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City of Irvine
Great Park Circulation Study

Final Report

November 2023

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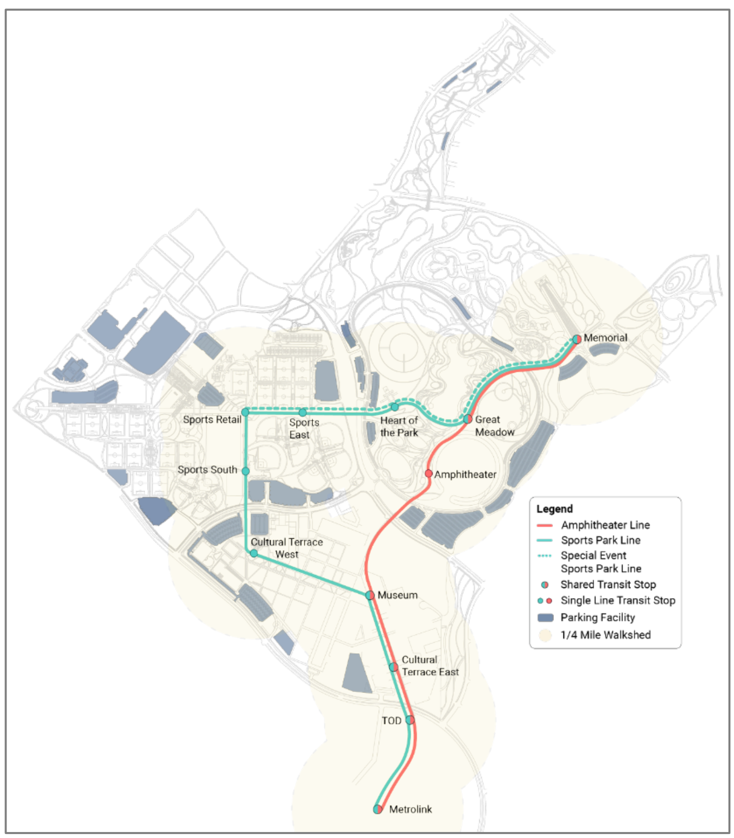
Executive Summary

Great Park has a lofty goal to be a world class sports park and cultural destination that attracts visitors from across the region. This Circulation Study was conducted to understand the key transportation movements across the park, and to determine what transit recommendation should be made to move visitors quickly, reliably, and conveniently across the site that spans over 1,200 acres.

Several steps were undertaken to complete this analysis. First, a market assessment was conducted to understand how existing and future conditions in and adjacent to the site will impact circulation. The team incorporated assumptions about the travel flows between the thematic districts, as well as the travel time competitiveness of a circulator system compared to walking to estimate the daily and peak hour ridership as well as to develop the recommended routes. Next, a series of three operations plans – from lower cost to higher cost – were then developed based on headway, operating speed, and operating hours assumptions.

Seven key areas were assessed during this analysis:

- **Operating Right of Way**: The transit operating environment is planned to be a single operating lane in most places with a width of 10 feet (**Appendix C**). Great Park designers could consider utilizing pavement treatments to delineate between different uses. These contrasting pavement treatments could help reduce potential conflicts between bicyclists and other micromobility users, pedestrians, and the circulator. To ensure that the system can operate properly in the narrow right-of-way, each transit stop, as well as two additional locations where transit stops are more than 0.5 miles apart, will have 100-foot layby lanes that allow the transit vehicles to bypass one another (14 locations in total).
- **Ridership Growth**: Based on our ridership model, the team projects that the circulator system would serve 380 average daily riders during the first year of operation in 2027, eventually growing to 1,750 average daily riders when the park is fully built out in 2042.
- **Service Plan:** The team recommends two routes with a total of 12 transit stops with frequent service operating at 10-minute headways during standard operating hours and five-minute headways during special events. The two routes will run between the Sports Park and the Cultural Terrace as well as between the Cultural Terrace and Botanic Gardens on a single lane road. We recommend operating a system with 10-minute headways; large special events will likely need service every 5 minutes.



- **Annual Operating Costs**: The team estimates that the annual operating cost for this system ranges from $200,000 to $800,000 annually (2027 dollars), and could grow to over $4,000,000 annually by 2042, depending on the hours and days of operation chosen by the city.
- **Preparing for autonomous service:** As autonomous vehicle (AV) technology matures, this plan recognizes that there is potential for the Great Park circulator to incorporate this technology and operate without a driver sometime in the near future. Incorporating AV technology will reduce vehicle conflicts, improve safety, and keep operating costs lower as compared to a human operated system. This plan recommends purchasing (or selecting an operator that has) autonomous vehicles, and transitioning to AV by 2032 with the completion of Great Park Phase 1.
- **Contracted Service**: The best course of action will be for Irvine to shift operation to a third party, which could significantly reduce capital costs. However, Irvine will still need to make key decisions on capital purchases, most notably whether vehicles are owned and maintained by the city.
- **Capital Costs**: The largest source of capital cost would be the vehicles, which could amount to up to $8,500,000 in 2023 dollars. This capital cost could be mitigated if the City of Irvine chooses to contract with third-party operator for the circulator service but would result in higher hourly operating costs.

  Circulator station amenities should include elements that boost rider comfort such as shelters, wayfinding signage, seating, lighting, and real-time information.

  The team recommends the use of electric vehicles to operate the circulator system, and that these vehicles should be stored in an indoor or outdoor storage facility on-site. Depending on the operator selected, this storage facility could be co-located with a MetroLink Station maintenance facility or located elsewhere. Heavy maintenance would need to be performed elsewhere.

Market Assessment

A market assessment was conducted for the Great Park to understand how existing and future conditions in and adjacent to the site will impact circulation for the future uses of the site. A primary goal for the market assessment was to understand the vision for Great Park and to develop a robust strategy for mobility improvements at the site. This included reviewing existing conditions information for how people currently travel to and through the Great Park area, the modes that they use to access the site, popular times and days, and regional transit amenities that provide options for visitors.

A key component of the market assessment was the development of a travel model that incorporates the existing conditions information to predict the demand for the proposed circulator system at the Great Park. Planning for a site and a circulator system at the scale of Great Park, and with its long-term timeframe for build out, creates the opportunity to put many of today's policy goals and tomorrow's technologies into play.

Model Overview

The Circulator Travel Model (CTM) was developed to understand and test the circulator supply and demand. This study defined three key phases during the Great Park build out: **Interim Phase 1 (2027), Phase 1 (2032), and Full Build (2042).** It is a spreadsheet model that estimates the ridership for the free circulator system serving Great Park during typical weekday, weekend, and three special event scenarios. Given the uncertainty in trying to estimate travel patterns over 20 years, the model was built with the flexibility to test different internal capture rate assumptions (the percent of trips that would be made within the site), headways, and operating speeds. Three special event scenarios, shown in **Table 1**, were also created to stress test the system, and to determine when additional capacity would need to be built into the system.

Small (Once a Month Event)	Medium (Once every 3-4 months)	Large (Once a Year Event)
› Typical Sporting Event (All day) › Farmer's Market (8am – 1pm) › Concert/Event (Evening) › Large Wedding/Private Event (Evening) *Total Attendance: 25,000*	› Large Sporting Event (All day) › Art Festival (10am – 5pm) › Seasonal event in gardens (e.g., Spring bloom) (All day) › Concert/Event (Evening) *Total Attendance: 50,000*	› Running Race: 5K, 10K, Marathon, etc. (7am – noon) › Numerous Large Sporting Events (All day) › Very Large Concert/Event (Evening) *Total Attendance: 75,000*

