Long Term Monitoring of Camping Beaches In Grand Canyon

Summary of Results for 2011 with Comparisons to Observations of the 1996 Beach Building/Habitat Flow

Annual Report of Repeat Photography
By Grand Canyon River Guides, Inc.[1]
(Adopt-A-Beach Program)

By
Paul Lauck[2]

June 12, 2012

Lower Tuna Camp, RM 99.7 L February, 1996
Lower Tuna Camp, RM 99.7 L September, 2011

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Adopt – A – Beach:
Long-Term Monitoring of Camping Beaches in Grand Canyon
Summary of Monitoring Observations for Year 2011

By Paul Lauck[1]

Abstract

For the past sixteen 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. The resulting evaluations are also segregated and examined dependent upon which of the four primary river reaches in which the beach resides.

For the time spanning the 2011 summer boating season, early April to mid-November, 37 of the 44 study beaches in the program had photographs and photographer comment sheets spanning a sufficient period of time to be evaluated. Of these 37 beaches, 27% were classified as Unchanged for the time period, 41% had Improved through the summer and 32% were considered as Degraded by the end of the season. Of the Unchanged beaches, 40% are located in the Marble Canyon reach, 30% in the Upper Granite Gorge reach, another 20% are contained in the Muav Gorge reach and one, or 10%, is in the Lower Granite Gorge. Twenty percent of the Improved beaches are located in the Marble Canyon reach, another 33% in the Upper Granite Gorge and 47% are found in the Muav Gorge reach. Neither of the two beaches included in the study this year and located in the Lower Granite Gorge were considered to have improved. For the beaches classified as Degraded for this time period, 25% are from the Marble Canyon reach, 42% are found in the Upper Granite Gorge, 25% in the Muav Gorge reach and one, or 8% was located in the Lower Granite Gorge reach. The primary factor cited as creating an Improved camp is an increase of sand on the beachfront, enlarging the beach and creating more favorable parking for boaters. This is attributed to deposition from river transported sediment or sand being moved downslope and forward to the beach-front by the extended flows in excess of 20K cfs through much of the season. An addition of sediment during September tributary inflows may also have been a factor. Beach-front erosion and severe cutbanks as a result of the higher seasonal flows are the most readily evident cause of Degradation. Another factor cited was vegetation increase/encroachment.

A comparison between the late 2011 and pre-Beach-Habitat Building Flow (BHBF) of 1996 beach conditions was conducted to evaluate the relative conditions and possible factors for change over the past sixteen years. Of the 34 beaches considered in this

portion of the analysis, 35% of the beaches were classified Unchanged, 18% are considered to be Degraded relative to the 1996 images, and 47% are Improved.

The following proportions were recorded per reach for these beaches. In the Marble Gorge, 43% were classified as Unchanged and 57% were recorded as being Improved compared to their 1996 pre-BHBF event conditions. None had degraded beyond the first image condition recorded by the study. Only seven of the eleven beaches currently being monitored in this reach were photographed during that first event. In the Upper Granite Gorge reach, 46% appeared to be the Same as in 1996, only two of the thirteen beaches considered, or 15% in this reach were classified as Degraded and 38% have an Improved appearance. Twentyone percent of the beaches located in the Muav Gorge reach currently have a Same classification, 29% are considered Degraded compared to the 1996 images and a strong 50% are recorded as Improved.

Most of the beaches considered as Improved when compared to the pre-BHBF are cited as having an expanded camp area and sand increase in general. Those beaches classified as having a more Degraded appearance in 2011 were largely impacted by vegetation increases and, to a lesser extent, loss of beach front from river flow erosion.

Since the 1996 BHBF, a primary concern of researchers has been the longevity of conditions for those beaches. Thirty three of the Adopt-A-Beach camps photographed in 2011 were available for comparison to the post-BHBF mid-season photographs acquired in 1996. Of these, 32% were considered to be about the Same condition now as in 1996, 21% were classified as remaining Improved since the BHBF and 47% have Degraded beyond their post BHBF condition.

When divided into their respective reaches, 50% of the beaches located in Marble Canyon were classified as Same and 50% were considered as Degraded. No beach located in this reach was considered to be Improved when compared to the 1996 images. Twenty-three percent of the beaches in the Upper Granite Gorge reach were classified as Same or Unchanged when compared to the 1996 photos, 62% received a Degraded classification and 15% of the beaches are considered as having improved since the 1996 BHBF. In the Muav Gorge reach 31% received a Same as 1996 designation, 31% have Degraded and 38% have Improved since the 1996 event. None of the beaches currently being studied in the Lower Granite Gorge was photographed in 1996.

For those beaches rated as Improved when compared to the post BHBF images, most had a greater camping area available at the end of 2011, particularly toward the rear of the camp area. This can possibly be attributed to sediment deposition from subsequent High Flow Experiments and reworking of the sand by wind action. The most predominant cause sited for a Degradation classification was a marked increase in vegetation, both surrounding the camp area and in the interior areas. Erosion of beach fronts from the recent seasonal flow regime also factored into many of the Degradation ratings.

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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).

In 1992, the Grand Canyon Protection Act was passed by Congress to ensure that ecological and cultural resources downstream of the dam would be monitored for changing conditions imposed by operation of the dam. It states that the 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. Sand bars 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).

