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

Summary of Monitoring Observations for 2021

By
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Example of devastation from a rain event, Martha's Camp, RM 38.6 L.
Photo on left taken April 3, 2021, on right October 2, 2021

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Abstract

For the past twenty-six years, excluding a brief break due to the COVID outbreak, volunteer photographers for the Adopt-A-Beach repeat photography program have been monitoring beaches along the Colorado River through Grand Canyon. Comparative examination of photos gathered through the year, often accompanied by on-the-spot observations contributed by the volunteers, reveal any changes in conditions pertaining to the desirability of the beach as a camp for rafting parties. Factors 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), 44 separate beaches distributed along 239 miles of river are in the study. The resulting evaluations are divided into seasonal change, Fall/Winter and Spring/Summer, and are additionally examined per their distribution in each of four separate geomorphic reaches. The conclusions are presented as observational, monitoring data only.

To qualify for analysis of change through the winter of 2020-2021, a beach needed be have been photographed in 2020 after mid-August, toward the end of the higher summer flow releases, and again in April 2021, prior to the start of the summer ramp-up releases. Of the 44 Adopt-A-Beach study beaches, 42 are included in the through-winter evaluation. Of the forty-two, 4 (10%) appear to have Improved, fifteen of the beaches (36%) have Degraded since summer 2020 and 23 (55%) show no appreciable change. The predominant factor associated with the higher percentage of Degraded beaches is the beach recession and cutbank formation usually associated with fluctuating flow releases. Beginning in early January 2021, releases from the dam rose to an average daily high of 14,000 cfs, which could account for the sand removal across the beach fronts. However, on March 15, the river dropped to less than 4500 cfs, remained steady for approximately 50 hours, and then quickly rose for 24 hours to a steady 20,000 cfs. It remained at this level for roughly 36 hours and was then reduced by half within a very short time. This reduction and subsequent spike would very likely create the beach carving action observed in the early April 2021 photos. Only Zoroaster Camp, RM 85.0 L, showed improvement during this evaluation period.

Forty-one of the 44 beaches had sufficient data for analysis through the 2021 summer season. Two of the three beaches excluded were not photographed after August 1, so no images were available late enough in the summer for seasonal analysis consideration. The third beach, Kanab Creek, experienced two major flood flows in July and the photographer's location for duplicate shots was inaccessible. Of the 41 beaches included in this portion of the analysis, 8 (20%) did not show significant changes, and were classified as Unchanged through the season. Thirty-two of the beaches (78%) had Degraded through the summer, and only 1 (2%) of the beaches evaluated was considered to have Improved by the Fall of 2021.

The summer of 2021 was arguably the most destructive to beaches from rain events ever recorded by the Adopt-A-Beach twenty-six year long program. Recession created by daily fluctuating flows continues to erode beach fronts and gnaws at valuable camping real estate, sometimes revealing obstructions such as rocks and logs in the process. Winds will never cease scouring beaches, though usually measured in centimeter increments each season. Foot traffic erosion and vegetation encroachment are sporadic and geographically limited minor offenses. But erosion from a rain event typical of the summer monsoon patterns found in this region can be beach encompassing instantaneous disaster. This was proven in mid-July at two of the study 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 Glen Canyon 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. 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). 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).

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, guide members of Grand Canyon River Guides, aided by guidance from GCES staff, 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. Start of Season baseline photos are acquired during the annual GCRG Guides Training spring river trip and professional river guides, private party river runners and occasional backpackers contribute photos throughout the year. Recently, these images have been supplemented by photographs taken during the GCMRC Fall monitoring trip. These 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 multiple date sets of repeat photographs and on-the-spot comments for their adopted study beach(es). With the end of the 2021 season, and the addition of 1675 new images, river runners have produced more than 18950 replicate photographs on more than 4560 dates with associated field sheets recording the sequential condition of beaches. More than 280 additional images, mostly used as location references, are also in the archive.

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 cutbanks formed from retreating beach fronts, 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 in this report as a possible component of vegetation as a factor of change.

The purpose of this report is to present the results of the monitoring effort for the period between late summer 2020 and late October 2021.

Research results include reporting positive “Improved” conditions, negative “Degraded” conditions or “Unchanged” conditions, when no changes were found in beaches. Examples of “Improvement” could be expansion of relatively level camp/sleeping area through sand addition or vegetation reduction, or ‘friendlier’ (less rocky) boat parking and ease of access when loading/unloading boats. A “Degraded” evaluation could be as result of loss of ‘campable area’ (defined as smooth, sandy area at less than 8 degrees of slope and of sufficient size to erect a small tent, Kearsley, 1995) at the camp for a variety of possible reasons, more rocks exposed along the front of a beach, or abrupt elevation change at the beach front which complicate the loading/unloading of boats. 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 2021?
- What changes occurred in beach conditions during the winter between late 2020 and April 2021?
- 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 40 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, 1996-2019. 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.

