

M E M O R A N D U M

To: Alexa Viets
From: Bonnie Nelson
Date: August 15, 2008
Subject: Muir Woods Shuttle Alternatives

This memorandum will assess the access implications of General Management Plan alternatives for operations at Muir Woods National Monument. Under one of the Preliminary Alternatives for Muir Woods identified in the 2008 plan, all non-accessible parking would be removed from Muir Woods lots (and, possibly, from adjacent Muir Woods Road) and relocated to a remote site; a major expansion of the existing limited shuttle service to Muir Woods would be necessary to support access to Muir Woods. Under the remaining two alternatives, some on-site parking would be retained for use during off-peak periods. These access elements are central to the park visions outlined in the GMP.

This memorandum summarizes existing access conditions, providing an understanding of the issues and opportunities associated with the current Muir Woods Shuttle. The memo includes opportunities to expand and alter the shuttle operation to respond to the potentially evolving access conditions at Muir Woods.

Following the discussion of existing conditions, the memo identifies the level and type of service that would be necessary to accommodate the current number of visitors at Muir Woods under different GMP alternatives. The memo focuses on the feasibility of operating the required shuttle system, and provides information about potential costs, operating plans, and changes in visitor experience.¹

Information included in this memorandum is synthesized from a number of sources, including Nelson\Nygaard's 2007 analysis of the Muir Woods shuttle service (which, in turn, included surveys of both shuttle riders and other park visitors) and parking occupancy surveys conducted in 2001 and 2004 as part of the Comprehensive Transportation Management Plan for Parklands in Southwestern Marin, or CTMP.

¹ This analysis was used in the Choosing By Advantages National Park Service decision-making process to determine the gross feasibility of the alternatives by gaining an understanding of the order of magnitude of shuttle services required. Analysis of these GMP alternatives will be refined for future Draft EIS analysis in the GMP process.

Executive Summary

Analysis of available data on existing conditions reveals a number of key issues:

- Muir Woods visitation patterns are heavily peaked – both seasonally (summer visitation is more than triple that in the winter) and on weekends.
- Surveys of Muir Woods visitors suggest that while a large majority access the Woods by auto, a strong market exists for expanded shuttle service, particularly new service to San Francisco.
- Existing parking at Muir Woods, while somewhat elastic in its capacity due to the availability of parking on the shoulder of Muir Woods Road some distance from the park entrance, is heavily-used during peak periods. Data suggests that limited space in off-street lots fills to capacity even on shoulder-season weekdays and off-season weekends.
- The Muir Woods Shuttle, a pilot program in its fourth year, now carries about 1 in 10 visitors to the Woods on summer weekends. Rates of ridership growth have outpaced expansions of service, and while a number of operational challenges remain, the service has so far exceeded expectations. However, as a grant-funded pilot program, its future is uncertain.
- Excess capacity exists in remote parking lots currently used by shuttle riders; however, this is largely due to that fact that shuttles only operate on weekends, when the lots are not in use by commuters.

Seven different scenarios for removal of on-site parking and expansion of shuttle service have been developed and screened for potential feasibility and compatibility with GMP objectives. The alternatives vary by degrees of on-site parking removal (100%, 50%, and 25%, as suggested by GMP alternatives) and accompanying increases in shuttle service; by whether or not new shuttle service to San Francisco is included; and by whether or not tour bus access is removed from the Woods.

Initial assessments indicate that:

- While significant removal of on-site parking would no doubt reduce visitation and, it follows, demand for expansion of shuttle service, new demand generated by expanded service would offset and might even negate that loss.
- The additional time required to access the Woods from a remote parking site would increase average parking duration and, in turn, increase occupancy rates by almost half. While shuttle service to San Francisco could reduce demand somewhat, demand for off-site parking is still likely, in scenarios calling for complete removal of parking from the Woods, to be much greater than existing demand for on-site parking and, on summer weekdays at least, to exceed existing capacity in lots now used by shuttle riders as well as adjacent lots that might potentially be made available.
- While detailed traffic analysis has not yet been conducted, initial evaluation raises reasonable concerns regarding traffic operations. Displacement of large numbers of cars to the area of Highways 101 and 1 might severely impact traffic operations, and the numbers of buses (up to one every three minutes) required to satisfy existing demand for park access might prove unacceptable to Caltrans and/or the community; they might also present significant operational challenges. Further analysis would be needed to determine the extent of these impacts.
- While the cost of expanded shuttle service might be mitigated by contracting operations to a less-expensive vendor, the volume of shuttle service required to maintain existing levels

of access without on-site parking could prove prohibitively expensive – potentially \$10 million or more to provide the transit frequencies required to maintain current levels of visitation.

- Alternatives maintaining some parking at the Woods appear to be significantly cheaper, and their impacts much easier to manage. Even relatively modest expansions of existing service could result in a much higher-quality transit product: under the most modest expansion scenario, peak frequencies would be reduced from 20 to 8 minutes, and service expanded to summer weekdays.
- New service to San Francisco, while relatively expensive to operate, could significantly reduce parking demand, greatly improve access to the Woods, and potentially attract many new visitors.
- Finally, retention of some parking on-site could serve as a means to fund expansion of shuttle service. If fees were charged equivalent to half the cost of shuttle fares, revenues would significantly exceed the existing program budget and the subsidy required of any major expansion would be significantly reduced.

Existing Conditions

Visitation at Muir Woods

Currently, about 760,000 paid visitors per year travel to Muir Woods. Visitation peaks during the summer months, particularly on weekends. According to counts provided to Nelson\Nygaard by the National Park Service, on its busiest day in 2007 Muir Woods recorded 5,004 paid visitors. Average attendance on Saturdays and Sundays over the course of the summer was 4,065.

Figures 1 and 2 on the following page illustrate trends in park visitation.

