Assessment of Design Alternatives: Proposed Relocation of Rainbow Marina, Glen Canyon National Recreation Area, Utah-Arizona

Philip E. Flores Associates, Inc.

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assessment of design alternatives
February 1979

Glen Canyon
Rainbow Marina
National Recreation Area / Utah-Arizona

Joel V. Rissman

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ENVIRONMENTAL REVIEW
PROPOSED RELOCATION OF RAINBOW MARINA
GLEN CANYON NATIONAL RECREATION AREA
UTAH-ARIZONA

The Assessment of Design Alternatives for relocation of the Rainbow Marina is based on the recommendation in the general management plan for Glen Canyon National Recreation Area that the existing facility be relocated because sewage and solid waste loads have increased to the point they can no longer be adequately handled at the existing facility.

The assessment considered a number of alternative sites for relocating the marina: Dangling Rope, Oak Canyon, San Juan River, and Llewellyn Bench.

Recommendation: The Dangling Rope site is recommended as the location which has the most favorable relationship to factors such as sufficient sheltered areas, suitable anchorage conditions, sufficient level land to accommodate shore-based facilities, and relative location to Rainbow Bridge National Monument and to the midpoint between the Bullfrog Basin and Wahweap developed areas of the national recreation area.

The assessment considered five alternative design plans that could be accommodated at Dangling Rope Canyon. One of these plans was "no action". The other plans would each have approximately equal effects on natural and cultural resources and socioeconomic factors. Carefully monitored construction techniques are expected to minimize any damage or disturbance to topography, geology, and soils; to dust in the air; to water turbidity; and to vegetation. Visual impacts of buildings against the skyline will be minimized by careful siting. Should cultural features be uncovered during construction, the project would be halted pending evaluation procedures. There would be a short-term positive effect from jobs created by the construction. Temporary disruption of boat service facilities during relocation of the facilities would be mitigated by conducting this operation during an off-peak use period.

During a review of design considerations such as landscape compatibility, optimal location of facilities for function and efficiency, energy requirements, and cost, it was determined that a modified version of Alternative four would probably best accommodate these factors. Most of the comments received concern construction concepts that will be addressed in detail at the comprehensive design stage.
The environmental impacts of the facilities at Dangling Rope will be about the same regardless of the juxtaposition of those facilities. Specific siting of the facilities will depend on final evaluation of factors such as geology, soils, slope, wind exposure and radiant heating. Engineering constraints will also be final determining factors, such as the gradient for the LCM launch ramp/road, the 10,000-foot minimum distance between housing units and sewage treatment areas as recommended by the State of Utah, distance of fuel storage areas from other facilities, and similar considerations. The comprehensive design stage of construction will establish design capacities to determine the actual size of the sewage treatment facility and other supporting utilities.

The total net cost given for Alternative four is $4,404,000, based on 1978 estimates. Our present understanding of the fiscal outlook for this development is that the gross cost will include about $323,000 available in fiscal year 1979 for planning, printing, and special studies; $1,056,000 is proposed in fiscal year 1980 for completion of planning and beginning construction; and that the balance of funding required in fiscal year 1981 is tentatively estimated at $5,577,000. These figures would result in a total cost of $6,956,000.

**Magnitude of the Project**

1. Major Federal action, significant effects  
   - No

2. Federal  
   - Yes

3. Substantive adverse impacts  
   - No

4. Highly controversial  
   - No

5. First time precedent setting  
   - No

6. Commits Service to future action*  
   - Yes

   *for development, maintenance and operation.
Recommendation: Based on a review and evaluation of the assessment of alternatives, a modified Alternative four as described above is recommended as the environmentally preferable alternative to accomplish the purposes of this project.

Finding of No Significant Impact: A review of the assessment of alternatives indicates that the effects resulting from or during construction of this project will not have a significant impact on the environment. Therefore, an environmental impact statement will not be required for the project.

Recommended: [Signature]  
Superintendent  
1/16/79

Approved: [Signature]  
Regional Director, Rocky Mountain Region  
2/1/79
ASSESSMENT OF DESIGN ALTERNATIVES

Proposed Relocation of Rainbow Marina
Glen Canyon National Recreation Area
Arizona/Utah

Prepared by
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153 Madison Street
Denver, Colorado 80206

Prepared for
Denver Service Center
National Park Service
Department of the Interior

January 1979
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I. PROBLEM STATEMENT

A. Introduction

The General Management Plan for Glen Canyon National Recreation Area recommends that the existing Rainbow Marina be relocated. This recommendation is based on a preliminary engineering study prepared in 1972 by Pope, Evans and Robbins, Inc. (San Francisco, California) on the Rainbow Marina, and on an environmental assessment of the sewage treatment plant at Rainbow Marina prepared by the National Park Service.

This document will identify and evaluate locations for the new boat service facility, outline public and private needs, develop alternative design plans to provide visitor services, and assess the impacts of these alternative design plans.

B. Rainbow Marina

Rainbow Marina is located at the approximate midpoint between the Wahweap and Bullfrog Basin/Halls Crossing developments to serve the boating public. The marina also serves as a visitor service facility to Rainbow Bridge National Monument and is located in a narrow side canyon which leads to the Monument. The marina, constructed in 1964, provides fuel, supplies, sanitary facilities and other services for visitors to the area. It also contains a ranger station and residence facilities for National Park Service and concessioner personnel. Because of its location in a narrow canyon with high vertical walls, access to the shore is not feasible for housing or for land-based utility services. The entire complex is thereby waterborne and completely self-contained: power is generated on the marina, water is drawn from the lake and treated, sanitary waste is treated and discharged to the lake. All supplies and services must be
transported thirty-five to fifty rrdles by watercraft to and from two main­land developments, Wahweap to the south and Bullfrog Basin/Halls Crossing to the north.

Traffic at the marina has increased to the level where the sewage treatment facilities can no longer adequately handle the quantity and character of the load. Solid waste loads have also increased and now add significantly to the operational problems at the marina.

The carrying capacity of the sewage treatment facilities at Rainbow Marina is determined by NPDES Discharge Permit. On the quarterly monitoring report, the approved affluent discharge is limited to an average of 3,000 gallons per day. During heavy use periods, the marina is exceeding permit conditions.

Expansion of the sewage treatment facility to a lagoon system on the adjacent flat mesas above the marina was studied. This was not considered viable because the lagoons would have to be located outside the boundaries of the Glen Canyon National Recreation Area on Navajo Tribal lands.

C. Criteria for Marina Location

The requirements for location of a boat service facility are:

- Sufficient sheltered water area to accommodate marina traffic during peak periods without need for a large wakeless speed area.
- Bottom and shore conditions that will permit installation of a safe and effective anchorage system.
- Adequate protection from wind and wave action, but open to sunlight for much of the day in the colder seasons.
• Access to shore, possibly with quarters and other facilities on shore
• Location close to the Rainbow Bridge National Monument so as to be able to provide services for visitors
• Location close to midpoint between Bullfrog Basin/Halls Crossing and Wahweap in order to provide refueling facilities and services equidistant from points of visitor origin
• Level land of sufficient area in the near vicinity, above lake high water level, but accessible from the lake, for a shore-based sewage disposal facility. The disposal facility should, preferably, be out of view from the marina, and removed from areas used by visitors and for employee housing

D. Program Needs

The elements which must be provided in the development of a shore-based boat service facility include:

• Potable water system using wells or lake intake
• Electrical system
• Sewage system with evaporative ponds and other necessary appurtenances including: sanitary boat dump station, sewage lift stations, and sewage collection system
• Public boating facilities including concessions store, comfort station, courtesy docks and floating fuel facilities. Also included will be necessary concessioner and National Park Service docking slips.
Designated "harbor of refuge" capable of accommodating up to 200 boats overnight

- Land-based housing area (apartment type units) including units for both National Park Service and concessioner use. These units are to be sited to take greatest advantage of the site from the standpoint of both topography and solar orientation.

- Shop/maintenance area to serve both National Park Service and concession facilities

- Emergency/administrative STOL air strip (not for public use)

- Service ramp and road for emergency repairs and service

- Road/trail system to service the air strip, maintenance area, sewage lagoons and housing area (including inner-housing area circulation)

- Sewage disposal system to handle up to twice the current loads (current load is approximately 833,210 gallons)
II. DESCRIPTION OF THE ENVIRONMENT

A. Location

Glen Canyon National Recreation Area is located in the heart of the canyonlands section of the Colorado Plateau, a physiographic province covering approximately 150,000 square miles of southeastern Utah, northern Arizona, northwestern New Mexico and southwestern Colorado. The Colorado Plateau region contains some of the most spectacular wild and scenic areas of the United States.

Glen Canyon National Recreation Area encompasses approximately 1,236,880 acres, the majority of which is in the natural land use category where human activities have little influence on natural processes. The majority of the Recreation Area lies in Utah; the Glen Canyon Dam and approximately three percent of the recreation lands are in northern Arizona. However, this small portion of land in Arizona receives eighty-five percent of the total visitation due to easy access and proximity to population centers. Glen Canyon is the only National Recreation Area among the National Park Service areas in Utah, which include five national parks and seven national monuments.

The area is cut by four major river drainages: the Colorado, the Dirty Devil, the Escalante, and the San Juan. These rivers, and their many tributaries, have created a labyrinth of deep and spectacular canyons, many of which are accessible by boat as a result of the area being inundated by Lake Powell. Lake Powell, at elevation 3,700 feet, comprises 163,000 surface acres. Creation of the lake has provided easy waterborne access to Rainbow Bridge National Monument. The Navajo Indian Reservation borders the eastern shore of Lake Powell from the San Juan River south to Page, Arizona.
The areas along Lake Powell to be investigated for relocation of the Rainbow Marina are located in close proximity to each other near the midpoint of the lake between Bullfrog Basin/Halls Crossing and Wahweap (see Location Map, page 7).

1. **Dangling Rope**

A long, narrow bench located in a wide-mouthed, short, south-facing canyon approximately 7 miles southwest of the existing Rainbow Marina. A boat service facility in this location would be off of the main channel of Lake Powell.

2. **Oak Canyon**

A small, compact bench located at the mouth of Oak Canyon approximately one mile northeast of the existing Rainbow Marina. A boat service facility in this location would be on the south side of the main channel of Lake Powell.

3. **San Juan River Site**

A large plateau located at the junction of the San Juan River and Lake Powell approximately 16 miles northeast of the existing Rainbow Marina. A boat service facility in this location would be on the south side of the main channel of Lake Powell.

4. **Llewellyn Bench**

A large plateau located at the mouth of a long, narrow, south-facing canyon approximately 14 miles northeast of the existing Rainbow Marina. Because of the narrowness of the canyon, a boat service facility in this location would be on the north side of the main channel of Lake Powell.
LOCATION MAP

GLEN CANYON NATIONAL RECREATION AREA

united states department of the interior/national park service
The natural and cultural features of this central portion of Glen Canyon National Recreation Area are very similar. Therefore, the following description of the environment pertains to all of the alternative locations being considered for the relocation of Rainbow Marina. Where significant differences do exist between alternative locations, appropriate descriptions are included.

B. Natural Environment

1. Topography

From a distance, the long stretches of the even skyline give the impression of a topography consisting of extensive flat surfaces that terminate in lines of cliffs. However, the canyonlands terrain in reality is intricately dissected, and closer inspection reveals a ruggedness possessed by few, if any other regions. Over large areas, the canyons are so narrow, so deep, and so thickly interlaced that the region appears to be made up of gorges, cliffs, and mesas intimately associated with a vast variety of minor erosional forms.

Watercourses in the canyonlands area are usually steep-walled, narrow canyons - sunken valleys whose beds are far below the level of the general surface. Glen Canyon, most of which is flooded by Lake Powell is one such canyon. The steep, rocky canyon walls rise 200-500 feet vertically from the lake to generally flat upland benches. Because of these steep canyon walls, access to the upland benches from the water is difficult in most places (only 25% of the shoreline affords easy access to the water). Easiest access is along sloping ridges (10% or greater gradient) or at the ends of drainage channels. The flat uplands, though relatively level, undulate and are often broken by drainages and steeply rising plateaus and benches. The size and extent of these upland areas varies significantly.
The topography at each of the alternative development locations is typical of Glen Canyon (See Topography Map, page 10). However, the size of the upland benches varies from Oak Canyon (approximately 12-15 acres) to Llewellyn, San Juan and Dangling Rope (approximately 45-55 acres each).

The subsurface topography is an important aspect in the location of water-based boat facilities. Generally, the subsurface topography to the canyon floor reflects the topography which is evident above water. Most critical is the location of any below water benches or plateaus that may be exposed with fluctuations of water level. At each of the alternative development locations, the subsurface topography will need to be thoroughly studied prior to its identification as a desirable marina location.

2. Geology

The canyonlands of the Colorado Plateau consist of a vast array of terraces, mesas, and cliffs that seem to have unlimited range in form, size, and color. The Plateau formation is approximately 5,000 to 7,000 feet above sea level. Outstanding geologic features are the widespread Triassic, Jurassic, and Cretaceous strata in approximately horizontal position, the gigantic cliffs, and the multitude of canyons. Edges of both sedimentary and igneous formations are fully exposed in vertical, unscaleable cliffs of seemingly interminable length that advance in headlands and retreat in bays, tower above adjacent lower lands, and extend backwards from their crests to the bases of similar escarpments.

Most of the exposed rock in the cliffs and benches of the Glen Canyon National Recreation Area is part of the Glen Canyon Group; Navajo, Entrada, Kayenta, and Windgate sandstones from the Jurassic period. The Glen Canyon Group
TOPOGRAPHY
ALTERNATIVE LOCATIONS
GLEN CANYON NATIONAL RECREATION AREA
united states department of the interior/national park service
ranges in depth from approximately 1,000 feet in the northern part of the National Recreation Area to more than 2,000 feet in the central and southern parts. This group consists almost entirely of fine grained sandstones which are relatively resistant to erosion - thus forming sheer cliffs and bench type topography. Along major drainages, these formations stand together as nearly vertical cliffs more than 1,500 feet high. These cliffs and escarpments form the shoreline of most of Lake Powell.

3. **Soils**

Generally, the surface material at Glen Canyon is classified as rockland consisting of bare rock and some shallow soils on benches and mesas. These soils are mostly less than twenty inches in depth and consist primarily of wind blown and water deposited materials. All of the soils are highly erosive and are readily transported by wind and water.

In general, runoff is rapid. Infiltration rates for the wind derived soils on gentle slopes of ten percent or less usually exceeds 3 to 4 inches per hour during initial stages (3 - 8 minutes) of potential runoff producing thunderstorms. After 30 minutes, the rate is reduced to about 2 inches per hour. Lower infiltration rates may be expected on steeper slopes with shallow soils and rock outcrops.

Because of the shallowness of the soils over most of the Recreation Area, the properties of the soil veneer have relatively little influence on most types of developments which are affected more by the engineering properties of the bedrock.

4. **Climate**

The climate of the Glen Canyon National Recreation Area is typical
of high desert areas. The mild climate is conducive to a long visitor use season from March to October for most activities. The average number of frost-free days ranges from 200 days at Glen Canyon City to 245 days at Hite.

a. Temperature. Over most of the area, temperature maximums exceed 90 degrees Fahrenheit on more than 100 days a year. Extremes of more than 100 degrees are common. Summer minimums average between 60 and 70 degrees during July and August. Winter maximums average in the upper 40's and 50's; winter minimums average well below freezing though rarely sub-zero.

