National Park Service
U.S. Department of the Interior

Yosemite National Park
California

User Capacity and Recreation Site Modeling for Yosemite Valley

Final Technical Report

February 2014

Prepared by:

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National Park Service, Yosemite National Park

Introduction

The studies included in this report examine the visitor use at attraction sites in Yosemite Valley, including: Bridalveil Fall, Lower Yosemite Falls, and Vernal Falls.

The goals of this work were to:

1) Ascertain the relationship between inbound vehicle traffic, visitor arrivals at key attraction sites, and visitor density (or crowding) at key attraction sites in Yosemite Valley.
2) Gain a better understanding of "current conditions" in the same terms as the proposed management standards for each attraction site
3) Build a greater understanding of the relationship between visitor density at the monitoring locations and inbound traffic to determine the most effective way to manage use at the site level.

Results from these analyses were used with other Yosemite visitor use studies to verify assumptions about alternatives, capacity management, and monitoring efforts represented in the Merced Wild and Scenic River Final Plan / EIS. For additional information on the research related to the Recreational ORV and Yosemite Valley user capacity please see "User Capacity and Visitor Use Management" (Chapter 6) and "White Paper on User Capacity and Visitor Use" (Appendix S) in the Final Merced River Plan /EIS.

MRP Modeling Task 3 Deliverable

Technical Memo
Attraction Site Visitor Densities – Existing Conditions

October 30, 2013

Prepared for
U.S. Department of the Interior
National Park Service
Yosemite National Park

Submitted by
Resource Systems Group

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Introduction

This technical memorandum reports results of simulating existing visitor use levels at three attraction sites in Yosemite Valley (Lower Yosemite Falls, Bridalveil Fall, and the Trail to Vernal Fall) and estimating corresponding visitor densities at key monitoring locations at each attraction site. The memo presents results by attraction site, and includes a summary of the following for each attraction site:

1. Baseline year selected for analysis and modeling, based on direction from the National Park Service (NPS).
2. Analysis of trail counter data recorded at each attraction site to:
    a. Identify the peak 14-day period during the baseline year.
    b. Identify the peak 6-hour period within the 14-day peak period.
3. Visitor density estimates derived from simulating existing peak period visitor use at the attraction sites.
4. Scatter plots to assess the validity of simulation model results.

In addition, a series of tables and figures designed to provide a more concise summary of the computer simulation modeling methods and results is included in an appendix at the end of this memo.

Lower Yosemite Falls

- **Baseline Year (2010):** To the extent possible, the Merced River Plan uses 2011 as the baseline year for documenting existing conditions of indicators, however, trail counter data were not collected at Lower Yosemite Falls during 2011. Therefore, the year 2010 was selected as the baseline year for analysis and modeling of existing visitor use levels and corresponding visitor densities at Lower Yosemite Falls, since it is the year closest to 2011 for which trail counter data were recorded.
- **Peak 14-day Period (June 26-July 9):** Calibrated, inbound daily visitor use at Lower Yosemite Falls from May 29 through September 28, 2010 is plotted in Figure 1 (excluding missing data on 13 days in August); as depicted, the peak 14-day period of visitor use at Lower Yosemite Falls during summer 2010 occurred from June 26 through July 9.

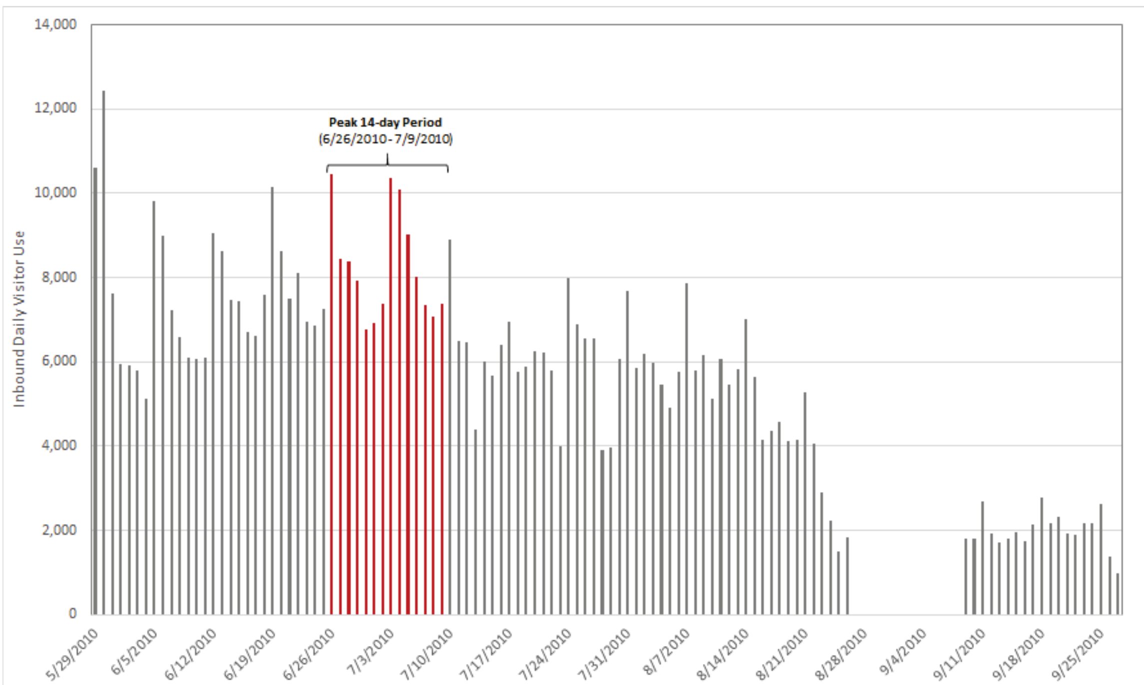

Figure 1. Daily visitor use (arrivals) at Lower Yosemite Falls, by date, summer 2010.

- **Peak 6-hour Period (11 AM-5 PM):** As depicted in Figure 2, the peak 6-hour period of visitor use at Lower Yosemite Falls during the peak 14-day period of summer 2010 was 11:00 AM to 5:00 PM.

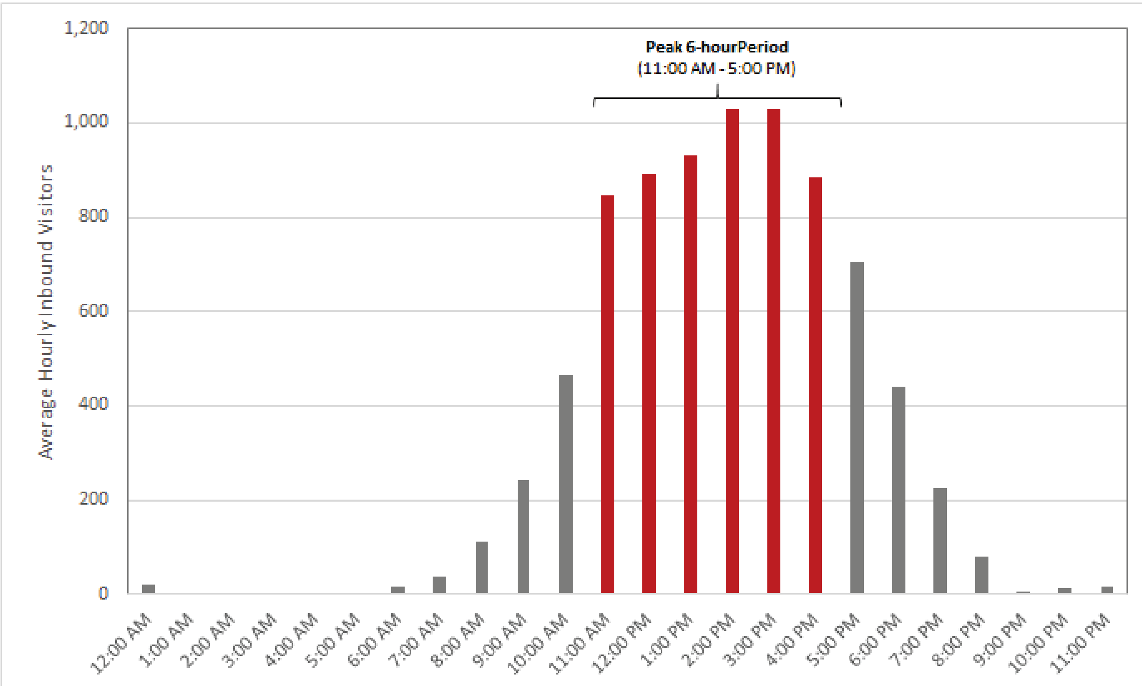

Figure 2. Average hourly visitor use during peak 14-day period at Lower Yosemite Falls, summer 2010.

- **Monitoring Locations:** Simulations were conducted with a computer model of existing visitor use levels at Lower Yosemite Falls to estimate average visitor densities for three monitoring locations, including:
    - **Trail to Lower Yosemite Falls:** A 793 square foot section of the trail to Lower Yosemite Falls corresponding to the trail section depicted in photo simulations used in visitor surveys conducted during 1998 and 2010 (Figure 3).

Figure 3. Photo simulation of visitor use on the trail to Lower Yosemite Falls.

- **Base of Lower Yosemite Falls (Photo Simulation Area):** A 1,971 square foot section of the viewing platform at the base of Lower Yosemite Falls corresponding to the area depicted in photo simulations used in visitor surveys conducted during 2010 (Figure 4).

Figure 4. Photo simulation of visitor use on the viewing platform at the base of Lower Yosemite Falls.

- **Base of Lower Yosemite Falls (Whole Platform Area):** The 3,108 square foot viewing platform at the base of Lower Yosemite Falls in its entirety (Figure 5).

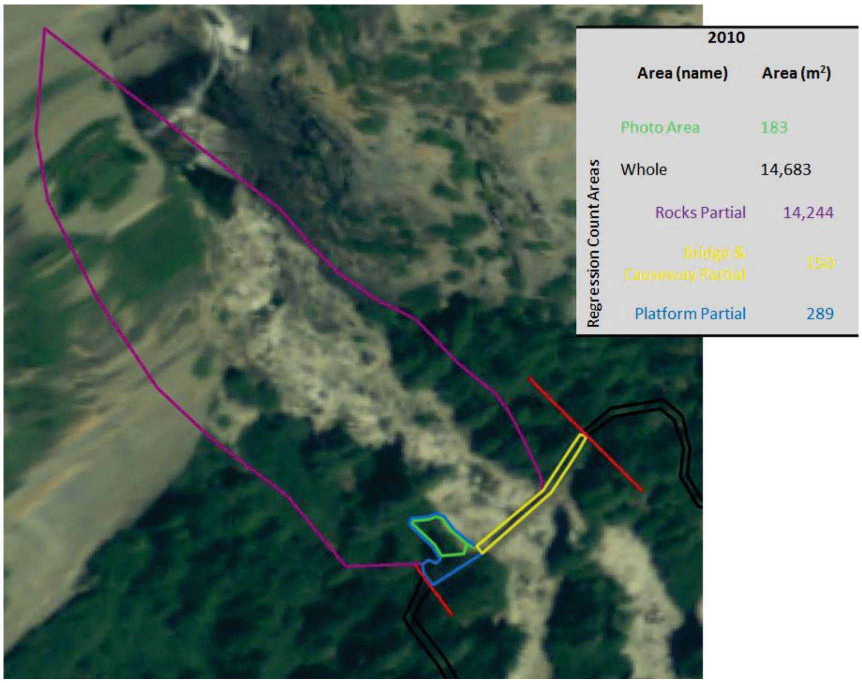

Figure 5. Map of the base of Lower Yosemite Falls, with viewing platform denoted with blue polygon and photo simulation area denoted with green polygon.

- **Mean visitor densities (square feet per person):** ***The visitor use simulation model results suggest visitor densities at the base of Lower Yosemite Falls violate the "Preference" density levels derived from results of visitor surveys conducted at Lower Yosemite Falls during 1998 and 2010, but do not violate the "Acceptable" or "Displacement" levels. The results suggest visitor densities on the trail to Lower Yosemite Falls do not violate any of the visitor survey-based density levels.*** In particular, Table 1 reports computer simulation model estimates of the average visitor density at each of the monitoring locations noted, based on existing peak period visitor use levels at Lower Yosemite Falls. In addition, Table 1 includes the visitor survey-based "Preference", "Acceptable", and "Displacement" density levels, for purposes of comparison.

Table 1. Visitor density estimates under existing conditions and visitor survey-based density levels – Lower Yosemite Falls.

Site	**Average Visitor Density** (ft^2/person)	**"Preference" Density Level** [a] (ft^2/person)	**"Acceptable" Density Level** [a] (ft^2/person)	**"Displacement" Density Level** [a] (ft^2/person)
Trail to Lower Yosemite Falls	63 (±4.6)	44	20	13
Lower Yosemite Falls Platform – Photo Simulation Area	35 (±2.5)	41	20	13
Lower Yosemite Falls Platform – Whole Platform Area	35 (±2.5)	41	20	13

[a] Derived from results of visitor surveys conducted at Lower Yosemite Falls in 1998 and 2010.

- **Model validation:** ***Model validation procedures conducted in this study suggest the visitor density estimates derived from the simulation model of visitor use at Lower Yosemite Falls can be used with a high degree of confidence in their accuracy.*** In particular, Figure 6 plots hourly visitor use at Lower Yosemite Falls on the x-axis, and the corresponding average hourly number of people at one time (PAOT) in the photo simulation area of the viewing platform at the base of Lower Yosemite Falls on the y-axis. As the figure legend denotes, the data points in Figure 6 are derived from direct observation counts conducted at Lower Yosemite Falls during summer 2010 and visitor use model estimates based on simulations of comparable levels of visitor use. As depicted in Figure 6, the data points derived from the model results overlap closely with those derived from the direct observation counts, which, as noted, suggests the visitor density estimates derived from the simulation model and reported in this memo are valid.

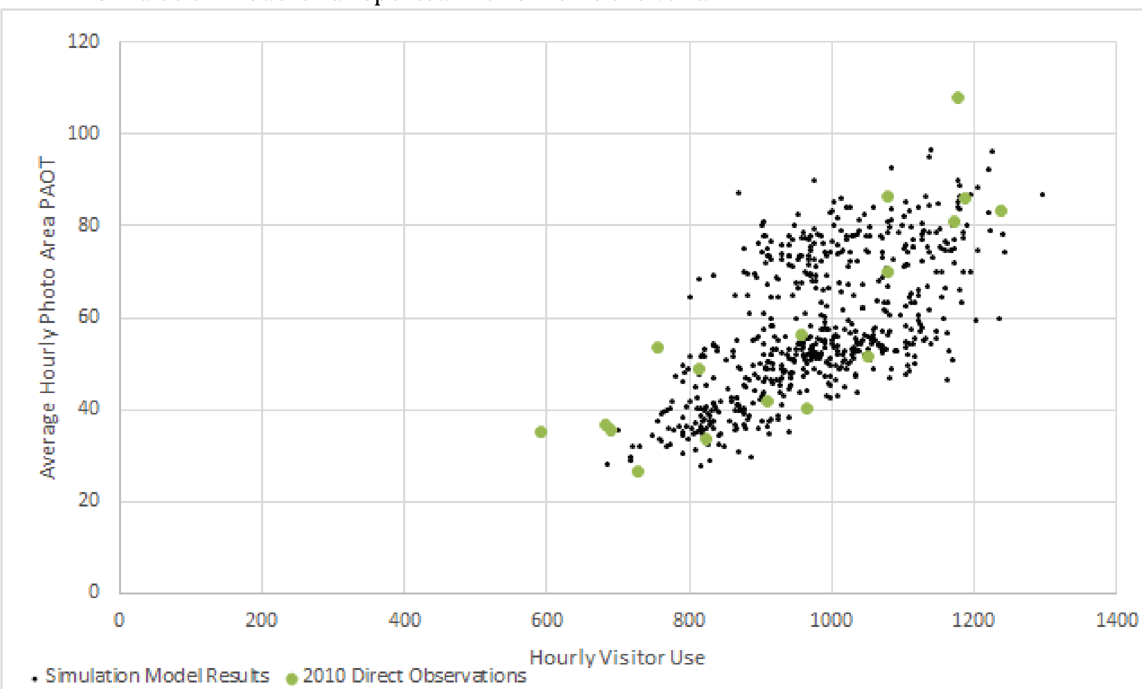

Figure 6. Scatterplot of hourly visitor use and corresponding hourly average number of people at one time (PAOT) in the photo simulation area of the viewing platform - 2010 direct observation counts and simulation model results.

- Finally, it should be noted, within both the observation and model data plotted in Figure 6, there is a strong, positive relationship between hourly visitor use at Lower Yosemite Falls and average hourly PAOT at the base of Lower Yosemite Falls. In particular, R-squared values for simple linear regression models fitting the observation and model data are 0.94 and 0.96, respectively. These findings suggest managing visitor use levels at Lower Yosemite Falls is an effective way to directly affect the number of people at one time, and correspondingly visitor densities, at the base of Lower Yosemite Falls.

Bridalveil Fall

- **Baseline Year (2011):** To the extent possible, the Merced River Plan uses 2011 as the baseline year for documenting existing conditions of indicators, and trail counter data were collected at Bridalveil Fall during 2011. Therefore, the year 2011 was selected as the baseline year for analysis and modeling of existing visitor use levels and corresponding visitor densities at Bridalveil Fall.
- **Peak 14-day Period (June 20-July 3):** Calibrated, inbound daily visitor use at Bridalveil Fall from June 16 through November 7, 2011 is plotted in Figure 7; as depicted, the peak 14-day period of visitor use at Bridalveil Fall during summer 2011 occurred from June 20 through July 3.

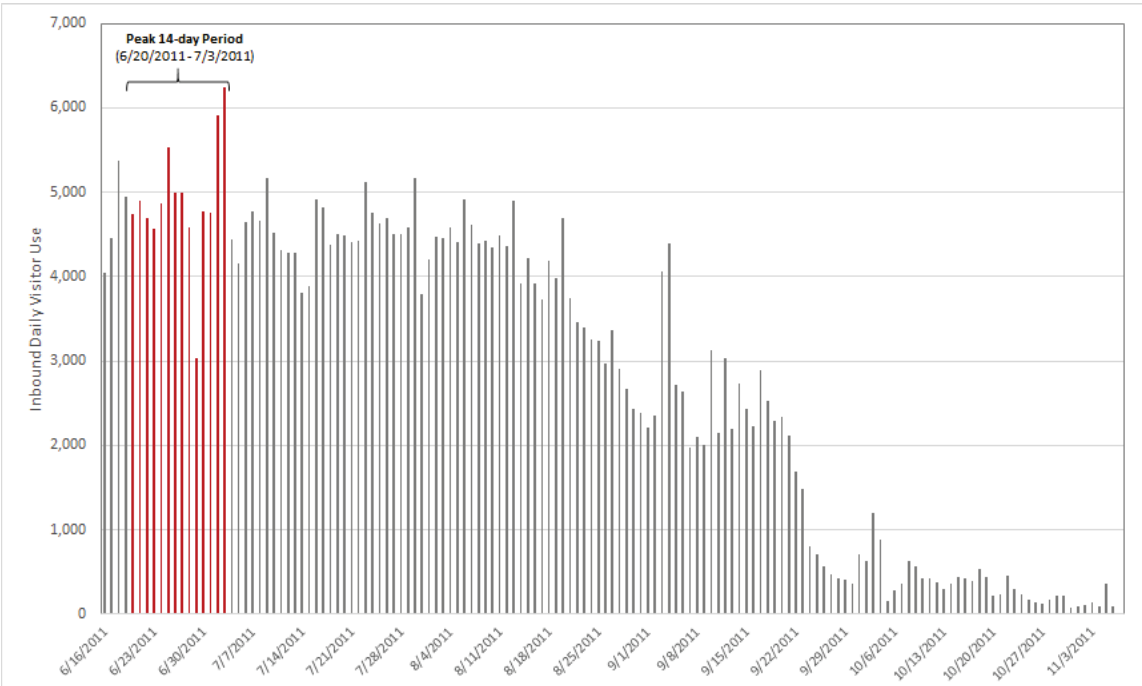

Figure 7. Daily visitor use (arrivals) at Bridalveil Fall, by date, summer 2011.

- **Peak 6-hour Period (10 AM-4 PM):** As depicted in Figure 8, the peak 6-hour period of visitor use at Lower Yosemite Falls during the peak 14-day period of summer 2011 was 10:00 AM to 4:00 PM.

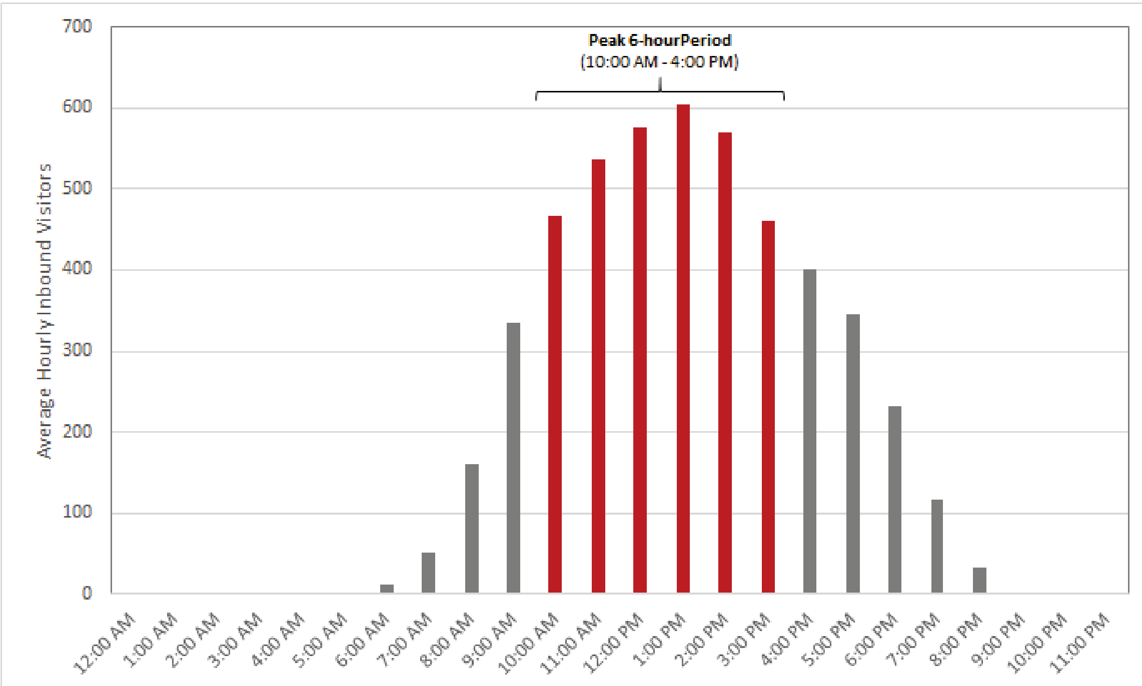

Figure 8. Average hourly visitor use during peak 14-day period at Bridalveil Fall, summer 2011.

- **Monitoring Locations:** Simulations were conducted with a computer model of existing visitor use levels at Bridalveil Fall to estimate average visitor densities for two monitoring locations, including:
  - **Trail to Bridalveil Fall:** A 1,164 square foot section of the trail to Bridalveil Fall corresponding to the trail section depicted in photo simulations used in a visitor survey conducted during 1999 (Figure 9).

Figure 9. Photo simulation of visitor use on the trail to Bridalveil Fall.

- **Base of Bridalveil Fall (Photo Simulation Area):** A 390 square foot section of the viewing platform at the base of Bridalveil Fall corresponding to the area depicted in photo simulations used in a visitor survey conducted during 1999 (Figure 10).

Figure 10. Photo simulation of visitor use on the viewing platform at the base of Bridalveil Fall.

- **Mean visitor densities (square feet per person):** ***The visitor use simulation model results suggest that, under existing levels of visitor use, visitor densities on the viewing platform at the base of Bridalveil Fall violate the "Preference", "Acceptable", and "Displacement" density levels derived from results of visitor surveys conducted at Bridalveil Fall during 1999. Moreover, accounting for the upper bounds of the visitor density estimate for the trail to Bridalveil Fall, the results suggest visitor densities on the trail violate the visitor survey-based "Preference" and "Acceptable" density levels under existing levels of visitor use. However, the results suggest visitor densities on the trail do not violate the visitor survey-based "Displacement" density level.*** In particular, Table 2 reports computer simulation model estimates of the average visitor density at each of the monitoring locations noted, based on existing peak period visitor use levels at Bridalveil Fall. In addition, Table 2 includes the visitor survey-based "Preference", "Acceptable", and "Displacement" density levels, for purposes of comparison.

