ADOPT-A-BEACH PROGRAM
Long-Term Monitoring of Camping Beaches in Grand Canyon

Summary of Monitoring Observations for Year 2016

By
Paul Lauck[1]

January 31, 2018

Example of sand depletion from beach due to wind activity over four month period.
Upper North Canyon Camp, RM 20.7 R. Photo on left taken April 4, 2016 and photo on right taken August 6, 2016.

[1]Grand Canyon River Guides, Inc.
PO Box 1934, Flagstaff, AZ 86002

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Abstract

For the past twenty-one years, the Adopt-A-Beach repeat photography program has been monitoring beaches along the Colorado River through Grand Canyon. By comparative examination of photo series and on-the-spot observations contributed by the volunteer photographers, conditions pertaining to the desirability of the beach as a camp for rafting parties are evaluated. Factors considered, which contribute to changes that may have an effect on the camp, both positive and negative, include: fluctuating river flows, aeolian action, vegetation increase/decrease, human introduced change, rain associated erosion or other actions, natural or anthropomorphic,. Beginning at River Mile 11.3, as measured downstream from the United States Geological Survey gaging station at Lees Ferry, AZ (USGS, 2013), the 239 miles of river in the study are divided into four separate geomorphic reaches, and the resulting evaluations are also segregated and examined by reach. The conclusions are presented as observational, monitoring data only.

For the time spanning the 2016 summer boating season, early April to late October, 39 of the 44 study beaches in the program had photographs and photographer comment sheets deemed of a sufficient period of time to be evaluated. Of these 39 beaches, 44% were classified as Unchanged for the time period, only one, or 3%, had Improved through the summer and 54% were considered as having Degraded by the end of the season. Of the 17 Unchanged beaches, 18% are located in the Marble Canyon reach, 53% in the Upper Granite Gorge reach, and 29% are contained in the Muav Gorge reach. None of the Unchanged beaches were in the Lower Granite Gorge reach. Twenty-four percent of the 21 beaches classified as Degraded are located in the Marble Canyon reach, another 24% in the Upper Granite Gorge reach, 43% are found in the Muav Gorge reach and 10% were located in the Lower Granite Gorge reach. The single Improved beach was located in the Upper Granite Gorge reach and was classified as Improved based solely on observer comments that parking of craft was easier at lower river levels. The primary factor cited for those camps classified as Degraded was the fluctuating flow releases from Glen Canyon Dam. This designation applied to 14 of the beaches. There were 5 beaches classified as Degraded were rain events are cited as the primary cause. Wind erosion, vegetation increase and human impacts were also cited as present, and all were considered the primary agent of change on at least one beach each.

A comparison of beach evolution from late season 2015 to early April 2016 was conducted on a total of 37 beaches. One third (32%) of the beaches appeared to have Improved by the spring of 2016, 19% of the beaches Degraded during the winter, and nearly half, 49%, were considered Unchanged. Of the 7 beaches classified as Degraded for this period, one (14%) is located in the Marble Canyon reach, none are found in the Upper Granite Gorge reach, 57% are in the Muav Gorge reach and 29% are in the Lower Granite Gorge. Twelve beaches showed an Improved state for this period, with 42% in the Marble Canyon reach, 33% in the Upper Granite Gorge, 17% in the Muav Gorge reach and 1 (8%) is in the Lower Granite Gorge reach. Of the 18 beaches classified as Unchanged over the winter, 17% reside in the Marble Canyon reach, the Upper Granite Gorge and Muav Gorge reaches had 44% and 39% respectively and none are located in the Lower Granite Gorge.

[1] Grand Canyon River Guides, Inc., Flagstaff, Arizona (928) 773-1075

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Introduction and Background

In 1981, the Glen Canyon Environmental Studies (GCES), under the administration of the Bureau of Reclamation, began to study the effects of controlled flow releases from the dam on the downstream river ecosystem (U.S. Department of Interior 1987). Included in this study were effects on sediment supply and recreational resources. Studies of sediment dynamics showed that fluctuating flow releases from the dam have had a degrading effect on sand bar deposits (Hazel and others 1993, Schmidt and Graf 1990) since the closure of the dam. However, beaches can also be replenished by high flows adequate to entrain bedload sand and cause deposition to high elevation areas of beaches (Parnell and others 1997, Wiele and others 1999). Studies of campsite resources demonstrated that the impact to sand bars due to erosion decreases the carrying capacity and camping area available for river parties and backpackers (Kearsley and Warren 1993, Kearsley and Quartaroli 1997).

The Grand Canyon Protection Act was passed by Congress in 1992 to ensure that ecological and cultural resources downstream of the dam would be monitored for changing conditions imposed by operation of the dam. The Act states that Glen Canyon Dam:

"….must be managed in such a way as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park….were established, including, but not limited to, natural and cultural resources and visitor use" (U.S. Department of Interior 1996).

In 1996, following completion of the "Operation of Glen Canyon Dam: Final Environmental Impact Statement" (EIS), a Record of Decision was signed and implemented which included provision for the use of "beach/habitat-building flows." Now referred to as High Flow Experiments (HFE), the EIS defined these events as "…scheduled high releases of a short duration designed to rebuild high elevation sandbars, deposit nutrients, restore backwater channels and provide some of the dynamics of a natural system" (U.S. Department of the Interior, 1995), with the added intent of restoring some of the dynamics that resulted from flooding in the ecosystem. Further, an HFE is defined as a flow release exceeding 31,500 ft^3/s. Sandbars form when sediment carried by the river, either from bed load or suspended load, is deposited by the action of eddy currents in recirculation zones. This occurs primarily on the downstream end of debris fans, but also in areas along the river's channel margin (Schmidt 1990). The first HFE was conducted in late March 1996, and consisted of a 7-day steady release of 45,000 ft^3/s that was preceded and followed by steady flows of 8000 ft^3/s for 4 days each (Melis, 2011).

Grand Canyon beaches form the substrate for communities of plants, invertebrates and vertebrates, including species such as riparian birds (Carothers and Brown, 1991). These beaches are also an important resource for river parties conducting trips through Grand Canyon. Both commercial and private river trips, as well as backpackers, rely on wide sandy areas for camping and recreation. Consequently, those who run the river are interested in observing the changes to camping beaches throughout the river corridor in the Grand Canyon. As a non-profit organization dedicated to protecting Grand Canyon and the Colorado River experience, Grand Canyon River Guides developed and implemented the Adopt-a-Beach Repeat Photography (AAB) program prior to the initial flood event in 1996 in order to assess the evolving state of the recreational resource. The use of photographic duplication over time, and analysis of the differences between photo duplicates as a means of detecting change in the Grand Canyon landscape, has been demonstrated previously (Turner and Karpiscak 1980, Webb 1996). AAB is a long term monitoring program that relies on systematic photograph replication to document and analyze changes in sand deposition and other physical attributes using a dataset of 44 camping beaches along the Colorado River corridor in Grand Canyon. A cooperative agreement with Grand Canyon Monitoring and Research Center (GCMRC), ensures that the extensive AAB photo archive and legacy data are incorporated into the GIS Campsite Atlas project to build a more complete and robust understanding of the status, trends and conditions of camping beaches in the river corridor affected by the operations of Glen Canyon Dam.

