- Legislative Approval: The implementation of pricing on the canyon roads is likely to require the approval of the Utah legislature, as both SR 190 and SR 210 are designated as state highways. Within the Utah Code, Title 72 Transportation Code, Chapter 6, Part 1, Section 118, Subsection 3(a) notes that "the department or other entity may not establish or operate a tollway on an existing state highway, except as approved by the commission and the Legislature."
- Basis of Tolling: State legislation appears to require that any tolls levied on state roadways be levied for use of the roadway. As such, implementing a tolling system for the purposes of addressing congestion within a confined area, such as a ski resort area, may be forbidden under state legislation. As such, it will be important to consider the impact of the adopted tolling structure on roadway users. For example, the tolling configuration cannot have the impact of charging for access to public lands.
- Use of Revenue: State legislation places limits on how the revenues from tolling systems on state highways can be used. It appears to allow revenues to be used for roadway operations, which would include transit operations and other potential operational strategies that might be deployed in the canyons. The usage of revenues would need to be verified in the planning process.
- Authorized Tolling Entity: If tolling is pursued, an entity will have to be designated to operate the system. This entity could be the Utah Department of Transportation, but other entities (such as UTA and/or USFS) may enter into agreement with UDOT to "design, finance, acquire, construct, reconstruct, maintain, repair, operate, extend, or expand a tollway facility."

It is also likely that any new tolling system will have to conform in some way to existing toll systems operated by UDOT. The research team therefore recommends that area officials and stakeholders immediately attain consensus on the desirability of tolling and initiate a dialogue with elected state officials and UDOT regarding the processes necessary for implementation.

Memorandum

To: Mountain Accord Stakeholders

From: WSP Parsons Brinckerhoff

Date: October 28, 2016

Subject: Mountain Accord – Cottonwood Canyons
Winter 2016-2017 Transportation Solutions Plan

1.0 BACKGROUND

The purpose of this memo is to document the concepts considered and recommendations provided for the Mountain Accord project for the 2016-2017 winter season. These immediate solutions are broken into three categories: bus service improvements, bus transit priority and other solutions which, include shoulder bus lanes, bus queue jumps, event-based traffic timing plans, chain law, and avalanche control. The solutions recommended for winter 2016-2017 are intended to be immediate options that do not require major capital improvements or the National Environmental Policy Act (NEPA) process for implementation.

2.0 BUS SERVICE IMPROVEMENTS

The Utah Transit Authority (UTA) has provided Ski Bus service to regional ski resorts since 1976. Throughout the nearly 40 years of service, UTA has provided winter service that is responsive to customer and resort needs. Figure 1 below illustrates a system route map of 2015-2016 Ski Bus service into Big and Little Cottonwood Canyons. The following section details analysis of customer and resort utilization of the Ski Bus service from the 2015-2016 season. Service alternatives have been suggested to optimize the Ski Bus network and generate higher customer ridership.

As shown in Figure 1, Ski Bus service in the 2015-2016 season consists of eight routes that extend to a number of significant destinations such as downtown and the University of Utah. During the 2015-2016 season, two buses per day provided access to downtown Salt Lake City. Figure 2 illustrates the number of seats available per day between destinations, headed inbound into the Canyons. Each bus has a capacity of 40 riders, which includes both standing and seated riders.

FIGURE 1: 2015-2016 UTA Ski Bus Service Daily Inbound Capacity

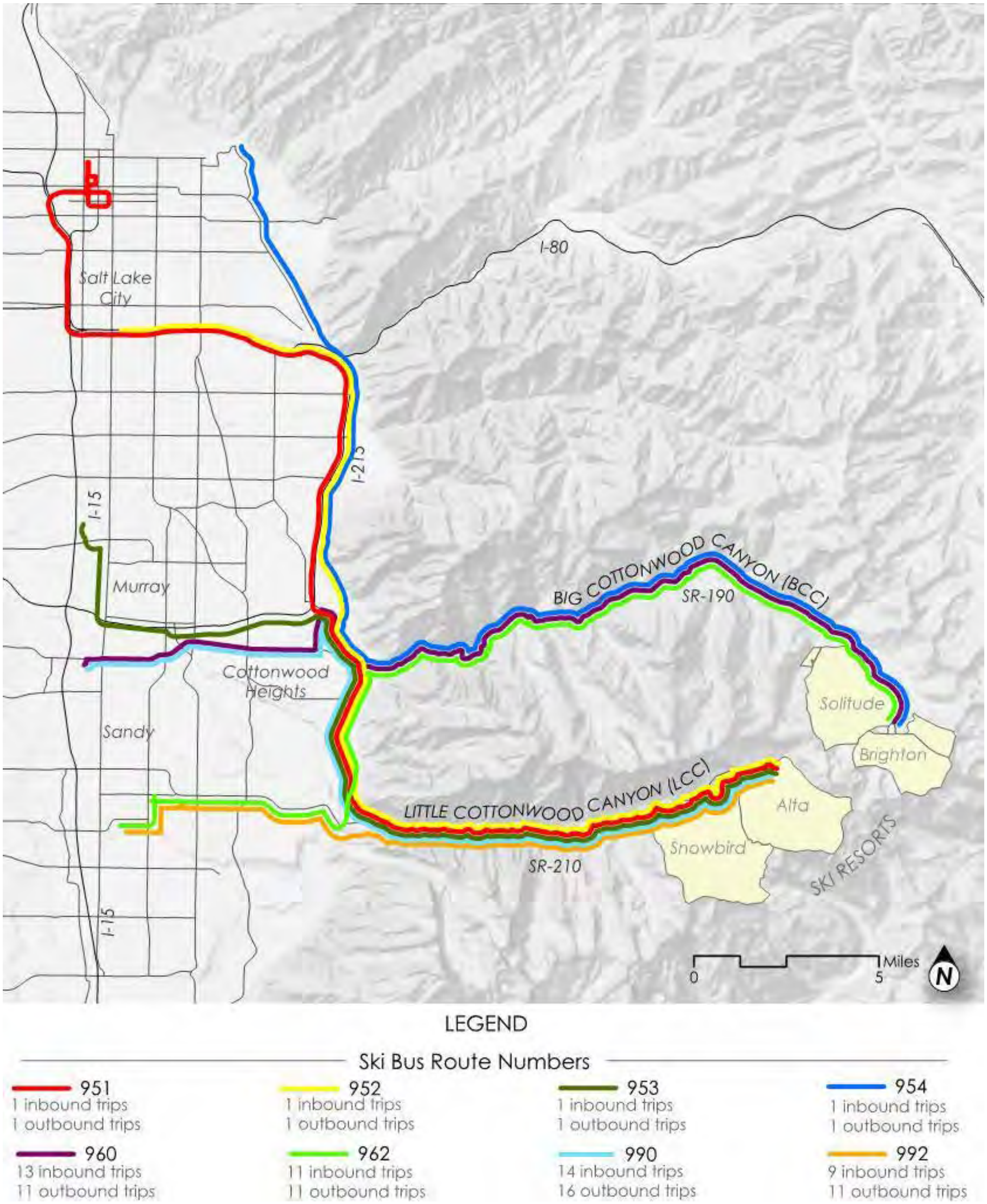
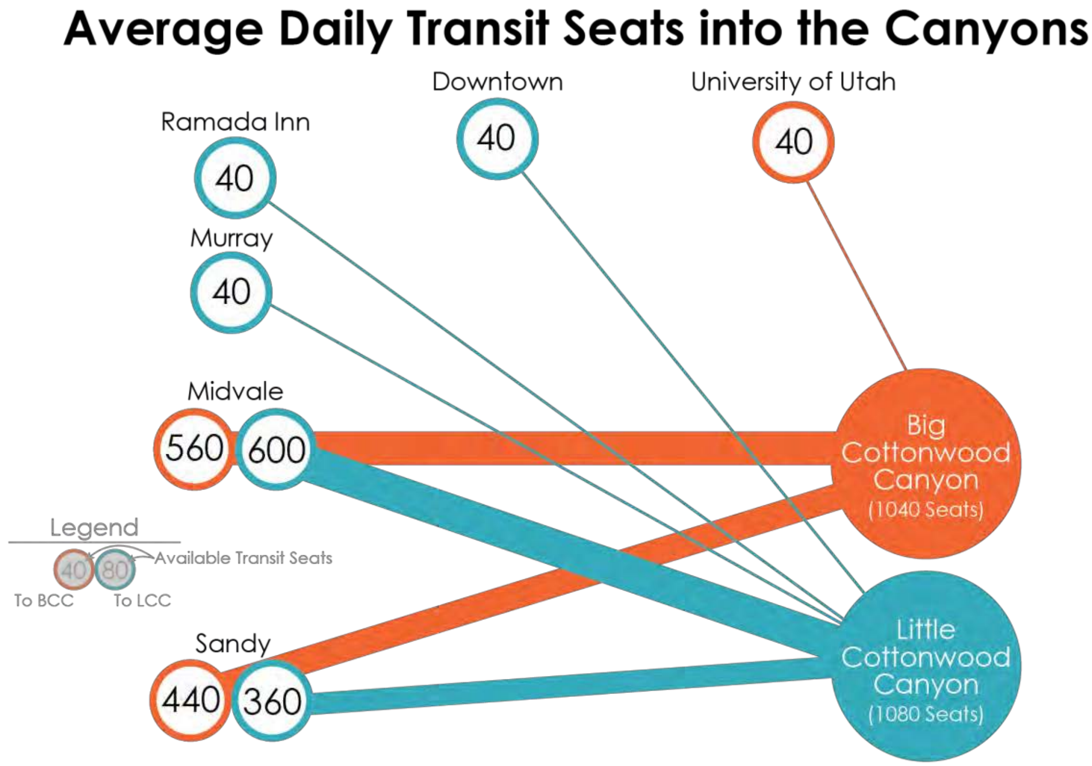


FIGURE 2: 2015-2016 UTA Ski Bus Service Daily Capacity (Inbound)



2.1 OBSERVATIONS AND FINDINGS

A significant amount of transit data was collected on Ski Bus ridership from the 2015-2016 season, which was analyzed to determine solutions for the 2016-2017 season. Additionally, discussions with stakeholders helped in highlighting challenges and needs for canyon users. The following are observations and findings from stakeholder discussions that serve as the basis for the proposed changes to Ski Bus service in the 2016-2017 winter season.

- **Overall Winter Travel Markets**
  - The four ski resorts located in the Canyons attract skiers from around the world. To gain a larger sense of the overall demand entering the Canyons on winter days, where trips originated, and the overall proportion of residents versus visitors, cell phone data was collected for the month of February 2016. A sizable percentage of visitor trips originate close to the mouth of the Canyons. However, there also exists a significant number of visitors that originate north of I-80 along I-15. These insights have informed the revision of the overall Ski Bus service – ideally capturing a greater proportion of those skiers who may otherwise drive into the Canyons.
- **Congestion in Canyons, reduce single occupant vehicles from Canyons**
  - **Parking Challenges**: one of the major transportation problems is parking shortages during heavily congested periods. On busy winter days, visitors into the Canyons can exceed 20,000 (*Source: Mountain Accord Cottonwood Canyons Transportation Framework*). Additionally, back country skiers and non-resort recreation users park on the shoulders of Canyon roadways, creating not only congestion but also road hazards as other cars and buses navigate narrow roads in wintry conditions.
  - **Additional Transit Capacity:** a primary goal is to remove vehicles from congested Canyon roads and constrained resort parking lots. These users can in turn access the Canyons by riding the optimized Ski Bus service, which will provide additional transit capacity into each Canyon.
- **Create a service that is responsive to stakeholder feedback**
  - **Ski Resorts:** staff from ski resorts in each Canyon provided data and feedback on transit use and needs. Each of the four ski resorts see the Ski Bus service as a benefit to both their customers and employees. For customers, the Ski Bus enables skiers to be dropped off, in some cases, at the base of the lift. Equally important to the resorts is employee access to transit. All four resorts provide transit passes to their employees. In addition to transit passes, some resorts supplement employee transportation options by offering vanpools and carpooling incentives. Resorts emphasized the need to have reliable transit service that allows employees to get to work early in the morning. Additionally, mid-day service is critical for the large number of part-time employees and customers who ski half a day.
  - **UTA:** due to the unique features of the vehicles, only ski buses are used for Ski Bus service during the winter season. Ski Buses include chain systems, special transmissions, and ski racks. Thus, the ability to draw from the wider fleet of available buses to enable efficiencies of operations and scheduling is not possible. To maximize the use of the existing Ski Bus fleet, a simplified operational model is preferred. The proposed model, discussed in greater detail below,

includes a fewer number of stops and routing where service is focused on park-and-ride lots outside of the Canyons and stops only at resorts inside the Canyons.

- **Create a service tailored to customer needs –** In analyzing data on boarding locations, the timing of boardings, and on what days of week the service is most used, a few patterns emerge on customers' service preferences. Greater detail will be provided below, though a few guiding principles illustrate overall customer preferences.
    - **Need for increased midday service.** It was observed that those routes with the greatest number of midday trips experienced a high number of boardings – often over-crowding conditions. As noted previously, ski resort staff are one group that utilize this service. However, families, visitors, even residents looking to go between the Valley and the Canyons in the middle of the day do not have a high number of transit options.
    - **Preference for park-and-ride lots.** Customers tend to prefer to access transit at a park-and-ride close to the mouth of each canyon. As those lots fill up, the secondary preference is to access transit via a park and ride lot adjacent to freeways. During the 2015-2016 season, Ski Bus riders were able to access nearly 2,600 parking spaces adjacent to the routes.
    - **Travel time is an impediment**. End-to-end travel time for most Ski Bus services run between 50 and 90 minutes. Ski Bus routes extending from Downtown and the University of Utah experience few boardings at either destination – most boardings occur at park-and-ride lots closer to each canyon, such as 6200 South. Eliminating stops and/or focusing service at park-and-ride lots will decrease the travel time on buses, which may help to increase ridership.
- **Create a financially constrained service –** the approximate 2015-2016 budget to operate the Ski Bus service was $1.4 million. This included the operation of 30 buses that made between 25 and 27 trips into each canyon daily. The 2015-2016 service operated between 6:30 AM to 6:00 PM.

2.2 PROPOSED SKI BUS SERVICE

The following service concept is proposed and has been put forward for public comment for the 2016-2017 Ski Bus service season. The proposed service concept provides a responsive solutions to serve the travel markets and to address the issues outlined above. Currently, UTA is working with stakeholders to implement the proposed ski bus service changes for the winter 2016-2017 season.

The proposed service consists of three bus routes, as shown in Figure 3. Route 964 originates at 7200 South and runs due east into Big Cottonwood Canyon. The route serves both Solitude and Brighton and operates between 6:30 A.M. and 6:00 P.M, providing approximately 31 trips into and 30 trips out of Big Cottonwood Canyon, including one evening bus that serves night skiers. Similarly, Route 997, originates at the 9400 South park-and-ride lot and extends east into Little Cottonwood Canyon stopping at both Snowbird and Alta. Route 997 operates the same hours and has approximately the same number of trips into and out of Little Cottonwood Canyon as Route 964. A third route would provide peak period only service from Murray Central Station into Little Cottonwood Canyon. This route would operate six buses into LCC in the morning and six out of LCC in the afternoon. These routes provide users with a simple and easily understood system. The proposed Ski Bus service headways for the 2016-2017 season are summarized below:

- 6:30 AM to 10:00 AM – Every 15 minutes
- 10:00 AM to 3:00 PM – Every 30 minutes
- 3:00 PM to 6:00 PM – Every 15 minutes

Additionally, the routing takes advantage of a number of park-and-ride lots, and would provide access to additional parking facilities. The number of available parking spaces adjacent to the proposed routes increases by over 10% as compared to the 2015-2016 Ski Bus service - to 2,890; the 6200 South park-and-ride lot is served by bus routes that operate into both of the Canyons. This park-and-ride lot is accessible to a large concentration of visitors coming from north of I-215 near I-80 that access each of the Canyons. Figure 3 below provides a map of the proposed alternative, and Figure 4 provides an overview of the seated capacity between each route's end point.

FIGURE 3: **Proposed UTA Ski Bus Service 2016-2017**

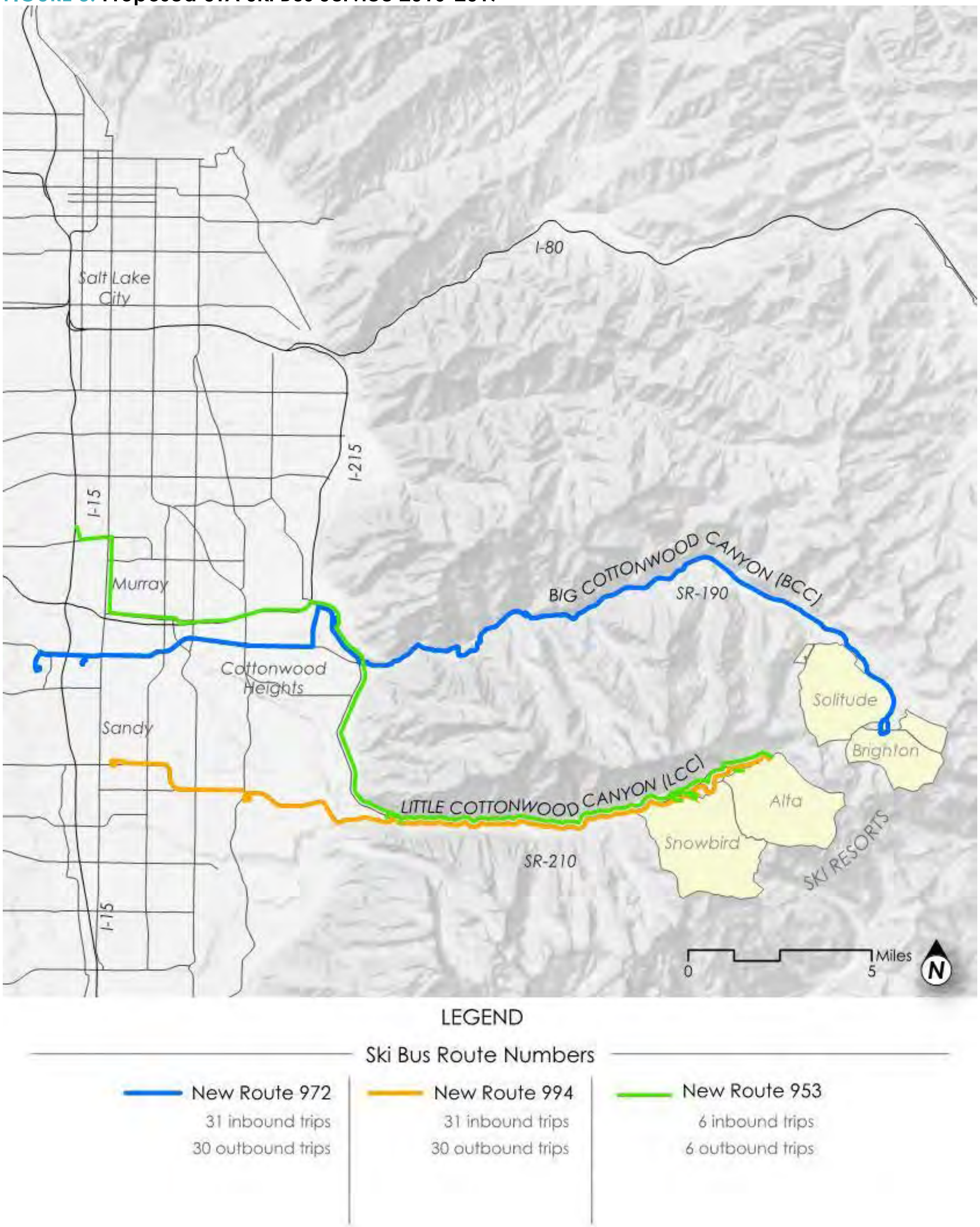
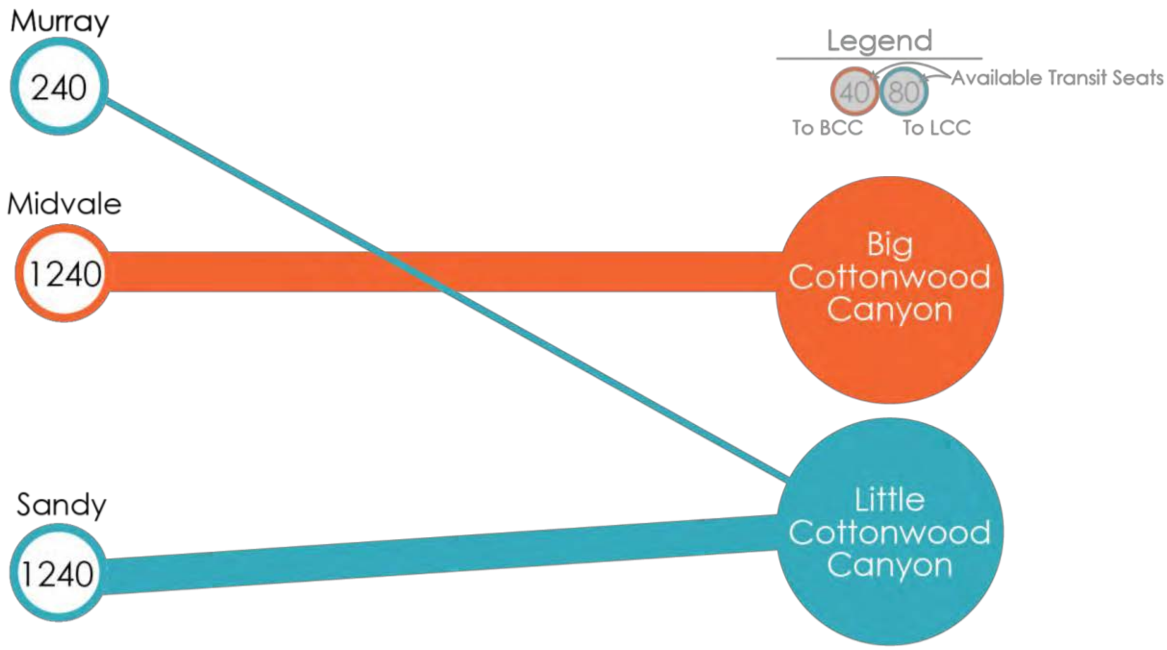


