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مركز مشاريع ودراسات القطاع العام

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LEBANON
WATER & WASTEWATER
OVERVIEW

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INTRODUCTION

Water-borne diseases are major health hazard to the Lebanese population as a result of defective wastewater system and a spread contamination of drinking water.

Statistics show that 78.6% of residences are connected to water distribution network, 9.6% have their private well or spring, 6% benefit of both network supply and well and 4.7% do not benefit from any water distribution network.

On the other hand, 59.4% of residence are hooked to the wastewater network system while 38% rely on private poorly designed septic tanks. The rest of the population depends on uncovered sewage or lack of any system.

Horizon 2000 gave priority to solve water and wastewater problems because of the extent of health problems resulted from deficient systems. Since gastro-intestinal diseases and poor sanitation are widely spread among the population, wastewater treatment facilities will then reduce bacteriological contamination of fresh water.

Wastewater could be recycled and utilized for irrigation purposes when subjected to a primary and secondary treatment facility.

However, little town and villages are not included in Horizon 2000 plan. Therefore, it is imperative to design for smaller scale units that could be easily implemented and funded with a limited budget.

The cost of such project could be recovered from the municipality taxation system in the long run. Such project has been selected for a typical city in Lebanon where a wastewater collection system is in place.

1. Water pollution

1- Types and sources of water pollution

Principal water pollutants

These are several classes of common water pollutants. One is *disease-causing agents (pathogens)*, which include bacteria, viruses, protozoa and parasitic worms that enter water from domestic sewage and untreated human and animal wastes (Table 1). In LCD's they prematurely kill an average of 13,700 people each day, half of them children under age 5.

Table 1 Common Disease Transmitted to Humans through Contaminated Drinking Water

Type of Organism	**Disease**	**Effects**
Bacteria	Typhoid fever	Diarrhea, severe vomiting, enlarged spleen, inflamed intestine, often fatal if untreated.
	Cholera	Diarrhea, severe vomiting, dehydration, often fatal if untreated.
	Bacterial dysentery	Diarrhea, rarely fatal except in infants without proper treatment.
	Enteritis	Severe stomach pain, nausea, vomiting, rarely fatal.
Viruses	Infectious hepatitis	fever, severe headache, loss of appetite, abdominal pain, jaundice, enlarged liver, rarely fatal but may cause permanent liver damage.
Parasitic protozoa	amoebic dysentery	Severe diarrhea, headache, abdominal pain, chills, fever, if not treated can Cause liver abscess, bowel perforation, and death.
	Giardiasis	Diarrhea, abdominal cramps, flatulence, belching, fatigue.
Parasitic worms	Schistosomiasis	Abdominal pain, skin rash, anemia, chronic fatigue, and chronic general ill health.

A good sign of the quality of water for drinking or swimming is the number of colonies of *coliform bacteria* present in a 100-ml sample of water. The World Health Organization recommends coliform bacteria count of 0 colonies per 100ml for drinking water and the EPA recommends a maximum level for swimming water of 200 colonies per 100ml. Because the average human ejects about 2 billion such organisms a day, we can see how easily untreated sewage can infect water.

A second category of water pollutants is *oxygen-demanding wastes*, organic wastes that can be decomposed by aerobic (oxygen-requiring) bacteria. Large populations of bacteria supported by theses wastes can degrade the water quality by depleting water of dissolved oxygen (**Fig.18-3**), causing fish and others forms of oxygen consuming aquatic life to end. The quantity of oxygen-demanding wastes in water can be determined by measuring the **biological oxygen demand (BOD)**: the amount of dissolved oxygen needed by aerobic decomposers to break down the organic materials in a certain volume of water over a 5 day incubation period at 20°C.

A third class of water pollutants is *water-soluble inorganic chemicals*, which are acids, salts, and compounds of toxic metals such as Mercury and Lead. High levels of these chemicals can make water unfit to drink, harm fish and other aquatic life, depress crop yields and accelerate corrosion of equipment that uses water.

Inorganic plant nutrients make up another class of water pollutants. They are water-soluble nitrates and phosphates that can cause excessive growth of algae and other aquatic plants, which then die and decay, depleting water of dissolved oxygen and killing fish. Among people who drink water with excessive level of nitrates, the oxygen-carrying capacity of their blood can be reduced; this can kill unborn children and infants, especially those under one year old.

Water can also be polluted by a variety of *organic chemicals*, which include oil, gasoline, plastics, pesticides, cleaning solvents, detergents, and many other chemicals. They threaten human health and harm fish and other aquatic life.

Another class of water pollutants is *sediment*, insoluble particles of soil and other solids that become suspended in water, mostly when soil is eroded from the land. By weight, this is by far the biggest water pollutant. Sediment clouds water and reduce photosynthesis; it also disrupts aquatic food webs and carries pesticides, bacteria, and other harmful substances. Sediment that settles out destroys feeding and spawning grounds of fish, and it clogs and fills lakes, artificial reservoirs, stream channels, and harbors.

Water can also be polluted by *water-soluble radioactive isotopes*, which are capable of being concentrated in various tissues and organs as they pass through food chains and webs. Ionizing radiation from such isotopes can cause birth defects, cancer, and genetic damage.

Heat absorbed by water used to cool industrial and power plants can lower water quality. The resulting rise in water temperature – *thermal pollution* – lowers dissolved oxygen and makes aquatic organisms more vulnerable to disease, parasites, and toxic chemicals.

Another form of water pollution, genetic pollution, occurs when aquatic systems are disrupted by the deliberate or accidental introduction of *nonnative species*. Each day several thousand species (mostly small ones such as mussels and phytoplankton) are transported in cargo and ballast water in ships to new marine system, where they may out compete many native species, decrease bio-diversity, and cause economic losses. Introduced marine species also spread through canals linking bodies of water and deliberate introduction to enhance fishery production.

In addition to health problems, water pollution causes economic losses amounting to about $20 billion per year in the USA only.

Point and Nonpoint sources pollution:

Point sources discharge pollutants at specific location through pipes, ditches, or sewers into bodies of surface water. Examples include factories, sewage treatment plants (which remove some but not all pollutants), active and abandoned underground mines, offshore oil wells and oil tankers. Because point sources are at specific places, mostly in urban areas, they are easy to identify, monitor, and regulate. In MDCs many industrial discharges are strictly controlled, whereas in most LDCs such discharges are largely uncontrolled.

Nonpoint sources are sources that cannot be traced to any single site of discharges. They are usually large, poorly defined areas that pollute water by runoff, subsurface flow, or deposition from atmosphere. Examples include runoff of chemicals into surface water (including storm water) and seepage into the ground from croplands, lawns. Livestock feedlots, logged forests, streets, septic tanks, construction sites, parking lots and roadways.

In the USA, nonpoint pollution from agriculture – mostly in the form of sediment, inorganic fertilizers, manure, salts dissolved in irrigation water, and pesticides – is responsible for an estimated 64% of the total mass of pollutants entering the streams, and 57% of those entering the lakes. According to the EPA, nonpoint runoff of storm water causes 33% of all contamination in lakes and estuaries, and 10% of all stream contamination. Little progress has been made in the control of nonpoint water pollution because of the difficulty and expense of identifying and controlling discharges from so many diffuse sources.

Contaminated drinking water:

Many rivers in Eastern Europe, Latin America, and Asia that are used as a source of drinking water are severely polluted, as are some rivers in MDCs. Aquifers used as sources of drinking water in many MDCs and LDCs are becoming contaminated with pesticides, fertilizers, and hazardous organic chemicals. In China, 41 large cities get their drinking water from polluted groundwater. In Russia, half of all tap water is unfit to drink, and a third of the aquifers are too contaminated for drinking purposes.

According to the World Health Organization, 1.2 billion people don't have a safe supply of drinking water, and 1.8 billion people lack adequate sanitation facilities. At least, 5 million year from waterborne diseases that could be prevented by clean drinking water and better sanitation.

In 1980, the United Nations recommended spending $300 billion to supply all of the world's people with clean drinking water and adequate sanitation by 1990. The $15-billion-per-year cost of this program is about what the world spends every 5 days for military purposes. Only about 1.5 billion per year was actually spent.

2- Pollution of streams:

Stream pollution.

Flowing streams recover rapidly from degradable, oxygen-demanding wastes and excess heat by a combination of dilution and bacterial decay. This natural recovery process works so long as streams are not stuffed with these pollutants, and so long as their flow is not reduced by drought, damming, or diversion for agriculture and industry. Slowly degradable and nondegradable pollutants are not eliminated by these natural dilution and degradation processes.

This breakdown of degradable wastes by bacteria depletes dissolved oxygen, which reduces or eliminates populations of organisms with high oxygen requirements until the stream is cleansed. The depth and width of the resulting oxygen decline curve **(fig. 18-4)**, and the time and distance required for a stream to recover, depend on the stream's volume, flow rate, temperature, and pH level, as well as the volume of incoming degradable wastes. The types of pollutants, flow rates, dilution capacities, and recovery times also vary in the major zones of a river as it flows from its headwaters, to its wider and deeper middle sections, and finally to an ocean or lake.

Requiring cities to withdraw their drinking water downstream rather than upstream would improve water quality because each city would be forced to clean up its own waste outputs rather then passing them downstream. However, upstream users, who already have the use of clean water without high cleanup costs, fight this pollution prevention approach.

Stream water quality.

Water pollution control laws enacted in the 1970s have greatly increased the number and quality of wastewater treatment plants in the USA and many other MDCs; laws have also required industries to reduce or eliminate point source discharges into surface waters. These efforts have enabled the USA to hold the line against increased pollution of most of its streams by disease-causing agents and oxygen-demanding wastes.

One success story is the cleanup of Ohio's Cuyahoga River, which was so polluted that in 1962 it caught fire as it, flowed through Cleveland. That mishap prompted city and state officials to enact laws limiting the discharge of industrial wastes into the river and sewage systems, and to appropriate funds to upgrade sewage treatment facilities. Today the river has made a comeback.

However, we still know relatively little about the nationwide quality of waterways because water quality has not been measured in 64% of the length of U.S streams. In addition, few existing monitoring stations are located in places that are suitable for assessing the presence or absence of pollutants from their drainage basins. Furthermore, even this limited monitoring does not measure toxins and ecological indicators of water quality.

Pollution control laws passed since 1970 have also led to improvements in dissolved oxygen content in many streams in Canada, Japan and most Western European countries. In the 1950s the Thames River was little more than a flowing anaerobic sewer, but after more then 30 years of effort, $250 million of British tax-payers' money, and millions more spent by industry, the Thames has made a remarkable recovery. Commercial fishing is thriving, and many species of waterfowl and wading birds have returned to their former feeding grounds.

Despite progress in improving stream quality in most MDCs, large fish kills and contamination of drinking water still occur. Most of these disasters are caused by accidental or deliberate releases of toxic inorganic and organic chemicals by industries, by mal-functioning sewage treatment plants, and by nonpoint runoff of pesticides from cropland. A 1986 fire at a Sandoz chemical warehouse in Switzerland, France, Germany, and the Netherlands before emptying into the North Sea. The chemicals killed aquatic life, forced temporary shutdowns of drinking-water plants and commercial fishing, and offset improvements made in the river's water quality between 1970 and 1986. The river is now making a slow comeback.

Available data indicate that stream pollution from huge discharges of sewage and industrial wastes is a serious and growing problem in most LDCs, where waste treatment is practically nonexistent. Numerous streams in the former Soviet Union and in eastern European countries are severely polluted. Currently, more then 2/3 of India's water resources are polluted with industrial wastes and sewage. Only 217 of India's 3119 municipalities have any type of sewage treatment, and only 8 have full modern treatment of the 78 streams monitored in China, 54 are seriously polluted with untreated sewage and industrial wastes. In Latin America and Africa, most streams passing through urban or industrial areas are severely polluted.

Case study:

Rivers and Streams

Forty-seven States, two Inter-state River Commissions, one Territory, the District of Columbia (hereafter collectively referred to as States), and three American Indian Tribes rated river water quality in their 1996 reports (see Appendix A, Table A-1, for individual State and Tribal information). These States and Tribes surveyed conditions in 693,905 miles of rivers and streams; most of the surveyed rivers and streams are perennial water bodies that flow all year. The surveyed rivers and streams represent 53% of the 1.3 million miles of perennial rivers and streams in the lower 48 States, or 19% of the estimated 3.6 million miles of all rivers and streams in the country, including non perennial streams that flow only during wet periods (Figure 2-1).

In all, the States and Tribes surveyed 78,099 more river miles in 1996 than in 1994. While most States surveyed about the same number of river miles in reporting cycles, Illinois, Maryland, North Dakota and Tennessee collectively, account for an increase of over 75,000-surveyed river miles. Since 1994, Illinois, North Dakota, and Tennessee have indexed all of their streams to the Reach File 3 (RF3) level in order to perform1/100,000 scale geographic analyses (see sidebar for a description of RF3). The refined stream estimates have increased the mileage associated with surveyed streams. These States have also initiated new monitoring projects since 1994. Illinois now rates all RF3 streams except for unnamed tributaries. North Dakota has instated a new biological monitoring program in the Red River basin. Tennessee has also increased its biological monitoring thanks to the Division of Water Pollution Control's Ecoregion project and the Tennessee Valley Authority's River Action Teams.

The summary information presented in this case study applies strictly to the portion of the USA rivers surveyed by the States and Tribes. EPA cannot make generalizations about the health of all of USA rivers based on data extracted from the reports because most States and Tribes rate their waters with information obtained from water monitoring programs designed to detect degraded water bodies. Very few States or Tribes select water-sampling sites with a statistical design to represent a cross section of water quality conditions in their jurisdictions. Instead, many States and Tribes direct their limited monitoring resources toward waters with suspected problems. Consequently, the surveyed rivers reflect conditions of targeted waters rather than a representative sampling of all waters.

In the future, increased use of statistically based monitoring programs will enable EPA and the States and Tribes to report more comprehensively on the general health of the States waters. Examples of statistically based programs include probability designs implemented by Delaware, Maryland, and Indiana; EPA's Environmental Monitoring and Assessment Program (EMAP); and EPA's Regional Environmental EPA's Regional Environmental Monitoring and Assessment Program (R-EMAP). EMAP is a long-term monitoring program with a unique approach that combines a probability-based sampling strategy with ecological indicators (quantifiable expressions of an environmental value) to assess the overall condition of ecological resources. R-EMAP applies the concepts, methods, and approach developed by EMAP to resolve specific environmental issues of importance to the EPA Regions and the States.

National data from other Federal agencies, such as the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA), and private organizations, such as The Nature Conservancy, will also clarify national water quality trends.

River Miles: Surveyed by States and Tribes

1996, 693,905miles = 19% surveyed Total miles: 3,634,152
1994, 615,806miles = 17% surveyed Total miles: 3,548,738
1992, 642,881miles = 18% surveyed Total miles: 3,551,247
1990, 647,066miles = 36% surveyed Total miles: 1,800,000

Note: In comparison with 1990, it appears that the States and Tribes assessed a smaller percentage of the Nation's rivers in 1996. However, in 1996, most States and Tribes included intermittent streams, canals, and ditches that were excluded from the 1990 estimates of total stream miles. Therefore, the national estimate of total stream miles almost doubled from 1.8 million miles in 1990 to more than 3.6 million miles in 1996.

The EPA Reach File Version 3 (RF3) is a database containing the geographic locations of over 3 million stream, lake, and estuary reaches in the continental U.S. and Hawaii. A reach is a stretch of stream between confluence and a segment of lake or estuary shoreline. RF3 provides unique identification numbers for points on these surface waters and Built-in River mileage. With RF3, users can prepare computerized maps of healthy and impaired waters, monitoring sites, drinking water intakes, pollution sources, and many other features. RF3 also allows computer modeling of the movement of pollutants through its hydrological connected network of waters.

The States and Tribes rate whether their water quality is good enough to fully support a healthy community of aquatic organisms as well as human activities, such as swimming, fishing, and drinking. The States designate specific activities for their rivers and streams, termed "individual designated uses." EPA and the States use the following terminology to rate their water quality:

Good/Fully Supporting: Good water quality supports a diverse community of fish, plants, and aquatic insects, as well as the array of human activities assigned to a river by the State.

Good/Threatened: Good water quality currently supports aquatic life and human activities in and on the river, but changes when factors such as land use threaten water quality or data indicate a trend of increasing pollution in the river.

Fair/Partially Supporting: Fair water quality supports aquatic communities with fewer species of fish, plants, and aquatic insects, and/or occasional pollution interferes with human activities. For example, occasional siltation problems may reduce the population of some aquatic species in a river, while other species are not affected.

Poor/Not Supporting: Poor water quality does not support a healthy aquatic community and/or prevents some human activities on the river. For example, persistent PCB contamination in river sediments (originating from discontinued industrial discharges) may contaminate fish and make the fish inedible for years.

Not Attainable: The State has performed a use-attainability analysis and demonstrated that use sup-port of one or more designated uses is not attainable due to one of six specific biological, chemical, physical, or economic/social conditions.

Most States and Tribes rate how well a river supports individual uses (such as swimming and aquatic life habitat) and then consolidate individual use ratings into a table of summary use support data. This table divides rivers into those miles fully supporting all of their uses, those fully supporting all uses but threatened for one or more uses, and those impaired for one or more uses. Impaired waters are the sum of partially and not supporting waters.

Forty-three States, three Tribes, two Interstate Commissions, Puerto Rico, and the District of Columbia reported summary use support status for rivers and streams in their 1996 reports (see Appendix A, Table A-2, for individual State and Tribal information). Another four States reported individual use support status but did not report summary use support status. In such cases, EPA used aquatic life use support status to represent summary water quality conditions in the State's rivers and streams.

In sum, States and Tribes reported that 64% of 693,905 surveyed river miles fully support all of their uses. Of these waters, 56% fully support designated uses and 8% have good water quality that fully supports all uses but is threatened for one or more uses. These threatened waters may deteriorate if we fail to manage potential sources of pollution (Figure 2-2). Some form of pollution or habitat degradation impairs the remaining 36% of the surveyed river miles.

Individual Use Support

Individual use support information provides additional detail about water quality problems in the surface waters. The States are responsible for designating their rivers and streams for State-specific uses, but EPA requests that the States rate how well their rivers support six standard uses so that EPA can summarize the State data. Aquatic life support is water quality good enough to support a healthy, balanced community of aquatic organisms, including fish, plants, insects, and algae? Fish consumption can people safely eat fish caught in the river or stream? Primary contact recreation (swimming) can people make full body contact with the water without risking their health? Secondary contact recreation is there a risk to public health from recreational activities on the water, such as boating, that expose the public to minor contact with the water?

Drinking water supply, can the river or stream provide a safe water supply with standard treatment? Agricultural uses Can the water be used for irrigating fields and watering livestock?

Surveyed Waters

Total rivers = 3.6 million miles
Total Surveyed = 693,905 miles
19% surveyed
81% not surveyed
Of the surveyed miles:
51% were monitored
41% were evaluated
8% were not specified

Only six States did not report individual use support status of their rivers and streams. The reporting States and Tribes surveyed the status of aquatic life and swimming uses most frequently and identified more impacts on aquatic life and swimming uses than on the other individual uses (Figure 2-3). These States and Tribes reported that fair or poor water quality impacts aquatic life in 201,558 stream miles (31% of the 641,611 miles surveyed for aquatic life support). Fair or poor water quality conditions also impair swimming activities in 86,710 miles (20% of the 434,421 miles surveyed for swimming use support).

Many States and Tribes did not rate fish consumption use support because they have not codified fish consumption as a use in their standards. Some of these States consider fishing use as a component of aquatic life use, i.e., that rivers and streams can provide a healthy habitat to support fishing activities even though anglers may not be able to eat their catch in these States. EPA encourages the States to designate fish consumption as a use in their water bodies to promote consistency in future reporting. Most States report information on fish consumption advisories (species and size of fish that should not be eaten) to EPA.

Water Quality Problems Identified in Rivers and Streams

Figures 2-4 and 2-5 identify the pollutants and sources of pollutants that impair the most river miles (i.e., prevent them from fully supporting designated uses), as reported by the States and Tribes. The two figures are based on the same data (contained in Appendix A, Tables A-4 and A-5), but each figure provides a different perspective on the extent of impairment attributed to individual pollutants and sources. Figure 2-4 compares the impacts of the leading pollutants and sources in all surveyed rivers. Figure 2-5 presents the relative impact of the leading pollutants and sources in impaired rivers, the subset of surveyed rivers with identified water quality problems.

The pollutants/processes and sources shown here may not correspond directly to one another (i.e., the leading pollutant may not originate from the leading source). This may occur for a number of reasons, such as a major pollutant may be released from many minor sources or States may not have the information to determine all the sources of a particular pollutant/stressor.

Agriculture is the leading source of pollution in surveyed rivers and streams. According to the States, agricultural pollution problems affect 25% of all rivers and streams surveyed, and contribute to 70% of all water quality problems identified in rivers and streams (see Figure 2-5).

Siltation is the most common pollutant affecting surveyed rivers and streams. Siltation is found in 18% of all rivers and streams surveyed (see Figure 2-4), and contributes to 51% of all the water quality problems.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair a river segment.

The following sections describe the leading pollutants and sources of impairment identified in rivers. It is important to note that the information about pollutants and sources is incomplete because the States do not identify the pollutant or source of pollutants responsible for every impaired river segment.

In some cases, a State may recognize that water quality does not fully support a designated use, but the State may not have adequate data to document that a specific pollutant or process is responsible for the impairment. Sources of impairment are even more difficult to identify than pollutants and processes.

Pollutants and Stressors Impacting Rivers and Streams

Fifty-one States and Tribes reported the number of river miles impacted by individual pollutants and stressors, such as invasion by exotic species (see Appendix A, Table A-4, for Individual State and Tribal information). EPA ranks the pollutants and stressors by the geographic extent of their impacts on aquatic life and human activities (i.e., the number of river miles impaired by each pollutant or stressor) rather than actual pollutant loads in rivers and streams. This approach targets the pollutants and stressors causing the most harms to aquatic life and public use of our waters, rather than the most abundant pollutants in our rivers and streams.

The States and Tribes report that siltation, composed of tiny soil particles, remains one of the most widespread pollutants impacting rivers and streams, impairing 126,763 river miles (18% of the surveyed river miles). Siltation alters aquatic habitat and suffocates fish eggs and bottom-dwelling organisms (see Figure 2-6).

Aquatic insects live in the spaces between cobbles, but their habitat is destroyed when silt fills in these spaces. The loss of aquatic insects adversely affects fish and other wildlife that eat these insects. Excessive siltation can also interfere with drinking water treatment processes and recreational use of a river. Sources of siltation include agriculture, urban runoff, construction, and forestry.

Siltation is one of the leading pollution problems in the Nation's rivers and streams. Over the long term, unchecked siltation can alter habitat with profound adverse effects on aquatic life. In the short term, silt can kill fish directly, destroy spawning beds, and increase water turbidity resulting in depressed photosynthetic rates. Nutrient pollution emerges as a significant cause of water quality impairment in the 1996 305(b) reports, with States and Tribes reporting impacts to 98,040 river miles (14% of the surveyed river miles). While nutrient pollution has commonly been a problem in the Nation's lakes and ponds, water quality managers have given significant attention to its effects on rivers and streams, particularly those that flow to sensitive estuarine and coastal waters. Excessive levels of nitrogen and phosphorus may accelerate growth of algae and underwater plants, depleting the water column of dissolved oxygen necessary to maintain populations of fish and desirable plant species. Nutrients may enter surface waters from municipal and industrial wastewater treatment discharges and runoff from agricultural lands, forestry operations, and urban areas.

The States and Tribes also report that bacteria (pathogens) pollute 79,820 river miles (12% of the surveyed river miles). Bacteria provide evidence of possible fecal contamination that may cause illness if the public ingests the water. States use bacterial indicators to determine if rivers are safe for swimming and drinking. Bacteria commonly enter surface waters in inadequately treated sewage, fecal material from wildlife, and runoff from pastures, feedlots, and urban areas.

In addition to siltation, nutrients, and bacteria, the States and Tribes also reported that oxygen-depleting substances, pesticides, habitat alterations, suspended solids, and metals impact more miles of rivers and streams than other pollutants and stressors. Often, several pollutants and processes affect a single river segment. For example, a process such as removal of shoreline vegetation may accelerate erosion of sediment and nutrients into a stream. In such cases, the States and Tribes count a single mile of river under each pollutant and process category that affects the river mile. Therefore, the river miles impaired by each pollutant or process do not add up to 100% in Figures 2-4 and 2-5.

Most States and Tribes also rate pollutants and processes as major or moderate/minor contributors to impairment. A major pollutant or process is solely responsible for an impact or predominates over other pollutants and processes. A moderate/ minor pollutant or process is one of multiple pollutants and processes that degrade aquatic life or interfere with human use of a river.

Currently, EPA ranks pollutants and processes by the geographic extent of their impacts (i.e., the number of miles impaired by each pollutant or process). However, less abundant pollutants or processes may have more severe impacts on short stream reaches. For example, a toxic chemical spill can eliminate aquatic life in a short stream while widely distributed bacteria do not affect aquatic life but occasionally indicate a potential human health hazard from swimming. The Individual State and Tribal 305(b) reports provide more detailed information about the severity of pollution in specific locations.

Sources of Pollutants Impacting Rivers and Streams

Fifty-one States and Tribes reported sources of pollution related to human activities that influence some of their rivers and streams (see Appendix A, Table A-5, for individual State and Tribal information). These States and Tribes reported that agriculture is the most widespread source of pollution in the Nation's surveyed rivers. Agriculture generates pollutants that degrade aquatic life or interfere with public use of 173,629 river miles (which equals 25% of the surveyed river miles) in 50 States and Tribes (Figures 2-4 and 2-5).

Twenty-two States reported the size of rivers impacted by specific types of agricultural activities:

Nonirrigated Crop Production- crop production that relies on rain as the sole source of water.

Irrigated Crop Production- crop production that uses irrigation systems to supplement rainwater.

Rangeland- land grazed by animals that is seldom enhanced by the application of fertilizers or pesticides, although land managers sometimes modify plant species to a limited extent.

Pastureland- land upon which a crop (such as alfalfa) is raised to feed animals, either by grazing the animals among the crops or harvesting the crops. Pastureland is actively managed to encourage selected plant species to grow, and fertilizers or pesticides may be applied more often on pastureland than Rangeland.

Feedlots- generally facilities where animals are fattened. By EPA's definition, feedlots are large sites where many animals are con-fined at high densities for market. These facilities are often located near packing plants or railroad access points.

Animal Holding Areas- facilities for confining animals briefly before slaughter. By EPA's definition, animal holding areas confine fewer animals than feedlots.

Animal Operations- generally livestock facilities other than large cattle feedlot operations. They may contain facilities for supplemental feeding or rearing animals, primarily poultry or swine.

Non-irrigated crop production leads the list of agricultural activities impacting rivers and streams, followed by irrigated crop production, Rangeland, pastureland, feedlots, animal operations, animal holding areas, and riparian grazing (Figure 2-7). Runoff from irrigated and non-irrigated cropland may introduce commercial fertilizers (that contain nitrogen and phosphorus), pesticides, and soil particles into rivers and streams. Manure applied to cropland as a fertilizer may also wash off irrigated and non-irrigated fields and prevent rivers and streams from fully supporting designated uses.

Sources of pollution from concentrated animal operations include feedlots, animal operations, and animal holding areas. Animal waste runoff from these operations can introduce pathogens, nutrients (including phosphorus and nitrogen), and organic material to near-by rivers and streams. Rangeland may generate both soil erosion and animal waste runoff.

Pastureland usually has good ground cover that protects the soil from eroding, but pastureland can become a source of animal waste runoff if animals graze on impermeable frozen pastureland during winter. Riparian grazing may generate stream bank erosion and animal waste runoff and result in modification of streamside habitat.

The States and Tribes also report that municipal sewage treatment plants pollute 35,087 river miles (5% of the surveyed river miles), hydrologic modifications degrade 34,190 river miles (5% of the surveyed river miles), habitat modifications degrade 34,127 river miles (5% of the surveyed river miles), resource extraction (e.g., mining and oil production) pollutes 33,051 river miles (5% of the surveyed river miles), urban runoff and storm sewers pollute 32,637 river miles (5% of the surveyed river miles), and removal of streamside vegetation pollutes 23,349 river miles (3% of the surveyed river miles).

The States and Tribes also report that "natural" sources impair many miles of rivers and streams in the absence of human activities. Natural sources include soils with natural deposits of arsenic or salts that leach into water bodies, waterfowl (a source of nutrients), and low-flow conditions and elevated water temperatures caused by drought. The total size of rivers impaired by natural sources is probably exaggerated because some States may automatically attribute water quality impairments to natural sources if the State cannot identify a human activity responsible for a water quality problem. Sources such as mining and forestry activities can play a more significant role in degrading water quality at a regional or local level than at the national level. For example, resource extraction (including acid mine drainage) contributes to the degradation of 36% of the impaired river miles in the coal belt States of Kentucky, Maryland, Ohio, Pennsylvania, and West Virginia. These States report that resource extraction impairs about 6,550 miles of rivers and streams. Yet, at the national level, resource extraction contributes to the degradation of only 13% of all the impaired river miles in the Nation. At the local level, streams impacted by acid mine drainage are devoid of fish and other aquatic life due to low pH levels and the smothering effects of iron and other metals deposited on stream beds. The primary sources of acid mine drainage are abandoned coal refuse disposal sites and surface and underground mines.

In the Pacific Northwest State of Washington, water quality managers identify forestry activities as responsible for almost a third (32%) of the impaired river miles, but, at the national level, States report that forestry activities contribute to the degradation of only 7% of the Nation's total impaired river miles. Forestry activities include harvesting timber, constructing logging roads, and stand maintenance. California, Florida, Louisiana, Mississippi, Montana, and West Virginia also report that forestry activities degrade over 1,000 miles of streams in each State.

Many States reported declines in pollution from sewage treatment plants and industrial discharges since enactment of the Clean Water Act in 1972. The States attributed improvements in water quality conditions to sewage treatment plant construction and upgrades and permit controls on industrial discharges. Despite the improvements, municipal sewage treatment plants remain the second most common source of pollution in rivers because population growth increases the burden on our municipal facilities.

Several States reported that they detected more subtle impacts from nonpoint sources, hydrologic modifications, and habitat alterations as they reduced conspicuous pollution from point sources. Hydrologic modifications and habitat alterations are a growing concern to the States. Hydrologic modifications include activities that alter the flow of water in a stream, such as channelization, de-watering, and damming of streams. Habitat alterations include removal of streamside vegetation that protects the stream from high temperatures and scouring of stream bottoms. Additional gains in water quality conditions that address these concerns will be subtler and require innovative management strategies that go beyond point source controls.

3- Lake pollution:

In Lakes, reservoirs, and ponds, dilution is less effective than in streams because lakes and reservoirs frequently contain stratified layers that undergo little vertical mixing, and ponds contain relatively small volumes of water. Stratification also reduces levels of dissolved oxygen, especially in the bottom layer. In addition, lakes, reservoirs, and ponds have little flow, further reducing dilution and replenishment of dissolved oxygen. The flushing and changing of water in lakes and large artificial reservoirs can take from 1 to 100 years, compared with several days to several weeks for streams.

Lakes, reservoirs and ponds are more vulnerable than streams to contamination by plant nutrients, oil, pesticides and toxic substances such as lead, mercury, and selenium that can destroy both bottom life and birds that feed on contaminated aquatic organisms. Atmospheric fallout and runoff of acids is a serious problem in lakes vulnerable to acid deposition.

In any body of water, some synthetic organic compounds and toxic metals such as lead, mercury and selenium are not biodegraded, and others are biodegraded very slowly. Many toxic chemicals, such as DTT, PCBs, some radioactive isotopes, and some mercury compounds, can be biologically amplified as they pass through food webs. Using data from 1992 National water quality Inventory that sampled about 18% of U.S rivers and lakes, the EPA estimated that about 43% of the lakes and 8% of the rivers sampled contain toxic contamination.