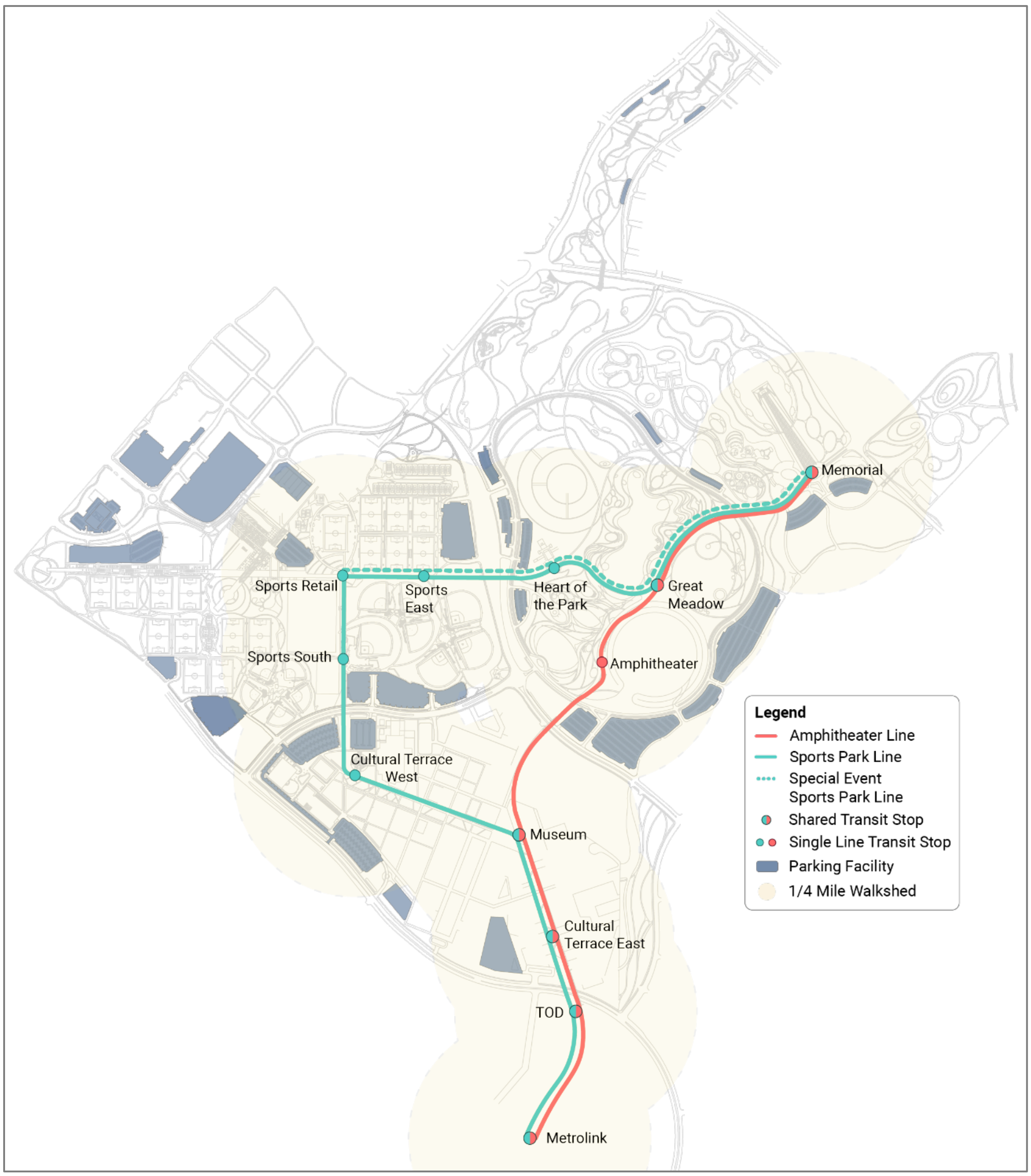
Table 1: Special Event Scenarios

For each phase of the project build out, the model estimates the circulator demand for each land use within the thematic districts of the park. The team incorporated assumptions about the travel flows between the thematic districts, as well as the travel time competitiveness of a circulator system compared to walking in order to estimate the daily and peak hour ridership. The travel time competitiveness of the circulator system incorporated average transfer and wait times, dwell times, and an average operating speed of 15 miles per hour (mph). A detailed overview of the modeling methodology, along with data sources and a description of the model spreadsheets, can be found in **Appendix A**.

Circulator Walksheds

During the modeling process, the team tested several different circulator alignments to optimize for a system that would provide the best connections between key areas throughout the park. **Figure 1** shows the circulator alignment that was modeled and selected along with a ¼ mile walkshed around the stations, highlighting the route coverage.

Figure 1: Map of Circulator Routes and the ¼ Mile Walkshed



Ridership Results

The following section provides an overview of the estimated ridership for the Great Park circulator system for each phase and scenario. **Figures 2 - 4** show the peak hour ridership for each phase of the park build out.

Figure 2: Interim Phase 1 Peak Hour Ridership

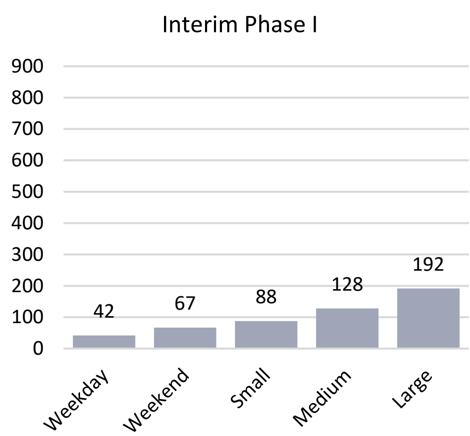


Figure 3: Phase 1 Peak Hour Ridership

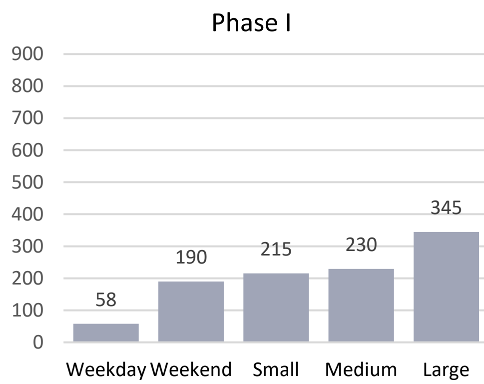
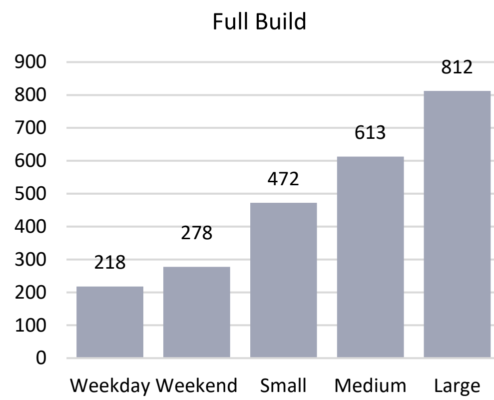


Figure 4: Full Build Peak Hour Ridership



As the park continues to be built out, and more land uses become activated, the ridership of the circulator system also continues to grow. Variations in the estimated ridership shown above can also be attributed to the assumptions around internal capture rates and projected visitor numbers for different special event scenarios.

Circulator Service Plan

Final Near- and Long-Term Alignments

In 2027 (Interim Phase I), the circulator would likely run as a circular loop around the core of the park or as an on-demand service in the core of the park, due to the fact that other areas will likely not have the required infrastructure to support a circulator during this early phase (**Figures 5 – 6**). In both the Circle Route and On-Demand scenarios, transit service would not be available at the Memorial, Cultural Terrace East, Transit Oriented Development (TOD), and Metrolink stops. It should be note that the TOD site is anticipated to be completed in 2042 when the Great Park site is fully built out. Operating as a 2.2-mile one-way Circle Route (**Figure 5**), travel time is 11.5 minutes and would operate on a 20-minute cycle time[1] with two vehicles in operation. The on-demand shuttle option, where riders call to request a ride at one of the eight transit stops and ride directly to their destination, making stops only if others are on board, would allow Great Park to provide on-site transit at lower operating costs (**Figure 6**). Two vehicles would be needed to operate the on-demand service. Projected ridership for Interim Phase 1 is expected to be low enough to sufficiently be served by an on-demand shuttle.

[1] Cycle time is the round-trip travel time plus recovery time at the end of the trip.

Figure 5: Interim Phase 1 Circle Route

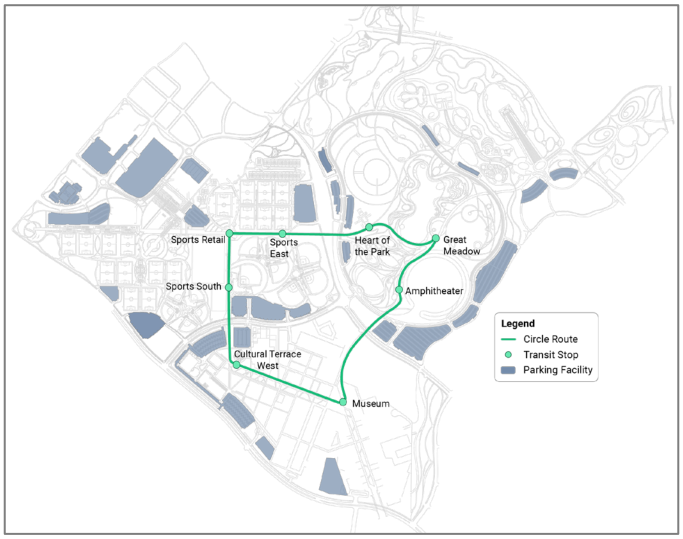
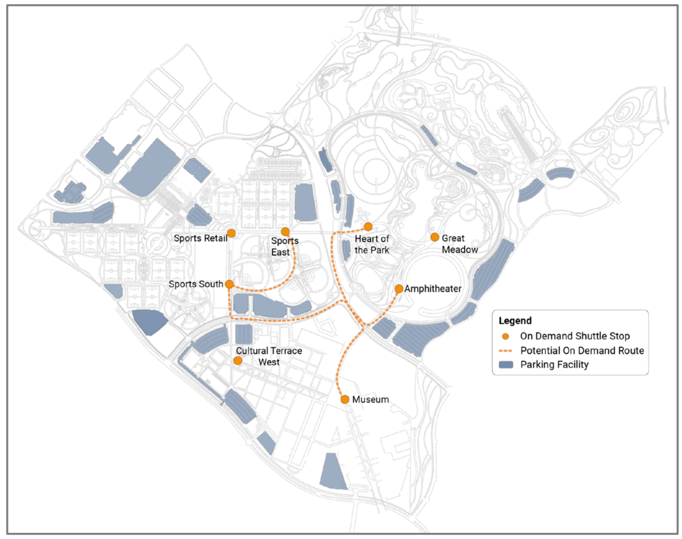


Figure 6: Interim Phase On-Demand Service



After Interim Phase 1, two routes at Great Park will facilitate the safe and efficient movement of visitors across the varied land uses on-site and enable visitors to park once and travel on alternative modes throughout the park to different activities. Once the park is fully built out, the team estimates that the highest travel affinities will exist between the Sports Park and the Cultural Terrace as well as between the Cultural Terrace and Botanic Gardens, therefore a line has been proposed traveling between these two origin and destination pairs. The Sports Park Line (shown in teal in **Figure 1**), will enable visitors to travel from the Metrolink through the Cultural Terrace to three stops within the Sports Park before travelling through the Heart of the Park to the Botanic Gardens. An optional special event route (shown as a teal dashed line in **Figure 1**) would enable visitors to rapidly travel along the spine of the park between sporting events. A more direct Amphitheater Line (shown in pink in **Figure 1**) enables visitors to travel directly from the Metrolink Station through the Cultural Terrace to the Amphitheater, with the route ending in the Botanic Gardens.

