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For the New Independent States
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By
A USAID Project Consortium Led by CH2M HILL

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Prepared by
Ukraine, Belarus & Moldova Regional Office
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PREFACE

Under the 1992 Freedom Support Act the United States Congress initiated a program to provide various forms of assistance to new independent states (NIS) of the former Soviet Union Cooperative Agreements were signed between representatives of the U S government and each country in which assistance was to be undertaken The U S Agency for International Development (USAID) was given the responsibility to coordinate all U S government assistance to the NIS under the Act

Through competitive bidding USAID awarded a multi-year contract to a team managed by CH2M HILL International Services Inc (CH2M HILL) to support implementation of an environmental assistance program to republics of the former Soviet Union Under this contract, termed the Environmental Policy & Technology (EPT) Project CH2M HILL is to assist USAID s missions in Moscow Kyiv and Almaty undertake a program to promote environmental improvements in the NIS The USAID mission in Kyiv supports environmental and other, assistance programs to Ukraine Belarus, and Moldova CH2M HILL established an office in Kyiv from which to perform services in these countries under the EPT Project

This report was prepared as a contractually required deliverable under a contract between USAID and CH2M HILL Although work on this report was conducted in cooperation with the assisted governments and USAID the findings and recommendations are those of the CH2M HILL team They do not necessarily represent official positions of the governments of the assisted countries nor of the United States of America

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- Consortium for International Development
- Ecojuris
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NOTIFICATIONS

NOTE ON TRANSLITERATION

Ukrainian personal, institutional, and place names used in EPT documents are transliterated into English from Ukrainian (not Russian) according to the modified U S Library of Congress standard for Ukrainian-to-English transliteration that has been adopted by many Western organizations and publications, including the *Encyclopedia of Ukraine* (University of Toronto Press, 5 vols, 1984-1993) and O Subtelny's authoritative *Ukraine A History* (University of Toronto Press, 1988, 2nd edition 1994), as well as by the Ukrainian Commission on Legal Terminology (Resolution No 9 dated 19 April, 1996)

NOTE ON COST ESTIMATES

The opinions of cost shown, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time the opinion was prepared The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors As a result, the final project costs may vary from the opinions of cost presented herein

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ABBREVIATIONS, ACRONYMS & GLOSSARY

A	Ampere
atm	atmosphere
BAH	Booz, Allen and Hamilton
CCN	Cooperating country national
CH2M HILL	CH2M HILL International Services, Inc A U S -based international environmental engineering consulting firm under contract to USAID to implement a large component of the EPT Project
COWI	COWI Consultants (Denmark)
DHF	District Heating Facility
DMT	District Maintenance Team
DO	Delivery Order
EBRD	European Bank for Reconstruction and Development
EPANET	Computerized simulation model
EPT Project	Environmental Policy & Technology (Project) A USAID-funded program to provide environmental assistance to New Independent States of the former Soviet Union
FSU	Former Soviet Union
h/d	hours a day
IC	Instrumentation and control
IFI	International Financial Institutions
konto	Vodokanal customer account based on a water supply connection
kW	kilowatt
kWh	kilowatt hour
lcd	liters per capita per day
LVK	Lviv Vodokanal (municipal public water utility)
MDAS	Monitoring and Data Acquisition System
m/s	meters per second
m^3/d	cubic meters per day
m^3/h	cubic meters per hour
m^3/mo	Cubic meters per month
mg/l	milligram per liter
N/D	no data
NIS	New Independent States (of the former Soviet Union)
No	number
PADCO	Planning & Development Collaborative, Inc A U S -based consulting firm under contract to USAID to implement part of the U S government's assistance program to Ukraine's housing and communal services sector
PS	Pump Station
TDH	Total Dynamic Head
UAH	Ukrainian hryvnia
US $ or USD	United States dollar
USAID	U S Agency for International Development
V	Volt
VAT	Value Added Tax

vodokanal	A quasi-government agency responsible for municipal water supply and wastewater collection and treatment A U S analogue would be a water utility
Water '98	Program for improving water supply in Lviv
WB	World Bank (International Bank for Reconstruction & Development)
WF	Well Field
WWTP	Waste Water Treatment Plant
ZhEK	A municipal entity responsible for operation and maintenance of houses and multi-apartment buildings owned by city administrations, as well as water, sewerage, gas, electricity, and heating systems within them

Section 1
INTRODUCTION

As part of a United States government bilateral assistance program, the U S Agency for International Development (USAID) is supporting environmental management in Ukraine Under direction from USAID, a consortium led by CH2M HILL International Services, Inc (CH2M HILL), is implementing part of USAID's Environmental Policy & Technology (EPT) Project by undertaking various tasks that have been agreed to by representatives of the governments of both countries

Under Delivery Order (DO) #9, Task U2 (Urban Water Management Demonstration), the EPT Project has provided evaluation (intervention), technical assistance, training, and equipment to the city and vodokanal (municipal public water utility) of Lviv in order to

> *develop technical and management model methodologies that will serve as a model for nationwide implementation of municipal water and wastewater sector economic reforms and at the same time reduce environmental health threats from poor drinking water quality*

This report is the final report for DO #9, Task U2 and contains a general summary of the information that was gathered in the tasks that were undertaken

The EPT Project established an office in the building used by Lviv Vodokanal (LVK), and a cooperating country national (CCN) staff of engineers, economists, computer specialists, and translators were hired to work on the project, supervised by an expatriate task leader and an expatriate senior technical adviser The Ukrainian engineering professionals were the key to this project Although most could not speak English they performed the investigations, analyzed data and prepared the reports (in Ukrainian) These reports were then translated into English, reviewed and edited by the expatriate staff and submitted to USAID as completed documents

Section 2
CONTRACTOR CO-ORDINATION

During the period 1995 through 1997 when the current DO 9 was in effect, USAID had two contractors working in Lviv with the municipality and the vodokanal This included CH2M HILL, funded under the Environmental Policy and Technology (EPT) project, and Planning & Development Collaborative International (PADCO), funded under the Shelter Sector Reform program

In addition, World Bank (WB) personnel made a series of visits to Lviv and came to some preliminary understandings with both the municipality and the vodokanal related to potential reorganization and possible loans They employed a Danish contractor, COWI to work on certain aspects of the Lviv Vodokanal's operations related to identifying potential WB-funded projects and ensuring that the financial situation will allow the repayment of loans to the WB The WB has expressed an interest in assisting the Lviv in privatizing or otherwise restructuring the vodokanal organization to promote efficient management and investment of capital (including possibly WB loans) to improve service

The activities of the three contractors were closely aligned with the Lviv Vodokanal and successfully complemented and reinforced each other to assist not only the vodokanal in Lviv but to be of benefit to many of the other vodokanals in the Ukraine

Table 2-1 is a summary of the activities that each of the three consultants relative to the Lviv Vodokanal

Table 2-1
Summary of Work by Contractors Related to the Lviv Vodokanal

Investigations	Contractors		
	CH2M HILL	PADCO	COWIconsult
Contract with	USAID - Environmental Policy & Technology program	USAID - Shelter Sector Reform program	The World Bank
Topic	Water only	Water only	Water & wastewater
Physical aspects of the water supply & distribution system	Yes - Concentrate on distribution in the city	No	Yes - Concentrated on water supply and transmission to the city
Physical aspects of the wastewater system	No	No	Yes
Evaluate water system operation & maintenance	Yes	No	Not specified
Water tariff structures	No	Yes - developed tariff rates (water only)	Yes - looked at water and wastewater
Finances	Yes - reviewed a financial methodology	Yes - developed information on expenditures and revenues in the Vodokanal	Yes - oriented towards capacity to support investments and ability to repay WB loans
Implementation plan for future water projects	Yes - as part of an overall strategy	No	Yes - oriented to what should be funded by the WB
Implementation plan for future wastewater projects	No	No	Yes - oriented to what should be funded by the WB
Demonstration project on the distribution system	Yes	No	No
Organization structure	Yes - reviewed program for overall institutional strengthening	No	Yes - oriented to establishing an autonomous utility
Ability of community to pay increased water tariffs	No	Some degree	Extensive study
Examine the legal relationship between the Vodokanal & other government agencies	No	Yes	No
Develop guidelines for use with all Ukrainian Vodokanals	Yes - strategic planning and institutional strengthening	Yes - legal reforms	No
Write terms of reference for contract operations or privatization	No	No	Yes

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Section 3
CURRENT WATER SYSTEM

3 1 OVERALL

The water supply in Lviv serves about 800,000 people Many parts of the service area receive water for only about six hours a day The water system suffers from an infrastructure which needs substantial replacement, and revenues which do not match expenses associated with system operation and maintenance

The City of Lviv is over 700 years old and its present public water supply and distribution system was started about 100 years ago The city obtains its water from 20 well fields located outside the city perimeter In order to obtain sufficient suitable water, the more recent well fields have been established as far away as 100 km from the city center (see Figure 3-1)

Water is pumped in from the well fields in transmission mains Usually these terminate at large pump stations at the city boundary, where additional pressure is added to facilitate water distribution within the city The city itself is built on a series of low hills and there is an elevation difference within the city of about 120 m In 1995, an average of about 335,000 m^3/d was pumped into the city distribution system The system has been divided into six theoretical distribution areas These are generally associated with individual well field transmission lines and/or pump stations on the edge of the city Much of the water distribution system for the city and outlining areas was built in the period 1970-1985 while the city was expanding to serve industrial facilities Lviv's historic water consumption is shown in Table 3-1

Due to an overall shortage of water (relative to usage demands within the system's distribution areas) the LVK is unable to maintain pressure throughout the system and the resulting service to the consumers is dependent on the location, elevation and demand in any area A portion of this usage is leakage within the distribution system This is assumed to be at least 20 percent and may be as high as 40 to 50 percent in some areas Portions of the installed distribution system have proved to be very susceptible to failure The reasons for this appear to be partly due to the joining cast iron pipe with mortar filled joints, and the use of thin-walled, uncoated, rolled-steel pipe that was supplied to the city during part of the post-war expansion This steel pipe suffers from localized surface (interior and exterior) corrosion, which creates numerous holes or weep-spots along the pipe This problem may be aggravated by the electric trams that operate in the city with resultant stray currents being grounded on the steel pipe (water mains) below the streets

During winter there is an additional problem with freezing water which can burst the piping The 1995-1996 winter was particularly harsh, and the frost line migrated down to the depth of the water mains in parts of the city This situation is further aggravated by stagnant flow in some of the pipes due to water outages

In 1994 the government of the City of Lviv directed a study to determine what would be necessary for the city to be able to have water 24 hours per day by the year 1998 The study,

entitled *Water '98*[1], developed a list of projects to improve the system The estimated cost of constructing all the projects was about US$ 550 million The study named some 10 activities, referred to as Category 1 projects, that would enable the city to have water 24 h/d The estimated total of these Priority 1 projects was about US$ 75 million These Priority 1 projects were associated with building a new well field about 80 km east of Lviv

The lack of water meters in the system, and potential inaccuracies in installed equipment and previous logged measurements of water, means that there is only a general understanding of how much water is produced and used

The extent of leakage is not known, and without universal metering of the system (it is reported that only 17 percent of the water is now metered), it is difficult to accurately gauge the extent of leakage Even in a system that is universally metered the amount of unaccounted-for water is usually in the range of 10-20 percent The official leakage estimate in Lviv is about 30 percent, which includes wastage by the consumers In fact, the amount of water lost from the system due to leakage is probably more, and would vary depending on the operating conditions of the system

The cost of energy for LVK constitutes 60-70 percent of the total cost of water production The proportion keeps increasing as the cost for electricity rises in accordance with national government policies and regulations This proportion, although similar to other vodokanals in Ukraine, is very high relative to most water utilities in other countries, and reducing energy is an obvious area on which to focus efforts and investment

Investment aimed at reducing energy consumption is critical to the long term viability of LVK If additional water is produced at the well fields and pumped into the system it could increase energy consumption without substantially increasing revenues This is because satisfying increased demand from consumers paying a flat rate for water would use more water without a commensurate boost in revenue This could make the financial position of LVK very difficult

The main usage of energy is for pumping and this is where energy reductions must be implemented This would be done by making wells and pump stations more efficient, or by modifying the overall operation of the system

3.1.1 Source of Water

The city of Lviv draws water from 173 wells in 20 different well fields The well fields are located at distances of 10 to 80 kilometers from Lviv Based on these locations and the connection they have to the water distribution system, they have been divided into four groups (North, West, South, East) The locations of the well fields are indicated on the map in Figure 3-1

Each group includes the following number of well fields and wells

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[1] *Water 98* was published in Ukrainian in October 1995 by a special task force which investigated the water supply situation in Lviv and presented certain solutions

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Group	Well Fields	Wells
North	7	45
West	6	53
South	4	59
East	3	16
Total	20	173

In addition to Lviv, the system supplies water to 90 villages and four towns, located in the zone of influence of the Lviv well fields

Water from 17 of the well fields is within the quality norms set by the State Drinking Water Standards (1984) Aggressive carbonic acid and hydrogen sulfide is present in small quantities at the Pluhiv well field Iron is present in the well fields at Remezivtsi and Budzen Total hardness of water in all well fields varies from 8 to 9 mg/l expressed as $CaCO_3$

The total potential yield of Lviv underground water resources is estimated at 730,000 m^3/d Present design capacity is based on the assumption that water is abstracted from 173 wells and is estimated to be 538,000 m^3/d According to LVK data, the water production in 1995 was possibly closer to 412,000 m^3/d The data on design capacity and actual yield of each well field are given in Table 3-2

3 1 1 1 Wells

Well design and aquifer characteristics can be divided into the following types according to the general geological and hydrogeological location of the well fields, the depth of water-bearing strata and water-bearing rock lithology In general

- all seven northern and two of the eastern well fields draw from upper Cretaceous siltstone and chalk deposits
- all six western and two of the southern well fields draw from Miocene sandstone
- the southernmost field (Stryi) draws from shallow quaternary alluvial complex
- one eastern field (Pluhiv) draws from the middle Devonian limestone interspersed with sand

The summary of depth and the casing used is as follows

Group	Depth (m)	Screen Diameter (mm)
North	60-75	377-426
West	45-85	377-426
South	30-75	426
East	70-200	426

Most of the wells have been constructed using a rotary-wash technique, which tends to negatively affect their operating lifespan Wells of the Stryi southern well field have been constructed using a percussion drilling technique Geological profile and well design as well as photo of the wire filter are shown at Figure 3-2

All the wells have Moldavian made (Moldavhidromash and Kishiniov) and Ukrainian made (Electroremontny plant, Sevastopil and Hydromash, Berdiansk) submersible well pumps installed Information on the well pumps in the Lviv well fields is given in Table 3-3

The time between repairs of pumps varies from one week to two years, with an average of seven to eight months Pumps are repaired by LVK in their workshops which are supervised by the chief mechanic When purchasing pumps, LVK tries to obtain the recommended mechanical and electrical spare parts from the manufacturers The time needed for a typical submersible pump repair is about five weeks This includes a week for dismantling and shipping to the workshop, and up to four weeks for actual repair

All well pumps operate 24 hours a day, and deliver water to the transmission pump stations Most of the transmission pump stations have tanks, although at some of them there are no tanks (Volia Dobrostanska, Velykopole, Kamianobrody)

3 1 1 2 Major Problems

Based on discussions with well field managers and an analysis of well field conditions, their operation and measurements, the following major problems have been identified

1 Low well field production The present production of the northern and western well fields (Karachyniv subsystem) is 50% lower than their design capacity, the safe yield

2 Flow meters do not exist at well fields Measurements of water produced are based on power consumption This method may not be correct since well production reduces with time, while power consumption remains at the same level Throttling pumps with valves distorts the relationship between power and production

3 Not enough money is spent on well field maintenance Insufficient means are available for well field maintenance, rehabilitation and repair, which leads to frequent down time and low water production

4 Well fields are not efficient as a result of poor design and/or reconstruction Pump characteristics at some well fields do not achieve the most efficient mode of work Well screens are of low quality The range of pumps available is not wide enough to provide efficient operation of well fields

5 Water quality factors The quality of water is generally acceptable Iron is a problem in the well fields at Budzen, Bibrka and Remezivtsi, and there is some treatment at the latter two locations only Aggressive water is a problem in Pluhiv To avoid corrosion the water is air stripped just after reaching the surface, but nevertheless causes a

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number of maintenance problems due to corrosion of the pipes and well casings Ammonium is higher in some wells than the European standards, this is particularly observed in Budzen, and it could be an indicator of contamination Traces of Strontium (Sr) can be found in some well fields, but it does not exceed the norms

3.1.2 Transmission System

The transmission system is divided into four major subsystems to match the well field groups The systems are made up of pipelines, tanks, and transmission pump stations The water is transmitted to the Lviv city distribution system according to the classic pumping process well - transmission line - tank - transmission pump station - transmission line - tank - city pump station The location of the major water supply lines is presented in Figure 3-3

When designing transmission mains it is assumed by LVK that the capacity of all well fields is equal to the safe yield plus 50 percent of the added yield, and that all this water is pumped further by transmission pump stations The optimum velocity for the majority of pipes is 1 2 to 1 3 m/s For now most of the well fields actually produce less water than their design capacity yield (see Table 3-2) Under such conditions velocity in the transmission mains is generally less than 1 m/s, so head losses is not significant

Transmission mains pipes are made of steel, cast iron and reinforced concrete with diameters of between 500 and 1400 mm The diameter and the material often vary even on the same transmission main, since supply shortages during construction resulted in using whatever diameter and material could be obtained at the time

The city of Lviv receives water from the transmission system through seven major city pump stations located around the city perimeter These pump stations add pressure to ensure water distribution around the city network

The total volume of water tanks located at the city and booster pump station sites, plus the volume of gravity tanks, is 141,000 m^3 This volume constitutes over 40 percent of average daily consumption

3 1 2 1 Transmission Mains

In accordance with the location of well fields, the transmission system is divided into four major systems

1 The Northern System This system includes transmission mains that were constructed during the period 1965-1973, totaling approximately 102 km Pipe diameters vary in the range of 200 to 400 mm for the feeder pipelines and 500 to 1000 mm for the transmission mains Transmission pipes are made of steel, cast iron and reinforced concrete

2 The Western System This system includes two major transmission mains

- The Karachyniv System These transmission mains were constructed during the period 1901-1935 with additional work in 1965, totaling approximately 83 km, pipe

diameters are 350 and 600 mm The transmission mains constructed during this period utilize British and Polish made cast iron pipes that have lead caulked socket ends The transmission mains constructed in 1965 utilize Soviet made steel pipes of 600 mm diameter

- The Budzen System These transmission mains were constructed in 1964, totaling approximately 18 km, pipe diameters vary in the range of 700 to 900 mm Transmission pipes are made of steel and cast iron

3 The Southern System This system includes four major transmission mains

- The Malechkovychi System These transmission mains were constructed in 1932, totaling approximately 14 km, pipe diameter is 225 mm The transmission mains utilize Polish made steel pipes

- The Hlynna-Navaria System This transmission main was constructed in 1971, totaling approximately 14 5 km, pipe diameters vary in the range of 600 to 700 mm Transmission pipes are made of steel

- The Sokilnyky System This transmission main was constructed in 1989, totaling approximately 75 km, pipe diameter is 1200 mm Transmission pipes are made of steel

- The Stare Selo System This transmission main was constructed in 1973, totaling approximately 15 9 km, pipe diameter is 600 mm Transmission pipes are made of steel

4 The Eastern System These transmission mains were constructed during the period 1982-1990, totaling approximately 109 km, pipe diameters vary in the range of 700 to 1200 mm Transmission pipes are made of steel and reinforced concrete

Based on assessments made by LVK, the condition of the 458 km of transmission mains can be classified as follows

- Bad condition, needing frequent repair 117 km or 26%, constructed mainly during the period 1945-1975

- Acceptable condition 128 7 km or 28%

- Good condition 212 3 km or 46%

3 1 2 2 Village Supply

Approximately 90 villages, with a total population of about 67,000 inhabitants, are supplied directly from the Lviv water supply system The figures include villages with less than 50 inhabitants and towns with populations of over 5,000

Some of these villages are connected directly to feeder pipes from single wells These villages often have very high water pressure, which can exceed what is necessary for a satisfactory supply Other villages are supplied directly from the transmission mains, where the pressure is normally in the range of 1 to 5 atm, which is a satisfactory range

According to LVK reported data, the number of villages supplied from the four major water transmission systems, and the amount of water supply, are as follows

- Northern system - 53 villages (about 3,285 m^3/d)
- Western system - 19 villages and towns (about 7,604 m^3/d)
- Southern system - 10 villages, (about 2,450 m^3/d)
- Eastern system - 11 villages and towns (about 5,931 m^3/d)

The total supplied is about 19,270 m^3/d

3 1 2 3 Pump Stations

The various pump stations that pump water to the Lviv water supply system are divided into transmission, city, and city booster stations The general condition of pump station sites can be classified as acceptable, and is presented in Table 3-4 Most pump stations have water tanks with the volume ranging from 100 to 10 000 m^3

