INVESTIGATION AND RECOMMENDATIONS
for
UPGRADING THE WATER SYSTEM
at
FORT HUACHUCA, ARIZONA

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INVESTIGATION AND RECOMMENDATIONS FOR UPGRADING THE WATER SYSTEM AT FORT HUACHUCA, ARIZONA

for

DEPARTMENT OF THE ARMY
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INVESTIGATIONS AND RECOMMENDATIONS
FOR UPGRADING THE WATER SYSTEM AT
FORT HUACHUCA, ARIZONA

I. INTRODUCTION

1. Authorization

The investigation reported herein was authorized through the District Engineer Sacramento by the Department of the Army, South Pacific Division, Corps of Engineers, Sacramento, California, through Job No. Fort Huachuca - 72-O&M-A, Directive No. SPD-3, dated 27 June 1972.

2. Purpose

Since its reestablishment on 1 February 1954, Fort Huachuca has been serving in several capacities. It is now under the control of the U.S. Army Strategic Communications Command.

In contrast to its 73 year history previous to 1954, development of permanent facilities and increased personnel has been accomplished in a rapid but orderly manner. Sources knowledgeable of the Fort's future agree that its expansion has probably reached its expected peak and that stable population conditions will prevail. It is therefore appropriate that the existing water supply and distribution system be re-evaluated and that recommendations be made to modify the current situation to one that will fully satisfy the needs of the present which in turn will satisfy the future.

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3. Background

From its establishment in March 1877 to 1939 the water supply came from springs in Huachuca and Garden Canyons, which are located several hundred feet above and southerly of the building complex. A 200,000 gallon ground storage masonry basin, built in 1911, and another 250,000 gallon concrete ground reservoir constructed in 1939, served as the springs' collection point. This system is known as the Old Post Reservoir (See Sketch #1).

In 1939 and 1940 Wells #1 and #2 (See Tabulation Sheets 1 and 2) were drilled at the Fort's Main Gate. Their supply was delivered via a 10" tar lined and coated steel pipe nearly 20,000 feet long to the Old Post Reservoir via Booster Pumps #1 and #2B. This was a supply main with no connections. (See Sketch #2). A 500,000 gallon elevated steel tank was installed in 1941 between the wells and the Old Post Reservoir near 4th Street and Railroad Avenue. It received its supply from the surge tank at Well #2 via a 12" steel line connected to Booster Pump 2-A. (See Sketch #3).

Increased activity in 1942 due to World War II, required the construction of Wells #3, #4, and #5 (See Tabulation Sheets 3-5) and three 50,000 gallon surge tanks from which Booster Pumps #3, #4, and #5 take suction. Also a three million gallon concrete ground storage reservoir together with distribution and supply mains were constructed as well as another 500,000 gallon elevated steel tank. The second elevated tank was disconnected in 1946 by the War Assets Administration (See Sketch #4). These 5 wells and the springs constituted the water supply facilities up to 1954. At that time the springs were discontinued as a source.

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By 1956 the Wherry, MCA, and Capehart Housing projects were constructed for military personnel assigned to the Electronics Proving Ground and their families. At this time the Wherry Booster Station, consisting of three booster pumps drawing from the 3 million gallon reservoir, was constructed to pump into a direct pressure distribution system serving the portions of these projects which were located too high in elevation to receive adequate elevation pressure from the reservoir. In 1958 a 1-1/2 million gallon prestressed concrete tank with high water elevation 223 feet above that in the 3 million gallon reservoir was completed. The Wherry Booster Station was then pumping both into the distribution mains and into the new reservoir which floats on the distribution system. (See Sketch #5).

Well #6, (see Tabulation Sheet #6) which was drilled in 1958, was tested and put into service. At approximately the same time, a fourth booster pump was installed at Wherry Station.

In 1962 three booster pumps were installed below the 1-1/2 million gallon tank to take suction from that tank to supply the Old Post Reservoir. The supply main from Well Pump Booster #1 and #2B was then to discharge overhead into the 1-1/2 million gallon reservoir. However, a junction box was installed so that this supply main could serve either the 1-1/2 million gallon and/or the Old Post Reservoirs.

In 1969, as a result of a 1966 study (WATER RESOURCES OF FORT HUACHUCA MILITARY RESERVATION, SOUTHEASTERN ARIZONA: GEOLOGICAL SURVEY WATER SUPPLY PAPER 1819 D), a 12" concrete steel cylinder pipe was installed from Garden Canyon Springs to the 1-1/2 million gallon prestressed tank and an 8" line was constructed between Huachuca Canyon Springs and Old Post Reservoir. The 30 year old 10" line from Wells 1 and 2 was

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replaced by a 12" concrete steel cylinder pipe that is connected into the 12" Garden Canyon Line (see Sketch #6). The old 10" line is only usable from the booster station taking suction from the 1-1/2 million gallon tank to the Old Post Reservoir.

As noted on page 18 of TEST WELL DRILLING AND STUDY OF HYDROGEOLOGIC CONDITIONS AT FORT HUACHUCA by the Corps of Engineers, April 1972, a full production well, labeled Test Well No. 5 (see Tabulation Sheet #7), has been tested at 1650 gpm with 59' of drawdown. This capped well is located approximately 4 miles north by northeast of the Fort's central distribution center (see Sketch #16).

As a supplement to the total water supply requirements of the Fort, a project was completed in September 1972 to store 2.5 million gallons of secondary treated chlorinated wastewater plant effluent. This source is used in supplying the separate piping systems for irrigation of the 18 hole golf course and Chaffee parade field. This recent innovation is expected to be sufficient to supply all present irrigation requirements for those areas that are now or may later be approved by the medical departments for irrigation with treated wastewater plant effluent excepting such areas as the Post cemetery which is too remote to make construction of piping to it practical.

The above is a general summary of events and significant developments of the water supply facilities at Fort Huachuca. Plate #1 illustrates the present overall supply and distribution facilities.

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II. PRESENT SITUATION

1. Water Usage

a. Domestic and Fire

The population consists of two classifications: 24 hour occupancy and 8 hour occupancy. This report will separate the population into those occupying each of 3 primary water pressure zones (See Plate I at end of this Section). The highest zone, Zone A, extends from the Post cemetery at elevation 5200 feet to Von Herman Circle at elevation 4920 feet. Zone B is from Henry Circle at elevation 5030 feet to Faison Circle at elevation 4810 feet. As the lowest, Zone C extends from the lower edge of Zone B to the northern boundary of the Fort at elevation 4400 feet. The present (1972) populations of these zones are as follows:

Zone	24-hour Occupancy	8-hour Occupancy	Equivalent 24-hour occupancy
A	1475	1400	1940
B	7100	2650	7980
C	2620	1325	3060

The present equivalent 24 hour occupancy population is 12,980. Using a capacity factor of 1.23, ST. LINE INTERPOLATION the design population is 15,970. Tabulated population reports for this period were supplied by the Post Housing Office. As indicated in the section "Purpose", this present equivalent population figure is expected to remain reasonably constant.

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The following calculations and evaluations of demand of the potable water system are based on the criteria set forth in the U.S. Army Corps of Engineers Manual, Series TM 5-813.

ZONE A

Equivalent Population x Capacity Factor = Design Population

1940 x 1.23 = 2385

Required Daily Domestic Demand:

2385 x 150 gpcpd = 358,000 gallons

Required Fire Demand:

1/2 x 358,000 + 1000 gpm x 4 hrs = 419,000 gallons

Since Fire Demand is greater than Domestic Demand for Zone A, it will be used in further analysis.

ZONE B

7980 x 1.23 = 9,800 Design Population

Required Daily Domestic Demand:

9,800 x 150 gpcpd = 1,470,000 gallons

Required Fire Demand:

1/2 x 1,470,000 + 1000 gpm x 2 fires x 4 hrs = 1,215,000 gallons

ZONE C

3060 x 1.23 = 3760 Design Population

Required Daily Domestic Demand:

3760 x 150 gpcpd = 564,000 gallons

Required Fire Demand:

1/2 x 564,000 + 1000 gpm x 4 hrs = 522,000 gallons

The total water required in all 3 zones for required daily domestic and fire demand is 419,000 + 1,470,000 + 564,000 = 2,453,000

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b. Irrigation

Using irrigation maps furnished by Buildings & Grounds section, it is estimated that there are 90 acres of lawns, trees and shrubs in public areas not irrigated by residents. This does not include the golf course and Chaffee Field which are irrigated with wastewater effluent. A contractor is hired to operate the manually controlled irrigation systems in these public areas. Irrigation of similar plant life around the housing projects is done by the residents of houses. These areas are estimated at 150 acres. Monthly water production records indicate that actual usage increases during the irrigation period by approximately 2.0 M.G.D. (See Chart 2 at the end of this Section). These estimates of acreages were derived from general site maps.

It is generally accepted practice to estimate that 9000 gallons per acre per day are necessary to maintain good lawn growth. Therefore, irrigation demand during the two peak months of May and June would be 240 acres x 9000 gpapd = 2,160,000 gallons per day. This estimate is fairly close to the observed increases in the recorded water production for the two maximum usage months. Average irrigation demand estimates according to Zones, is as follows:

Zone A	40 acres x 9000 gpdpac =	360,000	gpd
Zone B	120 acres x 9000 gpdpac =	1,080,000	gpd
Zone C	80 acres x 9000 gpdpac =	720,000	gpd
		2,160,000	

There is a standing Fort order that there shall be no irrigation on Wednesday. This allows reservoirs to be partly replenished prior to Thursday. The contractor that irrigates public areas not adjacent to residences usually waters at night when other irrigation is low. Seeds for grass and plants for landscaping are furnished by the Post, therefore some control is exercised over the planting of things that would use a large amount of water.

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C. Summary

Total consumption during the peak period of May and June is as follows:

ZONE A

419,000 gallons Fire Demand
360,000 gallons Irrigation

779,000 Total Daily Usage

ZONE B

1,470,000 gallons Domestic Demand
1,080,000 gallons Irrigation

2,550,000 Total Daily Usage

ZONE C

564,000 gallons Domestic Demand
720,000 gallons Irrigation

1,284,000 Total Daily Usage

Total Daily Usage = 4,613,000 gallons on an irrigation day.

This figure represents the amount necessary to satisfy the criteria set forth in the TM 5-813 series manuals, and is also the actual maximum use. It should be noted that the maximum daily water production figure was set in June 1972, at 5.34 M.G.D. (See Chart #2). Subtracting the 250,000 gallons that was used for golf course watering, which will be replaced by wastewater plant effluent in the future, will make the future peak daily production about the same as the daily design figure. Therefore, during the months of extensive irrigation, the demand occasionally approaches or equals the design daily usage.

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CHART #1

MONTHLY WELL PRODUCTION (1,000 GALLONS)

FORT HUACHUCA, ARIZONA

(PREPARED FROM POST REPORTS)

- year -

	1966	1967	1968	1969	1970	1971	1972
January	42,887	62,824	55,562	59,517	64,151	NA	59,994
February	40,443	70,192	63,317	57,893	71,839	50,798	58,885
March	77,902	110,266	77,481	80,824	82,113	92,909	84,957
April	82,837	89,402	80,781	97,623	94,846	83,860	98,282
May	95,971	114,644	120,722	116,505	123,237	117,417	129,137
June	105,577	119,959	124,496	140,426	125,683*	131,222	111,038
July	90,718	79,668	94,065	95,415	99,602*	87,340	106,908
August	67,469	77,962	79,975	86,713	77,655*	72,513	84,054
September	64,492	71,673	95,573	96,506	79,327	88,986	66,246
October	73,448	73,038	105,465	104,089	67,073	68,930	65,407
November	65,375	70,350	75,537	72,269	60,775	70,669	52,866
December	55,515	51,837	59,028	60,666	48,066	56,371	-
TOTAL	862,624	991,815	1,032,002	1,068,446	994,367		
AVERAGE							
Monthly	71,885	88,651	86,000	89,037			
Daily	2,360	2,720	2,820	2,920			

* Huachuca and Garden Canyon Spring collection systems contributing to water system.

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CHART #2

MAXIMUM DAY WATER PRODUCTION BY MONTHS

(Million Gallons)

FORT HUACHUCA, ARIZONA

(PREPARED FROM POST REPORTS)

Month	- year -						
	1966	1967	1968	1969	1970	1971	1972
January	2.01	3.00	2.69	2.22	3.81	NA	4.85
February	1.89	3.37	3.55	3.21	3.45	3.29	3.63
March	3.87	5.16	3.72	4.19	3.82	5.19	4.25
April	4.34	4.64	4.15	4.37	4.00	3.93	4.15
May	4.20	4.80	5.00	4.96	4.90	5.14	5.09
June	4.83	4.71	4.96	5.02	NA	5.07	5.34
July	4.46	3.54	4.49	4.94	5.30	4.95	5.05
August	2.69	4.05	3.19	3.92	4.65	3.57	4.13
September	2.93	3.25	4.34	4.30	4.16	5.22	3.34
October	3.39	3.02	4.56	4.48	3.41	3.30	3.54
November	2.62	2.93	3.42	3.56	3.34	2.74	2.29
December	2.56	2.25	2.56	2.76	2.97	2.60	

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2. Water Sources

a. Springs

Huachuca Canyon Springs are closer to the Post and higher than the Garden Canyon Springs but they develop less flow. A serious attempt by the U.S. Geological Survey to monitor total spring flow in each canyon from 1960 to 1963, indicated that during the driest period in sixty years, Huachuca Canyon produced about a minimum of 20 gpm and Garden Canyon yielded a minimum of 83 gpm. During that same three year period a combined maximum of over 2300 gpm was recorded. However, in the two-and-a-half year period since 1969 when the new water line and collection facilities were developed, Huachuca and Garden Canyon Springs have been metered. The greatest daily production was recorded as 1,190,000 gallons on September 14, 1971. The minimum was 9,000 gallons on August 23, 1972.

The springs contribute a noteworthy amount of good quality water to the Post water system as well as providing replenishment water to the two lakes at the golf course and the officers club. The pipelines are being provided with automatic discharge valves so that when the first water following a rainstorm is turbid, it will be discharged to the ground surface thereby preventing contamination of the Post water system with the muddy material. The water flow rates from the springs vary too much to be seriously considered as a basic water source during the dry season when maximum use occurs. However, this water supply provides a valuable resting period for the wells during the spring when snow melts feed the springs and during the rainy season.

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b. Deep Wells

The basic source of potable water for the Post is from the underground aquifer located about 500 feet below the ground surface. Pumps from 6 wells drilled into this aquifer discharge into adjacent surge tanks. Booster pumps, taking suction from these tanks, deliver water on demand to the various storage reservoirs which float on the 3 pressure zones in the distribution system.

As outlined in Part I, paragraph 3 of this report, the six wells were put into production at various times as water demands increased during the last 30 years. (See Tabulation Sheets #1-6). While all of them were considered good producers initially, significant changes in their capacity have been noted. Listed below in TABLE I is a comparison of each from tests performed by Post personnel showing these changes.

TABLE I

	PRODUCTION PER FOOT OF DRAWDOWN ON INDICATED DATES	1971 PRODUCTION PER FOOT OF DRAWDOWN
Well #1	16 gpm/ft @ 550 gpm (1963)	15.4 gpm/ft @ 593 gpm
Well #2	21 gpm/ft @ 620 gpm (1963)	17.1 gpm/ft @ 615 gpm
Well #3	25 gpm/ft @ 500 gpm (1963)	17.7 gpm/ft @ 760 gpm
Well #4	32 gpm/ft @ 450 gpm (1963)	40.7 gpm/ft @ 611 gpm
Well #5	10 gpm/ft @ 650 gpm (1963)	6.2 gpm/ft @*575 gpm
Well #6	25 gpm/ft @ 708 gpm (1958)	37.5 gpm/ft @ 601 gpm

* This quantity is presently only 450 gpm

At the present, water supply capacity from the wells for a 16 hour day, as recommended by Army Training Manual TM 5-813-2, would be about 3,500,000 gpd. However, these wells have been pumped as much as is necessary to meet the daily demand. While the quality of the water has not changed noticeably in the last 30 years, the level of the water table has

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dropped at the rate of 2-1/2' to 3' per year since 1958. Similar drops have occured in wells in the nearby city of Sierra Vista.

The Army Corps of Engineers Study that was published in January 1972 included the drilling and developing of a well for production purposes. Data on this Test Well #5, listed in the study's summary, is as follows:

The well is located in the Northeast 1/4 of Section 16, Twp 21S R20E of G & SRB & M.

Well Depth - 807'
Casing Diameter - 16"

Test Rates:

Drawdown		Specific Capacity
375 gpm	15 feet	25 gal/ft.
710 gpm	26 feet	27.3 gal/ft.
1150 gpm	40 feet	28.7 gal/ft.
1500 gpm	52 feet	28.9 gal/ft.
1650 gpm	59 feet	27.9 gal/ft.

Site Surface elevation - 4426
Static Water elevation - 4144

This data indicates that optimum usage of the well would be at 1500 gpm or 1.44 mgd for a 16 hour pumping schedule. At present the well is capped awaiting allocation of money and engineering plans for construction of pumping equipment and a transmission main for connecting it to the existing system. Approximately 15,000 feet of main will be required.

c. Wastewater Effluent

Although it is not an all-purpose source, stored effluent from the 2 wastewater plants at which secondary treatment and chlorination are provided, is being used to irrigate the 18 hole golf course and Chaffee Parade Grounds which collectively demand as much as a million gallons per day during the early summer season.

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A 1.8 million gallon concrete lined lagoon was completed about 1 September 1972, adjacent to Plant #2, to supplement the existing 0.7 million gallon earthen lagoon at Plant #1. A valved 4" potable water line is available to add to the non-potable supply for irrigation purposes if ever needed. The lowest recorded daily flow as averaged from the two successively lowest flow days during the high water use months of April, May, June, July, and August in 1972 was 1,213,000 gallons. The two lagoons, with a capacity of 2.5 million gallons will provide storage for two days of minimum flow from the two wastewater plants. This storage will accommodate a demand of as much as 2 million gallons on any one day and a subsequent demand of 1,213,000 gallons on the following days during the high irrigation period of the year.

Further relief of the potable water shortage could be provided if some of the other areas now being irrigated with potable water could be irrigated with wastewater. This change would depend on approval of the medical department and addition of pumping and piping for handling the wastewater. The areas around the residential areas and school playgrounds may not be approved for irrigation with wastewater plant effluent however, even though the residential irrigators are the major users of potable water for this purpose.

The phosphate content of the wastewater was measured to determine if it would be acceptable for replenishment of the evaporation from the lakes in lieu of using potable water. The wastewater as tested and analyzed with our equipment and confirmed by the Post laboratory technician contains about 8 mg/l of phosphates. This quantity is quite beneficial for plant life both on land and in water. However, profuse plant growth in the lakes is quite objectionable. Therefore, the

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wastewater should be used and its use extended to the maximum possible for irrigation of land plants and the low phosphate spring or well water should be used for replenishing the water evaporating from the lakes.