Lakes receive inputs of nutrients and silt from the surrounding land basin because of natural erosion and runoff. Over time some of these lakes become more eutrophic, but others do not because if differences in the surrounding water basin. Near urban or agricultural areas, the input of nutrients to a lake can be greatly accelerated by human activities, which results in a process known as cultural eutrophication. Nitrate and phosphate containing effluents from sewage treatment plants, run off fertilizers and animal wastes, and accelerated erosion of nutrient- rich topsoil cause such a change.

During hot weather or drought, this nutrient overload produces dense growths of organisms such as algae, cyanobacteria, water hyacinths, and duckweed. Dissolved oxygen in both the surfaces layer of water near the shore and in the bottom layer is depleted when large masses of algae die, fall to the bottom, and are decomposed by aerobic bacteria. This oxygen depletion can kill fish and other aquatic animals. If excess nutrients continue to flow into a lake, anaerobic bacteria take over and produce gaseous decomposition products such as smelly, highly toxic hydrogen sulfide and flammable methane.

About 1/3 of the 100000 medium-to-large lakes and about 85% of the large lakes near major population centers in the USA, suffer from some degree of cultural eutrophication. Quarters of china's lakes are classified as eutrophic.

The best solutions to cultural eutrophication are to reduce the flow of nutrients into lakes and reservoirs and to use pollution cleanup methods to clean up lakes already suffering from excessive eutrophication. Major prevention methods include advanced waste treatment; bans or limits on phosphates in household detergents and other cleaning agents; and soil conservation and land-use control to reduce nutrient runoff. Major cleanup methods are dredging bottom sediments to remove excess nutrient buildup;

removing excess weeds and controlling undesirable plant growth with algaecides and herbicides; and pumping air through lakes and reservoirs to avoid oxygen depletion.

As is typically the case, pollution prevention is more effective and usually cheaper in the long run than pollution control. If excessive inputs of limiting plant nutrients stop, a lake can usually return to its previous state.

Prevention methods must be equipped to each situation based on the limiting factor principal. For example, because phosphorus is the limiting factor in most freshwater lakes, its control should be emphasized. There is disagreement, however, over whether phosphorus inputs should be lowered but banning or limiting phosphates in laundry detergents and other cleaning agents, by removing phosphates from wastewater at sewage treatment plants, or both. Studies of over 400 bodies of water indicate that the total phosphate load must be reduced by at least 20% to produce a detectable improvement in water quality.

Currently, 8 states (Indiana, Maryland, Michigan, Minnesota, New York, Vermont, Virginia and Wisconsin), many US cities and many regions of Canada have banned the use of phosphate detergents. Such bans have contributed greatly to reducing cultural eutrophication in the great Lakes and other areas, and have saved taxpayers money.

In some lakes and in coastal waters and estuaries, nitrogen is the limiting factor. It is much more difficult to control nitrogen than phosphorus because nitrates are more water-soluble and run off from nonpoints sources (large areas of land).

Case study:

Lakes and reservoirs.

Forty-five States, Puerto Rico, and the District of Columbia (hereafter collectively referred to as States), and one Tribe rated lake water quality in their 1996 reports (see Appendix B, Table B-1, for individual State and Tribal data). These States and Tribes surveyed over 16.8 million acres of lakes, reservoirs, and ponds, which equals 40% of the 41.7 million acres of lakes in the Nation (Figure 3-1). The States and Tribes based 74% of their survey on monitored data and evaluated 20% of the surveyed lake acres with qualitative information (including best professional judgment by water quality managers). The States did not specify whether the remaining 7% of the surveyed lake acres were monitored or evaluated.

The number of surveyed Lake Acres declined from 17.1 million acres to 16.8 million acres between 1994 and 1996. Although California surveyed almost 300,000 additional lake acres in 1996 due to refined lake size estimates and new monitoring, a number of States, including Nevada, Washington, and Wisconsin, surveyed significantly fewer lakes. Funding issues forced Nevada to limit lake sampling to only those lakes near routine sampling locations on rivers and streams. Due to staffing concerns, Washington State was only able to use water quality data collected internally at the Department of Ecology. In previous years, the State incorporated data from other agencies into their reports. Wisconsin now surveys its lakes as part of the State's 5-year basin planning cycle. Although the number of lakes assessed varies from year to year, Wisconsin surveys almost all the lakes in its monitoring program over the 5-year cycle.

Differences in State survey methods undermine comparisons of Lake Information submitted by individual States. Lake Data should not be compared among States, which devote varying resources to monitoring biological integrity, water chemistry, and toxic pollutants in fish tissues. The discrepancies in State monitoring and survey methods rather than actual differences in water quality, often account for the wide range in water quality ratings reported by the States.

EPA cannot make generalizations about the health of all of the USA's lakes based on data extracted from the reports because most States and Tribes rate their waters with information obtained from water controlling programs designed to detect degraded water bodies. Very few States or Tribes incidentally select water-sampling sites to represent a cross section of water quality conditions in their jurisdiction. Instead, many States and Tribes direct their limited monitoring resources toward waters with suspected problems. Therefore, the surveyed lakes probably contain a higher percentage of polluted waters than all of the USA's lakes.

The States surveyed nearly 17 million acres of lakes for 1996.

1996, 16,818,769acres = 40% surveyed Total acres: 41,684,902
1994, 17,134,153acres = 42% surveyed Total acres: 40,826,064
1992, 18,300,000acres = 46% surveyed Total acres: 39,920,000
1990, 18,489,000acres = 47% surveyed Total acres: 39,400,000

The States and Tribes rate whether their water quality is good enough to fully support a healthy community of aquatic organisms and human activities, such as swimming, fishing, and drinking water use. The States and Tribes designate individual lakes for specific activities, termed "individual designated uses." EPA and the States use the following terminology to rate their water quality:

Good/Fully Supporting: Good water quality supports a diverse community of fish, plants, and aquatic insects, as well as the array of human activities assigned to a lake by the State.

Good/Threatened: Good water quality currently supports aquatic life and human activities in and on the lake, but changes in such factors as land use threaten water quality, or data indicate a trend of increasing pollution in the lake.

Fair/Partially Supporting: Fair water quality supports aquatic communities with fewer species of fish, plants, and aquatic insects, and/or occasional pollution interferes with human activities. For example, runoff during severe thunderstorms may temporarily elevate fecal coliform bacteria densities and indicate that swimming is not safe immediately following summer storms.

Poor/Not Supporting: Poor water quality does not support a healthy aquatic community and/or prevents some human activities on the lake. For example, Lake Waters may be devoid of fish for more than a month each summer because excessive nutrients from runoff initiate algal blooms that deplete oxygen concentrations.

Not Attainable: The State has performed a use-attainability analysis and demonstrated that use support of one or more designated beneficial uses is not attainable due to one of six specific biological, chemical, physical, or economic/social conditions.

Surveyed Waters
Total lakes = 41,684,902 acres
Total surveyed = 16,819,769acres

40% surveyed
60% not surveyed

Of the surveyed acres:

20% were monitored
74% were evaluated
7% were not specified

Most States and Tribes rate how well a lake supports individual uses (such as swimming and aquatic life) and then consolidate individual use ratings into a summary table. This table divides Lake Acres into those fully supporting all of their uses, those fully supporting all uses but threatened for one or more uses, and those impaired for one or more uses.

Forty-two States, one Tribe, Puerto Rico, and the District of Columbia reported summary use support status for lakes in their 1996 Section reports (see Appendix B, Table B-2, for individual State and Tribal information). Another four States reported individual use support status but did not report summary use support status. In such cases, EPA used aquatic life use support status or swimming use support status to represent general water quality conditions in the State's lakes.

It is important to note that four States did not include the effects of statewide fish consumption advisories for mercury when calculating their summary use support status. New Hampshire, Michigan, South Carolina, and Vermont excluded the impairment associated with statewide mercury advisories in order to convey information that would have been otherwise masked by the fish consumption advisories. If these advisories had been included, all of the States' waters would receive an impaired rating.

The States and Tribes reported that 61% of their surveyed 16.8 million lake acres have good water quality (Figure 3-2). Waters with good quality include 51% of the surveyed lake acres that fully support all uses and 10% of the surveyed lake acres that fully support all uses but are threatened for one or more uses and might deteriorate if we fail to manage potential sources of pollution. Some form of pollution or habitat degradation impairs the remaining 39% of the surveyed lake acres.

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Individual Use Support

Individual use support information provides additional detail about water quality problems in our Nation's surface waters. The States and Tribes are responsible for designating their lakes for specific uses, but EPA requests that the States and Tribes rate how well their lakes support six standard uses so that EPA can summarize the State and Tribal data. The standard uses consist of aquatic life support, fish consumption, primary contact recreation (such as swimming and diving), secondary contact recreation (such as boating), drinking water supply, and agricultural use.

Forty-two States, one Tribe, Puerto Rico, and the District of Columbia reported individual use support status of their lakes, reservoirs, and ponds (see Appendix B, Table B-3, for individual State and Tribal information). The reporting States and Tribes rated aquatic life use and swimming use in more lakes and identified more impacts on aquatic life use and swimming use than the other individual uses (Figure 3-3). These States and governments reported that fair or poor water quality affects aquatic life in over 4.4 million lake acres (31% of the 14.2 million acres surveyed for aquatic life support), and swimming criteria violations impact 3.8 million lake acres (24% of the 15.4 million acres surveyed for swimming use support).

Many States and Tribes did not rate fish consumption use support because they have not codified fish consumption as a use in their standards. Some of these States consider fishing use as a component of aquatic life use - lakes that provide a healthy habitat for fish support fishing activities even though anglers may not be able to eat their catch in these States. EPA encourages the States to designate fish consumption as a separate use in their water bodies to promote consistency in future reporting.

Water Quality Problems

Identified in Lakes, Reservoirs, and Ponds: Figure 3-4 identify the pollutants/stressors and sources of pollutants that impair (i.e., prevent from fully supporting designated uses) the most acres of lakes, as reported by the States. Figure 3-4 shows the relative impact of the leading pollutants/stressors and sources in all surveyed lakes

The following sections describe the leading pollutants/stressors and sources of impairment identified in lakes. It is important to note that the information about pollutants/stressors and sources is incomplete because the States do not identify the pollutants/stressors or source of pollutants impairing every impaired lake. In some cases, a State may recognize that water quality does not fully support a designated use, but the State may not have adequate data to document that a specific pollutant or stressor is responsible for the impairment. Sources are even more difficult to identify than pollutants and stressors.

Pollutants Impacting Lakes, Reservoirs, and Ponds

Forty-one States, the District of Columbia, and Puerto Rico reported the number of lake acres impacted by individual pollutants and processes, such as invasions by noxious aquatic plants (see Appendix B, Table B-4, for individual State and Tribal information). EPA measures the impact of each pollutant or process by summing the total lake acres impaired (i.e., not fully supporting designated uses) by each pollutant or process. EPA ranks the pollutants and processes by the extent of their impacts on aquatic life and human activities rather than actual pollutant loads in lakes. This approach targets the pollutants and processes causing the most harms to aquatic life and public use of our waters rather than the most abundant pollutants in our lakes, reservoirs, and ponds.

The States, District of Columbia, and Puerto Rico identified more lake acres polluted by nutrients and metals than any other pollutants or processes (Figure 3-4). They reported that metals and excess nutrients pollute 3.3 million Lake acres (which equals 20% of the surveyed lake acres and 51% of the impaired lake acres).

The pollutants/processes and sources shown here may not correspond directly to one another (i.e., the leading pollutant may not originate from the leading source). This may occur for a number of reasons, such as a major pollutant may be released from many minor sources or States may not have the information to determine all the sources of a particular pollutant/stressor.

Agriculture is the leading source of pollution in surveyed lakes. According to the States, agricultural pollution problem affects 19% of all lakes surveyed, and contribute to 49% of all water quality problems identified in rivers and streams

Healthy lake ecosystems contain nutrients in small quantities from natural sources, but extra inputs of nutrients (primarily nitrogen and phosphorus) unbalance lake ecosystems (Figure 3-6). When temperature and light conditions are favorable, excessive nutrients stimulate population explosions of defective algae and aquatic weeds. The algae sink to the lake bottom after they die, where bacteria consume the available dissolved oxygen as the bacteria decompose the algae. Fish kills and foul odors may result if dissolved oxygen is depleted.

States consistently report metals as a major cause of impairment to lakes. This is mainly due to the widespread detection of mercury in fish tissue samples. It is difficult to measure mercury in ambient water so most States rely on fish samples to indicate mercury contamination, since mercury bio-accumulates in tissue. States are actively studying the extent of the mercury problem, which is complex because it involves atmospheric transport from power-generating facilities and other sources.

In addition to nutrients and metals, the States, Puerto Rico, and the District of Columbia report that siltation pollutes 1.6 million lake acres (10% of the surveyed lake acres), enrichment by organic wastes that deplete oxygen impacts 1.4 million lake acres (8% of the surveyed lake acres), and noxious aquatic plants impact 1.0 million acres (6% of the surveyed lake acres).

Nutrients and metals are the most common pollutants affecting surveyed lakes. Nutrients and metals are found in 20% of all lakes surveyed (see Figure 3-4), and contribute to 51% of all water quality problems identified in lakes.

Often, several pollutants and processes affect a single lake. For example, a process such as removal of shoreline vegetation may accelerate erosion of sediment and nutrients into a lake. In such cases, the States and Tribes count a single lake acre under each pollutant and process category that influences the lake acre. Therefore, the lake acres impaired by each pollutant and process do not add up to 100% in Figure 3-4. Most States and Tribes also rate pollutants and processes as major or moderate/minor contributors to impairment. A major pollutant or process is solely responsible for an impact or predominates over other pollutants and stressors. A moderate/minor pollutant or stressor is one of multiple pollutants and stressors that degrade aquatic life or interfere with human use of a lake. The States report that metals are the most widespread major cause of impairment in lakes.

Currently, EPA ranks pollutants and stressors by the geographic extent of their impacts (i.e., the number of Lake Acres impaired by each pollutant or process).

However, less abundant pollutants or processes may have more severe impacts than the leading pollutants listed above. For example, extreme acidity (also known as low pH) can eliminate fish in isolated lakes, but acid impacts on lakes are concentrated in northeastern lakes and mining States and are not widespread across the country as a whole.

Sources of Pollutants Impacting Lakes, Reservoirs, and Ponds

Forty-one States, the District of Columbia, and Puerto Rico reported sources of pollution related to human activities that affect some of their lakes, reservoirs, and ponds. These States and Puerto Rico reported that agriculture is the most widespread source of pollution in the Nation's surveyed lakes (Figures 3-4). Agriculture generates pollutants that degrade aquatic life or interfere with public use of 3.2 million lake acres (19% of the surveyed lake acres).

The States and Puerto Rico also reported that unspecified nonpoint sources pollute 1.6 million lake acres (9% of the surveyed lake acres), atmospheric deposition of pollutants impairs 1.4 million lake acres (8% of the surveyed lake acres), urban runoff and storm sewers pollute 1.4 million lake acres (8% of the surveyed lake acres), municipal sewage treatment plants pollute 1.2 million lake acres (7% of the surveyed lake acres), and hydrologic modifications degrade 924,000 lake acres (6% of the surveyed lake acres). Many more States reported lake degradation from atmospheric deposition in 1996 than in past reporting cycles. This is due, in part, to a growing awareness of the magnitude of the atmospheric deposition problem. Researchers have found significant impacts to ecosystem and human health from atmospherically delivered pollutants.

The States, the District of Columbia, and Puerto Rico listed numerous sources that impact several hundred thousand lake acres, including construction, land disposal of wastes, industrial point sources, onsite wastewater systems (including septic tanks), forestry activities, habitat modification, flow regulation, contaminated sediments, highway maintenance

Case study

The Great Lakes:

The five interconnected Great lakes contain at least 95% of the surface fresh water in the USA and 20% of the world's fresh surface water. The Great Lakes basin is home for about 35 million people, about 30% of the Canadian population and 13% of the U.S. population. About 40% of the U.S. industry and 50% of Canadian industry are located in this watershed. Great Lakes tourism generates $16 billion annually, with $4 billion of that from sport fishing.

Despite their enormous size, these lakes are vulnerable to pollution from point and nonpoint sources because less than 1% of the water entering the Great Lakes flows out to the St. Lawrence River each year. In addition to land runoff, these lakes receive large quantities of acids, pesticides and other toxic chemicals by deposition from the atmosphere – often blown in from hundreds or thousands of kilometers away.

By the 1960s, many areas of the Great Lakes were suffering from severe cultural eutrophication, huge fish kills and contamination from bacteria and other wastes. The impact on lake Erie was particularly intense because it is shallowest of the Great Lakes.

Many bathing beaches had to be closed, and by 1970, the lake had lost nearly all its native fish.

Since 1972, a $20 billion pollution control program, carried out jointly by Canada and the United States, had significantly decreased levels of phosphates, coliform bacteria, and many toxic industrial chemicals in the Great Lakes. Algal blooms have also decreased, dissolved oxygen levels, sport, and commercial fishing have increased, and most swimming beaches have been reopened.

Mainly new or upgraded sewage treatment plants and improved treatment of industrial wastes brought about these improvements. Moreover, phosphate detergents, household cleaners, and water conditioners were banned or their phosphate levels reduced in many parts of the Great Lakes drainage basin.

The most serious pollution problem today is contamination from toxic wastes flowing into the lakes (especially Lake Erie and Lake Ontario) from land runoff, streams and atmospheric deposition (which accounts for an estimated 50% of the input of toxic compounds). Toxic chemicals such as PCBs have built up in food chains and, have contaminated many types of sport fish, and have depleted populations of birds, river otters, and other animals feeding on contaminated fish. A survey by Wisconsin biologists revealed that one fish in four taken from the Great Lakes is unsafe for human consumption.

In 1991, the U.S government passed a law requiring accelerated cleanup of the lakes, especially of 42 toxic "hot spots," and an immediate reduction in emissions of air pollutants in the region. However, a lack of federal and state funds may delay meeting these goals.

Environmentalists call for a ban on the use of chlorine as a bleach in the pulp and paper industry around Great Lakes, a ban on all new incinerators in the area, and an immediate ban on toxic discharge into the lakes of 70 toxic chemicals that threaten human health and wildlife.

Great Lakes fisheries face threats besides chemical pollution. Since 1800s, the Great Lakes have been invaded by numerous nonnative species that have sharply reduced populations of commercial and sport fish and have caused other problems. Canals built in the early 1800s allowed the lakes to be invaded by the sea lamprey, a parasite that attaches itself to the body of soft-skinned fish and sucks out blood and other body fluids. Between the 1920s and the nid-1950s, a combination of large populations of sea lampreys and overfishing devastated populations of game and commercial fish. In 1954, biologists found a poison that could kill the larvae of sea lampreys; by 1962, the poison had caused a sharp decline in sea lamprey populations, and a $10 million-per-year program has kept them under control since then.

Since the1980s, however, the sea lamprey has been breeding in nearby large rivers, which are difficult to treat with the poison. Unless other control methods are developed, the sea lamprey may again decimate populations of desirable game and commercial fish in the Great Lakes.

In 1986, larvae of another nonnative species – the zebra mussel- arrived in water discharged from a European ship near Detroit. With no known natural enemies, these tiny mussels have run amok; they deplete the food supply for other lake species, clog irrigation pipes, shut down water intake systems for power plants and city water supplies, foul beaches, and grow in huge masses on boat hulls, piers, and other surfaces.

These invaders cost the Great Lakes basin at least $500 million per year, and the annual costs could reach $5 billion by 2000. The zebra mussel is expected to spread unchecked and dramatically alter most freshwater communities in parts of the United States and southern Canada by 2000.

There is even worse news, in 1991, a large and potentially more destructive species – the quagga mussel – invaded the Great Lakes, probably brought in by Russian freighter. It can survive at greater depth and tolerate more extreme temperatures than the zebra mussel. There is concern that it may eventually colonize areas such as the Chesapeake Bay and waterways in parts of Florida.

Lake Baikal:

Lake Baikal is located in Siberia. This vast lake, which is the world's deepest and oldest body of fresh water, contains the world's largest volume of fresh water.

After a 20-million-year unbroken history of evolution, it is one of the most biologically rich lakes on Earth. It contains about 1,700 species of plants and animals, 1200 of that are not found anywhere else on Earth.

The lake's huge 326,000square-km watershed consists almost entirely of boreal forest or taiga. Maintaining the ecological integrity of this surrounding forest is crucial to protecting the unique bio-diversity of Lake Baikal.

The installation of 2 paper mills on the lake in the 1960s started within the former Soviet Union an environmental battle that continues today. There was concern over whether the proposed wastewater treatment plant at the 2 paper mills would be adequate to the task of preserving the quality of Lake Baikal's waters. This concern led to an upgrading of the waste treatment plants, appointment of a commission to monitor the lake's water quality, and the establishment of protected areas around parts of the lake to reduce the input of erosion from logging and other forms of land development. Officials subsequently decided to send the wood pulp produced at the plants elsewhere for processing into paper to reduce pollution of the lake.

Because of continuing pressure from scientists and environmentalists, one of the mills was converted in 1987 to a furniture-making factory (which is much less polluting), a closed cycle water system was ordered for the other plant, and reductions in timber cutting were imposed. Since the breakup of the Soviet Union, the lake has faced serious new threats; access to Siberia's vast timber resources (amounting to 26% of the world's remaining forests) and its oil and mineral deposits are being sought by unregulated Russian business interests and by German, Japanese, American and south Korean investors.

Because of its biological uniqueness, protection of the lake is ultimately a global concern. In 1992, a team of scientists, 2/3 Russian and 1/3 American, was assembled to evaluate the lake and its watershed and to develop a land-use-zoning plan for ecologically sustainable development of the entire watershed. In 1993, Russian President Boris Yeltsin created a Baikal commission to help implement the team's recommendations. However, by February 1995, no funds had been provided for the commission to carry out the zoning plan. UNESCO had stated that if these recommendations are implemented, the Baikal would qualify as a protected biosphere reserve.

Although success is not assured, the Lake Baikal plan is serving as a model for sustainable development of watersheds elsewhere. In 1994, China and Russia began drafting a similar plan for the Ussuri River Basin. The Haisla Indian Nation of British Colombia is also considering similar ideas, by the Miskito Indians of Nicaragua, and by officials in Chile and Bolivia.

4- Thermal pollution of streams and lakes:

About 2/3 of the energy in the fuel used by coal-burning and nuclear power plants is converted to heat that must be dissipated into the environment. The cheapest and easiest method is to withdraw cool water from a nearby body of surface water, pass it through the plant, and return the heated water to the same body of water. Almost half of all water withdrawn in the USA each year is for cooling electrical power plants.

This process has several drawbacks. For one thing, many fish die on intake screens used to prevent clogging of the heat exchanger pipes. For another, large inputs of heated water from one or more plants using the same lake or slow-moving stream can have harmful effects on aquatic life. This is called thermal pollution.

Warmer temperatures lower dissolved oxygen content by decreasing the solubility of oxygen in water. Warmer water also causes aquatic organisms to increase their respiration rates and consume oxygen faster, and it increases their susceptibility to disease, parasites and toxic chemicals. Discharge of heated water near the shore of a lake also may disrupt spawning and kill young fish. Moreover, when a power plant first opens or shuts down for repair, fish and other organisms adapted to a particular temperature range can be killed from thermal shock – the effect of sharp changes in water temperature. Experts rate thermal water pollution as a low risk ecological problem, although its localized impact can be quite severe.

Although some scientists call excess heat added to aquatic systems thermal pollution, others – emphasizing the beneficial uses of heated water – call it thermal enrichment. They point out that heated water prolongs the commercial fishing season and reduces winter ice cover in cold areas. Warm water from power plants can also be used for irrigation to extend the growing season in frost-prone areas and cycled through pens and ponds to speed the growth of commercially valuable fish and shellfish. Waste hot water is used to cultivate oysters in aqua-culture lagoons in Japan and in New York's Long Island sound, and to cultivate catfish and red fish in Texas.

In addition, the hot water can be used to heat nearby buildings and greenhouses and to desalinate ocean water, and it can be run under sidewalks to melt snow. However, because of dangers related to air pollution and release of radioactivity, most coal-burning and nuclear power plants are located too far from aquaculture operations, buildings and industries to make some applications of thermal enrichment economically feasible.

Major ways to reduce or control thermal water pollution are:

1- Using and wasting less energy.
2- Limiting the amount of heated water discharged into a body of water.
3- Returning the heated water some distance from the ecologically vulnerable shore zone.
4- Transferring the heat from the water to the atmosphere by means of huge cooling towers.

5- Discharging the heated water into shallow ponds or canals, allowing it to cool, and reusing it as cooling water.

5- Ocean pollution.

The oceans are the ultimate sinks for much of the waste matter we produce. About ¾ of the total amount of pollution entering the oceans, come from human activities on land.

Oceans can dilute, disperse and degrade large amounts of raw sewage, sewage sludge, oil and some types of industrial waste, especially in deep-water areas. Marine life has also proved to be more resilient than some scientists had expected, leading some of them to suggest that it is generally safer to dump sewage sludge and most other hazardous wastes into the deep ocean than to bury them on land or burn them in incinerators.

Other scientists dispute this idea, pointing out that we know less about the deep ocean than we do about outer space. They add that dumping waste in the ocean would delay urgently needed pollution prevention and promote further degradation of this vital part of Earth's life – support system.

Pollution's effects on Coastal areas:

Coastal areas – especially wetlands and estuaries, coral reefs, and mangrove swamps – endure our enormous inputs of wastes into the ocean. This is not surprising, for half the world's population lives on or within 100km of the coast. Nearly 1/5 of the world's people live in coastal cities, and coastal populations are growing at a more rapid rate than global population.

In most coastal LDCs and in some coastal MDCs, untreated municipal sewage and industrial wastes are often dumped into the sea without treatment. The most polluted seas lie off the densely populated coasts of Bangladesh, Indonesia, Malaysia, Thailand and the Philippines. About 85% of the sewage from large cities along the Mediterranean sea, which has a coastal population of 200 million people during tourist season, is discharged into the sea untreated, causing widespread beach pollution and shellfish contamination.

In the USA, about 35% of all municipal sewage end up virtually untreated in marine waters. Most U.S. harbors and bays are badly polluted from municipal sewage, industrial wastes, and oil. Scuba divers talk of swimming through clouds of half-dissolved feces, and of bay and harbor bottoms covered with foul and toxic sediment known as 'black mayonnaise'. They see lobsters and crabs with mysterious burn holes, and fish with cancerous sores and rotting fins.

Each year at least 1/3 of the area of U.S. coastal waters around the lower 48 states are closed to shellfish harvesters because of pollution and habitat disruption. In 1992, more than 2600 beach closings occurred in 22 coastal states, mostly because of bacterial contamination from inadequate and overloaded sewage treatment systems. Scientists believe that many more beaches would be closed if their waters were tested regularly.

Runoff of sewage and agricultural wastes into coastal waters introduces large quantities of nitrogen and phosphorus, which can cause explosive growth of algae. These algal blooms – called red, brown or green tides, depending on their color – damage fisheries, reduce tourism, and poison seafood, and have been reported in coastal areas around the world. When the algae die and decompose, coastal waters are depleted of oxygen and a variety of marine species dies.

The wetlands

Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support (and that under normal circumstances do support) a prevalence of vegetation typically adapted for life in saturated soil conditions (Figure 5-1). Wetlands generally include swamps, marshes, bogs, and similar areas. This is the definition of wetlands as it appears in the regulations jointly issued by the Army Corps of Engineers (COE) and the U.S. EPA.

A variety of wetlands exist across the USA because of regional and local differences in hydrology, vegetation, water chemistry, soils, topography, climate, and other factors. Wetland type is determined primarily by local hydrology, the unique pattern of water flow through an area. In general, there are two broad categories of wetlands: coastal and inland wetlands.

With the exception of the Great Lakes coastal wetlands, coastal wetlands are closely linked to estuaries, where seawater mixes with fresh water to form an environment of varying salinity and fluctuating water levels due to tidal action. Coastal marshes dominated by grasses, sedges, and rushes and halophytic (salt-tolerant) plants are generally located along the Atlantic and Gulf coasts due to the gradual slope of the land. Mangrove swamps, which are dominated by halophytic shrubs and trees, are common in Hawaii, Puerto Rico, Louisiana, and southern Florida.

Inland wetlands are most common on floodplains along rivers and streams, in isolated depressions surrounded by dry land, and along the margins of lakes and ponds. Inland wetlands include marshes and wet meadows dominated by grasses, sedges, rushes, and herbs; shrub swamps; and wooded swamps dominated by trees, such as hardwood forests along floodplains. Some regional wetland types include the pocosins of North Carolina, bogs and fens of the northeastern and north central States and Alaska, inland saline and alkaline marshes and riparian wetlands of the arid and semiarid West, vernal pools of California, playa lakes of the Southwest, cypress gum swamps of the South, wet tundra of Alaska, the South Florida Everglades, and prairie potholes of Minnesota, Iowa, and the Dakotas.

Functions and Values of Wetlands

In their natural condition, wetlands provide many benefits, including food and habitat for fish and wildlife, water quality improvement, flood protection, shoreline erosion control, ground water exchange, as well as natural products for human use and opportunities for recreation, education, and research.

Wetlands are critical to the survival of a variety of animals and plants, including numerous rare and endangered species. Wetlands are also primary habitats for many species, such as the wood duck, muskrat, and swamp rose. For others, wetlands provide important seasonal habitats where food, water, and cover are plentiful.

Wetlands are among the most productive natural ecosystems in the world. They produce great volumes of food, such as leaves and stems that break down in the water to form detritus (Figure 5-2). This enriched material is the principal food for many aquatic invertebrates, various shellfish, and forage fish that are food for larger commercial and recreational fish species such as bluefish and striped bass.

Wetlands help maintain and improve water quality by intercepting surface water runoff before it reaches open water, removing or retaining nutrients, processing chemical and organic wastes, and reducing sediment loads to receiving waters (Figure 5-3). As water moves through a wetland, plants slowly the water, allowing sediment and pollutants to settle out. Plant roots trap sediment and are then able to metabolize and detoxify pollutants and remove nutrients such as nitrogen and phosphorus.

Wetlands function like natural basins, storing either floodwater that overflows riverbanks or surface water that collects in isolated depressions. By doing so, wetlands help protect adjacent and downstream property from flood damage. Trees and other wetland vegetation help slow the speed of floodwaters. This action, combined with water storage, can lower flood heights and reduce the water's erosive potential (Figure 5-4).

In agricultural areas, wetlands can help reduce the likelihood of flood damage to crops. Wetlands within and upstream of urban areas are especially valuable for flood protection, since urban development increases the rate and volume of surface water runoff, thereby increasing the risk of flood damage.

Wetlands are often located between rivers and high ground (called uplands) and are therefore able to store flood waters and reduce channel erosion. Wetlands bind soil, dampen wave action, and reduce current velocity through friction. These properties are very valuable for stabilizing shorelines (Figure 5-5).

Wetland water storage capacity also allows recharge of ground water, which may be used, as sources of water for drinking or agricultural uses (Figure 5-6). Elevated ground water tables and water stored in wetlands are also important for maintaining stream base-flows. Water entering wetlands during wet periods is released slowly through ground water or as runoff, moderating stream flow volumes necessary for the survival of fish, wildlife, and plants that rely on the stream (Figure 5-7).

Wetlands produce a wealth of natural products, including fish and shellfish, timber, wildlife, and wild rice. Much of the Nation's fishing and shellfishing industry harvests wetlands-dependent species. A national survey conducted by the U.S. Fish and Wildlife Service (FWS) in 1991 illustrates the economic value of some of the wetlands-dependent products. Over 9 billion pounds of fish and shellfish landed in the United States in 1991 had a direct dockside value of $3.3 billion. This served as the basis of a seafood processing and sales industry that generated total expenditures of $26.8 billion. In addition, 35.6 million anglers spent $24 billion on freshwater and saltwater fishing. It is estimated that 71% of commercially valuable fish and shellfish depend directly or indirectly on coastal wetlands.