FIGURE 4: **Proposed UTA Ski Bus Service 2016-2017 Daily Capacity (Inbound)**



2.3 PROPOSED BUS SERVICE SUMMARY

The proposed Ski Bus service concept provides a revised, simplified service plan for resort patrons, employees, and residents in the Canyons. Each alternative addresses issues encountered in previous years of the service. Following is a summary of how the proposed service plan addresses those issues noted above:

- **Congestion in Canyons, remove vehicles from Canyons –** The proposed service will enable cars to be removed from the Canyons through increased transit capacity.
  - The proposed service concept provides an increase of 10% in park-and-ride lot spaces due to its connection to Murray Central Station.
- **Create a service that is responsive to stakeholder feedback**
  - **UTA:** The proposed service allows for a simplified, efficient, and easily navigated transit system for the Ski Bus service. Additionally, route simplification will create operational efficiencies for the UTA.
  - **Connection to Downtown Salt Lake City:** The 2015-2016 Ski Bus service provided one bus each way from downtown Salt Lake City, as well as one bus from just south of downtown; both buses serviced Little Cottonwood Canyon. This bus service is proposed to be discontinued in the 2016-2017 season. A connection to downtown Salt Lake City will be provided via a transfer to TRAX at the Sandy Civic Center and Midvale Fort Union. Additionally, 2016-2017 Ski Bus users will be able to transfer to the FrontRunner at the Murray Central Station. Thus, instead of two buses per day providing access to downtown, every Ski Bus will provide users the opportunity to access downtown.
- **Create a service tailored to customer needs –**
  - **Need for increased midday service –** as noted above, the proposed service concept will provide an increase in midday service over 2015-16 Ski Bus service levels. Midday service will run on 30 minute headways between 10:00 AM and 3:00 PM. During all other times, services will run on 15 minute headways.
  - **Preference for park-and-ride lots –** the proposed service concept represents a 10% increase in parking spaces that are easily accessible to the Ski Bus service.
- **Create a financially constrained service –** In the 2016-2017 season, UTA has allocated an additional $200,000 for Ski Bus service. The proposed service is estimated to stay within this proposed budget. This funding has been approved for 2016-2017 operations, but is not committed in the long-term.

ADDITIONAL SERVICE IMPROVEMENT MEASURES

In the course of of reviewing data and discussing stakeholder needs, three measures were suggested as methods that may also increase ridership but may require additional analysis to implement. These include:

1) Reducing the number of stops along each route to improve travel time.
2) Continuing one or more of either route north into Downtown. This may be limited to certain times of day.

3.0 BUS TRANSIT PRIORITY

Bus transit priority was considered as another immediate option to prioritize transit in Little Cottonwood Canyon. This section focuses on major canyon bound access routes for Little Cottonwood Canyon. These routes include Wasatch Boulevard (SR-210) and 9400 South/Little Cottonwood Canyon Road (SR-209). The solutions considered are focused on the "triangle area" at the mouth of Little Cottonwood Canyon bounded by Wasatch Boulevard, SR-210, and SR-209 (see Figure 5). These solutions were developed in collaboration with agency stakeholders of the Mountain Accord project including Salt Lake County, Salt Lake City, Sandy City, Cottonwood Heights, Utah Department of Transportation (UDOT), Utah Transit Authority (UTA), Salt Lake County Unified Police Department (UPD), and US Forest Service (USFS).

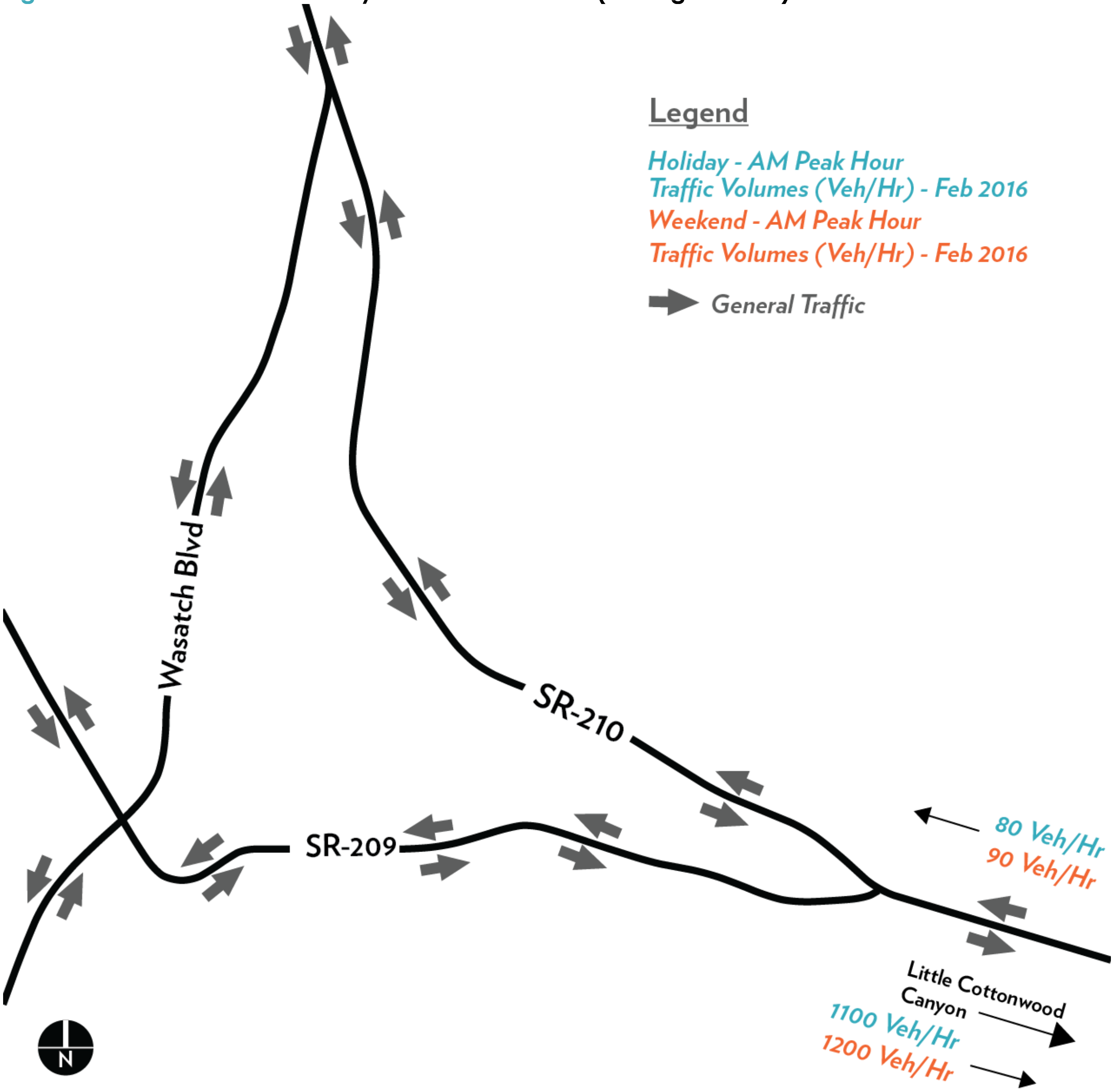
Figure 5 presents weekend and holiday morning peak hour traffic volumes for SR-210 east of the triangle area. These volumes were obtained from UDOT Automatic Traffic Recorder (ATR) station #317 located at SR-210 milepost 4.166. Weekend and holiday volumes were based on 8:00 to 9:00 am traffic volumes collected Saturday, February 6, 2016 and Monday, February 15, 2016 (Presidents Day). Turning movement counts for the triangle area were requested from agency stakeholders, including UDOT and Salt Lake County, but were not available. Approach volumes for the signalized intersections located within the triangle area were obtained through UDOT signal detector information and real time signal metrics. However, the approach volumes were found to be unreliable and therefore excluded from further consideration. The traffic volumes presented in Figure 5 were used to approximate the impacts of concepts considered.

3.1 BUS TRANSIT PRIORITY ALTERNATIVE DESCRIPTIONS

This section presents the transit priority alternatives considered for implementation. Due to the limited timeline for immediate solutions, it was recommended that these alternative do not require any capital improvements to be constructed. As such, these alternatives were considered for application on a trial pilot basis only during predetermined "bad days" expected to experience the highest levels of winter traffic congestion (see "Congestion Triggers" discussion below). This memo presents these pilot alternatives in general terms. Implementation details are not addressed in this memo. However, it is anticipated that implementation will require event-type permits and support from UDOT, public outreach and information from the Mountain Accord/Central Wasatch Commission, and traffic management and enforcement by UPD.

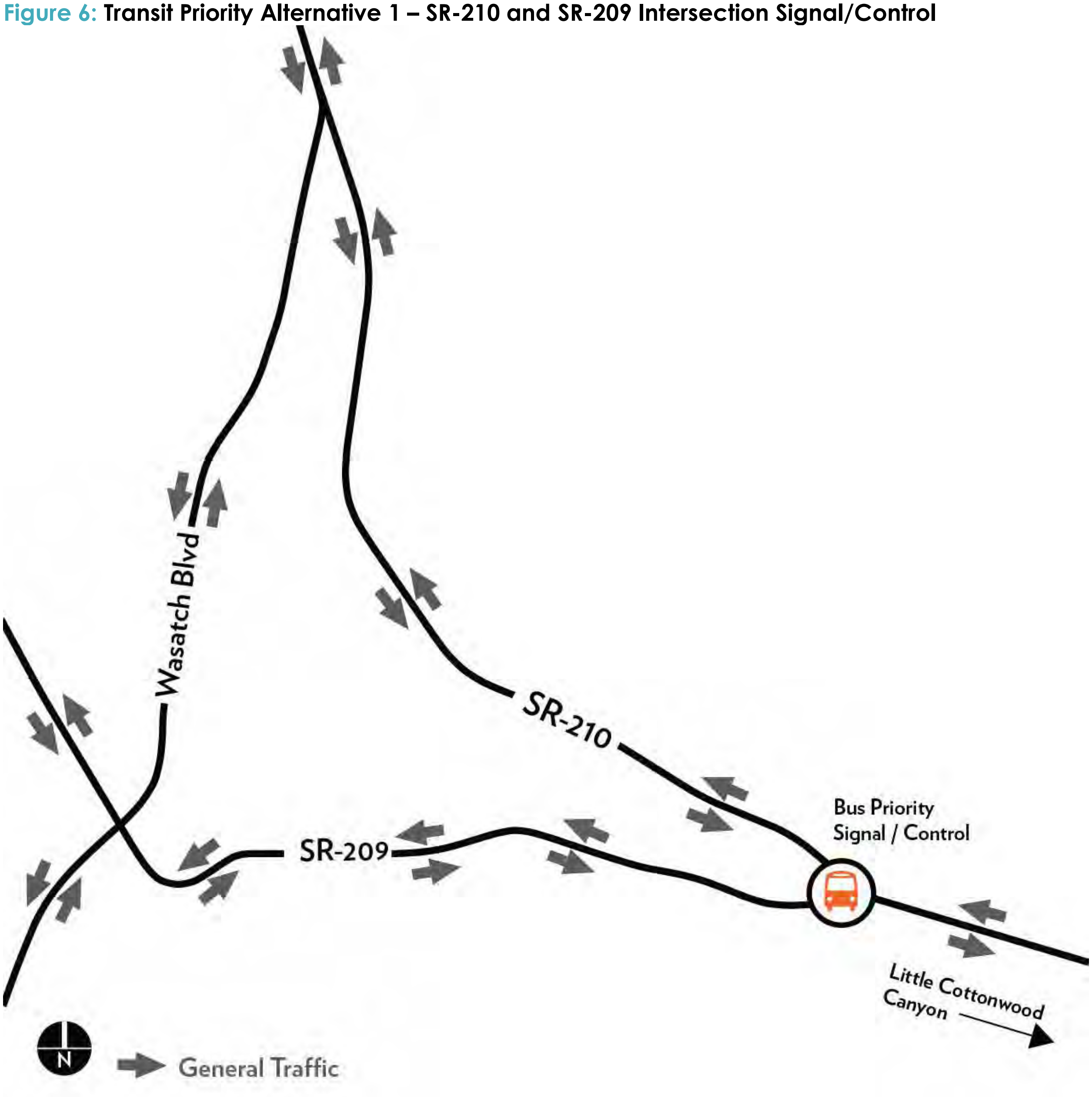
Based on discussions with the Mountain Accord Director, it was determined that implementation of bus transit priority for the winter 2016-2017 season would be unlikely. The bus transit priority alternatives created a number of operational challenges that require further traffic analysis for safe and efficient implementation. This analysis should include micro-simulation modeling (Synchro or VISSIM), which can analyze the effects of transit signal priority and contral-flow lanes. Nonetheless, the alternatives presented below provide initial concept evaluation that can be carried forth for future analysis.

Figure 5: **Little Cottonwood Canyon Access Context ("Triangle Area")**



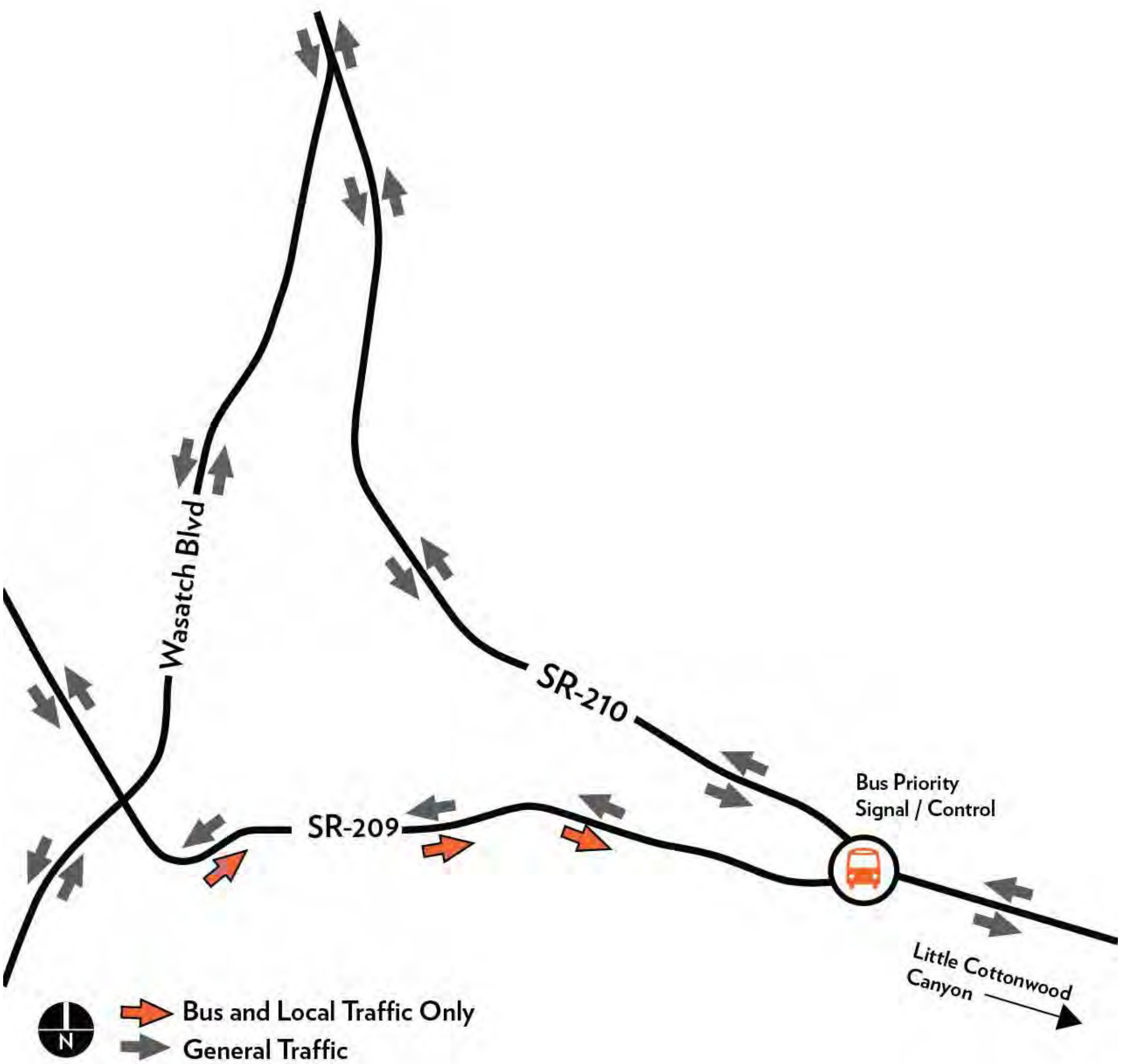
TRANSIT PRIORITY ALTERNATIVE 1: SR-210 and SR-209 Intersection Signal/Control
Alternative 1 would include a new traffic signal control (or similar temporary control) at the intersection of SR-210 and SR-209 (see Figure 6). For the short term, UPD or other enforcement may be utilized for traffic control at this location. Traffic control at the SR-210 and SR-190 intersection would be used to prioritize bus access to and from the nearby park and ride lot and to Little Cottonwood Canyon. Traffic control at this intersection (as well as the Big Cottonwood Canyon intersection) could also be used to meter and manage ("smooth") eastbound traffic for the Canyons. Alternative 1 could be implemented in conjunction with each of the other alternatives presented in this memo. UPD or other official traffic control at the SR-210 and SR-190 intersection could enforce transit use restrictions proposed by Alternatives 2 through 4.