The beaches form the substrate for communities of plants, invertebrates and vertebrates, including species such as riparian birds (Carothers and Brown, 1991). Those who run the river are also interested in observing the changes to camping beaches

throughout the river corridor in the Grand Canyon. To help document and better understand the impacts that the HEF and possible future events would have on sandbars used by river runners as primary campsites along the Colorado River, members of Grand Canyon River Guides (GCRG) began photographing selected beaches shortly before and after the original HFE occurred. GCRG is a nonprofit, grassroots organization that represents the interests of the Grand Canyon river running community. To monitor subsequent changes in the beaches of interest, the Adopt-A-Beach (AAB) program was created and utilized volunteer photographers to conduct repeat photography of these camps. These volunteers include commercial, private and scientific persons who travel by boat on the Colorado. Comment sheets, completed by the volunteers at the time the photographs are acquired, assist in the effort to document the beach conditions. 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.

Camping beaches are 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. As a way to contribute to resource management, AAB now submits annual results to the Glen Canyon Dam Adaptive Management Program (GCDAMP). The results and conclusions are synthesized through a representative that serves on the Technical Work Group (TWG). 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 season and between years. 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 so called tamarisk beetle, *Diohabda spp*. have been included in these comments.

The purpose of this report is to present the results of the monitoring effort for the period between late 2010 and November 2011. 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, and a comparison of the 2011 beach conditions with those photographed both before and after the initial “test flood’ conducted in March 1996 are included.

The AAB program has now completed its sixteenth year as a study that monitors camping beaches along the Colorado River in Grand Canyon. Results are submitted to various agencies such as the Cultural Resources Program of the Grand Canyon Monitoring and Research Center (GCMRC). Results are also presented to the GCDAMP so that private and commercial recreational interests are represented as stakeholders in Colorado River management as reported to the Secretary of the Interior (Lauck, 2010).

Volunteer photographers for this program are unique in that many run the Colorado River more than once in one season, and are therefore able to provide sets of repeat photographs and on-the-spot comments for each study beach. With the end of the 2011 season, river runners have produced nearly 4000 replicate photographs on more than 2800 dates with associated field sheets recording the sequential condition of beaches. Research results include reporting positive "Improved" conditions, negative "Degraded" conditions or "Same," that no changes were found in beaches; longevity of these camps; and attributes the primary and secondary processes that cause change in camping beach area and quality.

Specific research questions that are addressed by this report are:

- What changes, if any, are found at the beaches between early winter 2010 and early spring 2010?
- What changes, if any, are found at the beaches during the boating season of 2011?
- How do the beach conditions of late 2011 compare to those of early 1996, prior to the Beach-Habitat Building Flow of March 1996?
- How do the beach conditions of late 2011 compare to those of late Spring 1996, after the Beach-Habitat Building Flow?
- 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?

Methods

Study locations and beaches

Since 1996, the AAB program has studied an average of 38 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, 1996-2011. They 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 entire 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.

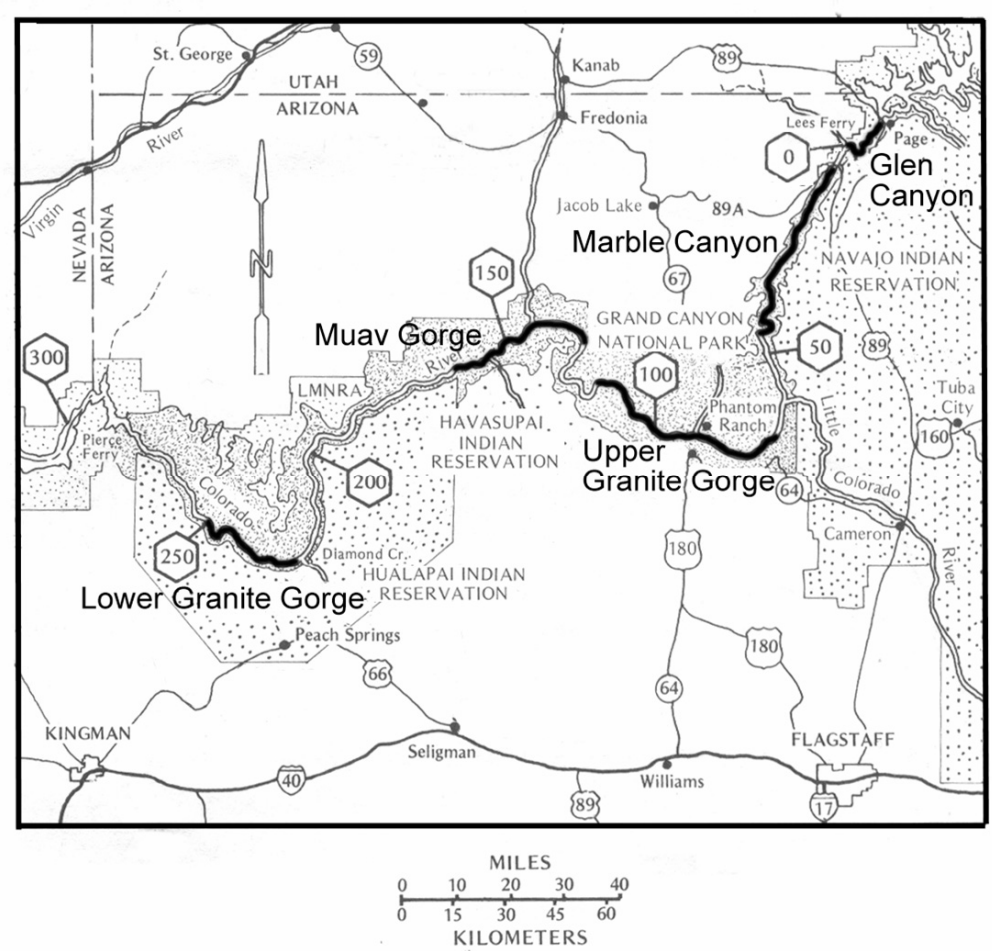

Figure 1. Locations of five critical reaches along the Colorado River in Grand Canyon National Park

