DATA SYNTHESIS OF EIGHT YEARS OF ARCHAEOLOGICAL MONITORING AND REMEDIAL ACTIONS **ALONG THE COLORADO RIVER CORRIDOR, GRAND CANYON NATIONAL PARK, ARIZONA**
[Summary of the Executive Summary]

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The winter of 1982-83 was especially wet in the upper basin of the Colorado River, resulting in high snowpack levels that could potentially translate into greatly increased flows in the river. This potential was realized when late winter and early spring storms added to the snowpack and increased the volume and rate of runoff from the mountains into the river. Lake Powell began to fill at an alarming rate, and the U.S. Bureau of Reclamation was forced to release an unprecedented volume of water-up to 93,000 cubic feet per second (cfs)-from Glen Canyon Dam. This unanticipated event accelerated awareness of dam operations and their potential effects on downstream cultural resources.

As a result, a number of archaeological sites in Glen Canyon National Recreation Area and Grand Canyon National Park were either freshly exposed or eroded and damaged by this clear-water flow. GRCA personnel initially documented the effects of the 1983 flood that autumn (Balsom 1984). It was realized that cultural resources might be more abundant in the river corridor than previously assumed (including substantial habitation sites below the historic high-water marks of the river), and that dam operations might have substantial adverse effects on such resources. Scientific studies of cultural resources obviously were needed to document the nature and scope of such potential effects.

During the 1980s, other factors promoted an increased awareness of the presence of cultural resources in the river corridor, and the potential effects of Glen Canyon Dam on these resources. One of these factors was a growing concern among a number of constituencies regarding the practice of increasing the amount of water released from the dam to coincide with peak demands for electrical power. It is possible for the operators of a hydroelectric dam, such as the one in Glen Canyon, to time the water releases so that more water is released, and thus more electricity generated, during times of highest regional power demand. These peaking power water releases, however, created unpredictable and widely fluctuating surges and drops in the river that were of great concern to resource managers, environmental groups, commercial interests, Indian tribes, and others.

One outcome of these concerns was the creation bv Reclamation of the Glen Canyon Environmental Studies (GCES) program, designed to study the effects of low and fluctuating river flows on a variety of natural resources downstream from the dam. These studies were also necessitated by a planned uprating and rewinding of the generators of Glen Canyon Dam, which would increase its power-generating capacity. Hence, in the early 1980s it was apparent that scientific studies were needed to assess the effects of the dam on downstream resources, especially regarding the issue of fluctuating flows. Cultural resources were not initially included in the list of affected resources, but a new paradigm of scientifically assessing the effects of the dam had been created. This was an essential step toward allowing studies of cultural resources to be incorporated at a later date.

One of the first of these investigations took place in the late 1980s as a collaborative pilot study between NPS and the U.S. Geological Survey (USGS). This study focused on only one site along the Colorado River, but its results suggested that the operation of the dam might indeed be contributing to the deterioration of archaeological sites elsewhere along the river corridor (Balsom et al. 1989).

In July of 1989 Secretary of the Interior Manuel Lujan directed Reclamation to prepare an Environmental Impact Statement (EIS) regarding the operation of Glen Canyon Dam. Thus, after more than a quarter-century, the dam's environmental effects were to be judged scientifically. The EIS for Glen Canyon Dam operations therefore mandated scientific studies of all resources within the area potentially affected by water releases. Further, Glen Canyon Dam operations are considered a federal undertaking that either directly, indirectly, or potentially affects cultural resources as defined by the National Historic

Preservation Act **(NEPA) of 1992** (amended). Under Section 106 of this act, agencies are responsible for the impacts to cultural resources caused by their actions, as well as preservation of resources under their management.