The abundant wildlife in wetlands also attracts outdoor recreationists. Visits by outdoor recreationists to national wildlife refuges (NWR), which often protect extensive wetlands, bring millions of dollars and many jobs to adjacent communities. The FWS estimated that in 1994, bird watchers and other outdoor recreationists spent $636,000 in the communities around the Quivara NWR in Kansas, $3.1 million around the Salton Sea NWR in California, and over $14 million around the Santa Ana NWR in Texas.

tied to the status and abundance of wetlands. As waterfowl populations are squeezed into the remaining wetlands, confined conditions favor outbreaks of avian cholera and other contagious diseases in waterfowl. In 1996, breeding duck populations reached their highest levels since 1979 because of consecutive years of abundant precipitation and continued public and private efforts to maintain and restore wetlands habitats.

The Arizona Game and Fish Department estimates that 75% or more of all of Arizona's native wildlife species depend on healthy riparian systems during some portion of their life cycle. Wetland loss and degradation also reduce water quality purification functions performed by wetlands. The Congaree Bottomland Hardwood Swamp in South Carolina provides valuable water quality services, such as removing and stabilizing sediment, nutrients, and toxic contaminants. The total cost of constructing, operating, and maintaining a tertiary treatment plant to perform the same functions would be $5 million.

Forested riparian wetlands play an important role in reducing nutrient loads entering the Chesapeake Bay. In one study, a riparian forest in a predominantly agricultural watershed removed about 80% of the phosphorus and 89% of the nitrogen from the runoff water before it entered a tributary to the Bay.

Destruction of such areas adversely affects the water quality of the Bay by increasing undesirable weed growth and algae blooms.

A study of two similar sites on the Hackensack River in New Jersey demonstrated the increase in erosion that results from the destruction of marshlands. In the study, marsh vegetation was cut at one site and left undisturbed at the other site. The bank at the cut site eroded nearly 2 meters (more than 6 feet) in 1 year while the uncut site exposed negligible bank erosion.

These examples illustrate the essential role of wetlands in our ecosystems and how wetland destruction and degradation can have expensive and permanent consequences. By preserving wetlands and their functions, wetlands will continue to provide many benefits to people and the environment.

States report that residential development and urban growth are the leading sources of recent wetland loss. Extent of the Resource Wetland Loss in the United States. It is estimated that over 200 million acres of wetlands existed in the lower 48 States at the time of European settlement. Since then, extensive wetlands acreage has been lost, with many of the original wetlands drained and converted to farmland and urban development. Today, less than half of our original wetlands remain. The losses amount to an area equal to the size of California (see Figure 5-8). According to the U.S. Fish and Wildlife Service's Wetlands Losses in the United States 1780's to 1980's, the three States that have sustained the greatest percentage of wetland loss are California (91%), Ohio (90%), and Iowa (89%).

According to FWS status and trends reports, the average annual loss of wetlands has decreased over the past 40 years. The average annual loss from the mid-1950s to the mid-1970s was 458,000 acres, and from the mid-1970s to mid-1980s, it was 290,000 acres. Agriculture was responsible for 87% of the loss from the mid-1950s to the mid-1970s and 54% of the loss from the mid-1970s to the mid-1980s. These estimates are based on aerial photographs.

A more recent estimate of wetlands losses from the National Resources Inventory (NRI), conducted by the Natural Resources Conservation Service (NRCS), indicates that 792,000 acres of wetlands were lost on non-Federal lands between 1982 and 1992 for a yearly loss estimate of 70,000 to 90,000 acres. This net loss is the result of gross losses of 1,561,300 acres of wetlands and gross gains of 768,700 acres of wetlands over the 10-year period. The NRI estimates, although they are based on hydric soils, are consistent with the trend of declining wetlands losses reported by FWS. Although losses have decreased, we still have to make progress toward our interim goal of no overall net loss of the Nation's remaining wetlands and the long-term goal of increasing the quantity and quality of the Nation's wetlands resource base.

The decline in wetlands losses is a result of the combined effect of several trends:
(1) the decline in profitability in converting wetlands for agricultural production
(2) Passage of Swampbuster in the 1985, 1990, and 1996 Farm Bills
(3) Presence of the CWA Section 404 permits programs as well as development of State management programs
(4) Greater public interest and support for wetlands protection
(5) Implementation of wetland restoration programs at the Federal, State, and local level.

Twelve States listed sources of recent wetlands loss in their 1996 reports (Fig. 5-9). Residential development and urban growth were cited as the leading sources of current losses (see Appendix D, Table D-1, for Individual State information). Other losses were due to agriculture; construction of roads, highways, and bridges; hydrologic modifications; filling and/or draining; channelization; and industrial development.

Several States and the District of Columbia reported on efforts to inventory wetlands. Some of the programs are designed to augment the FWS's National Wetlands Inventory (NWI), while others are designed to produce independent status and trend information. Some of the programs have already been completed and others have been authorized but not funded.

Alabama is evaluating and mapping wetland habitats in a portion of the Lower Mobile-Tensaw River Delta and Mobile Bay. With funding from USEPA's Gulf of Mexico Program, Alabama is digitizing wetlands habitats based on aerial photography from 1955, 1979, and 1988, using the NWI methodology. Delaware is currently mapping wetlands area in the State based on 1992 aerial photography. In 1996, the District of Columbia completed mapping of its wetlands based on a 1994 estimate of total wetland acreage generated by applying the Planogrid method to aerial NWI maps. The detail and resolution of the new methodology almost doubled previous estimates of wetland acreage. New Hampshire recently completed wetlands mapping project that translated LANDSAT digital imagery into a geographic information system (GIS) format. The project included extensive field verification and soils mapping in 7 of the 10 counties. The GIS mapping system revealed many small wetlands that were overlooked by previous surveys. Therefore, New Hampshire's estimate of total wetland acreage climbed from 200,000 acres to between 400,000 and 600,000 acres of nontidal wetlands and 7,500 acres of tidal wetlands.

In 1996, New York completed county maps of fresh water wetlands for all counties outside of the Adirondack Park. In addition, New York has completed its tidal wetland inventory that shows tidal wetlands on Long Island, in New York City, and in certain counties along the southern reaches of the Hudson River.

In 1996, Georgia finished an analysis of Landcover based on LANDSAT TM imagery. Georgia reported acreage of 15 Landcover classes for each county. Based on these data, Georgia estimates that 13% of its land area, nearly 5 million acres, is wetlands. The Ohio Department of Natural Resources (DNR) is conducting a statewide inventory of wetlands as part of its Remote Sensing Program with cooperation from numerous agencies. The program utilizes digital data From the LANDSAT Thematic Mapper, digitized soils data, low level aerial photographs, and topographic maps to identify and map different types of wetlands, including farmed wetlands. DNR plans to update the maps every 5 years.

More States are monitoring unimpacted wetlands to define baseline conditions in healthy wetlands.

Monitoring Wetlands Functions and Values

Wetlands monitoring programs are critical to the achievement of important national goals, such as no overall net loss of wetland functions and values. With States and Tribes developing water quality standards for their wetlands, State and Tribal monitoring programs are critical for determining if wetlands are meeting their existing and designated uses.

Monitoring programs are also needed to prioritize wetlands for protection and restoration and to develop performance standards for successful mitigation and restoration efforts.

Monitoring programs can provide the data needed to identify degradation of functions and values in wetlands and sources of that degradation, but specific wetlands monitoring programs are still in their infancy. Currently, no State is operating a statewide wetlands monitoring program, although several States include some wetlands in their ambient monitoring programs. A growing number of States are implementing monitoring projects at selected reference wetlands that are relatively free from impacts. These States will use the data collected from reference wetlands to define baseline conditions in healthy wetlands and to create standards to protect wetlands.

Minnesota initiated the Reference Wetlands Project in 1993 to develop a basis for assessing the biological and chemical integrity of wetlands. This project included 32 relatively undisturbed wetlands and three impacted wetlands to calibrate biological metrics. In 1995, Minnesota began a second wetland project in depressional wetlands. In the Impacted Wetland Project, 20 known impacted wetlands and six least-disturbed wetlands were sampled. In the Impacted Wetland Project, the focus was on regulate biological metrics across a gradient of disturbance. The disturbance gradient was represented by two primary stressors, conventional agricultural practice and storm water discharges. Both projects characterized the invertebrate community, vegetation, amphibians, water, and sediment chemistry. This information will provide the basis for determining use support status and evaluating depressional wetlands health in Minnesota.

Montana sampled 80 wetlands throughout the State during 1993 and 1994 to develop bio-assessment protocols. Wetlands were sampled for water column and sediment chemistry, macro-invertebrates, and diatoms. To partition natural variability between wetlands types, Montana developed a classification system to group reference wetlands by ecoregion and hydro-geomorphology. Montana used a multi-metric approach to develop a macro-invertebrate index to assess wetlands water quality. Preliminary results indicate detection of impairments caused by metals, nutrients, salinity, sediment, and fluctuating water levels.

North Dakota initiated a project in 1995 to develop bio-criteria and water quality standards for wetlands. North Dakota began sampling water chemistry, sediments, macro-invertebrates, Phyto-plankton, and vegetation in reference wetlands of the prairie pothole region. Based on continued field sampling, North Dakota plans to develop biological criteria for specific wetland classes.

Ohio initiated a project in 1994 to develop bio-criteria for wetlands. Ohio is applying the same approach to wetlands that it used to develop its stream bio-criteria program. Methodologies to assess vegetation, macro-invertebrates, and amphibian assemblages are under development. As with streams, Ohio is defining the biological integrity of wetlands based on a framework of least-impacted reference sites. Ohio will use wetland bio-criteria to define the attainable condition for a class of wetlands in a given region. Every 3 years, Kansas collects water quality samples from seven wetlands (covering 25,069 acres) owned by the State or the Federal government. The State monitors one station per wetland for nutrients, minerals, heavy metals, clarity, suspended solids, pesticides, bacteria, algae, temperature, and dissolved oxygen.

Kentucky added several wetlands to its reference reach monitoring program to characterize chemical water quality, sediment quality, fish tissue concentrations of contaminants, habitat conditions, and general biotic conditions in each physiographic region of the State. The information will be used to develop designated uses and biological criteria for wetlands.

Wetlands Acres; Surveyed by States and Tribes
Including Alaska's Wetlands 8,405,875 acres = 3% surveyed
Total acres (including Alaska) =277 million
Excluding Alaska's Wetlands 8,405,875 acres = 8% surveyed
Total acres (excluding Alaska) =107 million

The States, Tribes, and other jurisdictions are making progress in developing specific designated uses and water quality standards for wetlands, but many States and Tribes still lack specific water quality criteria and monitoring programs for wetlands. Without criteria and monitoring data, most States and Tribes cannot evaluate use support. To date, only nine States and Tribes reported the designated use support status for some of their wetlands (see Appendix D, Table D-1). Only Kansas used quantitative data as a basis for use support decisions.

California reported that 12% of the 124,178 acres of surveyed wetlands fully supports aquatic life use and 88% of the acres are impaired due to metals, nutrients, oxygen depletion, and salinity. Sources affecting wetlands include municipal wastewater treatment plants, urban runoff and storm sewers, and hydrologic and habitat modifications.

The Coyote Valley Band of Pomo Indians in northern California classified all 1.6 acres of their wetlands as partially supporting uses for wildlife and use as a riparian buffer. The use support analysis was based on reconnaissance surveys rather than monitoring in the wetlands. Exotic species, filling, raining, and other habitat alterations impair the wetlands.

The Hoopa Valley Tribe in northern California reported that all of its 3,200 acres of surveyed wetlands are impaired for aquatic life use, religious use, wildlife habitat use, and use as a riparian buffer. Filling and draining, flow alterations, other habitat alterations, and exotic species impair the wetlands. Agriculture, forestry, construction, hydrologic modifications, and unknown sources have degraded wetlands on the Hoopa Valley Reservation.

Iowa used best professional judgment to determine the use support of 26,062 wetland acres during 1994 and 1995. The State reported that 35% of the assessed wetlands fully supported designated uses, of which 32% are threatened for one or more uses.

Pesticides, ammonia, nutrients, siltation, and habitat alterations impair the nonsupporting acres. Sources of impairment include agriculture, urban runoff and storm sewers, land disposal of wastes, and hydromodification. Kansas assessed and determined the use support of 35,597 wetland acres during this reporting cycle. Of the 35,597 acres, 10,458 acres were of unknown use support. Of the remaining 26,139 acres, 9% fully support uses now but are threatened and 91% are impaired and exceed chronic aquatic life support criteria.

Kansas used monitoring data to determine use support in nine publicly owned wetlands (covering 25,069 acres) and qualitative information to assess one wetland (covering 70 acres). Louisiana assessed use support in over 1 million acres of its 8.7 million total acres of wetlands. The State reported that 92% of the assessed wetland acres fully support uses and 8% are impaired because of bacteria, siltation and suspended solids, and hydrologic modifications. Sources of impairment include channelization, dredging, flow regulation, drainage and filling, recreational activities, upstream sources, and natural sources.

Michigan assessed use support for 10 acres of wetlands. All 10 acres are impaired and do not support designated uses because of nickel contamination. Nevada surveyed use support in 19,326 acres (25%) of its 136,650 total acres of wetlands. Nevada reported that all of the surveyed wetlands fully supported designated uses.

North Carolina used aerial photographs and soil information from a 1992-1993 survey to rate use support by current land use. North Carolina rated wetlands on hydric soils with natural tree cover as fully supporting uses. Partially supporting wetlands have modified cover and hydrology but still retain wetland status and support most uses. For example, pine plantations still retain value for wildlife habitat, flood control, ground water recharge, nutrient removal, and aquatic habitat, although the modified wetlands support these uses less effectively than undisturbed wetlands. Wetlands converted to agriculture or urban land use are classified as not supporting original wetlands uses. The State used this methodology to survey use support in over 7 million acres of wetlands. The State reported that 66% of the surveyed wetlands fully support uses and 34% are impaired for one or more uses.

EPA cannot draw national conclusions about water quality conditions in all wetlands because the States used different methodologies 1to survey only 3% of the total wetlands in the Nation. Summarizing State wetland data would also produce misleading results because two States (North Carolina and Louisiana) contain 98% of the surveyed wetlands acreage. More States and Tribes will assess use support in wetlands as they develop standards for wetlands. Many States are still in the process of developing wetland water quality standards, which provide the baseline for determining beneficial use support. Improved standards will also provide a firmer foundation for assessing impairments in wetlands in those States already reporting use support in wetlands.

The States have even fewer data to quantify the extent of pollutants degrading wetlands and the sources of these pollutants. Although most States cannot quantify wetlands area impacted by individual causes and sources of degradation, nine States identified causes and sources known to degrade wetlands integrity to some extent (Figures 5-10 and 5-11). These States listed sediment and habitat alterations as the most widespread causes of degradation affecting wetlands, followed by draining and nutrients. Agriculture and hydrologic modifications topped the list of sources degrading wetlands, followed by urban runoff, construction, and draining (see Appendix D, Tables D-3 and D-4, for individual State information).

Currently, most States are not equipped to report on the integrity of their wetlands. Only six States and Tribes reported attainment of designated uses for wetlands in 1996. National trends cannot be drawn from this limited information. This is expected to change, however, as States adopt wetlands water quality standards and enhance their existing monitoring programs to more accurately assess designated use support in their wetlands.

Case study:

The Chesapeake Bay.

The Chesapeake Bay, the largest estuary in the United States, is in trouble because of human activities. Between 1940 and 1994 the number of people living in the Chesapeake Bay area grew from 3.7 million to 15 million and by 2000 its population may reach 18 million.

The estuaries receives wastes from point and nonpoint sources scattered throughout a huge drainage basin that includes nine large rivers and 141 smaller streams and creeks in parts of 6 states. The bay has become a huge pollution sink because it is quite shallow – it has an average depth of less than 7 meters – and because only 1% of the waste entering it is flushed into the Atlantic Ocean.

Levels of phosphates and nitrates have risen sharply in many parts of the bay, causing algal blooms and oxygen depletion. Studies have shown that point sources, primarily sewage treatment plants, contribute about 60% by weight of the phosphates. Nonpoint sources – mostly runoff from urban, suburban, and agricultural land and deposition from the atmosphere – are the origins of about 60% by weight of the nitrates.

Air pollutants account for nearly 30% of the nitrogen entering the estuary. In addition, large quantities of pesticides run off cropland and urban lawns, and industries discharge large amounts of toxic wastes, often in violation of their discharge permits. Commercial harvests of oysters, crabs, and several important fish species have fallen sharply since 1960 because of a combination of overfishing, pollution, and disease.

Since 1983, more than $700 million in state and federal funds have been spent on a Chesapeake Bay cleanup program that will ultimately cost several billion dollars. Nitrogen and phosphorus pollution from nonpoint sources dropped about 7% between 1987 and 1993, but goals for the year 2000 are unlikely to be met. To add to its problems. The bay will soon be invaded by zebra and quagga mussels, which now cause massive damage to the Great Lakes. Halting the deterioration of this vital estuary will require prolonged, cooperative, and expensive efforts of citizens, officials, and industries alike throughout the bay's entire watershed; much greater emphasis on pollution prevention is needed.

Ocean dumping.

Dumping of industrial waste off US coasts has stopped, although it occurs in a number of other MDCs and some LDCs. However, barges and ships still legally dump large quantities of *dredge spoils* (materials, often laden with toxic metals, scraped from the bottoms of harbors and rivers to maintain shipping channels) at 110 sites off the Atlantic, Pacific and Gulf coasts.

In addition, many countries, including Great Britain, dump into the ocean large quantities of sewage sludge – a gooey mixture of toxic chemicals, infectious agents, and settled solids removed from wastewater at sewage treatment plants. Although this practice was banned in the United States as of 1992, some elected officials and scientists argue that ocean disposal, especially in the deep ocean, is safer and cheaper than either land dumping or incineration at sea or on land.

Fifty countries with at least 80% of the world's merchant fleet have agreed not to dump sewage and garbage at sea, but this agreement is difficult to enforce and is often violated. Most ship owners save money by dumping wastes at sea and risking only small fines if they are caught. Each year as many as 2 million seabirds and more than 100000 marine mammals (including whales, seals, dolphins and sea lions) die when they ingest or become entangled in fishing nets, ropes, and other debris dumped into the sea and discarded on beaches.

Under the London Dumping Convention of 1972, 100 countries agreed not to dump highly toxic pollutants and high-level radioactive wastes in the open sea beyond the boundaries of national jurisdiction. Since 1983, these same nations have observed a moratorium on the dumping of low-level radioactive wastes at sea, which in 1994 became a permanent ban. However, France, Great Britain, Russia, China and Belgium may legally exempt themselves from this ban.

Oil pollution.

Crude petroleum (oil as it comes out of the ground) and *refined petroleum* (fuel oil, gasoline, and other processed petroleum products) are accidentally or deliberately released into the environment from number of sources.

According to a study by the U.S. National Academy of Sciences, oil pollution at sea declined by 60% between 1981 and 1989. Although tanker accidents and blowouts (oil escaping under high pressure from a borehole in the ocean floor) at offshore drilling rigs get most of the publicity, more oil is released during normal operation of offshore wells, from washing tankers and releasing the oily water, and from pipeline and storage tank leaks. A 1993, Friends of the Earth study estimated that each year U.S. oil companies unnecessarily spill, leak, or waste an amount of oil equal to that shipped in 1000 huge *Exxon Valdez* tankers or more oil than Australia uses.

Natural oil seeps also release large amount of oil into the ocean at some sites, bust most ocean pollution comes from activities on land. Almost half of the oil reaching the oceans is waste oil dumped, spilled or leaked onto the land or into sewers by cities, individuals and industries. Each year, a volume of oil equal to 20 times the amount spilled by the Exxon Valdez accident is improperly disposed of by U.S. motorists changing their own motor oil worldwide, about 10% of the oil that reaches the ocean comes from the atmosphere, mostly from oil fire smoke.

The effect of oil on ocean ecosystems depends on number of factors:

- Type of oil (crude or refined),
- Amount released,
- Distance of release from shore,
- Time of year,
- Weather conditions,
- Average water temperature,
- Ocean currents.

Volatile organic hydrocarbons in oil immediately kill a number of aquatic organisms, especially in their more vulnerable larval forms. Most of these toxic chemicals evaporate within a day or two in warm waters, but in cold waters this may take up to a week.

Some other chemicals form tarlike globs or mousse that floats on the surface. This floating oil coats the feathers of birds (especially diving birds and the fur of marine mammals, destroying the animals' natural insulation and buoyancy; many drown or die of exposure from loss of body heat.

Bacteria break down the globs of oil over several weeks or months, although they persist much longer in cold polar waters because of the chemical reactions involved in decomposition are slowed down. Heavy oil components that sink to the ocean floor or wash into estuaries can smother bottom-dwelling organisms such as crab, oysters, mussels, and clams or make them unfit for human consumption. Some oil spills have killed reef corals. A recent study also showed that diesel oil spilled at sea becomes more toxic to marine life with the passage of time.

Research shows that most but not all forms of marine life recover from exposure to large amount of crude oil within 3 years. However, recover y from exposure to refined oil, especially in estuaries, may take 10 years or longer. The effects of spills in cold waters and in shallow enclosed gulfs and bays generally last longer.

Oil slicks wash onto beaches can have a serious economic impact on coastal residents, who lose income from fishing and tourist activities. Oil-polluted beaches washed by strong waves or currents are cleaned up after about a year, but beaches in sheltered areas remain contaminated for several years. Estuaries and salt marshes suffer the most and longest-lasting damage. Despite their localized harmful impacts, experts as a low-risk ecological problem rate oil spills.

Case study:

The Valdez oil spill.

Crude oil from Alaska's North Slope fields near Prudhoe Bay is carried by pipeline to the port of Valdez and then shipped by tanker to the West Coast. On march

24, 1989, the *Exxon Valdez*, a tanker more then 3 football fields long, went off course in a 16-kilometer-wide channel in Prince William Sound near Valdez, Alaska. It hit submerged rocks, creating the worst oil spill ever in the U.S. waters.

The rapidly spreading oil slick coated more than 1600 kilometers of shoreline. Almost the length of the shoreline between 300000 and 645,000 birds (including 430 bald eagles), up to 5,500sea otters, 300 harbor seals, 23 whales, and unknown numbers of fish. The full loss of wildlife will never be known because most of the dead animals sank and decomposed without being counted.

In the early 1970s, environmentalists had predicted that a large, damaging spill might occur in these waters made treacherous by icebergs, submerged reefs, and violent storms. Environmentalists urged that Alaskan oil be brought to the lower 48 states by land pipeline to reduce potential damage.

Officials of Alyeska, a company formed by the 7 oil companies extracting oil from Alaska's North slope, countered that pipeline would take too long to build and that a large spill was highly unlikely. They also assured Congress that they would be at the scene of any accident within 5 hours and have enough equipment and trained people to clean up any spill. But when the Valdez spill occurred, Alyeska and Exxon officials did not have enough equipment and personnel and responded with too little too late. Although it become apparent that no amount of equipment and personnel could clean up such a large spill, a prompt response could have helped contain some of the leaking oil and reduce environmental impact.

Exxon spent $2.2 billion directly on the cleanup, but more aspects of the cleanup effort did more harms than good. For example, the use of high-pressure jets of water to clean beaches killed coastal plants and animals.

In 1990, the National Transportation Safety Board ruled that the accident was the result of drinking by the captain, a fatigued and overworked crew and inadequate traffic control by Coast Guard. In 1991, Exxon pleaded guilty to federal felony and misdemeanor charges and agreed to pay the federal government and the state of Alaska $1 billion in fines and civil damages.

In 1994, a federal jury found that Exxon was reckless in allowing Captain Joseph Hazlewood, who had a history in alcohol abuse, to command the *Exxon Valdez* (now repaired, renamed the *Sea River Mediterranean* and operating in the Mediterranean Sea). The jury also found that Hazlewood was negligent and reckless in light of testimony that he had 14 shots of vodka on the afternoon before the ship left port. The same jury awarded $5 billion in punitive damages to commercial fishermen, property owners, and others filing claims against Exxon. The courts are also evaluating thousands of individual claims brought by other plaintiffs.

This roughly $8.5 billion accident might have been prevented if Exxon had spent only $22.5 million to fit the taker with a double hull (which it still has not done). In the early 1970s, the Interior Secretary Rogers Morton told Congress that all oil tankers using Alaskan waters would have double hulls but under pressure from oil companies, the requirement was dropped.

Today, virtually all-merchant ships have double hulls, but only 15% of oil tankers have such hulls. Legislation passed since the spill requires all new tankers to have double hulls and all existing large single-hulled oil tankers to be phased out between 1995 and

2015. However, the oil industry is working to weaken these and other stricter requirements enacted since the spill as the public memory of the accident fades.

Others most share the blame for this tragedy. State officials had been lax in monitoring Alyeska, and the Coast Guard did not effectively monitor tanker traffic because of inadequate radar equipment and personnel.

This spill highlighted the importance of pollution prevention. Even with the best technology and a fast response by well-trained people, scientists estimate that no more than 11-15% of the oil from a major spill can be recovered.

Solutions: protecting Coastal Waters.

The key to protecting oceans is to reduce the flow of pollution from the land and from streams emptying into the ocean. Such efforts must also be integrated with efforts t prevent and control air pollution because an estimated 33% of all pollutants entering the ocean worldwide comes from air emissions from land-based sources.

Some ways various analysts have suggested preventing and reducing excessive pollution of coastal waters include the following:

Prevention:

- Encourage or require separate sewage and storm runoff lines in urban areas.
- Discourage ocean dumping of sludge and hazardous dredged materials.
- Protect sensitive and especially ecologically valuable coastal areas from development, oil drilling and oil shipping.
- Use ecological land-use planning to control and regulate coastal development.
- Require double hulls for all oil tankers by 2002.
- Recycle used oil

Cleanup:

- Improve oil-spill cleanup capabilities.
- Require at least secondary treatment of coastal sewage, or use wetlands, solar aquatic, or other environmentally acceptable methods.

6- Groundwater pollution and its prevention.

Even though highly visible oil spills get lots of media attention, a much greater threat to human health is the out-of-sight pollution of groundwater, which is a prime source of water for drinking and irrigation.

Ground water is a vital national resource that is used for myriad purposes. It is used for public and domestic water supply systems, for irrigation and livestock watering, and for industrial, commercial, mining, and thermoelectric power production purposes. In many parts of the World, ground water serves as the only reliable source of drinking and irrigation water. Unfortunately, this vital resource is vulnerable to contamination, and ground water contaminant problems are being reported throughout the countries.

When groundwater becomes contaminated, it cannot cleanse itself of degradable wastes, as surface water can if it is not overloaded. Because ground water flows are slow and are not turbulent, contaminants are not effectively diluted and dispersed. Groundwater also has much smaller populations of decomposing bacteria than do surface water systems, and its cold temperature slow decomposition reactions. Thus it can take hundreds to thousands of years for contaminated groundwater to cleanse itself of degradable wastes, and nondegradable wastes are there permanently on a human time scale.

To ascertain the extent to which the USA's ground water resources have been impacted by human activities, the Clean Water Act requests that each State monitor ground water quality and report the findings to Congress in their State Water Quality Reports. Evaluation of the ground water quality is complex and early efforts to provide a National assessment of ground water quality relied on generalized overviews presented by the State resource managers. These overviews were most frequently based on known or suspected contamination sites and on finished water quality data from public supplies systems. Unfortunately, these early assessments did not always provide a complete or accurate representation of ambient ground water quality conditions. Nor did they provide an indication of the extent and severity of ground water contamination problems.

EPA recognized that an accurate representation of the U.S ambient ground water quality conditions required developing a set of guidelines that would ultimately yield quantitative data for specific hydrogeologic units within a State. EPA, in partnership with interested States, developed guidelines for assessing ground water quality that took into account the complex spatial variations in aquifer systems, the differing levels of sophistication among State programs, and the expense of collecting ambient ground water data. States used these guidelines for reporting the 1996 ground water data.

The most significant change for 1996 was the request that States provide ground water information for selected aquifers or hydrogeologic settings (e.g., watersheds) within the State. The focus on specific aquifers or hydrogeologic settings provides for a quantitative assessment of ground water quality than was possible in previous reporting cycles.

State response to the revised ground water guidelines was excellent. Forty States, one Territory, and two Tribes used the new guidelines to assess and report ground water quality data in 1996. Each of these reporting entities (hereafter referred to as States) used the data that was available to them and, therefore, there was wide variation in reporting style. EPA anticipated this variation and States involved in developing the guidelines as it is a direct reflection of the administrative, technical, and programmatic diversity among our States. This variation is expected to decrease in future reporting cycles as many States have indicated they are developing plans to improve their data management to provide better coverage. Still other States indicated that the 1996 Guidelines provided incentive to modify their ground water programs to enhance their ability to provide more accurate and representative information.

Despite variations in reporting style, the 1996 State Water Quality Reports represent a first step in improving the assessment of State ambient ground water quality. For the first time, States provided quantitative data describing ground water quality. Furthermore, States provided quantitative information pertaining to contamination sources that have affected ground water quality.

Ground Water Use in the United States

Although 75% of the earth's surface is covered by water, less than 1% is fresh water available for our use. It has been estimated that approximately 96% of the world's available fresh water reserve are stored in the earth as ground water.

In the United States, ground water is used for agricultural, domestic, industrial, and commercial purposes. Ground water provides water for drinking and bathing, irrigation of croplands, livestock watering, mining, industrial and commercial uses, and thermoelectric cooling applications. Irrigation (63%) and public water supply (19%) are the largest uses of ground water withdraw.

In 1990, the United States Geological Survey reported that ground water supplied 51% of theU.S.'s overall population with drinking water. In rural areas of thestates, ground water supplied 95% of the population with drinking water. Therefore, the USA's dependence on this valuable resource is obvious. In their Water Quality Reports, States emphasized the importance of ground water as a drinking water resource.

Idaho is one of the top five States in the country for the volume of ground water used. Idahoans use an average of 9 billion gallons per day of ground water. Sixty percent of this water is used by agriculture for crop irrigation and stock animals. 36% is used by industry, and 3% to 4% is used for drinking water. Although the volume of ground water used for drinking water is relatively small in comparison to total ground water use, more than 90% of the population in Idaho rely on ground water for their drinking water supply. Currently, approximately 70% of the State's population are served by public systems regulated under the Safe Drinking Water Act; the remaining 30% obtain their drinking water through private systems typically represented by private wells.

Approximately 95% of the 11.5 million people in Illinois rely on public water supplies as a source of drinking water. About 4.1 million people use ground water as a source of public water supply. Furthermore, an estimated 400,000 residences in Illinois are served by private wells.

Kansas relies on ground water resources for public, rural domestic, industrial, irrigation, and livestock water supplies. Over 90% of all water used within Kansas is supplied by ground water. Although irrigation continues to be by far the largest user of ground water, ground water provides approximately 85% of the drinking water in rural areas. A total of 637 community public water supplies are dependent on ground water, either solely or in combination with surface water sources. These supplies serve 1,717,464 people.

South Dakota is heavily dependent on ground water to meet the needs of its population. More than 75% of the population use ground water for domestic needs. Over 80% of the State's public water supply systems rely on ground water and virtually everyone not supplied by the public water supply systems is dependent on ground water.

In 1990, the United States Geological Survey reported that ground water supplied 51% of the USA's overall population with drinking water. In rural areas of the states, ground water supplied 95% of the population with drinking water. Therefore, the USA's dependence on this valuable resource is obvious. In their Water Quality Reports, States emphasized the importance of ground water as a drinking water resource.

Ground water is the source of drinking water for 60% to 70% of the population of Washington State. In large areas east of the Cascade Mountain Range, 80% to 100% of available drinking water is obtained from ground water resources. As a whole, over 95%

of Washington's public water supply systems use ground water as their primary water source.

Ground water is also often directly connected to rivers, streams, lakes, and other surface water bodies, with water flowing back and forth from one resource to the other. In some areas of the country, ground water contributes significantly to the water in streams and lakes.