Since its inception in 1996, the Adopt-A-Beach program has utilized volunteer photographers to conduct repeat photography of these camps. Professional river guides and other river runners make the program possible, contributing 100% of the manpower, the entire dataset of repeat photographs, and valuable input about the condition of beaches throughout each field season and between years. Volunteer photographers for this program are unique in that many run the Colorado River more than once in one season, and are able to provide sets of repeat photographs and on-the-spot comments for each study beach. With the end of the 2016 season, and the addition of new 1440 images, river runners have produced more than 12400 replicate photographs on more than 3730 dates with associated field sheets recording the sequential condition of beaches.

Standardized comment forms completed by the volunteers at the time the photographs are acquired, assisting in the effort to document the beach conditions (see Appendix B). The program assesses the visible photographs and first-hand, objective comments pertaining to changes to beaches, and reports on the conditions as influenced by regulated flow regimes, rainfall, wind, vegetation, human impacts or any other factors that may be present. Monitoring includes information on natural and human-induced impacts to beaches such as cutbank retreat, wind erosion and dune formation, rain gully formation and the effects of visitation and camping (Lauck, 2009).

The presence and impact of the tamarisk beetle, *Diohabda spp*. have been included in these comments and documented photographically at least as early as 2011. Beginning with the 2014 season, photos are acquired simultaneous to the beach photographs with the specific intent on monitoring the beetle activity. This component of the analysis was added not only for ecological monitoring reasons, but also because of related questions pertaining to the recreational experience: will the beetle remove valuable shade from camping areas, how will other vegetation respond to the impacts on the tamarisk and how might these changes affect the camp.

The purpose of this report is to present the results of the monitoring effort for the period between late 2015 and late November 2016 prior to the HFE conducted during that month.

Research results include reporting positive “Improved” conditions, negative “Degraded” conditions or “Unchanged” conditions, when no changes were found in beaches. Attributes of the primary and secondary processes that cause change in camping beach area and quality are also included. Specific research questions that are addressed by this report are:

- What changes, if any, are found at the beaches through the boating season of 2016?
- What changes occurred in beach conditions during the winter between late 2015 and April 2016?
- How are the resulting observations distributed throughout the river corridor?
- Which processes resulting in a change of condition at a beach are most prevalent?

Methods

Study locations and beaches

Since 1996 the AAB program has studied an average of 37 of the 44 targeted beaches per year from within three of the five *critical reaches* of the river corridor (Figure 1). The practice of assessing camping beach resources within critical reaches was first developed by Kearsley and Warren (1993), and modified for the 1996 Adopt-a-Beach study by Thompson and others (1997). A critical reach is defined as a section of the river where camps are in high demand and few in number. The same reach system has been in use for all years of study, 1996-2015. All river miles used conform to the GCMRC mileage system (USGS, 2013). The reaches are as follows: 1) Marble Canyon, river miles 9-41; 2) Upper Granite Gorge, river miles 71-114; 3) Muav Gorge, river miles 131-165.

Two additional critical reaches were added during the 2003 monitoring season. The purpose was to increase the sample set of beaches in order to more widely represent the effects of beach erosion and building throughout the whole river corridor below Glen Canyon Dam. These new reaches included Glen Canyon, from the dam to Lees Ferry (river mile 0), and Lower Granite Gorge, from Diamond Creek (river mile 226) to Gneiss Canyon (river mile 236). Unfortunately, no data has been collected for the Glen Canyon reach for a few years, but the Lower Gorge reach, which was been extended to include the 250 Mile Camp in 2009, is still being actively monitored.

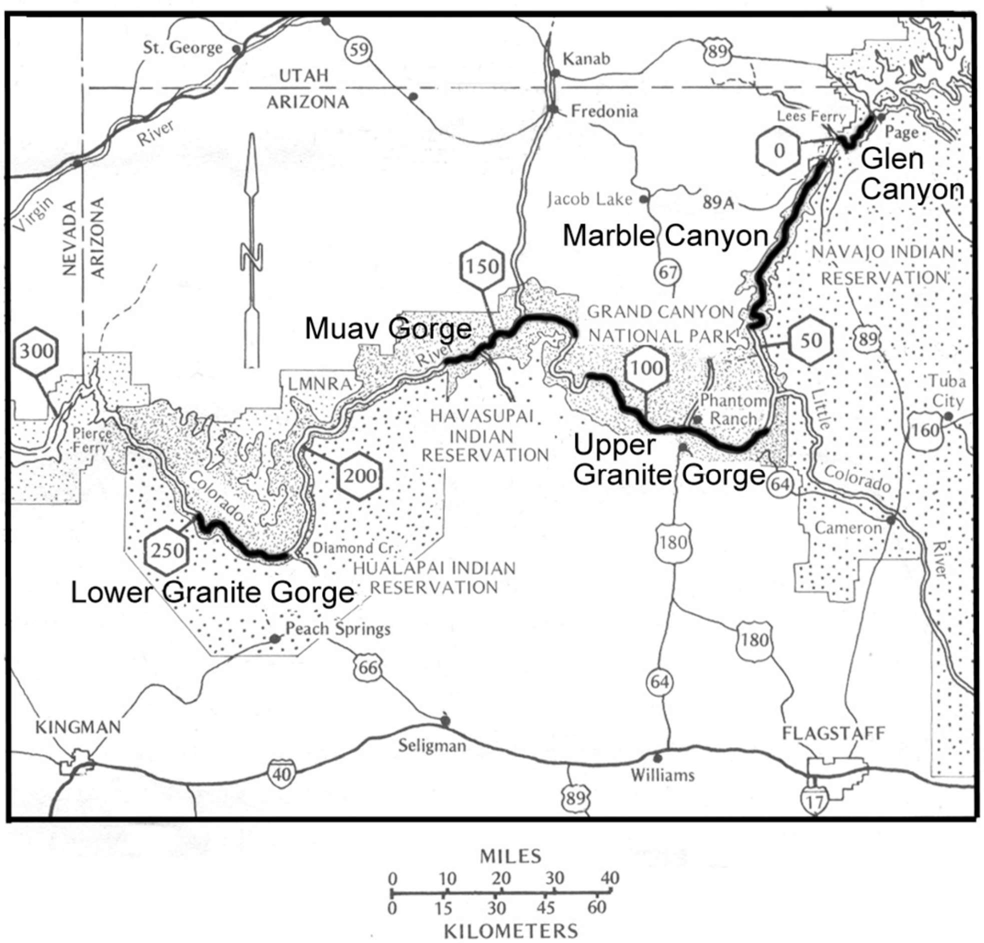

Figure 1. Locations of five critical reaches along the Colorado River in Grand Canyon National Park

Table 1 shows popular campsites (n = 44), 34 of which were originally inventoried in 1996, and includes beaches added in 2000, 2001 and 2009.

