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

Summary of Monitoring Observations for 2018

By
Paul Lauck[1]

December 15, 2019

Example of camp degradation due to both wind scour and rain events. Last Chance Camp, RM 156.26R
Photo on left taken April 12, 2018, on right October 31, 2018

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Abstract

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

A comparison of beach evolution from late season 2017 to early April 2018 was conducted on 23 of the 44 study beaches. One (4%) of the beaches, Olo at RM146.1L, showed Improvement into the spring of 2018, 7 (30%) of the beaches had Degraded between the latest 2017 photo and early spring 2018, and 15 (65%) were considered to be Unchanged for the same time period. Of the 7 beaches classified as Degraded for this period, three (43%) are located in the Marble Canyon reach and two (29%) were found in the Upper Granite Gorge reach. The Muav Gorge and the Lower Granite Gorge each had one (14%) beach considered as Degraded. Fifteen beaches remained Unchanged for this period, with 7 (47%) in the Marble Canyon reach, 3 (20%) in the Upper Granite Gorge, 5 (33%) in the Muav Gorge reach and none located in the Lower Granite Gorge reach. Only one of the 23 beaches examined was classified as Improved since late summer 2017 and was located in the Muav Gorge at Olo Camp, RM 146.1L. The appearance of new sand on the beach surprised both the volunteer who documented the beach and the analyst who compared before and after images.

For the time spanning the 2018 summer boating season, early April to late October, 31 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 31 beaches, 5 (16%) were classified as Unchanged for the time period, 24 (77%) were considered as having Degraded by the end of the season, and 2 (6%) of the 31 were seen to have Improved. Of the 5 Unchanged beaches, 40% are located in the Marble Canyon reach, 25% in the Upper Granite Gorge reach, and 50% are contained in the Muav Gorge reach. None of the Unchanged beaches were in the Lower Granite Gorge reach. Twenty-five percent of the 24 beaches classified as Degraded are located in the Marble Canyon reach, another 33% in the Upper Granite Gorge reach, 42% are found in the Muav Gorge reach and None were located in the Lower Granite Gorge reach. Occasionally, a beach will exhibit Improvement during a season but factors will conspire to Degrade it before Fall. In all instances, a beach will receive a classification based on its condition on the final date of evaluation for that season. The primary factor cited for 12 of the camps classified as Degraded was beach recession due to the fluctuating flow releases from Glen Canyon Dam. There were 10 beaches classified as Degraded with rain events cited as the primary cause. Wind erosion was a primary factor in one Degraded classification and Vegetation encroachment in one other. Human impacts, as well as the previously cited factors, were all noted as secondary agents of change on one or more beaches.

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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, Grams and others 2018). 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 between 31,500 ft^3/s and 45,000ft^3/s (Glen Canyon Dam Adaptive Management Program WIKI, HFE, n.d.). 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 who travel along the river side, rely on wide sandy areas for camping and recreation. Consequently, those who run the river are interested in observing the changes to camping beaches throughout the river corridor in the Grand Canyon. As a non-profit organization dedicated to protecting Grand Canyon and the Colorado River experience, Grand Canyon River Guides developed and implemented the Adopt-a-Beach Repeat Photography (AAB) program prior to the initial flood event in 1996 in order to assess the evolving state of the recreational resource. The use of photographic duplication over time, and analysis of the differences between photo duplicates as a means of detecting change in the Grand Canyon landscape, has been demonstrated previously (Turner and Karpiscak 1980, Webb 1996). AAB is a long term monitoring program that relies on systematic photograph replication to document and analyze changes in sand deposition and other physical attributes using a dataset of 44 camping beaches along the Colorado River corridor in Grand Canyon. A cooperative agreement with Grand Canyon Monitoring and Research Center (GCMRC), ensures that the extensive AAB photo archive and legacy data are incorporated into the GIS Campsite Atlas project to build a more complete and robust understanding of the status, trends and conditions of camping beaches in the river corridor affected by the operations of Glen Canyon Dam.

Since its inception in 1996, the Adopt-A-Beach program has utilized volunteer photographers to conduct repeat photography of these camps. With the exception of the annual baseline photos acquired during the annual GCRG Guides Training river trip, professional river guides, private party river runners and occasional backpackers make the program possible. These unpaid volunteers contribute 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 2018 season, and the addition of new 1358 images, river runners have produced more than 16400 replicate photographs on more than 3950 dates with associated field sheets recording the sequential condition of beaches.

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

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

The purpose of this report is to present the results of the monitoring effort for the period between late summer 2017 and late October 2018.

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

- What changes, if any, are found at the beaches through the boating season of 2018?
- What changes occurred in beach conditions during the winter between late 2017 and April 2018?
- How are the resulting observations distributed throughout the river corridor?
- Which processes resulting in a change of condition at a beach are most prevalent?

Methods

Study locations and beaches

Since 1996 the AAB program has studied an average of 35 of the 44 targeted beaches per year from within three of the five *critical reaches* of the river corridor (Figure 1). The practice of assessing camping beach resources within critical reaches was first developed by Kearsley and Warren (1993), and modified for the 1996 Adopt-a-Beach study by Thompson and others (1997). A critical reach is defined as a section of the river where camps are in high demand and few in number. The same reach system has been in use for all years of study, 1996-2018. All river miles used conform to the GCMRC mileage system (USGS, 2013). The reaches are as follows: 1) Marble Canyon, river miles 9-41; 2) Upper Granite Gorge, river miles 71-114; 3) and Muav Gorge, river miles 131-165.

