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REGIONAL PLANNING
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Regional Water and Wastewater Planning Study

for

Kerr County, Texas

Prepared for

City of Kerrville
Kerrville Public Utility Board
Upper Guadalupe River Authority

By

HDR

HDR Engineering, Inc.

Austin, Texas
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STATE OF TEXAS
JAMES R. GLASER
31737
REGISTERED
PROFESSIONAL ENGINEER

10/28/97

REGIONAL WATER AND WASTEWATER PLANNING STUDY
KERR COUNTY, TEXAS

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REGIONAL WATER AND WASTEWATER PLANNING STUDY for KERR COUNTY, TEXAS

EXECUTIVE SUMMARY

ES 1.0 INTRODUCTION

Kerr County is located in the Edwards Plateau region of Texas, with the central two-thirds of the county being the headwaters region of the Guadalupe River. The cities of Ingram and Center Point, plus approximately 75 privately owned water utilities which supply water to subdivisions that are located within a few miles of Kerrville along and near the Guadalupe River, obtain water from aquifers which underlie the area and use on-site wastewater disposal methods. The City of Kerrville, which has approximately 48 percent of Kerr County's population, obtains water from the Guadalupe River and aquifers which lie beneath the city. Kerrville has both a water distribution system and a centralized wastewater collection, treatment, and disposal system. Given that: 1) the aquifers upon which a large and rapidly growing part of Kerr County's population depends for water supply are severely limited; and 2) the soils and physical terrain of Kerr County are limited with respect to on-site waste disposal capabilities, it is necessary to consider the development of regional water supply and wastewater collection systems to serve the growing needs of the urbanizing centers of the county.

The objectives of this study are to:

1. Prepare population, water demand, and wastewater flow projections for Kerr County and each growth center for the county using Texas Water Development Board 1996 consensus water planning projections for the period from year 2000 to 2050, with wastewater flow projections for the period 2000 through 2020;

2. Inventory existing water providers of Kerr County, tabulate surface water permits held in Kerr County, assess the ground water supply of Kerr County, and estimate the ability of water providers to meet present and future water demands;

3. Develop a list of wastewater collection and treatment systems in Kerr County, estimate the ability to meet present and future needs, and review the need for regional wastewater systems in Kerr County; and,

4. Assess the implementation of regional water supply and wastewater systems including: a) development of a list of entities that could provide water and wastewater services on a regional basis including both existing and new entities; b) description of authority and potential methods for financing facilities needed for a regional system; and c) review of the statutory and contractual authority of Kerrville, Upper Guadalupe River Authority (UGRA), and Kerrville Public Utility Board (KPUB) to provide water and wastewater services in Kerr County.

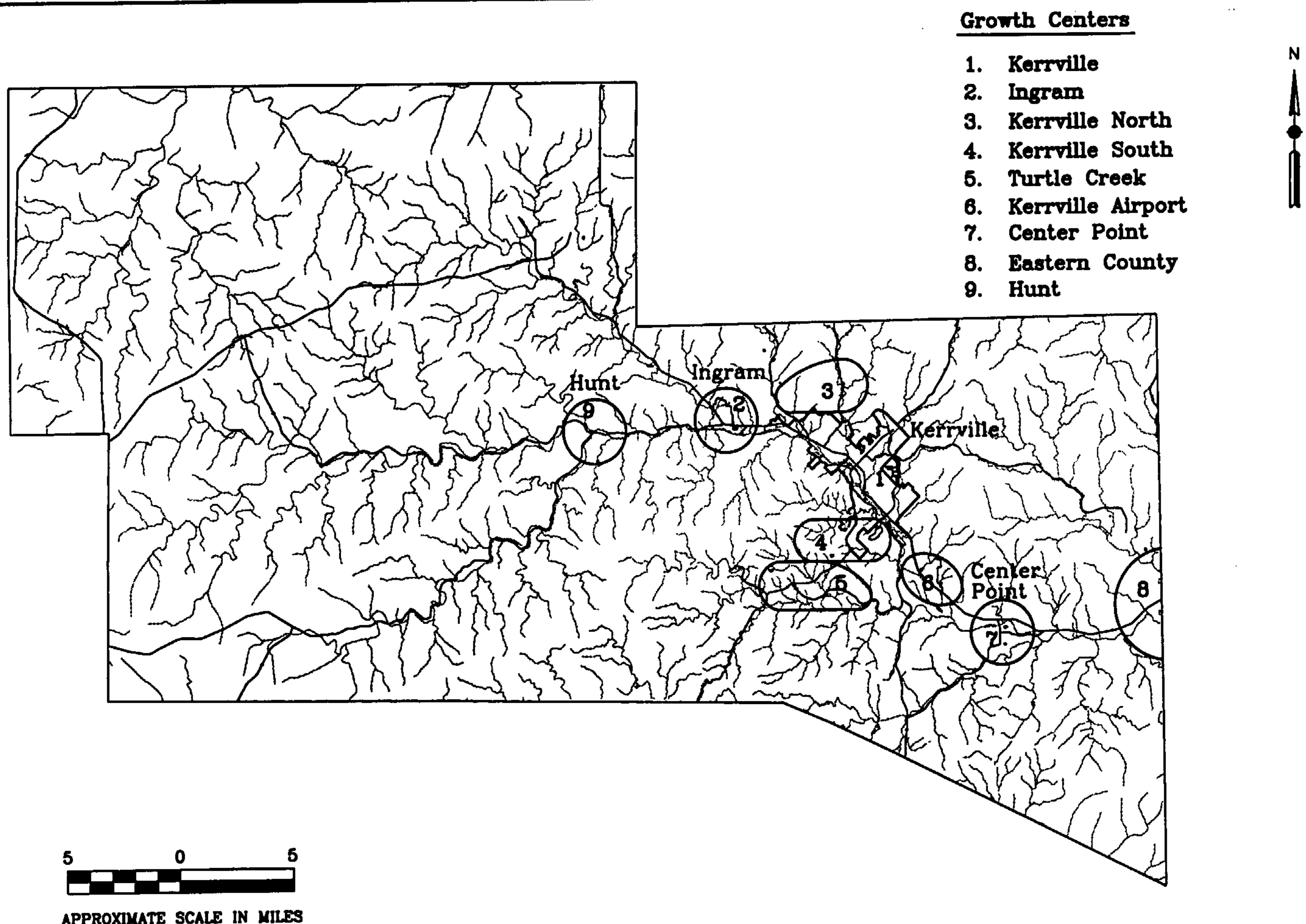
ES 2.0 POPULATION AND WATER DEMAND PROJECTIONS

Population Projections: The population of Kerr County increased from 28,780 in 1980 to 40,264 in 1995, with the population of Kerrville increasing from 15,276 in 1980 to 17,384 in 1990. At the present time, more than 95 percent of the population of Kerr County is located in nine centers in the eastern one-half of the county (Figure ES-1, as follows:

1. Kerrville
2. Ingram
3. Kerrville North
4. Kerrville South
5. Turtle Creek
6. Kerrville Airport
7. Center Point
8. Eastern County
9. Hunt

The population of Kerr County is projected to increase to 43,822 in year 2000, to 60,492 in year 2020, and to 85,669 in 2050.

The population of the City of Kerrville is projected to grow from 17,384 in 1990 to 21,191 in 2000, to 30,425 in 2020 and to 44,383 in 2050. If Kerrville extends service to 6 percent of areas near Ingram by 2000, 50 percent of Kerrville South by 2010 and 90 percent by 2020; 14 percent of the Turtle Creek area by 2030; 70 percent of the Kerrville



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REGIONAL WATER AND WASTEWATER STUDY

STUDY AREA

FIGURE ES-1

Airport area by 2000; and 15 percent of areas in the Center Point growth center by 2020, then Kerrville would have a service area population potential of 22,361 in year 2000, 29,704 in 2010, 44,482 in 2030, and 55,822 in 2050 (Figure ES-2).

Under the Kerrville service extension assumptions stated above, the Ingram area population would increase from 5,618 in 1990 to 6,745 in 2000, 9,004 in 2020, and 12,411 in 2050.[1]

The Kerrville North growth area was estimated to have a population of 742 in 1990, and is projected to grow to 1,189 in 2020, and to 1,639 in 2050. The Kerrville South area population was estimated at 3,892 in 1990. The area is projected to grow to a population of 4,673 in 2000, and 6,238 in 2020, of which 5,614 could be a part of the Kerrville service area through Kerrville's service extension. If Kerrville serves 90 percent of the Kerrville South subdivision by 2020, the area remaining is projected to have a population of 624 in year 2020, 689 in 2030, and 860 in 2050.

Estimated 1990 population of the Turtle Creek area was 2,076, with projections to 2020 of 3,326 and to 2050 of 4,585. For that portion of Turtle Creek that might be served by Kerrville, the population in 2030 is projected at 515, and at 2050 is projected at 642.

The Kerrville Airport area had an estimated population of 910 in 1990, and is projected to have a 2050 population of 2,011, of which 1,407 are included in parts of the area that might be served by Kerrville.

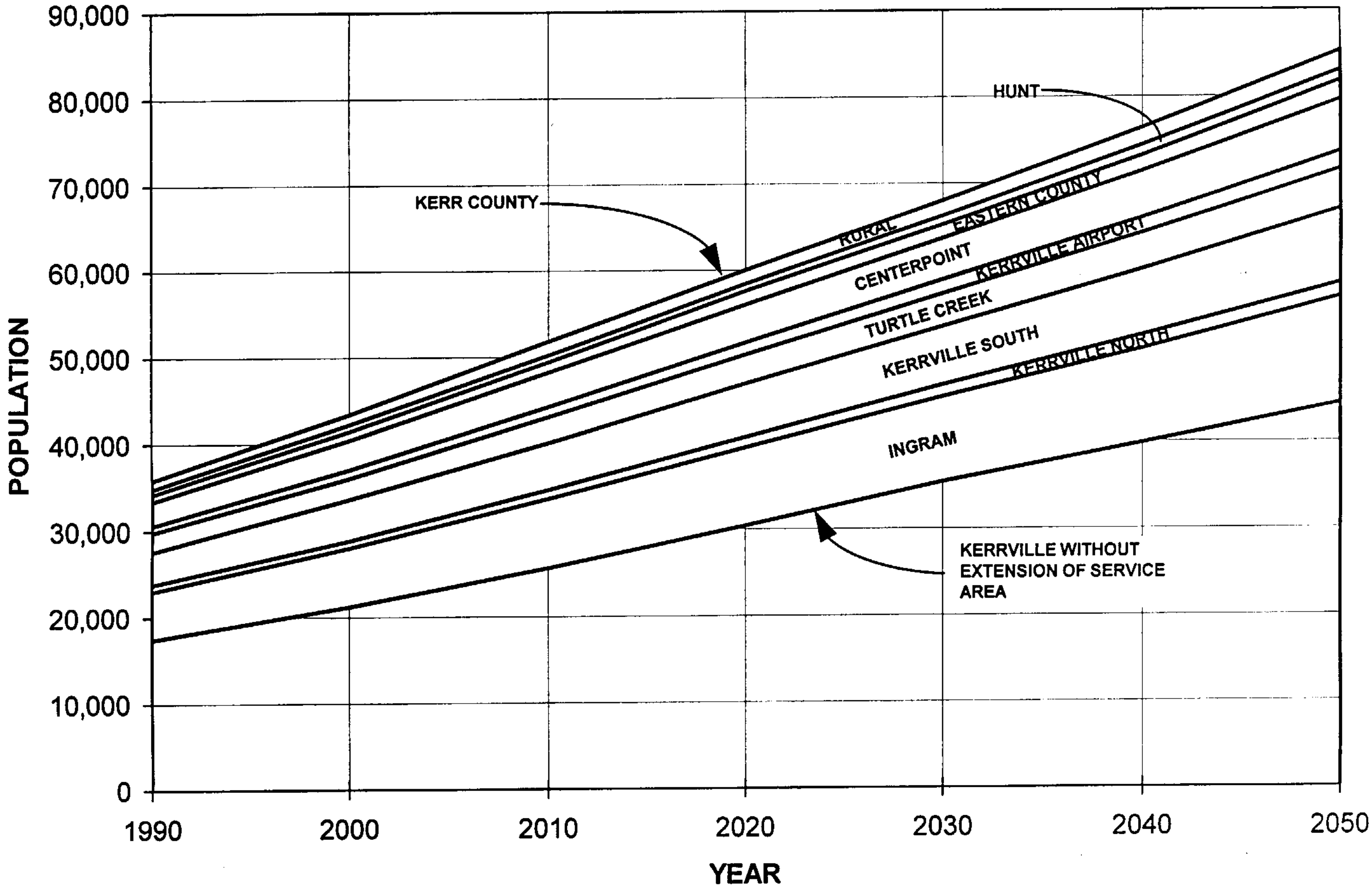
The estimated population of the Center Point area in 1990 was 2,738. The Center Point area's population is projected to be 6,048 in 2050, with 907 being in that part of the area that might be served by Kerrville.

The estimated population of the Eastern Kerr County growth center was 936 in 1990, and is projected to increase to 1,500 in 2020, and to 2,068 in 2050.

The Hunt area had an estimated 1990 population of 583, and is projected to grow to 934 in 2020, and to 1,287 in 2050.

Estimated population of the remainder of Kerr County ("Other") was 1,005 in 1990, and is projected at 1,610 in 2020, and 2,219 in 2050 (Figure ES-2).

[1] As of the date of this study, Kerrville wastewater service is being extended to parts of the Ingram area.



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REGIONAL WATER AND WASTEWATER STUDY
POPULATION PROJECTIONS
KERR COUNTY

FIGURE ES-2

Water Demand Projections: In Kerr County, the major water uses are for municipal and domestic purposes, with small quantities used for industrial, irrigation, mining, and livestock water purposes. Water demand projections for municipal purposes are based upon population projections for each respective area, as stated in the previous discussion, and per capita water use projections (gallons per person per day) of the population of each area. The per capita water use (gpcd) values used in this study are those expected for below normal precipitation conditions and average water conservation efforts, including the effects of low-flow plumbing fixtures being installed in new structures and in remodeling of existing structures.

In 1990, Kerr County water use was 143 gallons per person per day, with the Kerrville and Ingram urban area use at 179 and 155 gallons per person per day, respectively. The potential effects of low-flow plumbing fixtures and other water conservation measures could reduce dry weather per capita water use in Kerrville from 200 gpcd in year 2000 to 181 gpcd in 2020, and the Kerr County average from 169 gpcd in 2000 to 139 gpcd in 2050.

In 1990, municipal water use in Kerr County was 5,821 acft/yr, of which 3,492 acft were by the City of Kerrville, 244 acft were in the City of Ingram, and 2,085 acft were in the remaining areas of the county. Projected dry year municipal water demand for Kerr County in year 2000 is 8,601 acft/yr, with projected municipal water demand in 2020 of 10,591 acft/yr, and in 2050 of 14,335 acft/yr (Table ES-1). Projected total water demand for Kerr County is 10,155 acft/yr in 2000, and 15,707 acft/yr in 2050 (Table ES-1).

Wastewater flows presented in Table ES-2 were projected based on population projections and unit wastewater flows developed from City of Kerrville 1995 flow and population data. Projected City of Kerrville unit flows assume a 10 percent linear decline between 1995 and 2010 to account for water conservation efforts. Unit flows outside of the City of Kerrville were estimated to be 80 percent of the unit flow within the City of Kerrville due to fewer commercial and industrial developments outside the city.

TABLE ES-1 WATER DEMAND PROJECTIONS FOR KERR COUNTY WITH CONSERVATION							
	Use in	*Water Demand Projections (acft/yr)*					
Type of Use	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Municipal	5,821	8,601	9,650	10,591	11,777	12,941	14,335
Industrial	28	30	33	36	38	41	44
Irrigation	850	822	796	770	745	721	697
Mining	73	176	422	110	103	102	105
Livestock	382	526	526	526	526	526	526
Kerr County Total Water Demand	7,154	10,155	11,127	12,033	13,189	14,331	15,707

TABLE ES-2 WASTEWATER FLOW PROJECTIONS						
	Wastewater Flow Projection (mgd)					
Service Area	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Kerrville with Extended Service Areas	2.54	3.13	3.97	4.60	5.17	5.77
Remaining County Areas	1.91	1.90	1.88	2.03	2.27	2.53
Total County	4.45	5.03	5.85	6.63	7.44	8.30

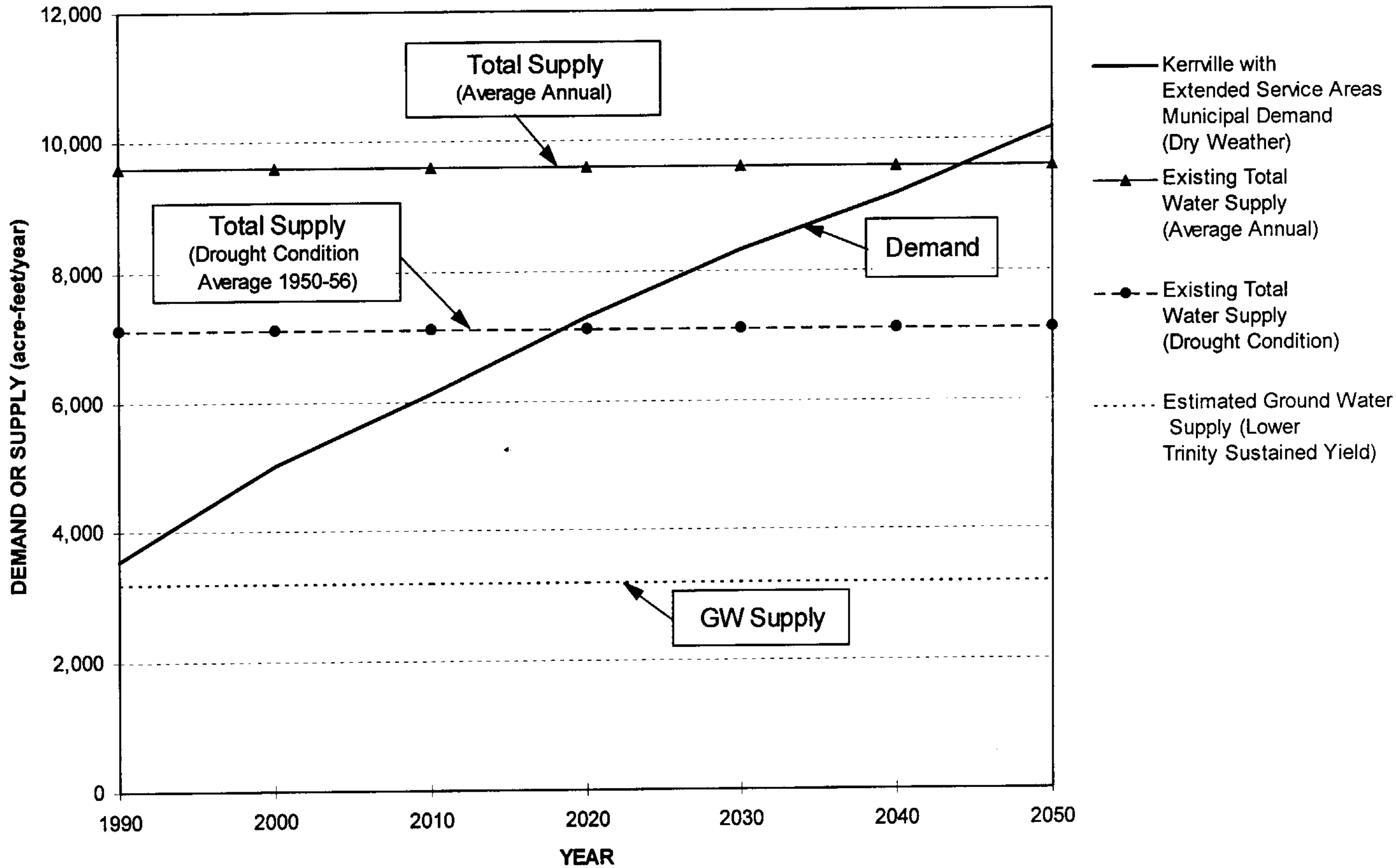
ES 3.0 WATER SUPPLY EVALUATION

Currently there are 75 retail water providers within Kerr County. In addition to the retail providers, the UGRA is a wholesale supplier of treated water from the Upper Guadalupe River to the City of Kerrville for municipal use. The City augments this supply with ground water withdrawn from the Lower Trinity Aquifer, while the remaining municipal water demands within the county are supplied by the Middle Trinity Group Aquifers.

Pressures in the Lower Trinity Aquifer near Kerrville have recovered since the development of surface water in 1981. However, based on a review of well hydrographs in eastern county Middle Trinity wells, it appears that the Middle Trinity Aquifer in the eastern part of the county is being over-drafted under current demand conditions. Therefore, it may benefit the eastern portion of Kerr County to supplement its ground water withdrawals with surface water in a manner similar to Kerrville.

Kerrville Service Area Water Demand and Supply Analysis: The estimated supply of ground water available to Kerrville from the Lower Trinity Aquifer is 3,200 acft/yr. The total permitted surface water diversion for the City, including the extended service areas, is the quantity allowed under TNRCC Permit Nos. 1996, 3505, and 5394 (1,100 acft/yr for Kerrville and 447 acft/yr for municipal areas to which Kerrville may extend service). The average annual quantity of surface water supply available under these permits was calculated at 4,835 acft/yr for the period of streamflow records (1934 through 1990). However, for the critical period of 1950 through 1956 (drought of record), the quantity of surface water available to Kerrville was calculated at 3,727 acft/yr. A graphic analysis of the projected water demand and supply for Kerrville, with service extensions to adjacent and nearby areas shows that, under drought conditions, present estimated supplies of 3,200 acft/yr of ground water plus drought condition supplies of surface water of 3,727 acft/yr would meet projected demands to about year 2017, while for average conditions, with surface water supplies of 4,835 acft/yr, projected demands could be met until about 2036 (Figure ES-3).

Kerr County Water Demand and Supply Analysis: The water demand and supply comparisons for Kerr County are based upon expectation that the Upper Trinity and Edwards Plateau aquifers will continue to meet the agricultural and domestic demands in the northern and western portions of the county. In addition, it is felt that 500 acft/yr of Middle Trinity ground water, along with existing irrigation surface water rights, will supply irrigation and livestock needs in Central and Eastern areas of the county. Existing surface water rights (153 acft/yr) are available to meet projected mining demands (105 acft/yr in 2050). Therefore, the surface water supply combined with the remaining yield of the Middle and Lower Trinity aquifers (4,200 acft/yr) can be compared to the projected total municipal demand of Kerr County for water supply planning purposes. For average weather conditions, the average annual surface water supply from permits for municipal water use in Kerr County was calculated at 6,396



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REGIONAL WATER AND WASTEWATER STUDY

PROJECTED KERRVILLE AREA MUNICIPAL WATER DEMANDS AND EXISTING SUPPLIES

(ASSUMES 3,200 ACFT/YR LOWER TRINITY SUSTAINED YIELD)

FIGURE ES-3

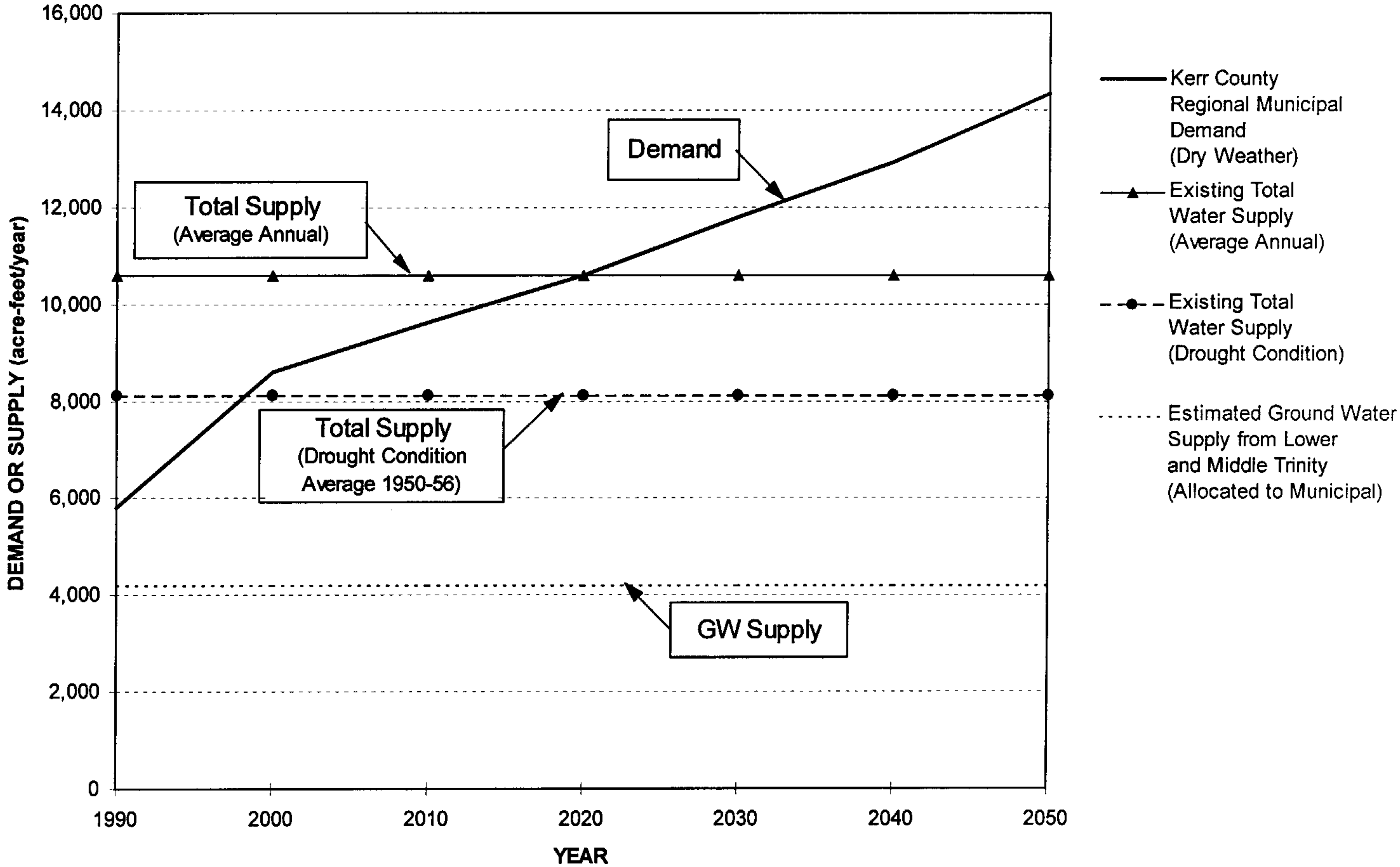
acft/yr including water available for aquifer injection. Supply available during drought conditions similar to the hydrology observed from 1950 through 1956 was computed to be 3,910 acft/yr, with no water available for aquifer injection. For average conditions, the supply available would meet projected Kerr County municipal water demands, including the Kerrville service area presented above, until about 2020. However, the water supply is vulnerable to drought conditions as shown in Figure ES-4.

The analysis presented in this document indicates the vulnerability of Kerr County water supplies during drought conditions. The existing system of private water suppliers relying only on ground water is inadequate for Kerr County in the near term. In order to supply the municipal water demand for Kerr County in the future, a regional water supplier is needed. The regional supplier should have powers to supply treated surface water on a wholesale basis to the population centers identified in this study. The regional supplier should evaluate methods to improve the reliability of water supply in Kerr County based on the analyses presented in this document and subsequent studies.

Options for increasing the available water supply include those that are listed below:

1. Obtaining additional surface water rights or contracting for additional surface water from the Guadalupe River.
2. Evaluating (or reevaluating) potential use of off-channel surface storage to allow capture of surface water during periods of high river flows for subsequent direct use or for ASR. Ability to capture and store raw water in an off-channel surface impoundment would not be limited by the capacity of the water treatment plant or the ASR injection rate.
3. Revising TNRCC surface water permits to allow higher diversion rates in off-peak demand months when stream flows are greater could increase the benefits of ASR, particularly during drought conditions.
4. Development of wells in remote locations (availability of ground water in such areas would need to be determined).

The four options listed above should be evaluated and a plan developed based on the combination that most economically meets the needs of the area. Any plan should include a means of controlling well size and spacing in Kerr County.



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REGIONAL WATER AND WASTEWATER STUDY

KERR COUNTY REGIONAL MUNICIPAL WATER DEMANDS AND EXISTING SUPPLIES

(ASSUMES COMBINED TRINITY SUSTAINED YIELD OF 4,700 ACFT/YR)

FIGURE ES-4

ES 4.0 WASTEWATER

The soils and terrain of Kerr County are generally not suitable for effective septic tank operation or land disposal systems, with the exception of small areas of Uvalde soils. Therefore, to prevent surface and ground water contamination, wastewater should be collected and treated. Centralized facilities are recommended over individual package plants to provide greater reliability. The recommended regional wastewater disposal system would collect and transport wastewater to centralized facilities located in the City of Kerrville and the Center Point area. Exact capacities of each plant would have to be determined based on the location of growth and collection system layout, but the combined plant capacity should be available to treat the projected average monthly flow of 5.03 mgd in 2020 and 8.30 mgd in 2050.

The regional wastewater option that appears to be most feasible for Kerr County involves expansion of the City of Kerrville Wastewater Treatment Plant to handle flows in several areas generally from Kerrville west and construction of a new wastewater treatment plant in the Center Point area to serve the Turtle Creek area and other areas east of Kerrville. If all projected year 2050 flows in the county were collected and treated at these two plants, the needed capacity projected at the Kerrville Plant would be approximately 7.0 mgd, and the needed capacity projected at the Center Point area plant would be approximately 1.3 mgd. Not all areas in the County will likely be served, so the actual needed 2050 combined capacity of the two facilities would be less than 8.3 mgd.

ES 5.0 REGIONAL WATER SUPPLY AND WASTEWATER SYSTEMS

There are 6 types of entities that would have powers to construct, own, and operate either or both regional water supply and wastewater systems in Kerr County. These are as follows: (1) Conservation and Reclamation Districts; (2) River Authorities; (3) Water Control and Improvement Districts; (4) Municipal Utility Districts; (5) Fresh Water Supply Districts; and, (6) Underground Water Conservation Districts. Conservation and Reclamation Districts have the powers to serve as regional water supply and wastewater systems. River authorities, such as the Upper Guadalupe River

Authority, are conservation and reclamation districts, under Article 16, Section 59 of the Texas Constitution, and therefore can serve as regional water supply and wastewater systems.

Water control and improvements districts (WCID) authorized under Chapter 51 of the Texas Water Code may be created by the County Commissioners Court if the district is located wholly within the county, or by TNRCC if more than one county is involved. WCID's have power to supply water but not wastewater services. Municipal utility districts (MUD) authorized by Chapter 54 of the Texas Water Code may be created by the TNRCC upon petition by landowners within the district. MUDs have both water and wastewater powers. Fresh water supply districts created under Chapter 53 of the Texas Water Code, can function as a regional water supplier, but do not have powers to provide wastewater services. Underground water conservation districts authorized by Chapter 36 of the Texas Water Code can be created by TNRCC upon petition by landowners of the area, and confirmed by election of the voters of the district. Such districts would be empowered to implement water but not wastewater services.

In addition to creating districts under general laws of the Texas Water Code, districts can be created by special act of the legislature. In this way, a district can be tailored to address the particular needs of an area, including powers, financing, and authority. The Interlocal Cooperation Act (Article 4413, (32C)), Vernon's Texas Civil Statutes, is a method whereby existing governmental entities can jointly own and operate water and wastewater projects. In addition, Article 1110F, Vernon's Texas Civil Statutes, allows existing political entities to create a public utility agency to construct, own, and operate water and wastewater facilities. However, such agencies can only finance projects through service revenues, since they do not have taxing authority.

Authority of Kerrville, Upper Guadalupe River Authority, and Kerrville Public Utility Board to Provide Water and Wastewater Services in Kerr County: The City of Kerrville is a "Home Rule City" which owns and operates its water and wastewater systems through its Department of Public Services. Through interlocal agreements, the City can provide such services on a wholesale basis to neighboring units of government, and through contracts with other public water utilities, the City could become a regional supplier of water and wastewater services within its immediate vicinity.

The UGRA is a conservation and reclamation district formed by the Texas Legislature. The District has the same boundaries as Kerr County, Texas. The UGRA has the necessary powers to develop and sell water to suppliers for beneficial use within the boundaries of the District and, as a necessary aid for beneficial use, the District was also given the power to construct, own, and operate sewage collection, transmission, and disposal services, including authority to enter into contracts with municipalities and others for such purposes.

The Kerrville Public Utility Board (KPUB) was created by the City of Kerrville to assume management and control of the Kerrville electric system. The KPUB Board, or a similar board, could be authorized by the City, to manage and operate its water and wastewater systems.

Financing Sources for Regional Water and Wastewater Systems: There are five major sources of financing for public water supply and water quality protection projects, including: (1) Bond Market; (2) Texas Water Development Fund; (3) State Participation Fund; (4) Community Development Block Grants; and (5) Rural Development Grants and Loans. Each source is explained below. Public agencies borrow funds in the financial markets through the issuance of bonds, then use the proceeds to construct public water supply and wastewater projects such as water supply reservoirs, water wells, pipelines, water treatment plants, sewage treatment plants, pump stations, storage tanks, and associated capital equipment. The bond holders are repaid with interest, using revenues and/or fees collected from those who receive water and/or sewer services, from taxes levied on property in the service area, or from a combination of revenues, fees, and taxes.

The Texas Water Development Board (TWDB) has authority to issue State of Texas General Obligation Bonds to provide loans to political subdivisions and special purpose districts for the construction of water supply, sewer, and flood control projects. The TWDB purchases the bonds of cities and local water districts and authorities, which in turn use the borrowed funds to pay for construction of local projects. The local district or city repays the TWDB, with interest.

The concept of State Participation, as it applies to water supply and water quality protection projects, is as follows. A local area needs an additional water source, transmission pipelines, storage reservoir, and treatment plant, or has wastewater collection and treatment plant needs, however, the area's existing customer base can only support monthly rates required to repay loans for a project sized to meet present needs. Through the State Participation Fund, the local entity could plan a larger project, and apply to the TWDB for state participation in the project. The TWDB would hold its project share until a future date, at which time the services are needed, and the local entity would buy the TWDB's share. In this way, costs to customers would be reduced through the phenomenon of economies of size.

The State Revolving Fund was established in 1987 to provide a financing source for wastewater treatment and non-point source pollution control projects. The SRF provides below market interest loans to eligible political subdivisions for construction, improvement, or expansion of sewage collection and treatment facilities. The SRF is funded through a combination of federal clean water grants and state water quality enhancement bond funds.

The Drinking Water State Revolving Fund (DWSRF) program was authorized as part of the 1996 Safe Drinking Water Act (SDWA) Amendments by the U.S. Congress. The program establishes a state revolving fund, which is being administered by the Texas Water Development Board (TWDB) and is scheduled to begin receiving applications in the fall of 1997. Under this program, political subdivisions and nonprofit water supply corporations may apply for low interest DWSRF loans to finance water supply projects that are required in order to comply with the federal Safe Drinking Water Act regulations. The source of financing the DWSRF is federal grants and state bonds.

The Community Development Block Grant (CDBG) program was created by Congress in 1974. It is administered at the federal level through the U.S. Department of Housing and Urban Development (HUD). The program is divided into two major categories: (1) entitlement (cities over 50,000 and qualifying counties over 200,000 in population); and, (2) non-entitlement (cities under 50,000 in population and counties not eligible for entitlement status). The Community Development Fund is the major funding category (about two-thirds of the total funding) under the Texas Community Development Program, and is the only category through which water supply and wastewater projects could be eligible. An annual competition, divided into regional allocations for eligible cities and counties in each of the state's 24 planning regions, is held. An application for the 1998 program would need to be filed with the Alamo Area Council of Governments (AACOG). The notice for application and schedule for filing will be announced in September or October of 1997 for the 1998 competition.

The Rural Development (RD) Administration (formerly known as the Farmer's Home Administration) of the U.S. Department of Agriculture is authorized to provide financial assistance in the forms of loans and grants for water supply development in rural areas and towns with populations of 10,000 or less. Grants may be made for up to 75 percent of eligible project costs for facilities serving low income areas. RD staff will advise applicants as to how to assemble information and file both grant and loan applications. Such applications are filed with the local RD district office, which for the study area is located in Fredericksburg, Texas.

RD grants and loan programs may be viable financing options for some entities in Kerr County for water supply facilities. This source of funding could perhaps be combined with Texas Water Development Board loans to secure a surface water supply for the study area.

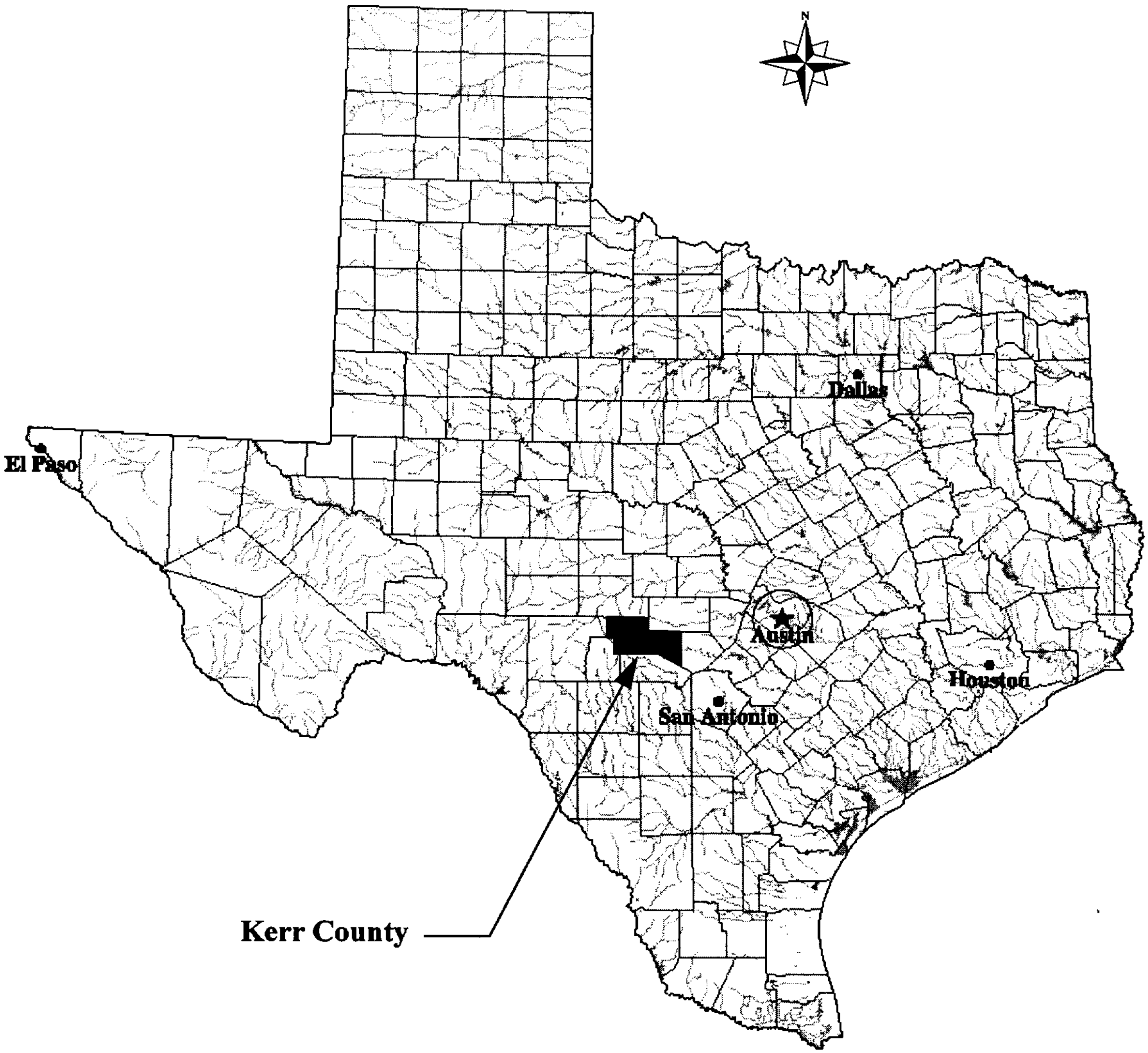
REGIONAL WATER AND WASTEWATER PLANNING STUDY *for* KERR COUNTY, TEXAS

1.0 INTRODUCTION

1.1 Background

The study area is Kerr County, located as shown in Figure 1-1 in the Edwards Plateau region of Texas. The county is located in 4 river basins, as follows. The northwestern portion and the northeastern corners of the county are located in the Colorado River Basin. A small area of the southwestern corner of the county is located in the Nueces River Basin. The southeastern corner and a small area of the south central part of the county are located in the San Antonio River Basin, with the central portion (approximately two-thirds of the county) located in the Guadalupe Basin. The areas of Kerr County that are located in the Colorado, Nueces, and San Antonio River Basins are rugged and sparsely populated, with the land being used primarily for livestock grazing and game production. These areas obtain drinking water from local aquifers and livestock water from local streams and on-site stock watering tanks.

The areas in the Guadalupe River Basin, along and near the Guadalupe River are the centers of population growth. The cities of Ingram and Center Point, plus approximately 75 privately owned water supply utilities located within a few miles of Kerrville along the Guadalupe River, obtain water from aquifers which underlie the area. The City of Kerrville, which has approximately 48 percent of Kerr County's population, obtains water from the Guadalupe River and aquifers which lie beneath the city. Kerrville has both a water distribution system and a centralized wastewater collection, treatment, and disposal system, whereas the remainder of the urbanizing areas have individual subdivision water distribution systems and septic tanks for sewage disposal. Given that: 1) the aquifers upon which a large and rapidly growing part of Kerr County's population depends for water supply are severely limited; and, 2) the soils and physical terrain of Kerr County are limited with respect to on-site waste disposal capabilities (i.e., soils are shallow, with low permeabililties, and the surface features of lands available are steep and rocky), it is necessary to consider the development of regional water



REGIONAL WATER AND WASTEWATER STUDY
LOCATION MAP
KERR COUNTY

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FIGURE 1-1

supply and wastewater collection systems to serve the growing needs of the urbanizing centers of the county.

1.2 Objectives and Scope

The objectives of this study are as follows:

1. Prepare population, water demand, and wastewater flow projections for Kerr County and each growth center of the county using Texas Water Development Board 1996 consensus water planning projections. Population and water demands are to be projected by decade from year 2000 to 2050, with wastewater flow projections to be for the period 2000 through 2020;
2. Inventory existing water providers of Kerr County, tabulate surface water permits held in Kerr County, assess the ground water supply of Kerr County, and estimate the ability of water providers to meet present and future water demands;
3. Develop a list of wastewater collection and treatment systems in Kerr County and estimate the ability to meet present and future needs. Review the need for regional wastewater systems in Kerr County; and,
4. Assess the implementation of regional water supply and wastewater systems including: a) development of a list of entities that could provide water and wastewater services on a regional basis including both existing and new entities; b) description of authority and potential methods for financing facilities needed for a regional system; and c) review of the statutory and contractual authority of Kerrville; UGRA, and KPUB to provide water and wastewater services in Kerr County.

2.0 POPULATION, WATER DEMAND, AND WASTEWATER FLOW PROJECTIONS

2.1 Population Projections

The population of Kerr County grew at a compound annual rate of 3.99 percent during the 1970's and 2.35 percent during the 1980's, with population of the county increasing from 19,454 in 1970 to 28,780 in 1980, and to 36,304 in 1990.[1] Estimated Kerr County population in 1995 was 40,264, which indicates a compound annual growth rate of 2.1 percent between 1990 and 1995. In 1980, 53 percent (15,276) of the Kerr County population resided in Kerrville, while in 1990, 47.9 percent (17,384) were residents of Kerrville. At the present time, more than 95 percent of the population of Kerr County is located in nine centers in the eastern one-half of the county (Figure 2-1). For purposes of this study, the population centers have been identified as follows:

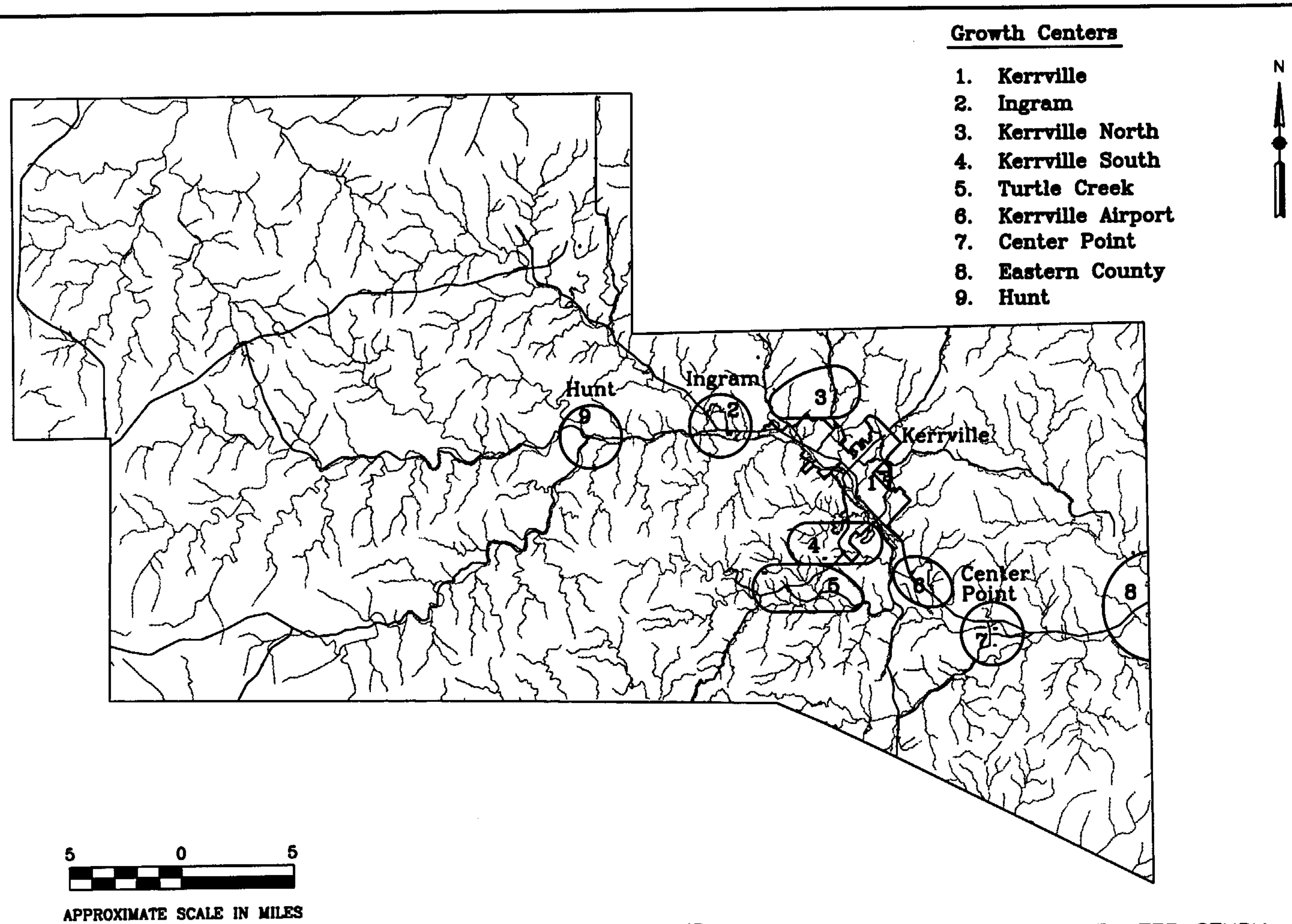
1. Kerrville
2. Ingram
3. Kerrville North
4. Kerrville South
5. Turtle Creek
6. Kerrville Airport
7. Center Point
8. Eastern County
9. Hunt

See Appendix A Table 1 for a list of water suppliers located within each population center listed above.

Texas Water Development Board (TWDB) 1996 consensus population projections for Kerr County are 43,278 in year 2000, 58,053 in 2020, and 71,993 in 2050 (Table 2-1). The TWDB population projections have a compound annual growth rate of 1.77 percent for the period 1990 through 2000; 1.47 percent for the first two decades of the 21st century; 1.25 percent for the period 2020 through 2030; 0.67 percent for the period 2030 through 2040; and 0.25 percent for the period 2040 through 2050 (Table 2-2).

In view of the facts that the Kerr County compound annual population growth rate for 1970 through 1980 was 3.99 percent, for 1980 through 1990 was 2.35 percent, and for 1990 through 1995 was estimated at 2.1 percent, and Kerr County school enrollment has steadily

[1] U.S. Bureau of the Census, U.S. Department of Commerce, 1990 Census of Population and Housing, Washington, DC, 1992.



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REGIONAL WATER AND WASTEWATER STUDY

STUDY AREA

FIGURE 2-1

Table 2-1 Population Projections — Kerr County Texas Water Development Board — 1996 Consensus Water Plan							
Area	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Kerrville	17,384	23,731	27,547	30,719	34,769	37,167	38,100
Ingram	1,408	1,788	2,112	2,361	2,685	2,876	2,953
Remainder	17,512	17,759	20,437	24,973	28,253	30,195	30,940
Total	36,304	43,278	50,096	58,053	65,707	70,238	71,993
Source: Texas Water Development Board; 1996 Consensus Water Planning Projections; Austin, Texas, Feb. 1997.							

Table 2-2 Compound Annual Population Growth Rates				
	Kerr County		**Kerrville**	
Decade	**TWDB**	**HDR**	**TWDB**	**HDR**
1970–1980	3.99	3.99	1.88	1.88
1980–1990	2.35	2.35	1.30	1.30
1990–2000	1.77	1.90	3.16	2.00
2000–2010	1.47	1.75	1.50	1.90
2010–2020	1.46	1.50	1.09	1.70
2020–2030	1.25	1.25	1.24	1.50
2030–2040	0.66	1.15	0.66	1.25
2040–2050	0.25	1.10	0.25	1.15

increased from 5,196 in the 1987–88 school year to 6,597 for the 1996–97 school year, which is a compound annual rate of 2.68 percent over the 9-year period, for purposes of this study, it was decided to calculate a new set of population projections for use in this study, as is presented and explained below. Population projections have been made based upon the population growth rates shown in Table 2-2. Using these growth rates, the Kerr County population is projected to increase to 43,822 in year 2000, to 60,492 in year 2020, and to 85,669 in 2050 (Table 2-3). The TWDB and the HDR projections are quite similar for the period 1990 through 2020, however the HDR projections are higher after 2020 due to the projected higher growth rates; i.e., 1.15 percent per year for 2030 through 2040, and 1.10 percent per year for the period 2040 through 2050,

Table 2-3 Kerr County Population Projections		
Decade	***HDR Alternative***	***TWDB Consensus***
1970	19,454	19,454
1980	28,780	28,780
1990	36,304	36,304
2000	43,822	43,278
2010	52,124	50,096
2020	60,492	58,053
2030	68,494	65,707
2040	76,791	70,238
2050	85,669	71,993

whereas the TWDB projections for these two decades were at rates of 0.67 percent per year and 0.25 percent per year respectively. Water demand projections are shown for both the TWDB 1996 consensus case, and the new set of population projections.

Population projections were made for Kerr County and each growth area of Kerr County as follows. Projections for Kerr County and the City of Kerrville (present city limits) were based upon the growth rates shown in Table 2-2. The City of Kerrville projection was subtracted from the Kerr County totals, at each decade, leaving the total projections for the growing areas not included within Kerrville.

The population projections for those parts of Kerr County which are not a part of the present City of Kerrville, were allocated among the remaining eight growth centers on the basis of each center's percentage of total water utility service connections for the period 1990 through 1995.[2] The 6-year average number of connections for each area, and percentage each is of total connections is as follows:

[2] Although Ingram is incorporated, the service area is larger than the City, thus, the Ingram area is presented in this manner in order to include subdivisions of the area that are outside the Ingram city limits.

	1990–1995 Average	
Growth Areas	*Number of Connections*	*Percent of Total*
Ingram Area	1,555	30.4
Kerrville North	206	4.0
Kerrville South	1,078	21.0
Turtle Creek	574	11.2
Kerrville Airport Area	251	4.9
Center Point	757	14.8
Eastern County Area	259	5.1
Hunt Area	162	3.2
Other	276	5.4
Totals	5,118	100.0

The population of the City of Kerrville is projected to grow from 17,384 in 1990 to 21,191 in 2000, to 30,425 in 2020 and to 44,383 in 2050 (Table 2-4). If Kerrville extends service to 6 percent of areas near Ingram by 2000, 50 percent of Kerrville South by 2010 and 90 percent by 2020; 14 percent of the Turtle Creek area by 2030; 70 percent of the Kerrville Airport area by 2000; and 15 percent of areas in the Center Point growth center by 2020, then Kerrville would have a service area population potential of 22,361 in year 2000, 29,704 in 2010, 44,482 in 2030, and 55,822 in 2050 (Table 2-4).

Under the Kerrville service extension assumptions stated above, and the number of water utility service connections in the Ingram area (city plus outside city service), the Ingram area population would increase from 5,618 in 1990 to 6,745 in 2000, 9,004 in 2020, and 12,411 in 2050 (Table 2-4 and Figure 2-2).[3]

The Kerrville North growth area was estimated to have a population of 742 in 1990, and is projected to grow to 1,189 in 2020, and to 1,639 in 2050 (Table 2-4). The Kerrville South area population was estimated at 3,892 in 1990. The area is projected to grow to a population of 4,673 in 2000, and 6,238 in 2020, of which 5,614 could be a part of the Kerrville service area through Kerrville's service extension (Table 2-4). The Kerrville South area's projected population in 2050 is 8,598, of which 7,738 would be served by Kerrville under the service extension assumptions stated above (Table 2-4). If Kerrville serves 90 percent of the Kerrville

[3] As of the date of this study, Kerrville waste water service is being extended to parts of the Ingram area.

Table 2-4

Population Projections--Kerr County*

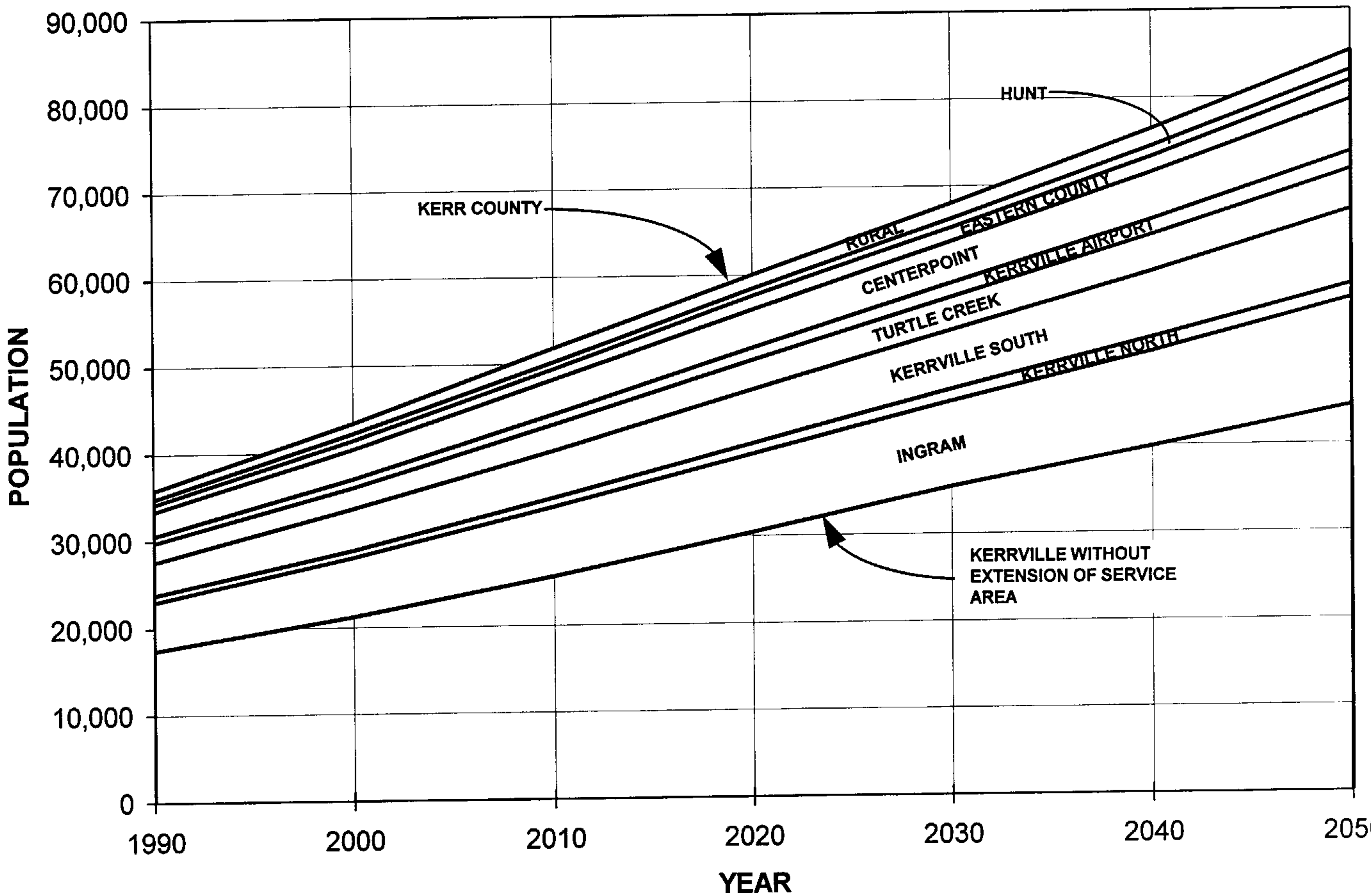
Service Area	1990	2000	2010	2020	2030	2040	2050
	Population Projections						
Areas without Kerrville Service Extensions							
Kerrville Area							
City of Kerrville[1]	17,384	21,191	25,580	30,425	35,310	39,784	44,383
Other Entities[2]	420	420	420	420	420	420	420
Subtotal	17,804	21,611	26,000	30,845	35,730	40,204	44,803
Ingram Area[3]	5,618	6,745	7,934	9,004	9,950	11,112	12,411
Kerrville North	742	891	1,048	1,189	1,314	1,467	1,639
Kerrville South	3,892	4,673	5,497	6,238	6,894	7,698	8,598
Turtle Creek	2,076	2,492	2,931	3,326	3,676	4,105	4,585
Kerrville Airport	910	1,093	1,285	1,459	1,612	1,800	2,011
Center Point	2,738	3,287	3,866	4,388	4,849	5,415	6,048
Eastern County	936	1,124	1,322	1,500	1,658	1,851	2,068
Hunt	583	700	823	934	1,032	1,153	1,287
Other	1,005	1,206	1,419	1,610	1,779	1,987	2,219
Kerr County Total	36,304	43,822	52,124	60,492	68,494	76,791	85,669
Kerrville with Service Extensions							
Kerrville[1]	17,384	21,191	25,580	30,425	35,310	39,784	44,383
Ingram Areas (6% by 2000)		405	476	540	597	667	745
Kerrville South (50%by 2010 &90% by 2020)			2,748	5,614	6,204	6,928	7,738
Turtle Creek (14% by 2030)					515	575	642
Airport Areas (70% by 2000)		765	900	1,021	1,128	1,260	1,407
Center Point Areas(15% by 2020)				658	727	812	907
Kerrville Potential/Subtotal	17,384	22,361	29,704	38,259	44,482	50,025	55,822
Other Entities[2]	420	420	420	420	420	420	420
Subtotal	17,804	22,781	30,124	38,679	44,902	50,445	56,242
Areas Remaining After Service Extensions By Kerrville							
Ingram[3]	5,618	6,341	7,458	8,464	9,353	10,445	11,666
Kerrville North	742	891	1,048	1,189	1,314	1,467	1,639
Kerrville South	3,892	4,762	2,748	624	689	770	860
Turtle Creek	2,076	2,539	2,978	3,374	3,161	3,530	3,943
Kerrville Airport	910	328	386	438	484	540	603
Center Point	2,738	3,349	3,929	3,730	4,122	4,603	5,141
Eastern County	936	1,124	1,322	1,500	1,658	1,851	2,068
Hunt	583	700	823	934	1,032	1,153	1,287
Other	1,005	1,206	1,419	1,610	1,779	1,987	2,219
Subtotal	18,500	21,239	22,110	21,861	23,592	26,346	29,426
Kerr County Total	36,304	43,822	52,124	60,492	68,494	76,791	85,669

* Projections prepared by HDR, based upon information obtained from Kerrville and local school districts.

[1] Projections are for Kerrville, as City Limits existed in 1997.

[2] Includes mobile home parks and subdivisions within and/or adjacent to Kerrville, which have their own water systems, and which appear to be fully occupied, thus, population is assumed to remain constant for the projection period.

[3] City of Ingram and nearby subdivisions, some of which are served by the same water system that supplies Ingram.



REGIONAL WATER AND WASTEWATER STUDY

POPULATION PROJECTIONS
KERR COUNTY

HDR Engineering, Inc.

FIGURE 2-2

South subdivision by 2020, the area remaining is projected to have a population of 624 in year 2020, 689 in 2030, and 860 in 2050 (Table 2-4 and Figure 2-2).

Estimated 1990 population of the Turtle Creek area was 2,076, with projections to 2020 of 3,326 and to 2050 of 4,585 (Table 2-4). For that portion of Turtle Creek that might be served by Kerrville, the population in 2030 is projected at 515, and at 2050 is projected at 642 (Table 2-4).

The Kerrville Airport area had an estimated population of 910 in 1990, and is projected to have a 2050 population of 2,011, of which 1,407 are included in parts of the area that might be served by Kerrville (Table 2-4).

The estimated population of the Center Point area in 1990 was 2,738 (Table 2-4). The Center Point area's population is projected to be 6,048 in 2050, with 907 being in that part of the area that might be served by Kerrville (Table 2-4).

The estimated population of the Eastern Kerr County growth center was 936 in 1990, and is projected to increase to 1,500 in 2020, and to 2,068 in 2050 (Table 2-4).

The Hunt area had an estimated 1990 population of 583, and is projected to grow to 934 in 2020, and to 1,287 in 2050 (Table 2-4 and Figure 2-2).

Estimated population of the remainder of Kerr County ("Other") was 1,005 in 1990, and is projected at 1,610 in 2020, and 2,219 in 2050 (Table 2-4 and Figure 2-2).

2.2 Water Demand Projections

In Kerr County, the major water uses are for municipal and domestic purposes, with small quantities used for industrial, irrigation, mining, and livestock water purposes. Water demand projections for municipal purposes are based upon population projections for each respective area (Table 2-4) and per capita water use projections (gallons per person per day) of the population of each area, according to the following formula:

$$\left(\begin{array}{c} \text{Municipal Water Demand} \\ \text{in acre-feet per year} \end{array} \right) = \frac{(\text{Population}) \times (\text{gpcd}) \times (365)}{325{,}851}$$

The per capita water use (gpcd) values used in this study are those expected for below normal precipitation conditions and average water conservation efforts, including the effects of low-flow plumbing fixtures being installed in new structures and in remodeling of existing structures.

Texas Water Development Board (TWDB) 1996 Consensus Water Demand projections, with conservation, were used for industrial, irrigation, mining, and livestock water. In the case of industrial and mining water demands, TWDB based the water demand projections upon the projected growth of each industry of the county. In the case of irrigation water demands, the projection set chosen for this study was the TWDB projections case of aggressive adoption of irrigation technology to achieve water conservation, and a reduction in Federal Farm Programs by one-half. In the case of livestock water, TWDB's water demand projection is based upon the nutritional water requirements per head of livestock and the estimated maximum numbers of each type (beef, sheep, goats, dairy, poultry, and horses) of livestock that the county's grazing land can support.

Per Capita Water Use: Per capita water use, in gallons per person per day (gpcd), was calculated for Kerrville and the growth areas using annual water use reports to the TWDB by the City of Kerrville and the other water suppliers of Kerr County.[4] The computation for 1990 was based upon actual use in 1990, and is an indication of a level of use for average weather conditions. The projected year 2000 per capita water use was computed by TWDB from the driest year of reports during the 1987 through 1991 period, and is representative of water demands during below normal precipitation periods in order to incorporate dry weather condition effects upon municipal water demands, including lawn watering. However, the estimated effects of low-flow plumbing fixtures being phased into municipal housing and commercial structures, and other water conservation measures were used by TWDB to make projections of per capita water use per the period of year 2000 to year 2050.[5] The results were to trend per capita water use downward for the year 2010 through 2050 projection period, with most of the effect being shown during the 2000 through 2020 period, as the low-flow plumbing fixtures are phased into new and remodeling construction (Table 2-5). For example, in 1990, the Kerr County average

[4] The per capita water use rates used in this study are the same as those used by the TWDB in its 1996 consensus water planning projections.