Utilizing a 10-minute headway and assumptions that the vehicle will operate at 15 mph and have a 20-second dwell time at each station, there are a total of seven layby locations that are needed to allow vehicles to pass one another during Phase 1 and Full Build as the circulator will run on a single lane road (**Figure 7**). To allow for increased operational flexibility, however, the team recommends each transit stop have a layby that shuttles pull off into when loading and unloading passengers (**Figure 8**). The team recommends each layby be 100 feet in length. Laybys will also provide additional space for emergency response vehicles.

Figure 7: Circulator Alignments & Meet Locations Based on 10-Minute Headway Operating Plan

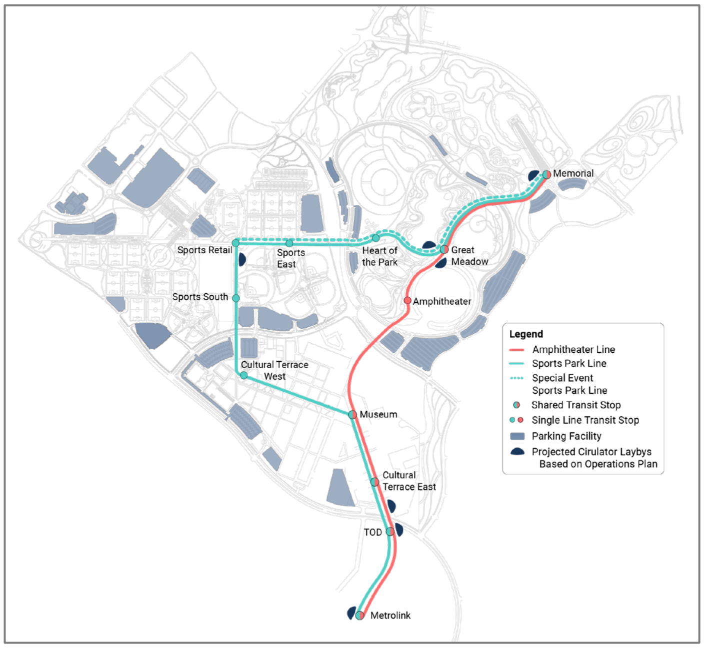
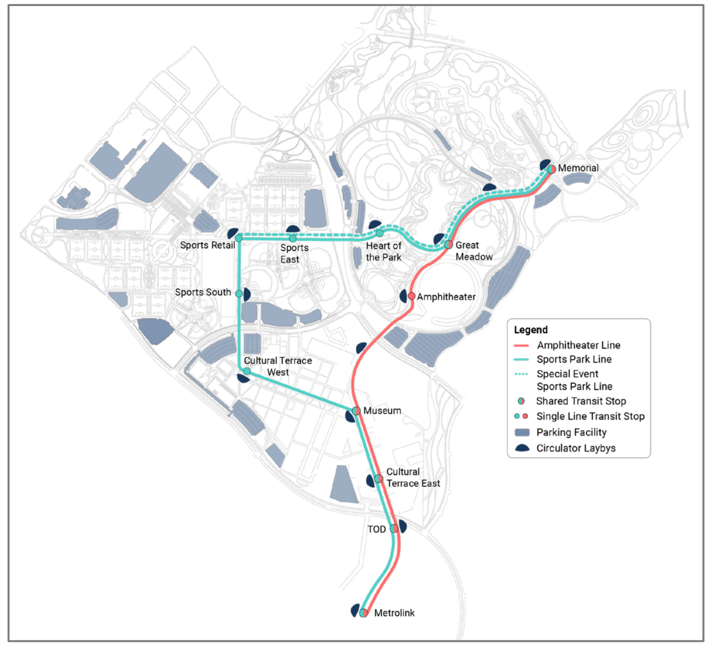


Figure 8: Circulator Alignments With All Bypass Locations



Service Characteristics

Once fully built out, the circulator system will have 12 stops in total. The Amphitheater Line will have seven stops, while the Sports Park Line will have 11 stops, six of which are shared between the two lines. At 1.8 miles long, the one-way travel time along the Amphitheater Line is 9.4 minutes, assuming 15 mph operating speeds and 20 seconds dwell per stop. The Amphitheater Line will need three vehicles during peak periods once the park is fully built and will operate on a 30-minute cycle time. At 2.6 miles long, the one-way travel time along the Sports Park Line is 13.6 minutes. With its longer travel distance, the Sports Park Line will need four vehicles during peak periods once the park is fully built and will operate on a 40-minute cycle time. Key route characteristics are summarized in **Table 2** below.

Table 2: Summary of Service Characteristics by Line

Amphitheater Line	Sports Park Line
› 1.84 miles one way › 9.4 min one-way travel time › 30-minute cycle time › 3 vehicles required in peak service	› 2.56 miles one way › 13.6 min one-way travel time › 40-minute cycle time › 4 vehicles required in peak service

Note: The above service characteristics apply after Interim Phase 1.

Three different operating options were developed along a low/medium/high cost arrangement, as shown in **Table 3**. Each route is proposed to operate with a 10-minute headway, which is the standard frequency for all phases. Special events have more variance. Between 2027 and 2031, the circulators will run on 10-minute headways; however, beginning in 2032, the circulator is proposed to operate with five-minute headways to provide seamless transportation for the larger crowds the park will attract for special events.

Hours of operation for the circulator system will vary by weekday and by phase of build out. For regular operating hours and special event operating hours, there are three potential operating plans, varying by cost (lower to higher cost). From 2027 – 2031, the system will be operated with human assistance; however, beginning in 2032, the system will be run autonomously. From 2027 – 2031, in the low-cost scenario, the circulator will not operate during weekdays, and it will only operate four hours a day on weekends and holidays. In the high-cost scenario, an on-demand shuttle will operate for eight hours a day during weekdays, and it will operate as a circulator for 10 hours a day on weekends and holidays. During this initial phase, the system will not operate during special events in the low-cost scenario, but in the high-cost scenario it will operate an overlay service for eight hours surrounding the event (up to 12 days per year). Moving through the second and third phases of the park's construction, the hours of operation for the circulator will slowly increase because it is assumed there will be more riders as additional attractions come online. After 2041, under the low-cost scenario, the service will run for eight hours a day on weekdays and 10 hours a day on weekends and holidays. In the high-cost scenario, the service will run for 12 hours a day on weekdays, weekends, and holidays. These different operating plans will provide park administrators the necessary flexibility to make service adjustments as construction plans and priorities evolve over time on-site.

Table 3: Summary of Operating Plan Options

Regular Operating Hours		2027-31	2032-41	After 2041
Low	Weekday	-	4 hrs	8 hrs
	Weekend/Holiday	4 hrs	8 hrs	10 hrs
Medium	Weekday	4 hrs (on demand)	8 hrs	10 hrs
	Weekend/Holiday	8 hrs	10 hrs	12 hrs
High	Weekday	8 hrs (on demand)	10 hrs	12 hrs
	Weekend/Holiday	10 hrs	12 hrs	12 hrs
Operating Assumption		Human-assisted	Autonomous	Autonomous

Special Event Operating Hours		2027-31	2032-41	After 2041
Low	Hours	-	6 hrs	8 hrs
	Days	-	6 days	12 days
Medium	Hours	6 hrs	8 hrs	8 hrs
	Days	6 days	12 days	20 days
High	Hours	8 hrs	8 hrs	8 hrs
	Days	12 days	20 days	30 days
Operating Assumption		Human-assisted	Autonomous	Autonomous

Note: Special event hours are assumed to occur while regular weekday or weekend service is already in operation.

Vehicle Technical Assessments

As autonomous vehicle (AV) technology matures, this plan recognizes that there is potential for the Great Park circulator to incorporate this technology and operate without a driver sometime in the future. AVs provide Great Park with the opportunity to reduce operating costs and create a more sustainable transit system. Planning with this technology in mind will allow for a smoother transition when AVs have reached a point where they can be successfully implemented at Great Park. There are four viable AV options currently in production and undergoing testing and pilot programs (**Table 4**).