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

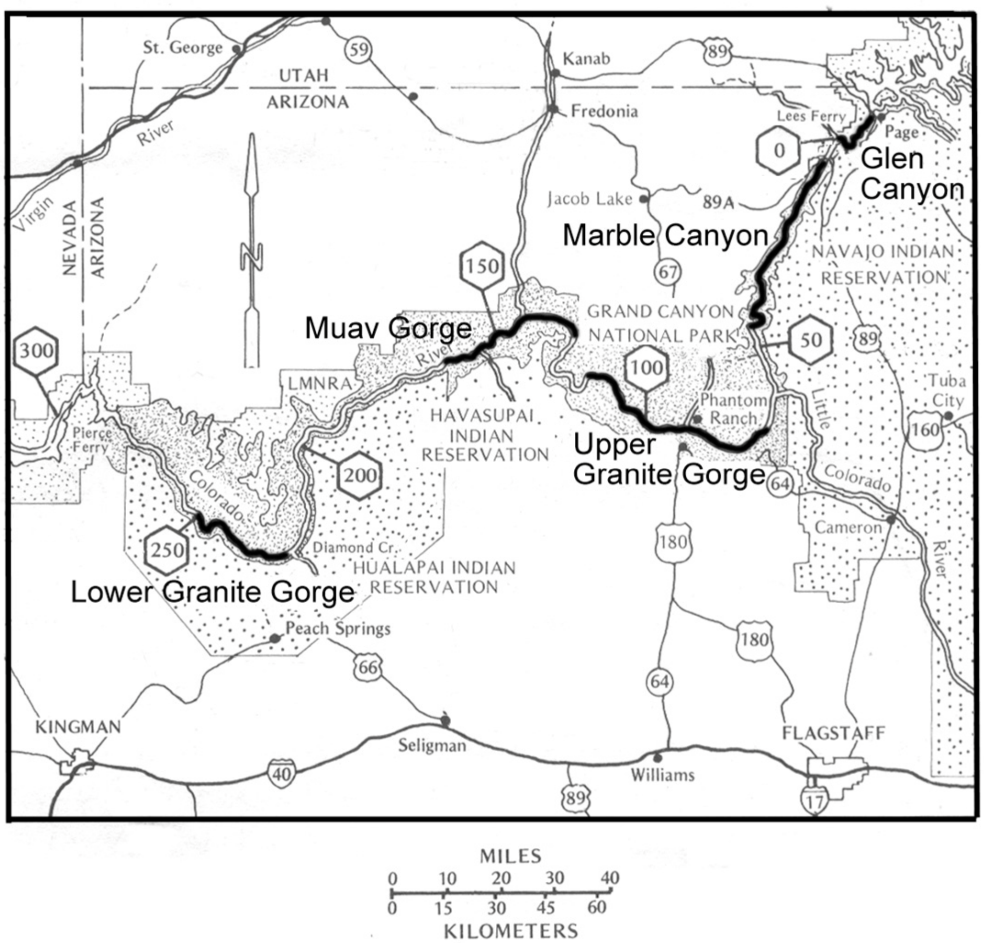


Figure 1. Locations of five critical reaches along the Colorado River in Grand Canyon National Park

Table 1 shows the study campsites (n = 46), 34 of which were originally inventoried in 1996, and includes beaches added in 2000, 2001 and 2009. Note that all analysis statistics are now based on 44 study beaches, beginning with Soap Creek at 11.3 miles downstream from Lees Ferry.

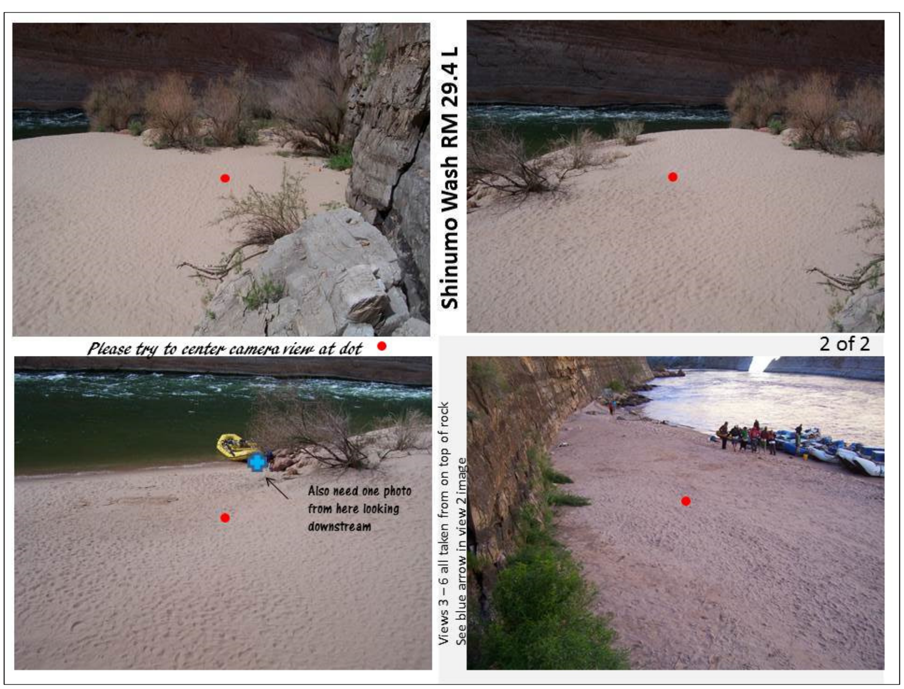
Glen Canyon		Marble Canyon		Upper Granite Gorge		Muav Gorge		Lower Granite Gorge	
Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp
-13.0	Dam Beach	11.3	Soap Creek	76.0	Nevill's	131.7	Below Bedrock	230.6	Travertine
-8.0	Lunch Beach	12.4	12.4 Mile	77.1	Hance	132.5	Stone Creek	236.1	Gneiss Canyon
		16.6	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	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	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 established photographic locations that show 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, photo sets are taken from the boat on the river, taken as a single image or overlapping 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 usually acquired as well. Combined, these views provide a considerable amount of information for analysis.

