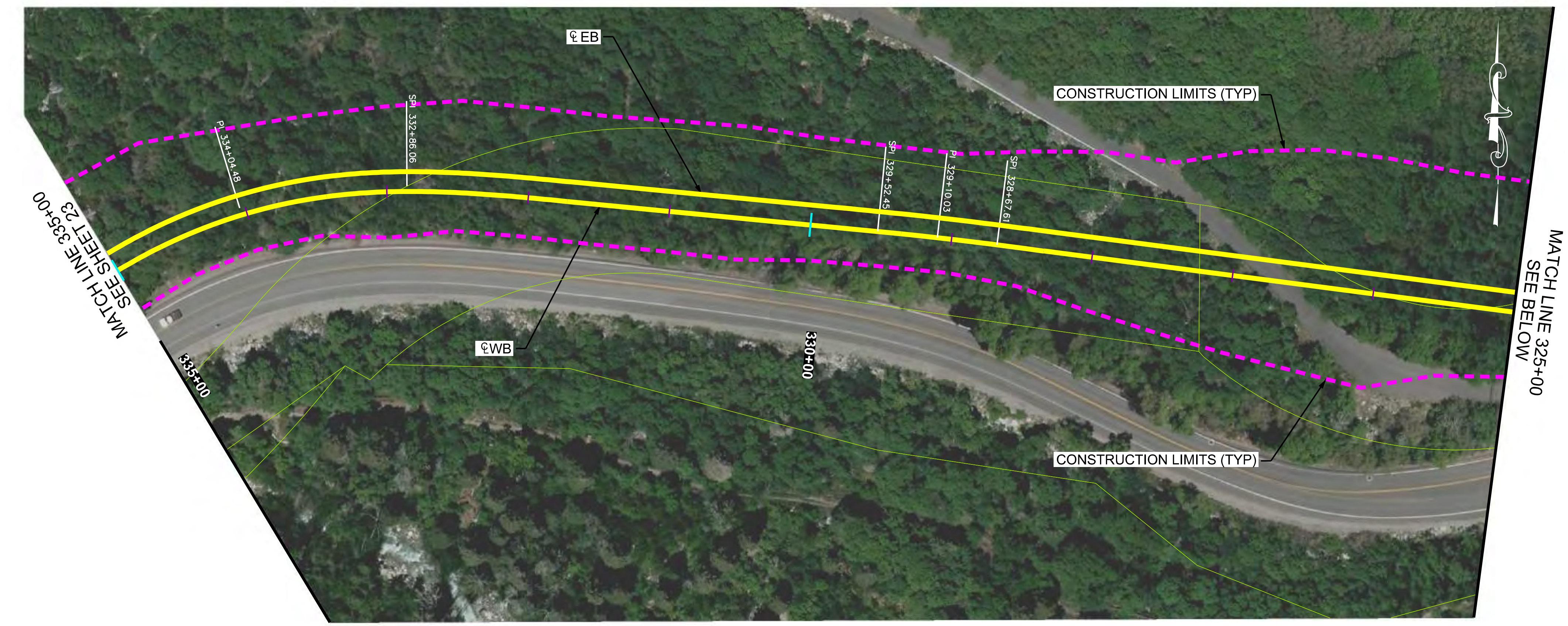

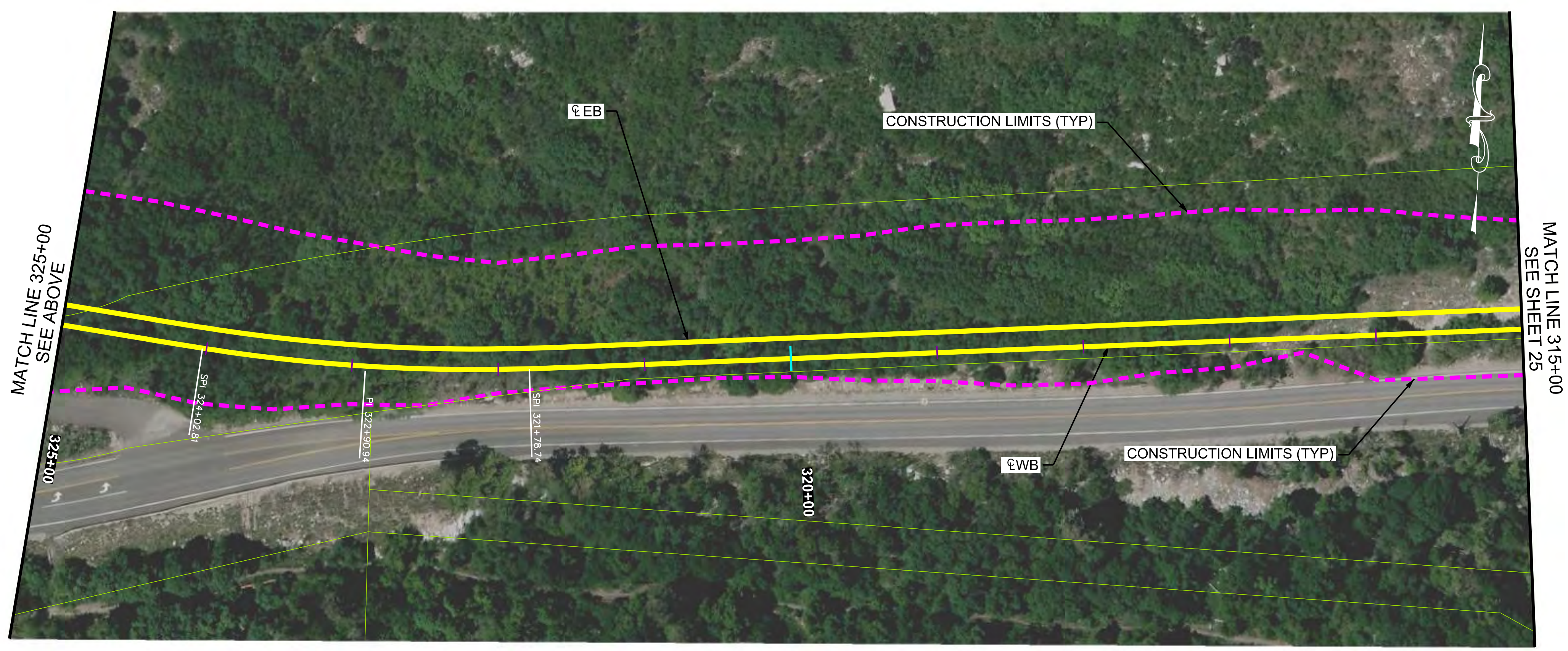

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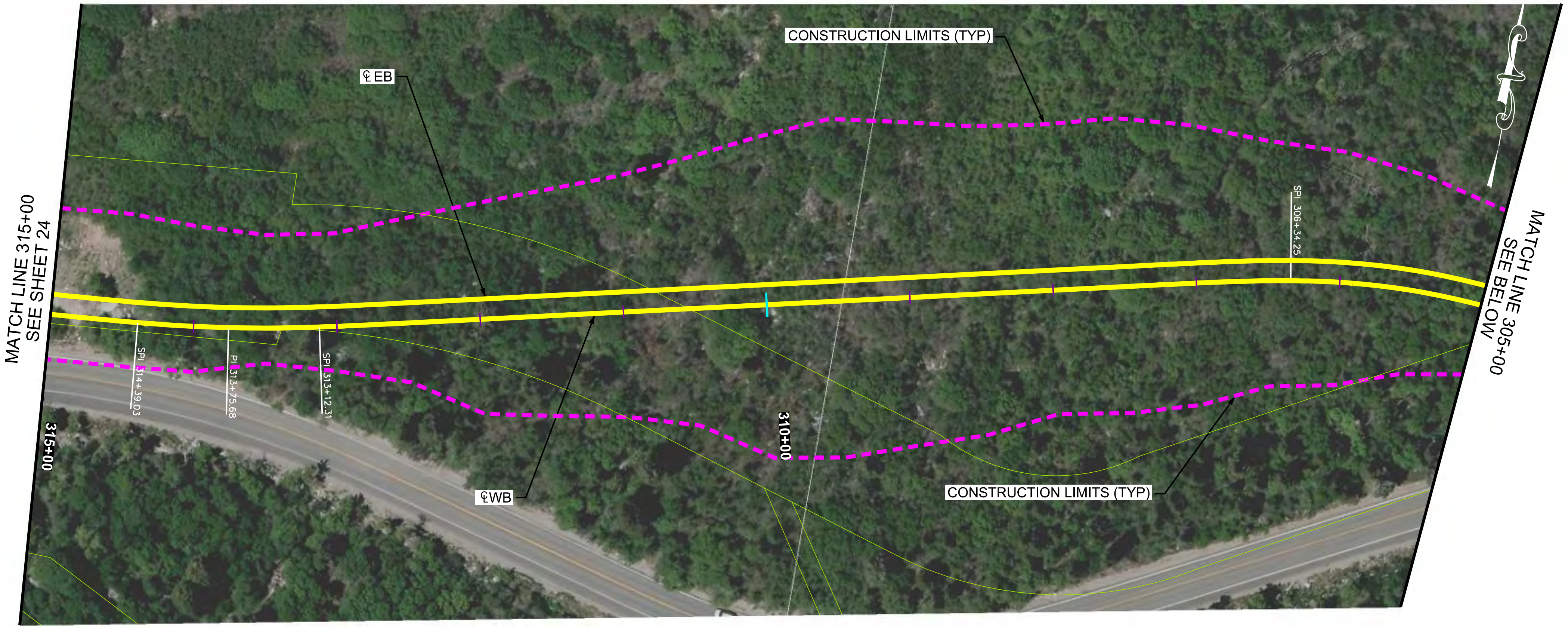

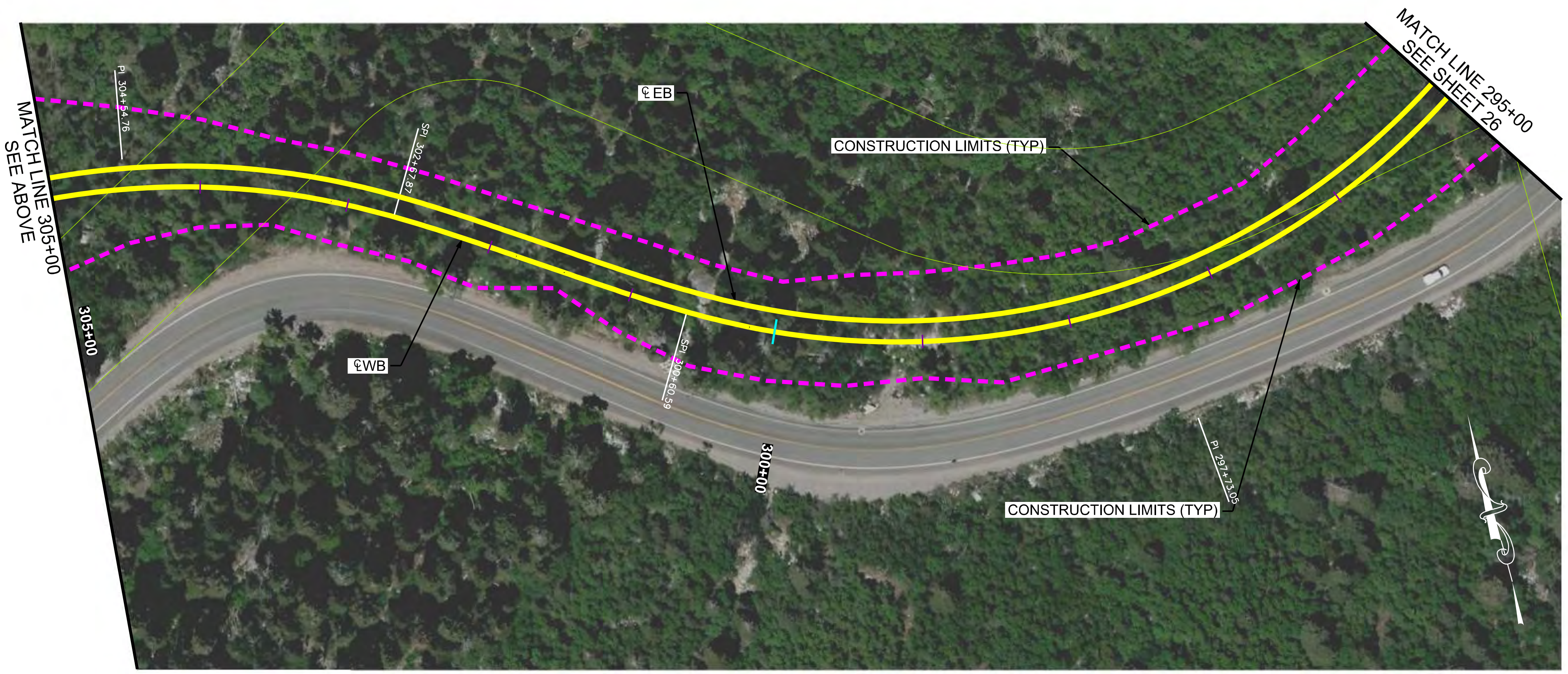

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COG RAIL SEGMENT 1

PROJECT NUMBER: XXXX

PIN: 16092

SHEET NO. 25

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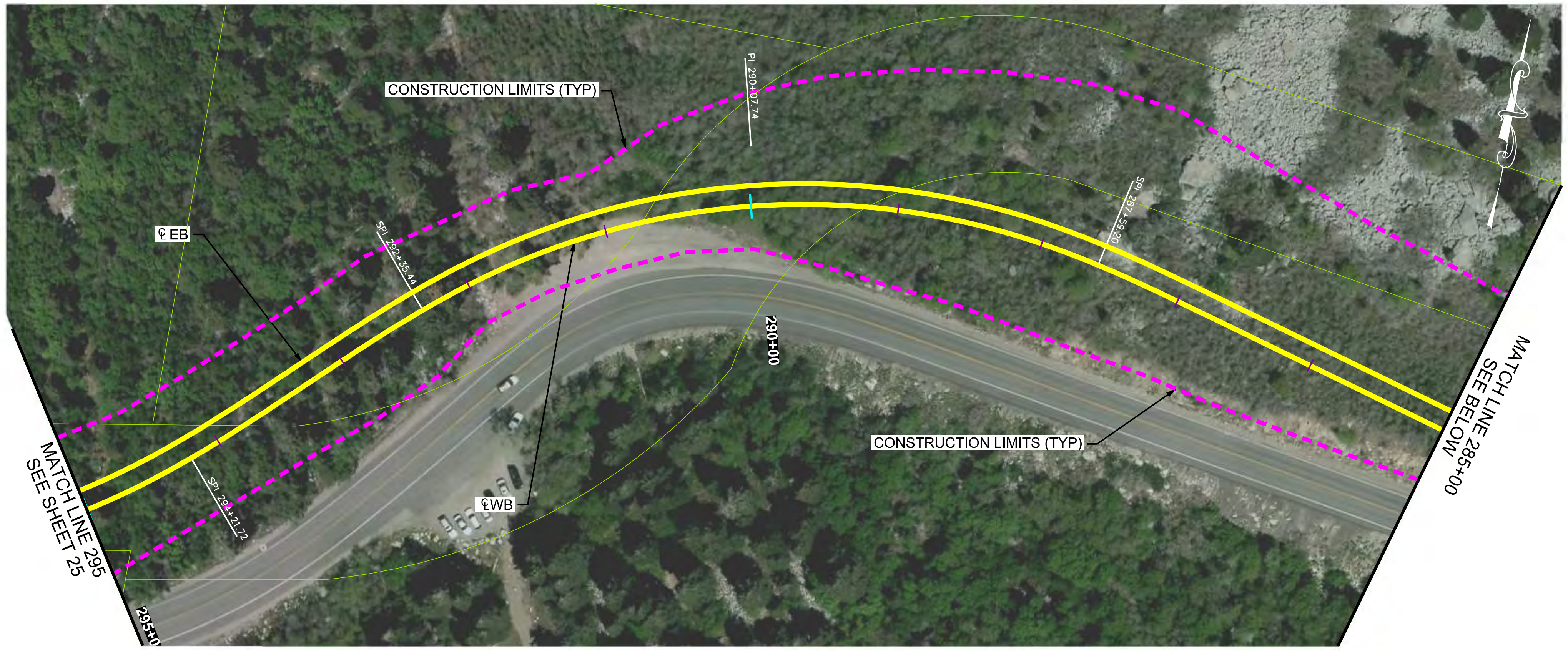

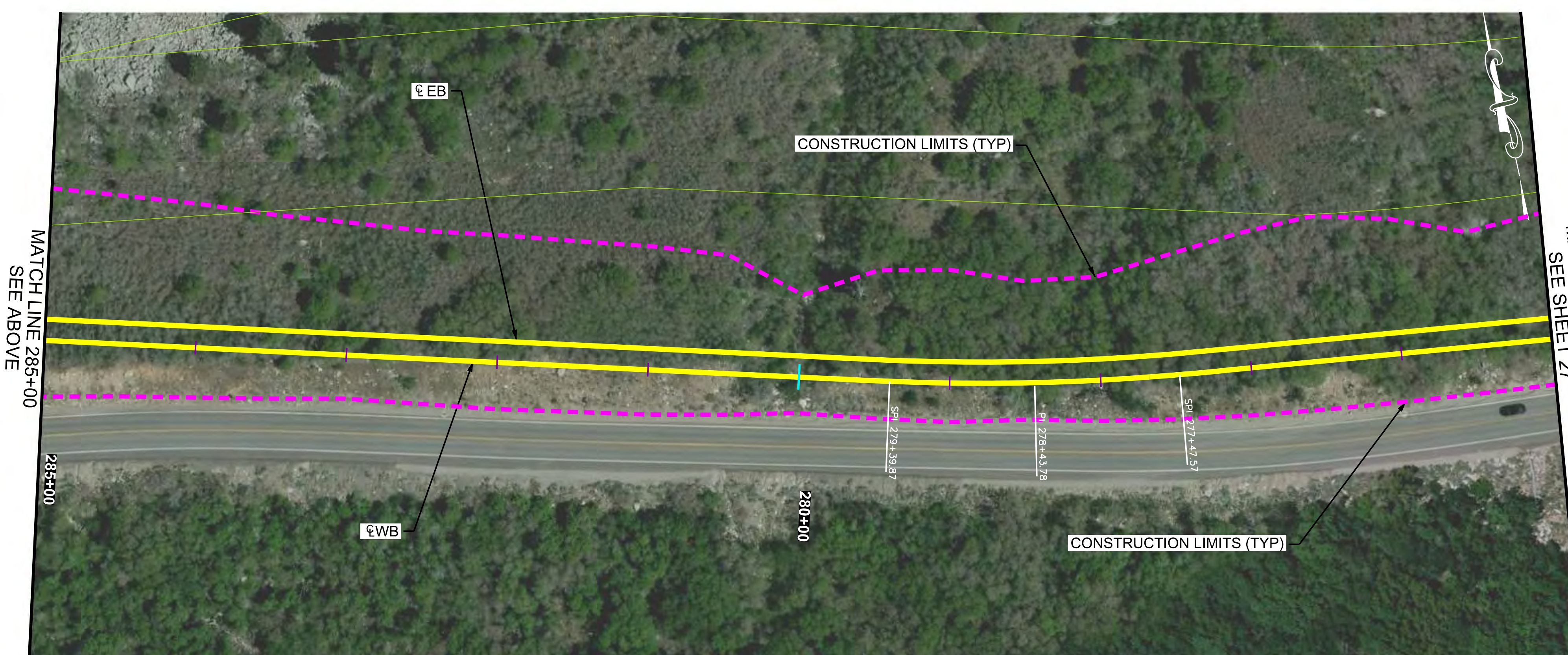

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COG RAIL SEGMENT 1

PIN 16092

PROJECT NUMBER XXXX

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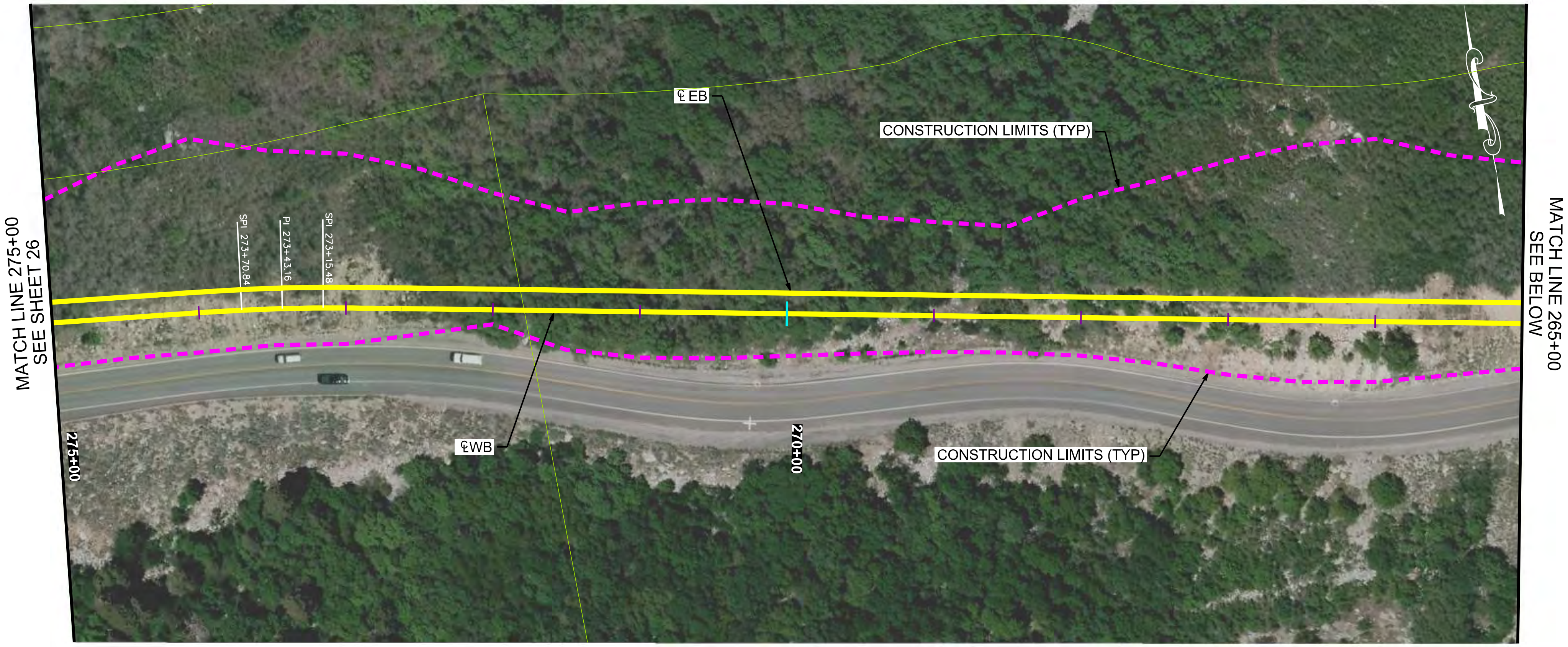

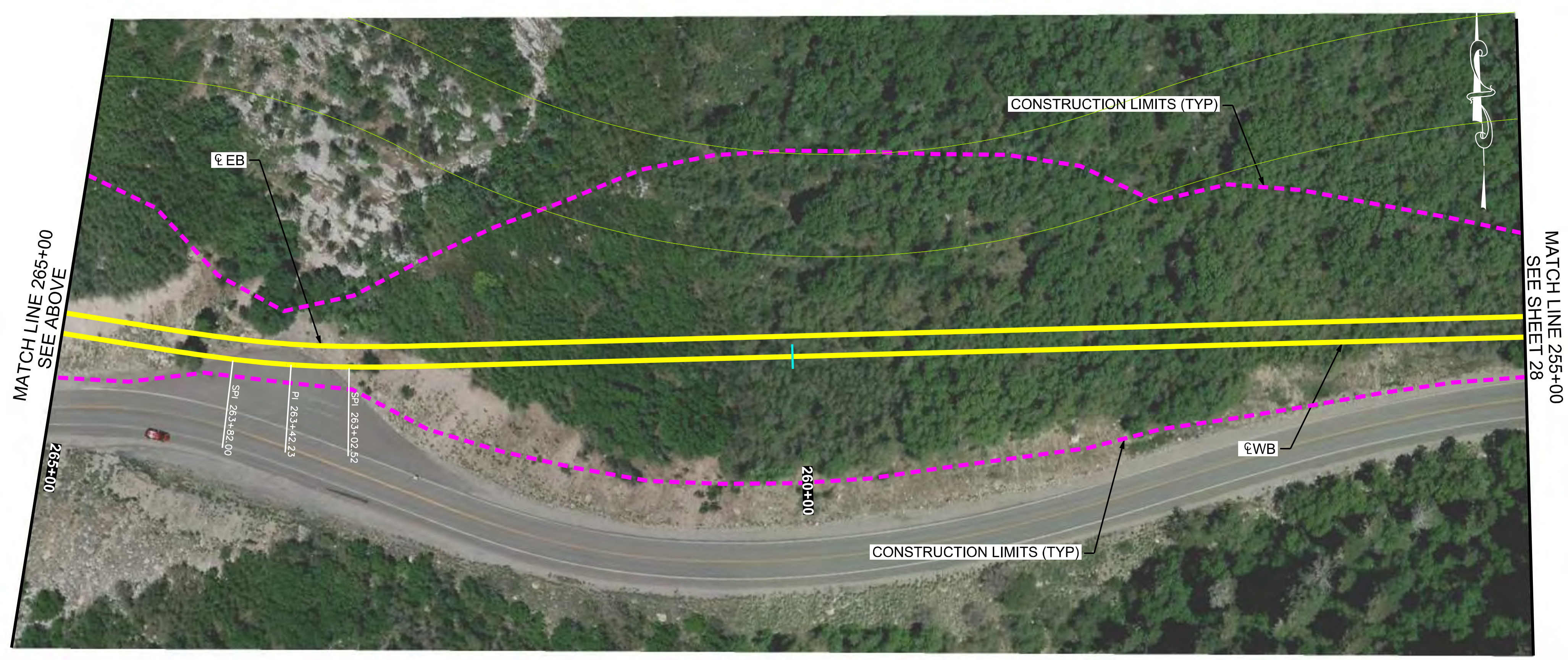

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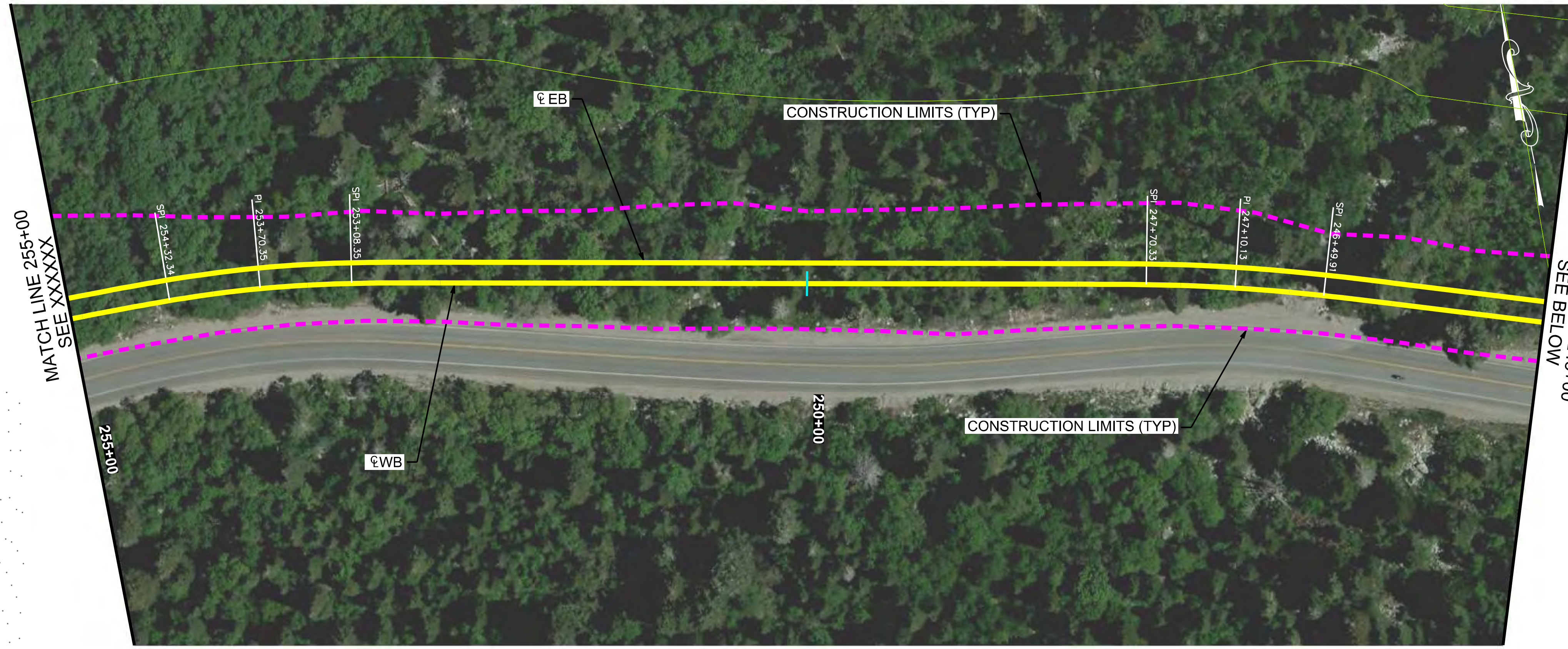

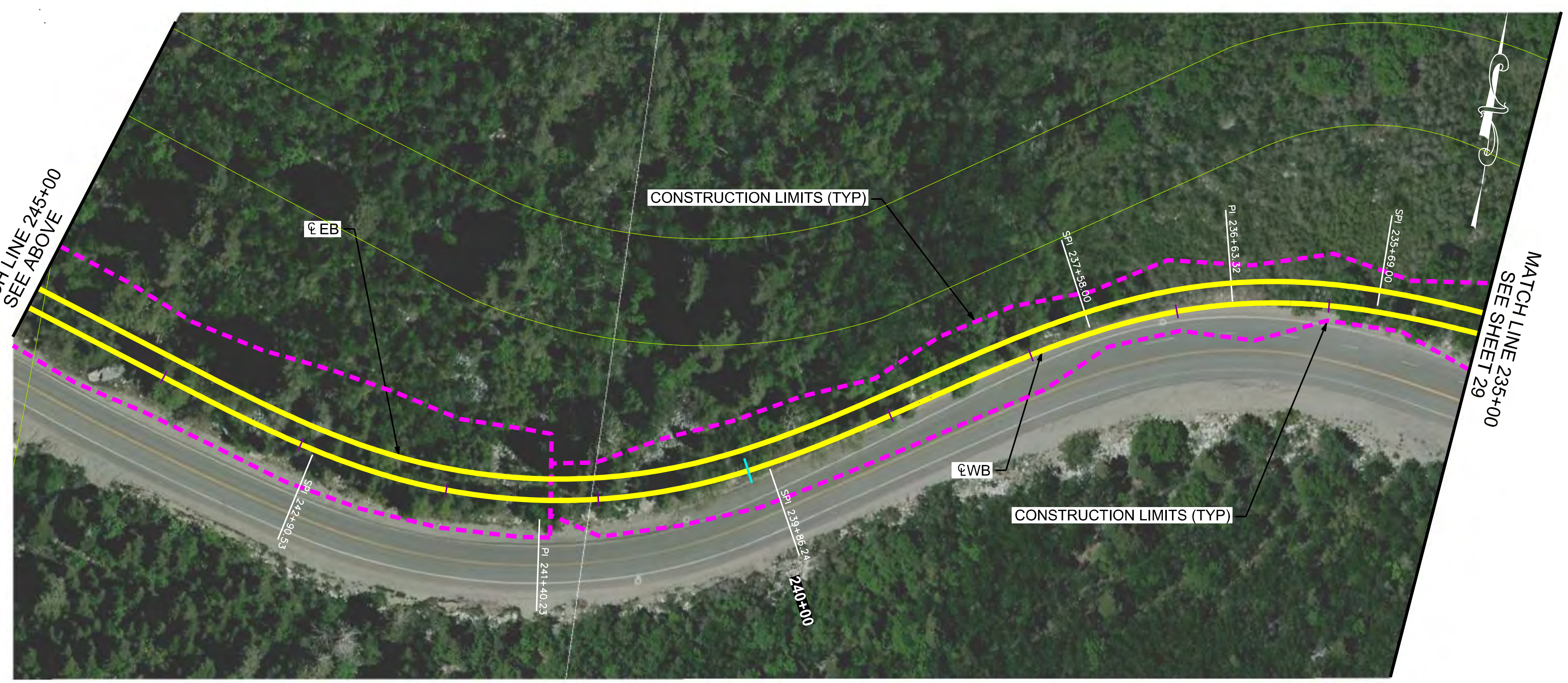

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COG RAIL SEGMENT 1

PIN 16092

PROJECT NUMBER XXXX

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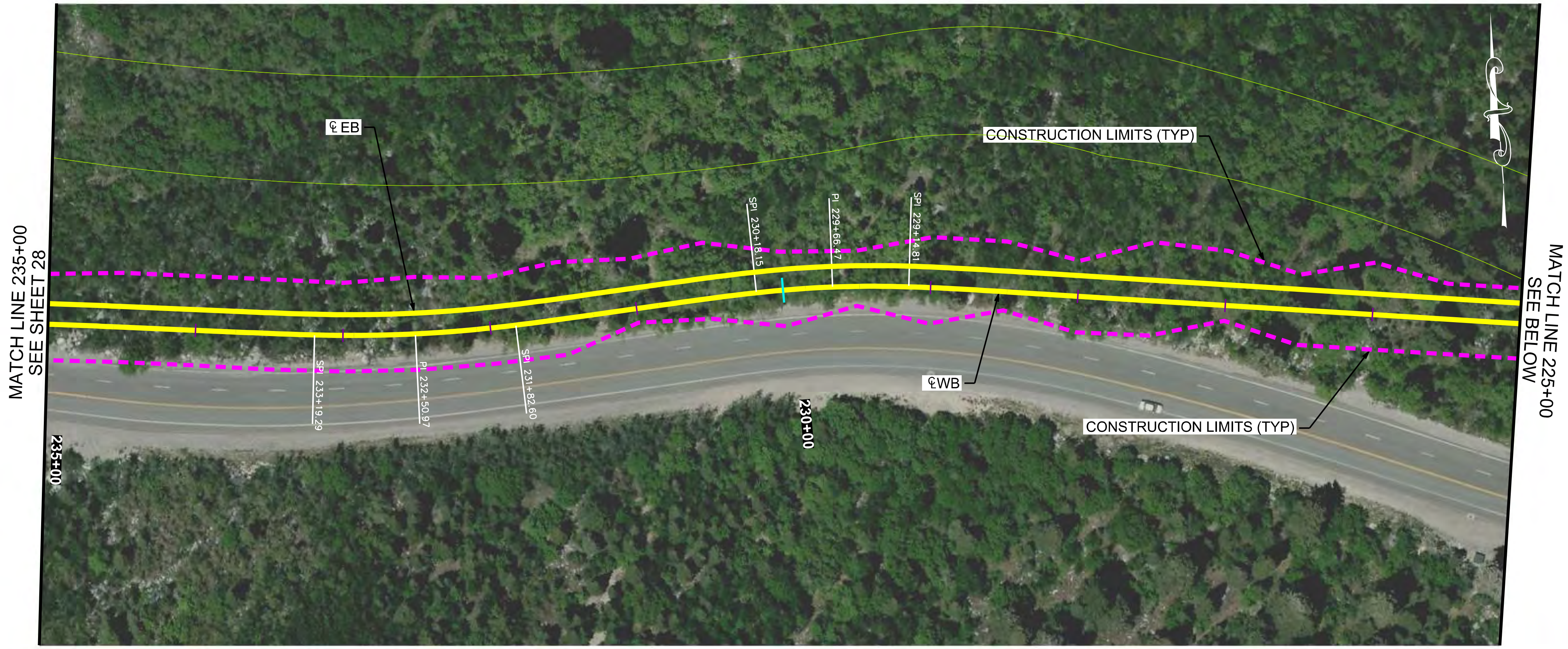

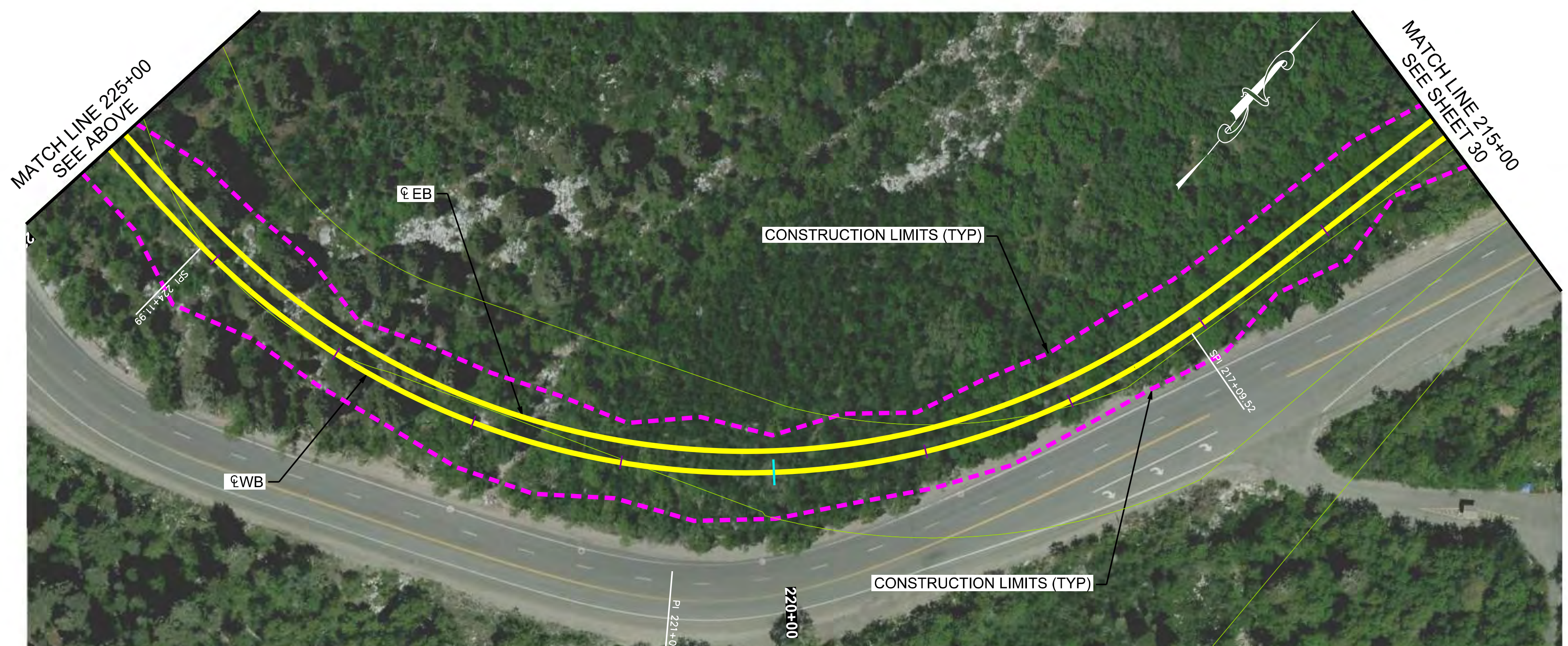

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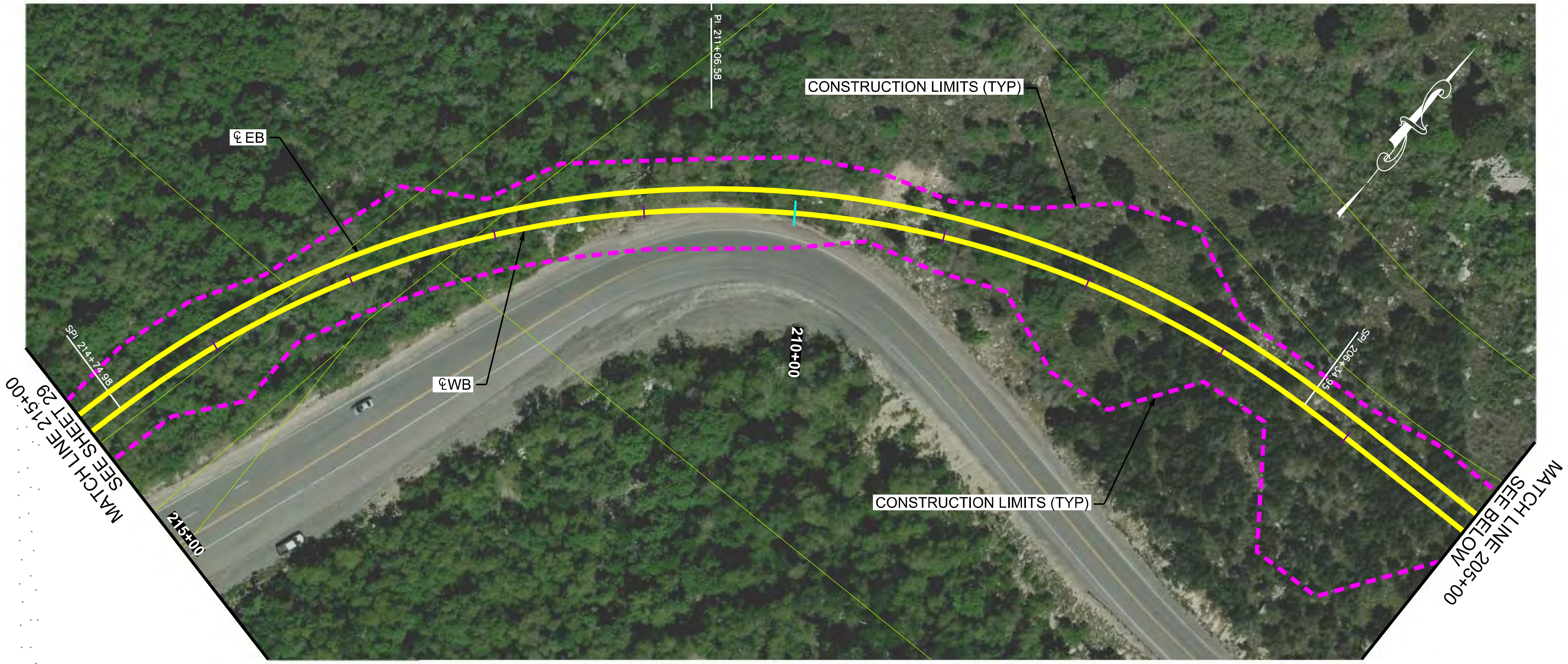

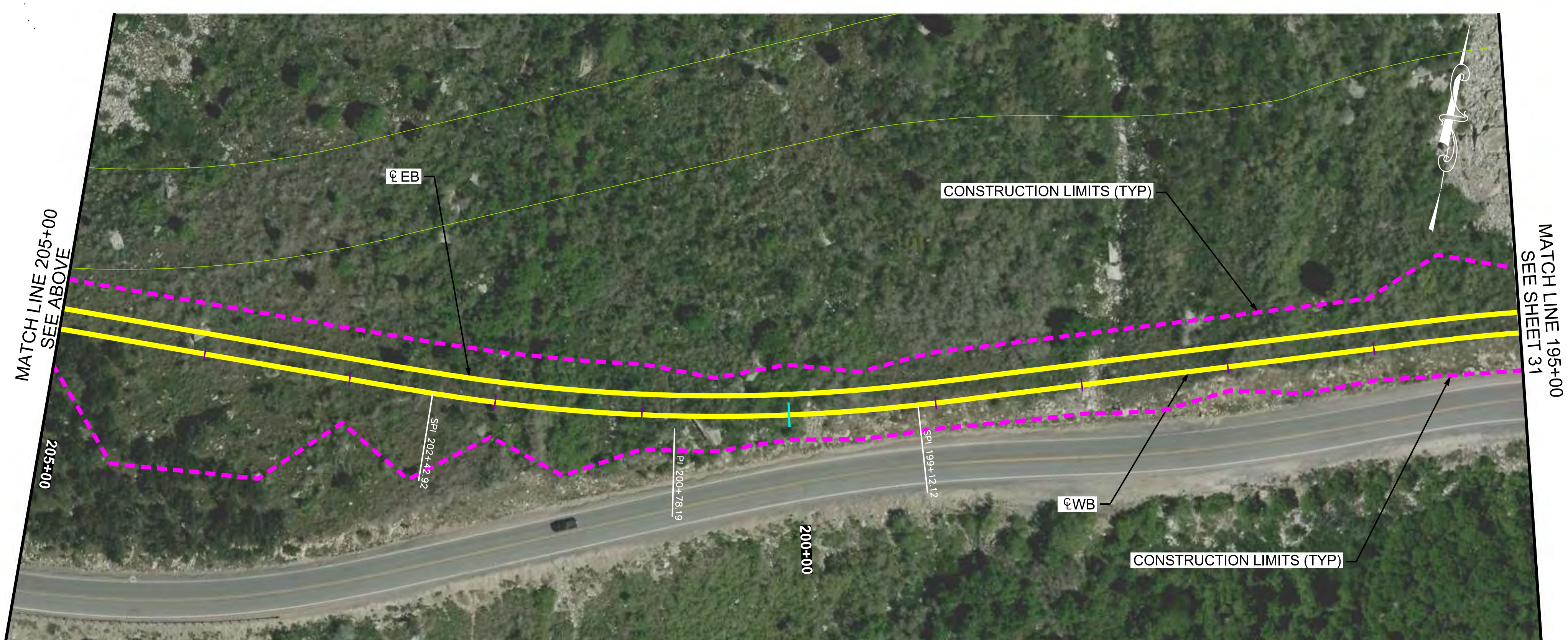

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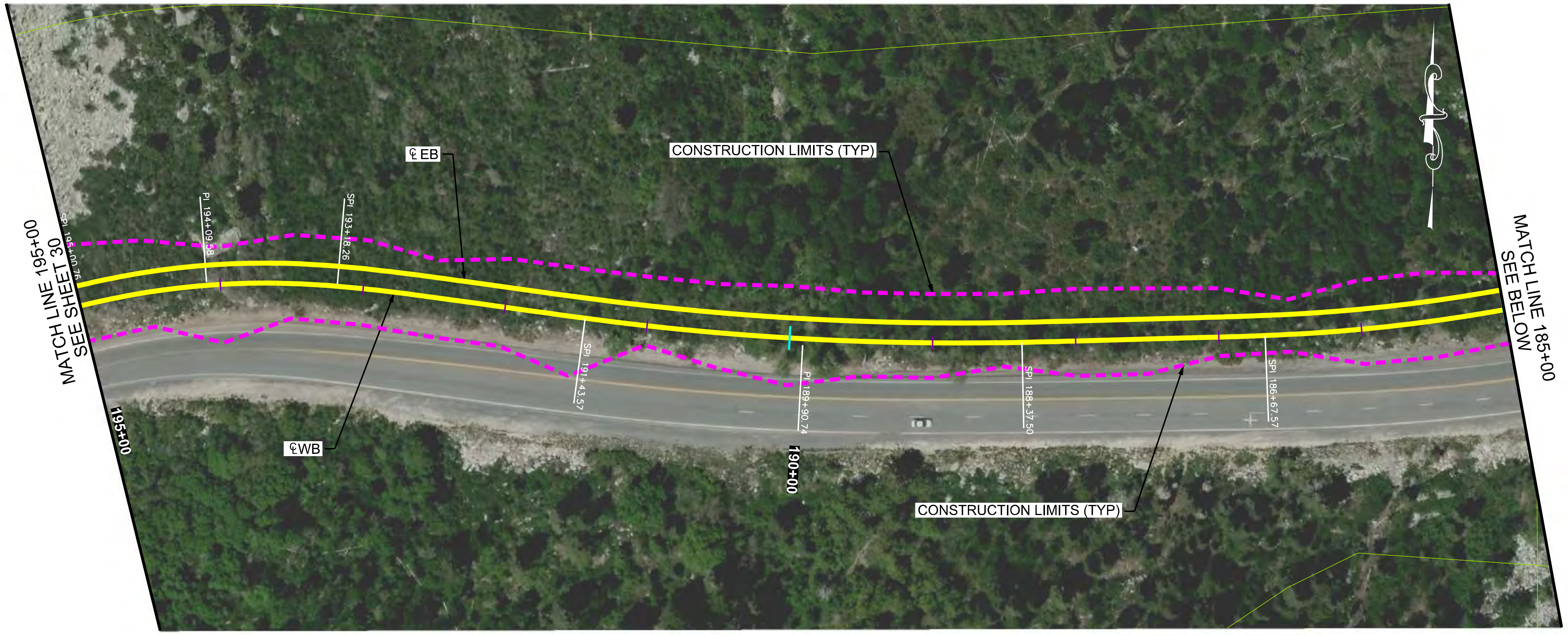

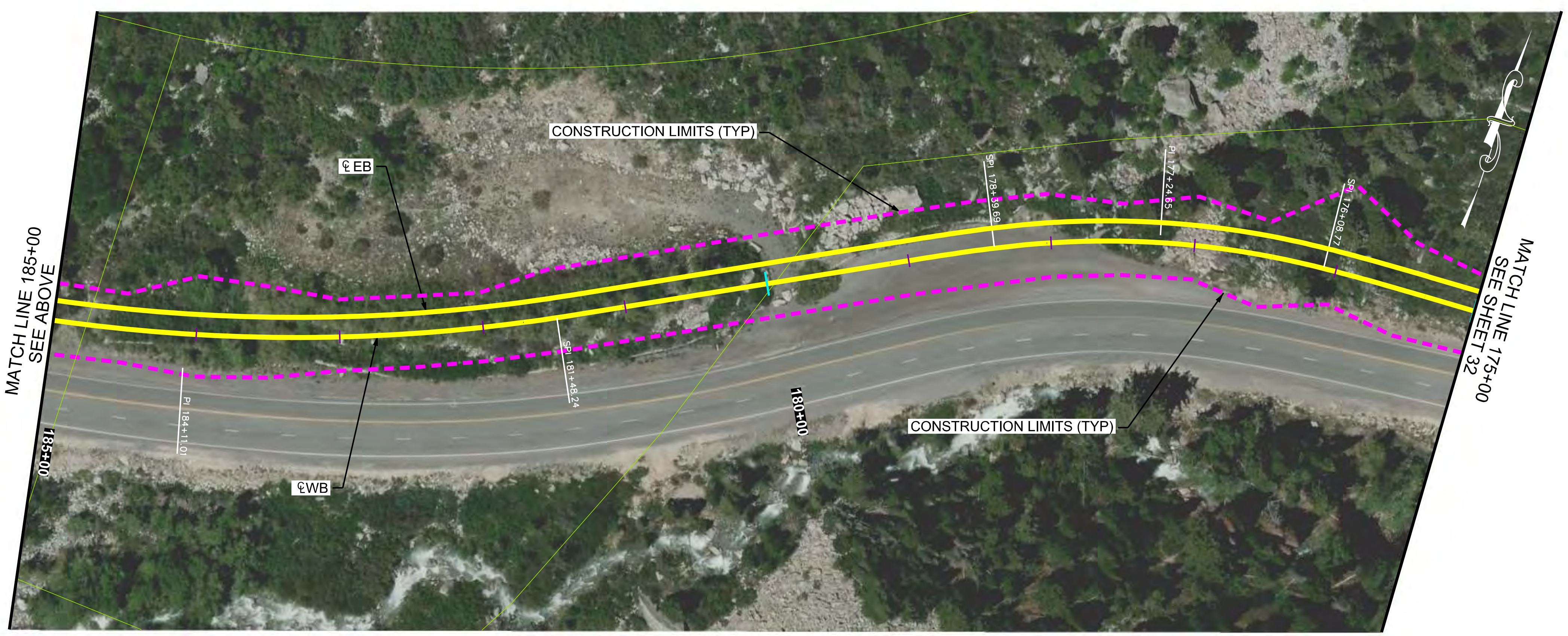

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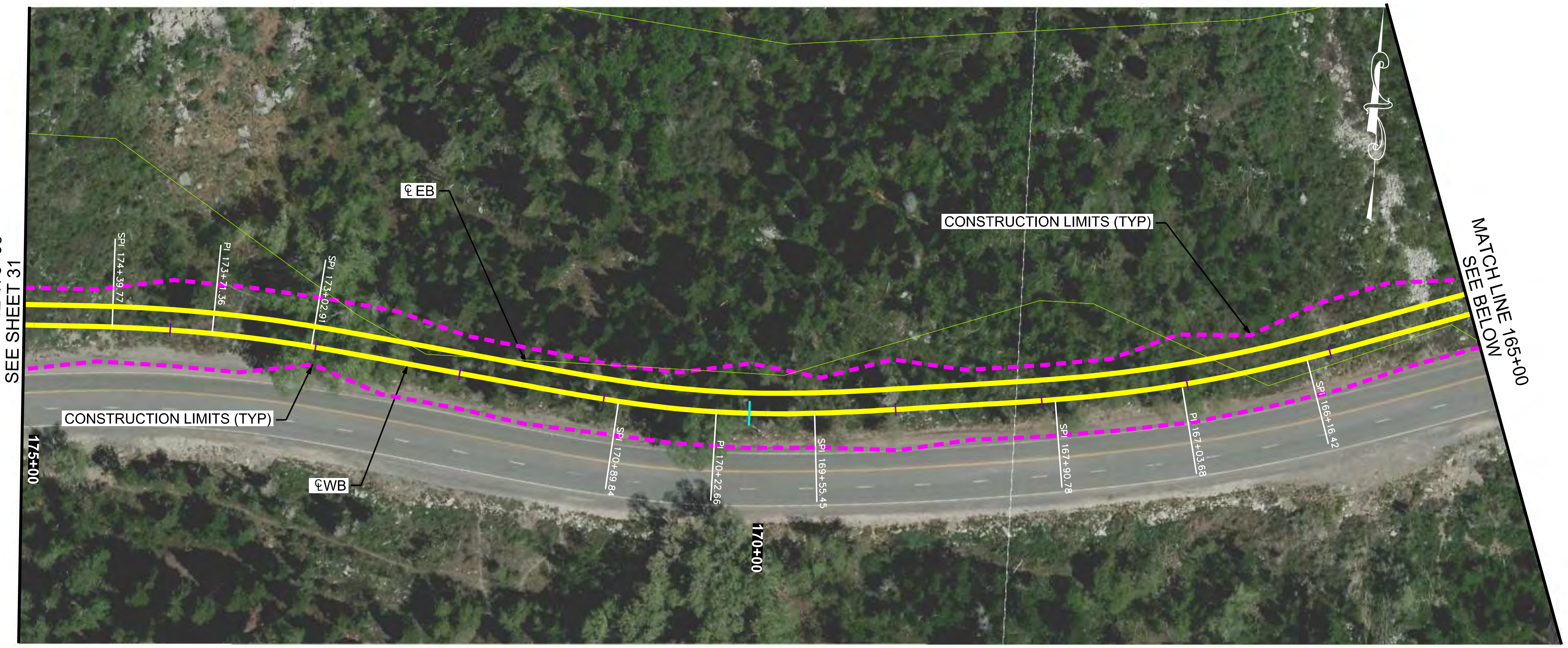

