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KAZAKHSTAN

FIELD REPORT

Investigation of Water Distribution Systems in Aralsk, Novokazalinsk and Kazalinsk, Kazakstan

by David Pask - April 1996

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Abbreviations and Acronyms

Abbreviations

gal.	gallon
km	kilometer(s)
km^2	square kilometers
kW	kilowatt
m	meter(s)
mg	milligram
mm	millimeter(s)
m^2	square meters
m^3	cubic meters

Acronyms

FWRC	Federal Water Resources Commission
GOK	Government of Kazakstan
polyethylene	PE
polyvinyl chloride	PVC
PS	Pumping Station
USAID	United States Agency for International Development
USG	United States Government

Executive Summary

1.0 Background

A USAID Environmental Policy and Technology (EPT) Project team visited Kazakstan's Kzyl Orda Oblast in September 1995. The purpose of the team's visit was to investigate the condition of the water pipeline distribution systems that serve the cities of Aralsk, Novokazalinsk and Kazalinsk as well as their respective water sources.[1] In addition, the EPT team reviewed the status and requirements of the sewage collection and disposal systems in these communities. The water supply of this area is derived from wellfields at Kosaman and Berdykol, approximately 100 km northwest of Aralsk. The condition and performance of the wellfields is detailed in the March 1996 EPT Kazakstan Field Report, *Proposed Rehabilitation Program for the Kosaman and Berdykol Wellsfields, Field Research: June-July & September 1995.*

These activities were developed under the Memorandum of Understanding (MOU) executed between the Governments of the United States and Kazakstan in March 1994. The work of the team was carried out under a short-term consultancy as part of EPT Delivery Order 7, Task 2. The team conducted extensive site visits and met with USAID Mission staff and representatives of the Government of Kazakstan (GOK).

It is important to note that as part of its work to investigate water sources, the EPT team reviewed the transmission main and pumping stations of the Kazakstan Federal Water Resources Commission (FWRC). The FWRC provides all of Aralsk's water, provides water to Novokazalinsk during emergencies and contributes the bulk of Kazalinsk's water supply.

2.0 Summary of Important Findings

2.1 Aralsk

Equipment for main laying and repairs is limited by lack of funds for parts, repairs and replacement. In the 6 months prior to the study, there were 286 "accidents" (burst pipes) in the system; equipment and supplies for repair of bursts are limited. The pumping station shows evidence of frequent modification for the replacement of obsolete pumps and burnt out motors. It would be difficult to plan for replacement of pumps and pipe work in the existing pump house without causing severe interruption to services.

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[1] Another EPT Project team visited Kazakstan's Kzyl Orda Oblast in June - July 1995 to investigate the condition of the chlorination system and the pump stations. The team was also charged with finalizing details concerning support from the Government of Kazakstan in the installation of equipment, and to develop a scope of work with Government representatives for other water distribution system improvements identified in Delivery Order 7. For more details, see the EPT Field Report, *Implementation Status of Water Distribution System Improvements, Kzyl Orda Oblast, Kazakstan - July 1995.*

There is an adjacent, new pump house building, which is structurally complete. However, the city does not have the funds to complete the new pumphouse. As a result, EPT's work will have to be done in the existing pumphouse.

There are no flow meters on the existing system, but demand is estimated from the FWRC supply meter and variations in reservoir level. The current mode of operation of the system is that, due to the incidence of burst pipes, the pressure on the system is kept as low as is feasible. This made it impossible to determine the probable leakage rate in the system. It was difficult to persuade the distribution engineer that higher pressures and elevated storage are necessary features of any system in order to maintain freedom from contamination due to inflow at leaks.

In terms of water requirements, the demand on the system during the summer is 15,000 m^3/day, falling to 3,000 m^3/day in the winter. With some conservation and leakage control measures, it is suggested that the overall demand should not exceed 15,000 m^3/day, even with the installation of a full sewage system in Aralsk. Finally, given the corrosive nature of the water, it is essential that any replacement pipes should be protected.

2.2 Novokazalinsk

Novokazalinsk receives the bulk of its water from the Syr Darya River, approximately 10 km from town. A new pumping station, reservoir and waterworks depot were begun in the early 1990s, but construction ceased in 1992. The distribution system consists of approximately 60 km of predominately cast iron water mains, some steel. Equipment for main laying and repairs is limited by lack of funds for parts, repairs and replacement. Information on the frequency of burst pipes was not determined. However, in 7 days in the area, at least three repairs were required, reportedly due to corrosion and frost heave. As in Aralsk, the water supply is aggressively causing severe corrosion problems, and equipment and supplies for repairs are limited.

There are no functioning flow meters. Demand is estimated from pump settings and the rise and fall in the treatment works storage reservoir, along with the reading of the FWRC supply meter when additional supplies are taken. Again, the current mode of operation is that, due to the incidence of burst pipes and limitations on filtration capacity, the pressure on the system is kept as low as feasible. As in Aralsk, it was difficult to persuade the distribution engineer that higher pressures and elevated storage are necessary features of any system to maintain freedom from contamination from inflow at leaks. More and better pipes were presented as a higher priority. The present condition of the water tower was not determined.

2.3 Kazalinsk

The Kazalinsk distribution system consists of approximately 15 km of cast iron and plastic (PVC) water mains, laid in 1988. Approximately 100 homes have service connections, while the remainder carry water from stand pipes. The pumping station is served by two concrete reservoirs. Information on the frequency of burst pipes was not available. However, bursts were reportedly due to corrosion and movement due to frost heave.

The water supply is aggressively causing severe corrosion problems with steel and iron pipes; some bursts can be attributed to, or are perhaps exacerbated by, the incidence of hydraulic surges, which are due to frequent power failures and the absence of surge suppression devices. Time was not available for a detailed investigation of the system and requirements for rehabilitation. The general comments and suggestions applying to Aralsk and Novokazalinsk are also expected to apply to Kazalinsk.

2.4 Sanitation

With the exception of a small section of Novokazalinsk, there is no system of public sewers in the three towns. In general, each home has a privy in the yard area. Homes with an inside water supply to the kitchen sink and bathroom usually have the gray water drainage led to a seepage pit, a concrete or block structure with an open base. Some areas of the towns are not yet served by water mains in every street.

In a comprehensive inspection of the towns' streets, there was no evidence of wastewater finding its way into open drainage channels in the streets. (Rainfall is low, averaging 150 mm per year, so there is no requirement for a storm water system.) Given the incidence of enteric disorders and disease, it is unlikely that the transmission route is by wastewater; there must be other vectors involved. Insects, personal hygiene and food handling/preparation practices may be suspect. There may be a need for continuing public education. Another route of infection may be the water supply distribution systems; the systems are subject to intermittent loss of pressure due to power failure, source failure and repairs to burst pipes.

The existing sanitation system is functional but inconvenient, especially in winter. As the towns develop economically, it is likely that homeowners will want to improve their sanitary facilities. With adequate controls and training, it is feasible that systems can be designed to accommodate ad hoc development of this nature and yet be integrated into a comprehensive sewer collection system at a later date. Technologies appropriate to the three towns are described in Appendix D.

2.5 Federal Water Resources Commission

During the EPT team's investigation in the Aralsk region, FWRC pumping stations were visited and operations engineers interviewed. During the team's 16 days in the region, there were at least five occasions when water was not available from the supply system due to power outages and burst pipes. At all of the pumping stations visited, there were an abnormally large number of discarded pump motors. While the cause of their failure could not be ascertained (by dismantling them), it is believed that the problem is due to electrical storms in the region – the stations are not equipped with power surge suppression devices. In addition, none of the pumping stations were equipped with hydraulic surge suppression equipment.

As reported earlier, this region's groundwater is very corrosive and this was proven using very basic field-testing equipment. Most of the large-diameter water transmission line is constructed using prestressed concrete pipe with an integral thin wall (3 mm) steel cylinder to assist in the manufacturing process. From information on the frequency and description of failures of the

transmission pipeline, it is apparent that the corrosive product water is penetrating the inner concrete lining of the pipes and causing extensive corrosion of the thin steel pipe cylinder.

3.0 Areas of Recommendation

At the conclusion of the field trip, the team made recommendations on the interim protection of the distribution systems. However, a more comprehensive study is recommended prior to instituting major improvements in water distribution and sewage collection in these areas. Specifically, recommendations were made in five areas:

1) how to bring the Aralsk Water System to a viable state of repair and operation (Section 2.3, page 2-4)

2) how to bring the Novokazalinsk Water System to a viable state of repair (Section 3.3, page 3-3)

3) how to bring the Kazalinsk Water System to a viable state of repair and operation (Section 4.3, page 4-2)

4) how to improve sewage collection, treatment and disposal in the three communities, including appropriate technological innovations (Section 5 and Appendix D)

5) how to protect the FWRC pipeline in the interim (Section 6.2, page 6-2)

Section 1
Introduction: Transmission and Distribution in the Region

A USAID Environmental Policy and Technology (EPT) Project team visited Kazakstan's Kzyl Orda Oblast in September 1995. The purpose of the team's visit was to investigate the condition of the water pipeline distribution systems that serve the cities of Aralsk, Novokazalinsk and Kazalinsk as well as their respective water sources. The water supply of this area is derived from wellfields at Kosaman and Berdykol, approximately 100 km northwest of Aralsk. The condition and performance of the wellfields are described in the March 1996 EPT Kazakstan Field Report, *Proposed Rehabilitation Program for the Kosaman and Berdykol Wellfields, Field Research: June-July & September 1995*. In addition, the EPT team reviewed the status and requirements of the sewage collection and disposal systems in these communities.

These activities were developed under the Memorandum of Understanding (MOU) executed between the Governments of the United States and Kazakstan in March 1994. The work of the team was carried out under a short-term consultancy as part of EPT Delivery Order 7, Task 2. The team conducted extensive site visits and met with USAID Mission staff and representatives of the Government of Kazakstan (GOK).

As part of its work to investigate water sources, the EPT team briefly reviewed the transmission main and pumping stations of the Kazakstan Federal Water Resources Commission (FWRC). The FWRC provides all of Aralsk's water, provides water to Novokazalinsk during emergencies and contributes the bulk of Kazalinsk's water supply.

Section 2

Aralsk

2.1 Water Supply

The town of Aralsk receives its entire water supply from the FWRC Transmission Pipeline. The water is discharged into a storage system of six reinforced concrete reservoirs of total capacity of 9,160 m^3 (2.4 mg) located at the waterworks depot to the northeast of the town. (One of the reservoirs is kept full as a reserve for fire emergencies.)

From the reservoirs the water is led a short distance to the pumping and chlorination station where a selection of pumps raise the pressure for delivery to consumers by the distribution network. The town is relatively compact and flat, covering a built up area of approximately 16 km^2, the furthest point being less than 5 km from the pumping station. The greatest variation in level is approximately 10 m and there is need for only one pressure zone.

2.2 Distribution System

The distribution system consists of approximately 67 km of prestressed concrete, steel and cast iron water mains varying in diameter from 100 to 500 mm. Accurate figures were not available but approximately 90 percent of homes have a service connection, the remainder carrying water from a number of stand pipes at strategic locations.

The system was originally balanced for pressure and variations in demand by a water tower on high ground to the northwest, but the tower collapsed under unknown circumstances and pressure is now controlled by manually varying the number of pumps in service according to demand.

The depth of bury of mains and services is generally from 2 to 2.5 m. In low-lying areas the main is sometimes laid at 1 m, with a further 1 m of imported cover above general ground level. Valves are fitted in unusually large chambers (up to 2 m^2) which may also contain a fire hydrant and several service connections. The advantage of access to connections being the ability to cut off supplies for default in payment. Services are typically made of ungalvanized steel pipe, often with welded connections. Of approximately 100 hydrants only eight remain in service, due to lack of replacement parts.

Equipment for main laying and repairs is limited by lack of funds for parts, repairs and replacement. Remaining serviceable heavy equipment consists of one hydraulic backhoe, one truck, one 20-seat bus and three tanker trucks for delivery of water when the system or parts thereof cannot be pressurized.

In the 6 months prior to the study, there were 286 "accidents" (burst pipes) in the system of varying causes. As previously noted the water supply is aggressive causing severe corrosion problems with steel and iron pipes especially in the vicinity of dissimilar metal connections. Some

fractures, especially in cast iron pipes are reportedly due to frost heave during the winter and subsequent settlement. Some bursts can be attributed to or are perhaps exacerbated by the incidence of hydraulic surges (water hammer) due to frequent power failures and the absence of surge suppression devices.

Equipment and supplies for repair of bursts is limited. Bolted gland collars, split collars and saddles are expensive imports and almost all current techniques use electric welding in some way. The most common practice is to fabricate a steel pipe with a welded steel bell joint at each end. The broken pipe is cut away to a convenient length, one bell end is pushed over the cut end the pipe is lined up and the second bell joint is pushed over the gap and is then welded in-situ (see Figure 9 diagram, Appendix A, page A-9). The bell joints are then packed with yarn, caulked and finished with cement mortar. No attempt is made to protect the repair from internal corrosion.

No long term statistics are available, but it is estimated that there are between 3,000 to 8,000 repairs on the distribution system or one every 8 to 24 m. It is assumed that better repair clamps or collars would have been available during the Soviet government period.

The pumping station shows evidence of frequent modification for the replacement of obsolete pumps and burnt out motors. Almost all of the pipe work now lacks smooth bends, swept tees or tapers to give minimum head loss. Wiring for the pumps is led across the floor and walkways with little or no protection. Access to frequently used and essential controls and valves can best be described as a scramble. (See Appendix C photographs, C-1 and C-2.)

It would be difficult to plan for replacement of pumps and pipe work in the existing pump house without causing severe interruption to services. Fortunately there is a new pump house building adjacent which is structurally complete but which requires the fitting of windows, pouring of concrete floors and installation of services. Work ceased on this building when the Soviet Union broke up. (See Appendix C, Photograph C-3a.)

The building is designed on the basis that ultraviolet disinfection equipment for the entering water supply will be installed. The Russian equipment is available at the site but without installation and operational documentation. The completion of the ultraviolet installation should be carefully reviewed considering these factors: 1) the need for a residual disinfectant in the distribution system; 2) power requirements and cost; 3) availability of spare parts; and 4) the low organic content of the source water with low production of chlorinated organic compounds with conventional disinfection.

As in the existing pump house there is no apparent provision for the installation of pressure surge control equipment. But, with some rearrangement space could be found for a pressure vessel or surge tower.

There are no flow meters on the existing system. However, demand is estimated from the FWRC supply meter and from variations in reservoir level. An ultrasonic flow meter was installed at a convenient location in the pump house and flows were monitored for a 24-hour period. The re-

cord showed essentially little or no variation in flow, indicating a high leakage rate or consumers with continually open taps. It is suspected that the cause is a combination of both. With the depressed economy, almost every home has a vegetable garden to supplement food supplies. The arid climate means that watering is essential and it is probable that homeowners take whatever water is available by leaving hoses on a continuous trickle.

Under the current mode of operation the pressure on the system is kept as low as feasible, due to the incidence of burst pipes. During summer days the pressure is maintained at 3 atmospheres at the pumping station, to ensure that water is delivered to all parts of town. In winter, when there is no demand for watering, 2 atmospheres is adequate. At night the pressure is dropped to 0.5 atmospheres to reduce demand to a minimum. In fact the pressure is so low and the demand so constant that it proved impossible to perform any tests to determine the probable leakage rate in the system. A limited pressure survey was made on the system during daytime hours. This survey showed a significantly low pressure in two areas of the town but it was not possible to determine the cause. (See drawing in Appendix A.)

