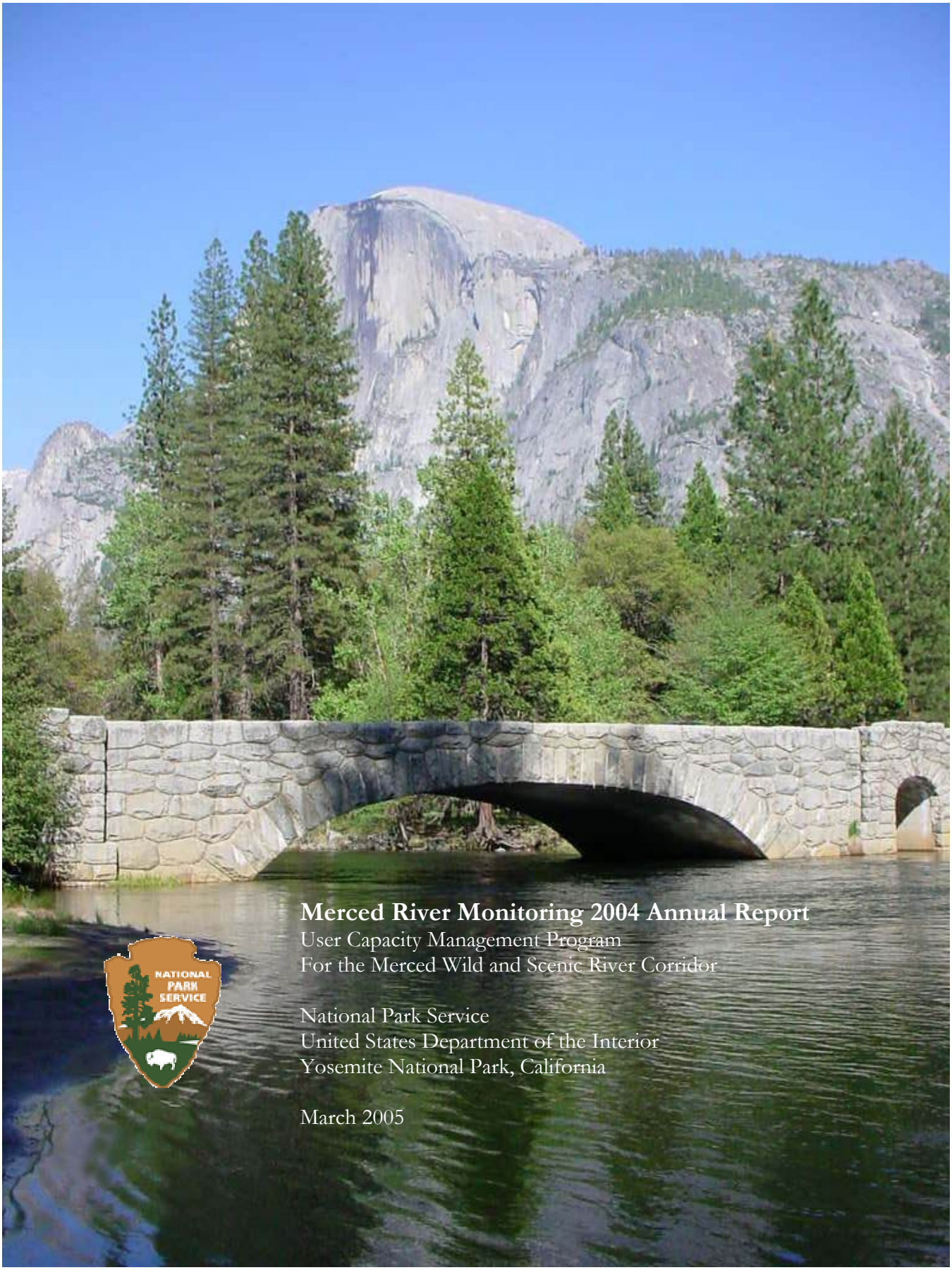

Merced River Monitoring 2004 Annual Report

User Capacity Management Program
For the Merced Wild and Scenic River Corridor

National Park Service
United States Department of the Interior
Yosemite National Park, California

March 2005

MERCED RIVER MONITORING ANNUAL REPORT
2004 SEASON

EXECUTIVE SUMMARY

This was the first year of Visitor Experience and Resource Protection monitoring in the Merced Wild and Scenic River Corridor. As is typical during initiation phases of a program, activities consisted of drafting and refining indicators, standards, monitoring protocol and field guides, in an iterative process that continued into the field season and the actual monitoring itself. Protocol and methodology continue to be revised and refined and this will continue in 2005.

Results of the 2004 monitoring effort, by indicator:

- ***Campsite number and condition***: A sampling strategy was tested. Of 29 locations surveyed, 5 included campsites and one was in Condition Class 4 (classes 4 and 5 represent the worst conditions). Inadequate sample size indicated need for refinement of sampling methods. *Monitoring of this indicator will be suspended in favor of more sensitive indicators.*
- ***Number of Encounters with other Parties***: A sampling strategy was tested. The short field season and resulting small sample size limit data validity. The average level of encounters was less that one party per hour. A larger sample size is indicated for 2005.
- ***People at One Time at Selected Sites***: The indicator as measured did not exceed the standard for number of people at one time. The maximum recorded number of people at one time was eighteen, compared to a standard of twenty.
- ***Exposed Tree Roots in Wilderness Campgrounds***: The indicator as measured did not exceed the standard of no more than 10% of the trees with moderate or severe level of exposed tree roots. *Monitoring of this indicator will be suspended in favor of more sensitive indicators.*
- ***Number of Social Trails***: Data collected in 2004 is regarded as baseline data and, as such, sets part of the standard for this indicator. Field staff identified 10 social trails originating near wetland features, an apparent violation of the "no trails in wetland features" portion of the standard for this indicator. These trails will be investigated in 2005 and, if appropriate, management action will be taken.
- ***Length of Social Trails in Meadows***: Data collected in 2004 is regarded as baseline data and, as such, will be used to establish the standard for this indicator. Staff recorded location and condition of all social trails in eight meadows in Yosemite Valley. High densities of social trails in El Capitan and Bridalveil Meadows will be investigated for potential restoration.
- ***River Bank Erosion that is Accelerated or Caused by Visitor Use***: The protocol for this indicator required first identifying high-use zones and then sampling from those zones. To avoid biases in data collection, no sampling and assessment occurred this year, only identification of the high use zones. *This protocol is being modified to better meet resource management and ecological restoration needs.*
- ***Exposed Tree Roots in Developed Campgrounds***: The indicator as measured showed that more than 95% of the campsites meet the "slight or none" root exposure criteria *Monitoring of this indicator will be suspended in favor or more sensitive indicators.*
- ***Water Quality***: Data collected from 2004 to 2007 will set the standard for water quality. Monitoring indicated decreasing concentrations of nitrate and fecal coliform and increasing phosphorous concentrations as water levels declined and water temperatures increased during the summer. Nutrient concentrations were all very low with respect to state drinking water standards.

Field staff recommended refinements for all monitoring protocols and, in some cases, the wording for the standards themselves. Monitoring results should be used to assess the real utility of the indicators and standards at helping manage and protect the Outstandingly Remarkable Values of the Merced Wild and Scenic River Corridor. In some cases there is a direct connection; in others the connection is less obvious. As such, opportunities remain to revise standards or adopt new ones that are better.

MERCED RIVER MONITORING 2004 ANNUAL REPORT

USER CAPACITY MANAGEMENT PROGRAM FOR THE MERCED WILD AND SCENIC RIVER CORRIDOR

NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

Yosemite National Park
California

2004

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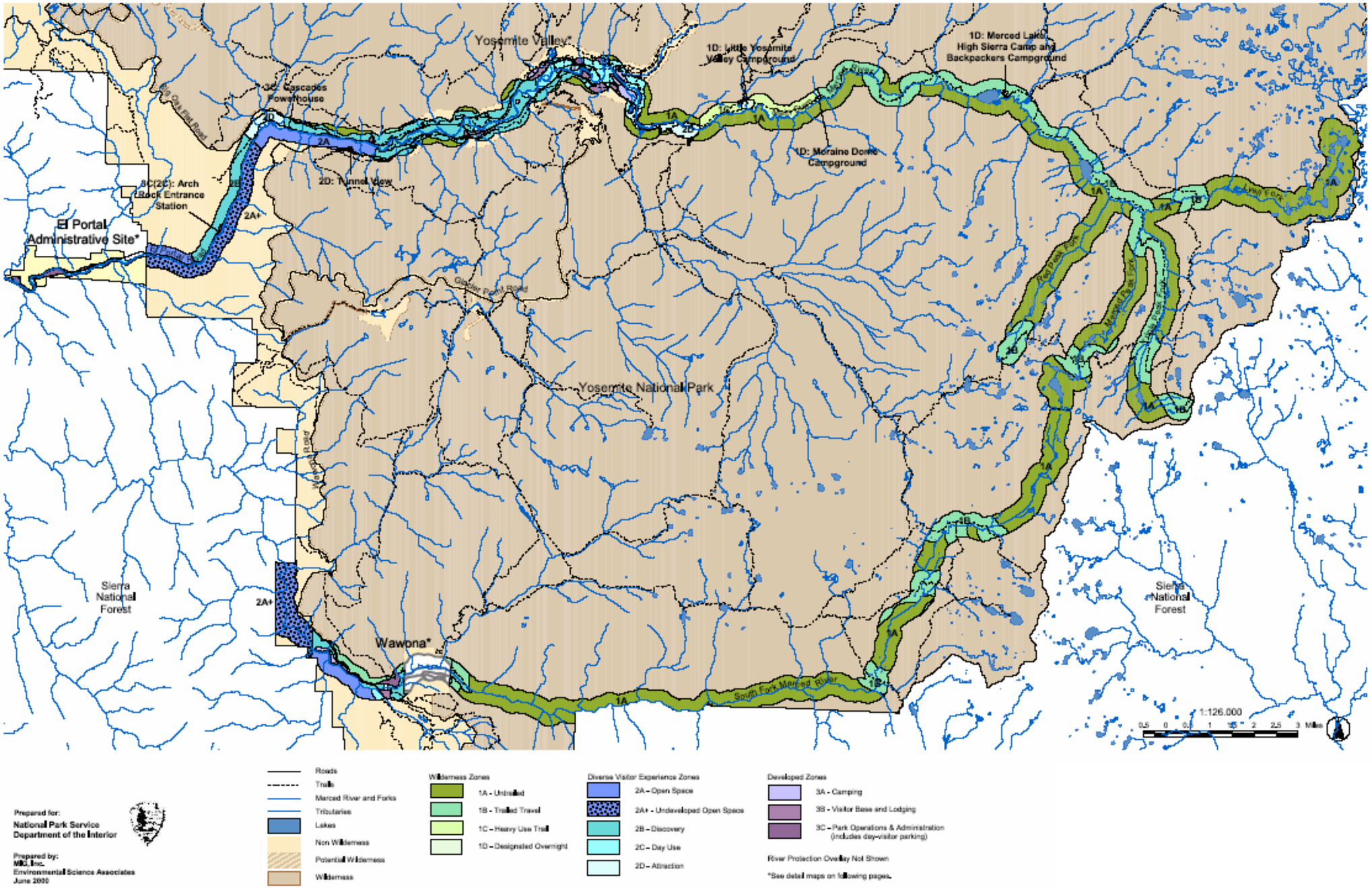
A.0 INTRODUCTION

This annual report summarizes monitoring efforts and results from the initial year of monitoring associated with the implementation of the user capacity management program, a result of The *Merced Wild and Scenic River Comprehensive Management Plan* (CMP, 2000). The *2004 User Capacity Management Plan* (hereafter referred to as the *User Capacity Management Plan)* outlines procedures and processes available to park management to protect resource condition and visitor experience along the Merced River corridor in Yosemite National Park. A significant part of this plan is the Visitor Experience and Resource Protection (VERP) process. The scope of this report is the monitoring efforts and results associated with the VERP program during 2004.

The VERP process allows the park to address broader resource protection and experiential issues in addition to those already dealt with though existing procedures. It does this through the monitoring of indicators, which will be used to inform actions aimed at protecting the Outstandingly Remarkable Values (ORV's) of the Merced Wild and Scenic River (as identified in the CMP). Indicators are specific, measurable quantities that reflect the overall condition of resources and/or visitor experience in a management zone. (Management zones along the Merced Wild and Scenic River corridor in Yosemite National Park are shown in Figure A.0.1 and defined in the CMP.) Resource indicators measure visitor impacts on the biological, physical, and/or cultural resources of a park; social indicators measure visitor impacts on the park visitor experience. In order to protect ORV's, each indicator must have an established standard or threshold that when exceeded necessitates management action to correct the problem.

It should be noted that 2004 was a year of brainstorming, development, refinement, implementation, reflection, and rethinking. The same should be anticipated for 2005. Several indicators that proved impractical or insensitive in the field will be set aside for 2005 and replaced with alternative indicators and standards. This iterative process assures that 1) monitoring provides meaningful and reliable results, and 2) monitoring results are directly related to values being protected. This report summarizes 2004 VERP monitoring results, identifies problem areas, proposes modified or alternative monitoring approaches, and makes management recommendations.

Figure A.0.1
Merced River and South Fork Merced corridor management zones (from the Merced Wild and Scenic River Comprehensive Management Plan).



A.1 MONITORING BACKGROUND

This being the first year of monitoring, activities and patterns of work were typical of a project's initiation. Indicators and standards were proposed by a work group made up of park staff, university researchers, and contractors familiar with Merced Wild and Scenic River issues, resources, and visitors. The concepts for these indicators and standards were subsequently written, reviewed, revised, and rewritten, culminating in the initial *User Capacity Management Program for the Merced Wild and Scenic River* in February 2004. Using this document as a guide, individuals with expertise in the development of standards, monitoring methodologies and analytical tools developed monitoring protocols for each of the indicators and standards proposed in the document.

The development of monitoring protocols was an iterative process. Meetings were held to consider indicators, standards, and the various monitoring methodologies that could be employed. Recommended methodologies were assessed for their ability to provide a sensitive measure of resources condition (as to whether a standard was attained), feasibility related to sampling, and complexity. In addition, methods for analysis were discussed and compared. In many cases, the wording for a standard was recognized as deficient or problematic. The expertise within the group made it possible to derive recommendations for revising or refining the standard.

The next step was to develop field monitoring protocols to guide staff in data collection and processing procedures. This guide included methodologies, data entry instructions and mock data sheets. A database was developed as well. After the Monitoring Guide was completed, and data collection begun, certain impracticalities or inapplicabilities of some monitoring methods were identified. Consultations between field staff and those responsible for protocol development resolved many of these issues. Refinements to the methodologies were carefully documented for subsequent use in the post-season revision to the monitoring guide.

As field work was completed and field forms and notes were archived, analysis began. Review of the results revealed strengths and weaknesses of field methodologies. Observations and recommendations from field staff guided a revised analysis of the data and a provided a foundation for monitoring efforts in 2005. This report is a summation of field activities, monitoring results, and management recommendations following the 2004 monitoring season.

A.2 SUMMARY OF PROCESS

The monitoring activities and results summarized in this document bring to a close the first year of the pilot monitoring phase of the Visitor Experience and Resource Protection program. While some indicators and standards are nearing full-implementation and need only minor refinements, others require several years of data collection to establish a baseline. Still others will be replaced with more appropriate standards. The following is a timeline for full implementation of VERP along the Merced River corridor.