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
				81.7	Grapevine	133.7	Talking Heads		
				84.6	Clear Creek	134.2	Race Track	250.0	250 Mile
		16.6	Hot Na Na	85.0	Zoroaster	134.5	Lower Tapeats		
		19.4	19.4 Mile	92.1	Trinity Creek	135.2	Owl Eyes		
		20.7	North Cyn	96.6	Schist	137.8	Back Eddy		
		22.7	23 Mile	97.3	Boucher	144.0	Kanab Creek		
		29.5	Shinumo Wash (Silver Grotto)	98.7	Crystal	146.1	Olo		
				100.2	Lwr Tuna	148.9	Matkat Hotel		
		35.0	Nautiloid (Middle&Lower)	108.3	Ross Wheeler	150.9	Upset Hotel		
				109.0	Lwr Bass	156.3	Last Chance		
		37.9	Tatahatso	110.0	110 Mile	165.2	Tuckup		
		38.6	Martha's (Bishop's)	114.9	Upper Garnet	167.0	Upper National		
				115.1	Lower Garnet	167.2	Lower National		
		41.2	Buck Farm						

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 location between beaches and the number of images acquired per beach are not the same for all beaches. 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. Martha's Camp RM 38.3 L. Photo on left taken 4/3/11, right taken 9/22/11. Documented change in beach front erosion for 2011 season.

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 2011 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 Hot Na Na (July 2000). These documented events and data are available to any interested researchers through Grand Canyon River Guides or Grand Canyon Monitoring and Research Center 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, 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. With the increasing use of digital cameras to collect the images, a date/time stamp on the photo will help eliminate this issue.

When comparing the photos for evaluation, numerous criteria are used to gather the empirical data used. 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) or the Paria River @ Lees Ferry, AZ (09382000). See Figures 6 – 9. 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.

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 effect 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 lower (downstream) end of Stone Creek Camp would be a good example of both of these results.

Figure 4 & 5. Stone Creek Camp, RM 132.0 RL, 04/10/11 (left) and 9/23/11 (right) display camp expansion from late season deposition.

The same kind of visual clues can also be used to determine aeolian action, particularly when the exposed or covered rocks and shelves are higher than any possible river flow level during the time period being examined. During the last 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 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 down stream. 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.

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 Same. While the designations of Same, 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.