In any conventional water distribution system it is usual to provide elevated storage capacity. This is done to balance the flows in the system, to provide a fire-fighting supply and to provide for continuity of supply during power failure. It was difficult to persuade the distribution engineer that higher pressures and elevated storage are necessary features of any system as a means of maintaining freedom from contamination due to inflow at leaks. More and better pipes were presented as a higher priority.

2.2.1 Water Requirements

The Distribution Engineer reported that the summer demand on the system is 15,000 m^3/day, falling to 3,000 m^3/day in the winter. This indicates that the domestic and commercial demand is approximately 75 liters per day per capita (20 gal.). This is a reasonable figure for a population with no waterborne sewage system. It is also an indication that the leakage rate from the pipe system is no more than 1,500 m^3/day (22.4 l/m/d); but this is a significant amount.

Of greater significance is the fact that during the growing season 12,000 m^3/day is supplied for garden irrigation. This represents a supply of 300 liters/day/person (80 gal.). Irrigation and livestock requirements for domestic purposes have not been researched but it is suggested that public education may be able to reduce this figure. It may be advantageous to consider charging for water, using water meters, to control consumption. With some conservation and leakage control measures it is suggested that the overall demand should not exceed 15,000 m^3/day even with the installation of a full sewage system in the town. Should the population increase, or water consuming industries be brought in, then these factors must be taken into account.

Time constraints precluded a complete analysis of the distribution system network. However, manual calculations indicated that if the overall pressure can be raised to a head of approximately 30 m, then the existing pipe network can provide for adequate flows to cover domestic demand and can give a minimum fire flow of 60 liters per second (1,000 gallons per minute) in most areas of the town. With the construction of a stand pipe water reservoir in the area of the former

tower, fire flows would be improved.

If the decision is made to replace the distribution system and tower, adequate pressures for domestic and fire services can be attained by doing the following: Install a 300-mm-diameter trunk main from the pump house to the tower, a network of 200-mm-diameter pipes along all roads to be served by fire hydrants and 100-mm-diameter pipes elsewhere. Without the tower, a larger diameter pipe of 400 mm would be required along the route of the existing 500-mm prestressed concrete pipeline crossing the railway. Given the difficulties of negotiating the laying of pipes beneath the railway it would be opportune to use the existing aging crossing as a duct to install the smaller diameter pipe.

2.2.2 Pipe Material

Given the corrosive nature of the water, it is essential that any replacement pipes be protected from corrosion. The two most available materials are the plastics, Polyvinyl Chloride (PVC) and Polyethylene (PE). At higher pressures PVC pipes are usually less expensive and easy to lay and join than PE. They do have limitations in that at low temperatures the material becomes brittle; to allow for movement without fracture the pipes must be surrounded by granular fill before the excavated area is covered. The extreme climate of the steppe leads to both low temperature embrittlement and susceptability to fracture from hydraulic surge pressures, and to excessive movement due to frost heave.

PE pipes, however, do have advantages at the pressure rating required for this location. They are competitive in price, do not suffer from embrittlement and are less restrictive in requirements for backfill. (Granular fill is not readily available in the area and must be imported.) They do, however, require special equipment for the fusion welded joints used for pipelaying and service connections.

2.3 Recommendations

It is recommended that consideration be given to the following actions to bring the Aralsk Water System to a viable state of repair and operation:

1) Require that the Pipeline authority provide a supply that is stabilized against corrosion.

2) Complete construction of the new pumping station, and install new pumps and motors with both hydraulic and electrical surge protection.

3) Construct a steel (bolted or welded) Stand Pipe Storage Tank in the northwest of the town of minimum capacity of 750 m^3 (2 hours fire flow) and minimum height of 25 m to top water level.

4) Provide the town with new essential equipment needed to economically and rap-

idly repair problems with the distribution system. Major items would include a new diesel backhoe, a truck equipped to transport men and materials, a mobile crane capable of lifting manhole sections and heavy fittings into a deep excavations, and new trench dewatering pumps.

5) Provide a supply of appropriate pipeline repair fittings. Institute a program to detect leaks, combined with a program of gradually increasing the water pressure in the system. This would be done until all weak spots are detected and repaired and the pressure can be maintained at a safe level of 2.5 atmospheres throughout the system, day and night.

6) Institute a replacement program of the whole distribution system. The distribution system would be replaced with a network of 300-, 200- and 100-mm-diameter PE distribution pipes with appropriate valves hydrants and fittings. Provide PE service tappings with water meters and require that all service pipes be replaced with small-diameter PE pipes.

Within the constraints of this current project it would be appropriate to concentrate efforts on items 4) and 6). If funds are available, it would be appropriate to supply a backhoe and an initial 1,000 m of 200-mm-diameter PE pipe, plus the necessary fusion welding apparatus for item 6). The GOK would use its own resources for installing the pipe.

It is important to remember that the recommended areas of concentration for improvements in Aralsk are made within the constraints of the EPT Project, as noted above. If possible, the remaining recommendations should be implemented by other international donors.

Section 3
Novokazalinsk

3.1 Water Supply

The town of Novokazalinsk receives the bulk of its water supply from the Syr Darya, a river approximately 10 km from town. Water is pumped from the river to a screening chamber, is dosed with aluminum sulphate to precipitate out silt and other contaminant particles, is passed through settling tanks and then through rapid gravity filters. After passing into a storage chamber the water is chlorinated and pumped through twin rising mains to the distribution system at Novokazalinsk. At the town boundary, Novokazalinsk has made a connection to the FWRC Transmission Pipeline, which allows it to tap reduced supplies during emergency conditions such as a local power failure or other emergencies at the treatment works.

In the early 1990s, construction began on a new pumping station (Pump Station 7A), reservoir (see Appendix C, Photos C-8 and C-9) and town waterworks depot. Construction ceased in 1992, leaving all three structures incomplete.

The town is relatively compact and flat, covering a built-up area of approximately 17.5 km^2, the furthest point being approximately 4 km from the new town pumping station and connection with the FWRC Pipeline. The greatest variation in level is less than 10 m and there is need for only one pressure zone.

3.2 Distribution System

The distribution system consists of approximately 60 km of predominantly cast iron water mains, some steel, varying in diameter from 100 to 400 mm. Accurate figures were not available, but approximately 50 percent of homes have a service connection. The rest of the residents carry water from a number of stand pipes at strategic locations.

The system was originally balanced for pressure and variations in demand by a water tower situated within the area of the Central Market. But it is no longer in service. Now, pressure is controlled by manually varying the number of pumps in service, according to demand.

The depths of bury of mains and services are generally from 2 to 2.5 m. Valves are fitted in unusually large chambers (up to 2 m^2), which may also contain a fire hydrant and several service connections. The advantage of having access to connections is being able to cut off supplies for payment default. Services are typically made of ungalvanized steel pipe, often with welded connections. The number of installed fire hydrants could not be determined, but only three remain in service, due to lack of replacement parts.

Equipment for main laying and repairs is limited by lack of funds for parts, repairs and replacement. Remaining serviceable heavy equipment consists of one hydraulic backhoe, one truck, one

20-seat bus and three tanker trucks for delivery of water when the system, or parts of the system, cannot be pressurized.

Information on the frequency of burst pipes was not available. During 7 days in the area at least three repairs were required. Bursts were reportedly the result of corrosion, and movement due to frost heave. As in Aralsk, the water supply is causing severe corrosion problems with steel and iron pipes. Some bursts can be attributed to, or are perhaps exacerbated by, the incidence of hydraulic surges (water hammer) due to frequent power failures and the absence of surge suppression devices.

As in Aralsk, equipment and supplies for the repair of bursts is limited. Bolted gland collars, split collars and saddles are expensive imports and almost all current techniques use electric welding in some way. The most common practice is to fabricate a steel pipe with a welded steel bell joint at each end. The broken pipe is cut away to a convenient length, one bell end is pushed over the cut end, the pipe is lined up and the second bell joint is pushed over the gap and is then welded in-situ (see Figure 9 diagram, Appendix A, page A-9). The bell joints are then packed with yarn, caulked and finished with cement mortar. No attempt is made to protect the repair from internal corrosion.

In the partially constructed pump house there is no apparent provision for the installation of pressure surge control equipment. However, with some rearrangement space could be found for a pressure vessel or surge tower. Before making this provision, a decision must be made as to whether to continue the operation of the Syr Darya intake and treatment works. One alternative would be to re-pump the filtered supply at the new pumping station.

There are no functioning flow meters on the existing system. Demand is estimated from pump settings and rise and fall in the treatment works storage reservoir, together with the FWRC supply meter when additional supplies are taken. An ultrasonic flow meter was installed at a convenient location in the treatment plant pump house. However, corrosion deposits in the pipe were such that measurements could not be made. It was understood that there is essentially little or no variation in flow, again indicating a high leakage rate or consumers with continually open taps. It is suspected that the cause is a combination of both. Almost every home has a vegetable garden to supplement food supplies, which is important in light of the depressed economy. The arid climate means that watering is essential and it is probable that homeowners take whatever water is available by leaving hoses on continuous trickle.

The current mode of operation is to keep pressure on the system as low as feasible. This is due to the incidence of burst pipes and limitations in filtration capacity. During the day the pressure is maintained at approximately one atmosphere at the pumping station. This pressure is adequate to deliver water to all parts of the town, but only to the ground floor of each building. At the hotel where the team resided, water was carried to the second floor. The pressure is so low and the demand so constant that it proved impossible to perform any tests to determine the probable leakage rate in the system.

One section of the town is a subdivision consisting of blocks of three-story flats. This section is

served by a small reservoir (500 m^3) pump (no standby) and an elevated tower (500 m^3 at 20 m elevation). The section also has a sewerage system (see Section 5).

With any conventional water distribution system, it is standard to provide elevated storage capacity. This is done to balance the flows in the system, to provide a firefighting water supply and to provide for continuity of supply during power failures. It was difficult to persuade the distribution engineer that higher pressures and elevated storage are necessary features of any system, in order to avoid the contamination that comes from the inflow at leaks. More and better pipes were presented as a higher priority.

The present condition of the tower was not determined. It is a steel tank supported on a circular brick structure. It is probable that the tank could be renovated, but the limited capacity should be examined in the light of the need to maintain supplies during power-outage periods.

3.3 Recommendations

The following actions are recommended to bring the Novokazalinsk Water System to a viable state of repair and operation:

1) Transfer the water source to FWRC system but require that the pipeline authority provide a supply that is stabilized against corrosion.

2) Complete the construction of the new reservoir, pumping station and depot, and install new pumps and motors with both hydraulic and electrical surge protection. It may be more advantageous to abandon the existing reservoir and construct a new prestressed concrete tank.

3) Recommission the existing water tower at the Market Square location or construct a steel (bolted or welded) Stand Pipe Storage Tank at the same location, with a minimum capacity of 750 m^3 (2 hours fire flow) and minimum height of 25 m to top water level.

4) Provide the town with new, essential equipment for the economic and rapid repair and replacement of distribution system failures. Major items would include a new diesel backhoe, a truck equipped for transport of men and materials, a mobile crane capable of lifting manhole sections and heavy fittings into a deep excavation and new trench dewatering pumps.

5) Provide a supply of appropriate pipeline repair fittings and institute a program of leak detection. This would be combined with gradually increasing the water pressure in the system until all weak spots are detected and repaired, and the pressure can be maintained at a safe level of 2.5 atmospheres throughout the system, day and night.

6) Institute a replacement program of the whole distribution system with a network of 300-, 200- and 100-mm diameter PE distribution pipes with appropriate valves, hydrants and fittings. Provide PE service tappings with water meters and require the replacement of all service pipes with PE small-diameter pipes.

Within the constraints of this current project it would be appropriate to concentrate efforts on items 4), 6) and possibly 2). If funds are available, it would be appropriate to supply a backhoe and an initial 1,000 m of 200 mm-diameter PE pipe plus the necessary fusion welding apparatus for item 6). Depending on the availability of funds under the EPT Project, item 2) could be partially financed. The World Bank is considering financing the construction of the new pump station (Pump Station 7A).

It is important to remember that the recommended areas of concentration for improvements in Novokazalinsk are made within the constraints of the EPT Project, as noted above. If possible, the remaining recommendations should be implemented by other international donors.

Section 4
Kazalinsk

4.1 Water Supply

The town of Kazalinsk takes the bulk of its water supply from the FWRC Transmission Pipeline at PS 7. An emergency supply connection can be made to a pipeline from the Novokazalinsk Treatment Works, a distance of some 10 km.

The town is relatively compact and flat. The greatest variation in level is less than 10 m and there is need for only one pressure zone. The population is approximately 8,000.

4.2 Distribution System

The distribution system consists of approximately 15 km of cast iron and plastic (PVC) water mains laid in 1988 and varying in diameter from 100 to 400 mm. Accurate figures were not available but approximately 100 homes have a service connection;, the remainder of the residents (90%) carry water from stand pipes located at strategic locations.

The pumping station is served by two concrete reservoirs of 1,200 m^3 capacity in total. Two pumps of 15 kw are installed. Only one was operational at the time of inspection; the other was awaiting replacement of the electric motor (see comments in Section 6). It is understood that the system was originally balanced for pressure by a stand pipe. Pressure is now controlled by manually throttling a sluice valve according to demand.

The depths of bury of mains and services is generally from 2 to 2.5 m. Valves are fitted in large chambers (up to 2 m^2) which may also contain a fire hydrant and several service connections. Services are typically made of ungalvanized steel pipe, often with welded connections. The number of installed fire hydrants is approximately 70 with most remaining in service being relatively new.

Information on the frequency burst pipes was not available. However, bursts were reportedly due to corrosion and movement due to frost heave. As in the case of Aralsk, the water supply is aggressive, causing severe corrosion problems with steel and iron pipes. Some bursts can be attributed to, or are perhaps exacerbated by, the incidence of hydraulic surges (water hammer) due to frequent power failures and the absence of surge suppression devices. The sections with PVC mains experience more frequent bursts, probably due to low temperature embrittlement and frost heave.

Time was not available for a detailed investigation of the system and requirements for rehabilitation. The general comments and suggestions in the previous two sections also are expected to apply to Kazalinsk.

4.3 Recommendations

The following actions are recommended to bring the Kazalinsk Water System to a viable state of repair and operation:

1) Continue the primary supply from the FWRC system but require that the authority provide a supply that is stabilized against corrosion.

2) Refurbish the pumping station and install new pumps and motors with both hydraulic and electrical surge protection.

3) Construct a steel (bolted or welded) stand pipe storage tank with a minimum capacity of 500 m^3 (1.3 hours fire flow) and minimum height of 25 m to top water level.

4) Provide a supply of appropriate pipeline repair fittings. Then institute a program of leak detection by gradually increasing the water pressure in the system until all weak spots are detected and repaired, and the pressure can be maintained at a safe level of 2.5 atmospheres throughout the system, day and night.

5) Institute a replacement program of the whole distribution system with a network of 200- and 100-mm diameter PE distribution pipes with appropriate valves, hydrants and fittings. Provide PE service tappings with water meters and require the replacement of all service pipes with PE small-diameter pipes.

Within the constraints of this current project, it would be appropriate to concentrate efforts on items 2) and 5). The pumps in Pump Station 7 are slated for replacement by an EPT team in the summer of 1996. An initial supply of 1,000 m of 200-mm diameter PE pipe, plus the necessary fusion welding equipment could be considered under the current project.

It is important to remember that the recommended areas of concentration for improvements in Kazalinsk are made within the constraints of the EPT Project, as noted above. If possible, the remaining recommendations should be implemented by other international donors.

Section 5

Sanitation in Aralsk, Kazalinsk and Novokazalinsk

5.1 Background

With the exception of a small section of Novokazalinsk, there is no system of public sewers in the three communities of Aralsk, Kazalinsk and Novokazalinsk. In general, each home has a privy in the yard area, typically along the property line as far from the house as possible, consistent with convenience. The privy consists of a square pit up to 2 m deep or as deep as the water table, up to 1 m^2 and often lined with wood for support against caving in. Over the pit is a concrete or wood floor with a hole, rarely covered, and a wood superstructure for privacy, usually well ventilated.

