Long-Term Monitoring of Camping Beaches in Grand Canyon

Summary of Monitoring Observations for Year 2014
and Overview of Results for 1996 through 2013 High Flow Events

By
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July 7, 2015

Stone Creek Camp, RM 132.4 R September 2013

Stone Creek Camp, RM 132.4 R April 2014

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Abstract

For the past nineteen years, the Adopt-A-Beach repeat photography program has been monitoring beaches along the Colorado River through Grand Canyon. Through comparative examination of photo series and on-the-spot observations contributed by the volunteer photographers, campsite conditions are evaluated. Factors considered which contribute to changes, 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, that may have an effect on the camp. Beginning at River Mile 11.3, as measured downstream from the United States Geological Survey gaging station at Lees Ferry, AZ, 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 2014 summer boating season, early April to late October, 29 of the 44 study beaches in the program had photographs and photographer comment sheets covering a sufficient period of time to be evaluated. Of these 29 beaches, 38% were classified as Unchanged for the time period, 3% had Improved through the summer and 59% were considered as Degraded by the end of the season. Of the Unchanged beaches, 36% are located in the Marble Canyon reach, 9% in the Upper Granite Gorge reach, another 46% are contained in the Muav Gorge reach and 9% are in the Lower Granite Gorge reach. Twelve percent of the Degraded beaches are located in the Marble Canyon reach, another 41% in the Upper Granite Gorge reach, 47% are found in the Muav Gorge reach and none were located in the Lower Granite Gorge reach. The primary factor cited for those camps classified as Degraded is the fluctuating flow releases from Glen Canyon Dam, with rain events cited as the second most common cause.

A comparison of the beaches from late season 2013, with photos obtained prior to the November High Flow Experiment (HFE), and early 2014 was conducted on a total of 32 beaches. With four exceptions, all of the beaches appeared Improved in the spring of 2014, despite a relatively high fluctuating flow regime in January. Of the 4 unimproved camps, 2 were in a Degraded condition and had beach recession and cutbanks indicative of erosion attributed to the fluctuating flows. Soap Creek Camp at River Mile 11.3 was classified as Degraded but was less definitive and the camp at 19.4 Mile incurred a significant amount of sand loss from both the beach front and the campable dune located in the eddy in front of the main beach.

Also included in this report is a compilation of the results of each of the past 5 High Flow Events. Three of the 44 beaches were excluded because they lacked at least three years of evaluation. Twentysix of the beaches were classified as Unchanged or Improved after each HFE and half of these had received only an Improved rating when evaluated.

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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 (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 of an initial 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 2014 season, and the addition of new 1075 images, river runners have produced nearly 9400 replicate photographs on more than 3700 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).

Recently, the presence and impacts of the tamarisk beetle, *Diohabda spp*. have been included in these comments and documented photographically. This component of the analysis has been 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 does this affect the camp. Also, in what ways may defoliation of tamarisk affect aeolian or streamflow related erosion. These are examples of recreational concerns.

The purpose of this report is to present the results of the monitoring effort for the period between late 2013 and late October 2014. Also, after each of the HFE events, beaches were shown to have eroded at differing rates (Thompson, Burke and Potochnik, 1997, Lauck 2009). Hence, researchers are concerned with the longevity of bars and camping areas augmented by the HFEs. A comparison of the 2013 beach conditions with those photographed both before and after the HFE conducted in November 2013 are included.

Research results include reporting positive “Improved” conditions, negative “Degraded” conditions or “Unchanged” conditions, when no changes were found in beaches. Longevity of these camps and 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 2014?
- What changes occurred in beach conditions during the winter between the November 2013 High Flow Experiment and April 2014?
- How are changes in the beaches, if any, distributed throughout the river corridor?
- Which processes resulting in a change of condition at a beach are most prevalent?
- How do the evaluation results compare for each High Flow Event?

Methods

Study locations and beaches

Since 1996 the AAB program has studied an average of 37 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, 1996-2014.

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 monitored.

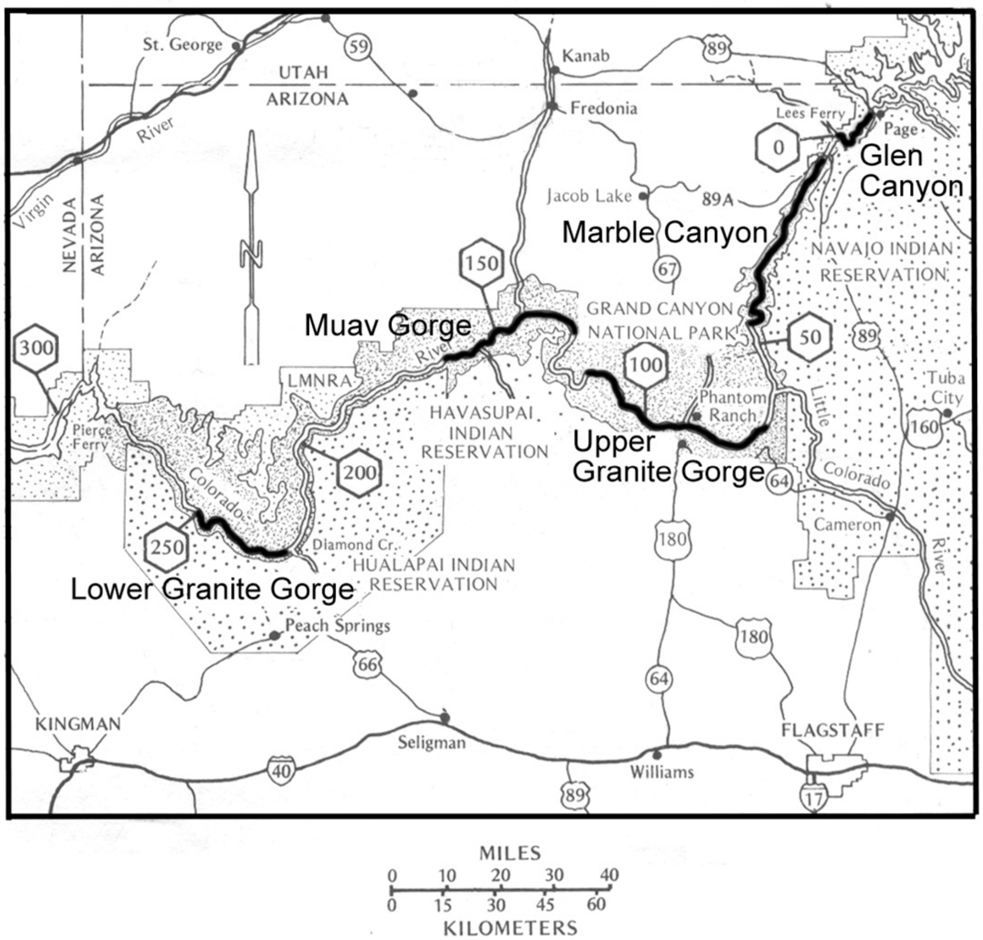

Figure 1. Locations of five critical reaches along the Colorado River in Grand Canyon National Park

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. Zoroaster Camp, RM 84.9 L, 9/12/2013 (top) and 4/6/214 (bottom)
Documents an increase in preferred camping area after the 2013 HFE.

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 2014 totaled 29. 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, 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). 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 @ 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). See Figures 6 – 11. 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.