Table 2. Visitor density estimates under existing conditions and visitor survey-based density levels – Bridalveil Fall.

Site	**Average Visitor Density** (ft^2/person)	**"Preference" Density Level [a]** (ft^2/person)	**"Acceptable" Density Level [a]** (ft^2/person)	**"Displacement" Density Level [a]** (ft^2/person)
Trail to Bridalveil Fall	67 (±4.6)	166	65	42
Bridalveil Fall Platform	11 (±0.8)	49	20	14

[a] Derived from results of visitor surveys conducted at Bridalveil Fall in 1999.

- **Model validation:** ***Model validation procedures conducted in this study suggest the visitor density estimates derived from the simulation model of visitor use at Bridalveil Fall can be used with a high degree of confidence in their accuracy.*** In particular, Figure 11 plots hourly visitor use at Bridalveil Fall on the x-axis, and the corresponding average hourly PAOT in the photo simulation area of the viewing platform at the base of Bridalveil Fall on the y-axis. Similarly, Figure 12 plots hourly visitor use at Bridalveil Fall on the x-axis, and the corresponding average hourly number of people per viewscape (PPV) in the photo simulation area of the trail to Bridalveil Fall on the y-axis. As the figure legends denote, the data points in Figure 11 and Figure 12 are derived from direct observation counts conducted at Bridalveil Fall during the summer of 1999, 2007 and 2011, and visitor use model estimates based on simulations of comparable levels of visitor use. As depicted in Figure 11 and Figure 12, the data points derived from the model results overlap closely with those derived from the direct observation counts, which, as noted, suggests the visitor density estimates derived from the simulation model and reported in this memo are valid.

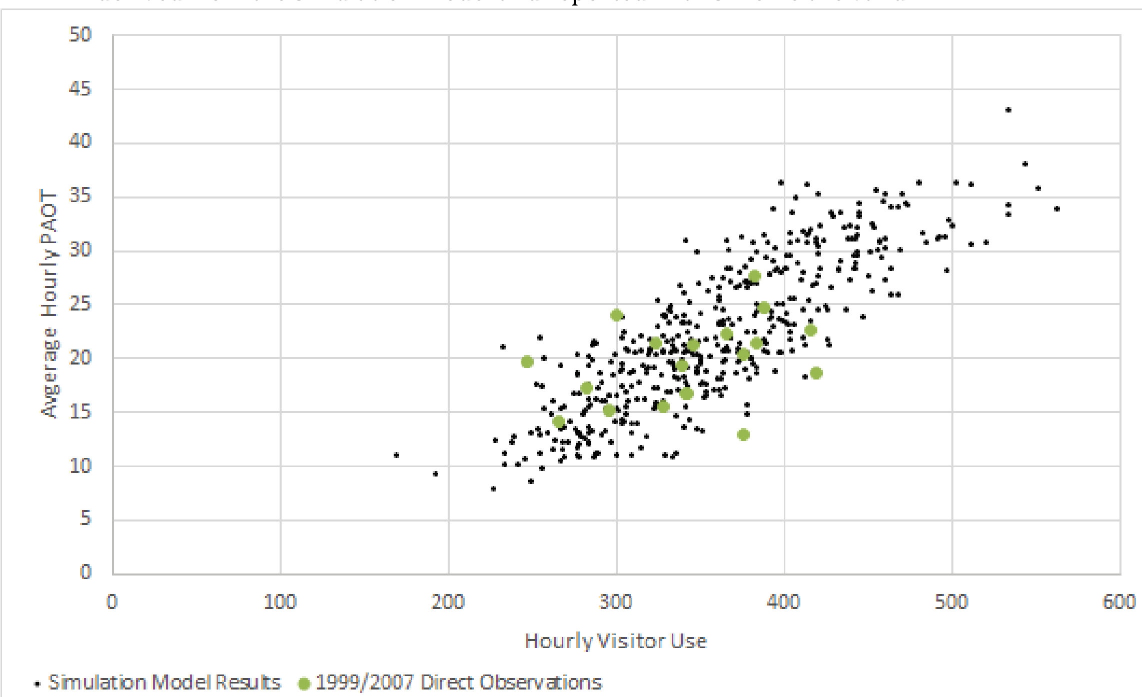

Figure 11. Scatterplot of hourly visitor use and corresponding hourly average number of people at one time (PAOT) in the photo simulation area of the viewing platform at Bridalveil Fall – 1999/2007 direct observation counts and simulation model results.

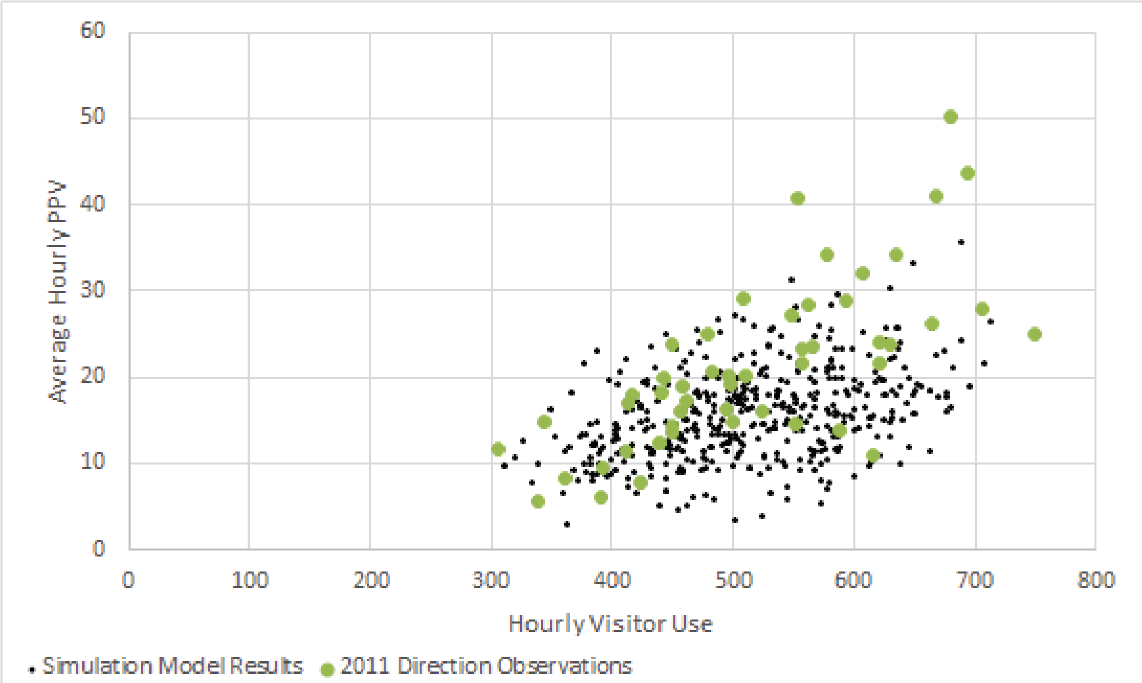

Figure 12. Scatterplot of hourly visitor use and corresponding hourly average number of people per viewscape (PPV) in the photo simulation area of the trail to Bridalveil Fall - 2011 direct observation counts and simulation model results.

- Finally, it should be noted, within both the observation and model data plotted in Figure 11, there is a strong, positive relationship between hourly visitor use at Bridalveil Fall and average hourly PAOT at the base of Bridalveil Fall. In particular, R-squared values for simple linear regression models fitting the observation and model data are 0.96 and 0.97, respectively. Similarly, within the observed and model data plotted in Figure 12, there is a strong, positive relationship between hourly visitor use at Bridalveil Fall and average hourly PPV on the trail to Bridalveil Fall, with simple linear regression model R-squared values of 0.90 and 0.92, respectively. These findings suggest managing visitor use levels at Bridalveil Fall is an effective way to directly affect the number of people at one time, and correspondingly visitor densities, at the base of Bridalveil Fall and on the trail to Bridalveil Fall.

Trail to Vernal Fall

- **Baseline Year (2011):** To the extent possible, the Merced River Plan uses 2011 as the baseline year for documenting existing conditions of indicators, and trail counter data were collected on the Trail to Vernal Fall (at the Happy Isles Trailhead) during 2011. Therefore, the year 2011 was selected as the baseline year for analysis and modeling of existing visitor use levels and corresponding visitor densities on the Trail to Vernal Fall.
- **Peak 14-day Period (May 18-June 2):** Calibrated, inbound daily visitor use on the Trail to Vernal Fall from May 17 through November 7, 2011 is plotted in Figure 13; as depicted, the peak 14-day period of visitor use on the Trail to Vernal Fall during summer 2011 occurred from May 18 through June 2.

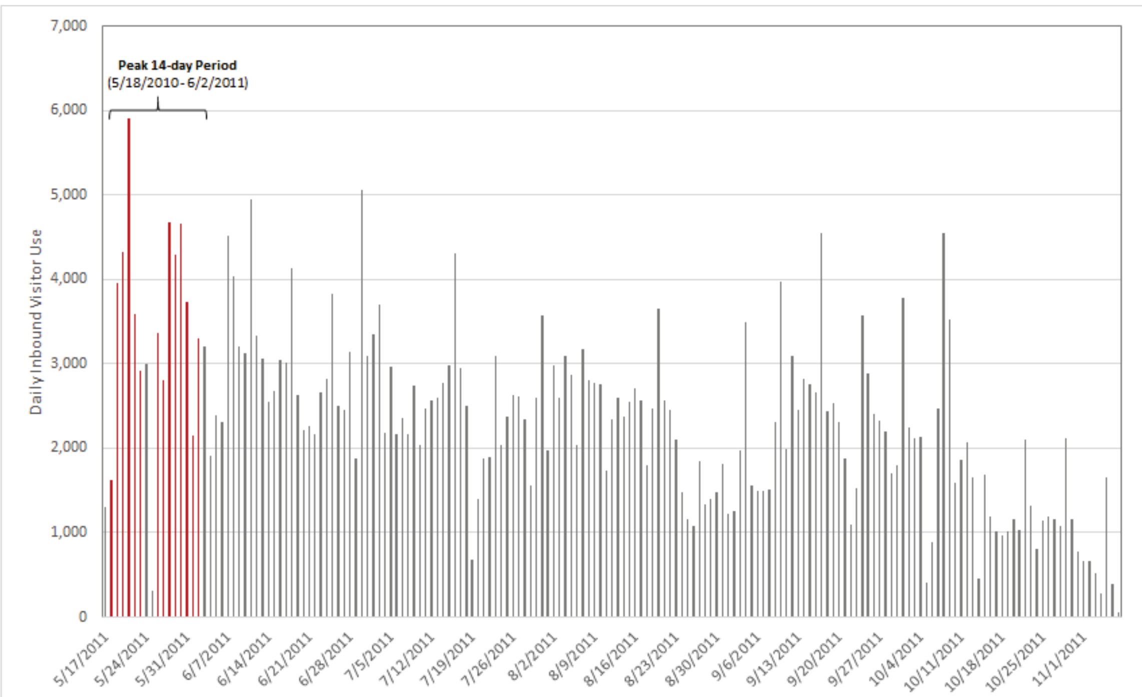

Figure 13. Daily visitor use (arrivals) on the Trail to Vernal Fall, by date, summer 2011.

- **Peak 6-hour Period (10 AM-4 PM):** As depicted in Figure 14, the peak 6-hour period of visitor use on the Trail to Vernal Fall during the peak 14-day period of summer 2011 was 10:00 AM to 4:00 PM.

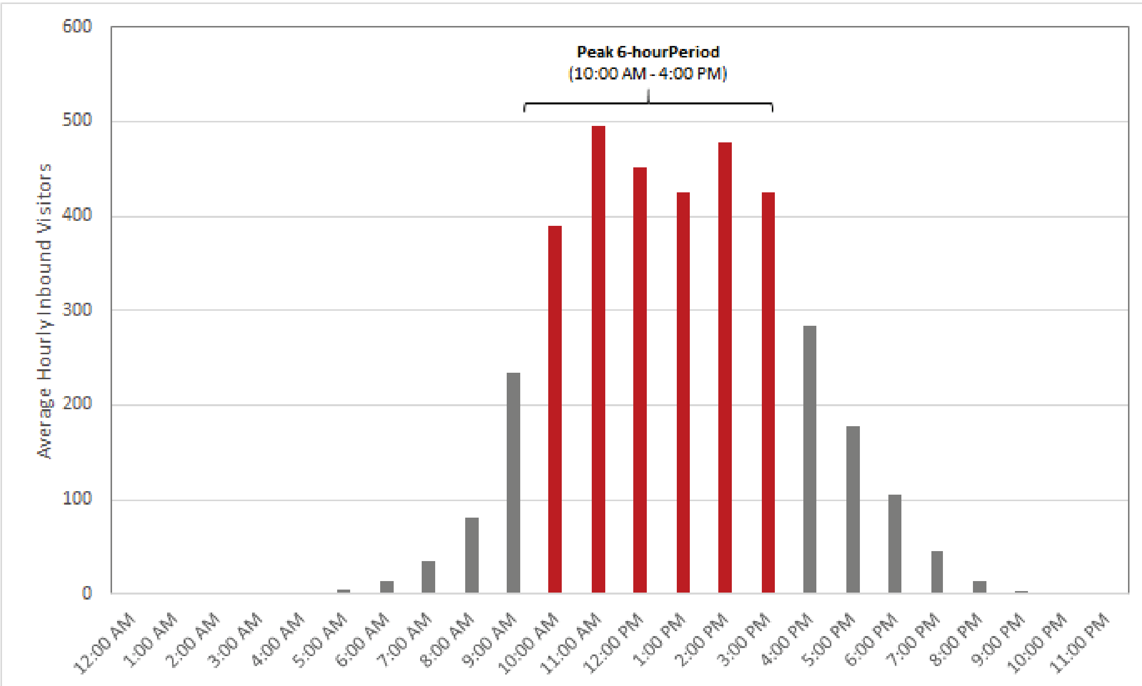

Figure 14. Average hourly visitor use during peak 14-day period on the Trail to Vernal Fall, summer 2011.

- **Monitoring Locations:** Simulations were conducted with a computer model of existing visitor use levels on the Trail to Vernal Fall to estimate average visitor density for one monitoring location, as follows:
  - **Trail to Vernal Fall:** A 860 square foot section of the Trail to Vernal Fall corresponding to the trail section depicted in photo simulations used in a visitor survey conducted during 1998 (Figure 15).

Figure 15. Photo simulation of visitor use on the Trail to Vernal Fall.

- **Mean visitor densities (square feet per person):** ***The visitor use simulation model results suggest that, under existing levels of visitor use, visitor densities on the Trail to Vernal Fall do not violate the "Acceptable", or "Displacement" density levels derived from results of visitor surveys conducted on the Trail to Vernal Fall during 1998. However accounting for the upper bounds of the visitor density estimate for the Trail to Vernal Fall, the visitor survey-based "Preference" density level is violated.*** In particular, Table 3 reports computer simulation model estimates of the average visitor density at the monitoring location noted, based on existing peak period visitor use levels on the Trail to Vernal Fall. In addition, Table 3 includes the visitor survey-based "Preference", "Acceptable", and "Displacement" density levels, for purposes of comparison.

Table 3. Visitor density estimates under existing conditions and visitor survey-based density levels – Trail to Vernal Fall.

Site	**Average Visitor Density** (ft^2/person)	**"Preference" Density Level** [a] (ft^2/person)	**"Acceptable" Density Level** [a] (ft^2/person)	**"Displacement" Density Level** [a] (ft^2/person)
Trail to Vernal Fall	80 (±11.0)	78	33	22

[a] Derived from results of visitor surveys conducted on the Trail to Vernal Fall in 1998.

- **Model validation: *Model validation procedures conducted in this study suggest the visitor density estimates derived from the simulation model of visitor use on the Trail to Vernal Fall can be used with a high degree of confidence in their accuracy.*** In particular, Figure 16 plots hourly visitor use on the Trail to Vernal Fall on the x-axis, and the corresponding average hourly number of people per viewscape (PPV) in the photo simulation area of the Trail to Vernal Fall on the y-axis. As the figure legend denotes, the data points in Figure 16 are derived from direct observation counts conducted on the Trail to Vernal Fall during summer 2011 and visitor use model estimates based on simulations of comparable levels of visitor use. As depicted in Figure 16, the data points derived from the model results overlap closely with those derived from the direct observation counts, which, as noted, suggests the visitor density estimates derived from the simulation model and reported in this memo are valid.

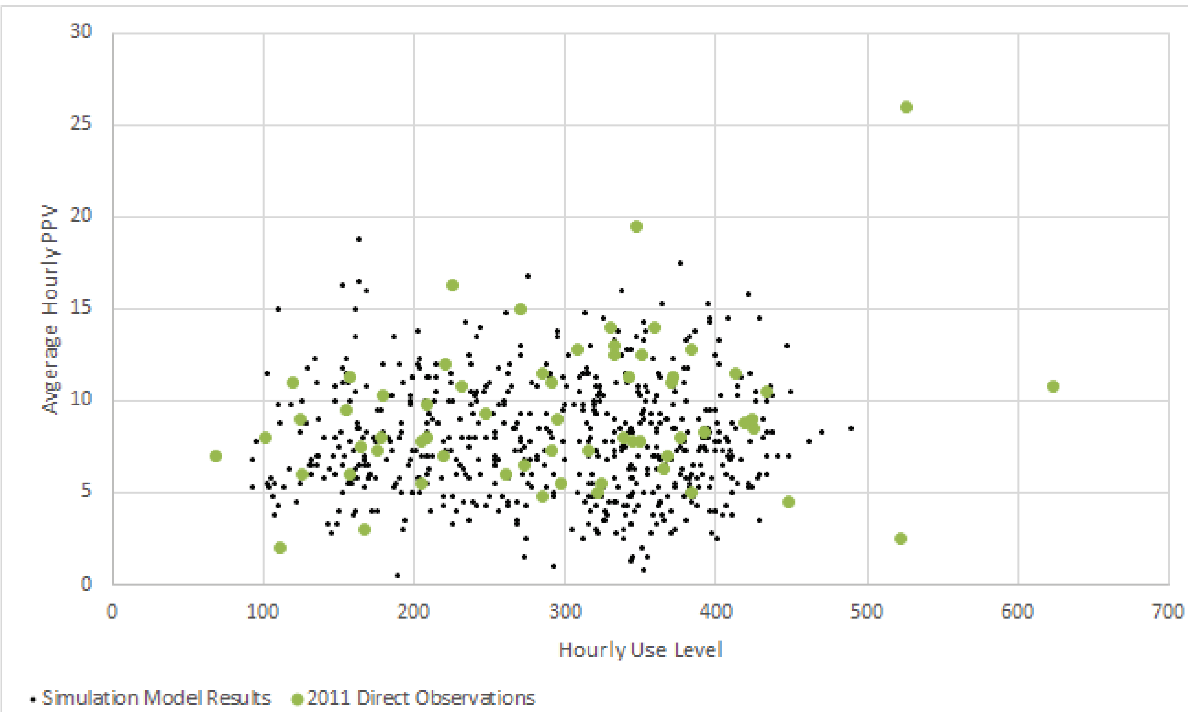

Figure 16. Scatterplot of hourly visitor use and corresponding hourly average number of people per viewscape (PPV) in the photo simulation area of the Trail to Vernal Fall - 2011 direct observation counts and simulation model results.

- Finally, it should be noted, within both the observation and model data plotted in Figure 16, there is a strong, positive relationship between hourly visitor use on the Trail to Vernal Fall and average hourly PPV on the trail, with simple linear regression model R-squared values of 0.80 and 0.79, respectively. Thus, managing visitor use levels on the Trail to Vernal Fall is an effective way to directly affect the number of people at one time, and correspondingly visitor densities, on the Trail to Vernal Fall.

MRP Modeling Task 4 Deliverable

Technical Memo
Regression Modeling of Chapel Straight Traffic Volumes and Visitor Use at Attraction Sites in Yosemite Valley

October 30, 2013

Prepared for
U.S. Department of the Interior
National Park Service
Yosemite National Park

Submitted by
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Introduction

This technical memorandum reports results of regression models correlating inbound traffic volume on Southside Drive at Chapel Straight with visitor use at three attraction sites in Yosemite Valley (Lower Yosemite Falls, Bridalveil Fall, and the Trail to Vernal Fall). Separate regression models were estimated for each of the attraction sites, with attraction site visitor use as the dependent variable in each model and Chapel Straight inbound traffic volume (including potential time of day, day of week, holiday, and seasonality effects) as the independent variable.

The results presented in the memo are based on an iterative model estimation process to optimize model specification (i.e., functional form and explanatory variables). The regression modeling results are reported by attraction site, and include the following information for each attraction site:

1. A series of figures depicting visitor use patterns at each attraction site, by day of week, time of day, and month of the year.
2. A line graph of daily inbound vehicle traffic at Chapel Straight and corresponding daily attraction site visitor use.
3. Scatterplots depicting the relationships between Chapel Straight traffic volumes and attraction site visitor use at a daily level, and at an hourly level, with various "lag times" between the traffic and trail use data observations to account for visitors' travel patterns.
4. Regression modeling results in graphical and tabular format, including model parameter estimates and R-square values.

Lower Yosemite Falls

- **Hourly Visitor Use, by Time of Day and Day of Week:** Figure 1 through Figure 3 present line graphs of average hourly visitor use at Lower Yosemite Falls during summer 2010, by time of day and day of week for June, July, and August, respectively. The graphs suggest during summer 2010:
    - Visitor use was highest in June and lowest in August.
    - Saturdays were the most popular day to visit Lower Yosemite Falls, throughout the summer.
    - In June and August, visitor use was generally higher on Sundays than during weekdays. In July, visitor use levels were similar on Sundays and Mondays, and both days were generally busier than Tuesdays through Fridays.
    - Visitor use at Lower Yosemite Falls was generally lower on Thursdays and Fridays than other days of the week, throughout the summer.
    - The peak period of visitor use at Lower Yosemite Falls generally occurred during the same time of the day (mid-afternoon), regardless of the month of the summer or day of week.

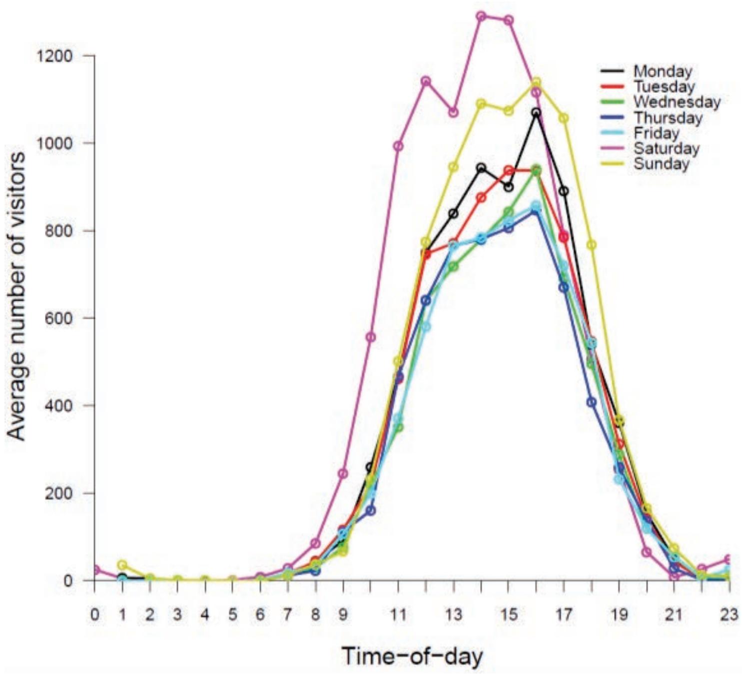

Figure 1. Average hourly visitor use at Lower Yosemite Falls, by time of day and day of week -June, 2010.