Glen Canyon		Marble Canyon		Upper Granite Gorge		Muav Gorge		Lower Granite Gorge	
Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp
-13.0	Dam Beach	11.3	Soap Creek	76.0	Nevill's	131.7	Below Bedrock	230.6	Travertine
-8.0	Lunch Beach	12.4	12.4 Mile (Salt Water Wash)	77.1	Hance	132.5	Stone Creek	236.1	Gneiss Canyon
		16.6	Hot Na Na	81.7	Grapevine	133.7	Talking Heads	250.0	250 Mile
		19.4	19.4 Mile	84.6	Clear Creek	134.2	Race Track		
		20.7	North Cyn	85.0	Zoroaster	134.5	Lower Tapeats		
		22.7	23 Mile	92.1	Trinity Creek	135.2	Owl Eyes		
		29.5	Shinumo Wash (Silver Grotto)	96.6	Schist	137.8	Back Eddy		
		35.0	Nautiloid (Middle&Lower)	97.3	Boucher	144.0	Kanab Creek		
		37.9	Tatahatso	98.7	Crystal	146.1	Olo		
		38.6	Martha's (Bishop's)	100.2	Lwr Tuna	148.9	Matkat Hotel		
		41.2	Buck Farm	108.3	Ross Wheeler	150.9	Upset Hotel		
				109.0	Lwr Bass	156.3	Last Chance		
				110.0	110 Mile	165.2	Tuckup		
				114.9	Upper Garnet	167.0	Upper National		
				115.1	Lower Garnet	167.2	Lower National		

Table 1. Sample set of camping beaches inventoried that lie within the five critical reaches.

Unlike other established re-photography studies, both within and outside of the Grand Canyon, the AAB program does not adhere to a regime which includes matching photos per a specific time of day or date (Webb1996, Webb, Boyer and Turner, 2010). The photographs obtained here are much more opportunistic and acquired whenever a volunteer happens to pass their chosen camp. However, guidelines for the volunteer are provided to help regulate the consistency required to make adequate comparisons between the images. Every beach in the inventory has an established photographic location that shows an optimum view of the beachfront and as much of the actual camping area as possible. However, the portion of the camp photographed at each beach, the relative photographic locations between beaches and the number of images acquired per beach are not all the same. This means that one beach may be evaluated through slightly differing information than another one, in that not every beach photo set contains the same 'clues.' The resulting evaluations can only be compared with results for camps using the same views. Most commonly, the photos are shot from the boat on the river, taken as a single image or series, to provide a full, upstream to downstream look at the beach. Photos taken from specifically designated locations on shore, looking across the front of the beach, usually from an elevated, oblique angle, are often acquired as well. Combined, these views provide a considerable amount of information for analysis.

A few beaches are photographed from the river only. Unfortunately, this often limits the visibility of the upper or rear part of the camp. Efforts are being made to expand these visits to include a shore-based view, but this is completely up to the volunteer and their time available. Also, almost half of the beaches have photo locations toward the back of the camp, looking across the upper part of the beach or toward the river. While not always practical, these views are invaluable additions to the beach dataset.

Each year, GCRG motivates guides to adopt as many beaches as possible. To encourage a relatively complete data set from year to year, GCRG encourages adoption of high-priority beaches (n = 27) first. These beaches have been adopted for most of the study years. Usually, they are camps that can be used year after year by the river community, and thus are continually in high demand. The remaining beaches are adopted once high-priority beaches have been claimed.

*Figure 2 & 3. Example of beach with fluctuating flow recession and rock exposure.
Stone Creek Camp, RM 132.5 R, April 12, 2016 (top) and September 13, 2016 (bottom).
Red dot identifies reference rock.*

The time-series photos taken within study locations allow assessment of relative change over the course of each season and between monitoring years. The number of adopted beaches with useable season long data in 2015 totaled 37. Each record in the data base represents an individual visit to a beach where each beach usually has 1-5 photos associated with it. Adopters often take extra snapshots of various impacts such as flash flooding in Schist Camp (August 2002) and North Canyon (October 2010) and debris flows at National Canyon (July 2012). These documented events and data are available to any interested researchers through Grand Canyon River Guides or Grand Canyon Monitoring and Research Center, http://www.gcmrc.gov/ and the images are currently available as part of the Adopt-A-Beach photo gallery, http://www.geanious.com/gallery/main.php. Part of the Adopt-A-Beach program is to provide photos of unusual natural events in Grand Canyon to interested parties.

Analysis

When a volunteer requests a camera and a beach assignment, they are asked to photograph a completed datasheet (Appendix B), identifying the beach name and mile, plus the photo date and time, immediately prior to photographing the camp. This information is included in the captioning of the image, and helps to correctly place the photo chronologically during analysis. While this practice occurs most of the time, occasionally the datasheet is photographed later or, rarely, not at all. Photos without a distinct date/time attribute in the photography sequence are examined by water color, shadowing on the surrounding walls, or other common elements such as guest attire when available, to help correctly identify the proper sequential placement of the image(s). Embedded metadata in the image can also be used as reference to correctly code the image by date and time. It is possible that the date/time attributes are incorrectly applied to a very few images.

When comparing the photos for evaluation, numerous criteria are used to gather the empirical data. After the images are sorted by camp and have been given a date and time caption, a consistent pattern of examination was conducted for every analysis. This began with the water level determination for the first image examined in any set. This was accomplished by consulting the flow graph of one or all of the following USGS gauges: Colorado River at Lees Ferry, AZ (09380000), Colorado River Near Grand Canyon, AZ (09402500), Little Colorado River Above Mouth Near Desert View, AZ (09402300), Kanab Creek Above the Mouth Near Supai, AZ (09403850), Havasu Creek Above the Mouth Near Supai, AZ (09404115) or the Paria River @ Lees Ferry, AZ (09382000) and Colorado River Above Diamond Creek near Peach Springs, AZ (09404200). See Figures 4 – 12. These graphs also helped determine when additional sediment may be entering the mainstem for possible deposition along beaches downstream. During comparison to each subsequent image, identification of a near-shore landmark or two and its proximity to the current shoreline was employed to help determine relative water levels. The flow graphs were also revisited if required, particularly when it appeared that the river volume and possible sediment load changed due to additional input from the Paria or Little Colorado tributaries.