Figure 1 Muir Woods Paid Visitation by Month, Oct. 2006-Sept. 2007

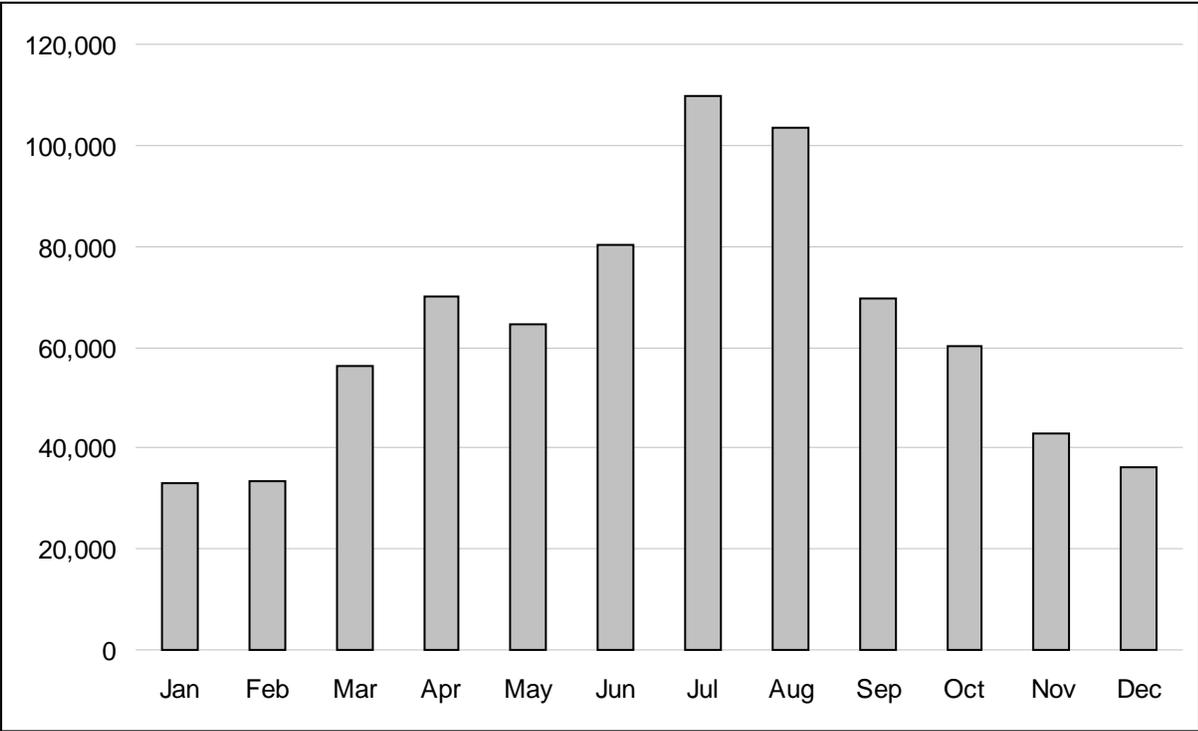
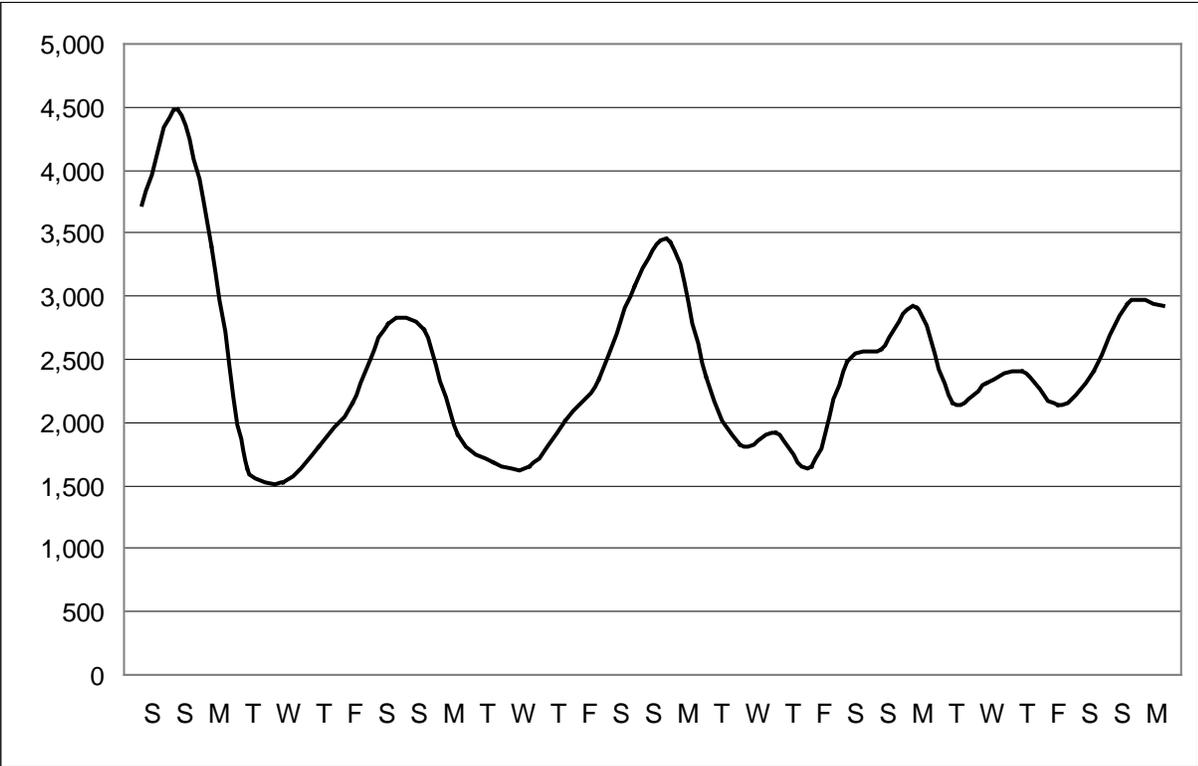


Figure 2 Muir Woods Paid Visitation by Day, July 2007



The Muir Woods Visitor

As part of its 2005, 2006, and 2007 evaluations of the Muir Woods shuttle, Nelson\Nygaard conducted extensive surveys of both shuttle riders and other visitors to the park. Among the key findings in the most recent survey:

- Over half of all respondents indicated they were visiting Muir Woods for the first time.
- Slightly less than three in five respondents lived outside the Bay Area.
- Approximately 44% of park visitors began their trips in San Francisco.
- Approximately 45% of respondents began their trips at a hotel.
- Approximately 73% of shuttle passengers traveled to the shuttle stop by car, while 22% took transit.
- Approximately 91% of non-shuttle users traveled to the park by car. About 34% of respondents had arrived in a rental car.
- Many shuttle riders (34%) chose to use the shuttle because they didn't want to drive in traffic or look for parking at Muir Woods.
- 26% chose the shuttle because they saw a variable-message sign on Highway 101 indicating that Muir Woods parking lots were full, and directing them to a shuttle stop.
- The most common rider-suggested improvements were increased frequency (24%), better connections to San Francisco (16%), and weekday service (9%).
- Almost 95% of shuttle passengers thought a fare of \$2.00 or greater was reasonable for shuttle service. (Note: the fare has since been increased to \$3.00 per round trip. Since increasing the fare, a slight reduction in ridership has been noted).
- Over half (55%) of non-riders were not aware of the shuttle, 26% knew about it but didn't have any information about it, and 19% knew about it but it wasn't appropriate for their travel needs.
- 20% of non-shuttle users who were aware of the shuttle said they did not use it because they were not returning to the place they started, or that the shuttle was not going to their next destination, and 14% said they either had too many people, or people with special needs in their party. Another 35% gave "other" reasons.
- Among non-riders, 17% said better connections to San Francisco would make them more likely to use the shuttle, and another 10% chose more frequent service. Only 4% said that they would not ride the shuttle under any circumstances.
- Average party sizes were about 3 for shuttle riders, and just over 4 for other visitors.
- Approximately 11% of respondents aboard shuttles said one or more members of their party was under the age of 18, compared to 16% of non-shuttle respondents.