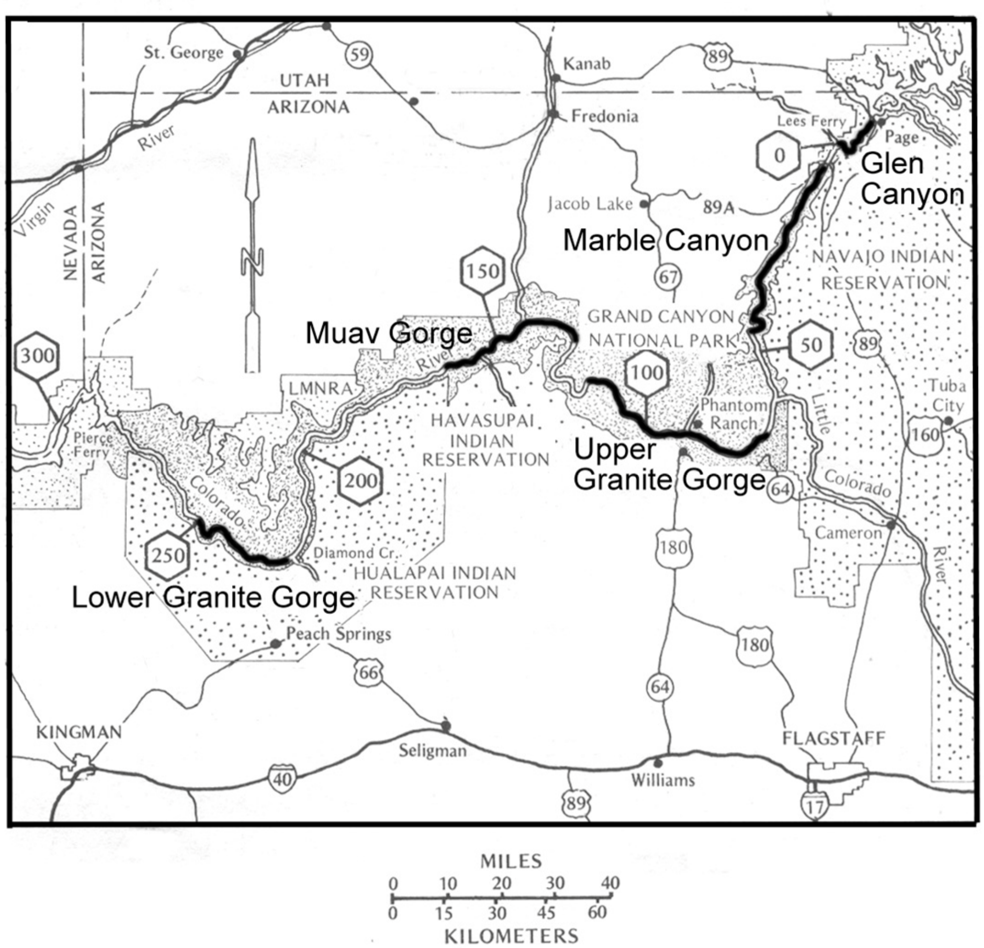


Figure 1. Locations of five critical reaches along the Colorado River in Grand Canyon National Park

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.

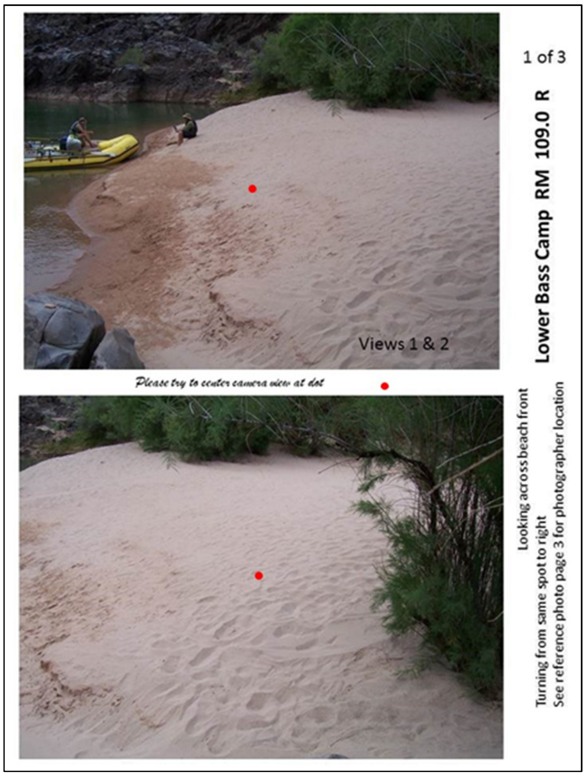
Glen Canyon		Marble Canyon		Upper Granite Gorge		Muav Gorge		Lower Granite Gorge	
Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp
-13.0	Dam Beach	11.3	Soap Creek	76.0	Nevill's	131.7	Below Bedrock	230.6	Travertine
-8.0	Lunch Beach	12.4	12.4 Mile	77.1	Hance	132.5	Stone Creek	236.1	Gneiss Canyon
		16.6	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		

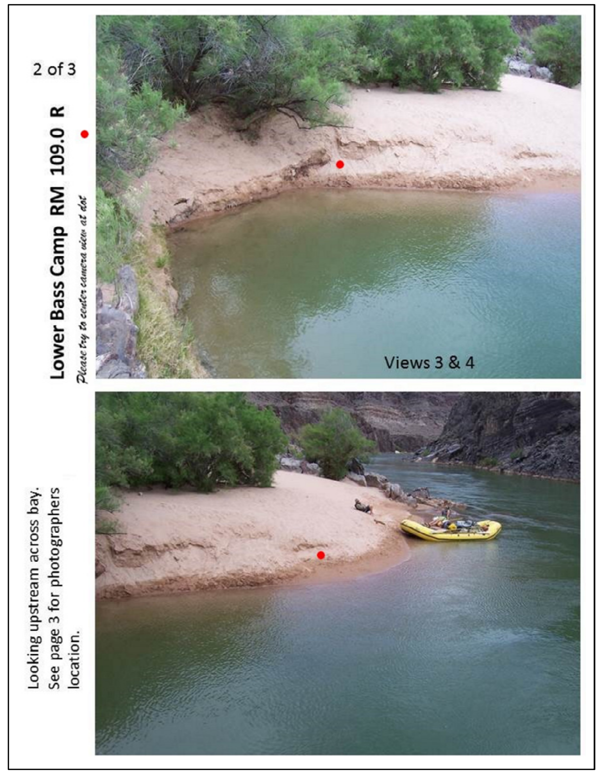
Table 1. Sample set of camping beaches inventoried that lie within the five critical reaches.

