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FINAL REPORT ON THE SOUTH AUSTIN METROPOLITAN AREA OF THE EDWARDS AQUIFER

PREPARED BY THE
ENVIRONMENTAL MANAGEMENT DEPARTMENT

NOVEMBER, 1983

FOREWORD

Recognizing the importance of and the citizens of Austin concern for the protection of the Edwards Aquifer, Mr. Nicholas M. Meiszer, City Manager, appointed the Director of the Environmental Department, to form and head a Task Force of City staff members, to develop a report that describes the physical setting of the Aquifer and outlines the perceived problems, goals and past, present and future strategies for its protection.

This Report represents the collaborative efforts of many individuals working within various City of Austin Departments and professional areas in meeting the directives of the City Manager.

It will be evident to the groundwater expert that the Report is not highly technical. It does not purport to educate the expert other than to offer her/him mainly a compendium of information. It assumes that many people other than those professionally qualified to deal with the Edwards Aquifer are interested in its protection, and will be involved in programs to protect it.

We would like to acknowledge the assistance of the following City Departments in submitting information, comments and recommendations: Health, Public Works, Parks and Recreation, Planning, Water and Wastewater, Legal and Urban Transportation. We also appreciate the assistance of personnel at various state and federal agencies and concerned citizens that provided input.

The Report was compiled and edited by Dr. Juan Valera-Lema of the Department of Environmental Management.

Maureen McReynolds, Ph.D., Director
Department of Environmental Management

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SUMMARY AND RECOMMENDATIONS ABSTRACT

One of the most outstanding natural features of the Austin area is the underground water bearing formation known as the Edwards Aquifer. The exposed outcrop of the Edwards formation delineates the Edwards Aquifer recharge zone, which includes the Barton Creek watershed, as well as the tributaries of Onion Creek in and west of, the Balcones fault zone. These watersheds provide the water source for Barton Springs which flows from the Edwards formation. Presently a few users rely on the Edwards Aquifer of the South Austin Metropolitan Area to provide for their water needs and Barton Springs directly supplies water to Town Lake in the vicinity of the intake of one of the City's water treatment plants. However, the main importance of the Edwards Aquifer as a resource to the City of Austin and Central Texas, has mainly been emphasized through the recreational, cultural and historical values of Barton Springs.

The Edwards Aquifer has a limited ability to cleanse recharge water, therefore the quality of its water and the water in Barton Springs is directly dependent on the quality of water of the creeks (Barton, Onion, Williamson, Slaughter and Bear) that contribute to the recharge. The water quality in these creeks, in turn, depends on the quality of the runoff of their contributing watersheds. Pollution from urban development sources may enter the creeks which cross the recharge area in the Balcones fault zone. The polluted water can then rapidly infiltrate into the Edwards Aquifer through the fissures prevalent in the creekbeds throughout the zone.

The danger of pollution from urban development in the Edwards Aquifer recharge zone poses a serious limitation to development in that

zone. Presently, it can be stated that the waters of the Aquifer and of Barton Springs are of very high quality, however, there have been some isolated instances that point to potential water quality degradation of Barton Springs and which could be attributed to urban development activities in the recharge zone.

As the process of urbanization continues in the areas of the Edwards Aquifer, it is expected that more serious groundwater pollution problems may be encountered. Therefore, a series of recommendations have been outlined in this report, with the intention of planning the urban development in the Austin Metropolitan Area of the Edwards Aquifer in an environmentally sensitive manner and with the prime objective of protecting one of the most important natural resources of the Austin area.

The following is an abstract of the recommendations of the report. A more detailed description of the recommendations will be found in the body of the Report.

1. Establish an intergovernmental task force of municipalities and agencies with jurisdiction over the Edwards Aquifer, to develop a regional strategy for the protection of the Aquifer.
2. Develop a regional public education and information program to create awareness of the importance of protection of the Aquifer.
3. Improve the coordination of review and exchange of information in the Edwards Aquifer related watersheds.
4. Continue the review of ordinances, policies and regulations relevant to protection of the Aquifer and evaluate and modify them to meet the goals of the City.

5. Continue and expand the research to improve the understanding of the hydrogeology of and impact of urbanization on the Aquifer
6. Provide for comprehensive evaluation and/or Environmental Assessments of development of the area of the Aquifer.
7. Identify and assess significant natural and cultural resources and provide for their preservation.
8. Develop a water and wastewater master plan that addresses provision of services in environmentally sensitive areas.
9. Discourage the construction of septic tanks and package treatment plants. Prohibit land fills and potentially polluting industrial uses. Regulate the transport or disposal of toxic chemicals over the area of the Aquifer.
10. Encourage the use of surface water sources rather than ground water in the Edwards recharge zone for drinking water supplies.
11. Control the quality of urban runoff.
12. Initiate a land use study and landowner projection of land use in the area of the Aquifer.

REPORT

ON THE SOUTH AUSTIN

METROPOLITAN AREA OF THE

EDWARDS AQUIFER

I. THE PHYSICAL SETTING

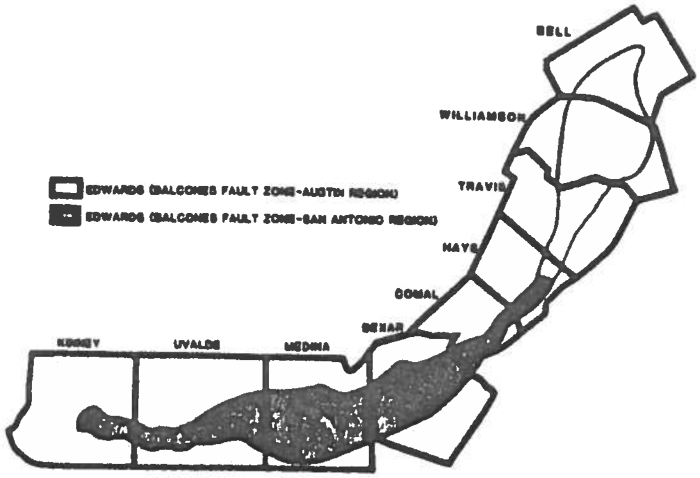
Geography.

The Edwards Aquifer is a complex limestone formation which outcrops in Kinney County, Texas and extends in an arcuate fashion through Central Texas into Bell County. The southern portion of the Aquifer, which spans from Kinney to Hays County, and is referred to as the "San Antonio area" (Fig. 1), supplies drinking water to over one million people, including the City of San Antonio, and has been designated a sole-source aquifer by the Environmental Protection Agency.

The northern section of the Edwards outcrop and referred to as the "Austin area" seems to be hydrologically separated from the "San Antonio area." The Austin area includes parts of Hays, Travis, Williamson and Bell Counties and extends about 80 miles in length from near Kyle to near Belton in Bell County, and has an irregular width of from 4 to 40 miles. The narrow portion is along the Colorado River in Austin (Fig. 1). About 1100 square miles are included within these boundaries.

The section of the "Austin area" aquifer which is the subject of this report, can be identified as the South Austin Metropolitan area of the Edwards Aquifer. The area, south of the Colorado River, is located in Travis and Hays counties and more specifically it encompasses the Barton, Onion, Williamson, Slaughter and Bear Creek watersheds (Fig2).

Figure 1.



Regions of the Edwards Aquifer

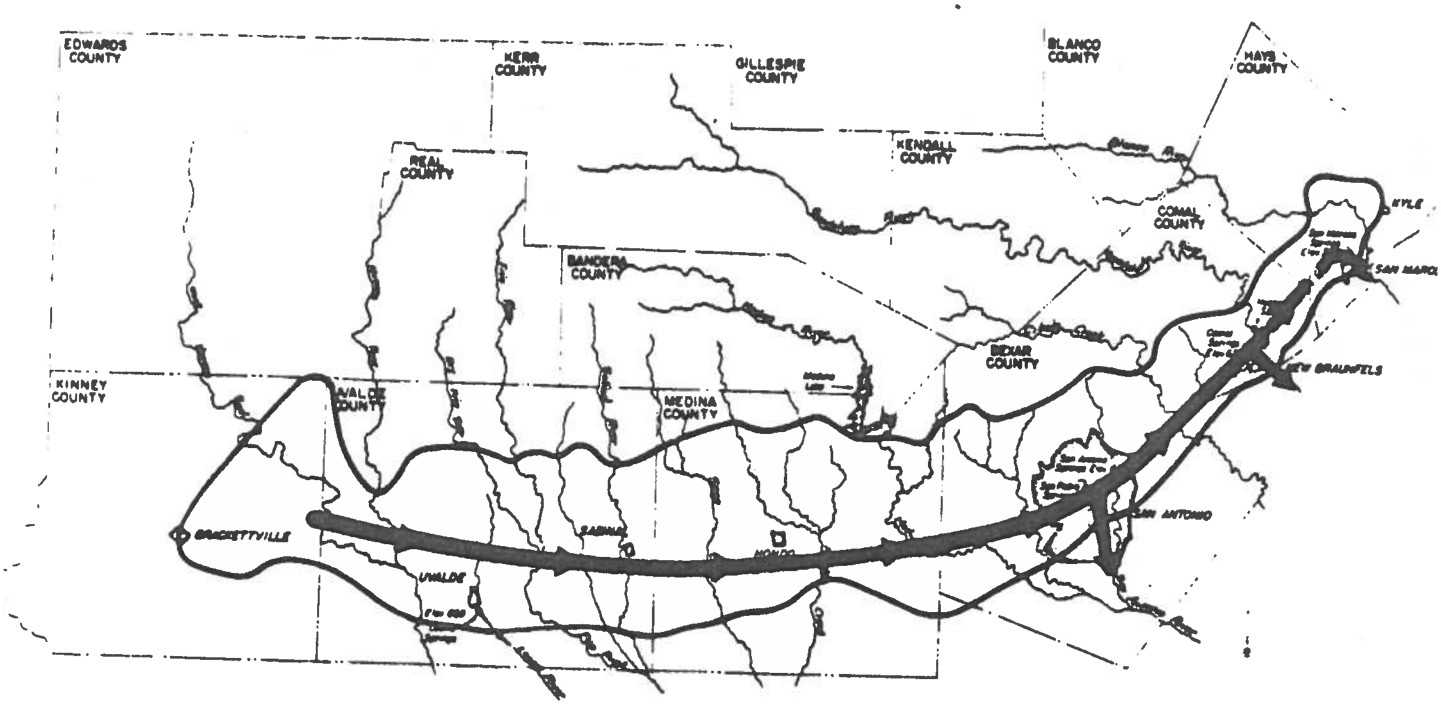
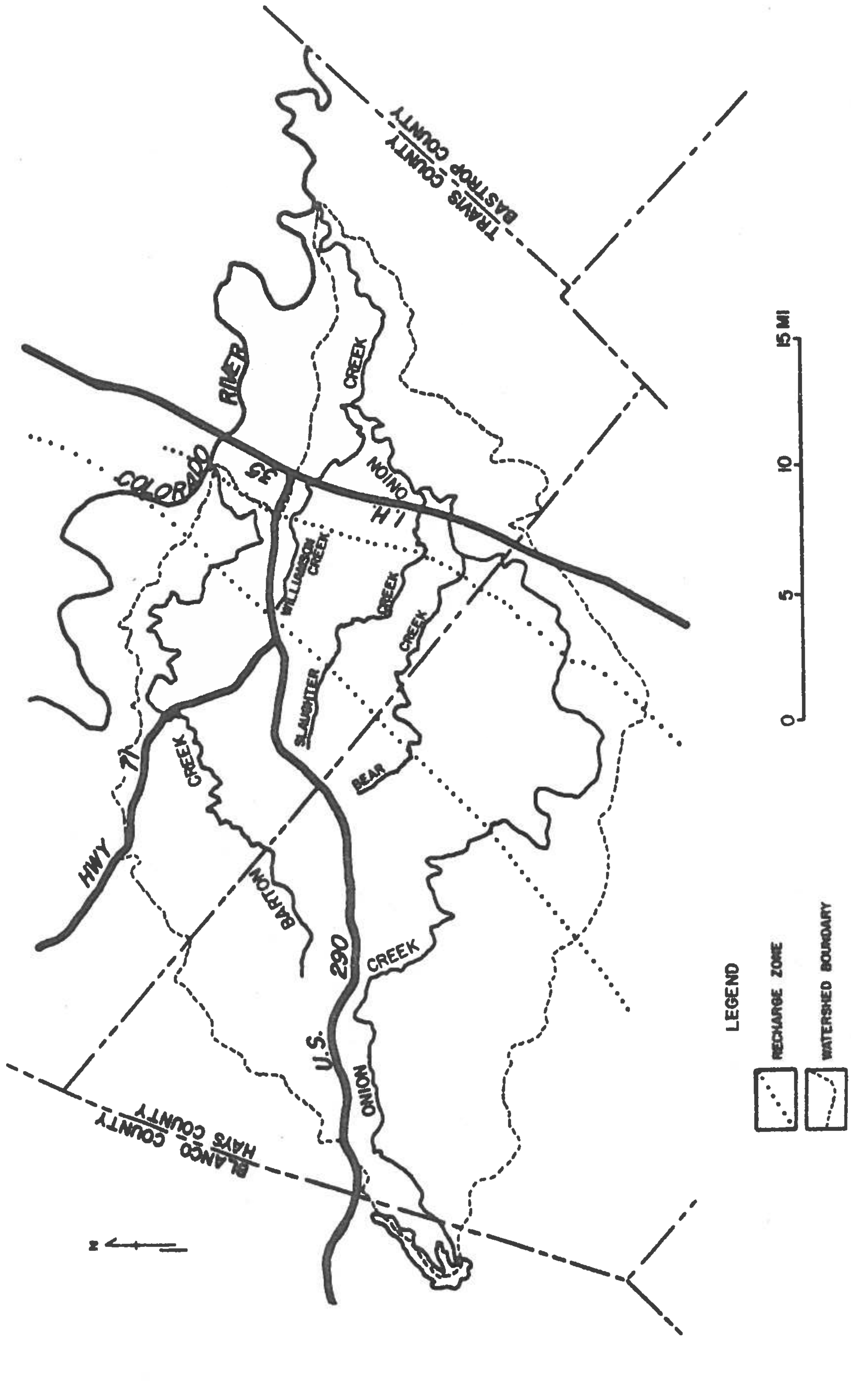


Figure 2.



The South Austin Metropolitan Area of the Edwards Aquifer

Hydrogeology[1]

Underground water resides in what are called aquifers. An aquifer is a layer of sand or rock that can store, transmit and yield water. The water is in the pores and cracks within the rock and sand. When water seeps through the soil or runs over cracks of porous rocks, it enters the ground. This process is called infiltration. Water also infiltrates the ground directly from rainfall (the amount of water entering the ground is especially large in the Edwards Aquifer area where the openings are extensive and numerous). Water travels downward into the ground through the soil and continues through permeable layers until reaching the impermeable layers. The water continues to collect in the porous rock and fills the pores. This is known as the zone of saturation because the pores are filled with water. The area above the zone of saturation is called the zone of aeration. In this zone the pores are partially filled with air. The junction of the two zones is the water table.

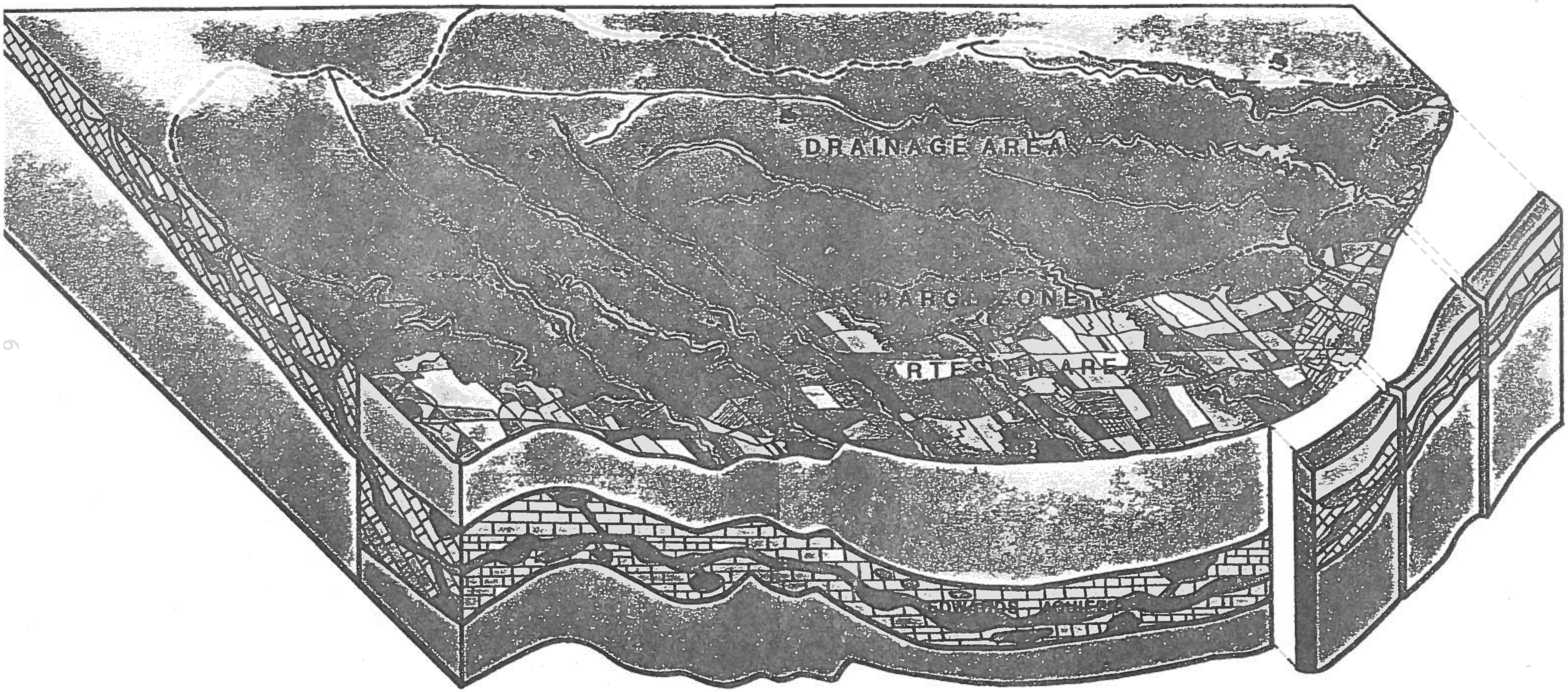
The Recharge zone of the Edwards Aquifer (Fig. 3) is that portion of the aquifer system where water sinks into the water to refill or, to be precise, recharge the underground system. Geologically speaking, the recharge zone is defined as the area where the Edwards and associated limestone formations, which is the waterbearing unit comprising the aquifer, are at the surface (the "outcrop"). Therefore, this Zone is a critical component in the aquifer system in terms of the amount of water which will be available for eventual use in irrigation, for urban purposes, and as spring flow. Water leaving the aquifer is referred to as discharge. Discharge occurs through wells or springs.