All transmission pump stations are operated 24 hours a day and transmit water from the well fields to the city pump stations

The water distribution network of Lviv is supplied from seven pump stations located around the city perimeter These pump stations supply water to the city distribution network directly, or they transmit water to booster pump stations or tanks located directly within the distribution system, that subsequently deliver water into the distribution system, or they operate both ways

According to LVK data the average total daily supply from these seven pump stations for 1996 was 320,000 m^3/d Detailed data on the city pump stations is given in Table 3-5

In addition, there are four booster pump stations located within the City boundaries Yanivska, Kryvchytsi, Dovha, and Miska Smuha

All well pumps are operated 24 hours a day They deliver water to the transmission pump stations Some of the stations have water tanks, others do not

The steady, 24-hour pumping from the transmission pump stations is manually adjusted to the supply from the well fields, thus the stations have to be staffed continuously The pumping from the transmission pump stations is adjusted by throttling or opening of valves, not by switch-on/shut-off instructions from the dispatcher's office Transmission pump stations with no tanks are operated on a 'noise level' basis This means that if there is insufficient feed water that the pump starts to cavitate creating a noise in the pump casing The operator than throttles the pump until cavitation stops Transmission pump stations with water tanks are operated by observation of the water level in the tank

Transmission pump stations transmit water to the tanks of the city pump stations These pump stations supply the city distribution network, including tanks and booster pump stations, primarily according to a six hour schedule of two periods lasting three hours each (6 00 to 9 00 am and 6 00 to 9 00 pm)

During these pumping periods, the tanks of the city pump stations are emptied down to the minimal water level, and the interim period is used to refill the water tanks

Sokilnyky pump station provides approximately one third of the total daily water supply to the city - 115,000 m^3/d A detailed analysis of the actual operation of this pump station showed that the actual daily energy consumption constitutes 200 percent of the productive theoretical consumption Schematic diagram of the Sokilnyky PS as well as photo of this pump station is shown at Figure 3-4

However, not all pump stations are operated like Sokilnyky At Budzen III, Sykhiv III, Zboisk, and Karachyniv pump stations, pumps are switched off during the periods of low supply However, even at these stations some occasional throttling of pumps is also practiced

3 1 2 4 Major Problems

Analysis of the Lviv water transmission system performance for 1995 revealed some of the following major problems of the transmission system

1 Age of the equipment The age of pumps in operation at many pump stations exceeds 20 to 25 years, some pumps have been operated for over 50 years

2 Energy effectiveness The actual capacity of many pumps in operation at the pump stations does not correspond to the supply from connected well fields Some booster pump stations are not provided with water tanks At other stations, the tanks are too small to ensure smooth operation of the booster pumps Several pump stations are operated without water tanks, thus operation of pumps at these pump stations depends on alterations in operation of the related well fields It means that the pumps need to be constantly throttled The result is higher unit energy consumption

3 Transmission line pipe material The frequency of failure by breakage for the transmission lines is high, and is highest for the western transmission system The weak point of the transmission system is reinforced concrete pipes - bell and spigot connections at the socket ends However, frequent breakages are also observed at connections between reinforced concrete and steel pipes

4 System hydraulics The direct pumping from wells and well fields to the transmission mains presents a potential problem Many of the well pumps have not been adjusted for changes that have taken place in the system's hydraulic conditions since its installation e g , new wells connected to the system or changes in the transmission mains In addition, the well pumps that are worn out or broken down are replaced by available pumps rather than by pumps designed to suit the hydraulic condition of the actual transmission system This results in operation of a significant number of pumps

outside their optimal ranges resulting in high unit energy use for water abstraction An example is the northern system where seven well fields with 44 wells, pump water directly to the transmission mains over a distance of 39 km

5 Other problems include wastage and consumption in villages, village supply (pressure and wastage), leakage, and insuffuicient storage tank volumes

3.1.3 Distribution System

3 1 3 1 Overview

The existing water supply system of Lviv has been developing and expanding concurrently with the city's development and construction of new well fields The water distribution system was designed on the basis of future water demands of new developing residential and industrial areas The pipes sizes were determined on the basis of hydraulic and technical-economic calculations based on the maximum normative water flow rates in pipes, and the flow rate required to meet fire fighting needs

The nearest pump station would supply these new areas with water, if the pump station's production and pressure were sufficient Otherwise, a new well field was designed with a pump station If the pressure of the existing pump station was not sufficient, local district heating facilities with booster pump units would create the necessary pressure

Cast iron pipes were generally used for the distribution network pipelines Beginning in 1980, steel pipes have also been used, pipes were laid at 1 6-1 8 m below ground to avoid freezing

Taking into account the 150 m difference in elevation within the city boundaries and the location of the existing pump stations, the schematic layout suggested dividing the water supply network into six zones each zone was to be supplied with water from pump station or by gravity from water storage tank Each pump station was to have storage tanks with sufficient water for fire fighting purposes in the given area Implementation of the schematic layout was finished in 1982

Presently the existing city distribution system is based on the above mentioned schematic layout and consists of

- ten pump stations, located either within the city limits or at the city boundaries, which serve to establish the necessary pressure in the network
- water storage tanks located close to the pump stations, used for storing and regulating water, and for fire fighting needs The Yanivska pump station is an exception because it takes water directly from a pipeline and does not have any tanks
- water chlorination units are located in the vicinity of the four major pump stations

The total length of the distribution system is 900 km Of this, 182 km consists of pipes which are 200 mm and larger

Due to a great number of valves which do not work, pressure zoning is hypothetical and zones are just associated with the pump stations The scheme of the network pump stations and zones are presented in Figure 3-5

At present, 70 percent of the residential sector has a six-hour scheduled water supply three hours in the morning and three hours in the evening and only 20 to 30 percent of residents receive water 24 hours a day

In view of growing housing and industrial construction in the 1980s, a new schematic layout had to be developed The revised *Schematic Layout of the Water Distribution System Development of Lviv* was accomplished by the Lvivdiprokomunbud Design Institute in 1987 This outlined the principal development direction of the water distribution system through 2005

3 1 3 2 Pressure Zones

The city of Lviv is situated on a land mass where the variance in elevation is 150 m (230 m to 380 m) In the old part of the city buildings generally have three or four floors In the new residential areas most buildings have five to nine stories and some have 14 stories

As the distribution system is not divided into pressure zones (where adequate pressure should be established), there are areas in the city where water is delivered less than 6 hours a day Some residents in these areas (living higher than the 3rd floor) do not receive any water for several days a week In accordance with the *Schematic Layout of the Water Distribution System Development of Lviv*, it was suggested that the distribution system should be divided into thirteen pressure zones It was planned that each zone would have a pump station or a group of pumps at the existing pump station to provide the required pressure in the given zone

Pressure zoning of the water distribution system was to be accomplished with pressure regulating valves The principal data regarding the design zones is presented in Table 3-6 In planning the pressure zones, the following parameters were taken into account

- difference in elevation of the pressure zone territory
- project design of the residential areas and industrial zones
- grouped location of multi-storied buildings
- distance from the pressure zones to water sources

3 1 3 3 Major Water Consumers

Major consumers and their daily average water consumption in the Lviv water distribution system are

- residential sector of Lviv - 164,300 m^3 (52 3%)
- industry - 21,000 m^3 (6 7%)
- communal services - 87,500 m^3 (27 8%)
- budget institutions - 21,900 m^3 (7%)
- populated area of Vynnyky - 2,800 m^3 (0 9%)
- other populated areas - 16,800 m^3 (5 3%)

The population of the city (805,900 residents not including Vynnyky, Rudno, and Briukhovychi) live in apartments (state or privatized), private houses, dormitories and cooperative residential buildings

The City of Lviv has 327 industrial enterprises which in 1987 consumed 129,100 m^3/d (84,000 m^3/d of this amount was consumed through the water distribution system) Presently most enterprises are not functioning, which is why their water consumption from the city distribution system is reduced

The communal consumer group includes both communal services and budget institutions

Entities such as restaurants, cafeterias, hotels, baths, cleaners, sport halls, administrative centers, city motor vehicles and electric transport enterprises, tourist facilities, factory dormitories etc belong to the communal services group

Budget institutions include educational institutions (higher and secondary) and their dormitories, kindergartens and hospitals

The location of many of the major water consumers is presented in Figure 3-6 Correlation between the water demand of various water consumer groups is presented in Tables 3-7

The data in Table 3-7 show that the residential sector is the largest water consumer However, water demand within this group varies for different consumers In the areas with residential buildings that have six and more floors, pressure is established by pumping equipment installed in the buildings because the pressure in the distribution system is not sufficient to provide all the floors with water This pumping equipment usually consists of 2 or 3 pumps installed in the local heating district facility (DHF) The pumps draw water straight from the water distribution system to transmit to the residential buildings Usually one DHF serves 1 to 40 residential buildings (100-30,000 residents) As the district heating facilities take water from the city distribution system, the LVK regards them as major water consumers of the residential sector group The other consumers of this group are grouped by residential buildings

3 1 3 4 Pipe Material

Lviv distribution pipe network consists of cast iron and steel pipes Distribution pipes laid before 1945 are generally British and Polish made cast iron pipes Pipes laid between 1945 and 1975 are mainly Soviet made cast iron and some Soviet made steel pipes Distribution pipes laid after 1975 are mostly steel and partly cast iron pipes of Soviet manufacture The length of pipes in the distribution and transmission system in the past 60 years are shown in Table 3-8

None of the distribution pipes have lining, although some steel pipes have bituminous coating The diameter and age of the distribution system pipes are presented in Table 3-9 according to age (the other 600 km are in the transmission system)

The overall picture is as follows

- Bad condition needing frequent repair — 680 km or 76% of total
- Acceptable condition — 220 km or 24% of total
- Good condition — none

The analysis of the 6,486 breakdowns that occurred in 1995 in the water distribution system gave the following results

- failures in pipes — 57%
- failures in fittings — 28%
- failures in service connections — 13%
- other — 2%

Out of breakdowns in water supply pipes

- 60% were caused by damaged or leaking bell and spigot joints, and
- 40% were caused by holes or cracks in the pipes

The total number of breakages amount to 6 1 per kilometer

3 1 3 5 Main Problems

1 Leakage Considering the number of breakdowns in the distribution network, it becomes clear that the major cause of water losses is the poor condition of the network

Samples of damaged cast iron and steel pipes have been collected and examined The samples show cracked cast iron pipes and badly corroded steel pipes with holes of up to 40 mm in diameter There is no trace of either internal or external coating Some of the steel pipes were less than ten years old Repairs are often made by plugging the holes with a wooden peg and welding a steel plate over it Bell and spigot joints are being repaired by caulking with hemp and filling with cement or pegs Cracked cast iron pipes are replaced

2 Wastage As result of poor control over housing installations and delays in repairing by ZhEKs (housing management associations), a considerable amount of water is wasted through dripping taps and running toilet cisterns

3 Metering As was mentioned earlier, only 10 percent of all connections have functioning water meters The interview with the LVK meter repair team revealed that meters were of poor quality and their operation period shorter than specified by the manufacturer

3 2 GENERAL SCHEMATIC OF THE SYSTEM

The EPT project developed general schematics for the Lviv water system These are covered in several illustrations including the schematics of the well fields and the transmissin system

presented in Figure 3-1, the pressure zones in the city in Figure 3-5 and the distribution system piping and major water consumers in Figure 3-6

3.3 HYDRAULIC ANALYSIS OF THE DISTRIBUTION NETWORK

The hydraulics of Lviv water distribution system was analyzed using EPANET simulator EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks A network may consist of pipes, nodes (pipe junctions), pumps, valves, and storage tanks or reservoirs EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a substance throughout the network during a multi-time period simulation In addition to substance concentrations, water age and source tracing can also be simulated

EPANET is the product of the Drinking Water Research Division of Risk Reduction Engineering Laboratory as being a part of U S Environmental Protection Agency

EPANET views a water distribution network as a collection of links connected together at their endpoints called nodes Links come in several varieties

1 pipes
2 pumps
3 valves

Besides being the junction point between connecting pipes, nodes can serve as

1 points of water consumption (demand nodes)
2 points of water input (source nodes)
3 locations of tanks or reservoirs (storage nodes)

When creating the hydraulic model of Lviv water distribution network, water consumption rate at separate nodes was defined basing on the following data total number of city residents (805 9 thousand), density of population within the city boundary, availability of household installations, standard of water supply during 24-hour period, norms of water consumption for different customer groups tapped to the Lviv water supply system (established by the Lviv City Council in 1996), and figures of actual consumption measured by EPT/Lviv

Water supply rate at nodes was defined basing on the LVK reported data on operation of pump stations for 1996, and on figures of actual water supply by the pump stations during the 24-hour period measured by EPT/Lviv

Total amount of water abstracted at well fields was assumed to be 396,300 m^3/d (according to the LVK reported data) Total amount pumped by the city pump stations to the city distribution system was assumed to be 314,500 m^3/d (according to EPT/Lviv measurements) Total water consumption for the City of Lviv was assumed to be 229,000 m^3/d (according to the estimation) Difference between water supply to the city and water consumption makes 85,500 m^3/d and is accounted for by network losses that were unevenly distributed throughout

the network depending on duration of the time period when water is supplied to the customer with the sufficient pressure

Node elevations above the sea level were calculated in the Baltic system of elevations

Value of time pattern coefficients for water usage was based on the actual water supply time pattern for the city pump stations

In order to simplify the hydraulic model, out of 1,500 km of the total length of Lviv water supply system only 350 km of 300-mm and larger diameter pipelines were included into the simulation model Header pipelines between wells, pipelines for rural water supply, and rural distribution networks as well as 200-mm and less diameter components of the city distribution network were not included

The Hazen-Williams formula was used in the hydraulic simulation of the Lviv water supply system First approximation for roughness coefficients was assumed the following

- 150 for steel pipes
- 130 for cast iron pipes
- 140 for reinforced concrete pipes

These coefficients were adjusted taking the age of pipe into account and were assumed the following

- 115 for steel pipes
- 100 for cast iron pipes
- 140 for reinforced concrete pipes

Pump characteristic curves were built according to pump characteristics measured by EPT/Lviv If not measured, the curves were built according to pump data sheets

One use for the EPANET computer program was to analyze the area to be covered by the demonstration program (See Section 10) Six simulation sessions were run separately under the varying conditions The results showed that the Pasichna area had the most severely deficient water service Figure 3-7 illustrates the graphic output from one of the simulations

In the future EPANET software may be used in the LVK dispatch service in order to make a forecast for possible network changes when modifying system control In order to approximate the simulation model to the existing system the first needs to be gradually calibrated by adding elements to the model that are present in the system (closed valves, heating station pumps, check valves, blind flanges) This will make the hydraulic model very close to the existing system, so simulation will give better understanding of processes taking place in the system, and this in its turn will aid in improving control over the system operation

3 4 OPERATION, MAINTENANCE AND REPAIR

3 4 1 Organization of Lviv Vodokanal

Lviv Vodokanal (LVK) is organized as a state communal enterprise which provides water and wastewater services for the city The enterprise is, in theory a self supporting legal entity Vodokanal is responsible for servicing its water supply lines, wastewater net, well fields pump stations and wastewater treatment plants

In 1995 LVK employed 1,300 people, 80 percent in operations and 20 percent in management These are organized into five divisions

- Water Supply Service
- Utility Engineering Service Division
- Mechanic Service Division
- Dispatcher Service Division
- District Maintenance Division

The most important operations division is the District Maintenance Divisions which maintain the city water distribution system This includes its buildings and equipment, repair breakdowns and leakages, required pressure at service entrances and distribution of water to all the water consumers within Lviv

Lviv water distribution system is maintained by five district maintenance teams (DMT) Maintenance is carried out in accordance with the maintenance rules for water and wastewater systems in residential areas in Ukraine Based on this, each district must not contain more than 500 km of pipes and must be within 10 km of the maintenance team location There are five district maintenance teams in Lviv, which correspond to the number of territorial divisions of the city The Lviv distribution system is divided into six zones The division of zones is based on the location of water supply sources and is not strictly defined since the zones within the city are not separated by valves The responsibilities of the DMT include

- maintaining good working condition of the system, its buildings and equipment, keeping the system clean and protection against freezing
- ensuring efficient operations
- ensuring required pressure and water distribution within the system
- providing sanitary maintenance of the system, cleaning and disinfection
- providing on-going and capital maintenance for breakdowns and leakages
- keeping technical documentation and technical reports
- construction control, installation of new lines and connections

The distribution system is checked by walking along the pipeline routes and visual inspection of the buildings and equipment Inspections are made once every two months Inspections include checking well appearance, availability, condition and securing of well lids, condition of well walls, ladders, presence of water, gases, leakages, ground sagging along the rout and near wells and operation of street hydrants

Maintenance works are not done on a regular basis DMTs together with consumer departments inspect the technical condition of consumer connections and meters Repairs are carried out according to the results of the inspection reports

All repairs are done by DMTs and allocated according to the extent of breakdowns and the type of work Every day each team receives (from the dispatcher service) information on location of breakdowns, transportation and equipment, tools and pumps for draining breakdown area

The most common breakdowns include damage to pipe walls, joints, valves, check valves and fittings DMTs are responsible for carrying out repair and rehabilitation works The organization of repair works is shown in Figure 3-8

3 4 2 Breakdown in the Water Supply System

Breakdowns in the distribution system disrupt water supply to households and industrial consumers According to the information received from the dispatcher division from the annual number of breakdowns is about 4,117 Computer analysis of the dispatcher center data on the distribution system showed that 6,486 breakdowns occurred in 1995, 6,268 of these happened in the distribution mains, 218 at the service connections

Analysis shows that up to 540 leakages occur in the system every month although most of the breakdowns happen in summer (June) and winter (December) It might be explained by seasonal variations in water consumption, ground freezing in winter and some delay in registering the time of breakdown The areas where the breakdowns occur most often are located around the following streets Naukova, V Velykoho, Medova Pechera, Pasichna, Zamarstynivska, Zelena, Lychakivska, Varshavska and several others (see Figure 3-9)

The city water distribution system consists of cast iron and steel pipes Most of the pipes are very old, the condition of pipes and joints depends on their age The method of repair depends more on the pipe material than on the pipe age or quality Breakdowns that occurred in the period from 1993 to 1995 were analyzed to establish a pattern Over that period 847 breakdowns occurred, 57 percent were pipe related, 28 percent were caused by broken valves and 13 percent occurred at service entrances Out of the total number of pipe related breakdowns 60 percent were caused by faults at bell and spigot joins of cast iron pipes, 27 percent were holes in steel pipes that could be fixed In other words the breakdowns in the distribution system are caused by faults at bell and spigot joint of cast iron pipes (61 percent), holes in steel pipes (33 percent) and cracks in cast iron pipes

Table 3-1 Lviv Water Consumption - 1900 to 1995			
Year	**Population (thou)**	**Water Supply (m^3/d)**	**Water Consumption (lcd)**
1900	160,000	N/A	N/A
1910	206,000	18,000	87 4
1920	210,000	18,000	85 7
1926	240,000	24,000	100 1
1931	312,000	28,000	90 3
1939	318,000	33,000	104 1
1945	165,000	21,000	124 5
1950	332,000	39,000	117 5
1955	380,000	55,000	144 6
1960	421,000	67,000	159 8
1965	496,000	105,000	211 0
1970	564,000	177,000	313 9
1975	629,000	254,000	403 9
1980	688,000	331,000	480 4
1985	735,000	397,000	540 3
1990	780,000	387,000	495 7
1995	806 000	295 000	365 6

