DRAFT

AMP Narrative of Desired Future Resource Conditions

Introduction

The strategic plan for the Glen Canyon Dam Adaptive Management Program (AMP) is based on the premise that key elements of natural ecological processes can, to a sufficient degree, be simulated by management actions to achieve desired future resource conditions for the Colorado River ecosystem (CRE)[1]. In addition, the principles developed by the Adaptive Management Work Group (AMWG) explicitly recognize that Glen Canyon Dam and its provision of water and power resources are an integral part of this ecosystem. The operation of Glen Canyon Dam has altered the natural processes and habitat that support the natural, physical, and cultural resources of the CRE. Together with the introduction of non-native species and other changes, these altered natural processes have led to substantial changes in the CRE.

The ecological and biophysical attributes of the pre-dam river represent the conditions under which the natural, physical, and cultural resources in the CRE developed. It is assumed that management actions that restore elements of these conditions, consistent with the Law of the River, the operational flexibility of the dam, Grand Canyon National Park values, and other guiding legal imperatives will improve conditions of the CRE. In some cases, additional management actions (e.g. mechanical removal of existing riparian vegetation or non-native fish control) may be needed to achieve the desired future resource conditions described below.

The Glen Canyon Dam Adaptive Management Program (AMP) seeks to return flows of the Colorado River to a more natural state, consistent with the philosophy contained in the Grand Canyon Protection Act (GCPA), Final Operation of Glen Canyon Dam Environmental Impact Statement (EIS) and the subsequent Record of Decision (ROD). The desired future resource conditions described below represent the AMWG's vision for what will result from successful implementation of the AMP strategic plan.

The AMWG's desired future resource condition for the CRE centers on retaining valued components of the new, post-dam system, while embarking on a path that leads us further in the

[1] The Colorado River ecosystem is defined as the Colorado River mainstem corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay of Glen Canyon Dam to the western boundary of Grand Canyon National Park, a distance of approximately 293 river miles (Figure 1).

direction of viable populations and communities of native plants and animals. The AMWG sees the CRE as a mosaic of natural, cultural and recreational resources influenced and controlled by dominant physical processes including climate, tributary flows and releases from Glen Canyon Dam. At the head of the CRE and included within it is Lake Powell and Glen Canyon Dam, at the other end is Lake Mead.

When taken as a whole, implementation of the ROD introduced greater stability of flows from day to day, but greater variability from year to year. It accomplished the first by reducing daily fluctuations, and the second by the testing of lower stable flows (LSSFs) during low water years and implementing large peak flows (BHBFs and HMFs). We desire a CRE, including the dam and humans, that is dynamic in nature and is temporally punctuated by flow events such as BHBFs, HMFs, LSSFs, daily/monthly hydropower operations, and tributary flows. Adaptation to these flow events (i.e., disturbance regimes), will predominately influence the structure and composition of the plant and animal communities within the CRE, as well as recreational quality and the protection of cultural values within the corridor. Thus individual resources will vary both spatially, depending on their location in the CRE, and temporally depending on the nature (i.e., timing, magnitude, duration) of the flow event and the time since the last flow event. See Figure ? for a portrayal of these temporal effects.

Target levels recognize and reflect this dynamism rather than some optimum level. They account for potential management actions in addition to dam operations in achieving desired resource conditions. Target levels are not single values, but ranges or descriptions that encapsulate the concepts of minimum or maximum threshold levels, rates of change, and the resource's role in the overall ecosystem.

Desired Future Aquatic Resource Conditions

We envision a system where the viability of native fish populations are not constrained or threatened by non-native predation or competition. The EIS and ROD flows have significantly increased the productivity of the aquatic environment and benefited trout, perhaps preferentially so, and management actions may need to be taken to reduce the impacts of non-native fish on native fish. We believe that the ROD leads us to test both flow and temperature variables in an attempt to reverse this threat. We desire a continuation of the nature of the current food base in the Lees Ferry reach, but recognize that the specific macrophyte and invertebrate species may change, both successionally and as efforts are made to enhance the native species below GCD.

The AMWG sees the clear-water Lees Ferry reach full of beds of benthic algae and rooted aquatic macrophytes. This plant life supports a diverse invertebrate community, and together they form the food base for a population of naturally reproducing rainbow trout in the Lees Ferry reach of Glen Canyon and native fish throughout the CRE.

