Environmental Policy and Technology Project

Contract No. CCN-0003-Q-00-3165

KAZAKSTAN

FIELD REPORT

Proposed Rehabilitation Program for the
Kosaman and Berdykol Wellfields,
Field Research: June-July & September 1995

March 1996
Delivery Order 12, Task 2 (100391.12)

Prepared for:
Central Asia Mission
U.S. Agency for International Development

Prepared by:
Central Asia Regional Office in Almaty, Kazakstan
Environmental Policy and Technology Project
For the New Independent States of the former Soviet Union
A USAID Project Consortium Led by CH2M HILL

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Appendix C: Kosaman and Berdykol Wellfield Conditions: Technical Data, Analyses and Discussion

Information

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Abbreviations and Acronyms

Abbreviations

in.	inch
ft	foot
Lps	liters per second
Lps/m	liters per second per meter
gpm	gallons per minute
gpm/ft	gallons per minute per foot
kg	kilogram(s)
km	kilometer(s)
kg/cm^2	kilograms per cubic meters
m	meter(s)
mm	millimeter(s)
No.	number
pH	hydrogen (ion) concentration

Acronyms

bgs	below ground surface
cfm	cubic feet per minute
EC	electrical conductivity
EPT	Environmental Policy and Technology
FY	Fiscal Year
GOK	Government of Kazakstan
GOST	State Standard of the Soviet Union (translated acronym)
MCL	maximum containment level
MOU	Memorandum of Understanding
O&M	operation and maintenance
PVC	polyvinyl chloride
ppm	parts per million
psi	pounds per square inch
rpm	revolutions per minute
TDH	total dynamic head
TDS	total dissolved solids
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
USG	United States Government
WHO	World Health Organization (of the United Nations)

Executive Summary

In accordance with the Memorandum of Understanding (MOU) between the United States Government and the Government of Kazakstan (GOK) dated March 18, 1994, USAID has allocated funds for improvements to the potable water systems in and around the cities of Aralsk and Novokazalinsk located in the Kzyl Orda Oblast of western Kazakstan. The potable water systems in Aralsk and Novokazalinsk Rayons are supplied with groundwater via a Federal transmission pipeline from the Kosaman and Berdykol Wellfields. Figure 1 (Appendix A) shows the location of the wellfields. The water is pumped into the 240-kilometer (km) Federal transmission pipeline that also supplies water to individual communities along the way.

Some of the other related activities in the MOU include the following: improvements in wellfield reliability, installation of booster pumps and chlorination systems at pumping stations along the Federal transmission pipeline, and improvements to the water distribution systems of individual communities. These activities are administered and overseen by CH2M HILL International, Inc., through the USAID Environmental Policy and Technology (EPT) Project, with offices in Washington, D.C., and Almaty, Kazakstan.

There are 30 wells at the Kosaman Wellfield and eight wells at the Berdykol Wellfield that supply water for the Federal transmission pipeline. Data collected during the summer (June-July) and fall (September) 1995 shows that the wellfield produces good quality water based on GOST, U.S. Environmental Protection Agency (USEPA), and World Health Organization (WHO) drinking water standards.

However, many of the wells produce sand, which is harmful to wellfield pumps and motors. The sand, in addition to the substandard power supply, may be responsible for the abnormally short useful life of the pumps at the wellfields. The technical details and data collected at the wellfields are summarized below and presented in detail in Appendix C. Field work was conducted in June-July and September 1995. The field team then analyzed the data and prepared the proposed rehabilitation program.

A pilot rehabilitation program was implemented to evaluate the effectiveness of well redevelopment techniques to improve well yields and initiate wellfield improvements. The results of the pilot program were used to develop a full-scale wellfield rehabilitation program that will improve the reliability of the wellfields to provide water to the Federal transmission pipeline. In the pilot rehabilitation program, three new pumps, motors, and electrical control panels were installed at the Kosaman Wellfield. This was done with the assistance of Government of Kazakstan (GOK) personnel and equipment.

During the pilot rehabilitation program, redevelopment techniques were applied to two of the wells (Wells 1 and 11) which were outfitted with new pumps. Well 1, which had never received a pump, was pump developed with the newly installed pump. Initial well efficiency was very low, but improved with time. Well discharge contained high levels of sand. Considerably more effort would be required to increase the efficiency of this well and reduce sand content. Well 11 was redeveloped using chemical treatment techniques. This treatment improved the yield of the well by over 40 percent.

Based on the results of the pilot rehabilitation program, it is recommended that a full-scale wellfield rehabilitation program be conducted in the spring and summer of 1996. The full-scale wellfield rehabilitation program will ensure that the wellfields can produce the GOK design flow rate of 630 liters per second (Lps) and provide a reliable source of water for the Federal transmission pipeline for years to come. The GOK design flow rate of 630 Lps is the rate for which the wellfields and pipeline were designed.

A full-scale wellfield rehabilitation program would consist of the following activities:

- installation of approximately 30 new pumps, motors, and electrical controls
- installation of approximately 15 new submersible sand separators
- redevelopment of selected wells to improve well yields
- development of an operations and maintenance (O&M) program to enhance pump longevity and wellfield reliability
- preparation of a report

New pumps installed in the wells would have low (9.5 Lps), medium (22 Lps), or high (31.5 Lps) flow rates, depending on a variety of factors, including the sand content of discharge water and pumping water levels. The new pump assemblies may include sand separators, which protect the pumps from the deleterious effects of sand abrasion during pumping. It is anticipated that one-half of the wells will be outfitted with sand separators.

The full-scale wellfield rehabilitation program would be performed during a 3- to 4-month field program, commencing in the spring and finishing in the fall of 1996. The EPT Project would provide fixed equipment, and professional services necessary to perform the wellfield rehabilitation program. The GOK would provide laborers and the installation equipment necessary to complete wellfield rehabilitation activities. The proposed schedule of activities for spring through fall 1996 is included in this report.

At the conclusion of the rehabilitation program, a project report and an operations and maintenance (O&M) manual will be prepared. The O&M manual will describe procedures and guidelines that will optimize pump and motor longevity and the reliability of the water supply. Both the report and the O&M manual will be prepared in English and translated into Russian.

Section 1
Introduction

In accordance with the Memorandum of Understanding (MOU) between the United States Government and the Government of Kazakstan (GOK) dated March 18, 1994, USAID has allocated funds for improvements to the potable water systems in and around the cities of Aralsk and Novokazalinsk located in the Kzyl Orda Oblast of western Kazakstan. The potable water systems in Aralsk and Novokazalinsk Rayons are supplied with groundwater via a Federal transmission pipeline from the Kosaman and Berdykol Wellfields. Figure 1 (Appendix A) shows the location of the wellfields. The water is pumped into the 240-kilometer (km) Federal transmission pipeline that also supplies water to individual communities along the way.

Some of the other related activities in the MOU include the following: improvements in wellfield reliability, installation of booster pumps and chlorination systems at pumping stations along the Federal transmission pipeline, and improvements to the water distribution systems of individual communities. These activities are administered and overseen by CH2M HILL International, Inc., through the USAID Environmental Policy and Technology (EPT) Project, with offices in Washington, D.C., and Almaty, Kazakstan.

The Kosaman and Berdykol Wellfields are unique in that most of the groundwater occurring in the regional area is brackish. Figure 2 shows the geology of the area in the vicinity of the Kosaman and Berdykol Wellfields, including the extent of potable groundwater, which, by local government standards known as GOST, and World Health Organization (WHO) drinking water standards, can contain total dissolved solids (TDS) up to 1,000 parts per million (ppm).

The objective of wellfield activities is to rehabilitate the Kosaman and Berdykol Wellfields to the extent that it can provide reliable groundwater supplies to the Federal transmission pipeline. The purpose of this report is to describe wellfield activities necessary to rehabilitate the Kosaman and Berdykol Wellfields. This report summarizes the wellfield investigation and pilot rehabilitation activities performed to date, and the scope of work necessary to perform a full-scale rehabilitation program.

Following this introductory section, this report is organized in the following major sections:

- Wellfield Activities: results of Pilot Wellfield Rehabilitation, which provide the basis for recommendations
- Recommendations: a proposed full-scale Wellfield Rehabilitation Program
- Appendixes A and B, which contain figures and tables, respectively
- Appendix C, which contains supporting information that provides technical aspects relevant to wellfield activities and scoping of proposed activities

Section 2
Wellfield Activities

2.1 Introduction to Activities

Wellfield activities that have been completed thus far include the following:

- assessment of wellfield conditions, including conditions of wells, groundwater and pumps
- implementation of a Pilot Rehabilitation Program, which included installation of three pumps and redevelopment of two wells

The results of these activities are summarized in the following paragraphs and described in detail in Appendix C.

2.2 Wellfield Conditions

Wellfield conditions were evaluated in two investigations. The first was conducted in June-July 1995 and the second in September 1995. The results of both investigations are summarized below. Specific activities conducted in the investigations include the following:

- assessment of well conditions, including groundwater quality, pumping rates, sand content of discharge water and wellhead conditions
- assessment of well and pump longevity based on current well conditions and discussions with local wellfield personnel
- development of a pilot rehabilitation program to assess the effectiveness of various redevelopment techniques that may be employed in full-scale wellfield rehabilitation.

The results of these activities are summarized below.

2.2.1 Well Conditions

Well conditions were assessed by a series of tests on selected wells. The activities performed include:

- groundwater quality analyses using field test kits and hand-held instruments
- measurements of pumping rate, drawdown, and sand content in well discharge
- assessment of wellhead, pipe and power supply conditions

The results of these activities are summarized below.

Groundwater Quality. Groundwater quality was assessed to provide baseline data for future reference. Groundwater from selected wells was analyzed using field test kits (i.e., Hach kits) and hand-held instruments. The results of these analyses are presented in Table 1 (Appendix B). A brief discussion of the analyzed parameters is presented in Appendix C. In general, groundwater quality is suitable for potable uses. There do not appear to be any health concerns related to groundwater quality from either the Kosaman or Berdykol Wellfields. From an equipment standpoint, the high corrosivity of the water is of concern. Field inspection of old pump column pipe and other pipes show that there is typically heavy corrosion, especially in pump column pipe set under water. Some pump column pipes are so corroded as to be unusable.

Pumping Rates, Drawdown and Sand Content. Pumping rates were measured during the September investigation in 11 wells at the Kosaman Wellfield using a Panametrics brand ultrasonic flow meter. Flow rates ranged from 2.4 Lps [38 gallons per minute (gpm)] to 26 Lps (412 gpm). Table 2 (Appendix B) summarizes flow rate data for both wellfields.

Pumping water levels were measured in six wells at the Kosaman Wellfield with a water level sounder. Static water level measurements were made at 11 wells at the Kosaman Wellfield. Static water levels were collected on two occasions (September 12 and 21, 1995) when pipeline breaks forced the wellfield to be shut down for a few days. Drawdowns were calculated by taking the difference between the static and pumping water level. For wells in which static water levels were not obtained, drawdown was estimated based on the static water level of the nearest wells. Table 3 (Appendix B) summarizes water level data from June-July and September 1995.

The sand content of discharge water from five wells in the Kosaman Wellfield was measured during the September investigation using a Rossum brand sand centrifuge. The sand contents for Wells 1, 10, 11, 24 and 26 were 265, 90, 10, 4 and >500 ppm, respectively. If the sand content is more than 50 ppm, according to pump motor manufacturers, excessive abrasion and wear on the pumps can occur, reducing the efficiency and shortening the life of pumps and motors. Three of the five wells tested have sand contents in excess of 50 ppm. This poses a potentially significant problem for some wells at the Kosaman Wellfield. This is supported by the extreme wear caused by sand observed in failed pumps and the abnormally short lifespan of the pumps.

According to GOK engineers, the average pump lifetime is about 2 years, whereas the usual average lifespan for a pump is about 10 years in the United States. Even though sand tests were not conducted at the Berdykol Wellfield, it is likely that some wells in this wellfield will also produce high levels of sand. This problem is discussed further in Appendix C, Well and Pump Longevity.

Wellhead Conditions. Wellhead conditions were evaluated for all 30 wells at the Kosaman Wellfield during an inspection conducted in September 1995. Table 4 (Appendix B) presents a summary of the findings from this inspection. In general, minor repairs are needed for the structures surrounding the wells (floor, door and top hatch), and some valves need to be replaced.

In September 1995 there were 13 operational pumps at the Kosaman Wellfield and three operational pumps at the Berdykol Wellfield. The remaining wells either have broken pumps or no pumps at all. From June to September 1995, three pumps at Kosaman and two pumps at Berdykol were lost due to failure. An inventory of pump column pipe shows that there is not enough pump column pipe to outfit each well. The pump column pipe carries water from the submersible pump to the surface. There are approximately 25 sets of pump columns at the Kosaman Wellfield; however, not all of this pipe is usable due to severe corrosion.

Periodic power failures and multiple voltage (power) surge events occurred during the September investigation. These fluctuations in voltage may be contributing to the abnormally short lifespan of the pumps.

2.3 Pilot Rehabilitation Program

A pilot rehabilitation program was conducted at the Kosaman Wellfield in September 1995 and consisted of the following:

- initiation of improvement activities using local personnel and equipment
- assessment of the effectiveness of well redevelopment techniques in improving well yields

The pilot rehabilitation program activities and results are summarized below.

2.3.1 Wellfield Improvement Activities

Wellfield improvements consisted primarily of the installation of three new submersible turbine pumps and motors, electrical control panels and related hardware. These were installed at Wells 1, 11 and 26 at the Kosaman Wellfield. A new pump was installed in Well 1 to evaluate the response of a well that had never received a pump after it was constructed. A new pump was installed in Well 11 in conjunction with extensive chemical and mechanical well redevelopment activities. A new pump was installed in Well 26 to provide more pumping capacity at the northern end of the wellfield. The new pumps in Wells 11 and 26 replaced broken Russian pumps.

Wellfield activities were supported by a crane provided by the GOK. The lift capacity of the crane exceeded wellfield activity needs. However, it had a short boom and was not able to remove the pump column pipe from wells that had 11-meter (36-foot) long sections of pump column pipe. At the time of the pilot wellfield rehabilitation program, a more suitable crane was either not available or operational. The pilot program required the involvement of up to

10 GOK personnel from the communities of Kosaman and Aralsk. The services provided by GOK personnel included crane operators, welders, metal smiths and laborers.

2.3.2 Well Development and Redevelopment

Wells 1 and 11 were chosen for redevelopment and new pump emplacement in order to evaluate the conditions of a well that had never received a pump (Well 1), and to assess the impact of chemicals in improving the yield of an inefficient well (Well 11). The development techniques applied to these wells are summarized below and are described in detail in Appendix C.

Well 1 did not receive a pump after it was constructed. Wells 8, 9 and 12 also did not receive pumps after construction. According to GOK wellfield personnel, these wells were not as extensively developed as the other wells. After a new pump was installed in Well 1, the well was developed using pump-surging techniques (i.e., turning the pump on and off). The specific capacity and sand content in this well, after several hours of surge pumping, was 1 per second per meter of drawdown (Lps/meter) (5 gpm/ft) and 265 ppm, respectively. The specific capacity is the ratio of pumping rate to drawdown. In the Kosaman Wellfield, the average specific capacity is 1.7 Lps/m (9 gpm/ft) with a maximum of 2.9 Lps/m (14 gpm/ft). The steady improvement in the specific capacity of Well 1 over time indicates this well may benefit from further development.

In the June-July 1995 investigation, the specific capacity of Well 11 was 1.5 LPs/meter (7 gpm/ft). Between July and September 1995, the pump in this well failed. The purpose for choosing this well for redevelopment was to try to assess the effectiveness of chemical and mechanical redevelopment techniques in improving the specific capacity of the well. After chemical redevelopment and several hours of surge pumping, the specific capacity improved to approximately 2 Lps/meter (10 gpm/ft). This represents improvement of more than 40 percent. The sand content from this well was measured at 10 ppm. The improvement in specific capacity suggests that use of chemical redevelopment techniques may be beneficial in selected wells during the full-scale rehabilitation program.

Section 3
Recommendations: A Full-Scale Rehabilitation Program

3.1 Objectives

A full-scale wellfield rehabilitation program is recommended based on the following objectives:

- Total wellfield production capacity should equal 420 Lps from the Kosaman Wellfield and 210 Lps from the Berdykol Wellfield, for a combined total of 630 Lps.

- Achieve overall production demand of 630 Lps using existing Kosaman and Berdykol wells.

- Perform the proposed field activities in Fiscal Year (FY) 1996. The proposed schedule is indicated in Figure 5 (Appendix A).

The total combined flow rate of 630 Lps is the flow rate for which the wellfields and pipeline were designed for by GOK engineers. Wellfield production levels are expected to provide this flow rate. However, based on discussions with local engineers, it is unlikely that the Federal transmission pipeline can handle more than one-third to one-half this flow rate. Based on an estimate provided by the Chief Engineer from the Aralsk-Sarbulak Pipeline, the current (September 1995) pipeline flow rates range between 200 and 250 Lps. This is because numerous breaks in the pipeline in recent years have weakened the pipeline such that it cannot withstand the pressure produced by higher rates of flow.

However, the GOK has assigned high priority to remedy the water transmission pipeline problem and, in collaboration with other donors, it is evaluating the water conveyance issue. The lifetime of the groundwater resource, as described in detail in the "Groundwater Survey and Hydrogeologic Characterization Report" (EPT, 1995), is expected to be greater than 50 years at the design production rate of 630 Lps.

The lifetime of wells at both wellfields is expected to be considerably less than that of the groundwater resource because of the well design and construction. While current production rates from individual wells are expected to total 630 Lps, the ability of the wellfield to sustain this flow rate will diminish with time, as wells go out of service.

3.2 Proposed Activities

Implementation of full-scale wellfield rehabilitation is proposed for 1996. The proposed wellfield activities at Kosaman and Berdykol consist of the following:

- well assessment to determine pump emplacement and redevelopment options
- redevelopment of selected wells
- installation of up to 30 new pumps, motors, and electric panels to provide a total production capacity of 630 LPs
- installation of sand separators on selected pumps
- development of an O&M manual and training of the operations personnel
- preparation of a report on wellfield activities

3.3 Well Assessments

Well assessments are required to determine pump emplacement and redevelopment options. The general guidelines employed for establishing well and redevelopment options are shown in Figure 4 (Appendix A) and summarized as follows.

- Wells having moderate to low specific capacity (<1 Lps/m) will be considered for redevelopment activities. Redevelopment activities may include air lifting, swabbing, surging or over pumping, and chemical treatment. Wells having high specific capacity (>2 Lps/m) will not be considered for redevelopment.

- Wells having discharge with sand content between 50 and 500 ppm will be fitted with pumps with sand separators. Wells with discharge greater than 500 ppm will be fitted with low flow pumps or considered for abandonment. The low flow pumps are designed to eliminate the abrasive effect of sand, thereby protecting the pump.

- Wells that contain large amounts of accumulated sand will be cleaned out. If the sand can be removed, the well will be fitted with a pump. If it cannot be removed, it indicates that there may be a failure in the well screen or casing and the well will be abandoned.

- High flow rate pumps will produce from 19 to 32 Lps (300 to 500 gpm) and low flow rate pumps will produce from 8 to 10 Lps (127 to 160 gpm).

- All wells that receive new pumps will be disinfected with chlorine before being put into service.

Appendix A

Figures

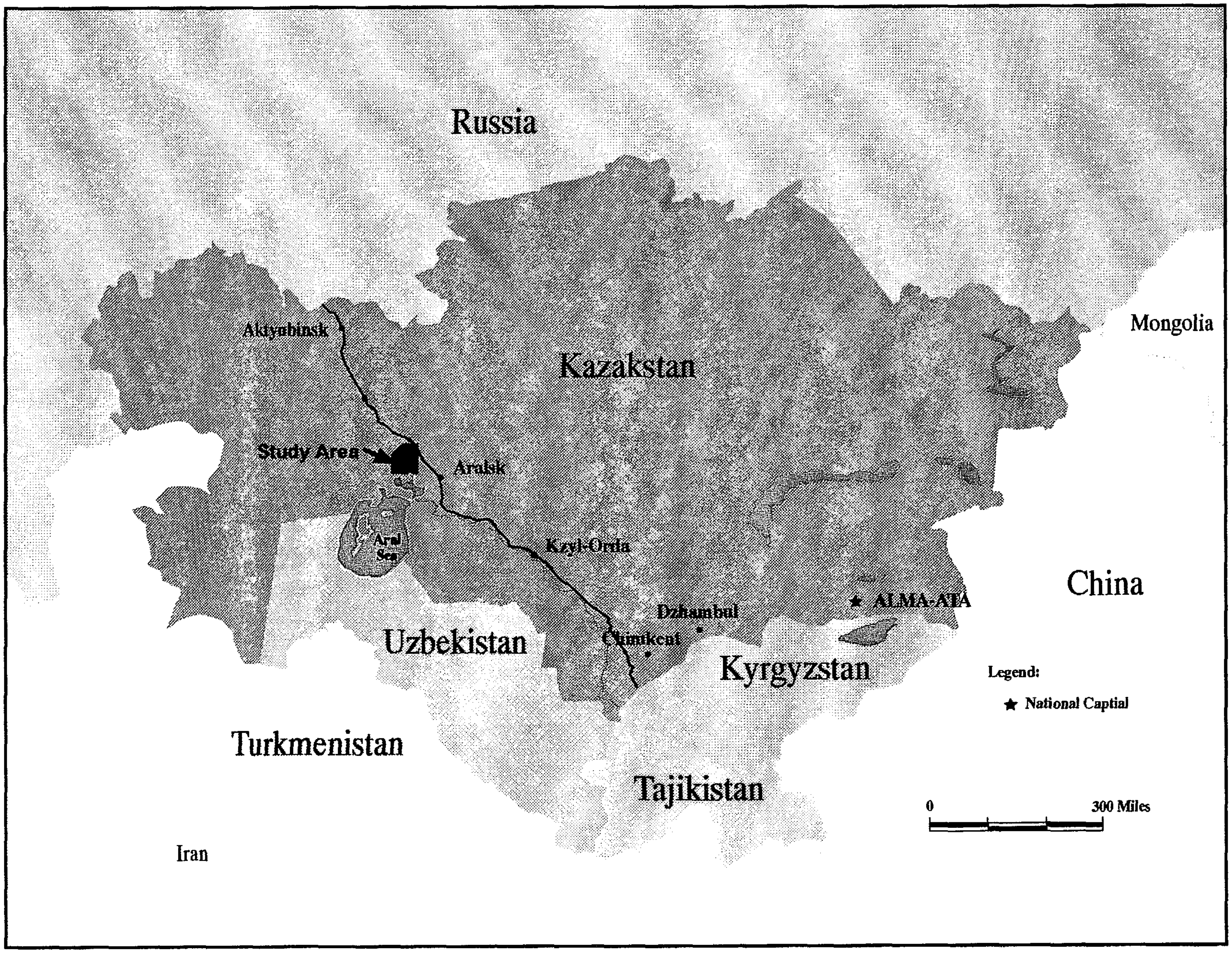

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Figure 1
Study Area Location Map

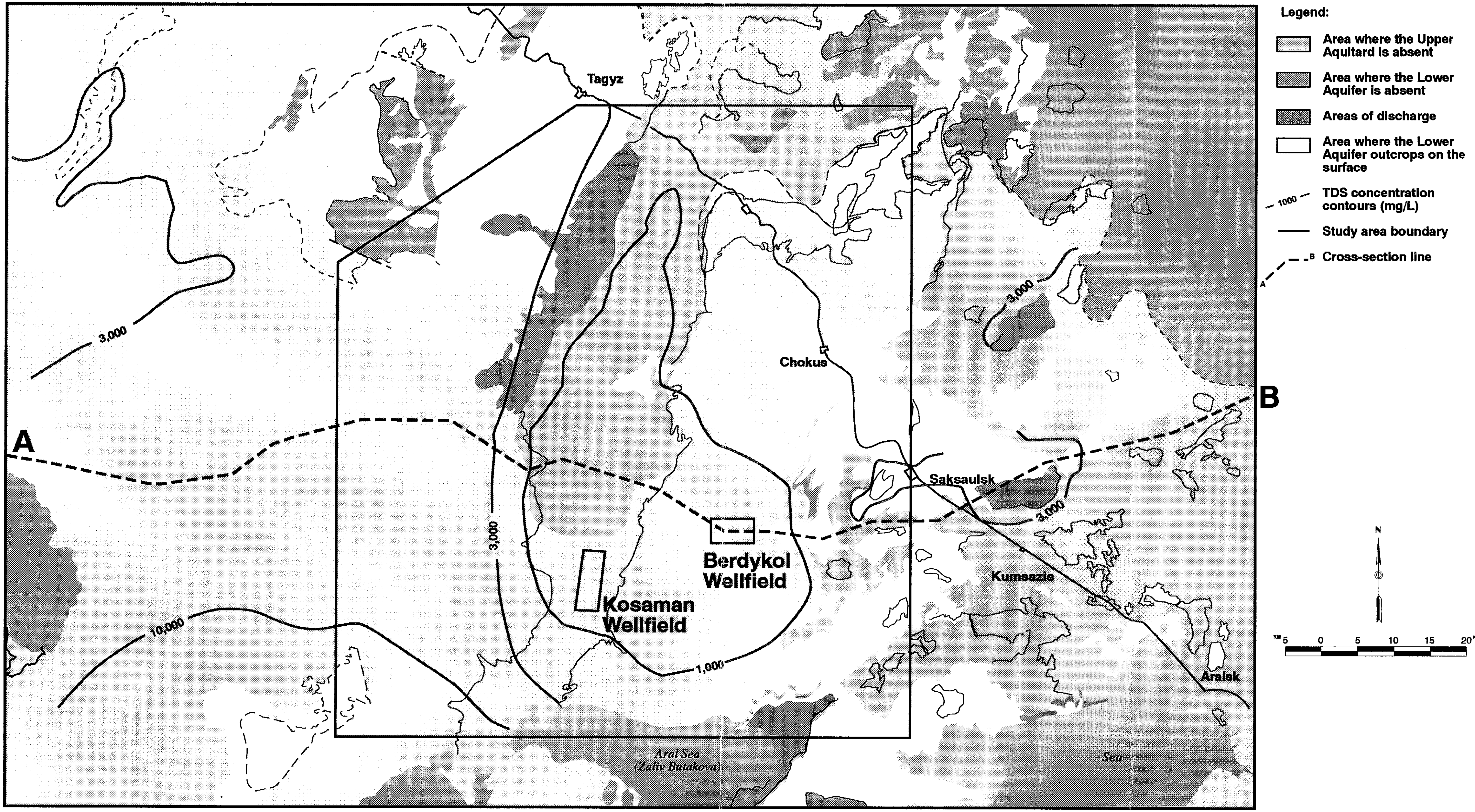

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Figure 2
Hydrogeologic Map of the Study Area