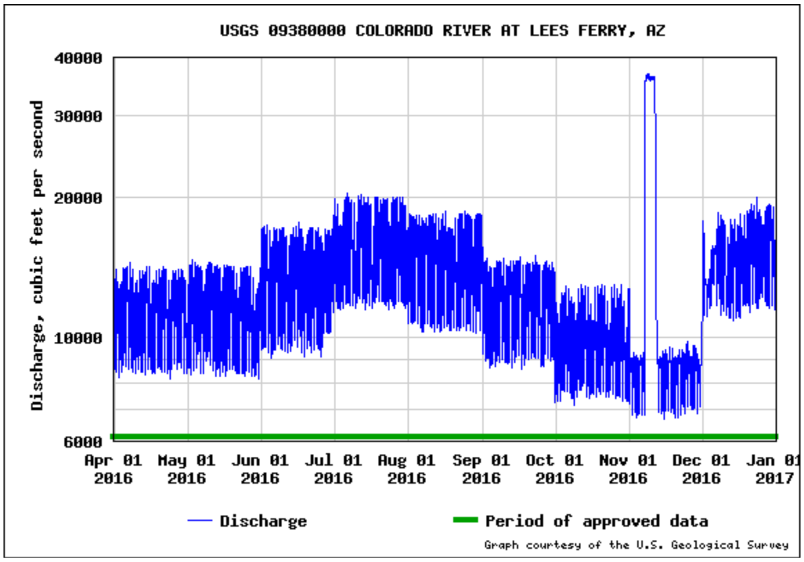

Figure 4. Flow graph for Colorado River at Lees Ferry, AZ., April 1 through Dec 31, 2016

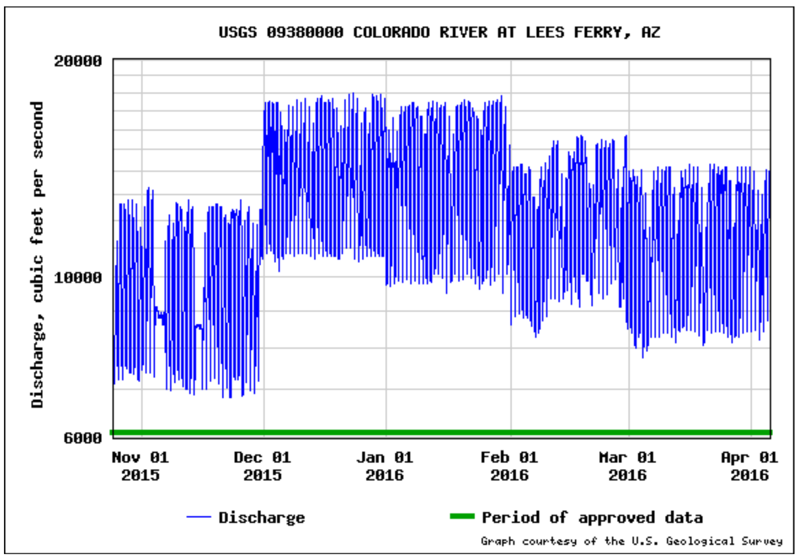

Figure 5. Flow graph for Colorado River at Lees Ferry, AZ., November 1, 2015 through April 1, 2016

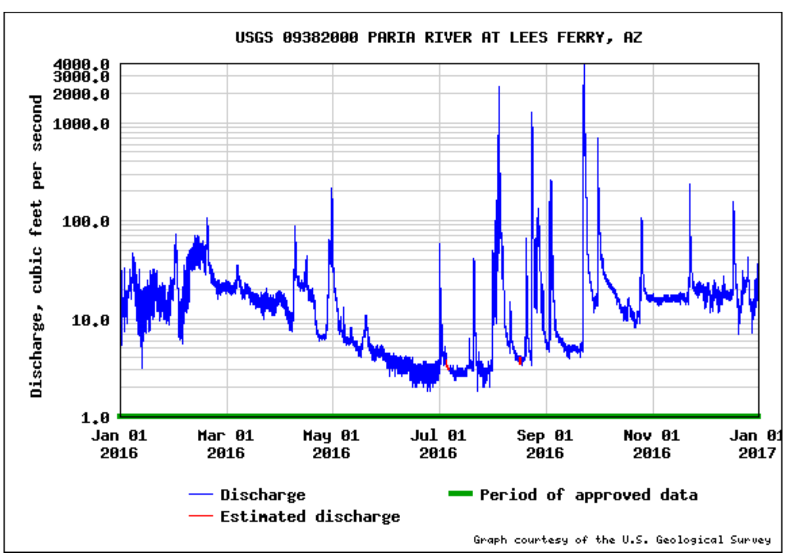

Figure 6. Flow graph for Paria River at Lees Ferry, AZ. January 1 through December 31, 2016

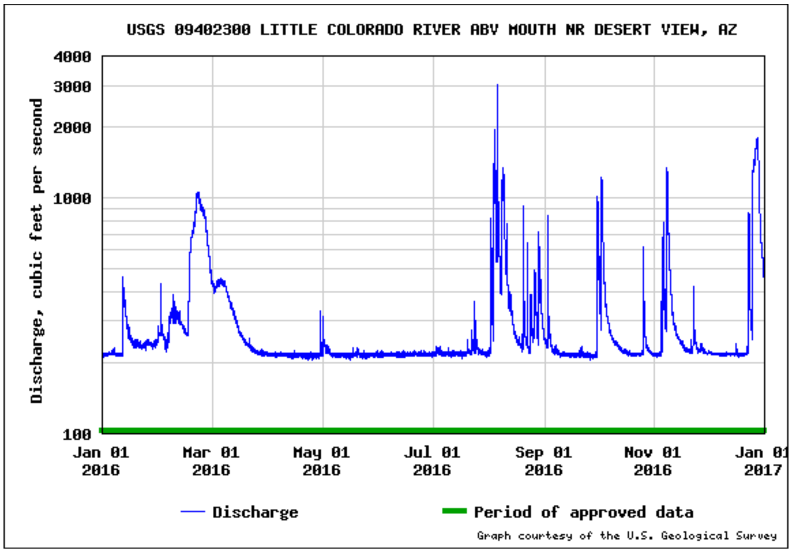

Figure 7. Flow graph for Little Colorado River above mouth near Desert View, AZ., January 1 through December 31, 2016

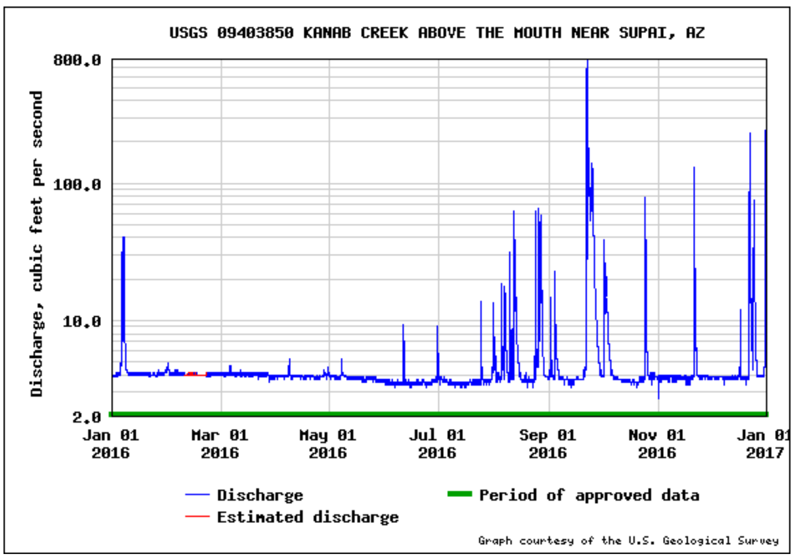

Figure 8. Flow graph for Kanab Creek above the mouth near Supai, AZ. January 1, 2016 through December 31, 2016