Table 4: AV Comparison Chart

	ZF	Holon	Zoox	Cruise
Vehicle Specifications	› Autonomous Level 4 shuttle › Capacity: 22 passengers › Size: 22 x 7.8 x 9.5 ft (6.7 x 2.4 x 2.9 m) › Current Speed: Unknown › Initial max speed: 35 mph › Future max speed: 50 mph › Bi-directional travel? Yes › Scheduled 	› Autonomous shuttle › Capacity: 15 passengers (10 seated, 5 standing) › Size: Unknown › Current Speed: Unknown › Maximum Speed: 37 mph › Bi-directional Travel? Unknown (Likely) › On-demand 	› Autonomous taxi › Capacity: 4 passenger › Size: 11.9 ft long and 6.4 ft tall › Current Speed: Unknown › Maximum Speed: 75 mph › Bi-directional travel? Yes › On-demand 	› Autonomous ride-hailing › Current Vehicle: Chevy Bolt › Next Generation Vehicle: The Origin; Level 4-5 › Capacity: 6 passengers (The Origin) › Size: Full-size sedan › Maximum Speed: 30 mph › Current Speed: Unknown › Bi-directional Travel? No (current model) › On-demand 
System Info	› Partnership between ZF Group and Beep (mobility services and service management platform) › Can operate in mixed traffic or dedicated lane (intended for dedicated lane in first iterations)	› Plans to deploy automotive grade, fully electric level 4 autonomous 'movers' › Designed to meet automotive industry safety standards for public road use › Intended for mixed traffic ROW	› Mobility-as-a-service in urban environments › Personal ride-hailing service and platform › Intended for mixed traffic, dedicated ROW possible	› Applications include commuter transportation and delivery › Subscription- or membership-based system
Deployments	› This is the next generation of 2getthere minibus › Not yet in production	› Fixed Guideway › Unknown › Mixed Traffic	› Fixed Guideway: Unknown › Mixed Traffic › L3 vehicles (autonomous Toyota Highlander) are being	› Fixed Guideway › Unknown › Mixed Traffic

		› First pilot announced in Germany with Hamburg's Hochbahn › Jacksonville Transportation Authority evaluating mixed-traffic route › Vehicle production scheduled to begin in 2025	tested/collecting data in Las Vegas, San Francisco, Foster City, and Seattle. Safety and Software operators in vehicle › Zoox vehicle (below) being tested on private roads	› San Francisco, Phoenix, and Austin all have deployments of Cruise in select areas › SF now offers driverless rides as of June 2022 › Presence of human driver depends on local laws and is rapidly changing
Ownership	› ZF Group	› Benteler's EV Systems unit has changed its name to Holon to focus on electric, autonomous 'movers' › Recently announced strategic collaboration between Pininfarina (design company), Beep (mobility provider), and Mobileye (developer of AV driving system) › Holon to provide engineering and manufacturing expertise	› Subsidiary of Amazon (2020)	› Acquired by General Motors

Vehicle Recommendations

In the near-term, through approximately 2031, the team recommends using an electric vehicle that is human operated but has the future capability to become autonomous. Through 2031, between three and five vehicles will be needed to maintain the level of service described above, depending on whether the low- or high-cost scenarios are selected. Once the park has matured in full Phase 1 (approximately 2032), the expectation is that 17 vehicles would be needed to maintain the level of service described above.[2] This is due mainly to operating high-frequency (5-minute headway) service during high demand special events. If the City of Irvine decides to purchase its own vehicles, the cost is estimated to be between $1.6 – 2.8M[3] in 2027 and another $7.8M in 2032 to expand the service. Another option for Irvine is to have a third-party operator procure and provide vehicles. The useful life of the vehicle is assumed to be approximately 15 years, and the selected vehicle should have a capacity of approximately 22 passengers (at least 15 seats). With the vehicle's useful life estimated to be 15 years, eight additional vehicles will need to be purchased in 2042 to replace the vehicles purchased in 2027.

As AV technology continues to mature at a rapid rate, it is estimated that beginning in 2032, the technology will have evolved enough to safely, reliably, and consistently provide service using the Great Park's dedicated transit right-of-way. While the upfront cost for an AV circulator is higher, the major benefit of shifting to an AV circulator system once the technology is mature is the added cost savings of having fewer operators and drivers to run the service.

Table 5: Summary of Require Vehicles Based in the Low- to High-Cost Scenarios

	2027-31	2032-41	After 2041
Low	3	17	17
Medium	5	17	17
High	5	17	17

Figures 9 – 11 below show the expected peak hour circulator ridership with the hourly vehicle capacity of a human-assisted vehicle with a capacity of 35 passengers and a smaller AV with a capacity of 20 passengers. It is critical to assess whether the Great Park Circulator service can carry all of the passengers projected to use the park during each phase of development. During Interim Phase 1 and Full Phase 1, both circulator vehicles will have the capacity to carry all passengers that are anticipated during peak hours, except for large events during Full Phase 1. Once the park is fully built, both vehicle types will be able to sufficiently transport the ridership anticipated during weekdays and weekends; however, during special events, there may be unmet demand. In these instances of unmet demand, Great Park may need to put more vehicles in service or utilize larger capacity transit vehicles.

[2] The vehicle requirements include a 20% spare ratio.

[3] Price range accounts for the different vehicle requirements in the low- and high-cost scenarios.

Figure 9: Interim Phase 1 Peak Hour Ridership & Vehicle Capacity Values

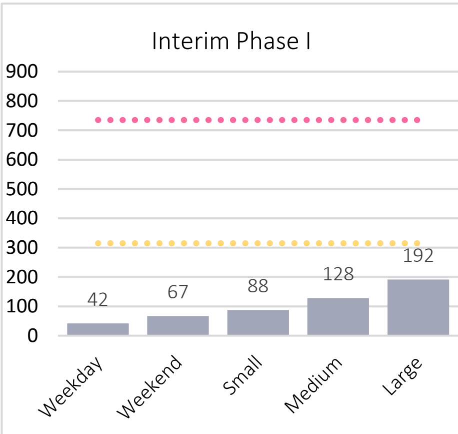


Figure 10: Phase 1 Peak Hour Ridership & Vehicle Capacity Values

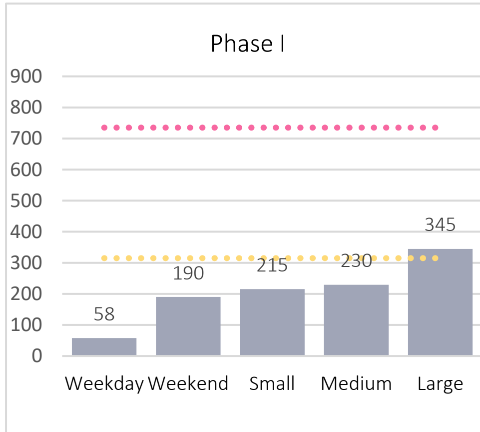
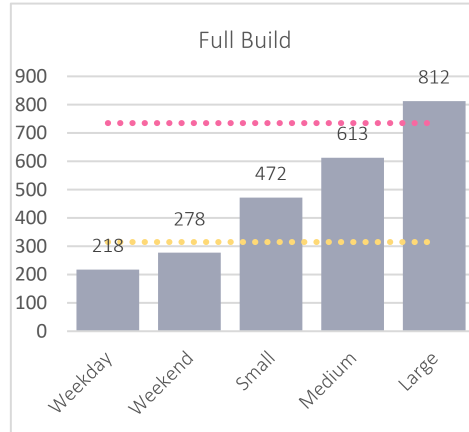


Figure 11: Full Build Peak Hour Ridership & Vehicle Capacity Values



•••••• *Traditional Tram Capacity (35 passengers / vehicle)*

•••••• *AV Shuttle Capacity (15 passengers / vehicle)*

Capital Costs

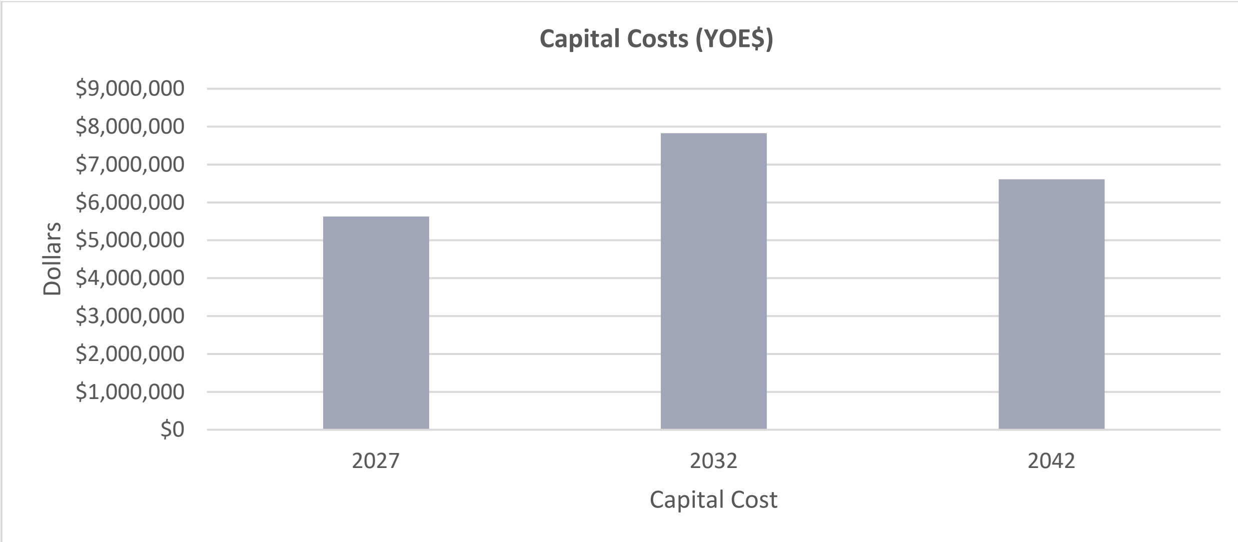
Assumptions & Methodology Overview

Capital costs are calculated as estimates for the year of purchase based on an annual 3.0% inflation rate. The costs described below are for three capital infrastructure components – vehicles, storage facility, and transit shelters – that should be acquired throughout the park's construction. All prices are shown in the year of purchase dollar value, based on an inflation rate of 3.0%. The capital costs also assume vehicles are in service for 15 years before being retired.

