

REPORT ON
WATER FACILITY REPAIR PROGRAM - PHASE II
SOUTH RIM
GRAND CANYON NATIONAL PARK

FOR THE NATIONAL PARK SERVICE
U.S. DEPARTMENT OF THE INTERIOR
CONTRACT NO. 14-10-0434-889
A MISSION 66 PROJECT

NOVEMBER 1962



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30 November 1962

Mr. Sanford Hill, Chief
Western Office
Division of Design and Construction
National Park Service
1000 Geary Street
San Francisco 9, California

Dear Sir:

Our report on the water facility repair program conducted at Grand Canyon National Park in accordance with our Contract No. 14-10-0434-889 is submitted herewith.

Maps showing the location of water mains within the area studied under this contract and the area studied under our previous Contract No. 14-10-0434-845 are combined into a single set of maps. The set of maps which is numbered NP-GC-3530A and a set of gate valve reference sheets are submitted under separate cover.

Very truly yours,

KENNEDY ENGINEERS

Robert M. Kennedy

RMK:fb
Encs.



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PLATE

1	MAP OF WATER DISTRIBUTION SYSTEM - PHASE I AND PHASE II AREAS
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INTRODUCTION

A leak survey and construction repair program was completed for a portion of the South Rim Water System at Grand Canyon National Park in December 1961. This project is referred to in this report as Phase I.

The Phase I project was recommended in the Kennedy Engineers report of June 1961 entitled "Water Survey for Grand Canyon National Park". Results and discussion of the Phase I project are presented in Kennedy Engineers report of January 1962 entitled "Report on Water Facility Repair Program for South Rim Grand Canyon National Park".

The results of the Phase I project in eliminating water leaks in the portion of the water system investigated indicated that it was feasible to locate and eliminate leaks in the other portions of the existing water system. National Park Service records indicated substantial quantities of remaining water loss in the unrepaired balance of the water system following the Phase I construction repair project. The Phase I construction repair project reduced measured loss from 2.49 million gallons per month to 0.42 million gallons per month within the project area, a reduction of 95 percent.

In May 1962, Kennedy Engineers was authorized to conduct an additional leak survey and supervise a construction repair program for the remaining portion of the original South Rim water system which was not included in the Phase I project. This project is referred to in this report as Phase II.

The water mains constructed during the past several years to serve new residential and service areas were not included in either the Phase I or Phase II program because it was considered that there was no significant leakage in this portion of the system.

The Phase II leak survey and construction repair program was completed in September 1962.



FINDINGS AND CONCLUSIONS

- (1) Water leakage of 2,170,000 gallons per month was found in the water system within the Phase II study area.
- (2) Construction repairs of leaks within the Phase II area resulted in the elimination of 2,110,000 gallons per month of water leakage, a 97 percent reduction in water loss in the water system within the project area.
- (3) Two unmetered services and two services metered twice were found. These conditions were corrected by construction repairs. The quantity of water that was metered twice is approximately equivalent to the quantity that was unmetered, resulting in a negligible net loss.
- (4) Correction of a leak at the automatic sprinkler system valve at the El Tovar Hotel (water main Section 8 within the Phase I study area) resulted in the elimination of 40,000 gallons of water loss per month.
- (5) Total water loss eliminated during the construction repair work of Phase II project is approximately 2,150,000 gallons per month, including the 40,000 gallons per month eliminated in the Phase I area. This amounts to a total elimination of water loss of approximately 4,520,000 gallons per month as a result of both the Phase I and Phase II projects.
- (6) Most of the leakage found was at lead joints in cast iron pipelines.
- (7) Major pipeline joint leaks found were observed to be caused by improper calking of lead joints, improper bedding of pipe, improper backfilling of trenches or a combination of these causes.
 - (a) Some lead joints appear not to have been calked at the time of original construction.
 - (b) Large rocks with voids between them were observed above the pipe in many instances. This condition allows shifting of the backfill material which in turn could cause displacement of the pipe, and joint leakage.
 - (c) Several elbows and tees were found not to be properly braced against thrust. This condition could also allow displacement of the pipe and cause joint leakage.



