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DEPARTMENT OF THE INTERIOR

DRAFT

ENVIRONMENTAL STATEMENT

Proposed

DEVELOPMENT CONCEPT PLANS

INDIAN GARDENS

GRAND CANYON NATIONAL PARK
ARIZONA

Prepared by

Denver Service Center
National Park Service
Department of the Interior

ca 1973

Director, Western Region

SUMMARY

( ) Final Environmental Statement

(X) Draft

United States Department of the Interior, National Park Service

I. Type of action: (X) Administrative ( ) Legislative

II. Brief description of action:
A development concept plan for Indian Gardens, Grand Canyon National Park containing management plan for new campground and facilities, and the addition of a new sewage treatment plant.

III. Summary of environmental impact and adverse environmental effects:
- a. Replacement of outmoded and poorly functioning sewage disposal system.
- b. Aesthetic disturbances of construction activity, aerial importation of supplies.
- c. Long-term social costs of moving the campground from hospitable environment.
- d. Long-term aesthitic costs of artifically vegetating a semi-desert plateau.
- e. Long-term effect of the spray field on the biological system.
  1. Nutrient build-up principally nitrogen and phosphorus.
  2. Effect of added salts — mainly calcium, potassium, sodium and magnisium.
  3. Effect of added water.
  4. Heavy metal build-up.
- f. Maintenance and enforcement costs associated with moving the campground and increasing distance to pumphouses.

IV. Alternatives considered:
- a. No action.
- b. Approval of a modified flash flood protection system, with a continued policy of rehabilitating existing campground.
- c. Retension of alternative developments of "b" with an activated sludge sewage treatment plant.
- d. Retension of alternatives "b" and "c" with the addition of a tertiary treatment made in sewage plant.

V. Comments have been requested from the following:
- a. Federal Agencies
  United States Department of Agriculture: Forest Service, Kaibab National Forest; Soil Conservation Service
  United States Department of the Interior: U.S. Geological Survey, National Park Service, Grand Canyon, Western Region
  United States Department of Health Education and Welfare: (Health Aspects) Environmental Protection Agency: Water Quality Office
- b. State Agencies
  Arizona State Department of Health
  Arizona Division Soil Conservation and Watershed Management
  Arizona Conservation Council

VI. Date made available to Council on Environmental Quality and the public:

General

Indian Gardens forms one of the most unique and well-known areas within Grand Canyon National Park. Of historical importance as a source of water, Indian Gardens today remains as an important stopping point for hikers and mule riders traversing the Bright Angel Trail from the South Rim to Phantom Ranch. Indian Gardens itself is located at an elevation of 3,700 feet which is 2,000 feet below the South Rim. It lies within the drainage of Garden Creek which was formed by the Indian Garden Springs lying within the Bright Angel fault system. The area of the gardens is small, and nestled along the creek bed for a few hundred yards. It is surrounded by the broad Tonto Plateau, a hostile environment of semidesert scrub. Figure 1 shows the map of the locale of Indian Gardens. Both the gardens and the Tonto Plateau are easily visible from vantage points on the South Rim.

I. DESCRIPTION OF THE PROPOSAL

A. TYPE OF ACTION

The development concept plan for Indian Gardens is oriented towards continuing its current use as a rest stop or campground for hikers going into or coming out of the canyon. However, due to the danger of flash floods in the present campground, it is suggested that the campground be moved to the bench of high ground across Bright Angel Creek from the present facility. Shade structures or trees would be provided there. A new sewage treatment facility would be built to replace the outmoded system.

Additional proposals call for construction of a new residence-office-contact station and bunkhouse facilities for the trail crew, maintenance, and protection personnel. The flood protection dikes in the present campground would be removed, and an advance warning system devised to inform campers of the potential threat of flash flood.

B. EXISTING DEVELOPMENT

As seen in figure 1, the developed area of Indian Gardens is very small. All of the developments are located in the bottom land either adjacent to or just above the springs that form Garden Creek. The shade in this bottom land from several large cottonwood trees invites welcome respite from the sun's heat on the trails both above and below the gardens.

Because of their location, most of the facilities, including the ranger-station-residence, campground, and comfort station, lie in the path of flash floods emanating chiefly from the two major drainages that converge in the area (figure 2). A recent flash flood, in fact, caused considerable damage to the area of the campground and undermined a portion of the stream bank. As shown in figure 1, a long rock wall diversion system was then constructed in an effort to channel runoff around the ranger station and the campground and into the stream channel.

In addition to the facilities so far mentioned, the pumping stations and reservoir for the trans-canyon waterline are also located at Indian Gardens. The terminus of this waterline gives added dimension to Indian Gardens as an important administrative site. At the upper end of the gardens area are found the mule corral and storage facilities.

Sewage Collection and Treatment Facilities

The facilities at Indian Gardens consist of a comfort station and a wastewater collection system which includes a septic tank, lift station, and leach field. Sewage from the ranger station, bunkhouse, and comfort station is treated in the septic tank and the effluent is then discharged into the lift station and pumped to a leaching field on the slope to the northwest above the campground. The present system is in disrepair, obsolete, and not large enough to handle the increasing volume of waste from hikers and backpackers. The manholes consist of rectangular concrete boxes with lumber slat covers which give easy access for dirt, rocks, surface runoff, and refuse. The plugging of the sewers is a subsequent maintenance problem. The leach field does not function properly, and liquid sewage seeps to the surface and is often seen in pools. Odor is often a problem. Soil percolation studies have not been conducted. These may give some explanation for the poor infiltration of the sewage liquid. However, the field itself is probably not big enough for the current use load.