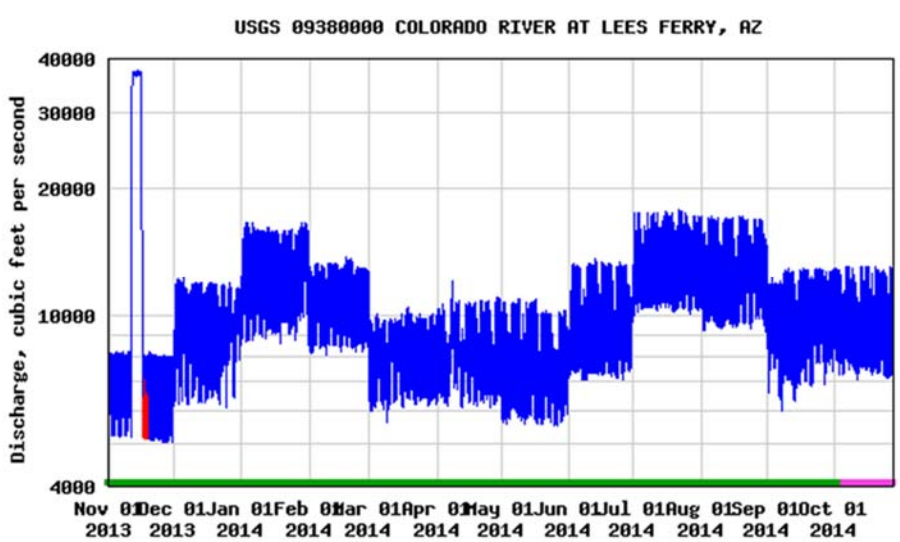

Figure 4. Flow graph for Colorado River at Lees Ferry, AZ., late 2013 through Oct 2014

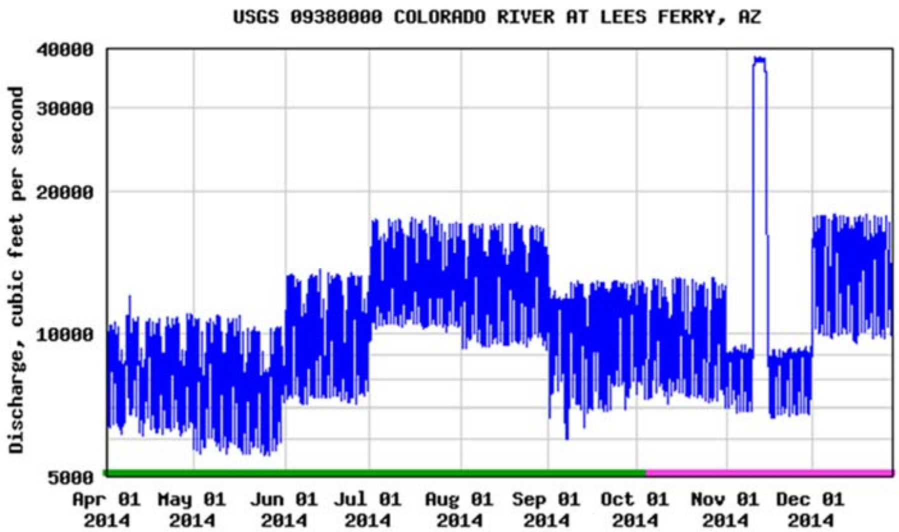

Figure 5. Flow graph for Colorado River at Lees Ferry, AZ., April through December 2014

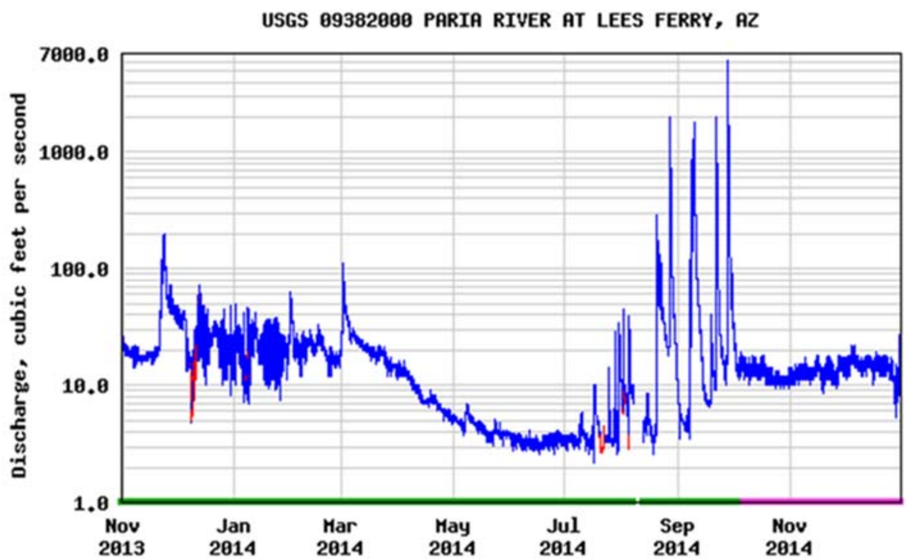

Figure 6. Flow graph for Paria River at Lees Ferry, AZ.

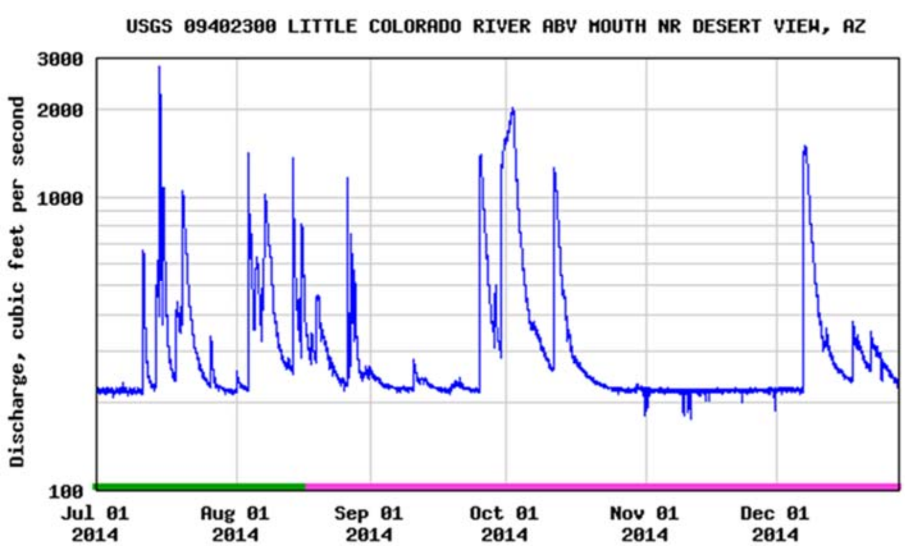

Figure 7. Flow graph for Little Colorado River above mouth near Desert View, AZ.,

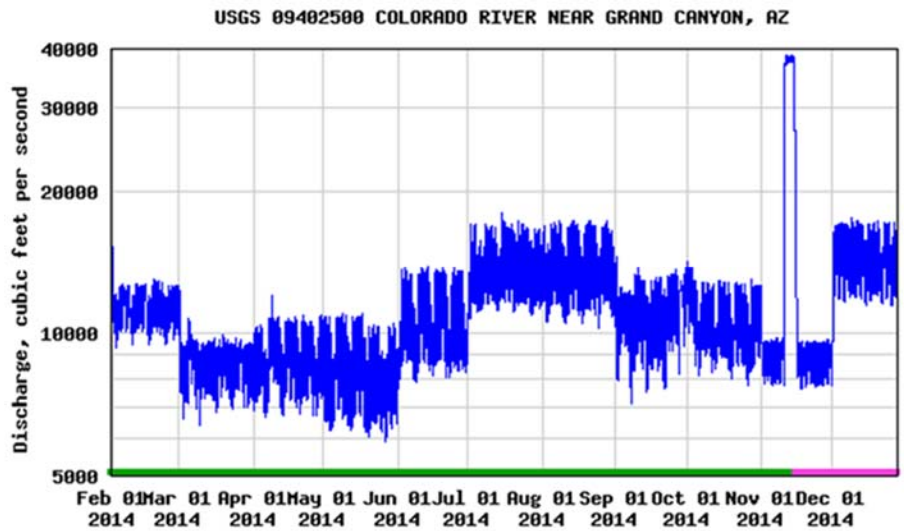

Figure 8. Flow graph for Colorado River near Grand Canyon, AZ.