Table 3-2
Lviv Well Fields Characteristics

No	Well Field Name	Year Built	Qty of Wells	Dist to Lviv	Static Water Depth	Design Capacity			Average Daily Production		Problem Constituents in Water	Number of Operating Personnel	Remarks
						Safe Yield	Added Yield	Total	1987	1995			
				km	m	m^3/d	m^3/d	m^3/d	m^3/d	m^3/d			
	North												
1	Rava-Ruska	1972	8	48	3 3	17 000	-	17 000	17,000	16 932	Strontium	8	
2	Meheriv	1971	4	40 5	3 8	17 200	9 800	27 000	8 800	8 466	Strontium	3	
3	Shostaky	1972	3	39 5	3 8	3 400		3 400	3 400	6 350		2	
4	Krekhiv	1970	5	29 5	4 8	15 600	-	15 600	13,500	13 611	Strontium	5	
5	Kunin	1970	2	30 5	4 8	5 700	-	5 700	5,400	5 444		2	
6	Mokrotyn	1966	7	19 8	4	16 100	8 000	24 100	18 000	16 222	Strontium	7	
7	Zarudtsi	1965	16	12 5	3 8	19 700	8 000	27 700	24,200	20 927	Strontium	16	
	Group total		**45**			**94,700**	**25,800**	**120,500**	**90,300**	**87,952**			
	West												
8	Volia Dobrostanska	1901	5	26 6	15	18 500	3 500	22 000	16 800	7,026	-	13	
9	Velykopole	1926	5	23 9	5 6	8 000	5 000	13 000	13 200	7 015	-	13	
10	Kamianobrody	1952	4	20	3 6	23,000	10 000	33 000	16 100	15 289	-	13	
11	Malchytsi	1967	9	11 6	7	15 700	5 600	21 300	10 300	15 868	-	6	
12	Budzen	1956	22	20 5	6 5	45 200	9 000	54 200	32 200	31 568	Ferrum, Strontium	12	No removal
13	Kernytsia	1969	8	20 5	6 5	9 000	6 400	15 400	12,000	11 479		4	
	Group total		**53**			**119,400**	**39,500**	**158,900**	**100,600**	**88,245**			
	South												
14	Stryi	1982	34	75	4	140,000	-	140 000	122,200	126 578	-	16	
15	Hlynna Navaria	1971	12	14 5	1 2	14 700	4 300	19 000	10,000	14,238	-	13	
16	Bibrka	1973	12	15 9	4 5	13 300	6,700	20,000	17 600	24 192	Ferrum	14	No removal
17	Malechkovychi	1932	1	7	1 2	5 000	-	5 000	5 000	4 910	-	5	
	Group total		**59**			**173,000**	**11,000**	**184,000**	**154,800**	**169,918**			
	East												
18	Remezivtsi	1986	4	72	2 6	34 500	24 800	59 300	7,000	7 377	Ferrum	Purchased water	No removal
19	Pluhiv	1989	8	74	2	70 000	20 000	90 000	30 200	50 572	Carbonate Hydrogen sulfide	14	Air stripping used to reduce hydrogen sulfide (H_2S)
20	Vilshanytsia	1989	4	40	3	16 400	10 500	26 900	-	8 577	-	10	
	Group total		**16**			**120,900**	**55,300**	**176,200**	**37,200**	**66,526**			
	Total		**173**			**508,000**	**131,600**	**639,600**	**382,900**	**412,641**			

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Table 3-3
Pumping Equipment of the Wells at Lviv Well Fields

No	Well Field Name	No of Pumps	Well Numbers	Type of Pumps	Pump Characteristic			Notes
					Q, m³/h	H, m	N, kW	
	North							
1	Rava Ruska	3	8 8a, 9a	ЕЦВ10 63 110	63	110	32	
		2	11 12	ЕЦВ12 160 140	160	140	90	
		3	7 9 10	ЕЦВ12 160 100	160	100	65	
2	Maheriv	1	4a	ЕЦВ10 63 110	63	110	32	
		1	6	ЕЦВ8 25 70	25	70	17	
		2	4 5	ЕЦВ12 160 100	160	100	65	
3	Shostaky	3	1 2 3	ЕЦВ12 160 100	160	100	65	
4	Krekhiv	3	1 3 5	ЕЦВ12 160 100	160	100	65	
		1	2	ЕЦВ10 63 110	63	110	32	
		1	4	ЕЦВ8 16 100	16	100	17	
5	Kunin	2	6 7	ЕЦВ12 160 100	160	100	65	
6	Mokrotyn	6	1-4 5a, 6	ЕЦВ12 160 100	160	100	65	
		1	5	ЕЦВ8 25 70	25	70	17	
7	Zarudtsi	5	1 3 5a 7 8	ЕЦВ10 120 60	120	65	32	
		5	2 2a, 4 6	ЕЦВ8 25-70	25	70	17	
	(Zavadiv)	5	1 1a, 2 2a, 3	ЕЦВ10 120 60	120	65	32	
		1	1b	ЕЦВ8 25-70	25	70	17	
	Group total	**45**						
	West							
8	Volia Dobrostanska	4	1 5 7	ЕЦВ12 160 65	160	65	45	
		1	11	ЕЦВ10 63 65	63	65	22	
9	Velykopole	2	1 5	ЕЦВ10 120 60	120	65	32	
		2	2 4	ЕЦВ12 160 65	160	65	45	
		1	3	ЕЦВ8 25 70	25	70	17	
10	Kamianobrody	4	1-4	ЕЦВ12 255 30	255	30	32	
11	Malchytsi	2	1 2a	ЕЦВ8 25 70	25	70	17	
		4	2 3 3a, 4a	ЕЦВ10 63 110	63	110	32	
		3	4 6	ЕЦВ12 160 65	160	65	45	
12	Budzen	16	1 2 6a, 7 7a, 8					
			9 9a, 10 10a, 11 11a					
			12 13 13a, 15a	ЕЦВ10 120 60	120	65	32	
		3	5 5a, 14a	ЕЦВ10 63 110	63	110	32	
		2	6 12a	ЕЦВ12 160 65	160	65	45	
		1	17	ЕЦВ8 25-70	25	70	17	
13	Kernytsia	7	1 1a, 3 3a, 4 6	ЕЦВ10 120 60	120	65	32	
		1	2	ЕЦВ12 160 65	160	65	45	
	Group total	**53**						
	South							
14	Stryi	10	1-6 8 11	ЕЦВ12 160 65	160	65	45	
		22	12 26 28 34	ЕЦВ12 255 30	255	30	32	
		1	7	ЕЦВ10 63 65	63	65	22	Rural water supply
		1	27	ЕЦВ12 255 30	255	30	32	
15	Hlynna Navaria	7	1 1a, 2a, 4 5 7 7a	ЕЦВ10 63 110	63	110	32	
		2	2 3	ЕЦВ8 16 140	16	100	17	
		3	6 6a, 8	ЕЦВ12 160 100	160	100	65	
16	Bibrka	5	1 3 4 4a, 6	ЕЦВ12 160 65	160	65	45	
		6	1a, 2a, 6a, 7 8 8a	ЕЦВ10 120 60	120	65	32	
		1	2	ЕЦВ8 25 70	25	70	17	
17	Malechkovychi	1	1	ЕЦВ12 160 65	160	65	45	
	Group total	**59**						
	East							
18	Remezivtsi	2	1 2	ЕЦВ10 120 60	120	65	32	Purchased water
		2	3 291	ЕЦВ12-210 60	210	60	22	
19	Pluhiv	8	1 8	ЕЦВ12 255 30	255	30	32	
20	Vilshanytsia	2	1 2	ЕЦВ12 160 140	160	140	90	
		1	3	ЕЦВ12 160 100	160	100	65	
		1	4	ЕЦВ10 63 110	63	110	32	
	Group total	**16**						
	Total	**173**						

Table 3-4
Condition of Lviv Pump Stations

Pump Station Name	Year		General Condition			Overall Site Condition	Remarks
	Built	Rehabilitated	Site	Mechanical	Elect & IC		
North							
Zarudtsi	1965	-	Good	Poor	Good	Fair	Very old pumps
Zboisk	1965		Fair	Poor	Good	Fair	Very old pumps
West							
Volia Dobrostanska	1901	1936	Good	Poor	Fair	Fair	Very old
Velykopole	1928	1936	Good	Poor	Fair	Fair	Very old
Kamianobrody	1952	-	Good	Poor	Fair	Fair	Very old pumps
Karachyniv	1928	1976	Good	Poor	Fair	Fair	Very old
Yanivska	1932	1965	Poor	Poor	Poor	Poor	Very old
Budzen II	1964		Poor	Poor	Poor	Very Poor	Very old
Budzen III	1989		Good	Good	Good	Good	No problem observed
South							
Malechkovychi	1932	1963	Fair	Fair	Fair	Fair	Very old
Mykolaiv	1978	-	Good	Good	Good	Good	No problem observed
Sokilnyky	1978	-	Good	Very Poor	Fair	Fair	No regulating drives
Hlynna-Navaria	1971		Fair	Poor	Fair	Fair	Very old pumps
Stare Selo	1973		Fair	Poor	Fair	Fair	Very old pumps
Sykhiv III	1971	1989	Good	Fair	Good	Good	Control problems
East							
Pluhiv	1982	-	Poor	Poor	Poor	Poor	Incomplete construction
Vynnyky	1980	1990	Good	Good	Good	Good	Incomplete construction
Kryvchytsi	1965	1966	Good	Good	Good	Good	Incomplete construction
Dovha	1995	-	Good	-	-	Good	Incomplete construction
Center							
Miska Smuha	1933	1978	Poor	Poor	Poor	Poor	Very old

Table 3-5
Lviv City Pump Stations

City Pump Station Name	Number of Pumps		Pump Characteristics			Pump Shaft Elev	Year		Design Daily Capacity	Average Daily Flow 1995	Annual Flow 1995	Power Supply Category	Power Usage in 1995		Dis-in-fec-tion
	Working	Stand by	m^3/h	atm	kW	m	Built	Rebuilt	m^3/d	m^3/d	1,000 m^3		kWh	kWh/m^3	
North															
Zboisk	1	1	1 260	3 2	250	321 9	1965	-	105 600	31 670	11,560	I	1 100 691	0 095	yes
	1	1	1 080	3 2	160										
	by gravity					324 0				47,300	17 265				
West															
Karachyniv		1	640	5 5	250	307 7	1928	1976	79 800	38 592	14 086	II	6,411 579	0 455	yes
	1	-	2 200	5 5	600										
	1	-	2 200	5 5	630										
	-	1	2 300	8 9	800										
Budzen III	2	2	1 250	6 5	320	314 3	1989	-	66,800	30 786	11 237	II	2,383 763	0 212	yes
South															
Malechkovychi	1	1	200	7	100	298	1932	1963	5 000	4,924	1 797	III	1 226 750	0 683	yes
Sokilnyky	2	1	3 200	7 5	800	338 5	1978	-	140 000	115,216	42 054	I	12,928 300	0 307	yes
	1	1	4,000	9 5	800										
Sykhiv III	3	-	540	9 4	250	345 2	1971	1989	39 000	31 723	11 579	II	3,477,500	0 300	no
	2	1	540	7 4	160										
	1	1	300	3 8	75										
	1	1	90	3	15										
East															
Vynnyky	1	1	1 250	13	630	284 3	1980	1990	65 000	62,460	22,798	I	9 088 000	0 399	yes
	3	-	1 250	6 5	250										
Total									**501,200**	**362,671**	**132,375**		**36,616,583**	**0 277**	

Table 3-6 Hydraulic Characteristics of Pressure Zones					
Zone Number	Elevation, m	Estimated		Zone Served by Pump Station	
		Demand, m^3/d	Pressure, m	Existing	Designed
I	275-310	42,000	26	Miska Smuha	
II	310-345	115,000	42	Sokilnyky, Malechkovychi	
III	365-38	17,000	42		Dovha
IV	295-330	100,000	26/42	Karachyniv, Budzen III	
V	250-300	82,000	22/42	Zboisk (Tank)	Zboisk
VI	300-340	10,000	42	Zboisk	
VII	250-300	8,000	42		Kryvchytsi
VIII	315-350	66,000	42	Sykhiv III	
IX	300-350	24,000	26/42	Kryvchytsi	
X	230-300	27,000	42		Vynnyky
XI	300-350	3,000	22		Zboisk
XII	230-350	3,000	26	Kryvchytsi (Tank)	
XIII	315-340	3,000	26	Yanivska	

Table 3-7 Estimated Water Usage by Consumer Group		
Consumer Group	m^3/d	Percent of Total
Residential Sector	164,300	56
Industry	21,000	7
Communal Services	87,500	3
Budget Institutions	21,900	7
Total	**294,700**	**100%**

Table 3-8 Development of Lviv Water Distribution System		
Year	Population of Lviv	Total Length of Pipes, km
1939	318,100	202
1945	165,000	202
1970	563,600	700
1985	734,800	1,300
1995	831,200	1,500

Table 3-9 Distribution Piping According to Age				
Diameter, mm	**< 1945**	**1945-75**	**1975-96**	**Total**
<100	139 0	51 0	89 0	279
150		77 0	130 0	207 0
200		89 0	94 2	183 2
250	2 5		63 5	66 4
300		19 2	22 0	41 2
350		14 3		14 3
400	1 9	25 0	13 7	40 6
500		4 2	17 0	21 2
600	7 5	22 6	7 2	37 3
700		4 0	2 0	6 0
800				
1000				
1100				
≥1200			4 3	4 3
Total	**151 3 km**	**306 3 km**	**442 9 km**	**900 5 km**

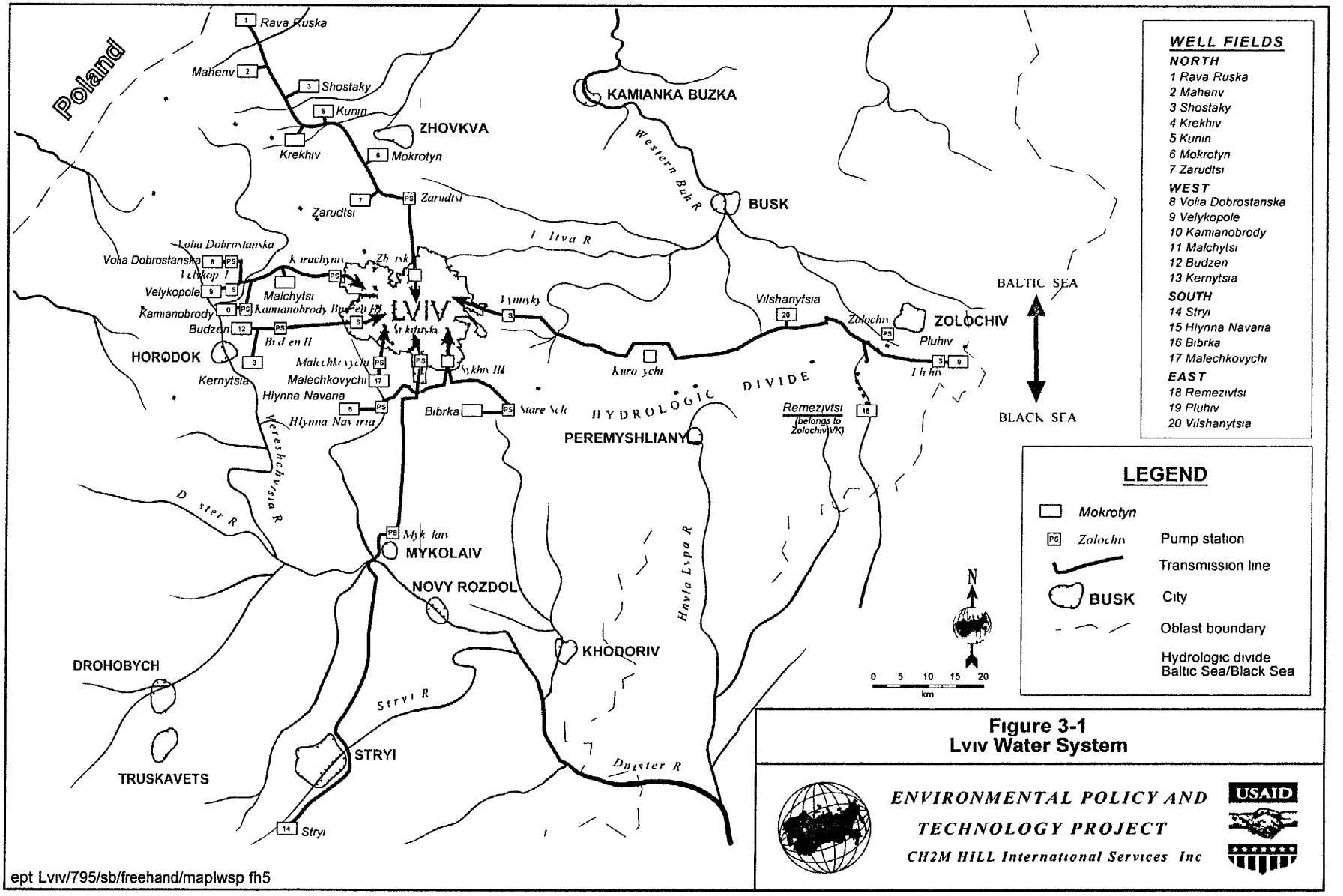
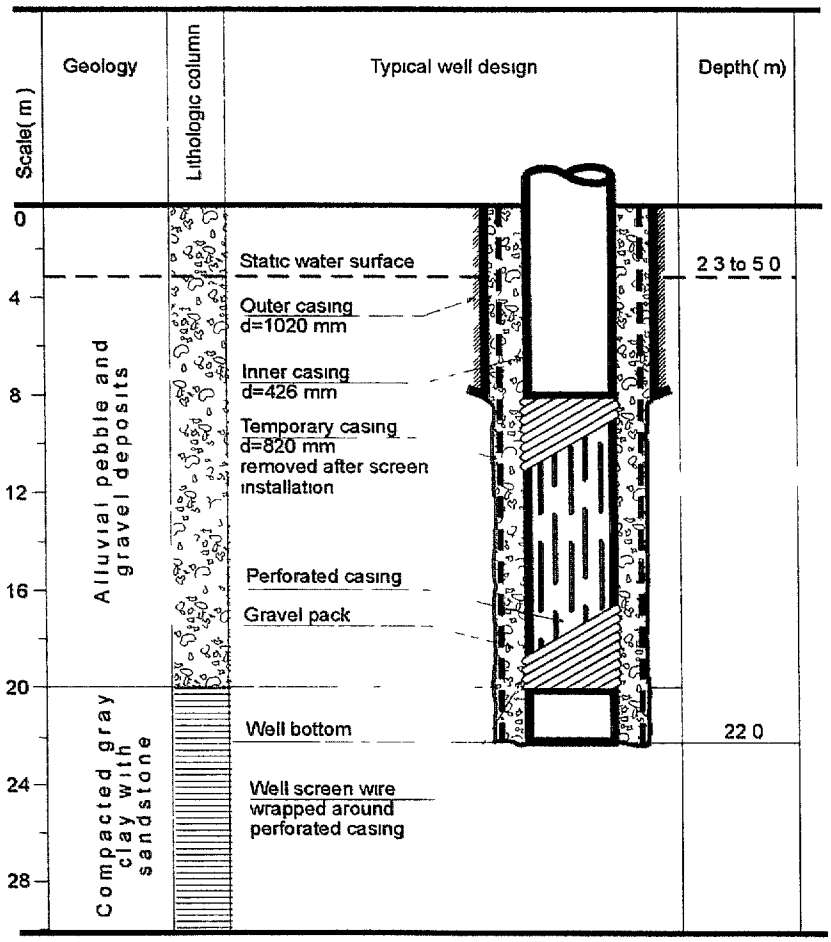
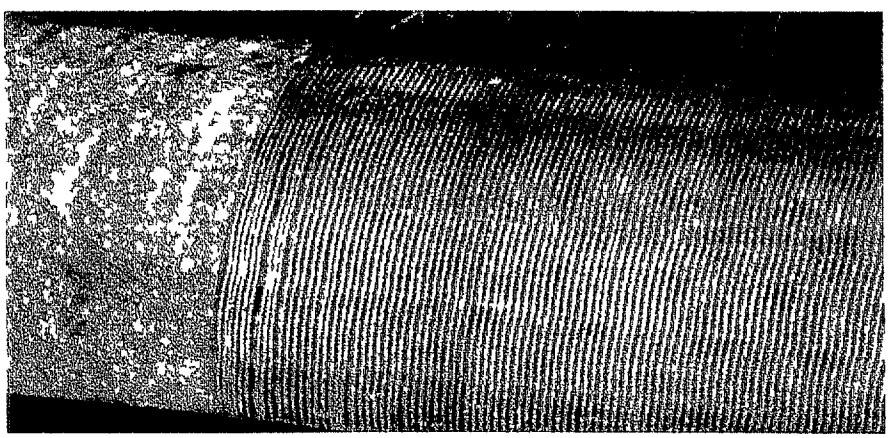


