CAPACITY ANALYSIS/WATER MANAGEMENT ALTERNATIVES
SOUTH RIM DEVELOPED AREA
GRAND CANYON NATIONAL PARK

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Indian Gardens Alternatives

Water travels through the Transcanyon Pipeline at the rate of 700 gpm and arrives at the Indian Garden pump station with a residual pressure of approximately 200 psi. The receiving reservoir holds 70,000 gallons of water and functions to collect and settle the sediment load brought over from Roaring Springs. Because the tank is open to the atmosphere, the system loses the residual pressure contained in the Transcanyon line. Either of the two 600-horsepower centrifugal pumps, although presently unable to utilize the 200 pounds pressure, boosts the water against an elevation head of 3,272 feet to the South Rim at a rate of 460 gpm or 420 gpm, depending on which pump is operating. The remaining 250 gpm returns to the Colorado River via Garden Creek. Both this inefficient use of available pressure and damage suffered by the pipeline due to corrosion from sand and silt have prompted work to commence soon at the Roaring Springs outflow to install a settling reservoir and a series of desanders. The Indian Gardens Pipeline is considered to be in fairly good shape and, historically, has performed with very few problems. Constructed in 1934, it is a 6-inch steel line with "Victualic" couplings, which, in recent years, have begun to leak at the joint gaskets. There is an urgent need to inspect the entire line and repair the weak spots, replacing gaskets and hangers as required. This line has a design capacity of 700 gpm at the maximum allowable velocity of 7.9 ft./sec.

The following alternatives do not consider the need for additional power to the pumps at Indian Gardens should the pumping capacity be increased. Depending upon the power requirements, the expense of extending additional lines to Indian Gardens could be substantial.

The alternatives which would add Indian Gardens water sources to the Transcanyon Pipeline supply would all require treatment of the water prior to mixing it with the previously treated supply from Roaring Springs. The development of treatment facilities at Indian Gardens could result in considerable expense to construct and operate.

I. Utilize Residual Pressure

Upon completion of the project on the North Rim to desand Roaring Springs water, it would be possible to connect the Transcanyon Pipeline directly to the Indian Gardens line. Consequently, the 200 pounds residual pressure arriving at the pumps can be used to great advantage, boosting the current pump capacity from an approximate 450 gpm flow rate to one of 500-530 gpm. The corresponding velocity through the Indian Gardens Pipeline would equal 5.7 ft./sec., which falls within the limit imposed and assures that the capacity and condition of the line is sufficient

without adjustments. By 2000, 19,000 day-visitors per day or 3.0 million per year could be accommodated with this supply and an additional 11.2 million gallons of equalization storage.

It should be emphasized that there is a major problem associated with the utilization of residual pressure. When the pumps shut down suddenly due to loss of power, the shock or water hammer ripples across the entire canyon and has the potential to blow weak sections of the line. To prevent line damage, two actions are required. The pipeline must be strengthened as it is repaired or replaced and the pumps must be modified to eliminate the water hammer.

II. Use Additional 250 gpm Overflow

Any proposition at this time to make use of the extra 250 gpm which overflows into Garden Creek from the settling tank assumes the park's legal right to it. If future water demands and public pressure to permit more day-visitors warrant a greater flow to South Rim Village, the existing 6-inch Indian Gardens Pipeline could deliver a rate of 700 gpm at the maximum allowable velocity of 7.9 ft./sec. Pumping capacity, however, would require the addition of another 250 horsepower pump or replacement of the existing pumps. After performing the necessary calculations and dependent upon maintaining reclaimed water use as now, day-visitation capacity figures for the years 1976 and 2000 are 56,200/day and 18,400/day, respectively.

III. Use 250 gpm Overflow Plus Garden Creek Supply

Water production could be increased, while retaining the existing condition and operation of the Transcanyon Pipeline, by not only completely utilizing the 700 gpm that arrives at Indian Gardens from Roaring Springs but also incorporating the approximate 200 gpm, potentially available at Indian Gardens, into the supply system. Contamination problems at Indian Gardens and methods for collecting the water are discussed in the following section. This combined total of 900 gpm doubles the present flow up to South Rim Village so, in turn, the additional utilities needed to transport this water would be equivalent to a duplicate of what is used now. Another 6-inch pipeline to the rim as well as another 600 horsepower pump would be installed, and then the water from Indian Gardens would require an equalizing pressure boost before entering either of the two lines. Access to the Indian Gardens supply will be contingent upon approved treatment of and protection from sources of pollution and whether or not the sentiment to return the environment in question to its state prior to the Transcanyon line is positive or negative. A flow of 900 gpm could accommodate 54,200 day-visitors per day or 19.8 million in the year 2000 with no storage required.