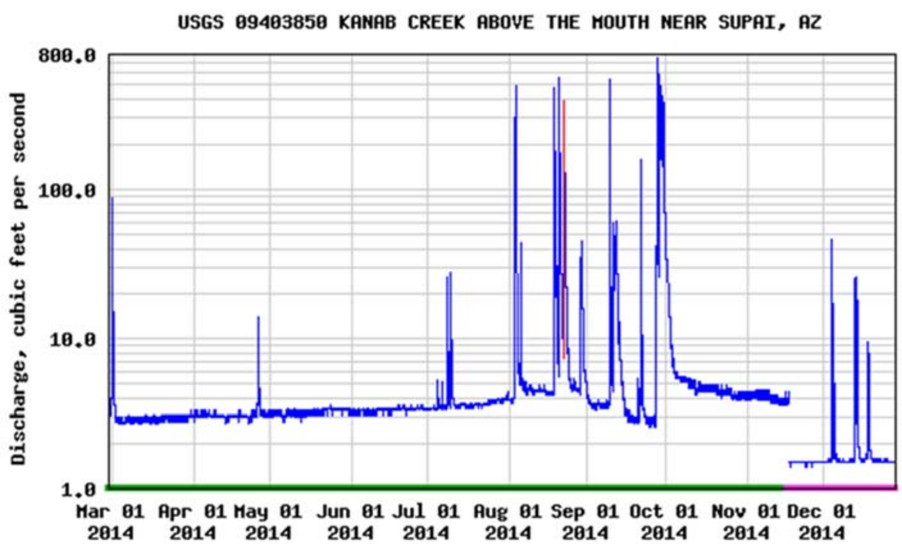

Figure 9. Flow graph for Kanab Creek above the mouth near Supai, AZ.

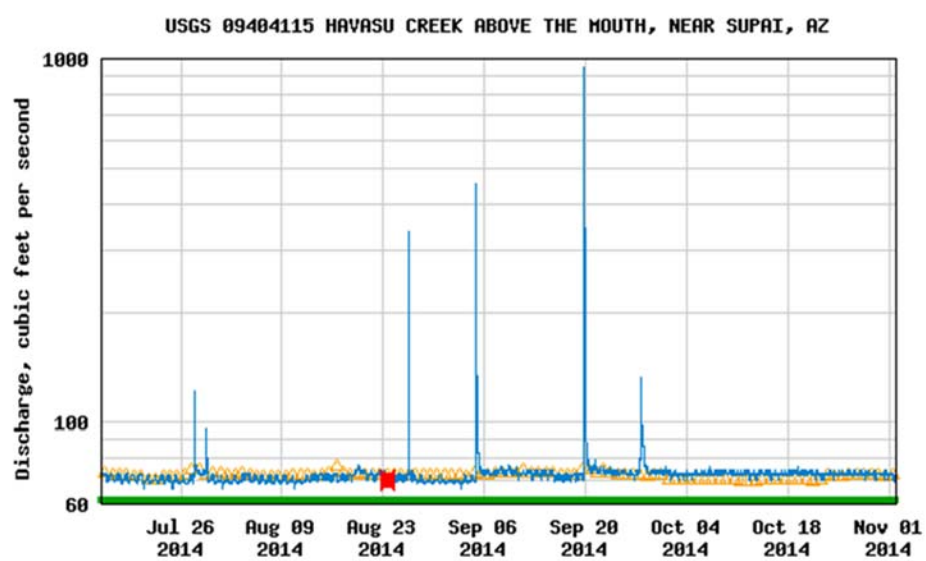

Figure 10. Flow graph for Havasu Creek above the mouth near Supai, AZ.

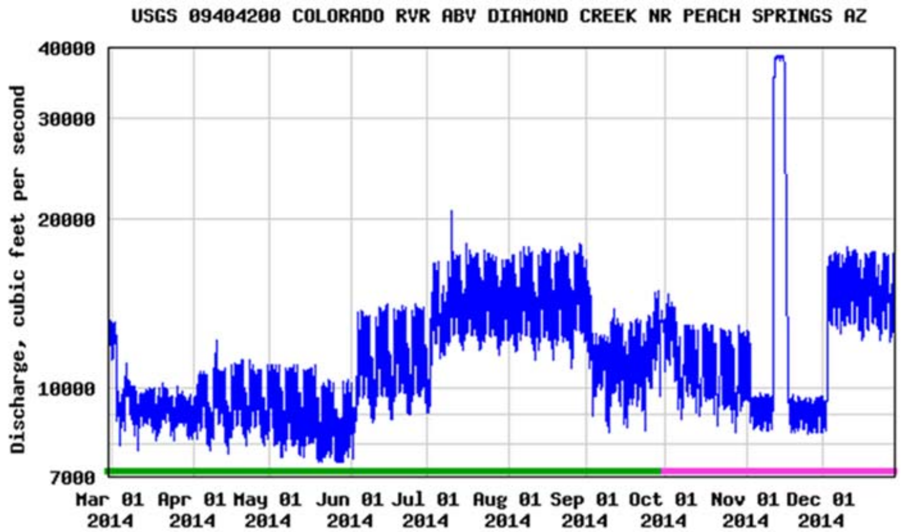

Figure 11. Flow graph for Colorado River above Diamond Creek near Peach Springs, AZ.

The images were viewed for evaluation using Adobe Photoshop v7.0 on two Sony 19' monitors, side-by-side, with one image on each. 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.

Figures 12 & 13. Upper Garnet Camp, RM 114.5 R. Photo on top taken July 22, 2014 and bottom taken September 10, 2014. Documented defoliation of tamarisk tree.

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 2013 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 portion of Lower Tuna Camp is an excellent example of this action.

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.

For those beaches where one or more tamarisk trees, or partial trees, are clearly visible in a photo, the percent of green, leafy branches were noted early in the season. If the same plant appears to have leaf loss in subsequently dated photos, and particularly if the same plant produces more foliage later in the summer, then the presence of *Diohabda spp.* is assumed and recorded. This method of analysis may need to be adjusted as the effects of the beetle on the trees changes. In a few instances, such as Kanab Creek Camp, where beetle damage to trees has already killed or partially killed trees, it is simply noted as evidence of beetles is present.

Knowledge of the study sites by this 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. For the season of 2014, evidence of change between April 1 and the latest photo acquired for the year before the November HFE, was evaluated. The majority of the ending date photos were taken from mid-September to October 30.