Most wells require pumping to produce water; however, some wells are in artesian aquifers. An artesian aquifer occurs when the water, which is confined by impermeable layers, rises or has the potential to rise above the surface. A spring is defined as a natural discharge of water from an aquifer. Some springs occur along the sides of valleys that have eroded below the level of the water table. This type of springs is found in the Edwards Plateau area and supplies water to the streams which eventually cross the recharge zone. Many of these streams lose their normal base flow into the recharge zone. Water is also discharged through water supply wells.

The outcrop of the Edwards Aquifer approximates the recharge area of the aquifer, although more precisely the boundary of the recharge area departs in places from the aquifer outcrop. The outcrop of the Edwards Aquifer has formed soils that are typically dark brown, grayish brown, reddish brown, silty to clayey loams. These soils have developed on the underlying limestone and marl that comprises the aquifer. The soils usually range in thichness from less than 5 inches to as much as perhaps 5 feet. In some places, however, soils are absent especially on the steep slopes, and where the bedrock is exposed.

The bedrock of the Edwards Aquifer outcrop consists of mostly hard to soft limestone but some interbedded marl is present on the outcrop and in the subsurface. The limestone and dolomite on the outcrop is typically dense, grayish to white, and massive. In some areas thin beds create a flaggy appearance. Chert is common in the limestone as hard nodules. In zones of intense weathering, honeycoming is characteristic, and in a few areas sinkholes and caves or caverns may be seen.

FIGURE 3



Since the *Edwards Formation* yields large quantities of water in many areas, it is referred to as the *Edwards Aquifer*.

Solution features, such as honeycombing, sinkholes, and caverns, allow for rapid infiltration of water on the outcrop as well as for rapid movement of groundwater within the aquifer. The intense faulting at the outcrop is an important feature that causes many of the solution features to develop.

The subsurface of the Edwards Aquifer within the report area varies in depth from place to place. A knowledge of the aquifer, elevation and depth to the top and base of the aquifer provides practical guidelines for drilling wells and, in general, for properly managing the orderly development and protection of the aquifer.

Channel gain and loss investigations on the 5 streams (Barton, Williamson, Slaughter, Bear and Onion Creeks) showed that moderate to large losses in streamflow occurred on the outcrop. These losses were more pronounced in the vicinity of faults, which facilitate groundwater recharge.

Major recharge to the Aquifer occurs in the major stream channels; minor recharge occurs in the tributaries to these streams. Therefore, it can be argued that if the water in the streams can be kept to an acceptable quality, then the Aquifer will remain of acceptable quality. Some recharge may occur along faults and via sinkholes away from stream channels. Natural groundwater discharge from the Edwards by springflow usually occurs near the eastern margin of the aquifer outcrop.

Barton Springs is the major site of groundwater discharge in the Austin area. Water that enters the Edwards Aquifer from precipitation and from stream flow south of the Colorado River in parts of

Travis and Hays Counties moves regionally northward through underground channels towards Barton Springs where an average 50 cfs are discharged daily. This spring flow then sustains the flow of Barton Creek which empties into Town Lake on the Colorado River. Discharge at Barton Springs was considerably below average in 1980 and considerably above average in 1979 and 1981. Near normal springflow may be expected whenever rainfall is near normal for an extended period of time. This relationship, however, is predicated on the basis that pumping of groundwater south of the Colorado River in the recharge zone remains minimal.

Water Quality.[2]

The quality of the Water in the Edwards Aquifer is directly affected by the total environment of the water from its origin as rainfall to its ultimate discharge from wells and springs in the aquifer. A major portion of dissolved matter in the groundwater is from the substance in the rocks that compose the aquifer. Another portion of the constituents found in water from the Edwards aquifer originated outside the aquifer between the time the relatively pure rainfall impacted upon the earth and its later entry into the aquifer from overland runoff. During this time various constituents, including possible human-related contaminants, are carried by the water, into the recharge zone of the aquifer.

The chemical quality of the water from Barton Springs is not constant but varies with the rate of flow. In general, the higher amounts of dissolved solids are associated with the lower flow rates.

As an example, during 1978--a year that was characterized by much lower-than-average flow of the springs--the dissolved solids were as much as about 415 mg/l when the flow was about 20 cfs. This relationship is reversed during periods of higher-than-average flow. At these times, the dissolved-solids content usually is less than 350 mg/l and has dropped below 300 mg/l during some high-flow periods. These variances are related to the different lengths of time that the water from recharge is in transit in the aquifer before being discharged. In the case of extended periods of below-normal flow, the increased mineralization is due to increased proportions of more highly mineralized water being contributed to the springflow from the zone of poorer-quality water in storage in the aquifer.

In August of 1981, the City of Austin began an intensive fecal coliform monitoring program of Barton Springs. Weekly samples were collected by the U.S. Geological Survey and analyzed for physical-chemical and microbiological properties. In January, 1982, the U.S.G.S. notified the City that levels of fecal coliform above 200 colonies/100 ml had been found in the Springs after rains of one inch or more. On February 16, a fecal coliform level of 4500 colonies per 100 ml was reported by the U.S.G.S. The apparent anomaly of a high fecal coliform count not preceded by one inch or greater rainfall raised conerns about possible leakage from sanitary sewers in the area.

Footnote 1 and 2. The Hydrogeology and Water Quality.
The information contained in these sections of the report are excerpts from a draft document entitled "Ground Water Resources of the Edwards Aquifer System in the Austin Area, Texas" which has been produced and is being readied for publication by a research team from the U.S. Geological Survey and the Texas Department of Water Resources. Those readers desiring a in-depth technical description of the hydrogeology of the Edwards aquifer system in the Austin area are advised to review the above mentioned document.

Daily monitoring generally showed very low fecal coliform levels at the Springs, except after rainfall events. Until November 1982, there appeared to be a human contamination source. After repair of three (3) breaks in the sewer lines near the creak, the bacteria pattern changed. There now appear to be persistent non-human sources of bacteria as measured by the ratio of fecal coliform to fecal streptococcus which contribute to the runoff related increases in bacteria at the Springs. These bacteria could originate in fecal matter of wild or domestic animals. Certain types of plants or soils may also contain bacteria which respond positively to the streptococcus test.

Soil Permeability

Permeability is an index of the rate at which water moves, or percolates, through the soil; it is a measure of the amount of interconnection of the pore spaces in the soil. Porosity is a measure of the volume of these pore spaces in a given volume of soil. Together these measures characterize the movement of groundwater.

Porosity and therefore permeability, is a function of the sorting, shape and arrangement of the grains making up the soil (its texture). Soils made up of large particles are said to be coarsely textured, while soils made up of smaller particles are said to be finely textured. The coarsely textured soils are commonly more permeable than the finer ones because they have larger spaces between their particles through which water can move.

In addition to soil texture, soil permeability is also affected by soil water content, vegetation and interparticle chemical deposits.

Of these additional factors, vegetation is perhaps the most significant as it both slows runoff from rainfall, allowing it to enter the soil, and provides, along the root of plants, points of entry and routes of movement of water. Where there is thin or no soil cover, as in the Edwards Aquifer Recharge Zone, permeability is largely controlled by fractures in the limestone bedrock. Soil Permeability is a key factor in the environmental management of the Edwards Aquifer area because of its relationship to septic tank suitability and aquifer protection and recharge.

The issue of aquifer protection is closely tied to soil permeability, especially in the Recharge Zone. The potential for contaminated water entering the aquifer poses so great a threat in the Recharge Zone that the siting of land uses with the capacity to discharge contaminated water must be carefully regulated. These uses include large commercial and residential projects with their associated parking lots and streets, as well as the more obvious industrial and agricultural uses.

Soil permeability is also a factor in aquifer recharge. The more permeable the surface over the Recharge Zone, the greater the amount of recharge that can occur through it. The amount of recharge can be reduced by haphazard urbanization, as permeable surfaces are replaced by impermeable concrete and asphalt ones; the construction of drainage systems however, can largely mitigate the effects of urbanization on recharge. Urbanization also tends to reduce the amount of vegetative cover, which may affect the rates of infiltration and surface runoff. Much of the recharge to the Edwards Aquifer, however, occurs directly in streambeds through outcrops and fractures of Edward's Limestone where there is little vegetation and the potential for urbanization is minimal. Urban runoff, of course, can affect the quality of the recharge waters.

Uses - Recreational, Water Supply.

The Edwards Aquifer in the Austin area is only slightly to moderately developed by wells. Unlike the San Antonio area where pumping from the Edwards Aquifer by the City of San Antonio and by irrigators is large, the aquifer in the Austin area is not pumped for municipal use by the City of Austin or used extensively for irrigation.

In Travis and Hays Counties, the total amount of groundwater discharged in 1978 and 1979 was 35,500 and 68,000 acre feet respectively. About 90 percent of the total water that was discharged is springflow, most of which is from Barton Springs. Cold and Deep Eddy Springs have a combined flow of about 2900 acre - feet per year. The 4,000 to 6,000 acre - feet of water that was discharged from wells in Travis and Hays Counties was mostly from municipal and industrial wells. Major municipal users include the Cities of Buda, Kyle, Sunset Valley, and San Leanna as well as the town of Manchaca.

The significance of Barton Springs in the Austin area abviously cannot be overemphasized. Besides its hydrologic role as the major point of discharge of the Edwards water, Barton Springs serves as a dependable source of stream flow for recreational use. Additionally, Barton Springs directly supplies water to Town Lake in the vicinity of the intake for one of the City of Austin's water treatment plants.

Groundwater recharge to the Edwards Aquifer is still essentially in balance with discharge from the aquifer. Springflow, the principal means of groundwater discharge is directly related to rainfall. Pumpage of ground water by wells can be an added stress on the aquifer, but at least until now, it has not had significant regional effect on the water level.

Ground water pumping, however, is expected to increase because of the rapid urban development that has been occuring in the South Austin Metropolitan Area of the Edwards Aquifer (Barton, Onion, Williamson, Slaughter and Bear Creek watersheds). For this reason, water-level trends cannot necessarily be projected to continue at the same rate into the future. Continued water-level monitoring and evaluation of the Edwards Aquifer will be necessary for predictive purposes.

Urban Development

For the purpose of providing information on urban development in the area, it is necessary to focus on each of the watersheds that make up the area of interest for this study. Most of the information for this section has been obtained from the Demographic and Land use projections and Distribution Chapter of the Water and Wastewater Master Plan of the City of Austin prepared by Metcalf and Eddy, Inc. The source of information for the land use and population projections for the Master Plan was the City of Austin Planning Dept., which was also responsible for writing that entire section.

It should be pointed out that the study area of the Metcalf and Eddy report only extends to the five (5) mile ETJ of the City. Therefore, only Williamson and Slaughter Creek are totally within the study area, while only sections of Barton, Onion and Bear Creeks are included. However, the information contained in Metcalf and Eddy's report provides the best current source of information for urban development trends in the South Austin metropolitan area at the Edwards Aquifer.

Table 1 (one) provides information by watershed of population estimates for 1980 and growth management scenario populations for 1990, 2000 and 2005.

Table 2 (two) indicates population densities by watershed in 1980 and growth management scenario densities for 1990, 2000, and 2005.

Table 3 (three) gives an estimate of Land Use Data for the drainage basins for 1980 and Tables 4 (four) and 5 (five) provide estimates for land use increments by watershed for 1980-1990 to 2000 respectively. During the past few months there has been an even increased interest in development over the area of the Edwards Aquifer as exemplified by the South Austin MUD #1, the Circle C Ranch MUDs 1-4, the South Austin Growth Corridon MUD and Maple Run MUD. A person with extended knowledge of the area, Mr. Ira Yates states that "the entire growth corridor in Slaughter Creek, together with the above mentioned MUDs are the growth areas for the next ten years".

Table 1. Population estimates for 1980 and growth management scenario populations for 1990, 2000 and 2005.

WATERSHED	1980 Population	1990	2000	2005
BARTON	9,400	13,600	16,500	17,200
WILLIAMSON	47,000	73,600	92,600	100,800
SLAUGHTER	6,500	9,700	18,000	29,400
BEAR	500	1,000	2,400	5,900
LITTLE BEAR	700	700	1,000	1,600
ONION	8,900	12,700	23,300	34,500

Table 2. Population Densities of Drainage Basins in 1980 and Growth Management Scenario Densities for 1990, 2000 and 2005. (Persons/Gross Acre).

WATERSHED	1980 Pop./Acre (Gross)	1990	2000	2005
BARTON	0.28	0.41	0.50	0.52
WILLIAMSON	2.42	3.79	4.77	5.20
SLAUGHTER	0.35	0.53	1.01	1.59
BEAR	0.09	0.18	0.44	1.08
LITTLE BEAR	0.32	0.32	0.45	0.73
ONION	0.32	0.46	0.85	1.25

Table 3. Estimated Land Use Data for Drainage BAsin for 1980 (In Acres)

WATERSHED	RES.	COM.	IND.	STREET	PUBLIC	UNDEV.	%	TOTAL
BARTON	1,262	30	0	228	600	30,862	93.6	32,982
WILLIAMSON	4,119	451	386	1,380	260	12,664	65.4	19,360
SLAUGHTER	870	23	12	151	104	17,164	93.7	18,324
BEAR	1,221	111	370	572	1,406	19,507	84.1	23,184
LITTLE BEAR	38	0	0	6	15	2,048	97.2	2,107
ONION	168	2	0	35	31	5,022	95.5	5,258

Table 4. Land Use Increments by Watershed for 1980 - 1990

WATERSHED	RES.	COM.	IND.	PUBLIC	STREET	TOTAL
BARTON	1,139	61	0	33	99	1,332
WILLIAMSON	2,583	237	297	657	693	4,467
SLAUGHTER	517	14	9	83	135	758
BEAR	53	1	0	31	20	105
LITTLE BEAR	0	0	0	0	0	0
ONION	692	15	52	219	137	1,115

Table 5. Land Use Increments by Watershed for 1990 - 2000

WATERSHED	RES.	COM.	IND.	PUBLIC	STREET	TOTAL
BARTON	725	42	0	23	62	852
WILLIAMSON	1,819	117	147	476	442	3,061
SLAUGHTER	1,267	48	9	319	419	2,062
BEAR	175	4	0	52	65	296
LITTLE BEAR	35	0	0	10	13	58
ONION	1,584	51	51	319	419	2,062

II. NATURE OF THE PROBLEM ON GROUNDWATER QUALITY

Water Quality Characteristics Due to Natural Causes.

The physical, chemical, and biological quality of water may range within wide limits even though there are no man-made influences. In fact, it is often impossible or at least difficult to distinguish the origin (man-made or natural) of many water-quality problems. The natural quality reflects the types and amounts of soluble and insoluble substances with which the water comes in contact. Surface water generally contains less dissolved solids than groundwater, although in areas where groundwater is the major source of streamflow, the quality of both types is similar except during times of floods, when surface water in the streams dominates the groundwater contribution. During periods of surface runoff , streams may contain large quantities of suspended materials and under some circumstances, a large amount of dissolved solids. Most commonly, however, during high rates of flow, the water has a lower dissolved-mineral concentration.

Water Quality Influenced by Man's Activities.

For centuries man has been disposing of his waste products by placing them in streams, storing them on the ground, or by various methods putting them in the ground. Man-made influences on stream water quality reflect not only waste discharge directly into the stream, but also include highly mineralized or polluted surface runoff , which can carry a wide variety of substances. Another major influence on surface-water quality is related to the discharge of groundwater into the stream. If the adjacent groundwater is polluted, stream quality tends to deteriorate. Fortunately in the latter case, the effect in the stream will not be as severe as it is in the ground, due to dilution and dispersion of the pollutant. In most cases, however, the general quality of groundwater is such that it actually serves as a dilutant to man-caused surface-water pollution.

The quality of groundwater, in addition to natural inputs, is most commonly affected by waste disposal. Another major source of pollution is the storage of waste materials in excavations, such as pits or mines. Water-soluble substances that are dumped, spilled, spread, or stored on the land surface or in excavations may eventually infiltrate to pollute groundwater resources. Groundwater is also polluted by the disposal of fluids through wells and, in limestone terrains, through sinkholes directly into aquifers. Likewise, infiltration of highly mineralized surfacewater has been a major cause of underground pollution in several places. Irrigation tends to increase the mineral content of both surface and groundwater. The degree of severity of pollution in cases such as these is related to the hydrologic properties of the aquifers, the type and amount of waste, disposal techniques, and climate.