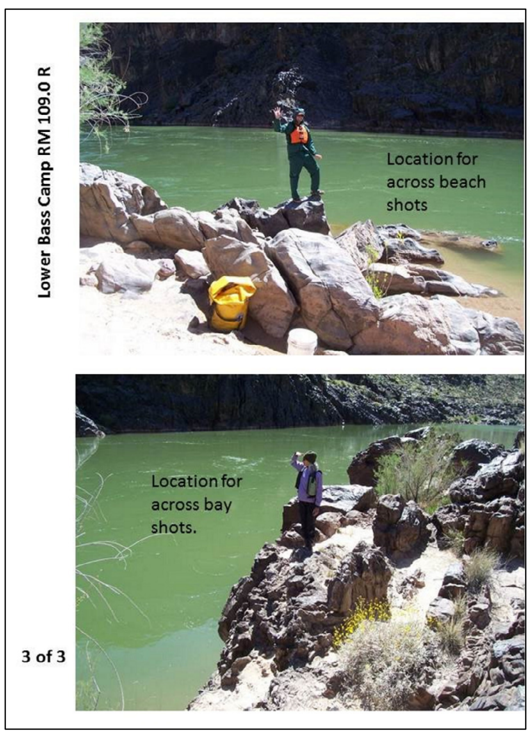
Unlike other established re-photography studies, both within and outside of the Grand Canyon, the AAB program does not adhere to a regime which includes matching photos per a specific time of day or date (Webb 1996, Webb, Boyer and Turner, 2010). The photographs obtained here are much more opportunistic 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 (See Figures 2 & 3). 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 & 4. 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 summer season long data in 2021 totaled 41. 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 Hot Na Na (July 2018) 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 grouped by water color, shadowing on the surrounding walls, or other common elements, such as attire of the people viewed in the photos when available, to help correctly identify the proper chronological 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 tributary.

Figures 5 & 6. Fluctuating flows from Glen Canyon dam often create cutbanks and create access difficulty. Gravity and foot traffic through the summer can eventually mitigate this problem. Zoroaster Camp, RM 84.9 L. Left, April 7, right October 7, 2021

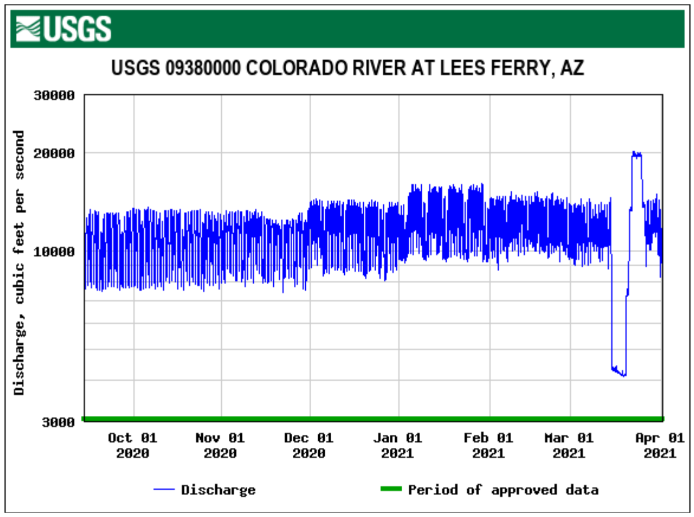


Figure 7. Flow graph for Colorado River at Lees Ferry, AZ., September 15, 2020 through April 1, 2021

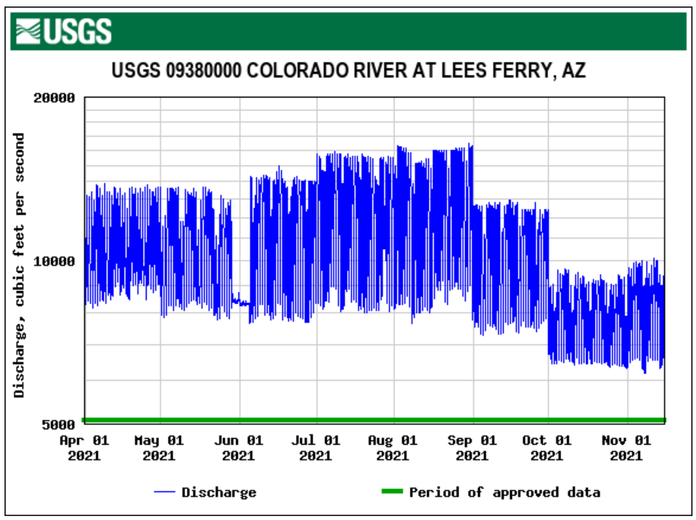


Figure 8. Flow graph for Colorado River at Lees Ferry, AZ., April 1 through November 15, 2021

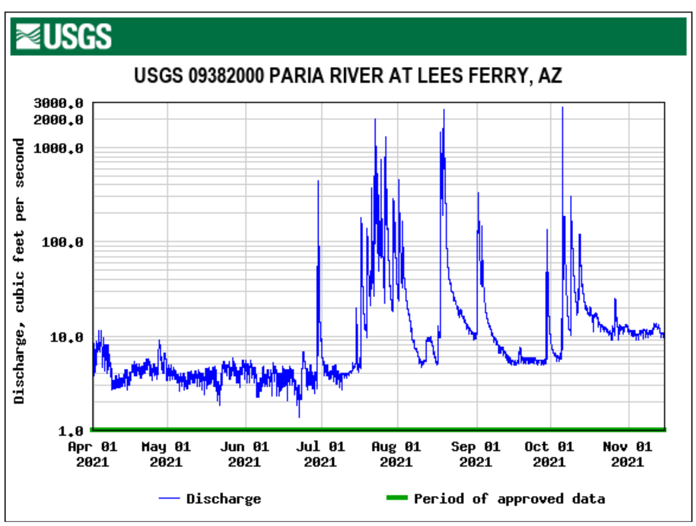


Figure 9. Flow graph for Paria River at Lees Ferry, AZ. April 1 through November 15, 2021