In addition to the extensive construction and maintenance costs, another factor which makes use of non-potable water undesirable in inhabitated areas is the danger of possible cross connections between the potable and non-potable systems by unknowing maintenance and construction personnel.

3. Booster Pumps

a. General

At present there are 14 existing potable water booster pumps which are identified as follows:

Facility	Location	Rated Capacity	THD
Booster #1	adjacent to Deep Well #1 & #2	450 gpm @	700 feet
Booster #2A	adjacent to Deep Well #1 & #2	700 gpm @	270 feet
Booster #2B	adjacent to Deep Well #1 & #2	700 gpm @	715 feet
Booster #3	adjacent to Deep Well #3	900 gpm @	320 feet
Booster #4	adjacent to Deep Well #4	900 gpm @	320 feet
Booster #5	adjacent to Deep Well #5	900 gpm @	320 feet
Booster #6	adjacent to Deep Well #6	700 gpm @	290 feet
Booster #6A	at Wherry Booster Station	*560 gpm @	252 feet
Booster #6B	at Wherry Booster Station	*590 gpm @	252 feet
Booster #6C	at Wherry Booster Station	*520 gpm @	252 feet
Booster #6D	at Wherry Booster Station	*680 gpm @	252 feet
Booster #7A	at 1-1/2 M Reservoir	500 gpm @	240 feet
Booster #7B	at 1-1/2 M Reservoir	500 gpm @	240 feet
Booster #7C	at 1-1/2 M Reservoir	500 gpm @	240 feet

*Actual Field Test Observations

In addition to these 14 potable water booster pumps, there are 4 boosters for the non-potable irrigation systems.

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b. Wells #1 and #2 Boosters (See Tabulation Sheet #8, Curves #1, #2 and #3, and Sketch #7 in APPENDIX): Boosters #1, #2A, and #2B can take suction from either of two 50,000 gallon concrete surge tanks located at Wells #1 and #2. Sketch #7 depicts the piping connections. As shown, each well can pump into either surge tank so that either one can be drained for repair work.

Boosters #1 and #2B discharge into a 16" steel main which connects into the 12" steel cylinder concrete pipe that supplies the 1-1/2 million gallon reservoir. The curves for these booster pumps (curves #1 and #3, in the APPENDIX) show design heads of 450 gpm at 700 feet TDH and 700 gpm at 715 feet TDH. The elevation head is about 470 feet. If there is 161 feet of friction head or a total head of 631 feet, the curves indicate delivery capacities of 630 gpm and 910 gpm respectively. (The 161' is from using "C" value of 100 and calculating losses in 17000' of 12" and 1600' of 16" pipe). Maximum pumpage requirements are normally required when the Huachuca springs are producing very little. Its flow from where it enters the transmission main near Huachuca Springs Road was therefore disregarded. The delivery from the booster pumps if operated at maximum rated capacity should therefore be 1540 gpm.

An attempt was made to determine the actual unrestricted flows from these 30 year old boosters, but it was found that they were valve throttled so that full flow was not being developed. The ampmeter on the booster pump motors registered excessive current usage when these restricting gate valves were momentarily opened fully. It is reported by Post operating personnel that these three booster pumps cannot be operated simultaneously without throwing the circuit breaker. However, Post personnel report that impellers have been examined within the last five years and that they show no wear and should still deliver their design capacity. As a result of the throttling, the combined flow of Booster #1 and #2B is less than the combined production of Wells #1 and #2. 1040 gpm against 1208 gpm. (See Table IA, page 15 and TABLE I, page 10).

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TABLE IA

WELL BOOSTER DELIVERY

Observations by: Nocho, Roahrig, Tencza
1-10-73 on charts in control panel and
meter dial on 2A

BOOSTER #1	(Throttled) 300 gpm	32.5 Amp draw (Motor is very noisy)
BOOSTER #2B	(Throttled) 830 gpm	47 Amp draw (Motor relatively quiet)
BOOSTER #1 & 2B	(Throttled) 1040 gpm	48 Amp & 32.5 Amp draw
BOOSTER #2A	(Throttled per existing operation to pull 32.5 amps while only it and #3 were operating) 900 gpm	
BOOSTER #3	(Throttled per existing operation while only it and #2A were operating) 780 gpm (at central recorder)	
BOOSTER #2A	(Throttled per existing operation while all well site boosters were operating) 630 gpm (at meter)	
BOOSTER #3	(Throttled per existing operation while all well site boosters were operating) 580 gpm (at central recorder)	
BOOSTER #4	(Throttled per existing operation while all well site boosters were operating) 450 gpm (at central recorder)	
BOOSTER #5	(Throttled per existing operation while all well site boosters were operating) 440 gpm (at central recorder)	
BOOSTER #6	(Throttled per existing operation while all well site boosters were operating) 580 gpm (at central recorder)	

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Booster Pump #2A takes suction from the same surge tank header and discharges to the lower zone distribution system on which the 3 million gallon reservoir and the 0.5 million gallon elevated tank float. Since the other two boosters (#1 and #2B) should be able to pump more than Well #1 and #2 can deliver, and since these booster pumps deliver water direct to the 1-1/2 million gallon reservoir without power being lost from boosting again at the Wherry Booster Station, there should be no need for Booster Pump #2A to be activated under normal conditions.

Curve #2 indicates that the shut-off head on pump #2A is 295'. Therefore when the other booster pumps discharging into the distribution system create a 45' friction loss, this pump should go entirely static. If the booster pumps from Wells #3, #4, #5, and #6 (See Curve #4-5 and Tabulation Sheet #9) were operated together at unthrottled design flow, the friction loss at the discharge point of Pump #2A into the system would be about 74 feet. (See Table II). However, the actual delivery of #2A with the above described boosters operating at the same time in a throttled condition was 630 gpm (See TABLE IIB, page 19a). This indicates that the pump curve information may be erroneous.

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TABLE II

FRICTION LOSSES IN WATER TRANSMISSION SYSTEM TO 3M.G. RESERVOIR & 0.5M.G. ELEVATED TANK WHEN BOOSTER PUMPS #3,4,5, & 6 ARE DISCHARGING AT THEIR RATED CAPACITY AGAINST STATIC PRESSURE AND AN ESTIMATED 74' FRICTION LOSS

* "C" - 100

(See Sketch #13 in APPENDIX)

Northerly

Pump #4 -	1550'	- 12"	@	770 gpm	@	2.6'/1000'	=	4.0'
	2800'	- 16"	@	820 gpm	@	0.7'/1000'	=	2.0'
	3100'	- 12"	@	1530 gpm	@	9.1'/1000'	=	28.2'
	2200'	- 12"	@	1470 gpm	@	8.4'/1000'	=	18.5'
	1200'	- 12"	@	1270 gpm	@	6.3'/1000'	=	7.6'
	550'	- 12"	@	970 gpm	@	2.9'/1000'	=	1.5'
	750'	- 12"	@	1220 gpm	@	5.9'/1000'	=	4.4'
	2400'	- 14"	@	1220 gpm	@	2.8'/1000'	=	6.7'
						Total Friction Loss	=	72.9'

Southerly

Pump #6 -	50'	- 12"	@	650 gpm	@	1.9'/1000'	=	0.1'
	900'	- 6"	@	600 gpm	@	0.4'/1000'	=	0.4'
	2200'	- 12"	@	1370 gpm	@	7.4'/1000'	=	16.3'
	4300'	- 12"	@	1370 gpm	@	7.4'/1000'	=	31.8'
	1150'	- 12"	@	900 gpm	@	3.4'/1000'	=	3.9'
	1750'	- 12"	@	650 gpm	@	1.9'/1000'	=	3.3'
	1150'	- 12"	@	915 gpm	@	3.5'/1000'	=	4.0'
	1050'	- 12"	@	965 gpm	@	3.8'/1000'	=	4.0'
	4500'	- 12"	@	715 gpm	@	2.3'/1000'	=	10.4'
						Total Friction Loss	=	74.2'

Balanced friction loss is about 74'

In TABLE II above the booster pump rated discharges are taken from heads shown on pump curves #4 and #5. Comparisons with discharges from matching well pumps in TABLE I page 10 follow:

	Booster Pumps				Well Pumps
Well No.	Static Head	Friction Head	Total Head	Discharge GPM	Discharge GPM
#3	269'	74'	343'	770	760
#4	269'	74'	343'	770	611
#5	278'	74'	352'	710	575**(450)
#6	241'	74'	315'	650	601

**Estimated present quantity

*A "C" value of 100 was used for these calculations because that is standard practice for older pipes some of which are ferrous such as these and it was not known what the friction coefficient should be.

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When all booster pumps in the well site areas are operating at their rated capacity against both the static and 74' friction head, they will pump approximately (from pump curves):

Booster #3	=	725 gpm	
Booster #4	=	755 gpm	
Booster #5	=	705 gpm	
Booster #6	=	680 gpm	
Booster #2A	=	0	(goes static 45' fr. loss)
		2865 gpm	

MAXIMUM RATED BOOSTER PUMP CAPACITY INCLUDING BOOSTER PUMPS #1 AND #2B IS 2865 + 1540 = 4405 gpm.

However, the #3, 4, 5, and 6 boosters are throttled by adjusting the outflow gate valves of each. Operating personnel explained that this practice limits the booster capacities to match the well pump capacities when the friction loss is low with only one booster pump operating. As a result, the friction loss corresponding to this reduced flow is less than 45' so that Booster Pump 2-A is able to contribute flow to the system. This condition was observed in the field. (See Tables I-A, II-A, and II-B, and Sketch #14).

Since Booster Pump #2A cannot theoretically be used during maximum water requirements, it should normally be valved off from the system and used only by manual operation when water use requirements are low and operation personnel may want to rest other pumps for servicing or for keeping #2A in operating condition for service during times of low water use.

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TABLE II-A

FRICTION LOSSES IN WATER TRANSMISSION SYSTEM TO 3M.G. RESERVOIR & 0.5M.G. ELEVATED TANK WHEN BOOSTER PUMPS #2A & #3 ARE OPERATING AT OBSERVED DISCHARGES WITH USUAL THROTTLED CONDITION

* "C" = 120

(See Sketch #13A in APPENDIX)

Northerly

Pump #3 -	1700' - 12"	@	780 gpm	@	1.9'/1000'	=	3.2'
	5200' - 16"	@	880 gpm	@	0.6'/1000'	=	3.1'
	3100' - 12"	@	880 gpm	@	2.3'/1000'	=	7.1'
	2200' - 12"	@	830 gpm	@	2.1'/1000'	=	4.6'
	1200' - 12"	@	730 gpm	@	1.7'/1000'	=	2.0'
	550' - 12"	@	600 gpm	@	1.1'/1000'	=	0.6'
	750' - 12"	@	750 gpm	@	1.7'/1000'	=	1.3'
	2400' - 14"	@	750 gpm	@	0.8'/1000'	=	1.9'
							23.8'

Southerly

Pump #2A -	1300' - 12"	@	900 gpm	@	2.4'/1000'	=	3.1'
	4300' - 12"	@	800 gpm	@	2.0'/1000'	=	8.6'
	1150' - 12"	@	600 gpm	@	1.1'/1000'	=	1.3'
	1750' - 12"	@	450 gpm	@	0.7'/1000'	=	1.2'
	1150' - 12"	@	610 gpm	@	1.2'/1000'	=	1.4'
	1050' - 12"	@	610 gpm	@	1.2'/1000'	=	1.3'
	4500' - 12"	@	460 gpm	@	0.7'/1000'	=	3.2'
							20.1'

Balanced friction loss is about 22'.

* A "C" value of 120 was used for these calculations because it was observed from pump curves under actual operating conditions that the pressure against the pumps from friction losses did not indicate that a higher friction was actually being developed.

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TABLE II-B

FRICTION LOSSES IN WATER TRANSMISSION SYSTEM TO 3 M.G. RESERVOIR & 0.5M.G. ELEVATED TANK WHEN BOOSTER PUMPS #2A, #3, #4, #5, AND #6 ARE OPERATING AT OBSERVED DISCHARGES WITH USUAL THROTTLED CONDITION

* "C" = 120
(See Sketch #13B in APPENDIX)

Northerly

Pump #6 -	50'	-	12"	@	580 gpm	@	1.1'/1000 =	0.1'
	1500'	-	16"	@	480 gpm	@	0.2'/1000 =	0.1'
	2800'	-	16"	@	930 gpm	@	0.6'/1000 =	1.7'
	3100'	-	12"	@	1370 gpm	@	5.2'/1000 =	16.1'
	2200'	-	12"	@	1300 gpm	@	4.9'/1000 =	10.8'
	1200'	-	12"	@	1230 gpm	@	4.3'/1000 =	5.2'
	550'	-	12"	@	1080 gpm	@	3.5'/1000 =	1.9'
	750'	-	12"	@	1350 gpm	@	5.1'/1000 =	3.8'
	2400'	-	14"	@	1350 gpm	@	2.4'/1000 =	5.8'
								45.5'

Southerly

Pump #6 -	50'	-	12"	@	580 gpm	@	1.1'/1000 =	0.1'
	900'	-	16"	@	100 gpm	@	0.1'/1000 =	0.1'
	2200'	-	16"	@	680 gpm	@	0.4'/1000 =	0.9'
	4300'	-	12"	@	1310 gpm	@	4.9'/1000 =	21.0'
	1150'	-	12"	@	900 gpm	@	2.4'/1000 =	2.8'
	1750'	-	12"	@	650 gpm	@	1.4'/1000 =	2.5'
	1150'	-	12"	@	1060 gpm	@	3.3'/1000 =	3.8'
	1050'	-	12"	@	1110 gpm	@	3.6'/1000 =	3.8'
	4500'	-	12"	@	840 gpm	@	2.1'/1000 =	9.5'
								44.5'

Balanced friction Loss = 45'.

At flow from 2 pumps (TABLE II-A) friction loss was 22' or a difference of 23'. The flow drop from Booster #3 was 200 gpm less than when only pumps #2A and #3 were operating. The Booster #3 curve indicated that balanced friction loss should have been 30'. This would indicate that the "C" factor should have been lower but this one curve is not entirely conclusive evidence for a decisive assumption.

* A "C" value of 120 was used for these calculations because it was observed from pump curves that the pressure against the pumps from friction losses did not indicate that a higher friction was actually being developed.

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c. Boosters at Wells #3, #4, #5 and #6 (See Tabulation Sheet #9, Curves #4 and #5, and Sketches #8 and #9 in APPENDIX).

Booster pumps at each of these well sites have as much or more capacity for discharge against the maximum head developed in the transmission mains than the well pumps can furnish to the respective 50,000 gallon tanks from which the boosters take suction. Their total capacities are shown in TABLE II, page 17, as 2865 gpm against maximum operating pressures.

However, due to the throttling conditions mentioned above, the combined flow as noted in TABLE IA, page 15 is only 2050 gpm. According to TABLE I, page 10, and Tabulation Sheets 3-6, total Well Production from Wells #3, 4, 5, and 6 should exceed 2420 gpm. This indicates that the total booster outflow was being throttled excessively in the data noted in TABLE IA, page 15.

d. Wherry Boosters

Booster Pumps 6A, 6B, 6C, and 6D (See Sketch #11 and Tabulation Sheet #10) each have a maximum positive suction head of 37' from the 3 million gallon reservoir. A maximum static head of 260 feet is reached at the pump levels when the 1-1/2 million gallon reservoir is full. Actual operating conditions are noted in TABLE IV, Page 22.

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TABLE IV

FRICTION LOSS EXAMINATION

FROM

WHERRY BOOSTER STATION

Observations on 11/20/72:
by: Nocho - Roahrig - Tencza

Pumps On	Discharge GPM	Pumps On	Discharge GPM
#6A	560	#6A	560
6B	590	6A-6B	1120
6C	420	6A-6B-6C	1520
6D	680	6A-6B-6C-6D	1960
TOTALS	2350		* 1960

* This total confirmed by observation again on 11/27/72

Observations on 11/27/72:

Pumps On	Time	Pump Discharge Pressure	10" Station Outlet	Hydrant, 900' S. on Rucker
None	10:25 AM			107 psi
#6A	10:32 AM	109 psi	109 psi	113 psi
#6A, 6B	10:36 AM	112 psi	111 psi	115 psi
#6A, 6B & 6C	10:30 AM	114 psi	112 psi	112 psi
#6A, 6B, 6C & 6D	10:44 AM	116 psi	115 psi	110 to 115 psi

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Elevation differential from the hydrant on Rucker to approximately 5' below the tank overflow = 5105 - 4860 = 245' = 106 psi. The above readings on the gauges which were furnished by the Post Fire Department and read as accurately as practicable, indicates about 8 psi maximum friction loss in the piping system during maximum pump discharge at 10:30 A.M. to 11:00 A.M. on a Monday morning which is considered to be an average water use period. (Two of the four pumps were operating just prior to starting the tests.)

The four Wherry boosters which have a total capacity of 1960 gpm are not capable of maintaining the water level at the top of the 1-1/2 million gallon reservoir during maximum demand. Installation of a new booster or repair of booster #1 would relieve the four Wherry boosters pumping requirement by the difference between the 1200 gpm well production and the 830 gpm capacity of booster #3 when pumping alone or 370 gpm. These calculated differences in flows are based on 24 hour operation.

Maximum water requirements in Zones "A" and "B" are approximately 72% of the total requirement. The calculated total is 4.93 mgd but actual use from TABLE V, page 34 is 5.25 mgd. The usage in the two zones is therefore actually measured as 3.78 mgd or 2620 gpm. If 1200 gpm of this requirement is satisfied by boosters #1 and #2B after booster #1 is replaced, the Wherry boosters would need a capacity of 1420 gpm if all boosters are operated 24 hours per day. However, if one of the #1 or #2B boosters is not operated so that 600 gpm is delivered direct to the 1-1/2 M reservoir,

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the Wherry boosters would need to pump 1420 + 600 = 2020 gpm for 24 hours. If operated 16 hours per day as recommended by the manual, Wherry area boosters would need a combined capacity of 3030 gpm which is 1070 gpm in excess of the existing combined capacity.

When additional boosters are installed in the Wherry area they should, however, be located to take suction from the 18 inch main and discharge to the 14 inch main on Craig Street because the piping in the present booster building is already loaded to capacity. The new boosters should be of similar size to the existing ones. There should be two new boosters added with each having a capacity of about 535 gpm against the static head plus about 30' of friction head.

e. Old Post Boosters (See Tabulation Sheet No. 10 and Sketch #11 in APPENDIX). (No curves are available): Booster pumps #7A, 7B, and 7C are manifolded in a weatherproof building about 100' to the north of the 1-1/2 million gallon reservoir. Installed in 1962, the boosters have a positive suction head of from 20 feet to 37 feet. Each is rated for 500 gpm at 240' TDH. The usage in Zone "A" to which these pumps discharge is reported by Post water system personnel to be low enough so that not more than two pumps ever operate at the same time. The maximum daily demand for water in Zone "A" served by these boosters from calculations shown under "II. PRESENT SITUATION, 1.c" page 5, is 818,250 gallons per day. This can be satisfied by two of the existing pumps operating about 14 hours per day.