No privies were seen with a vent pipe brought to roof level, normally required for exclusion of flying insects. Some of the pits are exposed at the side due to settlement thus allowing access to flying insects. The privy pit will normally last for a period of up to 10 years, and then be filled with soil and another pit dug two or more meters away from the first.

Homes with an inside water supply to the kitchen sink and bathroom usually have the gray water drainage led to a seepage pit, a concrete or block structure with an open base. The cover slab is usually buried for frost and child protection. When necessary, the pit may be pumped into a tanker for disposal beyond the town limits.

Some areas of the towns are not yet served by water mains in every street (see plans, Appendix A). Public access stand pipes have been erected at the nearest available location and water is carried to the homes. These homes may or may not have an installed gray water system. Some simply dispose of the wastewater onto the vegetable patch.

In a comprehensive inspection of the streets of the towns there was no evidence of wastewater finding its way into open drainage channels in the streets. (Rainfall is so low, averaging 150 mm per year, that there is no requirement for a storm water system.) Given the incidence of enteric disorders and disease, it is unlikely that the transmission route is by wastewater; there must be other vectors involved. Insects (flies), personal hygiene and food handling/preparation practices may be suspect. There may be a need for continuing public education.

Another route of infection may be the water supply distribution systems, which are subject to intermittent loss of pressure due to power failure, source failure and repairs to burst pipes. This subject is addressed more fully elsewhere in this report. (See Sections 2, 3 and 6.)

5.2 Future Directions

The existing sanitation system is functional but inconvenient, especially in winter conditions. As the towns develop economically it is likely that homeowners will wish to improve their sanitary

facilities, including an indoor bathroom with toilet and shower – in advance of the construction of an overall sewer system. With adequate controls and training, it is feasible that systems can be designed to accommodate ad hoc development of this nature and yet be integrated into a comprehensive sewer collection system at a later date, especially if based upon the "STEP" principle or "Septic Tank Effluent Pumping."

Improved sanitation technologies could be introduced in these communities through demonstrations. Technologies could be demonstrated at a number of sites, with an ascending range of technologies showing more advanced forms of treatment and disposal adapted to increasingly difficult environmental situations.

It should be noted that the town of Aralsk is located in an area of two basic soil types. The lower area is built upon soils of a marine or lacustrine sandy clay silt of relatively low permeability and has limitations in its ability to allow disposal of effluent below the surface. Other areas of the town have subsoils of relatively coarser windblown sands and, having higher permeability, use can be made of less expensive forms of on-site technology.

The towns of Kazalinsk and Novokazalinsk are situated on soils of apparently lower permeability and with a higher water table. There may be serious problems in attempting to dispose of even highly treated sewage effluent into the groundwater regime, except in limited quantities. A full flush toilet system would require disposal off-site due to hydraulic limitations.

In Novokazalinsk one housing development is in the form of several blocks of three-story apartments. The community has a zoned water system with storage tank, pump and elevated tower. A sewage collection system leads to a sump and pumping station. The raw sewage is conducted by force main to a primitive lagoon or disposal area situated on the steppe approximately 2 km beyond the town. At the time of the EPT team visit the pump was out of action, the force main had been fractured for some time and it was not possible to see the lagoon.

5.3 Proposed Technologies

Sewage collection, treatment and disposal technologies appropriate to the three communities are described in Appendix D. Particular attention is drawn to the need for the training requirements of operators, installers and pipe fitters.

Section 6

Federal Water Resources Commission

6.1 Transmission Main and Pumping Stations

Although not the primary object of the investigation, it is appropriate to comment on the transmission main and pumping stations that are part of the FWRC, as this system has implications on the rest of the study. During the EPT team's investigation in the Aralsk region from September 6 to 22, 1995, the team visited pumping stations and spoke with the engineers involved in the operation of the system.

During these 16 days there were at least five occasions when water was not available from the supply system due to power outages and burst pipes. At all of the pumping stations that were visited, it was noted that in and around the station were an abnormal number of discarded pump motors. It was not possible to dismantle a motor to ascertain the cause of failure but it was understood that replacement was required due to a failure in the winding rather than in bearings or coupling. Under normal circumstances, a motor is expected to last at least 20 years. However, this region is subject to occasional electrical storms. And, since the power transmission lines are typically the highest projection above the steppe, it is to be expected that the transmission lines will be subject to regular lightning strikes and thus electrical surges. The pumping stations are not equipped with power surge suppression devices and therefore it is suspected that the failure of motors is due to the electrical storms.

It was also noted that none of the pumping stations were equipped with hydraulic surge (water hammer) suppression equipment. Pump shut-down and start procedures were observed. In general, valves are opened before shut-down and after the start of motors. It was observed that the opening period was not long enough to substantially lower the hydraulic surge pressures in the pumping main. In any case, though, valving operations cannot reduce the incidence of pressure surges due to pumps stopping as a result of power supply failures.

(For calculations related to hydraulic surge pressure see Appendix E.)

It has been reported previously that this particular groundwater is corrosive. Using very basic field-testing equipment, the team ascertained that the Langelier index of corrosivity confirmed this supposition. Samples have been collected and submitted for limited laboratory analysis (see Appendix B).

Most of the large-diameter water transmission line is constructed using prestressed concrete pipe with an integral thin wall (3-mm) steel cylinder to assist in the manufacturing process. This cylinder has led to the erroneous local name of "steel" pipe. In manufacture, thicker steel spigot and socket (or bell) ends are welded to the ends of the cylinder. A lining and coating of concrete are applied and cured. High tensile steel wire is then wound around the pipe to apply pre-stress and secured by welding to the end steel sections. A further protective concrete coat is then applied to complete the manufacture.

From information on the frequency and description of failures of the transmission pipeline, it is apparent that the corrosive product water is penetrating the inner concrete lining of the pipes and causing extensive corrosion of the thin, steel pipe cylinder. In a pre-stressed concrete pipe this should not cause catastrophic failure as the concrete should be supported by the helical pre-stressing wires. However, it is probable that the excessive surge pressure caused by pump starts and unscheduled stops is causing a local failure of the bridging between pre-stress wires with a resulting massive leakage.

In the absence of more appropriate repair equipment and techniques, the pipeline staff is making repairs in the following way. They are breaking away the concrete to expose sound areas of the steel cylinder, cutting away the pre-stress wires – and making what can only be temporary repairs – by welding on a thin steel patch (approximately 3-mm thick), sometimes welding the wires to the patch and troweling on a protective coat of cement mortar. No attempt is made to restore any protection inside the pipe. The pre-stress has been released and the concrete will be more porous and more subject to corrosion, leading to failure again at the same location in a short time.

6.2 Recommendations

A detailed feasibility study of the transmission pipeline is currently being conducted by The World Bank. The following actions are recommended for consideration in the feasibility study for protection of the transmission pipeline:

1) Install chemical dosing equipment to control the corrosivity of the well water.

2) Install electrical surge protection equipment at each pumping station.

3) Install hydraulic surge protection equipment in the form of "burp" standpipes or surge pressure vessels.

4) Provide more appropriate equipment and fittings for the repair of burst pipes.

Appendixes

Appendix A
Figures

Aralsk

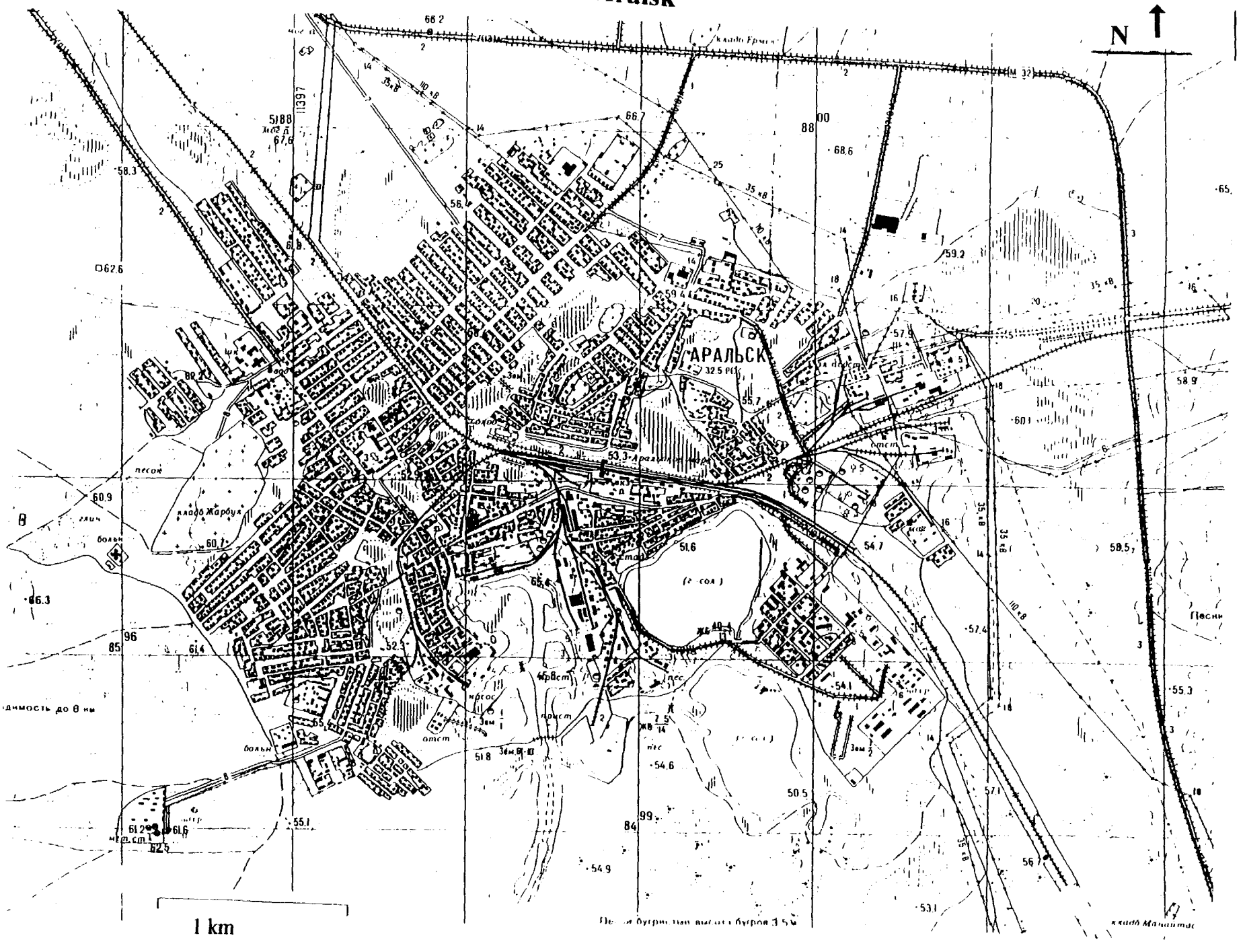
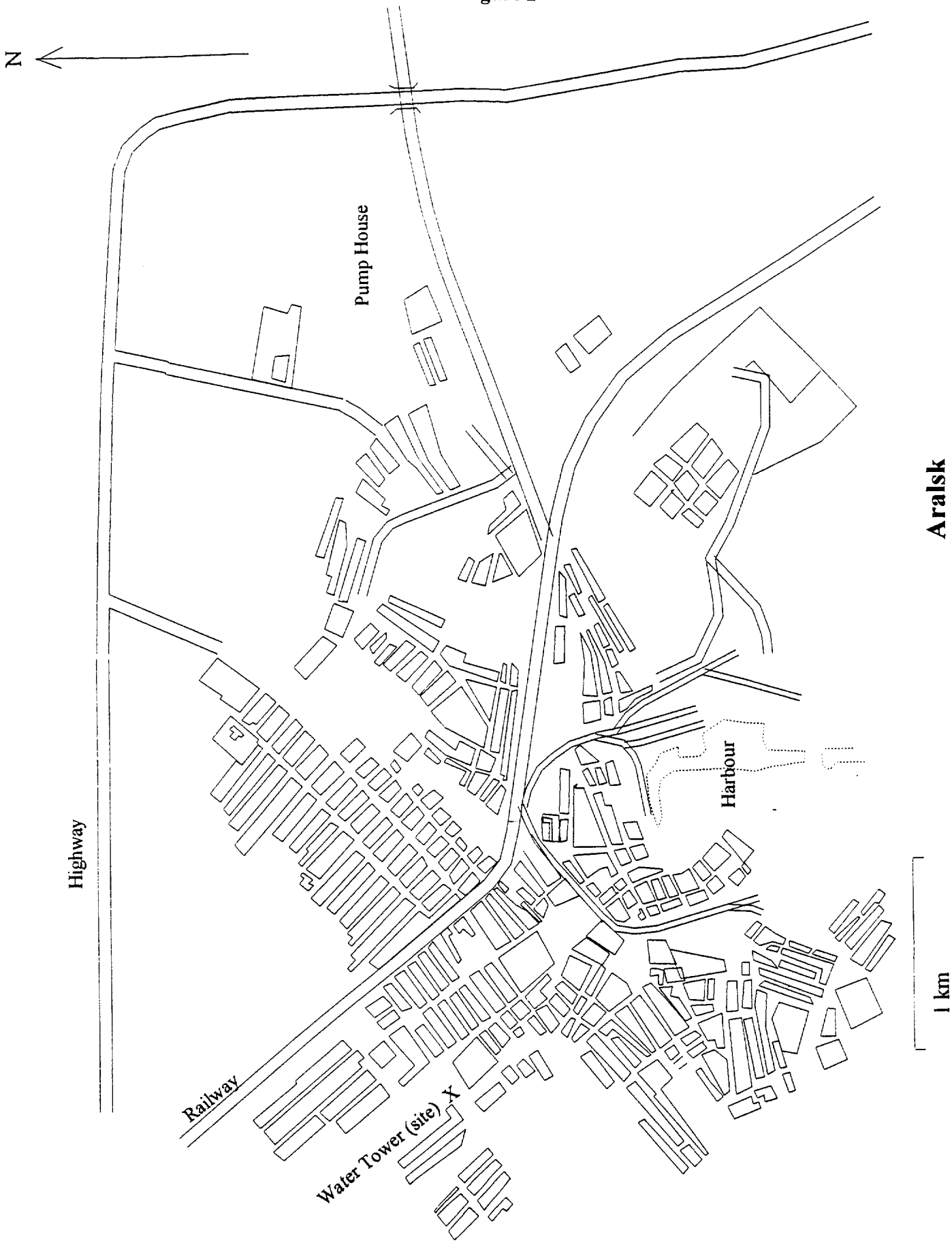
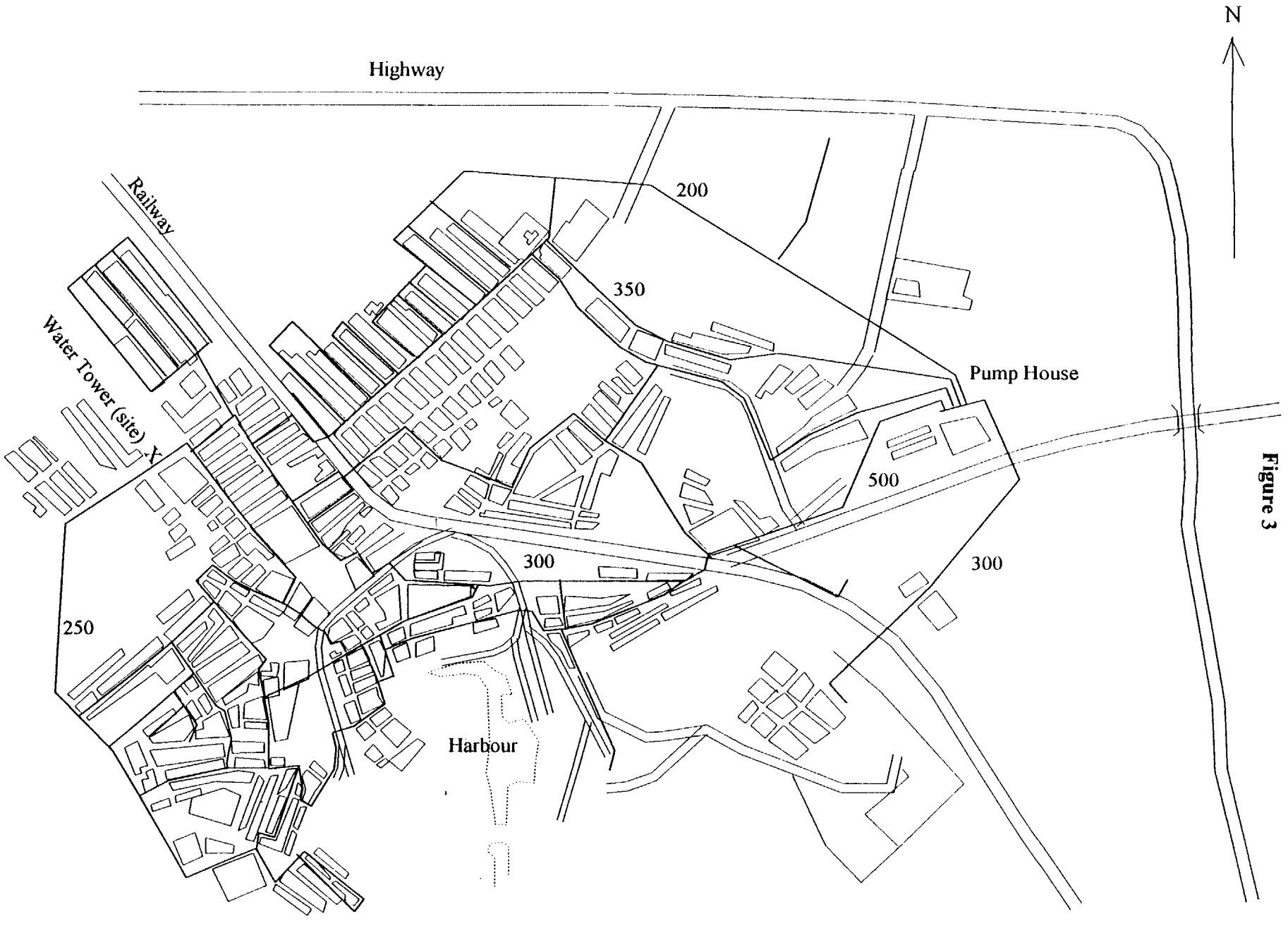


