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March 9, 1984

Dan Sagramoso
Chief Engineer and General Manager
Flood Control District of Maricopa County
3335 West Durango Street
Phoenix, Arizona 85009

RE: Spookhill Pumphouse Modification Report

Dear Dan:

Attached are six copies of the report made by Arthur Beard Engineers, Inc. on the necessary revisions to the pumphouse for your review and information.

Discussion of the report and further action needed can be made part of the agenda for our meeting on March 20, 1984.

Sincerely,

Don R. Phillips Acting For

Verne M. Bathurst
State Conservationist

Enclosures

FLOOD CONTROL DISTRICT
RECEIVED
MAR 14 '84

	CH ENG		HYDRO
3	ASST		LMgt
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2	ENGR		DESTROY
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REMARKS			

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SPOOKHILL FLOOD CONTROL STRUCTURE

IRRIGATION PUMP FACILITY ANALYSIS

FINDINGS, CONCLUSIONS & RECOMMENDATIONS

I. PURPOSE

The stated purpose of this report and analysis is to investigate the current conditions of the pumping facility which provides irrigation and moisture to the Spookhill Flood Control Structure, and to recommend a proposed course of action which would resolve the operating problems now being experienced at the facility. The recommended improvements should enable the facility to operate as it was originally intended, to the satisfaction of the USDA, Soil Conservation Service, as the agency in charge of construction, and the Maricopa County Flood Control District, the agency which will assume ownership, operation and control of the facility upon satisfactory completion of construction.

II. AUTHORIZATION

The preparation of this report has been authorized by Purchase Order No. 40-8A02-4-1121 from USDA, to Arthur Beard Engineers, Inc.

III. EXISTING CONDITIONS

The existing conditions at the irrigation and pumping facility are based on information obtained from plans and drawings made available by the Soil Conservation Service; from discussions with Mr. Jim Gaetjens of the Mesa Utility Department; and from discussions held during a site visit on February 6, 1984, at which representatives of the Soil Conservation Service, the Maricopa County Flood Control District, and Arthur Beard Engineers, Inc., were in attendance.

A. DESCRIPTION

1. Water Supply: Water supply to the system comes from a City of Mesa 12-inch waterline which runs along the north side of the pump station site. Service to the station is from a 4-inch waterline and a 3-inch turbine meter, which has a flow rating of 350 gallons per minute (gpm). Static water pressure at the meter is approximately 28 pounds per square inch (psi), and is relatively constant.

2. Pumping Station: The existing pumping station consists of a concrete vault installed underground, with access through a floor door on the top of the vault. Forced draft ventilation and interior lighting are provided in the vault.

   Pumping equipment consists of a 20-HP horizontal double-suction centrifugal pump, rated for 200 gpm at 220 feet total head. Also included at the station are a 2,000-gallon hydropneumatic tank, a 3-inch reduced pressure backflow preventer, and associated piping, valves and fittings. A schematic diagram of the pump system is shown in Figure 1.

   The irrigation system consists of pop-up impulse sprinkler heads arranged in 71 branches of up to 17 heads per branch. Each branch is controlled by an electric operated valve which is activated by one of three automatic controller stations located along the Spookhill Flood Control Structure. Water from the sprinklers performs the dual functions of providing irrigation water for the embankment plantings, and providing optimum moisture content to the embankment soils in an effort to control erosion.

B. SYSTEM OPERATION

The existing system operations are being performed by personnel from the Maricopa County Flood Control District. Operation of the system during the warm weather months is done at night time, on three nights per week for 12 hours per night.

A timer at the pump station turns the pumping system "on" at 8:00 p.m., and the pump brings the hydropneumatic tank up to operating pressure. Shortly after 8:00 p.m. timers located in each of the three circuit controller stations begin to open valves to sprinkler branches. These timers are set to allow each branch valve to be open for approximately 30 minutes per week. To accomplish this for the 71 branches in the three, 12-hour operations per week, two branch valves are usually open at the same time.

During the irrigation operations, the pump operates 'on' and 'off' automatically to maintain operating pressure to the sprinklers. This is accomplished by the use of pressure switches at the hydropneumatic tank.

At approximately 8:00 am, the pump timer turns the pumping system 'off', before the final sprinklers are shut off. With the pump off, these sprinkers allow the system to de-pressurize before the final branch valves are closed. The entire system is then at reset until the next operating cycle begins the following evening.

Safety provisions built into the system include the following:

1. A low-pressure shutoff switch on the pump suction which is currently inoperative.

2. A low-pressure shutoff switch on the tank discharge, which shuts down the pumping system if the tank pressure falls below a certain pre-set value. This condition would indicate a problem such as a broken water main or a malfunctioning branch valve which could cause damage to the embankments if allowed to continue for the entire pumping cycle.

3. A pressure relief valve located on the pump discharge which prevents excessive pressures from building up in the event of pressure switch failure.

4. A reduced-pressure backflow preventer which prevents water in the irrigation system from flowing back in the City water main.

5. The pump control system includes two solenoid-operated valves, one on the pump suction and one on the tank discharge, which open when the pump timer circuit is energized, and close when the circuit is off. This prevents City water from leaking into the irrigation system when the pump is off.

C. OPERATING PROBLEMS

Construction of the Spookhill Flood Control Structure, including the pump station and irrigation system was completed in the late 1970's. Ever since that time, numerous problems have contributed to the inability of the pump station and irrigation system to perform as it was originally intended to operate. The following discussions cover the major problems which have been encountered.

1. The pump station was originally designed to take suction from a Mesa 6-inch water-line which has a much higher static head (approximately 65 psi), instead of the current source of 28 psi in the 12-inch main. The switch over to the alternative water source occurred after construction of the project was completed, but no changes in the pumping system were made at that time. The change in source of supply was made in order to alleviate the following conditions:

a. Limitations on source of supply within the original Mesa system restricted both the rate and the time of day that water could be taken from Mesa. The rate was controlled by the initial installation of two, 2-inch disc meters, which had a combined capacity of approximately 160 gpm. This prevented the simultaneous operation of three sprinkler branches (as originally designed), since the sprinkler demand for three branches is 195 gpm (65 gpm per branch).

b. In the original 6-inch supply, there were large head losses during flowing conditions, since the Mesa subsystem consisted mainly of 6-inch and smaller piping. This in turn affected the operation of the pumping system, since the suction head for the pump was originally thought to be higher than it was.

c. The source of supply for the original Mesa system was a well which introduced a significant amount of sand into the pipeline. When the sand entered the Spookhill irrigation system, it fouled the valves and sprinkler heads, causing increased maintenance in the sprinkler system.

When Mesa switched the service over to the 12-inch water main, and the metering was changed to include a 3 inch turbine meter having a capacity of 350 gpm, the flow rate restrictions were no longer imposed, but the lower static suction pressure of 28 psi prevented the pump from operating at its design conditions to supply water to three branches operating simultaneously with a minimum pressure at each sprinkler head of 45 psi.

To correct this problem, the current method of operating only two branches simultaneously was started. Since the flow rates were now lower (130 gpm vs. the orignal 195 gpm), system head losses were considerably lower, and the pressure at each operating sprinkler head increased dramatically, to the point of causing failure of the sprinkler heads. To correct this problem the pressure switches at the hydropneumatic tank which control the pump were lowered, which in turn lowered the pressure at each sprinkler head.

At the new lower pressures which the existing pump now operates, the flow rate through the pump increased dramatically, which in turn greatly reduces the suction pressure to the pump, causing the pump impeller to operate in negative pressure conditions resulting in cavitation at the impeller. This condition greatly increases wear and tear on the pump, and will eventually result in pump failure.

2. The original intent of the hydropneumatic tank design called for manual air charging of the tank when it was necessary. In this installation, however, air charging is required at weekly intervals. The manual air charging procedure is a rather time-consuming process, as it involves draining the tank each time.