A summary of the relationships between the boosters, their supply mains, and their terminal storage facilities are depicted in Sketch #13.

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4. Water Distribution System

a. General

Although there is a relatively large percentage of steel pipe in the distribution system, maintenance personnel report that there are no unusual problems due to leaks or corrosion. While Plate #1 depicts the water transmission lines and the main feeder lines, the effectiveness of the system is discussed below for each pressure zone.

b. Transmission Lines

The transmission line from Well #1 and #2 booster station to the 1-1/2 million gallon reservoir is 12" steel cylinder concrete pipe except for 1600' of 16" steel pipe at the lower end. This steel pipe was installed in 1969 and so is assumed to be in good condition. The line from Garden Canyon Springs, a 12" steel cylinder concrete transmission line, is also assumed to be in good condition, since normal estimated life of this type pipe is 50 years.

The pipe lines from Wells #3, #4, #5, and #6 are cast iron of adequate size out to the 16" cast iron collector main located in Brainard Road. This 16" line is connected to a 12" cast iron line at Carter Street and to a 12" cast iron line at Well #3 outlet on Brainard. A 12" cast iron main runs from the intersection of Brainard Road and Carter Street to the populated area. It serves the smaller lines along the way to Cushing Street where it connects to a 14" A-C transmission line which is connected to the bottom of the three million gallon reservoir which floats on the line.

A 12" steel main runs from this Well #3 outlet on Brainard southerly thence westerly to a 0.5 million gallon elevated tank floating on the system and thence northerly to form a loop with the above described Carter Street 12" main.

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5. Water Pressure Zone Analysis

a. Zone "A" (Old Post Area)

Water is supplied in limited quantities to Zone A from Huachuca Canyon Springs via an 8" A-C line installed from a system of filter beds in the Canyon to the older portion of the Old Post Reservoir. The major supply is pumped via a 30 year old 10" steel pipe to both portions of the Old Post Reservoir by Boosters #7A, #7B, and #7C which take suction from the 1-1/2 million gallon reservoir. All distribution mains are 8" and 6" size of either cast iron or asbestos-cement mater.

There are 4 pressure reducing valves in the system to prevent excessive pressures in the lower areas of the system. This system distributes approximately 17% of the total daily potable water demand of the Fort. It is estimated that about 42% of the water used during peak demand periods in summer is used for irrigation of the landscaping around the residences, in the cemetery, and on the parade field along Grierson Avenue.

The water system maintenance personnel report that the booster plant for the Old Post Reservoirs is quite adequate but that during the dry and hot season, the 1-1/2 million gallon reservoir is almost empited several times each summer. This lowering of water level, however, is from use in the lower pressure zones rather than excessive use in Zone "A".

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Maintenance personnel report that there are complaints of low pressure at residences near the 1-1/2 million gallon reservoir when its water level is lower than normal (about 10' from top). Examinations of relative elevations in the area indicate that ground elevations of some residences around Mills Circle are as close as 50 feet below the low water levels in the tank. Since the houses are built above ground level, some of their upper stories could have only 30 feet or 13 psi of pressure. This pressure in inadequate for automatic washing machines, flushometer valve toilets, etc. These residences should therefore be served from the higher pressure zone. When these residences are served from Zone "A", at least one fire hydrant should be kept on the lower pressure zone for emergency use from the lower system.

The Apache Flats area and both Motor Pool areas (see Sketch 15) are at elevations at least 90 feet below the lower water level in the 1-1/2 million gallon reservoir (39 psi) and so these areas could be adequately served from the 1-1/2 million gallon reservoir instead of the Old Post reservoirs. It is desirable to make these changes in pressure zones to save boosting the water when it is not necessary. Also, the larger storage facility will provide more water for emergency use in the areas.

The above discussed pressure zone changes can be made by installing a total of about 2000 feet of 6" pipe at six locations and 100 feet of 8" pipe at one location. The locations are shown on Sketch Number 15.

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b. Zone "B"

Zone B, comprising that area from elevation 5020 to elevation 4810 is served from the 1-1/2 million gallon reservoir floating on the distribution system. This zone obtains its supply from Garden Canyon Springs; Booster Pumps #1 and #2B via a 16" and 12" steel cylinder concrete pipe; and from the Wherry Booster Station which draws from the 3 million gallon reservoir and discharges into the distribution system. The 14" A-C main into which the booster pumps discharge and the other branch lines in the system are adequate for serving the zone and are mostly A-C pipe reported to be in good condition. There are 8 pressure reducing valves in the system for preventing excessive pressures in the lower areas.

This distribution system satisfies about 55% of the total daily demand. It is estimated that approximately 40% of Zone "B" total demand during dry summertime is being used for irrigation of landscaping.

c. Zone "C"

Zone C extends from the lower end of Zone B to the Northern and Eastern limits of the Fort's boundary. The principal supply is from Wells #3, #4, #5, and #6 discharging thru 16" and 12" looped mains. These mains are connected to the 500,000 gallon elevated steel tank and the 3 million gallon reservoir which float on the system and thereby maintain the required pressure in the distribution system. An altitude valve on the elevated tank prevents its overflow since it fills up before the 3 million gallon reservoir because of friction loss in the longer lines to the 3 million gallon reservoir.

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Generally speaking, Zone C distribution system serves several warehouses, family housing, a laundry, the golf course, and two wastewater treatment plants. Of the remaining portion of daily demand to be accounted for, about 49% would be for domestic needs, and 51% for irrigation.

d. Discussion of another Pressure Zone

A fourth pressure zone could be established to provide a reduction in power usage due to less boosting and less variation in pressures within the zones. This extra zone would require its own storage facility. In fact, good practice is to have pressure zones with not over 100 feet of pressure head variation in each zone. This criteria would require 5 zones in the presently populated areas on the Fort. There are now 5 pseudo-pressure zones being operated by means of pressure reducing valves located in two of them to maintain practical pressures in the lower areas of the zones where pressures would otherwise be excessive. The present method of control has advantages and disadvantages, some of which are as follows:

(1) Advantages

(a) One storage facility provides a reserve for emergency that is larger than would be available at any particular point if the same storage quantity was split into additional reservoirs at different elevations.

(b) One storage facility is less costly per gallon to construct and maintain than two facilities.

(c) A lesser number of booster pumps are needed to provide adequate standby capacity for breakdowns.

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(d) Less transmission piping is required between the booster pumps and the storage facility. As an example, a storage facility might be desirable at elevation 4960 to serve a zone from elevations 4760 to 4860. This would require the storage reservoir, at least 8000 feet of 12" pipeline and appurtenances, as well as several other pipe changes and transmission main replacement along Smith Avenue and revision of and addition of booster pumps, piping, pumphouse, and controls.

(2) Disadvantages

(a) Approximately 15% of the potable water used is lifted about 100 feet higher than would be necessary if there were 5 fully independent zones.

(b) There are occasional problems encountered in maintaining the pressure reducing valves at the desired settings.

e. Summary

In view of the above discussion, it is concluded that retention of, and additions to, the existing storage facilities at the present working elevation are the preferred method of upgrading the storage and booster pumping facilities for all of the populated area. However, in order to satisfy pressure requirements in the area immediately below the 1-1/2 million gallon reservoir, this area should be placed in the higher Zone "A". Offsetting this would be an area in Apache Flats that could be removed from Zone "A" and placed in Zone "B".

Storage additions are discussed under the heading "WATER STORAGE REQUIREMENTS" of this report.

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6. Water Storage

a. Zone "A"

This zone serves the upper area of the Fort which has about 17% of the total potable water demand. Storage consists of the following facilities:

(1) 200,000 gallon ground masonry reservoir
Top Elevation = 5271.5
Bottom Elevation = 5256.4

(2) 250,000 gallon ground concrete reservoir
Top Elevation = 5264.5
Bottom Elevation = 5255.0

As shown in Sketch #16 these reservoirs are interconnected in such a way that water can be transferred from #1 to #2, but not from #2 to the southerly compartment of #1. These facilities are known as the Old Post Reservoir; they serve Zone A. It can be seen in Sketch #14 that, at present the south 100,000 gallons compartment in #1 is used for fire reserve only. Huachuca Springs water flows into the south compartment continuously. In addition, an open port in the wall separating the two compartments allows overflow of water from the south compartment into the north one. This entire reservoir is 7' higher than #2. However, the bottom of the north compartment of #1 and the #2 reservoir are interconnected so that the water surfaces are level. This results in the upper part of the north compartment of #1, with storage volume of about 70,000 gallons, being non-usable. The only practical way that this storage volume could be utilized in conjunction with reservoir #2 would be to construct the sides 7' higher on #2 reservoir. Another method would be to put an altitude valve on #2 reservoir and

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valve off and use the full capacity of #1 reservoir as the primary storage. However, this would cause water in the #2 reservoir to stagnate. Although these two facilities are 62 and 34 years old, they appear to be in good enough condition to serve for several more years. However, it is not thought to be feasible to construct additional structural material on top of #2 to revise the water level in it.

Water storage requirements for this zone for domestic purposes is 358,000 gallons per day. Water storage requirements for fire purposes for this zone in accodrance with TM 5-813-4 (EM 1110-345-223) are 358,000 gallons x 50% + 1000 gpm x 4 hours x 60 minutes = 419,000 gallons as shown in "II. PRESENT SITUATION, 1.c.". Total water usage including irrigation is 779,000 gallons per day. This is the coldest area of the Post and Post administrators do not expect any expansion of building or personnel in this zone. These reservoirs have been operated for several years with a 100,000 gallon compartment valved off for emergency fire use. This then always allows for utilizing 250,000 gallons + 30,000 gallons (or a total of 280,000 gallons) for normal storage and the additional 100,000 gallons for emergency use by manual operation of a gate valve.

Since the 280,000 gallons of storage is not adequate for that recommended by TM-5-813-4 criteria and since the reservoirs are quite old, the facility should have additional new storage to conform with the 419,000 gallon estimated requirement.

b. Zone "B"

Storage for this zone consists of a 1-1/2 million gallon prestressed concrete ground reservoir.

Top Elevation	=	5110
Bottom Elevation	=	5080

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Completed in May 1958, this tank is in good condition needing only normal maintenance. It floats on the Zone "B" distribution system which serves the central populated area of the Post which has about 55% of the total potable water demand. This reservoir also acts as the suction source for booster pumps #7A, #7B, and #7C to the Old Post reservoirs.

The storage requirement for this area in accordance with TM-5-813-4 (EM 1110-345-223) is 1,470,000 gallons x 50% + 1000 gpm x 2 fires x 4 hours x 60 minutes = 1,215,000 gallons as shown in "II. PRESENT SITUATION, 1.c". The total calculated water use including irrigation is 2,550,000 gallons per day. These water usage figures do not include the 779,000 gallons lifted into Zone "A" and so the total storage requirement must be based on the 3,329,000 gallons daily and the maximum hourly usage. On several occasions during the summer irrigation season 1,000,000 gallons have been drawn from the reservoir in a 2 hour period with all booster pumps operating as discussed under II, 3.b., page 14. The storage at this location needs to be increased to accommodate the domestic and irrigation requirements of Zone "B" of 2,550,000 gallons and the 779,000 gallons pumped to Zone "A" from Zone "B". In view of the actual experience discussed above, even when some administrative restrictions have been imposed on irrigation, it is quite essential that an additional storage facility be provided. If the added storage has 1,500,000 gallons capacity, it would obviate requirements for additional storage in Zone "A".

c. Zone "C"

Located in this Zone is a 3 million gallon concrete ground storage reservoir that floats on the Zone "C" distribution system which serves about 28% of the potable water demands.

Top Elevation = 4887
Bottom Elevation = 4870

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Although this unit is 30 years old, it has been well maintained. It has been re-roofed fairly recently so that no major maintenance is required at present.

A 500,000 gallon elevated steel tank also floats on Zone "C" and operates at the same elevation as the 3 million gallon reservoir.

Top Elevation = 4887
Bottom Elevation = 4870

This tank fills up sooner than the 3 million gallon reservoir which is fed thru longer transmission lines. An altitude valve has therefore been installed on it to prevent overflow.

This tank and reservoir not only furnish storage for Zone "C" but are the storage and suction source for the Wherry booster station which furnishes water to Zones "B" and "A". The daily water requirements for this Zone "C", as described in II.1., page 8, are 1,284,000 gallons. The storage requirements in accordance with TM 5-813-4 (EM 110-343-223) are 564,000 gpd x 50% + 1000 gpm x 4 hours x 60 minutes = 522,000 gallons.

On one recorded occasion during the summer irrigation season (June 1971 - See Table V on pages 35 and 36) the water storage during a 5 day period was depleted to as low as 1,650,000 gallons before operating booster pumps could replace the deficit. The fastest recorded depletion during a 2 hour period has been 400,000 gallons. Since the lowest storage volume of record (1,650,000 gallons) still exceeded the 1,408,500 gallon storage requirement, the storage is considered adequate.

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TABLE NO. V

RESERVOIR WATER DEPTHS & DAILY
STORAGE SHORTAGES DURING A CRITICAL PERIOD

JUNE 1971

RESERVOIR DEPTHS WHEN FULL

Old Post	9.0 feet
1-1/2 Million	29.0 feet
3 Million and 1/2 Million Tank	16.0 feet

Following depths are at 12:01 A.M. of date shown. Water production is to midnight of date shown. All pumping facilities were operating at maximum existing operating production capacity at all times.

Date	Old Post	Shortage	1-1/2 M	Shortage	3 M & 0.5 M	Shortage
10th	8.5'	10,000	27.5'	75,000	12.5'	250,000
11th	9.0'	0	11.0'	900,000	12.5'	250,000
12th	9.0'	0	11.0'	900,000	11.0'	350,000
13th	8.7'	5,000	19.0'	500,000	13.5'	175,000
14th	8.2'	20,000	10.0'	950,000	14.5'	105,000
15th	6.0'	90,000	10.0'	950,000	13.0'	210,000
16th	7.0'	60,000	2.0'	1,300,000	13.5'	175,000
17th	7.5'	45,000	26.0'	150,000	10.5'	385,000
18th	8.5'	10,000	7.0'	1,100,000	12.5'	250,000
19th	8.5'	10,000	6.0'	1,150,000	10.5'	385,000
20th	8.7'	NA	NA	NA	NA	NA

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Continuation - TABLE NO. V

SUMMARY OF MAXIMUM WATER USE

June 1971	Total Reservoir Shortage	Total Water Production	TOTAL DAILY POTABLE WATERUSE (Sum of Production & Reservoir Depletion)
Thursday 10	335,000	4,286,000	5,101,000
Friday 11	1,150,000	4,850,000	4,950,800
Saturday 12	1,250,000	4,946,600	4,376,600
Sunday 13	680,000	4,185,000	4,580,000
Monday 14	1,075,000	4,628,700	4,803,700
Tuesday 15	1,250,000	4,919,000	5,204,000
Wednesday 16	1,535,000	5,070,900	4,115,900
	(Irrigation Holiday)		
Thursday 17	580,000	4,464,700	5,244,700
Friday 18	1,360,000	5,037,800	5,222,800
Saturday 19	1,545,000	5,014,500	
20	CHARTS NOT OPERATING		

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d. Discussion of Storage Facilities

It was evident on the recording charts that the water level in the 1-1/2 million gallon reservoir was regularly lowered 10 feet to 13 feet in a 1-1/2 hour period beginning at 6:00 P.M. during this critical period. This is the time, from 6:00 P.M. to 7:30 P.M., when residents in all zones are allowed to turn on their lawn sprinklers. This rate of withdrawal of 650,000 gallons in 1-1/2 hours is 4400 gpm greater than all four Wherry boosters and Booster #2B can supply.

The problem of drastic withdrawal in the 1-1/2 million gallon tank during the 6-7:30 PM domestic irrigation period may be resolved in two ways. An additional 1.5 million gallon storage facility can be connected to the present tank, or the irrigation schedule could be modified so that only a small part of the total domestic irrigating is done at any one time. The additional 1.5 million gallons of storage would allow for present hourly irrigation schedules to be followed and still have 1.5 million gallons of storage for emergencies.

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7. Miscellany

A 500,000 gallon elevated steel tank, stripped of vital appurtenances in 1946, has been kept painted but is not considered available for use and no plans are known for putting it back into service.

Several 10,000 gallon tanks are used by specialized industries such as cold storage and the laundry. Their purpose is strictly for special local requirements and are not considered as a part of the system storage. There are also six 50,000 gallon surge tanks used at the six wells. However, only storage units described for zone storage, with a total capacity of 5,000,000 gallons, will be considered as Fort Huachuca's potable water storage.

Generally speaking, valving and metering of the lines and pumps is adequate. Swing check valves continue to be used to protect the booster pumps. These create serious water hammer and should at least be spring loaded checks. There are at least two instances where gate valves are used to shut off an abandoned line that was part of the existing system or connects to a lower pressure zone. It would be better to cut the abandoned lines and block the ends rather than depend on valves that may leak past the seat or that may have gates rusted out. Only those valves entirely necessary for emergency connection between pressure zones should be left in place.

There has been a considerable amount of effort expended and facilities constructed to develop and utilize the water from springs in Garden and Huachuca Canyons. These water sources have not contributed materially to the peak demands because these demands occur when spring flows are very low.

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The spring flows, however, are effective in relieving the pumping of water from the aquifers supplying the wells when there are large flows from the springs during rainy periods.

The total water production of the springs could be increased by development of a program allowing more rain and snow water to reach the spring-charging areas. Officials of the Post Forestry Department and the Engineer's Office suggested several methods for assisting in this endeavor. Fencing could be constructed so that debris and pollution from people using recreation areas would not get onto the spring-charging areas. There could also be selective spot clearing of phreatophites and strip cutting of timber so that snow lodged in tree crowns would be minimized and so there would be more open areas for runoff to occur. Also, clean-up of deadfall would provide more water absorption in the spring collection area.

Some additional collection of water from the springs could also be made. At Saw Mill Spring, located above the Boy Scout camp in Huachuca Canyon, a maximum of possibly 200,000 gallons per day during deluge rain periods could be collected. However, construction of a damming and filtering system and about 3 miles of 6" water line would be required. It is not considered to be practical to

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develop this spring for the limited quantity of water that could be collected. Another spring is evident along the roadway up Garden Canyon. This is adjacent to the transmission line from the upper collection points and so could be developed to collect possibly 200,000 gallons per day during deluge rain periods. Although the cost of developing this area would probably be considerably less than developing the Saw Mill Spring, again it is not considered practical as a source during peak demand periods and so if developed would be only for purposes of saving the mining of water from the aquifers at the well site.