The volume of ground water that is discharged to surface water bodies, thereby maintaining stream flow during periods of low flow or drought conditions, was previously unrecognized and unquantified. This volume, estimated at 492 billion gallons per day, is measured using special instruments or estimated using stream gagging and hydraulic gradient data. When ground water contributing to stream baseflow maintenance is included with the other ground water uses, it becomes evident just how important it can be. Stream baseflow maintenance accounts for 54% of ground water discharges. This baseflow contributes to maintaining healthy aquatic habitats in surface water.

With ground water playing such an important part in maintaining water flow in streams and lakes, the quality of the ground water can have an important effect on the overall condition of the surface water. Surface waters can become contaminated if the ground water serves as a means to transport contaminants to the surface water (and vice versa). This could affect drinking water supplies drawn from surface water, fish and wildlife habitats, swimming, boating, and fishing.

Ground Water Use

State	Uses of Ground Water Specific to Drinking Water	*Other Uses*
Alabama	40% of water is obtained from ground water	
Alaska	85% of public drinking water systems in the State use ground water as their source	Ground water is the major source of fresh water for public and private drinking water supply systems, industry, and agricultural development
Arkansas	47.2% of total ground water withdrawals are used for drinking water	Between 1975 and 1980, ground water use increased from 2,596 to 4,056 million gallons per day (a 56% increase); it increased from 4,056 to 4,708 million gallons per day between 1980 and 1990 (a 16% increase)
Colorado	59 of 63 counties use ground water for drinking water; 29 of these counties rely solely on ground water	Ground water supplies approximately 18% of total water withdrawals; 96% is used for irrigation

Delaware	67% of the State's population is dependent upon public and private wells for Sussex Counties rely 100% on ground water for drinking water	Overall, ground water use increased 13.31%, whereas overall surface water use decreased 18.87%
Georgia	In 1990, ground water made up 24% of the public water supply and 92% of rural drinking water sources; for all practical purposes, ground water is the dominant source of drinking water for areas outside the larger cities of the Piedmont	In 1990, ground water made up 60% of irrigation use and 51% of the industrial and mining use.
Indiana	Nearly 60% of the population uses ground water for drinking water and other household purposes; approximately 50% of the population served by public water supplies depends on ground water; over 0.5 million homes have private wells	Industry withdraws an average 190 million gallons/day; irrigation consumes 200 million gallons/day during the crop production season; and live-stock depend on an average of 45 million gallons/day
Kentucky	Approximately 14% of the population (500,000 people) rely on private wells for drinking water; there are 362 public water supply systems using ground water as principal, partial, or supplemental supplies	Large ground water withdrawals (>10,000 gallons/day) increased from 37.8 million gallons/day in 1980 to 320 million gallons/day in 1995
Maine	More than 60% of all households draw their drinking water from ground water supplied from private or public wells; ground water is the source of approximately 98% of all water used by households with private supplies	Nearly 60% of water needed for livestock is supplied by ground water; ground water also supplies more than 60% of industrial needs
Maryland	Ground water supplied 450 public water supply systems in 1995, serving a population of 960,000	

Missouri	Ground water is the main source of drinking water in the Ozarks and Southeast Lowlands for both public and private supplies; the cities of Independence, Columbia, and St. Charles use ground water adjacent to the Missouri River	
New York	Approximately 6,000,000 people use ground water as a source of drinking water; 50% of these people are on Long Island and the remainder are in upstate New York	
South Carolina	Ground water is a source of drinking water for more than 60% of the population	
Tennessee	More than 50% of the population relies on ground water for drinking water supplies (one in five of these households relies on a private well or spring); community public water systems withdraw approximately 243 million gallons/day	
Texas	About 41% of municipal water is derived from ground water resources	In 1992, approximately 56% of the water used for domestic, municipal, industrial, and agro-cultural purposes was derived from ground water
Utah	Ground water is a major source of public drinking water supplies with almost 67% of the population dependent upon this resource	
Vermont	Approximately 60% of the population depend on groundwater to meet their drinking water needs; in rural communities, ground water dependence is nearly 100%	
Virginia	Ground water is used solely or in part to supply 80% of the population with drinking water	Ground water accounts for approximately 22% of the water used exclusively for hydroelectric and thermo-electric purposes

Wisconsin	Ninety-seven percent of Wisconsin's villages and cities use ground water for drinking water, and 70% of the State's residents rely on ground water for their water supply	

Ground Water Quality

Ground Water Along the U.S. Coasts

Nationwide, many water quality problems may be caused by ground water/surface water interactions. Substantial evidence shows that it is common for contaminated ground water to discharge to and contaminate surface water. In other cases, contaminated surface water is seeping into and contaminating ground water. In their most recent reports on water quality, several states reported ground water/surface water interactions leading to contamination of one medium by the other. A few examples follow:

The Arkansas Department of Health (ADH) is investigating cases of ground water contaminated by microscopic organisms normally found in surface water. Because surface water carries disease-causing protozoa and other organisms resistant to the chlorination used to disinfect most public wells, the ADH must determine if public drinking water wells are supplied by sources of ground water under the direct influence (GWUDI) to surface water.

The ADH has developed an objective method to determine if a well is supplied by GWUDI. Water quality information is used to determine the potential for contamination and then evaluating the well's conformance to establish construction standards identifies possible pathways of contamination. Two primary defects in well construction that provide possible pathways for surface water contamination are: (1) unsuitable below-ground construction, particularly shallow casings and insufficient grout; and (2) well sites characterized by poor drainage, high soil infiltration rate, and highly permeable outcrops.

Arkansas has more than 1,700 public drinking water supply wells. In the 3 years since the GWUDI program began, the ADH has used the above method to determine that 900 of these wells are not supplied by sources of ground water under the influence of surface water. For many of the wells evaluated, the ADH has recommended simple, aboveground construction repairs or site maintenance procedures that effectively closed the pathways of surface water contamination.

In South Carolina, ground water serves to recharge most of the streams; thus, contaminated ground water impacts surface waters more often than surface waters impact ground water. In the State's Ground Water Contamination Inventory, 79 cases of contaminated ground water discharging from surficial aquifers to surface water have been noted. Detailed information on contaminant concentrations in both the aquifer and surface water is not available. However, in most of these cases, dilution of the contaminated ground water by uncontaminated surface water reduces the contaminant concentrations in the surface water to low or not detectable levels.

No single program addresses the water quality concerns that arise from ground water/surface water interactions in Maine. However, contamination, or potential contamination, of surface water through baseflow of contaminated ground water is being evaluated at several locations. At an egg production facility in Turner, Maine, past practices that included excessive land spreading of chicken manure, hen carcass disposal, and septage disposal resulted in nitrate contamination of large areas of a sand and gravel aquifer. The majority of the shallow ground water at the site discharges to streams on the east and west sides of the property. Monitoring points have been established on these streams to evaluate the effects of past practices and current wastewater disposal on surface water quality. To date, surface waters within the property and along the property boundary show evidence of nitrate contamination.

A similar situation occurs in Delaware. Past land-use practices, such as high septic system density and poultry houses, have contributed to nitrate contamination of ground water. This nitrate-contaminated groundwater discharges into the Rehoboth and Indian River bays contributing to eutrophication and algal bloom problems. In fact, it is estimated that certain subbasins within the Indian River Bay watershed contribute, through direct ground water discharge, almost 50% of the total nitrogen load that enters the bay. Furthermore, poultry-producing subbasins were found the source of greater nitrate loading than non-poultry-producing basins. Not too long ago, it was thought that soil provided a protective "filter" or "barrier" that immobilized the downward migration of contaminants released on the land surface and prevented ground water resources from being adversely impacted or contaminated. The discovery of pesticides and other contaminants in ground water demonstrated that ground water resources were indeed vulnerable to contamination resulting from human activities. The potential for a contaminant to affect ground water quality is dependent upon its being introduced to the environment and its ability to migrate through the overlying soils to the underlying ground water resource.

Ground water contamination can occur as relatively well defined, localized plumes emanating from specific sources such as leaking underground storage tanks, spills, landfills, waste lagoons, and/or industrial facilities. Contamination can also occur as a general deterioration of ground water quality over a wide area due to diffuse non-point sources such as agricultural fertilizer and pesticide applications, septic systems, urban runoff, leaking sewer networks, application of lawn chemicals, highway deicing materials, animal feedlots, salvage yards, and mining activities. Ground water quality degradation from diffuse non-point sources affects large areas, making it difficult to specify the exact source of the contamination.

Ground water contamination is most common in highly developed areas, agricultural areas, and industrial complexes. Frequently, ground water contamination is discovered long after it has occurred. One reason for this is the slow movement of ground water through aquifers, which, for finer-grained aquifers may be less than 1 foot per day.

Contaminants in the ground water do not mix or spread quickly, but remain concentrated in slow-moving, localized plumes that may persist for many years. This often results in a delay in the detection of ground water contamination. In some cases, contaminants introduced into the subsurface more than 10 years ago are only now being discovered. This also means that the practices of today may have affects on water quality well into the future.

Shallow, unconfined aquifers are especially susceptible to contamination from surface activities. Ground water contamination in the surficial aquifers can also affect ground water quality of the underlying confined aquifers. Confined aquifers are most frequently susceptible to contamination when low-permeability confining layers are thin or absent, thus enabling the unretarded downward migration of contaminants. Recent studies in southern New Castle County of Delaware have demonstrated the long-term susceptibility of the underlying aquifers to contamination. In Delaware, stream channels have cut down through confining layers at periods of low sea level. When sea level rose, the stream channels were filled with sand and gravel. These highly permeable channels can act as conduits for contaminant migration.

Ground water contaminant problems are frequently serious and can pose a threat to human health and/or result in increased costs to consumers. In the 1996, Guidelines States were asked to indicate the major uses (e.g., public water supply, private water supply, irrigation, industry and livestock watering) for water withdrawn from aquifers or hydrogeologic settings within the State. States were also asked to relate water use to uses that may have been affected by ground water contamination.

Although this information was considered optional, 20 States responded with information for a total of 66 aquifers or hydrogeologic units. Of these, 43 units reportedly supplied water for PWS, 45 units supplied water for private use, and 32 units supplied water for irrigation. Other important uses of the water included commercial (12 units), livestock (19 units), and industry (10 units).

When evaluating the different uses for ground water that have been affected by water quality problems, water supply for public and private use were the most frequently affected. Water supply to PWS was affected in 19 units (almost 45%) and water supply to private wells was affected in 23 units (>50%). Irrigation, commercial, livestock, and industry uses were less frequently affected. This may reflect lower water quality standards for these uses.

Ground Water Contaminant Sources

Ground water quality may be adversely impacted by a variety of potential contaminant sources. EPA developed a list of potential contaminant sources for the 1996 305(b) Guidelines and requested each State to indicate the 10 top sources that potentially threaten their ground water resources. The list was not considered comprehensive and States added sources as was necessary based on State-specific concerns. Factors that were considered by States in their selection include the number of each type of source in the State, the location of the various sources relative to ground water used for drinking water purposes, the size of the population at risk from contaminated drinking water, the risk posed to human health and/or the environment from releases, hydrogeologic sensitivity (the ease with which contaminants enter and travel through soil and reach aquifers), and the findings of the State's ground water protection strategy and/or related studies. For each of the indicated contaminant sources, States were also asked to identify the contaminants affecting ground water quality. Thirty-seven States provided information related to contaminant sources. As requested in the 1996 Guidelines, most States indicated the 10 top contaminant sources threatening ground water quality. In some cases, they not only specified the 10 top source, but provided additional information on sources of lesser, but still notable, importance. In a few other cases, they provided information on the majority of sources threatening ground water quality within the State.

Leaking underground storage tanks 35 out of 37 States as one of the top 10 potential sources of ground water contamination specified (UST). Two other States noted that leaking UST were a source of ground water contamination. Landfills, septic systems, hazardous waste sites, and surface impoundment were the next most frequently cited sources of concern.

Underground Storage Tanks

Leaking USTs were cited as the highest priority contaminant source of concern to States in 1996. The high priority assigned to leaking USTs in 1996 is consistent with information reported by States during previous 305(b) cycles. Although USTs are found in all populated areas, they are generally most concentrated in the more heavily developed urban and suburban areas of a State. USTs are primarily used to hold petroleum products such as gasoline, diesel fuel, and fuel oil. Because they are buried underground, leakage can be a significant source of ground water contamination that can go undetected for long periods.

States report that the organic chemicals associated with petroleum products are one of the most common ground water contaminants. Petroleum-related chemicals have adversely affected ground water quality in aquifers across the states. The most significant affects generally occur in the uppermost aquifer, which is frequently shallow and often used for domestic purposes. Petroleum-related chemicals threaten the use of ground water for human consumption because some (e.g., benzene) are known to cause cancer even at very low concentrations.

The primary causes of leakage in USTs are faulty installation and corrosion of tanks and pipelines. As of March 1996, more than 300,000 releases from USTs had been confirmed. EPA estimates that nationally 60% of these leaks have influenced ground water quality and, in some States, the percentage is as high as 90%.

In general, the threat from USTs was determined primarily based on the sheer number of leaking USTs.

There were almost 61,000 facilities containing 155,308 registered USTs in Texas in 1994. During that same year, the Texas Natural Resource Conservation Commission documented 4,894 cases of ground water contamination as being under enforcement. Fifty-two percent of the contamination cases are within the 10 most populous counties in Texas. Furthermore, leakage from storage tanks has been documented in 223 of 254 counties in the State and either has affected, or has the potential to affect, virtually every major and minor aquifer in the State.

As of August 1996, the State of Arizona was tracking approximately 8,960 facilities having 30,000 USTs. Of these 30,000 USTs, 5,935 have reported leaks and 917 have or may have contaminated ground water.

In the State of Delaware, there are over 9,000 regulated USTs (3,516 of which are currently in use) located at over 2,000 facilities. Over the period 1994-1995, 586 sites had confirmed releases with 80 having confirmed ground water releases.

As of December 31, 1995, 41,795 USTs have been registered at approximately 14,000 facilities in the State of Kentucky. Approximately 400 of these registered sites have ground water contamination at levels above the maximum contaminant levels for drinking water. On average, about 20 new USTs per year manifest ground water contamination above allowable limits.

The "registered USTs" and "facilities" described above represent tanks used for commercial and industrial purposes. Hundreds of thousands of household fuel oil USTs are not included in the numbers presented above. Many of these households USTs, installed 20-to-30 years ago as suburban communities were developed across the country, have reached or surpassed their normal service lifespans. Some of these tanks are undoubtedly leaking and threatening ground water supplies. Because household tanks are not regulated as commercial facilities are, however, it is not possible to determine the extent to which they threaten ground water quality. In addition, since the cost of replacing leaking USTs would be borne by the homeowner, there is little incentive for the homeowner to investigate the soundness of his/her home oil tank.

Recognizing the need to address and control the leaking UST situation, States across theUSA have acted. One excellent example is Maine. In 1985, the Maine Legislature passed a law to regulate all underground petroleum storage tanks. This law required that all tanks be registered with the Maine Department of Environmental Protection (DEP) by May 1, 1986, regardless of size, use, or contents. This law also established procedures for abandonment of tanks and prohibited the operation, maintenance, or storage of petroleum in any storage facility or tank that is not constructed of fiberglass, cathodically protected steel, or other noncorrosive material.

To date, approximately 39,850 tanks have been registered, with only an estimated 4,000 tanks pending registration. Since 1986, approximately 27,750 inactive or old tanks have been removed from the ground. The number of drinking water supply wells contaminated by leaking USTs has dropped dramatically. At the same time, the number of nonconforming USTs has decreased while the number of protected replacement USTs has increased. It is estimated by the Maine DEP that $3 of cleanup and third-party damage claim costs are avoided for every $1 spent on preventive measures.

Landfills

States cited landfills as the second highest contaminant source of concern in 1996. Landfills may be used to dispose of sanitary (municipal) and industrial wastes.

Municipal wastes, some industrial wastes, and relatively inert substances such as plastics are disposed of in sanitary landfills. Resulting contamination may be in the form of high dissolved solids, chemical and biochemical oxygen demand, and some volatile organic compounds.

Industrial landfills are site specific as to the nature of the disposed material. Common materials that may be disposed of in industrial landfills include plastics, metals, fly ash, sludge, coke, tailings, waste pigment particles, low-level radioactive wastes, polypropylene, wood, brick, cellulose, ceramics, synthetics, and other similar substances. Contamination from these landfills may be in the form of heavy metals, high sulfates, and volatile organic compounds. States indicated in their 1996 305(b) Water Quality Reports that the most common contaminants associated with landfills were metals, halogenated solvents, and petroleum compounds. To a lesser extent, organic and inorganic pesticides were also cited as a contaminant of concern.

Landfills of all types have long been used to dispose of wastes. In the past, little regard was given to the potential for ground water contamination in site selection. Landfills were generally sited on land considered to have no other uses. Unlined abandoned sand and gravel pits, old strip mines, marshlands, and sinkholes were often used. In many instances, the water table was at, or very near the surface, and the potential for ground water contamination was high. Although regulations involving the siting, construction, and monitoring of landfills have changed dramatically, past practices continue to cause a threat to ground water quality.

For example, although there are no currently active or operational solid waste disposal sites in the District of Columbia, historic records indicate that about 80 sites within the District of Columbia had been used as either a landfill or an open dump. Historic landfill sites continue to be discovered during routine environmental assessments and construction excavations. The exact location and materials disposed of are frequently unknown. Landfill sites that remain undiscovered have the potential to continue affecting ground water quality. Past handling and disposal practices cause concern because soil properties in the District of Columbia are unfavorable for use as a landfill. Specifically, soils are characterized by a relatively high permeability. In addition, the shallow depth to bedrock, high seasonal ground water level, and susceptibility to flooding make the area even more unsuitable.

To better govern municipal landfills, the State of Texas established a regulatory program in 1969 and began permitting new sites in 1975. From 1977 to 1981, previously existing landfills were either closed, permitted as grandfathered sites, or considered illegal/unauthorized sites. Records indicate from 1981 until 1994, 1,343 previously existing landfills (dumps), 1,810 permitted and grandfathered landfills, and 2,549 illegal/unauthorized sites have been closed. As a rule, ground water monitoring is not required at these 5,702 sites. In 1994, there were 360 active landfills operating under the jurisdiction of the Texas Natural Resource Conservation Commission. Of these sites, 196 were conducting ground water monitoring, 27 of which had documented ground water contamination. 391 municipal landfills have been identified in the State of Maine. As of December 1995, 206 landfills have been closed and capped. Seventeen landfills are partially closed with 168 yet to be closed. Of these 168 landfills, 45 are currently active sites and 123 are inactive sites that are no longer receiving solid waste. In all: 184 landfill sites are situated on sand and gravel aquifers and ground water contamination has been documented at 46 of these sites. 60 other sites have contaminated surface water and/or ground water and are considered substandard; 37 of these sites have serious ground water contamination.

Hazardous substances in the ground water are confirmed or suspected at 41 municipal landfills. Public or private water supplies are threatened at 13 of these sites. Public water supplies appear to be threatened by hazardous contaminants at three sites. Contaminants at the remaining 10 sites appear to threaten private water supplies.

Recognizing the problems associated with old, inactive landfill sites, States are acting to ensure that current and future landfills are less of a threat. In the State of Maine, active landfills are required to be licensed by the Department of Environmental Protection. Currently 57 landfills are licensed to operate in Maine. Eight of these are licensed to accept municipal solid waste only; 22 are licensed to accept special wastes (nonhazardous waste generated by sources other than domestic and typical commercial establishments), and 27 are approved to accept only construction and demolition debris. The landfills licensed to accept municipal solid waste and/or special wastes are secure landfills with leachate collection systems and treatment, thereby greatly reducing the risk of ground water contamination.

Septic Systems

29 out of 37 States as a potential source of ground water contamination cited septic systems. States based their decisions most heavily on three factors, including the location of septic systems relative to sources of drinking water, the large number of residential septic tank systems, and human health. These findings are consistent with previous 305(b) reporting cycles in which septic systems were consistently ranked among the top five sources of ground water contamination.

Septic systems include buried septic tanks with fluid distribution systems or leachfields. Septic systems are designed to release fluids or wastewater into constructed permeable leach beds, if present, and then to the shallow soil. Wastewater are then expected to be attacked by biological organisms in the soil and/or degraded by other natural processes over time. Ground water may be contaminated by releases from septic systems when the systems are poorly designed (tanks are installed in areas with inadequate soils or shallow depth to ground water); poorly constructed or sealed; are improperly used, located, or maintained; or are abandoned.

A variety of wastewaters are disposed of in septic systems and, as a consequence, a variety of different chemicals may be present in the system. States stressed that one of the more common uses is for disposal of domestic sewage and liquid household wastes. Typical contaminants from household septic systems include bacteria, nitrates, viruses, phosphates from detergents, and other chemicals that might originate from household cleaners.

Septic systems are generally found in rural areas of the states. For example, a large rural population characterizes Vermont. Due to the rural setting, homes and industries outside municipal service area lack access to sewers. Septic systems are now and probably will remain a significant nonpoint source of contamination with approximately 220 indirect discharge sites. These sites represent discharges to the subsurface of over 6,500 gallons of sewage per day. American households dispose of an estimated 3.5 billion gallons of liquid waste into these systems each day. Although the use of domestic septic systems is difficult to control, many States are initiating permitting processes. In addition, the local sale of products that pose a threat to ground water quality may be discouraged. Support of local collection programs may be encouraged through the increase in public awareness.

Although States most frequently cited domestic septic systems as a threat to ground water quality, similar systems are also used by commercial and industrial facilities to dispose of process wastewater. The most misused septic systems are those used by the automotive repair/service businesses that dispose of engine fluids, fuels, and cleaning solvents. As much as commercial sites into septic systems that have affected the drinking water of approximately 1.3 million Americans dispose of 4 million pounds of waste per year. The costs needed to clean up the contamination and supply new sources of drinking water have ranged from $30,000 to $3.8 million. States are currently enforcing waste management programs requiring businesses to properly dispose of their chemical waste.

State Overview of Contaminant Sources

For the first time in 1996, States were asked to provide information on the types and numbers of contaminant sources within a specified reporting area. Reporting contaminant source information for specific areas within States is new and not all States track this information in an easily accessible format. Of the States that do, 29 provided this information. The information is tabulated on a nationwide basis in

Requesting this type of information served two purposes. First, it was possible to determine what contaminant sources have the greatest potential to impact ground water quality based on the sheer number of such sites in a given area. Second, it was possible to determine how many of these sites actually impacted ground water quality.

As shown in Table 6-1, leaking USTs represent the highest number of potential sources. Over 100,000 leaking UST sites have been identified in 80 different areas of theUSA. Of these, over 17,000 have confirmed releases of ground water contamination. The next big category of potential contaminant sources is septic systems. States reported the presence of 10,656 sources in eight areas. Of these, 10,594 have confirmed releases. The next highest categories were State sites, with 2,614 confirmed ground water contamination incidents.

Table 6-1. Summary of Contaminant Source Type and Number

Source Type	Units for which Information was reported	Sites Reported Nationwide	Sites Listed and/or with Confirmed Releases Nationwide	Sites with confirmed ground water Contamination Nationwide
Leaking UST	80	100,921	40,363	17,827
UST Sites (no Releases found)	21	2,210	-----	-----
Septic Systems	8	10,656	10,594	----
State Sites	65	7,017	5,751	2,614
Underground Injection	49	5,006	1,077	911
CERCLIS (non-NPL)	54	2,399	1,332	645
RCRA Corrective Action	74	2,114	283	289
MN Dept of agriculture	1	600	164	50
DOD/DOE	77	404	234	166
Miscellaneous	55	229	905	514
Nonpoint Sources	17	171	190	62
NPL	63	167	250	204
Landfills	4	149	78	74
Wastewater Land Application	21	116	-----	24

Table 6-1. Summary of Contaminant Source Type and Number

Site Investigations Nationwide	Sites that are Stabilized or with Source Removed Nationwide	Sites with Corrective Action Plans Nationwide	Sites with Active Remediation Nationwide	Sites with Cleanup Completed Nationwide
22,362	9,367	6,143	6,301	19,379
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----	----	----	----	----
5,348	2,935	791	1,216	3,166
116	62	32	28	204
1,154	374	41	21	49
54	37	37	79	52
119	----	----	----	----
115	53	26	22	39
72	40	12	5	32
32	27	3	21	36
57	22	25	38	24
136	3	----	----	0
24	----	7	5	0

CERCLIS = Comprehensive Environmental Response, Compensation, and Liability Information System

DOD/DOE = Department of Defense/Department of Energy
MN = Minnesota
NPL = National Priority List (or Superfund)
RCRA = Resource Conservation and Recovery Act
UST = Underground Storage Tank — = Not available

Ground Water Assessments

For the first time in 1996, States were asked to report data for aquifers or hydrogeologic settings (e.g., watersheds) within the State. Reporting data for specific aquifers or hydrogeologic settings within States is new. EPA recognized that not every State would be able to report ground water data on an aquifer-specific basis. EPA also anticipated that there would be wide variation in reporting style.

Due to the diversity in reported data, evaluation of ground water quality on a national basis for 1996 is not possible at this time. However, the positive response from States showed they welcomed the changes made in 1996 and are developing and implementing plans to report more aquifer-specific information in the future.

Diversity of Reporting Units Thirty-three States reported data summarizing ground water quality. In total, data were reported for 162 specific aquifers and other hydrogeologic settings. States that were unable to report ground water quality data for specific aquifers assessed ground water quality using a number of different hydrogeologic settings or "reporting units," including statewide summaries, reporting by county, watershed, basin, and sites or areas chosen for specific reasons such as potential vulnerability to contamination. An overview of the States that were able to provide ground water quality data for specific or "differentiated hydrogeologic units" within the State. A brief description of several ground water assessment methods and their rationale follows.

Florida – Very Intense Study Area

Florida's Very Intense Study Area (VISA) Network, consisting of about 450 wells, began operating in 1990. The VISA Network monitors the effects of various land uses on ground water quality in specific aquifers in selected areas. The major land uses represented are intensive agriculture, mixed urban/suburban, industrial, and low impact. The VISAs were chosen based on their relative susceptibility to contamination. Currently, Florida has data on 23 VISAs and is in the process of analyzing the results of the first two rounds of sampling.

Wells in the VISA and Florida's background networks are sampled in the same year for various water chemistry indicators and groups of contaminants. By comparing VISA and background results in the same aquifer system, lists of contaminants commonly associated with different kinds of land use can be developed. This process helps Florida to plan for and regulate land uses that are a threat to ground water quality.

For the 1996 report, Florida chose to present information for the North Lake Apopka VISA, which consists of 36 square miles in the Lake Apopka Basin. The vulnerability to contamination of the surficial and Floridian aquifers and Lake Apopka was an important consideration in choosing the study area. Because land use in the Lake Apopka Basin is over 50% agricultural, this VISA helps Florida evaluate the impacts of intensive agricultural growing, processing, and packing on ground water quality.

Arkansas – Ambient Ground Water Monitoring Program

The Arkansas Department of Pollution Control and Ecology initiated an Ambient Ground Water Monitoring Program in 1986 in order to gather background, groundwater quality data from various aquifers in the State. Samples are collected every 3 years and analyzed for general water quality indicators, including metals, petroleum hydrocarbons, and pesticides. Three rounds of sampling and analysis have been completed in some areas since inception of this program.

For 1996, Arkansas presented information for the nine currently active monitoring areas. The areas are in different counties covering the diverse geologic, hydrologic, and economic regimes within the State. Each area was chosen for a particular reason and with particular objectives in mind. For example, one area is characterized by the largest community using ground water to meet all of its needs and one objective of the monitoring program is to monitor water quality within an area of the underlying aquifer that is affected by public and commercial well use.

Wyoming – County Summary

In 1992, the Wyoming Department of Environmental Quality, Water Resources Center and the State Engineer's Office implemented a prioritized approach for assessing aquifer sensitivity and ground water vulnerability at the county level on a statewide basis. Goshen County was selected as a pilot project area based on (1) the existence of recent studies and reports on ground water quality and aquifer characteristics; (2) Federal, State, and local interest in ground water and wellhead protection programs; and (3) the amount of related data and information available to complete sensitivity and vulnerability maps. Goshen County also ranked fourth out of 23 counties in overall vulnerability to contamination from pesticides. For 1996, Wyoming focused ground water assessment on the North Platte River alluvial aquifer located in Goshen County.

Indiana – Hydrogeologic Setting

To avoid the evaluation of ground water quality data across similar political boundaries, Indiana developed a system that allows data to be analyzed according to similar surface and subsurface environments. This was achieved by first producing a document that describes all the hydrogeologic settings found in Indiana. These hydrogeologic settings provide a conceptual model to interpret the sensitivity to contamination of ground water in relation to the surface and subsurface environments. For ground water quality data for 1996, the State of Indiana selected five hydrogeologic settings considered to be highly vulnerable to contamination (i.e., principally outwash deposits or fans of glacial origin) and occurring in largely populated areas (i.e., areas of greatest water demand).

Idaho – Hydrogeologic Subareas

The State of Idaho is divided into 22 hydrogeologic subareas, for Statewide monitoring purposes. These subareas represent geologically similar areas and generally encompass one or more of the 70 major ground water flow systems identified within the State. Each flow system includes at least one major aquifer, with some systems being comprised of several aquifers that may be interconnected.

Idaho reported ground water quality data for 20 of the 22 hydrogeologic subareas. Subareas 21 and 22 were not included in 1996 because few people use the ground water in these subareas and the aquifer systems are isolated from other major aquifers.

Arizona – Watershed Zone

Arizona presented ground water quality data for all 10 "watershed zones" within the State. The watershed zones are delineated along USGS Hydrologic Unit boundaries and correspond to the State's 13 surface water basins. A few surface water basins were combined and one was split to form the 10 watershed zones.

Each watershed zone is characterized in terms of several features, including size, population base, hydrologic provinces, ecoregions, ground water basins, hydrology, and geology. Investigations of potential ground water contamination problems have led to site remediation efforts through various State and Federal programs.

Alabama – Tuscumbia Fort Payne Aquifer

Alabama provided ground water quality data for the Tuscumbia Fort Payne Aquifer outcrop area located in northern Alabama adjacent to the Tennessee River. The Tuscumbia Limestone and the Fort Payne Chert geologic formations underlie this area. It is considered a unique karst area that is highly susceptible to contamination from surface sources. Surface and ground water interaction is rapid due to recharge through sinkholes and other karst features. Because the area is heavily farmed and pesticides associated with farming are used, the Alabama Department of Environmental Management has accumulated ground water monitoring data for this area.

Texas – Trinity and Dockum Aquifers, Rio Grande Alluvium, and Laredo Formation.

Ambient ground water quality monitoring is conducted continuously and extensively throughout the State of Texas. Therefore, boundaries and various characteristics of all the State's major and minor aquifers have been identified, including water availability, recharge, and geologic formation. In addition, major entities using ground water have been identified within each river basin, the aquifer(s) used, the quality of water being developed, and the quantity of water needed for a 50-year planning period.

For 1996, Texas selected the Trinity and Dockum Aquifers, Rio Grande Alluvium, and Laredo Formation for assessment. These selections represent one major, one minor, and two undifferentiated/local aquifers, respectively. The main selection criterion was to select a range of recently monitored aquifers and to develop an initial methodology for the assessment of the aquifers. The refinement of the assessment methodology for subsequent 305(b) reporting cycles is of primary importance.

Extent of Coverage States were encouraged to report ground water data for selected aquifers or hydrogeologic settings as part of the 1996 305(b) reporting cycle. EPA recognized that this was not always plausible and consequently, recommended that State ground water resources be assessed incrementally over time.

The extent of State coverage will increase as individual States develop and implement plans to assess ground water quality on an aquifer-specific basis. Greater quantities of ground water monitoring data will also become available as States complete source water delineation and source inventory/susceptibility analyses for public water supplies under the Source Water Assessment Program.

Ground Water Quality Data Sources

EPA recognizes that data collection and organization varies among the States, and that a single data source for assessing ground water quality does not exist for purposes of the 1996 Report to Congress. As a consequence, EPA suggested several types of data that could be used for assessment purposes (e.g., ambient ground water monitoring data, untreated water from private or unregulated wells, untreated water from public water supply wells, and special studies). States were encouraged to use available data that they believe best reflects the quality of the resource. Depending upon data availability and the judgment of the State ground water professionals, one or multiple sources of data were used in the assessments. The majority of the States opted to use multiple sources of data.