3. The piping configuration in the existing pump station makes it unsafe and inconvenient to gain access to the station electrical panel.

4. Miscellaneous features of the piping system in the station need some minor revisions, as follows:

   a. The existing bypass which fed the emitter system for trees and bushes along the flood control structure was used during the early years of operation. However, since native forms of vegetation were used, the plants are now well established, and the emitter system is no longer needed.

   b. The inoperative suction pipe low-pressure switch should be activated when the operation can be stabilized.

5. The existing piping configuration in the irrigation system does not provide manual shutoff valves in convenient locations in the system to allow for maintenance of the electric-operated branch valves. This maintenance action occurs relatively often, and requires personnel to drive all the way to the pump station to close a valve on the discharge piping there, before the branch valve can be taken apart for repair.

6. Problems in the past were encountered with sand in the piping system, which would foul the sprinklers and damage the branch valves. (Recently, however, the problems with sand have been greatly reduced since the switchover to the 12-inch water main as a source for water, as well as the installation of blowoffs along the 4-inch water main which supplies the branches).

IV. PROPOSED ALTERNATIVES

In order to resolve the problems noted above, alternatives which are considered must meet the following criteria:

1. The system, when completed, should be capable of operating automatically, based on the existing timers at the pump station and the irrigation system.

2. To the maximum extent practical, reuse of existing equipment in the proposed system should be employed.

3. Efficient use of both water and power is required.

A. PUMP REQUIREMENTS

From the discussion of operating problems as noted above, it is apparent that the primary need at the pump station is for the replacement of the existing 20 HP pump with one which is more nearly matched to the system demands in terms of both capacity and total head. The existing pump performs somewhere in between the system requirements with 2 or 3 branch circuits operating. (With 3 branches operating, the pump cannot generate enough head to provide the minimum pressure at each sprinkler. With 2 branches operating and the pressure switches reduced, the pump generates the proper head, but at a much higher flow rate which is beyond the capability of the pump suction piping). A new pump will therefore be required.

The new pump must satisfy one of the following conditions:

3-branch operation: 200 gpm at approx. 290' head
2-branch operation: 130 gpm at approx. 170' head

Of the above two conditions, the 2-branch method of operation is the preferred method for the pump revisions, for the following reasons:

1. A new pump sized to accommodate a 2-branch mode of operation would allow for the continuation of the present method of irrigating the flood control structure. Discussions with the Flood Control District personnel indicated that this method has proven to be satisfactory for their purposes.

2. The new pump would be sized to pump 130 gpm at approximately 170 feet of head, and would require a 10 HP motor. These revised values are considerably lower than the station was designed for, and will keep the additional changes at the pump station to a minimum.

3. The use of the 200 gpm pump would approach the limits of capacity for the pump suctions piping. A small change in the suction pressure could cause the larger pump to cavitate, which causes excessive wear on the pump and results in reduced pump efficiencies. The larger pump would also require a larger motor (30 HP), which would most likely require a new electric service to the station.

B. OTHER MODIFICATIONS AND PROVISIONS

Based on the operating problems noted in the existing conditions, the following list of items should also be considered during the pump station improvements:

1. Standby Facilities: The need for standby capabilities at the pump station is limited to protection from long-term outages caused by equipment breakdown. Short-term outages such as power failure and minor equipment breakdowns do not pose a problem, since the irrigation system is not vital to the flood control structure's day-to-day functioning.

   The only equipment at the pump station which could cause a long-term outage would be the pump itself. Since this size of pump is not normally a "shelf item" for the manufacturer, there could be a long lead time required to replace it if a complete pump failure occurred. However, there is no need to have two pumps installed and ready for service, since a pump could be replaced with an identical spare in a matter of one day if the need arises.

   We therefore feel that the furnishing of an identical spare pump is justified; however, it need not be installed.

2. Air Charging System: The present method of manually charging the hydropnematic tank on a weekly basis is a time-consuming and awkward task which could be greatly eased if a small air compressor were installed at the station. We therefore recommend that the air compressor be installed at the pump station.

3. Piping Revisions: During the site visit, it was evident that the location of the tank discharge piping is a potential safety hazard to personnel working on the electrical panel at the pump station. Currently, the only way to approach the electrical panel is to climb over the discharge piping. This piping could impede the rapid exit of a person during an emergency. We therefore recommend that the piping be relocated to provide an open walking space in front of the electrical panel, to the stairs at the access hatch.

   In addition, the existing by-pass piping which formerly served the emitter system is no longer needed, and should therefore be removed as a part of the overall pump station improvements.

4. Revisions to Controls: As a part of the overall station improvements, the three existing pressure switches in the station should be adjusted, repaired, or replaced as necessary to conform to the new operating conditions. These pressure switches perform the following functions:

   a) Pump 'on' and 'off'
   b) Low suction pressure cut-off
   c) Low discharge pressure cut-off

   The first switch controls the normal operation of the pump, based on the hydropneumatic tank pressure. The second switch shuts the pump off if the suction pressure drops below a pre-set value - this protects the pump from damage due to low suction pressure. The third switch, located on the hydropneumatic tank, shuts off the pump if the tank discharge pressure drops below a pre-set value. This condition would indicate a break or malfunction in the irrigation system, and could result in damage to the flood control structure if water flows continually for a period of time.

5. Irrigation System Isolation Valve: A particular need was expressed by Flood Control District personnel for a manually-operated isolation valve in the irrigation piping at the flood control structure, so the maintenance personnel could have a means to shut off the water mains to repair defective branch valves.

   Currently, if a branch valve needs to be repaired or replaced, maintenance personnel must drive several miles to the pump station in order to shut off the water supply to the irrigation system. By adding one valve to the pump discharge line under the flood control structure, a shutoff could be made without driving to the pump station.

While this valve is not vital to the operation of the pump station and irrigation system, its installation would greatly ease the difficulty in making repairs in the irrigation piping and control valves. We therefore recommend that this valve be considered for installation as a part of the pump station improvements.

V. FUTURE CONDITIONS

In discussions held with the City of Mesa regarding possible future changes in the water system which could affect the Spookhill pump system, it was learned that the Master Plan for water distribution in the area calls for consolidation of the numerous smaller sub-systems into a larger system which will have a hydraulic grade line sufficient to run the sprinkler system without the need of the pump station.

Development of this portion of the Master Plan for Mesa's water system is at some unspecified point in the future, and is highly dependent on economic conditions and on the growth rate experienced by Mesa in this area. It is currently estimated that this conversion will not take place for at least 6-12 years in the future. In the meantime, the existing method of serving the Spookhill pump station will remain.

VI. SUMMARY OF RECOMMENDATIONS

The improvements noted in Part IV of this report should be implemented as soon as arrangements can be made for design, bidding and construction. The recommended improvements include the following items:

1. Replace the existing 20 HP pump with a 10 HP pump, capable of pumping 130 gpm at a total head of approximately 171 feet (subject to verification during design).

2. Furnish one complete spare pump/motor unit identical to the new installed pump, to serve as a standby unit in case of future pump failure.

3. Install an air compressor system to maintain the proper air quantity in the hydropneumatic tank.

4. Relocate the tank discharge piping to provide better access to the electrical panel, and remove the bypass system which formerly operated the emitter irrigation system.

5. Modify the controls at the station to reflect the new operating conditions.

6. Install a 4-inch valve and valve box to the pump discharge pipe under the flood control structure.

A schematic diagram of the proposed pumping station improvements is shown in Figure 2.