Figures 14 & 15. Tuckup Canyon Camp, RM 165.1 R May 7, 2014 (top} and September 8, 2014 (bottom). Documented loss of camp area due to rain erosion through beach. Also note lack of evidence of beetles in tamarisk.

Results

Through 2014 boating season

For the period covering the 2014 summer boating season, photos were used which spanned from early April to late October, with the earliest fall season ending date being August 1, the latest being October 30 and the mean ending date at September 30. Twentynine of the 44 study beaches in the program had photographs and photographer comment sheets spanning a sufficient period of time to be evaluated. The highest release flows during the season started July 1 and continued through August. In order to include this factor in the analysis, with few exceptions, the earliest season ending date considered was September 1. Five of the beaches were not adopted for the 2014 season, but 8 others were not photographed late enough in the year to be considered for a complete season. Also, one camera was lost by theft late in the summer and one other was not returned in time to be included in the analysis. Of the 29 beaches included in this portion of the analysis, 36% did not show significant changes, and were classified as Unchanged through the season. Seventeen of the beaches, or 61%, were Degraded through the summer. One of the beaches evaluated was considered Improved in the Fall of 2014. This was the beach at 19.4 Mile. The sand deposited during the HFE the previous November remained in the eddy and slumped slightly making loading and unloading easier for rafters.

Per Classification

Those beaches classified as Unchanged were distributed sporadically through the four reaches, with 4 in the Marble Canyon reach, 1 in the Upper Granite Gorge reach, 5 residing in the Muav Gorge reach and 1 of the beaches located in the Lower Granite Gorge. The 17 Degraded beaches were located in the upper three reaches, with 12% in Marble Canyon, 41% in the Upper Granite Gorge, and the other 47% distributed through the Muav Gorge. The Improved beach was located in the Marble Canyon reach.

The most often cited cause of beach degradation this season was the erosion by fluctuating flows, particularly noticed after the higher flows during the second half of the season. Rain events also had a frequent impact and human causes, in the form of foot traffic erosion up slopes to and from the river, were noted more than in the past few years. Wind deflation of camps was present, but less significant than in recent years.

Per Reach

In the Marble Canyon reach, 4 beaches remained Unchanged, 1 was Improved at the end of the season and 2 had Degraded. Cutbanks and beach recession attributed to fluctuating dam releases were the primary causes cited. In the Upper Granite Gorge, 1 beach was classified as Same and 7 were found to have Degraded through the season. Fluctuating flows were again the leading culprit, with rain erosion also contributing to this classification. The Muav Gorge reach had 5 Unchanged beaches and 8 that had Degraded. Sand loss from fluctuating flows and rain erosion were about equal in this reach. Only one beach was considered in the Lower Granite Gorge and it remained the Same.

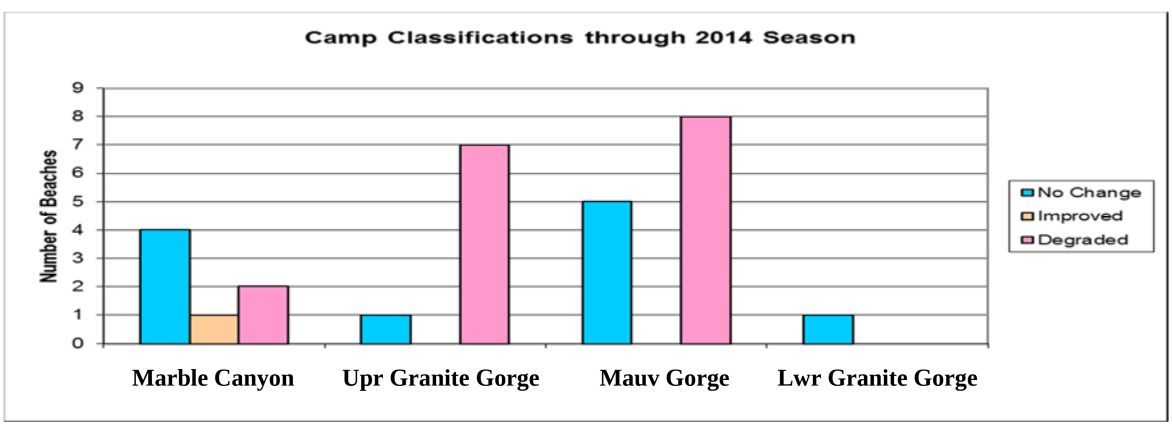

Figure 16. Graphic illustration for 2014 seasonal evaluations

Winter of 2013 - 2014

A High Flow Experiment was conducted in the Grand Canyon in November of 2013 (see Fig. 4). This event complicated the normal analysis of how the winter flow regime and weather factors affected the beaches between October 2013 and April 2014, as photos of the HFE results were not obtained until some months after the fact and after the winter flow regime. So, this evaluation partly addresses both instances.

All but four beaches demonstrated not only Improvement from the HFE but also the ability to hold that status despite a relatively high fluctuating flow regime in January. Soap Creek Camp at river mile 11.3 may have been reduced in size across the beach front but the differing water levels between photo dates made for a poor comparison. Martha's (RM 38.6) and Clear Creek (RM 84.6) both displayed considerable recession across the front with cutbanks that could have resulted from the higher fluctuating flows. The beach at 19.4 incurred a significant amount of sand loss from both the beach front and the campable dune located in the eddy in front of the main beach. Either of which may have occurred from action by the HFE, the dam releases or both.

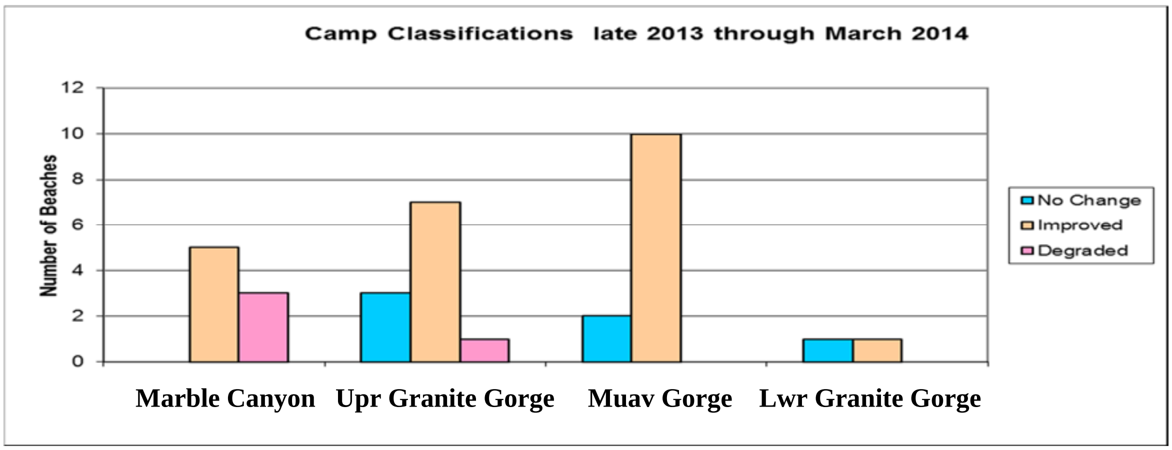

Figure 17. Graphic illustration for pre_HFE 2013 to Spring 2014 evaluations

Tamarisk beetle tracking

This is the third season that the AAB program has been noting and recording the presence of *Diohabda spp.*. As observed in the images, the effects of the beetle appear as trees that go from green foliage and full form early in the season, then appear leafless and/or burnt orange in early July, and finally return to partial green again later in the summer.