Figure 3-1
Lviv Water System

Typical Well Design at Stryi Well Field





Well Screen

Figure 3-2
Geological Profile and Well Design

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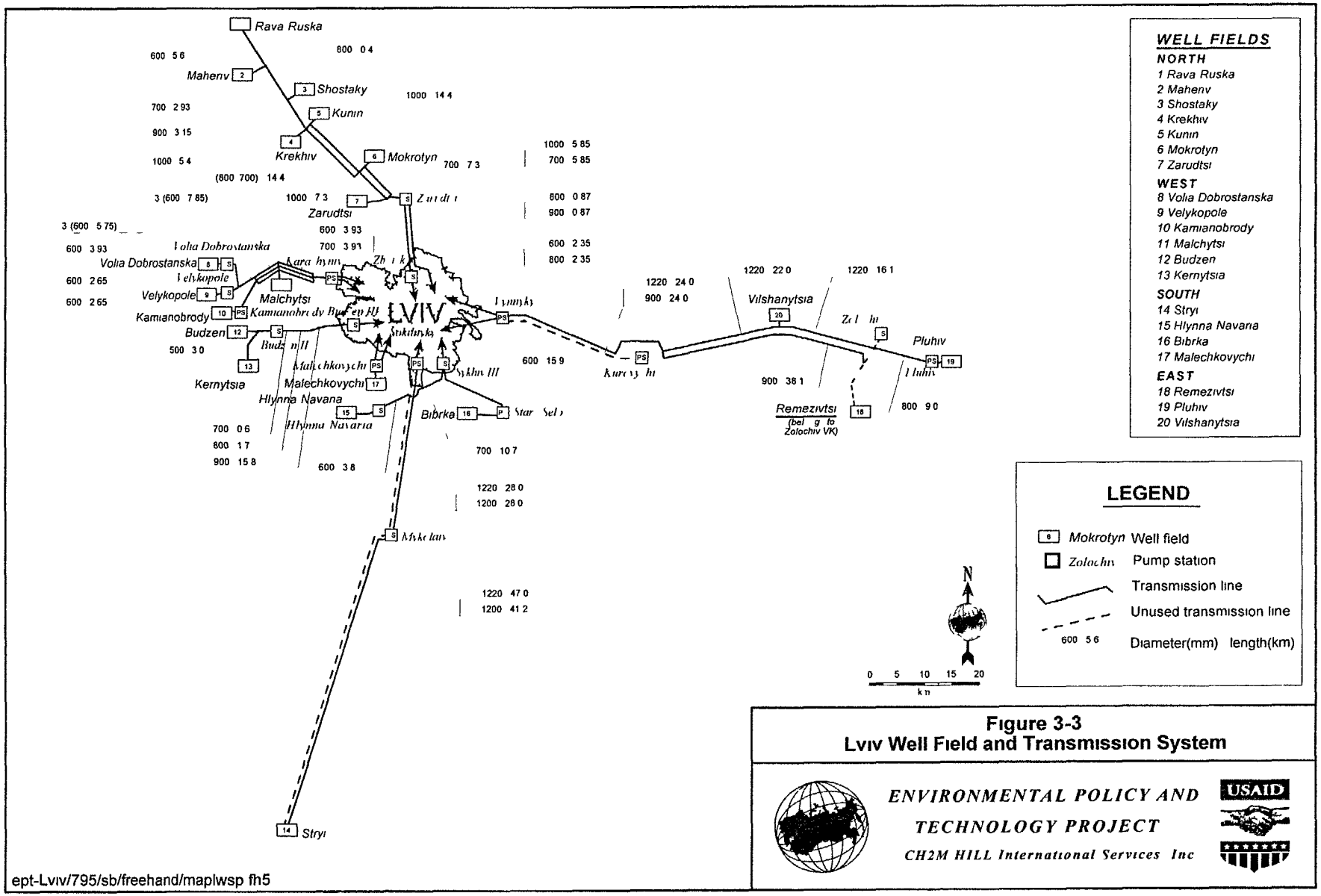

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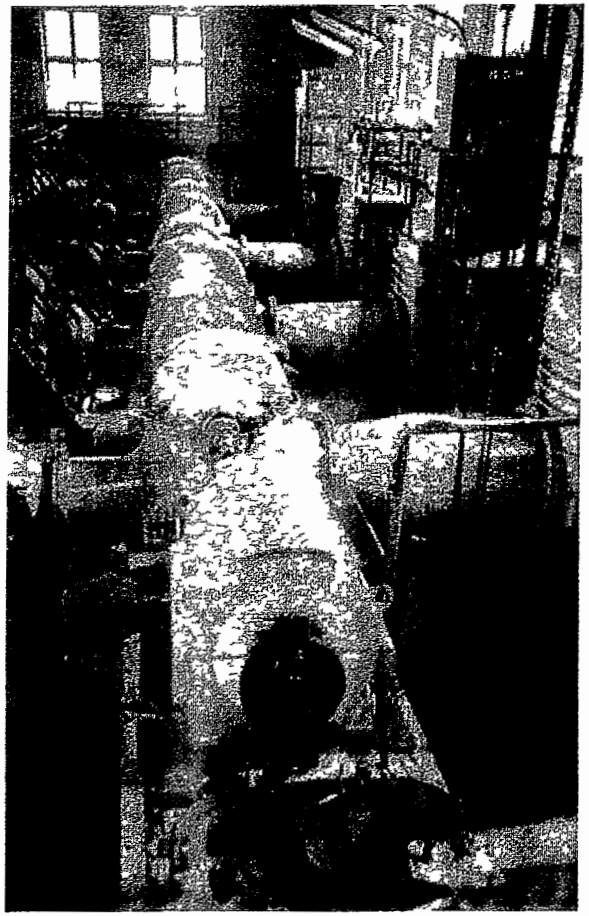
Figure 3-3
Lviv Well Field and Transmission System



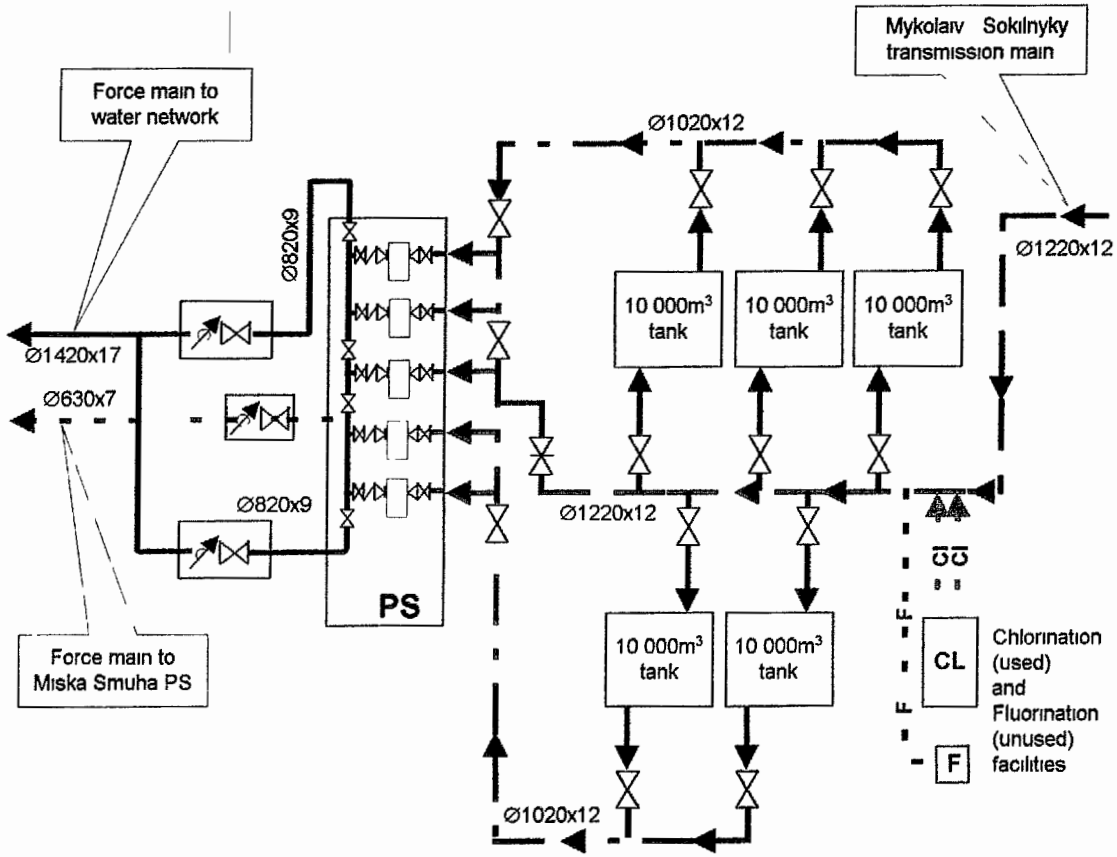


Figure 3-4
Sokilnyky Pump Station

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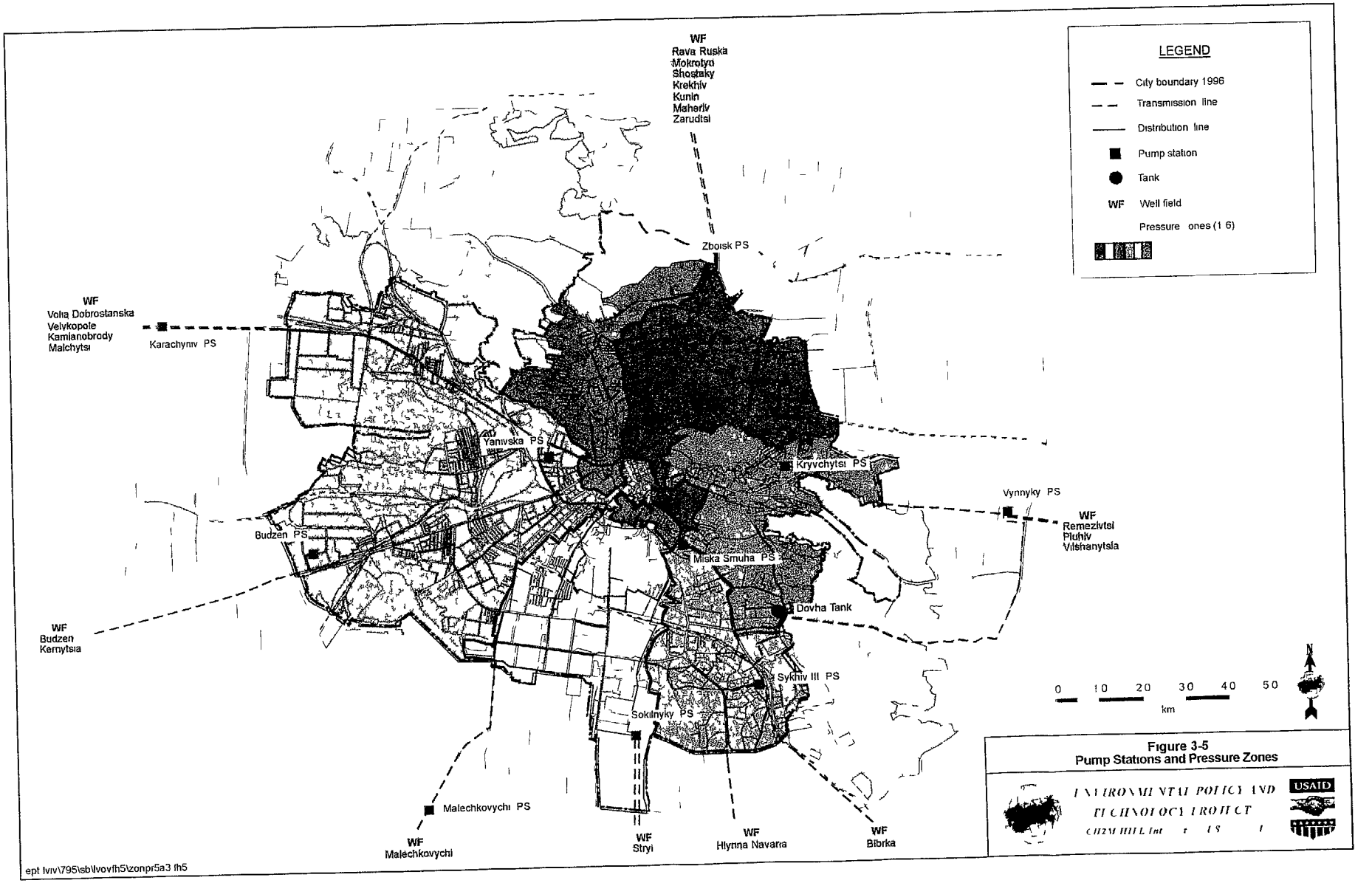

Figure 3-5
Pump Stations and Pressure Zones

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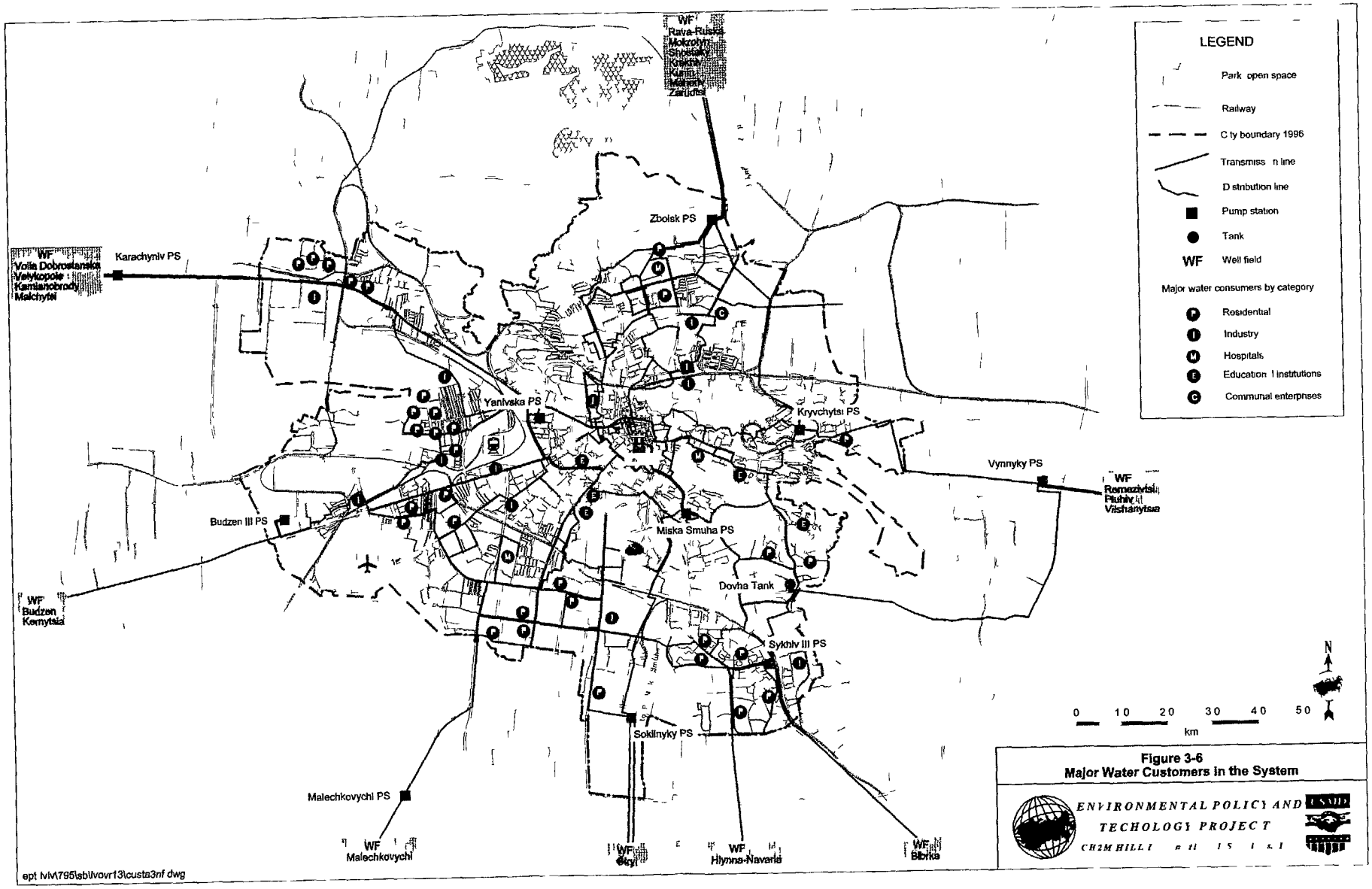

Figure 3-6
Major Water Customers in the System

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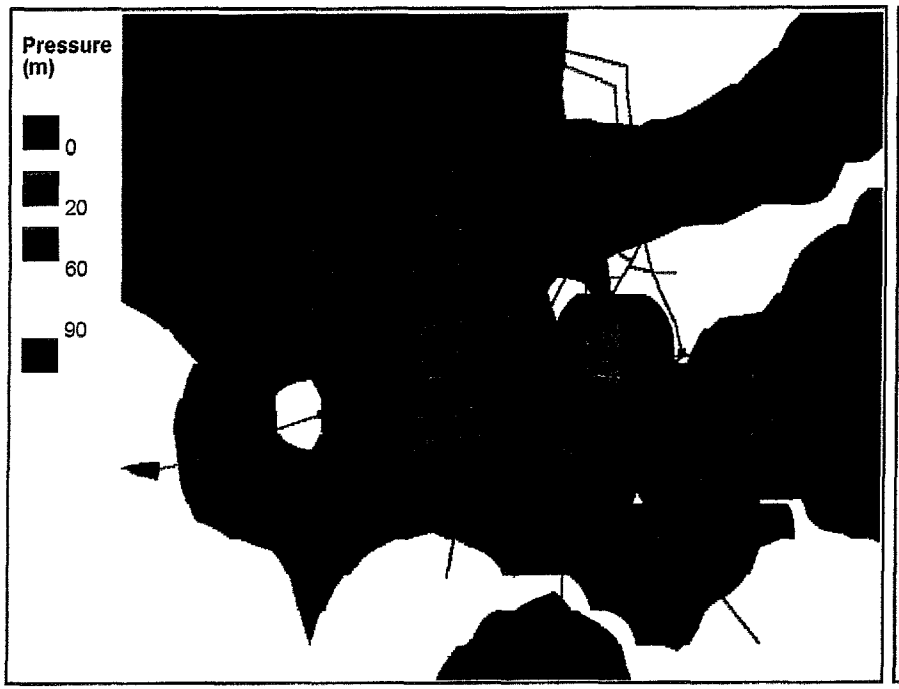
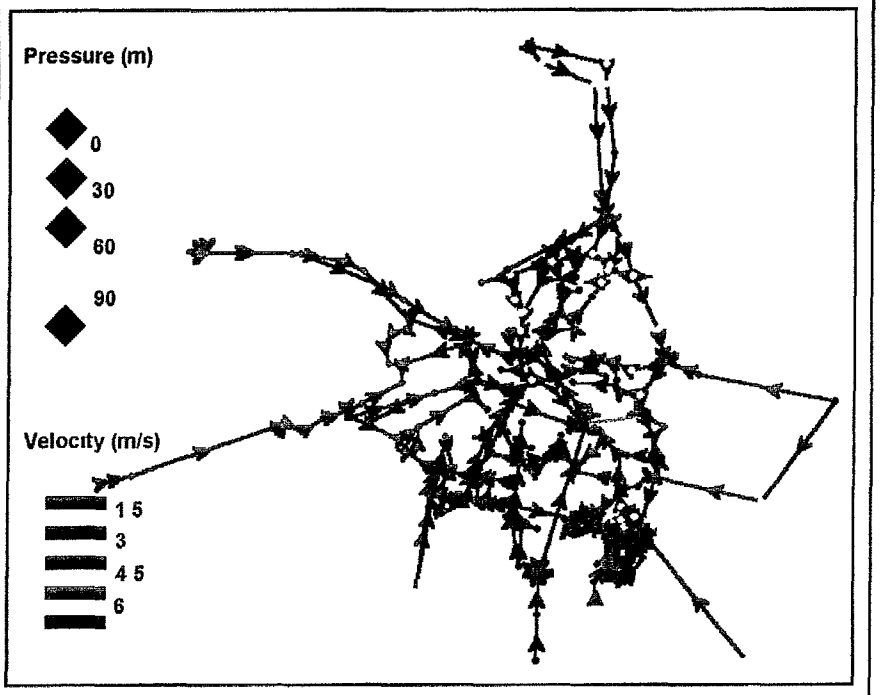
Analysis of the distribution system in the Pasichna area using the hydraulic modeling program EPANET



A System Pressure



B Velocity and Pressure in Pipes

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Figure 3-7
Network Analysis of the Pasichna Area