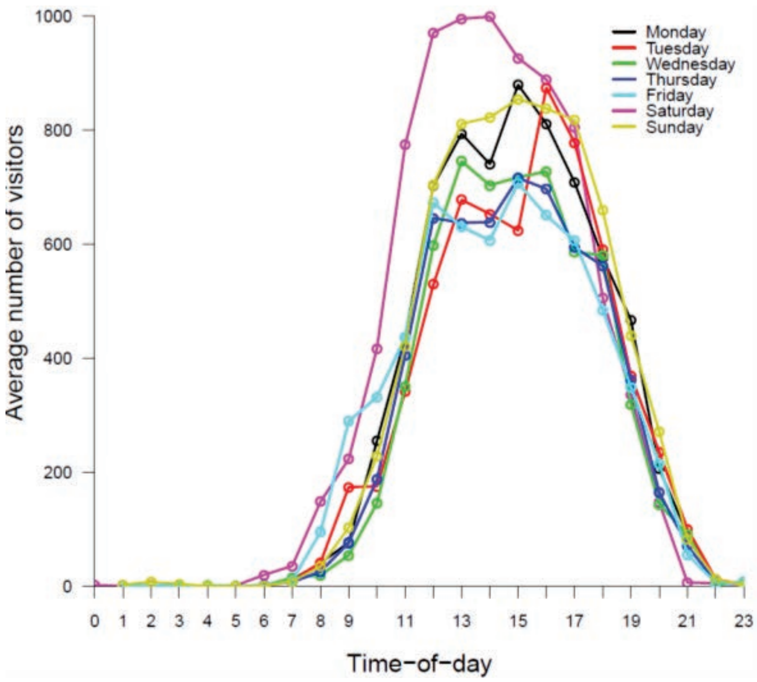

Figure 2. Average hourly visitor use at Lower Yosemite Falls, by time of day and day of week -July, 2010.

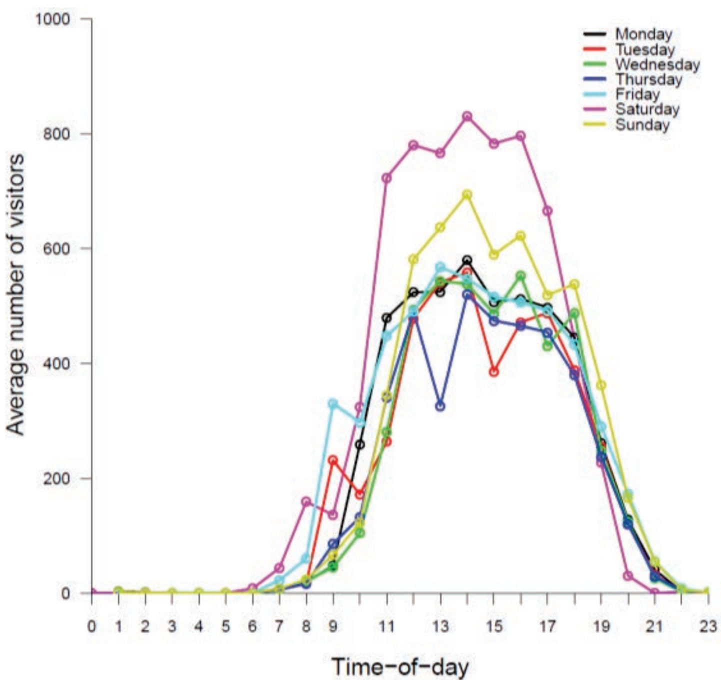

Figure 3. Average hourly visitor use at Lower Yosemite Falls, by time of day and day of week -August, 2010.

- **Daily Visitor Use, by Day of Week:** Figure 4 presents a bar chart of average daily visitor use at Lower Yosemite Falls during summer 2010, by day of week for June, July, and August. Conclusions about visitor use at Lower Yosemite Falls during summer 2010 based on the data in Figure 4 are consistent with those based on Figure 1 through Figure 3, including:
    - Visitor use was highest in June and lowest in August.
    - Saturdays were the most popular day to visit Lower Yosemite Falls, throughout the summer.

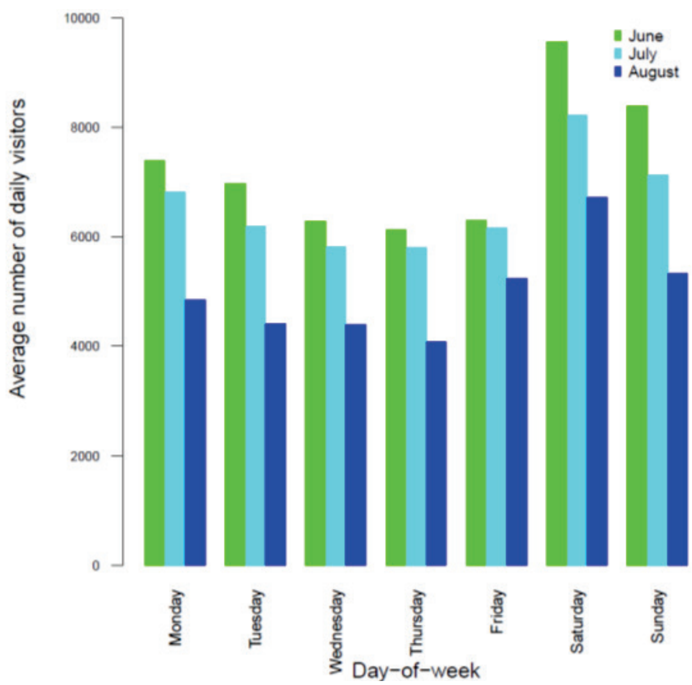

Figure 4. Average daily visitor use at Lower Yosemite Falls, by day of week and month –June-August, 2010.

- **Daily Visitor Use at Lower Yosemite Falls and Inbound Vehicle Traffic at Chapel Straight:** Figure 5 presents line graphs of daily visitor use (number of people) at Lower Yosemite Falls and daily inbound traffic volumes (number of vehicles) on Southside Drive at Chapel Straight for the period from May 29 through August 26, 2010. The line graphs suggest:
  - There is a distinct, positive correlation between inbound vehicle traffic at Chapel Straight and visitor use at Lower Yosemite Falls. However, the relationship is more pronounced during the first half of the summer, and less pronounced during late July and August.

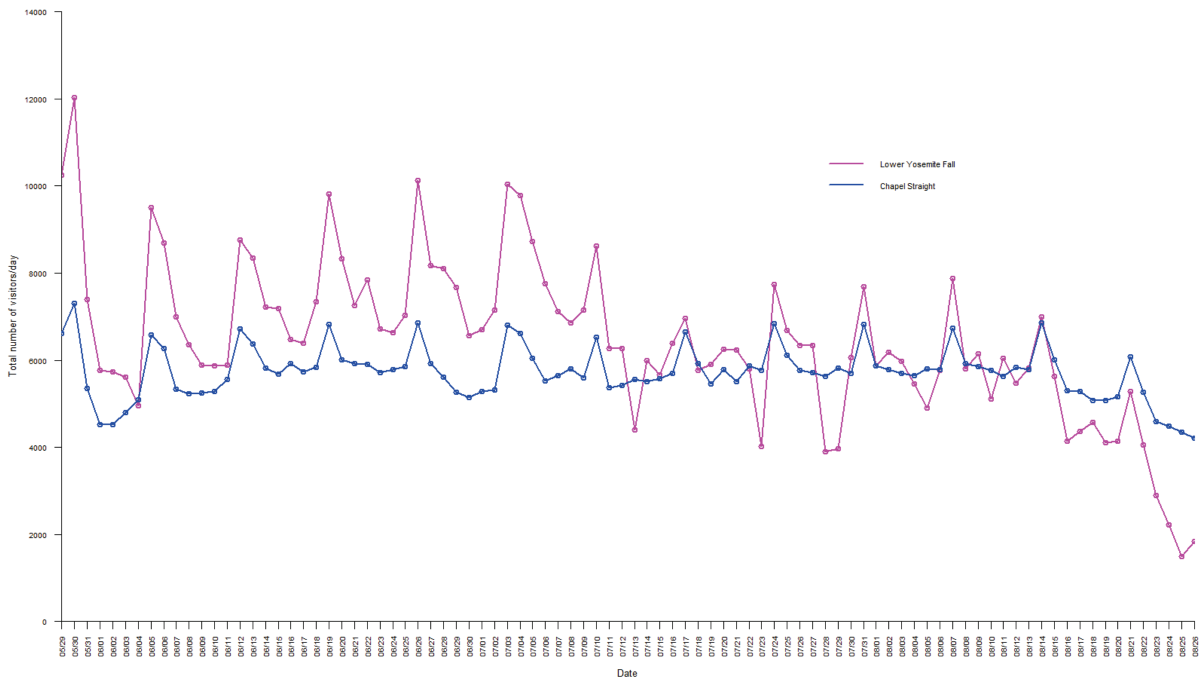

Figure 5. Daily visitor use (number of people) at Lower Yosemite Falls and inbound traffic (number of vehicles) at Chapel Straight, summer 2010.

- **Hourly Visitor Use at Lower Yosemite Falls and Inbound Vehicle Traffic at Chapel Straight, with Lag Times:** Figure 6 through Figure 10 present scatterplots of hourly inbound vehicle traffic at Chapel Straight and visitor use at Lower Yosemite Falls (linear and log transformed), with lag times ranging from no lag to a 4-hour lag between inbound vehicle traffic at Chapel Straight and hourly visitor use at Lower Yosemite Falls. The scatterplots suggest the correlation is highest between hourly inbound vehicle traffic at Chapel Straight and visitor use at Lower Yosemite Falls with a 2-hour or 3-hour lag, and that a linear or non-linear specification may be suitable for modeling the relationship.

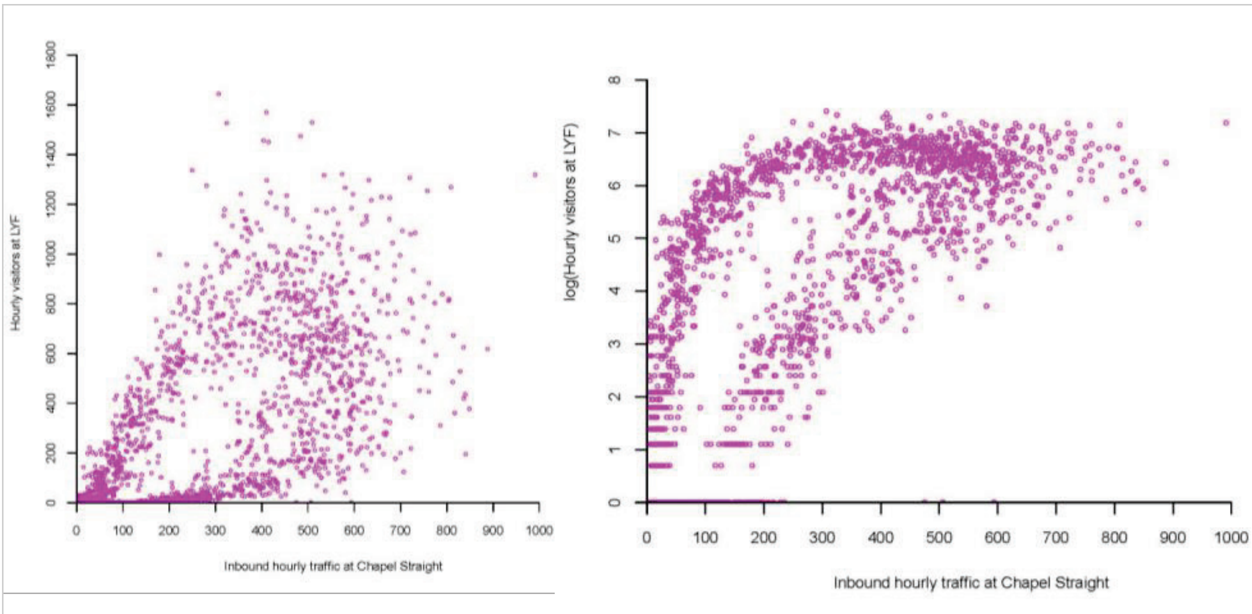

Figure 6. Hourly visitor use at Lower Yosemite Falls (linear and log transformed) and inbound traffic at Chapel Straight, summer 2010 – no lag.

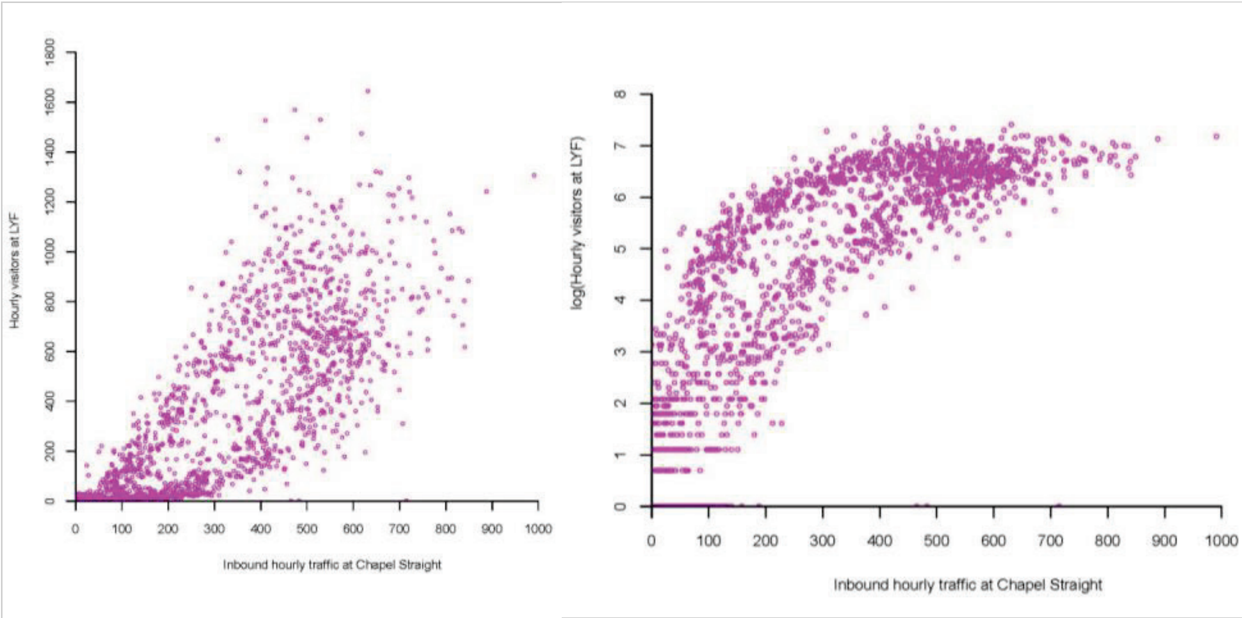

Figure 7. Hourly visitor use at Lower Yosemite Falls (linear and log transformed) and inbound traffic at Chapel Straight, summer 2010 – 1-hr lag.

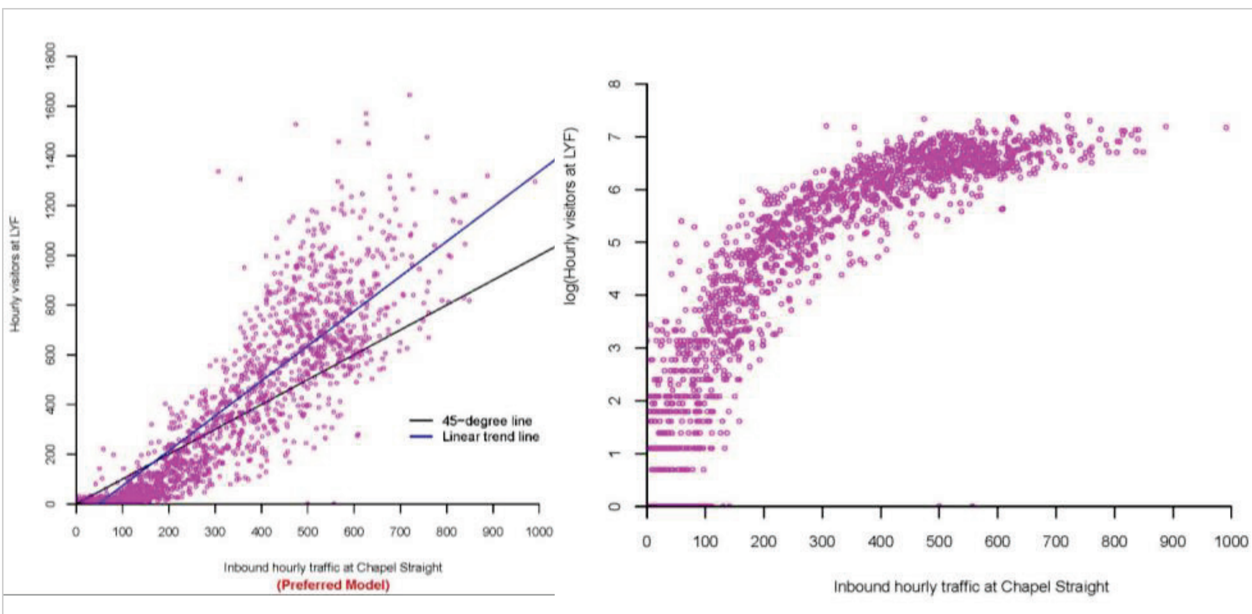

Figure 8. Hourly visitor use at Lower Yosemite Falls (linear and log transformed) and inbound traffic at Chapel Straight, summer 2010 – 2-hr lag.

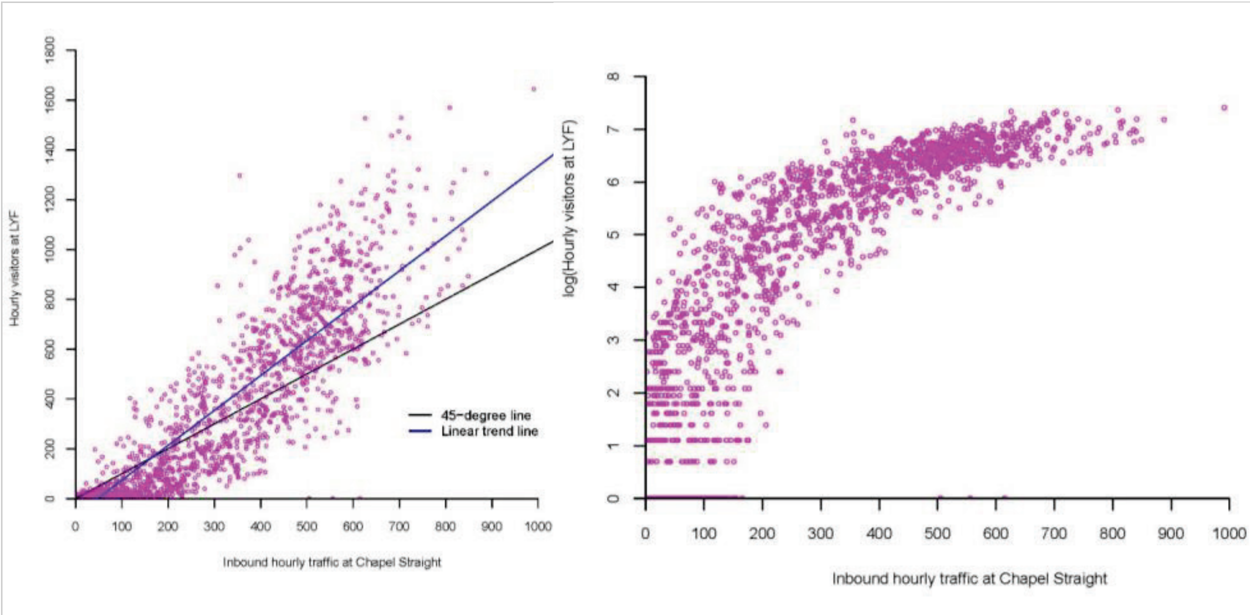

Figure 9. Hourly visitor use at Lower Yosemite Falls (linear and log transformed) and inbound traffic at Chapel Straight, summer 2010 – 3-hr lag.

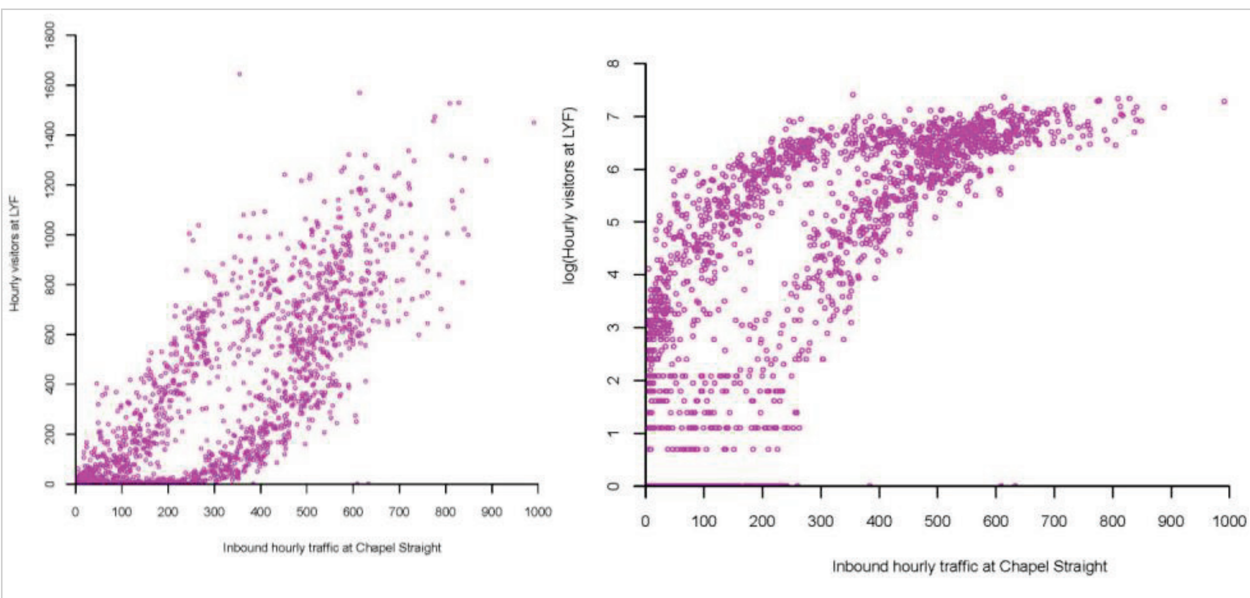

Figure 10. Hourly visitor use at Lower Yosemite Falls (linear and log transformed) and inbound traffic at Chapel Straight, summer 2010 – 4-hr lag.

- **Regression modeling results with hourly traffic volume and visitor use data:** Table 1 through Table 4 report results for linear and non-linear regression models, with hourly visitor use at Lower Yosemite Falls as the dependent variable and Chapel Straight inbound traffic volume (including time of day, day of week, holiday, and seasonality effects) as the independent variable (NOTE: The results for the preferred model include standardized coefficients and p-values). The results include models with 2-hour and 3-hour lags between hourly inbound vehicle traffic at Chapel Straight and hourly visitor use at Lower Yosemite Falls. ***The results suggest the linear model with a 2-hour lag fits the data best.***

Table 1.Linear model results for Lower Yosemite Falls, 2-hour lag.

	Dependent variable: Hourly visitor use at Lower Yosemite Falls; 2-hour lag				
	Unstandardized coefficients			Standardized coefficients	p-value
Coefficients:	**Estimate**	**C.I.(95%): Lower**	**C.I. (95%): Upper**		
Intercept	-	-	-	-	-
Chapel.St.	0.960	0.959	0.961	0.719	<0.001
Morning2.6.to.10	-110.914	-111.222	-110.606	-0.117	<0.001
Afternoon1.12.to.15	75.012	74.476	75.547	0.070	<0.001
Afternoon2.16.to.19	16.301	15.892	16.709	0.015	0.093
Afternoon1.12.to.15 * Saturday	142.867	142.040	143.694	0.051	<0.001
Afternoon2.16.to.19 * Saturday	178.333	177.534	179.133	0.064	<0.001
Chapel.St. * Sunday	0.168	0.167	0.169	0.052	<0.001
Chapel.St. * Monday	0.116	0.115	0.117	0.032	<0.001
Chapel.St. * June	0.371	0.371	0.372	0.159	<0.001
Chapel.St. * July	0.160	0.159	0.161	0.072	<0.001
Memorial.Day	76.056	74.951	77.162	0.018	0.004
Independence.Day	60.132	59.018	61.247	0.015	0.023
Adjusted R-squared	0.917				
Sample size	2160				
Comment	Preferred model				

Table 2. Log transformed model results for Lower Yosemite Falls, 2-hour lag.