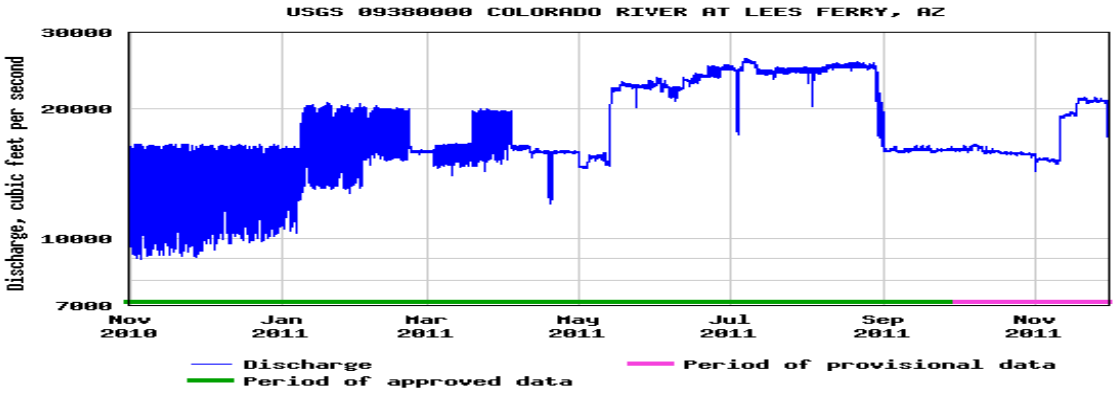

Figure 6. Flow graph for Colorado River at Lees Ferry, AZ., 2011

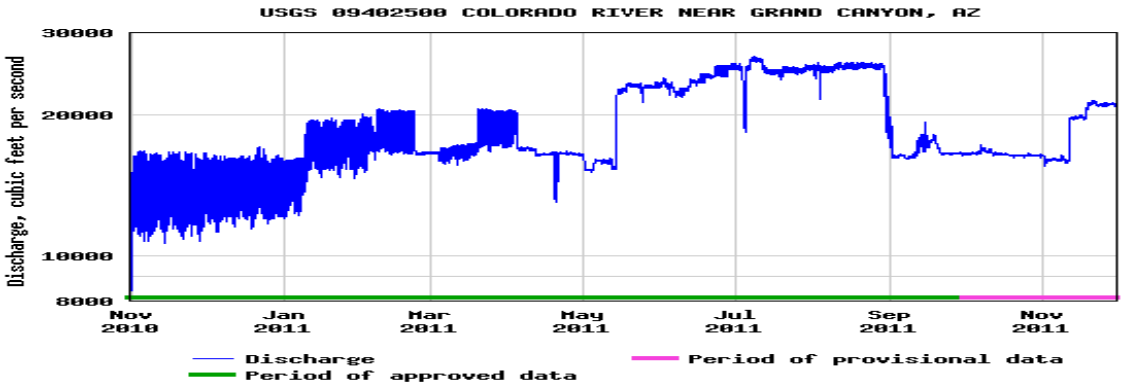

Figure 7. Flow graph for Colorado River near Grand Canyon, AZ., 2011

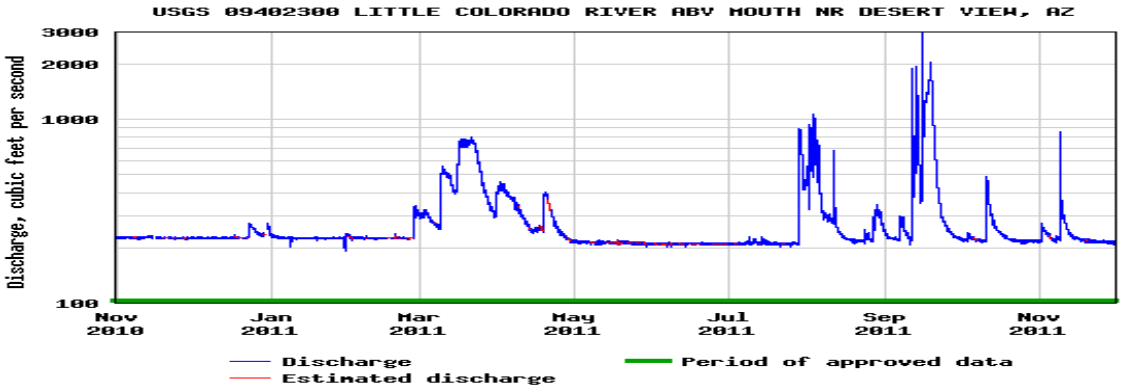

Figure 8. Flow graph for Little Colorado River above mouth near Desert View, AZ ., 2011

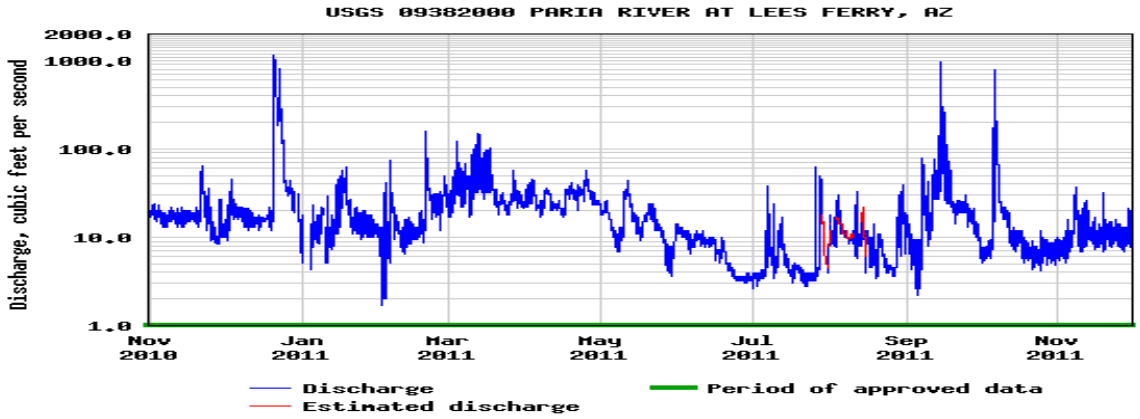

Figure 9. Flow graph for Paria River at Lees Ferry, AZ ., 2011

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 2011, evidence of change between April 1 and the latest photo acquired for the year was evaluated. The majority of the ending date photos were taken from mid-September into November. Five of the beaches which had early season information were not included in this portion of the study because the last photo of the beach was taken on or before August 1. Another analysis conducted with this data set compared the early April photographs to the end of season 2010. Finally, the end of 2011 season images were compared to photos taken immediately preceding and subsequent to the 1996 Beach-Habitat Building Flow event.

Figures 10 & 11. Talking Heads Camp, RM 133.0 L April 10, 2011 (left) and December 1, 2011 (right) documenting progressive beach loss due to high releases.