Figure 6: Transit Priority Alternative 1 – SR-210 and SR-209 Intersection Signal/Control



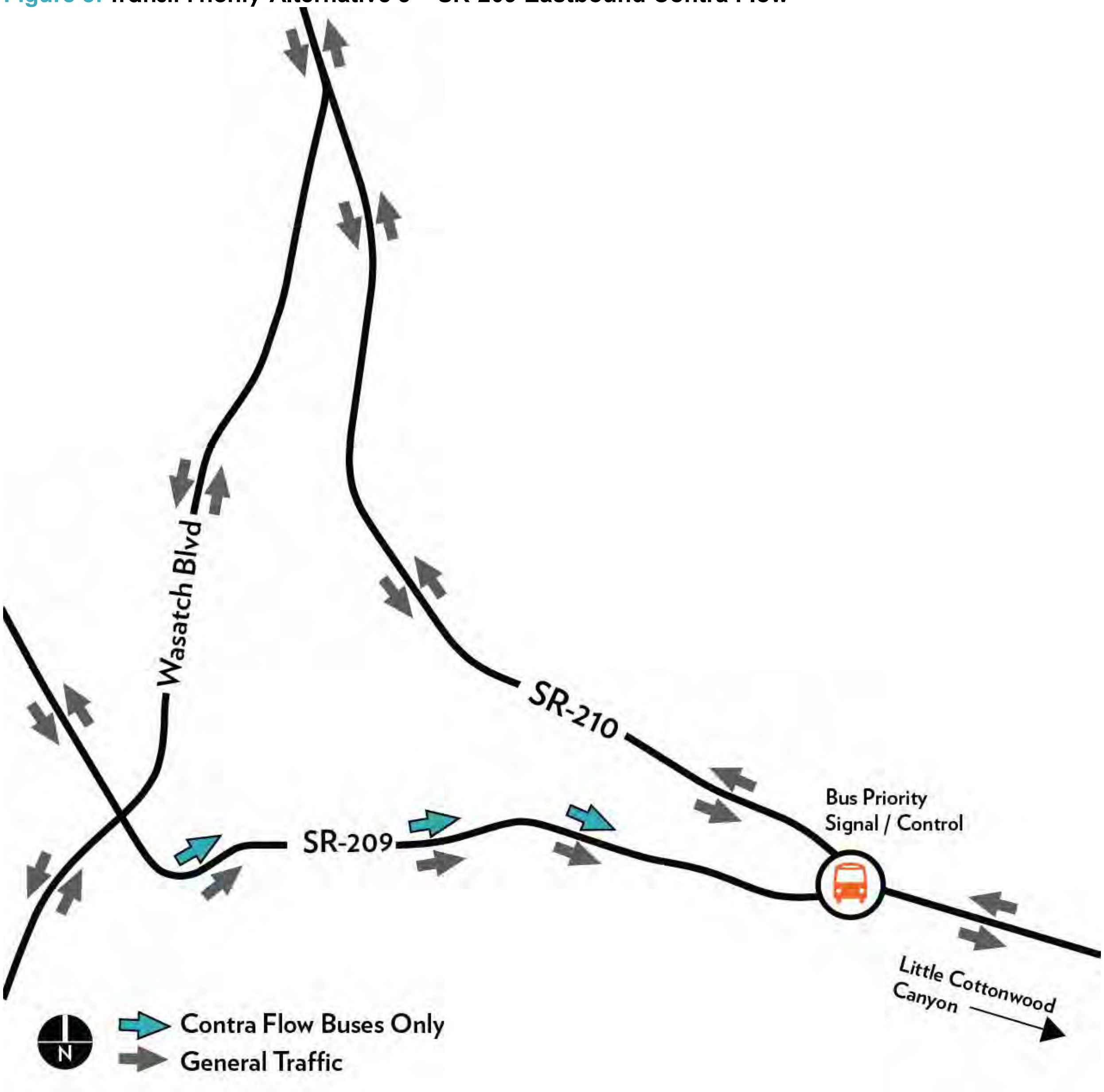
TRANSIT PRIORITY ALTERNATIVE 2: SR-209 Eastbound Buses and Local Traffic Only Restrictions
Alternative 2 would limit eastbound SR-209 traffic between Wasatch Boulevard and SR-210 to local traffic and buses only as shown in Figure 7. As with the other alternatives presented in this memo, Alternative 2 would be implemented on pre-determined, heavy-congestion weekends. Except for buses, all canyon-bound traffic would be required to use alternate routes, including Wasatch Boulevard and SR-210. Local triangle area residents could use the SR-209 eastbound lane for access to/from their residence, but would not be allowed to use this lane to access Little Cottonwood Canyon. Bus only canyon access from SR-209 could be enforced by UPD or other officials at the intersection of SR-209 and SR-210.

Figure 7: Transit Priority Alternative 2 – SR-209 Eastbound Buses and Local Traffic Only



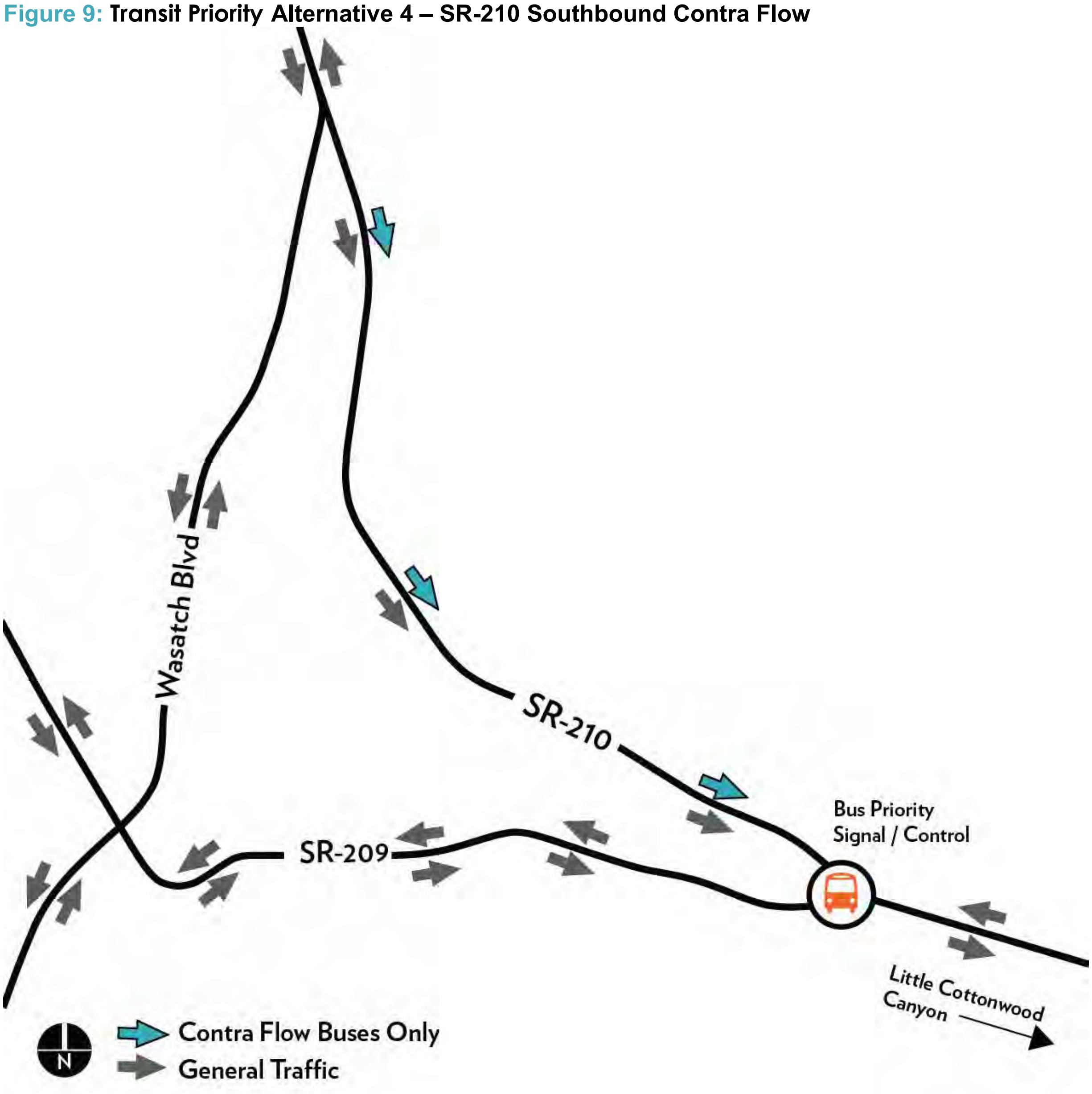
TRANSIT PRIORITY ALTERNATIVE 3: SR-209 Eastbound Contra Flow
Alternative 3 would eliminate westbound traffic for SR-209 between Wasatch Boulevard and SR-210. This westbound (left) lane of SR-209 would be restricted to eastbound (contra flow) bus and local traffic only as shown in Figure 8. As with the other alternatives presented in this memo, Alternative 3 would only be implemented during pre-determined, heavy-congestion weekends. Only buses would be allowed to access Little Cottonwood Canyon through the contra flow lane. Personal vehicles would not be allowed to use the contra flow lane to access Little Cottonwood Canyon. Local triangle area residents could use the contra flow lanes for access to/from their residence, but would not be allowed to use contra flow lanes to access Little Cottonwood Canyon. Bus only canyon access from the SR-209 contra flow lane could be enforced by UPD or other officials at the SR-209 and SR-210 intersection.

Figure 8: Transit Priority Alternative 3 – SR-209 Eastbound Contra Flow



TRANSIT PRIORITY ALTERNATIVE 4: SR-210 Southbound Contra Flow
Alternative 4 would eliminate northbound traffic for SR-210 between SR-209 and Wasatch Boulevard. This northbound (left) lane of SR-210 would be restricted to southbound (contra flow) bus and local traffic only, as shown in Figure 9. As with the other alternatives presented in this memo, Alternative 4 would only be implemented during pre-determined, heavy-congestion. Only buses would be allowed to access Little Cottonwood Canyon through the contra flow lane. Personal vehicles would not be allowed to use the contra flow lane to access Little Cottonwood Canyon, however, local triangle area residents could use the contra flow lanes for access to/from their residence. Bus only canyon access from the SR-210 contra flow lane could be enforced by UPD or other officials at the SR-209 and SR-210 intersection. As discussed previously in the Bus Service Improvements section, most buses into/out of Little Cottonwood Canyon will be routed on 9400 South for the 2016-2017 season. When Alternative 4 is in place, these buses would reroute from 9400 South onto SR-210.

Figure 9: Transit Priority Alternative 4 – SR-210 Southbound Contra Flow



3.2 CONGESTION TRIGGERS

This section considers heavily congested days ("bad days") for the most recent winter season (2015-2016 winter season) to forecast "bad" winter days. Winter roadway congestion in the Cottonwood Canyons is triggered by one or more of the following conditions:

1. **High demand** for canyon travel use, including weekends, holidays, and storm events
2. **Reduced capacity** caused by poor roadway conditions, including snow covered and icy roads
3. **Road closures** required for avalanche control and incident management

To classify bad days, roadway capacity was estimated for both Big and Little Cottonwood Canyons by comparing traffic volume and speed data collected by UDOT ATRs. For Little Cottonwood Canyon, traffic volumes were obtained from the UDOT ATR station #317 described earlier. For Big Cottonwood Canyon, data was obtained from UDOT ATR station #322, located near the mouth of the canyon at SR-190 milepost 2.460.

The days with highest daily vehicle traffic entering Big and Little Cottonwood Canyons are presented in Table 1 and Table 2, respectively. The days with highest hourly vehicle traffic entering Big and Little Cottonwood Canyons are presented in Table 3 and Table 4, respectively. Daily volumes provide a broader picture of demand in the Canyons, but peak hour volumes provide insight to the peak periods that are often problematic. In both daily and hourly volume cases, Saturdays and Sundays represent the busiest vehicle volumes. Saturdays and Sundays comprised 13 or the 15 busiest daily volume days and 10 of the 15 busiest peak hour volume days for Little Cottonwood Canyon. Winter weekends can therefore be used to approximate the busiest days for the Cottonwood Canyons.

Analysis of traffic and weather data obtained from UDOT showed that traffic in the Canyons increased significantly after a snow storm, including the day of the storm event and the two days following the storm event. Figure 10 presents traffic for the heaviest hour for days preceded by snow storm events compared to the heaviest hour for days not preceded by snow storm events. Increases in traffic volumes after snow storm events were less significant for Saturdays and Sundays when traffic volumes were high even when they were not preceded by snow storms. Despite the expected relationship between snow storms and busy days (particularly for weekdays), the uncertainty of date-specific long-term weather patterns makes snow storms an unreliable predictor for which days to apply pilot alternatives. However, the information provided in Figure 10 can be used for near-term predictions based on anticipated snow storm events.

Figure 11 presents the total number of bad days documented for the 2015-2016 winter season, including January 2016 through March 2016. The total number of bad days includes the number of weather events that may have reduced access capacity for the Cottonwood Canyons and road closures triggered by avalanche control and incident management purposes (see Mountain Accord Cottonwood Canyons Transportation Framework for additional information). In the case of the 2016 data for bad days, reduced capacity and road closures were driven by weather events and conditions. Because of the uncertainty of forecasting date-specific long-term weather events, this memo does not provide forecasts for triggering bad days based on weather conditions. Instead, the focus for dad day triggers is based on typically busy weekend conditions. However, it is important to note that these "weekend triggers" miss some of the worst congestion and delay conditions of avalanche closures.

Table 1: Highest Daily Vehicle Volumes Entering Big Cottonwood Canyon (Winter 2015-2016)

Rank	Month	Day of Week	Day of Month	Vehicle Volumes
1	January	Wednesday	9	5,231
2	February	Sunday	20	5,215
3	January	Wednesday	16	5,089
4	February	Sunday	6	5,040
5	February	Sunday	13	4,626
6	January	Thursday	31	4,588
7	January	Wednesday	23	4,550
8	December	Wednesday	30	4,525
9	January	Thursday	17	4,481
10	December	Saturday	26	4,455
11	February	Sunday	27	4,421
12	January	Thursday	10	4,331
13	December	Sunday	27	4,315
14	March	Saturday	19	4,276
15	January	Wednesday	2	4,251
16	February	Monday	21	4,228
17	March	Sunday	20	4,192
18	February	Tuesday	15	4,119
19	December	Monday	28	4,107
20	February	Monday	28	4,096

Table 2: Highest Daily Vehicle Volumes Entering Little Cottonwood Canyon (Winter 2015-2016)

Rank	Month	Day of Week	Day of Month	Vehicle Volumes
1	February	Saturday	6	6,887
2	January	Saturday	9	6,735
3	February	Saturday	20	6,714
4	January	Saturday	16	6,553
5	December	Thursday	31	6,532
6	February	Sunday	21	6,359
7	January	Sunday	31	6,257
8	February	Sunday	28	6,254
9	February	Saturday	13	6,249
10	February	Friday	19	6,232
11	January	Sunday	17	6,027
12	March	Sunday	20	5,977
13	January	Sunday	10	5,906
14	March	Saturday	19	5,902
15	January	Saturday	23	5,894
16	February	Saturday	27	5,857
17	March	Saturday	26	5,810
18	February	Sunday	7	5,802
19	January	Saturday	2	5,767
20	December	Thursday	24	5,680

Table 3: Highest Peak Hour Vehicle Volumes Entering Big Cottonwood Canyon (Winter 2015-16)

Rank	Month	Day of Week	Day of Month	Vehicle Volumes
1	January	Sunday	31	1,241
2	February	Saturday	6	1,129
3	January	Saturday	16	1,119
4	February	Saturday	20	1,105
5	December	Thursday	24	987
6	January	Saturday	23	984
7	January	Saturday	9	981
8	January	Sunday	17	960
9	February	Saturday	13	918
10	February	Sunday	21	905
11	February	Sunday	7	889
12	December	Monday	28	857
13	January	Monday	18	843
14	December	Saturday	26	838
15	February	Saturday	27	835
16	December	Tuesday	29	829
17	December	Wednesday	30	827
18	March	Monday	7	807
19	January	Sunday	10	796
20	February	Monday	15	786

Table 4: Highest Peak Hour Vehicle Volumes Entering Little Cottonwood Canyon (Winter 2015-16)

Rank	Month	Day of Week	Day of Month	Vehicle Volumes
1	February	Friday	19	1,350
2	February	Saturday	20	1,324
3	March	Tuesday	15	1,262
4	January	Saturday	23	1,259
5	February	Sunday	21	1,253
6	February	Sunday	7	1,248
7	March	Tuesday	29	1,231
8	March	Wednesday	16	1,230
9	March	Monday	7	1,214
10	January	Saturday	16	1,212
11	January	Saturday	16	1,212
12	January	Sunday	31	1,207
13	February	Saturday	6	1,193
14	January	Sunday	10	1,190
15	January	Sunday	17	1,168
16	January	Saturday	9	1,167
17	February	Sunday	28	1,156
18	January	Thursday	21	1,144
19	December	Sunday	24	1,132
20	February	Saturday	27	1,113

Figure 10: **Little Cottonwood Canyon Peak Hour Traffic after Snow Event (Winter 2016)**

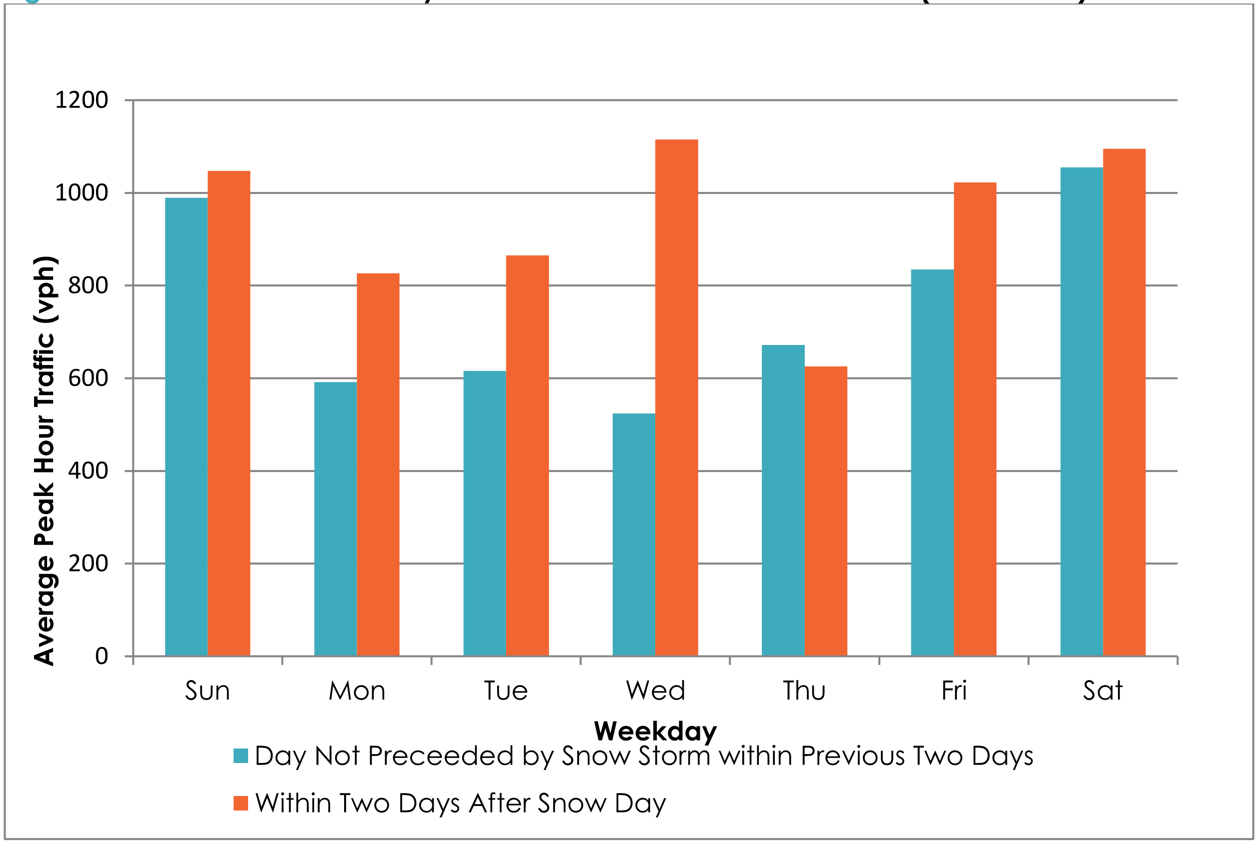
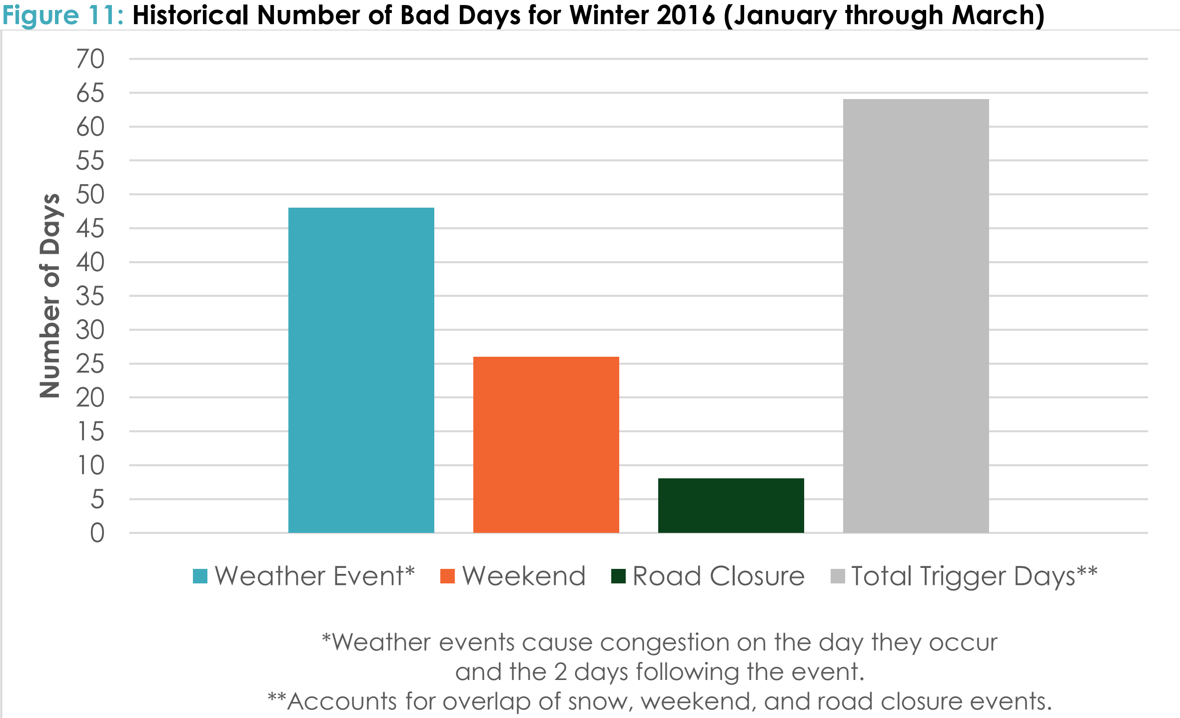


Figure 11: **Historical Number of Bad Days for Winter 2016 (January through March)**



3.3 TRANSIT PRIORITY ALTERNATIVES ASSESSMENT

This section presents the results for the assessment of the alternatives presented in Figures 6 through 9. This assessment presents technical-based conclusions and recommendations and only considers high-level vetting feedback provided by participating agencies, including Salt Lake City, Sandy City, Cottonwood Heights, UPD, USFS, UDOT, and UTA.