	Dependent variable: log(Hourly visitor use at Lower Yosemite Falls; 2-hour lag)				
Coefficients:	**Estimate**	**Std. Error**	**t value**	**C.I.(95%): Lower**	**C.I. (95%): Upper**
Intercept	0.485	0.033	14.68	0.484	0.486
Chapel.St.	0.010	0.000	50.61	0.010	0.010
Morning2.6.to.10	1.512	0.058	26.01	1.510	1.515
Afternoon1.12.to.15	0.412	0.096	4.30	0.408	0.416
Afternoon2.16.to.19	1.877	0.074	25.39	1.874	1.881
Afternoon1.12.to.15 * Saturday	-1.244	0.149	-8.37	-1.250	-1.238
Afternoon2.16.to.19 * Saturday	-0.024	0.143	-0.17	-0.030	-0.018
Chapel.St. * Sunday	-0.001	0.000	-4.22	-0.001	-0.001
Chapel.St. * Monday	0.000	0.000	0.56	0.000	0.000
Chapel.St. * June	0.001	0.000	5.44	0.001	0.001
Chapel.St. * July	0.000	0.000	2.15	0.000	0.000
Memorial.Day	0.377	0.198	1.90	0.369	0.385
Independence.Day	0.141	0.200	0.71	0.133	0.150
Adjusted R-squared	0.879				
Sample size	2160				
Comment					

Table 3. Linear model results for Lower Yosemite Falls, 3-hour lag.

	Dependent variable: Hourly visitor use at Lower Yosemite Falls; 3-hour lag				
Coefficients:	Estimate	Std. Error	t value	C.I.(95%): Lower	C.I. (95%): Upper
Intercept	-	-	-	-	-
Chapel.St.	1.046	0.031	33.73	1.045	1.047
Morning2.6.to.10	-36.143	7.353	-4.92	-36.453	-35.833
Afternoon1.12.to.15	23.115	15.715	1.47	22.452	23.778
Afternoon2.16.to.19	-104.238	13.119	-7.95	-104.792	-103.685
Afternoon2.16.to.19 * Saturday	78.908	23.713	3.33	77.908	79.908
Chapel.St. * Saturday	0.157	0.028	5.66	0.156	0.158
Chapel.St. * Sunday	0.176	0.026	6.87	0.175	0.177
Chapel.St. * Monday	0.112	0.029	3.88	0.110	0.113
Chapel.St. * June	0.369	0.023	16.33	0.368	0.370
Chapel.St. * July	0.155	0.022	6.96	0.154	0.156
Memorial.Day	70.495	28.448	2.48	69.295	71.695
Independence.Day	53.240	28.676	1.86	52.031	54.449
Adjusted R-squared	0.902				
Sample size	2160				
Comment					

Table 4. Log transformed model results for Lower Yosemite Falls, 3-hour lag.

	Dependent variable: log(Hourly visitor use at Lower Yosemite Falls; 3-hour lag)				
Coefficients:	Estimate	Std. Error	t value	C.I.(95%): Lower	C.I. (95%): Upper
Intercept	0.197	0.033	5.92	0.195953153	0.198765847
Chapel.St.	0.013	0.000	56.61	0.013	0.013
Morning2.6.to.10	2.183	0.052	41.60	2.180	2.185
Afternoon1.12.to.15	-1.048	0.107	-9.84	-1.053	-1.044
Afternoon2.16.to.19	0.186	0.088	2.13	0.183	0.190
Afternoon2.16.to.19 * Saturday	0.643	0.158	4.08	0.637	0.650
Chapel.St. * Saturday	-0.002	0.000	-12.88	-0.002	-0.002
Chapel.St. * Sunday	-0.001	0.000	-7.43	-0.001	-0.001
Chapel.St. * Monday	0.000	0.000	-0.61	0.000	0.000
Chapel.St. * June	0.001	0.000	5.62	0.001	0.001
Chapel.St. * July	0.000	0.000	2.02	0.000	0.000
Memorial.Day	0.390	0.190	2.06	0.382	0.398
Independence.Day	0.076	0.191	0.40	0.068	0.084
Adjusted R-squared	0.889				
Sample size	2160				
Comment					

- **Scatterplot and regression modeling results with daily traffic volume and visitor use data:** Figure 11 presents a scatterplot of daily inbound vehicle traffic at Chapel Straight and visitor use at Lower Yosemite Falls during the period of the summer when the relationship between them is most pronounced (i.e., May 29 through July 11, 2010), and Table 5 reports regression modeling results, with daily visitor use at Lower Yosemite Falls as the dependent variable and Chapel Straight inbound traffic volume as the independent variable. ***The scatterplot and regression results suggest there is a very strong, positive relationship between daily inbound vehicle traffic at Chapel Straight and daily visitor use at Lower Yosemite Falls.***

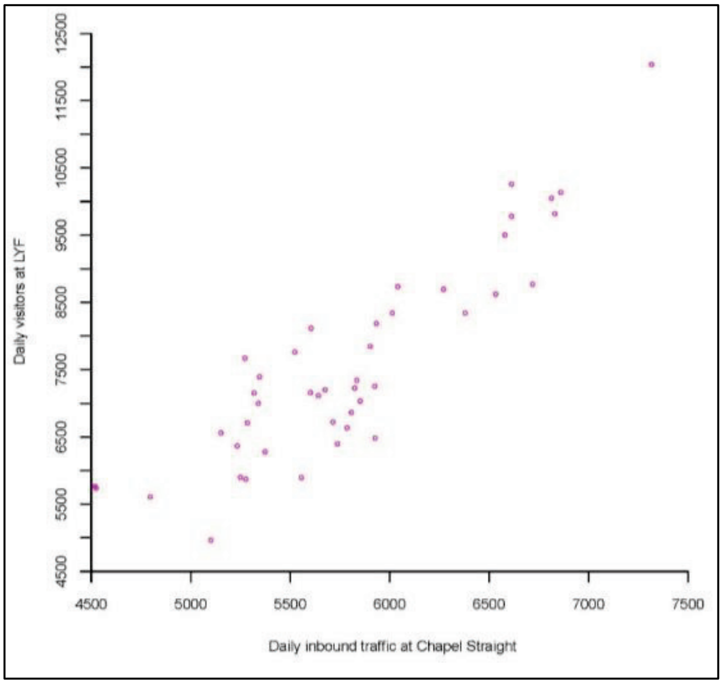

Figure 11. Daily visitor use at Lower Yosemite Falls and inbound traffic at Chapel Straight, summer 2010.

Table 5.Linear model results for Lower Yosemite Falls, daily traffic volume and visitor use.

	Dependent variable: Daily visitor use at Lower Yosemite Falls			
Coefficients:	**Estimate**	**Std. Error**	**t value**	**p-value**
Intercept	-	-	-	-
Daily traffic volume at the Chapel.St.	1.315	0.022	59.78	<0.001
Adjusted R-squared	0.9878			

Bridalveil Fall

- **Hourly Visitor Use, by Time of Day and Day of Week:** Figure 12 through Figure 15 present line graphs of average hourly visitor use at Bridalveil Fall during summer 2011, by time of day and day of week for June (starting June 15), July, August, and September (ending September 15), respectively. The graphs suggest during summer 2011:
  - Visitor use was highest in June and lowest in September.
  - Saturdays were the most popular day to visit Bridalveil Fall, throughout the summer, though this trend was less distinct during July and August.
  - In September, weekends were notably busier than weekdays.
  - The peak period of visitor use at Bridalveil Fall generally occurred during the same time of the day (mid-afternoon), regardless of the month of the summer or day of week.

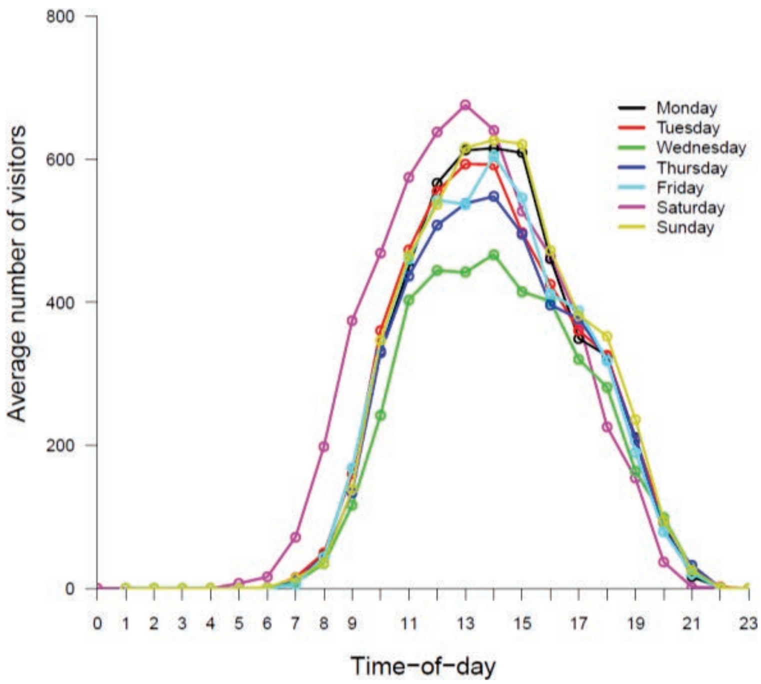

Figure 12. Average hourly visitor use at Bridalveil Fall, by time of day and day of week -June, 2011.

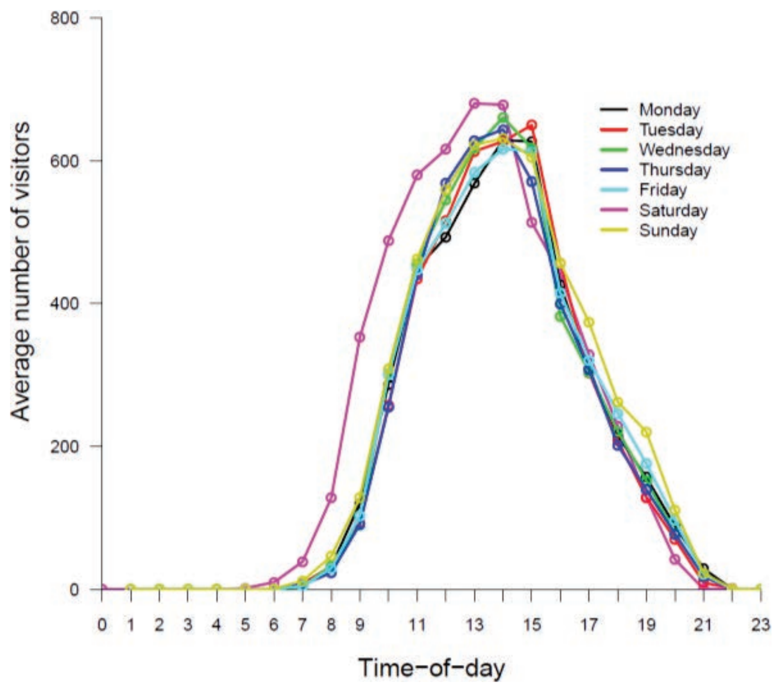

Figure 13. Average hourly visitor use at Bridalveil Fall, by time of day and day of week -July, 2011.

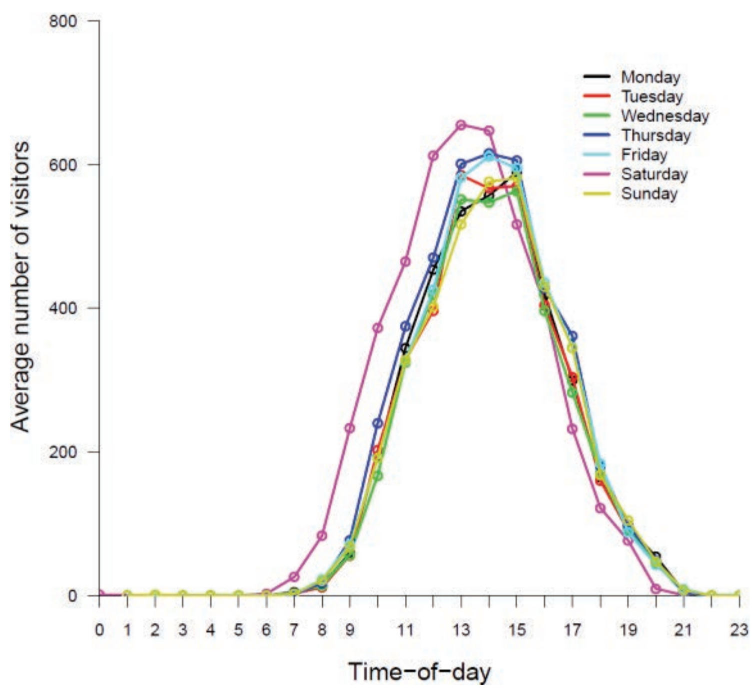

Figure 14. Average hourly visitor use at Bridalveil Fall, by time of day and day of week -August, 2011.

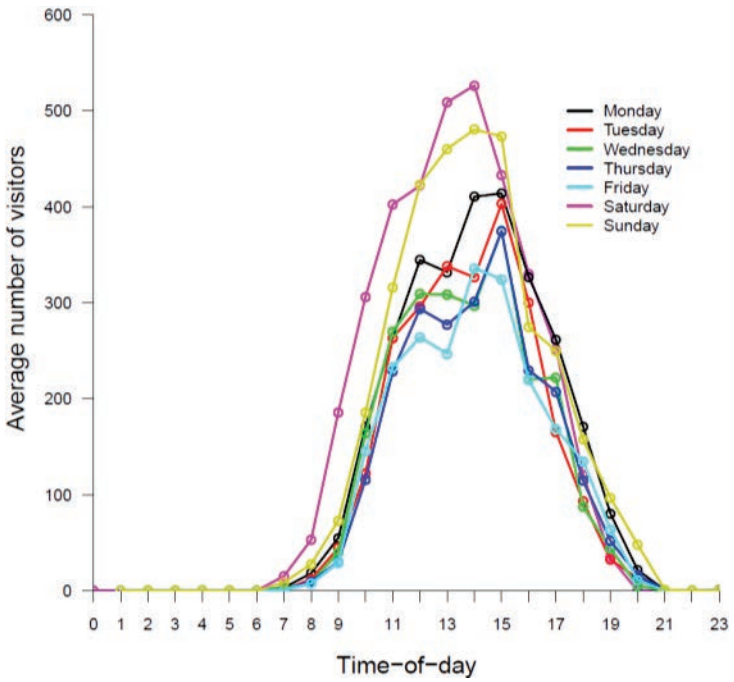

Figure 15. Average hourly visitor use at Bridalveil Fall, by time of day and day of week -September, 2011.

- **Daily Visitor Use, by Day of Week:** Figure 16 presents a bar chart of average daily visitor use at Bridalveil Fall during summer 2011, by day of week for June, July, August, and September. Conclusions about visitor use at Bridalveil Fall during summer 2011 based on the data in Figure 16 are consistent with those based on Figure 12 through Figure 15, including:
    - Visitor use was highest in June and lowest in September.
    - Saturdays were the most popular day to visit Bridalveil Fall, throughout the summer.

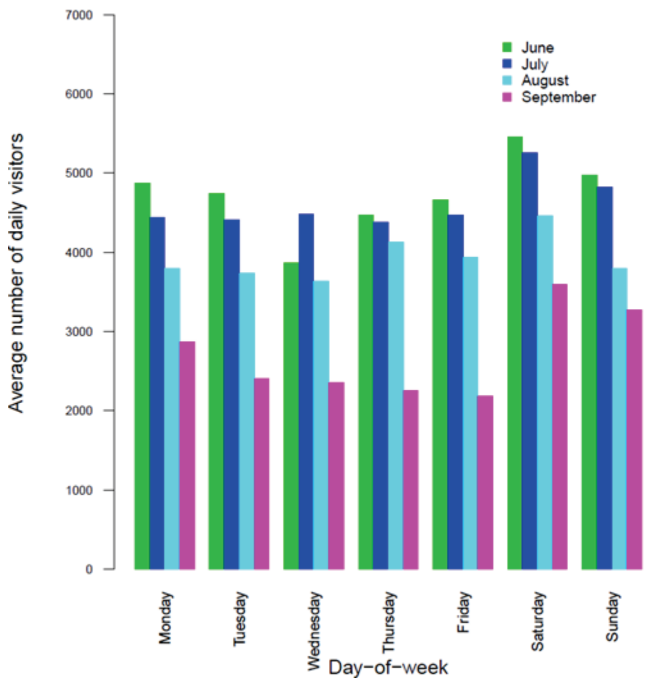

Figure 16. Average daily visitor use at Bridalveil Fall, by day of week and month –June-September, 2011.

- **Daily Visitor Use at Bridalveil Fall and Inbound Vehicle Traffic at Chapel Straight:** Figure 17 presents line graphs of daily visitor use (number of people) at Bridalveil Fall and daily inbound traffic volumes (number of vehicles) on Southside Drive at Chapel Straight for the period from June 16 through September 15, 2011. The line graphs suggest:
    - There is a strong positive correlation between inbound vehicle traffic at Chapel Straight and visitor use at Bridalveil Fall, and this statistical relationship persists throughout the summer.

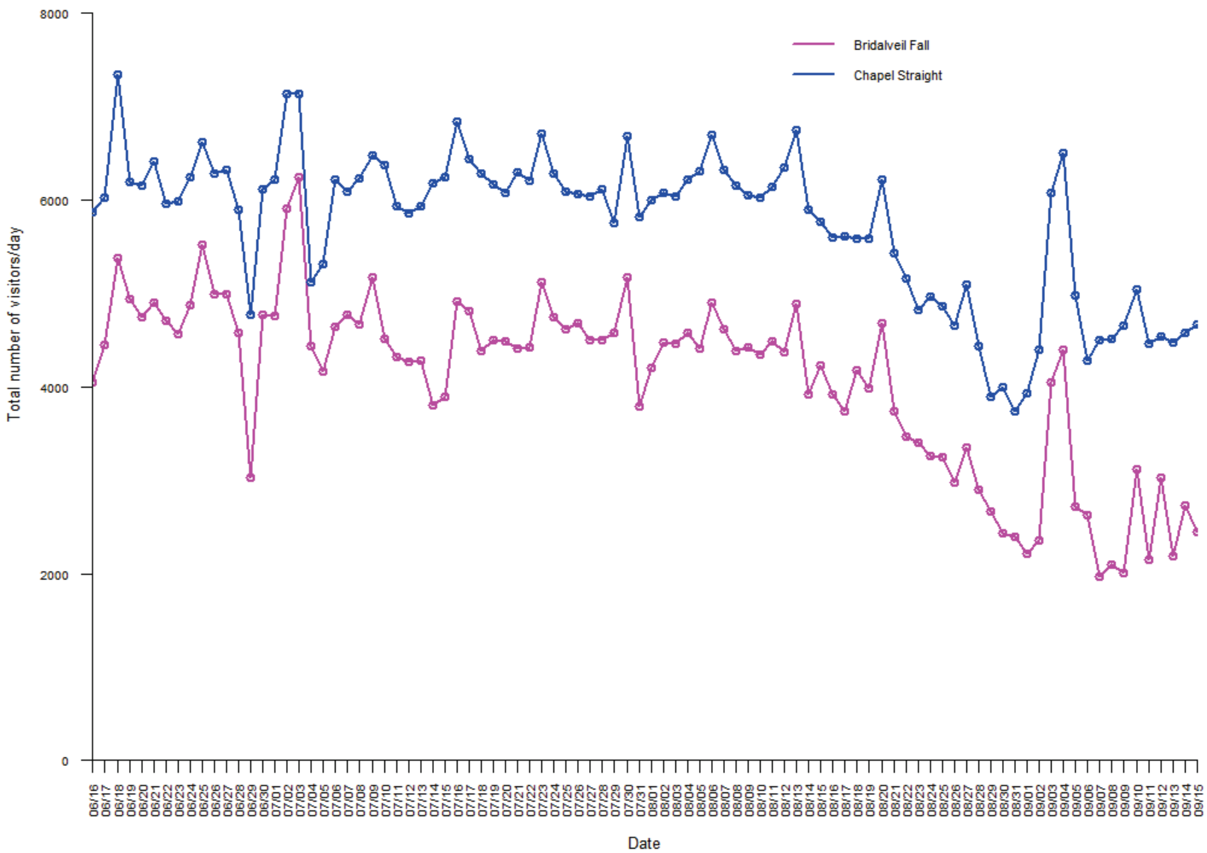

Figure 17. Daily visitor use (number of people) at Bridalveil Fall and inbound traffic (number of vehicles) at Chapel Straight, summer 2011.

- **Hourly Visitor Use at Bridalveil Fall and Inbound Vehicle Traffic at Chapel Straight, with Lag Times:** Figure 18 through Figure 22 present scatterplots of hourly inbound vehicle traffic at Chapel Straight and visitor use at Bridalveil Fall (linear and log transformed), with lag times ranging from no lag to a 4-hour lag between inbound vehicle traffic at Chapel Straight and hourly visitor use at Bridalveil Fall. Similarly, Figure 23 through Figure 25 present scatterplots of hourly inbound vehicle traffic at Chapel Straight and visitor use at Bridalveil Fall, but with "reverse lag times" (i.e., hourly traffic counts at Chapel Straight paired with Bridalveil Fall visitor use counts in the previous hour to three hours). The scatterplots suggest the correlation is highest between inbound vehicle traffic at Chapel Straight and visitor use at Bridalveil Fall with a 2-hour lag, and that a linear or non-linear specification may be suitable for modeling the relationship. The scatterplots further suggest there is very little or no correlation between the traffic count and visitor use data with a "reverse lag time" specified.

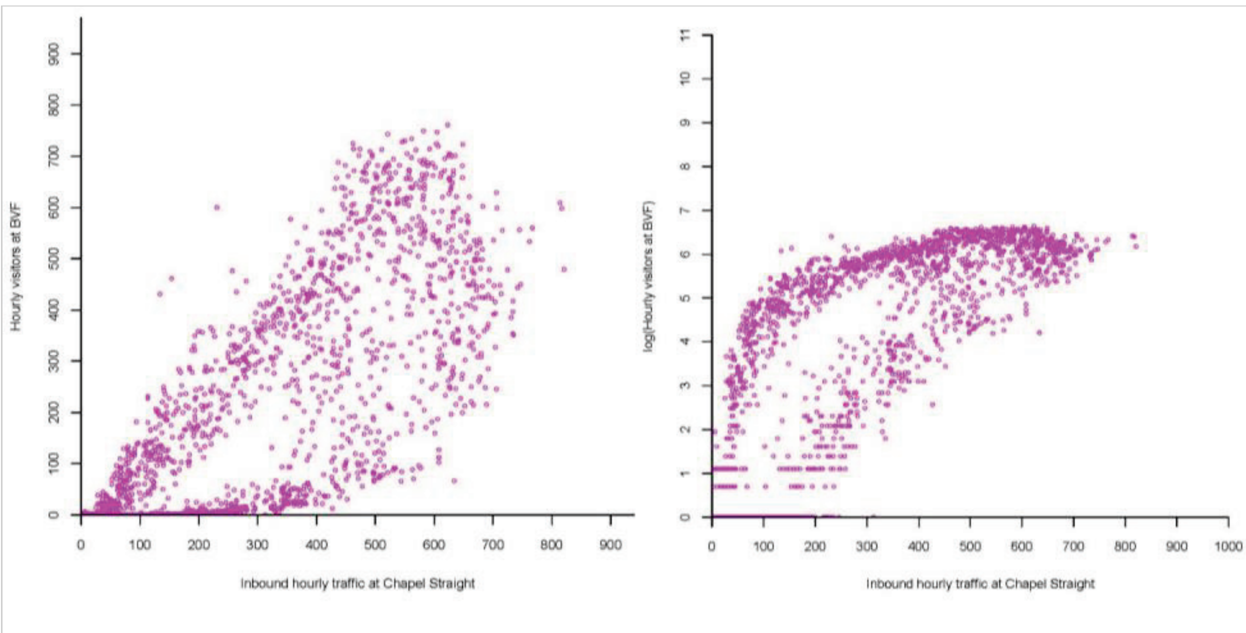

Figure 18. Hourly visitor use at Bridalveil Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – no lag.