[5] Senate Bill 587, Texas Legislature, Regular Session, 1991, Austin, Texas.

Table 2-5

Per Capita Water Use Projections--Kerr County[1]

With Conservation

Service Area		Use in 1990 gpcd[2]	Per Capita Water Use Projections 2000 gpcd	2010 gpcd	2020 gpcd	2030 gpcd	2040 gpcd	2050 gpcd
City of Kerrville	reported	179	200	190	181	178	175	174
Other Entities/Kerrville	reported	117	117	117	117	117	117	117
Ingram	reported	130	144	132	122	119	116	115
Kerrville North	Co Ave	115	169	160	149	145	141	139
Kerrville South	Co Other	110	131	121	113	109	106	106
Turtle Creek	Co Ave	93	169	160	149	145	141	139
Kerrville Airport	Co Ave	132	169	160	149	145	141	139
Center Point	Co Ave	82	169	160	149	145	141	139
Eastern County	Co Ave	111	169	160	149	145	141	139
Hunt	Co Ave	107	169	160	149	145	141	139
Other[3]	Co Other	88	131	121	113	109	106	106
Kerr County Average	Co Ave	143	169	160	149	145	141	139

[1] Computed from water use reports to the Texas Water Development Board, and TWDB projections.

[2] Gallons per person per day.

[3] Rural areas of Kerr County.

water use was 143 gallons per person per day, with the Kerrville and Ingram urban area use at 179 and 155 gallons per person per day, respectively. The potential effects of low-flow plumbing fixtures and other water conservation measures could reduce dry weather per capita water use in Kerrville from 200 gpcd in year 2000 to 181 gpcd in 2020, and the Kerr County average from 169 gpcd in 2000 to 139 gpcd in 2050 (Table 2-5).

Municipal Water Demand: In 1990, municipal water use in Kerr County was 5,821 acft/yr, of which 3,492 acft were by the City of Kerrville, 244 acft were in the City of Ingram, and 2,085 acft were in the remaining areas of the county (Table 2-6 and Figure 2-3). Using TWDB population projections of Table 2-1 and per capita water use projections of Table 2-5, the TWDB 1996 consensus water demand projections are shown in Table 2-6. The TWDB municipal water demand projections for Kerrville increase from 3,492 acft/yr in 1990 to 7,425 acft/yr in 2050, with Kerr County total water demands increasing from 7,154 acft/yr in 1990 to 12,837 acft/yr in 2050 (Table 2-6). However, in view of the review of local Kerr County population and school enrollment growth rates which are higher than those used in the TWDB 1996 consensus projections, and the fact that the TWDB did not make projections for the unincorporated areas of Kerr County, an alternative set of population and water demand projections was prepared for use in this water supply and wastewater planning study. Using the alternative population projections of Table 2-4 and the per capita water use projections of Table 2-5 (same as used by TWDB), projected dry year municipal water demand for Kerr County in year 2000 is 8,601 acft/yr (Table 2-7). Projected municipal water demand in 2020 is 10,591 acft/yr, and in 2050 is 14,335 acft/yr (Table 2-7). Projected municipal water demand for Kerrville increases from 4,747 in year 2000 to 8,650 acft/yr in 2050, without extension of service to neighboring areas. With potential extension of service to neighboring areas, as shown in Table 2-4, projected municipal water demand for Kerrville could be 7,288 acft/yr in 2020 and 10,181 acft/yr in 2050 (Table 2-7 and Figure 2-3).

Municipal water use in the Ingram area was 811 acft/yr in 1990 and is projected at 1,230 acft/yr in 2020 and 1,599 acft/yr in 2050 (Table 2-7). If Kerrville extends service to parts of the Ingram area, as set forth in Table 2-4, the municipal water demand for the remaining area would be 1,157 acft/yr in 2020, and 1,503 acft/yr in 2050 (Table 2-7).

Table 2-6

Water Demand Projections--Kerr County[1]

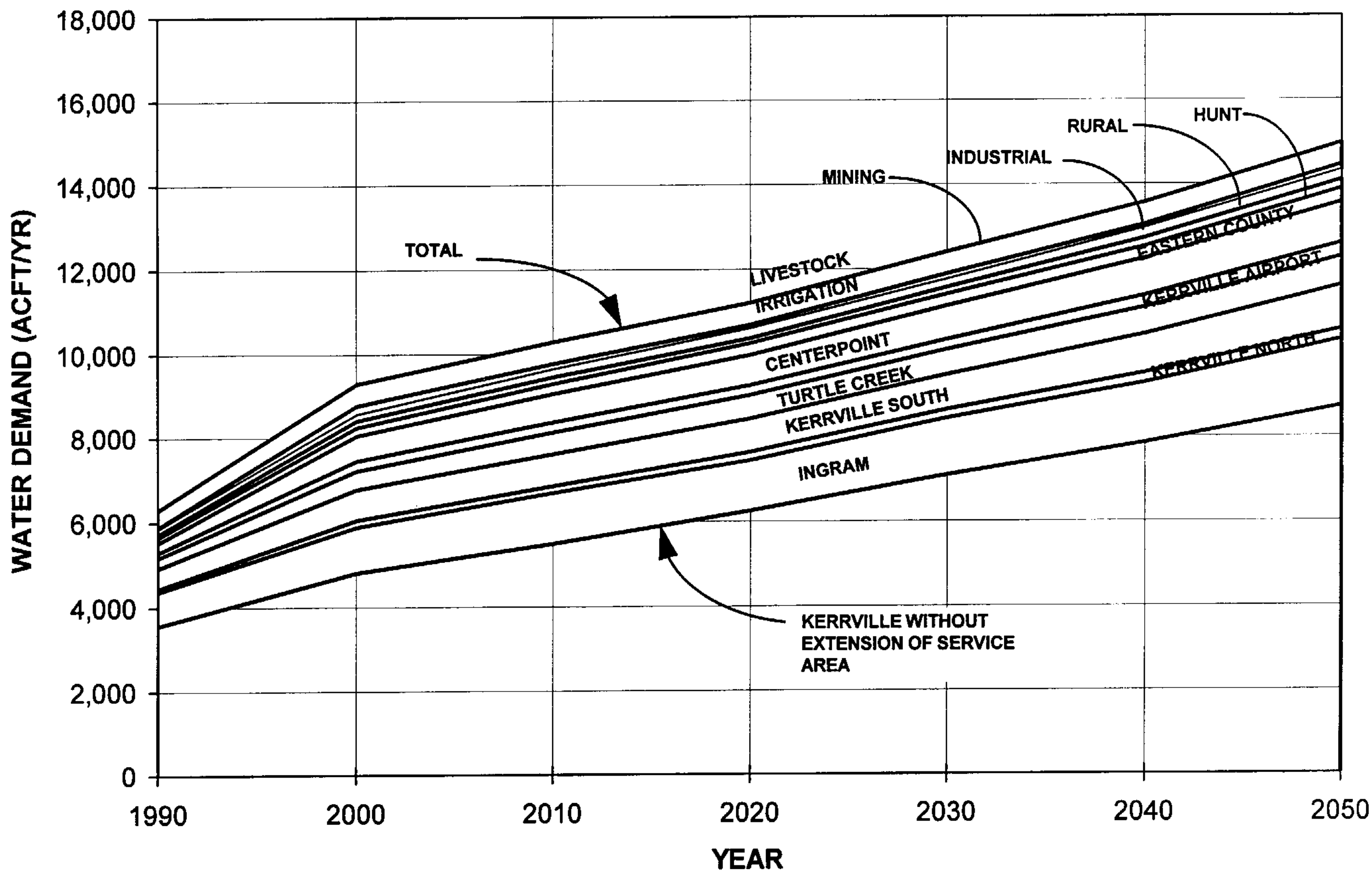
Texas Water Development Board -- 1996 Consensus Water Plan

Area	Use in 1990	Projections 2000	2010	2020	2030	2040	2050
Per capita Water Demand	**gpcd**	**gpcd**	**gpcd**	**gpcd**	**gpcd**	**gpcd**	**gpcd**
Kerrville	179	200	190	181	178	175	174
Ingram	155	144	132	122	119	116	115
Remainder of County	106	131	121	113	109	106	106
Municipal Water Demand	**acft**	**acft**	**acft**	**acft**	**acft**	**acft**	**acft**
Kerrville	3,492	5,317	5,863	6,228	6,933	7,285	7,425
Ingram	244	289	313	323	358	373	380
Remainder of County	2,085	2,599	2,779	3,161	3,444	3,576	3,660
Total Municipal Water Demand	5,821	8,204	8,954	9,712	10,735	11,234	11,465
Industrial Water Demand	28	30	33	36	38	41	44
Irrigation Water Demand	850	822	796	770	745	721	697
Mining Water Demand	73	176	122	110	103	102	105
Livestock Water Demand	382	526	526	526	526	526	526
Kerr County Total Water Demand	7,154	9,758	10,431	11,154	12,147	12,624	12,837

[1] Based upon 1996 Consensus Water Demand Projections of Table 2-1, and per capita water use rates listed in Table 2-5.

Table 2-7 Water Demand Projections--Kerr County* With Conservation							
	Use in	Water Demand Projections					
Service Area	1990	2000	2010	2020	2030	2040	2050
	acft	acft	acft	acft	acft	acft	acft
Municipal Water Demand for Areas without Service Extensions							
City of Kerrville[1]	3,492	4,747	5,444	6,169	7,040	7,799	8,650
Other Entities/Kerrville Area[2]	55	55	55	55	55	55	55
Subtotal	3,547	4,802	5,499	6,224	7,095	7,854	8,705
Ingram Area[3]	811	1,088	1,173	1,230	1,326	1,444	1,599
Kerrville North	95	169	188	198	213	232	255
Kerrville South	481	686	745	790	842	914	1,021
Turtle Creek	217	472	525	555	597	648	714
Kerrville Airport	135	207	230	243	262	284	313
Center Point	251	622	693	732	788	855	942
Eastern County	116	213	237	250	269	292	322
Hunt	70	132	147	156	168	182	200
Other	99	177	192	204	217	236	263
Kerr County Total/Municipal	5,821	8,601	9,650	10,591	11,777	12,941	14,335
Kerrville with Service Extensions							
City of Kerrville[1]	3,492	4,747	5,444	6,169	7,040	7,799	8,650
Ingram Areas(6% by 2000)[3]		65	70	74	80	87	96
Kerrville South(50% by 2010 & 90% by 2020)		0	373	711	757	823	919
Turtle Creek (14% by 2030)		0	0	0	84	91	100
Airport Areas(70% by 2000)		145	161	170	183	199	219
Center Point Areas(15% by 2020)		0	0	110	118	128	141
Kerrville Potential/Subtotal	3,492	4,957	6,048	7,233	8,262	9,126	10,126
Other Entities/Kerrville Area[2]	55	55	55	55	55	55	55
Subtotal	3,547	5,012	6,103	7,288	8,317	9,181	10,181
Areas Remaining After Service Extensions By Kerrville							
Ingram	811	1,023	1,103	1,157	1,247	1,357	1,503
Kerrville North	95	169	188	198	213	232	255
Kerrville South	481	699	373	79	84	91	102
Turtle Creek	217	481	534	563	513	558	614
Kerrville Airport	135	62	69	73	79	85	94
Center Point	251	634	704	622	669	727	800
Eastern County	116	213	237	250	269	292	322
Hunt	70	132	147	156	168	182	200
Other	99	177	192	204	217	236	263
Subtotal	2,274	3,589	3,547	3,303	3,460	3,760	4,154
Kerr County Total/Municipal	5,821	8,601	9,650	10,591	11,777	12,941	14,335
Industrial Water Demand	28	30	33	36	38	41	44
Irrigation Water Demand	850	822	796	770	745	721	697
Mining Water Demand	73	176	122	110	103	102	105
Livestock Water Demand	382	526	526	526	526	526	526
Kerr County Total Water Demand	7,154	10,155	11,127	12,033	13,189	14,331	15,707

[1] Projections are for Kerrville, as City Limits existed in 1997.
[2] Includes mobile home parks and subdivisions within and/or adjacent to Kerrville, which have their own water systems, and which appear to be fully occupied, thus, population is assumed to remain constant for the projection period.
[3] City of Ingram and nearby subdivisions, some of which are served by the same water system that supplies Ingram.



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REGIONAL WATER AND WASTEWATER STUDY

WATER DEMAND FOR BELOW NORMAL PRECIPITATION AND AVERAGE WATER CONSERVATION FOR KERR COUNTY

FIGURE 2-3

Irrigation Water Demand: Irrigation water use in 1990 in Kerr County was estimated at 850 acft/yr, and is projected at 770 acft/yr in 2020 and 697 acft/yr in 2050 for the case of increased conservation, and reduced government programs (Table 2-7 and Figure 2-3).

Mining Water Demand: Mining water use in 1990 in Kerr County was 73 acft/yr. Mining water demand for the county in 2020 is projected at 100 acft/yr, and in 2050 is 105 acft/yr (Table 2-7).

Livestock Water Demand: In Kerr County in 1990, water use for livestock was estimated at 382 acft/yr. Livestock water demand is projected at 526 acft/yr for the period 2000 through 2050 (Table 2-7).

Total Water Demand: In 1990, total water use in Kerr County for all purposes was 7,154 acft/yr of which 5,821 acft/yr (83 percent) was for municipal purposes (Table 2-7 and Figure 2-3). Projected total water demand in Kerr County in 2020 is 12,033 acft/yr, and in 2050 is 15,707 acft/yr (Table 2-7). Of the projected total demand in 2020, 88 percent is for municipal purposes, 0.30 percent is for industrial purposes, 6.4 percent is for irrigation, 0.92 percent is for mining, and 4.4 percent is for livestock purposes. Of the 15,707 acft/yr demand projected for 2050, 91 percent is for municipal purposes, with 0.28 percent for industry, 4.4 percent for irrigation, 0.67 percent for mining, and 3.4 percent for livestock. It is important to note that the alternative projections used in the study are 4.4 percent higher than the TWDB consensus projections in year 2000, 8.9 percent higher in 2020, and 25.0 percent higher in 2050, with most of the difference being in municipal water demand (Table 2-6 vs. Table 2-7).

2.3 Wastewater Flows

Wastewater flow projections for Kerr County have been prepared based on projected populations developed in this study and upon past wastewater flow data for the City of Kerrville. Wastewater flow projections were developed for the county population centers for which populations were projected. Projected populations for the county were developed and presented in Section 2.1.

Wastewater flow data from the City of Kerrville for the year 1995 were used to develop estimates of the current unit wastewater flow from the City of Kerrville in gallons per capita per day (gpcd). The average wastewater flow from the City of Kerrville in 1995 was 2.18 million gallons per day (mgd), and the estimated population was 18,280. The estimated 1995 population was calculated by multiplying the 1990 population by the ratio of the number of connections in 1995 divided by the number of connections in 1990.

Future unit wastewater flows from the City of Kerrville, in gpcd, were projected by decreasing the 1995 unit flow by ten percent at a linear rate between 1995 and 2010. The unit flow was decreased to account for the anticipated effect of conservation on wastewater flows.

Unit wastewater flows from areas outside the City of Kerrville were estimated to be eighty percent of the unit wastewater flows from the City of Kerrville. A reduced unit flow for areas outside the City of Kerrville was used to account for the reduced effect that commercial and industrial developments would have on flows from areas outside the City.

Unit wastewater flow projections are shown in Table 2-8, along with a summary of the information that was used to develop the unit flows. Unit wastewater flow from the City of Kerrville was estimated to be 119 gpcd in 1995, and is projected to be 107 gpcd in 2010 and to remain at this value through 2050. Unit wastewater flow for areas outside the City of Kerrville was estimated to be 95 gpcd in 1995 and is projected to decrease to 86 gpcd in 2010, and to remain level thereafter.

Wastewater flow projections for Kerr County are listed in Table 2-9 and illustrated in Figure 2-4. Total annual average wastewater generation in Kerr County is estimated to be 5.03 mgd in year 2010, 6.63 mgd in 2030, and 8.30 mgd in 2050. Projected annual average wastewater flow from the City of Kerrville is projected to be 3.29 mgd in 2010, 4.58 mgd in 2030, and 5.73 mgd in 2050. Projected flows are also shown graphically in Figure 2-4.

TABLE 2-8
KERR COUNTY REGIONAL WATER AND WASTEWATER STUDY
UNIT WASTEWATER FLOW PROJECTIONS

Basis

1995 City of Kerrville Average Flow = 2.18 million gallons per day (mgd)

Estimated City of Kerrville 1995 population, Based on 1990 population times ratio of 1995 connections to 1990 conections = 18,280

Estimated 1995 per capita flow = 119 gallons per capita per day (gpcd)

Projections

City of Kerrville

Project ten percent decrease in per capita flows over 15 years due to conservation, then constant

Other Areas

Project unit flows of 80 percent of Kerrville unit flows due to impact of commercial/industrial on Kerrville

Per Capita Wastewater Flow Projections--Kerr County

		Per Capita Wastewater Flow Projections, gpcd						
Service Area		1995	2000	2010	2020	2030	2040	2050
Kerrville	calculated	119	113	107	107	107	107	107
Ingram		95	90	86	86	86	86	86
Kerrville North		95	90	86	86	86	86	86
Kerrville South		95	90	86	86	86	86	86
Turtle Creek		95	90	86	86	86	86	86
Kerrville Airport		95	90	86	86	86	86	86
Center Point		95	90	86	86	86	86	86
Eastern County		95	90	86	86	86	86	86
Hunt		95	90	86	86	86	86	86
Other		95	90	86	86	86	86	86

TABLE 2-9

KERR COUNTY REGIONAL WATER AND WASTEWATER STUDY

PROJECTED AVERAGE MONTHLY WASTEWATER FLOWS

Service Area		2000	2010	2020	2030	2040	2050
Kerrville with Service Extensions							
Kerrville	calculated	2.40	2.74	3.26	3.78	4.26	4.75
Ingram (6% by 2000)		0.04	0.04	0.05	0.05	0.06	0.06
Kv So (50%by 2010, 90 % by 2020)		0.00	0.24	0.48	0.53	0.60	0.67
Turtle Creek (14% by 2030) Ing		0.00	0.00	0.00	0.04	0.05	0.06
Airport 70% by 2010		0.07	0.08	0.09	0.10	0.11	0.12
Center Point(0.15 by2020)		0.00	0.00	0.06	0.06	0.07	0.08
Total Kerrville Potential		2.50	3.09	3.93	4.57	5.14	5.73
Other Entities		0.04	0.04	0.04	0.04	0.04	0.04
Subtotal		2.54	3.13	3.97	4.60	5.17	5.77
Areas Remaining After Service Area Extensions							
Ingram		0.57	0.64	0.73	0.80	0.90	1.00
Kerrville North		0.08	0.09	0.10	0.11	0.13	0.14
Kerrville South		0.43	0.24	0.05	0.06	0.07	0.07
Turtle Creek		0.23	0.26	0.29	0.27	0.30	0.34
Kerrville Airport		0.03	0.03	0.04	0.04	0.05	0.05
Center Point		0.30	0.34	0.32	0.35	0.40	0.44
Eastern County		0.10	0.11	0.13	0.14	0.16	0.18
Hunt		0.06	0.07	0.08	0.09	0.10	0.11
Other		0.11	0.12	0.14	0.15	0.17	0.19
Total Outside City of Kerrville And Service Extensions		1.91	1.90	1.88	2.03	2.27	2.53
Total County		4.45	5.03	5.85	6.63	7.44	8.30

Water use in the Kerrville North area was 95 acft/yr in 1990, and is projected at 198 acft/yr in 2020, and 255 acft/yr in 2050 (Table 2-7 and Figure 2-3).

In the Kerrville South area, water use in 1990 was 481 acft/yr and is projected at 790 acft/yr in 2020, of which 711 acft/yr is for areas that might be served by Kerrville (Table 2-7). Projected demand for the Kerrville South area in 2050 is 1,021 acft/yr, of which 919 acft/yr is for the areas that might be served by Kerrville (Table 2-7).

In the Turtle Creek area, 1990 water use was 217 acft/yr. Projected demand is 555 acft/yr in 2020, and 714 acft/yr in 2050 (Table 2-7). If Kerrville extends service as stated in Table 2-4, 84 acft/yr of the projected 597 acft/yr in 2030, and 100 acft/yr of the projected 2050 demands would be for parts of Turtle Creek that would be served by Kerrville (Table 2-7).

In 1990, water use in the Kerrville Airport area was 135 acft/yr. Projected demand for this area in 2020 is 243 acft/yr, and for 2050 is 313 acft/yr (Table 2-7). For the Kerrville service extension case, as presented in Table 2-4, 170 of the projected 243 acft/yr demand in 2020, and 219 acft/yr of the 313 acft/yr demand in 2050 would be for airport areas that might be served by Kerrville (Table 2-7).

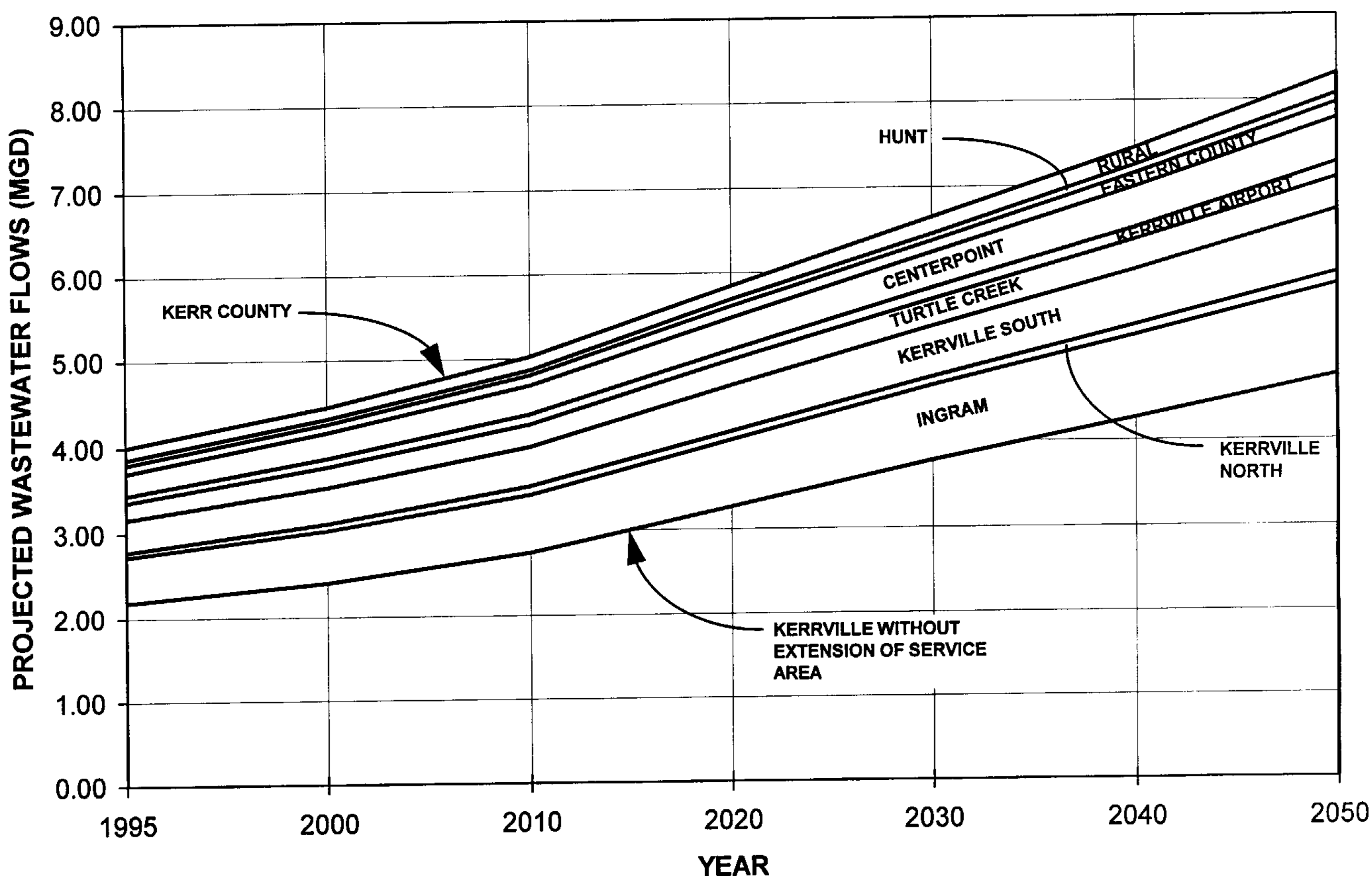
Water use in the Center Point area was 251 acft/yr in 1990, and is projected at 732 acft/yr in 2020, and 942 acft/yr in 2050 (Table 2-7). Of the year 2020 projection, 110 acft/yr is for areas that might be served by Kerrville; for 2050, 141 acft/yr are for those potential Kerrville service areas.

In the Eastern County growth area, water use in 1990 was 116 acft/yr and is projected at 250 acft/yr in 2020, and 322 acft/yr in 2050 (Table 2-7).

For the Hunt area, 1990 water use was 70 acft/yr, and is projected at 156 acft/yr in 2020, and 200 acft/yr in 2050 (Table 2-7).

The rural areas of Kerr County used 99 acft/yr of water for household and domestic purposes (municipal type) in 1990, and have a projected demand in 2020 of 204 acft/yr with a year 2050 projected demand of 263 acft/yr (Table 2-7).

Industrial Water Demand: In 1990, industrial water use in Kerr County was reported at 28 acft/yr. Projected industrial demand in 2020 is 36 acft/yr and in 2050 is 44 acft/yr (Table 2-7).



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REGIONAL WATER AND WASTEWATER STUDY

PROJECTED WASTEWATER FLOWS

FIGURE 2-4

3.0 INVENTORY OF WATER PROVIDERS

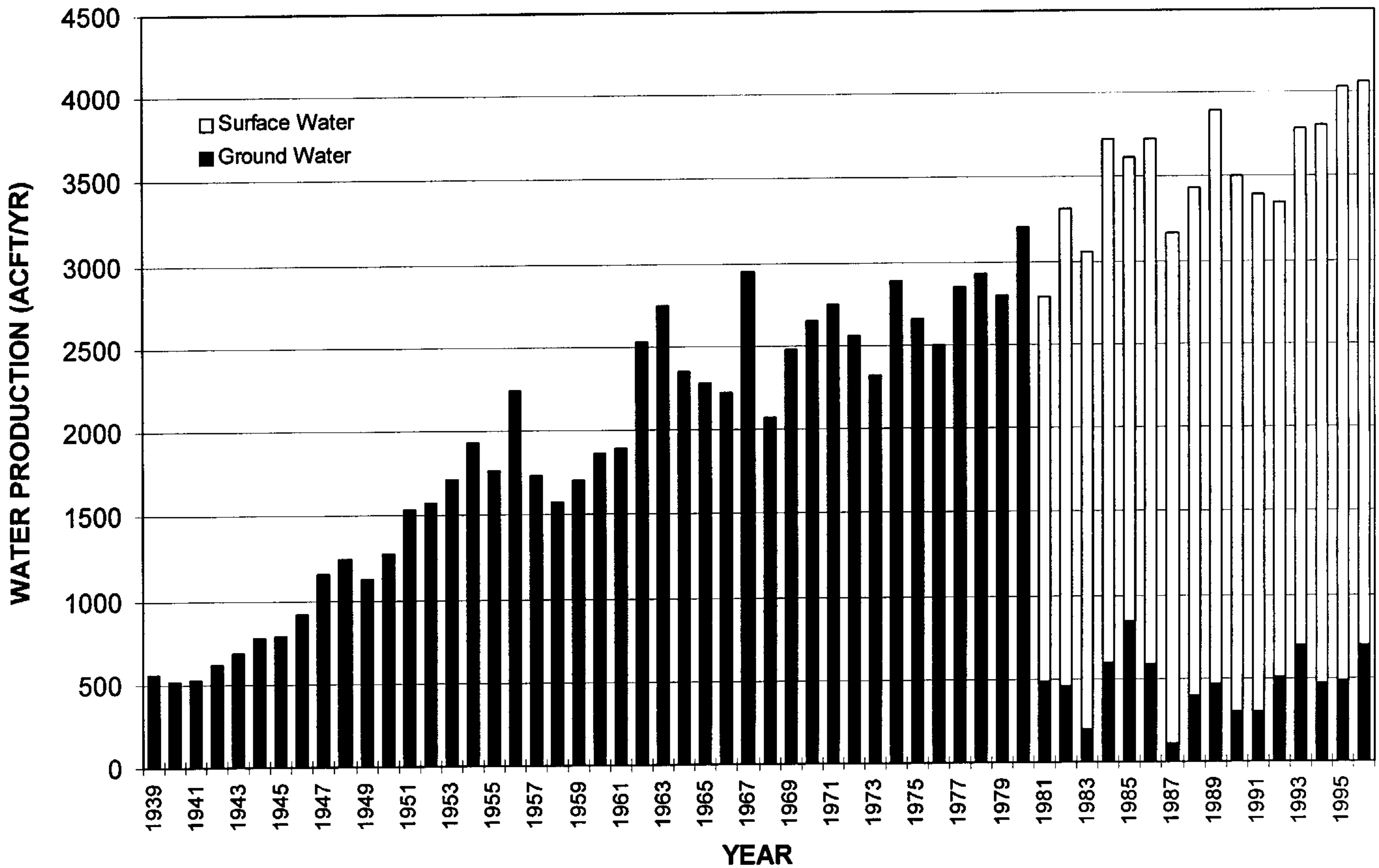
This section provides a description of water providers in Kerr County. Water sources for each provider are also discussed.

3.1 Water Providers of Kerr County

A list of 75 retail water providers is presented in Appendix A Table 1. The list is grouped by the nine growth centers identified in Section 2. The reported number of connections from 1990 through 1995 are included and subtotaled for each group. In addition to the retail water providers, the UGRA is a wholesale supplier of treated water for municipal use to the City of Kerrville. The UGRA holds Permit No. 3505 for 3,603 acre-feet/year (acft/yr) and Permit No. 5394 for 1,100 acft/yr and 1,408 acft/yr for beneficial purpose of the City of Kerrville. In addition, Permit No. 5394 provides 1,661 acft/yr to be contracted from the UGRA for municipal use in Kerr County by entities other than the City of Kerrville. A more detailed description of these arrangements is provided in Section 4.1.1.

3.2 Water Source for Each Provider

The source of water that UGRA provides to the City of Kerrville and is permitted to contract to other Kerr County entities is the Upper Guadalupe River. River water is treated at the UGRA's water treatment plant prior to distribution or injection to the aquifer for subsequent municipal use. The remaining water suppliers provide water pumped from the Trinity Group aquifers. The City of Kerrville meets its base demand with surface water provide by UGRA and meets the difference between its base and peak demands with ground water from the Lower Trinity aquifer. This combined use of ground and surface water supplies is illustrated in Figure 3-1. The figure shows the partial conversion of supply to surface water with the construction of the UGRA water treatment plant in 1981. Center Point and several areas surrounding the City of Kerrville (Guadalupe Heights and Kerrville South Silver Creek) operate wells opened to the Lower Trinity formation. Municipal supply outside of the Kerrville area is derived primarily from the Middle Trinity aquifer.



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REGIONAL WATER AND WASTEWATER STUDY

HISTORICAL WATER USE
CITY OF KERRVILLE

FIGURE 3-1

4.0 WATER SUPPLY EVALUATION

The water resources of Kerr County include the headwaters of the Guadalupe River and four aquifer units. In this section, the surface water supplies available from existing water rights, and the quantities of ground water available from the aquifers of the county are presented. In addition, water supplies available are compared to projected water demands in order to present estimates of the future dates at which additional supplies will be needed. This section concludes with a discussion of the potential for augmenting the water supply and the need for water system regionalization.

4.1 Surface Water

4.1.1 Surface Water Rights

Surface Water Rights Administration

Surface water rights are administered by the TNRCC (Texas Natural Resource Conservation Commission). For municipalities, the TNRCC will issue a permit only if the hydrologic record shows that 100% of the water can be expected to be available 100% of the time, unless a backup source is available.[1] For a municipality that has access to a backup supply, such as ground water, the TNRCC may decide to issue a permit to use water that can be expected to be available less than 100% of the time. Each new permit is assigned a priority date. Most municipal permits are issued in perpetuity and may be bought and sold like other property interests.

Domestic and livestock uses within the riparian zone (property adjacent to a stream or river) are always senior to any kind of appropriated water right. For all appropriated rights, the legal doctrine of prior appropriation (first in time is first in right) governs the priority of water diversions during times of low flow or shortage. The doctrine of prior appropriation does not grant municipal uses higher priority than other uses, such as irrigation, except in the lower and middle Rio Grande Basin. However, the South Texas watermaster who serves the Guadalupe River Basin, as well as other basins, may yield to municipal need during critical water shortages. During periods of diminished streamflow the watermaster allocates flows among users in accordance with the time priority system described above.

[1] Texas Natural Resource Conservation Commission, 1996, *Surface Water Rights in Texas: How they work and What to Do When They Don't*, Austin Texas.

Marketing of Water Rights

Water rights in Texas can be bought and sold. It may be possible to purchase a water right for another type of use and amend it for municipal use. If the amended municipal right is not the sole supply of water to the municipality, the state may grant the full original diversion amount upon amendment. Amending the point of diversion is also possible. However, if the diversion is moved upstream, instream flow requirements may be attached to the amended right, thereby decreasing the utility of the right. If the diversion is moved downstream, it is probable that no additional instream flow requirements would be attached to the amended permit. When the point of diversion is moved downstream, the amended right may become junior to some of the water rights located between the original and amended points of diversion.[2]

Water Rights Held in Kerr County

A summary of surface water rights held in Kerr County is presented in Table 4-1. The list of water rights was obtained from the TNRCC database. The summary illustrates the number of permits held and the annual diversion quantity available. Table 4-1 also summarizes water rights held in the Upper Guadalupe River down to and including Canyon Lake. Permitted diversions are summarized by type of use and location relative to the UGRA diversion. The major water right holder in this reach is GBRA (Guadalupe Blanco River Authority) with 50,025 acft/yr permitted for municipal and industrial use. A detailed listing of surface water rights in the Upper Guadalupe River is presented in Appendix B. Surface Water Rights in Appendix B are grouped by type of use and location relative to the UGRA diversion point and are presented in order of priority date.

Municipal Rights Held by UGRA and Kerrville

Table 4-2 summarizes existing municipal surface water rights held by the UGRA and the City of Kerrville. Permit No. 3505 allows for the diversion of 3,603 acft/yr out of the supply reservoir at a maximum rate of 9.7 cfs. The annual total of diversions authorized are allocated to each month based on historic municipal patterns of usage, as shown in Figure 4-1. Permit 1996A allows for the diversion of 150 acft/yr from the supply reservoir. Neither of these permits

[2] Slade, Terry, 1997, Personal Communication, Texas Natural Resources Conservation Commission.

contain instream flow requirements. However, diversion is not permitted if the water level in the UGRA supply reservoir falls below elevation 1,608 feet msl.

Permit No. 5394 specifically addresses allocation of diversions between Kerrville and non-Kerrville municipal uses and provides instream flow requirements. In addition, the permit provides for run of river diversion rights for injection into the Lower Trinity aquifer. The maximum diversion rate, in combination with Permit 3505 diversions, is 15.5 cfs (approximately 10 mgd). Water diverted that is not consumed is required to be returned to the river via the wastewater treatment plant discharge outfall. Diversions would be curtailed if the UGRA supply reservoir water level falls below elevation 1,608 feet msl.

In-stream flow requirements are imposed on Permit No. 5349, as indicated in Table 4-2. The flow in the Guadalupe river downstream of the supply reservoir must be equal to or greater than the specified rate to permit the diversion during that season or inflow condition. Minimum instream flows range from 30 to 60 cfs.

Permit No. 5394 specifically allocates diverted waters for municipal purposes. Water quantities up to 1,100 acft/yr may be used by the City of Kerrville. The 1,100 acft/yr includes water either directly diverted from the river or surface water injected into the aquifer and subsequently retrieved. Water quantities up to 1,661 acft/yr may be used by non-Kerrville municipal entities. The 1,661 acft/yr includes water either directly diverted from the river or surface water injected into the aquifer and subsequently retrieved. The remaining 1,408 acft/yr of water shall be used for injection into the aquifer for storage to maintain the firm yield of the system. If, on any given day, the daily allocation is not needed or not available, the allocations under Permit No. 5394 can be made up on future days within that year provided that flows downstream of the UGRA supply reservoir are at least 60 cfs. Permit 5394 is presented in Appendix C.

4.1.2 Aquifer Storage and Recovery (ASR) Project

A full scale ASR well was constructed and tested in 1991 for the UGRA. The well injects treated surface water into the Lower Trinity aquifer during times of surplus and recovers a stored water during shortfalls. The combined recharge capacity of the ASR well and City of Kerrville Well No. 5, also equipped for ASR, is 1.58 mgd (148 acft/month).

4.1.3 Surface Water Available for Municipal Use

The only surface water source presently available in the area for municipal use is the Upper Guadalupe River. The quantity available for use is a function of senior water rights, streamflow, permitted diversions, demand patterns, facilities for treatment and distribution, and aquifer storage capabilities. Due to the complexity of surface water diversion permits and the considerable flow variability in the Upper Guadalupe River, estimation of existing surface water availability requires simulation of the demand and supply system. System performance has been simulated subject to future water demands and water supply augmentation alternatives as discussed below in Section 4.4.

4.2 Ground Water

4.2.1 Geology and Recharge

Geologic cross-sections in the Kerr County area are provided by Reeves[3], Ashworth[4], and Bluntzer.[5] The geological stratigraphy beneath Kerr County is presented in order of descending depth in Table 4-3. The upper and lower members of the Glen Rose Limestone receive the greatest amount of direct recharge. The other units, Hensell Sand, Cow Creek Limestone, and Hosston Sand are recharged by vertical leakage from other strata[6] and outcrop areas outside of Kerr County.[7] Ashworth[8] estimates the effective recharge to the Trinity Group aquifer to be about 4% of average annual rainfall, while Bluntzer[9] estimates it to be about 6.7%. Average monthly precipitation near Kerrville is illustrated in Figure 4-2 with average annual precipitation estimated to be 31.42 inches. Based on Bluntzer's estimated recharge rate (6.7% of precipitation), the quantity of recharge from precipitation would be 123,400 acft/yr in Kerr County. However, this is not the quantity of water available to wells completed in the aquifers of

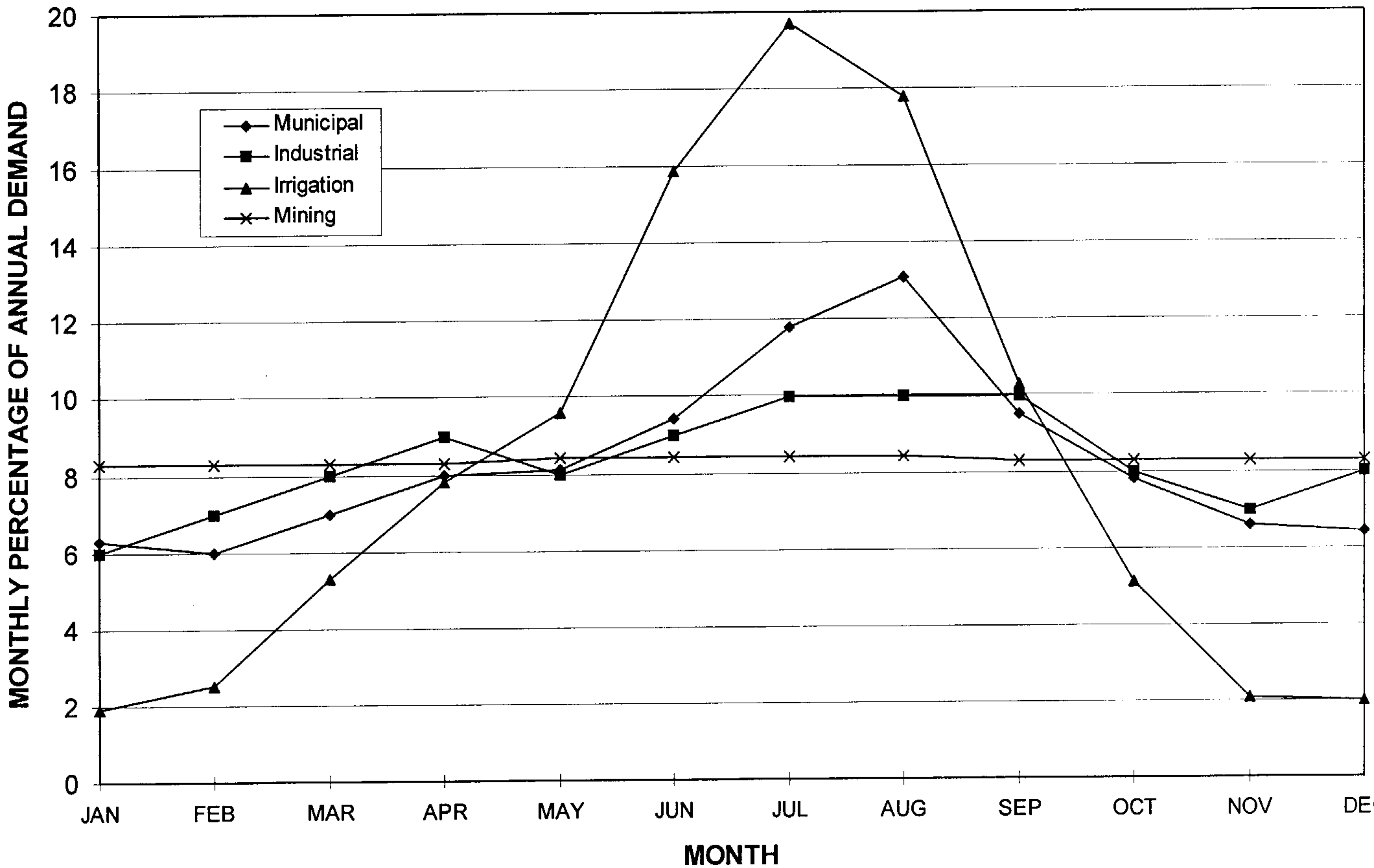
[3] Reeves, Richard D.,1969, Report 102 *Ground Water Resources of Kerr County,* Texas Water Development Board, Austin TX.
[4] Ashworth, John B, 1983, Report 273 *Ground Water Availability of the Lower Cretaceous Formations in the Hill Country of South-Central Texas,* Texas Department of Water Resources, Austin, TX.
[5] Bluntzer, Robert L., 1992, Report 339 *Evaluation of the Ground Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas,* Texas Water Development Board, Austin TX.
[6] Ashworth, John B, 1983, Report 273 *Ground Water Availability of the Lower Cretaceous Formations in the Hill Country of South-Central Texas,* Texas Department of Water Resources, Austin, TX.
[7] Guyton WF & Associates, 1973, *Report on Ground Water Conditions in the Kerrville Area.* Austin, TX.
[8] Ashworth, John B, 1983, Report 273 *Ground Water Availability of the Lower Cretaceous Formations in the Hill Country of South-Central Texas,* Texas Department of Water Resources, Austin, TX.
[9] Bluntzer, Robert L., 1992, Report 339 *Evaluation of the Ground Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas,* Texas Water Development Board, Austin TX.

TABLE 4-1
SURFACE WATER RIGHT PERMIT SUMMARY
MAY, 1997

	Kerr County			Upper Guadalupe through Canyon Lake		
Type of Use	No. of Permits	Total Quantity (acft/yr)	Percent of Total	Quantity of Water Rights Upstream of UGRA (acft/yr)	Quantity of Water Rights Held by UGRA/ Kerrville (acft/yr)	Quantity of Water Rights Downstream of UGRA (acft/yr)
Municipal	14	8,086	37%	153	7,922	35,250
Industrial	4	6,197	29%	6,197	0	14,775
Irrigation	138	6,845	32%	2,019	75	5,789
Mining	2	153	1%	10	0	143
Recreation	11	411	2%	0	0	45
Total	169	21,692	100%	8,379	7,997	56,002

TABLE 4-2
EXISTING MUNICIPAL WATER RIGHTS
UGRA AND KERRVILLE

Permit or Certificate of Adjudication Number	Diversion (ac-ft/yr)	Holder (Allocation)	Priority Date	Restrictions
3505	3,603	UGRA	1977/05/23	Senior Rights Maximum Diversion Rate 9.7 cfs
1996A	150	Kerrville	1914/04/04	Senior Rights
5394	1,100	UGRA (Kerrville Municipal)	1992/01/06	Senior Rights Combined Max. Diversion Rate 15.5 cfs Downstream flow required to divert: • Oct-May: 40 cfs • June-Sept: 30 cfs • Anytime inflow > 50 cfs: 50 cfs
	1,661	UGRA (County Municipal)	1992/01/06	Senior Rights Combined Max. Diversion Rate 15.5 cfs Instream Flows (30 to 50 cfs)
	1,408	UGRA (ASR Injection)	1992/01/06	All senior water rights Combined Max. Diversion Rate 15.5 cfs Instream flows (30 to 50 cfs)



Source: UGRA Permit 5394 for Municipal Pattern.

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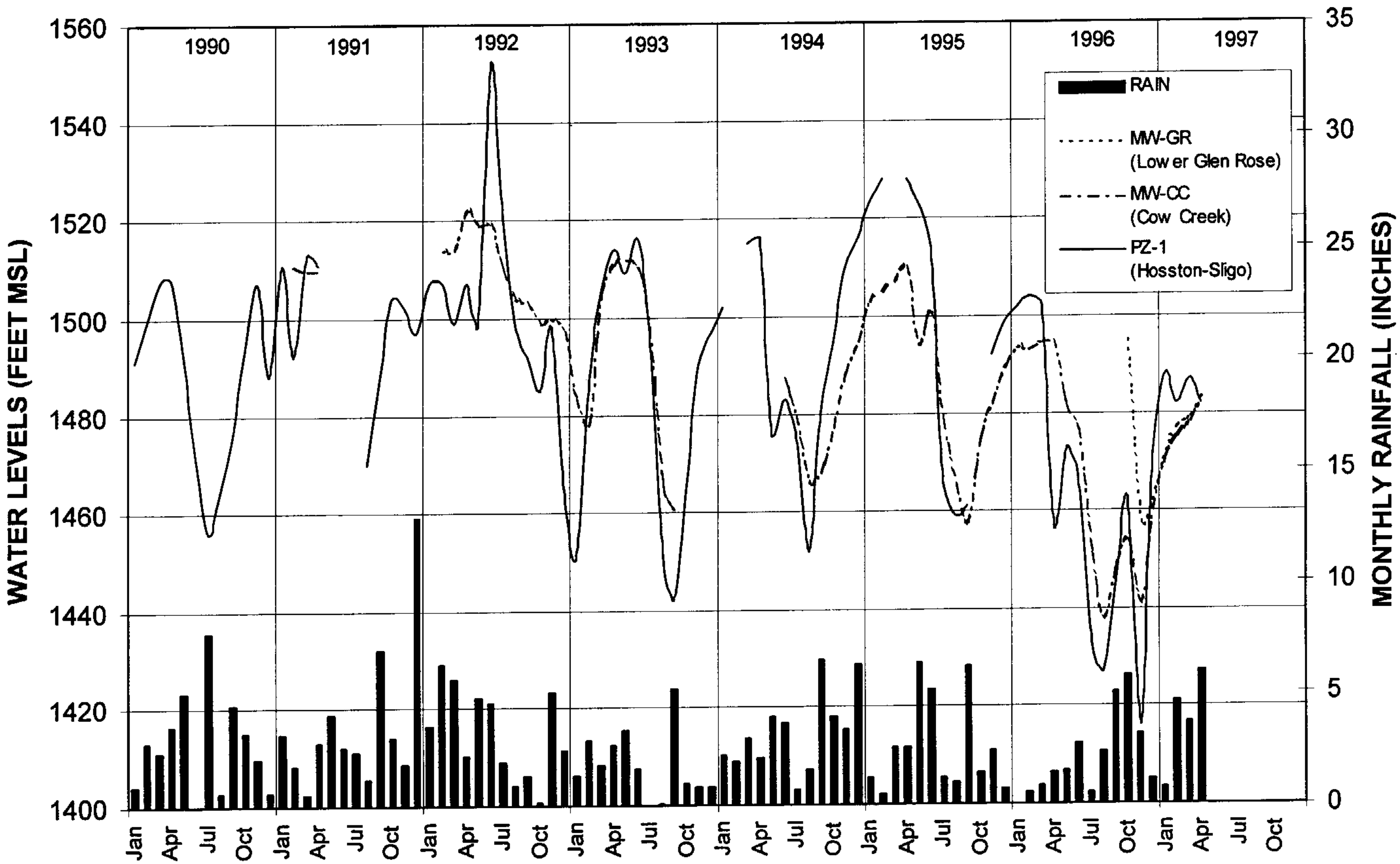
REGIONAL WATER AND WASTEWATER STUDY

MONTHLY WATER DEMAND PATTERN BY TYPE OF USE FOR KERR COUNTY

FIGURE 4-1



Source: UGRA, 1997.

HDR Engineering, Inc.

REGIONAL WATER AND WASTEWATER STUDY

WELL WATER LEVELS AND RAINFALL
UGRA NESTED PIEZOMETERS
1990-1997

FIGURE 4-3

the county, since much of this water exits the aquifers in the form of springs and seeps into streams of the county.

Table 4-3
Stratigraphic Units and Their Water Bearing Properties

Hydrologic Unit	***Stratigraphic Unit***	***Depth to Top of Stratigraphic Unit Near Kerrville (ft)***	***Approximate Saturated Thickness Near Kerrville (ft)***	***Water Bearing Properties***
Edwards	Edwards Limestone	NA	NA	Yields small quantities (5-20 gpm) of fresh water
Upper Trinity	Upper Glen Rose			Yields very small to small quantities (0-20 gpm) of relatively highly mineralized water
Middle Trinity	Lower Glen Rose	170	300	Yields small to moderate quantities (5-100 gpm) of fresh to slightly saline water.
	Hensell Sand	380		
	Cow Creek Limestone	450		
	Hammett Shale			Not known to yield water
Lower Trinity	Hosston Sand	530	100	Yields small to large quantities (5-100+ gpm) of fresh to slightly saline water.
Pre-Cretaceous rocks		600		

Source: Ashworth, 1983

4.2.2 Aquifer Characteristics

Upper Trinity

The upper Trinity aquifer generally produces water of poor quality, with excessive sulfate concentrations resulting from prolonged contact of water with evaporate zones. Further use of this aquifer is not recommended to meet future municipal demand increases. Water quality deterioration in the Upper Trinity aquifer may shift demand from this unit to the Middle Trinity aquifer.[10]

[10] UGRA, 1997, Personal Communication with Jim T. Brown, General Manager, and Daniel N. Keeler, Geologist, Upper Guadalupe River Authority, Kerrville, TX.

Middle Trinity

The middle Trinity aquifer provides fresh water with Total Dissolved Solids concentrations usually under 1,000 mg/L in Kerr County. Ground water in the middle Trinity moves to the southeast on a regional basis within Kerr County, but also flows toward the Guadalupe River as indicated by Bluntzer.[11]

Lower Trinity

The lower Trinity aquifer provides fresh water with Total Dissolved Solids concentrations usually under 500 mg/L in Kerr County. Ground water movement in the Lower Trinity is generally to the southwest in Kerr County. Ashworth estimates the average transmissivity to be 20,000 gal/d/ft and the storativity to be 3.8×10^{-5} for the Lower Trinity aquifer within Kerr County.[12] Guyton estimates the transmissivity of the Lower Trinity in the Kerrville area to be 20,000 gal/d/ft and the storativity to range between 4.6×10^{-5} and 9.2×10^{-4}.[13]

Hydrological Continuity

As reported by Bluntzer,[14] even though the Hammett shale member is considered to be a consistently occurring confining unit throughout Kerr County, the Lower and Middle Trinity aquifers are hydrologically connected. Bluntzer concludes that the three aquifers of the Trinity group should be considered a leaky aquifer system. This conclusion is corroborated by more recent information from UGRA nested Piezometers presented in Figure 4-3. The piezometer nest is located near the UGRA water treatment plant. The Piezometers are opened to the Lower Glen Rose and Cow Creek Limestone (part of the Middle Trinity aquifer), and the Hosston Sligo Sand (part of the Lower Trinity aquifer) as indicated in Figure 4-3. The close relation of water levels in the Cow Creek Limestone and the Hosston Sand formations in response to rainfall and

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[11] Bluntzer, Robert L., 1992, Report 339 *Evaluation of the Ground Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas,* Texas Water Development Board, Austin TX.
[12] Ashworth, John B, 1983, Report 273 *Ground Water Availability of the Lower Cretaceous Formations in the Hill Country of South-Central Texas,* Texas Department of Water Resources, Austin, TX.
[13] Guyton WF & Associates, 1973, *Report on Ground Water Conditions in the Kerrville Area.* Austin, TX.
[14] Bluntzer, Robert L., 1992, Report 339 *Evaluation of the Ground Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas,* Texas Water Development Board, Austin TX.

pumping in the Lower Trinity aquifer indicate hydraulic communication between these two geologic units (Lower and Middle Trinity Aquifers) in the Kerrville Area.

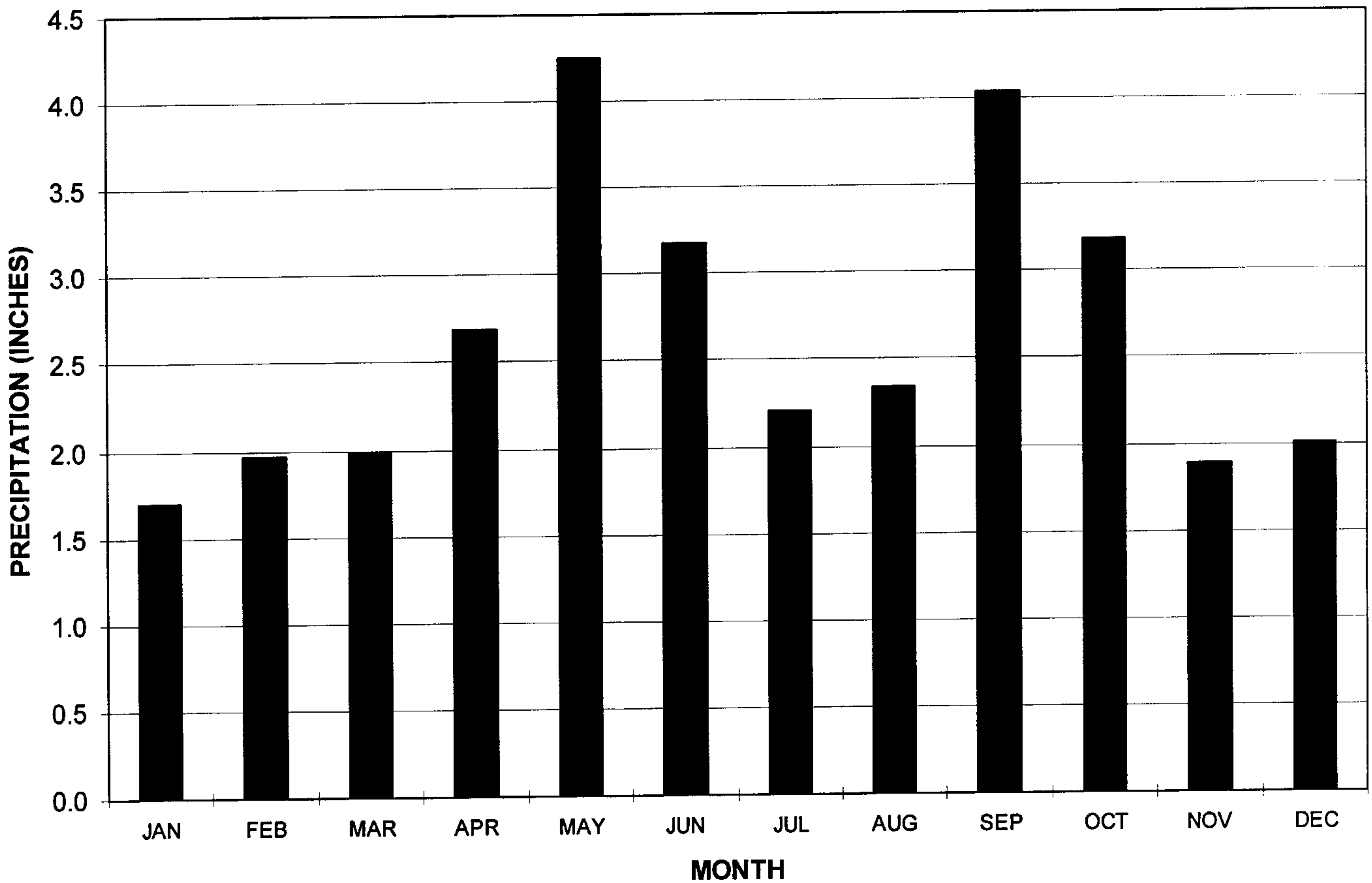
4.2.3 Ground Water Use, Water Levels, and Development Potential

Factors that can account for water level or piezometric surface changes over time include the natural changes of recharge-discharge conditions, the frequency, amount, and distribution of withdrawals by wells, and the amount and distribution of the aquifer's coefficients of transmissivity and storativity that control the flow and availability of water to replenish the withdrawals by wells.[15]

If the frequency, amount, and distribution of withdrawals by wells results in excessive or large quantities of well water level drawdowns, the problem could be associated with withdrawal intensity -- a problem associated with the short term extraction rate that causes a cone of depression in either the piezometric surface of a confined aquifer or the water table of an unconfined aquifer. The size of the cone of depression is proportional to the pumping rate. If one well overlaps another, additional lowering of water levels will occur as the wells compete for the same water. Problems related to withdrawal intensity appear in hydrographs as sharp drawdown levels followed by rapid recovery.

If the aquifer's coefficients limit the flow and availability of water to replenish the withdrawals by wells causing excessive drawdowns, the problem could be associated with over-drafting of the aquifer -- a problem associated with the long-term average extraction rate. Problems associated with long-term over-drafting appear in hydrographs as gradual declines in the water levels as water is withdrawn from storage in the aquifer. Figure 4-4 gives an indication of water level changes over an extended monitoring period in the Lower and Middle Trinity Aquifers and the Edwards Plateau Aquifer. Since water quality limits the potential use of the Upper Trinity Aquifer for municipal purposes, no water level data have been reviewed for the Upper Trinity aquifer.

[15] Ibid.



Source: National Weather Service, 1997.

HDR Engineering, Inc.

REGIONAL WATER AND WASTEWATER STUDY
AVERAGE PRECIPITATION IN KERRVILLE
1931 THROUGH 1995
ANNUAL AVERAGE = 31.42 INCHES

FIGURE 4-2

Edwards Plateau Aquifer

The Edwards Plateau aquifer is used primarily in western Kerr County for domestic and agricultural purposes. No trends can be established for the Edwards Plateau Aquifer from Well 56-53-304 and there appears to be no problems in either withdrawal intensity or over-drafting of this aquifer. It is estimated that this aquifer can continue to supply its domestic and agricultural uses in western Kerr County, with no limitations anticipated during the planning period for these purposes.

Upper Trinity Aquifer

The Upper Trinity is used primarily in northern and western Kerr County for agricultural purposes. Water quality limits its maximum use to the current estimated quantity of 500 acft/yr.[16] As mentioned previously, water quality deterioration may shift demand from this unit to the Middle Trinity aquifer.[17]

Middle Trinity Aquifer

The Middle Trinity aquifer is used primarily in the Central and Southeast portions of Kerr County for municipal and agricultural purposes. The water level declines observed in Middle Trinity wells in eastern Kerr county appear to result from a widespread gradual depletion of water from storage in the aquifer associated with over-drafting (see Figure 4-4, wells 57-57-703, 67-08-201, 68-01-505, 69-16-201). Long-term gradual water level declines result when pumpage is greater than recharge and some of the water obtained from the aquifer must be withdrawn from storage. Therefore, the declining water levels in eastern Kerr County Middle Trinity wells indicate that existing aquifer recharge cannot support the current rate of ground water extraction. If this trend continues in the Middle Trinity, transmissivities may decrease and waters with excessive sulfate concentrations in the evaporate beds of the overlying Upper Trinity may leak downward into the Middle Trinity aquifer and deteriorate ground water quality. In addition to the long-term problems associated with pressure depletion in the Middle Trinity in

[16] CH2M Hill, 1993, *Kerr County Regional Water Plan Final Report,* for Upper Guadalupe River Authority with City of Kerrville, City of Ingram, Kerr County.

[17] UGRA, 1997, Personal Communication with Jim T. Brown, General Manager, and Daniel N. Keeler, Geologist, Upper Guadalupe River Authority, Kerrville, TX.

the eastern portion of the county, the declining water surface could fall below pump settings during critical periods such as the summer of 1996 (see Figure 4-4). Lowered static water surface elevations require greater pumping lift, increasing the annual costs of water supply. Therefore, it may benefit the eastern portion of Kerr County, under current conditions, to supplement its ground water withdrawals with surface water in a manner similar to Kerrville. Augmentation with surface water would reduce ground water withdrawals for the same total supply, allowing the recovery of water surface elevations. Conjunctive use of surface and ground waters in eastern Kerr County would reduce the vulnerability of supply during droughts and the risk of encroachment by poor quality water.

The gradual decline of water levels in the Middle Trinity wells appears to have started around 1980, based on examination of hydrographs in Figure 4-4. Therefore the extraction rate from the middle Trinity in 1980 (the onset of water level decline) may approximate a maximum sustained yield from this aquifer. Bluntzer[18] reports that the total use from the Trinity group aquifers in 1980 was 4,764 acft. Subtracting Kerrville's extraction of 3,209 acft from the Lower Trinity leaves approximately 1,500 acft having been extracted from the Middle Trinity at the onset of water level decline. On this basis, 1,500 acft/yr is suggested as a reasonable maximum sustained yield from the Middle Trinity for planning purposes.[19]

Lower Trinity Aquifer

The Lower Trinity aquifer provides water to the City of Kerrville for municipal and industrial uses. When considering the water level changes for the Lower Trinity presented in Figure 4-4 it is important to recognize the partial conversion to surface water by UGRA and the City of Kerrville in 1981. This affects the Lower Trinity aquifer in the vicinity of Kerrville. The data indicate full recovery of pressures in the Lower Trinity aquifer near Kerrville subsequent to surface water use (see Figure 4-4, wells 69-08-101, 56-63-608, 56-64-701, 56-63-604). However, during peak ground water extraction periods (summer months), piezometric pressures fall dramatically for the duration of pumping.

[18] Bluntzer, Robert L., 1992, Report 339 *Evaluation of the Ground Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas,* Texas Water Development Board, Austin TX.
[19] This is 500 acft/yr greater than estimated by CH2M Hill (1993) based on regional gradients and estimated transmissivities.

