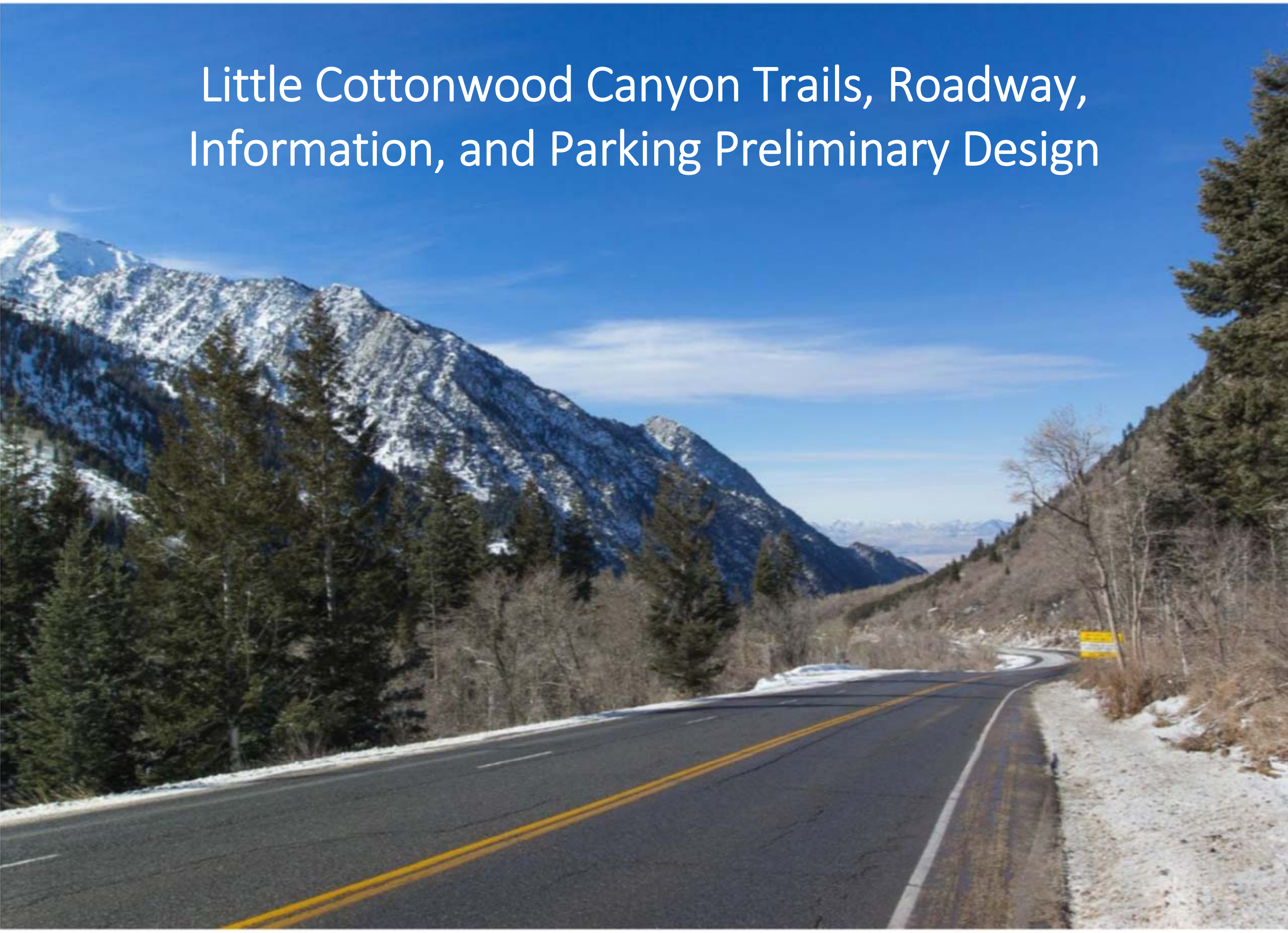
Department of
CIVIL & ENVIRONMENTAL ENGINEERING
THE UNIVERSITY OF UTAH

Little Cottonwood Canyon Trails, Roadway, Information, and Parking Preliminary Design



Bringing transportation diversity, information, and safety to LCC

Prepared for Granite Community Council
by Student Engineering Associates

CVEEN 4910 Professional Practice and Design [Spring 2018]
Department of Civil and Environmental Engineering
The University of Utah

PROJECT TEAM LETTER

Dear Granite Community Council,

The Student Engineering Associates (SEA) from the University of Utah Civil and Environmental Engineering Department are delighted to present the Little Cottonwood Canyon Trails, Roadway, Information, and Parking (TRIP) Preliminary Design Report to the Granite Community Council (GCC).

Vision Statement

We envision Little Cottonwood Canyon (LCC) to remain a natural and captivating destination for people with diverse interests and hobbies to safely experience Utah's Wasatch Mountains. We believe this will be accomplished by protecting the Canyon's sensitive ecosystem and by minimizing the footprint of future transportation systems operating within its boundaries. We hold that these goals can be accomplished while maintaining the vitality of nearby communities. We propose to accomplish this vision through the introduction of intelligent transportation systems (ITS); automated vehicle networks (AVN); improved avalanche control and mitigation features; and additional roadway, pedestrian, and cyclist safety improvements to the Canyon.

Limitations of Study

During our 16-week semester, our team provided an academic effort for development of the TRIP Feasibility Study (FS) and this Preliminary Design Report. Each of the reports were presented to the client and the public was welcomed to attend. With endless amounts of research, meetings, and conversations with our academic mentors, SEA has developed these documents to the best of our ability. There are several ideas for transportation solutions for LCC that have been suggested; however, SEA is unable to look at every possible alternative. We attempted to include alternatives and features that we believed could make the most difference in LCC and that the GCC deemed essential. Considering all limitations, we believe that the FS and Preliminary Design Report will provide new alternatives or previously presented alternatives shown in a different perspective that the GCC can help suggest for implementation in the near future.

Appreciation

The SEA is very grateful to the GCC for all the help they have provided us, and for giving us this opportunity to gain experience on such a complex transportation system. We would also like to thank Utah Department of Transportation (UDOT), Utah Transit Authority (UTA), HDR Consultants, United States Forest Service, the Town of Alta, and the Central Wasatch Commission (CWC), for providing us with prior studies, presenting to our class, or providing information necessary to complete this study.

Sincerely,

Student Engineering Associates

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EXECUTIVE SUMMARY

The Utah Department of Transportation is currently conducting an Environmental Impact Statement that is exploring a range of solutions to improve safety and access to the Little Cottonwood Canyon. We, the Student Engineering Associates of the University of Utah, have been retained by the Granite Community Council to explore and analyze potential solutions for lengthy traffic jams that have plagued their community, particularly on heavy ski-traffic days. We quickly concluded that scope and extent of the issues are significant and widespread; hence they need to be address in a comprehensive manner. The significant roadway and operational issues extend beyond Little Cottonwood Canyon Road (i.e., SR-210) and include parking at the ski resorts and the transportation and parking systems that are found within the Salt Lake Valley.

There appears to be three main causes for most of the congestion events:

- Excess traffic on SR-210 during peak snow days creates a “jam”
- Additional delays and backing when available and coordinated parking at the ski resorts is exhausted; hence the remaining vehicles select ad hoc, unsafe and illegal parking
- Periodic closure of SR-210 for avalanche cleanup or routine snow removal

These issues can be summarized as: (1) the current roadway system does not have sufficient capacity at peak times due to demand primarily from private vehicles, (2) there is inadequate in-Canyon parking for such vehicles once they arrive, causing further delays and backing, and (3) adverse weather conditions (i.e., large snowfall events) and other roadway and parking operational issues often result in Canyon closures, often when demand is high.

Regarding (1) above, a potential solution offered by some parties is the potential widening of SR-210 to incorporate a continuous “flex lane” throughout much of the Canyon. However, we believe that such widening would require a minimum of three lanes and would be not only very costly, but also would not be the best solution. For example, the option of improving traffic movement and flow up the Canyon would not alleviate the parking, congestion and other over usage and environmental issues within the Canyon (e.g., unsafe parking outside the designated parking lots, trails, pullouts etc.).

Regarding (2) above, there are estimated to be a total of 4,600 designated (safe) parking spaces between the two ski resorts. However, as many as 6,600 vehicles have been observed on the busiest days: and this is clearly a primary cause of congestion (as drivers seek a place to park), and in our opinion, is an unsafe situation. To put it simply, there are too many vehicles competing for limited accommodations. To expand in-canyon parking would require modifications to the resorts’ master plans with the associated permitting and approvals; may cause impacts to the quality of the watershed and aesthetics of the Canyon; and may not protect, preserve, and enhances the historic, cultural, and natural resources of the Canyon.

Instead, we believe a better solution would be to provide a safe, convenient, and comfortable 21st-century, mass transit system using public-private partnerships. This would allow many visitors access to the Canyon's amenities without the need of using personal vehicles. Such a system must be efficient and user friendly so that future visitors will be favorably inclined to utilize transit options. Nonetheless, limiting the number of personal vehicles accessing the Canyon will require significant changes in visitor behavior. And to make those changes as painless as possible, convenient, adaptable and comfortable transit options will be a necessity. What would be required? We believe there are four components to an effective system. (Note the usage of "effective system" implies a re-thinking of Canyon access rather than incremental modifications to the status quo.) These components are: (1) modernization of the transit system operating within an near the Canyon, (2) implementation of user fees, via variable tolling, and (3) construction of avalanche mitigation (i.e., snow sheds, etc.) and other parking lot egress/ingress improvements.

Regarding (1), our most forward-looking recommendation is that the use of autonomous vehicles (intelligent vehicles) be researched and ultimately incorporated into the overall transit system. These vehicles might effectively be 6- to 10-passenger vans, driver-assisted or ultimately driverless. Vehicle-to-vehicle (V2V) communications could facilitate clustering, such that a platoon of these vehicles could coordinate and operate as "mini-trains" or convoys, effectively increasing Canyon vehicular capacity and reducing roadway congestion. Further, these autonomous vehicles could function at every trip stage: home pickup, park-n-ride lots pickup, or major hub pickup. This would be very advantageous and convenient for Canyon visitors, making the use of mass transit options an efficient, predictable pleasure and augmenting their overall Canyon experience.

In addition, we propose a comprehensive "know before you go" information system for the Canyon. This would allow potential Canyon visitors vital information regarding their transit and recreational activities and choices including current canyon conditions, potential tolls (if they were to drive personal vehicles), ride-share opportunities, mass transit locations and schedules, and hub parking, etc. We envision that perhaps some visitors might book a parking place at one of the destinations before departure. Further, they might even be inclined to schedule home pickup from a transit van or from a rideshare buddy. These features could be made available on handheld devices; the technology is already available, but the information system(s) have not been integrated.

Regarding (2), a concept that appears to be growing in public support is that of implementation of user fees via roadway tolling. Variable user fees assessed according to vehicle occupancy and peak congestion times can not only improve the efficiency of the roadway but be a means for funding future improvements and operations. Our evaluations suggest that some method of discouraging low occupancy vehicles will be a necessity to alleviate congestion during peak flow events. We have therefore proposed a variable tolling system that could impose fees based on ridership (number of persons per vehicle), traffic conditions, seasonal factors, day-of-the-week, etc. In addition, we recommend that revenues be reinvested in projects and operations within the Canyon. Hence, money collected for use of LCC would stay in LCC. We have also found that current tolling technology is adequate to determine the type of vehicle, its owner, the number of persons in the vehicle, and all the other variables needed to assign a variable toll.

Regarding (3), we believe to reduce, if not almost eliminate Canyon closures and improve safety, avalanche sheds at key locations will be a must. Such structures can divert avalanches over the top of the highway. In addition to improving ingress and egress from current parking lots, especially at Snowbird, grade separations with automated traffic control devices are recommended. Such underpass (i.e., tunnel) features can eliminate roadway conflicts created at parking lot entrances and exits by allowing more free flow. In addition, traffic control devices, lane separations and metering could be implemented to give priority to high occupancy vehicles. In addition, increasing the available equipment for snow removal and staging, thus expediting the opening of SR-210 after large snow events, is important.

As part of the solution, we recommend a management group to coordinate public use and safety operations: a Coordinated Cottonwood Canyons Resource Team (CCCRT). The Central Wasatch Commission is specifically mentioned as a potential parent entity for creating and administering the CCCRT.

In summary, we envision that the successful implementation of these recommended changes, systems and safety features will allow Little Cottonwood Canyon to continue to provide a natural and inviting destination for people with diverse interests and hobbies to safely experience Utah's Wasatch Mountains. We believe this can be accomplished by protecting the Canyon's sensitive ecosystem and by minimizing the footprint of future transportation systems operating within the Canyon boundaries.

ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act of 1990
AI	Artificial Intelligence
app	Application
ASCE	American Society of Civil Engineers
AV	Autonomous Vehicle
AVN	Automated Vehicle Network
B2C	Business-to-Consumer
BCC	Big Cottonwood Canyon
Blvd.	Boulevard
Canyon	Little Cottonwood Canyon
CCCRT	Coordinated Cottonwood Canyon Resource Team
CNS	Courier Network Services
CWC	Central Wasatch Commission
DSRC	Dedicated Short Range Communication
FHWA	Federal Highway Administration
Forest Service	United States Forest Service
GB	Green Book
GCC	Granite Community Council
GPS	Global Positioning System
HOV	High Occupancy Vehicle
ICS	Incident Command System
ITS	Intelligent Transportation System
IVT	Intelligent Vehicle Technology
LCC	Little Cottonwood Canyon

LIDAR	Light Detection and Ranging
MA	Mountain Accord
mph	Miles per hour
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
P2P	Peer-to-Peer
P&R	Park and Ride
SAE	Society of Automotive Engineers
SB 71	Senate Bill 71
SB 277	Senate Bill 277
SEA	Student Engineering Associates
sec	Second
SG	Signal
SR-209	State Route 209 (S. Little Cottonwood Rd.)
SR-210	State Route 210 (N. Little Cottonwood Rd.)
TMS	Transportation Management System
TNC	Transportation Network Company
TRIP FS	Little Cottonwood Canyon Trails, Roadway, Information, and Parking Feasibility Study
UDOT	Utah Department of Transportation
UFA	Unified Fire Authority
UPD	Unified Police Department
UTA	Utah Transit Authority
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
Valley	Salt Lake Metropolitan Valley
VC	Visitor Center
VMS	Variable Messaging Sign

GLOSSARY

Autonomous Vehicle	Autonomous vehicles (AV) have been built by companies that can navigate existing roads with almost no human input. The connected vehicle systems use wireless signals, digital imagery, global positioning system (GPS), and light detection and ranging (LIDAR) to relay informational data between other vehicles, roadside infrastructure, and other modes of transportation (pedestrians, bikes, etc.).
Intelligent Transportation System	The intelligent transportation system (ITS) is an advanced application that provides innovative services to differing modes of transportation and the overall traffic management system. This technology allows traffic to be more coordinated and safer, thus making transportation networks more efficient.
Multimodal Transportation Hub	A location where passengers and cargo are exchanged between vehicles or between transportation modes. This report uses a hub to bring common users – LCC visitors – to a location that allows them to leave their personal vehicle to get into a different mode of transportation – bus, shuttle, or other high occupancy.
Network	Little Cottonwood Canyon Network, consisting of SR-209, SR-210, infrastructure features (e.g., UTA Park and Ride lots, intersections, signage, pullouts, etc.)
Roadway	S. Little Cottonwood Rd. (SR-209) and N. Little Cottonwood Rd. (SR-210) join near the mouth of LCC and SR-210 becomes Little Cottonwood Rd.
System	Little Cottonwood Canyon System, consisting of Network and roadway users (e.g., vehicles, bicyclists, pedestrians, etc.)

1.0 INTRODUCTION

This document summarizes potential improvements to increase safety and awareness in Little Cottonwood Canyon (LCC), Utah, and to decrease congestion within the associated transportation network. Before this report, SEA developed the TRIP Feasibility Study, which is presented as Appendix A. Reference the TRIP FS for additional background information and existing conditions within LCC.

LCC is located near the southeast corner of Salt Lake County in Utah. This Canyon is located within the Wasatch Mountains bordered by Twin Peaks Wilderness and Uinta-Wasatch-Cache National Forest (National Forest) to the north, the Town of Alta and National Forest to the east, Lone Peak Wilderness, National Forest, and Little Cottonwood Creek to the south, and the Salt Lake Metropolitan Valley (Valley) to the west. The unincorporated community of Granite includes all of LCC, except for the Town of Alta. The transportation route serving this Canyon is a convergence of 9400 South, which becomes S. Little Cottonwood Rd., and Wasatch Boulevard (Blvd.) to State Route 210 (SR-210), also referred to as Little Cottonwood Canyon Road (Figure 1). SR-210 provides an access route for Canyon visitors to reach destinations, which allow them to enjoy various recreational activities, such as hiking, climbing, skiing, snowboarding, biking, running, and shopping within LCC. In addition to recreational Canyon visitors, SR-210 provides access for residents to reach their year-round homes, employees to reach resorts, and tourists and residents to reach restaurants and other businesses.

For purposes of this study, the transportation network (Network), municipalities and other recreational features considered are:

- Salt Lake Metropolitan Valley
  - Park and Ride Parking Lots; and
  - Roadways: 9400 South (SR-209) and Wasatch Blvd. (SR-210).
- SR-210
  - Parking Areas;
  - Trailheads;
  - Campgrounds;
  - Ski and Snowboarding Resorts;
  - The Bypass Road; and
  - The Town of Alta.

The roadway users consist of vehicles, buses, vans, bicyclists, and pedestrians that must be accommodated in the Network; thus, this becomes the transportation system (System) and its potential users.

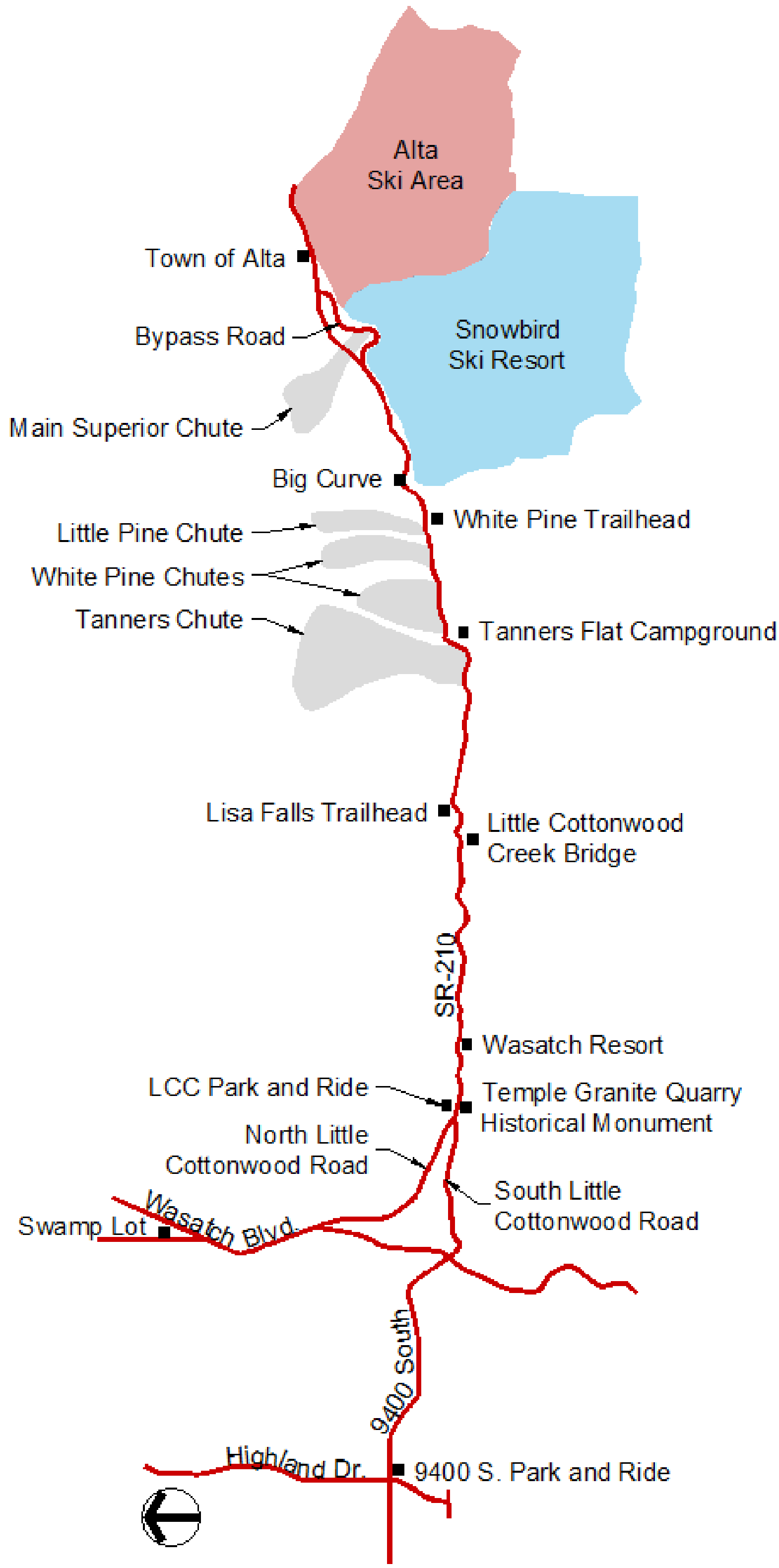


Figure 1 – Little Cottonwood Canyon System

2.0 STATEMENT OF NEEDS

The transportation system in and around LCC is suffering from severe congestion, especially during peak snow days and holiday weekends when many visitors are trying to access the Canyon. Congestion and severe weather events have caused significant delays (at times up to several hours) in accessing and traveling within the Canyon. The subsequent traffic backup in roadways and residential streets near the Canyon has greatly frustrated residents to the point where they feel "trapped" in their own homes, unable to leave their driveways. More extreme cases have involved children missing school because school buses have not been able to reach their driveways. Therefore, it is understandable why residents of the Granite Community have long been frustrated with this given situation, and without future planning and significant improvements, these conditions will only worsen.

Figure 2 – Two lanes of LCC traffic backed up to Fort Union Blvd [1]

For example, Figure 2 shows traffic along Wasatch Blvd. with backing to Fort Union Blvd., which is approximately 4 miles from the convergence of 9400 South and Wasatch Blvd. near the mouth of LCC [1]. The two lanes of traffic shown in this photo are forced to merge in approximately 0.75-miles, followed by another merge at the mouth of the Canyon with 9400 South Street.

In addition, roadway closures in the Canyon and at its mouth have caused significant delays in accessing the Canyon as shown in Table 1. According to information gathered from UDOT's Avalanche Control Team during the 2016/2017 winter season, LCC ski and snowboard visitors experienced 28 roadway closures, causing 80-hours of traffic delay. These roadway closures appear to be a major source of congestion that delays access to the Canyon and contributes to major traffic backups on 9400 South (SR-209) and Wasatch Blvd. (SR-210). Unfortunately, any congestion that causes vehicular traffic to become slow or stopped increases the risk of avalanche injury or death, impedes emergency response access, and diminishes the recreational experience in LCC.

Table 1 – SR-210 road closures impacting ski and snowboarding traffic (2016/2017 winter season)

	Snowbird Village		**Mid Canyon**		**Highway 210**		**TOTALS**	
	# of Closures	**Time (hours)**	**# of Closures**	**Time (hours)**	**# of Closures**	**Time (hours)**	**# of Closures**	**Time (hours)**
November 2016	-	-	-	-	1	1.5	**1**	**1.50**
December 2016	1	0.5	1	1.25	2	4.5	**4**	**6.25**
January 2017	4	1.5	2	3	6	31.25	**12**	**35.75**
February 2017	1	0.5	2	6.5	5	23.25	**8**	**30.25**
March 2017	-	-	2	4	1	2.25	**3**	**6.25**
April 2017	-	-	-	-	-	-	**-**	**-**
May 2017	-	-	-	-	-	-	**-**	**-**
							28	**80.00**

Source: UDOT

In addition, future growth would add to congestion of the Canyon if management and future improvements do not accommodate such growth. For example, the Forest Service estimates a 2% annual increase (not compounded) (i.e.,1.4 percent compounded) for the Canyon. Thus, in 50-years, the Forest Service projects that LCC would experience a doubling in the number of users. Therefore, we estimate that present 12,400 visitors may increase to approximately 24,800 visitors by 2068.

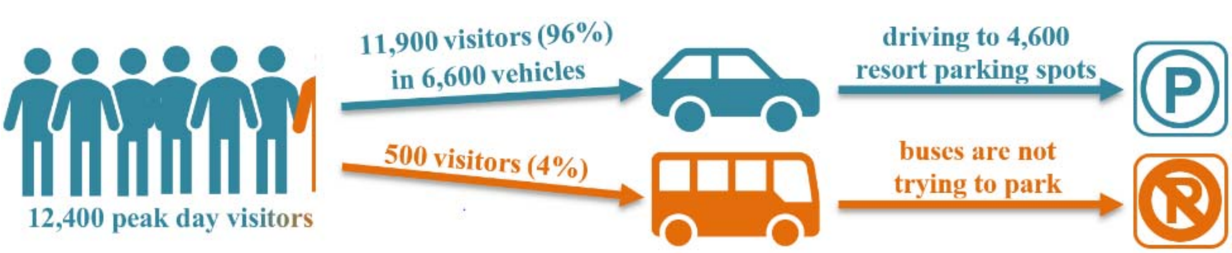


Figure 3 – Visual representation of present day Canyon visitors, their preferred transportation method, and the number of parking spaces at resorts

Further, the way people access the Canyon (e.g., car, van, bus, etc.) has a significant impact on congestion. Currently, the average vehicle occupancy is relatively low. For example, of the estimated 12,400 daily visitors, only 500 are using buses and 11,900 are traveling in personal vehicles. Therefore, on a daily average, there are about 1.8 occupants per vehicle, consisting of approximately 6,600 vehicles accessing the Canyon. If this behavior continues to 2068, there would be 13,200 vehicles trying to enter LCC daily. This is unsustainable growth, both in terms of roadway and in-Canyon parking capacity, unless timely and prudent countermeasures are taken. Obviously, this behavior must change to accommodate eco-friendly and sustainable growth within the Canyon.

Lastly, the mix of users recreating in the Canyon and seasonal demands are changing. Non-skier use (e.g., pedestrian, hikers, joggers, climbers, cyclists, bird watchers, picnickers, snowshoeing, etc.) is significantly increasing and could continue to place new demands on the roadway and parking systems of the Canyon. These demands introduce the potential for vehicular-pedestrian or vehicular-cyclist accidents on the roadway and its shoulders. For example, informal or unsafe vehicular parking on roadside shoulders exposes cyclists and pedestrians to significant traffic risks due to the narrow and dangerous shoulders of the Canyon.