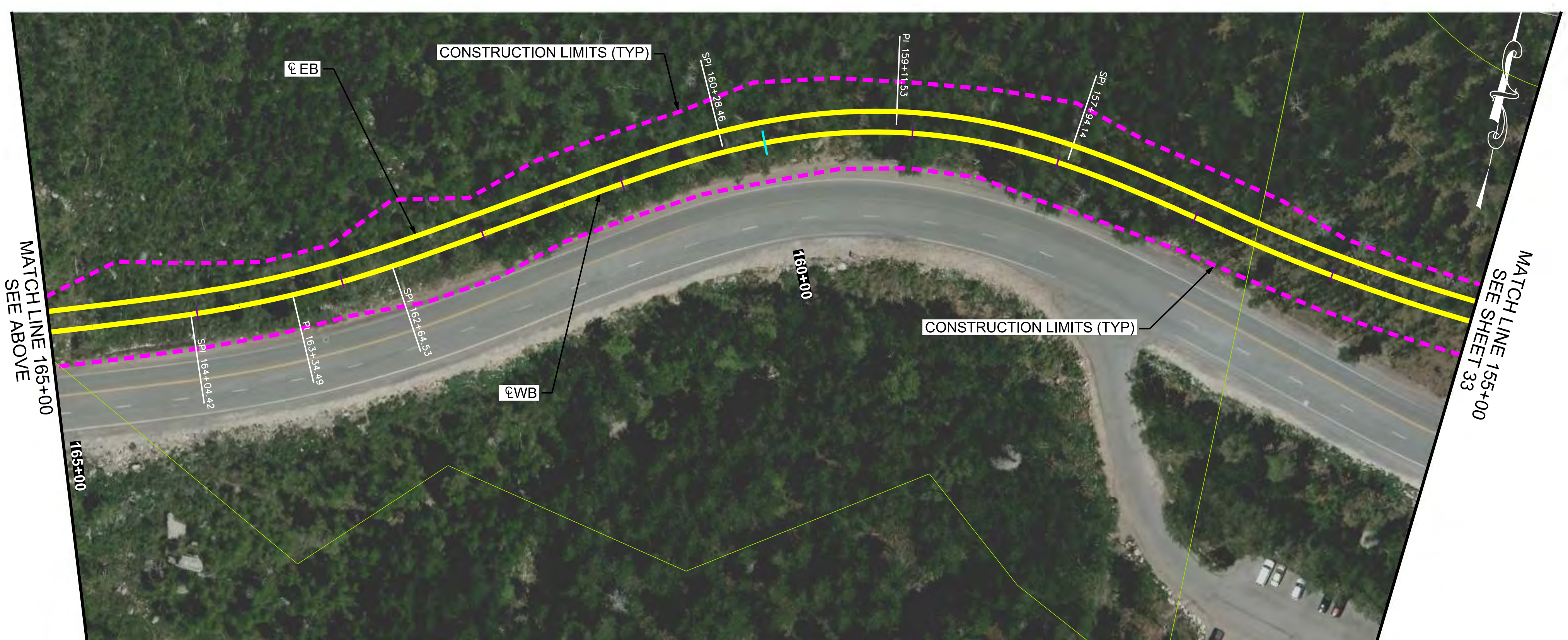

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PROJECT NUMBER: XXXX

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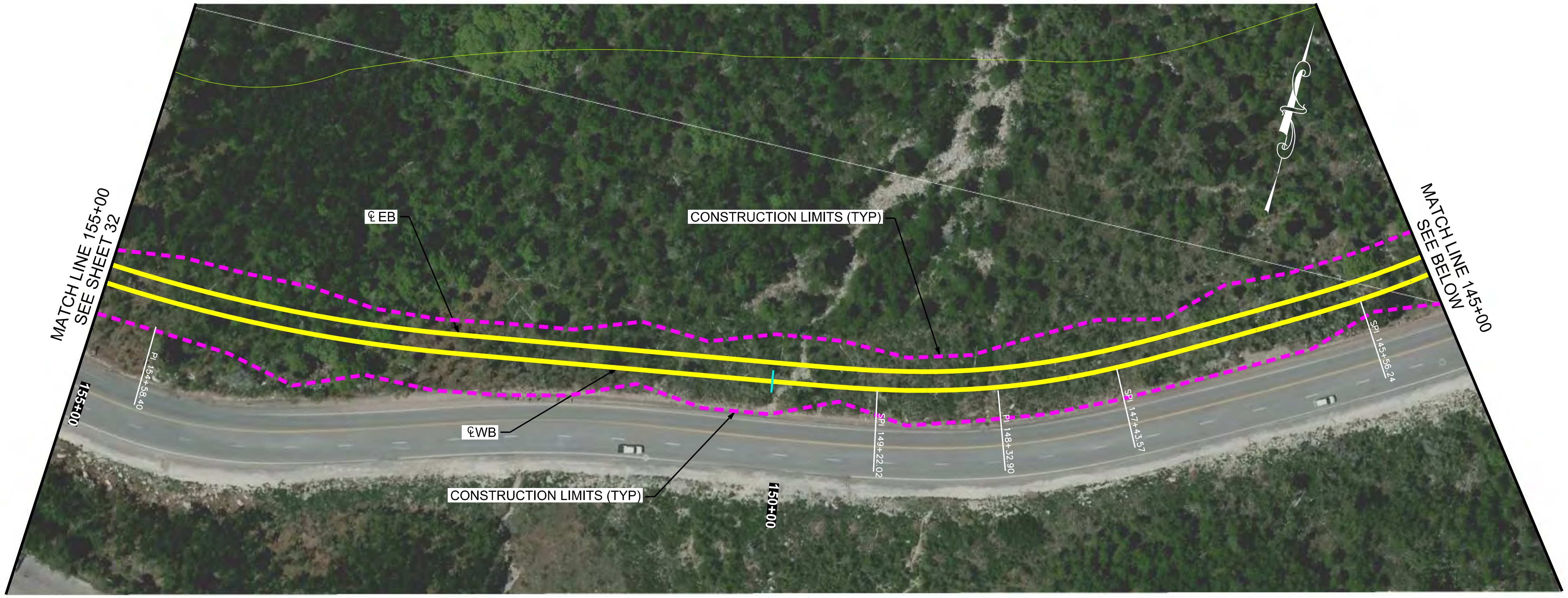

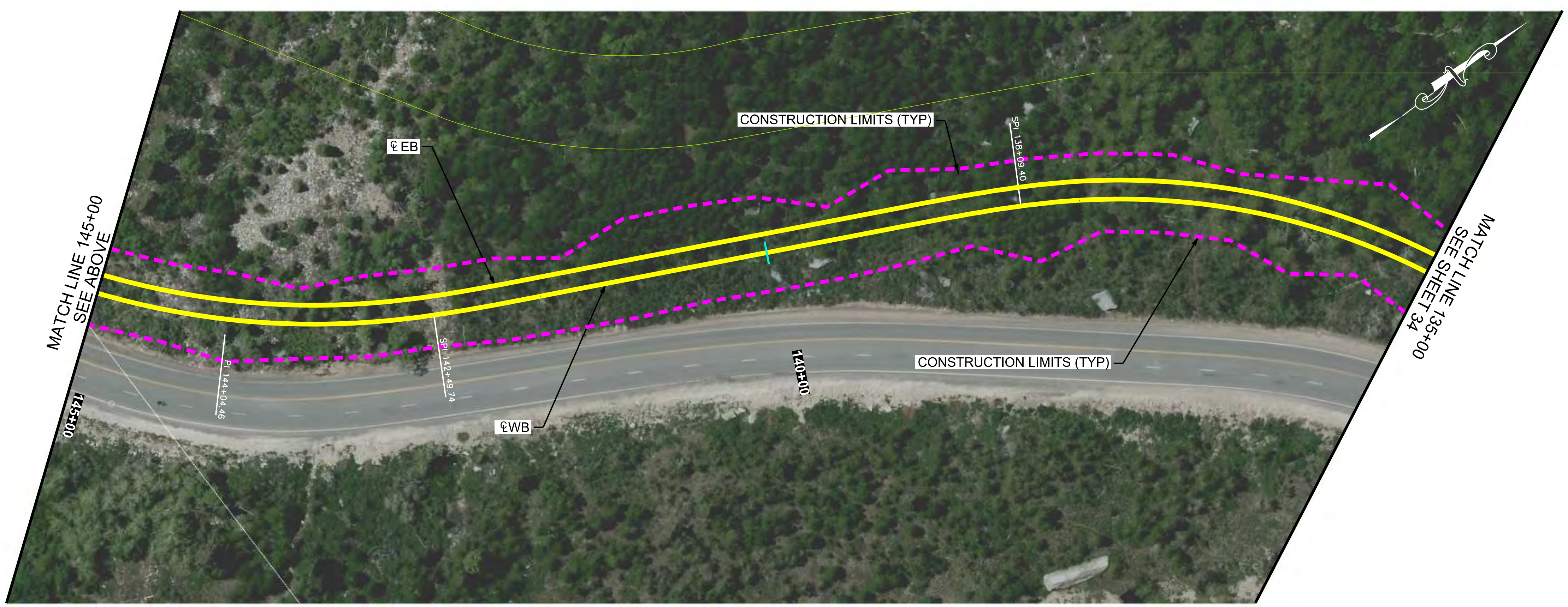

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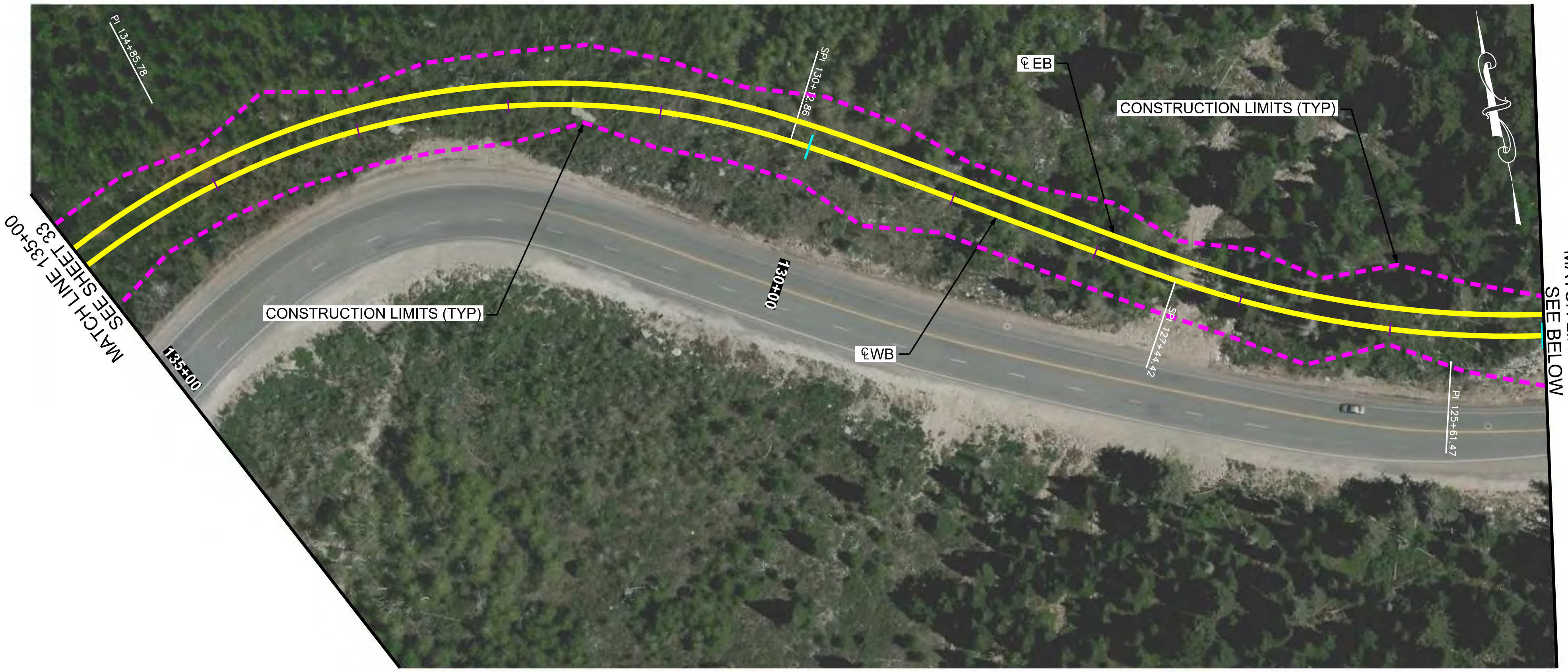

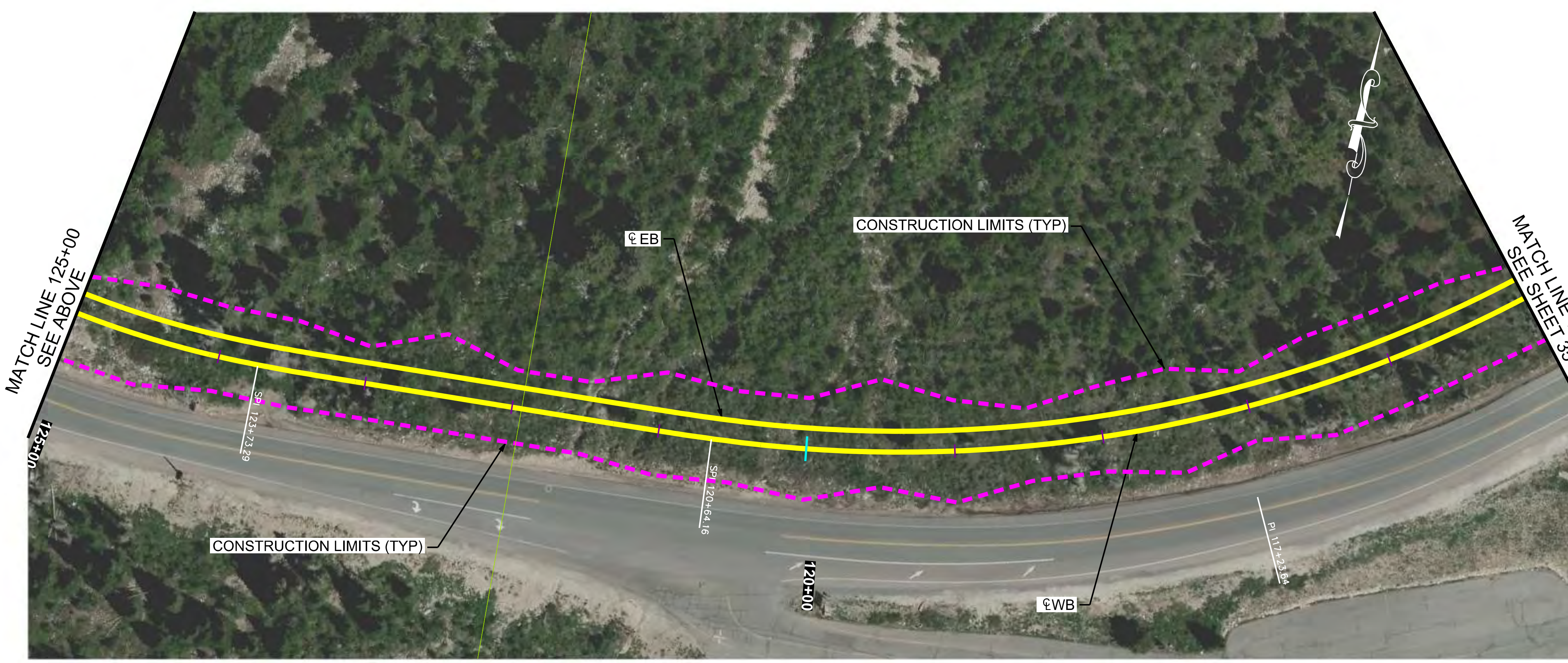

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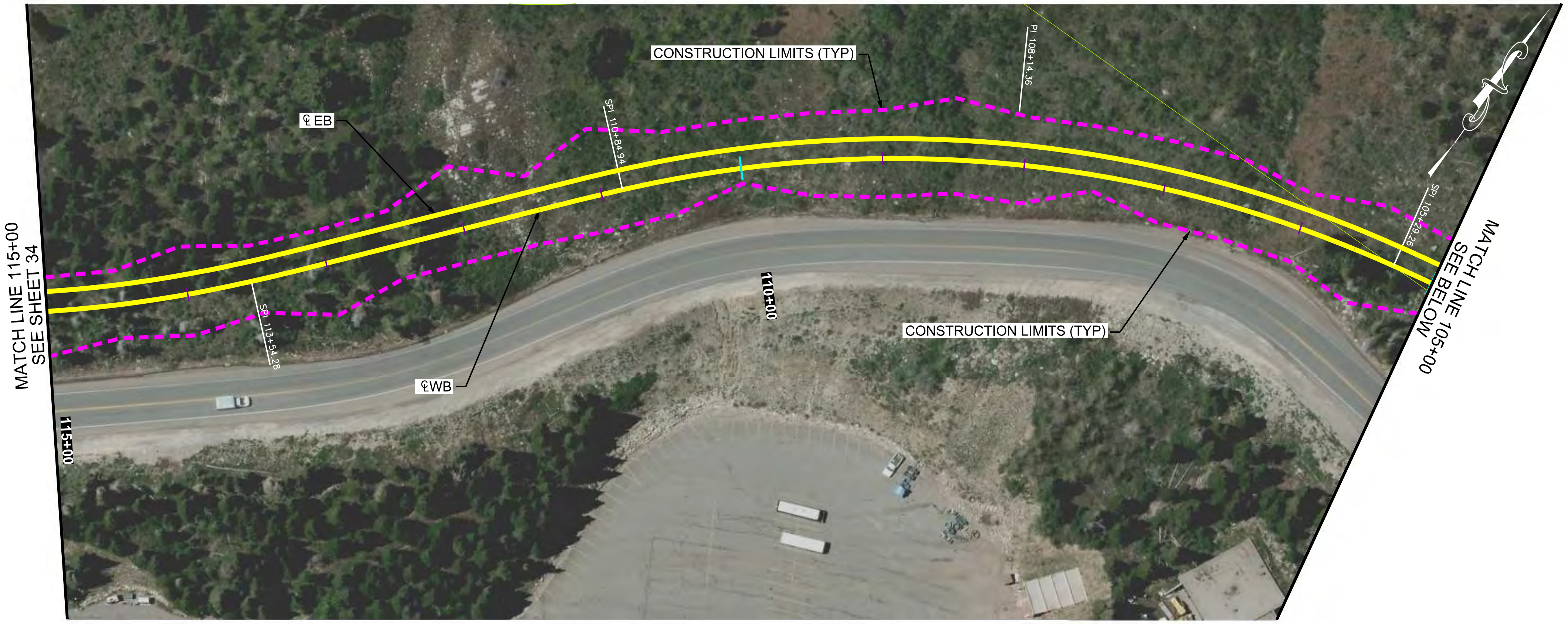

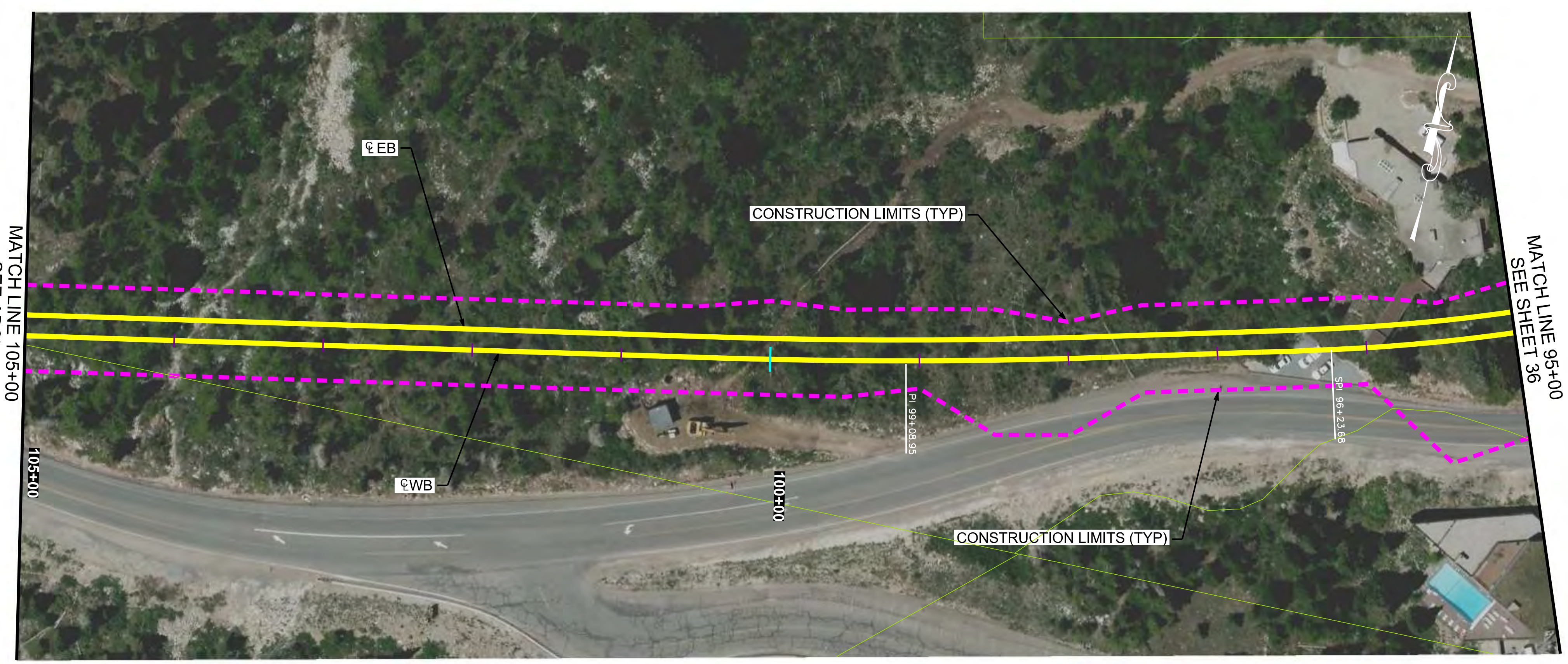

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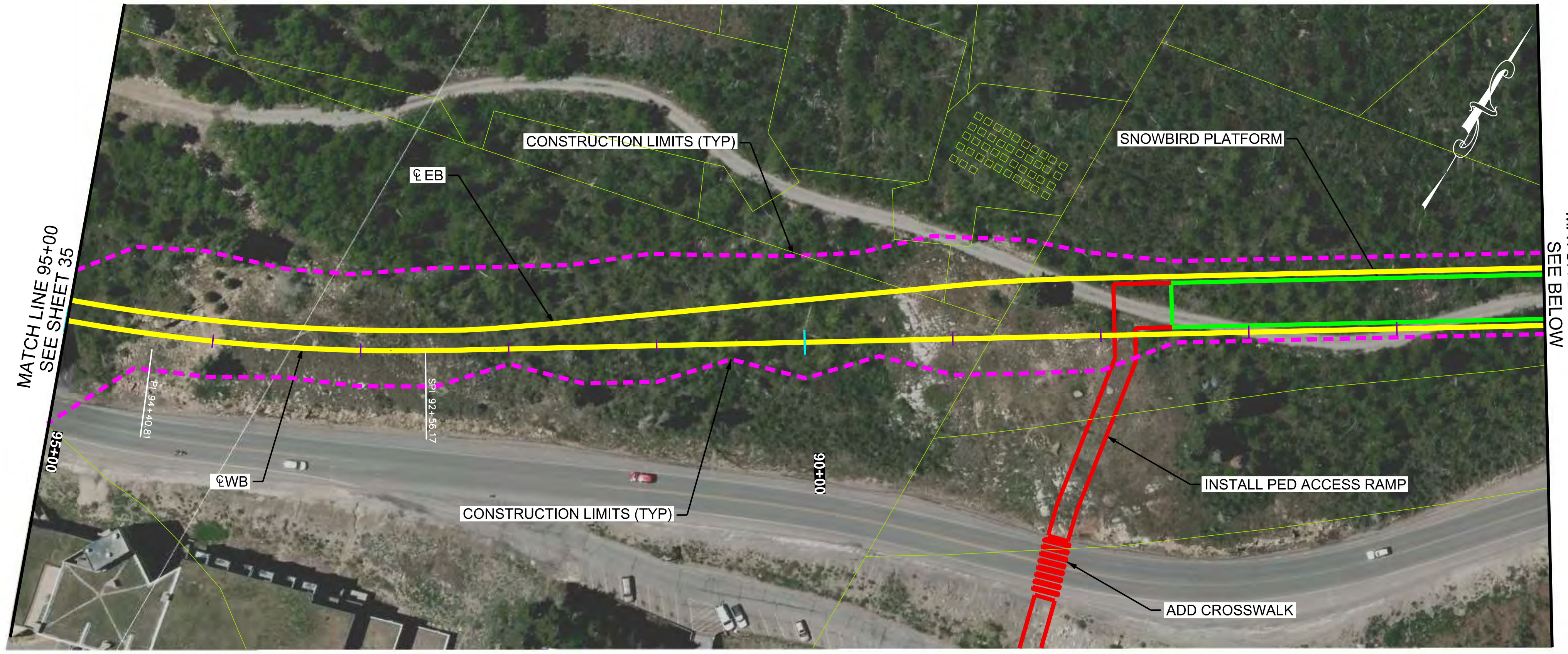

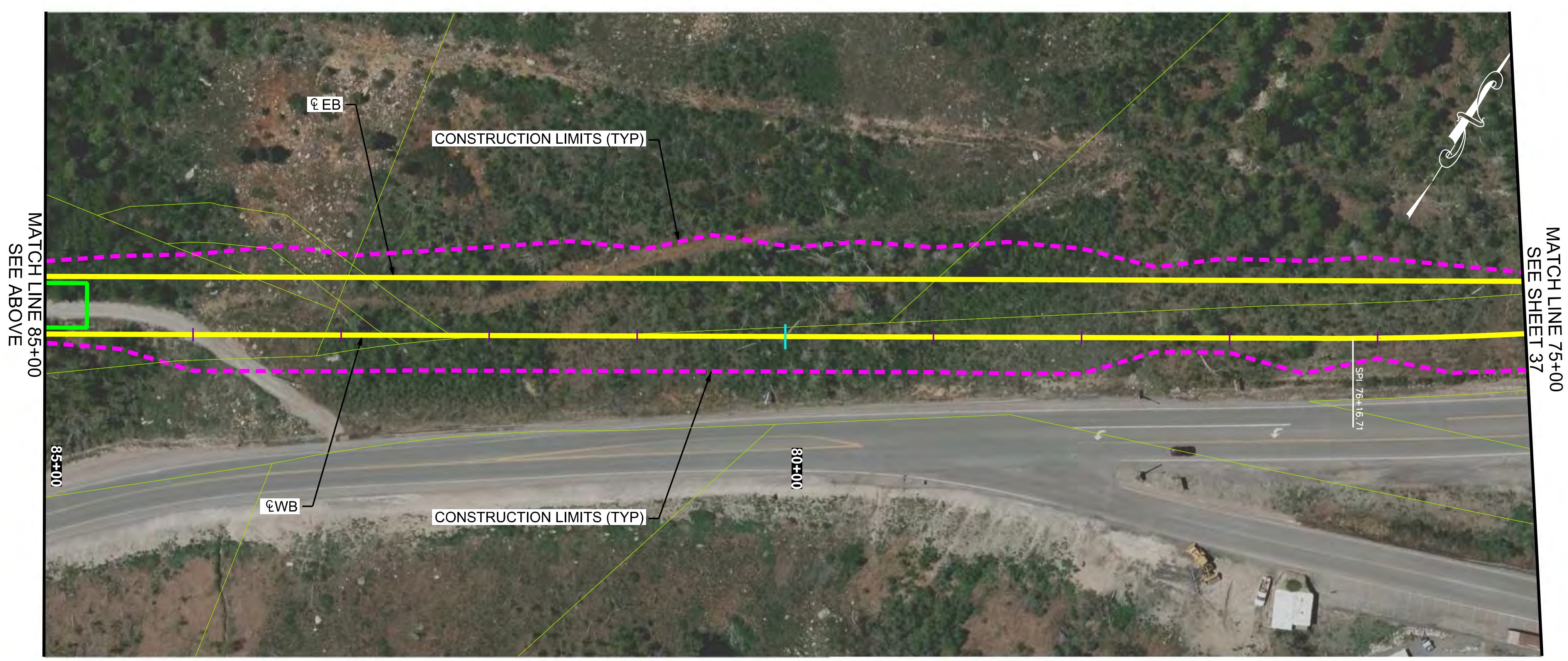

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COG RAIL SEGMENT 1

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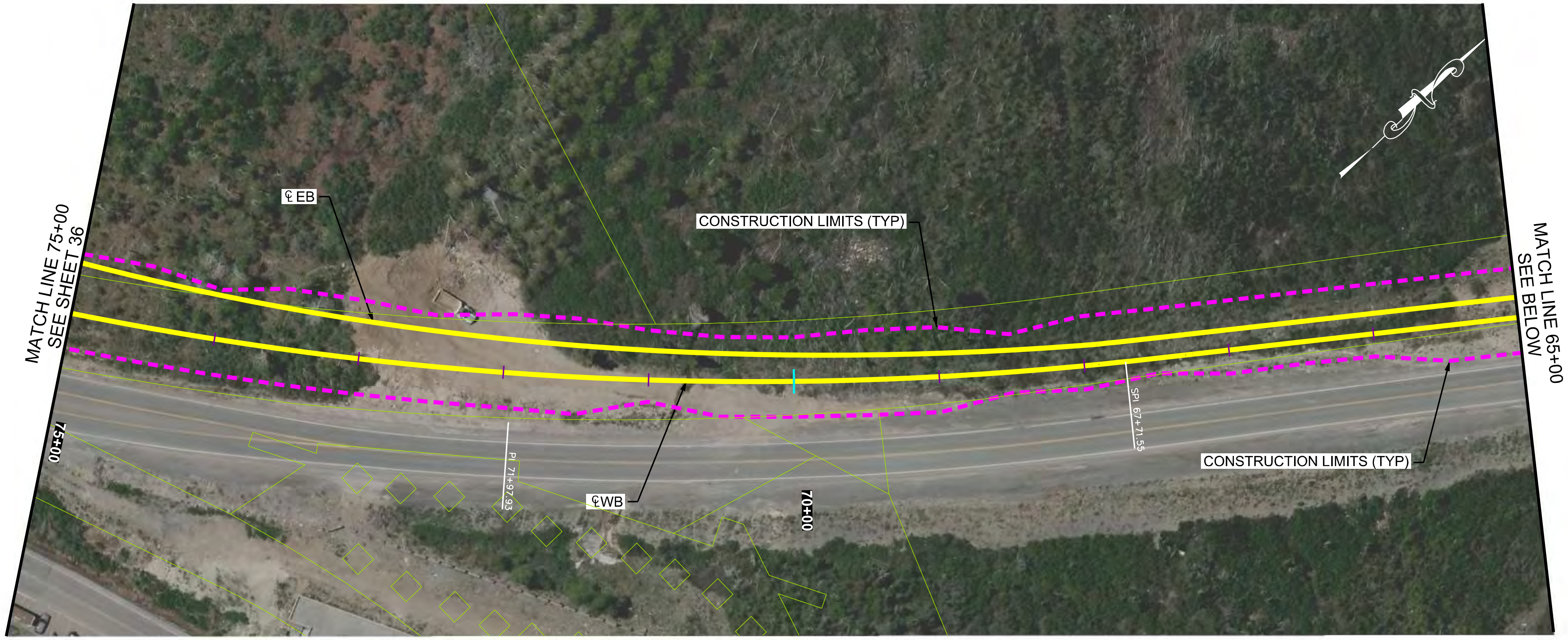

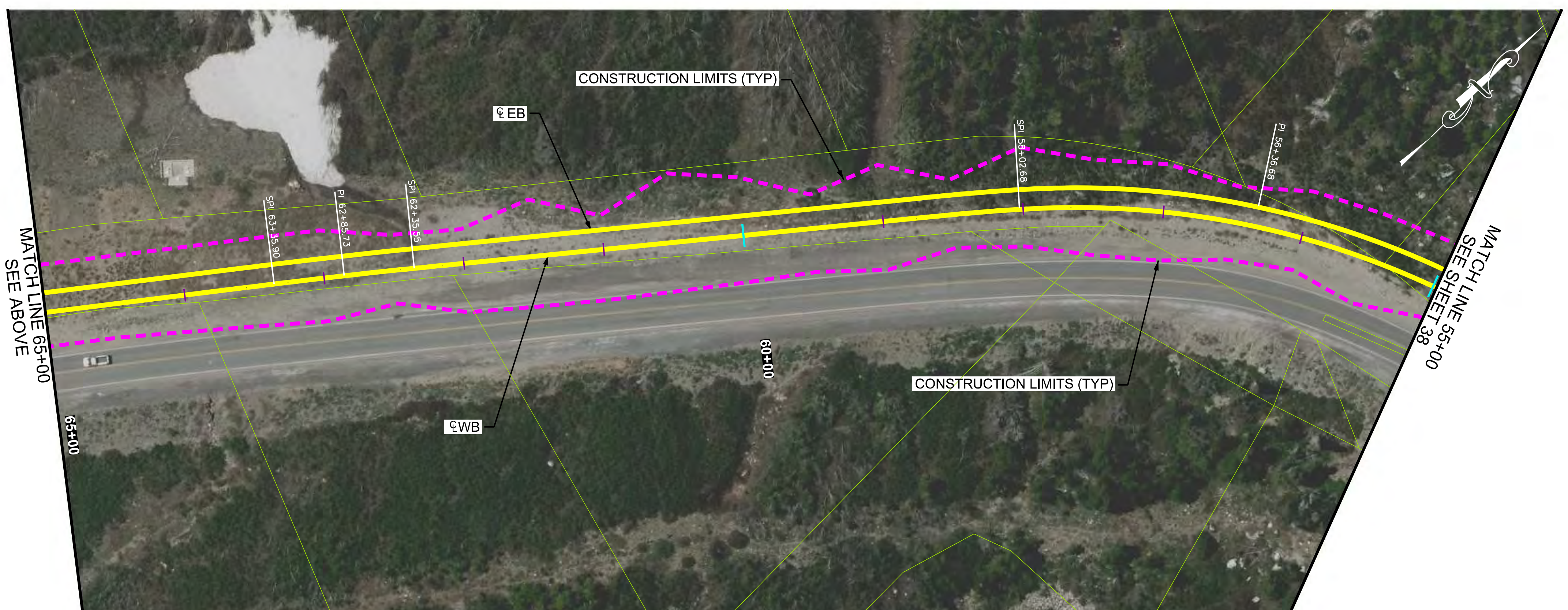

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COG RAIL SEGMENT 1

PROJECT NUMBER: XXXX

PIN: 16092

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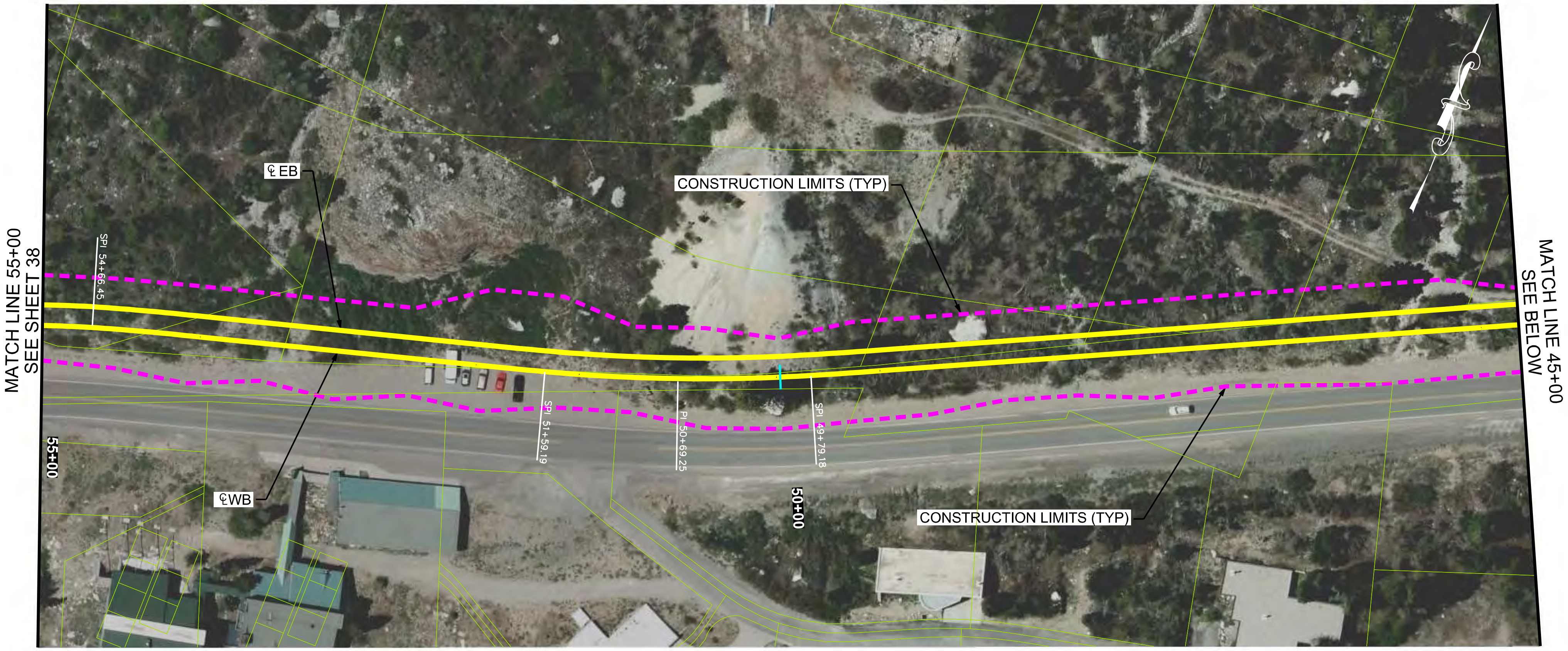
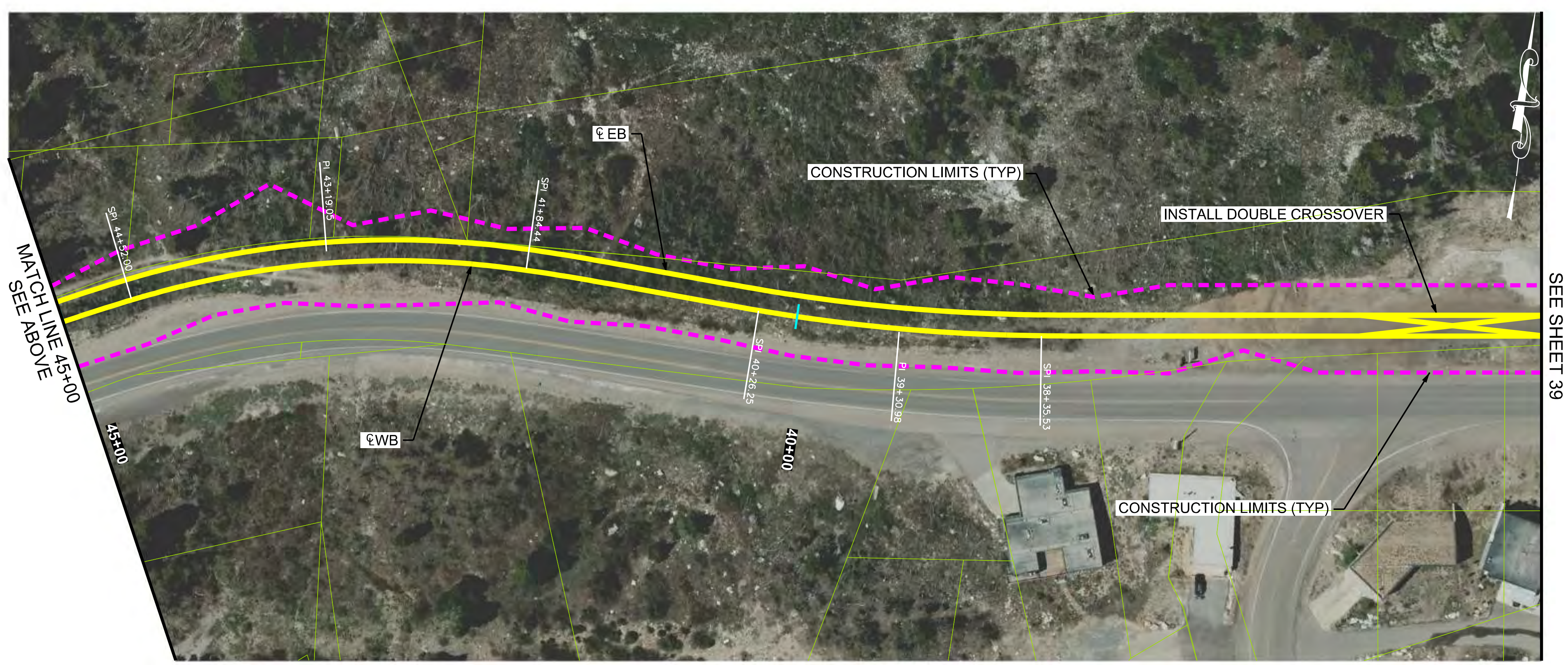
2/17/2020





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COG RAIL SEGMENT 1

PROJECT NUMBER: XXXX

PIN: 16092

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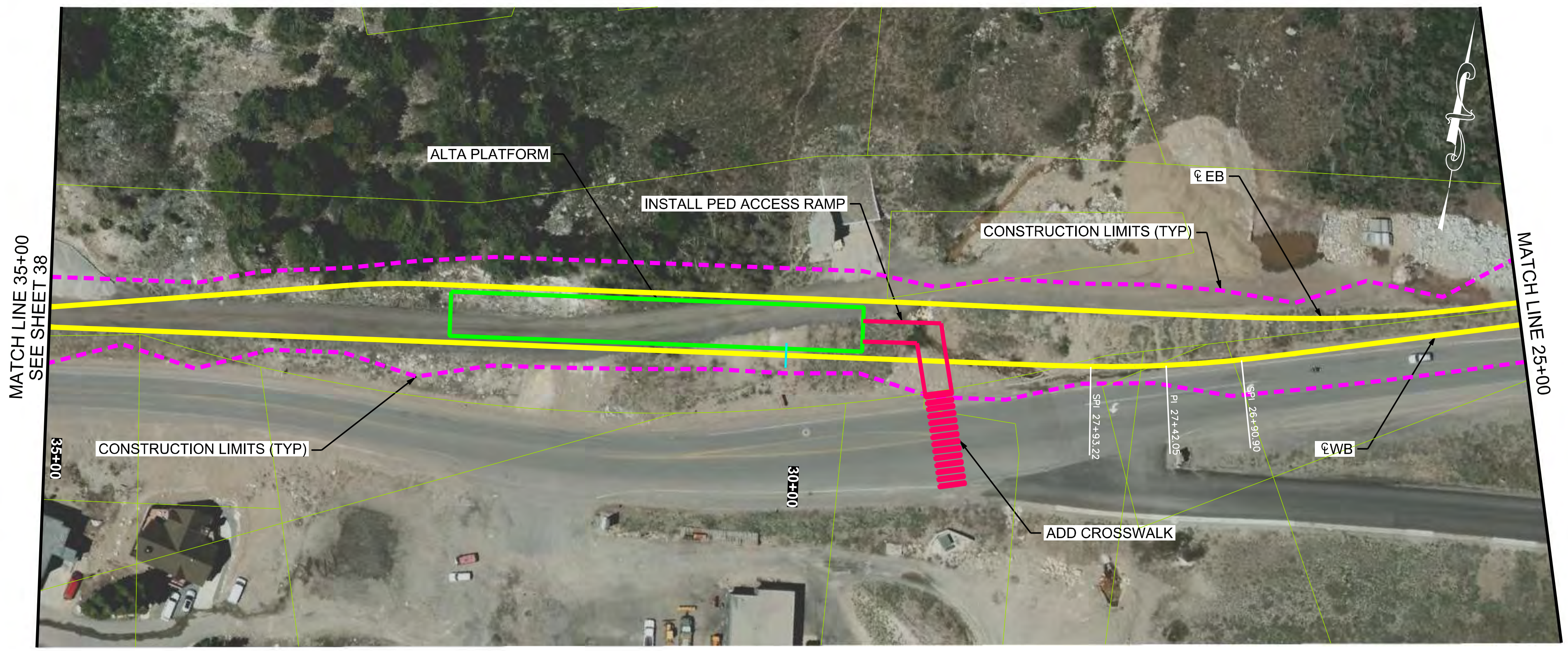
2/17/2020



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COG RAIL SEGMENT 1

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PROJECT NUMBER XXXX

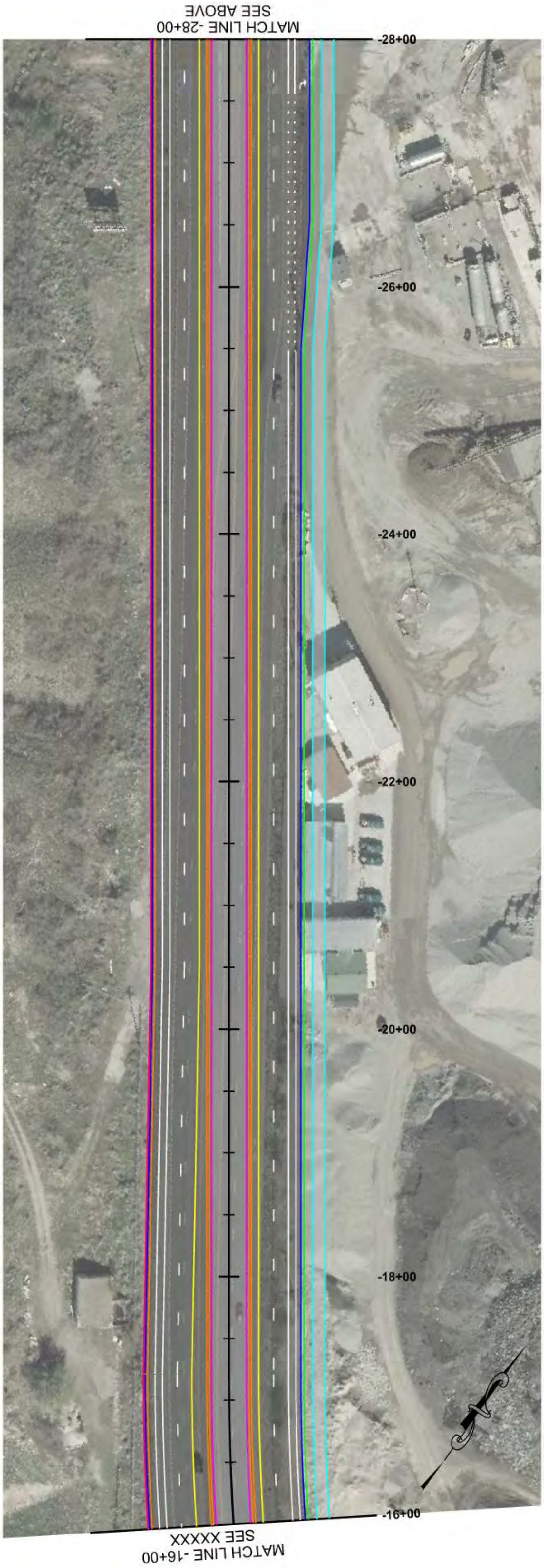
SHEET NO. 39

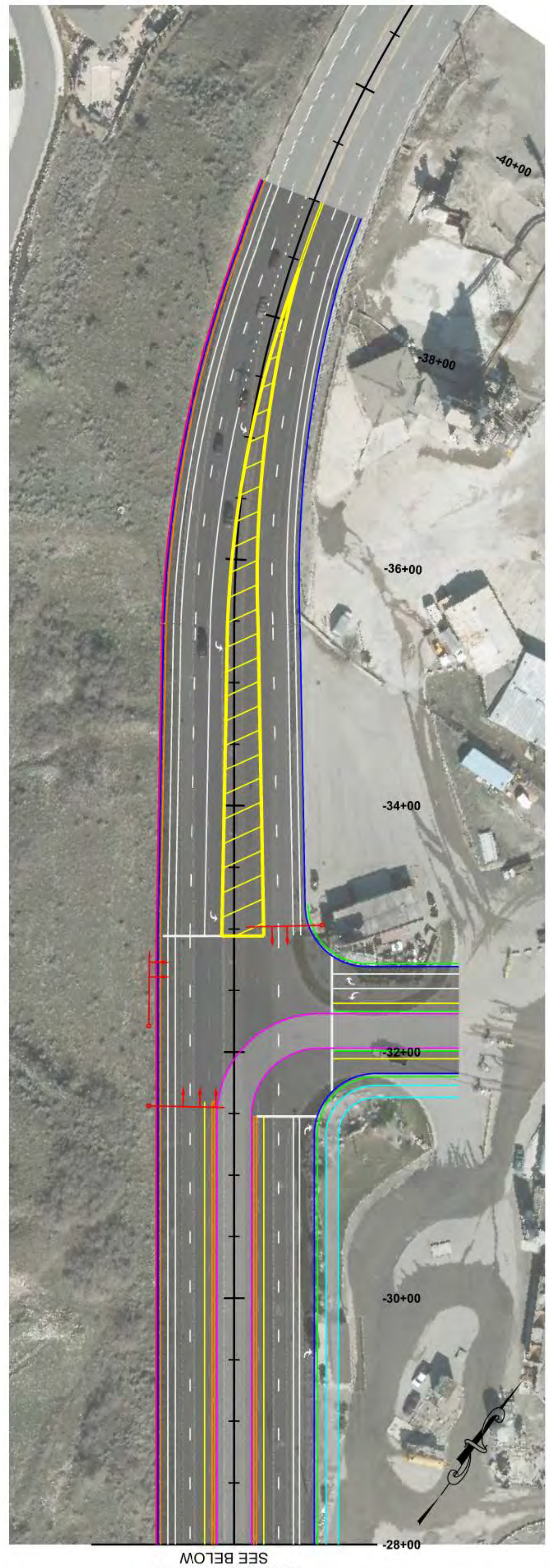
2/17/2020

APPENDIX B2

Preliminary Design Plans for Segment 2 –
Gravel Pit to Mouth of Little Cottonwood Canyon