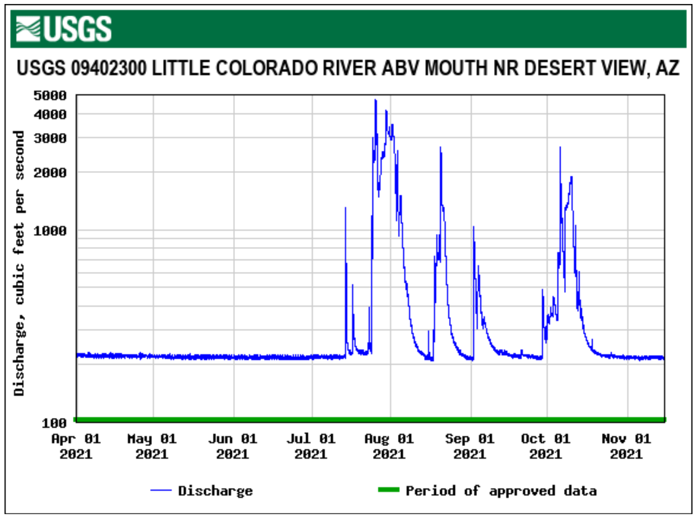


Figure 10. Flow graph for Little Colorado River above mouth near Desert View, AZ April 1 through November 15, 2021

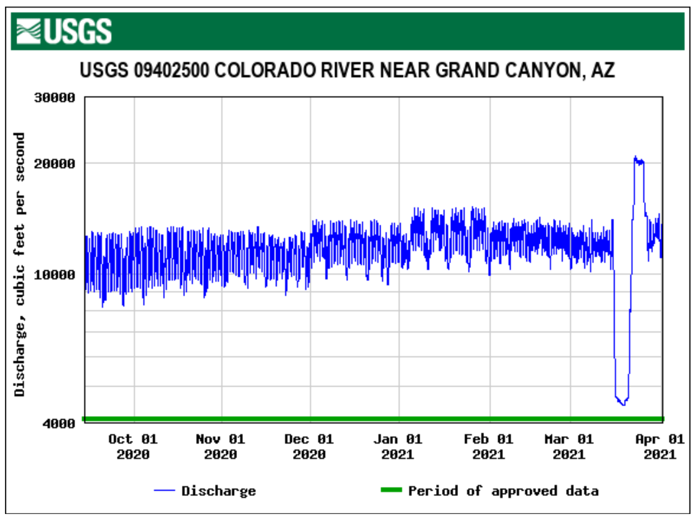


Figure 11. Flow graph for Colorado River near Grand Canyon, AZ September 15, 2020 through April 1, 2021

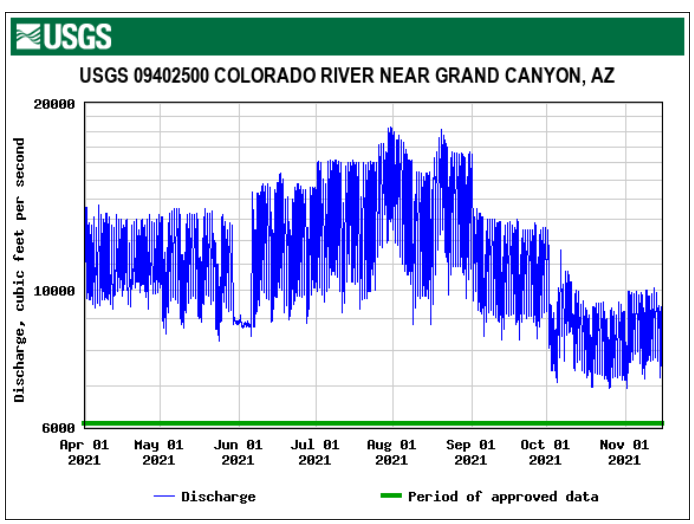


Figure 12. Flow graph for Colorado River near Grand Canyon, AZ April 1, through November 15, 2021

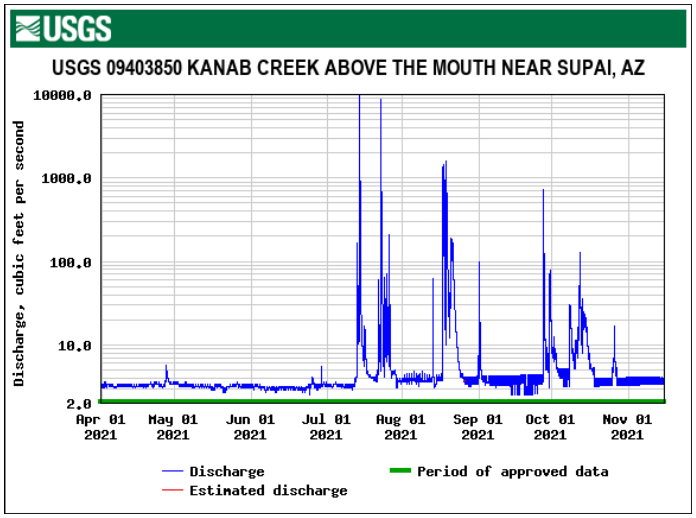


Figure 13. Flow graph for Kanab Creek above the mouth near Supai, AZ April 1, through November 15, 2021

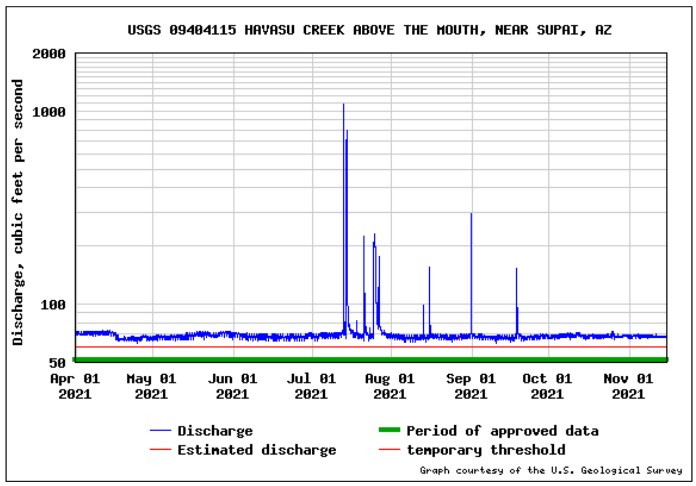


Figure 14. Flow graph for Havasu Creek above the mouth near Supai, AZ April 1, through November 15, 2021