Cost Estimates

There will be three years between now and 2050 (2027, 2032, and 2042) that require significant capital investment in order to run the circulator system at Great Park. In 2027, the park will need to purchase its fleet of AV compatible electric vehicles, develop a fleet storage facility, and construct eight transit stops to support the Interim Phase 1 Circle Route plan. The City of Irvine can purchase infrastructure for the remaining four transit stops with the completion of Interim Phase 1. As mentioned previously, the estimated vehicle costs are between $1.6 – 2.8M in 2027 and an additional $7.8M in 2032 to expand the service. In Interim Phase 1, the capital cost of eight stations would be approximately $225,000, and in Phase 1, the capital cost of four stations would be an additional $131,000. The storage facility for the vehicles is estimated to cost approximately $563,000 in 2027 dollars. **Figure 12** summarizes the potential capital costs (utilizing the high-cost scenario) at three key years during the park's construction.

Figure 12: Summary of Expenses during Major Capital Spending Years



Note: 2027 capital costs displayed utilize the high-cost scenario. Initial capital costs in 2027 could be lower if the low- or medium-cost scenarios are utilized.

Annual Operating Costs

Assumptions & Methodology Overview

The annual revenue hours calculation is based on peak weekday, weekend/holiday, and special event service characteristics for low-, medium-, and high-cost scenarios. Characteristics include, headway time, route distance, vehicle travel speed, number of stops along the route, one-way travel time, layover time, cycle time, hours of service, and days of operation. With these parameters, one can estimate the number of vehicles that are required to maintain the level of service and how many revenue hours will be needed to run the service, ultimately shedding light on the cost of running the service with a human driver (through 2031) and as an AV (beyond 2031).

To develop human-assisted costs per revenue hour, the team used the National Transit Database (NTD) data for transit agencies in the region to develop a baseline assumption for real-world human-assisted operations. Agencies included in this research were Pasadena Area Rapid Transit System (ARTS), Riverside Transit Agency (RTA), San Diego Metropolitan Transit System (MTA), Beach Cities Transit (BCT), and Orange County Transportation Authority (OCTA). Taking the average revenue hour cost from this research, the human-assisted revenue hour cost in 2023 is assumed to be $114.55 and the AV revenue hour cost is assumed to be $83.00 in 2023. The AV revenue hour cost is lower due to the assumption that vehicle operation costs will be lower (approximately one dispatcher will be required to manage ten vehicles as opposed to one dispatcher and ten operators to run a service with ten human-operated vehicles). The assumptions for vehicle maintenance, general administration, and facility maintenance costs remain the same regardless of whether the service is human-operated or autonomous.

Cost Estimates

Based on the service assumptions presented above, the consultant team estimated annual revenue hours for each development phase of the park. A revenue hour is an hour of transit service, including both the in-service time and the out of service time that occurs at the end of the route before the vehicle turns around for a return trip. Revenue hours are directly reflective of the number of vehicles in operation (and the number of drivers needed to maintain a particular frequency). Higher frequency means more vehicles means more revenue hours. Longer service hours also impacts revenue hours.

The low-cost scenario has fewer revenue hours than the high-cost scenarios, reflective of the operating hours, frequency, and number of vehicles needed for service. Due to the length of the Sports Park Line and the number of vehicles needed to provide service at the 10-minute headways, the revenue hours for each year are longer for this line than the Amphitheater Line. From 2027 through 2031, the analysis projects between 1,300 and 6,600 revenue hours annually. From 2032 through 2041, the analysis projects between 14,900 and 28,900 revenue hours annually (**Table 6**). Once the park is fully built after 2041, the circulation service projects to have between 23,300 and 32,300 revenue hours annually.

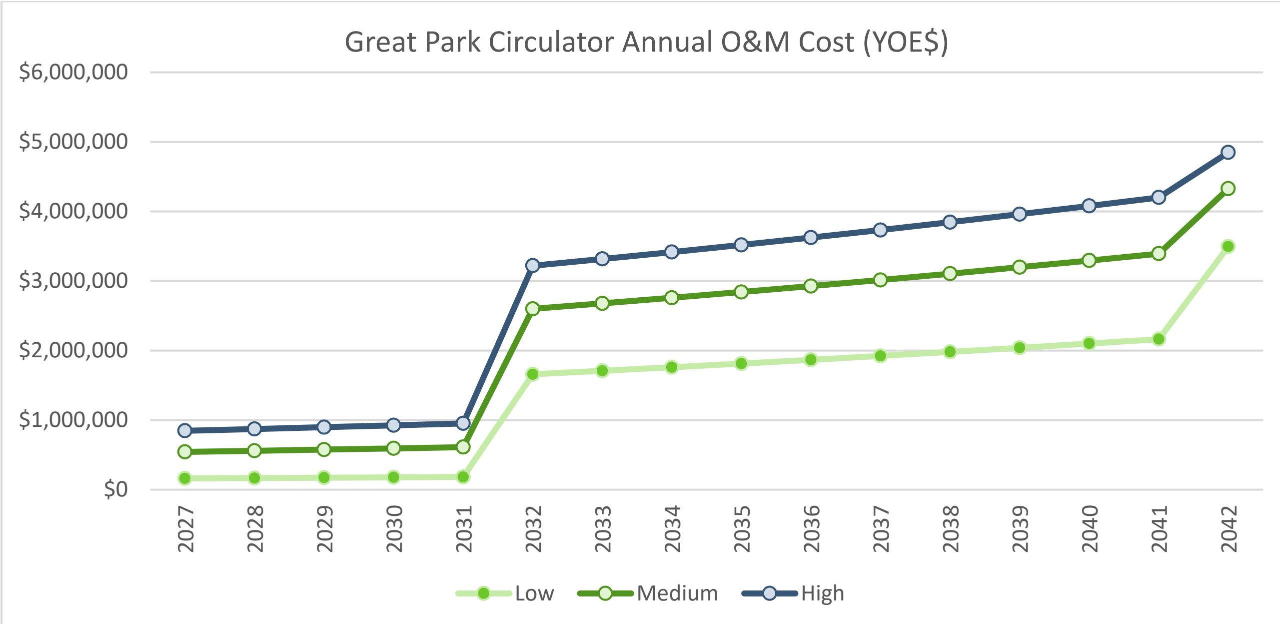
Table 6: Revenue Hours by Year

	Revenue Hours by Year		
	2027-2031	**2032-2041**	**After 2041**
Low	1,256	14,868	23,310
Medium	4,212	23,310	28,868
High	6,564	28,868	32,340

The consultant team developed operating and maintenance costs for the service. We started by developing a cost per revenue hour both for a human-assisted shuttle ($114.55 in 2023 dollars) and an AV shuttle ($83.00 in 2023 dollars). Each of these costs was based on National Transit Database information for purchased transportation services in California. The consultant team decided to use purchased transportation because it is exceedingly likely Irvine would use a third-party operator for the service. In 2027, the annual operating costs range from $161,900 (low-cost scenario) to $846,200 (high-cost scenario). By 2042, after adjusting for inflation, the annual operating costs range from $3.4M (low-cost scenario) to $4.8M (high-cost scenario). However, these are dependent on service choices that Irvine will make as the park matures. It will be critical to monitor the demand for services and tailor to actual demand, understanding that it will take some time for the transit market at the park to develop.

As shown in **Figure 13**, the operating costs will increase slightly from year to year due to the assumed 3.0% inflation rate. In 2032, the service hours will also expand, however, because the vehicles are anticipated to become autonomous by that year, the costs do not rise significantly. Looking at the annual operating costs of the low-cost scenario (light green line in **Figure 13**), there will be an increase in cost beginning in 2032, as the operating plan includes four weekday operating hours. The low-cost scenario sees another large increase in cost in 2041 when the weekday operating hours double to eight and weekend and holiday operating hours increase to ten. A similar trend in cost increases is shown in the medium-cost scenario (dark green line) and high-cost scenario (dark blue line) (**Figure 13**) and can be attributed to increasing the operating hours.

Figure 13: Annual O&M Costs for the Circulator Service



Implementation Plan

Planning and Implementation Best Practices

In the planning and implementation of an effective transit circulator system, several best practices are important to ensure broad success. The emphasis should be on frequent and simple service, as these are critical factors in determining ridership and convenience. This can be achieved by implementing headways of 10 minutes or less in combination with short routes. Short routes not only help in reducing operational costs but also offer the advantage of connecting multiple destinations while maintaining reliability. Adjustments to service must be made in real-time, considering changing needs in the region. The route design should focus on direct connections and should be fare-free to simplify the user experience. Branding of the service also plays an essential role, especially when the target market includes tourists, visitors, and non-transit riders. Creating this identity can be accomplished through a distinctive paint/graphics scheme and training operators to function as site ambassadors. Stable funding, particularly for operating expenses, is cited as a significant constraint leading to the discontinuation or non-implementation of many circulator services. Finally, when focusing on attracting non-transit riders, convenience must be prioritized at all levels as any inconvenience will deter this segment from using the service.