Man-influenced groundwater quality problems are most commonly related to: (a) water soluble products that are placed on the land surface and in streams; (b) substances that are deposited or stored in the ground above the water table; and (c) disposal, storage, or extraction of material below the water table. Many of the pollution problems related to these situations are highly complex, and some are not well understood. Technical solutions to many groundwater quality problems are straightforward and controls are easily implemented, at least insofar as techniques are concerned. Legal and social constraints, however, may prevent effective control.

A. Groundwater Quality Problems That Originate on the Land Surface

Many groundwater quality problems are caused by the disposal of wastes directly into streams and by the dumping, spreading, or storage of soluble substances on the land surface. The following table, although not all inclusive, lists the major causes of groundwater pollution that originate on the land surface.

1. Inflitration of polluted surface water.
2. Land disposal of either solid or liquid waste materials.
3. Stockpiles
4. Dumps.
5. Disposal of sewage and water-treatment plant sludge.
6. Salt spreading on roads, airport runways, and parking lots.
7. Animal feedlots.
8. Fertilizers and pesticides.
9. Accidental spills of hazardous materials, including atomic wastes.
10. Particulate matter from airborne sources.

B. Groundwater Quality Problems Which Originate In the Ground Above the Water Table

Many different types of materials are stored, extracted, or disposed of in the ground above the water table. Water pollution can originate from many of these operations. Some of these are:

1. Septic tanks, cesspools, and privies.
2. Holding ponds and lagoons.
3. Sanitary landfills.
4. Waste disposal in excavations.
5. Leakage from underground storage tanks.
6. Leakage from underground pipelines.
7. Artificial recharge.
8. Sumps and dry wells.
9. Graveyards.
10. Sanitary sewer collection lines.

C. <u>Groundwater Quality Problems that Originate In The Ground Below The Water Table</u>

The following table lists a number of major causes of groundwater pollution produced by the use and misuse of space in the ground below the water table.

1. Waste disposal in wet excavations.
2. Drainage wells and canals.
3. Well disposal of wastes.
4. Underground storage.
5. Secondary recovery of petroleum products.
6. Mines.
7. Exploratory wells.
8. Abandoned wells.
9, Water supply wells.
10. Groundwater development (Exploration and Pumping).

Urbanization and Groundwater

Urbanization can refer to the change in land use from a predominantly agricultural area with only scattered housing, or otherwise undeveloped lands, to a residential area of low to medium density, or to a change from a low density suburban area to high density residential-industrial area. The first change involves installation of wells and septic systems and a small increase in impervious land area. The second change can involve installation of sewer systems and deep, large capacity wells and loss of aquifer recharge due to large increases in impervious area.

Urbanization can result in lowered groundwater levels, loss of recharge to aquifers, and degradation of water quality in streams and goundwater. The lower groundwater levels can be caused by increased pumping from the aquifer and loss of recharge due to development in recharge areas. Water quality changes can be caused by high infiltration of contaminated runoff. Lowered groundwater levels can contribute to quality problems by inducing infiltration from surface water bodies or waste disposal sites. These problems highlight the need of areas experiencing urbanization to protect aquifer recharge zones and to consider the effects on groundwater quality of land use and zoning policies.

Reclamation of Contaminated Aquifers

Aquifers react in a manner similar to a sponge. Visualize, for example, a bath sponge that has been liberally injected with soap. Even though the soapy sponge is filled and the water squeezed out of it many times, soap bubbles continue to appear with each new flushing.

It may require hours of flushing and squeezing to remove all the soap.

The situation is similar in polluted aquifer--once polluted, they may be exceedingly difficult or impossible to reclaim. The polluted water in the aquifer can be treated, perhaps even economically, but the earth materials forming the aquifer cannot be so treated. Several natural processes tend to degrade or remove certain substances as polluted water flows through an aquifer. These natural renovation processes include dispersion and dilution, in addition to several geochemical reactions which act as filtration. Techniques to restore an aquifer include pumping the polluted groundwater and diluting it by artificial recharge methods that are expensive and commonly of questionable economic value. Obviously the most effective method of groundwater quality control is protection from pollution.

III. THE PERCEIVED PROBLEMS OF GROUNDWATER PROTECTION IN THE SOUTH AUSTIN METROPOLITAN AREA OF THE EDWARDS AQUIFER

The superior quality of Austin's environment is identified in large measure with its natural landscape--the hills, creeks, streams and waterways--and with public enjoyment and concern for protection of these natural resources.

One of the most outstanding natural features of the Austin area is the underground water bearing formation known as the Edwards Aquifer. The exposed outcrop of the Edwards formation defines the Edwards Aquifer recharge zone which includes the Barton Creek watershed, as well as the tributaries of Onion Creek in, and west of, the Balcones fault zone. These watersheds provide the water source for Barton Springs which flows from the Edwards formation. Presently, a few users rely on the Edwards Aquifer of the South Austin Metropolitan area to provide for their water needs and Barton Springs directly supplies water to Town Lake in the vicinity of the intake of one of the City's water treatment plants. However, the main importance of the Edwards Aquifer as a resource to the City of Austin and Central Texas, has mainly been emphasized through the recreational, cultural and historical values of Barton Springs.

The Edwards Aquifer has a limited ability to cleanse recharge water, therefore, the quality of its water and the water in Barton Springs is directly dependent on the quality of water of the creeks (Barton, Onion and its tributaries) that contribute to the recharge. The water quality in these creeks, in turn, depends on the quality of the runoff in their contributing watersheds. The watercourses themselves, like the beach between land and sea represent crucial interface areas where filtration occurs as runoff is held by vegetation and in marshy areas before recharging the aquifer. Creeks by their very nature are formed in areas less resistant to erosion, usually exhibiting greater porosity. Pollution from urban runoff and sewage treatment systems may enter the creeks which cross the recharge area in the Balcones fault zone. The polluted water can rapidly infiltrate into the Edwards Aquifer through the cracks, fissures and cavities prevalent in the creek beds throughout the zone. The danger of pollution from urban development in the Edwards Aquifer recharge zone poses a serious limitation to development in the Barton Creek watershed and parts of the watersheds of Onion Creek and its tributaries.

At the present, based upon preliminary evaluations of the Edwards Aquifer, it can be stated that the waters of the Aquifer and of Barton Springs are of very high quality, however, there have been some isolated instances, as those described below and in the water quality description of the section of this report, that point to potential water quality degradation of the Springs.

<u>Turbidity</u>

Local newspaper articles during the early part of the century report that floods in the Austin area caused extensive damage to and siltation at the Barton Springs Pool, that resulted in temporary closings of the pool. The sporadic flood events, together with the concern that disturbance of the watershed by urban development activities would add to the problems of siltration and turbid waters in the pool, prompted the City of Austin to build a flood water bypass at Barton Springs.

Installation of the bypass was completed in 1976 and it has enabled the pool to continue operating during most of the summer season; whereas without the bypass normal operations would have been severely curtailed.

A September 1982 report by the manager of Barton Springs Pool states that: "Another unanticipated benefit of the bypass has emerged in the last two years. Many times after heavy rains, the fecal coliform levels in Barton Creek have remained long after they have decreased to safe levels in the pool. If the creek water continued to flow through the pool, we would have to close several days longer to allow the fecal coliform bacteria levels to go down in Barton Creek before opening the pool to swimmers. Along the same lines, the creek water remains turbid long after the pool clears. Again the pool would have to remain closed until the water in the creek cleared up. This would result in additional days closed. In 1982, this would have caused the pool to be closed at lease 10 extra days."

The Barton Creek Square Mall

One of the major concerns in the preservation of water quality in Barton and the other creeks that contribute to the recharge of the Edwards Aquifer is the erosion and sedimentation problem caused by development activities within the watersheds of these creeks. Problems were encountered in the clearing, evacuation, grading and construction phases of developeing the Barton Creek Square Mall and the south extension of Loop I (MoPac Boulevard).

The Barton Creek Square Mall is located at the northwest corner of the intersection of Loop 360 and Loop 1 South. The entire site for this center, with the possible exception of several acres on the northern boundary, lie within the Barton Creek watershed. The site contains approximately 101 acres of paving, 21 acres of building and 24 acres of open, landscaped or conservation area.

In 1975, at the time the GR zoning was recommended by the Planning Commission and granted by the City Council, the developers agreed to deed restrictions to protect Barton Creek. Review of the site work and drainage plans revolved primarily along the restrictive covenants agreed to at the time of zoning and the creek ordinance provisions for development affecting a waterway, which are primarily associated with erosion and sediment control:

1) Detention ponds to allow silt to settle before discharge to the creek.
2) Berms to direct runoff away from slopes.
3) Hay bales or, brush berms to filter silt from runoff.

Difficulties in consistently achieving erosion controls arose because of several factors:

1) The large size of the exposed soil surfaces.
2) The steep slopes.
3) Initial coordination problems between city staff and representatives of the Indiana development firm.

4) Hay bales were not as effective as predicted.

5) Difficulties in revegetating the disturbed areas.

During the construction of this project, the City of Austin received reports from citizens that silt from the Mall entered Barton Creek after rains. It was also suggested that silt had entered the Edwards Aquifer via Barton Creek and this had resulted in cloudiness of the water at Batton Springs. Cursory investigations and observations by City and U.S.G.S. staff, tend to substantiate these claims, but no regular monitoring was done to determine quatities of pollutants leaving the Mall site and entering the Creek.

In the summer of 1981, City staff were informed of turbidity in the Creek as a result of construction upstream from the mall site. Approximately 24 - 36 hours later, the Springs became cloudy. This event suggest that silt in the Creek can be conveyed directly to the Springs.

Diethyl Phthalate

In October 1981, the U.S. Geological Survey took samples at Barton Springs during a rainstorm. They tested samples for various possible urban runoff contaminants as part of their contract with the City.

An organic chemical called diethyl phtlalate was found at a concentration of 110 micrograms/liter. The U.S.G.S. did a second sample in mid-December (under non-storm conditions) and recorded levels of 1.2 micrograms/l and 0.8 micrograms/l in two separate tests. On December 30, they collected a third sample. In order to be certain that the results were not a function of sampling analysis errors, Aqua Lab, a local water quality testing laboratory, collected an independent sample. Both laboratories reported a barely detectable quantity of diethyl phthalate in these samples.

Diethyl phthalate is one of the "priority pollutants" listed by EPA. It is midly toxic and probably not toxic in the levels found. There has, however, been one report that this compound causes birth defects (its teratogenic) when injected in rather large amounts. There is suspected carcinogenicity, but that has not been demonstrated conclusively.

From subsequent testing of the Springs and the failure to detect diethyl phthalate in the water, it has been determined that this may have been an isolated contamination event or a result of sampling error.

Fecal Coliform Counts

The Barton Springs intensive monitoring program began in August, 1981. Weekly samples were collected by the U.S. Geological Survey and analyzed for physical-chemical and microbiological properties. In January, 1982, the U.S. Geological Survey notified the City staff that levels of fecal coliform above 200 colonies/100 ml had been found in the Springs after rains of one inch (1") or more.

On February 16, 1982, a fecal coliform level of 4500 col/100 ml was reported by the U.S.G.S. There had been only a trace of rainfall in the previous 24 hours. The apparent anomaly of high fecal coliform count not preceded by 1" or greater rainfall raised concerns about possible leakage from sanitary sewers in the area. The City immediately initiated a daily monitoring program for fecal bacteria.

The City continued its daily monitoring program for twelve months and recently has begun monitoring less frequently. Fecal coliform levels at the Springs have generally been very low except after rainfall events. The fecal coliform levels have returned to normal within two or three days after the rainfall event.

The State of Texas Department of Water Resources in its publication, Texas Surface Water Quality Standards (VIIII.) Lists two water quality criteria for surface water suitable for contact recreation.

"Surface waters suitable for contact recreation shall not exceed a logarithmic mean fecal coliform content of 200 organisms per 100 ml from a representative sampling of not less than 5 (five) samples collected over not more than 30 days, as determined by either multiple-tube fermentation or membrane filter techniques. No more than 10% of the total samples taken during any 30 day period shall exceed a logarithmic mean fecal coliform content of 400 organisms per 100 ml."

Table 6, shows the results from the first nine months sampling:

Table 6. Fecal Coliform Samples At Barton Springs

MONTH	# OF SAMPLES	GEOMETRIC MEAN OF FECAL COLIFORM	# OF SAMPLES EXCEEDING 400 ORGANISMS PER 100 ML
MARCH	30	36.9	7%
APRIL	30	15.0	14%
MAY	29	59.0	10.3%
JUNE	30	12.7	3.3%
JULY	31	2.2	0
AUGUST	30	2	0
SEPTEMBER	27	11.3	7.4%
OCTOBER	29	4.7	3.4%
NOVEMBER	27	18.5	7.4%

Although the geometric mean has not exceeded 200 organisms per 100 ml, during the months of May and April 1982 an excess of 10% of the samples taken contained over 400 organisms per 100 ml.

During February - November 1982, city staff attempted to locate the source or sources of bacterial contamination. Dr. Raymond Slade of the U.S. Geological Survey hypothesized that the source of bacteria would be very near the Springs. His hypothesis was based on observations and analysis by the U.S.G.S. on the rate of water movement within the Edwards Aquifer. He has found that during the winter months, the water gradient is relatively flat in the vicinity of Barton Springs. Travel time for water in this system is very slow. Since it has been reported that fecal coliform bacteria generally do not live longer than 48 hours in fresh water, he speculated that the bacteria were from a source within one-half mile of the Springs.

Literature indicates that waste from human sources tends to contain larger amounts of fecal coliform than fecal streptococcus and animal waste shows the opposite relationship.

Earlier water and wastewater maintenance personnel had surveyed sewer lines in the Zilker Park and Barton Hills areas using TV camera techniques. The Water and Wastewater Department felt that, if there were sewer line leaks, this area would most likely be the location because of the age of the lines.

An extensive list of possible cracks was developed by using the TV technique. The worst looking problems were investigated but only one cracked pipe was actually found. It was in Cliffside Drive. The leak was very small and appeared to be contained by clay soil around the line. The section of pipe was replaced.

Working with the U.S. Geological survey, the city crews turned to a quicker method of detecting leakage from lines--the use of a red tracer dye, rotamine. The dye can be added to sewer lines or septic systems. In this case, if a leak were present dye could show up at Barton Springs.

Four sewer lines in the immediate vicinity of Barton Springs Pool were dyed during separate rainfall events. The U.S.G.S. placed a floating automatic sampling device in the pool water. The sampler collected samples every 100 minutes for about 1½ days.

No dye was recovered from testing three of the four lines. Dye was recovered when the 4th line was tested. This line crosses Barton Creek from the north side of the pool and provides wastewater collection service to the Stratford Drive area along Town Lake. After the dye test indicated that there was a leak from the sewer line, the wastewater crew used the TV camera to locate the break. A substantial displacement was observed in the line and that section of line was replaced.

After this section of line was replaced in May, 1982, there was a period of very little rainfall.

Almost without exception, elevated bacteria counts during February to November period followed rainfall events. The anomalous result of February 16, appears to be related to the action taken that date by the Parks Department to lower the pool for cleaning. The pool was lowered below the level of the Springs, approximately five feet. This could have created a hydraulic gradient which conceivably could simulate a runoff surface phenomenon event regarding fecal bacteria elevation.

Bacterial counts following three fall rainfall events (table 7) suggested that a human source of contamination still existed as late as November, 1982. The relationship of fecal coliform to fecal streptococcus density may provide information on the potential source(s) of contamination. Ratios greater than 4:1 are indicative of pollution derived from domestic wastes containing man's body wastes. Ratios of less than 0.7 suggest that contamination originates from non-human sources. There are several precautions to be observed when ratios are being used.

1) Bacterial densities can be altered drastically when the ph of the sample is below 4.0 or above 9.0.
2) Due to the limited survival capability of some of the fecal streptococci, it is essential to sample close to the pollution source to obtain reliable ratios.
3) It is difficult to use ratios effectively when mixed pollution sources are present.

Table 7. Bacterial counts at Barton Springs following three rainfall events.

DATE OF RAINFALL	AMOUNT	FECAL COLIFORM	FECAL STREPTOCOCCUS	FC/FS
9-3-82	0.58"	4	5	.8
9-5-82	0	5700	770	7.4
10-28-82	0.39"	7	19	.37
10-30-82	T	60	360	.17
10-31-82	0	460	52	8.8
11-23-82	0.24"	21	16	1.3
11-24-82	0.15"	4	8	.5
11-25-82	0.14"	1120	860	1.3

4) If fecal streptococcal counts are less than 100/100 ml., ratios should not be applied.

During the September to November sampling, at least eleven additional rainfall events occured. Following these rains, the fecal streptococcus level was considerably higher than the previous 24 hour period, with fecal coliform levels only slightly raised. The ratio of fecal coliform to fecal streptococcus after those eleven events indicates a non-human source for bacteria.

There appear to be persistent non-human sources of bacteria which contribute to the runoff related increased in bacteria at the Springs. These bacteria could originate in fecal matter of wild (raccoons, opposum, deer, etc.) or domestic (dog, cats) animals. Certain types of plants or soils may also contain bacteria which respond positively to the fecal streptococcus test.

In November, 1982, the Water and Wastewater Department repaired a sewer line in the Barton Hills area where effluent appeared to flow into a tributary of Barton Creek near a fault line. Since that time, the fecal coliform to fecal streptococcus ratios after storm events have ccnsistently indicated a non-human source of the bacteria. Furthermore, the fecal coliform levels have rarely exceeded 200 colonies/100 ml.

Although there currently does not appear to be contamination of Barton Springs from human sources, the Springs are still monitored regularly. If bacteria counts at some future date indicate a probable human source of contamination, sewer lines in the area will again be checked.

Non-human sources of bacterial contamination can also be checked. Initially, the City staff plans to look at tributaries of Barton Creek near the pool. Since runoff from streets empties into storm drains and these to Barton Creek, opportunities for control of non-human sources of bacteria in this heavily urbanized area are limited.