Transit Priority Alternative 1 Assessment: SR-210 and SR-209 Intersection Signal/Control

Currently, the intersection of SR-209 and SR-210 is stop-controlled on Little Cottonwood Canyon Road (SR-209). Signalizing this intersection would allow canyon-bound traffic to be metered to facilitate smooth and safe movement of vehicles up the Canyons. Additionally, the traffic signal would allow for prioritization of buses. This alternative has limited or no impacts to local triangle area traffic and is therefore recommended for further consideration and possible implementation in the near future. However, intersection improvements may impact adjacent properties, including the property located west of the intersection. Immediatelly west of the intersection, the right-of-way is owned by USFS and the adjacent property to the west is owned by a private homeowner. To prevent flooding, this private property owner has added landscape features within its adjacent USFS property. As such, any modifications to this intersection, including intersection widening and signalization, should consider design impacts and potential flooding to the west of the intersection.

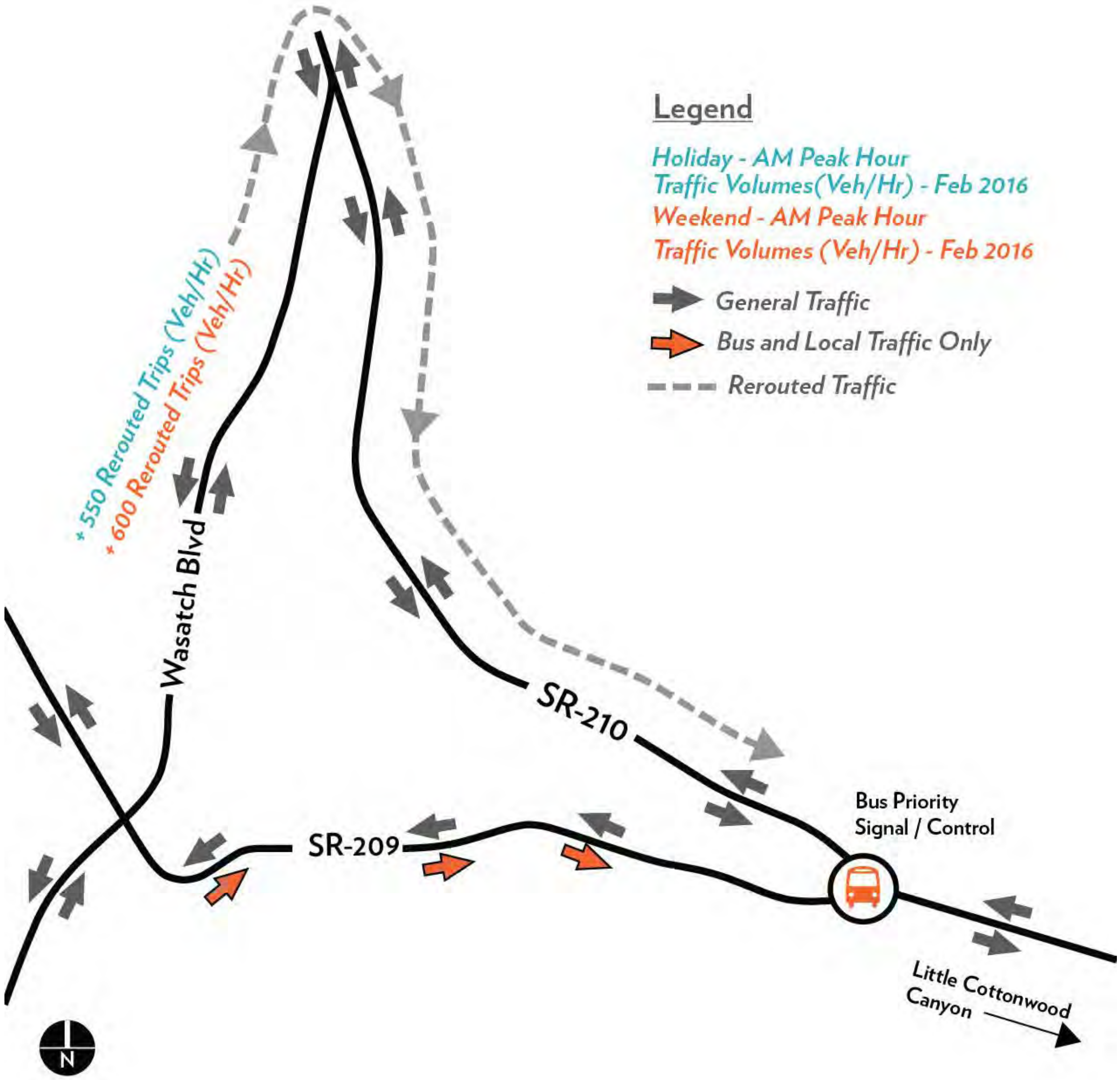
Transit Priority Alternative 2 Assessment: SR-209 Eastbound Buses and Local Traffic Only Restriction

Because Alternative 2 allows triangle area residents to use the eastbound SR-209 traffic lane for local access, it would only impact through eastbound traffic using SR-209 to access Little Cottonwood Canyon. Figure 12 presents the approximate number of morning peak hour vehicles that would be required to reroute through Wasatch Boulevard and SR-210 to access the canyon. Because of the limited availability of winter traffic data for the triangle area roadways, the rerouted traffic volume was assumed to comprise half of the overall canyon bound traffic measured at the Little Cottonwood Canyon ATR station located east of the triangle area. Compared to the other alternatives considered, Alternative 2 impacts the greatest number of vehicles. It is also expected to more negatively impact trips originating from south Salt Lake County, including Sandy and Draper, compared to trips originating from central and northern Salt Lake County.

During summer 2017, UDOT plans to construct a High-T intersection at SR-210 and Wasatch Boulevard, as described below in the Short Term Planned Projects section. The High-T intersection is expected to improve traffic operations and flow of traffic by accommodating left turns into/out-of Wasatch Boulevard. In the case of Alternative 2, it may be helpful to consider retiming the traffic signal at SR-210 and Wasatch Boulevard to better accommodate rerouted traffic during busy weekend.

In terms of bus routing, Alternative 2 favors the proposed 2016-2017 Bus Service Improvements. While a majority of buses accessing Little Cottonwood Canyon use 9400 South, there are six buses which use SR-210, originating from Murray. These buses would need to be rerouted onto 9400 South using Wasatch Boulevard. Alternative 2 impacts the greatest number of vehicles with an unquantified benefit for transit service. As such, Alternative 2 should not be considered further for implementation until an analysis can be completed to justify the additional impact to vehicles traveling up the canyon.

Figure 12: **Transit Priority Alternative 2 Assessment – SR-209 Eastbound Buses and Local Traffic Only**



Transit Priority Alternative 3 Assessment: SR-209 Eastbound Contra Flow

Because Alternative 3 restricts the use of the westbound SR-209 lane for eastbound contra-flow traffic only, it primarily impacts traffic for triangle area residents with direct access to and from SR-209. Closure of westbound SR-209 movements would require some local triangle area traffic to be rerouted. Alternative 3 would also impact the portion of low-volume outbound canyon traffic which uses SR-209 for westbound travel during the morning peak period. Figure 13 presents the estimated morning peak hour volumes impacted by Alternative 3.

Because of the limited availability of winter traffic data for the triangle area roadways, the local rerouted resident traffic was calculated based on estimated morning trips generated by triangle area residents with direct access to and from SR-209. Trip generation assumed approximately 150 homes accessible through the triangle segment of SR-209 and was calculated using Institute of Transportation Engineers (ITE) trip generation rates (ITE Trip Generation Manual, 9th Edition). Conservatively assuming that about 80 percent of home-based trips typically use westbound SR-209, this estimate resulted in rerouting of approximately 60 local triangle area peak morning hour trips (based on weekend/Saturday pattern estimates).

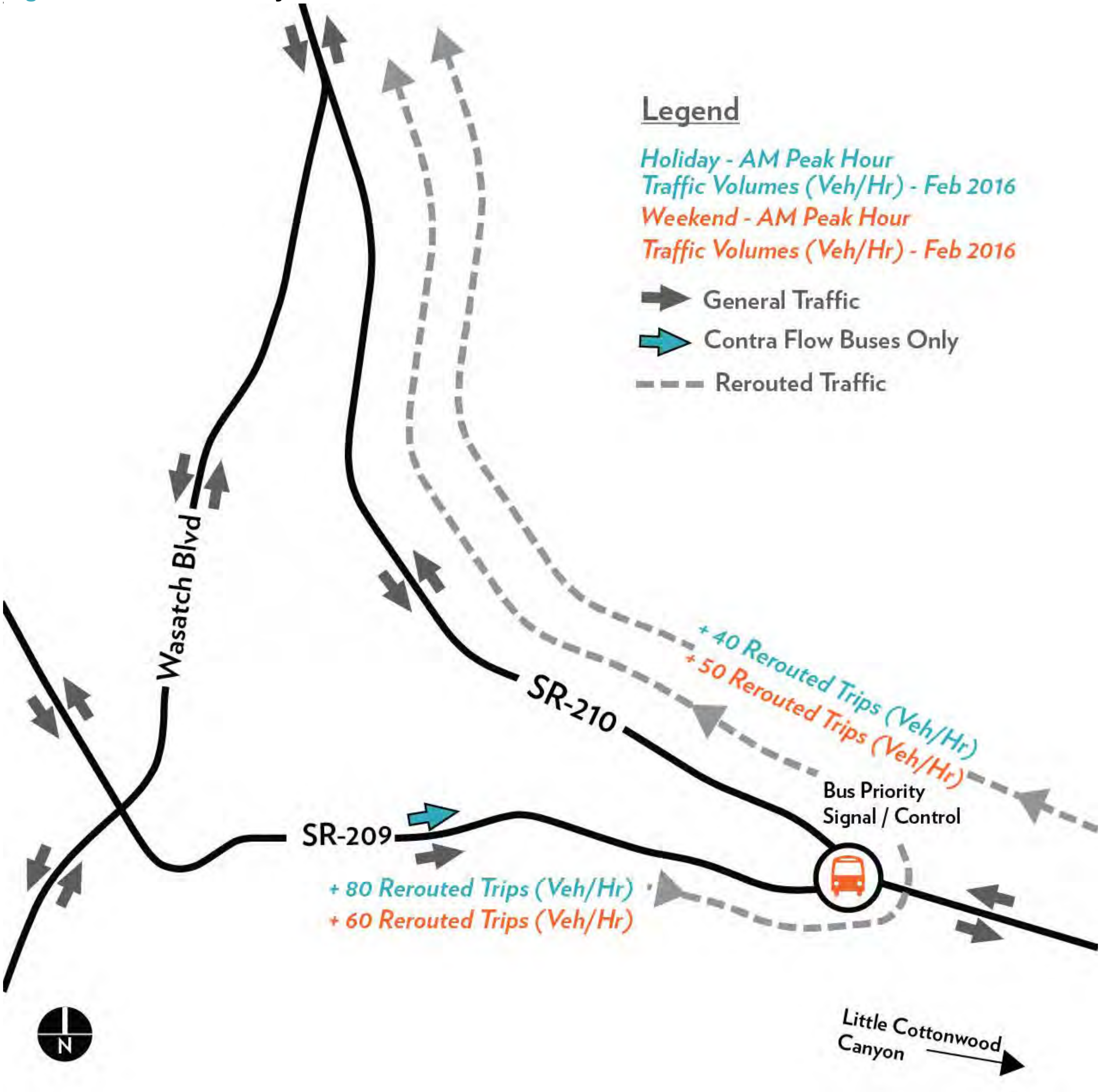
Assuming half of the westbound (outbound) morning peak hour traffic for Little Cottonwood Canyon use SR-209, an additional approximately 40 to 50 morning trips would have to be routed through SR-210. To access southern or western Salt Lake County destinations, these trips would have to turn left or turn around at or north of Wasatch Boulevard. Rerouted local triangle area traffic bound for southern or western Salt Lake County would need to make similar left turn or U-turn movements. However, it should be noted that currently, northbound left turns on SR-210 are not allowed at the intersection on Wasatch Boulevard.

In regards to transit, Alternative 3 favors the previously proposed 2016-2017 Bus Service Alternatives. Although most buses accessing Little Cottonwood Canyon use 9400 South, there are six buses originating from Murray which would use SR-210. These six buses would need to be rerouted onto 9400 South from Wasatch Boulevard.

In addition to effectively rerouting local and canyon traffic, Alternative 3 would require measures to ensure local triangle area traffic does not use the temporaty contra-flow lane for the typical opposing direction of travel. Between Wasatch Boulevard and SR-210, SR-209 provides multiple unique and single-point accesses for approximately 150 residential units. These accesses represent potential conflict points where residents could access the temporary eastbound contra flow lane for opposing westbound movements. As such, potential implementation of Alternative 3 must include careful and effective signing, education, and enforcement measures to eliminate the potential for hazardous conflicts between contra flow bus use and local triangle area traffic. To avoid conflicts with non-triangle area traffic, effective control and enforcement would also be required at the intersection of SR-209 and SR-210.

In comparison to Alternative 2, Alternative 3 impacts fewer vehicles and favors the proposed alternatives for transit service. However, with a contra-flow operation, this may raise operational challenges and require a higher level of traffic enforcement. As with Alternative 2, Alternative 3 does not have a quantified benefit to justify the additional expense of contral flow traffic control and the potential hazard of local traffic conflicts with contral flow bus use. As such, Alternative 3 should not be considered further for implementation.

Figure 13: **Transit Priority Alternative 3 Assessment – SR-209 Eastbound Contra Flow**



Transit Priority Alternative 4 Assessment: SR-210 Southbound Contra Flow

Because Alternative 4 restricts the use of the northbound SR-210 lane for southbound contra-flow traffic only, it primarily impacts traffic for triangle area residents with direct access to and from SR-210 between Wasatch Boulevard and SR-209 (particularly near the mouth of Little Cottonwood Canyon). Closure of northbound SR-210 movements would require some local triangle area traffic to be rerouted. Alternative 4 would also impact the portion of low-volume outbound canyon traffic which typically uses SR-210 for northbound travel during the morning peak period. Figure 14 presents the estimated morning peak hour volumes impacted by Alternative 4.

In terms of transit, Alternative 4 may have the most conflicts with the previously presented winter 2016-2017 Bus Service Improvements. With the proposed bus service, six buses from Murray will use SR-210 to access Little Cottonwood Canyon, while all other buses are routed through 9400 South and SR-209. Therefore, most bus service will need to be rerouted. This may raise challenges for operations, particularly at the intersection of SR-210 and Wasatch Boulevard, where rerouted buses would need to make a sharp northbound right-turn onto SR-210. While this intersection is currently planned to be redesigned as a High-T intersection (see Short Term Planned Projects section), bus operations and turning movements would need to be evaluated.

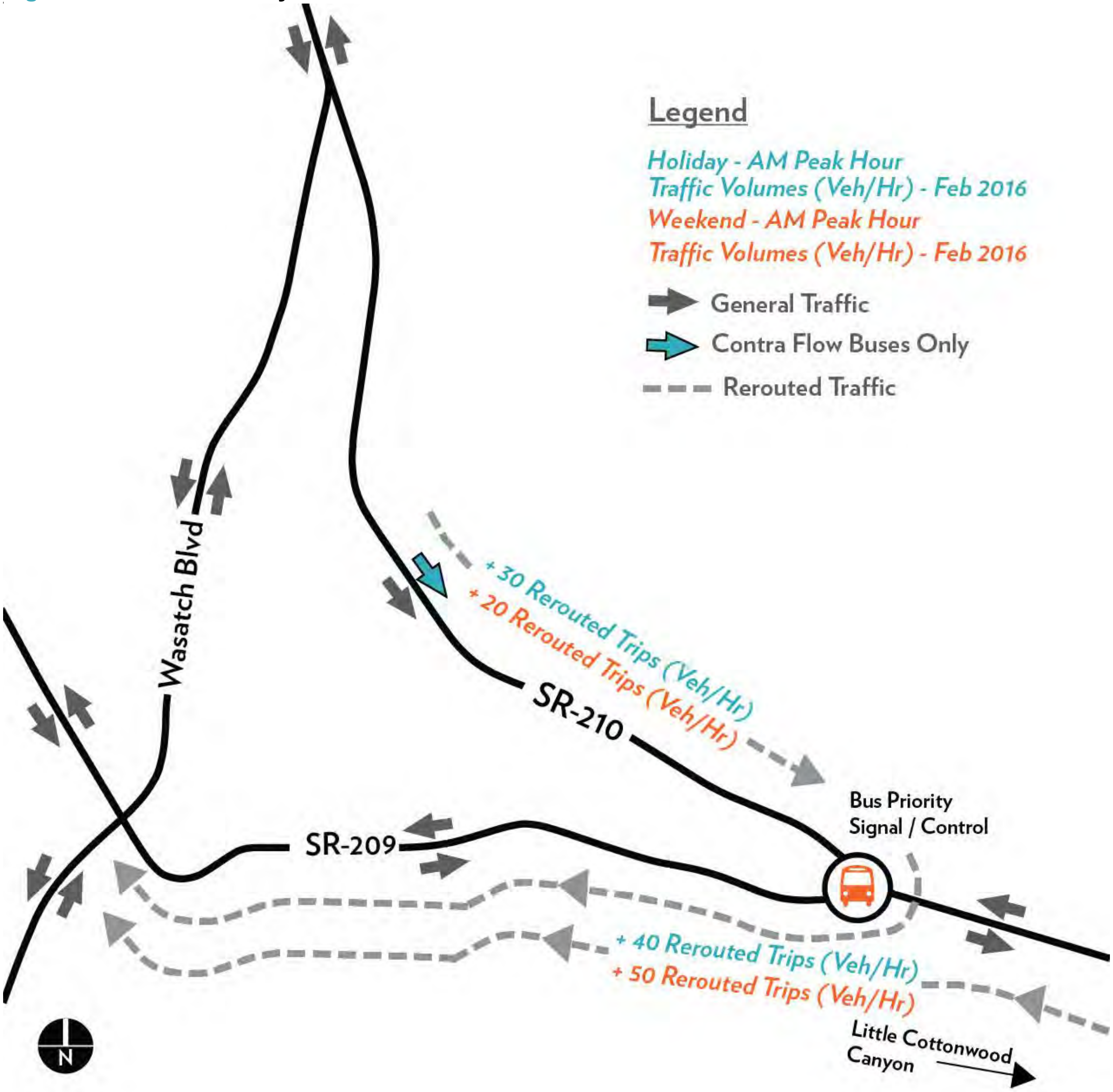
Because of the limited availability of winter traffic data for the triangle area roadways, the local rerouted resident traffic was calculated based on estimated morning trips generated by triangle area residents with direct access to and from SR-210. Trip generation assumed approximately 40 homes accessible through the triangle segment of SR-210 and was calculated using ITE trip generation rates (ITE Trip Generation Manual, 9th Edition).

Conservatively assuming that about 80 percent of home-based trips typically use northbound SR-210, this estimate resulted in rerouting of approximately 20 local triangle area peak morning hour trips (based on weekend/Saturday pattern estimates). Note that the number of homes assumed for this estimate do not include homes accessible from SR-210 via Alpen Way located in the northern portion of the triangle area. For Alternative 4, the Alpen Way access to SR-210 would be closed and nearby residents would be required to use other SR-210 access points, such as Golden Hills Avenue or Kings Hill Drive. Assuming half of the westbound (outbound) morning peak hour traffic for Little Cottonwood Canyon use SR-210, an additional approximately 40 to 50 morning trips would have to be routed through SR-209.