VII. ESTIMATED DESIGN AND CONSTRUCTION COSTS

Based on the recommended system improvements, the estimated construction costs are as follows:

		Materials	Labor	Total
1.	New Pumping Equipment			
	a. Installed Pump	1,000.00	800.00	1,800.00
	b. Spare Pump (not installed)	1,000.00	-	1,000.00
2.	Air Compressor - Installed	1,000.00	1,000.00	2,000.00
3.	Piping Revisions	1,000.00	800.00	1,800.00
4.	Electrical Revisions	400.00	800.00	1,200.00
5.	4" Valve Cut-in	300.00	300.00	600.00
6.	Exist. System Adjustments	-	500.00	500.00
			SUBTOTAL	$ 8,900.00
			Construction Contingency (20%)	1,800.00
			ESTIMATED CONSTRUCTION TOTAL	$10,700.00

Engineering Services

a)	Design	$ 3,500.00
b)	Bidding Assistance	1,000.00
c)	Construction Services	2,500.00

ESTIMATED ENGINEERING COSTS $ 7,000.00

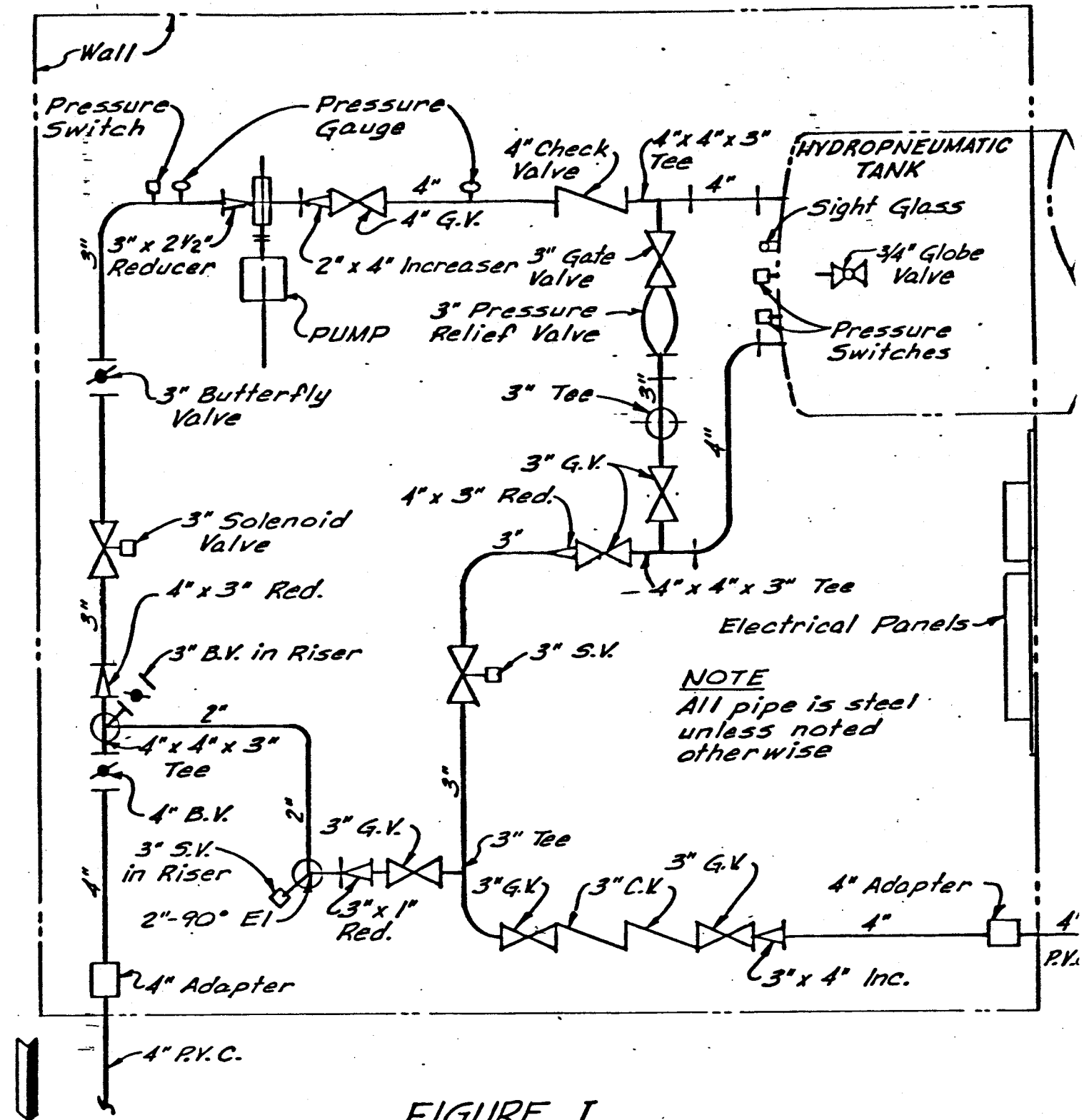

FIGURE I

SPOOK HILL PUMP STATION

EXISTING PIPING PLAN

N.T.S.

arthur beard engineers, inc.

February 1984

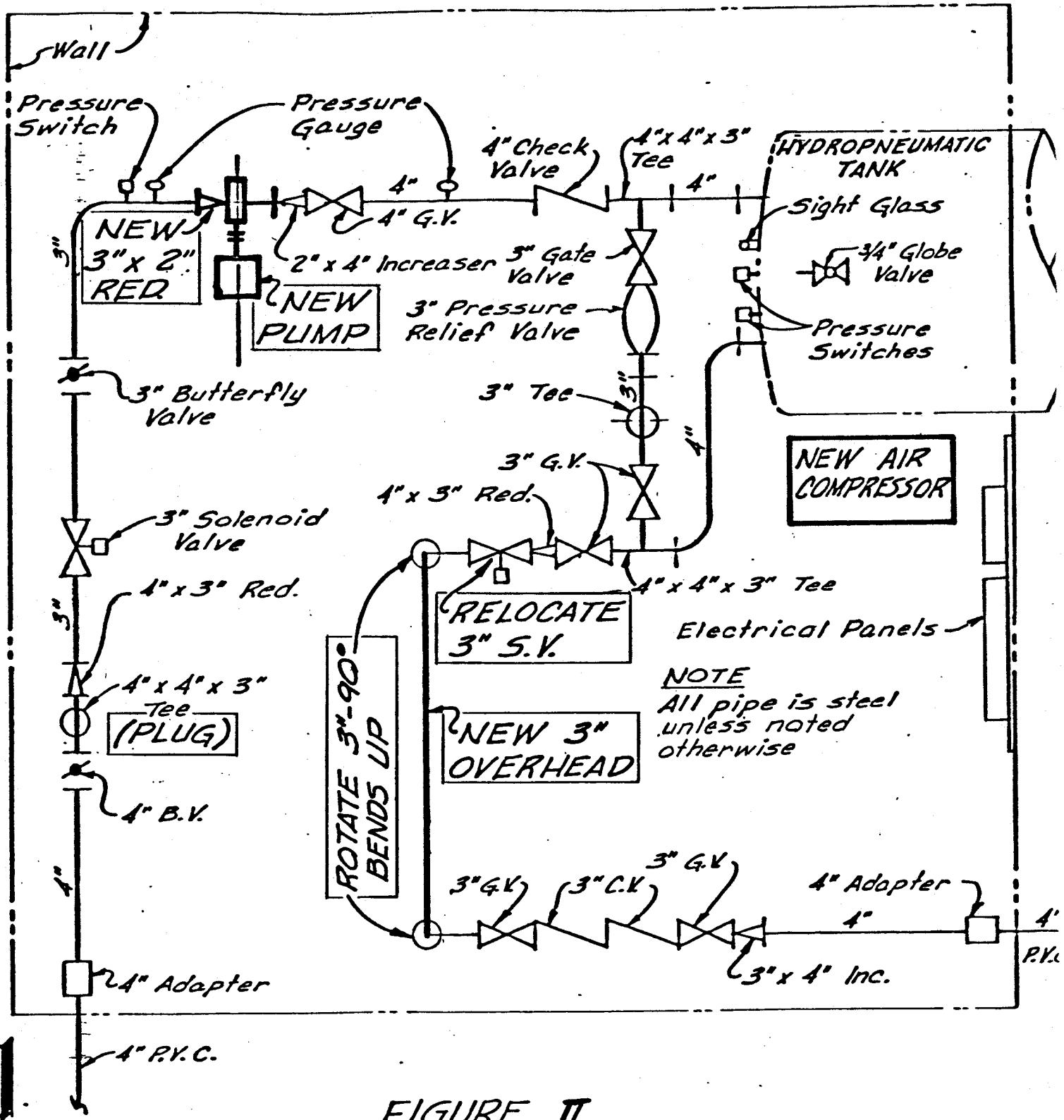

FIGURE II

SPOOK HILL PUMP STATION

PROPOSED IMPROVEMENTS

N.T.S.

arthur beard engineers, inc.