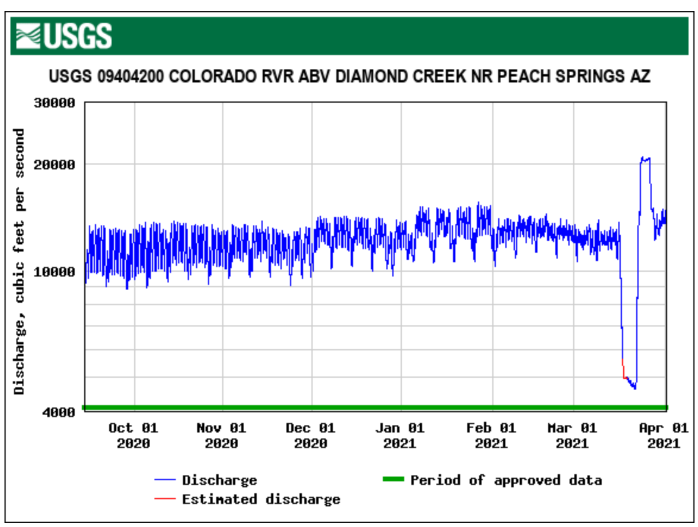


Figure 15. Flow graph for Colorado River Above Diamond Creek near Peach Springs, AZ September 15, 2020 through April 1, 2021

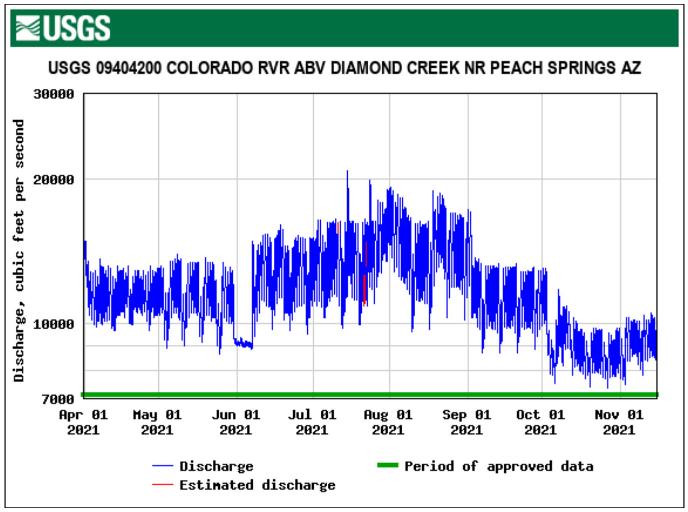


Figure 16. Flow graph for Colorado River above Diamond Creek near Peach Springs, AZ April 1, through November 15, 2021

Prior to visual analysis, each set of datasheets for that particular beach is consulted to identify the photographers' impressions and to note any factor or event that should be evident during the analysis.

The images were viewed for evaluation using the Adobe Photoshop v7.0 and Windows 10 PhotoViewer software viewed 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. For example, during the November 2018 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 presumably as a result of wind scour, as no river flow levels have risen enough to impact that portion of the beach.

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 differing patterns of photo acquisition between beaches may bias the evidence of an agent of change for a particular beach. 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.

Noted impact(s) for a beach were quantified using a simple gradation system. Impacts were assigned an evaluation number ranging between -2.0 to 2.0, in 0.5 increments. These correspond to the perceived degree of influence by the impact ***during the specific period of evaluation*** and are not meant to represent cumulative effects through multiple years. A -2.0 rating would indicate that the beach was negatively damaged by an event or events to the point where it could no longer be considered a viable camp. A -1.5 rating indicates destruction of a large portion of the camp, resulting in a serious reduction of campable area. A -1.0 rating would be assigned if an impact made the camp more difficult to negotiate. Examples of this would include rain erosion gullies which effectively bisect a camp, making travel from one area to another difficult, or cutbanks that are tall and steep, necessitating further erosion to allow access from one level to another. A rating of -0.5 would indicate that a negative, degrading impact is found, but one which does not hinder use of the camp. Zero would of course indicate that no significant change is found at the beach.

A rating of 0.5 is given if a positive impact is noted but one which does not enhance the campable area of the beach. Deposition of sediment which covers some rocky areas along the beach front, improving the boat parking options, is one example. A rating of 1.0 is assigned to denote an expansion of the camp in some way. A beach may be rated with a 1.5 to designate a marked, probably unexpected, improvement/rehabilitation of the overall camp. A rating of 2.0 would only be assigned if a camp was either restored to a useable state after a particularly destructive event or created anew. A 2.0 rating could conceivably only occur subsequent to an HFE or similar flood event.

Using these numeric analysis designations, the beaches reside in one of three 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 17 & 18. Devastation of a camp by combined rain events, debris flow and rock fall. Tatahatso Camp, RM 38.6 L, April 3, 2021 (upper) and October 2, 2021 (lower).

A note about the Winter 2019-2020 and Summer 2020 analysis

The river was closed to boat traffic between late March and mid-June 2020, which prevented collection of photos during this important seasonal transition period. Without the "bookends" of dates which end the 2019-2020 winter analysis period and thus begin the summer 2020 seasonal record, very little photographic data was acquired that meets the criteria for seasonal analysis. Indeed, only five beaches had sufficient data to make a 2020 Summer seasonal comparison and none had season ending winter photos. Any photos taken between late summer 2019 and late summer 2020 are recorded in the database and archived in the Adopt-A-Beach data files.