Figure 1

Figure 2


N
Pump House
Highway
Railway
Water Tower (site)
X
Harbour
1 km
Aralsk

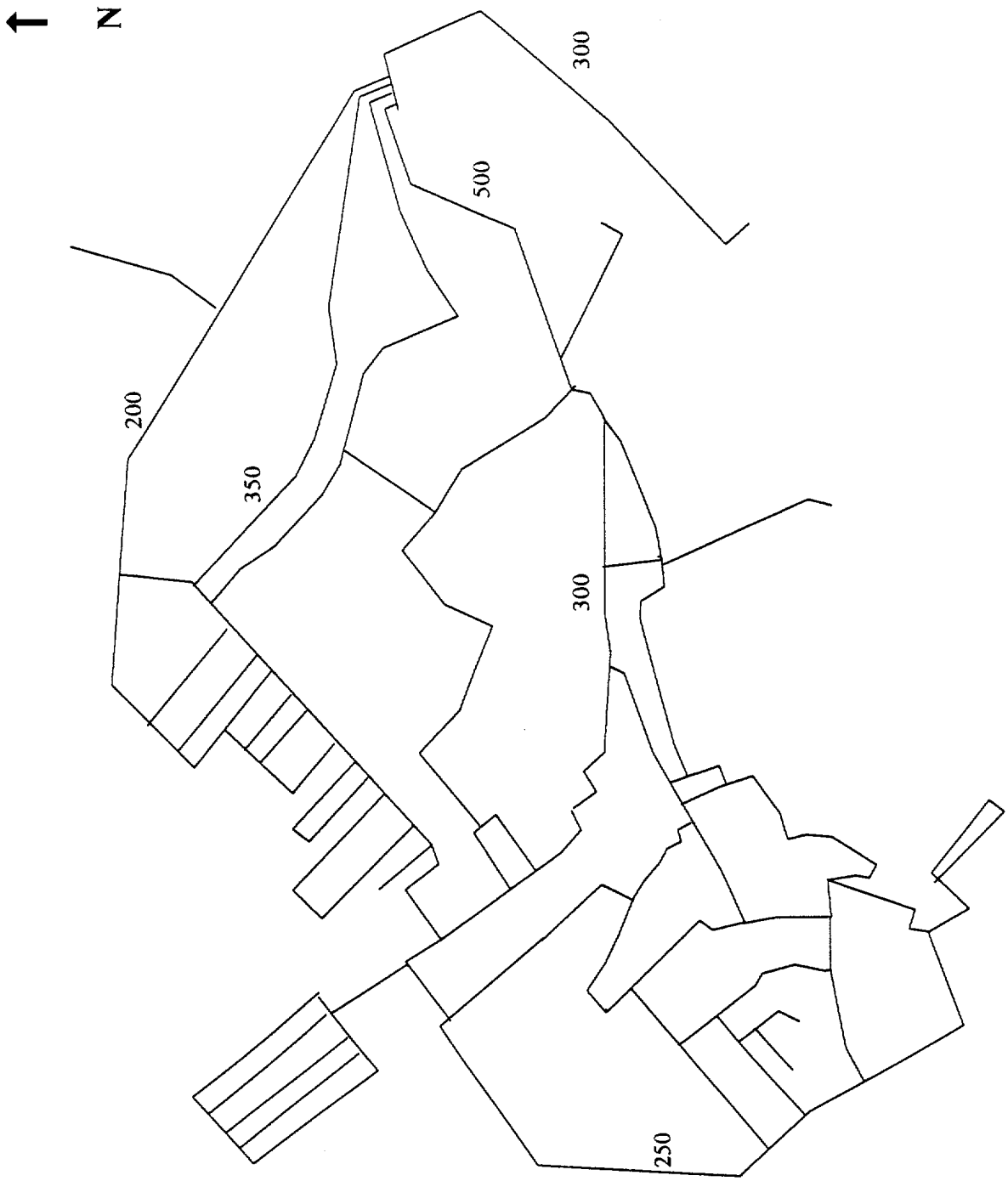


Aralsk Water Distribution System

Figure 3

30

Figure 4



Aralsk Water Distribution System

31

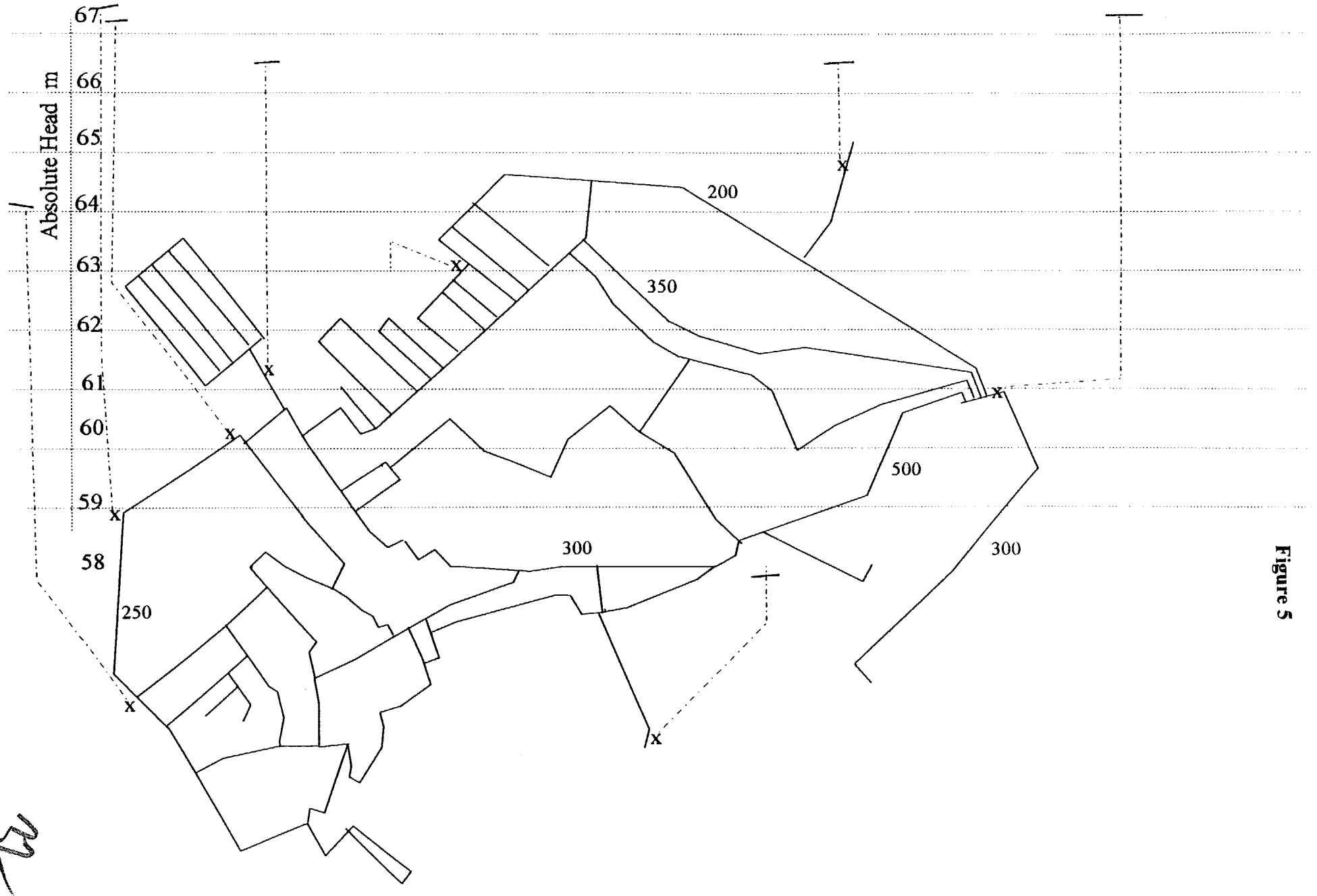


Figure 5

Aralsk Water Distribution System
Pressure Survey

32

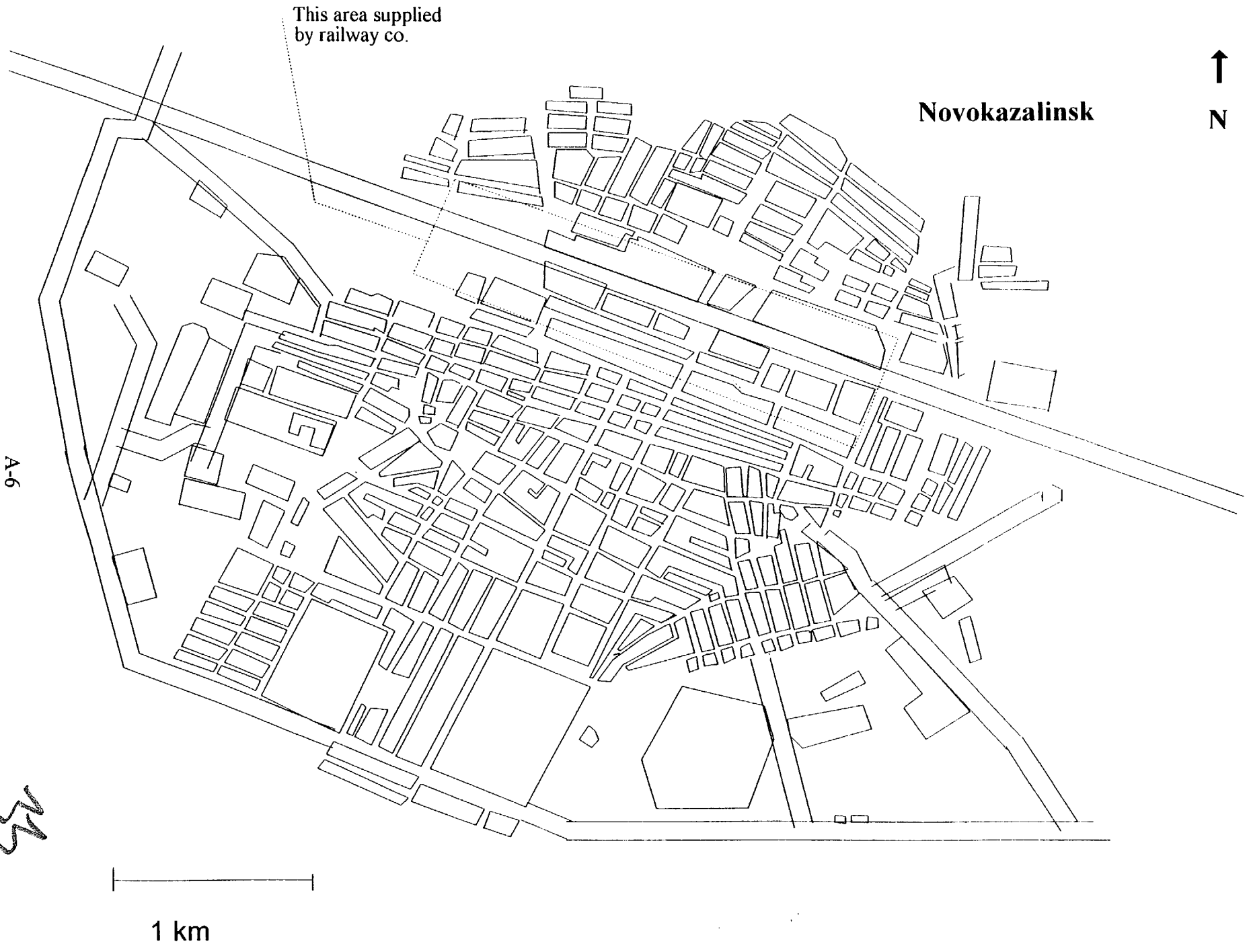


Figure 6

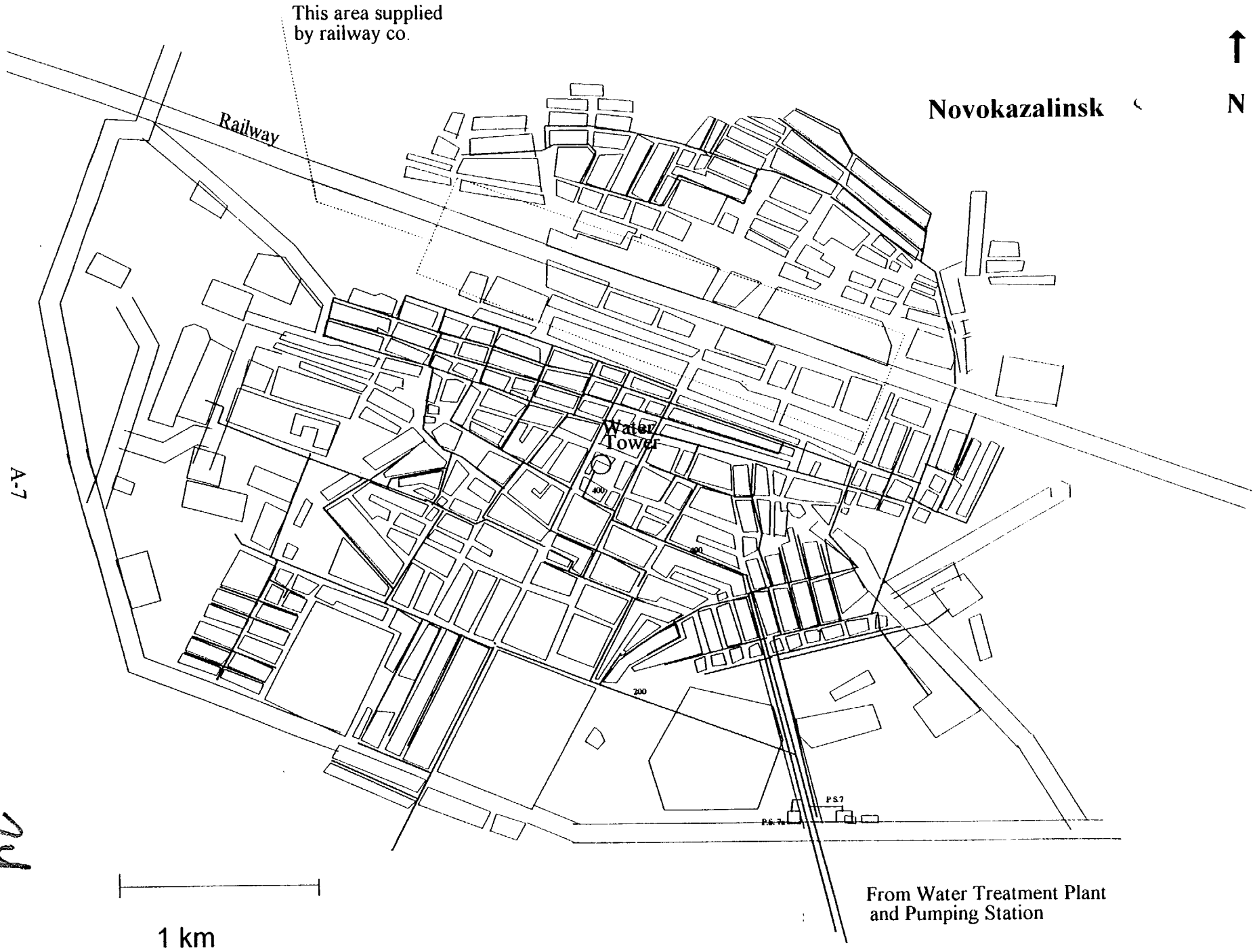

This area supplied
by railway co.
Railway
Novokazalinsk
N
Water
Tower
400
600
200
PS7
PS-7a
From Water Treatment Plant
and Pumping Station
1 km

Figure 7

34

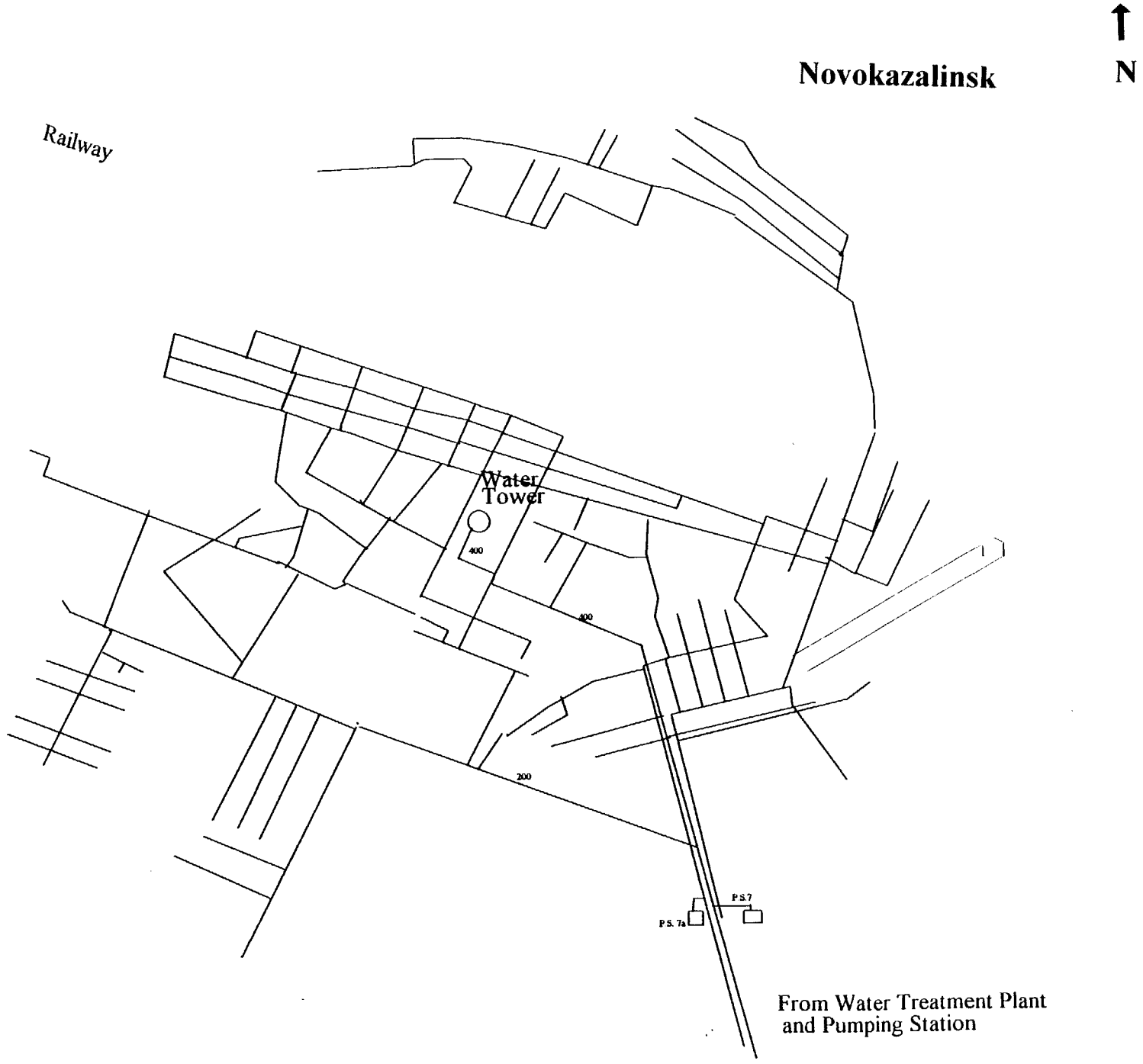
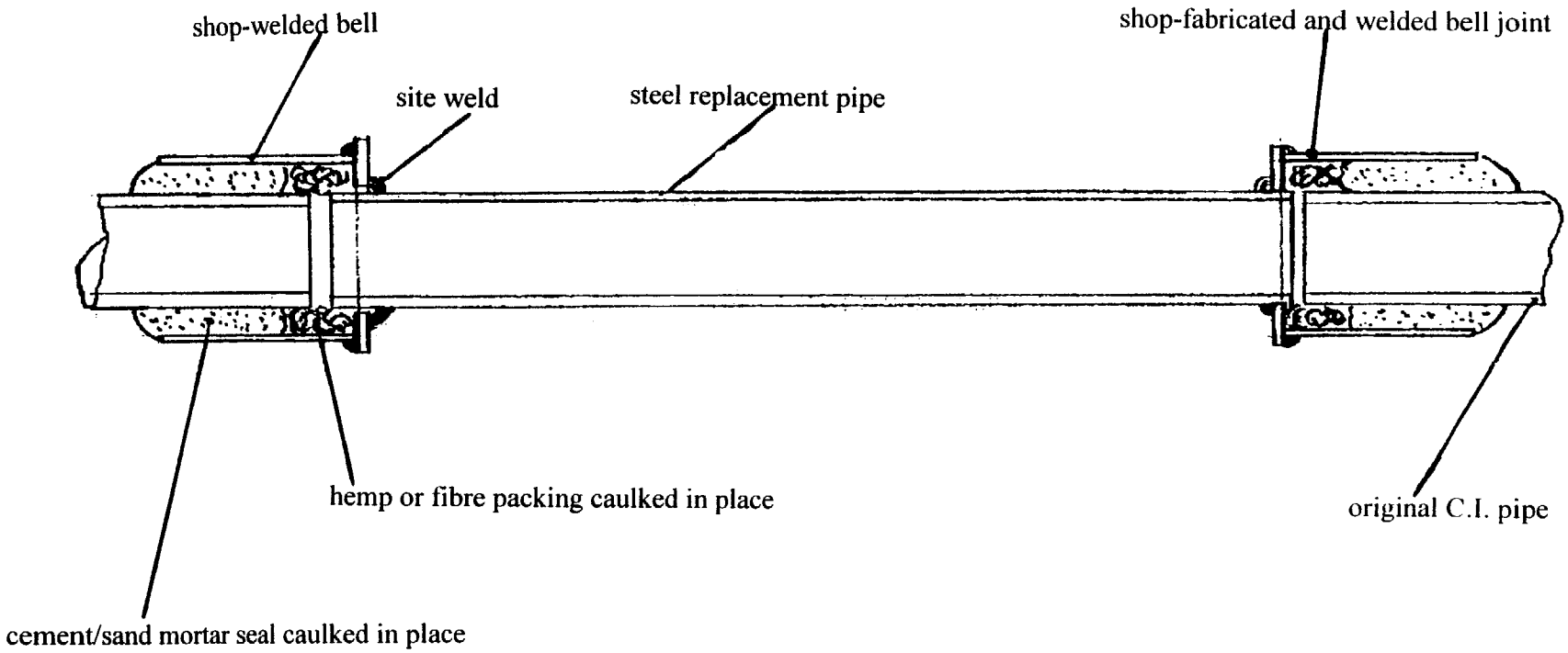

Novokazalinsk
N
Railway
Water Tower
400
400
200
P.S.7
P.S. 7a
From Water Treatment Plant and Pumping Station

Figure 8

35

Figure 9

Typical Repair Method for Fractured and/or Corroded Pipe



Appendix B

Control of Corrosion in Aral Area Water Systems

Appendix B
Control of Corrosion in Aral Area Water Systems

The viability of these water distribution systems is, in the long term, related to the corrosive properties of the water. Without control of the corrosion the pipe work will be subject to more and frequent failures due to this cause.

Approximate Analysis of Aral Area Waters:

Element	Kosaman Wellfield	PS7	Syr Darya River
As	ND	ND	0.38
B	2.56	4.15	2.33
Ba	ND	ND	0.15
Be	ND	ND	ND
Ca	12.5	13.6	182
Cd	ND	ND	ND
Co	NA	NA	NA
Cr	ND	ND	ND
Cu	ND	ND	ND
Fe	0.32	0.72	1.87
Hg	NA	NA	NA