1/29/2020





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PROJECT NUMBER	XXXX	PIN	16092

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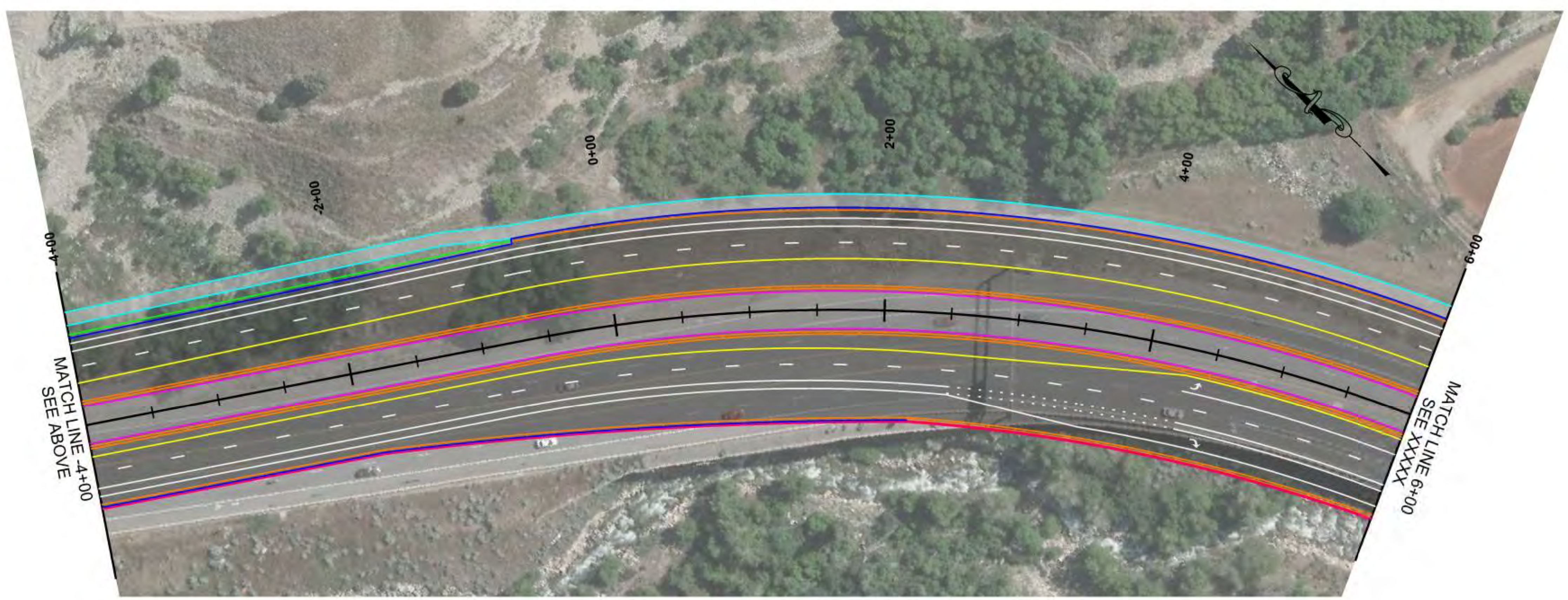

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COG RAIL SEGMENT

PROJECT NUMBER: XXXX

PIN 16092

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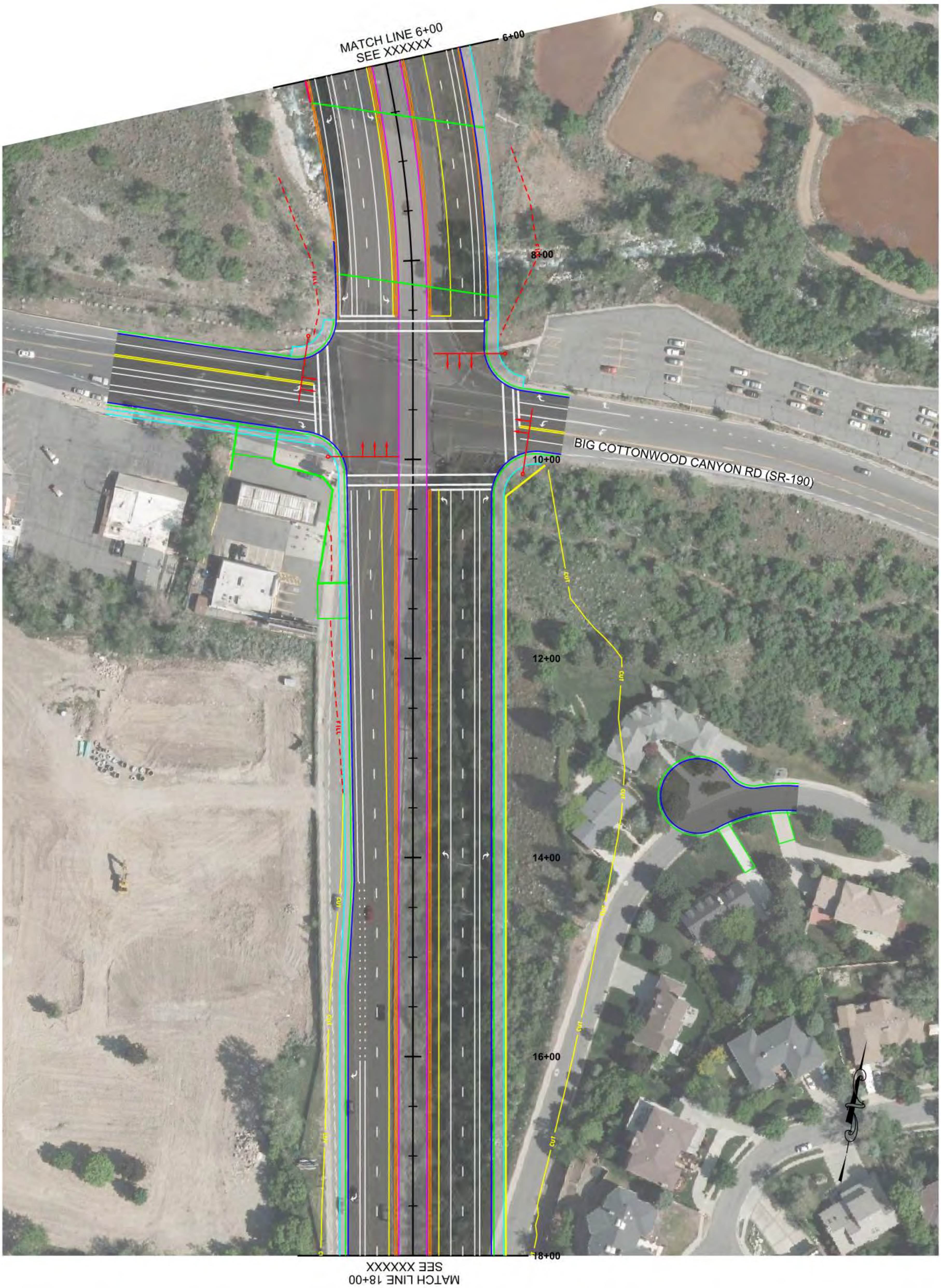

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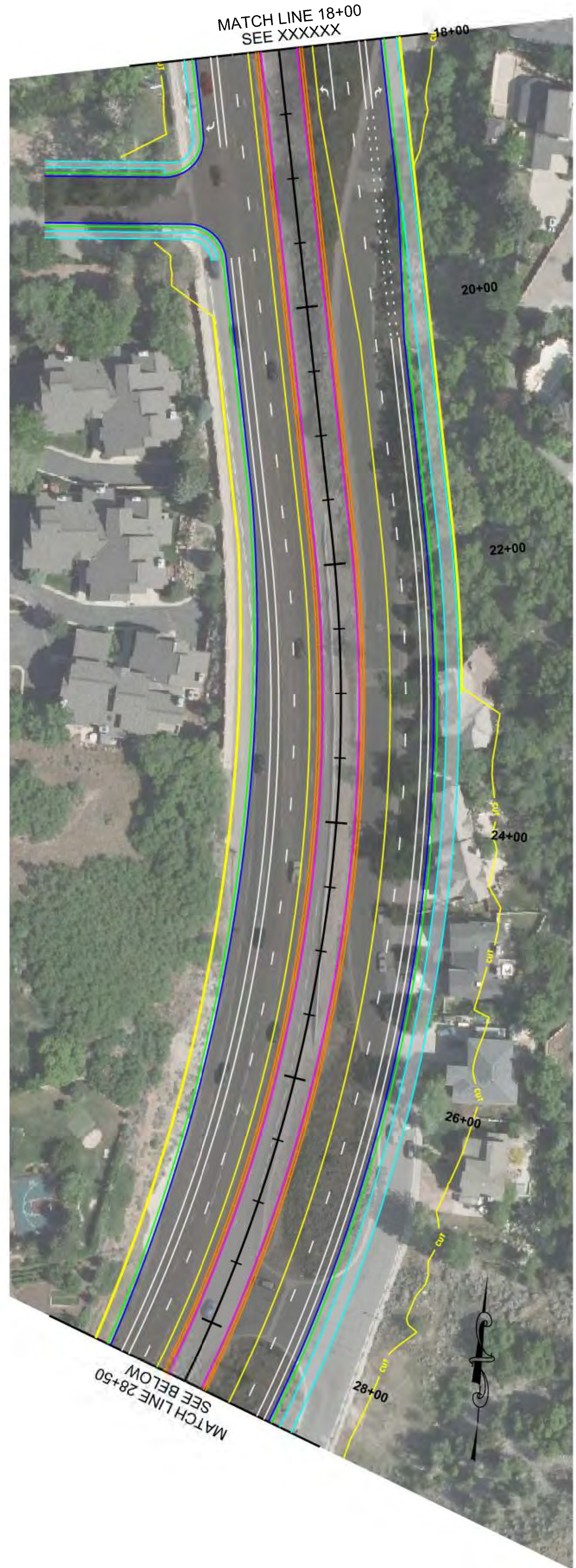

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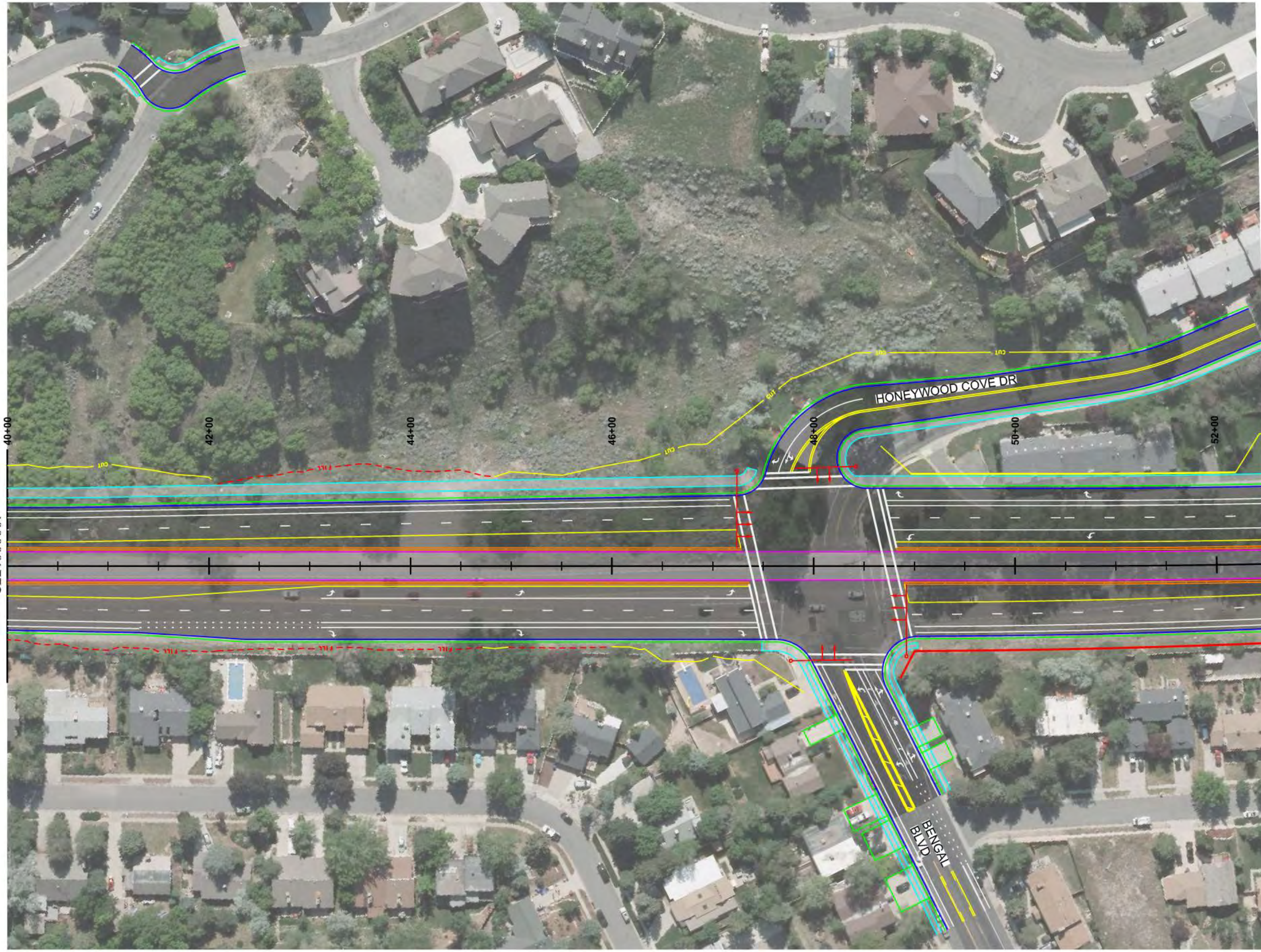

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PROJECT NUMBER: XXXX

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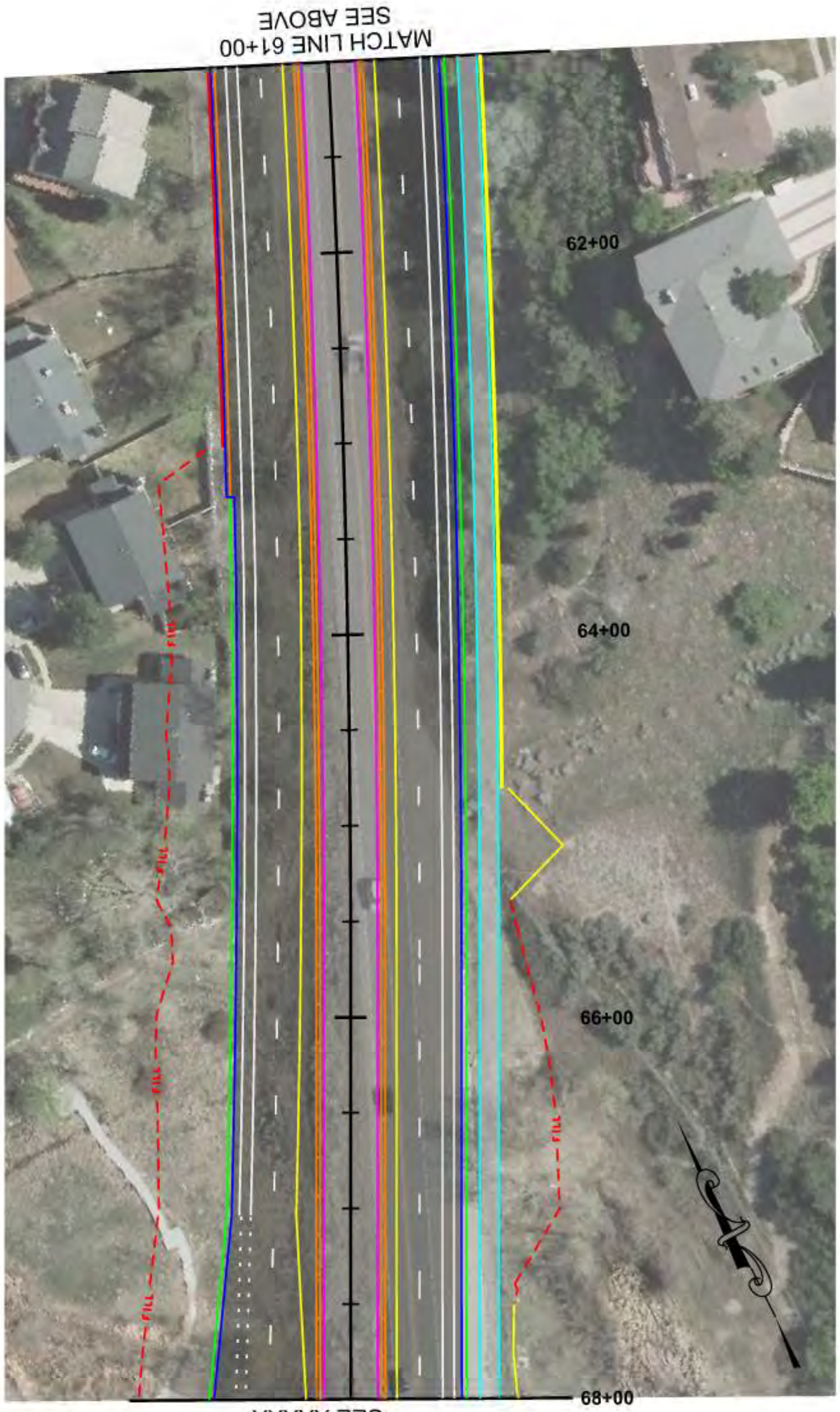

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	PROJECT NUMBER	XXXX	PIN	16092	

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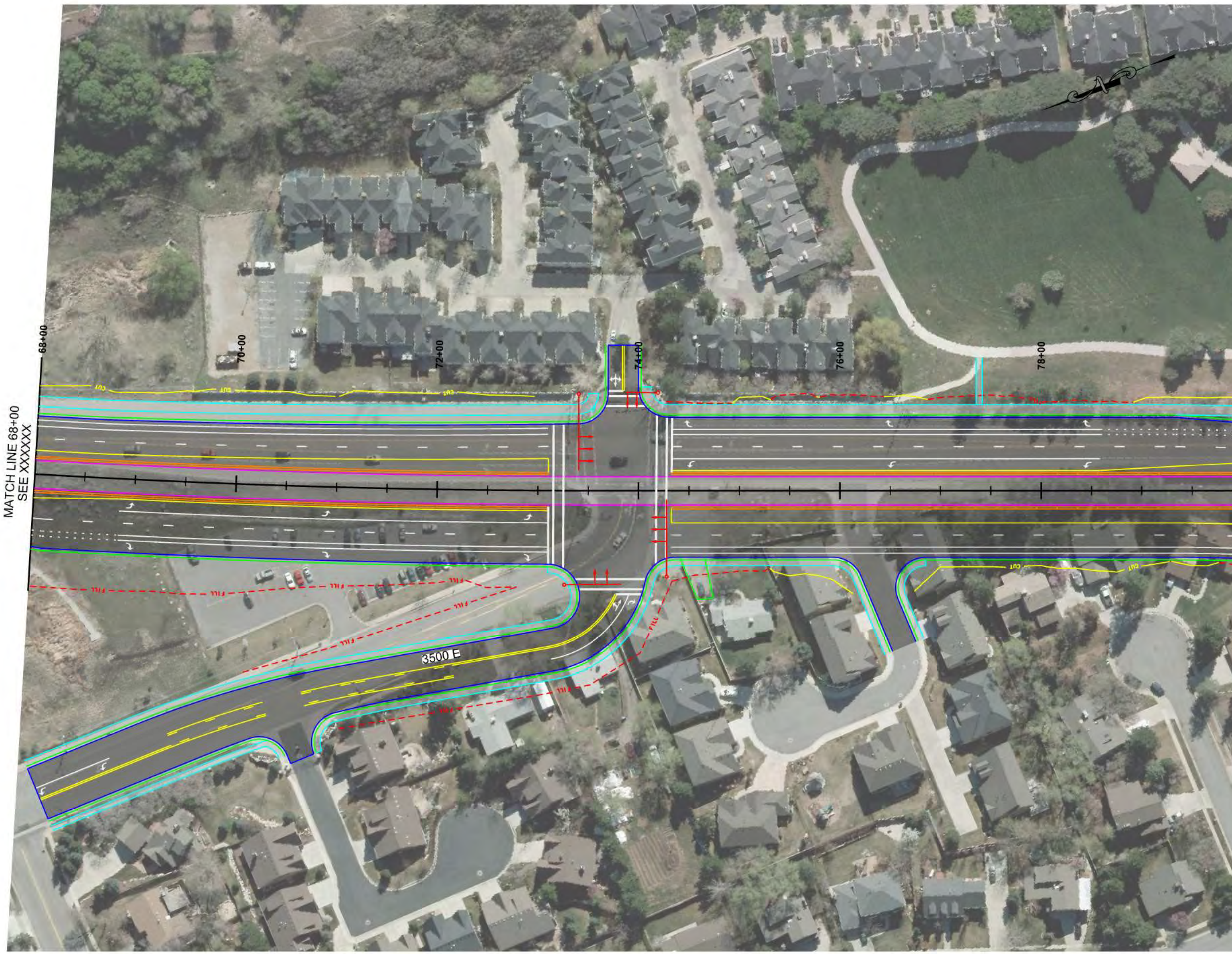

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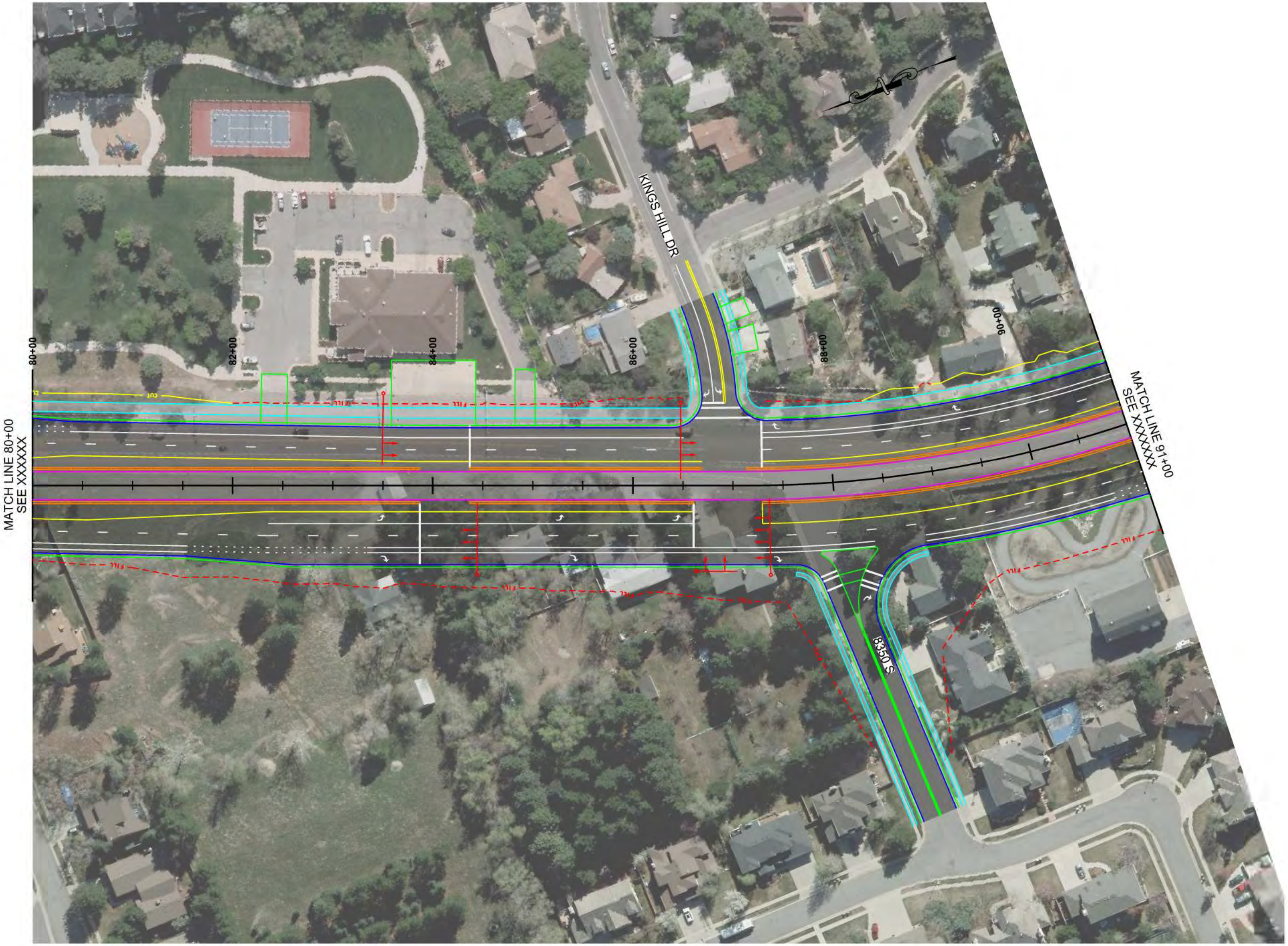

LITTLE COTTONWOOD CANYON EIS

COG RAIL SEGMENT

PROJECT	LITTLE COTTONWOOD CANYON EIS COG RAIL SEGMENT
PROJECT NUMBER	XXXX
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COG RAIL SEGMENT

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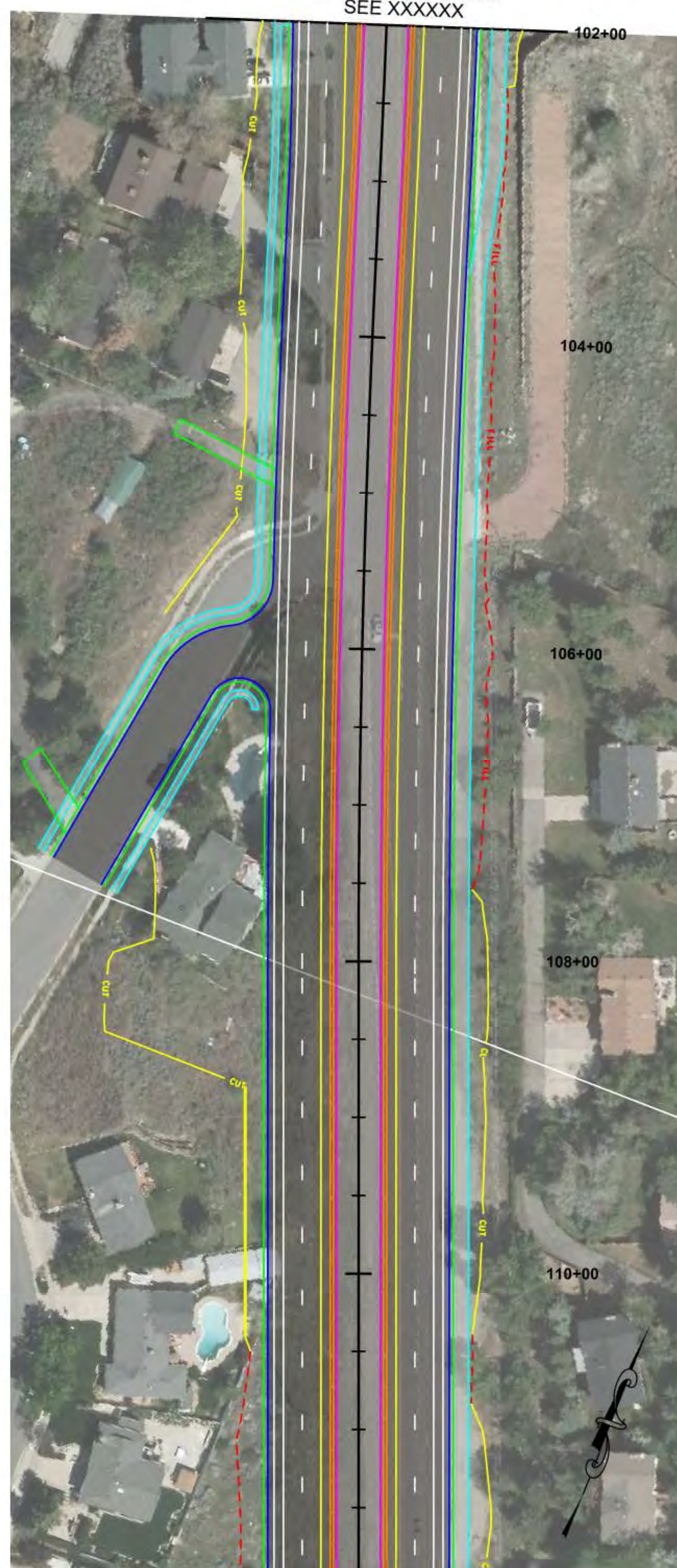

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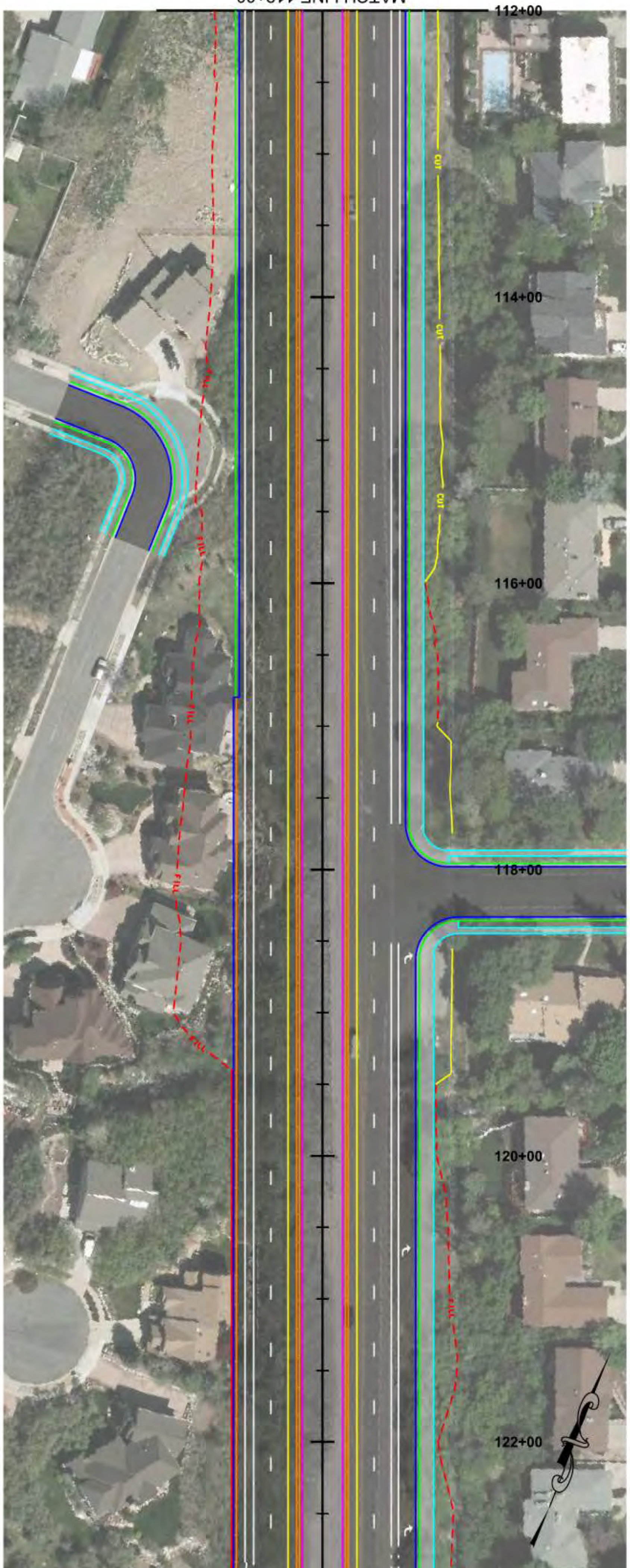

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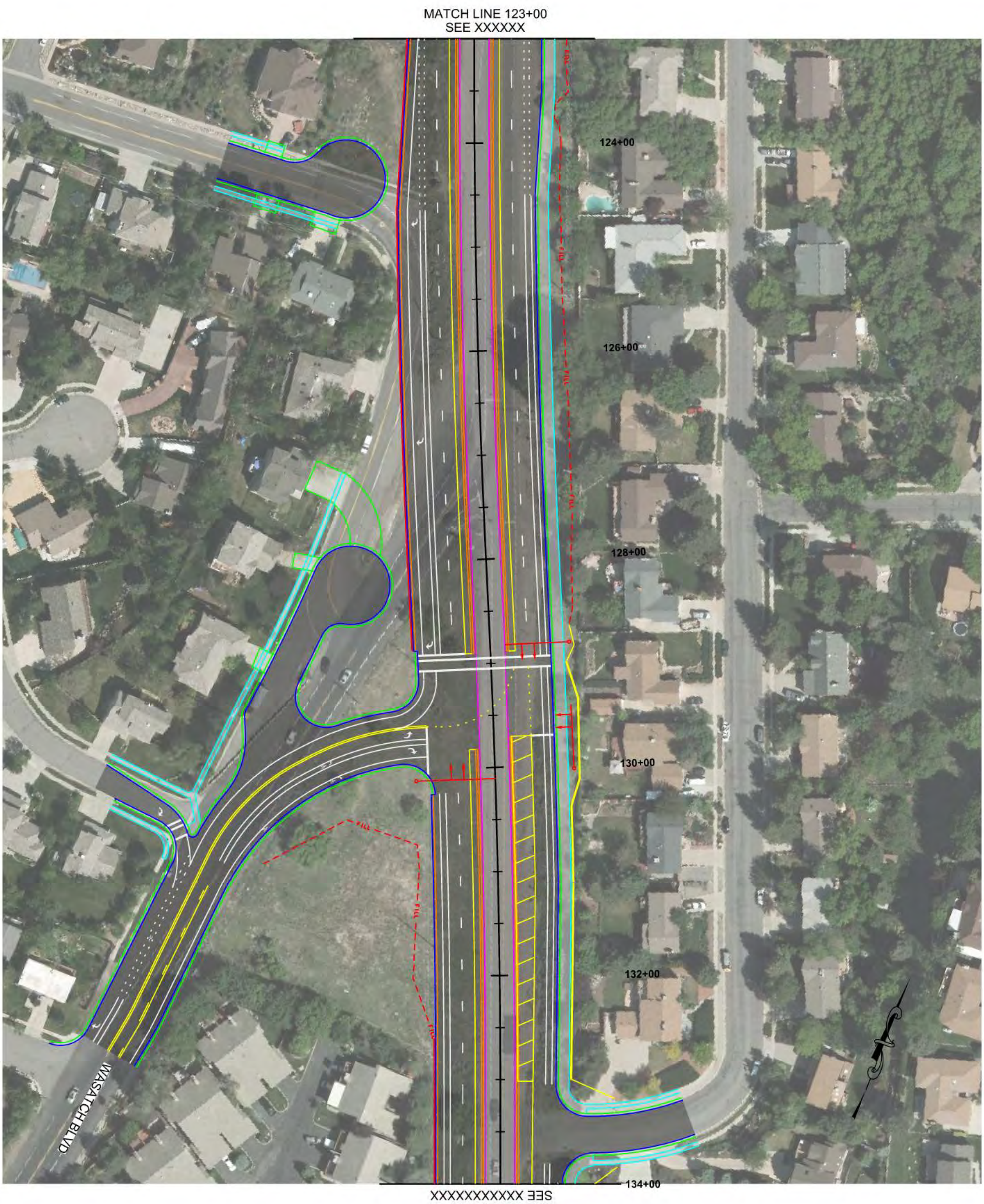
	COG RAIL SEGMENT				
PROJECT NUMBER	XXXX	PIN 16092	APPROVED	DRAWN BY	
			PROFESSIONAL ENGINEER / DATE	QC CHECKED BY	

REVISIONS

NO.	DATE	APPROVED BY	REMARKS

SHEET NO.

1/29/2020



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	PROJECT NUMBER	XXXX	PIN 16092	APPROVED PROFESSIONAL ENGINEER DATE
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				QC CHECKED BY

REVISIONS

NO.	DATE	APPROVED BY	REMARKS

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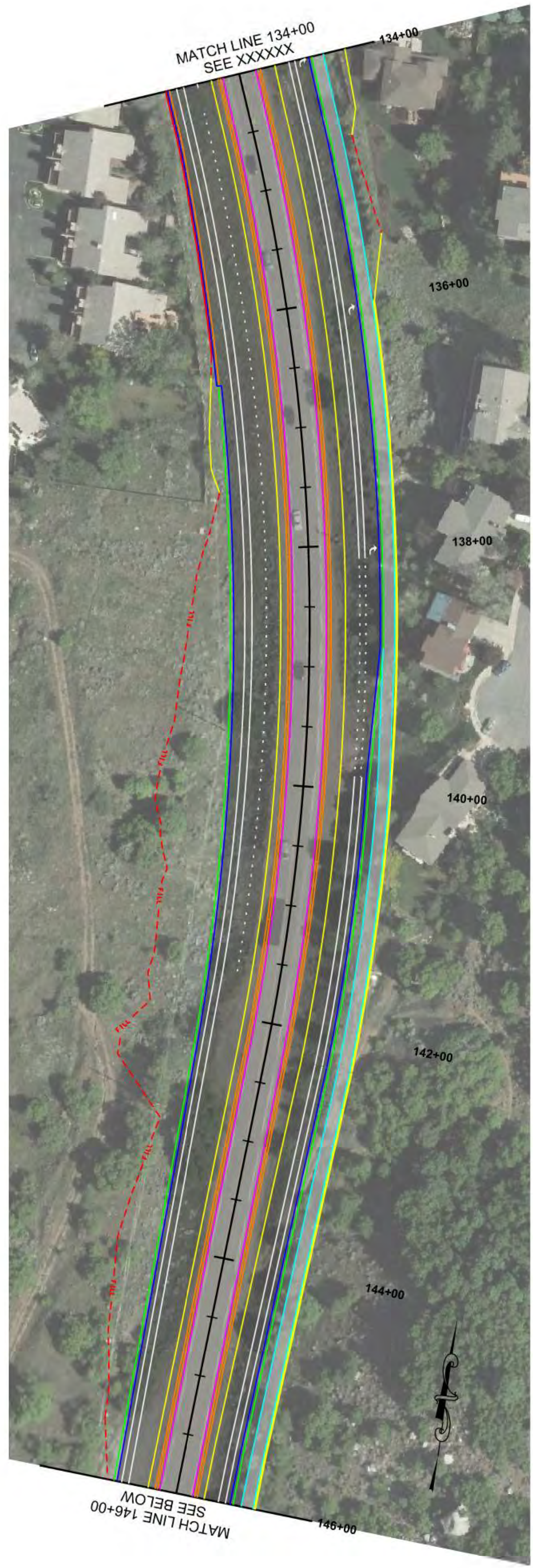

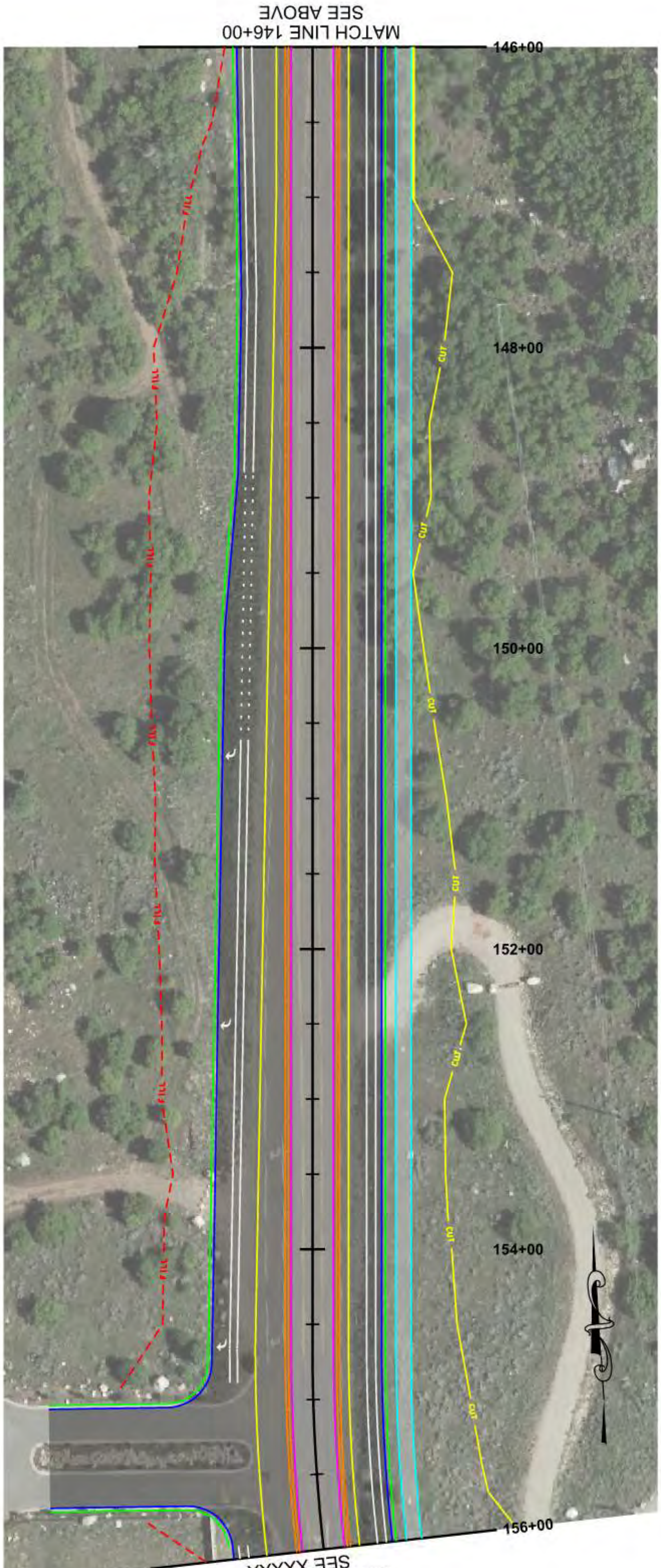

PROJECT	LITTLE COTTONWOOD CANYON EIS COG RAIL SEGMENT			
PROJECT NUMBER	XXXX	PIN	16092	

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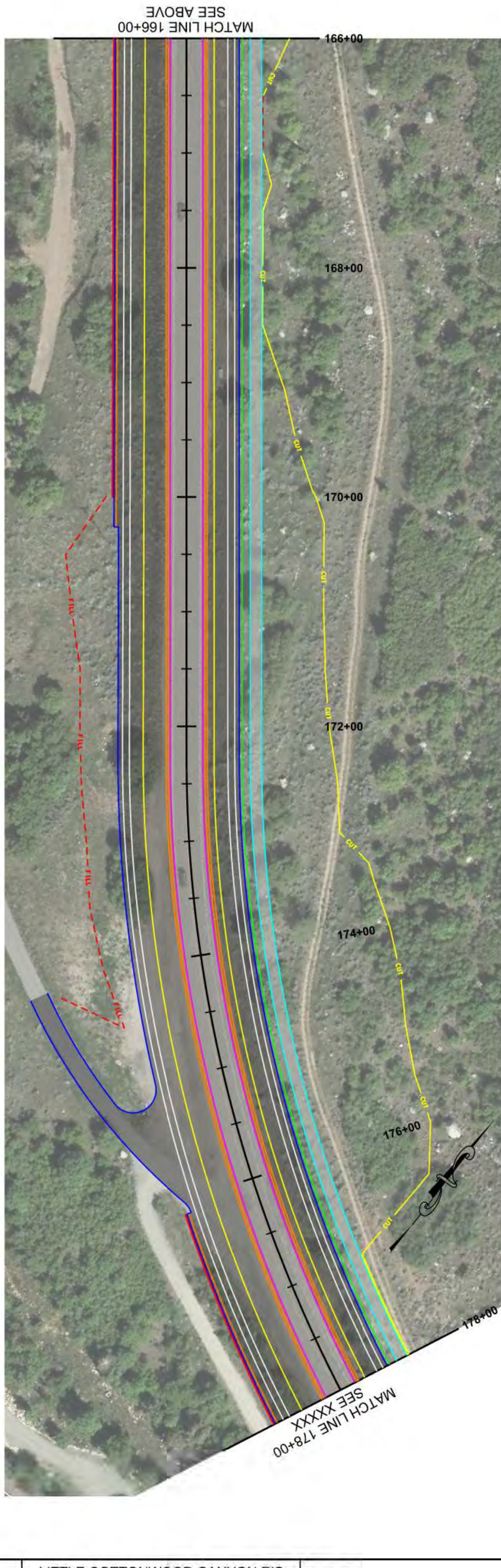
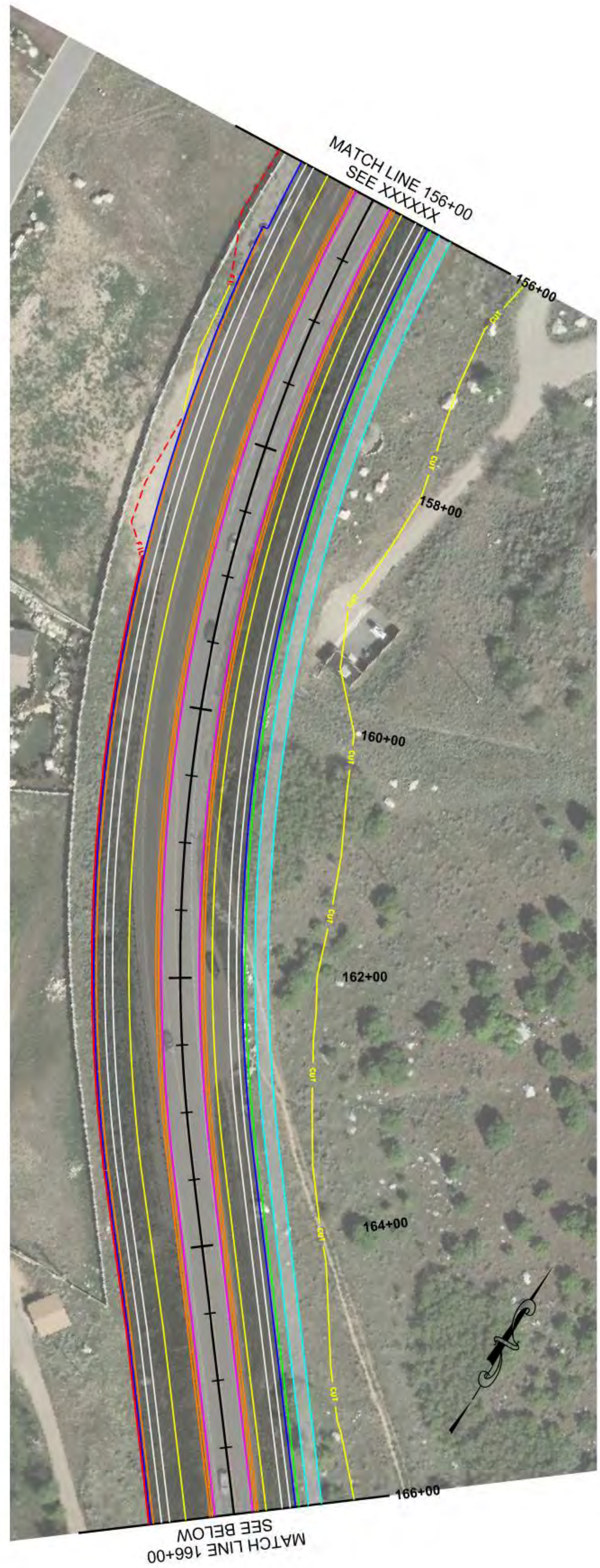
SHEET NO.