The pilot monitoring phase is anticipated to last for five years. Each year will contain the following elements:

1) Initial season meeting in January or February to review the previous season's results and lessons learned, identify knowledge gaps, and lay out a schedule for the coming season.
2) Spring workshop to review standards and indicators, assign monitoring duties, assign protocol development (park staff or contracted researchers) for new indicators (March or April). Any violations of standards identified in the previous season's monitoring should be addressed at this time.

3) Field monitoring guide development and distribution to those responsible for monitoring duties (May).
4) Field data collection. (June – October) Data collection will generally be centered around the summer months, since this is when visitation is highest and thus has the greatest impact on resources and visitor experience.
5) Data entry and initial analysis (October and November).
6) Fall workshop to review field season, make refinements as necessary in protocols, identify research needs, and review data (November or December).
7) Annual report and final field monitoring guide production for that year's monitoring (February of the following year).

The goal of this pilot phase is to develop robust indicators and standards that accurately and efficiently monitor the impacts of visitor use. By the end of the fifth year of the process (2008), VERP monitoring will be fully developed and integrated into management activities of the Merced River corridor. A monitoring schedule and annual report will be produced each year thereafter. As monitoring results or conditions warrant, park staff will review and update indicators and standards or take management action to correct deviation beyond standard(s). Indicators and standards and associated monitoring methodogies developed in the Merced River corridor are expected to be used in other parts of the park to assess user capacity issues.

B.0 INDICATORS AND STANDARDS

The following sections (B.1 – B.9) summarize each indicator and standard evaluated in 2004, monitoring results and analysis, recommended refinements, and management recommendations.

B.1 CAMPSITE NUMBER AND CAMPSITE CONDITION

The *Merced Wild and Scenic River Comprehensive Management Plan* (CMP) identified several biological Outstandingly Remarkable Values that are influenced by numbers of campsites and their condition in wilderness zones. Campsites can affect water quality and biological resources, such as vegetation and wildlife. Depending on their location, this indicator will also provide data relevant to visitor experience as expressed in the recreational, scenic, and cultural Outstandingly Remarkable Values.

The *User Capacity Management Program* identified two zones that should be monitored to determine the quality of the resource and the effects of current management actions. Campsite Number and Campsite Condition were discussed separately in the *User Capacity Management Program;* however, because the sampling sites for each indicator can be the same, it was determined that combining the two tasks would be more cost and time efficient. A more detailed description of these indicators is presented in the *User Capacity Management Program* on pages 45 to 48. The procedures for Campsite Number and Campsite Condition field monitoring are presented in Section B.1 of the *Merced River Monitoring Field Guide - 2004 Pilot Season.*

Zones:
- Zone 1A: Untrailed
- Zone 1B: Trailed Travel

Standards for Campsite Number:
- **Zone 1A: Untrailed—**No net increase in number of active (non-recovering) campsites over the 2004 baseline.
- **Zone 1B: Trailed Travel—**No net increase in number of active (non-recovering) campsites over the 2004 baseline.

Standards for Campsite Condition:
- **Zone 1A: Untrailed—** Less than 10 percent of existing campsites are Class 4 or 5 (classes 4 and 5 represent the worst conditions).
- **Zone 1B: Trailed Travel—** Less than 10 percent of existing campsites are Class 4 or 5.

B.1.1 Summary Statements

Number of Campsites:

There was no assessment of attainment/non-attainment of number of campsites for this monitoring year. The purpose of measuring of this indicator in 2004 was to establish the baseline which would have served as the standard to which future monitoring would be compared. The 2004 sampling proved difficult due to deficiencies in geographic data used to focus sampling efforts. Monitoring of this indicator will not be continued until such time as the sampling methodology is refined and/or it is applied to larger more diverse areas of Wilderness beyond the Merced River corridor.

Campsite Condition:

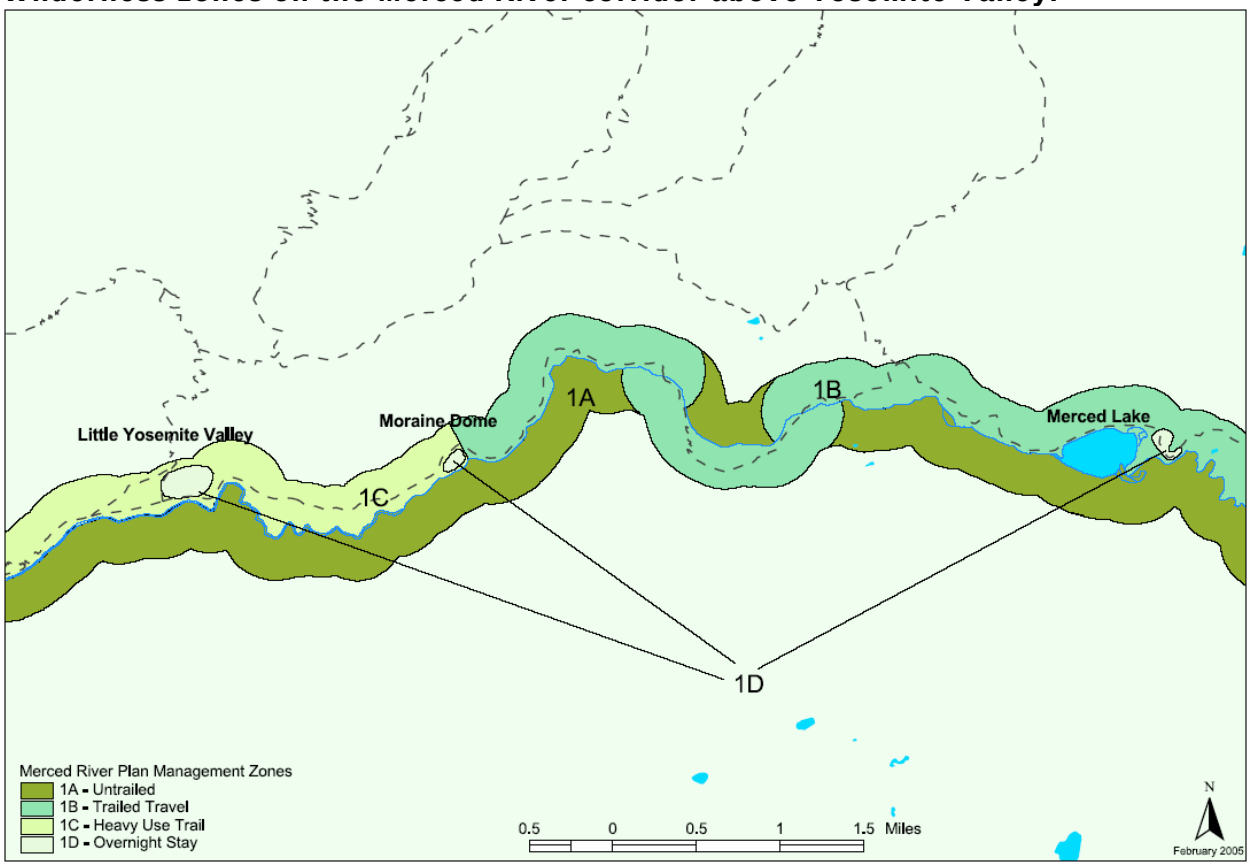
Though one of the campsites found through the sampling methodology was in condition class four or five (the worst condition classes), the sample size was too small to make a

general statement about the condition of all campsites in zones 1A and 1B. Monitoring of this indicator will not be continued until such time as the sampling methodology is refined and/or it is applied to larger more diverse areas of Wilderness beyond the Merced River corridor.

B.1.2 Monitoring Activities

Staff visited 29 locations in Zones 1A and 1B (Figure B.1.1) during July-September, 2004. At each location, they identified the number and condition of all campsites within a 25-meter radius of the point. Campsite condition was assessed using a standardized set of photos depicting a range of conditions, from condition class one (Barely discernable recreational site) to condition class five (Heavily developed campsite).

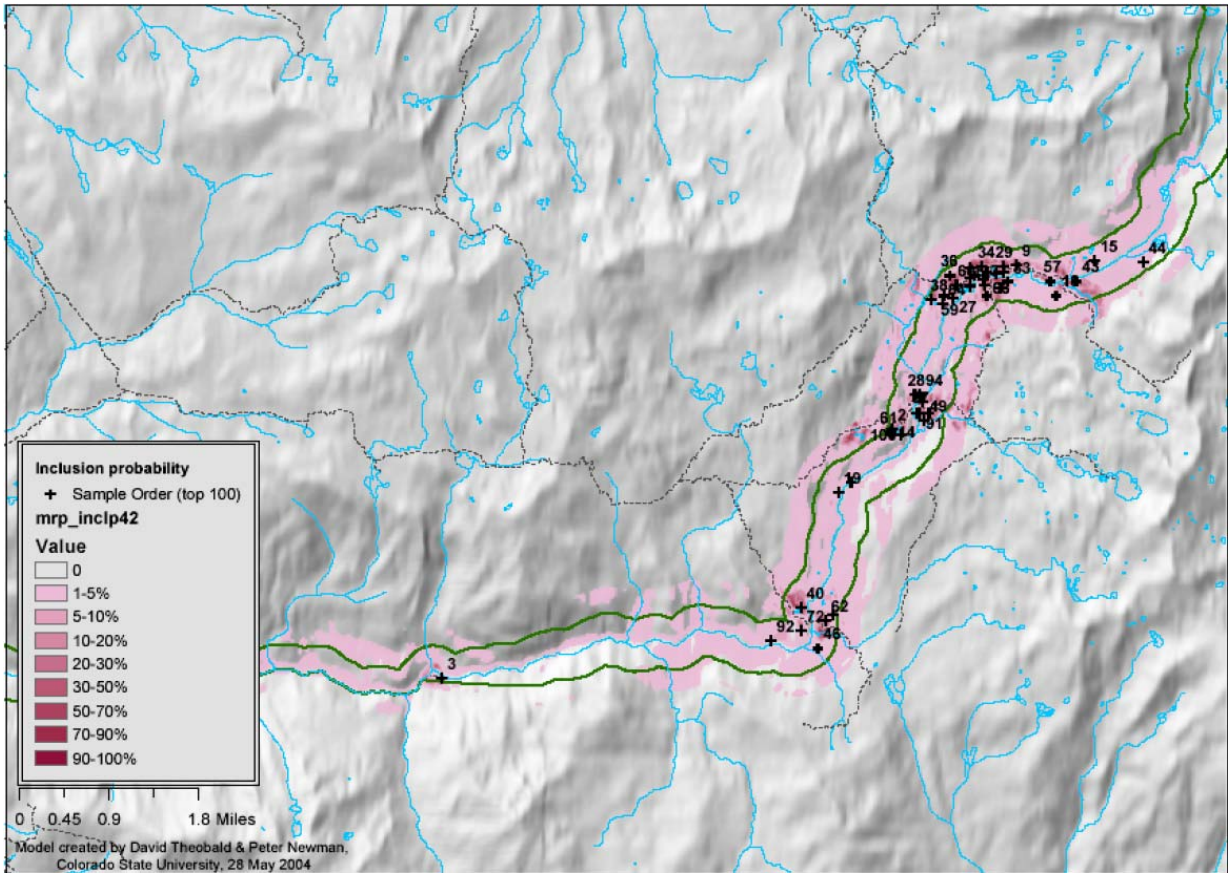
Figure B.1.1
Wilderness zones on the Merced River corridor above Yosemite Valley.



Sampling locations were selected randomly from a Geographical Information System (GIS) analysis of probable campsite locations in the river corridor. Five factors were determined to strongly influence the likelihood of finding campsites along the Merced River corridor (Figure B.1.2). The five factors included: distance along trails from trailheads (in Yosemite Valley, north from Tuolumne and Gravelly Ford from south); slope; distance from water (perennial streams and lakes); distance traveled off-trail from established trails (assume that hikers cannot cross the main-stem and south fork of Merced River) and designated no camping zones. See the *Merced River Monitoring Field Guide – 2004 Pilot Season* (Section B.1 and Appendix A) for a complete description of the monitoring protocol.

Figure B.1.2

Map of sample locations and sampling order on the South Fork of the Merced River, for monitoring campsite numbers and condition in wilderness segments of the Merced Wild and Scenic River corridor.



B.1.3 Monitoring Results

5,466 acres of potential campsite area were identified through the use of the above described GIS model. Of 100 randomly selected sampling locations, the 29 locations with the highest probability of containing campsites were visited during the summer of 2004 Five campsites were found, one of which was condition class four (Classes four and five are worst). Analysis of variance indicates that sample size should be increased to a minimum of fifty sampling points.

B.1.4 Discussion and Conclusions

The sampling strategy was designed to permit extrapolation of results to the all 1A and 1B zones. Because the samples were drawn from the population of potential camping locations using an unequal inclusion probability, the importance of each sample was weighted based on the inverse of their inclusion probability. That is, the more likely that a location was sampled (e.g., approaching 1.0), the smaller the weight – and the less likely that a location was sampled (e.g., 0.1), the larger the weight (1/0.1 = 10). The strength of using a probability-based sample is that a statistically reliable estimate of the population can be made. Conversely, sampling where it is convenient (e.g. during a routine patrol) does not allow one to infer a total population.

The weight for each of the 29 samples was computed as well as the proportion of the total potential camping area each sample represented. The five samples where campsites were found totaled 7.91%, meaning that roughly 8% of the potential camping area has evidence of a campsite. This translates to roughly 432.3 acres that are “camped on” in the wilderness portion of the Merced River corridor. If the average size or distribution of sizes of campsites

were known (which could be determined through future study), one could then determine the number of campsites this represented. For example:

> If it were determined that each campsite occupies 0.95 acres (35 m radius), then there are about 454 campsites. If each campsite occupies 1.94 acres (50 m radius), then there are roughly 222 campsites.

Note that campsite class condition was not differentiated in this analysis.

An analysis of the precision of the above estimates suggests that with thirty samples (reflecting the weighting scheme) the average proportion of the potential camping area represented by a sample is 3.3% (+- 0.2%). With fifty samples, the average proportion reduces to 2.0% (+-0.09%).

B.1.5 Recommended Refinements to Monitoring Program

The sampling model needs to be refined both to increase the probability of sample points being potential camping areas and to reduce staff time in locating sites. On-site inspection of the sampling points suggested that the GIS model captured some potential campsites, but many sites were not of the character typically chosen by wilderness users for campsites. Some areas were not suitable/attractive, but were included based on the model. Other factors (vegetation, micro-geography, deviation from normal fire return interval) could be considered to improve the model. This model was intended to be an unbiased method, to reduce the level of effort needed to find the most representative sample of campsites/sampling points. It is a good method in principal and requires more development.

Because this sampling regime establishes the standard for campsite number, this baseline should be established based on 3-5 years of sampling. While campsite number and condition are not being carried forward for the Merced River corridor, the methodology established here may be readily applicable to the park as whole because it provides an actual number of campsites in wilderness.

A more useful approach from a management perspective could be to conduct a census of campsites in low, medium, and high-use zones in the corridor and then sample within those zones. A similar approach could be stratified random sampling within these zones. This would increase the probability that management could react to or anticipate potential impacts. At the same time, however, this method would limit the ability to extrapolate data to the rest of the corridor.