Approximately 16 miles downstream of the dam, we see the first hint of the vestigial Colorado River as a small stream, the Paria River, enters from the right-hand shore. The size of the stream belies its importance, because it is a major producer of fine sediments during floods. The fine clays, silts, and sands entering the Colorado drown the sun's light as it passes through the water, stealing from the aquatic plants the very energy that allows their existence. Other ungaged tributaries, with their sporadic floods, add their contributions in the downstream journey, further suppressing light penetration and forcing the system deeper toward its past, back to its nature before the dam had its way. The Little Colorado River strikes another major blow to the world of light and plant life. This tributary enters the mainstem 75 miles below the dam after draining nearly 27,000 square miles of mountain and desert lands in northeastern Arizona. Only when the Paria, Little Colorado, and other sediment-bearing tributaries are at base flow does the river that flows from the dam retain its clear water character in the journey through Grand Canyon.

In the world of alternating darkness and light below the Paria River, the Colorado and its tributaries support a community of native fish--viable, self-sustaining populations that benefit from purposeful variations in dam releases. Except for the Lees Ferry population of rainbow trout, non-native fish are not welcome in the CRE, and positive efforts will be made to reduce their numbers.

Water quality will vary wildly though time and space dependent upon water releases and tributary flows and will greatly influence the aquatic environment. We expect that the native species adapted to the pre-dam extremes will persist and flourish within this dynamic environment.

Desired Future Riparian Resource Conditions

With respect to riparian resources, we see a resource that varies longitudinally down river in response to substrate geomorphology, water availability, climate and the disturbance regime. The pre-dam flooding regime has limited the establishment of marshes and near-shore riparian areas. Flooding is now largely under human control through the operations of Glen Canyon Dam

and these near-shore riparian areas have come to dominate the ecosystem. A flooding regime will continue within the CRE that preserves extreme disturbance variability and supports native plant and animal communities and their habitat to the point described below. Management floods will be triggered if sufficient sand is available for deposition. Within such a regime, beaches will expand and contract through natural processes. Beach number and area within the CRE will vary between xx-yy% of the pre-dam condition. The median grain size of beach sand will tend to be zz% coarser but will support the conditions expected for riparian and animal habitat as well as recreational use.

Marshes are most affected by flooding and will come and go in specific locations quickly in response to this influence. We expect that the absolute amount to vary between virtually zero and five percent of the total riparian vegetation within the corridor. The near-shore riparian zone is more permanently established and will tend to better resist the extreme fluctuations predicted for marshes. Near-shore riparian vegetation will vary between xx-yy% of the total vegetation within the corridor depending upon the severity of the flooding regime imposed. Upslope riparian vegetation blends into the terrestrial community forming a broad ecotone that is less influenced by flooding. This community will vary xx-yy% depending on the flooding regime imposed.

We desire a change toward a more native riparian species composition, gradually eliminating non-native species, especially noxious species. We believe that aggressive management actions will be required to accomplish this. However, even with a return to native species, we desire a mix of both pre- and post-dam riparian communities such as the old high-water zone (OHWZ), new high-water zone (NHWZ), bare sand beaches and marshes. We envision a resource that changes longitudinally as one moves downstream from GCD to Lake Mead in response to changing reach geomorphology, sediment inputs, and climatic factors. We also recognize that there will be a frequency associated with the presence / absence (coming or going) of riparian features such as marshes and bare sand beaches, expecting that beach/habitat-building flows (BHBFs) will enhance the OHWZ and bare sand beaches and that in subsequent years between BHBFs the NHWZ and marshes will be favored. (See Figure ? for a diagram of how the channel cross section might change with time). As these communities change, we will continually assess our protection of endangered species, perhaps from the perspective of threshold levels of habitat that will not jeopardize the future existence of the species.

The natural communities native to the Grand Canyon will dominate the riparian ecosystem. The area above the high-water line of major floods supports native riparian communities dominated by Apache plume above river mile 40, and mesquite-acacia below river mile 40. Below the high-water line is a scour zone dominated by ephemeral species. Neither non-native species nor invasive native species will be dominant. They will not impair the abundance, composition, and distribution of natural communities nor alter the natural processes that shape these communities.