Summary of Potential Water Supply Combinations

Alternatives	gpm	Potential Supply Combinations 1	2	3	4	5	6	7	8	9
Existing Trans-Canyon Pipeline 6" & 8" Pipe	700			700	700			700	700	
Present Maximum Pump Rate	460	460								
Pump Rate Using Residual Pressure at Indian Gardens	500		500							
Expand Transcanyon Pipeline to 8" & 10" Pipe	1,200					1,200	1,200			1,200
Construct Second Transcanyon Pipeline 6" & 8" Pipe	700							700	700	
Construct Second Transcanyon Pipeline 8" & 10" Pipe	1,200									1,200
Indian Gardens Source	200				200		200		200	200
Total Gallons Per Min.		460	500	700	900	1,200	1,400	1,400	1,600	2,600
Annual Supply in Millions of Gallons @ 83% Pumping Rate		200.67	218.12	305.37	392.62	523.50	610.75	610.75	698.00	1,134.24

Column 1 is existing capacity (maximum)
Columns 2-9 assume residual pressure is used at Indian Gardens
Columns 3-9 require additional pumping capacity at Indian Gardens
Columns 4-9 require additional pipelines from Indian Gardens to the South Rim
OTHER SUPPLY COMBINATIONS ARE, OF COURSE, POSSIBLE

Indian Gardens Water Supply Quality Enhancement Alternatives

Prior to construction of the Transcanyon Pipeline in 1970 and the use of Roaring Springs as a source of water for the South Rim, the park's only supply of potable water was from Garden Creek and Springs, located at Indian Gardens. Protection against contamination from human contact, the mule corral and leach field seepage was not ensured, since regulations as to these concerns had not yet been established by the Federal Water Pollution Control Act of 1972. One report, containing a water quality analysis of the Indian Gardens source, was in April of 1964 and is included in CH_2M & Hill's study of Grand Canyon's water resources (1973): hardness was found to be 226 mg/1 $CaCO_3$, the pH was 7.5, and total dissolved solids was 241 mg/1. Past operation of the system included a series of underground collector pipes (places in aquifers through which water traveled to wells) to which was added water gathered by a small dam far enough downstream to catch the majority of the surfacing flow. The total quantity being pumped up to the rim was a rate of approximately 180-200 gpm against a head of 3,272 feet. Settling of solids and chlorination was the treatment applied to the water before potable use. Any modern proposal for the supplemental use of the Indian Gardens water source must take into serious consideration pertinent legislation regarding the quality of the water and its protection from contamination.

I. Remove All Development from Indian Gardens (except pipeline and pumphouse)

This alternative though rather extreme, would mean the elimination of park staff support facilities, the campground, comfort station, and mule corral. The Transcanyon and Indian Gardens Pipelines and pumphouse would, of course, remain, as would the Bright Angel Trail to the canyon floor. Removal on this scale would significantly reduce production of animal and human effluent, both dangerous as pollutants, and would leave only the threat of human contact by weary hikers with which to deal. A type of barrier vegetation, even perhaps the extension of the existing blackberry bushes, could be planted to discourage hikers. The use of fencing with accompanying foliage to camouflage this obstruction could also be employed. Environmental integrity should be maintained in this area while safekeeping this potential clean water source. Provisions for canyon hikers, under this plan, would be limited to the present resthouses and a fountain or resthouse at Indian Gardens and overnight camping at Phantom Ranch only. This alternative conflicts with the approved General Management Plan for the park which endorses continuation of visitor services at Indian Gardens.