Septic Tanks and Package Treatment Plants

A recent report (January 27, 1983) by the Health Department of the City of Austin estimates that there are approximately 1000 individual sewage disposal systems on the Edwards Aquifer recharge zone within Travis County. Pollution from septic tank systems can potentially occur from both system failures and the installation of inappropriately designed systems. Health Department records indicate 64 system failures on the recharge zone since 1978, with another 11 failures recorded immediately to the west of the recharge zone.

During system failure, overflowing effluent may find its way into a creek or tributary and enter the aquifer through a fault or possibly drain directly into an undetected fault. Extensive development with septic systems in the recharge zone is likely to confine pollution to localized areas. Once development is completed, however, it is almost impossible to locate these critical areas. Generally, a septic system failure that would contribute to surface water contamination is evidenced by surfacing effluent from the drainfield. In most cases this type of failure is discovered and corrected fairly quickly and in dry weather a discharge from a residence is not likely to find its way into a creek. Surface water contamination from septic systems is most likely to occur during rainy weather or when a commercial building with high water use is involved.

Subsurface contamination from septic system effluent is something that is not easily measured or even detected. Effluent may travel freely underground through the faults and fractures of bed rock common throughout the recharge zone. These faults and fissures cannot usually be detected at the time the septic system drainfield is constructed.

The problem of illegal repairs and illegal installations of septic systems is one which may be a significant threat to the Edwards Aquifer. The Health Department estimates that it is notified of no more than fifty percent of the septic system failures that occur. They suspect that when unauthorized construction or repairs take place, contractors often use methods that could be very damaging to the environment. These methods include boring large diameter holes through drainfields, drilling deep wells through drainfields and the excessive use of explosives.

Because the issue of Aquifer pollution caused by septic tanks is a controversial one, it is of interest to include in this report the following paragraphs extracted from the comments and observations on the Preliminary Report on the South Austin Metropolitan Area of the Edwards Aquifer, provided by Mr. Bob Kent of Underground Resource Management, Inc.

> "The argument about septic tanks polluting the Aquifer cannot be supported by existing data. In fact, there is an overwhelming body of evidence to suggest that they are not responsible for contamination of the Edwards Aquifer. Please look at the following case points:
>
> The Cities of Rollingwood and Westlake Hills have septic tanks and have for years. There are numerous wells in this area and, although bacteria has been detected in some wells, none of the professional people I know believe the Edwards under Rollingwood and Westlake is polluted.
>
> There are many subdivisions on the Edwards near San Antonio. Most are on septic tanks, most have water wells in town, and these wells have not been polluted.
>
> One experiment at Lakeway injected seware into boreholes and did not detect sewage in nearby monitor wells.
>
> In the last ten years, I believe that septic tanks have been maligned. True, these systems have problems, but so does every organized system. A review of the Texas Department of Water Resources files indicates most all plants will have upsets and most will occasionally allow raw sewage to discharge to our creeks and rivers. This is a fact even if we don't want to publicly admit it. Therefore, are we helping the environment if we continuously downgrade septic tanks and praise sewage treatment plants when the evidence does not support that more harm is done by septic tanks.
>
> Please note that I completely agree with the regulation of septic tank systems. I believe that large lots should be required for septic tank systems over the Edwards (this also reduces runoff).

> I believe in very large lots where septic tanks and private wells are used (five acres). This is where the majority of well pollution has occurred where lots are small and septic tanks and wells are on the same tract of ground."

At least one tributary of Slaughter Creek, upstream of the recharge area is significantly choked with vegetation which suggests that additional nutrients are present - possibly from septic tanks upstream.

The Health Department report also indicates that there are currently four package sewage treatment plants on the Edwards Aquifer recharge zone in Travis County, and another three immediately adjacent to the west. Three of the four plants on the recharge zone have no-discharge permits which means that they irrigate with the treated effluent from the treatment plant. This irrigation method involves the use of holding ponds and the subsequent spray irrigation of green belt areas. The plants utilizing this method are the Westlake High School Plant, the Travis County Subdivision Plant and the Oak Hill Elementary School Plant. The Shady Hollow Subdivision Plant discharges to Slaughter Creek. West of the recharge zone are the Lost Creek Municipal Utility District Plant which also irrigates. Also located to the west are the Valley View Acres Treatment Plant and the Country Aire Mobile Home Park Treatment Plant - both discharge into Williamson Creek. Since package treatment plants in general have a reputation for creating problems, all of these plants are potential polluters of the Edwards Aquifer. Those plants which discharge directly into a stream which recharges the aquifer are obviously the most significant threat.

The most recent example of potential threat from a package treatment plant is the Country Aire Mobile Home Park Treatment Plant on

Williamson Creek. For the last several months this plant has been under notice from the Texas Department of Water Resources because it has been violating its discharge permit. Before that, the nearby Scenic Brook West Sewage Treatment Plant, also on Williamson Creek, was out of compliance for approximately two years before the City eventually extended the sanitary sewer and connected this subdivision into the City of Austin's system. Although problems with package treatment plants are often detected early, the mechanism for getting these problems corrected may take a very long time. During this time the treatment plants often are continually discharging substandard effluent. The most common reason for these problems to occur is when a subdivision outgrows its treatment plant capacity.

<u>Urban Runoff</u>

Although no extensive storm runoff quality or quantitive studies have been reported for the area of the Edwards Aquifer, it can be generalized that the quality of numerous water resources in and near Austin have been seriously endangered by storm runoff generated in urbanized areas. As the process of urbanization continues in the areas of the Edwards Aquifer, it is expected that there will be an increase of pollutant load in urban runoff. Although population estimates indicate that population densities in the Barton, Onion, Slaughter, Bear and Little Bear watersheds will be below 1.6 persons per acre in the year 2000, it is expected that for localized areas in the recharge zone, the population density will be much higher than that.

Water Supply Wells Pollution

Although the following description of an incident involving Public Health and the Edwards Aquifer occurred north of the Balcones Fault, in the Georgetown area, it exemplifies the possibility of wells to be polluted on the South Austin Metropolitan area of the Edwards Aquifer.

In April of 1982, Mr. Tom Tiner, Director of the Division of Water Hygiene, Texas Department of Health presented the following report during the SYMPOSIUM entitled "Perspectives on the Edwards Aquifer: which was sponsored by the Edwards Aquifer Research and Data Center of Southwest Texas State University.

> "I will now discuss a specific instance involving public health and the Edwards Aquifer, namely a waterborne disease outbreak which occurred in the summer of 1980 at Georgetown, Texas. Even though this outbreak resulted by Edwards wells located north of Austin and the Balcones Fault, it could have happened on the Edwards south of the fault or for that matter on any aquifer. This waterborne disease was a viral outbreak which afflicted 7,900 citizens. It was shown epidemiologically and bacteriologically that the City's four (4) wells at the main water plant were the cause of the outbreak. Bacterial samples collected directly from the wells showed fecal coliform counts ranging from 150 to 1,500 per 100 milliliters. I wish to emphasize that these were fecal coliform counts and not total. Fecal coliform limits the source of pollution to be from the intestinal tract of warm-blooded animals. To determine if it is human or animal, a fecal coliform to fecal strep ratio is made. Where did the viruses come from? As of today, we are still not certain. Speculatively, they came from one of the following:
>
> 1. From the filling of Lake Georgetown by heavy rains a month before the outbreak. This could have created a hydrostatic head on the Edwards formation which carried contaminants into the City's wells.
>
> 2. Another possibility which is based on the porous nature of the Edwards is from improperly installed septic tanks located outside the City limits in the recharge area.
>
> 3. Even though a thorough investigation was made of the sewer lines near the wells at the main water plant, the contamination could have resulted from line leakage. Extensive smoke and dye tests were conducted but no ruptured sewer lines were found.

4. Last but certainly not least, the problem may have been associated with an unplugged dug well adjacent to the City's wells.

This could have been the culprit since raw water samples now being collected for bacterial analysis are not showing anywhere near the degree of contamination since the dug well was properly plugged. Of course as previously mentioned, unplugged abandoned wells are a source of contamination not only to the Edwards Aquifer but to all aquifers in the State.

In the past it has been felt that when water wells were properly located and constructed, coliform organisms should not be present in the raw water. Today, however, we are finding more and more raw water positive samples from wells producing from various aquifers across the State. This is very alarming to all of us."

The U.S.G.S. has reported that some wells in the South Austin Metropolitan area of the Edwards Aquifer consistently show higher levels of nitrogen concentration than the leachground groundwater quality. The source is unknown.

There are numerous wells in the North Austin, Round Rock, Georgetown area of the Edwards Aquifer which show high levels of nitrogrn compounds. The occurence of high nitrogen concentrations in the groundwater appears to be associated with the very thin soils in the area. There may also be a relationship to the thickness of the Edwards formation which is less thick in the northernmost segment than in the San Antonio or South Austin areas.

IV. GOALS OF THE CITY OF AUSTIN FOR THE PROTECTION OF THE AQUIFER

The Austin Tomorrow Comprehensive Plan established as one of its goals (330.0) that: "The quality of numerous water resources in and near Austin has already been seriously endangered by the process of urbanization. The City should strive to protect its nearby water resources in order to maintain a healthy water supply and prevent expensive treatment prior to public use, to maintain the excellent recreation utility of the nearby lakes and springs and to maintain the quality of water resources."

The City should actively pursue these goals through comprehensive utilization of pertinent state-enabling legislation. Included in Section 21.357 of the Texas Water Code, which enables the development of plans for controlling and decreasing pollution or potential pollution from generalized discharges of waste which are not traceable to a specifc source, such as storm sewer discharges and urban runoff from rainwater.

More specifically, at a meeting on July 9, 1982, of a task force composed of City staff from the Water and Wastewater, Public Works, Environmental Management, Engineering, Legal, Health and Planning Departments, the following goals were outlined:

1) Barton Springs should be suitable for contact recreation.
2) Maintain surface water quality in Barton Creek and other creeks which contribute to the aquifer.
3) Maintain an adequate flow at the Springs year round, so that turnover in the pool is rapid enough to avoid the need

for cholorination.

4) Seek alternative sources of water other than pumpage from the Aquifer to development on and upstream of the recharge zone.

5) Obtain the necessary easements and construct recharge dams on major stream channels, if appropriate.

6) Review the growth potential of the Southwest area of the City and plan for water service accordingly.

V. CITY OF AUSTIN ACTIVITIES RELATED TO EDWARDS AQUIFER PROTECTION

Since 1974, the City of Austin has emphasized interest in the protection of the section of the aquifer within its legal jurisdiction, through the following actions:

- In 1974, at the request of the City, Bovay Engineering Inc. conducted a preliminary engineering report on various alignments for extending the Barton Creek wastewater interceptor from Skunk Hollow to Lost Creek subdivision. At the recommendation of the Environmental Board, Tracor, Inc. prepared an Environmental Assessment in which recommendations were made on the most acceptable path for the wastewater interceptor. However, the following recommendation was also made: "Development of the Barton Creek watershed should proceed in such a manner as to minimize impervious cover in order to control pollution of Barton Creek and the Edwards Aquifer by urban runoff. Surface runoff problems should be evaluated carefully before development plans are approved."
- In 1975, in the Supplemental Environmental Report on the proposed Barton Creek wastewater interceptor, submitted by Tracor, Inc., the following recommendation was made: "Do not extend the interceptor past its present location until a comprehensive plan for the area is developed and the entire environmental impact can be assessed." Furthermore, An Environmental Watershed Plan for Barton Creek was outlined in the report.
- In FY76-77, the Austin City Council instructed the City staff to proceed with the Barton Creek Watershed Study proposed by the Environmental Board. The Office of Environmental Resource Management coordinated the City's efforts. The stated purposes of

the plan were:

(1) To preserve Barton Springs water quality to the greatest extent feasible for recreational use and for use as part of the City of Austin water supply. Because of the complexity of the Edwards Aquifer Recharge Zone and its relationship to Barton Springs, a hydrogeology study of this problem was to be included in the watershed study.

(2) To preserve Barton Creek water quality

   a. For recreational use in the creek,

   b. Indirectly, to maintain the water quality of the Springs;

(3) To preserve environmentally sensitive areas for recreational, scenic and wildlife values;

(4) To evaluate existing environmental quality and interpret the environmental characteristics to reveal opportunities for development;

(5) To develop a land use management plan and program which will minimize adverse effects of development on Barton Creek and Barton Springs.

During this same year the City amended its contract with the U.S. Geological Survey to include a hydrologic and waterquality study of the Edwards Aquifer. Although the final report has not been published by the U.S.G.S., communication between City staff and the Geological Survey has enabled the City to incorporate the Survey's findings into subsequent ordinances and reports.

-In October, 1977, Espey, Huston and Associates, Inc. entered into a contract with the City of Austin, to provide data on the hydrogeology, biology and archaeology of the Barton Creek watershed.

The study was completed in 1979 and presented to the City. The study provided basic information pertinent to surface water quality, ecology, groundwater conditions, Barton Springs discharges and cultural resource conditions. The findings of the study as suggested by the consultants, "can provide considerable guidance in developing a Barton Creek Management Plan." The study also included office investigation and review of information on the local Edwards Aquifer and its relationship to Barton Springs.

-In late September, 1979, the Austin City Council authorized Espey, Huston and Associates, Inc. to continue the Barton Creek study and perform additional analysis of existing data in order to develop an ordinance for consideration by the Countil. Phase II was completed in December 1979 and a draft ordinance for the Barton Creek Watershed was produced.

-In the Fall of 1979, the City Council appointed a six member Barton Creek Task Force to provide citizen input and comment on the technical analysis and ordinance development undertaken by Espey, Huston and Associates.

-Results of the Barton Creek Watershed Study Phases I and II, input from the City of Austin Staff and public participation through the Barton Creek Task Force served to provide the technical, economic, administrative and political input utilized in developing a draft ordinance for managing urban development in the Barton Creek Watershed. In April of 1980, the City Council passed and approved Ordinance No. 810439-C which provides standards for the development of land located within the watershed of Barton Creek. One of the specific objectives of the ordinance is to "prevent loss of recharge to the Edwards Aquifer and protect the quality of the recharge to the Edwards Aquifer."

-With the awareness that portions of the watersheds of Williamson, Slaughter, Bear, Little Bear and Onion Creeks are within the Edwards Aquifer area and that development on those watersheds may have an impact on the Edwards Aquifer, the City Council appointed the Edwards Aquifer Task Force in the Fall of 1980. The Task Force, in cooperation with City staff and through public input, developed a series of ordinances dealing with special requirements for subdivisions and site development in environmentally sensitive areas. These ordinances have been passed and approved by the City Council. Ordinance No. 810319-M (May 7, 1981) provides standards for the development of land located within the aquifer-related watershed of Williamson Creek. Ordinances No. 810514-S (May 14, 1981) and 910514-T (May 14, 1981) provide standards for the development of land located within the aquifer-related watersheds of Slaughter, Bear, Little Bear and Onion Creeks.

In March, 1982, Mr. Nicholas M. Meiszer, City Manager, appointed the Director of Environmental Department to head a Task Force of city staff members to explore in detail the various options which the City has, in dealing with developments which will potentially or actually affect water quality in the Edwards Aquifer, Barton Springs, Town Lake and other watersheds of the community. In response to the City Manager's request, a Task Force composed of City staff from the Water and Wastewater, Public Works and Engineering, Legal, Health, and Planning Department of the City, was assembled.

In addition, the Director of the Environmental Department directed her staff to develop a preliminary report on options available for water pollution control of the Edwards Aquifer. This document served as a position paper to begin discussion on the development of strategies for pollution control of the Edwards Aquifer.

-In June of 1982, the Austin City Council appointed a task force of concerned citizens and gave them the title "Alternative On-Site Sewage Disposal System Task Force." Their main goal is to study different on-site sewage disposal systems and designs and the performances of each to try to determine if any of the various alternative designs are more effective or preferable to the others. With the information they gain, they hope to make recommendations for regulation or changes which will minimize adverse effects to the more environmentally sensitive parts of Travis County.

-In November, 1983, the Travis County Commissioners approved a septic tank order which will be forwarded to the Texas Water Development Board for adoption as a Board Order. The proposed order specifically prohibits blasting for the installation of septic tanks in the Edwards Aquifer Recharge Area. The Commission is concerned that the use of explosive could induce additional cracks and fissures through which effluent could seep into the ground water.

VI. CURRENT CITY OF AUSTIN REGULATIONS AND POLICIES CONCERNING PROTECTION OF THE EDWARDS AQUIFER

This section of the report identifies and examines current regulations that are available to the City of Austin for the protection of the Edwards Aquifer. Some of the regulations deal specifically with protection of water quality of the aquifer while others are indirectly related.

Subdivision Regulations.

The City has the power to regulate the subdivision of land within the corporate limits and within its extraterritorial jurisdiction. Authority for platting is granted under article 974a - Vernon's Annotated Revised Civil Statutes. The City's subdivision ordinance can take into account the effect land development will have on aesthetics, recreation, aquatic life, and drinking water in the promulgation of any land development control. Additionally, Section 126.177(5), Texas Water Code, specifically authorizes the "development and execution of reasonable and realistic plans for controlling and abating pollution, or potential pollution, resulting from generalized discharges of wastes which are not traceable to a specific source, such as storm sewer discharges and urban runoff from rainwater." It is under this authorization that the City of Austin has adopted special ordinances to protect various sensitive watersheds. Austin's three watershed ordinances are tailored to the constraints within the watersheds they cover.

- The Lake Austin Ordinance was established to protect the City's water supply from urban runoff caused by development.