3.0 VISION STATEMENT

We envision Little Cottonwood Canyon to remain a natural and captivating destination for people with diverse interests and hobbies to safely experience Utah's Wasatch Mountains. We believe this could be accomplished by protecting the Canyon's sensitive ecosystem and by minimizing the footprint of future transportation systems operating within its boundaries. We hold that these goals can be accomplished while maintaining the vitality of nearby communities. We propose to accomplish this vision through the introduction of intelligent transportation systems (ITS); automated vehicle networks (AVN); improved avalanche control and mitigation features; and additional roadway, pedestrian and cyclist safety improvements to the Canyon.

4.0 APPROACH

As the population in and around the Wasatch Canyons continue to grow, stewards of these lands will need to manage them responsibility for long-term environmental prosperity. Although not all components of this vision have a preliminary design and been presented in this Report, we believe they should be developed farther for the overall benefit of the Canyon. This vision was developed from community responses, the Forest Service, the Salt Lake County Wasatch Plan, and long-term visions from SEA. SEA understands the interconnectedness between LCC and Big Cottonwood Canyon (BCC), and we believe similar visions may exist in both Canyons. Since our study duration lasted 16 weeks, we did not have the resources to develop this relationship and provide suggestions for both Canyons.

4.1 MANAGED CANYON FOR THE FUTURE

Coordination with the Forest Services has allowed us to provide a vision for the following ideas: visitor center and recreation site amenities, toilet facilities, potable water, law enforcement, trail maintenance, watershed protection and education, parking, and new trails and trailheads. Responses from the community has allowed us to provide a vision for user fees to help reduce traffic congestion and give back to the People's Canyon. Review of Salt Lake County's Wasatch Canyons General Plan has allowed us to provide a vision that aligns with shared values for the following: land use, environment, recreation, transportation, and economy. Through our University mentors, UDOT, and our individually generated ideas, we have provided a vision for the Canyon's future connection to intelligent information systems.

4.1.1 COORDINATED COTTONWOOD CANYON RESOURCE TEAM

To bring a coordinated Canyon to visitors, it is vital for agreements across jurisdictions, governmental agencies, Canyon residents, Canyon visitors, and businesses to be in place for the overall success of LCC. In some circumstances, agreements between UDOT and UTA or UDOT and the Forest Service are needed to allow user fees to be generated by UDOT and reciprocated back to other entities for their management of this coordinated Canyon. Additionally, businesses within the Canyon should help foster a "more visitors, less vehicles" motto for the Canyon to help retain its natural beauty. Canyon visitors also have the responsibility to develop behaviors that align with preserving the Canyon for future visitors.

After discussions with several entities, we believe the Canyon needs a non-affiliated team – both politically and economically – to provide special services to the entire Canyon System, namely the Coordinated Cottonwood Canyon Resource Team (CCCRT). This team could be structured as a non-profit, and funding through grants could also help generate funding for the needs of the Canyon. We believe the CCCRT would provide the following services for the Canyon System:

- Development and implementation of the ITS interface that provides the Canyon visitor with necessary traffic information, stewardship opportunities, weather information, and other Canyon-appropriate information;

- Development and implementation of the Incident Command System (ICS) during Canyon roadway management between multiple agencies;

- Management of the Public Stewardship Program that fosters Canyon education and provides an opportunity for visitors to obtain the Cottonwood Recreational Pass; and

- Development and maintenance of the National Forest Service existing trails and proposed trails within the Canyon.

To ensure a quality control and quality assurance organization of this entity, a Board comprised of representation from varying jurisdictions would be developed. At a minimum, this Board would include: UDOT, the Town of Alta, UTA, United States Forest Service (Forest Service), Unified Police Department (UPD), Unified Fire Authority (UFA), Salt Lake County, environmentally conscious agencies, and businesses within the Canyon. It is anticipated that an agreement between these representatives – for the benefit of the Canyon – would be signed as an initiative to the Coordinate Cottonwood Canyon Resource Team's formulation. Although these entities would still operate within the Canyon with their current functions, we believe certain roles needed within the System require a non-affiliate team to operate them.

Many of the concepts presented in this report were formulated after our having reviewed the recommendations of the Mountain Accord Program. Additionally, the Mountain Accord Program Manager, Laynee Jones, attended a session of CVEEN 4910, providing us with immensely valuable insights and information about the program, its results, and its most significant recommendation: the formation of the Central Wasatch Commission (CWC). Specifically:

> The Central Wasatch Commission (CWC) [be] formed as an interlocal agency and a political subdivision of the State of Utah. The CWC will formalize collaboration and streamline decision-making among the multiple jurisdictions with authorities in the Central Wasatch Mountains.

It is apparent that the CWC, now that it has been formed and is operational, could effectively server as the parent entity for the Coordinate Cottonwood Canyon Resource Team.

4.1.1.1 COTTONWOOD CANYON VISITOR INFORMATION

The ITS, described in Section 7, would have the ability to communicate necessary Canyon information through a user interface to the Canyon visitor. The visitor would obtain information through a single online resource, which could be accessed through an application or website, called the user interface. Information describing the interface would be described in depth in a later section. At a minimum, the user interface would include the following:

- Parking availability in the Salt Lake Valley and within the Canyon;
- Coordination between Canyon visitors and shuttle services to provide high occupancy vehicles accessing the Canyon;
- Information directly from the Incident Command System regarding transportation;
- Opportunities with the Public Stewardship Program to obtain the Cottonwood Recreational Pass; and
- Trail information within the Canyon and ways to proposed new trail ideas or trail maintenance needs.

The CCCRT would manage the user interface and would be funded by the Cottonwood Recreational Pass. Although several components of the above-mentioned information already exist, the user interface would bring all components necessary for Canyon visitation into a single, online location; this would provide information for the tourist and convenience for the local neighborhoods. Therefore, existing entities that currently provide information to the public would continue, and this interface would bring those together and additional Canyon-specific information would be included that does not exist today. This interface would remain dynamic and provide necessary information through the life of this design.

4.1.1.2 INCIDENT COMMAND SYSTEM

The Incident Command System was developed to provide a standardized approach between multiple agencies responding to an emergency. Although originally developed to support firefighting activities, several disciplines have adopted the ICS to manage emergencies, planned events, natural disasters, and acts of terrorism. The ICS lends itself to support the transportation efforts on SR-210. As mentioned in the TRIP FS, entities that help operate and maintain the System include: UDOT, Town of Alta, UPD, Forest Service, UFA, UTA, Alta Ski Area, and Snowbird Ski Resort. These entities meet monthly in Alta to discuss specific operations and maintenance that occur to support SR-210 traffic. Although a non-formalized organization of their response activities may already be in place, we believe a non-affiliated entity could facilitate the five major functional areas: command, operations, planning, logistic, and finance and administration. This entity would have the ability to communicate directly through the intelligent transportation system and dynamic traffic messaging systems leading to the Canyon and along SR-210 to convey immediate Canyon information to the public. A hierarchy chart showing the relation between command and the other functional areas is shown in Figure 4.

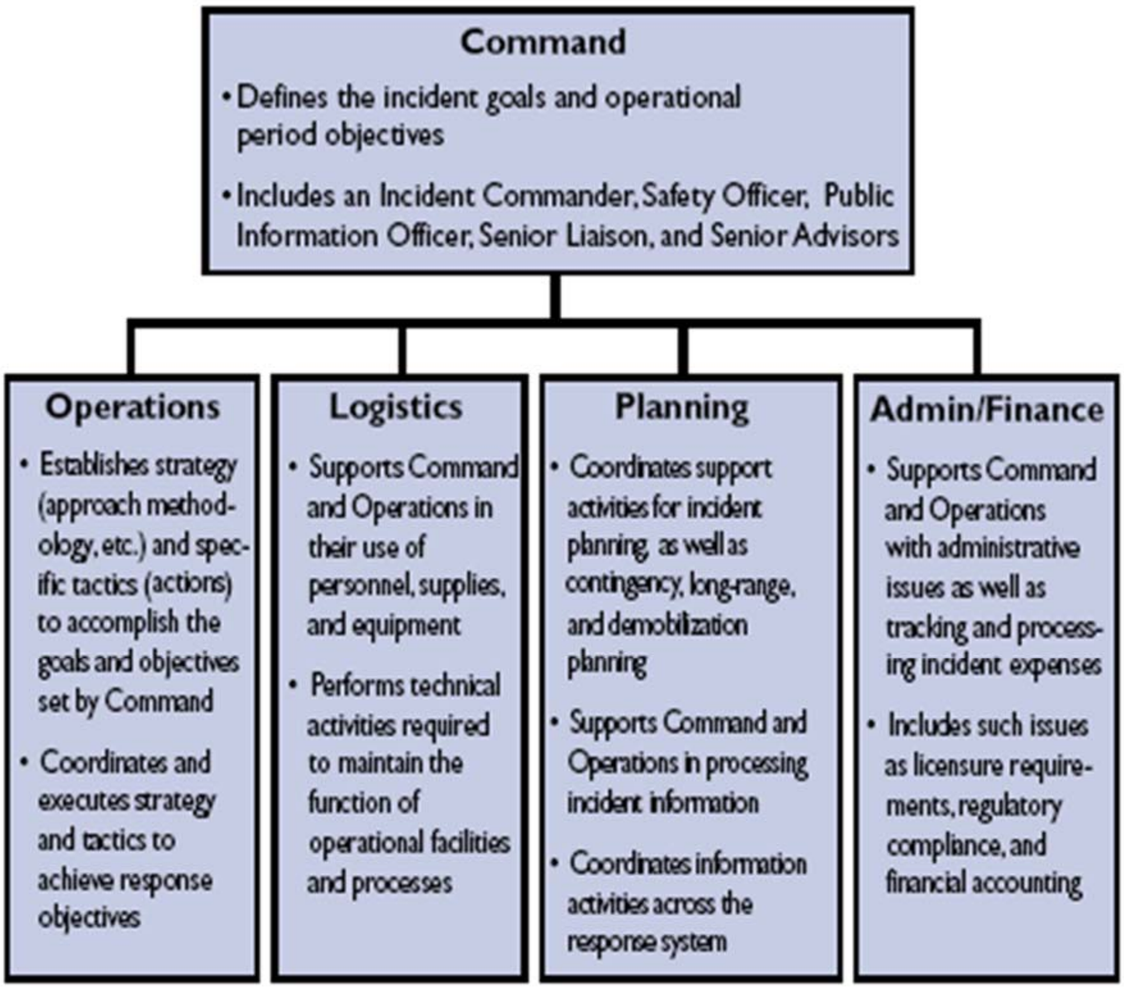


Figure 4 – Incident Command System [2]

We believe a structurally developed operations and maintenance team would provide the coordinated Canyon with necessary facilitation to offer efficient operations. Funding for this entity would come from the Cottonwood Recreation Pass.

4.1.1.3 PUBLIC STEWARDSHIP PROGRAM

Regarding environment, the Salt Lake County’s Wasatch Canyons General Plan states: “Collaborate with public and private entities to support clean watersheds, biodiversity, healthy forests, and resilient landscape.” We believe this could be fostered through stewardship, outreach, and educational programs that would allow Canyon visitors the opportunity to:

- Provide trail maintenance;
- Remove invasive species;
- Restore informal and unsafe parking stalls to their pre-disturbance natural setting;
- Guide hikes with an educational focus;
- Provide winter snow removal services at Forest Service sites;
- Plant trees;
- Complete community outreach; or
- Clean-up along SR-210, at Lisa Falls, at Tanners Flat, or other recreational sites.

The Public Stewardship Program would be offered in exchange for an annual user access pass, the Cottonwood Recreational Pass, to the Canyon should they choose to provide a service for their pass. The above-mentioned opportunities would help support:

- The efforts of: Friends of Alta, Save our Canyons, and Cottonwood Canyons Foundation;
- Years of trail maintenance backlog for the Forest Service; and
- The Canyon visitor's educational need for long-term responsible use within the Canyon.

This Public Stewardship Program would need program coordination, field oversight, management of the Canyon visitor's time spent contributing to the Canyon, and an agreement between the Public Stewardship Program and UDOT to allow funds to flow from the Cottonwood Recreational Pass back to the Program's Canyon-specific sustainable efforts. Program opportunities would be communicated through the intelligent transportation system interface.

Figure 5 – Individual contributions lead to comfortable recreational experiences

Regarding community, the Salt Lake County's Wasatch Canyons General Plan states: "Support quality planning and zoning that encourages social and community relationships, healthy lifestyles, and public safety." As mentioned above, the Public Stewardship Program can provide these opportunities that would lead to community relationships and provide experiences that foster a healthy relationship with the Canyon's pristine beauty for generations to come.

4.1.1.4 NATIONAL FOREST SYSTEM TRAILS

The Forest Service has expressed an interest in collaborating with an entity that could provide the following types of services:

- Create inventory, assess purpose, and assess needs of existing trails;
- Determine how the Forest Trail System integrates with trails on surrounding jurisdictions;
- Generate proposed trail ideas from user groups;
- Evaluate proposed trails through the National Environmental Policy Act (NEPA); and
- Implement new trails into the Forest Trail System as determined necessary and beneficial.