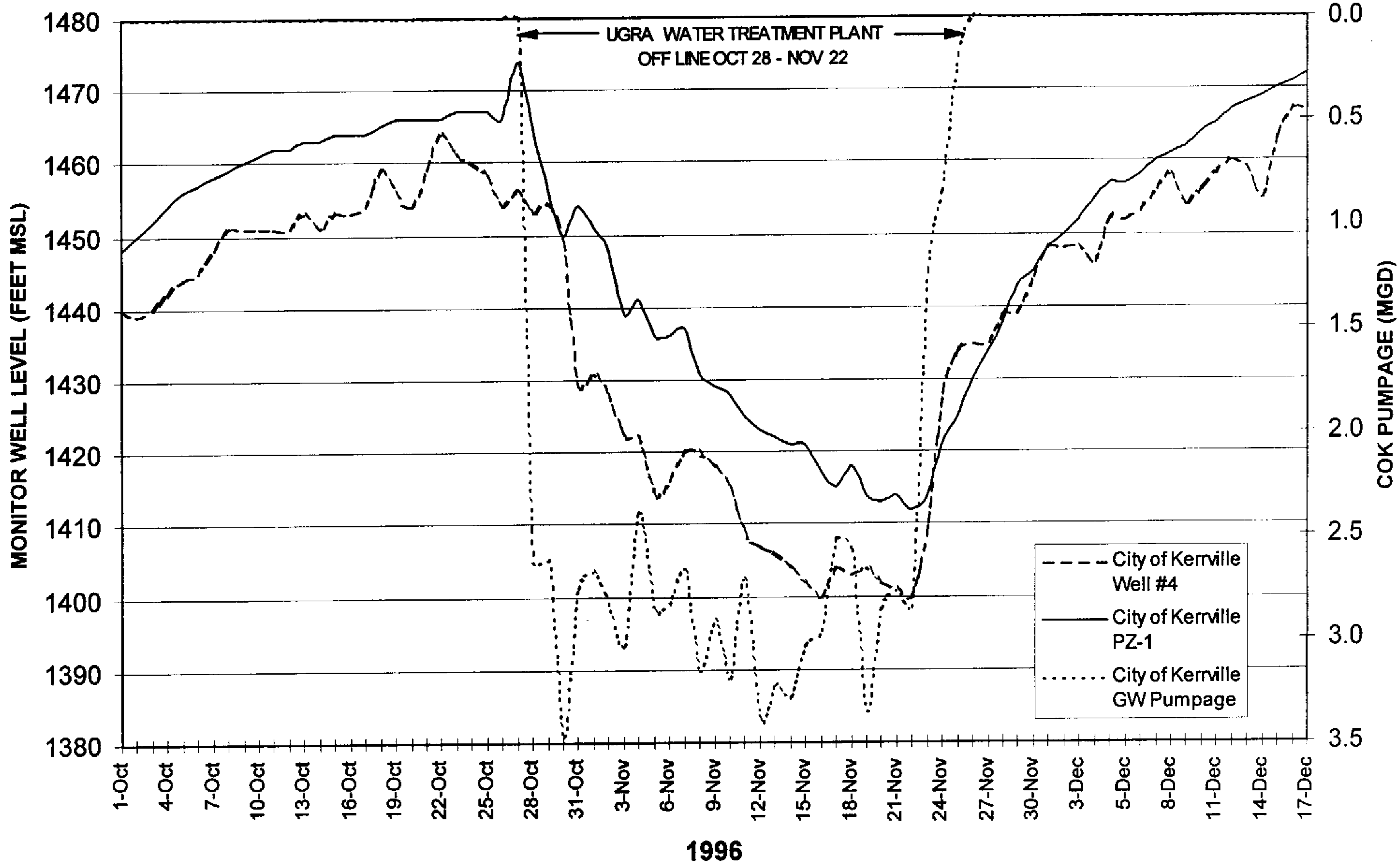
Figure 4-5 presents a well hydrograph for the fall of 1996 for wells in the Lower Trinity aquifer near Kerrville. The surface water treatment plant was taken off-line on October 28, 1996, and resumed operation on November 22, 1996. This temporary shut-down of the surface water supply forced ground water extractions to supply the entire demand for this period of one month. The water levels in Wells PZ-1 and COK #4 display the classic theoretical drawdown and recovery shape associated with intermittent pumping. The average withdrawal rate was about 3 mgd (3361 acft/yr). Extrapolating the drawdown curve from well COK #4 indicates that the steady state water level associated with this pumping rate might be in the range of 1,350 to 1,380 feet National Geodetic Vertical Datum (NGVD). This is a very similar situation to the conditions in 1980 just prior to the development of surface water. In 1980 (Figure 4-6, the annual withdrawal was 3,209 acft/yr and the water level in October was 1,348 ft (the monthly average pumping rate in October 1980 was 2,891 acft/yr). Because the conditions observed during pumping in 1996 under fully recovered piezometric conditions are very similar to the conditions observed in 1980 after continual pumping, it is concluded that the 1980 ground water conditions result primarily from the long-term withdrawal rate, and not from a short term over-drafting of the aquifer.

After extensive hydraulic testing and analysis, Guyton estimated the long-term yield near Kerrville to be about 3 mgd (3,361 acft/yr) or about 4 mgd (4,481 acft/yr) if the pumps are set at their maximum depths.[20] Guyton's estimates were based on operating the wells continuously at these rates, with no fluctuations due to seasonal demands. Bluntzer estimates the sustained yield of the combined Trinity group aquifers to be 7,200 acft/yr over the entire county.[21] Based on the above analysis and the additional estimates provided for purposes of this study, the long-term sustained yield of the Lower Trinity Aquifer near Kerrville is estimated to be 3,200 acft/yr.

4.3 Estimated Ability to Meet Present and Future Demands of Kerrville Area and Kerr County

The water supply and demand comparison presented below focuses on 1) Kerrville with extended service areas as shown in Table 2-4 and, 2) entire Kerr County. In this report, water

[20] Guyton WF & Associates, 1973, *Report on Ground Water Conditions in the Kerrville Area.* Austin, TX.
[21] Bluntzer, Robert L., 1992, Report 339 *Evaluation of the Ground Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas,* Texas Water Development Board, Austin TX.



Source: UGRA, 1997.

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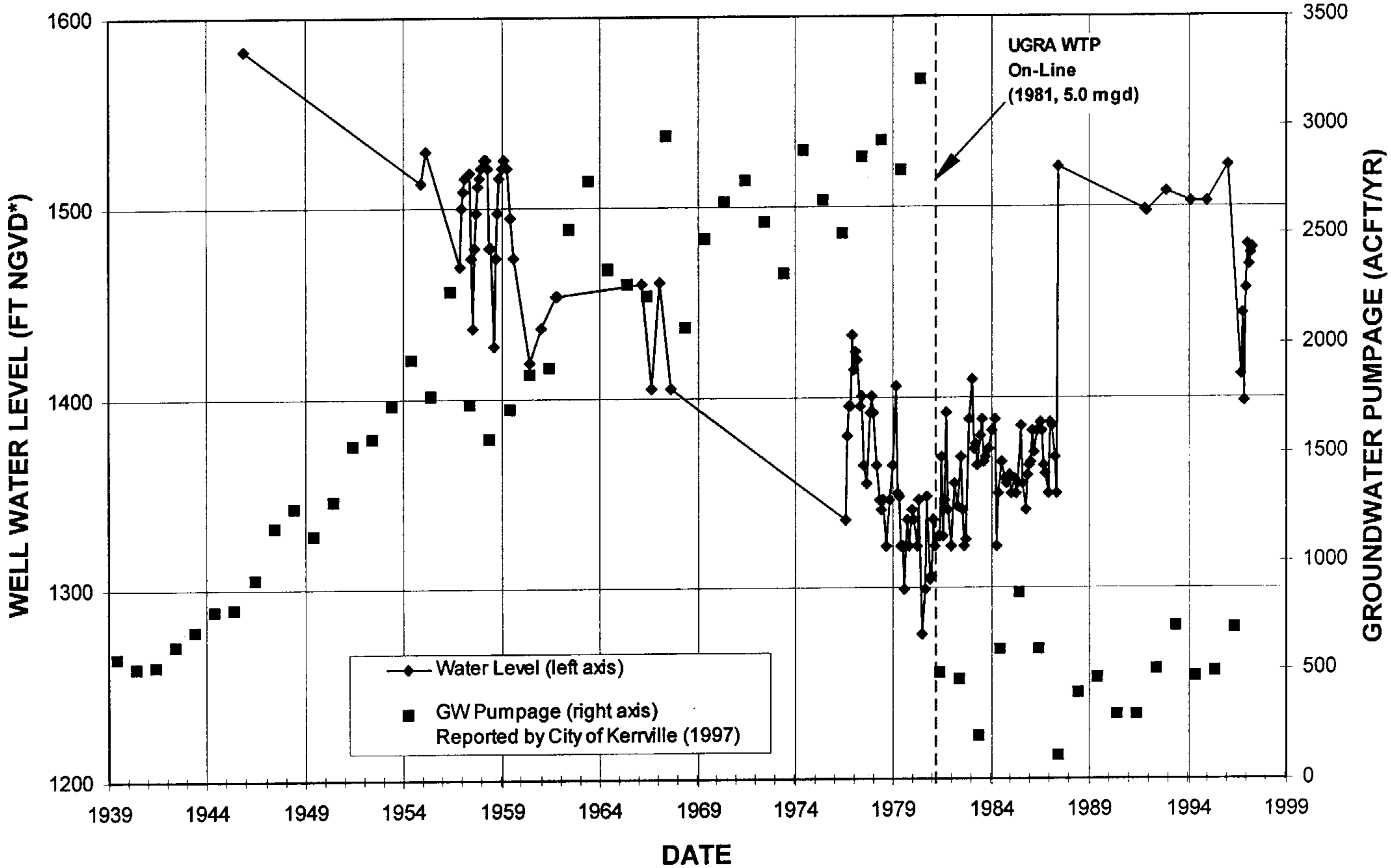
REGIONAL WATER AND WASTEWATER STUDY

CITY OF KERRVILLE
GROUND WATER EXTRACTION AND MONITORING WELL RESPONSES

FIGURE 4-5



*NGVD: National Geodetic Vertical Datum

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REGIONAL WATER AND WASTEWATER STUDY
HISTORICAL GROUND WATER CONDITIONS
LOWER TRINITY AQUIFER
KERR COUNTY

FIGURE 4-6

supply and demand are compared on an average annual basis over the period of hydrologic record and over the drought of record from 1950 through 1956. For the Kerrville analysis, only municipal demands are considered, while the Kerr County analysis includes uses of all types as described in the respective sections for each analysis. Providing an estimate of the ability of the existing supply system to meet the present and future needs of Kerrville and Kerr County requires estimating both surface and ground water availability when used conjunctively with the potential for aquifer storage and recovery of surface water (ASR), since TNRCC has issued a permit for ASR. To evaluate surface water availability, a computer model of the hydrologic and supply system was developed. A simulation model was necessary because of the complicated nature of permitted diversions and the variable stream flow in the Upper Guadalupe River. The model computes surface water availability on a monthly basis over a 56-year period of time (i.e., 1934 through 1989). The surface water shortfall, the difference between the water demand and surface water availability, is assumed to be supplied by ground water. The model provides a water balance of supply and demand only and does not attempt to model ground water level drawdowns associated with withdrawals. Storage in Kerrville's channel reservoir is ignored in modeling since the reservoir is not currently drawn down for water supply.

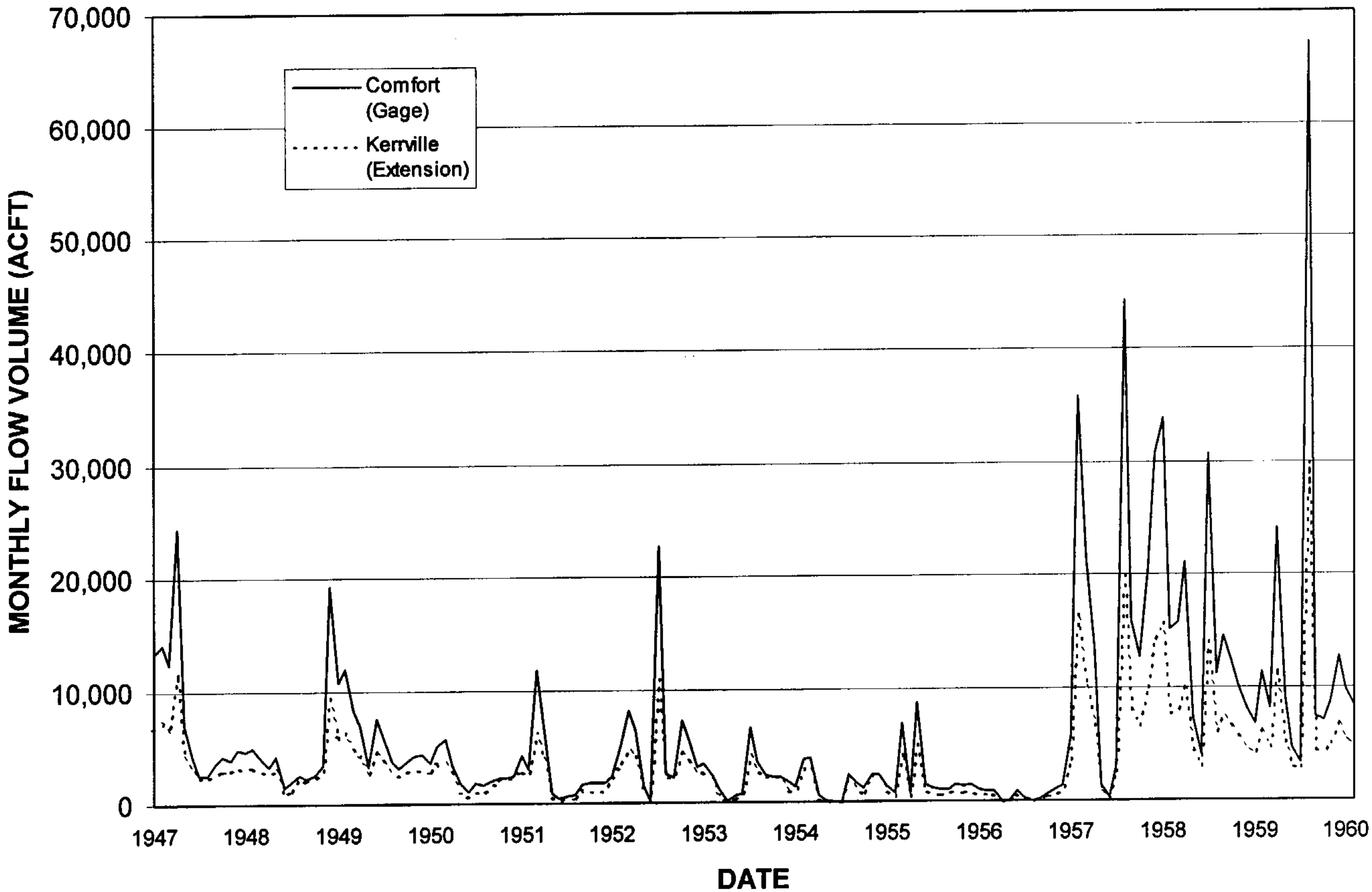
4.3.1 Model Development

The surface water availability model allows the water demand in any demand year to be analyzed on a monthly basis for the 56-year streamflow record for the Guadalupe River at Kerrville. The monthly time step of the model tends to over-estimate water availability subject to daily flow patterns, instream flow requirements, instantaneous maximum diversion rate and water treatment plant capacity. With the simulation model, it is possible to estimate both the mean and extreme conditions expected to occur for any demand condition, based on the historical streamflow record. Water supply over the period of record which includes several periods of drought are compared with projected future water demands.

For any given month, the model computes the surface water available to meet water demands and for injection into the aquifer for storage. The surface water shortfall (difference between demand and surface water availability) is assumed to be met by ground water withdrawals. The results on a monthly basis can be summarized on an annual basis or averaged over the period of streamflow record (56 years) for any given demand decade (i.e., for year 2020 demand projections). The water supply during drought streamflow conditions that occurred for the period 1950 through 1956, but with existing water diversion permits is a worst case water supply condition for the study area based on the hydrologic record. For this study, average annual surface water availability over the period of record is considered appropriate for summation with the estimated sustained yields of the aquifers for estimating the long term dependable water supply for the area, since the ASR permit allows the use of surface water to firm up ground water supplies.

The primary components of the model include:

- Demand patterns: Future demands for water are assumed to occur according to the projections developed in Section 2 of this report. Annual demands are expressed in terms of monthly demands using the demand pattern presented in Figure 4-1.
- Upper Guadalupe stream flow at Kerrville: The record for the Upper Guadalupe at Kerrville was synthesized from the 56 year record at Comfort, TX, and the 11 year record at Kerrville, using the correlation between the two gages during the overlap period. The record developed for the Guadalupe River at Kerrville is compared to the Comfort gage in Figure 4-7 for the critical drought period observed during the 1950's.
- Water rights: Upstream senior municipal water rights were assumed to be diverted from the river upstream of Kerrville, while senior irrigation water rights upstream (2,019 acft/yr as presented in Table 4-1) were assumed not to be used. This assumes that agreement could be obtained with irrigators for water during critical shortages. Downstream water rights were not considered and potential impacts on GBRA's water rights would have to be computed using more sophisticated approaches. For purposes of this study, it was assumed that an agreement could be reached with GBRA for mitigation of any yield impact to Canyon Lake associated with Permit 3505.
- Permitted Diversions: The permitted diversions held by UGRA and the City of Kerrville discussed above in Section 4.1.1 are allowed to occur subject to upstream municipal water rights, flow in the river, water treatment capacity, and instream flow requirements. Figure 4-8 indicates the magnitude of Permit 5394 instream flow requirements relative to the expected flow in the Guadalupe River at Kerrville. Diversion under Permit No. 5394 is only permitted when the Guadalupe river exceeds minimum instream flow requirements. Diversions are required to occur in the historical demand pattern. If the permitted diversion under permit No. 5394 is not available at a given time, it can be diverted at a future time in that year, subject to the instream flow constraint of 60 cfs. To determine the sufficiency of supply, a water treatment plant capacity of 10 mgd was assumed for compatibility with the maximum permitted diversion rate.
- Ground water Pumpage: Ground water is assumed to be withdrawn to meet municipal demands that cannot be satisfied by surface water diversions (surface water shortfalls).



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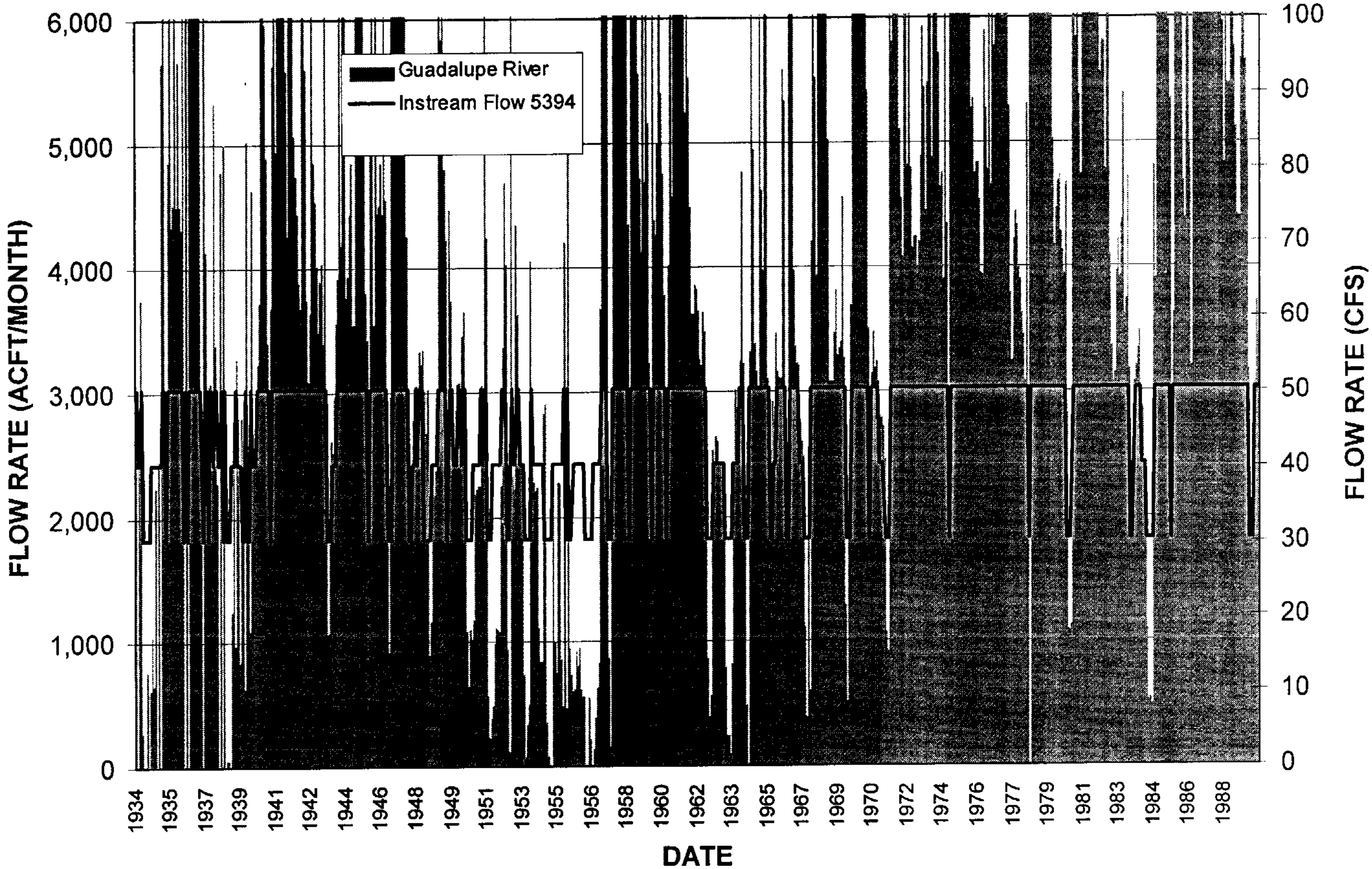
REGIONAL WATER AND WASTEWATER STUDY
STREAMFLOW RECORD EXTENSION
GUADALUPE RIVER AT KERRVILLE

FIGURE 4-7



Note:

When Guadalupe River flow falls below instream flow requirement, no diversion is allowed under Permit 5394.

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REGIONAL WATER AND WASTEWATER STUDY

INSTREAM FLOW REQUIREMENTS FOR PERMIT 5394

FIGURE 4-8

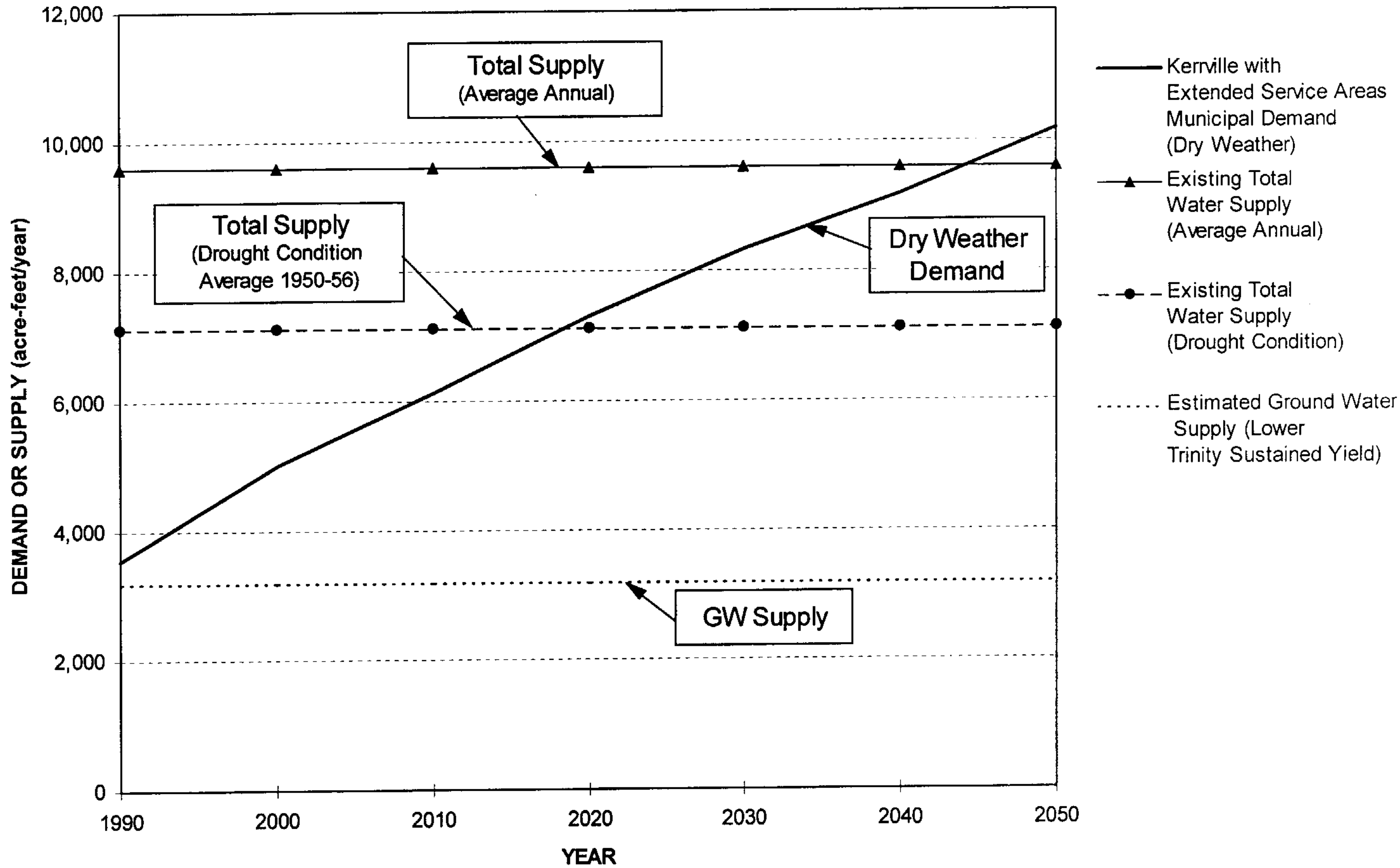
- ASR Injection Potential: The potential for diverting water for injection to the lower Trinity aquifer is evaluated based on Permit 5394 rights and restrictions and available treatment capacity.

4.3.2 Kerrville with Extended Service Areas

Water demand projections for the City of Kerrville area, including its extended service areas are presented in Table 2-7. The maximum sustained ground water supply for the City of Kerrville is considered to be 3,200 ac-ft/year from the Lower Trinity aquifer with no contributions from the Middle Trinity aquifer. This assumes that developing areas outside but adjacent to Kerrville will not impact the ground water resources available to Kerrville. The surface water supply for the City with extended service areas is derived from Permits 1996, 3505 and 5394. The total diversion allowed under Permit 5394 is 1,100 acft/yr for the City of Kerrville, and 447 (1,661 x 27%) acft/yr for municipal areas within Kerr County outside of Kerrville (pro-rata share of the 1,661 acft/yr of supply available to areas outside of Kerrville estimated to be extended service by Kerrville). See Section 4.1 for a detailed discussion of existing water rights held by Kerrville and UGRA.

Figure 4-9 illustrates the demands of Kerrville and extended service areas throughout the planning period. The figure shows the existing supplies under average annual period of record and drought conditions. The sustained yield of 3,200 acft/yr of ground water from the Lower Trinity aquifer is a component of both average annual and drought condition supplies. This analysis is simplified in considering the Kerrville ground water supply to be independent of further ground water development outside of the Kerrville area. In reality, ground water development outside the Kerrville area could decrease the Kerrville ground water supply, especially if not adequately regulated.

Surface water available over the period of record (1934-1989) averages 4,834 acft/yr, with 793 acft/yr available for aquifer injection. Under drought streamflow conditions from 1950 through 1956, surface water availability would average about 3,727 ac-ft/yr, with 16 acft/yr available for aquifer injection. Total supply on an average annual basis over the period of record would meet projected demands until 2044. However, projected demand would exceed drought conditions supply by 2018.



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REGIONAL WATER AND WASTEWATER STUDY

PROJECTED KERRVILLE AREA MUNICIPAL WATER DEMANDS AND EXISTING SUPPLIES

(ASSUMES 3,200 ACFT/YR LOWER TRINITY SUSTAINED YIELD)

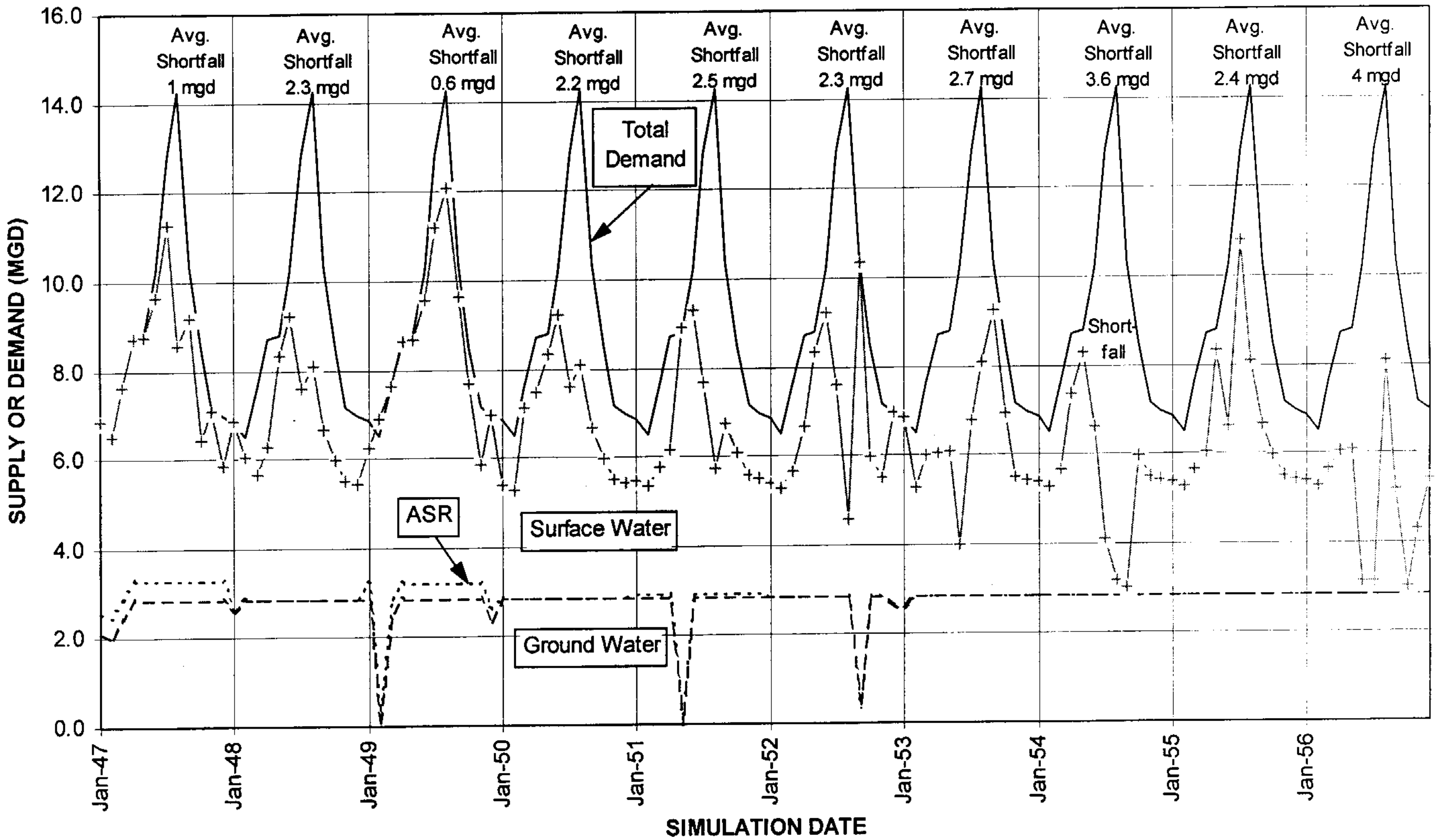
FIGURE 4-9

Figure 4-10 and Table 4-4 present a more detailed description of potential water supply under 1950-56 drought hydrology conditions and 2050 projected demands for Kerrville with extended service areas. Figure 4-10 illustrates ground, surface, and ASR water yields as components of the total water supply to meet the total demand. The average difference between the demand and supply lines is the annual shortfall, shown above each year in Figure 4-10. The average shortfall over the drought (1950-56) is 2.8 mgd. Although ASR contributes a small amount to the supply early in the drought, ASR does not improve water supply during the critical latter stages of the drought. It is not the ASR system itself that is deficient, but the permit to divert water for aquifer injection. In other words, the restrictions associated with Permit 5394 are too stringent to allow the ASR system to divert river water during periods of critical need. The restrictions include both minimum instream flow requirements and allocations of the annual diversion allotment to months based on the pattern of historical demands. Table 4-4 provides a 10-year annual summary of the drought period and averages over the critical period from 1950 through 1956.

Table 4-4
Municipal Water Demand / Supply Annual Summary
Kerrville And Extended Service Areas
Drought Conditions Under 2050 Demands

	Annual Averages from Water Demand/Supply Simulation					
Simulation Year	Total Water Demand (mgd)	Ground Water Sustained Yield (mgd)	ASR Yield (mgd)	Surface Water Supply (mgd)	Total Water Supply (mgd)	Water Shortfall (mgd)
1947	9.1	2.7	0.4	4.9	8.0	1.0
1948	9.1	2.8	0.0	4.0	6.8	2.3
1949	9.1	2.5	0.4	5.5	8.4	0.6
1950	9.1	2.8	0.0	4.0	6.8	2.2
1951	9.1	2.6	0.1	3.8	6.5	2.5
1952	9.1	2.6	0.0	4.2	6.8	2.3
1953	9.1	2.8	0.0	3.5	6.4	2.7
1954	9.1	2.8	0.0	2.6	5.5	3.6
1955	9.1	2.8	0.0	3.8	6.6	2.4
1956	9.1	2.8	0.0	2.2	5.1	4.0
Averages 1950-56	9.1	2.8	0.0	3.4	6.2	2.8

Note: Ground water dips below sustained yield in any month if not needed due to sufficient surface water.



Notes:
Average drought (1950-56) shortfall = 2.8 mgd.
Values noted on chart indicate annual average water shortfalls in million gallons per day.
Groundwater use dips below sustained yield if not needed due to sufficient surface water.

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REGIONAL WATER AND WASTEWATER STUDY
KERRVILLE AND EXTENDED SERVICE AREAS
DROUGHT CONDITIONS WATER SUPPLY
UNDER 2050 MUNICIPAL DEMANDS

FIGURE 4-10

Drought conditions supply could be expanded by withdrawing ground water at a rate greater than the sustained yield. However, over the 6-year drought period this would result in overdrafting this portion of the aquifer by a total of 3,256 acft. It is unclear exactly how this would affect ground water pressures over the six year drought period or the water transmission characteristics of the formation. Mandatory demand reductions of 20% during drought condition could extend the drought supply to meet reduced needs until only about the year 2030. Combinations of demand reduction during drought and pumping greater than the sustained yield of the aquifer could prolong the area's water supplies. However, reliance on these two concepts has a significant degree of risk involved.

Water reuse could be practiced to effectively lower the water demand curve shown in Figure 4-9. For instance, if water reuse could offset 600 acft/yr of demand, this could prolong the sufficiency of drought condition supply to about the year 2020. The supply curves shown in Figure 4-9 assume that the existing 5 mgd water treatment plant will be expanded to 10 mgd capacity.

4.3.3 Kerr County Results

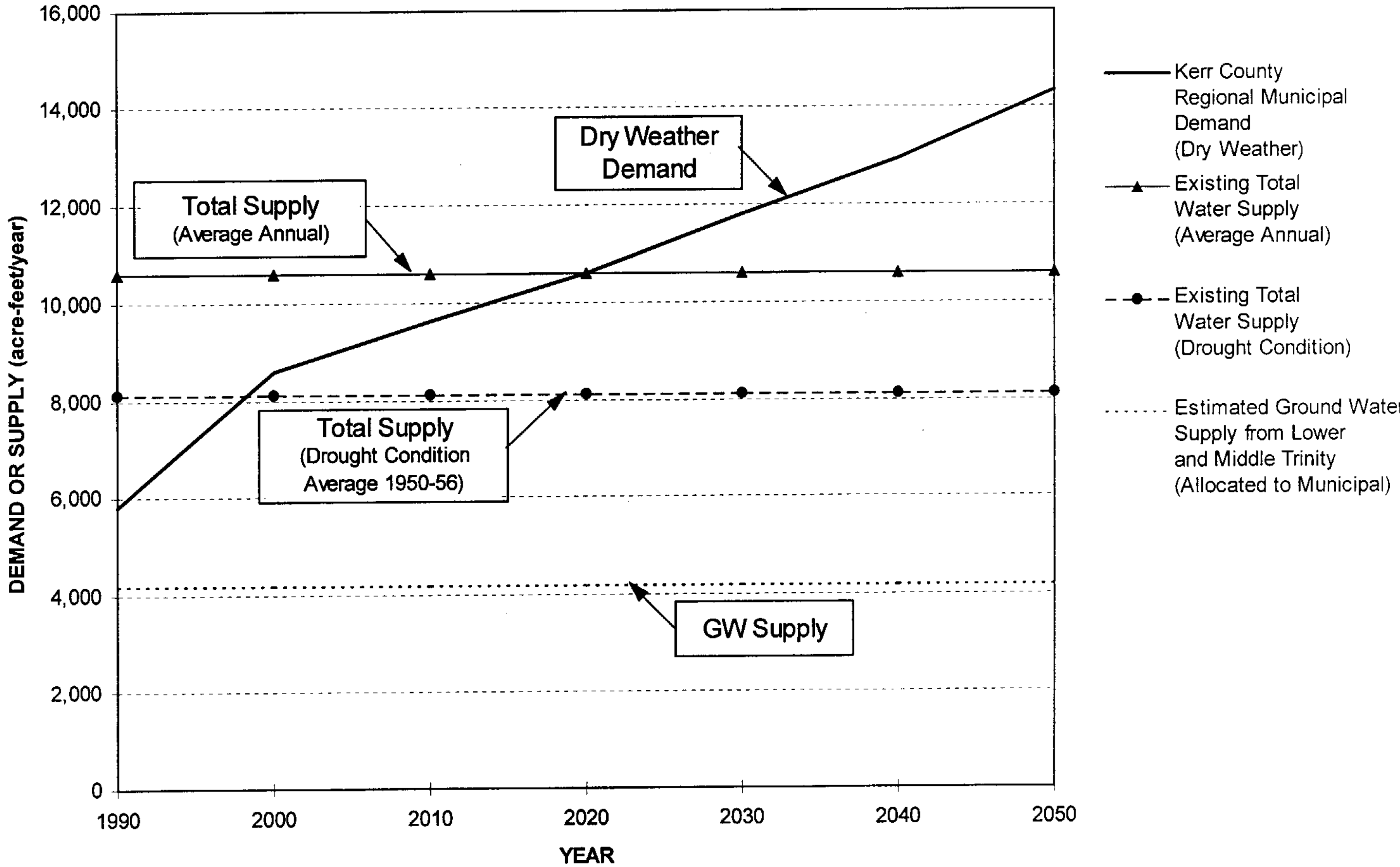
The water demand and supply analysis for Kerr County is similar to the analysis presented above for the Kerrville area, with the following exceptions. The supply and demand analysis for the county focuses on meeting projected municipal demands within the identified growth areas for Kerr County. It is expected that the Upper Trinity and Edwards Plateau aquifers will continue to meet agricultural and domestic demands in the northern and western portions of the county. In addition, it is assumed that 500 acft/yr of Middle Trinity sustained yield, along with existing irrigation surface water rights, will supply irrigation and livestock needs in Central and Eastern Kerr County. Existing surface water rights (153 acft/yr) are available to meet projected mining demands (105 acft/yr in 2050). The ground water resources available to the county are greater than available to the Kerrville area because the ground water is developed over a larger area. The estimated sustained yield of the presently developed portions of the Middle and Lower Trinity aquifers is 4,700 acft/yr. Therefore, the surface water availability combined with the remaining sustained yield of the Middle and Lower Trinity aquifers allocated to municipal purposes (4,200 acft/yr) can be compared to the total municipal demand of Kerr County for water supply planning purposes.

Figure 4-11 illustrates the existing supply and regional municipal demands of Kerr County over the planning period. The two supply curves shown are for average annual period of record and drought conditions. The sustained yield of 4,200 acft/yr of Middle and Lower Trinity ground water (allocated to municipal purposes) is a component of both the average annual and drought condition supplies.

Surface water available over the period of record (1934-1989) averages 5,749 acft/yr, with 647 acft/yr available for aquifer injection. Under drought streamflow conditions from 1950 through 1956, surface water availability would average about 3,910 ac-ft/yr, with 0 acft/yr available for aquifer injection. Total supply on an average annual basis over the period of record would meet projected demands until 2020. However, projected demand would exceed drought conditions supply by 1999. The sufficiency of drought conditions supply could be prolonged into the future by enforcing drought demand reductions or by allowing withdrawals to exceed the sustained yield of the Middle and Lower Trinity aquifers. However, over the 6-year drought period this would result in overdrafting this portion of the aquifer by 6,225 acft. It is uncertain how exceeding the sustained yield of the aquifers over the historical six year drought period would affect ground water pressures and the water transmission properties of the Trinity aquifers.

Figure 4-12 presents the Kerr County water supply situation under drought conditions in detail under 2050 projected demands. The figure indicates significant annual shortfalls averaging about 5.6 mgd using 1950 through 1956 hydrology. As in the Kerrville analysis presented above, ASR is not expected to significantly improve the water supply during drought due to the stringent permit restrictions. Table 4-5 provides a listing of annual average water supply and demand rates over the period 1950-56.

Figures 4-11 and 4-12 emphasizes the critical nature of the Kerr County water supply condition. The water supply situation in Kerr County would benefit by the formation of a regional authority that could make water supply planning decisions considering the situation of the entire county, leveraging the benefits of economies of scale. The water supply for Kerr County could be augmented by obtaining additional effective water rights for either direct use or storage for later use. Current water rights (Permit 5394) to divert from the Upper Guadalupe River for aquifer injection are limited due to stringent minimum instream flow requirements and requirements that diversions must follow historical demand patterns. For water rights that may



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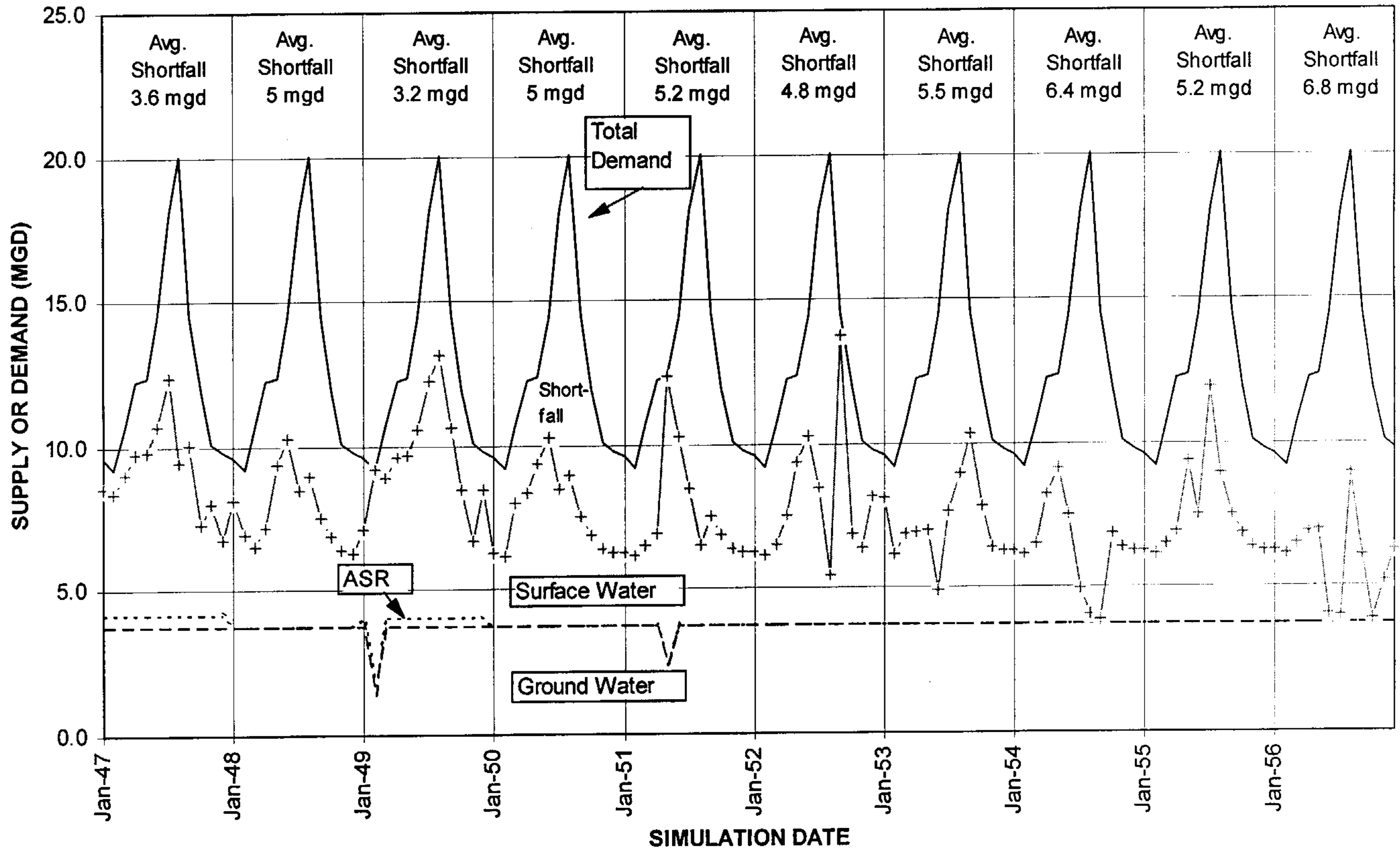
REGIONAL WATER AND WASTEWATER STUDY

KERR COUNTY REGIONAL MUNICIPAL WATER DEMANDS AND EXISTING SUPPLIES

(ASSUMES COMBINED TRINITY SUSTAINED YIELD OF 4,700 ACFT/YR)

FIGURE 4-11



Notes:
Average drought (1950-56) shortfall = 5.6 mgd.
Values noted on chart indicate annual average water shortfalls in million gallons per day.
Groundwater use dips below sustained yield if not needed due to sufficient surface water.

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REGIONAL WATER AND WASTEWATER STUDY
KERR COUNTY DROUGHT CONDITIONS WATER SUPPLY UNDER MUNICIPAL 2050 DEMANDS

FIGURE 4-12

Table 4-5
Water Demand / Supply Annual Summary
Kerr County
Drought Conditions Under 2050 Demands

Simulation Year	Annual Averages from Water Demand/Supply Simulation					
	Total Water Demand (mgd)	Ground Water Sustained Yield (mgd)	ASR Yield (mgd)	Surface Water Supply (mgd)	Total Water Supply (mgd)	Water Shortfall (mgd)
1947	12.8	3.7	0.4	5.0	9.2	3.6
1948	12.8	3.7	0.0	4.0	7.7	5.0
1949	12.8	3.5	0.3	5.7	9.6	3.2
1950	12.8	3.7	0.0	4.0	7.8	5.0
1951	12.8	3.6	0.0	3.9	7.6	5.2
1952	12.8	3.7	0.0	4.2	7.9	4.8
1953	12.8	3.7	0.0	3.6	7.3	5.5
1954	12.8	3.7	0.0	2.6	6.4	6.4
1955	12.8	3.7	0.0	3.8	7.6	5.2
1956	12.8	3.7	0.0	2.2	6.0	6.8
Averages 1950-56	12.8	3.7	0.0	3.5	7.2	5.6

Note: Ground water dips below sustained yield in any month if not needed due to sufficient surface water.

be acquired in the future, significant effort should be made to allow diversions different from the historical demand pattern so that in spring and winter higher streamflows could be captured and stored to be utilized at a later time. Instream flow requirements also limit the diversions associated with Permit 5394. To attempt to avoid such instream flow encumbrances, purchase of water rights from existing permit holders should be strongly considered.

Remote wells in the county, located away from current pumping centers may increase the sustained yield of the aquifers[22]. However, such additional ground water development and use will be costly and will require careful initial assessments and planning, considerable exploration

[22] Bluntzer, Robert L., 1992, Report 339 *Evaluation of the Ground Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas,* Texas Water Development Board, Austin TX.

and testing, potential acquisition of ground water leases and land for production well sites, construction of additional properly spaced production wells, pipelines for delivery of water to the area of use, and in some cases additional ground storage and water treatment facilities.

4.3.4 Summary of Ability to Meet Demands

Information presented in Paragraphs 4.3.2 and 4.3.3 indicates, respectively, that (1) projected demands for the City of Kerrville with extended service area would exceed drought condition supply on an annual average basis in approximately 2017, and (2) projected demands for Kerr County would exceed drought condition supply on an annual average basis in about 1999. Some means of increasing the available water supply are listed below:

1. Obtaining additional surface water rights or contracting for additional surface water from the Guadalupe River.
2. Evaluating potential use of off-channel surface storage to allow capture of surface water during periods of high river flows for subsequent direct use or for ASR. Ability to capture and store raw water in an off-channel surface impoundment would not be limited by the capacity of the water treatment plant or the ASR injection rate.
3. Revising TNRCC surface water permits to allow higher diversion rates in off-peak demand months when stream flows are greater could increase the benefits of ASR, particularly during drought conditions.
4. Development of wells in remote locations (availability of ground water in such areas would need to be determined).

All four options listed above should be evaluated. Based on the results of the evaluation, a conjunctive use plan should be developed that would allow optimal development of available water to meet projected demands.

Any plan developed should include implementation of a ground water management plan for Kerr County that would control well spacing and well capacities. A ground water management plan would help ensure ground water use remains within the capabilities of the aquifers to meet the long-term demands of Kerrville and Kerr County.

4.4 Need for a Regional Water System

Based on a review of ground water hydrographs provided in Figure 4-4 for Middle Trinity wells in eastern Kerr County, it appears that this aquifer is being overdrafted under current conditions. Overdrafting of the aquifer reduces the available drawdown, increasing the vulnerability of this water source during drought conditions. In addition, overdrafting may cause encroachment of poor quality water from the overlying Upper Trinity Aquifer and increases the pumping lift and, thereby, annual costs of water supply. For these reasons, it may benefit the eastern portion of Kerr County, under current conditions, to supplement its ground water withdrawals with surface water in a manner similar to Kerrville. Augmentation with surface water would allow a reduction in ground water withdrawals, allowing the recovery of water surface elevations. Conjunctive use of surface and ground water in eastern Kerr County would reduce the vulnerability of supply during droughts and the risk of encroachment by poor quality water.

Figures 4-11 and 4-12 emphasizes the critical nature of the Kerr County water supply condition. The water supply situation in Kerr County would benefit by a regional supplier that could make water supply planning decisions considering the situation of the entire county, leveraging the benefits of economies of scale.

Meeting municipal water demands of Kerr County on a sustainable basis would require adequate supply, treatment and distribution facilities. The analysis described herein suggests that an expansion of the water treatment plant from 5 to 10 mgd would be necessary by about year 2005 to meet regional demands. Substantial additional surface water suppliers are needed in order to meet projected 50-year water demands. Since water rights are granted based on a time priority basis, these additional water rights should be obtained as soon as possible.

5.0 WASTEWATER EVALUATION

5.1 Existing Wastewater Treatment and Collection Systems In County

The Texas Natural Resource Conservation Commission (TNRCC) current listing of wastewater discharge permits for Kerr County lists three active municipal permits in the county. Only one of the three active permits is a discharge permit; the other two permits are for no-discharge systems. Active permits in Kerr County are listed in Table 5-1.

Table 5-1
Active TNRCC Municipal Wastewater Permits
Kerr County

Permit No.	*Permit Name/Holder*	*Type*	*Permitted Flow (mgd)*
10576-001	City of Kerrville	Discharge	3.52[1]
10768-001	Presbyterian Mo-Ranch Assembly	No Discharge	0.04
11594-001	City of Kerrville	No Discharge	0.03

[1]The City of Kerrville has applied for an amendment to increase the permitted flow to 4.5 mgd.

The only wastewater collection system in Kerr County is located in the City of Kerrville. A detailed analysis of the collection system was not included in the scope of this study. A previous wastewater study (Regional Wastewater Treatment Plan, City of Kerrville, Upper Guadalupe River Authority, and City of Ingram, February 1985) included a fairly detailed evaluation of collection system capacity. The study indicated that some of the lines in the existing system would need to be paralleled to handle projected flows, which should still hold true. Since the 1985 study was performed, the City has extended an interceptor along Highway 27 on the west side of the City, and the extended interceptor does have some capacity to handle flows from un-sewered areas west of the City.

5.2 Ability of Systems to Meet Current and Future Wastewater Needs

The total active permitted wastewater flow in Kerr County is 3.59 mgd. In the past, permitted flow was based on the anticipated peak month flow expected at a facility, as the TNRCC based compliance on reported monthly flows compared with permitted flow. The TNRCC is reportedly considering changing policy such that compliance with permits will be based on the monthly average flow for the preceding twelve month period compared to permitted flow, which, in effect, means that the permitted flow would be the anticipated average flow. Peak month flows can be significantly greater than average month flows, so the TNRCC policy regarding compliance monitoring can markedly effect the permitted capacity appropriate or needed at a facility.

Projected wastewater flows were presented in Section 2.3. Summary data is listed below in Table 5-2 for ease of comparison with permitted flows.

Table 5-2
Projected Average Monthly Flows

Flow Area	*Projected Average Monthly Flow (mgd)*					
	2000	**2010**	**2020**	**2030**	**2040**	**2050**
City of Kerrville plus extensions	2.54	3.13	3.97	4.60	5.17	5.77
Kerr County	3.87	4.45	5.03	5.85	6.63	8.30

The projected year 2000 wastewater flow from Kerr County exceeds the currently permitted wastewater treatment capacity of the county. The projected wastewater flow from the City of Kerrville plus areas to which service is to be extended is expected to exceed the currently permitted flow sometime after year 2010. Thus, additional wastewater treatment facilities will need to be permitted and constructed if projected growth is to be served by a centralized wastewater system or systems

5.2.1 On-Site Systems

On-site wastewater systems currently serve essentially all of Kerr County that is not served by the City of Kerrville. On-site systems include septic tanks and assorted leaching fields plus other types of systems that are designed to remove solids from the wastewater stream and then disperse the liquid primarily by evapotranspiration.

Soils in Kerr County are not generally compatible with on-site systems that rely on evapotranspiration. Table 5-3 summarizes information from the United States Soil Conservation Service (SCS) Soil Survey regarding types and characteristics in Kerr County; and includes information regarding the expected performance of septic tanks and associated leaching fields constructed in the soil type.

Table 5-3 General Information Regarding Soil Types (Based on Information in Soil Conservation Service Soil Survey of Kerr County, Texas)		
Area	***Type Soils***	***Comments Regarding Septic Tanks***
Hunt	Uvalde Silty Clay (NUB)	Moderate, percolates slowly
	Orif-Boerne (OB)	Severe, flooding
	Kerrville (KeD)	Severe, depth to rock
	Uvalde (NUA)	Moderate, percolates, slowly
	Eckrant-Rock (ERG)	Severe, depth to rock
Ingram	Oakalla (Oa)	Severe, flooding
	Oakalla (Ob)	Severe, flooding
	Orif-Boerne (OB)	Severe, flooding
	Uvalde (NUA)	Moderate, percolates slowly
	Uvalde (NUB)	Moderate, percolates slowly
	Kerrville (KNG)	Severe, depth to rock
	Doss (DSC)	Severe, depth to rock slow percolation
South of Kerrville	Kerrville (KNG)	Severe, depth to rock
	Doss (DSD)	Severe, depth to rock, percolates slowly
	Oakalla (Oa)	Severe, flooding
	Urban land-Nuvaldo (UdB)	Moderate permeability requires careful design of septic fields and may fail in wet weather
	Urban land-Oakalla (UK)	Moderate permeability, septic systems should be oversited
	Kerrville (KeD)	Severe, depth to rock
North of Kerrville	Kerrville (KNG)	Severe, depth to rock
	Doss (DSC)	Severe, depth to rock
	Eckrant-Rock (ERG)	Severe, depth to rock
	Eckrant (ECC)	Severe, depth to rock
Airport Area	Orif-Boerne (OB)	Severe, flooding
	Oakalla (Oa)	Severe, flooding
	Uvalde (NUA)	Moderate, percolates slowly
	Uvalde (NUB)	Moderate, percolates slowly
	Boerne (Be)	Severe, flooding
	Doss (DSC)	Severe, depth to rock slow percolation
	Kerrville (KeD)	Severe, depth to rock
	Denton (DnB)	Severe, depth to rock slow percolation
	Purves (PTD)	Severe, depth to rock
Center Point	Barbarosa (BaA)	Severe, slow percolation
	Depalt (DpB)	Severe, slow percolation
	Uvalde (NUB)	Moderate, percolates slowly
	Uvalde (NUA)	Moderate, percolates slowly
	Boerne (Be)	Severe, flooding
	Orif-Boerne (OB)	Severe, flooding
	Oakalla (Oa)	Severe, flooding

Generally, the SCS Soil Survey information summarized in Table 5.3 indicates that Kerr County is not a good area for large scale use of septic tanks. At best, relatively large leach field areas would be required due to limited soil permeability or rock.

5.2.2 Land Disposal Systems

Use of treated effluent for irrigation of agricultural land, golf courses, and other areas such as roadway median is a fairly common practice. In Texas, the TNRCC has two sets of regulation under which such use can be approved; the two sets of regulations are described in Table 5-4.

Table 5-4
Summary Information Regarding TNRCC Regulations
Regarding Use of Treated Wastewater

TNRCC Regulations	Comments
Irrigation Water Chapter 210	1. Allows use of treated wastewater on a demand, or as needed basis 2. Because use is on an as-needed bases, the wastewater discharge permits permitted flow must be for the full expected flow. 3. The TNRCC has different sets of effluent requirements for different uses of the effluent. 4. TNRCC approval is by means of a notification procedure, which tends to be fairly routine for most projects. 5. Storage facilities are not required other than for operational requirements, and implementation costs usually only involve the cost of conveyance facilities.
Land Disposal (irrigation) Chapter 317	1. Amount of effluent going to land disposal is identified in permit, and the permitted discharge flow may be the total flow minus the amount of effluent going to land disposal. 2. TNRCC approval for new systems involves a major amendment of the wastewater discharge permit, which can be a lengthy and expensive procedure. 3. Effluent storage is required to insure that effluent permitted for land disposal is not discharged during periods when land application is not possible. Storage facilities can be expensive.

Suitability of land in Kerr County for land disposal operation is impacted by many of the same factors that impact suitability of the county for septic tank systems. Topography also impacts the suitability of land for land disposal, as grades above about ten percent are generally not suitable for land disposal.

Based on the topography and soil conditions in Kerr County, extensive development of land disposal operations in the area of anticipated development does not appear feasible.

Even though soil conditions and topography in Kerr County make it unlikely that all projected effluent flow can be used for irrigation, an ongoing effort should be made to reuse effluent under either chapter 210 or chapter 317 provision where such reuse is economically feasible. Reuse of effluent would reduce the amount of water needed for water supply purposes in the county, which needs to be considered at anytime that reuse is considered. Reused effluent would not be free water, as the Guadalupe-Blanco River Authority (GBRA) has the authority to collect a fee for effluent that is reused rather than discharged, but the fee is relatively small.

5.3 Need for and Feasibility of a Regional Wastewater System

The poor quality soils and topography in Kerr County indicate the need for collection and treatment rather than using on-site septic systems or land disposal systems to protect the quality of down gradient surface and ground water resources. A regional wastewater collection and treatment system would provide greater reliability and, therefore, water resource protection than individual package wastewater treatment plants. In addition, regional systems provide the opportunity for economics of scale associated with treatment plant construction.

Two basic options have been identified for a regional wastewater system. Numerous options are possible, but the two listed in Table 5-5 appear most feasible and include: 1) centralization of all wastewater treatment at the City of Kerrville wastewater treatment plant; or, 2) treat wastewater generated in Kerrville and west of Kerrville at the City of Kerrville wastewater treatment plant and treat wastewater generated in areas east of Kerrville at a new plant in the Center Point area. Figures 5-1 and 5-2 illustrate the Regional Options 1 and 2 with the wastewater flows projected. Option 2 is recommended because wastewater generated east of Kerrville can generally flow by gravity to a new plant in the Center Point area.

Table 5-5
Information Regarding Select Regional Wastewater Options
Kerr County

OPTION 1

Centralize all wastewater treatment at City of Kerrville Wastewater Treatment Plant.

Wastewater treatment plant would serve as a distribution point for Chapter 210 Use of Reclaimed Water or Chapter 309 Land Disposal of Treated Effluent.

Effluent Standards would be expected to become more stringent as flows increase in future, and discharge point might change.

Maximum plant capacity would be about 8.3 mgd.

OPTION 2

Treat wastewater from Kerrville and points west at City of Kerrville Wastewater Treatment Plant. Maximum plant capacity about 7.03 mgd.

Treat flows from areas east of Kerrville at new plant in Center Point area. Maximum plant capacity about 1.27 mgd.

Chapter 210 Reclaimed Water and Chapter 309 Land Disposal Water would be distributed from both plants.

Future discharge effluent standards would be expected to be more stringent than current standards.

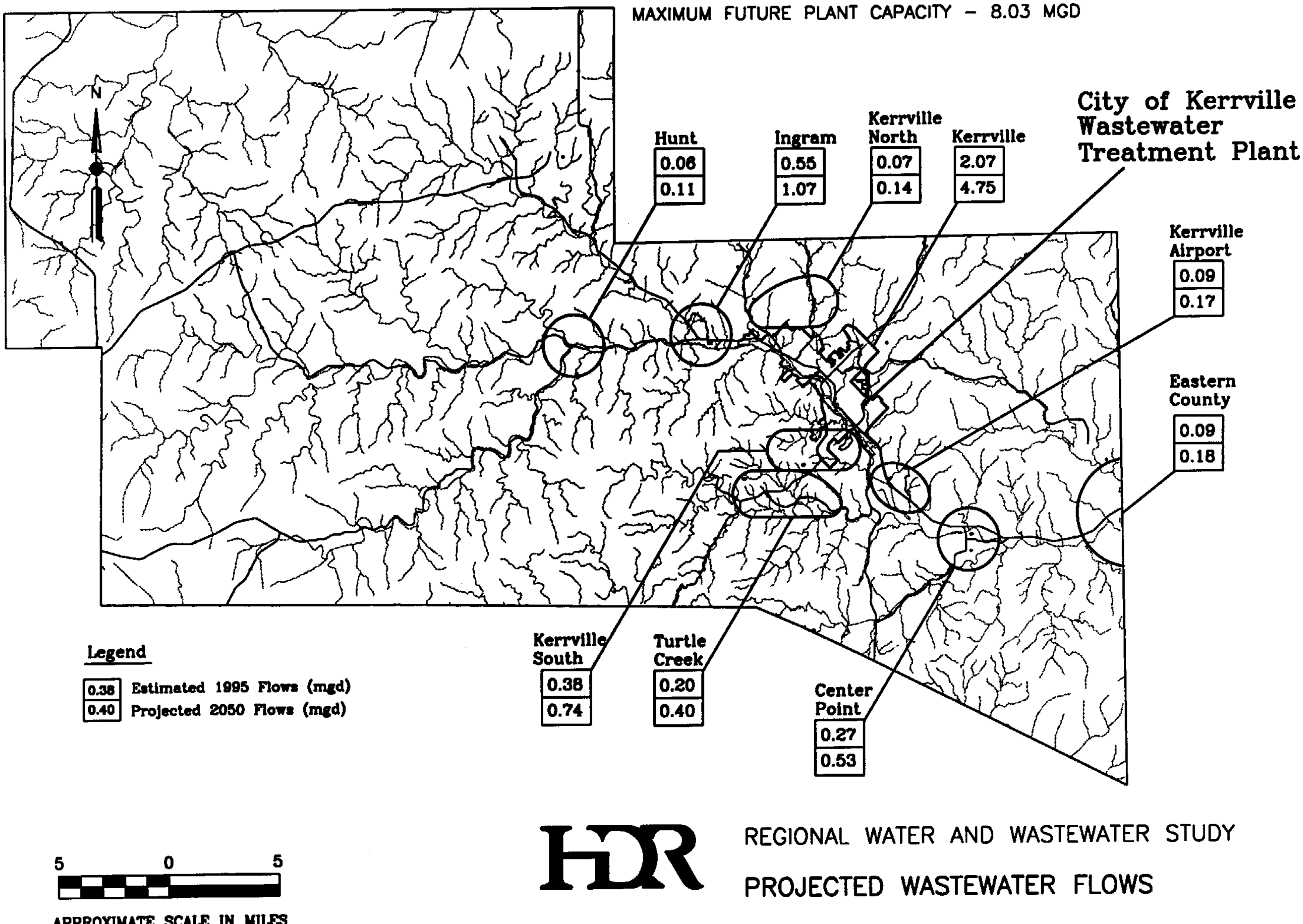
The information in Table 5-5 indicates the maximum treatment capacity that would be needed to treat projected year 2050 flows. There will always be some on-site systems in Kerr County because it will not be feasible to provide collection and treatment systems in some areas due to development density; thus required treatment capacity will be somewhat less than total wastewater flow from the county.

Reuse of effluent, such as at golf courses, will increase in the future. Most such reuse will likely require good quality effluent and thus will not likely reduce required treatment capacity.

Implementation of a regional system will require construction of collection and conveyance systems to convey wastewater from the point of generation to treatment points. Costs of collection and conveyance systems will be substantial.