Of the 44 beaches photographed in early April 2014, 23 had enough photographic evidence through the season to evaluate the presence or absence of the beetles. Of these, three beaches were considered as having beetle infestation and 20 are classified as being beetle free. The remaining 21 beaches were fairly evenly divided into categories of 1.) Not sufficient evidence to assume presence, 2.) No tamarisk was found in the photos, and 3.) Photo sequences for the beach were deficient of temporal information to make an evaluation. An effort to locate and photograph trees closely associated with all beaches was implemented in 2014 to help broaden this database but is not complete at this time.

In the Marble Canyon reach, were 11 beaches are located, 6 of the 7 classified beaches were considered to be absent of beetles. The one camp with evidence of beetles was the furthest upstream beach to be evaluated. In the Upper Granite Gorge, 6 of the possible 15 beaches qualified for examination. Two exhibited beetle evidence, and these were at the camps furthest downstream. The Muav Gorge reach contained 10 of 15 beaches where analysis could determine Presence/Absence. Of these, all 10 were decidedly beetle free. The Lower Granite Gorge reach had no beaches that were evaluated.

High Flow Event positive results

Since 1996, it has been photographically documented that HFE can and do positively affect camping beaches. The question arises as to whether these Improved classification results are consistent across individual beaches and by reach. In this section, beaches which received only Improved classifications after each HFE and responded positively to at least three HFE actions and are examined. No camps classified as Unchanged or Degraded are considered. It should be noted that all of the beaches tracked by the Adopt-A-Beach program are included in this examination but three, which were excluded because, while they both had Improved responses exclusively, neither had the required three years of results.

Cursory evaluation of the results revealed one distinct spatial pattern. Of the 13 beaches deemed Improved consistently by the HFEs, 9 were located more than 125 miles downstream from the dam. It should also be noted that 13 additional beaches never received a Degraded classification, only Improved or No Change. These beaches were also most often located greater than 100 miles downstream of the dam. See Page 4 of Appendix A for a more detailed listing.

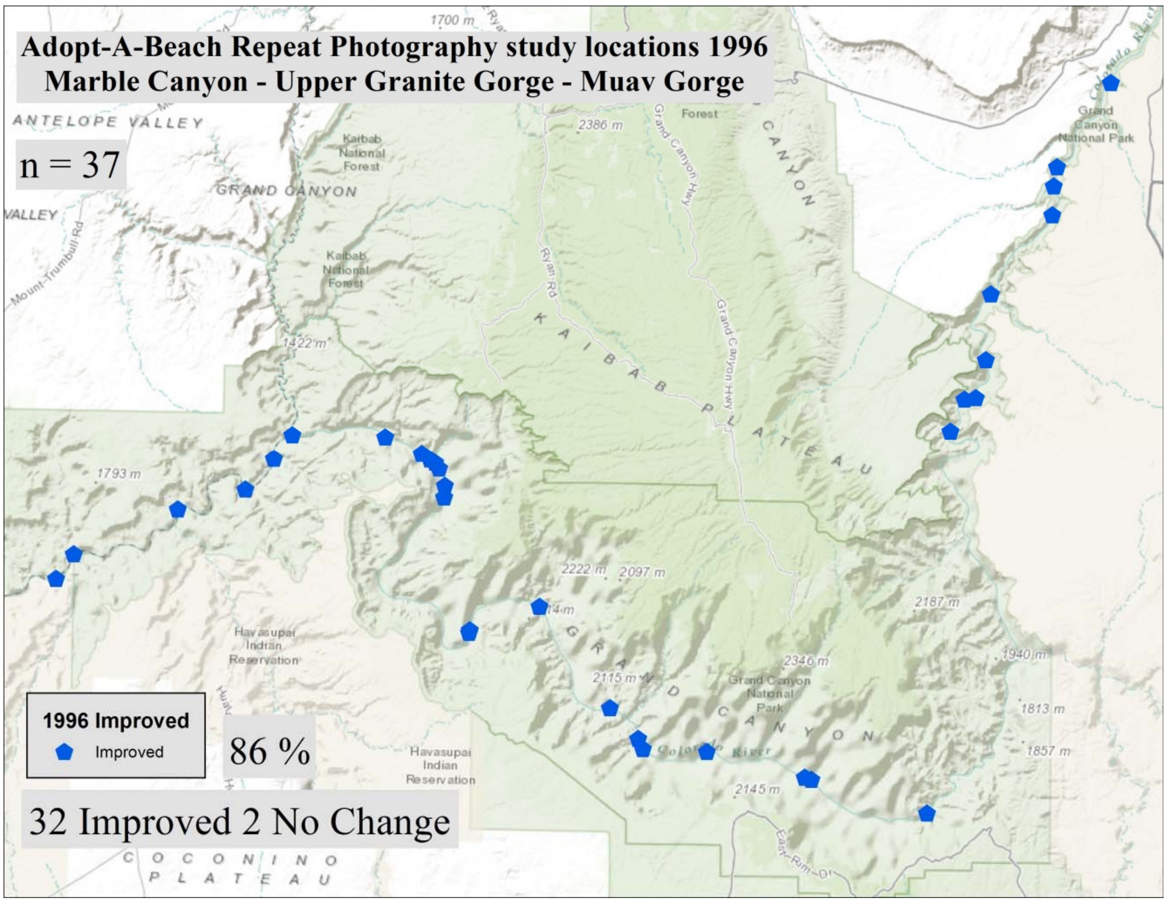

Figure 18. Spatial distribution of beaches classified Improved after the 1996 High Flow Event