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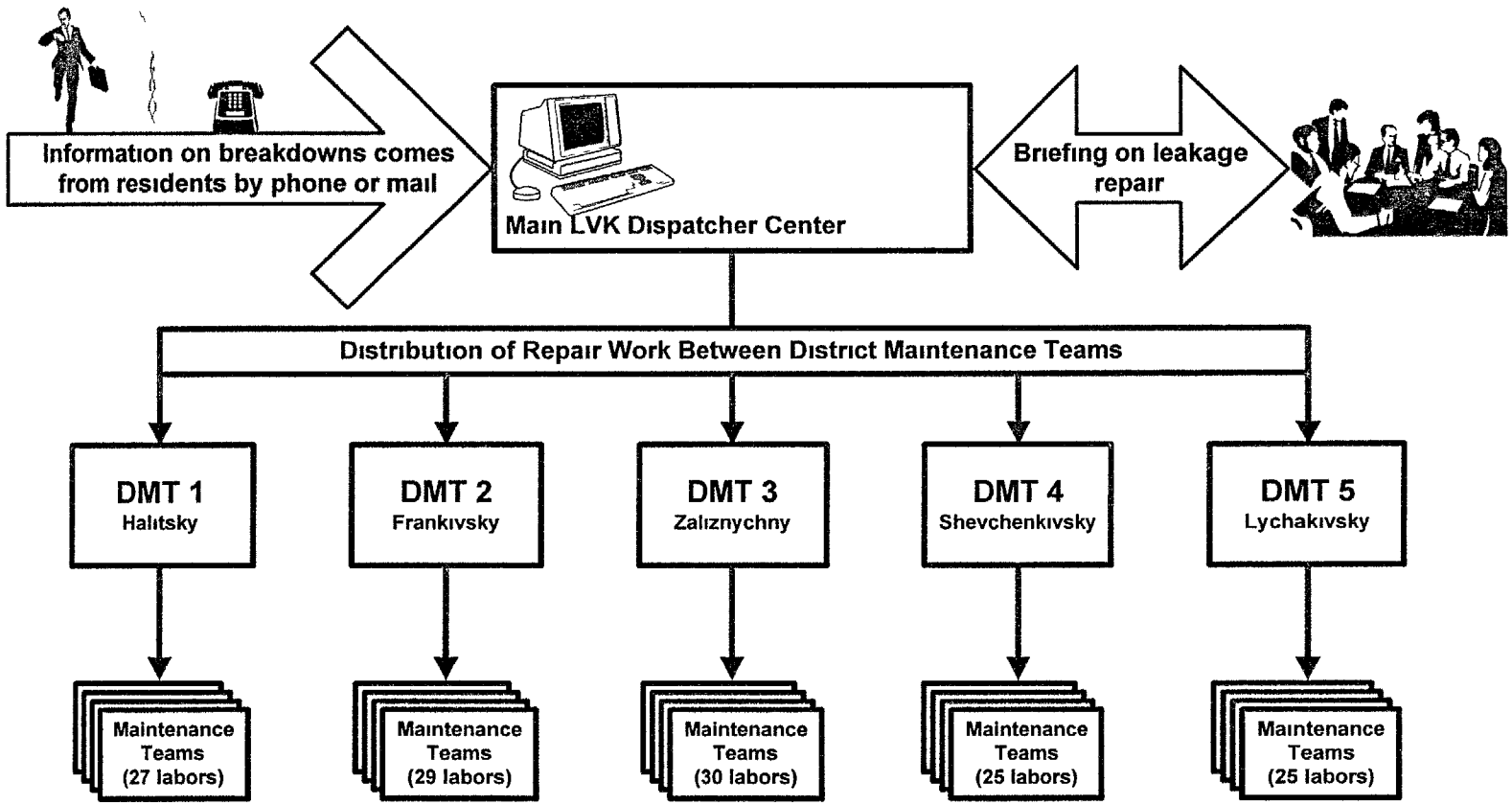

Fegure 3-8
Flowchart for Repair Work in the Distribution System

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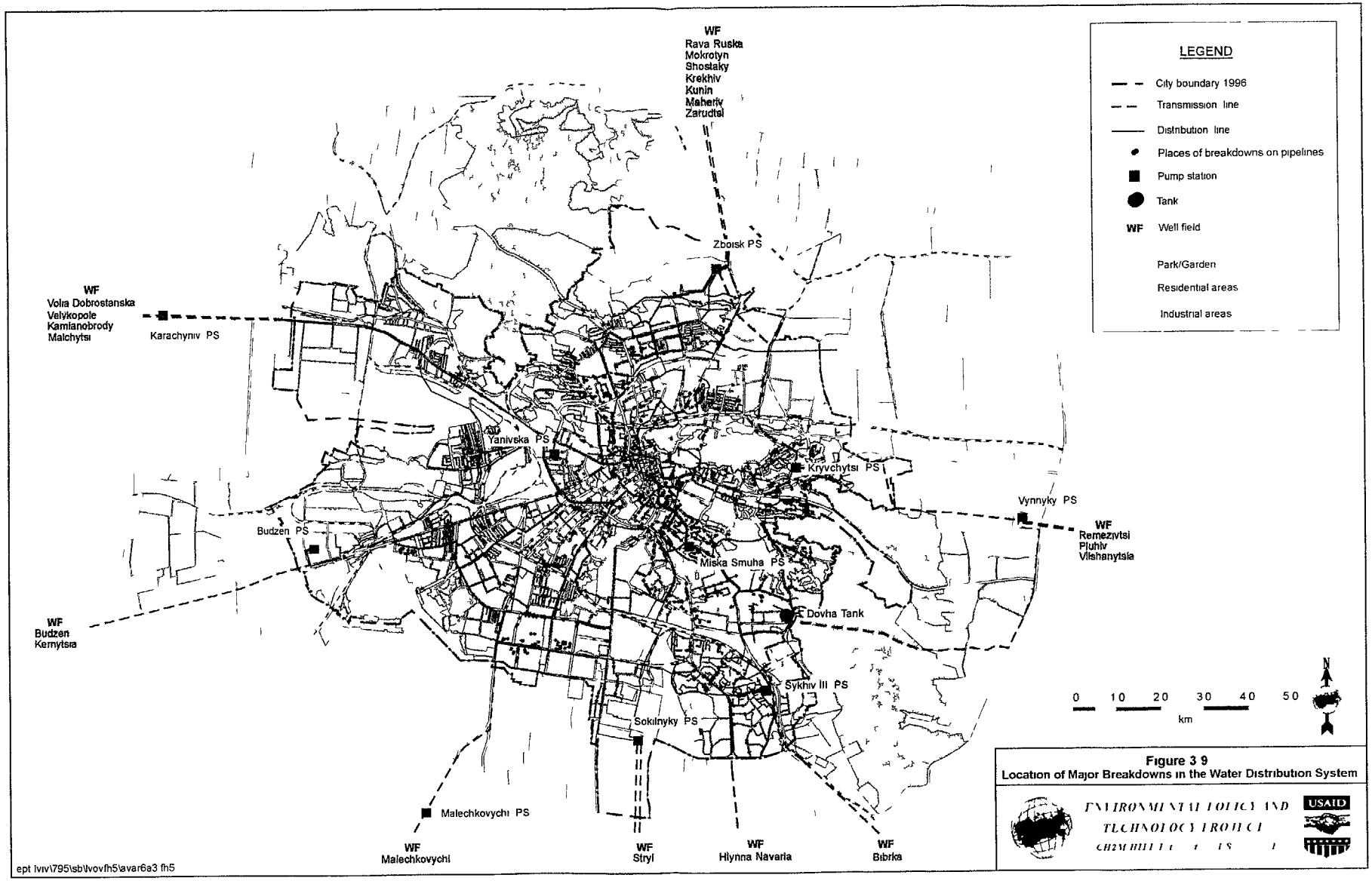

Figure 3 9
Location of Major Breakdowns in the Water Distribution System

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Section 4
FINANCIAL IMPACT

4.1 FINANCIAL LOSSES

The LVK current financial situation is critical At the present time the LVK cannot pay its current bills and increase expenses to maintain the system at a level to prevent further deterioration of its physical condition Production costs incurred by the LVK exceeded the payments for the services collected from the consumers To make advanced payments for the system operation, the LVK has had in the past to use the suppliers' cash funds temporarily at the LVK disposal Under such circumstances, payments to suppliers (for instance for electricity) may be postponed until the consumers pay their debts This critical situation with the collections resulted in a reduction of funds for capital repair and maintenance and considerable expansion of the LVK's debt especially to the electricity supplier By the end of the first half of 1996 the debt to the electricity supplier amounted to about US$6 million

Payments collected from the consumers remain the principal source of the LVK income The tariffs are theoretically set so they are sufficient for paying all necessary expenses and producing a profit The consumers of the LVK services have not fully paid their bills services for several years The total consumer debt for the LVK services has been growing from year to year and by the end of June 1996 the total consumer debt amounted to US$6 million In the 1st half of 1996 the payment collection rate was 78 percent versus 71 percent in 1995 Unfortunately, LVK now has no legal right to suspend the water supply of the buildings where part of the residents have already paid for LVK services The State Administration does not take any enforcing actions in order to make the residents pay for the LVK services because many residents do not receive their salaries and wages regularly or at all

There is almost no cash in the LVK bank account as the largest (by payment) class of user "industry" often pays the LVK by means of barter and mutual clearing of debts - rather than cash The state is a direct and indirect debtor to the LVK because of unpaid bills of budget organizations funded by state and because of added costs for subsidies for part of the residential sector

The long-term lack of adequate funds does not allow the LVK to properly maintain the water and wastewater system The situation is further complicated because state legislative system does not allow the LVK to include the cost of capital investments for upgrading the system into the tariffs and the state is no longer making any capital funds available to the LVK for the system improvements

As a result of a constricted financial situation, from the local budget only some small capital investments were allocated for the water and wastewater system The capital investments allocated to the LVK from budget during the period from 1993 till 1st half of 1996 were much smaller than the LVK payments to the budget which the LVK pays as taxes and obligatory levies The LVK pays taxes and levies not only to the city budget but also to the oblast budget The LVK has not received so far any funds from the oblast budget

The existing taxation system, especially the value added tax (VAT) is a burden on the LVK financial status Among all the other taxes the VAT has the largest share When paying the VAT, the LVK constantly makes advanced payments to the state budget as it has not collected the consumers payments for the current month

4 2 WATER LOSSES

Table 4-1 presents main technological indices of the Lviv water distribution system on the basis of the 1996 LVK reported

Water losses in water supply systems are caused by the following factors

- leakage in transmission mains
- leakage in rural piping
- leaky tanks
- tank losses due to leakage and overflows
- leakage in the distribution system
- leakage within plumbing systems

Currently there is no way to know what the quantity of water losses are in the overall system as the production data can vary from the estimate (but probably not more than 10 percent) and the data on customer usage is subject to much larger errors There are few working meters for consumers in the system and much of the consumer usage is based on state established norms There have been a number of estimates of the total quantity of the losses and the split between leakage (from piping and tanks) and wastage (from internal plumbing fixtures)

The LVK accounts for losses in the transmission mains and the water distribution system by estimating the difference between water produced and billed According to the LVK data for 1996, the losses amounted to 103,000 m^3 daily which is 26 percent of the total water production This includes both leakage (in pipes and tanks) and wastage (due to leakage in internal plumbing)

According to the COWI report[1], the total losses in the system are about 30 percent of the total water produced (or about 120,000 m^3/d) This does not include wastage in the system The EPT project has found no evidence to lead us to believe that the losses due to leakage in the system are any less than that estimated by COWI

The Lviv city distribution system consists of areas with 24-hour and 6-hour water supply which have different amounts of leakage The length of the pipes in the city distribution system is approximately

- 225 km in the areas with 24-h water supply
- 675 km in the areas with 6-h water supply

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[1] COWI *Lviv Water and Wastewater Project Preparation Study Final Report February 1997*

Even during the time when the six hour areas are not provided full service, they generally do have some pressure applied to the pipelines to keep them from being contaminated so some leakage does occur during that period but the leakage is accelerated by the periods with high pressure Leakage tends to be proportional to pressure, time, and pipe surface area (length) The high proportion of pipe that are available for additional leakage if the system went to a completely 24-hour supply indicates that the amount of leakage possible with a 24-hour supply could exceed 50 percent

Right now the financial losses from the leakage and wastage is covered by the LVK in their overall rates Since they use norms instead of actual meter readings for most of their bills they can include any water in the bill that doesn't reach the consumer but is part of the norm In addition all production costs are spread over the amount of water said to be delivered to consumers whether it is or not If the LVK went to a universal metering system it could create some new challenges in allocating the costs for water lost before it is registered in the meter

Typical of losses in the system is COWI's estimate of the leakage in the transmission mains that they put at about 34,300 m^3/d, which is about 9 percent of the total amount of water abstracted at the well fields This is caused mainly through general leakage, due to corrosion and bad joints as well as failures in the mains A map showing the historic location of these failures in the transmission system is shown in Figure 4-1

As discussed in Section 4 1, the Lviv water system cannot cover its expenses with its actual income The major problem is the cost of energy which is 60 to 70 percent of the total cost Energy usage is very sensitive to water usage within the city as water must be pumped into the city from well fields located far away From a financial standpoint, increasing the supply creates more expense and generally will not increase income as most water is billed based on norms instead of actual usage Therefore when the system is not functioning, it is better off from a financial viewpoint than if it is functioning This means that the expeditious repair of minor breakdowns are not a priority from a financial side (like they would be in most locations in the USA) although they are important from a water service and public health aspect

This situation will not really change until a majority of water is sold by actual usage and the bills are paid when rendered to the consumer Neither of these situations exist at the present time and are no likely to exist in the near future

Table 4-1
Main Indices of Lviv Water Distribution System

No	Item	Amount
1	Water Delivered by City Pump Stations	320,500 m^3/d (100%)
2	Water Billed within City Boundaries	276,300 m^3/d (86%)
3	Total Leakage from City Distribution System	44,300 m^3/d (14%)
4	Total Length	900 km
5	Annual Average Number of Breakdowns per 1 km of pipe	5 6 breakdowns
6	Daily Average Water Leakage per 1 km of pipe	49 2 m^3/d per km
7	Hourly Average Water Leakage per 1 km of pipe	2 05 m^3/h per km

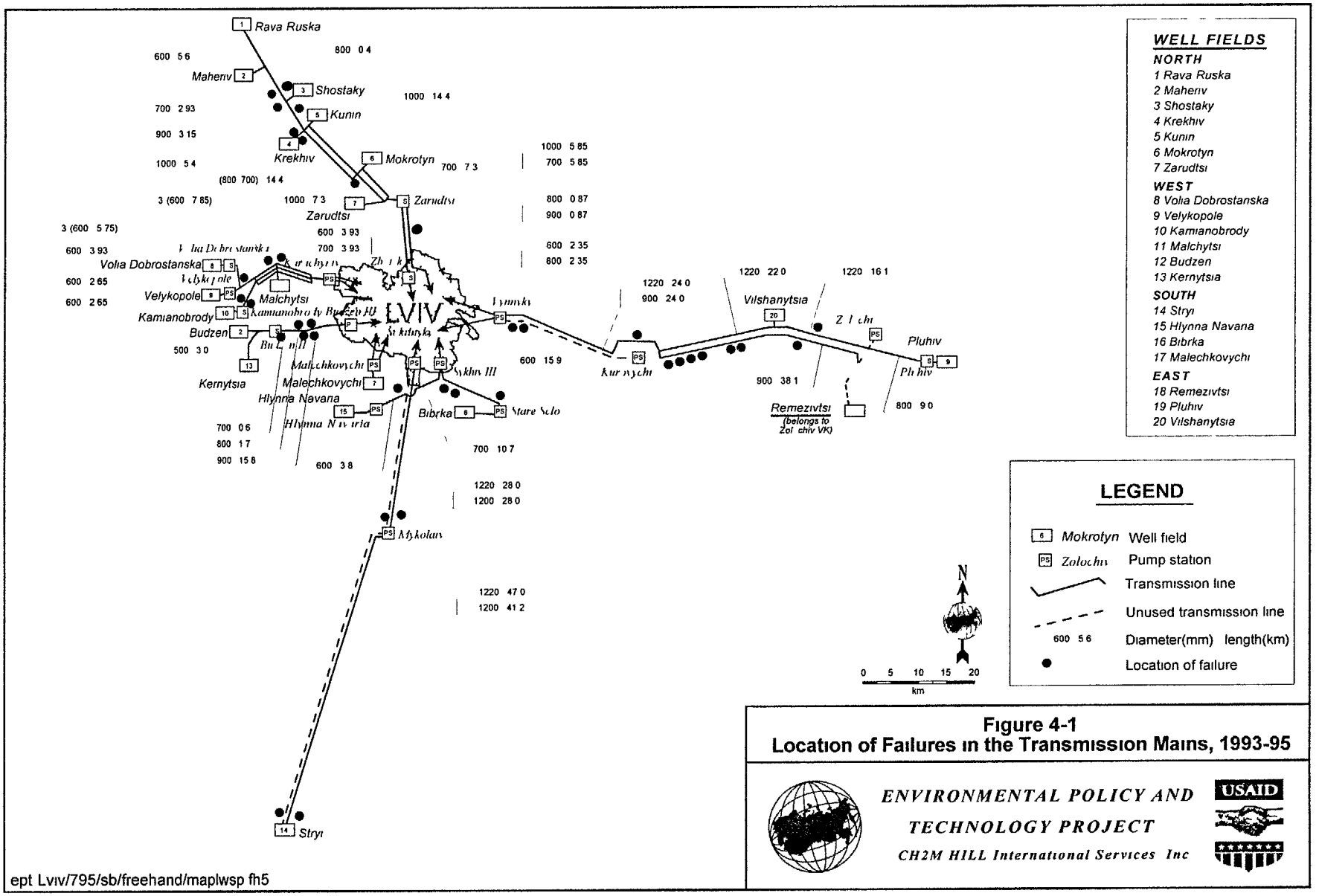

Figure 4-1
Location of Failures in the Transmission Mains, 1993-95

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Section 5
GUIDELINES FOR ECONOMIC ANALYSIS

The economic analysis of vodokanal operations is crucial to understanding the enterprise's financial performance and production results The World Bank has recommended that Ukrainian vodokanals fill in the Standard Report " Sales Revenue and Production Costs' every month The lack of the up-to-date guidelines for the economic analysis complicates analytical work of an enterprise In order to standardize the procedure for filling in the Standard Report on a uniform methodological basis, the "Guidelines for Economic Data Analysis" have been drawn up using the Lviv vodokanal as an example The guidelines also allow to exert control over filling in the Standard Report The basis of the guidelines is an information model that plays the role of a link between main figures included into the Standard Report and enterprise's documents containing the necessary information

The Standard Report " Sales Revenue and Production Costs" consists of three parts 1) revenue from water and wastewater services including payments in cash and barter, 2) expenditures in both cash and barter) and, 3) the balance

The Revenue Part of the Standard report contains the main figures characterizing production performance of the vodokanal including cost of the services provided, payment collection rate (cash and barter) for water and wastewater services, and revenue from the other LVK activities The Expenditure Part of the Standard Report contains data on operational expenditures grouped according to the natural classification and expenditure items under recommendations of the World Bank The Balance Part shows results of the production performance of the enterprise (cash and barter) and electricity bill arrears The Revenue and Expenditure parts contain data sourced from appropriate documents and data obtained as a result of calculations The third part -- Balance -- is a result of calculations after filling in Parts 1 and 2 of the Standard Report (see Table 5-1)

The "Guidelines for Economic Data Analysis" is purely of practical importance The purpose of the document is the following

- regulate the procedure for calculation of water and wastewater services production costs as a basis for tariff setting for vodokanals' services
- provide a standardized methodological approach for accomplishing an economic analysis
- provide guidelines on the documents to be source in order to avoid ambiguity
- give objective data on the vodokanal's production performance
- standardize the procedure for filling in the Standard Report by vodokanals
- reduce time for collecting data to fill in the Standard Report as any member of staff (not only highly skilled staff) can fill in the Standard Report

Table 5-1
Standard Report (1996)

I Revenue from Water and Wastewater Services (Payments in Cash and Barter)

#	Items	Water /Ww Billed	Water/Ww Tariff	Amount Billed	Total Collected		Of Which Collected in Cash	
		1,000 m³	UAH/m³	x 1,000 UAH	%	x 1,000 UAH	%	x 1,000 UAH
1	Industry	5,659	2 15	12,172	133	16 208	24	3,826
2		11 654	0 55	6 401	128	8 196	24	2 006
3	Communal	34 820	0 22	7 605	9	668	100	668
4	Services	29 705	0 09	2,643	9	236	100	236
5	Residential	66 746	0 13	8 886	31	2 778	100	2 778
6	Sector	65 115	0 06	4 013	31	1 237	100	1 237
7	Total	107,225		28,663	69	19,654	37	7,272
8		106 473		13 057	74	9,669	36	3 479
9	Average		0 27					
10			0 12					
11	Subsidies							
12	Discounts			1 585	19	300	100	300
13	Other Revenues			3 863	100	3 864	1	28
14	**Total Revenue**			**47,168**	**71**	**33,487**	**33**	**11,079**

II Expenditure (Cash and Barter)

	Items		UAH	x 1,000 UAH	%	x 1,000 UAH	%	x 1,000 UAH
		Number of Workers	Average Salary	Total of Salary	Salary Paid		Of Which Paid in Cash	
15	Salary	1,464	120	2 112	98	2,079	97	2,025
		KWh x1,000	Average Price	Total Amount Billed	Total Amount Paid		Of Which Paid in Cash	
16	Energy	154 807	0 08	11,895	58	6 930	9	599
	Energy (transit)	107 879	0 05	5 445	57	3 114		0
17	Maintenance	21 890	0 07	2 474	100	2 474		4
18	Depreciation including			5 977	93	5,545		0
19	Capital Repair			0		1,467		0
20	Depreciation Fund			0		4 078		0
21	Other Expenses			6 151	88	5 409	59	3 167
22	Taxes			2 064	93	1 926	98	1 896
23	Production Cost			36 116	76	27,476	28	7,690
24	Other Taxes			691	96	663	93	617
25	VAT			5,603	95	5 344	47	2,512
26	**Total Expenditures**			**42,411**	**79**	**33,482**	**32**	**10,819**

