PB88-183389

# Sandy Beach Area Survey Along the Colorado River in the Grand Canyon National Park

(U.S.) Glen Canyon Environmental Studies
Flagstaff, AZ



19 Aug 87

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
NTIS
PHY500

50272-101

| REPORT DOCUMENTATION PAGE | 1. REPORT NO. GCES/06/87 | 2. | PB88-183389 |
|---|---|---|---|

4. Title and Subtitle
Sandy Beach Area Survey Along the Colorado River in the Grand Canyon National Park

5. Report Date
August 19, 1987

6.

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9. Performing Organization Name and Address
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10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
Glen Canyon Environmental Studies
Bureau of Reclamation, Upper Colorado Region
P.O. Box 11568
Salt Lake City, UT 84147-1568

13. Type of Report & Period Covered
Final

14.

15. Supplementary Notes
Prepared in cooperation with the Glen Canyon Environmental Studies

16. Abstract (Limit: 200 words)

Beach profile elevation information was gathered and contour maps drawn for 23 Colorado River beaches, showing prominent vegetation, use areas, rocks, and sandy areas. Due to the changes in beach profiles after the 1983 high flows in excess of 90,000 cfs, detailed mapping was needed to establish a data base for monitoring future beach changes. Ten profile lines at 6 sites previously surveyed in 1974-75 and 1980 were resurveyed. Profile lines give a detailed two-dimensional description of the transect line but do not always reflect change for the entire beach area. A general comparison of the profile lines shows no change at 2 sites and deposition or erosion of up to 2 feet at the other 4 sites. No conclusions about the total beach area changes can be made until the 23 sites are resurveyed.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms



c. COSATI Field/Group

18. Availability Statement
No restriction on distribution
Available from National Technical Information Service, Springfield, VA 22161

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
15

22. Price

# SANDY BEACH AREA SURVEY
# ALONG THE COLORADO RIVER IN
# THE GRAND CANYON NATIONAL PARK

Glen Canyon Dam
Environmental Study

August 19, 1987

Bureau of Reclamation
Durango Projects Office

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# SANDY BEACH AREA SURVEY ALONG THE COLORADO RIVER IN THE GRAND CANYON NATIONAL PARK

This report is part of the Glen Canyon Environmental Studies, which have the overall objective of measuring and defining the impacts of the operation of Glen Canyon Dam on the environment along the Colorado River in Grand Canyon National Park. Any changes in the sandy beach areas can be monitored by comparing the survey data collected in the future with the data base established by this study.

## Introduction

The Glen Canyon Environmental studies are a joint effort of several Federal and state agencies, and private contractors. The studies, begun in 1983, are under the direction of a team consisting of people from the above agencies and private contractors. The team consist of three subteams--biology, hydrology-sediment (sediment), and recreation. This beach survey study is under the direction of the sediment subteam with information provided by the other subteams.

The beaches along the Colorado River are a major concern because they are part of the Grand Canyon National Park river environment and because of their use by river rafters. Before the construction of Glen Canyon Dam, the sandy beaches in the Grand Canyon were almost always in a state of change, either being built up or eroded away through wide ranges in flows and generally high sediment loads. Since completion of construction, the clear water releases from the dam now have more of an erosion effect on the beaches.

When this study was initiated, the major emphasis was the measuring of the erosional rate of the sandy beaches. This emphasis was slightly modified after the high 1983 Glen Canyon Dam spill release. This high release altered the sandy beaches by eroding, eliminating, or building-up existing beaches, or by creating some new ones.

Many examples of erosion and build-up of the beaches have been seen over the years, but a quantitative rate and pattern of these changes was lacking until Alan Howard of the University of Virginia developed a method for measurement and analysis. A detailed description of Howard's study method and analysis and the survey data is contained in a technical report entitled, "Establishment of Benchmark Study Sites Along the Colorado River in Grand Canyon National Park for Monitoring of Beach Erosion Caused by Natural Forces and Human Impact." A copy of this report may be obtained from the Grand Canyon Office of the National Park Service or the University of Virginia.

Howard's work established 20 beach study sites during 1974 and 1975 river trips. The beach study sites had from 1 to 3 profile lines running roughly perpendicular to the river. A total of 38 profile lines were surveyed at the 20 study sites. The 20 sites have been re-surveyed over the years by several survey parties.