C. PROPOSED DEVELOPMENT

The proposal calls for the moving of the campground and picnic area to a safer area on the bench to the east and south of the present campground above Bright Angel Creek (figure 3). This is an open area and therefore attendant shade structures would be constructed, and cottonwood trees would be planted to be watered by the irrigation system. This new area would be larger and thus offer more space for the same number of campers and picnickers. The land area slopes upward to the east from the current drainage channel. This slope terminates on a bench that is at a minimum about 30 feet above the drainage channels and thus places the new campground out of danger of flash floods. The proposal also calls for the new construction of an residence-office-contact station and bunkhouse facilities for the new trail crew, maintenance, and protection personnel. These would be located at the upper end of the campground at its southernmost point. The construction of the new campground would eliminate the need for the two gabion walled dikes constructed to channel flash flood overflow and these would therefore be removed.

Sewage Treatment Facilities

The outline of the proposed secondary wastewater treatment system for Indian Gardens is shown in figure 3. The existing lift station would be used to pump the wastewater to a new treatment plant located on the slope to the south and above the existing pump stations. An 8-inch trunk sewer would extend from the ranger station area to the treatment facility with 4-inch connections for the bunkhouse, ranger's quarters, and two comfort stations to be placed in the relocated campground area. The wastewater would be treated, chlorinated, and the effluent discharged into a wet well. This plant is designed for a minimum 90 percent reduction in BOD, and would have a capacity of treating 5,000 gallons a day (gad). From the wet well, the effluent would be pumped through a 3-inch pipe to the new campground area for use as irrigation. An 8-inch outfall line would be provided to discharge that portion of the effluent which is not used for irrigation to the area below the treatment plant into Garden Creek. The proposed wastewater collection system would require approximately 100 feet of 4-inch and 1,000 feet of 8-inch pipe with four manholes. The treatment facility itself would be an activated sludge package plant, a 110-gallon chlorine contact chamber, an effluent wet well, and a 7½ hp. pump in the lift station to pump the effluent into the irrigation system. Irrigation water may be diverted from this irrigation pressure line at any number of locations. An irrigation system of open shallow trenches would gravity feed water to most of the proposed campground area. Excess water would be used in aerial spray. If both the irrigation and spraying mechanisma fail, the overflow pipe would carry the treatment plant effluent to the stream.

The capacity of the proposed sewage treatment plant is based on a maximum design population of 366 individuals per day. For terms of waste treatment, the population of the area is characterized by either permanent residents, bunkhouse residents, campers, hikers, or mule riders. Based on 1971 data, the maximum per day use of Indian Gardens was 56 percent of the maximum design population.

II. DESCRIPTION OF THE ENVIRONMENT

A. CLIMATE

The area around Indian Gardens contains two strikingly differing ecosystems, sharply delineated, but which both have importance — especially in view of the development proposal for the campground.

There is no climatic data for the Indian Gardens area itself. Located as it is at an elevation intermediate between Phantom Ranch and the South Rim, and with the two very different vegetative systems, it is difficult to extrapolate a mean between these two stations.

The riparian environment of the springs forms an oasis in the desert, with a climate that contrasts sharply with the unshaded shelf of the surrounding Tonto Plateau. Here, without the ameliorating effect of the vegetation, great diurnal variations in temperature are not uncommon. The conditions on the plateau more resemble those of Phantom Ranch, being extremely hot throughout the summer and receiving between 6 and 8 inches of precipitation each year. With the high reradiation, night temperatures can be quite cold.

B. BIOTIC FEATURES

1. Vegetation

Because of the entirely different perspective offered by the "gardens" per se and the surrounding Tonto Plateau, the vegetative features of each will be treated separately.

The harsh environmental conditions of the Tonto Plateau have produced a plant community capable of sustaining extremely hot daytime temperatures and sharp cooling at night. The xerophytic vegetation is dominated by low profile, spreading sclerophyllous shrubs with shallow spreading roots designed to maximize the uptake of the rainstorms. Because of the severe moisture competition from the shrubs, the basal cover of the mostly bunch grasses is low, often less than 10 percent. The plateau can be characterized as a semidesert shrub grassland dominated by blackbrush, mesquite, and catclaw. The principal vegetation types are listed in appendix 1.

In sharp contrast is the riparian environment of the gardens itself. It is this area, of course, which makes the trip worthwhile. In the area nourished by the spring waters, vegetation includes several species of willows and sedges, and the aspect is dominated by the large cottonwood trees, many of them over 70 years old, which give the area its character. A listing of the most common vegetative types at the gardens is given in appendix 4 (Merkel 1962, USDA 1937, Sutton and Sutton 1971, Rand 1958).

2. Fauna

Because the area of the gardens is so small and isolated, most of the fauna, except for a few amphibians and some migratory bird species, are adapted to the dry desert scrub environment. The mammalian fauna is dominated by members of the Rodentia, herbivorous and feeding on the seeds and fruits of the vegetation. The major predaceous species include the bobcat and coyote. Because of the heat, most of the mammal activity is nocturnal and is rarely noticed. Many of the species use the gardens area for water. The reptilian fauna, as would be expected, is quite large. A complete listing of the fauna of the Indian Gardens area is given in appendix 2. (Bailey 1939, Scharff 1967, Gehlback 1966).