OTHER SUPPLY COMBINATIONS ARE, OF COURSE, POSSIBLE

II. Relocate Facilities Away from Water Supply

Under this alternative developments at Indian Gardens need not be removed completely but simply relocated to a more favorable area of some distance from the water supply. One possible location, described by John Carollo Engineers in 1972, was to transfer the mule corral, campground, comfort station, and park staff quarters to a level plot on the east slope of the streambed. This site is greater in area and at a safe distance from the water supply; although it is above two of the three spring catchment areas at Indian Gardens. One disadvantage is the absence of trees for shade and the apparent inability of the dry soil to support trees if planted. John Carollo Engineers proposed a wastewater treatment plant of nominal size to produce irrigation water that would be distributed by shallow open ditches. Water for vegetation might also be provided through a dual septic tank and leach field system in which the effluent lines are spread beneath the new developed areas. Plants and trees can thrive on such nutrient-laden moisture, though problems could arise from roots clogging the pipe perforations. If it is desired, this could be avoided - irrigation lines could surface at the plant itself. The bubbler outlets should be located in obscure places, hidden from view, and the water should be chlorinated in case of human contact. Particular information concerning size and placement of facilities can be obtained from the Wastewater Treatment Facilities Study, Grand Canyon National Park, Indian Gardens and Phantom Ranch, by John Carollo Engineers, 1972. The environmental consequences of such a move are the return of the presently impacted zone to more natural conditions, whereas the reverse process occurs on the proposed development site. Assurance against contamination of Garden Creek must be furnished as described previously, since the refreshment this water can offer a weary hiker is luring indeed.

This alternative would need further study to assure that water sources would be adequately protected and that archeological sites are not adversely affected. The alternative is generally in compliance with the concepts in the General Management Plan for the park.

III. Treat Indian Gardens Water Before Use

Under this alternative the current status of the Indian Gardens complex would be maintained, allowing all facilities to remain, if water stored in the catchment can be adequately treated. Treatment would have to be supplied at Indian Gardens since water is supplied to spigots at rest stops along the Bright Angel Trail. Treatment would comprise settling of solids, filtration, and chlorination.

In producing an additional potable water supply of 200 gpm, another pump capable of lifting this quantity to the rim would be required. A study

of feasible locations for this water treatment utility would be necessary, as would appropriate points of connection into the distribution system.

IV. Construct Underground Catchment Upstream of Facilities

Groundwater flow on the South Rim is directed into the Bright Angel fault zone by the regional slope of the subsurface topography. This water feeds the springs and creek at Indian Gardens, which then assimilates the overflow from the Transcanyon Pipeline and joins the Colorado River at the canyon floor. The alternative here is to protect this source from contamination by collecting and storing the water underground and upstream of all development. A widespread system of perforated inlet pipe would be laid according to guidelines established by appropriate research and testing performed prior to installation. By conducting experimentation relating to the quality and characteristics of the soil and water, placement of the receiving and storage systems would be certain to accumulate the maximum supply available. Water quality should be such that minimal treatment before distribution would be necessary. Settling of solids would occur in the underground holding tank previous to being pumped for distribution. And in contrast to the water collected above surface and downstream of the support facilities, the chlorination process, in this instance, could be significantly reduced. present development would remain as is and chance of human contact eliminated. This alternative is considered preferable to other alternatives using surface water but requires further study to determine if the theory is in fact, practical. The environmental impacts would be substantial including disruption of normal subsurface water flows and extensive surface disturbance.

Distribution System Alternatives

The distribution system for the South Rim of the Grand Canyon, according to CH_2M & Hill, is inadequate in several major aspects of its operation. Specific problems will be discussed under the appropriate alternative, although particular attention should be given to the matter of unaccounted water. Information received from park staff confirms an annual production figure of 155 million gallons of water entering the distribution system and a total use figure of 127.8 million gallons, which does not include reclaimed water and was computed directly from 1976 meter records. This difference of 27.2 million gallons in what was produced and what was metered verifies the percent of water left unaccounted for, calculated by CH_2M & Hill in 1972, at 19 percent. In part, this unaccounted water can be explained by non-metered services, such as testing, flushing, and fire protection. However, the opinion of park personnel reasons that a majority of the loss is due to leakage, estimating that escapes through pipe failures equal 20.0 million gallons per year or 38 gallons per minute. The amount of 155 million gallons per year over the rim represents a pumping schedule of 240 days at 450 gpm or 256 days at 420 gpm.