Our desire in purposefully varying dam releases is to move the physical world of the Colorado River closer to its roots, closer to the seasonal cycles experienced in pre-dam times. Yet not so close as to be too far away from the world that has allowed colonization of the streamside corridor by new forms of vegetation, both marsh and riparian. Here we balance precariously between the old and the new, for we desire to maintain pre-dam vegetation, the so-called old high water zone that was able to persist in the face of large-scale floods, yet retain the lower marsh and riparian corridor habitats.

As we pass down the river, we search for sandy beaches nestled among the expanses of marsh and riparian areas. These beaches are our refuges at the end of the day when we river runners leave the current and retreat to land before the sun sets and darkness settles over the river. To have these beaches, we must have floods; floods that will remove portions of the marsh and riparian vegetation, rise to quench the thirst of the old high water zone, and deposit clean sands to form our refugia.

Flow effects will vary as the river passes downstream, depending upon the geometry and geology of the streambed and its shores. The effects also will vary with time; large flows will serve to reset the system, to force plant communities back to earlier successional stages and to maintain a patchwork mosaic of open beaches and vegetated zones. During intervening periods, biological interactions and physical processes will change the pattern of the mosaic, and the frequency of its components, but differences in the landscape coupled with the effects of the next large flow will maintain the diversity of features that we desire in this ecosystem.

The vertebrates native to the CRE will dominate the riverine ecosystem. Native species that are/were resident to the CRE will exist as viable populations. The natural processes imposed by species that were transient to the CRE, but are now extirpated, may be mimicked by the creation of small resident populations or other management actions. Non-native species will not

be dominant and they will not impair the abundance and distribution of native species nor alter the natural processes that shape these communities.

Desired Future Cultural Resource Conditions

The goal for cultural resources affected by the operations of Glen Canyon Dam is to identify, evaluate, register and treat the full range of properties representing significant aspects of American history, architecture, archeology, engineering, and culture. Each cultural resource or property will be evaluated within its historic context and its association with important events or persons, design or construction, information potential or traditional or cultural value will be described, classified, and assessed. A series of preservation goals will be systematically developed for each historic context and property type based upon the principles that cultural resources are irreplaceable and should be preserved in place if possible. Preservation goals and priorities will be integrated with other planning and preservation concerns and will be established based on active consultation with affected groups and with others interested in the cultural resources present within the CRE. To improve the preservation, protection and interpretation of cultural resources, all activities and decisions should be made based on principles of stewardship, accountability, consultation, and public education and outreach. Increased communication with Native American tribes will help us better respect and integrate their concerns.

Desired Future Recreational Resource Conditions

We expect the CRE to provide a setting that facilitates an appropriate spectrum of recreational activities within the context of a full wilderness setting. Appropriate activities include hiking, fishing, boating and river running, photography, wildlife viewing etc. Specifically, visitor experience will emphasize the appreciation of wilderness values.

The nature of recreational camping beaches will change from year to year as sediment is deposited and eroded. During periods of high runoff years, large magnitude BHBFs will deposit sand high on the banks and available for visitor use, while periods of low runoff years will benefit from fall habitat maintenance flows (HMFs), released following fall tributary inputs. These disturbance releases (BHBFs and HMFs) will each be significantly higher in magnitude than dam releases ongoing at that point in time.

Recreational activity will not impair the aesthetic, ecological, cultural and spiritual values of the Grand Canyon, but will result in a deep appreciation for these values. Recreation takes the river "on its own terms" and celebrates the primitive conditions of one of the seven wonders of the world.

Recreational opportunities will be enhanced and research activities will have minimal impact on the CRE. A high value will be placed on the extensive wilderness qualities of the river corridor. The CRE is remarkable in the length and breadth of its unbroken primitive character. It provides unique opportunities for experiencing natural sounds and natural quiet of the desert and river. Opportunities for solitude, connection to nature, and personal contemplation outside the trappings of civilization will be deeply valued.

Desired Future Water and Power Resource Conditions

We anticipate that Glen Canyon Dam and the Power Plant will continue to be operated in a manner consistent with the "Law of the River," including the Grand Canyon Protection Act. This will allow the Upper Basin States to develop their compact allocations of water and deliver water to the Lower Basin States as required by compact. The power plant will be operated to maximize the value of the power resource. This will be done consistent with the resource balancing anticipated in the EIS, ROD, and the operating criteria established by the Secretary. We also acknowledge that these "operating criteria" may be modified in the future as the result of the long-term monitoring of their effects and further research, through the adaptive management process.