The trails master plan would be implemented by this non-affiliated entity in collaboration with the Forest Service. This entity would have the ability to send trail-related information to the intelligent transportation system interface and Canyon visitors would receive communication regarding new trails, new features at trailheads, upcoming trail maintenance, and requests for trail proposals. This entity would receive funding through the Cottonwood Recreational Pass.

Regarding regulatory tools, the Salt Lake County's Wasatch Canyons General Plan states: "Maintain zoning that allows development in appropriate areas and preserves lands for watershed, recreation, scenic value, and wildlife." This vision can be accomplished through the non-affiliated entity described above. For instance, review of recreational needs that are implemented with watershed protection and preservation of wildlife habitat could be engrained in proposed development.

4.1.2 ADDITIONAL CANYON FEATURES

In addition to the management structure, we envision several other features being implemented to provide safer roadways, education, stewardship, comfortable and convenient recreational experiences, and responsible reductions of environmental impacts to LCC. The features described in the following section have been allocated a dollar value within our financial model.

4.1.2.1 VISITOR CENTER AND CANYON EDUCATION

To continue fostering education within the Canyon, we believe a visitor center near the mouth of LCC would make a great welcoming to the entrance of our Canyon. LCC is a magnificent natural resource, with unprecedented accessibility, recreation, and educational opportunities leading this vision to become a venue that showcases these resources and to educate users on its protection and value. This visitor center would also serve as a location for mass transportation and an Americans with Disabilities Act of 1990 (ADA) accessible trail leading into the Canyon. Additionally, amenities at individual recreation sites would serve to educate and enhance user recreation experiences. Such amenities may include, but are not limited to, intelligent information kiosks, trash receptacles/service, picnic tables, toilet facilities, and potable water.

In addition to the education that would be provided at the visitor center, Forest Service personnel actively reaching Canyon visitors on trails and in recreational areas would greatly increase awareness in the Canyon. The focus of two Forest Service Wilderness Stewards would be to:

- Educate public on importance of watershed protection and why dogs are not allowed in the watershed;
- Permit more physical presence in the Canyon to educate users and enforce protection measures;
- Patrol trails and recreation areas within the Canyon, while interacting and educating forest users; and
- Help organize wilderness stewardship activities and present to groups such as scouts, campers, church groups, and schools about the importance of “leave no trace” and how to manage campsites after using a campfire.

As mentioned previously, this study does not account for other canyons along the Wasatch Front and a visitor center more centrally located may better serve all canyons.

4.1.2.2 PARKING

Except for new parking at the visitor center, SEA believes that management of existing safe parking stalls within the Canyon should be maintained and not developed farther.

We believe a non-parking initiative should be encouraged along with a focus on high occupancy vehicles traveling to desired destinations on designated routes or dynamic destination drop-offs that fit the Canyon visitor's needs. Present day safe parking stalls include existing paved surfaces located on Forest Service land, at resorts or near the mouth of the Canyon. Informal and unsafe parking stalls developed by Canyon visitors would be restored to their pre-disturbance condition, while the invasive species that have settled into these areas would be eradicated prior to replanting of a native high desert mountain seed mix approved by the Forest Service. Signage would be placed in these areas to communicate the restoration efforts and fines associated with violations.

Forest parking areas are closed in the winter due to limited Forest Service resources for snow plowing and associated facility operations and maintenance (e.g., toilets). Due to the harsh mountain environment, parking areas also require significant summer maintenance, such as repaving, sealing, and striping. Additionally, accessible pathways must be maintained from accessible parking stalls to nearby trailhead facilities. The Public Stewardship Program lends an opportunity to local snow removal companies to provide donated services in exchange for Cottonwood Recreational Passes that could be awarded to employees. Winter snow removal would include surface lot removal and manual removal around trail facilities, such as toilets and kiosks.

4.1.2.3 UTILITIES: POTABLE WATER AND TOILET FACILITIES

Many sites within the Canyon have inadequate toilet facilities due to increasing demand, aged infrastructure, and limited Forest Service resources for operations, maintenance, and capital improvements. Due to the cost of operations and maintenance, lack of water and sewer at some sites, lack of electricity (for heating), and the hardship of potential year-round operation at some Forest recreational sites, the Forest Service typically installs vault toilets. Additionally, the Forest Service does not maintain water rights within the Canyon; therefore, they cannot accommodate the expense to provide and maintain potable water at recreation sites for drinking or hand-wash sinks. However, through funding by the Cottonwood Recreational Pass, potable water, sewer, and electricity could be installed at recreational sites. These utilities would allow for flush toilets at the recreational sites.

Several considerations are necessary for the implementation of these utilities:

- Toilet Facilities
  - Utah Code and Salt Lake County requirement of mandatory connection to sewer for toilets within 300-feet of sewer line.
  - Water requirement and source/cost for flush systems (also see issues under Potable Water, even though flush toilets may be operated with non-potable water). The Forest Service does not possess water rights within the Canyon.

- Ongoing operations and maintenance funding, including cleaning/repair staff, utilities, snow removal, etc.

- Potable Water
    - Source, water rights/utility payment, regular testing if spring/well source, infrastructure maintenance, insulation/heating in winter (if kept available in winter months).

Regarding these facilities, the Salt Lake County's Wasatch Canyons General Plan states: "Provide support through grants and/or other funding revenues for recreational facility maintenance, trailheads, and restrooms." This vision lends itself to a collaboration opportunity between the Forest Service and Salt Lake County's funding streams. As mentioned above, the CCCRT could function as a non-profit and receive grant funding for these facility needs as well.

4.1.2.4 LAW ENFORCEMENT

Implementing safety improvements for the transportation system on snow days is a vital part of reducing the congestion at the mouth of the canyons. On snow days, LCC regularly requires vehicles to be prepared for traveling within the Canyon; typically, with chains for 4-wheel drive. Therefore, enforcement for these restrictions is needed and additional law enforcement resources are necessary. LCC needs the space available for vehicles to pull over and be prepared for the Canyon prior to the mouth of LCC. We envision a section of Wasatch Blvd. and 9400 South that would have designated areas with a large enough chain-up areas for law enforcement to patrol and Canyon visitors to prepare their vehicles for the Canyon's snowy conditions. We recognize that technology may become available during the next 50-years that could sense a vehicle's Canyon-readiness and identify canyon residents or other users with special access or needs.

Due to limited resources, the Forest Service has insufficient law enforcement personnel to patrol and protect all parts of the Canyon. The Forest Service has developed partnerships with the Town of Alta, UPD and Sandy City to supplement this shortfall, but growing visitation to the Canyon would require more law enforcement personnel. Additionally, partnerships with external law enforcement agencies are beneficial, since Forest Service Law Enforcement Officers may be limited in some cases by Federal Law. Combining federal Forest Service law enforcement with local/state law enforcement provides more comprehensive protection for the forest and intermingled/adjacent non-federal lands.

4.1.2.5 SKI AND SNOWBOARDING RESORTS

By encouraging more recreators to use public transit when traveling within the LCC transportation system, SEA envisions that Alta and Snowbird resorts would provide convenient areas for visitors to store their personal items during the day, so visitors are less inclined to drive their personal vehicles for comfort reasons. For example, lockers that are accessible near mass transit locations would provide an area for visitors to store their personal items safely. Also developing the resorts' drop-off and pick-up areas with amenities provides a more convenient and visitor-friendly area.

4.1.2.6 SNOW SHEDS

Implementing snow sheds in LCC would alleviate the congestion that is formed when the Canyon is shut down for avalanche control and reduce the amount of snow clearing time. Although this feature was not brought into the preliminary design, SEA highly recommends that snow sheds be evaluated further for the safety impacts that they could have on LCC. For more information regarding our snow shed study and improving avalanche control with snow sheds and Gazex® device, please see Appendix A.

4.1.2.7 RESORT INTERSECTIONS

Reconstruction of some of the resort entries and exits would improve the traffic flow of the Canyon moving in both directions, as well as increase the safety in the Canyon by reducing the potential crash hazards near the intersections due to steep grades and a skewed intersections, which are common at many of Snowbird's facilities. In the preliminary design SEA redesigned Snowbird Entry 1 and realigned the Big Curve for a freer flow of traffic. Later in this report, the redesign will be discussed in more detail. Although SEA did not redesign the remaining intersections, we recommend those intersections be evaluated for potential reconfiguration. During the evaluation, SEA recommends the use of intelligent metering systems, such as the intelligent signal and metering system discussed in our redesign of Snowbird Entry 1.

5.0 ALTERNATIVES STUDY CONCLUSION

The purpose of the LCC transportation study is to develop solutions that address congestion, improve parking, improve information, and improve safety of Canyon visitors. The completed TRIP FS recommended and detailed features that were evaluated through the ranking of safety, serviceability/mobility, environmental impact, cost, and aesthetics. The FS addressed concerns from GCC regarding safety and congestion of the Canyon, which determined the alternatives of the TRIP FS with the following themes: Trails, Roadway, Information, and Parking. To review the TRIP FS in its entirety, reference Appendix A.

The SEA recommended key features, within our resource limitations, from the TRIP FS to continue evaluating and to develop a preliminary design. The specific features that received high ranking during the evaluation process, as well as positive client and community feedback, have been advanced into this design. We understand the importance and sensitivity of proceeding with some of these designs with the natural habitat of the Canyon for enhancing mobility within the Canyon. The recommended transportation System we considered are: implementation of an improved transportation system, improvement of bike and pedestrian path, and a roadway improvement near Snowbird Entry 1.

A critical phase for Canyon congestion is to reduce the amount of vehicle traveling up-Canyon without reducing the number of Canyon visitors. The AVN and multimodal hub would reduce the congestion in Canyon by migrating visitors of the Canyon to park and communicate outside of the Canyon limits. In conjunction, the multimodal hub would serve as an alternative for visitors and possibly an area of distributed parking throughout the Valley that could communicate with the AVN, buses, shuttles, and private vehicles to improve the transportation system for commuting Canyon visitors.

Improvements to the roadway would increase safety in the Canyon while reducing congestion in and out of the Canyon. Implementing avalanche mitigation in the Canyon would control the out-of-Canyon congestion on Wasatch Blvd, as well as 9400 South, and minimize the amount of time and days that the Canyon would be closed to avalanche snow removal. Redesigning the resort intersections would improve the safety and local congestion located in the Canyon.

An improvement to Canyon safety could be achieved by developing a bike and pedestrian path on Old Quarry Road. Improving the trail and making it ADA accessible provides more access to other user groups. Further investigation can be completed for: expanding the trail up the Canyon, improving sanitation for visitors, and development of utilities to align with the path.

6.0 PRELIMINARY DESIGN

Based on the information and feedback gathered from GCC and other stakeholders, we generated the following features for the preliminary design study:

- Utilizing an intelligent transportation system;
- Improving Snowbird Entry 1 resort exit;
- Realigning the Big Curve;
- Developing a visitor center;
- Paving a portion of the Temple Quarry Road for ADA access; and
- Establishing a financial model.

The following sections will provide an introduction to the feature, the performance goals or requirements of the feature, design guidance and requirements set forth by industry standards and codes, the design of the feature, and a cost estimate.

7.0 INTELLIGENT TRANSPORTATION NETWORK

7.1 USER INFORMATION INTERFACE

7.1.1 INTRODUCTION

The development of a user information and services system to integrate road conditions and closures, parking availability, and carpool information into a single interface would lead to a reduction in congestion of roadways. This system could be both an application (app) for a smart phone and a web-based tool that provides up-to-date information to allow the Canyon visitor to make decisions that reduce congestion within LCC. The user interface is broken down into a long-term vision for the entire transportation system including technologies not yet available, and a shorter-term implementation of a smart phone application to manage present-day, non-intelligent vehicle traffic with the Canyon's transportation system. This application would require cooperation among different entities, which could be managed under one entity, namely CCCRT as mentioned previously. The application would receive data from UDOT traffic updates including variable messaging signs (VMS) currently in place and future installed VMS [3].

Two scenarios for this user interface are described below:

Scenario 1: If you are in downtown Salt Lake City, traveling alone, and want to go to Snowbird, you could look at this app to know the conditions and transportation system information before you go. The app would first provide travel times and road conditions for the LCC transportation system, then the app would provide options for carpooling at several nearby locations (nodes) where the visitor could park and get into another vehicle to carpool into the Canyon. You would also have the option to become the carpool driver and invite others to ride with you. If you wanted to drive alone, the app would give the amount of parking available within LCC and how long the traffic wait time is within the Canyon. As extra motivation to carpool it would also display the single-occupancy vehicle user fee. The app provides you with options to be a responsible Canyon visitor and help reduce the environmental impact within the Canyon.

Scenario 2: You just arrive in Salt Lake City at the airport; the information desk tells you to download this app since you are planning to visit LCC. Your family is excited to visit Snowbird during the fall and hike up Hidden Peak. It is a weekend during Octoberfest and you have no idea what the event is or what traffic conditions could be like for you and your family. Since you downloaded the app in advance, you are now informed with information about recreation and transportation in the Canyon. As you plan your day, the app tells you and your family that the Snowbird parking lot is almost full, so the fee for parking is $10, while the Canyon user fee for the day is $15. You and your family are budget-conscious, and you were not interested in the event, just hiking. You also notice the travel time delay for the roadway, and on top of that there is a rainstorm approaching that will hit the Canyon in the early afternoon, so your family decides to hike on a weekday instead, when the area is quieter, and the user and parking fees are cheaper. The app provided your family with information to make decisions about your trip before you were already on the road.