K	6.6	6.95	11.9
Li	111	102	124
Mg	4.54	2.23	73.3
Mn	ND	ND	0.16
Mo	ND	ND	ND
Na	188	236	285
Ni	ND	ND	ND
Pb	0.471 *	0.00387	0.00238
Sb	ND	ND	ND
Si	37.8	37.6	27.1
Sr	ND	ND	4.08
V	ND	ND	ND
Zn	ND	2.18	ND
Cl	62.5	72.5	165
SO4	58	64	441

*** Note:** The high value of lead detected in the sample of water from Kosaman Wellfield is of some concern, as it is well above the Action Level for this element. The result may be an anomaly due to sampling procedure or to contamination of sample containers. The sample taken at Pumping Station 7 showed a level more consistent with the nature of the pumps and pipeline and the corrosivity of the water. A further sample is being collected for a repeat analysis.

Langelier Index of Aralsk water 95 09 12:

TDS by Hach meter - 360, pH - 7.8,
Total Alk - 180 ppm,
Hardness - 6.0 gr/g = 103 mg/l

Langelier Index = -2.7 (corrosive)

The Langelier Index (LI) was developed for assessing the corrosivity of boiler feed water but is a useful indicator in potable water supplies. An index that is negative in value is an indication that the water is aggressive, the higher the number the more so.

It is defined as

LI = pH (actual) - pH (saturated CaCO3)

where the pH (sat) is calculated as

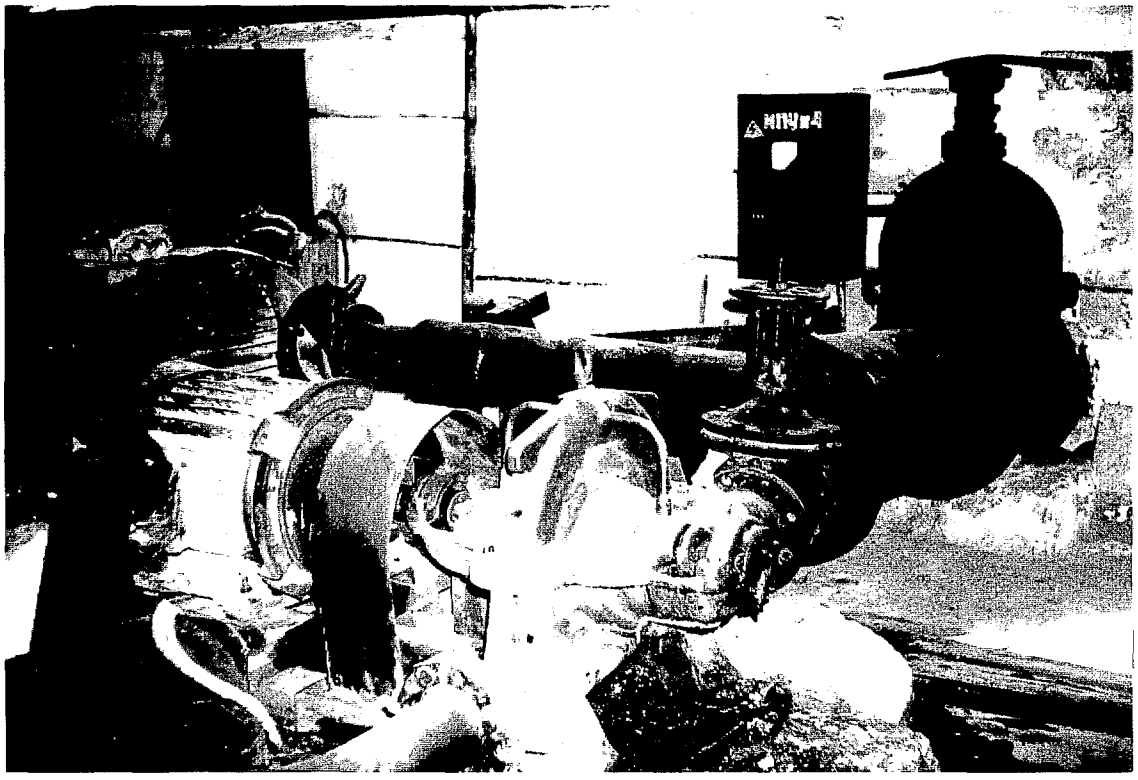
pH (sat) = A + B - C - D

where A = 2.6 - (0.02333 T) [T=temperature Celsius]
B = 9.519 + (0.567 logn TDS) [T=Total Dissolved Solids]
C = 0.123 + (0.433 logn Hardness)
D = 0.123 + (0.433 logn Alkalinity)