- (8) Leaking lead joints observed were generally concentrated within certain sections of pipeline. There was no leakage or a negligible amount of leakage detected in many sections of pipelines. The leakage from several sections of pipelines was divided among several separate leaks at different locations. It appears probable that certain contractors or persons did a good job of original construction and others did not.
- (9) Initial measured leakage was less than 0.1 gallons per minute and required no corrective work in each of 31 of the 48 sections of water mains tested during the Phase I and Phase II construction repair programs. The measured leakage in each of another 7 sections requiring repair work was reduced through repairs to less than 0.1 gpm. The present remaining leakage after construction repairs from each of the other 10 sections is less than 0.5 gpm. Electronic leak detecting equipment is of limited value in locating leaks of less than 0.5 gpm.
- (10) Leakage rates from water main Sections 4 and 6, which were repaired during Phase I, have increased slightly since last December.
- (11) No external corrosion was observed on any of the cast iron pipe that was exposed.
- (12) Severe corrosion was observed on some of the old steel service lines exposed, particularly in valve boxes and meter boxes where the pipe is exposed to the atmosphere. Sawdust and other insulating materials placed in meter and valve boxes to prevent freezing tends to accumulate moisture in the presence of air and increase corrosion effect.
- (13) Indicated water loss from the Indian Gardens pump discharge main between Indian Gardens and the Bright Angel Lodge is 1.95 gpm as indicated by a pressure test. However, a portion or possibly all of this indicated loss could have been through the closed gate valve adjacent to the pump house. The gate valve was closed during the test, but a positive check on the watertightness of the valve closure was not feasible. Construction repair of the Indian Gardens pump discharge main was not within the scope of this project. However, loss of less than 2 gpm in this pipeline is not excessive, considering the long length of pipeline (2 miles) and the high pressures (to 1400 psi) involved. Construction repairs of this pipeline are not considered necessary.
- (14) Three water meter installations outside of the area of operations of this project are of doubtful adequacy. These installations are of interest to this project because metering accuracy affects the apparent water loss indicated by the Park Service's records. The three installations are as follows:



- (a) Two 4-inch Hersey Model T meters serve the Trailer Village. These meters will not accurately measure flows less than 20 gpm. Flows of less than 20 gpm are probably quite common in the Trailer Village.
- (b) A 1-1/2-inch Hersey Model HD meter bypassing a 6-inch Hersey Model DC detector check valve meters the water flow to the new Camp Ground. This installation will not accurately measure flow rates greater than 30 gpm. Considering the water using facilities in the Camp Ground, it is probable that rates of flow of 30 gpm are often exceeded. Based on a fixture unit analysis, the peak campground flow is estimated to be 180 gpm. While a flow of 30 gpm may not be exceeded during the winter, it is undoubtedly exceeded for at least short periods of time during summer peak flows.



RECOMMENDATIONS

- (1) When there are indications of increases in system leakage, establish a construction repair program of anchoring fittings and calking those lead joints in water main Sections 2, 4, 6, 11, 28, 29, 39, 45A, and 45B which were not uncovered and calked during the construction repairs under either Phase I or Phase II projects (the location of all joints calked during both Phase I and Phase II are shown in Tables 3 and 4). While the present remaining rate of leakage from each of these sections is less than 0.35 gpm these are felt to be the potential trouble areas as these sections and Section 44A accounted for most of the original measured leakage. All but 11 joints of Section 44A were calked during Phase II and the remaining leakage was reduced to 0.01 gpm. Fittings should be adequately anchored for thrust during the calking program.
- (2) Establish a schedule for periodically operating the new gate valves which were installed under the construction repair program. It is recommended that each new valve, including the valves at water meters, be fully closed and opened at least once every six months to provide reasonable assurance of continuous proper operation and watertight closure. Pressure tests if necessary can be made to determine leakage quantities.
- (3) Galvanized steel pipe should receive a protective coating of coal tar or suitable paint at all locations where the pipe is exposed to the atmosphere, particularly at meter boxes and valve boxes where insulating material such as sawdust is placed around the pipe.
- (4) Establish a program for replacing steel pipelines as necessary to prevent future leaks. The following pipelines should be observed periodically and replaced when necessary.
 - (a) During the Phase I construction repair program the northerly end of Section 9 was observed to be in poor condition. At least a portion of this section must be replaced during the next several years.
 - (b) The service pipelines connected to Section 11 were observed to be in poor condition.
- (5) Use rubber joint cast iron pipe for all water distribution system additions.
- (6) Install all future pipelines on well compacted select bedding and use select backfill to an elevation at least one foot over top of pipe.
- (7) Replace the existing 4-inch meters serving the Trailer Village and the 6-inch detector check valve serving the new campground with compound meters.



CONSTRUCTION

The 6-inch diameter cast iron pipeline under the elevated tank was connected to the 10-inch diameter cast iron pipeline near its junction with the 8-inch diameter asbestos-cement pipeline from the 7,000,000 gallon storage tanks. The 2-inch diameter steel pipeline near the Nurses' Dormitory (Building 24) was connected to the 6-inch diameter cast iron pipeline near the northerly corner of the Nurses' Dormitory at the point of intersection of the two lines. Both of these connections are between the originally separated domestic and fire systems which have not been operated separately for many years. These connections greatly increased flexibility of operation and permitted minimum areas of the Park to be removed from water service during the installation of gate valves and the testing operations.

New gate valves were installed in the existing pipelines to enable measurement of leakage by pressure testing and to sectionalize the pipelines for construction repair of leaks. The following new gate valves were installed:

Valve Size, inches	Number Installed		Total
	New Locations	Replacing Existing Valves	
1/2	0	51	51
3/4	1	71	72
1	3	7	10
1-1/4	0	4	4
1-1/2	2	6	8
2	4	18	22
3	0	1	1
4	1	2	3
6	7	15	22
8	2	1	3
10	1	0	1
12	2	0	2
Totals	23	176	199

Where possible, as in the Phase I construction repair program, the new gate valves were located to provide maximum flexibility of future water system operation. Most of the gate valves smaller than 2-inch size were installed adjacent to meters at water services to replace existing valves. The location of gate valves is shown on Plate 1 and on the set of drawings and valve reference sheets submitted with this report.