Finished water quality data from public water supply systems were the most frequently used source of data. Ambient monitoring networks and untreated water quality data from private and unregulated wells were the next frequently used sources of data.

States used a variety of data sources to report on ground water quality. Although there was a strong reliance on finished water quality data from public water supply systems, these data were frequently reported in conjunction with other sources of data to provide a more meaningful assessment of ground water quality than was possible in previous reporting cycles

Ground Water Quality Data

Ground water quality data reported by States in 1996 represent different sources, often with different monitoring purposes. Therefore, national comparisons are not appropriate. Rather, ground water quality assessments are performed using comparable data groupings. Data most closely approximating actual ground water quality conditions (e.g., untreated ground water) are given special consideration in these assessments. Specifically, this report focuses on nitrate, VOCs, SVOCs, pesticides, bacteria, and metals. These parameter groups/constituents were selected, as they are indicative of ground water degradation because of human

Nitrate

States reported data for nitrate more frequently than for any other parameter or parameter group. It was the second most frequently cited ground water contaminant after petroleum compounds. Twelve States specifically referenced nitrate as a widespread and significant cause of ground water contamination in their 1996 State Water Quality Reports.

The focus on nitrate as a ground water contaminant is justified. It is soluble in water, and consequently, is easily transported from the soil surface to the underlying ground water resource. Extensive application of nitrate in fertilizer to agricultural lands, residential lawns, and golf courses has resulted in widespread degradation of ground water resources. The misuse of septic systems and improper disposal of domestic wastewater and sludge have also caused ground water contamination. At exposures greater than 10 milligrams per liter, its presence in water can lead to methemoglobinemia or "blue-baby syndrome" (an inability to fix oxygen in the blood). It is also an environmental concern as a potential source of nutrient enrichment in coastal waters.

Table 6-3 presents ground water quality information for nitrate. As shown, 15 States reported nitrate data for ambient monitoring networks. Nitrate was measured at concentrations exceeding the MCL of 10 milligrams per liter in 8 of the 15 States for a total of 26 units and 267 wells impacted by nitrate. Thus, approximately 50% of the reporting States indicated elevated levels of nitrate in ground water collected from ambient monitoring networks. This percentage is even higher for States reporting data for untreated water from PWS and from private/ unregulated wells (i.e., nitrate levels exceeding the MCL were reported by five out of seven States for untreated water from PWS and by nine out of ten States for untreated water from private/ unregulated wells) (Table 6-3).

VOC/SVOCs/Pesticides

States cited VOCs and SVOCs (including pesticides) as among the top five contaminants of concern. This is not unexpected Given that the number of identified man-made organic compounds totaled near 2 million in 1977 and was believed to be growing at a rate of about 250,000 new formulations annually.

Organic compounds can be released to the environment through a number of different avenues. Generally, organic compounds are released to ground water via pesticide applications, disposal practices, and spills. As reported in their 1996 State Water Quality Reports, disposal practices generated the most concern among States. Disposal practices that were cited as having the potential to adversely impact ground water quality included landfills, hazardous waste sites, surface impoundment, and shallow injection wells.

The organic compounds that pose the greatest threat to ground water quality are those that are relatively soluble, not easily converted to the vapor state, and not subject to chemical or biological degradation. Their presence in ground water is becoming increasingly pervasive and a cause for national concern due to the carcinogenic effects of many of the organic compounds.

Tables 6-4 through 6-6 present data related to VOCs, SVOCs, and pesticides. As shown, more States reported information for VOCs than for either SVOCs or pesticides. This is consistent with the fact that VOCs are the most frequently detected class of organic priority pollutants and they are the most frequently detected individual compounds affecting ground water quality at RCRA and CERCLA sites.

Based on the information presented in Tables 6-4 through 6-6, it appears that ground water contamination by VOCs is indeed more prevalent than either SVOCs or pesticides. Seventy percent of the reporting States (i.e., 7 out of 10 States) indicated that VOCs were measured at levels exceeding MCL values in ground water collected from ambient monitoring networks as opposed to 43% (3 out of 7 States) for SVOCs and 25% (2 out of 8 States) for pesticides. Furthermore, VOCs were measured at levels exceeding MCL values in a total of 16 units and 30 wells. Again, this can be compared to SVOCs impacting three units and five wells and pesticides impacting two units and five wells.

As was noted with nitrates, elevated levels of VOCs were found more frequently in untreated ground water collected from PWS and private/unregulated wells. Although VOCs were measured at levels exceeding MCL levels in ground water collected from PWS and private/unregulated wells in only five and two States, respectively, a total of 77 and 96 wells were impacted (**Table 6-4**). The same pattern was not observed for SVOCs (**Table 6-5**). Although elevated levels of pesticide were measured in untreated ground water collected from private/unregulated wells, these data include one area known to have been heavily contaminated by pesticide usage (**Table 6-6**).

Metals

States identified metals as the fourth highest contaminant of concern with respect to ground water degradation. The **Table 6-7** shows that metals comprise a broad category of individual constituents that may be present in ground water singularly or in combination, depending on the contaminant source. Although normal background ground water conditions may be characterized by elevated metal concentrations in some parts of thestates (e.g., southwestern United States), metals are generally considered an indicator of ground water contamination resulting from human activities.

Metals are present in numerous commercial and industrial processes and waste streams. Depending on handling and disposal practices, metals can be released to the environment and can affect ground water quality. Because metals are not easily broken down, they tend to be Persistent and can affect ground water quality for long periods.

Ground water contamination by metals most frequently occurs as a result of improper operation and/or inappropriate design of landfills, disposal of liquid or solid mining wastes or tailings, or ineffective containment of nuclear wastes. States cited landfills, hazardous waste sites, surface impoundment, shallow injection wells, land application, industrial facilities, and mining as prime sources of metal contamination in ground water.

Table 6-7 presents the information reported by States for metals. Metals were most frequently tested and detected in ground water collected from ambient monitoring networks. Eleven States reported metal data for ambient monitoring networks. Metals were measured at concentrations exceeding MCL values in 7 of the 11 States for a total of 33 units and 195 wells impacted by metal contamination. Thus, approximately 65% of the reporting States indicated elevated levels of metals in ground water collected from ambient monitoring networks.

Metals were less frequently tested in ground water collected from either PWS or private/unregulated wells. Still, a total of 100 wells were found to exceed MCL values for metals in untreated ground water collected from PWS wells.

Bacteria

The sixth most common ground water contaminant cited in the 1996 State Water Quality Reports was bacteria. One of the most common sources of bacteria in ground water is septic system. Other important sources include landfills, animal feedlots, surface impoundment, and pipelines and sewers.

High concentrations of disease-causing bacteria in ground water may be a source of human health problems. The most common diseases spread by these pathogenic bacteria are related to the consumption of contaminated drinking water (e.g., gastroenteritis, campylobacteriosis, and hepatitis).

For purposes of their 1996 State Water Quality Reports, States focused less on bacteria than on other contaminant groupings. Still, one out of the three States reporting data on bacteria indicated levels that exceeded MCL values. As shown in **Table 6-8**, bacteria in 10 ambient monitoring wells impacted ground water. In a special study conducted in the Boise River Valley by the State of Idaho, total coliform bacteria were detected at levels exceeding MCL values in 95 out of 720 samples.

Assessing the quality of the USA's ground water resources is no easy task. An accurate and representative assessment of ambient ground water conditions ideally requires a well planned and well executed monitoring plan. Such plans are expensive and may not be compatible with State administrative, technical, and programmatic initiatives. As a consequence, EPA and interested States developed guidelines for the assessment of ground water quality that took into account the complex spatial variations in aquifer systems, the differing levels of sophistication among State programs, and the expense of collecting ambient ground water monitoring data. The newly developed guidelines incorporated the flexibility necessary to accommodate differences in State programs.

State response to the new guidelines was excellent. Thirty-three States reported ground water quality data for 162 aquifers and other hydrogeologic settings. From this response, it was evident that States welcomed the changes made in 1996. It was also evident that the flexibility purposely incorporated into the 1996 Ground Water assessment Guidelines expended diversity in reported data. This diversity presented a challenge in assessing ground water quality. Some of the more challenging aspects were highlighted in this report. Following are changes that are expected to occur over time to improve our picture of ground water quality:

State reporting styles varied significantly in 1996. Although this variability was expected, final data interpretation was challenging because data compilations required the use of a single defined data structure. When State data did not exactly conform to this structure, some interpretation on the part of EPA was necessary.

As the direction and focus of groundwater assessments becomes clearer, State response will grow and more accurate characterization of groundwater quality will be possible.

Because ground water monitoring is expensive, few States have access to ambient ground water quality data. EPA suggested a number of data sources that could be used in the absence of ambient ground water monitoring data. Although finished water quality data from PWS were one of those sources, these data do not provide the most accurate representation of ground water quality. As States continue to develop new sources of ground water data, the reliance on finished water quality data will decrease. Furthermore, it is expected that the variability in data sources and types will decrease as States continue program development.

Pumping polluted groundwater to the surface, cleaning it up, and returning it to the aquifer is usually prohibitively expensive - $5-10 million or more for a single aquifer. Recent attempts to pump and treat contaminated aquifers indicate that it may take 50-1000 years of continuous pumping before all of the contamination is forced to the surface and drinking-water quality is achieved. Thus preventing contamination by various means is considered the only effective protection for groundwater resources. Ways to do this include the following:

- Monitoring aquifers near landfills and underground tanks.
- Requiring leak detection systems for existing and new underground tanks used to store hazardous liquids.
- Requiring liability insurance for old and new underground tanks used to store hazardous liquids
- Banning or more strictly regulating disposal of hazardous wastes in deep injection wells and in landfills.

Storing hazardous liquids above ground in tanks with systems for detecting and collecting any leaks.

7- Preventing and reducing surface-water pollution.

Nonpoint sources of pollution.

The leading nonpoint source of water pollution is agriculture. Farmers can sharply reduce fertilizer runoff into surface waters and leaching into aquifers by using only moderate amounts of fertilizer – and by using none at all steeply sloped land. They can use slow-release fertilizers and alternate their planting between row crops and soybeans or other nitrogen-fixing plants to reduce the need for fertilizers. Farmers can also be required to plant buffer zones of permanent vegetation between cultivated fields and nearby surface water.

Applying pesticides only when needed can reduce pesticide runoff and leaching. Farmers can also reduce the need for pesticides by using biological control or integrated pest management. Non-farm uses of inorganic fertilizers and pesticides – on golf courses, lawns, and public lands, for example – could also be sharply reduced and replaced with organic methods.

Livestock growers can control runoff and infiltration of manure from feedlots and barnyards by managing animal density, by planting buffers, and by not locating feedlots on steeply sloping land near surface water. Diverting the runoff into detention basins would allow the nutrient-rich water to be pumped out and applied as fertilizer to cropland or forestland.

The 1990 Farm Bill encourages farmers to voluntarily participate in programs that reduce use of pesticides, fertilizers, and control agricultural runoff. However, the financial incentives for these programs are much lower than those of other U.S. department of Agriculture programs that encourage land exploitation and intensive use of pesticides and fertilizers to promote high yields.

Another way to reduce nonpoint water pollution, especially from eroded soil, is to reforest critical watersheds. Besides reducing water pollution from sediments, reforestation would reduce oil erosion and the severity of flooding, it would also help slow projected global warming and loss of wildlife habitat.

Point source pollution: the legal approach.

In many LDCs and in some MDCs, sewage and waterborne industrial wastes are discharged without treatment into the nearest waterway or into wastewater lagoons. In Latin America, less than 2% of urban sewage is treated. Only 15% of the urban wastewater in China receive treatment, and treatment facilities in India protect water quality for less than a third of the urban population.

In MCDs, most wastes from point sources are purified to varying degrees. The Federal Water Pollution Control Act of 1972 – renamed the Clean Water act when it was amended in 1977 – and the 1987 water quality Act from the basis of U.S. efforts to control pollution of the country's surface waters. The main goals of the Clean Water Act were to make all U.S. surface waters safe for fishing and swimming by 1983, and to restore and maintain the chemical, physical and biological integrity of the nation's waters. Progress has been made, but these goals have not been met.

Between 1972 and 1993, U.S. taxpayers and the private sector spent more than $575 billion on water pollution control – nearly all of it on end-of-pipe controls on municipal and industrial discharges from point sources, as mandated by these laws. These acts require the EPA to establish national effluent standards and to set up a nationwide system for monitoring water quality. The effluent standards limit the amounts of certain conventional and toxic water pollutants that can be discharged into surface waters from factories, sewage treatment plants, and other point sources. Each point-source discharge must get a permit specifying the amount of each pollutant that a facility can liberate.

However, a 1993 study found that about 18% of the 7000 major U.S. industries have found it cheaper to pay repeated fines for violating their permits (by dumping wastes into waterways) than to eliminate such pollution.

The original 1972 act emphasized pollution prevention. It forbade the discharge of any toxic pollutants into U.S. surface waters by 1985 – a requirement that has not been enforced. Another requirement of the 1972 act was that then-clean surface waters in the United States be kept clean. Protecting existing clean waters from pollution was left up already-polluted waters, money-short state governments have not implemented this requirement.

The 1972 act also requires states to develop and execute plans to control nonpoint pollution – something that largely has not been done. It also established a federal wetlands protection program that has been partially successful.

Most environmentalists believe that the original goals of the 1972 Clean water act – requiring pollution prevention and protecting existing clean waters from pollution – are sound. The problem is that we need to be more conscientious about implementing these requirements. They agree that doing this will be costly, but they point out that not doing it will be much costlier in the long run.

Despite significant progress, a 1994 report by the EPA revealed a number of problems. Antiquated sewage systems in 1100 cities still dump poorly treated sewage into streams, lakes and coastal waters. Between 1995 and 2015, aging municipal water and sewer systems will need $400-500 billion to comply with existing federal clean water regulations.

In 1992, 44% of lakes, 37% of rivers and 32% of estuaries in the USA that were tested were unsafe for fishing, swimming, and other recreational uses. Fish caught in more than 1400 different waterways are unsafe to eat because of high levels of pesticides and other toxic substances.

Environmentalists call for the Clean Water Act to be strengthened

1- Increasing funding and the authority to control nonpoint sources of pollution
2- Strengthening programs to prevent and control toxic water pollution, including phasing out use of certain toxic discharges.
3- Providing more funding and authority from watershed planning
4- Expanding the ability of citizens to bring lawsuits to ensure that water pollution laws are enforced.

Industries, some state, and local officials oppose these proposals, contending that they are too costly.

Point source pollution: the technological approach.

In rural and suburban areas with suitable soils, sewage from each house is usually discharged into a *septic tank*. About 25% of all homes in the United states are served by septic tanks, which must be cleaned out every 3 to 5 years by a reputable contractor so that they won't contribute to groundwater pollution.

In urban areas, most waterborne wastes from homes, businesses, factories, and storm runoff flow through a network of sewer pipes to wastewater treatment plants. Some cities have separate lines for storm water runoff, but in 1200 US cities the line for these 2 systems are cOombined because it is cheaper. When rains cause combined sewer systems to overflow, they discharge untreated sewage directly into surface waters.

When sewage reaches a treatment plant, it can undergo up to 3 levels of purification, depending on the type of plant and the degree of purity desired. *Primary sewage treatment* is a mechanical process that uses screens to filter out debris such as sticks, stones, and rags; suspended solids settle out as sludge in a settling tank. Improved primary treatment uses chemically treated polymers to remove suspended solids more thoroughly.

Secondary sewage treatment is a biological process in which aerobic bacteria are used to remove up to 90% of biodegradable, oxygen-demanding organic wastes. Some plant use trickling filter,s, in which aerobic bacteria degrade sewage as it seeps through a bed crushed stones covered with bacteria and protozoa. Others use an activated sludge process, in which the sewage is pumped into a large tank and mixed for several hours with bacteria-rich sludge and air bubbles to facilitate degradation by microorganisms. The water then goes to a sedimentation tank, where most of the suspended solids and microorganisms settle out as sludge. The sludge produced from primary or secondary treatment is broken down in an anaerobic digester and either incinerated, dumped in the ocean or a landfill, or applied to land as fertilizer.

Even after secondary treatment, however, wastewater still contains about 3-5% by weight of the oxygen-demanding wastes, 3% of the suspended solids, 50% of the nitrogen (mostly as nitrates), 70% of the phosphorus (mostly as phosphates), and 30% of the most toxic metal compounds and synthetic organic chemicals. Virtually none of any long-lived radioactive isotopes or persistent organic substances such as pesticides is removed.

As a result of the Clean Water act, most U.S. cities have secondary sewage treatment plants. In 1989, however, the EPA found that more than 66% of sewage treatment plants have either water quality or public health problems; and studies by the General Accounting Office have shown that most industries have violated regulations. Moreover, 500 cities have failed to meet federal standards for sewage treatment plants, and 34 East Coast cities simply screen out large floating objects from their sewage before discharging it into coastal waters.

Advanced sewage treatment is a series of specialized chemical and physical processes that remove specific pollutants left in water after primary and secondary treatment. Types of advanced treatment vary according to the specific contaminants to be removed. Without advanced treatment, sewage treatment plant effluents contain enough nitrates and phosphates to contribute to accelerate eutrophication of lakes, slow-moving streams and coastal waters. Advanced treatment is rarely used because such plants typically cost twice as much to build and 4 times as much to operate as secondary plants. However, despite the cost, advanced treatment is used for more than a third of the population in Finland, the former West Germany, Switzerland and Sweden and to a lesser degree in Denmark and Norway.

Before water is discharged after primary, secondary or advanced treatment, it is bleached to remove water coloration and disinfected to kill disease-carrying bacteria and some viruses. The usual method for doing this is chlorination. However, chlorine can react with organic materials in water to form small amounts of chlorinated hydrocarbons. Some of which cause cancers in test animals. Indeed, some preliminary research in 1992 suggested that chlorinated drinking water might cause 7-10% of all cancers in the United States. Disinfectants such as ozone and ultraviolet light are being used in some places, but they cost more than chlorination.

Some communities and individuals are seeking better ways to purify contaminated water by working with nature. In 1993, William Jewell and his colleagues at Cornell university tested a system using only bacteria and plants that cleans sewage better than current secondary treatment systems. Sewage first passes through a slurry of suspended bacteria, which convert organic matter to carbon dioxide and methane. The remaining waste is removed as water flows over the roots of plants, such as cattails, wild irises and roses, grown hydroponically (with chemicals not soil). Such a treatment system is modular and can be expanded as needed.

Protecting drinking water.

Treatment of water for drinking by urban residents is much like wastewater treatment, areas that depend on surface water usually store it in a reservoir for several days to improve clarity and taste by allowing the dissolved oxygen content to increase and suspended matter to settle out. The water is then pumped to a purification plant, where it is treated to meet government drinking water standards. Usually the water is run through sand filters and activated charcoal before it is disinfected. In areas with very pure sources of groundwater, little, if any, treatment is necessary.

Only about 54 countries, most of them in North America and Europe have safe drinking water standards. The safe Drinking water act of 1974 requires the EPA to establish national drinking water standard called *Maximum contaminant levels*, for any pollutants that may have adverse effects in human health. This act has helped improve drinking water in much of the United States, but attempts to weaken this law continue. At least 700 potential pollutants have been found in municipal drinking water supplies. Of the pollutants that have been tested, 97 cause cancers, 82 cause mutations, 28 are toxic and 23 promote tumors on test animals.

Privately owned wells in suburban and rural areas are not required to meet federal drinking water standards, primarily because of the costs of testing each well regularly and ideological opposition to mandatory testing and compliance by some homeowners.

According to a 1994 report by the Natural Resources Defense Council, in 1992 the drinking water of 50 million people violated one or more EPA pollutant standards. The study also found that nearly half of the 58000 systems providing drinking water in the United States reported violations of one or more pollution standards during 1992. In most cases, people were notified when their drinking water was contaminated. This and earlier studies suggest that dirty drinking water is responsible for an estimated 1 million illnesses and 900 deaths per year in the United States. A recent study by the American water works association also found that 64% of current U.S drinking-water-treatment plants use obsolete contaminant-removal techniques.

According to the Natural Resources Defense Council, drinking water supplies in the United States could be made safer at a cost of only about $25 a year per household. Currently, more money is spent on military bands each year than on the EPA's enforcement of the Safe Drinking Water act.

One might expect that such information would lead to public pressure to upgrade drinking water in the United States. Instead, Congress is being pressured by industry to weaken the Safe Drinking Water Act by:

1- Eliminating national tests of drinking water
2- Eliminating the requirement that the media be advised of emergency water health violations and that water system officials notify their customers of such violations
3- Allowing states to give drinking water systems a permanent right to violate the standard for a given contaminant if the provider claims it can't afford to comply
4- Eliminating the requirement that water systems use affordable, feasible technology to remove cancer-causing contaminants.

Bottled water and home purification systems.

Contaminated wells and concern about possible contamination of public drinking water supplies have stimulated many U.S citizens to drink bottled water at costs about 1,500 times more than that of tap water, or to add water purification devices to their home systems. Studies indicate that many bottled water drinkers are being ripped off by the $2,7 billion-a-year bottled water industry. More than ¼ of the 7000 domestic brands of bottled water comes from the same sources used to supply tap water, which is regulated much more strictly than bottled water.

To be safe, consumers should purchase bottled water only from companies that have their water frequently tested and certified, ideally by EPA-certified laboratories. Before buying bottled water, consumers should determine whether the bottler belongs to the International Bottled Water association (IBWA) and adheres to its testing requirements. The IBWA requires its members to test for 181 contaminants, and annually it sends an inspector to bottling plants to check all pertinent records and ensure that the plant is run cleanly. Some companies pay $2500 annually to obtain more stringent certification by the National Sanitation Foundation, an independent agency that tests for 200 chemical and biological contaminants.

U.S. consumers now spend about $1 billion a year on the following home water purification devices, each with certain advantages and disadvantages.

- *Activated carbon filters* ($200-2500). This process removes most synthetic organic chemicals, chlorine, and radon if the filter is changed regularly; however, it does not remove bacteria, viruses, nitrates and other dissolved salts, and toxic metals such s lead and mercury. Unless the filter is changed regularly and kept scrupulously clean, it can serve as a breeding ground for disease-causing bacteria.
- *Reverse-osmosis* ($600-1000). This process removes most particulate and dissolved solids and some volatile synthetic organic chemicals; however, it does not remove radon, arsenic, chloroform and phenol. Some models do not do well in removing bacteria and viruses; filters must be changed regularly. Calcium must be removed by a water softener, and water must have a pH below 8. In addition, this process wastes 15 liters of water for each 4 liters it produces.

- *Distillation* ($200-700). This process removes toxic metals, radioactive contamination, and non-volatile organic compounds and it kills bacteria. However, it does not remove volatile organic chemicals or radon, it is expensive to operate and uses lots of energy, it produces flat-tasting water, and it is a slow process with low output. Moreover, the equipment must be cleaned and serviced regularly.
- *Ultraviolet light*. UV light kills most bacteria and some viruses, but does not remove other pollutants.
- *Water softener* ($1000). These removes dissolved minerals and prevent scales in water pipes and equipment, but they do not remove bacteria viruses and most toxic substances.

Machines that combine several approaches can remove most pollutants at a cost of at least $100 per year. Before buying expensive purifiers, health officials suggest that consumers have their water tested by local health authorities or private labs to identify what contaminants, if any, must be removed, and then they should be sure to buy a unit that does the required job.

Buyers should be suspicious of door-to-door salespeople, telephone appeals, scare tactics, and companies offering free water tests (which often are neither accurate nor carried out by certified labs). They should carefully check out companies selling such equipment and demand a copy of purifying claims by EPA- certified laboratories. Buyers should also be wary of claims that the EPA has approved a treatment device. Although the EPA does register such devices, it neither tests nor approves them.

Sustainable use of water resources.

Using Earth's water resources sustainably involves developing an integrated approach to managing water resources and water pollution throughout each watershed. Once we stop overloading aquatic systems with pollutants, they recover amazingly fast.

Environmentalists believe that doing this requires that we shift our emphasis from pollution cleanup to pollution prevention. This involves:

1- Source reduction to reduce the toxicity or volume of pollutants (for example, replacing organic solvent-based inks and paints with water-based materials).
2- Reuse of wastewater instead of discharging it (for example, reusing treated wastewater for irrigation).
3- Recycling pollutants (for example, cleaning up and recycling contaminated solvents for reuse) instead of discharging them.

To make such a shift we must accept that the environment – air, water, soil, life – is an interconnected whole. Without an integrated approach to all forms of pollution, we will continue to shift environmental problems from one part of the environment to another.

CURRENT SITUATION

Lebanon, different from neighboring countries, does not suffer from lack of natural waters. Nevertheless, a good administration and allocation of the hydraulic resources are necessary conditions for preserving this blessing.

Lebanon's Mediterranean climate receives in average 9,400 millions of cubic meters per year in the form of rain. Only 2,500 millions are available on the surface, the rest is lost either by evaporation, by infiltration or by flow to neighboring countries. The underground exploitable water is estimated in 400 million of cubic meters.

There are 19 water offices and 209 committees responsible for the administration and allocation of waters in Lebanon. They are under the direction of the Ministry of Energy and Hydraulic Resources. The performance of the Ministry have been handicapped by the lack of foreseen budget funds ant the weakening of human potential. (out of 502 available administrative posts, 257 are vacant)

The 18 treatment stations have suffer damages and are currently working at a very weak level. Chlorine machines are badly maintained due to the lack of technical personnel and funds. Out of 120 available units only 12 work satisfactorily. Water charges are relatively weak and they only cover the production costs partially.

Qualitative water studies have revealed that 80% of the collected samples are polluted. In fact, the water resources are not protected adequately and the distribution networks are infiltrated by the wastewater adding to the pollution of subterranean waters mostly due to over exploitation of quarries and badly designed septic tanks. The table below show the evolution of main data in the water sector during the past 10 years.

REGION	NUMBER OF RESERVOIR	CAPACITY Cubic Meters
ACHRAFIEH	8	28,500
TALLET EL-KHAYAT	2	32,250
MECHREF	1	100
DAMOUR	1	500
NAAMEH	5	11,000
TOTAL:	17	72,350

DISTRIBUTION NETWORK

Potable water distribution to citizens is performed by water offices as mentioned above. They use water counters to measure daily consumption and administer supply.

Distribution from wells depends on EDL capacity to ascertain electric power, with the exception of some wells equipped with electric generators.

Public reservoirs capacity in Beirut and suburbs is 86,750 cubic meters. They are used to feed the subscribers.

The table below shows the reservoir current capacity distribution in Beirut.

OFFICE	POPULATION (X 000)	ORIGIN		AVAILABLE QTY.	
		CURRENT WATER	WELLS	SUMMER	WINTER
BEYROUTH	1.300	3	47	207.700	307.700
AIN EL DELBE	600	2	22	100.600	118.600
KOBEYAT	46	5	5	8.853	8.653
TRIPOLI	625	23	35	72.450	73.800
NABAA EL KADI	102	52	30	13.522	20.622
NABAA EL GHAR	73	5	24	16.965	19.090
BATROUN	51	4	3	16.000	65.800
JBEIL	75	7	5	24.150	47.100
BECHARRE	92	30	9	11.806	12.625
KESROUAN	317	6	3	43.700	45.800
METN	168	6		35.600	38.000
BAROUK	275	14	41	49.880	49.980
SAIDA	140	2	8	34.400	49.900
NABAA EL TASSET	245	22	44	38.125	44.625
TYR	182	3	35	58.770	58.650
JABAL AMEL	173	3	5	18.320	21.020
BAALBECK-HERMEL	350	23	28	20.920	25.750
ZAHLE	250	24	7	35.035	65.465
CHEMSSINE	140	9	9	19.380	49.360
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

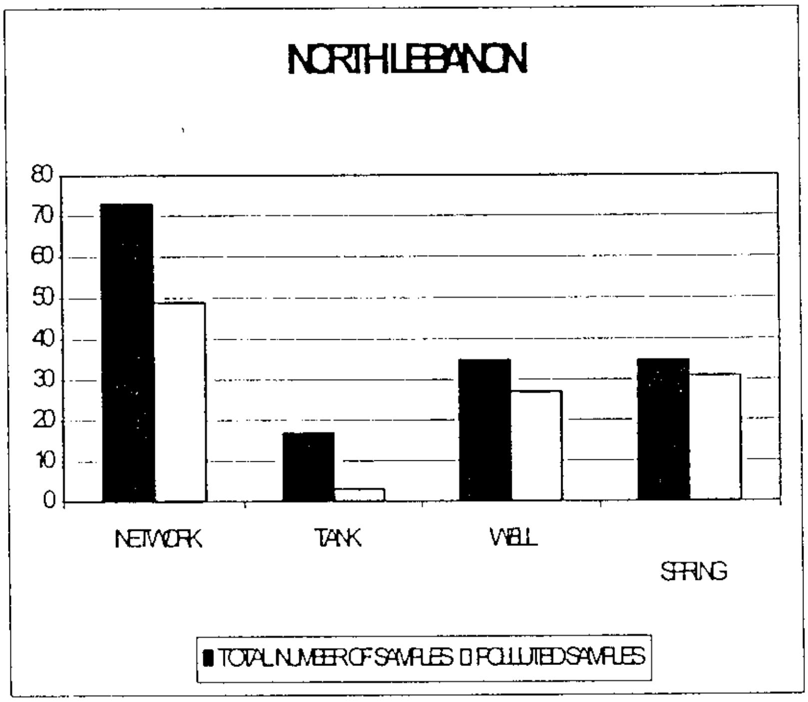
The main water pumping sources and the available capacities are indicated in the table next page.

NORTH LEBANON SAMPLE RESULTS

	NETWORK	TANK	WELL	SPRING
TOTAL NUMBER OF SAMPLES	73	17	35	35
POLLUTED SAMPLES	49	3	27	31
PERCENT POLLUTED	67	18	77	89
NUMBER POLLUTED BY E.COLI	41	2	24	27
PERCENT POLLUTED	56	12	69	77
AVERAGE E.COLI COUNT	48	18	54	61
NUMBER POLLUTED BY COLIFORM	48	3	27	31
PERCENT POLLUTED	66	18	77	89
AVERAGE COLIFORM COUNT	101	35	113	99

SAMPLING RESULTS

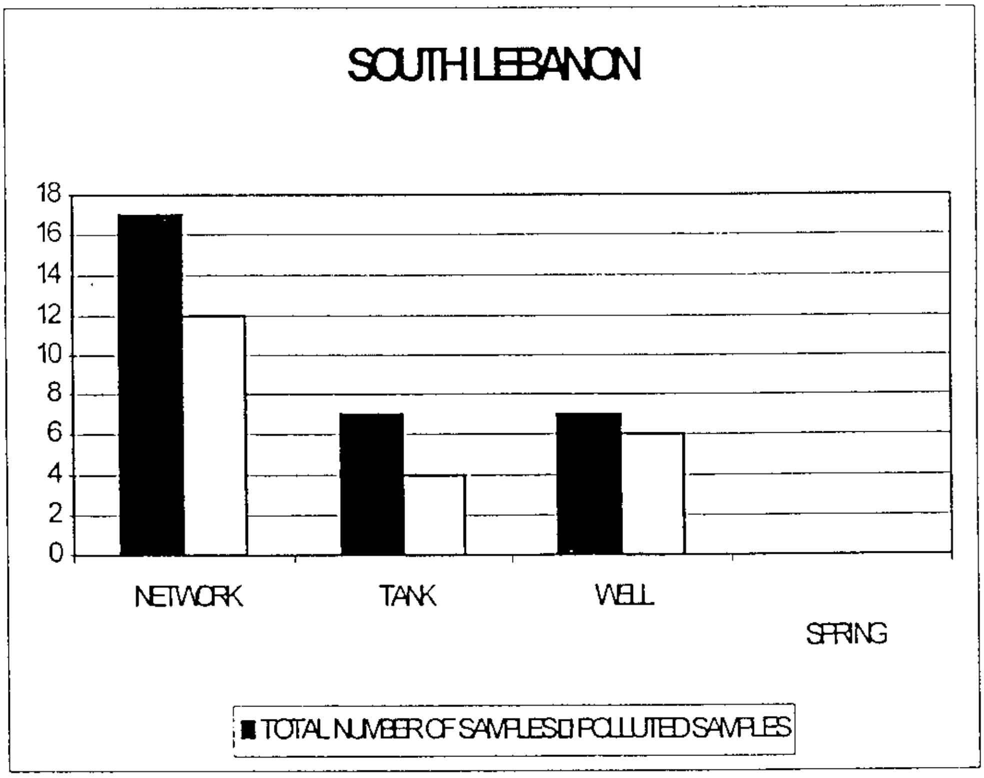
The following table show the sampling results for North Lebanon, including networks available, tanks, wells, and springs. Next page shows it in a graphs for understanding purposes.