While meters are installed at each booster pumping unit, not all of their recorders are operative. It would be useful to repair all meters and make regular 24 hour readings of each. It appears that some servicing needs to be done on the automatic control panel also. Post operations personnel reported that the meter installed on the wastewater effluent line leading to the Golf Course irrigation system was not operating properly. This should be repaired and daily reading of it should be reinstated.

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III. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

a. Pressure Zone Changes.

Better utilization of available pressure may be accomplished by changing the distribution system serving both upper and lower motor pool and Apache Flats areas from Zone A to Zone B. A pressure reducing valve currently prevents damage to the fittings in this area due to excessive pressure. This valve should be deactivated or removed. Similarly, a certain portion of Mills Circle residents would benefit by changing this water system from Zone B to Zone A. Pressures as low as 13 psi are experienced throughout the summer months in this area.

b. Production.

The peak daily water pumped from the 50,000 gallon supply reservoirs at the wells was 5,340,000 gallons on June 30, 1972. The maximum capacity of the six wells is 5.24 mgd on a 24 hour basis and evidently an additional 100,000 gallons was pumped from storage in the 50,000 gallon reservoirs. The maximum well capacity on a 16 hour pumping basis is 3.49 mgd. The minimum wastewater treatment plant effluent is 1,250,000 gallons per day. About 1.0 mgd of this water is being used for irrigation on the golf course and Chaffee Field. The maximum water used on any one day was 5.25 on Thursday, June 17, 1971 (See TABLE V, page 34). It is estimated that prior to September 1972 0.25 mgd was being used during summer days for supplementing the treated wastewater lagoon supply for golf course irrigation. This will no longer be necessary and so the 24 hour pumping of all wells could supply the daily water requirements. The deficit on the basis of 16 hour pumping of wells is 5.0 mgd - 3.49 mgd = 1.51 mgd. Additional sources of water therefore need to be introduced as soon as practicable.

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c. Wells #1 and #2

It can be noted from Tabulation Sheets 1 and 2 that the bowl settings on Wells #1 and #2 have reached their limits. Both will require bowl lowering in the near future. It would be desirable to install new pumps and motors for these wells that would have sufficient head characteristics to discharge directly into the transmission main. This would eliminate the low efficiency of operation now prevailing with the double pumping system.

d. Well #5

A project for increasing the specific capacity of Well #5 would be worthwhile. Since its capacity has been good in the past, but is now about 60% of original capacity, it would be expected that a well driller could economically acidize and surge and redevelop it to its original capacity.

e. Test Well #5

Test Well #5, located in the east Range, has been proven to be a high production well. This well could be equipped and connected to the water system as an additional source of supply. The well has been tested to 1650 gpm and has maximum specific capacity or yield at 1500 gpm and so this should be a practical pumping rate for it. In order to maximize efficiency of pumping facilities and controlling operation the deep well pump should discharge directly into the transmission main. The pump should be capable of discharging against both elevation head and friction of 60'.

An 18" transmission main should be constructed from the well to the 18" main now serving Libby Field. If this main is constructed of asbestos-cement, or cement lined pipe with smooth bore, a "C" factor for friction of 120 can be used.

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Under these conditions an 18" pipe from the well to the 3 million gallon reservoir (22,000') would develop a friction loss of 0.86 x 22.0 = 19'. If additional flow of 1280 gpm is introduced later making a total of 2780 gpm, friction loss would be 2.7 x 22.0 = 60'. If the main was enlarged to 24" the friction loss would be 2.7 x 7.0 + 0.65 x 15.0 = 28'. Since it is estimated that the larger pipe would cost 50% more than the 18", the 18" pipe should be used. Consideration was given to looping the new main with the existing 12" main on Carter Street. However the friction loss in the existing looped system from the presently connected wells was not thought to be excessive under present pumping conditions. Therefore, expenditure of funds for the line over to the new main is not thought to be justifiable.

f. Well Pump Meters

The arrangement of existing supply lines and booster pumps at the well sites is adequate. However, there are no meters on well pump discharge piping to determine flows.

g. Zone "B" Storage

It has been found that the storage capacity of the prestressed 1.5 million gallon reservoir is not sufficient to provide storage for emergency fire protection during maximum hourly use. In fact, frequently during peak demand periods 1,000,000 gallons above pumping replacement capacities were used during a 2 hour period. Although two additional booster pumps are recommended, they will only provide 65,000 gallons per hour. As discussed in "6. Water Storage, b. Zone B", a new 1.5 million gallon reservoir should be constructed at the same site and at the same high water and working level elevation as the 1.5 million gallon reservoir.

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h. Spring Production

Although additional water sources can be developed from springs, their production is practically nil during peak demand periods and so it is not considered practical to develop more springs except for the purpose of lessening overdraw from the aquifers at the well sites.

i. Old Post Reservoir

The Old Post Reservoir has about 70,000 gallons of storage capacity that is not being used and another 100,000 gallons that is valved off for emergency use only. This 100,000 gallons is available only by opening a gate valve manually. However, the situation has operated satisfactorily since 1939. Since no changes in water use in the zone are anticipated, no changes in equipment or operations will be recommended in this report.

j. Booster Pumps #1, #2A, and #2B

There are no pressure control valves on the discharge side of Booster Pumps #1 and #2B. However, there is no unusual water hammer in the piping when pumps are turned on and off. The amp meters indicate that the motors are overloaded when flow is not throttled. Pump curves indicate that there should be no overload. Also, the motor on pump #1 is very noisy indicating some malfunction. Post operating personnel say that they cannot turn on Booster #1, #2A and #2B without tripping the circuit breakers. This situation should be investigated, and appropriate modifications or repairs implemented. Since the well pumps require modifying and lowering and since booster pumping and electrical switch gear are quite old and not operating efficiently, it would be desirable to eliminate the booster system and install new well pumps that discharge directly into the transmission main.

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k. Operational Controls

On one occasion it was observed that the surge tank drain at Well #1 was open and continuously draining water from it without the operator being aware of it. A tell-tale device in the operating room could prevent this happening.

l. Abandoned Lines

It was observed that the gate valve on the old potable water inlet to the wastewater lagoon was leaking. It would be advisable for this line, the old line to the 1-1/2 million gallon reservoir, and any other lines that have been abandoned to be cut off and plugged.

m. Booster Replacement

Under existing operating conditions Booster Pump #1 is delivering only about 300 gpm against 500' TDH instead of its design capacity of 450 gpm against 710' TDH. Its motor is very noisy and sounds like it may be defective. Since this pump and motor are 34 years old they should be replaced instead of repaired.

n. Wastewater Reuse

The treated wastewater from the two plants has been used successfully for irrigating the golf course and Chaffee Field at a maximum rate of about 1.0 mgd. The minimum average daily flow of any 2 day period from the two treatment plants is about 1.25 million gallons. There is therefore 250,000 gallons per day of treated wastewater available for irrigating areas now being irrigated with potable water. These additional areas would have to be approved by the Medical Department. Some of these areas might be those

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around Greeley Hall and Barnes Field as well as other less definable areas. Prior to September 1972, an estimated 250,000 gallons per day maximum of potable water was being used for golf course irrigation. This potable water will no longer be needed for irrigation. Although the Post cemetery is one of the larger irrigated areas, its location is too far from the available wastewater source to be considered for use of wastewater. If the Medical Department should permit use of wastewater plant effluent for irrigation of the hospital ground, there is a possibility that the abandoned 10" water transmission main could be used as a portion of the transmission system for the effluent if a surge tank is used for settling particles that may spall off from its interior. The 8 mg/l of phosphates in the wastewater make it unsuitable for use in the lakes because it creates profuse plant growth. The plant growth is desirable on land and so the wastewater should be used to the utmost for land irrigation.

o. Wherry Booster Additions

The Wherry Booster Station has not been able to keep up with the peak demands in Zone "B". They also create objectionable water hammer when starting and stopping and so should have spring loaded check valves on their discharge lines. The existing piping system in the booster station and building are not adaptable to expansion. It is therefore necessary to construct another booster station. This preferably should take suction from the 18" pipe and the 12" pipe now discharging overhead into the 3 million gallon reservoir and should also be tapped underground and connected to the suction header.

p. Automatic Controls

The pump control system is not yet being utilized continuously and so there is some question as to whether the pumping facilities are being operated at maximum efficiency.

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Although, according to the curve data sheets, the motors were quite adequately sized to operate the booster pumps under all head conditions, some of the pumps are being throttled to prevent what is thought to be an overload on the motors at lower head conditions. The 12" discharge valve for booster pump #2B was found to be about 85% closed. Other booster pumps at the well sites are also being throttled with gate valves to prevent exhausting the storage in suction reservoirs faster than the well pumps can fill them. A more efficient method of controlling the discharge would be to install a control valve in conjunction with an orifice plate for sensing head differentials to control the flow to a constant quantity under varying head conditions.

q. Storage Level Adjustments

The well pump storage tank water levels and the booster pump shut-off at low reservoir levels are controlled by Mercoid switches with sensing line connected to the booster pump suction lines rather than to the reservoirs. This makes them difficult to adjust properly and so the operating differential is only about 4 feet in the 10 foot deep reservoirs rather than a desirable 7 feet.

r. Irrigation Scheduling

As a temporary means of operating the present water system until construction of recommended facilities can be completed, irrigation might be staggered by administrative direction so as not to concentrate it during any short period of time and to have opposite sides of streets or alternate blocks of houses to irrigate on only a 2 day alternating basis. Commercial irrigation might similarly be alternated.

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2. Recommendations

The previous sections of this report have described the current status of Fort Huachuca's water supply system. This section lists recommendations for the major factors involved in adding to and changing the existing system and its operation to provide adequate water service to the Post facilities. Some other minor factors that could probably be accomplished by Post personnel were discussed under "1. Conclusions" above, and are not repeated below. Either planning for or actually processing the following recommendations should be started as soon as practicable: (Location of recommendations a thru k are shown on PLATE NO. 2).

a. Pressure Zone Changes

The boundary between Zones "A" and "B" should be changed by connecting water mains and by blocking the ends of others at seven locations as shown on Sketch No. 15.

b. Well #5 Pumping Equipment & Transmission Main

The existing test well #5 located in Section 16 should be equipped with well pumping equipment capable of delivering about 1500 gpm of water directly into the transmission main thru adequate water pressure control equipment against a head of 520 feet at the inlet to the main. The pumping equipment should be controlled from the central control panel and have its starting and stopping sequenced with pumps at the other wells. The panel should have motor running lights, on-off-automatic switch, and an indicator-totalizer-recorder showing meter performance.

An 18" transmission main should then be constructed from the well pump to tie into the 18" main at Libby Field. (See Sketch 16).

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c. Additional Booster Pumps

A new booster station consisting of two pumps with capacity of 535 gpm each and necessary housing should be constructed to supplement the Wherry booster station. The pumps should take suction from the 18" main near Hatfield and Burns Streets and discharge into the 14" main at a discharge pressure at the entrance into the 14" main of 230 feet or 100 psi.

The pumps should be controlled from the central control station and have starting and stopping sequenced and alternated with pumps #6A, 6B, 6C, and 6D. The 12" main that discharges overhead into the 3 million gallon reservoir should also be tapped underground and connected to the booster station suction header with a 12" pipe.

d. Booster Pump Replacement

Booster Pump #1 and motor should be replaced. However, as described in "1. Conclusions, paragraphs c. and j."above, the present double pumping station should be eliminated and replaced with well pumps discharging directly into the transmission main.

e. Additional Storage

A 1.5 million gallon storage reservoir should be constructed at the same site and top water level working elevation as the existing 1-1/2 million gallon reservoir in Zone "B". It should be interconnected with the existing reservoir supply piping.

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f. Power Supplies & Motors

The motors on all pumps should be checked out and should be replaced if overloaded by the pumps at maximum load conditions. The electrical power equipment at the site of Wells #1 and #2 should be reconditioned or replaced so that all pumps in the area can be operating simultaneously.

g. Pump Controls

Pump controls should be arranged or supplemented for activating and alternating the starting sequence of booster pump numbers 3, 4, 5, 6, and the proposed new test well #5 pump from water elevations in the 3 million gallon reservoir.

Similarly the controls for the four Wherry booster pumps and the proposed two new booster pumps nearby should be supplemented to activate the new pumps and to alternate their starting sequence with the existing pumps. Activation should be sensed from water elevations in the 1-1/2 million gallon reservoir but none of these pumps should start until pumps at the site of Wells #1 and #2 are unable to keep the reservoir full.

The automatic controls for pumps at the site of Wells #1 and #2 should continue to be activated from sensors in the 1-1/2 million gallon reservoir to maintain the water level as near the overflow as practicable.

h. Redevelop Well #5

Well #5 should be acidized and redeveloped by a well driller to obtain as nearly as practicable its original capacity.

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i. Plug Abandoned Lines

The valves on the steel lines at the wastewater treatment lagoon and near the 1-1/2 million gallon reservoir should be removed and the lines plugged to prevent leakage. Any other abandoned lines not found during the investigation for this report should also be plugged.

j. Reset Well #1 and #2 Pump Bowls

Bowl settings on Well #1 and Well #2 pumps are fairly close to the danger point and should be lowered before they start sucking air. In lieu of lowering present pumps, it would increase operating efficiency by an estimated 100% if new pumps were installed in the wells and discharged directly into the distribution main.

k. Valving Changes

Install spring loaded check valves on all booster pump discharge lines on which patented slam valves are not currently installed. Wherry booster pumps particularly need these valves.

l. Extend non-potable irrigation system

The wastewater irrigation lines in the Chaffee Field area should be extended to any other locations such as areas around Greely Hall, Barnes Field House, and barracks complexes which the Medical Department will approve for the use of treated wastewater in Zone "B". Wastewater pumping facilities should then be expanded to transport and pressurize the approximately 0.25 mgd of surplus wastewater now available to the proposed new irrigation lines.

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m. Additional Well Development

Drill, equip, and connect to the existing water system a new water well at a location directed by the Corps of Engineers from information either already developed or to be developed. This would be used for supplementing the existing water sources as additional supply may be needed in the future due to increases in average per capita uses or possible population increases.

n. Booster Pumping Station Replacement

As equipment at the #3, #4, #5, and #6 well site booster pumping stations deteriorates it would be desirable to eliminate the low efficiency of double pumping by installing pumps in the wells to discharge direct to the transmission mains.

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REFERENCES

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USF200002134

TABULATION SHEET NO. 1

DEEP WELL AND PUMP NO. 1 - Floor Elev. = 4641.00

DRILLED:	1939
DRILLER:	W.E. Lane, Warren, Arizona
DIAMETER:	14 inches
CASED DEPTH:	703 ft. (Elev. 3938)
STATIC WATER LEVEL:	489 ft. (Elev. 4152) 1958
	519 ft. (Elev. 4122) 1971
RUNNING WATER LEVEL:	520 ft. @ 500 gpm (Elev. 4121) 1958
	*558 ft. @ 594 gpm (Elev. 4083) 1971
TOP OF BOWL SETTING:	560 ft. (Elev. 4081)
PUMP:	Submersible
PRIME MOVER:	Information Not available

* New pump after first test

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TABULATION SHEET NO. 2

DEEP WELL AND PUMP NO. 2 - Floor Elev. = 4641.2

DRILLED:	1940
DRILLER:	W. E. Lane, Warren, Arizona
DIAMETER:	14 inches
CASED DEPTH:	710 ft. (Elev. 3931)
STATIC WATER LEVEL:	490 ft. (Elev. 4153) 1958
	516 ft. (Elev. 4125) 1971
RUNNING WATER LEVEL:	520 ft. @ 750 gpm (Elev. 4124) 1958
	552 ft. @ 615 gpm (Elev. 4089) 1971
TOP OF BOWL SETTING:	560 ft. (Elev. 4081)
PUMP:	Wintroath Pumps, Inc. Alhambra, California Serial #2803 Elev. C/L discharge = 4642.5
PRIME MOVER:	U.S. Asbestos Protected Motor Serial No. 1000340 Type: CVF NRR H.P: 125, 3 Ph Power: 2300 volts, 60 excess

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TABULATION SHEET NO. 3

DEEP WELL AND PUMP NO. 3 - Floor Elev. = 4619.3

DRILLED:	1942
DRILLER:	Unknown
DIAMETER:	18 - 16 inches
CASED DEPTH:	802 ft. (Elev. 3817)
STATIC WATER LEVEL:	471 ft. (Elev. 4148) 1958
	503 ft. (Elev. 4116) 1971
RUNNING WATER LEVEL:	504 ft. @ 700 gpm (Elev. 4115) 1958
	*546 ft. @ 760 gpm (Elev. 4073) 1971
TOP OF BOWL SETTING:	650 ft. (Elev. 3969)
PUMP:	Worthington Size: 12 M903 8 stage Serial #VTP 23671
PRIME MOVER:	U.S. Motor Hollowshaft H.P: 200, 3 phase Power: 2300 volts, 60 cycles, 46 amps Speed: 1770 RPM

* New pump after first test

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TABULATION SHEET NO. 4

DEEP WELL AND PUMP NO. 4 - Floor Elev. = 4619.3

DRILLED:	1942
DRILLER:	Unknown
DIAMETER:	18 inches
CASED DEPTH:	807 ft. (Elev. 3812)
STATIC WATER LEVEL:	462 ft. (Elev. 4157) 1942
	490 ft. (Elev. 4129) 1971
RUNNING WATER LEVEL:	480 ft. @ 700 gpm (Elev. 4139) 1942
	505 ft. @ 610 gpm (Elev. 4115) 1971
TOP OF BOWL SETTING:	555 ft. (Elev. 4064)
PUMP:	Pomona Serial #B-737 Elev. C/L of Discharge = 4620.1
PRIME MOVER:	General Electric Motor Model 12 F 3306 Type: KF H.P: 125 2300 volts, 3 phase, 29.2 amps

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TABULATION SHEET NO. 5

DEEP WELL AND PUMP NO. 5 - Floor Elev. = 4610

DRILLED:	1942
DRILLER:	Unknown
DIAMETER:	18 - 16 inches
CASED DEPTH:	800 ft.
STATIC WATER LEVEL:	454 ft. (Elev. 4156) 1958
	489 ft. (Elev. 4121) 1971
RUNNING WATER LEVEL:	504 ft. (Elev. 4106) @ 700 gpm 1958
	583 ft. (Elev. 4027) @ 576 gpm 1971 (Throttled to 450 gpm)
TOP OF BOWL SETTING:	650 ft. (Elev. 3960)
PUMP:	K C 2721 - A - Worthington 12 M 90 E = 8 stage Serial #VTP 23673
PRIME MOVER:	U.S. Electrical Motors Model: Hollowshaft J1422422 Type: H V Speed: 1770 RPM Power: 2300 volts, 3 phase, 60 cycles H.P: 200

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TABULATION SHEET NO. 6

DEEP WELL AND PUMP NO. 6 - Ground Elev. = 4642.7

DRILLED:	Feb. 15, 1958
DRILLER:	J.R. Sharp, Bisbee, Arizona
DIAMETER:	16 - 18 inches
DEPTH:	0'to 803'(16" Ø); 803'to 1230'(8"Ø)
CASED DEPTH:	803 ft.
DIAMETER:	16" I.D. 5/16" Wall, Welded Plate Pipe with 1-1/4" x 12" Drive Shoe, Perforated from 500' to 760'.
STATIC WATER LEVEL:	492 ft. (Elev. 4151) 1958 516 ft. (Elev. 4127) 1971
RUNNING WATER LEVEL:	Not available in 1958 532 ft. @ 600 gpm (Elev. 4111) 1971
TOP OF BOWL SETTING:	570 ft. (Elev. 4073)
PUMP:	Johnson Submersible Serial #JR 5981 Type: 10 DS - 14 stages H.P: 150 Model #S 1S50B3,10D Power: 440 volts, 3 phase, 60 cycles Capacity: 750 gpm @ 555' TDH

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TABULATION SHEET NO. 7

DEEP WELL AND PUMP NO. Test Well #5 - Ground Eelv.= about 4426

DRILLED:	1971
DRILLER:	Beylik Drilling, Inc. La Habra, California
DIAMETER:	16 inches
CASING DEPTH:	800'
STATIC WATER ELEV:	4144±
RUNNING WATER ELEV:	4118± ft. @ 710 gpm (Test Pump) 4085± ft. @ 1650 gpm (Test Pump)
TOP OF BOWL SETTING:	415 ft. (Elev. 4011) (Test Pump)
PUMP:	(Temporary) 8" Peerless Turbine
PRIME MOVER:	(Temporary) GMC Diesel Engine

This Test Well has been capped, pending authorization for further development.