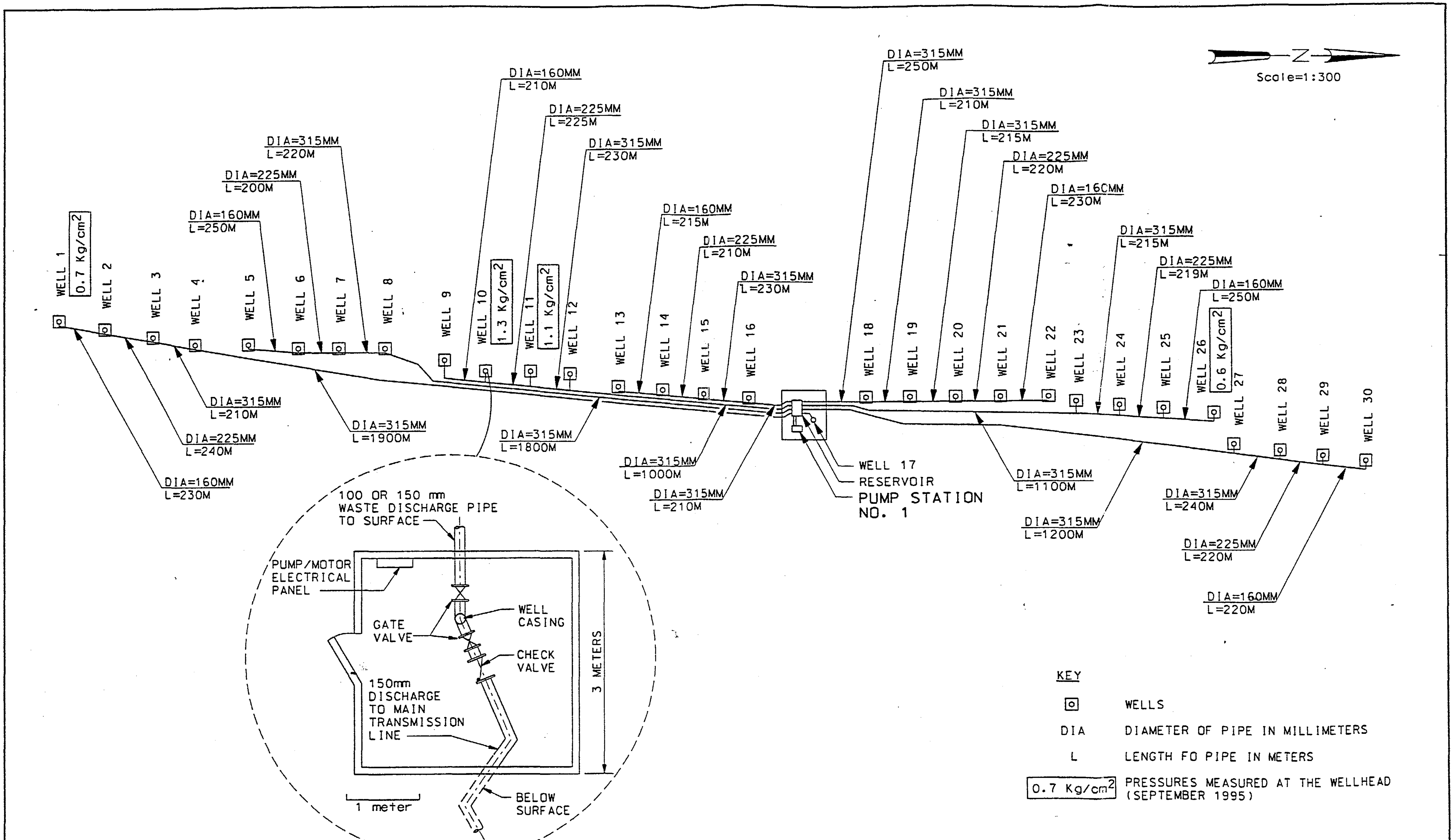

Figure 3
Kosaman Wellfield
Pipe and Pumphouse
Layout (as Designed)

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Figure 4
Decision Flow Diagram for Wellfield Rehabilition

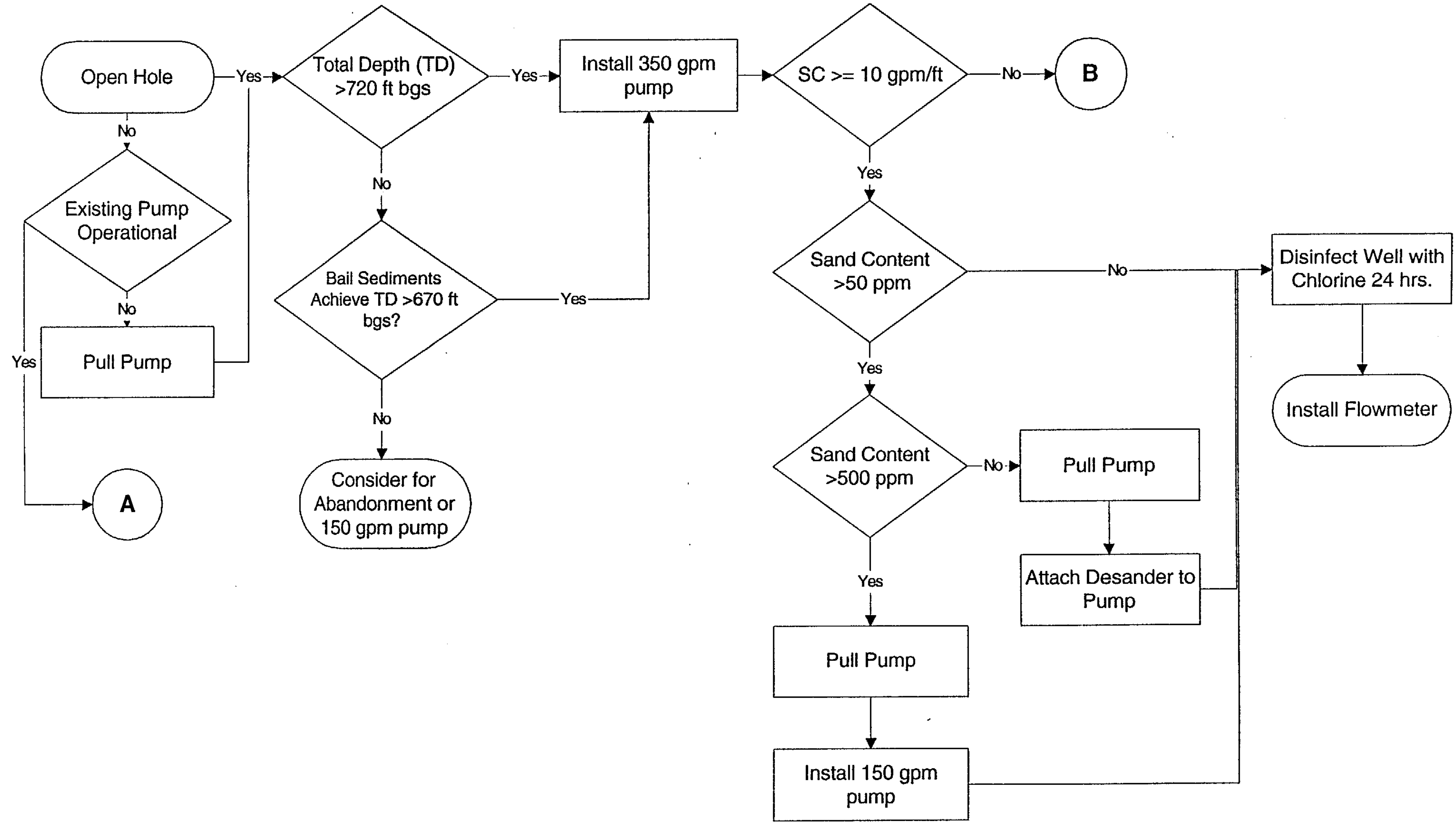

Figure 4
Decision Flow Diagram for Wellfield Rehabilition

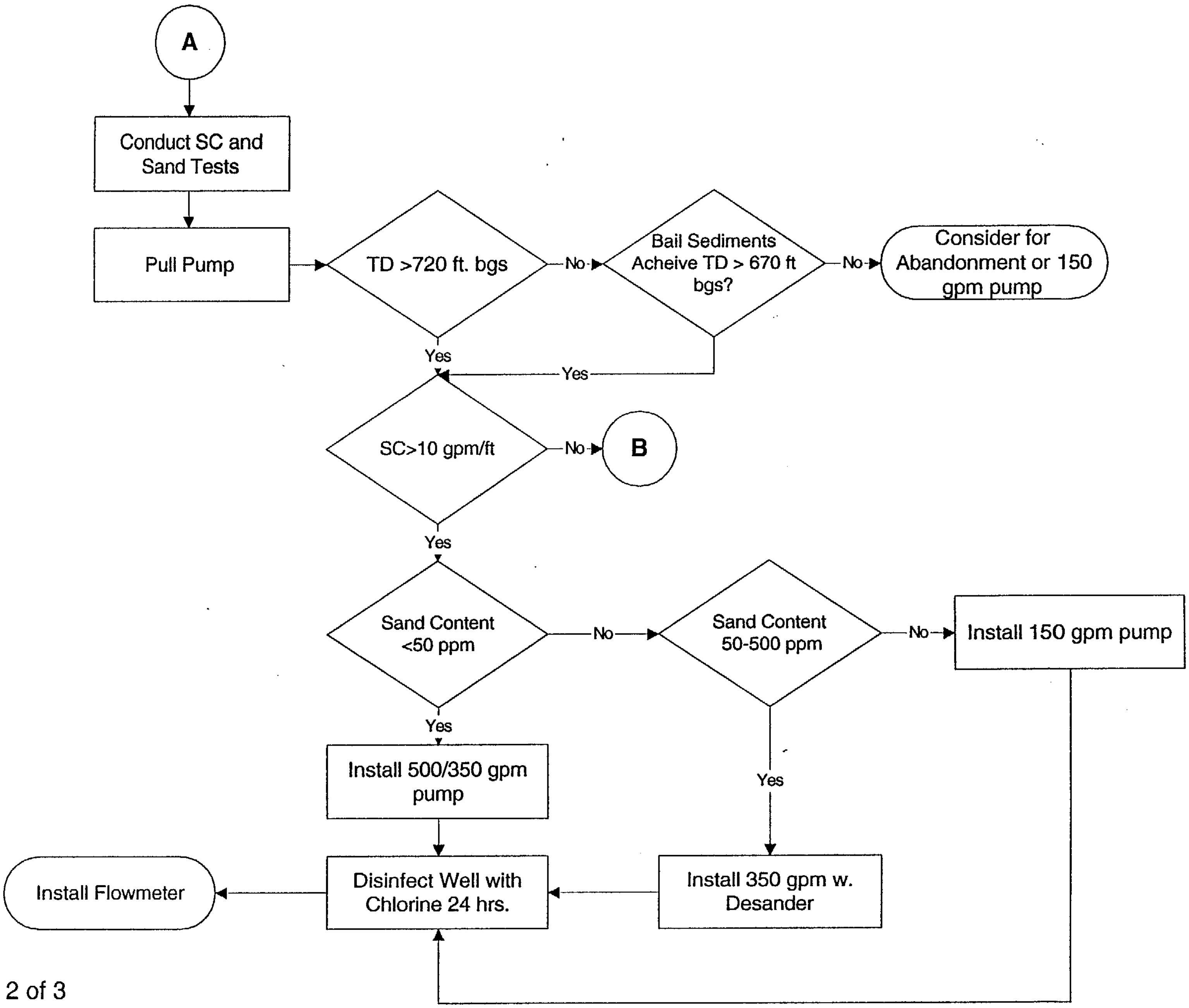

Figure 4
Decision Flow Diagram for Wellfield Rehabilition

These wells have SC <10 gpm/ft

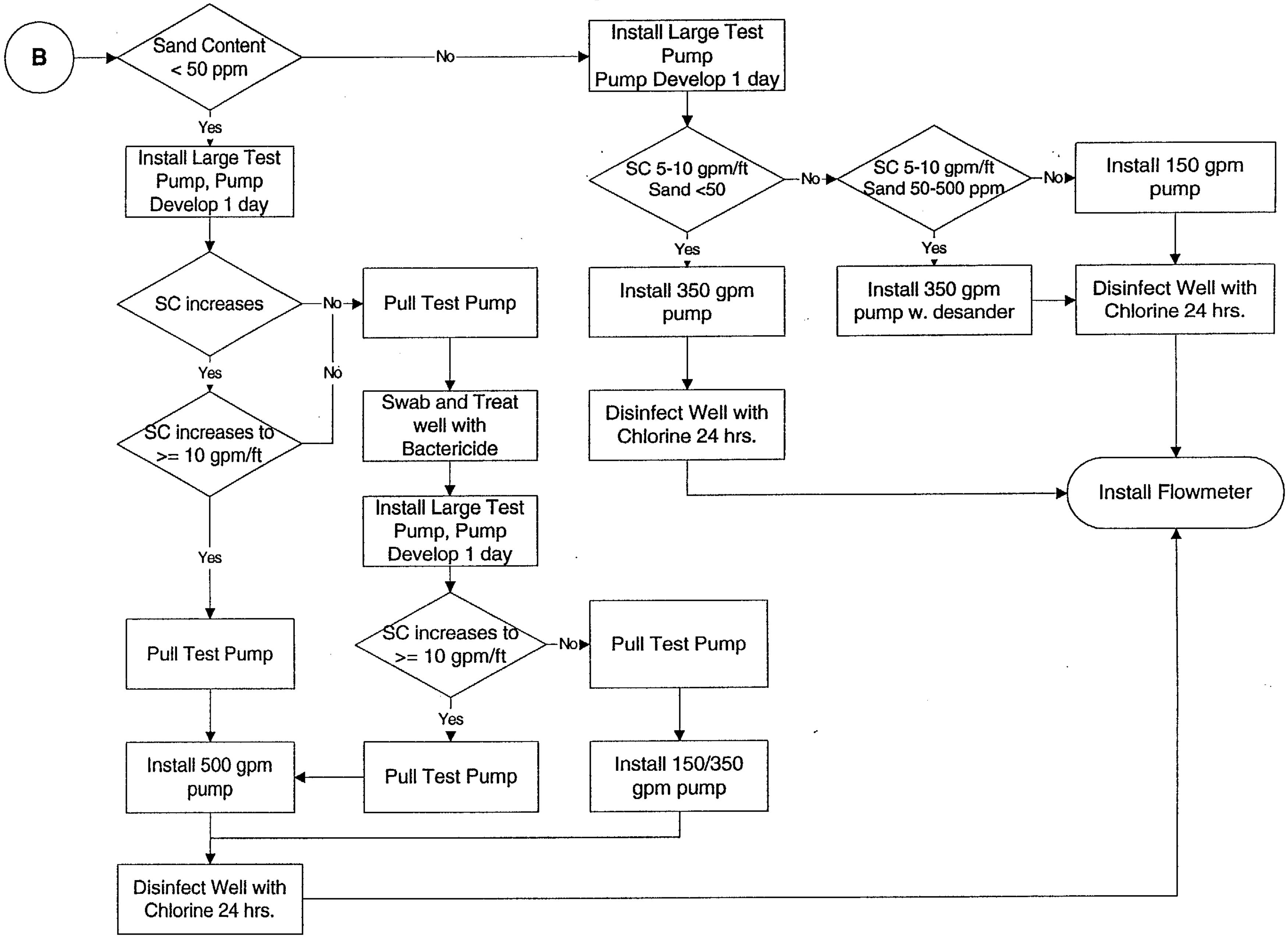

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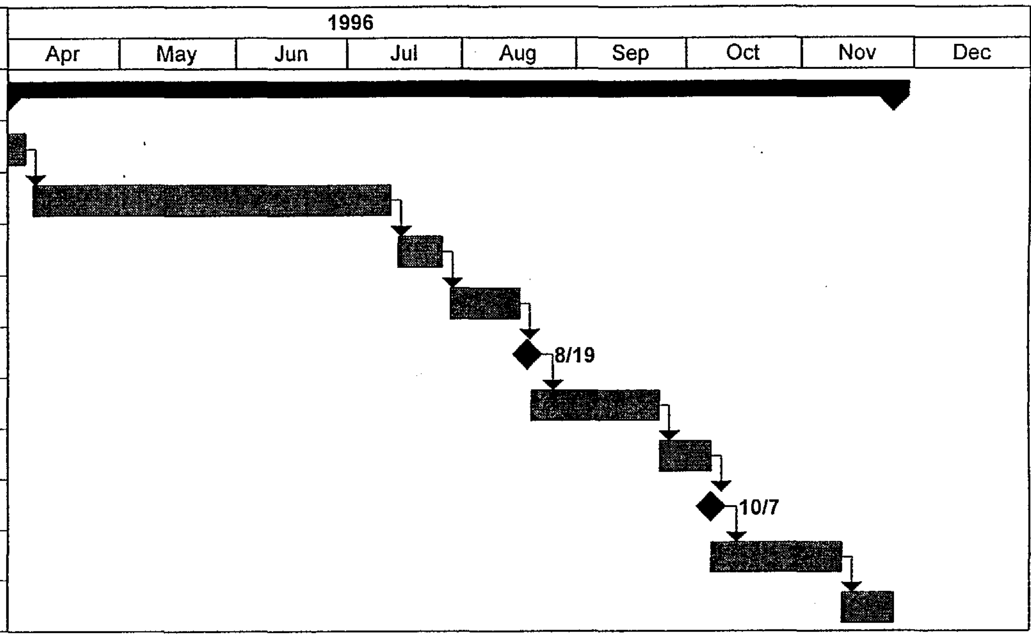
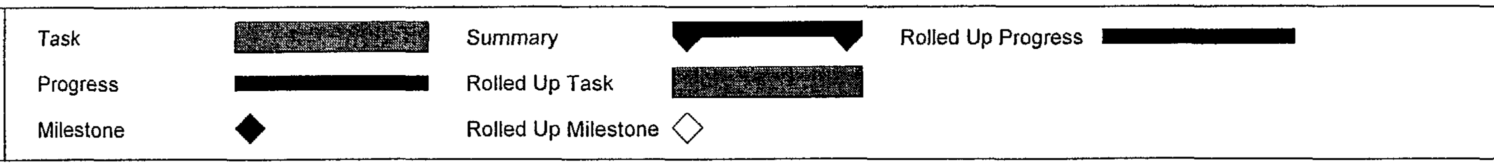
Figure 5
Proposed Schedule for Full-Scale Wellfield Rehabilitation

ID	Task Name	Start	Finish
1	**Wellfield Rehabilitation**	**Mon 4/1/96**	**Mon 11/25/96**
2	Meetings with GOK and USAID	Mon 4/1/96	Fri 4/5/96
3	Field Activities	Mon 4/8/96	Fri 7/12/96
4	Meetings with GOK and USAID	Mon 7/15/96	Fri 7/26/96
5	Draft Report Preparation	Mon 7/29/96	Fri 8/16/96
6	Submit Report to USAID	Mon 8/19/96	Mon 8/19/96
7	Incorporate USAID Comments	Tue 8/20/96	Mon 9/23/96
8	Translate Report into Russian	Tue 9/24/96	Mon 10/7/96
9	Submit Report to GOK	Mon 10/7/96	Mon 10/7/96
10	Incorporate GOK Comments	Tue 10/8/96	Mon 11/11/96
11	Prepare Final Report	Tue 11/12/96	Mon 11/25/96





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Appendix B

Tables

Table 1
Water Quality: Kosaman Wellfield

Well No.	Date	Conduc	TDS	Temp	pH	Eh	SO4	Fe	Mn	Chloride	Alkalinity	Hardness	Langelier	Ryznar	Sand Content	Remarks
		(us/cm)	(ppm)	(oC)		(mV)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm total)	(ppm CaCO3	Index	Stab. Index	(ppm)	
1	Sep-95	1040	522					2.6	0	30	190	20	-3.7	7.5	265	20% Rust, 80% Sand, For LI pH = 7.7
2	Jun-95	910	580	21.3	7.9	284	150	0.7	0	160	204	20	-3.5	6.7		
3																
4	Jun-95	970	620	20.7	7.7	284										
5																
6																
7																
8																
9																
10	Jun-95	710	450	19.7	7.6	284									90	Flood of Sand at 5 min, filled tube in <1min
11	Jun-95	670	430	21.6	7.0		125	0.75	0	100	150	20	-4.4	9.8	10	30% Rust, 70% Sand
	Sep-95									76	149.6					
12																
13																
14																
15																
16	Jun-95	470	300	13.5	9.8											
17																
18																
19																
20																
21																
22																
23																
24	Jun-95	720	460		7.1	324	115	1.2	0	100	170	60	-3.9	8.8	4	For LI, T assumed to be 17C
25	Jun-95	730	470	17.5												
26	Jun-95	550	350	14.4												
	Sep-95	470	240				90	2	0	100	68	60	-4.0	9.7	>500	For LI, pH assumed to be 7.0, T=15C
27																
28	Jun-95	540	350	18.3	7.0		85	>5	0		153	80	-3.7	8.7		
29																
30	Jun-95	490	310	13.1												
							Water Quality: Berdykol Wellfield									
1	Jun-95	1000		25		146										
2	Jun-95	1880	880	20.3	8.3	70	125	1	0		187	20	-3.4	7.4		
3	Jun-95	960	480	20.4	7.3	70										
4	Jun-95	950	470	21.2	7.8	78										
5	Jun-95	1010	450	21.1												
6	Jun-95	1530	760	21.2			170	> 5	0		187	60	-3.8	8.4		For LI, pH assumed to be 7.3
7																
8																

Table 2 *(Page 1 of 2)*
Kosaman Wellfield: June-July 1995 Data

Well No.	Pumping?	Backup Well?	WL Probe Access ?	Pump Installed ?	Q (Lps)	WL (m bgs)	Assumed static WL (m bgs)	Drawown (meters)	Specific Capacity (Lps/m)	Efficiency (assumed SC=3.1 Lps/m)	Date Drilled	Well Depth (m bgs)	Depth to top of screen (m bgs)	Depth to bottom of screen (m bgs)	Telescope depth (m)	Pump never installed	Remarks
1	N		Y	Y												Y	
2	Y		Y	Y	26.5	30.5	19.8	10.7	2.5	80%							
3	N	Y	Y	Y													sanding
4	Y		Y	Y	17.4	26.5	19.8	6.6	2.6	84%							5 amps
5	N	Y	Y	Y													
6	N	Y															caved floor ("due to flooding")
7	N	Y															sanding
8																Y	
9	N		Y	Y		20.8										Y	
10	Y		Y	Y	24.4	28.3	19.8	8.5	2.9	93%							6 amps
11	Y		Y	Y	16.4	31.1	19.8	11.3	1.4	47%							7 amps; pump vibrates a lot
12	N		N	Y												Y	
13	N	Y	N	Y							1987	240	195	235	160		
14	N	Y	N	Y							1987	235	195	235	49/171		
15	N	Y	Y	Y							1987	239	199	239	45/171		Pump broken off in well; 3 telescope sections
16	N		Y	N		17.4					1987	240	195	235	170		open hole
17											1987	240	196	235	170		screen clogged, pumps dry; @ PS-1
18											1987						
19						17.2											
20		Y				16.5					1987	232	189	228	162		
21						16.3					1987	245	192	219	163		
22											1987						
23		Y									1987						
24	Y		Y	Y	25.9	33.6	15.2	18.3	1.4	45%							sample at discharge outlet
25	Y		Y	Y	20.9	44.9	15.2	29.7	0.7	23%							5.4 amps; cable warm
26	N		Y	N		15.8											open hole; pump column on ground
27	N		Y	N													open hole
28	Y		Y		11.1	19.9	13.7	6.2	1.8	58%							6 amps, power cable very hot; sample at startup (Fe contam?)
29																	
30	N		Y	N		13.1											open hole; caved near top; bail sample
Berdykol Wellfield: June-July 1995 Data																	
1	N		Y	N		17.6											pump column collapsed inside the casing
2	Y		N	Y	11.4												well is pumped into the system
3	Y		Y	Y	9.34	25.5	17.1	8.4	1.1	35%							well is pumped into the system
4	N*	Y	Y	Y	25.8	17.9											well is pumped into the system
5	N*	Y	Y	Y	3.34	20.5					1985	52	42	52	26		well is pumped into the system
6	N		Y	Y		24.1											well has significant sanding, settleable matter 20ml/l
7	N		Y	Y		22.5					1985	52	41	50	27		well is not connected to the system
8	N		Y	Y		23.7											well is not connected to the system

Note: Construction details based on Russian Engineering Reports.
* Well was turned off at the time of site visit due to request from the city of Aralsk.