In addition to effectively rerouting local and canyon traffic, Alternative 4 would require measures to ensure local triangle area traffic does not use the temporary contra-flow lane for the typical opposing direction of travel. Between Wasatch Boulevard and SR-209, SR-210 provides multiple unique and single point accesses for approximately 40 residential units. These accesses represent potential conflict points where residents could access the temporary eastbound contra flow lane for opposing westbound movements. Although the conflict access points for Alternative 4 are considerably lower than for Alternative 3, potential implementation of Alternative 4 must include careful and effective signing, educational, and enforcement measures to eliminate the potential for hazardous conflicts between contra flow bus use and local triangle area traffic. To avoid conflicts with non-triangle area traffic, effective control and enforcement would also be required at the intersection of SR-209 and SR-210.

In comparison with Alternative 2 and 3, Althernative 4 has lower traffic rerouting impacts and a lower number of residential access points requiring control. However, due to the number of buses that would need to be rerouted per the proposed bus service alternatives, Alternative 4 is less favorable than Alternatives 2 and 3. Therefore, Alternative 4 is not recommended for further consideration.

Figure 14: Transit Priority Alternative 4 Assessment – SR-210 Southbound Contra Flow



4.0 OTHER CONCEPTS CONSIDERED

The following concepts were also considered for immediate transportation solutions. While some of these concepts may be implemented with the immediate solutions, others may need to be reconsidered further for implemention in the mid- to long-term. Similar to other solutions already presented, these concepts do not require major capital improvements or the NEPA process for implementation.

SHOULDER BUS LANES

Shoulder bus lanes were considered as a potential approach to allow buses to bypass traffic congestion along key transit access routes for Little Cottonwood Canyon, namely SR-210 and 9400 South/Little Cottonwood Canyon Road. UDOT shoulder information and aerial photography were reviewed to assess the viability of using existing SR-210 and 9400 South shoulders to accommodate bus traffic. Data for roadway shoulder width was obtained from the UDOT Data Portal, where a KML file was used to obtain roadway characteristics.

The existing shoulder widths were reviewed for SR-210 between the mouth of Little and Big Cottonwood Canyons. Existing shoulder widths were also reviewed for 9400 South/Little Cottonwood Canyon Road between the Mouth of Little Cottonwood Canyon and 2000 East. This review showed that the existing shoulders for the key transit access routes for Little Cottonwood Canyon cannot accommodate bus running without widening improvements. Therefore, this concept was deemed ineffective for the winter 2016-2017 season. For the mid- and long-range solutions, if roadway improvements can provide adequate shoulder width for buses, this concept may be revisited.

BUS QUEUE JUMP

Although queue jump signal priority can provide bus transit benefits for corridors constrained by the limited capacity of signalized intersections, the heavy delays for access roads to Little Cottonwood Canyon are not typically created by traffic signal delays. Providing bus queue jump at signals would likely result in minimal benefits to the overall transit travel time. As such, the applicability and benefit of bus queue jump lanes were assessed to be an ineffective solution.

EVENT-BASED TRAFFIC TIMING PLANS

Event-based signal timing plans can help minimize overall delays by “flushing” the preferred movements, such as the heavy outbound traffic from Little Cottonwood Canyon in the afternoon peak on bad days. Currently, the signals in the triangle area have some special event timing plans available for ski days. UDOT signal #7826, located at SR-209/Wasatch Boulevard, runs on free but uses alternate maximum times. UDOT signal #7827, located at SR-210/Wasatch Boulevard, runs on special coordination patterns during winter weekends and holidays. These signals also have the option to use plans with higher cycle lengths that can be run manually by an operator in the UDOT Traffic Operations Center (TOC).

Although existing event-based traffic timing plans are already in-place, with the coversion of SR-210/Wasatch Boulevard into a High-T intersection (see Short-Term Planned Project section), it may be worth reevaluating traffic signal timing plans for future seasons. Signal retiming is one of the more cost-effective options to improving traffic flow, as it does not require additional capital improvements or infrastructure.

CHAIN LAW
During inclement weather, hazardous road conditions may require vehicles to have snow tires or chains. UDOT requires that between October 1st and April 30th, motorists traveling on SR-190 and SR-210 must carry steel link chains or have mounted snow tires. Although there are existing chain-up areas in the Canyons, these locations are not convenient or well signed. As drivers stop roadside to attach chains, this can impact traffic operations and slow the progression of vehicles up the Canyons. Furthermore, if a vehicle does not have snow tires or chains attached, the slippery roads can lead to further delays.

For the winter 2016-2017 seasons, it is recommended that additional signage be added to provide more advanced warning of chain requirements and chain-up locations. As shown in Figure 15, existing signs warn drivers of required chains at the mouth of Little Cottonwood Canyon. Additional signage, such as static sigs and VMS signs, should be placed on roadways leading up to the mouth of the canyon. A portable VMS could be placed on eastbound 9400 South, warning drivers of chain laws in-place and providing locations of chain-up stations or park-and-rides.

The location of chain-up stations should be reassessed for winter 2016-2017. In addition to improved signage, the location may not be the most convenient or intuitive. By reevaluating the need to improve and add chain-up areas, this may help accommodate commercial vehicles that need to apply chains and reduce the overall delay during winter weather. One potential location for an additional park-and-ride and/or chain-up station is the northwest corner of SR-209/Wasatch Boulevard. UDOT currently owns this lot; it could potentially be paved and signed to accommodate additional traffic before the mouth of the canyon.

Additionally, driver education programs can help to educate and inform the public about the proper equipment necessary for driving in the Canyons during winter weather. These programs can allow motorists to make more informed decisions and be aware of the necessary chains or snow tires required, reducing the likelihood of slipping on roadways and the need to turn around half-way up the canyon.

Figure 15: Existing Chain Law Alert at Mouth of Little Cottonwood Canyon

(Source: Google Street View)

AVALANCHE CONTROL

The UDOT Avalanche Safety Office works to gather critical weather data, evaluate current snowpack, and monitor avalanche activity. In order to test snowpack stability and reduce avalanche hazards, military artillery has been used to reach inaccessible avalanche starting zones. As shown in Figure 16, artillery cannons are fired to release loose snow, preventing the likelihood of a natural avalanche occurring. Currently, avalanche control is done in a single phase. To ensure safety, road closures are in place during firing for avalanche mitigation.

One potential solution is to consider staging avalanche control and progressing traffic up the canyon as shooting begins at lower stages and moves up. This creates more roadway storage and will help mitigate congestion caused by avalanche control. UDOT has been studying this issue and started to implement some of the recommendations from the *Little Cottonwood Canyon Avalanche Safety Improvement Plan*, completed in June of 2016. This should have a positive effect on mitigating the canyon delays for avalance control in the 2016-2017 ski season.

Figure 16: Avalanche Control Operations

(Source: UDOT)

5.0 SHORT-TERM PLANNED PROJECTS

This section presents near-term projects planned for Big and Little Cottonwood Canyon roads and access roads planned for implementation in 2016 and 2017. Anticipated construction dates and opening dates are detailed below.

UDOT Bike Lane Improvements for Wasatch Boulevard
Scheduled to open fall 2016, UDOT is renovating SR-210 from Big Cottonwood to Little Cottonwood Canyons. This project will extend the life of the pavement, by allowing for more cost effective treatments before major rehabilitiation is required.

Currently, this segment of SR-210 is defined as a bike route in the Utah Collaborative Active Transportation Study (UCATS). As a part of the SR-210 renovations, UDOT will provide five-foot wide bike lanes for SR-210 between the mouth of Little and Big Cottonwood Canyons. Lanes will be provided in each direction, enhancing the dedicated infrastructure for cyclists. Construction for this project is slated to begin August 2016 and run through November 2016.

UDOT Intersection Improvements at SR-210/Wasatch Boulevard
Anticipated for summer 2017, UDOT will construct at High-T intersection at SR-210 and Wasatch Boulevard (located just north of the mouth of Little Cottonwood Canyon). The High-T intersection will improve left turns into and out of Wasatch Boulevard at SR-210 by provide continuous northbound movement for SR-210 while accommodating northbound left turn movements. This Hight-T intersection is expected to improve the flow of traffic leaving Little Cottonwood Canyon during heavy use days. Additionally, the intersection will improve the turning radius for northbound right turns on Wasatch Boulevard.

Mountain Accord Cottonwood Canyons Long Term Transportation Solutions Technical Memorandum

May 2017

This report was prepared by WSP/PB under contract with Wasatch Front Regional Council, in consultation with the Utah Depatment of Transportation and the Utah Trnasit Authority, and with funds from the Mountain Accord program. The report is provided for information purposes and has not been publicly reviewed or adopted.

Contents

Tables

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1 Introduction

Growth in visitation to the Cottonwood Canyons has steadily increased in recent years, and has highlighted the need for year-round transportation solutions to alleviate congestion and single-occupant vehicle travel. Winter visitation, which is primarily destined for ski resorts, creates a slow-moving line of cars that stretch nearly the length of each canyon on busy winter days. In the summer, however, multiple destinations such as trailheads, picnic areas, and fishing spots create a more dispersed pattern of use in each canyon. Additionally, summer visitors access the canyons on bike and as pedestrians, sharing the roadways and shoulder areas with auto users. Over the next 20 years, this pattern of use is expected to intensify and further strain the sensitive natural environment of the canyons as well as transportation infrastructure. The following seeks to evaluate potential long term transportation solutions that will meet the diverse needs of canyon users while reducing the impact of users within the canyons.

Long range transportation solutions in the Cottonwood Canyons achieve a number of significant goals of the Mountain Accord. The proposed solutions, described in the following memo, will accommodate and manage growth in use and the varied travel markets while maintaining positive recreation experiences and minimizing impacts to natural resources. For the purpose of this memo, "long range" is intended to be the year 2040. This planning horizon is adequate to understand the impact of and plan for potential infrastructure investments in the Cottonwood Canyons.

2 Long Range Alternative Screening

Transportation solutions for the Cottonwood Canyons have been the subject of a number of previous studies. A range of transportation solutions, from minor operational and low cost capital improvements to significant infrastructure investments, were discussed in these studies. The “universe” of the significant transportation infrastructure investments serve as the basis for the following evaluation. The full universe of solutions may be found in Appendix A.

The following first includes a Tier 1 evaluation which suggests that transportation alternatives that include high impact, high cost design and operational challenges are not appropriate long term solutions. The Tier 1 evaluation process and results draw on findings from previous studies which found some alternatives to be infeasible in the canyons. From this analysis, a smaller set of alternatives emerge. A second phase, a Tier 2 evaluation, is then conducted on the smaller set of alternatives. The goal of the Tier 2 evaluation is to refine the project definition, cost, and service plans in sufficient detail to update the existing project definition in Wasatch Front Regional Council (WFRC) Long Range Plan (LRP), and to further regional planning discussions.

2.1 Tier 1 Evaluation Methodology

Nearly 130 short and long term transportation solutions have been proposed and evaluated in 47 previous studies. The intent of this effort and the Tier 1 analysis is to summarize the findings and categorize feasible solutions already established for further study. A detailed review of these studies and alternatives is included as Appendix A. The alternatives presented in Section 3 below reflect findings and serve as the starting point for this memo and analysis.

2.2 Tier 2 Evaluation Methodology

Once the Tier 1 universe of alternatives were evaluated, the Tier 2 evaluation process analyzed the recommended alternatives using both qualitative and quantitative measures. This process of evaluation considered the following criteria.

- Cost: The capital/operating cost – this measure calculates the capital cost, annual operations and maintenance costs, and lifecycle costs for each alternative and connection.
- Transit: Transit ridership for canyon access – forecasted ridership for each alternative and connection. Average daily canyon-wide boardings have been estimated in both existing (2016) and forecasted (2040) conditions.
- Cars: The number of single-occupancy vehicles (SOVs) accessing the canyons – this measure estimated the number of single occupant vehicles that enter the Canyons daily.
- Parking: Reduced demand for parking in and near the canyons - This measure allows an assessment of the number of SOVs removed from the canyon roads due to the implementation of each alternative
- Environment: The qualitative impacts to water, lands, and environment within the identified footprint – this measure provides an estimate of the size of impact each alternative may have in the canyons. This is a simple measurement of the number of square feet affected by the project’s footprint.

Data was collected and analyzed for each of the five evaluation criteria. Detailed findings for each alternative are presented in Section 4.

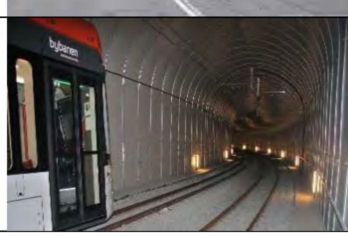
3 Tier 1 Alternatives

Due to the large number of long-term infrastructure investments proposed, Table 1 presents a summary of each transportation "mode" or category as well as recommendation for each.

Table 1: Summary of Tier 1 Long Range Alternatives, Recommended Action

Mode	Example	Characteristics	Recommendation
Maglev		• Uses magnetic levitation • Exclusive guideway • Very high speed	• Not feasible for sharp curves and steep grades found in canyons. • Not recommended
Cable Liner		• Accommodate grades between 10-15%. • Top speed 30 MPH. • Optimal for corridors from .3 to 1.8 miles	• Not feasible for corridors over 6 miles • Not recommended
Heavy Rail		• Exclusive guideway • Utilizes "third rail" infrastructure	• Not feasible along steep grades found in canyons • Not recommended
Commuter Rail		• Exclusive guideway • Railroad-type operations	• Not feasible for sharp curves and steep grades found in canyons. • Not recommended
Monorail		• Exclusive, elevated guideway	• Not feasible along steep grades found in canyons • Not recommended

Mode	Example	Characteristics	Recommendation
Funicular		• Top speed 30 MPH • Operates on steep grades for short distances	• Small service capacity not appropriate for corridors longer than 2 to 3 miles. • Not recommended
Light Rail		• Fixed guideway • High capacity vehicles	• Not feasible for grades exceeding 6% for lengths in excess of 1500' • Not recommended
Cog Rail		• Feasible for steep grades • High capacity vehicles • Adequate speed • Large environmental footprint • High capital costs • Limited by sharp horizontal curves	• Recommended for further consideration
Hyperloop		• Very high speed 650 MPH • Exclusive, elevated guideway	• Not appropriate for sharp curves; radius necessary for top speeds approach 57,000' • Not recommended
Funifor		• Top speed: 30 MPH	• Operational limitation • Not recommended
Gondola 3S – Aerial Tram		• Medium range capital costs • Small environmental footprint • High operating costs • Top speed 17 MPH – high travel time • Visual impacts	• Long travel time up canyons • Limited access • Not recommended

Mode	Example	Characteristics	Recommendation
Bus Rapid Transit (BRT)		• Medium range capital cost • Large environmental footprint w/dedicated lane • Adequate speed in canyons • Good capacity	• Recommended for further consideration
Enhanced Bus		• Expansion of existing service • Low capital costs • Low operating costs • Small environmental footprint • Adequate speeds • Good capacity	• Recommended for further consideration
Widen Roadways		• Medium range capital costs • Large environmental footprint • Adequate speeds	• Considerable environmental footprint • Not recommended
Limitations on Vehicles – Transit Only		• High capital and operating costs to accommodate visitation • Adequate speed in canyons • Good capacity	• High capital cost • High operating costs • Not recommended
Tunnel – Little Cottonwood Canyon		• Tunnel along entire length of LCC • Limited access	• High capital cost • High operating costs • Not recommended
Tunnel – Alta to Brighton (Transit Only)		• High capital costs • High operating costs • Increases transit ridership capacity	• Recommended for further consideration in conjunction with additional transit investment

Mode	Example	Characteristics	Recommendation
Aerial connection – Alta to Brighton		• High capital costs • High operating costs • Requires transfer from other modes	• Recommended for further consideration in conjunction with additional transit investment

3.1 Recommended Alternatives

Based on Tier 1 evaluation of the universe of solutions, the following alternatives were selected for further consideration. It should be noted that while there are three modal (ie: bus, rail, etc) alternatives, additional infrastructure and design alternatives are considered in conjunction with the modal alternatives. Thus, the transit-only tunnel and aerial connections between Alta and Brighton ski resorts are considered and evaluated in conjunction with rail and bus alternatives in the canyons. The consideration of the connections expands the total number of Tier 2 alternatives to nine. These alternatives include:

Alternative 1: Enhanced Bus: This option provides bus services with 15-minute headways in both canyons.

Option 1A: Enhanced Bus + Bus Tunnel: This option builds on the enhanced bus service by creating a bus-only tunnel connection between the bases of Alta and Brighton ski resorts.

Option 1B: Enhanced Bus + Aerial Connection: This option builds on the enhanced bus service by creating an aerial connection between the bases of Alta and Brighton ski resorts.

Alternative 2: BRT: This option provides bus service on exclusive bus lanes in Little Cottonwood Canyon (LCC). Headways are projected at 30 minutes.

Option 2A: BRT + Bus Tunnel: This option builds on the BRT bus service by creating a bus-only tunnel connection between the bases of Alta and Brighton ski resorts.

Option 2B: BRT + Aerial Connection: This option builds on the BRT service by creating an aerial connection between the bases of Alta and Brighton ski resorts.

Alternative 3: Cog Rail: This option provides cog rail service on an exclusive, fixed railway in LCC. It is recognized that a light rail line is feasible in the Valley, and thus a design alternative includes the consideration of a light rail alternative in the Valley and a cog rail alternative in LCC. However, for the purposes of this evaluation, one continuous rail line from the Valley into LCC is assumed. Headways are projected at 30 minutes.

Option 3A: Cog Rail + Rail Tunnel: This option builds on the cog rail infrastructure by creating a rail-only tunnel connection between the bases of Alta and Brighton ski resorts.

Option 3B: Cog Rail + Aerial Connection: This option builds on the cog rail by creating an aerial connection between the bases of Alta and Brighton ski resorts.

4 Tier 2 Alternatives

As a part of the overall evaluation and feasibility analysis for solutions, it was decided that major-capital long-term improvements would be proposed for LCC over BCC due to several reasons. These include:

- Currently, UTA reports higher ridership in LCC
- Geography in BCC makes rail construction more expensive
- Year-round destination for visitors
- Seasonal attractions and destinations

4.1 Travel Forecast Methodology and Assumptions

A sketch-level model was developed to forecast the 2040 ridership for each of the Tier 2 alternatives and connection options. The model was developed using a straightforward technical approach and grounded in existing travel model input and 2015, 2016 observed data. The model was developed using the existing WFRC travel demand model and calibrated toward all types of recreation. The results from this model provide a conservative estimate, using the best available information currently available. Given additional data set(s), the model would likely show improved results. However, there are limitations in understanding the travel markets outside of the canyons. Further studies and work should be done to better understand the travel markets in the valley. Additional detail on the development of the travel demand model, as well as its abilities and limitations, are provided in Appendix B.

Table 2 below presents an overview of the data utilized to create this model. A more detailed methodology report for the forecasting efforts is included in Appendix B. Results from the sketch model are included for each alternative in the following sections, with more detailed results also included in Appendix B.

Table 2: Data Sources for Mountain Accord Sketch Model

Type	Description	Source	Use to Mountain Accord Sketch	File Name
Data	Spreadsheet summary of Traffic at the entry point of Big and Little Cottonwood Canyon Roads 2013-2015	UDOT / Special Traffic Collection	Canyon demand, auto occupancy, hourly entering and exiting traffic, trends over three years, seasonal variation	Big & Little Cottonwood Canyon 24 hour counts Jan 2013 to May 2016.XLS
Network	Cube software highway network file	WFRC	Canyon highway network (supply) guidance	MtnMdl_MasterNet_v31.NET
SE Data	2010 and 2040 Socioeconomic data	WFRC	Canyon trip tables (demand) guidance	SE_2010_MA_101214.DBF; SE_2040_MA_101214
GIS	Base and Future Year TAZ GIS file (identical dimensions)	WFRC	Guidance on zone system	MTN_MODEL_TAZ_112114_BASEYR.SHP
GIS	Parking Data (Lot Capacity Transit Route	WFRC	Guide attraction development	Various *.SHP files
Report	2012 Parking Study Reports	WFRC	Guide parking point development	Canyons Existing Conditions Memo Final 042612.PDF; Canyons Parking Study Data Collection Summary.PDF and Cottonwood_Canyons_Parking_Study_Recommendations Sep12.PDF
Survey Data	2015-2015 Transit Onboard Survey	WFRC (requested from UTA)	Guide transit approach	UTA OD Dataset wo personal data.XLXS
Cell Phone Data	Mountain Accord Deliverables	AirSage	Verify Person movements / traffic	OS5797_MountainAccord_Deliverables
Report	Mountain Model Methodology	WFRC	Guide overall approach	Model Development Documentation_FINAL.PDF

4.2 Alternative 1: Enhanced Bus

The enhanced bus option, shown in Figure 1 below, is intended to provide tangible improvements in transit service and operations through operational improvements and minor infrastructure. Bus service would operate much the same as today. That is, service would operate on existing streets and utilize existing stops. Of the three Tier 2 alternatives, the enhanced bus option is comparatively lower in capital cost due to the limited right-of-way and construction required.