REGIONAL OPTION 1

TREAT WASTEWATER AT CITY OF KERRVILLE PLANT
MAXIMUM FUTURE PLANT CAPACITY – 8.03 MGD



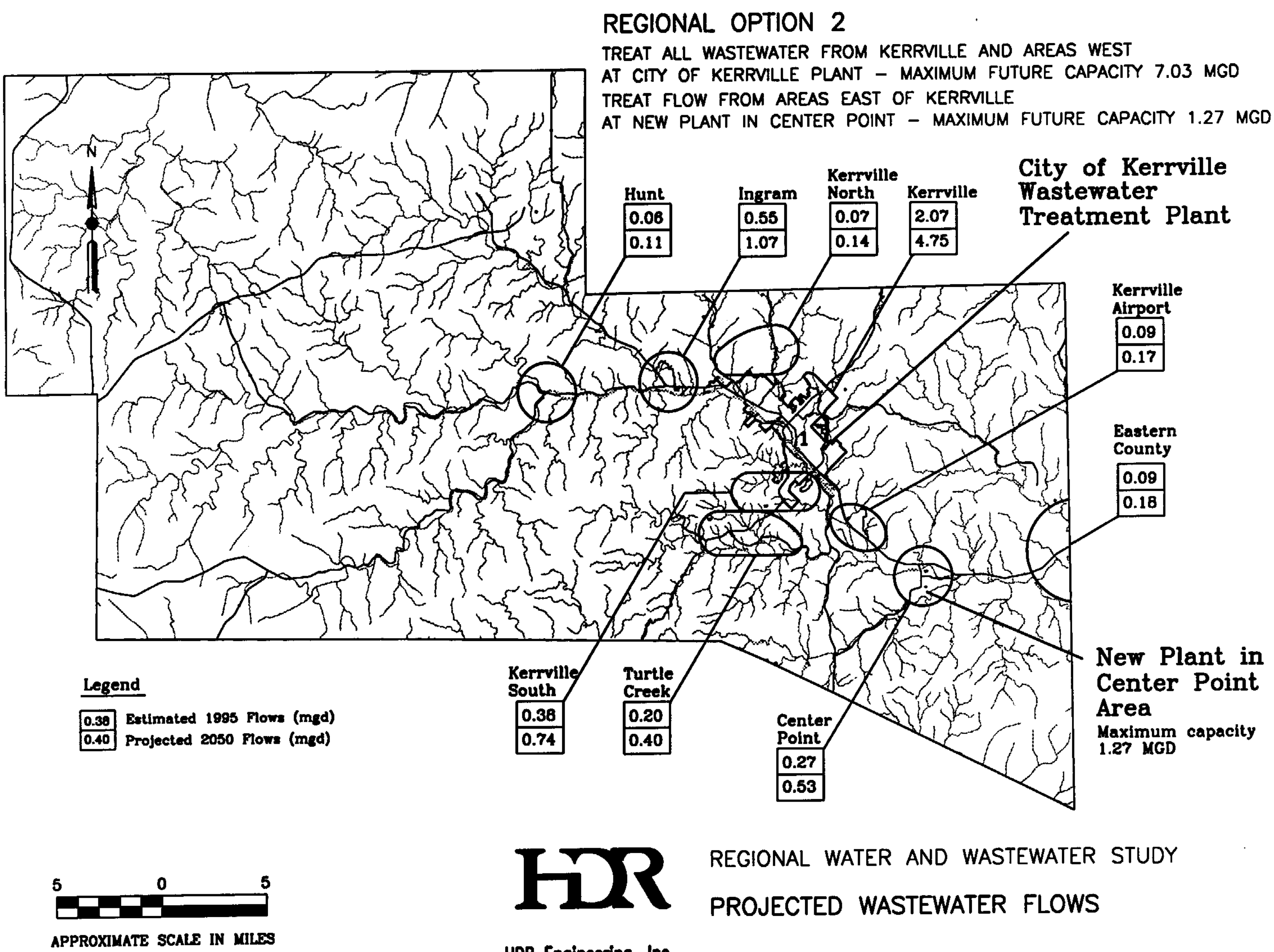
HDR

HDR Engineering, Inc.

REGIONAL WATER AND WASTEWATER STUDY

PROJECTED WASTEWATER FLOWS

FIGURE 5–1



HDR Engineering, Inc.

REGIONAL WATER AND WASTEWATER STUDY

PROJECTED WASTEWATER FLOWS

FIGURE 5-2

6.0 IMPLEMENTATION OF A REGIONAL WATER AND WASTEWATER SYSTEM

At the present time, approximately 48 percent of the Kerr County population resides in the City of Kerrville, which is supplied surface water from the Guadalupe River and ground water from the City's wells through its centralized water distribution system. The City also has a centralized sewage collection, treatment and disposal system, which serves its citizenry. However, most of the remainder of the county, with the exception of farm and ranch homes, is supplied water for household purposes by public water supply utilities which serve one or more housing subdivisions from ground water sources via wells located within or near each respective subdivision. There are approximately 75 water supply utilities within Kerr County, with a large proportion located within a few miles of Kerrville (Figure 2-1). However, none of the subdivisions have centralized wastewater collection and disposal facilities.

Given that: (1) the aquifers upon which a large and rapidly growing part of Kerr County's population depends upon for water supply are severely limited (see Section 4.2); and, (2) the soils and physical terrain of Kerr County are limited with respect to on-site waste disposal capabilities; i.e., soils are shallow, with low permeabilities, and the surface features of lands available are steep and rocky, it is desirable from the cost standpoint and may be necessary from the water quality protection standpoint, to develop regional water distribution and wastewater collection systems to serve a part or all of the growing needs of the urbanizing or growth centers of the county (see Section 4 and 5 for potential regional systems). The purposes of the following discussion are to: (1) identify possible entities that could provide regional water and wastewater service; (2) summarize the authorities and powers of the City of Kerrville, Upper Guadalupe River Authority, and Kerrville Public Service Board to provide water and wastewater services within Kerr County; and (3) identify and briefly describe financing options for regional water and wastewater systems.

6.1 Possible Entities That Could Provide Regional Water and Wastewater Services in Kerr County

There are 6 types of entities that would have powers to construct, own, and operate either or both regional water supply and wastewater systems in Kerr County. These are as follows: (1)

Conservation and Reclamation Districts; (2) River Authorities; (3) Water Control and Improvement Districts; (4) Municipal Utility Districts; (5) Fresh Water Supply Districts; and, (6) Underground Water Conservation Districts. The powers and financing methods of each type of entity are presented below.

Conservation and Reclamation Districts: Conservation and Reclamation Districts created under Article 16, Section 59 of the Texas Constitution have the powers to serve as regional water supply and wastewater systems. Such districts can be created either under provisions of the Texas Water Code or by special act of the legislature. Financing of operations can be either by revenues, taxes, or a combination of revenues and taxes, but all taxing authority must be approved by the voters of the district.

River Authorities: River authorities, such as the Upper Guadalupe River Authority, are conservation and reclamation districts, under Article 16, Section 59 of the Texas Constitution, and therefore can serve as regional water supply and wastewater systems if their respective authorizing legislation so specifies. River authorities do not have taxing authority, unless provided for in their respective acts, and approved by the voters within their boundaries.

Water Control and Improvement Districts: Water control and improvements districts (WCID) authorized under Chapter 51 of the Texas Water Code may be created by the county Commissioners Court if the district is located wholly within the county, or by TNRCC if more than one county is involved. WCID's have power to supply water but not wastewater services. Such districts are created by the Commissioners Court or TNRCC upon a petition signed by landowners within the district. If authorized, voters of the district are required to confirm the creation at an election for that purpose. The district is governed by a 5-member Board of Directors elected by voters of the district. Taxes may be levied only if approved by the voters.

Municipal Utility Districts: Municipal utility districts (MUD) authorized by Chapter 54 of the Texas Water Code may be created by the TNRCC upon petition by landowners within the district. However, no land within the corporate limits of a city or the extraterritorial jurisdiction (ETJ) of a city may be included in such a district without written consent by the city. If created, voters in the district must confirm the creation at an election held for that purpose. Likewise, taxing authority must be approved by the voters of the district. MUDs have both water and wastewater powers, and like WCIDs, are governed by a board of 5 directors elected by voters of the district.

Fresh Water Supply Districts: Fresh water supply districts created under Chapter 53 of the Texas Water Code, can function as a regional water supplier, but do not have powers to provide wastewater services. Each of these districts can be created by the Commissioners Court or TNRCC upon petition by landowners within the district and confirmed at an election held for that purpose.

Underground Water Conservation Districts: Underground water conservation districts authorized by Chapter 36 of the Texas Water Code can be created by TNRCC upon petition by landowners of the area, and confirmed by election of the voters of the district. Such districts would be empowered to implement water but not wastewater services, and if authorized by the voters, could have taxing authority.

Other Approaches: In addition to creating districts under general laws of the Texas Water Code, districts can be created by special act of the legislature. In this way, a district can be tailored to address the particular needs of an area, including powers, financing, and authority. The Legislature usually requires a confirmation election, and elections to approve any bonds to be issued by such a district are required by the Texas Constitution.

The Interlocal Cooperation Act (Article 4413, (32C)), Vernon's Texas Civil Statutes, is a method whereby existing governmental entities can jointly own and operate water and wastewater projects. Financing of jointly owned projects is usually borne separately by each participating entity for its prorata share of project costs.

Article 1110F, Vernon's Texas Civil Statutes, allows existing political entities to create a public utility agency to construct, own, and operate water and wastewater facilities. However, the public utility agency is a separate governmental entity governed by a board of directors appointed by the member political entities. Such agencies can only finance projects through service revenues, since they do not have taxing authority.

6.2 Authorities of Kerrville, Upper Guadalupe River Authority, and Kerrville Public Utility Board to Provide Water and Wastewater Services in Kerr County

City of Kerrville: The City of Kerrville is a "Home Rule City" chartered on February 25, 1942. The City owns and operates its water and wastewater systems through its Department of Public Services, and through interlocal agreements can provide such services on a wholesale basis to neighboring units of government. Through contracts with other public water utilities, the City can also provide water and wastewater services on a wholesale basis. Through contracts with public water suppliers, the City could become a regional supplier of water and wastewater services within its immediate vicinity. However, adoption of such policies obviously depends upon approval by the Kerrville voters.

Upper Guadalupe River Authority: The Upper Guadalupe River Authority (UGRA) is a conservation and reclamation district formed by the Texas Legislature, pursuant to the provisions of Article 16, Section 59 of the Constitution of Texas.[1] The District comprises all of the territory within and has the same boundaries as Kerr County, Texas. Section 16 of Article 8280-124 grants the UGRA the necessary powers to develop and sell water suppliers for beneficial use within the boundaries of the District and, as a necessary aid for beneficial use, the District was also given the power to construct, own, and operate sewage collection, transmission, and disposal services, including authority to enter into contracts with municipalities and others for such purposes. The District also has the authority to issue both revenue and general obligation bonds, if the latter are approved by the voters. Thus, UGRA has the necessary powers and authorities to be a regional water supply and wastewater service provider for all or parts of Kerr County.

Kerrville Public Utility Board: The Kerrville Public Utility Board (KPUB) was created by the City of Kerrville by Kerrville Ordinance No. 87-45 to assume management and control of the Kerrville electric system. The KPUB Board, or a similar board, could be authorized by the City, to manage and operate its water and wastewater systems. However, insofar as the matter of regional water and wastewater services are concerned, a city-created board could only perform those services for which the City has authority, including area to be served.

[1] Article 8280-124, Vernon's Revised Civil Statutes, as amended.

6.3 Financing Options For Regional Water and Wastewater Systems

There are five major sources of financing for public water supply and water quality protection projects, including: (1) Bond Market; (2) Texas Water Development Fund; (3) State Participation Fund; (4) Community Development Block Grants; and (5) Rural Development Grants and Loans. Each source is discussed below.

6.3.1 Bond Market

Public agencies borrow funds in the financial markets through the issuance of bonds, then use the proceeds to construct public water supply and wastewater projects such as water supply reservoirs, water wells, pipelines, water treatment plants, sewage treatment plants, pump stations, storage tanks, and associated capital equipment. The bond holders are repaid with interest, using revenues and/or fees collected from those who receive water and sewer services, from taxes levied on property in the service area, or from a combination of revenues, fees, and taxes. In cases where public entities issue bonds to supply water and/or wastewater services to the public, the bonds are classified under federal laws as "tax exempt." On tax exempt bonds, the interest paid to the bond holders is not considered as ordinary income; therefore, the bond holder does not have to pay income tax on the earnings from these investments. As a result, individuals and other investors are willing to lend their capital to governmental entities at lower interest rates than would be the case if the interest on those loans (bonds) were taxed by the federal government.

6.3.2 Texas Water Development Fund

The Texas Water Development Board (TWDB) has authority granted by Texas Constitutional Amendments and State Statutes to issue State of Texas General Obligation Bonds to provide loans to political subdivisions and special purpose districts for the construction of water supply, sewer, and flood control projects (Water Supply, Water Quality Enhancement, and Flood Control Accounts). The TWDB uses the proceeds of its bond sales to purchase the bonds (either general obligation or revenue) of cities and local water districts and authorities, which in turn use the borrowed funds to pay for construction of local projects. The local district or city repays the TWDB, with interest equal to the rate that the TWDB must pay on its bonds plus 0.5

percent, which the TWDB uses to retire the bonds it issued. The 0.5 percent assists the state in paying the cost of administering the loan program. This State of Texas water resources loan program enables some cities and local districts, especially smaller entities that do not have a credit rating to utilize the credit of the state in financing projects and thereby obtain financing at lower interest rates than if they were to sell their bonds on the open bond market. However, the interest rate on TWDB bonds is specific to each TWDB bond sale and therefore varies as market conditions change.

To be eligible to borrow from the Texas Water Development Fund, the applicants must have one or all of the following authorities and/or conditions, as appropriate: (1) authority to supply water; (2) a source of water; (3) authority to provide wastewater services; and, (4) a water conservation plan, unless the applicant is exempted from this requirement. The conditions for exemption from a conservation plan are: (1) in cases of emergency; (2) for applications of $500,000 of less; or, (3) if the applicant demonstrates and the TWDB finds that a conservation plan is not necessary to facilitate conservation. However, if the application is filed as an emergency case and is for a loan in excess of $500,000, a conservation plan must be developed and implemented within six months of the date of the TWDB's approval of the loan.

In the case of individual cities and individual special purpose districts and authorities, the applicants must be classified as "hardship cases." In order to be classified as a "hardship case," the TWDB must determine that the applicant cannot secure financing in the open market or elsewhere at a reasonable rate of interest. Smaller districts or smaller cities that do not have a credit history and a credit rating usually meet the "hardship" criteria. However, the applicant must present evidence that it can repay the loan for which it is applying.

If the project for which the loan is needed is regional (i.e., serves more than one entity or serves and area involving more than one county, city, special district, or other political subdivision), then the hardship requirements does not apply. In other words, water supply loans can be obtained for regional water supply projects even though the members are not classified as hardship cases. Thus, it appears that surface water and water quality protection projects in the Kerr County area would be eligible for loans from the TWDB for financing up to 100 percent of the costs of such projects.

6.3.3 State Participation Fund

The concept of State Participation, as it applies to water supply and water quality protection projects, is as follows. A local area needs an additional water source, transmission pipelines, storage reservoir, and treatment plant, or has wastewater collection and treatment plant needs. The area's existing customer base can only support monthly rates required to repay loans for a project sized to meet present needs. However, if a project is built to only meet present needs, it may soon be inadequate. Thus, through the State Participation Fund, the local entity could plan a larger project, with phased construction of the separate elements to the extent possible, and apply to the TWDB for state participation in the project. Under this arrangement, the TWDB would become a "silent partner" in the project by entering into an agreement with the local entity to pay up to half of the project costs initially. The TWDB would hold the remaining project share until a future date, at which time the local entity would be required to buy the TWDB's share.

The terms and conditions of such an agreement are negotiated for each case. Typically, the local entities are required to pay simple interest on the TWDB's share of the project cost from the beginning and to begin buying the TWDB's share, including accumulated interest, at a specified future date, usually within 8 to 12 years of project completion. By lending the state's credit to local areas, an optimal development plan for growing areas can be implemented at lower costs. However, the local beneficiaries of the program will be required to repay the TWDB, including interest and financing costs incurred. It is emphasized, however, the state participation fund is appropriate and reasonable only for additional project capacities that will be needed within the foreseeable future.

6.3.4 State Revolving Fund (SRF)

The State Revolving Fund was established in 1987 to provide a financing source for wastewater treatment and non-point source pollution control projects. The SRF provides below market interest loans to eligible political subdivisions for construction, improvement, or expansion of sewage collection and treatment facilities. The SRF is funded through a combination of federal clean water grants and state water quality enhancement bond funds. In order to be eligible for SRF financing, an applicant must be a political entity with the authority to own and operate a sewage system. In Kerr County, the Cities of Kerrville and Ingram and the Upper Guadalupe River Authority have these powers.

6.3.5 Drinking Water State Revolving Fund (DWSRF)

The Drinking Water State Revolving Fund (DWSRF) program was authorized as part of the 1996 Safe Drinking Water Act (SDWA) Amendments by the U.S. Congress. The program establishes a state revolving fund, which in Texas is being administered by the Texas Water Development Board (TWDB) and is scheduled to begin receiving applications in the fall of 1997. Under this program, political subdivisions and nonprofit water supply corporations may apply for low interest DWSRF loans to finance water supply projects that are required in order to comply with the federal Safe Drinking Water Act regulations. The source of financing the DWSRF is federal grants and state bonds. The TWDB plans to assess cost recovery charges to DWSRF loan recipients, in the same manner as is done for the TWDB's wastewater SRF (Section 6.3.4).

DWSRF loans can be used for planning, design, and construction of projects to upgrade or replace water supply infrastructure, to correct exceedances of SDWA health standards, to consolidate water supplies, and to purchase capacity in water systems.

Potential loan applicants will be required to submit a brief DWSRF Information Form to the Texas Water Development Board (Board) each year for inclusion in an Intended Use Plan (IUP) developed for that year. The Information Form will describe the applicant's existing water facilities, additional facility needs, and the nature of projects being considered for meeting those needs, and project cost estimates. Eligible projects will then be prioritized according to need using information contained in Texas Natural Resource Conservation Commission files. Loan funds will be distributed based upon the priority rating and an applicant's readiness to proceed.

6.3.6 Community Development Block Grants

The Community Development Block Grant (CDBG) program was created by Congress in 1974. It is administered at the federal level through the U.S. Department of Housing and Urban Development (HUD). The program is divided into two major categories: (1) entitlement (cities over 50,000 and qualifying counties over 200,000 in population); and, (2) non-entitlement (cities under 50,000 in population and counties not eligible for entitlement status). In the State of

Texas, there are 47 entitlement cities, 5 entitlement counties, and approximately 1,313 non-entitlement cities and counties. Entitlement cities receive an annual allocation of funds directly from HUD for eligible activities, whereas non-entitlement localities generally have to compete on a statewide basis for funding.

In 1981, Congress transferred the responsibilities of administering several federal block grant programs to the states. This law authorized the states to administer the non-entitlement portion of the CDBG program. The State of Texas assumed administration of this program in federal fiscal year 1983. It is administered by the Texas Department of Housing and Community Affairs. The Texas Development Program provides grants and loans on a competitive basis to non-entitlement cities in Texas. Thus, an application for such funding would need to be made by participating entities for a relevant part of the regional water supply or water quality protection plan. Among the threshold requirements of applicants, there must be a particular problem that poses a serious and immediate threat to the health and safety of the public and the applicant must have the ability to levy a local property tax and/or local sales tax.

The Community Development Fund is the major funding category (about two-thirds of the total funding) under the Texas Community Development Program, and is the only category through which water supply and wastewater projects could be eligible. Typical types of public works projects funded include water and sewer improvements, street and drainage improvements, community and senior centers, and handicapped accessibility projects. An annual competition, divided into regional allocations for eligible cities and counties in each of the state's 24 planning regions, is held. An application for the 1998 program would need to be filed with the Alamo Area Council of Governments (AACOG). The notice for application and schedule for filing will be announced in September or October of 1997 for the 1998 competition. The applications are reviewed by Texas Department of Housing and Community Affairs staff, and the AACOG regional advisory committee. The committee, which is comprised of 12 locally elected officials appointed by the Governor for two-year terms of office, would meet publicly to review and score applications in accordance with previously established scoring criteria. Award recommendations are made to the Department of Housing and Community Development's Executive Director on the basis of scores of the regional review committee. The Executive Director makes final funding decisions on the basis of these recommendations.

6.3.7 Rural Development (RD) Grants and Loans

The Rural Development Administration (formerly known as the Farmer's Home Administration) of the U.S. Department of Agriculture is authorized to provide financial assistance in the forms of loans and grants for water supply development in rural areas and towns with populations of 10,000 or less. Public entities, including cities, special purpose districts, and nonprofit corporations, are eligible for such assistance to restore a deteriorating water supply or to enlarge an inadequate system. Preference is given to entities in areas smaller than 5,500 people, to areas wanting to merge small facilities, and to serve low-income communities. To qualify for RD financing, applicants must: (1) be unable to obtain funds elsewhere at reasonable rates and terms; (2) have legal authority to borrow and repay loans and operate water facilities; and, (3) have a financially sound project based on revenues, fees, taxes, or other sources of income. Water systems must be consistent with state water development plans and comply with all local, state, and federal laws.

Funds from RD for water systems may be used for construction or modification of facilities such as reservoirs, pipelines, wells, and pump stations; acquisition of water rights or water supplies; legal and engineering fees required for the project; rights-of-way and easements; and relocations of roads and utilities. RD funds may be used in conjunction with funds from other sources, such as loans from the Texas Water Development Fund or bonds sold on the open market.

The maximum length or term for RD loans is 40 years, the statutory limitations of the organization borrowing funds, or the useful life of the project, whichever is less. Interest rates are set periodically, in accordance with the law, and as of June 1997, rates ranged between 4.5% and 6.0% percent.

Grants may be made for up to 75 percent of eligible project costs for facilities serving low income areas. RD staff will advise applicants as to how to assemble information and file both grant and loan applications. Such applications are filed with the local RD district office, which for the study area is located in Fredericksburg, Texas. Pre-applications to the district office are reviewed by the local area Council of Governments (AACOG) and, upon favorable review, a formal application together with an environmental assessment is filed through the local district office to the state office in Temple, Texas. Pre-application conferences with RECD staff are recommended to obtain specific details about making application for funds.

RD grants and loan programs may be viable financing option for some of the participants for water supply facilities. This source of funding could perhaps be combined with Texas Water Development Board loans to secure a surface water supply for the study area.

APPENDIX A

KERR COUNTY WATER PROVIDERS

Appendix Table 1
Water Suppliers of Kerr County
Number of Connections--- 1990-1995

	Name of Water Supplier	1990	1991	1992	1993	1994	1995	Region
		Number of Connections						
		no.	no.	no.	no.	no.	no.	
	Kerrville Area							
1	City of Kerrville	7,047	6,789	7,616	7,368	7,386	7,410	1
11	Cherokee Mobile Home Park	30	60	30	30	30	30	1
30	Hill Country Utilities/Horseshoe Oaks System	28	28	28	28	30	32	1
43	Oak Grove Trailer Park	82	82	82	82	82	86	1
60	Veterans Adm. Hospital	0	0	0	0	0	0	1
74	Village West Water System	0	0	10	13	15	19	1
75	Hill Country Utilities/Midway Ind Park	0	0	0	8	31	31	1
	Subtotal	7,187	6,959	7,766	7,529	7,574	7,608	1
	Ingram Area							
2	City of Ingram/See No. 34							2
5	Blue Ridge Mobile Home Park	25	25	25	20	36	30	2
7	Cedar Springs Mobile Home Village	48	48	48	48	49	49	2
16	Hideaway Mobile Home Park	45	47	47	45	45	45	2
29	Hills-N-Dales Subdivision/Widenfeld	45	47	47	58	59	60	2
32	Ingram High/Elementary-C.H.							2
33	Ingram Oaks Retirement Community	75	85	120	111	164	164	2
34	Ingram Water Supply Company/HillCountryUti	1,047	1,065	1,085	1,089	1,145	1,145	2
40	Hill Country Utilities/White Oak Subdivision	18	18	18	21	21	24	2
41	Midway Mobile Park Water Supply	22	22	22	22	25	25	2
49	Riverfront Village	85	85	88	88	88	88	2
66	Woodhaven MHP	37	29	29	31	31	31	2
68	YMCA Camp Flaming Arrow					13	13	2
	Subtotal	1,447	1,471	1,529	1,533	1,676	1,674	2
	Kerrville North Area							
21	Hill Country Utilities/Cardinal Acres	17	17	17	17	21	21	3
22	Hill Country Utilities/Sleepy Hollow	84	84	54	54	93	54	3
28	Hill Country Utilities/Westwood Oaks MHP	61	61	68	68	79	91	3
36	Kamira Subdivision	6	5	6	7	10	12	3
39	Woodtrail Water Supply	36	40	40	31	40	40	3
	Subtotal	204	207	185	177	243	218	3

	Name of Water Supplier	Number of Connections 1990 no.	1991 no.	1992 no.	1993 no.	1994 no.	1995 no.	Region
	Kerrville South Area							
4	Hill Country Utilities/Bear Paw Ranch	29	32	32	38	38	45	4
18	Hill Country Utilities/Real Oaks Subdivision	10	10	10	10	15	14	4
19	Hill Country Utilities/Four Seasons System	16	16	21	21	24	25	4
23	Hill Country Utilities/Woodcreek Water Supply	94	94	120	120	120	126	4
26	Hill Country Utilities/Nickerson Farms System	29	29	29	29	33	35	4
38	Kerrville South Water Company 2/3	563	567	587	611	614	649	4
42	Montebello Estates Water Company	25	33	35	32	32	32	4
50	Royal Oaks Water System	38	38	38	37	37	37	4
54	Silver Creek Water Supply	63	63	63	85	63	58	4
58	Texas Parks & Wildlife Dept.	100	100	100	100	125	125	4
73	Verde Park Estates Water System		25	25	42	35	27	4
	Subtotal	967	1,007	1,060	1,125	1,136	1,173	4
	Turtle Creek Area							
13	Hill Country Utilities/Kerrville South System	170	170	170	170	177	176	5
38	Kerrville South Water Company 1/3	291	293	303	316	316	334	5
55	Southern Hills Water System/Wiedenfeld	15	15	15	22	22	22	5
67	The Woods Water Supply Corp.	84	68	70	70	68	88	5
	Subtotal	560	546	558	578	583	620	5
	Kerrville Airport Area							
14	Guadalupe Heights Utility Company	250	250	215	215	220	220	6
56	Split Rock Water Supply	23	23	23	23	23	22	6
	Subtotal	273	273	238	238	243	242	6
	Center Point Area							
3	Aqua Vista Utilities Company	82	82	89	90	90	92	7
8	Center Point ISD							7
9	Hill Country Utilities/Center Point North	68	68	72	72	72	75	7
10	Center Point Water Works	179	179	170	175	189	190	7
15	Center Point/Wiedenfeld System	48	40	84	52	48	70	7
24	Hill Country Utilities/Northwest Hills	31	31	33	33	34	48	7
27	Hill Country Utilities/Pecan Valley System	20	20	24	24	26	26	7
37	Kerr Villa MHP	30	83	83	72	72	72	7
44	Oak Ridge Estates Water System	29	29	31	29	29	30	7
46	Park Place Subdivision	15	16	16	16	20	23	7
52	Scenic Loop Estates Water Co.	60	60	60	60	60	60	7
59	Verde Hills Water Supply Corp.	20	21	22	22	21	20	7
63	Wilderness Park	120	103	104	109	100	99	7
	Subtotal	702	732	788	754	761	805	7

Appendix Table 2

Water Suppliers of Kerr County

Reported Water Use---1990-1995

	Water Supplier	1990 ac-ft	1991 ac-ft	1992 ac-ft	1993 ac-ft	1994 ac-ft	1995 ac-ft	Region
		Reported Water Use						
	Kerrville Area							
1	City of Kerrville	3,553.2	3,376.5	3,447.0	3,789.2	3,829.9	4,053.1	1
11	Cherokee Mobile Home Park	1.1	1.1	1.1	1.1	3.7	3.7	1
30	Hill Country Utilities/Horseshoe Oaks System	6.1	6.1	6.1	6.1	6.5	12.0	1
43	Oak Grove Trailer Park	23.3	11.5	14.3	12.7	16.0	15.0	1
60	Veterans Adm. Hospital	24.7	24.0	161.3	159.1	185.0	175.9	1
74	Village West Water System			8.4	1.8	2.1	13.3	1
75	Hill Country Utilities/Midway Ind Park				2.2	8.7	10.1	1
	Subtotal	3,608.4	3,419.2	3,638.2	3,972.2	4,051.9	4,283.1	1
	Ingram Area							
2	City of Ingram/See No. 34							2
5	Blue Ridge Mobile Home Park	4.4	4.4	5.6	5.6	10.1	16.6	2
7	Cedar Springs Mobile Home Village	8.4	9.1	9.7	10.0	10.1	9.6	2
16	Hideaway Mobile Home Park	1.5	4.3	7.1	8.3	8.3	7.4	2
29	Hills-N-Dales Subdivision/Widenfeld	5.0	5.3	5.3	19.9	21.4	19.2	2
32	Ingram High/Elementary-C.H.	13.0	12.6	12.4	10.8	10.7	17.6	2
33	Ingram Oaks Retirement Community		4.1	5.5	5.6	56.8	72.1	2
34	Ingram Water Supply Company/HillCountryUti	406.2	409.7	421.6	484.1	454.3	454.3	2
40	Hill Country Utilities/White Oak Subdivision	3.5	3.5	3.5	4.1	4.1	10.4	2
41	Midway Mobile Park Water Supply	3.1	3.1	3.1	3.1	3.5	3.5	2
49	Riverfront Village	27.2	25.5	26.3	30.6	28.2	27.5	2
66	Woodhaven MHP	5.8	4.5	4.5	4.8	4.8	4.7	2
68	YMCA Camp Flaming Arrow	0.8	7.0	6.5	4.7	3.7	3.7	2
	Subtotal	478.9	493.1	511.1	591.6	616.0	646.6	2
	Kerrville North Area							
21	Hill Country Utilities/Cardinal Acres	2.3	2.3	2.3	2.3	2.8	5.9	3
22	Hill Country Utilities/Sleepy Hollow	30.3	30.3	19.5	19.5	33.5	41.9	3
28	Hill Country Utilities/Westwood Oaks MHP	11.2	11.2	12.5	12.5	14.5	24.9	3
36	Kamira Subdivision	3.5	3.1	3.7	5.5	2.1	2.5	3
39	Woodtrail Water Supply	8.9	7.5	8.3	8.3	10.8	10.8	3
	Subtotal	56.2	54.4	46.3	48.1	63.7	86.0	3

	Water Supplier	Reported Water Use 1990 ac-ft	1991 ac-ft	1992 ac-ft	1993 ac-ft	1994 ac-ft	1995 ac-ft	Region
	Kerrville South Area							
4	Hill Country Utilities/Bear Paw Ranch	9.6	10.5	10.5	12.5	12.5	14.6	4
18	Hill Country Utilities/Real Oaks Subdivision	1.3	1.3	1.3	1.3	2.0	8.2	4
19	Hill Country Utilities/Four Seasons System	2.1	2.1	2.7	2.7	3.1	17.0	4
23	Hill Country Utilities/Woodcreek Water Supply	16.8	16.8	21.5	21.5	21.5	45.8	4
26	Hill Country Utilities/Nickerson Farms System	6.6	6.6	6.6	6.6	7.5	14.9	4
38	Kerrville South Water Company 2/3	196.8	194.3	186.9	216.1	206.0	222.5	4
42	Montebello Estates Water Company	5.1	8.7	9.2	7.4	8.3	8.3	4
50	Royal Oaks Water System	17.3	14.0	13.9	13.9	15.9	15.6	4
54	Silver Creek Water Supply	17.6	17.6	17.6	25.7	25.2	22.7	4
58	Texas Parks & Wildlife Dept.	8.5	8.5	6.8	8.7	8.1	9.8	4
73	Verde Park Estates Water System		8.4	8.4	11.2	6.9	13.3	4
	Subtotal	281.7	288.8	285.4	327.6	317.0	392.7	4
	Turtle Creek Area							
13	Hill Country Utilities/Kerrville South System	40.5	40.4	40.4	40.4	42.0	68.9	5
38	Kerrville South Water Company 1/3	65.0	64.1	61.7	71.3	68.0	73.4	5
55	Southern Hills Water System/Wiedenfeld	4.3	4.3	4.3	4.4	4.4	11.7	5
67	The Woods Water Supply Corp.	16.7	19.6	20.2	36.8	37.5	55.4	5
	Subtotal	126.5	128.4	126.6	152.9	151.9	209.4	5
	Kerrville Airport Area							
14	Guadalupe Heights Utility Company	70.8	59.8	74.5	65.1	61.5	58.1	6
56	Split Rock Water Supply	7.7	7.7	7.0	17.8	6.4	8.6	6
	Subtotal	78.5	67.5	81.5	82.9	67.9	66.7	6
	Center Point Area							
3	Aqua Vista Utilities Company	22.1	20.4	21.2	24.3	22.8	24.1	7
8	Center Point ISD	4.7	4.7	4.7	4.7	4.7	4.7	7
9	Hill Country Utilities/Center Point North	15.3	15.3	16.2	16.2	16.2	44.5	7
10	Center Point Water Works	39.0	42.0	27.9	35.3	38.1	25.9	7
15	Center Point/Wiedenfeld System	10.4	9.2	18.5	17.0	22.0	22.0	7
24	Hill Country Utilities/Northwest Hills	9.2	9.2	9.8	9.8	10.1	19.1	7
27	Hill Country Utilities/Pecan Valley System	4.2	4.2	5.1	5.1	5.5	8.5	7
37	Kerr Villa MHP	3.4	8.7	3.0	3.0	2.9	2.9	7
44	Oak Ridge Estates Water System	6.1	6.7	6.9	7.4	7.0	6.4	7
46	Park Place Subdivision	2.8	3.6	3.2	4.2	5.0	5.1	7
52	Scenic Loop Estates Water Co.	15.8						7
59	Verde Hills Water Supply Corp.	8.8	8.4	7.7	8.5	8.6	8.0	7
63	Wilderness Park	5.0	16.6	14.6	19.5	16.2	20.2	7
	Subtotal	146.8	149.0	138.8	155.0	159.1	191.4	7

	Water Supplier	Reported Water Use						
		1990	1991	1992	1993	1994	1995	Region
		ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	
	Eastern County Area							
25	Hill Country Utilities/Oak Forest Subdivision	48.3	46.0	46.0	46.0	46.0	106.8	8
62	Westwood Park Water System	19.7	22.0	21.4	23.6	25.5	23.2	8
	Kendall WCID No. 1							
	Subtotal	68.0	68.0	67.4	69.6	71.5	130.0	8
	Hunt Area							
6	Canyon Springs Water System	31.3	21.8	23.1	13.9	24.4	34.4	9
31	Hunt Public School	0.3	0.4	0.4	0.4	2.7	2.2	9
35	Japonica Hills Owners Association	3.4	3.6	3.7	4.0	3.5	3.4	9
61	Vista Water Works	6.4	4.4	4.4	4.3	3.0	5.3	9
72	Hunt Community Group WSC		3.7	4.4	26.3	5.6	16.1	9
	Subtotal	41.4	33.9	36.0	48.9	39.2	61.4	9
	Remainder of County							
12	Del Valle Mobile Home Park	0.1	0.1	0.1	0.1	0.1	0.1	10
17	Hill Country Mobile Home Park	1.1	1.1	3.3	3.2	4.3	4.3	10
20	Hill Country Ranch Estates	6.5	5.8	5.8	5.8	5.5	5.6	10
45	Ox Hollow Water System	6.9	7.5	7.1	6.8	8.3	8.2	10
47	Rancho Oaks MHP	2.7	4.9	6.2	1.0	13.5	4.5	10
48	Rio Algera Homeowners Assn	2.0						10
51	Rustic Hills Water Company	4.6	2.4	2.4	3.4	0.8	3.6	10
53	Scenic Valley Park	18.6	17.5	20.1	23.7	22.2	22.8	10
57	Texas Highway Dept.	1.4	11.8	13.9	11.4	12.0	15.5	10
64	Windcrest MHP	4.4	3.7	6.1	6.0	6.0	6.0	10
65	Windwood Oaks Water System	9.7	4.4	3.9	3.5	5.7	5.8	10
69	Cherry Ridge Water Company		5.6	5.6	5.6	5.6	5.6	10
70	Elmwood MHP		5.3	6.8	8.0	9.7	9.7	10
71	Forest Oaks MHP		9.0	9.0	9.0	9.0	9.0	10
	Subtotal	58.0	79.1	90.3	87.5	102.7	100.7	10
	Total	4,944.4	4,781.4	5,021.5	5,536.4	5,640.8	6,168.0	

Source: Texas Water Development Board.

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Apendix Table 3

Water Suppliers of Kerr County

Water Use Per Connection Per Day---1990-1995

	Water Supplier	1990 gpdc	1991 gpdc	1992 gpdc	1993 gpdc	1994 gpdc	1995 gpdc	Region
		Gallons per day per Connection						
	Kerrville Area							
1	City of Kerrville	450.13	444.00	404.06	459.12	462.92	488.31	1
11	Cherokee Mobile Home Park	32.73	16.37	32.73	32.73	110.10	110.10	1
30	Hill Country Utilities/Horseshoe Oaks System	194.49	194.49	194.49	194.49	193.43	334.78	1
43	Oak Grove Trailer Park	253.67	125.20	155.69	138.27	174.19	155.71	1
60	Veterans Adm. Hospital							1
74	Village West Water System			749.90	123.61	124.98	624.92	1
75	Hill Country Utilities/Midway Ind Park				245.50	250.54	290.86	1
	Ingram Area							2
5	Blue Ridge Mobile Home Park	157.12	157.12	199.97	249.97	250.46	493.98	2
7	Cedar Springs Mobile Home Village	156.23	169.25	180.41	185.99	184.01	174.90	2
16	Hideaway Mobile Home Park	29.76	81.68	134.86	164.66	164.66	146.81	2
29	Hills-N-Dales Subdivision/Widenfeld	99.19	100.67	100.67	306.30	323.81	285.68	2
32	Ingram High/Elementary-C.H.							2
33	Ingram Oaks Retirement Community		43.06	40.92	45.04	309.19	392.48	2
34	Ingram Water Supply Company/HillCountryUti	346.35	343.43	346.89	396.86	354.21	0.00	2
40	Hill Country Utilities/White Oak Subdivision	173.59	173.59	173.59	174.30	174.30	386.86	2
41	Midway Mobile Park Water Supply	125.80	125.80	125.80	125.80	124.98		2
49	Riverfront Village	285.68	267.82	266.81	310.43	286.08	278.98	2
66	Woodhaven MHP	139.94	138.53	138.53	138.23	138.23		2
68	YMCA Camp Flaming Arrow							
	Kerrville North Area							
21	Hill Country Utilities/Cardinal Acres	120.78	120.78	120.78	120.78	119.03	250.82	3
22	Hill Country Utilities/Sleepy Hollow	322.02	322.02	322.38	322.38	321.58	692.70	3
28	Hill Country Utilities/Westwood Oaks MHP	163.91	163.91	164.11	164.11	163.86	244.28	3
36	Kamira Subdivision	520.77	553.50	550.52	701.44	187.48	185.99	3
39	Woodtrail Water Supply	220.71	167.39	185.24	239.02	241.04		3

	Water Supplier	1990 gpdc	1991 gpdc	1992 gpdc	1993 gpdc	1994 gpdc	1995 gpdc	Region
		Gallons per day per Connection						
	Kerrville South Area							
4	Hill Country Utilities/Bear Paw Ranch	295.53	292.93	292.93	293.67	293.67	289.65	4
18	Hill Country Utilities/Real Oaks Subdivision	116.06	116.06	116.06	116.06	119.03	522.89	4
19	Hill Country Utilities/Four Seasons System	117.17	117.17	114.78	114.78	115.31	607.06	4
23	Hill Country Utilities/Woodcreek Water Supply	159.55	159.55	159.95	159.95	159.95	324.50	4
26	Hill Country Utilities/Nickerson Farms System	203.18	203.18	203.18	203.18	202.90	380.05	4
38	Kerrville South Water Company 2/3	307.13	301.04	279.76	310.68	295.08	301.61	4
42	Montebello Estates Water Company	182.12	235.36	234.66	206.45	231.56		4
50	Royal Oaks Water System	406.43	328.91		335.38	383.64	376.40	4
54	Silver Creek Water Supply	249.40	249.40	249.40	269.92	357.10	349.40	4
58	Texas Parks & Wildlife Dept.	75.88	75.88	60.71	77.67	57.85		4
73	Verde Park Estates Water System		299.96	299.96	238.06	176.00	439.76	4
	Turtle Creek Area							
13	Hill Country Utilities/Kerrville South System	212.68	212.16	212.16	212.16	211.84	349.49	5
38	Kerrville South Water Company 1/3	307.13	301.04	279.76	310.68	295.08	301.61	5
55	Southern Hills Water System/Wiedenfeld	255.92	255.92	255.92	178.55	178.55	474.78	5
67	The Woods Water Supply Corp.	177.49	257.32	257.62	469.33	492.32	562.02	5
	Kerrville Airport Area							
14	Guadalupe Heights Utility Company	252.82	213.54	309.35	270.31	249.56	235.77	6
56	Split Rock Water Supply	298.87	298.87	271.70	690.91	248.42	348.98	6
	Center Point Area							
3	Aqua Vista Utilities Company	240.60	222.10	212.65	241.04	226.16	233.86	7
8	Center Point ISD							7
9	Hill Country Utilities/Center Point North	200.87	200.87	200.87	200.87	200.87	529.69	7
10	Center Point Water Works	194.51	209.47	146.51	180.08	179.97	0.00	7
15	Center Point/Wiedenfeld System	193.43	205.33	196.62	291.86	409.17	280.58	7
24	Hill Country Utilities/Northwest Hills	264.94	264.94	265.12	265.12	265.20	355.24	7
27	Hill Country Utilities/Pecan Valley System	187.48	187.48	189.71	189.71	188.85	291.86	7
37	Kerr Villa MHP	101.18	93.58	32.27	37.20	35.96	35.96	7
44	Oak Ridge Estates Water System	187.78	206.25	198.71	227.80	215.49	190.45	7
46	Park Place Subdivision	166.65	200.87	178.55	234.34	223.19	197.96	7
52	Scenic Loop Estates Water Co.	235.09						7
59	Verde Hills Water Supply Corp.	392.81	357.10	312.46	344.92	365.60	357.10	3
63	Wilderness Park	37.20	143.88	125.33	159.71	144.62	182.16	7

	Water Supplier	1990 gpdc	1991 gpdc	1992 gpdc	1993 gpdc	1994 gpdc	1995 gpdc	Region
		Gallons per day per Connection						
	Eastern County Area							
25	Hill Country Utilities/Oak Forest Subdivision	226.94	226.88	226.88	226.88	226.88	479.12	8
62	Westwood Park Water System	270.57	261.87	265.34	277.22	303.53	268.98	8
	Kendall WCID No. 1							
	Hunt Area							
6	Canyon Springs Water System	410.92	286.20	286.42	139.43	224.57	295.29	9
31	Hunt Public School							9
35	Japonica Hills Owners Association	379.42	401.73	412.89	446.37	390.57	275.94	9
61	Vista Water Works	114.27	115.53	115.53	109.68	76.52	107.53	9
72	Hunt Community Group WSC		113.90	135.45	757.39	161.27	463.65	9
	Remainder of County							
12	Del Valle Mobile Home Park	8.93						10
17	Hill Country Mobile Home Park	65.47	65.47	196.40	190.45	255.92		10
20	Hill Country Ranch Estates	362.68	272.52	272.52	272.52	272.78		10
45	Ox Hollow Water System	198.71	215.99	204.47	195.83	239.02	236.14	10
47	Rancho Oaks MHP	114.78	208.31	307.50	42.51	502.17	174.67	10
48	Rio Algera Homeowners Assn							10
51	Rustic Hills Water Company	117.33	119.03	119.03	86.72	28.57	110.82	10
53	Scenic Valley Park	251.59	240.35	252.73	293.86	271.49	278.83	10
57	Texas Highway Dept.							10
64	Windcrest MHP	163.67	165.16	272.29	267.82	267.82		10
65	Windwood Oaks Water System	865.96	357.10	290.14	284.05	339.24	323.62	10
69	Cherry Ridge Water Company		238.06	238.06	238.06	238.06		10
70	Elmwood MHP		236.58	303.53	357.10	432.98	432.98	10
71	Forest Oaks MHP		730.43	669.56	730.43	535.65		10
	Computed from data in Appendix Tables 1 and 2.							
*								

APPENDIX B

SURFACE WATER RIGHTS

SURFACE WATER RIGHTS
UPPER GUADALUPE RIVER TO CANYON LAKE
As of September, 1995

Basin	County	River Order	Permit	Alpha M	Name	Stream	Use	Amount in Ac-Ft/Yr	Amount Senior in Use Category afy	Max Div. Rate tenths CFS	Res Cap in Ac-Ft	Priority
	MUNICIPAL USE											
18	046	7542000000		2748205	GUADALUPE-BLANCO RIVER AUTH	GUADALUPE RIVER	1	35125	0		740900	19560319
18	046	7542000000		2748205	GUADLUPE-BLANCO RIVER AUTH	GUADALUPE RIVER	1	100	35125			19560319
18	130	7550350000	004125	6960915	TEXAS PARKS & WILDLIFE DEPT	GUADALUPE RIVER	1	25	35225	1		19810323
	D/S KERRVILLE								35250			
[redacted]												
									7922			
	U/S KERRVILLE											
18	133	9220000000		2997900	CARL HAWKINS	GUADALUPE RIVER	1	10	0	8		19130701
18	133	9680000000		1125505	CAMP MYSTIC INC	CYPRESS&SFGUAD	1	14	10	3	20	19270315
18	133	9675000000		0655295	BOB/KAT INC	S FK GUAD	1	10	24	1		19271231
18	133	9625000000		1125305	CAMP LA JUNTA INC	S FK GUADALUPE	1	14	34			19281231
18	133	9505000000		5697100	J CONRAD PYLE, ET AL	N FK GUADALUPE	1	14	48	2		19451231
18	133	9670000000		1612995	WILTON CRIDER	S FK GUAD	1	3	62	7		19471231
18	133	9560000000		5626010	PRESBYTERIAN MO-RANCH ASSEMBLY	N FK GUAD	1	60	65	6		19481231
18	133	9480000000		2749010	GUAD VALLEY LOT OWNERS ASSN	N FK GUAD	1	3	125			19601231
18	133	9897000000		5930195	RIVER INN ASSOC OF UNIT OWNERS	S FK GUAD	1	10	128	8		19840703
18	133	9660000000	005331	2270000	KATHLEEN B FLOURNOY, ET AL	SO FK GUAD RV	1	15	138	7	30	19901108
						MUNICIPAL USE SUBTOTAL		43325	153			
	INDUSTRIAL USE											
18	046	7542000000		2748205	GUADALUPE-BLANCO RIVER AUTH	GUADALUPE RIVER	2	2700	0			19560313
18	046	7542000000		2748205	GUADALUPE-BLANCO RIVER AUTH	GUADALUPE RIVER	2	6075	2700			19560319
18	046	7542000000		2748205	GUADALUPE-BLANCO RIVER AUTH	GUADALUPE RIVER	2	6000	8775			19560319
	KERRVILLE								14775			
18	133	9260000000		0622070	TOMMIE SMITH BLACKBURN	GUAD & KELLY	2	15	0	10	15	19140629
18	133	9025000000		6957710	TEXAS PARKS & WILDLIFE DEPT	FESSENDEN BR	2	400	15	250		19250701
18	133	9025000000		6957710	TEXAS PARKS & WILDLIFE DEPT	FESSENDEN BR	2	5780	415	15	72	19250701
18	133	8310000000		4224995	DARRELL G LOCHTE ET AL	GUADALUPE RIVER	2	2	6195			19461231
						INDUSTRIAL USE SUBTOTAL		20972	6197			
	IRRIGATION USE											
18	133	8151000000		5191495	JAMES E NUGENT	GUADALUPE R	3	27	0	11		18871231
18	133	8185500000		0656505	HARRIET BOCKHOFF ESTATE	GUADALUPE R	3	59	27	13		19001231
18	130	7619250000		6742195	MARSHALL STEVES	GUADALUPE R	3	8	86	3		19121231
18	130	7619300000		4204400	LION'S LAIR LLC	GUADALUPE RIVER	3	16.38	94		10	19121231
18	130	7619300000		6742300	PATRICIA GALT STEVES	GUADALUPE RIVER	3	1.62	110.38			19121231
18	133	8287000000		3817505	KERRVILLE, CITY OF	GUADALUPE RIVER	3	75	112	22	75	19140404
18	046	7549900000		2748600	GUADALUPE RIVER RANCH & CATTLE	GUADALUPE R	3	1	187	0		19140616
18	133	7970000000		4982065	ROBERT LEE MOSTY	GUADALUPE R	3	60	188	7		19140622
18	133	7940000000		4981700	RAYMOND F MOSTY ET AL	GUADALUPE R	3	103	248	10	5	19141124
18	133	7950000000		4982055	ROBERT LEE MOSTY	GUADALUPE R	3	17	351	7	20	19141124
18	133	7925000000		6120300	BYNO SALSMAN ET UX	GUADALUPE RIVER	3		368			19170424
18	133	7925000000		7841900	DAVID B WRAY	GUADALUPE RIVER	3		368			19170424
18	133	7925000000		7842005	HARRY J WRAY	GUADALUPE RIVER	3	155	368	11		19170424
18	133	8250000000		7584925	WHEATCRAFT, INC.	GUADALUPE R	3	42	523	9		19171011
18	133	8230000000		2160900	FARM CREDIT BANK OF TEXAS	GUADALUPE R	3	136	565	24		19241231
18	133	8255000000		4723005	CARL D. MEEK	GUADALUPE RIVER	3	295	701	24		19241231
18	133	7935000000		2688995	ROY A GREEN	GUADALUPE R	3	7	996	11		19301231
18	133	7930000000		5868504	CARL E RHODES	GUADALUPE R	3	114	1003	21		19321231

Notes:
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SURFACE WATER RIGHTS
UPPER GUADALUPE RIVER TO CANYON LAKE
As of September, 1995

Basin	County	River Order	Permit	Alpha M	Name	Stream	Use	Amount in Ac-Ft/Yr	Amount Senior in Use Category afy	Max Div. Rate tenths CFS	Res Cap in Ac-Ft	Priority
18	133	7999000000		4982005	ROBERT L MOSTY ET AL	GUADALUPE RIVER	3	158	1117	27		19321231
18	133	8150500000		3232380	DORIS J HODGES	GUADALUPE	3	8	1275	3		19461231
18	133	7701000000		4789800	JOSEPH PAUL MILLER ET UX	GUADALUPE RIVER	3	115	1283	16		19511231
18	133	8049500000		4981505	LEE ANTHONY MOSTY	GUADALUPE R	3	154	1398	22		19511231
18	133	8174000000		2160901	FARM CREDIT BANK OF TEXAS	GUADALUPE RIVER	3	179.06	1552			19521231
18	133	8174000000		0022000	1967 SHELTON TRUSTS PART ET AL	GUADALUPE RIVER	3	106.9	1731.06			19521231
18	133	8174000000		7628300	KENNETH W WHITEWOOD ET UX	GUADALUPE RIVER	3	34.04	1837.96			19521231
18	130	7580000000		7933800	ZARCO FOWARDING, INC	GUADALUPE R	3	232	1872	11		19531231
18	130	7618000000		6297005	H C SEIDENSTICKER	GUADALUPE R	3	20	2104	11		19541231
18	130	7560000000		2384605	FROST-LANCASTER PROPERTIES	GUADALUPE	3	44.38	2124	13		19550117
18	130	7560000000		5003550	KENNETH D MULLER ET UX	GUADALUPE	3	8.1	2168.38			19550117
18	130	7560000000		0303200	RONALD L BAETZ ET AL	GUADALUPE	3	14.61	2176.48			19550117
18	130	7617800000		3882495	ERWIN KLEMSTEIN	GUADALUPE R	3	136	2191.09	15		19551231
18	130	7618500000		6661005	WILLIAM G & MILDRED D SPROWLS	GUADALUPE R	3	28	2327.09	22		19571231
18	130	7558810000		5732704	TY RAMPY ET AL	GUADALUPE R	3	20	2355.09	20		19581231
18	046	7545000000		2425200	ELOY GARCIA JR ET UX	GUADALUPE R	3	35	2375.09	18		19601231
18	133	7700700000		3729005	ROBERT JORRIE	GUADALUPE R	3	10	2410.09	1		19601231
18	133	7699500000		3049505	CHESTER P HEINEN ET AL	GUADALUPE RIVER	3	2	2420.09	2		19611231
18	133	7699900000		5858040	JAVIER G REYES ET UX	GUADALUPE R	3	90	2422.09	33		19611231
18	133	7920000000		3736200	ELGIN JUNG	GUADALUPE	3	3.309	2512.09			19611231
18	133	7920000000		5334790	JERRY B PARKER ET UX	GUADALUPE	3	17.83	2515.399			19611231
18	133	7920000000		5974900	ZANE H ROBINSON ET UX	GUADALUPE	3	53.945	2533.229	12		19611231
18	133	7920000000		7628400	KENNETH W WHITEWOOD ET UX	GUADALUPE	3	49.916	2587.174			19611231
18	130	7570500000		5834000	ROBERT C REINARZ ET AL	GUADALUPE R	3	39	2637.09	13		19621231
18	130	7570000000		6936305	TEXAS BEVERAGE PACKERS INC	GUADALUPE R	3	90	2676.09	20		19630630
18	046	7550000000		6690005	FRANK A STANUSH	GUADALUPE R	3	22	2766.09	22		19631231
18	130	7658000000		4717005	HARRY C MECKEL	GUADALUPE R	3	2	2788.09	7		19631231
18	130	7657000000		0194000	WILLIAM K ANDERSON ET UX	GUADALUPE RIV	3	125	2790.09	22	65	19641231
18	130	7579500000		6648495	ERNO SPENRATH	GUADALUPE RIVER	3	32	2915.09	10		19651231
18	130	7569500000		3474000	MARJORIE RANZAU INGENHUETT	GUADALUPE	3	17.61	2947.09			19661231
18	130	7569500000		2196600	LOUIS SCOTT FELDER ET UX	GUADALUPE	3	15.65	2964.7			19661231
18	130	7569500000		7768200	MURRAY A WINN JR	GUADALUPE	3	36.74	2980.35	11		19661231
18	130	7571000000		3756005	OTTO KASTEN	GUADALUPE R	3	40	3017.09	9		19661231
18	130	7579000000		0506400	EDMUND BEHR ESTATE	GUADALUPE RIVER	3	80	3057.09	18		19661231
18	130	7617900000		6068105	KENNETH M & CYNTHIA RUSCH	GUADALUPE RIVER	3	5	3137.09	11		19661231
18	130	7558810000		5732704	TY RAMPY ET AL	GUADALUPE R	3	20	3142.09	11	28	19730806
18	133	8260010000		5930105	RIVERHILL COUNTRY CLUB INC	GUAD&CP MEETIN	3	350	3162.09	22	70	19740429
18	130	7552000000		3743945	KWW RANCH	GUAD & WALTER	3	165	3512.09	3	620	19750224
18	133	8275500000	003635	3817510	CITY OF KERRVILLE	QUINLAN CR	3	80	3677.09	17	10	19780814
18	130	7578900000	004255	7702400	GEORGE M WILLIAMS SR ET AL	GUADALUPE RIVER	3	50	3757.09	9		19850709
18	130	7619350000	004285	2458300	JACOB C GASS	GUADALUPE RIVER	3	80	3807.09	22		19850730
18	046	7548000000	004291	5681050	PURALLOY INC	GUADALUPE RIVER	3	50	3887.09	13		19850828
18	130	7657200000	005107	0194050	WILLIAM K ANDERSON ET UX	GUAD&UNNAMED	3	518	3937.09	33		19861023
18	133	8150800000	005122	6787800	JAMES C STORM	GUADALUPE RIVER	3	75	4455.09	6	8	19870319
18	133	8174000000		2160901	FARM CREDIT BANK OF TEXAS	GUADALUPE RIVER	3	83.94	4530.09			19890000
18	133	8174000000		0022000	1967 SHELTON TRUSTS PART ET AL	GUADALUPE RIVER	3	50.1	4614.03			19890000
18	133	8174000000		7628300	KENNETH W WHITEWOOD ET UX	GUADALUPE RIVER	3	15.96	4664.13			19890000

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SURFACE WATER RIGHTS
UPPER GUADALUPE RIVER TO CANYON LAKE
As of September, 1995

Basin	County	River Order	Permit	Alpha M	Name	Stream	Use	Amount in Ac-Ft/Yr	Amount Senior in Use Category afy	Max Div. Rate tenths CFS	Res Cap in Ac-Ft	Priority
18	130	7584000000	005474	6086000	ELTON RUST	GUADALUPE	3	10	4680.09	16		19931116
18	133	7701250000	005479	1330200	CITY SOUTH MANAGEMENT CORP.	GUADALUPE	3	566	4690.09	2.67		19940222
18	130	7610000000	005490	0664100	BILLY J. & KARAN R. BOLES	GUADALUPE RIV	3	10	5256.09	22		19940531
18	130	7618900000	005528	6212280	GEORGE A SCHMIDT ET UX	GUADALUPE	3	98	5266.09	0.56		19950519
18	133	8185700000	005531	1540100	LEE ROY COSPER ET UX	GUADALUPE	3	80	5364.09	1.78		19950621
18	130	7609000000	005534	1025870	MARGOT O BURRELL	GUADALUPE	3	20	5444.09	2.23		19950717
18	133	7701350000	005536	3579800	ROBERT H & CHARLOTTE JENNINGS	GUADALUPE	3	400	5464.09	3.56		19950728
	KERRVILLE								5864.09			
18	133	9261000000		1889010	LOUIS DOMINGUES	GUAD & KELLY	3	10	0	11		18891231
18	133	9110000000		0220800	ARANSAS BAY COMPANY	WELSH BRANCH	3	0.05	10	11		19001231
18	133	9110000000		2063510	WESLEY ELLEBRACHT	WELSH BRANCH	3	0.8	10.05	11		19001231
18	133	9110000000		7536800	WELCH CREEK PARTNERS LTD	WELSH BRANCH	3	5.15	10.85	11		19001231
18	133	9486000000		2654005	LUTHER GRAHAM	HONEY CREEK	3	28	16	8	17	19001231
18	133	9488000000		1212600	WILLIAM O CARTER, TRUSTEE	SPRNG ON HONEY	3	27	44	3		19001231
18	133	8815000000		6085805	A J RUST	JOHNSON CR	3	33	71	18		19021231
18	133	9487000000		1970025	JOHN H DUNCAN	HONEY CREEK	3	6	104	6	13	19031231
18	133	9523000000		0226650	WILLIAM H ARLITT JR ET UX	N FK GUAD	3	17	110	13	5	19090802
18	133	8746000000		2123705	GERVIS H & GLENDA EUDALEY	JOHNSON CREEK	3	80	127	10		19101231
18	133	9220000000		2997900	CARL HAWKINS	GUADALUPE RIVER	3	32	207			19130701
18	133	8750000000		6284400	MICHAEL E & GAIL SEARS	JOHNSON CREEK	3	1	239	1		19140429
18	133	8770000000		4383805	N V MAMIMAR	JOHNSON CREEK	3	32	240	10		19140429
18	133	8950000000		7949100	F P ZOCH III TRUST & ZEE RANCH	FESSENDEN BR	3	29	272	9		19140610
18	133	8600000000		6095700	MARK A RYLANDER ET AL	JOHNSON CREEK	3	23	301	8		19140624
18	133	9476000000		4171000	LAURA B LEWIS ET VIR	N FK GUAD	3	40	324	7		19140626
18	133	9050000000		6352215	SHELTON RANCHES INC	SMITHS BRANCH	3	70	364	33	15	19140629
18	133	9100000000		6352209	SHELTON RANCHES INC	SMITHS BRANCH	3	10	434	10	6	19140629
18	133	8650000000		7115500	DOROTHY L THOMPSON ET AL	JOHNSON CREEK	3	3	444	1		19140630
18	133	9489000000		1970005	JOHN H DUNCAN	BRUSHY CREEK	3	7	447	3		19140918
18	133	8500000000		4878005	M H & MARY FRANCES MONTGOMERY	GUADALUPE R	3	5	454	5		19140923
18	133	8808000000		4709495	KEITH S MEADOW	BYAS CREEK	3	18	459	10		19141231
18	133	9476500000		1970015	JOHN H DUNCAN	HONEY CREEK	3	40	477	22	25	19151231
18	133	9485000000		3194510	JOHN P HILL ADMINISTRATOR	N FK GUAD	3	11	517	15		19151231
18	133	9485010000		3195010	JOHN P HILL	N FK GUAD	3	25	528	15		19151231
18	133	9620000000		2653800	LAWRENCE L GRAHAM ET AL	S FK GUADALUPE	3	2	553	10	21	19170529
18	133	8800000000		1339505	JACK D CLARK JR ET AL	JOHNSON CR	3	32	555	13		19180128
18	133	8805000000		489460	A L MOORE	JOHNSON CR	3	12	587	1		19180128
18	133	8550000000		4210005	ROY LITTLEFIELD	JOHNSON CREEK	3	50	599	11	4	19180218
18	133	9980000000		2962300	BRUCE F. HARRISON	S FK GUADALUPE	3	6	649	2	17	19211231
18	133	9310000000		7951000	BILLIE ZUBER, ET AL	GUADALUPE R	3	17	655	18		19261231
18	133	9675000000		0655295	BOB/KAT INC	S FK GUAD	3	10	672	2		19271231
18	133	9625000000		1125305	CAMP LA JUNTA INC	S FK GUADALUPE	3	26	682	10	30	19281231
18	133	9570000000		5835600	HERSHEL REID, ET UX	FLAT ROCK CR	3	69	708	13	35	19301231
18	133	9515000000		6823510	LOUIS H STUMBERG	BEAR CREEK	3	15	777	29		19331231
18	133	8744000000		7469805	REGINALD E WARREN JR	JOHNSON CREEK	3	90	792	11		19341231
18	133	9511000000		5700010	B E QUINN III ET AL	N FK GUAD/GUAD	3	32	882	21	10	19361231
18	133	9510000000		2087095	DALE B AND MARSHA G ELMORE	N FK GUADALUPE	3	8	914	10	20	19371231
18	133	9780000000		4923510	T J MOORE ESTATE	CYPRESS CREEK	3	20	922	3	100	19381205

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SURFACE WATER RIGHTS
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As of September, 1995

Basin	County	River Order	Permit	Alpha M	Name	Stream	Use	Amount in Ac-Ft/Yr	Amount Senior in Use Category afy	Max Div. Rate tenths CFS	Res Cap in Ac-Ft	Priority
18	133	9490000000		5715505	SILAS B RAGSDALE	N FK GUAD	3	21	942	11		19411231
18	133	9528000000		3508225	LUTZ ISSLIEB ET AL	N FK GUADALUPE	3	30	963	13	30	19411231
18	133	9260000000		0622070	TOMMIE SMITH BLACKBURN	GUAD & KELLY	3	108	993	16		19461231
18	133	9670000000		1612995	WILTON CRIDER	S FK GUAD	3	1	1101			19471231
18	133	9488000000		1212600	WILLIAM O CARTER, TRUSTEE	HONEY CREEK	3	6	1102	1		19481231
18	133	9515000000		6823510	LOUIS H STUMBERG	N FK GUAD	3	2	1108	29		19481231
18	133	9560000000		5626010	PRESBYTERIAN MO-RANCH ASSEMBLY	N FK GUAD	3	14	1110			19481231
18	133	9640000000		3652000	VIRGINIA MOORE JOHNSTON	TEGENER & TRIB	3	10	1124	14	12	19481231
18	133	8451000000		2709000	HENRY GRIFFIN CONSTRUCTION CO	GOAT CREEK	3	11	1134	7	6	19511231
18	133	9512000000		6823610	LOUIS H STRUMBERG	GRAPE CREEK	3	3	1145	29	6	19521231
18	133	9680000000		1125505	CAMP MYSTIC INC	CYPRESS&SFGUAD	3	12	1148	6		19521231
18	133	8770000000		1517200	DAVID J COPELAND ET UX	JOHNSON CR	3		1160			19531231
18	133	8770000000		1517200	DAVID J COPELAND ET UX	JOHNSON CR	3		1160			19531231
18	133	8770000000		4383805	N V MAMIMAR	JOHNSON CR	3	67	1160	10		19531231
18	133	8775000000		6530815	LOLA DEAN SMITH	JOHNSON CR	3	133	1227	6	12	19551231
18	133	9350000000		6405195	ALICE CYNTHIA SIMKINS	TEGENER CREEK	3	6	1360	6		19551231
18	133	8615001000		4068200	LAZY HILLS GUEST RANCH INC	HENDERSON BR	3	21	1366	4		19601231
18	133	8720000000		5699500	JIMMIE L QUERNER SR ESTATE	FALL BRANCH	3	128	1387	16		19601231
18	133	9480000000		2749010	GUAD VALLEY LOT OWNERS ASSN	N FK GUAD	3	6	1515	1		19601231
18	133	9523000000		0226650	WILLIAM H ARLITT JR ET UX	INDIAN CREEK	3	134	1521	12		19601231
18	133	8800000000		1339505	JACK D CLARK JR ET AL	JOHNSON CR	3	143	1655	11		19611231
18	133	9507000000		6204505	L F SCHERER	N FK GUADALUPE	3	1	1798	1		19611231
18	133	9525100000		3146710	CHARLES K HICKEY ET AL	N FK GUAD	3	8	1799	1		19671231
18	133	9527000000		3146700	CHARLES K HICKEY ET AL	DRY CREEK	3	2	1807	1		19671231
18	133	8839000000		6937805	TEXAS CATHOLIC BOYS' HOME	JOHNSON CR	3	23	1809	11	23	19691201
18	133	9105000000	004100	6352250	SHELTON RANCHES INC	JOHNSON CR	3	20	1832	4	39	19820614
18	133	8710000000	005060	1392100	HORACE COFER ASSOCIATES, INC	FALL BR CR	3	10	1852	9		19860520
18	133	9660000000	005331	2270000	KATHLEEN B FLOURNOY, ET AL	SO FK GUAD RV	3	96	1862			19901108
18	133	9526000000	005348	1901550	BRYON DONZIS	NF GUADALUPE R	3	5	1958	1		19910305
18	133	9650000000	005352	0672050	BONITA OWNERS ASSOC INC	S FK GUAD RV	3	2	1963	1		19910328
18	133	8490000000	005444	2748650	GUADALUPE RIVER R V RESORT,INC	GUADALUPE	3	10	1965	3		19930105
18	133	8300050000	005521	7742400	DON D WILSON	GUADALUPE LAKE	3	30	1975	0.22		19950202
18	133	9476150000	005541	0433600	BASHARDT LTD	NORTH FORK GUADALU	3	14	2005	0.67		19950831
	MINING USE					*IRRIGATION USE SUBTOTAL*		7883.09	2019			
18	133	8250000000		6352206	SHELTON RANCH CORPORATION	GUADALUPE R	4	10	0			19171011
	KERRVILLE								10			
18	133	8310000000		4224995	DARRELL G LOCHTE ET AL	GUADALUPE RIVER	4	143	0	18		19461231
	RECREATIONAL USE					*MINING USE SUBTOTAL*		153	143			
18	133	8050000000		3812005	COUNTY OF KERR	GUADALUPE R	7	0	0		87	19550404
18	133	8200000000		3812505	COUNTY OF KERR	GUADALUPE R	7		0		720	19550404
18	133	8279000000	005029	6597000	SOUTHEASTERN SAVINGS ASSN	GUADALUPE RIVER	7		0		12	19851030
	KERRVILLE								0			
18	133	9620000000		2653800	LAWRENCE L GRAHAM ET AL	S FK GUADALUPE	7		0		16	19170529
18	133	9980000000		2962300	BRUCE F. HARRISON	S FK GUADALUPE	7		0		10	19270729
18	133	9880000000		3594710	JOHN F JOBES	S FK GUAD	7	0	0		10	19281214
18	133	9560000000		5626010	PRESBYTERIAN MO-RANCH ASSEMBLY	N FK GUAD	7	25	0	91	20	19290403
18	133	9897000000		5930195	RIVER INN ASSOC OF UNIT OWNERS	S FK GUAD	7	0	25		50	19361231

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18	133	9515200000		0736620	BOY SCOUTS- ALAMO AREA	BEAR CREEK	7	0	25		10	19381231
18	133	8950000000		7949100	F P ZOCH III TRUST & ZEE RANCH	FESSENDEN BR	7		25		184	19410725
18	133	9550000000		3761700	CHLOE CULLUM KEARNEY ET AL	N FK GUADALUPE	7		25		100	19481231
18	133	9140000000		3813010	COUNTY OF KERR	GUADALUPE RIVER	7	0	25		450	19550404
18	133	9305000000		1046995	SARAH HICKS BUSS	GUAD & TRIB	7	20	25	3		19710802
18	133	9040000000	003743	6352240	SHELTON RANCHES INC	JOHNSON CR	7	0	45		122	19800331
18	133	8705000000	005322	6587100	E RAND SOUTHARD ET UX	FALL BRANCH	7		45			19901102
18	133	9800000000	005495	7557390	LOIS & JOSEPH WESSENDORF ET AL	SOUTH FORK GUADALU	7		45		9	19940727
						RECREATIONAL USE SUBTOTAL		45	45			

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APPENDIX C

UGRA SURFACE WATER PERMIT No. 5394

PERMIT TO
APPROPRIATE AND USE STATE WATER

APPLICATION NO. 5394		PERMIT NO. 5394		TYPE:	11.121

Permittee:	Upper Guadalupe River Authority	Address:	P.O. Box 1278 Kerrville, Tx. 78029-1278
Filed	January 6, 1992	Granted:	August 25, 1993
Purposes:	Municipal and Recharge	County:	Kerr
Watercourse:	Guadalupe River	Watershed:	Guadalupe River Basin

WHEREAS, the Upper Guadalupe River Authority (UGRA) has requested authorization to divert not to exceed 4,760 acre-feet of water per annum on a firm-yield basis from an existing 840 acre-foot capacity reservoir (included in UGRA's Water Use Permit No. 3505) in Kerr County, approximately 1.5 miles west-northwest of the Kerr County Courthouse on the Guadalupe River, for municipal purposes and/or injection via wells into an underground aquifer reservoir known as the Hosston-Sligo Sands of the Lower Trinity formation for subsequent retrieval and use for municipal purposes in Kerr County; and

WHEREAS, UGRA has indicated that the water requested will be utilized to meet the future municipal demands of its existing wholesale customer the City of Kerrville, and anticipated wholesale customers in Kerr County, including but not limited to, the City of Ingram and the unincorporated community at Center Point; and

WHEREAS, Kerr County is included in a "critical groundwater area" as designated by the Texas Water Commission; and

WHEREAS, UGRA has indicated that water injected into the aquifer will also have an incidental effect of temporarily recharging the aquifer during the period of storage; and

WHEREAS, UGRA has indicated that diversions of the water requested will only be made when the elevation of the water in the referenced reservoir is above 1,608 feet mean sea level; and

WHEREAS, Permit No. 3505 includes authorization for the diversion of not to exceed 3,603 acre-feet of water per annum for municipal purposes from a point on the west bank of the referenced reservoir at a maximum diversion rate of 9.7 cfs and limits diversion of water to only those times when the water level in the reservoir is above 1,608 feet mean sea level; and

WHEREAS, the Commission finds that UGRA does not have existing contracts for all of the water requested for diversion under Application No. 5394; and

WHEREAS, the Commission finds that water sought to be diverted under Application No. 5394 for which UGRA does not have existing water supply contracts should be limited to a term of years if such contracts are not hereafter entered into, submitted to Commission staff and approved in accordance with Commission Rules; and

WHEREAS, the Commission considered the "Kerr County Water Conservation Plan and Drought Contingency Plan (May 12, 1992)" submitted by the Upper Guadalupe River Authority in support of this Application and such plan evidences that permittee shall use reasonable diligence to achieve water conservation; and

WHEREAS, the water requested in this application is included in a Subordination Agreement between the applicant and the Guadalupe-Blanco River Authority; and

WHEREAS, the Commission finds that jurisdiction over the application is established; and

WHEREAS, a public hearing was held on the granting of this application after the publication of all notice requirements; and

WHEREAS, the Commission has complied with the requirements of the Texas Water Code and Rules of the Commission in issuing this permit.