Surface water temperatures of Lake Powell vary from 40 degrees Fahrenheit in winter months to 80 degrees in summer. The deeper waters remain cold all year long. Generally, the lake surface does not freeze at the alternative development locations. Close to the lake, the relative humidity increases due to lake surface evaporation.

b. Precipitation. The Recreation Area generally receives an average of 6 to 7 inches of precipitation per year, although canyon bottoms may receive less and high plateaus may receive several inches more. The range in annual precipitation varies between 4 and 10 inches. Brief, intense thunderstorms produce practically all the moisture received during the summer. August and September are generally the wettest months with June the driest. Heavy summer thunderstorms may cause flooding where drainage areas are insufficient to retain large volumes of water.

Snow may fall during the winter months, but it stays on the ground only 2 or 3 days, except at the higher elevations.

c. Wind. Measurement of wind direction and velocity recorded at Glen Canyon National Recreation Area show that prevailing winds come from the
southwest but may vary seasonally. Occasional strong gusty winds can be expected during much of the year. From December to April, winds are associated with the passage of active storm fronts. Preceding a front, winds are from the southerly quadrant; following the frontal passage, winds shift and come from the northerly quadrant. From April to September, strong gusty winds are common as part of active thunderstorms and may reach velocities of 70 miles per hour. Summer storms can come from any direction. From October to December, winds are calm except when associated with storm fronts.

d. Microclimates. Microclimates occur wherever landforms (from ridges and canyons to individual boulders) create zones that are sheltered from the frequent winds and intense sun. In these locations, shade, cooler temperatures, and relative abundance of moisture fosters plant growth and stability as well as providing various human comfort areas.

e. Solar Information. The Glen Canyon National Recreation Area has excellent solar characteristics. Long-term solar information has not been collected for the region. However, information is available for Albuquerque, New Mexico (latitude 37° north) which is approximately comparable (Source: United States Department of Commerce - NOA): See appendix E for complete solar information.

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<td>2280</td>
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5. Hydrology

a. Lake Elevation. Lake Powell serves as the principal storage unit of the Upper Colorado Region. The volume of water present in the lake (lake elevation) is dependent on supply runoff from the upper Colorado Region and down-
stream water obligations in the lower Colorado Region. As climatic cycles change from years of high precipitation to dry years, the lake level alternately rises as water accumulates or lowers as water is drawn down to meet downstream needs.

Glen Canyon Dam and power plant have been planned and constructed to operate between the elevations of 3,490 and 3,700 feet above sea level. During the first 50 years of operation the water level is expected to remain between 3,600 and 3,700 feet (average elevation to be 3,650 feet). The average seasonal fluctuation is expected to be 25 feet (varying between 5 and 60 feet). High water elevation is 3,700 feet although it could reach 3,711 feet (elevation of the spillways). Anticipated low water elevation is 3,570 feet.

Fluctuating lake levels will affect the location of water-based boat service facilities. Specifically, this pertains to the variable size of the bay or cove in which the marina will be located, its ability to accommodate the numbers of boats at times of drawdown, and the ability to maintain a physical connection between water-based facilities and shore-based support facilities via permanent walkway and utility chase. The main portion of the lake fluctuation zone is unuseable for permanent land-based facilities.

b. Water Supply. Fresh water to be used by the National Park Service and the concessioner will be taken directly from wells drilled on the upland benches or taken from the lake. At this time, no tests have been conducted at any of the alternative development sites to determine water quality from possible wells. Existing water sources within the Recreation Area come from deep wells with exceptions of Lees Ferry, where water is taken directly from the Colorado River, and Rainbow Marina and Hite, where it is taken directly from Lake Powell.
c. Water Quality. The quality of the water in Lake Powell may be characterized as good. It does not pose any restraint on the development and use of the Recreation Area. Sewage effluents, petroleum residues and rubbish at the four major access points (Wahweap, Bullfrog, Halls Crossing, and Hite) and from boats on the lake are entering the aquatic environment in negligible quantities compared to the total volume of water in the lake. Levels of mercury are increasing (due to increased sedimentation in the lake) but present no major health problems.

6. Air Quality/Noise

a. Air Quality. No current data on the quality of the air at Glen Canyon National Recreation Area is available. Air studies completed in 1974 prior to the construction of the Navajo Power Plant in Page concluded that the air was "clean and quiet". The average visibility described in that study as "excellent" (about 125 miles) is now noticeably less due to the emissions from the plant - a conspicuous brown haze lies over the area during predominantly calm weather conditions.

Air quality at each of the alternative development locations may be affected in periods of high wind by the blowing of the unstable sandy soils on the upland benches.

b. Noise. Natural noise levels in the desert are low because there is little wildlife and little rustling vegetation. People and motor vehicles on both the land and the lake increase the noise levels in this area where sounds reverberate in canyons and travel unobstructed across the vast open spaces of Glen Canyon and Lake Powell.
No data and analysis of specific noise levels at the alternative development locations have been recorded.

7. Vegetation

Vegetation of the Recreation Area displays a far greater diversity than is apparent from the casual inspection that the vast majority of visitors give it. Although this diversity contributes little to the landscape's macro-scale aesthetics (which are overwhelmingly determined by the lake and its stark contrast with the shapes and colors of rock and sand), it does provide important variety for the microscale experience of the hiker and boater exploring the side canyons of the reservoir. The vegetation of Glen Canyon National Recreation Area consists of three principal associations:

a. Northern Desert Shrub Association. Comprises the vegetation of lower elevation hillsides and valleys (below approximately 6,000 feet). The association is typified by communities of sagebrush, shadscale, blackbrush, greasewood, saltbrush, and rabbit brush. The numerous variations are dependent upon the latitude, the nature of the topography, slope exposure, and soil salinity and moisture. The aspect of the vegetation is one of openness with considerable areas of exposed reddish soil. The dominant shrubs are widely spaced, mainly of grayish-green color, and range from about 1 to 7 feet in height. They are commonly oriented along the joint planes of the underlying sandstone where water tends to collect and soil depths are slightly greater. The vegetative cover generally varies from about 10 to 50 percent.

b. Pinyon-Juniper Woodland Association. The Pinyon-Juniper Woodland Association is more uniform than the Desert Shrub, although it, too, shows some variation within its range, particularly with respect to density. Occurring principally on the higher benches and slopes where the soil is rocky or sandy and where the rainfall is generally greater, the arboreal flora is composed almost
exclusively of double-needle pinyon pine, single-needle pinyon pine, Utah juniper, and one seed juniper. Antelope bitterbrush, joint-fir, cliff rose, gallenta, blue grama, and Indian ricegrass are some of the more common shrubs and herbs.

Also within this zone on a few shady, north-facing ledges and cliff faces are found pockets of Douglas fir, Rocky Mountain maple, rock spirea, and other plants normally found at higher elevations.

c. Cottonwood-Willow-Saltcedar Floodplain. Characteristically borders waterways and sandy washes and consists of drought resistant shrubs, forbs, and grasses with blackbrush the dominant species. Plants of this association prefer well-drained shallow, rocky soils of sedimentary origin.

There are no known endangered plant species in the alternative development locations.

8. Wildlife

The rather sterile-looking aspect of the Recreation Area's landscape belies the wealth of animal life that it hosts. Many species and large populations of small mammals, birds, and reptiles may be found almost everywhere, from the deepest canyon bottoms to the tops of the highest plateaus.

Flat lands are characterized by numerous benches and flat bottomed valleys. The mammals of this area include ground squirrels, kangaroo rats, jackrabbits, and various lizards and snakes. Birds characteristic of this area include larks, finches, crows, ravens, red-tailed hawks, and golden eagles.

Canyon lands are mostly vertical and largely rock with intermittent water seeps and springs. The vertical cliffs provide nesting areas for birds such as swifts, crows, ravens, red-tailed hawks, and golden eagles. The cliffs
also provide habitat for pack rats, deer mice, and rock squirrels, as well as snakes and lizards.

Slope areas occur in locations between the water and steeper cliffs or between various bench areas. They are often characterized by blow sand areas, slickrock, and extensive soil erosion. Bird life here is limited to a few nesting species such as horned larks and transient or foraging species such as ravens, crows, various hawks, and golden eagles. Mammals are more limited here than on bench lands, but include antelope, ground squirrels, jackrabbits, and an occasional coyote. Some lizards and snakes frequent this area although their numbers are generally low.

The most common game fish of this area are the largemouth bass, crappie, and channel catfish. All of these fish were stocked originally although not necessarily directly into Lake Powell and their biological interrelationship is not known. Striped bass is the only species that is currently stocked. The habitat for these fish may improve as lake levels increase, but historically, fish production tends to decrease as a reservoir ages.

There are known populations of endangered species in the vicinity of the alternative development locations, specifically, the Colorado River squawfish, and the humpback chub. The endangered peregrine falcon is found in Glen Canyon National Recreation Area although none are known to exist near the locations being considered for development. The canyon provide significant winter roosting habitat for the Bald Eagle.

9. Visual/Scenic Quality

The visual experience at Glen Canyon varies as to whether the view aspect is from the lowland canyons or from the upland benches and mesas. From the canyons (and Lake Powell), the scenic character is experienced within
the varied enclosure that the steep vertical walls provide. The main canyon in the central section of the lake is quite wide, and the sheer-faced walls are seemingly piled one upon the other and the variety of short- and mid-range views are seemingly endless and ever changing. The side canyons, much narrower and more enclosed, offer beautiful and intricate scenery. They contain a fascinating environment of sheer cliffs decorated with tapestries of desert varnish and entrenched meanders carved into huge overhanging vaults.

In contrast to this canyon environment, the visual experience of the windswept mesas and benches high above consists of broad vistas and feelings of unbroken solitude. The view aspect is oriented up and towards the horizon in series of long-range vistas.

Throughout, the visual experience is characterized by minimal indication of man's presence in the area. Only the "ring" around the canyon walls resulting from fluctuating water levels and the widely separated visitor service facilities at the road heads and marinas, indicating man's presence, interrupt the unbroken natural scenic character of the area. For many, these visual intrusions may, in fact, signal a welcome opportunity to contrast the natural experience.

C. Cultural Resources

1. Pre-History

The Recreation Area contains evidence of seven periods of aboriginal use: Desert Archaic; Basketmaker I and III; and Pueblo I, II, III, and IV. Occupancy was not continuous nor equally heavy throughout the area. The canyonlands cannot be shown to have been used much by man prior to the Christian era. This may be due more to gaps in the data than to lack of early occupation.
In 1976, the area of Dangling Rope Canyon was intensively surveyed by the National Park Service (Alan Schroedl, Midwest Archaeological Center) for the presence of archaeological remain. Six concentrations of lithic artifacts were noted, although the entire bench proposed for development appeared to have a low density of artifact scatter. These six sites were tentatively assigned to the Archaic stage on the basis of several lines of evidence (Schroedl, 1976). The Archaic period in central Utah ranges from about 6,000 B.C. to approximately A.D. 200. It is a period when small groups of nomadic hunters and gatherers ranged over large areas, subsisting primarily on wild plants and animals.

In 1977, further testing by the National Park Service of several of the heavy surface lithic scatters at Dangling Rope Canyon yielded no subsurface evidence of occupation. These tests did indicate that the artifact scatters were not of sufficient importance to be included on the National Register of Historic Places.

No extensive archaeological surveys have been conducted at any of the other alternative development locations. If a determination is made to utilize any of these locations, an archaeological investigation must be undertaken prior to development.

2. History

Little else is known about canyon country until the arrival of the Spanish. A few Spanish explorers came during the end of the 16th and beginning of the 17th centuries in search of mines and a water passage connecting the Atlantic and Pacific Oceans. By this time, modern Indian tribes, the Navajos, Utes, and Paiutes were inhabiting canyon country. The Navajos are latecomers to this area. They arrived about 500 years ago, while the Utes and the Paiutes
are descended from the early desert cultures (Upper Colorado Region State-Federal Inter-Agency Committee, 1971). In 1776, Fathers Dominguez and Escalante, attempting to establish trails connecting the frontier provinces of Spain, made a circle tour of canyon country through the Colorado Plateau and the Great Basin. The maps and diary from this expedition vastly expanded knowledge of canyon country. Following the Escalante expedition, slave traders, fur trappers, and other Spanish explorers continued to traverse the land, but none settled near Glen Canyon (Crampton, 1964).

In the 1850s, the U.S. Topographical Engineers began to map the Utah canyon lands. John Wesley Powell made two exploration trips down the Colorado River; one in 1869 and one in 1871-1872 and helped complete the regional topography and solve some of the mysteries of the Colorado River canyons. During expansion of the Mormon frontier of settlement outward from Salt Lake City in the 1880s, ferryboats were used to transport settlers across the nearly impassable river.

Rumors of gold and secret Navajo silver mines in canyon country spread through the United States during the 1880s. Prospectors came in increasing numbers through the latter part of the 19th century but the enormous deposits hoped for never materialized. Small deposits of copper and placer gold and small veins of silver kept prospectors seeking the rumored riches. This region has continued to attract prospectors in search of gold, copper, oil, coal, and uranium up through the present.

D. Socio-Economic Environment

1. Regional Economy

a. Employment. The area around Glen Canyon National Recreation Area is generally at a low level of economic development. Most of the economic activity is dependent upon agriculture, mining, and recreation/tourism.
Many areas of the region do not employ enough people to meet the needs for goods and services required. These areas must import the commodities required from the outside. This situation is characteristic of many rural areas and does not imply economic depression or lack of opportunity. It may, in fact, show a potential for economic expansion in the region.

The narrowness of the economic base in the region does present problems of stability. If slowdowns in key areas of economic activity should occur, economic dislocations may be severe (i.e. a slowdown in recreation/tourism as reflected in retail trade and personal services) which could upset regional economic stability.

Growth and economic vitality of the region around Glen Canyon National Recreation Area are constrained by relatively high levels of unemployment. In 1971, the region had unemployment rates of 13% and higher. Agriculture, construction, and tourism all exhibit a strong pattern of seasonal activity - accentuating the problems of unemployment.

b. Income. Personal income in the region is generally low. In 1969, the income of 67% of the families was less than $10,000. By comparison, only 55% of the families in the state of Utah had incomes below $10,000 for the same year.

c. Population. The area which surrounds the Glen Canyon National Recreation Area is sparsely settled (1 person/square mile) whereas the statewide averages for both Arizona and Utah are 14 persons per square mile. Population is predominantly scattered in rural, non-farming residences although there are a number of communities with populations of up to 2,500 persons. The area is further characterized by high rates of out-migration - generally among the younger people who leave
for education and employment opportunities elsewhere.

2. Visitation

The mid-lake location of the existing Rainbow Marina provides services to visitors from both the Wahweap and Bullfrog Basin/Halls Crossing mainland developments. In addition, there are many sightseers (either in private boats or in concessioner-operated tour boats) that stop at the marina on their way to and/or from visiting nearby Rainbow Bridge National Monument (records indicate that at present, approximately one-half of the visitors who stop at the marina also visit Rainbow Bridge).

Heaviest visitation to the marina occurs between 9:00 am and 5:00 pm daily during the months of May to October. Visitation is significantly less from November to February. Annual visitation figures are indicated below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Visitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>87,300</td>
</tr>
<tr>
<td>1976</td>
<td>81,875</td>
</tr>
<tr>
<td>1975</td>
<td>65,171</td>
</tr>
<tr>
<td>1974</td>
<td>55,104</td>
</tr>
<tr>
<td>1973</td>
<td>57,077</td>
</tr>
</tbody>
</table>

Projections from these figures indicate that ultimate visitation to the marina may be as high as 218,000 (with approximately 109,000 of these projected to also visit Rainbow Bridge National Monument).