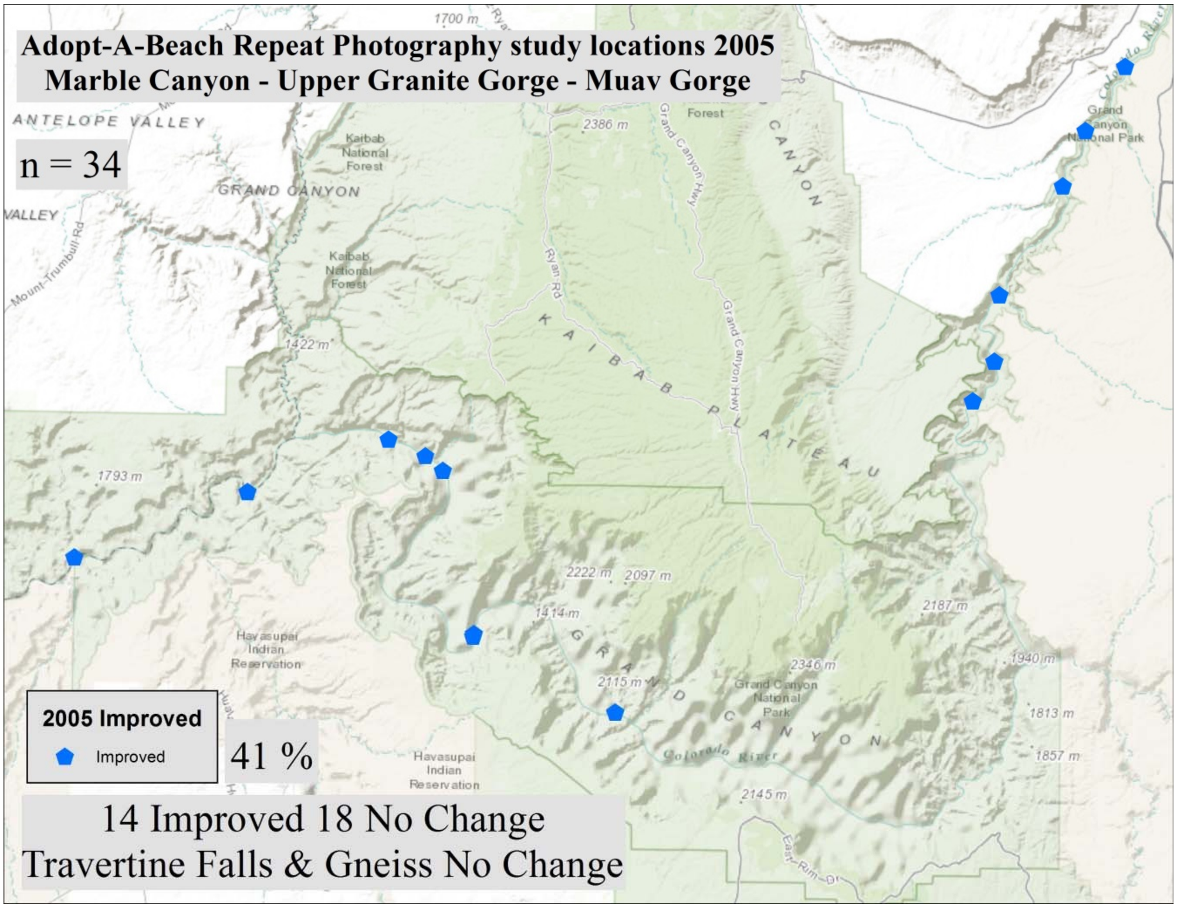

Figure 19. Spatial distribution of beaches classified Improved after the 2005 High Flow Event

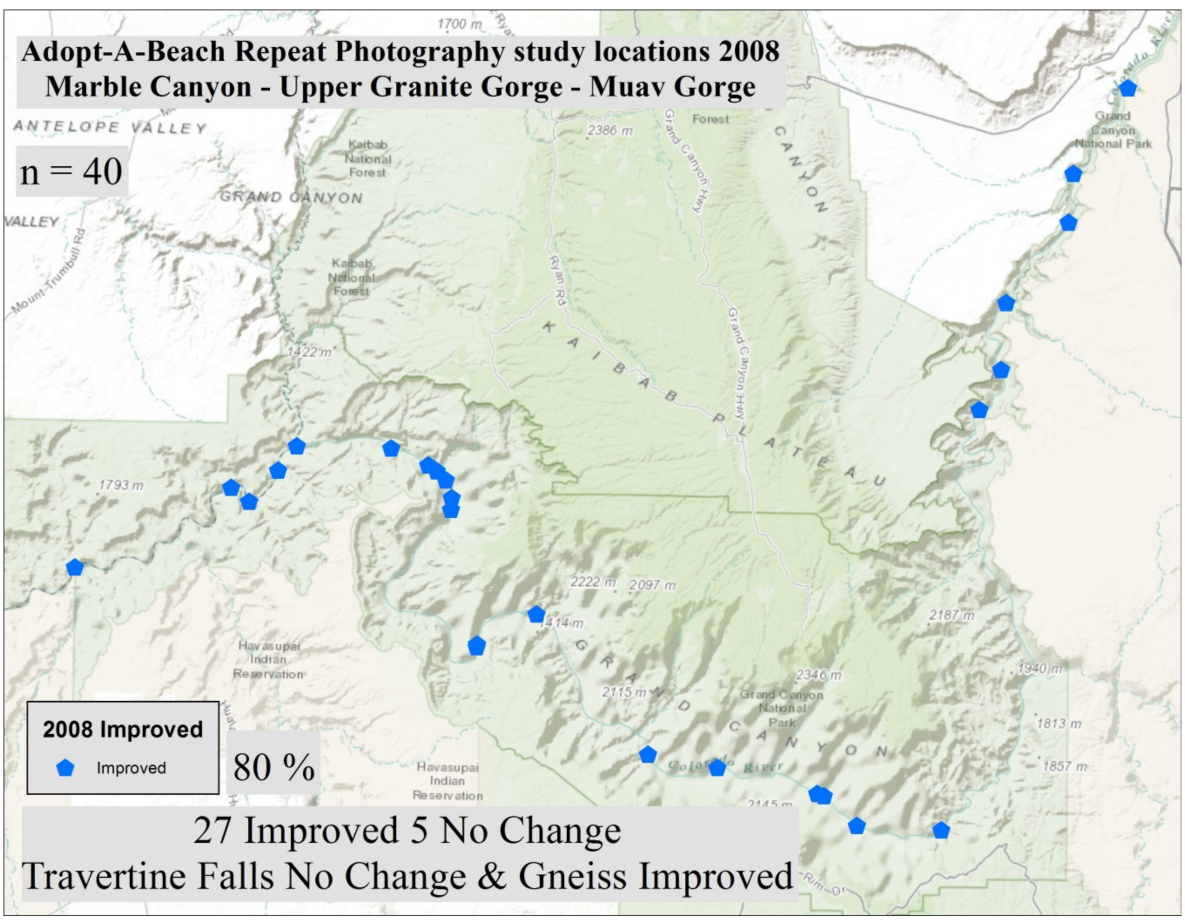

Figure 20. Spatial distribution of beaches classified Improved after the 2008 High Flow Event