Results

Through 2011 boating season

For the time spanning the 2011 summer boating season, early April to mid-November, 37 of the 44 study beaches in the program had photographs and photographer comment sheets spanning a sufficient period of time to be evaluated. Of these 37 beaches, 27% were classified as Unchanged for the time period, 41% had Improved through the summer and 32% were considered as Degraded by the end of the season. Of

the Unchanged beaches, 40% are located in the Marble Canyon reach, 30% in the Upper Granite Gorge reach, another 20% are contained in the Muav Gorge reach and one, or 10%, is in the Lower Granite Gorge. Twenty percent of the Improved beaches are located in the Marble Canyon reach, another 33% in the Upper Granite Gorge and 47% are found in the Muav Gorge reach. Neither of the two beaches included in the study this year and located in the Lower Granite Gorge was considered to have improved. For the beaches classified as Degraded for this time period, 25% are from the Marble Canyon reach, 42% are found in the Upper Granite Gorge, 25% in the Muav Gorge reach and one, or 8% was located in the Lower Granite Gorge reach. The primary factor sited as creating an Improved camp is an increase of sand on the beach front enlarging the beach and creating more favorable parking for boaters. This is attributed to deposition from river transported sediment or sand being moved downslope and forward to the beach front by the extended flows in excess of 20K cfs through much of the season. An addition of sediment during September tributary inflows may also have been a factor. Due to the prolonged release of high water during this season, few if any noticeable changes could be readily identified during the mid-May through August time period. Beach front erosion and severe cutbanks as a result of the higher seasonal flows are the most readily evident cause of Degradation. Another factor often sited was vegetation increase/encroachment. One tributary flash event, at Trinity Camp, was noted by both the volunteer photographer and the analyst, and did have a significant effect.

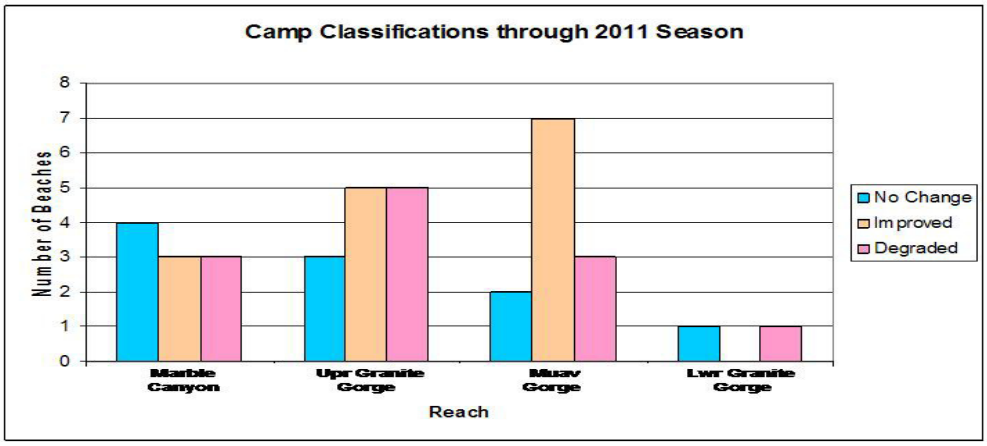

Figure 12. Graphic illustration for 2011 seasonal evaluations

Winter of 2010 - 2011

This analysis is ongoing and will be included in the final report before July 1.

Changes since 1996 Beach Habitat Building Flow event

Since 1996, a primary concern of researchers has been the longevity of conditions for those beaches which were considered as Improved by the BHBF in 1996. When reviewing the results for this section of the analysis, it is important to remember that there have been other HFE and tributary events influencing the outcomes of these comparisons. It is possible that beaches have "improved" since 1996 by any number of causes, and these results do not reflect directly on comparison to the 1996 results.

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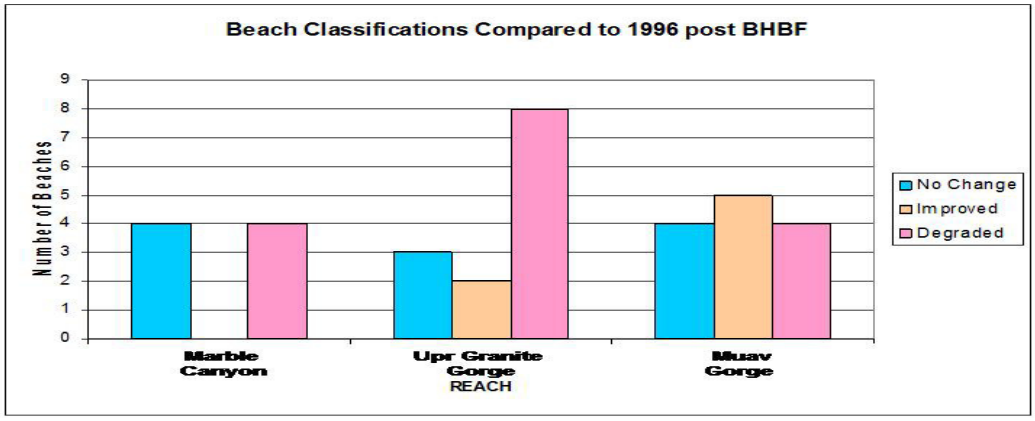

Figure 13. Graphic illustration of 2011 beaches compared to post 1996 BHBF

Changes since 1996, preceding the Beach Habitat Building Flow event

Of the 34 beaches considered in this portion of the analysis, 35% of the beaches were classified Unchanged, 18% are considered to be Degraded relative to the 1996 images, and 47% are Improved.

The following proportions were recorded per reach for these beaches. In the Marble Gorge, 43% were classified as Unchanged and 57% were recorded as being Improved compared to their 1996 pre-BHBF event conditions. None had degraded beyond the first image condition recorded by the study. Only seven of the eleven beaches currently being monitored in this reach were photographed during that first event. In the Upper Granite Gorge reach, 46% appeared to be the Same as in 1996, only two of the thirteen beaches considered, or 15% in this reach were classified as Degraded and 38% have an Improved appearance. Twenty-one percent of the beaches located in the Muav Gorge reach currently have a Same classification, 29% are considered Degraded compared to the 1996 images and a strong 50% are recorded as Improved.