It was suggested that the standard for campsite condition be changed to “no net increase in campsites with condition classes 3, 4, and 5”. Campsite condition class is currently managed to an average level of 2.5. The above change would reinforce this existing management objective.

B.1.6 Management Implications

Conditions at the five campsites found and monitored in 2004 do not indicate the need for immediate management action. Though one campsite was condition class four (in violation of the proposed standard), the small sample size was insufficient to allow extrapolation of the result throughout the entire Wilderness portion of the Merced River corridor.

B.2 NUMBER OF ENCOUNTERS WITH OTHER PARTIES

One of the components of the recreational Outstanding Remarkable Value for the Merced River Plan (CMP) is the opportunity for solitude. The Untrailed and Trailed zones (1A and 1B) should provide high opportunities for solitude, which is also one of the components of federally designated Wilderness. Expectations of levels of solitude and actual numbers of groups encountered have a significant affect on the quality of visitor experience. Encounters are also an excellent way to assess levels of use, which can affect other Outstandingly Remarkable Values such as the biological, cultural, and scientific values set for the river corridor. For example, higher levels of use may result in compromised water quality.

The *User Capacity Management Program* identified two zones that should be monitored. A more detailed description of this indicator is presented on page 49 of the *User Capacity Management Program.* The procedures for Number of Encounters with other Parties field monitoring are presented in Section B.2 of the *Merced River Monitoring Field Guide - 2004 Pilot Season.*

Zones:

- Zone 1A: Untrailed
- Zone 1B: Trailed Travel

Standards:

- **Zone 1A: Untrailed—**No more than one encounter with another party per day, 80% of the time.
- **Zone 1B: Trailed Travel—**No more than six encounters with another party per day, 80% of the time.

B.2.1 Summary Statement

The sample sizes for "Number of encounters with other parties" in 1A (n=2) and 1B (n=10) zones were too small to represent an accurate assessment of this indicator. However, basic analysis was performed on summer 2004 pilot season data and can inform the development of protocols for this indicator and wording of the standard for the 2005 season.

During the 2004 pilot season, ten samples were taken between July 31, 2004 and September 7, 2004. During this time counts were performed in 1B zones for 31.5 hours. A total of 42 encounters were recorded during this time, or just over one encounter with another party per hour. If a hiker is on the trail for an eight hour day, this would translate to eight encounters per day. At this time there is no information suggesting hikers spend eight hours per day in 1B zones. This suggests that the indicator should be adjusted to a "per hour" measure as opposed to a "per day" measure. Encounters per hour may more accurately reflect the typical visitor experience in a 1B zone.

B.2.2 Monitoring Activities

Staff recorded the number of parties encountered during routine patrols in Zones 1A and 1B (see Figure B.1.1) between July and September 2004. Days were selected at random to sample mid-week, weekends, holiday mid-week, and holiday weekends. This protocol differs from existing patrol procedure only in that Rangers must note the zone where encounters take place. See the *Merced River Monitoring Field Guide - 2004 Pilot Season* for a complete description of the monitoring protocol.

B.2.3 Monitoring Results

Counts were taken on ten different sampling days in 1B zones. Sampling periods varied over the time of day and duration of sample. Means were computed based on the average number of encounters per sampling hour. This means that encounters per day may vary based on the amount of time spent in a 1B zone. The mean number of encounters per hour was approximately one (0.75) person per hour. In an eight hour day, this suggests that people could have encountered eight parties, however it is unclear at this time whether visitors spent a full day in 1B zones. It appears that the number of encounters was affected by time of day, but it is not possible to verify this observation given the small sample size. Table B.2.1 presents the number of encounters per hours of sampling.

Table B.2.1. Frequencies of encounters based on sample. Samples taken on the same day represent morning (8-12 pm) and afternoon (12- 5pm) counts.

Date of Sample	Hours in Zone 1B	Number of Encounters
07/31/04	1.5	5
07/31/04	3.5	11
08/01/04	1.0	1
08/01/04	1.5	1
08/01/04	2.0	1
08/02/04	2.5	2
08/02/04	1.5	2
08/12/04	2.0	1
08/12/04	1.5	0
08/16/04	1.0	0
08/16/04	1.0	1
08/17/04	1.0	0
08/17/04	1.0	3
08/18/04	1.0	0
08/18/04	1.5	1
09/02/04	2.0	5
09/02/04	1.5	2
09/04/04	1.0	0
09/07/04	1.0	0
09/07/04	2.5	6

B.2.4 Discussion and Conclusions

As stated above, the data suggests that one can expect approximately one encounter with another group per hour. However, there is insufficient data to extrapolate the mean number of encounters per hour at different hours of the day. This suggests that the standard might be violated at certain times of the day and depending on how long a visitor spends in 1B zones.

B.2.5 Recommended Refinements to Monitoring Program

A recommended refinement to the wording for the 2004 standard is to change the standard from: “No more than six encounters with another party per day”, to, ***No more than 6 encounters with another party per day, 80% of the time.*** Under the previous wording, one violation (regardless of reason) would have constituted a violation of the standard. Moreover, it is not known whether visitors spend a full day in zone 1B and the standard might better be reflected in a per hour measure.

Staff recommended adjusting the sampling effort to account for bias near High Sierra Camps. They also raised the following questions that have implications for monitoring methodologies:

a) How long does a visitor spend in this zone?
b) Is there is a difference between a ranger's and a visitor's use of the zone (e.g. rate of speed in hiking or duration in the zone)?

Staff also recommended that consideration be given to developing one standard for the High Sierra Camp loop, and another for other parts of the river corridor. Published data should be consulted to determine what percent of time one might spend on this section of trail.

B.2.6 Management Implications

Additional study and consideration should be given to the zoning, amount of wilderness traffic in route to High Sierra Camps, and other variables, and how the encounter level standards and monitoring strategies can be used to provide information needed to improve visitor experience in certain areas. More information is also needed to inform the duration of time that visitors spend in 1B zones. Indicators should reflect the visitor experience. If visitors spend less than one day in 1B zones, then the standard should reflect this by using an "encounters per hour" measure.

B.3 PEOPLE AT ONE TIME AT SELECTED SITES (PAOT)

The Merced River Plan zoned only one area as Heavy Use Trail: The section of the corridor from Moraine Dome Campground to the top of Nevada Fall. The Heavy Use Trail zone is characterized by exceptionally high amounts of day use in designated Wilderness due to Half Dome traffic, as well as large amounts of overnight users headed to Little Yosemite Valley. This indicator will allow managers to assess encounter levels and visitor satisfaction more reasonably than numbers of groups encountered (Section B.2, this document) due the large numbers of visitors on this section of trail. Numbers of people at one time can also be used to assess levels of use, which can affect other Outstandingly Remarkable Values such as the biological, cultural, and scientific values set for the river corridor. Higher levels of use may result in compromised water quality ("excellent water quality" is a component of the hydrologic processes Outstandingly Remarkable Value in wild segments of the river).

The *User Capacity Management Program* focuses on one zone in the park to monitor for exceptionally high volumes of hikers. A more detailed description of this indicator is presented on page 51 in the *User Capacity Management Program.* The procedures for Number of Encounters with other Parties field monitoring are presented in Section B.3 of the *Merced River Monitoring Field Guide - 2004 Pilot Season.*

Zone:

- Zone 1C: Heavy Use Trail

Standard:

- **Zone 1C: Heavy Use Trail—**Not more than 20 people on a 50-meter section of the trail, 80% of the time, which equates to 66 square feet per person in this zone.

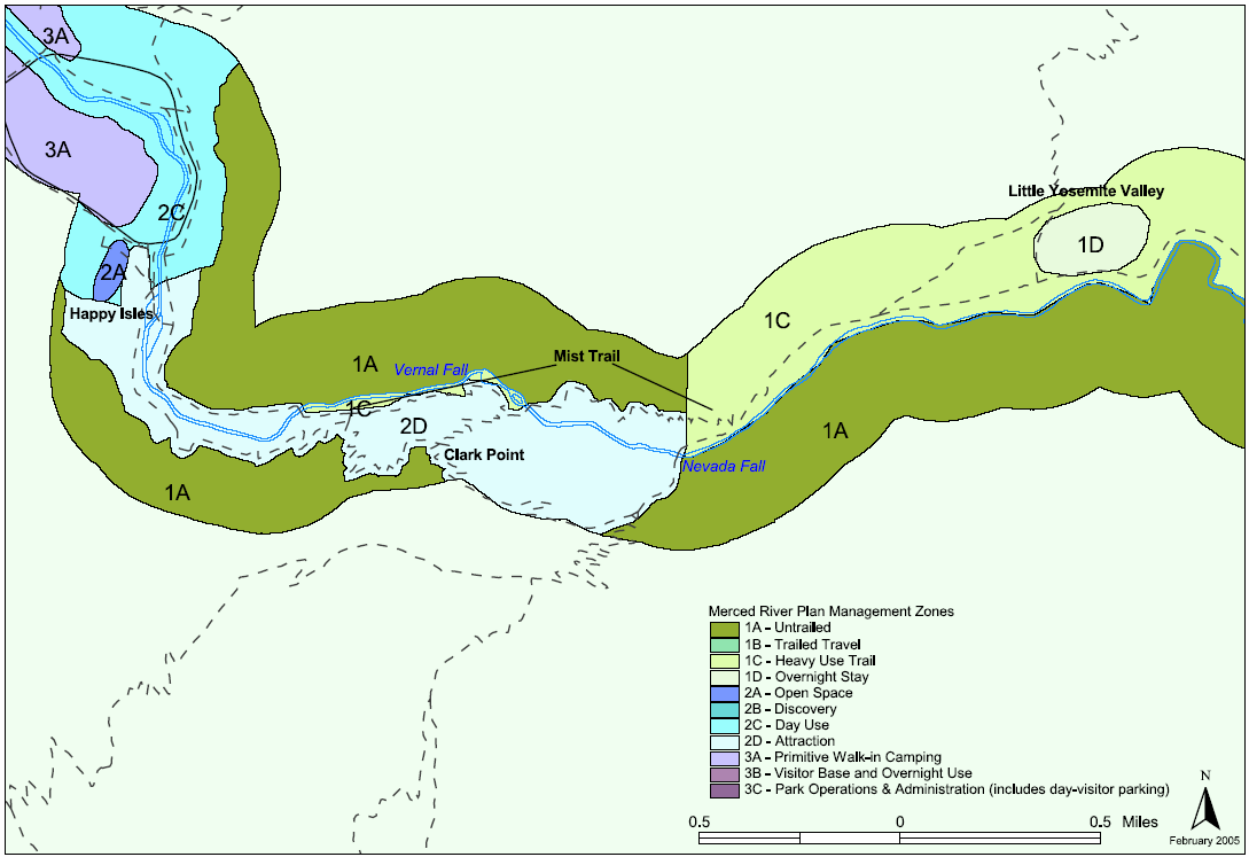
B.3.1 Summary Statement

The indicator as measured did not exceed the standard for number of people at one time. The maximum recorded number of people at one time was 18.

B.3.2 Monitoring Activities

Wilderness staff monitored a fifty-meter section of trail between Nevada Fall and Little Yosemite Valley in Zone 1C (Figure B.3.1), recording the number of people in the section each minute for three hours. Sampling days were selected at random to sample mid-week, weekends, holiday mid-week, and holiday weekends. On occasion, additional sampling beyond three hours was conducted in order to better understand fluctuations throughout the day. See the *Merced River Monitoring Field Guide - 2004 Pilot Season* for a complete description of the monitoring protocol.

Figure B.3.1
Zone 1C between Nevada Fall and Little Yosemite Valley.



B.3.3 Monitoring Results

During the 2004 Pilot Season, a total of twelve sampling days occurred between August 10 and September 15. A total of 2812 one-minute counts were conducted representing morning and afternoon conditions. This represented approximately 47 hours of sampling (Table B.3.1).

Table B.3.1.
Frequency of one-minute sampling counts for PAOT in a 50 meter section of zone 1C.

Date	Frequency †	Percent*	Valid Percent**	Cumulative Percent
08/10/04	360	12.8	12.8	12.8
08/18/04	180	6.4	6.4	19.2
08/20/04	176	6.3	6.3	25.5
08/21/04	180	6.4	6.4	31.9
08/24/04	179	6.4	6.4	38.2
08/27/04	296	10.5	10.5	48.8
08/28/04	300	10.7	10.7	59.4
09/02/04	180	6.4	6.4	65.8
09/04/04	421	15.0	15.0	80.8
09/06/04	180	6.4	6.4	87.2
09/12/04	180	6.4	6.4	93.6
09/15/04	180	6.4	6.4	100.0
TOTAL	2812	100.0	100.0	

† Number of one-minute counts per day
* Percent refers to the percentage of total counts represented by each sampling date.
**Valid Percent refers to the percentage of total counts represented by each sampling date that were valid.

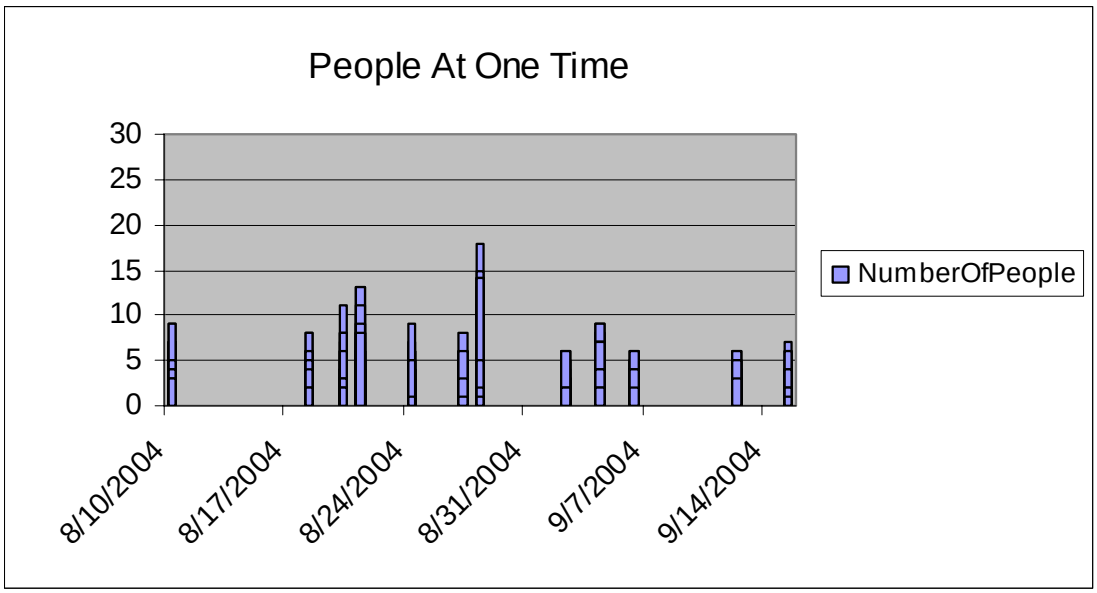
Descriptive statistics were calculated and included mean, median, mode and frequencies of the sampling period. The mean number of PAOT was just over one with a median and mode of zero. Table B.3.2 displays the frequencies of results of the PAOT counts. The table shows that more than 96 % of the time there were less than five people at one time in the fifty-meter section of the 1C trail. However, 0.5 percent of the counts recorded more than ten people at one time. Figure B.3.1 shows that although counts were recorded as high as eighteen people at one time, the standard of twenty was never violated during the sampling period.