III Balance

27	Billed Revenue less Incurred Expenditure	4 757				
28	Collected Revenue less Incurred Expenditure			8 923		
29	Collected Cash Revenue less Incurred Expenditure					-31 332
30	Collected Revenue less Paid Expenditure			5		
31	Collected Cash Revenue less Paid Expenditure					-22 404
32	Cash Payments Collected less Paid Cash Expenditure					260

Electricity Bill Arrears

			%	x 1000 UAH		
33	Cumulative at the beginning of the December 1996			15 289		
34	Cumulative at the end of the December 1996			15 240		
35	Increase (Decrease) at the end of the month			-49		

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Section 6
WORKSHOPS

Under DO #9, Task U2, CH2M HILL conducted a series of workshops in Lviv on work-in-progress and lessons-learned regarding development of methods to demonstrate in vodokanal operations The workshops dealt with the following topics

- water utility organization and operations
- water utility financial and legal aspects
- Lviv Vodokanal (LVK) systems operations
- LVK financial aspects (income and capitalization)
- Institutional strengthening

The first two of these workshops were held on October 25 and 27, 1995 in a conference hall of the LVK Attendees included LVK staff, representatives from the City of Lviv, USAID/Kyiv, and other consulting firms funded by USAID and international donors The workshops focused on presenting, to a wider audience of officials in Lviv responsible for water supply, information learned by participants of a U S study tour

Workshops 3 and 4 were held on March 27 and 28, 1996 in the Session Hall of the Lviv City Hall and focused on technical, financial and institutional aspects of the LVK The target audience were representatives of LVK, the city of Lviv administration, and the World Bank Apart from USAID, other donors and lenders represented were the World Bank, Danish Environmental Protection agency, and the British Know-How Fund Presenters at the workshops included consultants retained by these donors and lenders, and included CH2M HILL, Planning and Development Collaborative (PADCO), COWI (Danish consultants), and Booz Allen & Hamilton (BAH) from Warsaw

Workshop 5 was organized by and held in the EPT/Lviv office (on LVK premises) on 14 June 1996 Attendees included the LVK staff, the Lviv Water Inspectorate, and PADCO representatives

This workshop dealt with the following topics

- Importance of system measurements
- Meter installations and repair
- LVK billing and payment collection
- Inspection and analysis of LVK customers with water meters installed
- Measurements at major water pump stations
- Maintenance of the city distribution system
- Breakages in the water distribution system
- Measurement of flow at the wastewater treatment plant

Workshops proved to be successful New concepts were introduced, and the analysis of discussed problems has represented another important step to continue project development and implementation in Lviv The discussion (see Figure 6-1) revealed a strong desire to incorporate many of the ideas and practices presented at the Workshops

Workshop presentation Kris Buros and Tamara Gipp (both from the EPT/Lviv staff) making a joint presentation using overheads on the need to reduce leakage in the distribution system so as to reduce energy usage in Lviv

World Bank participation Walter Stottmann of the World Bank discusses in one of the workshops some of the key areas where the World Bank would like to assist the LVK with a future capital improvements loan

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Figure 6-1 EPT and World Bank staff participate in the workshops

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Section 7

DEVELOPMENT OF A FEASIBILITY STUDY

7.1 COWI STUDY

The Danish consulting firm, COWI, was funded by the Danish Environmental Protection Agency to prepare a feasibility report that could be used by the LVK to obtain a WB loan

COWI worked in Lviv for most of 1996 on the study and published the findings of the study entitled, *Studies for the Preparation of Lviv Water and Wastewater Project, Lviv, Ukraine,* in Mach 1997 During the study the staff of COWI and EPT worked closely together on the water issues, data to be developed and the production of graphic information for the COWI and EPT reports The COWI report was reviewed by EPT personnel and there was general agreement with the recommendations and conclusions

7.2 STUDY RECOMMENDATIONS

The major overall strategic recommendation of the study related to water are as follows

1 The current volume of water production is already as high as 412,000 m^3/d equivalent to approximately 450 lcd

2 Large increases in water extraction and pumping would lead to parallel increases in power consumption and expenditures The population could not afford to pay the resulting tariff increases

3 While a significant increase in the volume of water pumped into the city would lead to a higher service level more than 60 percent of the extra water pumped into the city would be lost in network losses and wastage

To supplement these on a practical basis COWI recommended a WB investment program of about 48 5 million USD as shown in Table 7-1 The program's Priority 1, 2 and 3 would be made up of the following elements

The program's Priority 1 projects (total US$8 64 million) include

- Rehabilitation of well fields - US$1 5 million
- Establish pressure zones - US$0 5 million
- Replacement of leaky pipes in the distribution system - US$2 2 million
- Energy conservation at the pump stations - US$1 52 million
- Completion of the Poltva collector
- Inlet pumps at WWTP No 2 - US$1 07 million
- Aeration system at the WWTPs - US$1 35 million

The program's Priority 2 projects (total US$7 92 million) include

- Replacement of leaky pipes in the distribution system - US$3 9 million
- Renewal of Collector IV - US$0 5 million
- Pump station (Naukova) to Western Collector - US$0 21 million
- Inlet pumps at WWTP No 2 (Phase 2) - US$1 07 million
- Rehabilitation of WWTP sedimentation tanks - US$0 91 million
- Sludge dewatering - US$0 61 million

The program's Priority 3 projects (total US$4 57 million) include

- Redrilling of wells - US$0 59 million
- Replacement of leaky pipes in the distribution system - US$2 million
- Replacement of pipes at the well fields - US$0 78 million
- Rehabilitation of Promyslova St collector - US$1 2 million

Table 7-1
COWI's Proposed Investment Program for the LVK

No	Item	Investment Cost (millions USD)
1	Priority 1 projects	8 60
2	Priority 2 projects	7 90
3	Priority 3 projects	4 60
	Total for priority projects	21 10
4	Management contractor	6 75
5	Rehabilitation fund	10 00
6	Contingencies	3 80
7	Value added tax	6 80
	Total	**48 00**

This funding program is now being reviewed by the World Bank and serious consideration is being given to extending a loan to the LVK during 1998

Section 8
METERING, BILLING AND REVENUES

Consumers in the Lviv water system are divided into three classes for purposes of tariffs These are residential, communal and industrial enterprises

The Lviv city distribution system has 26,166 primary users (kontos) as reported by the LVK Each connection may serve many people and activities Only 10 percent of this number have working meters installed (Table 8-1)

Due to lack of flow meters, the amount of water consumed is estimated on the basis of norms Norms of water demand of various water consumers have been developed and approved by the State Construction and Architecture Committee of Ukraine Under state regulations, the Lviv Executive Committee has approved the *Water Demand Norms for Residential and Public Buildings and Institutions*, which is the basis for calculations regarding water demand

The vast majority of users in Lviv are charged using an estimated rate of water usage based on either the characteristics of the particular user category or the size of the connection to the system The concept of estimating the probable amount of average water use by user category is employed in other countries, such as the USA, to assess water demand in a system These norms are presently being utilized in Lviv to invoice most LVK customers for their water use However, this method allows users to pay a flat fee for unlimited water consumption

Primary customers with meters installed have their meter readings taken by inspectors and are billed in accordance with the readings for water consumed, and also are charged for wastewater services in accordance with established norms If there are no meters installed, the primary customers are billed in accordance with the established norms on water and wastewater services If the water meters are not functioning, the inspectors calculate the average daily water consumption for the last two months that the meter functioned and multiply it by the number of days in the current month

Table 8-2 shows the amount of water supplied and billed for by LVK in 1995 The tariffs for water and wastewater during 1993 to 1996 are shown in Table 8-3 and the collection rates during that period are shown in Table 8-4 The payment collection rate for the residential sector was 26 percent in 1993, 63 percent in 1994, 42 percent in 1995, and 23 percent in the 1st half of 1996 The overall low collection rate from the residential sector is thought to be caused by the following

- Part of the population is entitled to discounts for the water and wastewater services In 1995, the state granted a targeted subsidy to persons with low incomes However, it only paid back a small portion of the subsidies and discounts to LVK

- Due to poor economic conditions in the country, a considerable part of residential consumers did not receive regular salary payments, which resulted in delayed payments for communal services, including LVK services

- There is a lack of enforcing measures for those residents that do not pay for LVK services Current legislation does not sanction applying enforcement measures for collecting debts and there are no penalty clauses for non-payment for LVK services

In the beginning of August 1996, LVK suspended delivery of water to part of the residential sector with the largest debts About 90 percent of the debtors paid their bills within two weeks This action was of an experimental nature, but in the opinion of the LVK Sales Department it cannot become a policy since apartment buildings have no valves allowing water supply to be cut off to individual apartments Water supply cut off to an entire residential building may cause unfair hardship to those residents who have already paid for LVK services In addition, the legality of this action is questionable, since there are no clear-cut clauses in current legislation permitting cutting off supply in return for non-payment

The total consumer debt for the LVK services has been growing from year to year and by the end of June 1996 the total consumer debt amounted to US$6 million During the survey period, budget institutions were LVK's principal debtor There has been almost no cutoff of water supply to budget organizations, because among the LVK's largest debtors within this consumer group are hospitals, educational establishments, and kindergartens, and it is doubtful whether the State Sanitary-Epidemiology Service and the City Administration would give permission for suspending their water supply

Table 8-1
Meters Installed and Estimated Consumption by Consumer Group -1995

Group	Number of Kontos	Estimated			Meters			% of Total Flow Metered
		m^3/d	%	$m^3/d/konto$	Number Installed	Number Working	Working %	
Residential Sector	19,632	164,300	55 8	8 37	13,609	509	3	2
Industry	3,489	21,000	7 1	6 02	No data	1179	34	2
Communal Services	2,058	87,500	29 7	42 52	No data	675	33	10
Budget Institutions	987	21,900	7 4	22 19	No data	260	26	2
Total	**26,166**	**294,700**	**100**	**11 26**	**No data**	**2623**	**10**	**16**

Table 8-2
Water Supplied and Billed - 1995

Consumer Location	Reported Amount of Water Supplied (m^3)		Amount of Water Billed (m^3)	
	per year	per day	per year	per day
Lviv	141,053,000	386,000	107,554,000	295,000
Villages	3,256,000	9,000	2,397,000	7,000
Vynnyky	1,659,000	5,000	1,029,000	3,000
Other	4,571,000	12,000	3,737,000	10,000
Total	**150,539,000**	**412,000**	**114,717,000**	**314,000**

Table 8-3 Water and Wastewater Tariffs								
Consumers	1993		1994		1995		1st half of 1996	
	$/m³	% of Average	$/m³	% of Average	$/m³	% of Average	$/m³	% of Average
Water Tariff								
Average	**0 15**	**100**	**0 05**	**100**	**0 12**	**100**	**0 15**	**100**
Residential Sector	0 01	4%	0 01	10%	0 03	29%	0 12	76%
Budget Institutions	0 04	26%	0 01	13%	0 14	116%	0 19	123%
Communal Services	0 13	86%	0 07	143%	0 14	116%	0 19	123%
Industry	1 13	742%	0 74	1435%	1 38	1157%	1 06	694%
Wastewater Tariff								
Average	0 05	100	0 03	100	0 08	100	0 06	100
Residential Sector	0 00	7%	0 00	10%	0 02	23%	0 05	81%
Budget Institutions	0 01	27%	0 00	12%	0 06	77%	0 08	134%
Communal Services	0 10	199%	0 04	146%	0 07	85%	0 08	134%
Industry	0 56	1147%	0 23	833%	0 28	352%	0 30	483%

Note The tariffs were in effect at the end of the accountable periods

Table 8-4 LVK Collection Rate					
No	Consumers	Total (USD)		Collection Rate	Total Receivables
		Amount Billed[1]	Payments Collected[1]		
1993					
1	Residential sector	124,000	32,000	26%	92,000
2	Industry	3,635,000	3,045,000	84%	605,000
3	Others[2]	377,000	324,000	86%	56,000
	Total	**4,136,000**	**3,401,000**	**82%**	**753,000**
1994					
1	Residential sector	118,000	74,000	63%	86,000
2	Industry	2,989,000	2,346,000	78%	837,000
3	Others[2]	292,000	223,000	76%	121,000
	Total	**3,399,000**	**2,643,000**	**78%**	**1,044,000**
1995					
1	Residential sector	2,132,000	904,000	42%	1,294,000
2	Industry	10,425,000	8,246,000	79%	2,797,000
3	Others[2]	1,874,000	1,060,000	57%	1,060 000
	Total	**14,431,000**	**10,211,000**	**71%**	**5,151,000**
1st half 1996					
1	Residential sector	3 229,000	758,000	23%	2,210,000
2	Industry	6,127,000	7,413,000	121%	2,776,000
3	Others[2]	2,120,000	821,000	39%	1,605,000
	Total	**11,475,000**	**8,992,000**	**78%**	**6,591,000**

Note

1 "Amount billed" and "payments collected" include the service cost of LVK structure

2 The "others" include communal sector, budget organizations and collective farms

Section 9
PROBLEMS OF SYSTEM MEASUREMENT

9.1 MAJOR PROBLEMS

Data on water consumption, flow, power usage, etc in the LVK's water system are very important for understanding, analyzing and changing the operation of the system These data can and should be used to guide and plan improvements in system operation and make critical decisions on capital investments

At present, data are generally collected because they are and always have been "required" Log books have pages to fill in, tariff formulas need figures so that calculations can be made and so on With the need to reduce operating costs and prioritize investments with any future World Bank loan (or other donor money), both additional data and an improved quality of data are required

There are a number of significant problems with data and measurements in the LVK system First, there are insufficient data points and types of data collected in the system to provide the LVK with an adequate basis on which analyze its operation For example, out of about 26,000 consumer connections to the distribution system, only about ten percent are equipped with operating water meters This also applies to water pressure, energy consumption, water production, etc Second, the accuracy of the collected data is unknown in many cases, especially historical data Examples of this are the norms of water consumption used to bill domestic consumers based on the number of stories in a building, provision for hot water, etc Other important data, such as power consumption, is sometimes calculated using uncalibrated instruments or inappropriate time periods, other data are simply repeats of what was logged in the book previously, and in the past data may have reflected expected norms or plans The third significant problem is that collected data exists but it is in a form that is laborious to breakdown and hence not readily available for analysis An example of this is the logs maintained by repair crew on work done on the pipes in the distribution system

Although it would be useful to have a wide range of data, the cost of intensive instrumentation in the system is too high to be able to install all of the instruments that might be desired Therefore some balance must be made by the LVK as to the degree of data collection and the accuracy needed for these data

The EPT Project examined existing data and made new measurements in the areas of water consumption, flows and pressures in the distribution and transmission systems, production at well fields and energy consumption In addition, it made recommendations for extending the number and installation of measurement devices in the system

9 2 IMPORTANCE OF SYSTEM DATA

Two major reasons for improving the measurements in the system at this time are to enhance operations and prioritize future capital investments With the amount of cash that can be

earned limited by the willingness of people to pay and the ability of the LVK to collect, it is important to increase the efficiency of system operations to reduce the cost of water actually delivered to the consumer This requires accurate data on what is actually happening in the system in order to take appropriate and effective measures to improve operations

The second reason is that the LVK has an opportunity to borrow something between 20 and 40 million USD for capital investment during the next five to ten years Decisions on investment priorities must be made and accurate data is critical to making these decisions

9.3 NORMS

During the Soviet period a data base was created using information from many cities and regions which could be used to predict average values for a wide variety of parameters within a water system These are predictive values for parameters like consumption per person based on apartment size, consumption in an industry based on the amount of product produced, wastage per appliance, leakage per km of pipe, maximum flow expected in a system, etc These are very similar to standard design parameters used by engineers and planners in Western Europe and the USA

In the FSU this went further than design and came to be also used for charging for water where meters did not exist and for predicting other losses for tariff purposes These were essentially average values calculated at a certain point in time based on a large sample taken over an extensive region (e g , Vladivostok to Lviv) which has many different conditions Therefore it should not be surprising that in any specific area, especially with the wider availability of water-using appliances and newer materials, that the actual usage, leakage, etc varies from the established norms

When the FSU was one large, planned and financed economic system the variations from location to location did not make much difference to the overall State economy when using norms to establish tariffs and bills for water usage Where norms instead of measurements are used in an isolated system for both predicting operating conditions and establishing tariffs then problems can occur in the measurement and financing of the system when there is a major variation between actual and theoretical (norms) values

For these reasons it is critical for a vodokanal, such as the LVK, which is heavily dependent on the use of norms, to understand what the relationship is between the actual and normative values

9 4 SYSTEM MEASUREMENTS - CONSUMPTION

The ability to know the total consumption by users in the system is severely limited by the lack of water meters on the direct connections (kontos) of consumers to the distribution system If the estimated consumption was evenly distributed within the kontos of each user group, then the amount of water that is actually measured by meter is about 15 to 16 percent

of the total Conversely it means that the LVK is estimating about 85 percent of the consumption in their system

These consumption estimates, which represent almost 85 percent of the water that is alleged to be delivered to consumers, are based on State established norms, previous readings when an installed meter did exist or an estimate by someone in the LVK This means that the potential for error in estimating the total consumption in the system is high Since the State established norms are the most frequently used means for estimating the consumption by the LVK, it was felt to be important to verify the validity of the norms for various groups of users under different conditions of water service

9.4 1 Residential

Many residents live in four to nine story apartment buildings in the suburbs of the city The average number of floors is 6 4 According to the LVK data, the residential sector has 509 flow meters (out of 19,632 kontos) installed which are both working and calibrated There are another 13,600 flow meters which are installed but not working and cannot be repaired There are almost no functioning flow meters in the higher apartment buildings in new areas of Lviv

To make an estimate of the accuracy of data, fifteen smaller residential buildings were inspected by EPT staff and ten were selected for further analysis Table 9-1 compares the predicted water consumption based on norms to the actual consumption as indicated by metered flow This data show that the water usage in the residential buildings with a 24-hour water supply exceeds the predicted norm by about 100 percent, while the water usage in the residential buildings with a six hour water supply almost equals the norm

9 4 2 Industrial Enterprises

There are many mechanical engineering, food, light industry enterprises and other industries in Lviv and they amount to almost 3,500 kontos Water consumption of the enterprises depends on the character of production, raw material, final product, water usage in production and water supply scheme In 1995, the average water usage for an industrial connection was estimated to be about 6 m^3/d/konto or a total average flow of 21,000 m^3/d (about seven percent of Lviv's estimated water consumption)

The LVK's list of 3,500 industrial customers was reviewed and 18 enterprises were selected for inspection Based on the inspection, 15 were selected for a more thorough analysis One of the selection criteria was the presence of a calibrated flow meter These 15 enterprises consume about 8,000 m^3/d or 38 percent of water estimated to be used by all the industrial enterprises Table 9-2 compares the predicted water consumption based on norms to the actual consumption as indicated by metered flow for these industrial enterprises

9.4 3 Communal Services and Budget Institutions

According to the LVK method of classification, this consumer group includes various enterprises and institutions ranging from cultural institutes to public transport and collective farms Out of 2,000 communal users 11 were inspected and five were chosen for further

analysis The total actual water usage of the communal users inspected conformed approximately with the total water usage that would be predicted using State norms Table 9-3 compares the results of the calculated usage (based on State norms) and the daily water usage measured by the installed meters

9.4.4 Water Meters

The LVK reports that presently the water supply system has about 26,000 consumer (kontos) connections to the system Each connection may serve many people and activities Only ten percent of these connections have working meters installed It is known that more than 50 percent of all connections had meters installed at one time but many of these have either failed and/or were removed

An inspection of the service connections was made at 48 locations, representing different consumer groups selected at random that are billed according to the norms of water consumption (see Table 9-4) The inspection has revealed that 89 percent of the locations had meters installed but only 30 percent of locations had meters that were functioning

This has two implications One, many locations in the city have the fittings to enable a functioning meter to be installed and this would ease the widespread installation of meters The second is that even if meters are functioning, the LVK in some cases are still using norms to bill the consumers

9 5 SYSTEM MEASUREMENT - PRODUCTION

A significant problem in system measurement is the lack of adequate data on the amount of water that is produced to supply the system Most well fields do not have flow meters to measure either individual wells or production from entire well fields There are 20 well fields that supply the Lviv system

To improve the understanding of the production of the well fields and the characteristics of individual wells, measurements and observations were made from August to October 1996, at selected well fields in the North, West and South groups To assist LVK measurements and analysis were made at the rest of the Lviv well fields in the first half of 1997 Based on these measurements, the amount of water produced by the well fields reported by the LVK seems to be reasonably in line with the data obtained by the EPT/Lviv (see Table 9-5)