A 3-inch pressure relief valve set to relieve at 75 psi was installed on the 6-inch diameter Indian Gardens pump discharge pipeline to protect the pumps in the event of accidental closure of any of the several gate valves installed in the pump discharge main. The relief valve is located under the Bright Angel Lodge in the pipe tunnel. Locking devices were installed at all new gate valves in the Indian Gardens pump discharge main and at the new valves installed in the 12-inch pump suction main to the rehandling pump in the power house.

Taps were made in all of the pipeline sections for use during pressure tests. In most sections, 3/4-inch corporation stops were used. For future reference the location of pipeline taps in the Phase I area is shown in Table 1. These locations were not shown in the Phase I report. The location of taps in the Phase II area is shown in Table 2.

A 3/4-inch meter was installed at the Fred Harvey Maintenance Building where an unmetered service was found.

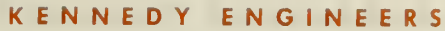
The meters were relocated at the Fred Harvey Men's Dormitory and the Fred Harvey Indian Men's Dormitory. The meters were moved from under the respective buildings to an outside location. The meter for the Indian Men's Dormitory as relocated also meters the flow to the boiler plant located between the two dormitories. The boiler plant service was originally found not to be metered. The relocation of the two meters simplified access for reading the meters.

The meter originally serving the National Park Service Fire Cache (Building 97) was removed. This meter had been also metering flows to one residence (Building 12), the Sign Shop (Building 95), and the Mule Barn (Building 95), which were also being metered at two other separate locations. The meter for the service to Building 12 is located adjacent to the building. The meter for the service to Buildings 95 and 98 was relocated to also meter the service to Building 97. The removal of one meter and the relocation of another meter eliminated the double metering of water.

The water system was simplified where practical during the course of the Phase II construction repair work.

The meter serving the campground west of the Fred Harvey Cafeteria was relocated. It was moved from under the cafeteria floor to an outside location and was connected to a 6-inch main. The meter had been connected to the previously metered cafeteria service system. The meter readings are no longer included in the readings of the meter serving the cafeteria. The relocation also simplified access for reading the meter.

Two abandoned detector check valves, one abandoned regulating valve, and three abandoned master meters were removed.





LOCATING AND EVALUATING LEAKS

Kennedy Engineers prepared a bill of material and a schedule of construction immediately after the project was authorized. Park Service forces began construction on 5 July 1962.

New gate valves were installed at locations required to sectionalize the water system and isolate leaks. Each section of the water system within the area of operations was pressure tested to determine the rate of leakage. Pressure tests were conducted both before and after construction repairs in order to evaluate the effectiveness of the construction repair work. The sections were tested at or near 100 psi. Measured leakage at test pressure was converted to leakage at average operating pressure based on the criteria that leakage varies in proportion to the square root of pressure.

The use of a microphone probe rod for direct contact with the pipe was not possible due to the rock backfill over the pipelines. It was necessary to uncover the pipelines at points where electronic leak detection readings were taken.

The pipeline trenches in the Phase II area are located in material less pervious than in the Phase I area near the Canyon rim. Water accumulated in the trench at most of the leaks found in the Phase II area. Water did not accumulate in the trench at the largest leak found during Phase I, 28.8 gpm. Most of the leaks found during Phase II construction were relatively small compared to those found during Phase I. The three largest leaks in the Phase II area were located near abandoned steam lines. In these three instances, the leakage escaped from the immediate areas of the leaks through terracotta steam line conduits, which were not watertight.

The equipment used for pressure testing enabled the measurement of pipeline leakage to within 0.01 gpm when the total leakage was less than 5 gpm and within 0.1 gpm when the total leakage was more than 5 gpm. All leaks found and eliminated except two were measured by pressure tests. A leak was found under the elevated tank at a location that was not practical to sectionalize and test. This leak was measured with the aid of a weir and found to be 1.8 gpm. Another leak was found while searching for the unmetered service to the Fred Harvey Maintenance Building. During the excavation the leaking service pipe was disturbed, which caused a leak through the service saddle gasket to increase to above an estimated 20 gpm. This occurred prior to the initial pressure test of the water main section involved. Therefore, it was not possible to measure the original leakage rate at the service saddle. The stream of escaping water had eroded the coal tar coating off the adjacent pipe and had polished the pipe to a brilliant shine. The original leakage rate from under the service saddle was estimated to be 10.0 gpm.



The total leakage measured in the Phase II area, including the estimated 10 gpm, was 50.3 gpm (2.17 million gallons per month). The total leakage reduction in the Phase II area was 48.8 gpm (2.11 million gallons per month). This amounts to a 97 percent reduction in leakage in the Phase II area.