- The Barton Creek Ordinance was written to prevent deterioration of the ecosystem and the base flow of and water quality of Barton Creek and to prevent the loss of recharge to the Edwards Aquifer and protect the quality of the recharge to the Edwards Aquifer.

- The Aquifer-Related Ordinances covering Williamson, Slaughter, Bear, Little Bear and Onion Creek Watersheds were adopted to generate appropriate development rules and regulations for the purpose of protecting the Edwards Aquifer.

It should be emphasized that Section 4 of Article 970a authorizes the City of Austin to extend the applicability of its subdivision ordinance to its extraterritorial jurisdiction. Additionally, Section 26.177, Texas Water Code authorizes the City to extend its water pollution control and abatement program into "areas within the extra-territorial jurisdiction which in the judgment of the City should be included to enable the City to achieve the objectives of the area within its territorial jurisdiction."

Zoning.

Municipalities in Texas derive their power to adopt zoning regulations exclusively from the enabling statutes (Article 1011a, et seq. V.A.C.S.). Austin's zoning authority is derived from said article, which specifies the purpose for which zoning may be used:

"For the purpose of promoting health, safety, morals, and for the protection of places and areas of historical and cultural significance or the general welfare of the community, the legislative body is empowered to regulate and restrict ... the size of yards, courts and other open spaces, the density of population, and the location and use of buildings, structures and land for trade, residence or other purposes."

The use of zoning regulations for managing the growth of a municipality is clearly an authorized purpose of zoning. Within the enabling legislation are two sections which expressly recognize regulation of urban development as a valid purpose. In the Grant of Power, Article 1011a, quoted above, regulation for the size of open spaces and the density of population are expressly stated. Article 1011c, Purposes in View, states as follows:

"Such regulations shall be made in accordance with a comprehensive plan and designed to ... prevent the overcrowding of land; to avoid undue concentration of population; to facilitate the adequate provision of transportation, water, sewage, schools, parks, and other public requirements... Such regulations shall be made with reasonable consideration, among other things, with a view toward conserving the value of buildings and encouraging the most appropriate use of land through such municipality..." There are currently no specific provisions in the zoning ordinance which deal with protection of water quality or sensitive natural areas.

Full purpose annexation

The Municipal Annexation Act of the State of Texas provides a procedure for determining the area of City's jurisdiction over the unincorporated area which is contiguous to the City's corporate limits. When a city annexes additional territory, the ETJ of the city expands. A City may annex in any one calendar year only territory equivalent in size to ten percent of the total corporate area of such city.

In full purpose annexation, the City of Austin has a very useful tool to extend the City's regulatory powers to assure protection or improvement of environmental factors. An aggressive annexation policy in the area of the Edwards Aquifer could in a relatively short period of time, extend the City's subdivision regulation to the entire Aquifer area and thus enforce those regulations specifically dealing with the protection of the Edwards Aquifer.

The main drawback in full purpose annexation is that the City might be obligated to provide municipal services to the annexed areas at a high fiscal cost. Furthermore, the 1982 Annexation Study prepared by the Department of Planning of the City states that: "The rate of annexation can affect the total city versus out-of-city population split. Under a moderate rate of annexation, the city population split is projected at 80 percent of the county's by 1995. With no further annexation the city can be expected to reach a population of only about 400,000 persons in 1995 or only 60 percent of the projected county population. With a high rate of annexation, including annexation of most all areas showing any potential for out-of-city growth, the city could reach up to approximately 90 percent of the county, or nearly 600,000 persons." The Annexation Study further states that: "The rate of annexation also affects the rate of growth of individual areas after annexation. With a moderate rate of annexation of about three percent of the existing city's land per year, each annexation area can be expected to follow past population trends of areas annexed, dependent on the environmental access school district and special district amenities available. An accelerated rate of full purpose annexation would tend to dilute the population growth of each annexed area. If much more land were available with city services, development would disperse into the additional serviced areas."

Limited Purpose Annexation

Limited purpose annexation is not provided for in the Texas Constitution or in any Texas statutes, but is referenced in the 1981 amendment to the Municipal Annexation Act. Section 7 of Article 1 of the Austin City Charter, which was adopted prior to the Municipal Annexation Act, provides for limited purpose annexation as follows: The City may annex territory...for the limited purpose of "Planning and Zoning" and/or Sanitation and Health Protection.

The main objective in dealing with limited purpose annexation within the context of options for water pollution control of the Edwards would be to incorporate adjacent areas into the ETJ of the city, however, a legal opinion by the City Attorney indicates that limited purpose annexation does not allow extension of the ETJ by the City.

Septic Tank Regulations and Package Treatment Plant Policy.

The Texas Water Code provides that cities of five thousand or more people, may adopt water pollution control plans and specific programs, and ordinances necessary to implement the plan. Pursuant to this authority, the City may (1) regulate waste disposal facilities and methods so that sewage does not contaminate the city's water supply or adversely affect water quality and (2) regulate lot size in the context of land needed for adequate septic systems and drainage fields. Various State Attorney General opinions have concluded that the Texas Water Code granted broad authority to cities and that such authority may be exercised in the ETJ: and that such authority includes the power to regulate private sewage facilities.

Other sources of City authority to regulate septic tanks and other sewage disposal systems are as follows:

(1) Article 1175(19) VTCS., including the power to prohibit nuisances; to prohibit pollution of streams that may constitute water sources for the City; and to protect watersheds.

(2) Article 1175(28) VTCS provides for the establishment of a health department and the making and enforcement of rules and regulations.

(3) Article 4477-1, 5, 12(1) and 23 regarding waste disposal, approved plans and for public water supplies and sewerage systems.

(4) Texas Water Code 26.031 and 26.177, regarding private sewage facilities and water pollution control duties of cities.

Pursuant to this authority, the City has enacted a number of ordinances and regulations applicable to development in the City and in the ETJ, including the following:

(1) Ordinance No. 791115-G, Septic Tank Systems Ordinances (Nov. 15, 1979);

(2) Package Treatment Plant Policy (Aug. 20, 1979) (Reaffirmed May 29, 1982);

(3) Regulations for Individual Septic Tank Systems and

Subdivision Review of Septic Tank System Development (Austin - Travis - County Health Department, Sept. 1972).

The health regulations are implemented via the City-County Health Department. City authority is via the Texas Water Code. Health Department responsibility covers only septic tanks. Package Treatment Plants are permitted directly by the Texas Department of Water Resources. Septic systems regulations occur through the subdivision review and approval process and also on individual lots in older, approved subdivisions. Concern over direct infiltration of discharge from septic tank drainfields has prompted the City of Austin to regulate use of conventional septic tanks in the Aquifer Recharge Zone. The Barton Creek Ordinance allows septic tanks in the Barton Creek Watershed and prohibits standard septic tanks in the Aquifer Overlay Zone. The Aquifer-Related Ordinances state that the minimum size of all lots not served by organized wastewater collection and disposal systems shall be at least one acre and that unsewered lots overlaying the Aquifer Recharge Zone shall use sewage disposal systems that must be lined to prevent any infiltration to the aquifer and shall be installed in accordance with Ordinance 720928-A, as amended. The land controls implication of septic tank regulations is that the City can indirectly control density of development in the ETJ and thus will allow for low density residential development. Intensive commercial land uses are very difficult to be served by septic tank systems, consequently development in the Edwards Recharge zone will be probably limited to low density residential and small scale commercial establishments, unless centralized wastewater service is available.

Although Wastewater Treatment Plant applications are approved or denied by the Texas Water Commission, the City of Austin has developed some policies concerning small wastewater treatment plants in the ETJ of the City. (Many small wastewater plants are composed of prefabricated units giving rise to the general term - package plants). Furthermore, the City of Austin Water and Wastewater Department reveiws engineering plans for all package treatment plants within the City's ETJ, pursuant to Section 41-53 of the Subdivision Ordinance. The main interest of the Package Treatment Plant Policy in reference to the Edwards area is stated as follows:

(1) "That when wastewater treatment plants are contemplated in watersheds or streams contributing to the recharge areas of the Edwards Aquifer all possible alternatives be considered to allowing a direct discharge that would tend to degrade the water quality of the Aquifer and Barton Springs.

(2) That the disposal of effluent by irrigation be encouraged as an alternative to the direct discharge when conditions warrant, and that adequate land be dedicated for that purpose."

Package Treatment Plants dispose of effluent primarily through two means: land irrigation and discharge into a waterway. Land application of effluent requires a minimum irrigation field size. The use of land irrigation package treatment plants in the Aquifer Recharge Zone would limit development density due to the irrigation field requirements and the special requirements for subdivisions in environmentally sensitive areas. Package Treatment Plants that discharge effluent into a waterway do not impose the density constraints on development that are inherent to land irrigation.

The Austin Tomorrow Comprehensive Plan

The Austin Tomorrow Comprehensive Plan addresses the problem of protecting the local Edwards Aquifer from degradation with a policy statement that development activity in the recharge zone "should not contribute to any increase in pollution of surface or groundwater above that expected to occur in the natural, undisturbed state." The Comprehensive Plan further states that "Impervious surfaces in the zone should be minimized, in order to permit storm runoff infiltration to the aquifer."

The Creek Ordinance

The Creek Ordinance requires that all development impacting a creek, stream, or drainageway utilize control measures to minimize erosion and siltration of the waterway, and that proposed development "preserve the natural and traditional character of the land and waterway to the greatest extent feasible." All development adjacent to or crossed by a waterway must obtain a development permit from the City Engineer, following review of the application by the Public Works and Environmental Resource Management Departments. The ordinance does not specify control strategies to be employed in the development plan, and is only enforced inside the city limits. The ordinance does not specifically address water quality.

Site Development Ordinances

Site Development permits are required in the portion of the ETJ covered by the Barton Creek, Williamson Creek and lower watersheds ordinances. Permits are required for tracts of land which do not

The Water and Wastewater Department, however, is emphatic in stating that: "they have found that package treatment plants disposing of treated effluents by irrigation generally do not have water quality permit parameters for treated wastewater and that while the treatment plants are designed with considerations for effluent quality standards, many owners/operators of such facilities feel no necessity for meeting or maintaining those treatment quality standards." Furthermore, the Water and Wastewater Department points out that: "while it is generally presented in the microbiology literature that fecal coliforms have an average life of 48 hours and do not reproduce outside the enteric tract, we have experienced clear exceptions to that fact. For example, the polishing filters used at the Walnut Creek Wastewater Treatment Plant occassionally seem to "grow" fecal coliforms. Extensive testing of filter influent and effluent has not produced data to the contrary."

The City's Municipal Utility District Ordinance prohibits treatment plants constructed, in whole or in part, with bond proceeds from discharging effluent over the Edwards Aquifer recharge zone or in the Barton Creek Watershed. However, the MUD Ordinance applies to growth areas III and IV only, which leaves much of the Aquifer Recharge Area unprotected from effluent discharge. A policy for MUD's located in Area V is currently being developed.

If package treatment plants are prohibited from discharging effluent in any area of the Aquifer Recharge Area, centralized wastewater systems will be limited to City service or land irrigation systems.

require subdivision to be developed and are generally issued for multi-family, office and commercial projects. The authority for the Site Development permit is Section 26.177 of the Texas Water Code. The authority of the City to enforce site development permits has been challenged in court.

Water and Wastewater Master Plan Concept

The provision of water and wastewater services by the City is a governmental function with the City acting as a "public" utility, through the City Council. Because most utility decisions are "governmental" and legislative in nature, the local governing body exercises broad discretion in making such decisions within utility law parameters. The governing body may discriminate in rate charges, in services and in other aspects of service, so long as there is a reasonable utility-related basis for the classification. A utility need not hold itself out as a service-provider to all areas. However, once the utility holds itself out as a service-provider in a particular area, it must provide service to all those similarly situated in a non-discriminatory way. Communities with large jurisdictional areas where there are few alternative service-providers can effectively manage the location, direction and type of growth and development directly through utility extension and service policies coordinated with a local comprehensive plan and land use control mechanisms. Austin's ability to utilize the provision of water and wastewater services directly is somewhat hampered, because its jurisdictional area of control is relatively constrained and because there are some alternative service-providers. These two factors place some limitations to the City's ability to rely exclusively or directly on the Water and Wastewater Master Plan as a growth management plan implementation tool.

As mentioned, the City is somewhat constrained in its long-range planning efforts by the presence and availability of alternative service-providers within the City's ETJ. Water can be purchased at wholesale from LCRA while water treatment and distribution as well as sewage collection and treatment can be provided by water districts and/or private utility corporations. Thus, City utility planning and programming does not have total control on the timing, location, density, or type of development in the ETJ or beyond. While alternative service entities must receive a certificate of convenience and necessity for their area from the Public Utility Commission, such certificates will not be withheld where the City cannot (due to financing limitations or management principles) service the area itself.

P.A.R.D. Master Plan

As a guide for community development, The Austin Tomorrow Comprehensive Plan stresses the importance which Austin residents place on protecting the community's well known amenities. The Plan calls for preparation of a master plan for parks and recreation, and addresses over twenty policies related to specific recreation planning functions.

As planning funds became available through the 1978-79 Capital Improvements Programs, the development of a parks and recreation master plan emerged as a logical progression of Austin Tomorrow planning - to focus on the leisure and amenity system that is essential for implementation of the comprehensive plan.

The purpose of the master planning program is the establishment of a vehicle for developing a comprehensive information system, a sound procedure for decision-making and the basis for park and recreation policy. In this sense the planning document is intended to be used as a facilitator for the process of decision-making more than simply an assemblage of data translated into information.

Specific planning objectives were also identified:

1) To develop an open and responsive program for identifying community and neighborhood goals, objectives and standards for parks, recreation and open spaces.
2) To inventory and evaluate the resource values of Austin and its urban fringe; these include aesthetic, historical, cultural and architectural values of the built and non-built environment.
3) To examine social, environmental and economic trends as they affect the quality of life in Austin.
4) To determine the role of parks and open spaces in shaping urban growth using the Comprehensive Plan and Austin Tomorrow Goals Program as planning criteria.
5) To determine strengths, deficiencies and suitability of the existing parks, recreation and open space system, with specific recommendations for renovation and upgrading.
6) To develop specific policies and practices for funding, developing and administering parks and recreation programs that are responsive to the needs of Austin Citizens.

The Parks and Recreation Department, among all agencies of Austin's municipal government, has the only mandate to acquire and use land on the basis of its natural amenities. Therefore, a pivotal role could be assumed by the Parks and Recreation Department in the future preservation of special natural areas for the public's leisure enjoyment.

Under the guidance of these planning objectives and mandates, P.A.R.D. has through land dedication by owners and purchasing acquired extensive tracts of land along Barton and Williamson Creeks. For example, the City now owns a greenbelt along Barton Creek which extends from Town Lake to the Lost Creek subdivision. In Williamson Creek, about one and one half miles of green belt in the Oak Hill area have been acquired by the City.

As urban development progresses along the watersheds of the creeks that contribute to the recharge of the Edwards Aquifer, P.A.R.D. is committed to continue acquiring land either through dedication or purchasing.

Beyond these initial steps, the Parks and Recreation Department has been active in attempting to utilize newer, more environmentally sensitive methods of developing parks and greenbelts. Such innovations could prove to have wider relevance as far as setting criteria for development within the aquifer region.

Standard Construction Specifications for the Water and Wastewater Department

The Special Requirements for Subdivisions in Environmentally Sensitive Areas (Chapter 41-A of the Austin City Code) requires that all construction of sewer systems within the Edwards Aquifer Recharge Zone comply with the special standards of Section VII-B of the City of Austin manual, "Standard Specifications for Water and Wastewater Utility Construction." These specifications are directed to ensuring that sewer lines malfunctions do not contribute to pollution of the Edwards Aquifer, however, the Water and Wastewater Department feels that the standards adopted need review and reconsideration, and the Department is pursuing a proposal for changing them.

Section VII-B of the Standard Specifications are stated as follows:

VIIB-1. Materials

Material will meet the requirements as specified in section VII-1.

In addition the only pipe material that will be allowed in the aquifer recharge zone is Polyvinyl Chloride (PVC) pipe, unless otherwise specified or approved by the Engineer

VIIB1.1. Polyvinyl Chloride (PVC) Pipe

PVC pipe will meet the requirements as specified in Section VIIA-1.5.

VIIB-1.1a Joint Material

The joint material for type PSM PVC pipe will conform to the requirements as specified in Section VIIA-1.5

VIIB-1.2. Manholes

Manholes constructed in an Aquifer recharge zone will be monolithically cast in place concrete. The concrete will conform to the mix and strength as required as Section VIIA-1.11. The concrete shall be poured in such a manner as to produce a dense, compact wall free of honey comb surfaces (i.e., the concrete should be vibrated throughout the pour). No cold joints will be allowed. The base must be poured monolithically with the walls of the manhole. The walls will not be less than eight inches (8") thick.

VIIB-1.2.a. Manhole Base

The base of the manhole will be eight inches (8") greater in diameter than the outside diameter of the manhole. The base will extend in the ditch of the lowest line both in the influent and effluent direction, forming a cradle to the first joint or 36" whichever is farther.

VIIB-1.2.b. Reinforcing Steel

Reinforcing Steel will meet the requirement in Section VIIA-1.11.g. The steel will be placed according to the plans. Reinforcing steel will not be required if the base is 12" thick or more at the minimum section under the pipe.

VIIB-2. Acceptance Testing

All pipe installed under this contract will be tested for infiltration, exfiltration and pipeline settlement. The testing will be conducted in accordance with Section VIIA-5.