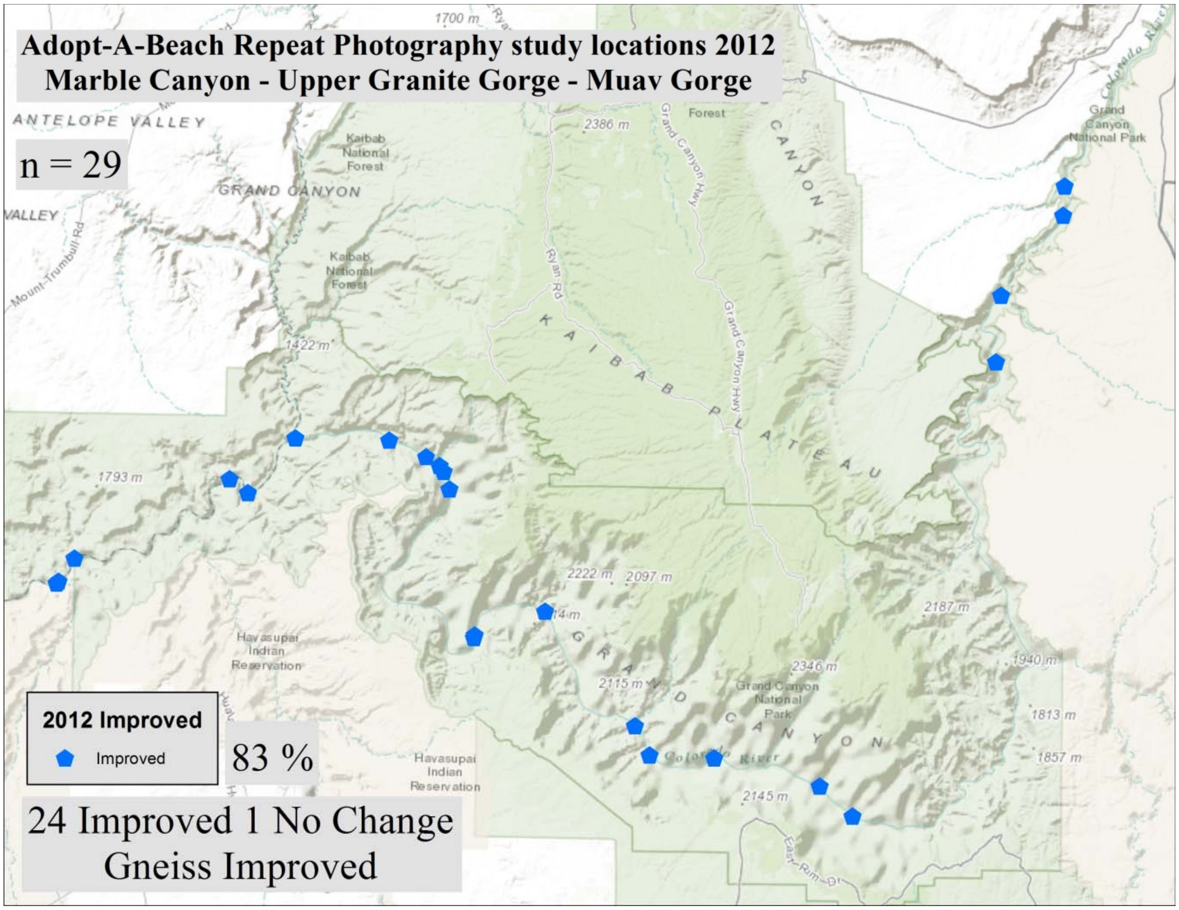

Figure 21. Spatial distribution of beaches classified Improved after the 2012 High Flow Event

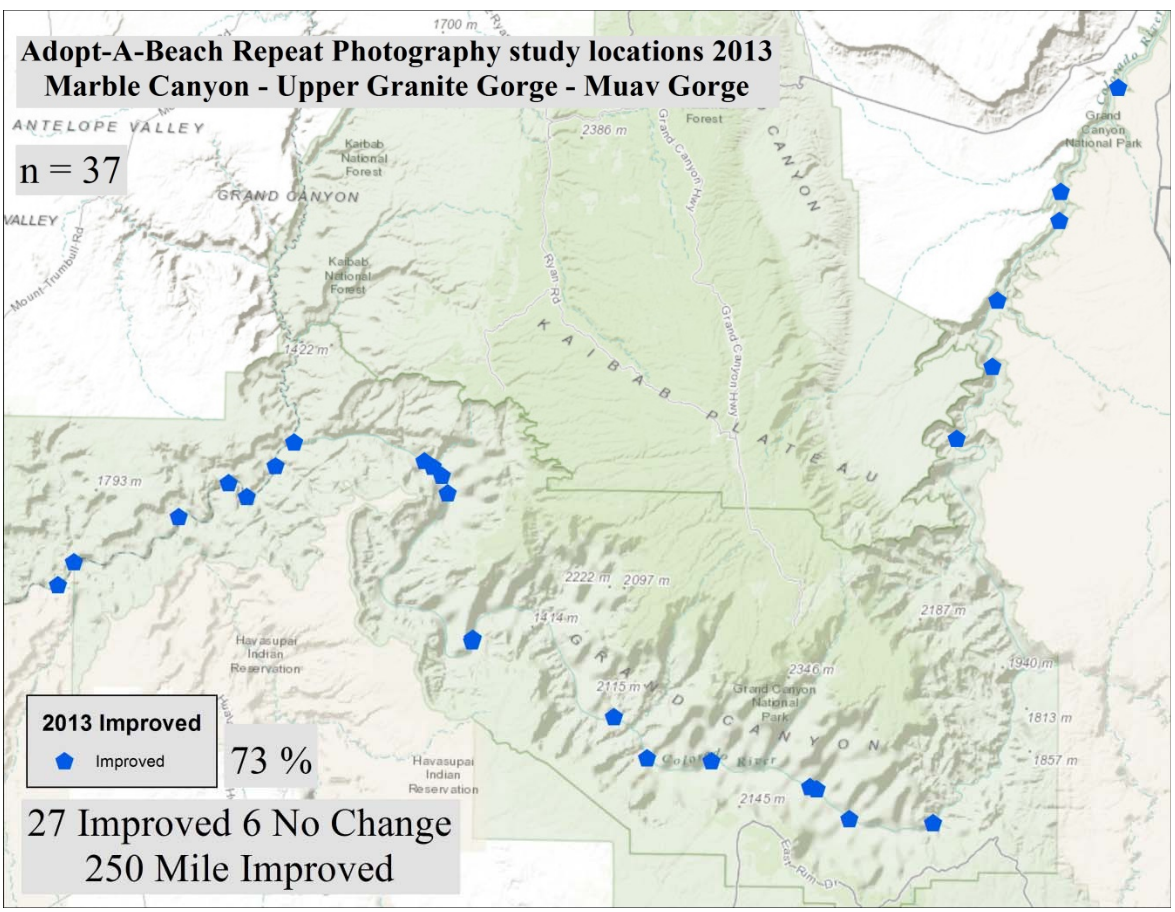

Figure 22. Spatial distribution of beaches classified Improved after the 2013 High Flow Event

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 factor.

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

ACKNOWLEDGEMENTS

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 seventeen plus 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.

Special thanks to Lynn Hamilton for exhaustive work in support of this project.

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Web

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Appendix A

Results of Analysis in Tabular Form

Page 1   Results of evaluations, late 2013 season to early April 2014, including 2013 HFE

Camp name	Rvr mile	Late 2013	to	Early 2014	reason
		Same	Improved	Degraded	POST HFE
Soap Creek	11.3 R			X	Poor comparison due to differing H2O levels
12.4 Mile	12.4 L		X		Gully filled, bigger camp
Hot Na Na	16.6 L				No late season 2013 photo for comparison
19.4 Mile	19.4 L			X	Huge loss of sand (high flow?)
Upper North Canyon	20.7 R		X		Rocks covered in camp
23 Mile	22.7 L		X		Better parking
Shinumo Wash	29.5 L		X		Longer & wider, but severe cutbank
Nautaloid	35 L				No late season 2013 photo for comparison
Tatahatso	37.9 L				No late season 2013 photo for comparison
Martha's	38.6 L			X	Sand lost across front parking area
Buck Farm	41.2 R		X		More camp area on upper end
Total above	11	0	5	3	
Nevills	76 L		X		Better parking, more camp area
Hance	77.1 L				No late season 2013 photo for comparison
Grapevine	81.7 L		X		Rocks covered in camp, still steep
Clear Creek	84.6 R			X	Steeper with cutbank, still heavy veg
Zoroaster	85 L		X		Much improved, much larger
Trinity Creek	92.1 R		X		Lots of rocks covered, gully filled
Schist	96.6 R		X		Rain erosion covered
Boucher	97.3 L	X			Lots of driftwood in camp, more sand area
Crystal	98.7 R	X			Steeper, but rain erosion covered
Lower Tuna	100.2 L				No late season 2013 photo for comparison
Ross Wheeler	108.3 L	X			No change
Bass	109 R				No late season 2013 photo for comparison
110 mile	110 R				No late season 2013 photo for comparison
Upper Garnet	114.9 R		X		Much larger camp area
Lower Garnet	115.1 R		X		Gully filled, bigger camp
Total above	15	3	7	1	
Below Bedrock	131.7 R	X			Modified but not improved
Stone Creek	132.5 R		X		Beach wider, higher, rocks covered
Talking Heads	133.7 L		X		More useable area, flatter
Racetrack	134.2 R	X			Slight sand deposit increase across front
Lower Tapeats	134.5 R		X		Much larger camp area
Owl Eyes	135.2 L		X		Larger, flattened
Backeddy	137.8 L				No late season 2013 photo for comparison
Kanab	144 R		X		Huge increase in camp area
Olo	146.1 L		X		Huge increase in camp area
Matkat Hotel	148.9 L				No late season 2013 photo for comparison
Upset Hotel	150.9 L		X		Better parking, rocks covered
Last Chance	156.3 R		X		Lots of sand added to camp area
Tuckup	165.2 R		X		Lots of rocks covered, gully filled
Upper National	167 L		X		Some camp area added, still bad parking
Lower National	167.2 L				No late season 2013 photo for comparison
Total above	15	2	10	0	
Travertine Falls	230.6 L				No early season 2014 photo for comparison
Gneiss	236.1 R	X			Little or no change
250 Mile	250.0 R		X		Some useable beach added
Total above	3	1	1	0	
Totals	44	6	22	4	

Page 2 Results of evaluations, April through October 2014 season, pre-HFE.