Appendix A: Circulator Travel Model Methodology

The Circulator Travel Model (CTM) was developed to understand and test the circulator supply and demand during three phases of the Great Park build out: Interim Phase 1 (2027), Phase 1 (2032), and Full Build (2042). It is a spreadsheet model primarily based on the Great Park Land Use and Trip Generation Phase 1 Baseline developed by ITERIS in June 2023. The objective of the model is to estimate the ridership for a free circulator system serving Great Park during typical a weekday, weekend, and three special event scenarios. The three different special event scenarios that were modeled include: a small, once a month event with 25,000 visitors; a medium, once every 3-4 months event with 50,000 visitors; and a large, once a year event with 75,000 visitors.

The CTM first determines the demand for the circulator originating from each land use within each of the park's five thematic districts (Heart of the Park, Botanic Gardens, Cultural Terrace, Sports Park, and Bosque) during each time period (weekday, weekend, and the three special event periods). The CTM then assigns origin-destination (OD) pairs from each of the land uses between the thematic districts to determine the circulator demand between the zones, and, more specifically, between land uses. Lastly, the transit verses walk time competitiveness and circulator site coverage are factored in to determine the total daily and peak hour ridership.

Model Inputs & Development Assumptions

As mentioned, the ITERIS Great Park Land Use and Trip Generation Phase 1 Baseline Average Daily Traffic (ADT) data is the foundation of the model. As this trip generation analysis was conducted for the Phase 1 land uses, the Great Park Phasing Summary file is used to determine which land uses would be built by Interim Phase 1 (2027).

Additional information provided by the City of Irvine on the destination retail planned at the intersection of Beacon and Grand Park Boulevard is incorporated into the Interim Phase 1 and Phase 1 inputs, where 90,000 square feet of grocery-anchored retail is assumed to be built by Interim Phase 1 and the remaining 100,000 square feet of destination retail to be built by Phase 1. The planned transit-oriented development (TOD) site adjacent to the Metrolink Station with 90,000 square feet of retail and 3,700 dwelling units is incorporated into the Full Build inputs. A trip generation analysis was performed for each phase of the planned retail development and the TOD site and incorporated as a separate land use in the Sports Park thematic district, and TOD thematic district, respectively.

The ITERIS Trip Generation ADT data is used as the baseline for the vehicle trips, and trip volumes for other modes are derived using the Fall 2022 Replica mode split data. Replica's modeled Thursday results are used to derive mode split for typical weekday trips and Replica's modeled Saturday results are used to derive mode split for a typical weekend and special event trips. Transit trips are split into further detail (bus, rail) based on the existing bus and rail ridership data from Amtrak, OCTA, and Metrolink. The trip mode is broken down as follows: auto, taxi (including Transportation Network Companies (TNCs)), bus, rail, walk, and bike. The mode split data for the Amphitheater and the Wild Rivers land uses are derived from data provided in the ITERIS Trip Generation analysis, as these have higher levels of taxi mode split based on existing field observations.

For the weekend and special event scenarios, the weekday ITERIS Trip Generation ADT data is adjusted to account for variances in weekday vs weekend trip rates based on data from the Institute of Transportation Engineers (ITE) Trip Generation Manual.

Determining Circulator Demand

Once the number of trips by mode is determined, bicycle trips are excluded (it is assumed that demand from cyclists would be minimal), and an internal capture rate is applied to determine the demand for the circulator originating from each land use. The internal capture rates for each phase and scenario are shown in **Table A1** below and can be easily adjusted in the spreadsheet model using a dropdown to estimate the circulator ridership with varying assumptions. Information regarding typical internal capture rates from different agencies across the country, from the *NCHRP Report 684: Enhancing Internal Trip Capture Estimation for Mixed-Use Developments*, was used as a reference and adjusted based on professional adjustment.

Table A2: Internal Capture Rates

	Weekday	Weekend	Special Event
Interim Phase 1 (2027)	Low	Low	Low
	2.5%	2.5%	2.5%
Phase 1 (2032)	Low	Medium	Medium
	2.5%	5.0%	5.0%
Full Build (2042)	Medium	Medium	High
	5.0%	5.0%	7.5%

Next, the circulator demand originating from each land use is allocated to destinations across the site by applying the affinity matrix percentages. The affinity matrices were developed using planning judgement to forecast synergies between all OD land uses.

Circulator Travel Time Competitiveness

The circulator ridership is then calculated as the circulator demand for each OD pair multiplied by the travel time competitiveness of the circulator system as compared to walking and the circulator route coverage. The travel time competitiveness is determined by calculating the average travel time between stops using the circulator, accounting for the distance between stops, an average operating speed of 15 mph, an average dwell time of 20 seconds, and an average wait and transfer time of ½ of the headway time. Different headway times of 5-, 10-, and 15-minutes were tested as part of the modeling process. This was compared to the average walking travel time between stops assuming a walking speed of 3 mph (20 minutes per mile). The route coverage is determined by calculating the percentage of total land area within a ¼-mile buffer of a circulator stop. The daily ridership is the sum of the resulting ridership between each OD pair. The peak hour ridership is determined for each land use based on the typical peak hour for similar land uses. For the average weekend, the peak hour was determined to be between 2 pm – 4 pm.

This process is repeated for both the Phase 1 and Full Build time periods to estimate the circulator demand and ridership. Mode splits were adjusted to more closely reflect the transportation characteristics of the site and the projected changes in travel patterns of the site's visitors in 2032 and 2042. The future mode splits were based off mode split trends at Balboa Park in San Diego, which has similar size, land use characteristics throughout the park, as well as parking availability.

The following pages provide a detailed description of the model structure, components, and data sources.

Model Inputs

- ITERIS Great Park Land Use and Trip Generation Phase 1 Baseline (June 2023)
- Great Park Phasing Details (IGP Phase 1 Project Summary_230511)
- Replica Average Thursday/Saturday Mode Share for Great Park and Balboa Park (Fall 2022)
- Average Transit Ridership, Weekday/Weekend:
    - Metrolink (January 2022 – May 2023)
    - Amtrak (January 2022 – August 2022)
    - OCTA (October 2022, May 2023)
- Sam Schwartz Trip Generation (September 2023)
    - Transit Oriented Development Site
    - Retail Center Development
- Lake Park / Great Meadow Use Intensive Study (August 2023)
- Peak Hour Estimates, Weekday/Weekend:
    - ITE Trip Generation Manual, 11th Edition
    - Replica Average Thursday/Saturday (Fall 2022)
    - Google Maps

Model Outputs

- Circulator daily ridership estimate for each phase and scenario
- Circulator peak hour ridership estimate for each phase and scenario

Description of Model Sheets

- **Summary**
    - Summary output of the circulator peak hour and daily ridership for each phase and each scenario in chart and table format.

Model Outputs

- **Interim Phase 1**
    - **Interim Phase 1 Trips**
        - Calculates the total number of trips by mode for each land use in each thematic district for the weekday, weekend, and special event scenarios. Dropdowns for the internal capture rate and special event type allow the user to toggle between different assumptions that automatically update the results on the 'Summary' tab.
    - **Interim Phase 1 Circulator Demand**
        - Allocates the demand for the circulator between different land uses within the park based on the affinity matrix.
    - **Interim Phase 1 Circulator Ridership**
        - Calculates the circulator ridership based on the transit vs. walk time competitiveness and the coverage area of the circulator. Peak hour ridership is estimated based on the typical peak hour percentage of trips for similar land uses.

- **Phase 1 (10 Year)**
    - **Phase 1 Trips**
        - Calculates the total number of trips by mode for each land use in each thematic district for the weekday, weekend, and special event scenarios. Dropdowns for the internal capture rate and special event type allow the user to toggle between different assumptions that automatically update the results on the 'Summary' tab.
    - **Phase 1 Circulator Demand**
        - Allocates the demand for the circulator between different land uses within the park based on the affinity matrix.
    - **Phase 1 Circulator Ridership**
        - Calculates the circulator ridership based on the transit vs. walk time competitiveness and the coverage area of the circulator. Peak hour ridership is estimated based on the typical peak hour percentage of trips for similar land uses.
- **Full Build (20 Year)**
    - **Full Build Trips**
        - Calculates the total number of trips by mode for each land use in each thematic district for the weekday, weekend, and special event scenarios. Dropdowns for the internal capture rate and special event type allow the user to toggle between different assumptions that automatically update the results on the 'Summary' tab.
    - **Full Build Circulator Demand**
        - Allocates the demand for the circulator between different land uses within the park based on the affinity matrix.
    - **Full Build Circulator Ridership**
        - Calculates the circulator ridership based on the transit vs. walk time competitiveness and the coverage area of the circulator. Peak hour ridership is estimated based on the typical peak hour percentage of trips for similar land uses.