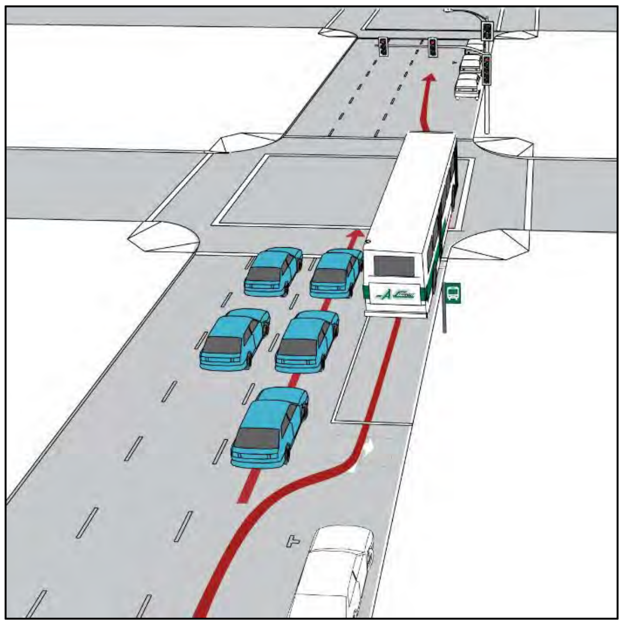
Figure 1: Enhanced Bus Alignment

By utilizing Intelligent Transportation Systems (ITS) components such as those suggested below, Utah Transit Authority (UTA) can further improve its existing bus operations, vehicle efficiency, and overall ridership experience. The proposed enhanced bus service will include the following elements:

- All-day 15-minute headways: 15-minute headways are assumed throughout an 18-hour day, including the AM-peak, mid-day, and PM-peak hours, for both winter ski bus and summer transit services.
- Transit signal priority/queue jump lanes: Transit Signal Priority (TSP) provides preferential treatment to transit vehicles at traffic signals by allowing transit vehicles to pass through intersections first. By allowing transit vehicles an advanced green signal, this allows for the vehicles to “jump” the queue in front of mixed traffic and reduce the delay time from waiting at signals. With reduced signal delays, buses can decrease travel times and provide more efficient, on-time services. This can be either in the form of a camera or loop detector. Additionally, a bus priority

signal would need to be installed to allow for buses to have a green signal prior to general traffic. In the proposed bus enhancement, TSP and/or queue jump lanes are planned for all current signalized intersections along the existing UTA bus routes servicing the canyons. Within the valley, this includes signals along 7200 South, 9400 South, and Wasatch Boulevard. Within the canyons, this may include any new intersections at ski resorts and trail heads that have been implemented since the short term.

Figure 2: Bus Queue Jump Operations



(Source: AC Transit)

4.2.1 Alternative 1A: Enhanced Bus + Bus Tunnel

In order to connect Big Cottonwood Canyon and Little Cottonwood Canyon, a tunnel is proposed to connect the base of Brighton ski area with the base of Alta ski area. This tunnel would help in providing a direct connection between the two canyons and resorts, serving skiers who desire to visit both resorts, as well as making transfers to Snowbird or Solitude. In the case of an emergency need to shut down the highway, this tunnel could also provide a detour route of egress in the event of a national disaster (i.e. wildfire, avalanche, rockslide, etc.). This would serve as a benefit to canyon residents and visitors.

Tunnel construction will require two single-bore tunnels, each with a single guideway to accommodate buses. Bus traffic would utilize the tunnel couplet to provide two-way traffic between Alta and Brighton. Fire and life safety code requirements necessitate that a cross-tunnel connection be provided every 750 feet between the two tunnels, in case of an emergency. Currently, the proposed alignment takes the shortest, reasonable path between Alta and Brighton bases, while maintaining a reasonable grade for the tunnel boring machine.

Greater detail on the estimated costs for the tunnel's construction and operation of buses is listed in Table 3 below. Figures 3 and 4 below show two cross sections of how bus operations in a tunnel could operate. Figure 3 shows the operation of buses in two, parallel tunnels. Figure 4 presents a cross section of a tunnel operation with a connection between the two parallel tunnels. These cross sections are also applicable to a BRT tunnel operation that will be discussed in subsequent sections.

Figure 3: Bus Operations in Dual, Parallel Tunnels

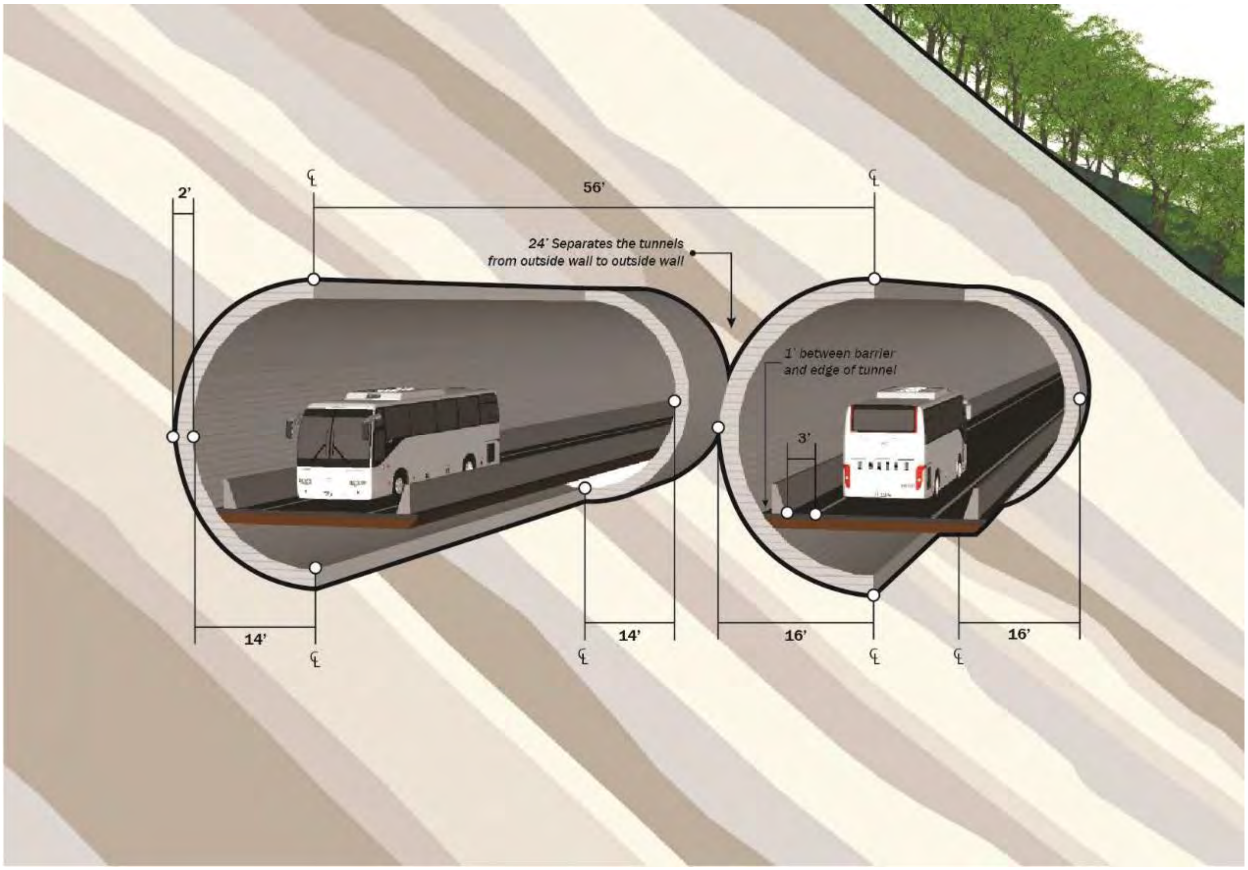
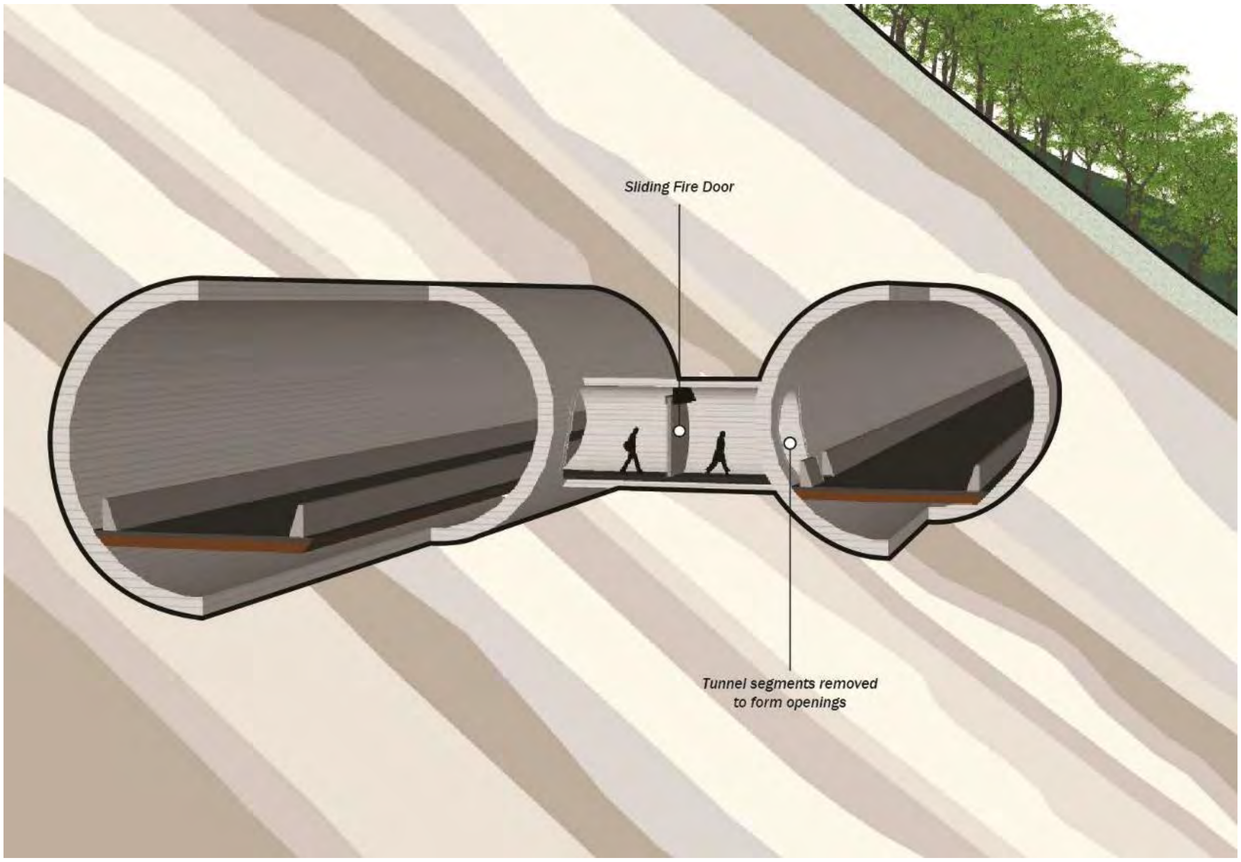


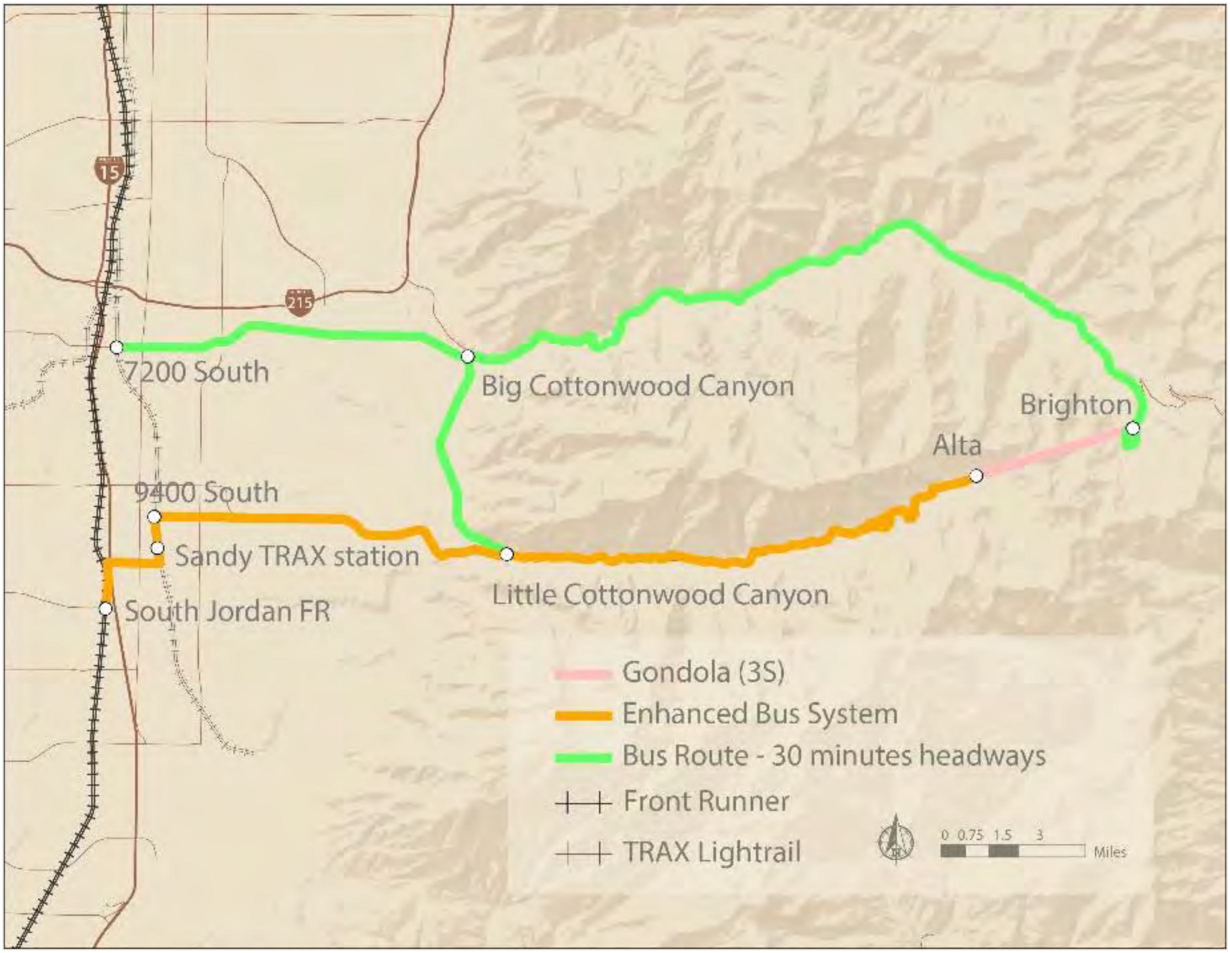
Figure 4: Detailed View of Tunnel Connection



4.2.2 Alternative 1B: Enhanced Bus + Aerial Connection

Using 3S Gondola Lift technology, the proposed aerial system operates with detachable gondolas that can traverse the canyon ridge. The proposed alignment parallels the existing transmission power line corridor in the canyons, which is also an historic wagon trail route. The aerial tramway would have a terminal point at the base of Alta ski resort, go up and over the mountain ridge, past Twin Lakes, and then terminate at the base of Brighton ski resort. There is potential that the tramway may also make a stop at the top of the ridge to accommodate backcountry skiers in the winter and hikers/visitors during the summer. In the case of an emergency need to shut down the highway, this tram could also provide a detour route of egress in the event of a national disaster (i.e. wildfire, avalanche, rockslide, etc.). This would serve as a benefit to canyon residents and visitors. Figure 5 depicts this connection to an enhanced bus system. However, the aerial connection is also applicable to the BRT and rail alternatives, as it would operate independent of the connecting transit mode.

Figure 5: Enhanced Bus Operation with Aerial Connection



Of the various ridge connection options, the aerial ridge connection is the only alternative that can be implemented independently. This will force a transfer between transit modes, adding travel time to one's trip. One existing technology, the 3S Gondola system, produced by Doppelmayr, contains two fixed, fully locked track ropes on which the carrier travels and a circulating haul rope which is clamped to the 8-wheel carriages. The system is continuously moving and combines the benefits of a gondola lift with reversible aerial tramway. Each gondola cabin can fit up to 35 passengers.

4.2.3 Alternative 1 Evaluation

Table 3 below presents the evaluation of Alternative 1 based on the six criteria discussed in Section 2.2 above. Detailed cost estimates for both the canyon and connection alternatives as well as the evaluation are presented in Appendices C, D, and E respectively.

Table 3: Tier 2 Evaluation of Alternative 1 – Enhanced Bus

Criteria	Alt 1: Enhanced Bus	Alt 1A: With Tunnel	Alt 1B: With Aerial
Capital Costs Low ($ 2017)	$ 44,000,000	$ 618,000,000	$ 159,000,000
Capital Costs High ($ 2017)	$ 54,000,000	$ 734,000,000	$ 224,000,000
Annual Operating Costs Low ($ 2017)	$ 9,200,000	$ 19,200,000	$ 14,300,000
Annual Operating Costs High ($ 2017)	$ 11,200,000	$ 24,200,000	$ 17,500,000

Criteria	Alt 1: Enhanced Bus	Alt 1A: With Tunnel	Alt 1B: With Aerial
Lifecycle Costs ($2017)	$605,000,000	$2,936,000,000	$1,255,000,000
Total Daily Boardings (2040)	3,300	3,700	3,700
Cars Removed from Canyon (daily)	250	350	350
Travel Time: 9400 South to Alta (min)	54		
Environmental Footprint (sq. feet)*	48,000	2,238,000	48,294

Source: WSP | Parsons Brinckerhoff

*NOTE: Difference in square footage associated with aerial tram represents the poles and infrastructure needed for the tram.

**NOTE: All calculations are at a high level estimate of the actual impact on the environment. These assumptions do not include analysis of visual impacts.

4.3 Alternative 2: Bus Rapid Transit (BRT)

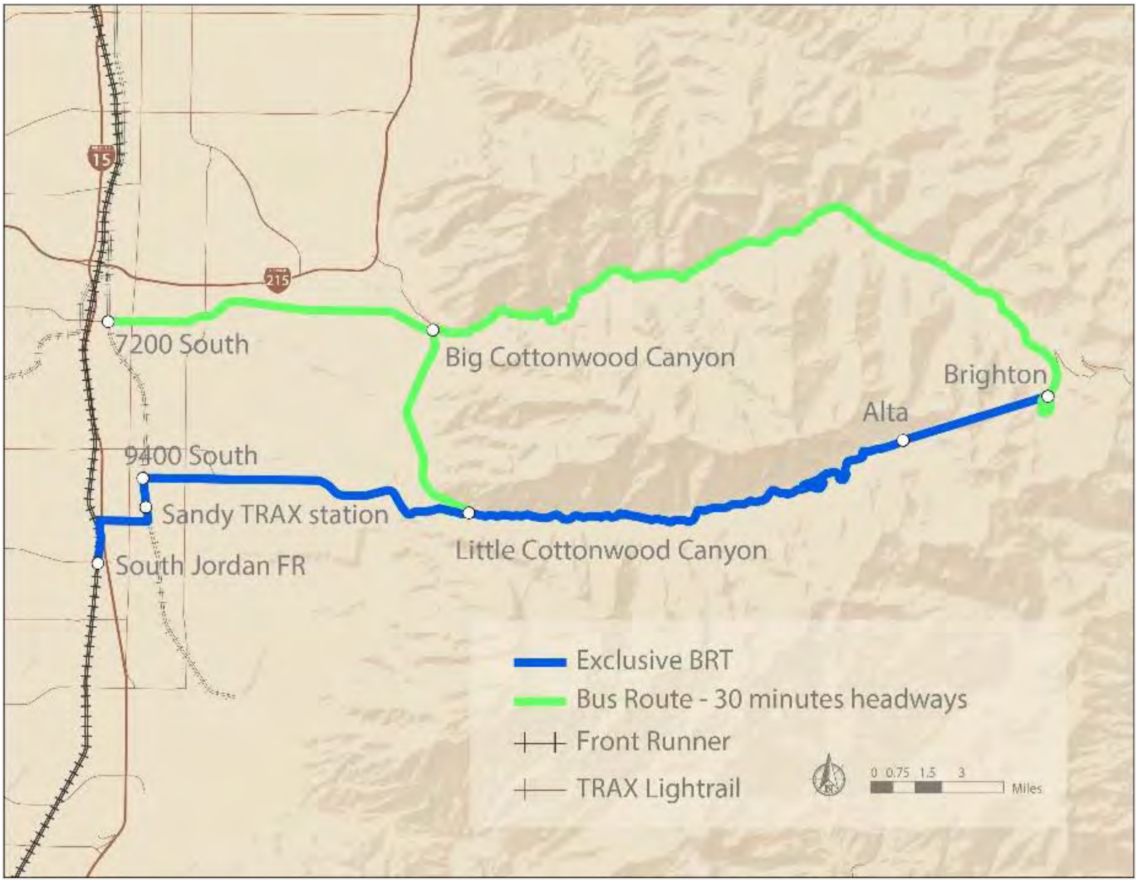
Bus Rapid Transit (BRT) is an option that would provide fast, reliable transit service into the canyons. BRT is a high-quality transit mode that has features similar to light rail, making it more reliable and faster than standard bus services. BRT is able to avoid delays experienced by standard mixed-traffic buses, such as congestion delays and queueing at traffic signals. As shown in Figure 6 below, this bus system would start from the South Jordan Front Runner station, go past the Sandy TRAX station, and then follow 9400 South into LCC. Within the Little Cottonwood Canyon corridor, the proposed BRT system is planned to have exclusive lanes for buses up the canyon. These bus lanes would be separated from general traffic, allowing for buses to bypass traffic queues. Cross sections of sample portions of the alignment both in the Valley and in the canyons may be found in Appendix E.