Occasionally, 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 consistently 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. Due to Park regulations or changes in the river channel, seldom used beaches, like Hance, Kanab Creek, Lower Tapeats or Gneiss are considered as lower priority but are still photographed regularly. The remaining beaches are adopted once high-priority beaches have been claimed.



Figures 2 & 3. Examples of reference sheets supplied to volunteers directing photographer on where to stand and which views should be acquired.

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 2018 totaled 31. Each record in the data base represents an individual visit to a beach where each beach usually has 2-5 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 at https://www.flickr.com/photos/147271391@N08/collections Part of the Adopt-A-Beach program is to provide photos of unusual natural events in Grand Canyon to interested parties.

Analysis

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

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

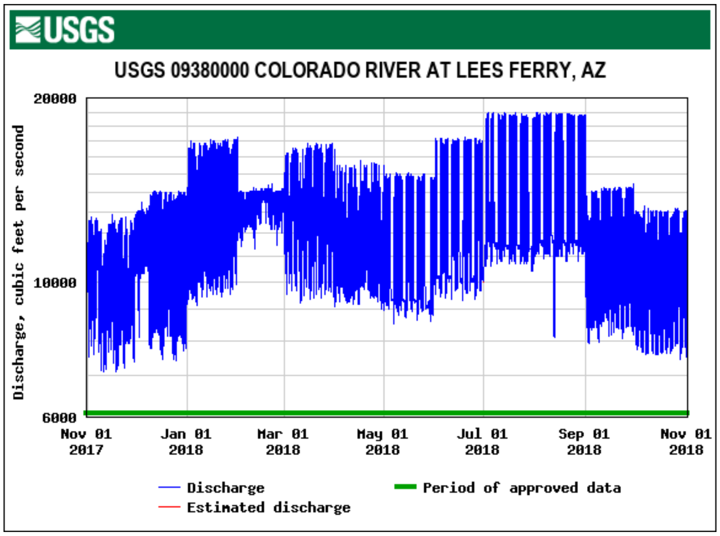


Figure 4. Flow graph for Colorado River at Lees Ferry, AZ., November 1, 2017 through November 1, 2018

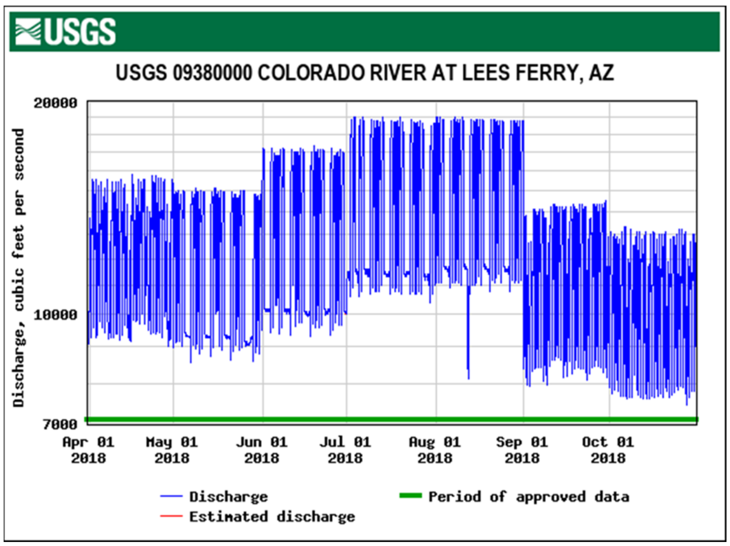


Figure 5. Flow graph for Colorado River at Lees Ferry, AZ., April 1 through November 1, 2018

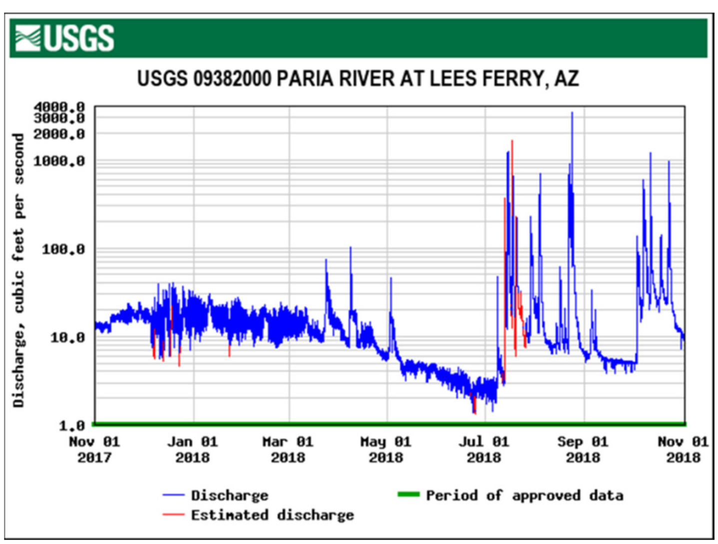


Figure 6. Flow graph for Paria River at Lees Ferry, AZ., November 1, 2017 through November 1, 2018