Riparian Vegetation Attachment

Riparian vegetation assemblages in the CRE may be classified into 4 zones as one moves up-slope from the river. These include the hydro-riparian zone (HRZ; marsh), lower riparian zone (LRZ; "New High Water Zone"), middle riparian zone (MRZ), and upper riparian zone (URZ; "Old High Water Zone"). These riparian zones develop in response to flow (flood disturbance, inundation frequency and moisture availability), sediment type, (grain size, moisture retention and nutrient content), and the physical characteristics of a given geomorphic reach. Thirteen geomorphic reaches have been identified within the CRE.

Narrow geomorphic reaches encompass approximately 40% of the CRE and are characterized by steep rocky or bedrock banks. Narrow geomorphic reaches have sparse to no

riparian vegetation. Extensive riparian vegetation cannot develop in narrow reaches because little sand or suitable germination sites exist, grain size is generally larger, and stage-to-discharge relationships are steeper (more stage gain per unit increase in discharge). Wide geomorphic reaches have abundant riparian vegetation. Extensive riparian vegetation can develop in wide geomorphic reaches due to the availability of sand and suitable germination sites and lower flow gradients. In addition, within the CRE one finds debris-fan eddy complexes (DFCs) in both narrow and wide geomorphic reaches. DFCs create conditions that can support the hydro-riparian zone in low velocity, near-shore and return current channel settings, LRZ sand bar habitats, and fine-grained URZ terraces.

The distribution of riparian vegetation assemblages is strongly related to flood and inundation frequency, and grain-size. Riparian vegetation development takes place in response to changes in these state variables, and over time; however, vegetation development does not occur as a perfect stage-for-time replacement process, because of variability in life history traits of the more than 700 plant species that occur in the river corridor.

The HRZ (8-25,000 cfs stage): Data from the 1983-1992 time period indicates that redevelopment of marshes takes place over a 5-10 yr time period in specific fluvial habitats (rarely scoured near-shore and return channel habitats). The establishment of marsh vegetation (cattail, reed, horsetail, sedge, bullrush and rushes) requires sandy silt soils that are inundated at least 5% of the growing period. Some marsh species may persist through low-flow years with no inundation (for example, cattail stands at Lees Ferry persisted for 4 yr after the subsidence of the mid-1980's high flows). Constant water levels allow cattail to quickly (2-4 yr) dominate return current channel marshes, eliminating many other marsh species, whereas highly variable and lower inundation frequency settings favor horsetail and reed. Because these habitats are low-lying and particularly susceptible to scour during high flows, moderately increased flooding is likely to maintain diversity, whereas high flood frequency is likely to scour and eliminate riverine marshes. High productivity is strongly related to invasibility by non-native plant species, and this the case in the HRZ.

The LRZ (ca 18,000-45,000 cfs stage): Lower riparian zone vegetation develops in a variety of geomorphic settings and grain-sizes, including sand bars, channel margins, debris fans, and, sparsely, on rocky talus slopes. Composition is dominated by tamarisk, coyote willow, arrowweed, seep-willow, and numerous grasses and herbs. URZ vegetation is gradually

invading this zone, but this invasion is retarded by higher flood frequency because URZ dominants (mesquite and catclaw) are less flood tolerant than the phreatophytes that generally dominate the LRZ. The LRZ can redevelop swiftly after moderate floods (i.e., 1-3 yr after the 1996 flood), moderately slowly after larger floods (i.e., 5-10 yr after the 1983-1986 high flows), and cannot persist with frequent, high floods (i.e., those that characterized the pre-dam hydrograph). Like the HRZ, the relatively high productivity of this zone makes it particularly prone to invasion by non-native plant species, and tamarisk, camelthorn and numerous non-native grass and herb species dominate many LRZ settings.

The MRZ (45,000-125,000 cfs stage): This zone exists in a state of dynamic disequilibrium, with establishment of phreatophyes after high floods (most of which soon perish from desiccation) offset by the downslope invasion of slow-growing, flood intolerant desert plant species (i.e., cacti, creosotebush, brittlebush), which are eliminated by high flows. Compositional change in this low-productivity zone results from the gradual dominance of species like catclaw that are facultative riparian species with moderate inundation tolerance.