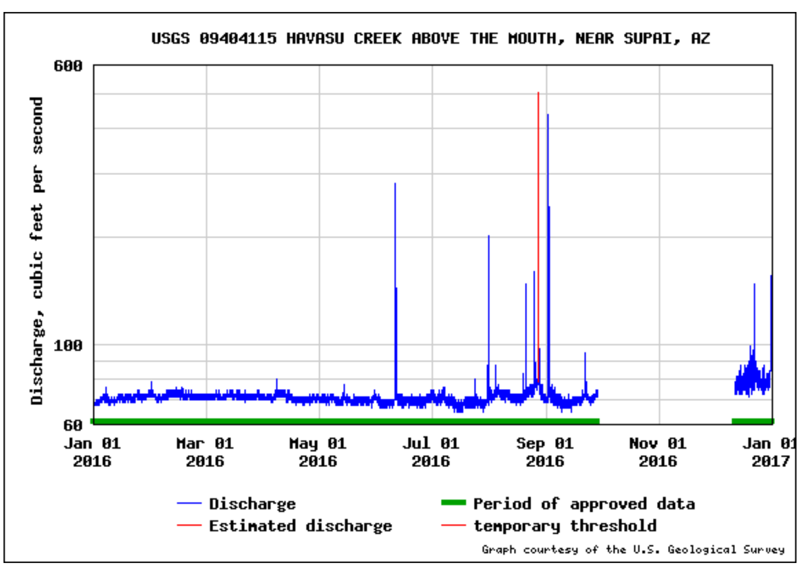

Figure 9. Flow graph for Havasu Creek above the mouth near Supai, AZ. January 1 through December 31, 2016

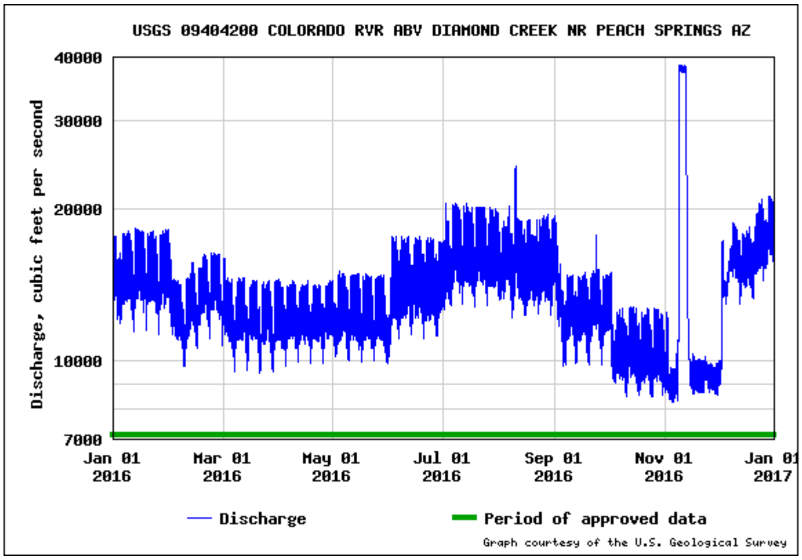

Figure 10. Flow graph for Colorado River above Diamond Creek near Peach Springs, AZ. January 1 through December 31, 2016

The images were viewed for evaluation using the Adobe Photoshop v7.0 software on a Dell 24" monitor. Beginning at the front, or shoreline of the beach, the images were examined and compared. The presence/absence of rocks or debris, either hindering or enhancing boat parking, were noted. Due to the variety of river flow levels between the comparison photos, change in the 'parking' at a particular beach is often difficult to evaluate, and, when covered at higher flows, is considered only when recorded by the AAB observer. Any beach front cutbanks which would affect unloading/loading of boats at similar flow levels, or which indicated erosion of the beach by the river flow were also noted. Conversely, the absence of a cutbank or smoothing of an access slope helped determine the possible addition of sand by sediment augmentation or other river action that benefited the camping desirability of the beach.

The images being compared were then examined progressively from front to back to note the absence or addition of rocks or other debris which would impact the total area being used as a camp. The location and visual extent of emerging rocks can usually indicate the physical action which occurred to reveal the rocks. As an example, rocks which were covered in image "A" by sand, covered by river flow in image "B" and subsequently revealed as the water level receded, are noted as indicators of river flow erosion. Conversely, the reverse action would be noted as an indicator of sediment deposition.

The same kind of visual clues can also be used to determine aeolian action, particularly when the exposed and/or covered rocks and shelves are higher than any possible river flow level during the time period being examined. During the November 2014 HFE, some camp areas increased as a result of boulders and bedrock being covered by sand carried onto the beach at the higher flow. Since then, some of these rocks have re-emerged as a result of wind scour, resulting in a decrease in camp area. The Upper North Canyon Camp is an excellent example of this action (See cover page).

Determining whether a beach was uncomfortably steep for access was easily assessed if one of the photos was taken across the front, either looking up or downstream. But beaches with only head-on photos are more difficult to discern. Well-trodden paths, leading to and from obvious access points, creating easily eroded channels, are the primary clues. Human caused erosion is usually noted by the volunteer photographer and can be correlated with the images.

Beach images acquired from various viewpoints were the easiest to determine changes in vegetation. When this was not possible, such as head-on only shots, a systematic comparison from one end of the beach to the other was used. Baccharis species, arrow-weed (*Pluchea sericea*), Russian thistle (*Salsola tragus*), coyote willow (*Salix* species) and camelthorn (*Alhagi* species) were usually identifiable when noted moving into a previously open sand area, or were missing from subsequent images.

Because of varying photo locations from one beach to the next, some agents of change are more readily apparent than others. Deposition/erosion across a beach front at waterline is always more prominent in the images than perhaps vegetation incursion or loss. Aeolian activity on a beach is more apparent when the photograph is acquired from an angle slightly higher than the beach itself, and vegetation changes are more readily denoted when there are images of the beach in addition to the beach front itself. Not all beach photos include areas where human impacts would most likely be found.

While every effort is made to ensure an even, consistent analysis of the beaches, the patterns of photo acquisition on any particular beach may bias the evidence of an agent of change. Conversely, some bias towards a No Change determination may be present in other photo acquisition sets. The final determination is sometimes dependent on the patterns of photo acquisition established for a particular beach and, to a lesser extent, the effort exerted by the volunteer photographer.

Prior knowledge of the study sites by the investigator was also considered, though this did not determine the final classification used for any particular beach. Using these analysis criteria, the beaches are given classifications indicating desirability as camping beaches, stated as Improved, Degraded or Unchanged. While the designations of Unchanged, Improved and Degraded are inherently subjective, the results are reflective of the stated evaluation purpose of determining the beach as a useable camp for river trips. No photogrammetry techniques were employed and this should not be interpreted in any way that results were obtained using anything other than objective evaluation.