Table B.3.2.
Frequency of results of PAOT sampling counts.

People at one time	Frequency†	Percent	Valid Percent	Cumulative Percent
0	1739	61.8	61.9	61.9
1	208	7.4	7.4	69.3
2	408	14.5	14.5	83.8
3	168	6.0	6.0	89.8
4	107	3.8	3.8	93.6
5	70	2.5	2.5	96.1
6	49	1.7	1.7	97.8
7	20	0.7	0.7	98.5
8	16	0.6	0.6	99.1
9	8	0.3	0.3	99.4
10	3	0.1	0.1	99.5
11	6	0.2	0.2	99.7
12	1	0.0	0.0	99.7
13	3	0.1	0.1	99.8
14	3	0.1	0.1	99.9
15	1	0.0	0.0	100.0
18	1	0.0	0.0	100.0
TOTAL	2811	100.0	100.0	
Missing data	1	0.0		
TOTAL	2812	100.0		

† Number of one-minute counts that yielded a given PAOT number

Figure B.3.2
PAOT for 50 meter section of trail in a 1C zone.



B.3.4 Discussion and Conclusions

As stated above, the number of PAOT was just over one with a median and mode of zero. More than 96% of the time there were less than five people at one time in the fifty-meter section of the 1C trail. However, 0.5 percent of the counts recorded more than ten people at one time. Although one count of eighteen people at one time was recorded, the standard of people was never violated during the sampling period. These results suggest that the PAOT is within standard and that no management action is warranted at this time.

B.3.5 Recommended Refinements to Monitoring Program

The standard for this indicator has been changed from "No more than 20 PAOT" to ***No more than 20 PAOT, 80% of the time***. This change accounts for random spikes in the numbers of people that cannot be addressed through management action.

Future surveys of PAOT may warrant a higher sample size in order to better understand spikes in use in 1C zones. Sampling should be conducted during "morning" periods and "afternoon" periods in order to calculate accurate descriptive statistics for different times of day, in particular to capture pulses associated with people climbing Half Dome. Sampling location also needs to be evaluated in order to make sure that the current location is representative of 1C conditions.

Staff were only able to sample 50% of the time recommended in the monitoring protocols which amounted to 47 hours of sample time. As mentioned in the discussion above, a higher sample size is warranted. Periodic closures of the Half Dome trail during 2005 will likely significantly affect sampling results.

B.3.6 Management Implications

Results from 2004 do not indicate the need for actions to manage encounters with people at one time.

B.4 EXPOSED TREE ROOTS IN WILDERNESS CAMPGROUNDS

Several Outstandingly Remarkable Values are directly affected by exposed tree roots and the impact they represent, including impacts to water quality, cultural resources, ecological habitats, and the scientific integrity of an unchanged environment. Exposed roots also negatively affect the recreational experience. Prolonged or extreme amounts of exposed roots can kill the tree.

The *User Capacity Management Program* focuses on one zone in the park to monitor for soil erosion caused by human or stock use at Little Yosemite Valley (LYV) Campground. A more detailed description of this indicator is presented on page 53 in the *User Capacity Management Program.* The procedures for Number of Encounters with other Parties field monitoring are presented in Section B.4 of the *Merced River Monitoring Field Guide - 2004 Pilot Season.*

Zone:

- Zone 1D: Designated Overnight

Standard (Revised):

- **Zone 1D: Designated Overnight—**No more than 10% sampled trees with moderate or severe level of exposed tree roots.

B.4.1 Summary Statement

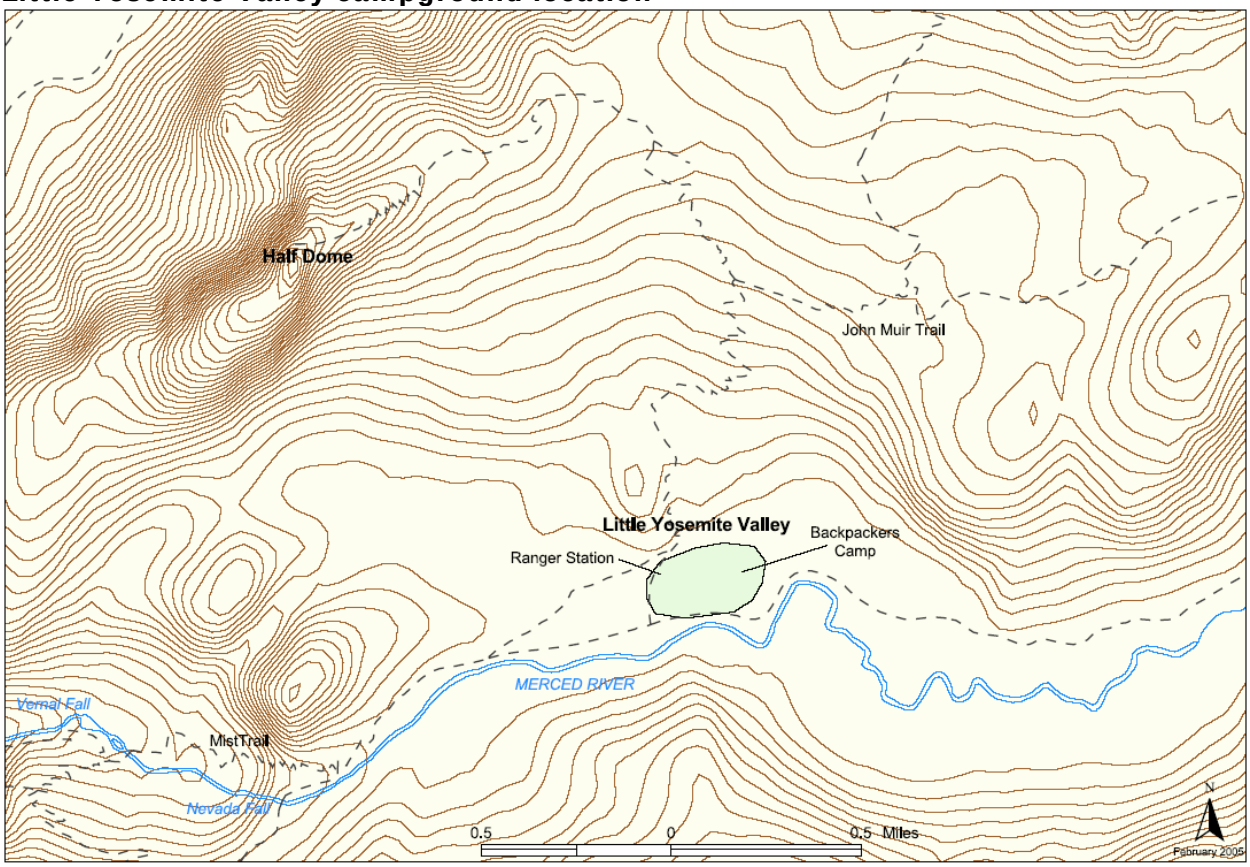
The indicator as measured did not exceed the standard of no more than 10% of the trees with moderate or severe level of exposed tree roots. This indicator appeared to be less sensitive to resource conditions than anticipated and will be discontinued in favor of other indicators.

B.4.2 Monitoring Activities

Staff constructed three parallel transects across the Little Yosemite Valley campground (Figure B.4.1) on one field day in September 2004. Trees within one meter of the transect were assigned root-exposure condition classes ranging from one (slight/none) to five (severe), after Marion (1991). See the *Merced River Monitoring Field Guide - 2004 Pilot Season* for a complete description of the monitoring protocol.

Figure B.4.1

Little Yosemite Valley campground location



B.4.3 Monitoring Results

A summary of monitoring results is provided in Table B.4.1. All forty trees assessed along the three transects received the 'none/slight' rating for root exposure with no variation.

Table B.4.1
Results summary: Root exposure in Little Yosemite Valley campground.

Transect	Tree Assessed (#)	Condition Rating		
		None/Slight	*Moderate*	*Severe*
North	12	12*	0	0
Central	11	11	0	0
South	17	17	0	0
Overall	40	40	0	0

* *Number of trees.*

B.4.4 Discussion and Conclusions

The first-year monitoring identified no discernible root exposure on all sampled trees within Zone 1D, the Little Yosemite Valley Campground. Such results suggest that minimal cumulative soil erosion exists on the campground, and that the root system of trees is subject to little mechanical stress by human trampling forces.

The non-existence of variation in root exposure condition may also be a result of the limited sensitivity of Marion's rating scale (Marion, 1991). Refinement of this scale may be

considered to detect sub-category changes that may have social, ecological, or managerial significance.

B.4.5 Recommended Refinements to Monitoring Program

This indicator was less sensitive than originally anticipated. Discussions of this indicator and the similar indicator in developed campgrounds suggest that a better measure of impacts due to camping would be to evaluate the areal extent of bare ground, compacted soil, or loss of duff in a camping zone. Changes of this impacted area would likely be more sensitive to levels of use and allow more timely management response.

B.4.6 Management Implications

The standard as measured was not exceeded and would, therefore, indicate no need for management action. It was determined, however, that this indicator was less sensitive to impacts in the area evaluated than originally thought. While monitoring of this indicator will be discontinued for this reason, it may be more applicable in other areas of the park, particularly at higher elevations.

B.5 NUMBER OF SOCIAL TRAILS

A social trail is an informal trail caused by human use of an area that may not have developed trails available. Several Outstandingly Remarkable Values (ORV's) are affected by the number of social trails. The *User Capacity Management Program* identified two zones that should be monitored for number of social trails to determine if visitors are impacting wetland areas along the Merced River corridor. The standards presented in the *User Capacity Management Program* were based on 1990 data. After further evaluation it was determined that the 1990 data was not as rigorous as needed to conduct monitoring. A more detailed description (including the previous standards) of this indicator is presented in the *User Capacity Management Program* on pages 55 and 56. The procedures for Number of Social Trails field monitoring are presented in Section B.5 of the *Merced River Monitoring Field Guide - 2004 Pilot Season.*

Zones:

- Zone 2A: Open Space
- Zone 2A+: Undeveloped Open Space

Revised Standards:

- **Zone 2A: Open Space—**No net increase in number from 2004 baseline for linear features. No social trails for wetland features.
- **Zone 2A+: Undeveloped Open Space—**No net increase in number from 2004 baseline.

B.5.1 Summary Statement

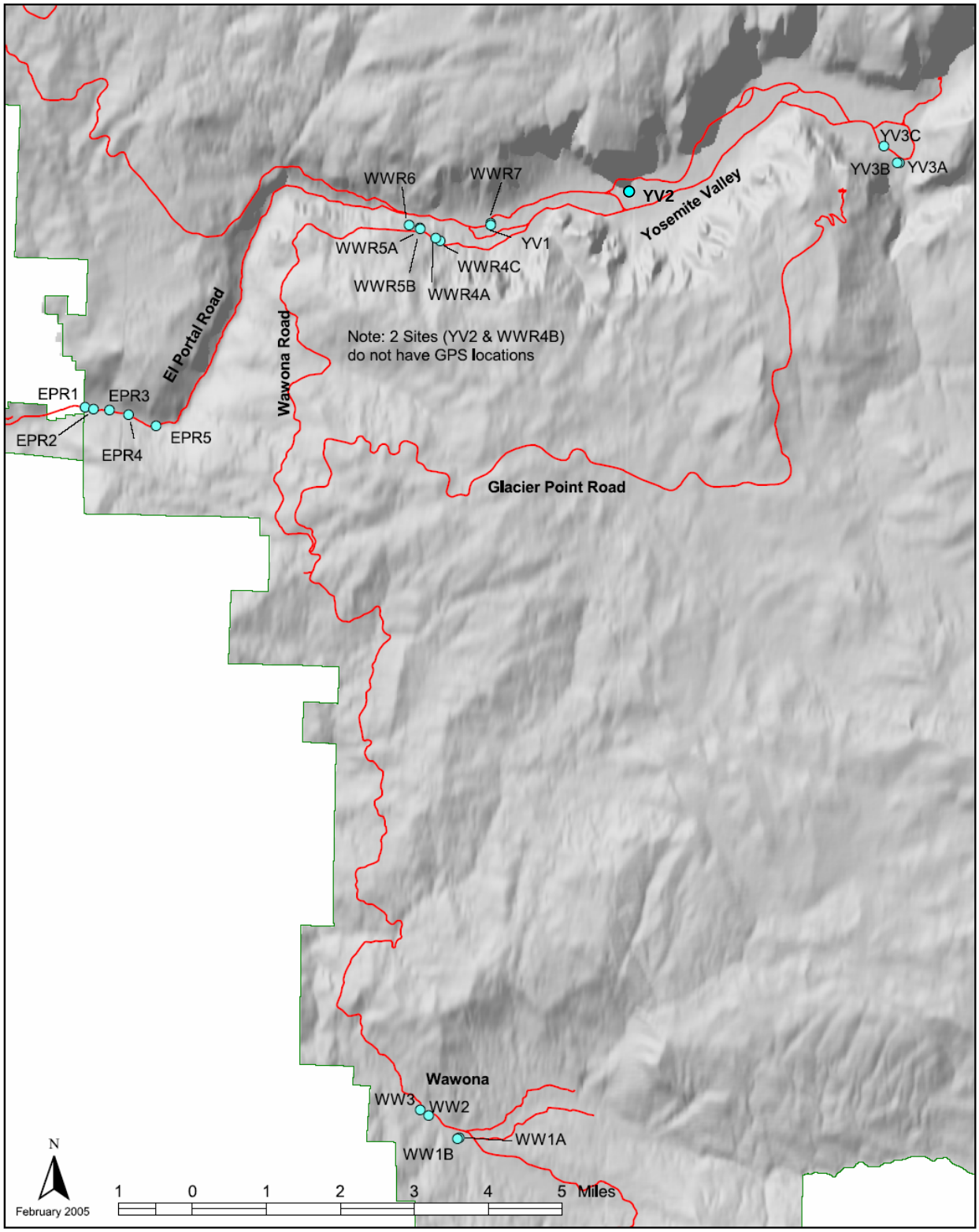
Data collected in 2004 is regarded as baseline data and, as such, sets the standard for this indicator. Field staff identified ten social trails originating near wetland features, an apparent violation of the standard for this indicator. These trails will be investigated in 2005 and, if appropriate, management action will be taken.

B.5.2 Monitoring Activities

Staff conducted a census of social trails within Zones 2A and 2A+ for a total of seven field days between July 21 and August 17, 2004 (Figure B.5.1). Trail heads or origin locations along roads and in pull-outs were identified using the Global Positioning System (GPS) and photographed. See the *Merced River Monitoring Field Guide - 2004 Pilot Season* for a complete description of the monitoring protocol.

Figure B.5.1

Number of social trails census locations in 2004. Site designators are defined in Table B.5.1.



B.5.3 Monitoring Results

Table B.5.1 provides a summary of monitoring results, which serves as a baseline against which future monitoring of the same indicator can be compared. A total of 36 social trail heads were documented at 22 different sites in seven parking locations within Zones 2A and 2A+. Seventy-two percent (26) of these social trails originated along major roadways or from non-wetland features in the Wawona area. Multiple trail heads existed at popular turnouts such as the Yosemite Welcome sign on El Portal Road, and at scenic overlooks such as Discovery View Parking Lot off Wawona Road by the tunnel. No discernible social trails were identified at the South Fork of the Merced.