The URZ (125,000-300,000 cfs stage): This belt of pre-dam vegetation exists upslope from the 10-yr pre-dam flood return stage (125,000 cfs). The dominant woody species (mesquite, catclaw, netleaf hackberry) are long-lived (100-750 yr in age at least), and are highly resilient, having persisted through enormous pre-dam flows. Detailed studies in the mid-1980s failed to demonstrate any relationship between flooding and growth of URZ vegetation. Pre-dam flows of the 100-yr return frequency (>250,000 cfs) may have been necessary for germination of mesquite, and absence of such flows may gradually shift the composition from mesquite to catclaw; however, this process is likely to proceed at a multidecadal to century time scale because of the low productivity of this zone.

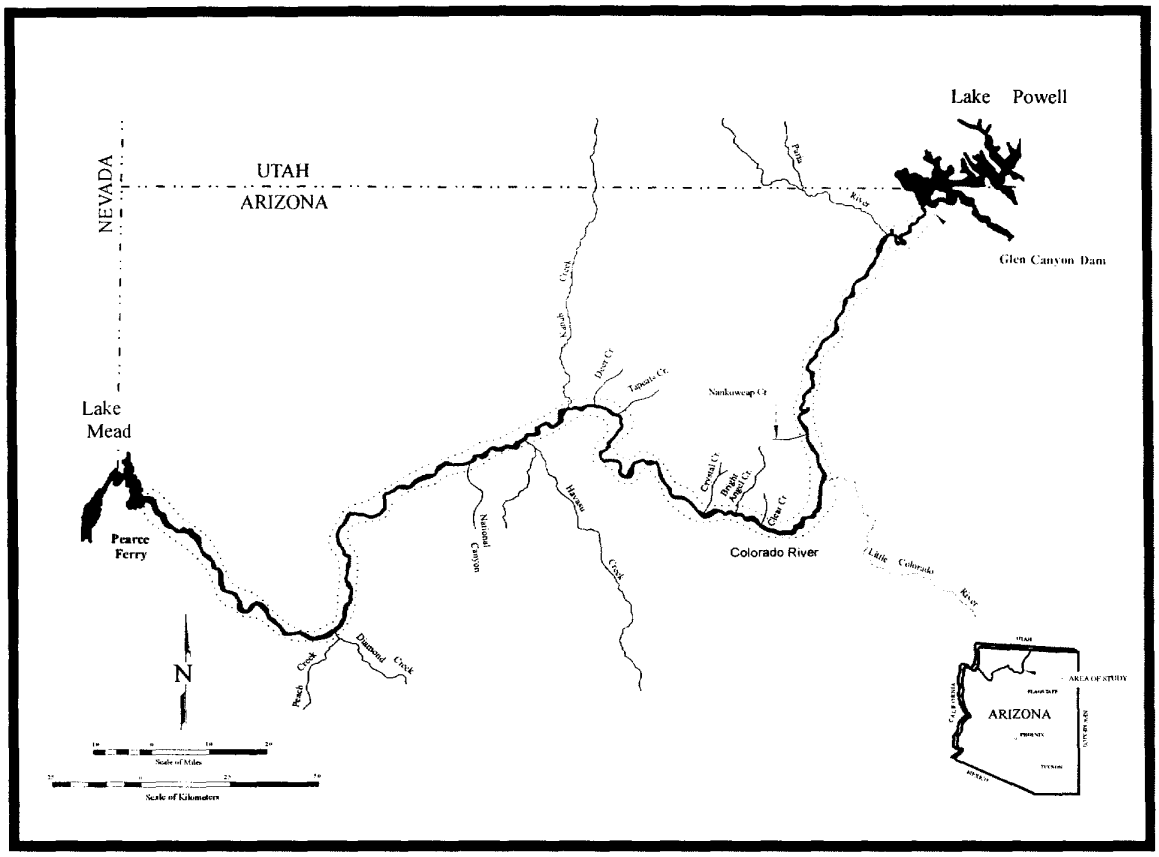

Figure 1. Map of the Geographic Extent of the Colorado River Ecosystem

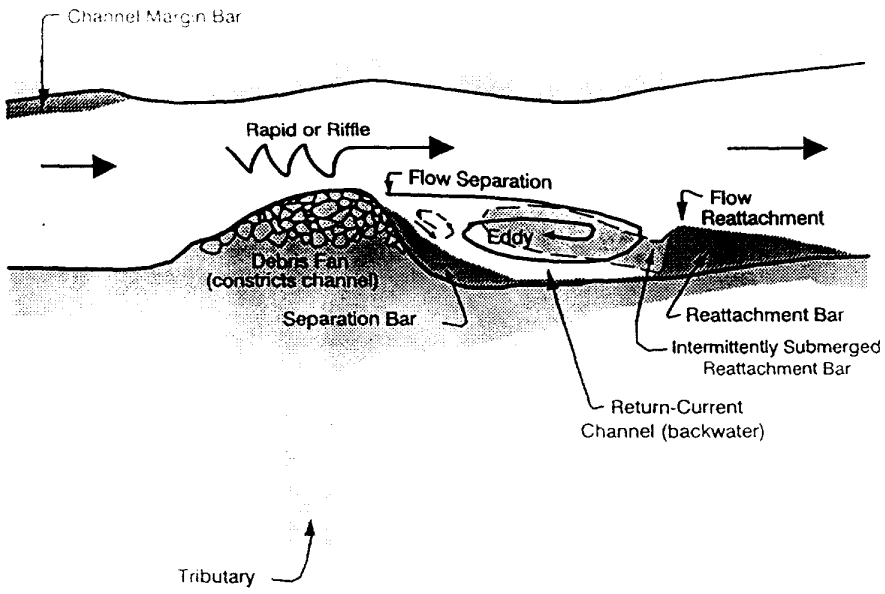

Figure III-17.—Relationship of sandbars and flow patterns. Riverflow is constricted in a rapid, causing an eddy downstream. Sand is suspended in the highly turbulent currents of the rapid and deposited on sandbars associated with the relatively tranquil eddy currents.

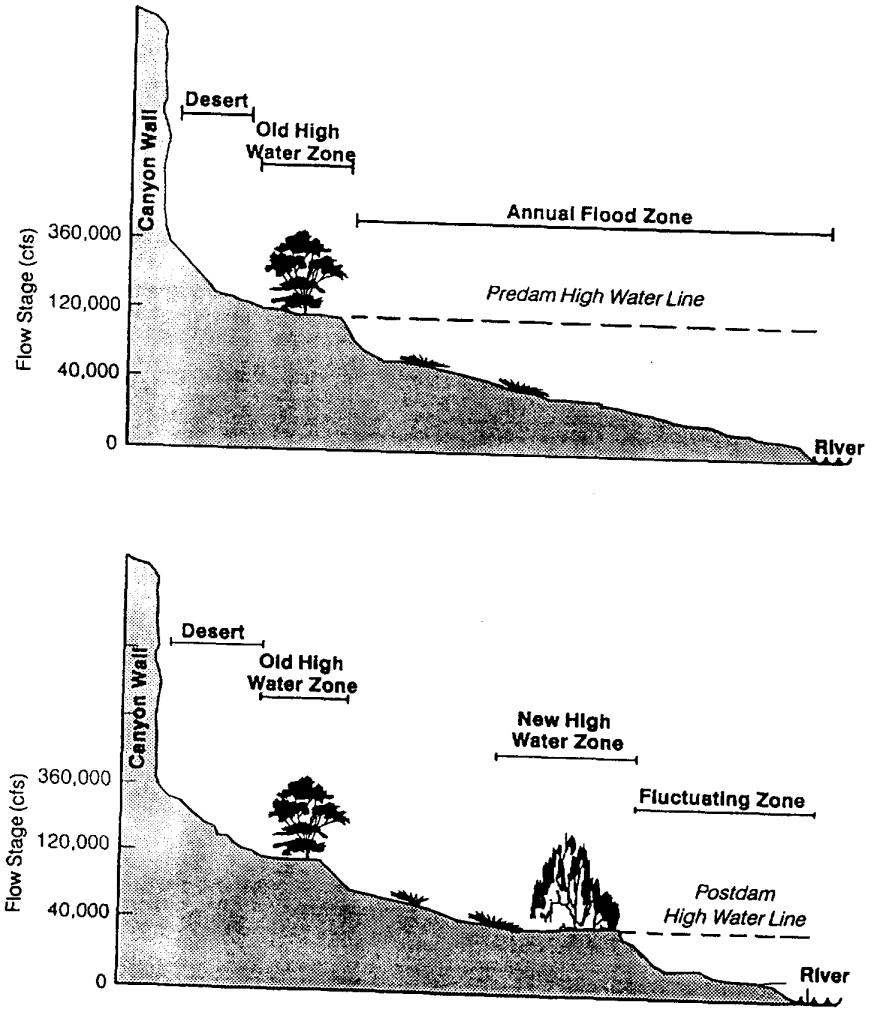

Figure III-30.—Grand Canyon riparian zone, predam (before 1963) and postdam (after 1963).