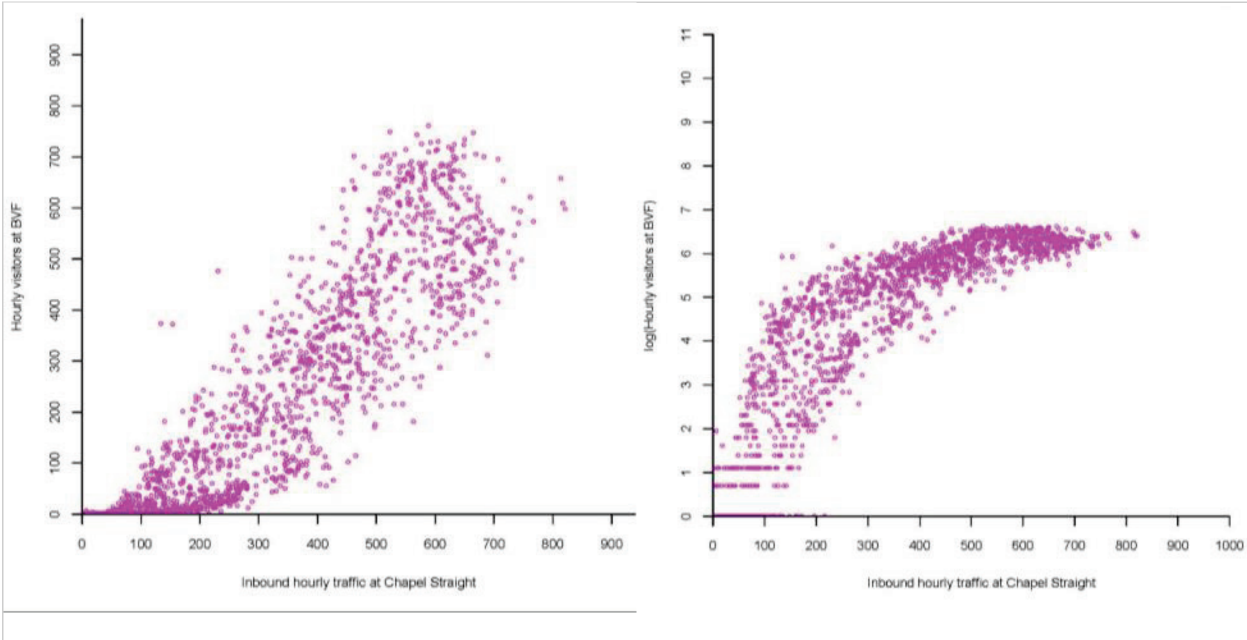

Figure 19. Hourly visitor use at Bridalveil Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 1-hr lag.

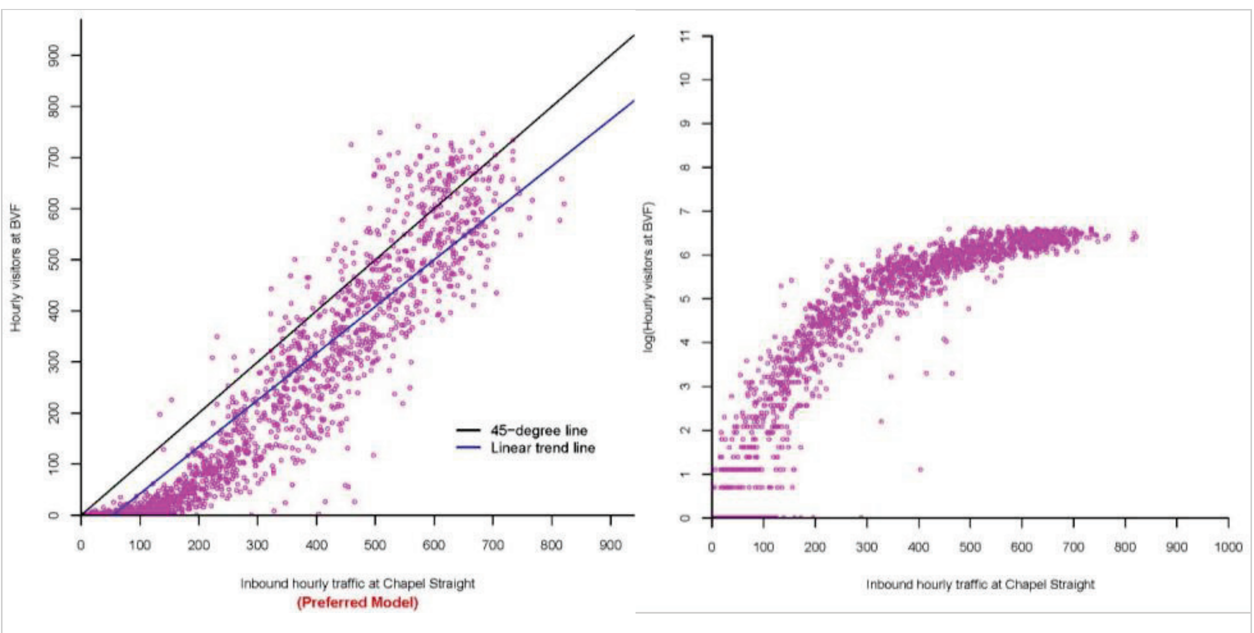

Figure 20. Hourly visitor use at Bridalveil Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 2-hr lag.

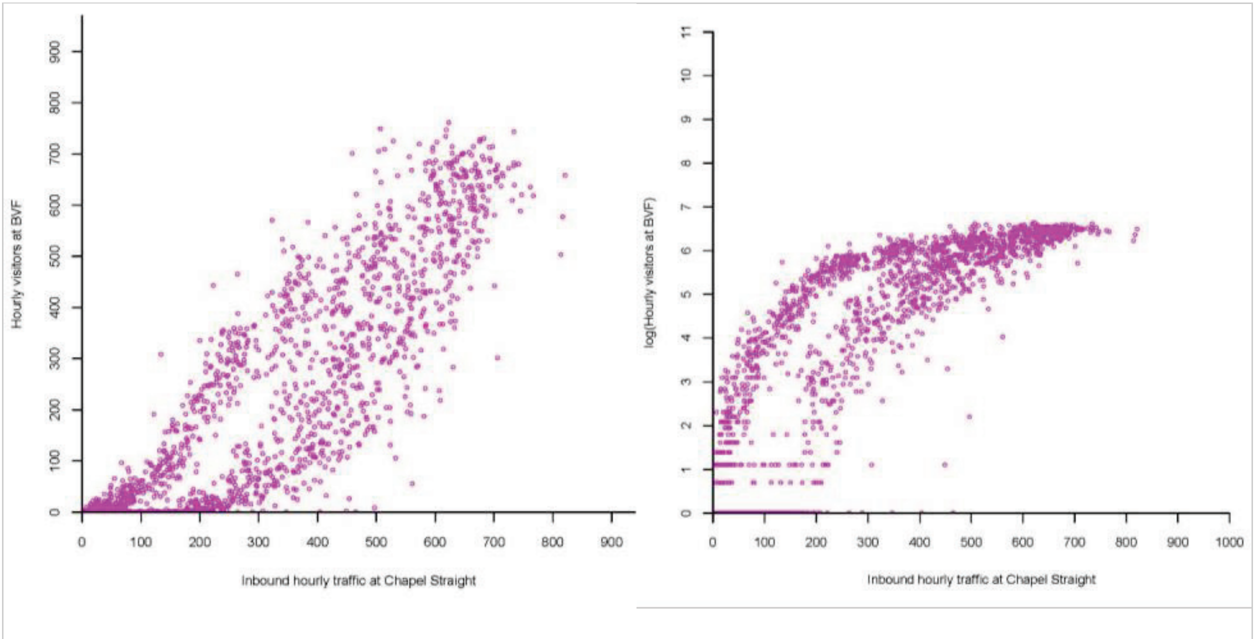

Figure 21. Hourly visitor use at Bridalveil Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 3-hr lag.

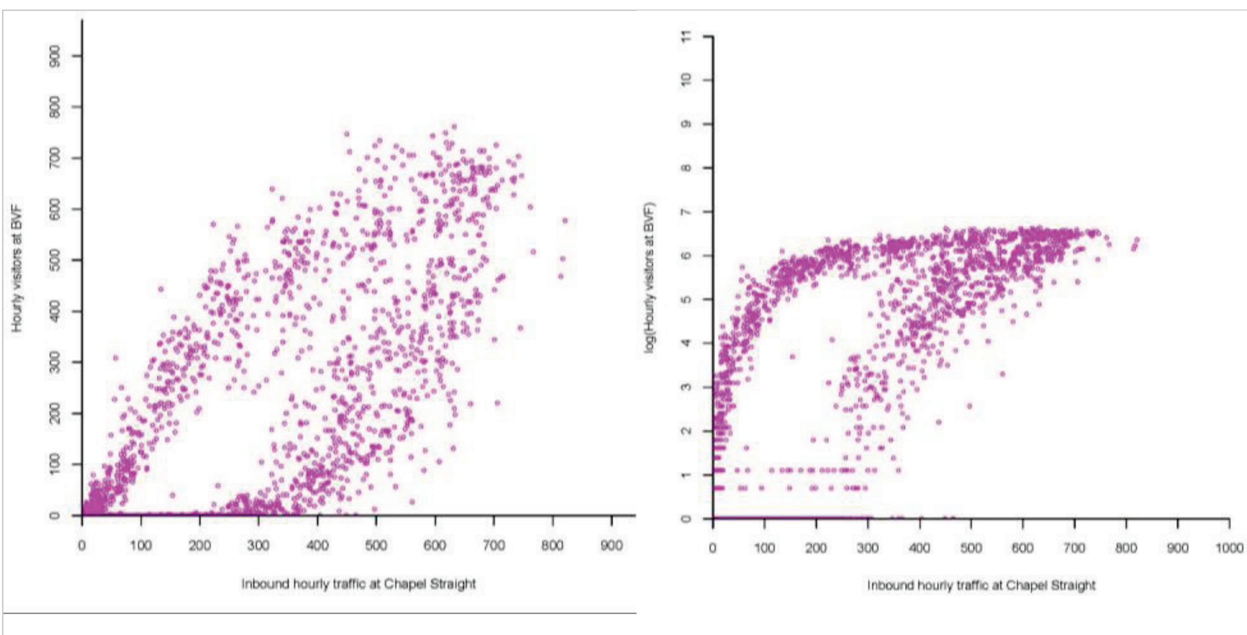

Figure 22. Hourly visitor use at Bridalveil Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 4-hr lag.

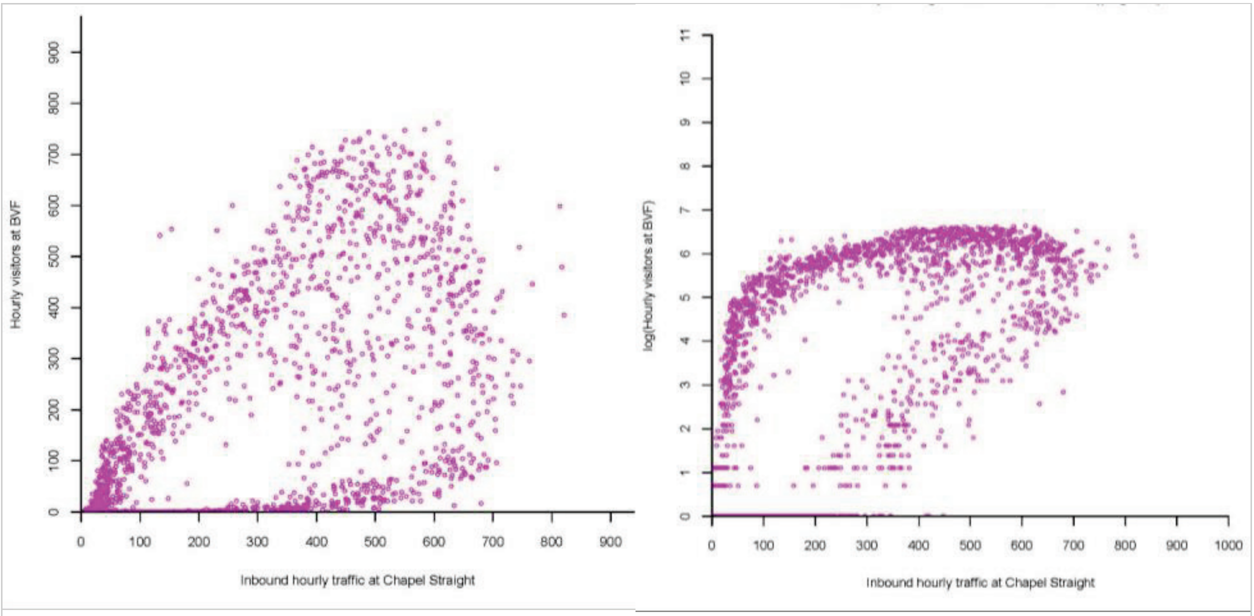

Figure 23. Hourly visitor use at Bridalveil Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 1-hr "reverse lag."

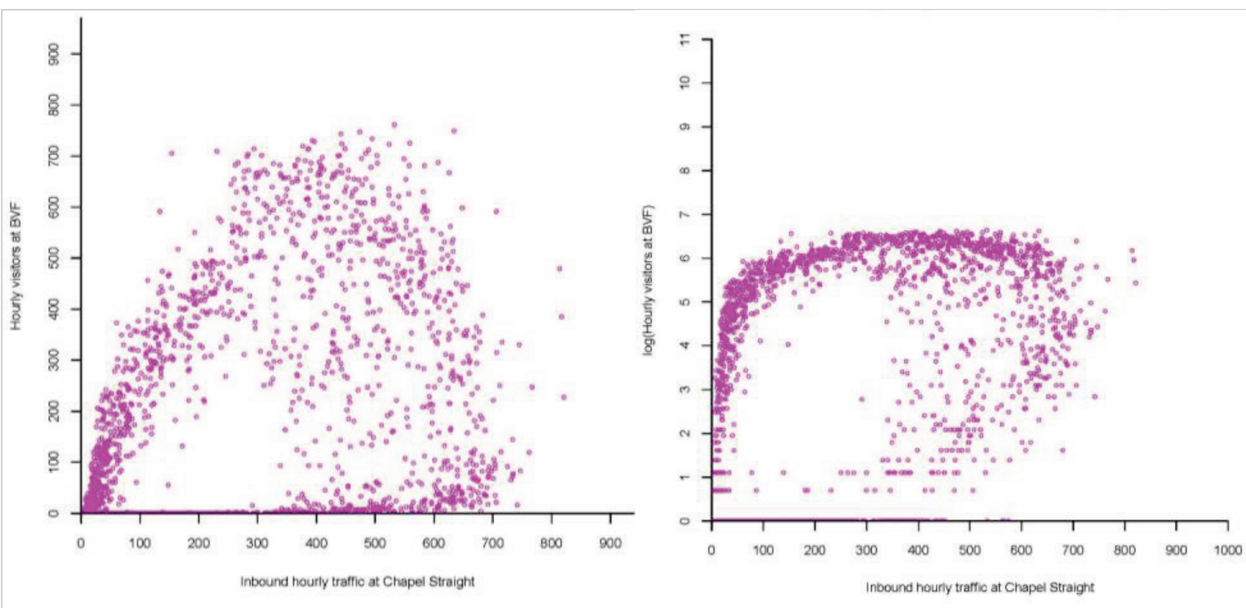

Figure 24. Hourly visitor use at Bridalveil Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 2-hr "reverse lag."

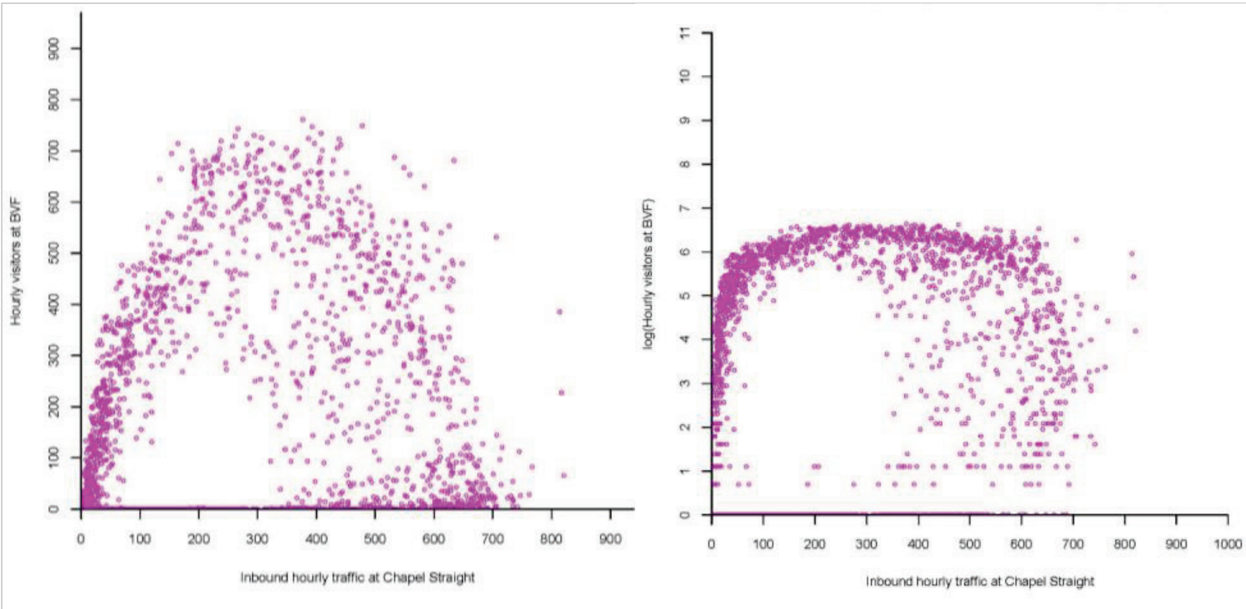

Figure 25. Hourly visitor use at Bridalveil Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 3-hr "reverse lag."

- **Regression modeling results with hourly traffic volume and visitor use data:** Table 6 and Table 7 report results for linear and non-linear regression models, with hourly visitor use at Bridalveil Fall as the dependent variable and Chapel Straight inbound traffic volume (including time of day, day of week, holiday, and seasonality effects) as the independent variable (NOTE: The results for the preferred model include standardized coefficients and p-values). The models were specified with a 2-hour lag between hourly inbound vehicle traffic at Chapel Straight and hourly visitor use at Bridalveil Fall. ***The results suggest the linear model with a 2-hour lag fits the data best.***

Table 6. Linear model results for Bridalveil Fall, 2-hour lag.

	Dependent variable: Hourly visitor use at Bridalveil Fall; 2-hour lag				
	Unstandardized coefficients			Standardized coefficients	p-value
Coefficients:	Estimate	C.I.(95%): Lower	C.I. (95%): Upper		
Intercept	-	-	-	-	-
Chapel.St.	0.505	0.504	0.505	.600	<0.001
Morning2.6.to.10	-16.886	-17.029	-16.743	-.028	<0.001
Afternoon1.12.to.15	137.451	137.241	137.662	.203	<0.001
Chapel.St. * Saturday	0.040	0.040	0.041	.020	<0.001
Chapel.St. * June	0.219	0.219	0.220	.112	<0.001
Chapel.St. * July	0.214	0.214	0.215	.158	<0.001
Chapel.St. * August	0.186	0.185	0.186	.124	<0.001
Chapel.St. * Independence.Day	0.102	0.100	0.104	.011	0.028
Adjusted R-squared	0.945				
Sample size	2207				
Comment	Preferred model				

Table 7. Log transformed model results for Bridalveil Fall, 2-hour lag.

	Dependent variable: log(Hourly visitor use at Bridalveil Fall); 2-hour lag				
Coefficients:	Estimate	Std. Error	t value	C.I.(95%): Lower	C.I. (95%): Upper
Intercept	0.145	0.030	4.93	0.1441	0.1465
Chapel.St.	0.013	0.000	59.58	0.0125	0.0126
Morning2.6.to.10	1.125	0.049	23.07	1.1225	1.1265
Afternoon1.12.to.15	-0.350	0.069	-5.04	-0.3526	-0.3468
Chapel.St. * Saturday	-0.001	0.000	-5.08	-0.0008	-0.0008
Chapel.St. * June	-0.001	0.000	-5.23	-0.0012	-0.0011
Chapel.St. * July	-0.001	0.000	-7.07	-0.0014	-0.0014
Chapel.St. * August	-0.001	0.000	-3.83	-0.0008	-0.0008
Chapel.St. * Independence.Day	0.002	0.001	3.83	0.0024	0.0025
Adjusted R-squared	0.891				
Sample size	2207				
Comment					

- **Scatterplot and regression modeling results with daily traffic volume and visitor use data:** Figure 26 presents a scatterplot of daily inbound vehicle traffic at Chapel Straight and visitor use at Bridalveil Fall, and Table 8 reports regression modeling results, with daily visitor use at Bridalveil Fall as the dependent variable and Chapel Straight inbound traffic volume as the independent variable for the period June 16 through September 15, 2011. ***The scatterplot and regression results suggest there is a very strong, positive relationship between daily inbound vehicle traffic at Chapel Straight and daily visitor use at Bridalveil Fall.***

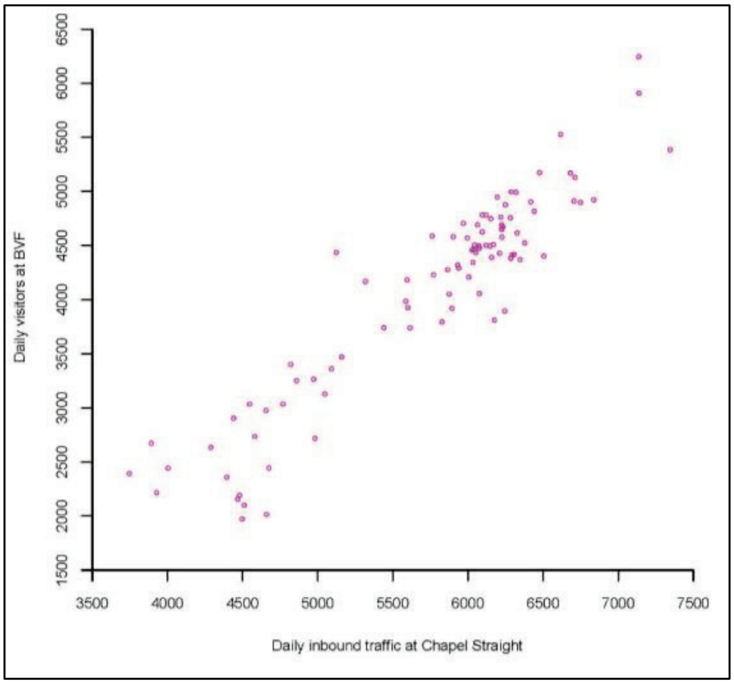

Figure 26. Daily visitor use at Bridalveil Fall and inbound traffic at Chapel Straight, summer 2011.

Table 8.Linear model results for Bridalveil Fall, daily traffic volume and visitor use.

	Dependent variable: Daily visitor use at Bridalveil Fall			
Coefficients:	**Estimate**	**Std. Error**	**t value**	**p-value**
Intercept	-	-	-	-
Daily traffic volume at the Chapel.St.	0.717101	0.008173	87.75	<0.001
Adjusted R-squared	0.9882			

Trail to Vernal Fall

- **Hourly Visitor Use, by Time of Day and Day of Week:** Figure 27 through Figure 31 present line graphs of average hourly visitor use on the Trail to Vernal Fall during summer 2011, by time of day and day of week for May, June, July, August, and September (ending September 15), respectively. The graphs suggest during summer 2011:
  - Visitor use was highest in May and lowest in September.
  - Saturdays were the most popular day to visit the Trail to Vernal Fall, throughout the summer.
  - In May and September, weekends were notably busier than weekdays; during July and August, there was not a distinct difference between weekend and weekday use levels.
  - The peak period of visitor use on the Trail to Vernal Fall generally occurred during the same time of the day (early afternoon), regardless of the month of the summer or day of week.

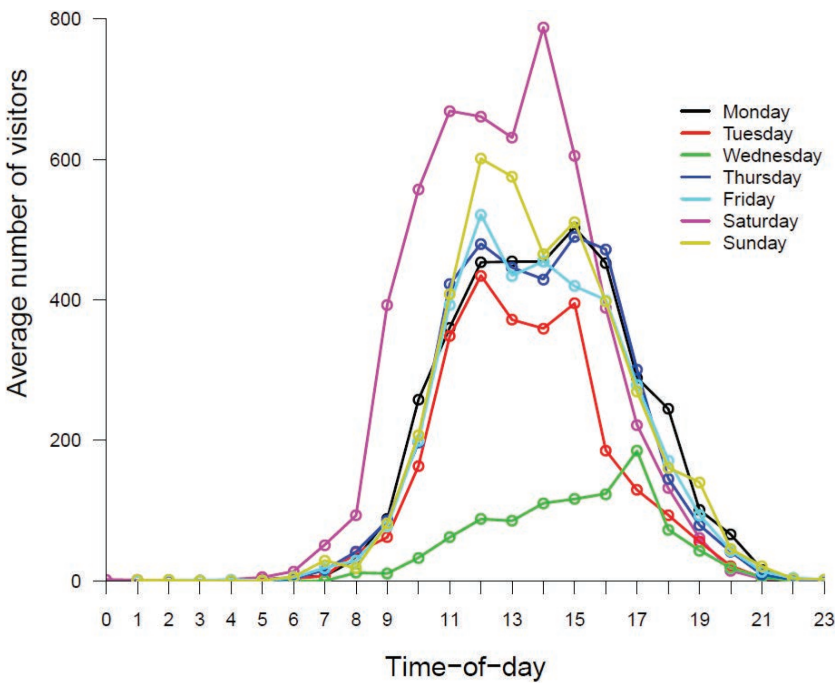

Figure 27. Average hourly visitor use on the Trail to Vernal Fall, by time of day and day of week -May, 2011.