Table 2 *(Page 2 of 2)*
Kosaman Wellfield: September 1995 Data

Well No.	Pump Installed	Pump Operational	Q (gpm)	Velocity (ft/sec)	Static WL (ft bgs)	Pumping Water Level (ft bgs)	Drawdown (feet)	Specific Capacity (gpm/ft)	Efficiency (assumed SC=15	Current (amps)	Pressure (psi)	Well Depth (ft)	Distance from previous well (ft)	Remarks
1	Y	Y	295	7.9	66	126	60	5	33%	63	10	725	0	**New pump installed (9/22/95)**, sanding
2	Y	Y	290	3.4						52			720	Smooth pump, replaced in 1994
3	Y	N											765	Pump shuts off in <2 min, possible sanding problems
4	Y	Y	210	2.4						50			750	Smooth pump
5	Y	N	25?							58			720	Believed to pump 200 to 230 gpm (Chengis), Pump shutting off
6	Y	Y	288	3.6						62			820	
7	Y	Y	370	4.5						67			660	Sanding problems, replaced in Nov. 1994
8	N												700	Never had pump
9	N											775	720	Never had pump, suspect telescope at 550 ft bgs.
10	Y	Y	356	4.2						55	18		620	Smooth pump
11	Y	Y	290	2.8	66	94.3	28	10	69%	66	15	763	720	**New pump installed (9/19/95)**
12	N												645	Never had pump
13	Y	?											640	Leakage back into well through backflow valve
14	Y	?											480	
15	Y												700	Control panel missing
16	Y	N										500*	600	Pump Broken off in well, not able to get past 500 ft bgs
17	N											460	640	Possibly filled with sand, open hole
18	N											755	775	Open hole
19	N											290*	520	Open hole,obstruction at 290 ft.
20	Y	?											620	
21	N											490*	790	Open hole,obstruction at 490 ft.
22	N												690	Open hole
23	Y	Y	295	3.5						54			690	
24	Y	Y	412	4.9						57			690	Pump installed in Sept. 1994. Prev. pump lasted 2 yrs.
25	Y	N											690	Check valve leaking, 11 meter pump column
26	Y	Y	382	9.9	46	85.1	39	9.9	66%	58	9	550	690	**New pump installed (9/12/95)**
27	N												690	Open hole, no electric control panel
28	Y	N	38	0.3						56			820	Faulty valve may be restricting pump flow,broke 9/95
29	N												650	Open hole
30	N											350*	650	Open hole, pump broken off in well

* Maximum depth obtainable with bottom sounder

Table 3 **Water Level Data: Kosaman Wellfield** (meters below ground surface)				
Well No.	Date 6/15/95	Date 9/8/95	Date 9/12/95	Date 9/21/95
1		23.9	20.2	18.3
2	**30.5**	**30.7**		
3	**21.0**	**25.6**		
4	**26.5**	**30.4**		
5		Pumping		
6		Pumping		
7		Pumping		
8		25.5	20.1	
9	20.8	25.8		
10	**28.3**	**31.0**		
11	**31.1**	24.1	20.4	
12		23.0		
13		21.4		
14		22.1		
15				
16	17.4	20.6	18.7	17.1
17		20.3		16.6
18		16.1	14.6	13.6
19	17.2	21.0		16.4
20	16.5			
21	16.3	20.2		15.2
22		20.9		
23		Pumping		
24	**33.6**	Pumping		
25	**44.9**	18.9		
26	15.8	17.0	14.2	
27		16.9	14.5	
28	**19.9**	**18.8**		
29		15.9	15.4	
30	13.1	14.7		

Notes:

1) Bold values are pumping water levels.

2) Pipeline break forced all wells to be off from 9/11 to 9/13 and from 9/20 to 9/21.

Table 4 Kosaman Wellfield Conditions Survey: September 1995											
Well No.	Pumping	Gate Condition	Pump House Type	Pumphouse Door Condition	Pumphouse Top Hatch	Pump Condition	Floor Condition	Valve Conditions	Electric Panel	Remarks
1	Yes	needs small repair	pre-cast	good	repair/replace	new Sept 1995	good	good	new	
2	Yes	good	pre-cast	good	repair/replace	active/good	okay	small backflow into well	active	smooth pump, replaced in 1994
3	Yes	good	pre-cast	good	repair/replace	active/good	minor repairs needed	small leak onto floor	active	
4	Yes	needs small repair	pre-cast	good	repair/replace	active/good	minor repairs needed	good; handles broken	active	
5	Yes	needs repaired	pre-cast	good	repair/replace	active/good	major repairs needed	okay	active	pump vibrates slightly
6	Yes	needs repairs	pre-cast	good	repair/replace	vibrates	minor repairs needed	okay	active	pump vibrates
7	Yes	needs minor repairs	pre-cast	good	fair	active/good	minor repairs needed	okay	active	new pump Nov. 1994
8	No	hinge frozen	pre-cast	okay	needs replaced	no pump	okay	handles need replaced	inactive	never pumped
9	No	okay	pre-cast	okay	okay	no pump	minor repairs needed	small leak onto floor	missing	angle of first pipe suggests incomplete column length
10	Yes	needs minor repairs	pre-cast	okay	needs replaced	active/good	terrible; needed	one handle broken	active	major repairs needed to restore floor of pump house
11	Yes	okay	pre-cast	okay	okay	new Sept. 1995	okay	okay	new	redeveloped then replaced pump and panel
12	No	good	pre-cast	good	okay	never pumped	minor cracks	okay	missing	unknown column lengths
13		okay	brick	poor	repair/replace		minor repairs needed	small leakage into well	intact	leakage back into well through backflow valve
14		okay	brick	poor	repair/replace		okay	okay	intact	
15	No	okay	brick	poor	okay		minor repairs needed	small leakage into well	missing	
16	No	okay	brick	poor	missing	none	okay	okay	missing	6-4.5 m pump column sections (150mm); used 4 for Well #1
17	No	good	brick/concrete	okay	okay	open hole	okay	good	missing	8-4.5m (poor cond) & 1-11m (good cond) pipe sections (150mm)
18	No	okay, sags	brick/concrete	okay	repair/replace	open hole	minor repairs needed	okay	intact	top head, plate outside
19	No	okay	brick/concrete	poor	repair/replace	open hole	okay	main rusted, rest okay	gutted	7-4.5m (poor cond) pipe sections (150mm); top head and plate
20		needs repairs	brick/concrete	poor	repair/replace	unknown	minor repairs needed	good	intact	
21	No	okay	brick	poor	repair/replace	open hole	okay	needs replaced	intact	6-6m pipe sections (150 mm, poor cond)
22	No	okay	brick	poor	repair/replace	open hole	terrible; excavation	okay	intact	2-6m pipe sections, 2-4.5m sections (150mm,fair cond)
23	Yes	okay	pre-cast	okay	repair/replace	active/good	minor repairs needed	handle to main broken	active	
24	Yes	okay	pre-cast	okay	repair/replace	active/good	minor repairs needed	handle to main broken	active	
25	No	good	pre-cast	okay	missing	recently failed	minor repairs needed	okay	active	check valve leaking; pump recently stopped--needs replaced
26	Yes	needs repaired	pre-cast	okay	missing	new	major repairs needed	good	new	new pump and panel installed Sept. 1995
27	No	goods	pre-cast	okay	okay	open hole	minor repairs needed	okay	missing	5-11m pipes & 1-6m pipe (d=100mm, good cond) on ground
28	Yes	okay	pre-cast	okay	okay	rattles	okay	rattles	active	pump clatters as if closed; flow rate appears low
29	No	okay	pre-cast	okay	okay	open hole	major repairs needed	missing valves	intact	5-11m & 1-6m pipe sections (d=100 mm, good condition) on ground
30	No	okay	pre-cast	okay	repair/replace	open hole	major repairs needed	missing valves	missing	open hole; pump & column in bottom of well

Table 5 Specific Capacity and Efficiency Data for Selection of Redevelopment: June - July 1995				
Well	**Pumping Rate (Lps)**	**Drawdown (meters)**	**Specific Capacity (Lps/m)**	**Efficiency (%)**
Well 2	26.5	10.7	2.5	17
Well 4	17.4	6.6	2.6	84
Well 10	24.4	8.5	2.9	93
Well 11	16.4	11.3	1.5	47
Well 24	25.9	18.3	1.4	45
Well 25	20.9	29.7	0.7	23
Well 28	11.1	6.2	18	58

Table 6
Kosaman Wellfield
Total Dynamic Head (TDH) Calculation Summary

Current Operating Conditions

	Static Water Level (m bgs)	Drawdown* (m)	Lift to Reservoir (m)	Friction Loss in Pipes (m)	Friction Loss in Fittings (m)	TDH (m)
Average	15	15	5	6	2	**42**
Maximum	15	15	5	16	2	**52**
Minimum	15	15	5	1	2	**37**

Current operating conditions assume 7 wells pumping at 340 gpm (1,857 m3/day/well)

* Drawdown taken from *Groundwater Survey and Hydrogeologic Characterization Report* (EPT, Nov. 1995)

Initial Design Conditions

	Static Water Level (m bgs)	Drawdown* (m)	Lift to Reservoir (m)	Friction Loss in Pipes (m)	Friction Loss in Fittings (m)	TDH (m)
Average	15	45	5	3	1	**70**
Maximum	15	45	5	14	2	**80**
Minimum	15	45	5	1	0	**66**

Initial Design Conditions assumptions:
1) 5 wells at 150 gpm (818 m3/day/well)
2) 15 wells at 350 gpm (1,909 m3/day/well)
3) 5 wells at 500 gpm (2,727 m3/day/well)

* Drawdown taken from *Groundwater Survey and Hydrogeologic Characterization Report (EPT, 1995)*

Note: Maximum and minimum TDH depends on location of well, pipe diameter, and pumping rate as shown in Tables 7 and 8

Table 7
Calculation of TDH: Current Operating Conditions

Well No.	Flow Rate (Lps)	Pipe Length (m)	Cumulative Flow (Lps)	Pipe Diameter (mm)	Loss to Fittings (m)	Loss in Pipe (m)	Total Fittings and Pipe (m)	Lift Head Reservoi (m)	Lift Head WL to Surf * (m)	TDH (m)
1	21	230	21	160	1.6	5.3	6.8	5	30	42
2	21	240	43	225	1.6	4.0	5.6	5	30	40
3	21	210	64	315	1.6	1.1	2.6	5	30	37
4	21	1,900	86	315	1.6	15.9	17.5	5	30	52
5	21	250	21	160	1.6	5.7	7.3	5	30	42
6	21	200	43	225	1.6	3.4	4.9	5	30	40
7	21	220	64	315	1.6	1.1	2.7	5	30	37
8		1,800	64	315		9.2		5		0
9		210		160				5		0
10		225		225				5		0
11		230		315				5		0
12		1,000		315				5		0
13		215		160				5		0
14		210		225				5		0
15		230		315				5		0
16		210		315				5		0
17										
18		250		315				5		0
19		210		315				5		0
20		215		315				5		0
21		220		225				5		0
22		230		160				5		0
23		1,100		315				5		0
24		215		315				5		0
25		219		225				5		0
26		250		160				5		0
27		1,200		315				5		0
28		240		315				5		0
29		220		225				5		0
30		220		160				5		0
Total	150			Avg.	2	6	7			42
				Max	2	16	17			52
				Min	2	1	3			37

* This includes lift from pumping water level (static water level+drawdown) to surface as indicated in Groundwater Survey and Hydrogeologic Characterization Report, Nov. 1995.

Head losses in pipes & fittings based on roughness coefficient of 80 for corroded cast iron pipe and the Hazen-Williams Equation.

Fittings are calculated for wellheads only (160 mm diameter fittings) and include:

3 Regular L's	3
1 Globe Valve	1
1 Swing Check Valve	1
1 Tree Branch Flow	1

Table 8
Calculation of TDH: Initial Design Conditions

Well No.	Flow Rate (Lps)	Pipe Length (m)	Cumulative Flow (Lps)	Pipe Diameter (mm)	Loss to Fittings (m)	Loss in Pipe (m)	Total Fitting and Pipe (m)	Lift Head Reservoir (m)	Lift Head WL to Surf* (m)	TDH (m)
1	9	230	9	160	0	1	1	5	60	68
2	22	240	32	225	2	2	4	5	60	71
3	22	210	54	315	2	1	2	5	60	69
4	22	1,900	76	315	2	14	15	5	60	86
5	9	250	9	160	0	1	1	5	60	68
6	22	200	32	225	2	2	4	5	60	71
7	22	220	54	315	2	1	2	5	60	69
8	22	1,800	76	315	2	13	15	5	60	85
9	9	210	9	160	0	1	1	5	60	68
10	22	225	32	225	2	2	4	5	60	71
11	22	230	54	315	2	1	2	5	60	69
12	22	1,000	76	315	2	7	9	5	60	78
13	9	215	9	160	0	1	1	5	60	68
14	22	210	32	225	2	2	4	5	60	71
15	32	230	63	315	2	1	4	5	60	71
16	32	210	95	315	2	2	5	5	60	72
17										
18	32	250	117	315	2	4	6	5	60	74
19	32	210	117	315	2	3	6	5	60	74
20	32	215	85	315	2	2	4	5	60	72
21	22	220	54	225	2	6	8	5	60	76
22	22	230	22	160	2	5	7	5	60	75
23	22	1,100	66	315	2	6	7	5	60	76
24	22	215	66	315	2	1	3	5	60	70
25	22	219	44	225	2	4	6	5	60	74
26	9	250	22	160	0	1	1	5	60	68
27		1,200		315				5	60	#N/A
28		240		315				5	60	#N/A
29		220		225				5	60	#N/A
30		220		160				5	60	#N/A
Total	536			Avg.	1	3	5			73
				Max	2	14	15			86
				Min	0	1	1			68

* This includes lift from pumping water level (static water level+drawdown) to surface as indicated in Groundwater Survey and Hydrogeologic Characterization Report, Nov. 1995.

Head losses in pipes & fittings based on roughness coefficient of 80 for corroded cast iron pipe and the Hazen-Williams Equation

Fittings are calculated for wellheads only (160 mm diameter fittings) and include:
3 Regular L's
1 Globe Valve
1 Swing Check Valve
1 Tree Branch Flow

Appendix C

Kosaman and Berdykol Wellfield Conditions: Technical Data, Analyses and Discussion

Section 1
Introduction

Wellfield conditions were evaluated based on investigations conducted in June-July 1995 and September 1995. This appendix includes technical data, analyses and discussions that support the findings and recommendations presented in the main body of this report.

This appendix presents discussions of the following:

- initiation of wellfield improvements
- well development and redevelopment
- groundwater and well conditions
- wellhead conditions
- well and pump design and specifications
- recommendations for future work

Each of these subjects are discussed in the following sections.

Section 2
Initiation of Wellfield Improvements

Wellfield improvements consisted primarily of the installation of three new submersible turbine pumps (5-stage, 6-in., closed impeller) and motors (50-horsepower, 3,000 revolutions per minute) and related hardware. These were installed at Kosaman Wells 1, 11 and 26. New electrical cable (#2, 3-strand) and control panels (Asco-Delta full voltage) were installed with each new pump and motor.

Attachment 3 contains the technical specifications for the pump, motor and control panel. Pressure gauges and sampling ports were installed in the discharge line of Wells 1, 10, 11 and 26. Well redevelopment activities were also performed in conjunction with new pump installations, and these are discussed in more detail in the next section. The rationale for installation of new pumps are presented below.

A new pump was installed in Well 1 to evaluate the response of a well that had never received a pump. According to available records, this well had limited well development after completion. The pump designated for this well at the time of completion was intercepted for installation in a well where the pump had failed. The bottom of the well was sounded at the depth of 221 meters below ground surface (bgs) (725 feet bgs); this is near the apparent design depth of 230 meters. After several hours of surge pumping, the pumping rate was measured at 19 lps (295 gpm), and the specific capacity was approximately 1 Lps/meter (5 gpm/ft). The sand content in the discharge from this well was 265 ppm.

As a reference, the pump motor manufacturer's specifications for maximum allowable sand content is 50 ppm. Because this well had never been pumped and the gradual increase in specific capacity during development, the specific capacity may be expected to increase and the sand content decrease the longer the well is developed.

A new pump was installed in Well 11 in conjunction with extensive well redevelopment activities including use of chemicals and mechanical techniques. The primary purpose for choosing this well was to try to improve the specific capacity of an inefficient well. After chemical redevelopment and several hours of surge pumping, the pumping rate was measured at 19 Lps (295 gpm), and the specific capacity was approximately 2 lps/meter (10 gpm/ft). The sand content from this well was measured at 10 ppm. (Sand content is discussed in more detail later in this appendix.)

A new pump was installed in Well 26 to provide more pumping capacity at the northern end of the wellfield. According to wellfield personnel, Well 26 produced more than 20 lps (310 gpm) when the existing pump, which ceased operating in the fall of 1994, was operational. The new pump produced 25 lps (380 gpm), and the specific capacity was 2 lps/meter (10 gpm/ft). The sand content was greater than 500 ppm. It is likely that the high sand content in the discharge water is due to a failure in the well screen.

During the June-July and September visits, a maximum of seven pumps were active at any given time. During the June-July visit, nine additional pumps were operational but inactive, leaving a total of 16 operational pumps. Between July and September, four pumps ceased to operate, leaving 12 operational pumps. The three new pumps installed as part of the wellfield improvements, raised the total number of operational pumps to 15 in September.

Wellfield activities were supported by a crane provided by the GOK. The lift capacity of the crane exceeded wellfield activity needs. However, it had a short boom and was not able to remove the pump column from wells that had 11-meter (36-foot) long pump column pipe. The crane was able to remove pumps having 4.5-meter (15-foot) and 6-meter (20-foot) long pump column pipe. Additionally, the short cable on the crane (estimated to be about 35 meters long) prevented it from lowering tools into the well screen zone, located approximately 185 to 235 meters bgs (607 to 770 feet bgs).

Activities at the site required up to 10 individuals from the communities of Kosaman and Aralsk. Five members of the EPT support team were also employed for this phase of the project. The success of this phase of the project was possible because of the response of the GOK and the participation of the community of Kosaman.

Section 3
Well Development and Redevelopment

Data collected in June-July 1995 indicated that three of the active pumping wells had relatively low specific capacities and low theoretical well efficiencies (Wells 11, 24 and 25), and that four wells (Wells 1, 8, 9 and 12) had never been pumped and had limited development after well completion. Table 5 (Appendix B) summarizes specific capacity and efficiency data for wells pumping in June-July 1995. The specific capacity and efficiency data were used to select Wells 11, 24 and 25 as potential choices for redevelopment.

Editor's Note: Tables 6, 7 and 8 provide more detailed information. The three tables are, respectively: Kosaman Wellfield TDH Calculation Summary; Calculation of TDH, Current Operating Conditions; and Calculation of TDH, Initial Design Conditions.

Well 24 was removed from consideration because this well has a high pumping rate, and its uninterrupted service was required to provide water from the northern area of the wellfield. An attempt was made to remove the broken pump in Well 25. However, the 11-meter (36-foot) long pump column pipes were too long for the crane to lift out of the well, thereby removing this well from further consideration. Well 11 had 6-meter long pump column pipes, and was selected for redevelopment. Additionally, Well 1 was chosen for redevelopment and new pump emplacement in order to evaluate the conditions of wells that had never received pumps and may have been underdeveloped. The development techniques applied to Wells 1 and 11 are described below.

3.1 Well 1 Development

Well 1 had never received a pump after it was constructed. This well was developed using pump-surging techniques (i.e., turning the pump on and off). The pumping rate at the end of development was 19 lps (295 gpm), and the specific capacity was 1 lps/meter (5 gpm/ft). The sand content in the well discharge, after several hours of surge pumping, was 265 ppm. The gradual improvement in specific capacity over time indicates that this well may benefit from further development. It was not possible to redevelop this well using a surge block attached to the crane because the upward and downward movement of the crane line was judged to be too slow to sufficiently agitate the formation around the well. Other mechanical techniques for development, such as air lifting or heavy pumping, were not available.

It is likely that continued pumping with the newly installed pump will increase the specific capacity and lower the sand content; however, there is risk that the high sand content will adversely wear the pump and motor. If, upon further pump redevelopment, the sand content does not decrease significantly, then the pump will be pulled and a test pump will be installed to redevelop the well. After the well is developed, a dedicated pump will be installed. The test pump is a sacrificial pump that is used only for pump redevelopment purposes. Upon completion of field activities, this pump will be left at the wellfield to be available for future redevelopment activities undertaken by GOK wellfield personnel.

3.2 Well 11 Redevelopment

Well 11 was the subject of extensive redevelopment that targeted possible encrustation of the well screen. If there was encrustation of the well screen, could it be removed to improve specific capacity and efficiency? The pump in Well 11 failed in August 1995. The pump, motor and pump column were removed from the well using the crane and local laborers. Then the well was treated with Swyco S/C and Swyco B/E. Swyco S/C is mainly sulfamic acid (H_3NO_3S) with some dispersants and inhibitors. The acid removes the protective coating of the bacteria in the well. Dispersants are designed to keep dissolved chemicals in suspension until removal by pumping, while inhibitors are designed to minimize corrosion of the casing and well screen during treatment.

Swyco B/E, which consists primarily of glycolic acid, attacks the exposed bacteria and dissolves the iron and manganese compounds deposited by the bacteria. After adding the Swyco S/C and B/E, a surge block, suspended from a 220-meter chain, was used to agitate the screened interval in 6-meter (20-foot) sections. Surging of the screened interval took place over 2 consecutive days. The pH of water in the well on the second day of treatment was below 2, an appropriate level, according to manufacturers' specifications. After the treatment was complete, a new pump was installed and the water in the well was pumped to a discharge line emptying out onto the ground surface (see Photo 5 in Attachment 1). The well was pumped for more than 3 hours, until groundwater chemistry parameters were the same as those prior to redevelopment. The total time of acid treatment was 6 days.

The new pump in Well 11 produced 18.5 lps (290 gpm), and the well had a specific capacity of 2 lps/meter (10 gpm/ft). The specific capacity of Well 11 prior to redevelopment was 1.5 lps/meter (7 gpm/ft). This indicates that chemical redevelopment may have improved the specific capacity by 0.63 lps/meter (3 gpm/ft), or 43 percent. This improvement is significant and shows that chemical redevelopment is effective and should be used in future redevelopment activities. Table 2 (Appendix B) presents specific capacity and other data for wells in both wellfields.

Section 4
Groundwater and Well Conditions

Well conditions were assessed for the Kosaman Wellfield in order to evaluate groundwater quality, and reliability of the groundwater supply. Data collected during both the June-July and September 1995 investigations are discussed to provide a comprehensive assessment. The conditions assessed include; groundwater quality, pumping rates, line pressures, and wellhead conditions. Wellhead conditions refer to the condition of the pump houses, well-head valves, and piping. Discussions of the hydrogeology are presented in the report entitled "Groundwater Survey and Hydrogeological Characterization, Kosaman and Berdykol Wellfields" (EPT, 1995), which was prepared in conjunction with this project.

4.1 Groundwater Quality

The quality of groundwater from the both wellfields is suitable for potable uses. To provide a baseline of groundwater quality for future reference, groundwater quality was assessed in selected wells using field test kits (i.e., Hach kits) and hand-held instruments. Water quality parameters assessed include: electrical conductivity (EC) and total dissolved solids (TDS); physical parameters (temperature, pH, and Eh); selected ions, including sulfate (SO_4), iron (Fe), manganese (Mn), chloride (Cl), alkalinity, hardness, sand content, and corrosivity. The results of these analyses are presented in Table 1 (Appendix B). A brief discussion of each group of parameters is presented below.

4.1.1 EC and TDS

EC is a measure of the electrical conductivity of water, which is generally related to the level of TDS in the water. EC values at the Kosaman Wellfield ranged from 470 to 1,040 microsiemens per square centimeter ($\mu s/cm^2$) and averaged 690 $\mu s/cm^2$. EC values at the Berdykol Wellfield ranged from 950 to 1880 $\mu s/cm^2$ and averaged 1,200 $\mu s/cm^2$. TDS concentrations ranged from 240 to 620 ppm and averaged 420 ppm at the Kosaman Wellfield and ranged from 450 to 880 ppm and averaged 600 ppm at the Berdykol Wellfield. As a reference, the recommended secondary standard for TDS concentration established by the USEPA (1995) is 500 ppm. WHO secondary standards and local government standards (GOST) are 1,000 ppm. The lower average TDS concentration at the Kosaman Wellfield indicates that groundwater quality from this wellfield is generally of superior quality than groundwater from the Berdykol Wellfield.

4.1.2 Physical Parameters

Physical parameters measured include pH and temperature. The pH of the groundwater ranges from 7.0 to 9.8, and averages 8.4. This indicates the water is neutral to slightly alkaline. The temperature ranges from 13.5°C to 21.6°C and averages 17.8°C. The variability in pH and temperature measurement may reflect variations in the field measurements and collection methods, rather than the actual groundwater conditions. According to GOST standards, the pH of water should be between 6 and 9.