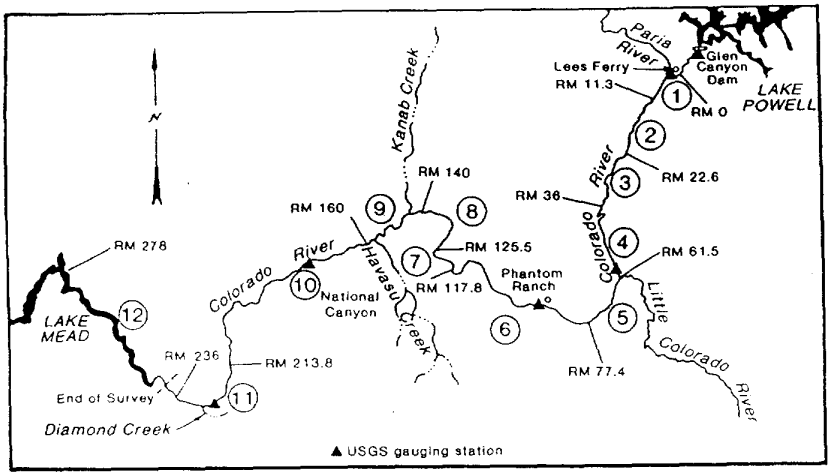

Figure III-14.—Geologic reaches within Grand Canyon (modified from Schmidt and Graf, 1990). Reach characteristics are listed in table III-7.

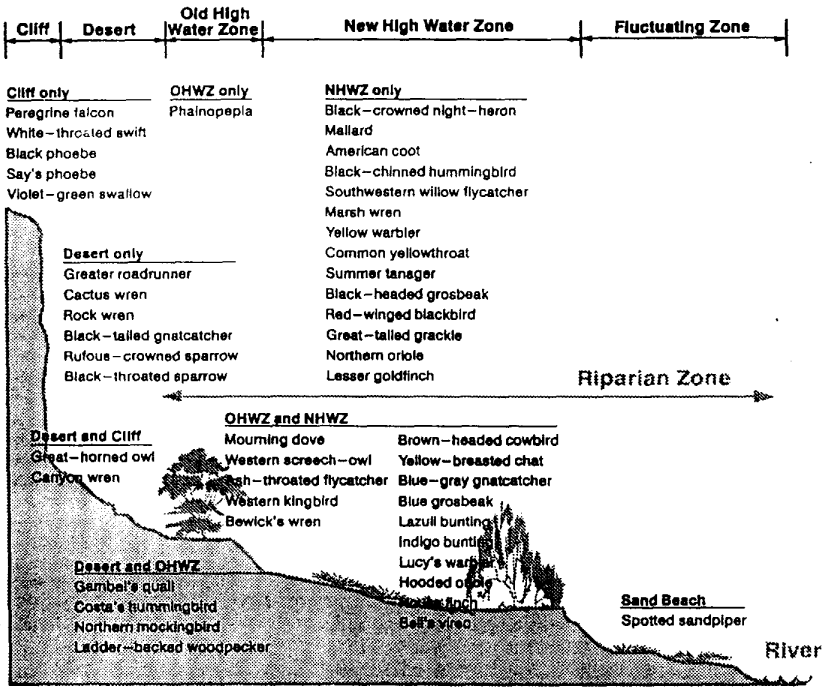

Figure III-32.—The importance of riparian vegetation as wildlife habitat is exemplified by nesting birds. The majority of birds nesting along the river corridor (30 to 48 species) nest in riparian vegetation.