In a joint venture, Reclamation and NPS decided that the first step in the EIS process with respect to cultural resources was to conduct an intensive inventory of archaeological sites in the river corridor. The area surveyed encompassed a 255-mile stretch of the river corridor, extending from Glen Canyon Dam to Separation Canyon. The vertical extent of the survey area was the riverine environment that incorporated all terrestrial river-derived sediments below the estimated 300,000 cfs level. The estimated 300,000 cfs level was considered an approximation of the pre-dam flood terraces and was not considered an absolute number representing an exact elevation,

The survey was conducted from 24 August 1990 to 30 April 1991. During this time some 1,968 persondays were spent surveying about 10,506 acres. The primary goal of site inventory was accomplished, with a total of 475 archaeological sites and 389 isolated occurrences of artifacts or features located and recorded. This total included 118 sites that were previously located and recorded, and 357 newly discovered sites. For the purpose of impact analysis for the EIS, it was initially determined that 336 of the 475 recorded sites existed in locations that could potentially be adversely affected by dam operations. Of the 336 sites potentially affected by dam operations, 322 were deten-nined eligible for listing on the National Register of Historic Places. Since 1992, the project staff has been able to refine the site impact categories initially identified by Fairley et al. (Fairley et al. 1994). As a result, 264 sites are currently considered affected by the operations of Glen Canyon Dam.

It is sufficient to note that the cultural monitoring program has operated from its inception within a complicated framework of laws, regulations, and other directives that are not always in accord with one another. At times, there has been an inherent conflict between complying with the provisions of Section 106 of NHPA (mitigating the effects of a federally sponsored undertaking), and at the same time recognizing and adhering to long-standing NPS policies (i.e., Section 110 of NEPA) regarding the "preservation-in-place" of cultural resources.

To fulfill Reclamation's Section 106 responsibilities and NPS mandates, a Programmatic Agreement (PA) was written and implemented in 1994. This PA, written specifically for dam operations, was signed by officials from Reclamation, the Advisory Council on Historic Preservation, the Arizona State Historic Preservation Officer, the National Park Service, and six Indian tribes and nations-the Hopi Tribe, the Hualapal Nation, the Kalbab Paiute Tribe, the Navajo Nation, the Paiute Indian Tribe of Utah for the Shivwits Band, and Zuni Pueblo-with an interest in National Register-eligible proper-ties affected by dam operations.

The PA outlines the responsibilities of Reclamation for the mitigation of these adverse effects under Section 106 of NHPA, spelling out the responsibilities taken on by the NPS as follows:

> The purpose of the Monitoring and Remedial Action Plan shall be to generate data regarding the effects of Dam operations on historic properties, identify ongoing impacts to historic properties within the APE [Area of Potential Effect], and develop and implement remedial measures for treating historic properties subject to damage.

Currently, all work conducted by the program has been completed under stipulations in the Monitoring and Remedial Action Plan (MRAP). Until a final Historic Preservation Plan is completed, as outlined in the PA, the MRAP guides the ongoing process for the identification, monitoring, and remedial actions for cultural resources impacted, or potentially impacted, as a result of the operations of Glen Canyon Dam.

The PA identifies more than 300 National Register-eligible properties within the APE that are potentially subject to monitoring and remedial action. (This has since been reduced to 264 sites within GRCA.) The PA also recognizes that additional identification and evaluation of properties should take place within the APE, and it directs Reclamation and NPS to conduct appropriate studies to identify Traditional Cultural Properties within the APE.

The PA ratifies a number of important issues relevant to Section 106 compliance. Among these, it states that the legal authority for the PA derives not only from NEPA, but also from Interior Secretary LuJan's directive to prepare an EIS for the operation of Glen Canyon Dam, and the language in the Grand Canyon Protection Act (GCPA) of 1992 ordering continued monitoring and management of resources within the area of the dam's effects. The PA also states that Reclamation is the lead agency for Section

106 compliance regarding the impacts of Glen Canyon Dam, and it notes that Reclamation has acknowledged potential adverse effects on cultural resources from dam operations. The PA declares further that "given their mutual responsibilities [Section 106 and Section 110 of NEPA, respectively], Reclamation and the NPS have determined to coordinate their respective roles in the management and consideration of historic properties which may be affected by the Program [i.e., operation of Glen Canyon Dam]." In 1992 GRCA contracted with NAU (Northern Arizona University) to conduct the joint Reclamation-NPS (GRCA) project referred to as the River Corridor Monitoring Project (RCMP). The administrative structure for the RCMP is established by a cooperative agreement between GRCA and NAU. This agreement provides the framework by which the National Park Service at Grand Canyon cooperates with NAU to conduct the RCMP as a collaborative venture.