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	COG RAIL SEGMENT			
PROJECT NUMBER	XXXX	PIN	16092	

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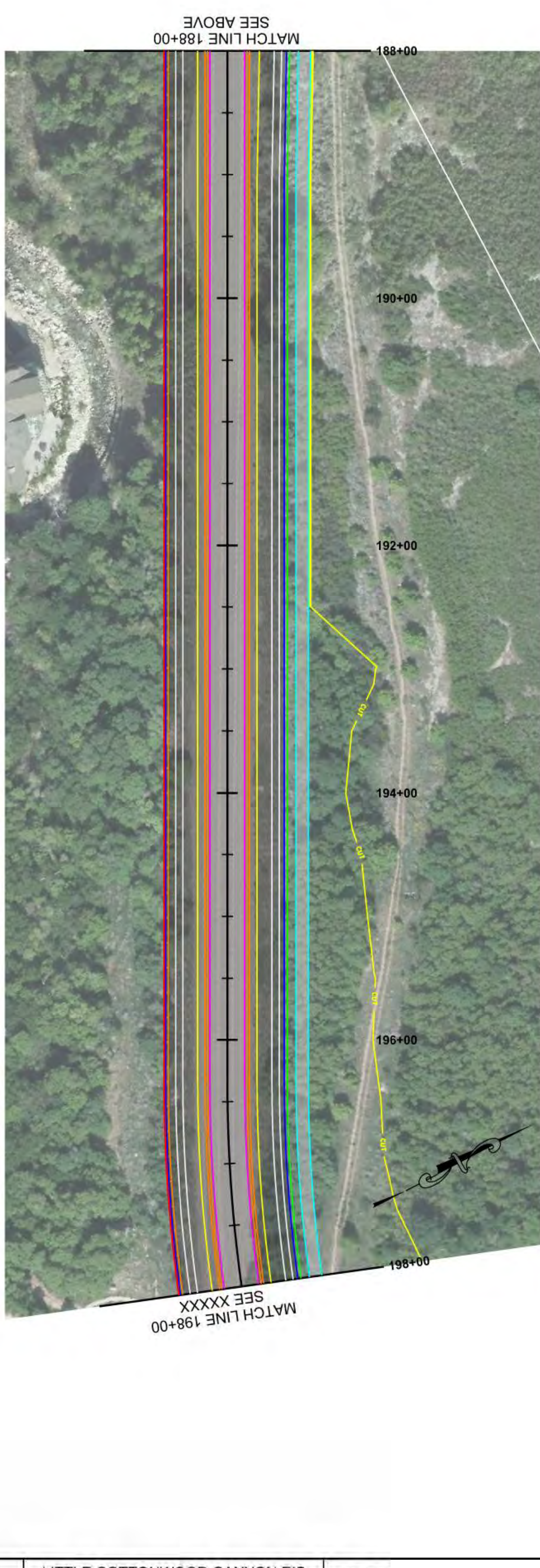

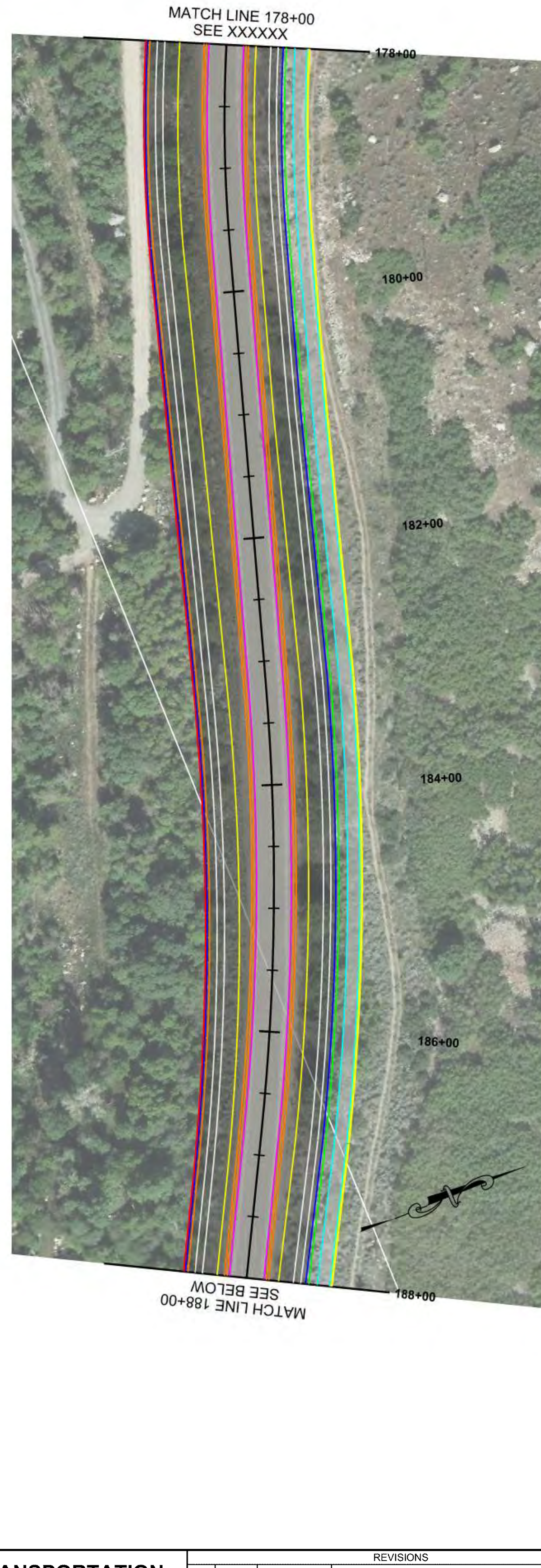

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		COG RAIL SEGMENT	
	PROJECT NUMBER	XXXX	PIN 16092

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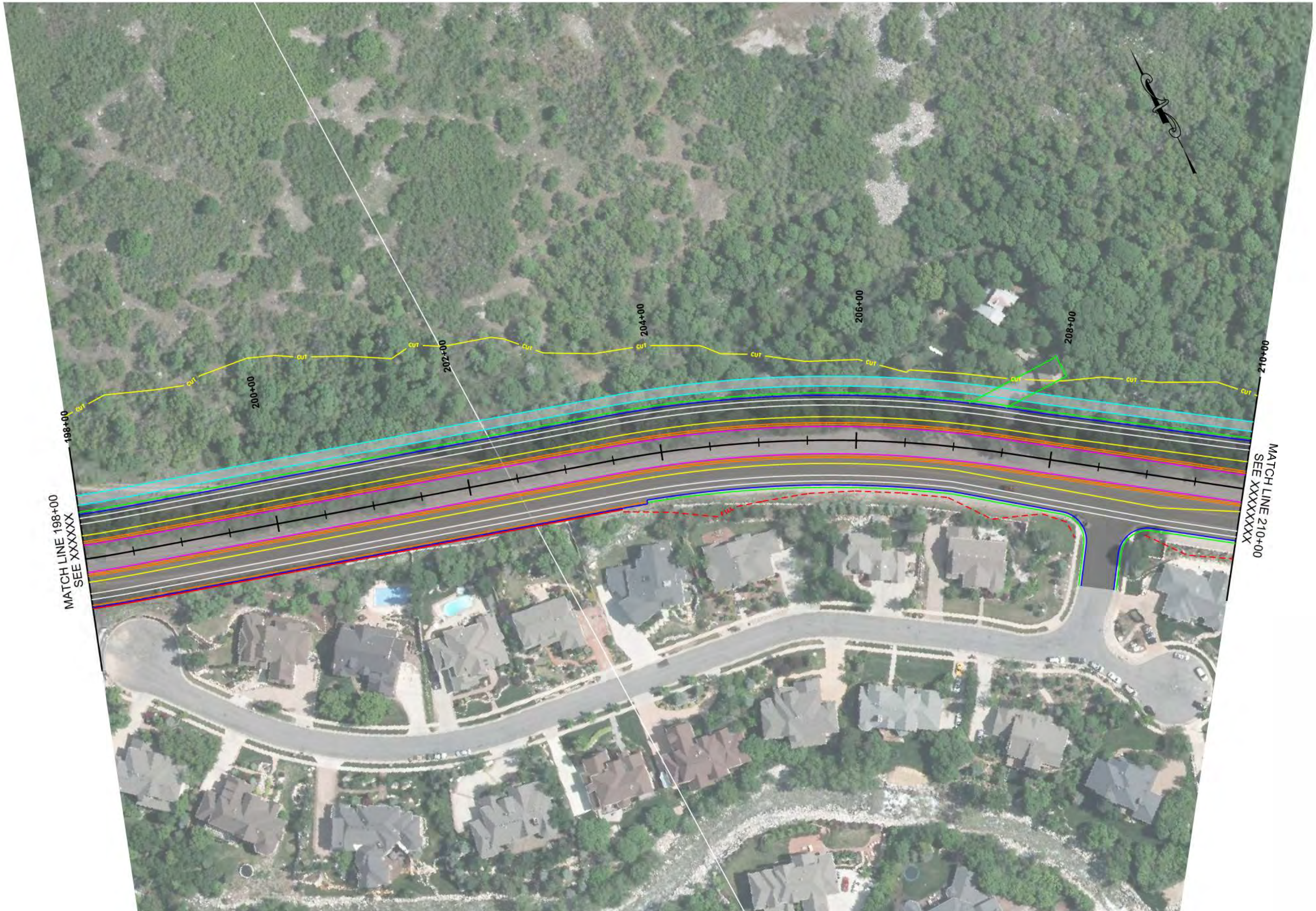

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PIN 16092

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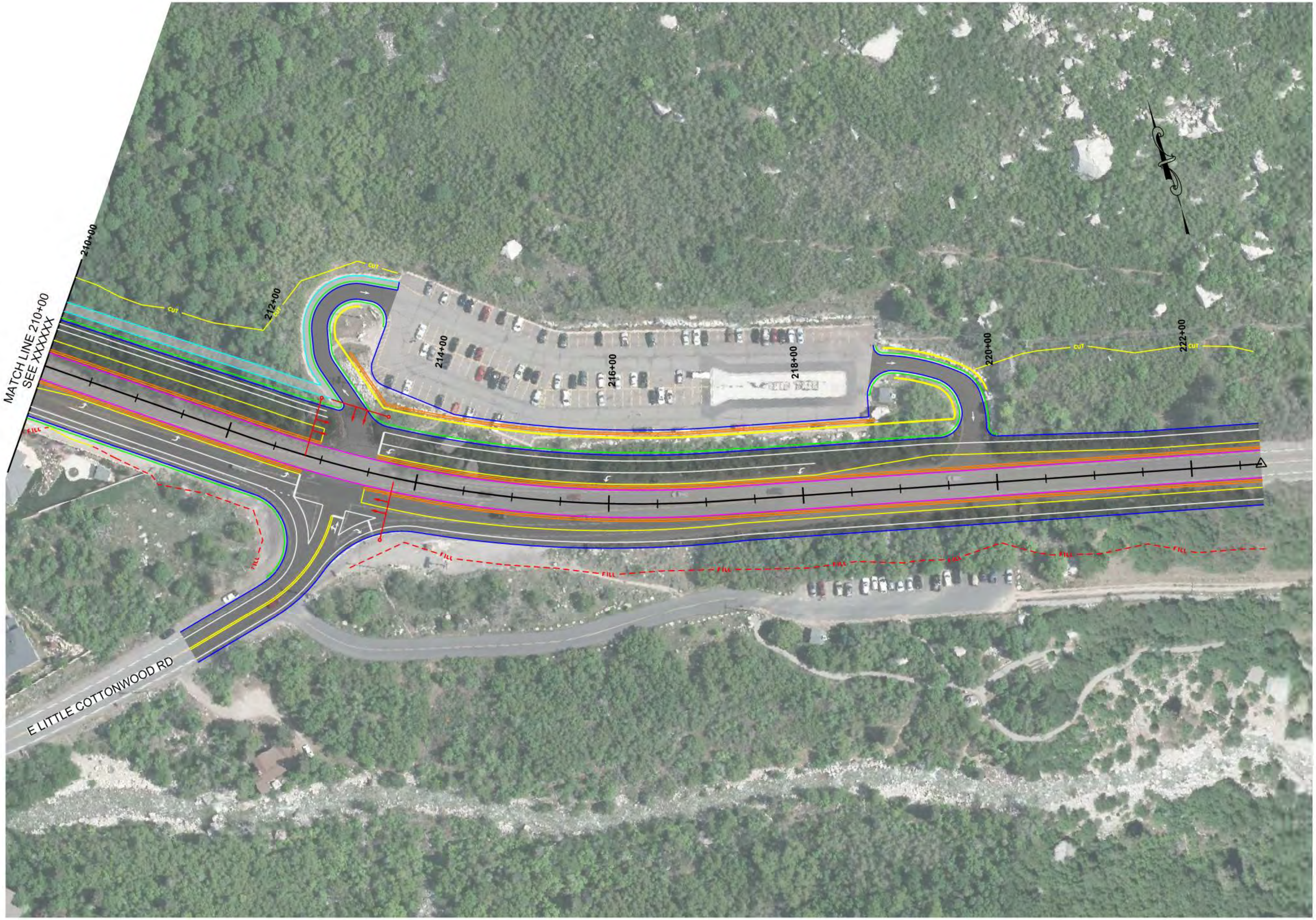

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COG RAIL SEGMENT

PIN 16092

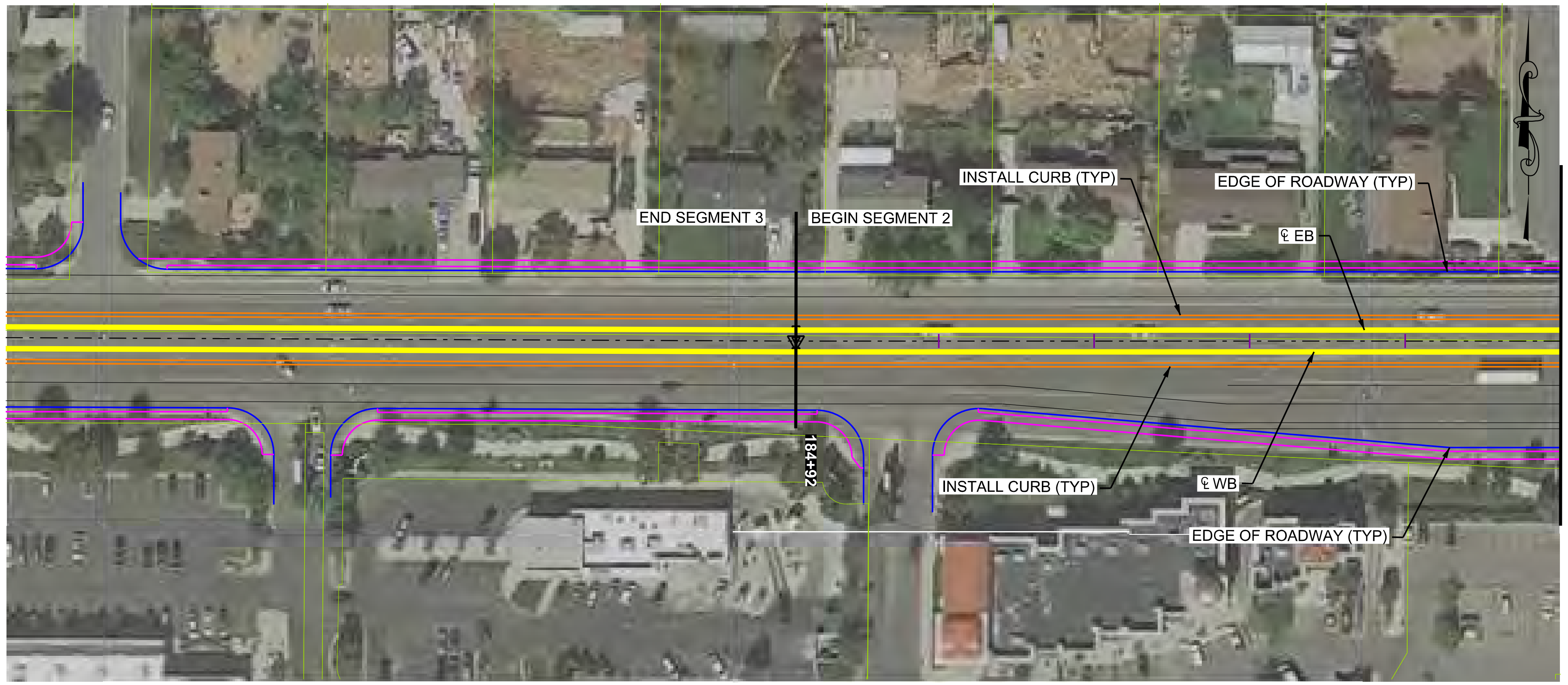
PROJECT NUMBER: XXXX

SHEET NO.

1/29/2020

APPENDIX B3

Preliminary Design Plans for Segment 3 – 9400 South and Highland Drive to Mouth of Little Cottonwood Canyon



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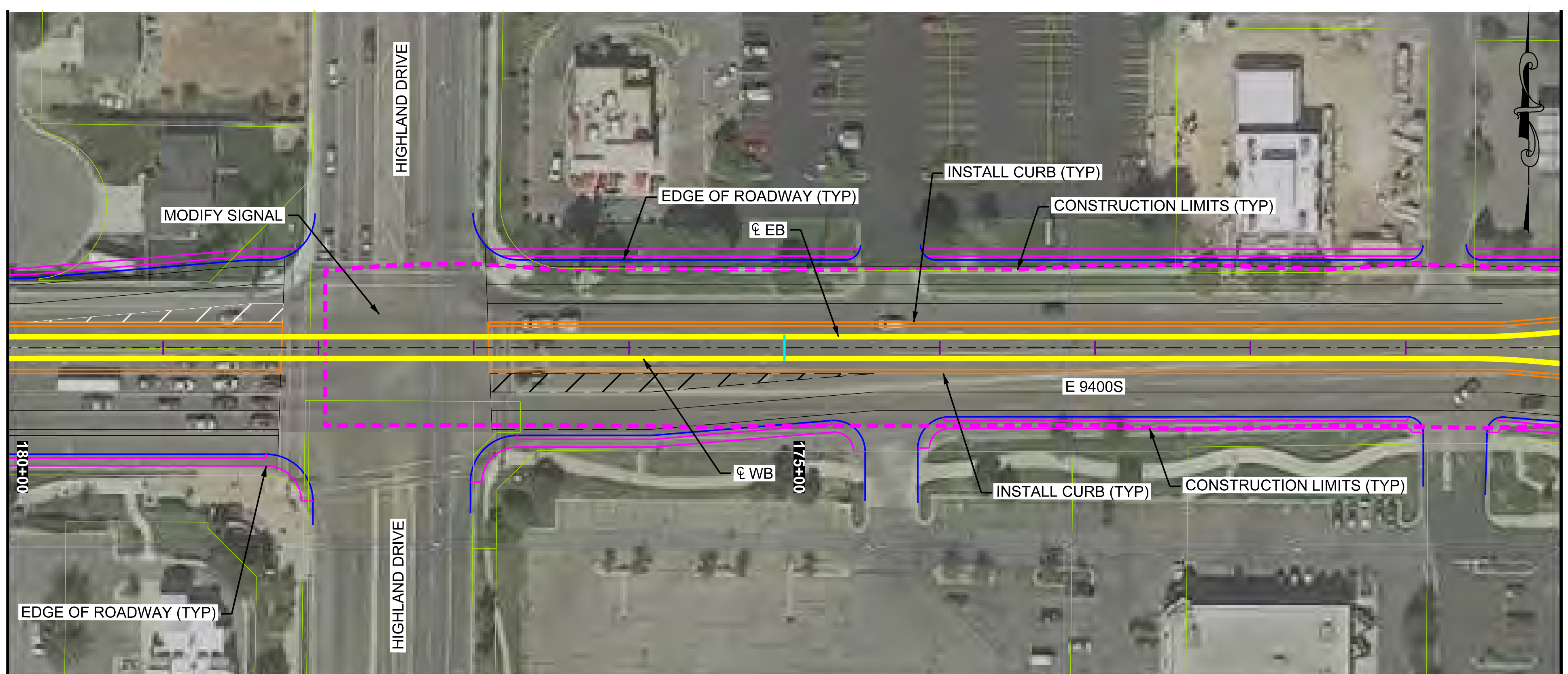

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COG RAIL SEGMENT 2

PIN: 16092

PROJECT NUMBER: XXXX

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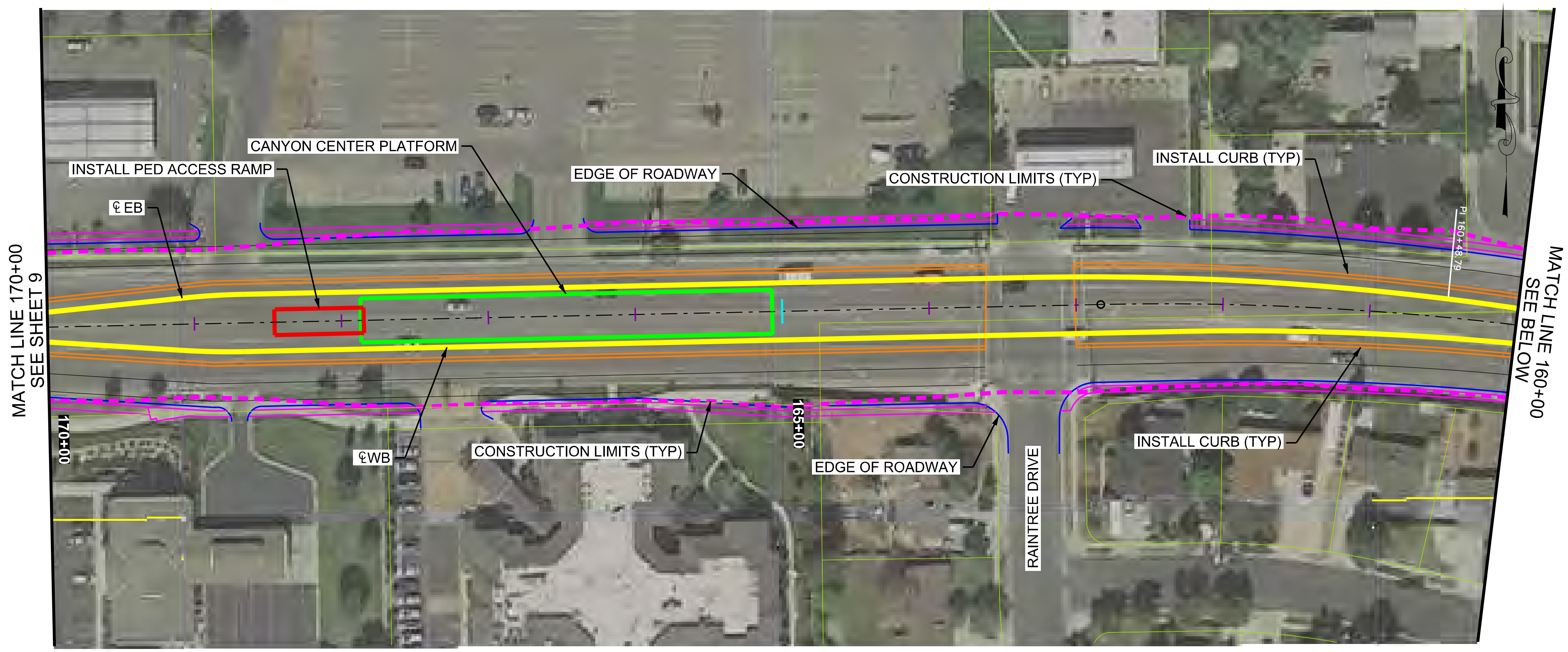

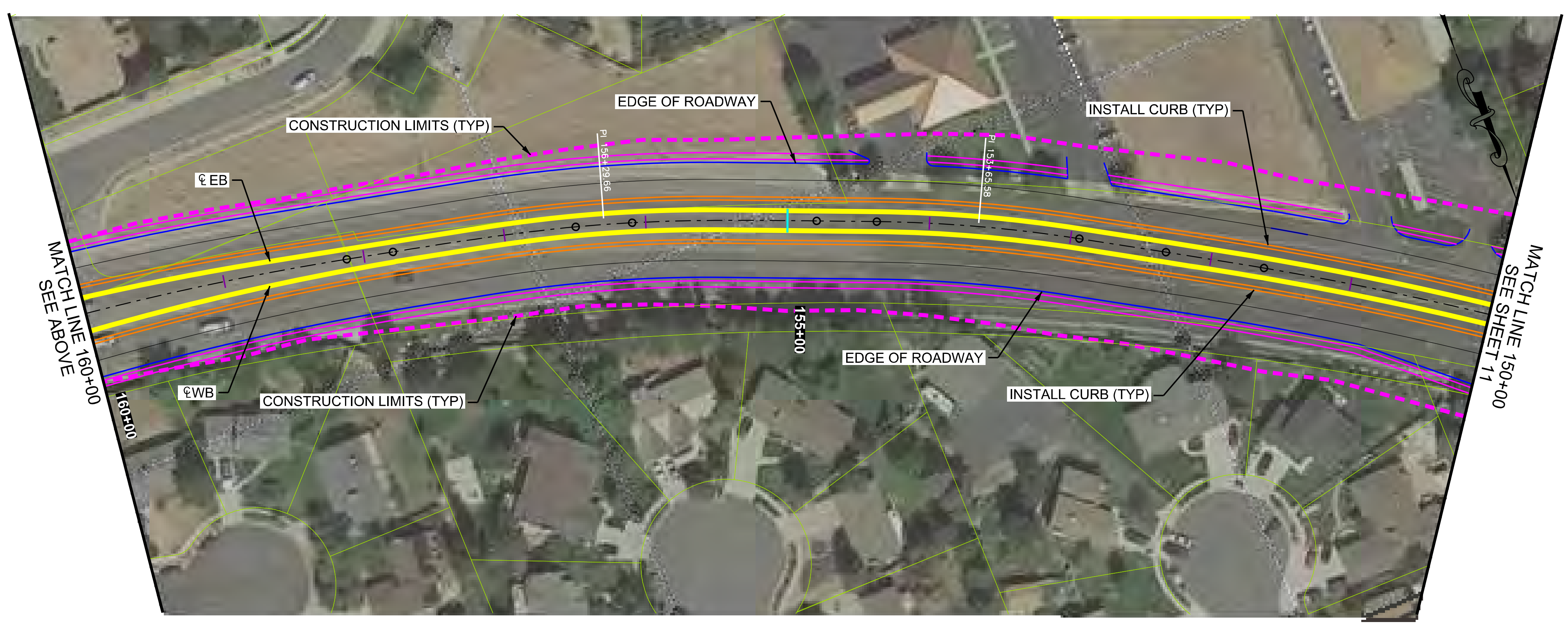

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PROJECT: LITTLE COTTONWOOD CANYON EIS

COG RAIL SEGMENT 2

PIN: 16092

PROJECT NUMBER: XXXX

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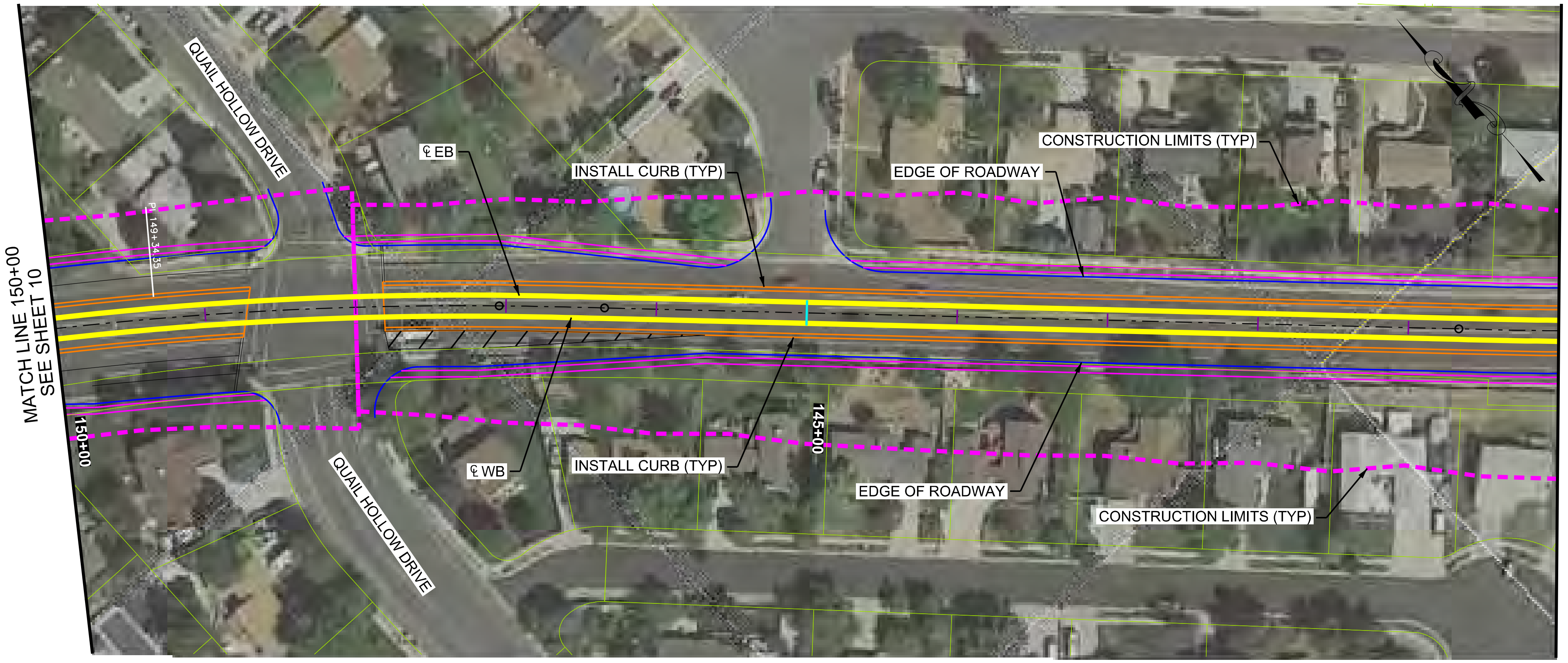

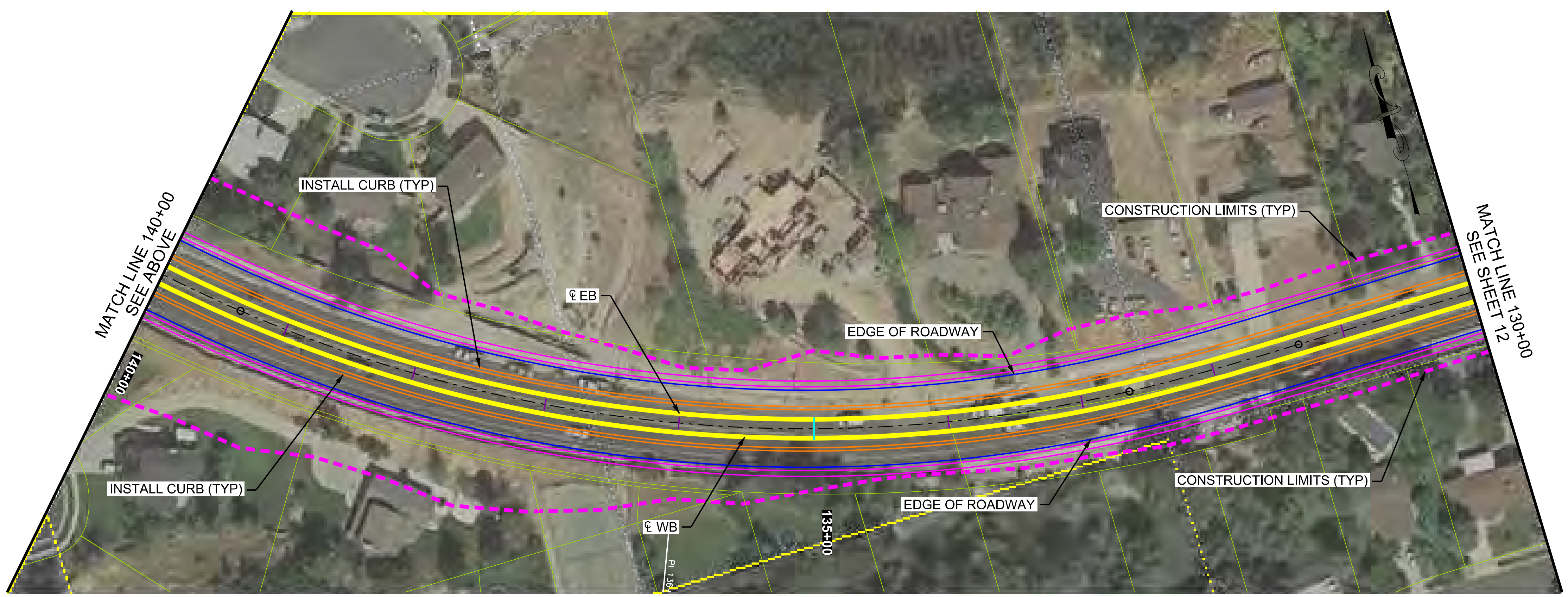

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COG RAIL SEGMENT 2

PIN 16092

PROJECT NUMBER XXXX

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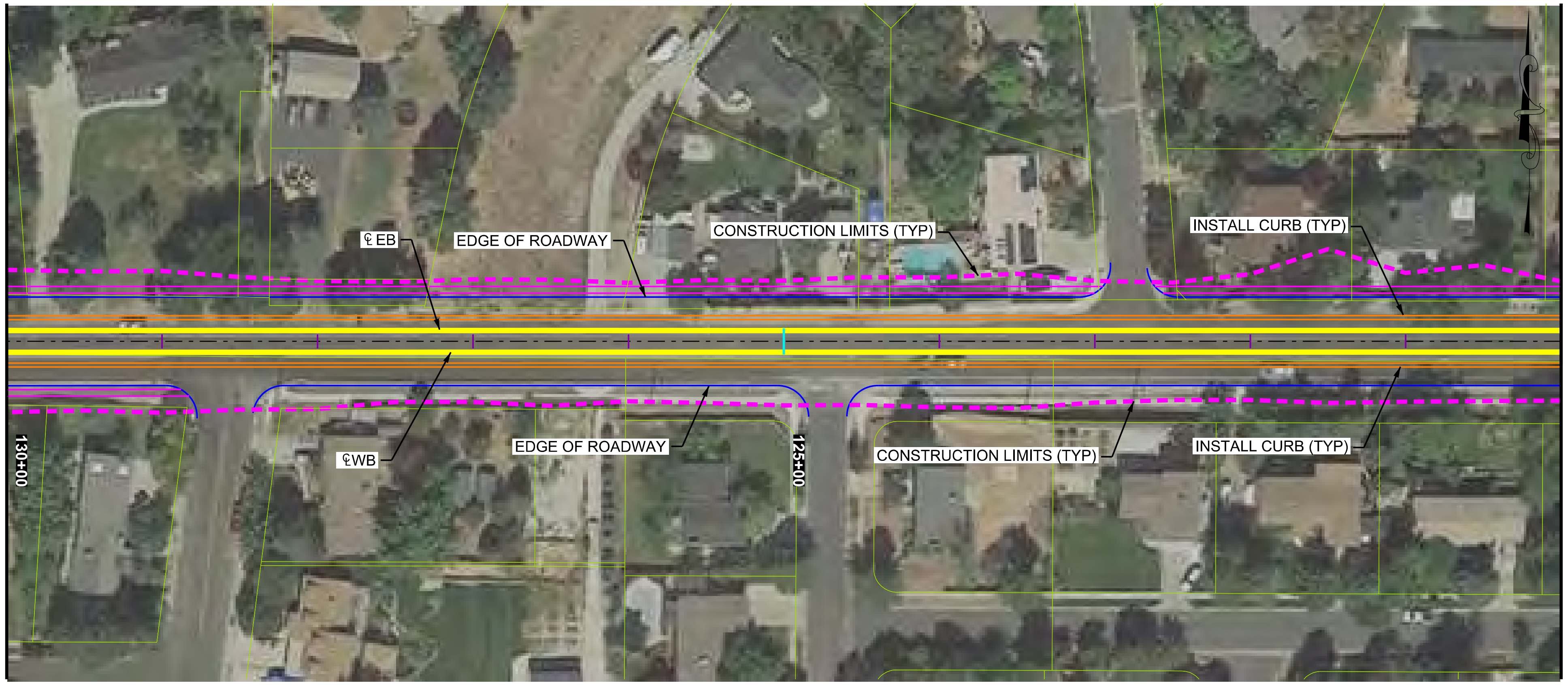

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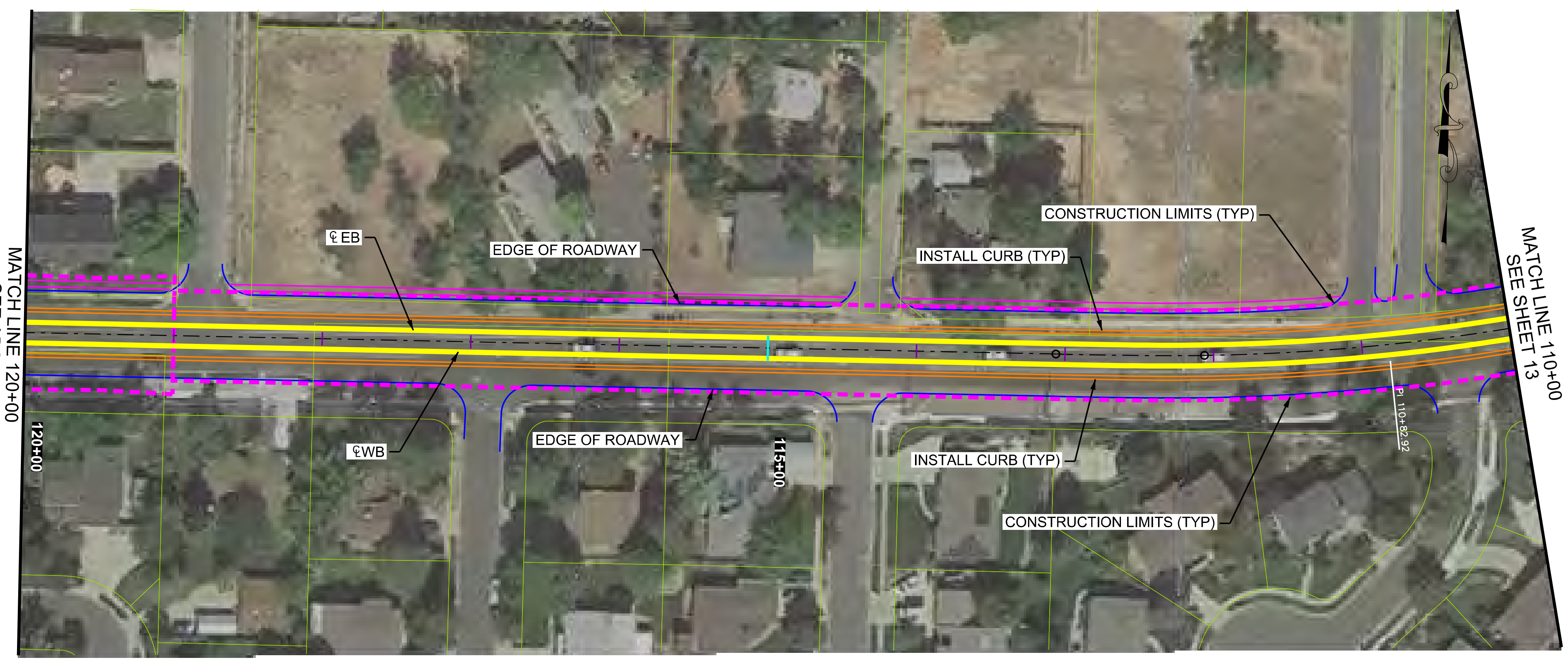

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PROJECT: LITTLE COTTONWOOD CANYON EIS
COG RAIL SEGMENT 2
PIN 16092
PROJECT NUMBER XXXX

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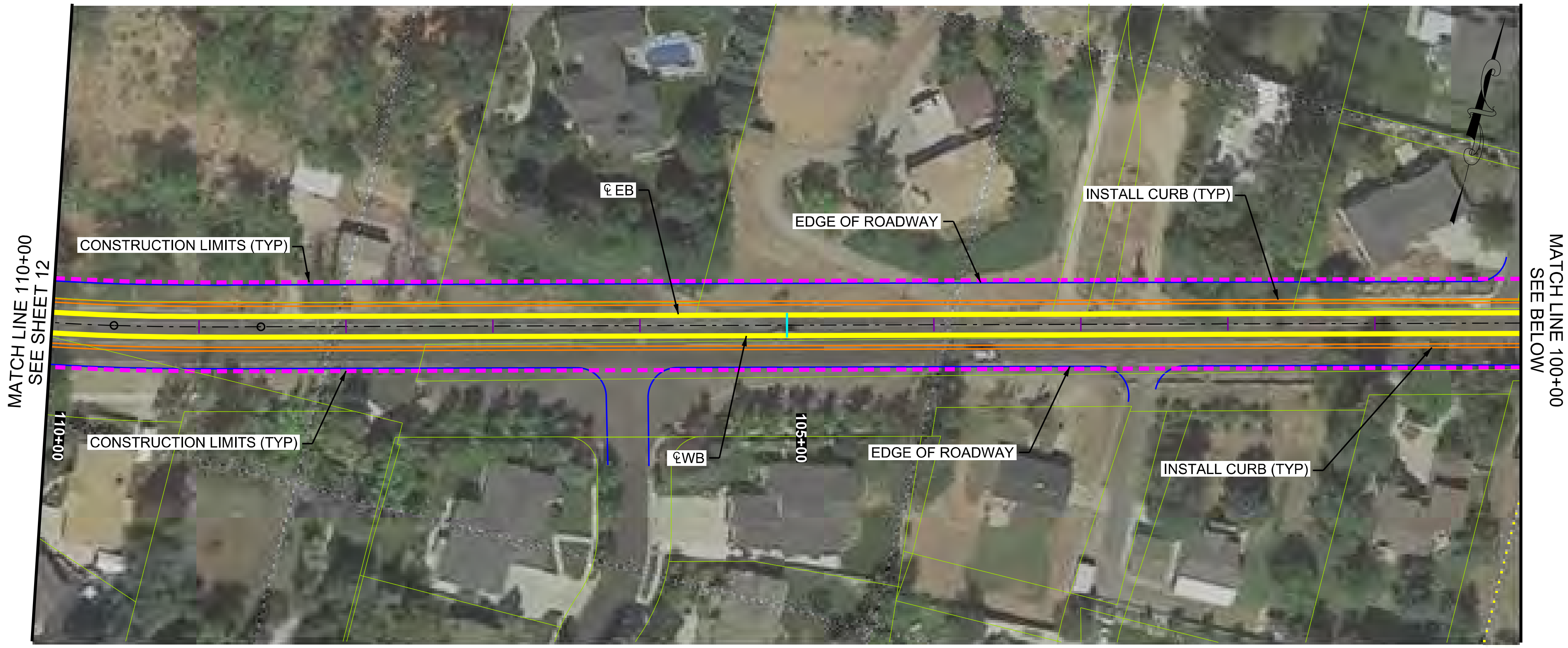

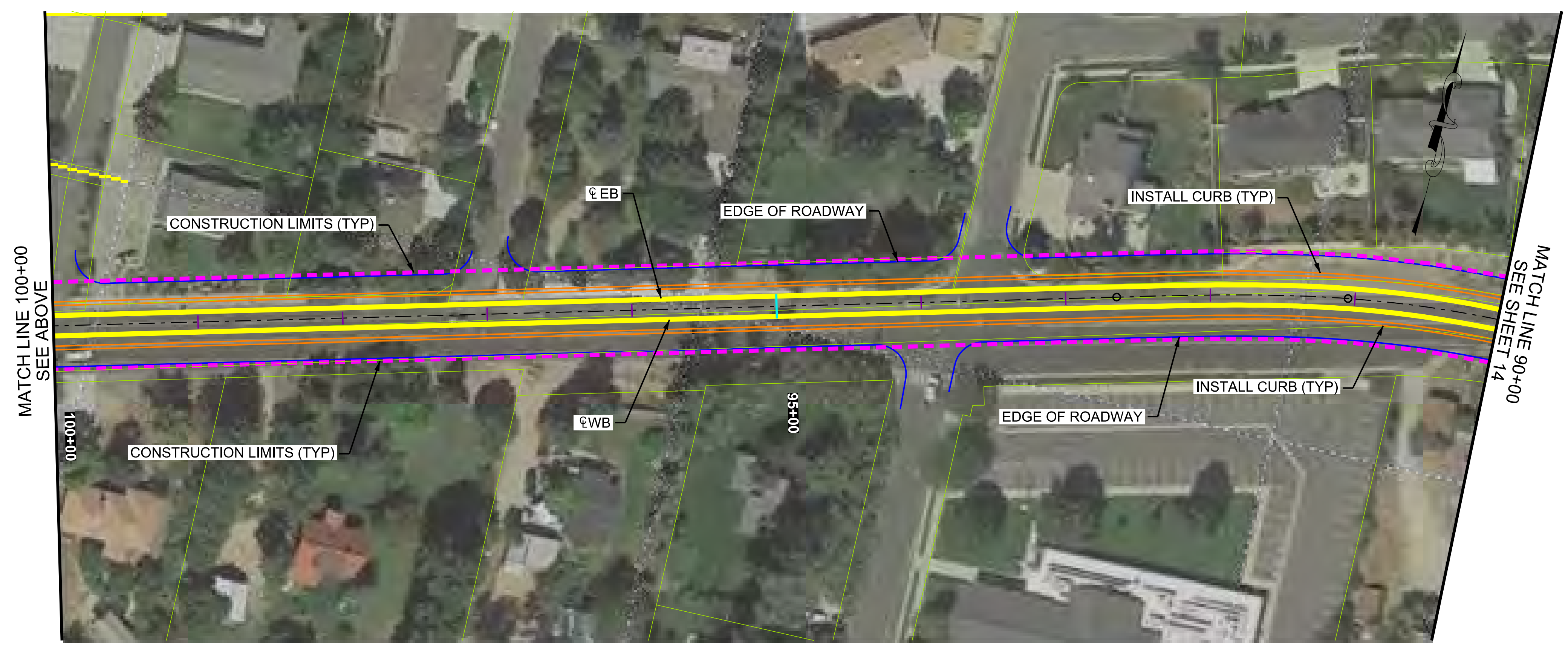

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PROJECT: LITTLE COTTONWOOD CANYON EIS
COG RAIL SEGMENT 2

PIN 16092

PROJECT NUMBER: XXXX

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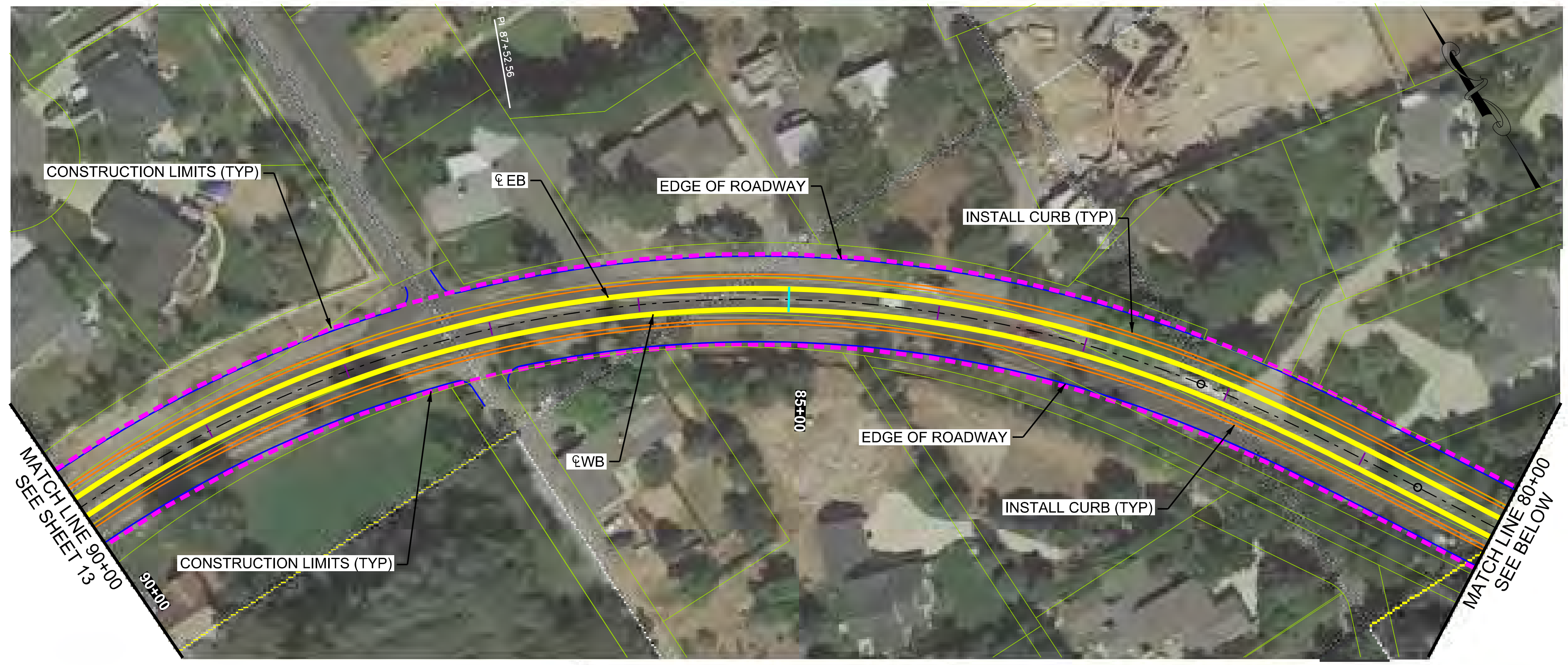

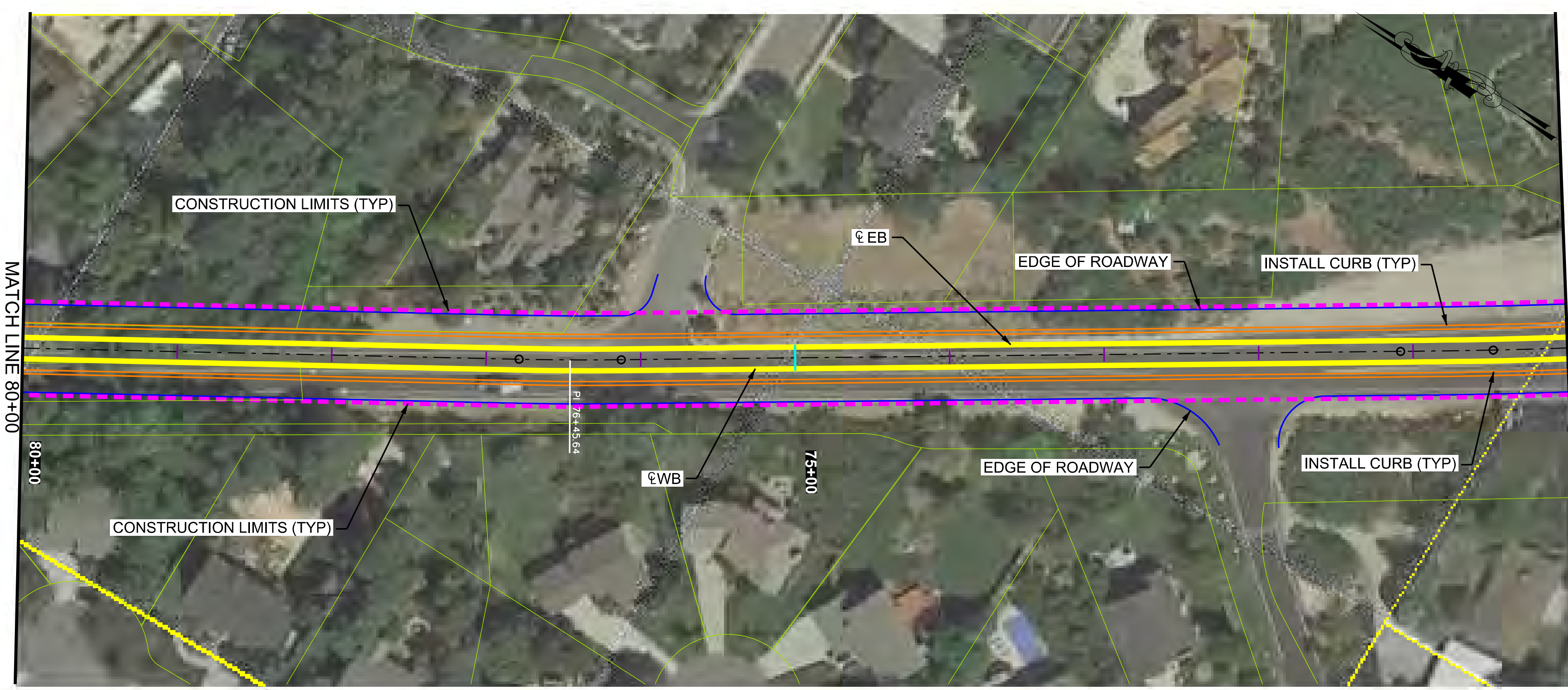

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PROJECT: LITTLE COTTONWOOD CANYON EIS
COG RAIL SEGMENT 2

PIN: 16092

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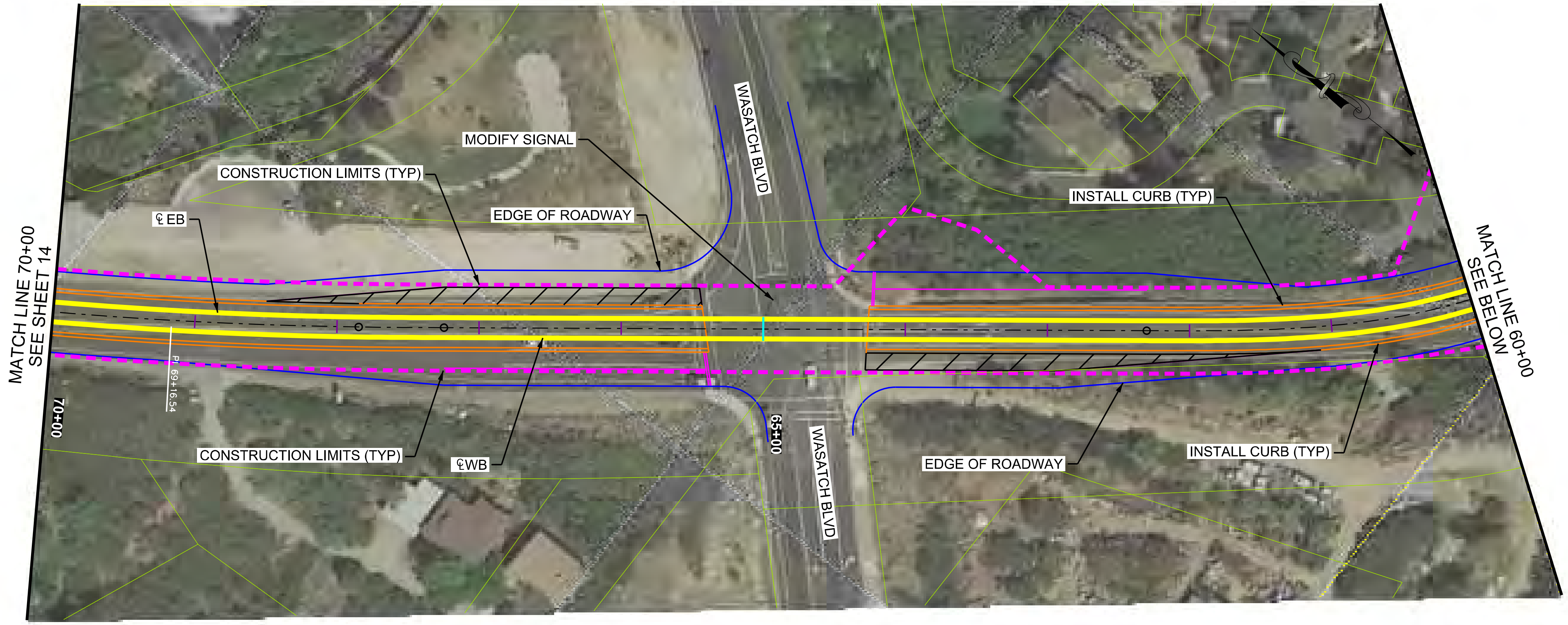