During Phase II operations some leakage was eliminated from water main Section 8 in the Phase I area. Fred Harvey Operations repaired a leaking drain valve at the automatic sprinkler system valve in the El Tovar Hotel. This resulted in the elimination of 0.96 gpm of the 0.98 gpm measured during Phase I. Therefore, the total leakage eliminated during Phase II operations was 49.7 gpm (2.15 million gallons per month). The location of leaks repaired during Phase II are shown in Table 6. A summary of leakage evaluation data for Phase II is shown in Table 8. In order to provide all pertinent leakage data regarding the water facility repair program under a single cover, the locations of leaks repaired and a summary of leakage evaluation data for Phase I are shown in Tables 5 and 7 respectively.



ACKNOWLEDGMENTS

We express our appreciation for the cooperation received from the Park Engineer's staff and the maintenance personnel at Grand Canyon National Park. Mr. Waldo Wilcox, Park Engineer, and Mr. Nelson Short, Assistant Park Engineer, made every effort to coordinate the procurement of materials, the employment of manpower, and the execution of the work with the ever-changing requirements during the course of this unusual project.

We also express our appreciation to the many Park Service employees and families who were asked to do without water service for several hours on several occasions during the course of the project.



TABLE 1

LOCATION OF PIPELINE TAPS USED FOR TESTING - PHASE I

A 3/4-inch corporation stop is located within 3 feet of the designated valve unless otherwise indicated.

<u>Pipeline Section No.</u>	<u>Location of Taps</u>
1	W of Valve 11
2	S of Valve 8
3	N of Valve 9, SW of Valve 20 (2 corps)
4	NE of Valve 22
5	SW of Valve 19
6	NE of Valve 19
7	W of Valve 26
8	SE of Valve 23
9	Near meter in El Tovar Hotel - 3/4-inch gate valve
10	Near meter in Bright Angel Lodge - hose bib
11	E of Valve 6
12	N of Valve 43 - 3/4-inch plug in tee coupling
13	E of meter - Building 2 - 3/4-inch plug in tee coupling
14	E of Valve 39 - 3/4-inch plug in tee coupling
15	NE of Valve 39 - 3/4-inch plug in tee coupling
16	Santa Fe Depot Service - subsequently relocated
6-inch C.I. - 1961	E of Valve 46



TABLE 2

LOCATION OF PIPELINE TAPS USED FOR TESTING - PHASE II

A 3/4-inch corporation stop is located within 3 feet of the designated valve unless otherwise indicated.

<u>Pipeline Section No.</u>	<u>Location of Taps</u>
17	NW of Valve 71
18	5 feet S of Valve 1
19	26 feet E of Valve 4
20	S of Valve 79
21	W of Valve 118
22	W of Valve 48
23	N of Valve 81
24	E of Valve 75
25	S of Valve 49, S of Valve 84 (2 corps)
26	Abandoned service to reclaimed water tank
27	E of Valve 36
28	N of Valve 102
29	N of Valve 103
30	W of Valve 96
31	S of Valve 59
32	W of Valve 86
33	S of meter to Firehouse and Sign Shop - plugged tee
34	E of Valve 93
35	W of Valve 92
36	E of Valve 95
37	E of Valve 100
38	E of Valve 98
39	E of Valve 105
40	N of Valve 61
41	E of Valve 68
42A	W of Valve 68
42B	N of Valve 65
42C	W of Valve 64
43	7 feet S of S wall - Bright Angel Lodge
44A	N of Valve 69
44B	W of Valve 67
45A	2 feet S of Valve 1 in 12-inch main running diagonally over 6-inch main of Section 18
45B	SW of Valve 80
46	SW of Valve 51
47	W of Valve 52
48	In Plumbing Shop - hose bib



TABLE 3

LOCATION OF JOINTS UNCOVERED AND CALKED - PHASE I

Section No.	Reference Points		Joints Calked	
	Station	Description	* Station	Remarks
1 Left	0 + 00	Valve No. 12	1 + 71 to 2 + 33	
2	0 + 00	Valve No. 2	0 + 16 to 0 + 94	Opposite joints in Section 11 also calked
	2 + 81	S face of rock wall		
	3 + 19	Valve No. 8	2 + 60	
			3 + 09	Plugged tee in Section 5
			3 + 11	Plugged tee
4 and 6	0 + 00	Valve No. 22	1 + 50	
	3 + 68	Angle point near NW corner Hopi House	3 + 46 to 4 + 02	
			5 + 46	
			5 + 78	
	5 + 23	Hydrant near SW corner Hopi House	6 + 75	
	6 + 14	Valve No. 25	6 + 89	
	9 + 17	Hydrant near Superintendent's Residence	7 + 21	
			7 + 53	
			7 + 85 to 8 + 97	
	10 + 65	Valve No. 32		
6			7 + 01	Tee
			44', 50' and 66' NE	
			of 10" main in 6"	
			line to hydrant near Verkamp's	

Note: Pipe lengths in Sections 1 Left, 2, 4, and 6 are generally 16 feet.