4.1.3 Selected Ions

Selected ions were measured using field test (Hach) kits. The concentration of chloride, sulfate, and manganese is lower than GOST and U.S. secondary drinking water standards. GOST standards for chloride, sulfate and manganese are 350, 500 and 1 ppm, respectively. However, the concentrations for iron exceed the GOST standard and the U.S. secondary maximum contaminant level (MCL) of 0.3 ppm. The iron concentrations in groundwater ranged from 0.7 to >5 ppm and averaged 1.5 ppm. Iron concentrations above 0.3 ppm do not pose a health risk. The MCL is set at 0.3 ppm, mainly for aesthetic reasons (e.g., staining of clothes and plumbing fixtures, and taste).

Hardness is the concentration of ions in the water that will react to sodium soap to precipitate an insoluble residue. The hardness of groundwater at the wellfield ranges from 20 to 80 ppm and averages 43 ppm. Water with a hardness of 0 to 60 ppm is considered "soft," while water with a hardness of 60 to 120 is considered "hard." Groundwater at the Kosaman Wellfield is, generally, soft.

4.1.4 Sand Content

The sand content of discharge water was measured at five wells. The sand content for Wells 1, 10, 11, 24 and 26 was 265, 90, 10, 4 and >500 ppm, respectively. At high levels, abrasion by the sand can cause excessive wear on the pump, reducing its efficiency and shortening the life of both the pump and motor. According to the manufacturer of the motors used for the new pumps installed in September 1995, sand content should not exceed 50 ppm in order to protect pump longevity and the motor warranty.

Measurements of sand content were made using a Rossum brand sand centrifuge. Some wells produced a slug of sand after approximately 5 minutes of pumping. This is the estimated time period for water from the screened section to reach the pump intake. Sand content was determined by measurement of the accumulation of sand over a 10-minute period of pumping, except in the cases of Wells 1 and 26, where sand contents were high enough to fill the sand traps in less than 10 minutes. Sand tests were run after a minimum of 15 minutes of steady pumping. Comparisons of sand content after 15 minutes of steady pumping and 2 hours of steady pumping, showed negligible differences.

In general, some wells produce high levels of sand, which may pose significant problems for some pumps at the Kosaman Wellfield. Even though sand tests were not conducted at the Berdykol Wellfield, it is likely, based on similar well construction, qualitative observations of sanding, and short pump life, that some wells in this wellfield also produce high levels of sand. This problem is discussed further in the Section 6.1, Well Design and Sanding.

4.1.5 Corrosivity/Encrusting Potential

Corrosivity refers to the potential for water to corrode or rust metal through electrochemical or chemical action. Encrustation refers to the potential for the precipitation of carbonate minerals. To assess the corrosivity/encrusting potential of the water, the Langelier Index and the Ryznar Stability Index were calculated for groundwater from eight wells. If the Langelier Index is negative, then the water has the tendency to be corrosive, if it is positive it has the tendency to be encrusting. For the Ryznar Stability Index, values greater than 7 indicate corrosive waters, while values less than 7 indicate encrusting waters.

For groundwater from the Kosaman Wellfield, the Langelier Index ranged from -3.5 to -4.4, and averaged -3.8. The Ryznar Stability Index ranged from 6.7 to 9.8, and averaged 8.4. These values indicate the water is corrosive and there is minimal tendency for encrustation. Field inspection of old pump column and other pipes confirm this, in that there is typically heavy corrosion, and no evidence of carbonate encrustation.

4.2 Well Conditions

4.2.1 Pumping Rates

Pumping rates were estimated with a Panametrics brand ultrasonic flowmeter. Propeller-type flowmeters are a part of each wellhead assembly. However, none of them are operational. Measured pumping rates in September ranged from 2.4 to 26 lps (38 to 420 gpm), with all but three wells producing greater than 18 lps (290 gpm). Well 28 had an exceptionally low pumping rate of 2.4 lps (38 gpm). This pump failed on October 1, 1995, apparently due to motor breakdown. Observed pumping rates are listed in Table 2 (Appendix B).

According to the original wellfield design report provided by GOK engineers, the wells were designed to produce approximately 20 lps (310 gpm) at 100 meters (330 feet) of total dynamic head (TDH). It is likely many of the pumps do not meet these design specifications. It appears that the wells at the Kosaman Wellfield were installed based on their availability. An assessment of suitable pumping rates for wells at the both wellfields is discussed below.

4.2.2 Groundwater Levels

In September, the depth to groundwater in inactive wells ranged from 13 to 21 meters bgs (43 to 69 feet bgs). Pumping water levels ranged from 20 to 45 meters bgs (65 to 147 feet bgs). Because of pipeline problems, the pumps at the Kosaman Wellfield were shut down on two occasions for 2 days. Groundwater levels were measured from selected wells on both occasions to assess static conditions.

Under static conditions, depths to groundwater ranged from approximately 18 meters bgs (60 feet bgs), at the southern end of the wellfield (Well 1), to 14 meters bgs (42 feet bgs), at the northern end of the wellfield (Well 27). This indicates the piezometric head increases fairly uniformly from south to north, assuming the ground elevation is the same across the site. Table 3 (Appendix B) contains all groundwater level measurements at the Kosaman Wellfield for both June-July and September visits.

4.2.3 Distribution Line Pressures

Distribution line pressures were measured at the wellhead discharge lines of four wells that were pumping. All sampling ports and pressure gauges were installed as part of this phase of work. Discharge line pressures ranged from 0.7 to 1.3 kilograms per square centimeter (kg/cm^2) (10 to 18 pounds per square inch psi). Table 2 (Appendix B) gives the distribution of line pressures observed during September. Figure 3 (Appendix A) is a schematic of the wellfield piping system and shows the locations of line pressure measurements.

Section 5

Wellhead Conditions

There are three basic styles of pump house construction, which are related to the period of installation:

1) wells having brick pump houses (Wells 13 to 17 and 21 to 22), which were constructed between 1985 and 1987

2) wells having brick pump houses with concrete facings (Wells 18 to 20), which were also constructed between 1985 and 1987

3) wells having precast concrete pump houses (Wells 1 to 12 and 23 to 30), which were constructed between 1991 and 1992.

A typical pump house layout is illustrated in Figure 3. An example of each pump house type is shown in Photos 2 and 3 in Attachment 1. The overall condition of the pump houses varied, and reconditioning activities are required for some, to protect hardware investments. It is recommended that the materials to perform these activities be supplied during the next phase of activities. GOK personnel are expected to provide the labor to implement these improvements.

Wellhead conditions were evaluated to provide assessment of activities which may be needed to protect the wells, pumps, and electric panels from the impact of weather. In addition, qualitative observations were made regarding the conditions of valves and pipes exposed at the surface. Attachment 2 presents a photo log of each wellhead in the Kosaman Wellfield. Table 4 (Appendix B) provides a qualitative evaluation of wellhead conditions including gate, pump house door, top hatch (Photo 4 in Attachment 1), wellhead assembly (Photos 6 and 7 in Attachment 1), valves and pump house floor (Photo 8 in Attachment 1). Pump column pipes that were exposed on the ground were also evaluated.

Section 6
Well and Pump Design and Specifications

From June to September 1995, three pumps at both the Kosaman and Berdykol Wellfields ceased operating following failure of the pump motors. Based on discussions with local officials, pumps in Kosaman and Berdykol Wellfield wells operate for an average of 2 years before failure. Under normal conditions, a pump should last at least 7 to 10 years. There are several factors at the Kosaman and Berdykol Wellfields that contribute to the reduced lifespan of pumps. These factors are:

- possible poor design, materials, and construction of wells, which allows sand flow into wells
- irregular electric current and voltage

Each of these factors is discussed below.

6.1 Well Design and Sanding

The wells at Kosaman and Berdykol were designed and constructed to develop a natural filter pack from the formation surrounding the screened interval of the well. At the Kosaman Wellfield, the screened interval consists of 168-mm (6-in.) internal diameter steel pipe with approximately 15-mm circular perforations evenly distributed throughout the screened section. At the Berdykol Wellfield, the screened interval consists of 219-mm internal diameter steel pipe with the same sized perforations as at Kosaman. This section was wrapped with stainless steel wire mesh (0.7-mm sized openings) and emplaced in the well. The screened sections were then subjected to air lifting for a period of 1 to 3 weeks. A natural filter pack develops during the air lifting when the fine sediments (i.e., less than 0.7 mm) pass through the screen and are lifted out of the well, trapping larger sediments behind the screen. Potential problems using this design can arise from the following:

- the lack of natural filter pack development, which does not prevent fine-grained sediments from entering the wells
- punctures, tears and displacement of the externally wrapped screen allowing sand to flow into wells

These potential problems are discussed below.

If the wall is naturally developed, the slot size should allow no more than 50 percent of the formation to pass through the screen. However, based on grain-size distributions of the aquifer material, approximately 90 percent of the grains will pass through the screen. This suggests that the screen slot size for the Kosaman and Berdykol Wellfields has been improperly selected. The impact of sand flowing into the well is twofold. First, sand may be entrained in the water column and carried to the pump, causing abrasion of pump impellers and excessive wear to the pumps, which may lead to premature motor failure. Second, sand can accumulate in the well and eventually choke off the flow of groundwater into the well.

Another potential mechanism allowing sand to enter the well is holes in the well screen. During lowering of the well screen into the well bore, at the time of installation, the screen mesh can be torn or displaced, allowing sand to enter the well unimpeded.

6.2 Improper Pump Design

Performance characteristics of pumps at the Kosaman Wellfield appear to be poorly matched to field conditions. According to GOK engineers and the wellfield design report, the pumps at Kosaman were designed to produce 17.5 lps at 110 m (361 ft.) total dynamic head (TDH), while the pumps at Berdykol were designed to produce 33 lps at 60 m (196 ft.) head. The pumps have been selected for design operating conditions, with assigned drawdowns to be larger than current drawdowns. Because of different head conditions, the pumps might operate out of recommended operating range. Moreover, pumps of different type and model might have been installed. There appears to be little or no record keeping on site regarding type and duration of pumps in use. The TDH is the sum of all the forces the pump must overcome in delivering water to the reservoir. These forces include the lifting head, which is the change in elevation from the water surface to the reservoir, and the friction head, which is caused by friction losses in the pipes and valves.

A re-evaluation of site system conditions shows that the TDH ranges from 40 to 80 meters (131 to 262 feet) depending on the pumping rate of individual wells and how the wellfield is operated. This TDH requirement includes 30 to 50 meters (98 to 164 feet) of lift required to pump the groundwater from the well to the reservoir, and 4 to 8 meters (13 to 26 feet) of head to overcome line losses and discharge pressure into the reservoirs at Pump Station No. 1. Tables 6 through 8 (Appendix B) summarize the results of an initial evaluation of TDH conditions at the Kosaman Wellfield.

A more detailed evaluation will be conducted as specifications for new pumps are developed. Based on the initial review of existing field conditions, the current TDH is less than the design TDH of 100 meters. Operating pumps at a significantly lower TDH than designed for leads to a "run-out-condition," which will cause the pump to spin at a higher rate than it was designed for, causing excessive mechanical wear and damage to the impellers. Over a sustained period of time, a run-out-condition will lead to excessive wear on the pump bearings, cause imbalance and friction buildup in the pump, and ultimately produce motor failure.

The pumps observed in the field were typically five-stage pumps with plastic impellers and flutes. The plastic impellers and flutes appear disposed to excessive wear as noted by obvious abrasion marks. Photo 10 in Attachment 1 shows the failed pump and motor removed from Well 26. It is evident that significant abrasion has occurred to the impellers and scarring of the line-shaft that turned the impellers. This pump was operational for about 8 months. The sand content of groundwater pumped from this well was over 500 ppm.

6.3 Irregular Electric Current

The power supply at Kosaman and Berdykol has a frequency of 50 Hertz and 380 volts. Photo 9 in Attachment 1 shows a typical electrical transformer connected to the regional grid that provides power to each well. Variations of electric frequency and voltage can cause damage to a running pump and motor. During the time spent in the Kosaman Wellfield, lights flickered or shut off for short periods of time and the voltage varied from well to well.

The electric panels that control the power to each pump have switches that are locked on. When power fails, the pumps shut down. During momentary power failure, the pumps shut down and restart as quickly as the power returns. This can create significant pump and motor strain, especially in cases where the pump is rotating backward due to water falling through the pump column pipe and into the well, when the pump restarts. This abrupt reversal in flow direction strains the pump and motor and can cause premature failure. As a reference, pump and motor manufacturers' specifications typically call for pumps to be shut down for a period of 5 minutes prior to restarting.

The new electric control panels installed in September have safeguards against irregular electric surges and power failures. These safeguards include automatic shut-off switches, based on voltage fluctuations, which prevent destructive impacts to pumps and motors. Once tripped, the automatic shut-off switches require a manual restart.

Section 7
Recommendations

Recommendations for future wellfield activities are presented in this section. Recommendations for future work are based on the following objectives:

- Total wellfield production capacity should equal 420 lps from the Kosaman Wellfield and 210 lps from the Berdykol Wellfield, for a total of 630 lps.

- Overall production demand of 630 lps be achieved using existing Kosaman and Berdykol Wells.

Based on the results of the field investigations, a series of future redevelopment activities are proposed. These proposed activities would be completed in 1996 and are discussed below.

7.1 Wellfield Production

While wellfield production levels are expected to provide the combined total of 630 lps, it is unlikely that the Federal transmission pipeline in its current condition can handle more than one-third to one-half this rate of flow. Numerous breaks in the pipeline in recent years have weakened the pipeline such that it cannot withstand the pressure of high flow rates. Based on an estimate provided by the Chief Engineer from the Aralsk-Sarbulak Pipeline, the current (September 1995) maximum flow rates the pipeline can sustain range between 200 to 250 lps. The current estimate is considerably below its design rate because of numerous breaks and repairs on the pipeline. Currently, the GOK and international donors are conducting a study of the feasibility of improving the pipeline.

The lifetime expectancy of the groundwater resource, as described in more detail in the "Groundwater Survey and Hydrogeological Characterization Report, Kosaman and Berdykol Wellfields" (EPT, 1995), is expected to be greater than 50 years at the design production rate of 630 lps. However, the lifetime of individual wells will be much shorter. Wells constructed using typical U.S. standards (e.g., steel louvers and filter packs) are expected to last from 20 to 50 years.

The wells of Kosaman and Berdykol may not have the life expectancy of equivalent U.S. wells because of the well design and construction. Many of these wells will produce significant groundwater flow; however, the high sand content observed in some wells, and large amount of sand that has settled in other wells, suggest some wells are either presently or will soon be no longer suitable for use. While current production rates from individual wells are expected to total 630 lps, the ability of the wellfield to sustain this flow rate will diminish with time, as wells go out of service.

7.2 Proposed Activities for 1996

Implementation of wellfield rehabilitation is proposed for FY 1996. The proposed activities consist of the following:

- well assessment to determine pump emplacement and redevelopment options
- redevelopment of selected wells
- installation of up to 30 new pumps, motors, and electric controls to provide an total production capacity of 630 lps
- installing sand separators on selected pumps
- operator training
- development of an O&M manual
- preparation of a report on wellfield activities

Each of these activities is discussed below.

7.2.1 Well Assessment

Well assessment is required to determine pump emplacement and redevelopment options. Most of the wells that have operational pumps have already been assessed. However, most of the wells do not have operational pumps and will require a full assessment. To conduct the assessment, each well will be pumped with water levels, flow rates and sand contents monitored during pumping. For wells without operational pumps, a pump would be installed prior to assessment. Sounding of the well bottom will provide another important measurement. In cases where the pump is already in place, it may not be possible to measure the well depth without pulling the pump.

The general guidelines employed for establishing well and redevelopment options are as follows.

- Wells having moderate to low specific capacity will be considered for redevelopment activities. Redevelopment activities may include air lifting, swabbing, surging or over pumping, and chemical treatment. Wells having high specific capacity will not be considered for redevelopment
- Wells having discharge with sand content between 50 and 500 ppm will be fitted with pumps with sand separators. Well discharge containing more than 500 ppm of sand will be fitted with low flow pumps or considered for aban-

donment. The low flow pumps are designed to prevent the entrainment of sand in the discharge water, thereby protecting the pump.

- Wells that contain large amounts of accumulated sand will be cleaned out. If the sand can be removed, the well will be fitted with a pump. If it cannot be removed, it indicates that there is a failure in the well screen or casing and the well will be abandoned.

- High flow rate pumps will produce from 19 to 32 lps (300 to 500 gpm) and low flow rate pumps will produce from 8 to 10 lps (127 to 160 gpm)

- All wells fitted with new pumps will be disinfected with chlorine before being put into service.

7.2.2 Redevelopment

The purpose of well redevelopment is to improve the well yield and to eliminate the sanding problem. Well redevelopment activities at the Kosaman and Berdykol Wellfields fall into two categories: mechanical and chemical. The purpose of mechanical development is to improve well yield and reduce the volume of sand entering the well by agitating the formation to force fine sediments into the well, leaving the coarser grained sediments behind as a filter pack to prevent further sand flow into the well. Chemical redevelopment targets encrustation and biological growth that can clog the well screen and reduce well efficiency.

Mechanical redevelopment methods include air lifting, swabbing, surging and over pumping. Chemical redevelopment consists primarily in treating the wells with various types of acid. The methods that will actually be employed in full-scale wellfield rehabilitation activities is dependent on the availability of equipment and the condition of the wells.

Air lifting requires of the use of air compressors to provide lifting of water and sediments from the well. The air compressor must be capable of producing a volume of air of at least 17 m^3/min. (600 cfm) at a pressure of 10 atmosphere (150 psi). At least 250 meters of eductor pipe and 150 m of air pipe will be required to reach the bottom portion of the well to evacuate accumulated sediments from the bottom of the well.

Swabbing requires using a swab suspended from a cable attached to a crane or drill rig to agitate the well screen. The equipment used in September 1995, consisting of a crane and a chain attached to the crane line, provided marginal success during swabbing because the vertical movement of the crane's cable was too slow to provide optimal agitation in the screened interval.

The next phase of development would require a crane capable of at least 250 meters of lift and a higher lift speed than the crane used in September 1995. This means the crane cannot have a block-and-tackle assembly, such as used by the crane used in September 1995. If sediments accumulate to thicknesses in excess of 5 to 10 meters as a result of development, they will need to be removed from the well. Sediments may be removed by air lifting or bailing. Surging or over pumping can provide an effective means to develop the well. By starting and stopping the pump, the well screen area is developed by flow into the well during pumping, and flow out into the formation as water in the pump column falls into the well when the pump is turned off. This method can be employed easily using oversized pumps and high pumping rates.

Chemical development methods would primarily consist of treatment for iron bacteria and other biological clogging mechanisms. Only wells having low specific capacities (<1 lps/m) and low sand contents (<50 ppm) would be candidates for chemical treatment (see Figure 4, Appendix A). The need to clear the well screen of mineral encrustation does not seem relevant due to the overall corrosive character of the groundwater and the values of the Langelier and Ryznar Stability Index.

7.2.3 Pump Emplacement

Wells suitable for pump emplacement will be evaluated based on the sand content of pumped water, as outlined above, and the level of accumulated sand in the well. If sand content is above the manufacturer's recommended level of 50 ppm, the pumps are subject to excessive wear due to abrasion. At the same time, if sand levels are at, or above, the top of the well screen (i.e., at, or above, a depth of about 185 meters bgs), the well may not be suitable for emplacement of a pump without clearing the sand from the screened section. If the sand cannot be cleared from the screen section, the well will likely have to be abandoned.

The design flow rate of 630 lps from Kosaman and Berdykol Wellfields can be achieved by about 30 new pumps producing an average flow rate of 21 lps each. Based on the current understanding of wellfield conditions, this flow rate is achievable; however, not all the wells will be fitted with the same size pumps. Some wells are not capable of producing 21 lps without entrainment of sand, and some wells are probably capable of producing much more than 21 lps.

The size of the pump placed in each well will be determined by considering the sand content well discharge, the specific capacity, and the volume of sand accumulated within the screened interval. Figure 4 (Appendix A) shows the rationale for what size pump will be emplaced in wells under various conditions.

In general , it is recommended that pumps, capable of producing flow rates of about 8 to 10 lps, be provided for emplacement in wells that produce high sand content and pumps capable of producing 30 to 32 lps be provided for emplacement in wells that have high specific capacity (>2 lps/m) and low sand content (i.e., <50 ppm). TDH requirements for the pumps producing higher or lower flow rates will be considered in final pump specifications.

New electric panels and cables should be provided with each new pump. Photo 7 in Attachment 1 shows the new control panel installed for Well 26. The existing control panels and cable are incompatible with the new equipment. Pump house conditions should be restored using GOK labors to protect the investment of new hardware.

7.2.4 Sand Separators and Well Screens

When wells have moderate or high production of sand, there are two major alternatives to abandonment: retrofitting pumps with sand separators or and retrofitting well screened sections with new screens. Each of these alternatives are described below.

Submergible sand separators for pumps may be employed to prevent sand flow into pumps for wells having moderate sand contents (i.e., greater than 50 ppm and less than 500 ppm). Separations do not prevent sand accumulation in the well. Sand separators use centrifugal force to remove sand from the water before it reaches the pump intake After the sand is removed, it falls to the bottom of the well. Reportedly, the wells seldom fill up because as sand accumulates, flow pathways to the well develop, which disperses the energy that originally brought sand into the well. If the sand content is over 500 ppm, and the level of accumulation in the well is high (i.e., approaching the top of the well screen section), it is suspected that the well may have more serious problems, such as holes or gaps in the well screen. In these cases, the well may have to be abandoned.

The sanding problem may be eliminated by installing new, smaller screens into the existing screens. Both standard and prepared screens could be used. Pre-packed filter screens are made of two steel or polyvinyl chloride (PVC) screens, one smaller than the other, with filter pack placed between the two screens. These would be placed inside the existing screened section and would serve to filter out sand entering the well. Standard screens, without prepacking, may be used as well. Well redeveloping would be required after new screen installation.

7.2.5 Operations Manual

At the conclusion of wellfield activities, an O&M Manual will be prepared. The purpose of the manual is to provide local wellfield personnel with operational guidance in foreseeable circumstances. The circumstances that should be provided for include:

- operation strategies during peak and low-demand periods
- maintenance routines to provide optimal pump and motor longevity
- engineering specification and diagrams for all hardware

Operation strategies would include optimization of well flow distributions to avoid development of excessive drawdowns and electrical current demand. These strategies would take into account conditions at the time of implementation and potential future conditions.

Maintenance routines would include practices that will provide optimal pump and motor longevity. These routines would take into account conditions at the time of implementation and potential future conditions. Since the present pumping capacity appears to exceed the transmission pipeline capacity by about 300 percent, special care would be taken to design simple pumping schedules to rotate the use of each pump to optimize pump longevity.

Engineering specifications and diagrams would be included in the O&M Manual to give engineers providing oversight at the wellfield all the material necessary to make decisions. The manual will be written in English, translated into Russian and provided to local wellfield staff as well as other involved individuals and agencies.

7.2.6 Report of Wellfield Activities

Following completion of wellfield activities and once personnel have returned from Kazakstan, a report will be prepared for submittal to USAID and the GOK. The report will provide details of the activities, the conditions observed at the wellfield, and an inventory of the installed hardware. The report will be prepared in English and translated into Russian.

7.3 Schedule

The performance of the above recommended activities would require approximately 3 to 4 months of field work. This assumes two crews and two sets of installation/development equipment would be operating simultaneously to set pumps and perform redevelopment, as needed. This also assumes the GOK would provide skilled laborers to assist with the activities. It is anticipated field activities would begin as the weather becomes suitable (i.e., about the end of April to early May 1996). The proposed schedule of wellfield activities is presented in Figure 5 (Appendix A). A more detailed schedule and list of activities will be presented prior to mobilization.