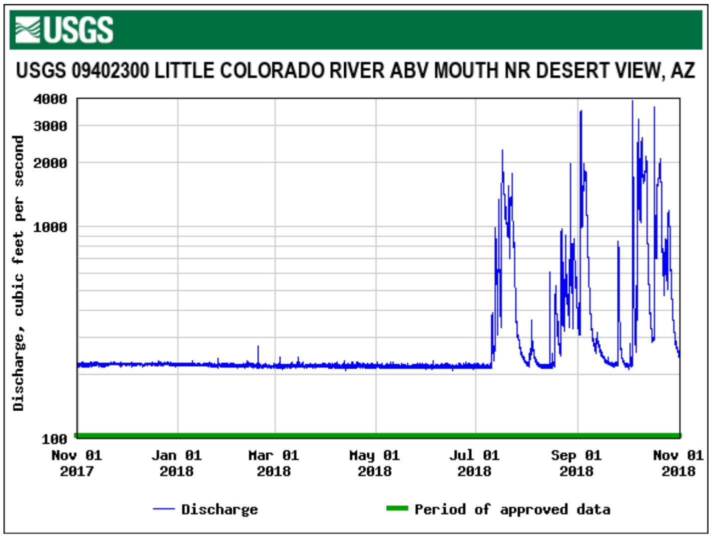


Figure 7. Flow graph for Little Colorado River above mouth near Desert View, AZ November 1, 2017 through November 1, 2018

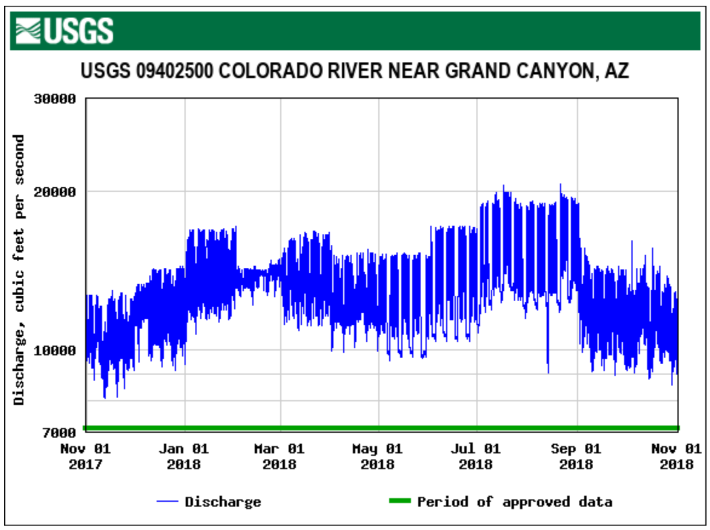


Figure 8. Flow graph for Colorado River near Grand Canyon, AZ. November 1, 2017 through November 1, 2018

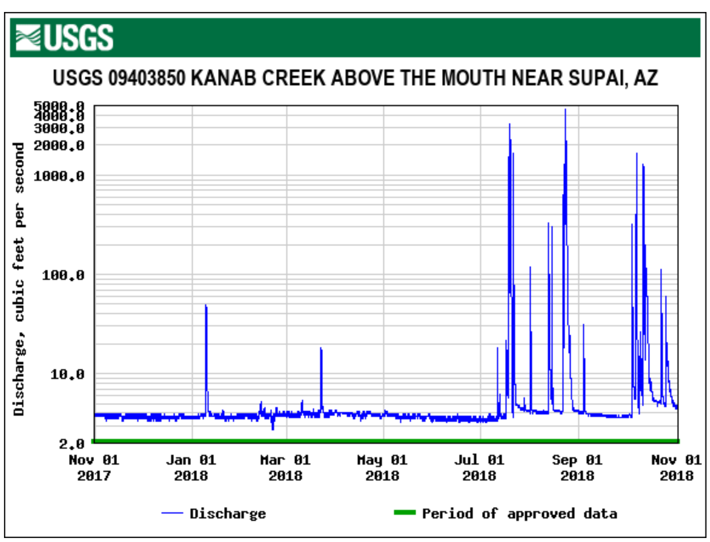


Figure 9. Flow graph for Kanab Creek above the mouth near Supai, AZ. November 1, 2017 through November 1, 2018

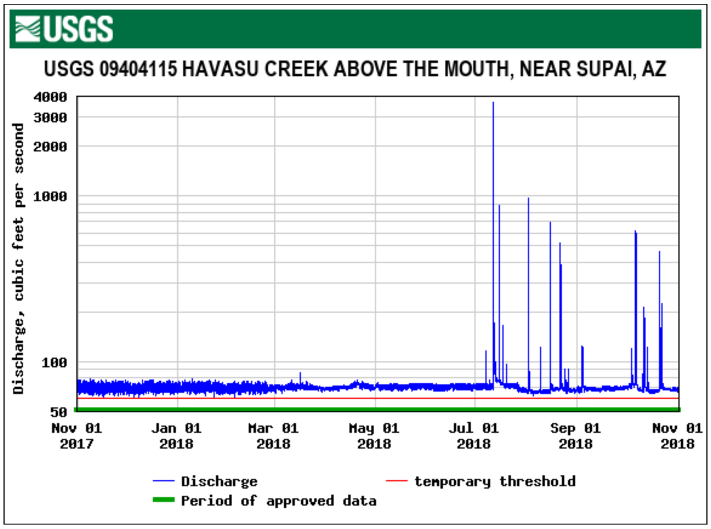


Figure 10. Flow graph for Havasu Creek above the mouth near Supai, AZ. November 1, 2017 through November 1, 2018

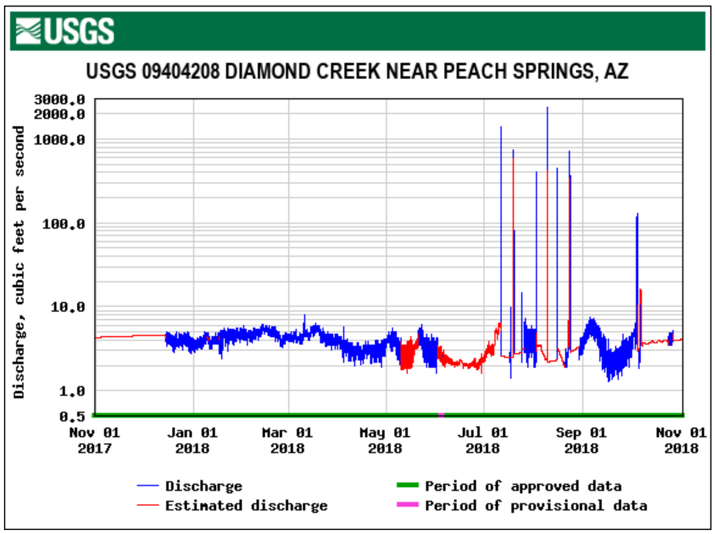


Figure 11. Flow graph for Diamond Creek near Peach Springs, AZ. April 1 through November 1, 2018