Ten of the trails (28%) assessed occurred in the vicinity of defined wetland features, with seven trails leading into Happy Isles Fen near Happy Isles Nature Center. Multiple trail heads exist in two of the three sites where social trails were identified in this area. There were three social trail heads identified at Bridalveil Meadow Unique Wetland area. No discernible social trails were found at Woskey Pond.

Table B.5.1. Summary of results: Number of social trails.

Parking Location*	**No. of Sites Assessed**	**No. of Social Trail Heads**
Wetland Features		
Bridalveil Meadow Unique Wetland (YV1)	2	3
Happy Isles Fen (YV3)	3	7
Woskey Pond (YV2)	1	0
Non-Wetland Features		
El Portal Road (ERP)	5	6
South Fork Merced River (WW)	2	0
Wawona Area (WW)	4	5
Wawona Road (WWR)	15	15
Total	**22**	**36**

*Pullouts or parking areas adjacent to "wetland" or "non-wetland" areas.

B.5.4 Discussion and Conclusions

The monitoring results suggest that social trails exist on both wetland and non-wetland features. The spatial distribution of these unofficial trails appears to be related to visitor attractions. Multiple trail heads at several sites may be an early indication of potential proliferation of social trails and associated resource damage at these sites. Finally, the existence of social trails on wetland features suggests a violation of current VERP standard for this specific indicator, calling for management attention to these locations. These trails will be investigated further in 2005 to determine what management actions may be necessary to correct the problem.

B.5.5 Recommended Refinements to Monitoring Program

The major shortcoming of this monitoring protocol was a lack of social trail condition class photographs to guide field personnel. This is being addressed and next year, photos and classifications developed for the Length of Social Trails in Meadows Indicator (Section B.6, this document) will be added to the field protocol for this indicator.

Though some areas are classified as having wetland features, social trails documented at an adjacent parking area or pullout do not necessarily traverse these areas. Documentation of social trails in these areas needs to reflect this. Data presented in Section B.5.3 would indicate that there were ten social trails documented in wetland areas. While staff will verify this data during the 2005 field season, it is likely that most of these social trails do not

traverse wetlands. This issue could be addressed by asking field personnel to record the number of trails that actually enter the wetland areas.

Other possible improvements include the development of better large-scale field maps with the management zones plotted on them. These would aid field personnel when deciding if a particular trail might traverse management zones 2A or 2A+. Field personnel found it helpful to draw a sketch map of each area. This step will be incorporated into the field protocol.

B.5.6 Management Implications

The 2004 monitoring data indicate the presence of ten trails in wetland features, an apparent violation of the standard for this indicator. Staff plan to do a field evaluation of these trails in 2005 to determine 1) if they actually enter a wetland and 2) if they are in the wetland, what measures are necessary to eliminate their use and, if appropriate, restore them.

B.6 LENGTH OF SOCIAL TRAILS IN MEADOWS

A social trail is an informal trail caused by human use of an area that may not have developed trails available. The meadows in Yosemite Valley's Discovery and Day Use zones (2B and 2C) constitute a component of the biological Outstanding Remarkable Value within this segment of the Merced River corridor. Their ecological integrity and scenic quality are degraded by multiple social trails that cross them. Increases in social trails can also affect the recreational Outstandingly Remarkable Value.

The *User Capacity Management Program* identified two zones to be monitored. The Yosemite meadows in those zones are: Bridalveil, El Capitan, Woskey Pond, Leidig, Sentinel, Cooks, Ahwahnee, Stoneman, Laymon, Orchard, and Mirror Lake. As with The Number of Social Trails indicator, the standards presented in the *User Capacity Management Program* for Length of Social Trails in Meadows were based on 1990 data. After further evaluation it was determined that the 1990 data was not as rigorous as needed to conduct monitoring. A more detailed description of this indicator, and the previous standards, is presented in the *User Capacity Management Program* on pages 57 and 58. The procedures for Length of Social Trails in Meadows field monitoring are presented in Section B.6 of the *Merced River Monitoring Field Guide - 2004 Field Season.*

Zones:

- Zone 2B: Discovery
- Zone 2C: Day Use

Revised Standards:

- **Zone 2B: Discovery—**No net increase in length of linear features from 2004 baseline.
- **Zone 2C: Day Use—**No net increase in length of linear features from 2004 baseline.

B.6.1 Summary Statement

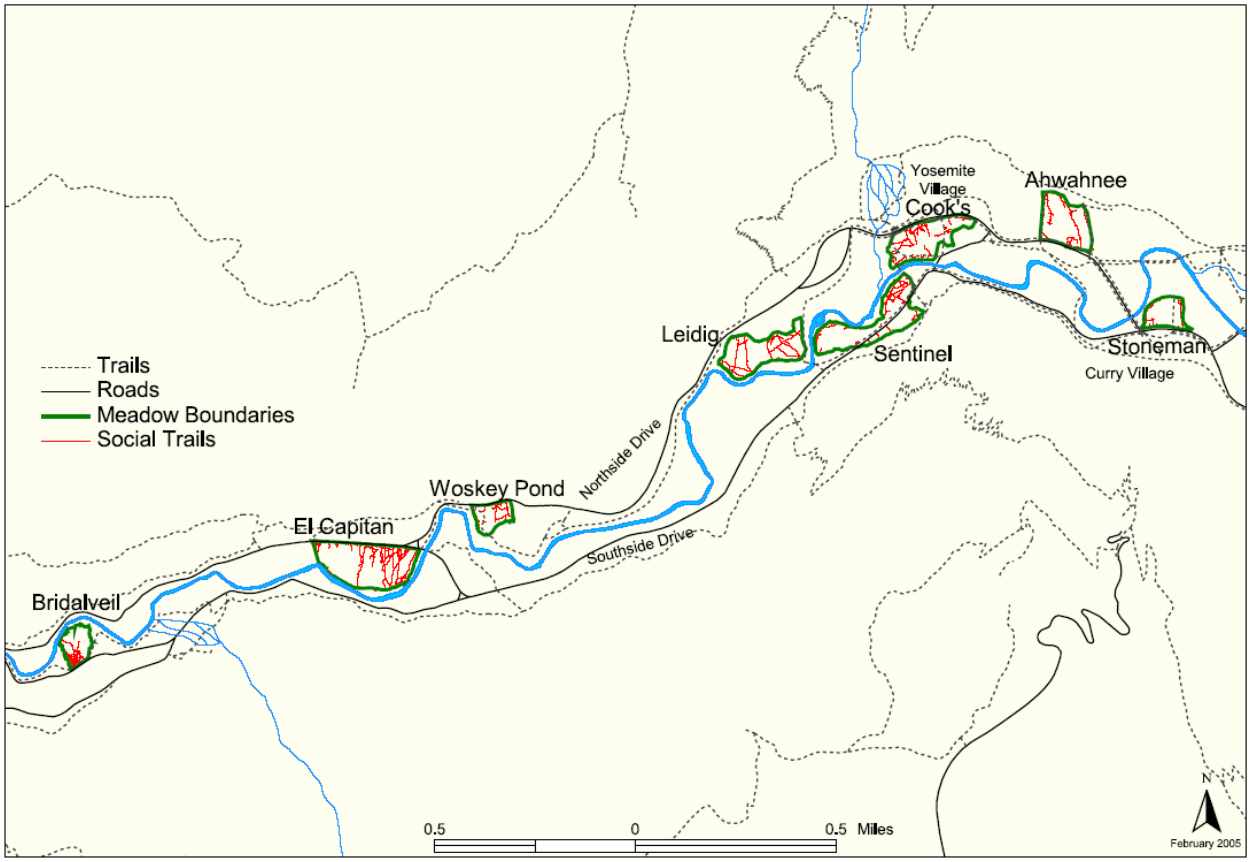
Data collected in 2004 is regarded as baseline data and, as such, will be used to establish the standard for this indicator. Staff recorded spatial location and condition of all social trails in eight meadows in Yosemite Valley. While this data serves as a baseline, field staff noted areas in El Capital and Bridalveil Meadows that had excessive densities of social trails. Further development of the standard is needed, therefore, to take into account trail densities.

B.6.2 Monitoring Activities

Staff used Global Positioning System (GPS) equipment to record the location and condition class of all social trails in eight meadows in Yosemite Valley (Bridalveil, Woskey Pond, El Capitan, Leidig, Sentinel, Cooks, Ahwahnee, and Stoneman) (Figure B.6.1). Field data collection included 175 person hours in thirteen days between September and November 2004. Where a trail was bare soil, a width was recorded as well. Condition classes ranged from barely discernable to trampled vegetation to bare ground. Areas of extensive disturbance were identified and measured as well. See the *Merced River Monitoring Field Guide - 2004 Pilot Season* for a complete description of the monitoring protocol.

Figure B.6.1

Meadows in Yosemite Valley assessed for social trails in 2004.



B.6.3 Monitoring Results

A total of 21.8 km of social trails were identified and measured in eight different meadows. (Table B.6.1). More than one fourth of the total trail length (5.9km) occurred in El Capitan Meadow (Figure B.6.2). There were also over three kilometers of social trails in Leidig and Sentinel Meadows, respectively. Stoneman and Woskey Pond Meadows had the fewest social trails, with only 0.8 km (3.6%) and 1.2 km (5.4%), respectively.

Resource conditions of social trails were assessed using a 4-point classification. Figure B.6.3. illustrates the composition of social trails in different conditions. While Stoneman Meadow had the lowest cumulative length of social trails, a substantial proportion of these trails were most established as indicated by their barren conditions (Figure B.6.3). On the other hand, about 80% of the social trail length in Bridalveil Meadow was on flattened vegetation, indicating a less damaged condition on these paths with good potential for recovery.

The collection of spatial data using GPS for this indicator provides a rich dataset for further examination and analyses of social trails with respect to their spatial extent and distribution in relation to other physical features. Figure B.6.4 illustrates the utility of spatially displaying social trail data in addition to tabular and diagrammatic formats. In this example of Cooks Meadow, most social trails were radiating from road corridors or connecting roads and official trails. Few social trails existed in the interior of the meadow. Such information may inform management decisions if actions are necessary. The ecological significance of social trail proliferation can also be evaluated when social trail data layer is integrated with other park resources GIS layers such as wetland features and habitats of rare or threatened species.

Table B.6.1

Descriptive statistics on social trail length.

Meadow	Social Trail Segments (#)	Social Trail Length (m)			
		Mean	*Median*	*Std. Dev.*	***Sum***
Ahwahnee	81	29.5	21.8	24.9	**2390.4**
Bridalveil	212	11.4	7.1	12.9	**2426.7**
Cooks	115	23.6	18.3	21.9	**2717.9**
El Capitan	247	23.8	17.4	25.0	**5881.3**
Leidig	100	32.6	23.7	32.9	**3257.3**
Sentinel	121	26.3	19.2	23.8	**3178.0**
Stoneman	25	31.0	20.3	30.7	**774.5**
Woskey Pond	47	25.1	18.1	22.5	**1181.8**
Overall	948	23.0	16.5	24.3	**21807.9**

Figure B.6.2
Sum of social trail length in eight meadows.

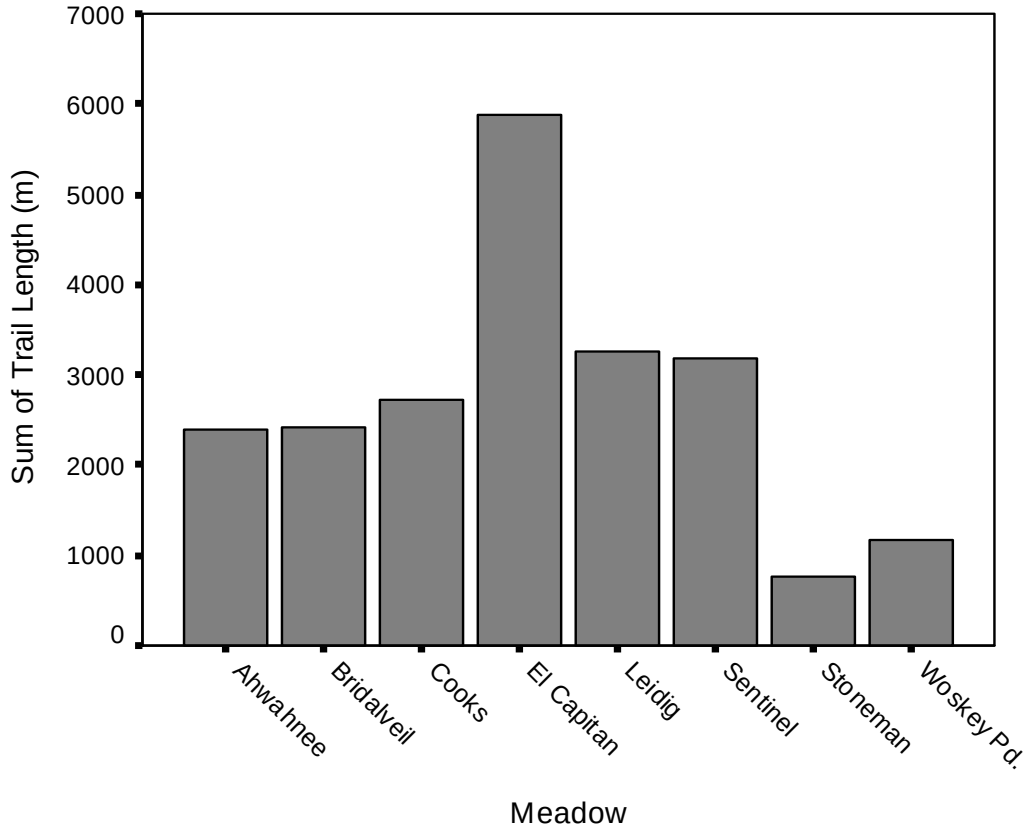


Figure B.6.3
Composition of resource conditions on social trails in eight meadows.