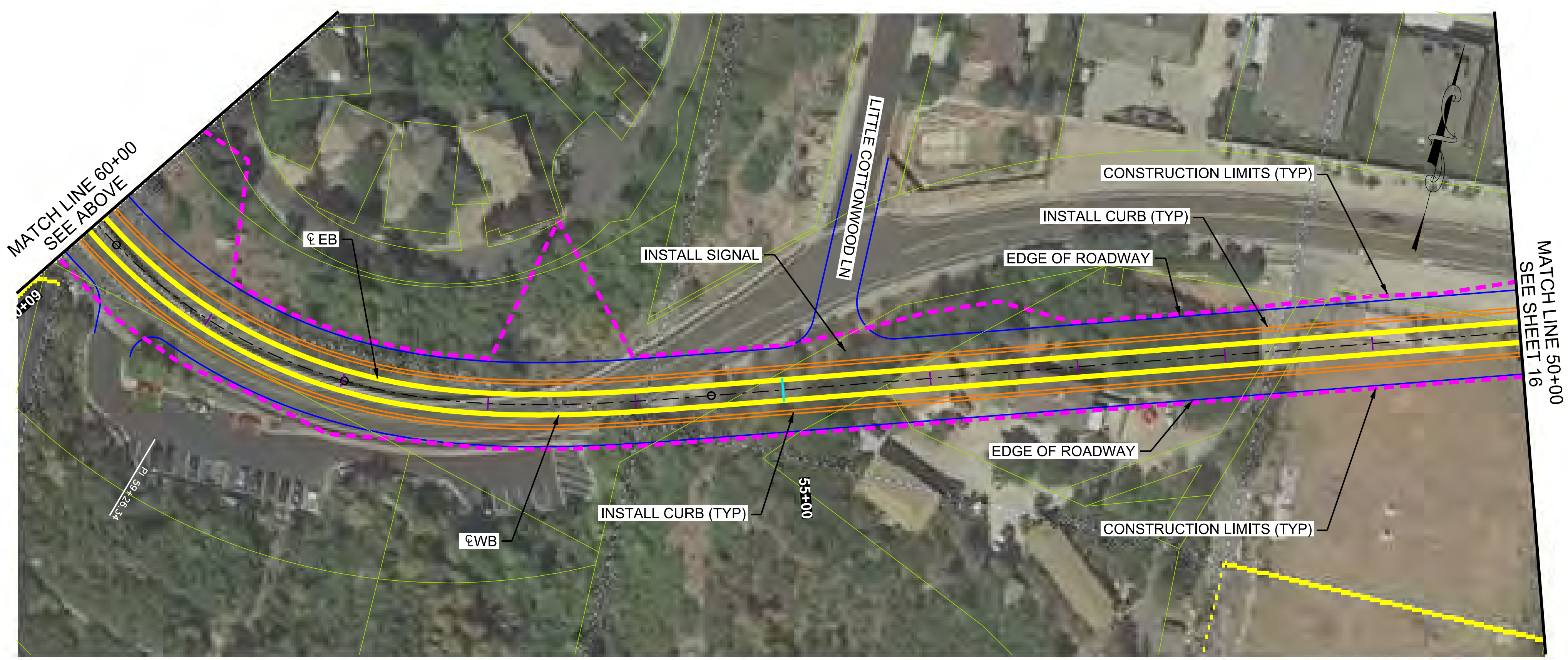

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COG RAIL SEGMENT 2

PIN 16092

PROJECT NUMBER: XXXX

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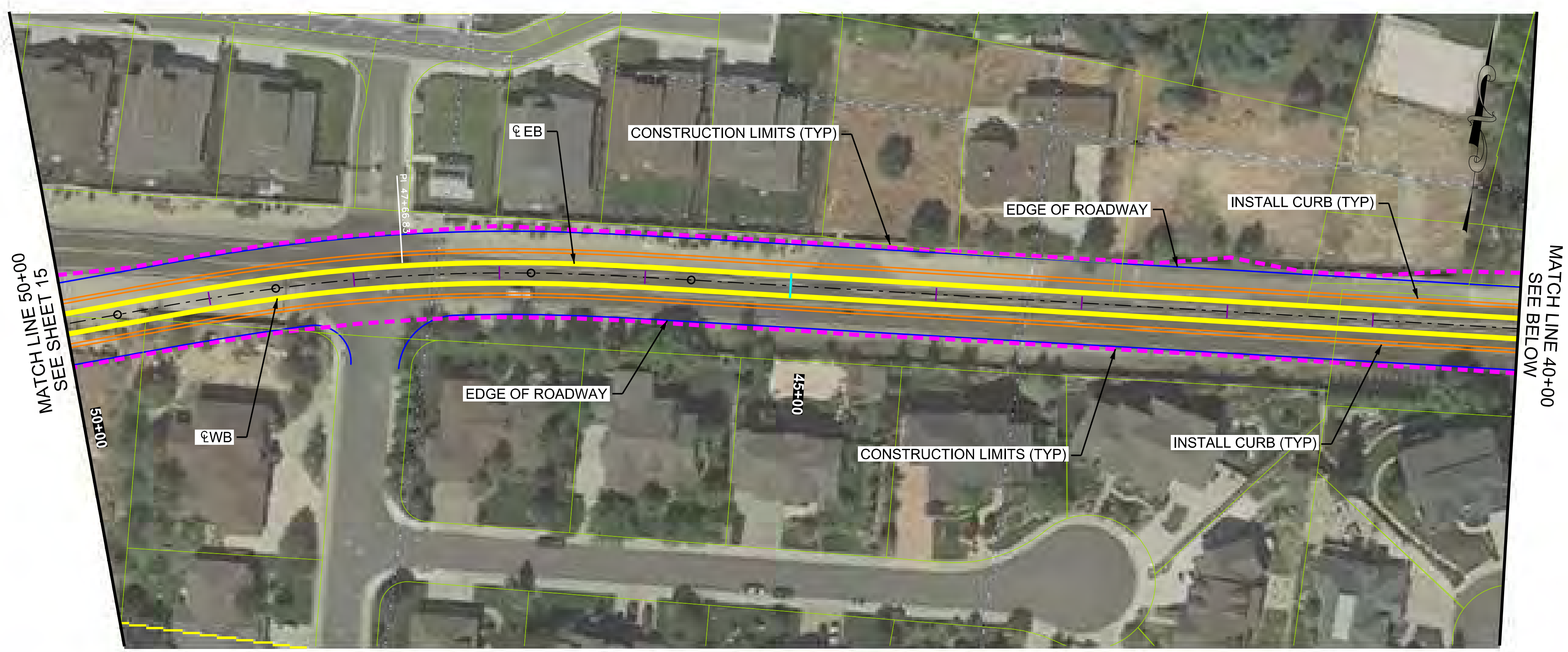
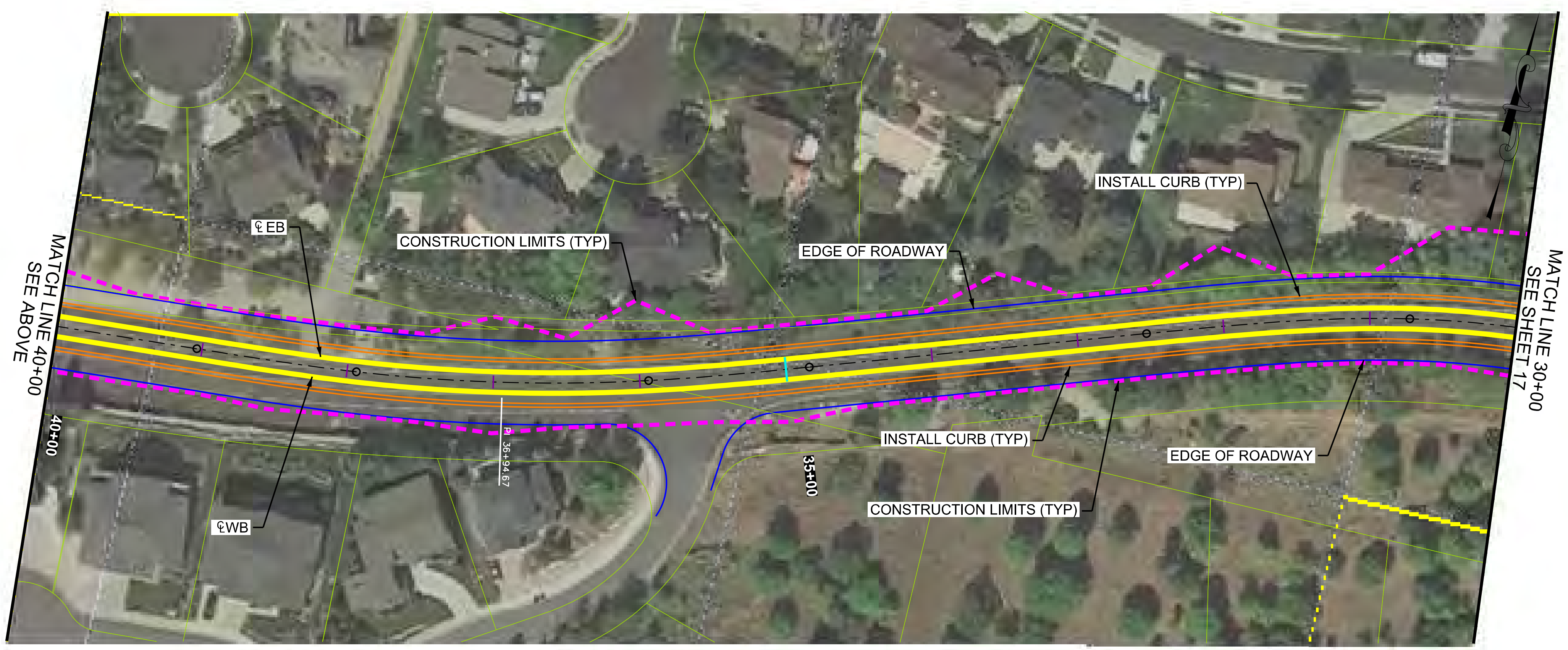
2/15/2020





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PROJECT: LITTLE COTTONWOOD CANYON EIS

COG RAIL SEGMENT 2

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PIN: 16092

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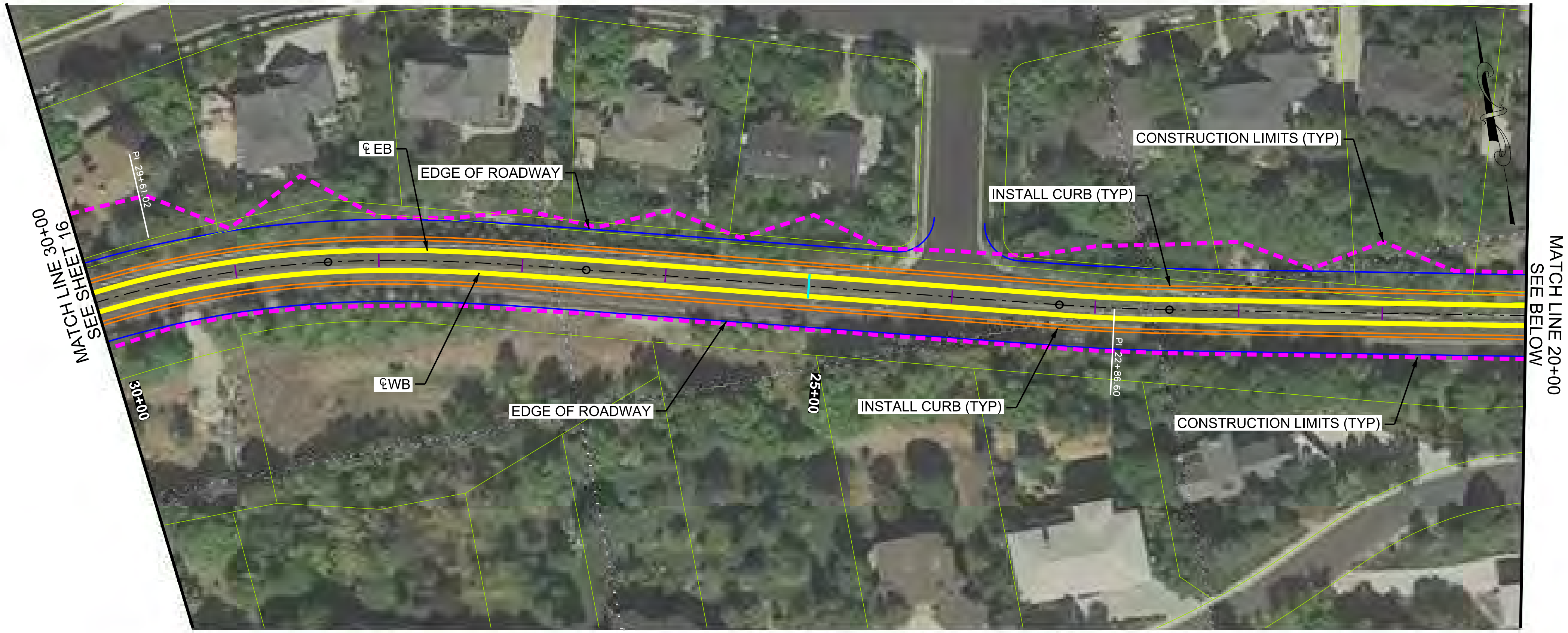
2/15/2020



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PROJECT: LITTLE COTTONWOOD CANYON EIS

COG RAIL SEGMENT 2

PIN 16092

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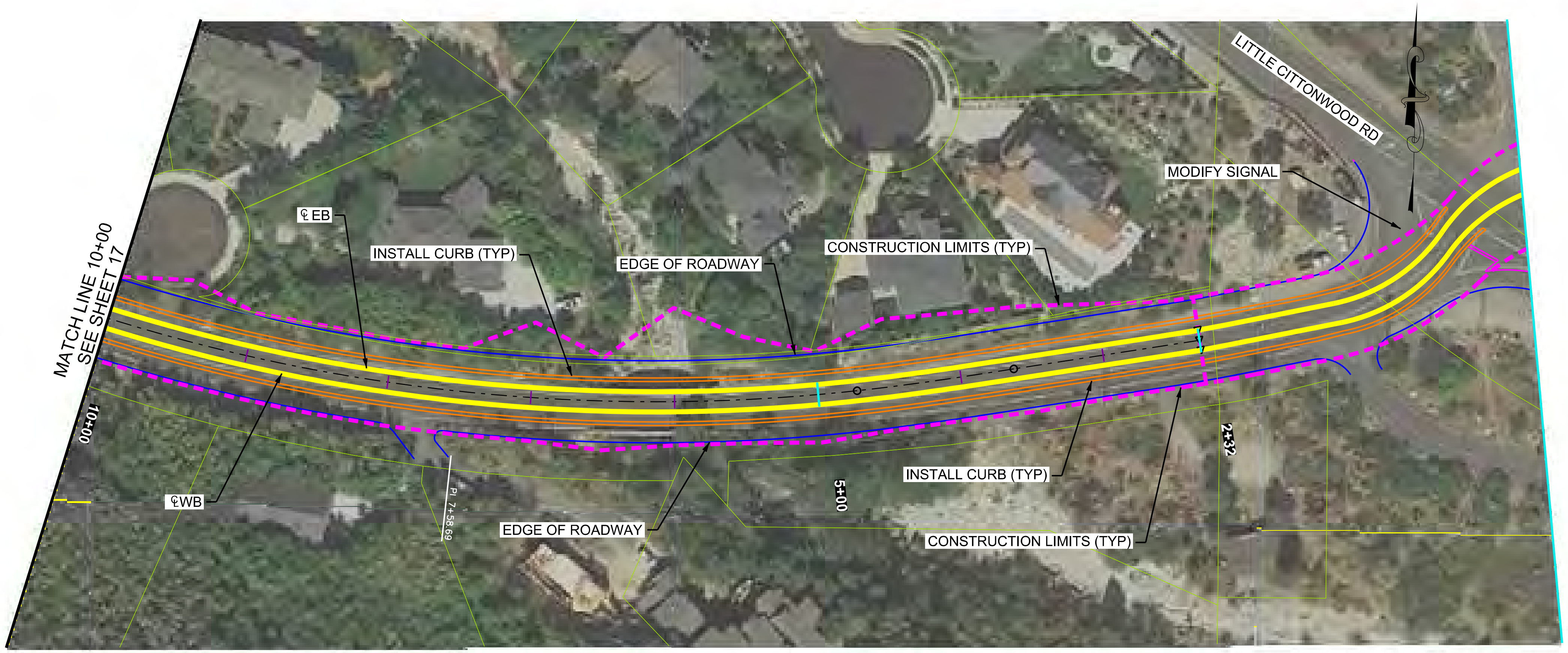

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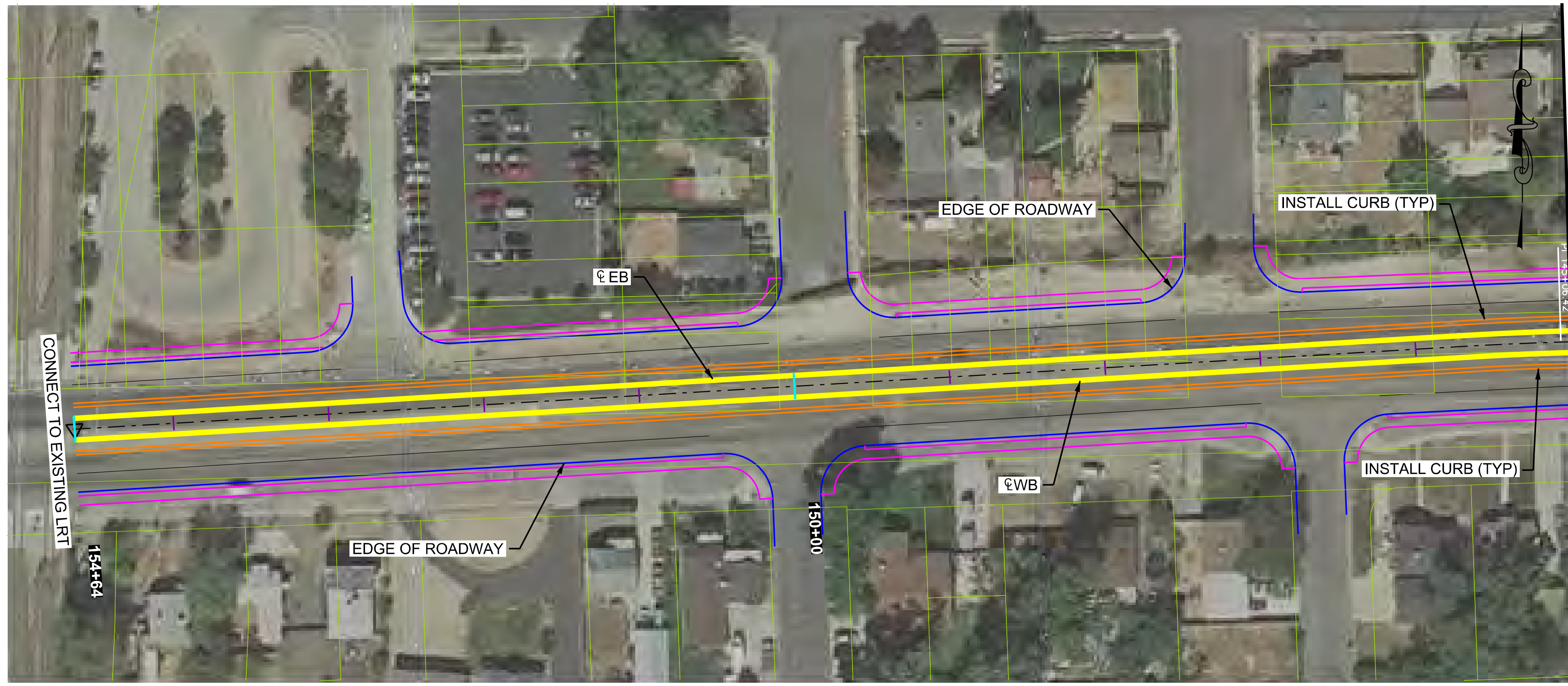
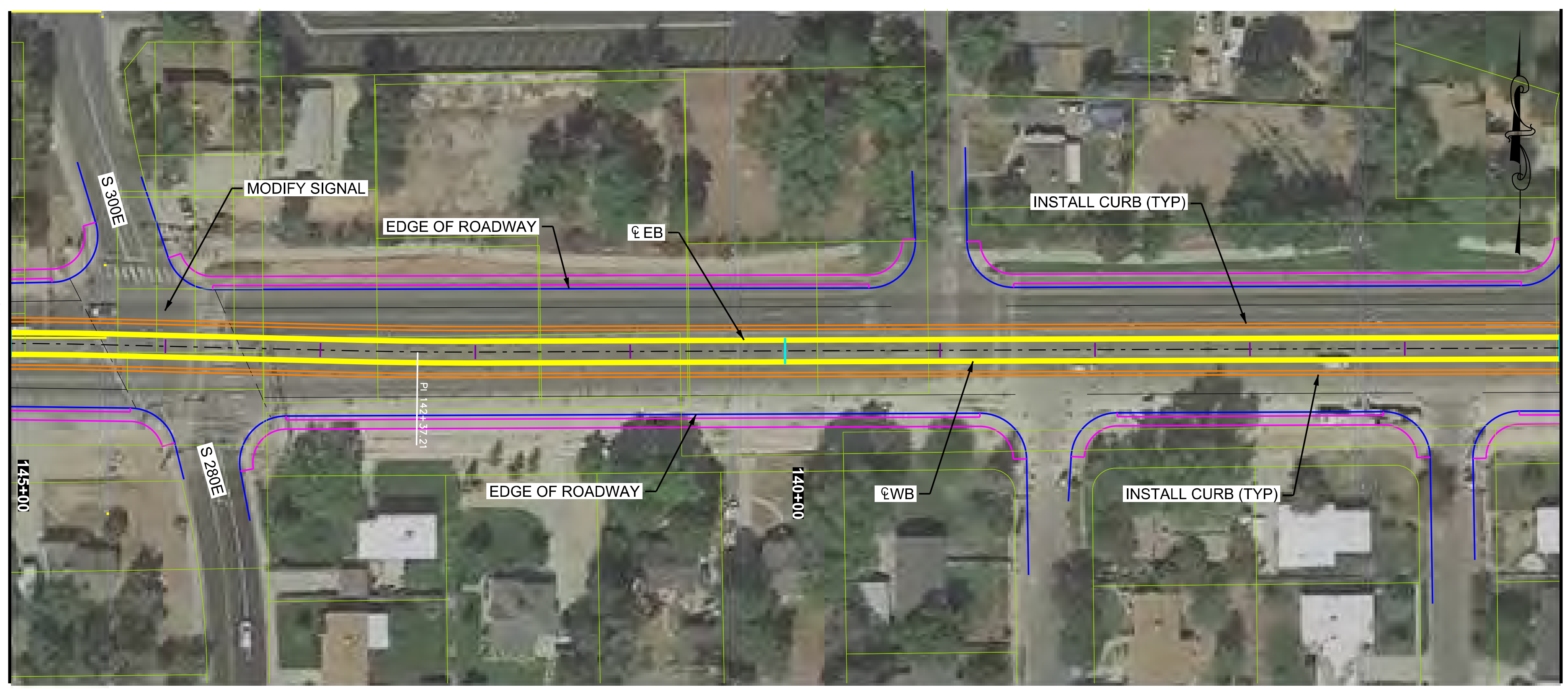
2/16/2020

APPENDIX B4

Preliminary Design Plans for Segment 4 – Historic Sandy TRAX Station 9400 South and Highland Drive





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PIN 16092

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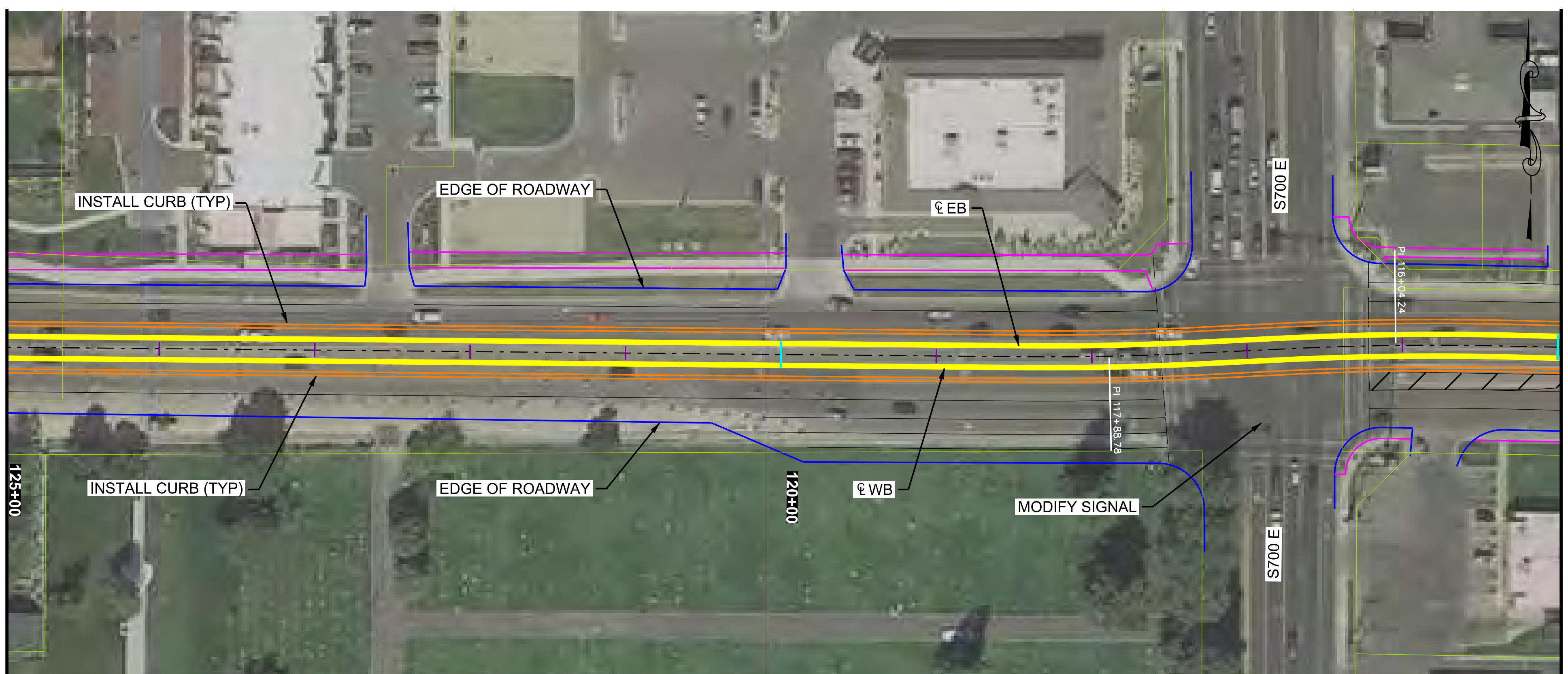

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COG RAIL SEGMENT 3

PIN 16092

PROJECT NUMBER XXXX

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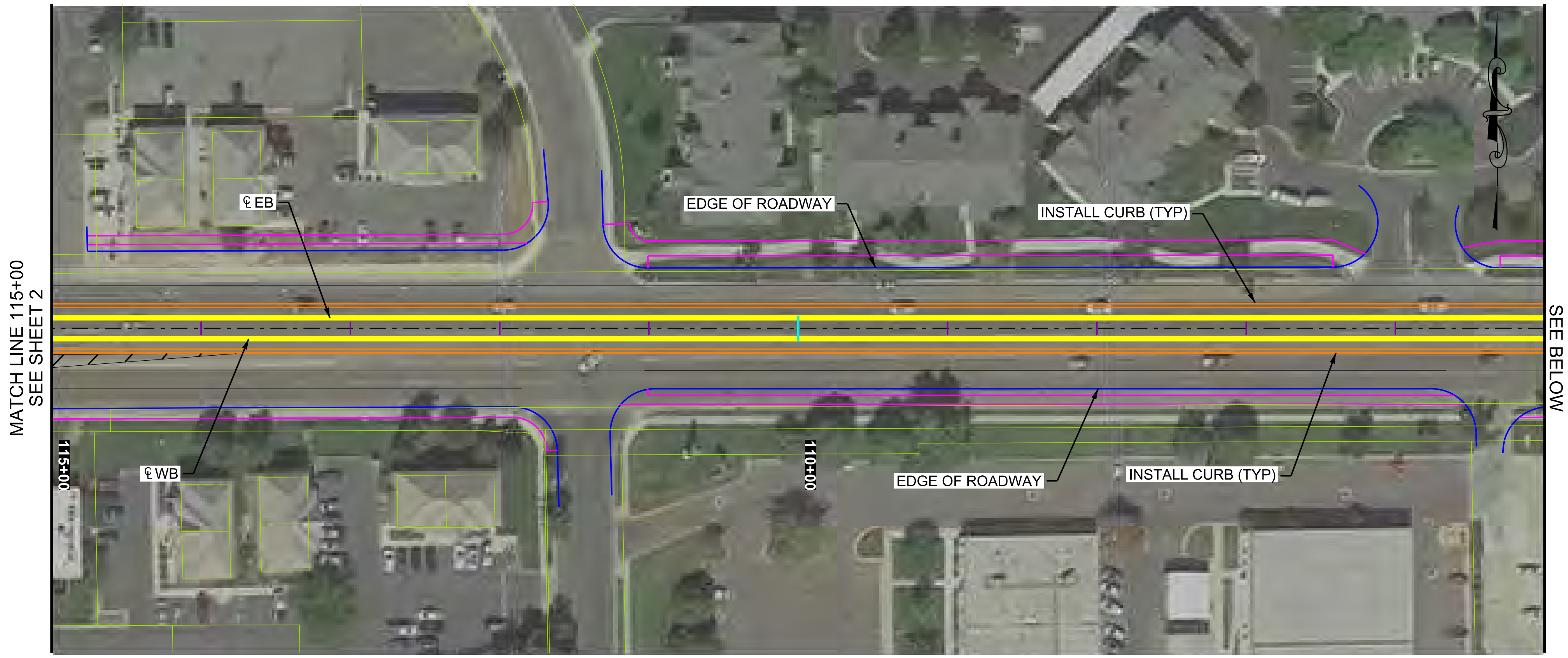

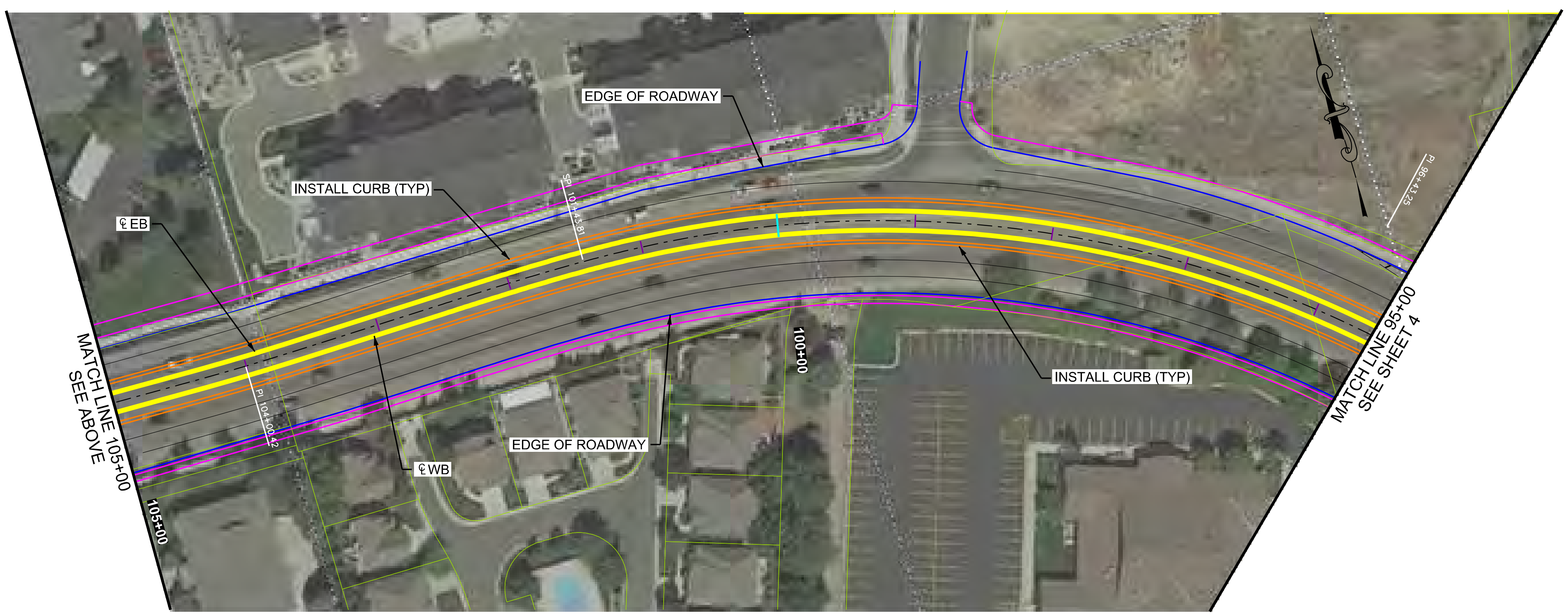

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COG RAIL SEGMENT 3

PIN 16092

PROJECT NUMBER XXXX

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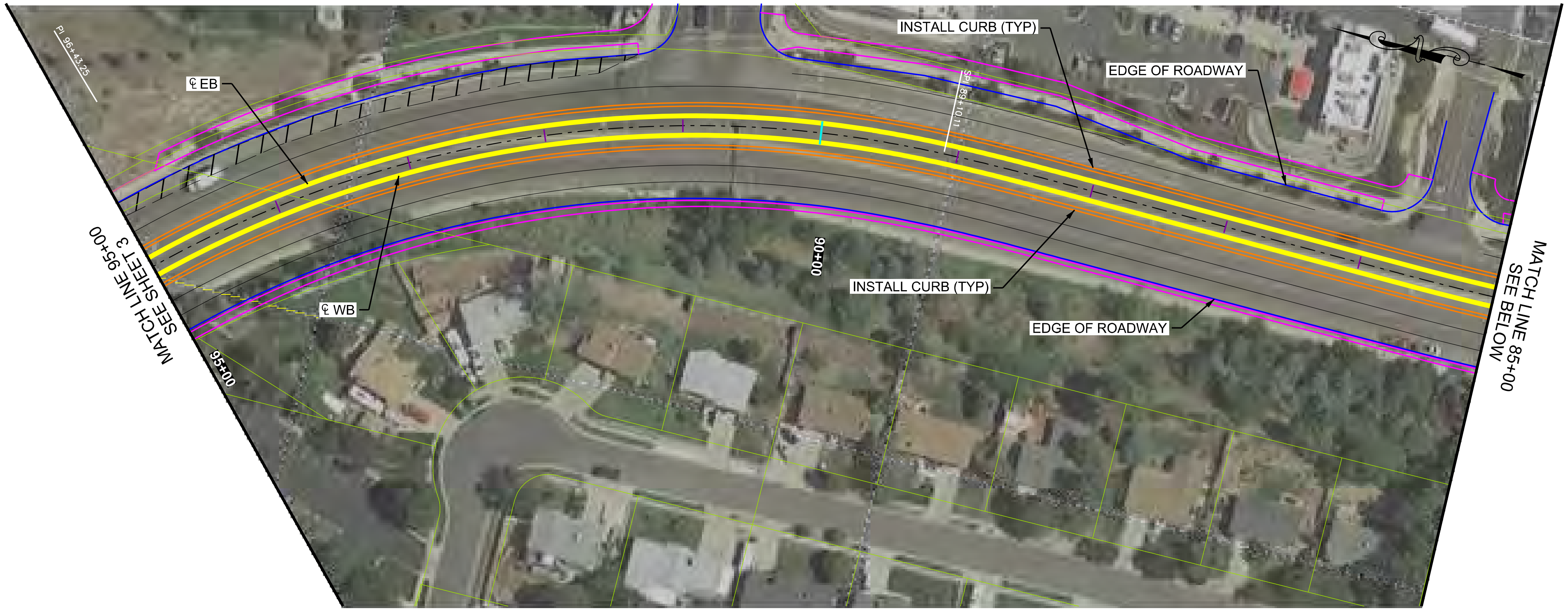
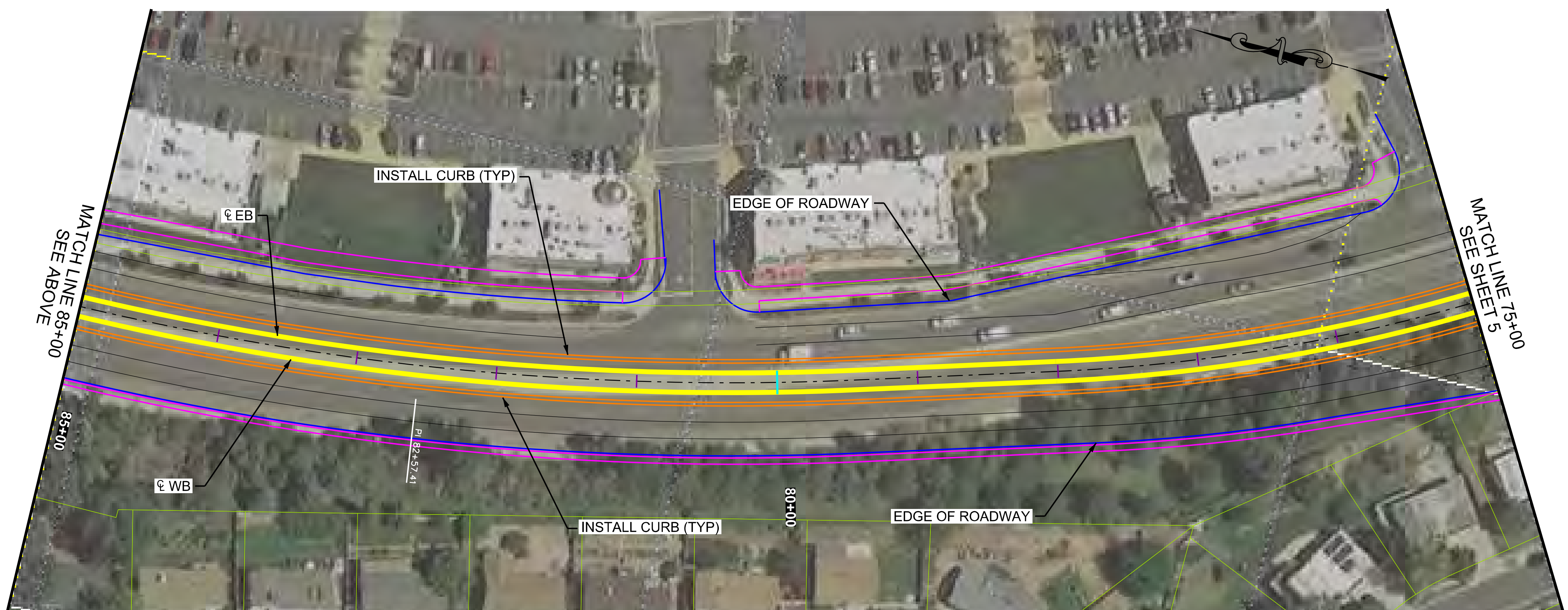
2/14/2020





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PIN: 16092

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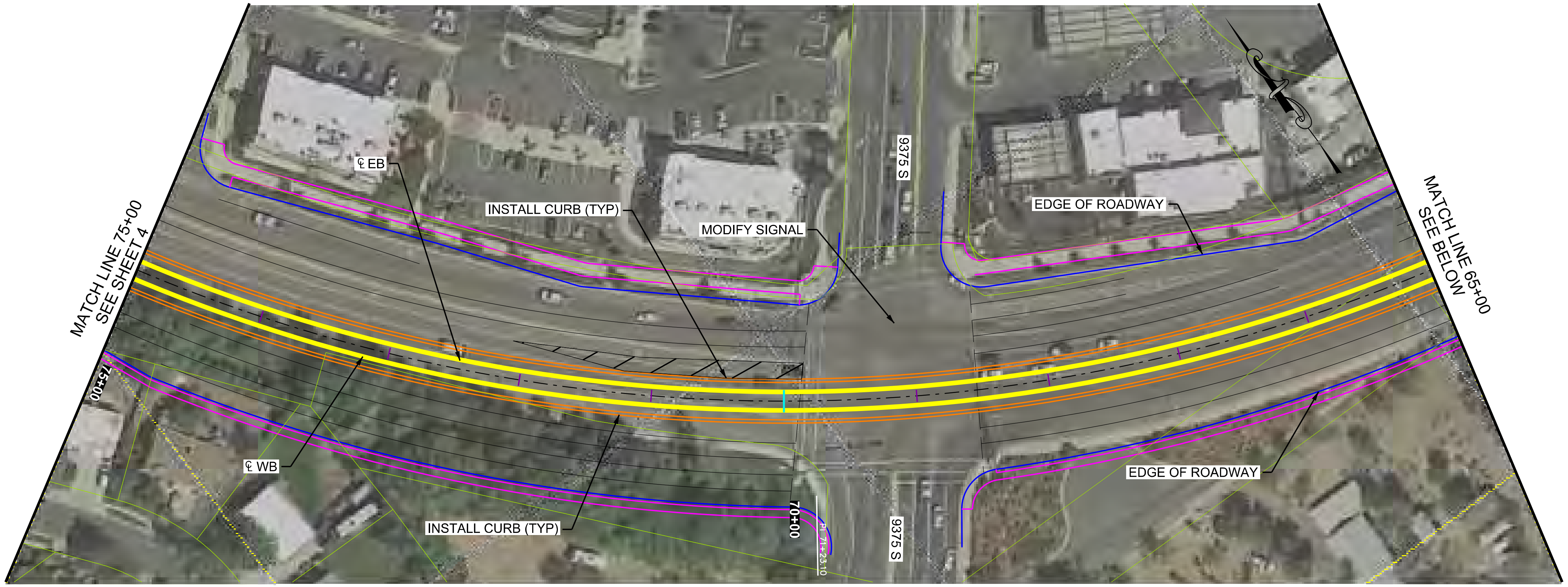
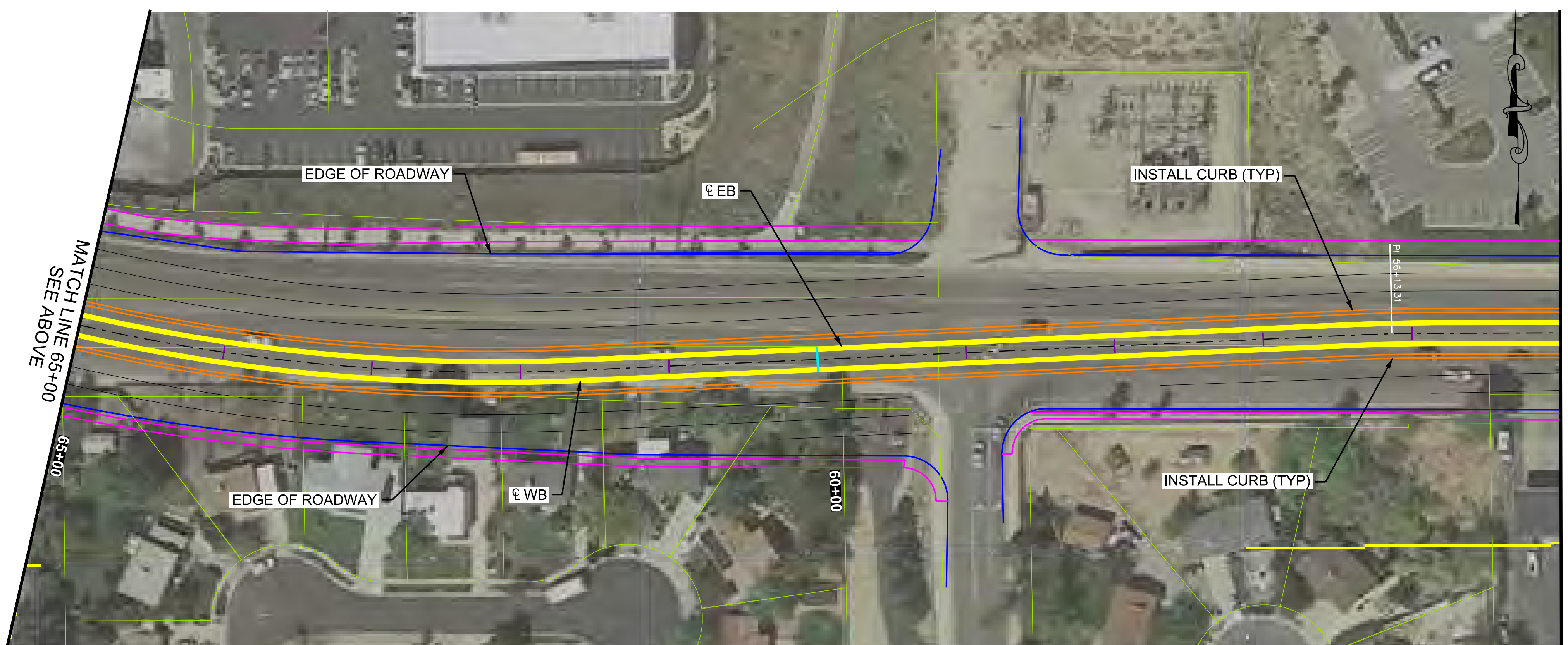
SHEET NO. 4

2/17/2020





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COG RAIL SEGMENT 3

PIN 16092

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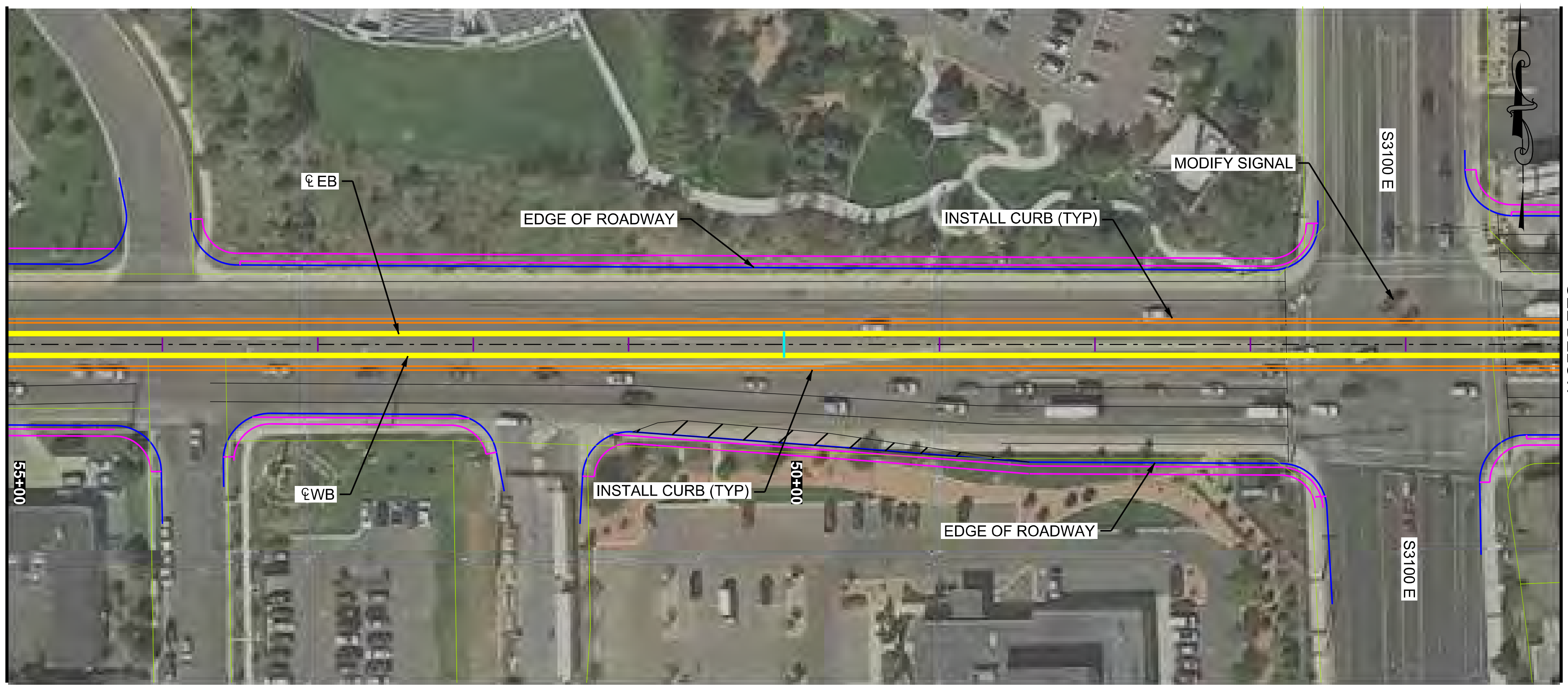

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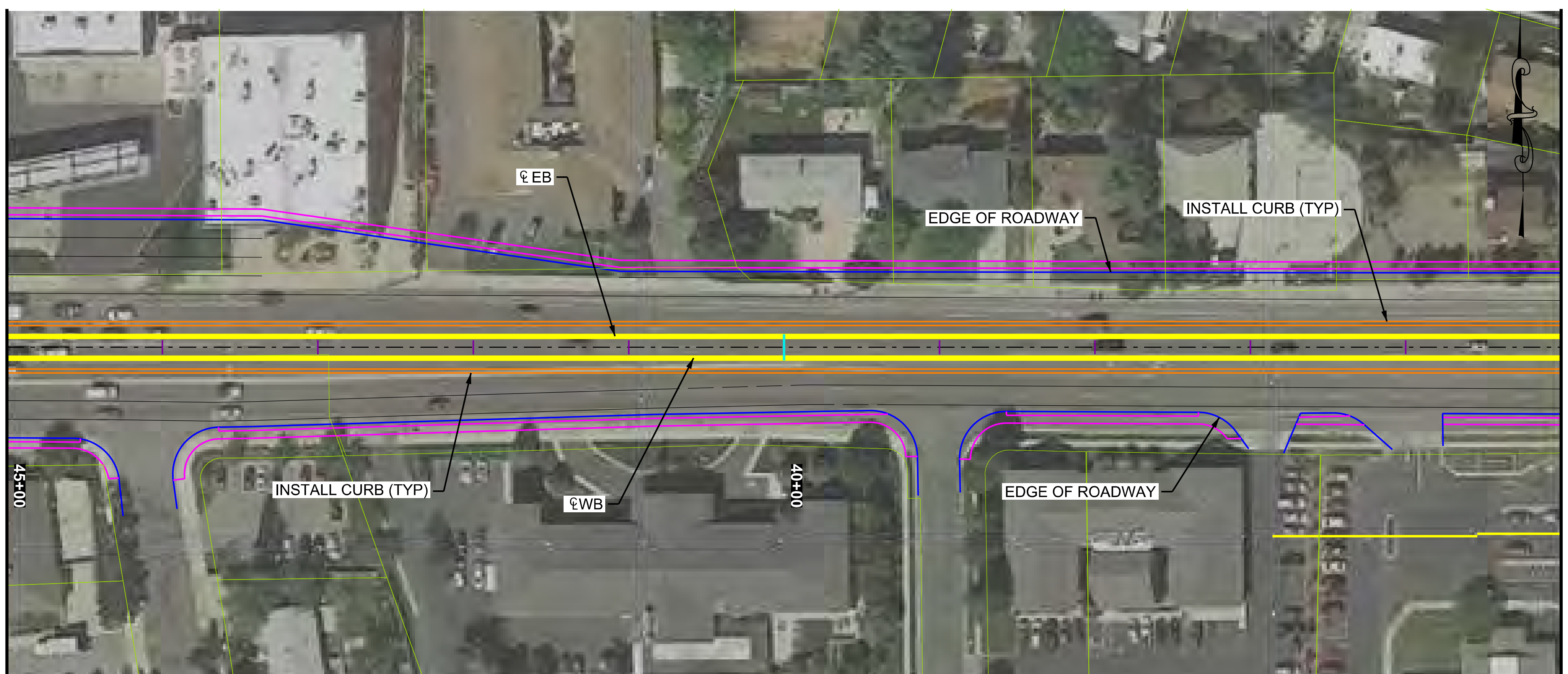