Attachment 1 to Appendix C

Photos 1 through 11 - Pumphouses

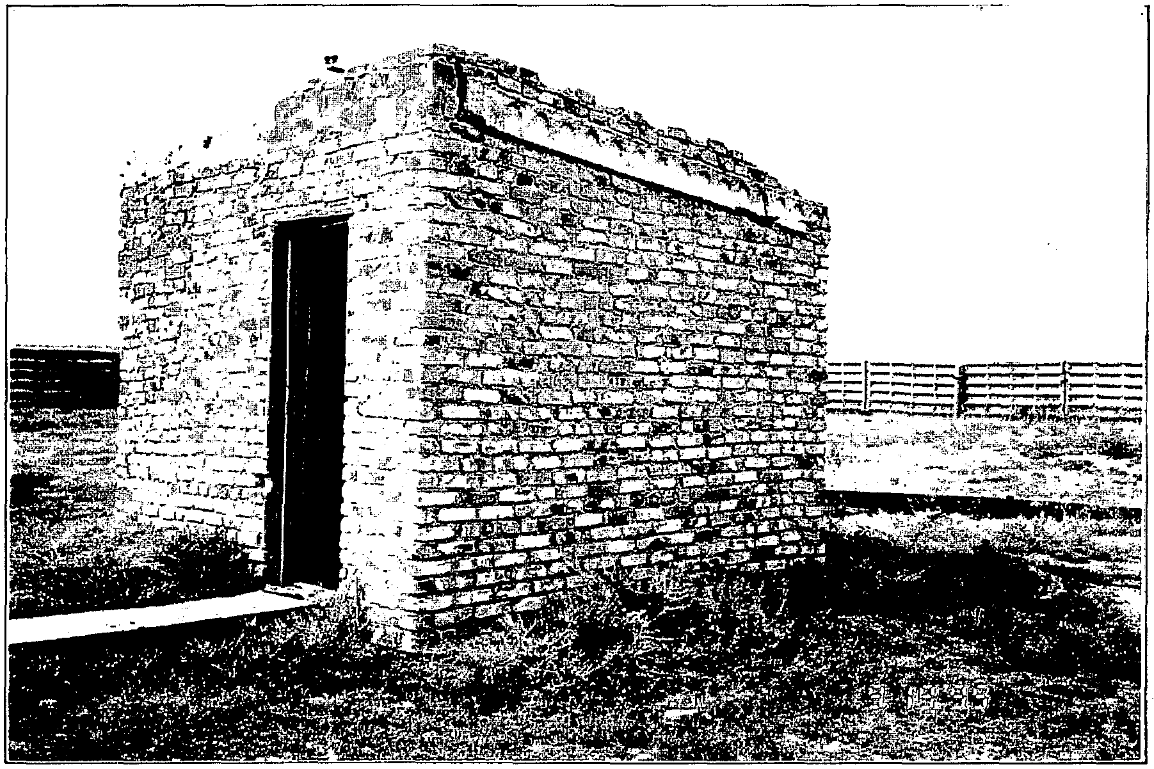


Photo 1. *Pumphouse construction of brick and mortar, typical of Wells 13 to 17 and 21 to 22. Constructed from 1985 to 1987.*

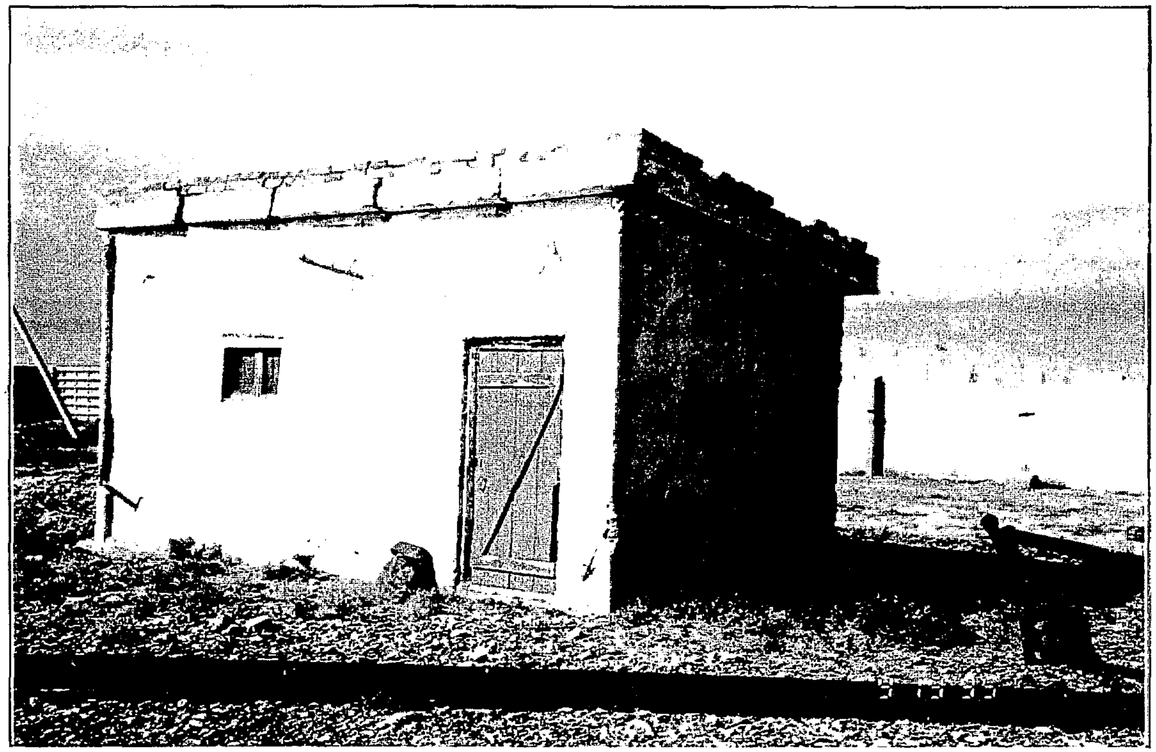


Photo 2. *Pumphouse construction of brick and mortar, covered by concrete plaster, typical of Wells 18 to 20. Constructed from 1985 to 1987.*

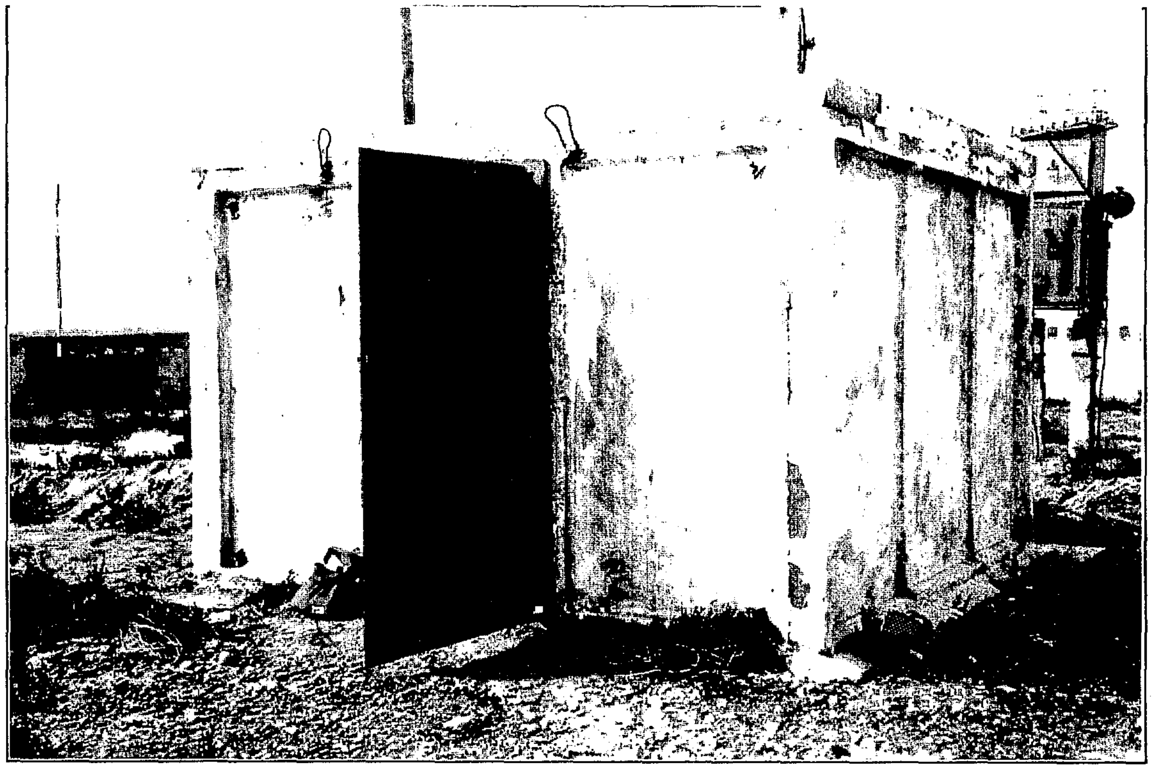


Photo 3. *Pumphouse construction of pre-cast concrete, typical of Wells 1 to 12 and 23 to 30. Constructed from 1990 to 1992.*

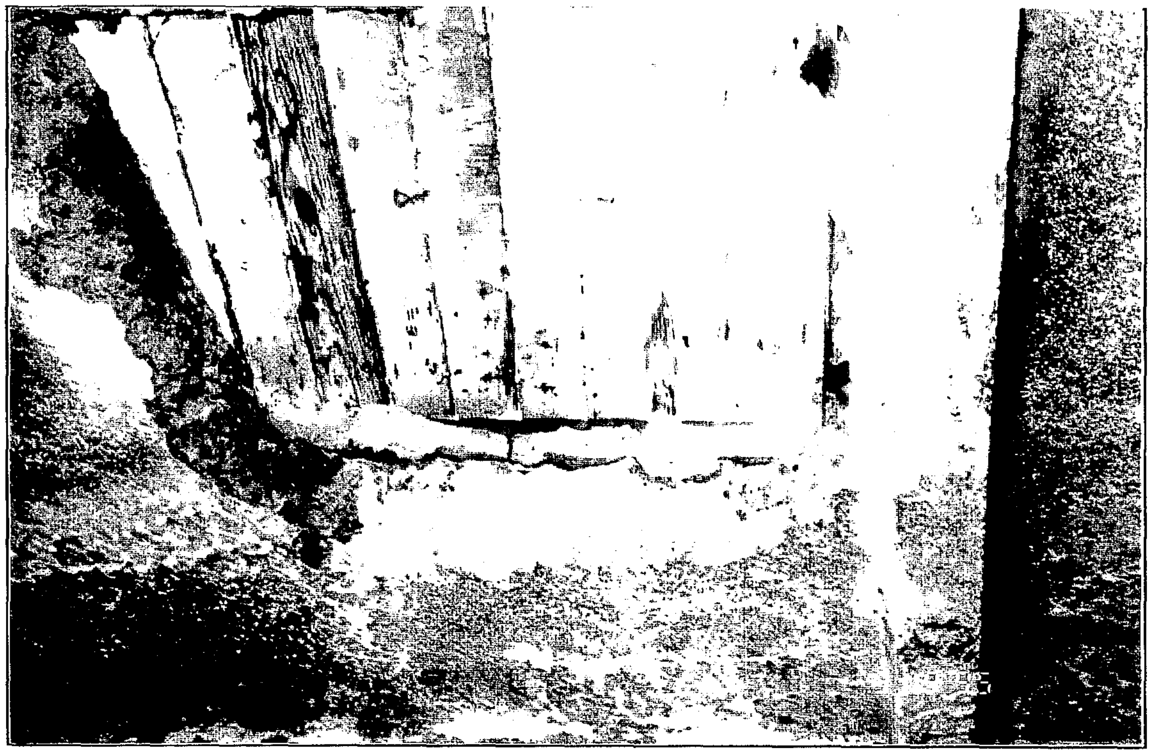


Photo 4. *Typical top-hatch of pumphouses located directly above wells. Dimensions are approximtely 2 feet by 2 feet.*

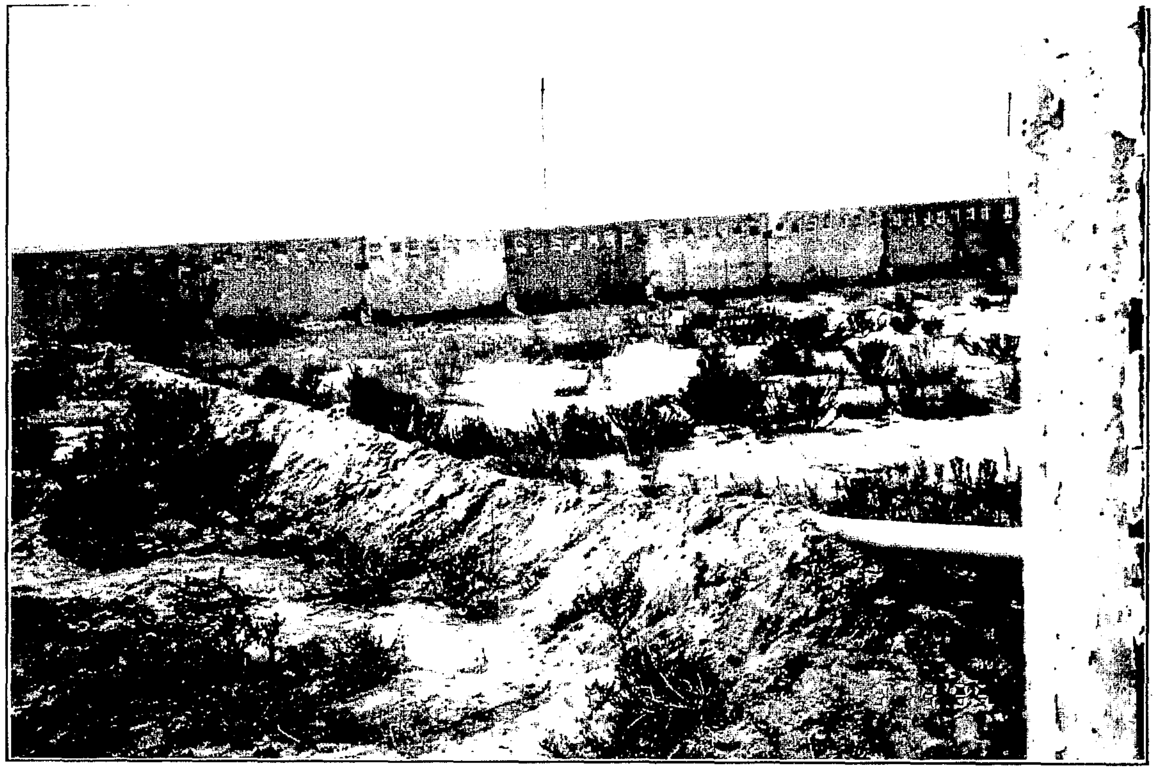


Photo 5. ***Waste water discharge line leading from pumphouse. Discharge is onto ground surface on opposite side of concrete wall in background.***

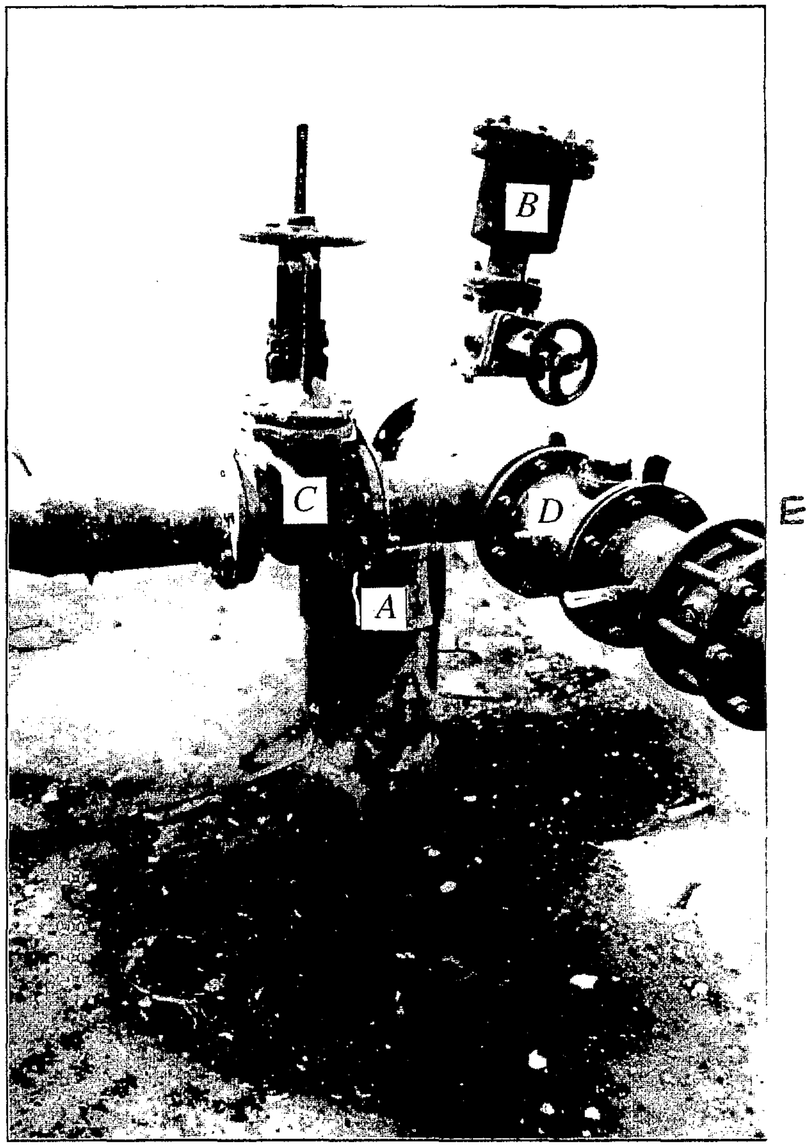


Photo 6. *A.= well casing*
B.= blow-off valve
C.= valve to discharge line
~~*D.= check valve*~~ → FLO

E= CHECK VALVE

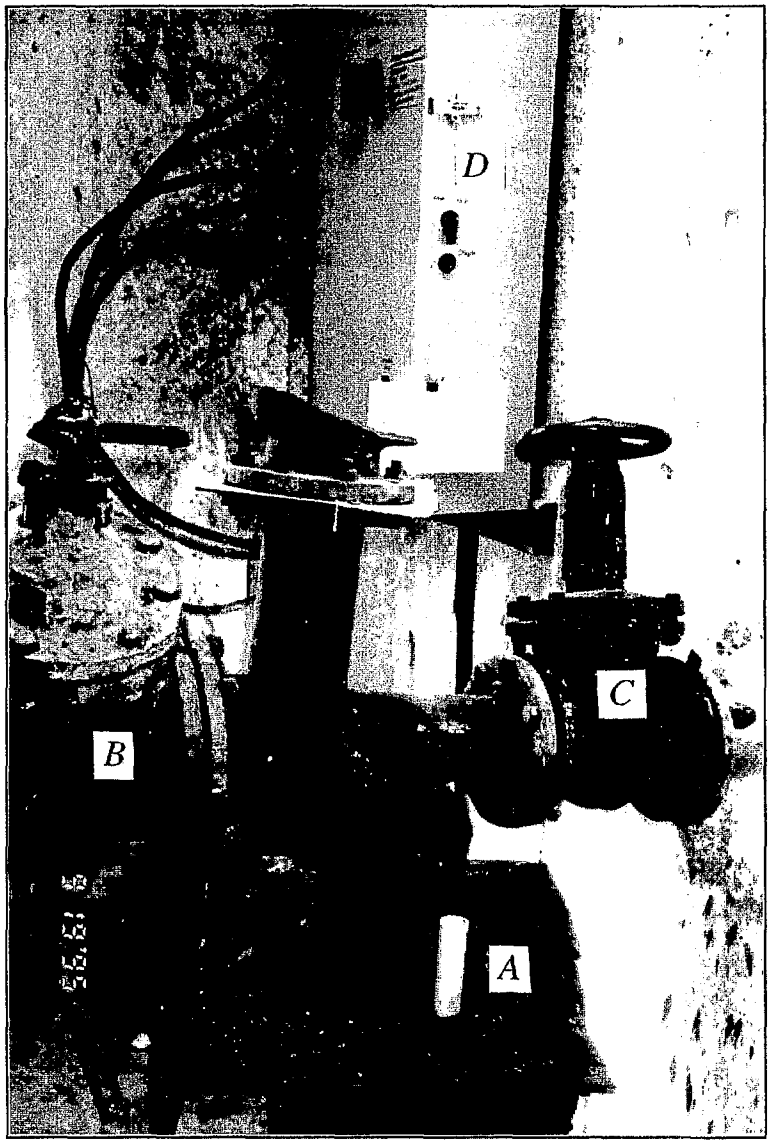


Photo 7. *A.= well plate*
B.= valve to system
C.= valve to discharge line
D.= electric panel

Photo 8. *Well 30 showing collapsed floor surounding well casing.*

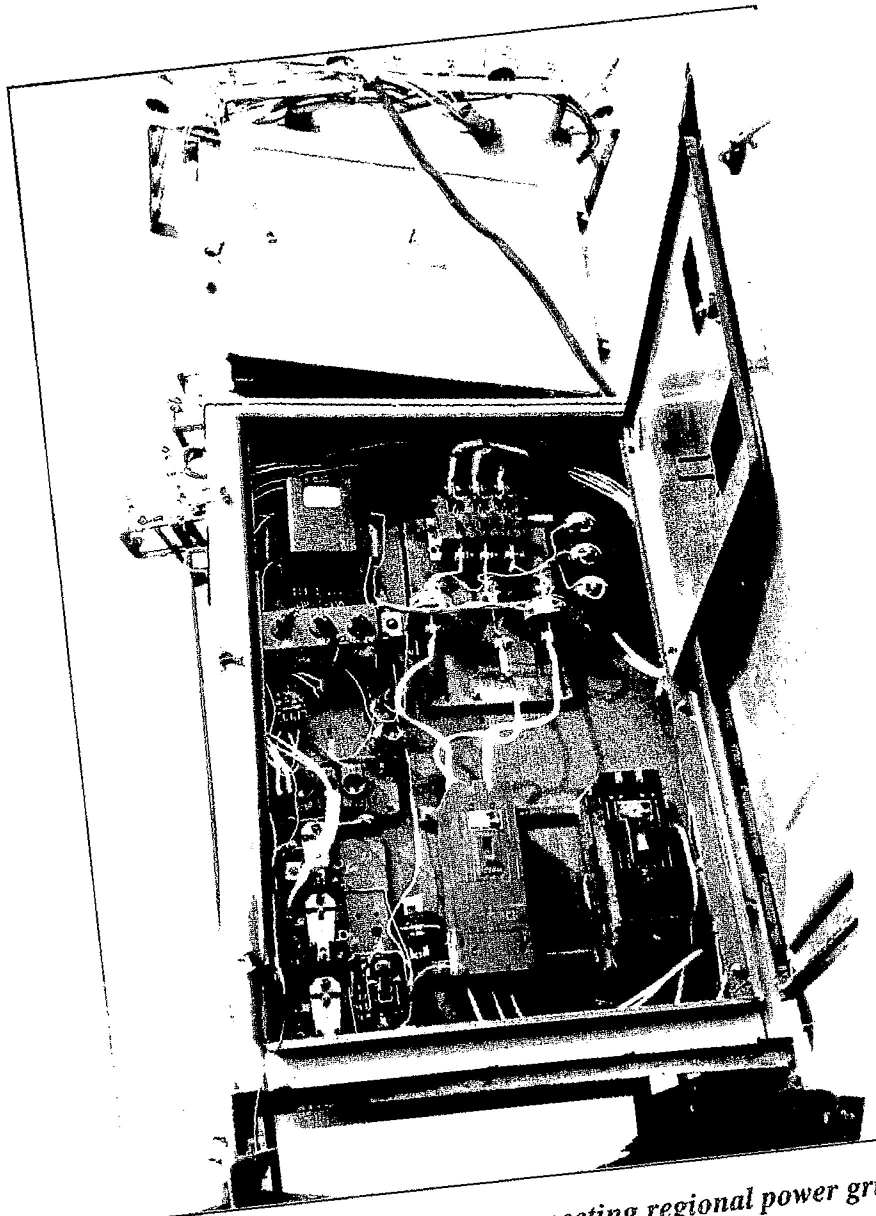


Photo 9. ***Electric transformer connecting regional power grid to pump control panel at well.***

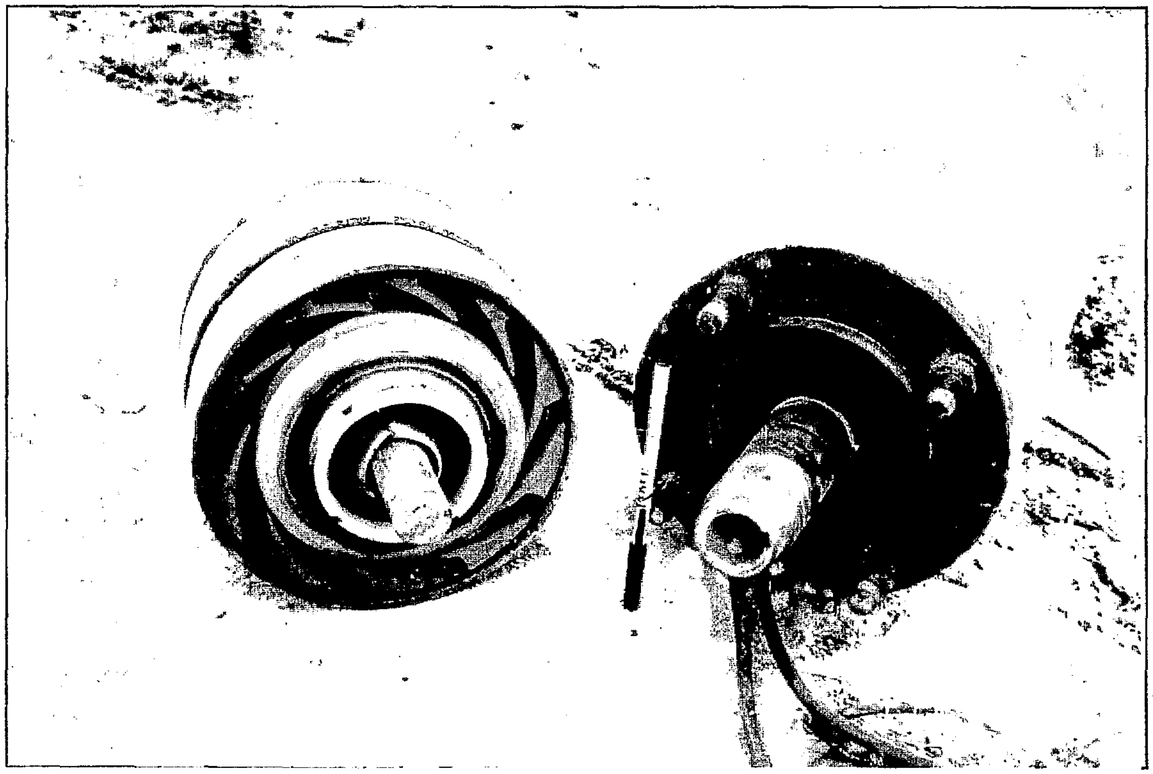


Photo 10. *Typical well pump and motor. Three of the five stages of the pump are shown.*
Note plastic pump interior.
Motor failure occurred less than 1 year after installation.