* These stations are approximate. The measurements were made during Phase II nine months after the openings were backfilled.



TABLE 4

LOCATION OF JOINTS UNCOVERED AND CALKED - PHASE II

Section No.	Reference Points		Joints Calked		Remarks
	Station	Description	Station		
28 & 29	0 + 00	Valve No. 32	1 + 18		Tee
	10 + 32	Tee to domestic services	1 + 23		Elbow
			1 + 51		
	12 + 81	Valve No. 102	2 + 18		
			2 + 66		
			3 + 14		
			3 + 62 to 4 + 27		
			4 + 91		
			5 + 39		
			5 + 87		
			6 + 34 to 6 + 66		
			7 + 15		
			7 + 63		
			8 + 10		
39			10 + 78		
	0 + 00	Valve No. 105	0 + 58		Elbow
	0 + 20	Angle point	0 + 92		
	3 + 36	Tee to hydrant	1 + 07		
	8 + 23	Tee to hydrant	1 + 23		
			1 + 40		
			1 + 88		
			2 + 04		
			2 + 11 to 2 + 75		
			3 + 09		
			3 + 25		
			3 + 49		East end of elbow
			3 + 54		
			3 + 76		
			3 + 92		
			4 + 23 to 5 + 41		
			6 + 91		
			7 + 24		

Note: Pipe lengths in Sections 28, 29, and 39 are generally 16 feet.



TABLE 4 - (Cont'd.)

LOCATION OF JOINTS UNCOVERED AND CALKED - PHASE II

Section No.	Reference Points		Joints Calked		Remarks
	Station	Description	Station		
44A	0 + 00	Valve No. 55	0 + 00 to 7 + 65		
	2 + 07	Opposite power pole near SW corner of laundry	8 + 01 8 + 37 8 + 73		
	3 + 19	Angle point	9 + 09 to 12 + 11		
	3 + 80	Angle point	12 + 58 to 14 + 69		
	4 + 61	Opposite valve No. 52			
	12 + 26	Tee near valve No. 67			All joints were calked except at stations 7 + 77, 7 + 89, 8 + 13, 8 + 25, 8 + 49, 8 + 61, 8 + 85, 8 + 97, 12 + 26 (tee), 12 + 34, and 12 + 46
	13 + 27	Angle point			
	14 + 69	Valve No. 69			
45A	0 + 00	Angle point 38 ft W of SE corner of Power House	0 + 00 to 2 + 41 2 + 65 2 + 77		
	1 + 53	Center line of double RR tracks	3 + 80 5 + 00		
	2 + 91	Angle point	5 + 61		
	5 + 98	Tee to hydrant	6 + 05		
	8 + 13	Valve No. 80			
45B	0 + 00	Valve No. 80	0 + 62		
	3 + 12	Centerline of MH at SW corner of A and D Streets	4 + 19 4 + 67 5 + 16		
	5 + 04	Angle point at SE corner of MH	5 + 40 5 + 93 to 6 + 29		
	5 + 58	Opposite valve No. 71			
	6 + 44	Valve No. 70			

Note: Pipe lengths in Sections 44A, 45A, and 45B are generally 12 feet.



TABLE 5
LOCATION OF LEAKS REPAIRED DURING PHASE I

<u>Pipeline Section No.</u>	<u>Station or Location</u>	<u>Description</u>	<u>Leakage gpm</u>
1	1 + 87 Left	Lead joint	0.92
2	---	Six lead joints recalked between Stations 0 + 00 and 1 + 10	0.88
4	1 + 50	Lead joint	3.00
	8 + 33	Lead joint	13.1
	6 + 57	Lead joint	2.35
6	50 feet NE of 10-inch diameter main in 6-inch diameter pipeline to fire hydrant near Verkamp's - lead joint		28.75
11	Valve No. 5	Valve packing	5.02
16	Service to A. T. & S. F. Depot - abandoned and replaced		0.83
	Total leakage eliminated during Phase I		54.85



TABLE 6

LOCATION OF LEAKS REPAIRED DURING PHASE II

<u>Pipeline Section No.</u>	<u>Station or Location</u>	<u>Description</u>	<u>Leakage gpm</u>
28	4 + 19	Lead joint	0.34
	6 + 48	Lead joint	0.36
29	4 + 35	Lead joint	0.12
	10 + 76	Lead joint	1.59
30	Gate valve at fire hydrant near water truck loading standpipe - valve packing		0.11
39	1 + 23	Lead joint	0.64
	2 + 27	Lead joint	0.45
	5 + 11	Lead joint	0.43
41	Service to Fred Harvey Maintenance Building - gasket under service saddle		*10.0
42C	Fire hydrant near SE corner of Fred Harvey Cafeteria - hydrant valve		3.89
44A	0 + 29	Lead joint	0.16
	2 + 20	Lead joint	0.79
	2 + 93	Lead joint	0.36
	4 + 77	Lead joint	12.9
	7 + 14	Lead joint	0.28
45A	1 + 26	Lead joint	0.05
	1 + 38	Lead joint at 90° elbow	0.7
	1 + 56	Lead joint	1.8
	1 + 79	Lead joint	11.6
	2 + 27	Lead joint	0.04
45B	5 + 93	Lead joint	0.09
	6 + 29	Lead joint	0.26
---	Under elevated tank - lead joint		<u>1.8</u>
	Total leakage eliminated in Phase II area		48.76
8	Phase I area - drain valve for automatic sprinkler system at El Tovar Hotel		<u>0.96</u>
	Total leakage eliminated during Phase II		49.72