E. Existing Development

Currently, the marina contains fuel docks, a concession store, concessioner residence facilities, a comfort station, a utility shop, a boat sanitary
pump out station, a sewage treatment plant, diesel-powered electricity generating plant, water treatment facilities, Park Service personnel residence houseboats, and a laundry shed. These floating facilities are interconnected with floating walkways and decks. Power and water distribution systems and the sewage collection system are suspended below the interconnecting walkways.

Sewage is received at the treatment plant from two lift stations and the boat sanitary pump out station. One lift station serves the Park Service houseboats and laundry shed; the other serves the store, concessioner residence, and the comfort station. Additional wastewater reaches the treatment plant from boat pump-out stations located on the marina. The pump-out stations are required because boats are not permitted to discharge waste overboard, but must hold it until it can be discharged into a sewage system.

The sewage collection and treatment system consists of an aeration package activated sludge plant, a clarifier, and a chlorine contact tank. The effluent discharges about 300 feet below the lake surface.

Continuous, sectionalized steel pipe pontoons under the deck sections and walkways provide for marina floatation. The pontoon sections are constructed so that they can be partially flooded, as required, to adjust deck freeboard to keep the various sections of the dock level.

The comfort station houseboat consists of four water closets for women and two water closets and two urinals for men.

The residential facilities on the marina consist of three houseboats for Park Service personnel and a floating apartment complex for concessioner employees. At the peak season, about ten employees live on the marina. During
winter months, concession service employees and two Park Service employees remain on the marina to assist visitors.

Solid waste is collected and stored at the marina in covered barges that are towed to the Wahweap developed area at regular intervals for disposal.

All existing Marina facilities which can be utilized and incorporated in the design of Dangling Rope Marina will be relocated.
III. ASSESSMENT OF ALTERNATIVES

A. Development Program

The facilities required for development of a shore-based boat service operation to replace the Rainbow Marina complex are described below (including land area requirements where appropriate). This development program has evolved through discussions between the National Park Service and concession operator.

1. Shore Based-Facilities
   a. Housing. Housing units for both National Park Service and concessioner staff to be grouped together in a designated housing area. Included will be all utility lines necessary for the habitation of these units (water, sewer, electricity). Within or close by are to be located an indoor recreation/lounge facility and level ground for outdoor recreation activities. Ultimate housing development program to consist of:

   - 13 family-type units (6 NPS units, 7 concessioner units)
   - 1, six person seasonal dormitory
   - Land area requirement = 160,000 square feet

The housing is to be located on predominantly flat lands to provide opportunity for clustering units. Location is to be such as to have good sun exposure during all seasons, to ensure direct physical access and visual contact with the marina, and to be free of potential noise and odor impacts from other shore-based activity areas (Utah State Department of Health Code of Waste Disposal Regulations recommends that the distance between the lagoons and possible human habitation be not less than 1,000 feet).
b. Maintenance. Maintenance/shop facilities for both the National Park Service and the concession are to be grouped together in a designated maintenance area but physically separated. All necessary utility lines will be run to this area (water, sewer, electricity). The housing for the diesel generators may be located here. The maintenance area development program consists of the following:

- 40' X 100' NPS warehouse (shop, supply storage, garage for vehicles).
- 50' X 100' concessioner warehouse (emergency boat repair, supply storage, ice plant optional location).
- 500 square feet housing for electric generators (optional location).
- Land area requirement = 12,000 square feet

The maintenance area should be located on predominantly flat lands with direct access to the marina. Location is to be approximately 1,200 feet from housing area if diesel generators are to be located here. If hospital mufflers are used, the 1,200 foot distance requirement can be dropped.

c. Fuel Storage. Gasoline and diesel fuel storage facilities for both the National Park Service and the concessioner are to be grouped together in a designated fuel storage area. Land area requirement = 2,000 square feet. The fuel storage area should be located downwind and approximately 1,200 feet from all major activity areas (housing, maintenance/shop area, marina) for greatest protection in case of fire. Location is to be such as to provide direct fuel supply to floating fuel docks but also to ensure that fuel spills and fires could be channeled away from the marina.
d. STOL Air Strip. For emergency/administrative use by National Park Service STOL aircraft only. Runway lighting and two plane pull-off area to be provided. **Design dimensions = 1,500 feet X 100 feet = 150,000 square feet**

Air strip to be aligned directly with the prevailing winds. Maximum longitudinal gradient to be approximately 5% with minimal transverse gradient. Nearest structures to be located 200 feet from centerline of air strip. Federal Aviation Administration will be adhered to wherever possible.

e. Utilities. Shore-based utilities are to consist of the following:

- Sewage treatment system with all necessary appurtenances and lines to provide treatment of the shore-based facilities as well as the water-based boat pump-out stations. **Land area requirement = 76,800 square feet (3 sewage lagoons 160' X 160' each).** Sewage lagoons to be located on predominantly flat lands downwind from major shore- and water-based activity areas to minimize anticipated odor impacts. Location should also be set back from edges of mesas and benches to ensure percolation of sewage through the soil to the lake waters in case of leakage. Lagoons to be placed to avoid obstruction of important surface drainages.

- 2 200 KVA and 1 100 KVA diesel power generators and distribution system

- Portable water supply and distribution system

f. Trails/Service Access. Internal circulation system interconnecting shore-based facilities and facilitating movement of staff and supplies between water- and shore-based operations. LCM ramp/road to be located where both a useable water-edge condition for LCM unloading exists and a materials/equipment
access up the rock cliff can be actually constructed. Location to be such as to
hide this facility from the main channel of the reservoir.

2. Marina Facilities

Marina is to be located to minimize exposure to major winds, thereby
reducing the type of damaging effects that exist at Rainbow Marina, and eliminating
the need for a breakwater at the marina location. Location to also be where the bay
is adequate to accommodate anticipated boat traffic. Sub-surface topography should be
such that varying water elevations result in vertical marina movement rather than
requiring lateral or horizontal movement of the marina.

a. Store. 40' x 80' unit (including snackbar and storage of
supplies, ice plant optional location).

b. Mooring. To include mooring field for location of three
courtesy docks, 12 concessioner docking slips (including 2 boat service slips with
hydrohoist), and 5 National Park Service slips (patrol boats, LCM, solid waste scows,
etc.).

c. Fueling. Fuel docking operation to remain as presently exists
at Rainbow Marina with additional pumps only if demand exceeds peak day capacity
of 33,000 gallons.

d. Housing. One unit (only) for use of concessioner.

e. Visitor Float. 60' x 80' float including 12 boat sanitary
pump-out stations and public access comfort station.

d. Harbor of Refuge

Designated area capable of accommodating up to 200 boats over-
night. No provisions for mooring or shore development to be provided.
B. Assessment of Alternative Locations

Criteria for the determination of a desirable location for the development of a shore-based boat service facility at Glen Canyon National Recreation Area are listed in Section I - "Problem Statement". The ability of each alternative location (including existing Rainbow Marina) to accommodate these criteria is assessed in the following matrix (Alternative Location Assessment, page 31).

Based on this assessment, the Dangling Rope location best accommodates the defined criteria.

The remainder of this report is a description of various alternative boat service facility design plans at the Dangling Rope location, their anticipated impacts, and their impact mitigation measures.
### ALTERNATIVE LOCATIONS

<table>
<thead>
<tr>
<th>LLEWELLYN BENCH</th>
<th>SAN JUAN RIVER</th>
<th>OAK CANYON</th>
<th>DANGLING ROPE</th>
<th>RAINBOW BRIDGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient area. Marina traffic would restrict all boat traffic.</td>
<td>Insufficient area. Marina traffic would restrict all boat traffic.</td>
<td>Limited area. Boats using marina may restrict all boat traffic.</td>
<td>Sufficient area in Canyon. No impact on lake traffic.</td>
<td>Limited area. Small canyon causes congestion with traffic going to Rainbow Bridge National Monument.</td>
</tr>
<tr>
<td>Located on main channel of lake. Wakeless speed area would affect all boaters.</td>
<td>Located on main channel of lake. Wakeless speed area would affect all boaters.</td>
<td>Located off of main channel. Wakeless speed area would not affect general traffic.</td>
<td>Located in narrow canyon off of main channel. Wakeless speed area necessary.</td>
<td></td>
</tr>
<tr>
<td>Fluctuations of water elevation would require extensive lateral movement of marina.</td>
<td>Fluctuations of water elevation would require extensive lateral movement of marina.</td>
<td>Fluctuations of water elevation would require some lateral movement of marina.</td>
<td>Fluctuations of water elevation would require primarily vertical movement of marina.</td>
<td></td>
</tr>
<tr>
<td>No protection—located on main channel of the reservoir.</td>
<td>No protection—located on main channel of the reservoir.</td>
<td>No protection—located on main channel of the reservoir.</td>
<td>Minimal protection—open to storm winds which may cause swells in the canyon.</td>
<td>Optimal protection—narrow canyon impedes wind and wave action.</td>
</tr>
<tr>
<td>Optimal exposure—open to the southwest.</td>
<td>Optimal exposure—open to the southwest.</td>
<td>Limited sun exposure during cold seasons due to high canyon walls surrounding site.</td>
<td>Optimal exposure—open to the southwest.</td>
<td>No sun during cold seasons due to high canyon walls surrounding site.</td>
</tr>
<tr>
<td>Approximately 65 acres of land at 0-10% gradient.</td>
<td>Approximately 50 acres of land at 0-10% gradient.</td>
<td>Approximately 15 acres of land at 0-10% gradient.</td>
<td>Approximately 50 acres of land at 0-10% gradient.</td>
<td>No adjacent level land in National Recreation Area.</td>
</tr>
<tr>
<td>Location Description</td>
<td>Notes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located 14 miles northeast of Rainbow Bridge National Monument.</td>
<td>Positive relationship</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located 10 miles northeast of Rainbow Bridge National Monument.</td>
<td>Marginal relationship</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located 1 mile southwest of Rainbow Bridge National Monument.</td>
<td>Poor relationship</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located in same canyon as Rainbow Bridge National Monument.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located approximately 11 miles northeast of midpoint.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located 7 miles northeast of midpoint.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located approximately at midpoint.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located 10 miles southwest of midpoint.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Located 2.5 miles southwest of midpoint.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:  
- Positive relationship  
- Marginal relationship  
- Poor relationship
C. Alternative I - Concentrated Central Development

1. Description

Development will be concentrated on the upland bench above the proposed marina located on the leeward side of the central bay of Dangling Rope Canyon. The STOL air strip will be located on the central southwesterly/northeast ridge and will parallel the prevailing winds. This location will minimize the amount of turning necessary during approach over high ridges to the northeast. The sewage lagoons will be located on the relatively flat lands along the western side of this ridge upwind of the STOL air strip. The housing area will be located on the eastern side of this ridge, south of the sewage lagoons, and overlooking the marina. Residents will have direct physical access to and visual contact with the marina facility. There is level land to the south for outdoor recreational use.

The maintenance area will be located north of the housing area at the upper terminus of the vertical circulation element allowing easy movement between this area and the marina. The fuel storage area will be located on a flat bench north of the maintenance area and downwind and downstream of the marina. This location ensures greatest safety during spills and fire. Either LCM ramp/road alignment can be utilized with this alternative. All proposed development will be outside of major drainage channels (See Alternative I - Concentrated Central Development, page 33).

2. Impacts of the Proposed Action

a. Topography. The topography of the site will be altered to accommodate the sewage lagoons and the STOL air strip. The existing transverse ground slope across the air strip/lagoon site is eight percent. Development of the lagoons will require extensive cutting of the adjacent ridge. The downhill
ALTERNATIVE 1
CONCENTRATED CENTRAL DEVELOPMENT
DANGLING ROPE
GLEN CANYON NATIONAL RECREATION AREA
united states department of the interior/national park service.
bank of the lagoons will require a small amount of fill material thereby requiring use of a membrane liner. The total amount of topographic disturbance will be 4.0 acres.

Subsurface topography is optimal for marina location and anchorage. Fluctuations of water level will require only vertical movement of the marina.

b. Geology. Geologic formations would be disturbed in all areas where facilities are planned and constructed: STOL air strip, sewage treatment lagoons, maintenance area, fuel storage area, trenching for utility lines, on site trails, and the housing area. The total amount of geologic disturbance will be 9.6 acres.

c. Soils. Soils would be disturbed in all areas where excavation, grading and compaction occurs during construction. During construction, there would be increased potential for soil erosion from wind and water. Erosion would be minimal because most development would occur on level benches rather than on the steeper canyon slopes. Soils that are used for fill material in construction on the lagoons are not suitable for holding effluent without use of membrane liner. The total amount of soil disturbance will be 9.6 acres.

d. Air Quality/Noise. The quality of the air will decrease during project construction, particularly increased levels of airborne dust. Temporary discomfort to visitors may occur in some instances. During calm days potential odors from the sewage lagoons could be a problem in the housing area which is located approximately 650 feet to the south on the other side of the central ridge.
Noise levels in the general area of Dangling Rope Canyon will likely increase during construction. These noise impacts would be of a temporary nature. Upon full development of the area, noise will be generated by the lake traffic utilizing the boat service facility and the land-based generators supplying power to the site. Noise from the electrical generators affecting the housing area may require their location outside the maintenance area which is 600 feet away to the north.

e. Water Resources. With the influx of more people and boats to the Dangling Rope area there is a potential for increased pollution from fuel spills and carelessness with trash and waste.

Although studies have shown that outboard engine exhaust contributes oil, lead, phenols and aldehydes to the water, it has been concluded that unusually low water volumes per unit of fuel consumed must occur before outboard motors alone would result in extreme pollution. In general, biological and chemical analysis showed that differences between stressed ponds and control ponds were statistically insignificant (Boating Industry Association, 1973).

The surface area of water in this central bay of Dangling Rope Canyon will be sufficient to accommodate the anticipated amount of boat traffic to the marina.

f. Vegetation. During construction, approximately 9.6 acres of Northern Desert Shrub Association will be disturbed. Loss of vegetative cover will contribute to the erodibility of the soils on the site.

g. Wildlife. Implementation of this proposal will impact local wildlife in that it will significantly reduce the animal habitat and food sources
in the area directly affected by construction. Specific quantities and kinds of animals that will be displaced are not known since no wildlife inventory has been taken at Dangling Rope. However, typical species affected might be ground squirrels, kangaroo rats, jackrabbits, and various lizards and snakes. It is likely these displaced animals cannot relocate in the immediate surrounding environment which already supports its maximum number of wildlife inhabitants.

h. Scenery/Visual Quality. The visual quality of the area will be adversely affected by the visibility of the development from the reservoir. Visible against the skyline, forming a contrast with the natural environment. The other elements of the development, particularly the access road and sewage lagoons, will be partially visible to the visitor boating in the canyons on either side of Dangling Rope.

i. History/Archaeology. Archaeological investigations have been undertaken at Dangling Rope. A number of sites were discovered at Dangling Rope however, these sites were determined to be ineligible for inclusion on the National Register. They were scientifically removed by professional archeologists, the data recovered was studied, and a report on the findings is available. (Weber, 1977)

j. Regional Economy. The economy will be positively affected by the jobs that are created during construction of the development. Relocation of the concession facilities from the immediate vicinity of Rainbow Bridge National Monument will have little affect on the visitation rate to the boat service facility.

k. Visitation. Visitation to Rainbow Bridge National Monument and Rainbow Marina would be negatively affected by a temporary suspension of services during the relocation of the boat service facility. Relocation of the boat service facility is not expected to cause visitation to decline at Rainbow Bridge National Monument. However, movement to Dangling Rope may cause a decline in visitation to the boat service facility.
See "Environmental Factors", page 58 for a summary of the impacts of the three alternative design plans for relocation of Rainbow Marina to a shore-based facility at Dangling Rope Canyon. Shaded portions of the chart indicate unavoidable adverse impacts.