February 1984

SPOOKHILL FLOOD CONTROL STRUCTURE

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A. DESCRIPTION

1. Water Supply: Water supply to the system comes from a City of Mesa 12-inch waterline which runs along the north side of the pump station site. Service to the station is from a 4-inch waterline and a 3-inch turbine meter, which has a flow rating of 350 gallons per minute (gpm). Static water pressure at the meter is approximately 28 pounds per square inch (psi), and is relatively constant.

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Safety provisions built into the system include the following:

1. A low-pressure shutoff switch on the pump suction which is currently inoperative.

2. A low-pressure shutoff switch on the tank discharge, which shuts down the pumping system if the tank pressure falls below a certain pre-set value. This condition would indicate a problem such as a broken water main or a malfunctioning branch valve which could cause damage to the embankments if allowed to continue for the entire pumping cycle.

3. A pressure relief valve located on the pump discharge which prevents excessive pressures from building up in the event of pressure switch failure.

4. A reduced-pressure backflow preventer which prevents water in the irrigation system from flowing back in the City water main.

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C. OPERATING PROBLEMS

Construction of the Spookhill Flood Control Structure, including the pump station and irrigation system was completed in the late 1970's. Ever since that time, numerous problems have contributed to the inability of the pump station and irrigation system to perform as it was originally intended to operate. The following discussions cover the major problems which have been encountered.

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a. Limitations on source of supply within the original Mesa system restricted both the rate and the time of day that water could be taken from Mesa. The rate was controlled by the initial installation of two, 2-inch disc meters, which had a combined capacity of approximately 160 gpm. This prevented the simultaneous operation of three sprinkler branches (as originally designed), since the sprinkler demand for three branches is 195 gpm (65 gpm per branch).

b. In the original 6-inch supply, there were large head losses during flowing conditions, since the Mesa subsystem consisted mainly of 6-inch and smaller piping. This in turn affected the operation of the pumping system, since the suction head for the pump was originally thought to be higher than it was.

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When Mesa switched the service over to the 12-inch water main, and the metering was changed to include a 3 inch turbine meter having a capacity of 350 gpm, the flow rate restrictions were no longer imposed, but the lower static suction pressure of 28 psi prevented the pump from operating at its design conditions to supply water to three branches operating simultaneously with a minimum pressure at each sprinkler head of 45 psi.

To correct this problem, the current method of operating only two branches simultaneously was started. Since the flow rates were now lower (130 gpm vs. the orignal 195 gpm), system head losses were considerably lower, and the pressure at each operating sprinkler head increased dramatically, to the point of causing failure of the sprinkler heads. To correct this problem the pressure switches at the hydropneumatic tank which control the pump were lowered, which in turn lowered the pressure at each sprinkler head.

At the new lower pressures which the existing pump now operates, the flow rate through the pump increased dramatically, which in turn greatly reduces the suction pressure to the pump, causing the pump impeller to operate in negative pressure conditions resulting in cavitation at the impeller. This condition greatly increases wear and tear on the pump, and will eventually result in pump failure.

2. The original intent of the hydropneumatic tank design called for manual air charging of the tank when it was necessary. In this installation, however, air charging is required at weekly intervals. The manual air charging procedure is a rather time-consuming process, as it involves draining the tank each time.

3. The piping configuration in the existing pump station makes it unsafe and inconvenient to gain access to the station electrical panel.

4. Miscellaneous features of the piping system in the station need some minor revisions, as follows:

   a. The existing bypass which fed the emitter system for trees and bushes along the flood control structure was used during the early years of operation. However, since native forms of vegetation were used, the plants are now well established, and the emitter system is no longer needed.

   b. The inoperative suction pipe low-pressure switch should be activated when the operation can be stabilized.

5. The existing piping configuration in the irrigation system does not provide manual shutoff valves in convenient locations in the system to allow for maintenance of the electric-operated branch valves. This maintenance action occurs relatively often, and requires personnel to drive all the way to the pump station to close a valve on the discharge piping there, before the branch valve can be taken apart for repair.

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IV. PROPOSED ALTERNATIVES

In order to resolve the problems noted above, alternatives which are considered must meet the following criteria:

1. The system, when completed, should be capable of operating automatically, based on the existing timers at the pump station and the irrigation system.

2. To the maximum extent practical, reuse of existing equipment in the proposed system should be employed.

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A. PUMP REQUIREMENTS

From the discussion of operating problems as noted above, it is apparent that the primary need at the pump station is for the replacement of the existing 20 HP pump with one which is more nearly matched to the system demands in terms of both capacity and total head. The existing pump performs somewhere in between the system requirements with 2 or 3 branch circuits operating. (With 3 branches operating, the pump cannot generate enough head to provide the minimum pressure at each sprinkler. With 2 branches operating and the pressure switches reduced, the pump generates the proper head, but at a much higher flow rate which is beyond the capability of the pump suction piping). A new pump will therefore be required.

The new pump must satisfy one of the following conditions:

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2-branch operation: 130 gpm at approx. 170' head

Of the above two conditions, the 2-branch method of operation is the preferred method for the pump revisions, for the following reasons:

1. A new pump sized to accommodate a 2-branch mode of operation would allow for the continuation of the present method of irrigating the flood control structure. Discussions with the Flood Control District personnel indicated that this method has proven to be satisfactory for their purposes.

2. The new pump would be sized to pump 130 gpm at approximately 170 feet of head, and would require a 10 HP motor. These revised values are considerably lower than the station was designed for, and will keep the additional changes at the pump station to a minimum.

3. The use of the 200 gpm pump would approach the limits of capacity for the pump suctions piping. A small change in the suction pressure could cause the larger pump to cavitate, which causes excessive wear on the pump and results in reduced pump efficiencies. The larger pump would also require a larger motor (30 HP), which would most likely require a new electric service to the station.

B. OTHER MODIFICATIONS AND PROVISIONS

Based on the operating problems noted in the existing conditions, the following list of items should also be considered during the pump station improvements:

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   b) Low suction pressure cut-off
   c) Low discharge pressure cut-off

   The first switch controls the normal operation of the pump, based on the hydropneumatic tank pressure. The second switch shuts the pump off if the suction pressure drops below a pre-set value - this protects the pump from damage due to low suction pressure. The third switch, located on the hydropneumatic tank, shuts off the pump if the tank discharge pressure drops below a pre-set value. This condition would indicate a break or malfunction in the irrigation system, and could result in damage to the flood control structure if water flows continually for a period of time.

5. Irrigation System Isolation Valve: A particular need was expressed by Flood Control District personnel for a manually-operated isolation valve in the irrigation piping at the flood control structure, so the maintenance personnel could have a means to shut off the water mains to repair defective branch valves.

   Currently, if a branch valve needs to be repaired or replaced, maintenance personnel must drive several miles to the pump station in order to shut off the water supply to the irrigation system. By adding one valve to the pump discharge line under the flood control structure, a shutoff could be made without driving to the pump station.

While this valve is not vital to the operation of the pump station and irrigation system, its installation would greatly ease the difficulty in making repairs in the irrigation piping and control valves. We therefore recommend that this valve be considered for installation as a part of the pump station improvements.