Most of the beaches considered as Improved when compared to the pre-BHBF are cited as having an expanded camp area and sand increase in general. Those beaches classified as having a more Degraded appearance in 2011 were largely impacted by vegetation increases and, to a lesser extent, loss of beach front from river flow erosion.

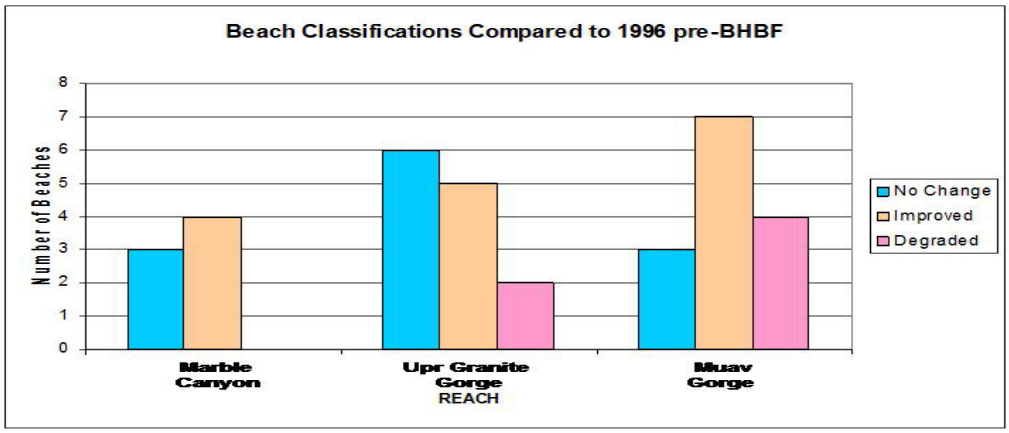

Figure 14. Graphic illustration for 2011 beach classifications compared to 1996 pre-BHBF .

Conclusions

Throughout the sixteen years that the Adopt-A-Beach program has been in existence, the results have shown that the beaches used for camping along the Colorado River in Grand Canyon are continually subject to change. This study illustrates that all of the factors and results are very beach dependent and not consistent. The geomorphic makeup of each individual beach will largely dictate how it responds to variations in river flow patterns and all other forces, both natural and anthropomorphic, at work on it. The river flow fluctuations still create impacts, both positive and negative. Rain still falls and runs across beaches creating gullies as it washes sand into the mainstem channel. When camping activity slows on a beach for any appreciable length of time, or conditions are created which promote propagation, vegetation growth will expand to fill in the unoccupied areas, just as high flows can remove portions of that vegetation. Aeolian activity constantly re-sculptures surfaces and disperses the sand, usually with degrading effects on campsites by exposing previously covered rock. And human use of the beaches continues to erode trails and introduce modifications. It is hoped that, through continued monitoring, sustainable patterns will emerge that may help direct management

toward actions that will most benefit the beaches that are so integral to the numerous activities taking place along the river.

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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 ten 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 our resource in Grand Canyon is enhanced, degraded or maintained by the influence of man and technology.

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REFERENCES

Hazel, J.E. Jr., Kaplinski, M.A., Beus, S.S., and Tedrow, L.A., 1993. Sand bar stability and response to interim flows after a bar-building event on the Colorado River, Arizona: implications for sediment storage and sand bar maintenance: EOS Fall Meeting Abstracts, vol. 74. p. 43

Kaplinski, M.A., Hazel, J.E. Jr., and Beus, S.S., 1994. Monitoring the effects of interim flows from Glen Canyon Dam on sand bars in the Colorado River corridor, Grand Canyon National Park, Arizona: Report for Glen Canyon Environmental Studies, Northern Arizoan University, Department of Geology. 62 p.

Kearsley, L.H., and Warren, K.W., 1993. River campsites in Grand Canyon National Park: inventory and effects of discharge on campsite size and availability: National Park Service Division of Resource Management, Grand Canyon National Park, Grand Canyon. 65 p.

Kearsley, L.H., and Quartaroli, R., 1997. Effects of a beach/habitat building flow on campsites in Grand Canyon: Final Report of Applied Technology Associates for the Glen Canyon Environmental Studies. 18 p.

Lauck, Paul, 2010. Adopt-A-Beach Long-term Monitoring of Camping Beaches in Grand Canyon: Summary of Results for Year 2009.

Lauck, Paul, 2009. Adopt-A-Beach: Long Term Monitoring of Camping Beaches In Grand Canyon Summary of Results for Years 2007 - 2008.

Melis, T.S., ed., 2011. Effects of three high-flow experiments on the Colorado River ecosystem downstream from Glen Canyon Dam, Arizona: U.S. Geological Circular 1366.

Parnell, R.A., Dexter, L., Kaplinski, M.A., Hazel, J.E. Jr., Manone, M.F., and Dale, A., 1997. Effects of the 1996 controlled high flow release from Glen Canyon Dam on Colorado River sand bars in Grand Canyon: Final report for the beach habitat building flow: submitted to Glen Canyon Environmental Studies by Northern Arizona University, Department of Geology, 22p.