Implementation of a monitoring and remedial action program as specified in the PA does not represent a, typical compliance project for a variety of reasons. This project is considerably more complex than most Section 106 actions partly because of the various legal requirements that guide the specifics of Section 106 compliance in this instance (e.g., the EIS, the Record of Decision [ROD], and the GCPA), and because compliance is sought by one agency (Reclamation) within the jurisdiction of a second agency (NPS) bound by stringent preservation requirements. Also, site conditions are constantly changing, and new erosion is exposing areas not previously identified, causing a loss of resources over time. This theme-the tension between a traditional model of Section 106 compliance, and the obligation to preserve the unique, highly significant, and fragile cultural resources of Grand Canyon National Park (GRCA)- surfaces repeatedly.

All monitoring and remedial efforts pursued under the PA are subject to approval by the PA signatories. All proposed efforts must also comply with Wilderness Act requirements due to the proposed wilderness area designation of the Colorado River in the Grand Canyon. Remedial efforts are to be recommended by NPS and Reclamation on a site-specific basis in consultation with the Arizona State Historic Preservation Officer and the tribes that have signed the PA. Since its inception the RCMP has operated in a framework of intensive tribal consultation. Tribal concerns have been incorporated into the project in multiple ways, ranging from determination of monitoring schedules to proposed remedial actions.

The existence and significance of each tribe's traditional cultural properties (TCPs) have been documented through intensive ethnographic research (Ferguson 1998; Hart 1995; Havatone 1992; Hualapal 1992; Masayesva 1992; Roberts et al. 1995; Secakuku 1997; Stevens 1996; Stoffle et al. 1994). Tribes affiliated with or having an interest in river corridor sites have indicated that the entire Grand Canyon is crucial to maintaining the cultural identity of each tribe's community. The tribes have endorsed the long-term monitoring and preservation of archaeological sites in the river corridor due to the accelerated erosion caused by dam operations (Ferguson 1998; Hart 1995; Roberts et al. 1995; Secakuku 1997; Havatone 1992; Hualapai 1992; Masayesva 1992; Stevens 1996; Stoffle et al. 1994).

The tribes have also stated their position when dealing with properties that have religious or cultural significance (Ferguson 1998; Hart 1995; HLialapai 1992; Masayesva 1992; Roberts et al. 1995; Secakuku 1997; Stevens 1996; Stoffle et al. 1994). The preferred actions are preservation measures and continued long-term monitoring of these resources. The consultation process has indicated that the tribes have certain TCPs that are off limits to any mitigation measures. These are clearly identified in tribal reports and exclude most archaeological sites (Ferguson 1998; Hart 1995; Hualapai 1992; Masayesva 1992; Roberts et al. 1995; Secakuku 1997; Stevens 1996; Stoffle et al. 1994). Overall, the tribes maintain that mitigation should be performed when adverse effects are of man-made origin (in this case, operation of Glen Canyon Dam). If the physical erosion were entirely a natural process at these sites, current information suggests that the tribes would prefer natural deterioration to any prerservation.

With the passage of the GCPA in 1992, the cultural resources staff at GRCA-NAU was presented with a considerable challenge. The law and execution of the PA mandated monitoring of cultural resources, yet there were virtually no precedents to be found anywhere in the world regarding reliable methods for monitoring the condition of archaeological sites through time, especially within a legal framework that involved multiple agencies, Indian tribes, and uncertainties regarding the potential effects of humaninduced hydrological regimes. Historically, there has been very little attention to systematic, detailed monitoring of the condition of archaeological sites anywhere in the world (Downum et al. 1997).

The RCMP thus embarked on its monitoring program fully aware that its efforts would be experimental in many respects, and that much would be learned as the project progressed. According to Kunde (I 999a), efforts at monitoring cultural resources are primarily limited to short-term programs, and previous monitoring programs for federal agency resource management have no guidelines for implementing monitoring protocols. Furthermore, several programs have gathered data for resource management in terms of human impact only (Des Jean 1991; Des Jean and Wilson 1991; Gale 1985; Goldsmith 199 1). No programs have yet moved beyond the information stage to develop a trigger mechanism for implementing management actions. Additionally, their short-term nature did not lead to the identification of trends through time, or the fon-nulation of predictive models **(Kunde 1999a).**

Although the general theoretical and methodological frameworks of natural resource monitoring are useful, they also have their limits when it comes to cultural resources. As with natural resources, monitoring the condition of cultural resources is an indispensable tool for their effective management. Cultural resource monitoring is difficult, however, because such resources are fragile and **irreplaceable,** and their information content is in a steady (though often exceedingly slow) state of decline. Unlike many biological or other natural resources, cultural resources cannot be replenished, cleansed, or regenerated. Because they are composed of human-made or altered objects and deposits, subject to decay, breakage, disarrangement, and loss, the information conveyed by cultural resources also inevitably degrades through time. At least with respect to information potential (and probably other areas of significance as well), all cultural resources are, in some measure, in worse condition today than when they were initially created.