Figure 6: Bus Rapid Transit Alternative

4.3.1 Alternative 2A: BRT + Bus Tunnel

The proposed alignment for the BRT tunnel connecting the canyons is shown in Figure 7 below. The tunnel serves as an add-on option, such that it must be coupled with either the enhanced bus or BRT option in LCC. The cross sections for this alternative mirror those described and illustrated above in section 4.2.1.

Figure 7: Bus Rapid Transit Alternative with Tunnel Connection



4.3.2 Alternative 2B: BRT + Aerial Connection

Please refer to Section 4.2.2 for a description of the aerial connection. As stated, the aerial connection operates independent of transit mode, and would require a transfer between the BRT line and the aerial tram.

4.3.3 Alternative 2 Evaluation

Table 4 below presents the evaluation of Alternative 2 based on the six criteria discussed in Section 2.2 above. Detailed cost estimates for both the canyon and connection alternatives as well as the evaluation are presented in Appendices C, D, and E respectively.

Table 4: Tier 2 Evaluation of Alternative 2 – BRT

Criteria	Alt 2: BRT	Alt 2A: With Tunnel	Alt 2B: With Aerial
Capital Costs Low ($ 2017)	$ 270,000,000	$ 834,000,000	$ 375,000,000
Capital Costs High ($ 2017)	$ 330,000,000	$ 1,020,000,000	$ 510,000,000
Annual Operating Costs Low ($ 2017)	$ 9,200,000	$ 19,200,000	$ 14,300,000
Annual Operating Costs High ($ 2017)	$ 11,300,000	$ 24,300,000	$ 17,600,000
Lifecycle Costs ($ 2017)	$ 1,190,000,000	$ 3,521,000,000	$ 1,840,000,000
Total Daily Boardings (2040)	3,400	3,800	3,800

Criteria	Alt 2: BRT	Alt 2A: With Tunnel	Alt 2B: With Aerial
Cars Removed from Canyon (daily)	300	400	400
Travel Time: 9400 South to Alta (min)	44		
Environmental Footprint (sq. feet)	2,190,000	2,190,000	2,190,294

Source: WSP | Parsons Brinckerhoff

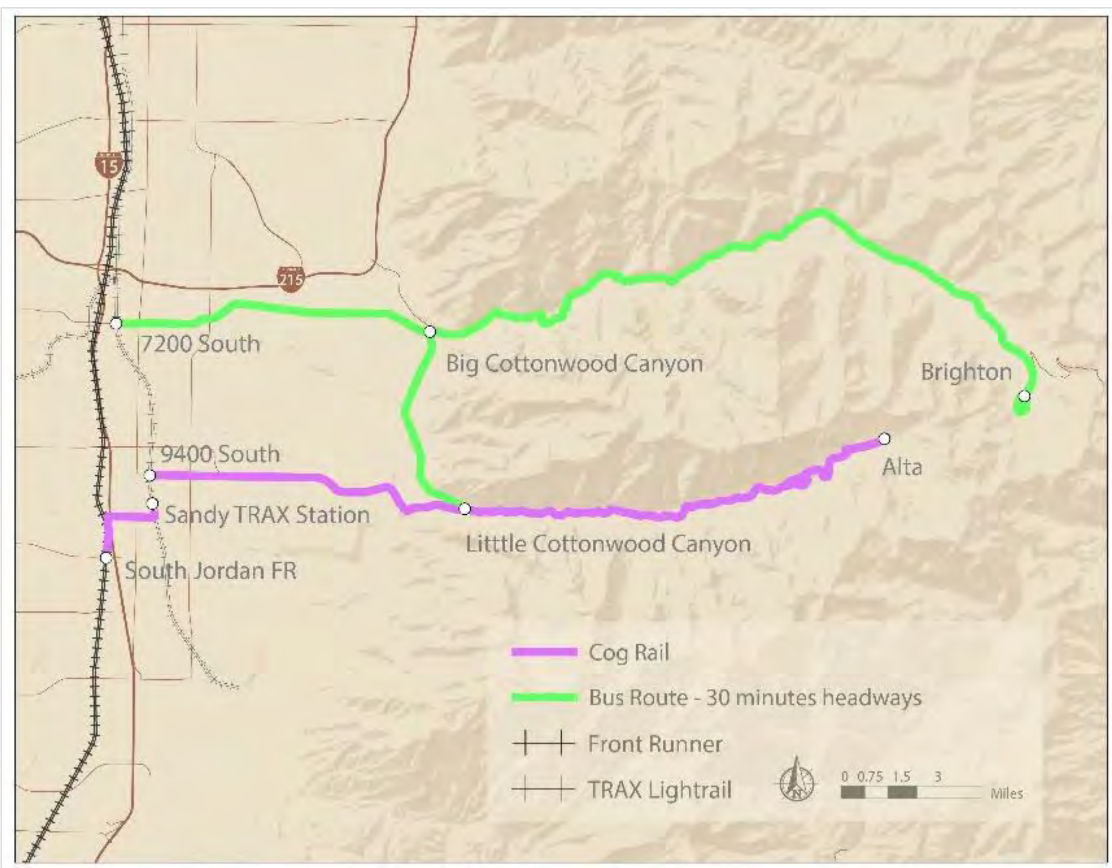
*NOTE: All calculations are at a high level estimate of the actual impact on the environment. These assumptions do not include analysis of visual impacts.

4.4 Alternative 3: Cog Rail

A rail option for traveling the Little Cottonwood Canyon corridor has been discussed in previous planning efforts, including Wasatch Canyons Tomorrow and Mountain Accord Blueprint, and has been brought forward for detailed consideration. The proposed railway would function as light rail where grades are less than 6%, and transition to cog rail as it ascends up steeper grades in the canyon. A map of the alternative is presented in Figure 8 below. Cog rail technology allows train cars to climb steeper grades by using cog wheels, which work like gears meshing with a special complementary track. The rail alternative would require a dedicated alignment; in the valley, the railway track will run down the middle of the road, and in the canyon the railway will run parallel to the existing roadway on the north side. For more details on the design and alignment, please refer to the cross sections in Appendix F. This alignment would require widening both in the valley to accommodate the track in the center of the road, and in the canyons to accommodate the width of the track on the north side of the existing roadway. The required widening would result in a large environmental footprint for this alterative.

Upon implementation of cog rail, UTA and its partners would seek out input from the public to analyze and determine stop locations. Once rail is implemented in LCC, bus services are no longer necessary in the canyons due to duplicate service. Instead, the connection between the valley and canyon rail will be evaluated to ensure passengers have smooth, seamless transfers between the two modes.

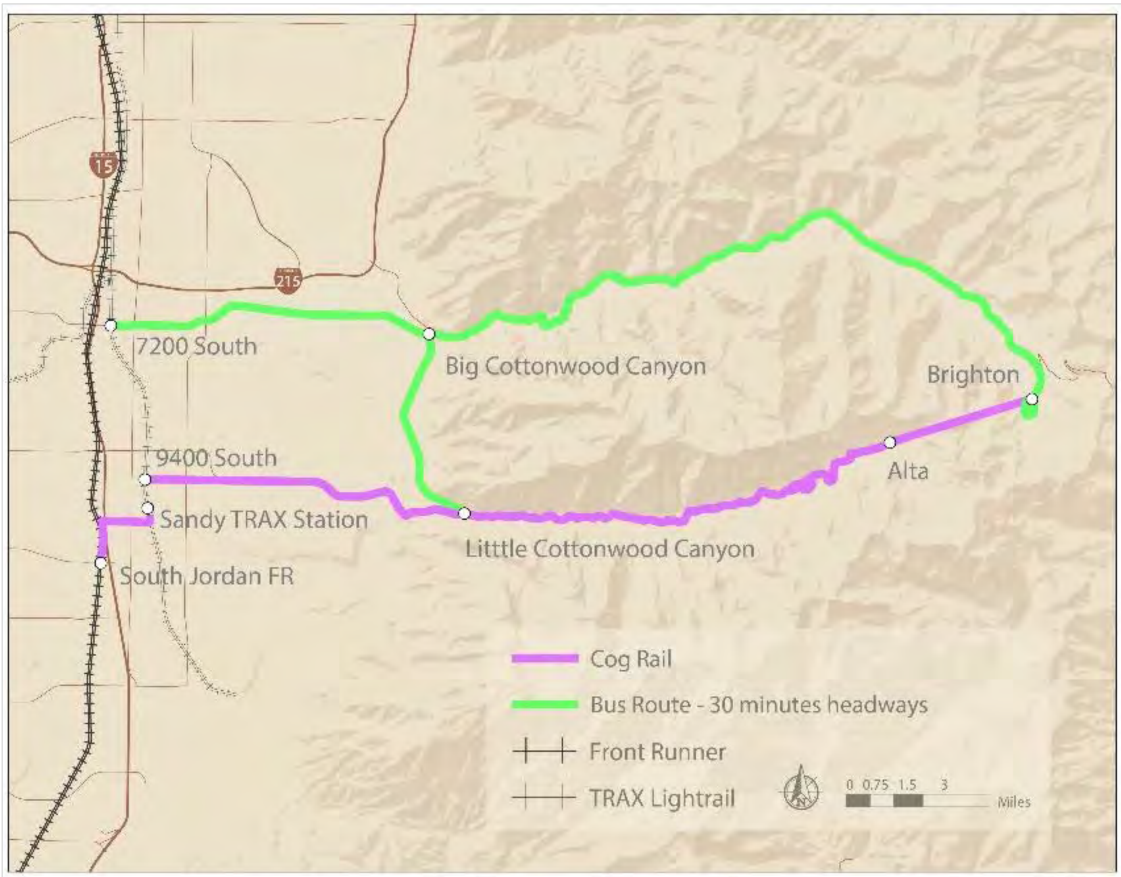
Figure 8: Cog Rail Alternative



4.4.1 Alternative 3A: Cog Rail + Rail Tunnel

A cog rail tunnel to connect Big and Little Cottonwood Canyons would allow railcars to continue from the LCC corridor at Alta through to Brighton. Users who ride the train into LCC would be able to continue into BCC without changing modes. The alignment for the cog rail tunnel is also shown in Figure 9.

Figure 9: Cog Rail Alternative with Rail Tunnel Connection



Figures 10, 11, and 12 below show three cross sections of how a cog or light rail alignment could operate in a tunnel. Figure 10 shows a single tunnel with dual direction cog or light rail tracks. Figures 11 and 12 show dual, parallel tunnels each with a single track for cog or light rail and the same but with a crossing between the tunnels.

Figure 10: Rail Operations in Single Tunnel

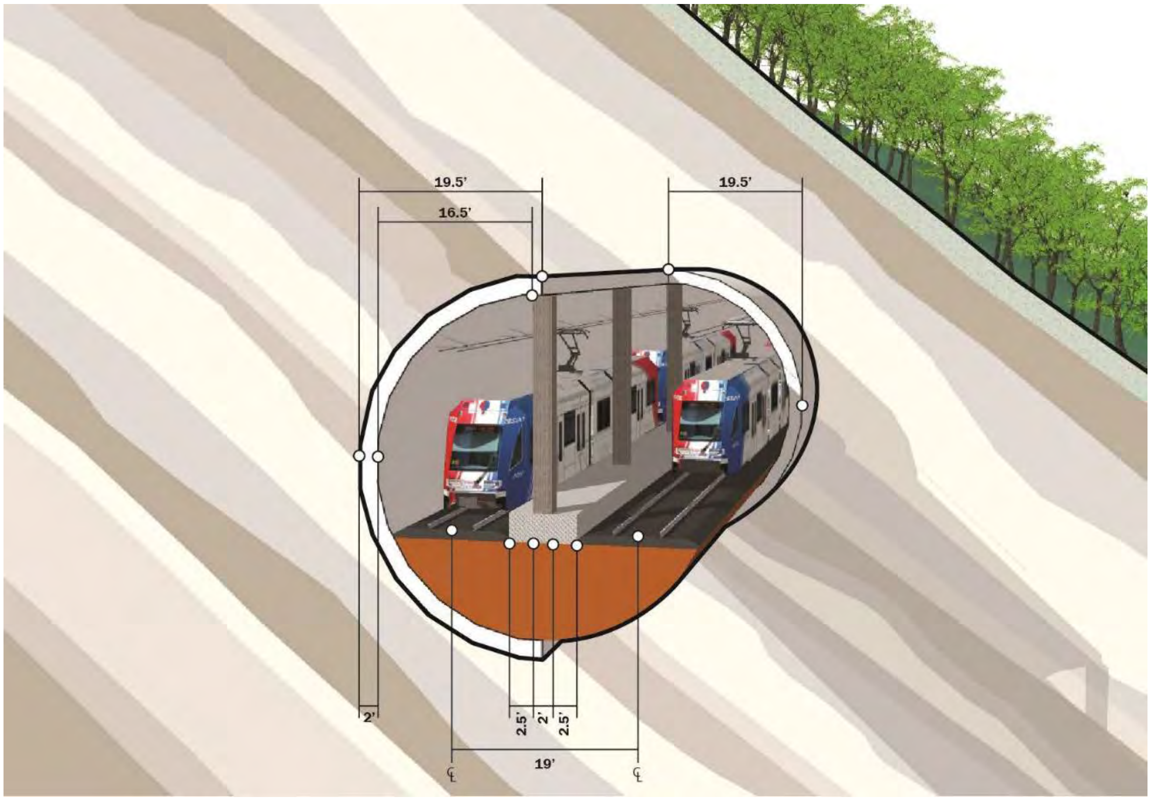


Figure 11: Rail Operations in Dual, Parallel Not Connected Tunnels

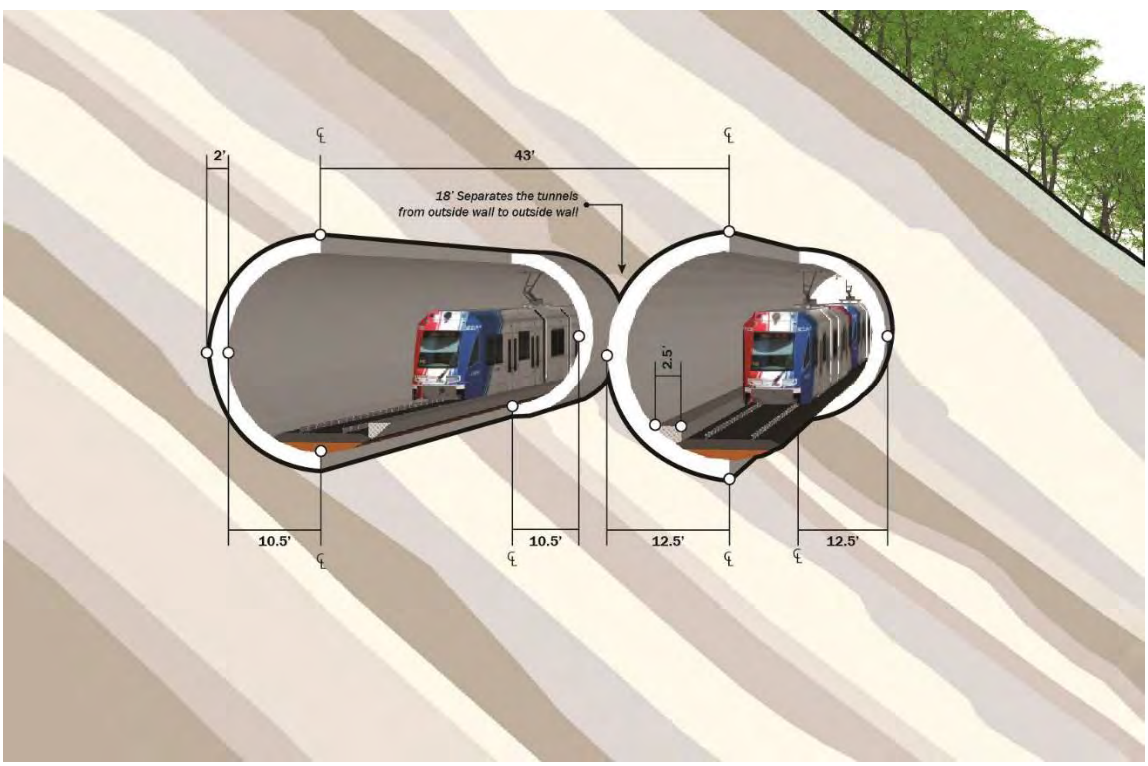
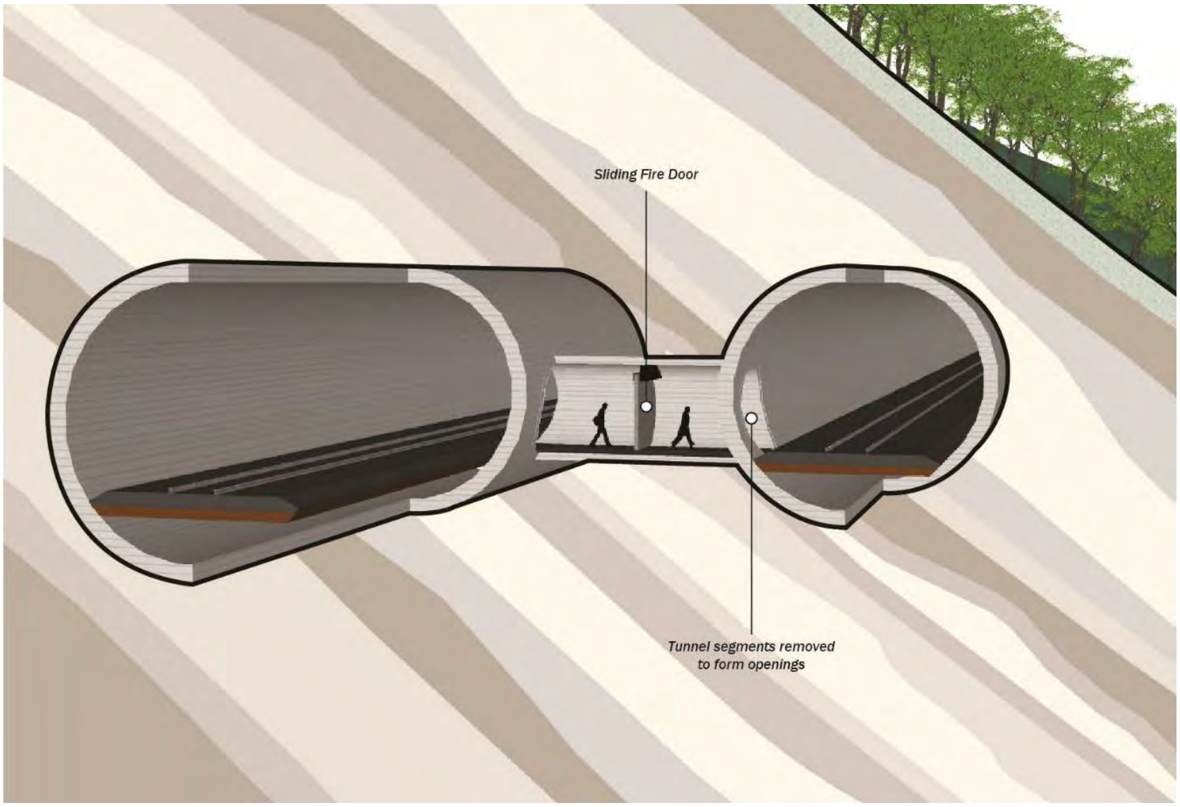


Figure 12: Rail Operations in Dual, Parallel Connected Tunnels



4.4.2 Alternative 3B: Cog Rail Alternative + Aerial Connection

Please refer to Section 4.2.2 for a description of the aerial connection. As stated, the aerial connection operates independent of transit mode, and would require a transfer between the rail line and the aerial tram.