Camp name	Rvr mile	2014	thru	season	reason
		Same	Improved	Degraded	
Soap Creek	11.3 R				No late season photos
12.4 Mile	12.4 L				No late season photos
Hot Na Na	16.6 L	x			
19.4 Mile	19.4 L		x		
Upper North Canyon	20.7 R				No late season photos
23 Mile	22.7 L				No late season photos
Shinumo Wash	29.5 L			x	Cutbank/recession from fluc flows, human trailing
Nautaloid	35 L	x			Limited views for evaluation
Tatahatso	37.9 L	x			Slight modification at parking area
Martha's	38.6 L			x	Fluc flow and human erosion at parking
Buck Farm	41.2 R	x			Slight sand loss on upper end
Total above	11	4	1	2	
Nevills	76 L			x	Fluc flow recession
Hance	77.1 L				No late season photos
Grapevine	81.7 L				No late season photos
Clear Creek	84.6 R			x	Fluc flow impact, recession
Zoroaster	85 L			x	Cutbank, recession from fluc flow
Trinity Creek	92.1 R			x	Rain gully, slight veg increase
Schist	96.6 R			x	Both fluc flow impact and wind scour
Boucher	97.3 L				No late season photos
Crystal	98.7 R				No late season photos
Lower Tuna	100.2 L				No late season photos
Ross Wheeler	108.3 L				No late season photos
Bass	109 R				No late season photos
110 mile	110 R	x			Some fluc flow recession on lower end
Upper Garnet	114.9 R			x	Rocks exposed from wind scour
Lower Garnet	115.1 R			x	Rain gully, steep parking area, human trailing
Total above	15	1	0	7	
Below Bedrock	131.7 R			x	Cutbank/recession from fluc flows, human trailing
Stone Creek	132.5 R			x	Cutbank/recession from fluc flows, more rocks
Talking Heads	133.7 L			x	Cutbank/recession from fluc flows
Racetrack	134.2 R	x			Slight change along front
Lower Tapeats	134.5 R			x	Some sand loss, dangerous driftwood piles
Owl Eyes	135.2 L	x			Looks good. HFE results held
Backeddy	137.8 L	x			Less steep but slight rain gully
Kanab	144 R	x			Looks good. HFE results held
Olo	146.1 L			x	Cutbank/recession, flash removed most of beach
Matkat Hotel	148.9 L			x	Lots of rain damage, poss human impact to veg
Upset Hotel	150.9 L				No late season photos
Last Chance	156.3 R			x	Sand loss in back from rain
Tuckup	165.2 R			x	Lots of rain gully damage
Upper National	167 L	x			Parking still rocky, veg increase, small gully
Lower National	167.2 L				No late season photos
Total above	15	5	0	8	
Travertine Falls	230.6 L				No late season photos
Gneiss	236.1 R				No late season photos
250 Mile	250.0 R	x			Slightly less sand on beach, some veg increase
Total above	3	1	0	0	
Totals	44	11	1	17	

 Results of tamarisk beetle observations, end of 2014 season

Camp name	Rvr mile	Tamarisk beetle evident 2014
Soap Creek	11.3 R	
12.4 Mile	12.4 L	
Hot Na Na	16.6 L	Y
19.4 Mile	19.4 L	N
Upper North Canyon	20.7 R	N
23 Mile	22.7 L	
Shinumo Wash	29.5 L	N
Nautaloid	35 L	N
Tatahatso	37.9 L	N
Martha's	38.6 L	N
Buck Farm	41.2 R	
Total above	11	7
Nevills	76 L	
Hance	77.1 L	
Grapevine	81.7 L	
Clear Creek	84.6 R	N
Zoroaster	85 L	N
Trinity Creek	92.1 R	N
Schist	96.6 R	
Boucher	97.3 L	
Crystal	98.7 R	
Lower Tuna	100.2 L	
Ross Wheeler	108.3 L	
Bass	109 R	
110 mile	110 R	N
Upper Garnet	114.9 R	Y
Lower Garnet	115.1 R	Y
Total above	15	6
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	N
Backeddy	137.8 L	N
Kanab	144 R	
Olo	146.1 L	
Matkat Hotel	148.9 L	N
Upset Hotel	150.9 L	
Last Chance	156.3 R	
Tuckup	165.2 R	N
Upper National	167 L	N
Lower National	167.2 L	
Total above	15	10
Travertine Falls	230.6 L	
Gneiss	236.1 R	
250 Mile	250.0 R	
Total above	3	0
	44	23

Page 4 Compilation of results for High Flow Events 1996 - 2013

Camp	1996 Improved	1996 Degraded	1996 Same	2005 Improved	2005 Degraded	2005 Same	2008 Improved	2008 Degraded	2008 Same	2012 Improved	2012 Degraded	2012 Same	2013 Improved	2013 Degraded	2013 Same
Soap				X				X			X			X	
12.4	X					X	X						X		
Hot Na Na				X											
19.4	X					X	X				X			X	
North	X			X				X		X			X		
23	X					X	X			X			X		
Shinumo	X			X			X			X			X		
Nautiloids	X			X			X			X			X		
Tatahatso	X							X							X
Marthas	X			X			X							X	
Buck Farm	X				X			X			X		X		
Nevills	X					X	X						X		
Hance			X												
Grapevine						X	X			X			X		
Clear Creek	X						X			X			X		
Zoroaster	X						X						X		
Trinity	X						X			X			X		
Schist	X					X			X	X			X		
Boucher	X						X								X
Crystal			X			X		X		X					X
Lower Tuna	X			X									X		
Ross Wheeler		X				X			X						X
Bass	X				X			X		X					
110		X					X				X				
Upr Garnet	X			X			X			X			X		
Lwr Garnet	X			X			X			X			X		
Below Bedrock	X					X	X					X			X
Stone	X					X	X			X			X		
Talking Heads	X			X			X			X			X		
Racetrack	X					X			X	X					X
Tapeats	X					X	X						X		
Owl Eyes	X			X			X			X			X		
Backeddy	X			X			X			X					
Kanab	X					X	X			X			X		
Olo	X						X						X		
Matkat	X			X			X			X			X		
Upset							X			X			X		
Last Chance	X					X			X				X		
Tuckup	X			X			X			X			X		
Upr National		X				X		X		X			X		
Lwr National	X					X		X		X				X	
Travertine						X			X						
Gneiss						X	X			X					X
250													X		

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

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)