The data are compared and analyzed according to the research questions that are most applicable for the time period being studied.

Figures 11, 12 & 13. Documentation of continued degradation of camp area due to rain erosion through beach. Matkatamiba Camp, RM 148.9 L   April 11, 2015 (top} and October 8, 2015 (middle) and October 4, 2016 lower).

Results

Through 2016 boating season

Per Classification

For the period covering the 2016 summer boating season, photos were used which spanned from April 4 to November 8. The highest release flows during the season started July 1, maximized at near 20,000 cubic feet second and continued through that month. Weekday daily flow fluctuations were consistently near 8000 cubic feet second (cfs) through the 2016 season, with weekend fluctuations slightly lower. Release flows were consistent at 8000 to 14000 cfs during March through May, stepped up 4000 cfs for the month of June, and another 2000 cfs through July. The releases were lowered by 2000 cfs for the month of August, 4000 cfs through September and yet again by 2000 cfs for the month of October. In order to include this factor in the analysis, the earliest season ending date considered was July 31 with three exceptions. Those dates are in mid-July and were only included because factors were already evident indicating significant change had occurred to the beach. A large percentage of the ending dates fall between mid-September and mid-October. Forty-three of the 44 beaches were adopted for the 2016 season with 39 having photographs and photographer comment sheets spanning a sufficient period of time to be evaluated. Four were not photographed late enough in the season to be considered for a complete season analysis and one had a photo set that began late in the summer, so it was not evaluated. Of the 39 beaches included in this portion of the analysis, 17 (44%) did not show significant changes, and were classified as Unchanged through the season. Twenty-one of the beaches (54%) had Degraded through the summer, and one (3%) of the beaches evaluated was considered Improved by the Fall of 2016. This was the beach at Buck Farm Canyon, RM 41.2 R and, although photographic evidence indicated a possible Degradation of the beach due to recession, the commenter stated that parking had Improved at lower river levels towards the end of the summer.

The most often cited cause of beach Degradation during the 2016 season was beachfront erosion by fluctuating flows, particularly noticed after the higher flows during July. This was considered the primary cause in eleven cases and as a contributing factor in an additional four instances. Rain events were the second most often cited cause for Degradation, with three instances where rain was the primary reason and another three instances where rain was a significant contributing factor. These impacts occurred as both flash flooding from an associated tributary or as more localized erosion from hillside runoff at the camp. Wind deflation of camps was frequently present, easily perceived as rocks became exposed above the maximum waterline, and figured predominantly in a classification of Degraded at two of the beaches. Erosion from human action and decrease in camp area by vegetation encroachment were also secondary contributing factors at two beaches each.

Per Reach

Those beaches classified as Unchanged were not distributed evenly through the four reaches, with 3 in the Marble Canyon reach, 9 in the Upper Granite Gorge reach and 5 in the Muav Gorge reach. None of the beaches located in the Lower Granite Gorge were Unchanged. The 21 Degraded beaches were located in all four reaches, with 5 in Marble Canyon, 5 in the Upper Granite Gorge, 9 distributed through the Muav Gorge and 2 of the beaches located in the Lower Granite Gorge. The Improved beach was located in the Marble Canyon reach.

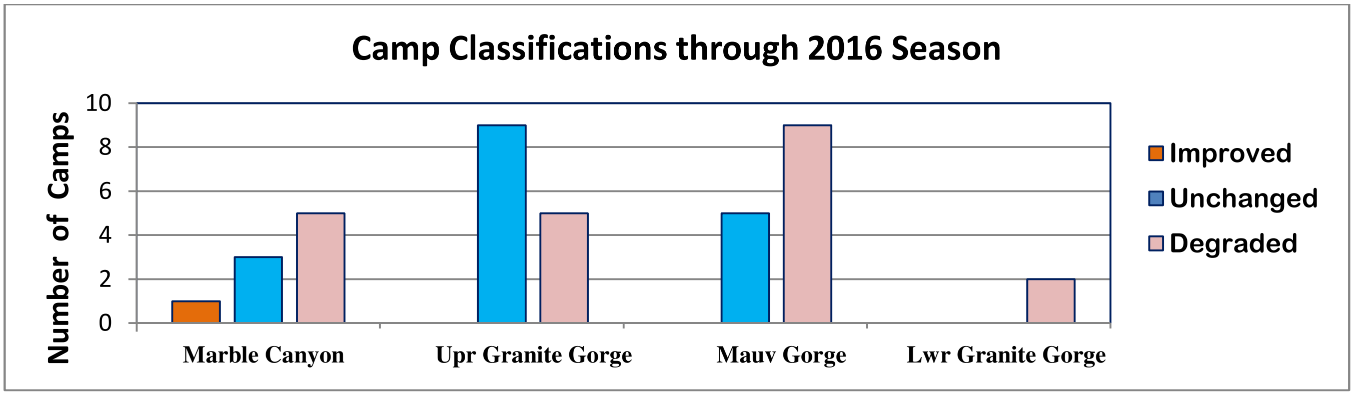

Figure 14. Graphic illustration for 2016 seasonal evaluations

Figures 15, 16 & 17 Resurgence and proliferation of willows following the November 2014 HFE.
Photo dates: April 6, 2015 (top), April 9, 2016 (middle) and September 25, 2016 (bottom).
Grapevine Camp RM 81.7 L

Winter of 2015 - 2016

Per Classification

There was no HFE following the 2015 season, so none of the changes, when they occurred, were the results of a spike release from Glen Canyon Dam. An examination of the tributary flow-graphs for this period reveals one noticeable inflow from the Little Colorado River which lasted for a two or three day period in late February. The resulting increase in river flow of approximately 800 cfs (cubic feet per second) would probably not be significant except that it occurred immediately after the maximum daily fluctuating release flows had been reduced by 2000 cfs. Any sediment deposition on a beach resulting from this brief rise would have therefore been higher than any subsequent damn releases for the remainder of the spring. There was no apparent change to a beach downstream of the Little Colorado river that could be attributed to this inflow however.

At the beginning of April 2016, 37 of the beaches had enough photographic evidence available to be evaluated for changes during the previous 5 months. Of the thirty-seven, 12 (32%) appeared to have Improved seven of the beaches (19%) had Degraded over the winter and 18 (49%) showed no appreciable change. A majority of those beaches which had Improved were considered more accessible due to sand slumping across the front of the beach, improving parking, making loading/unloading of boats easier and giving more convenient access to the camp from the waters edge. In at least four instances erosion gullies had been partially or completely filled in the main camp area, possibly by sand redistribution through wind action. At least one beach showed evidence of human reworking to allow much better access to the camp.

Those beaches which degraded during the winter suffered equally from bank recession/cutbanks, wind erosion, rain events and human caused erosion along the beach front. Rarely did two of these factors play a role in the degradation.