V. FUTURE CONDITIONS

In discussions held with the City of Mesa regarding possible future changes in the water system which could affect the Spookhill pump system, it was learned that the Master Plan for water distribution in the area calls for consolidation of the numerous smaller sub-systems into a larger system which will have a hydraulic grade line sufficient to run the sprinkler system without the need of the pump station.

Development of this portion of the Master Plan for Mesa's water system is at some unspecified point in the future, and is highly dependent on economic conditions and on the growth rate experienced by Mesa in this area. It is currently estimated that this conversion will not take place for at least 6-12 years in the future. In the meantime, the existing method of serving the Spookhill pump station will remain.

VI. SUMMARY OF RECOMMENDATIONS

The improvements noted in Part IV of this report should be implemented as soon as arrangements can be made for design, bidding and construction. The recommended improvements include the following items:

1. Replace the existing 20 HP pump with a 10 HP pump, capable of pumping 130 gpm at a total head of approximately 171 feet (subject to verification during design).

2. Furnish one complete spare pump/motor unit identical to the new installed pump, to serve as a standby unit in case of future pump failure.

3. Install an air compressor system to maintain the proper air quantity in the hydropneumatic tank.

4. Relocate the tank discharge piping to provide better access to the electrical panel, and remove the bypass system which formerly operated the emitter irrigation system.

5. Modify the controls at the station to reflect the new operating conditions.

6. Install a 4-inch valve and valve box to the pump discharge pipe under the flood control structure.

A schematic diagram of the proposed pumping station improvements is shown in Figure 2.

VII. ESTIMATED DESIGN AND CONSTRUCTION COSTS

Based on the recommended system improvements, the estimated construction costs are as follows:

		Materials	Labor	Total
1.	New Pumping Equipment			
	a. Installed Pump	1,000.00	800.00	1,800.00
	b. Spare Pump (not installed)	1,000.00	-	1,000.00
2.	Air Compressor - Installed	1,000.00	1,000.00	2,000.00
3.	Piping Revisions	1,000.00	800.00	1,800.00
4.	Electrical Revisions	400.00	800.00	1,200.00
5.	4" Valve Cut-in	300.00	300.00	600.00
6.	Exist. System Adjustments	-	500.00	500.00
			SUBTOTAL	$ 8,900.00
			Construction Contingency (20%)	1,800.00
			ESTIMATED CONSTRUCTION TOTAL	$10,700.00

Engineering Services

a)	Design	$ 3,500.00
b)	Bidding Assistance	1,000.00
c)	Construction Services	2,500.00
	ESTIMATED ENGINEERING COSTS	$ 7,000.00