Parking at the Woods Today

Most visitors arrive at Muir Woods by automobile. Muir Woods provides 179 parking spaces in three parking lots, supplemented by approximately 175 legal spaces along Muir Woods Road. Parking on the roadway historically has extended to areas where parking is prohibited, and there is minimal enforcement. Marin County has recently fenced off some of the shoulder area.

Parking conditions were most recently observed as part of the CTMP². Data were collected by Robert Peccia & Associates on select peak (Memorial Day to Labor Day), shoulder-season (May and September) and off-peak days in 2001 and 2002; follow-up checks of occupancy were then conducted over a two-month period during summer in 2004. Key findings included:

- In 2004, the highest observed number of vehicles parked at the Woods was 475. This includes parking alongside Muir Woods Road.
- The 2004 peak-season average maximum occupancy on weekends was approximately 403 (410 on Sundays, and 396 on Saturdays).
- The peak observed occupancy in 2001, of 448 vehicles, occurred at 2:50 p.m. on a Saturday; however, the peak hour for arrival rates was between 11 a.m. and noon, when 344 vehicles arrived, and lots were observed at capacity as early as 10:45 a.m.
- The highest total number of vehicles observed arriving at the Woods between 9 a.m. and 5 p.m. in 2001 was 1,218, on a Saturday. As maximum occupancy that day was 448, this indicated a turnover rate of approximately 2.7.
- Average stays varied slightly depending on season, but generally were in the 90- to 110-minute range in 2001. (While no data is available on average lengths of shuttle riders' visits, logic suggests that they would be longer, as those who arrive by shuttle must return to their original stops before visiting another destination – making it more likely that they would be “making a day” of the Woods rather than “just stopping by.”)

The Muir Woods Shuttle Today

The Muir Woods Shuttle, a partnership of the National Park Service, Marin County and Golden Gate Transit, was introduced in the summer of 2005. Originally intended to be a three-year pilot program funded by a federal earmark, it has been extended to the 2008 season and has been expanded each year.

The service, also known as Golden Gate Transit Route 66, now consists of two routes: May-September service from the Golden Gate Transit hub at the Gateway Center in Marin City, with interim stops at Pohono Street (Monument-bound) and Manzanita (in the reverse direction), and a second route in the peak season only, between Memorial Day Weekend and Labor Day Weekend, from the Sausalito Ferry Landing, with interim stops at Pohono/Manzanita. Both routes operate on Saturdays and Sundays during park hours. The Marin City route operates on 20-minute headways during the peak season and 30 minutes off-peak, while the Sausalito route is timed to meet ferry arrivals and departures. Scheduled one-way travel times are between 20 and 30 minutes, and fares are \$3 round-trip.

Shuttle riders and other park visitors have been surveyed every year of the shuttle's operation. Key findings from the 2007 survey include:

- In 2007, the highest ridership in a single day was 1,143 boardings, representing approximately 572 park visitors. Average daily ridership was 713 boardings or about 355 visitors.
- The highest mode share achieved by the shuttle on any given day was 14.2 percent. Average over the peak season (Memorial Day through Labor Day) was 10.4 percent, and over the entire course of the season, including shoulder months, it was 9.4 percent. This

² The Comprehensive Transportation Management Plan for Parklands in Southwestern Marin, completed in 2004, was a conservation planning and environmental impact analysis process regarding transportation access and improvements to the roadway network between the Highways 101 and 1 interchange and Stinson Beach.

means that about 1 in 10 visitors to Muir Woods took the shuttle on days when the shuttle was available.

- Ridership has grown substantially each year of the service. In 2007, it was 290 percent higher than in 2005; while this can be attributed in part to increased service (a new route, greater frequencies, and shoulder-season service), peak-season ridership remained 83 percent higher over the same period than it was in 2006.
- Likewise, peak-season productivity has increased from 13.4 passengers per revenue service hour in 2005 to 22.6 in 2007.
- Ridership patterns are heavily peaked, in the direction of the Woods between 11 a.m. and 3:30 p.m. and for return trips, between 1 p.m. and 6 p.m.
- Despite the relatively high expense (\$320,276 in 2007) of operating a service that is, by necessity, rather cost-ineffective, by 2007 its farebox recovery ratio had reached 15.2 percent.
- For a variety of reasons, the service's on-time performance is problematic: 25.5 percent of buses were more than 10 minutes late in 2007.

As currently designed, the service suffers from a number of deficiencies, both from an operational and passenger perspective. As a pilot program with limited capital funding, it provides few passenger amenities; the busiest Woods-bound stop, at Pohono Street, is especially spartan, a condition that is made less bearable by regular pass-ups (see below for further explanation). But perhaps most importantly, while the shuttle is considered quite successful when compared to other rural services, it is unavoidably inefficient, with demands highly peaked in one direction, requiring a large amount of service that operates essentially empty in one direction over most of the day. From a transit operations perspective, there are too many buses in operation to be efficient; and from a passenger's perspective, there are too few buses in operation – pass-ups in the peak direction continue to be common despite increases in service (on the busiest observed day in 2007, pass-ups as a percentage of all boardings reached 41.6 percent, and over all eight observed days, the average was 24.5 percent). Transit providers would typically address this issue by operating larger vehicles, but due to the nature of the route (with a number of hairpin turns, some of them effectively “blind”), the 35-foot vehicles already in use are the largest possible. The service also suffers from frequent delays caused by traffic congestion at Tamalpais Junction and long boarding times that are caused by queues of new riders boarding single-file, many stopping to ask questions of the driver. All of these sources of delay have resulted in Golden Gate Transit “padding” the schedule by adding one more bus than would normally be necessary given the operation's headways and cycle times.

Despite the Shuttle's limitations, visitation to the Woods on weekends in June, July and August grew 7 percent from 2004, the last year before the shuttle began operation, to 2007, its third year in service. Parking supply has not been increased, and the Shuttle now carries about 1 in 10 visitors to the park when it's in operation, suggesting that the service has captured latent demand and attracted new park visitors.