Results

Winter of 2020-2021

Per Classification

To qualify for analysis of change through the winter of 2020-2021, a beach needed be have been photographed in 2020 after mid-August, toward the end of the higher summer flow releases, and again in April 2021, prior to the start of the summer ramp-up releases. Of the 44 Adopt-A-Beach study beaches, 42 are included in the through-winter evaluation. Of the forty-two, 4 (10%) appear to have Improved, fifteen of the beaches (36%) have Degraded since summer 2020 and 23 (55%) show no appreciable change. The predominant factor associated with the higher percentage of Degraded beaches is the beach recession and cutbank formation usually associated with fluctuating flow releases. Beginning in early January 2021, releases from the dam rose to an average daily high of 14,000 cfs, which could account for the sand removal across the beach fronts. However, on March 15, the river dropped to less than 4500 cfs, remained steady for approximately 50 hours, and then quickly rose for 24 hours to a steady 20,000 cfs. It remained at this level for roughly 36 hours and was then reduced by half within a very short time. This reduction and subsequent spike would very likely create the beach carving action observed in the early April 2021 photos. Only Zoroaster Camp, RM 85.0 L showed improvement. This presented as a result of a slumping cutbank, possibly instigated by the spike.

Per Reach

The locations of the 15 beaches which Degraded are evenly distributed through the first three reaches, with 5 (33%) per reach. Note that two of the three beaches located in the Lower Granite Gorge reach were unrated due to insufficient data.

Distribution of the twenty-three beaches (55% total) with Unchanged classification include 5 (22%) in the Marble Canyon reach, 9 (39%) located in the Upper Granite Gorge and 9 (39%) found in the Muav Gorge and are fairly well distributed through the corridor from River Mile 11.3 to mile 167.2.

The Improved beaches were distributed evenly throughout all four reaches, with 1 (25%) located in each reach. Three of the Improved beaches benefited from sand deposition, possibly carried downstream during the 20,000 spike flow in March.

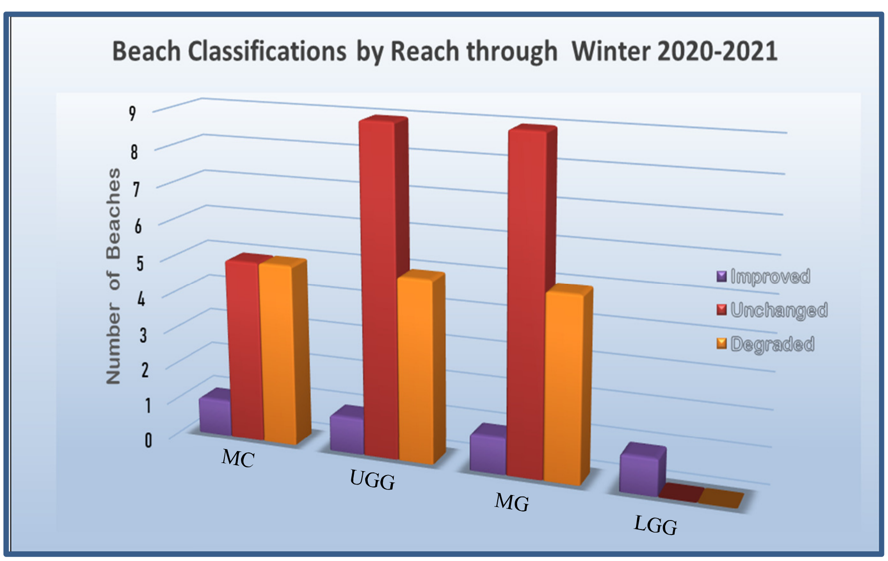


Figure 19. Graphic illustration for Winter 2020/2021 evaluations per Reach.

Through 2021 boating season

For the period covering the 2021 summer boating season, photos were used which spanned from April 1 to October 21. The minimum range of dates considered was April 15 through September 30. Daily fluctuating flows occurred steadily during the study period, with the largest daily swings ranging from slightly higher than 8000 cfs up to 16000 cfs from the dam for all of July and August. The daily fluctuations from April 1 through June averaged 8000 to 14000 cfs. September daily fluctuations averaged between a low of 7800 cfs and a high of 12600 cfs and October releases dropped to a range of 6000 to 9000 cfs per day. Daily fluctuations are proven to have negative impacts on the beaches, with the greatest impacts associated with the largest fluctuating range.

Per Classification

Forty-one of the 44 beaches had sufficient data for analysis through the 2021 season. Two of the three beaches excluded were not photographed after August 1, so no images were available late enough in the summer for seasonal analysis consideration. The third beach, Kanab Creek, experienced two major flood flows in July and the photographer's location for duplicate shots was inaccessible. Of the 41 beaches included in this portion of the analysis, 8 (20%) did not show significant changes, and were classified as Unchanged through the season. Thirty-two of the beaches (78%) had Degraded through the summer, and only 1 (2%) of the beaches evaluated was considered to have Improved by the Fall of 2021.

The most frequently cited cause of beach Degradation during the 2021 season was beach erosion from rain events, which rendered two camps unusable and seriously damaged at least 8 of the other 11 affected by rainfall. The two camps which were destroyed, Tatahatso, RM 37.9 L and Martha's, RM 38.6, were hit by the same late afternoon deluge in mid-July.

Beach recession and cutbanks are common results of fluctuating flows. During the 2021 season, the number of occurrences of degradation citing these causes was almost as frequent as rain but the resulting harm was minimal per instance compared to most rain events. Wind erosion was another noted factor of degradation, exposing rocks in the camp area, but foot traffic, particularly erosion gullies incised into steep cutbank was much more evident. It's difficult to assess that this erosion would be considered as a negative impact as it facilitates camp access. However, it also usually results in the eroded sand being carried by gravity closer to the beach front where it is easily washed away by a rise in flow level.