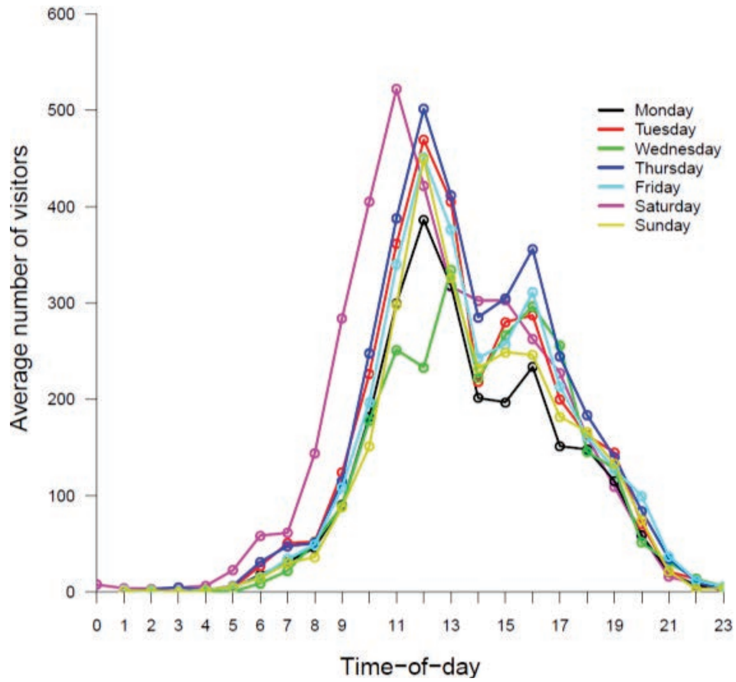

Figure 28. Average hourly visitor use on the Trail to Vernal Fall, by time of day and day of week -June, 2011.

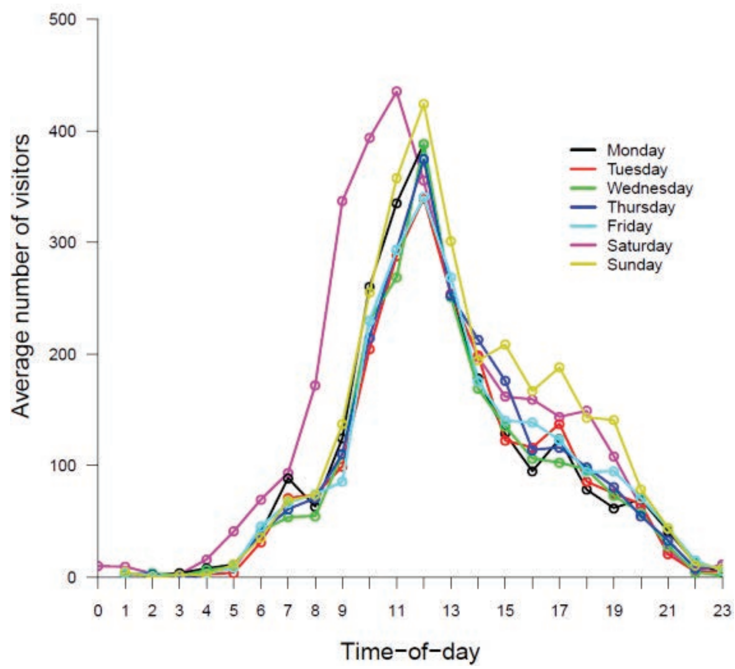

Figure 29. Average hourly visitor use on the Trail to Vernal Fall, by time of day and day of week -July, 2011.

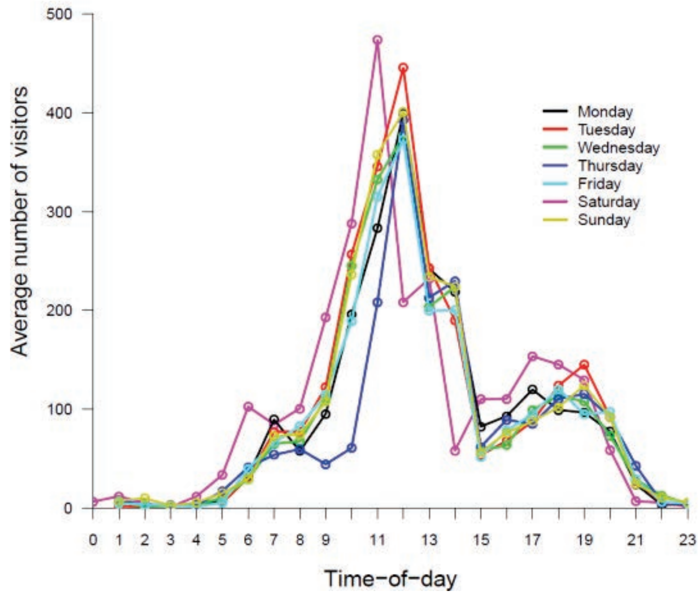

Figure 30. Average hourly visitor use on the Trail to Vernal Fall, by time of day and day of week -August, 2011.

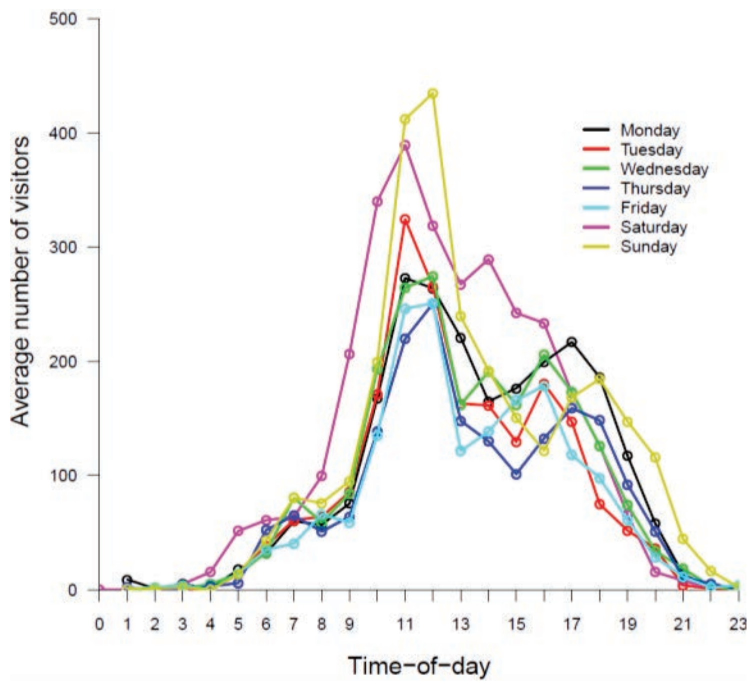

Figure 31. Average hourly visitor use on the Trail to Vernal Fall, by time of day and day of week -September, 2011.

- **Daily Visitor Use, by Day of Week:** Figure 32 presents a bar chart of average daily visitor use on the Trail to Vernal Fall during summer 2011, by day of week for May, June, July, August, and September. Conclusions about visitor use on the Trail to Vernal Fall during summer 2011 based on the data in Figure 32 are consistent with those based on Figure 27 through Figure 31, including:
    - Visitor use was generally highest in May and lowest in September.
    - Saturdays were the most popular day to visit the Trail to Vernal Fall, throughout the summer.

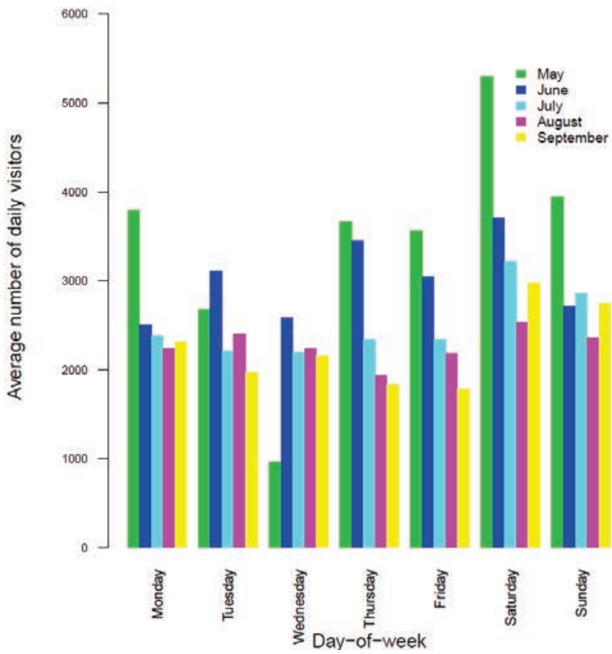

Figure 32. Average daily visitor use on the Trail to Vernal Fall, by day of week –May-September, 2011.

- **Daily Visitor Use on the Trail to Vernal Fall and Inbound Vehicle Traffic at Chapel Straight:** Figure 33 presents line graphs of daily visitor use (number of people) on the Trail to Vernal Fall and daily inbound traffic volumes (number of vehicles) on Southside Drive at Chapel Straight for the period from May 17 through September 15, 2011. The line graphs suggest:
    - There is a positive correlation between inbound vehicle traffic at Chapel Straight and visitor use on the trail to Vernal Fall, and this statistical relationship persists throughout the summer.

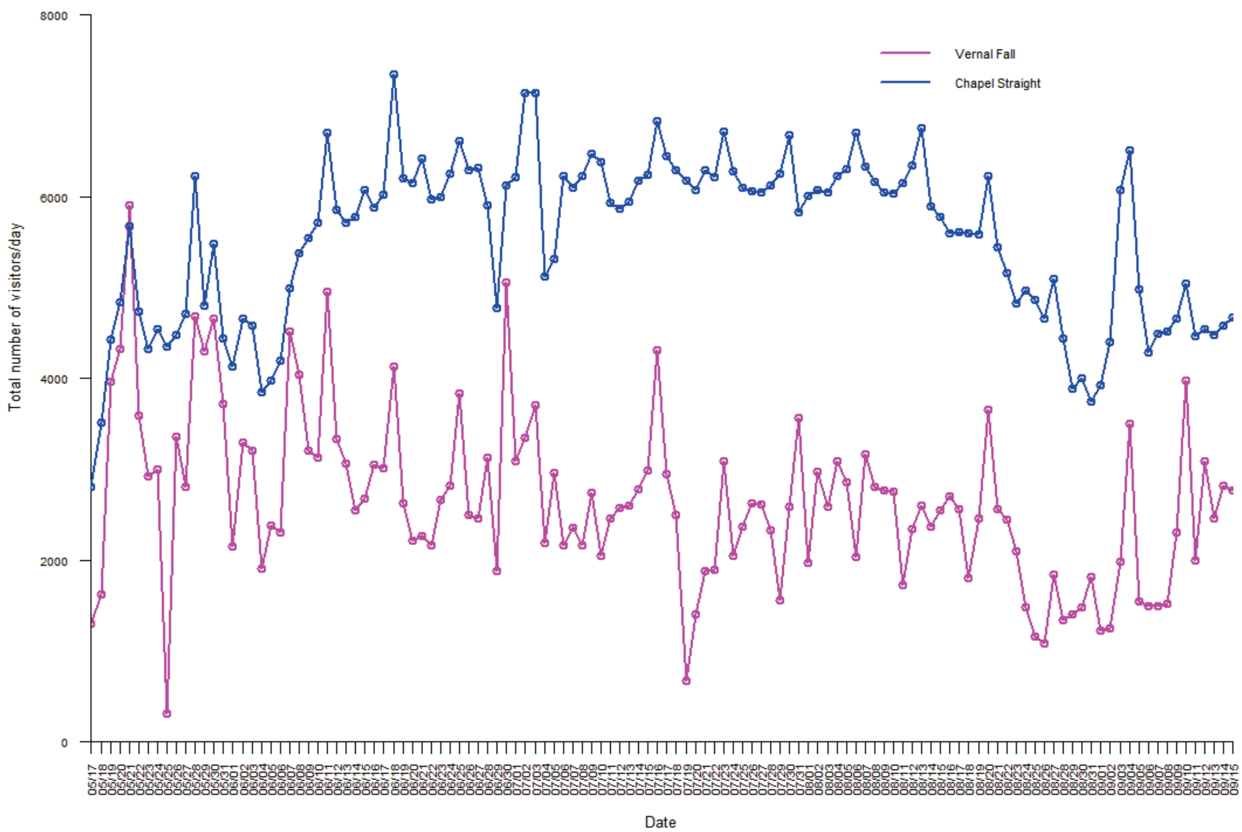

Figure 33. Daily visitor use (number of people) on the Trail to Vernal Fall and inbound traffic (number of vehicles) at Chapel Straight, summer 2011.

- **Hourly Visitor Use on the Trail to Vernal Fall and Inbound Vehicle Traffic at Chapel Straight, with Lag Times:** Figure 34 through Figure 38 present scatterplots of hourly inbound vehicle traffic at Chapel Straight and visitor use on the Trail to Vernal Fall (linear and log transformed), with lag times ranging from no lag to a 4-hour lag between inbound vehicle traffic at Chapel Straight and hourly visitor use on the Trail to Vernal Fall. The scatterplots suggest the correlation is highest between inbound vehicle traffic at Chapel Straight and visitor use on the Trail to Vernal Fall with a 1-hour or 2-hour lag, and that a linear or non-linear specification may be suitable for modeling the relationship.

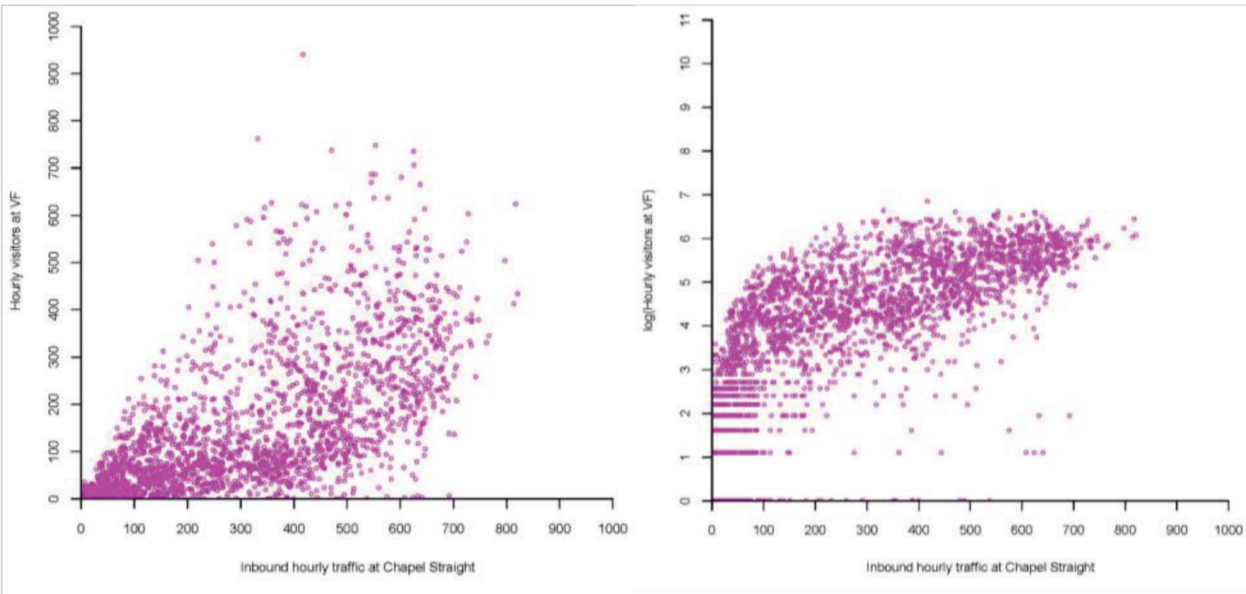

Figure 34. Hourly visitor use on the Trail to Vernal Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – no lag.

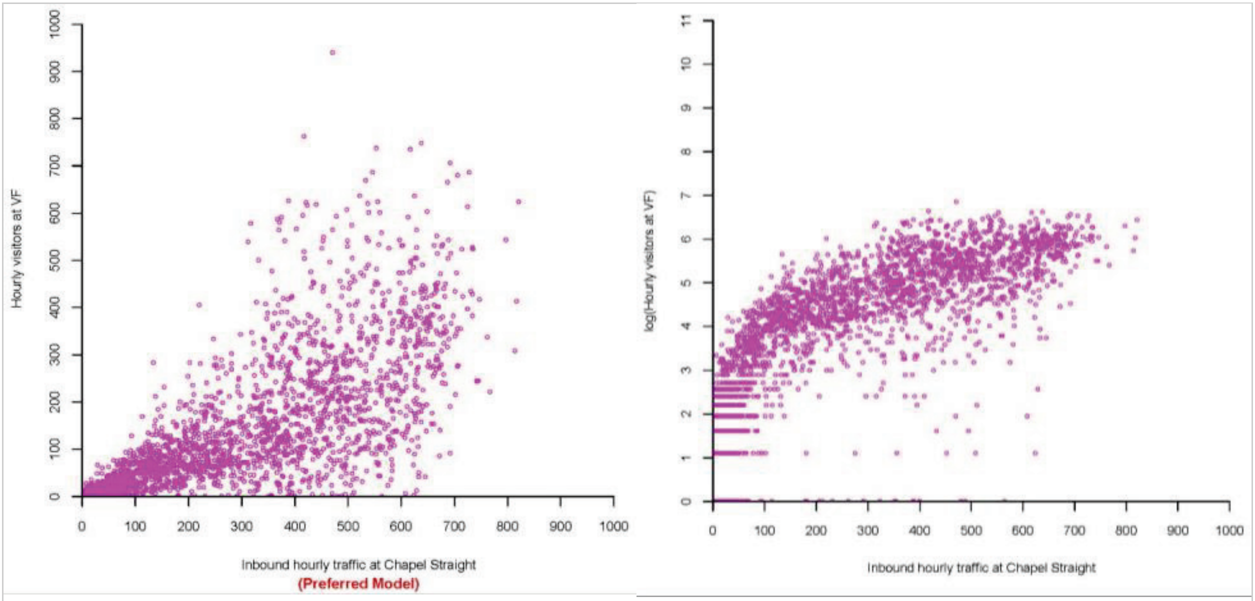

Figure 35. Hourly visitor use on the Trail to Vernal Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 1-hr lag.

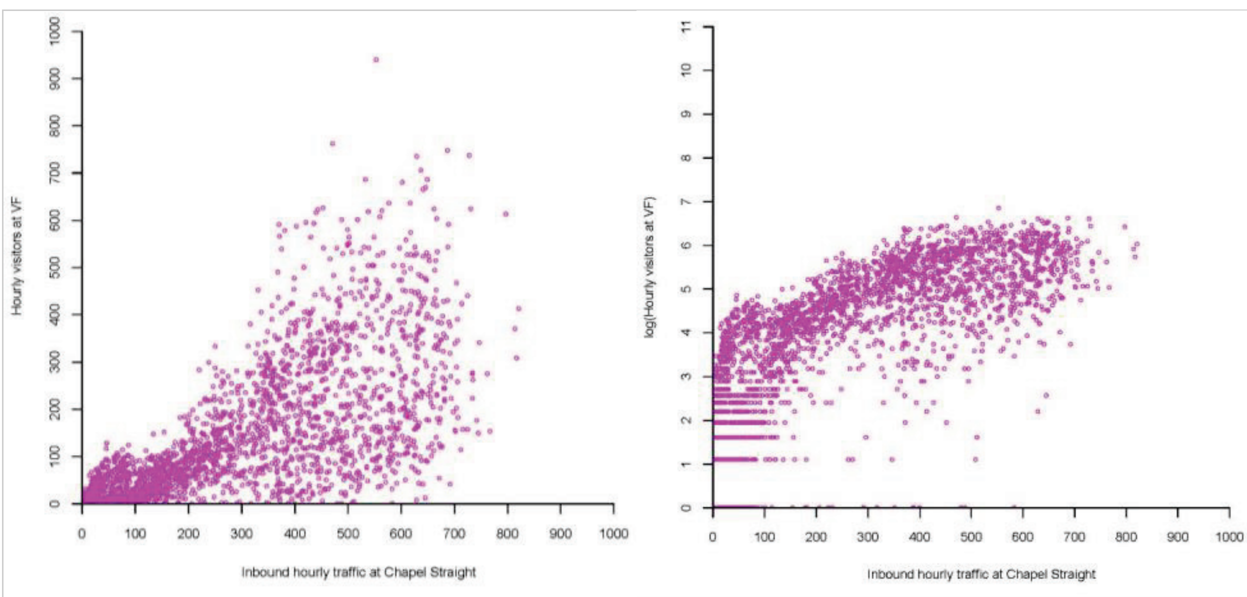

Figure 36. Hourly visitor use on the Trail to Vernal Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 2-hr lag.

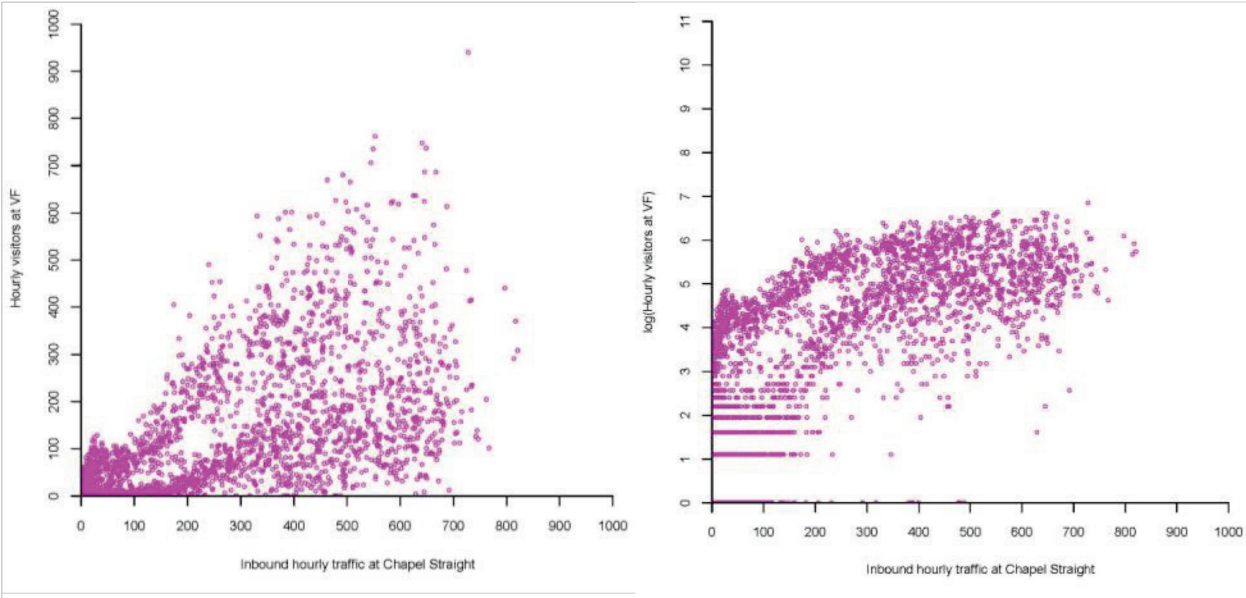

Figure 37. Hourly visitor use on the Trail to Vernal Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 3-hr lag.