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COG RAIL SEGMENT 3

PIN 16092

PROJECT NUMBER XXXX

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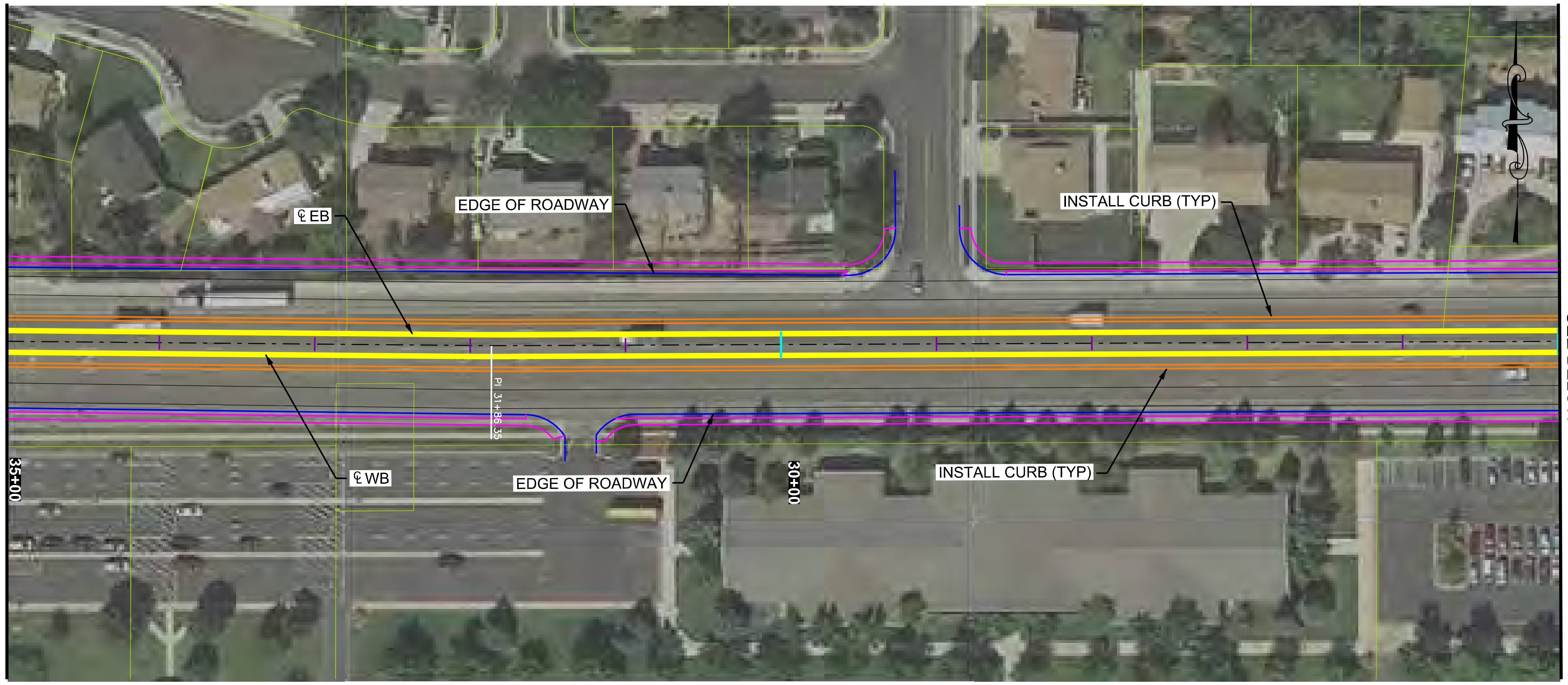

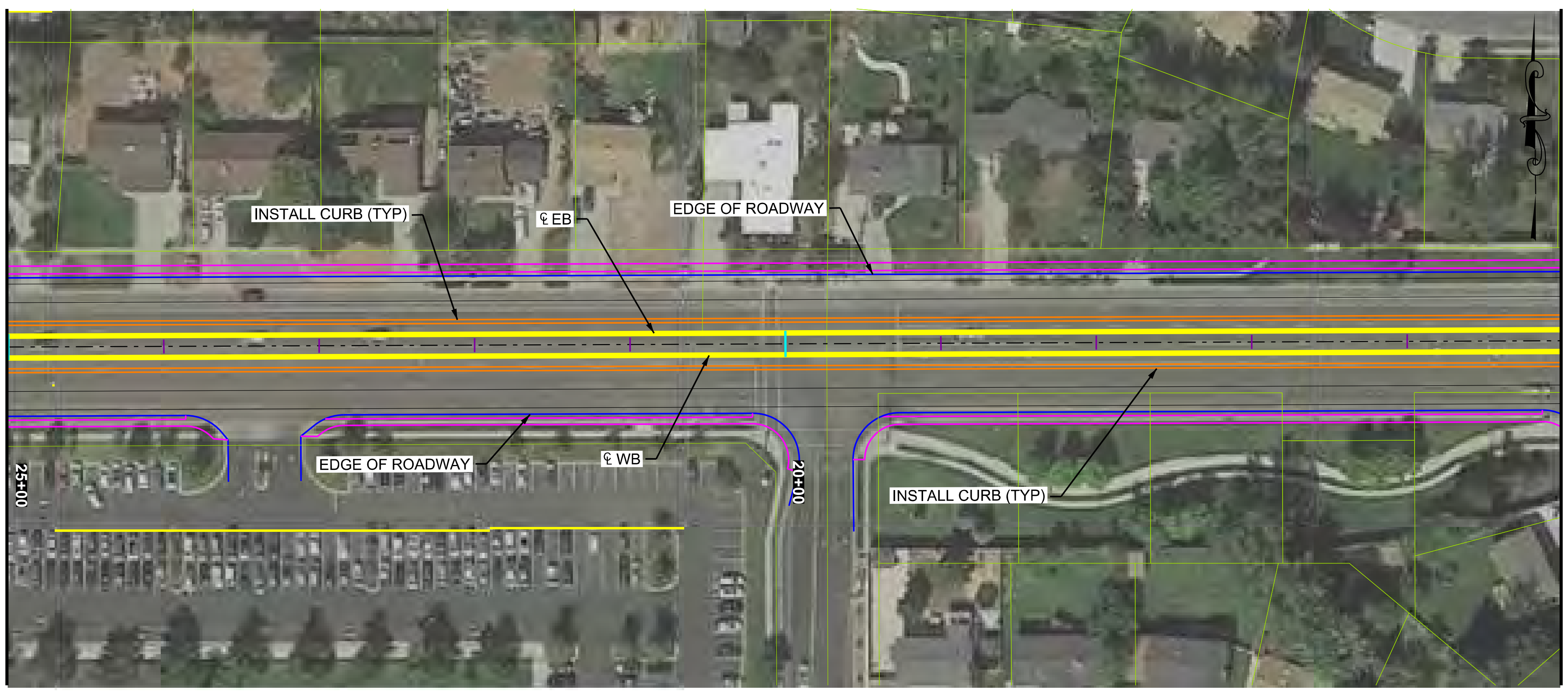

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COG RAIL SEGMENT 3

PIN 16092

PROJECT NUMBER XXXX

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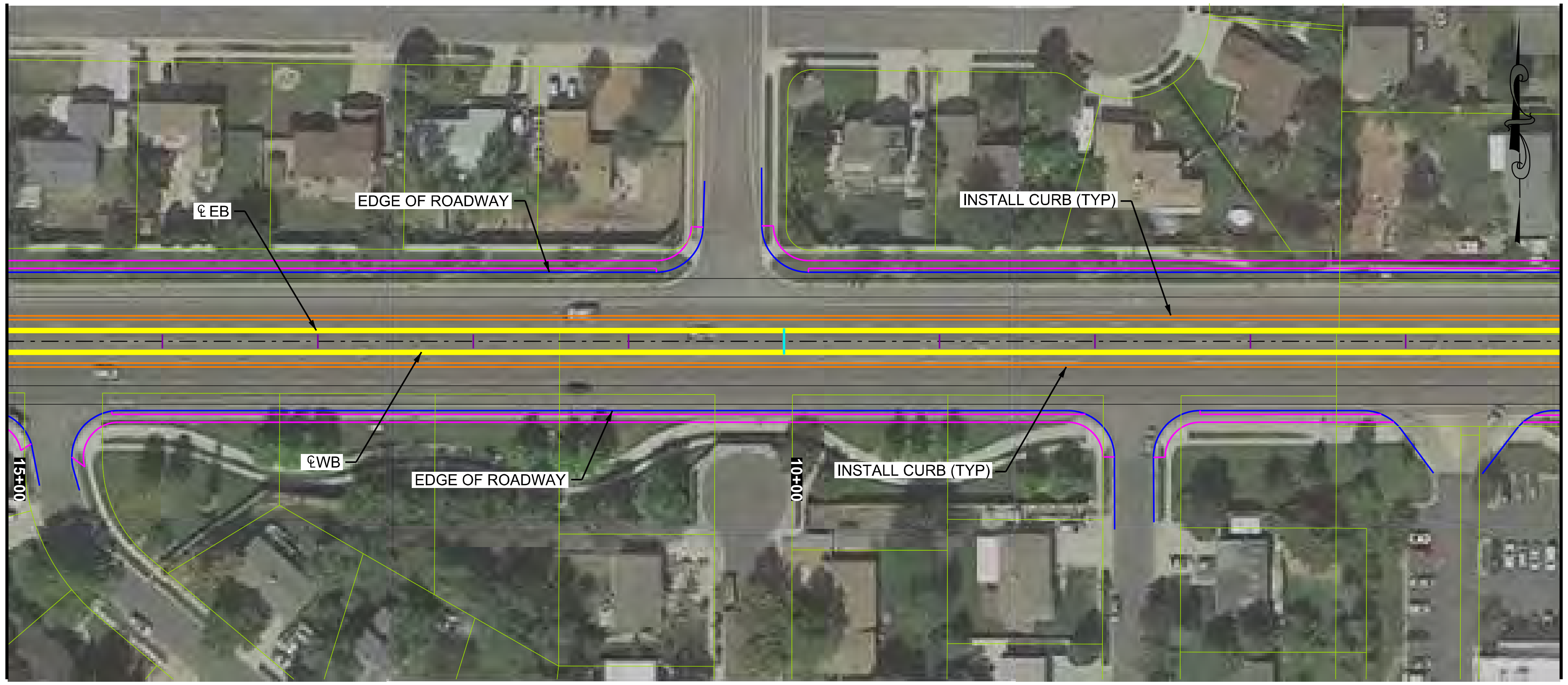

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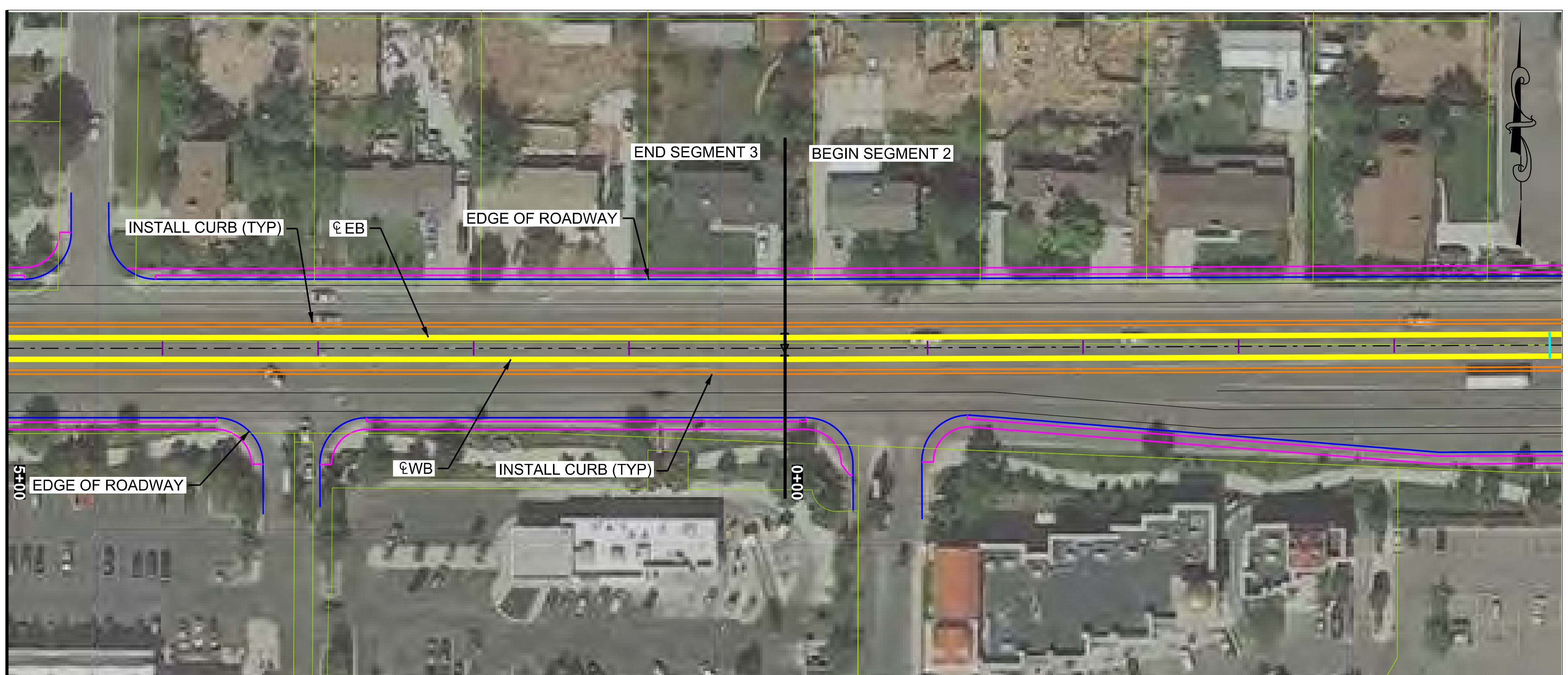

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COG RAIL SEGMENT 3

PIN 16092

PROJECT NUMBER XXXX

SHEET NO. 8

2/14/2020

APPENDIX G

Park City to Little Cottonwood Canyon Traffic Analysis

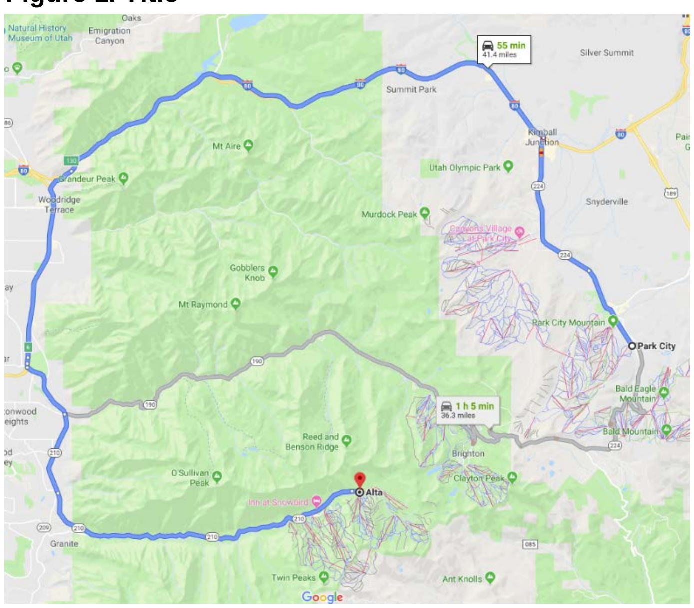
Memo

Date:	Friday, April 03, 2020
Project:	Little Cottonwood Canyon EIS, S.R. 210 – Wasatch Boulevard to Alta
To:	Utah Department of Transportation
From:	HDR
Subject:	**Park City to Little Cottonwood Canyon Traffic Analysis**

Introduction

This memo describes the analysis that HDR performed to identify the percentage of traffic on Little Cottonwood Canyon Road (State Route [S.R.] 210) in Little Cottonwood Canyon (LCC) that originates from Park City during different time periods throughout the year or during peak periods on a typical day. The fastest vehicular travel route from Park City to LCC during the winter is about 55 miles and follows a route heading southbound on S.R. 224 to westbound Interstate 80, down Parley's Canyon to southbound Interstate 215 to exit 6, to southbound Wasatch Boulevard to S.R. 210. Figure 1 shows this travel route in blue. The primary trip type for this travel route is residents of and visitors to Park City traveling to LCC to enjoy its recreation offerings.

Figure 1. Title



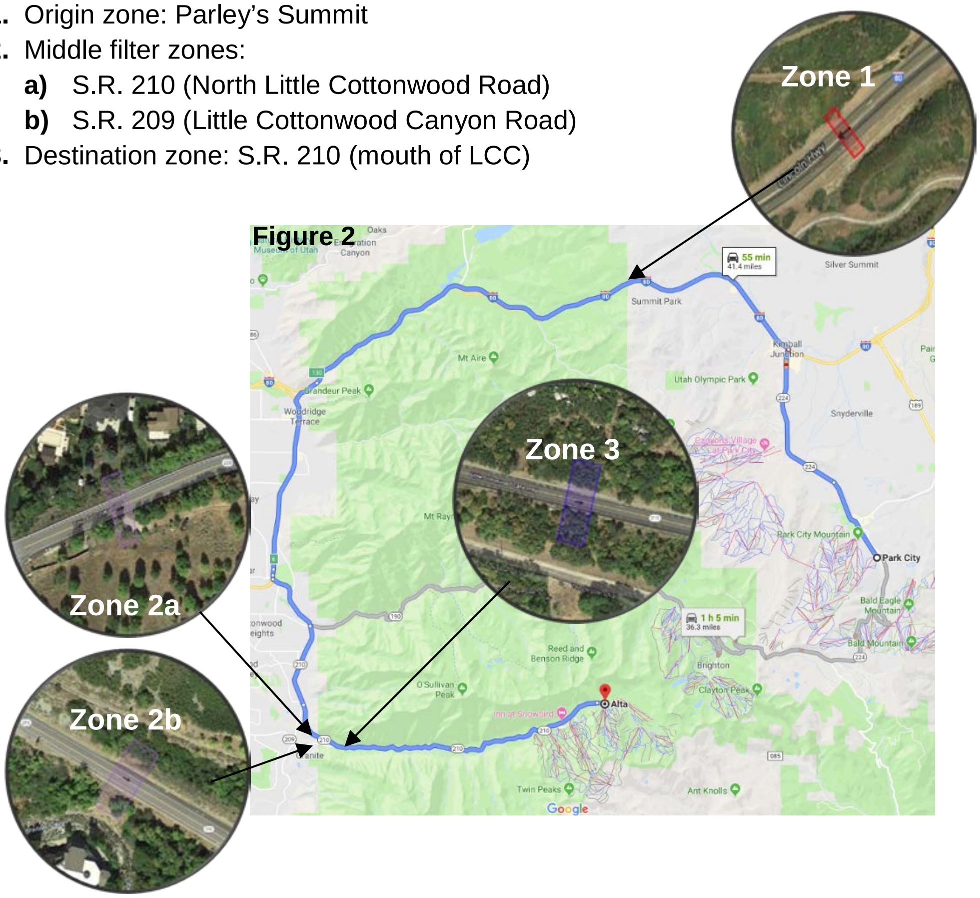
Methodology

HDR conducted an origin-destination (OD) analysis between Park City and LCC. OD analyses are conducted to help transportation planners understand travel patterns associated with trips from an origin location to a destination location. HDR used the StreetLight InSight web software platform to assist in this analysis. StreetLight Data (https://www.streetlightdata.com) is a big-data vendor that processes location-based data from smart phones and other navigation devices in connected cars and trucks for transportation planning purposes. There are three components to an OD analysis that must be defined: travel zones, time period, and output day types and day parts.

The StreetLights InSight software allows the software user to place travel zones or “gates” at specific locations, and the software filters the results based on the traffic that passes through those zones. For the OD analysis, the zones were placed across the primary travel route shown in Figure 1. The methodology included directionality at each zone to specify traffic for the trips ***from*** Park City ***to*** LCC. This method filtered trips based on this direction only and did not include trips heading in the opposing direction (***from*** LCC ***to*** Park City). Little Cottonwood Canyon Road is a dead-end road with no exit, so HDR set middle filter zones at all possible entrance points into the canyon to capture all inbound trips. The zones for all analyses were placed at the following locations (see Figure 2):

Zone 1. Origin zone: Parley’s Summit
Zone 2. Middle filter zones:
- **a)** S.R. 210 (North Little Cottonwood Road)
- **b)** S.R. 209 (Little Cottonwood Canyon Road)

Zone 3. Destination zone: S.R. 210 (mouth of LCC)



Three time periods were defined to help HDR gain a broad insight into travel patterns for the Park City to LCC trip. The time periods are important because the results are filtered just to the specific date ranges specified. The three time periods are:

1. **Peak Winter**
   - This time period for analysis is constrained to the winter months of January, February, and March for 2016–2019.
   - This time period captures the busiest months of ski traffic and prime operating season of the resorts in both LCC and Park City.

2. Holiday Specific

- This time period for analysis is constrained to the dates of the Martin Luther King, Jr. Day (MLK) and Presidents' Day holiday weekends. These weekends are historically busy days in LCC, with traffic counts from this time period consistently ranking in the top 30 days of the year.
  - 2016: MLK 1/15–1/18, Presidents' Day 2/12–2/15
  - 2017: MLK 1/13–1/16, Presidents' Day 2/17–2/20
  - 2018: MLK 1/12–1/15, Presidents' Day 2/16–2/19
  - 2019: MLK 1/18–1/21, Presidents' Day 2/15–2/18

3. Year Round

- This time period includes all days from January 1, 2016, to April 30, 2019.This time period captures all seasons of use and visitation.

The following day types and day parts were also defined for our analysis. The analysis output across all three time periods above was further categorized by the following day types and day parts. The results for these categories are mutually exclusive, meaning that one cannot use the sum of results from 1b and 1c below to produce an average day result. The results for each category are specific to that day type and period.

1. Day Type

a. Average Day: Monday–Sunday
b. Average Weekday: Monday–Thursday
c. Average Weekend Day: Friday–Sunday

2. Day Part

a. All Day: 12 AM–12 AM
b. Early AM: 12 AM–7 AM
c. Peak AM: 7 AM–11 AM
d. Mid-day: 11 AM–3 PM
e. PM: 3 PM–12 AM

Results

The results of the OD analysis are summarized in Table 1. Table 1 identifies the average percentage of total inbound trips passing through Zone 3 in LCC that originated from Park City Zone 1 for the specific day type and day part identified. These results show, for example, that 5.7% of daily traffic entering LCC during the winter months of January–March (Peak Winter time period) is originating from the Park City area. The average percentage of traffic is developed from the StreetLight InSight methodology of sampling all trips for that time period passing through Zones 1–3 and then identifying an average number of trips that followed the specified travel route identified. The resulting number varies because the number of trips sampled varies for each time period.

Table 1. Average Percent of Trips Originating from Park City

Day Type	Day Part	Time Period		
		Peak Winter	Holiday	Year Round
Average Day (M–Su)	All Day (12 AM–12 AM)	5.7%	6.0%	4.1%
	Peak AM (7 AM–11 AM)	7.8%	7.7%	6.8%
Average Weekday (M–Th)	All Day (12 AM–12 AM)	6.3%	5.5%	4.4%
	Peak AM (7 AM–11 AM)	8.5%	7.5%	7.0%
Average Weekend Day (F–Su)	All Day (12 AM–12 AM)	5.2%	6.2%	3.8%
	Peak AM (7 AM–11 AM)	7.0%	7.8%	6.6%

Across all three time periods, the results range from a low of 3.8% of LCC traffic originating from Park City during the Year Round time period to a high of 8.5% during the Peak Winter time period. The Year Round results are lower in all day parts than the results from the other two time periods. This meets observations, given that the Park City to LCC trip type is known to be more prevalent during the winter rather than during other seasons because of the ski resort attractions in both locations. Given this consistency in the results, we can be confident that the results are representative of traffic for each time period.

Is it important to remember that the results shown are *average* percentages of traffic relative to the time periods selected for analysis and therefore indicate a different traffic volume or number of cars. Historically, there is more traffic observed during the Peak AM day part in the winter than compared to Peak AM volumes averaged across the Year Round time period. For example, the Year Round result of 7.0% during the Average Weekday Peak AM day part does not indicate the same number of vehicles as the result of 7.0% in the Peak Winter results column. The Peak Winter percentage represents a higher number of vehicles. This is validated by UDOT Traffic Statistics reports showing that traffic volumes on S.R. 210 during the winter are, on average, higher than the yearly average.

To develop an estimated volume from the results in Table 1, we need to identify a representative volume of traffic for the specific day parts presented. Although all three time periods provide good insight into this travel pattern, we recommend using the Peak Winter or Year Round time period results. The Peak Winter results ensure that the trip sample used in the analysis is reflecting the true winter-based recreation trips that are most pertinent to the travel pattern we are studying in this analysis. The Year Round results provide us with a good control and estimation of total trips across all time periods. Table 2 was developed using the Peak Winter results to estimate a number of vehicles. Given that the Peak Winter results were higher than the Year Round results and represent the highest traffic volumes, our estimates for the number of vehicles will yield conservative findings.

Table 2. Winter Daily Traffic from Park City

Day Type	Day Part	% Peak Winter	2017 AADT	Estimated Volume
Average Day (M–Su)	All Day (12 AM–12 AM)	5.7%	7,927	450
Average Weekday (M–Th)	All Day (12 AM–12 AM)	6.3%	7,141	446
Average Weekend Day (F–Su)	All Day (12 AM–12 AM)	5.2%	8,712	454

Using UDOT-published traffic counts for 2017 that most closely match the day types and time periods from this OD analysis, we calculated an estimated number of vehicles for each day type. Table 2 shows the results for the All Day day type. For comparable annual average daily traffic (AADT), we used the 2017 traffic volumes published in Table 3 to develop an equivalent AADT for winter months.

Table 3. Average Traffic Volumes in LCC (2017)

Month	Sat – Sun	Mon – Fri
January	8,556	6,645
February	9,011	7,805
March	8,569	6,973
Average	8,712	7,141

Table 4 shows the results for the Peak AM day part. The 30th-highest hour of peak hour of eastbound (EB) or inbound traffic was used for this reference. The inbound traffic count was used because it identifies users entering LCC and matches the directionality associated with the OD analysis.

Table 4. Park City Traffic Entering LCC during the Peak Hour

Day Type	Day Part	% Peak Winter	30th EB Hour	Estimated Volume
Average Day (M–Su)	Peak AM (7 AM–11 AM)	7.8%	1,061	83
Average Weekday (M–Th)	Peak AM (7 AM–11 AM)	8.5%	1,061	91
Average Weekend Day (F–Su)	Peak AM (7 AM–11 AM)	7.0%	1,061	75

APPENDIX H

Draft Evaluation of Mobility Hub Locations

Little Cottonwood Canyon ENVIRONMENTAL IMPACT STATEMENT
S.R. 210 | Wasatch Blvd. to Alta

Draft Evaluation of Transit Hub Locations

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 – Wasatch Boulevard to Alta

Utah Department of Transportation

April 3, 2020

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1.0 Introduction

This report evaluates potential transit hub locations to support parking for transit alternatives for Little Cottonwood Canyon. The purpose of the transit hub concept is to improve overall mobility in Little Cottonwood Canyon by providing a more efficient transit system.

The transit hub concept would support the transit alternatives (bus, train, and gondola) being considered for the Little Cottonwood Canyon Environmental Impact Statement (EIS). These transit alternatives would require additional parking to be provided in order for the alternatives to operate efficiently. A transit hub could support winter access to the four ski resorts and weekday commuter-related transit if possible.

2.0 Transit Criteria

2.1 Transit Hub Screening Criteria

To determine the location(s) of the transit hub(s), the Utah Department of Transportation (UDOT) used the following criteria to screen alternatives:

- The alternative must be available on weekdays, weekends, holidays, heavy snow days, and extended vacation periods (for example, the Christmas, Presidents' Day, and Easter holiday).
- The alternative must provide convenient access to Little Cottonwood Canyon to improve bus travel times, reduce out-of-direction travel, minimize traffic conflicts in residential areas, and reduce potential traffic conflicts for transit.
- For new or existing transit hub locations, the area must be about 4 acres or must accommodate about 672 to 3,475 parking stalls [see Section 2.2, Transit Hub(s) Sizing Requirements]. One or more sites could meet this need.

2.2 Transit Hub(s) Sizing Requirements

UDOT determined the number of parking spaces and amount of land required for the transit hub(s) based on the transit alternatives being considered for Little Cottonwood Canyon. Table 1 shows the parking spaces and land requirements for the transit hub(s) in 2050. For the Little Cottonwood Canyon EIS transit alternatives, UDOT assumed that two transit hubs would be required: one for transit users coming from the south part of the Salt Lake Valley and one for transit users coming from the north part of the valley.

According to traffic counts taken by UDOT in March 2018 (L2 Data Collection 2018), about 40% of the traffic going to Little Cottonwood Canyon comes from the south Salt Lake Valley and uses 9400 South and State Route (S.R.) 209, and about 60% comes from the north and uses S.R. 210. Based on the traffic count data, UDOT assumed that about 40% of transit users would park at the south transit hub and about 60% would park at the north transit hub.

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Table 1. Transit Hub Sizing Requirements Based on the Little Cottonwood Canyon EIS Transit Alternatives (in 2050)

Transit Ridership[a]	Daily Ridership[b]	Estimated Number of Parking Stalls[c]		Parking Garage Size (square feet)[d]		Cost (millions)[e]	
	Little Cottonwood Canyon	North Hub	South Hub	North Hub	South Hub	North Hub	South Hub
20% ridership	3,650	1,020	680	333,041	222,028	$22	$14
30% ridership	5,200	1,440	960	474,470	316,313	$31	$20

[a] Transit ridership is either 20% or 30% of the total number of people going to the canyons on the 30th-busiest day.

[b] Estimated one-way ridership from a transit hub to a ski resort.

[c] Based on 2.17 average occupants for entire day per vehicle in Little Cottonwood Canyon.

[d] Includes the following assumptions: for transit users going to Little Cottonwood Canyon, 40% of parking stalls are at the south transit hub and 60% of parking stalls are at the north transit hub. Lot size is based on 330 square feet per parking stall (Kimley Horn 2016).

[e] Cost is based on $64.77 per square foot (WGI 2019).

As shown in Table 1 above, a total of between 1,700 and 2,400 parking stalls would be required at the transit hubs, depending on the percentage of transit riders. This number of parking stalls would require between 13 and 18 acres for a surface parking lot. A parking lot of this size would require an internal transit system, which would increase the operating cost of such an alternative and would increase the travel time for skiers, and thus was eliminated from consideration.

Typically, in parking lots, the level of service is based on the following:

- **Level of service A (best):** walking distance of 300 feet or less
- **Level of service B (good):** walking distance of 600 feet or less
- **Level of service C (average):** walking distance of 900 feet or less
- **Level of service D (below average):** walking distance of 1,200 feet or less

One factor to consider with the transit hub(s) is that users could be in ski boots and carrying skis and ski equipment, so a short walking distance of 300 to 400 feet should be maintained. Based on a 400-foot-by-400-foot-area, the amount of land required would be about 3.6 acres, or about 4 acres, or about 528 parking stalls (4 acres = 174,240 square feet, divided by 330 square feet per stall = 528 stalls). Thus, a multistory garage with elevators would be required to meet the parking demand. Although smaller area dimensions, such as a 300-foot-by-300-foot or 2-acre area (about 264 parking stalls) could have been used in the analysis, it would increase the number of stories required to meet the demand, which would create greater visual impacts. To meet the transit demand, the 400-foot-by-400-foot-area garage would need to be about three stories for the north lot. However, the dimensions of the structure can be changed to reduce or increase the number of stories.

To accommodate users of Little Cottonwood Canyon who use 9400 South and S.R. 209 to access the canyon, about 675 to 960 parking stalls (or 222,028 to 316,313 square feet) would be required in a separate location. The reason for a separate transit hub for these users is to reduce the amount of vehicle-miles traveled if users were to bypass Little Cottonwood Canyon to park at another parking location farther north. To meet the demand using the same assumptions as for the north Little Cottonwood Canyon lot, the structure would need to be about two to three stories.

3.0 Transit Hub Evaluation

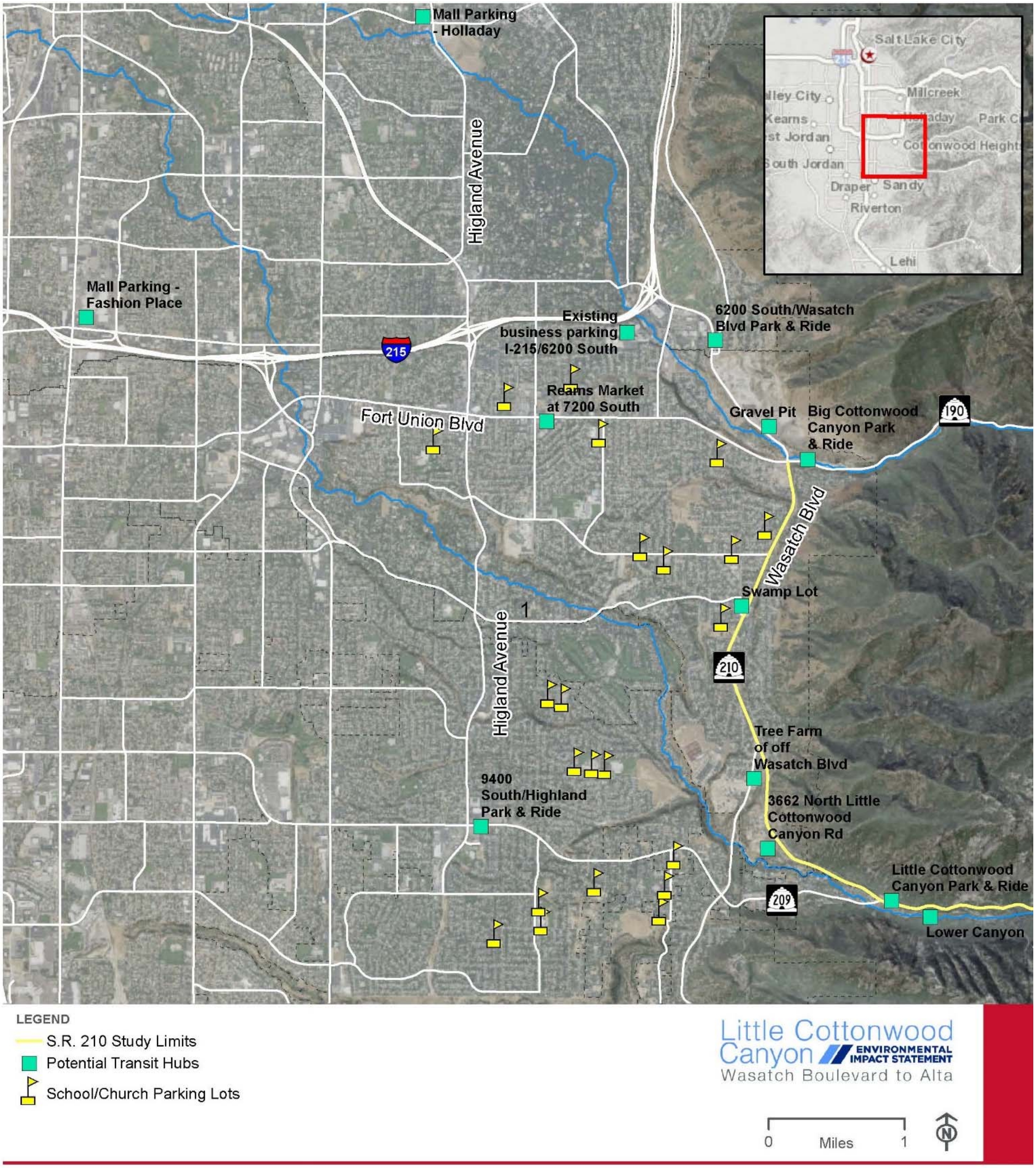
3.1 Transit Hub Alternatives Considered

During the scoping process for the Little Cottonwood Canyon EIS, UDOT received numerous comments regarding potential transit hub locations. Table 2 lists the transit hub alternatives that UDOT brought forward for consideration in this report. Figure 1 shows the locations of the transit hub alternatives listed in Table 2.

Table 2. Transit Hub Alternatives Being Considered

Alternative	Location	Lot Size	Primary Current Use
Little Cottonwood Canyon Park-and-Ride	Intersection of S.R. 210 and S.R. 209	1.3 acres	Winter transit park-and-ride lot for skiers. Summer lot for recreational users and trailhead.
Big Cottonwood Canyon Park-and-Ride	Intersection of S.R. 210 and Fort Union Blvd.	1.6 acres	Winter transit park-and-ride lot for skiers. Summer lot for recreational users and trailhead.
9400 South/Highland Drive Park-and-Ride	Intersection of 9400 South and Highland Drive	4 acres	Utah Transit Authority (UTA) park-and-ride lot. Currently about 275 parking stalls.
6200 South/Wasatch Blvd. Park-and-Ride	Intersection of 6200 South and Wasatch Blvd.	1.6 acres	UTA park-and-ride lot.
Reams Market at 7200 South	Fort Union Blvd. and 2300 East	500 parking stalls	Strip mall parking.
Tree Farm off of Wasatch Blvd.	3802 North Little Cottonwood Road	28.9 acres	Tree farm and vacant land between Wasatch Blvd. and North Little Cottonwood Road. Some of the land is steep and narrow and might not be suitable for construction of a parking garage.
3662 North Little Cottonwood Canyon Rd	3662 North Little Cottonwood Canyon Rd	6.65 acres	Vacant land between two residential developments about 0.8 mile west of S.R. 210/S.R 209 intersection.
Swamp Lot	8101 South 3500 East	2.1 acres	UTA park-and-ride lot.
Lower Canyon	1,000 feet east of S.R. 209/S.R. 210 intersection	6.5 acres	Trail. USDA FS land with trail south of S.R. 210 and north of Little Cottonwood Creek.
School and Church Parking Lots	Various	Not applicable	Various parking lots used by schools during the week and special events and churches on weekends and other times during the week.
Existing Business Parking at I-215/6200 South	6200 South and 3000 East	3,000 parking stalls	Parking used generally during the week in support of various office buildings.
Gravel Pit	6900 South and Wasatch Blvd.	65 acres	Gravel Pit.
Mall Parking – Holladay	Murray Holladay Road and Highland Drive	48 acres	Vacant land that once contained shopping mall.
Mall Parking – Fashion Place	6191 S. State Street in Murray	4,900 parking stalls	Shopping mall.

Figure 1. Locations Considered for the Transit Hub Alternatives



3.2 Screening of Transit Hub Alternatives

UDOT reviewed the alternatives for transit hub locations listed in Table 2 above against the screening criteria (see Section 2.1, Transit Hub Screening Criteria) to determine which could be potential reasonable alternatives. Table 3 summarizes the screening analysis.

For the screening analysis, UDOT assumed that, to reduce cost and improve transit use, both Little Cottonwood Canyon transit users using the 6200 South exit from I-215 and Big Cottonwood Canyon transit users would share the same transit hub. This would allow UTA to operate a more efficient system with shared buses, drivers, and ticketing at one location that serves both canyons. In addition, the transit hub could be used as a regional transit hub for commuters on weekdays. UDOT also assumed that, for Little Cottonwood Canyon, about 40% of the transit users would come from south of 9400 South and would want to reduce their travel time and avoid out-of-direction travel by parking at a lot that is closer to the canyon.

Table 3. Summary of Screening Results of Transit Hub Alternatives

Alternative	Screening Criteria (Green = Pass, Red = Eliminated)				
	Available[a] (Yes/No)	Convenient Access[b] (Yes/No)	Lot Size[c]	Pass Screening (Yes/No)	Notes
Little Cottonwood Canyon Park-and-Ride	Yes	Yes	1.3 acres	No	Lot size is too small to accommodate parking requirements and would result in potential traffic congestion at the S.R. 209/S.R. 210 intersection similar to existing conditions.
Big Cottonwood Canyon Park-and-Ride	Yes	Yes	1.6 acres	No	Lot size is too small to accommodate parking requirements.
9400 South/ Highland Drive Park-and-Ride	Yes	Yes	4 acres	Yes	—
6200 South/ Wasatch Blvd. Park-and-Ride	Yes	Yes	1.6 acres	No	Lot size is too small to accommodate parking requirements Little Cottonwood Canyon.
Reams Market at 7200 South	No	Yes	500 parking stalls	No	Currently in use for commercial business. Lot would not be available.
Tree Farm off of Wasatch Blvd.	Yes	No	28.9 acres	No	The lot includes steep train that may make construction difficult. In addition, the lot would but a high level of traffic in residential area and would be located in a residential area not compatible with a parking structure.
3662 North Little Cottonwood Canyon Rd	Yes	No	6.85 acres	No	Location would cause congestion on Wasatch Blvd during peak use times in a residential area similar to current conditions. Land is between two residential subdivisions which would not be compatible with parking structure.
Swamp Lot	Yes	No	2.1 acres	No	Lot size is too small to accommodate parking requirements for Little Cottonwood Canyon.
Lower Canyon	Yes	No	6.5 acres	No	The lot would impact a heavily used Little Cottonwood Canyon hiking trail and would be immediately adjacent to Little Cottonwood Canyon Creek. Lot would result in potential traffic congestion at the S.R. 209/S.R. 210 intersection similar to existing conditions

Table 3. Summary of Screening Results of Transit Hub Alternatives

Alternative	Screening Criteria (Green = Pass, Red = Eliminated)				
	Available[a] (Yes/No)	Convenient Access[b] (Yes/No)	Lot Size[c]	Pass Screening (Yes/No)	Notes
School and Church Parking Lots	No	No	Not applicable	No	Church lots would not be available on Sundays and some weekends during special events. School lots might may not be available during weekdays, weekends during special events, and some holidays.
Existing Business Parking at I-215/ 6200 South	No	Yes	3,000 parking stalls	No	An agreement with the owner would need to be reached to allow use and address liability concerns. Lot would may not be available on weekdays and holidays.
Gravel Pit	Yes	Yes	65 acres	Yes	—
Mall Parking – Holladay	Yes	No	48 acres	No	Area does not have convenient freeway access. Would increase transit travel times and out-of-direction travel for users.
Mall Parking – Fashion Place	No	Yes	4,900 parking stalls	No	Currently in use for commercial business and would not be available on weekdays, weekends, and holidays.

[a] The alternative must be available on weekdays, weekends, holidays, heavy snow days, and extended vacation periods (for example, the Christmas, Presidents' Day, and Easter holidays).

[b] The alternative must provide convenient access to traffic from the south end and north ends of the Salt Lake Valley, reduce out-of-direction travel, reduce potential traffic conflicts with residential traffic, and provide convenient bus access to Little Cottonwood Canyon.

[c] For new or existing transit hub locations, the area must be about 4 acres or must accommodate about 680 to 1,440 parking stalls [see Section 2.2, Transit Hub(s) Sizing Requirements]. One or more sites could meet this need.

4.0 Preferred Transit Hub Locations

Based on the alternatives screening summarized in Table 3 above, UDOT determined that the best locations for transit hubs were the Gravel Pit and the UTA park-and-ride lot at 9400 South and Highland Drive. Both locations meet the lot size and availability requirements and would provide convenient access for users and transit to the Cottonwood Canyons.

4.1 Gravel Pit Location and Access

The Gravel Pit, located at 6900 South and Wasatch Boulevard, is an operational gravel and sand material business. The City of Cottonwood Heights is working with the property owner to create a development plan for the southern portion of the site, which could include a transit hub. The site would be accessed from Wasatch Boulevard, with most traffic coming from the 6200 South exit from I-215.

Table 4 shows the traffic analysis for the Gravel Pit site, including the expected number of vehicles entering and exiting the site during the AM and PM peak traffic periods (8 to 9 AM and 4 to 5 PM), the recommended number of access points into the parking structure, and recommendations for access from Wasatch Boulevard. The UDOT access agreement to the site recommends a single access point for the southern Gravel Pit property. With a single access point at 30% transit, a second access from Wasatch Boulevard or a flyover access over northbound Wasatch Boulevard might be required.

Table 4. Traffic Analysis for the Gravel Pit Site

Transit Alternative	Number of Stalls	Number of Vehicles during the Peak Hour		Recommended Parking Structure Access	Wasatch Boulevard Access Recommendation
		AM Peak-hour Vehicles Entering the Site[a]	PM Peak-hour Vehicles Exiting the Site[a]		
20% transit	1,020	459	414	1	Dual lefts
30% transit	1,440	684	584	2	Might need two access points or flyover access

Source: Fehr and Peers 2019

[a] The AM analysis assumes that 45% of users arrive at the site during the AM peak hour, and the PM analysis assumes that 35% of users leave the site during the PM peak hour. Traffic does not include that caused by other traffic generators, such as hotels, residences, retail businesses, or restaurants, in the area.

4.2 9400 South/Highland Drive Location and Access

An existing 4-acre UTA park-and-ride lot at 9400 South and Highland Drive is currently used for ski bus service during the winter. The site is accessed from Highland Drive, 9400 South, and 9510 South and has shared use with a retail business.

Table 5 shows the traffic analysis for this park-and-ride lot, including the expected number of vehicles entering and exiting the site during the AM and PM peak traffic periods (8 to 9 AM and 4 to 5 PM), the recommended number of access points into the parking structure, and access recommendations.

Table 5. Traffic Analysis for the 9400 South/Highland Drive Park-and-Ride Lot

Transit Alternative	Number of Stalls	Number of Vehicles during the Peak Hour		Recommended Parking Structure Access	Access Recommendation
		AM Peak-hour Vehicles Entering the Site[a]	PM Peak-hour Vehicles Exiting the Site[a]		
20% transit	680	306	238	1	Use existing access
30% transit	960	432	336	1	Use existing access

Source: Fehr and Peers 2019

[a] The AM analysis assumes that 45% of users arrive at the site during the AM peak hour, and the PM analysis assumes that 35% of users leave the site during the PM peak hour. Traffic does not include that caused by other traffic generators, such as hotels, residences, retail businesses, or restaurants, in the area.

4.3 Transit Hub Phasing

The analysis in this report assumes full build-out of the transit hubs at 20% and 30% ridership in 2050. Initial construction is likely to occur 20 years prior to 2050 when parking demand and ridership numbers are lower. Other factors could reduce the number of parking stalls needed, factors such as UTA providing regional express bus or light rail service to the transit hubs once they are in operation. Therefore, the transit hubs likely would be constructed in phases, starting as small lots and increasing in size as needed based on demand. This phased construction would also allow UTA or private vendors to look at options to deliver skiers to the transit hub from locations across the Wasatch Front as demand at the transit hubs increases.

5.0 References

Fehr and Peers

2019 Gravel Pit parking model. October.

Kimley Horn

2016 Parking Structure Design Guidelines, Final. Prepared for Capital City Development Corp., Boise, Idaho.

L2 Data Collection

2018 Traffic counts for intersection of S.R. 210 and S.R. 209. March 15.

WGI

2019 Parking Structure Cost Outlook for 2019. https://wginc.com/parking-outlook. Accessed August 8, 2019.

APPENDIX I

Draft Vehicle Mobility Analysis

Little Cottonwood Canyon ENVIRONMENTAL IMPACT STATEMENT
S.R. 210 | Wasatch Blvd. to Alta

Draft Vehicle Mobility Analysis

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 - Wasatch Boulevard to Alta

Lead agency:
Utah Department of Transportation

April 3, 2020

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Acronyms and Abbreviations

HOV	high-occupancy vehicle
PPSL	peak-period shoulder lane
S.R.	state route
SPT	Sketch Planning Tool
UDOT	Utah Department of Transportation

Glossary

30th-busiest hour: the 30th-busiest hour on a road as determined by traffic counts taken on the road over an entire year. For this analysis, the traffic volume on S.R. 210 during the 30th-busiest hour in 2017 was used as the basis for the traffic volume during the design hour in 2050.

design hour: the future hour whose projected traffic volume is used as the basis for designing or improving a road. A roadway is designed to accommodate the number of vehicles (traffic volume) during the design hour. For this analysis, the design hour is in 2050.

peak hour: the single busiest hour on a road as determined by traffic counts taken on the road over an entire year.

peak period: a period of the day with a high volume of traffic. Peak periods occur on S.R. 210 during the morning and afternoon.

1.0 Introduction

The purpose of this report is to explain the methods used, evaluation, and results of the per-person travel and queuing length analysis for the alternatives considered in the Little Cottonwood Canyon Environmental Impact Statement (EIS). The analysis is for roadway-based alternatives only. Travel times for gondola and train alternatives are provided in a separate report.

2.0 Design-hour Travel Time Analysis

2.1 Design Hour and Traffic Volume Used in the Analysis

Roads are designed to accommodate a specific number of vehicles per hour. This traffic volume, called the design-hour traffic volume, is typically less traffic than what is expected during the single busiest or peak) hour on that road during the entire year. Designing for the yearly peak hour is usually not economical or feasible because it would mean building the road to accommodate more vehicles than what will be on the road most days (FHWA 2018).

What is the design-hour traffic volume?

The design-hour traffic volume is the maximum number of vehicles per hour that a roadway is designed to accommodate.

For the Little Cottonwood Canyon Project, the Utah Department of Transportation (UDOT) is proposing improvements to S.R. 210 in the canyon. These improvements consider future travel in the canyon in 2050 (the project's design year). To determine the design-hour traffic volume, UDOT performed the following two steps.

1. Using traffic count data, select a specific hour during which S.R. 210 had a high volume of traffic during a recent year. Typically, in rural settings similar to S.R. 210 in Little Cottonwood Canyon, the hour that is selected is the 30th-busiest hour over the entire year (FHWA 2018). By using the 30th-busiest hour, UDOT avoids designing roads for extremely busy days that are outliers from the more common traffic volumes.
2. Determine the rate at which traffic volumes are projected to increase in the future, and use this rate to increase the traffic volume during the recent 30th-busiest hour to the projected traffic volume during the future design hour. This is the design-hour traffic volume.

Roadway projects are usually designed using a single design hour and associated design-hour traffic volume. However, in Little Cottonwood Canyon, there are different traffic impacts for people entering the canyon in the morning (traveling eastbound) and people leaving the canyon in the afternoon (traveling westbound). For this reason, UDOT initially looked at two 30th-busiest hours for S.R. 210 in the canyon: one for traffic going eastbound and one for traffic going westbound.

To determine the 30th-busiest hours, UDOT used traffic data from 2017 from its automated traffic counters in the canyon (Fehr & Peers 2018a).

- **Eastbound.** The 30th-busiest hour on S.R. 210 for eastbound traffic was the hour from 10 AM to 11 AM on Saturday, January 14. According to the traffic data, 1,061 vehicles entered the canyon going eastbound during this hour in 2017.
- **Westbound.** The 30th-busiest hour on S.R. 210 for westbound traffic was the hour from 4 PM to 5 PM on Friday, March 3. According to the traffic data, 1,051 vehicles left the canyon going westbound during this hour in 2017.

Since these traffic counts were similar, and since the 30th-busiest hour in either direction occurred in the eastbound direction, UDOT decided to use the 30th-busiest hour in the eastbound direction as the basis for the future design hour. Therefore, the traffic volume during the 30th-busiest hour in 2017 was 1,061 vehicles.

The Little Cottonwood Canyon EIS is using 2050 as its design year. To determine the expected traffic volume during the design hour in 2050, UDOT increased the traffic volume from the 30th-busiest hour in 2017. According to an analysis conducted for UDOT (Fehr & Peers 2018b), traffic on S.R. 210 has been increasing at a rate of 1.2% per year. Using this rate, UDOT increased the traffic volume during the 30th-busiest hour in 2017 (1,061 vehicles) over a 32-year period (2018 to 2050) to calculate the projected traffic volume during the design hour in 2050 (1,555 vehicles).

What are the design hour and design-hour traffic volume for this analysis?

For this analysis, the design hour is the 30th-busiest hour in the eastbound direction on S.R. 210 in 2050, and the design-hour traffic volume is 1,555 vehicles.

Therefore, for this analysis, the design hour is the 30th-busiest hour in the eastbound direction on S.R. 210 in 2050, and the design-hour traffic volume is 1,555 vehicles. This number is assumed to include both personal vehicles and buses.

2.2 Design-hour Person Demand Used in the Analysis

UDOT next determined the number of people who would be traveling on S.R. 210 during the design hour in 2050 as this would be the basis for screening alternatives. According to vehicle occupancy data from 2018 (L2 Data Collection 2018), the average number of occupants during the peak morning hour (on a weekend day) was 1.89 occupants per personal vehicle and 42 occupants per bus. For buses, the current 15-minute headways on Routes 953 and 994 were assumed (that is, 4 buses per route for a total of 8 buses per hour).