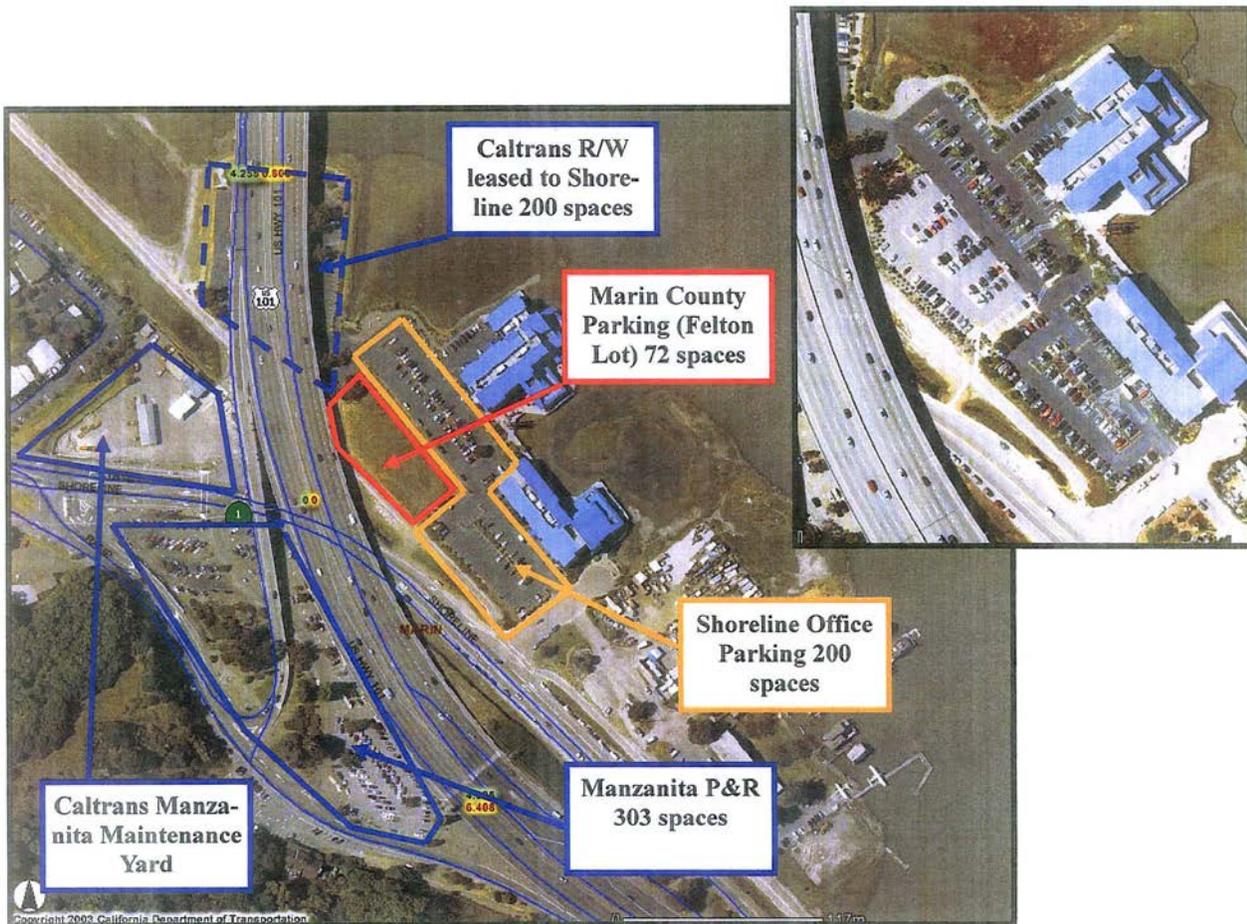
Shuttle Parking Today

Since shuttle service began in 2005, the Manzanita Park and Ride at U.S. Highways 1 and 101, owned by Caltrans, has acted on weekends as a satellite lot for Muir Woods; additional parking adjacent to the Pohono Street stop, on the opposite side of 101, is also leased by Marin County for shuttle use. Limited parking for shuttle riders is available on an informal basis at the Gateway Center in Marin City (analysis of survey data suggests that approximately 12 percent of shuttle riders drive to Marin City), and since 2007, the shuttle has made connections to ferries at Sausalito, where additional parking is available (and where, in the most recent months for which data is available, June and July of 2008, approximately 11 percent of shuttle riders boarded).

There are approximately 290 spaces at Manzanita. Located along a Highway 101 on-ramp and served by several Golden Gate Transit commuter bus routes, it is heavily patronized on weekdays: In 2001, maximum observed weekday occupancy, including overflow onto adjacent streets, was 367 vehicles, the lot reached capacity by 8 a.m., and maximum occupancy was observed at 9:30 a.m. On weekends, however, the highest observed count was just 81 vehicles. This, it should be noted, was before shuttle service began.

In the so-called Felton lot adjacent Pohono, meanwhile, there are another 72 spaces, and shuttle riders regularly park in the adjacent Shoreline Office Park lots, which have a combined capacity of 400 spaces including space leased by Caltrans to Shoreline. While occupancy data on these lots is unavailable, observation suggests that, like at Manzanita, the lots are well-used by commuters on weekdays, but plenty of excess capacity is currently available for shuttle users on weekends.

Figure 3 Manzanita-Area Parking³



Alternatives

General Management Plan

The GMP, the GGNRA's in-development vision for the future of Muir Woods and other GGNRA sites, lays out three preliminary scenarios for possible changes to the physical design and

³ The Felton Lot was purchased by Marin County, using a Public Lands Highways Discretionary grant, specifically for purposes of recreational shuttle parking use.

management of the Woods. The “Arrival” elements, and thus the transportation implications, of two of the three alternatives are identical.

- In Alternatives 1 (“Connecting People with the Parks”) and 3 (“Focusing on National Treasures”), a “Diverse Opportunities Zone” arrival scenario calls for restoration of the Upper Parking Lot as a meadow, and for “parking retained at the Woods to serve visitors during non-peak times (to) be modified to reduce impacts.” To offset the lost parking, “permanent shuttle service to Muir Woods would be provided, supported by new welcome centers at Muir Woods and in the vicinity of Highway 1/Interstate 101. ... Parking would be provided at the off-site welcome center.”
- In Alternative 2 (“Preserving and Enjoying Coastal Ecosystems”), a restored “Sensitive Resources Zone” would take the place of almost all on-site parking. A remaining “Park Operations Zone” in the area of the Lower lot would include “a small parking area ... available for accessibility” and a shuttle stop. Potentially, it might not include a pick-up/drop-off area for tour bus or auto passengers. Removal of parking on this scale would require year-round shuttle service from “a transit center in the vicinity of “Highway 1/Interstate 101.”