Model Inputs

- **Phasing Details**
    - Phasing details summarized from the IGP Phase 1 Project Summary_230511 PDF Document.
- **ITERIS Trip Generation (June 2023)**
    - ITERIS Trip Generation analysis average weekday results dated June 2023.
- **Trip Generation Weekday + Peak Hour**
    - Average weekday and Saturday trip rate data from the Institute of Transportation Engineers (ITE) Trip Generation Manual, 11th Edition as well as the average weekday, weekend, and special event peak hour estimates.
- **Lake Park Assumptions**
    - Lake Park / Great Meadow attendance estimates provided by Steven Kellenberg.
- **Trip Generation – Retail Interim Phase 1, Retail Phase 1, and Transit Oriented Development**

  - Trips generated from the retail and transit-oriented development sites for the Interim Phase 1, Phase 1, and Full Build periods.
- **Replica Mode Share**
  - Summary of the average Thursday and average Saturday mode split and temporal distribution data for Great Park and Balboa Park in San Diego.
- **Land Use Hourly Distribution**
  - Summary of the temporal distribution of trips data from ITE and Google Maps.
- **Existing Transit Ridership**
  - Summary of transit ridership data for Metrolink, Amtrak, OCTA routes 86 and 480, and the iShuttle.
- **Affinity Matrix – Interim Phase 1, Phase 1, and Full Build**
  - Estimates of the flows between the different thematic districts and land uses across the park.
- **Walk Time Competitiveness**
  - Calculation of circulator and walking distances and travel times between the different circulator stops between each thematic district.

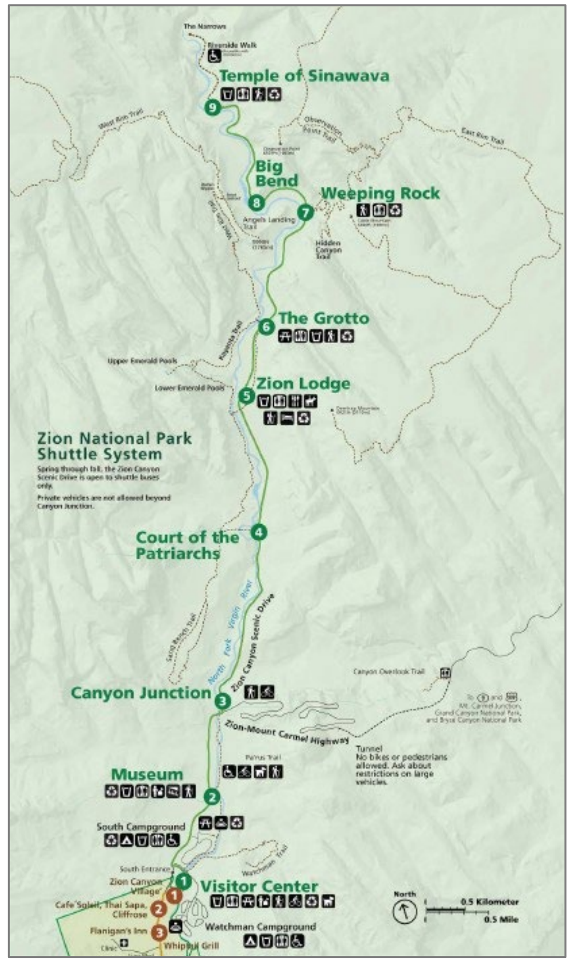
Appendix B: Case Studies

Case studies were reviewed in the interest of gathering information and themes from a wide range of locations that are comparable to Great Park in size, use, and/or circulator usage. Important key points were gathered for each case to help paint a picture of how different service designs function across different parks. Each of the 8 examples are detailed below:

Zion National Park

Springdale, Utah

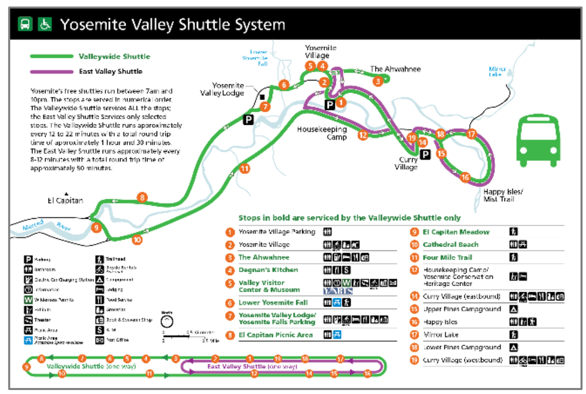
Park Size & Number of Visitors	Parking Characteristics
› Park is 146,560 Acres (229 Sq. Mi.) › 4.7 million visitors in 2022 › More than 400k visitors per month between March-October (peak season) › Park is 122x larger than Great Park	› Three main parking lots provide visitor access (free) › Town of Springdale has additional, overflow parking facilities ($15-20/day) › In the off-season, when the shuttle is not running, a limited number of visitors can drive into and park in Zion Canyon
Transit Serving Park	**Mode Share & Transit Ridership**
› Zion Canyon's free shuttle (run by NPS) runs through Springdale and along the Zion Canyon Scenic Drive from 7 a.m. – 7:15 p.m. › Shuttle season varies from year to year	› Majority of visitors take the shuttle when visiting the park (90% in 2002)



Yosemite National Park

Yosemite Valley, California

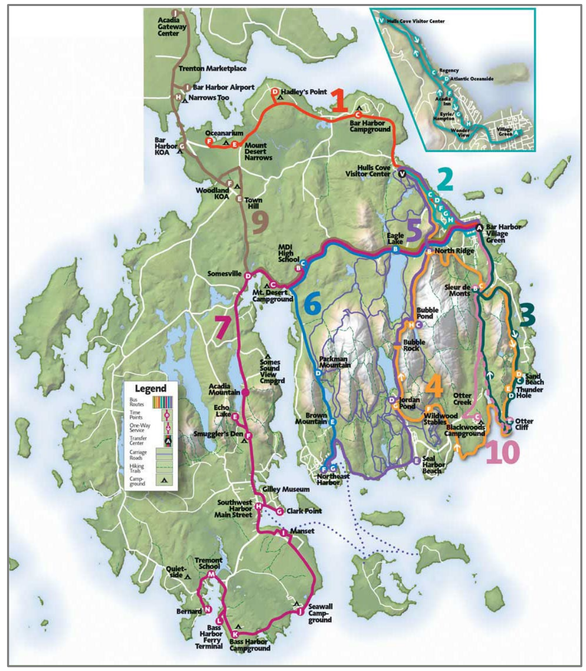
Park Size & Number of Visitors	Parking Characteristics
› Park is 759,620 acres (1,169 sq mi) › 3.5 million visitors per year › More than 300k visitors per month between June-October (peak season) › Park is 633x larger than Great Park	› Parking (free) available in main village but is limited › Parking elsewhere is discouraged due to congestion, shuttles are encouraged
Transit Serving Park	**Mode Share & Transit Ridership**
› YARTS (purchase tickets) – 1 year- round route, 3 seasonal routes (shown in top photo) › Transfers visitors from surrounding regions to the park › 2 free shuttles within the park running from 7am to 10pm › Shuttles arrive every 8-22 minutes	› YARTS provides travel for over 120,000 visitors per year › Shuttles carry more than 3 million visitors per year – more than 85% of visitors use the shuttles per year



Acadia National Park

Bar Harbor, Maine

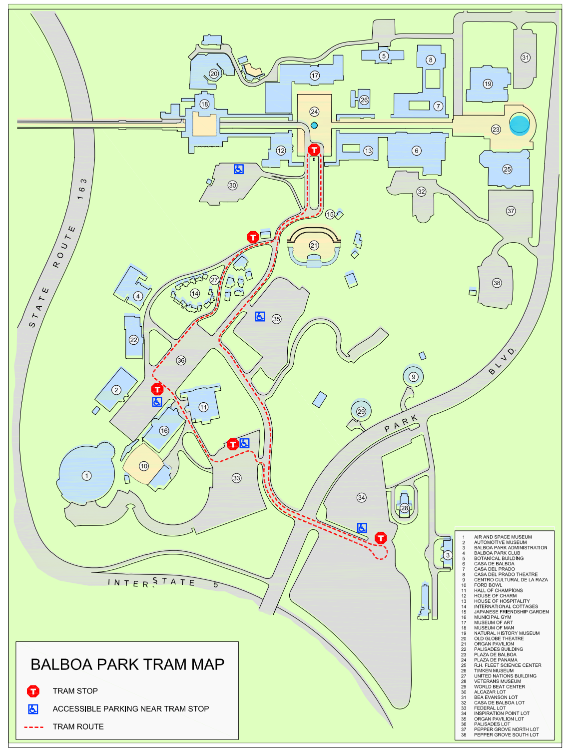
Park Size & Number of Visitors	Parking Characteristics
› Park is 47,000 acres (73 Sq Miles) › 4 million visitors per year › More than 500k visitors per month between June-October (peak season) › Park is 39x larger than Great Park	› 4 main parking lots provide visitor access
Transit Serving Park	**Mode Share & Transit Ridership**
› The Island Explorer bus service (free) provides 11 routes with headways between 30 min to 2 hour › Bus schedules vary by season and most operate from June to October › Buses owned by private non-profit (Downeast Transportation)	› The service averages 5,000-6,000 riders per day, up to 8,000 on busy days › Originally $2 to ride, removed fare and ridership increased 600% › Around 50% of visitors use the bus service per year*



Balboa Park

San Diego, California

Park Size & Number of Visitors	**Parking Characteristics**
› Park is 1,294 acres (56,388,259 sq ft) › 14 million visitors per year › Park is essentially the same size as Great Park	› 11 free parking lots › Electric car charging stations in 2 parking lots
Transit Serving Park	**Mode Share & Transit Ridership**
› The free tram arrives every 10-15 minutes and runs from 9am-7:45pm (Summer) and 9am-5:45pm (Winter) › The tram has 5 stops › It has room for ~72 passengers	› Prior to 2020, tram system averaged 36,500 riders per month & 438,360 per year › Nearly 3% of visitors use the tram per year***



National Mall National Park

Downtown, Washington D.C.