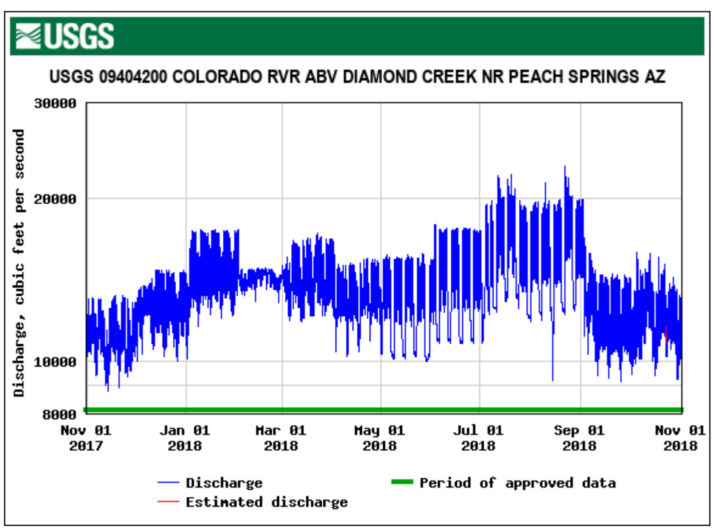


Figure 12. Flow graph for Colorado River above Diamond Creek near Peach Springs, AZ. November 1, 2017 through November 1, 2018

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

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

The same kind of visual clues can also be used to determine aeolian impact, 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 2016 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.

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

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

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

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

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

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

Figures 13 & 14. Documentation of beach degradation following rain event. Martha's Camp, RM 38.6 L, April 4, 2018 (upper) and September 1, 2018 (lower).

Results

Winter of 2017 - 2018

Per Classification

To qualify for analysis of change through the winter of 2017-2018, a beach needed be have been photographed in 2017 after August 15, and again in April 2018. Of the 44 Adopt-A-Beach study beaches, 23 are included in the through-winter evaluation. Of the twenty-three, 1 (4%) appear to have Improved, seven of the beaches (30%) have Degraded since summer 2017 and 15 (65%) show no appreciable change. It should be noted that there are beaches with some slight beach front recession or small cutbanks, but not extensive enough to qualify for a Degraded classification.

Five of the 7 beaches which Degraded during the winter had sand eroded from the camp front, probably from fluctuating flow dam releases. One had Degraded through obvious wind scour, which was also a secondary factor at two additional camps, and one beach suffered from human traffic erosion. Distribution of the 15 beaches with Unchanged classification include 7 in the Marble Canyon reach, 3 located in the Upper Granite Gorge and 5 found in the Muav Gorge. There are three beaches with a Degraded classification in the Marble Canyon reach, 2 located in the Upper Granite Gorge and one each in the Muav Gorge Lower Granite Gorge reaches. See figure 15.

The lone beach which was Improved during the period between late summer 2017 and April 2018 was Olo Camp, RM 146.1 L. The Improvement was perceived as a significant deposit of sand available for camp in the mouth of the drainage at the high teen cfs flow elevation. A check of the flow graphs for the dam release and Kanab Creek may explain this deposition. The dam release pattern for January 2018 is a weekday daily fluctuation which maximized at 17,000 cfs. Kanab Creek, located 4.5 miles upstream of this camp, had a spike in flow of 50 cfs in early January. It seems reasonable that sediment brought into the main stem from Kanab Creek was carried into the camp at the mouth of Olo Canyon concurrent to the time when the maximum dam release reached this site.

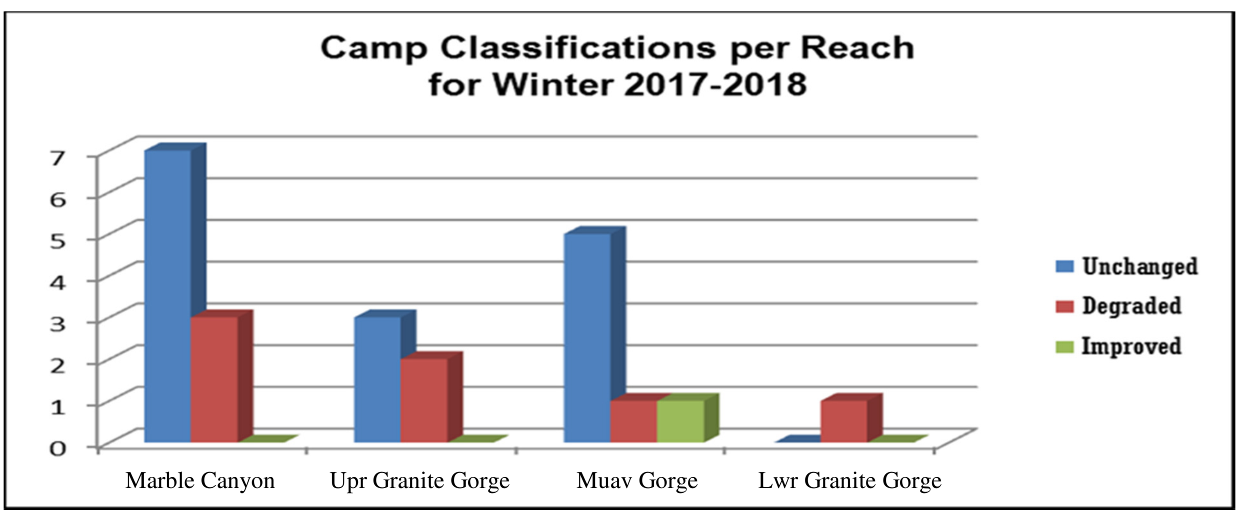


Figure 15. Graphic illustration for Winter 2017 to 2018 evaluations per Reach.