From a scientific standpoint, understanding past human activities at archaeological sites relies on patterning, i.e., it relies on an ability to decipher the relationship between material objects (architecture, hearths, refuse, human burials) and the human behavior that produced and arrangred those objects in three-dimensional space. Thus, at the time of site abandonment, the interpretable "structure' of a sitethe patterned relationship between and among material objects and the human behavior that produced them-is at its peak. As time passes, various agents, some physical and some human, act to destroy the original patterns, breaking down the material remains and organized structure of the site and making it less interpretable (Schiffer 1987). This fact of decreasing quantity and structure of material remains through time applies to all archaeological sites, not just those within the Colorado River corridor -where operation of Glen Canyon Dam has had some effect.

Since 1992, the RCMP staff has made 33 monitoring trips to assess the condition of cultural resources along the Colorado River corridor. On average, RCMP staff members have monitored 130 sites per year. In a total of 1,042 monitoring visits, approximately 80,000 observations have been made on site condition variables. Thus far, an estimated total of 9,000 photographs have been taken. The photo record, especially photos taken with a medium-forinat camera, have produced an immensely useful database for future environmental studies based on repeat photography.

Site impacts are divided into two categories: physical impacts and visitor-related impacts. Physical impacts include surface erosion, gullying, arroyo cutting, bank slump, eolian or alluvial deposition or erosion, and side-canyon erosion. The RCMP has been documenting physical impacts since the original archaeological sun-ev. During the course of the survey, numerous observations were made on the geomorphic settings, site sediments, and other factors that might relate to site erosion. These observations laid the foundation for a later collaborative study between NPS and USGS (Hereford et al. 1993) that proposed a model for relating dam operations to site erosional processes.

Geomorphic studies conducted in the late 1980s (Balsom et al. 1989) and early to mid 1990s (Hereford 1993, 1996; Hereford et al. 1993, 1995, 1996b) influenced RCMP staff and NPS survey personnel to pay particular attention to archaeological sites situated on the alluvial deposits (river terraces) of the Colorado River that contain gullies and arroyos, two of the main physical forces actively eroding sites, The entrenched channels of small tributary streams, referred to as arroyos or gullies, that cross the terraces are erosional features that dissect the terraces as they extend headward. "The process of arroyo development destroys or damages surface and subsurface archaeologic sites" (Hereford 1993:9).

Geological mapping by Hereford and others (1993, 1995, 1996) has helped to determine how the ongoing erosion of terraces and archaeological deposits by arroyos and gullies is affected by regulated streamflow. The water and sediment discharge regimen of the Colorado River has been regulated since 1963 by the operation of Glen Canyon Dam. It has experienced substantially reduced sediment load, sediment concentration, duration of high flow, and peak-flow rates compared with the unregulated strearnflow of the pre-dam era (Hereford 1993). In the present discharge regimen, sediment load has been reduced by a factor of six (90% reduction in sediment load) and the annual flood, which was the principal agent of natural geologic change, has been eliminated (Hereford 1993).

Hereford and others (1993) denoted two types of channels (gullies and arroyos): terrace based and river based. These channels are streams that begin with a catchment (collecting pool) and subsequent cutting into terraces that flow downward toward some effective base-level, or lowest point. Several factors detennine this base-level, including the size of the catchment, the length of the channel, and the type of soil the stream flows over. For instance, a large collecting pool will hold more water, which will have the gravitational power to create a longer, deeper channel with a lower base-level. However, if the water flows over porous (e.g., sandy) soil or over a relatively large, flat terrace, the base-level will be higher (Hereford 1993; Hereford et al. 1993; Kieffer 1990; Thompson and Potochnik 2000).