Shuttle Expansion

Were any of the GMP alternatives to be implemented, much of the Muir Woods access currently provided by on-site parking would be lost. Assuming that such a significant reduction of access is not acceptable, shuttle service would, logically, be expected to be the primary mode of access for Muir Woods visitors, as potential for increased access by bicycle, on foot or by tour bus is limited. Moreover, continued, reasonably convenient access is essential to maintain (and if possible, enhance) a high-quality visitor experience.

The key question to be answered in any analysis of shuttle expansion scenarios is this: How much more demand for shuttle service could be met given existing physical constraints? Any expansion will require additional resources; but it may be that expansion to the point necessary to maintain existing levels of access would require capital investments so large as to be impractical.

The concept-level analyses to follow rely on these assumptions:

Parking Demand

To estimate demand for parking at a satellite lot – and determine whether existing parking might be able to satisfy that demand – a model was developed that uses available data or, where data are not available, extrapolates from available data “baseline” levels of demand (average daily maximum occupancy) for weekdays and weekend days by season. Those estimates were then adjusted to account for projected changes in parking duration and mode share that might result from relocation of parking to a remote site, as both factors would logically impact occupancy.

To estimate demand at different times, seven different demand conditions were analyzed:

- “Peak of the peak” – the highest occupancy at any point
- Peak-season weekend average
- Peak-season weekday average
- Shoulder-season weekend average
- Shoulder-season weekday average
- Off-season weekend average

- Off-season weekday average

To analyze parking requirements under each of these conditions, a variety of existing source data was used to estimate parking demand in each time period. These estimates were then rounded for simplicity. The baseline number of parking spaces required for each time frame under current operating conditions is summarized in Figure 4 below.

Figure 4 Estimated “Baseline” Parking Demand

Peak of Peak		480
Peak-Season (July/August)	Sat.-Sun.	400
	Mon.-Fri.	280
Shoulder-Season (May)	Sat.-Sun.	310
	Mon.-Fri.	180
Off-Season (February)	Sat.-Sun.	200
	Mon.-Fri.	80

Baseline levels were then adjusted for duration and shuttle-access mode share. Duration of stay is an important component of parking demand because the longer a space remains occupied, the less often it is available for “turnover” to the next visitor. While length-of-visit data for shuttle users is not directly available, there is anecdotal evidence to suggest that shuttle visitors do tend to remain at the Woods longer than drivers. This only makes sense, as, having taken a 30-minute bus trip to the Woods, visitors would be less likely to leave quickly.

The CTMP, which did analyze visitor duration, found average peak-season parking duration of approximately 90 minutes.⁴ The amount of time required to access the park from adjacent parking spaces is, at most, a few minutes. However, if parking were relocated off-site, parking duration would increase commensurate with additional travel time between the satellite lot and the Woods. In other words, even if visitors do not increase the duration of their visit, their parking space would be occupied from the time they arrive at the remote parking lot to the time they return to their car – time that includes travel to and from the Woods as well as the duration of stay at Muir Woods. Adding the shuttle’s approximate round-trip travel time from Manzanita of 40 minutes results in an average duration of 130 minutes, and an accompanying increase in parking occupancy rates of approximately 45 percent.⁵

Figure 5 below shows estimated parking demand adjusted for duration of stay.

Figure 5 Estimated Parking Demand Adjusted for Shuttle Duration

Peak of Peak		690
Peak-Season (July/August)	Sat.-Sun.	580
	Mon.-Fri.	410
Shoulder-Season (May)	Sat.-Sun.	460
	Mon.-Fri.	260
Off-Season (February)	Sat.-Sun.	290
	Mon.-Fri.	120

⁴ CTMP *Existing Conditions Technical Memorandum*, Section 5.2, Figs. 5-10 & 5-11

⁵ This duration was assumed for all seasons. Observed durations were slightly longer at other times.

As the table demonstrates, if existing demand for parking were entirely relocated to Manzanita and the Felton Lot at Pohono, the facilities, with a combined capacity of 362, would be unable to accommodate it in their current configuration – not just on busy weekends, but on weekdays when the Manzanita lot is heavily used by commuters. This is because relocation of parking is not a matter of “one-for-one” replacement; if access time is increased, occupancy increases as well.

A shift in modes of access to the shuttle, meanwhile, could reduce parking demand. The single most effective way to reduce parking demand for shuttle users would be to operate a shuttle directly from San Francisco. Nearly half of all Muir Woods visitors begin their trip in San Francisco, and in the 2007 survey, one out of six drivers said they would consider taking a shuttle from San Francisco. Many who start their trips in San Francisco would not need to drive at all if there were a convenient shuttle available that served hotels and connected to a number of Muni routes. An additional benefit of a San Francisco-based shuttle is that good regional transit exists into San Francisco from the East Bay (via BART and AC Transit) and from the south (via Caltrain, BART and SamTrans), making it possible for visitors from all over the Bay Area to access Muir Woods by transit. It’s been assumed, then, that off-site parking demand might be reduced by 25 percent or more were shuttle service extended to San Francisco.

Figure 5 below shows estimated parking demand adjusted for duration of stay and shuttle service to San Francisco.

Figure 5 Estimated Parking Demand Adjusted for Shuttle Duration and Availability of San Francisco Service

Peak of Peak		520
Peak-Season (July/August)	Sat.-Sun.	440
	Mon.-Fri.	310
Shoulder-Season (May)	Sat.-Sun.	340
	Mon.-Fri.	190
Off-Season (February)	Sat.-Sun.	220
	Mon.-Fri.	90

Shuttle Demand

In addition to parking requirements, any analysis of shuttle capacity must make certain assumptions about levels of service and their impact on ridership. When, in 2007, peak-season headways on the main, Marin City route were reduced from 30 to 20 minutes – a 50 percent increase in service – ridership rose 86 percent. The percentage of non-riders who said that more frequent service might encourage them to use the shuttle, meanwhile, declined from 20 percent to 10 percent. If parking were removed entirely from the Woods, the shuttle’s potential to gain further market share from autos would be rendered irrelevant, as driving to the Woods would no longer be an option. Nonetheless, some new riders of the shuttle may also be expected to be new park visitors, and as service is further improved, this market can be anticipated to grow.