In the fall of 1980, the Durango Projects Office (Durango) of the Bureau of Reclamation (Reclamation) re-surveyed the profile lines at the 20 beach sites and established 4 additional beach study sites. The profile lines of a beach, for example, gave a detailed two-dimensional description of that particular area of the beach, but the changes that occurred at these profile lines did not always represent an entire

beach area. Some of the profile lines were located in areas affected by side-canyon flash-flood flows or human activity and were not representative of the rest of the beach area. Conclusions could not easily be made about the rate of change of the total beach areas by using the data collected at these few profile lines.

The study team concluded that detailed mapping of several pre-selected beach sites was needed to establish a data base for monitoring total beach area changes over time. In consultation with the study team, 24 sites were selected to be surveyed. Of the 24 sites, 16 were newly established sites, and 8 were surveyed earlier by Howard in 1974 and 1975 and Durango in 1980. Personnel from Durango conducted the surveys for this study during trips in May and September of 1985.

## Objective

The objective of the surveys was to establish a data base of information from several sandy beach areas along the Colorado River in Grand Canyon National Park for use in monitoring their changes. The beach areas' changes over time can be measured by comparing future survey data with this study's data base. This report contains the survey data and the beach area maps for the study sites along with a summary of the study. This data can be used to recreate the beach area maps during future survey trips.

## Acknowledgments

Durango was responsible for gathering the field data and for assembling this report. The data collection was accomplished by the

joint effort of Reclamation, the Park Service, and the Humbre Summit River Guides (HSRG). Following is a list of the people who were involved in one or both of the survey trips. These people should be contacted if assistance is needed during future beach surveys or to obtain answers to questions about this report.

Survey Trip Participants

| Reclamation | HSRG | Park Service |
|---|---|---|
| Rex Edwards | Stan Bore | Durl Burkham |
| Ronald Ferrari* | Brian Dierker | Martha Hahn-O'Neill |
| Steve Hansen | Janet Moody | |
| Ken Mullen | Tom Moody | |
| Stan Powers* | Tom Yard | |
| Tim Randle | | |
| John Simons | | |
| Janet Stransky | | |
| Ruth Swickard | | |
| Jerry Young | | |

*Assisted in the survey of all the beach area maps contained in this report.

## Survey Method and Procedure

For this study, Reclamation used a survey technique combining the profile line method used by the Howard surveys and the standard transit-stadia topography survey method. A base line with profile lines covering the beach area were established for all of the new sites surveyed by this study. For the previously established sites, attempts were made to locate and use any reference points, base lines, and profile lines from past surveys. A detailed beach survey was obtained by spacing the profile lines 25- to 50-feet apart and perpendicular to the base line. The spacing of the profile lines was determined by the amount of terrain change along the base line, the length of the base line, and the time available for the survey. The transit-stadia

topography survey method was used to obtain data in areas the profile lines did not cover.

At each beach, the base line and reference points were established in stable areas above the effects of the normal fluctuating river stage. The majority of the reference points were located on the base line and were set in stable boulders and rock outcrops. The location of the reference points are indicated by a chiseled "X" or "Y" in a rock, a nail driven in a rock or tree, or the high point of a rock. These points are documented by written descriptions and photographs. The written description includes the location, color, size, and other pertinent facts to help in locating the point.

If a base line was 300 feet or less in length, the alignment was determined by stretching a steel tape taut between the reference points. Once the tape was taut the distance between the reference points was determined, and the profile line locations were marked along the base line with wooden stakes. The theodolite was used for aligning base lines greater than 300 feet by sighting a second reference point while stationed over the first reference point. The theodolite was used for keeping the steel tape on line while measuring the distance and for locating the profile line intersections.

The survey notes and maps describe the setting of the base lines that were not aligned between reference points. These base lines were established by turning angles with a theodolite. With the theodolite over the indicated reference point, a backsight was taken of a second reference point. This initial sighting was set at 0°-0'-0". The angles in the notes were relative to this initial sighted reference point and were always determined by turning the instrument clockwise.

The profile lines were surveyed by using a level, rod, 100-foot cloth tape, and penta-prism. The penta-prism was used to align the profile lines perpendicular to the base line. The theodolite was used for determining the profile line alignments that did not run perpendicular to the base line. The penta-prism provided a fast, easy, and accurate system for viewing line alignment both to the left and right while standing over the profile line intersection and using the base line as the line of sight.