NOW, THEREFORE, this permit to appropriate and use State water is issued to the Upper Guadalupe River Authority, subject to the following terms and conditions:

1. USE

Permittee is authorized to divert not to exceed 4,169 acre-feet of water per annum from the reservoir on the Guadalupe River included in Water Use Permit No. 3505. Of this total amount, 2,761 acre-feet per annum is available on a firm yield basis, with the remaining 1,408 acre-feet per annum available on a "run-of-river" basis. Such total amount of water shall be used for municipal use and/or injected into the Hosston-Sligo Aquifer of the Lower Trinity formation for subsequent retrieval for municipal use.

2. DIVERSION

Permittee is authorized to divert water from the point on the reservoir authorized in Permit No. 3505 at a maximum rate, in combination with the rate included in Permit No. 3505, of not to exceed 15.5 cfs. Prior to the diversion of the water authorized hereunder, Permittee shall have installed a metering device in accordance with Commission Rules.

3. POINT OF RETURN

Water diverted for use by the City of Kerrville but not consumed shall be returned to the City of Kerrville's wastewater treatment plant discharge outfall.

4. WATER CONSERVATION

Permittee shall implement the aforesaid "Kerr County Water Conservation Plan and Drought Contingency Plan" dated May 12, 1992. Any subsequent plan used by permittee shall provide for the utilizing of those practices, techniques, and technologies that reduce or maintain the consumption of water, prevent of reduce the loss or waste of water, maintain or improve the efficiency in the use of water, increase the recycling and reuse of water, or prevent the pollution of water, so that a water supply is made available for future use or alternative uses. Such plan shall include a requirement in every wholesale water supply contract entered into, on or after the effective date of this permit, including any contract extension or renewal, that each successive wholesale customer develop and implement water conservation measures. If the customer intends to resell the water, then the contract for the resale of the water must have water conservation requirements so that each successive customer in the resale of the water will be required to implement water conservation measures.

5. SPECIAL CONDITIONS

A. Permittee is authorized to divert water hereunder only when the water level in the referenced existing reservoir is above 1,608 feet mean sea level.

B. During the months of October through May, Permittee is authorized to divert water hereunder only when the flow of the Guadalupe River exceeds 40 cfs at a reference device to be installed by the Permittee immediately downstream of the dam for the referenced reservoir at a location to be approved by the Executive Director. During the months of

June through September, Permittee is authorized to divert water hereunder only when the flow of the Guadalupe River exceeds 30 cfs at the aforesaid reference device.

C. In addition to the variable flow restrictions contained in Paragraph 5. SPECIAL CONDITIONS B., if inflows into the referenced reservoir are 50 cfs or greater, Permittee must restrict the diversions hereunder authorized to allow a flow of at least 50 cfs to pass the reference device described in that paragraph. The inflows are to be measured at a separate reference device or devices installed by Permittee upstream of the reservoir at a specific location to be approved by the Executive Director.

D. Of the 4,169 acre-feet of water authorized for diversion per annum in Paragraph 1. USE, such water shall be used as follows:

i. Not to exceed 1,100 acre-feet of water per annum may be contracted for municipal use by the City of Kerrville (either water diverted directly from the river or surface water injected into the aforesaid aquifer and subsequently retrieved);

ii. Not to exceed 1,661 acre-feet of water per annum may be contracted for municipal use by Kerr County entities other than the City of Kerrville (either water diverted directly from the river or surface water injected into the said aquifer and subsequently retrieved); and

iii. The remaining 1,408 acre-feet of water per annum shall be used for injection into the said aquifer for storage to maintain the firm yield of the system.

E. Authorization to divert and use any portion of the 1,661 acre-feet of water per annum referenced in Paragraph 5. SPECIAL CONDITIONS, D. ii. which UGRA has not committed to a binding take-or-pay contract and submitted to the Commission by midnight, December 31, 2010, will be subject to cancellation and by January 17, 2011, UGRA shall submit to the Commission a document requesting voluntary cancellation of that portion of the 1,661 acre-feet of water not included in a contract.

F. The authorizations hereunder are subject to the maintenance of the June 8, 1987 "Subordination

Agreement" or extensions thereof, between permittee and the Guadalupe-Blanco River Authority. The Commission shall be notified immediately by the permittee upon amendment or expiration of such agreement and provided with copies of appropriate documents effecting such changes.

G. Water diverted under this permit for storage in the aquifer shall be treated to drinking water standards as per Texas Water Commission Rules.

H. The annual total of the diversions authorized under Permit No. 3505 and under this permit shall be allocated to each day based on historic patterns of usage, as reflected in Exhibit A attached to this permit. If, on any given day, the daily allocation is not needed or not available under either permit, then such allocations shall not be made up on future days, except that allocations under this permit (No. 5394) may be made up on future days provided that flows at the downstream reference device described in Paragraph 5. SPECIAL CONDITIONS, B. are at least 60 cfs on those future days.

This permit is issued subject to all superior and senior water rights in the Guadalupe River Basin.

Permittee agrees to be bound by the terms, conditions and provisions contained herein and such agreement is a condition precedent to the granting of this permit.

All other matters requested in the application which are not specifically granted by this permit are denied.

This permit is issued subject to the Rules of the Texas Water Commission and to the right of continuing supervision of State water resources exercised by the Commission.

DATE ISSUED: OCT 12 1993

TEXAS WATER COMMISSION

John Hall

John Hall, Chairman

ATTEST:

Mamie M. Black

for Gloria A. Vasquez, Chief Clerk

John Hall, *Chairman*
Pam Reed, *Commissioner*
Peggy Garner, *Commissioner*
Anthony Grigsby, *Executive Director*

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

October 21, 1993

Mr. Edmond R. McCarthy, Jr., Attorney
1300 Capitol Center, 919 Congress Ave.
Austin, TX 78701

RE: UPPER GUADALUPE RIVER AUTHORITY; PERMIT NO. 5394

Dear Mr. McCarthy:

On October 13, 1993, the Texas Natural Resource Conservation Commission issued an Order with the permit pending, subject to motion for rehearing. Due to an administrative oversight, the final page of the permit, Exhibit A, was inadvertently omitted. Therefore, enclosed are five copies of Exhibit A. By copy of this letter and Exhibit A, all parties listed below and on the attached service list have been informed of the addition.

We regret any inconvenience this error may have caused. Should you have questions, please feel free to contact Kristen Kayga in the Office of the Chief Clerk at (512) 463-5836.

Sincerely,

Gloria A. Vasquez

Gloria A. Vasquez
Chief Clerk, TNRCC

GAV:kk

enclosure

cc w/enclosure:
Mr. Mike Rogan, Hearings Examiner, TNRCC
Mr. Terry Slade, Watershed Management, TNRCC
Mr. Myron Hess, Attorney; Texas Parks & Wildlife Department; 4200 Smith School Road; Austin, TX 78744

P.O. Box 13087 • Austin, Texas 78711-3087 • 512/908-1000

CCO MAILING LIST

UPPER GUADALUPE RIVER AUTHORITY
PERMIT NUMBER 5394

Mr. Ed McCarthy, Attorney
Upper Guadalupe River Authority
1300 Capitol Center; 919 Congress
Austin, TX 78701

Mr. Myron Hess, Attorney
Texas Parks & Wildlife Department
4200 Smith School Road
Austin, TX 78744

Ms. Diane Smith, Attorney
Legal Division, TNRCC
P. O. Box 13087
Austin, TX 78711-3087

Mr. Charles E. Thrash, Attorney
Public Interest Counsel, TNRCC
P. O. Box 13087
Austin, TX 78711-3087

Mr. William G. Bunch, Attorney
Texas Rivers Protection Assoc.
& William C. Perkins
1800 Guadalupe, Suite B
Austin, TX 78701

Richard L. Johnston
Lower Guadalupe Property Owners
Four Paradise Avenue
Kerrville, TX 78028

Mr. Wendall Lyons
424 Susie
Canyon Lake, TX 78133

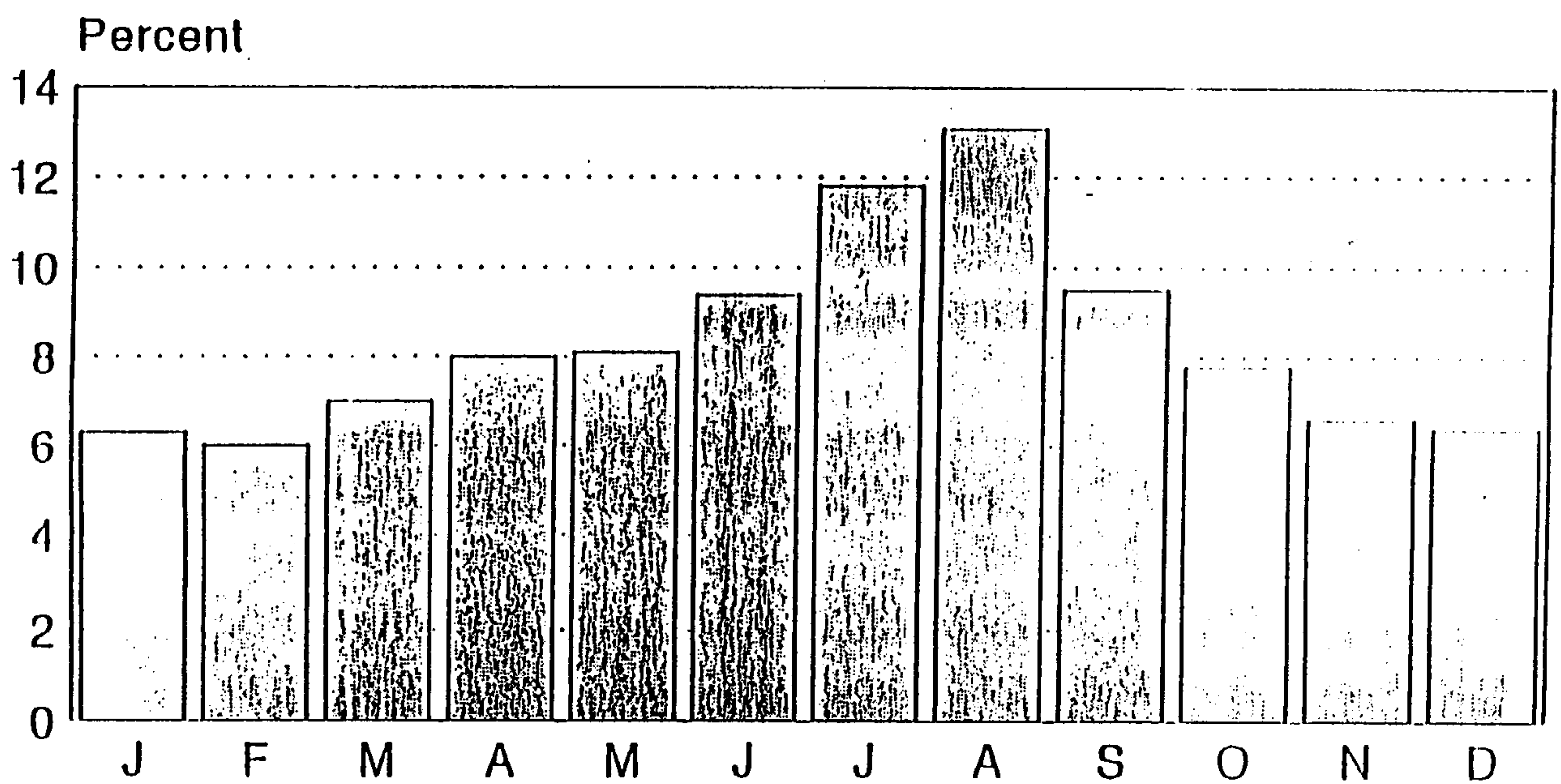
Mr. Byno Salsman
P. O. Box 184
Center Point, TX 78010

Bryan Craven
984 N. Cooper
Arlington, TX 76012

EXHIBIT A

UGRA Demand Distribution

(Used in Modeling)



	J	F	M	A	M	J	J	A	S	O	N	D
Monthly □	6.3	6	7	8	8.1	9.4	11.8	13.1	9.5	7.8	6.6	6.4

Based on historical use for City of Kerrville

APPENDIX D

WATER SUPPLY AND DEMAND MODELING

Technical Appendix -- Water Supply and Demand Model

Kerr County Regional Water and Wastewater Plan

This technical appendix is provided as a supplement to the Regional Water and Wastewater Plan developed for Kerr County entities. The technical appendix provides a brief description of the model, detailed water supply model output and a listing of the water supply model. The appendix is organized as follows:

Model Description

Model Output Summary

Detailed Model Output

Schematic Diagrams

Variable Listing, Documentation, and Detailed Model Logic

Model description. The model was created by HDR Engineering for the Upper Guadalupe River Authority and the City of Kerrville to simulate the existing (1997) supply system and the projected water demands for Kerr County. The objective of modeling is to evaluate the availability of surface water for use in accordance with permit rights and requirements and demand patterns.

By evaluating surface water availability and assuming that shortfalls (difference between demand and available surface water) are made up by ground water extractions, the demands on ground water resources are also estimated. In addition, the model computes the potential quantity of water that may be available for injection into the aquifer for the Aquifer Storage and Recovery (ASR) project.

The simulation occurs using the historical streamflow record in the Guadalupe River (extended from Comfort to the Kerrville location). The duration of the record is 57 years or 672 monthly time steps (the model operates on a monthly time step). Units used are mgd: million gallons per day, afm: acre-feet per month, and afy: acre feet per year.

The user can input the demand year and evaluate the system under those projected demand conditions over the historical streamflow record by running the model. The model allows any demand year to be analyzed against a 57 year synthesized streamflow record for the Guadalupe River at Kerrville. In this manner, it is possible to estimate both the mean and extreme conditions expected to occur based on the historical record. The primary components of the model include:

- Demand patterns: Demands are assumed to occur according to the projections developed in Section 2 of this report. Annual demands are expressed in terms of monthly demands using the demand pattern presented in Figure 4-1.
- Upper Guadalupe stream flow at Kerrville: This was developed from the 57 year record at Comfort TX and the 11 year record at Kerrville, using the correlation between the two gages during the overlap period. The record developed for the Guadalupe River at Kerrville is compared to the Comfort gage in Figure 4-7 for the critical drought of record observed in the 1950's.
- Water rights: Upstream senior municipal water rights were assumed to be diverted from the river upstream of Kerrville, while senior irrigation water rights upstream were assumed not

to be used. This assumes that agreement could be obtained with irrigators for water during critical shortages. Upstream irrigation rights account for 2,019 afyr as presented in Table 4-1. Downstream water rights were not considered and potential impacts on GBRA's water rights would have to be computed using more sophisticated approaches. This assumes that an agreement would be reached with GBRA for mitigation of any yield impact to Canyon Lake associated with Permit 3505.

- Permitted Diversions: The permitted diversions discussed above are allowed to occur subject to upstream municipal water rights, flow in the river, water treatment capacity, and instream flow requirements. Figure 4-8 indicates the magnitude of Permit 5394 instream flow requirements relative to the expected flow in the Guadalupe River at Kerrville over the synthesized record. Diversion under Permit No. 5394 is only permitted when the Guadalupe river exceeds minimum instream flow requirements. Diversions are required to occur in the historical demand pattern. If the permitted diversion under permit No. 5394 is not available at a given time, it can be diverted at a future time in the year, subject to the instream flow constraint of 60 cfs.
- Groundwater Pumpage: Ground water is assumed to be withdrawn to meet municipal demands that cannot be satisfied by surface water diversions (surface water shortfalls).
- ASR Injection Potential: The potential for diverting water for injection to the lower Trinity aquifer is evaluated based on Permit 5394 rights and restrictions and available treatment capacity.

The different supply augmentation alternatives supported by the model include expanding the water treatment plant and obtaining additional water rights.

- Expand surface water treatment plant. The initital plant expansion is assumed to be from 5 to 10 mgd. The plant could be expanded to 20 mgd (CH2M Hill, 1993).

Additional surface water rights. For the purpose of this analysis, it is assumed that 10,000 afyr is purchased and that this water diversion right is subject to similar instream flow restrictions to Permit 5394 (see Figure 4-8). The value of 10,000 afyr is a modeling assumption and does not necessarily reflect the quantity available or the quantity recommended for purchase. As mentioned in Section 4.1.1, if rights could be purchased upstream, it is likely that no instream flow requirements would be attached upon amendment.

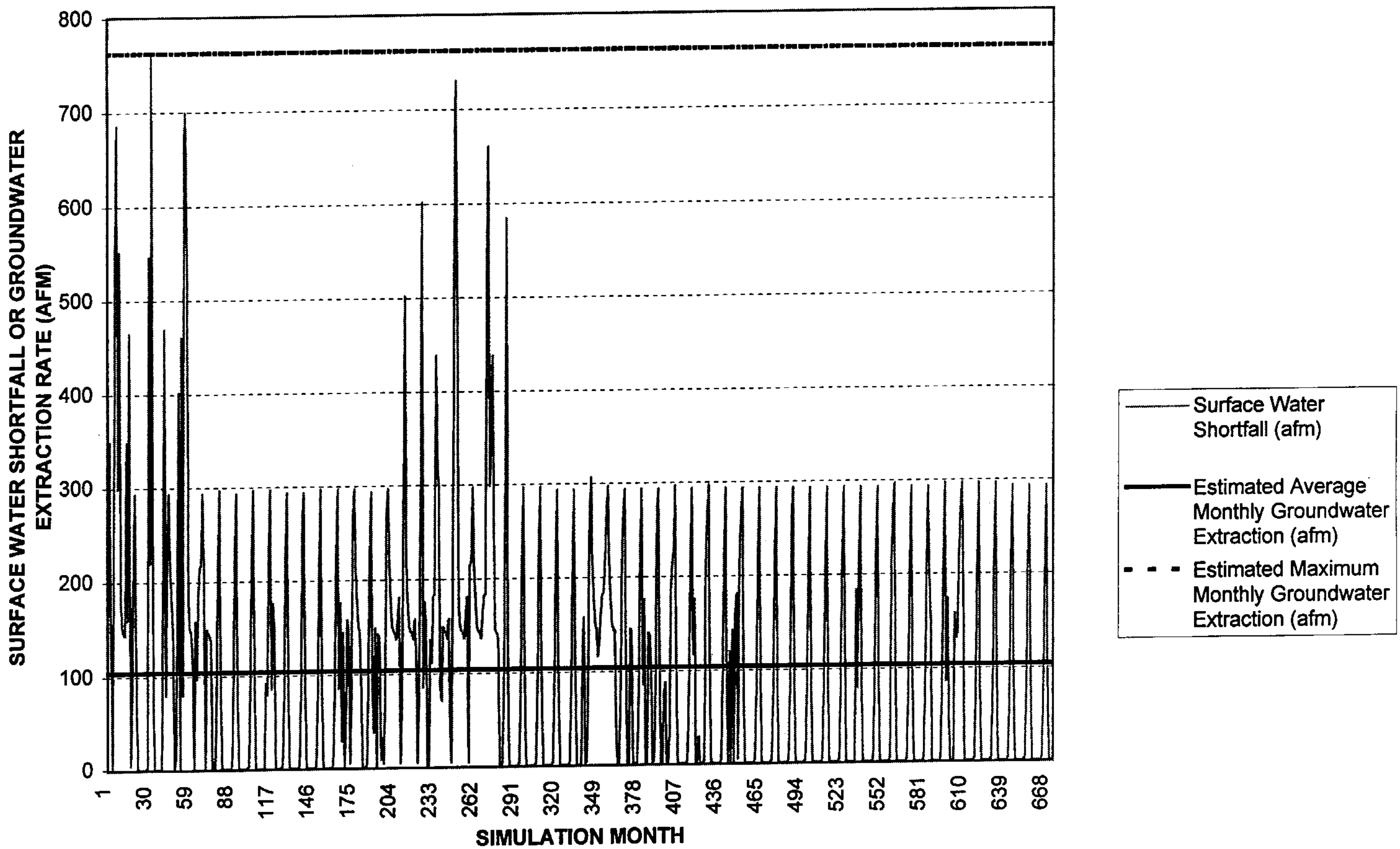
MODEL OUTPUT SUMMARY

TABLE C-1
MODEL OUTPUT SUMMARY

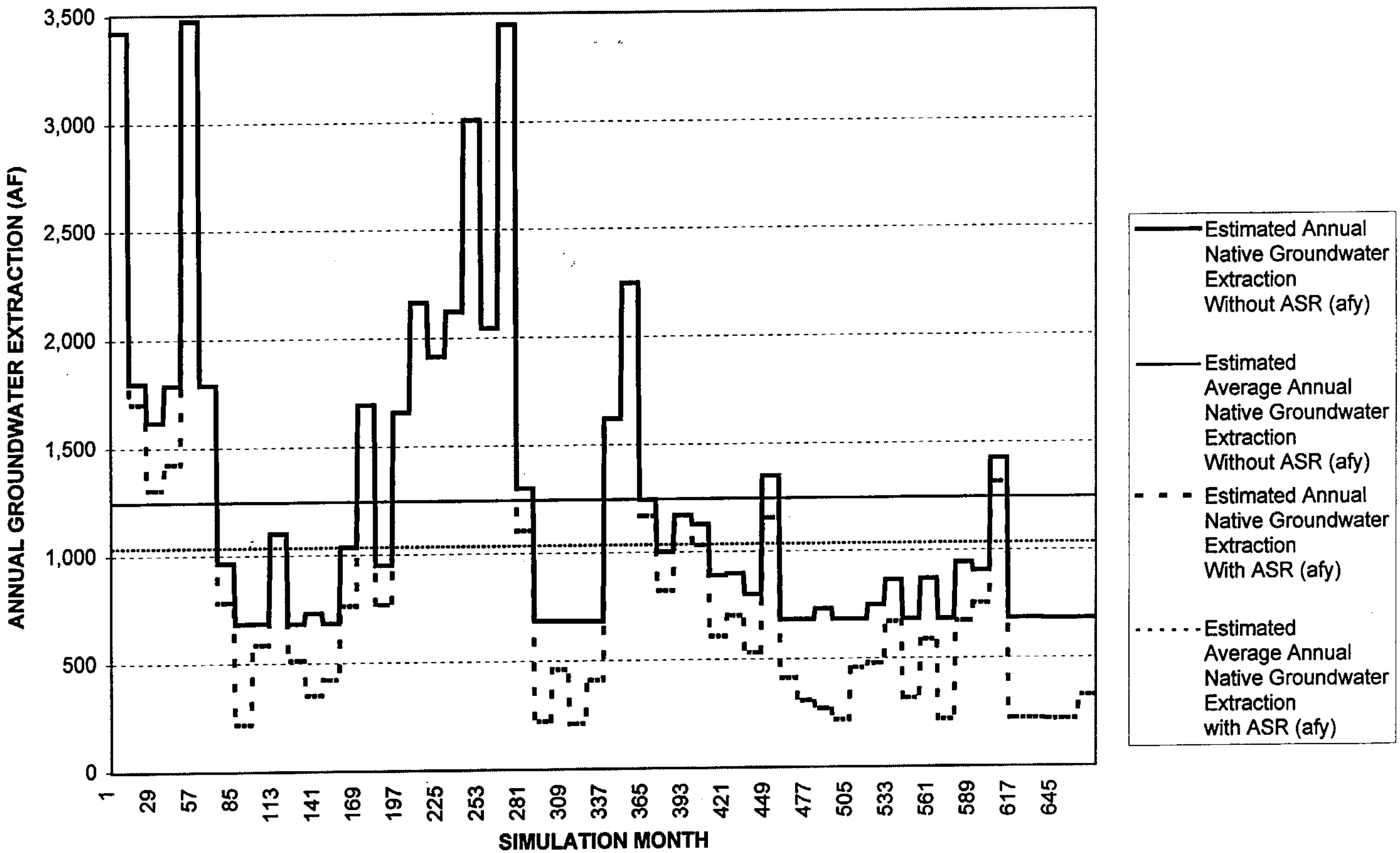
Demand Year	Water Treatment Plant Capacity (mgd)	Supplemental Rights (acft/yr)	Average Surface Water Use (acft/yr)	Average Ground Water Use (acft/yr)	Average Water Available for Injection (acft/yr)	Max. Monthly Surface Water Use (acft/mo)	Max. Monthly Ground Water Use (acft/mo)	Max. Monthly Water Available for Injection (acft/mo)
1990	5	0	4568	1247	212	468	763	119
1990	10	0	4962	852	1161	763	763	564
1990	10	10000	4962	852	2111	763	763	587
2000	5	0	4812	3781	63	468	1127	77
2000	10	0	5605	2988	791	936	1127	519
2000	10	10000	6602	1990	1144	936	1127	420
2010	5	0	4812	4830	63	468	1264	77
2010	10	0	5663	3980	733	936	1264	519
2010	10	10000	7089	2550	826	936	1264	357
2020	5	0	4812	5771	63	468	1387	77
2020	10	0	5698	4885	697	936	1387	519
2020	10	10000	7439	3139	598	936	1387	301
2030	5	0	4812	6957	63	468	1543	77
2030	10	0	5733	6037	663	936	1543	519
2030	10	10000	7826	3937	346	936	1543	229
2040	5	0	4812	8121	63	468	1695	77
2040	10	0	5743	7190	653	936	1695	519
2040	10	10000	8054	4872	191	936	1695	160
2050	5	0	4812	9515	63	468	1878	77
2050	10	0	5749	8578	647	936	1878	519
2050	10	10000	8266	6052	49	936	1878	76

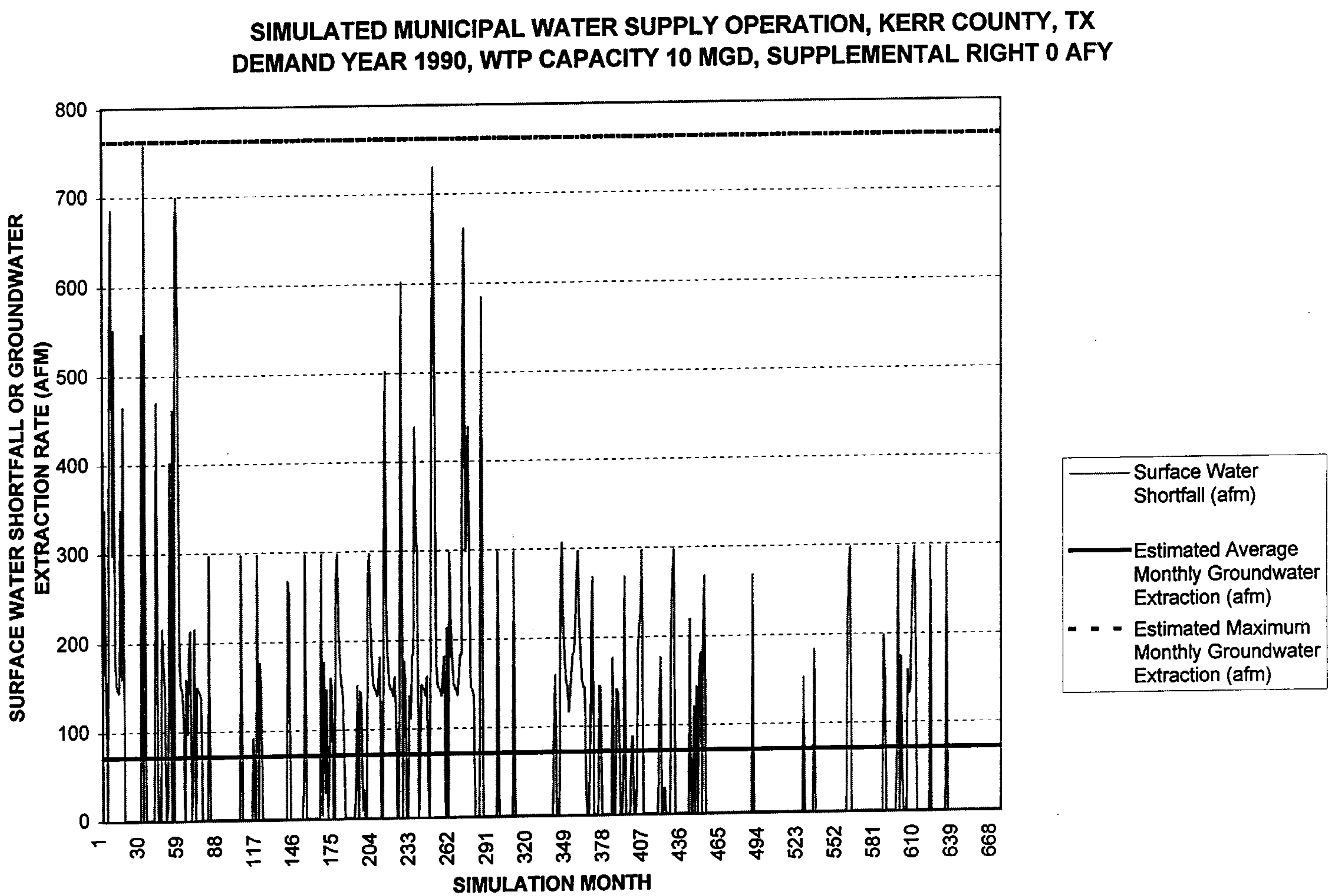
DETAILED MODEL OUTPUT

SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 1990, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY

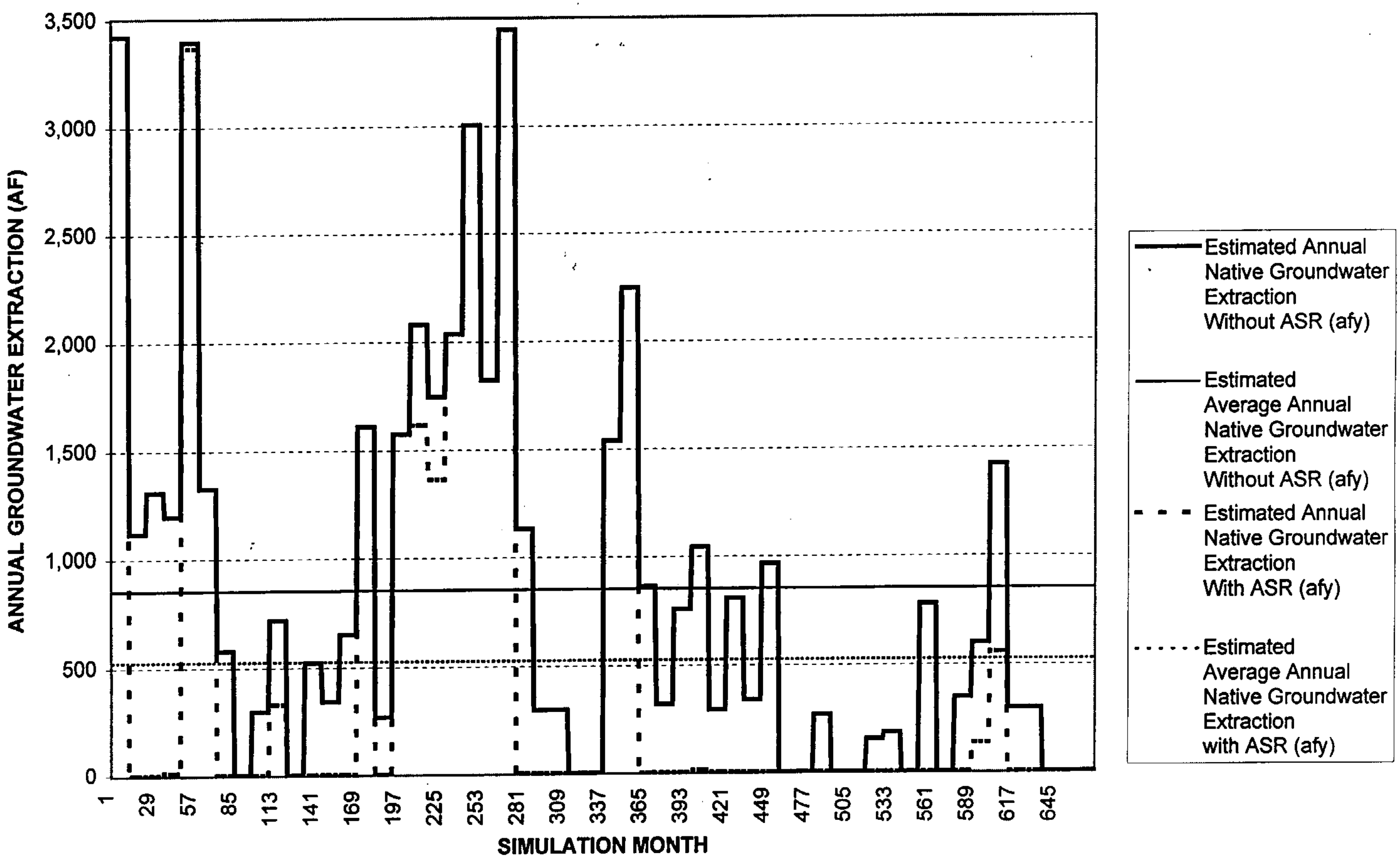


POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS DEMAND YEAR 1990, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY

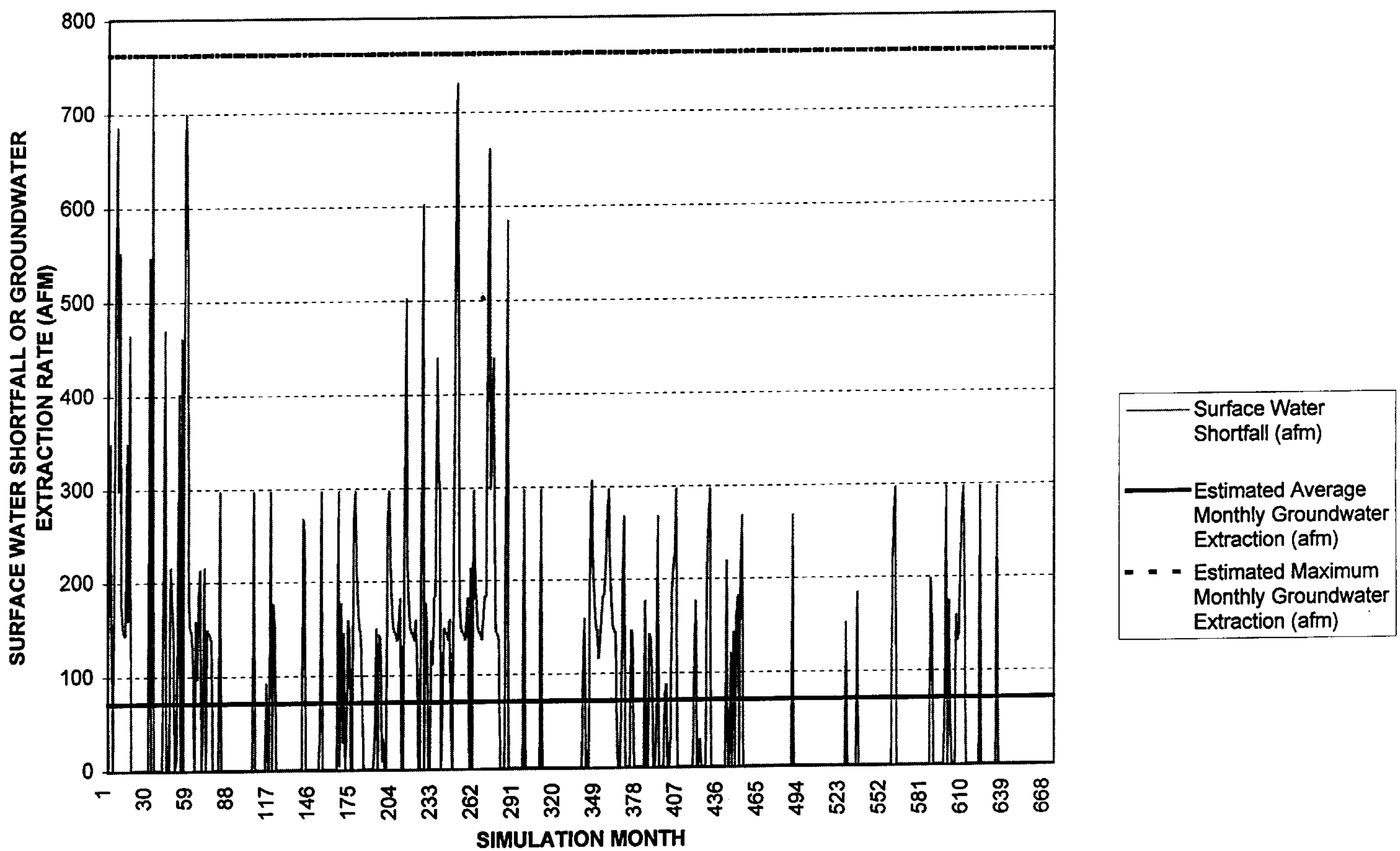


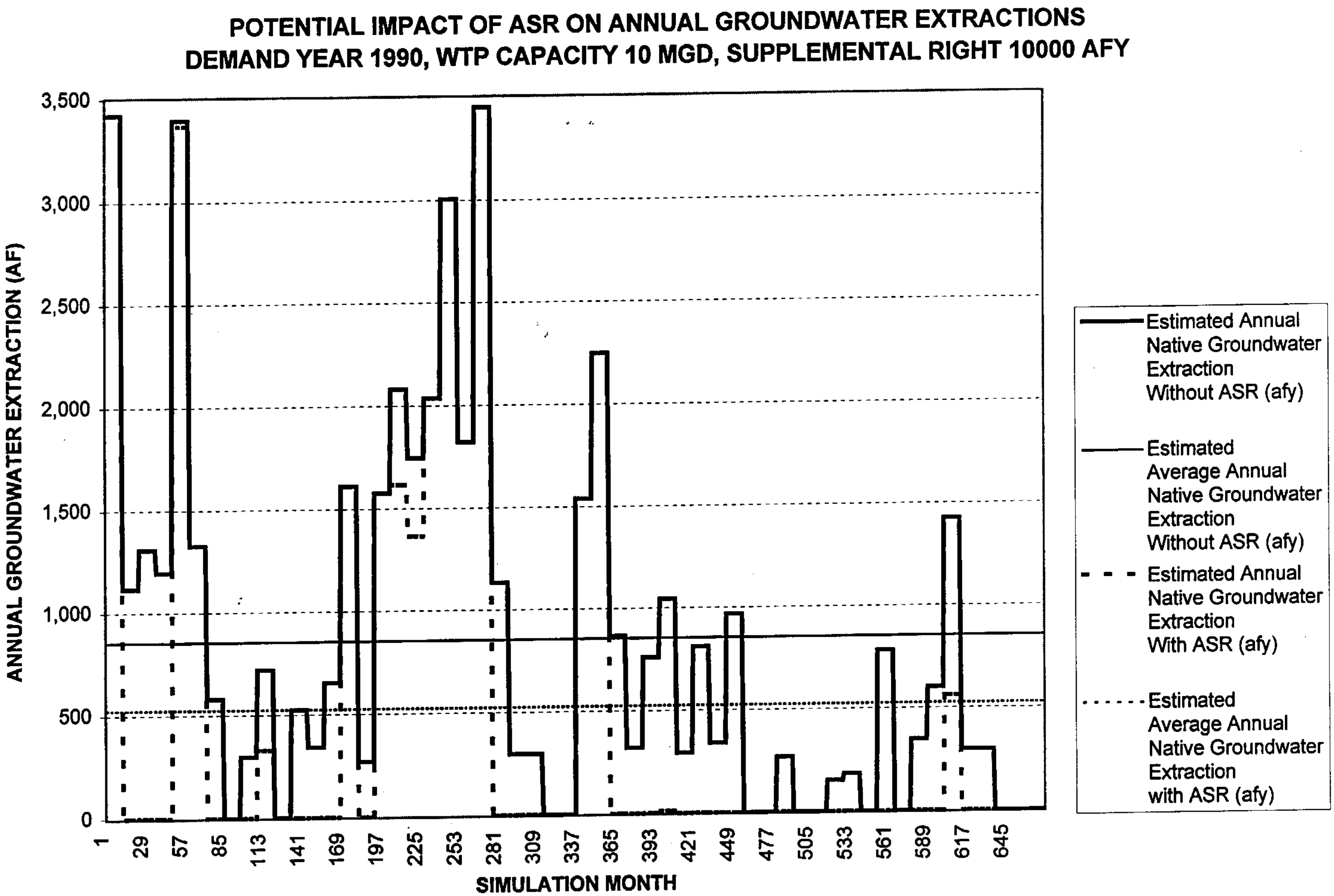

SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 1990, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY
SURFACE WATER SHORTFALL OR GROUNDWATER EXTRACTION RATE (AFM)
800
700
600
500
400
300
200
100
0
1
30
59
88
117
146
175
204
233
262
291
320
349
378
407
436
465
494
523
552
581
610
639
668
SIMULATION MONTH
Surface Water Shortfall (afm)
Estimated Average Monthly Groundwater Extraction (afm)
Estimated Maximum Monthly Groundwater Extraction (afm)

POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS DEMAND YEAR 1990, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY

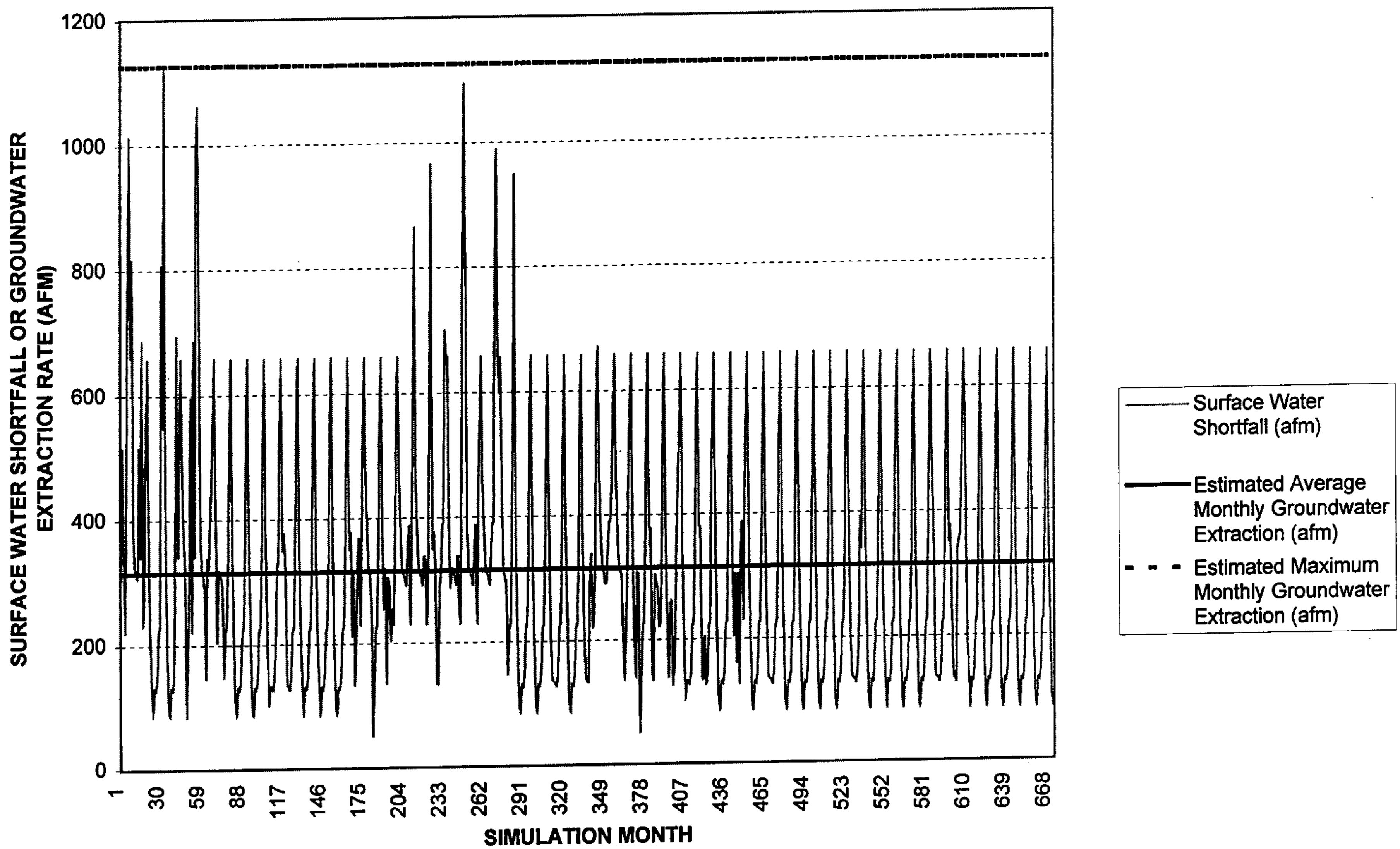


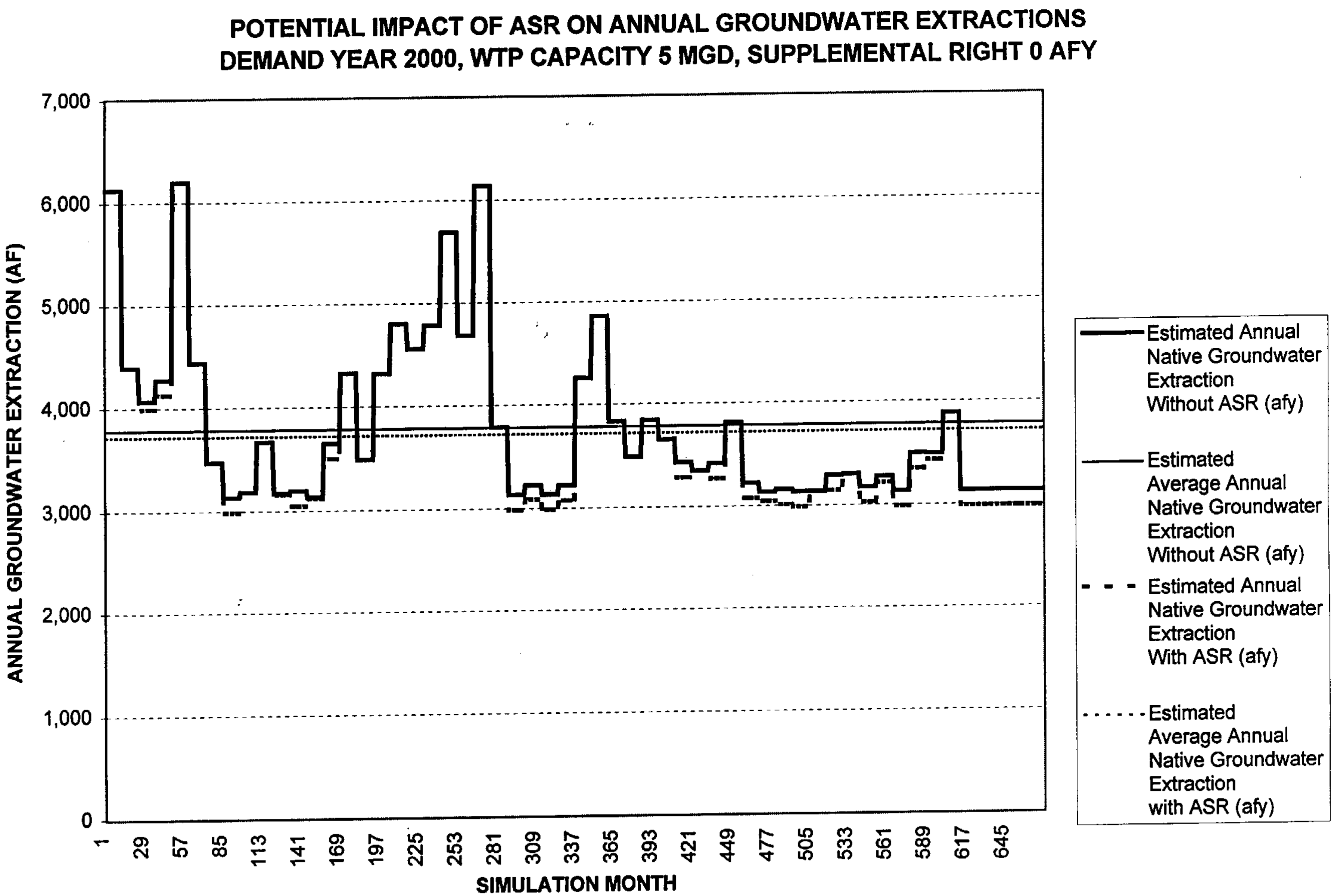
SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 1990, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY



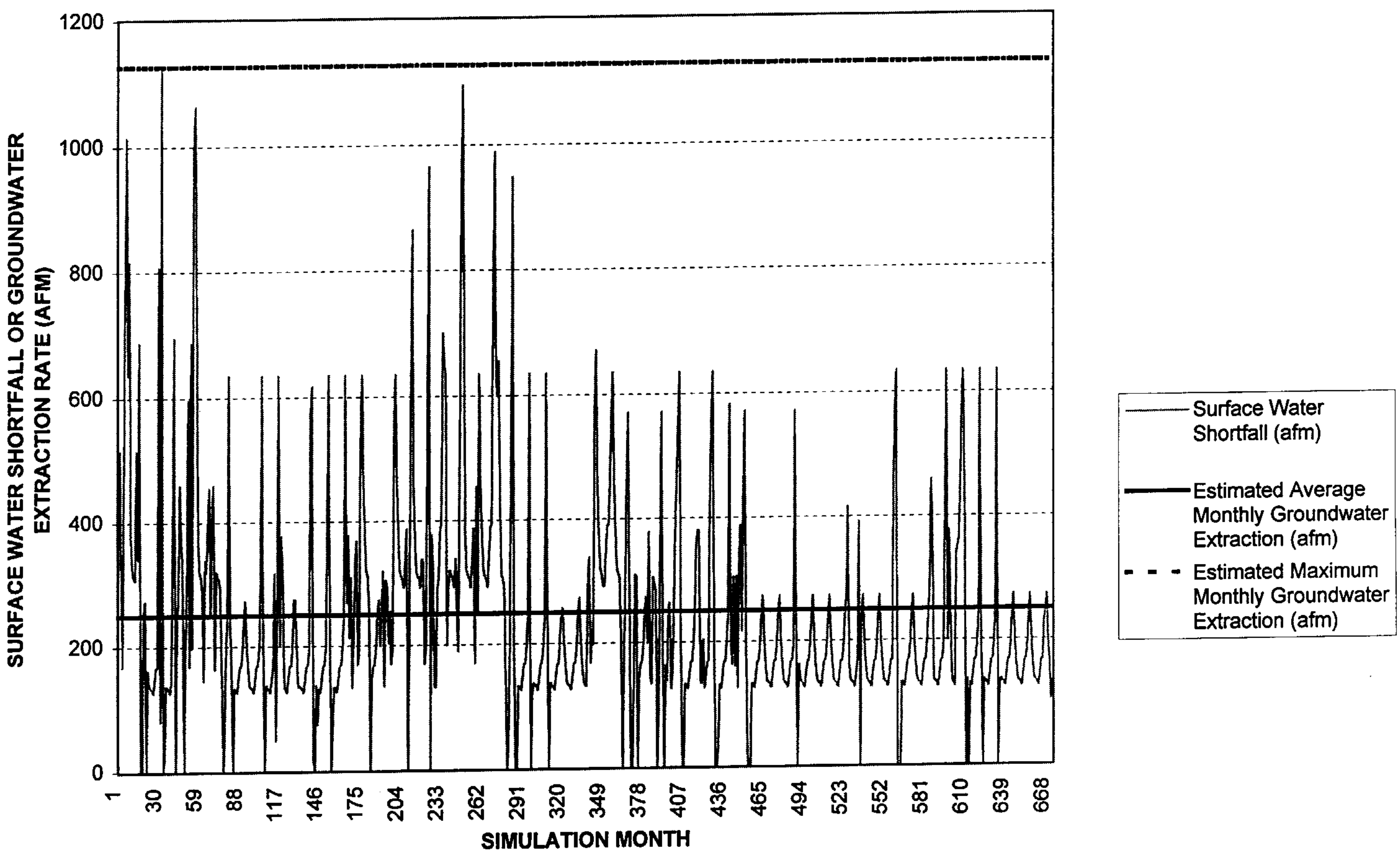

POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 1990, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY
ANNUAL GROUNDWATER EXTRACTION (AF)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1
29
57
85
113
141
169
197
225
253
281
309
337
365
393
421
449
477
505
533
561
589
617
645
SIMULATION MONTH
Estimated Annual Native Groundwater Extraction Without ASR (afy)
Estimated Average Annual Native Groundwater Extraction Without ASR (afy)
Estimated Annual Native Groundwater Extraction With ASR (afy)
Estimated Average Annual Native Groundwater Extraction with ASR (afy)

SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2000, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY

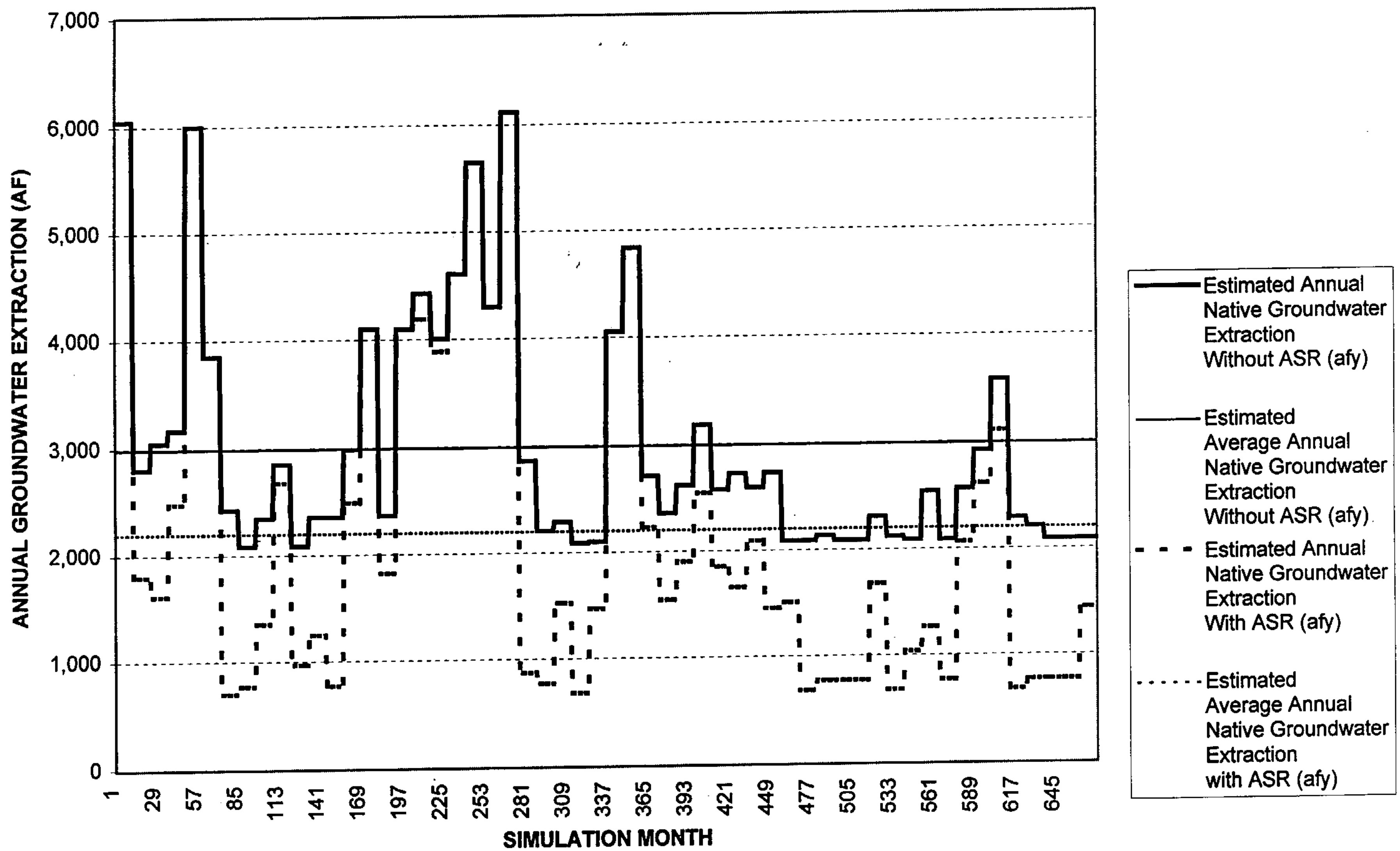



POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2000, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY
ANNUAL GROUNDWATER EXTRACTION (AF)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1
29
57
85
113
141
169
197
225
253
281
309
337
365
393
421
449
477
505
533
561
589
617
645
SIMULATION MONTH
Estimated Annual Native Groundwater Extraction Without ASR (afy)
Estimated Average Annual Native Groundwater Extraction Without ASR (afy)
Estimated Annual Native Groundwater Extraction With ASR (afy)
Estimated Average Annual Native Groundwater Extraction with ASR (afy)