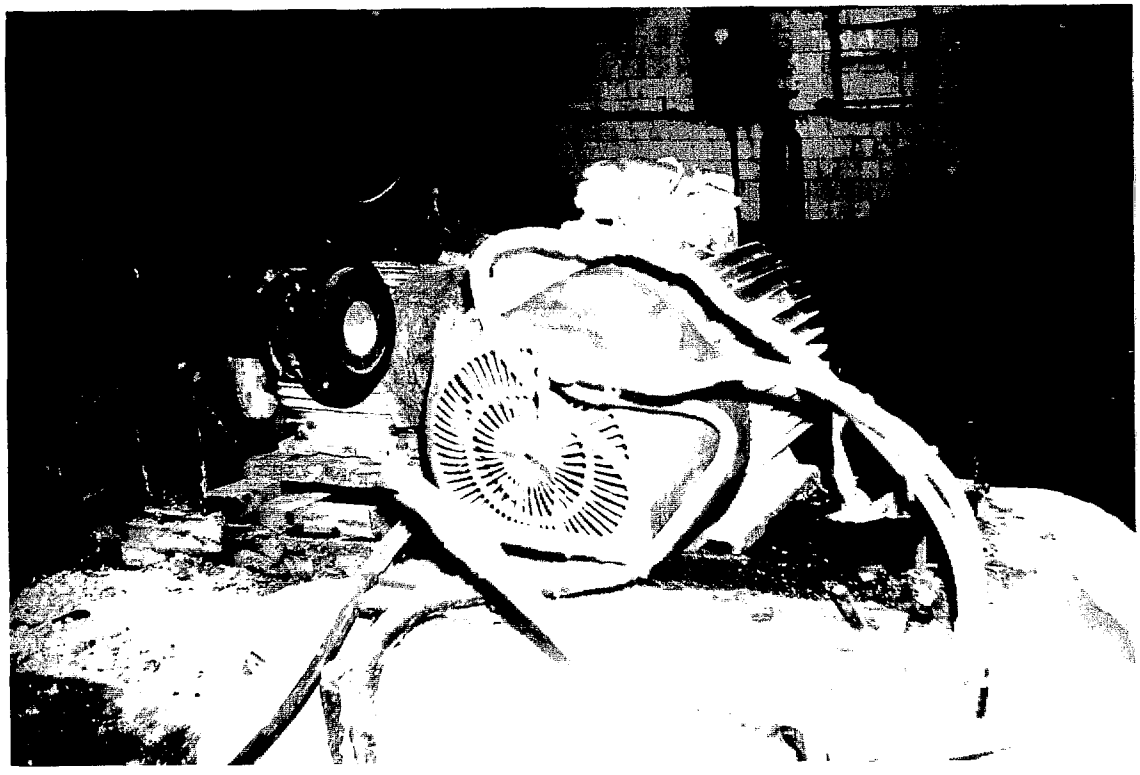
It can be seen that simple means to reduce the corrosivity of this water are limited. Adding lime or calcium carbonate to increase the pH, alkalinity and hardness could not create a positive index on its own. The addition of corrosion inhibitors such as silicates and phosphates may prove to be effective. another method would be to install reverse osmosis equipment to reduce the mineral content of the water. The most effective and economic means can only be determined by experimentation.

A larger sample of the wellfield water will be obtained and sent to a laboratory for further testing for methods of corrosion control.

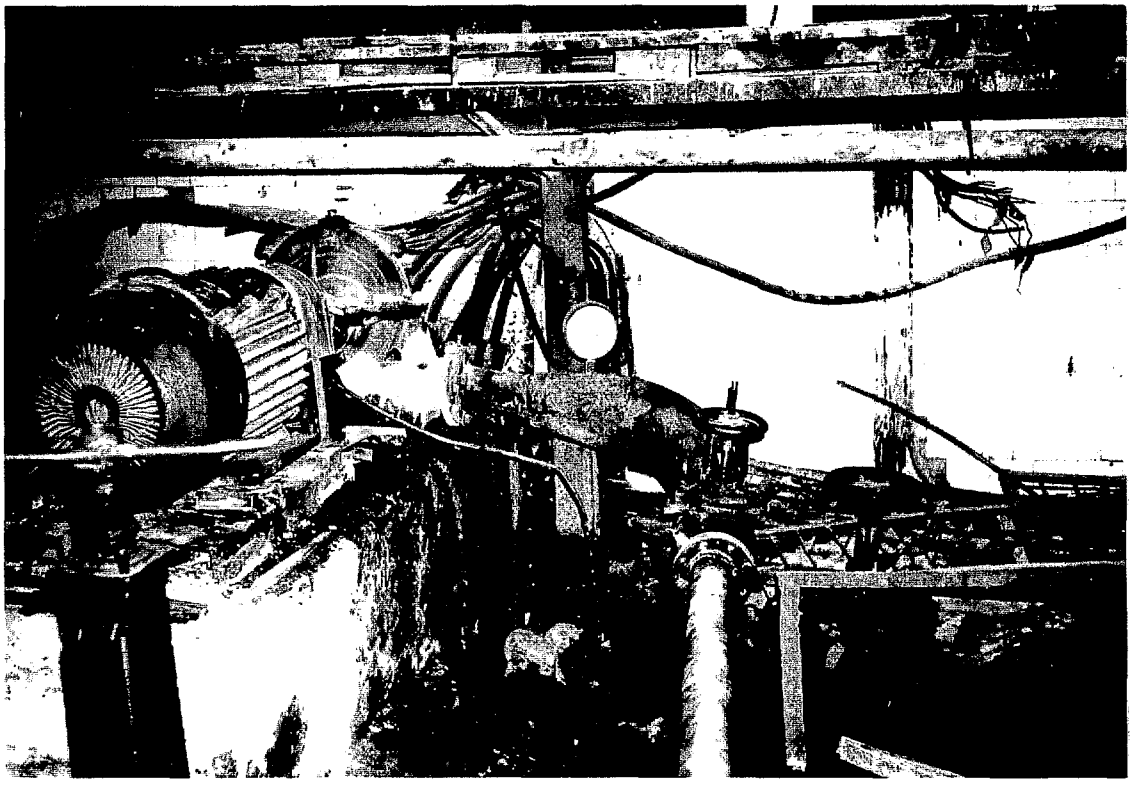
Appendix C
Photographs



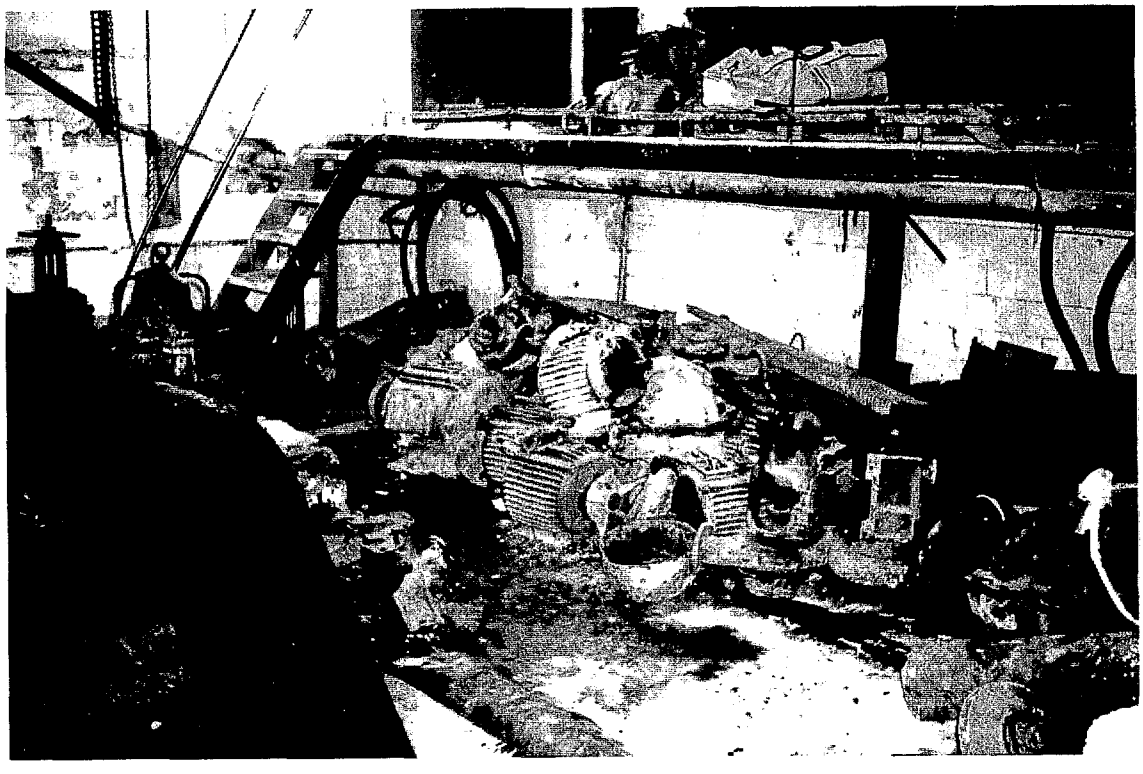
a) Aralsk Pump House - Welded Pipe Connections



b) Aralsk Pump House - Dismantled Pump and Motor Cable

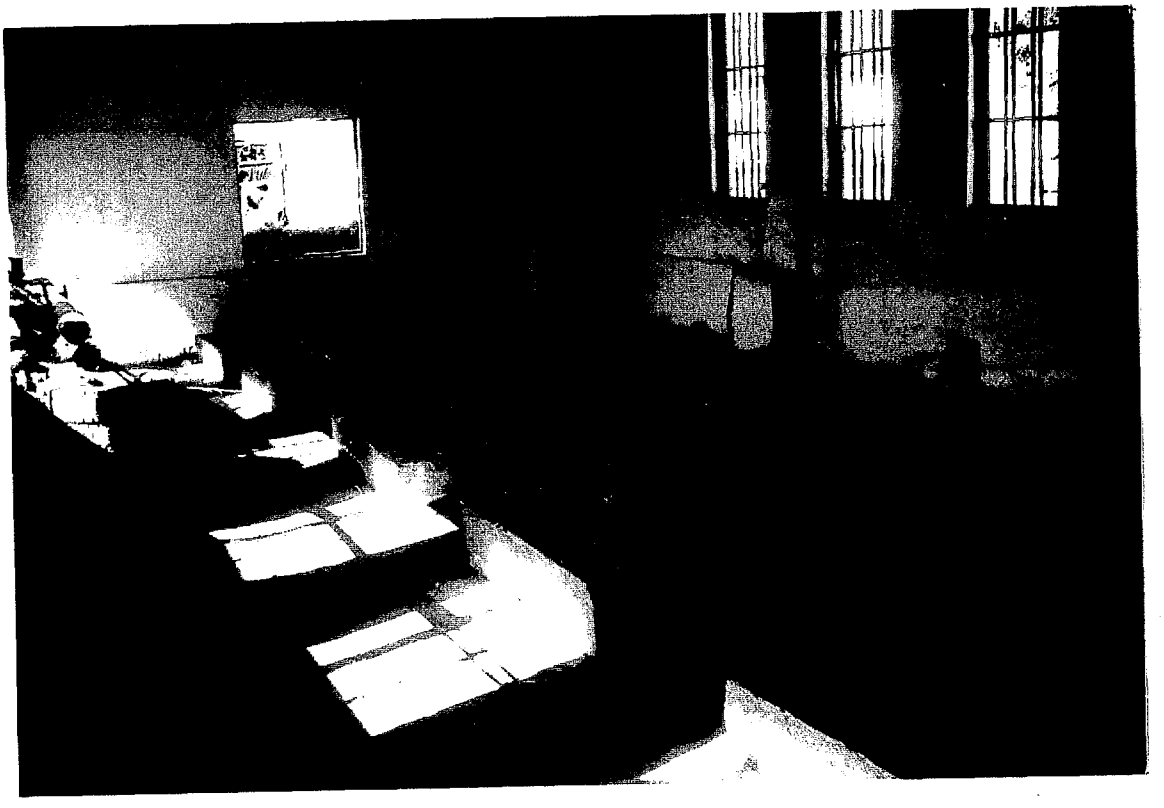


a) Aralsk Pump House - Access Problems



b) Aralsk Pump House - Discarded Pump Motors (12?)

42

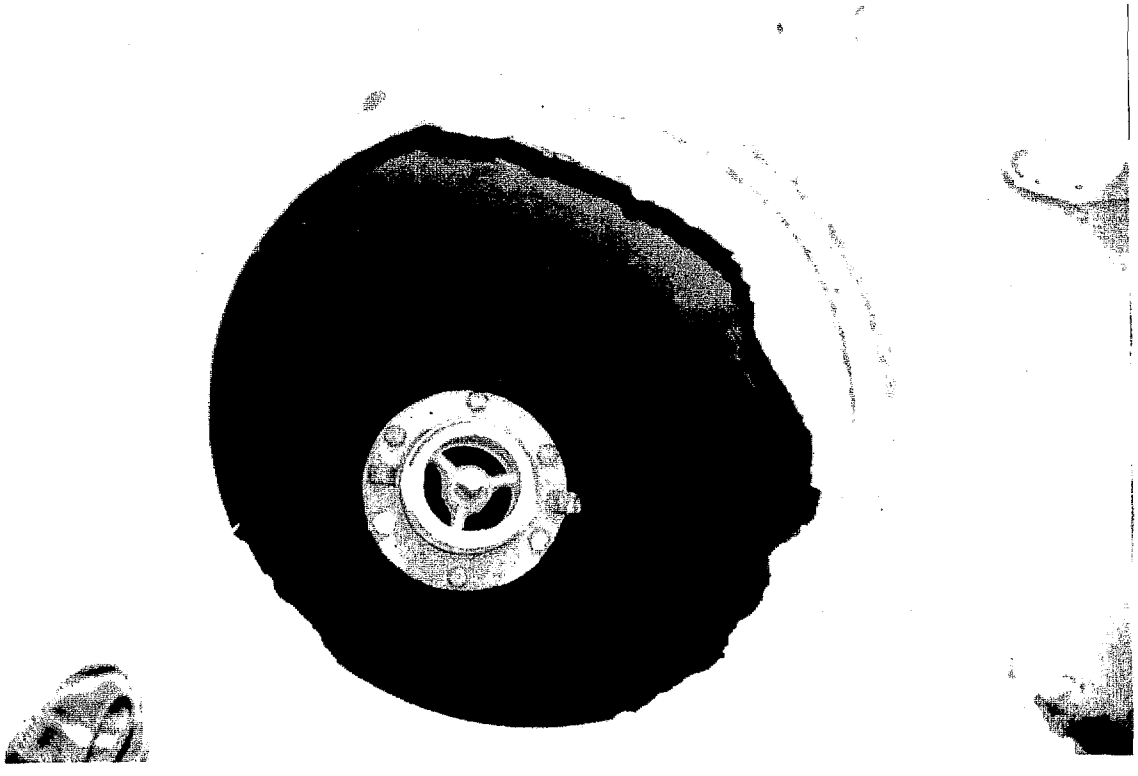


a) Aralsk Pump House - Partially Constructed New Building

b) Aralsk - Demolished Water Tower
(foundation of brick structure in foreground)