VII. CURRENT GROUNDWATER REGULATIONS BY THE STATE OF TEXAS[3]

In Texas, underground water (groundwater) is legally recognized as being the property of the landowner beneath whose property such water can be found, i.e., groundwater is subject to the right of capture by landowners, as long as the water is put to beneficial use and not wasted. In many parts of Texas the value of the land depends upon the quantity and the quality of water which occurs beneath it. Groundwater supplies about one-half of the water used by cities to supply urban dwellers. Groundwater is also used extensively by industry and by farmers. In most areas groundwater levels are declining to some extent, in some areas land is sinking (subsiding) as groundwater is pumped, and in some areas saline water is moving into zones from which fresh water is being withdrawn. In the higher rainfall areas, aquifers that capture, transmit, and store groundwater are recharged in significant quantities. In the drier areas, aquifers receive very little natural recharge and any appreciable use of water from them will ultimately deplete the supply. At the present time, aquifers provide approximately 69 percent of the water used in Texas, and the water supplies of several major aquifers are being depleted. The rate of depletion varies from area to area and depends upon the geologic and hydrologic (water bearing) characteristics of each aquifer, the quantity of natural recharge, and the rate of pumpage within each area. Aquifers which receive appreciable recharge could perhaps be managed by limiting the quantities of water pumped to some specified quantity, i.e., restricting pumpage to the long-term average recharge.

However, those aquifers which receive very little natural recharge do not lend themselves to such a management approach. For such aquifers, the question is "Over what period of time should the water stored in the aquifer be withdrawn and used?"

As groundwater levels decline in an area, it is desirable to practice water conservation to minimize waste and to become more efficient in all types of water use, to develop supplemental surface-water supplies, obtain groundwater from other locations, or select a combination of these methods in order to meet future water needs. In the past, and at the present time, these types of decisions and implementation of water conservation programs and regulations are made by local units of government, by water conservation districts in areas where the voters have elected to organize such districts under Texas law, and by individuals where districts have not been formed. Underground Water Conservation Districts have been formed and are functioning in some areas of the State, including parts of the area underlain by the Ogallala Aquifer in the Texas High Plains and parts of the area underlain by the Edwards Balcones Fault Zone Aquifer near to and including San Antonio. The Harris-Galveston Subsidence District was formed pursuant to an act of the Texas Legislature in 1975 for the purpose of reducing groundwater pumpage in Harris and Galveston Counties in an attempt to stop land subsidence that results from lowering groundwater levels in these two counties. As groundwater levels decline and as growth in water needs increases, the competition for remaining surface-water and groundwater resources will continue to increase, resulting in fewer and fewer options for adding new water supplies. In addition, under present practices of groundwater development and use, it is difficult to predict accurately the time of need and staging of reservoirs that will be needed to supply surface water to offset declining groundwater supplies. For example, neither local nor State water planners have adequate information about future use of groundwater by the many groundwater users to be able to predict the quantities of groundwater that can be depended upon in specific areas of the State and in the future. As a consequence there has been a tendency to use past trends to predict future use of groundwater in an area. However, present knowledge indicates that the solution to land subsidence, saline water encroachment, spring flow protection, and other considerations dictates that pumpage rates different from past trends of groundwater use are desirable and needed in some areas.

An Underground Water Conservation District (UWCD) or other special district, with limitations, has broad powers as described in Chapter 52, Subchapter D, Texas Water Code. One of the powers granted districts is stated in Section 52.117, as follows:

> "In order to minimize as far as practicable the drawdown of the water table or the reduction of artesian pressure, to control subsidence, or to prevent waste, the district may provide for the spacing of water wells and may regulate the production of wells."

This Section, and Section 52.002 of the Texas Water Code, have, through the creation and operation of UWCD's, established a means of correlative rights. Section 52.002 supports this doctrine of correlative rights as follows:

> "The ownership and rights of the owner of the land and his lessees and assigns in underground water are hereby recognized, and nothing in this code (Texas Water Code) shall be construed as depriving or divesting the owner or his lessees and assigns of the ownership or rights, subject to the rules promulgated by a district under Chapter 52."

Various court cases have upheld the right of capture of groundwater in Texas. Other court cases have upheld the power of UWCDs to regulate groundwater production through well spacing, thus supporting the correlative rights doctrine in local areas under the jurisdiction of UWCDs.

Therefore, in Texas groundwater resources can be managed and controlled by local units of government either by the creation of Underground Water Conservation Districts or by special districts created directly by the Legislature (the Harris-Galveston Coastal Subsidence District is an example). Underground Water Conservation Districts are generally ratified by a vote of the residents/users of the groundwater. Several conservation districts have been formed; however, a significant part of the groundwater resources in the State is not within the jurisdiction of the five currently active underground-water districts. In those areas within the jurisdiction of underground-water districts, only the Harris-Galveston Subsidence District directly regulates the quantity of water that can be pumped. Existing groundwater conservation districts have promulgated and are enforcing rules to prohibit waste of water and control spacing of wells to reduce competition among wells. In addition, these districts carry out water conservation information and education programs, some sponsor and implement aquifer recharge projects, and some are participating in various types of water conservation research and development projects within their respective areas. The districts are supported by the revenue generated from groundwater users.

In view of the fact that much of the groundwater resources of the States of Texas is not within a conservation district, the rate of use of this resource remains unregulated except by personal decision of the owner of the land overlying the water source. As our State grown in population and in water usage, and as aquifers are depleted, the need for solutions to this problem will grow.

It has been suggested that essentially all of the state outside the boundaries of an existing conservation district be placed in one or more conservation districts that would be subject to State regulations as to the withdrawal of water. Under this suggested plan, the citizens of an area could decide to organize locally and operate a conservation district. This plan would afford local control over the groundwater resources in that area, but would provide State regulation should the citizens choose not to organize such a district.

Footnote 3 - This section has been excerpted from a document entitled An Overview of Texas Water Resource Problems and Water Issues prepared by the Texas Department of Water Resources (February, 1982).

VIII. CURRENT FEDERAL REGULATION OF AQUIFERS

Laws and Regulations Applicable to Ground Water Protection[4]

At present there is no federal program dealing specifically with the problem of ground water contamination. The framework of federal laws that can be used for ground water protection is a group of statutes which are aimed primarily at other environmental problems but which touch indirectly on ground water problems. One of the principal statutes of this type is the Resource Conservation and Recovery Act of 1976, which establishes guidelines for the management of solid and hazardous wastes (33). The Safe Drinking Water Act of 1974 contains an underground injection control program to prevent ground water contamination by waste injection wells and to protect sole-source aquifers for drinking water. The Clean Water Act of 1977 requires the EPA to establish, equip, and maintain a water quality surveillance system for ground water as well as surface water. The Toxic Substances Control Act of 1976 and the Surface Mining Control and Reclamation Act both have provisions that could offer a measure of protection to ground water. The Comprehensive Environmental Response, Compensation and Liability Act of 1980 authorizes the federal government to clean up contamination caused by inactive waste disposal sites or spills, many of which pose immediate threats to ground water quality.

These are not the only federal statutes that could be used to protect ground water, but they are the most important ones. They have been unevenly implemented, and as a result they are, at present, not very effective in controlling and preventing ground water contamination.

The states have long been involved with ground water allocation law and water rights, but it is only in the last few years that they have made large efforts to prevent, abate, and monitor ground water pollution. The considerable variation in natural ground water quality and in the quantity used, and the regional characteristics of the major sources of ground water contamination may account for the uneven handling of these problems and the diversity of state regulatory mechanisms and organizational structures.

State regulations that may affect ground water quality fall into three main categories; (i) those dealing with particular sources of pollution such as septic tank systems and waste disposal sites, (ii) those establishing and implementing water quality standards for aquifer water, and (iii) those regulating the use of land in areas overlying critical aquifer recharge zones.

As with federal regulations, the state and local controls that effectively protect ground water often are not designed for that purpose. Even when a regulation is adopted with ground water protection in mind, this may only be one of several regulatory objectives.

EPA Policy on Ground Water Protection[5]

In 1980, after more than a year of discussion and study, EPA proposed a national ground water strategy (27, 34, 35). Its goal was to prevent ground water contamination rather than provide remedial action. The suggested approach included the development of state management and protection strategies; the development of a ground water classification system; and EPA coordination of existing federal programs for ground water protection. The proposed strategy was aimed at protecting gound water quality according to its value and use, and the technical approach adopted included the use of siting and design criteria, best management practices, effluent standards, innovative and alternative technologies to achieve performance standards, and, to a lesser extent, numerical ground water quality standards and economic incentives. In 1981, EPA was questioned by the chairman of the House Government Operations Subcommitted on Environment, Energy and Natural Resources about its lack of action on the proposed national ground water strategy. In response, EPA created two separate gound water task forces, one for policy and one for technical purposes, to develop a consistent agencywide strategy.

The EPA is now revising its ground water policy statement. The statement developed by the two task forces apparently did not resolve inconsistent regulatory issues on ground water protection (36) and did not set policies on state classification of ground water. Institutional relations - for example, intrastate and state and local government relations - and EPA commitment to the policy in terms of time and money were not resolved.

Appendix A obtained from a document entitled Developing an EPA Gound Water Strategy (USGPO:1980--311--726/3897), contains a brief synopsis of those Federal Laws which impact ground water and an analysis of how those laws might be used to implement a ground water protection strategy.

Footnotes 4 and 5. Excerpted from Ground Water Contamination in the United States, Science, August 19th, 1983.

IX. SOME NATIONWIDE INNOVATIVE PRACTICES IN LOCAL GOVERNMENT REGULATORY PROGRAMS

In searching for information about how other areas in the country deal with the issue of groundwater protection, it was found that the prime concern is directed towards water conservation rather than protection of water quality. The type of options considered in this section include actions that have been taken at the level of a regional planning agency such as coordination of wastewater management under the 208 program; and actions at the local level including restrictions on allowable activities in recharge zones and near wells, best management practices for waste disposal and restrictions on development.

The Tetra Tech Inc. Study Areas

What follows is a summary of groundwater management approaches taken by four local government areas which were studied and reported by Tetra Tech Inc. of Lafayette, California, under contract with the Office of Water Research and Technology of the U.S. Department of Interior.

The four example areas encompass different hydrogeologic conditions, land uses and management approaches. The areas studied were Suffolk County, Long Island; the Old Colony Planning Council of southeastern Massachusetts; the Spokane aquifer, Washington; and the San Bernardino area, California.

Changes in water levels and/or groundwater quality have been observed in the four areas studied. To summarize the quantity issues, two of the areas--the Spokane, Washington and Suffolk County, New York areas--have not experienced large water-level declines and have adequate supplies for the projected future neds. There is concern, however, in Suffolk County about declining baseflow in the groundwater-fed streams after installation of a regional sewer system. The other two areas have water-supply problems. In the Old Colony Planning Council area, several towns have declining water levels partly due to the 1980-1981 drought and partly due to the increased water demands. These towns are concerned about their capacity to meet future water demands. Several have already restricted water use. The San Bernardino area has had large water-level declines, which have partly recovered after implementation of an artificial recharge program.

The groundwater in the four areas studied has shown increased concentrations of dissolved solids. Chloride and sodium concentrations were quite high due to road salting in the three northern areas. In the San Bernardino area increased chloride concentrations were attributed to infiltration of irrigation water. In the areas with high density septic tank systems, increased nitrate, ammonia, and sulfate concentrations were found. High iron and manganese concentrations were present in Suffolk County and the Old Colony Planning Council area, although the natural variation is also high. Halogenated organic chemicals from septic systems and industrial sources were present in several of the areas. Localized high concentrations of metals and other toxic substances were found near industrial waste disposal sites in Suffolk County and the Spokane area.

Various methods for groundwater management have been implemented in each of the areas studied. The approaches which have been used in the four areas to improve water supply problems are water conservation, artificial recharge, and weather modification. Water conservation methods used include restrictions on household use and outdoor sprinkling in residential areas, recycling of household gray water, and recycling of industrial process water. Conservation decreases the volume of water withdrawn from the aquifer.

Artificial recharge can involve storm water runoff from highways, treated wastewater, surface water from within the same basin, or water imported from outside the basin. The recharge programs can increase aquifer storage and keep water levels from declining in drought conditions; these effects were observed in the San Bernardino area. Depending on the type of water being recharged, concentrations of dissolved solids and nitrogen can increase in the groundwater. In instances where high concentrations of nitrates or other constituents exist in the recharge area prior to the start of recharge, these constituents can be mobilized by the recharge water and move from the unsaturated zone into the saturated zone. This phenomenon occurred in the San Bernardino area where the earlier use of the land was citrus orchards. The use of recharge basins for storm runoff can mitigate the decrease in recharge and consequent decreased baseflow to streams as shown by the difference in percentage of baseflow between Penataquit and Orowoc Creek basins in Suffolk County.

The only area studied where weather modification has been utilized is the San Bernardino area, reflecting the differences in the semi-arid conditions of the west and southwest versus the northern part of the country. The cloud-seeding has been successful in increasing the amount of winter precipitation. The resulting streamflow is then partly recharged to the groundwater through a series of water-spreading grounds. A problem which can occur with cloud-seeding is increasing the precipitation in large storms to the extent that flooding occurs. Another problem can be controlling the location of the increased precipitation. Because of the mountains on the boundary of the San Bernardino area, the location of the precipitation is fixed by meteorological factors.

On-site septic tank systems also recharge water to aquifers. The change from septic tanks to a central sewer system contributed to declines in water levels in Nassau County, Long Island and the decrease in baseflow of the streams there. For this reason, Suffolk County has been investigating the potential for decreased baseflow to the streams and the feasibility of streamflow augmentation. At low densities of septic tanks per acre and when the systems are properly sited and maintained, on-site waste disposal can be an appropriate water conservation method. At high densities, septic tank systems result in elevated nitrate, ammonia, and sulfate concentrations reaching the groundwater as occurred in Suffolk County. Restricting the siting of on-site waste disposal decreases the amount of these constituents reaching the groundwater. Septic tanks can also contribute organic chemicals to the groundwater when septic tank degreasing and cleaning products are used.

A major source of increased chloride and sodium concentrations in the northern part of the country is highway deicing. In the Suffolk County basins, chloride concentrations decrease with increasing distance from the Long Island expressway. In the Spokane area, isosalinity profiles show lower concentrations in the summer. Reductions in salt loading or mixing with sand result in lower chloride and sodium concentrations in the groundwater. Covering salt storage piles as planned in Massachusetts also decreases the infiltration of chloride and sodium.

Protecting groundwater from contamination from waste disposal sites is done by restricting activities in the aquifer recharge zone and in the immediate vicinity of water supply wells and by restricting waste disposal activities in general. Two of the areas studied--Suffolk County and Spokane--have aquifers which have been designated Sole Source Aquifers. The designation requires that the impact on ground water of federal actions must be determined and any significant impacts must be mitigated. Such a designation gives groundwater problems visibility, and thus encourages protective measures by state and local agencies in addition to the federal actions. Well protection districts prohibit waste disposal within a specified distance of public supply wells. In Avon the size of the protected areas was increased from the 400 ft. radius specified by the State of Massachusetts to a radius based on the recharge area of the individual well. The experience of the town of Rockaway, New Jersey, where organic chemicals traveled 1200 ft. to a public well from an abandoned industrial waste disposal site, strongly supports larger protection zones around the wells. Contamination from specific industrial sites has occurred downgradient of the Babylon landfill in the Santapogue basin of Suffolk County and at sites in the Spokane area. These occurrences will be mitigated by enforcement of the RCRA regulations. Some wells have been closed and/or treatment of the well water instituted.

Contamination of groundwater due to agriculture has occurred in the Spokane and San Bernardino areas. In both cases recommendations were made to decrease the use of pesticides and fertilizer and to improve irrigation efficiency. Work in the San Bernardino area shows that the effect of added pesticides and fertilizers can be minimized by timing the applications according to crop needs and by decreasing the irrigation rate. Uses of pesticides have also been restricted in Nassau and Suffolk Counties to reduce the concentrations reaching surface and groundwater. One delayed effect of heavy fertilization in the San Bernardino area is the build-up of nitrate concentrations in the shallow groundwater. When recharge due to irrigation takes place in this area, the high nitrate concentrations move deeper into the aquifer and are withdrawn by water-supply wells.

The Edwards Underground Water District

Over a million people in Southwest Texas, including the residents of San Antonio, are dependent on the Edwards Aquifer for their water supply. The aquifer is fed by large fractures, caverns, and other natural channels in the rock, so that it is particularly sensitive to pollutants. Protection of the aquifer is complicated because the recharge area sprawls across seven counties. Consequently, the Edwards Underground Water District was created by a special act of the Texas State Legislature in 1959. The Texas Department of Water Resources adopted and has primary enforcement responsibility for the Edwards

Aquifer rules. The regulations operate essentially like a county zoning ordinance and at this point represent the most detailed specifications in the United States for protecting groundwater from contamination. The order from the Texas Water Development Board (formerly Texas Water Quality Board) maps the recharge areas in each county and details special regulations for these areas. The order:

(1) Requires whereever feasible that effluents be transported away from the recharge area. If this is not possible, then sewage disposal systems must meet strict effluent standards. In addition these facilities must be equipped with emergency power facilities, spare parts, and remote monitoring systems to protect against breakdown or malfunctioning. For regional sewage collection systems, there is a similar set of requirements concerning their construction and maintenance;

(2) Forces licensing and inspection of all new private sewage systems, and registration of existing systems;

(3) Bans feed lots, landfill disposal operations, pit privies, cesspools, and injection wells in the recharge area; and

(4) Makes developers gain approval from the state board before new subdivisions can go in over the recharge area. The board may require the developer to provide special facilities for sewage disposal, to clean streets frequently with a "vacuum-type" cleaner, to guarantee at least six inches of topsoil for lawns, to restrict the use of lawn fertilizers, to provide special construction of any facilities for the storage or transmission of hydrocarbon products, and to provide a groundwater monitoring system for the subdivision.

As with any ordinance with elaborate specification requirements, there is some concern that some of the requirements are too strict and others not strict enough. The Texas Water Development Board is refining these requirements. Even with state action, this regulation has not been easy to implement; and the rural counties feel that they are receiving the brunt of the regulation, while San Antonio is doing most of the polluting.