Per Reach

Those beaches receiving a classification of Unchanged only occur in the upper three reaches, with 3 in the Marble Canyon reach, 8 in the Upper Granite Gorge section and 7 in the Muav Gorge reach. Beaches which Degraded were found in three of the reaches. While the Marble Canyon reach contained one of these beaches, the Muav Gorge section contained 4 and both of the Lower Granite Gorge reach beaches had degraded. Improved beaches were distributed through the first three reaches. There were three in Marble Canyon, 8 in the Upper Granite Gorge, 7 in the Muav Gorge section.

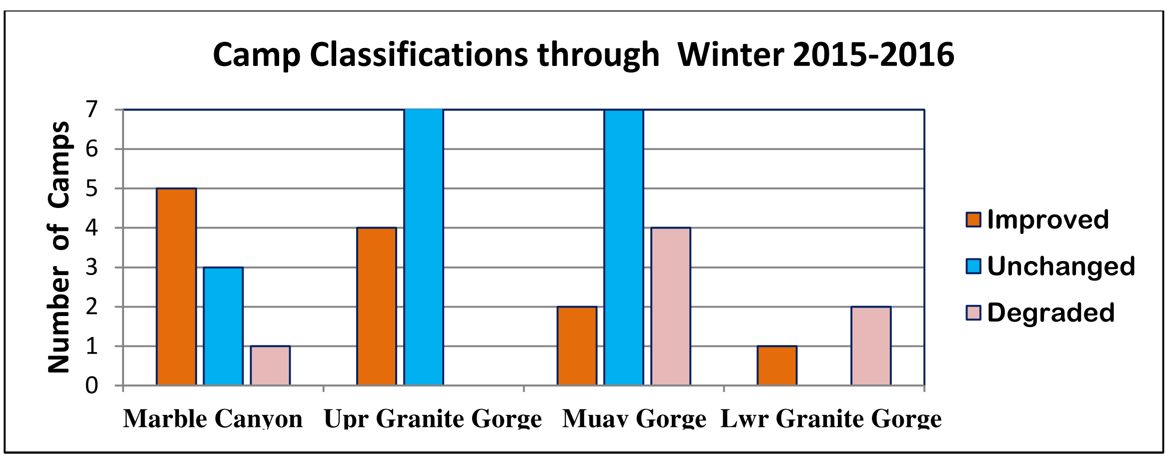

Figure 18. Graphic illustration for winter 2014 to 2015 evaluations

Conclusions

While this analysis is limited to reporting monitoring observations and presumptive factors affecting change, it does provide evidence of changes in the beaches and the effects on associated recreational camping. Both natural and manmade actions contribute to the acceptability of a beach as a desired recreational camp area. As reported in earlier studies by various investigations, fluctuating releases from Glen Canyon Dam are usually the agent of change most often associated with beach degradation, but it is certainly not the only, nor always the primary, factor.

Subsequent analysis using the results accumulated during the past twenty years of observations could perhaps consider the hierarchical role of these factors of change.

Most interesting is the observation of positive changes in this, the second winter following an HFE. The analysis of the beaches over the winter of 2014-2015 indicate the previous HFE was indeed successful in replenishing sand upon the beaches. The same analysis firmly establishes that the high fluctuating flow releases that closely followed the HFE resulted in severe cutbanks along the beach fronts (Lauck, 2016). Some of these cutbanks were extreme enough to prohibit access to the camps. During the subsequent 17 months, many of these embankments slumped or calved in a way which made the camps more inviting. It was refreshing to add still more positive camp responses, no matter the length of time it took, as a result of the 2014 HFE.

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Grand Canyon River Guides, Inc. would like to thank all of the adopters for volunteering the time to pull over and photograph their beaches and for their valuable observations and written comments. It takes time and effort to do this, and the dedication shown by guides has literally kept this program alive for twenty years. The result is the most comprehensive collection of repeat photographs of critical camping beaches in the Grand Canyon. An added benefit is the public outreach fostered by the volunteers' actions. By taking time to include guests as active participants and by answering their questions, volunteers can further explain how this resource in Grand Canyon is enhanced, degraded or maintained by the influence of man and technology.

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Web

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Appendix A

Results of Analysis in Tabular Form

Page 1 Table 2 Results of evaluations, late 2015 season to early April 2016

Camp name	Rvr mile	Late 2015	to	Early 2016	reason
		Same	Improved	Degraded	POST HFE
Soap Creek	11.3 R		X		Sand increased at parking
12.4 Mile	12.4 L		X		More veg but also more sand across front
Hot Na Na	16.6 L	X			No change found
19.4 Mile	19.4 L	X			Sand rearranged but same area
Upper North Canyon	20.7 R		X		Improved parking area
23 Mile	22.7 L			X	New cut bank. Less sand at parking
Shinumo Wash	29.5 L				No late season 2015
Nautaloid	35 L				No early season 2016
Tatahatso	37.9 L		X		Cut bank softened by slump. Human erosion?
Martha's	38.6 L		X		Gully filled. Sand slump/wind action?
Buck Farm	41.2 R	X			No change found
Total per Reach	11	3	5	1	
Nevills	76 L	X			Same
Hance	77.1 L	X			Same
Grapevine	81.7 L		X		Some veg removed by beavers. Slightly more room
Clear Creek	84.6 R	X			No change found
Zoroaster	85 L		X		Cut bank and gullies softened.
Trinity Creek	92.1 R	X			Hard to evaluate from photos
Schist	96.6 R	X			Same
Boucher	97.3 L				No late season 2015
Crystal	98.7 R	X			No change found
Lower Tuna	100.2 L		X		Some gully fill at parking. Sand slump??
Ross Wheeler	108.3 L	X			No change found
Bass	109 R		X		Cut bank reduced making easier access
110 mile	110 R	X			No change found
Upper Garnet	114.9 R				No late season 2015
Lower Garnet	115.1 R				No late season 2015
Total per Reach	15	8	4	0	
Below Bedrock	131.7 R	X			No change found
Stone Creek	132.5 R			X	Considerable sand loss across front of beach
Talking Heads	133.7 L				No late season 2015
Racetrack	134.2 R		X		Cut bank reduced, probly from human traffic
Lower Tapeats	134.5 R	X			No change found
Owl Eyes	135.2 L	X			Very little change
Backeddy	137.8 L			X	More veg in parking area, inhibiting access
Kanab	144 R	X			Same
Olo	146.1 L				No late season 2015
Matkat Hotel	148.9 L			X	Erosion apparently from human loading/unloading
Upset Hotel	150.9 L	X			Same
Last Chance	156.3 R	X			No change found
Tuckup	165.2 R		X		Erosion gullies filled.
Upper National	167 L	X			No change found
Lower National	167.2 L			X	Slight. Less sand on gravel at parking, kitchen
Total per Reach	15	7	2	4	
Travertine Falls	230.6 L		X		Slight. Access improved, probly human erosion
Gneiss	236.1 R			X	Sand loss, aeolian action
250 Mile	250.0 R			X	Flash flood reduced already tiny camp area
Total per Reach	3	0	1	2	
Totals	**37/44**	**18**	**12**	**7**	