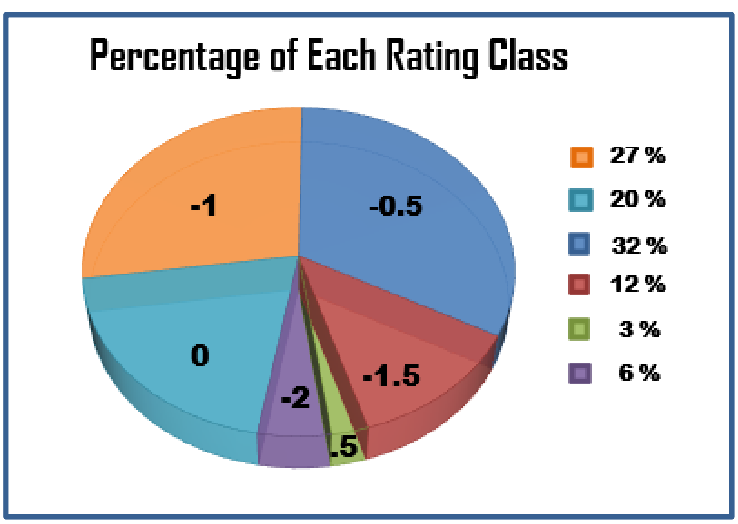


Figure 20. Graphic illustration for rating frequencies assigned to any change during 2021 season

Figures 21 & 22. Beach erosion from rain events which reduce camp viability.
Racetrack, RM 134.2 R, October 10, 2021 (upper) and Tuckup, RM 165.2 R, October 12, 2021 (lower).

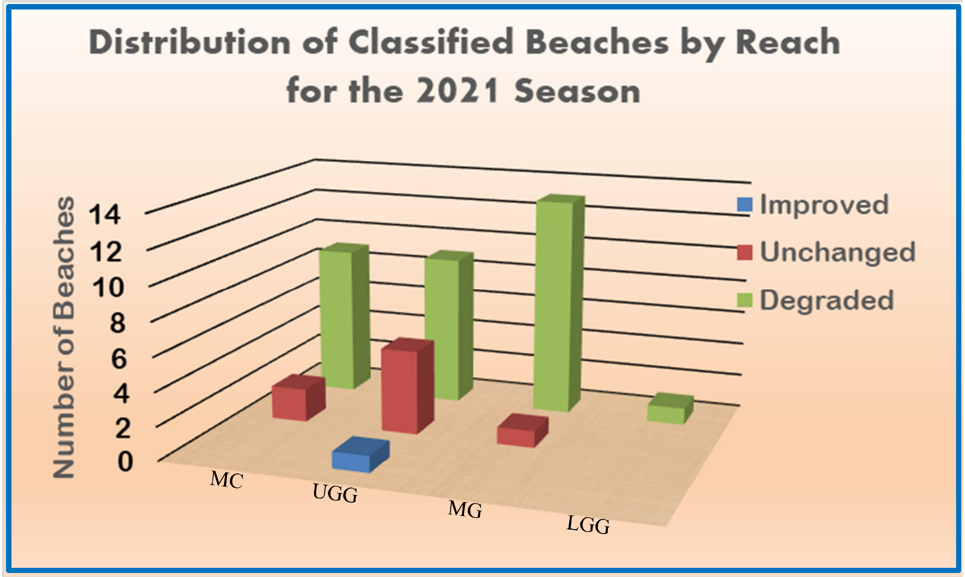


Figure 23. Graphic illustration for 2021 season classifications by reach

Per Reach

Those beaches classified as Unchanged through the 2021 season were distributed between three reaches, the Marble Canyon reach containing 2, the Upper Granite Gorge held 5 and one located in the Muav Gorge. Very minor impacts were noted at 3 of the beaches in the Upper Granite Gorge but were not sufficient to change the classification.

Only one of the forty-one evaluated beaches received an Improved classification. This was in the Marble Canyon reach at Zoroaster Camp, RM 85.0 L. Early in the season the main camp had a substantial cutbank and was difficult to access, particularly at lower flows. The steep bank slumped early in the season, possibly as a result of undermining during the March spike flow. This, combined with foot traffic erosion through the summer, reduced the angle of the slope negotiated when loading and unloading boats.

As stated earlier, the combination of fluctuating flows and, more importantly, heavy rain erosion, took a substantial toll on the beaches during the 2021 season. A total of 32 beaches suffered impacts through the summer resulting in a classification as Degraded. Eighteen of which rated a score of -1 to -2, high enough to indicate that use as a camp could be challenging. Of these 32, nine (28%) were located in the Marble Canyon reach, nine (28%) were located in the Upper Granite Gorge reach, thirteen (41%) were found in the Muav Gorge reach and one (3%) was in the Lower Granite Gorge.

Conclusions

The summer of 2021 was arguably the most destructive to beaches from rain events ever recorded by the Adopt-A-Beach twenty-six year long program. Recession created by daily fluctuating flows continues to erode beach fronts and gnaws at valuable camping real estate, sometimes revealing obstructions such as rocks and logs in the process. Winds will never cease scouring beaches, though usually measured in centimeter increments each season. Foot traffic erosion and vegetation encroachment are sporadic and geographically limited minor offenses. But erosion from a rain event typical of the summer monsoon patterns found in this region can be beach encompassing instantaneous disaster. This was proven in mid-July at two of the study beaches.

Without the healing benefits of an HFE like the last spike release in late 2018, it is almost impossible for the beaches to be rejuvenated. Unfortunately, the 20,000 cfs spike in March 2021 only appears to have aggravated an already declining camping environment. Reclamation of some camps by mechanical vegetation removal has been suggested and may be a short term solution, but this can only be applied to a fraction of the beaches, and newly exposed sand would be subject to more aeolian erosion.

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.

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

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DISCLAIMER

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Geological Survey. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Geological Survey.