SOUTH LEBANON SAMPLE RESULTS

	NETWORK	TANK	WELL	SPRING
TOTAL NUMBER OF SAMPLES	17	7	7	0
POLLUTED SAMPLES	12	4	6	0
PERCENT POLLUTED	71	57	86	0
NUMBER POLLUTED BY E.COLI	11	4	6	0
PERCENT POLLUTED	65	57	86	0
AVERAGE E.COLI COUNT	12	86	100	0
NUMBER POLLUTED BY COLIFORM	12	5	6	0
PERCENT POLLUTED	71	35	86	0
AVERAGE COLIFORM COUNT	65	116	154	0

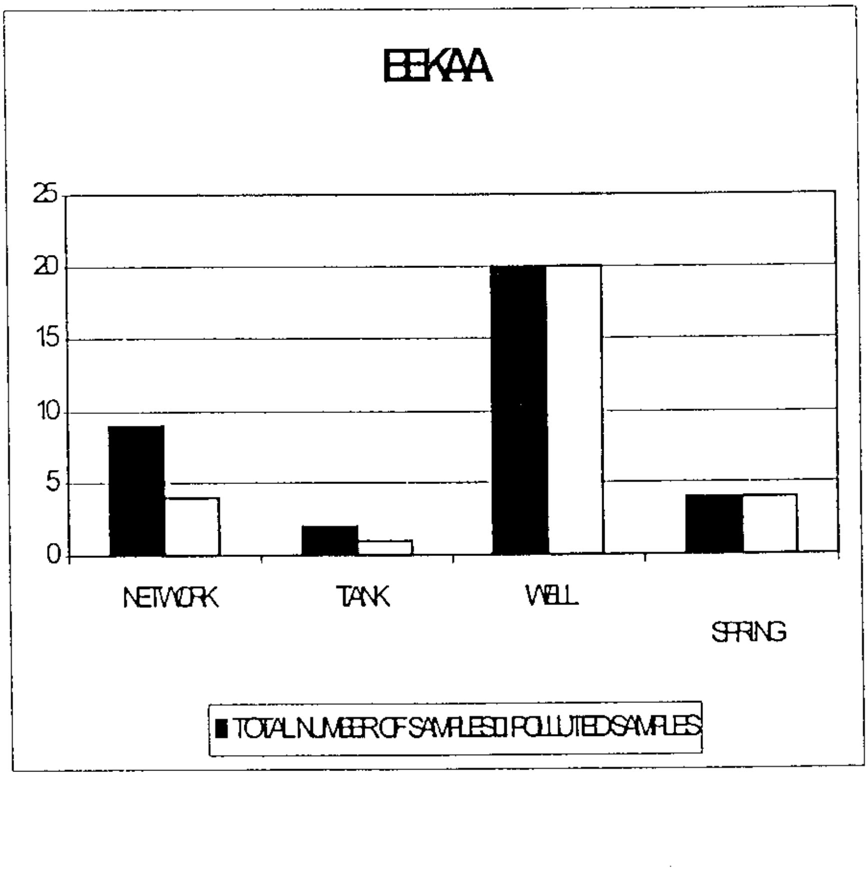
The following table show the sampling results for South Lebanon, including networks available, tanks, wells, and springs. Next page shows it in a graphs for understanding purposes.



BEKAA SAMPLE RESULTS

	NETWORK	TANK	WELL	SPRING
TOTAL NUMBER OF SAMPLES	9	2	20	4
POLLUTED SAMPLES	4	1	20	4
PERCENT POLLUTED	44	50	100	100
NUMBER POLLUTED BY E.COLI	4	1	12	4
PERCENT POLLUTED	44	50	60	100
AVERAGE E.COLICOUNT	45	50	56	71
NUMBER POLLUTED BY COLIFORM	4	1	20	4
PERCENT POLLUTED	44	50	100	100
AVERAGE COLIFORM COUNT	64	100	158	143

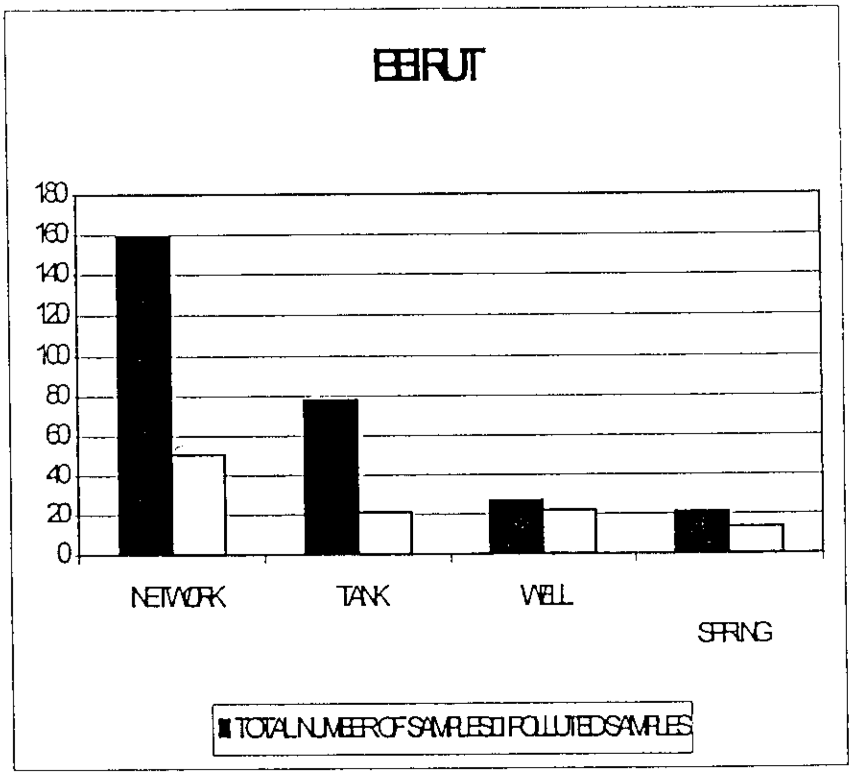
The following table show the sampling results for Bekaa Valley, including networks available, tanks, wells, and springs. Next page shows it in a graphs for understanding purposes.



BEIRUT SAMPLE RESULTS

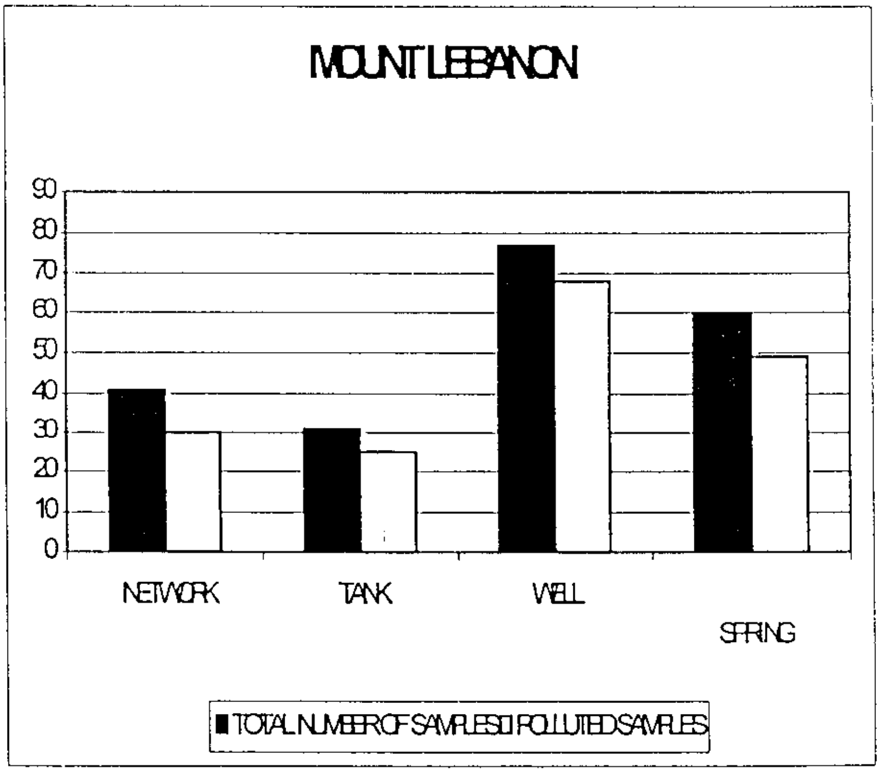
	NETWORK	TANK	WELL	SPRING
TOTAL NUMBER OF SAMPLES	159	78	27	21
POLLUTED SAMPLES	51	21	22	13
PERCENT POLLUTED	32	27	81	62
NUMBER POLLUTED BY E.COLI	26	12	16	1
PERCENT POLLUTED	16	15	59	5
AVERAGE E.COLICOUNT	14	16	48	4
NUMBER POLLUTED BY COLIFORM	51	21	22	13
PERCENT POLLUTED	32	27	81	62
AVERAGE COLIFORM COUNT	37	36	121	116

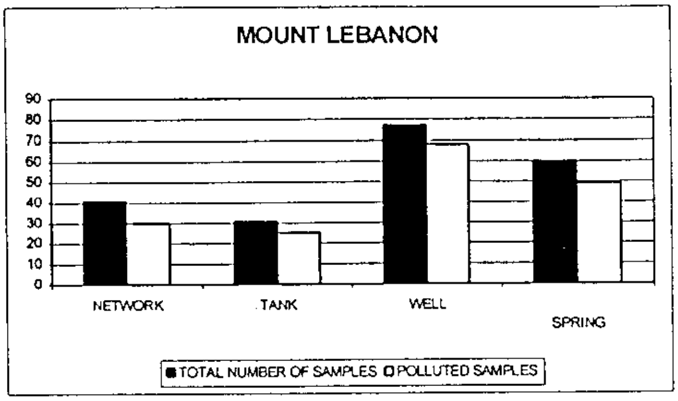
The following table show the sampling results for Beirut, including networks available, tanks, wells, and springs. Next page shows it in a graphs for understanding purposes.



MOUNT LEBANON SAMPLE RESULTS	NETWORK	TANK	WELL	SPRING
TOTAL NUMBER OF SAMPLES	41	31	77	60
POLLUTED SAMPLES	30	25	68	49
PERCENT POLLUTED	73	81	88	82
NUMBER POLLUTED BY E.COLI	24	18	51	41
PERCENT POLLUTED	59	58	66	68
AVERAGE E.COLI COUNT	67	42	40	63
NUMBER POLLUTED BY COLIFORM	30	25	68	51
PERCENT POLLUTED	73	81	88	85
AVERAGE COLIFORM COUNT	111	126	125	136

The following table show the sampling results for Mount Lebanon, including networks available, tanks, wells, and springs. Next page shows it in a graphs for understanding purposes.




MOUNT LEBANON
90
80
70
60
50
40
30
20
10
0
NETWORK
TANK
WELL
SPRING
■ TOTAL NUMBER OF SAMPLES
□ POLLUTED SAMPLES

RESULTS INTERPRETATION

Polluted Samples

The following observations were made regarding the number of polluted samples by Mohafaza:

Network: The highest number of polluted samples were found in Beirut 51, North 49, and Mount Lebanon 30.

Tanks: The highest number of polluted samples were found in Mount Lebanon 25, and Beirut 21.

Wells: The highest number of polluted samples were found in Mount Lebanon 68, and North Lebanon 27.

Springs: The highest number of polluted samples were found in Mount Lebanon 49 and North Lebanon 31.

Percentage of polluted samples

The information from the figures can be summarized as follows:

Network: the highest percentage of polluted samples were found in Mount Lebanon 73, South Lebanon 71, and North Lebanon 67. Less than 50% of the samples in the Bekaa and Beirut were polluted.

Tanks: the highest percentage of polluted samples were found in Mount Lebanon 81, and South Lebanon 57. Less than 50% of the samples in North Lebanon, Bekaa and Beirut were polluted.

Wells: more than 77% of all the samples taken from wells were polluted. In Bekaa 100% of the samples were polluted. In South Lebanon and Mount Lebanon more than 80 % of the samples were polluted.

Springs: No samples were available for South Lebanon. More than 62 % of the samples taken from springs were polluted. One hundred percent of the samples taken from Bekaa area were polluted. 89 % of the samples taken from springs in the South were polluted. 82 % of the samples taken in Mount Lebanon were polluted.

Bacterial Count

Network: The highest bacterial count for E. Coli was found in Mount Lebanon (67).

Tanks: The highest bacterial count for E. Coli was found in South Lebanon (86).

Wells: The highest bacterial count for E. Coli was found in South Lebanon (100).

Springs: The highest bacterial count for E. Coli was found in the Bekaa Valley (71).

Interpretation:

Beirut has the lowest bacterial levels but these results can be attributed to:

- The low number of samples from springs (21)
- Bacterial pollution in Beirut is more prevalent in underground water resources which is reflected in the bacterial counts from the wells.
- Adequate treatment of the water distributed by Beirut water authority
- Repairs been completed on the water distribution of the city.

Sampling Conclusions:

Pollution from agricultural areas in the North, South and Bekaa areas may explain the high bacterial count for E. Coli.

The water samples taken from tanks are relatively less polluted than those taken from other sources.

If the World Health Organization (WHO) standards stating that no bacterial count should be found in any of the water samples intended for drinking purposes and for water pumped in the water distribution network, the results are quite clear in the sense that with exception of the water treated by the water authorities, all water sources in Lebanon are highly polluted.

SOLUTION PROPOSALS

The program for rehabilitation of the water sources and its preparation for human consumption comprises:

- Rehabilitation of pumping stations, wells, sources, reservoirs, and transit/distribution networks. The goal is to set these services at a level comparable with the situation before the war and extend the networks to serve new urbanized zones.

- Technical assistance to the Ministry of Hydraulic and Electric Resources (MRHE) and the water offices to bring know-how to these entities through international experts.

- Development and extension of water infrastructures to complete the rehabilitation phase. On one hand to improve the hydraulic resources and extend the water collection and distribution networks and on the other to build networks for wastewater and treatment stations to protect the water resources.

CDR launched a study for restructuration of the water sector with financing from the World Bank. The study was performed in 1994 and it has been translated in the text for the law approved by the Council of Ministers.

As far as technical assistance to the MRHE, two contracts have been developed:

- One financed by the French protocol (2.6 MUSD) with Lyonnaise des Eaux for assistance to the Direction of Exploitation (Aug.93-Aug.96). It concerns support to the water offices related to technical and administrative affairs.

- One contract financed (Grant) by the European Union (6.1 MUSD) with Binnie & Partners for assistance in the Direction of Equipment. Its goal was to provide job execution assistance according to CDR's program (SIU-1).

At infrastructure level the list of works performed to date is as follows:

Five contracts in the sector of transportation of water for 45 MUSD:

Transmission and Distribution	14.5 MUSD
Sources and Drilling	3.5 MUSD
Treatment and Chlorination	3.8 MUSD
Pumping Stations	12.3 MUSD
Reservoirs	11.3 MUSD

Two contracts in the sector of purification of water for 14.8 MUSD:

Purification network	14.1 MUSD
Pumping Stations	0.7 MUSD

Supervision of these works has been secured within the frame of nine contracts of supervision for the sum of 4.1 MUSD.

Besides, a contract to purchase canalization and accessory materials value in 4.6 MUSD financed within the French protocol. The equipment has been given to Barouk Water office for the priority works lead by the administration in the regions of Metn, Chouf and Aley.

COST DATA

This section presents valuable information required to properly design and implement the proposed projects as follows:

Figure A10.2.1. Asbestos Cement Price List Chart

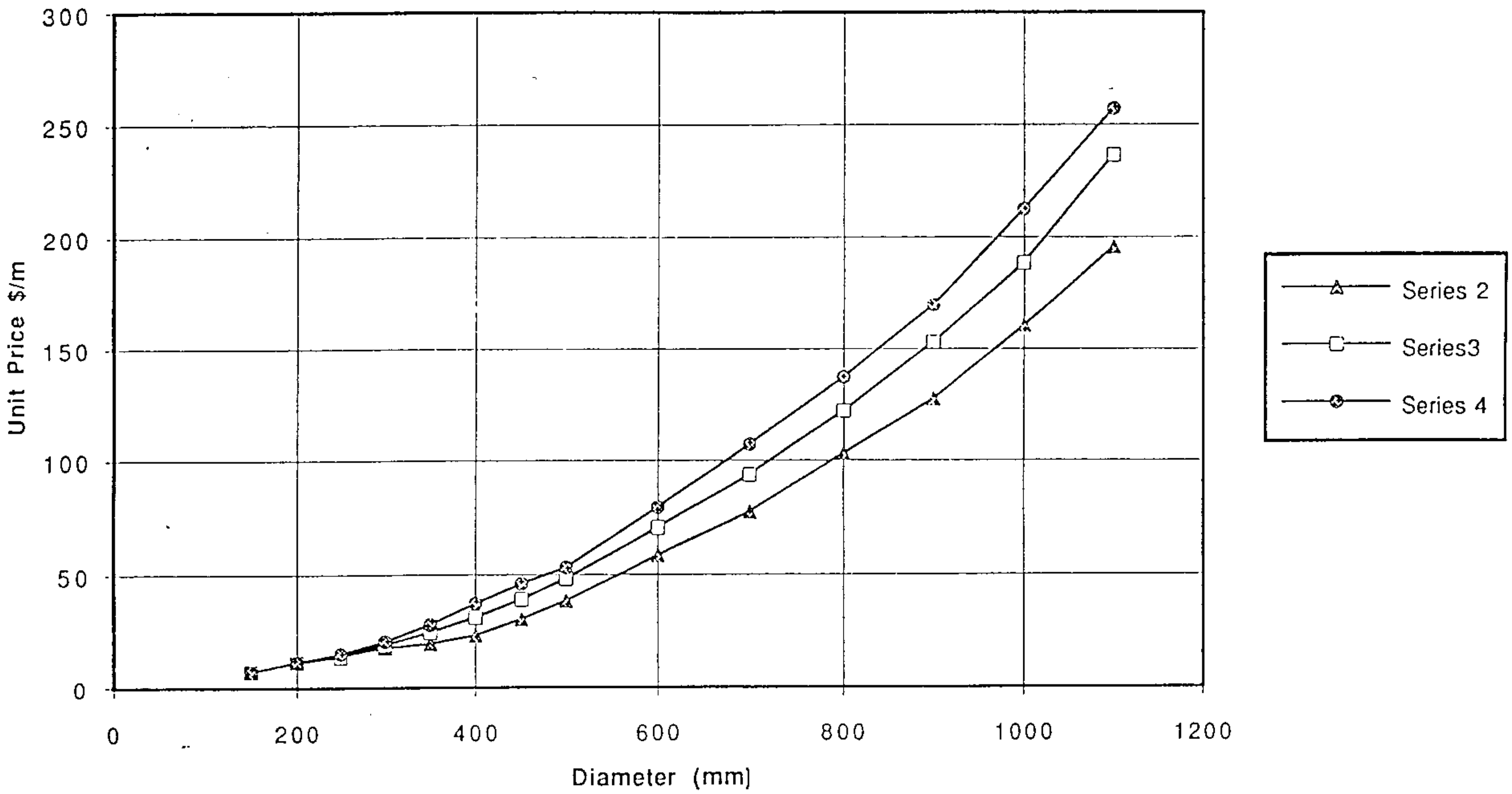


Table A10.3.1. Asbestos Cement Pressure Pipes Price List

PRESURE PIPES UNIT PRICE $/m

DIAMETER	CLASS 18	CLASS 24
(MM)	9 BARS W.P.	12 BARS W.P.
80.00	4.77	4.77
100.00	5.70	5.90
150.00	9.30	11.13
200.00	17.71	22.79
250.00	23.99	28.71
300.00	32.67	39.86
350.00	43.18	53.11
400.00	54.37	64.77
500.00	71.54	83.72

Table A10.3.2. Asbestos Cement Pressure Pipes Price List

PRESURE PIPES UNIT PRICE $/m

Pipe Cost with Bitumen Coating Using Nitrogen Proof 10 from FOSOG

DIAMETER	CLASS 18	CLASS 24
(MM)	9 BARS W.P.	12 BARS W.P.
80.00	4.82	4.82
100.00	5.76	5.96
150.00	9.39	11.22
200.00	17.84	22.92
250.00	24.15	28.87
300.00	32.86	40.05
350.00	43.40	53.33
400.00	54.62	65.02
500.00	71.85	84.03

Table A8.3.3. Asbestos Cement Pressure Pipes Price List

PRESURE PIPES UNIT PRICE $/m

Pipe Cost with Epoxy Coating Using Nitrocot ET 550 from FOSOG

DIAMETER	CLASS 18	CLASS 24
(MM)	9 BARS W.P.	12 BARS W.P.
80.00	5.78	5.02
100.00	6.96	6.21
150.00	11.18	11.60
200.00	20.22	23.42
250.00	27.13	29.50
300.00	36.44	40.80
350.00	47.58	54.21
400.00	59.40	66.03
500.00	77.82	85.29

Table A10.12.1

TABLE 2.8-1 PROPOSED WASTEWATER SYSTEM OPERATIONAL PERSONNEL (NWMP82)

	1986 2000	1987 2001	1988 2002	1989 2003	1990 2004	1991 2005
NUMBER OF TREATMENT PLANTS						
Tripoli		1	1	1	1	1
Other North Lebanon						5
Jounieh		1	1	1	1	1
North Metn		1	1	1	1	1
Other Mt. Lebanon						8
Saida		1	1	1	1	1
Other Zahle			1	1	1	1
Bekaa						4
		----	----	----	----	----
TOTAL		4	5	5	5	22
DESIGN TMT CAPACITY (MED)						
Tripoli		240	240	240	240	240
Other North Lebanon						19
Jounieh		43	43	43	43	43
North Metn		476	476	476	476	476
Other Mt. Lebanon						34
Saida		85	85	85	85	85
Zahle			75	75	75	75
Bekaa						38
		-----	-----	-----	-----	-------
TOTAL		844	919	919	919	1,010
NO. OF PUMP STATIONS						
Tripoli		4	4	4	4	4
Other North Lebanon						
Jounieh		3	3	3	3	3
North Metn		3	3	3	3	3
Other Mt. Lebanon						
Saida		3	3	3	3	3
Bekaa						
		----	----	----	----	----
TOTAL		13	13	13	13	13
OPERATING STAFF BY FUNCTION (1)						
Treatment Plant		30	30	30	90	200
Pump Stations		45	50	50	50	50
Sewer Maintenance	300	325	400	450	500	600
Administration/Eng.	50	55	60	65	70	100
	-----	-----	-----	-----	-----	-----
TOTAL	350	455	540	595	710	950
OPERATING STAFF BY LOCATION						
Tripoli	90	120	135	150	170	180
Other North Lebanon						
Jounieh	25	30	35	40	45	50
North Metn	185	225	295	315	340	400
Other Mt. Lebanon						
Saida	45	60	70	85	95	130
Bekaa	5	5	5	5	60	190
	-----	-----	-----	-----	-----	-----
TOTAL	350	440	540	595	710	950

(1) Categories of operational personnel are listed in volume VI, Institutional Studies.

Table A10.3.4. Asbestos Cement Pressure Pipes Price List

PRESURE PIPES UNIT PRICE $/m

Cost Comparison Table For Two Types Of AC Pressure Pipes (Coated and Not Coated)

DIAMETER	CLASS 18	CLASS 24	CLASS 18	CLASS 24	CLASS 18	CLASS 24
(MM)	9 BARS W.P.	12 BARS W.P.	9 BARS W.P.	12 BARS W.P.	9 BARS W.P.	12 BARS W.P.
80	4.77	4.77	4.82	4.82	5.78	5.02
100	5.70	5.90	5.76	5.96	6.96	6.21
150	9.30	11.13	9.39	11.22	11.18	11.60
200	17.71	22.79	17.84	22.92	20.22	23.42
250	23.99	28.71	24.15	28.87	27.13	29.50
300	32.67	39.86	32.86	40.05	36.44	40.80
350	43.18	53.11	43.40	53.33	47.58	54.21
400	54.37	64.77	54.62	65.02	59.40	66.03
500	71.54	83.72	71.85	84.03	77.82	85.29

Figure 10.4.1. Concrete Gravity Pipe Price List Charts

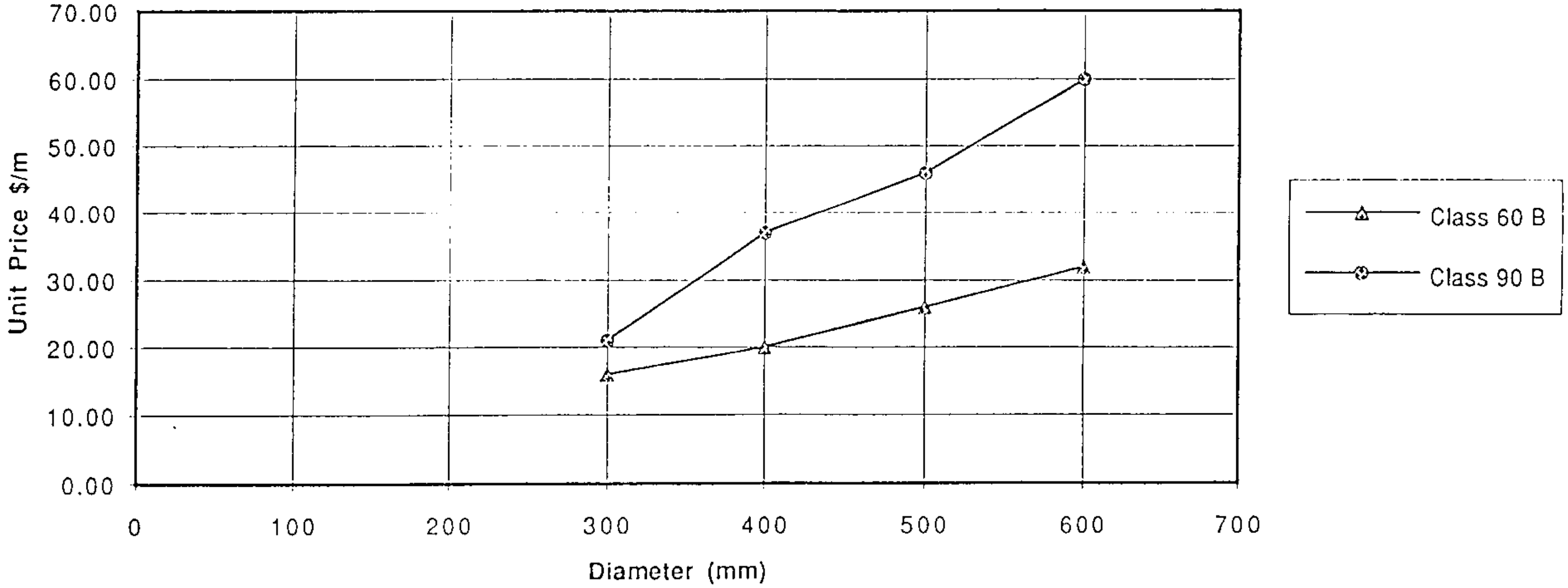
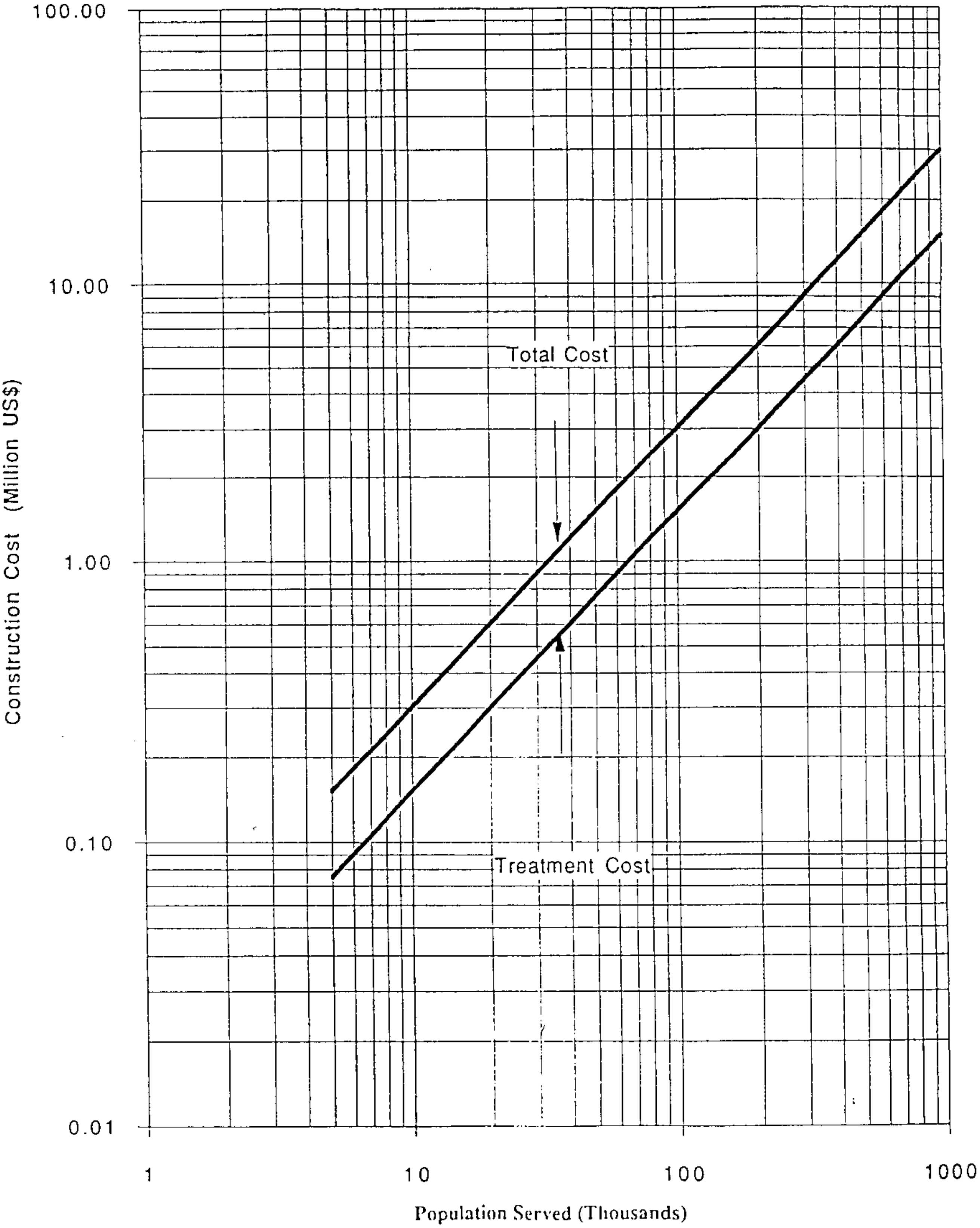


Table A10.5.1. Reinforced Concrete pipes Price List

Gravity Pipe Unit Price $/m

Nominal diameter (mm)	Available Length (m)	Class 6000	Class 9000	Class 13500	Class 18000
200	2.41	14.65			
300	2.41	19.20	25.20		
400	2.41	24.00	44.40		
500	2.41	32.50	57.50		
600	2.41	40.00	75.00		
750	2.41		85.29		
900	2.41		105.15		
1200	2.41			162.13	
1500	2.41				445.88

Figure A10.1.14 Cost Curves for Primary Sewage Treatment Construction.