4.4.3 Alternative 3 Evaluation

Table 5 below presents the evaluation of Alternative 3 based on the six criteria discussed in Section 2.2 above. Detailed cost estimates for both the canyon and connection alternatives as well as the evaluation are presented in Appendices C, D, and E respectively.

Table 5: Tier 2 Evaluation of Alternative 3 – Cog Rail

Criteria	Alt 3: Cog Rail	Alt 3A: With Tunnel	Alt 3B: With Aerial
Capital Costs Low ($2017)	$1,340,000,000	$1,710,000,000	$1,445,000,000
Capital Costs High ($2017)	$1,640,000,000	$2,090,000,000	$1,820,000,000
Annual Operating Costs Low ($2017)	$8,900,000	$18,900,000	$14,000,000
Annual Operating Costs High ($2017)	$10,900,000	$23,900,000	$17,200,000
Lifecycle Costs ($2017)	$3,920,000,000	$5,430,000,000	$4,570,000,000
Total Daily Boardings (2040)	3,600	4,000	4,000
Cars Removed from Canyon (daily)	330	450	450
Travel Time: 9400 South to Alta (min)	41	41	41

Criteria	Alt 3: Cog Rail	Alt 3A: With Tunnel	Alt 3B: With Aerial
Environmental Footprint (sq. feet)	1,550,000	1,550,000	1,550,294

Source: WSP | Parsons Brinckerhoff

*NOTE: All calculations are at a high level estimate of the actual impact on the environment. These assumptions do not include analysis of visual impacts.

5 Summary and Conclusions

5.1 2050 Long Range Transportation Plan

Table 6 below presents a summary of the evaluation results for each Tier 2 alternative as well as the tunnel and aerial connection. This analysis progressed the understanding of major capital transit improvements within the Cottonwood Canyons, and includes significant information that may be used in an update of WFRC's Long Range Plan. The following additional insights are drawn from the evaluation and offered for consideration.

5.1.1 Cost

Each alternative, including the tunnel and aerial connection between the canyons included sufficient design to estimate the overall footprint of the project and to calculate an estimated capital cost considering the area of effect. Specific assumptions included in the cost estimates are included in Appendix C. As noted for a number of Tier 1 alternatives, the addition of transit infrastructure - whether for bus or rail projects – is costly in the narrow and steep canyon roadways. Alternatives with a lower capital cost seem to provide comparable benefits in terms of ridership and reduction in single occupant auto use to those with a higher capital cost.

5.1.2 Transit, Cars, and Parking

As may be seen in Table 6 below, there is little difference in the forecasted ridership values amongst the alternatives. This may be due to a number of factors, many of which are discussed in the ridership methodology memo found in Appendix B. However, the sketch model was developed using available data and conservative assumptions given the lack of available year-round data on the travel patterns of canyon users. In addition to the estimation of daily transit boardings, the sketch model was used to estimate the number of and the reduction in single occupant autos and parking space utilization. While the estimates provided below are intentionally conservative, they provide a relative comparison among alternatives. The model may not, however, have enough data to understand a user's preference for one mode over another. Thus, transit modes are seen as relatively equal when a rail mode, for example, may make someone more likely to want to park their car prior to entering the canyons.

5.1.3 Environment

This stage of analysis included a measurement of the approximate "footprint" of each alternative. The bus and BRT alternatives do not require as significant of roadway widening as the rail alternative may. However, the estimation of actual environmental impact of a rail alternative requires a greater level of design. The analysis of the footprint of the rail alternative was limited to the actual cross section and did not include slope cuts or retaining walls to accommodate the construction of rail in the canyons.

5.2 Next Step: NEPA Planning and Analysis

Each of the major capital improvements discussed in this memo would require a NEPA analysis to document environmental impacts as a federal action. The cog rail and BRT canyon alternative would likely require an Environmental Impact Statement (EIS), due to the significant environmental effects. The tunnel and/or aerial connection options would need to be part of an EIS, either combined with a canyon corridor alternative, or, in the case of the aerial ridge connection, as a potential stand-alone project. The enhanced bus alternative would have a lower environmental footprint, but would likely require NEPA analysis, possibly an EA with the potential for escalation to an EIS.

Table 6: Summary of Evaluation of Alternatives

Criteria	Alternative 1: Enhanced Bus			Alternative 2: Bus Rapid Transit			Alternative 3: Cog Rail		
	1: Enhanced Bus	1A: Tunnel Connection	1B: Aerial Connection	2: BRT	2A: Tunnel Connection	2B: Aerial Connection	3: Cog Rail	3A: Tunnel Connection	3B: Aerial Connection
Capital Costs Low ($2017)	$44,000,000	$618,000,000	$159,000,000	$270,000,000	$834,000,000	$375,000,000	$1,340,000,000	$1,710,000,000	$1,445,000,000
Capital Costs High ($2017)	$54,000,000	$734,000,000	$224,000,000	$330,000,000	$1,020,000,000	$510,000,000	$1,640,000,000	$2,090,000,000	$1,820,000,000
Annual Operating Costs Low ($2017)	$9,200,000	$19,200,000	$14,300,000	$9,200,000	$19,200,000	$14,300,000	$8,900,000	$18,900,000	$14,000,000
Annual Operating Costs High ($2017)	$11,200,000	$24,200,000	$17,500,000	$11,300,000	$24,300,000	$17,600,000	$10,900,000	$23,900,000	$17,200,000
Lifecycle Costs ($2017)	$605,000,000	$2,936,000,000	$1,255,000,000	$1,190,000,000	$3,521,000,000	$1,840,000,000	$3,920,000,000	$5,430,000,000	$4,570,000,000
Total Daily Boardings (2040)	3,300	3,700	3,700	3,400	3,800	3,800	3,600	4,000	4,000
Cars Removed from Canyon (daily)	250	350	350	300	400	400	330	450	450
Travel Time: 9400 South to Alta (min)	54			44			41		
Environmental Footprint (unit acres)	1.10	51.38	1.11	50.28	50.28	50.28	35.58	35.58	35.59

*NOTE: All calculations are at a high level estimate of the actual impact on the environment. These assumptions do not include analysis of visual impacts.

Appendix A: Universe of Solutions

Appendix B: Travel Forecast Methodology Report and Results

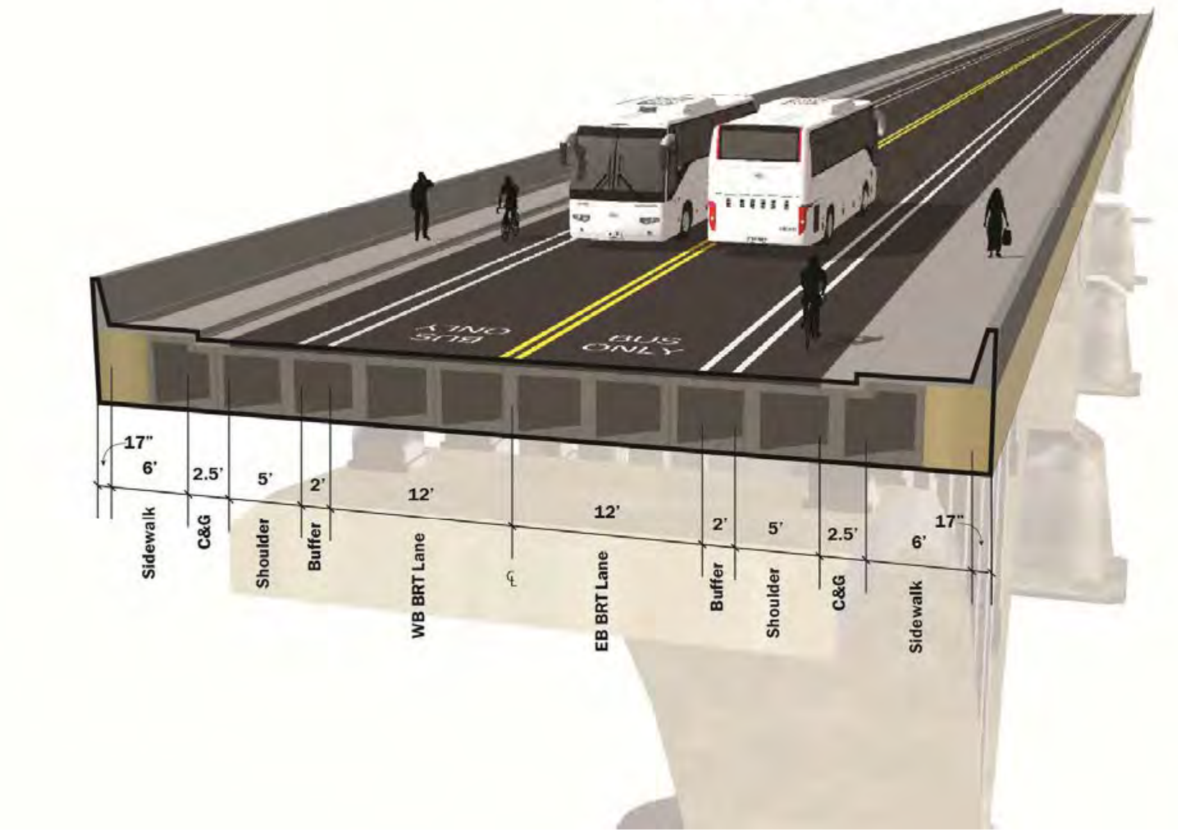
Appendix C: Capital and Operational Cost Estimates for Alternatives

Appendix D: Detailed Evaluation Matrices of Alternatives

Appendix E: Sample Cross Sections of BRT Alternative

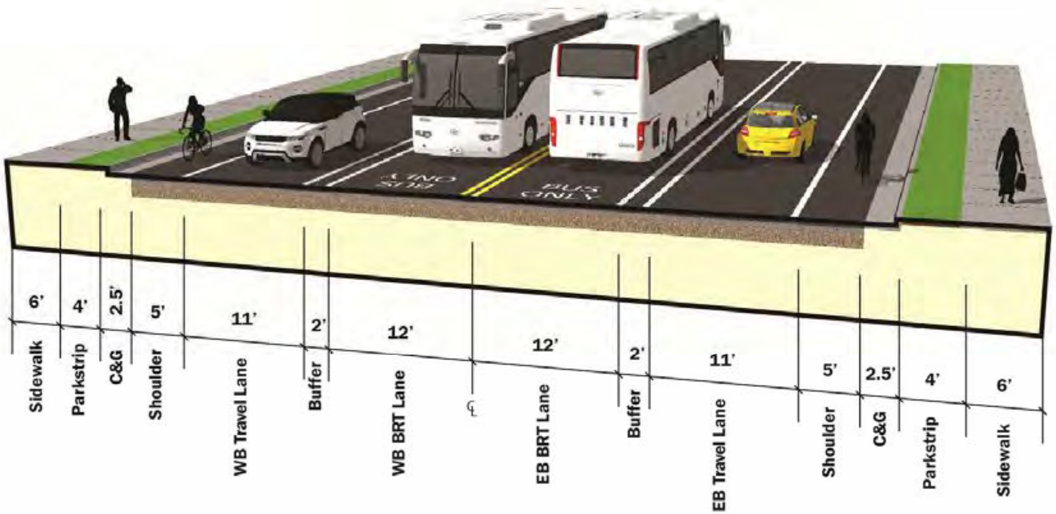
BRT Typical Section #1

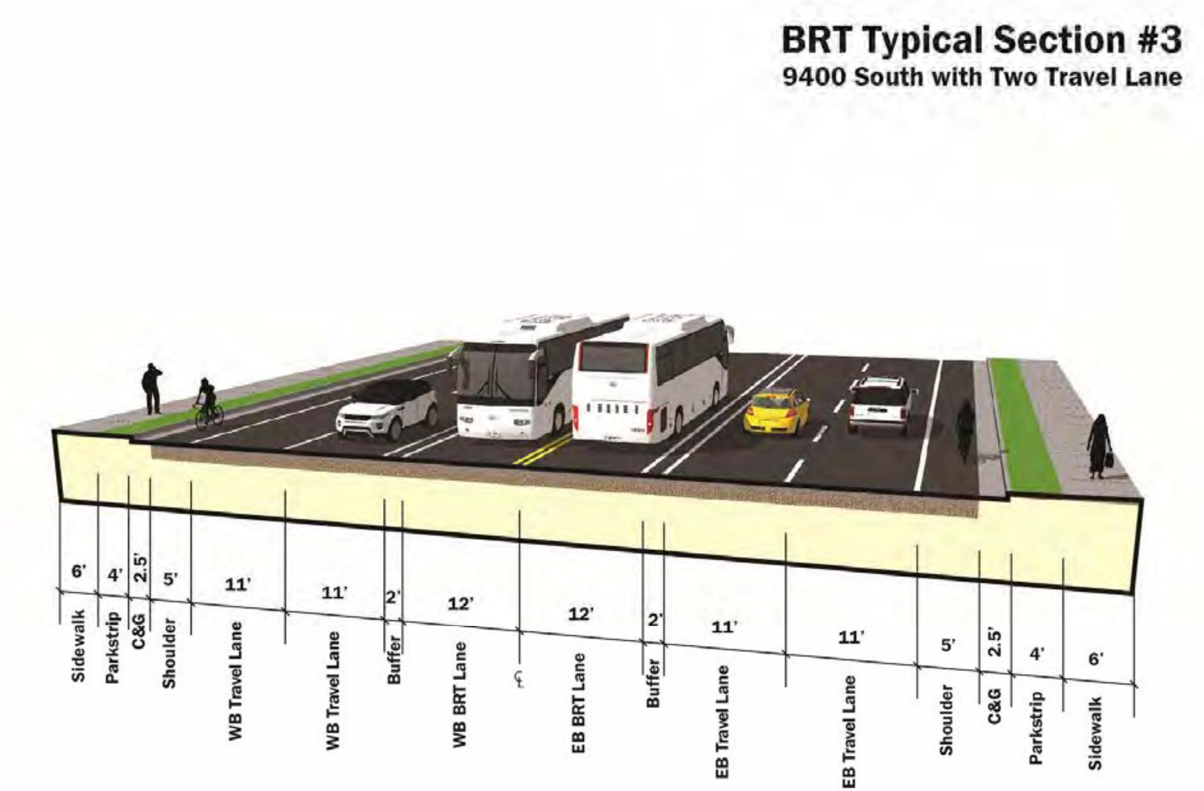
10200 South Bridge (Over Railroad Tracks)



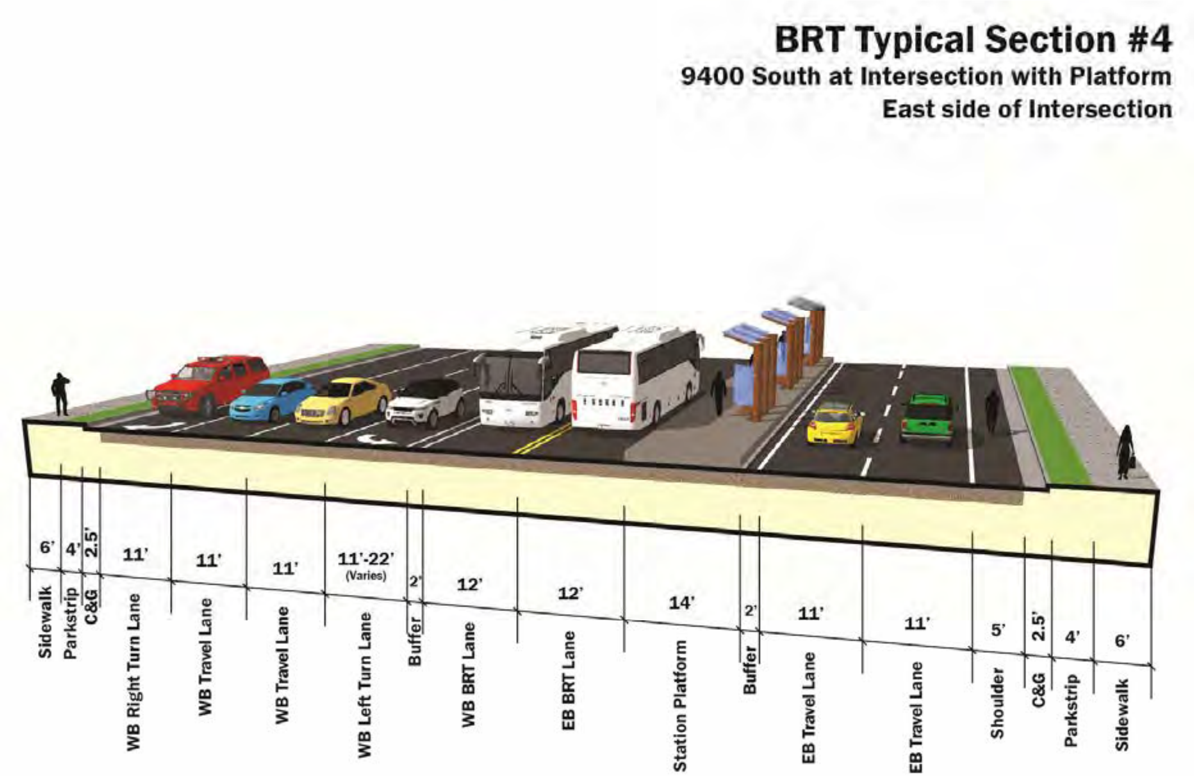
BRT Typical Section #2

9400 South with One Travel Lane



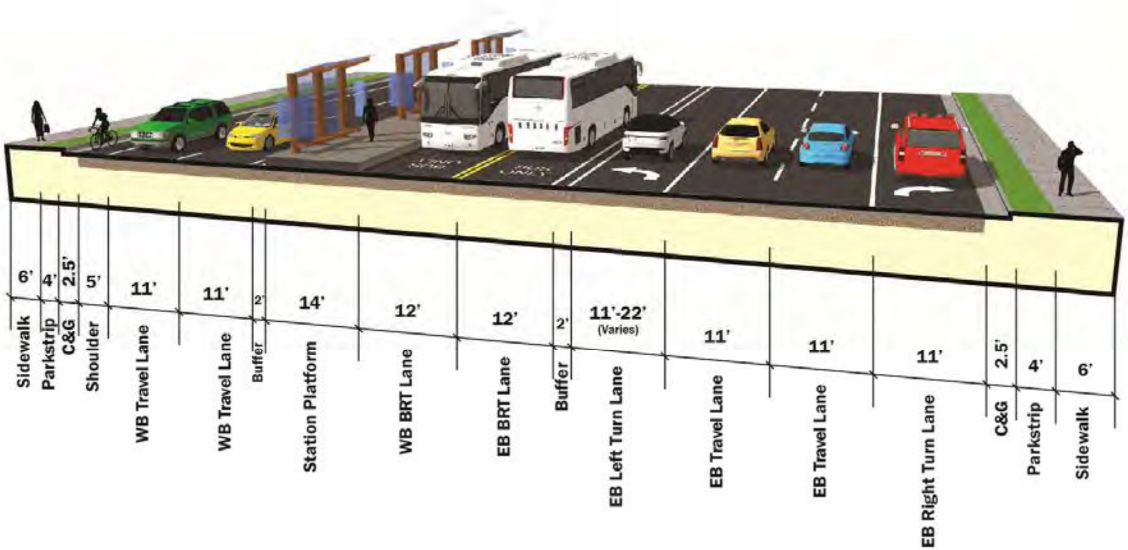

BRT Typical Section #3
9400 South with Two Travel Lane
6'
Sidewalk
4'
Parkstrip
2.5'
C&G
5'
Shoulder
11'
WB Travel Lane
11'
WB Travel Lane
2'
Buffer
12'
WB BRT Lane
℄
12'
EB BRT Lane
2'
Buffer
11'
EB Travel Lane
11'
EB Travel Lane
5'
Shoulder
2.5'
C&G
4'
Parkstrip
6'
Sidewalk

Mountain Accord



BRT Typical Section #5

9400 South at Intersection with Platform
West Side of Intersection



BRT Typical Section #6

Little Cottonwood Canyon

Appendix F: Sample Cross Sections of Cog Rail Alternative

MOUNTAIN ACCORD

Light Rail Transit Section 1
10200 South Bridge (Over Railroad Tracks)