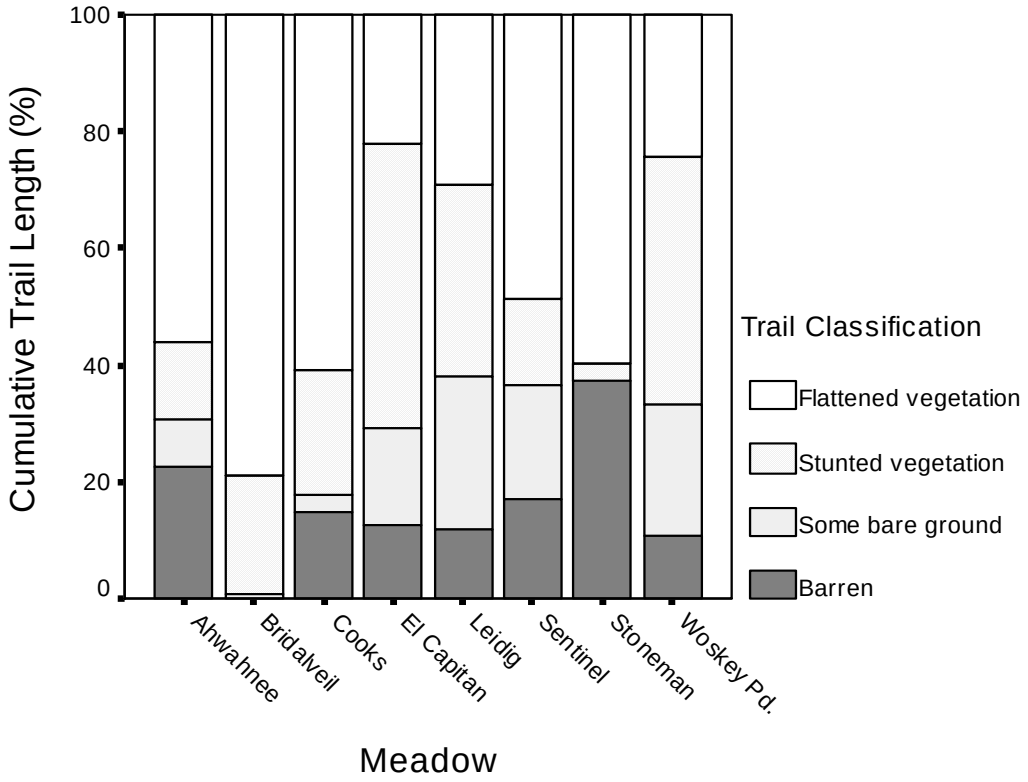
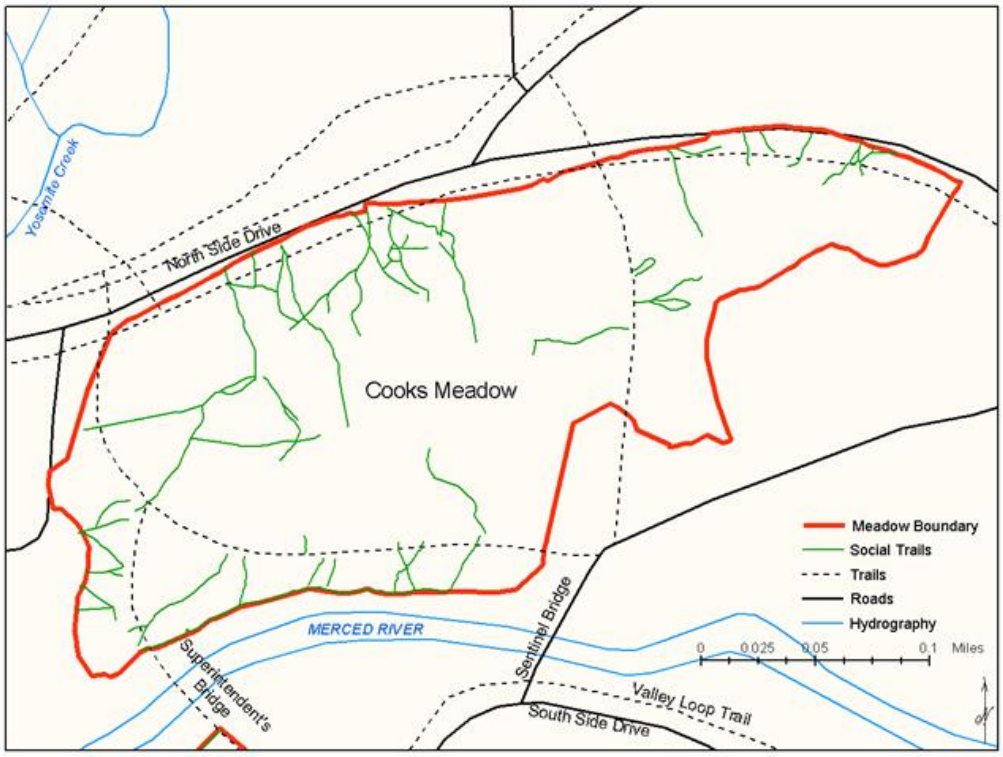


Figure B.6.4
Social trail map generated from the GPS/GIS data for Cooks Meadow.



B.6.4 Discussion and Conclusions

The first-cycle monitoring effort yielded a rich data set that serves as baseline for future monitoring. The results show common existence of social trails in all eight meadows, which are popular visitor attractions within Yosemite Valley. Many social trails originated from roadways where visitors park their vehicles and explore the meadows. Due to its location at the base of El Capitan and the associated location for viewing climbers, El Capitan Meadow had the most extensive network of social trails.

The complete baseline data set also facilitates development and evaluation of various indicator measures (or metrics/indices) in addition to total length. Examples include social trail length per unit meadow size, length of degraded social trails per unit meadow size, etc. While this is an excellent start, more work is needed to better define and assess social trails in such a way that field decisions can be made consistently and efficiently (see the following section for more discussion).

The utility of geospatial technologies in monitoring social trails was also revealed by the results. The communication of monitoring results was substantially enhanced using maps. The baseline data will inform sampling design and help prioritize monitoring effort for future monitoring when a complete inventory of social trails may not be feasible or necessary. The spatial patterns of social trails also enables analyses that would shed light on potential causes of the problem and management actions, especially when other resource data layers are integrated into this dataset.

B.6.5 Recommended Refinements to Monitoring Program

Wildlife trails caused some confusion during data collection. Field staff recommended conducting the survey before the fall deer rut to minimize the considerable time and effort required to distinguish animal and human-caused trails and map them. This type of data is very time-consuming to collect due to the area covered and the difficulty obtaining good

satellite coverage for GPS use in Yosemite Valley. The resulting data, however, is very useful. While refinements to the protocol will be implemented in 2005, the eventual frequency of monitoring could be every three years rather than every year.

Field staff also noted that the fifty-foot minimum trail length requirement for mapping, resulted in missing trail data for some significant (but short) trails. This issue will be examined further in the coming field season. It was also noted that there could be variability in social trail mapping and condition class assignment depending on the field personnel. For this reason, it is recommended that the standard be modified to include a 10% error factor.

B.6.6 Management Implications

The comprehensive survey of social trails in meadows in 2004 serves as a baseline and standard to which future surveys will be compared. As mentioned above, there were two areas where staff felt trail densities were excessive, though the rest of the meadow had low trail densities. The standard may need to be modified to take into account trail densities and provide management actions appropriate to reduce trail density.

B.7 RIVER BANK EROSION THAT IS ACCELERATED OR CAUSED BY VISITOR USE

River bank erosion has been selected as an indicator because soils are integral to the stability and integrity of riparian ecosystems which impact a number of Outstandingly Remarkable Values. Although soil erosion occurs along the river as a result of natural river processes, such erosion can be accelerated and exacerbated by visitor use (i.e., repeated trampling). Increasing visitor use on susceptible soils often results in increased soil erosion, so this indicator is valuable for assessing a site's ability to sustain varying amounts of visitor use.

The *User Capacity Management Program* identified two zones where riverbank erosion would be monitored. A more detailed description of this indicator is presented in the *User Capacity Management Program* on pages 59 and 60. The procedures for monitoring river bank erosion are presented in Section B.7 of the *Merced River Monitoring Field Guide - 2004 Pilot Season.*

Zones:

- Zone 2B: Discovery
- Zone 2C: Day Use

Standards:

- **Zone 2B: Discovery—**No net increase over baseline in linear extent of riverbank erosion that is accelerated or caused by visitor use; no riverbank erosion that exceeds Condition Class 2.
- **Zone 2C: Day Use—**No net increase over baseline in linear extent of riverbank erosion that is accelerated or caused by visitor use; no riverbank erosion that exceeds Condition Class 2.

B.7.1 Summary Statement

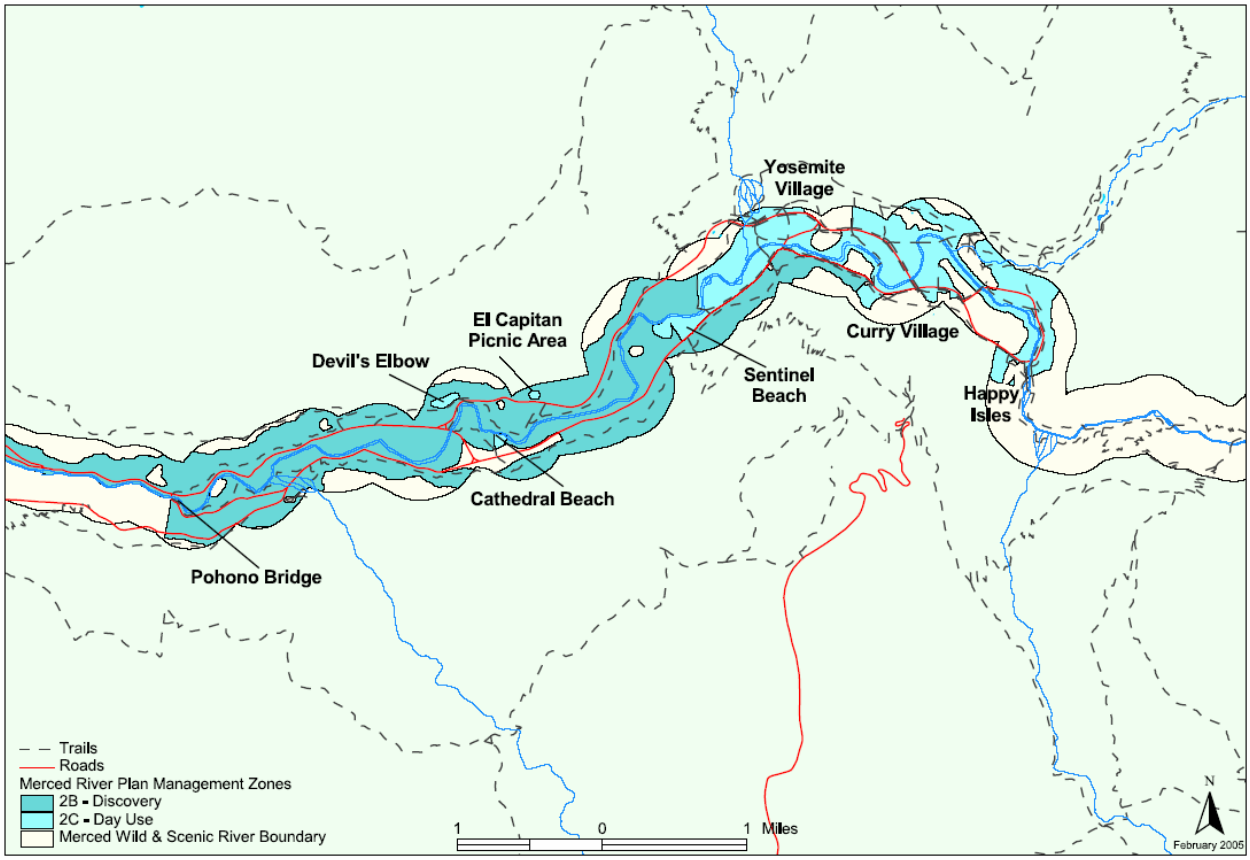
The protocol for this indicator required first identifying high-use zones and then sampling from those zones. To avoid biases in data collection, no sampling and assessment occurred this year, only identification of high use zones. *This protocol is being modified to better meet resource management and ecological restoration needs.*

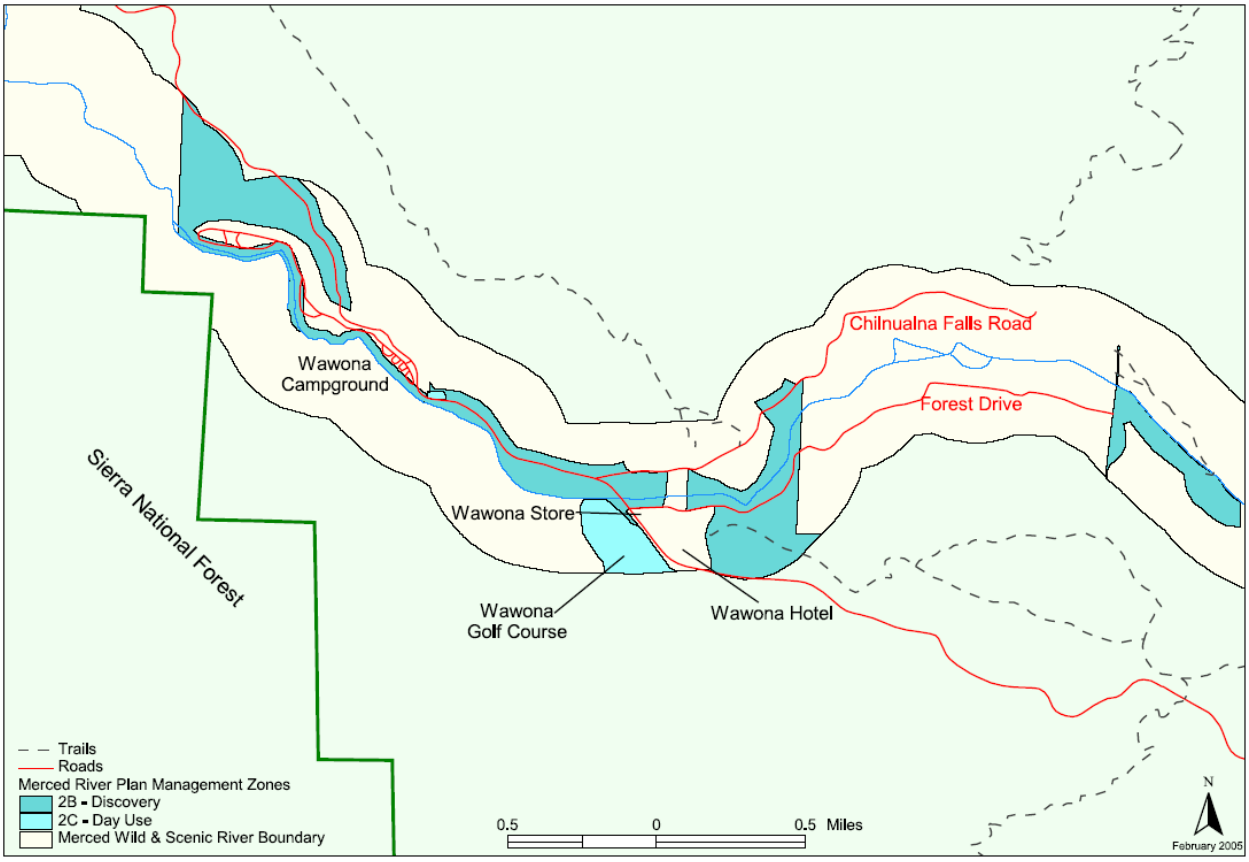
B.7.2 Monitoring Activities

Staff mapped and photographed high use zones along the river in management zones 2B and 2C (Figure B.7.1). These zones are characterized by greater than 75% vegetation loss and pulverized duff as compared to surrounding undisturbed areas. No sub-sampling of these zones was done. See the *Merced River Monitoring Field Guide - 2004 Pilot Season* for a complete description of the monitoring protocol.

Figure B.7.1

Locations of Management Zones 2B and 2C in Yosemite Valley (top) and along the South Fork Merced in Wawona (bottom).





B.7.3 Monitoring Results

As discussed in Section B.7.1 no assessment was performed in the 2004 field season. Field staff identified and established seventeen high use zones within the Valley for future monitoring purposes. The location of each zone was GPS mapped. No low use zones have been identified.

B.7.4 Discussion and Conclusions

No assessment results are available to support any discussion or conclusions.