I. Lay Additional Mains as per CH_2M & Hill

In their report of 1973, CH_2M & Hill did an extensive study of the Grand Canyon Village distribution system, using mathematical models to simulate the performances of their alternatives. The final proposal recommended the laying of additional distribution mains in both the upper and lower pressure zones in order to create an entire loop within the grid system. Not only would this eliminate dead ends currently hindering flow, but fire flows would be increased and residual pressures during peak demand times improved. A mention of investigating for and repairing existing leaks was not included in their publication; however, we consider such action as most advantageous if it is the purpose of the park to maximize its resources. The unaccounted water due to leakage, perhaps being as high as 20 million gallons per year, would enhance the park's peak daily water supply by 55,000 gallons and serve an additional day population of 8,500 guests. Details outlining this plan can be obtained from the CH_2M & Hill study of Grand Canyon's water supply.

II. Lay All New Potable System

Installing a new, complete potable water distribution system could solve several of the primary deficiencies and failures affecting present operation. Leakage would cease with the use of new pipe plus expansion of the reclaimed distribution system would be substantially simplified by adopting the old potable lines to be used for non-potable utilities. The approved distribution mains must be easily identifiable, so that a plumber or serviceman could distinguish between potable and non-potable lines during any kind of hookup procedure. Some types of coding that would be acceptable are to utilize a completely different pipe material from what is used now, possibly aluminum or plastic; to use descriptive colors for good and bad water, such as green or red or corresponding symbols; or to cover with boards or plastic the trench bearing the new potable water lines. Because potential production of reclaimed water far exceeds demands at this time, the loss of this water through exfiltration from the old pipe would be of little consequence. Park and concessioner housing, lodge units, and other miscellaneous support facilities would require minimal effort to be connected into the non-potable system. To accomplish such a plan would involve a project of large-scale proportions, though the time and expense could be warranted if maximizing reclaimed water became a necessary practice or if deterioration of the pipe itself forced its replacement by a new line. The existing distribution system will have to be retired eventually, so construction now of improved mains could be economically advantageous, viewed in the light of rising construction and material costs.

III. Maintenance Improvements

The fresh water supply at South Rim Village could be appreciably increased by monitoring and controlling losses from the system. Inoperative and inaccurate water meters make any attempt at determining total park consumption almost futile. A program to test and repair faulty meters would improve not only recordkeeping but the authenticity of data based on these records. Too, cyclic maintenance to detect and repair leaks in the distribution mains would reduce waste by 20 million gallons of water per year. It seems the water rushes down fissures in the limestone layer and, consequently, is rarely seen on the surface. Such a program, drawn up by park staff to rehabilitate the entire 306,000 feet of mains, would extend over a 30-year period and require 270 man-days of labor per year. Common belief is that the joints and seals connecting the pipes, not the pipes themselves, are seriously worn and allowing the heavy losses. Water-saving plumbing fixtures would help conserve water, as would a campaign to promote reasonable water conservation habits. A combination of all or some of these proposals could contribute valuable water to the potable system and perhaps lessen the detrimental impacts at some related point in this system.

Reclaimed Water Alternatives

The reclamation of wastewater for non-potable uses on the South Rim of the Grand Canyon began with the operation of the wastewater treatment plant built by the Santa Fe Railroad Company in 1926. This water has traditionally been used for such purposes as flush water, car washing, and irrigation, supplying 7-10 percent of total potable water use or around 9.0 million gallons per year. In 1972 a new activated sludge treatment plant was constructed to replace the old plant and, now being located separately, the effluent diverted for reclamation must be pumped to the old facility for filtration and chlorination. These two latter processes constitute final treatment of the water before distribution for non-potable demands. While an average of 110 million gallons of wastewater are processed annually, only 9 million gallons are reclaimed. With minor modifications, the present facilities could reclaim virtually all of the wastewater, but major improvements to distribution and storage systems would be required in order to use the additional reclaimed water. The fresh water supplies, made available for potable purposes because of increased reclamation, are considered here as supplements to the primary supply. This means the additional day-visitation capacity attributed to the proposal assumes that base demands will be met by the primary supply.

I. Abandon Reclamation

Elimination of the reclamation plant would directly affect the potable water supply, since this system would be forced to accommodate those