Most detail measurements have been accomplished at Stryi well field, that provides 35 percent of Lviv's water supply However, there are no flow meters installed in the well field to measure either the individual or total flows from the wells Using the EPT ultrasonic flow meter, a measurement of the flow in the main water transmission system coming from the well field was made The result of this 24-hour measurement was a flow of about 123,670 m^3/d During the period, September through November 1996 a number of measurements and observations were made at the Stryi well field Some of these data are shown in Tables 9-6 and 9-7

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9.5.2 Transmission System

In order to estimate losses in the water mains caused by leakage and nonauthorized connections, measurements were carried out at four points on the water transmission main connecting the Stryi well fields to the Mykolaiv and Sokilnyky pump stations Measurements were carried out over a period of two weeks (see Table 9-8) at four points on the 1200-mm diameter water transmission main, that goes from the Stryi well field to the Sokilnyky pump station Measurements showed that the losses between Derevach and Sokilnyky amounted to about 8,000 m^3/d which makes 6 5% of the total water supply The difference in upstream and downstream measurements could be caused by leakage from the pipeline, water being diverted by secondary connections for use by others along the route of the transmission main and by measurement error

The EPT/Lviv staff accomplished measurements of water flow, pressure and power consumption at the seven principal seven pump stations located at the city boundaries Data gathered by portable ultrasonic meter are in line with data obtained by LVK meter installed (see Table 9-8) This demonstrated that the LVK's installed meters were suitable for estimating flow but that tank level readings to measure the flow from previous pump stations were not EPT's portable ultrasonic flow meter permitted the EPT staff to estimate the daily and hourly flow at selected pump stations The Table 9-9 and Figure 9-1 presents the data on the amount of water discharged by the main pump stations

Based on these measurements, the amount of water discharged by the pump stations reported by the LVK seems to be reasonably in line with the data obtained by the EPT/Lviv

9 6 ULTRASONIC US MADE FLOWMETER (PANAMETRICS TRANSPORT™ MODEL PT868)

General understanding how much water is produced at the well field and delivered to the city distribution system developed using a portable ultrasonic clamp-on flowmeter As a clamp-on meter, it allows to accomplish measurements and obtain flow rates at any point of transmission or distribution system where straight piece of long enough pipe of different materials, wall thickness and with diameter ranges from 50 mm to 2000 mm is exposed

The flowmeter is especially valuable in collecting information and its use together with pressure recorders and electrical multimeter, data on well flow rates, energy efficiency, pump characteristics and flow patterns During the program study two persons from LVK learned to use this equipment

The TransPort™ Model PT868 is a transit-time flowmeter which has all features of a full size flowmeter, with the advantages of a portable It is based on the following principles when ultrasonic pulses are transmitted through a moving liquid, the pulses that travel in the same direction as the fluid flow (downstream), travel slightly faster that the pulses that travel against the flow (upstream) The TransPort uses various digital signal processing techniques, including cross-correlation, to determine transmit times and uses these to calculate flow velocity

Table 9-1 Residential Water Usage - Measured versus Predicted							
Hours of Water Service	Address	Number of Residents	Usage				Actual/ Norm Ratio
			Measured (meter)		Predicted (by norm)		
			m^3/mo	lcd	m^3/mo	lcd	
24	Dragomanova, 36	14	304	700	91	210	3 33
24	N Levytskoho, 16	36	576	516	234	210	2 46
24	Snopkivska, 8	17	236	448	111	210	2 13
24	Hlibova, 3	31	413	429	202	210	2 04
24	Hlibova, 8	18	107	192	117	210	0 92
Subtotal (24 hours)		**116**	**1,635**		**755**		**2 17**
6	Bohuna, 9	40	535	431	260	210	2 05
6	Donetska, 10	26	199	247	169	210	1 17
6	Vyhovskoho, 63	264	994	121	1,187	145	0 84
6	Mikhnovskykh, 25	41	198	156	267	210	0 74
6	Trusha, 24	17	54	103	111	210	0 49
Subtotal (6 hours)		**388**	**1,980**		**1,994**		**0 99**
Total		**502**	**7,230**		**5,498**		**1 32**

Table 9-2 Industrial Water Usage - Measured versus Predicted					
No	Water Consumer	Description of Product	Usage (m^3/d)		Actual/ Norm
			Actual (Measured)	Predicted (by Norm)	
1	Production Amalgamation Microprylad	instruments, measurement instruments, consumer goods	1,093	94	11 63
2	Lviv Fat Products Plant	margarine, mayonnaise	825	140	5 89
3	Lviv Stock Holding Company HALKA	instant and ground coffee, coffee beans	196	52	3 77
4	Lviv Milk Plant	milk products	848	263	3 22
5	Lviv Milk Plant	milk products	906	351	2 58
6	Ceramics Plant	ceramic tiles, roof tiles, plumbing fittings	274	107	2 56
7	Vodka Plant	liqueur, vodka, vinegar	326	133	2 45
8	Transport Enterprise	transportation of passengers	116	64	1 82
9	Insulation Plant	insulators, glass blocks	234	186	1 26
10	Iskra Stock Holding Company	electric bulbs	1,347	1 194	1 13
11	Promin Knitted Goods Factory	knitted goods	560	620	0 90
12	Lviv Bakery No 2	wheat bread	94	136	0 69
13	Halichfarm Pharmaceutical Factory	medicines	479	778	0 62
14	Lviv Bakery No 3	bread	46	80	0 58
15	Joint Venture Coca-Cola	soft drinks	630	2,225	0 28
	Total		**7,974**	**6,422**	**1 24**

Note Measurements were accomplished during March - April 1996

Table 9-3 Communal Water Usage - Measured versus Predicted				
No	Water Consumer	Usage (m^3/d)		Actual/ Norm
		Actual (measured)	Predicted (by Norm)	
1	Lviv Hotel, Simsotrichia Lvova St , 7	273 4	166 8	1 64
2	LvivPrylad Club, Ivana Franko St , 175	1 95	2 15	0 91
3	Halychyna Cinema, Liubinska St , 95	2 61	3 12	0 84
4	Grand Hotel, Svobody Ave , 13	36 4	50 4	0 7
5	State Circus, Horodotska St , 83	100 5	170 7	0 59
	Total	**415**	**393**	**1 06**

Note
Measurements were made during March - May 1996

Table 9-4 Survey of Service Connections					
Group	Locations	Meters Installed		Functioning Meters	
		Number	%	Number	%
Residential	26	22	85	5	19
Budget	14	14	100	6	43
Communal	7	6	86	2	28
Industrial	1	1	100	1	100
Total	**48**	**43**	**89**	**14**	**30**

Table 9-5 Inspection of Well Fields						
Well Field Name	Q-ty of Wells	Average Capacity * (m^3/d)		Measurement results		
		1995	1996	Date	Q-ty of Working Wells	Flow (m^3/d)
North						
Rava-Ruska	8			09 97	7	16,400
Maheriv	4	31,711	30,925	09 97	4	10,700
Shostaky	3			07 97	3	10,100
Krekhiv	5			7 02 97	4	13,000
Kunin	2	19,032	17,347	7 02 97	2	5,000
Mokrotyn	7	11,815	8,894	7 02 97	3	3,600
Zarudtsi & Zavadiv	16	25,312	19,668	24 02 97	14	15,400
Subtotal	**45**	**87,870**	**76,834**		**37**	**74,200**
West						
Volia Dobrostanska	5	7,018	8,063	22 11 96	N/D	14,100
Velykopole	5	7,007	7,368	22 11 96	N/D	11,700
Kamianobrody	4	15,269	12,686	22 11 96	N/D	12,000
Malchytsi	9	15,856	16,056	01 07 97	6	8,400
Budzen	22			3 06 97	N/D	31,100
Kernytsia	8	43,002	41,298	3 06 97	7	12,900
Subtotal	**53**	**88,152**	**85,471**		**N/D**	**90,200**
South						
Stryi	34	126,375	128,894	10-11 96	32	116,600
Hlynna-Navaria	12	14,221	14,188	31 03 97	8	12,900
Stare Selo	12	24,1	18,554	5 09 96	N/D	19,400
Malechkovychi	1	4,916	5,841	_	1	5,800
Subtotal	**59**	**169,660**	**167,477**		**N/D**	**154,700**
East						
Pluhiv	8	50 486	52,691	03 04 97	8	49,400
Remezivtsi	4	7,377	5,150	18 03 97	N/D	6,700
Vilshanytsia	4	8,572	6,233	18 03 97	4	14,400
Subtotal	**16**	**66,435**	**64,074**		**N/D**	**70,500**
Total	**173**	**412,117**	**393,856**			**389,600**

Note
* Reported by LVK

Table 9-6 Measurement Results at Stryi Well Field, Well Group 1, November 1996									
Well No	Outside ⌀	Flow	Velocity	Pressure	Dynamic Depth to Water	Current	Voltage	Capacity	Specific Power Consumption
	mm	m^3/h	m/s	atm	m	A	V	kW	(kWh/m^3)
1	not measured								
2	159	139	2 26	4 4	6 2	62	380	41	0 294
3	165	188	2 88	4 6	6 15	70	380	46	0 245
4	219	126	1 05	4 3	5 2	70	380	46	0 366
5	154	195	3 31	4 0	6 0	71 5	380	47	0 241
6	165	212	3 17	4 2	4 6	70	380	46	0 217
8	219	218	1 8	3 4	5 4	73	380	48	0 220
9	219	252	2 05	3 3	4 7	72	380	47	0 188
10	219	229	1 89	3 3	5 2	71	380	47	0 204
11	219	48	0 39	3 0	3 8	52	380	34	0 713
Total		**1607**						**402**	**0 250**
7*	165	84	1 27	3 0	4 5	27	380	16	0 190

Notes
* Water for Villages

Table 9-7 Power Consumption at Stryi Well Field, October-November 1996			
Group No	Flow	Capacity	Specific Power Consumption
	m^3/d	kW	kWh/m^3
I	1607	402	0 250
II	1609	326	0 203
III	1641	410	0 250
Total	**4857**	**1139**	**0 235**

Table 9-8 Measurements at Pump Stations Total Water Flow								
No	Pump Station Name and Place of Flow Metering	Measurements Started		Duration of Measure-	Water Flow by PT 868		LVK Flow Meter	Δ
		Date	Time	ments (h)	m^3	m^3/d	m^3/d	%
1	Stryi Well Field Water Main	2 07 96	15 00	24		123 672	not installed	
	Mykolaiv PS							
2	Inlet to PS	5 07 96	14 00	1	5 047	121 128		
3	near Village of Derevach	5 07 96	16 00	1	5 150	123 600	not installed	
	Sokilnyky PS							
4	Inlet to PS	12 07 96	21 45	24		115 649	not installed	
5	Outlet to City 1	2 09 96	14 30	24		47 669	not functioning	
6	Outlet to City 2	2 09 96	14 30	24		52 467	54 164	3
7	Outlet to Miska Smuha PS	2 09 96	14 30	24		11 555	10 648	8
	Total Amount Discharged from Sokilnyky PS					**111,691**		
	Miska Smuha PS							
8	Outlet to City 1	13 09 96	13 00	24		1 691		
	Outlet to City 2	no measurements						
	Vynnyky PS							
9	Received from East	6 08 96	15 00	24		**60,114**	not installed	
10	Outlet to Dovha PS	29 06 96	10 00	24		11 540		
	Outlet to Kryvchytsi PS	no measurements						
	Kryvchytsi PS							
11	Outlet to Maiorivka Area	13 09 96	12 00	24		25 212		
12	Outlet to Center	13 09 96	12 00	24		11 282		
	Total discharged from Kryvchytsi PS					**36,494**		
	Zboisk PS							
13	Inlet from Zarudtsi PS Water Main 1	10 07 96	15 40	24		32 195	not installed	
14	Inlet from Zarudtsi PS Water Main 2	14 07 96	9 00	24		18 644	not installed	
	Total Received from Zarudtsi PS					**50,839**		
15	Pressure Pipe 1 Outlet to City	15 07 96	18 30	3	6 161	6 161		
	Pressure Pipe 1 Outlet to City	16 07 96	6 00	3	5 454	5 454		
16	Pressure Pipe 2 Outlet to City	15 10 96	8 00	1	1 586	4 758		
	Pressure Pipe 2 Outlet to City	15 10 96	18 30	1	1 540	4 620		
17	Gravity Pipe Outlet to City	17 07 96	11 00	24		12 104		
18	Gravity Pipe Outlet to Kryvchytsi	17 10 96	18 00	24		13 079		
	Total Discharged from Zboisk PS					**46,176**		
	Hlynna-Navaria PS							
19	Outlet to City	4 09 96	11 30	24		14 386	14 676	2
20	Outlet to Villages	13 08 96	18 30	1	41	979	not installed	
	Stare Selo PS							
21	Outlet to City	5 09 96	16 00	24		19 381	19 896	3
22	Outlet to Villages	5 09 96	16 00	24		445	not installed	
	Sykhiv III PS							
23	Outlet to City	6 09 96	19 30	24		13 691		
24	Outlet to Plant	6 09 96	19 30	24		567		
25	Outlet to Tuberculosis Hospital	6 09 96	19 30	24		175		
	Total Discharged from Sykhiv III PS					**14,433**		
	Budzen II PS							
26	Outlet to Budzen III	9 09 96	14 00	24		32 360	36 329	12
27	Outlet to Horodok 1	9 09 96	14 00	24		1 265	not functioning	
28	Outlet to Rudki	9 09 96	14 00	24			263	
	Outlet to Horodok 2	no measurements					not installed	
	Budzen III							
29	Outlet to City	9 09 96	14 00	24		**25,135**	24 770	1
	Karachyniv PS							
30	Outlet to City	10 09 96	18 00	24		**33,263**		
	Yaniivska							
31	Outlet to City	10 09 96	19 00	24		3 926	not installed	

Table 9-9 Estimated Water Flow by EPT at Principal Pump Stations, June-September 1996			
Pump Station	**Flow**		**Location of Flow Meter**
	m^3/d	**Percent of total Flow**	
Zboisk	51,000	17	inlet
Karachyniv	33,000	11	outlet
Budzen III	25,000	8	outlet
Sokilnyky	116,000	38	inlet
Sykhiv III	14,000	5	outlet
Malechkovychi	5,000*	2	no measurements
Vynnyky	60,000	20	inlet
Total	304,000	100	

* Data reported by LVK

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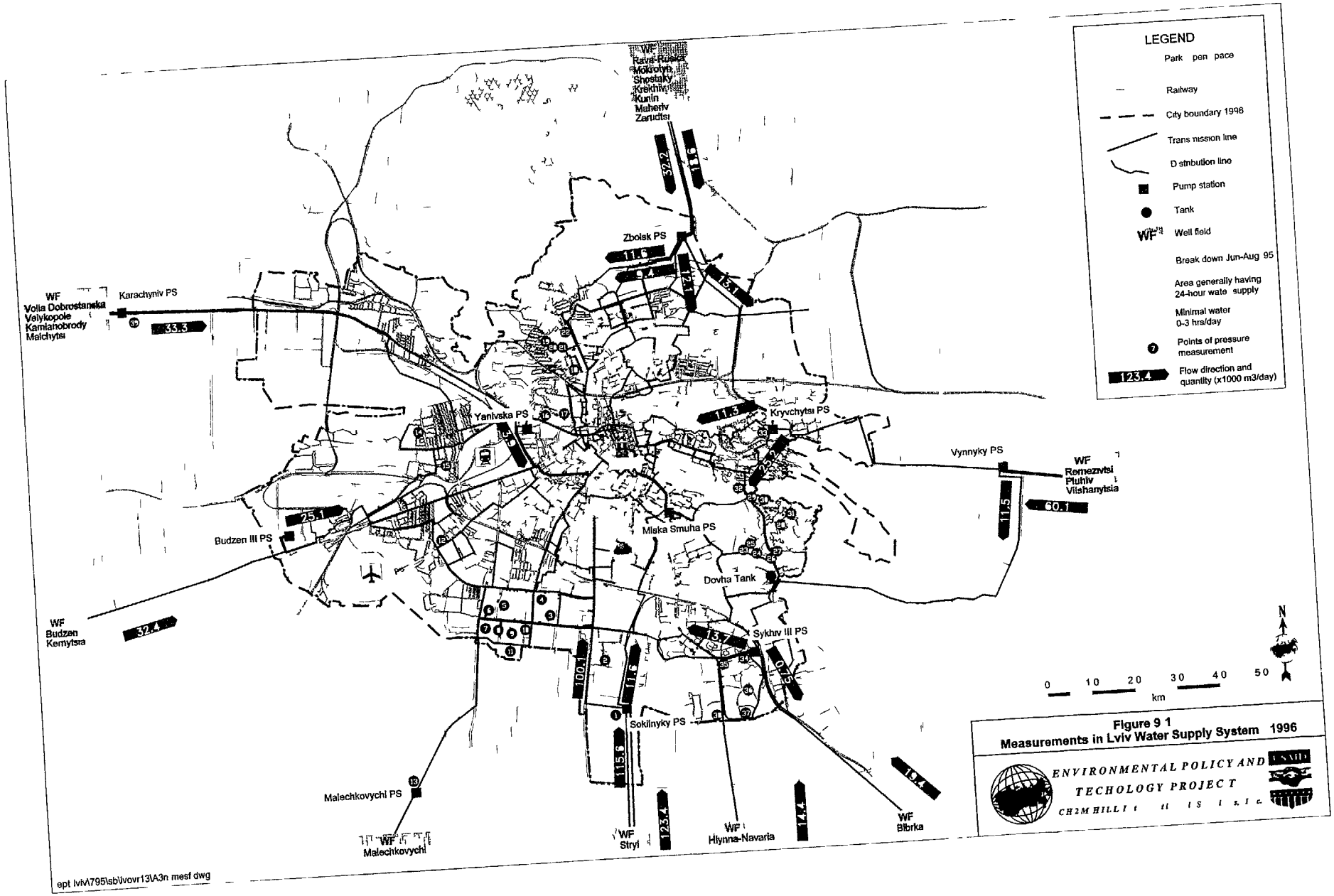

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Section 10
DEMONSTRATION PROGRAM

The staff of the EPT office in Lviv worked with the LVK and Lviv City administration to identify the areas of the city with "severely deficient" water service The Pasichna area (Figure 10-1) with the population of about 32,000 residents was selected for a demonstration project because improvements of water delivery there would allow to improve the service level to a great number of residents within the budgets available to USAID and the City

The Lviv City Administration and USAID agreed to implement a joint project on improving water service to the Pasichna area in the shortest possible period of time To do this both parties agreed to fund a portion of the project USAID funded the construction of a temporary pump station and the Lviv City Administration funded the completion of two 10,000 m^3 storage tanks and the balance of the site work to complete the facility at Dovha

The objective of this demonstration project was to segregate a portion of the city's water distribution system, the Pasichna area, in order to demonstrate how creation and operation of a water distribution subsystem would improve water delivery

To enhance water deliveries to customers in the Pasichna residential community, the following improvements were at the Dovha site and surrounding areas

- segregation of a portion of the overall Lviv distribution system by installing gate valves to establish the Pasichna water distribution subsystem
- construction of a temporary pump station
- completion of construction of the two remaining 10,000 m^3 water storage tanks
- installation of connecting pipes and valves between the pump station, tanks, and water distribution mains

The above mentioned improvements created a distribution subsystem, increased water storage capacity in the area, and then increased pressure of the water in the subsystem (pressure zone), so that it could be more readily used by area customers It demonstrated to LVK the concept of distribution subsystems to improve water service by being able to control pressure in specific portions and reduce the loss of water that flows uncontrolled to lower elevations

Work begun on design in July, 1996 and the construction work was completed at the end of 1996, when the facility was transferred to the LVK A dedication ceremony was held on site in January, 1997 Some of construction and installation works as well as dedication ceremony are shown in Figures 10-2 and 10-3

The Pasichna Demonstration Project successfully achieved the following

1 Directly improved water service to about 32,000 Lviv residents in the Pasichna area that had experienced severe water deficiencies

- daily water delivery time was increased to 10 hours per day
- the availability of water has allowed the daily average per capita consumption to increase from 149 lcd to 229 lcd (Table 10-1)
- pressure at the inlets to the heating stations has increased from the range of 2 to 7 m to the range of 10 to 12 m

2 Improved water service in adjacent areas that are still being served by the Sykhiv III and Kryvchytsi pump stations The adjacent areas affected have a population of about 75,000

3 Improved the hydraulic mode of the Pasichna area distribution system which brought down the number of pipeline breakdowns from 135 in the first half of 1995 to 71 over the same period of 1997

4 Created favorable conditions for energy saving in the future as a result of pumps replacement at the Pasichna heating stations for better matched pumps (as planned for 1997) taking advantage of the stable system pressure created by the temporary pump station at Dovha

5 Demonstrated to LVK, the City of Lviv administration, and other vodokanals, that instead of undertaking massive capital investments in new water source development, relatively minor improvements in water delivery infrastructure and system optimization, such as creation of distribution subsystems, can significantly improve water service