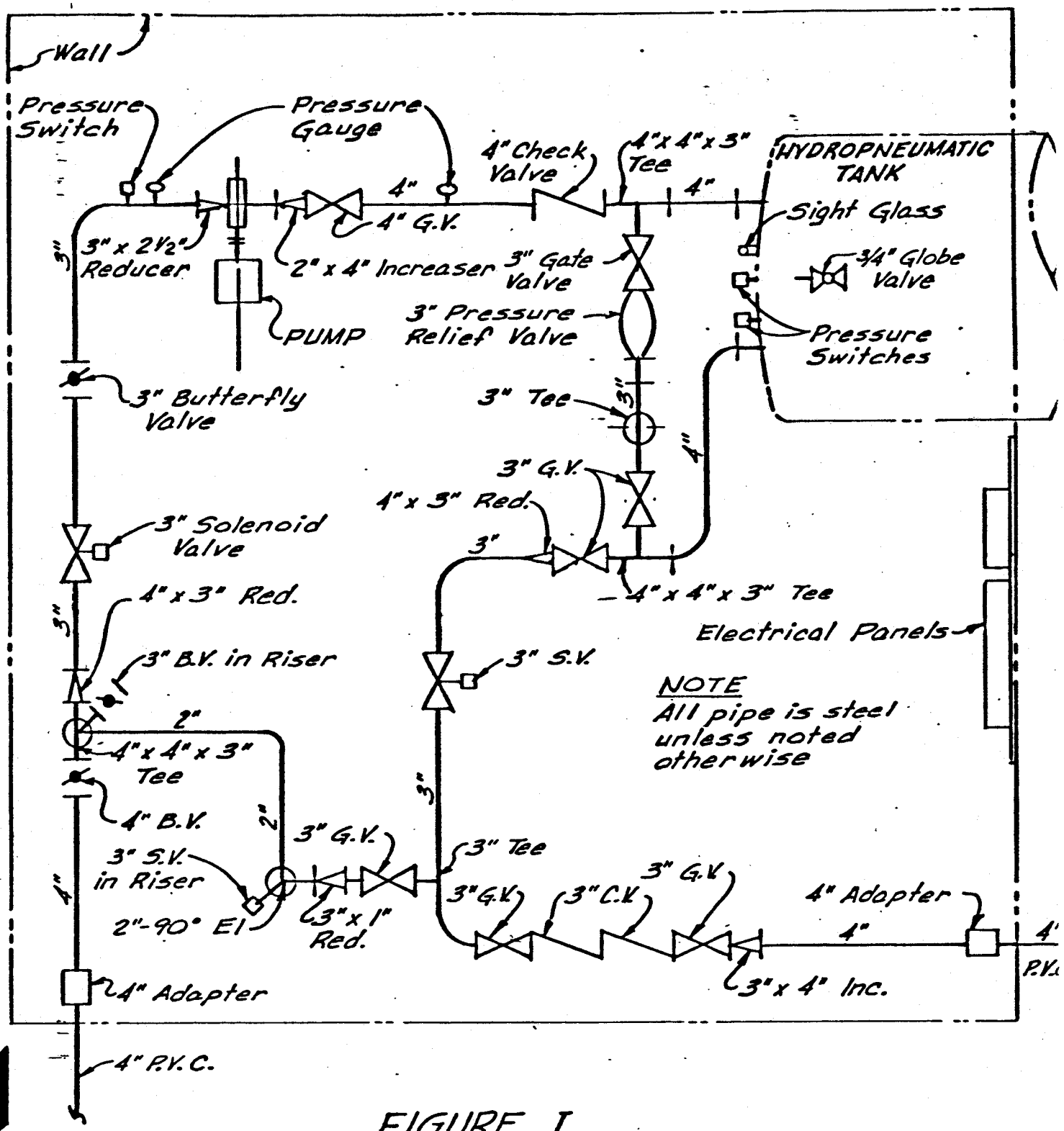

FIGURE I

SPOOK HILL PUMP STATION

EXISTING PIPING PLAN

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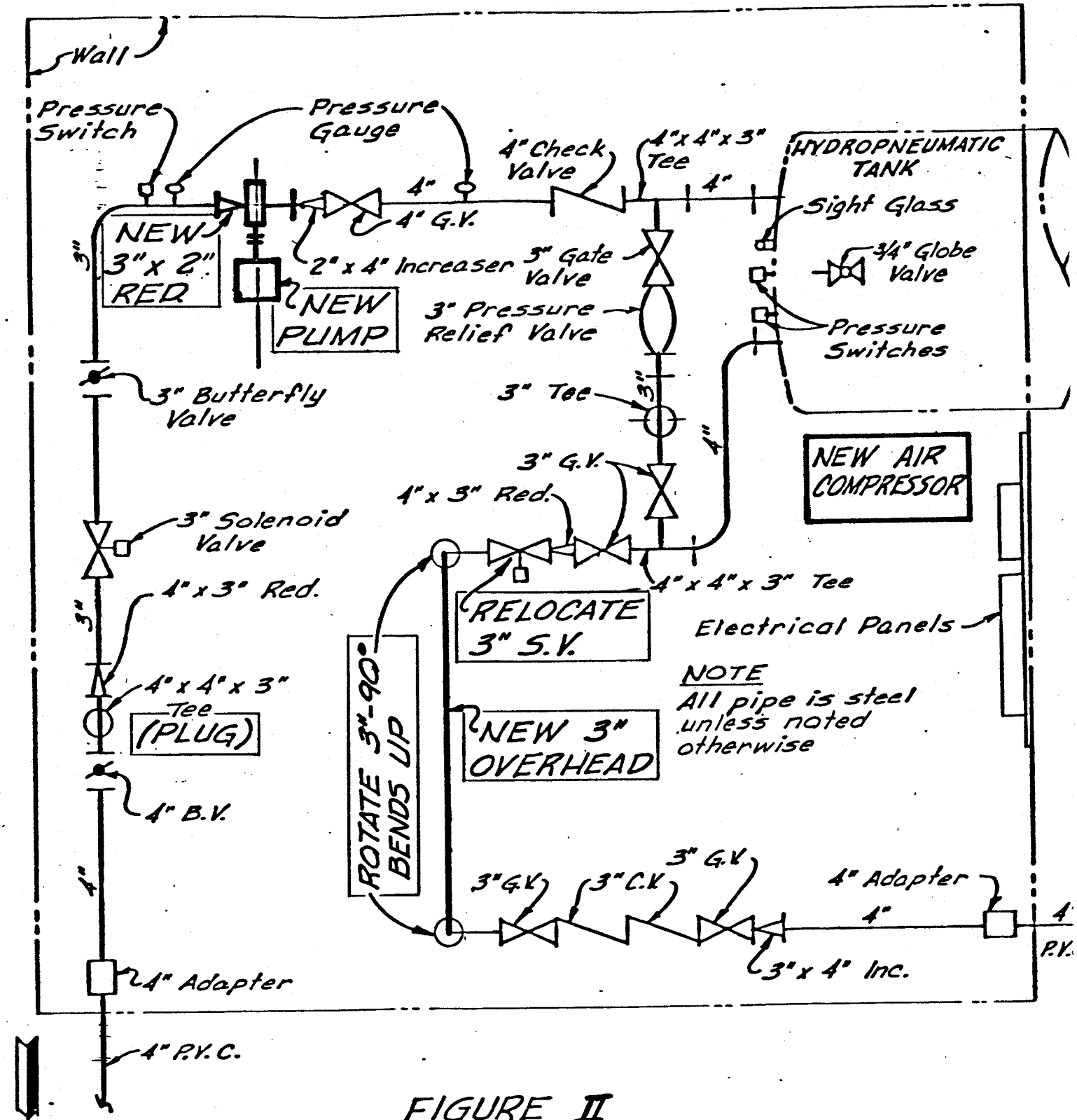

FIGURE II

SPOOK HILL PUMP STATION

PROPOSED IMPROVEMENTS

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SPOOKHILL FLOOD CONTROL STRUCTURE

IRRIGATION PUMP FACILITY ANALYSIS

FINDINGS, CONCLUSIONS & RECOMMENDATIONS

I. PURPOSE

The stated purpose of this report and analysis is to investigate the current conditions of the pumping facility which provides irrigation and moisture to the Spookhill Flood Control Structure, and to recommend a proposed course of action which would resolve the operating problems now being experienced at the facility. The recommended improvements should enable the facility to operate as it was originally intended, to the satisfaction of the USDA, Soil Conservation Service, as the agency in charge of construction, and the Maricopa County Flood Control District, the agency which will assume ownership, operation and control of the facility upon satisfactory completion of construction.

II. AUTHORIZATION

The preparation of this report has been authorized by Purchase Order No. 40-8A02-4-1121 from USDA, to Arthur Beard Engineers, Inc.

III. EXISTING CONDITIONS

The existing conditions at the irrigation and pumping facility are based on information obtained from plans and drawings made available by the Soil Conservation Service; from discussions with Mr. Jim Gaetjens of the Mesa Utility Department; and from discussions held during a site visit on February 6, 1984, at which representatives of the Soil Conservation Service, the Maricopa County Flood Control District, and Arthur Beard Engineers, Inc., were in attendance.

A. DESCRIPTION

1. Water Supply: Water supply to the system comes from a City of Mesa 12-inch waterline which runs along the north side of the pump station site. Service to the station is from a 4-inch waterline and a 3-inch turbine meter, which has a flow rating of 350 gallons per minute (gpm). Static water pressure at the meter is approximately 28 pounds per square inch (psi), and is relatively constant.

2. Pumping Station: The existing pumping station consists of a concrete vault installed underground, with access through a floor door on the top of the vault. Forced draft ventilation and interior lighting are provided in the vault.

   Pumping equipment consists of a 20-HP horizontal double-suction centrifugal pump, rated for 200 gpm at 220 feet total head. Also included at the station are a 2,000-gallon hydropneumatic tank, a 3-inch reduced pressure backflow preventer, and associated piping, valves and fittings. A schematic diagram of the pump system is shown in Figure 1.

   The irrigation system consists of pop-up impulse sprinkler heads arranged in 71 branches of up to 17 heads per branch. Each branch is controlled by an electric operated valve which is activated by one of three automatic controller stations located along the Spookhill Flood Control Structure. Water from the sprinklers performs the dual functions of providing irrigation water for the embankment plantings, and providing optimum moisture content to the embankment soils in an effort to control erosion.

B. SYSTEM OPERATION

The existing system operations are being performed by personnel from the Maricopa County Flood Control District. Operation of the system during the warm weather months is done at night time, on three nights per week for 12 hours per night.

A timer at the pump station turns the pumping system "on" at 8:00 p.m., and the pump brings the hydropneumatic tank up to operating pressure. Shortly after 8:00 p.m. timers located in each of the three circuit controller stations begin to open valves to sprinkler branches. These timers are set to allow each branch valve to be open for approximately 30 minutes per week. To accomplish this for the 71 branches in the three, 12-hour operations per week, two branch valves are usually open at the same time.

During the irrigation operations, the pump operates 'on' and 'off' automatically to maintain operating pressure to the sprinklers. This is accomplished by the use of pressure switches at the hydropneumatic tank.

At approximately 8:00 am, the pump timer turns the pumping system 'off', before the final sprinklers are shut off. With the pump off, these sprinkers allow the system to de-pressurize before the final branch valves are closed. The entire system is then at reset until the next operating cycle begins the following evening.

Safety provisions built into the system include the following:

1. A low-pressure shutoff switch on the pump suction which is currently inoperative.

2. A low-pressure shutoff switch on the tank discharge, which shuts down the pumping system if the tank pressure falls below a certain pre-set value. This condition would indicate a problem such as a broken water main or a malfunctioning branch valve which could cause damage to the embankments if allowed to continue for the entire pumping cycle.

3. A pressure relief valve located on the pump discharge which prevents excessive pressures from building up in the event of pressure switch failure.

4. A reduced-pressure backflow preventer which prevents water in the irrigation system from flowing back in the City water main.

5. The pump control system includes two solenoid-operated valves, one on the pump suction and one on the tank discharge, which open when the pump timer circuit is energized, and close when the circuit is off. This prevents City water from leaking into the irrigation system when the pump is off.

C. OPERATING PROBLEMS

Construction of the Spookhill Flood Control Structure, including the pump station and irrigation system was completed in the late 1970's. Ever since that time, numerous problems have contributed to the inability of the pump station and irrigation system to perform as it was originally intended to operate. The following discussions cover the major problems which have been encountered.

1. The pump station was originally designed to take suction from a Mesa 6-inch water-line which has a much higher static head (approximately 65 psi), instead of the current source of 28 psi in the 12-inch main. The switch over to the alternative water source occurred after construction of the project was completed, but no changes in the pumping system were made at that time. The change in source of supply was made in order to alleviate the following conditions:

a. Limitations on source of supply within the original Mesa system restricted both the rate and the time of day that water could be taken from Mesa. The rate was controlled by the initial installation of two, 2-inch disc meters, which had a combined capacity of approximately 160 gpm. This prevented the simultaneous operation of three sprinkler branches (as originally designed), since the sprinkler demand for three branches is 195 gpm (65 gpm per branch).

b. In the original 6-inch supply, there were large head losses during flowing conditions, since the Mesa subsystem consisted mainly of 6-inch and smaller piping. This in turn affected the operation of the pumping system, since the suction head for the pump was originally thought to be higher than it was.

c. The source of supply for the original Mesa system was a well which introduced a significant amount of sand into the pipeline. When the sand entered the Spookhill irrigation system, it fouled the valves and sprinkler heads, causing increased maintenance in the sprinkler system.