Park Size & Number of Visitors	Parking Characteristics
› Park is 309 acres (13,460,040 sq ft) › 36 million visitors per year › Park is 74% smaller than Great Park	› 1,200 metered parking spaces available at \$2.30/hour, max 3 hours › 400 free parking spaces › Parking is very scarce
Transit Serving Park	**Mode Share & Transit Ridership**
› Washington D.C. circulator (\$1) – National Mall Route is 1 of 6 routes provided › It has 15 stops and arrives every 10 minutes › It runs from 7am-8pm on weekdays and 9am-8pm on weekends (changes seasonally) › 1 hour 5 mins to complete full route	› More than 400,000 people ride this route per year – about 1% of all visitors per year*

Disneyland

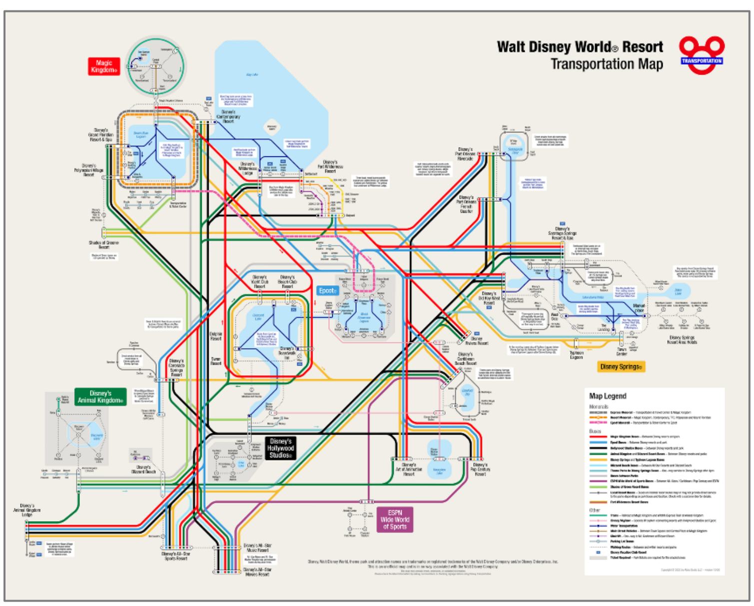
Anaheim, California

Park Size & Number of Visitors	Parking Characteristics
› Park is 500 acres (21,780,000 sq ft) › 8.5 million visitors in 2021 › Park is 58% smaller than Great Park	› 3 main parking areas ($30/day) › Small amount of electric vehicle charging stations
Transit Serving Park	**Mode Share & Transit Ridership**
› Free monorails (red line on map) and trams transfer patrons from parking to park entrances › Arrives every 10 minutes › Monorail can fit 120 riders; roundtrip is 2.5 miles and tales 12 mins	› Metrolink, Amtrak Metrolink, Amtrak, and intercity buses stop at **ARTIC**, a transit center two miles east of Disneyland. › Anaheim Resort Transit shuttle and OCTA routes: 50 provide connection between Disneyland and ARTIC.

Walt Disney World

Lake Buena Vista, Florida

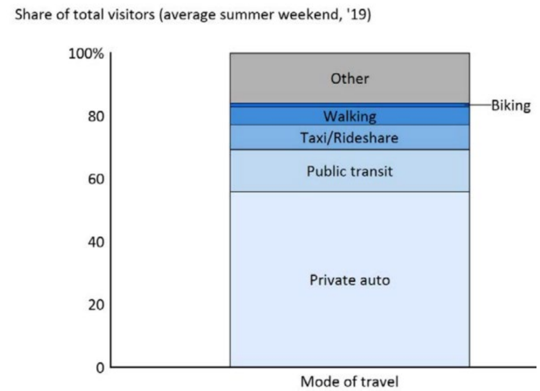
Park Size & Number of Visitors	Parking Characteristics
› Park is 27,520 acres (43 square miles) › 58 million visitors per year › Park is 23x larger than Great Park	› Each of the 4 theme parks and resorts have their own parking lots (Up to $25/day)
Transit Serving Park	**Mode Share & Transit Ridership**
› Free buses, monorails and trams transfer patrons from parking to park entrances › Monorail lines (3) span 14.7 miles and arrive every 20 minutes › Trams (4) can transport 300 visitors each › Nearly 325 buses circulate visitors, arrive every 20 mins › Boat/ferries/water taxis have 15-30 min headways	› Monorail services 50 million riders per year › Over 150,000 riders per day in 2016 – nearly 94% of visitors per year



Museum Campus

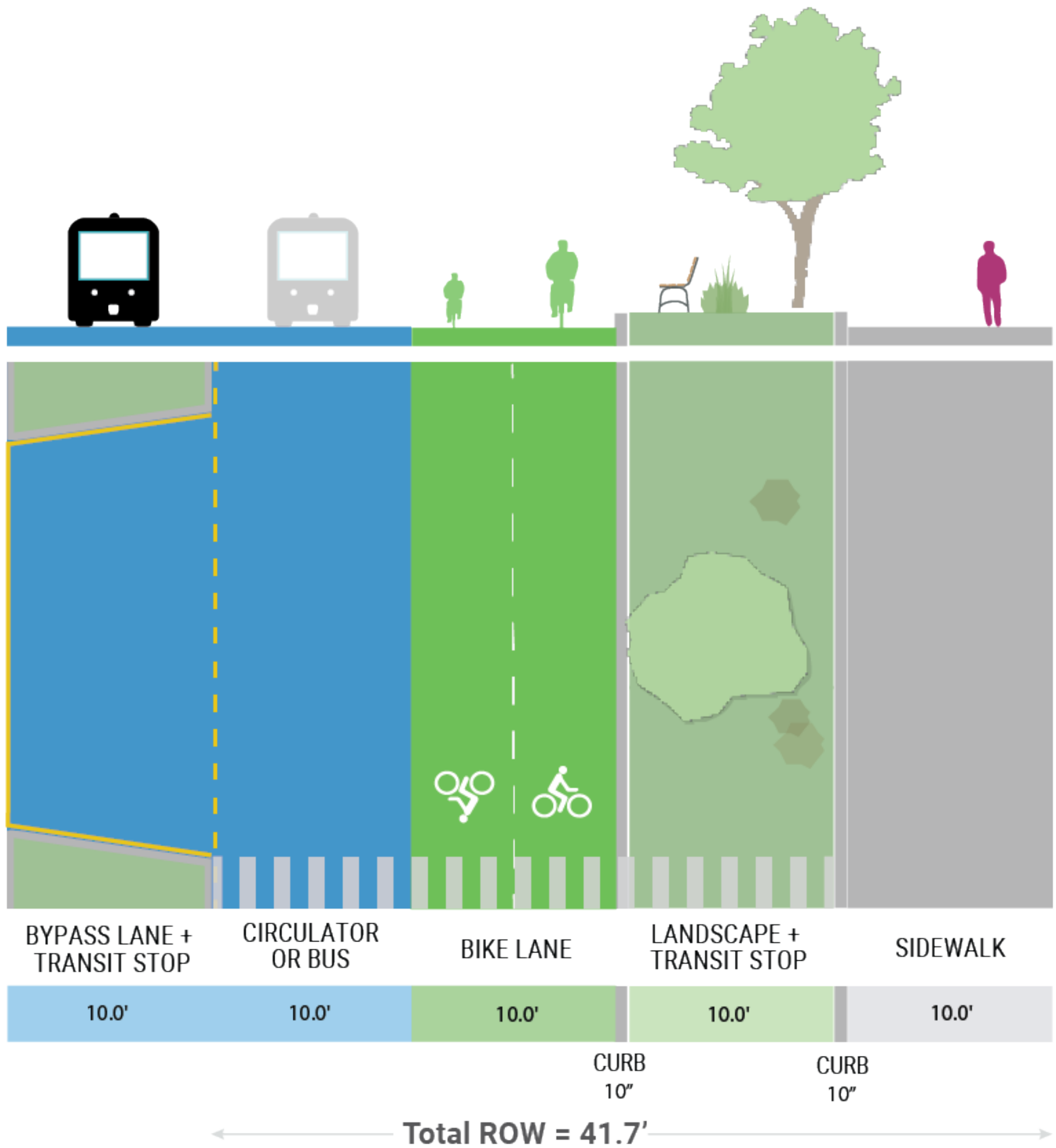
Grant Park, Chicago, Illinois

Park Size & Number of Visitors	**Parking Characteristics**
› Park is 307 acres (0.48 sq mile) › Over 5 million visitors per year; typical Summer Saturday has about 19,000 visitors (2019) › Park is 75% smaller than Great Park	› About 7,100 parking spots available › Multiple parking garages available, average price is $22-26 on ordinary days
Transit Serving Park	**Mode Share & Transit Ridership**
› 2 CTA Bus Routes serve the campus › CTA 130 operates seasonally from Memorial Day weekend through Labor Day; runs roughly every 15 mins › CTA 146 operates daily	› More than half of all daily visitors arrive by private motor vehicles and only 13% traveled via public transit (2019) – view graphic on right



Appendix C: Circulator Lane Configurations

Better Lane Configuration



Best Lange Configuration