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TABULATION SHEET NO. 8

BOOSTER PUMP NO. 1:

United Iron Works*
Oakland, California
Size: 4" M.S. - C. 4 stage
Job #4135
Date: 5-31-39
Rated @ 450 gpm @ 710' head
Elev. C/L Pump = 4637
(For additional information see Curve #4)

Prime Mover:
Ideal Electric & Manufacturing Co.
Model #228053
Type A
150 HP
2300 Volts

BOOSTER PUMP NO. 2A:

United Iron Works*
Oakland, California
Size: 6" - M.S.-C. 2 stage
Job #8830
Date: 1-23-41
Rated @ 700 gpm @ 270' head
Elev. C/L Pump = 4638.5
(For additional information see Curve #5)

BOOSTER PUMP NO. 2B:

United Iron Works*
Oakland, California
Size: 4" M.S.-C. 4 stage
Job #8829
Date: 1-10-41
Rated @ 700 gpm @ 710' Head
Elev. C/L Pump = 4638.5
(For Additional information see Curve #6)

Prime Mover:
U.S. Electric
J 1422438
100 H.P.
2300 V.

* NOW: United Centrifugal Pumps
580 Second Street
Oakland 7, Calif.

USF200002142

TABULATION SHEET NO. 9

BOOSTER PUMPS NO. 3, 4, and 5:

Floway Pumps, Inc.
P.O. Box 104, Fresno, California
Item 1 D4EA 18-68-C-0272
Size: 12" - Type D OMH, 5 stages
900 gpm; 320' TDH;
Serial #68-3161

Prime Mover:
U.S. Electric Hollowshaft
Serial #J 1422438
Type: R V, Design B, Code F
H.P: 100
Power: 2300 volts, 23.5 amps, 3 phase, 60 cycles
Speed: 1770 RPM

BOOSTER PUMP NO. 6:

Johnston Vertical Pump
Serial #JW - 3338

Prime Mover:
General Electric Motor
Model L #5 K 62266 x C88A
H.P. 75, 440 volts
Type: K, Code F
Speed: 3550 RPM

USF200002143

TABULATION SHEET NO. 10

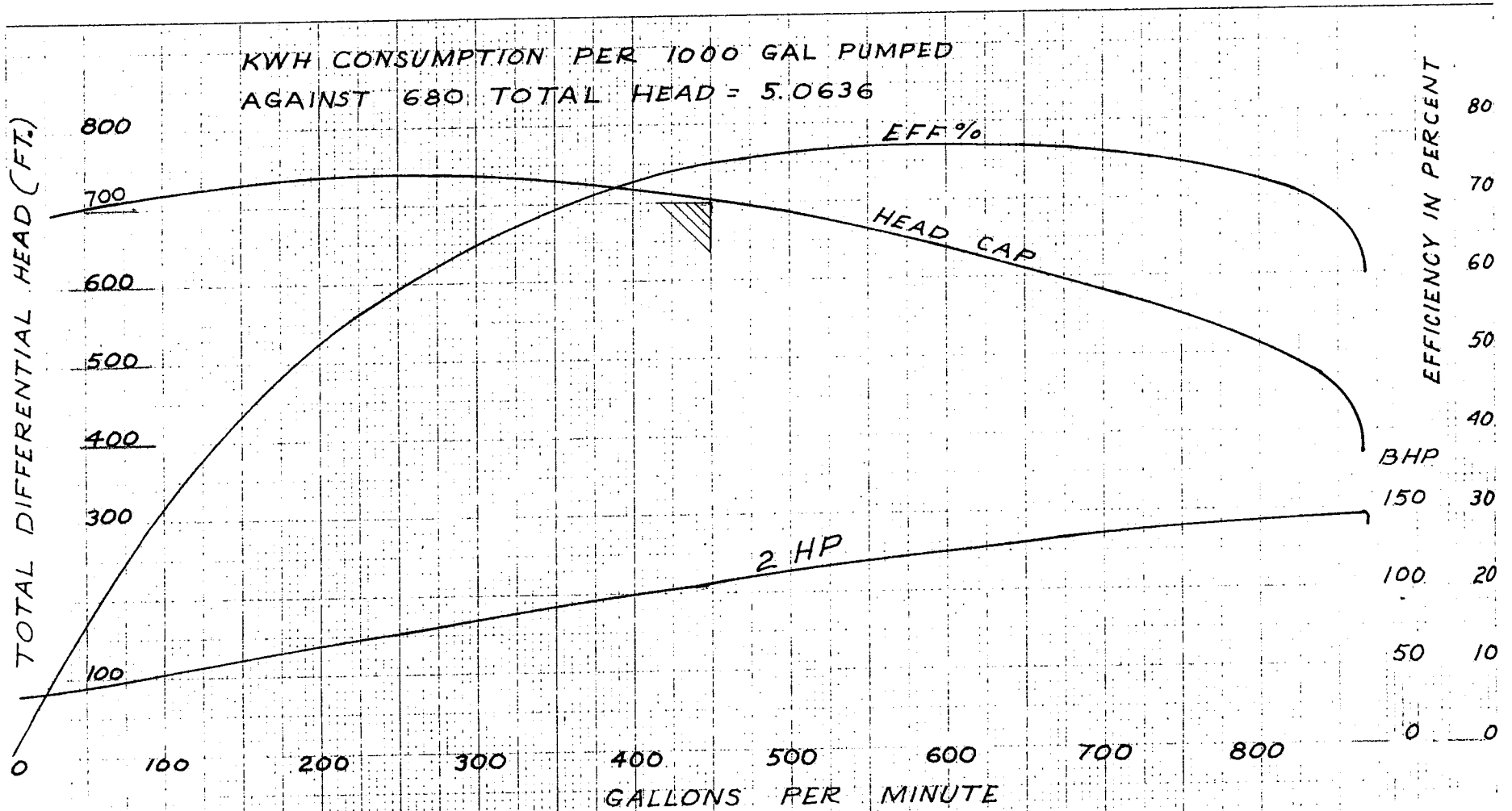
BOOSTER PUMPS NO. 6A, 6B, 6C, and 6D: (are identical)

PUMP:	Fairbanks-Morse 4" 5814 K56070 5814 K66690 5814 K67516 K67509
PRIME MOVER:	Fairbanks-Morse 50 H.P. 1770 RPM 440 volts, 59 amps, 3 phase S.F. 1.15 Type: K 2 K
SEE TABLE:	24 hour duty

BOOSTER PUMPS NO. 7A, 7B, and 7C: (are identical)

PUMP:	Worthington Serial #440411 500 gpm, 240' TDH 3600 RPM, 8-1/2" ø impeller
PRIME MOVER:	Marathon Electric Model # XE 364 USTDR5AA Type: TDR-BE H.P: 50 Power: 480 volts, 53 amps, 60 cycles Serial #X 52273

USF200002144



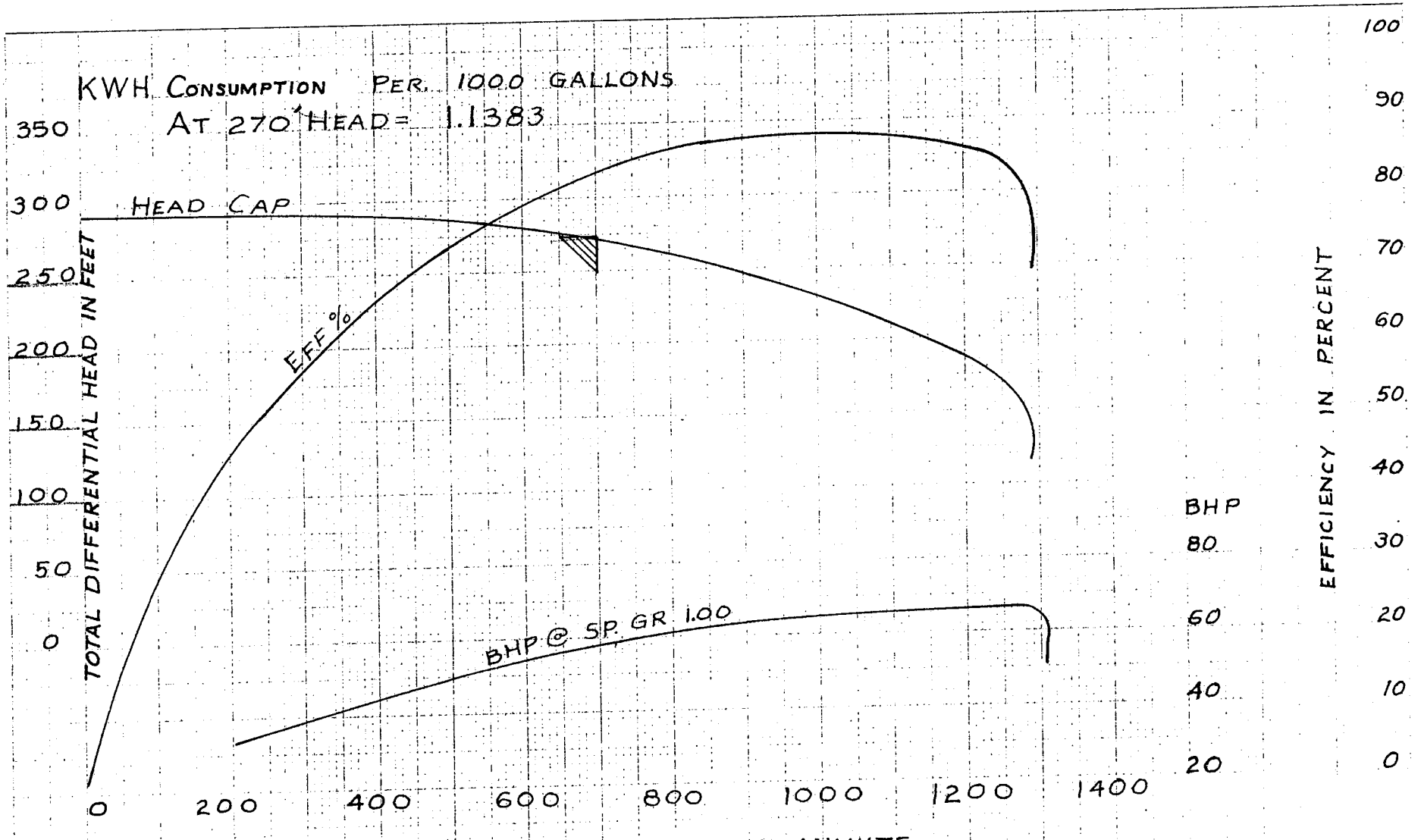
PUMP SERIAL Nº 4135 IN 1939

IMPELLER DIA. 13 5/16"	4" MS-C 4 STG PUMP		
14 3/4" MAX. DIA.	IMPELLER MAT'L. BRZ	IMPELLER 851 HI	1770 RPM

BOOSTER PUMP Nº 1

CURVE #1

USF2000021 45



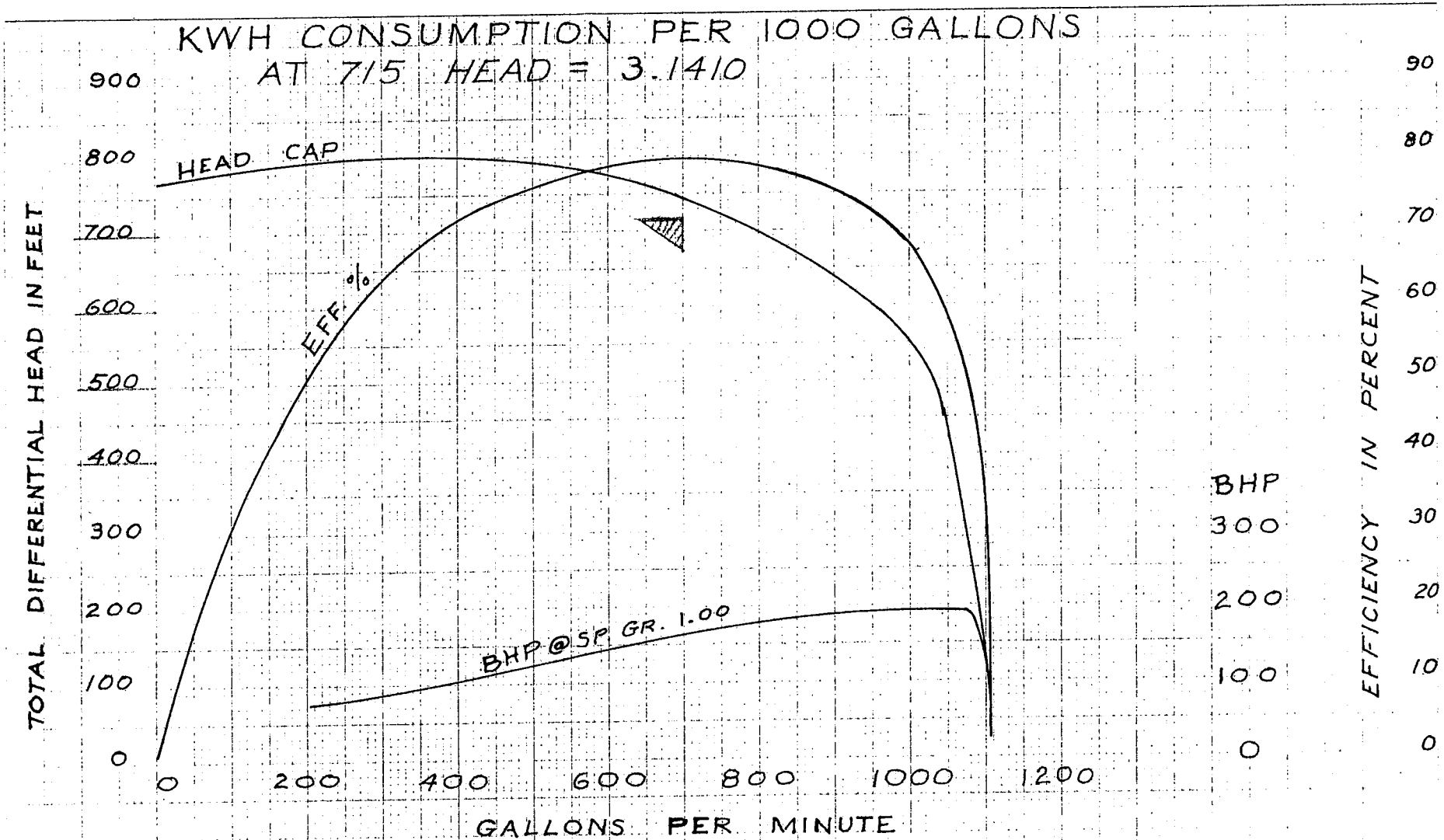
PUMP SERIAL Nº 8830 IN 1941

IMPELLER $11\frac{7}{8}$"	6"- MS-C 2-STAGE PUMP		
$11\frac{7}{8}$" MAX. DIA.	IMPELLER MAT'L. BRZ	IMPELLER 429-H	1780 RPM

BOOSTER PUMP Nº 2A

CURVE #2

USF2000021 46



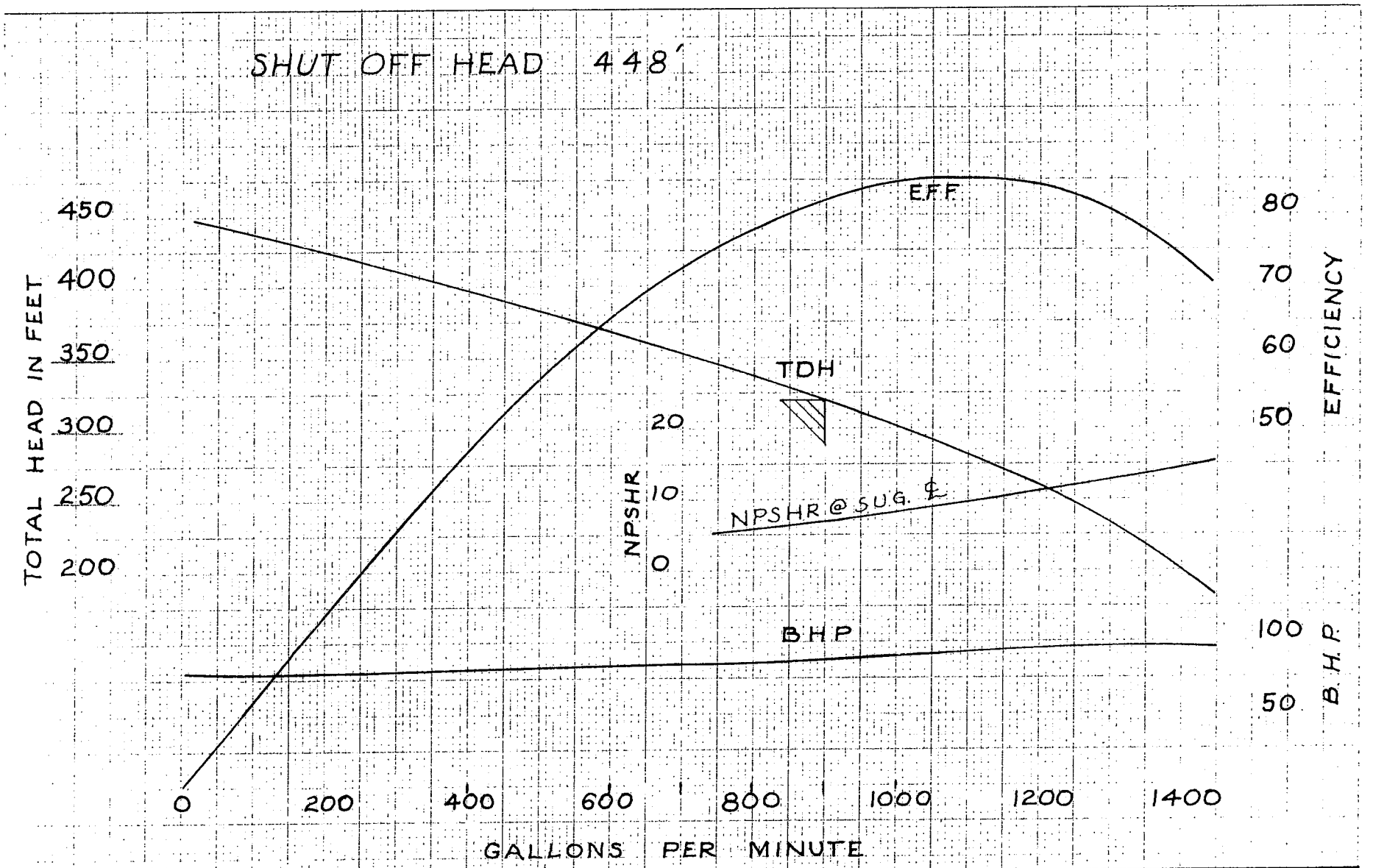
PUMP SERIAL Nº 8829 IN 1941

IMPELLER 13 11/16"	4" MS-C4-STAGE PUMP		
14 3/4" MAX DIA.	IMPELLER MAT'L. BRZ	851-H IMPELLER 851-H2	1770 R.P.M.