C. TOPOGRAPHY-GEOLOGY

At an elevation of about 3,700 feet, 2,000 feet below the South Rim, the gardens itself is located within the Bright Angel Fault corridor, a post-Paleozoic normal fault (Maxson 1961). This fault is the major factor influencing the drainage patterns of the area and is the resultant factor in the occurrence of the natural springs, which are one of the few natural sources of water in all of the canyon. A considerable surface soil layer has been accumulated within the gardens itself, mainly from deposition and it is held by the riparian vegetation in the area. Soil texture is mainly a coarse silt to silt-clay.

The sandstone of the Tonto Plateau is thick and coarse and is made up of resistant Tapeats sandstone overlain with a layer of soft and easily erodible Bright Angel shale. Here, topsoil is scarce, and the friable nature of the surface shale along with the lack of soil makes the plateau area extremely susceptible to damage by erosion or overuse. The low biotic diversity only adds to its lack of stability. Scars and overuse on the plateau are thus not easily healed or erased.

D. SOCIAL RESOURCES

Other than a Park Service ranger, there is no permanent residential population at Indian Gardens, and none is planned. Because of the trans-canyon pumping station, an individual must be on duty at the gardens at all times. This responsibility is normally rotated among several individuals.

E. ARCHEOLOGICAL-HISTORICAL-PALEONTOLOGICAL RESOURCES

The long history and habitation of the Indian Gardens area as a site for farming by the early Indian tribes gives added archeological importance to this site. From the evidence available, it appears as if the prehistoric predecessors of the historic inhabitants, the Havasupai, entered the region of Grand Canyon about A.D. 600 (Schwartz 1957). How long it took them to occupy the gardens area itself is not known, but the rapid population increase experienced by this tribe a few hundred years after its settlement would lead one to expect that it was at this time that the areas of the inner and lower canyon were first utilized for farming. The available water source of the gardens was certainly an important drawing card. As with the Phantom Ranch, the Development Concept Plan for Indian Gardens unfortunately does not make any reference to the possible archeological sites at the gardens.

Again, similar documents referred to in the Phantom Ranch EIS were consulted, including Marshall and Schwartz (1969) and Schwartz (1958, 1965, 1969, and 1970). No known archeological sites are located within the gardens area. The proposed development will include excavations along the bench to the east and south of the gardens and near the current pumping station.

Because of the possibilities of archeological or paleontological finds, excavations should proceed with great care, and should significant findings be uncovered, work will be discontinued until material found can be professionally evaluated. No properties listed in the National Register of Historic Places will be affected by the development.

F. FUTURE ENVIRONMENT WITHOUT THE PROJECT

As will be discussed below, the proposed development concept plan may well preclude a continued use of the Indian Gardens area and set in motion events which might cause irreparable environmental harm and administrative inconveniences. Although the current sewage disposal system is definitely in need of corrective action (and with increasing use further breakdown of the system may well occur), the corrective action *in toto* may well be more harmful than the existing problems.

III. ENVIRONMENTAL IMPACT OF PROPOSED ACTION

A. ENVIRONMENTAL COSTS

1. Temporal Aesthetic Disturbances

Although it is important to those people experiencing them, the environmental costs associated with the construction phases of the development plans would play only a small role in the overall costs associated with this project. The construction of the treatment plant would require considerable excavation and probably some blasting into the hillside. Likewise, some excavation would be required for the construction of the two new comfort stations, the ranger station, and the bunkhouse. Trenching would be required for the 1,100 feet or more of new sewage lines to be installed. As with Phantom Ranch, much of the disturbance is due to the isolation of Indian Gardens and the necessity of moving all construction supplies and manpower into the site by helicopter. The noise of this activity would be most disturbing to those campers staying at the gardens and to those hikers along the trail leading up to the South Rim.

Since most of the construction activity would take place on the slope to the east and south of the present camping area, only the construction of the treatment facility itself and the eventual removal of the storm-channel dikes would be of severe detriment to those staying at the gardens.

2. Temporal Physical Disturbances

Given the lack of vegetation cover on the slopes surrounding the Indian Gardens, the lack of soil, and the fragile nature of the area, damage to the physical environment caused by trenching and excavation could be quite severe, long-lasting, and very noticeable when viewing the gardens from upper levels, including the South Rim.

3. Long-term Costs

The long-term costs associated with any project are often the most difficult to evaluate, especially in the absence of any experimental data or simulation models of the proposed development. This is particularly true when the project involved is concerned with processes, be they biological or sociological. The long-term costs of the Indian Gardens development fall into three basic categories; those associated with the aesthetic environment, the social environment, and the biological system itself. Evaluated on an arbitrary scale, the hypothetical long-term effects can be illustrated in the conceptual manner shown in figure 4. The rationale for these curves and for the environmental costs is as follows:

(a) **Social Costs** The curves show the social costs starting out at a very high level maintaining this degree over a long-term interval and then gradually decreasing. Social costs are related to the disturbances experienced by the users of Indian Gardens, principally the campers and hikers. The present campground at Indian Gardens is a most enjoyable environment, particularly after spending severalhours on the hot trails of the inner-canyon. To require the people to set up camp on the exposed slopes of the surrounding plateau void of shade when the present shaded campground is only a short distance away, will cause considerable friction between users of the facility and those required to maintain order. These disturbances are particularly upsetting to the camper when he realizes that the only reason the present campground cannot be used is because of flash flood danger. On a day when the temperature may approach 110^{o} on the exposed plateau, this possibility may well seem remote.