See "Other Factors", page 60 for a summary of design considerations for development of a shore-based facility at Dangling Rope Canyon.

3. Mitigating Measures Included in the Proposed Action

a. Topography/Geology/Soils. During construction, measures to stabilize the excavated and exposed soils will be taken in order to minimize man-made erosion. Exposed soils will be watered or compacted to control dust and blowing sand. Soil and rock will be stockpiled in protected locations that are least susceptible to wind and water erosion.

Construction vehicles will only be allowed in the immediate vicinity of construction sites to minimize disturbance of surrounding land and compaction of soils.

Specific design of facilities and roadways will follow contours where possible, avoid excess cut and fill, minimize grading, and avoid any potentially unstable areas or drainages where slopes are steep.

b. Air Quality/Noise. Noise problems will be minimized by separating the noise generators from the living areas the greatest distance possible. Airborne particles will be minimized by the construction techniques discussed in Part a, "above".
carefully designed in order to prevent spills which could contribute to a decline in water quality. The fuel storage tanks for the marina will be located on a level area of land northwest of the boat service facility. This location will minimize the length of the fuel lines between the storage tanks and the floating fuel dock. EPA Fuel Storage Standards and Spill Prevention Plan requirements will be adhered to as appropriate for the volume of fuel stored.

d. Vegetation. Paths and utility lines will be located in a single corridor to minimize disruption. The STOL air strip will also serve as a portion of the access road to further eliminate excessive construction. When possible, all land circulation will be concentrated to minimize trampling of vegetation in the area.

e. History/Archaeology. Although no significant sites are known to exist, should resources be uncovered during construction, the project will be halted pending evaluation of the resource according to National Park Service operation procedures.

f. Visitation. To minimize the impact of no boat service facility in operation between Bullfrog Basin/Halls Crossing and Wahweap the relocation should occur during low visitation periods. A visitor awareness program should be instituted to make boaters aware of the shutdown of the marina and to minimize that inconvenience.

Redistribution of visitor use patterns from Rainbow Marina to Dangling Rope may improve visitor safety by taking the Marina out of the boat traffic patterns.

4. Unavoidable Adverse Effects

a. Topography. Disturbance will occur on approximately 4.0 acres of presently undisturbed lands.

b. Geology/Soils. Disturbance will occur on approximately 9.6 acres of presently undisturbed lands.
c. Air Quality. Odor problems will occur in the housing area during calm days due to the close proximity of the sewage lagoons to the housing area (650 feet).

d. Water Resources. Increased boat usage of Dangling Rope Canyon will minimally increase the contamination level of the waters. This contamination will include fuel spillage, waste and trash, and fuel exhaust which includes hydrocarbons, lead, phenols, and aldehydes.

e. Scenery/Visual Quality. The silhouetting of proposed structures against the skyline will significantly increase the visual intrusion of these elements into the open, natural environment at Dangling Rope Canyon.

5. Short-term/Long-term Relationships

The proposed development for Dangling Rope Canyon will alter the framework of an existing service facility in order to improve the serviceability and manageability of the area around Rainbow Bridge National Monument. Visitor increases, which have occurred sooner than anticipated have shown that the sewage system can no longer handle the quantity or character of the sewage loads. The loss of a service facility at Rainbow Bridge will be offset by the development at Dangling Rope which will accommodate the boating needs on this section of the reservoir.

The proposed plan is designed to provide for existing and anticipated visitation at Dangling Rope Canyon. Although implementation of this plan will require the removal of additional acres from biological productivity in order to commit them to land-based boat service facilities, the plan will provide for activities in a more manageable framework. This can improve visitor experience and limit further adverse impacts and sprawl on the land as well as the adjoining land's long-term recreational productivity.
6. Irreversible and Irretrievable Commitments of Resources

The implementation of the Dangling Rope development does not include any irreversible or irretrievable commitment of natural resources other than those lands that are required in providing for the land-based facilities. Within this framework, disturbance of the natural environment and removal of soil and vegetation to develop facilities at Dangling Rope is considered an irretrievable commitment of natural resources.

The commitment of this land to a specific use will preclude any other use for the lifespan of the project. The consumption of resources to build, operate, and maintain these facilities is an irretrievable use of materials. Construction materials used are irretrievable. Water and fuel that are used for the duration of the project are irretrievable.
D. Alternative 2 - Open Development

1. Description

The dispersed development will be on the upland bench above the proposed marina located on the leeward side of the most southerly bay of Dangling Rope Canyon. The STOL air strip will be located along the same ridge as described in Alternative 1, although it is slightly oriented to the north to provide additional area for location of the sewage lagoons along the eastern side of the upwind end of the air strip. The housing area will be located approximately 2,000 feet to the south, on a long, narrow bench at the base of a high escarpment. Housing in this area will overlook the marina facility with access to the marina via a path to the vertical circulation element. There is level land immediately to the north for outdoor recreational use.

The maintenance area will be located west of the upwind end of the air strip and will be linked to the vertical circulation element via on-site trail across relatively flat bench topography. The fuel storage area will be located on a flat bench immediately adjacent to the vertical circulation element and downwind and downstream of the marina facility. Either LCM ramp/road alignment can be utilized with this alternative. All proposed development will be outside of major drainage channels except the vertical circulation element (See Alternative 2 - Open Development, page 42).

2. Impacts of the Proposed Action

a. Topography. The topography of the site will be altered to accommodate the sewage lagoons and the STOL air strip. The existing transverse ground slope across the air strip/lagoon site is six percent. Development of the
ALTERNATIVE 2
OPEN DEVELOPMENT
DANGLING ROPE
GLEN CANYON NATIONAL RECREATION AREA
united states department of the interior/national park service
500 40,128
600 70,700
42
lagoons will require extensive cutting of the ridge upon which the STOL air strip is located (a minimum of 50 feet horizontal clearance between the air strip and the sewage lagoons is to be maintained). The downhill bank of the lagoons will require increased amount of fill material thereby requiring use of a membrane liner. The total amount of topographic disturbance will be 4.0 acres.

Subsurface topography is adequate for marina location and anchorage. Fluctuations of water level will require minimal lateral movement of the marina.

b. Geology. Same as Alternative 1, page 34. Total amount of disturbance will be 10.1 acres.

c. Soils. Same as Alternative 1, page 34. Total amount of soil disturbance will be 10.1 acres.

d. Air Quality/Noise. Same as Alternative 1, page 34, except that odors in the housing area from the sewage lagoons will not be a problem because of the distance between these areas (2,000 feet).

e. Water Resources. Same as Alternative 1, page 35. The surface area of water in this southerly bay of Dangling Rope Canyon will be sufficient to accommodate the anticipated amount of boat traffic to the marina.

f. Vegetation. Same as Alternative 1, page 35. Total amount of disturbance to the Northern Desert Shrub Association will be 10.1 acres.

g. Wildlife. Same as Alternative 1, page 35.

h. Scenery/Visual Quality. The visual quality of the area will be adversely affected by the visibility of the housing development from the main
channel of Lake Powell (as viewed from the east). However, the extent of this impact will be substantially reduced because of the natural backdrop provided by the adjacent escarpment. This escarpment precludes the visual problem of silhouetting structural elements against the skyline. The other elements of this plan will be partially visible to boaters in the waters on either side of Dangling Rope.

i. History/Archaeology. Same as Alternative 1, page 36.

j. Regional Economy. Same as Alternative 1, page 36.

k. Visitation. Same as Alternative 1, page 36.

See "Environmental Factors", page 58, for a summary of the impacts of the three alternative design plans for relocation of Rainbow Bridge Marina to a shore-based facility at Dangling Rope Canyon. Shaded portions of the chart indicate unavoidable adverse impacts.

See "Other Factors", page 60, for a summary of design considerations for development of a shore-based facility at Dangling Rope Canyon.

3. Mitigating Measures Included in the Proposed Action

a. Topography/Geology/Soils. Same as Alternative 1, page 37.

b. Air Quality/Noise. Same as Alternative 1, page 37.

c. Water Resources. Same as Alternative 1, page 38.

d. Vegetation. Same as Alternative 1, page 38.

e. History/Archaeology. Same as Alternative 1, page 38.

f. Visitation. Same as Alternative 1, page 38.
4. Unavoidable Adverse Affects
   a. Topography. Disturbance will occur on approximately 4.0 acres of presently undisturbed lands.
   b. Geology/Soils. Disturbance will occur on approximately 10.1 acres of presently undisturbed lands.
   c. Water Resources. Increased boat usage of Dangling Rope Canyon will minimally increase the contamination level of the waters. This contamination will include fuel spillage, waste and trash, and fuel exhaust which includes hydro-carbons, lead, phenols, and aldehydes.

5. Short-term/Long-term Relationships
   Same as Alternative 1, page 39.

6. Irreversible and Irretrievable Commitments of Resources
   Same as Alternative 1, page 40.
E. Alternative 3 - Concentrated North Development

1. Description

Development will be concentrated on the upland bench above the proposed marina located on the leeward side of the most northerly bay of Dangling Rope Canyon. The STOL air strip will be located as described in Alternative 1. The sewage lagoons will be located on relatively flat lands along the western side of this ridge at the downwind end of the air strip. The housing area will be located on the eastern side of this ridge on a long, narrow irregularly shaped site south of the lagoons. This location utilizes the ridge line to obscure views of the lagoons from the housing area. Approximately 200 feet clearance is maintained between the housing and the center line of the air strip. Residents will have direct physical access to and visual contact with the marina facility. There is level land immediately to the south for outdoor recreational use.

The maintenance area will be located west of the upwind end of the air strip (same as Alternative 2) and will be linked to the marina via use of the LCM ramp/road which functions also as the vertical circulation element in this alternative. The fuel storage area is located on a small, flat bench northeast of the housing area and downwind and downstream of the marina. LCM ramp/road "B" only can be utilized with this alternative. All proposed development is outside of major drainage channels except the LCM ramp/road (See Alternative 3 - Concentrated North Development, page 47).

2. Impacts of the Proposed Action

a. Topography. The topography of the site will be altered to accommodate the sewage lagoons and the STOL air strip. The existing transverse ground
ALTERNATIVE 3
CONCENTRATED NORTH DEVELOPMENT
DANGLING ROPE
GLEN CANYON NATIONAL RECREATION AREA
united states department of the interior/national park service
slope across the air strip/lagoon site is four percent. Development of the lagoons will require moderate to extensive cutting of the ridge upon which the air strip is located (a minimum of 50 feet horizontal clearance between the air strip and the sewage lagoons is to be maintained). The downhill bank of the lagoons will require extensive fill material thereby requiring use of a membrane liner. The total amount of topographic disturbance will be 4.0 acres.

Subsurface topography is marginal for marina location and anchorage. Fluctuations of water level will require extensive lateral movement of the marina.

b. Geology. Same as Alternative 1, page 34. The total amount of geologic disturbance will be 9.5 acres.

c. Soils. Same as Alternative 1, page 34. The total amount of soil disturbance will be 9.5 acres.

d. Air Quality/Noise. Same as Alternative 1, page 34. During calm days, potential odors from the sewage lagoons could be a problem in the housing area which is located approximately 450 feet to the south on the other side of the central ridge.

e. Water Resources. Same as Alternative 1, page 35. The surface area of water in this northerly bay of Dangling Rope Canyon will be insufficient to accommodate the anticipated amount of boat traffic to the marina.

f. Vegetation. Same as Alternative 1, page 35. The total amount of disturbance to the Northern Desert Shrub Association will be 9.5 acres.
g. Wildlife. Same as Alternative 1, page 35.

h. Scenery/Visual Quality. The visual quality of the area will be adversely affected by the visibility of the development from the small canyons on either side of Dangling Rope. The housing development will be silhouetted against the skyline, forming a contrast with the natural environment. The extent of this impact will be somewhat reduced because of the location of the development at the northern end of Dangling Rope Canyon which will minimize the visibility of main channel of the reservoir.

i. History/Archaeology. Same as Alternative 1, page 36.

j. Regional Economy. Same as Alternative 1, page 36.

k. Visitation. Same as Alternative 1, page 36.

See "Environmental Factors", page 58 for a summary of the impacts of the three alternative design plans for relocation of Rainbow Bridge Marina to a shore-based facility at Dangling Rope Canyon. Shaded portions of the chart indicate unavoidable adverse impacts.

See "Other Factors", page 60, for a summary of design considerations for development of a shore-based facility at Dangling Rope Canyon.

3. Mitigating Measures Included in the Proposed Action

Mitigating measures are the same as those listed for Alternative 1, page 37.

4. Unavoidable Adverse Affects

a. Topography. Disturbance will occur on approximately 4.0 acres
of presently undisturbed lands.

b. Geology/Soils. Disturbance will occur on approximately 9.5 acres of presently undisturbed lands.

c. Air Quality. Odor problems will occur in the housing area during calm days due to the close proximity of the sewage lagoons to the housing area (450 feet).

d. Water Resources. Increased boat usage of Dangling Rope Canyon will minimally increase the contamination level of the waters. This contamination will include fuel spillage, waste and trash, and fuel exhaust which includes hydrocarbons, lead, phenol, and aldehydes.

e. Scenery/Visual Quality. The silhouetting of proposed structures against the skyline will increase the visual intrusion of these elements into the open, natural environment at Dangling Rope Canyon.

5. Short-term/Long-term Relationships

Same as Alternative 1, page 39

6. Irreversible and Irretrievable Commitments of Resources

Same as Alternative 1, page 40.
F. Alternative 4 - Linear Development

1. Description

Development will extend along the entire length of the bench above the proposed marina which is located on the leeward side of the most southerly bay at Dangling Rope Canyon. The STOL air strip will be located as described in Alternative 1. The sewage lagoons will be located on relatively flat lands along the western side of this ridge at the downwind end of the air strip with room for future expansion to the north or the south. The housing area will be located approximately 2,500 feet to the south, on a long, narrow bench to the west of a high escarpment. Housing in this area will overlook the main channel of the reservoir. Residents will have direct physical access to the marina. There is level land to the north for outdoor recreational use.

The maintenance area will be located north of the housing area just off the south east edge of the STOL air strip. The maintenance area will be linked to the vertical circulation element via on-site trail across relatively flat bench topography. The fuel storage area will be located on a flat area on the west side of the bench. LCM ramp/road is located north of the other LCM alignments. A gravity water tank will be seperated from maintenance yard and located north of the STOL air strip on a flat bench. All proposed development will be outside of major drainage channels (see Alternative 4 Linear development page 52).

2. Impacts of the Proposed Action

a. Topography. The topography of the site will be altered to accomodate the sewage lagoons and the STOL air strip. The existing traverse ground slope across the air strip lagoon site is four percent. Development of the lagoons will require moderate to extensive cutting of the ridge upon which the air strip is located (a minimum of 50 feet horizontal clearance between the air strip and the sewage lagoons is to be maintained). The downhill bank of the lagoons will require
ALTERNATIVE 4
LINEAR DEVELOPMENT
DANGLING ROPE
GLEN CANYON NATIONAL RECREATION AREA
united states department of the interior/national park service
extensive fill material thereby requiring use of a membrane liner. The total amount of topographic disturbance will be 4.0 acres.