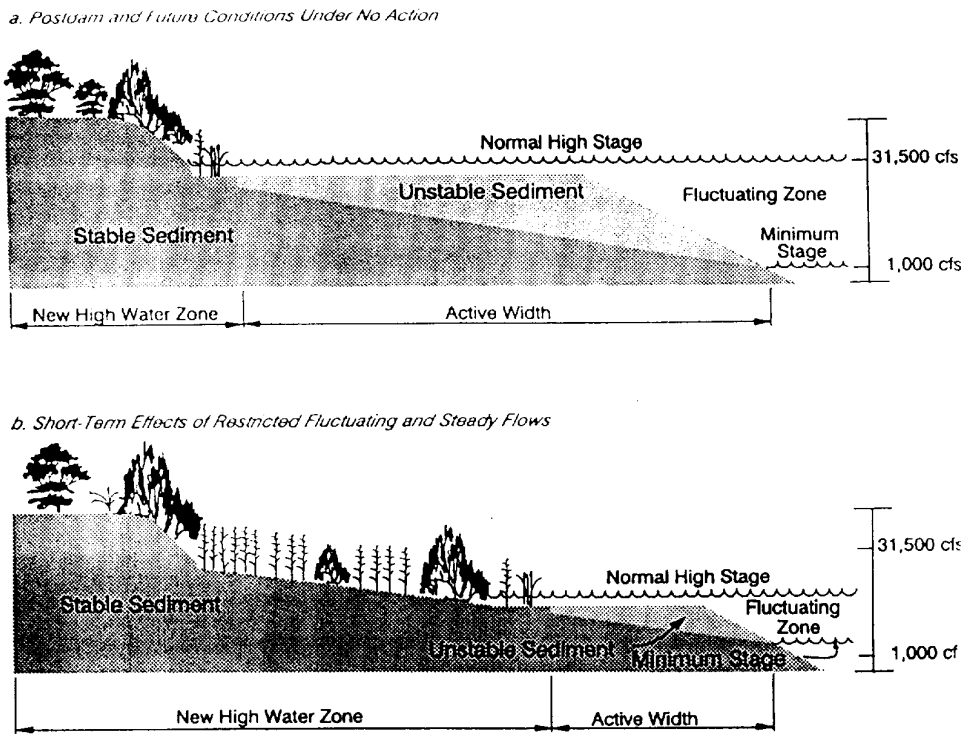

Figure IV-13.—Reduced maximum flows would affect riparian vegetation in the new high water zone (NHWZ) by reducing the width of unstable sandbars and, thus, increasing the area of stable deposits available for plant development. In general, mesquite occupies the upper, dryer elevations with other plants occupying sites closer to the high flow stage (a). Tamarisk, willow, horsetail, and cattails also would develop on suitable sites exposed by reduced high flows (b). Some mortality of woody plants may occur at upper elevations of the NHWZ under alternatives with reduced maximum flows. However, changes in species composition (and area) depend on site-specific characteristics and cannot be estimated.

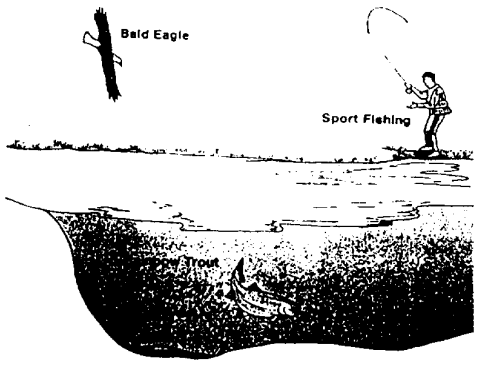

Figure III-3.—The effects of dam operations on linkages between aquatic and terrestrial resources are exemplified by the trout fishery. Fluctuating flows can affect food abundance, trout spawning in the river and tributaries, the availability of trout as prey for eagles, and the sport fishery. These resources were not found in the Colorado River corridor through Grand Canyon before construction of Glen Canyon Dam.

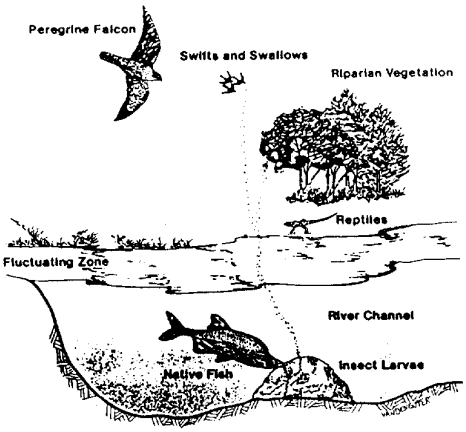

Figure III-4.—Insects are an important linkage between aquatic and terrestrial systems in Grand Canyon. Some insects emerge from the river as adults and become food for various wildlife species using the river corridor. For example, swallows, swifts, and bats feed on emerging insects; peregrine falcons, an endangered species, feed on these foraging species.