BOOSTER PUMP Nº 2-B

CURVE #3

USF2000002147

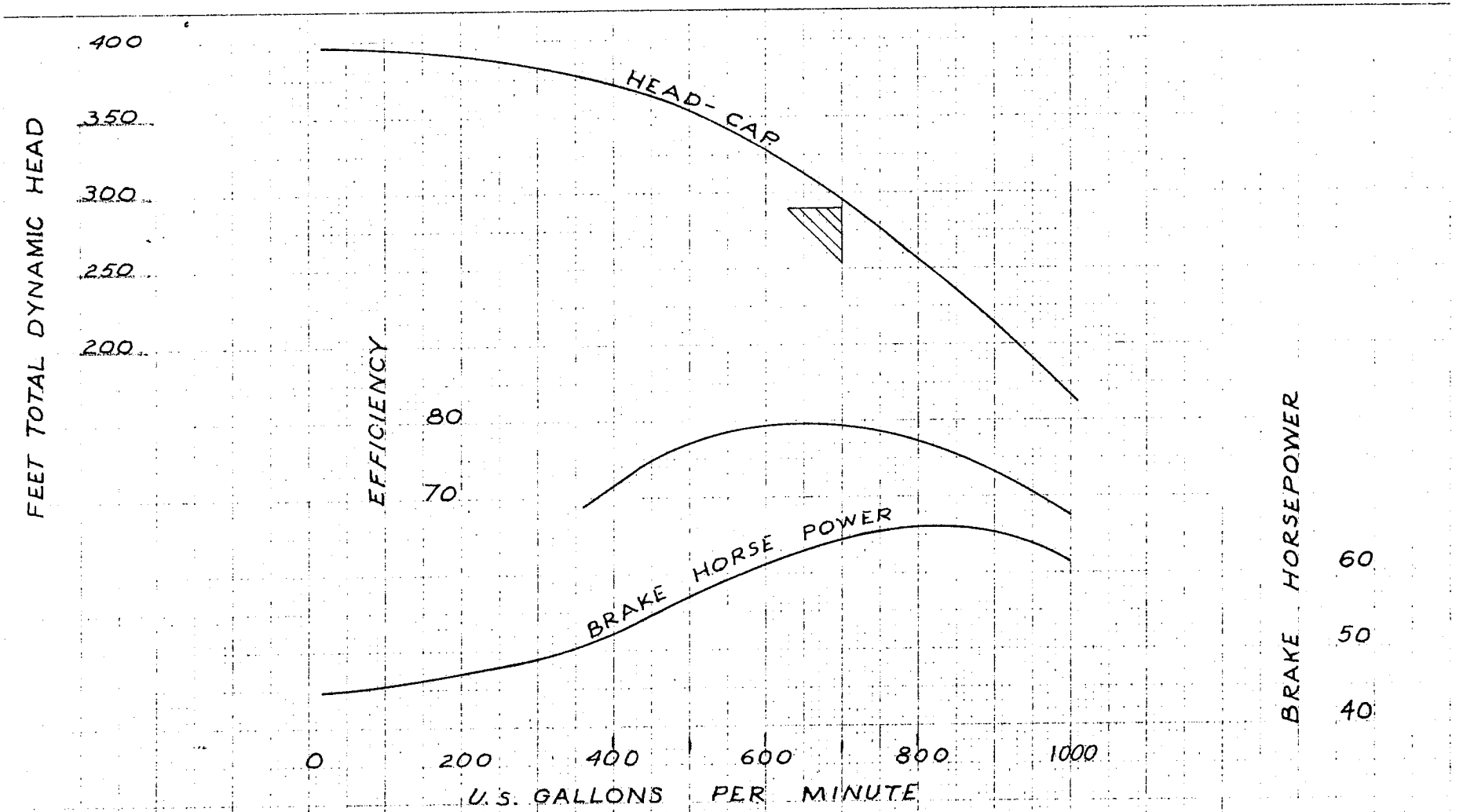


BOOSTER PUMPS Nº 3, 4, & 5

CURVE #4

5 STAGE TURBINE PUMP		
SIZE 12 DOMH	1770 RPM	

USF2000002148



BOOSTER PUMP Nº 6

CURVE #5

IMPELLER DIA. 7 1/8"	10AO TURBINE PUMP		
STAGES 2	IMPELLER BRONZE	BOWL CAST IRON	3500 R.P.M.

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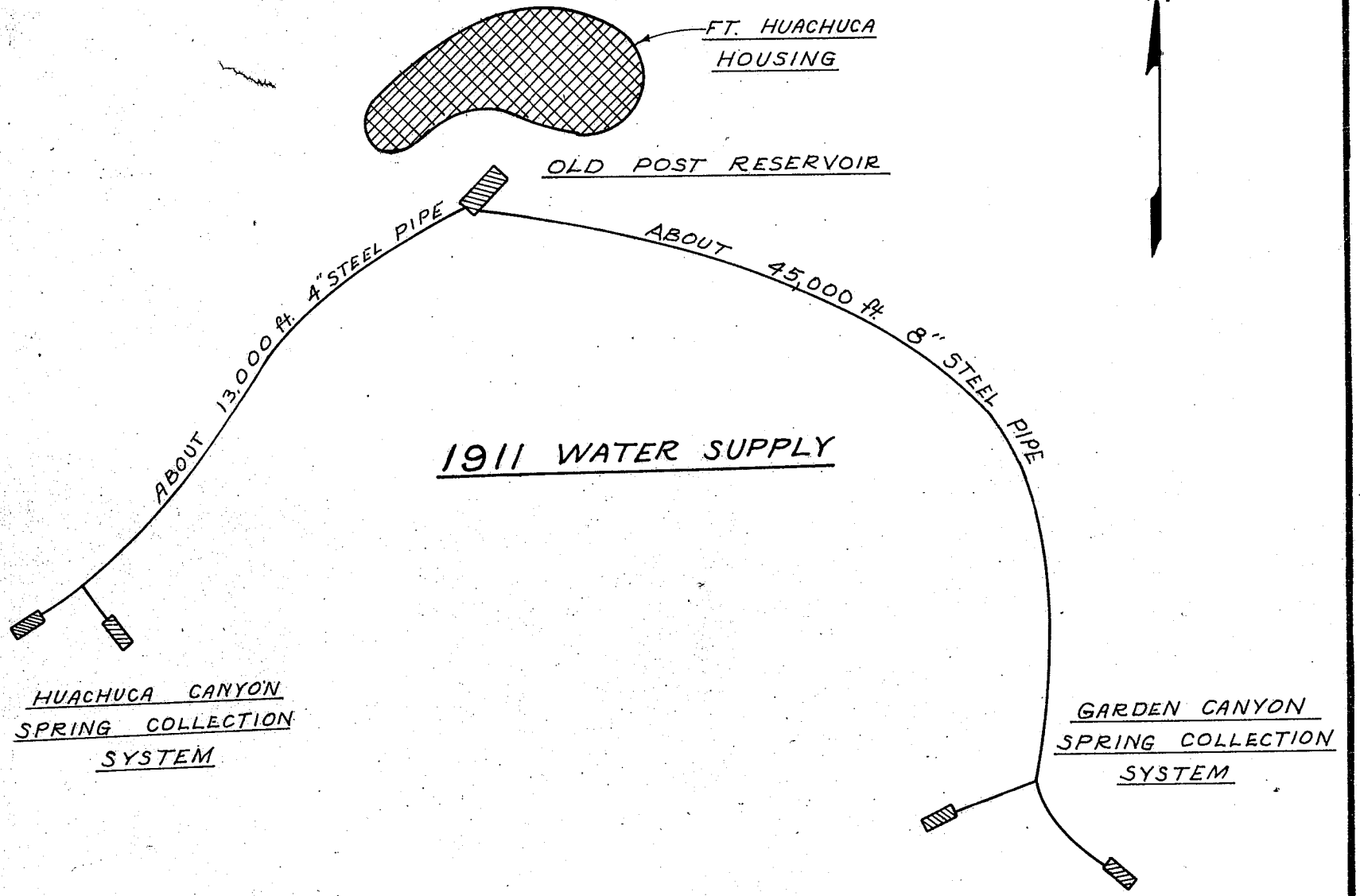

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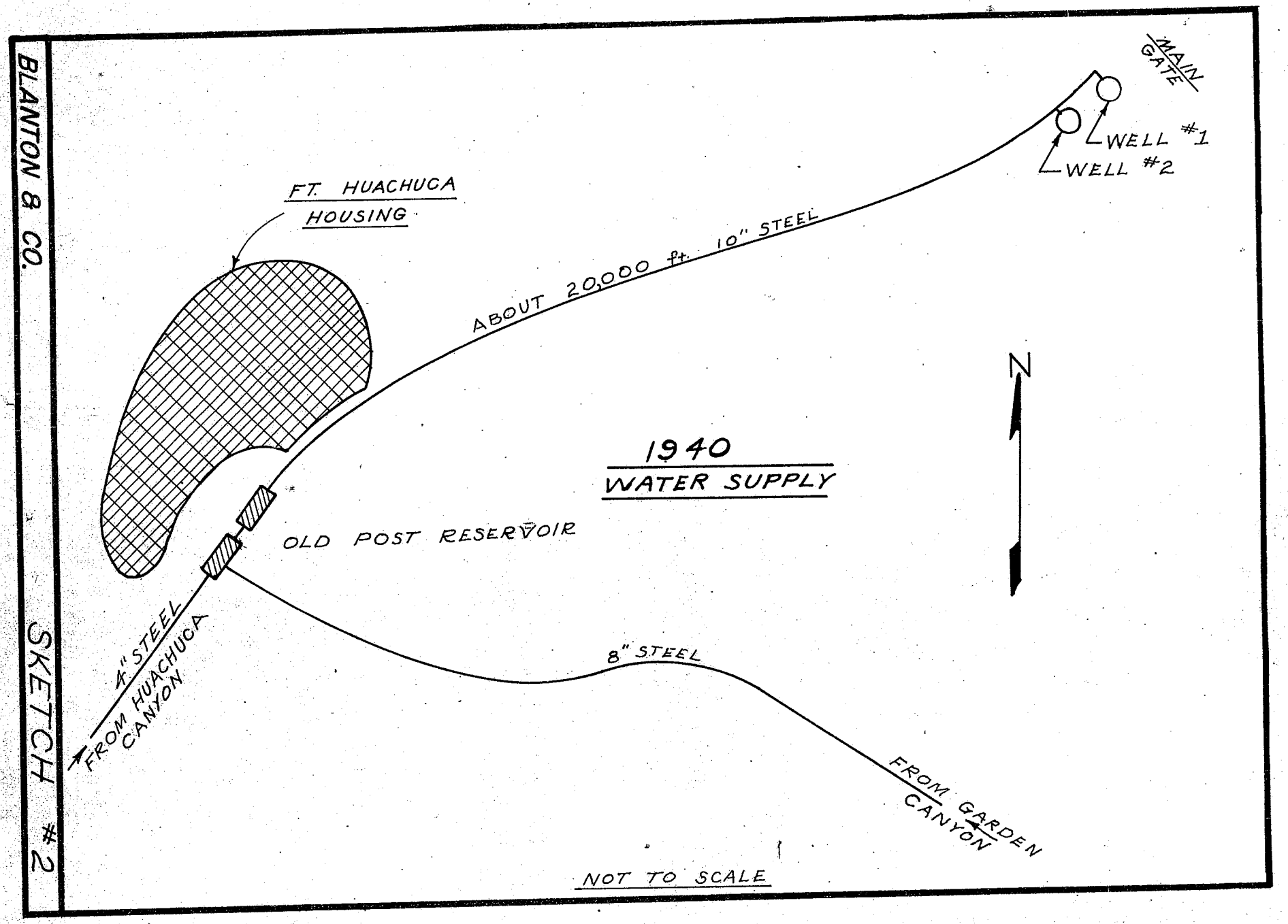
SKETCH #1

USF200002150



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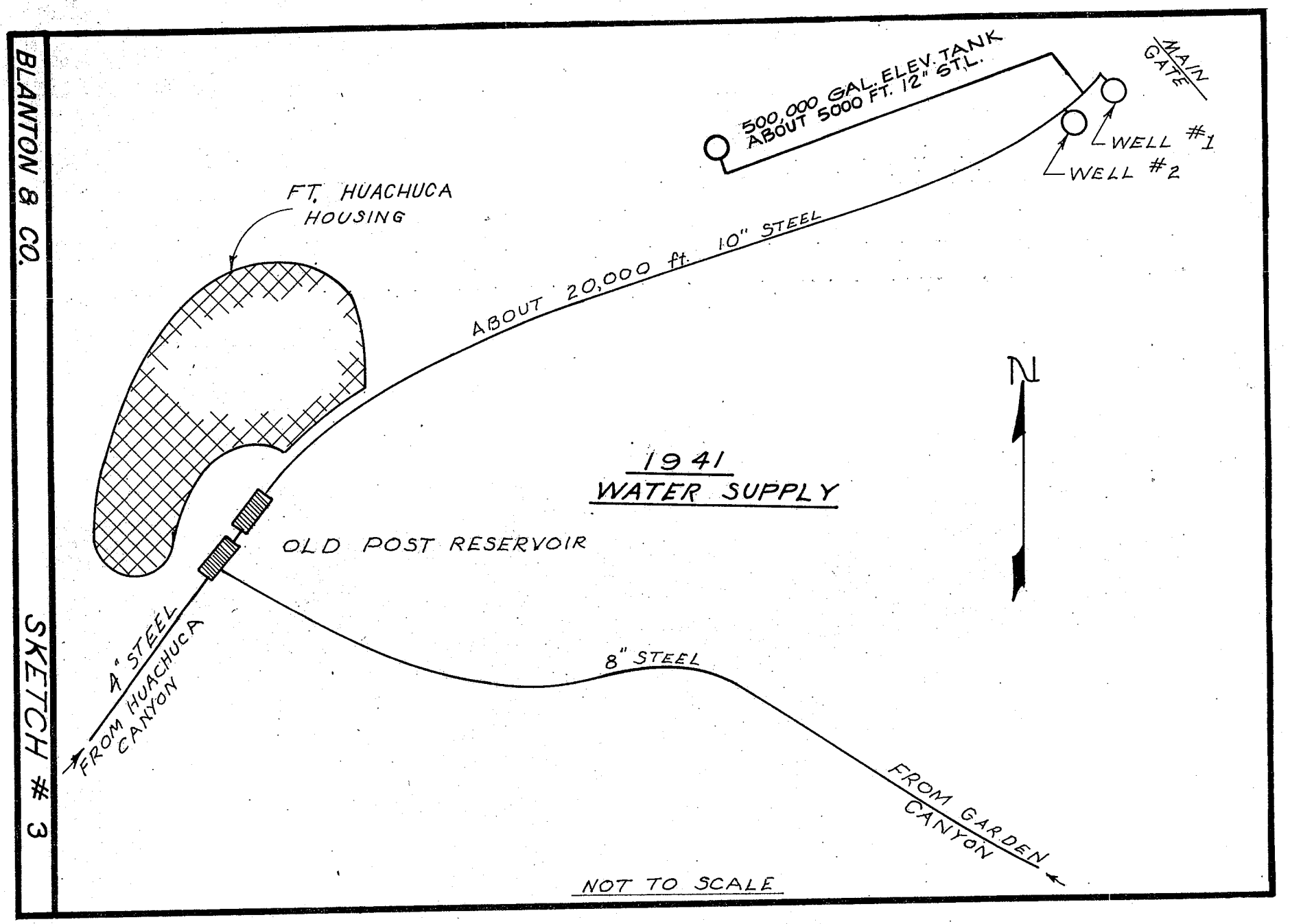