The graph shows the social costs gradually decreasing because new cottonwood trees will have grown as a result of irrigation. The original deterrent to the campground on the exposed slopes will have dissipated.

(b) Aesthetic Costs The curve for aesthetic costs, it may be noted, interacts highly with the curve for social costs, and the sum of the area of the two curves integrated over time approaches unity. The curves, however, are inversely proportional. The reason for this is clear. In the first time interval, the aesthetic costs of artificially revegetating an area that can be clearly seen from most of the major viewing points of the South Rim will be negligible. However, over time, with the continuous application of irrigation spraywater, the effective rainfall of the area will have essentially quadrupled each year. As different vegetation forms take root and grow, the aesthetic costs will grow accordingly. The slope of the curve is inversely proportional to that for the social costs. The intrusion of this vegetation on or into the scrub desert of the plateau will be noticeable by all but the most casual observers from the South Rim. Eventually, a climax community, adjusted to the conditions, is attained. Thus, after a passage of at least 40 years, this curve will level off.

(c) Effects on the Biological-physical System Environmental costs, as shown by the third curve in figure 4, start off at a rather high level. This is due primarily to the physical disturbance of the area in the construction phases. Within a few years these costs will begin to decrease and at least stabilize. At this juncture, we find two divergent curves are possible. These indicate the possible effects of the spray-field irrigation on the plateau ecosystem itself. One curve indicated that these costs slowly increase and reach an untenable level; the second indicates that they will slowly decrease and reach a negligible level. Thus, one of the most important and unknown quantities in the development plan for Indian Gardens is not (as contrasted to Phantom Ranch) the method of sewage treatment, but rather the method of removal of the liquid sewage effluent after it has been treated.

(1) Spray Fields — General. Because of their importance to this and the subsequent impact statement, and the lack of good research on the subject, it is important that this subject be delved into in considerable detail.

Spray fields are basically an attempt to use the entire biological system. The soil and vegetation act as a filter to renovate sewage effluent before it is returned to the ground water sources. The practice of disposing of sewage effluent by irrigation dates from the 1920's and originated in Germany on forested land. It has been used in the United States on an ever-growing scale since 1947 (Sepp 1965).

Much of the research on the subject until recently has been limited to the ability of the soil to dispose of increasing amounts of effluents, and the ability of the effluent to serve as a substitute for fertilizers in agricultural situations. Only recently has emphasis been directed towards the effect of the effluent on the ecosystem itself and in particular natural systems.

The studies in general have indicated that the living filter of most ecosystems is highly efficient in removing important constituents from the applied sewage waste water. The ability of effluent to fertilize crops is likewise most impressive (Day *et al.* 1962, Day and Tucker 1959).

Sepp (1965) has reported on the effects of sewage treatment-irrigation systems based on a survey of 30 California systems. He noted that most of the treatment plants are effective in retaining the effluent on the land during dry weather and in light rains, whereas there is some runoff from the land areas during times of heavy rains. The spray areas constructed on forest soils generally worked best because of the increased absorption capacities of the humus and litter. Application rates of 30,000 to 55,000 gad were maintained during summer weekends on some forest soils without runoff with corresponding weekday loads of 15,000 gad. He noted that in eight of the areas, the spray fields were failing because of runoff problems. No marked changes were noted in those areas where ponding was avoided. Chase (1960) reported applications of sewage effluent of between 12,000 and 27,000 gad on sandy forest soils in Washington with no ill effects, and similar results were reported for volumes up to 10,000 for sandy New Jersey soils by Seabrook (1957).

On natural systems, the best and most comprehensive studies are those being carried out at Pennsylvania State University (see Kardos and Sopper 1972, Kardos 1970, Kardos 1971, Parizek 1967, and Pennypacker, *et al.* 1967). The work from these researches will be incorporated into the following discussion.

The probable effects of irrigating an area with sewage effluent can be brokedown into four main areas. These four effects are those concerned with the addition of:

1. Nutrients, principally nitrogen and phosphorus
2. Water
3. Salts, principally calcium, potassium, sodium, and magnesium
4. Heavy metals

Nutrients

The pathways of the principal nutrient additions, nitrogen and phosphorus can be seen by their biogeochemical cycles shown in appendix 3.

Nitrogen

Nitrogen is an important nutrient in the phenomena of eutrophication. Nitrogen cycles through the biosphere in a complex manner that involves a gaseous phase. It is broken down from an organic to an inorganic form by a series of decomposer bacteria, and some of it ends up as nitrate, the form most readily used by green plants. The air, containing 90 percent of the nitrogen, is the reservoir and safety valve for the system.

Because of the normal rate of nitrification that usually occurs in the forest floor and surface soil horizons, the average concentration of nitrate generally increases in areas which receive continuous irrigation from sewage effluent and which are not harvested. The buildup of nitrate in non-harvested systems is one of the big unknowns and it could become a major problem and a deterrent to the long-term use of areas as disposal sites for sewage effluent. Perennial grasses appear to be most efficient in removing nitrogen because their root systems, although dormant in the winter, are ready to begin absorption in the spring when the seasonal bulge of nitrogen occurs, and when annual grasses have yet to extend their roots (Kardos 1970).