Subsurface topography is adequate for marina location and anchorage. Fluctuations of water level will require minimal lateral movement of the marina.

b. Geology. Same as Alternative 1 page 34. The total amount of geologic disturbance would be raised to 11.0 acres.

c. Soils. Same as Alternative 1 page 34. Total amount of soil disturbance will be 10.5 acres.

d. Air quality/Noise. Same as alternative 1 page 34 except that odors in the housing area from the sewage lagoons will not be a problem because of the distance between these areas (2,500 feet).

e. Water Resources. Same as Alternative 2 page 43.

f. Vegetation. Same as Alternative 1 page 35. Total amount of disturbance to the Northern Desert Shrub Association will be 11.0 acres.

g. Wildlife. Same as Alternative 1 page 35.

h. Scenery/Visual Quality. The visual quality of the area will be adversely affected by the visibility of the housing development from the main channel of Lake Powell (as viewed from the west). However, the extent of this impact will be substantially reduced because of the natural backdrop provided by the adjacent escarpment. This escarpment precludes the visual problem of silhouetting structural elements against the skyline. The other elements of this plan will be partially visible to boaters in the waters on either side of Dangling Rope.
i. History/Archaeology. Same as Alternative 1 page 36.

j. Regional Economy. Same as Alternative 1 page 36.

k. Visitation. Same as Alternative 1 page 36

See environmental factors, page 59 for a summary of the impacts of the four alternative design plans for relocation of Rainbow Marina to a shore-based facility at Dangling Rope Canyon. Shaded portions of the chart indicate unavoidable adverse impacts.

See "other factors", page 61 for a summary of design considerations for development of a shore-based facility at Dangling Rope Canyon.

3. Mitigating Measures Included in the Proposed Action

a. Topography/Geology/Soils. Same as Alternative 1 page 37.

b. Air Quality/Noise. Same as Alternative 1 page 37.

c. Water Resources. Same as Alternative 1 page 38.

d. Vegetation. Same as Alternative 1 page 38.

e. History/Archaeology. Same as Alternative 1 page 38.

f. Visitation. Same as Alternative 1 page 38.

4. Unavoidable Adverse Affects

a. Topography. Disturbance will occur on approximately 4.0 acres of presently undisturbed lands.

b. Geology/Soils. Disturbance will occur on approximately 11.0 acres of presently undisturbed lands.
c. Water Resources. Increased boat usage of Dangling Rope Canyon will minimally increase the contamination level of the waters. This contamination will include fuel spillage, waste and trash, and fuel exhaust which includes hydrocarbons, lead, phenols, and aldehydes.

5. **Short-term/Long-term Relationships**

Same as alternative 1 page 39.

6. **Irreversible and Irretrievable Commitments of Resources**

Same as Alternative 1 page 40.
G. Alternative 5 - No Action

1. Description

The no action alternative implies continued utilization of the completely water-based Rainbow Marina located in Forbidding Canyon.

2. Impacts of the Proposed Action

a. Water Resources. The present sewage treatment plant will continue to fail to meet the standards set by the State of Utah and by the U.S. Public Health Service. Unacceptable effluent will continue to be released into the waters of Lake Powell. There will be a deleterious effect on the aquatic life in the immediate vicinity of the marina. This effect will decrease in proportion to the distance from the effluent discharge into the lake.

b. Scenery/Visual Quality. An adverse visual impact is created by discharging effluent into the lake water (which contain nitrogen and phosphorus as well as high coliform densities). Excessive nutrients tend to cause algal blooms under certain conditions and visual evidence of waste water disposal (slicks, scums, and foams).

c. Wildlife. There will be unknown effects on aquatic life due to degradation of water quality in the vicinity of the marina.

d. Visitation. Increased visitation of Rainbow Bridge National Monument and the marina will create congestion in narrow, winding Forbidding Canyon.

See "Environmental Factors", page 59, for a summary of the impacts of the alternative to retain the Rainbow Marina. Shaded portions of the chart indicate unavoidable adverse impacts.
See "Other Factors", page 61 for a summary of design considerations of continued utilization of the Rainbow Bridge Marina.

3. **Mitigating Measures Included in the Proposed Action**

With no action taken to improve or alter the existing situation, closer monitoring of the sewage treatment plant would enable the operator to determine the time for maintenance or regulation of the "dumping" to allow the system to operate as efficiently as is presently possible.

4. **Unavoidable Adverse Affects**

In the present location, there is no opportunity to convert to a zero discharge system. The canyon walls which surround the marina are nearly vertical rising 80 feet from the water. The adjacent bench areas are located outside the boundaries of the Glen Canyon National Recreation Area on Navajo tribal land.

5. **Short-term/Long-term Relationships**

None

6. **Irreversible and Irretrievable Commitments of Resources**

None
<table>
<thead>
<tr>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrated development on the upland bench above a proposed marina located on the central bay of Dangling Rope Canyon.</td>
<td>Open, dispersed development on the upland bench above a proposed marina located on the most southerly bay of Dangling Rope Canyon.</td>
<td>Concentrated development on the upland bench above a proposed marina located on the most northerly bay of Dangling Rope Canyon.</td>
</tr>
<tr>
<td>Approximately 4.0 acres of slope modification to the topography of the upland bench from construction of sewage lagoons and STOL air strip.</td>
<td>Approximately 4.0 acres of slope modification to the topography of the upland bench from construction of sewage lagoons and STOL air strip.</td>
<td>Approximately 4.0 acres of slope modification to the topography of the upland bench from construction of sewage lagoons and STOL air strip.</td>
</tr>
<tr>
<td>Careful construction techniques and site restoration can help minimize damage.</td>
<td>Careful construction techniques and site restoration can help minimize damage.</td>
<td>Careful construction techniques and site restoration can help minimize damage.</td>
</tr>
<tr>
<td>Approximately 9.6 acres of local disturbance from construction of all shore-based facilities.</td>
<td>Approximately 10.1 acres of local disturbance from construction of all shore-based facilities.</td>
<td>Approximately 9.5 acres of local disturbance from construction of all shore-based facilities.</td>
</tr>
<tr>
<td>None.</td>
<td>None.</td>
<td>None.</td>
</tr>
<tr>
<td>None required.</td>
<td>None required.</td>
<td>None required.</td>
</tr>
<tr>
<td>Odor in housing area from sewage lagoons. Dust problems at all disturbed areas.</td>
<td>There will be local dust problems at all disturbed areas.</td>
<td>- Odor in housing area from sewage lagoons. - Noise in housing area from electric generators. - Dust problems in disturbed areas.</td>
</tr>
<tr>
<td>Odor can be minimized by locating housing further from sewage lagoons. Dust can be minimized by construction techniques.</td>
<td>Odor/noise can be minimized by locating housing further from impact generators. Dust can be minimized by construction techniques.</td>
<td>Odor/noise can be minimized by locating housing further from impact generators. Dust can be minimized by construction techniques.</td>
</tr>
<tr>
<td>Petroleum/litter contamination of canyon waters. Temporary increase in turbidity during construction.</td>
<td>Petroleum/litter contamination of canyon waters. Temporary increase in turbidity during construction.</td>
<td>Petroleum/litter contamination of canyon waters. Temporary increase in turbidity during construction.</td>
</tr>
<tr>
<td>Contamination/turbidity can be minimized by careful operating and construction techniques.</td>
<td>Contamination/turbidity can be minimized by careful operating and construction techniques.</td>
<td>Contamination/turbidity can be minimized by careful operating and construction techniques.</td>
</tr>
<tr>
<td>Approximately 9.6 acres of Northern Desert Shrub Association will be disturbed. Damage can be minimized by careful construction techniques.</td>
<td>Approximately 10.1 acres of Northern Desert Shrub Association will be disturbed. Damage can be minimized by careful construction techniques.</td>
<td>Approximately 9.5 acres of Northern Desert Shrub Association will be disturbed. Damage can be minimized by careful construction techniques.</td>
</tr>
<tr>
<td>ENVIRONMENTAL FACTORS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td></td>
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<tr>
<td>Notes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indicates unavoidable adverse impact. See text for discussion.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impact</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy</td>
<td>Mitigation</td>
</tr>
<tr>
<td>Visitation</td>
<td>Mitigation</td>
</tr>
<tr>
<td>Regional</td>
<td>Mitigation</td>
</tr>
<tr>
<td>Archaeology</td>
<td>Mitigation</td>
</tr>
<tr>
<td>History</td>
<td>Mitigation</td>
</tr>
<tr>
<td>Quality</td>
<td>Mitigation</td>
</tr>
<tr>
<td>Scenery/Visual</td>
<td>Mitigation</td>
</tr>
<tr>
<td>Wildlife</td>
<td>Mitigation</td>
</tr>
<tr>
<td>Resources</td>
<td>Mitigation</td>
</tr>
<tr>
<td>Socioeconomic</td>
<td>Mitigation</td>
</tr>
<tr>
<td>Cultural</td>
<td>Mitigation</td>
</tr>
</tbody>
</table>

Notes:
- Indicates unavoidable adverse impact. See text for discussion.
<table>
<thead>
<tr>
<th>Alternative 4</th>
<th>Alternative 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open dispersed development on the upland bench above a proposed marina located on the most southerly bay of Dangling Rope Canyon.</td>
<td>No action.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography</td>
<td>Geology</td>
</tr>
<tr>
<td>Soils</td>
<td>Climate</td>
</tr>
<tr>
<td>Air Quality/Noise</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximately 4.0 acres of slope modification to the topography of the upland bench from construction of sewage lagoons and STOL air strip.</td>
<td>None.</td>
</tr>
<tr>
<td>Careful construction techniques and site restoration can help minimize damage.</td>
<td>None required.</td>
</tr>
<tr>
<td>Approximately 11.0 acres of local disturbance from construction of all shore based facilities.</td>
<td>None.</td>
</tr>
<tr>
<td>Careful construction techniques can help minimize damage.</td>
<td>None required.</td>
</tr>
<tr>
<td>Approximately 11.0 acres of disturbance creating increased opportunity for wind and water erosion.</td>
<td>None.</td>
</tr>
<tr>
<td>Careful construction techniques can help minimize damage.</td>
<td>None required.</td>
</tr>
<tr>
<td>None.</td>
<td>None.</td>
</tr>
<tr>
<td>None required.</td>
<td>None required.</td>
</tr>
<tr>
<td>There will be local dust problems at all disturbed areas.</td>
<td>None.</td>
</tr>
<tr>
<td>Dust can be minimized by careful construction techniques.</td>
<td>None required.</td>
</tr>
<tr>
<td>ENVIRONMENTAL FACTORS</td>
<td>Notes: Indicates unavoidable adverse impacts. See text for</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Water Resources</strong></td>
<td></td>
</tr>
<tr>
<td>Contamination/turbidity can be minimized by careful operating and construction techniques.</td>
<td>Contamination can be minimized by conversion to zero discharge of treated wastes and by careful operating techniques.</td>
</tr>
<tr>
<td>Approximately 11.0 acres of northern desert shrub association will be disturbed.</td>
<td>None.</td>
</tr>
<tr>
<td>Damage can be minimized by careful construction techniques.</td>
<td>None required.</td>
</tr>
<tr>
<td>There will be unknown effects on wildlife due to construction.</td>
<td>There will be unknown effects on aquatic life due to degradation of water quality.</td>
</tr>
<tr>
<td>Not applicable.</td>
<td>None.</td>
</tr>
<tr>
<td>There will be visual intrusion where vertical circulation traverses steep cliffs.</td>
<td>Algal growth and visual evidence of waste water disposal.</td>
</tr>
<tr>
<td>Careful siting can minimize visual impact of development.</td>
<td>None required.</td>
</tr>
<tr>
<td>None expected.</td>
<td>None.</td>
</tr>
<tr>
<td>Should resources be uncovered during construction, the project will be halted pending evaluation of the resources according to NPS operating procedures.</td>
<td>None required.</td>
</tr>
<tr>
<td>Short-term effect due to jobs created by the construction of facilities.</td>
<td>None.</td>
</tr>
<tr>
<td>None required.</td>
<td>None required.</td>
</tr>
<tr>
<td>Temporary disruption of boat services during relocation. Unknown reduction in visitation due to location away from Rainbow Bridge Nat’l. Monument.</td>
<td>Increased visitation to marina and Rainbow Bridge to create congestion in narrow Forbidding Canyon.</td>
</tr>
<tr>
<td>Relocate boat service facility during off peak time with visitor awareness program.</td>
<td>None.</td>
</tr>
<tr>
<td>None.</td>
<td>None.</td>
</tr>
</tbody>
</table>

**Vegetation**

None required.

**Wildlife**

None.

**Scenery/Visual Quality**

None.

**History/Archaeology**

None required.

**Regional Economy**

None.

**Visitation**

None required.
<table>
<thead>
<tr>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrated development on the upland bench above a proposed marina located on the most southerly bay of Dangling Rope Canyon.</td>
<td>Open, dispersed development on the upland bench above a proposed marina located on the most southerly bay of Dangling Rope Canyon.</td>
<td>Concentrated development on the upland bench above a proposed marina located on the most southerly bay of Dangling Rope Canyon.</td>
</tr>
</tbody>
</table>

- Maximum sun exposure at all times, sufficient water area for boat traffic at all times, below-surface topography optimal for marina location/anchorage. Location requires 1.0 miles of wakeless speed area.  
- Sun exposure limited during certain times of each day, sufficient water area for boat traffic at all times, below-surface topography adequate for marina location/anchorance. Location requires .75 miles of wakeless speed area.  
- Sun exposure during all times, water area for boat traffic limited (especially at low-water), below-surface topography marginal for marina location/anchorage. Location requires 1.1 miles of wakeless speed area.  

- Direct surveillance of visitor traffic to Rainbow Bridge National Monument no longer possible. No on site historical/archaeological resources affected.  
- Direct surveillance of visitor traffic to Rainbow Bridge National Monument no longer possible. No on site historical/archaeological resources affected.  
- Direct surveillance of visitor traffic to Rainbow Bridge National Monument no longer possible. No on site historical/archaeological resources affected.  

- Location 7 miles southwest of Rainbow Bridge National Monument may impact number of visitors to marina.  
- Location 7 miles southwest of Rainbow Bridge National Monument may impact number of visitors to marina.  
- Location 7 miles southwest of Rainbow Bridge National Monument may impact number of visitors to marina.  

- Moderate compatibility. Fuel storage in area where construction will be difficult, sewage lagoons moderately difficult to construct, housing in optimal location for clustering with minimal site impacts.  
- Uses are compatible with designated locations, however utilities and main on-site circulation trail/road crosses the narrow ridge area where construction will be more difficult. Housing location minimizes cluster opportunity.  
- Low compatibility. Steep land in this area increases site impacts from construction of housing, sewage lagoons and on-site trails/road.  

- Maintenance area convenient to marina. Housing not 1,000 feet from sewage lagoons. Proximity of housing requires location of generators outside maintenance area. Good opportunity to consolidate utility chase to marina with vertical circulation element.  
- Maintenance area not convenient to marina. Fuel storage location may hinder vertical circulation access in case of fire. Good opportunity to consolidate utility chase to marina with vertical circulation element.  
- Maintenance area not convenient to marina. Housing less than 1,000 feet from sewage lagoons and less than 1,200 feet from fuel storage area. Proximity of housing requires location of generators outside maintenance area. Consolidation of vertical circulation element and ICM ramp/road.  