Analysis, then, must take into account latent demand. How many of those who cannot or will not drive to the Woods might consider a convenient alternative; how many more might visit Muir Woods if the wait for a bus (or the penalty for being passed up by a bus) were not 20 minutes, but 10 or even 5 minutes? Transit industry research has found elasticity for transit ridership with respect to frequency of 0.5,⁶ meaning that for every doubling of service, the number of new users

⁶ Richard H. Pratt (1999-2007), *Travel Response To Transportation System Changes*, TCRP Report 95, Transportation Research Board (www.trb.org); at www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=1034. (Citation from Victoria Transport Policy Institute, www.vtpi.org.)

attracted to the service should increase by half. In 2007, the elasticity for Muir Woods ridership with respect to frequency was 1.72 – meaning that if the trend were to continue, reducing frequencies from 20 to 5 minutes would increase ridership by 688 percent *without any change in parking policies*. Logic, however, dictates some flattening of this curve.

Conversely, there exists the “elephant in the room” of depressed visitation if parking at the Woods were made more difficult or impossible. In the 2007 survey, 20 percent of those who said they were aware of the shuttle but who had not used the service said that they had not done so because they would be moving on after leaving the Woods to another destination (e.g., Stinson Beach or Mount Tamalpais). Another 14 percent, meanwhile, said either that their party was too large to take transit together, or that a member of the party had “special needs” that rendered transit use impractical. Together, these respondents accounted for more than one-third of all those who had not used the shuttle despite being aware of its existence.

It is difficult, then, if not impossible to accurately model the relative impacts of increased transit and decreased auto access to the Woods on total visitation and, by extension, shuttle ridership without a much more resource-intensive analysis. The conceptual analysis to follow will simply assume relatively static visitor levels – it will assume, in other words, that any demand induced by increased shuttle service is likely to be more or less offset by reductions in direct auto access and demand.

Shuttle service, in turn, will simply be scaled up to meet demand for 2007 levels of access as measured using 2007 off-season (February), shoulder (May, excluding Memorial Day weekend) and peak (July) visitor counts, assuming non-shuttle mode share splits as suggested by responses to the 2007 survey⁷, and assuming shuttle mode splits as observed in July 2007. During the shoulder season, shuttle mode splits are currently lower; however, assuming the higher peak “baseline” mode split has the effect of assuming that less of an increase in service would be necessary to satisfy remaining visitor demand at off-peak times, which might result in greater productivity, if possibly constraining passenger levels of service during peak periods. Finally, in scenarios in which some parking is retained, whenever demand for parking is less than available on-site supply, headways are reduced to existing peak season levels (every 20 minutes) or, if total visitation and parking demand is very low, service is eliminated altogether.

Shuttle Costs and Operations

Operating costs for expansion alternatives are likewise difficult to precisely predict given “soft costs” such as administration and marketing (while outreach efforts would likely be scaled up along with increases in service – particularly if all or most parking is removed from the Woods – economies of scale might exist) and flexibilities in scheduling and allocation of resources that would be enabled by additional service. However, it is possible to project order-of-magnitude costs using a per-unit model. In 2007, the average total operating cost per revenue hour (including layover, recovery and deadhead time) for the service, as provided under contract by Golden Gate Transit, was approximately \$138 (the total rate per hour, including administrative costs, was approximately \$177). MV Transportation, however, operates West Marin Stage service for Marin County at a base rate of approximately \$60 per year, not including minor additional flat costs and administrative costs. West Marin Stage vehicles are much smaller than those used for Muir Woods; however, it might ultimately be less expensive (and potentially safer given operating conditions) to operate more, smaller vehicles than the existing 35-foot models.

⁷ In 2007 surveyors were instructed not to survey tour bus passengers. GGNRA estimates that tour bus passengers account for approximately 20 percent of park visitor. Six of the seven alternatives modeled in this memorandum assume that tour bus access to the park would be retained; the seventh assumes additional shuttle and parking demand if tour bus access were displaced, as it might be under GMP Alternative 2. Calculations of additional demand assume that 50 percent of tour bus riders would not visit the park, and that 75 percent of the remaining would use San Francisco shuttles rather than drive to a stop in Marin County.

Alternate-fuel vehicles such as CNG buses, while more expensive to purchase, might also generate operational savings. In any case, a range of costs between \$75 and \$180 per hour has been estimated.

Each of the scenarios also assumes efficiencies that could be realized by increasing service. The number of buses needed to operate any service is equal to the cycle time divided by the headway, and cycle time needs to include not only travel time but also time for operator layover and recovery to return to schedule. In a service such as the Muir Woods Shuttle, a relatively large amount of layover and recovery needs to be built into the schedule, especially during peak periods when traffic and loading times can be highly variable (loading and unloading takes longer when, as is the case here, many riders are unfamiliar with the service, don't know how to pay, and have questions for the operator). Currently, 9 minutes are built into the schedule at Muir Woods, partly for loading and unloading and partly to get back on schedule. Up to an additional 30 minutes is allocated at Marin City for the same reasons.

It should be noted that while operating costs have been assessed, fare revenues have not. In the 2007 rider survey, 95 percent of respondents indicated that the fare at that time of \$2 per round trip was reasonable. The fare has since been increased to \$3, and while ridership has continued to increase, one out of six passengers interviewed in 2008 pointed out the inequity of charging shuttle users while parking remains free. Inevitably, increasing fares will impact ridership at some point – recent research suggests elasticity for bus ridership with regard to fares of approximately -0.4, meaning that a 10 percent fare increase should reduce ridership by 4 percent⁸ – although if a fee were instituted for parking or if all parking were removed from the Woods, increased fares might have somewhat less of an impact. In any case, it should not be simply assumed that fares can be significantly increased to help offset increased operating costs without some loss of ridership and park visitation.

Shuttle Expansion Scenarios

Seven scenarios are analyzed on the following pages. These scenarios assume three levels of parking replacement – 100 percent, 50 percent, and 25 percent of current Woods parking relocated off-site – and at each level of parking replacement, scenarios with and without new shuttle service to San Francisco are analyzed. In a seventh scenario, it is assumed that four buses would be denied access to the park. The 100-percent replacement scenarios correspond to GMP Alternative 2, while the 50-percent and 25-percent scenarios were developed in order to provide a range that might be useful in developing details of Alternatives 1 and 3, which call for unspecified partial removal of parking.