Phosphorus

Phosphorus is another of the nutrients responsible for the eutrophication in both streams and lakes. The phosphorous cycle in comparision to the nitrogen is simpler and the great reservoir is not the air but the sediments and rocks. A necessary constituent of protoplasm, phosphorus tends to circulate as an organic compound, being broken down eventually to phosphates which are available to plants. The soil appears to be a more effective filter for phosphorus than for nitrogen. Kardos and Sopper (1972) have found that the soil and vegetation in forested areas receiving two inches of effluent weekly were able to decrease the phosphorous concentration up to 99 percent in the first 1-foot depth of soil in the first year, and by 92 percent at the 4-foot depth in the third.

Eventually the amount of phosphorous that can be used by the vegetation is attained and the vegetation may not be able to utilize additional supplies of phosphorus added in wastewater irrigation. On agricultural plots, on the other hand, where the plants are harvested, phosphorous is continually being removed from the system and, therefore, can be added continually each year without a concomitant buildup. Kardos (1970) found that clover irrigated with 1 inch of effluent per week removed between 49 and 63 percent of the phosphorous. Fig. 5 shows a generalized pattern of nutrient cycling and buildup in harvested and non-harvested systems.

Salts

Sewage effluent also contains several dissolved mineral salts; the chief ones being potassium, calcium, magnesium, and sodium. For soil to remain in balance and fertile, soil's salts must be held at a level desirable for the plants growing in it and must be removed by the plants or by drainage as fast as new ones are added. In dry climates, where the evaporation rates are high, irrigation water will evaporate leaving the salts behind. Harvested crops will remove a substantial fraction of the mineral salts except sodium. In non-harvested situations, the salts will gradually accumulate in the upper soil horizons, killing the indigenous plant populations. The amount and rate of salt buildup is greatly dependent on the soil drainage. In soils of silt and clays where surface drainage is slow, the water lays on the surface longer and has a greater chance of evaporating.

Water

A spray-field irrigation on an area of natural vegetation is somewhat analogous to a small-scale weather modification project. The existent vegetation of the plateau area, as described above, has evolved over the eons into a balance with the current moisture regimes. Any increase in the effective moisture will upset this balance, allowing an invasion by those species that are adapted to a more moist climate. These new species will, in turn, upset the competitive equilibrium and, in the long run, probably kill the existing plant life.

This document has already referred to the change in the vegetation as having a disturbing aesthetic effect on those experiencing Indian Gardens from the South Rim. The increased irrigation, of course, will enable the growth and development of planted cottonwood trees and probably some forms of perennial grasses. To what extent the additional moisture will enable the growth and spread of native shrub species, such as desert thorn, blackbrush, and mesquite, is not known. However, research conducted by Wright (1972) has alluded to the great ability of shrubs such as mesquite to usurp the available moisture in an area and dominate the vegetation pattern. Such shrubs, especially in a campground-picnic-ground area are generally considered to be obnoxious. It is probable that some continuing form of vegetation management will be required; a practice which is generally not consistent with Park Service practices. Of equal consideration is not only the amount of water added to the system *per se,* but the percentage increase. In arid regions this will be great.

Heavy Metals (Iron, Aluminum, Zinc, Manganese, Copper)

The heavy-metal buildup in an area is a distinctly unknown quantity. This is because generally the rate of application is so small and the little research that has been done on the subject has shown that heavy metal buildup does not occur except over a very long period of time. B. Sabey (personal communication) has pointed out that it is only recently that high concentrations of heavy metals have been noted in soils outside of those of Paris and Berlin on which sewage has been applied for over 50 years.

(2) Indian Gardens — Specific Effects Sopper and Kardos (1972) have indicated that about 130 acres of land are needed to dispose of a million gallons of effluent per week applied at 2 inches per week. On this basis, the 3.5 acres of land for the proposed spray field could handle the design population sewage effluent if applied at the rate of one-half inch per week. It would be more optimal to divide the area in half and apply at the rate of one inch every other week.

This would result in an approximate addition of 27 inches of water/unit area or a fourfold increase over the average precipitation of the plateau. Evaporation losses from the spray and ground would result in a loss of about 10 to 25 percent of the added water, reducing the increment to 22 inches or a 360 percent increase.

A diagram of the possible effects of the added nutrients and water to the herbaceous vegetation on the Tonto Plateau is shown in figure 6. In both cases, the time scale is over a period of years and the units are an arbitrary scale of biomass. Both cases start from the stable ecosystem, such as seen in appendix 4, that has the additional driving variable of the spray effluents added to it. The herbaceous vegetation follows a characteristic cyclical growth pattern, building up to a peak at the end of the growing season and dying back in the winter. Under both cases, at the initiation of the spray field project, the buildup in the vegetation is clear. The difference in the two cases is related to the ability of the decomposer population to build up in sufficient numbers to limit the growth of plant litter. In the first case, this is what happens, the decomposer population increases as a result of the increased nutrients in the soil and the additional plant litter. The amount of litter buildup is low, and thus the plant population is able to continue to increase until a new equilibrium is reached with the existing moisture and nutrient additions. In the second case, the decomposer population is not able to build up to a sufficient degree to consume the produced litter, and therefore the plant growth is slowed and eventually litter buildup precludes herbage growth beyond that produced before the advent of the spray field.