7.1.2 PERFORMANCE GOALS AND REQUIREMENTS

The overall requirement of the information system is to increase efficiency of transportation in LCC on existing physical infrastructure by informing the visitors. Improving efficiency means transporting higher volume of people in fewer vehicles (i.e., increasing average occupancy). It also means that the number of unnecessary trips made during peak hours would be reduced, for instance, by visitors who return down the Canyon immediately due to poor weather conditions or no parking availability at resorts. Several goals have also been developed as items that SEA would like to see implemented for the interface.

7.1.2.1 REQUIREMENTS

- Improve parking availability, wait time, and probability for finding parking at different lots in the Canyon and out of the Canyon during peak hours and to making a parking reservation.
- Improve carpooling availability, along with locations for parking to carpool separated from the existing UTA P&Rs, and link to carpooling app.
- Evaluate or determine weather and road specific conditions (e.g., are chains or snow tires required in the morning or will those be requirements in the afternoon?).
- Produce alerts and updates on closure times due to UDOT avalanche mitigation or closures due to accidents in LCC.
- Inform regarding Current Canyon visitor fee based on occupancy, time of day, weather conditions, etc.

7.1.2.2 GOALS

- Map with real-time traffic flow on Little Cottonwood Canyon Rd. and other key transit information, such as, traffic conditions, including travel time and delays, and location of plows.

- Avalanche conditions from Utah Avalanche Center.
- Allow for purchasing of resort ski and snowboarding passes.
- Remain dynamic to allow for other functionalities that are not yet available.
- Provide seamless access to third party apps that currently exist and apps that may be relevant in the future.
- Provide other Canyon specific information; this could be a list of hyperlinks that direct visitors to other organizations' webpages or to specific articles.
- Encourage volunteer opportunities through the Public Stewardship Program for Canyon visitors to obtain their Cottonwood Recreation Pass.

7.1.3 DESIGN GUIDANCE

The Federal Highway Administration (FHWA) recognizes that mobile applications are changing the way people travel and the characteristics of travel. In Smartphone Applications to Influence Travel Choices: Practices and Policies [4], it is stated that four main categories of applications have significant impact on travel characteristics:

1. Mobility apps;
2. Vehicle connectivity apps;
3. Smart parking apps; and
4. Courier network services (CNS) apps.

The broadest category FHWA describes is the mobility category. The following eight different types of apps already on the market are listed below:

- <u>Business-to-Consumer (B2C) Sharing Apps:</u> sell the use of shared transportation vehicles from a business to an individual consumer, including one-way and roundtrip trip car-sharing (e.g., Zipcar).
- <u>Mobility Trackers:</u> track the speed, heading, and elapsed travel time of a traveler. These apps often include both wayfinding and fitness functions that are colored by metrics, such as caloric consumption while walking (e.g., GPS Tracker Pro).
- <u>Peer-to-Peer (P2P) Sharing Apps:</u> enable private owners of transportation vehicles to share them peer-to-peer, generally for a fee (e.g., Spinlister).
- <u>Public Transit Apps:</u> enable the user to search public transit routes, schedules, near-term arrival predictions, and connections. These apps may also include a ticketing feature, thereby providing the traveler with easier booking and

payment for public transit services (e.g., Washington, DC's Metrorail and Metrobus).

- Real-Time Information Apps: display real-time travel information across multiple modes including current traffic data, public transit wait-times, and bike-sharing and parking availability (e.g., Snarl).

- Ride-Sourcing/Transportation Network Company (TNC) Apps: provide a platform for sourcing rides. This category is expansive in its definition so as to include "ride-splitting" services in which fares and rides are split among multiple strangers who are traveling in the same direction (e.g., UberPOOL and Lyft Line).

- Taxi e-Hail Apps: supplement street hails by allowing location-aware, on-demand hailing of regulated city taxicabs (e.g., Flywheel).

- Trip Aggregator Apps: route users by considering multiple modes of transportation and providing the user with travel times, connection information, and distance and trip cost (e.g., Transit App) [4].

The second category, vehicle connectivity apps, provides access to personal vehicles through a smart phone, primarily for emergencies, but there is potential for further development as autonomous vehicle systems develop in the future.

Smart parking apps, the third category, provide easy access information about parking location availability and cost from different vendors. They help streamline the parking experience for the visitor and can potentially provide parking reservations in advance. Improving parking efficiency reduces visitor frustration as well as time spent driving around looking for parking in the Canyon.

A futuristic vision for the user information interface would be to have the functionalities from all these types of apps available and easily accessible, perhaps aided by artificial intelligence (AI) such as Apple's Siri, or Amazon's Alexa. That way the visitor would not have to consider all the different options and information to base their decisions for travelling. Rather the AI-assisted transportation system could help the Canyon visitor with their travel choices.

In the short term, this app would be a combination of some of the apps listed above, providing features from some or all these types of apps into a single, easy to use interface. One example of an app that would be similar to the LCC app is Transit. This is a transportation app that combines directions using public transportation, biking, or walking. Transit also includes an option to order an Uber. The app fills out the pickup and destination information then transfers the user to the Uber app for payment. The planned LCC app would use a carpooling app instead of Uber, but the process would still be very similar. The features of the app described above are recommendations by the SEA, but will need alterations as stakeholders and Canyon visitors, including the client, provide feedback.

7.1.4 DESIGN

It is important that the design of the application be as streamlined and easy to use as possible, to accommodate as many users as possible. As with any component that we propose for the LCC system, time saving and easy access to information will dictate the actual design of the app, so it will attract enough users. Third party apps will also need to be easily accessible through the app and some may be integrated in the app as features.

A mobile application would require development through incremental steps, where software updates are produced regularly. In the first phase or generation of the app, the most critical features would be implemented to an extent that corresponds with capital funding provided. Such features would include a map with real-time updates on traffic and travel times. In addition, it would provide key information from weather services, snow reports/avalanche conditions, parking availability as monitoring systems are added to the parking lots in the Canyon, and more. It should accommodate redirection to third party apps, including a broad selection of different mobility apps, like the FHWA describes above. That way users that are unaware of the alternative modes of travel will learn about the possibilities other than low occupancy personal vehicles, and established sharing app users will get easy access through the app.

The app must accommodate a broad user base due to the varying Canyon visitors. To make the LCC app user friendly to differing visitors, the app must be highly adaptable to individual users' needs. That is, the display, information flow, and notifications/alerts need to be adjustable in the user settings so that the app does not display unnecessary information and features.

7.1.5 COST ESTIMATE

Development of the app should occur incrementally, and cost for design and maintenance would be phased over time. The initial phase should include a system that accommodates most Canyon visitors during the highest traffic congestion times and provides key information as described in the Design section discussed above. Capital cost estimates for an app, website, and communication are roughly $1 million with operational costs of $75 thousand [5]. To accommodate the available budget, various levels of detail can be included in the initial phasing. It is anticipated that the CCCRT could staff IT managers to help maintain the application.

Another cost associated with the system will be to retrieve data from third parties such as UDOT, National Oceanic and Atmospheric Administration (NOAA), and a map services provider, which would be used in the alerts and notifications. The cost of this data collection is unknown; however, as the concepts develop from visitor feedback are obtained, app needs can be accurately determined, and costs could become more refined.

7.2 INTELLIGENT TRANSPORTATION NETWORK

7.2.1 INTRODUCTION

LCC is serviced by a transportation network that includes parking within the Canyon and within the Valley. The key focus of our analysis was to determine the network's ability to sustain the increased recreation within LCC during periods of peak use. The Canyon maintains roughly 4,300 to 4,600 legal parking spaces during the winter season [5]. This number varies due to the common occurrence of illegal curbside parking throughout the Canyon. On peak days, the parking in the Canyon is at capacity while the Valley parking lots see various, usually low, rates of utilization.

The trends surrounding the visitor's method of transportation are uniform, as roughly 96% of users commuted in passenger cars on peak days, according to data obtained from the Mountain Accord (MA). Among those riding in passenger cars, the average occupancy rate was below 2 people per vehicle [6].

Two main problems arise with these trends: one, the discrepancy between the number of vehicles entering the Canyon and the number of parking spaces available within the Canyon; and two, the ability of the roadway to sustain the peak traffic flow rates.

7.2.2 PERFORMANCE REQUIREMENTS

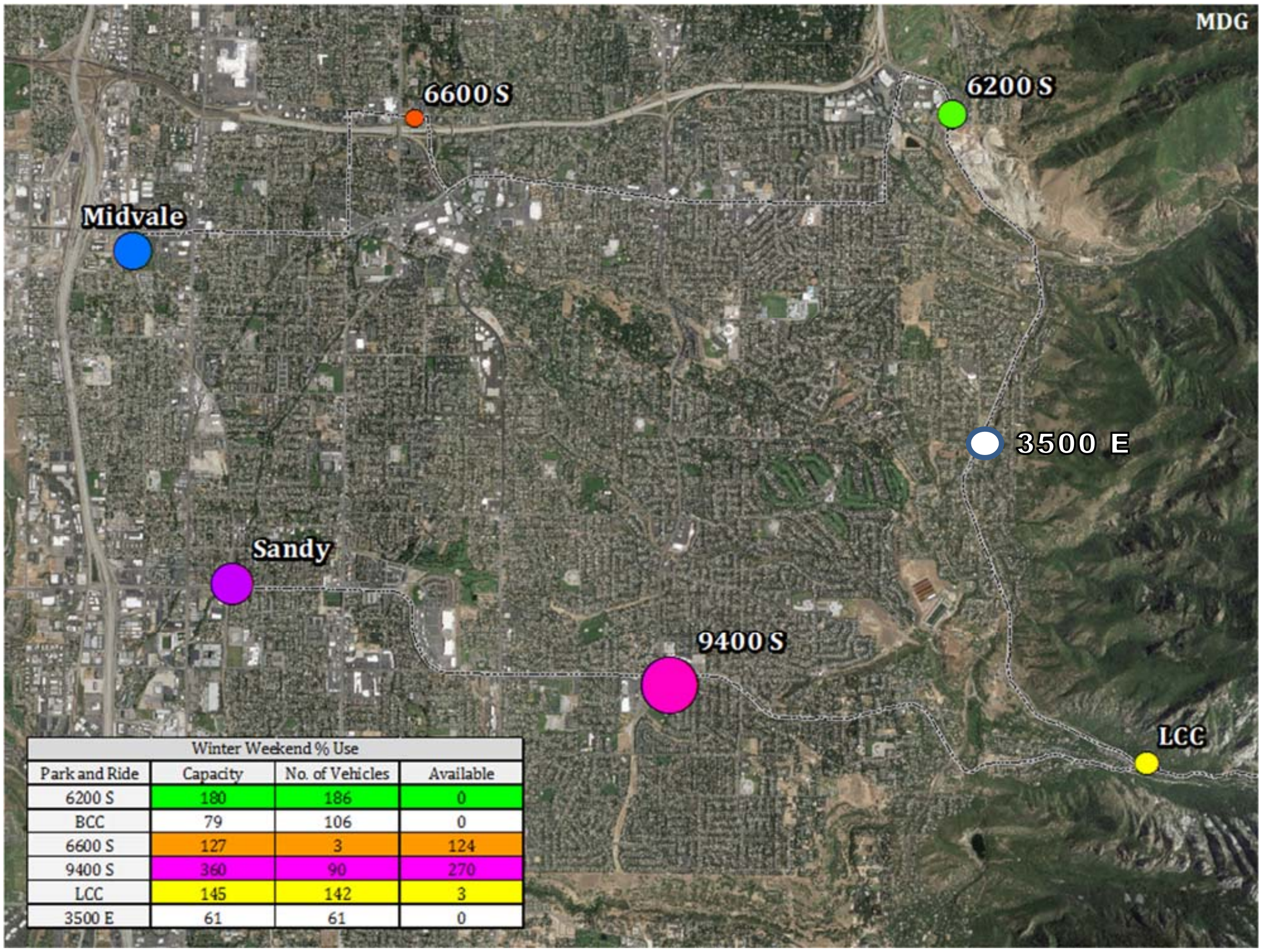
We envision a system that will reduce traffic congestion, increase ridership among high occupancy vehicles (HOV), and maintain a minimal footprint within the Canyon and environmentally sensitive areas.

We propose the optimization of existing park and ride (P&R) locations through the following performance requirements:

- Parking nodes (i.e., parking lots) should be identified by available outbound mode(s) of transportation.
- Shuttle services are required to meet the changing needs of the visitors as well as various Canyon destinations that cannot accommodate bus access through increased pick-up locations and number of shuttles in use.
- Capacity count systems should be implemented at high volume nodes to communicate with the user interface and redirect traffic congestion.

7.2.3 DESIGN CRITERIA AND GUIDANCE

Current parking capacity estimates are detailed in Figure 6. It is evident that parking availability between nodes is poorly distributed. At maximum use, only one-third of the lot at 9400 South and Highland Drive is occupied; meanwhile, the lot at the mouth of LCC is 98% occupied [7]. The lot a 3500 E and Wasatch Blvd. (i.e., "swamp lot") is rather small (61 spaces) and would be a good site for additional capacity.