The scenarios are:

- **Alternatives 1 & 3, Scenario A:** The current model of service between Marin City and the Woods, with stops westbound at Pohono and eastbound at Manzanita, as well as supplemental service between Sausalito and the Woods making stops at Pohono and Manzanita; with the period of service expanded to summer weekdays; and 25 percent removal of existing parking at Muir Woods, including spaces along Muir Woods Road.
- **Alternatives 1 & 3, Scenario B:** The current model plus San Francisco service; with the period of service expanded to summer weekdays; and 25 percent removal of existing parking at Muir Woods, including spaces along Muir Woods Road.
- **Alternatives 1 & 3, Scenario C:** The current model; with the period of service expanded to weekdays May through September, and weekends throughout the year; and 50 percent removal of existing parking at Muir Woods, including spaces along Muir Woods Road.

⁸ *Fare Elasticity and Its Application to Forecasting Transit Demand*, American Public Transportation Association (<http://www.apta.com/research/info/online/elastic.cfm>)

- **Alternatives 1 & 3, Scenario D:** The current model plus San Francisco service; with the period of service expanded to weekdays May through September, and weekends throughout the year; and 50 percent removal of existing parking at Muir Woods, including spaces along Muir Woods Road.
- **Alternative 2, Scenario A:** The current model of service; year-round service; and 100 percent removal of existing parking at Muir Woods, including spaces along Muir Woods Road.
- **Alternative 2, Scenario B:** The current model plus a third route, between San Francisco and the Woods with a possible interim stop at Marin City; year-round service; and 100 percent removal of existing parking at Muir Woods, including spaces along Muir Woods Road.
- **Alternative 2, Scenario C:** The current model plus a third route, between San Francisco and the Woods with a possible interim stop at Marin City; year-round service; 100 percent removal of existing parking at Muir Woods, including spaces along Muir Woods Road; and removal of tour bus access to Muir Woods.

These alternatives are illustrated in Figure 6 below.

Figure 6 Summary of Scenarios

	Peak Period Buses per Hour			Operating Times					
	Marin City	Sausalito	San Francisco	Summer		May & Sept.		Oct.-Apr.	
				S-S	M-F	S-S	M-F	S-S	M-F
Scenario 1-3-A: 75% on-site parking	7	2	0	x	x	x			
Scenario 1-3-B: 75% on-site parking, S.F. shuttles	5	1	2	x	x	x			
Scenario 1-3-C: 50% on-site parking	12	2	0	x	x	x	x	x	
Scenario 1-3-D: 50% on-site parking, S.F. shuttles	9	1	3	x	x	x	x	x	
Scenario 2-A: 0% on-site parking	20	3	0	x	x	x	x	x	x
Scenario 2-B: 0% on-site parking, S.F. shuttles	15	2	5	x	x	x	x	x	x
Scenario 2-C: 0% on-site parking, no tour bus, S.F. shuttles	16	2	7	x	x	x	x	x	x

Each scenario expands daily Marin City (and San Francisco) service at a rate consistent with increased demand. In the scenarios under which some parking is retained (1-3-A, 1-3-B, 1-3-C and 1-3-D), periods of service further reflect patterns of visitation and parking demand. In Scenarios 1-3-B, 1-3-D and 2-B, San Francisco service is designed to accommodate 25 percent of total shuttle demand. In Scenario 2-C, San Francisco demand is designed to accommodate slightly more (approximately 31 percent) of total demand, as it is assumed that tour bus passengers no longer able to directly access the site would be likelier than former drivers to use San Francisco service.

Because Sausalito shuttles are timed to meet ferry arrivals, making it impractical to increase service several times over, service would be expanded more modestly: in Scenario 2-A, three vehicles would meet each ferry on summer weekends (perhaps departing 5, 10, and 15 minutes

after arrivals), two vehicles would do so on summer weekdays and weekends in May and September, and one vehicle would continue to do so on remaining weekends (this service pattern reflects visitation trends). In Scenarios 1-3-A, 1-3-C, 2-B and 2-C, two shuttles would meet each ferry on summer weekends and one would do so on summer weekdays and shoulder weekends. In Scenarios 1-3-B and 1-3-D, no expansion of Sausalito service is assumed, meaning that while shuttles would continue to connect to ferries on summer weekends, direct service to San Francisco would satisfy city-based demand at all other times.

While the analysis does not rely upon a specific San Francisco alignment, in order to achieve the 25 percent reduction in parking demand assumed for the remote lot in Marin County, it is essential that the route effectively:

- serve major concentrations of hotels;
- make key transit connections; and
- remain relatively direct.

Fortunately, such a route between San Francisco and Marin County already exists: Muni's 76-Marin Headlands. It starts from (and lays over at) the Caltrain station at 4th and King streets in the South of Market district, where transit riders from the Peninsula and South Bay Area can connect to the service. It then proceeds to the Transbay Terminal and Embarcadero BART station, where East Bay riders can transfer. It operates westbound on Sutter Street and eastbound on Post Street through the Union Square area, with its dense concentration of hotels. It then continues north along Van Ness Avenue and west on Lombard Street to the Golden Gate Bridge, making a series of connections to other Muni routes.

Figure 7 below summarizes key findings of the analysis of the seven scenarios. Note that its estimated costs are for operations only; capital costs such as the purchase of vehicles (each standard 30-foot vehicle like the smaller buses currently operated would likely cost at least \$300,000, and alternate-fuel vehicles could cost \$375,000 or more) and stop amenities are not included.

Figure 7 Summary of Scenarios Analysis

	Peak off-site parking demand	Peak buses per hour	Fleet requirement	Annual Cost	
				\$75/hr.	\$180/hr.
Scenario 1-3-A: 75% on-site parking	170	9	9	\$500,000	\$1,200,000
Scenario 1-3-B: 75% on-site parking, S.F. shuttles	130	8	10	\$600,000	\$1,400,000
Scenario 1-3-C: 50% on-site parking	340	14	14	\$1,300,000	\$3,000,000
Scenario 1-3-D: 50% on-site parking, S.F. shuttles	260	13	16	\$1,600,000	\$3,900,000
Scenario 2-A: 0% on-site parking	690	23	23	\$3,000,000	\$7,300,000
Scenario 2-B: 0% on-site parking, S.F. shuttles	520	22	28	\$4,000,000	\$9,500,000
Scenario 2-C: 0% on-site parking, no tour bus, S.F. shuttles	550	25	34	\$4,800,000	\$11,500,000

A number of important conclusions can be drawn from the analysis:

- Scenarios involving complete removal of parking appear to be prohibitively expensive – as much as \$9.5 million per year for a package including San Francisco service. If tour bus access were removed, costs would increase further, to as much as \$11.5 million per year.
- While available parking supply at Manzanita and Pohono could conceivably accommodate peak demand on weekends (and, if reconfigured, another 110 spaces might be added to the Manzanita lot, bringing total physical capacity in the area to nearly 900 spaces), the weekday supply at those locations is currently almost fully utilized by commuters. On an average summer weekday, parking demand for Muir Woods visitors would exceed 400 spaces, with virtually no supply available.
- Further, roadway capacity at Manzanita and Pohono is constrained – lines of cars waiting to turn left from Shoreline Highway could result in unacceptably degraded levels of service and might even impact operations on Highway 101. Were the 100% off-site parking scenarios pursued, extensive analysis of both parking and roadway capacity would be required (it should be emphasized that while detailed traffic analysis has not yet been conducted, initial evaluation raises reasonable concerns regarding traffic operation). Caltrans would not allow any more turning movements in a single hour at that location than exist in a weekday peak period for the commuter and office park lots. More analysis of arrivals by hour is needed to determine whether there could be significant impacts to levels of service, but this intersection is already problematic because the usual remedy of implementing a traffic signal is not possible at this location due to possible impacts on freeway operation.
- Moreover, the level of shuttle service required to accommodate the additional demand would, despite net reduction of traffic on Highway 1 (survey data on average party size suggests that even a half-empty shuttle removes 4.5 cars from the road), result in more shuttle traffic on the road than would likely be acceptable to Caltrans or members of the community: a vehicle every three minutes in the peak condition. This level of shuttle service would also challenge operations, as inevitable variations in dwell and travel times would inevitably result in significant “bunching,” a “caravan” or “elephant train” of shuttles on Shoreline Highway.
- On the other hand, total removal of on-site parking would significantly enhance the Muir Woods visitor experience in many ways. In addition to the obvious environmental benefits, shuttles operating every three minutes would ensure door-to-door travel times comparable to or better than those enjoyed by drivers today, and a level of convenience far greater than that enjoyed by current shuttle riders.
- Scenarios retaining some on-site parking at Muir Woods, while less attractive in some ways, appear much more manageable – particularly if that parking were used to fund expansion of shuttle service (see “Conclusions”, below). Even under Alternatives 1-3-A and 1-3-B, the most modest expansions of service, current 20-minute headways on the peak-season Marin City service would be reduced to a much more attractive 8 minutes (without service to San Francisco) or perhaps 10 minutes (with service to San Francisco).
- In the 50 percent parking removal scenario, some parking demand would remain off-site on summer weekdays, when the commuter lot at Manzanita is regularly full. However, the amount is modest enough (peak occupancy of 62 vehicles, or 46 if San Francisco service were offered) that it could be accommodated at Marin City if arrangements were made to formally use excess weekday capacity at the Gateway Center.
- New service to San Francisco could significantly reduce demand for parking and improve connections to existing transit and, by extension, access to Muir Woods for Bay Area residents. However, the additional cycle time required to complete a round trip –

approximately 90 minutes – would require a not-insignificant investment of additional resources in order to maintain capacity and reasonably convenient frequencies.

An eighth scenario, consolidation of shuttle operations at Marin City with no service to Manzanita or Pohono, was identified but not analyzed, as it would require not just formalization of the currently informal parking arrangement at Gateway Center but dedication of a significant portion of the lot, which is privately owned.

As this is largely a technical analysis of costs and feasibility, issues of rider amenities also have not been assessed in detail. However, a remote welcome center might go some distance toward mitigating the existing shortcomings in the passenger experience, not just in terms of comfort, but by providing a “sense of arrival” to the Woods for Shuttle passengers whose first experience often now consists of standing in a long line, alongside a busy highway, in the sun.

Conclusions

While concerns unrelated to visitor access should certainly be an important consideration in planning for the future of parking at the Woods, analysis of access alternatives strongly suggests the following:

- Removal of all parking from the Woods would be highly problematic, both in terms of costs and impacts (assuming, that is, that existing access levels were maintained using expanded shuttle service).
- A combination of partial parking removal and more modest shuttle expansion would be both less expensive and more feasible.
- Further, retention of some on-site parking could serve as a mechanism for funding expanded shuttle service. If all autos parking at the Woods were charged a \$6 fee (an amount that, given average auto occupancy of four, amounts to half what shuttle riders pay), as much as \$800,000 in annual revenue could be generated. Depending on the amount diverted to administrative costs, this could fund more than half of the annual cost of Scenario 1-3-B, which would add service on summer weekdays, would add direct service to San Francisco, and would double Marin City-Manzanita-Pohono service on summer weekends, reducing frequencies to 10 minutes. (However, this assumes that parking for spaces on Muir Woods Road, which is owned by the County, could be priced, and while technically feasible, such an idea might prove politically impractical.)

Appendix A Baseline Shuttle Demand Calculations

The following table illustrates the logic used to calculate additional demand for shuttle service if parking were removed from Muir Woods. Additional-demand percentages were manually adjusted during periods when parking demand would not exceed resulting capacity (either to current base levels or service or, if parking demand would be well below capacity, shuttle service was eliminated altogether).

Total Mode Share	Baseline Shuttle Share	Estimated Tour Bus Share	Auto Share of Remainder	Estimated Auto Mode Share	Baseline Addt'l Shuttle Demand if Parking Removed at Rate of		
					0%	50%	75%
100.00%	10.94%	20.00%	90.96%	62.82%	574.24%	287.12%	143.56%

Appendix B Off-Site Parking Demand by Period Under Each Scenario

The following table illustrates off-site parking demand during different periods for each scenario. Demand is determined by available on-site parking supply and whether direct shuttle service to San Francisco is available. Whenever demand for parking is less than available on-site supply, shuttle headways have been reduced to existing peak season levels (every 20 minutes) or, if total visitation and parking demand is very low, service has been eliminated altogether.

	Summer		May & Sept.		Oct.-Apr.	
	S-S	M-F	S-S	M-F	S-S	M-F
Scenario 1-3-A: 75% on-site parking	70	(0)	(0)	<i>No Service</i>	<i>No Service</i>	<i>No Service</i>
Scenario 1-3-B: 75% on-site parking, S.F. shuttles	50	(0)	(0)	<i>No Service</i>	<i>No Service</i>	<i>No Service</i>
Scenario 1-3-C: 50% on-site parking	240	60	110	(0)	(0)	<i>No Service</i>
Scenario 1-3-D: 50% on-site parking, S.F. shuttles	180	50	80	(0)	(0)	<i>No Service</i>
Scenario 2-A: 0% on-site parking	580	410	450	260	290	120
Scenario 2-B: 0% on-site parking, S.F. shuttles	440	300	340	190	220	90
Scenario 2-C: 0% on-site parking, no tour bus, S.F. shuttles	470	320	360	210	230	100