Schmidt, J.C., and Graf, J.B., 1990. Aggradation and degradation of alluvial sand deposits, 1965 to 1985, Colorado River, Grand Canyon National Park, Arizona: U.S. Geological Survey Professional Paper 1493, 74 p.

Thompson, K.S., Burke, K. and Potochnik, A., 1997. Effects of the Beach-Habitat Building Flow and Subsequent Interim Flows from Glen Canyon Dam on Grand Canyon Camping Beaches, 1996: A Repeat Photography Study by Grand Canyon

River Guides (Adopt-A-Beach Program).

Thompson, K.S., 2004. Long Term Monitoring of Camping Beaches in Grand Canyon: A Summary of Results from 1996 – 2003. Annual Report of Repeat Photography By Grand Canyon River Guides, Inc. (Adopt-A-Beach Program), 14 p.

U.S. Department of the Interior, 1987. *River and Dam Management*: A review of the Bureau of Reclamation's Glen Canyon Environmental Studies: National Academy Press, Washington, D.C., 203 p.

U.S. Department of the Interior, 1996. Record of Decision (ROD) on the Operation of Glen Canyon Dam Final Environmental Impact Statement (EIS): Bureau of Reclamation, Salt Lake City, Utah.

Webb, Robert H., 1996. Grand Canyon, a Century of Change. Rephotography of the 1889-1890 Stanton Expedition. University of Arizona Press, Tucson, AZ.

Webb, R.H., Boyer, D. E and Turner, R. M., 2010. Repeat Photography: Methods and Applications in the Natural Sciences. Island Press, Washington, D.C.

Wiele, S.M., Andrews, E.D., and Griffin, E.R, 1999. The effect of sand concentration on depositional rate, magnitude and location in the Colorado River below the Little Colorado River: in *The Controlled Flood in Grand Canyon:* Geophysical Monograph Series, vol. 110, p. 113-145.

Web

Geanious, Chris. Website gallery for Adopt-A-Beach images
http://www.geanious.com/gallery/main.php

Appendix A

Results of Analysis in Tabular Form

 Results of evaluations, through summer season of 2011

2011 Season Camp name	2011 Same	thru Improved	season Degraded	reason
Soap Creek	X			Tamarisk beetle impact noted
12.4 Mile			X	Veg increase, erosion, steep access
Hot Na Na	X			Almost identical
19.4 Mile	X			No change noted at camp
Upper North Canyon			X	Guide notes scour in rear from river,
23 Mile	_	_	_	No late season view
Shinumo Wash		X		Cutbank and slope smoothed from flow
Nautaloid		X		Slightly better parking Beetle impact
Tatahatso	X			Slight cutbank at end of season
Martha's			X	Smaller landing area, more rocks, eolian dunes
Buck Farm		X		River flow removed, then replaced, beach front
Total above	4	3	3	
Nevills	X			Slightly less veg
Hance			X	Beach front has receded
Grapevine		X		Some sand deposition on upper end
Clear Creek		X		More beach area, no veg increase
Zoroaster			X	Severe beach loss and cutbanks Beetle noted
Trinity Creek			X	Gully from flash, beach front loss
Schist		X		Better parking, slope smoothed
Boucher			X	Sand loss from flow and wind
Crystal	X			No change noted
Lower Tuna			X	Severe beach front loss, veg increase
Ross Wheeler	X			Veg increase, but also beach increase
Bass	_	_	_	No late season view Cutbank 7/24
110 mile	_	_	_	No late season view Lots of beach front loss 7/16
Upper Garnet		X		Better parking
Lower Garnet		X		Better parking, slope smoothed
Total above	3	5	5	
Below Bedrock			X	Sand loss at front, rocks at parking. Beetle noted
Stone Creek		X		More sand, but new cutbanks starting at lower end
Talking Heads			X	Huge cutbank, severe loss of sand
Racetrack			X	New cutbank at 26K level
Lower Tapeats		X		Better parking at reduced flow
Owl Eyes		X		Big dune has softened = more camp area
Backeddy	_	_	_	No late season view
Kanab	X			Almost no change. Beetle noted
Olo		X		Huge sand beach deposited by 20K + flow
Matkat Hotel	_	_	_	No late season view. Beetle noted

Upset Hotel		X		Better parking at reduced flow
Last Chance		X		Lower end camp has replentished
Tuckup	X			Some human impact noted
Upper National		X		New beach front Better parking
Lower National	_	_	_	No late season view
Total above	2	7	3	
Travertine Falls	X			No change noted
Gneiss			X	Beach receded, more slope
250 Mile	_	_	_	No early season view
Total above				
	1	0	1	
Totals	**10**	**15**	**12**	
% of beaches	**27**	**41**	**32**	