Winter Weekend % Use			
Park and Ride	Capacity	No. of Vehicles	Available
6200 S	180	186	0
BCC	79	106	0
6600 S	127	3	124
9400 S	360	90	270
LCC	145	142	3
3500 E	61	61	0

Figure 6 – Valley parking utilization

Increases to parking within the valley were considered with the guidance of previous studies. The preliminary design prepared by the MA provided out-of-Canyon parking based on two scenarios: one, centralized parking hubs with locations near the mouth of the Canyon; and two, dispersed parking nodes throughout the nearby Valley (Table 2). The SEA prefers the dispersed parking model and hub location of 9400 S. and Highland Drive [5]. Centralized parking is generally accommodated with multi-story parking facilities; whereas dispersed parking can be accommodated with smaller structures and the construction of multi-modal transit hubs as potential transfer points to mass transit buses, etc.

Table 2 – Parking increases from Mountain Accord 2017

Location		Additional Parking Spaces
9400 South & Highland Dr.	centralized	2,850
	dispersed	1,400
6200 S & Wasatch		1,080
Hypothetical Park and Ride near BCC		2,650

Past studies also produced trip-origin data for both tourists and non-tourists visiting the Canyon. The split between the two types was roughly equal [5]. The distribution of non-tourist visitors was a significant element used in the preliminary design of multimodal parking nodes throughout the Valley. To accommodate the tourist population, nodes (i.e., parking locations) were extended into the downtown district of Salt Lake City.

UTA's Ski Bus schedule and P&R locations were also taken into consideration. While the Ski Bus routes have recently shifted to better accommodate LCC riders, the routes do not offer pick-up locations within the central or northern region of the Salt Lake City Valley; therefore, the Network would aim to extend shuttle service to those areas beyond the existing Ski Bus lines.

During community meetings with members of the GCC, the SEA received numerous requests for existing infrastructure to be incorporated into parking systems prior to the recommendation of new construction. Public opinion also expressed a desire to better incorporate carpooling and shuttle services with the existing parking network. These concerns have been a strong driver in our preliminary design for a multimodal transportation system.

7.2.4 DESIGN

7.2.4.1 NODE SELECTION AND MODE DISTINCTION

Node selection included limited parking areas that already exist in order to maintain a minimal footprint, with the exception of two multimodal hubs which would require infrastructure improvements. The two ideal locations, covering both the northern and southern approach to LCC, are envisioned to be located at 6600 South and 950 East and 9400 South and Highland Dr. P&R, respectfully.

Three classifications of parking nodes have been created to distinguish parking locations by the method of outbound transit available. The classifications were based on the following factors: maximum parking capacity, land ownership, and the land use of the surrounding areas. The preliminary layout and design of the Network can be found in Appendix B.

Type 1: Informal for Carpooling and Shuttles

Outbound modes of transit include carpooling and shuttle services, shown as blue circles on the map presented in Appendix B. Ideal locations include churches and schools. These nodes are considered "informal" and would require the coordination between land owner and a governing transportation agency to ensure the lots were available to their patrons first. Parking availability could be displaced in the form of physical signs displaying the hours and days when parking is available or electronically through a user interface. Since these locations have varying hours of operations (for winter LCC parking), a computer application that helps the user navigate the Network would create a reliable relationship between the visitor and the Network.

Type 2: Formal for Buses and Shuttles

Outbound modes of transit include the Ski Bus and shuttle services. Type 2 nodes are best suited for large P&R locations that are already along the existing bus routes. Shown on the map in Appendix B are multimodal hub nodes (green circles) and other P&R locations (yellow circles). The combination of under-utilized parking lots with increased parking facilities offers a prospective space for multimodal transportation. Locations such as the P&R at 6600 South and 9400 South offer unused space and the potential for increased ridership. The hub would offer visitors the option of transit in a more intimate and flexible experience, and visitors could choose between the two modes based on available vehicle, cost, and destination. If both services, bus and shuttle, offer unique benefits to the Canyon visitors, then they are not in competition with each other but rather operating in unison.

Type 3: Formal for Buses Only

Outbound mode of transit includes the Ski Buses only due to limited parking space and at-capacity conditions during peak times. These locations are shown as red circles on the map presented in Appendix B. Locations include parking at the mouth of both LCC and BCC, the "swamp lot" and 6200 South and Wasatch (assuming no additional parking is constructed). The reason for distinguishing these nodes is because they play a pivotal role in the transportation Network and would continue to be a vital source of parking for residents that live within a proximity to the Canyon entrance that would cause the visitor to travel in the opposite direction to use a Type 1 or 2 node.

7.2.4.2 NETWORK COMMUNICATION

Due to the informal nature of Type 1 parking and the frequency at which Type 3 reaches capacity, the System relies on the communication/information sharing between the visitor and the Network. The visitor's ability to navigate the Network with ease is critical to the success of the System; therefore, a responsive user interface that prompts the visitor to the nearest available parking for each node type would be required. The installation of parking sensors at each lot for the conveyance of real time parking availability information direct to visitors would enable the visitor to receive real time information and make decisions about their trip before leaving their home.

7.2.5 COST ESTIMATE

Costly items for the Network include construction of multimodal hub locations and parking data collection. These two items were estimated during the Mountain Acord studies to be $91 million and $4 million, respectively. If only one parking structure was constructed as a multimodal hub, the construction cost would greatly decrease. A location at 9400 South and Highland Dr. that creates an additional 1,400 spaces was estimated to cost $38 million by the same economic study. The transportation Network would benefit greatly from the implementation of a user interface, as they work together to create an adaptive, intelligent transportation system; therefore, their costs are interconnected.

7.3 INTELLIGENT VEHICLE TECHNOLOGY

7.3.1 INTRODUCTION

As humans continue to evolve technologically, the implementation of Intelligent Vehicle Technology (IVT) follows. Over recent years using computerization in a vehicle allows for small degree of automation with a human driver. Some automated features that exist today are lane assist, adaptive cruise control, and parking assist, where the driver initiates or allows the feature to operate. Autonomous vehicles (AV) have been built by companies that can navigate existing roads with almost no human input. The connected vehicle systems use wireless signals, digital imagery, global positioning system (GPS), and light detection and ranging (LIDAR) to relay informational data between other vehicles, roadside infrastructure, and other modes of transportation (pedestrians, bikes, etc.). If AV and their technologies become successful and readily available to the mass market, they could change the transportation network by reducing congestion, increasing safety, saving fuel, and lowering emissions. This would dramatically enhance the LCC visitor experience and reduce traffic frustration for surrounding communities.

7.3.2 PERFORMANCE GOALS

Fully autonomous vehicles (Society of Automotive Engineers [SAE] level 5) and their supporting technologies are still in testing phases; however, there are levels of automation that are being used now. Currently, levels 1 and 2 are implemented on our roadways. The performance requirements of these levels are described and listed in Figure 7, courtesy of Blaine D. Leonard, P.E., UDOT.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Figure 7 – Level of autonomous vehicle technology

Since there are multiple levels of automation in vehicles, there are different performance goals that are associated with each one. Instead of looking at each level's individual goals and what it accomplishes, an overall goal should be looked at as the levels progress to full automation. In general, the goal of autonomous vehicles is to safely improve and enhance the way we travel and interact with the roadway.

AV technology can also be used in public transit applications. Buses and shuttles are currently being utilized as low and high level autonomous vehicles in Utah, and around the world, that offer a comprehensive communication system surrounding the designated travel area. The communication system lets the user interact and obtain useful information from the system, such as request pick-up and drop-off or schedules. This allows the AV to transport more riders safely and efficiently by allowing communication between the user, buses or shuttles, and roadside infrastructure.

In Utah, there are semi-autonomous buses being operated on 11 miles of Redwood Road from 400 South to 8020 South. There are 24 radio transponders along this stretch that give and receive information to and from the buses about its speed, direction, and lane location. The software incorporated into the buses and infrastructure coordinates this information to determine if the buses are on schedule or not. If it is not, then the system could permit a longer green light phase to help the buses move through. Using this system has shown that it does increase overall efficiency and allows the buses to return to its planned schedule.

Another example that will use full AV technology, is in Lincoln, Nebraska. They will incorporate a driverless micro-shuttle that operates in mixed-traffic. It will include a demand-responsive system that will only operate when called upon by the user for requests for pick-up and drop-off along a predefined route. Implementation is foreseen in 2019, depending on funding.

7.3.3 DESIGN GUIDANCE

As previously stated, there are multiple technologies that can be used to relay information between vehicles and infrastructure. Some of the technological advancements that are used and coming into use are dedicated short range communication (DSRC) and cellular 5G technology (5.9GHz, not currently available) that would allow the vehicle to connect to all transit features (e.g., other vehicles, traffic signals, cyclists, etc.) and provide safety and mobility information on a dedicated bandwidth. These technological advancements could be used to communicate with all levels of automation, within their capabilities, until full market penetration of full AV arrives.

7.3.4 DESIGN

The benefits of connecting vehicle-to-vehicle (V2V) would be the vehicle's ability to learn throughout the increasing levels of automation. From this, AV will be able to adapt to other vehicles' driving patterns and unique road conditions allowing vehicles to interact seamlessly. Full AV technology would increase road capacity by decreasing the distance between vehicles, called platooning. This would greatly improve traffic flow, safety, and fuel efficiency. The AV would be able to connect with roadside infrastructure, vehicle-to-infrastructure (V2I) where communication between them could be conveyed by fiber optics, DSRC, or software applications. Significant infrastructure is not required; however, improving visibility of lane stripes, consistent signage, and traffic signal-to-vehicle communication would be needed.

7.3.5 COST ESTIMATE

The cost estimation for the IVT system is based on funding for full AV implementation of a similar project in Lincoln, Nebraska. This project is called the AV pilot program and in 2019 the program should be implemented using cost relatable AV technology which is in line with the LCC vision. From this, the cost for the IVT system is evaluated at approximately $6 million, which includes roadside infrastructure, AV technology, user communication capabilities, etc.

8.0 ROADWAY

8.1 INTRODUCTION

The desired intersection design is a box culvert tunnel that creates an exit from Snowbird Entry 1 to SR-210. The slope of the Canyon at this intersection would provide enough height for private and low occupancy vehicles to enter and merge into the downhill lane of SR-210. The entrance of the tunnel would be situated at the exit from the ski resort, which then goes underneath the uphill SR-210 lane. The exit of the box culvert would be situated in what is currently the merge lane for downhill traffic. Preliminary design drawings are presented in Appendix C. Although the preliminary design described below represents one resort exit, SEA believes all resort intersection should be evaluated for high traffic flow efficiencies.

8.2 PERFORMANCE GOALS AND REQUIREMENTS

The focus for the intersection is to create an alternative design to allow traffic to merge into and out of SR-210 from Snowbird Entry 1. This would increase the safety of drivers by reducing potential crashes with both pedestrians and vehicles and improve traffic flow efficiency for both directions in the Canyon. In addition, carbon emissions would be reduced due to the absence of vehicles waiting extended periods of time to depart the resort.

8.2.1 GOALS

The primary performance goal is to reduce the potential for accidents of vehicles and/or pedestrians by providing protected free flow out of the lot via tunnel. To achieve optimal safety measures for the intersection, the design would emphasize the following objectives:

- Decrease need for traffic enforcement, safety of officers;
- Removing conflict point crossing up-Canyon traffic;
- Faster evacuation;
- Better sight distance;
- Reduce congestion in:
    - Average time to empty parking lot
    - Average time for one car through intersection (10-second [sec])
        - Goal: Reduce time by half

        - At free flow capacity 15-feet per second (ft/s), 2-sec headway signifies 30-feet and 40-feet per car at 15-ft/s means about 3-sec/car

- Increase flow rate out of parking lot; and
- Prioritize high occupancy vehicles to exit.

8.2.2 REQUIREMENTS

The performance requirement developed for the box culvert tunnel during the construction phase would include the following:

- one lane must remain open to continue traffic flow using an alternating traffic pattern
- off-peak hour construction

8.3 DESIGN CRITERIA AND GUIDENECE

The following design criteria have been developed by the team in consideration of standards established by UDOT and the American Association of State Highway and Transportation Officials (AASHTO) Green Book (GB).

- Design speed – 15 miles per hour (mph), speed at the Big Curve
- Radii – 44-ft at 2% (GB Table 3-13b)
- Shoulder – 4-ft
- Lane Widths – 12-ft
- Taper/merge length
- Grades of line
- Cross slope
- Drainage
- Height clearance
- Striping
- Signage

8.4 DESIGN

The conceptual layout of the box culvert tunnel utilized design standards from UDOT 2017 Standard Drawings, as well as guidelines established by FHWA and AASHTO.

The entry of the box culvert tunnel would begin at the Snowbird Entry 1 parking lot Figure 8. The tunnel would be above ground for vehicles to enter, then would progress underneath the SR-210 uphill traffic. The exit of the box culvert would be stationed in what is currently the merge lane for down canyon vehicles. From there, a ramp, approximately 700-feet in length, would allow the low occupancy and private vehicles to resurface onto the slope grade of the mountain and merge into the SR-210 downhill traffic. Barriers would surround the low occupancy and private vehicle lane to prevent traffic from entering the tunnel and causing potential vehicular accidents.

The dimension of the box culvert tunnel would be comprised of a width of 20-feet and a height of 14-feet. This tunnel would be for single lane traffic, where the width of the lane would be 12-feet with two 4-feet shoulders. Structural walls would occupy the remaining width to support the tunnel. The tunnel would potentially extend for 275-feet, starting from the resort parking lot.

For the downhill merging process, the high occupancy vehicle lane would congregate into the SR-210 downhill traffic lane. Upon completion of the first merge, the low occupancy and private vehicle lane would join the SR-210 downhill traffic lane through a metered process, with the HOV traffic receiving signal priority.