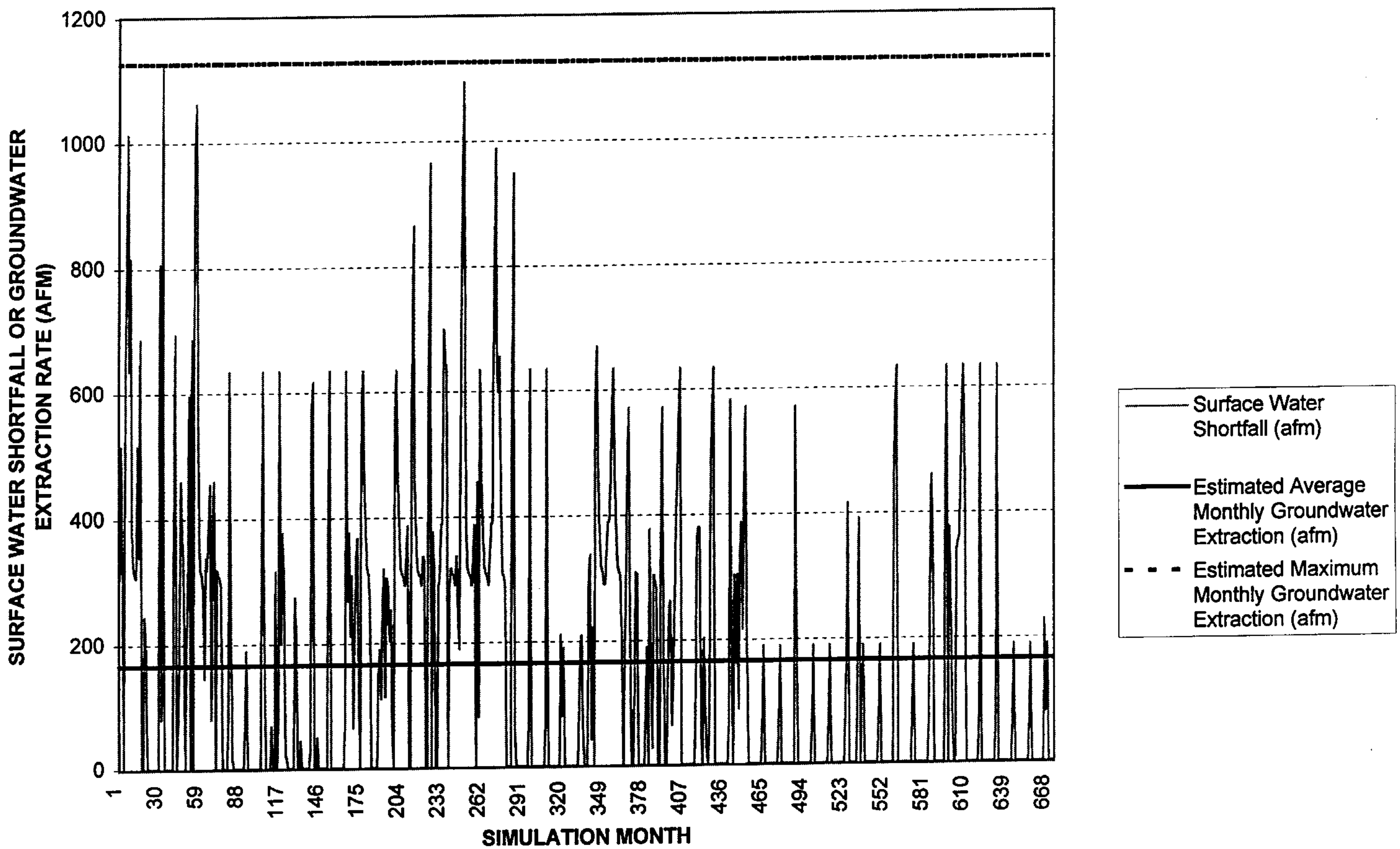
SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2000, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY

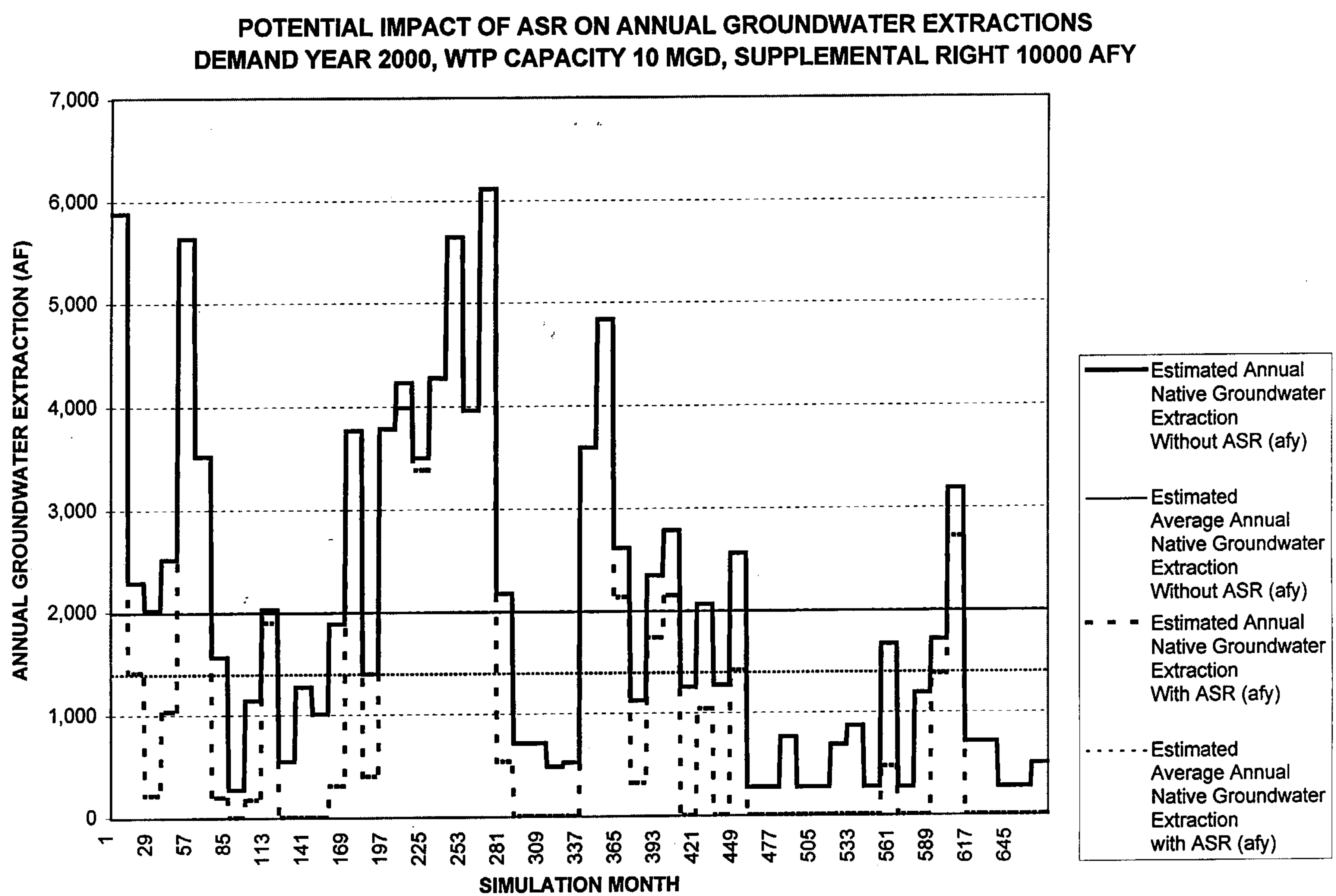


POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS DEMAND YEAR 2000, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY

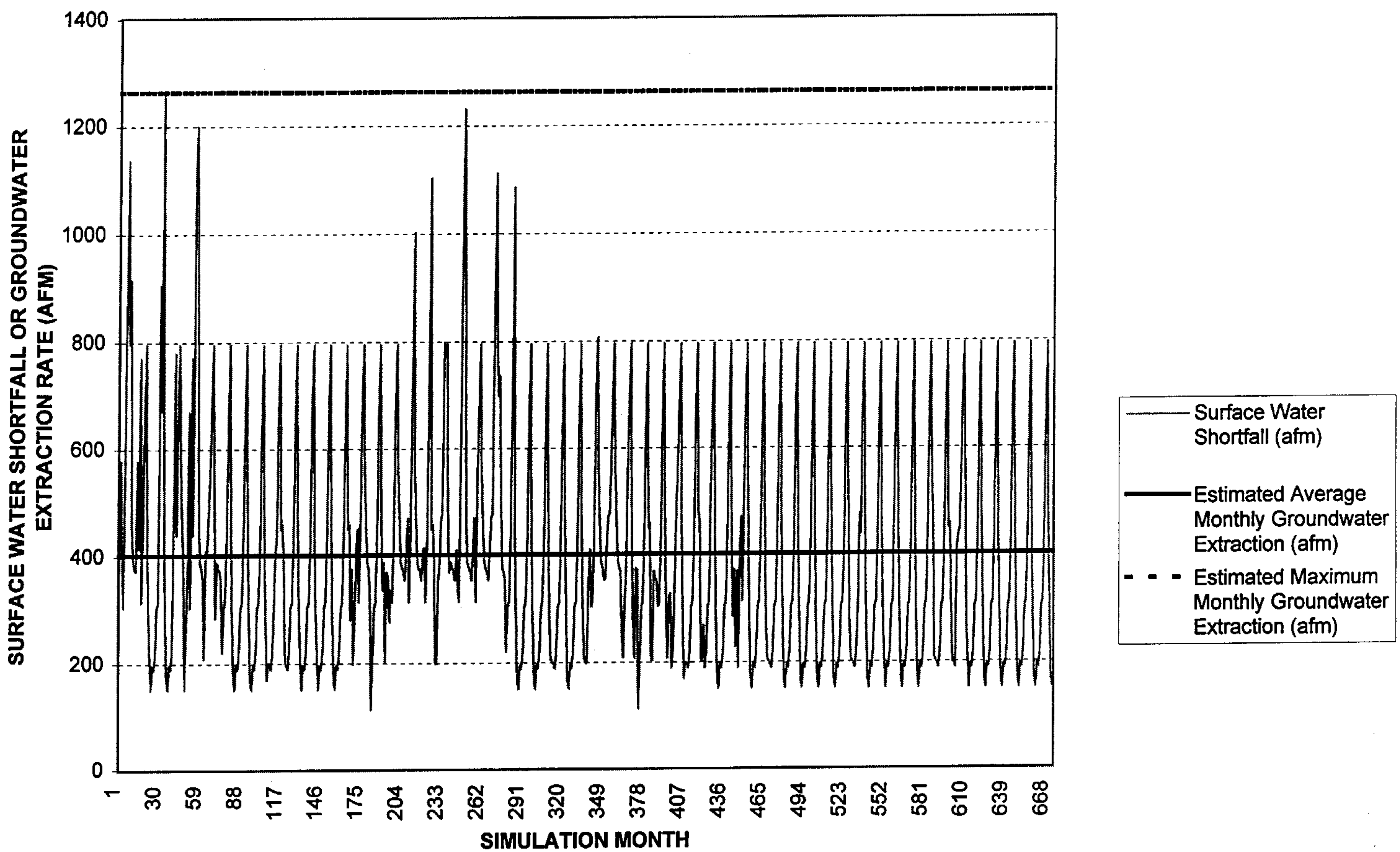


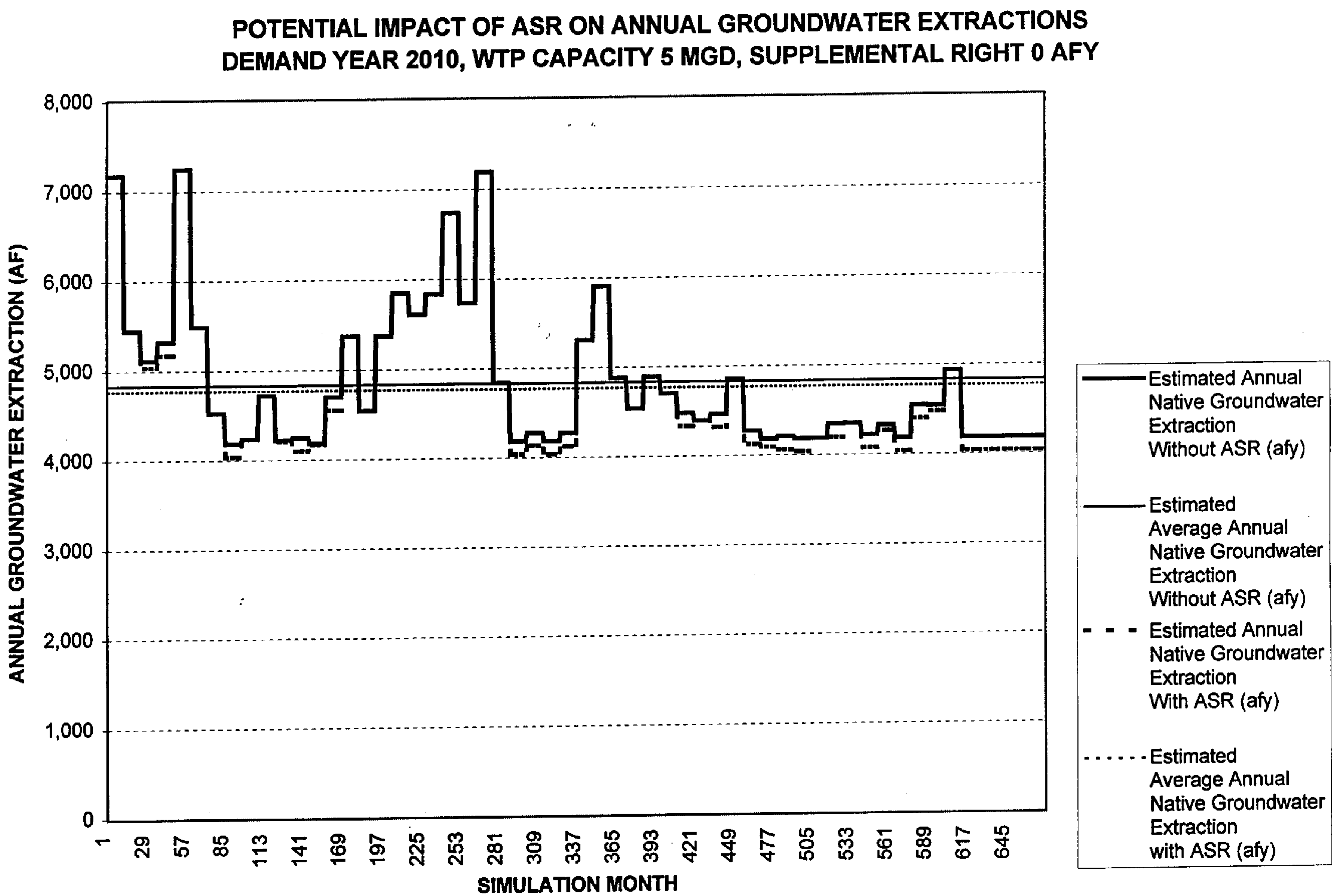
SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2000, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY




POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2000, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY
ANNUAL GROUNDWATER EXTRACTION (AF)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1
29
57
85
113
141
169
197
225
253
281
309
337
365
393
421
449
477
505
533
561
589
617
645
SIMULATION MONTH
Estimated Annual Native Groundwater Extraction Without ASR (afy)
Estimated Average Annual Native Groundwater Extraction Without ASR (afy)
Estimated Annual Native Groundwater Extraction With ASR (afy)
Estimated Average Annual Native Groundwater Extraction with ASR (afy)

SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2010, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY




POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2010, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY
ANNUAL GROUNDWATER EXTRACTION (AF)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1
29
57
85
113
141
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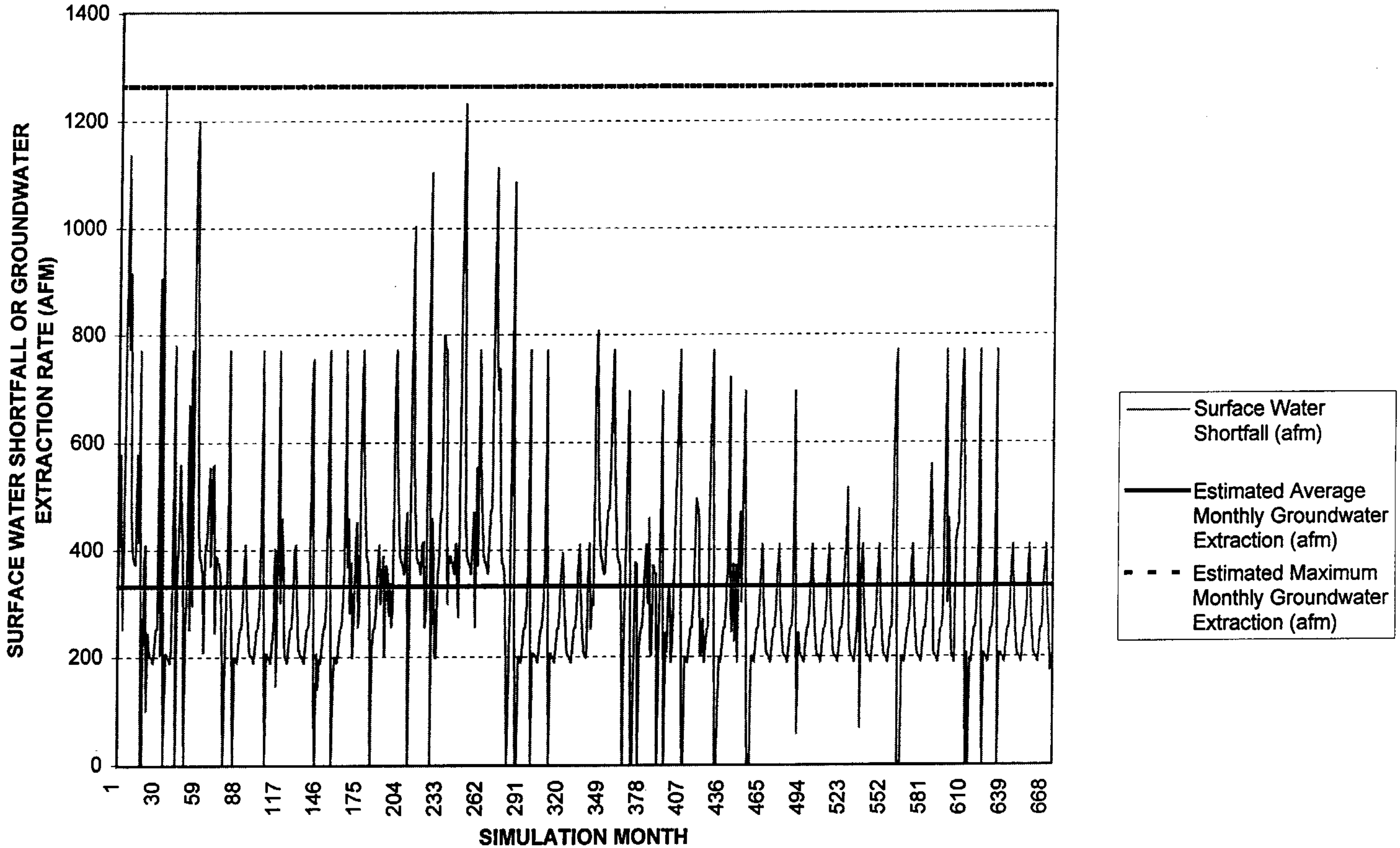
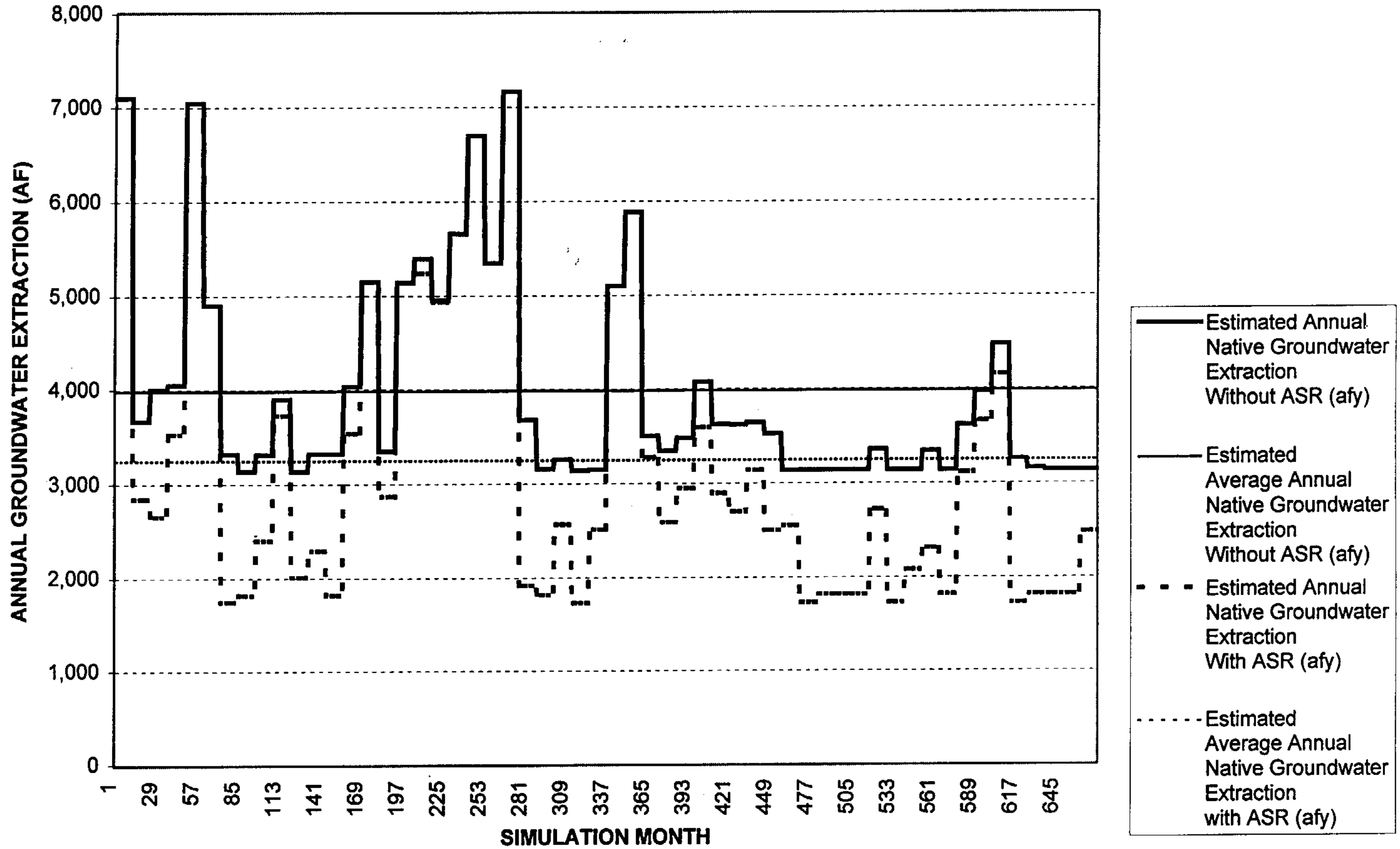
533
561
589
617
645
SIMULATION MONTH
Estimated Annual Native Groundwater Extraction Without ASR (afy)
Estimated Average Annual Native Groundwater Extraction Without ASR (afy)
Estimated Annual Native Groundwater Extraction With ASR (afy)
Estimated Average Annual Native Groundwater Extraction with ASR (afy)

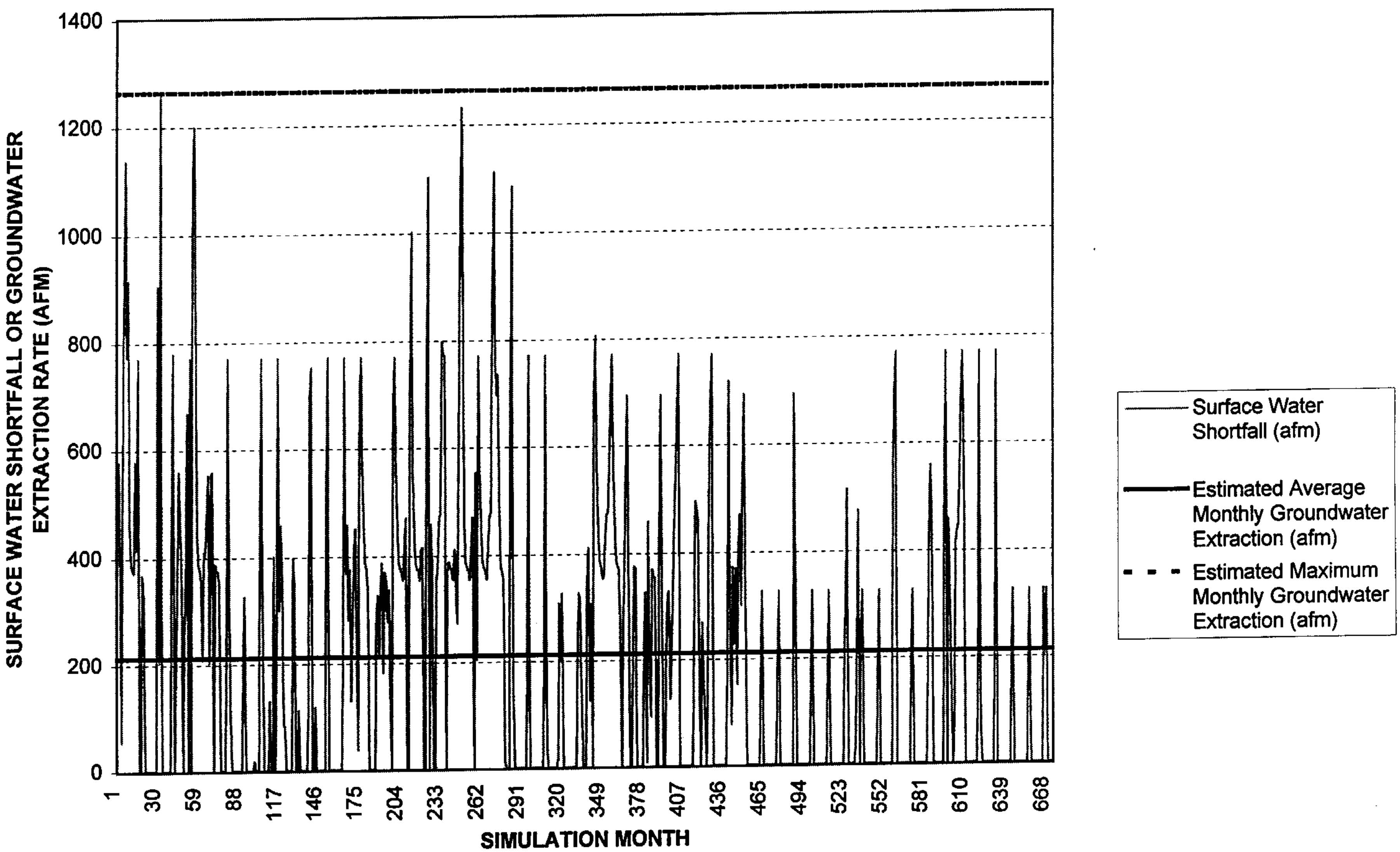
SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2010, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY



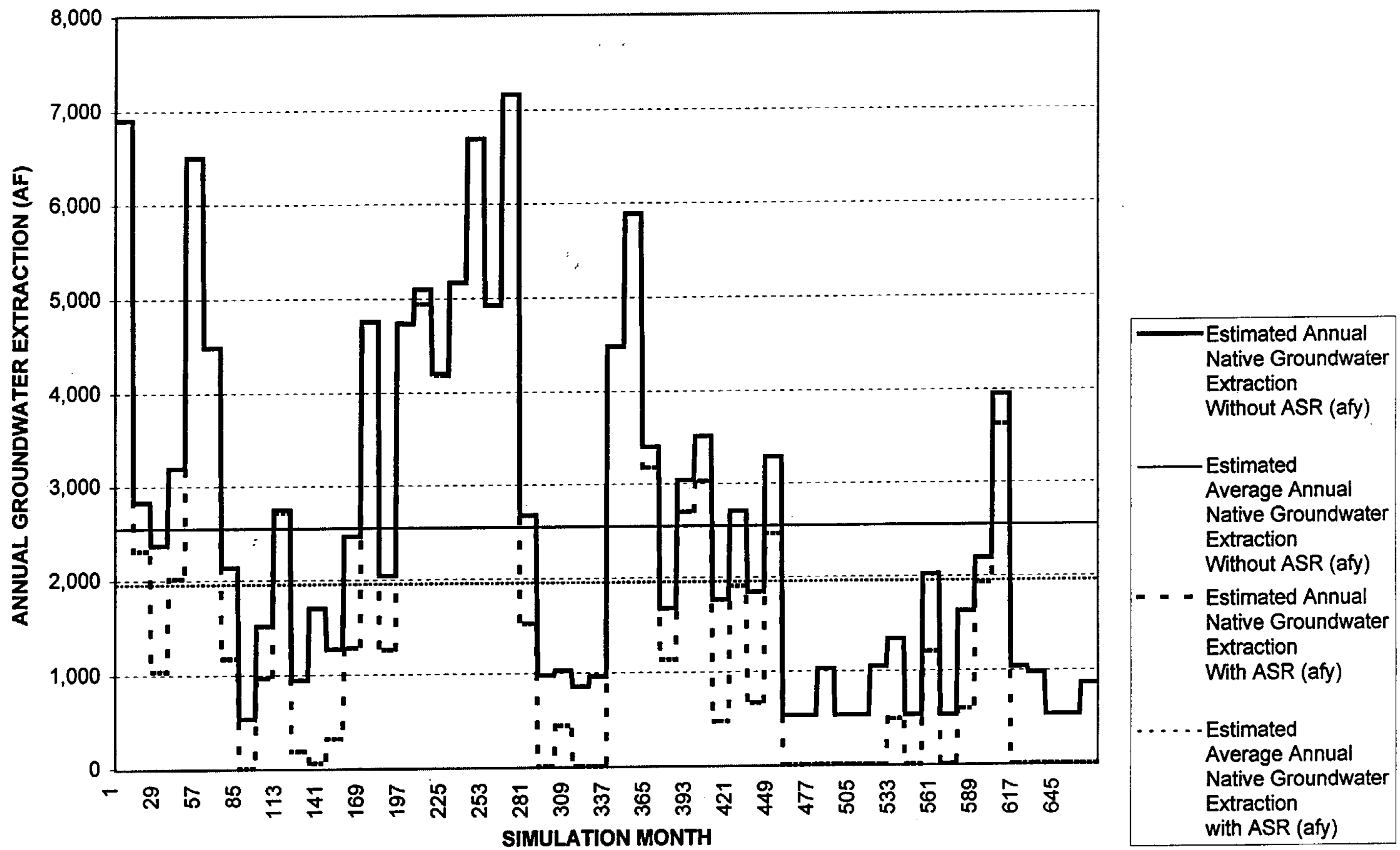
POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2010, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY



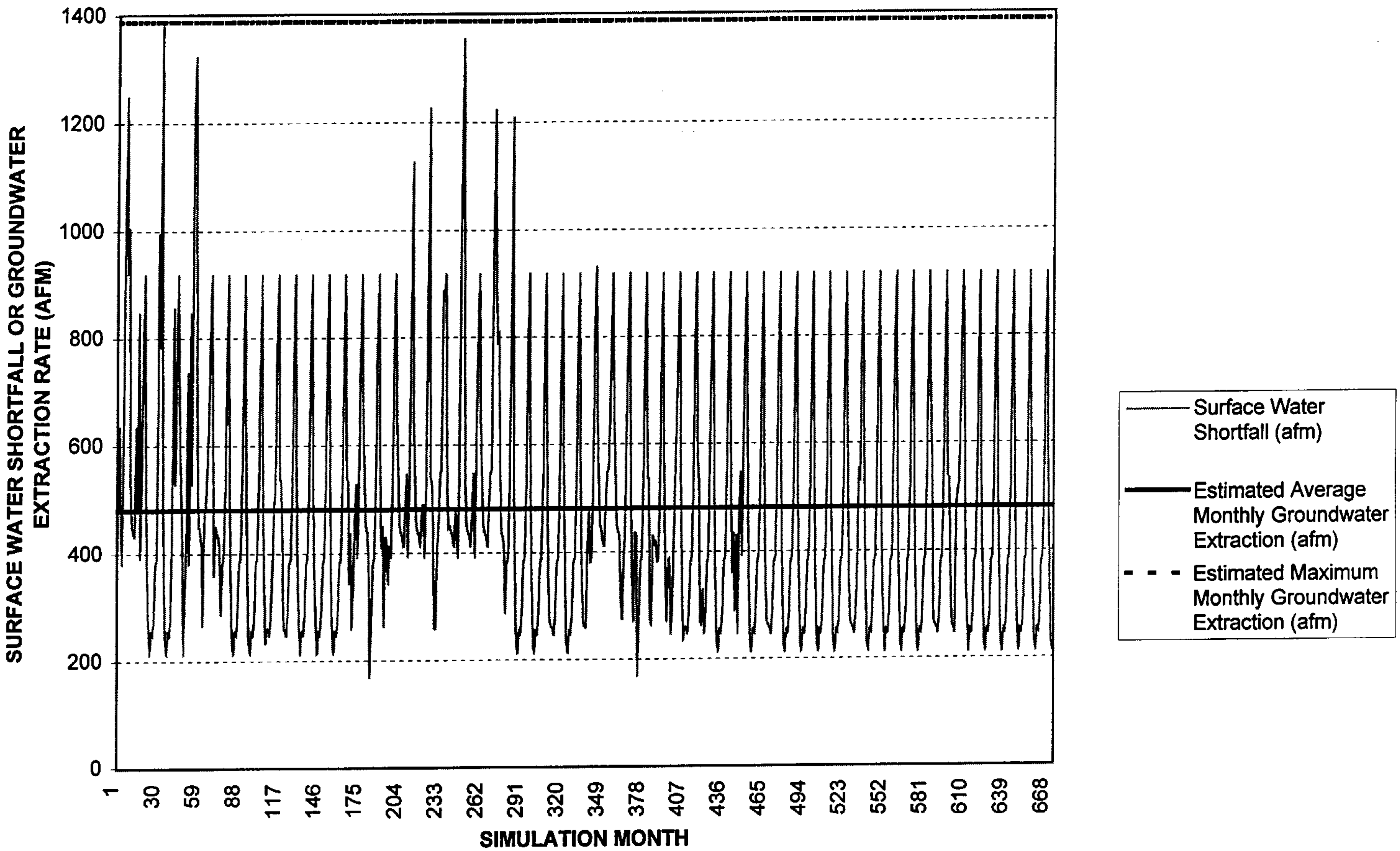
SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2010, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY



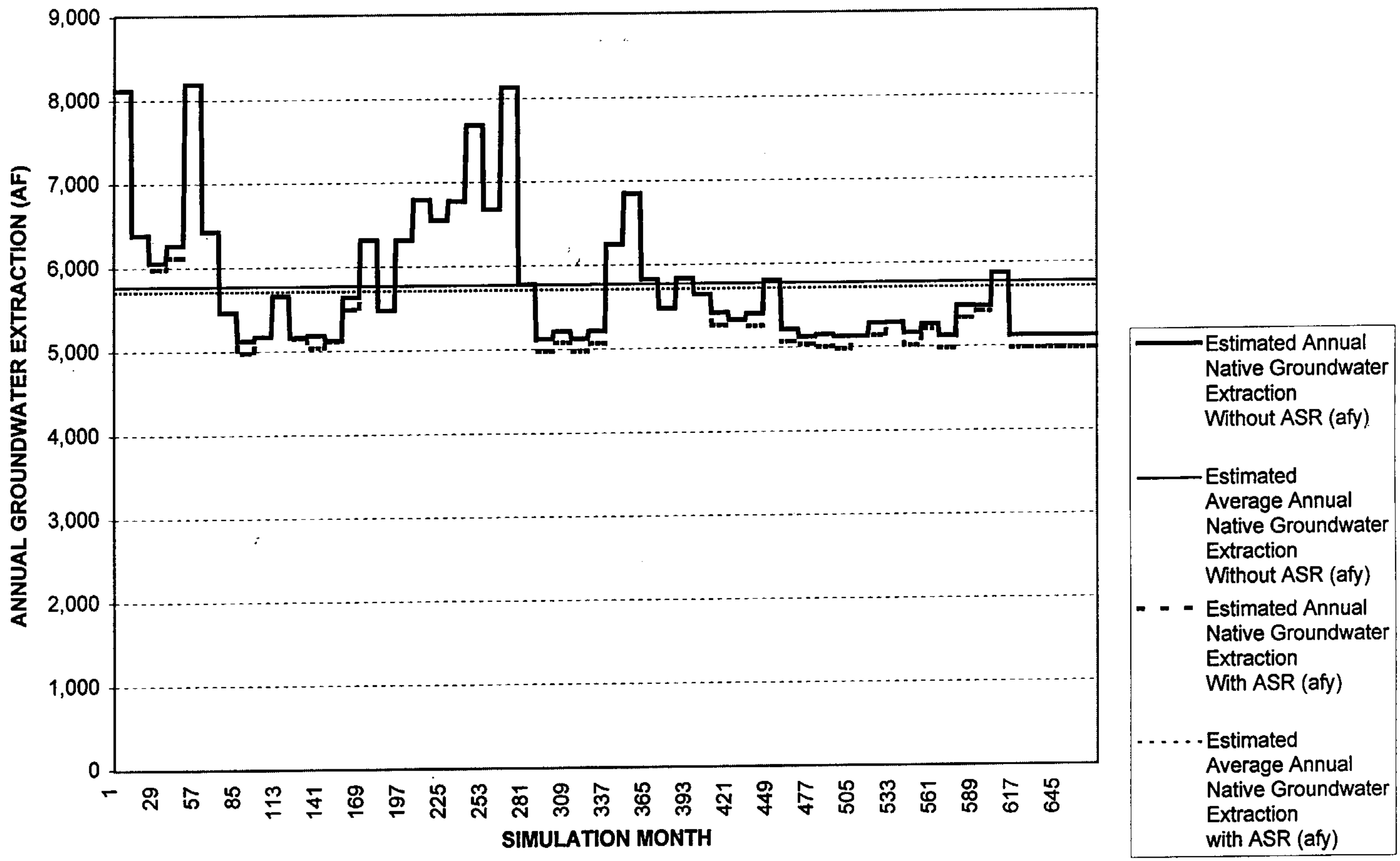
POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2010, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY

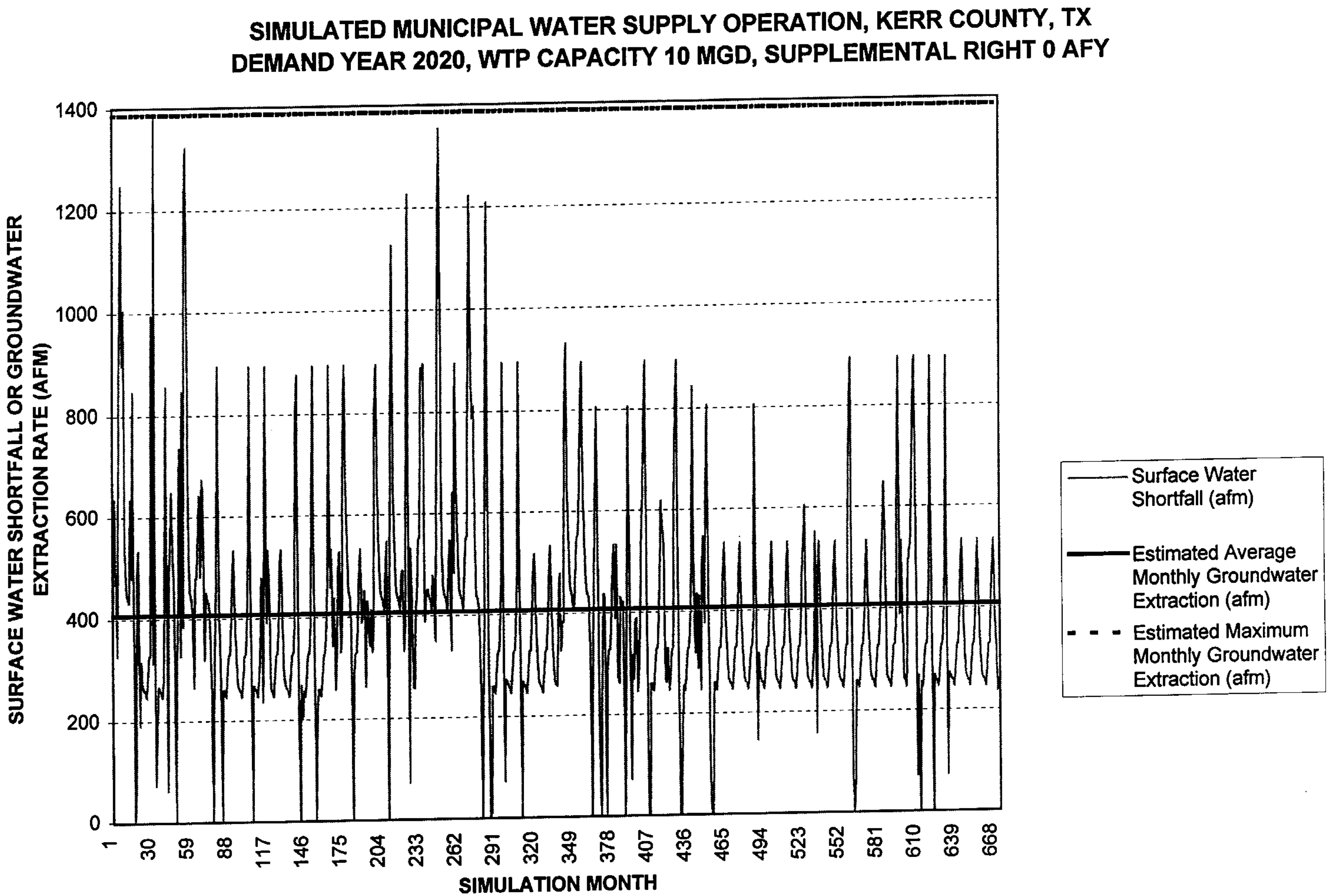


SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2020, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY

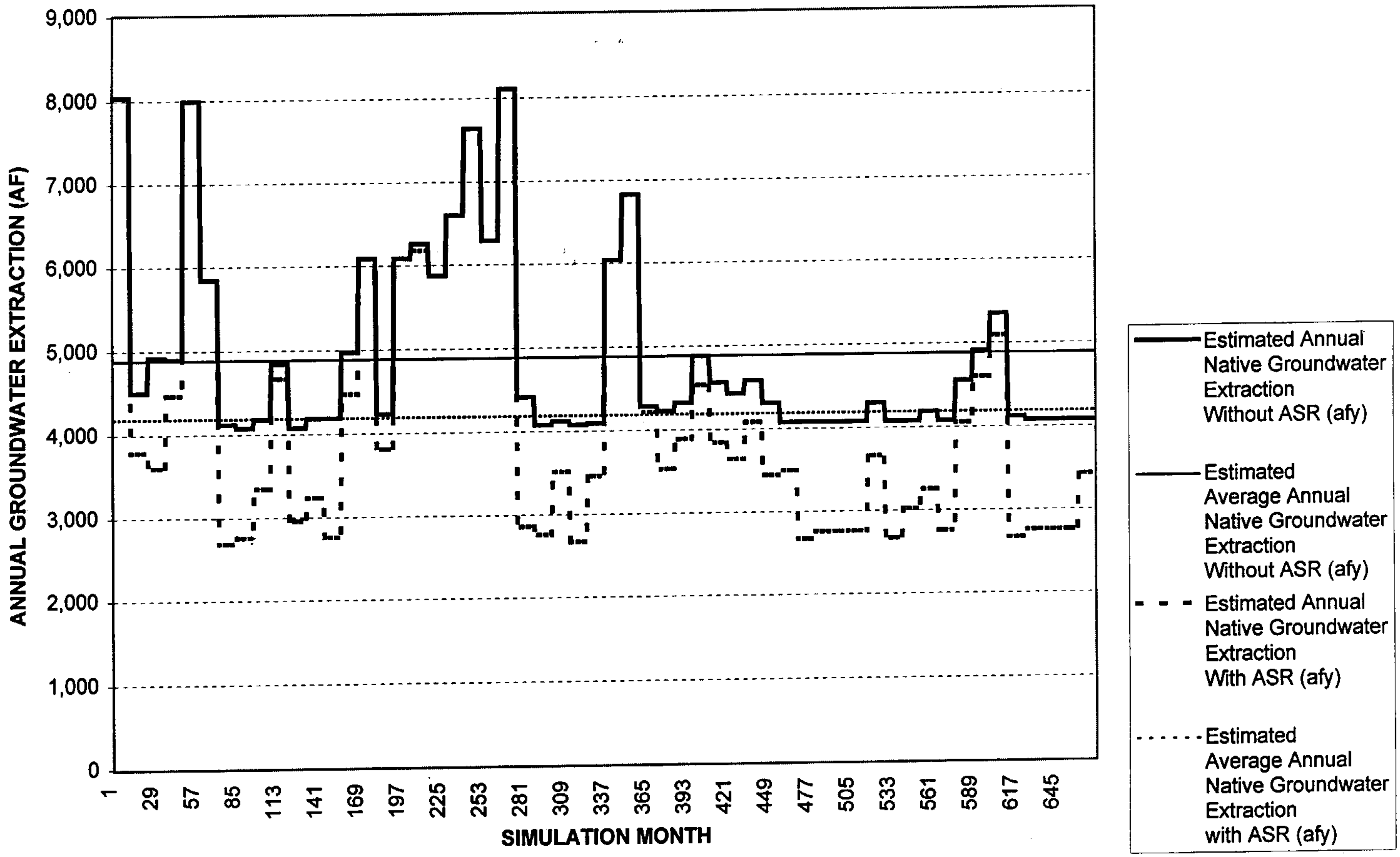


POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS DEMAND YEAR 2020, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY

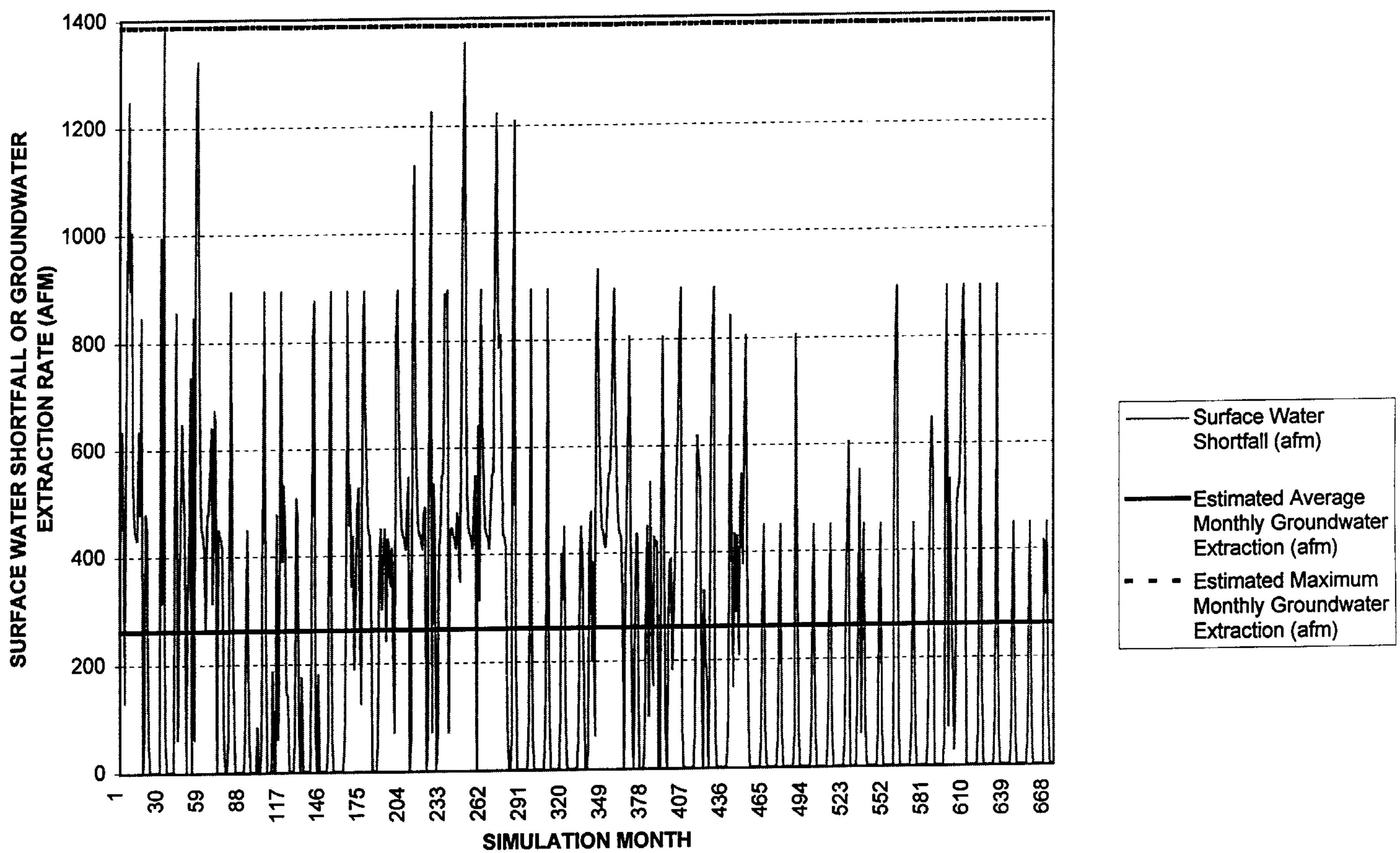



SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2020, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY
SURFACE WATER SHORTFALL OR GROUNDWATER EXTRACTION RATE (AFM)
1400
1200
1000
800
600
400
200
0
1
30
59
88
117
146
175
204
233
262
291
320
349
378
407
436
465
494
523
552
581
610
639
668
SIMULATION MONTH
Surface Water Shortfall (afm)
Estimated Average Monthly Groundwater Extraction (afm)
Estimated Maximum Monthly Groundwater Extraction (afm)

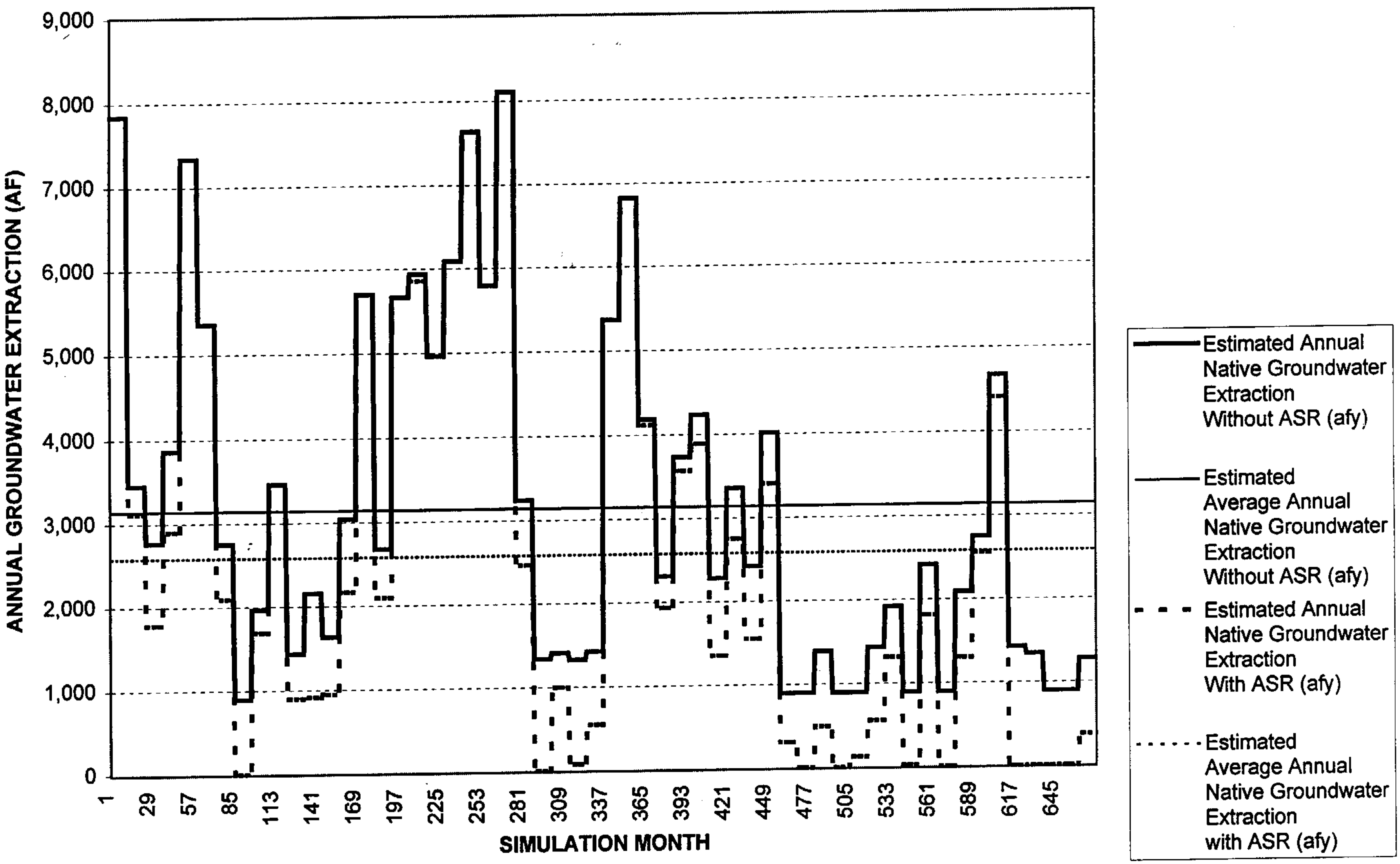
POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2020, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY



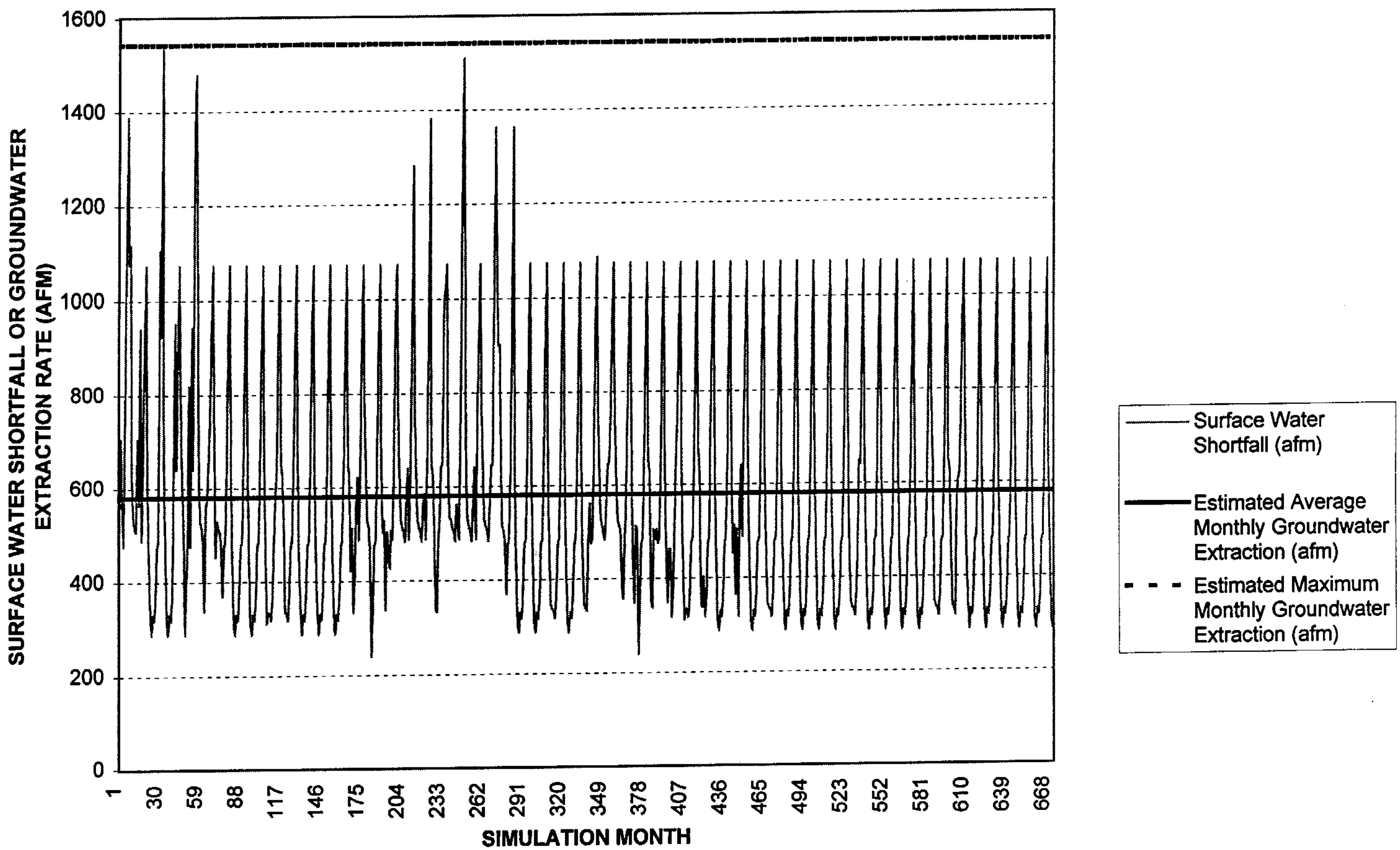
SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2020, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY



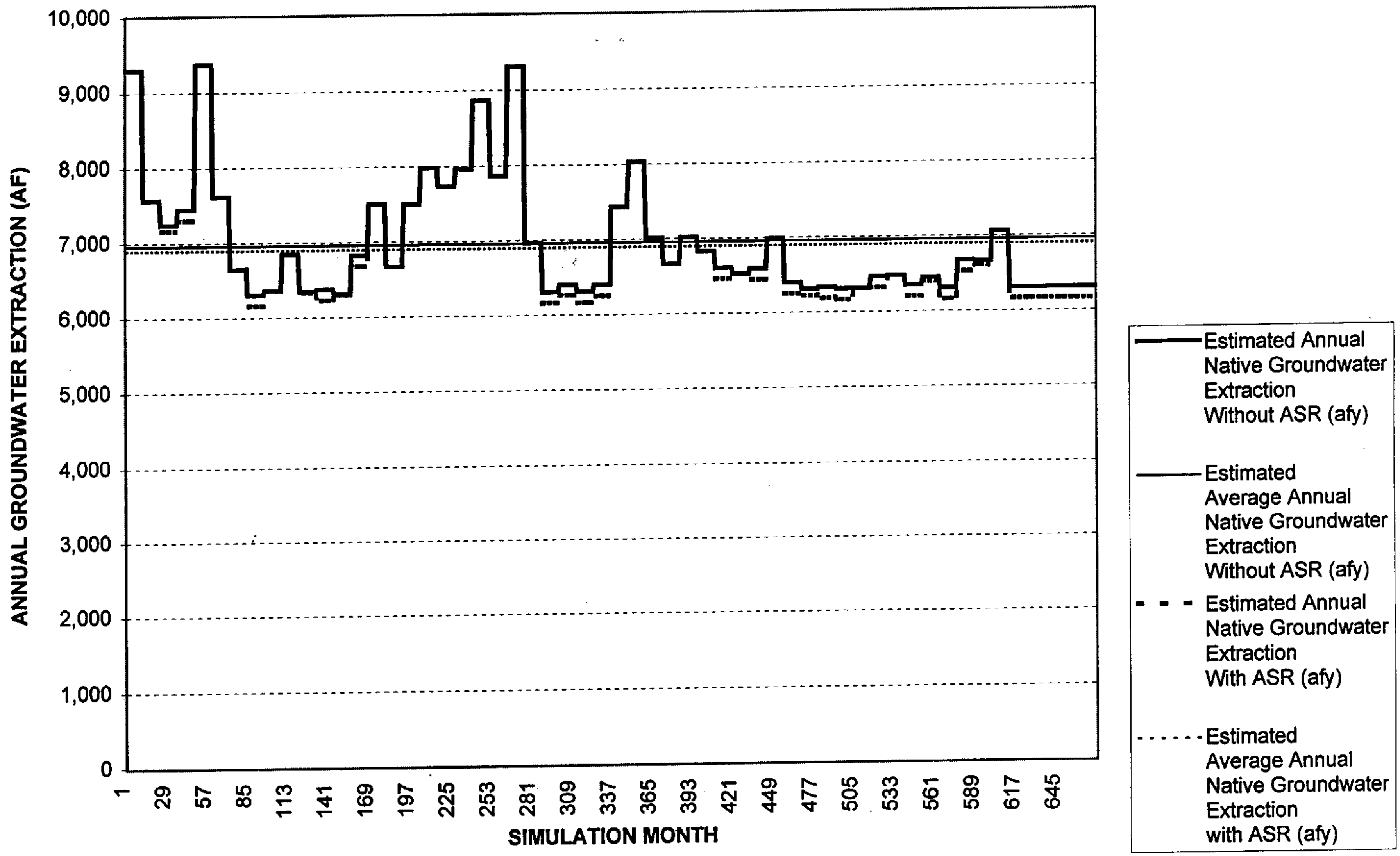
POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS DEMAND YEAR 2020, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY

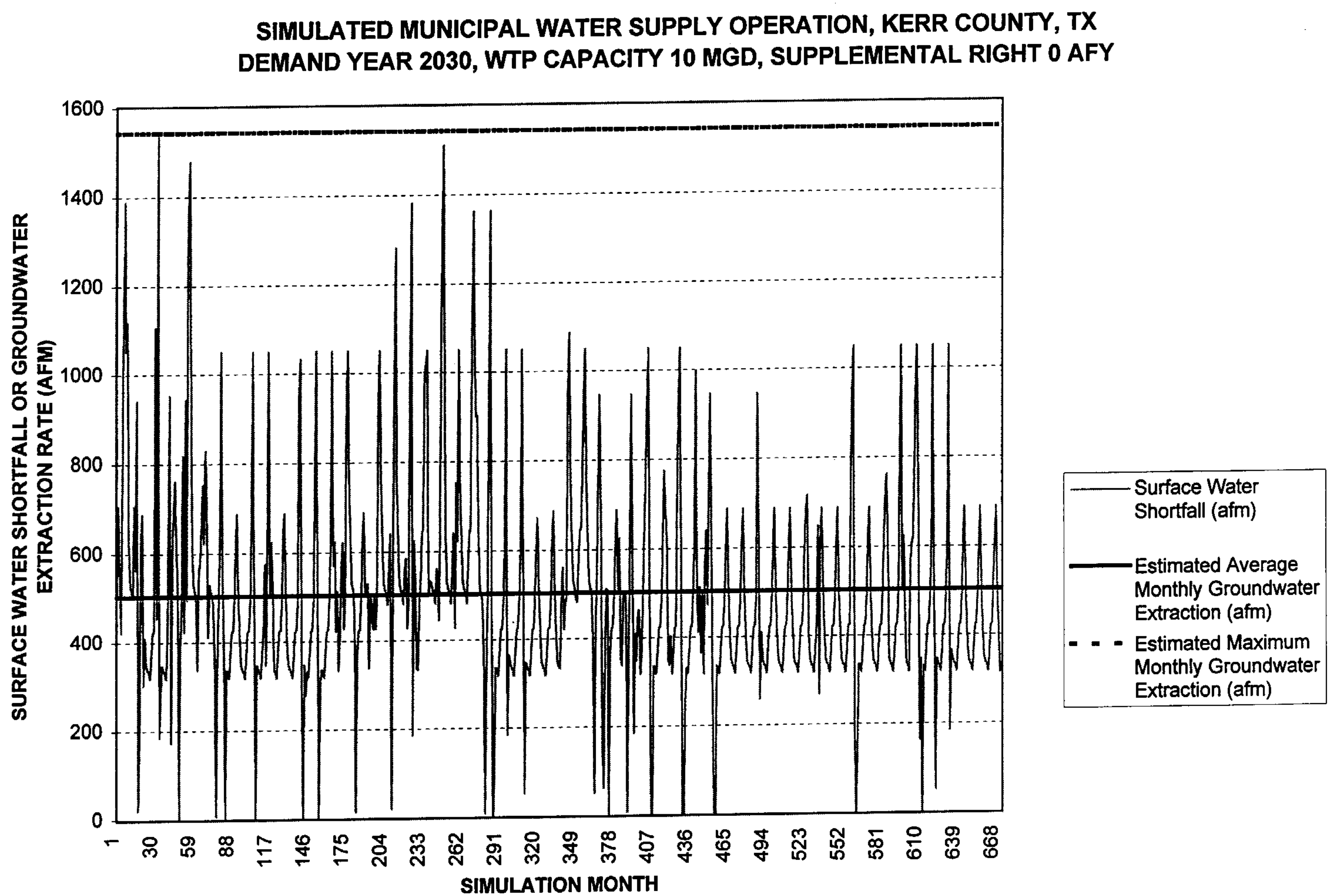


SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2030, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY

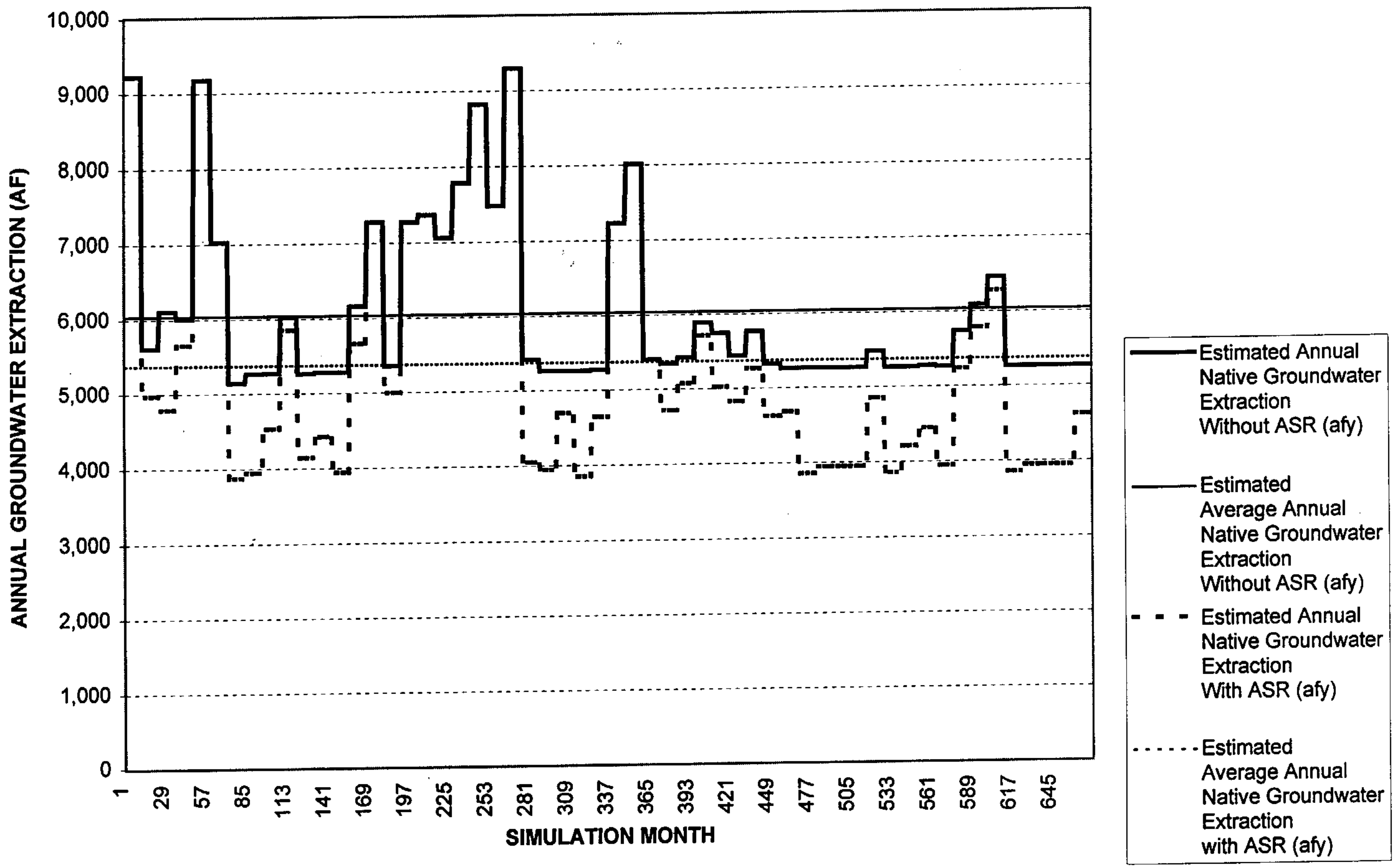


POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS DEMAND YEAR 2030, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY

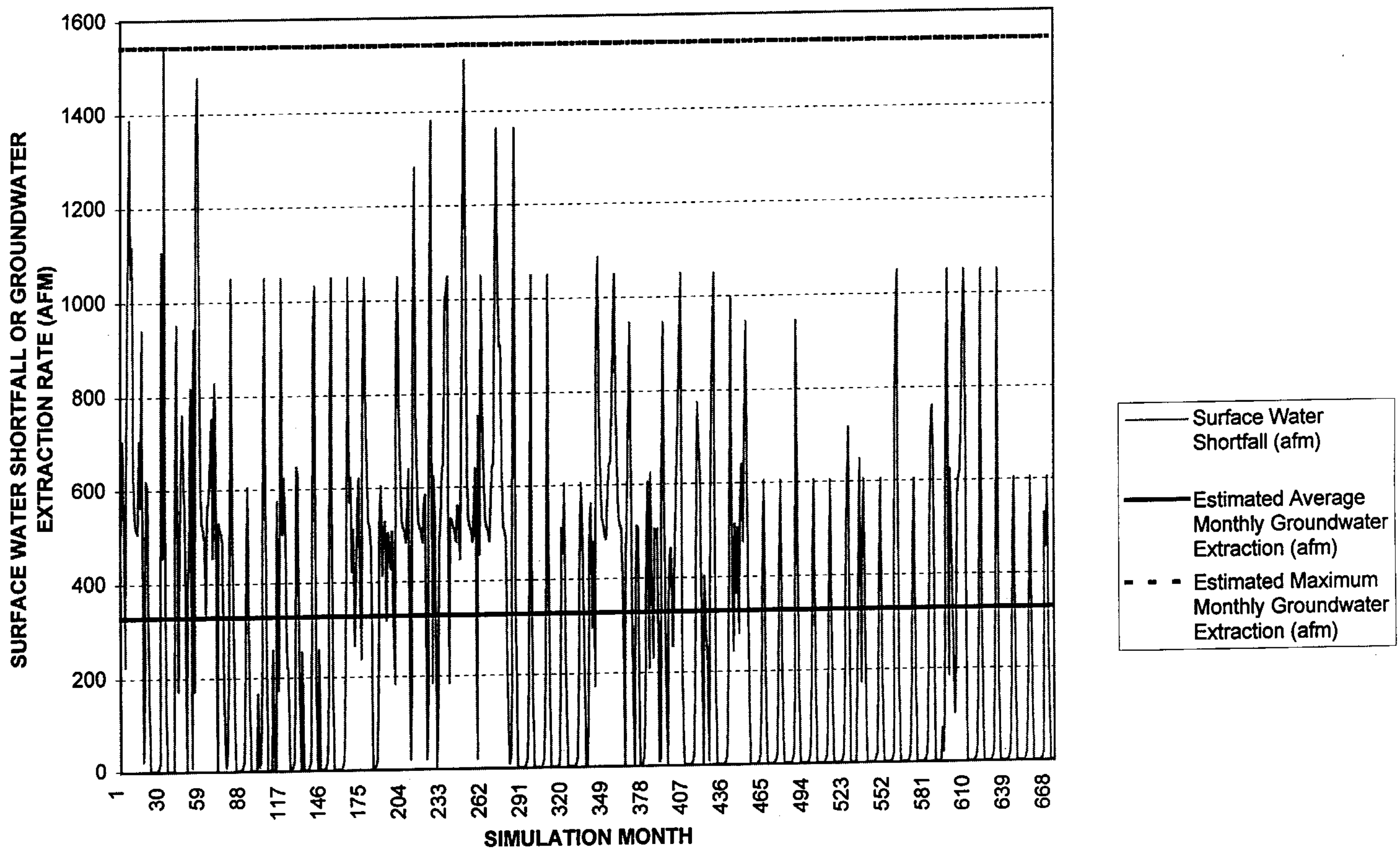



SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2030, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY
SURFACE WATER SHORTFALL OR GROUNDWATER EXTRACTION RATE (AFM)
0
200
400
600
800
1000
1200
1400
1600
1
30
59
88
117
146
175
204
233
262
291
320
349
378
407
436
465
494
523
552
581
610
639
668
SIMULATION MONTH
Surface Water Shortfall (afm)
Estimated Average Monthly Groundwater Extraction (afm)
Estimated Maximum Monthly Groundwater Extraction (afm)

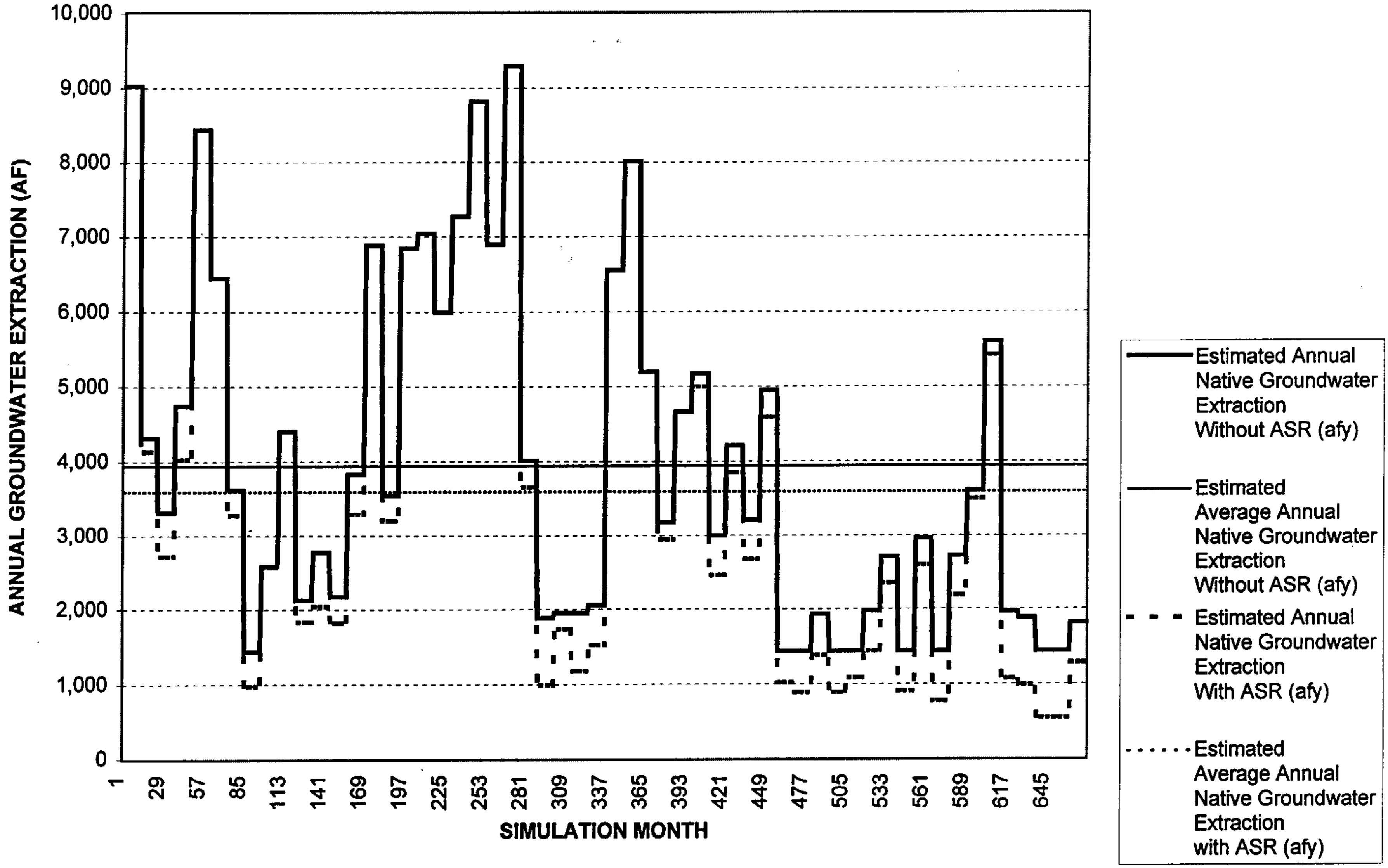
POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS DEMAND YEAR 2030, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY

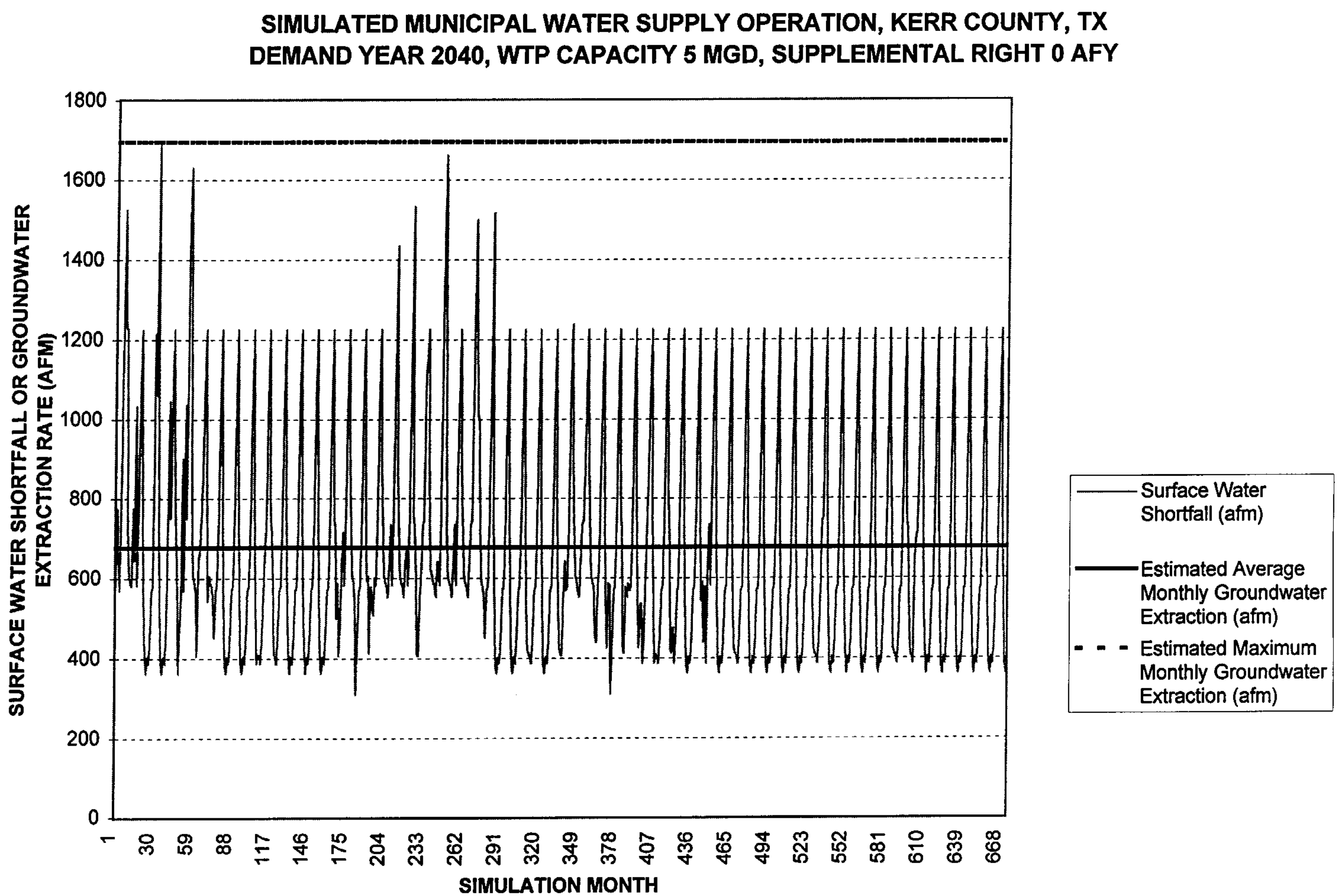


SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX DEMAND YEAR 2030, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY

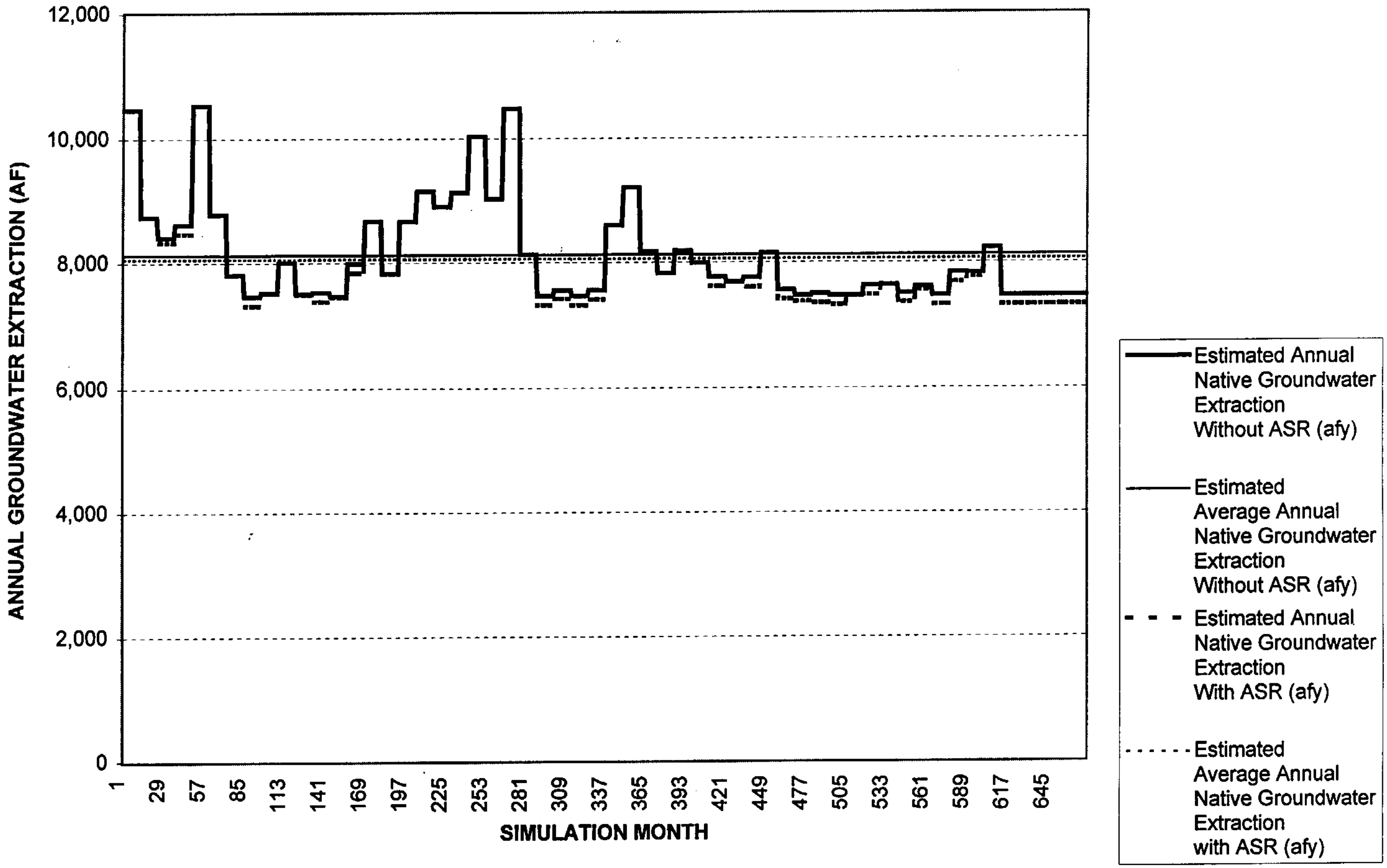


POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2030, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY

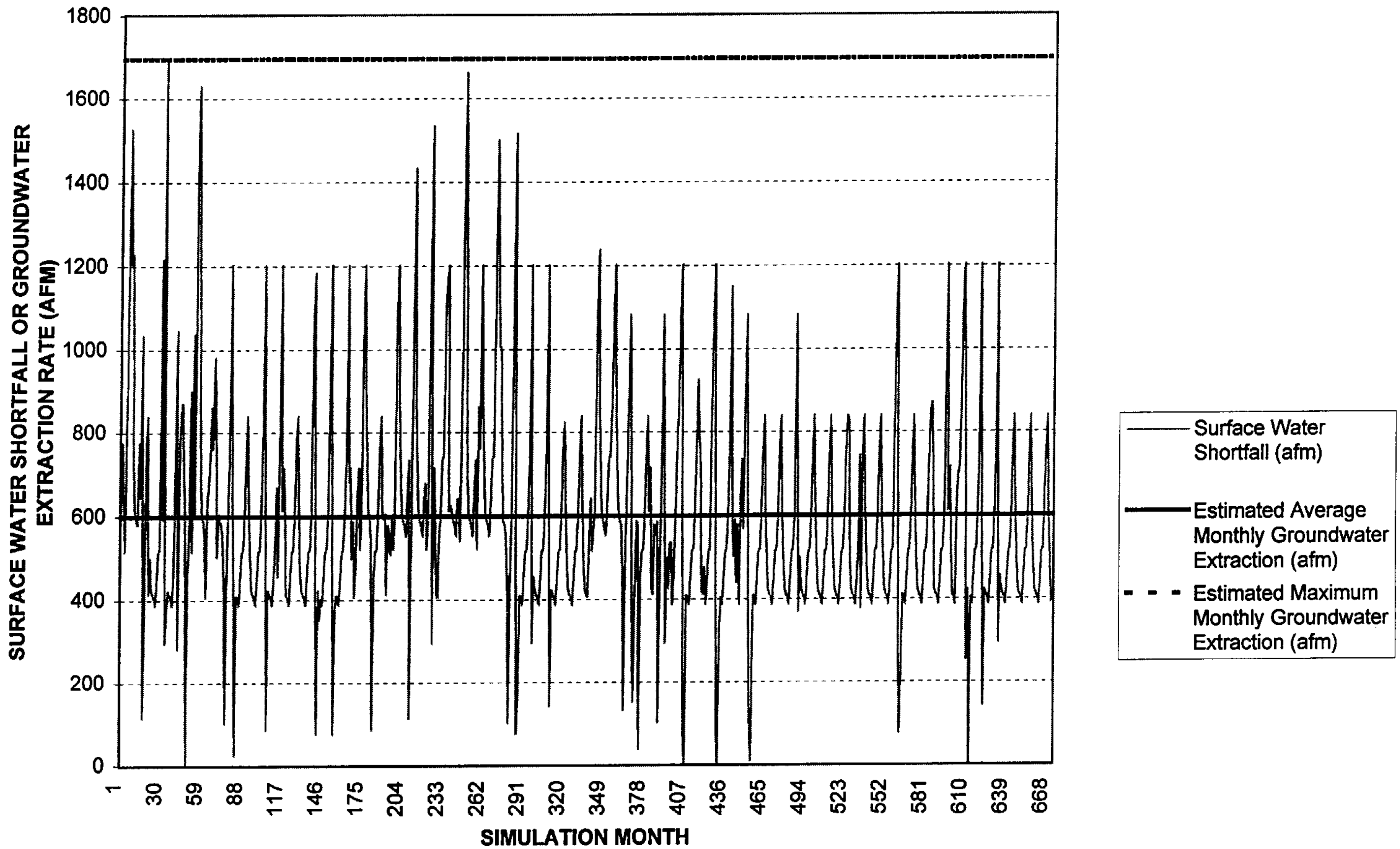



SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2040, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY
SURFACE WATER SHORTFALL OR GROUNDWATER EXTRACTION RATE (AFM)
0
200
400
600
800
1000
1200
1400
1600
1800
1
30
59
88
117
146
175
204
233
262
291
320
349
378
407
436
465
494
523
552
581
610
639
668
SIMULATION MONTH
Surface Water Shortfall (afm)
Estimated Average Monthly Groundwater Extraction (afm)
Estimated Maximum Monthly Groundwater Extraction (afm)

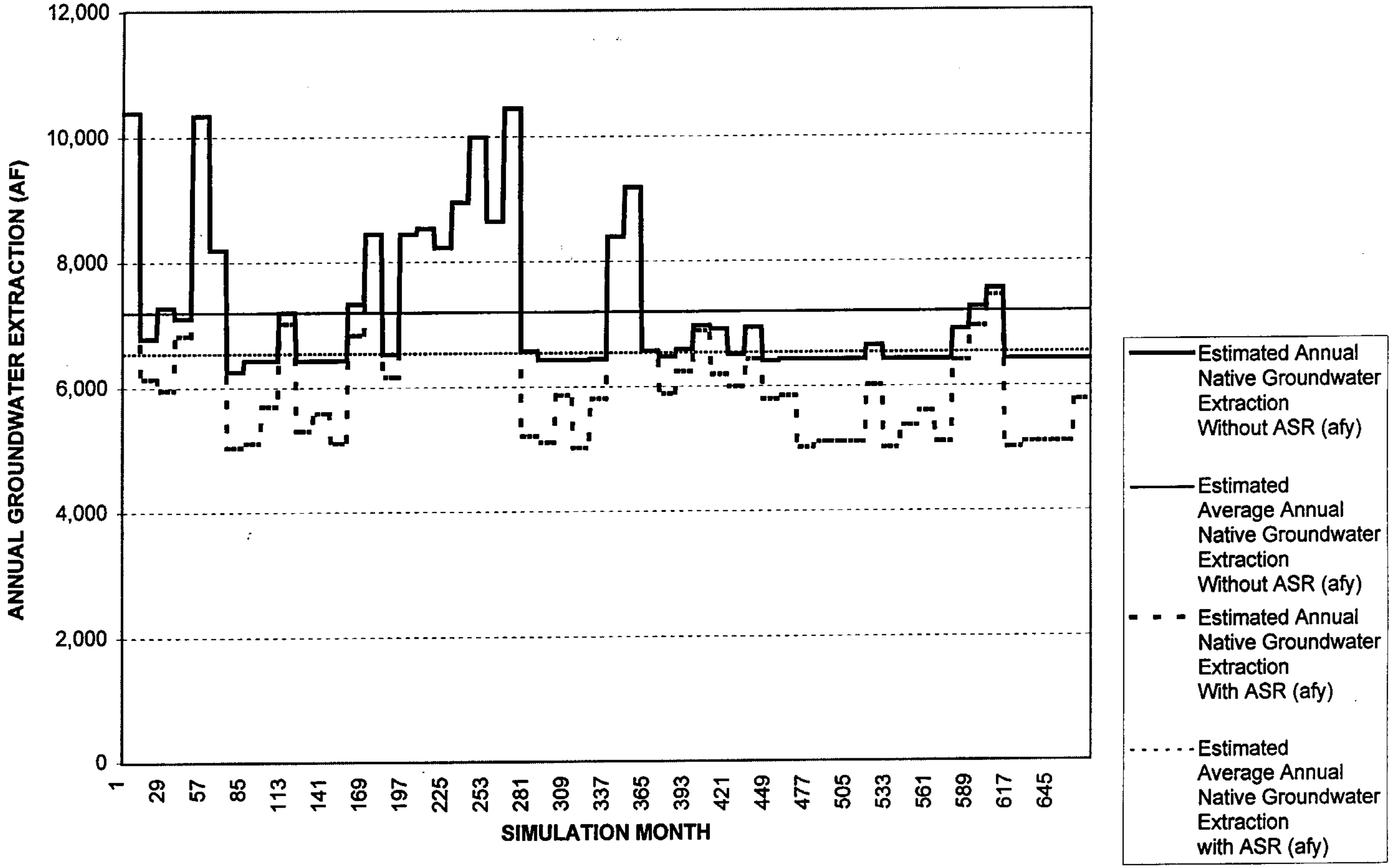
POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS DEMAND YEAR 2040, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY



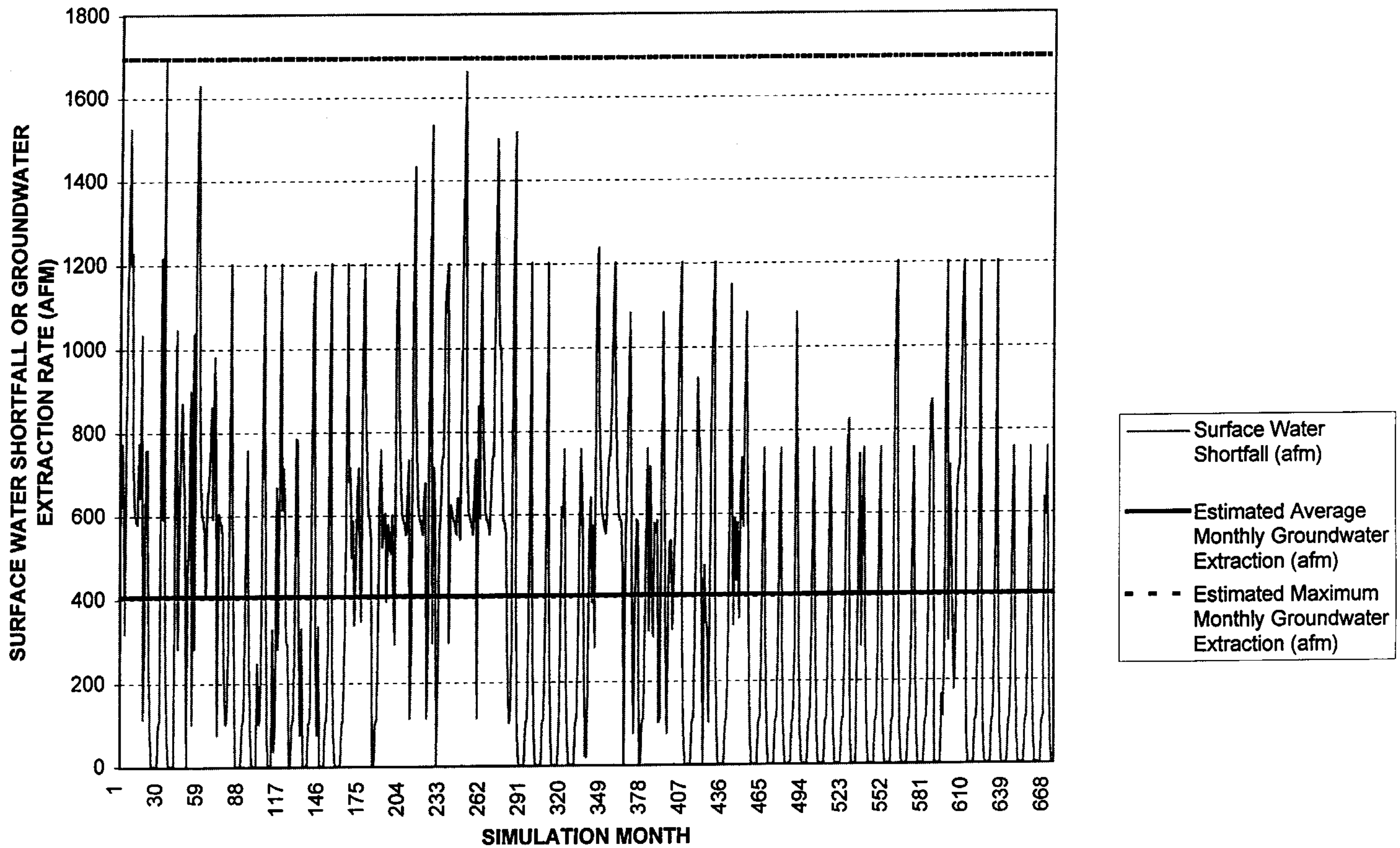
SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2040, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY

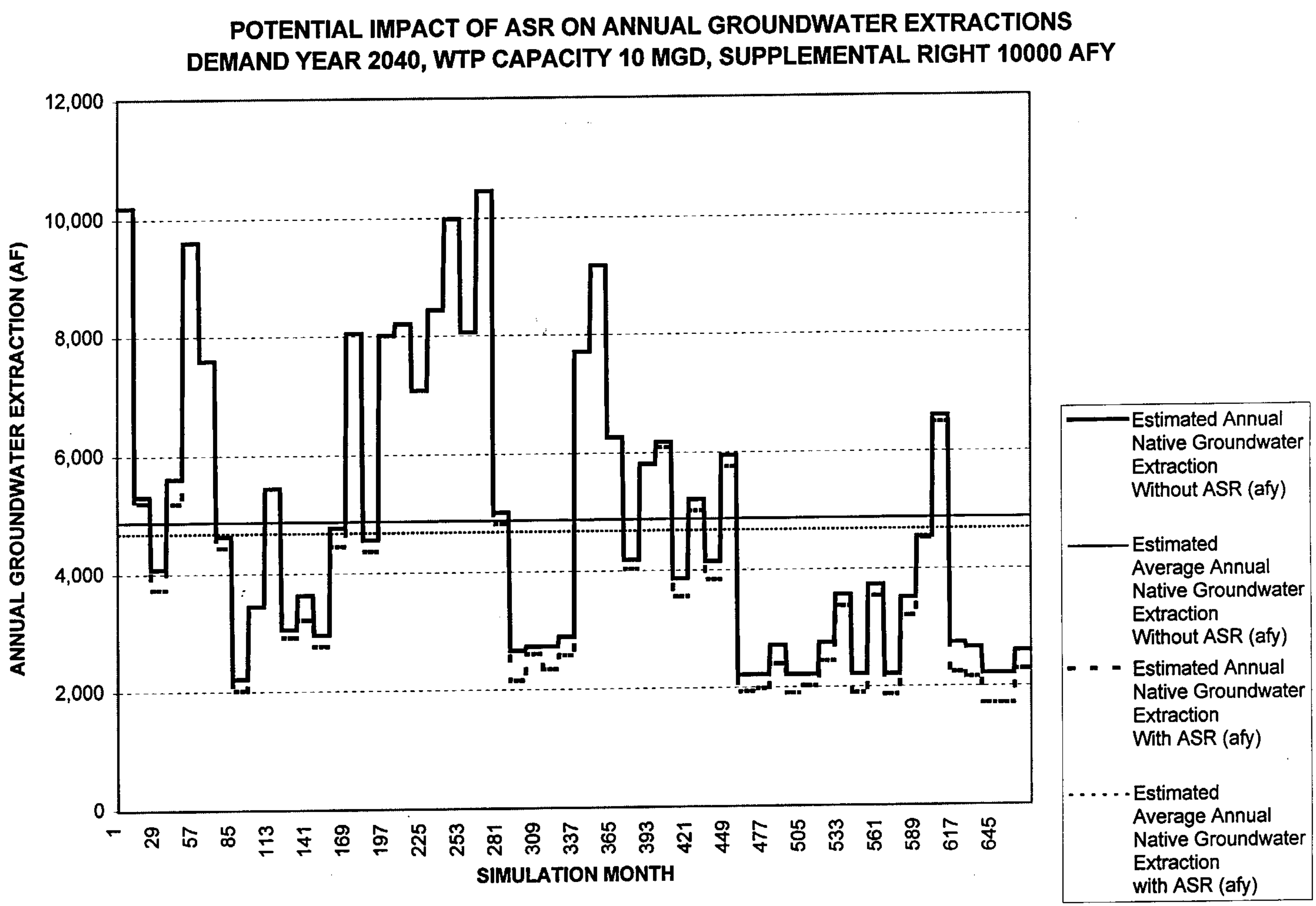


POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2040, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY

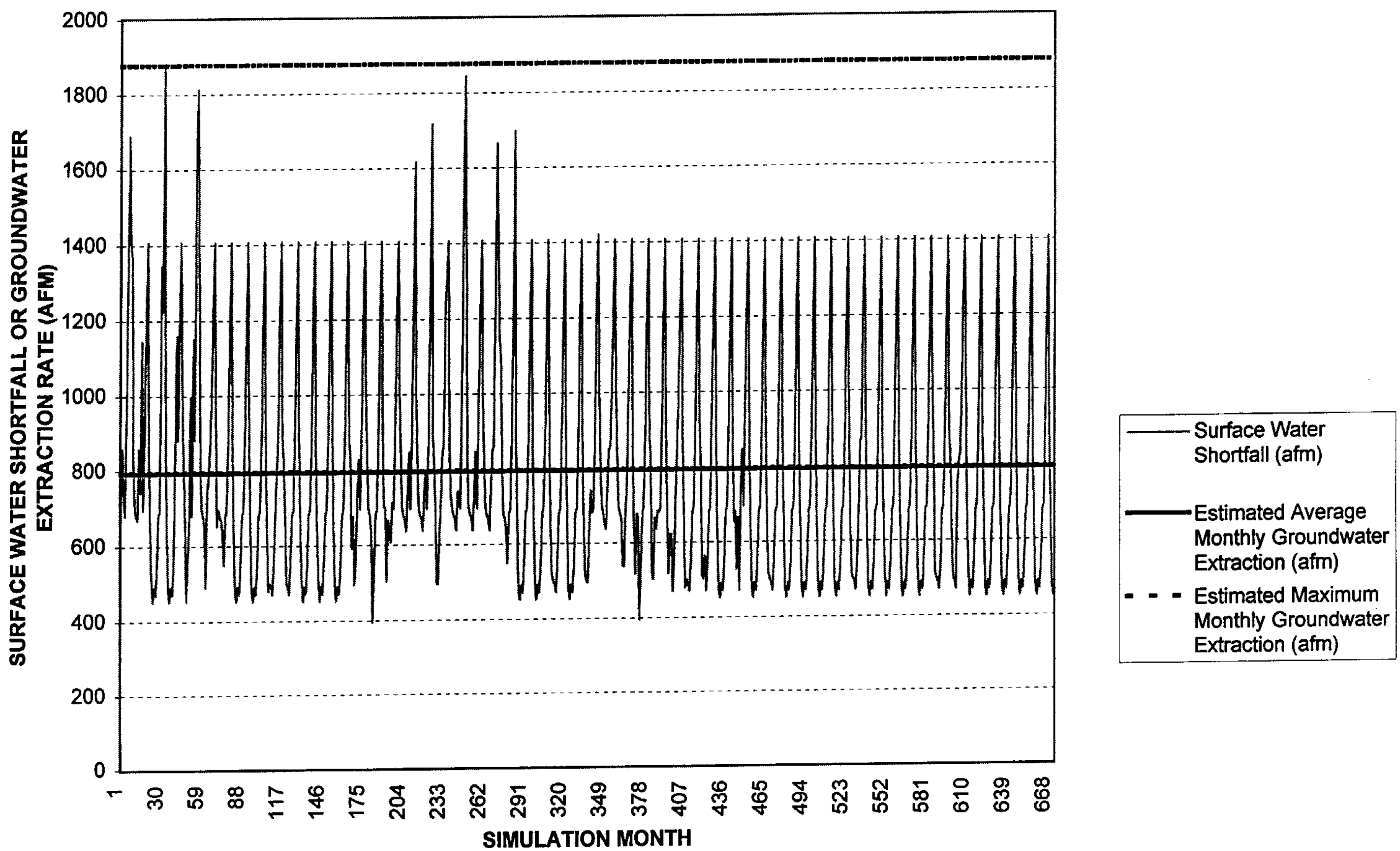


SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2040, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY

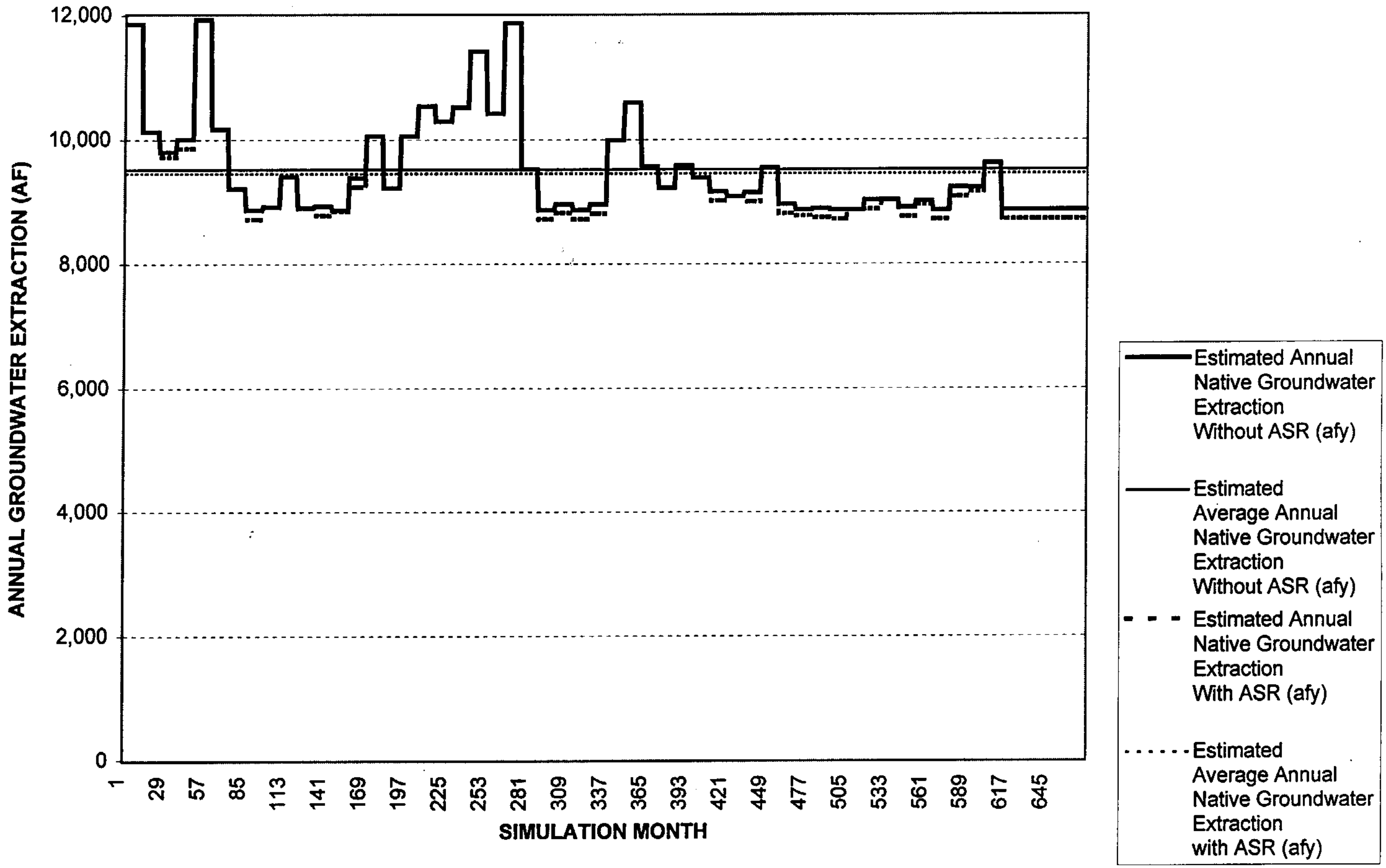



POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2040, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY
ANNUAL GROUNDWATER EXTRACTION (AF)
12,000
10,000
8,000
6,000
4,000
2,000
0
1
29
57
85
113
141
169
197
225
253
281
309
337
365
393
421
449
477
505
533
561
589
617
645
SIMULATION MONTH
Estimated Annual Native Groundwater Extraction Without ASR (afy)
Estimated Average Annual Native Groundwater Extraction Without ASR (afy)
Estimated Annual Native Groundwater Extraction With ASR (afy)
Estimated Average Annual Native Groundwater Extraction with ASR (afy)

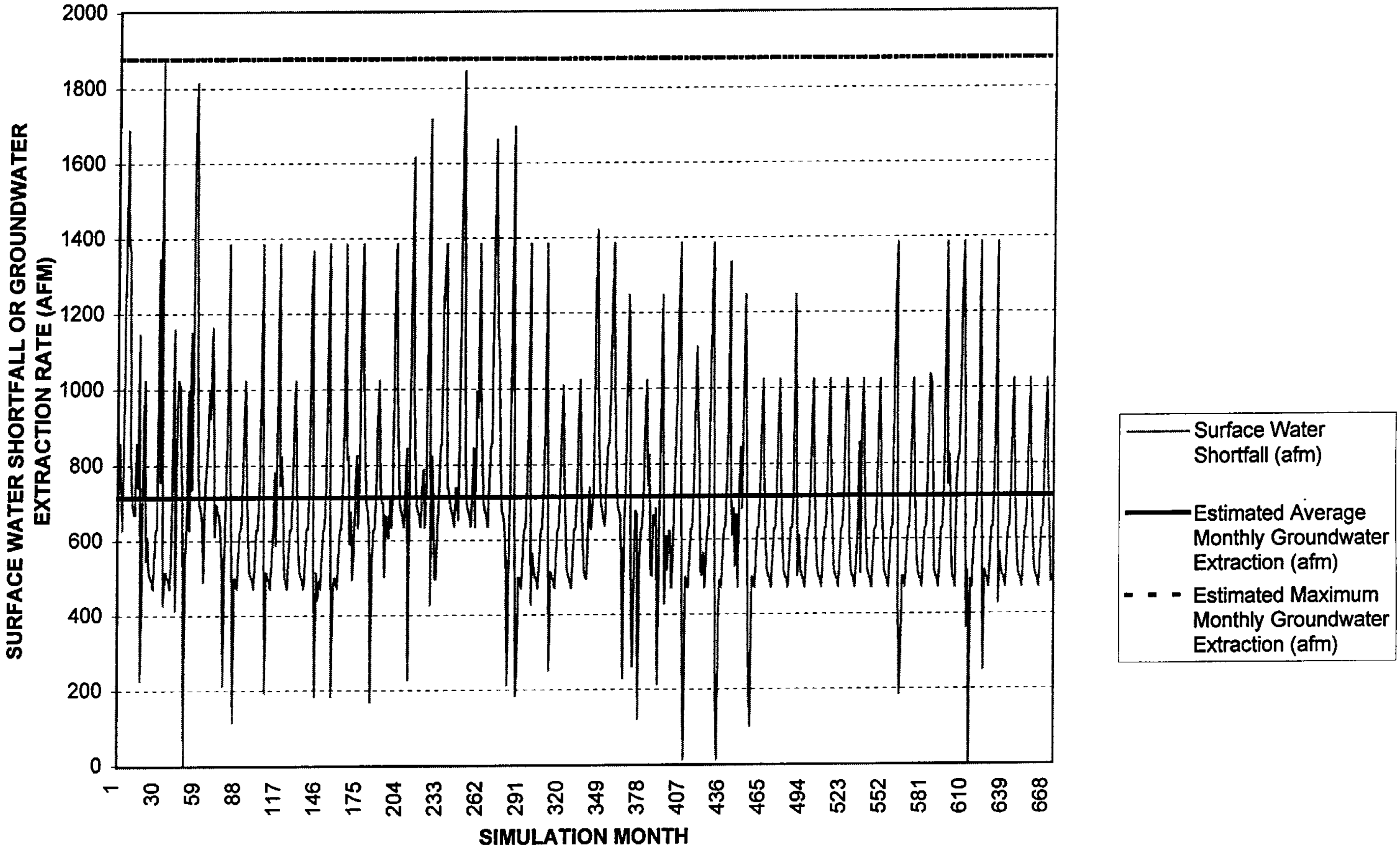
SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX DEMAND YEAR 2050, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY



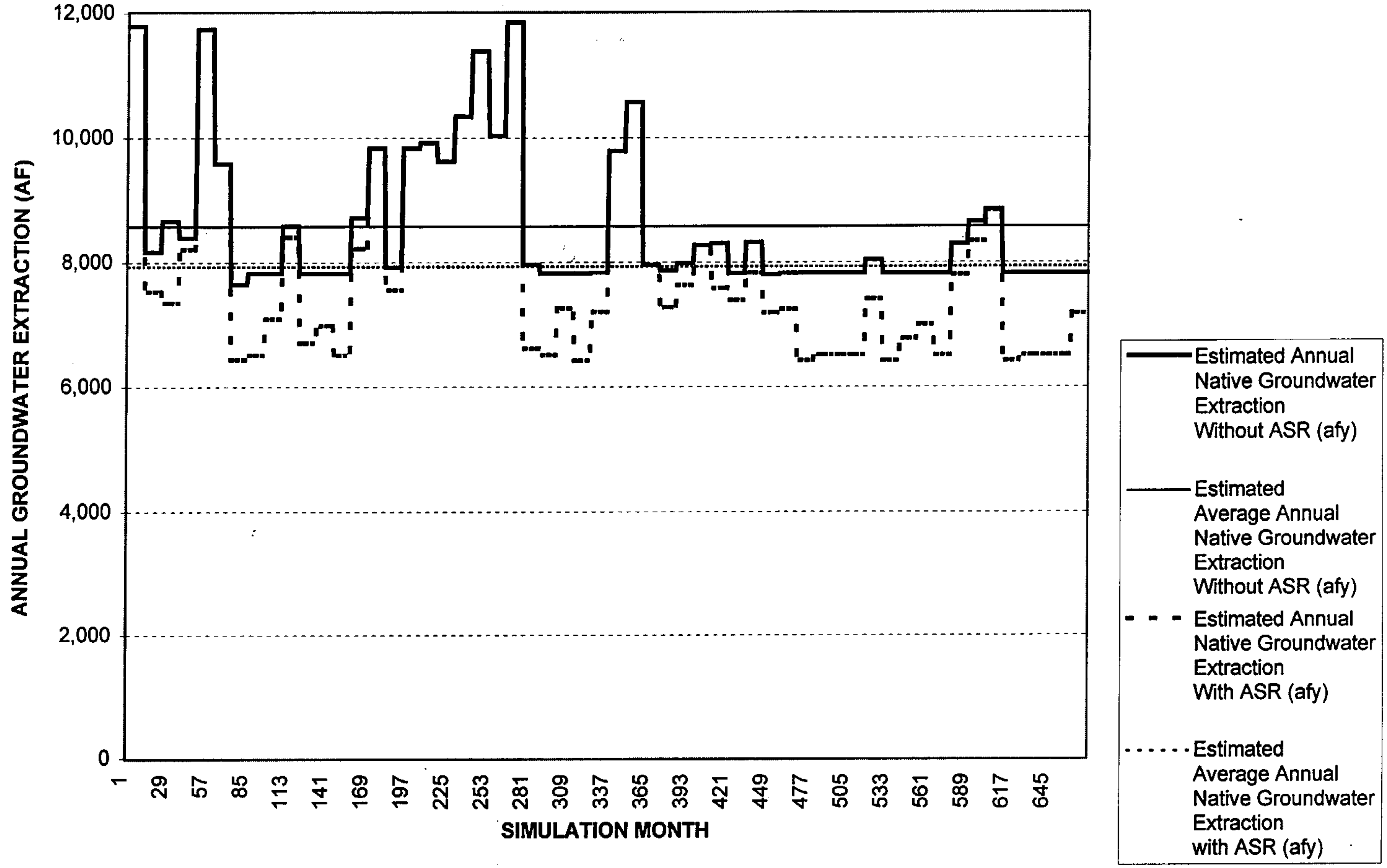
POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2050, WTP CAPACITY 5 MGD, SUPPLEMENTAL RIGHT 0 AFY



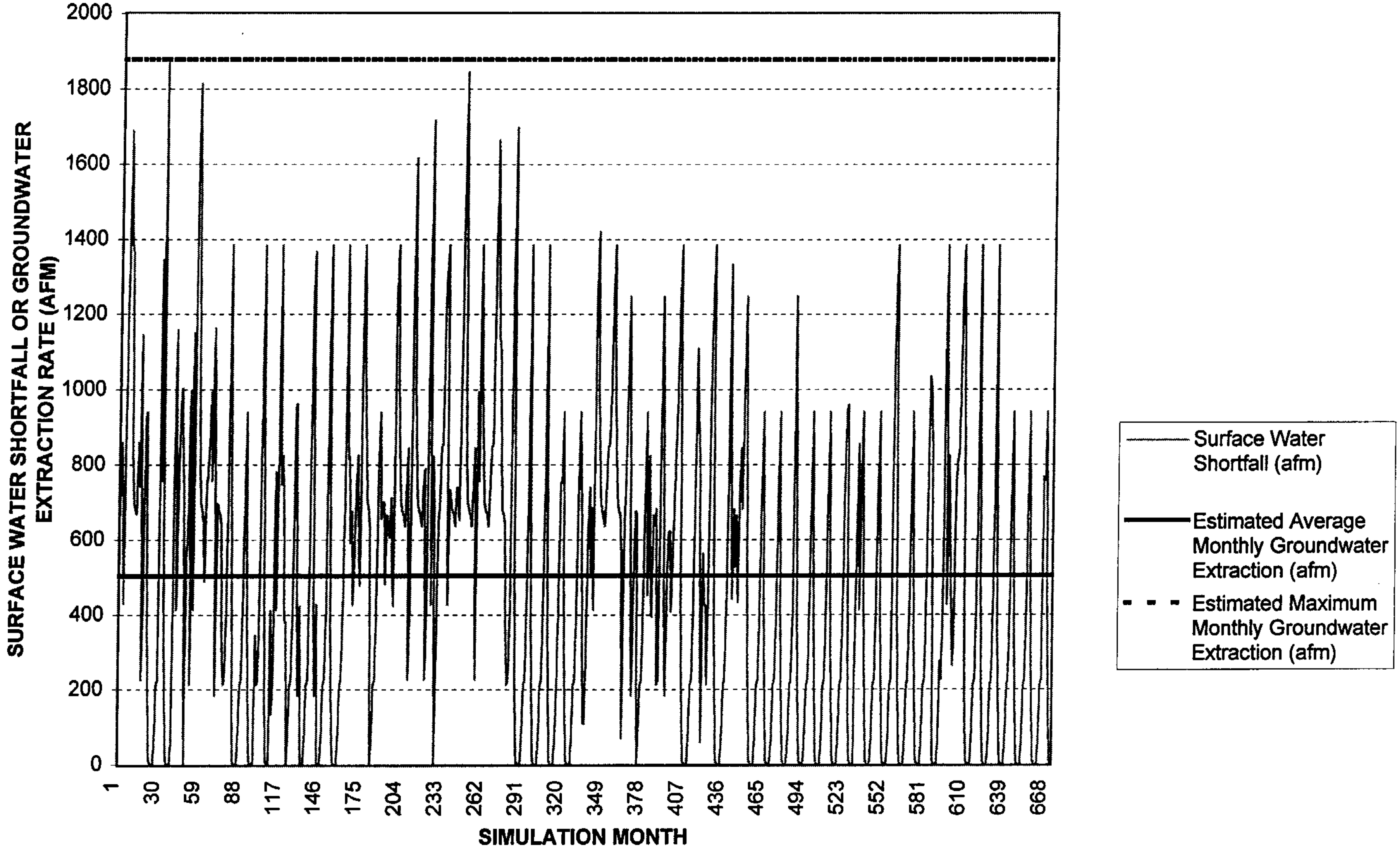
SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2050, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY



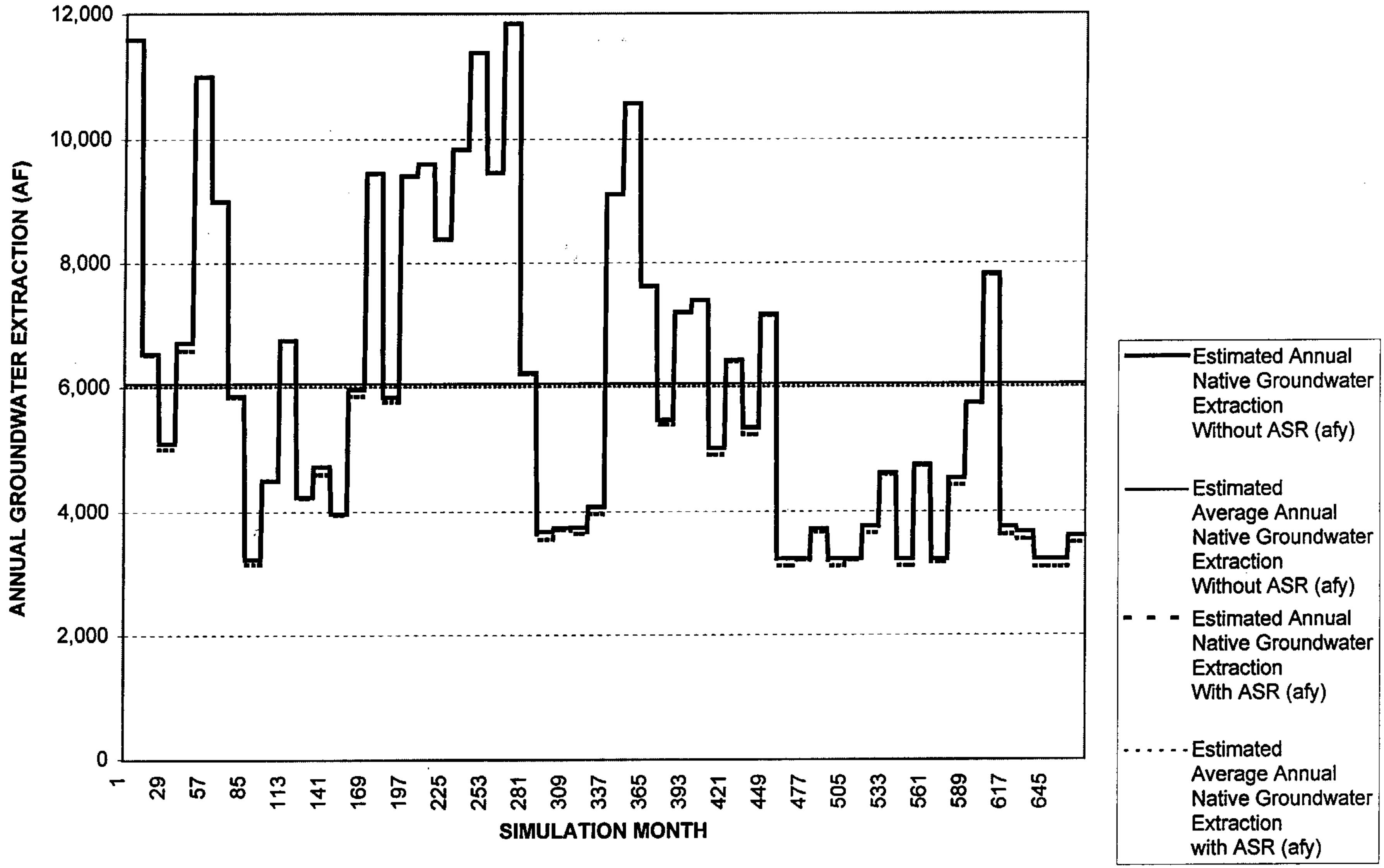
POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2050, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 0 AFY



SIMULATED MUNICIPAL WATER SUPPLY OPERATION, KERR COUNTY, TX
DEMAND YEAR 2050, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY



POTENTIAL IMPACT OF ASR ON ANNUAL GROUNDWATER EXTRACTIONS
DEMAND YEAR 2050, WTP CAPACITY 10 MGD, SUPPLEMENTAL RIGHT 10000 AFY



SCHEMATIC DIAGRAMS

SUPPLY/DEMAND MODEL

KERR COUNTY REGIONAL WATER SUPPLY SYSTEM

This model was created by HDR Engineering for the Upper Guadalupe River Authority and the City of Kerrville. The model simulates the existing (1997) supply system and the projected water demands for Kerr County. The objective of this model is to evaluate the availability of surface water for use in accordance with permit rights and requirements and demand patterns.

By evaluating surface water availability and assuming that shortfalls (difference between demand and available surface water) are made up by ground water extractions, the demands on ground water resources are also estimated. In addition, the model computes the potential quantity of water that may be available for injection into the aquifer for the Aquifer Storage and Recovery (ASR) project.

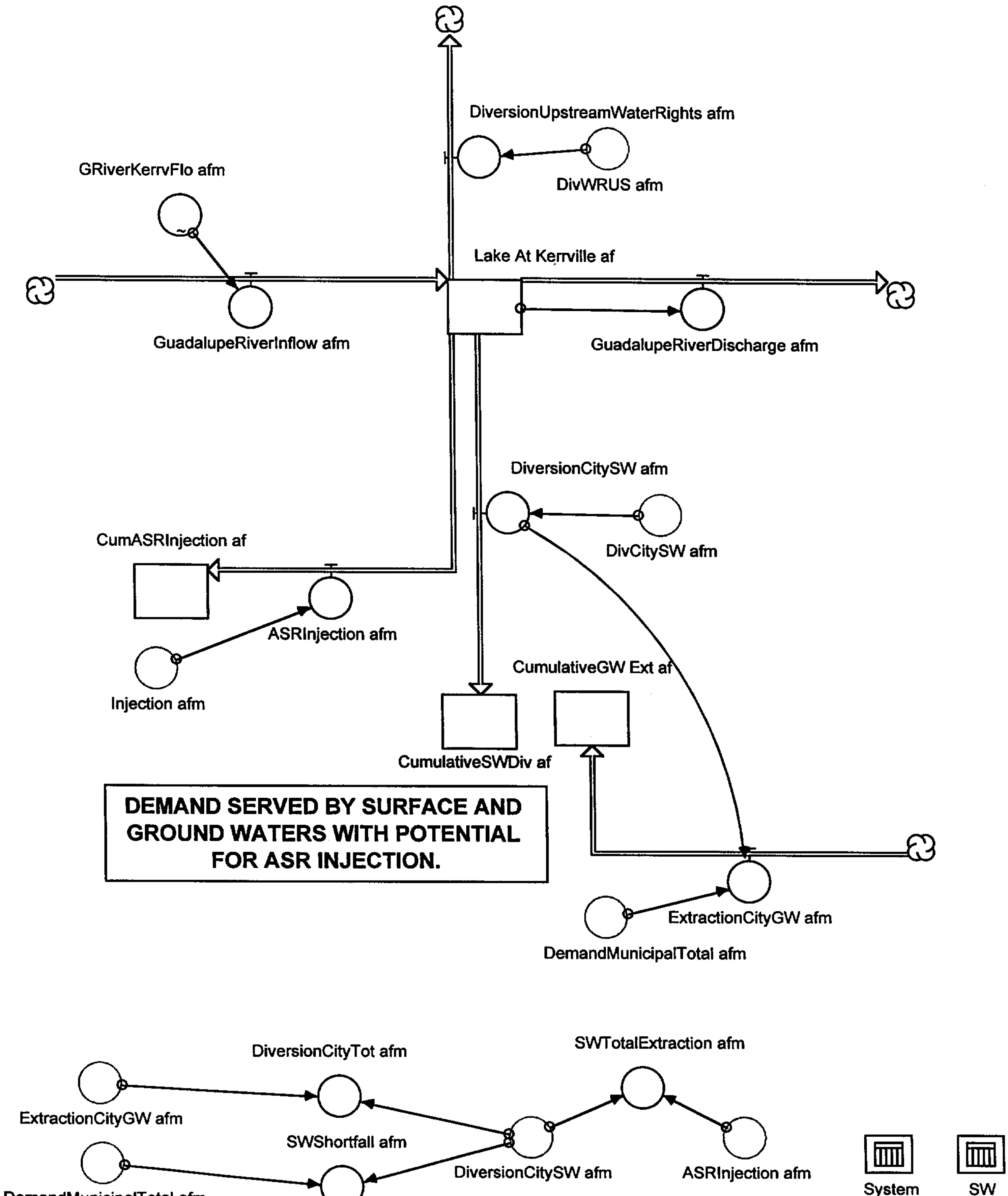
The simulation occurs using the historical streamflow record in the Guadalupe River (extended from Comfort to the Kerrville location). The duration of the record is 57 years or 672 monthly time steps. The model operates on a monthly time step. Units used are mgd: million gallons per day, afm: acre-feet per month, and afy: acre feet per year.

The user can input the demand year and evaluate the system under those projected demand conditions over the historical streamflow record by running the model. The different supply augmentation alternatives supported by the model include

SCROLL RIGHT TO VIEW SUPPLY SYSTEM DIAGRAM

SCROLL DOWN TO CONTROL SIMULATION AND VIEW RESULTS

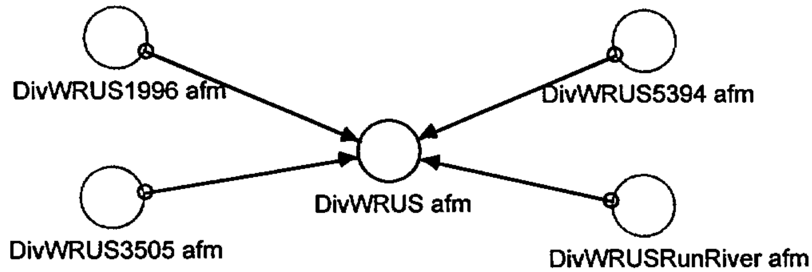
WATER SUPPLY SYSTEM DIAGRAM NEAR KERRVILLE, TX.



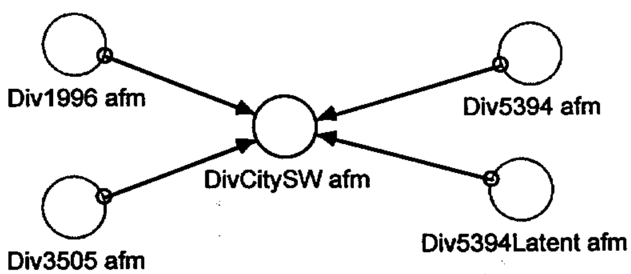
DEMAND SERVED BY SURFACE AND GROUND WATERS WITH POTENTIAL FOR ASR INJECTION.