43

a) Aralsk - Typical Valve or Fire Hydrant Chamber



b) Aralsk - Fire Hydrant

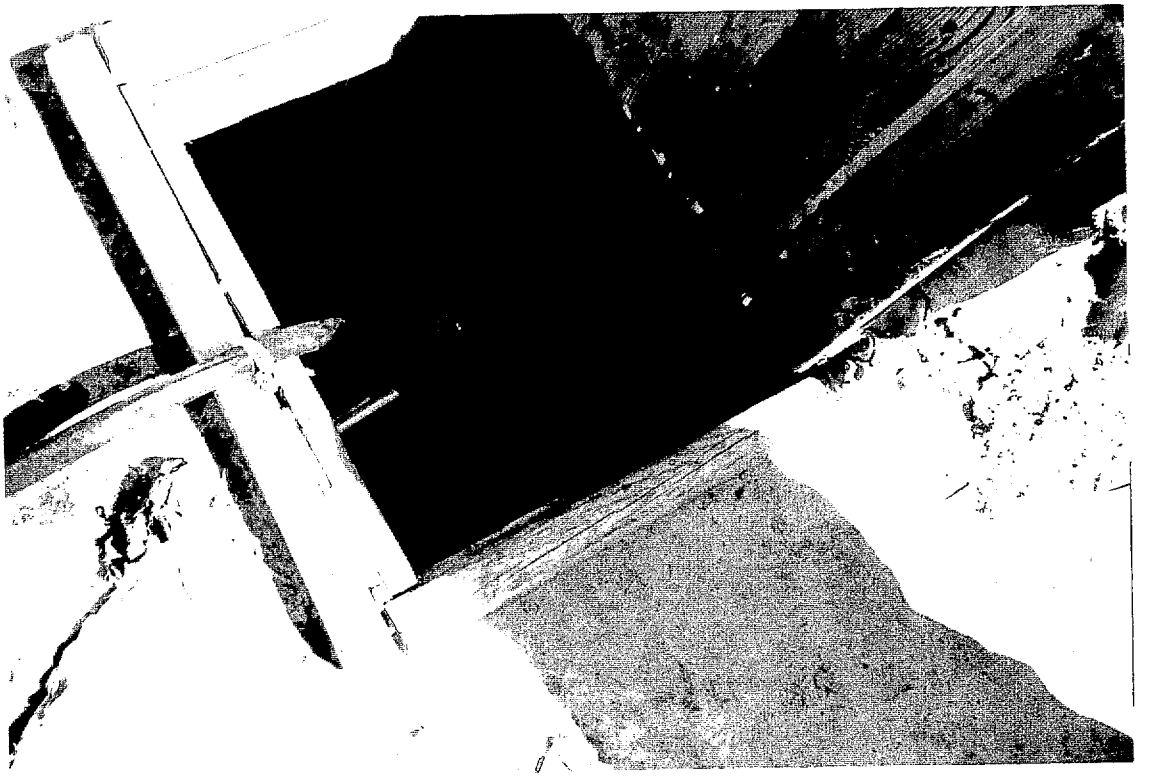
44

a) Aralsk - Fire Hydrant (awaiting service)

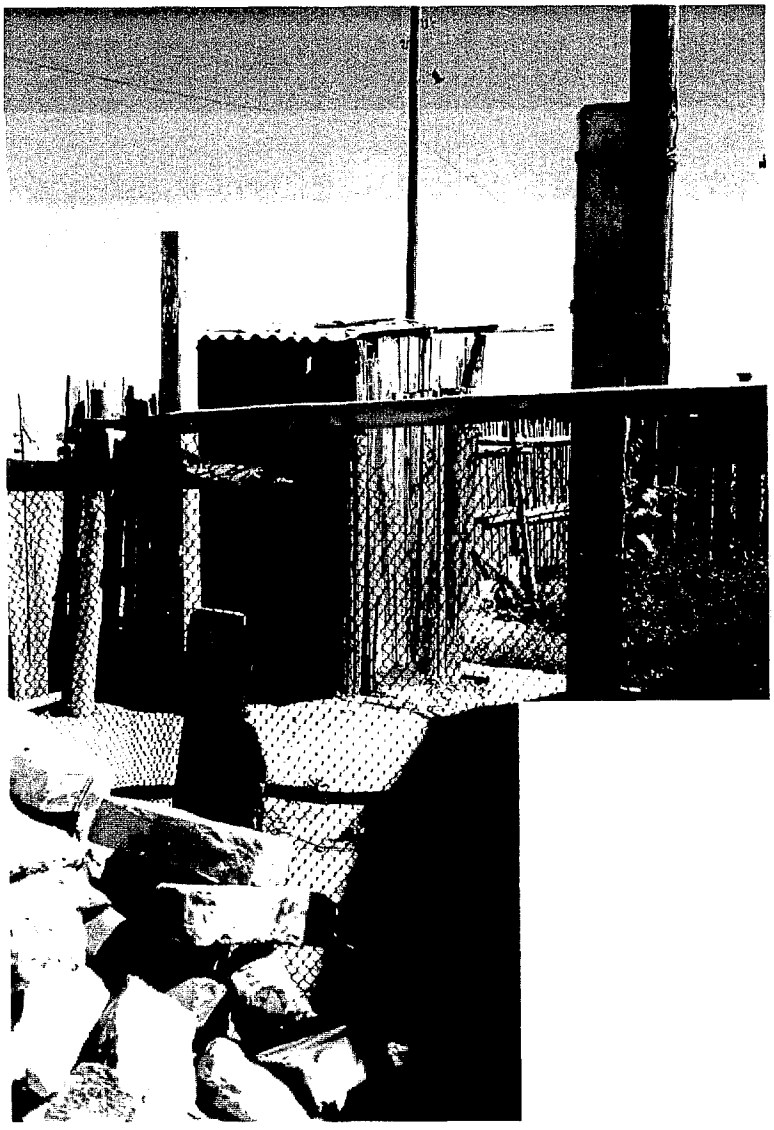
b) Aralsk - Water main burst - In-situ welding of repair fitting

45

a) Aralsk - Irrigation of domestic vegetable garden

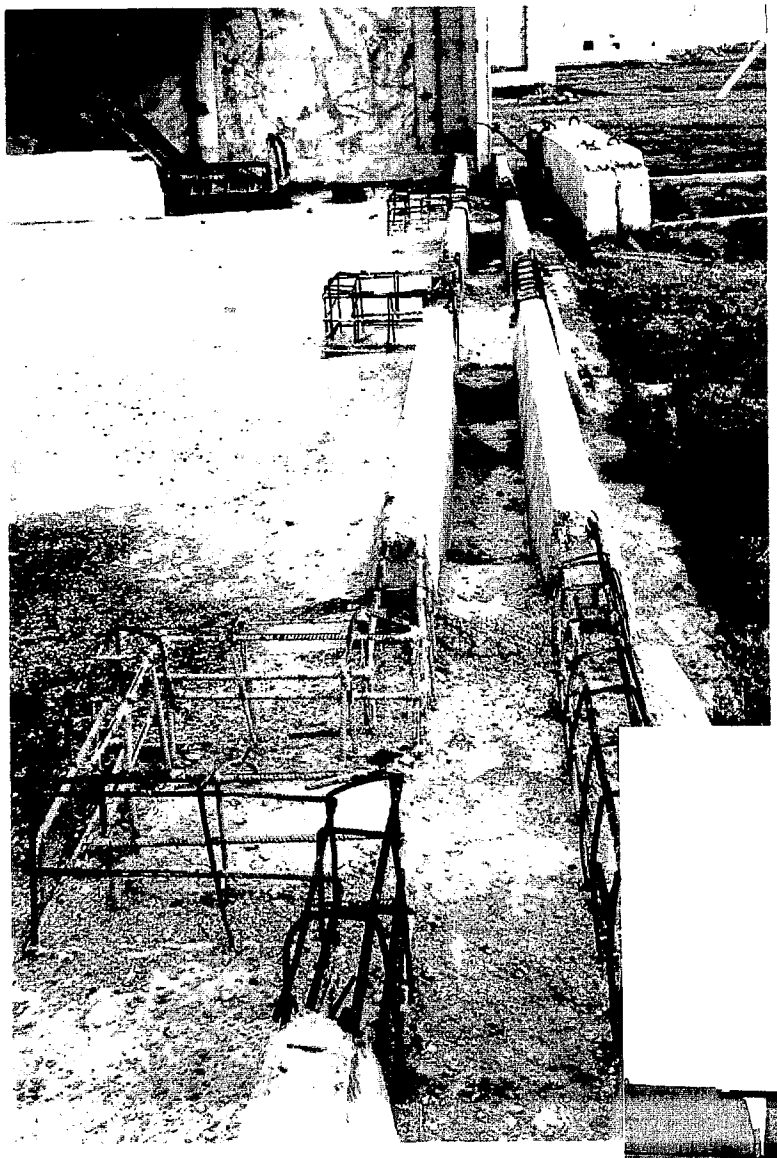


b) Aralsk - Service connection pit



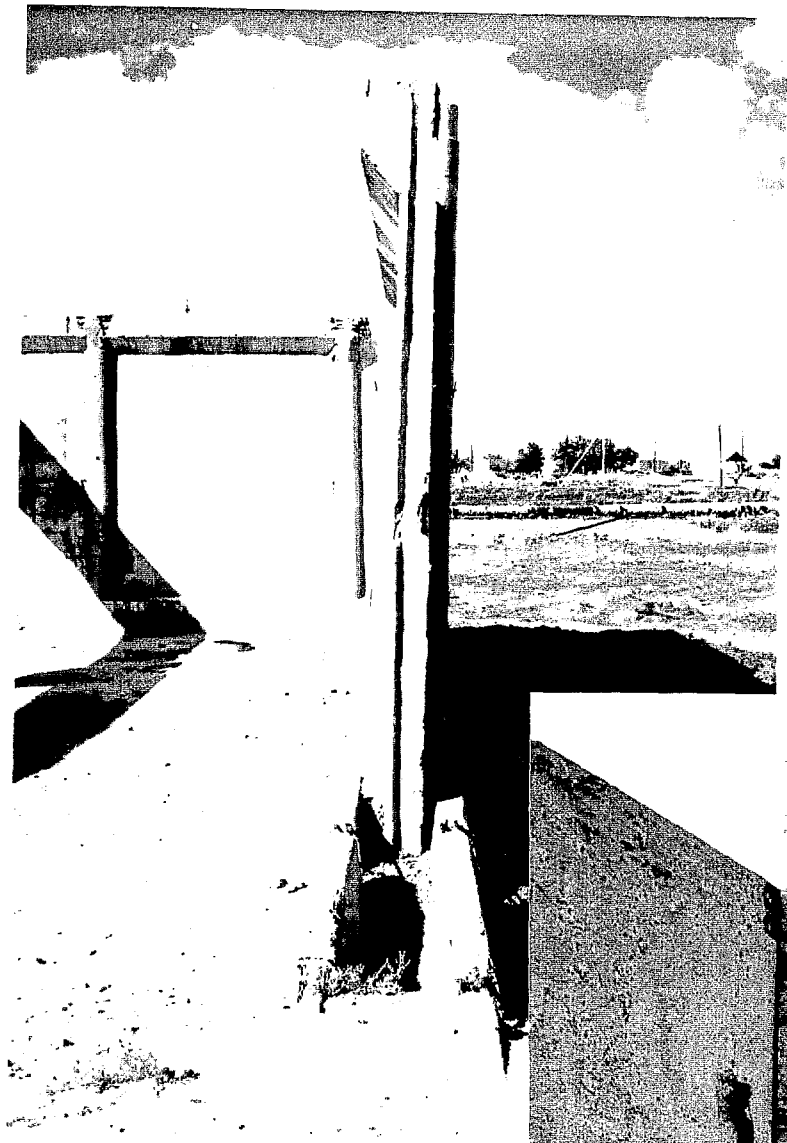
a) Aralsk - Typical household privy

b) Novokazalinsk - Water Tower at the Syr Darya Treatment Plant

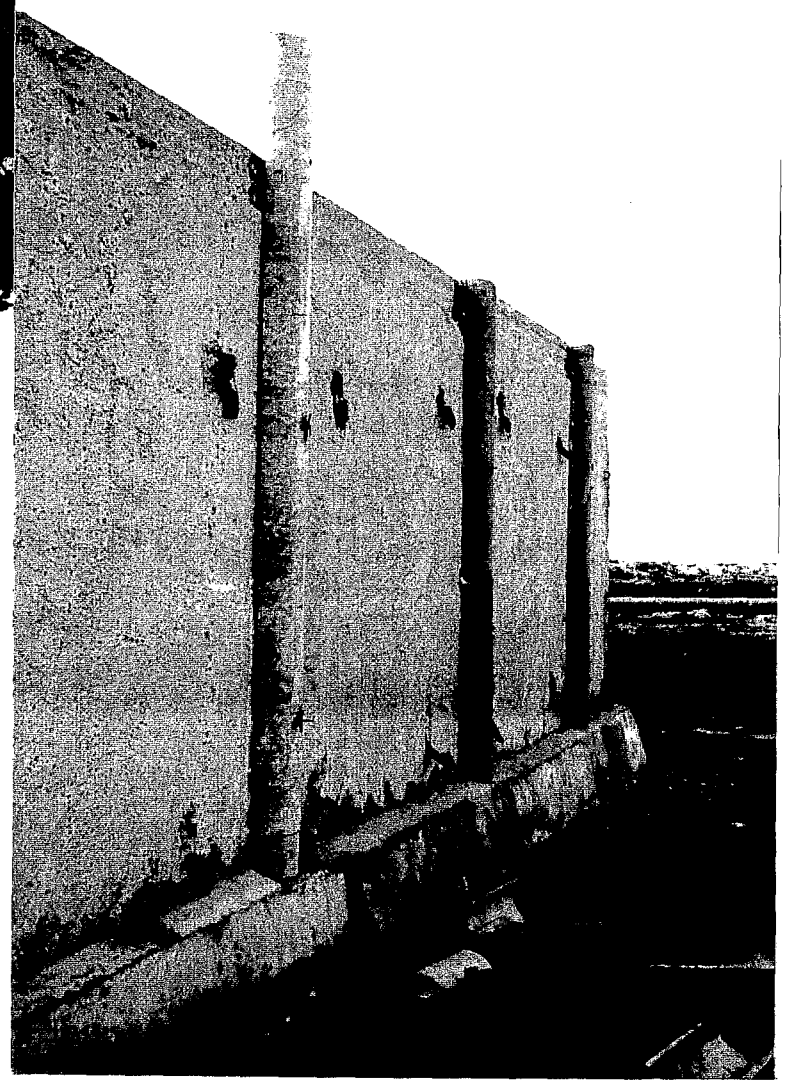


a) Novokazalinsk - Partly completed new reservoir: wall footing (Pump Station 7A)

b) Novokazalinsk - Partly completed new reservoir: pre-cast concrete columns and beams (Pump Station 7A)



a) Novokazalinsk - Partly completed new reservoir: wall section (Pump Station 7A



b) Novokazalinsk - Partly completed new reservoir: wall joint (Pump Station 7A)

Appendix D

Demonstration of Low-Technology Sewage Treatment and Disposal Systems

Appendix D

Demonstration of Low-Technology Sewage Treatment and Disposal Systems

Background

As part of the overall EPT Project in Central Asia the sector on Public Health Education saw the need for demonstration projects in Alternative Technology for Sanitation other than expensive central sewers and conventional sewage treatment and disposal. The technologies proposed are based on current advanced alternative and innovative septic tank systems developed in rural North America and modified to suit the local conditions of Kazakstan.

Proposed Technologies

These technologies are arranged in ascending order of sophistication and some are capable of being upgraded to a higher level. Construction would be by local contractors in each location and would be in conjunction with seminars on site investigation, design methods and construction techniques.

Level 1. Improved Pit Latrine. Features – lined pit, reinforced concrete cover slab, polished, painted or tiled finish for ease in cleaning, raised pedestal, seat cover, vent pipe to roof level, superstructure of available materials (e.g., wattle and daub).

Level 2. Improved gray water disposal system. Features – septic tank of 1 to 2 m^3, soil infiltration trench 0.6 m x 10 m.

Level 3. Pour flush toilet, septic tank (3 to 5 m^3) and lateral flow sand filter with seasonal discharge of treated effluent to storm water channel.

Level 4. Pour flush toilet, shower and kitchen sink to septic tank (3 to 5 m^3), soil infiltration trench (20 to 30 m^2).

Level 5. Small Institution system (school, regional airport, local clinic, etc). Septic tank (10 to 20 m^2) to long contour soil infiltration trench (150 to 500 m by 1 m.)