With increased rainfall or size of the collecting pool, the channel may deepen and widen, smoothing out the course of the stream. This permits more efficient water transportation, allowing the stream to finally reach the river. When the stream reaches the river, the channel continues to widen and deepen, becoming a permanent feature of the landscape (Hereford 1993; Hereford et al. 1993; Thompson and Potochnik 2000).

The aforementioned factors determine whether a channel will remain terrace based or will become river based. This is an especially important consideration for cultural resource management because monitoring efforts can identify and mitigate terrace-based streams with tools such as checkdams. Riverbased streams represent a more or less perinarient feature (Hereford 1993; Thompson and Potochnik 2000). According to Hereford, sites with river-based drainages have a small chance of being preserved, whereas all other sites, including sites with terrace-based drainages, have a better chance of preservation in place.

Geomorphology studies, incorporated by the RCMP staff, have resulted in all 264 sites being divided into four drainage- defined groups. These four group s-river-based, teFrace-based, side canyon-based, and undeveloped drainages-form the basic categories for the monitoring program. Although Hereford did not differentiate areas with side canyon-based drainages due to their small number, this small group is recognized within this synthesis.

Seventy sites have been identified as having river-based drainages. Impacts to these sites are directly related to dam operations. Because these drainages reach the river, the river directly controls their depth and width. If river flows are high, the drainages retreat; if flows are low, drainages deepen to reach the river. It is a direct cause-and-effect relationship. Sites with river-based drainages have always been a high priority in the monitoring effort in accordance with the base-level lowering hypothesis (Hereford et al. 1993) in conjunction with sediment depletion.

The original archaeological resource inventory and subsequent monitoring efforts have led to the identification of 70 sites containing terrace-based drainages. These sites are indirectly impacted by dam operations. Terrace-based drainages do not drain to the river, but instead die out on the older and higher base-level of the Colorado River, analogous to the river level prior to the construction of Glen Canyon Dam. These drainages are the most critical to preserve (Hereford 1996; Hereford et al. 1993, 1995, 1996b; Leap 1996f, Thompson et al. 1996).

Monitors have recorded the effects of large tributary floods on archaeological sites since 1992. Most tributary floods and debris flows occur during July to October, due to localized thunderstorms with rainfall intensities up to 40 mm/hr (Griffiths et al. 1997). Researchers have identified at least 600 tributaries in the Grand Canyon from Lees Ferry to Surprise Canyon where debris flows occur (Griffiths et al. 1997; Melis et al. 1997). Upon re-eNaluation of the RCMP data, archaeologists identified six sites with side canyon-based drainages.

Sites with undeveloped drainages comprise 40 percent (I IS sites) of the 264 archaeological sites. These sites do not have a drainage(s) deeper than 10 cm. Instead, water drains into dunes or shallow, ephemeral channels. Sites within this group do not currently exhibit gullying or arroyo cutting, but they have the potential to do so if their current drainage network transitions from surface runoff to a downcutting process. These sites are potentially impacted by dam operations.

Using these four site groups, several frequency calculations were completed for this synthesis. For example, comparison of a site's condition identified during the 1991 survey (Fairley et al. 1994) with RCMP's current site evaluations shows that 49 sites (19%) have deteriorated over the past 8 years. The sites with river-based drainages show the most change. Since the survey there has been a 144 percent increase in the number of sites in poor condition (50% or more disturbed). Sites indirectly and potentially impacted by dam operations demonstrate small variations in the numbers, but sites directly and indirectly impacted by dam operations show general deterioration over the years.

Overall, most sites with river-based drainages **are in fair to poor condition, of which** 67 percent are actively eroding. Sites with terrace- and side canyon-based drainages are commonly in good or fair condition, but 3 8 percent show active erosion. Most sites with undeveloped drainages are in excellent or good condition; only 17 percent are actively eroding.

Eighty-six percent of the sites with river-based drainages are in poor condition and are actively eroding. Sitcs with terrace- and side canyon-based drainages illustrate four sites in poor condition and all but one are actively eroding. Fourteen sites with undeveloped drainages are in poor condition, however, only one site is physically eroding. It is likely that visitor impacts account for the other 13 sites in poor condition.

Of the 264 sites currently thought to be affected by the dam, 87 have been placed on the inactive monitoring list. This list represents sites that are located within the APE but for various reasons are not monitored by this program. Of the 87 sites on the inactive list, 78 do not show active erosion and are considered stable.