2011 Season Camp name	GCMRC River mile	2011	to	PRE 1996 HFE	reason
		Same	Improved	Degraded	
Soap Creek	11.3 R	_	_	_	Not recorded in 1996
12.4 Mile	12.4 L	_	_	_	Not recorded in 1996
Hot Na Na	16.6 L	_	_	_	Not recorded in 1996
19.4 Mile	19.4 L	_	_	_	Not recorded in 1996
Upper North Canyon	20.7 R		X		More camp area, fewer rocks
23 Mile	22.7 L		X		More camp area, fewer rocks
Shinumo Wash	29.5 L	X			Almost identical, no difference found
Nautaloid	35 L		X		Better parking, camp area
Tatahatso	37.9 L	X			Camp area same, but more peripheral veg
Martha's	38.6 L	X			Almost identical, no change found
Buck Farm	41.2 R		X		More camp area, sand
Total above	11	3	4	0	
Nevills	76 L	X			Almost identical, no change found
Hance	77.1 L	X			Almost identical in camp area
Grapevine	81.7 L				Not recorded in 1996
Clear Creek	84.6 R			X	Less camp area, more veg
Zoroaster	85 L		X		Slightly more camp area
Trinity Creek	92.1 R	_	_	_	Not recorded in 1996
Schist	96.6 R			X	Poor parking
Boucher	97.3 L		X		More camp area now offsets veg increase
Crystal	98.7 R	X			Almost identical, no change found
Lower Tuna	100.2 L		X		More sand and camp area
Ross Wheeler	108.3 L	X			Almost identical, slight veg increase
Bass	109 R	X			Almost identical, no change found
110 mile	110 R	X			Roughly same camp area
Upper Garnet	114.9 R		X		Slightly more camp area
Lower Garnet	115.1 R		X		Considerably nicer as camp

Total above	15	6	5	2	
Below Bedrock	131.7 R		X		Much more camp area even though more veg
Stone Creek	132.5 R		X		Slightly more camp in back of beach
Talking Heads	133.7 L			X	Less beach, large cutbank
Racetrack	134.2 R		X		Camp area increase
Lower Tapeats	134.5 R	X			Almost identical, no change found
Owl Eyes	135.2 L	X			Almost identical, no change found
Backeddy	137.8 L	X			No significant difference found
Kanab	144 R			X	Significantly more veg
Olo	146.1 L		X		Much more camp area
Matkat Hotel	148.9 L			X	Definitely more veg cover, tamarisk
Upset Hotel	150.9 L	_	_	_	Not recorded in 1996
Last Chance	156.3 R		X		Slightly larger, more sand visible
Tuckup	165.2 R		X		Large increase in sand from HFE
Upper National	167 L		X		Slightly more camp area available
Lower National	167.2 L				No late season 2011 image but more veg 4/11
Total above	15	3	7	4	
Travertine Falls	230.6 L	_	_	_	Not recorded in 1996
Gneiss	236.1 R	_	_	_	Not recorded in 1996
250 Mile	250.0 R	_	_	_	Not recorded in 1996
Total above	3	0	0	0	
Totals	44	12	16	6	
% of beaches		35.3	47.1	17.6	

 Results of evaluations for late 2011 compare to post-1996 BHBF

2011 Season Camp name	2011 Same	to Improved	POST 1996 HFE Degraded	reason
Soap Creek	_	_	_	Not recorded in 1996
12.4 Mile			X	Degraded in many ways including erosion, veg, wind
Hot Na Na	_	_	_	Not recorded in 1996
19.4 Mile	_	_	_	Not recorded in 1996
Upper North Canyon	X			Mixed. Less camp area, better parking, less slope
23 Mile	X			Slight change noted
Shinumo Wash			X	Less sand in lower end camp
Nautaloid			X	Poor parking, more veg
Tatahatso	X			Much more veg but more sand/camp area
Martha's	X			Almost identical, no change found
Buck Farm			X	Veg increase offsets camp area expansion
Total above	4	0	4	
Nevills			X	Slightly better camp after BHBF
Hance			X	Much more veg
Grapevine				Not recorded in 1996
Clear Creek			X	Much more veg
Zoroaster			X	Less camp area, severe cutbanks and erosion
Trinity Creek	_	_	_	Not recorded in 1996
Schist		X		More sand in rear of camp, not as steep as post HFE
Boucher			X	Sand loss and veg increase
Crystal	X			Slightly more veg
Lower Tuna		X		More veg, but camp still larger
Ross Wheeler	X			Almost identical, no change found
Bass	X			Almost identical, no change found
110 mile			X	Much more veg
Upper Garnet			X	Less camp area, worse parking

Lower Garnet			X	Less camp area, worse parking
Total above	3	2	8	
Below Bedrock			X	More rocks exposed in camp, veg increase also
Stone Creek		X		More sand at rear of camp, but only slightly bigger
Talking Heads			X	Severe scour by recent higher flows
Racetrack		X		More sand at front now
Lower Tapeats	X			Almost identical, no change found
Owl Eyes	X			Almost identical, no change found
Backeddy	X			No significant difference found
Kanab			X	Significantly more veg
Olo		X		Much more camp area
Matkat Hotel			X	More veg and erosion features
Upset Hotel	_	_	_	Not recorded in 1996
Last Chance	X			Lwr camp has veg increase, upr end is bigger
Tuckup		X		Slightly more camp area available
Upper National		X		More sand at front now. '96 HFE scoured beach
Lower National				No late season 2011 image but more veg 4/11
Total above	4	5	4	
Travertine Falls	_	_	_	Not recorded in 1996
Gneiss	_	_	_	Not recorded in 1996
250 Mile	_	_	_	Not recorded in 1996
Total above	0	0	0	
Totals	11	7	16	
% of beaches	32.4	20.6	47.1	

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

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)