* Estimated



TABLE 7

SUMMARY OF LEAKAGE EVALUATION DATA - PHASE I

These data are taken from Table 1 of "Report on Water Facility Repair Program for South Rim Grand Canyon National Park" dated January 1962. Loss rates are expressed in terms of gallons per minute (gpm) rather than gallons per hour (gph) as indicated on Table 1 of the January (Phase I) report.

Section No.	Location	Pipeline Size in.	Pipeline Length ft.	Initial Loss Rate gpm	Loss Rate After Repairs gpm	Estimated Savings gpm
1	Near B.A. Lodge	8 6	850 1300	0.92	0.00	0.92
2	P.H. - B.A.	6	320	1.35	0.47	0.88
3	B.A. - El Tovar	6	760	0.01	0.01	---
4	El Tovar - R.R.	6	1065	18.6	0.15	18.45
5	P.H. - El Tovar	8 10	760 210	0.02	0.02	---
6	El Tovar - R.R.	8 10	475 590	29.1	0.35	28.75
7	Rear of El Tovar	8 6	600 180	0.03	0.03	---
8	Front of El Tovar	8	130	0.98	*0.98	---
9	El Tovar Service	4 3	180 210	0.32	0.32	---
10	B.A. Service	4	250	0.01	0.01	---
11	Near P.H.	10 6 3/4	160 380 365	5.44	0.42	5.02
12	Near Res. 24	2 1-1/2	130 220	0	0	---
13	Near Hospital	1-1/2 1	80 440	0	0	---
14	Near Res. 3, 4, & 5	2 1	100 430	0	0	---
15	Near Res. 9	2 3/4	140 250	0	0	---
16	A.T. & S.F. Service	1	370	0.83	**0	0.83
Totals				57.61	2.76	54.85

Total water loss measured during Phase I = 57.61 gpm = 2.49 mg per month
 Total water loss eliminated during Phase I = 54.85 gpm = 2.37 mg per month

* Loss of 0.96 gpm was eliminated from Section 8 during Phase II

** Section 16 was abandoned and a new service to A.T. & S.F. was installed.



TABLE 8

SUMMARY OF LEAKAGE EVALUATION DATA - PHASE II

Section No.	Location	Pipeline Size in.	Pipeline Length ft	Initial Loss Rate gpm	Loss Rate After Repairs gpm	Estimated Savings gpm
17	F.H. Caf. service	8 4	460 50	0.06	0.06	---
18	D St. - A St. to P.H.	6	1050	0.04	0.04	---
19	P.H. to Babbitts Store	6 1	1140 160	0.07	0.07	---
20	D St. S of A St.	6 1	960 50	0.02	0.02	---
21	Tent City service	2 1-1/2	1140 260	0	0	---
22	A Street	6	1220	0	0	---
23	N side of A St.	2 3/4	910 410	0.01	0.01	---
24	S side of A St.	2 3/4	1020 790	0	0	---
		6 2	1870 310			
25	B Street	1 3/4 1/2	330 40 170	0.01	0.01	---
26	Abandoned fresh water service to reclaimed water tank					
27	Nr. F.H. Garage	6 3/4	790 130	0.03	0.03	---
28	Elev. Tank to R.R.	6 4	1280 140	1.04	0.34	0.70
		10	1280			
29	Elev. Tank to R.R.	8 6	70 50	1.89	0.18	1.71
30	Near NPS Shops	6	1300	0.19	0.08	0.11
31	Near Residence 11	2	360	0	0	---
32	N of NPS Shops	2 3/4	560 100	0	0	---
34	NW of Elev. Tank	2 3/4	120 400	0	0	---



TABLE 8 - (Cont'd.)