- Concentrated development provides optimal efficiencies in utility development and site maintenance.  
- Open, dispersed development significantly adds to the complexity of utility development and site maintenance.  
- Concentrated development does not provide for efficiencies of utility development and site maintenance.  

**Natural Resource Factors**  
**Cultural Resource Factors**  
**Socioeconomic Compatibility Factors**  
**Design Considerations**
Direct surveillance of visitor traffic to Rainbow Bridge National Monument no longer possible. No on site historical/archaeological resources affected.

Location 7 miles southwest of Rainbow Bridge National Monument may impact number of visitors to marina.

Moderate compatibility. Fuel storage in area where construction will be difficult, sewage lagoons moderately difficult to construct, housing in optimal location for clustering with minimal site impacts.

Maintenance area convenient to marina. Housing not 1,000 feet from sewage lagoons. Proximity of housing requires location of generators outside maintenance area. Good opportunity to consolidate utility chase to marina with vertical circulation element.

Concentrated development provides optimal efficiencies in utility development and site maintenance.

2-200 and 1-100 KW diesel engine electric generators

Optimum opportunity for alternative energy sources (wind, solar).

Total cost $ 4,176,000

Unknown.

Site Utilities $ 760,000
Verticle Circ./Util. Chase 280,000
Marina Development 422,000
Shop/Maintenance Bldgs. 535,000
On Site Trails 11,000
STOL Air Strip 112,000
Housing 1,830,000
Relocation Rainbow Marina 100,000
TOTAL $ 4,176,000

Notes: 1. All prices are 1978 estimated cost
2. Either LCM ramp/road can be utilized with Alternative 1 and 2.
<table>
<thead>
<tr>
<th>Alternative 4</th>
<th>Alternative 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open dispersed development on the upland bench above a proposed marina located on the most southerly bay at Dangling Rope Canyon.</td>
<td>No action</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Natural Resource Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun exposure on marina limited during certain times of each day, sufficient water area for boat traffic at all times, below surface topography adequate for marina location anchorage. Location requires .75 miles of wakeless speed area. Location maximizes solar possibilities.</td>
</tr>
<tr>
<td>Lack of sun exposure creates undesirable work environment. Condition of marina has deteriorated from wind and wave action. Adjacent topography restricts access to shore.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultural Resource Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct surveillance of visitor traffic to Rainbow Bridge National Monument. No on-site historical/archaeological resources affected.</td>
</tr>
<tr>
<td>Ideally located with respect to access to Rainbow Bridge National Monument. Adjacent Navajo Indian Lands preclude development of shore-based facilities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Socioeconomic Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location 7 miles southwest of Rainbow Bridge National Monument may impact number of visitors to marina.</td>
</tr>
<tr>
<td>Location close to midpoint of Lake Powell between Wahweap and Bullfrog Basin/Halls Crossing and adjacent to Rainbow Bridge National Monument optimum for ease of visitor access and concession operation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Functional Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses are compatible with designated locations, however, utilities and main on-site circulation trail/road crosses the narrow ridge area where construction will be more difficult. Housing location minimizes cluster opportunities.</td>
</tr>
<tr>
<td>No applicable.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Utility/Maintenance Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance area not convenient to marina. Fuel storage location opposite of marina will facilitate fuel transfer during marina operation. Good opportunity to consolidate utility chase to marina with vertical circulation element.</td>
</tr>
<tr>
<td>Location of floating fuel storage tanks could prevent evacuation of marina area in case of fire.</td>
</tr>
</tbody>
</table>

| Open dispersed development significantly adds to the development and site maintenance. |
| Complexity of maintenance and operations would increase with growing numbers of visitors to the marina. |
2-200 and 1-100 KW diesel engine electric generators.

Excellent opportunity for alternative energy sources (wind, solar).

| Total Cost       | $ 4,404,000
total cost:     |         |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown.</td>
<td>Not applicable.</td>
</tr>
<tr>
<td>Site Utilities</td>
<td>$ 940,000</td>
</tr>
<tr>
<td>Vertical Circ./Util. Chase</td>
<td>280,000</td>
</tr>
<tr>
<td>Marina Development</td>
<td>422,000</td>
</tr>
<tr>
<td>Shop/Maintenance Bldgs.</td>
<td>535,000</td>
</tr>
<tr>
<td>On Site Trails</td>
<td>35,000</td>
</tr>
<tr>
<td>LCM Launch Ramp/Road</td>
<td>150,000</td>
</tr>
<tr>
<td>STOL Air Strip</td>
<td>112,000</td>
</tr>
<tr>
<td>Housing</td>
<td>1,830,000</td>
</tr>
<tr>
<td>Relocation Rainbow Marina</td>
<td>100,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$ 4,404,000</strong></td>
</tr>
</tbody>
</table>

**Notes**

1. All prices are 1978 estimated cost.
CONSULTATION AND COORDINATION WITH OTHERS

During the preparation of this assessment of the relocation of the Rainbow Bridge Marina to a shore-based facility, various groups and agencies were consulted. A list of these groups and agencies and their contributions are as follows:

National Park Service (Denver Service Center) - Supplied data on the existing Rainbow Bridge Marina and on the various alternative development sites in Glen Canyon National Recreation Area.

National Park Service (Glen Canyon National Recreation Area) - Supplied data on the existing Rainbow Bridge Marina operations and anticipated future needs of a shore-based facility.

Del E. Webb Corporation (Concessioner) - Supplied data on existing concessions operation at Rainbow Bridge Marina and projected the future concessioner needs of a shore-based facility.

United States Department of Commerce - Supplied solar information.
V. REFERENCES SITED

CRAMPTON, C. GREGORY


POPE, EVANS AND ROBBINS INCORPORATED
Study of existing problems and expected developments over the next ten years. For U. S. Department of the Interior, National Park Service, 1972.

SCHROEDL, ALAN R.
Archeological Survey of the Dangling Rope Area, Department of Anthropology, University of Utah manuscript, a report submitted to the National Park Service, Midwest Archeological Center, Lincoln, Nebraska, October, 1976.

UNITED STATES DEPARTMENT OF THE INTERIOR, NATIONAL PARK SERVICE, General Management Plan, Wilderness Proposal, Road Study Alternatives and Draft Environmental Statement - Glen Canyon National Recreation Area, Volumes 1, 2, 3 and 4, 1977.


UNITED STATES DEPARTMENT OF THE INTERIOR, NATIONAL PARK SERVICE, Environmental Assessment, Sewage Treatment Plant, Rainbow Bridge Marina, Glen Canyon National Recreation Area.


WEDER, DENNIS G.
Analysis of the lithic remains from Lake, Moqui and Gypsum Canyons and the Dangling Rope Area, Glen Canyon National Recreation Area, National Park Service, Midwest Archeological Center, Lincoln, Nebraska, 1977.
APPENDICES

Appendix A - Engineering Assessment of Alternative Design Plans
(Sellards and Grigg, Inc., 1978).

Appendix B - Archaeology of the Dangling Rope Area: A Brief Summary
(Schroedl, 1976).

Appendix C - Engineers response to N. P. S. comments and Assessment
of Alternative 4 Linear Development. Sellards & Grigg, Inc., 1978

Appendix D - Below Water Investigation of Alternative Marina
Location

Appendix E - Glen Canyon National Recreation Area Solar Data
APPENDIX A

Engineering Assessment of Alternative Design Plans
(Sellards and Grigg, Inc., 1978)
February 1, 1978

Mr. Larry W. Gibson  
P.E. Flores & Assoc.  
110 Garfield Street  
Denver, Colorado  80206

Re: Dangling Rope Boat Service Facility  
S & G No. 77014-41

Dear Mr. Gibson:

We have prepared brief comments regarding engineering aspects of various portions of the project. The main goals were to identify preliminary quantities for sizing and to define the relationships between various utility systems and the land based housing.

The following list provides the titles of the Sections transmitted to you with this letter.

Sewer Systems  
Sewage Treatment Facility  
Water Supply System  
Electrical Power Generation  
LCM/Supplies Access Road  
Vertical Circulation System  
Fuel Storage and Handling  
Summary of Impacts and Preliminary Costs for Utility Schemes

Please call if you have any questions or require any additional information for the level of planning that is being done on this phase of the contract.

Very truly yours,
SELLARDS & GRIGG, INC.

Thomas A. Young, P.E.

TAY:is
Sewage Treatment Facility

The data used in sizing the proposed sewage treatment facility at Dangling Rope are based on the extensive amount of data available from the existing Rainbow Marina. This data revealed the following information from November 1, 1976 to October 31, 1977.

**Existing Conditions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Annual Effluent Treated</td>
<td>883,210 gals.</td>
</tr>
<tr>
<td>Average Day</td>
<td>2,420 gals.</td>
</tr>
<tr>
<td>Peak Day (July 30, 1977)</td>
<td>7,550 gals.</td>
</tr>
<tr>
<td>Peak Month (June, 1977)</td>
<td>132,825 gals.</td>
</tr>
<tr>
<td>Average Day in Peak Month</td>
<td>4,428 gals.</td>
</tr>
</tbody>
</table>

The total visitation during this period to the National Recreation Area was slightly less than 2,000,000 visitors. Based on a projected 5,000,000 visitors to the area, a factor of 2.5 times existing conditions was used to determine design parameters.

**Design Conditions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Annual Effluent Treated</td>
<td>2,208,025 gals.</td>
</tr>
<tr>
<td>Average Day</td>
<td>6,050 gals.</td>
</tr>
<tr>
<td>Peak Day</td>
<td>18,875 gals.</td>
</tr>
<tr>
<td>Peak Month</td>
<td>332,065 gals.</td>
</tr>
<tr>
<td>Average Day in Peak Month</td>
<td>11,070 gals.</td>
</tr>
</tbody>
</table>

**General Design Requirements**

- Maximum B.O.D. loading (during peak month) 40 lbs./acre/day
- Minimum Number of Cells 3
- Maximum Pond Depth 6 feet
- Minimum Pond Depth 3 feet
- Evaporation rate 92"/yr x 71% = 65 inch/year
- Average Annual Precipitation 5 inch/year
- Percolation none

In the past, about 25% of the total sewage treated has come from boat pump out waste. It is assumed that as the number of house boats increase and their holding tanks increase in size, that approximately 33% of the total sewage to be treated during the design year will come from boat pump out wastes. Thus, using 300 ppm and 1000 ppm for BOD₅ of domestic and boat pump out waste, respectively, it will be determined that the BOD loading on the average day is 27 pounds per day. The average day in the peak month will then have a BOD loading of 49 pounds per day.
Based on evaporation, the required pond area is 59,196 ft.\(^2\) and based on BOD loading, the required area is 53,905 ft.\(^2\).

Adding twenty percent as additional factor of safety, three cells with a gross water surface area of 74,000 ft.\(^2\) should be provided. Three square cells, each 160 feet on a side, will provide 76,800 ft.\(^2\). The cells will be six feet deep plus two feet of freeboard. The berms will have 3:1 side slopes inside and out. The final design of the system should consider aeration of the primary pond.

There are three potential sites for the proposed lagoons. These will be referred to as follows:

- **Site A** - Southwest location - Detailed on Alternative No. 1
- **Site B** - East location - Detailed on Alternative No. 2
- **Site C** - Northwest location - Detailed on Alternative No. 3

**Site A:**

Space is available to locate the three square ponds at this location. The land form takes a drop in this area of a little over ten feet. The average transverse ground slope is around eight percent. The site will require a lot of cut and fill. The ponds would have their downhill bank in fill. Due to this condition, all proposed lagoons should be lined with a membrane liner which would provide a positive barrier against breaching of the berm. This site would be classified as moderately difficult to work with.

The lagoons would lie right at the end of the approach for the STOL strip. The fencing and fill for the lagoon berms would be visible from the main channel of Lake Powell.

The Utah State Department of Health Code of Waste Disposal Regulations recommends that the distance between the lagoons and possible human habitation be not less than 1000 feet. The prevailing winds are also assumed to be from south to north. Therefore, Site A is: (1) too close to Site A (Alternative No. 1) housing, (2) too close and upwind to Site C (Alternative No. 3) housing, and (3) a reasonable distance from Site B (Alternative No. 2) housing.

**Site B:**

The space is available to locate the three square ponds. This site has the most uniform land slope of any area with the transverse grade of about six percent. The ponds should have a membrane liner because of the downhill side fill for berm. The berm fill and fencing would probably be visible to everyone coming into the Dangling Rope finger. This site would be classified as the easiest to work with.
The site is: (1) where housing Alternative C would be located, (2) too close to Alternative A housing, and (3) a reasonable distance from Alternative B housing.

Site C:
There is space available to locate two ponds easily here or three if a lot of material is moved. A second possibility is locate the third pond 800 feet north around elevation 3840. The ponds should have a membrane liner because of the downhill side fill for the berm. The site is in a good location for what should be the prevailing wind direction from south to north. The location visually puts the site over the ridge and out of site from the residential areas. The fencing and berm fill should be seen only from a small area on the water on the west side of the peninsula. There is good horizontal separation between the lagoons and housing area except for Alternative C housing which is immediately on the east side of the proposed air strip.

The transverse ground slopes average near 4%. This site would be classified as average difficulty to work on. If the ponds could be made to work without encroaching on the steeper ground forms towards the north end, it would be the easiest site to develop.

Recommendation
Each of the sites will work. The final selection will need to be predicated on the relationship of the lagoons to the housing area. One thousand feet should be the minimum separation when considering the location for final design.
Sewer Systems

There are two choices for the sewage collection system.
1. gravity system with lift stations, or
2. low pressure sewer system.

Both are similar in that the proposed sewage treatment areas are separated and generally at a higher elevation than the discharge points. Both systems require pumping the sewage to the treatment area. The gravity system requires sewers laid to grade, then the effluent collected at larger lift stations and pumped via a force main to the treatment areas. This would require probably three lift stations (marina, residents, and maintenance area). However, since the force main would extend from the farthest point of development to the treatment area, and in itself is a pressurized sewer, the entire system should be looked at as a low pressure sewer system.

On a low pressure sewer system, each point where sewage is generated has its own small holding tank and grinder pump which injects the sewage into the force main. Some advantages are:
1. the sewer lines follow the grade of the land
2. the flow becomes more uniform and continuous than in big slugs which happens with larger lift stations and holding tanks
3. during off season periods when the flow is less, there will still be more frequent cycles with the smaller pumps which move the solids along rather than letting them sit for extended periods
4. as modules are added to the marina for boat pump out, they can have their own individual holding tanks and pump system.

The disadvantages are:
1. there are more mechanical units to maintain (however, malfunction affects fewer people than with large lift stations)
2. there is more potential problem from grease buildup within the smaller sized lines (however, when design velocities are kept between 2 fps and 5 fps, excessive accumulations can be prevented)

Low pressure sewer lines can be laid at the same depth as the water distribution lines. This is, just below frost depth. At Dangling Rope, the required bury depth would probably be 2.5 feet to 3.0 feet. Considering the sandstone formation, excavation will be considerably more simple if depths of excavation can be minimized. The sewer lines can be placed on one edge of trails and the water lines can be placed at the other edge with at least ten feet between them.