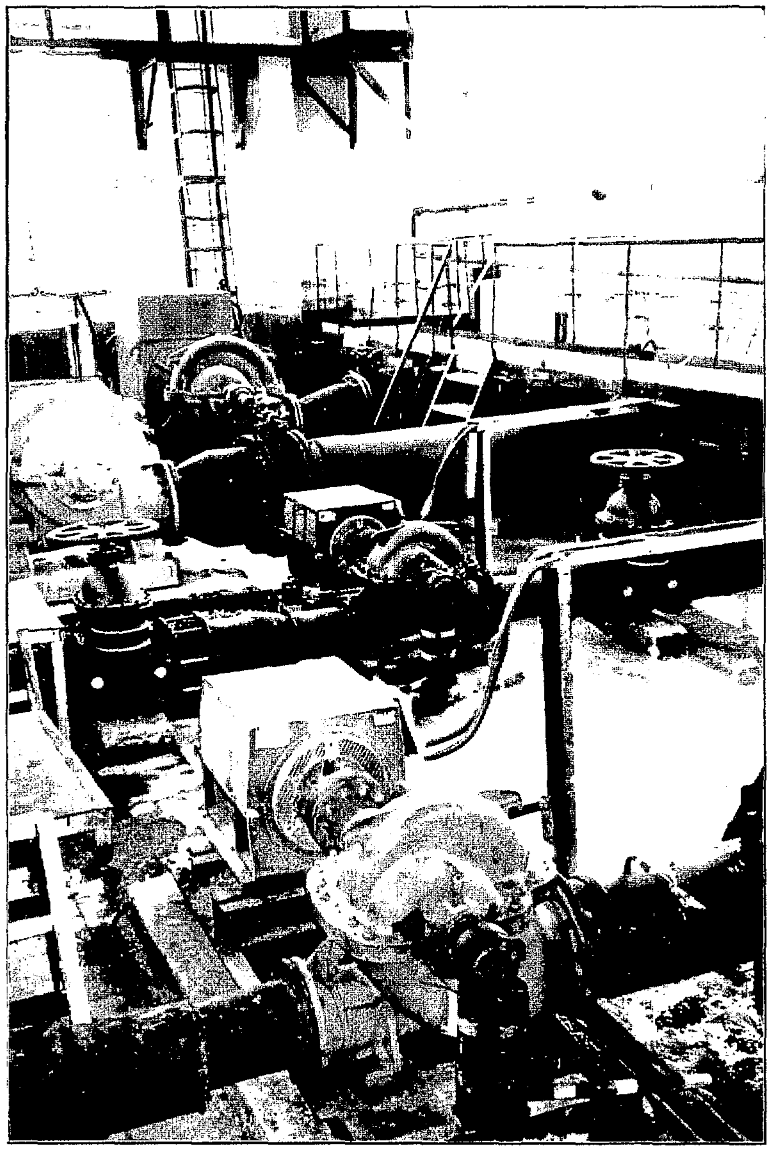
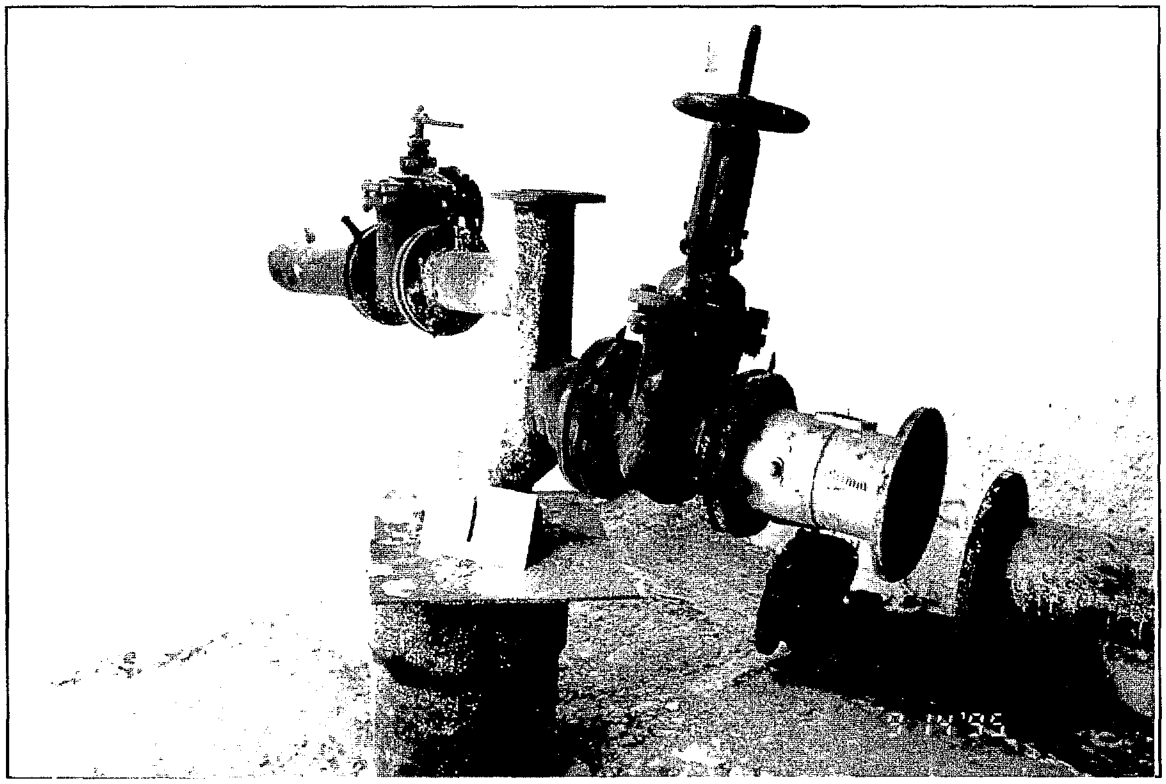


Photo 11. *Pump Station Number 1 showing federal transmission pipeline pumps.*

Attachment 2 to Appendix C

Photo Log of Wellheads 1 through 30 at Kosaman Wellfield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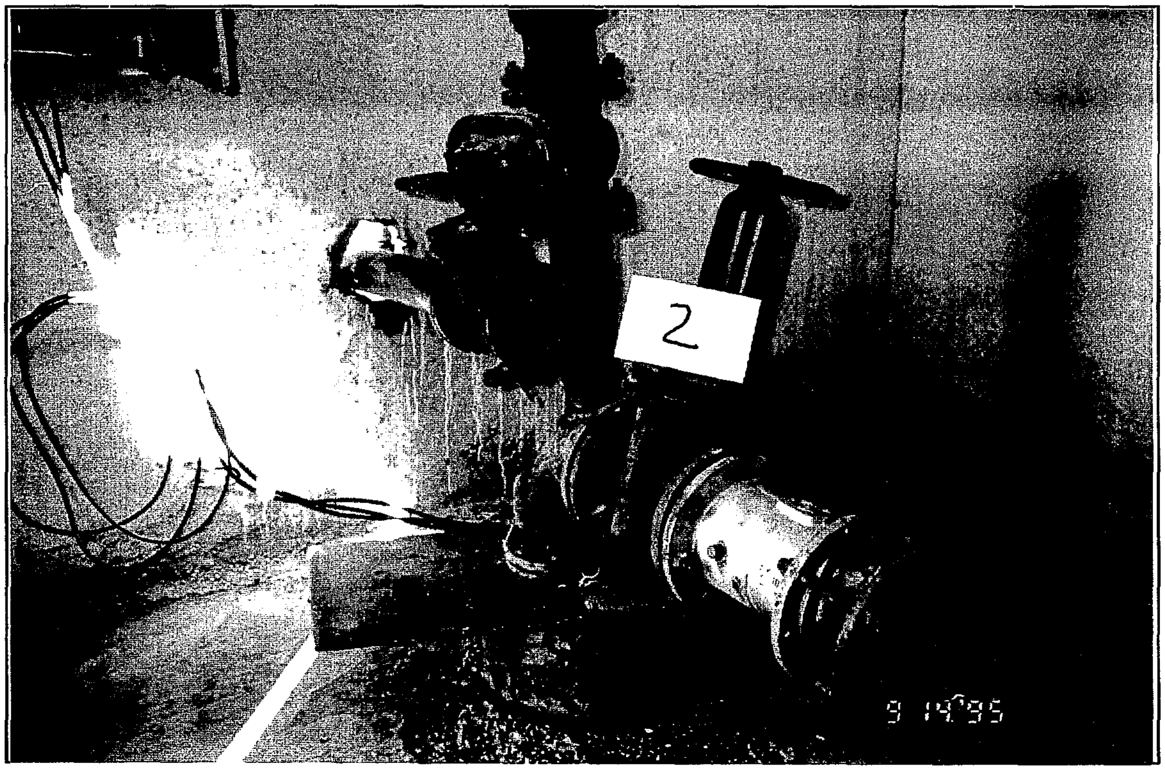
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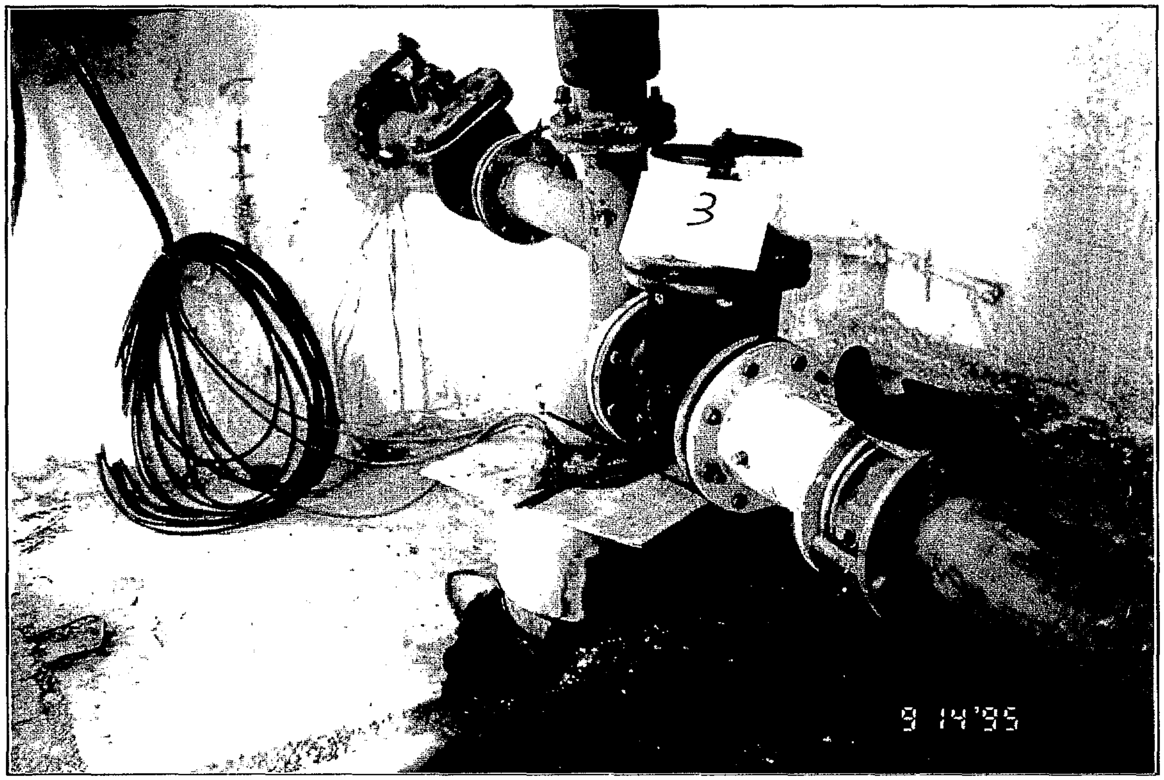
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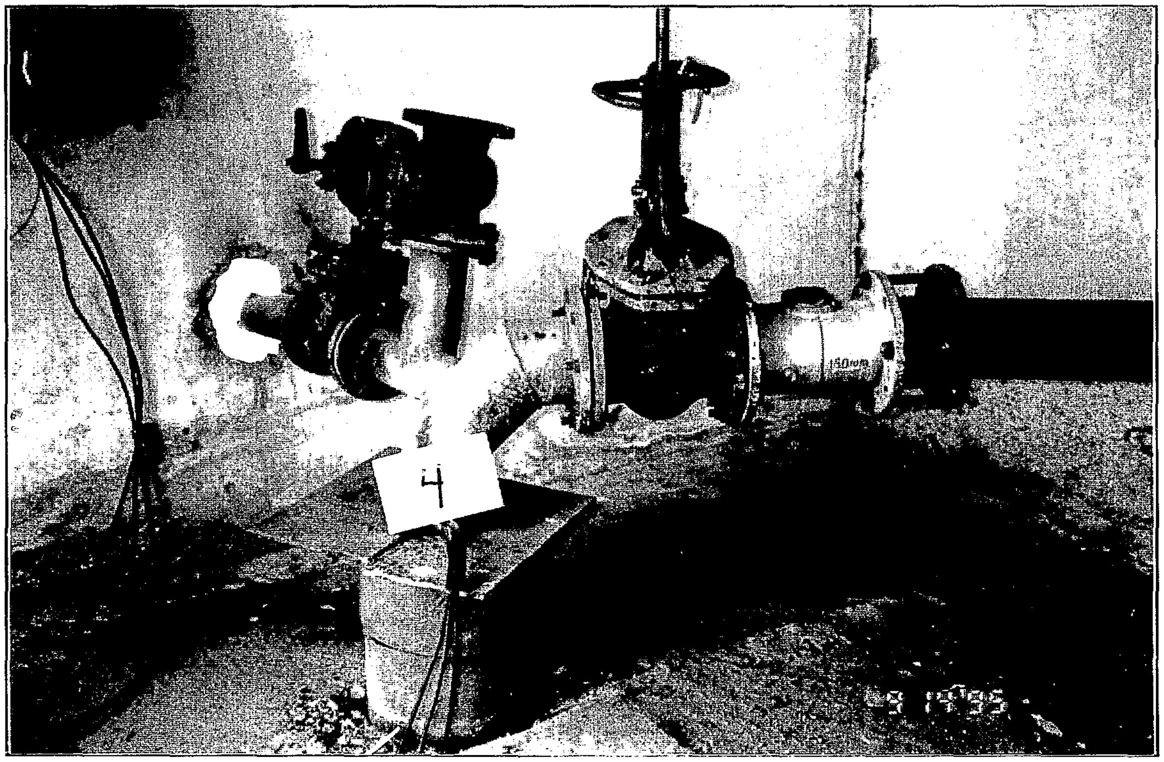
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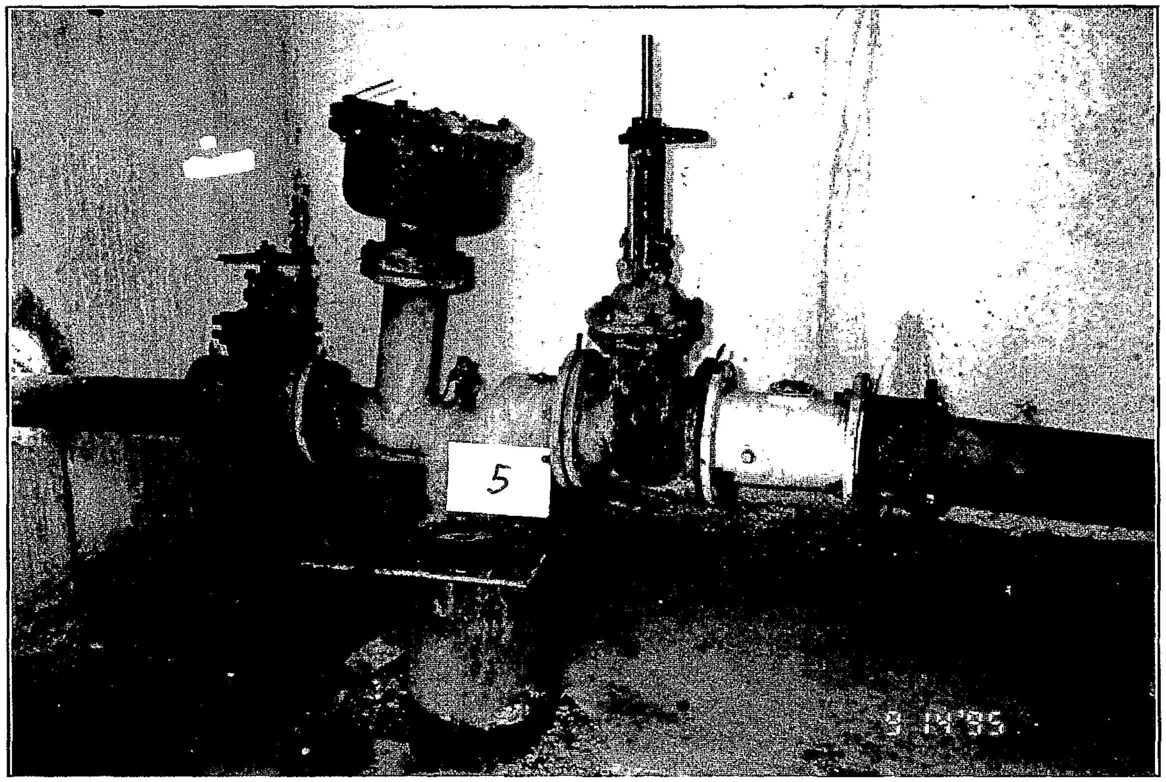
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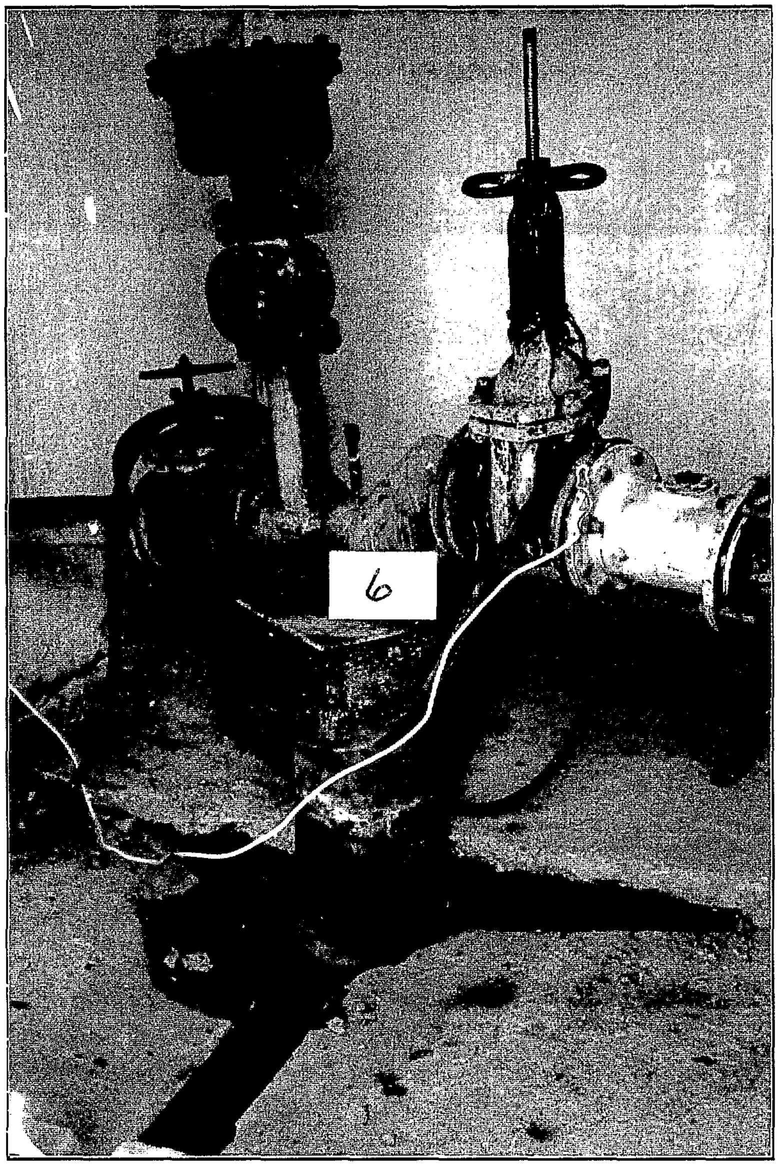
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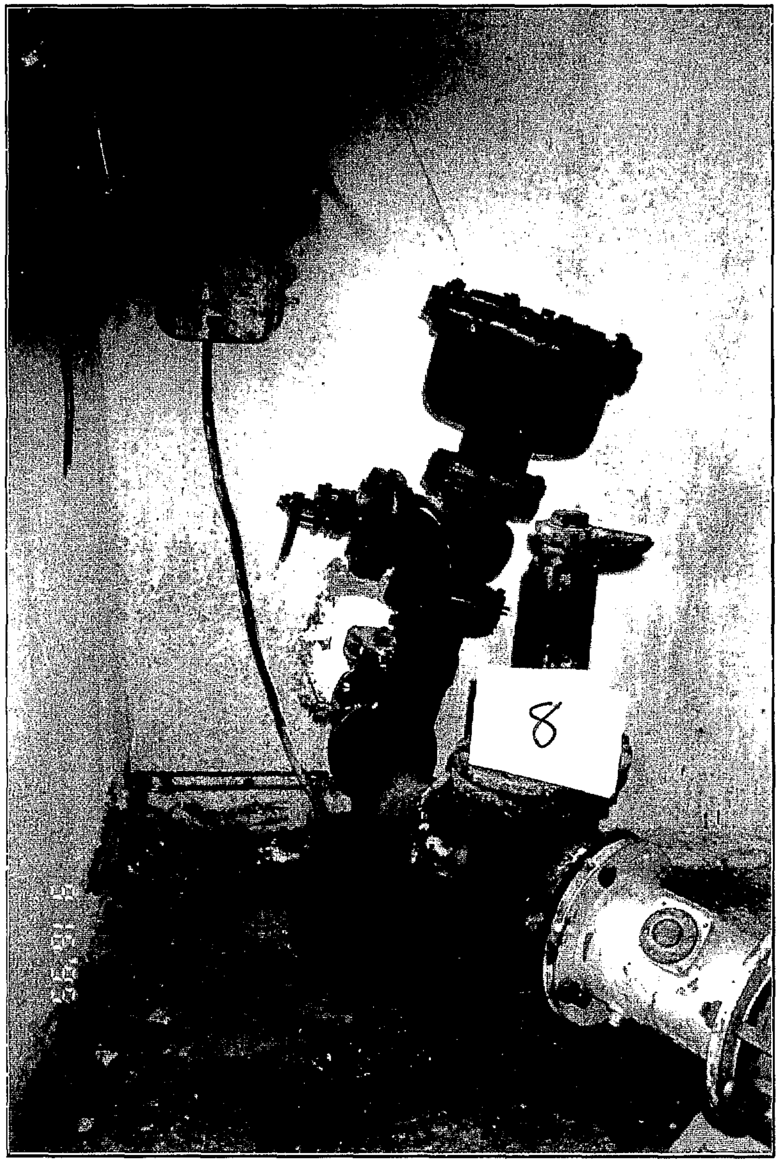
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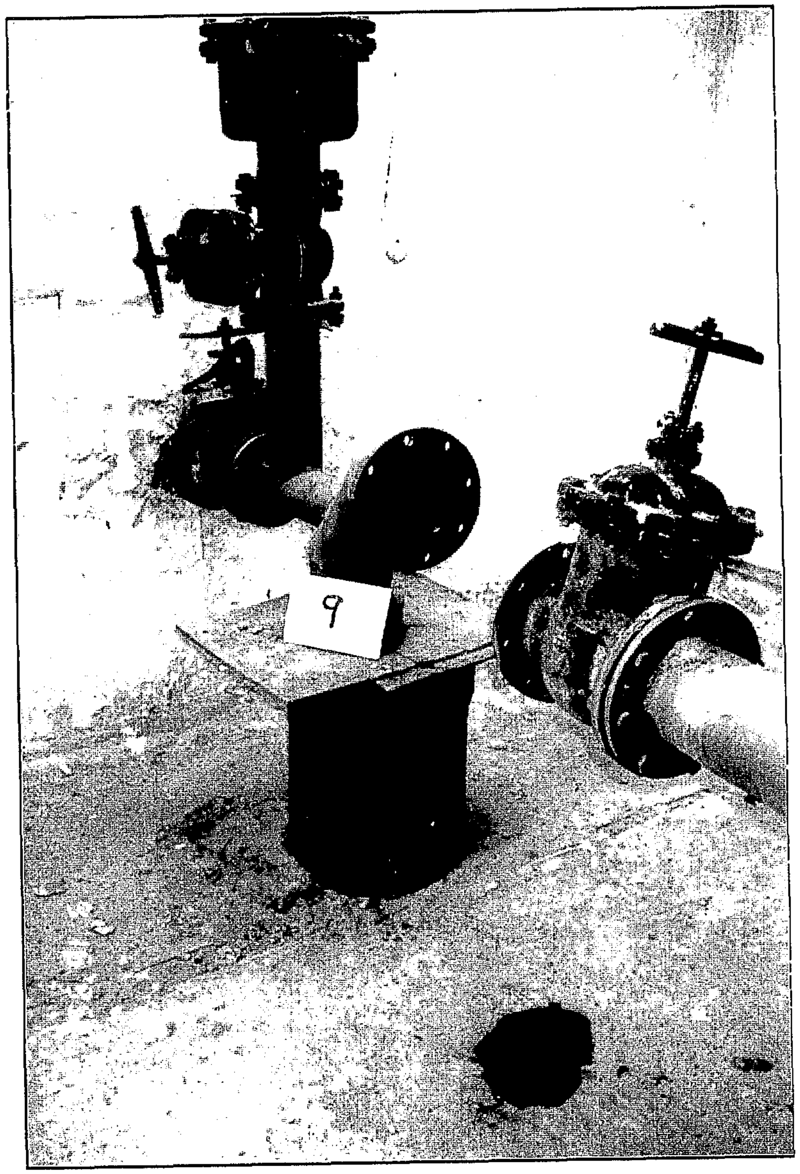
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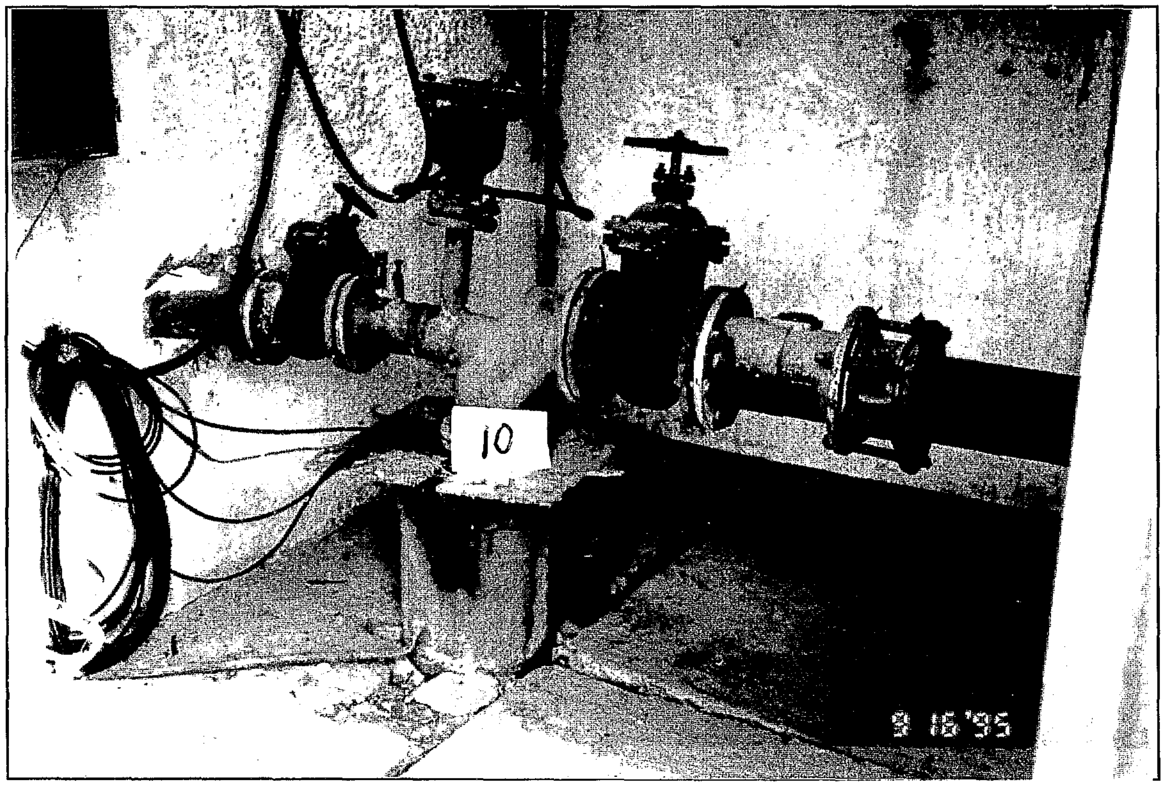
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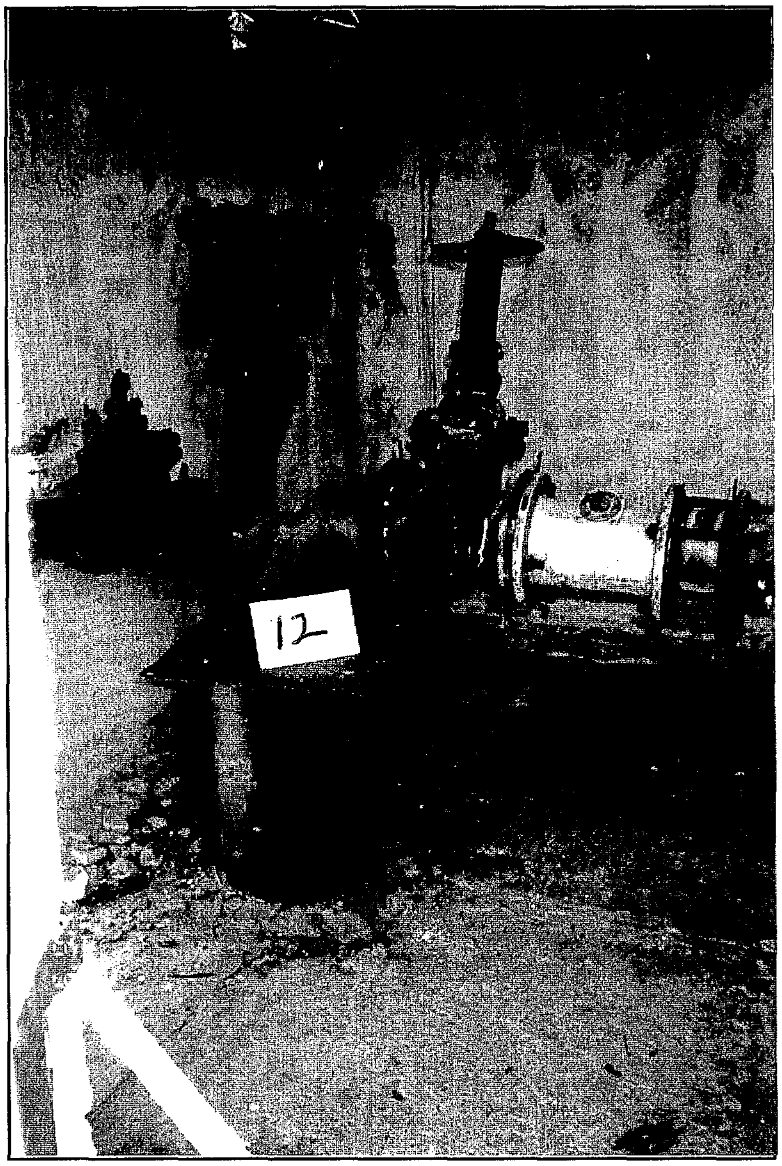