SUMMARY OF LEAKAGE EVALUATION DATA - PHASE II

Section No.	Location	Pipeline Size in.	Pipeline Length ft.	Initial Loss Rate gpm	Loss Rate After Repairs gpm	Estimated Savings gpm
35	NW of Elev. Tank	2 3/4	480 340	0	0	---
36	Near Res. 19 & 27	2 1 3/4	840 230 320	0	0	---
37	Near Res. 29 & 49	2 1-1/2 3/4	880 350 550	0	0	---
38	Near Res. 28	6	910	0.02	0.02	---
39	SE of Elev. Tank	6 4 2	920 180 150	1.77	0.25	1.52
41	Nr. Laundry & Men's Dorm.	8 6	530 960	10.02	0.02	*10.0
42A	E of F.H. Cafeteria	6	560	0	0	---
42B	N of F.H. Cafeteria	6	430	0	0	---
42C	S of F.H. Cafeteria	6	1270	3.89	0	3.89
43	I.G. Disch. - B.A. to P.H.	6	510	0	0	---
44A	I.G. Disch. - P.H. to Tank	8 6	250 1220	14.5	0.01	14.49
44B	R.R. Unloading Pump Discharge	8	210	0.06	0.06	---
45A	Community Bldg. - P.H.	12	810	14.4	0.21	14.19
45B	Tanks - Community Bldg.	12	640	0.45	0.10	0.35
46	Serv. to F.H. Men's Dorm.	4	70	0	0	---
47	Fire Serv. to Indian Men's Dorm.	6 4	80 150	0	0	---
--	Under Elev. Tank	10	---	<u>1.8</u>	<u>0</u>	<u>1.8</u>
Totals - Phase II area				50.27	1.51	48.76

* Estimated



TABLE 8 - (Cont'd.)

SUMMARY OF LEAKAGE EVALUATION DATA - PHASE II

Total water loss measured in Phase II area = 50.27 gpm = 2.17 mg/mo.

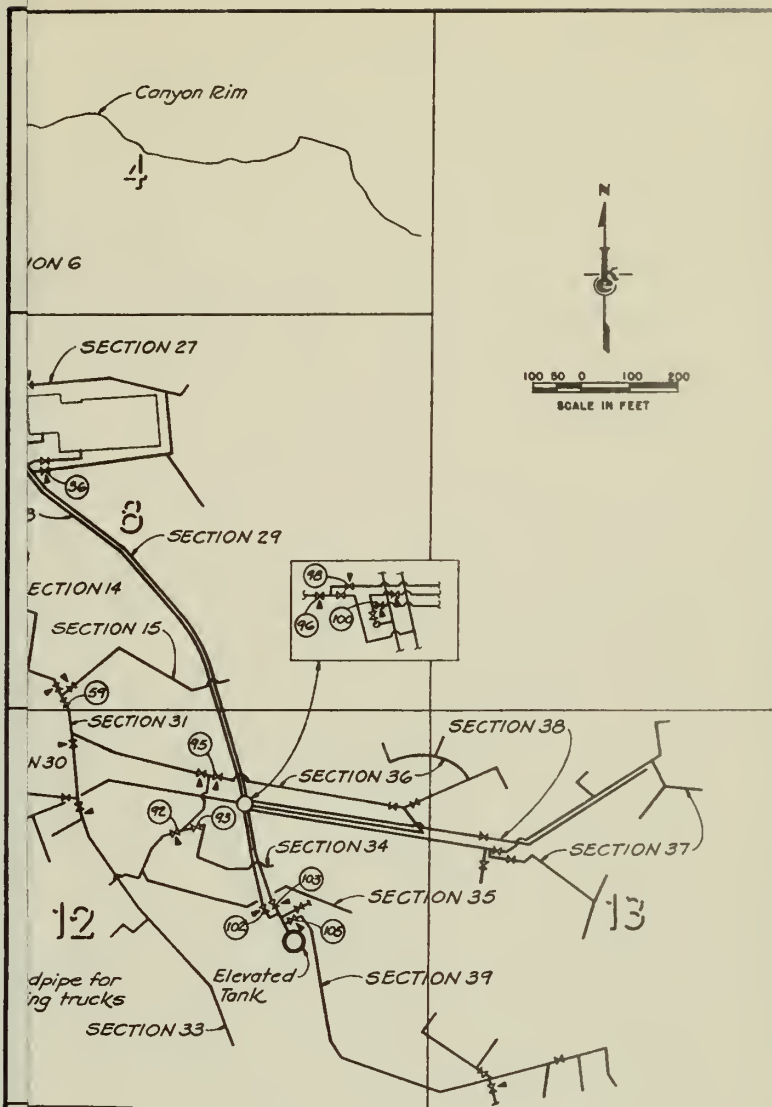
Total water loss eliminated in Phase II area = 48.76 gpm = 2.11 mg/mo.

Section No.	Location	Pipeline Size in.	Pipeline Length ft.	Metered Sections		Estimated Savings gpm
				Initial Loss Rate gpm	Loss Rate After Repairs gpm	
33	Service to Sign Shop	3/4	680	0	0	---
40	Campground W of Cafeteria	1	1160	0.14	0.14	---
		3/4	730			
48	Serv. to NPS Shops	2	500	0.03	0.03	---
		1	160			
		3/4	170			

Additional Leakage Eliminated from Phase I Area:

8	Front of El Tovar	8	130	0.98	0.02	0.96
---	-------------------	---	-----	------	------	------

Total water loss eliminated during Phase II = 49.72 gpm = 2.15 mg/mo.