Table 10-1
Comparative Flow Measurement Results for District Heating Stations

Name	Location (address)	Flow (m^3/d)		Number of Residents	Consumption (lcd)	
		1996	1997		1996	1997
DHF-5W	Washingtona, 5a	70	109	221	317	493
DHF-16	Shafaryka, 16a	642	1,159	4,365	147	266
DHF-13	Washingtona, 13	512	702	2,416	212	290
DHF-98	Pasichna, 98(a)	289	453	1,785	162	254
	Pasichna, 98(b)	136	214	893	152	240
DHF-5L	Lysenytska, 5a	797	994	2,261	352	440
DHF-89	Pasichna, 89a	501	500	4,039	124	124
DHF-12	Kytaiska, 12a	341	790	4,352	78	181
DHF-59	Pasichna, 59	21	36	154	136	234
DHF-69	Medova Pechera, 69	295	593	3,790	78	156
	Total	**3,604**	**5,550**	**24,276**	**149**	**229**

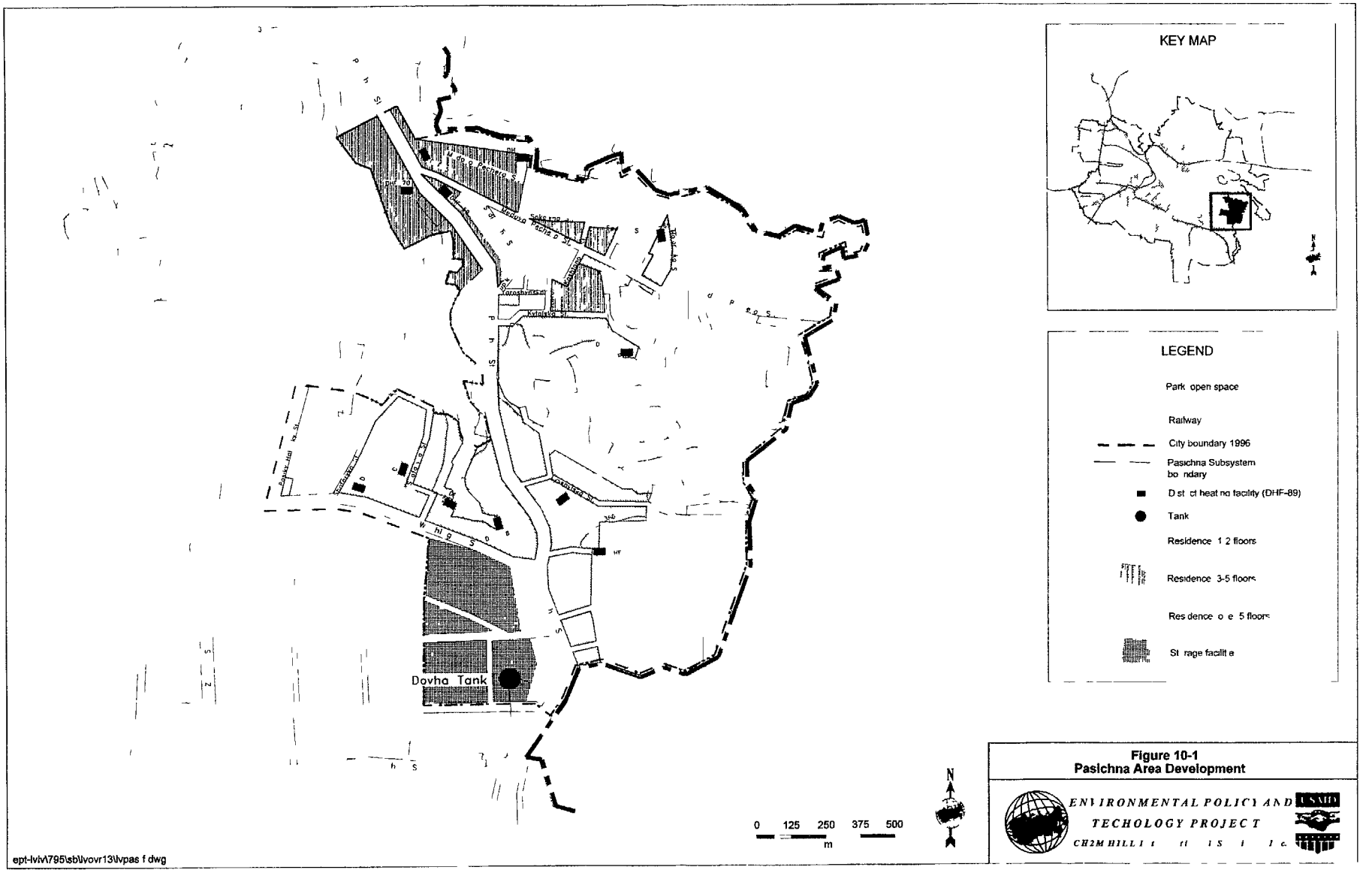

Figure 10-1
Pasichna Area Development

ENVIRONMENTAL POLICY AND TECHOLOGY PROJECT
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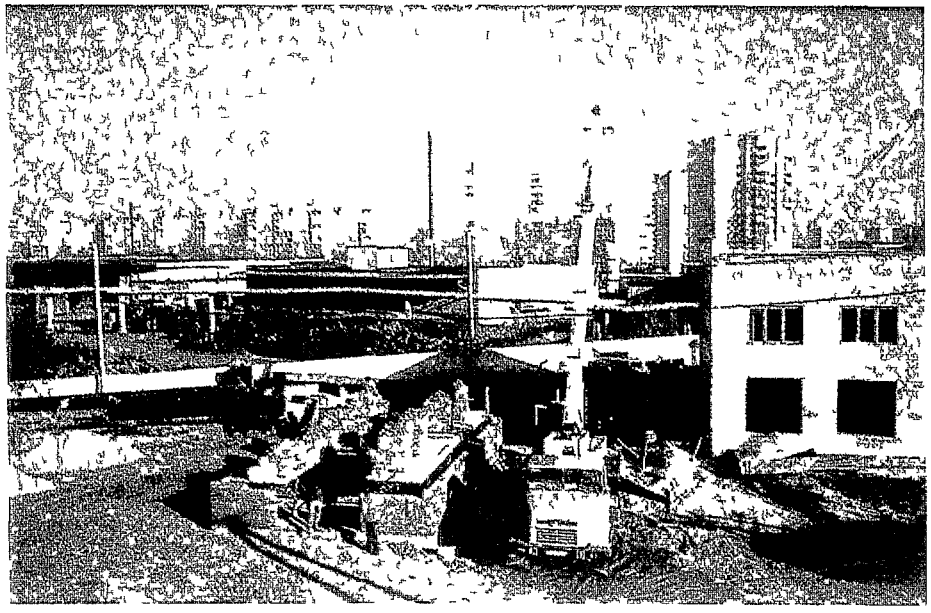
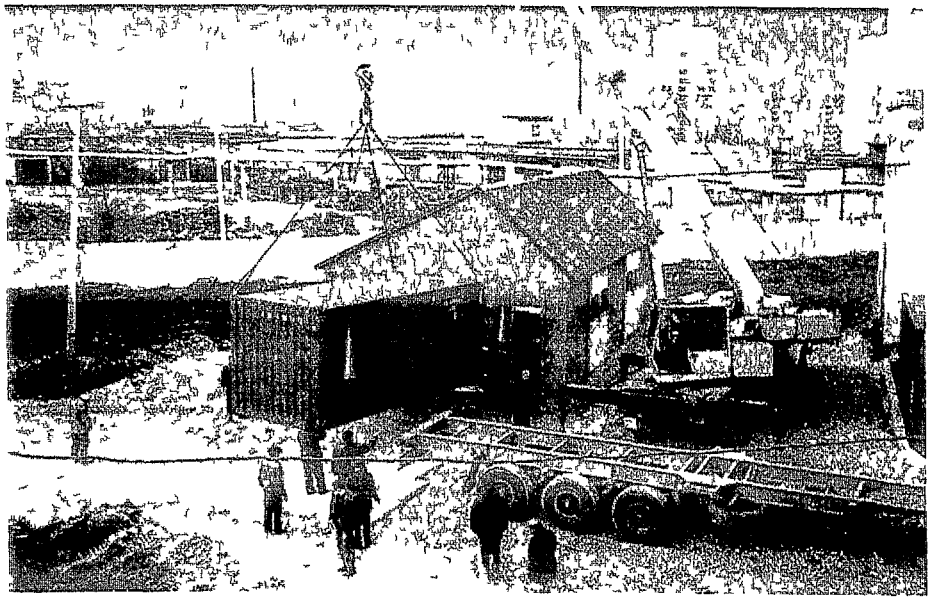


Work begins on the brick masonry walls The walls are 380-mm thick to provide insulating capability The apartments in the background will be supplied with water from the temporary pump station The incomplete permanent station is to the right 15 Oct 96



The sea freight container with the modular pump skid is unloaded at the site The pumps were manufactured in the USA and shipped by boat and truck via Germany and Poland to Lviv 19 Nov 96

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Figure 10-2 Dovha Temporary Pump Station under Construction

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The modular pump skid being removed from the shipping container by EPT staff A system of hand operated winches jacks and rollers was used to move the 10 ton pump skid from the container to its proper place in the pump station 19 Nov 96

Dedication ceremony for the pump station Shown cutting the ribbon are Gregory Huger USAID Mission Director in Kyiv and Lviv Mayor Vasil Kuibida Also present was Volodymyr Kostenko Ukrainian Minister of Ecology 10 Jan 97

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Figure 10-3 Dovha Temporary Pump Station Equipment Installation and Dedication

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Section 11

STRATEGIC POLICY FOR THE LVIV VODOKANAL

11.1 OPTIONS

The City has three logical approaches to their future water and wastewater service 1) continue operating as they are at present, 2) borrow a large amount of money and obtain grants to try to correct the major problems quickly or, 3) try to fund improvements on a pay-as-you-go mode of operations One thing is fairly certain, the central government will not be able to fund any significant water system capital improvements in Lviv for at least the next 10 to 20 years

Continuing as usual will work, as it does now but it means ever-diminishing service (and no expansion) and to function financially it relies on bartering, debt swapping and non-payment of bills (especially energy) being allowed However, once it is necessary that energy bills be paid promptly (and in cash) then water service will need to be drastically reduced as that is the only way to significantly cut costs Any service reduction will in turn probably negatively affect revenue from bills which will again reduce the ability to pay for energy, etc , etc Continuing as usual has the advantage that it does not require any increase in tariffs or push for payments It has the disadvantage of people continuing to be unhappy with their water service and once full energy payments are required from the LVK they will be very unhappy

Borrowing a large sum of money would allow the LVK to invest in reducing operating costs through the purchasing of equipment and undertaking projects that will reduce the cost to deliver each cubic meter of water to the consumer This would be mostly by investing in leakage and wastage reduction and reducing inefficient pumping operations By reducing leakage and wastage it would make additional water available to the consumers that could be used to increase service hours without increasing supply or the overall cost Any reduction in energy usage help to will reduce overall production costs A large loan has an advantage in that service can be noticeably improved in a short period of time (five years) A loan's big disadvantage is that it is expensive and comes with lots of conditions attached As a consequence the tariffs and rate of payments consumers will need to drastically increase - some of it before any improvement is noticed In addition a successful International Financial Institutions (IFI) loan will probably attract IFI grants

A pay-as-you-go program for capital investment is possible by simply raising the tariff and payment level as one would to repay a loan but use the money to directly improve the system The advantage to this is that this would avoid the conditions and costs (interest, foreign consultants, etc) imposed by outside loan agencies and perhaps tariffs wouldn't need to be quite so high The disadvantage is that improvements would happen gradually over a long period of time, perhaps 10 to 20 years, so they would be less noticeable

11.2 WORLD BANK LOAN

The World Bank (WB) has offered Lviv an opportunity for a loan of about USD 30 million If the city can fulfill the conditions it can obtain the loan by mid-1998 The conditions include

- The LVK must demonstrate its financial ability to repay the loan
- The WB and the LVK must agree upon a project investment program
- The LVK must hire (and pay for with the loan) a foreign management contractor
- The Government of the Ukraine must declassify Lviv water system information
- The LVK must agree to certain institutional and organizational changes

The finances are the most critical item of all in the mind of the WB (and any other lending agency) Currently it appears that the LVK cannot even fully fund its current operation much less repay a loan or pay its counterpart contributions for taxes, duties, etc The WB is pressing for additional data that must be provided immediately To satisfy the financial conditions the LVK will need to increase tariffs and drastically improve the level of collections and the cash percentage of these collections Essentially the LVK must rapidly transform itself as soon as possible into an enterprise whose income at least meets its budgeted expenses

11.3 A SUGGESTED STRATEGY

First the city and LVK should review the three options above and decide if they really want to take this WB loan There has been some discussion of using a loan from the EBRD but if LVK does not, or cannot obtain this WB loan, then it is doubtful that other international financing institution (IFI) loans will be easy to get and would probably delay the process for another three to four years

If it is decided to apply for the loan then the city and LVK must quickly and jointly work together and with the Ministry of Finance on the entire loan package and plans on how to make the loan successful A default on the loan for water would probably discourage other investments in the public sector in Lviv The LVK doesn't have sufficient management resources to handle all of the complex paperwork that is involved in a loan of this magnitude It is suggested that the LVK should contact other vodokanals who are obtaining WB loans both in Ukraine (Odesa) and the Russian Federation as well as entities that have recently gotten loans to share experiences, information and strategies It is important to understand all the costs (like designs, construction inspection, administrative charges) involved in the program

The LVK must take a very active part in defining the role of the management contractor so that they can get some valuable services for this WB mandatory expense One of the advantages of a WB loan and a good foreign management contractor is that together they can possibly attract other IFI funding in the form of grants that could possibly offset part of the cost (through the donation of equipment or services) of the contractor The idea of the contractor is to help turn the LVK into a solvent business

Achievable and acceptable service goals (like increasing water service for all to 10 hours/day) must be agreed up These must be achievable within the budget and the investment program designed to meet these goals so that public support is maintained Where possible emphasize logical projects like rehabilitation and replacement of pipelines could provide a market for Ukrainian equipment and labor

The loan must be paid through increased tariffs Public support must be gained for the program as they are the ones who must pay for the loan through their water bills Under the present system it is difficult to force the population to pay their bills In part they need to be persuaded to pay The LVK should start a long term public relations and education program related to the loan and make public involvement a priority with the help of non-governmental organizations in Lviv In addition, a commitment by the municipality and oblast for payment by the communal organizations is essential As a group they have an historically low rate of payment and without their payments in the future, the loan cannot be repaid

The WB loan will force the LVK and the City to make the utility into a operating business where income equals or exceeds expenses (including loan repayment) Eventually it must be done anyway if Lviv is to have a functioning water and wastewater system Although this process will be very painful, once done it means that water system will steadily improve (instead of steadily degrading) and the municipal government will have a self-supporting operating public service

Section 12
INSTITUTIONAL ASSESSMENT AND STRENGTHENING

In the post-war years in Ukraine almost all housing and utilities, especially heat and water supply and wastewater facilities, under the responsibility of local radas, were largely constructed using state budget funds, and also some funds generated from shared participation of ministries and agencies Enormous funds were used to create the existing infrastructure Over the years this infrastructure became obsolete and technically outdated and now, in addition to capital repairs, it requires extensive reconstruction and construction of some new facilities In the previous centrally planned economy these issues, although not easily, were almost always resolved using centralized funds

Nowadays the centrally planned economy does not exist Nevertheless the housing and communal sector exists and operates, as before, according to the centralized economic principles If not restructured, the housing and communal sector will cease to exist due to the conflict between its operating and financial structure and the reality of current conditions

At this time, when the Ukrainian economy is transforming itself into a mixed-type economy based on transferring state-owned property and privatizing industrial enterprises The issue of finding a methodological grounding for structural changes in regional industrial complexes, and determining an economically efficient balance of ownership of different types of production means, has gained particular importance Not the least important in terms of institutional change is the issue of partially transferring of state-owned municipal utilities, including those involved in water supply and wastewater collection They are among the most complex when it comes to determining the future of municipal communal property

According to the current Ukrainian legislation on privatization, most of these facilities are not subject to privatization (i e , facilities belonging to engineering infrastructures, including networks, facilities, and equipment for supplying users with water, natural gas, heat, as well as wastewater collection and treatment), or can be only partly privatized

In the situation when state financial support of this vital sphere is practically nonexistent, the emerging problems in the water and wastewater sector can be at least partially resolved by institutional changes

The LVK is an independent state self-sustaining enterprise which operates water and wastewater systems At first glance, LVK has considerable freedom in terms of possession, management, and disposal of fixed production assets However, the City Council, as the actual owner, has the right of ultimate control over LVK Within these limiting conditions, the reform of LVK's institutional structure aims at gaining it more financial freedom, including expanded rights over its fixed assets

In LVK's case, institutional strengthening could be accomplished by its corporatization There are the following options for corporatization

- remain as it is as a state communal enterprise

- remain a state communal enterprise, while its charter would be amended to include a number of private service subdivisions

- convert to a joint stock-company, which would be a lessee of fixed assets and owner of other production means
-
- convert to joint venture company with financial help from an outside (probably foreign) company

Before the LVK makes any significant change in its institutional structure it must make some meaningful change in its financial condition No matter what form of institutional structure it decides to become, it cannot be successful if it is operating with its expenses far exceeding its income The current large amounts of accounts receivable and creditor debt would destroy any new organization before it got started Until that time there is a lot of merit in remaining a state communal enterprise where it is reasonably protected from bankruptcy

The LVK is seriously considering undertaking a large WB loan, in the order of 30 million USD that would used to repair part of the worn-out infrastructure to reduce leakage and overall energy use As part of this loan agreement the LVK will need to agree to several peripheral conditions These include

- balancing income and expenses on a cash basis
- raising sufficient additional revenue to repay the loan and interest
- making a Management Contract with an outside (foreign) organization

If all of these actions are undertaken and fulfilled, then the LVK will be in a new position where it will have both a physically improved system, a positive cash flow and the potential to gain experience in working in a market oriented economy using the best of both the past in-country knowledge and practices along with those appropriate ideas from Western Europe or the USA

It is at this time, preferably after operating a number of years (at least one) in this condition, that the LVK should consider institutional restructuring

It should be remembered that any of the institutional structures can work There are examples of all of them around the world that are successful The key to all the successes are financial stability, a management that balances financial management with water services, a management team that is focused on positive goals and an economic and legal climate in the country and municipality that will permit a business to succeed

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Section 13
CONCLUSIONS

The work in under DO#9, Task U2 has allowed the EPT/Lviv staff to cooperate with the LVK in learning how a typical large vodokanal in the Ukraine operates from a technical, financial and institutional viewpoints The EPT project employed a large staff of Ukrainian professionals in Lviv that performed most of the investigations and then prepared the reports in Ukrainian This allowed the USAID to obtain information about the local workings of the LVK and gave the Ukrainian professionals an opportunity to work with American professionals in the analysis of the LVK and its operations

In general, it was determined that the LVK, like most other vodokanals (water and wastewater utilities) in Ukraine, suffers from a severe lack of capital investment for infrastructure renewal and maintenance over the past 20 years, although the basic design of the water system is sound, the water infrastructure (mostly underground piping and pumps) is old and much of the system is beyond its designed service life The major consequences of this are high water losses in the system and excessive use of energy relative to deliver water

Lviv's water system serves about 850,000 people and water service is now restricted to about six hours a day due to the lack of water Even if water was available the cost of pumping the water from outlying well fields and the heavy losses due to leakage in the pipe network would make it very expensive to operate At present the LVK's budgeted expenses exceed its income from revenue The system continues to function by not paying certain bills (much of it energy), using barter and debt swapping to cover some expenses and income, and using monetarized barter (which is hard to spend) to fund depreciation and other accounts Routine replacement (through depreciation funding) is not carried out If the LVK had to operate on an entirely cash basis then it probably could only furnish water for about two to three hours a day Energy is its largest expense (about 70 percent) followed by taxes and then labor

This financial situation means that the LVK is in a position where the more service they provide, the more money they lose This is mainly due to the large energy component of their costs and the fact that billing is based on norms rather than actual use The usage of energy is almost directly proportional to the amount of water that they try to deliver to the system On a long term basis this is counterproductive to providing improved service to their customers To turn this around it will be necessary for the LVK to structure their bills on a consumption basis and to get their finances so that income from water sold equals, or exceeds, their total expenses One of the keys to this is to reduce the overall cost of energy to the system

The work undertaken in DO#9 has laid the framework and background to continue with work in DO #15 DO#15 provides for the EPT/Lviv staff to work with the LVK on further water service improvements and a number of energy efficiency demonstration projects In addition the EPT/Lviv staff will take some of the lessons learned from working with LVK and use them to roll out the ideas on planning and water service improvements to other vodokanals in Ukraine

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