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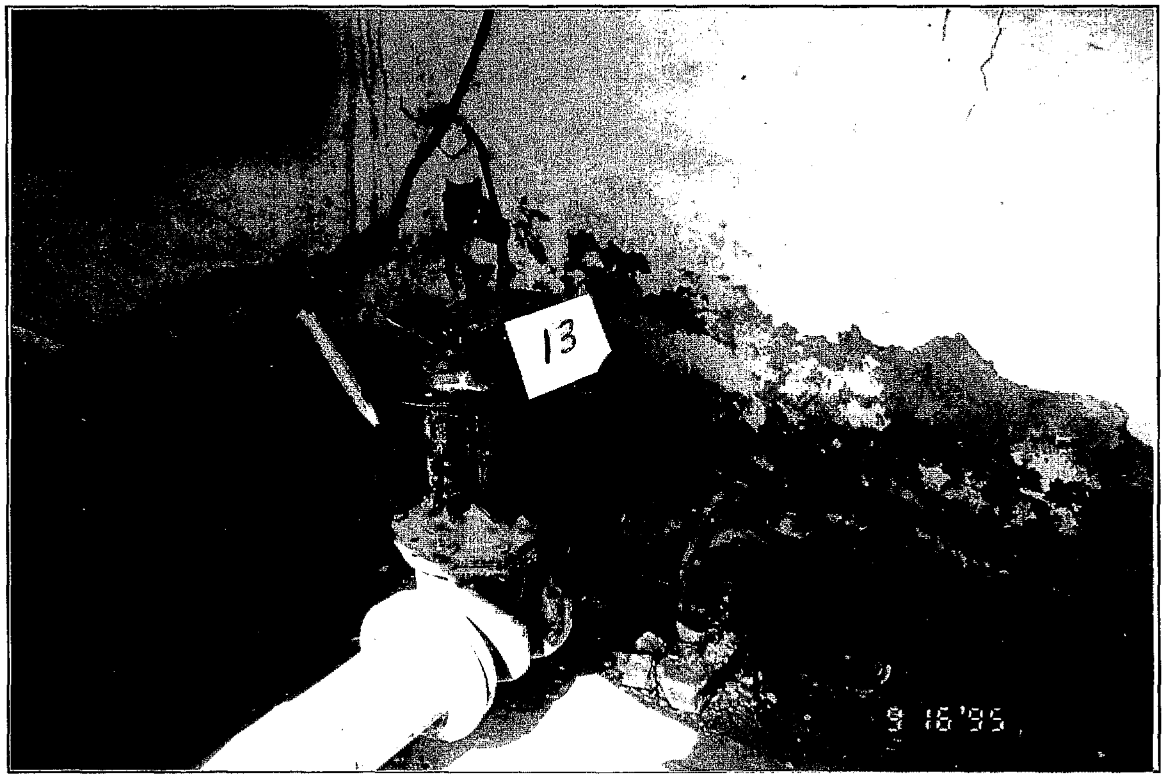
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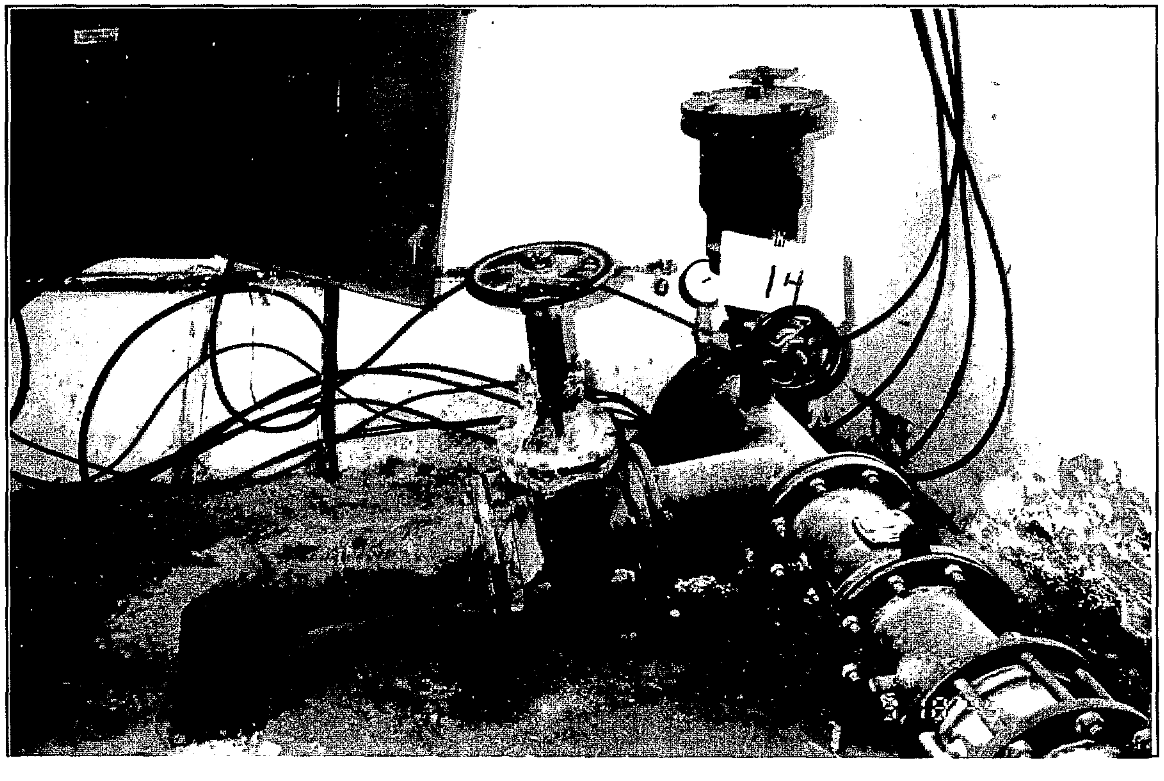
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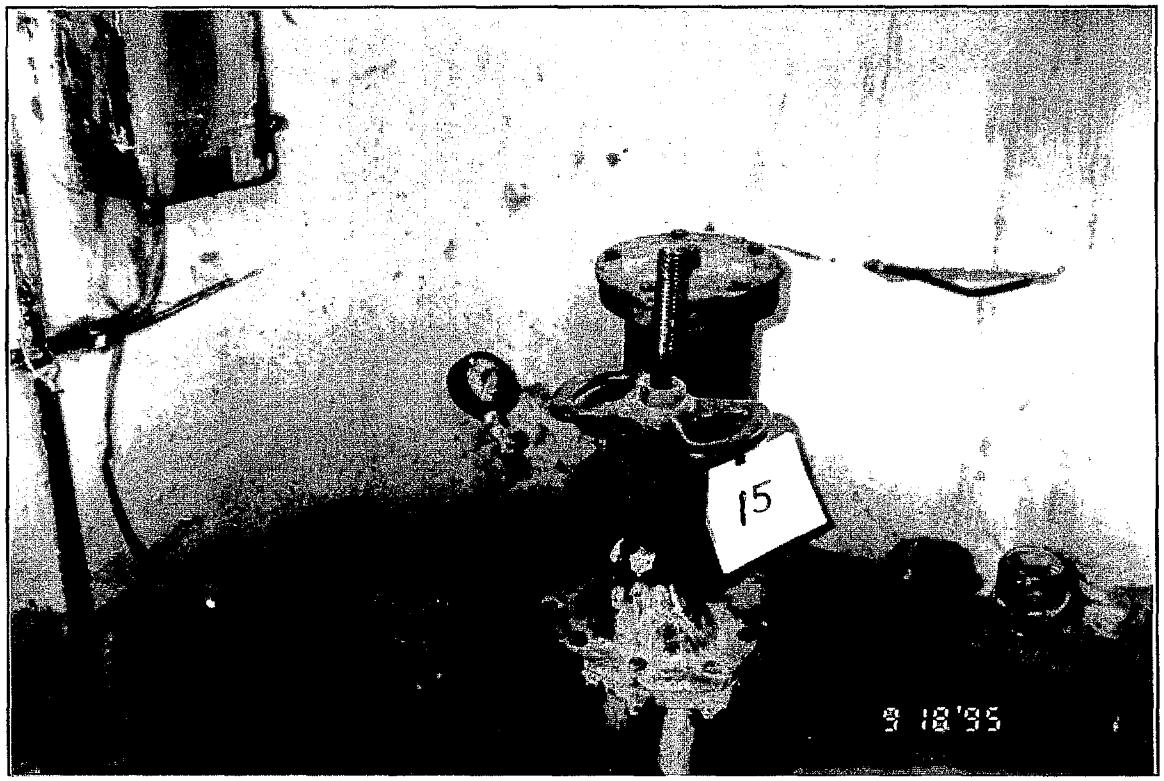
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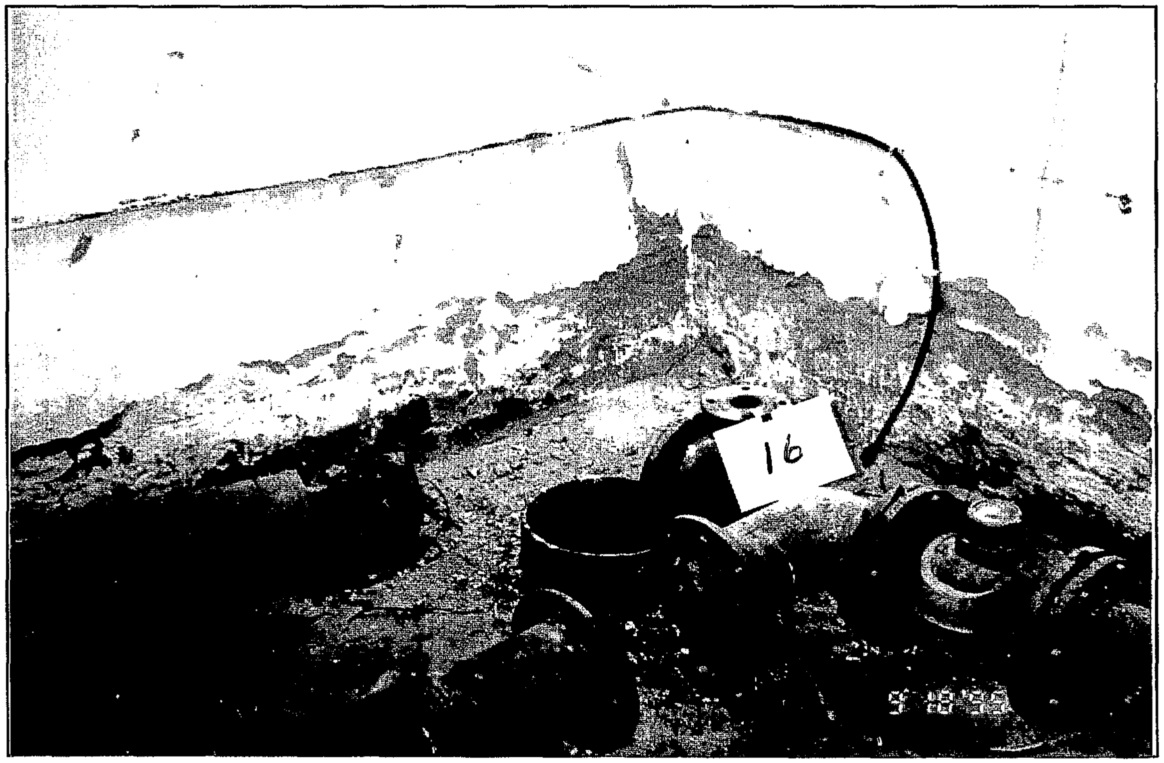
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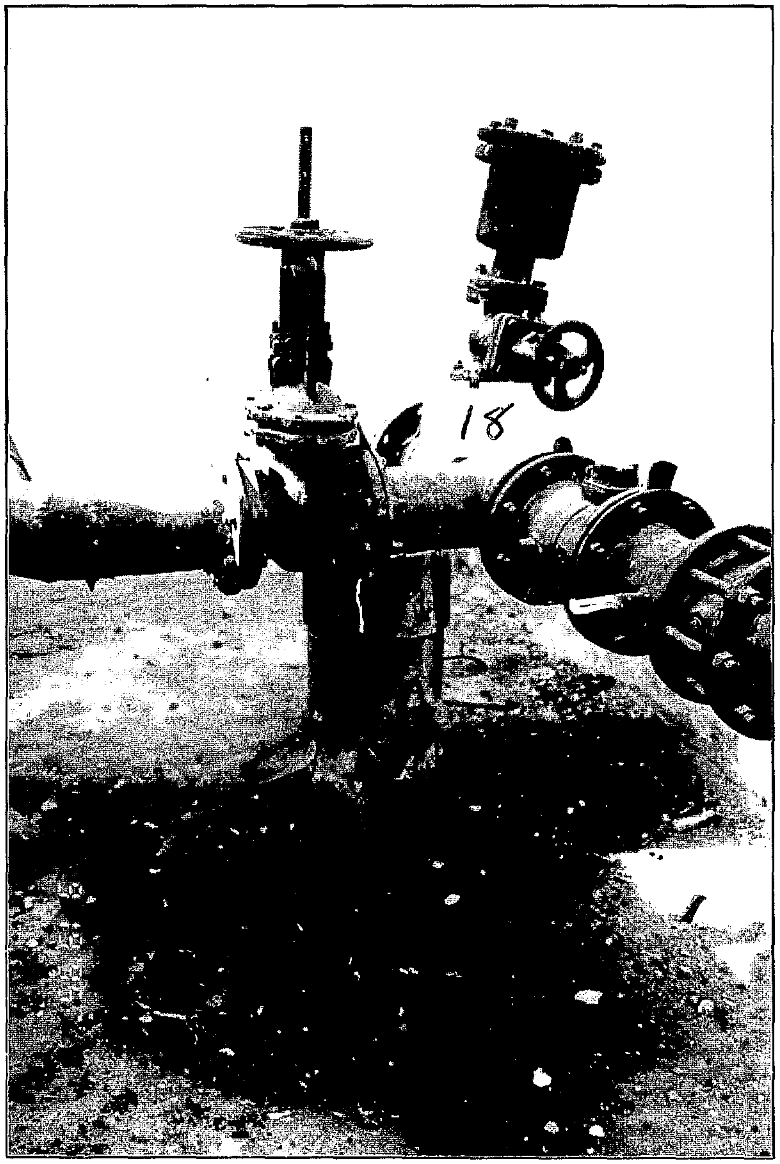
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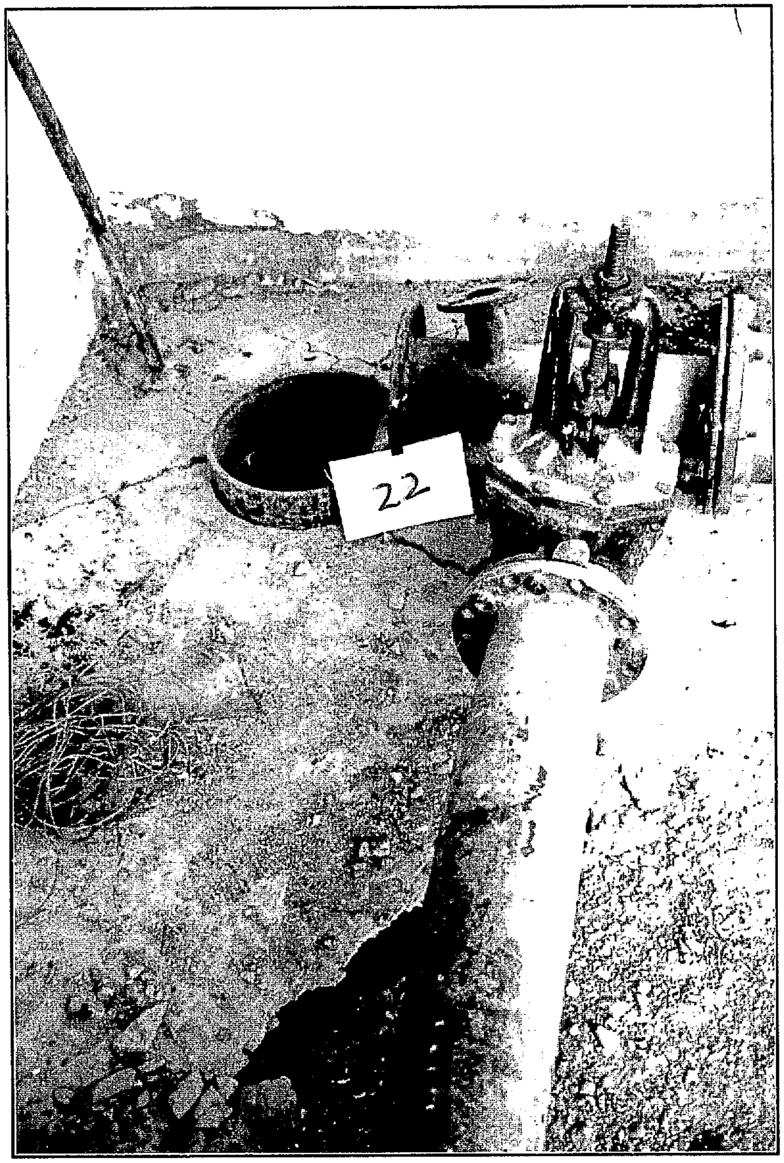
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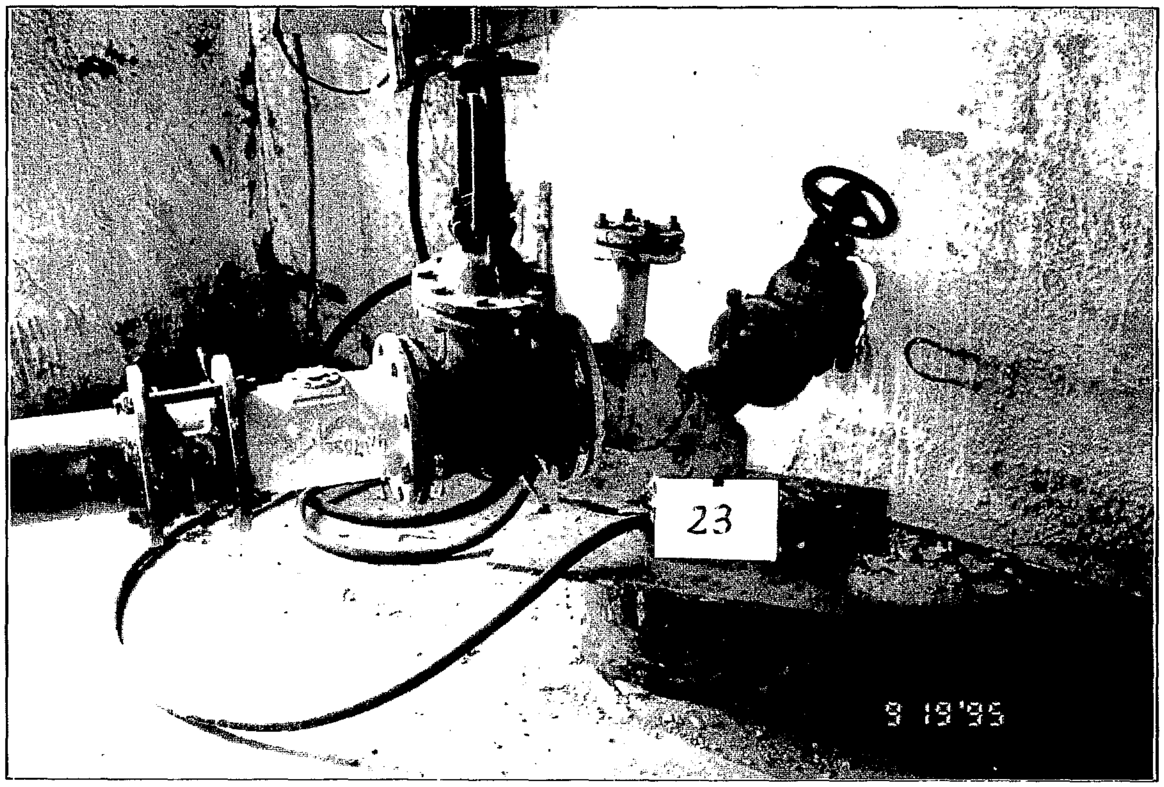
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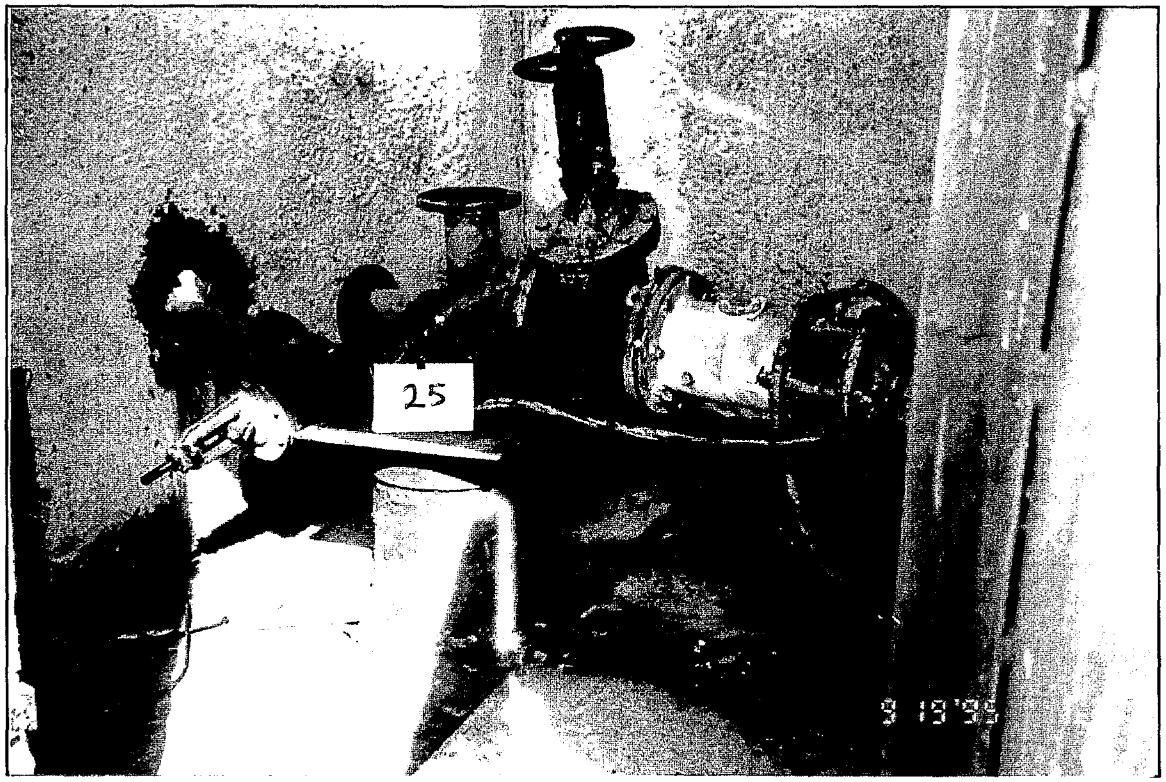