Representatives of the PA signatories have expressed concern regarding visitor-related impacts at sites along the river. SWCA's data synthesis report points out that tribes see visitation as the primary impact to cultural resources (Neal et al. 2000); however, RCMP monitoring data demonstrate that only 25 percent of the monitored sites have active visitor-related impacts, and these impacts rarely affect site integrity.

Visitor-related disturbances recorded by RCMP personnel include collection piles (artifacts gathered by visitors and placed in piles), on-site camping, criminal vandalism, and trailing. Trailing is the most frequently recorded impact. Trail maintenance and obliteration remains a priority because RCMP staff have observed and documented that if trails are not maintained or obliterated, they can easily become entrenched river- or terrace-based gullies.

Researchers have been recording the loss of "suitable campsites" in the river corridor due to accelerated erosion for many years (Beus et al. 1985; Kearsley and Warren 1993; Schmidt et al. 1992; Schmidt 1989; Webb et al. 1987). The reduction of suitable campsites since the construction of Glen Canyon Dam was documented by Kearsley and Warren in 1993. Researchers inventoried existing river corri . dor campsites in 1991 and compared the results with previous inventories in 1973 and 1983 (Brian and Thomas 1984; Weeden 1975). The 1991 inventory showed 48 percent fewer campsites since 1983, and 51 percent fewer large campsites since 1973 (Kearsley and Warren 1993:12).

Dam operations reduce beach-building sediment in the river and prevent the annual floods that replenish beaches. For this reason, the reduction of campsites in the river corridor is directly linked to dam operations (Kearsley and Warren 1993). This reduction translates into higher concentrations of riverrunners at a limited number of campsites, which means higher occurrences of visitor-related impacts at the archaeological sites located within the vicinity of these camps (Coder et al. 1995a, 1995b; Hubbard 1999b; Kunde 1998a; Leap et al. 1996, 1997, 1998).

The research flood of 1996 illustrated the importance of sediment replenishment. The high flow redeveloped existing beaches and created new camping beaches, a process that happened annually before the dam. The experimental 45,000 cfs flood gave incontrovertible evidence that floods affect the existence of beaches, and it also highlighted which beaches river-runners prefer due to certain variables, Such as beach size, location to attraction sites, flat areas for camping, and beach aesthetics.

The RCMP staff attributes most visitor-related impacts in the river corridor to river-runners. Archaeological sites with consistently high frequencies of impacts are often located directly above primary river camps (Kearsley and Warren 1993). Sixty-eight percent of the sites with active visitorrelated impacts have a river-runners' camp within I kin (Coder et al. 1994b). It should be noted that many of the sites in this group have camps less than 500 in away. Archaeological sites with no history of visitation are often located far from river camps. Some archaeological sites with consistently high visitor-related impacts have primary river camps below the sites as well as nearby backeountry trail systems. This combination results in the highest frequencies of visitor impacts to archaeological sites (Coder et al. 1995a, 1995b; Hubbard 1999b; Kunde 1998a; Leap et al. 1996, 1997, 1998).

The various impacts observed and recorded have precipitated several remedial actions, such as preservation and data recovery treatments, beginning in 1995. The current goal of the existing PA (U.S. Department of the Interior et al. 1994), MRAP (U.S. Department of the Interior and Service 1997), and draft Historic Preservation Plan (U.S. Department of the Interior et al. 1997) is pre servation-in-pl ace in lieu of excavation.

Preservation actions have therefore been completed at 96 sites. Treatments include checkdarn construction, planting vegetation, and trail work. Other forms of treatment that could be considered preservation-in-nature include medium-format photography (48 sites) and mapping of archaeological sitps with a total station instrument (68 sites). Most preservation work has been completed on sites with river-based drainages and on sites in fair to poor condition.

Another method involving preservation is public education about archaeological sites, factors that erode a site, and management actions implemented to preserve or retrieve archaeological data. Public education about archaeological sites along the river corridor has consisted of both formal and informal presentations, such as talks at professional archaeological conferences, Guides Training Seminars (annual seminars with approximately 200 commercial river guides attending), meetings with GRCA park employees and visitors, and talks given at education centers such as Northern Arizona University and various elementary and high schools in the Flagstaff area. Written updates and general comments have also been published in handbooks (Harmon 1997), as abstracts *(Archaeology* 1996), in the *Boatinen's Quarterly* (Bulletts 1995; Jackson and Leap 1996), in *Nature Notes* (Kunde 1998b; Hubbard 1999c; Leap 1999b, 1999c), in *Arizona Highways* (Kuhn 1999), and in science magazines (Balsom 1999; Randall 1992).