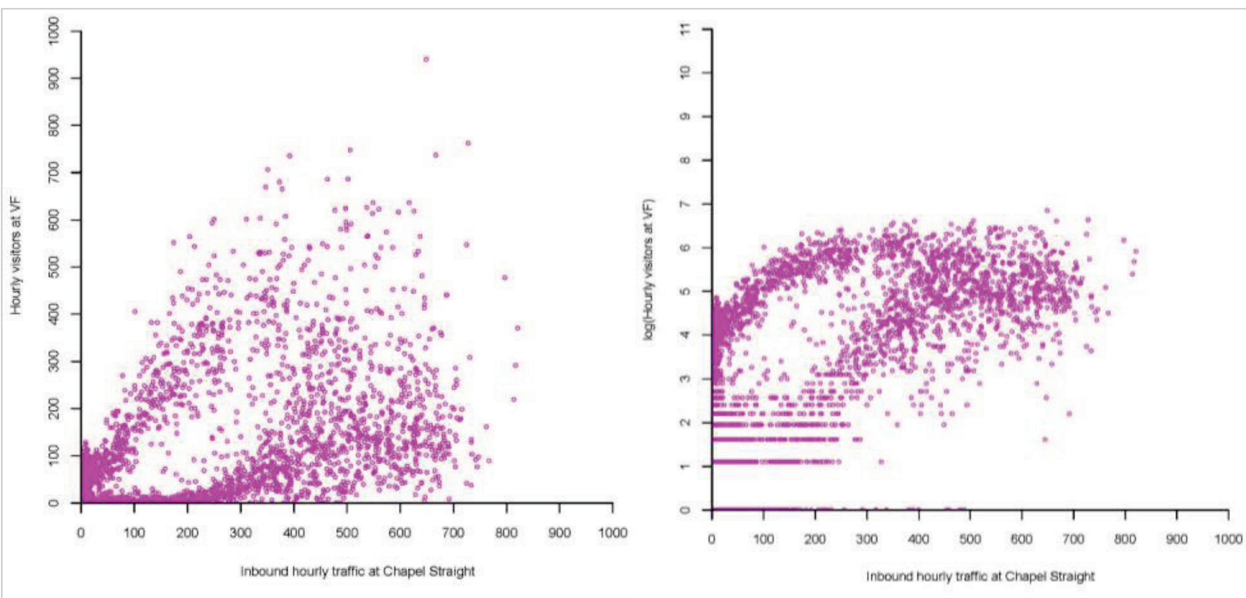

Figure 38. Hourly visitor use on the Trail to Vernal Fall (linear and log transformed) and inbound traffic at Chapel Straight, summer 2011 – 4-hr lag.

- **Regression modeling results with hourly traffic volume and visitor use data:** Table 9 through Table 12 report results for linear and non-linear regression models, with hourly visitor use on the Trail to Vernal Fall as the dependent variable and Chapel Straight inbound traffic volume (including time of day, day of week, holiday, and seasonality effects) as the independent variable (NOTE: The results for the preferred model include standardized coefficients and p-values). The results include models with 1-hour and 2-hour lags between hourly inbound vehicle traffic at Chapel Straight and hourly visitor use on the Trail to Vernal Fall. ***The results suggest the linear model with a 1-hour lag fits the data best.***

Table 9. Linear model results for the Trail to Vernal Fall, 1-hour lag.

	Dependent variable: Hourly visitor use at Vernal Fall; 1-hour lag				
	Unstandardized coefficients			Standardized coefficients	p-value
Coefficients:	**Estimate**	**C.I.(95%): Lower**	**C.I. (95%): Upper**		
Intercept	-	-	-	-	-
Chapel.St.	0.422	0.422	0.423	0.750	<0.001
Morning2.6.to.10	-22.795	-22.927	-22.663	-0.058	<0.001
Chapel.St. * Saturday	0.066	0.065	0.066	0.049	<0.001
Chapel.St. * Sunday	0.024	0.023	0.024	0.016	0.069
Chapel.St. * May	0.387	0.386	0.388	0.204	<0.001
Chapel.St. * June	0.137	0.136	0.137	0.122	<0.001
Chapel.St. * Memorial.Day	0.096	0.094	0.098	0.015	0.071
Adjusted R-squared	0.807				
Sample size	2928				
Comment	Preferred model				

Table 10. Log transformed model results for the Trail to Vernal Fall, 1-hour lag.

	Dependent variable: log(Hourly visitor use on the Trail to Vernal Fall); 1-hour lag				
Coefficients:	Estimate	Std. Error	t value	C.I.(95%): Lower	C.I. (95%): Upper
Intercept	1.657	0.033	50.568	1.6558	1.6582
Chapel.St.	0.007	0.000	54.653	0.0070	0.0070
Morning2.6.to.10	0.482	0.056	8.579	0.4797	0.4837
Chapel.St. * Saturday	0.000	0.000	-1.345	-0.0003	-0.0002
Chapel.St. * Sunday	0.000	0.000	-0.289	-0.0001	0.0000
Chapel.St. * May	0.001	0.000	5.611	0.0015	0.0015
Chapel.St. * June	0.001	0.000	4.237	0.0007	0.0007
Chapel.St. * Memorial.Day	0.0003	0.0008	0.3550	0.0003	0.0003
Adjusted R-squared	0.651				
Sample size	2928				

Table 11. Linear model results for the Trail to Vernal Fall, 2-hour lag.

	Dependent variable: Hourly visitor use on the Trail to Vernal Fall; 2-hour lag				
Coefficients:	Estimate	Std. Error	t value	C.I.(95%): Lower	C.I. (95%): Upper
Intercept	-	-	-	-	-
Chapel.St.	0.370667	0.006889	53.808	0.3704	0.3709
Morning2.6.to.10	38.462388	3.47203	11.078	38.3366	38.5882
Chapel.St. * Saturday	0.07692	0.012635	6.088	0.0765	0.0774
Chapel.St. * Sunday	0.032886	0.013356	2.462	0.0324	0.0334
Chapel.St. * May	0.408291	0.017628	23.162	0.4077	0.4089
Chapel.St. * June	0.150155	0.010975	13.682	0.1498	0.1506
Chapel.St. * Memorial.Day	0.120198	0.054556	2.203	0.1182	0.1222
Adjusted R-squared	0.797				
Sample size	2928				
Comment					

Table 12. Log transformed model results for the Trail to Vernal Fall, 2-hour lag.

	Dependent variable: log(Hourly visitor use on the Trail to Vernal Fall); 2-hour lag				
Coefficients:	Estimate	Std. Error	t value	C.I.(95%): Lower	C.I. (95%): Upper
Intercept	1.462	0.03194	45.786	1.4608	1.4632
Chapel.St.	0.006926	0.0001167	59.352	0.0069	0.0069
Morning2.6.to.10	1.39	0.05091	27.306	1.3882	1.3918
Chapel.St. * Saturday	-0.0002448	0.0001757	-1.394	-0.0003	-0.0002
Chapel.St. * Sunday	-0.00003951	0.0001855	-0.213	0.0000	0.0000
Chapel.St. * May	0.00168	0.0002451	6.855	0.0017	0.0017
Chapel.St. * June	0.0008012	0.0001524	5.258	0.0008	0.0008
Chapel.St. * Memorial.Day	0.0003148	0.0007576	0.415	0.0003	0.0003
Adjusted R-squared	0.694				
Sample size	2928				
Comment					

- **Scatterplot and regression modeling results with daily traffic volume and visitor use data:** Figure 39 presents a scatterplot of daily inbound vehicle traffic at Chapel Straight and visitor use on the Trail to Vernal Fall during the periods of the year when the relationship between them is most pronounced (i.e., May 17 through June 6, and September 5 through October 9, 2011), and Table 13 reports regression modeling results, with daily visitor use on the Trail to Vernal Fall as the dependent variable and Chapel Straight inbound traffic volume as the independent variable. ***The scatterplot and regression results suggest there is a very strong, positive relationship between daily inbound vehicle traffic at Chapel Straight and daily visitor use on the Trail to Vernal Fall.***

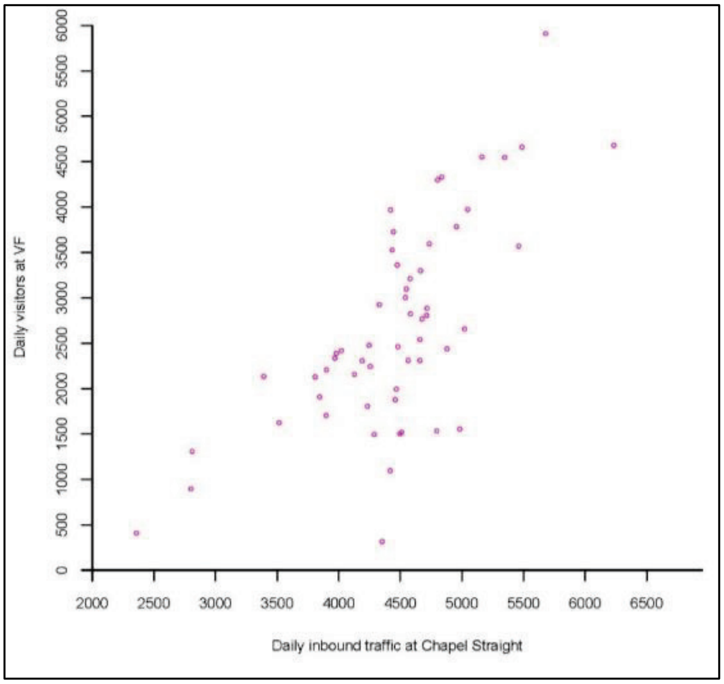

Figure 39. Daily visitor use on the Trail to Vernal Fall and inbound traffic at Chapel Straight, summer 2011.

- **Regression modeling results with daily traffic volume and visitor use data:** Table 13 reports regression modeling results, with daily visitor use on the Trail to Vernal Fall as the dependent variable and Chapel Straight inbound traffic volume as the independent variable. ***The results suggest there is a strong, positive relationship between daily inbound vehicle traffic at Chapel Straight and daily visitor use on the Trail to Vernal Fall.***

Table 13.Linear model results for the Trail to Vernal Fall, daily traffic volume and visitor use.

	Dependent variable: Daily visitor use at Vernal Fall			
Coefficients:	**Estimate**	**Std. Error**	**t value**	**p-value**
Intercept	-	-	-	-
Daily traffic volume at the Chapel.St.	0.6120	0.0268	22.820	<0.001
Adjusted R-squared	0.9027			

RESOURCE SYSTEMS GROUP, INC.

MRP Modeling Tasks 5 & 8 Deliverable

Technical Memo
Attraction Site Visitor Density Estimates for Selected Alternatives in the Merced River Plan

January 15, 2014

Prepared for

U.S. Department of the Interior
National Park Service
Yosemite National Park

Submitted by

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Introduction

This technical memorandum reports results of regression and computer simulation modeling to estimate visitor densities at three attraction sites in Yosemite Valley (Lower Yosemite Falls, Bridalveil Fall, and the Trail to Vernal Fall) corresponding to three alternatives in the Merced River Plan (MRP). The visitor density estimates are derived from computer simulation models of visitor use at each of the attraction sites, and based on the expected daily inbound vehicle traffic at Chapel Straight and corresponding daily visitor use at the attraction sites for each alternative included in the analysis.

More specifically, the visitor density estimates reported in this technical memorandum for each attraction site and MRP Alternative were derived based on the following modeling steps:

1. For each alternative, traffic micro-simulation model results from a previous study were used to estimate daily inbound vehicle traffic at Chapel Straight; it should be noted, this step was completed by the National Park Service (NPS).

2. For each alternative, regression models developed in Task 4 of this project were used to estimate daily visitor use at Lower Yosemite Falls, Bridalveil Fall, and the Trail to Vernal Fall corresponding to daily inbound vehicle traffic estimated in Step 1.

3. For each alternative, computer simulation models of attraction site visitor use were used to estimate visitor densities at Lower Yosemite Falls, Bridalveil Fall, and the Trail to Vernal Fall during the peak six-hour period of the day, based on daily visitor use levels estimated in Step 2.

For example, Figure 1 illustrates conceptually the modeling process used in this study to estimate visitor density at the base of Yosemite Falls for each alternative.

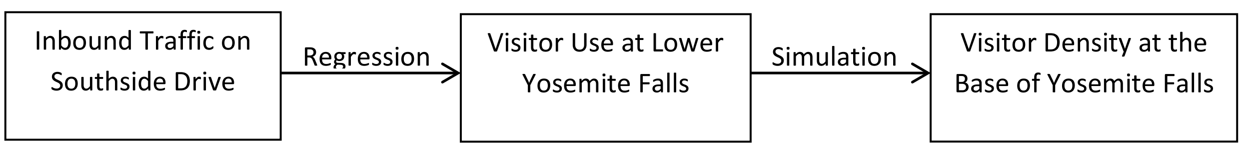

Figure 1. Conceptual model of modeling process to estimate visitor densities for MRP Alternatives.

The results of these modeling steps are reported in this technical memorandum and include:

1. Estimated daily inbound vehicle traffic at Chapel Straight, by alternative.
2. Estimated daily visitor use at each attraction site, by alternative.
3. Estimated visitor densities at key locations within each attraction site, by alternative.

Chapel Straight Daily Inbound Vehicle Traffic Volumes

As noted, for each alternative included in this analysis, NPS estimated daily inbound vehicle traffic at Chapel Straight based on traffic micro-simulation model results from a previous study. The resultant estimates of daily inbound vehicle traffic at Chapel Straight are reported in Table 1, and range from a low of roughly 4,500 vehicles per day for Alternative 3 to a high of just under 7,500 vehicles per day for Alternative 6. The estimate of daily inbound traffic at Chapel Straight for the Preferred Alternative is approximately 6,500 vehicles per day.

Table 1. Estimated daily inbound vehicle traffic at Chapel Straight, by alternative.

	MRP Alternative 3	MRP Alternative 5	MRP Alternative 6
Daily inbound vehicles	4,486	6,600	7,330

Lower Yosemite Falls

Daily Visitor Use

A regression model was estimated in Task 4 of this project correlating daily inbound vehicle traffic at Chapel Straight and daily visitor use at Lower Yosemite Falls. The following equation was derived from the regression model and used to estimate daily visitor use at Lower Yosemite Falls for each of the MRP Alternatives included in this analysis:

Equation 1: $VU_{LYF} = 1.315 * VT_{CS}$

where,

VU_{LYF} = Daily visitor use (people) at Lower Yosemite Falls
VT_{CS} = Daily inbound traffic (vehicles) at Chapel Straight
1.315 = Regression model parameter estimate

The resultant estimates of daily visitor use at Lower Yosemite Falls are reported in Table 2, and range from a low of roughly 5,700 people per day for Alternative 3 to a high of just under 9,500 people per day for Alternative 6. The estimate of daily visitor use at Lower Yosemite Falls for the Preferred Alternative is approximately 8,500 people per day.

Table 2. Estimated daily visitor use at Lower Yosemite Falls, by alternative – 7:00 AM to 8:00 PM.

	MRP Alternative 3	MRP Alternative 5	MRP Alternative 6
Daily visitor use	5,713	8,405	9,335

Visitor Densities

For each alternative, simulations were conducted of the corresponding daily visitor use at Lower Yosemite Falls to estimate visitor densities at the base of Lower Yosemite Falls. The simulation modeling results for each alternative are reported in Table 3 (Note, visitor densities were also estimated for the Trail to Lower Yosemite Falls and results are included in Appendix A). In addition, Table 3 includes visitor density estimates for existing conditions derived in Task 3 of this project, for the purpose of comparison.

Table 3. Visitor density estimates under existing conditions and MRP Alternatives – base of Lower Yosemite Falls. [a]

Site	Existing Conditions 7,838 [b] (ft^2/person)	MRP Alternative 3 5,713 [b] (ft^2/person)	MRP Alternative 5 8,405 [b] (ft^2/person)	MRP Alternative 6 9,335 [b] (ft^2/person)
Lower Yosemite Falls Platform – Photo Simulation Area	35 (±2.5)	48 (±0.2)	33 (±0.1)	29 (±0.1)
Lower Yosemite Falls Platform – Whole Platform Area	35 (±2.5)	49 (±0.2)	33 (±0.1)	30 (±0.1)

[a] Average visitor density for the peak 6-hour period, 11:00 AM – 5:00 PM.
[b] Average daily visitor use from 7:00 AM to 8:00 PM.

Table 4 reports visitor survey-based density levels for the base of Lower Yosemite Falls, which provide one basis for evaluating the visitor density estimates in Table 3. The results in Table 3 suggest none of the MRP Alternatives included in the analysis would result in visitor densities at the base of Lower Yosemite Falls that violate the “Acceptable” or “Displacement” density levels in Table 4.

Table 4. Visitor survey-based density levels – base of Lower Yosemite Falls.

Site	**"Acceptable" Density Level [a]** (ft²/person)	**"Displacement" Density Level [a]** (ft²/person)
Lower Yosemite Falls Platform – Photo Simulation Area	20	13
Lower Yosemite Falls Platform – Whole Platform Area	20	13

[a] Derived from results of visitor surveys conducted at Lower Yosemite Falls in 1998 and 2010.

Figure 2 and Figure 3 display computer simulation model estimates of mean visitor densities at the base of Lower Yosemite Falls, by time of day, for existing conditions and each of the three MRP Alternatives included in the analysis. It should be noted, visitor densities are expressed as square feet per person, thus, lower values on the y-axes correspond to higher visitor densities. The horizontal lines in Figure 2 and Figure 3 correspond to the visitor survey-based density levels in Table 4. Finally, the grey shaded area buffering the existing conditions line in Figure 2 and Figure 3 represents the 95% confidence interval for the visitor density estimates under existing conditions.

The graphical results in Figure 2 and Figure 3 support the same general conclusions about the MRP Alternatives as the tabular results in Table 3. In particular, the graphical results suggest visitor densities at the base of Lower Yosemite Falls would not violate the visitor survey-based density levels in Table 4 under any of the MRP Alternatives included in the analysis. However, the graphical results in Figure 2 and Figure 3 suggest under Alternatives 5 and 6 visitor densities would approach the "Acceptable" density levels during the peak period of the day.

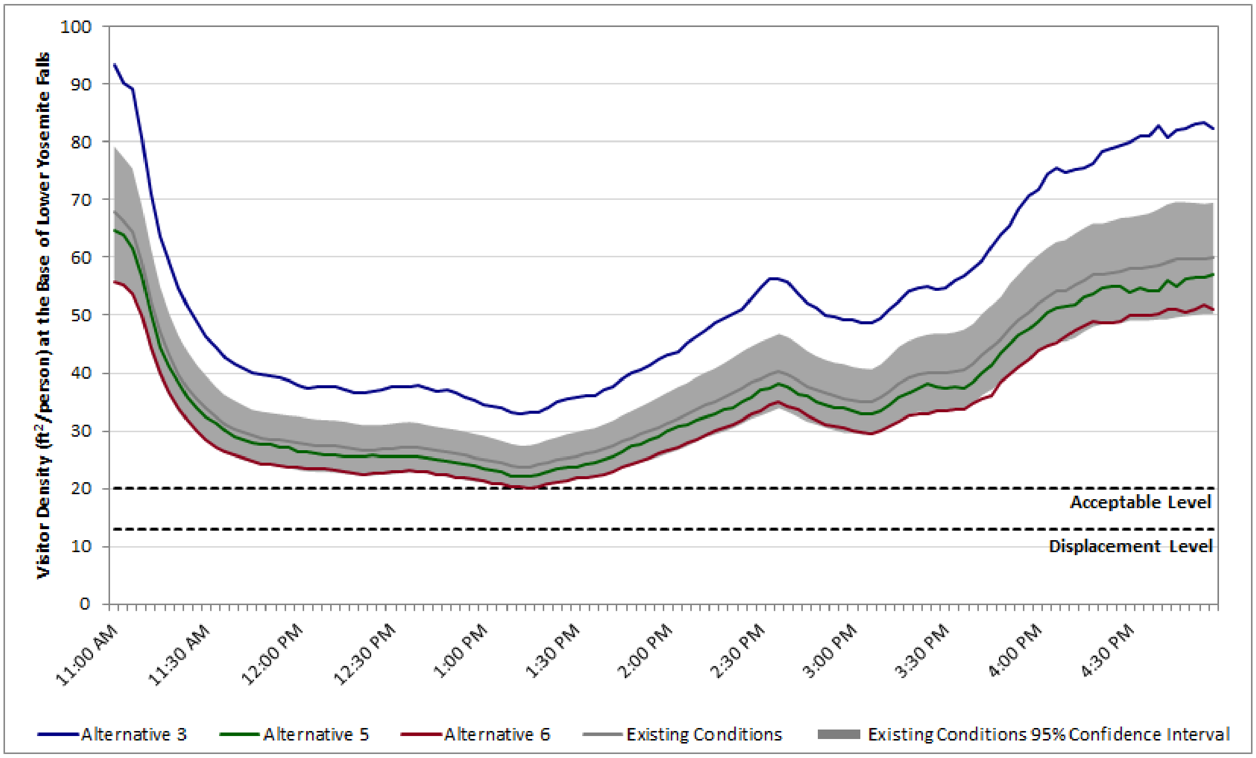

Figure 2. Visitor density estimates under existing conditions and MRP Alternatives – base of Lower Yosemite Falls (Photo Simulation Area).

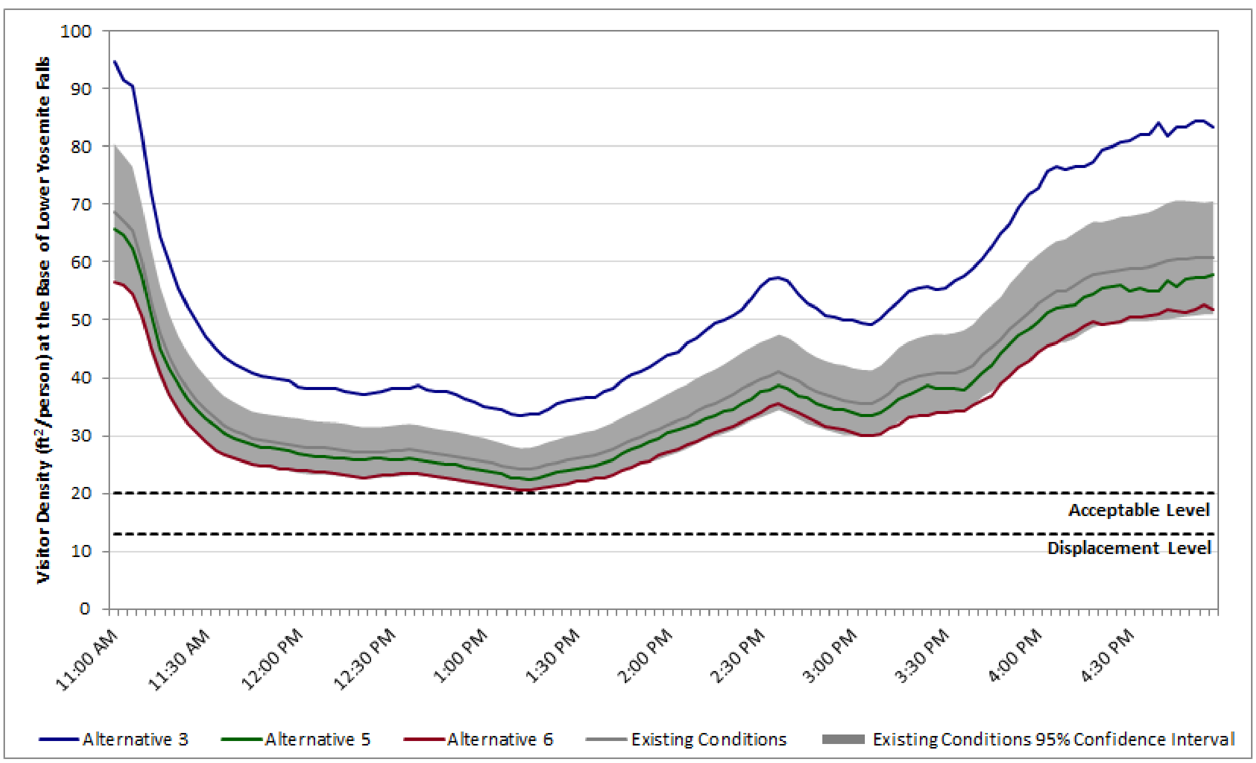

Figure 3. Visitor density estimates under existing conditions and MRP Alternatives – base of Lower Yosemite Falls (Whole Platform Area).

Bridalveil Fall

Daily Visitor Use

A regression model was estimated in Task 4 of this project correlating daily inbound vehicle traffic at Chapel Straight and daily visitor use at Bridalveil Fall. The following equation was derived from the regression model and used to estimate daily visitor use at Bridalveil Fall for each of the MRP Alternatives included in this analysis:

Equation 2: $VU_{BVF} = 0.717 * VT_{CS}$

where,

VU_{BVF} = Daily visitor use (people) at Bridalveil Fall
VT_{CS} = Daily inbound traffic (vehicles) at Chapel Straight
0.717 = Regression model parameter estimate

The resultant estimates of daily visitor use at Bridalveil Fall are reported in Table 5, and range from a low of 3,200 people per day for Alternative 3 to a high of just over 5,200 people per day for Alternative 6. The estimate of daily visitor use at Bridalveil Fall for the Preferred Alternative is approximately 4,700 people per day.

Table 5. Estimated daily visitor use at Bridalveil Fall, by alternative – 7:00 AM to 8:00 PM.