During periods of peak traffic, three signal devices would be utilized to direct the flow of vehicles traveling through the Canyon. Signal-01 (SG-01) would be situated at the entry to the resort for SR-210 uphill traffic to stop for high occupancy vehicles leaving the resort. SG-02 would be positioned at the resort exit, signalizing vehicles to merge with the SR-210 downhill traffic lane. This feature would be beneficial for vehicles to exit the resort in situations where maintenance must be performed on the tunnel or for vehicles larger than the tunnel. SG-03 will be a bollard traffic signal located at the end of the box culvert tunnel and would meter low occupancy and private traffic entering the ramp to merge with the SR-210 downhill traffic.

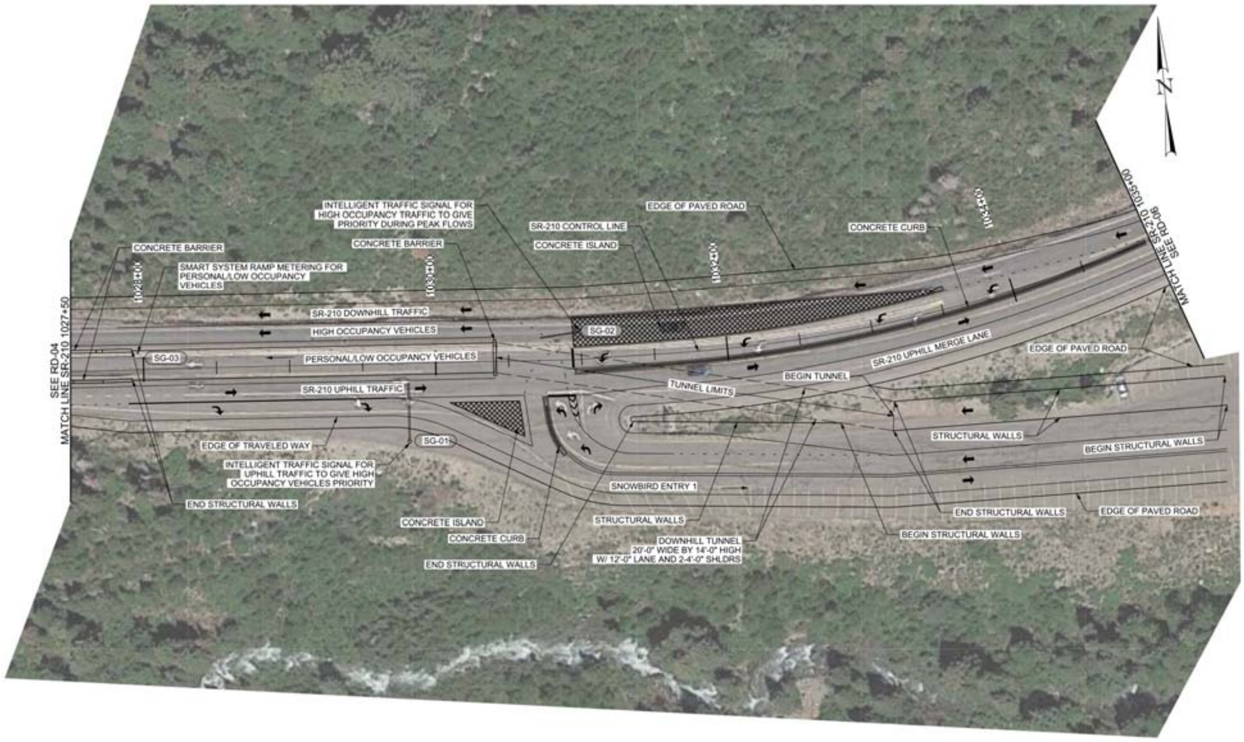


Figure 8 - Roadway design for Snowbird Entrance / Exit Number 1.

9.0 VISITOR CENTER AND TEMPLE QUARRY TRAIL

9.1 INTRODUCTION

The Old Quarry Road parking lot in LCC is a potential location for a visitor center. However, it should be noted that this location will require further assessment to ensure it complies with Forest Service and NEPA requirements. This visitor center (VC) would be used as a recreation hub as well as an education center for the Canyon visitors. This center would have the ability to communicate with the intelligent system and convey information regarding parking availability, events at the VC, or available carpooling options. The vision for this area is to improve and provide a trail from the VC that is ADA accessible. The Old Quarry Road Trail will be improved by paving approximately 0.5-miles toward Wasatch Resort Road.

9.2 PERFORMANCE GOALS AND REQUIREMENTS

- To introduce a path that is multi-use friendly.

- Make a section of the path ADA accessible that is connected to the VC.
- Keep environmental impact low with sustainable design.
- Provide a location for educational and recreational use in the Canyon (Visitor Center).

9.3 DESIGN CRITERIA AND GUIDANCE

The design codes listed below would be used in the design of the paved trail and the constructional design of the VC. AASHTO standards and ADA Accessibility Guidelines would aide in the asphalt trail design for a multi-purpose visitor trail. The American Society of Civil Engineers (ASCE) 7-10, Steel Construction Manual 15th Edition, ASTM Masonry Standards and the ASTM Wood Standards would be used to construct the building. This building can be developed with a combination of these materials but requires an appearance to blend with the natural surrounding area.

9.3.1 DESIGN CODES

Two studies were used as guidance in the development of this preliminary design; they are The University of Utah Big Cottonwood Canyon 3T Improvement Study [8] along with the Parley's Canyon Feasibility Study [9]. Both provided extensive guidelines and examples for how large-scale infrastructure improvement projects in Utah should be handled. Additionally, the Forest Service has worked closely with the design team to provide feedback and resources in how to design features such as the bike path and VC that would benefit Canyon visitors. The following codes should be utilized during design:

- AASHTO
- ASCE 7-10
- ADA Accessibility Guidelines
- Steel Construction Manual 15th Edition
- ASTM Masonry Standards
- ASTM Wood Standards

9.3.2 GUIDANCE

- University of Utah BCC 3T Study
- Parley's Canyon Feasibility Study
- Forest Service

9.4 DESIGN

For the path design, the Parley's Canyon Feasibility Study was referenced, and a 12-foot wide paved path is recommended for use. This path would span from the beginning of Old Quarry Road to Wasatch Resort Road (0.5-miles up Canyon). Figure 9 shows a general location of the trail that could be used for the bike path. At the end of the path at Wasatch Resort Road, a pedestrian bridge would be placed for unpaved trail access returning to the VC. The bike path would have a 6-foot designation for the uphill users and a 6-foot designation for the downhill users. The path should have striping down the middle to help keep the different users from interfering with one another. The figures below provide a detail on how the bike path could be designed. The cross-section shown in Figure 10 shows how the path should have at least 3-inches of asphalt and 4-inches of sub-base or otherwise stated by a geotechnical engineer's report for LCC. Figure 11 shows a typical plan view of the bike path with the two different sides designated to the users divided by a striped line.

Figure 9 - General location of the bike path

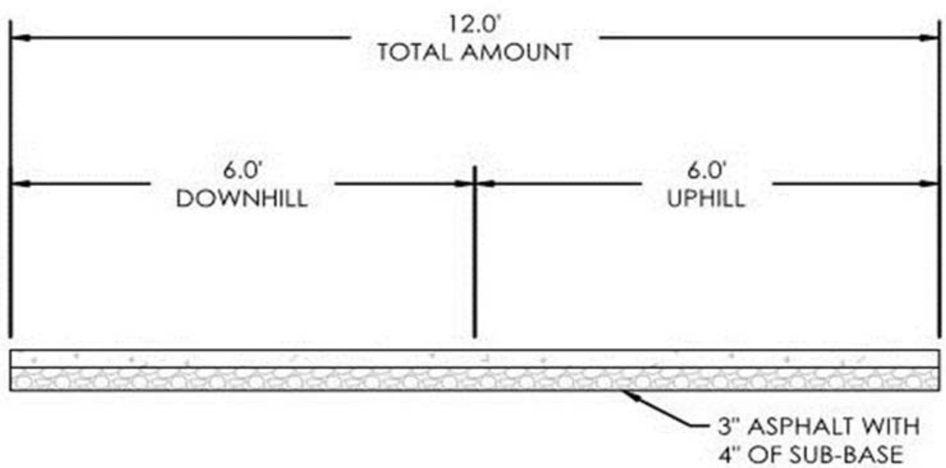


Figure 10 – Cross-section of bike path

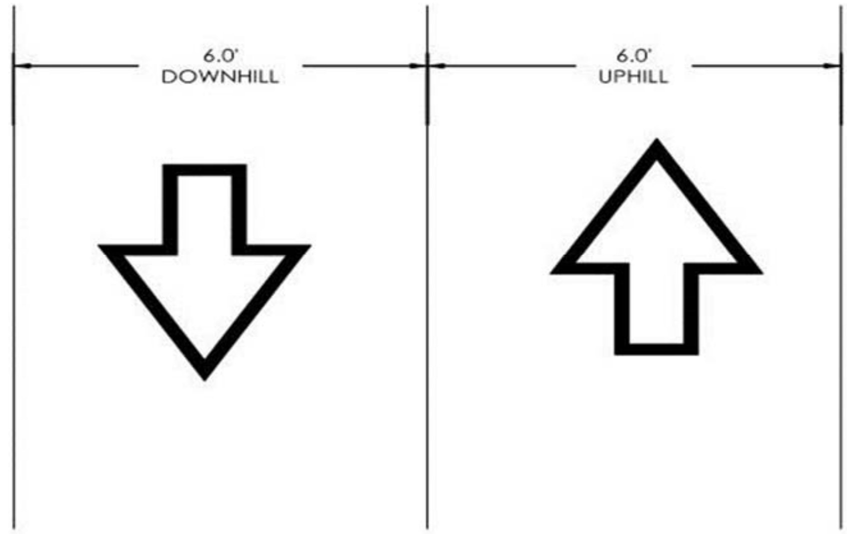


Figure 11 – Typical plan view of bike path

The VC could be placed at the mouth of LCC near the beginning of the trail with an approximate space of 10,000 square feet. We envision this being a 1-story building that would accommodate educational areas, forest ranger offices, recreational meeting rooms, and water and restroom accessibility. We recommend the construction of the building blend into the natural environment with timber and stone material. Designers of the VC should also consider a low profile to maintain the existing views at the mouth of LCC. Figure 12 below shows the approximate location that would work for the VC; however, this location should be evaluated with a thorough study. As mentioned previously, this study does not consider all canyons near Salt Lake City and a more centrally located VC may better serve all canyons. By utilizing the existing Old Quarry Road and paving it 0.5-miles, this would mitigate the environmental impact that can occur when visitors make wider trails without approvals. In addition, the VC would assist in educating visitors about the environment and could help minimize existing non-environmentally friendly impacts occurring within the Canyon today.

Figure 12 – Recommended approximate location for visitor center

10.0 FINANCIAL MODEL

10.1 SUMMARY

The SEA has evaluated financial models for the recommended canyon improvements and operating and maintenance (O&M) costs for a 50-year time frame (i.e., to year 2070). The required capital for the improvements is estimated to be $190 M, and the O&M costs are approximately $270 M for the 50-year period (Table 3). Because the cost of the recommended improvements exceeds the currently appropriated monies, the SEA recommends that improvements be implemented in phases, with the capital expenditures for the first phase targeted at $65 million, thus matching the expected allocation to UDOT by the State of Utah (Table 3).

The SEA recommends that fee collection be implemented during Phase 1 and monies obtained from such fees directly support future improvements and O&M costs. A summary of the estimated costs and the recommended phasing is shown in Table 3. In addition, Appendix D lists the recommended improvements and their respective phasing.

Table 3 - Costs and phasing schedule

Phase	Costs (millions) (Present Value)		Total Cost (millions)
	Capital	O&M	
Phase 1	$33	$32	$65
Phase 2	$48	$66	$114
Phase 3	$49	$87	$137
Phase 4	$59	$86	$145
Total Costs	**$189**	**$271**	**$460**

10.2 SELF-SUSTAINING FUNDING GENERATION FOR LCC

10.2.1 USER FEES

Senate Bill 71 (SB 71), which passed in 2018, allows UDOT to impose tolls on certain roads in Utah. State Route 210 services LCC, and it is expected that UDOT would be allowed to accept tolls from users. Because additional appropriations by the State of Utah beyond the current $65 M are uncertain for LCC; it is likely that other funding sources will be required. Therefore, the SEA proposes that user fees be instituted as a potential funding mechanism for future improvements and O&M costs.

In addition, user fees can be implemented to reduce congestion during peak system demand and fund safety and other recreational improvements within LCC. Regarding congestion, one of the desired outcomes is to incentivize visitors of the Canyon to increase ridership in their private vehicles, or to utilize public transit, or to participate in vanpooling. Increased ridership will decrease the amount of congestion seen by residents of the Canyon and would potentially reduce the level of emissions from vehicles with combustion engines.

To implement the user fee, the SEA recommends that a traffic management system (TMS) be constructed at the mouth of the Canyon. This type of system is capable of assigning a fee to each vehicle as it drives past sensor cameras (Figure 13). The proposed fees would be variable and might be adjusted according to factors such as: season, amount of congestion, vehicle occupancy, day of the week, time of day, weather conditions, etc.