When Mesa switched the service over to the 12-inch water main, and the metering was changed to include a 3 inch turbine meter having a capacity of 350 gpm, the flow rate restrictions were no longer imposed, but the lower static suction pressure of 28 psi prevented the pump from operating at its design conditions to supply water to three branches operating simultaneously with a minimum pressure at each sprinkler head of 45 psi.

To correct this problem, the current method of operating only two branches simultaneously was started. Since the flow rates were now lower (130 gpm vs. the orignal 195 gpm), system head losses were considerably lower, and the pressure at each operating sprinkler head increased dramatically, to the point of causing failure of the sprinkler heads. To correct this problem the pressure switches at the hydropneumatic tank which control the pump were lowered, which in turn lowered the pressure at each sprinkler head.

At the new lower pressures which the existing pump now operates, the flow rate through the pump increased dramatically, which in turn greatly reduces the suction pressure to the pump, causing the pump impeller to operate in negative pressure conditions resulting in cavitation at the impeller. This condition greatly increases wear and tear on the pump, and will eventually result in pump failure.

2. The original intent of the hydropneumatic tank design called for manual air charging of the tank when it was necessary. In this installation, however, air charging is required at weekly intervals. The manual air charging procedure is a rather time-consuming process, as it involves draining the tank each time.

3. The piping configuration in the existing pump station makes it unsafe and inconvenient to gain access to the station electrical panel.

4. Miscellaneous features of the piping system in the station need some minor revisions, as follows:

   a. The existing bypass which fed the emitter system for trees and bushes along the flood control structure was used during the early years of operation. However, since native forms of vegetation were used, the plants are now well established, and the emitter system is no longer needed.

   b. The inoperative suction pipe low-pressure switch should be activated when the operation can be stabilized.

5. The existing piping configuration in the irrigation system does not provide manual shutoff valves in convenient locations in the system to allow for maintenance of the electric-operated branch valves. This maintenance action occurs relatively often, and requires personnel to drive all the way to the pump station to close a valve on the discharge piping there, before the branch valve can be taken apart for repair.

6. Problems in the past were encountered with sand in the piping system, which would foul the sprinklers and damage the branch valves. (Recently, however, the problems with sand have been greatly reduced since the switchover to the 12-inch water main as a source for water, as well as the installation of blowoffs along the 4-inch water main which supplies the branches).

IV. PROPOSED ALTERNATIVES

In order to resolve the problems noted above, alternatives which are considered must meet the following criteria:

1. The system, when completed, should be capable of operating automatically, based on the existing timers at the pump station and the irrigation system.

2. To the maximum extent practical, reuse of existing equipment in the proposed system should be employed.

3. Efficient use of both water and power is required.

A. PUMP REQUIREMENTS

From the discussion of operating problems as noted above, it is apparent that the primary need at the pump station is for the replacement of the existing 20 HP pump with one which is more nearly matched to the system demands in terms of both capacity and total head. The existing pump performs somewhere in between the system requirements with 2 or 3 branch circuits operating. (With 3 branches operating, the pump cannot generate enough head to provide the minimum pressure at each sprinkler. With 2 branches operating and the pressure switches reduced, the pump generates the proper head, but at a much higher flow rate which is beyond the capability of the pump suction piping). A new pump will therefore be required.

The new pump must satisfy one of the following conditions:

3-branch operation: 200 gpm at approx. 290' head
2-branch operation: 130 gpm at approx. 170' head

Of the above two conditions, the 2-branch method of operation is the preferred method for the pump revisions, for the following reasons:

1. A new pump sized to accommodate a 2-branch mode of operation would allow for the continuation of the present method of irrigating the flood control structure. Discussions with the Flood Control District personnel indicated that this method has proven to be satisfactory for their purposes.

2. The new pump would be sized to pump 130 gpm at approximately 170 feet of head, and would require a 10 HP motor. These revised values are considerably lower than the station was designed for, and will keep the additional changes at the pump station to a minimum.

3. The use of the 200 gpm pump would approach the limits of capacity for the pump suctions piping. A small change in the suction pressure could cause the larger pump to cavitate, which causes excessive wear on the pump and results in reduced pump efficiencies. The larger pump would also require a larger motor (30 HP), which would most likely require a new electric service to the station.

B. OTHER MODIFICATIONS AND PROVISIONS

Based on the operating problems noted in the existing conditions, the following list of items should also be considered during the pump station improvements:

1. Standby Facilities: The need for standby capabilities at the pump station is limited to protection from long-term outages caused by equipment breakdown. Short-term outages such as power failure and minor equipment breakdowns do not pose a problem, since the irrigation system is not vital to the flood control structure's day-to-day functioning.

   The only equipment at the pump station which could cause a long-term outage would be the pump itself. Since this size of pump is not normally a "shelf item" for the manufacturer, there could be a long lead time required to replace it if a complete pump failure occurred. However, there is no need to have two pumps installed and ready for service, since a pump could be replaced with an identical spare in a matter of one day if the need arises.

   We therefore feel that the furnishing of an identical spare pump is justified; however, it need not be installed.

2. Air Charging System: The present method of manually charging the hydropnematic tank on a weekly basis is a time-consuming and awkward task which could be greatly eased if a small air compressor were installed at the station. We therefore recommend that the air compressor be installed at the pump station.

3. Piping Revisions: During the site visit, it was evident that the location of the tank discharge piping is a potential safety hazard to personnel working on the electrical panel at the pump station. Currently, the only way to approach the electrical panel is to climb over the discharge piping. This piping could impede the rapid exit of a person during an emergency. We therefore recommend that the piping be relocated to provide an open walking space in front of the electrical panel, to the stairs at the access hatch.

   In addition, the existing by-pass piping which formerly served the emitter system is no longer needed, and should therefore be removed as a part of the overall pump station improvements.

4. Revisions to Controls: As a part of the overall station improvements, the three existing pressure switches in the station should be adjusted, repaired, or replaced as necessary to conform to the new operating conditions. These pressure switches perform the following functions:

   a) Pump 'on' and 'off'
   b) Low suction pressure cut-off
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   The first switch controls the normal operation of the pump, based on the hydropneumatic tank pressure. The second switch shuts the pump off if the suction pressure drops below a pre-set value - this protects the pump from damage due to low suction pressure. The third switch, located on the hydropneumatic tank, shuts off the pump if the tank discharge pressure drops below a pre-set value. This condition would indicate a break or malfunction in the irrigation system, and could result in damage to the flood control structure if water flows continually for a period of time.

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While this valve is not vital to the operation of the pump station and irrigation system, its installation would greatly ease the difficulty in making repairs in the irrigation piping and control valves. We therefore recommend that this valve be considered for installation as a part of the pump station improvements.

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3. Install an air compressor system to maintain the proper air quantity in the hydropneumatic tank.

4. Relocate the tank discharge piping to provide better access to the electrical panel, and remove the bypass system which formerly operated the emitter irrigation system.

5. Modify the controls at the station to reflect the new operating conditions.

6. Install a 4-inch valve and valve box to the pump discharge pipe under the flood control structure.

A schematic diagram of the proposed pumping station improvements is shown in Figure 2.