Our recommendation is that a low pressure sewer system be considered for this project.
Electrical Power Generation

Based on the size and configuration of the proposed facilities, some electrical load estimates are tabulated below. These estimates were based on some simplifying assumptions. These are: (1) The land-based facilities were looked at in detail, (2) The marina load is estimated without an inventory of any existing facilities other than present generation size, (3) All dwelling units were assumed to be all-electric with the exception of space heating. Space heating of the units has been assumed to originate from central boilers, possibly fueled by #2 oil which could be the same fuel as for diesel-engine units, and located within the centralized maintenance facility. (4) Estimated loads include provision at dwelling units for air conditioning, electric hot water heating, electric cooking and clothes drying.

The loads were evaluated in terms of three basic usage periods: the (summer) seasonal daytime loads which could be expected to represent an annual peak condition; the (summer/tourist) seasonal nighttime loads; and a non-tourist or off-season load which represents more than five months of the calendar year. In evaluating the load entities, it was assumed that some of the loads could be deferred until nighttime off-peak hours with prudent operation of the equipment and adequate storage facilities. Examples include deferral of such operations as domestic (well) water pumping, fuel transfer, charging of battery-operated transportation vehicles, domestic hot water heating, and a portion or all of the ice-making.

Thus, the preliminary estimate of the electrical loads is as follows:
<table>
<thead>
<tr>
<th>Load Entity</th>
<th>Summer</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daytime</td>
<td>Nighttime</td>
<td>Off-Season</td>
</tr>
<tr>
<td>6 - Apartment Units for Park Service Employees</td>
<td>48</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>6 - Motel-Type Units for Park Service Employees</td>
<td>36</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>1 - Common Cooking Facility for Motel-Type Residents</td>
<td>8</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>10 - Housing Units for Concessionaire Employees</td>
<td>80</td>
<td>40</td>
<td>--</td>
</tr>
<tr>
<td>20 - Primative Cabins for Overnight Use Only</td>
<td>30</td>
<td>15</td>
<td>--</td>
</tr>
<tr>
<td>Concessionaire Ice-Making Equipment</td>
<td>55</td>
<td>55</td>
<td>--</td>
</tr>
<tr>
<td>Sewage Treatment Facility</td>
<td>30</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Recreation Facility</td>
<td>6</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Maintenance Facility/ Central Heating Plant</td>
<td>15</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Deep Well Pump</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Security and Protective Lighting</td>
<td>--</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Transportation Vehicles Battery Charger</td>
<td>--</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Fuel Transfer Facility</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Emergency Airstrip Lighting</td>
<td>--</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Marina</td>
<td>80</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>413</td>
<td>290</td>
<td>175</td>
</tr>
<tr>
<td>Spare for Contingency - 20%</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Estimated Load</td>
<td>495</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I-vii
From the tabulated estimated loads and considering possibilities of electrical load management to exercise control over kilowatt demands, it is recommended, as a minimum, that two approximately 200 kw (or 250 kva at 0.8 Power Factor) diesel engine-generators be installed. This combination would permit operating only a single unit for off-season and/or nighttime seasonal load periods with the second unit as a standby. To serve summer daytime loads, it would be necessary to run both units without standby capacity available. The estimated cost for two units and their complete installation is $110,000 (not including any building or soundproofing).

If it is desirable to have a standby unit available for all operating modes, a third unit would be required. A second consideration would be to make the third generator one-half the size of the larger units; then during operation, it would be easier to have a combination of generators running which would more nearly approximate the demand. The three-unit installation would cost an estimated $150,000. A minimum space for housing the generators would be 18 feet by 27 feet.

Noise is a big factor in the design of the diesel units. The building housing the units should be well insulated for sound and the engines should be equipped with the best possible mufflers. Another consideration in the design is the 200 kw generators will each consume more than 15 gallons per hour of #2 diesel fuel. This will require significant sums of money for operating costs.

For these reasons, there are other sources of energy which should be considered - solar, wind, and photo-voltec. Each is in a different state of development. Since there is some period of time between this report and when the actual design will take place, additional technology will be available to assist in the final decision.

Solar energy is in a good state of the art for consideration in space heating and water heating. Since the electrical analysis did not provide for space heating, solar energy should be given strong consideration for this function. All the structures could be designed so that solar collectors would be an integral part of the design.

Wind turbine generators are practical for consideration here because of the high cost of diesel fuel. After the cost of the initial system installation, the cost of operation and maintenance would be less than for the diesel powered units. The proposed wind study for this area would give information on the amount of time the generator would operate and establish a factor of reliability for this location. It is possible that
A smaller diesel generating capability might be used as a back up to a wind system.

Another long range consideration for wind is that it may be reasonable to consider designing the entire system to operate on direct current (DC). This would eliminate the design problems associated with converting to alternating current (AC). From an esthetic point of view, the supporting towers generally need to extend at least 40 feet above the ground.

The last alternative to consider is photo-voltaic. This method is in the early stages of development and is quite expensive. Present costs are running between $21 and $28 per peak watt of output. This cost includes storage, inverters, distribution and control equipment.

For a system as is proposed here, the average power required could be assumed to be 365 kw, the average summer demand. Peak watts are equal to five times the average watts. Thus, this would yield a system with a first cost of $38,325,000. As technology increases, the Department of Energy has set the goal of reducing the cost to about 50 cents per peak watt. However, this would still have a cost of around $1,000,000 which does not seem to compete with the other options available at the present time.

Our recommendation is that diesel engine generators be considered as the primary source of electrical power with wind turbine generators receiving more consideration once wind data is available. Solar energy should be considered for heating buildings and hot water.
Water Supply System

The amount of water required for the development will be assumed to equal the peak day sewage production plus the 3,000 gallons of water for the peak day ice production by the concessionaire. Thus, the peak day water demand is about 22,000 gallons.

There are two alternatives for a water supply - reservoir water and ground water via a deep well. Using reservoir water requires treatment to meet current water quality standards. Water from a deep well should only require chlorination to meet the standards. Therefore, to reduce manpower requirements and eliminate the need for a mechanical water treatment plant, it is recommended to drill a deep well.

The minimum yield of the well is critical. With an additional 25% factor added to the above demand, the well would need to produce approximately 20 gpm to meet the needs of the peak day. The well pump should not be significantly oversized due to the limited power supply. Overdesign of motors requires the power generator equipment to be overdesigned and ultimately increases operation costs. The required water storage is also a function of the supply versus peak demand. This storage should be sized during the design phase.

The distribution system will require two separate systems - a gravity system to serve the marina and a mechanically pressurized system to serve the mesa. The latter can be done in two ways, either by constant head variable discharge pumps, or by using a hydro-neumatic tank. The hydro-neumatic tank would be the more efficient in terms of power consumption.

Providing fire protection for the development requires significant consideration. The gravity distribution system to the marina can be oversized to provide a fire flow of 200 gpm or more. However, on the mesa a fire flow of this magnitude would quickly drain the hydro-neumatic tank. If fire protection is required, the system might be supplied with a booster pump which could pump larger flows directly from the gravity storage tank into an oversized distribution system. An alternate method for developing fire protection on the marina would be to use a fire pump located on the marina which would pump reservoir water. An added benefit would be if this pump had the capacity of pumping water up to the mesa which would provide protection to both levels of the development. This is an alternative which should be reviewed in detail during the preliminary design phase.
Summary of Impacts and Preliminary Costs for Utility Schemes

General expenses which are generally applicable to all the Alternatives.

| Service                                      | Cost  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage Lagoons</td>
<td>$405,000</td>
</tr>
<tr>
<td>Well, Pumps, Chlorination, Storage</td>
<td>50,000</td>
</tr>
<tr>
<td>Utility Chase to Marina</td>
<td>80,000</td>
</tr>
<tr>
<td>Road A</td>
<td>95,000</td>
</tr>
<tr>
<td>Road B</td>
<td>50,000</td>
</tr>
<tr>
<td>Diesel Power Generation, Storage Tanks, Building, Fuel Lines</td>
<td>225,000</td>
</tr>
</tbody>
</table>

Total                                                  $905,000

It is impossible to have a good feel for what the vertical circulation system may cost. However, perhaps a $200,000 allowance could be used during this phase while developing preliminary program costs. No estimate has been made for site lighting costs.

Alternative No. 1

The site is compact. All the utilities are on top of the mesa where construction should be the easiest.

| Utility Service                          | Cost  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilities with lagoon site A</td>
<td>$80,000</td>
</tr>
<tr>
<td>Utilities with lagoon site C</td>
<td>120,000</td>
</tr>
<tr>
<td>Trails to Developed Areas</td>
<td>11,000</td>
</tr>
</tbody>
</table>

Alternative No. 2

The site is fairly spread out. All the utilities and the trail pass through the narrow ridge area where construction will be more difficult. The "sprawl" adds an estimated $100,000 to utility costs. This cost difference has to be compared with other factors relating to the total development before any decision can be reached.

| Utility Service                          | Cost  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilities with lagoon site B</td>
<td>$195,000</td>
</tr>
<tr>
<td>Utilities with lagoon site C</td>
<td>210,000</td>
</tr>
<tr>
<td>Trails to Developed Areas</td>
<td>31,000</td>
</tr>
</tbody>
</table>

Alternative No. 3

This Alternative utilizes the roads more and could potentially eliminate a mechanical vertical circulation lift. With this as the case, more money could be used in improving the road.
access to the top. Utility construction will be very difficult because of the terrain.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilities with lagoon site C &amp; housing site C</td>
<td>$120,000</td>
</tr>
<tr>
<td>Utilities with lagoon site C &amp; housing site A</td>
<td>$150,000</td>
</tr>
<tr>
<td>Trails with housing site C</td>
<td>$5,000</td>
</tr>
<tr>
<td>Trails with housing site A</td>
<td>$20,000</td>
</tr>
</tbody>
</table>
Fuel Storage and Handling

The present rainbow marina has floating fuel storage tanks. The concessionaire has 34,000 gallons of fuel for boats and the National Park Service has 4,000 gallons of diesel fuel storage for electricity generators.

Future projections for land based storage indicate the concessionaire would require about 85,000 gallons of gasoline storage and 5,000 gallons of diesel fuel. The National Park Service will require about 20,000 gallons of diesel fuel storage for the proposed generators. This supply represents slightly more than one month supply for National Park Service during peak months of consumption.

The fuel storage site requires several considerations. These include access for construction, routes for fuel lines, control of fuel spills, horizontal separation for fire safety, and location relative to the marina. A brief description of the three proposed sites and how these considerations affect them follows.

Alternative No. 1 - Site A

The access to the proposed storage site is not good for construction. The fuel lines from the tanks to the marina and diesel engine generators are over very rough ground. Fuel lines would be separate from the vertical circulation corridor. Fuel spills and fires could be channeled away from the marina.

The location could be improved by moving the site about 400 feet west and 100 feet north to a point about 200 feet off the STOL strip. Fuel lines could possibly follow the vertical circulation corridor and would be located in an area which would facilitate construction.

Alternative No. 2 - Site B

The access to the proposed storage site is good. The fuel lines would be relatively easy to construct. Fuel spills and fires could be channeled away from the marina.

Alternative No. 3 - Site C

The access is not good for construction. The site seems small without some excavation. The fuel lines would be over very rough terrain. Fuel spills and fires could be channeled away from the marina.
Recommendation

Consideration has to be given to construction and maintenance. Therefore, the recommendation is for the suggested relocation site for Alternative No. 1 or the site of Alternative No. 2. Steel storage tanks or rubber pillow storage tanks should both be considered in the next phase when fuel storage regulations will be investigated for this type of application.
LCM/Supplies Access Road

Two routes are identified on all the alternatives for access to the mesa from the reservoir water surface. Many routes were walked with these two presenting the most feasible opportunities for getting wheeled vehicles from the water to the upper level without having to totally carve the alignment out of natural sandstone.

The road surfaces should be in cut below elevation 3711. The existing sandstone would provide the finished road surface since it can be anticipated that the road would be submerged and subjected to wave action during its life time. Above elevation 3711, the road could be placed on some areas of stabilized fill if needed in the design.

Route A, the northerly serpentine alignment, is longer and could be designed with an average grade of about 10%. Below elevation 3711, the road would be required to cross an existing drainage route. This crossing would require either a bridge or rock structure which would be stable if submerged. The alignment has a series of curves with 35 foot radii. These curves would be difficult for construction vehicles hauling loads to negotiate, but should be suitable for the service vehicle traffic after all construction is completed.

Route B, the southern alignment, is shorter and a fairly direct route to the top. The average grade would be about 15% which probably would require special design of the service vehicles using it on a regular basis. This route does not have the sharp curves that are a part of Route A and would generally not require any special structures.

Neither alignment would require an excessive amount of cut or fill. Wherever possible, the existing ground surface would be used as the finished road grade. Transverse slopes of 6% would be common. Some excavation would most likely have to be done by blasting. It is anticipated that the remaining excavation would be done by ripping.
Vertical Circulation System

Access from the marina level to the top of the mesa via a mechanical means has been considered. Delivery of all the supplies and the assigned staff, park and concessionaire, will require many trips up and down the 150(±) feet each day.

The users and their loads for the mechanical lift need to be defined before the conveyance can be sized. The operators would probably be National Park Service personnel and designated concessionaire employees. Due to safety requirements, the operators would be limited to this group. The loads would probably be passengers, daily suppliers, repair parts, boat parts, small boats (?), and concessionaire ice (estimated 24,000 lbs. on peak days).

The two most probable and practical drive mechanisms for conveyances on a two to one slope would be cable drawn or cog gear on a center rail. With a cog gear drive, the motor would be mounted on the traveling unit. While with a cable drawn conveyance, the motor would be mounted in a fixed position at the top of the mesa.

The conveyances would most probably be cars mounted on either rubber tires or steel wheels. Rubber tired cars would require a guideway made of reinforced concrete. Steel wheels would best operate on steel rails. To provide the structure to support the conveyance, it would be possible to build a utility chase out of reinforced concrete which would be multi-purposed and meet the needs. The lower end of the structure would be submerged on occasion. Any exposed steel items would be subject to corrosion and would probably require replacement periodically.

Cog drive conveyances are not common in the United States. Most of these run on fixed rails with more than one car. The final design and construction of the machinery would probably be done outside the U.S.A. since this would be a fairly complicated piece of machinery.

Cable drawn conveyances fall into two categories: (1) funicular railroad with two cars and four rails, or (2) single car with hoist. Both of these are custom designs, but they are done and built in the U.S.A. The single car with hoist is a common unit used by the mining industry.

The location of the vertical circulation system is critical. Alternative No. 1 shows the system located between the marina and the maintenance area. Since most activities involving significant loads will be between these two points, this appears to be a good relationship. Alternative Nos. 2 and 3 have the maintenance area separated from the vertical circulation system and the marina area.
APPENDIX B

Archaeology of the Dangling Rope Area: A Brief Summary
(Schroedl, 1976)
APPENDIX B

Archaeology of the Dangling Rope Area: A Brief Summary

by Alan Schroedl

In 1976 the area of Dangling Rope Canyon proposed for development was intensively surveyed for the presence of archaeological remains. Six concentrations of lithic artifacts were noted, although the entire bench proposed for development appeared to have a low density of artifact scatter. These six sites (42KA1705-42KA1710) were tentatively assigned to the Archaic stage on the basis of several lines of evidence (Schroedl 1976). The Archaic period in central Utah ranges from about 6000 B.C. to approximately A.D. 200. It is a period when small groups of nomadic hunters and gatherers ranged over large areas, subsisting primarily on wild plants and animals.