Figure 7 shows the long-term effects of the addition of spray effluents to the ecosystem steady state. As was illustrated in figure 6, the herbaceous vegetation is the first to benefit by the addition of nutrients and water, and its rapid rise is seen during the first time interval. No rise is noted in the woody vegetation whose response to the additional nutrients and water lags the grasses. Exotic vegetation is that which is present in small amounts in the natural system, but which is characteristic of more moist environs, and therefore is at the extreme of its range. It is this category of vegetation that one would expect to increase the greatest as the condition for growth becomes more optimum. Also included in this category are the vegetative forms artificially planted to give shade and ground cover.

A small rise in the consumer population is seen as a lag response to the increased herbage. Because of the human element, the consumer population will not, over any of these periods, build up to a great level, but the populations in the undistrubed areas around the sprayfield, with access to more food, will increase greatly.

All of the components except the herbaceous vegetation build up slightly during the second time interval and reach a second steady state with the altered environmental conditions. The herbaceous vegetation also reaches a steady state but not until it has declined considerably. Part of this decline is a function of increased competition from exotic vegetative forms, and part is attributable to the loss of native vegetation because of unfavorable conditions for growth. A third source of loss is due to the fact that the consumer populations have "caught up" with the herbage increase. A fourth factor precipitating decline may be due to the buildup in litter as shown in case 2 of figure 5.

Whether or not the steady state which is proposed will be maintained, and for how long, is a major question. One possible set of effects are illustrated in the last time interval of figure 7. Here the native herbage continues to decline as a result of increased competition from newer forms and possibly because of an increase in soil salinity resulting from the irrigation. The consumer population may also continue to decrease, as a function of nitrate poisoning from an over-abundance of nitrate buildup in the vegetation.

Other side problems such as the ponding and runoff of effluent from the spray field can be important if the rate of application is too severe or if the system is not maintained properly. In surveying existing sewage projects, one is constantly struck by the fact that many of the current systems are only obsolete in that they have been allowed to fall into such a state of disrepair that they cannot function optimally. A side benefit to the waterlogging of soil with sewage effluent might be the fact that under anaerobic conditions, the nitrate is reduced to nitrogen gas whereupon it is lost to the atmosphere by the process of denitrification. (Delwiche 1967).

4. Peripheral Costs

Two important interrelated factors related to the campground replacement not considered in the Development Concept Plan are related to the maintenance of the pumping station and to the maintenance and order within the campground. The pumping station at the Indian Gardens campground receives water via an inverted syphon pipeline from Roaring Springs located below the North Rim. A portion of the water received via this pipeline is pumped to the South Rim storage facilities, it being the only source of water from the South Rim, and the remainder of the water is returned to Garden Creek. Any factor which interrupts the operation of the pumps for even a short time has important consequences for those on the South Rim. It has been the experience of the personnel maintaining the pumps that the electrical equipment is very subject to short-circuits, especially during electrical storms. At such time, an alarm sounds and the ranger on duty must manually reset the breakers and run a check on all of the equipment. This phenomenon can occur up to seven times a week in the thunderstorm seasons. (Rosales — personal communication).

The distance between the current Ranger Station and the pumphouse is less than one-tenth of a mile. The distance between the proposed site for the new Ranger Station and the current pumphouse is over a quarter of a mile. Given the current maintenance status of the operation of thypumps, this increased distance will result in extreme inconvenience to the personnel who are required to service the pumps.

On the map in figure 1 above, it can be noted that the riparian vegetation regime of Indian Gardens extends well beyond the present campground. This area is watered not only by the Garden Creek Springs, but also from the overflow from the trans-canyon pipeline which is not pumped to the South Rim. At most times of the year, the volume of water from each source is about equal. This is a rather broad marshy area with several cottonwoods and dense thickets of willow. It is frequented by campers and hikers, especially those arriving from Phantom Ranch. The increasing use of illicit drugs over the past few years has added an increasing burden to those enforcing the use of this area. Removing the Ranger Station to the bench to the south of the gardens area, would add to this burden manyfold, especially in view of the fact that camping in the present gardens area would also be eliminated.

B. ENVIRONMENTAL BENEFITS

The major tangible environmental benefit of the proposed development concept plan would be the elimination of the present septic tank based sewage disposal system. The present sewage collection system, with its inadequate leach field and obsolete manholes, is not only inadequate in the face of increasing use but may eventually pose an important health problem. The elimination of camping and the removal of the present facilities from the floodplain area will, for all intents, eliminate the possibility of loss of life and property due to flash floods. As indicated in the environmental impact statement for Phantom Ranch, the eventual removal of concessionaire use from the trails and of their stopping at Indian Gardens includes certain tangible bemefots. such as less compaction and degradation of the trails and the elimination of possible disease factors in the fecal material at the trail and in the present campground. Likewise, the intangible benefit includes the dissolution of the inherent incompatability between mule use and hiker use.

IV. MITIGATING EFFECTS

As with Phantom Ranch, over the years a great deal of miscellaneous artifacts and other junk have accumulated at Indian Gardens. Although this situation is not as severe as at Phantom Ranch and the deposits are more ordered and out of sight of the general public, a mitigating factor in the need for ferrying in construction supplies by helicopter would be to use these same planes to carry out junk in what would otherwise be an empty flight. As with Phantom Ranch, detailed planning would be necessary and the operation would probably have to be written into the construction contract. All materials not used in the construction programs themselves would, of course, be removed. All flights for material should be programmed to be performed in as small a time interval as possible, and schedules should be done during low periods of visitation. Likewise, flights for manpower and perishable supplies should be held to a minimum and notice of the construction activities should be posted at both rims to make hikers aware of the situation before they arrive at the gardens. The most feasible situation would be to have the construction activities at Phantom Ranch and Indian Gardens programmed coincidentally. This would work espeically well if both treatment systems were the same, such as activated treatment sludge. The advantage to this would be to minimize the time period of the construction activity disturbance in the inner canyon and a possibility to lessen the total number of flights for supply and manpower in that the same individuals could work on both jobs. Likewise, the flying in of supplies could be centralized from a certain point. The possible mitigating effect in the need for the construction of a new bunkhouse-ranger-station complex would be that these could be used initially to house the construction crew working on the sewage collection and disposal system and the new campground.