Costs are based on a per capita flow of 200 liters/day.

Total cost is complete including land cost and related civil works.

Treatment cost consists of treatment units costs and all related electromechanical works.

Figure A10.1.16 Cost Curves for O&M (Primary Treatment).

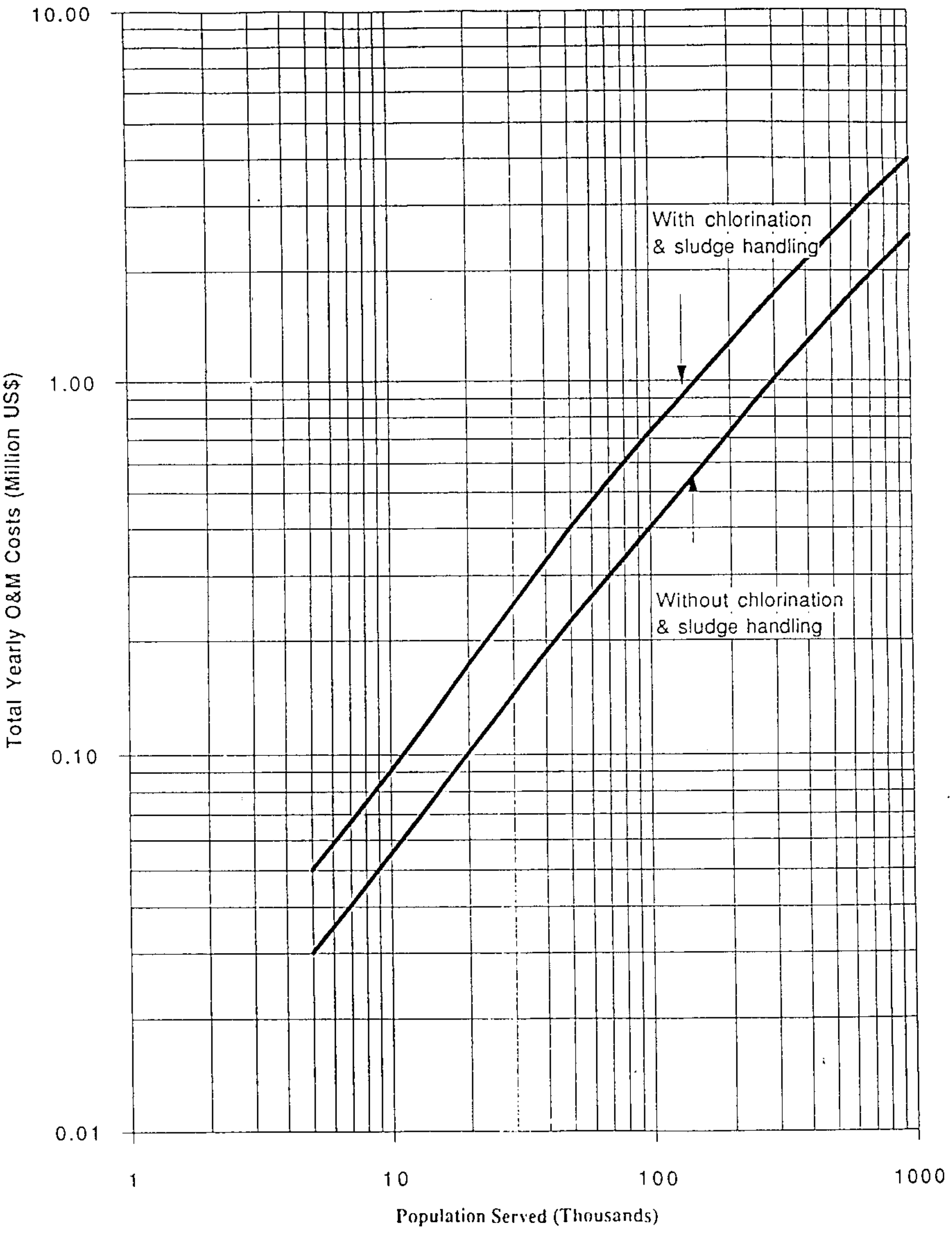
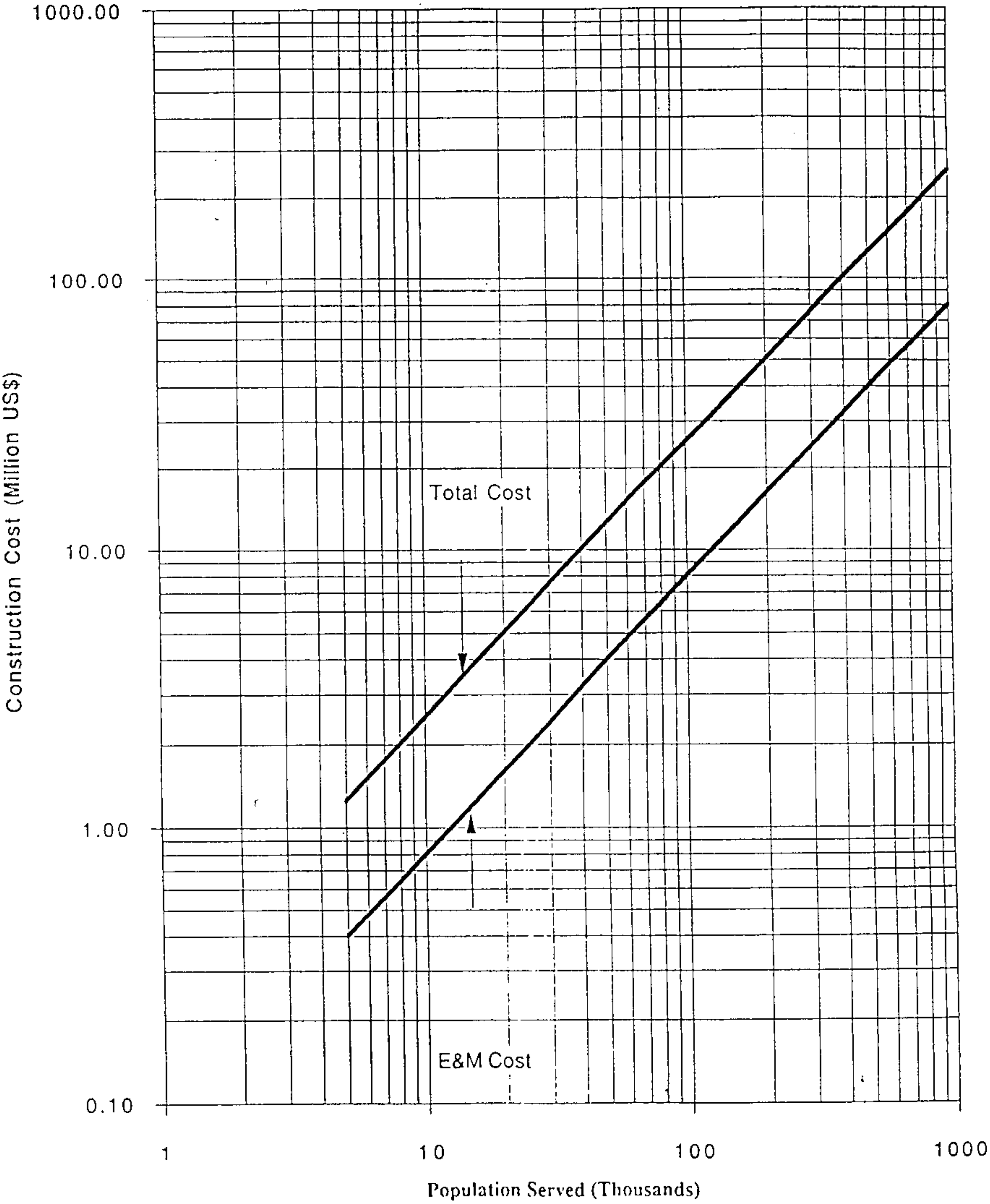


Table A10.6.1. GRP PIPES - Standard

Price shown is for standard 12 ML unit including one coupler

Diameter	PN-6 Stress				PN-10 Stress				PN-16 Stress			
(mm)	1250	2500	5000	10000	1250	2500	5000	10000	1250	2500	5000	10000
350	70.10	72.01	75.54	80.70	70.92	73.64	76.63	81.52	77.17	78.53	79.89	82.88
400	72.82	76.35	83.42	87.22	77.17	79.34	85.87	88.58	83.96	85.32	87.77	91.57
450	79.62	84.78	87.77	98.09	84.24	87.50	92.12	99.18	93.48	95.38	97.01	104.07
500	93.75	98.64	103.53	116.30	98.91	102.72	108.96	117.66	110.32	112.77	115.49	122.58
600	108.70	116.84	123.91	134.20	117.93	123.64	132.33	144.02	133.15	137.22	144.83	151.08
700	127.71	138.31	148.09	172.82	141.30	147.01	158.15	175.81	159.78	165.70	175.54	185.59
800	153.80	167.12	180.16	213.58	171.74	179.62	185.10	216.03	195.38	203.26	217.12	229.07
900	178.26	193.48	211.14	253.26	198.64	208.15	228.00	255.43	228.80	239.13	254.07	276.90
1000	202.71	223.10	243.20	295.65	229.62	241.30	264.95	299.72	270.10	279.07	298.37	323.67
1100	232.33	254.62	281.79	343.20	264.40	274.72	304.62	346.74	302.72	322.55	345.65	374.73
1200	262.77	292.40	323.72	389.10	300.81	324.18	354.90	401.90	358.42	373.37	401.90	438.58
1300	297.00	327.17	365.76	453.00	335.87	363.58	401.35	455.98	411.68	423.37	454.34	497.55
1400	329.07	370.11	410.32	512.75	379.35	412.77	449.72	520.65	463.04	478.26	516.30	566.37
1500	372.55	413.58	481.25	581.00	422.00	463.31	514.40	599.72	522.00	540.76	584.24	638.31
1600	408.42	463.85	543.20	650.50	471.20	512.50	576.63	658.15	580.40	610.05	653.80	719.83
1700	455.43	510.05	597.55		517.66	570.38	639.95		642.12	675.27	720.65	
1800	494.56	560.32	662.22		566.57	625.54	705.43		707.60	747.28	799.73	
1900	545.38	619.56	732.06		626.08	693.20	781.00		786.14	831.25		
2000	593.20	679.89	807.33		686.41	760.87	858.40		858.15	909.24		
2100	668.20	744.56			753.00	840.21						
2200	732.33	807.06			807.90	903.00						
2300	782.06	870.38			868.75	976.63						
2400	831.25	944.56			954.90	1054.90						

Figure A10.1.17 Cost Curves for Sewage Treatment Construction (Aerated Lagoons).

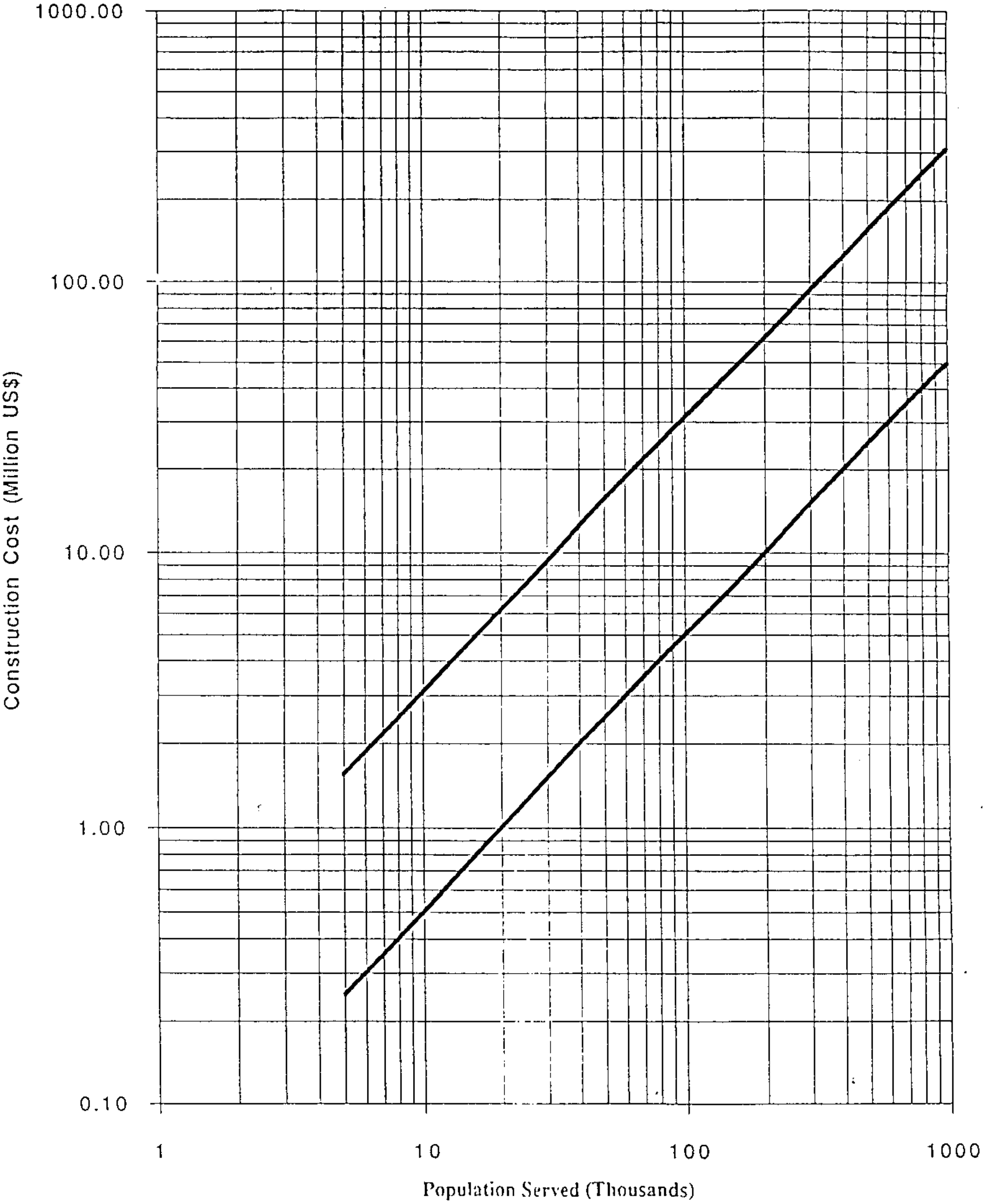


Costs are based on a per capita flow of 200 liters/day.

Total cost is complete including land cost and related civil works.

Treatment cost consists of treatment units costs and all related electromechanical works.

Figure A10.1.18 Cost Curves for Sewage Treatment Construction (Oxidation Ponds).



Costs are based on a per capita flow of 200 liters/day.

Total cost is complete including land cost and related civil works.

Treatment cost consists of treatment units costs and all related electromechanical works.

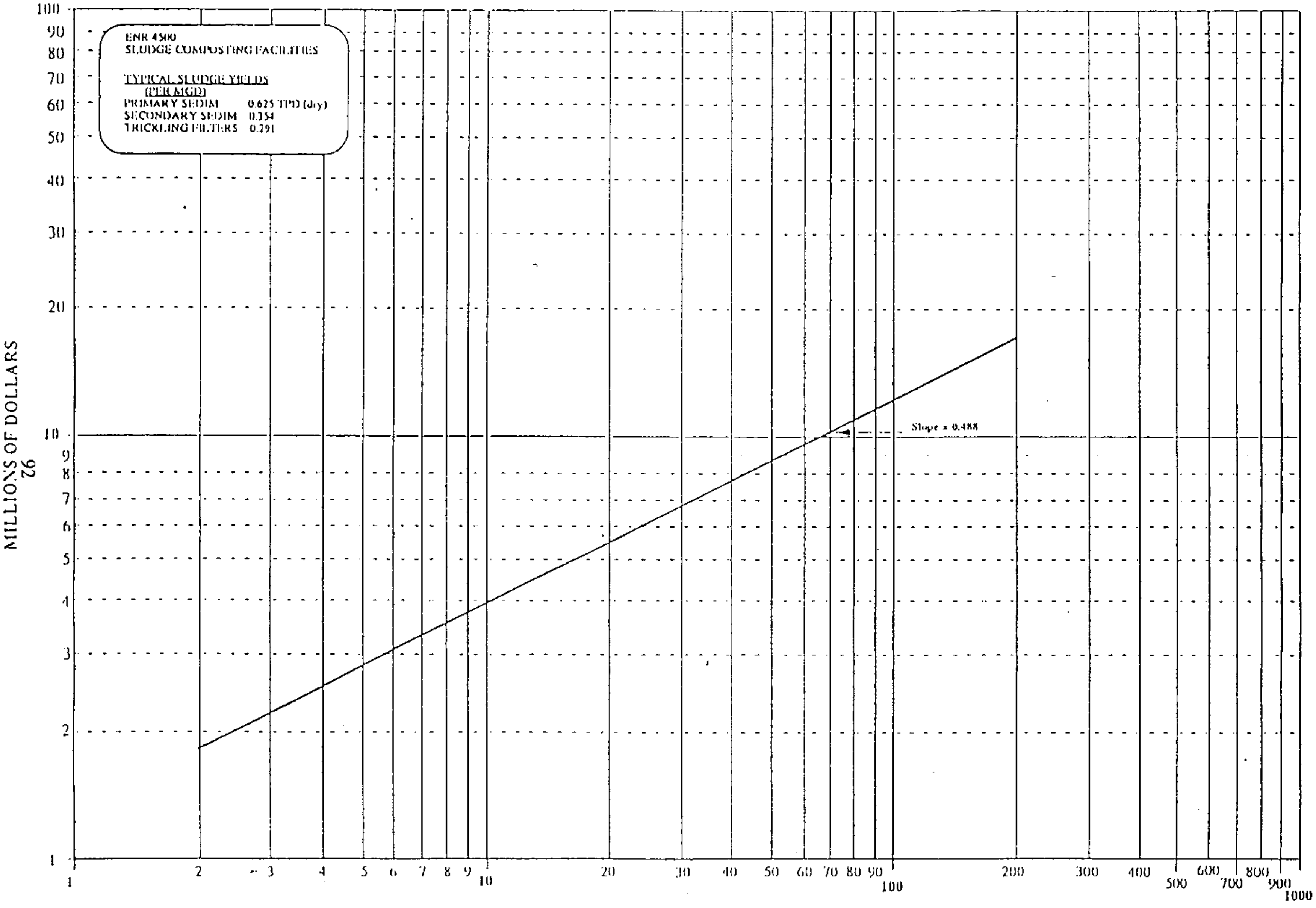
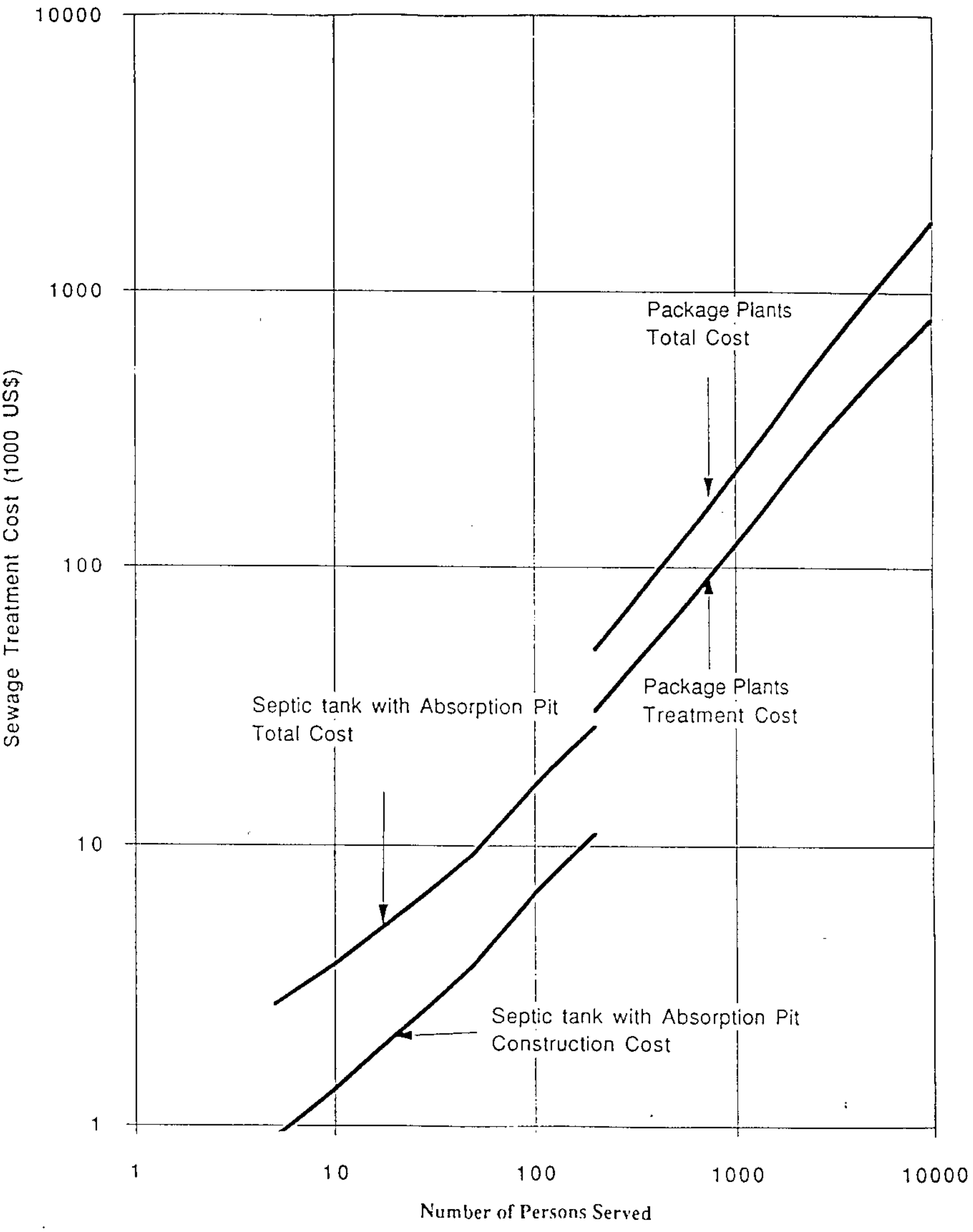


Figure A10.14.7 : SLUDGE COMPOSTING FACILITIES

Source: METCALF & EDDY

tons/day	metric tons
1	1.016
2	2.032
3	3.048
4	4.064
5	5.08
6	6.096
7	7.112
8	8.128
9	9.144
10	10.16
20	20.32
30	30.48
40	40.64
50	50.8
60	60.96
70	71.12
80	81.28
90	91.44
100	101.6
200	203.2
300	304.8
400	406.4
500	508
600	609.6
700	711.2
800	812.8
900	914.4
1000	1016

Figure A10.1.9 Cost Curves for Sewage Treatment - Small Communities.



Costs are based on a per capita flow of 200 liters/day.

Total cost is complete including land cost and related civil works.

Treatment cost consists of treatment units costs and all related electromechanical works.

Figure A10.1.3 Cost Curve for Collection System (House Connections Excluded)

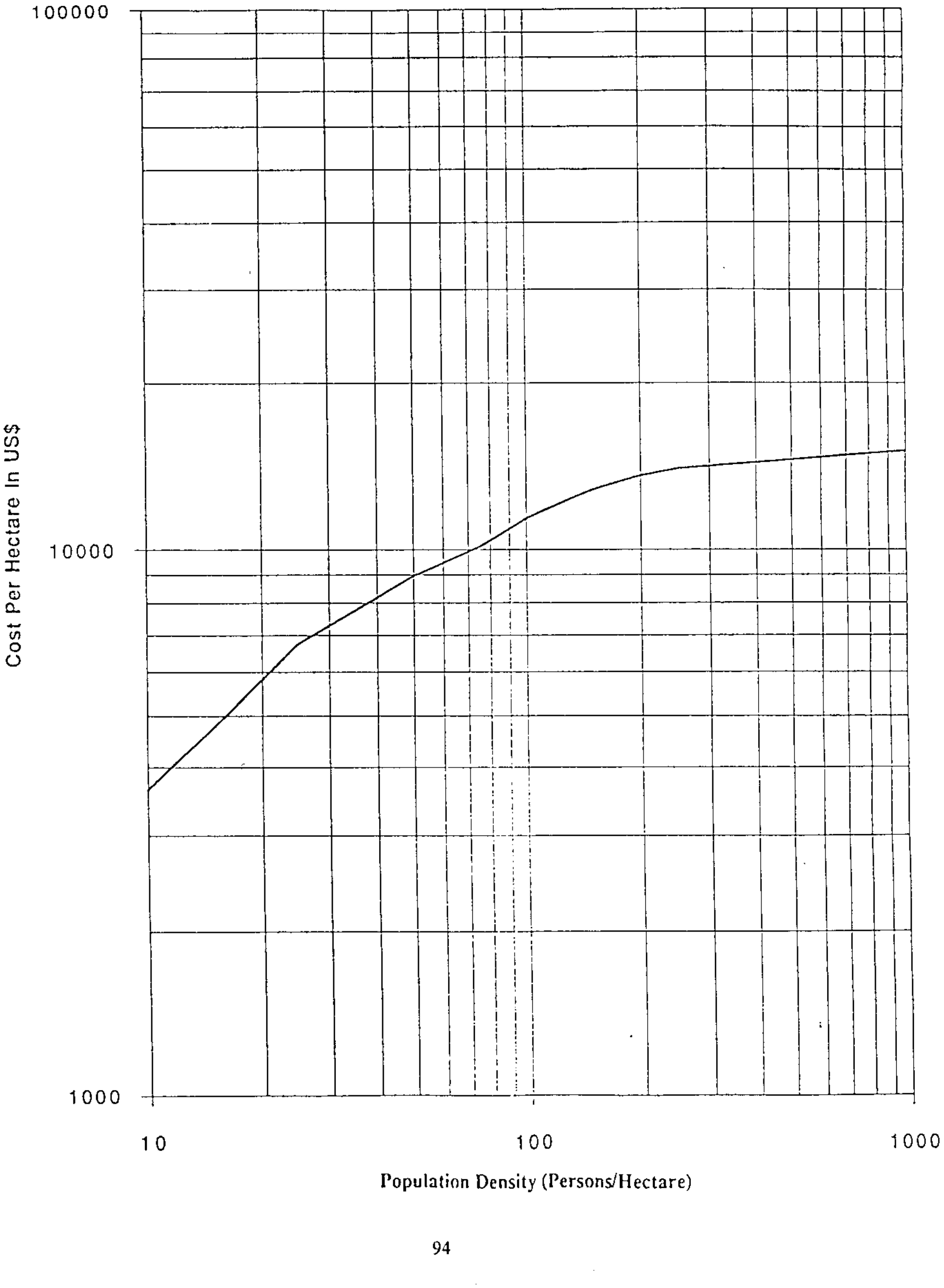


Figure A10.1.13 Cost Curves for O&M of Sewer Systems.

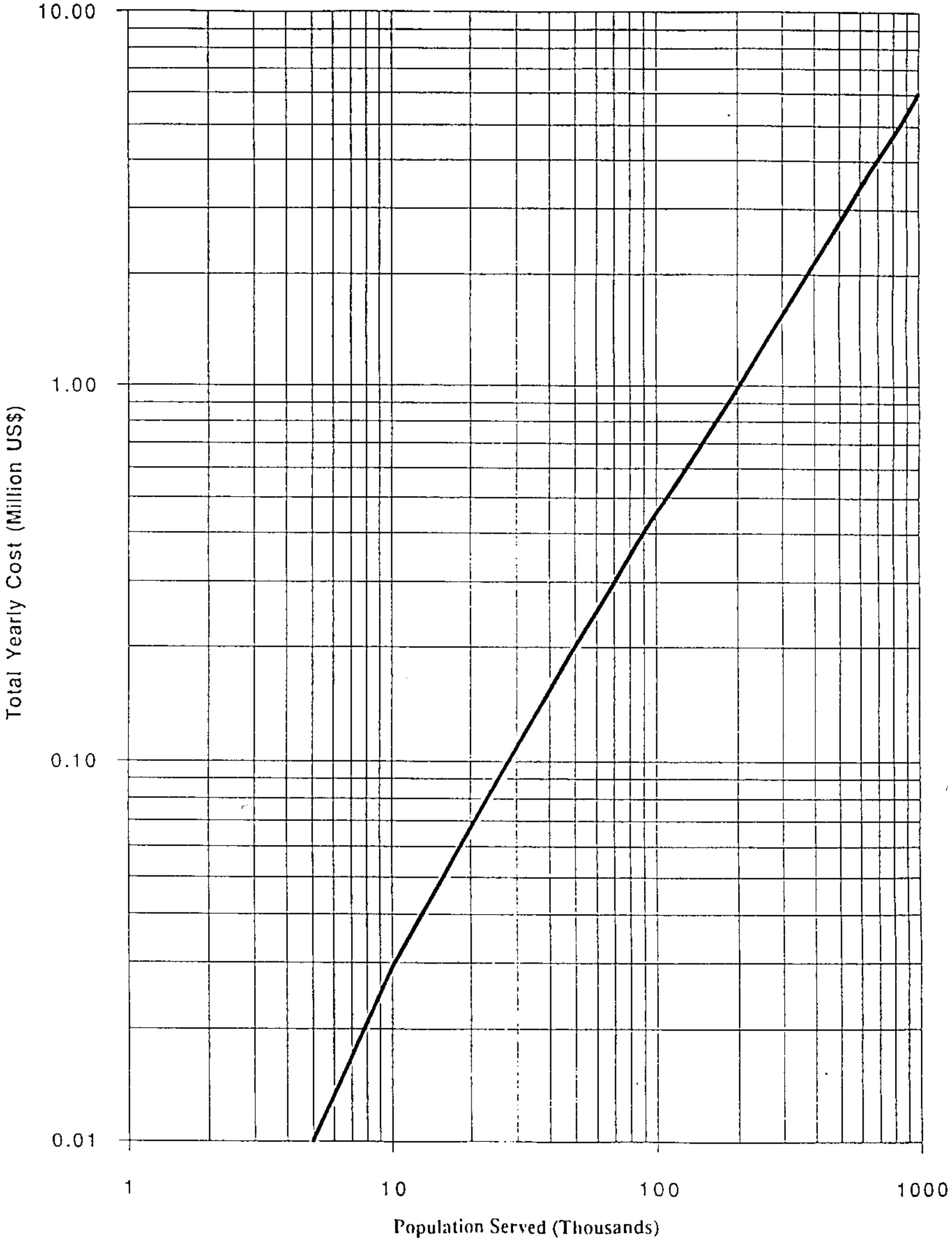
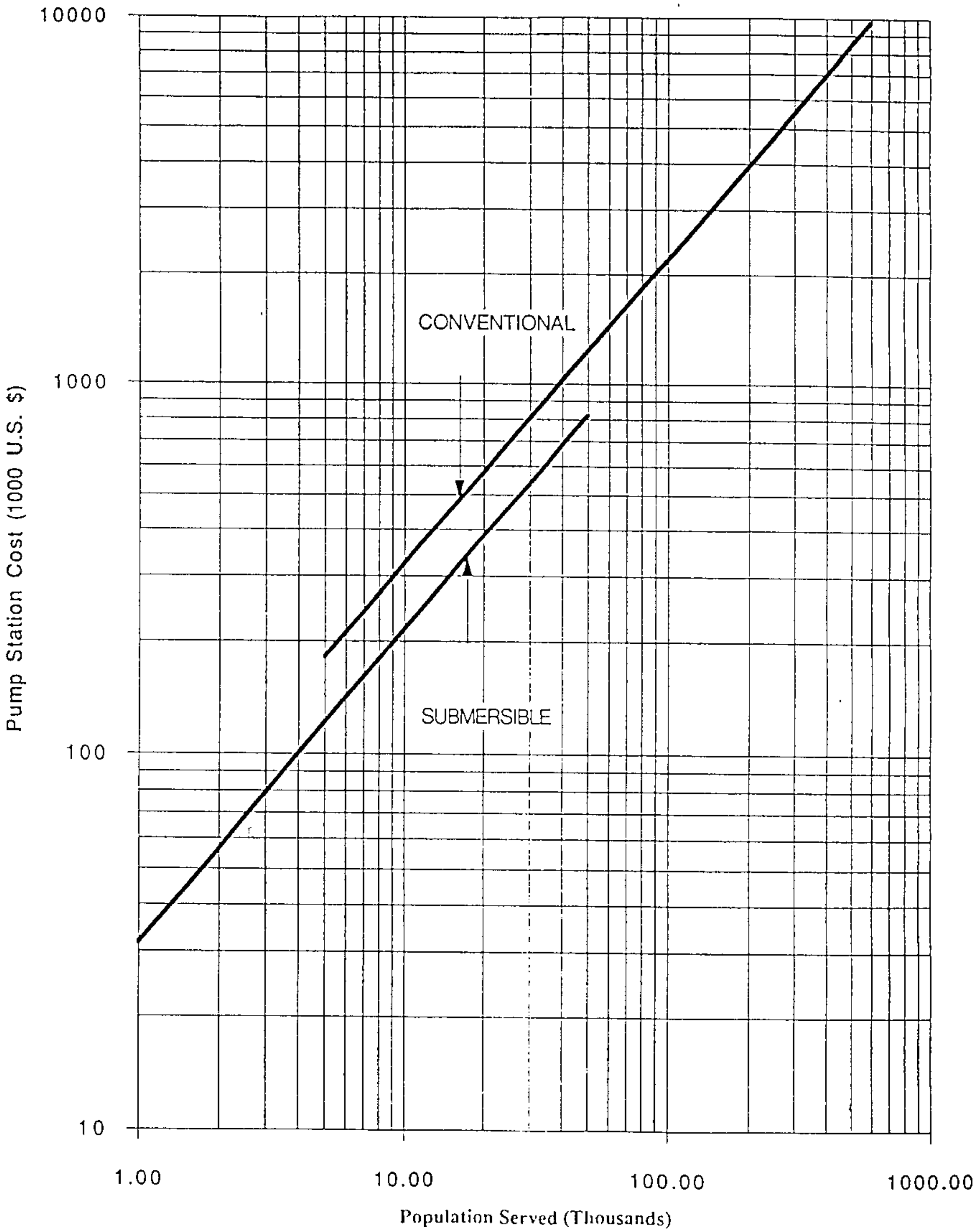


Table A10.8.1. GENERAL REHABILITATION WORK COST

Includes Labour, Overhead, Equipment, and Installation

	Description	Unit	Unit Price $/Unit
A	Rehabilitation of sewer Manholes		
A1	Rehabilitation of existing manhole walls	UNIT	31.60
A2	Cleanig of sewer manholes	UNIT	18.76
A3	Furnishing and installation of galvanized steel steps	UNIT	4.81
B	New Manholes		
	Excavation of a new manhole for pipe diameter:		
B1	200	UNIT	1503.52
B2	300	UNIT	1614.89
B3	400	UNIT	1614.89
B4	500	UNIT	1614.89
B5	600	UNIT	1949.00
B6	750	UNIT	2505.86
B7	900	UNIT	2784.29
B8	1200	UNIT	3300.00
B9	1500	UNIT	3842.32
C	Asphalt paving, including all necessary asphalt layers, prime and tack coats.	SQ.M	6.21
D	Rehabilitation of Side walks.	SQ.M	11.90

Figure A10.1.6 Cost Curves for Pump Stations.