In 2050 during the design hour (1,555 vehicles), 336 people are projected to travel by bus (8 buses × 42 occupants) and about 2,924 people are projected to travel by personal vehicle (1,547 personal vehicles × 1.89 occupants) for a total of about 3,260 people entering Little Cottonwood Canyon during the design hour.

2.3 Per-person Travel Time Used in the Analysis

What is headway?

As used in this report, *headway* is the time between two buses arriving at the same location on the same route.

One purpose of the Little Cottonwood Canyon Project is to improve mobility on S.R. 210. UDOT used a reduction in travel time per person to measure this mobility criterion. Such a reduction in travel time per person allows an equal comparison of the alternatives analyzed in this report, alternatives that have different of configurations of travel mode (bus or personal vehicle), number and type of lanes, and bus headways. This would show the benefit for all users independent of traveling in a personal car or bus. For example, if a dedicated bus lane was implemented with a faster travel time for a bus than a personal vehicle the 42 persons in the bus would have a faster travel time than the 2 people in the personal vehicle giving a greater benefit to bus service.

To further allow an equal comparison of travel times between alternatives, UDOT used common starting and ending points of travel for all travel modes. For personal vehicles, travel time was calculated starting at Fort Union Boulevard and ending at the Alta ski resort. For buses, travel time was calculated starting at Fort Union Boulevard and ending at the Alta ski resort but also included time to transfer from one mode to another. Each transfer between modes was assumed to take 12 minutes. For example, UDOT assumed that it would take 12 minutes of additional time to park a personal vehicle in a parking garage and board a bus versus driving a personal vehicle directly to the ski resort.

The per-person travel time was modeled using the Little Cottonwood Canyon Sketch Planning Tool (see the following section).

2.4 Per-person Travel Time Modeling

The Little Cottonwood Canyon Sketch Planning Tool (SPT or model) is a data-driven planning tool designed for Little Cottonwood Canyon to estimate travel times in the canyon based on changes in travel demand and potential transportation improvements. The SPT is a system dynamics model that uses a Microsoft Excel format. System dynamics models are applicable to systems that have many individually dynamic components that are interrelated. The SPT focuses on relationships between travel demand in Little Cottonwood Canyon, travel mode choice, and travel times. Each approach to the canyon from Fort Union Boulevard to the Alta ski resort is programmed into the model, along with the existing number of travel lanes and the posted speed limits (HDR 2019a).

The SPT analyzes traffic from outside the canyon (at the intersection of S.R. 210 and Fort Union Boulevard) to the Alta ski resort. The SPT is able to adjust the overall daily travel demand for the canyon (the number of people who enter the canyon on a given day), hourly arrival times, mode(s) of transportation used by each person, bus headways and ridership capacities, and parking lot capacities throughout the canyon.

The SPT can evaluate various alternatives and estimate their expected travel times. A variety of scenarios can be evaluated, including combinations of the following elements:

- Number of travel lanes
- Speed limits
- Transit-only (bus-only) lane
- A high-occupancy vehicle (HOV) lane for buses and carpooling vehicles
- Bus schedule(s) and route(s)
- Mode of transportation used by each person (for example, carpooling versus taking a bus)
- Time of day when people arrive at or leave the canyon (for example, arriving or leaving later on closure days)

For the travel time analysis in this report, UDOT used the SPT to calculate travel times for personal vehicles and buses and the number of people in single-occupant vehicles, high-occupancy vehicles, and buses.

2.4.1 Travel Time Estimations

The SPT is sub-divided into several analysis modules, organized to mimic a person's travel decisions when choosing to visit Little Cottonwood Canyon, including:

- Built environment (physical infrastructure and policy decisions)
- Persons traveling to Little Cottonwood Canyon
- Mode choice distribution
- Hourly vehicle travel profiles (i.e. entering or exiting the canyon)
- Transit system operating characteristics

The model is heavily data-driven, and uses historic traffic patterns and local observations to estimate the impacts of future scenarios on travel times. As changes are made within the model to simulate a future scenario, the SPT automatically incorporates the effects from early modules into the results of subsequent analysis modules, creating a cohesive evaluation of travel times based upon the compounding effects of all of the transportation improvements implemented in the future scenario.

The travel time models within the SPT are based upon Greenshields model of traffic flow, which defines the interrelationships between traffic density, travel speed, and traffic flow. The key parameters necessary for applying this traffic flow model (e.g. maximum vehicle flow rate, jam density, free flow travel speed) were set as variables within the SPT, which automatically adjust to incorporate changes to the built environment as new scenarios are evaluated.

The adjustments redefine the relationships between vehicle flow, vehicle density, and travel speed for each future scenario, thereby creating a dynamic model which provides travel time estimations for the corridor. As vehicle density increases (i.e. cars are closer together – similar to a traffic jam), vehicles travel at slower speeds and therefore fewer vehicles can traverse the road segment (i.e. reduced vehicle flow). As vehicle density decreases (i.e. fewer cars on the roadway), vehicles may travel faster and there will be more vehicles that can traverse the road segment (i.e. increased vehicle flow). Similar changes occur as adjustments are made to vehicle speed (density and flow rate change) and vehicle flow rates (speed and density change).

These three parameters are directly influenced by the transportation improvements selected for modeling. For example, adding an additional travel lane to the roadway increases its overall capacity, maximum vehicle flow rate, and the maximum vehicle density (i.e. jam density), and would result in decreased travel times (assuming travel demand and the free flow speed remained constant).

In another example, changes to add a transit lane along the corridor (assuming one general purpose lane and one transit lane) would move buses with slower climbing speeds to their own lane. This would allow vehicles to travel up to the posted speed limit, rather than be limited by the bus climbing speed. This scenario would calculate travel times separately for the vehicles traveling in the general purpose lane and the buses traveling within the transit lane.

The model also makes adjustments to account for scenarios where travel demand exceeds the capacity of the roadway, increasing the travel time estimation to incorporate the effects of vehicle queuing on the roadway.

2.5 Alternatives Evaluated

For the travel time analysis, UDOT evaluated multiple alternatives to determine the per-person travel time for each alternative during the design hour in 2050. Table 1 lists the alternatives that were evaluated which came from public, agency, and previous reports. The analysis for bus service includes headways of either 15 minutes (current conditions), 7.5 minutes, or 5 minutes to meet the ridership demand for the alternatives. Headways less than 5 minutes were considered infeasible because there would not be enough time for all riders to exit or board the bus and retrieve or stow their ski gear before the next bus arrived (UTA 2019).

The headways for the alternatives listed in Table 1 assume that two buses leave at the same time from two transit hubs: one at a gravel pit off of Wasatch Boulevard near Fort Union Boulevard and a second at 9400 South and Highland Drive. Therefore, a 5-minute headway assume a bus leaving every 5 minutes from both transit hubs to the ski resorts (2 buses every 5 minutes, or 24 buses per hour).

Table 1. Alternatives Evaluated in the Travel Time Analysis for the Peak-direction (Eastbound) Conditions in the Design Hour

Alternative	Number of Vehicles		Person Demand		
	Personal Vehicles[a]	Buses[b]	People in Personal Vehicles	People in Buses	Total Person Demand[c]
Baseline Conditions					
1. 2017 Baseline • Wasatch Blvd. – One lane each direction • Little Cottonwood Canyon – One lane each direction • Transit – 15-minute bus headways on two separate routes	1,053	8	1,990	336	2,326
2. 2050 Baseline (No-Action Alternative)[d] • Wasatch Blvd. – One lane each direction • Little Cottonwood Canyon – One lane each direction • Transit – 15-minute bus headways on two separate routes	1,547	8	2,924	336	3,260
No Additional Capacity to Wasatch Blvd. or Little Cottonwood Canyon Road and Increase Transit (Bus)					
3. Bus service with 5-minute headways on two separate routes • Wasatch Blvd. – One lane each direction • Little Cottonwood Canyon – One lane each direction • Transit – 5-minute bus headways on two separate routes	1,190	24	2,249	1,008	3,257
Additional Roadway Capacity to Wasatch Blvd. with No Additional Capacity to Little Cottonwood Canyon Road and Increase Transit (Bus)					
4. Bus service with 7.5-minute headways on two separate routes • Wasatch Blvd. – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – One lane each direction • Transit – 7.5-minute bus headways on two separate routes	1,368	16	2,585	672	3,257
5. Bus service with 5-minute headways on two separate routes • Wasatch Blvd. – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – One lane each direction • Transit – 5-minute bus headways on two separate routes	1,190	24	2,249	1,008	3,257

(*continued on next page*)

Table 1. Alternatives Evaluated in the Travel Time Analysis for the Peak-direction (Eastbound) Conditions in the Design Hour

Alternative	Number of Vehicles		Person Demand		
	Personal Vehicles[a]	Buses[b]	People in Personal Vehicles	People in Buses	Total Person Demand[c]
Additional Roadway Capacity to Wasatch Blvd. and Peak-period Shoulder Lanes on Little Cottonwood Canyon Road and Increase Transit (Bus)					
6. One general-purpose lane and one bus-only lane in shoulder with bus 7.5-minute headways on two separate routes • Wasatch Blvd. – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – one lane each direction plus peak-period shoulders • Transit – 7.5-minute bus headways on two separate routes	1,368	16	2,585	672	3,257
7. One general-purpose lane and one-bus only lane in shoulder with bus 5-minute headways on two separate routes • Wasatch Blvd. – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – one lane each direction plus peak-period shoulder lanes • Transit – 5-minute bus headways on two separate routes	1,190	24	2,249	1,008	3,257

[a] Assumes 1.89 people per vehicle during the design hour based on vehicle occupancy counts conducted in 2018.

[b] Assumes buses from transit hubs at both the Gravel Pit and at 9400 South and Highland Drive. Buses have a standing capacity of 42 riders.

[d] Person demand in the design hour would need to be greater than 3,250 to meet 2050 demand.

[d] The No-Action Alternative serves as baseline against which to compare the action alternatives and is not evaluated against the screening criteria.

Since traffic volumes, bus service, and person throughput are nearly identical for both the eastbound (AM) 30th-busiest hour and the westbound (PM) 30th-busiest hour, the values in this table apply to both travel directions during the design hour.

Figure 1 shows the lane configuration for Alternatives 1 through 5. This lane configuration is the same as the existing roadway in Little Cottonwood Canyon.

Figure 1. S.R. 210 in Little Cottonwood Canyon – Existing Conditions

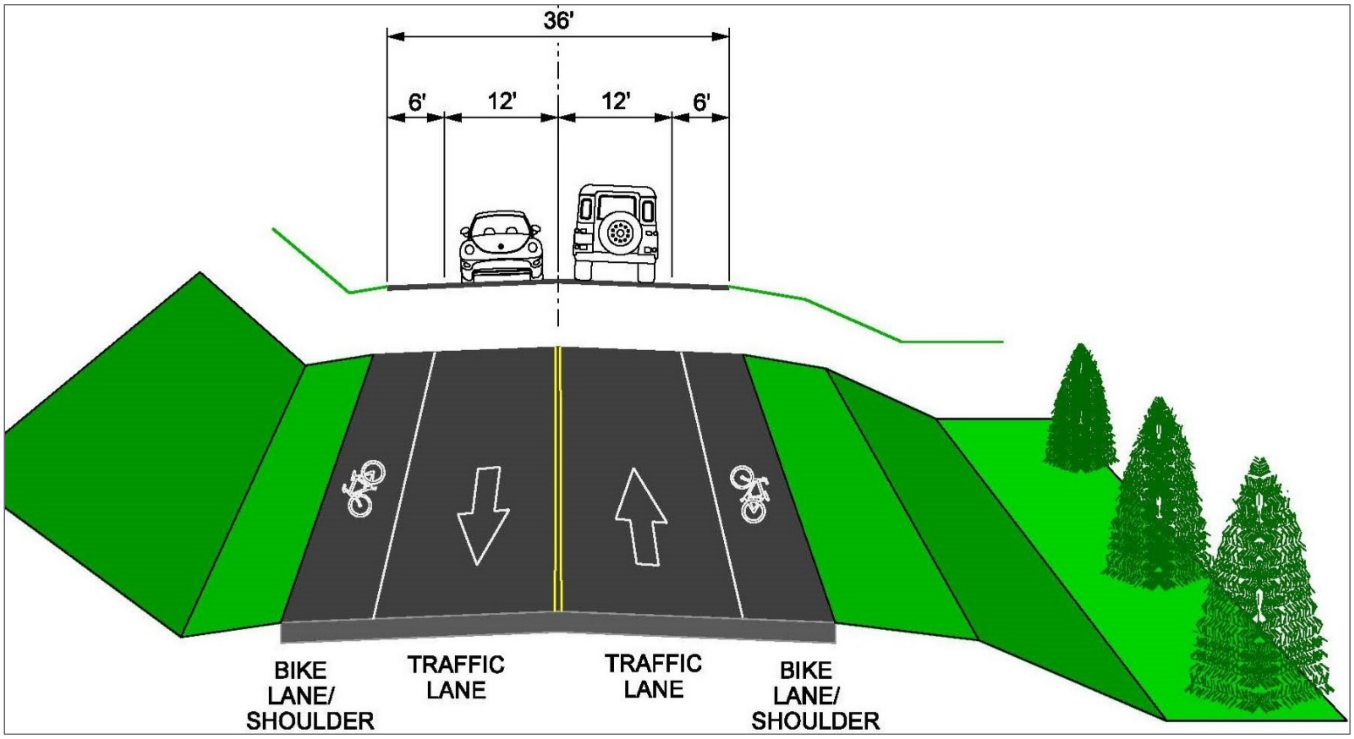


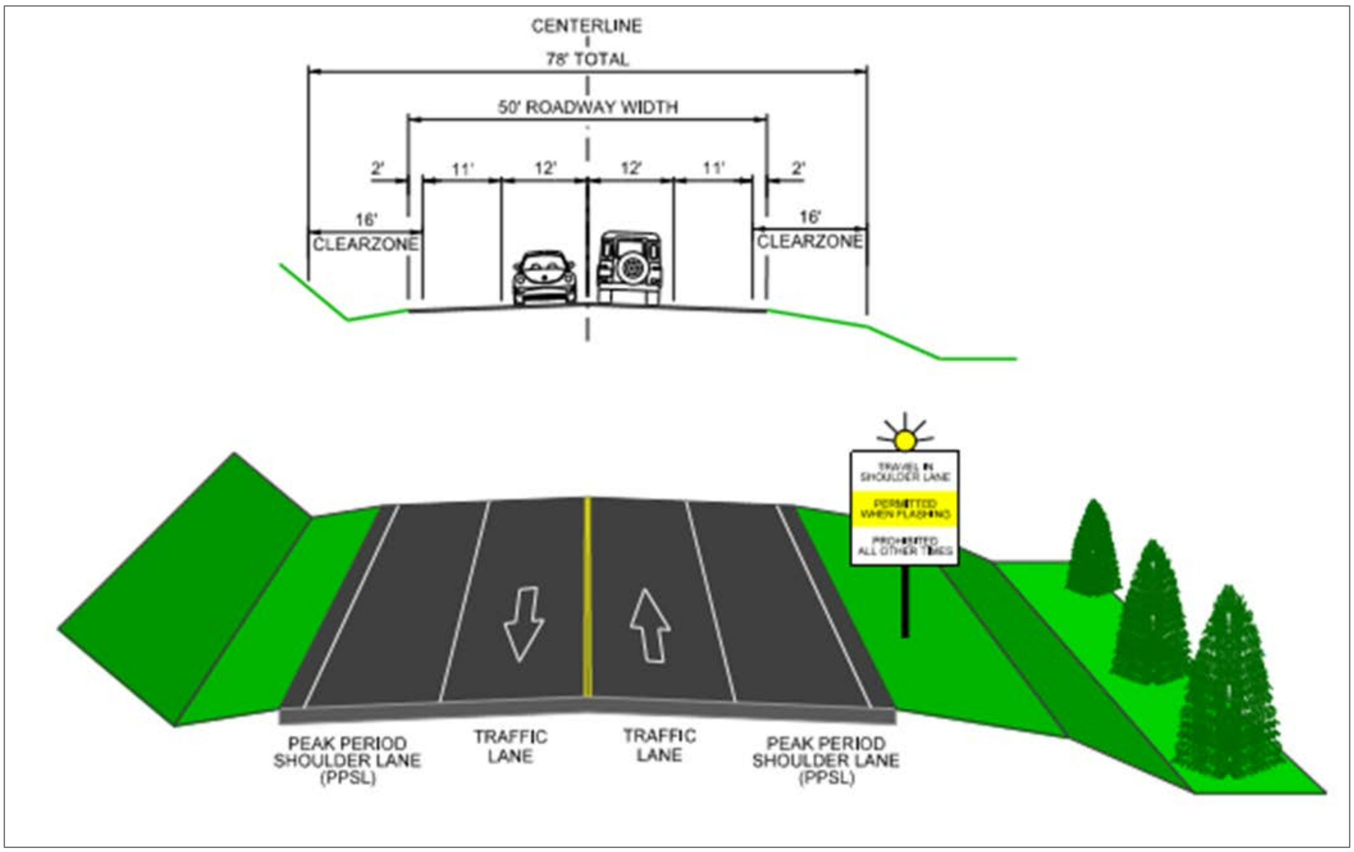
Figure 2 shows the configuration of peak-period shoulder lanes (PPSLs) for Alternatives 6 through 10. These lanes would be open to eastbound traffic in the morning and westbound traffic in the afternoon on heavy traffic days. The lanes would be closed for traffic during the summer and during the winter outside of peak periods unless UDOT observes congested conditions on S.R. 210. The PPSLs could be open to general-purpose traffic without restrictions, or they could be limited to buses only.

What are peak periods?

Peak periods are the periods of the day with the heaviest traffic. For this analysis, the peak periods on S.R. 210 occur in the morning and afternoon on busy ski days.

The transition areas at the beginning and end of the PPSLs would be fairly straightforward. Dynamic message signs would alert drivers whether the PPSL is open or closed. When a PPSL is closed, drivers would merge from the PPSL in the shoulder back into the general-purpose travel lane.

Figure 2. S.R. 210 in Little Cottonwood Canyon – Peak-period Shoulder Lanes



2.6 Travel Time Results

2.6.1 Design Hour Travel Time in the Morning (Eastbound Entering Canyon)

For UDOT's analysis of the travel time during the design hour in the eastbound direction (morning traffic), the number of vehicles entering Little Cottonwood Canyon and the number of travel lanes were the main factors that determined the travel time. Table 2 shows the per-person travel time analysis in 2050 by number of vehicles and lanes. The transit travel times in Table 2 do not include a 12 minute travel time addition for parking personal vehicle, unloading gear, bus wait time, and bus loading

With regard to the travel time per person using personal vehicles, travel times would be very similar for personal vehicles when all vehicles are placed in a single lane. For example, if both buses and personal vehicles share the same general-purpose lanes, and with bus service at 7.5-minute or 5-minute headways, the travel time per person for people using personal vehicles would be 52 minutes and 42 minutes, respectively. With the bus-only lane added and all personal vehicles in a single travel lane, and with bus service at 7.5-minute or 5-minute headways, the travel time per person for people using personal vehicles would be 50 minutes and 38 minutes, respectively. With the bus-only lane, travel times would improve because the buses would be removed from the lane with the personal vehicles. With bus/high-occupancy vehicle (HOV) lanes and all general-purpose lanes, and with bus service at 15-minute headways, the travel time per person for people using personal vehicles would improve to 28 minutes because personal vehicles would be allowed to use all travel lanes.

Travel times on narrow and steep canyon roads are very sensitive to the number of vehicles on the road. On S.R. 210 from the intersection with S.R. 209(the entrance to Little Cottonwood Canyon) to the Alta ski resort, if there are 900 vehicles on the road per hour, the road is operating under free-flow conditions (freely flowing traffic with little congestion or delay). Under these conditions, the travel time is about 23 minutes per person. However, once the number of vehicles exceeds 900 vehicles per hour, the road exceeds capacity, and the additional vehicles dramatically increase the travel time per person. Following are the modeled travel times per person in 2050 if no improvements are made S.R. 210 from the intersection with S.R. 209 to the Alta ski resort:

- 900 vehicles per hour = 23 minutes per person
- 1,200 vehicles per hour = 36 minutes per person
- 1,350 vehicles per hour = 46 minutes per person
- 1,550 vehicles per hour = 58 minutes per person

Table 2. Travel Time Analysis for the Design Hour in the Eastbound Direction (AM)

Alternative	Number of AM Eastbound Lanes in Little Cottonwood Canyon	Number of People	Average Travel Time per Person (minutes)		
			People in Personal Vehicles	People in Buses[a]	Combined
Baseline Conditions					
1. 2017 Baseline • 15-minute bus headways • 1,061 vehicles (8 buses + 1,053 personal vehicles)	One general-purpose lane	2,326	42	42	40–45
2. 2050 Baseline (No-Action Alternative) • 15-minute bus headways • 1,555 vehicles (8 buses + 1,547 personal vehicles)	One general-purpose lane	3.,260	84	84	80–85
No Additional Capacity to Wasatch Blvd. or Little Cottonwood Canyon Road and Increase Transit (Bus)					
3. 5-Minute Bus Headways • 1,214 vehicles (24 buses + 1,190 personal vehicles)	One general-purpose lane	3,257	47	47	45–50
Additional Roadway Capacity to Wasatch Blvd. with No Additional Capacity to Little Cottonwood Canyon Road and Increase Transit (Bus)[b]					
4. 7.5-Minute Bus Headways • 1,384 vehicles (16 buses + 1,368 personal vehicles)	One general-purpose lane	3,257	52	52	50–55
5. 5-Minute Bus Headways • 1,214 vehicles (24 buses + 1,190 personal vehicles)	One general-purpose lane	3,257	42	42	40–45
Additional Roadway Capacity to Wasatch Blvd. and Peak-period Shoulder Lanes on Little Cottonwood Canyon Road and Increase Transit (Bus)[b]					
6. 7.5-Minute Bus Headways • 1,384 vehicles (16 buses + 1,368 personal vehicles)	One bus-only lane and one general-purpose lane	3,257	50	24	45–50
7. 5-Minute Bus Headways • 1,214 vehicles (24 buses + 1,190 personal vehicles)	One bus-only lane and one general-purpose lane	3,257	38	24	35–40

(*continued on next page*)

Table 2. Travel Time Analysis for the Design Hour in the Eastbound Direction (AM)

Alternative	Number of AM Eastbound Lanes in Little Cottonwood Canyon	Number of People	Average Travel Time per Person (minutes)		
			People in Personal Vehicles	People in Buses[a]	Combined

[a] Assumes transit priority on Wasatch Blvd. for all action alternatives. Travel time does not include bus transfer time from personal vehicle of 12 minutes.

[b] Assumes that Wasatch Blvd. is either 4 or 5 lanes to meet UDOT's PM design-hour objective of level of service (LOS) D or better.

[c] Assumes about 50% of personal vehicles are HOV sharing bus lane.

2.6.2 Design Hour Travel Time in the Afternoon (Westbound Leaving Canyon)

For UDOT's analysis of the travel time during the design hour in the westbound direction (afternoon traffic), the number of vehicles leaving Little Cottonwood Canyon and the number of travel lanes were the main factors that determined the travel time. Table 3 shows the per-person travel time analysis in 2050 by number of vehicles and lanes.

With regard to the travel time per person using personal vehicles, travel times would be very similar for personal vehicles when all vehicles are placed in a single lane. For example, if both buses and personal vehicles share the same lanes, and with bus service at 7.5-minute or 5-minute headways, the travel time per person for people using personal vehicles would be are 53 minutes and 43 minutes, respectively. With the bus-only lane added and all personal vehicles in a single travel lane, and with bus service at 7.5-minute or 5-minute headways, the travel time per person for people using personal vehicles would be 48 minutes and 36 minutes, respectively. With the bus-only lane, the travel time per person for people using personal vehicles would slightly improve because the buses would be removed from the lane with the personal vehicles. The transit travel times in Table 3 do not include a 12 minute travel time addition for parking personal vehicle, unloading gear, bus wait time, and bus loading

Table 3. Travel Time Analysis for the Design Hour in the Westbound Direction (PM)

Alternative	Number of PM Westbound Lanes in Little Cottonwood Canyon	Number of People	Average Travel Time per Person (minutes)		
			People in Personal Vehicles	People in Buses[a]	Combined
Baseline Conditions					
1. 2017 Baseline • 15-minute bus headways • 1,061 vehicles (8 buses + 1,053 personal vehicles)	One general-purpose lane	2,326	42	42	40–45
2. 2050 Baseline (No-Action Alternative) • 15-minute bus headways • 1,555 vehicles (8 buses + 1,047 personal vehicles)	One general-purpose lane	3,260	82	82	80–85
No Additional Capacity to Wasatch Blvd. or Little Cottonwood Canyon Road and Increase Transit (Bus)					
3. 5-Minute Bus Headways • 1,214 vehicles (24 buses + 1,190 personal vehicles)	One general-purpose lane	3,257	48	48	45–50
Additional Roadway Capacity to Wasatch Blvd. with No Additional Capacity to Little Cottonwood Canyon Road and Increase Transit (Bus)[b]					
4. 7.5-Minute Bus Headways • 1,384 vehicles (16 buses + 1,368 personal vehicles)	One general-purpose lane	3,257	53	53	50–55
5. 5-Minute Bus Headways • 1,214 vehicles (24 buses + 1,190 personal vehicles)	One general-purpose lane	3,257	43	43	40–45
Additional Roadway Capacity to Wasatch Blvd. and Peak-period Shoulder Lanes on Little Cottonwood Canyon Road and Increase Transit (Bus)[b]					
6. 7.5-Minute Bus Headways • 1,384 vehicles (16 buses + 1,368 personal vehicles)	One bus-only lane and one general-purpose lane	3,257	48	32	45–50
7. 5-Minute Bus Headways • 1,214 vehicles (24 buses + 1,190 personal vehicles)	One bus-only lane and one general-purpose lane	3,257	36	30	35–40

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Table 3. Travel Time Analysis for the Design Hour in the Westbound Direction (PM)

Alternative	Number of PM Westbound Lanes in Little Cottonwood Canyon	Number of People	Average Travel Time per Person (minutes)		
			People in Personal Vehicles	People in Buses[a]	Combined

[a] Assumes transit priority on Wasatch Blvd. for all action alternatives. Travel time does not include bus transfer time to personal vehicle of 12 minutes.

[b] Assumes that Wasatch Blvd. is either 4 or 5 lanes to meet UDOT's PM design-hour objective of LOS D or better.

[c] Assumes about 50% of personal vehicles are HOV sharing bus lane

2.7 Tolling Considerations

If UDOT were to implement a toll on S.R. 210 along with improved bus travel times, drivers would be forced to decide whether the toll makes the ski bus a better option. A toll along with improved bus travel times would be a tool to incentivize transit use. The amount of the toll has yet to be determined.

Congestion (variable) pricing is in use in areas around the United States and the world. For example, drivers could be offered a discount if they traveled during off-peak periods. This type of toll structure would encourage drivers to shift to the bus during peak periods or to drive during off-peak or discount periods.

Although the exact type of tolling system has yet to be decided, it would likely be an electronic pass system and/or a license plate recognition system. The advantage of tolling is that the toll could be used to pay for some or all of ski bus operations and thus result in free or substantially reduced fares.

Tolling would be most effective with a separate or shared bus/HOV lane where the bus travel time is faster than vehicle travel times. The toll to the vehicle along with the faster travel time would make the bus service more attractive given the inconvenience of transferring from a vehicle to the bus and carrying ski gear onto the bus.

3.0 Vehicle Queuing Analysis

One of the screening criteria for the alternatives analysis is to substantially reduce vehicle backups on S.R. 210 and S.R. 209 through residential areas on busy ski days. For this analysis, UDOT used a VISSIM model to determine the length of vehicles backing up from the S.R. 209/S.R. 210 intersection. The analysis is based on UDOT's Traffic Analysis Guidelines (UDOT 2018). The backup length criterion used in the analysis is the 95th-percentile vehicle queue, which is defined to be the vehicle queue length that has only a 5% probability of being exceeded during the analysis period. The length is measured from the stop bar of an intersection or from the beginning of a roadway bottleneck to the end of the last vehicle in the line.

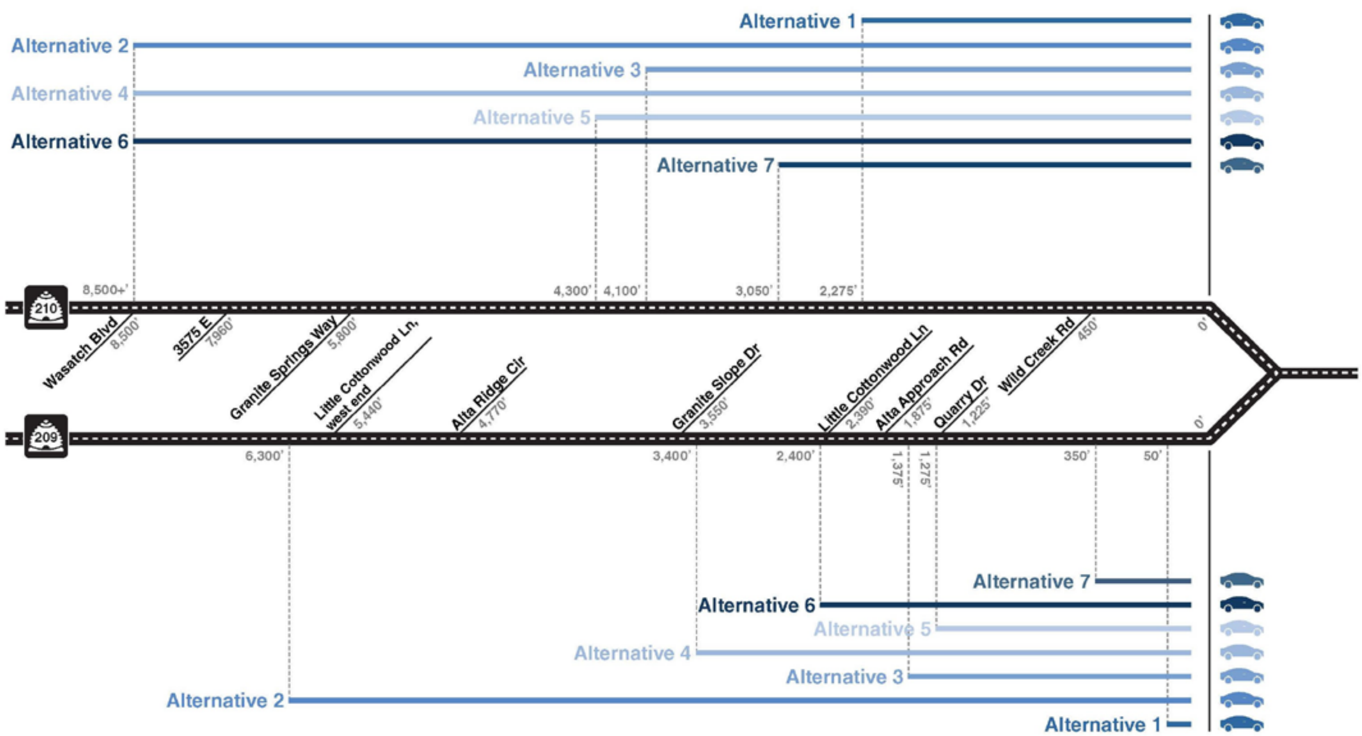
The purpose of using this screening criterion is to substantially reduce vehicle backups compared to the baseline (no-action) conditions in 2050 (that is, the conditions if no improvements are made to S.R. 210). As shown in Table 5 and Figure 3, under the baseline conditions (without improvements) in 2050, the vehicle backups on S.R. 209 are projected to extend past the traffic signal at the intersection of 9400 South and Wasatch Boulevard, and the vehicle backups on S.R. 210 are projected to extend past the traffic signal at the intersection of Wasatch Boulevard and North Little Cottonwood Road. Based on origin-destination data collected by UDOT, about 60% of the traffic entering Little Cottonwood Canyon comes from S.R. 210 and 40% comes from S.R. 209.

Table 4. Queuing Analysis during the Design Hour in the Eastbound Direction (AM)

Alternative	Number of AM Eastbound Lanes in Little Cottonwood Canyon	Queuing on S.R. 209 (feet)	Queuing on S.R. 210 (feet)
Baseline Conditions			
1. 2017 Baseline • 15-minute bus headways • 1,061 vehicles (8 buses + 1,053 personal vehicles)	One general-purpose lane	50	2,275
2. 2050 Baseline (No-Action Alternative) • 15-minute bus headways • 1,555 vehicles (8 buses + 1,047 personal vehicles)	One general-purpose lane	6,300+ (beyond traffic signals at 9400 South/Wasatch Blvd. intersection)	8,500+ (beyond traffic signals at Wasatch Blvd./North Little Cottonwood Road intersection)
No Additional Capacity to Wasatch Blvd. or Little Cottonwood Canyon Road and Increase Transit (Bus)			
3. 5-Minute Bus Headways • 1,214 vehicles (24 buses + 1,190 personal vehicles)	One general-purpose lane	1,375 (backup to Quarry Drive)	4,100 (backup halfway to Wasatch Blvd./ North Little Cottonwood Road intersection)
Additional Roadway Capacity to Wasatch Blvd. with No Additional Capacity to Little Cottonwood Canyon Road and Increase Transit (Bus)[a]			
4. 7.5-Minute Bus Headways • 1,384 vehicles (16 buses + 1,368 personal vehicles)	One general-purpose lane	3,400 (backup near Granite Slope Drive)	8,500+ (beyond traffic signals at Wasatch Blvd/North Little Cottonwood Road intersection)
5. 5-Minute Bus Headways • 1,214 vehicles (24 buses + 1,190 personal vehicles)	One general-purpose lane	1,275	4,300
Additional Roadway Capacity to Wasatch Blvd. and Peak-period Shoulder Lanes on Little Cottonwood Canyon Road and Increase Transit (Bus)[a]			
6. 7.5-Minute Bus Headways • 1,384 vehicles (16 buses + 1,368 personal vehicles)	One bus-only lane and one general-purpose lane	2,450 (backup to Little Cottonwood Lane)	8,500+ (beyond traffic signals at Wasatch Blvd./North Little Cottonwood Road intersection)
7. 5-Minute Bus Headways • 1,214 vehicles (24 buses + 1,190 personal vehicles)	One bus-only lane and one general-purpose lane	350	3,050 (backup one-third to Wasatch Blvd./North Little Cottonwood Road intersection

[a] Assumes that Wasatch Blvd. is either 4 or 5 lanes to meet UDOT's PM design-hour objective of LOS D or better.

Figure 3. Queuing Results



4.0 Results of the Travel Time and Vehicle Queuing Analysis

Table 6 shows the consolidated results of UDOT's analysis of travel time per person and vehicle queuing for the alternatives analyzed in this report. The transit travel times in Table 6 include a 12 minute travel time addition for parking their personal vehicle, unloading gear, bus wait time, and bus loading.

Table 5. Travel Time and Queuing Analysis Results during the Design Hour in the Eastbound (AM) and Westbound (PM) Directions

Alternative	Number of Vehicles		Person Demand			Travel Time per Person Eastbound/Westbound (minutes)[d]	Vehicle Backup (feet)	
	Personal Vehicles[a]	Buses[b]	People in Personal Vehicles	People in Buses	Total Person Demand[c]		On S.R. 209	On S.R. 210
Baseline Conditions								
1. 2017 Baseline • Wasatch Blvd. – One lane each direction • Little Cottonwood Canyon – One lane each direction • Transit – 15-minute bus headways on two separate routes	1,053	8	1,990	336	2,326	40–45 / 40–45 (40-45/40-45 – vehicle) (50-55/50-55 - bus)	50	2,775
2. 2050 Baseline (No-Action Alternative)[e] • Wasatch Blvd. – One lane each direction • Little Cottonwood Canyon – One lane each direction • Transit – 15-minute bus headways on two separate routes	1,547	8	2,924	336	3,260	80–85 / 80–85 (80-85/80-85 – vehicle) (95-100/90-95 - bus)	6,300+ (beyond traffic signals at 9400 South/Wasatch Blvd. intersection)	8,500+ (beyond traffic signals at Wasatch Blvd./North Little Cottonwood Road intersection)
No Additional Capacity to Wasatch Blvd. or Little Cottonwood Canyon Road and Increase Transit (Bus)								
3. Bus service with 5-minute headways on two separate routes • Wasatch Blvd. – One lane each direction • Little Cottonwood Canyon – One lane each direction • Transit – 5-minute bus headways on two separate routes	1,190	24	2,249	1,008	3,257	50-55 / 50-55 (45-50/45-50 – vehicle) (60-65/60-65 - bus)	1,375 (backup to Quarry Drive)	4,100 (backup halfway to Wasatch Blvd./North Little Cottonwood Road intersection)
Additional Roadway Capacity to Wasatch Blvd. with No Additional Capacity to Little Cottonwood Canyon Road and Increase Transit (Bus)								
4. Bus service with 7.5-minute headways on two separate routes • Wasatch Blvd. – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – One lane each direction • Transit – 7.5-minute bus headways on two separate routes	1,368	16	2,585	672	3.257	50–55 / 50–55 (50–55/50-55– vehicle) (60-65/60-65 - bus)	3,400 (backup near Granite Slope Drive)	8,500+ (beyond traffic signals at Wasatch Blvd./North Little Cottonwood Road intersection)
5. Bus service with 5-minute headways on two separate routes • Wasatch Blvd. – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – One lane each direction • Transit – 5-minute bus headways on two separate routes	1,190	24	2,249	1,008	3,257	45–50 / 45–50 (40–45/40-45 – vehicle) (50-55/50-55 – bus)	1,275	4,300
Additional Roadway Capacity to Wasatch Blvd. and Peak-period Shoulder Lanes on Little Cottonwood Canyon Road and Increase Transit (Bus)								
6. One general-purpose lane and one bus-only lane in shoulder with bus 7.5-minute headways on two separate routes • Wasatch Blvd. – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – one lane each direction plus peak-period shoulders • Transit – 7.5-minute bus headways on two separate routes	1,368	16	2,585	672	3,257	45–50 / 45–50 (45–50/45-50 – vehicle) (35-40/40-45 – bus)	2,450 (backup to Little Cottonwood Lane)	8,500+ (beyond traffic signals at Wasatch Blvd./North Little Cottonwood Road intersection)
7. One general-purpose lane and one bus-only lane in shoulder with bus 5-minute headways on two separate routes • Wasatch Blvd. – 4 or 5 lanes with transit priority • Little Cottonwood Canyon – one lane each direction plus peak-period shoulders • Transit – 5-minute bus headways on two separate routes	1,190	24	2,173	1,008	3,257	35–40 / 35–40 (35–40/35-40 – vehicle) (35-40/40-45 – bus)	350	3,050 (backup one-third to Wasatch Blvd./North Little Cottonwood Road intersection)

[a] Assumes 1.89 people per vehicle during the design hour based on vehicle occupancy counts conducted in 2018.
[b] Assumes buses from transit hubs at both the Gravel Pit and at 9400 South and Highland Drive. Buses have a standing capacity of 42 riders.
[c] Person demand in the design hour would need to be greater than 3,250 to meet 2050 demand.
[d] Travel times include 12 minutes to transfer from personal vehicle to bus eastbound or from bus to vehicle westbound.
[e] The No-Action Alternative serves as baseline against which to compare the action alternatives and is not evaluated against the screening criteria.

5.0 References

[FHWA] Federal Highway Administration

2018 Traffic Data Computation Method Pocket Guide Publication No. FHWA-PL-18-027. August.

Fehr & Peers

2018a Traffic Data for S.R. 210 Little Cottonwood Canyon Environmental Impact Statement. April 5.

2018b Visitation Estimates for Little Cottonwood Canyon. May.

HDR, Inc.

2019a Sketch Planning Tool Methodology. September 12.

2019b Cottonwood Canyon Mode Shift Tool v2.1. September.

L2 Data Collection

2018 Traffic counts for intersection of S.R. 210 and S.R. 209. March 15.

[UDOT] Utah Department of Transportation

2018 Traffic Analysis Guideline. December.

[UTA] Utah Transit Authority

2019 Meeting notes between UDOT and UTA regarding winter bus service. August 6.

APPENDIX J

Draft Snow Shed Concepts

Little Cottonwood Canyon ENVIRONMENTAL IMPACT STATEMENT
S.R. 210 | Wasatch Blvd. to Alta

Draft Snow Shed Concepts

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 - Wasatch Boulevard to Alta

Lead agency:
Utah Department of Transportation

May 11, 2020

Contents

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Appendixes

1.0 Introduction

This technical memorandum describes applicable special design codes, standards, guidance, and recommended practices for snow sheds and lists site-specific design considerations as the Utah Department of Transportation (UDOT) evaluates snow sheds as passive avalanche mitigation for the more active avalanche paths along State Route (S.R.) 210 in Little Cottonwood Canyon. This memorandum also presents a conceptual structural design for snow sheds and summarizes planning-level cost estimates.

2.0 Background

HDR, Inc., is working with UDOT on the Little Cottonwood Canyon (S.R. 210) Environmental Impact Statement. Dynamic Avalanche Consulting, Ltd. (Dynamic), has been engaged to assess the current avalanche hazards and to evaluate hazard-mitigation options to protect the traveling public on S.R. 210.

What is the main reference for special design considerations for snow sheds?

The main reference is the standard NFPA 502 from the National Fire Protection Association. This memorandum references NFPA 502 and other applicable references.

Dynamic worked closely with UDOT personnel to understand the current conditions. Dynamic conceptually evaluated several passive avalanche-risk-mitigation options. The most feasible and practical option for reducing the avalanche hazard in Little Cottonwood Canyon appears to be snow sheds covering S.R. 210 through three avalanche paths on which avalanches occur most frequently.[1] Therefore, UDOT asked HDR to evaluate and conceptually design the snow sheds and provide planning-level cost estimates.

In its National Tunnel Inspection Standards, the Federal Highway Administration (FHWA) defines a *tunnel*[2] as “an enclosed roadway for motor vehicle traffic with vehicle access limited to portals, regardless of type of structure or method of construction, that requires, based on the owner’s determination, special design considerations to include lighting, ventilation, fire protection systems, and emergency egress capacity.” The American Association of State Highway and Transportation Officials (AASHTO) echoes that definition. In addition, the National Fire Protection Association (NFPA) defines a *road tunnel* as “an enclosed roadway for motor vehicles with vehicle access that is limited to portals.” [3]

What are portals?

As used in this memorandum, *portal* refers to the entrance and exit points of a snow shed.

The references mentioned above are not a comprehensive list and, in fact, the code and manuals HDR reviewed list other applicable references. Not all of these references were reviewed in preparing this memorandum. However, HDR’s subject-matter experts for fire and life safety and tunnel inspections were consulted, and this memorandum provides UDOT with general information about the additional requirements and considerations for constructing these snow sheds and the major cost implications.

[1] *Snow Avalanche Hazard Baseline Report* (Phase 1), Dynamic, July 2018.

[2] 23 Code of Federal Regulations (CFR) Part 650, *Bridges, Structures, and Hydraulics*, Subpart E, *National Tunnel Inspection Standard*, Section 505, *Definitions*

[3] NFPA 502, *Standards for Road Tunnels and Other Limited Access Highways*, 2017 Edition

NFPA 502 is the main reference for special design considerations for snow sheds (road tunnels). NFPA 502 requires a holistic, multidisciplinary engineering analysis of the fire protection and life safety requirements for a road tunnel regardless of the length of the tunnel.[4] See Appendix A, NFPA 502, which is an excerpt from NFPA 502 with the requirements for the engineering analysis of show sheds.

Per NFPA 502, where a roadway is not fully enclosed, the decision by the "authority having jurisdiction" to consider the roadway as a road tunnel shall be made after an engineering analysis is performed.[5] The "authority having jurisdiction" is a broad term, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is a primary consideration, the authority having jurisdiction might be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority.[6] In the context of Little Cottonwood Canyon, the authority(ies) having jurisdiction could include UDOT, the U.S. Forest Service, the Unified Fire Authority, and others. FHWA also gives owners flexibility regarding whether to consider rock sheds, snow sheds, and other three-sided structures as highway tunnels as they relate to the inspection requirements in the National Tunnel Inspection Standards.[7]

[4] NFPA 502, Section 4.3.1

[5] NFPA 502, Section 7.2.1

[6] NFPA 502, Annex A, *Explanatory Material*, Section A3.2.2

[7] FHWA, Informational Memorandum, *Guidance on Structures Subject to the National Tunnel Inspection Standards*, October 2015

3.0 Snow Shed Design

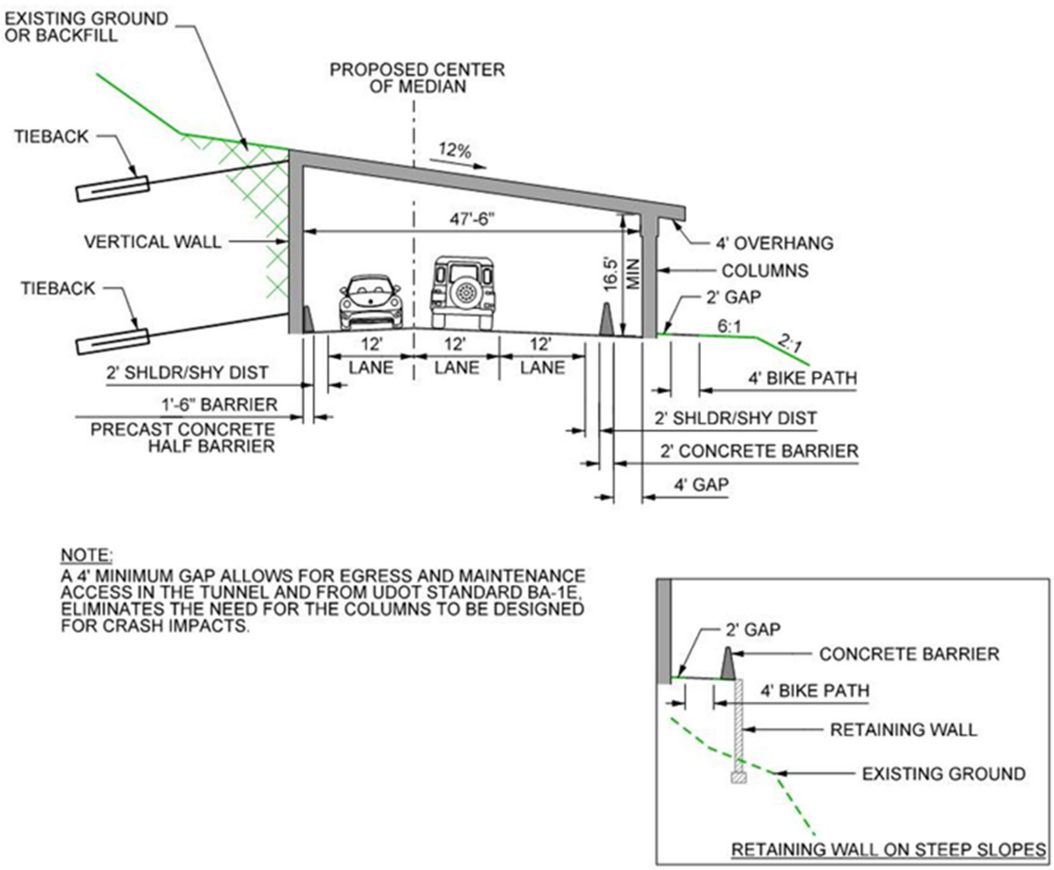
3.1 Cross-section

The preliminary snow shed cross-section is shown in Figure 3-1. FHWA recommends a barrier to protect the vertical wall of the snow shed, and a minimum of a 2-foot shoulder/shy distance to the barrier is common.[8] As stated in the note in Figure 3-1, UDOT's standards require a barrier and 4-foot gap to protect snow shed's columns from the high-impact force of a vehicle striking the column. The snow sheds were designed to match the existing three-lane roadway on S.R. 210 at the locations of the proposed snow sheds. With standard 12-foot-wide travel lanes, the total roadway span for the snow shed evaluated by HDR is 47 feet 6 inches.

What is a shoulder/shy distance?

A shoulder/shy distance is buffer to increase roadside safety when roadside barriers, walls or other vertical elements are present in the roadway.

Figure 3-1. Cross-section for Three-lane Snow Shed



8 FHWA, *Technical Manual for Design of Road Tunnels – Civil Elements*, 2009

Note that UDOT's Maintenance Division prefers placing the barrier adjacent to the columns because snow would accumulate in the gap between the barrier and columns. Moving the barrier would result in a 4-foot shoulder/shy distance from the edge of the travel lane to the barriers and maintain a 47-foot internal span. Note, however, that HDR did not design the columns to resist vehicle impacts.

3.2 Structure

HDR consulted with geotechnical firm Gerhart Cole to determine the potential foundation and structural elements for the snow sheds. Gerhart Cole performed a feasibility-level geologic and geotechnical assessment of the S.R. 210 corridor in August 2018.[9] Gerhart Cole reviewed existing literature and performed a field reconnaissance; no geotechnical borings were taken or subsurface investigations performed. No detailed hillside or fill slope stability, seismic stability, rock fall risk, hydrologic and hydraulic, or debris hazard analyses were performed. The approximate location of bedrock was based on limited field visits and literature search only.

Dynamic modeled the avalanche paths to approximate the required snow shed locations. Dynamic estimated the structural loads for the show shed for the White Pine Chutes 1–4 avalanche paths. Dynamic modeled an avalanche flowing over previous avalanche deposits and snow cover to determine the roof and lateral loads for the White Pine Chutes 1–4 snow shed as follows:

- Normal (vertical load) of 790 pounds per square foot (psf)
- Lateral (parallel) load of 120 psf

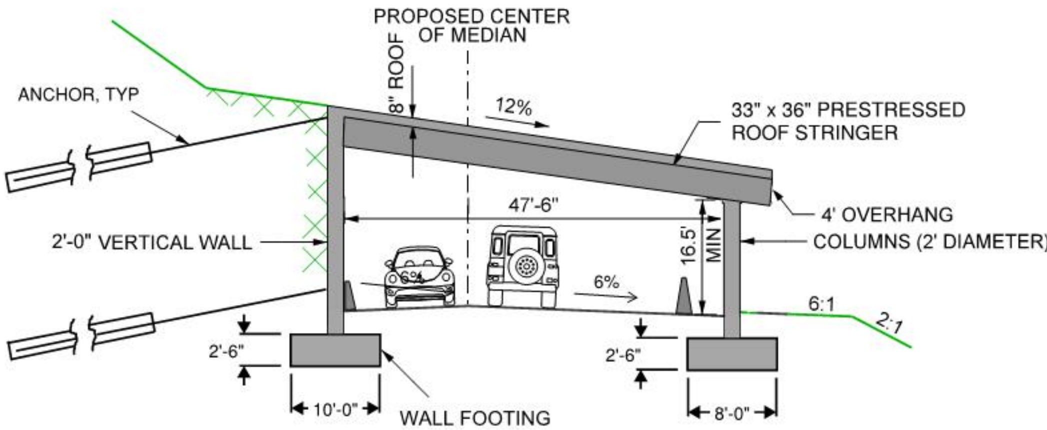
According to Dynamic, these loads assume an approximate 100-year return frequency (that is, a 1% chance of occurring in a given year) but do not include engineering safety factors.[10] As mentioned, these loads were calculated for the White Pine Chutes 1–4 snow shed only; the loading for the other snow sheds might vary. HDR applied a load factor of 1.5 to the snow loads listed above for preliminary structural design calculations.

HDR determined that the avalanche design loads for the White Pine Chutes 1–4 snow shed could be supported by an 8-inch-thick, cast-in-place (CIP) concrete slab roof supported by 33-inch-deep, prestressed concrete roof box beams at about 10-foot spacing. These beams are AASHTO Type BII-36 box beams, which are common. There would also need to be a 2-foot-thick CIP retaining wall on the mountain side founded on a 2.5-foot-thick, 10-foot-wide spread footing. On the other (stream) side, 2-foot-diameter concrete columns would need to be spaced every 10 feet and would bear on 2.5-foot-thick, 8-foot-wide spread footings. Figure 3-2 shows these dimensions.

[9] Gerhart Cole Technical Memorandum, Little Cottonwood Canyon EIS, August 8, 2018

[10] Email from Jordy Henrikx to Terry Warner, August 29, 2018

Figure 3-2. Preliminary Design of Three-lane Snow Shed



Note that this basic preliminary design was assumed by HDR to apply to all snow sheds. However, avalanche loading could be different for the White Pine and/or Little Pine snow shed.