V. SIGNIFICANT ADVERSE EFFECTS THAT CANNOT BE AVOIDED

The significant adverse effect of the proposed development would be the change that would take place on the Tonto Plateau utilized as a sprayfield and new campground. Not only would the new buildings impose a disruption on this area but they could be disconcertingly viewed from the viewpoints on the South Rim. Likewise, the scars left by the trenching processes along with the gradual change in vegetation characteristics of the present shrub desert would be a readily apparent unnatural intrusion in this area. (The long-term effects of utilizing spray field effluence were discussed above.) The treatment system itself will also be a permanent facility, and therefore affect a change of the system. However, located as it is near the present pumphouse complex, this factor is not considered important.

VI. RELATION BETWEEN SHORT-TERM USE AND LONG-TERM PRODUCTIVITY

Some of the possible long-term changes in the productivity of the land, the change in diversity and vegetation characteristics, and the resultant change in the fauna were discussed in Section III.B. With the lack of long-term research findings on spray fields and their resultant effect, some of these speculations are merely probablistic and may not at all be well-founded. However, they do offer one possible long-term effect.

VII. IRREVERSIBLE COMMITMENT OF RESOURCES

Except for the land rescurce alluded to above and its change in status, the use of nonrenewable resources is not contemplated in this proposal and this consideration is to this extent not relevant to this development plan.

VIII. ALTERNATIVES TO THE PROPOSED ACTION

A. NO ACTION

For this proposal, the no-action alternative is in some ways a feasible plan. The reasons for this are as follows:

1) The chief reason for moving the campground is the danger of flash floods. The danger of a flood approaching the intensity of that which struck a few years ago is remote. Based on the last flood, the physical damage would be negligible and with precautionary removal of the people from the campground, the danger of loss of life is negligible also.

The last flood was termed a once-in-a-100-year event. Such a frequency analysis is based on a cost relationship indicating the period of time needed to amortize the cost of lost physical facilities. The lack of expansive facilities within Indian Gardens makes this convention meaningless. The age of the cottonwood trees would indicate however that a flood severe enough for their destruction has not occurred for at least 75 years.

2) The present campground is operated on a permit basis limiting the number of campers per night to 75 people. This puts an upper limit on the strain imposed on the sewage facilities. Under this alternative, the existing plant may prove to be barely adequate in subsequent years. This would require a more rigorous maintenance commitment including cleaning of the leach lines.

B. LIMITED ACTION ALTERNATIVES

1. A more feasible solution would be a limited action set of alternatives which would include the following:

a) **Flash Flood Protection System**

It was pointed out to the author that much of the damage done by the recent flood at Indian Gardens seemed to have been caused by the improper construction of the gabion wall. It is probable that simple extension of this wall a few feet to the east and on the opposite end to the northwest would have precluded much of the damage done by the storm and prevented the flood water from damaging the ranger's house, or entering the campground at all. This improvement, along with all others to be discussed, is seen on figure 8. Another improvement which might further decrease the probability of flood in the campground would be to have an engineering study to examine the possibility of excavating the stream channel entering the campground from the south at the point at which it joins the gabion-walled wash from the northwest. Excavation of this channel with a bridge over the trail to the trough where it joins the channelized wash would greatly facilitate the flow of flood waters through the area and prevent their subsequent spreading to the campground.

Respective washes drain various areas of relatively small size. The one running to the south of the campground parallels the trail for about a mile and drains this area. The one running to the northwest drains an even smaller area within the canyon with floodwaters coming from the top of the plateau. In either case, a major flash flood is generally presaged by a severe thunderstorm in the area and severe floods by water running over the top of the plateau and into the wash to the northwest. In either case, adequate advanced warning signs are available, especially to a trained observer, to give adequate time to evacuate the campground area. It would probably be worthwhile to have all potential rangers and maintenance men staying in Indian Gardens attend a brief training course on the potential signs of a flash flood with what to do in case one occurs. Likewise, signs to that effect could be posted in the campground.

b) Campground Renovation and Expansion

Through the action of one of the current resident rangers (Ray Rosales), the campground, through plantings of perennial grasses and cottonwood seedlings, has been considerably improved following destruction from the flood. Areas in the campground have been partitioned off so that revegetation might take place, and the irrigation system here and in the area below the campground has been improved, further promoting revegetation.

Continuation and expansion of this practice, particularly utilizing the area north of the present campground in the lower riparian area while the upper end is being revegetated, would greatly enhance the attractiveness and utility of the area. Removal of mules as proposed in the DCP will aid in this process.

c) Renovation of Facilities

The current ranger station appears to be structurally sound and a rather attractive building. Its location is quite adequate to monitor the use of the present campground and the area below the present campground. This building was constructed in 1932 and lacks sufficient insulation and has a damaged foundation, partly owing to the recent flood. Satisfying both of these requirements, and minor renovation of the interior, would appear to make this building more than adequate for its existing use. As indicated above, its present location also facilitates maintenance of the pumphouse facilities. Likewise, renovation of the existing bunkhouse, possibly more extensive, would be sufficient. It would appear to serve its needs.