Through 2018 boating season

Per Classification

For the period covering the 2018 summer boating season, photos were used which spanned from April 2 to October 28, though the largest portion spanned April 2 to the last week of September. Daily fluctuating flows occurred steadily during the study period with the exception of the weekend steady invertebrate enhancement or "bug flows." The weekday fluctuations in April and May averaged 9 – 15000 cfs, in June the flow range increased to 9500 – 17000cfs. July and August bumped up slightly to 11 – 19000 cfs, and September flows dropped to daily fluctuations of 8500 – 14000cfs, with another slight drop in October. The steady weekend releases began the first weekend of May with a steady maintained flow release of approximately 9500 cfs. In June this flow was increased to an average of 10000 cfs and was raised again for July and August to 11500 cfs. These steady weekend levels ended at the end of August. Only four beaches included in the analysis were evaluated per photos acquired before the flow change September 1. Each of these beaches had photos taken in August at lower river levels which allowed a clear view of the beach front.

Thirty-five of the 44 beaches were adopted for the 2018 season with 31 having photographs and adopter comment sheets spanning a sufficient period of time to be evaluated. The nine beaches excluded were not photographed after August 1 and no images were available to be late enough in the season to be considered for a complete season analysis. Of the 31 beaches included in this portion of the analysis, 5 (16%) did not show significant changes, and were classified as Unchanged through the season. Twenty-four of the beaches (77%) had Degraded through the summer, and 2 (6%) of the beaches evaluated was considered to have Improved by the Fall of 2018.

The most often cited cause of beach Degradation during the 2018 season was beachfront erosion by fluctuating flows, particularly noticed after the higher flows during August. This was considered the primary cause in twelve cases and as a contributing factor in 4 additional instances. Rain events were the second most often cited cause for Degradation, with ten instances where rain was the primary reason and one instance where rain was a significant contributing factor (See Figures 16). These impacts occurred as both flash flooding from an associated tributary or as more localized erosion from hillside runoff at the camp. Wind deflation of camps was frequently present, easily perceived as rocks became exposed above the maximum waterline, and figured as the primary factor in a classification of Degraded at one of the beaches and as a secondary factor in two instances. Vegetation encroachment was considered as the primary contributing factor for Degradation at one beach and was a secondary factor at 4 others. Erosion due to human traffic was cited as a significant, though not primary factor at one beach.