VII. ESTIMATED DESIGN AND CONSTRUCTION COSTS

Based on the recommended system improvements, the estimated construction costs are as follows:

		Materials	Labor	Total
1.	New Pumping Equipment			
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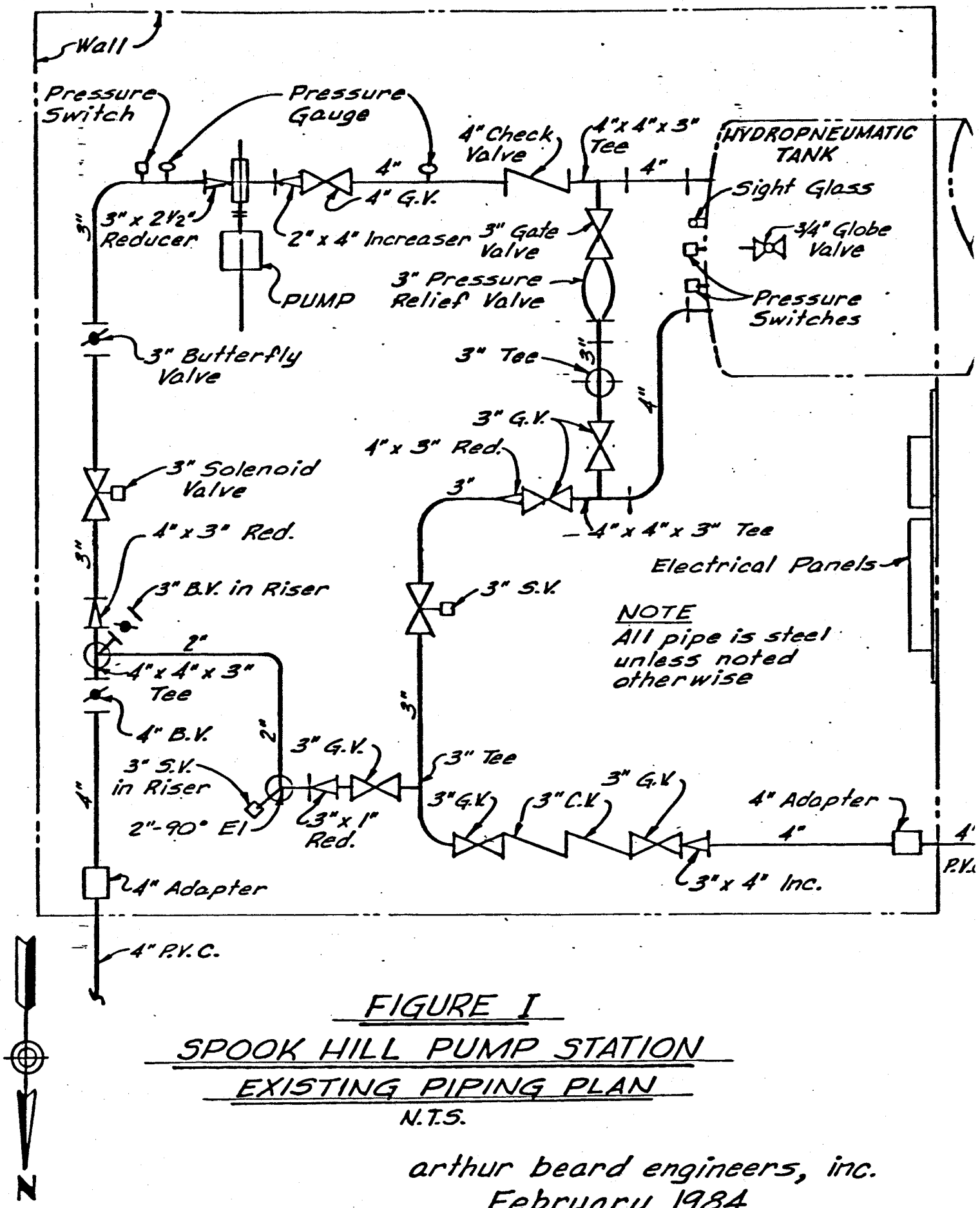

FIGURE I

SPOOK HILL PUMP STATION

EXISTING PIPING PLAN

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February 1984

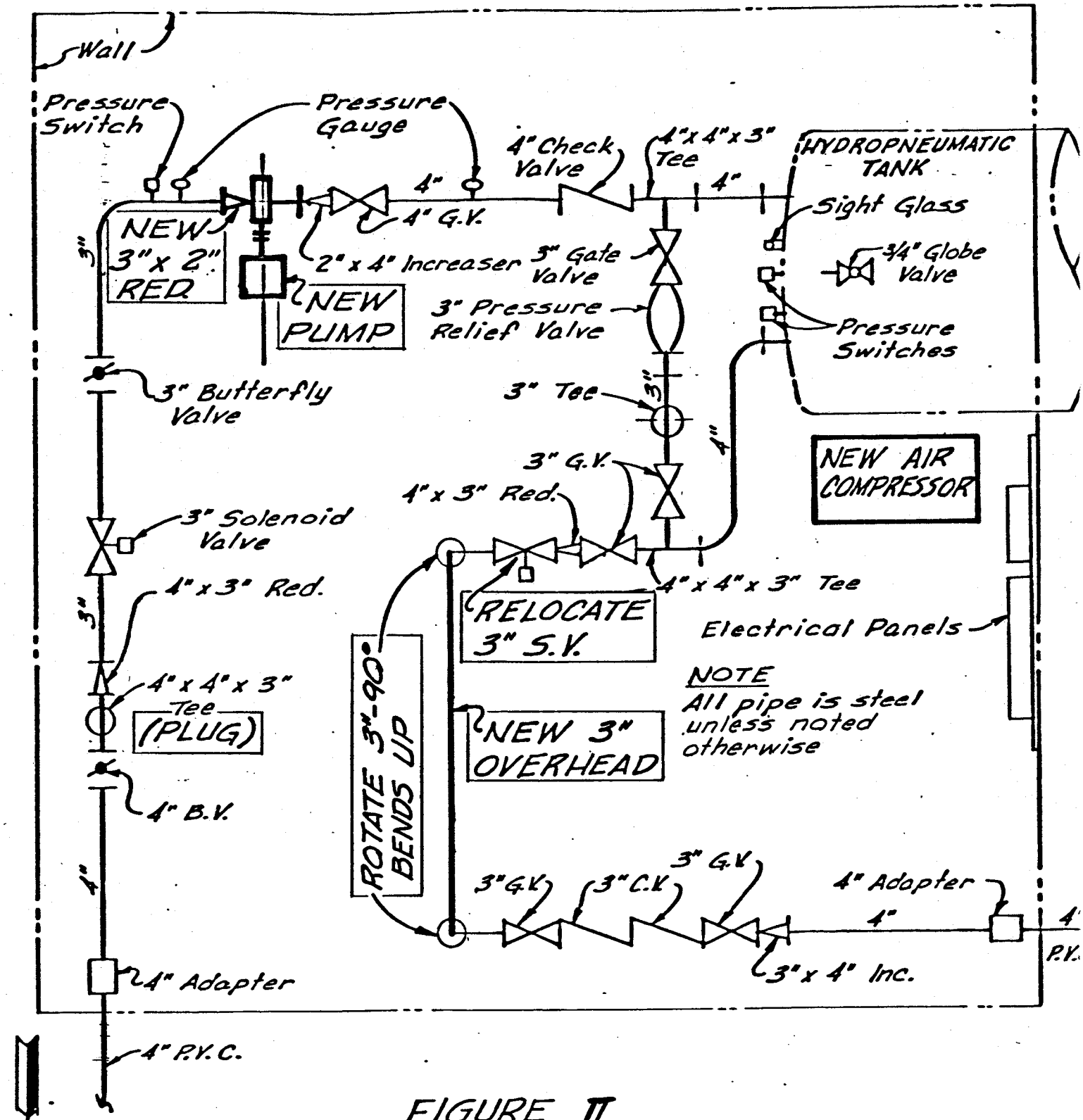

FIGURE II

SPOOK HILL PUMP STATION

PROPOSED IMPROVEMENTS

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