Amherst, Massachusetts

Amherst, Massachusetts, is attempting to institute similar regulations as those of the Edwards Underground District on the local level. In Amherst, the well fields are in a valley wetland supplied with clean water from the shallow aquifer which immediately surrounds it. While it is possible for the community to go to the next township to find additional water, the difficulty of developing intergovernmental agreements on the use of the water has made it obvious that they should also conserve the water resources within their own boundaries.

In part, preserving their water supply is a simple matter of preserving recharge area from being sealed by buildings and roads. The prime recharge areas are characterized by deep sand and gravel, and these are also prime development sites. The sand and gravel base make building cheaper by reducing the costs of initial foundation construction and also lessening the chance of damage from frost.

The more critical issue, however, has been pollution entering the aquifer through these soils. As well as being good building sites, the porous soils, with their rapid percolation, appear to be good soils for septic systems, and these private waste systems are potentially dangerous to the municipal water supply. In addition, this particular community has other land-use problems that immediately threaten the water supply. The town's present landfill site is located on top of one of the aquifer recharge areas; leachates from the fill, chemical wastes, and salt-laden road snow at the site threaten one of the wells with contamination. Finally, there are a number of gasoline and fuel oil storage facilities on the recharge areas that pose a threat to the water supply either from leaking or "normal" spillage.

The town's selectmen have adopted a policy to protect the recharge areas, but are still considering specific regulatory techniques, focusing on contaminants. The system that has been recommended includes establishing a recharge zone which would limit and regulate activities that are particularly dangerous to the recharge of water.

The following are the recommended restrictions on fuel storage, in the aquifer recharge areas:

> 7.401.3. The board has expressed its concern for the protection of the aquifer recharge areas and has adopted policy statements to insure the protection of these areas... The Board hereby adopts the following specific statements:...
>
> 7.401.31. Within the aquifer recharge area the noncommercial storage of fuel is allowed, either in above-ground or below-ground storage in quantities of 550 gallons or less, to be in compliance with all applicable town specifications.
>
> 7.401.32. A fuel oil storage in excess of 550 gallons must be

stored underground in fiberglass tanks in compliance with applicable town specifications and regardless of the provisions of Section 7.401.2 above.

7.401.33. All fuel oil storage in excess of 10,000 gallons per site within the mapped aquifer recharge area is prohibited.

7.401.34. The noncommercial storage of gasoline in quantities of 500 gallons or less is allowed within the mapped aquifer recharge area, stored either above or below ground, in compliance with applicable town specifications.

7.401.35. All gasoline storage, either commercial or non-commercial, in excess of 500 gallons is prohibited within the mapped aquifer recharge areas.

These recommendations are part of a series of recommendations for handling the aquifer recharge problems. Most of the rest are provisions to deal with the specific problem of the landfill site: not renewing the lease of an auto parts company that uses the site for dumping hydrocarbons and battery acid, providing a chemical waste tank at the fill site, dumping the salted snow where it will do the least damage, and setting up a system of monitoring wells around the landfill in order to determine pollution problems before they reach the city well field itself.

Many of these first recommendations are designed to try to minimize the present hazards. While the aquifer recharge area is officially mapped, at this point it does not constitute a typical zoning district with a list of prohibited and permitted uses. Instead it is used to administer general ordinances like those described above.

RECOMMENDATIONS

General

1. Because the issue of protection of the Edwards Aquifer is a regional concern that extends outside the City of Austin's jurisdiction, there is a need to establish a task force made up of representatives of municipalities located in the watersheds of creeks that contribute to Edwards Aquifer. A proposed makeup for the task force should be: representatives of the cities of San Leanna, Sunset Valley and Hays City and Austin; the County Commissioners for Hays and Travis County that have jurisdiction for the area that encompasses the Edwards Aquifer region; rperesentatives from the Texas Department of Water Resources and the U.S. Geological Survey. The activities of this task force should be coordinated by the Capitol Area Council of Governments Office. The objective of the task force would be to develop regional strategies for the protection of the Aquifer. Some of the options to be considered chould be designation of Edwards as a Sole Source Aquifer, extension of the Edwards Aquifer Board Orders or creation of a special District.

   Regional groundwater problems usually are addressed in Texas by formation of an underground water protection district. The South Austin Metropolitan Area of the Edwards Aquifer is unique in that, in addition to drinking and irrigation water supplies to local residents, the Aquifer provides a significant recreational resource in Barton Springs pool and contributes to the City of Austin drinking water supply. Underground Water Districts are usually taxing entities which collect revenue from users of the groundwater. The user typically vote on creation of a district and elect the District Board members. If such a District is created for Barton Springs the recommended Task Force will need to determine if groundwater users can be defined in the typical way, who should be allowed to vote to create a district and how to raise revenue for district operations.

2. In conjunction with the creation of a task force, a regional public education and information program should be developed. This program would mainly deal with the issue of the importance of protecting the Edwards Aquifer. Among the topics to be emphasized should be: the proper installation, use and maintenance of septic tanks; use of garbage grinders (a problem for septic tank systems), proper use of fertilizers, pesticides and other chemicals by home owners and farmers; and water conservation measures. Technical information regarding the location of the recharge area and mechanism of recharge would also be important.

The public education program should include development of informational brochures for home owners and other interested citizens' displays at parks and shopping centers especially in the Edwards Aquifer Recharge area; programs for presentation in public schools; radio and TV public service announcements and feature presentations; special events that emphasize the uses of the Aquifer and Barton Springs.

Industrial Land Uses

3. Develop regulations which restrict and control the storage of gasoline, oil and potentially hazardous chemicals within the recharge zone.

   Leakage from old gasoline storage tanks at service stations is a serious potential threat to the Aquifer. Problems from such leakage have been reported nationwide. Austin has experienced two cases of leakage from underground gasoline storage tanks. Both resulted in gasoline entering the surface water of creeks at some distance from the storage tanks. The spongy nature of the Edwards Aquifer limestone can result in some gasoline, oil, or other chemical material being retained in the rock and being slowly released over a long period of time.

   In addition to developing regulations for new construction, all existing facilities in the near the Recharge Zone which utilize undergound storage should be inventoried.

A program for periodic testing of the tanks should be developed.

4. Prohibit construction and operation of industries which dispose of organic solvents or heavy metals by use of on-site impoundments or storm sewer flushing. The current city industrial waste ordinance addresses this problem for land inside the city limits.
5. Regulate the transport of toxic, radiological and other hazardous materials through the Aquifer area. There may be some legal constraints prohibiting restriction on the use of state or federally funded highways. However, because of the potential for accidents and spills, the city should consider the designation of hauling routes; the time of day for hauling; and other appropriate precautions.
6. Prohibit the location of landfills in Aquifer sensitive areas. Landfill applications must be approved by the State Health Department. Although the design and review process is much more stringent now than in the past, the potential for leachate travel can pose a threat to the Aquifer.

Wastewater Disposal

7. Prepare a Water and Wastewater Plan that deals specifically with the provision of services to the watersheds of Edwards Aquifer area. The plan should include needs of services for the area as well as the environmental

considerations. Of great importance are strategies, techniques and methodologies available or to be developed to provide wastewater systems to environmentally sensitive lands.

8. To the maximum extent feasible, connect all existing septic tank systems and package treatment plants to the City of Austin wastewater system.

   Data presented to the City by Espey-Huston in Barton Creek Watershed Study - Phase II, indicate that a centralized sewer collection system would provide the best assurance for Aquifer protection from wastewater flows. Recommendations 8 and 9 need to be balanced with overall city growth management objectives.

9. Restrict growth on the Aquifer sensitive areas so that all new development can be served by City of Austin sewer systems, or that lot size is sufficient for adequate on-site disposal.

10. Enforce Section VIIB of the Water and Wastewater Specifications for Construction Projects (or revised standards) which deal with special requirements for construction of sewer lines in Aquifer sensitive areas.

11. Request that the Texas Department of Water Resources prohibit any sewage treatment plant discharge within five (5) miles upstream or on the recharge zone.

Water Supply

12. Develop and enforce adequate well construction standards and require proper closing of open or abandoned wells.

Contamination of ground water is often associated with improperly constructed or abandoned wells which carry surface pollutants into the Aquifer.

13. Encourage use of surface water sources rather than groundwater in the Edwards recharge zone.

    Since the volume of Edwards Aquifer water is limited, the development of major new users of groundwater should be minimized, particularly where other water sources are a viable alternative. Extensive pumping could lead to water shortage problems in parts of the Aquifer. Contamination problems could be more severe in a reduced volume of ground water. This could affect both those users who rely on the Aquifer for drinking water and those who utilize Barton Springs for recreation.

14. Provide for increased recharge via stormwater detention, if this is necessary to maintain the flow at Barton Springs and after determining that the water to be recharged is of acceptable quality.

    The Edwards Underground District in San Antonio has had considerable success in increasing Aquifer recharge by building dams in various locations. This seems to be a desireable step as groundwater usage increases.

<u>Storm Water Runoff</u>

15. Enforce existing erosion control requirements of the aquifer-related watersheds.

16. Provide for undeveloped buffer areas or intercept all runoff from developed areas in the aquifer recharge

zone by grass swales, filtration ponds or other control strategies.

Land Use

17. Require comprehensive evaluation and/or Environmental Assessments of developments on the area of the Edwards Aquifer.
18. Survey and evaluate significant natural and cultural resources, with particular emphasis on locating those environmental areas which directly contribute to the protection of water quality. The City Council has funded a geologic mapping program in Fy 83-84 to delineate faults, sinkholes and other geologic features. This information can then be used in land use planning. Identification of other material and cultural resources would not only provide the basic data for acquisition by the City of some selected areas, should that be deemed desirable, but also provide information in advance of development about areas in need of special protection.
19. Improve the coordination of review and exchange of information on development projects in the Edwards Aquifer related watersheds. (For example by holding regular meetings of staff involved in the review process; inviting experts to provide information and technical support).
20. Continue the review of ordinances, policies and regulations relevant to protection of the Aquifer and evaluate and modify them as necessary to meet the goals of the City.
21. Continue and expand research such as that currently being

conducted by the City and the U.S.G.S. to better understand the hydrogeology of and impact of urbanization of the Edwards Aquifer.

XI. APPENDIX A

U. S. Department of Agriculture (USDA)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Federal Assistance, Resources Conservation and Development Projects 7 U.S.C. 1010-1013	S1010. Land conservation and land utilization—a program of land conservation and land utilization to correct maladjustments in land use, and assist in controlling soil erosion, reforestation, preserving natural resources, protecting fish and wildlife, developing and protecting recreational facilities, mitigating floods, preventing impairment of dams and reservoirs, conserving surface and subsurface moisture, protecting the watersheds of navigable streams, and protecting the public lands, health, safety, and welfare, but not to build industrial parks or establish private industrial or commercial enterprises.	Secretary authorized and directed to develop land utilization program—to assist in conserving surface and subsurface moisture, protect watersheds; health.
	S1010a. Secretary of Agriculture is directed to carry out a land inventory and monitoring program to include, but not be related to, studies and surveys of erosion and sediment damages, flood plain identification and utilization, land use changes and trends, and degradation of the environment resulting from improper use of soil, water, and related resources and issue a land inventory every 20 years.	Includes study of degradation of environment resulting from improper use of soil, water, and related resources.

U. S. Department of Agriculture (USDA)
Agricultural Stabilization and Conservation Service (ASCS)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Water Bank Act 16 U.S.C. 1301-1311	Secretary of Agriculture is authorized and directed to formulate and carry out a continuous program to prevent the serious loss of wetlands, and to preserve, restore, and improve such lands.	Preserve, restore, improve and prevent loss of wetlands and thereby conserve surface waters . . . contribute to improved water quality . . . contribute to improved subsurface moisture . . . promote comprehensive and total water management planning.
	Secretary has authority to enter into agreements with landowners and operators in important migratory waterfowl nesting and breeding areas for the conservation of water on specified farm, ranch, or other wetlands identified in a conservation plan developed in cooperation with Soil and Water Conservation Districts.	Agreements with land owners and operators for conservation of water on specified farm, ranch, or other wetlands identified in a conservation plan could affect ground water.
	U. S. Department of Agriculture (USDA) Soil Conservation Service (SCS)	
Fish & Wildlife Conservation at Small Watershed Projects 16 U.S.C. 1001-1009	Erosion, floodwater, and sediment damages in the watersheds of the rivers and streams of the United States, causing loss of life and damage to property, constitute a menace to the national welfare. Cooperate with States and their political subdivisions, soil or water conservation districts, flood prevention or control districts, and other local public agencies to prevent damage and to further conservation, developing utilization and disposal of water, and the conservation and utilization of land.	Further conservation development, utilization and disposal of water.

U. S. Department of Agriculture (USDA)
Soil Conservation Service (SCS)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Resource Conservation & Development Program 7 U.S.C. 1010 et seq.	The Resource Conservation and Development Program was initiated in 1964 to encourage conservation and wise utilization of natural resources in rural areas.	Encourage conservation and wise utilization of natural resources in rural areas.
		Land treatment—impacts subsurface—but positively in terms of quality and conservation.
Soil & Water Resources Conservation Act of 1977 16 U.S.C. 2001 et seq.	The Act directs the Secretary of Agriculture to conduct periodic appraisal of soil and water conservation programs to ensure that they are responsible to the long-term needs of the Nation.	Assess overall effects of SCS programs on . . . water quality, water conservation.
	Section 6(a) (5) of the Act directs that an analysis be done of the feasibility and desirability of recycling agricultural, municipal and industrial organic waste materials for use as fertilizer.	
Watershed Protection & Flood Prevention Act 16 U.S.C. 1001 et seq.	The Act provides for the prevention of erosion, floodwater, and sediment damages in the watersheds of the rivers and streams of the United States. The Soil Conservation Service (SCS) administers the Act by providing technical and financial assistance to local organizations for planning and installing measures to prevent damage to watersheds.	Technical and financial assistance to local organizations for planning and installing measures to prevent damage to watershed.

U. S. Department of Agriculture (USDA)
Agricultural Stabilization and Conservation Service (ASCS)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Water Bank Act 16 U.S.C. 1301-1311	Secretary of Agriculture is authorized and directed to formulate and carry out a continuous program to prevent the serious loss of wetlands, and to preserve, restore, and improve such lands.	Preserve, restore, improve and prevent loss of wetlands and thereby conserve surface waters . . . contribute to improved water quality . . . contribute to improved subsurface moisture . . . promote comprehensive and total water management planning.
	Secretary has authority to enter into agreements with landowners and operators in important migratory waterfowl nesting and breeding areas for the conservation of water on specified farm, ranch, or other wetlands identified in a conservation plan developed in cooperation with Soil and Water Conservation Districts.	Agreements with land owners and operators for conservation of water on specified farm, ranch, or other wetlands identified in a conservation plan could affect ground water.

U. S. Department of Agriculture (USDA)
Soil Conservation Service (SCS)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Fish & wildlife Conservation at Small Watershed Projects 16 U.S.C. 1001-1009	Erosion, floodwater, and sediment damages in the watersheds of the rivers and streams of the United States, causing loss of life and damage to property, constitute a menace to the national welfare. Cooperate with States and their political subdivisions, soil or water conservation districts, flood prevention or control districts, and other local public agencies to prevent damage and to further conservation, developing utilization and disposal of water, and the conservation and utilization of land.	Further conservation development, utilization and disposal of water.

U. S. Department of Agriculture (USDA)

Act	Coverage of the Act	Potential Futre Role in Ground Water Strategy
Agricultural Credit for Pollution Control 7 U.S.C. 1921-1926, 1932	Loans may be made or insured under this subchapter for (1) acquiring, or enlarging, or improving farms, including land and water development, use and conservation, (2) recreational uses and facilities.	Loans made or insured for land and water development, use, and conservation.
	S1924. Soil and water conservation, recreational facilities and uses, and rural enterprise loans to farmers for the purposes of land and water development use and conservation.	Water and waste facility loans and grants.
	S1926. Water and waste facility loans and grants. Criteria; definitions, limitation on allowable users of Federal funds; inclusion of interest or other income in gross income on sale of insured loan.	
	Provides loans for private business enterprises and pollution abatement and control projects; loan guarantees.	
	U. S. Department of Agriculture (USDA) United States Forest Service (USFS)	
National Forest Management Act 16 U.S.C. 1604(g) (3) (E) (iii)	This section provides for the protection of water resources in the development of forest management plants.	Strong potential role—but limited to areas within jurisdiction of U.S. Forest Service. In being responsible for the entire management of Forest Service lands under the NFMA, the Forest Service has great latitude in protecting ground water.

U. S. Department of Commerce (DOC)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Public Works & Development Act 42 U.S.C. 3131-3133; 3135-3136	Direct and supplementary grants for acquisition or development of facilities; required findings precedent to making of direct grants; supplementary grants to provide matching share funds; sewer and other waste disposal facilities; certification by Administrator of the Environmental Protection Agency regarding adequate treatment prior to discharge into streams.	The Congress is presently considering expanded economic development and public assistance (result and impacts of population growth and public works and development facilities on water quality, uses, development and conservation).
	U. S. Department of Commerce (DOC) Office of Coastal Zone Management)OCZM)	
Coastal Zone Management Act of 1972 16 U.S.C. 1451 et seq.	This provides for financial and technical assistance and Federal guidance to the States and territories to conserve and manage coastal resources. The Office of Coastal Zone Management (OCZM) was created in 1973 to implement the provisions of this Act.	Approved State Coastal Zone Management programs are a strong mechanism for controlling Federal actions within an affected State coast zone. This would include ground-water quantity or quality if it were included within an approved Coastal Zone Management plan. The specific procedure is a "Federal consistency determination" required by S307. Potential for ground water to be included specifically in the scope of the Act. Title I of MPRSA has some limited potential impact on ground-water quality which may result in the pollution of the marine environment.