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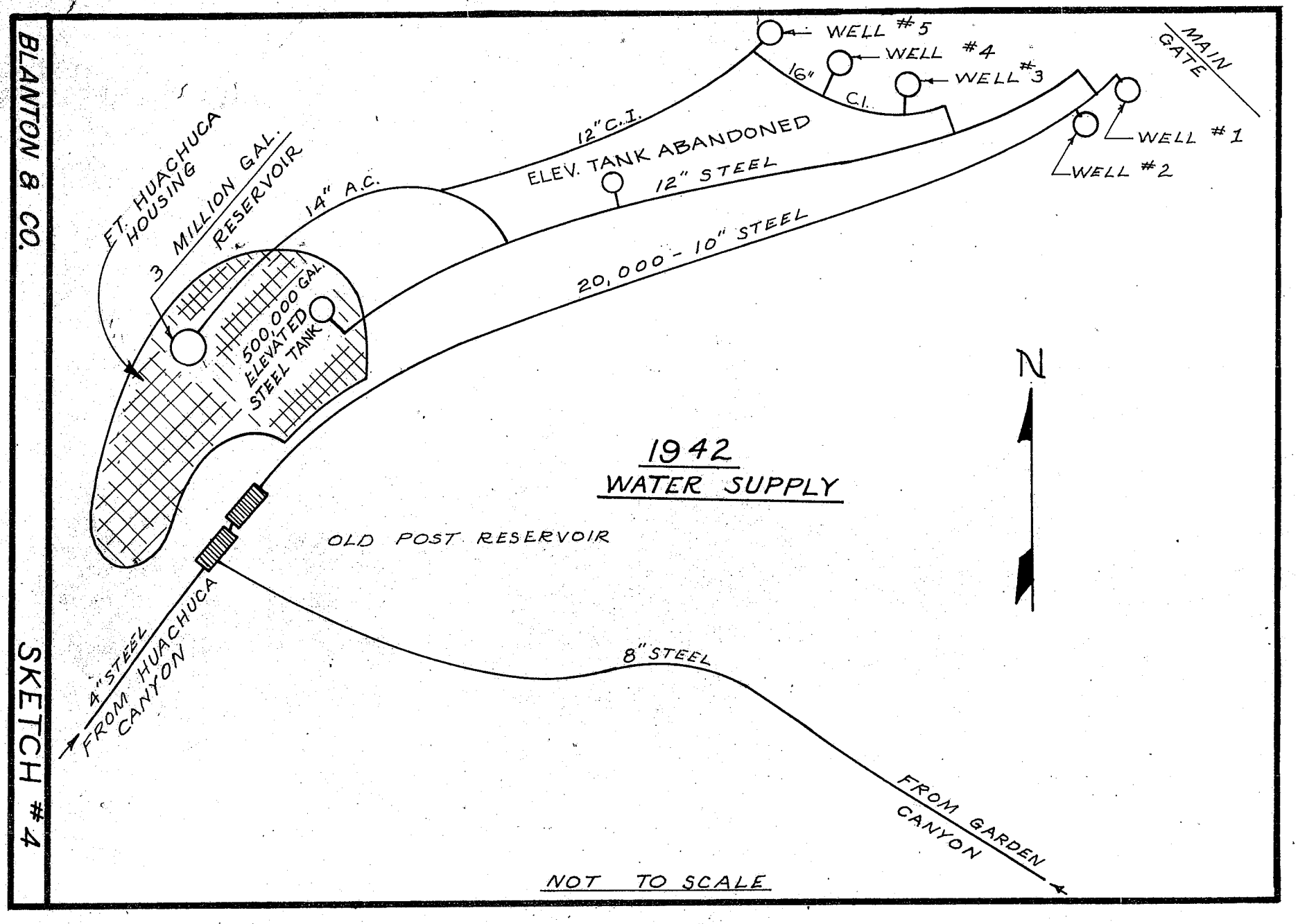

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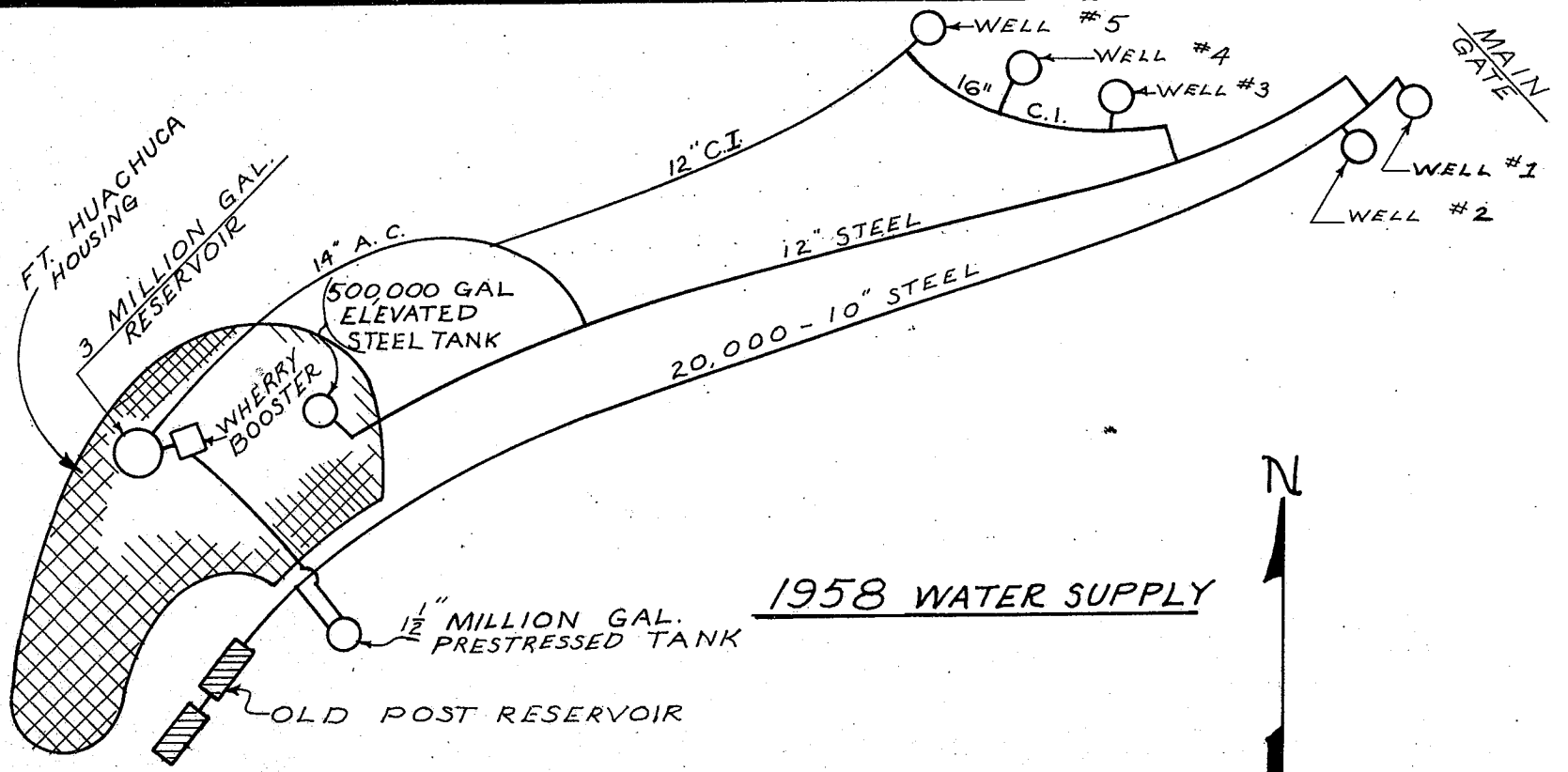


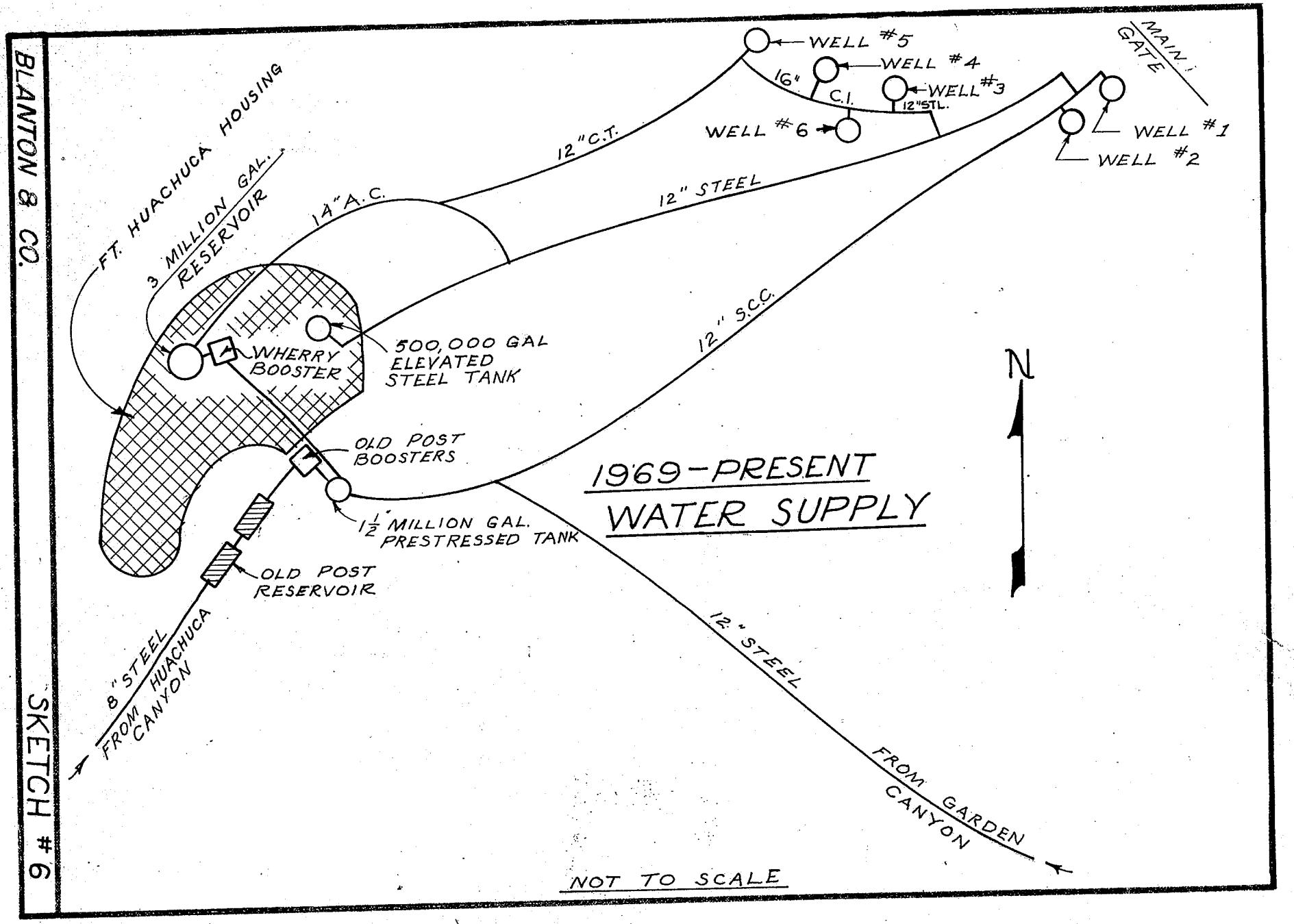
1958 WATER SUPPLY

NOT TO SCALE

BLANTON & CO.

SKETCH #5

USF2000002154



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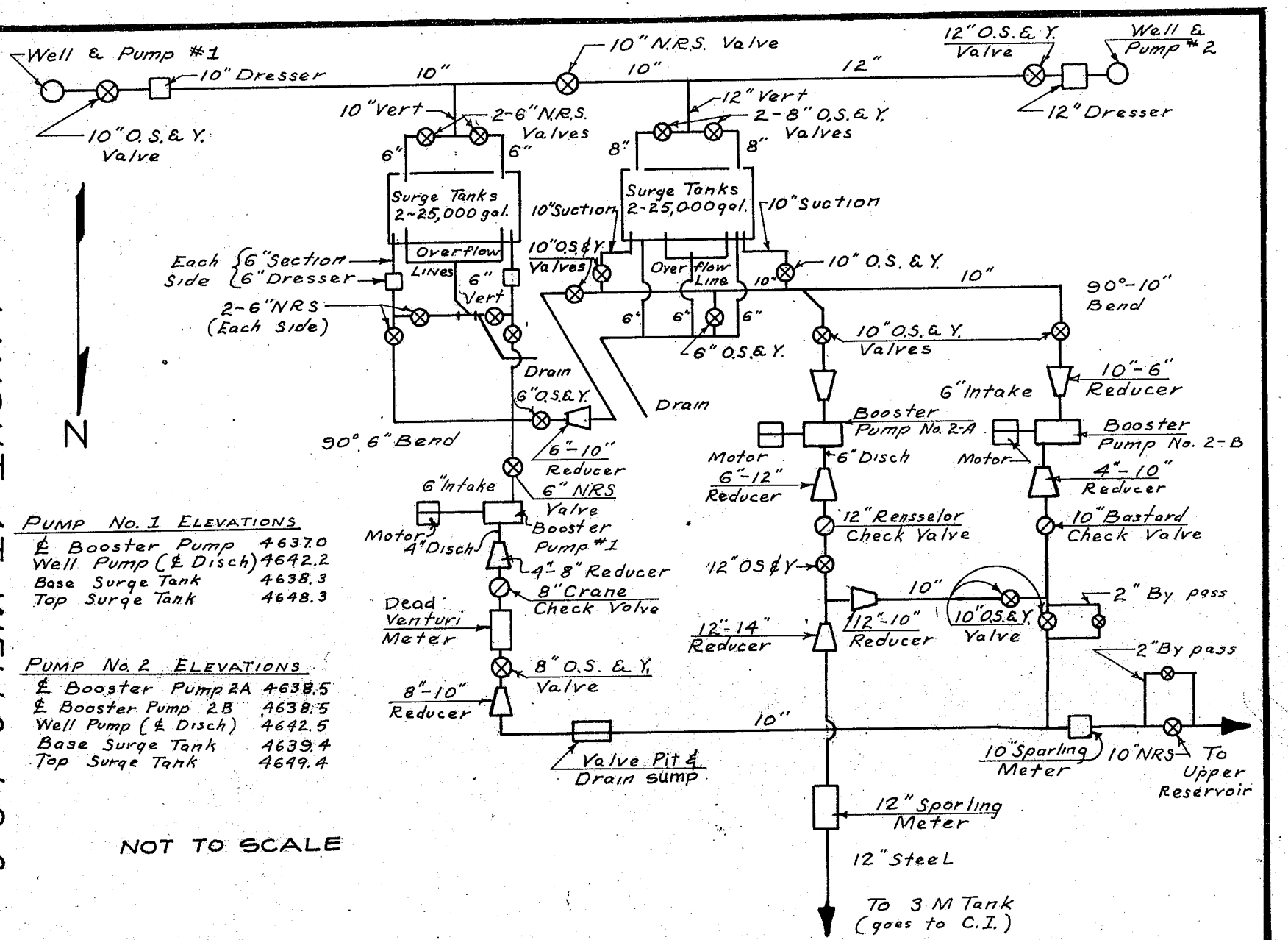
LAYOUT AT WELLS 1 & 2

SKETCH # 7



PUMP No. 1 ELEVATIONS

℄ Booster Pump	4637.0
Well Pump (℄ Disch)	4642.2
Base Surge Tank	4638.3
Top Surge Tank	4648.3

PUMP No. 2 ELEVATIONS

℄ Booster Pump 2A	4638.5
℄ Booster Pump 2B	4638.5
Well Pump (℄ Disch)	4642.5
Base Surge Tank	4639.4
Top Surge Tank	4649.4

USF200002156

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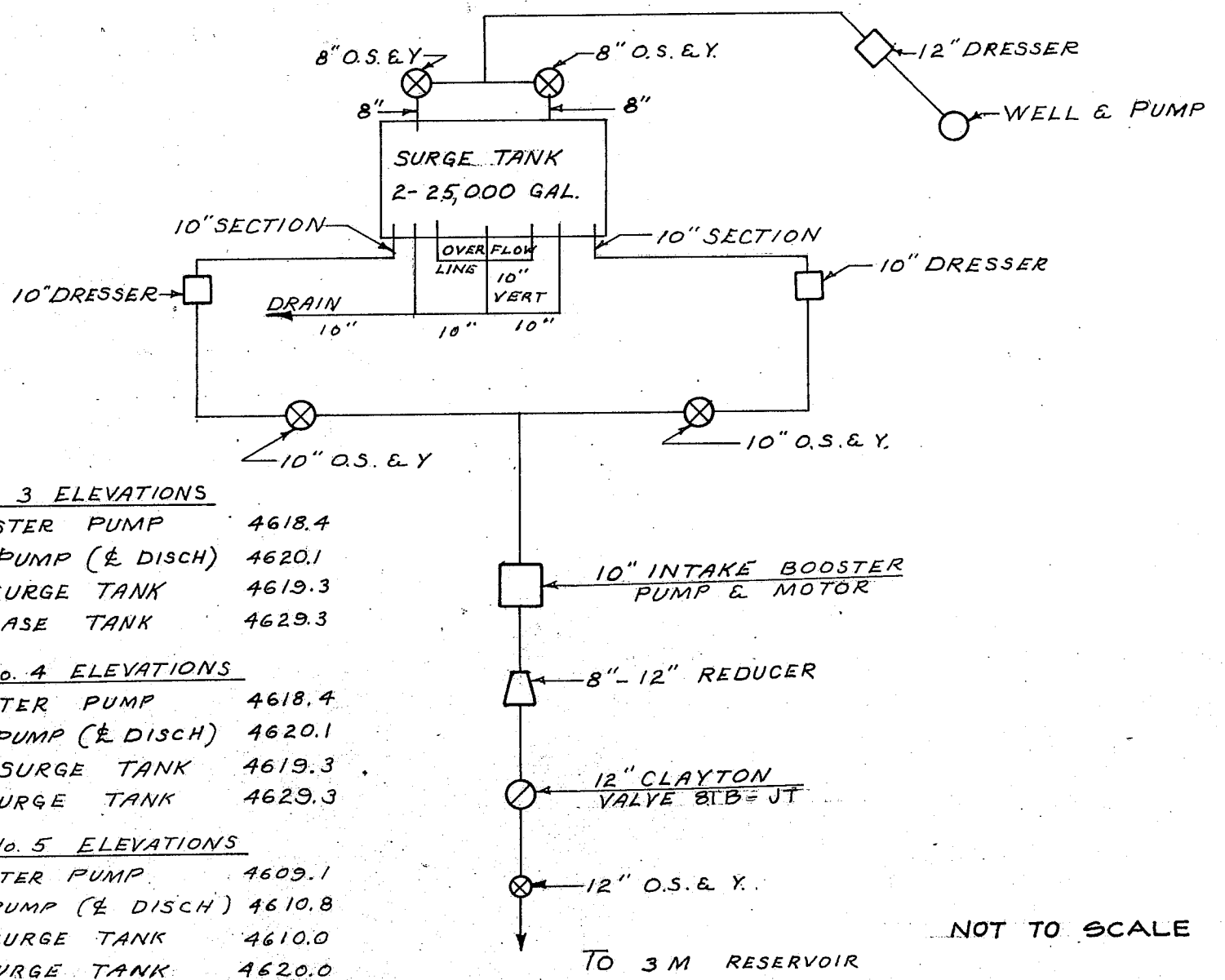
TYPICAL LAYOUT WELLS 3, 4 & 5.