The survey report (Schroedl 1976:7) recommended that several of the concentrations be tested "to ascertain the extent and depth of the cultural deposits and to determine more precisely their cultural affiliations" in order to evaluate the sites for possible inclusion on the National Register of Historic Places. It was also recommended that surface collections be made where anticipated construction would encroach upon the sites.

In 1977 a National Park Service crew of archaeologists returned to Dangling Rope Canyon to carry out these recommendations. Testing in several of the heavy surface lithic scatters yielded no subsurface evidence of occupation. It indicated that those artifact scatters were not of sufficient importance to be included on the National Register of Historic Places.
The second aspect of the field work in Dangling Rope Canyon was an intensive surface collection of the benchland area where development is proposed. Most of the 1.1 km. x .3 km. benchland was gridded into square units 50 m. on a side. Within each of the 81 grid units, an intensive surface collection procedure was instituted. Each unit was systematically crossed by several archaeologists and every observed artifact collected. This was a manageable task for two reasons: First, the number of artifacts per grid unit was not large, averaging about 140 per 50 m.² unit (2500 m.²). Second, the only identifiable artifacts were ground and chipped stone remains. No pottery, bone artifacts or organic materials were recovered. Location of the chipped stone artifacts was easy because every piece of siliceous material; that is, the chert, quartzite, jasper, etc.; was an artifact. These rock types are not found naturally on the benchland. All the chipped stone artifacts were of these "exotic" or non-local materials and they were very hard to miss.

Through this intensive, systematic procedure, both artifacts and isolated cultural features were located. One shallow hearth, one rock-filled hearth and one vertical slab-lined cist were discovered and excavated. In addition to these features, one complete milling stone and several handstones were also recovered. The complete artifact inventory includes over 11,000 individual specimens, most of which are waste flakes from the tool manufacturing process. The artifact density on the Dangling Rope benchland is approximately .06 artifacts per square meter or one artifact for every 18 m.².

The final analysis of the artifactual material from Dangling Rope is not yet complete, however, some preliminary conclusions can be advanced:
The kinds of waste flakes present indicate that the prehistoric peoples in the Dangling Rope area were exploiting Pleistocene age gravels located on the higher terraces, doing the rough shaping of cores and blanks on the spot. The cores and blanks were then carried down to the Dangling Rope bench where more prefabrication took place; the blanks were shaped into preforms. Preforms are lithic objects having a definite shape that can later be finished only into a particular tool type. The specimens from the Dangling Rope bench are primarily knife and projectile point preforms. Thus, the complete sequence of stone tool manufacture is represented by the lithic artifacts collected in Dangling Rope Canyon.

The most distinctive and diagnostic artifacts collected were the 14 projectile points. Only four specimens can be classified as arrow points, which in the Glen Canyon area are known to date after A.D. 300 or 400. The remaining specimens are large, stemmed and notched points generally associated with Archaic period occupations on the Colorado Plateau. The abundance of large points, the presence of "one-hand" handstones and the lack of pottery, are sufficient evidence to suggest that the artifactual materials and sites date from Archaic rather than Pueblo times. This interpretation is also strengthened by the presence of a deeply stratified site, Benchmark Cave, very near the mouth of Dangling Rope Canyon, which is now inundated. Although no radiocarbon dates were obtained for any of the occupation units at this site, the artifacts, particularly the projectile points, show a great deal of similarity to Archaic types. Although the original excavators assigned the lower levels to an aceramic Pueblo occupation (A.D. 700-900), it now seems more likely that the
material in Benchmark Cave is Archaic and is hundreds and perhaps even thousands of years older.

In summary, the archeological evidence overwhelmingly indicates that the Dangling Rope benchland was a stone tool manufacturing locality during Archaic times, and perhaps, as evidenced by the presence of grinding stones, the bench also served as an area for the gathering and processing of wild seeds and grasses.

Methodologically, the Dangling Rope area is significant in that it is the largest area ever to have been intensively surface collected in Utah. Although, initially, it was not known if any useful information could be derived from collecting such a large area, it is now clear that this is a valuable procedure and much significant information can be acquired. When the analysis is complete, it will provide a very detailed picture of an entire tool manufacturing sequence (Weder 1977).

It has also been demonstrated that the artifactual materials represent Archaic period occupations. Without this surface evidence, gathered through systematic collection, it would be possible only to guess about the age of the prehistoric occupation.

Finally, by undertaking the intensive surface collection not only has information and data of scholarly and academic interest been acquired, but the area has also been surveyed for future Park Service development. From the benchland virtually all of the available artifactual data have been recovered, within the limits of known archeological field methodology today; construction and development in the area can be undertaken without fear of destroying archaeological resources. It is possible,
however, that there are large, intact areas of subsurface cultural material, although this is not very likely given the topography, geology and depth of the soil on the benchland. Construction personnel should be aware of the possibility of subsurface archaeological materials and make a habit of inspecting the working area periodically for such evidence, alerting appropriate Park Service archaeologists if remains are encountered.

REFERENCES CITED

Schroedl, Alan

Weder, Dennis
APPENDIX C

Engineers response to N. P. S. comments and Assessment of Alternative 4 Linear Development
(Sellards and Grigg, Inc., 1978)
August 23, 1978

Mr. Phil Flores
Phillip E. Flores Associates
110 Garfield St.
Denver, Colorado 80206

Re: Dangling Rope Boat Service Facility
S & G No. 77014-44

Dear Mr. Flores:

This letter is to respond to some of the National Park Service comments regarding the original "Assessment of Design Alternatives" and the New Alternative 4, Linear Development, under consideration.

The three areas needing clarification from the original report pertained to 1) the carrying capacity of the proposed sewage lagoons, 2) the proposed size of the diesel powered generators, and 3) the handling of solid waste. I would respond as follows on these particular items:

1) Carrying Capacity of the Proposed Sewage Lagoons

In preparing the preliminary sizing of the sewage lagoons, it was assumed that one-third of the hydraulic loading was from house boat pump out waste. Therefore, on an average day in the peak month, the 11,070 gallons of sewage would be appropriated thusly:

| Staff, 32 people @ 50 gpd/person          | 1600 gallons |
| Boat Pump out Waste                      | 3690 gallons |
| Visitors                                 | 5780 gallons |
| **Total**                                | **11,070 gallons per day** |

III-1
Assuming the average visitor uses 6 gallons per stop (flush toilet and wash hands), then approximately 1000 visitors could use the facilities. Since the lagoons were oversized by 20% as a factor of safety, 1200 visitors could use the facilities and a comparable number of boats be pumped out without overloading the system. This yields that 36,000 visitors could use the facilities during the peak month.

2) Proposed Size of the Diesel Powered Generators

We agree with the Park Service comment regarding three generators and the estimates reflect three being used. The loads are determined as accurately as they can be at the present. Because of the cost of operating these large generators and also the big spread in demand from winter night-time to peak summer demand, we proposed that possibly one 100 kw and two 200 kw generators be used to offer greater flexibility in matching output with demand. This method of operation might require that the system have the capability to shed some load if one of the large generators were to break down.

3) Handling of Solid Waste

No special attention was given the handling of solid waste. It was my understanding that the Park Service already was working toward a new handling system that would provide units that could be mechanically dumped. Assuming a 250 percent increase in visitation during the design period, it could be anticipated that there would be a 250 percent increase in the volume of solid waste.

A modification which should be considered as future volumes increase would be to utilize a trash compactor. Using a compactor that achieves a 5 to 1 reduction in volume would reduce the volume (not the weight) of the ultimate development to approximately half of the volume being handled now. I have not made any effort to estimate the cost of this kind of system.
Comments regarding new Alternative 4, Linear Development

1) The layout is similar to previous proposals. The housing area is similar to location "B" except that it is placed on the west side of the knoll. With the sewage lagoons located at site "B", this gives the highest utility cost due to the "sprawl" but the best relationship in habitat with the nearly one half mile separation of housing and lagoons.

2) It has always been assumed that the power generators would be located near or at the maintenance area. Fuel storage for these generators would have to be near. It has been assumed that approximately 20,000 gallons would be required. The fuel storage area for the marina has never been located conveniently to the maintenance area but always away from and below this area. Therefore, it should be considered that the fuel storage for the power generators would be in the vicinity of the generators.

3) The proposed location of the fuel storage area doesn't readily lend itself to a gravity feed system to the marina unless a siphon is developed. The siphon will work but will always require priming of each line when the suction is broken. I have not checked applicable codes to see if there are any restrictions concerning siphons on fuel handling systems.

4) A gravity water storage tank would need to be located at a ground elevation of 3900 or higher to provide a minimum static water pressure of 40 psi at all outlets. The tank is shown on an elevation 3840 contour.

5) The LCM launch ramp road is longer and in an area not detailed in our onsite review. It may present design problems unanticipated at this time.

This proposed alignment will provide a fairly uniform grade of 12%. The use of the proposed roadway has never been clearly defined other than to provide construction access to the mesa. It appears that this will be the period when the road will receive its greatest use.

Previous estimates did not include asphalt surfacing down to elevation 3711 and concrete surfacing below elevation 3711. These numbers are included below.
6) The following summary of costs would be applicable to this alternative:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage Lagoons</td>
<td>$405,000</td>
</tr>
<tr>
<td>Well, Pumps, Chlorination, Storage</td>
<td>50,000</td>
</tr>
<tr>
<td>Extra for Pipe, etc. to remote gravity tank</td>
<td>50,000</td>
</tr>
<tr>
<td>Utility Chase to Marina</td>
<td>80,000</td>
</tr>
<tr>
<td>New Road &quot;C&quot; (Without Surfacing)</td>
<td>100,000</td>
</tr>
<tr>
<td>Diesel Power Generation, Storage, Tanks, Building, Fuel Lines</td>
<td>225,000</td>
</tr>
<tr>
<td>Vertical Circulation System (Very Preliminary Estimate)</td>
<td>200,000</td>
</tr>
<tr>
<td>Utilities with Lagoon Site &quot;B&quot;</td>
<td>195,000</td>
</tr>
<tr>
<td>Sewage Lift Stations</td>
<td>40,000</td>
</tr>
<tr>
<td>Trails to Developed Areas (Alternative 4)</td>
<td>20,000</td>
</tr>
<tr>
<td>STOL Air Strip</td>
<td>92,000</td>
</tr>
</tbody>
</table>

If the three road alternatives are paved with 4" average thickness of asphalt or 8" average thickness of concrete twelve feet wide, these surfacing costs would be:

<table>
<thead>
<tr>
<th>Road</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road A</td>
<td>$36,300</td>
</tr>
<tr>
<td>Road B</td>
<td>29,100</td>
</tr>
<tr>
<td>Road C</td>
<td>50,000</td>
</tr>
</tbody>
</table>

The STOL Air Strip includes 8" compacted thickness aggregate base course over a 40 foot width for the full length of the strip.

Some areas we have not estimated include:

a) Solid Waste Handling
b) Site Lighting
c) Telephone (onsite) Communication System

I believe this responds to all the requests. I would add perhaps 10% to the above estimates for unitemized expenses during the design which can not be detailed at present. I would also note that the above estimates are 1978 dollars. If additional information is needed at this time, I will be happy to try and assemble it for you.

Very truly yours,
SELLARDS & GRIGG, INC.

Thomas A. Young, P.E.

TAY/kd
APPENDIX D
Below Water Investigation of Alternative Marina Location
APPENDIX D

Alternative 1
Concentrated Central Development

Alternatives 2 & 4
Open Development & Linear Development

Alternative 3
Concentrated North Development

BELOW
WATER INVESTIGATION
GLEN CANYON NATIONAL RECREATION AREA
united states department of the interior
national park service
APPENDIX E

Glen Canyon National Recreation Area Solar Data
### GLEN CANYON NATIONAL RECREATION AREA: SOLAR DATA (latitude 37° 45' North)

<table>
<thead>
<tr>
<th>Month</th>
<th>mid-Jan</th>
<th>mid-Feb</th>
<th>mid-Mar</th>
<th>mid-Apr</th>
<th>mid-May</th>
<th>mid-June</th>
<th>mid-July</th>
<th>mid-Aug</th>
<th>mid-Sept</th>
<th>mid-Oct</th>
<th>mid-Nov</th>
<th>mid-Dec</th>
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</thead>
<tbody>
<tr>
<td>Total days</td>
<td>15</td>
<td>46</td>
<td>76</td>
<td>105</td>
<td>135</td>
<td>166</td>
<td>196</td>
<td>277</td>
<td>258</td>
<td>288</td>
<td>319</td>
<td>349</td>
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<tr>
<th>Declination</th>
<th>degrees</th>
<th>-21.3</th>
<th>-13.6</th>
<th>-2.8</th>
<th>+9.4</th>
<th>+18.8</th>
<th>+23.3</th>
<th>+21.5</th>
<th>+13.8</th>
<th>+2.2</th>
<th>-9.6</th>
<th>-19.2</th>
<th>-23.3</th>
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<tr>
<th>Sunrise angle</th>
<th>degrees</th>
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<th>79.2</th>
<th>87.8</th>
<th>97.4</th>
<th>105.3</th>
<th>109.5</th>
<th>107.8</th>
<th>101.0</th>
<th>91.7</th>
<th>82.5</th>
<th>74.4</th>
<th>70.5</th>
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<table>
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<tr>
<th>Total daylight hours</th>
<th>9.65</th>
<th>10.6</th>
<th>11.7</th>
<th>13.0</th>
<th>14.0</th>
<th>14.6</th>
<th>14.4</th>
<th>13.5</th>
<th>12.2</th>
<th>11.0</th>
<th>9.9</th>
<th>9.4</th>
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<table>
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<tr>
<th>Mean temperature</th>
<th>degrees</th>
<th>22.9</th>
<th>26.8</th>
<th>32.6</th>
<th>41.4</th>
<th>51.0</th>
<th>60.4</th>
<th>64.6</th>
<th>62.5</th>
<th>56.1</th>
<th>45.1</th>
<th>33.0</th>
<th>23.8</th>
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<table>
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<tr>
<th>Mean high temperature</th>
<th>degrees F.</th>
<th>35.1</th>
<th>39.4</th>
<th>46.4</th>
<th>55.3</th>
<th>65.6</th>
<th>76.2</th>
<th>80.0</th>
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<th>71.4</th>
<th>60.2</th>
<th>45.4</th>
<th>35.9</th>
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<table>
<thead>
<tr>
<th>Mean low temperature</th>
<th>degrees F.</th>
<th>10.6</th>
<th>14.1</th>
<th>18.8</th>
<th>27.5</th>
<th>35.4</th>
<th>44.6</th>
<th>49.1</th>
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<table>
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<tr>
<th>Degree-days heating (base 65°F.)*</th>
<th>1,476</th>
<th>1,162</th>
<th>1,020</th>
<th>696</th>
<th>440</th>
<th>163</th>
<th>65</th>
<th>99</th>
<th>279</th>
<th>639</th>
<th>1,065</th>
<th>1,420</th>
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<table>
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<tr>
<th>Mean daily solar radiation BTU/ft²**</th>
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<th>1,400</th>
<th>1,885</th>
<th>2,280</th>
<th>2,530</th>
<th>2,675</th>
<th>2,520</th>
<th>2,300</th>
<th>2,040</th>
<th>1,615</th>
<th>1,230</th>
<th>1,000</th>
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</table>

* Alamosa, Colorado data ** Albequerque, New Mexico data