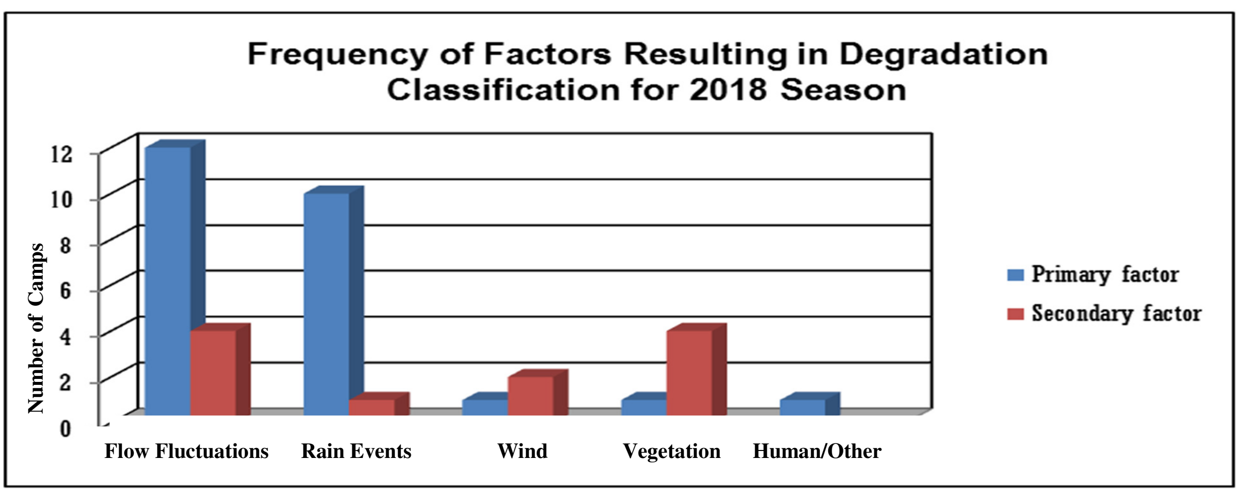


Figure 16. Graphic illustration for 2018 classification factor frequencies

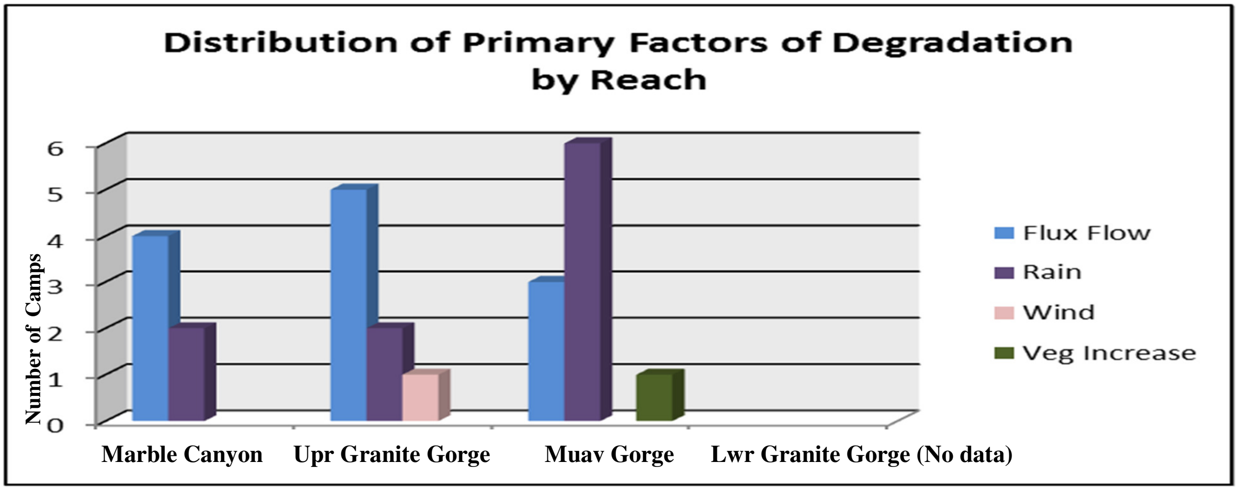


Figure 17. Graphic illustration for 2018 classification factor frequencies

Figures 18 & 19. Documentation of beach degradation following rain event.
Hot Na Na Camp, RM 16.6 L, April 3, 2018 (upper) and July 19, 2018 (lower).

Per Reach

Those beaches classified as Unchanged through the 2018 season were distributed fairly evenly through the four reaches, with 2 (40%) in the Marble Canyon reach, 2 (40%) in the Upper Granite Gorge, and only one (20%) in the Muav Gorge. Please note that none of the three beaches located in the Lower Granite Gorge qualified for use in the summer seasonal analysis.

The 24 Degraded beaches were distributed throughout the first three reaches. There were 6 (25%) found in Marble Canyon, 8 (33%) in the Upper Granite Gorge, and 10 (42%) distributed through the Muav Gorge. (See Figure 17).

Conclusions

For the winter 2017-2018, 30% of the beaches degraded. There was no HFE during the fall of 2017, which has proven to benefit the beach conditions. The fluctuating flows for January and March of 2018 were relatively high, so, as shown in past years, some recession and cutbanks are expected. However, sand removal along beach fronts by daily tides, although still unfortunate, is not usually catastrophic.

Through the years, rain events have proven to be more destructive than the perennial fluctuating flow regime. Water flowing from rainfall, either as close proximity runoff or that which is carried far through an adjacent tributary, has a greater ability to impact the beach as a whole, not just the area adjacent to the river. During the summer 2018 season the frequency of Degradation associated with rain events was very high, and was considered a primary factor of beach decline almost equal to that of fluctuating flows. In actuality, rain events had a greater effect on each Degraded beach than all of the other factors combined. While beach recession and rock exposure at the parking areas are rarely cause to abandon camping or other use at a beach during a season, severe runoff and flash floods can be more impactful to the beach overall and can make use of the beach prohibitive. This summer was one of the most destructive by rain events recorded by the Adopt-A-Beach program. Without rejuvenation by either a fall HFE or some other occurrence, many river parties will be greatly disappointed when they arrive at a beach early next year and find the camp as less than desirable. These are not predictable events and cannot be managed pre-emptively. The Adopt-A-Beach Project still advocates for management of dam releases which are not detrimental to the beach environment and which support beach enhancement for recreational opportunities.

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.

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 twenty years. The result is the most comprehensive collection of repeat photographs of critical camping beaches in the Grand Canyon. An added benefit is the public outreach fostered by the volunteers' actions. By taking time to include guests as active participants and by answering their questions, volunteers can further explain how this resource in Grand Canyon is enhanced, degraded or maintained by the influence of man and technology.

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DISCLAIMER

REFERENCES

Grams, Paul, Buscombe, Daniel, Gushue, Tom, Hamill, Dan, Hazel, Joseph, Kaplinski, Matt, Kohl, Keith, Mueller, Erich, Ross, Robert, Tusso, Robert, 2018. Sandbars and Sediment Storage in Marble and Grand Canyons: Response to Recent High-flow Experiments and :Long Term Trends. Grand Canyon Monitoring and Research Center Project B, PowerPoint presentation 17 p. Retrieved from https://www.usbr.gov/uc/progact/amp/twg/2018-01-25- twg-meeting/AR03.pdf

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 Arizona 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, 2016. Adopt-A-Beach Long-Term Monitoring of Camping Beaches in Grand Canyon: Summary of Monitoring Observations for Year 2015

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.

Turner, R. M. and Karpiscak, M. 1980. Recent Vegetation Changes along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona: U.S. Geological Survey Professional Paper 1132, Washington, D.C.

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.

U.S. Geological Survey, 2013, Grand Canyon Monitoring and Research Center, Colorado Mileage System [Spatial Database, GIS.BASE_GCMRC_TenthMile], 1st revised edition: U.S. Geological Survey database, accessed September 18, 2013, at http://www.gcmrc.gov/gis/silveratlas1.aspx

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
https://www.flickr.com/photos/147271391@N08/collections

Glen Canyon Adaptive Management Program WIKI, 2016. Retrieved from
http://gcdamp.com/index.php?title=GCDAMP-_HFE_2016