LEGEND

- domestic water pipeline
 - valve and valve number
 - indicates limit of pipeline sections
 - of number of
 drawing no. NP-GC-3530A

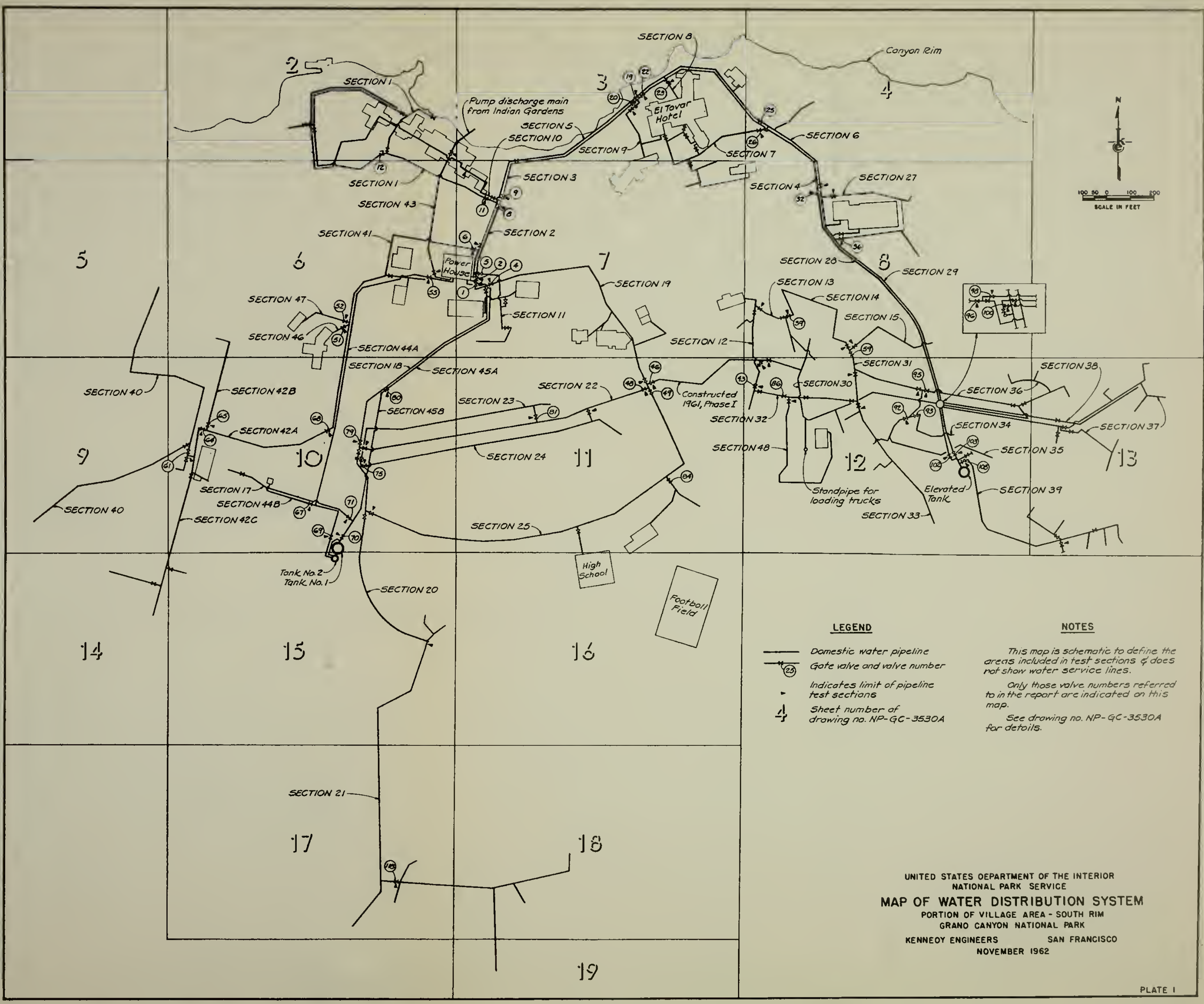
NOTES

This map is schematic to define the areas included in test sections & does not show water service lines.

Only those valve numbers referred to in the report are indicated on this map.

See drawing no. NP-GC-3530A for details.

UNITED STATES DEPARTMENT OF THE INTERIOR
 NATIONAL PARK SERVICE
MAP OF WATER DISTRIBUTION SYSTEM
 PORTION OF VILLAGE AREA - SOUTH RIM
 GRAND CANYON NATIONAL PARK
 KENNEDY ENGINEERS SAN FRANCISCO
 NOVEMBER 1962



LEGEND

- Domestic water pipeline
- Gate valve and valve number
- Indicates limit of pipeline test sections
- Sheet number of drawing no. NP-GC-3530A

NOTES

This map is schematic to define the areas included in test sections & does not show water service lines.

Only those valve numbers referred to in the report are indicated on this map.

See drawing no. NP-GC-3530A for details.

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MAP OF WATER DISTRIBUTION SYSTEM
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