B.7.5 Recommended Refinements to Monitoring Program

This monitoring protocol is being significantly modified for the 2005 season. Rather than defining high use zones and sampling within those zones, staff will map vegetation cover / erosion classes on river banks in the 2B and 2C zones. Once a baseline is established, this mapping would take place every three years to coincide with ongoing river cross-section surveys and would serve to prioritize riverbank restoration projects.

B.7.6 Management Implications

The standard for this indicator will be based on a baseline survey of the riverbanks. This baseline will be established in 2005.

B.8 EXPOSED TREE ROOTS IN DEVELOPED CAMPGROUNDS

This indicator is being monitored because several Outstandingly Remarkable Values associated with the Merced River are directly impacted by soil erosion. The *User Capacity Management Program* identified Zone 3A for monitoring of this indicator. A more detailed description of this indicator is presented on page 61 of the *User Capacity Management Program.* The procedures for conducting inventories of exposed tree roots are presented in Section B.8 of the *Merced River Monitoring Field Guide - 2004 Pilot Season.*

Zone:

- Zone 3A: Camping

Standard:

- **Zone 3A: Camping—**95 percent of campsites meet the none, slight, or moderate root exposure criteria as defined by inventory and monitoring guidelines (Marion, 1991).

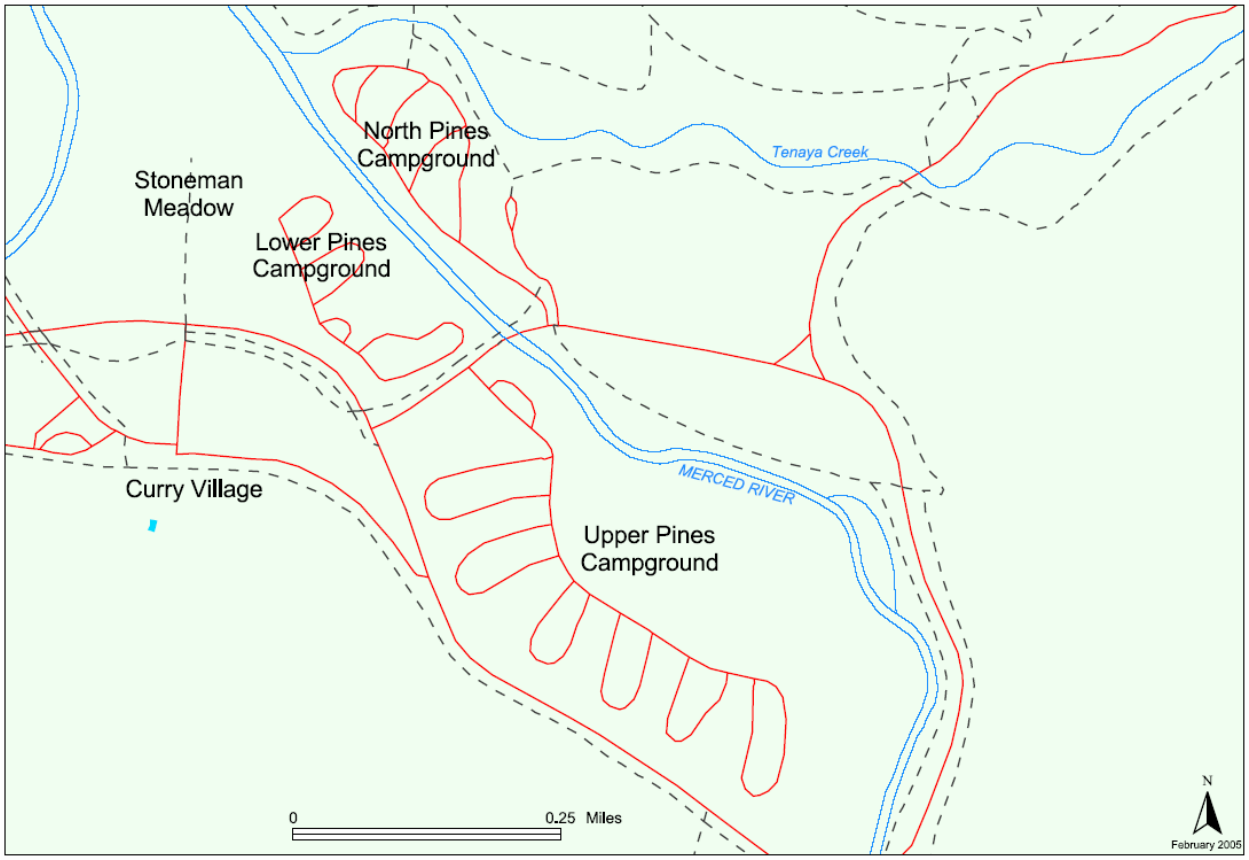
B.8.1 Summary Statement

The indicator as measured shows that greater than 95% of the campsites meet the "slight or none" root exposure criteria. This indicator appeared to be less sensitive to resource conditions than anticipated and will be discontinued in favor of other indicators.

B.8.2 Monitoring Activities

Staff recorded the condition class of four trees at each of 10% of campsites in North Pines, Lower Pines, and Upper Pines campgrounds in Yosemite Valley for a total of seven field days between July 14 and August 2, 2004 (Figure B.8.1). The tree nearest the campsite marker in each of four quadrants with a diameter greater than six inches was evaluated. Tree root exposure condition classes ranged from one (slight/none) to three (moderate) to five (severe). See the *Merced River Monitoring Field Guide - 2004 Pilot Season* for a complete description of the monitoring protocol.

Figure B.8.1
Campground areas in East Yosemite Valley sampled for tree root exposure in 2004.



B.8.3 Monitoring Results

A summary of monitoring results is provided in Table B.8.1. All 164 sampled trees received the 'none/slight' rating for root exposure with no variation.

Table B.8.1.
Results summary: Root exposure on developed campgrounds.

Campground	Sampling Points (#)	Trees Assessed (#)	Condition Rating		
			None/Slight	*Moderate*	*Severe*
North Pines	9	36	36*	0	0
Lower Pines	8	32	32	0	0
Upper Pines	24	96	96	0	0
Overall	41	164	164	0	0

** Number of trees.*

B.8.4 Discussion and Conclusions

The first-year monitoring identified no discernible root exposure on all randomly-selected trees at the three Zone 3A campgrounds. Such results suggest that minimal cumulative soil erosion exists on the campgrounds, and that the root system of trees is subject to little mechanical stress by human trampling forces.

The non-existence of variation in root exposure condition may also be a result of the limited sensitivity of Marion's rating scale (Marion, 1991). Refinement of this scale may be considered to detect sub-category changes that may have social, ecological or managerial significance.

B.8.5 Recommended Refinements to Monitoring Program

Staff noted that because all trees surveyed in the campground were condition class one (None/Slight), the method was not very sensitive and would be better for areas of riverbank adjacent to the campgrounds. Their observations were consistent with Wilderness staff comments on this methodology as applied to the Little Yosemite Valley Wilderness campground. As such, monitoring of this indicator will be discontinued.

This indicator may be more sensitive to soil erosion at higher elevations, such as Tuolumne Meadows and may eventually be employed as the VERP program is expanded to the rest of the park. For the Merced River corridor, monitoring of riverbank erosion (section B.7) adjacent to campgrounds will likely be more protective of the ORV's for which tree root exposure was intended.

B.8.6 Management Implications

Given the insensitive nature of this indicator as measured in 2004, measurement of this indicator will not be continued in favor of other indicators. This does not discount the value of this indicator and lessons learned from the 2004 season may well be applied in a user capacity program that encompasses the entire park. In its present form, however, this indicator is not very sensitive to change and does not address expansion of impact beyond developed campgrounds. Future forms of this indicator should place emphasis on the spread of impacts from highly developed and managed areas such as campgrounds to surrounding areas that are managed to allow natural processes predominate.

B.9 WATER QUALITY

This indicator is being monitored because water quality of the Merced River is directly impacted by human activities and contact. A more detailed description of this indicator is presented on pages 63 and 64 of the February 2004 *User Capacity Management Program.* The procedures for conducting water quality sampling and analysis are presented in Section B.9 of the *Merced River Monitoring Field Guide - 2004 Pilot Season.*

Standard:

- Anti-degradation for each segment, for fecal coliform, nutrients (total dissolved nitrogen, nitrate, total dissolved phosphorous, and total phosphorus), and petroleum hydrocarbons.

B.9.1 Summary Statement

Water quality sampling on the Merced River from June through October 2004 revealed decreasing concentrations of nitrate and dissolved nitrogen compounds and fecal coliform as water levels declined and water temperatures increased through the summer. During the same period, total phosphorous and dissolved phosphorous concentrations increased. Nutrient concentrations were all quite low with respect to state drinking water standards and below the detection limit of many standard analytical methods.

Fecal coliform levels were all well below the state standard for recreational contact. One particularly high reading was obtained from one storm-event sample taken at the Foresta Bridge (900 MPN/100 ml on October 19th, 2004). High values such as this are expected following the first large storm after the long summer dry season.

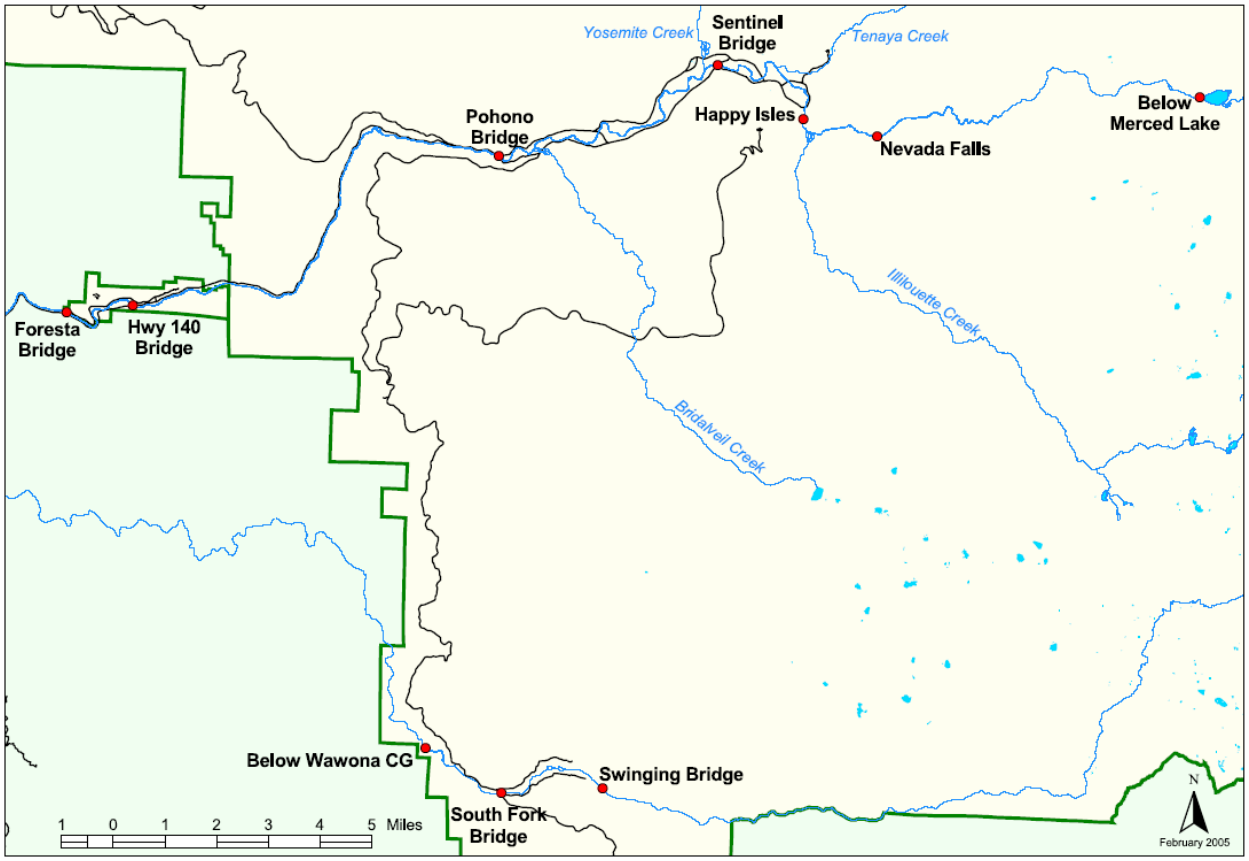
No petroleum hydrocarbons were detected during this period.

B.9.2 Monitoring Activities

Staff sampled at ten locations monthly on the Merced River and South Fork (Figure B.9.1) in coordination with state-mandated water quality sampling conducted by Park utilities personnel at the waste water treatment plants in Wawona and El Portal. In addition, the first winter storm of the season was sampled on two different days in October. Nutrients (total dissolved nitrogen, nitrate, total phosphorous, and total dissolved phosphorous) were sampled at all sites. Fecal coliform was sampled only at front country sites due to the maximum six-hour hold time for these samples. Total petroleum hydrocarbons were sampled at three locations downstream of developed areas. In addition to collecting samples, field staff measured water temperature, specific conductivity, pH, and dissolved oxygen as well as river stage where possible. See the *Merced River Monitoring Field Guide - 2004 Pilot Season* for a complete description of the monitoring protocol.

Figure B.9.1

Water quality sampling locations.



B.9.3 Monitoring Results

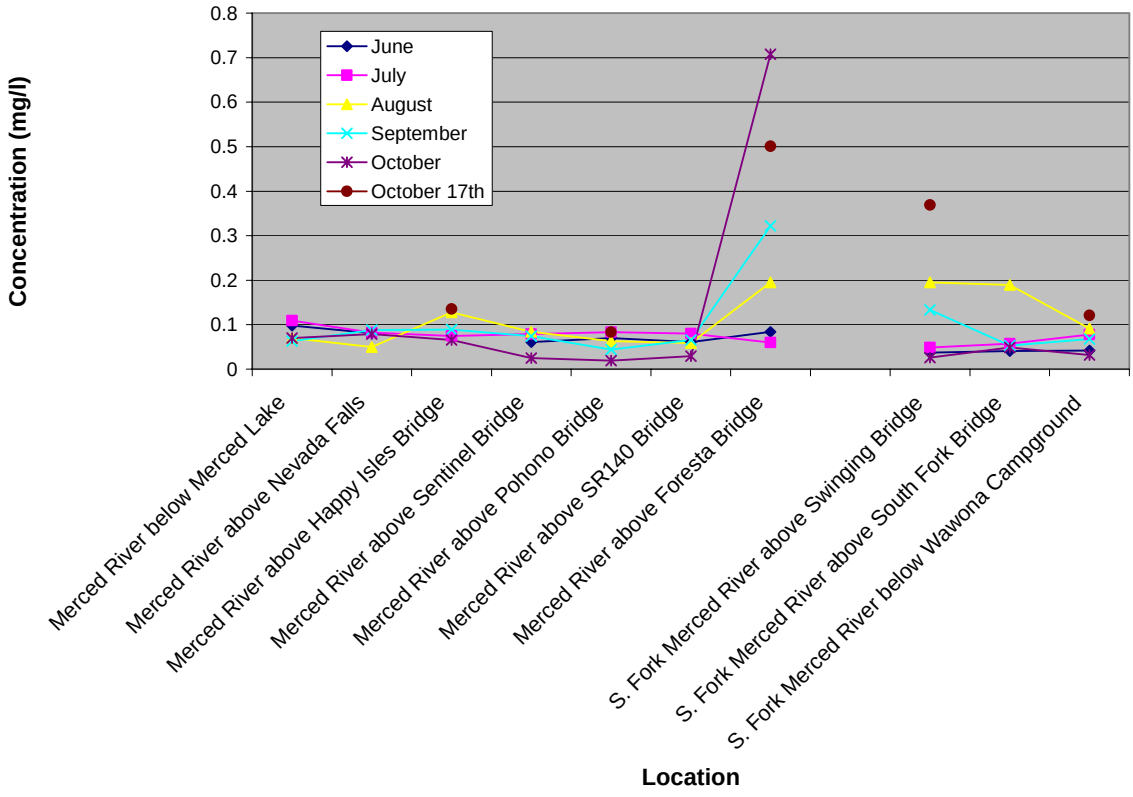
Table B.9.1 summarizes descriptive statistics on field parameters measured as a part of sampling.