Pump stations costs are based on a per capita flow of 200 liters/day.

Figure A10.1.7 Cost Curves for Force Mains.

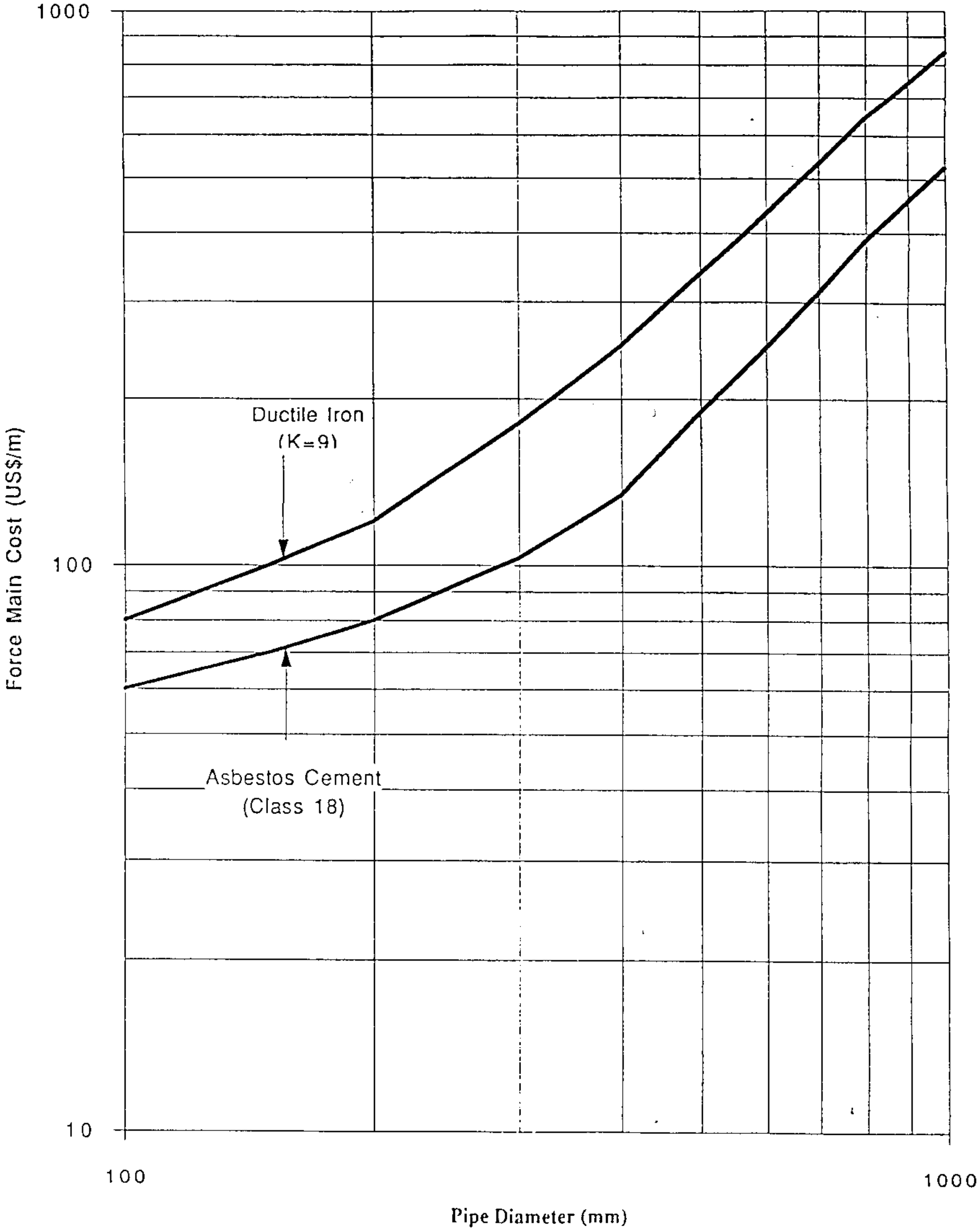


Figure A10.1.8 Cost Curves for Sewage Treatment Construction - Secondary (Activated Sludge for Trickling Filter)

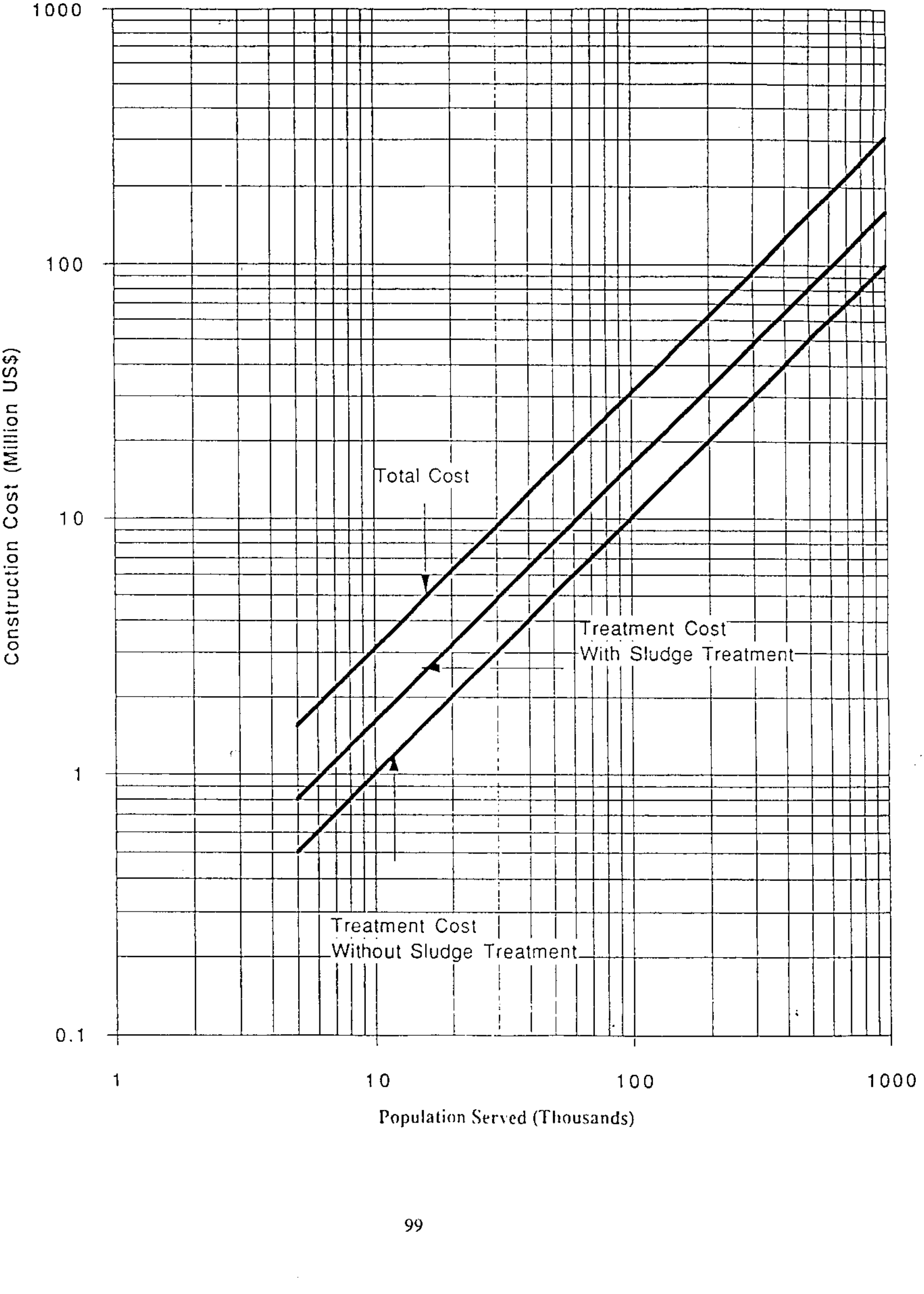
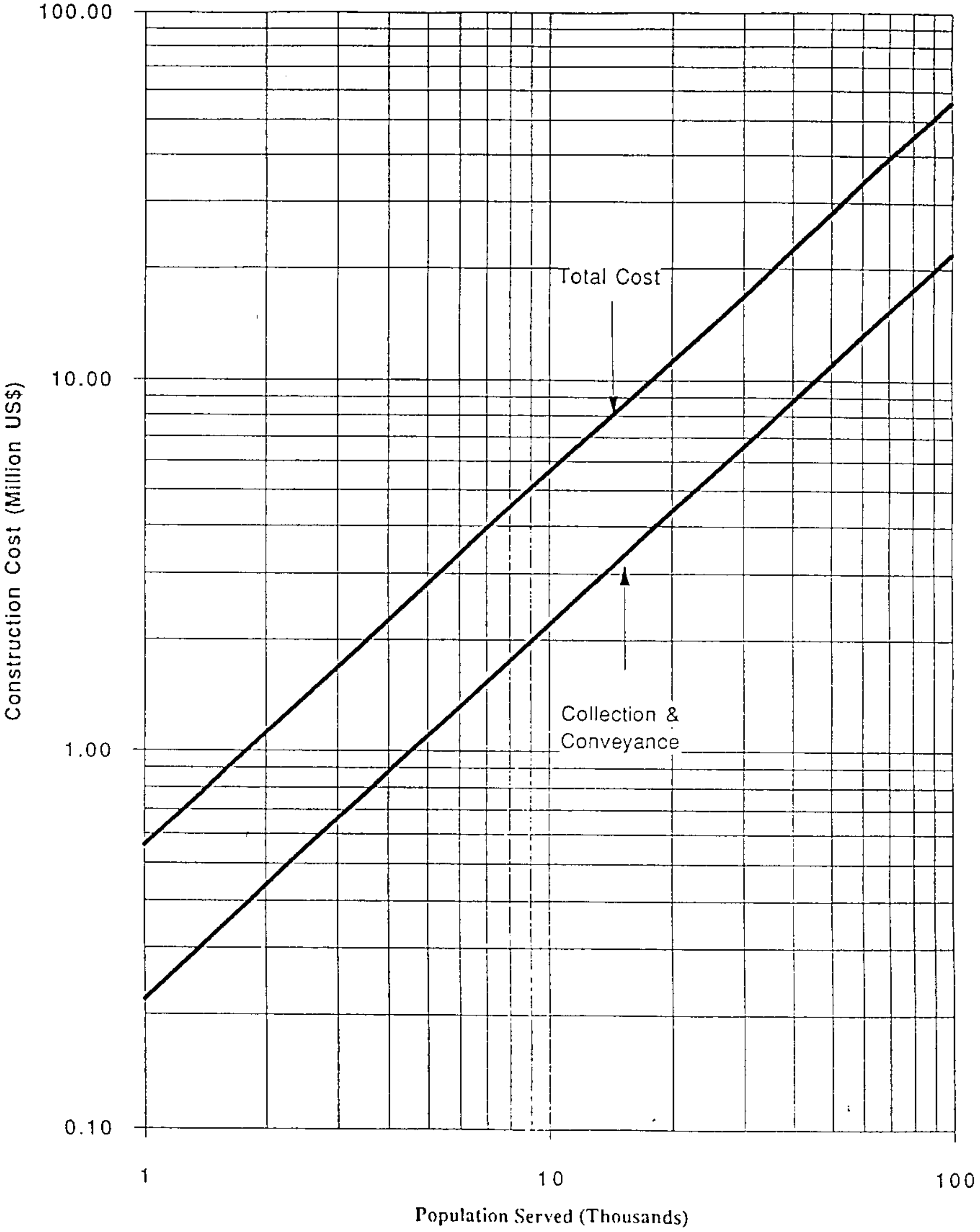
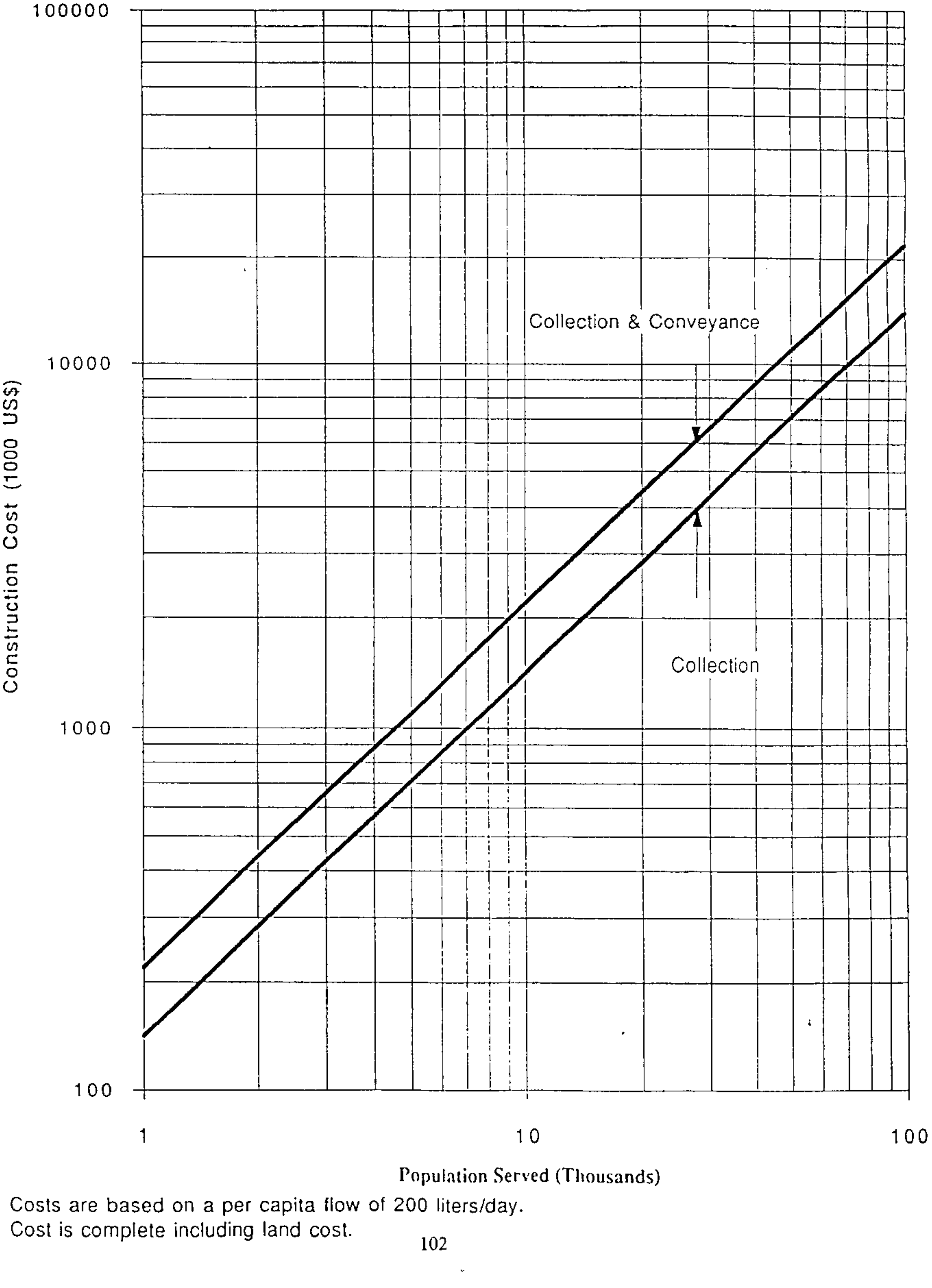


Figure A10.1.10 Cost Curves for Sewer Construction.



Total cost includes sewage treatment, sludge handling and disposal costs.

Figure A10.1.5 Cost Curves for Sewer Systems Constrcution (Collection and Conveyance).



Costs are based on a per capita flow of 200 liters/day.
Cost is complete including land cost.

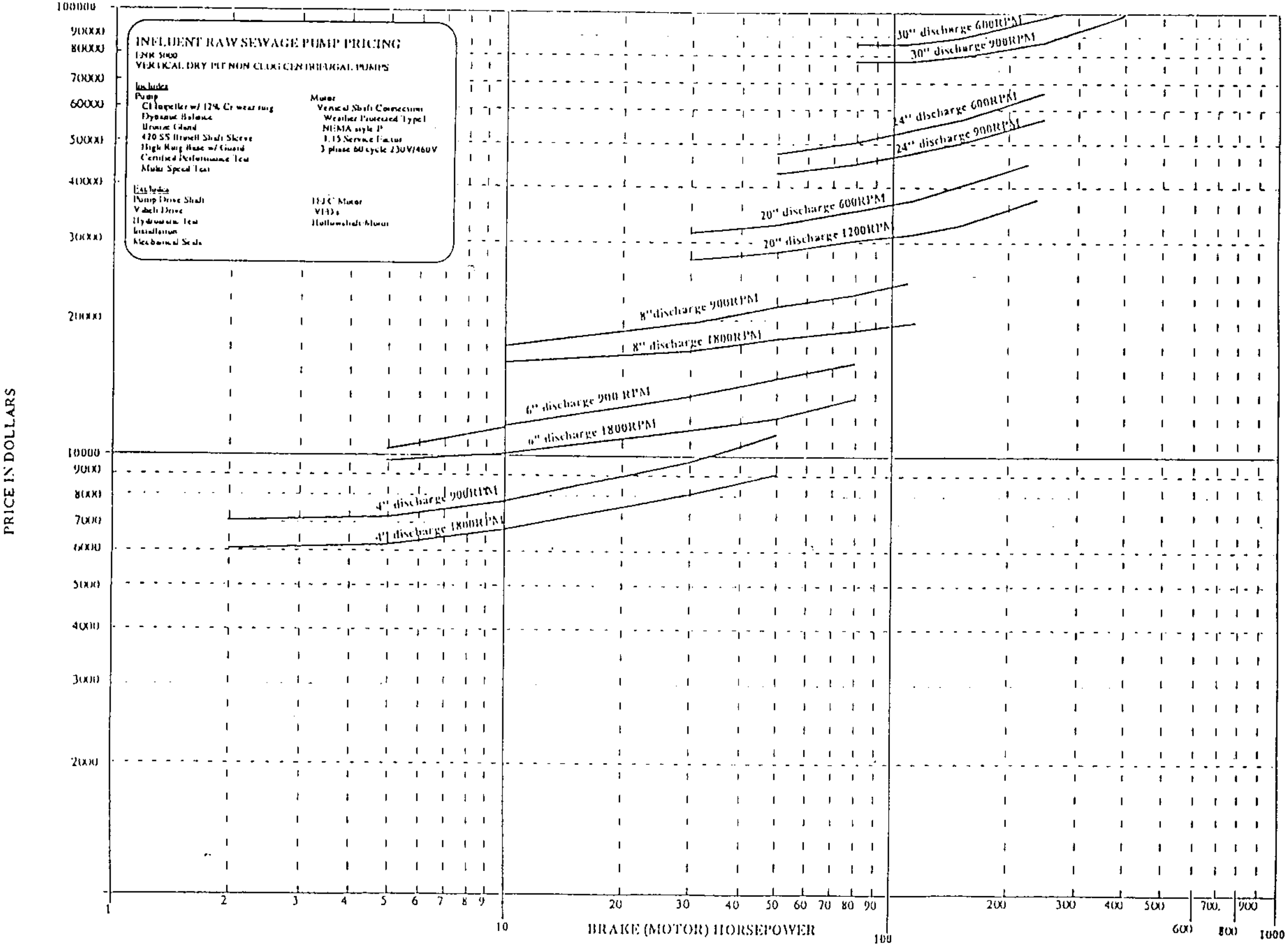
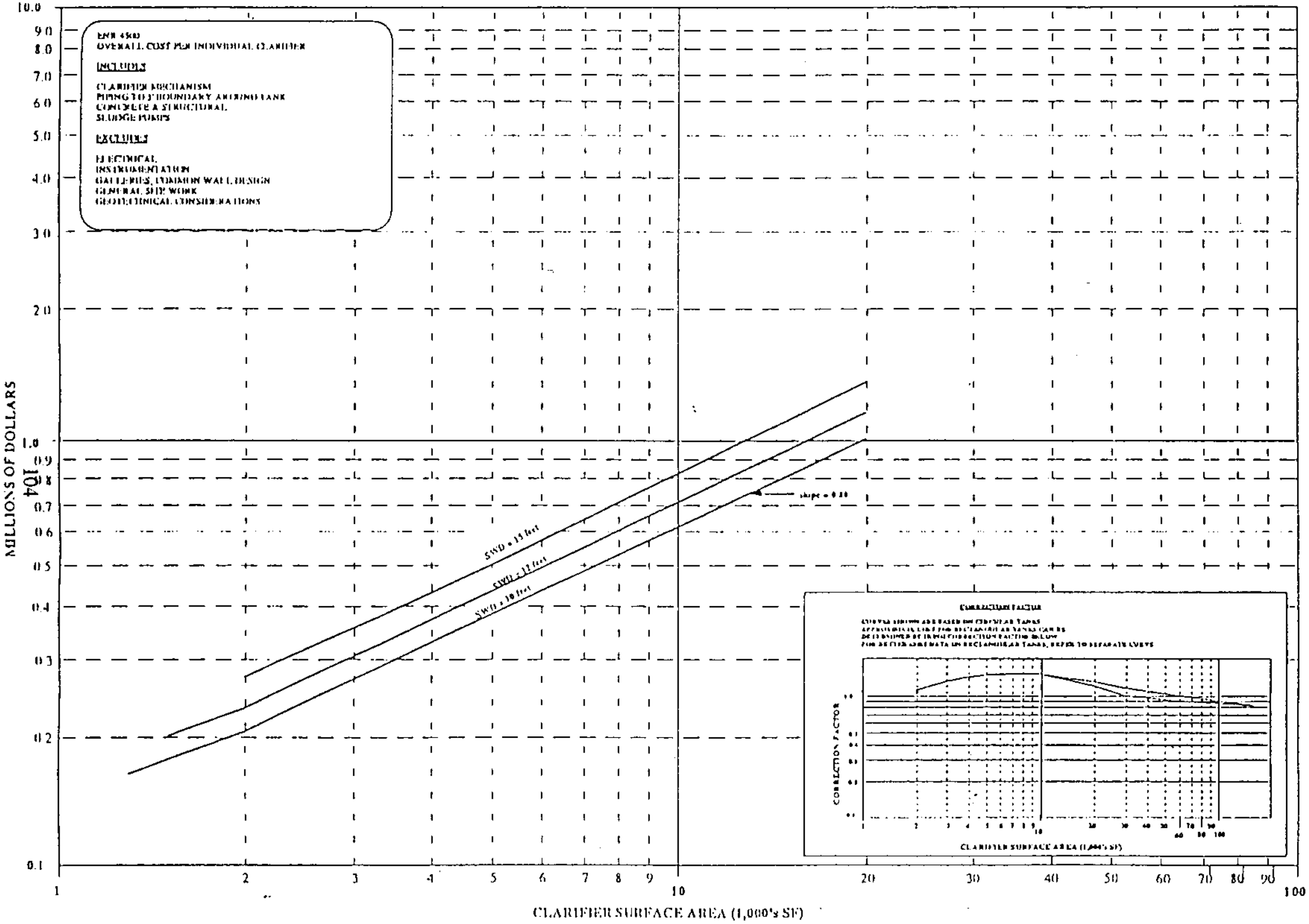


Figure A10.14.2 INFLUENT RAW SEWAGE PUMP PRICING

Source: METCALF & EDDY

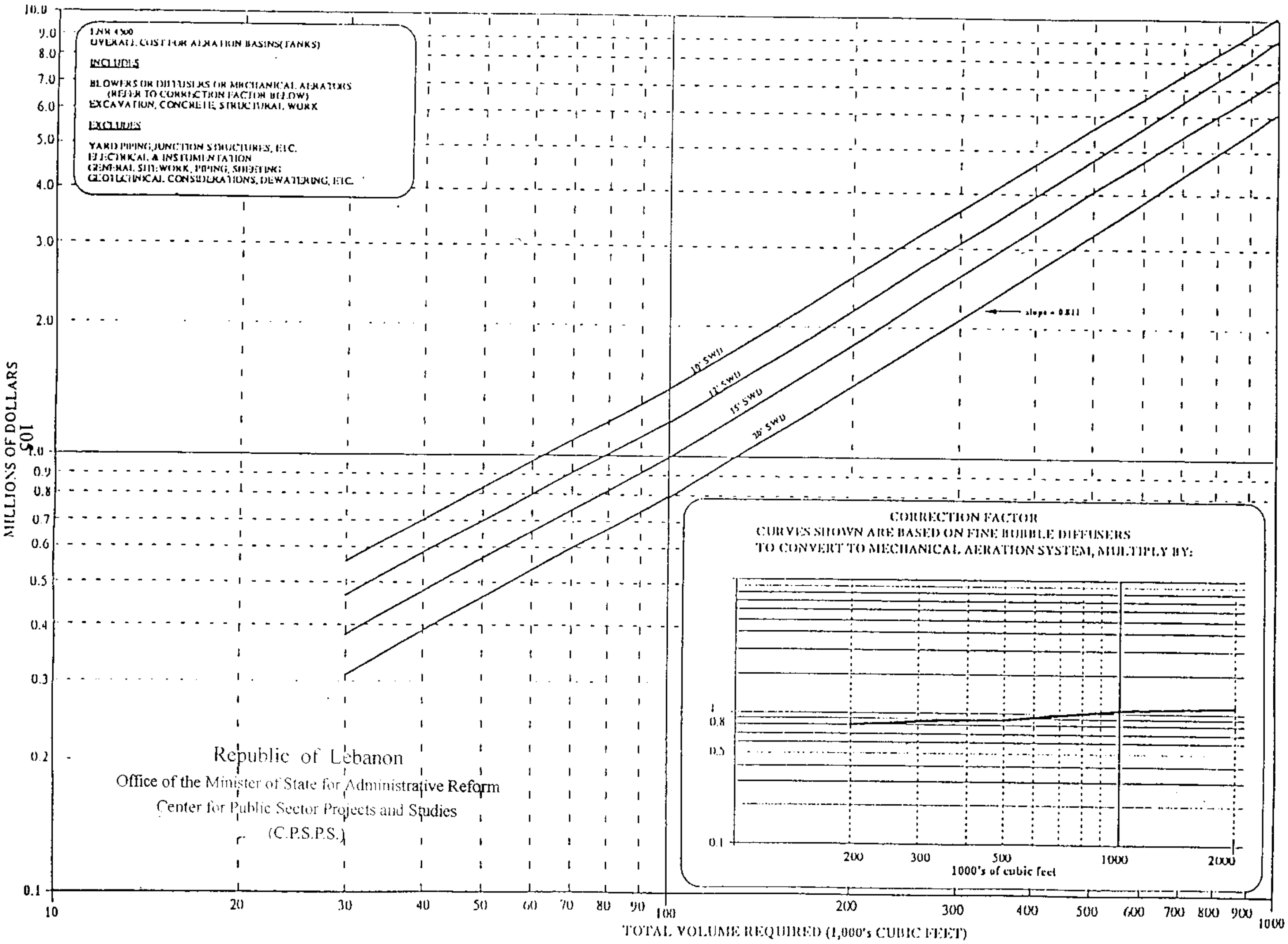
Horsepower	Kilowat.
1	0.7457
2	1.4914
3	2.2371
4	2.9828
5	3.7285
6	4.4742
7	5.2199
8	5.9656
9	6.7113
10	7.457
20	14.914
30	22.371
40	29.828
50	37.285
60	44.742
70	52.199
80	59.656
90	67.113
100	74.57
200	149.14
300	223.71
400	298.28
500	372.85
600	447.42
700	521.99
800	596.56
900	671.13
1000	745.7

square feet	meter square
1	0.092903
2	0.185806
3	0.278709
4	0.371512
5	0.464515
6	0.557418
7	0.650321
8	0.743224
9	0.836127
10	0.92903
20	1.85806
30	2.78709
40	3.71612
50	4.64515
60	5.57418
70	6.50321
80	7.43224
90	8.36127
100	9.2903



Source : METCALF & EDDY

Figure A10.14.3 CIRCULAR CLARIFIERS/SETTLING TANKS



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(C.P.S.P.S.)

Source METCALF & EDDY

Figure A10.14.4 : AERATION TANKS (BASINS)

cubic feet	meter cube
1	2.83E-02
10	2.83E-01
20	5.66E-01
30	8.50E-01
40	1.13E+00
50	1.42E+00
60	1.70E+00
70	1.98E+00
80	2.27E+00
90	2.55E+00
100	2.83E+00
200	5.66E+00
400	1.13E+01
700	1.98E+01
800	2.27E+01
900	2.55E+01
1000	2.83E+01