U. S. Department of Commerce (DOC)
Office of Coastal Zone Management (OCZM)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Marine Protection, Research, & Sanctuaries Act 33 U.S.C. 1401 et seq.	The Ocean Dumping Act establishes a permit system for the regulation of ocean dumping of materials that could degrade the marine environment. The Corps of Engineers has responsibility under Title I for the regulation of the dumping of dredged spoil, through the issuance of permits in accordance with criteria and test procedures developed cooperatively with EPA. Title II of the Act deals with research into the effects of pollution in the marine environment.	

U. S. Department of Defense (DOD)
Army Corps of Engineers (ACOE)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Appalachian Regional Development Act Amendments of 1975 40 App. U.S.C. 1-2, 203, 205-206, 212	The Secretary of the Army is to prepare a comprehensive plan for the development and efficient use of the water and related resources of the Appalachian region and to recommend measures for the control of floods, the regulation of rivers to enhance their value as sources of water supply for industrial and municipal development, the generation of hydroelectric power, the prevention of water pollution by drainage from mines, the development and enhancement of the recreational potentials of the region, the improvement of rivers for navigation where this would further industrial development at less cost than would the improvement of other modes of transportation, the conservation, and efficient utilization of the land resource, and such other measures as may be found necessary to achieve the objectives of this section.	Could have major potential. Might for example, help to identify sole source or principle aquifers. Also a potential vehicle to inform public of importance of ground water in "water rich" Northeast.

U. S. Department of Defense (DOD)
Army Corps of Engineers (ACO)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Marine Protection, Research and Sanctuaries Act 33 U.S.C. 1401 et seq.	The Corps of Engineers has responsibility under Title I for the regulation of the dumping of dredged spoil, through the issuance of permits in accordance with criteria and test procedures developed cooperatively with EPA.	
Clean Water Act 33 U.S.C. 1344	Section 404 authorizes the Secretary of the Army to issue permits for the discharge of dredge or fill material into the waters of the United States at specified disposal sites.	404 potential very significant. Wetlands effects as recharge areas.
River & Harbor Act of 1899 33 U.S.C. 401, 403	Section 9 of the River and Harbor Act prohibits the construction of any dam or dike without Congressional consent and approval of the plans by the Chief of Engineers and the Secretary of the Army. Where the navigable portions of the waterbody lie wholly within the limts of a single State, the structure may be built under authority of the legislation of that State, if the location and plans are approved by the Chief of Engineers and the Secretary of the Army. The instrument of authorization is a permit. A Department of the Army permit is required for the discharge of dredged or fill material into waters of the United States associated with bridges and causeways pursuant to Section 404 of the Clean Water Act. Section 10 prohibits the unauthorized obstruction or alteration of any navigable water of the United States. The construction of any structure in or over any navigable water of the United States, the excavation form or depositing.	Impacts usually deal with recharge areas and reservoir and loss of natural recharge areas.

U. S. Department of Energy (DOE)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Nonnuclear Energy Research and Development Act 42 U.S.C. 5901 et seq.	A report by the Department of Energy on compliance with Section 13 of the Nonnuclear Energy Research and Development Act of 1974 indicates that this section provides for a cooperative program between the Department of Energy (DOE) and the Water Resources Council (WRS) to examine the impacts on water resources of emerging energy technologies. Implementation has concentrated primarily on the preparation of basinwide assessments of water resources availability and the impacts of energy development on the environmental, social, and economic resources of the region. There is a growing need for implementation of the provisions for site-specific studies of the impacts of demonstration and commercialization projects. The DOE is required to request site-specific assessments for demonstrating plants having "significant effects," and for commercialization projects.	Portion of the R&D funding provided under this act would be devoted to assessing the ground water impacts of managing energy technologies. Some work is already going on in this area.
Geothermal Loan Guaranty Program under Title II of the Geothermal Energy R&D Act of 1974	The program provides Federal loan guarantees for the acquisition of geothermal resources and development, construction, and operation and geothermal facilities.	Geothermal energy has the potential for causing major ground water impacts.

U. S. Department of the Interior (DOI)
Bureau of Land Management (BLM)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Federal Land Policy and Management Act of 1976 P. L. 94-579 (90 Stat. 2743)	Establish public land policies and establish guidelines for their administration; to provide for the management, protection, development, and enhancement of the lands and its resources. Selected sections of the Federal Land Policy and Management Act (FLPMA) provide for the designation and protection of areas of critical environmental concern (ACECs) in the preparation of land-use plans for public lands, and for compliance with applicable State and Federal pollution control laws.	This land use planning could be directed to include protection of ground water; i.e., those recharge areas could have restricted activities.
Outer Continental Shelf Lands Act 43 U.S.C. 1334 and 1346	Provides for conservation of marine life, recreational potential, aesthetic values, as well as reserves of gas and oil on the OCS.	OCS oil/gas and sulpher operations result in development of coastal infrastructure, and almost invariably, secondary economic development. This development changes land configurations, which may decrease the rate of ground water recharging, owing to increased runoff. Increased growth may at the same time put increased demand on ground water. The diminished water in the aquifer can result in salt water intrusion of ground water along the coastal zone. Disposal of toxic drilling and well-treatment fluids on land without proper containment may result in contamination of ground water by leaching of organic chemicals, heavy metals and hydrocarbons.

U. S. Department of the Interior (DOI)
Water and Power Resource Service (WPRS)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Flood Control Act of 1960 74 Stat. 472 (not codified)	Study means of recharging and replenishing Edwards Underground Reservoirs.	
The Reclamation Act 32 Stat. 388; 43 U.S.C. 91	This Act provides authority for the Water and Power Resource Administration for the examination and survey for construction and maintenance of irrigation works for the storage, diversion, and development of waters for the reclamation of arid and semi-arid lands in the Western states.	Water service contracts of WPRS can be used to ensure irrigators follow best management practices designed to protect ground-water quality. WPRS requires conservancy district to use BMP as condition to receipt of project water.
	Subsequent authorizations, under individual pieces of legislation, have been made for specific projects or groups of projects. These include, for example, Boulder Canyon Project Act, Colorado River Storage Project of 1956, Spokane Valley Project, and Colorado River Basin Project, Central Arizona Project.	There have been many court cases to determine the "rights of the United States." Generally, the U.S. as the owner of an irrigation project may retain control over and re-use seepage waters from the project.

U. S. Department of the Interior (DOI)
Bureau of Reclamation (BuRec)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Colorado River Basin Salinity Control 43 U.S.C. 1571-1599	Provides for various water quality improvements, canal or canal lining and salinity control programs, research and other programs downstream and upstream from the Imperial Dam.	

U. S. Department of the Interior (DOI)
Fish and Wildlife Service

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Endangered Species Act 16 U.S.C. 1251 et seq.	The Act established a Federal-State effort to identify, protect, and recover animals and plants which are in danger of extinction. A significant proportion of the ecosystems which the Act seeks to conserve includes or is affected by acuatic, wetland, or marine areas.	Limited to specific geographic areas of habitat—but strong protection against Federal actions which could impact ground water if it is critical to the maintenance of endangered species.
Fish & Wildlife Coordination Act 16 U.S.C. 661-667c	The FWCA ensures that the conservation and enhancement of fish and wildlife resources are considered equally with all other aspects of water resources development projects.	Potentially significant role in ground-water protection—but limited to weak "coordination" requirements which are not enforceable.
	The FWCA requires Federal agencies which propose or are authorized to undertake water resource development projects to consult with State and Federal wildlife agencies for the purpose of mitigating and compensating for project-occasioned losses to wildlife resources.	

U. S. Department of the Interior (DOL)
Heritage Conservation and Recreation Service

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Wild & Scenic Rivers Act 16 U.S.C. 1271 et seq.	The Act established the policy that certain rivers which, with their immediate environments, possess outstanding scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, will be preserved and protected.	Limited potential role—any real protection authority would be borrowed from CWA's nondegradation protection for "outstanding national resource waters of CWA's101(a) and 40 CFR 35.155(e)." A determination of "no direct and adverse effect" must be provided by the Secretary of Agriculture or Interior for any Federal action affecting water resources of a study category or designated river under Section 7(a), 7(b) of WSRA.

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
	U. S. Department of the Interior (DOI) Heritage Conservation and Recreation Service	
Land and Water Conservation Fund 16 U.S.C. 4601-4 through 4601-11	Assists in preserving, developing, and assuring accessibility to the quality and quantity of outdoor recreational resources.	Acquisition contributes to preservation for recharge, and restricted use which may protect water quality from degradation.
	U. S. Department of the Interior (DOI) National Park Service and Office of Surface Mining	
National Park System Mining Activity Regulation P.L. 94-429 (90 Stat. 1342)	Regulates mining activity within areas of the National Park System to prevent or minimize damage to the environment and other resource values.	SMCRA has high potential future role in ground water strategy in limited areas. Control of surface activities, such as erosion control, has high potential impact on ground water by affecting runoff to recharging ratios. Surface coal mining may directly impact ground water by hitting water tables, or lowering them for mining needs.
	U. S. Department of the Interior (DOI) Office of Surface Mining	
Surface Mining Control and Reclamation Act 30 U.S.C. 1201 et seq.		Abandoned mine land reclamation will reduce the number of acid mine drainage incidents and other toxic material leaching problems. There is high potential for EPA coordinating with OSM on ground water quality issues.

U. S. Department of the Interior (DOI)
Office of Surface Mining

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Appalachian Regional Development Act of 1975 40 App. U.S.C. 205	Makes financial contributions to States in the region to seal and fill voids in abandoned coal mines and abandoned oil and gas wells, and to reclaim and rehabilitate lands affected by the strip and surface mining and processing of coal and other minerals.	Control and abatement of mine drainage pollution on abandoned and active mine sites improves quality of water recharging aquifers.
Water Resources Research Act 42 U.S.C. 1961-1961c-8	Conducts research, investigations, experiments and the training of scientists in the fields of water and of resources which affect water.	Contributes to needed manpower supply and knowledge development for ground-water protection.
Saline Water Conservation Water Act of 1971 42 U.S.C. 1959-1959h	Supports researach and studies of development of processes and equipment for converting saline water, engineering and technical work for development of desalting processes and plant design concepts for scaled demonstrations, methods for recovery and marketing of by-products as offsets against treatment costs; reduction of impact on environment from discharge of brine into water and economic studies and surveys on water production costs; information concerning relation of desalting to other aspects of comprehensive water resource planning.	

U. S. Department of the Interior (DOI)
U. S. Geological Survey

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Act of March 3, 1870 43 U.S.C. 31 (and subsequent legislation)	Establishes functions of the Geological Survey and designates USGS as the lead agency for coordinating the activities of all Federal agencies in the acquisition of certain water data from streams, lakes, reservoirs, estuaries and ground water. USGS also provides for cooperative (joint) funding of geological survey scientific and technical investigations with State and local governmental agencies.	Provides data base on amount, quality, location, movement, and changes in U.S. water supply for decision making regarding protection and enhancement of ground-water quality.

Housing and Urban Development (HUD)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Housing and Community Development Act of 1974	Establishes a grant program to undertake a broad range of community development activites including the Community Development Block Grant Program and the Economic Development Administration Program.	Federal grants, loans, guarantees and other financial assistance programs support projects which directly impact the environment. EDA funds physical on land facilities which impact solid waste, water and air pollution. These projects are subject to environmental controls when the nature of the activity constitutes a major Federal action requiring an environmental impact statement under NEPA or the activity must meet specific site, size, or pollution criteria or requirements. The individual Federal actions may be dimensionally small (in size, money or resources) but are pervasive and potentially significant when considered in the aggregate on a regional basis. In terms of financial resources, the aggregate Federal investment exceeds EPA's construction grants program.
National Housing Act Pub. L. 479, 48 Stat. 1246. 12 U.S.C. 1701 et seq.	To ensure adequate and safe housing for the Nation's population.	As with other Federal community and economic development programs projects receiving Federal financial assistance are pervasive in their geographical distribution and should be considered in any national ground-water protection strategy.

Nuclear Regulatory Commission

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Energy Organization Act of 1974	Regulates the development of nuclear power facilities.	direct impact
The Uranium Mill Tailings Radiation Control Act of 1978	Mandates the EPA to establish minimum radiation standards for uranium mill tailings and the Nuclear Regulatory Commission (NRC) to implement and enforce the standards.	direct impact
Atomic Energy Development and Control	Regulates development, use, and control of atomic energy including the regulation of the disposal into the ocean or sea of by-product, source, or special nuclear waste materials as defined in regulations or orders of the Commission.	

Water Resources Council

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Water Resources Planning Act 42 U.S.C. 1962 et seq.	Provides for the optimum development of the Nation's natural resources through the coordinated planning of water and related land resources, through the establishment of a water resource council and river basin commissions, and by providing financial assistance to the States in order to increase State participation in such planning.	Stimulates increased agency effort in the planning and protection of ground-water resources in Federal programs. The Council's Principles and Standards for Planning Water and Related Land Resources set forth general water planning stipulations that increase emphasis on ground water in agency planning. The Manual of Procedures now being developed by the Water Resources Council aids implementation of the Principles and Standards and transmits ground water planning measures to Federal agencies.

All Federal Agencies

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
National Environmental Policy Act 42 U.S.C. 4321 et seq.	The National Environmental Policy Act of 1969 (NEPA) mandates the preparation of an environmental impact statement for major Federal actions significantly affecting the quality of the human environment. As water construction projects as well as other Federal activities commonly have an impact on the ground-water resource, an environmental impact statement is one of the tools that should be used by Federal agencies in the planning process as it relates to the ground-water resource. Agencies subject to Principals and Standards generally are required to meet NEPA responsibilities in conjunction with activities according to Agency Procedures. A Council on Environmental Quality Memorandum dated November 19, 1976, provides guidance and Instructions to Federal agencies for evaluation of the impact of federally assisted projects on ground-water supplies.	
	Environmental Protection Agency (EPA) 1/	
Clean Water Act Section 101	Restoration, maintenance of chemical, physical biological integrity of Nation's waters; prohibition of discharge of toxics; development and implementation of areawide management planning process; prevention, reduction, elimination of pollutants.	
Clean Water Act Section 102	Development of comprehensive program to eliminate pollution.	
Clean Water Act Section 104(a) (5)	Establish ground-water surveillance program with States, political subdivisions and other Federal agencies.	

1/ See Appendix VI for more detailed analysis.

Environmental Protection Agency (EPA)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Clean Water Act Section 201	Grants for construction of treatment works to achieve pollution control goals of the Act.	
Clean Water Act Section 202(a) (2)	Grants for innovative or alternative projects can be for 85% of cost of construction rather than 75%.	
Clean Water Act Section 106	Grants to assist States in administering programs for the prevention, reduction, and elimination of pollution.	
Clean Water Act Section 208	Development and implementation of areawide waste treatment management plans.	
Clean Water Act Section 209	Level B Basin Plan	
Clean Water Act (State/EPA Agreement Development)	Emphasis of linkages between programs covered under CWA, RCRA and SDWA.	
Clean Water Act Section 303	Water quality standards to protect highest possible uses for surface water bodies; includes pollutant level allocations where necessary.	
Clean Water Act Section 303(e)	Planning process for surface water no State may receive NPDES authority without this process.	
Clean Water Act Section 304(e)	Best management practices of ancillary activities of point source discharges of section 307(a) toxic pollutants and section 311 hazardous substances.	
Clean Water Act Section 304(f)	Guidance on precautions of nonpoint source water pollution.	

Environmental Protection Agency (EPA)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Clean Water Act Section 311(j)	Regulations to prevent spills of hazardous substances into surface water from vessels and onshore and offshore facilities.	
Clean Water Act Section 311	Cleanup and cost recovery of spills of hazardous substances.	
Clean Water Act Section 402(b) (1) (D)	Control well disposal.	
Clean Water Act Section 404	Regulatory. Defines requirements for standard setting, permitting, exempting categories, state program delegation, and enforcement.	
Clean Water Act Section 405	Guidelines on POTWs sludge disposal.	
Clean Water Act SEA	Combining specific statutory requirements to achieve common or complementary environmental goals.	
	All Agencies	
Federal Water Policy Initiatives	Issues surrounding ground water.	
	Environmental Protection Agency (EPA)	
Clean Water Act (Regs.) Section 35.918-3	Requirements for discharge of effluents (BPWTT).	
Clean Water Act Section 35.925-2	The project must be consistent with any applicable approval water quality management plan.	

Environmental Protection Agency (EPA)

Act	Coverage of the Act	Potential Future Role in Ground Water Strategy
Clean Water Act Section 35.927-1	Infiltration/inflow analysis to be performed to show possible existence of excessive I/I in the sewer system.	
Clean Water Act Appendix A	Cost-effectiveness analysis guidelines requires evaluation of the costs and effects of flow reduction measures.	
Clean Water Act Appendix E	Innovative and alternative technology guidelines--identifying and evaluating criteria. Alternative includes aquifer recharge. Innovative methods include those that involve greater recycling and conservation of water resources.	
Guidelines for Preparing Facility Plan (May 1975)	Analysis of existing conditions should assess impacts of the various alternatives; including no action, on water quality (incl. ground water).	
Wastewater Treatment Pond (Technical Bulletin)	Discusses protection of ground water from pond seepage.	
Evaluation of Land Applications System (Technical Bulletin)	Environmental assessment of this alternative must assess impacts on ground water.	
Federal Insecticide, Fungicide and Rodenticide Act Section 6(b) and 6(c)	Regulatory product licensing and use restriction. Protects health and the environment by prohibiting the uses of pesticides shown to cause unreasonable adverse effects.	