Figure 13 – Gantry and cameras for user fee assessment

The TMS is capable of assessing vehicle occupancy (i.e., number of persons in the vehicle) using infrared technology. The TMS would have a license plate reader for vehicles that are not equipped with a transponder, and a fee could be mailed to the visitor. Frequent users might obtain transponders whereby they could deposit funds, and the TMS would deduct the assigned fee at the time of entrance from their account. The residents of LCC would be given transponders according to number of vehicles per household. These transponders would allow access without paying a fee. Ski resorts and other businesses operating in the Canyon (e.g., vehicle rentals, tours, private shuttles, etc.) would be responsible for providing for their employees, perhaps using reduced rate or possibly "no charge" transponders.

TMS technology is still developing. One consideration with utilizing these systems occurs during periods of high heat, primarily experienced in the summer months. The higher temperatures can alter the heat signatures of the infrared cameras and produce less accurate results. As an alternative method, the SEA discussed the usage of photographic imagery for vehicles traversing the Canyon during the summer months. This would require placement of cameras to capture images of the vehicles and use of photographic means of evaluating the number of individuals in the vehicle. In addition, similar to the process used for HOV lanes, a fee would be charged to lower-occupancy vehicles.

10.2.2 MODELING OF POTENTIAL REVENUE

One question posed to the SEA was: "what would be a reasonable user fee schedule for the Canyon?" To answer this question requires a complex economic evaluation considering several future variables and human behavioral factors which are not currently known. Such evaluations are recommended for future studies of the Canyon performed by UDOT and other interested stakeholders.

Nonetheless, the SEA performed a simplistic analysis with the primary goal to see if "reasonable and variable" user fees might be able to fund the recommended improvements and costs in the Canyon using current traffic and behavioral information. This involved: (1) analysis of current traffic flow patterns, (2) identifying ridership for the various access modes in the Canyon, (3) establishing a variable fee schedule, (4) estimating annual fee generation, and (5) factors involved in establishing a fee schedule.

10.2.2.1 TRAFFIC FLOW PATTERNS

To determine how to project our estimated revenue based on user fees, we first had to analyze current traffic patterns and determine times of significant congestion. UDOT sensor data for traffic traveling up the Canyon was obtained, and then average hourly traffic flow patterns were determined for each season. Hours with significant traffic were selected and given a weight that represented which hours experienced the most congestion. These weights were used to determine the season and time of day when visitors might expect to be charged a higher user fee.

10.2.2.2 RIDERSHIP FOR VARIOUS MODES OF ACCESSING THE CANYON

The next step involved determining how visitors are travelling up the Canyon. This entailed estimating ridership statistics, such as whether visitors were utilizing private or public transit and estimating the maximum number of persons using the Canyon on a single day. Estimates of these statistics were obtained from documents prepared by Mountain Accord and other [10][11][12]. In addition, the Canyon visitor growth was projected for a 50-year period using the estimated growth rate for Canyon use also prepared by Mountain Accord. Considering the projected visitor growth estimate of the Canyon for a peak day and dividing that value by the number of legal parking spots found within the Canyon provided us with a target peak ridership for our study.

For example, on a peak day approximately 12,400 visitors access the canyon, 11,900 of these (96%) use personal vehicles and 500 of these (4%) use mass transit. In terms of ridership, currently 65% of visitors access the Canyon using a personal vehicle with single occupancy, 31% use a personal vehicle with multiple occupancy and 4% use public transit. In terms of available parking, there are approximately 4,600 available resort parking spots. Therefore, the desired average vehicle occupancy is about 2.6 persons per car in order to accommodate these visitors under current conditions. Factoring in future growth, but keeping the ridership at 2.6 persons per car, we estimate that approximately 13% of the ridership will need to be accommodated on mass transit. However, if the future ridership could be raised to 3 persons per car, then significant increases in mass transit ridership may not be needed. Therefore, based on these estimates, it is clear that future personal vehicle and shuttle occupancy needs to be raised from about 1.8 (current average) to about 2.5 to 3 persons and that some increased mass transit ridership will be necessary in the Canyon to accommodate future growth.

10.2.2.3 VARIABLE FEE SCHEDULE

Factors that might be used to set the user fee charged to a vehicle might include: vehicle occupancy, season, day of week, time of day, etc. The SEA proposes user fees that increase when these factors create a situation that would potentially lead to severe congestion. Ideally, when there are conditions that cause congestion, corresponding and adaptive increases in user fees would encourage Canyon visitors to move to mass transit or ridesharing options, or reschedule their visit.

10.2.2.4 ANNUAL FEE GENERATION

With a variable fee model created, the next step was to estimate the expected total amount of revenue needed from fees to make the Canyon self-sustaining. To represent the number of persons traveling up the Canyon, we created a normal distribution that reflected the Mountain Accord statistics concerning current ridership up the Canyon and employed this distribution to depict the level of ridership in a situation where no user fee would be charged. We then changed the standard deviation and mean incrementally as fees increased from the minimum to maximum fee to symbolize what we believe to be a reasonable estimate of how Canyon visitor behavior might change as visitors modify their transportation behavior to other modes such as rideshare and mass transit. A month of randomized days of weather for each season was simulated to estimate the percentage of vehicles with different ridership levels in a typical month for a typical season.

10.2.2.5 FACTORS INVOVLED IN ESTABLISHING A FEE SCHEDULE

Using current and projected targets for mass transit, private shuttle service, and personal vehicle use, the total number of Canyon visitors were divided into their respective transportation modes and then allotted into personal vehicles based on seasonal percentages. The total yearly self-sustaining funds from user fees was projected based on the number of riders and their mode of transportation and expected ridership. This was done for two different scenarios based on future targets for mass transit use up the Canyon. Total yearly values at 5-year increments were generated and used to predict the timeline of affordability for future Canyon improvements.

Table 4 shows a series of tables with hypothetical fees. However, due to a multitude of different factors that influence future costs, revenues and possible changes in driving behavior, these hypothetical fees are shown only to illustrate how a variable and relative fee schedule could be established to operate the Canyon in a financially sustainable manner. In addition, it is recommended that a comparable fee schedule be established for Big Cottonwood Canyon in order to establish fee schedule parity amongst the Canyons.

Table 4 – Hypothetical User Fees

				User Fee	
Vehicle Occupancy (persons)	Season	Day of Week	Time of Day	/Car	/Person
1	Spring	Weekend	8 am	$1	$1
			12 pm	$1	$1
		Weekday	8 am	$0	$0
			12 pm	$0	$0
	Summer/ Fall	Weekend	8 am	$3	$3
			12 pm	$3	$3
		Weekday	8 am	$0	$0
			12 pm	$0	$0
	Winter	Weekend	8 am	$45	$45
			12 pm	$14	$14
		Weekday	8 am	$23	$23
			12 pm	$7	$7

Vehicle Occupancy	Season	Day of Week	Time of Day	User Fee /Car	User Fee /Person
2	Spring	Weekend	8 am	$2	$1.00
			12 pm	$2	$1.00
		Weekday	8 am	$0	$0.00
			12 pm	$0	$0.00
	Summer/ Fall	Weekend	8 am	$4	$2.00
			12 pm	$4	$2.00
		Weekday	8 am	$0	$0.00
			12 pm	$0	$0.00
	Winter	Weekend	8 am	$45	$22.50
			12 pm	$14	$7.00
		Weekday	8 am	$23	$11.50
			12 pm	$7	$3.50

Vehicle Occupancy	Season	Day of Week	Time of Day	User Fee /Car	User Fee /Person
3	Spring	Weekend	8 am	$1	$0.25
			12 pm	$1	$0.25
		Weekday	8 am	$0	$0.00
			12 pm	$0	$0.00
	Summer/ Fall	Weekend	8 am	$2	$0.75
			12 pm	$2	$0.75
		Weekday	8 am	$0	$0.00
			12 pm	$0	$0.00
	Winter	Weekend	8 am	$33	$11.00
			12 pm	$10	$3.25
		Weekday	8 am	$16	$5.25
			12 pm	$5	$1.75

Vehicle Occupancy	Season	Day of Week	Time of Day	User Fee /Car	User Fee /Person
4	Spring	Weekend	8 am	$1	$0.25
			12 pm	$1	$0.25
		Weekday	8 am	$0	$0.00
			12 pm	$0	$0.00
	Summer/ Fall	Weekend	8 am	$2	$0.50
			12 pm	$2	$0.50
		Weekday	8 am	$0	$0.00
			12 pm	$0	$0.00
	Winter	Weekend	8 am	$30	$7.50
			12 pm	$9	$2.25
		Weekday	8 am	$15	$3.75
			12 pm	$5	$1.25

Vehicle Occupancy	Season	Day of Week	Time of Day	User Fee /Car	User Fee /Person
5+	Spring	Weekend	8 am	$0	$0
			12 pm	$0	$0
		Weekday	8 am	$0	$0
			12 pm	$0	$0
	Summer/ Fall	Weekend	8 am	$0	$0
			12 pm	$0	$0
		Weekday	8 am	$0	$0
			12 pm	$0	$0
	Winter	Weekend	8 am	$0	$0
			12 pm	$0	$0
		Weekday	8 am	$0	$0
			12 pm	$0	$0

10.3 SELF-SUSTAINING LCC

The revenue gained from user fees would be directed to Canyon improvements and operational costs in a self-sustaining manner. The system would have the ability to project necessary future fee schedules to remain financially self-sustaining. We recommend that improvements be introduced in phases that consider to the capital and operation and maintenance costs required for and during the corresponding next phase.

Therefore our vision for the Canyon is to:

- Increase visitation but reduce the number of vehicles;
- Reduce vehicular congestion;
- Ensure Canyon safety through minor roadway alignments;
- Improve law enforcement activity to maintain an efficient System;
- Provide recreation facilities (potable water and flushable toilets);
- Educate Canyon visitors about the watershed and environment; and
- Make the Canyon more accessible.

User fees generated in a self-sustaining funding model would be needed to accomplish this vision and ensure the longevity of the Canyon. A tolling system that considers occupancy and congestion would reduce the amount of congestion, and influence people to carpool or utilize public transit. This would be made simple with the ITS for the public to identify the rates, weather conditions, parking available, and trail information. Redesigning the Big Curve, adding box-culvert tunnels to the resort exits, and improving avalanche control with snow sheds and Gazex® devices would improve the safety of the Canyon. A VC with forest service stewards would help educate visitors about the watershed and vulnerabilities of the Canyon. Bike paths; improved trails; utilities at trail heads, such as potable water and flushable toilets; and ADA access would make the Canyon more accessible and improved conveniences for visitors of the Canyon.

Our financial model estimates the first phase to be $65 million over 10-years. The second phase would be $114 million over 15-years, the third phase would be $137 million over 15-years, and the last phase would be $145 million over 10-years. To accomplish a self-sustaining funding model, the user fees were set for the funding needed to meet these costs. These estimated total costs include a 30% contingency to account for unknown factors.

11.0 CONCLUSION

Through these features and designs, the safety and access to the Canyon would be improved significantly to reduce the congestion period for Canyon visitors and nearby communities. In addition, we hope to achieve protection of the Canyon's sensitive ecosystem by minimizing the footprint of future transportation systems operating within its boundaries. While this is a potential first step for improvements to the Canyon, there are other methods and processes to consider preparing for the incoming population growth and usage of the Canyon. Through the SEA's preliminary design, we hope to not just provide you with details on potential solutions to community issues, but also with considerations on how to continuously improve in the future.

Based on the evaluations presented herein, we recommend the following concepts be further developed for the Little Cottonwood Canyon transportation system:

1. We recommend an intelligent transportation system (ITS) be developed that includes an autonomous vehicle network (AVN). We believe that such a system can be developed without the need of significantly widening or increasing the roadway footprint within the Canyon. We do not recommend significant widening of the Canyon roadway to support a dedicated high occupancy vehicle (HOV) lane. We believe such a lane is largely unnecessary, has the potential to degrade the Canyon's ecosystem, and is expensive (approximately $80 to $120 million) based on similar projects in mountainous terrain.

2. We recommend multimodal hubs be established to support the ITS and AVN. These can become a focal point of transit and allow for more disseminated out-of-canyon parking. We recommend that the first hub be established at 9400 South and Highland Drive. We do not recommend a Gondola System for implementation at this time. This system has cost and operational issues that make it challenging to implement. While the system has the potential to generate economic growth and serve as an additional attraction to the Canyon, the result of increased parking at the mouth of the Canyon would create congestion. Also, it is not known if system revenue will pay for the initial capital cost and future operational costs.

3. We believe that several roadway improvements are necessary to improve safety and traffic operations in the Canyon. These include:
    - Snow sheds;
    - Improvements to ingress/egress at the resort parking lots;
    - Minor alignment changes and widening to improve sight distance, merging, and passing; and
    - Shoulder improvements to improve cyclist safety.

4. We recommend a dedicated bike/pedestrian path be established within the lower limits of the Canyon. We recommend part of this trail be paved for ADA access. Such a path might be incorporated with a new VC constructed near the mouth of the Canyon.

We envision that the successful implementation of these recommended systems and safety features will allow Little Cottonwood Canyon to continue to provide a natural and inviting destination for people with diverse interests and hobbies to safely experience Utah's Wasatch Mountains. We believe this can be accomplished by protecting the Canyon's sensitive ecosystem and by minimizing the footprint of future transportation systems operating within the Canyon boundaries.

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APPENDIX A – LITTLE COTTONWOOD CANYON TRAILS, ROADWAY, INFORMATION, AND PARKING FEASIBILITY STUDY

APPENDIX B – PARK AND RIDE MODE DISTINCTION FIGURE

APPENDIX C – ROADWAY DESIGN FIGURES

APPENDIX D – ESTIMATED COSTS AND PROPOSED PHASING