The measurement of each point on the profile line was determined by stretching the cloth tape from the base line to the point of interest. The tape was kept as level as possible and the distance was rounded to the nearest foot. The profile lines extending from the base line to the river were described by positive (+) distances, and the line extending from the base line and away from the river was described by negative (-) distances.

Using a level, elevations of each point on the profile lines were determined by sighting the height on the rod sitting on the point. The rod height was subtracted from the known instrument height to obtain the elevation of each point relative to a datum. The datum elevation, usually a reference point, was assumed to be 100.0 feet, unless a known elevation point was located. The calculations were done while in the field to check for errors. These elevations were rounded to the nearest tenth. Points on the profile lines were selected to best describe the beach area with the fewest possible sightings. These points were located at the top and toe of slopes, a break in slope, and distinctive changes such as edge of sand, rock, vegetation, water, camping area, etc. The elevation, distance, and a brief description

were written in the survey notes, and the elevation and location of the point were indicated on the map. The elevation of the river water surface was taken, when possible, for each profile line. The date and time was indicated in the survey notes so that the river discharge for the measured water surface could be estimated from the reservoir release records.

The transit-stadia topography method was used to obtain additional points if the profile lines did not provide adequate points to prepare the map of the area. Generally these points were along the river's edge or along vegetation and rock lines. Angles for all of the points located by the theodolite were turned and read to the right of the initial sight point, which was set at 0°-0'-0". The distance to the point was obtained by reading and calculating the stadia distance from the rod to the theodolite. Elevations of each shot were also obtained by reading the rod with the level instrument. The distance, angle, elevation and description were written in the field notes and drawn on the map. On completion of the survey, a back check to the initial sighting point or a known elevation point was completed to verify all calculations.

The field notes supplemented the maps drawn in the field. The notes were transcribed and checked in the office before being typed for this report. The note-taking format was similar to the standard stadia traverse note-taking format. A rough sketch was drawn in the original notes detailing the base line, benchmarks, river and other details of interest. The date, time, weather conditions, and other pertinent facts were indicated in the notes. A description of the area was given for the majority of the survey points. The notes include the necessary facts for recreating the baseline and profile line alignment.

A plane table map was sketched during the field survey with the base line and benchmarks oriented to true north using a Brunton handheld compass. The scale used was dependent on the length and width of the beach area. The measured field elevations were placed on the map along with a general description of the area and other pertinent information. A 360-degree protractor templet was used to draw the points located by the transit-stadia topography survey method. The draftsman sketched in areas of interest between the survey points, including vegetation, rocks, sand clearings, etc. The draftsman also controlled the speed of the survey and requested the additional points needed to complete the map.

Photographs were taken to document the reference points and beach areas. The use of two cameras with wide-angle lenses proved beneficial because some photos were lost through camera malfunction, lack of focus, and film breakage. To assist in orientation, while taking pictures of the reference points, attempts were made to include the skyline or other distinct features in the background. Some close-up photos of the reference marks were taken to assist future crews. Photographs of the total beach area were taken whenever possible.

After returning to the office and making a comparison between the maps and the survey notes, only a few differences were found. These differences usually were due to the inability of the note taker and the draftsman to hear clearly while working near the loud river noise. The majority of these differences were rectified while still in the field. The differences found in the office were corrected if the errors were easily recognized.

The survey equipment used by Durango was selected for its durability under the Grand Canyon conditions and for its compactness

and availability. It included two theodolites, two levels, two 25-foot telescoping leveling rods, two penta-prisms, two 100-foot cloth tapes, a 300-foot steel tape, a plane table, waterproof field books, and other basic surveying equipment. Extra pieces of equipment were taken so that the job could be accomplished if there were damage or loss.

A crew of five people was used for this survey and is an ideal number for developing the beach area maps while in the field and for the speed of the survey. The crew consisted of an instrument person, map drawer, note taker and two rod persons. To avoid loss time from illness or injury, at least two of the five-person crew should be proficient in all the needed survey skills. A large motorized raft was used to transport the crew and equipment to the sites because it decreased the travel time between the sites and was faster for loading and unloading the survey equipment.