The following represent potential higher level upgrades to Levels 3 to 5, but will ***not*** be demonstrated at this time:

Level 6. Conversion of any systems level 3 to 5 to Small bore central sewer system STEP (Septic Tank Effluent Pumping) System.

Level 7. Sewage Treatment and Disposal System. Treatment of septic tank effluent from the STEP collection system by a total retention Facultative Lagoon. This would consist of a shallow excavation with earthen embankments to form a lagoon or pond of 1.5 to 2.0 meters depth with a storage capacity of a 6- to 12- month flow. Treatment would occur by natural bacteriological and biological action. Treatment would continue through the winter under ice cover. Under most design conditions, the flow would be expected to be dispersed by lateral and vertical infiltration into the groundwater regime (the lagoon would be unlined) and by evapotranspiration into the atmosphere. Under exceptional circumstances it may be necessary to use temporary spray irrigation onto the adjacent steppe should accumulation of liquid warrant. After many years of operation solids would accumulate and reconstruction would be appropriate.

A very suitable site for the demonstration of Level 5, the larger scale contour system, would be at the Regional Airport at Kzyl Orda. The existing facilities for passengers and staff at this locality are extremely primitive and insanitary. A comparatively small investment would have far reaching effects because it would be noticed by thousands of travelers, many of them local politicians and officials. With appropriate descriptive displays, the technology would have the potential to be transferred to other areas of the country.

Appendix E
Hydraulic Surge in Transmission Main

Appendix E
Hydraulic Surge in Transmission Main

Approximate calculations based upon available data.

Assumed parameters:

Section PS 2 to PS 3
length 81.5 km, diameter 1 m, velocity 0.8 m/sec. (Vo)
Static head 20 m, Dynamic head 38 m, total 58 m
Effective thickness of prestressed concrete pipe as mild steel 10 mm
(allowing for steel cylinder, pre-stressing wire helix and concrete)

Velocity of pressure wave (a) 1017 m/sec
Reflection time of wave (T) 160 sec
Maximum possible deceleration surge pressure a.Vo/g = 83 m
Pump will shut down on power outage in less than reflection time, therefore the maximum surge pressure will be generated. As the wave will be negative the pressure will drop below the vapor pressure of the water and separation of the water column will occur. Recombination of the water column may produce higher positive pressures than the deceleration surge.

If head is allowed to drop to no less than 8 m, deceleration of water column will be 0.006m/sec/sec and column will stop in approximately 130 seconds. A surge tank or tower would be required to deliver 85 m^3 of water in that time and an orifice of 200-mm diameter would produce the required flow. The recommended capacity would be at least 100 m^3, but should be confirmed by more precise calculations.

Appendix F
Trip Itinerary of David Pask

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Trip Itinerary of David Pask

1995

August	27	Depart West Virginia
	29	Arrive Almaty, Kazakstan
	30	Orientation and preparation
September	1	Orientation and preparation
	2	Travel to Kzyl Orda
	4	Meeting with Federal Water Resources Commission
	5	Travel to Aralsk
	6 to 15	Inspection and investigation of Aralsk water supply and sanitation systems
	16	Travel to Novokazalinsk
	17 to 22	Inspection and investigation of Nova Kazalinsk and Kazalinsk
	22	Water supply and sanitation systems
	23	Travel to Kzyl Orda
	24 to 25	Travel to Almaty
	25 to 29	Drafting strategy on sanitation Collection of additional data
	29	Drafting initial reports
	30	Depart Almaty, via United Kingdom
October	3	Arrive West Virginia

Appendix G
Cost Estimates of Some Materials for Construction

Appendix G

Preliminary Cost Estimates of Some Materials for Construction

The following costs were obtained by telephone conversation with a limited number of suppliers in the United States in January 1996. These costs may only be used for very approximate budgeting purposes and cannot be guaranteed or verified.

Polyethylene Pipe

High density polyethylene pipe of Dimension Ratio (DR) 17, suitable for drinking water distribution at a working pressure of 100 pounds per square inch (psi) or 7 atmospheres.

Prices ex-factory		
6-in. diameter nominal (150 mm)	$2.35/ft	($8.95/m)
8-in. diameter nominal (200 mm)	$3.98/ft	($13.06/m)
12-in. diameter nominal (300 mm)	$8.70/ft	($28.54/m)

4 in. to 12 in. Fusion welding machine	$25,000.00
4 in. to 8 in. Fusion welding machine	$14,000.00

Example:

one truck load of 8-in. diameter pipe is 3,600 ft. (1,097 m)

Ex manufacturer	$14,328.00
Trucking to west coast port	$ 1,500.00
Shipping to Kazakhstan	$12,000.00
Total	$27,828.00

Stand Pipe Tank

One sectional tank of 35,000 gallons (1,350 m^3), 29 ft. (8.8 m) diameter by 72 ft. (22 m) high (supplied as pre-formed, drilled and epoxy coated steel plates with sealed bolts and other materials loaded into two shipping containers):

Cost ex-factory	$75,000.00
Shipping to Kazakhstan	$16,000.00

Additional costs to be applied:

Concrete pad foundation
Assembly on site (1,000 man hours)
Crane and other equipment rental
Fittings and Connection to water mains
Supervision

Appendix H

Aralsk: Hydraulic Analysis of Proposed Replacement Water Distribution System

Appendix H

Aralsk: Hydraulic Analysis of Proposed Replacement Water Distribution System

This analysis is based upon a basic network of 200-mm diameter polyethylene pipes laid along all streets to be served by fire hydrants, 100-mm diameter pipes in all other streets and a 300-mm diameter trunk main from the pumping station to a stand pipe tower 25 m high, replacing the demolished tower. Three scenarios are represented. The first simulates a normal peak demand of 420 l/sec. (36,000 m^3/day) distributed evenly throughout the town. The second superimposes a fire hydrant flow of 63 l/sec (1,000 U.S. gal/min) in the S.W. perimeter on the normal peak demand. The third situates the hydrant flow in the N.W. perimeter.

The simulations were performed by computer using a program, "EPANET4W," developed by the U.S. Environmental Protection Agency, ORD, Cincinnati. With the pump specified, in the first scenario the pressures in the system range from approximately 15 to 34 m head. In the second the pressure drops to 2.7 m at the operating fire hydrant (Node 12 on the diagram, page H-5). This is adequate for pumped fire appliances. In the third scenario the pressure drops to 13.3 m at the hydrant at node 25.

Partial Tabulation of Data Output

Scenario 1

Input Data File: kzanet5
Output Report File: kzanet5r
Map File: KZANET3.MAP
Number of Pipes: 57
Number of Nodes: 42

Scenario 1: Node Results				
Node	Elevation (m)	Demand (L/s)	Grade (m)	Pressure (m)
1	58.00	10.00	92.02	34.02
4	59.00	10.00	80.09	21.09
7	60.00	10.00	81.44	21.44
11	60.00	10.00	74.89	14.89
12	60.00	10.00	74.88	14.88
22	60.00	10.00	79.78	19.78
25	60.00	10.00	79.56	19.56
32	60.00	10.00	80.53	20.53
37	58.00	10.00	85.30	27.30

Scenario 1: Pipe or Link Results						
Pipe	Start Node	End Node	Diameter (mm)	Flow (l/s)	Velocity (m/s)	Head loss (m/1,000 m)
3	3	4	296.00	64.56	0.94	2.36
7	7	8	296.00	-123.22	1.79	7.80
30	24	23	203.00	22.51	0.70	2.11
45	42	32	203.00	29.23	0.90	3.42
53	34	33	203.00	15.35	0.47	1.04

(Pump)
57 41 40 276.78 96 kW -35.53 Pump

Scenario 2

Input Data File	kzanet6
Map File	KZANET3.MAP
Number of Pipes	57
Number of Nodes	42
Number of Tanks	2
Number of Pumps	1

Scenario 2: Node Results				
Node	Elevation (m)	Demand (L/s)	Grade (m)	Pressure (m)
1	58.00	10.00	91.04	33.04
4	59.00	10.00	76.77	17.77
7	60.00	10.00	80.11	20.11
11	60.00	10.00	62.95	2.95
12	60.00	73.00	62.66	2.66
22	60.00	10.00	77.67	17.67
25	60.00	10.00	77.52	17.52
32	60.00	10.00	78.64	18.64
37	58.00	10.00	83.84	25.84

Scenario 2: Pipe or Link Results						
Pipe	Start Node	End Node	Diameter (mm)	Flow (l/s)	Velocity (m/s)	Head loss (m/1,000 m)
3	3	4	296.00	76.21	1.11	3.21
7	7	8	296.00	-171.94	2.50	14.45
30	24	23	203.00	22.39	0.69	2.09
45	42	32	203.00	30.54	0.94	3.71
53	34	33	203.00	15.59	0.48	1.07

(Pump)
57 41 40 291.06 101 kW -35.21

Scenario 3

Input Data File	kzanet7
Output Report File	kzanet5r
Map File	KZANET3.MAP
Number of Pipes	57
Number of Nodes	42
Number of Tanks	2
Number of Pumps	1

Scenario 3: Node Results				
Node	Elevation (m)	Demand (L/s)	Grade (m)	Pressure (m)
1	58.00	10.00	90.65	32.65
4	59.00	10.00	77.91	18.91
7	60.00	10.00	80.28	20.28
11	60.00	10.00	72.99	12.99
12	60.00	10.00	72.98	12.98
22	60.00	10.00	75.24	15.24
25	60.00	73.00	73.31	13.31
32	60.00	10.00	75.47	15.47
37	58.00	10.00	82.81	24.81

Scenario 3: Pipe or Link Results						
Pipe	Start Node	End Node	Diameter (mm)	Flow (l/s)	Velocity (m/s)	Head loss (m/1,000 m)
3	3	4	296.00	62.62	0.91	2.23
7	7	8	296.00	-166.47	2.42	13.61
30	24	23	203.00	28.83	0.89	3.33
45	42	32	203.00	34.31	1.06	4.60
53	34	33	203.00	18.89	0.58	1.52

(Pump)
57 41 40 296.53 102 kW -35.08 Pump

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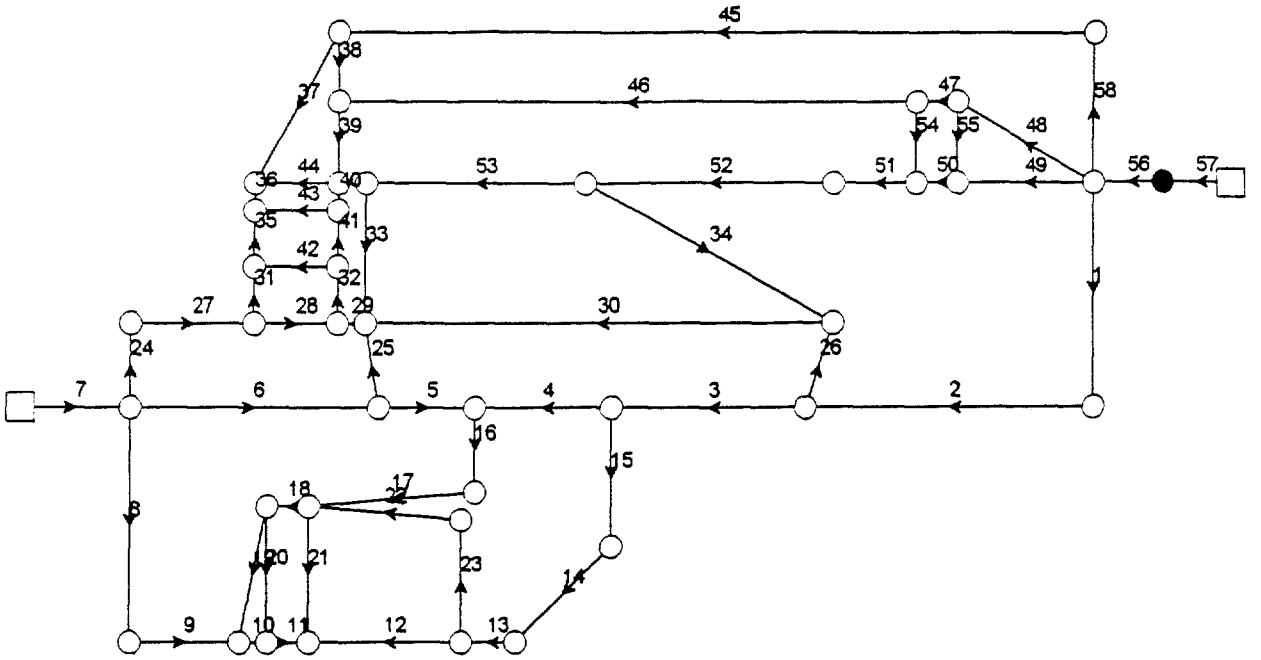
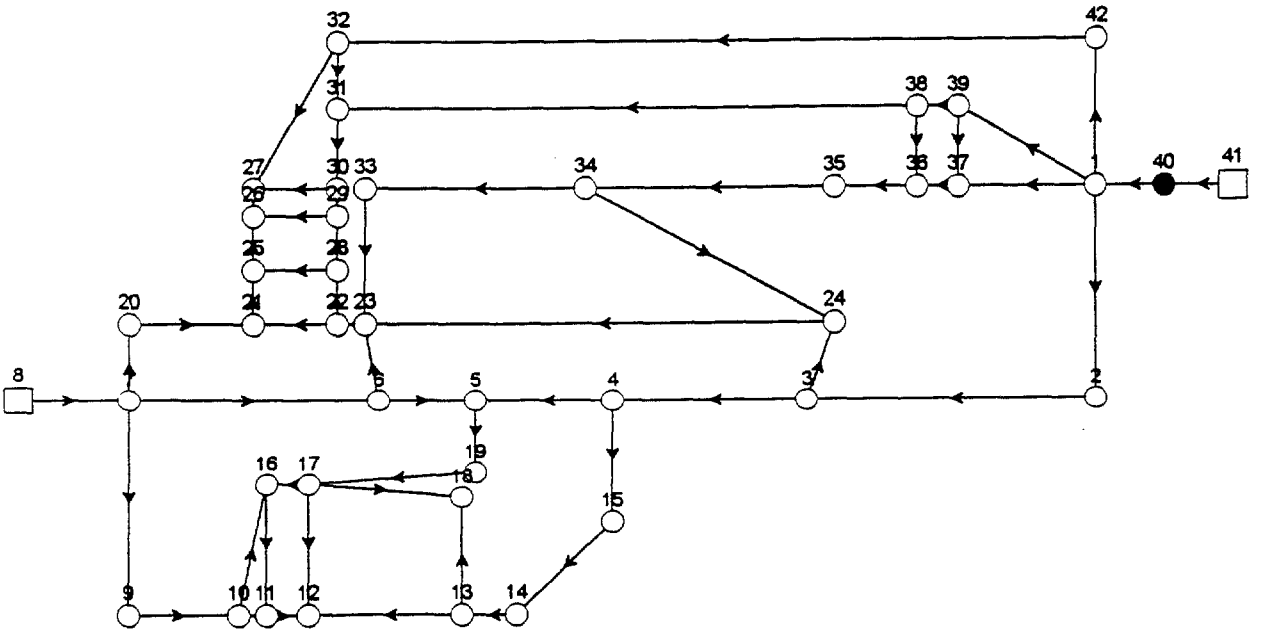
Diagrams

PIPE NUMBERS



NOTE Pipe numbers 1 through 7 are 300 mm diameter, the remainder are 200 mm diameter. Pipes of 100 mm diameter are not shown.

NODE NUMBERS



Reservoir - Node 41, Pump - Node 40, Elevated Tank - Node 8
Fire Hydrants are simulated at Nodes 12 & 25