	MRP Alternative 3	MRP Alternative 5	MRP Alternative 6
Daily visitor use	3,200	4,708	5,228

Visitor Densities

For each alternative, simulations were conducted of the corresponding daily visitor use at Bridalveil Fall to estimate visitor densities at the base of Bridalveil Fall. The simulation modeling results for each alternative are reported in Table 6 (Note, visitor densities were also estimated for the Trail to Bridalveil Fall and results are included in Appendix A). In addition, Table 6 includes visitor density estimates for existing conditions derived in Task 3 of this project, for the purpose of comparison.

Table 6. Visitor density estimates under existing conditions and MRP Alternatives – base of Bridalveil Fall. [a]

Site	Existing Conditions 4,853 [b] (ft^2/person)	MRP Alternative 3 3,200 [b] (ft^2/person)	MRP Alternative 5 4,708 [b] (ft^2/person)	MRP Alternative 6 5,228 [b] (ft^2/person)
Bridalveil Fall Platform	11 (±0.8)	17 (±0.1)	11 (±0.1)	10 (±0.1)

[a] Average visitor density for the peak 6-hour period, 10:00 AM – 4:00 PM.
[b] Average daily visitor use between 7:00 AM and 8:00 PM.

Table 7 reports visitor survey-based density levels for the base of Bridalveil Fall, which provide one basis for evaluating the visitor density estimates in Table 6. The results in Table 6 suggest all three of the MRP Alternatives included in the analysis would result in visitor densities at the base of Bridalveil Fall that violate the “Acceptable” density level in Table 7, and only Alternative 3 would not violate the “Displacement” density level for the base of Bridalveil Fall.

Table 7. Visitor survey-based density levels – base of Bridalveil Fall.

Site	"Acceptable" Density Level [a] (ft²/person)	"Displacement" Density Level [a] (ft²/person)
Bridalveil Fall Platform	20	14

[a] Derived from results of visitor surveys conducted at Bridalveil Fall in 1999.

Figure 4 displays computer simulation model estimates of mean visitor densities at the base of Bridalveil Fall, by time of day, for existing conditions and each of the three MRP Alternatives included in the analysis. It should be noted, visitor densities are expressed as square feet per person, thus, lower values on the y-axes correspond to higher visitor densities. The horizontal lines in Figure 4 correspond to the visitor survey-based density levels in Table 7. Finally, the grey shaded area buffering the existing conditions line in Figure 4 represents the 95% confidence interval for the visitor density estimates under existing conditions.

The graphical results in Figure 4 support the same general conclusions about the MRP Alternatives as the tabular results in Table 6. In particular, the results in Figure 4 suggest that for all three MRP Alternatives included in the analysis, visitor densities at the base of Bridalveil Fall would violate the "Acceptable" density levels nearly the entire time during the peak period of the day. Moreover, Alternatives 5 and 6 would result in visitor densities at the base of Bridalveil Fall that violate the "Displacement" density level most of the time during peak hours of the day (Figure 4).

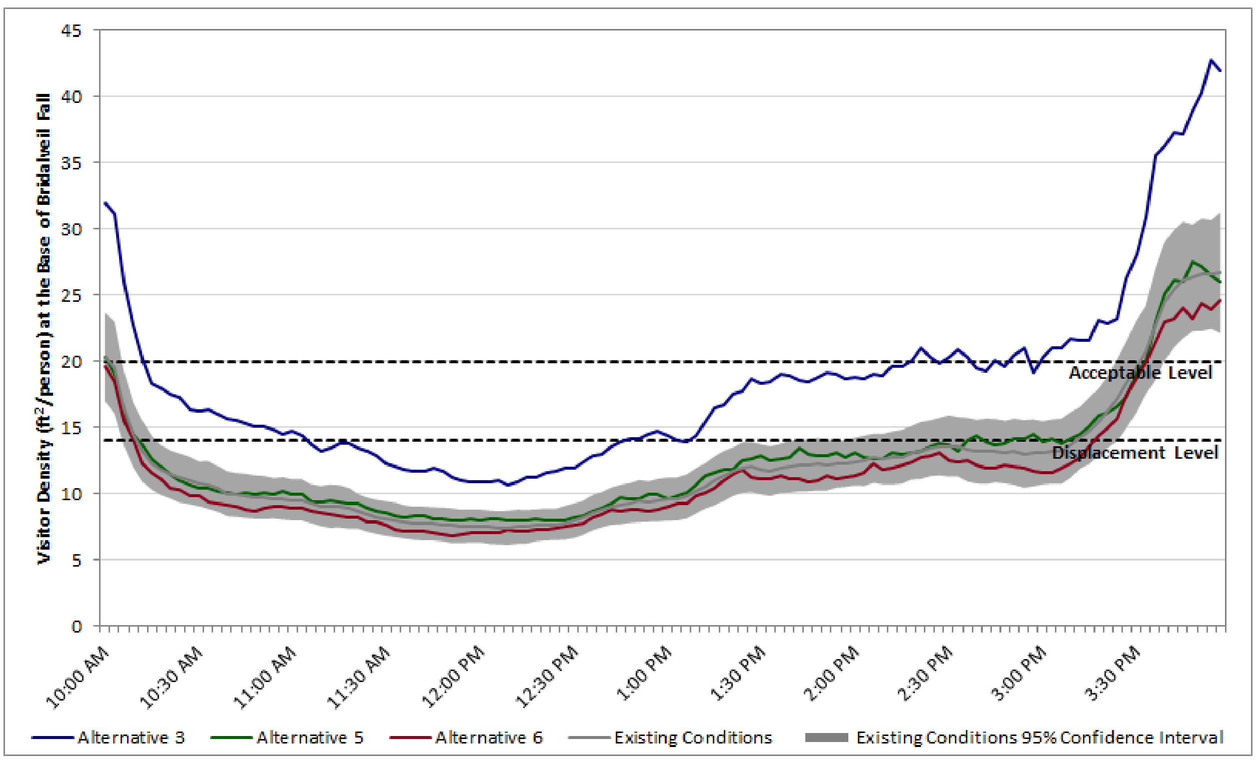

Figure 4. Visitor density estimates under existing conditions and MRP Alternatives – base of Bridalveil Fall.

Trail to Vernal Fall

Daily Visitor Use

A regression model was estimated in Task 4 of this project correlating daily inbound vehicle traffic at Chapel Straight and daily visitor use on the Trail to Vernal Fall. The following equation was derived from the regression model and used to estimate daily visitor use on the Trail to Vernal Fall for each of the MRP Alternatives included in this analysis:

Equation 3: $VU_{TVF} = 0.612 * VT_{CS}$

where,

VU_{TVF} = Daily visitor use (people) on the Trail to Vernal Fall
VT_{CS} = Daily inbound traffic (vehicles) at Chapel Straight
0.612 = Regression model parameter estimate

The resultant estimates of daily visitor use on the Trail to Vernal Fall are reported in Table 8, and range from a low of just over 2,500 people per day for Alternative 3 to a high of just over 4,000 people per day for Alternative 6. The estimate of daily visitor use on the Trail to Vernal Fall for the Preferred Alternative is approximately 3,700 people per day.

Table 8. Estimated daily visitor use on the Trail to Vernal Fall, by alternative – 7:00 AM to 8:00 PM.

	MRP Alternative 3	MRP Alternative 5	MRP Alternative 6
Daily visitor use	2,559	3,765	4,182

Visitor Densities

For each alternative, simulations were conducted of the corresponding daily visitor use on the Trail to Vernal Fall to estimate visitor densities on the trail. The simulation modeling results for each alternative are reported in Table 9. In addition, Table 9 includes visitor density estimates for existing conditions derived in Task 3 of this project, for the purpose of comparison.

Table 9. Visitor density estimates under existing conditions and MRP Alternatives – Trail to Vernal Fall. [a]

Site	Existing Conditions 3,627 [b] (ft^2/person)	MRP Alternative 3 2,559 [b] (ft^2/person)	MRP Alternative 5 3,765 [b] (ft^2/person)	MRP Alternative 6 4,182 [b] (ft^2/person)
Trail to Vernal Fall	80 (±11.0)	112 (±3.7)	76 (±2.1)	69 (±1.8)

[a] Average visitor density for the peak 6-hour period, 10:00 AM – 4:00 PM.
[b] Average daily visitor use between 7:00 AM and 8:00 PM.

Table 10 reports visitor survey-based density levels for the Trail to Vernal Fall, which provide one basis for evaluating the visitor density estimates in Table 9. The results in Table 9 suggest that none of the MRP Alternatives included in the analysis would result in visitor densities on the Trail to Vernal Fall that violate the “Acceptable” or “Displacement” density levels in Table 10.

Table 10. Visitor survey-based density levels – Trail to Vernal Fall.

Site	"Acceptable" Density Level [a] (ft²/person)	"Displacement" Density Level [a] (ft²/person)
Trail to Vernal Fall	33	22

[a] Derived from results of visitor surveys conducted on the Trail to Vernal Fall in 1998.

Figure 5 displays computer simulation model estimates of mean visitor densities on the Trail to Vernal Fall, by time of day, for existing conditions and each of the three MRP Alternatives included in the analysis. It should be noted, visitor densities are expressed as square feet per person, thus, lower values on the y-axis correspond to higher visitor densities. The horizontal lines in Figure 5 correspond to the visitor survey-based density levels in Table 10. Finally, the grey shaded area buffering the existing conditions line in Figure 5 represents the 95% confidence interval for the visitor density estimates under existing conditions.

The graphical results in Figure 5 support the same general conclusions about the MRP Alternatives as the tabular results in Table 9. In particular, the results in Figure 5 suggest none of the alternatives included in the analysis would result in visitor densities on the Trail to Vernal Fall that violate the "Acceptable" or "Displacement" density levels.

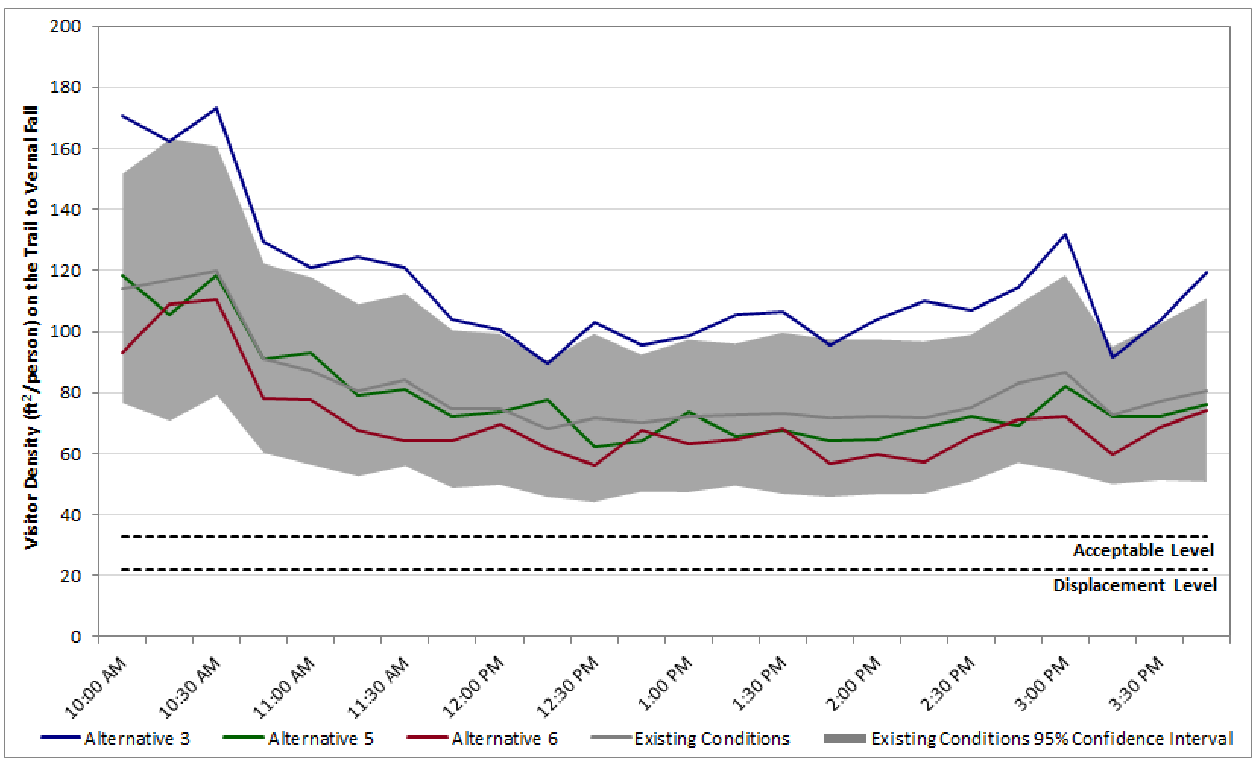

Figure 5. Visitor density estimates under existing conditions and MRP Alternatives –Trail to Vernal Fall.

Appendix A. Supporting Results for the Trail to Lower Yosemite Falls and the Trail to Bridalveil Fall

Trail to Lower Yosemite Falls

As noted, for each alternative, simulations were conducted of the corresponding daily visitor use at Lower Yosemite Falls to estimate visitor densities on the Trail to Lower Yosemite Falls. The simulation modeling results for each alternative are reported in Table 11, along with visitor density estimates for existing conditions derived in Task 3 of this project.

Table 11. Visitor density estimates under existing conditions and MRP Alternatives – Trail to Lower Yosemite Falls. [a]

Site	**Existing Conditions** 7,838 [b] (ft^2/person)	**MRP Alternative 3** 5,713 [b] (ft^2/person)	**MRP Alternative 5** 8,405 [b] (ft^2/person)	**MRP Alternative 6** 9,335 [b] (ft^2/person)
Trail to Lower Yosemite Falls	63 (±4.6)	88 (±0.9)	60 (±0.5)	54 (±0.4)

[a] Average visitor density for the peak 6-hour period, 11:00 AM – 5:00 PM.
[b] Average daily visitor use from 7:00 AM to 8:00 PM.

Table 12 reports visitor survey-based density levels for the Trail to Lower Yosemite Falls, which provide one basis for evaluating the visitor density estimates in Table 11. The results in Table 11 suggest none of the MRP Alternatives included in the analysis would result in visitor densities on the Trail to Lower Yosemite Falls that violate the “Acceptable” or “Displacement” density levels in Table 12.

Table 12. Visitor survey-based density levels – Trail to Lower Yosemite Falls.

Site	**“Acceptable” Density Level** [a] (ft^2/person)	**“Displacement” Density Level** [a] (ft^2/person)
Trail to Lower Yosemite Falls	20	13

[a] Derived from results of visitor surveys conducted at Lower Yosemite Falls in 1998 and 2010.

Figure 6 displays computer simulation model estimates of mean visitor densities on the Trail to Lower Yosemite Falls, by time of day, for existing conditions and each of the three MRP Alternatives included in the analysis. It should be noted, visitor densities are expressed as square feet per person, thus, lower values on the y-axes correspond to higher visitor densities. The horizontal lines in Figure 6 correspond to the visitor survey-based density levels in. Finally, the grey shaded area buffering the existing conditions line in Figure 6 represents the 95% confidence interval for the visitor density estimates under existing conditions.

The graphical results in Figure 6 support the same general conclusions about the MRP Alternatives as the tabular results in Table 11. In particular, the graphical results suggest visitor densities on the Trail to Lower Yosemite Falls would not violate the visitor survey-based density levels in under any of the MRP Alternatives included in the analysis.

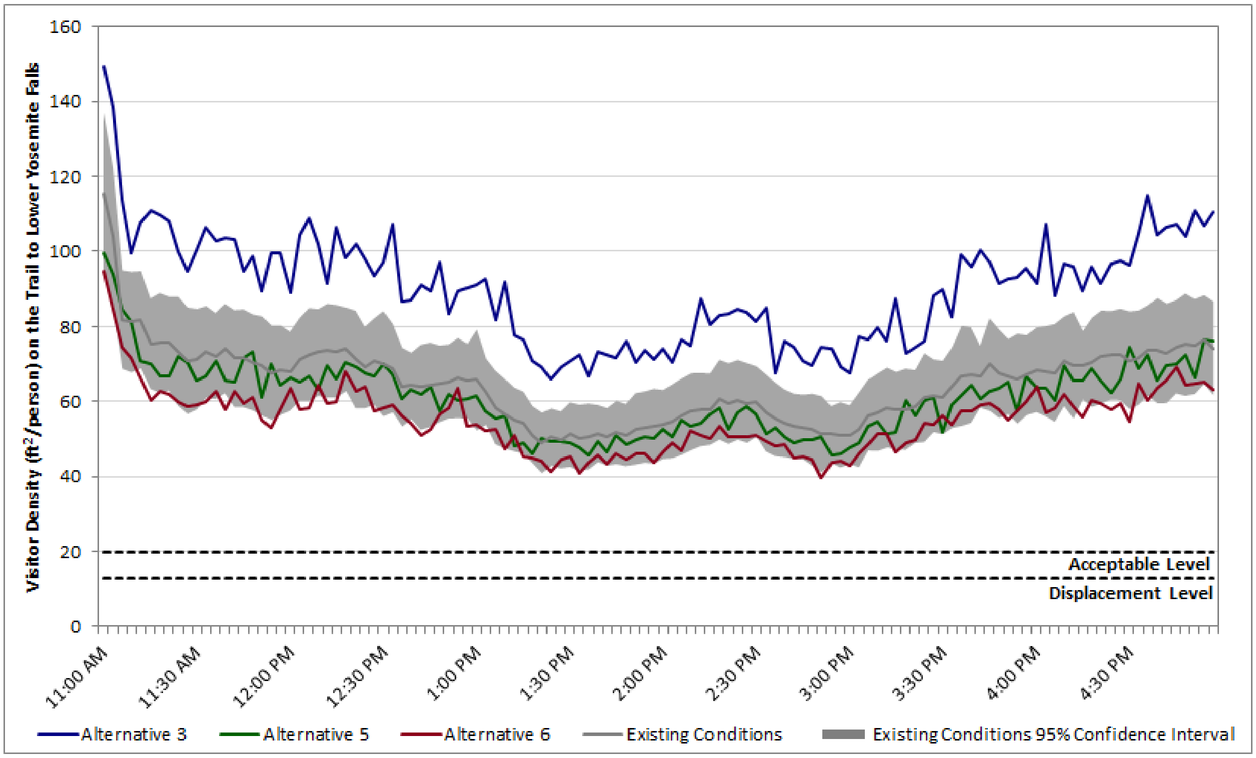

Figure 6. Visitor density estimates under existing conditions and MRP Alternatives – Trail to Lower Yosemite Falls.

Trail to Bridalveil Fall

As noted, for each alternative, simulations were conducted of the corresponding daily visitor use at Bridalveil Fall to estimate visitor densities on the Trail to Bridalveil Fall. The simulation modeling results for each alternative are reported in Table 13, along with visitor density estimates for existing conditions derived in Task 3 of this project.

Table 13. Visitor density estimates under existing conditions and MRP Alternatives – Trail to Bridalveil Fall. [a]

Site	**Existing Conditions** 4,853 [b] (ft^2/person)	**MRP Alternative 3** 3,200 [b] (ft^2/person)	**MRP Alternative 5** 4,708 [b] (ft^2/person)	**MRP Alternative 6** 5,228 [b] (ft^2/person)
Trail to Bridalveil Fall	67 (±4.6)	102 (±3.5)	71 (±2.1)	64 (±1.7)

[a] Average visitor density for the peak 6-hour period, 10:00 AM – 4:00 PM.
[b] Average daily visitor use between 7:00 AM and 8:00 PM.

Table 14 reports visitor survey-based density levels for the Trail to Bridalveil Fall, which provide one basis for evaluating the visitor density estimates in Table 13. The results in Table 13 suggest only Alternative 6 would result in visitor densities on the Trail to Bridalveil Fall that violate the “Acceptable” density level, and none of the MRP Alternatives included in the analysis would violate the “Displacement” density level for the trail.

Table 14. Visitor survey-based density levels – Trail to Bridalveil Fall.

Site	**“Acceptable” Density Level** [a] (ft^2/person)	**“Displacement” Density Level** [a] (ft^2/person)
Trail to Bridalveil Fall	65	42

[a] Derived from results of visitor surveys conducted at Bridalveil Fall in 1999.

Figure 7 displays computer simulation model estimates of mean visitor densities on the Trail to Bridalveil Fall, by time of day, for existing conditions and each of the three MRP Alternatives included in the analysis. It should be noted, visitor densities are expressed as square feet per person, thus, lower values on the y-axes correspond to higher visitor densities. The horizontal lines in Figure 7 correspond to the visitor survey-based density levels in Table 14. Finally, the grey shaded area buffering the existing conditions line in Figure 7 represents the 95% confidence interval for the visitor density estimates under existing conditions.

The graphical results in Figure 7 support the same general conclusions about the MRP Alternatives as the tabular results in Table 13. In particular, the graphical results suggest none of the alternatives included in the analysis would result in visitor densities on the Trail to Bridalveil Fall that violate the “Displacement” density level. The graphical results further suggest that, under Alternative 6, visitor densities on the Trail to Bridalveil Fall would violate the “Acceptable” density level for a substantial portion of the peak period of the day. Moreover, results in Figure 7 suggest Alternative 5 would result in visitor densities on the Trail to Bridalveil Fall that remain at or near the “Acceptable” density level most of the time during the peak period, though mean visitor density on the trail under this alternative would not violate the “Acceptable” density level.

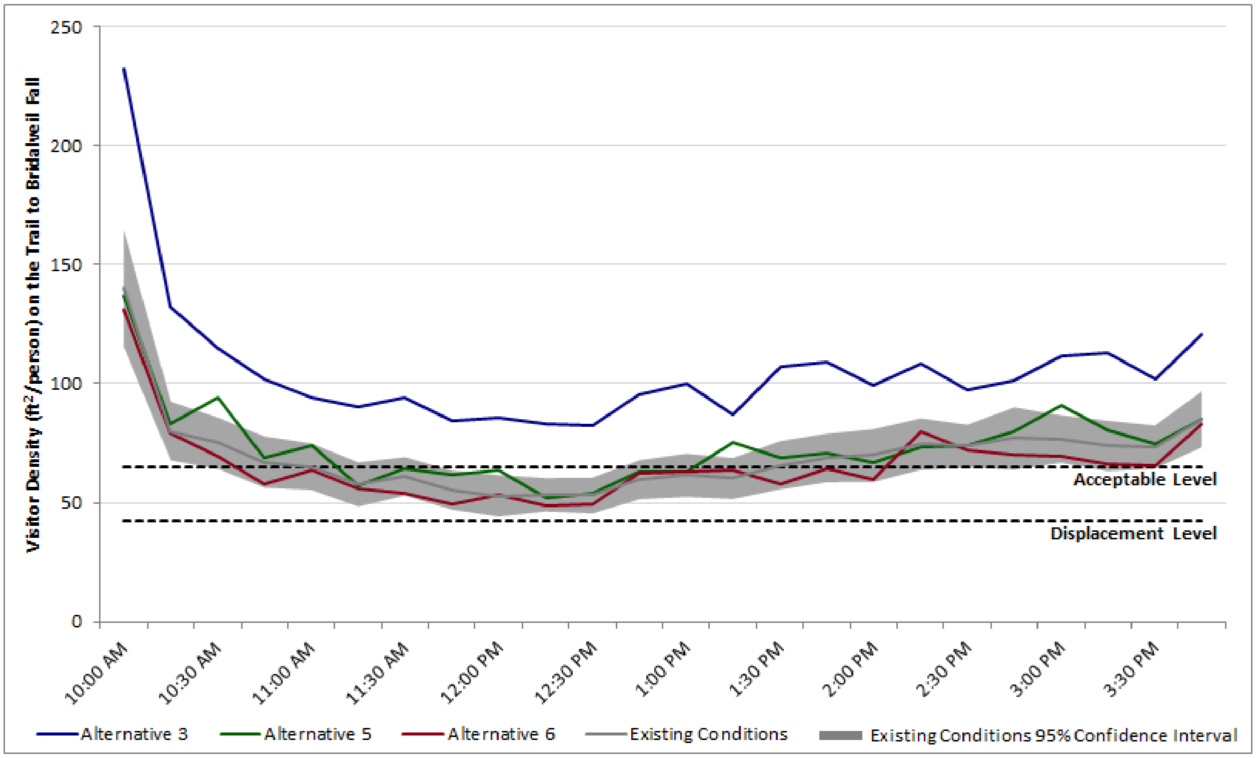

Figure 7. Visitor density estimates under existing conditions and MRP Alternatives – Trail to Bridalveil Fall.