Table B.9.1
Field Parameter Statistics, water quality monitoring results

Parameter	Mean	Median	Mode	Minimum	Maximum
Water Temperature (°C)	14.2	13.1	10.6	7.6	21.8
Specific Conductivity (µS/cm)	32.1	33.4	9.4	6.6	73
pH	6.9	6.9	6.4	6.2	7.6
Dissolved Oxygen (mg/l)	8.4	8.6	7.3	5.8	10.2

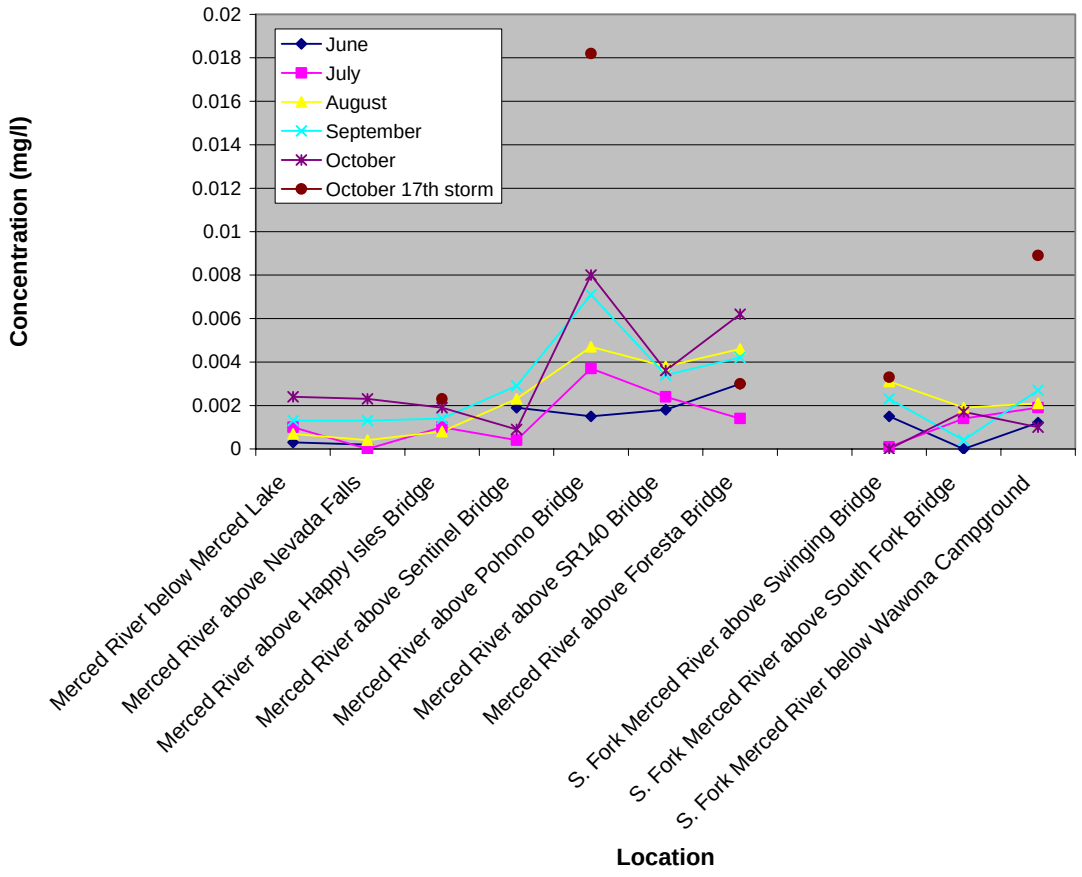
Concentrations of dissolved nitrogen generally decreased as the summer progressed and downstream with some exceptions (Figure B.9.1). Samples from below Foresta Bridge indicated increasing concentrations until the October 17th storm. This concentration could have been increasing simply as a result of decreasing flow volume during this period. Nonetheless, there was a source of total dissolved total nitrogen (most of which was nitrate) between the State Route 140 Bridge and the Foresta Bridge. These concentrations were below the detection limit of most standard tests for nitrate (2 mg/l) and well below the state standard for nitrate in drinking water (50 mg/l).

Figure B.9.2
Total Dissolved Nitrogen (June – October 2004).



Phosphorous species concentration generally increased as the summer progressed and downstream (Figure B.9.2). These increases were most noticeable at Pohono Bridge and Foresta Bridge. While intriguing, concentrations were extremely low, near or below the reporting limit (Method Reporting Limit = 0.004 mg/l). Values below the Method Reporting Limit are displayed for illustration purposes only and are not considered valid data. Monitoring of these constituents will continue in the interest of affirming their extremely low concentrations.

Figure B.9.3
Total Dissolved Phosphorous Concentration (June - October 2004)



Fecal coliform results were quite scattered with the exception of the one storm event sample (Table B.9.2). In general, though, fecal coliform levels were quite low for the period of measurement. The higher values obtained during the October 17th storm were consistent with the first flush of sediment and animal waste from the surrounding hillslopes following at least six months without significant precipitation. One would expect to see lower values through the winter and during spring runoff. The state standard for recreational contact is 400 MPN/100 ml (geometric mean of five samples in a one month period). Though one value of 900 MPN/100 ml was high, a geometric mean of five samples taken over the course of the month would likely reveal a much lower value.

Table B.9.2
Summary of Fecal Coliform Data, June to October, 2004

Site Name	Date	FecalColiform (MPN/100ml)*
Merced River above Happy Isles Bridge	7/01/2004	<2
	8/05/2004	23
	9/02/2004	4
	10/07/2004	<2
	10/19/2004	50
Merced River above Sentinel Bridge	7/01/2004	4
	8/05/2004	17
	10/07/2004	17
Merced River above Pohono Bridge	7/01/2004	2
	8/05/2004	2
	9/02/2004	<2
	10/07/2004	<2
	10/19/2004	130
Merced River above SR140 Bridge	7/01/2004	<2
	8/05/2004	<2
Merced River above Foresta Bridge	7/01/2004	<2
	8/05/2004	<2
	10/19/2004	900
S. Fork Merced River above Swinging Bridge	6/30/2004	<2
	8/04/2004	2
	9/01/2004	2
	10/06/2004	2
	10/19/2004	30
S. Fork Merced River above South Fork Bridge	6/30/2004	50
	8/04/2004	30
	9/01/2004	11
	10/07/2004	8
S. Fork Merced River below Wawona Campground	6/30/2004	30
	8/04/2004	14
	9/01/2004	7
	9/01/2004	8
	10/06/2004	<2
	10/19/2004	220

*Most Probable Number (of colonies) per 100 milliliters

No petroleum hydrocarbons were detected in samples collected during the sampling period. The method detection limit of the utilized analytical method was 1mg/l. While this is good news, there is a need to shift to more sensitive methods in the future in order to establish a baseline.

B.9.4 Discussion and Conclusions

Results from water quality sampling indicate low levels of nutrients, fecal coliform, and petroleum hydrocarbons. It should be emphasized that these data are being collected to construct a baseline and standard for water quality and represents less than 50% of the sampling scheduled to take place annually over the next 2-4 years. In order to establish this baseline, all nutrient analyses are being conducted by the U.S. Geological Survey National Water Quality Laboratory which has available much lower detection limits than conventional commercial laboratories. While some interesting spatial patterns have emerged thus far, the observations on this season's data are not rigorously supported by the data. Until more complete data exist that represent an entire annual cycle and inter-annual variability, any observations must be qualitative in nature.

Future analysis will be presented in terms of descriptive non-parametric statistics for each sampling location. This would consist of box and whisker diagrams depicting 20 and 80 percentile values, mean, median, mode, and extremes for each analyte.

B.9.5 Recommended Refinements to Monitoring Program

Very few changes are recommended for the coming year of water quality monitoring. Most of the following recommendations would be carried out as field experiments to increase the accuracy of measurements and streamline the process:

1) Sample at several different times of day during the summer to see if increased temperatures and human use later in the day has an effect on concentrations of nutrients and fecal coliform bacteria. This would depend on the ability to analyze fecal coliform in-park given the six-hour hold time for these samples.

2) Use autosamplers to sample storm events, and refine the definition of a storm event; a trigger point such as a doubling of discharge during the course of the storm as measured at Happy Isles Gage could be used.

3) Switch to a more sensitive measure of total petroleum hydrocarbons.

4) Experiment with sampling using depth integrated samplers verses grab-samples at high water and low water. Grab samples are much easier to collect and less time-consuming.

5) Enter data on a PDA.

B.9.6 Management Implications

All data to date indicate very good water quality along the main stem and South Fork of the Merced River. The sample size is very small with respect to the potential variability in the data, however, and it is not yet possible to draw conclusions for the purposes of deciding potential management actions.

A more sensitive method of total petroleum hydrocarbon analysis should be used to establish baseline levels. If after using more sensitive analyses, petroleum hydrocarbon levels are found to be quite low or undetectable, consideration should be given to reducing the sampling frequency. Sampling in this case could be conducted every third year and whenever road resurfacing activities occur (or as recommended by the NPS Water Resources Division). These tests are expensive and the cost savings could support other monitoring activities.

C.1 SUMMARY

During 2004, ten indicators of resource condition or visitor experience and their respective standards were developed to address the need to monitor Outstandingly Remarkable Values of the Merced Wild and Scenic River corridor. Subsequent development of field monitoring protocols, data collection and organization, and season review have led to the publication of this report. This process has led to the decision to retain six of the 2004 indicators and standards, in modified forms, for the 2005 season. These are:

- Encounters with other parties in Wilderness
- Number of people at one time (PAOT) in Wilderness
- Number of social trails
- Length of social trails in meadows
- Riverbank erosion
- Water quality

The remaining 2004 indicators need significant modification to be applicable in the Merced River corridor. Modified or unaltered, these indicators and standards may be applicable in other areas of the park. Documentation of the 2004 results in this document is a record for future consideration of these indicators as VERP expands to the rest of the park.

Of the six indicators to be retained, several required modification of the standard to reflect data collection limitations or more protective indices. The encounters with other parties in Wilderness indicators should be measured in terms of parties encountered per hour until more research indicates the amount of time people spend in specific management zones. The standard for length of social trails in meadows could be modified to length of social trail per unit area of meadow in order to address the issue of high trail densities in some meadows. In cases where the standard was obviously violated (Number of social trails), staff will investigate the situation and suggest management action(s).

In 2005, the park will monitor an additional five indicators developed over the past year. These are:

- Integrity and condition of three traditional plant resources
- Proportion of day use facilities occupied
- Occupied parking versus capacity
- Exposure of wildlife to human food
- Number of people involved with recreational activities in the river corridor

This sequence of indicator and standard development, monitoring protocol development, field testing and protocol refinement, and data review will be typical of the sequence of activities each year during the pilot phase of VERP monitoring.

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F.1. GLOSSARY

Carrying Capacity: As it applies to parks, carrying capacity is the type and level of visitor use that can be accommodated while sustaining the desired resource and social conditions that complement the purpose of a park unit and its management objectives.

Geographic Information System (GIS): A computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically, a Geographical Information System (or Spatial Information System) is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image of a map.

Global Positioning System (GPS): The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS.

Grab Sample: Water sample collected in a bottle from the edge of a river or lake. Such a sample is often subject to local influences and may not be representative of the entire water body.

Indicator: Indicators are specific, measurable physical, ecological, or social variables that reflect the overall condition of a management zone. Resource indicators measure visitor impacts on the biological, physical, and/or cultural resources of a park; social indicators measure visitor impacts on the park visitor experience.

Integrated Sample: Water sample collected with device designed to assure uniform distribution of sampling. For example: A depth-integrated sample would contain equal amounts of water from all depths in the middle of a river. Such a sample is often more representative of the entire water body.

Management zone (zone): A geographical area for which management directions or prescriptions have been developed to determine what can and cannot occur in terms of resource management, visitor use, access, facilities or development, and park operations.

Method Detection Limit: Lowest reliable concentration of a chemical constituent detectable by a particular analytical method.

Method Reporting Limit: Lowest reportable concentration of a chemical constituent of a particular analytical method. Generally 2-3 times the Method Detection Limit.

Outstandingly Remarkable Values (ORVs): Those resources in the corridor of a Wild and Scenic River that are of special value and warrant protection. ORVs are the “scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values…that shall be protected for the benefit and enjoyment of present and future generations” (16 USC 1272).

River corridor: The area within the boundaries of a Wild and Scenic River (e.g., the Merced River corridor).

Standard: Standards define the minimum acceptable condition of each indicator variable. A standard does not define an intolerable condition.

Social Trail: A social trail is an informal, nondesignated trail between two locations. Social trails often result in trampling stresses to sensitive vegetation types.

User capacity: As it applies to parks, user capacity is the type and level of visitor use that can be accommodated while sustaining the desired resource and social conditions based on the purpose and objectives of a park unit.

Visitor experience: The perceptions, feelings, and reactions a park visitor has in relationship with the surrounding environment.

Visitor Experience Resource Protection (VERP): A process developed for the National Park Service to help manage the impacts of visitor use on the visitor experiences and resource conditions in national parks.

Wetland: Wetlands are defined by the U.S. Army Corps of Engineers (CFR, Section 328.3[b], 1986) as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Wild and Scenic Rivers: Those rivers receiving special protection under the Wild and Scenic Rivers Act.

Wilderness: Those areas protected by the provisions of the 1964 Wilderness Act. These areas are characterized by a lack of human interference in natural processes.

Wilderness Impact Monitoring System (WIMS): An inventory process that monitors campsite and trail conditions in Yosemite National Park backcountry and wilderness.

G.1. ACRONYMS

°C	Degrees Centigrade.
CMP	(Merced Wild and Scenic River) Comprehensive Management Plan
DO	Dissolved Oxygen
DOQs	Digital Orthophotographic Quadrangles
GIS	Geographic Information System
GPS	Global Positioning System
Km	Kilometer
L	Liter
M	Meter
mg/l	Milligram per Liter
ml	Milliliter
MDL	Method Detection Limit
MPN	Most Probable Number (of colonies)
NPS	National Park Service
PDA	Personal Data Assistant
PAOT	People at one time
pH	Potential Hydrogen
SOP	Standard Operating Procedure
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
µS/cm	Micro-Siemens (a measure of electrical conductivity)
VERP	Visitor Experience and Resource Protection
WIMS	Wilderness Impacts Monitoring System