Appendix A

Results of Analysis in Tabular Form

Page 1 Table 2 Results of evaluations, late 2017 season to early April 2018

Camp name	Rvr mile	2017	to	2018	Reason
		No change	Degraded	Improved	
Soap Creek	11.3 R				No late season 2017
12.4 Mile	12.4 L	X			Hard to discern due to river level diff
Hot Na Na	16.6 L		X		Cutbank recession across front
19.4 Mile	19.4 L	X			No appreciable change
Upper North Canyon	20.7 R	X			Possibly slight improvement
23 Mile	22.7 L		X		Sand loss in camp from wind
Shinumo Wash	29.5 L	X			Stable through winter
Nautaloid	35.0 L		X		Sand loss at lower camp parking
Tatahatso	37.9 L	X			No appreciable change
Martha's	38.6 L	X			Stable through winter
Buck Farm	41.2 R	X			Slight sand loss below 14K cfs only
Total per Reach	11	7	3	0	
Nevills	76.0 L				No late season 2017, cutbank across front
Hance	77.1 L				No late season 2017
Grapevine	81.7 L				No late season 2017, beaver remove veg
Clear Creek	84.6 R				No late season 2017, veg increase
Zoroaster	85.0 L		X		Cutbank, recession, some wind scour
Trinity Creek	92.1 R	X			No appreciable change
Schist	96.6 R		X		Some recession across front
Boucher	97.3 L				No late season 2017
Crystal	98.7 R	X			Perhaps slight recession
Lower Tuna	100.2 L				No late season 2017, slight loss overall
Ross Wheeler	108.3 L				No late season 2017, improved parking
Bass	109.0 R				No late season 2017
110 mile	110.0 R	X			Stable through winter
Upper Garnet	114.9 R				No late season 2017
Lower Garnet	115.1 R				No late season 2017
Total per Reach	15	3	2	0	
Below Bedrock	131.7 R				No late season 2017
Stone Creek	132.5 R	X			Hard to discern due to river level diff
Talking Heads	133.7 L				No late season 2017
Racetrack	134.2 R				No late season 2017
Lower Tapeats	134.5 R				No late season 2017, dates not varifiable
Owl Eyes	135.2 L	X			No appreciable change
Backeddy	137.8 L				No late season 2017, veg increase
Kanab	144.0 R				No late season 2017
Olo	146.1 L			X	Lots of new sand in mouth at parking, camp
Matkat Hotel	148.9 L		X		Sand loss at parking from human traffic
Upset Hotel	150.9 L				No late season 2017, slight loss from traffic
Last Chance	156.3 R	X			Stable through winter
Tuckup	165.2 R	X			Slight veg increase
Upper National	167.0 L				No late season 2017, slight cutbank
Lower National	167.2 L	X			No appreciable change
Total per Reach	15	5	1	1	
Travertine Falls	230.6 L				No late season 2017
Gneiss	236.1 R				No late season 2017
250 Mile	250.0 R		X		Huge veg increase, sand loss from wind
Total per Reach	3	0	1	0	
Total Reporting	**23 of 44**	**15**	**7**	**1**	

Page 2 Table 3 Results of evaluations, April through October 2018 season

Camp name	Rvr mile	2018	thru	Season	Reason
		No change	Degraded	Improved	
Soap Creek	11.3 R			X	Parking improved at both upper and lower
12.4 Mile	12.4 L	X			No appreciable change
Hot Na Na	16.6 L		X		Most of camp removed by flash
19.4 Mile	19.4 L				No late season 2018
Upper North Canyon	20.7 R		X		Recession and cutbank, wind scour
23 Mile	22.7 L				No late season 2018
Shinumo Wash	29.5 L		X		Recession and cutbank
Nautaloid	35.0 L		X		Recession, rocks exposed at parking
Tatahatso	37.9 L	X			No appreciable change
Martha's	38.6 L		X		Rain gully trhrough camp, cutbank
Buck Farm	41.2 R		X		Recession, erosion from traffic, more veg
Total per Reach	11	2	6	1	
Nevills	76.0 L		X		Reccession and cutbank, rain erosion
Hance	77.1 L				No late season 2018
Grapevine	81.7 L		X		Wind scour, recession at front, veg increase
Clear Creek	84.6 R				No late season 2018
Zoroaster	85.0 L				No late season 2018
Trinity Creek	92.1 R				No late season 2018
Schist	96.6 R				No late season 2018
Boucher	97.3 L	X			Sand moved by wind without negative effect
Crystal	98.7 R		X		Cutbank at higher CFS level
Lower Tuna	100.2 L		X		Recession across front, veg increase
Ross Wheeler	108.3 L	X			Maybe slight veg increase
Bass	109.0 R		X		Rain erosion and cutbank
110 mile	110.0 R		X		Cutbank and veg increase
Upper Garnet	114.9 R		X		Rocks exposed at parking
Lower Garnet	115.1 R		X		Rain gully and cutbank
Total per Reach	15	2	8	0	
Below Bedrock	131.7 R				No late season 2018
Stone Creek	132.5 R		X		Cutbank, severe recession
Talking Heads	133.7 L		X		Cutbank, severe recession
Racetrack	134.2 R			X	Graded at parking due to human traffic
Lower Tapeats	134.5 R				No late season 2018
Owl Eyes	135.2 L		X		Lots of recession across front
Backeddy	137.8 L		X		Vegetation increase
Kanab	144.0 R				No late season 2018
Olo	146.1 L		X		Trib flashes erode camp
Matkat Hotel	148.9 L		X		Multiple rain ersion gullies, steeper
Upset Hotel	150.9 L	X			Multiple changes thru season balance out
Last Chance	156.3 R		X		Rain erosion and possible wind scour
Tuckup	165.2 R		X		Huge rain gully and cutbank recession
Upper National	167.0 L		X		Rain erosion gullies thru camp
Lower National	167.2 L		X		Multiple flashes remove sand, deposit rock
Total per Reach	15	1	10	1	
Travertine Falls	230.6 L				No late season 2018
Gneiss	236.1 R				No late season 2018
250 Mile	250.0 R				No late season 2018
Total per Reach	3	0	0	0	
Total Reporting	**31 of 44**	**5**	**24**	**2**	

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)