To date, no whole-site improvements have been observed since the implementation of preservation treatments in 1995. As recognized by the NRC (Council 1999), when evaluating a long-term monitoring program, discussing the success of preservation actions can be premature and will not yield significant results. However, the RCMP staff has acknowledged and documented sediment collection in gullies and arroyos from checkdams, vegetation growth from transplanting and planting new seedlings, and successful trail projects.

The only real way to evaluate the short-term success of preservation actions is to conduct frequent visits to a site and to collect very detailed information (Council 1999). This type of monitoring has been completed in the past 2 years using a total station instrument, but due to the redistribution of funds, this method of tracking success or failure by quantifying change has been discontinued. Other methods for tracking the success of preservation treatments are currently being investigated by project personnel and the Grand Canyon Monitoring and Research Center (GCMRC).

Currently, preservation treatments have rarely affected the frequency of monitoring. Yearly monitoring by the Zuni Conservation Project and GRCA revegetation crews has occurred in cases where checkdams are located and in some cases where trail Nvork is completed. It is presumed that the success of these treatments should be evaluated intensely for several years. After these evaluations, a decline in the monitoring schedule is anticipated.

Data recovery has been completed at 42 sites in the form of feature-based excavations (excavation of a single feature that cannot be preserved, not excavation of the entire site), collection of radiocarbon dating samples, or testing specific features for intact subsurface cultural deposits. The majority of the work has been conducted at thermal and roasting sites. Carbon samples were taken at 20 sites in the late 1980s and early 1990s in conjunction with the research completed by Hereford.

The RCMP staff has prioritized preservation and data recovery treatments based on the findings of this program. Although each site is assessed individually for various treatments, certain descriptive generalizations can be made to assess priority. Based merely on descriptive analyses, it is clear that the stages of erosion are more advanced at sites with river-based drainages; most are actively eroding and in poor condition. However, this observation is based solely on preliminary results, which show that maintenance was performed on checkdams at sites with river-based drainages more often than sites with terrace- or side canyon-based drainages. All checkdams installed in the various drainage types need to be researched much more closely to determine their effectiveness. This entails detailed mapping of the areas to measure volumetric change in sediment. It is possible that this work will be completed by GCMRC this fiscal year.

Until this work is completed, no conclusive evidence exists to suggest that river-based drainages cannot be stabilized. However, because of the advanced stages of erosion, all sites with river-based drainages recommended for data recovery should be scheduled for such data recovery work. Of the 19 sites recommended for data recovery, 6 had already been slated for (Leap 1999a).

The first priority for preservation treatments should be* sites with terrace- and side canyon-based drainages, and then sites with undeveloped drainages. The goal is to prevent any drainage system from becoming river based. The status of these sites is very fragile and if preservation in place is postponed, it is very likely that these sites will be listed for data recovery in the future. Hereford speculated that after drainages are river based, erosion control is nearly impossible because the drainages are too advanced. They are connected to a much larger erosive force, the Colorado River. These sites need to be the focus of preservation treatment.

Several additional factors should be considered prior to conducting any remedial tasks. For example, a research design should be in place prior to any data recovery, as mentioned above. This will aid in completing excavations on sites that will benefit the archaeological record within the corridor and within the area.

Another factor to consider is the geomorphological setting. The work completed by Thompson and Potochnik (2000) provides a good starting point. Sediment type, catchment systems, slope, and general drainage cross-sections are all factors that should be considered prior to implementing a preservation treatment. Information about the vegetation in the area would supplement this data. The maturity of the plants and the root systems can aid in the success or failure of a preservation project. Archaeological data potential, integrity, and significance are also critical elements in the decision process.

The history of the RCMP reveals a steady refinement in our knowledge of how the operation of Glen Canyon Dam is impacting cultural resources in Grand Canyon National Park, and how best to mitigate those impacts. RCMP personnel continue to investigate and consider methods with the potential to improve and streamline documentation, monitoring, and treatment of cultural resources along the river corridor in the Grand Canyon.