Under this set of alternatives no sewage treatment plant would be proposed, but rather a renovation of the existing sewage treatment facility and extension and additions to the leach field. This is based on the assumption that a number of permits issued for campground use will remain as is.

2. Under this set of alternatives, the first four suggestions put forth in Alternative A would be retained and the only change would be in the sewage collection and disposal system. Under this alternative, the waste collection facility as proposed would be constructed, but the comfort station would remain in its existing location and a new 4-inch pressure sewerline indicated

in figure 3 would be constructed. The effluent would be treated to approved state standards and piped into Garden Creek below the campground area. The type of sewage treatment system proposed, a packaged-activated sludge treatment plant, would appear to be the most viable form of treatment facility that might be constructed. Of the various types of activated sludge processes, the extended aeration-type plants would seem to be best, due to its better effluent quality and smaller accumulation of sludge. Accumulated sludge could be used for soil-building practices in the area below the present campground. Such a plant would match that proposed in Alternative C-2 for Phantom Ranch. The presence of two compatible treatment plants would greatly facilitate maintenance operations.

3. The further refinement of the activated sludge treatment process with a tertiary treatment mode would, if maintenance problems could be worked out, be an even better alternative. This would eliminate the deposition of nutrients such as nitrogen and phosphorus into Garden Creek and the subsequent chance of its beginning stages of eutrophication.

4. Because of its location and high visibility from the South Rim, treatment practices which employ lagoons, either oxidative or mechanically aerated, are not considered to be feasible solutions here.

IX. CONSULTATION AND COORDINATION WITH OTHERS

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APPENDIXES

APPENDIX 1

VEGETATION OF THE INDIAN GARDENS AREA

I. **Desert-shrub Tonto Plateau:**

blackbrush *(Coleogyne ramosissima)*
desert thorn *(Lycium pallidum)*
bursaye *(Franseria erioccentra)*
agave *(Agave utahensis)*
narrowleaf yucca *(Yucca angustissima)*
pricklypear cactus *(Opuntia* sp.)
white brittlebrush *(Encelia Frutiscens)*
Sacred datura *(Datura meteloides)*
milkvetch *(Astragalus* sp.)

II. **Riparian Indian Gardens:**

cottonwood *(Populus fremontii)*
narrowleaf willow *(Solix exiqua)*
Dudley willow *(Solix goodingii)*
catclaw *(Acadia greggii)*
mesquite *(Prosopis juliflora)*
blackberry bush *(Rubus* sp.)
California scrub oak *(Ouercus dumosa)*
blackbrush *(Coleogyne ramosissima)*
pricklypear cactus *(Opuntia* sp.)

APPENDIX 2

FAUNA OF INDIAN GARDENS AREA

I. **Mammals:**

White-tailed antelope squirrel *(Ammospermophilus leucurus)*
cliff chipmunk *(Eutamias dorsalis)*
canyon mouse *(Peromyscus crinitus)*
cactus mouse *(Peromyscus erimicus)*
Desert wood rat *(Neotoma lepida)*
white throated wood rat *(Neotoma albigula)*
bighorn *(Ovis conadensis)*
desert shrew *(Notiosorex crowfordi)*
Ord's Kangaroo rat *(Dipodomys ordii)*
Silky pocket mouse *(Perognathus slavus)*
spotted skunk *(Spilogale putorius)*
rock squirrel *(Citellus variegatus)*
spotted ground squirrel *(Citellus spilosoma)*
Gunnison's prairie dog *(Cynomys gunnisori)*
black-tailed jackrabbit *(Lepus californicus)*
short-tailed grasshopper mouse *(Onyclomys leucogaster)*

II. **Reptiles**

chuckwallow *(Sauromaleus obesus)*
collored lizard *(Crotaphytus colloris)*
striped whipsnake *(Masticophis vaeneatus)*
western rattlesnake *(Crotalis viridis)*
Grand Canyon rattlesnake *(Crotalis viridis abysisus)*
common kingsnake *(Lampropeltis getulus)*
gopher snake *(Petuophis melano leucus)*
Western ground snake *(Sonora semi-annulatoa)*

banded gecko *(Coleonyx variegatus)*
tree lizard *(Uta ornata)*
fence lizard *(Sceloporus undulatus)*
desert spiny lizard *(Sceloporus magister)*
Western whiptail *(Cnemidophorus tigris)*
Plateau whiptail *(Cnemidophorus velox)*

III. **Amphibians:**

red spotted toad *(Bufo punctatus)*
canyon tree frog *(Hyla arenicolor)*

IV. **Birds:**

chipping sparrow *(Chlorura)*
green-tailed towhee *(Chlorura)*
scrub-jay *(Aphelocoma coerulescens)*
grey-headed junca *(Junco caniceps)*
canyon wren *(Catherpes mexicanus)*
violet greenswallow *(Tachycineta thalassina)*
desert sparrow *(Amphispiza nevadensis)*
house finch *(Carpodacus mexicanus)*
raven *(Corvus corax)*
pinion jay *(Gyminor hinus cyanocephalus)*