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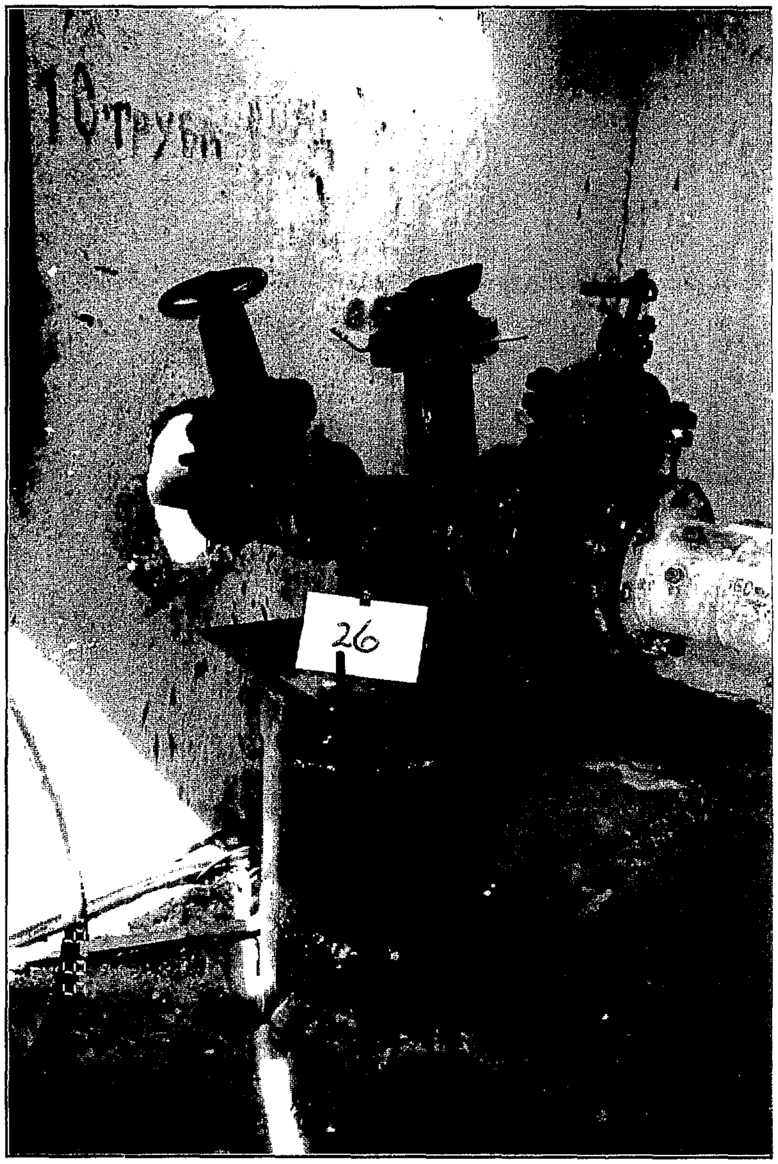
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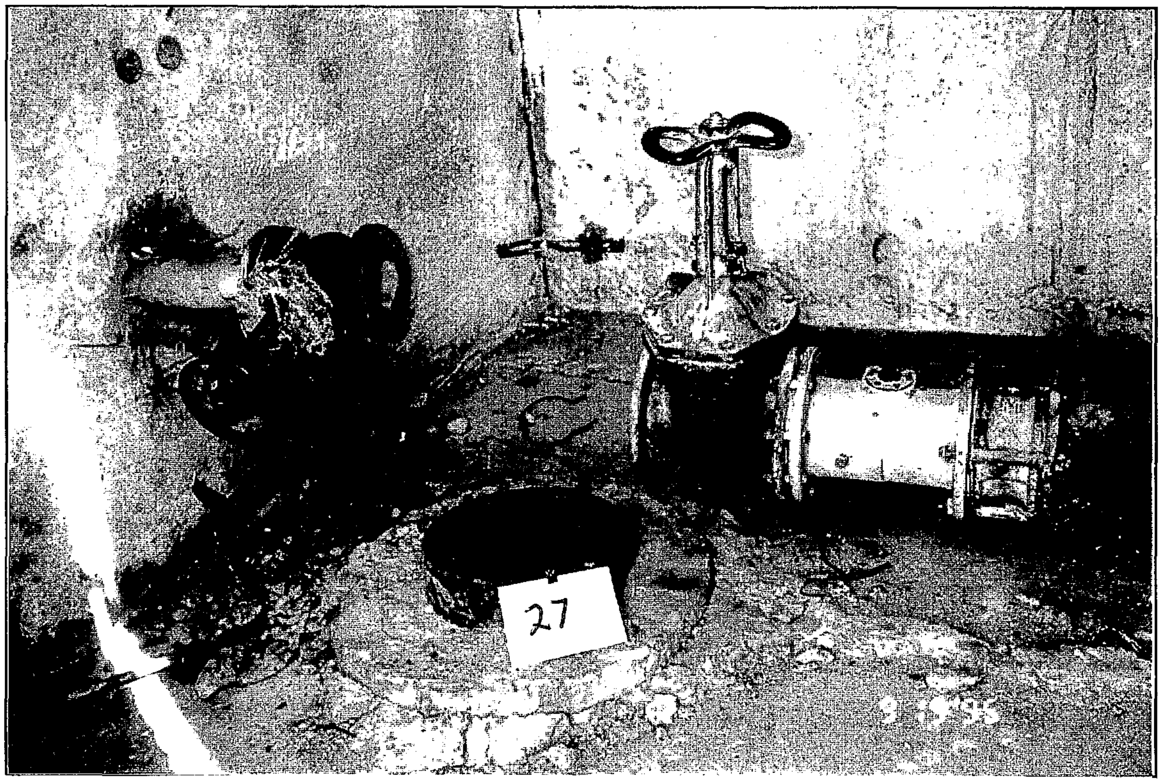
27


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Attachment 3 to Appendix C

Technical Specifications of Pumps, Motors and Control Panels Installed in September 1995

BEST AVAILABLE DOCUMENT

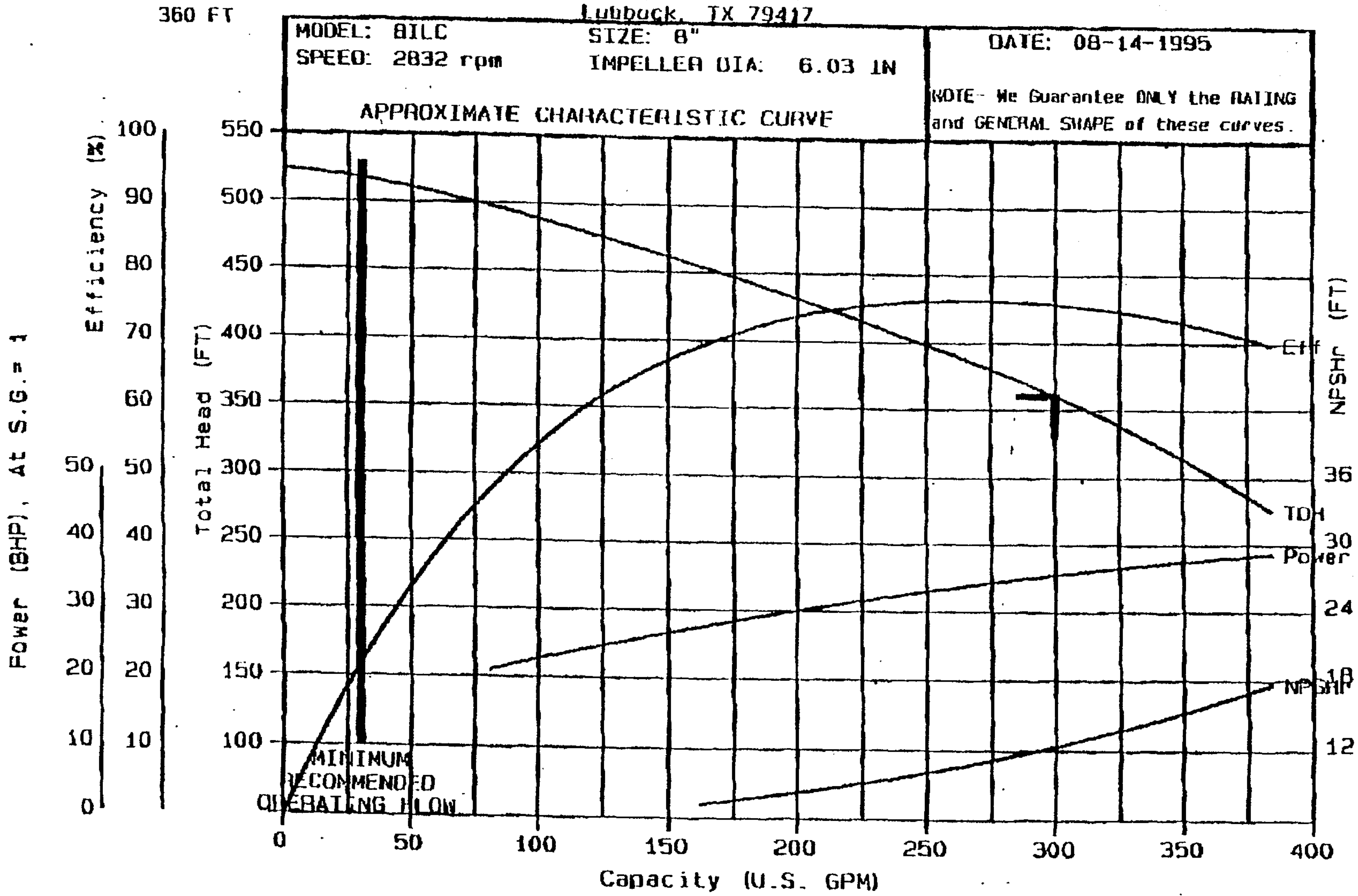
FOR: GOULUS PUMPS INC.

GOULDS PUMPS INC

CURVE NO: 123123

RATING: 300 GPM
360 FT

WTG Turbine Div
Lubbock, TX 79417



89

Y92-15-9

Date: 9/ 9/92
Supersedes: NEW

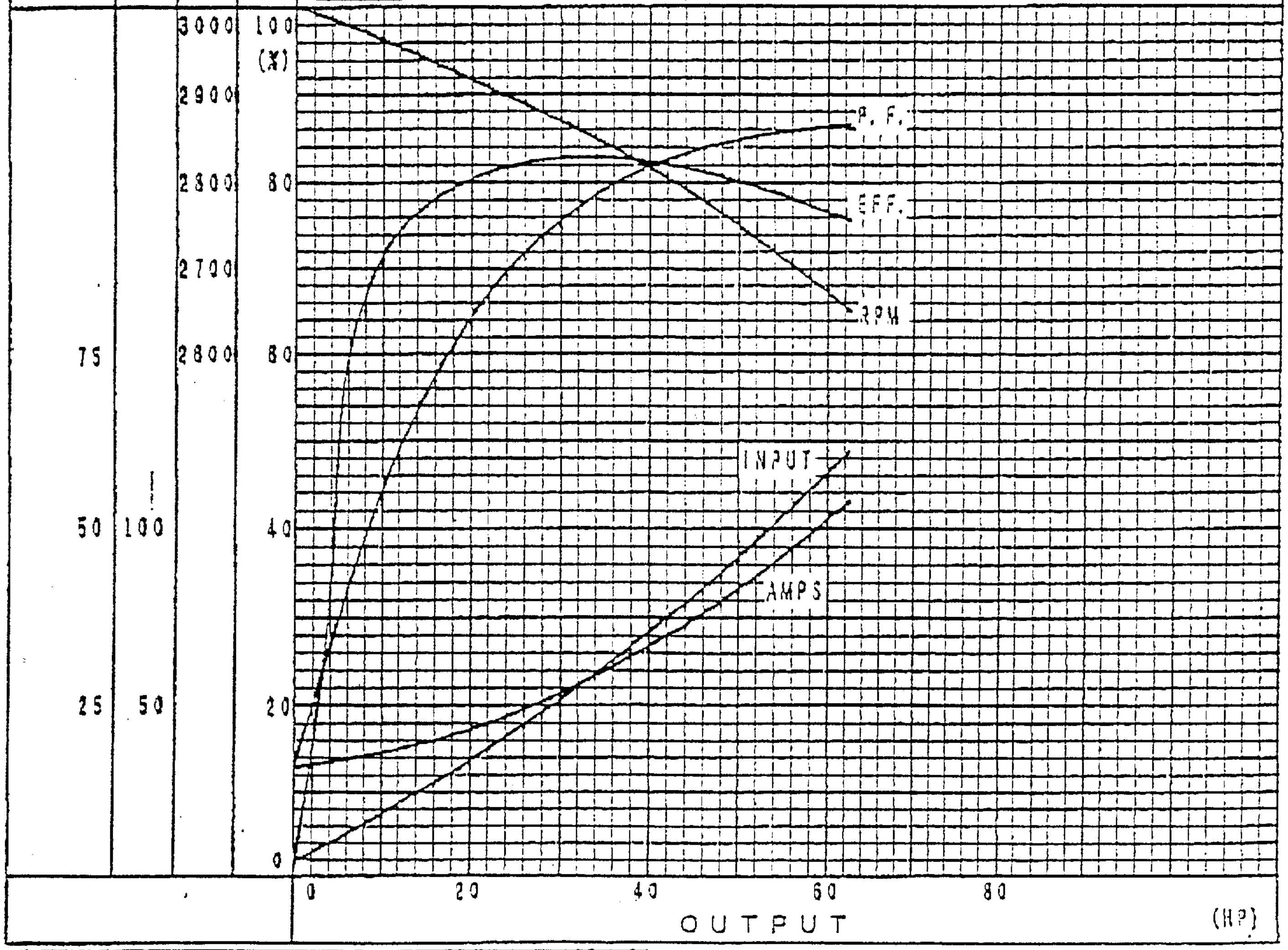
6" SUBMERSIBLE MOTOR PERFORMANCE CHARACTERISTICS

50HP
3000RPM

CAN-EPOXY Type | 50 HP | 3000 RPM

3 Phase | 380 Volt | 50 Cycle

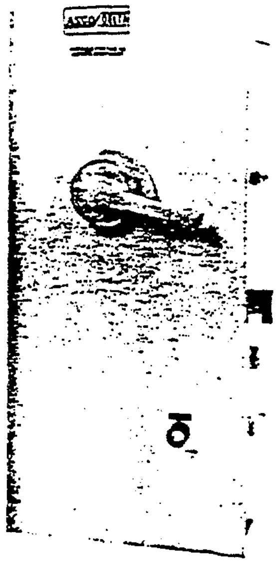
1.0 S.F. | 25℃(77°F) Max. Amb. Water | 10000 lbs Thrust Load



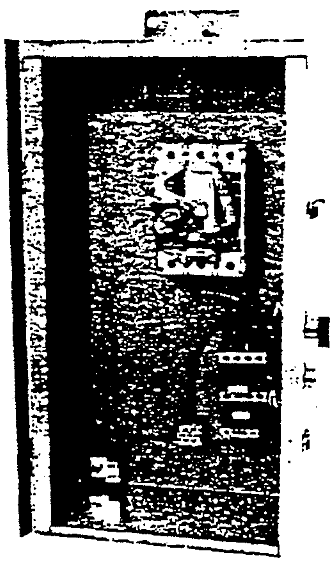
LOAD (HP)	No load (-)	25% (12.5)	50% (25)	75% (37.5)	100% (50)	125% (62.5)
AMPS	32.1	37.4	43.5	63.8	82.9	107.4
EFF.	0	75.1	82.0	82.3	80.0	75.9
P.F.	13.1	50.0	70.7	80.4	84.7	86.2
RPM	3000	2950	2896	2832	2755	2552
WATTS	2760	12417	22744	33992	46625	61430

Full load Torque 94.7 Foot Pounds
Break Down Torque 247 Foot Pounds
Locked Rotor Torque 192 Foot Pounds
Locked Rotor Current 450 Amperes
KVA Code G

BEST AVAILABLE DOCUMENT



CLASS 22-103
MCP TYPE



APPLICATION

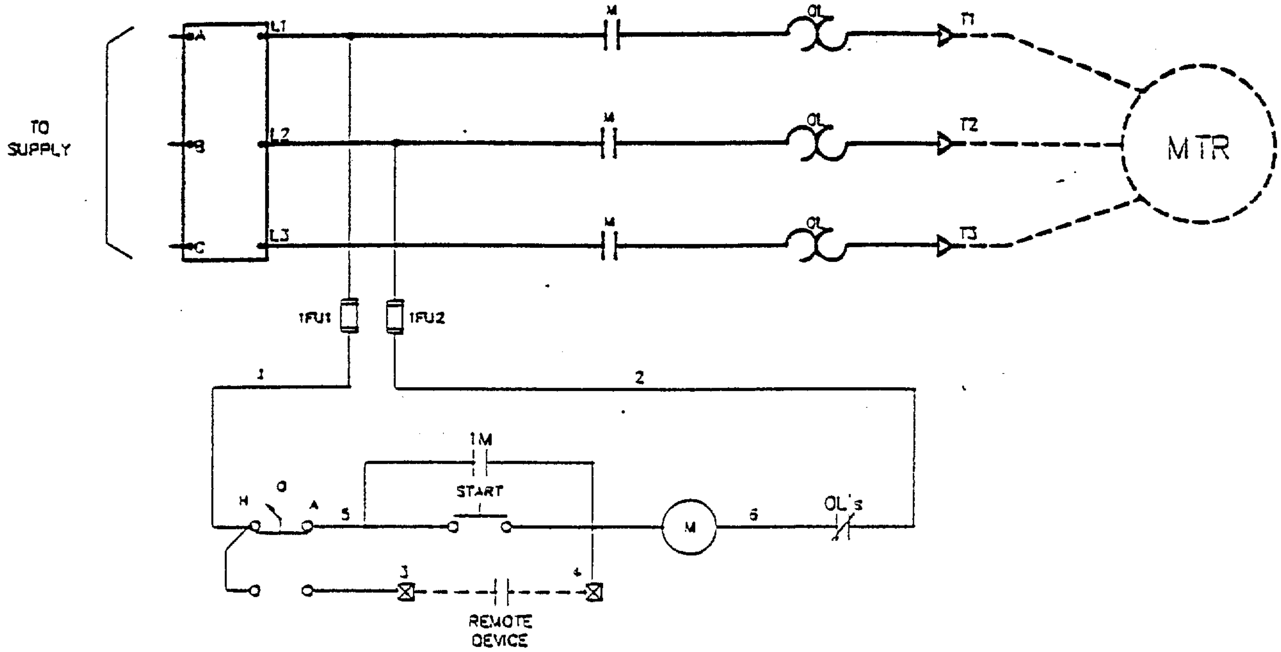
ASCO/DELTA FULL-VOLTAGE START PUMP CONTROL PANELS PROVIDE THE MAXIMUM STARTING TORQUE IN THOSE APPLICATIONS WHERE INRUSH CURRENT RESTRICTIONS DO NOT PREVENT THEIR USE. ACROSS-THE-LINE START PUMP CONTROL PANELS ARE DESIGNED TO CONNECT MOTORS DIRECTLY TO THE FULL MOTOR VOLTAGE. THE CURRENT DRAWN FROM THE POWER LINE BY A MOTOR STARTED ACROSS-THE-LINE IS TYPICALLY 600% OF NORMAL FULL LOAD CURRENT. THIS HIGH CURRENT DEMAND COULD CAUSE LINE VOLTAGE DIPS AND BROWN-OUTS. IN ADDITION TO HIGH STARTING CURRENTS, THE MOTOR ALSO PRODUCES A STARTING TORQUE WHICH IS HIGHER THAN FULL LOAD TORQUE. MOTORS STARTED AT FULL-VOLTAGE MUST BE ABLE TO WITHSTAND THE IMPACT OF THE STARTING TORQUE. ACROSS-THE-LINE STARTING PROVIDES THE LOWEST INITIAL COST AND THE LOWEST MAINTENANCE REQUIREMENTS. TYPICAL APPLICATIONS INCLUDE AGRICULTURAL, OIL FIELDS, INDUSTRIAL, AND MUNICIPAL INSTALLATIONS.

FEATURES

- RAIN AND SLEET RESISTANT NEMA 3R OUTDOOR ENCLOSURE.
- HEAVY DUTY STEEL CONSTRUCTION SUITABLE FOR USE IN MOST DEMANDING ENVIRONMENTS.
- FULLY GASKETED HINGED DOOR WITH PROVISION FOR PADLOCKING.
- MOTOR CIRCUIT PROTECTOR OR FUSIBLE DISCONNECT SWITCH.
- THROUGH THE DOOR DISCONNECT OPERATING HANDLE WITH PROVISION FOR UP TO 3 PADLOCKS.
- MOTOR STARTER SIZED TO CLOSELY MATCH COMMON MOTOR RATINGS.
- QUICK-TRIP CLASS 10 OVERLOAD RELAY WITH ADJUSTABLE CURRENT SETTING FOR MAXIMUM MOTOR PROTECTION.
- OIL-TIGHT HAND-OFF-AUTO SELECTOR SWITCH AND START PUSHBUTTON.
- AUTO MODE OF H-O-A SWITCH WIRED TO TERMINAL BLOCK FOR EASE OF CONNECTIONS TO REMOTE PILOT DEVICES.
- UL AND CSA LISTED.
- SUITABLE FOR USE AS SERVICE EQUIPMENT.

SCHEMATICS

ACROSS-THE-LINE START PUMP CONTROL PANEL
ELEMENTARY SCHEMATIC



ACROSS-THE-LINE START PUMP CONTROL PANEL
WITH CONTROL POWER TRANSFORMER AND RUN LIGHT

Optional