## Recommendations

Copies of the report containing the survey data will be sent to the National Park Service at the Grand Canyon National Park and to the Bureau of Reclamation's Upper Colorado Regional Office in Salt Lake City. A copy will also be retained in the Durango Projects Office. These reports will be lent to groups planning to re-survey the study sites. To preserve the data, these groups will be required to return the reports on completion of their trips.

It is recommended that the minimum time interval between the re-survey should be one year, with a maximum interval of five years. The re-survey should create a new map using the original datum, base line, and profile lines. The re-survey of the profile lines should

also extend to the water surface or beyond. Lastly, future studies of the Grand Canyon beaches would benefit if all of the collected data from all investigations were sent to one or more of the above offices.

The inherent problems with this type of study occur when comparisons were made with past data. If the survey crew does not have clear photos, maps and notes of the original survey, the reestablishing of the profile lines can be difficult if not impossible to do. The major problem results from future changes, such as the inability to locate a few of the reference points because of flash flood flows completely changing an area, people altering a site, or vegetation covering a site. The survey crews have the task of selecting the points in stable areas and can help in avoiding the loss of the study site if the area is well documented with good photographs and survey data. All reference point elevations should be tied to the datum, and the orientation of each line should be to true north.

## Site Documentation

Appended to this summary is the tabulated survey notes, photographs with descriptions, and maps, as listed in the table of contents. Each site is designated by its commonly used name and river mile. The name may differ from others given to the area, but the river mileage will help in distinguishing the sites. River miles were attained using the Buzz Belknap "Grand Canyon River Guide," which calculated the river miles through the Grand Canyon. The "L" and "R" with the river mile indicates the left and right side of the river while looking downstream.

Following are additional abbreviations that were used.

| | |
|---|---|
| AZM - azimuth | cfs - cubic feet per second |
| dia - diameter | EOL - end of line |
| Fd - found | HI - height of instrument |
| mag - magnetic | No. - number |
| Pt - point | Q - river discharge |
| RP - reference point | "T" - instrument |
| TP - turn point | veg - vegetation |
| w/ - with | ws - water surface |
| "X" - symbol chiseled in rock | "Y" - symbol chiseled in rock |
| & - and | @ - at, location at |
| +0 - plus rod | -0 - minus rod |
| # - number | ) - angle |
| 10+00 - 1,000 feet | Tammy - Tamarisk |

The individual study sites have up to four types of data:

I. Survey data sheets:

The data sheets contain the name, river mile location, reference point description, and the surveyed points for each study site. The orientation of the base line was given as a magnetic bearing. A rough size was given for most of the reference points. For example, 10'x9'x4'-6' indicates an object 10 feet wide, 9 feet long and 4-feet to 6-feet high.

II. Aerial photos:

Photo copies of aerial photographs were included with the majority of the study site data packages. These low level aerial photographs, taken October 21-23, 1984 and during low river discharge, illustrate features on the beach in addition to how the beach relates to the river and the location of rapids. The majority of the reference points indicated on these photos will assist in orientation of the beach area to the river area.

III. Plane table maps:

This report contains 23 maps of the beach areas surveyed. The maps originally sketched during the field survey were redrawn by the Durango Office for clarity during reproduction. A map was not sketched for the Below Little Colorado site because of the limited time available during the survey.

IV. Photos:

The enclosed photographs document the majority of the reference points and some of the beach areas. Each photo

is identified by a number, such as GC 20.0L 05. GC stands for Grand Canyon. The number 20 indicates river mile 20.0. The L indicates the left bank looking downstream. The number of the photo is indicated by 05. A written description accompanies each photo. The number following the written description, such as CN-65-406-92A, is used by Durango for filing the negatives.

Blank copies of the survey data sheets are in the back of this report for use by the future survey crews in their work if they so desire.

## Literature Cited

Howard, Alan. 1976. "Establishment of Benchmark Study Sites along the Colorado River in the Grand Canyon National Park for Monitoring of Beach Erosion Caused by Natural Forces and Human Impact." Technical Report No. 1. University of Virginia Grand Canyon Study. Charlottesville, Virginia.

Belknap, Buzz. 1969. "Powell Centennial Grand Canyon River Guide." Western River Guides Association. Boulder City, Nevada.