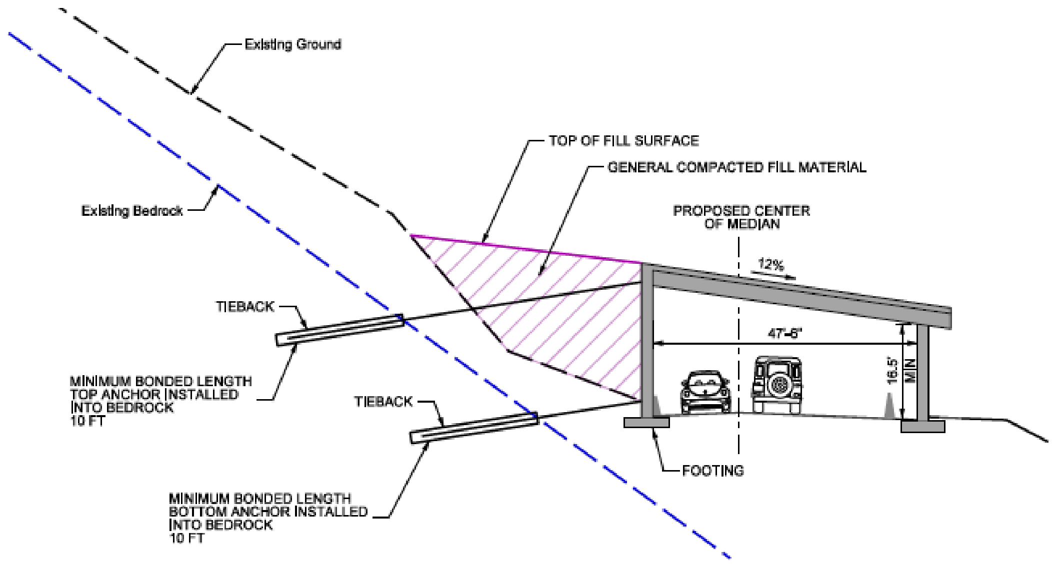
3.3 Anchoring Options

To resist the lateral loads, the show shed must be anchored to the mountain. Gerhart Cole estimated that two rows of tie-backs (one near the top and one about 20 feet below the top of the wall) would be required about every 6 feet, as shown above in Figure 3-2. HDR and Gerhart Cole evaluated two options for constructing anchors: (1) anchors in bedrock and (2) anchors in imported fill.

3.3.1 Option 1: Anchors in Bedrock

In areas where the snow sheds would be located close to the mountainside, primarily at White Pine Chutes 1–4, HDR assumed that rock excavation would be required at limited areas only and that the tie-back anchors could be drilled and secured into the underlying bedrock. The area behind the snow shed walls would then be backfilled with free-draining aggregate to fill in the space between the tie-backs and to allow water to drain from behind the snow shed retaining wall. The shed roof slope of 12% would be continued into the hillside to maintain the flow of snow over the top of the shed. The configuration for option 1 is shown in Figure 3-3. As shown in Figure 3-3, about 10 feet of bonded anchors secured into bedrock at the end of each steel strand would be needed to resist lateral loads.

Figure 3-3. Option 1: Anchors in Bedrock



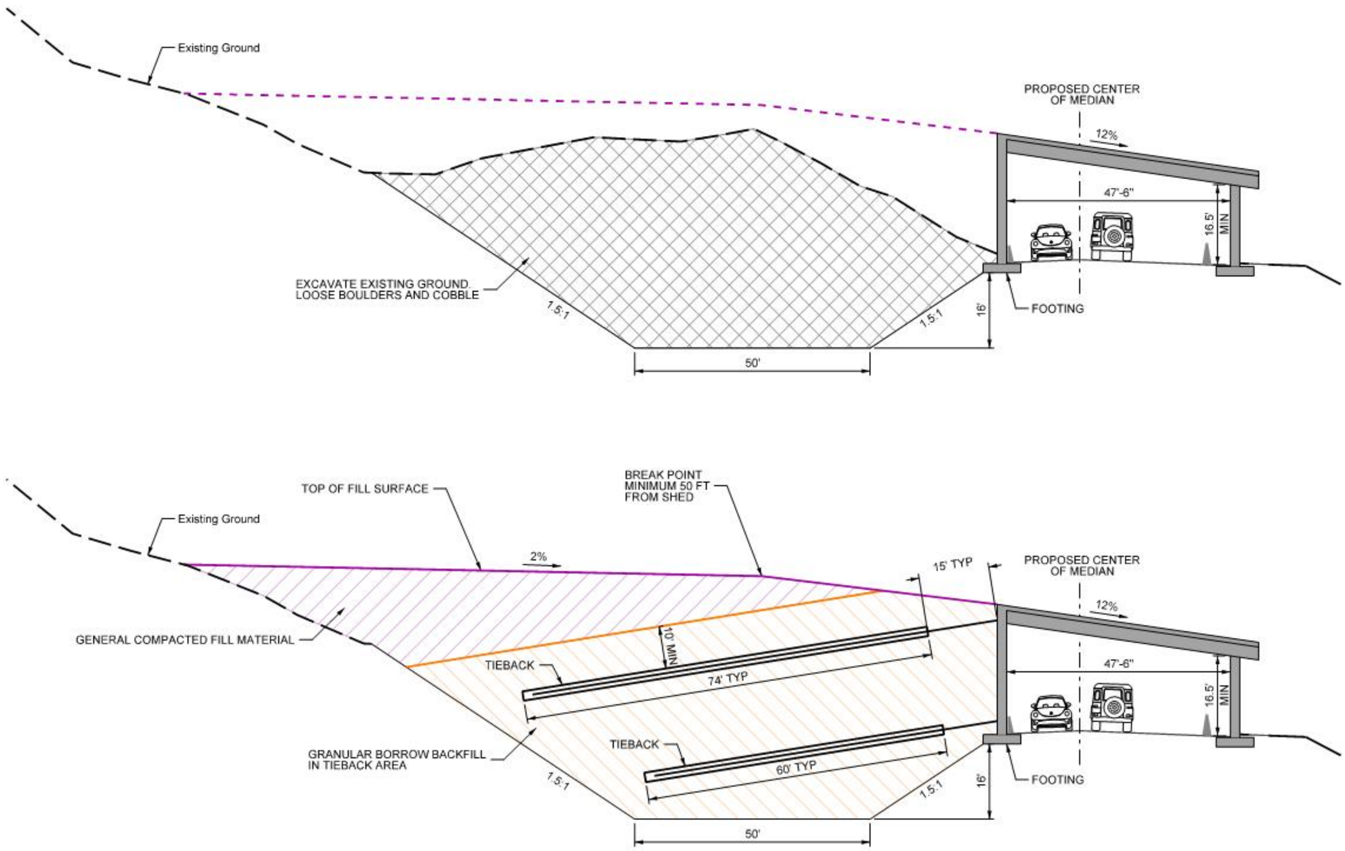
3.3.2 Option 2: Anchors in Imported Fill

Along some of the snow shed areas, primarily at White Pine and Little Pine, the roadway is inside the avalanche run-out zone, but the road is located away from the mountainside and in gently sloping rubble and talus fields. In these areas, in order to maintain the avalanche flow across the top of the sheds and to avoid avalanche flows being blocked by the shed, large quantities of fill would be placed on the mountain side of the shed to maintain a slope extending from the roof of the shed to the mountain. The top of the snow sheds with the required interior clearance would be above much of the surrounding terrain, and fill behind the snow shed would tie into the mountainside several hundred feet away. Therefore, the length of the steel strands that connect to the anchor that actually bonds to the bedrock would also be long, over about 100 to 150 feet.

HDR assumes that the existing boulder and talus material on the mountain side of the snow shed in these areas contains large boulders of various sizes. The large boulders and voids between the boulders would make drilling anchors extremely difficult. In addition, with unknown bedrock conditions at each anchor, construction could result in poor grouting and bonding or involve many ineffective attempts at anchoring the steel cables into the mountainside. Therefore, HDR and Gerhart Cole evaluated the feasibility of importing a granular fill material (or manufacturing a suitable fill from on-site material) and anchoring the snow sheds into the imported granular fill. With this method, UDOT would control the fill quality, and this fill would then become the anchoring medium for the snow shed.

The construction approach for anchoring option 2 would excavate a 16-foot-deep zone behind the snow shed. Suitable granular fill borrow material would be placed in the tie-back zone. Gerhart Cole estimated that bonded lengths of anchors of about 74 feet (top anchors) and 60 feet (bottom anchors) in the granular fill would be needed to resist the lateral avalanche loads. The approximate excavation and required anchor lengths for option 2 are shown in Figure 3-4.

Figure 3-4. Option 2: Anchors in Imported Manufactured Fill



In the area above the anchors, a more general fill material could be used to save cost. The roof fill slope of 12% would be continued into the mountainside to maintain the flow of snow over the shed, but, at about 50 feet from the shed, the slope could be reduced to 2% or less to reduce the amount of additional fill required.

3.4 Snow Shed Lengths

Dynamic provided approximate lengths for the snow sheds that would serve as passive avalanche mitigation measures for the paths that have the largest effect on the AHI calculation (Table 3-1 and Figure 3-5). At these lengths, the White Pine and Little Pine snow sheds would need guiding earthen berms running up the mountain on the north side to help minimize the lateral spread of the avalanches and keep the flow on the snow sheds.

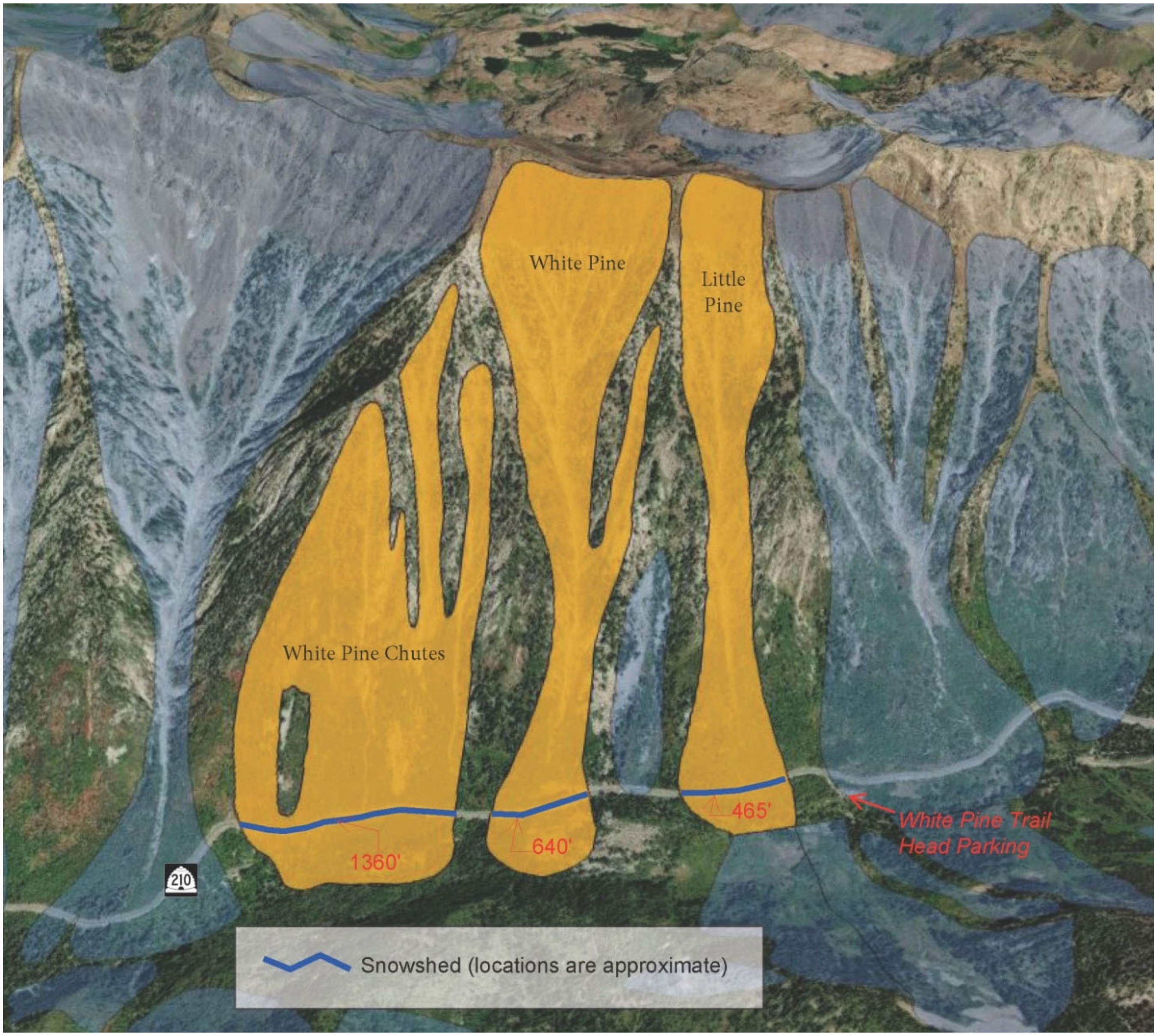
Table 3-1. Approximate Snow Shed Lengths

Avalanche Path	Approximate Length (feet)[a]
White Pine Chutes 1–4	1,360
White Pine	640[b]
Little Pine	465[b]

[a] Snow shed lengths were provided by Dynamic Avalanche on August 28, 2018. They are preliminary and are subject to change.

[b] The snow shed length assumes a guiding berm earthen 10 to 20 feet high and about 300 feet long on the mountain side of the shed at the portals.

Figure 3-5. Approximate Snow Shed Locations and Lengths



4.0 Snow Shed Concepts

HDR evaluated the following three conceptual snow shed layouts in order to compare their environmental footprints (which will be evaluated in a separate report) and to allow HDR to estimate their costs. The snow shed cross-section and structure (Sections 3.1 and 3.2) would be the same for all of them. The anchoring option (Section 3.3) used for each snow shed would depend on more-detailed geotechnical investigation.

- Concept 1: No Berms
- Concept 2: Earthen Berms
- Concept 3: No Berms, Realign Road

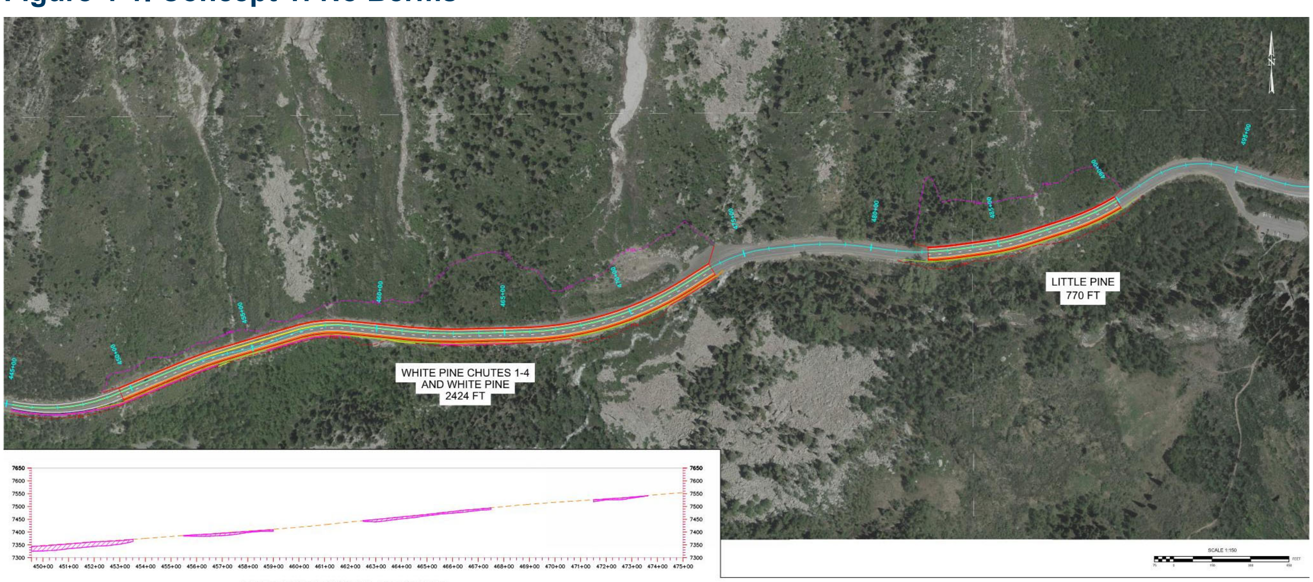
4.1 Concept 1: No Berms

This concept assumes that snow sheds are built along the existing roadway alignment, both horizontal and vertical alignments, and that no earthen avalanche-guiding berms are used to limit the length of the snow sheds. Without guiding berms, the overall length of the sheds needs to be long enough to cover enough of the avalanche run-out area to be effective.

With Concept 1, the preliminary snow shed length at White Pine results in a gap between the White Pine and White Pine Chutes 1–4 snow sheds of about 200 feet. This short distance presents several safety and driving issues. One issue is that a driver's eyes would need to adjust to the light difference as the vehicle exits one shed and enters the next. The sheds could possibly have lighting at the portals as a standard design element to minimize the "black hole effect" (the snow shed portal appearing like the entrance to a dark cave) and help with visibility, but the short transition distance might not be the safest option. For example, if vehicles are traveling at 35 miles per hour (mph), there would be a travel time of only about 4 seconds between these two sheds. Given this short distance, HDR recommends combining these two sheds into one continuous snow shed.

The length of the combined White Pine and White Pine Chutes 1–4 shed would be about 2,424 feet. The length of the Little Pine shed without berms would be about 770 feet. Figure 4-1 shows a plan view of this layout.

Figure 4-1. Concept 1: No Berms



4.2 Concept 2: Earthen Berms

This concept includes separate snow sheds for White Pine Chutes 1–4 and White Pine. Dynamic recommended using earthen guiding berms at Little Pine and White Pine as a way to reduce the required length of the snow shed and potentially reduce costs. These guiding berms would be about 300 feet long. They would be constructed up the mountain side from the tops of the shed portals and would extend along the avalanche paths to help direct avalanche flows across the tops of the sheds. The berm geometry was assumed to be 20 feet high and 10 feet wide at the top, with 1.5:1 (horizontal:vertical) side slopes. The recommended lengths of sheds with earthen berms was approximated by Dynamic and is shown in Table 3-1 above.

To allow a comparison to Concept 1, Concept 2 would also be built along the existing roadway. Figure 4-2 shows a plan view of this layout, and Figure 4-3 shows a typical cross-section of the guiding berm.

Figure 4-2. Concept 2: Earthen Berms

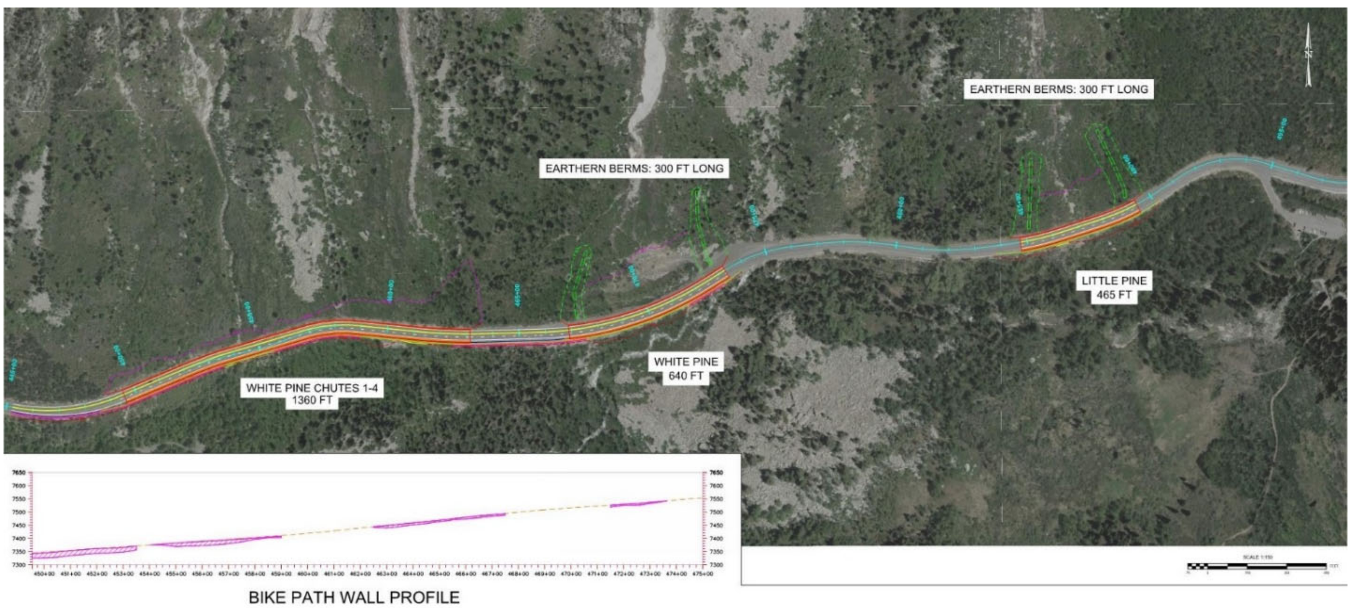
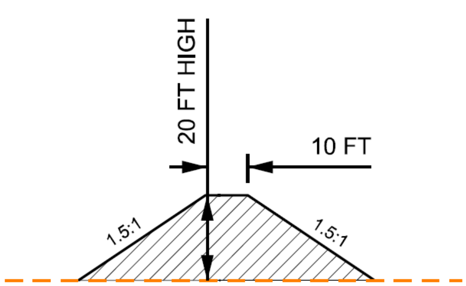


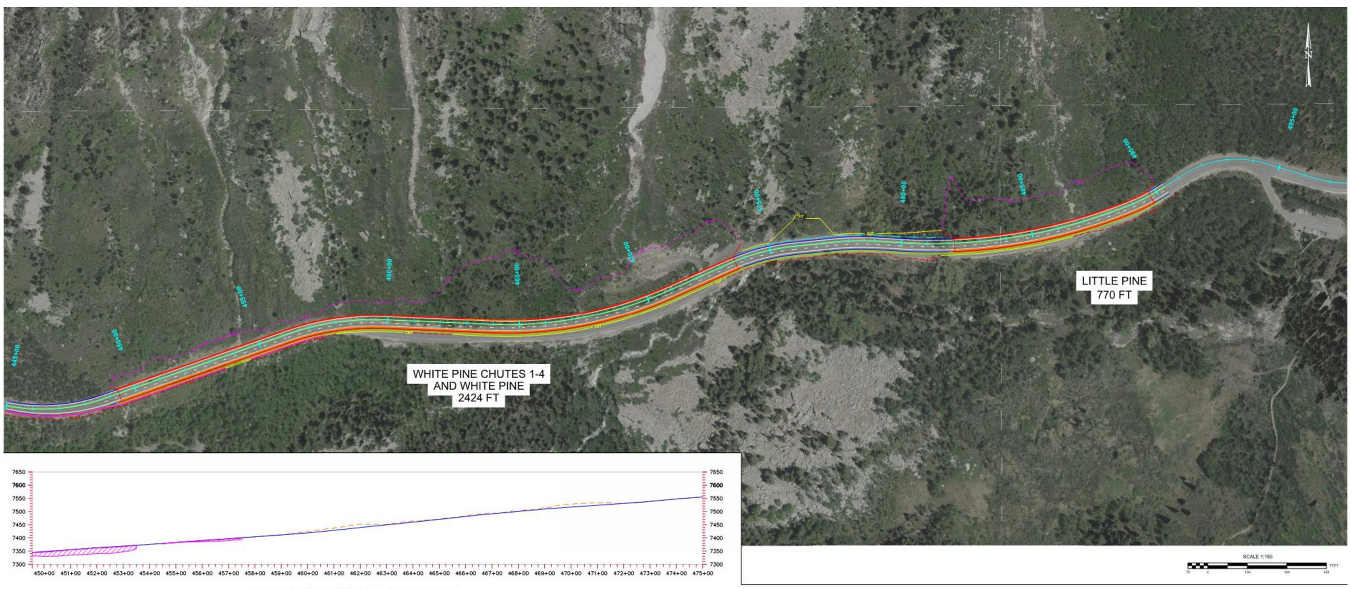
Figure 4-3. Earthen Berm Cross-section



4.3 Concept 3: No Berms, Realign Road

For this concept, HDR used the same snow shed lengths and considerations as for Concept 1 (a continuous snow shed for White Pine Chutes 1–4 and White Pine). HDR looked at realigning the existing roadway to be closer to the mountain side in order to potentially reduce the amounts of fill needed behind the snow sheds as well as to improve curve radii and sight distances inside the snow sheds. The sight distances on the existing alignment inside the sheds would be suitable for a 30-mph design speed. The realigned road with snow sheds would be suitable for a 35-mph design speed.[11] Concept 3 would, however, require UDOT to fully reconstruct the roadway cross-section and potentially relocate all utilities in the project area, including between the sheds and along the roadway leading up to the snow shed zone. Figure 4-4 shows a plan view of this layout.

Figure 4-4. Concept 3: No Berms, Realign Road



Moving the road and widening it toward the mountain side would also reduce the amount of fill or walls required on the downhill or stream side for the widened road and the bicycle lane that would be outside the sheds. The geotechnical composition and bedrock locations of the new roadway area were not evaluated.

[11] Based on AASHTO stopping sight distance requirements

4.4 Cost Estimates for Snow Shed Concepts

HDR estimated the major material quantities for snow sheds on a per-linear-foot basis and applied this unit cost to the lengths of all snow sheds per concept. We included the site-specific needs, which were a new water line from Snowbird for fire suppression and sewer and utility relocations under the sheds. We also included special design criteria features for roadway tunnels (standpipe, fire suppression, alarm, communications, and lighting systems), which were estimated based on a per-square-foot unit cost.

HDR prepared an engineer's estimate of probable bid costs, which includes estimates for the contractor's markup, administration, and mobilization. Estimates also include values for mobilization, traffic control, and maintenance of traffic. The bid estimates prepared do not include any right-of-way or inflation. HDR added contingencies and professional services (design and construction engineering, geotechnical analysis, and insurance, incentives, and stipends).

Table 4-1 summarizes the cost estimate for each of the concepts described in this memorandum. The bid cost derivation is provided as Appendix B, Bid Cost Estimate.

Table 4-1. Planning-level Cost Estimate Summary

Category	Contingencies and Markups	Snow Shed Concept (cost in $)		
		Concept 1 – No Berms	Concept 2 – Earthen Berms	Concept 3 – No Berms, Realign Road
Total bid estimate	—	65,772,696	53,327,810	63,211,016
Other items not estimated	4%	2,630,908	2,133,112	2,528,441
Subtotal		**68,403,604**	**55,460,922**	**65,739,457**
Contingency	10%	6,840,360	5,546,092	6,573,946
Construction subtotal		**75,243,964**	**61,007,015**	**72,313,402**
Environmental clearances and permits	4.0%	3,009,759	2,440,281	2,892,536
PM, geotechnical, PE, and procurement	5.0%	3,762,198	3,050,351	3,615,670
Geotechnical, and final design	3.0%	2,257,319	1,830,210	2,169,402
Construction engineering	3.0%	2,257,319	1,830,210	2,169,402
Environmental mitigation	2.0%	1,504,879	1,220,140	1,446,268
Insurance, incentives, and stipends	1.5%	1,128,659	915,105	1,084,701
Total		**89,164,098**	**72,293,312**	**85,691,382**

PE = preliminary engineering, PM = project management

A planning-level construction cost estimate for three-lane snow shed is about $23,000 to $25,000 per linear foot of structure. Adding professional services, geotechnical explorations, an allowance for environmental mitigation, and contractor insurance, incentives, and stipends at the percentages shown in Table 4-1 above, the budgetary cost estimate is $27,000 to $29,000 per linear foot of structure.

The planning-level cost estimate for Concept 1 (three-lane snow sheds without guiding berms and no roadway realignment) is about $89 million.

The planning-level cost estimate for Concepts 1 and 3 (no guiding berms but with roadway realignment) are similar. Concept 3 moves the new alignment closer to the mountainside, which decreases the amount of fill required in the flatter areas but increases the amount of roadway excavation and reconstruction work needed. Concept 3 provides improved sight distance inside the tunnels and requires fewer retaining walls on the stream side of the snow sheds for a new bicycle path. The planning-level cost estimate for Concept 3 is about $86 million.

Concept 2 (with guiding berms and no roadway alignment) has a lower planning-level cost estimate ($72 million) than either Concept 1 (no guiding berms) or Concept 3 (no guiding berms but with roadway realignment). The cost of the snow sheds and the amount of fill is driving the cost estimates. With Concept 2, the three separate snow sheds would overall be about 660 feet shorter than with either Concept 1 or Concept 3.

5.0 Design Considerations

A detailed engineering analysis would confirm or eliminate some of the following design considerations and might introduce other fire and life safety considerations.

5.1 Design Considerations for Road Tunnels

For the preliminary feasibility analysis presented in this memorandum, HDR assumed that the snow sheds are road tunnels and that the minimum requirements in NFPA 502 are applicable. The minimum requirements (provisions) are classified as (1) “mandatory requirements,” which are prefaced with the word *shall*, meaning that they are the standards, and (2) “conditionally mandatory requirements,” which are requirements, but confirmation is based on the results of an engineering analysis.[12]

The minimum requirements based on tunnel length are as follows. In the following requirements, underlining indicates the minimum provision for each length category.

- **Category X (L < 300 feet)** – Where the tunnel length (L) is less than 300 feet, an engineering analysis shall be performed for fire protection and life safety requirements, an evaluation of the protection of structural elements shall be conducted, and <u>traffic control systems</u> shall be installed.
- **Category A (L ≥ 300 feet)** – Where the tunnel length (L) is equal to or greater than 300 feet, an engineering analysis shall be performed for fire protection and life safety requirements, an evaluation of the protection of structural elements shall be conducted, and <u>traffic control systems shall be installed. In addition, a water supply and standpipe system</u> shall be installed.
- **Category B (L ≥ 800 feet)** – Where the tunnel length (L) is equal to or greater than 800 feet and the maximum distance from any point within the tunnel to a point of safety exceeds 400 feet, <u>all provisions of NFPA 502 shall apply unless noted otherwise</u>.
- **Category C (L ≥ 1,000 feet)** – Where the tunnel length (L) is equal to or greater than 1,000 feet, <u>all provisions of NFPA 502 shall apply unless noted otherwise</u>.
- **Category D (L ≥ 3,280 feet)** – Where the tunnel length (L) is equal to or greater than 3,280 feet, <u>all provisions of NFPA 502 shall apply</u>.

[12] NFPA 502, Section 3.3.39

A description of the minimum provisions of NFPA 502 is provided below. In summary, the design considerations for snow sheds in Little Cottonwood Canyon are the following:

- Traffic-control devices at the approaches to the snow sheds and within the snow sheds
- Fire-detection and alarm systems (minimum requirement is a manual system)
- Two-way communications
- A water connection to local water infrastructure
- Dry pipeline and dry standpipes in the snow sheds
- Portable fire extinguishers
- Fixed water-based fire-fighting systems
- Tunnel drainage systems
- Means of egress
- Electrical systems and emergency power

The following sections provide more information regarding these design considerations.

5.1.1 Protection of Structural Elements

Regardless of tunnel length, acceptable means shall be included within the design of the tunnel to prevent progressive collapse of primary structural elements in accordance with this standard to achieve the following functional requirements (in addition to life safety): support fire fighter accessibility, minimize economic impact, and mitigate structural damage. As part of the engineering analysis, modeling (for example, using Fire Dynamics Simulator or Computer Fluid Dynamics) of the approved design fire shall be performed to determine the protective measures needed to prevent progressive structural collapse and mitigation of structural damage.

5.1.2 Fire Alarm and Detection

Road tunnels equal to or greater than 800 feet (Category B, C, and D) shall have at least one manual means of identifying and locating a fire. This would require installing manual fire boxes at approved intervals and locations accessible to the public and tunnel personnel. Tunnels without 24-hour supervision shall include automatic fire-detection systems. Closed-circuit television systems can be used to identify and locate fires.

5.1.3 Emergency Communication Systems

Two-way radio communication enhancement systems shall be installed in new and existing tunnels and ancillary facilities where required by the authority having jurisdiction or by other applicable governing laws, codes, or standards. Inclusion of a communication system is a conditionally mandatory requirement for all tunnel lengths.

5.1.4 Tunnel Closure and Traffic Control

All road tunnels shall be provided with a means to stop approaching traffic. Road tunnels longer than 800 feet (Category B, C, and D) shall be provided with a means to stop traffic from entering the direct approaches to the tunnel, to control traffic within the tunnel, and to clear traffic downstream of the fire site following activation of a fire alarm within the tunnel. An important consideration is a means to expedite the flow of vehicles from the tunnel, downstream of the incident site, in all traffic conditions. If expeditious traffic flow is not possible, then a fixed water-based fire-fighting system shall be installed to establish a tenable environment for safe evacuation and emergency service access.[13] Also see the discussion under Fire Protection below.

5.1.5 Fire Protection

NFPA 502 groups many of its provisions under a broad fire-protection category. As described above in the introduction to Section 5.1, some of the provisions are classified as mandatory requirements and some as conditionally mandatory requirements, implementation of which are all based on the results of an engineering analysis. The minimum provisions based on the length of snow sheds are provided below.

Fire Apparatus. A fire apparatus is a piece of mobile fire-fighting equipment suitable for fighting fires within the tunnels that should be available within the general facility area to allow a rapid response to a fire emergency. Such apparatus should be equipped to deal effectively with flammable-liquid and hazardous-material fires. NFPA 502 does not mandate that an apparatus be at the tunnel site. Unified Fire Station 113 is about 1 mile from the proposed Little Pine snow shed. Therefore, HDR assumes that no additional apparatus or expanded facilities would be needed. However, the final determination would be made after a detailed analysis of the emergency response and the needs for fire and life safety systems.

Standpipe, Fire Hydrants, and Water Supply. A water supply and standpipes shall be provided in road tunnels for all lengths greater than 300 feet. A standpipe is a vertical pipe extending from a water supply main. Because the water lines would be subject to freezing conditions, and to eliminate the need to circulate the water and to install heat tracing tape and insulation, we assume that a dry standpipe system could be used. With a dry system, water is turned on at a source and shall be delivered to all hose connections in 10 minutes or less. A municipal source—Salt Lake County Service Area #3 (Canyon Water), a government water and sewer district—might be available. Canyon Water's rights are restricted to delivering water within its defined service area, which is outside the proposed snow shed area. An agreement with the Salt Lake City Department of Public Utilities would be required to deliver water to the snow sheds. Canyon Water believes it has adequate storage capacity and infrastructure to supply fire flows (1,000 gallons per minute for about 2 hours) to the snow sheds.[14] Assuming a connection near Snowbird Entry 1, a 1.75-mile-long water line would be needed to supply water to the sheds. To fill the line in 10 minutes or less, about a 4- to 6-inch water line would be required. A detailed hydraulic analysis would be required to define the fire flows, size the water main and standpipe systems (and/or sprinklers), and confirm the existing system's capacity.

Portable Fire Extinguishers. Portable fire extinguishers that are less than 20 pounds shall be placed in cabinets at intervals of not more than 300 feet.

Fixed Water-Based Fire-Fighting Systems. These systems include equipment that is permanently attached to a road tunnel that, when operated, has the intended effect of reducing the heat release and fire growth rates and is able to spread an extinguishing agent in all or part of the tunnel using a network of pipes and nozzles. These systems are conditionally mandatory in Category C (≥ 1,000 feet) and Category D (≥ 3,280 feet) tunnels. A detailed engineering analysis would need to be performed to determine the

[13] NFPA 502, Section 7.6.2(3)

[14] Terry Warner, telephone conversation with Keith Hanson of Canyon Water, August 29, 2018

effectiveness (for both fire and life safety and for structure protection) and impact on other safety measures.[15] The proposed snow shed protecting the road from the avalanche path for White Pine Chutes 1–4 would be about 1,360 feet long, which meets the length category for a conditionally mandatory provision. NFPA acknowledges that fixed water-based firefighting systems are highly regarded by fire protection professionals and fire fighters and can be effective in controlling a fuel based fire by actually limiting the spread of the fire and protecting the structure. Because we assume that all of the snow sheds would be treated as one system from the standpoint of fire detection and alarm and traffic control, for cost estimating purposes, we assume that a fixed water-based fire-fighting system would be incorporated in all snow sheds.

Emergency Ventilation. Emergency ventilation is a conditionally mandatory requirement in road tunnels longer than 800 feet. However, NFPA 502 states that emergency ventilation is not required in tunnels less than 3,280 feet long, where it can be shown by an engineering analysis that the level of safety provided by a mechanical ventilation system can be equaled or exceeded by enhancing the means of egress, the use of natural ventilation, or the use of smoke storage, and shall be permitted only where approved by the authority having jurisdiction.[16] Our initial structural analysis assumes that the snow sheds have one side (the south side) open between roof support columns to provide natural ventilation and to facilitate emergency egress from the travel lanes and the snow sheds. Therefore, we assume that the smoke and gases from a fire can be evacuated adequately, that a tenable environment can be maintained along the egress paths, and that no supplemental or emergency ventilation would be required. As mentioned in Section 5.1.1, a detailed computer model, prepared as part of the engineering analysis, would be needed to prove that a tenable environment can be achieved using natural ventilation.

Tunnel Drainage Systems. A tunnel drainage system is required, and it should be designed to capture spills of hazardous or flammable liquids so that they cannot spread or cause flame propagation.[17] The tunnel drainage system shall be provided with an oil and fuel separator and a storage capacity sufficient for the design spill rate for hazardous liquids, the size of which is a function of the size of hazardous or flammable transport vehicles. A tunnel drainage system should be considered given the proximity of Little Cottonwood Creek. The drainage and storage system can introduce additional requirements associated with hazardous locations (confined space) and require hydrocarbon detection. These items were not evaluated. For cost estimates, we assume 12-inch-diameter concrete pipe and standard catch basins.

5.1.6 Means of Egress

NFPA 502 includes egress requirements as mandatory requirements for road tunnels. NFPA 502 also cross-references the requirements of NFPA 101, *Life Safety Code*, Chapter 7, for the means of egress requirements for all road tunnels. This reference was not reviewed for this preliminary evaluation of snow sheds. The applicable egress requirements of NFPA 502 are summarized as follows: add reflective or lighted direction signs, incorporate slip-resistant surfaces, and be continuously maintained. For the preliminary analysis, we assume a snow shed cross-section that includes a barrier and a 4-foot gap between the barrier and the support columns. The gap exceeds the minimum clear pathway of 3.7 feet required by NFPA 502. From an egress perspective, if the barrier were placed adjacent to the columns or if, in the

[15] NFPA 502, Section 9.6 and Annex E

[16] NFPA 502, Section 11.1.1

[17] FHWA, *Technical Manual for Design of Road Tunnels – Civil Elements*, 2009

winter, snow fills the gap, NFPA allows the roadway tunnel surface to be considered as part of the egress pathway. The required detailed engineering analysis and emergency response planning efforts (see Section 5.3) would define the required means of egress.

5.1.7 Electrical Systems

Power is needed to support life safety operations, fire emergency operations, and normal operations, that latter of which includes communications, illuminating the signs and traffic-control devices, monitoring, and lighting the snow sheds. Lighting is an important design element to assist drivers in identifying hazards and disabled vehicles and to minimize the contrast between the portals and the interior of the snow shed. Power needs were not determined. We assume that existing power is a reliable power source (for example, the power source has not experienced any shutdowns longer than 4 continuous hours during 1 year). We also assume that the existing power line that runs under the roadway is adequate to supply power and, although the existing line might need to be relocated, UDOT would not need to install a newer, higher-capacity power cable along the length of the canyon.

5.2 Site-specific Considerations

An existing 10-inch-diameter sewer line runs near the westbound edge of the pavement through the snow shed zone. This sewer line might need to be relocated outside the snow shed footprint or outside the snow shed foundations (Little Pine to White Pine Chute 4). This sewer line might need to be relocated for a potential total distance of about 4,200 feet (assuming that the line needs to be relocated in the space between the snow sheds). Other utilities that might also need to be relocated include power and gas, the locations of which are not currently known.

5.3 Operations, Maintenance, Inspections, and Evaluation Overview

The operating requirements for the snow sheds would be defined by the level of traffic, the availability of emergency responders, and other conditions specific to the snow shed locations and their ultimate design. UDOT needs to employ the appropriate personnel to operate the tunnels safely and provide reliable levels of service.[18] Emergency response plans are required for all road tunnel lengths and shall be submitted for acceptance and approval by the authority having jurisdiction.[19] The outcome of preparing and reviewing the emergency response plan, which will include coordinating with many participating agencies, will define the required snow shed staff, their roles and qualifications, and their ongoing training needs. It will also determine whether a stand-alone operations and control center near the snow sheds is needed or whether remote monitoring is feasible.

An effective maintenance program helps reduce costs, decrease the number of tunnel closures, increase public safety, and ensure adequate levels of service.[20] Maintenance activities include routine activities such as removing snow, ice, and debris; regularly scheduled preventative maintenance such as checking portable

[18] FHWA, *Tunnel Operations, Maintenance, Inspection, and Evaluation (TOMIE) Manual*, 2015

[19] NFPA 502, Chapter 13, *Emergency Response*

[20] FHWA, *Technical Manual for Design of Road Tunnels – Civil Elements*, 2009

fire extinguishers, washing tunnel surfaces, flushing drain systems, and servicing equipment; and corrective maintenance such as repairing pavement or addressing the sudden failure of functional equipment.

FHWA developed the National Tunnel Inspection Standards; the *Tunnel Operations, Maintenance, Inspection, and Evaluation (TOMIE) Manual*; and the Specifications for National Tunnel Inventory to help safeguard tunnels and to ensure reliable levels of service on all public roads. The general requirements of these programs are as follows:[21]

- Performing regularly scheduled tunnel inspections:
  - Routine inspections every 24 months
  - In-depth inspections at a frequency determined by the program manager[22]
  - Damage inspection after a seismic event, fire, collision, avalanche, rockslide, etc.
- Maintaining tunnel records and inventories
- Submitting tunnel inventory and inspection data to FHWA
- Reporting critical findings and responding to safety and/or structural concerns
- Maintaining current load ratings on all applicable tunnel structures
- Developing and maintaining a quality control and quality assurance program
- Establishing responsibilities for the tunnel inspection organization and qualifications for tunnel inspection personnel
- Training and national certification of tunnel inspectors

A tunnel evaluation should be performed after an inspection to evaluate risks and prioritize repairs. In addition, we suggest periodically reviewing the fire and life safety engineering analysis and the emergency response plan. Lessons learned from the training exercises and drills should also be considered and plans updated accordingly.

[21] FHWA, *Technical Manual for Design of Road Tunnels – Civil Elements*, 2009

[22] The individual in charge of tunnel inspections in Utah.

Appendix A. NFPA 502

4.3.1* Regardless of the length of the facility, at a minimum, the following factors shall be considered as part of a holistic multidisciplinary engineering analysis of the fire protection and life safety requirements for the facilities covered by this standard:

(1) New facility or alteration of a facility
(2) Transportation modes using the facility
(3) Anticipated traffic mix and volume
(4) Restricted vehicle access and egress
(5) Fire emergencies ranging from minor incidents to major catastrophes
(6) Potential fire emergencies including but not limited to the following:
   (a) At one or more locations inside or on the facility
   (b) In close proximity to the facility
   (c) At facilities a long distance from emergency response facilities
(7) Exposure of emergency systems and structures to elevated temperatures
(8) Traffic congestion and control requirements during emergencies
(9) Fire protection features, including but not limited to the following:
   (a) Fire alarm and detection systems
   (b) Standpipe systems
   (c) Water-based fire-fighting systems
   (d) Ventilation systems
   (e) Emergency communications systems
   (f) Protection of structural elements
(10) Facility components, including emergency systems
(11) Evacuation and rescue requirements
(12) Emergency response time
(13) Emergency vehicle access points
(14) Emergency communications to appropriate agencies
(15) Facility location such as urban or rural (risk level and response capacity)
(16) Physical dimensions, number of traffic lanes, and roadway geometry
(17) Natural factors, including prevailing wind and pressure conditions
(18) Anticipated cargo
(19) Impact to buildings or landmarks near the facility
(20) Impacts to facility from external conditions and/or incidents
(21) Traffic operating mode (unidirectional, bidirectional, switchable, or reversible)

Appendix B. Bid Cost Estimate

18-034-ALT#1 Little Cottonw ALT #1 No berms old align Young, Stephen Archiblald 05/11/2020 1:31 PM

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
10	Mobilization	1.000	LS	5,589,251.91	5,589,251.91
20	Traffic Control	1.000	LS	727,164.53	727,164.53
30	Maintenance of Traffic	1.000	LS	321,557.17	321,557.17
40	Dust Control and Watering	9,858.000	MGAL	19.09	188,189.22
50	Borrow (Plan Quantity)	208,905.000	CY	31.13	6,503,212.65
60	Granular Borrow (Plan Quantity)	5,360.000	CY	28.08	150,508.80
70	Clearing and Grubbing	1.000	LS	71,003.22	71,003.22
90	Untreated Base Course (Plan Quantity)	4,538.000	CY	32.78	148,755.64
100	Micro-Surfacing	20,795.000	SY	12.05	250,579.75
110	HMA - 1/2 Inch	8,817.000	TON	99.95	881,259.15
130	Remove Asphalt Paving	19,388.000	SY	9.53	184,767.64
140	Pavement Marking Paint	164.000	GALL	280.06	45,929.84
150	Precast Concrete Barrier - 32 Inch (New Jersey Sha	8,500.000	LF	77.46	658,410.00
200	Concrete Drainage Structure 5 ft to 7 ft deep - CB	9.000	EA	4,588.19	41,293.71
210	Retaining Wall	18,510.000	SF	59.59	1,103,010.90
220	White Pine Chutes + White Pine	2,424.000	LF	13,785.39	33,415,785.36
230	Little Pine	770.000	LF	12,775.74	9,837,319.80
280	10" Sewer Line Relocation	3,194.000	LF	84.60	270,212.40
285	4' Manhole Standard	5.000	EA	5,720.34	28,601.70
286	4" Gas Relocation	4,200.000	LF	178.76	750,792.00
290	Electrical	4,200.000	L;F	31.70	133,140.00
300	Lighting	3,194.000	LF	55.97	178,768.18
310	Communications	4,200.000	LF	35.47	148,974.00
320	Signing	11.000	EACH	1,625.10	17,876.10
330	4" Waterline	8,450.000	LF	65.38	552,461.00
340	Fixed Water Based Suppression	151,715.000	SF	14.30	2,169,524.50
350	Fire Alarm System	151,715.000	SF	7.75	1,175,791.25
360	Water Standpipes	12.000	EA	3,147.15	37,765.80
370	Portable Fire Extinguishers and Cabinets	12.000	EA	417.11	5,005.32
380	12" Conc. Drain	3,194.000	LF	58.10	185,571.40
	Bid Total				**$65,772,482.94**

18-034-ALT#2 Little Cottnwood Canyon ALT # 2 w/berms Young, Stephen Archiblald 05/11/2020 1:36 PM

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
10	Mobilization	1.000	LS	4,978,440.26	4,978,440.26
20	Traffic Control	1.000	LS	724,988.51	724,988.51
30	Maintenance of Traffic	1.000	LS	320,594.92	320,594.92
40	Dust Control and Watering	8,859.000	MGAL	19.03	168,586.77
50	Borrow (Plan Quantity)	187,050.000	CY	31.04	5,806,032.00
60	Granular Borrow (Plan Quantity)	5,186.000	CY	28.00	145,208.00
70	Clearing and Grubbing	1.000	LS	70,790.75	70,790.75
90	Untreated Base Course (Plan Quantity)	4,388.000	CY	32.68	143,399.84
100	Micro-Surfacing	20,102.000	SY	12.01	241,425.02
110	HMA - 1/2 Inch	8,527.000	TON	99.65	849,715.55
130	Remove Asphalt Pavement	18,483.333	SY	9.51	175,776.50
140	Pavement Marking Paint	158.000	GAL	279.22	44,116.76
150	Precast Concrete Barrier - 32 Inch (New Jersey Sha	7,100.000	LF	77.23	548,333.00
200	Concrete Drainage Structure 5 ft to 7 ft deep - CB	9.000	EA	4,574.46	41,170.14
210	Retaining Wall	15,700.000	SF	59.41	932,737.00
220	White Pine Chutes	1,360.000	LF	13,744.27	18,692,207.20
230	White Pine	640.000	LF	13,743.42	8,795,788.80
240	Little Pine	465.000	LF	12,740.14	5,924,165.10
290	10" Sewer Line Relocation	2,465.000	LF	84.35	207,922.75
295	4' Manhole Standard	5.000	EA	5,703.22	28,516.10
296	4" Gas Relocation	4,200.000	LF	178.23	748,566.00
300	Electrical	4,200.000	LF	31.61	132,762.00
310	Lighting	2,465.000	LF	55.67	137,226.55
320	Communications	4,200.000	LF	35.36	148,512.00
330	Signing	11.000	EA	1,620.24	17,822.64
340	4" Water Line	8,450.000	LF	65.17	550,686.50
350	Fixed Water Based Suppression	117,088.000	SF	14.26	1,669,674.88
360	Fire Alarm System	117,088.000	SF	7.72	903,919.36
370	Water Standpipes	10.000	EA	3,136.93	31,369.30
380	Portable Fire Extinguishers and Cabinets	10.000	EA	415.86	4,158.60
390	12" Concrete Drain	2,465.000	LF	57.93	142,797.45
	Bid Total				**$53,327,410.25**

18-034-ALT#3 Little Cottnwood ALT#3 w/o berms n align Young, Stephen Archiblald 05/11/2020 2:01 PM

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
10	Mobilization	1.000	LS	5,270,952.25	5,270,952.25
20	Traffic Control	1.000	LS	724,365.83	724,365.83
30	Maintenance of Traffic	1.000	LS	320,319.56	320,319.56
40	Dust Control and Watering	6,419.000	MGAL	19.02	122,089.38
50	Borrow (Plan Quantity)	129,914.000	CY	31.01	4,028,633.14
60	Granular Borrow (Plan Quantity)	6,726.000	CY	27.97	188,126.22
70	Clearing and Grubbing	1.000	LS	70,729.94	70,729.94
80	Roadway Excavation (Plan Quantity)	12,986.000	CY	22.16	287,769.76
90	Untreated Base Course (Plan Quantity)	5,690.000	CY	32.65	185,778.50
100	Micro-Surfacing	26,065.000	SY	12.00	312,780.00
110	HMA - 1/2 Inch	11,060.000	TON	99.57	1,101,244.20
130	Remove Asphalt Pavement	23,923.000	SY	9.50	227,268.50
140	Pavement Marking Paint	204.000	GAL	278.98	56,911.92
150	Precast Concrete Barrier - 32 Inch (New Jersey Sha	7,800.000	LF	77.16	601,848.00
200	Concrete Drainage Structure 5 ft to 7 ft deep - CB	11.000	EA	4,570.53	50,275.83
210	Retaining Wall	13,145.000	SF	59.36	780,287.20
220	White Pine Chutes + White Pine	2,424.000	LF	13,732.33	33,287,167.92
230	Little Pine	770.000	LF	12,726.57	9,799,458.90
280	10" Sewer Line Relocation	4,200.000	LF	84.28	353,976.00
285	4' Manhole Standard	9.000	EA	5,698.33	51,284.97
286	4" Gas Line Relocation	4,200.000	LF	178.07	747,894.00
290	Electrical	4,200.000	LF	31.58	132,636.00
300	Lighting	3,194.000	LF	72.48	231,501.12
310	Communications	4,200.000	LF	35.33	148,386.00
320	Signing	11.000	EA	1,618.85	17,807.35
330	4" Water line	8,450.000	LF	65.12	550,264.00
340	Fixed Water Based Fire Suppression	151,715.000	SF	14.25	2,161,938.75
350	Fire Alarm System	151,715.000	SF	7.72	1,171,239.80
360	Water Standpipes	12.000	EA	3,135.14	37,621.68
370	Portable Fire Extinguishers with Cabinets	12.000	EA	415.50	4,986.00
380	12" Conctete Drain Line	3,194.000	LF	57.88	184,868.72
	Bid Total				**$63,210,411.44**