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Appendix A

Results of Analysis in Tabular Form

Page 1   Table 2 Results of evaluations, late 2020 season to early April 2021

Camp name	Rvr mile	Late 2020	to	Early 2021	Impact causes
		Same	Improved	Degraded	
Soap Creek	11.3 R	0			No noticable change
12.4 Mile	12.4 L			-0.5	Difficult access up cutbank and slope
Hot Na Na	16.6 L	0			No change
19.4 Mile	19.4 L	0			Same through winter
Upper North Canyon	20.7 R			-0.5	Wind scour
23 Mile	22.7 L	0			No noticable change
Shinumo Wash	29.5 L			-1	Cutbank and recession
Nautaloid	35 L	0			Same through winter
Tatahatso	37.9 L			-0.5	Steeper access
Martha's	38.6 L			-1	Recession, rocks exposed
Buck Farm	41.2 R		0.5		Sand increase on upper beach
Total MC Reach	11	5	1	5	
Nevills	76 L			-0.5	Cutbank, interior rocks exposed from wind scour
Hance	77.1 L	0			Poor photos for compare. Possible traffic erosion
Grapevine	81.7 L			-1	Cutbank and recession
Clear Creek	84.6 R	0			Same through winter
Zoroaster	85 L			-1	Big cutbank, step into camp. Some recession.
Trinity Creek	92.1 R			-0.5	Cutbank and recession
Schist	96.6 R	0			Same through winter
Boucher	97.3 L	0			Still a steep cutbank at access
Crystal	98.7 R	0			No change
Lower Tuna	100.2 L		0.5		Sand increase in kitchen area. Slump distribution??
Ross Wheeler	108.3 L	0			No change
Bass	109 R	0			Same through winter
110 mile	110 R	0			Same through winter
Upper Garnet	114.9 R	0			No change
Lower Garnet	115.1 R			-1.5	Severe rain erosion
Total UGG Reach	15	9	1	5	
Below Bedrock	131.7 R	0			Minor veg increase
Stone Creek	132.5 R			-1	Cutbank and recession along entire beach
Talking Heads	133.7 L	0			Possible slight cutbank increase
Racetrack	134.2 R	0			No change
Lower Tapeats	134.5 R			-0.5	Cutbank and recession. Not much camp remains.
Owl Eyes	135.2 L			-0.5	Cutbank and recession at lower end
Backeddy	137.8 L	0			Same through winter
Kanab	144 R	0			Slight new cutbank
Olo	146.1 L	0			Slight deposition across front
Matkat Hotel	148.9 L			-1	Cutbank, recession and rain gully
Upset Hotel	150.9 L	0			Same through winter
Last Chance	156.3 R	0			No change
Tuckup	165.2 R			-1	New cutbank and recession. Gully partially filled.
Upper National	167 L		0.5		Rocks covered at parking. More sand at access.
Lower National	167.2 L	0			Same through winter
Total MG Reach	15	9	1	5	
Travertine Falls	230.6 L		0.5		Some sand deposition at parking, but steep
Gneiss	236.1 R				No late 2020 images
250 Mile	250.0 R				No late 2020 images
Total LGG Reach	3	0	1	0	
Totals	42	23	4	15	

 Table 3 Results of evaluations, April through October 2021 season

Camp name	Rvr mile	Early 2021	to	Late 2021	Impact causes
		Same	Improved	Degraded	
Soap Creek	11.3 R	0			Minor rain erosion
12.4 Mile	12.4 L			-1.5	Considerable recession. Traffic erosion. Steep.
Hot Na Na	16.6 L			-1	Cutbank and fluc flow recession
19.4 Mile	19.4 L			-1.5	Lots of cutbank and fluc flow recession. Rain gully.
Upper North Canyon	20.7 R			-1	Cutbank, recession at front, wind scour
23 Mile	22.7 L	0			No noticable change
Shinumo Wash	29.5 L			-0.5	Some recession and cutbank. Traffic erosion.
Nautaloid	35 L			-0.5	Rain and traffic erosion
Tatahatso	37.9 L			-2	Beach/camp destroyed by rain event
Martha's	38.6 L			-2	Beach/camp destroyed by rain event
Buck Farm	41.2 R			-0.5	Sand loss and cutbank upper end
Total MC Reach	11	2	0	9	
Nevills	76 L	0			Very minor change
Hance	77.1 L	0			Slight veg increase
Grapevine	81.7 L	0			Minor rain erosion
Clear Creek	84.6 R			-0.5	Rain erosion and steeper
Zoroaster	85 L		0.5		Old cutbank has slumped, easier access from boats
Trinity Creek	92.1 R			-0.5	Some trib erosion. Lots of wind scour.
Schist	96.6 R			-0.5	Rain gully splits camp
Boucher	97.3 L			-1	Fluc flow recession with cutbank. Rocks at parking
Crystal	98.7 R			-0.5	Cutbanks at three water levels
Lower Tuna	100.2 L			-0.5	Gully increase from rain, more rocks at parknig
Ross Wheeler	108.3 L			-1	Rain erosion through camp, wind scour
Bass	109 R	0			No noticable change
110 mile	110 R	0			Lots of new driftwood
Upper Garnet	114.9 R			-0.5	Cutbank and recession at parking
Lower Garnet	115.1 R			-1.5	Severe rain damage. Cutbank, recession, more rocks
Total UGG Reach	15	5	1	9	
Below Bedrock	131.7 R			-0.5	Noticable recession and wind scour. New driftwood
Stone Creek	132.5 R			-1	Rain erosion both ends. Recession and lots of wood
Talking Heads	133.7 L			-1	Rain gullies, cutbank and traffic erosion
Racetrack	134.2 R			-1	Rain gullies divide camp areas
Lower Tapeats	134.5 R			-0.5	Fluc flow recession. Very little sand remains
Owl Eyes	135.2 L			-0.5	Rain erosion throughout
Backeddy	137.8 L			-0.5	Trib erosion enlarged
Kanab	144 R				Major flash, late season photos unobtainable
Olo	146.1 L			-1	Beach loss from trib flash. Small cutbank
Matkat Hotel	148.9 L			-1	Gully expansion. Cutbank and recession
Upset Hotel	150.9 L			-0.5	Rocks exposed across parking, traffic erosion
Last Chance	156.3 R			-1.5	Major rain erosion throughout camp area
Tuckup	165.2 R			-1.5	Huge gully expanded through season
Upper National	167 L			-1	Debris flow into parking area. Rain gullies
Lower National	167.2 L	0			Not much change. Lots of new driftwood.
Total MG Reach	15	1	0	13	
Travertine Falls	230.6 L				No late 2021 images
Gneiss	236.1 R			-1	Wind and rain erosion. New veg growth.
250 Mile	250.0 R				No late 2021 images
Total LGG Reach	3	0	0	1	
Totals	41	8	1	32	

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 cutback
- ☐ 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)