 Table 3 Results of evaluations, April through October 2016 season

Camp name	Rvr mile	2016	thru	season	Reason
		Same	Improved	Degraded	
Soap Creek	11.3 R			X	Recession from FF and erosion from drainage flow
12.4 Mile	12.4 L	X			Slight change to degraded, FF, veg increase
Hot Na Na	16.6 L	X			No change observed
19.4 Mile	19.4 L			X	Fluc flow sand loss in parking area, rain gully formed
Upper North Canyon	20.7 R			X	Rocks exposed in interior from wind erosion, recession
23 Mile	22.7 L	X			No change observed
Shinumo Wash	29.5 L			x	No late 2016 - heavy erosion from fluc flow mid July
Nautaloid	35 L				No early 2016
Tatahatso	37.9 L			X	Rain erosion - accentuated by human traffic
Martha's	38.6 L				No late 2016
Buck Farm	41.2 R		X		Observer states improved but only parking at low water
Total per Reach	11	3	1	5	
Nevills	76 L	x			No late 2016 - no change as of mid July
Hance	77.1 L			X	Sand loss at parking from fluc flow and human traffic
Grapevine	81.7 L			X	Willows much heavier in lower camp.
Clear Creek	84.6 R	x			No late 2016 - no change as of mid July
Zoroaster	85 L			x	No late 2016 - recession from fluc flow and wind loss mid July
Trinity Creek	92.1 R	X			No change observed
Schist	96.6 R	X			Upper parking may be slightly improved
Boucher	97.3 L	X			No change observed
Crystal	98.7 R	X			No change observed
Lower Tuna	100.2 L	X			No change observed
Ross Wheeler	108.3 L	X			Gully in kitchen area remains from 2015
Bass	109 R				No late 2016
110 mile	110 R	X			Limited data available to compare
Upper Garnet	114.9 R			X	Cutbank across front. New debris at upper parking area
Lower Garnet	115.1 R			X	Recession and cut bank. Erosion gullies from traffic
Total per Reach	15	9	0	5	
Below Bedrock	131.7 R			X	Aeolian sand loss from interior
Stone Creek	132.5 R			X	Much recession in lower half of beach
Talking Heads	133.7 L			X	Recession across entire beach
Racetrack	134.2 R			X	Substantial gully through camp from rain, veg increase
Lower Tapeats	134.5 R			x	Flucuating flow recession by mid July
Owl Eyes	135.2 L			X	Cut bank and recession along length of beach
Backeddy	137.8 L	X			No change observed
Kanab	144 R	X			Some shear of beach but new debris deposit
Olo	146.1 L			X	Sand loss at parking, rocks exposed
Matkat Hotel	148.9 L			X	Rain erosion increased, new gullies, some sand loss
Upset Hotel	150.9 L	X			No change observed
Last Chance	156.3 R	X			No change, limited data available to compare
Tuckup	165.2 R				No late season 2016
Upper National	167 L			X	Sand loss at parking, more veg in camp
Lower National	167.2 L	X			Almost exactly same
Total per Reach	15	5	0	9	
Travertine Falls	230.6 L			X	Recession at upper end
Gneiss	236.1 R				No late season 2016
250 Mile	250.0 R			X	Another debris flow covers lower camp area
Total per Reach	3	0	0	2	
Totals	39/44	17	1	21	

Note: Small "x" indicates that the beach was classified using observations obtained before August 1

 Table 4 Results of evaluations for beetle presence through October 2016 season

Camp name	Rvr mile	Tamarisk beetle evident 2016
Soap Creek	11.3 R	Y
12.4 Mile	12.4 L	Y
Hot Na Na	16.6 L	Y
19.4 Mile	19.4 L	Y
Upper North Canyon	20.7 R	Y
23 Mile	22.7 L	Y
Shinumo Wash	29.5 L	N
Nautaloid	35 L	N
Tatahatso	37.9 L	N
Martha's	38.6 L	
Buck Farm	41.2 R	N
Total per Reach	11	
Nevills	76 L	N
Hance	77.1 L	Y
Grapevine	81.7 L	N
Clear Creek	84.6 R	N
Zoroaster	85 L	N
Trinity Creek	92.1 R	N
Schist	96.6 R	N
Boucher	97.3 L	N
Crystal	98.7 R	N
Lower Tuna	100.2 L	N
Ross Wheeler	108.3 L	N
Bass	109 R	
110 mile	110 R	N
Upper Garnet	114.9 R	N
Lower Garnet	115.1 R	N
Total per Reach	15	
Below Bedrock	131.7 R	N
Stone Creek	132.5 R	N
Talking Heads	133.7 L	N
Racetrack	134.2 R	N
Lower Tapeats	134.5 R	N
Owl Eyes	135.2 L	Y
Backeddy	137.8 L	N
Kanab	144 R	N
Olo	146.1 L	N
Matkat Hotel	148.9 L	N
Upset Hotel	150.9 L	N
Last Chance	156.3 R	N
Tuckup	165.2 R	
Upper National	167 L	N
Lower National	167.2 L	N
Total per Reach	15	
Travertine Falls	230.6 L	N
Gneiss	236.1 R	
250 Mile	250.0 R	N
Total per Reach	3	
Totals	**44**	

Appendix B

Adopt-A-Beach Data Sheet
Used by Volunteers to Record Comments

Adopt a Beach Data Entry Form

Guide s Name ______________________

Camp Name ______________________

Camp Mile ____________________

Date ____________________

River Flow (circle one) Low (5-12K) Med (12-18K) High (18-25K)

Photo Numbers: ______________ (remaining)

Any Comments about Beach Change? (describe in this space)

Change in Beach Size from Previous Visit (circle one): Increase Decrease Same

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Dominant Cause of Change (circle one):

Spike	Daily/Monthly Flow	Rain	Wind	People	Don't Know

Supporting Observations for Dominant Cause (check any that are appropriate):

- ☐ New cutbank
- ☐ Change of slope
- ☐ Bench in eddy
- ☐ Gully
- ☐ Trib/Debris flow
- ☐ Scour from wind or people
- ☐ Mounded sand

Secondary Cause of Change (circle one):

Spike	Daily/Monthly Flow	Rain	Wind	People	Don't Know

Supporting Observations for Secondary Cause (check any that are appropriate):

- ☐ New cutbank
- ☐ Change of slope
- ☐ Bench in eddy
- ☐ Gully
- ☐ Trib/Debris flow
- ☐ Scour from wind or people
- ☐ Mounded sand

Do you find evidence of tamarisk beetles currently in/near this beach? YES NO

Campsite Quality Compared to Last Visit (circle one): Same Better Worse

Supporting Observations for Campsite Quality (check any that are appropriate):

- ☐ Boat parking
- ☐ Rockiness
- ☐ Vegetation encroachment
- ☐ Steepness
- ☐ Trail erosion
- ☐ Open sand area
- ☐ Human impacts- ants, pee spots, litter (circle those that apply)

Any Comments about Campsite Condition? (describe in this space)