NOT TO SCALE

PUMP No. 3 ELEVATIONS

℄ BOOSTER PUMP	4618.4
WELL PUMP (℄ DISCH)	4620.1
BASE SURGE TANK	4619.3
TOP BASE TANK	4629.3

PUMP No. 4 ELEVATIONS

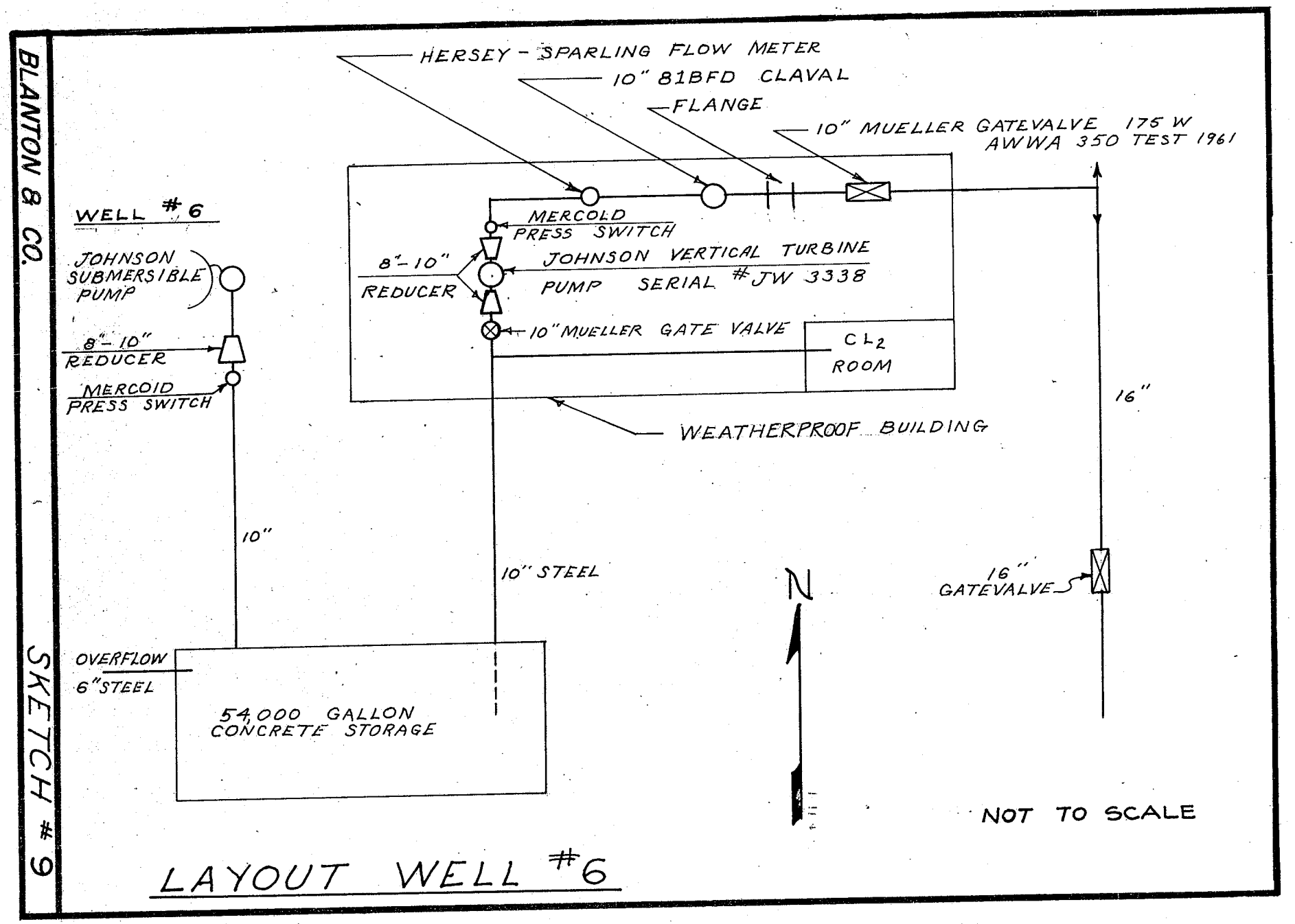
℄ BOOSTER PUMP	4618.4
WELL PUMP (℄ DISCH)	4620.1
BASE SURGE TANK	4619.3
TOP SURGE TANK	4629.3

PUMP No. 5 ELEVATIONS

℄ BOOSTER PUMP	4609.1
WELL PUMP (℄ DISCH)	4610.8
BASE SURGE TANK	4610.0
TOP SURGE TANK	4620.0

SKETCH #8

USF2000002157



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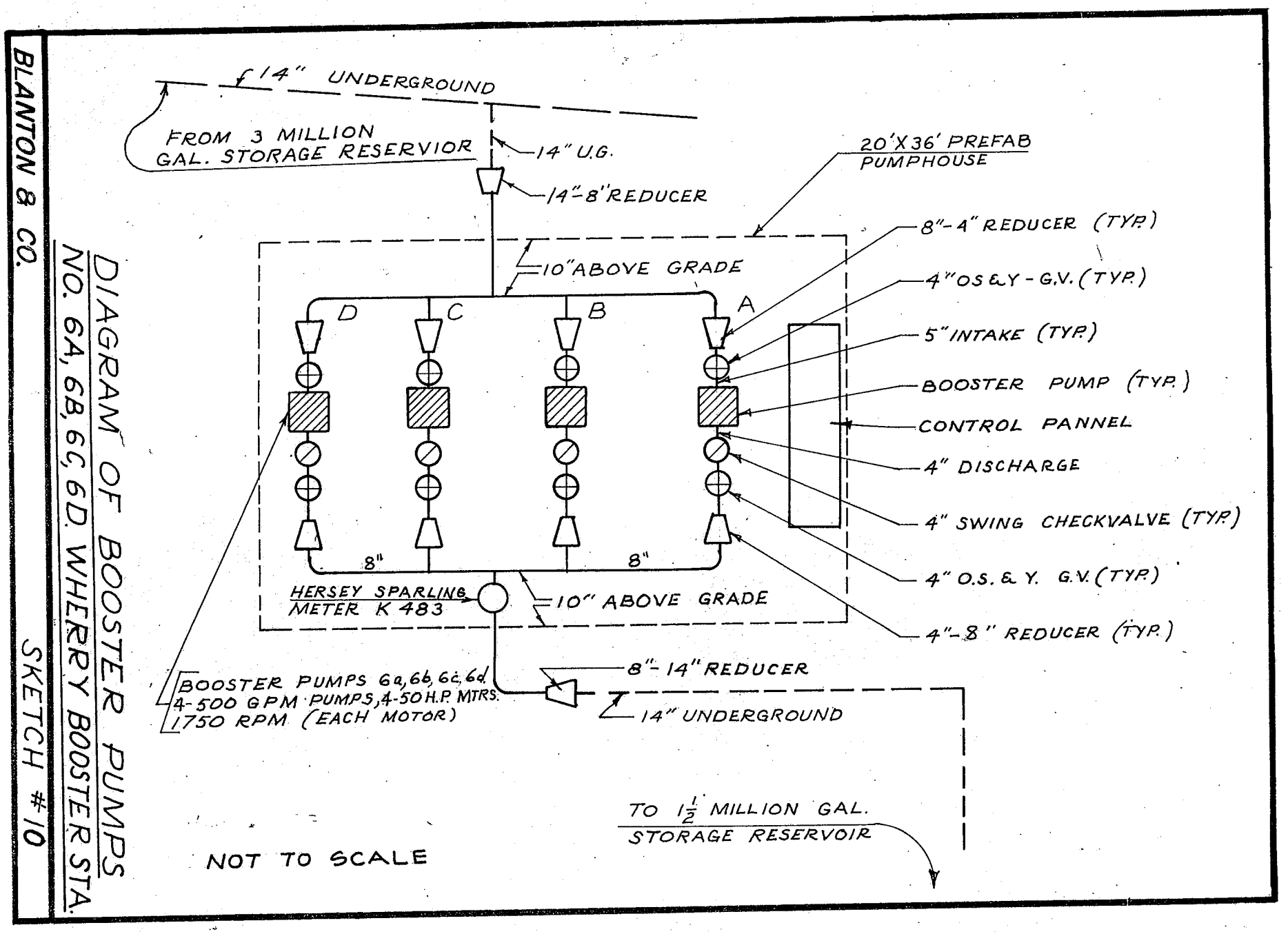

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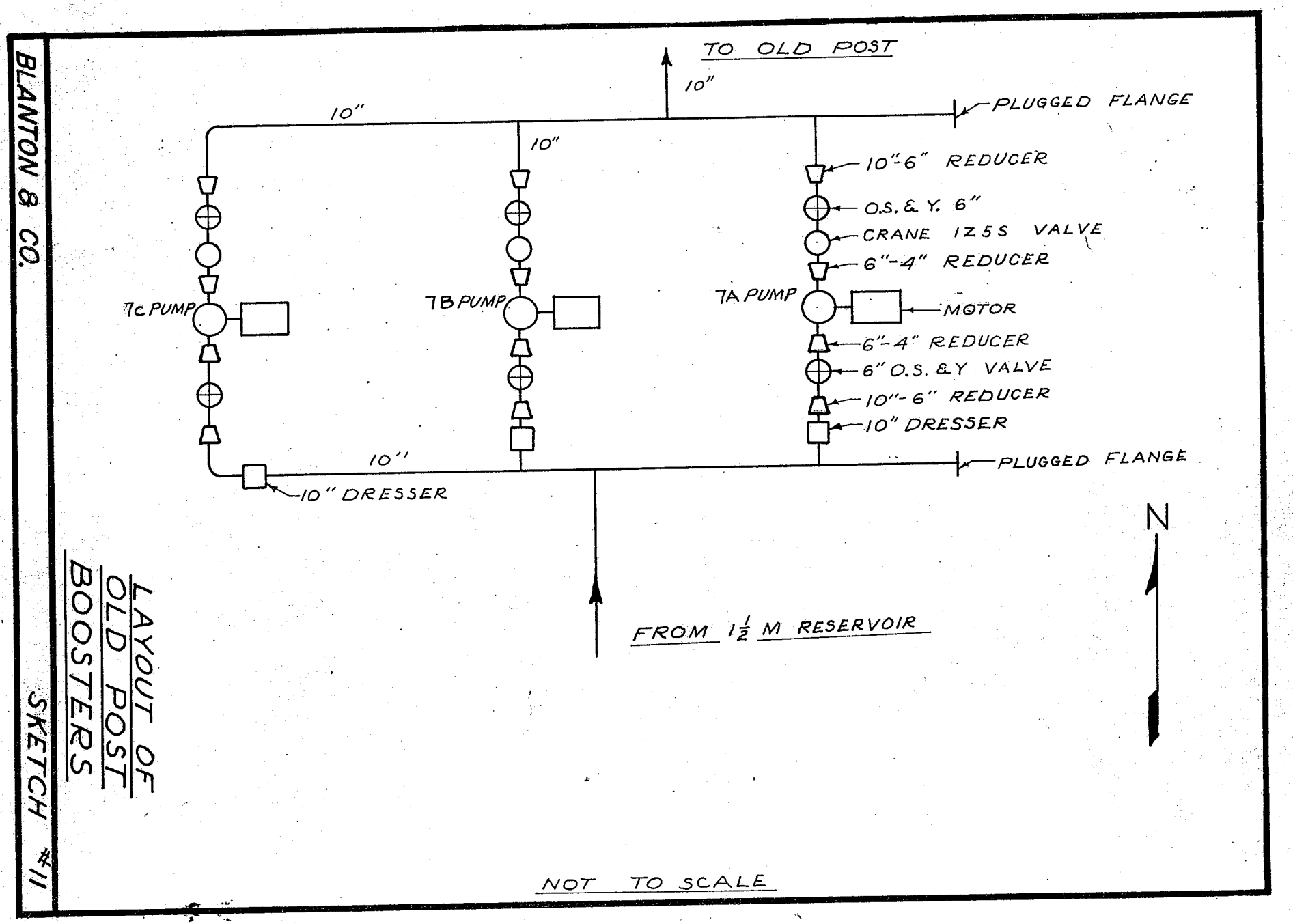

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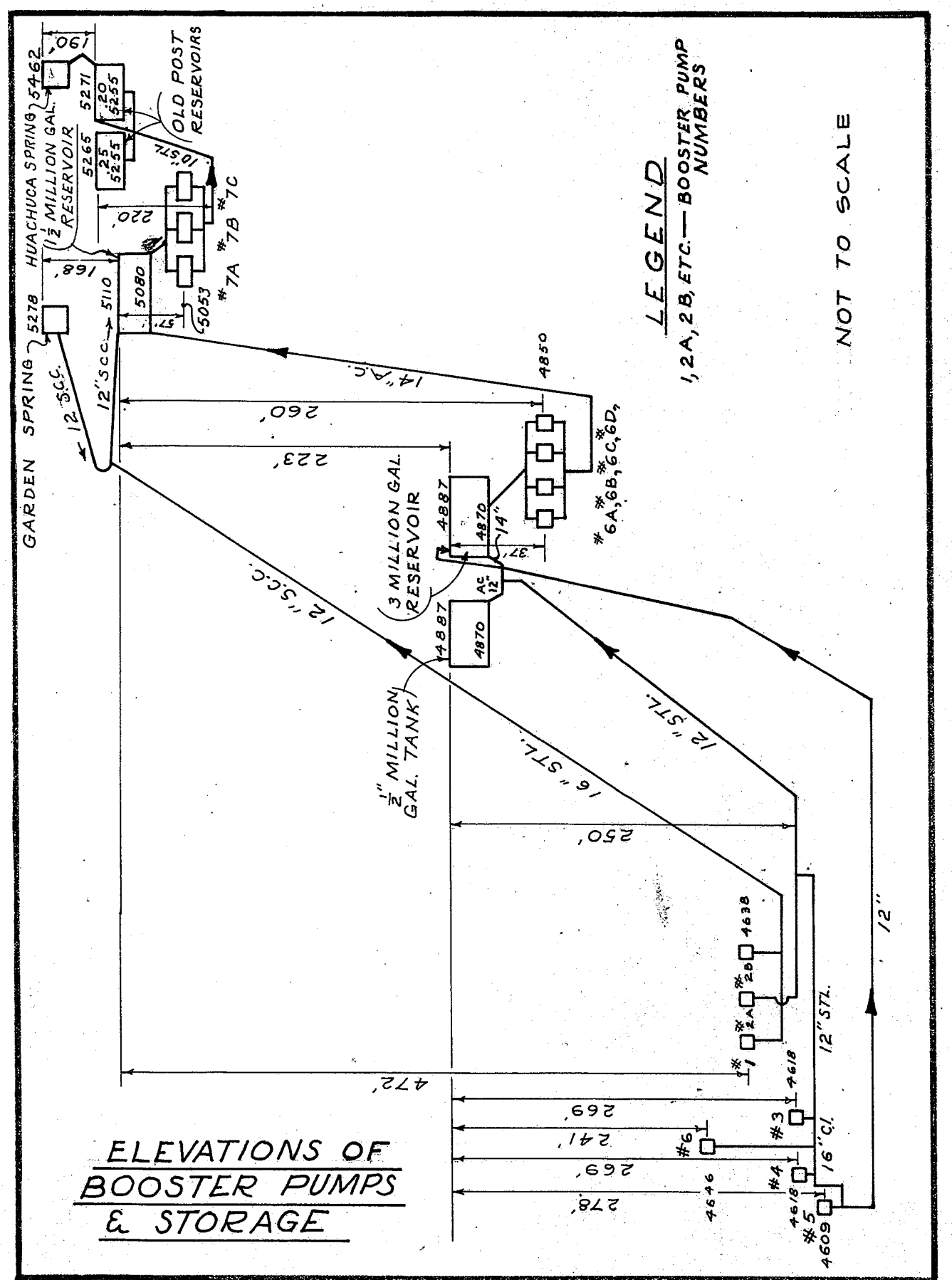
LAYOUT OF OLD POST BOOSTERS

SKETCH #11

USF200002160



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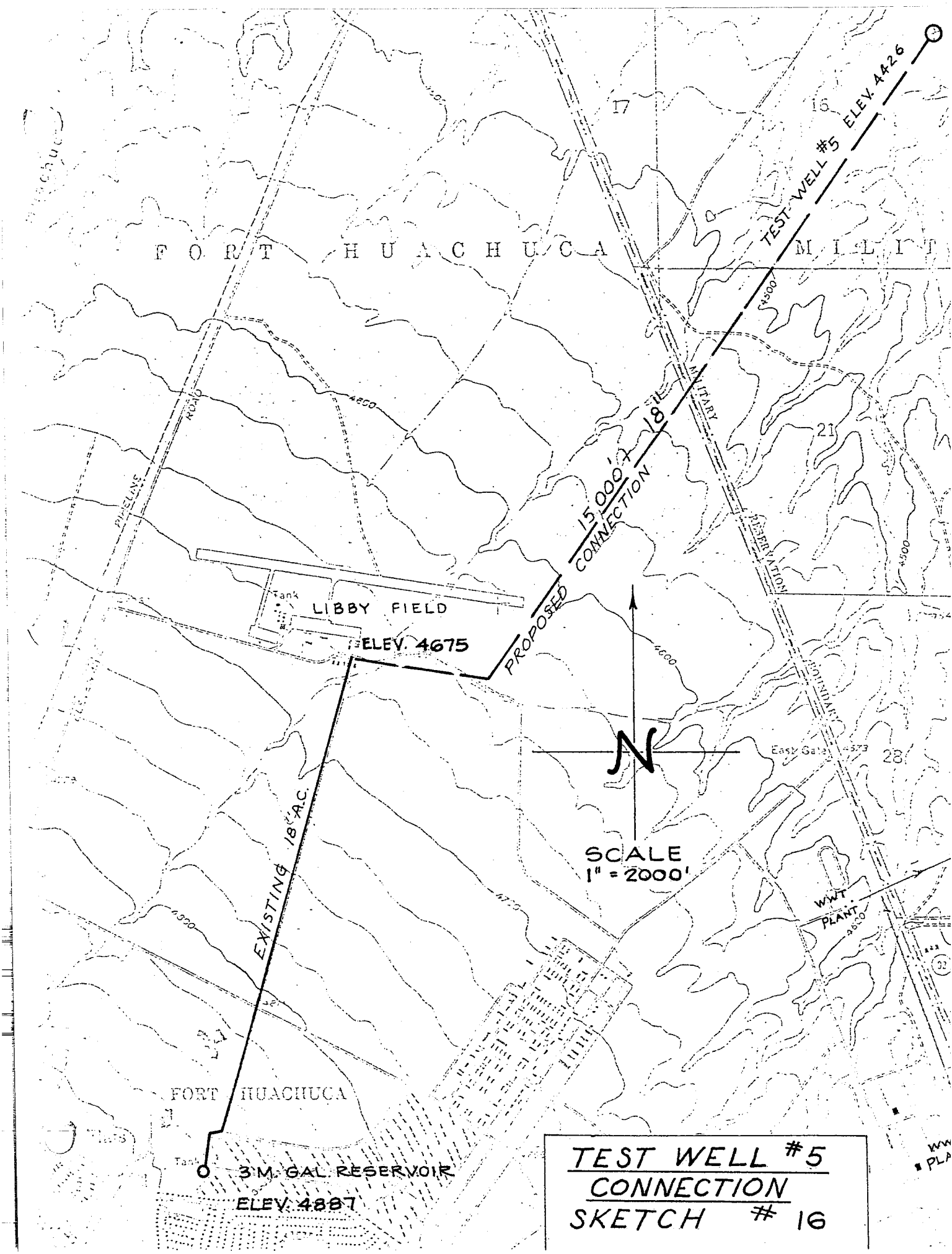

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