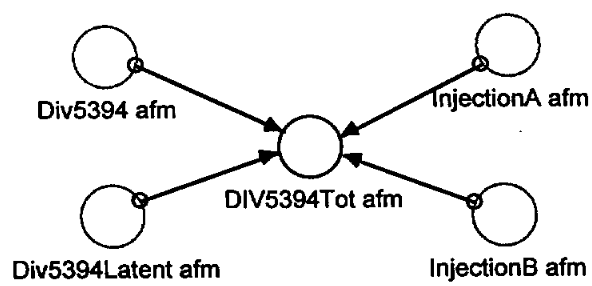
DIVERSION TOTALS

Total diversions to meet upstream water rights.

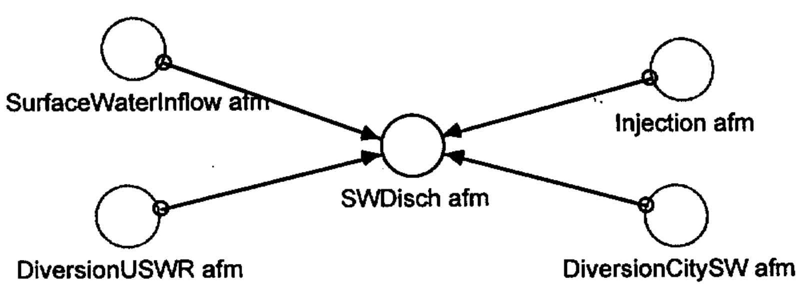


Total surface water diversions to meet demands. Compsed of Permits 1996, 3505, and 5394. Permit 5394 includes latent rights that could not be diverted at the appropriate time due to limited water availabillity but are diverted at a later time that year if adequate stream flow exists.



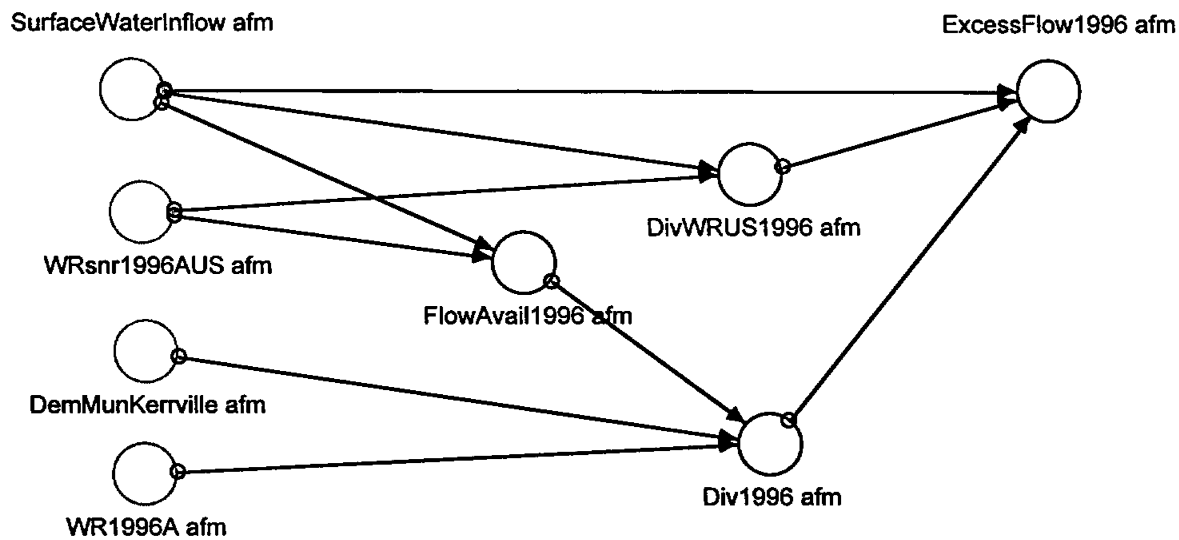


Total surface water discharge from the Kerrville Lake adjusted for diversions.

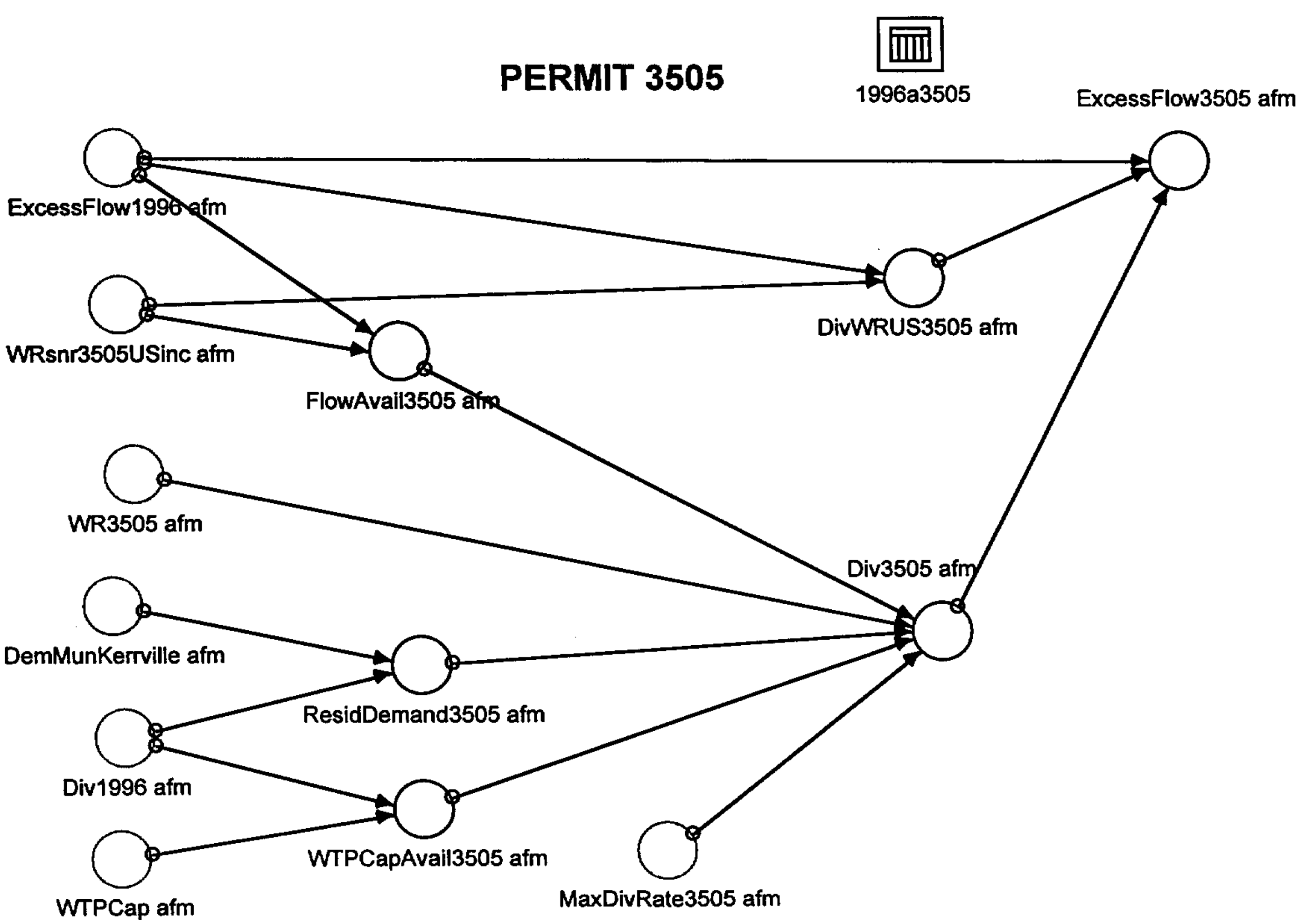


PERMIT DIVERSIONS

PERMIT 1996A

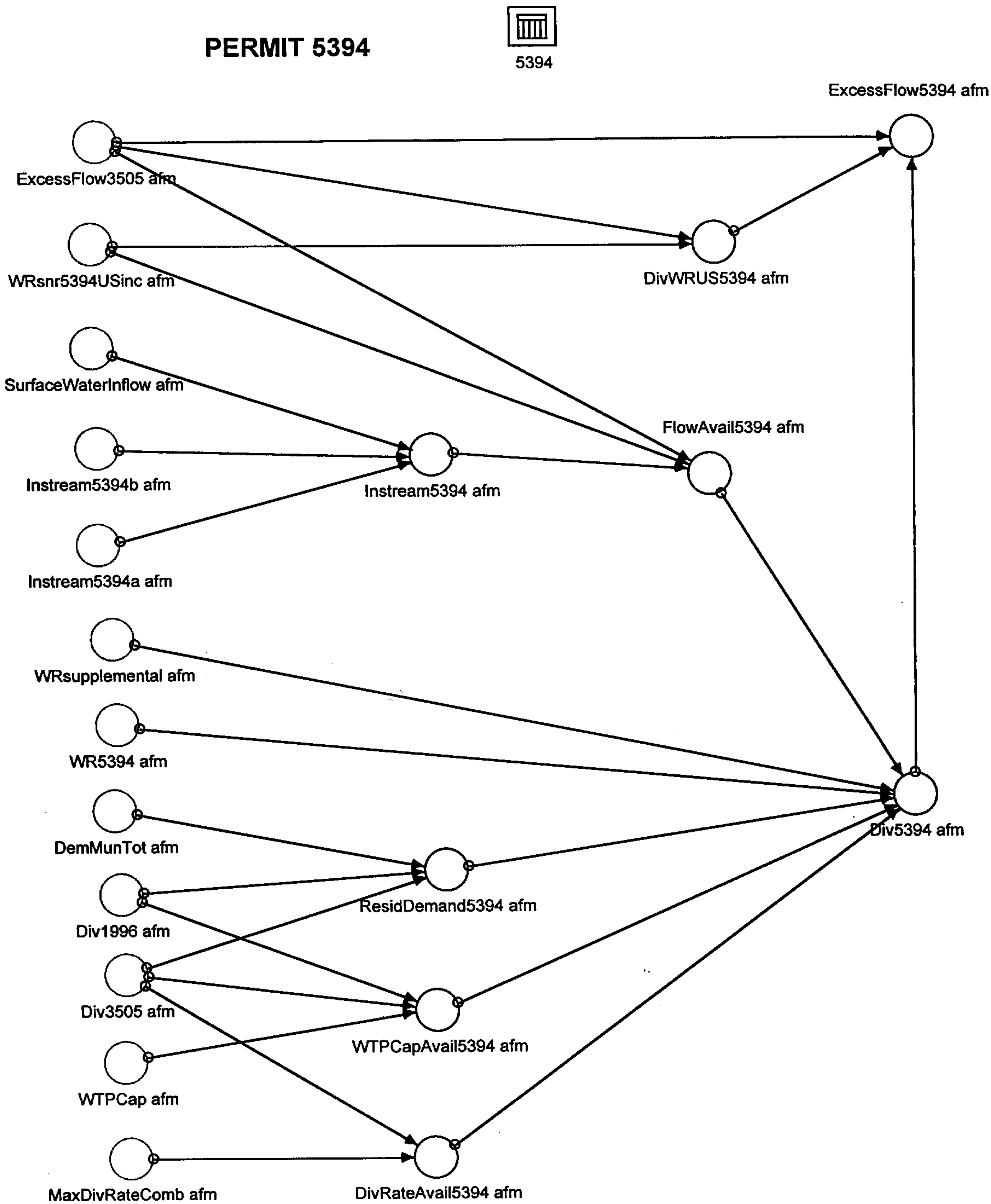


PERMIT 3505



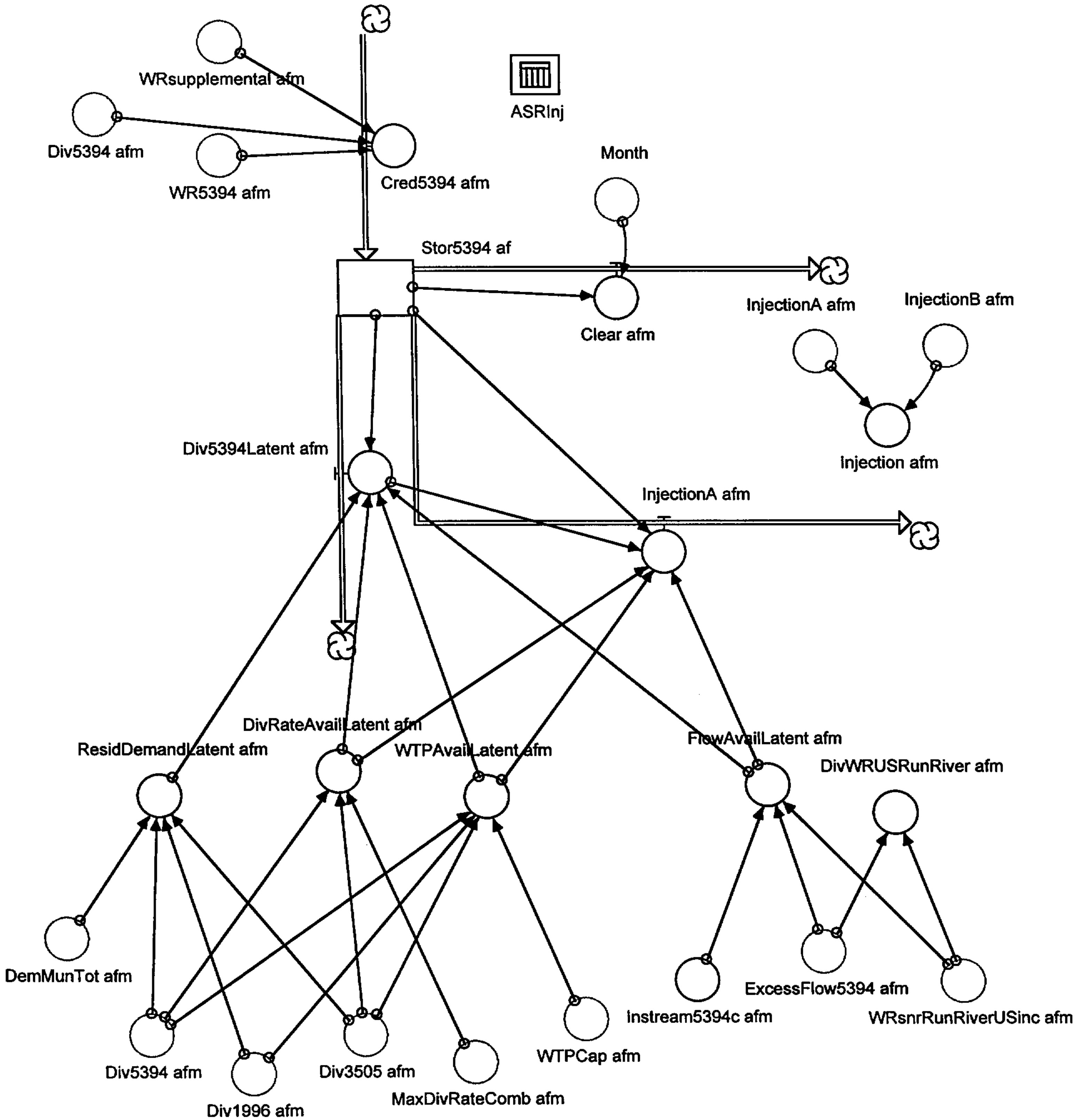
PERMIT DIVERSIONS

PERMIT 5394

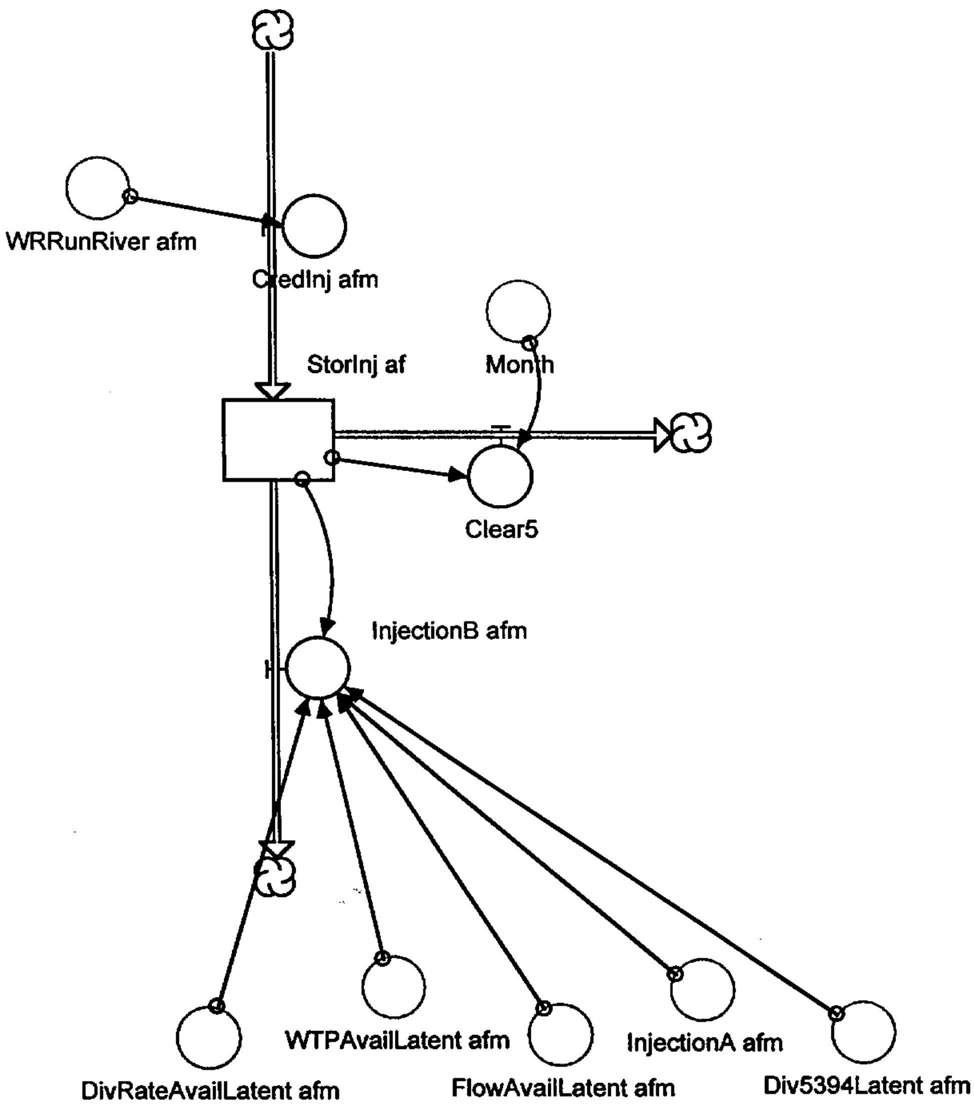


PERMIT DIVERSIONS

LATENT RIGHT, PERMIT 5394



INJECTION, PERMIT 5394



INPUT VARIABLES TO CONTROL THE SIMULATION

DemandYear

Enter the year of water demand to determine surface water availability and demand on groundwater resources.

WTPCap mgd

Enter the Water Treatment Plant Capacity (mgd). Should be 5 mgd for existing conditions.

WRsupplemental afy

Enter the quantity of water rights to be purchased (acft/yr). For modeling, these rights are subject to the instream flow requirements associated with Permit 5394 (30, 40, and 50 cfs).

Echo Input:

DemandYear	2,050
WTPCap mgd	5.0
WRsupplemental afy	0

RESULTS

RUNNING AVERAGE ANNUAL SURFACE WATER USE (ACRE-FEET/YEAR)

RunAvgAnnSWDiv ...	4,812

RUNNING AVERAGE ANNUAL GROUND WATER USE (ACRE-FEET/YEAR)

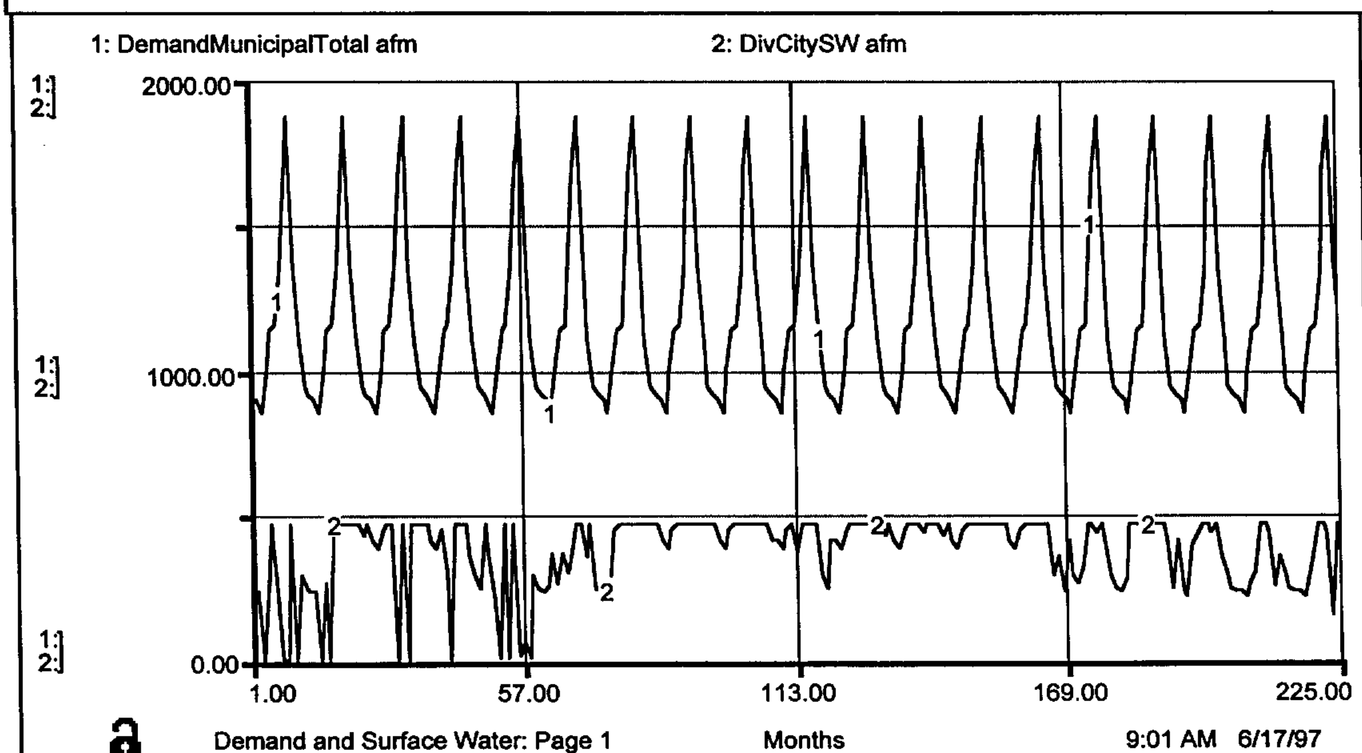
RunAvgAnnGWExt...	9,507

To view output tables below, double click green icon. Highlight, Copy (control C) and Paste (control v) into Excel if desired.

Demand and Surface Water

Ground Water Extraction

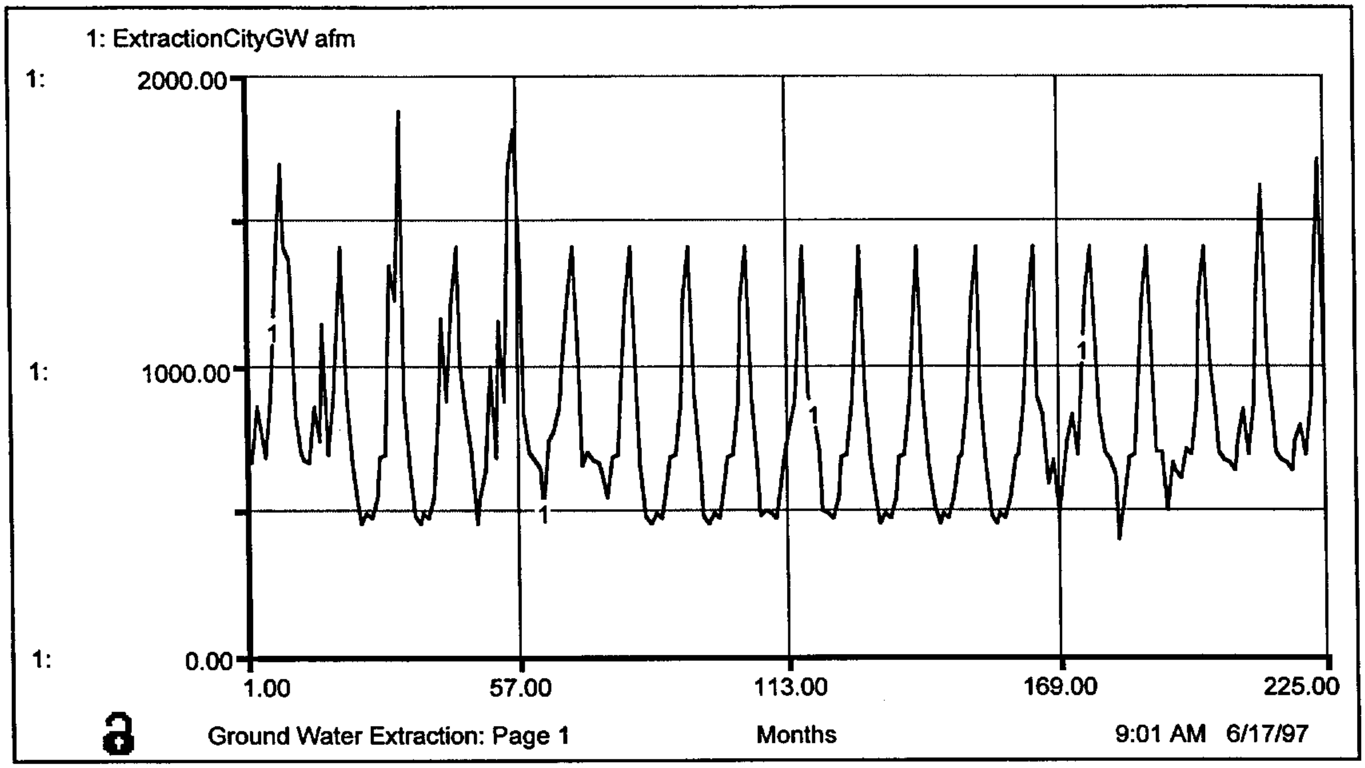
Graph 1 -- Total Municipal Water Demand and Surface Water Supply in acre-feet per month.



Demand and Surface Water

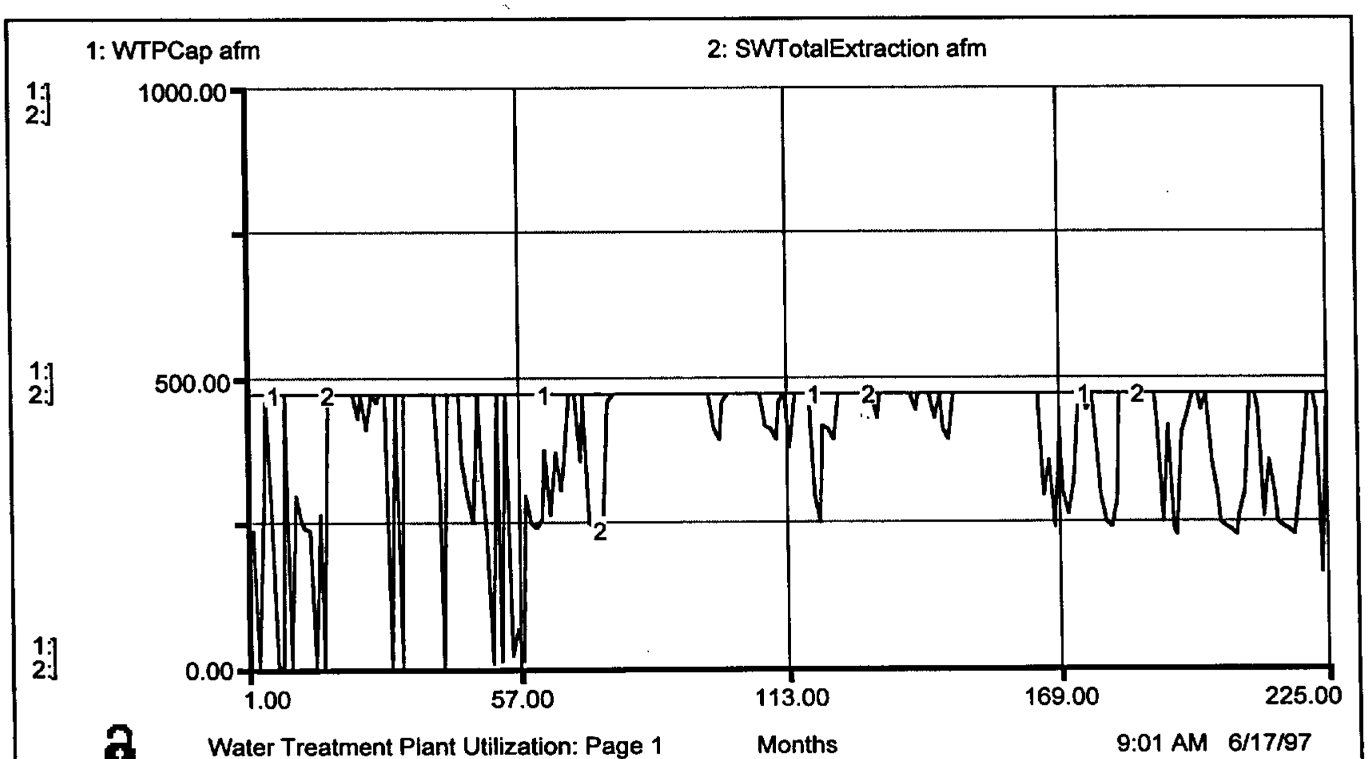
GRAPHICAL RESULTS

Graph 2 -- Total Monthly Ground Water Extraction in acre feet per month.



Ground Water Extraction

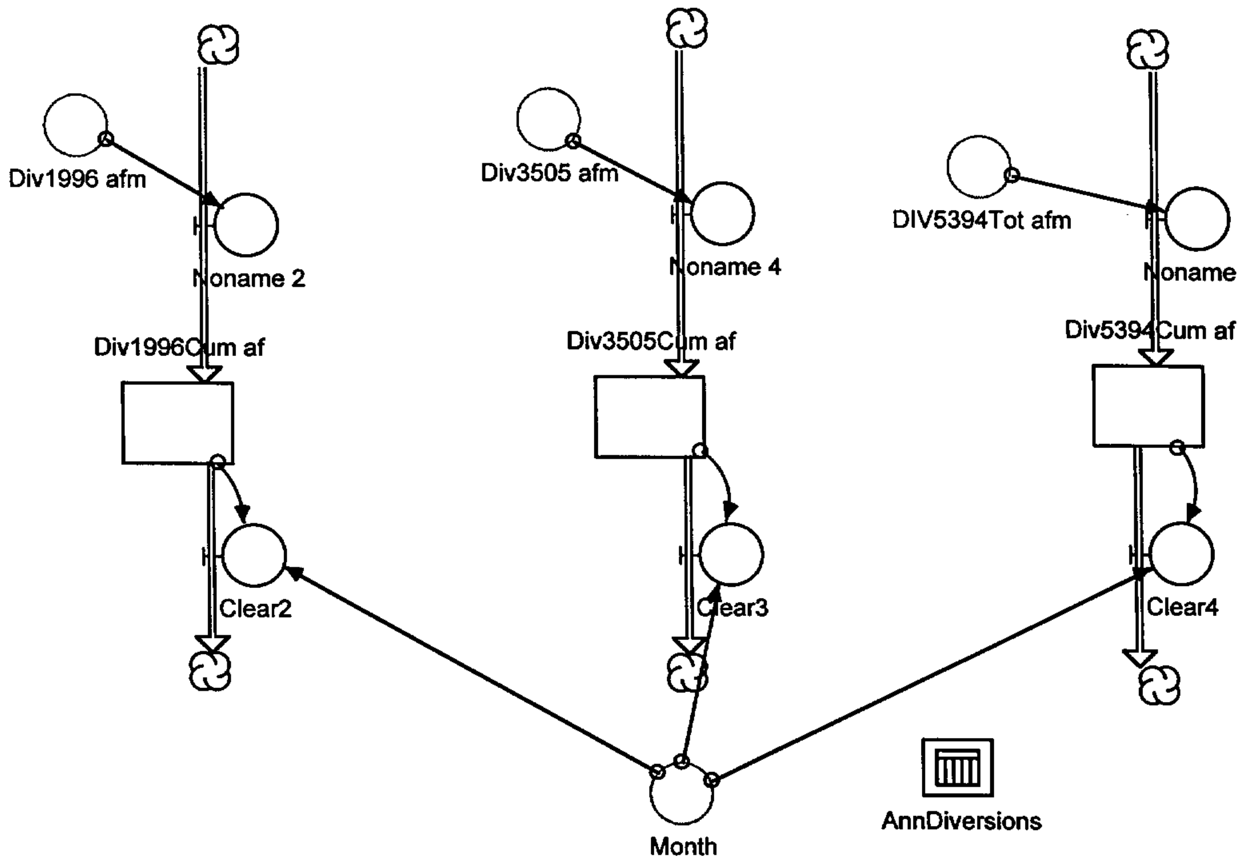
Graph 3 -- Water Treatment Plant Utilization



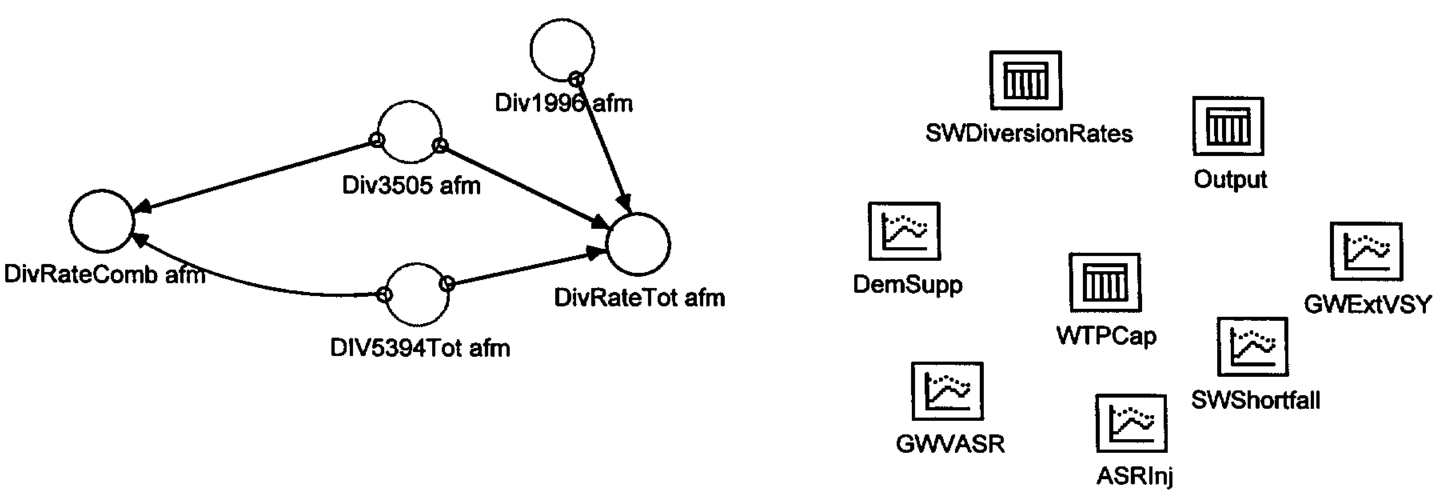
Water Treatment Plant Utilization

CHECKS AND BALANCES

This calculation checks to see if the annual diversions are less than or equal to the permitted rights.



This calculation checks to see if the combined diversion rate is less than or equal to the treatment capacity or the maximum combined diversion rate.



WATER RIGHTS

PERMIT 3505

WR3505 afy

MaxDivRate3505 cfs

WRsnr3505US afy

Quantity (acre-feet per year) of UGRA Permit 3505 water right and upstream senior water rights. Maximum diversion rate associated with Permit 3505.

PERMIT 1996A

WR1996A afy

WRsnr1996AUS afy

Quantity (acre-feet per year) of Kerrville Permit 1996A water right and upstream senior water rights.

PERMIT 5394

WR5394 afy

Instream5394a cfs

WRsnr5394US afy

MaxDivRateComb cfs

Instream5394Latent cfs

Quantity (acre-feet per year) of UGRA Permit 5394 water right and upstream senior water rights. Maximum diversion rate (cfs) when combined with Permit 3505 diversion and associated minimum instream flow requirements downstream of diversion point (cfs). The latent right associated with Permit 5394 is the difference between the permitted right and the actual diversions in that year. Diversions are permitted up to the latent right subject to the instream flow requirement associated with the latent right.

WRRunRiver afy

WRsnrRunRiverUS afy

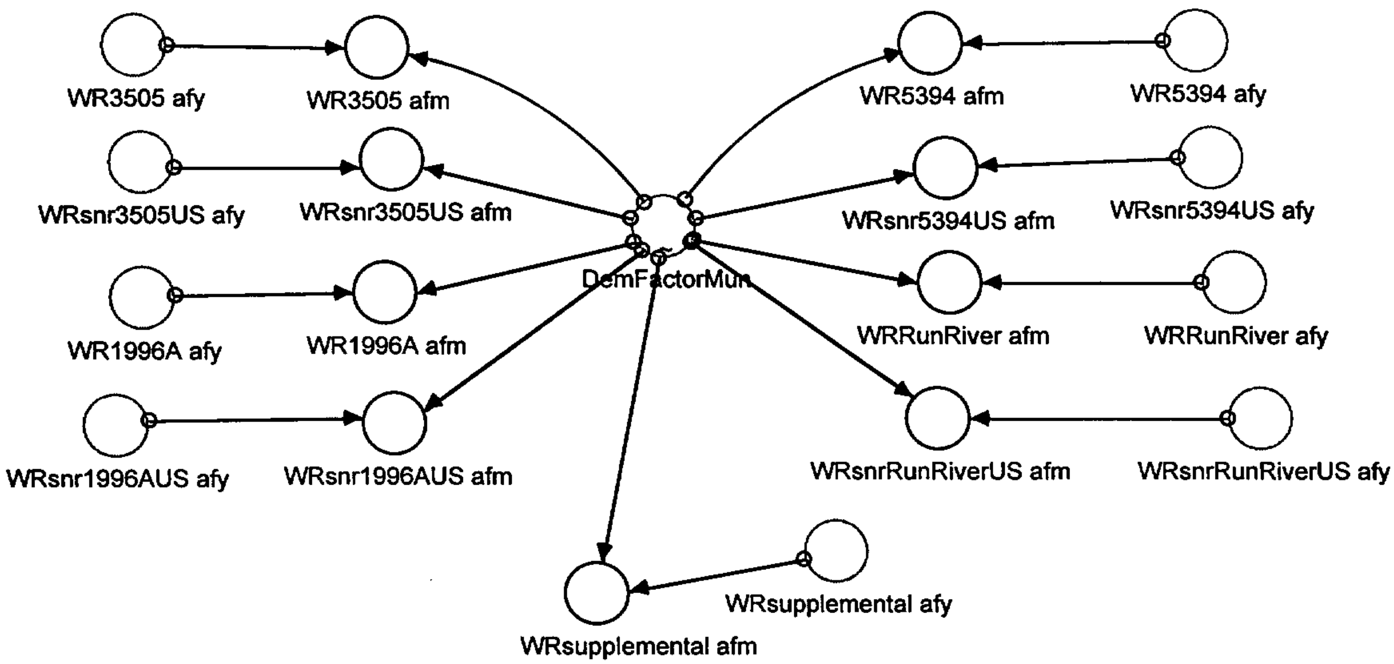
Quantity (acre-feet per year) of ASR Injection (Run of River) water right in Permit 5394 and upstream senior water rights.

SUPPLEMENTAL RIGHTS TO BE

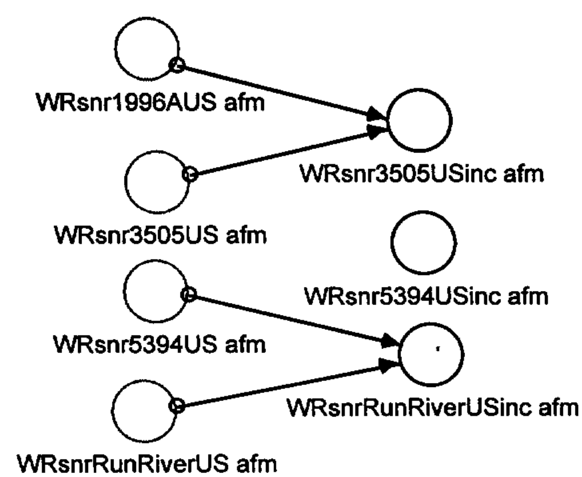
WRsupplemental afy

Quantity (acre-feet per year) of Supplemental water right. This right is assumed to be subject to same instream flows and senior rights as Permit 5394.

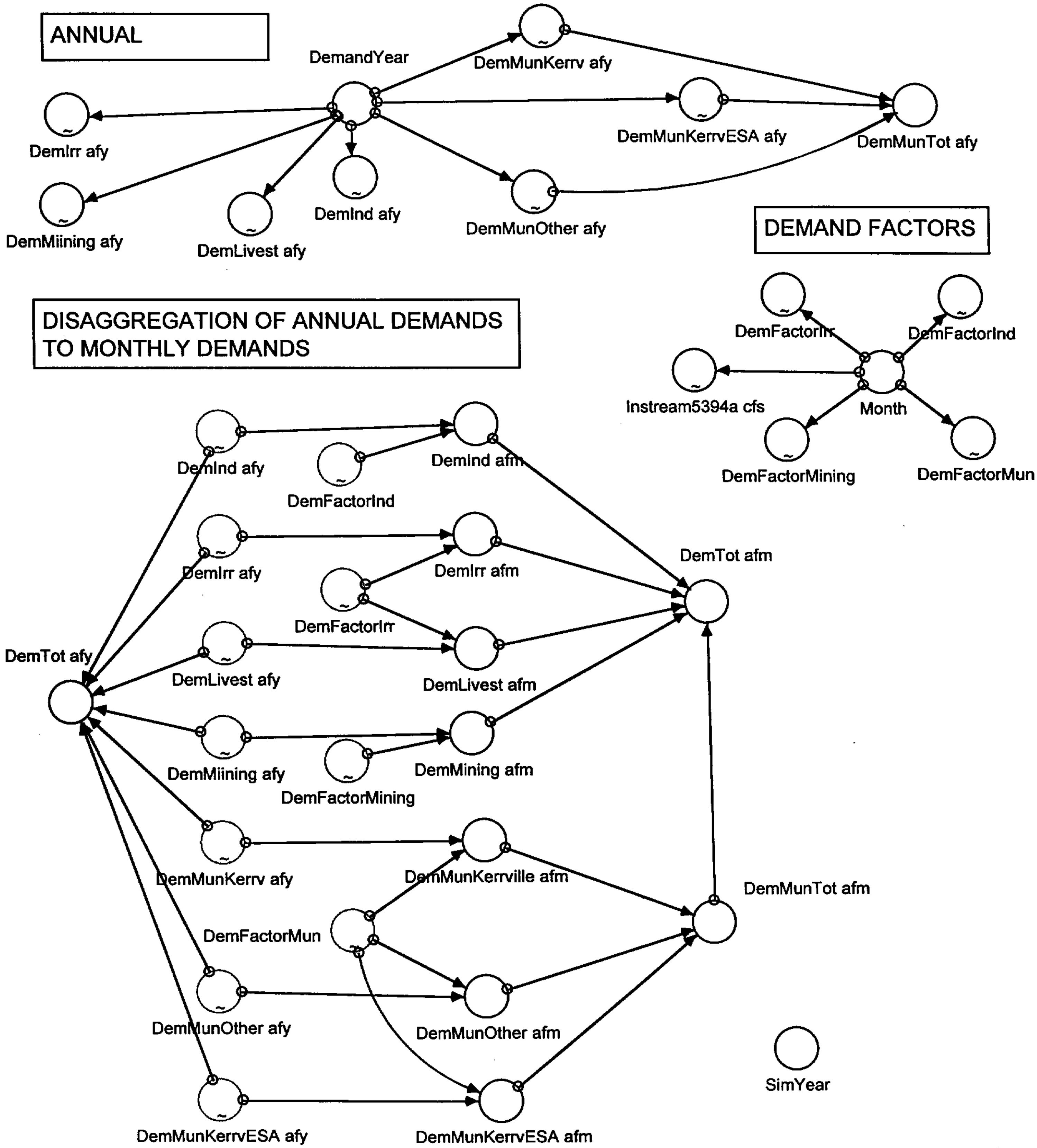
WATER RIGHTS
Icons on this page include water rights held by UGRA or Kerrville and rights held upstream of UGRA diversion point. The annual rights are disaggregated to a monthly basis using a municipal demand factor. For the purpose of modeling only senior municipal water rights upstream of diversion are assumed to diminish available streamflow. Downstream water rights are not considered (i.e. impacts to firm yield of Canyon Lake).



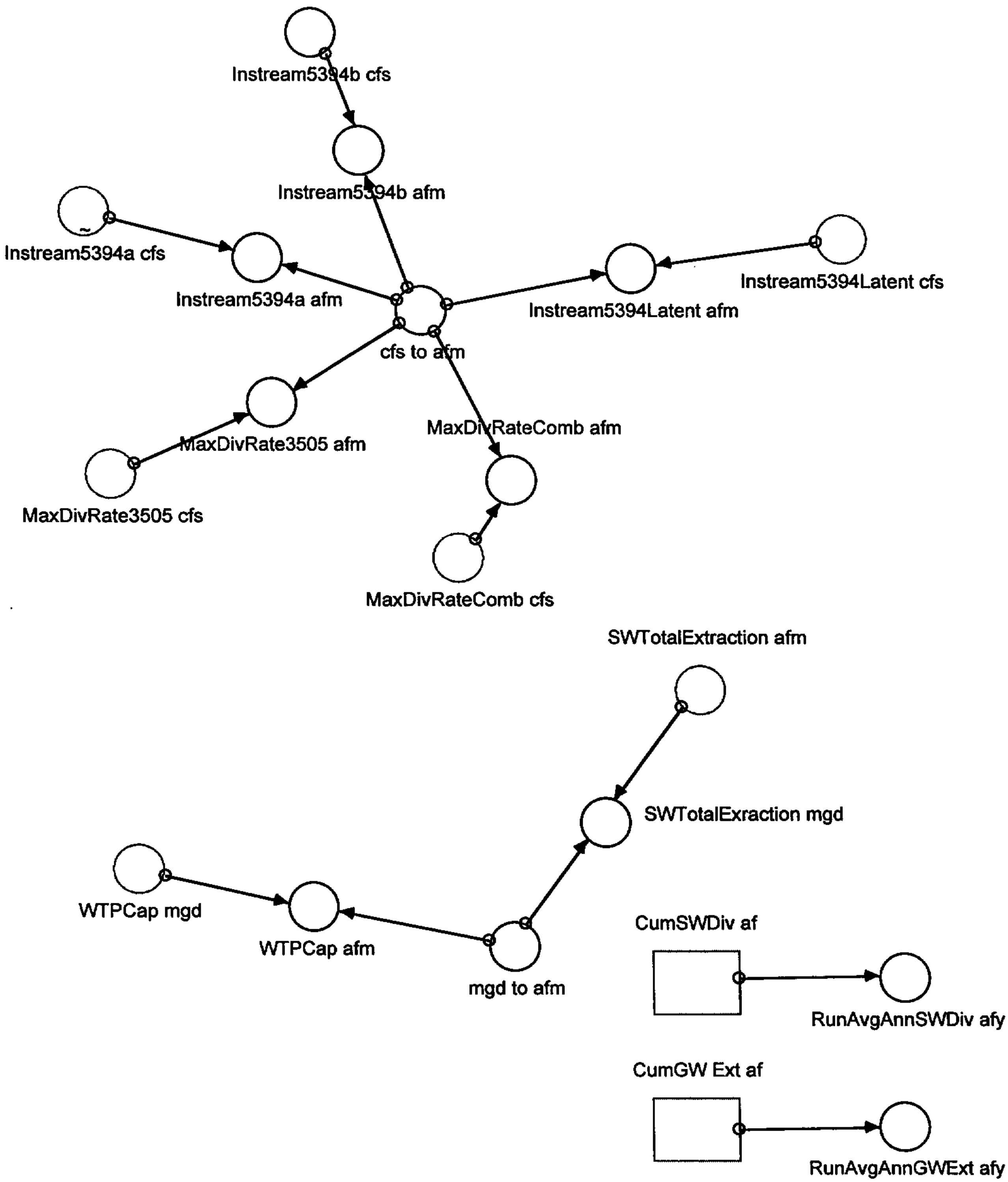
This calculates incremental senior rights between two permits.



WATER DEMANDS
Icons on this page are used to compute water demands projected and described in the text of the report. The water demands are distributed to a monthly basis by multiplying by a monthly demand factor.



UNIT CONVERSIONS
Icons on this page make the necessary unit conversions for flow rate (i.e. convert mgd to acft/yr)



VARIABLE LISTING, DOCUMENTATION AND DETAILED MODEL LOGIC

☐ CumASRInj_af(t) = CumASRInj_af(t - dt) + (ASRInj_afm) * dt
INIT CumASRInj_af = 0

DOCUMENT: This is the cumulative quantity of water available for injection into the aquifer in acre-feet.

INFLOWS:

ASRInj_afm = Injection_afm
DOCUMENT: This is the quanitity of water available for injection to aquifer in acre-feet/month.

☐ CumGW_Ext_af(t) = CumGW_Ext_af(t - dt) + (DiversionCityGW_afm) * dt
INIT CumGW_Ext_af = 0

DOCUMENT: This is the cumulative groundwater extraction in acre-feet.

INFLOWS:

DiversionCityGW_afm = DemMunTot_afm-DiversionCitySW_afm
DOCUMENT: Ground water extraction required to meet water demand in acre-feet/month.

☐ CumSWDiv_af(t) = CumSWDiv_af(t - dt) + (DiversionCitySW_afm) * dt
INIT CumSWDiv_af = 0

DOCUMENT: This is the cumulative surface water diversion to meet water demands in acre-feet.

INFLOWS:

DiversionCitySW_afm = DivCitySW_afm
DOCUMENT: This is the diversion of surface water for direct use (not injection) in acre-feet/month.

☐ Div1996Cum_af(t) = Div1996Cum_af(t - dt) + (Noname_2 - Clear2) * dt
INIT Div1996Cum_af = 0

DOCUMENT: This is the cumulative diversion on an annual basis associated with Permit 1996 in acre-feet.

INFLOWS:

Noname_2 = Div1996_afm
DOCUMENT: This is the diversion associated with Permit 1996A in acre-feet/month.

OUTFLOWS:

Clear2 = IF Month=1 THEN Div1996Cum_af ELSE 0

☐ Div3505Cum_af(t) = Div3505Cum_af(t - dt) + (Noname_4 - Clear3) * dt
INIT Div3505Cum_af = 0

DOCUMENT: This is the cumulative diversionon an annual basis associated with Permit 3505 in acre-feet.

INFLOWS:

Noname_4 = Div3505_afm
DOCUMENT: This is the diversion associated with Permit 3505 in acre-feet/month.

OUTFLOWS:

Clear3 = IF Month = 1 THEN Div3505Cum_af ELSE 0
DOCUMENT: This clears the stored value in January.

☐ Div5394Cum_af(t) = Div5394Cum_af(t - dt) + (Noname_6 - Clear4) * dt
INIT Div5394Cum_af = 0

DOCUMENT: This is the cumulative diversion on an annual basis associated with Permit 5394 in acre-feet.

INFLOWS:

Noname_6 = DIV5394Tot_afm

OUTFLOWS:

Clear4 = IF Month = 1 THEN Div5394Cum_af ELSE 0
DOCUMENT: This clears the stored value in January.

☐ Stor5394_af(t) = Stor5394_af(t - dt) + (Cred5394_afm - Div5394Latent_afm - InjectionA_afm - Clear_afm) * dt
INIT Stor5394_af = 0

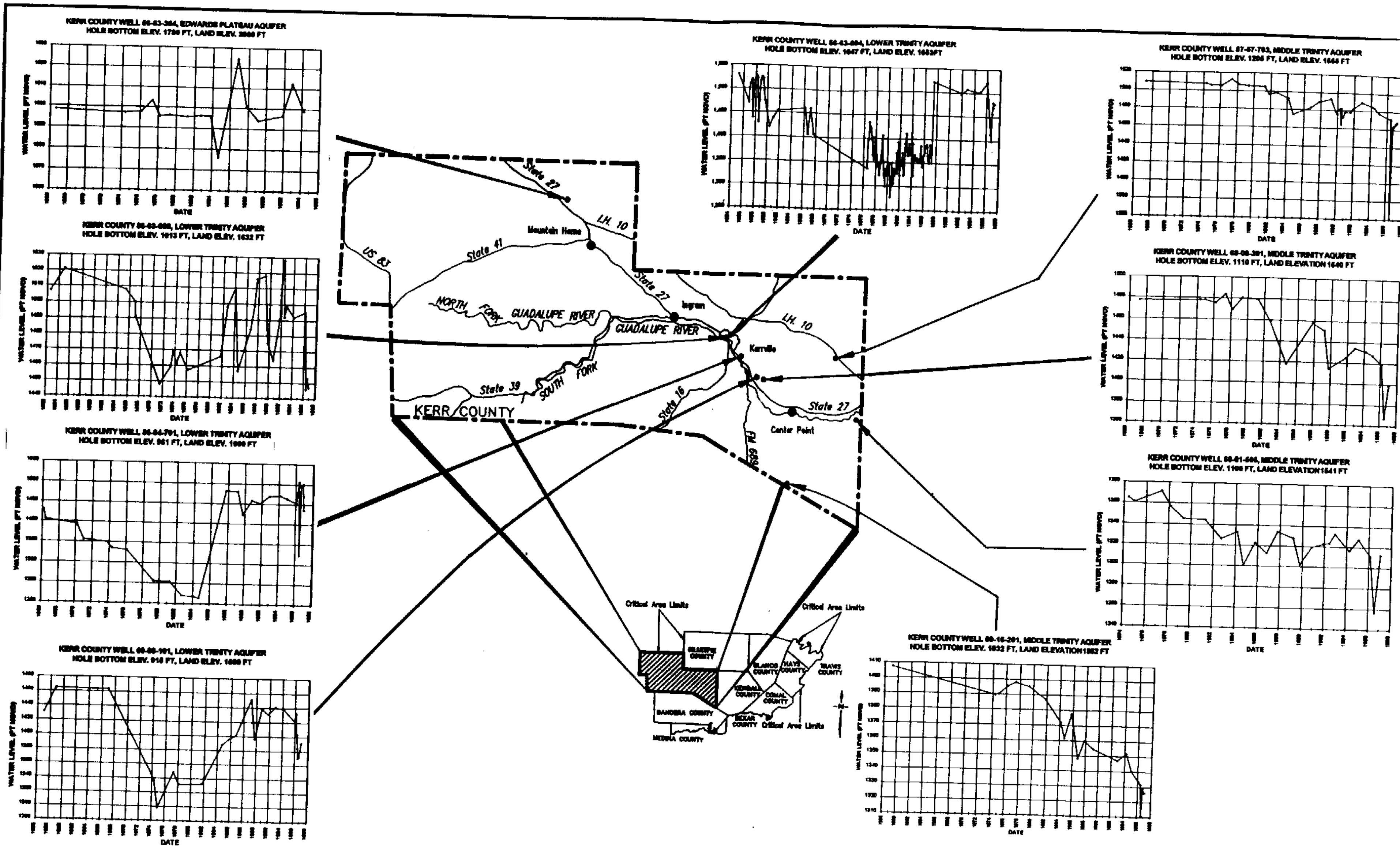
DOCUMENT: This is the Latent right associated with Permit 5394 in acre-feet. If the Permit 5394 right cannont be diverted at any time, the shortfall can be saved as a latent right for use later that year provided the stream flow is adequate to meet instream requirements.

INFLOWS:

Cred5394_afm = MAX(0,WR5394_afm+WRsupplemental_afm-Div5394_afm)
DOCUMENT: This is the monthly latent right with Permit 5394 in acre-feet/month.

OUTFLOWS:

Div5394Latent_afm = MIN(Stor5394_af,ResidDemandLatent_afm,FlowAvailLatent_afm,DivRateAvailLatent_afm,WTPAvailLatent_afm)
DOCUMENT: This is the diversion associated with latent rights from Permit 5394 in acre-feet/month.



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SELECTED OBSERVATION WELLS
KERR COUNTY TEXAS

FIGURE 4-4

InjectionA_afm = MIN(MAX(0,Stor5394_af-Div5394Latent_afm),FlowAvailLatent_afm-Div5394Latent_afm,DivRateAvailLatent_afm-Div5394Latent_afm,WTPAvailLatent_afm-Div5394Latent_afm)
DOCUMENT: This is the divesion associated with Permit 5394 injection rights in acre-feet/month.

Clear_afm = IF Month=12 THEN Stor5394_af ELSE 0

StorInj_af(t) = StorInj_af(t - dt) + (CredInj_afm - Clear5 - InjectionB_afm) * dt
INIT StorInj_af = 0

DOCUMENT: This is the total right to divert water for injection to the aquifer in acre-feet. These rights can be stored for use later in the year, if water is not available at the current time.

INFLOWS:

CredInj_afm = WRRunRiver_afm
DOCUMENT: This is the monthly water right for injection into the aquifer in acre-feet/month.

OUTFLOWS:

Clear5 = IF Month=12 THEN StorInj_af ELSE 0
DOCUMENT: This clears the stored value when month is December.

InjectionB_afm = MIN(StorInj_af,FlowAvailLatent_afm-Div5394Latent_afm-InjectionA_afm,DivRateAvailLatent_afm-Div5394Latent_afm-InjectionA_afm,WTPAvailLatent_afm-Div5394Latent_afm-InjectionA_afm)
DOCUMENT: This is the monthly water available for injection associated with Run of River Permit.

SWStorage_af(t) = SWStorage_af(t - dt) + (SurfaceWaterInflow_afm - SurfaceWaterDischarge_afm - DiversionCitySW_afm - ASRInj_afm - DiversionUSWR_afm) * dt
INIT SWStorage_af = 0

DOCUMENT: This represents the lake impounded behind the dam at Kerrville. The model does not allow for water storage and drawdown, or evaporation from reservoir.

INFLOWS:

SurfaceWaterInflow_afm = GRiverKerrvFlo_afm
DOCUMENT: Guadalupe river flow at Kerrville in acre-feet/month.

OUTFLOWS:

SurfaceWaterDischarge_afm = SWStorage_af
DOCUMENT: Surface water discharge from Kerrville Lake in acre-feet/month.

DiversionCitySW_afm = DivCitySW_afm
DOCUMENT: This is the diversion of surface water for direct use (not injection) in acre-feet/month.

ASRInj_afm = Injection_afm
DOCUMENT: This is the quanitity of water available for injection to aquifer in acre-feet/month.

DiversionUSWR_afm = DivWRUS_afm
DOCUMENT: Diversion by senior upstream water right holders in acre-feet/month.

○ cfs_to_afm = 1/43560*60*60*24*30.5
DOCUMENT: Converts cubic feet per second to acre-feet per month.

○ DemandYear = 2050
DOCUMENT: Enter the demand year to be simulated (i.e. 1990, 2000, 2010, 2020, 2030, 2040, 2050). This will select the projected demands for that year and use the historical record to determine surface water supply capabilities and required groundwater extractions.

○ DemInd_afm = DemInd_afy*DemFactorInd
DOCUMENT: Total MONTHL;Y industrial demand in Kerr County (acre-feet/month).

○ DemIrr_afm = DemIrr_afy*DemFactorIrr
DOCUMENT: Total MONTHLY demand by irrigation in Kerr County in acre-feet/month.

○ DemLivest_afm = DemLivest_afy*DemFactorIrr
DOCUMENT: Total MONTHLY livestock demand in Kerr County in acre-feet/month.

○ DemMining_afm = DemMiining_afy*DemFactorMining
DOCUMENT: Total MONTHLY mining demand in Kerr County in acre-feet/month.

○ DemMunKerrvESA_afm = DemMunKerrvESA_afy*DemFactorMun
DOCUMENT: Total MONTHLY municipal demand in areas that may potentially be served by Kerrville in the future in acre-feet/month.

○ DemMunKerrville_afm = DemMunKerrv_afy*DemFactorMun
DOCUMENT: Total MONTHLY municipal demand in Kerrville without extended service areas in acre-feet/month.

○ DemMunOther_afm = DemMunOther_afy*DemFactorMun
DOCUMENT: Total MONTHLY municipal demand in areas outside of Kerrville and its potential extended service area in acre-feet/month.

○ DemMunTot_afm = DemMunKerrville_afm+DemMunOther_afm+DemMunKerrvESA_afm
DOCUMENT: Total MONTHLY municipal demand in Kerr County in acre-feet/month.

- DemMunTot_afy = DemMunKerrv_afy+DemMunOther_afy+DemMunKerrvESA_afy
  DOCUMENT: Total Municipal water demand in Kerr County (acre-feet/year). Composed of Kerrville (DemMunKerrv), areas that Kerrville is expected to service in the future (DemMunKerrvESA, and areas of municipal demand within Kerr County but outside of Kerrville and its potential extended service areas (DemMunOther)..

- DemTot_afm = DemInd_afm+DemIrr_afm+DemMining_afm+DemMunTot_afm+DemLivest_afm
  DOCUMENT: Total water demand in Kerr County in acre-feet/month.

- DemTot_afy = DemInd_afy+DemIrr_afy+DemMunKerrv_afy+DemMunOther_afy+DemMiining_afy+DemLivest_afy+DemMunKerrvESA_afy
  DOCUMENT: Total ANNUAL water demand in Kerr County (acre-feet/year).

- Div1996_afm = MIN(FlowAvail1996_afm,DemMunKerrville_afm,WR1996A_afm)
  DOCUMENT: This is the diversion associated with Permit 1996A in acre-feet/month.

- Div3505_afm = MIN(FlowAvail3505_afm,ResidDemand3505_afm,WR3505_afm,MaxDivRate3505_afm,WTPCapAvail3505_afm)
  DOCUMENT: This is the diversion associated with Permit 3505 in acre-feet/month.

- DIV5394Tot_afm = Div5394Latent_afm+Div5394_afm+InjectionA_afm+InjectionB_afm
  DOCUMENT: This is the total monthly diversion associated with Permit 5394 in acre-feet per month.

- Div5394_afm = MIN(FlowAvail5394_afm,ResidDemand5394_afm,WR5394_afm+WRsupplemental_afm,DivRateAvail5394_afm,WTPCapAvail5394_afm)
  DOCUMENT: This is the diversion associated with direct municipal use portion of Permit 5394 in acre-feet/month. This part of Permit 5394 for direct municipal use is assumed to be 2,761 acre-feet/year.

- DivCitySW_afm = Div1996_afm+Div3505_afm+Div5394_afm+Div5394Latent_afm
  DOCUMENT: This is the total surface water diversion for direct use (not injection) in acre-feet/month.

- DiversionCityTot_afm = DiversionCityGW_afm+DiversionCitySW_afm
  DOCUMENT: This is the total water supply for direct use (both ground and surface water) to meet demands in acre-feet/month.

- DivRateAvail5394_afm = MaxDivRateComb_afm-Div3505_afm
  DOCUMENT: This is the balance of the remaining maximum combined diversion rate specified in acre-feet/month.

- DivRateAvailLatent_afm = MaxDivRateComb_afm-Div5394_afm-Div3505_afm
  DOCUMENT: This is the balance of the combined diversion rate remaining in acre-feet/month.

- DivRateComb_afm = DIV5394Tot_afm+Div3505_afm
  DOCUMENT: This is the combined diversion rate associated with Permits 3505 and 5394 in acre-feet/month.

- DivRateTot_afm = DIV5394Tot_afm+Div1996_afm+Div3505_afm
  DOCUMENT: This is the combined diversion rate associated with Permits 1996, 3505 and 5394 in acre-feet/month.

- DivWRUS1996_afm = MIN(SurfaceWaterInflow_afm,WRsnr1996AUS_afm)
  DOCUMENT: This is the diversion of surface water associated with Permit 1996A upstream senior surface water rights in acre-feet/month.

- DivWRUS3505_afm = MIN(ExcessFlow1996_afm,WRsnr3505USinc_afm)
  DOCUMENT: This is the diversion associated with senior to Permit 3505 water rights upstream of UGRA diversion in acre-feet/month.

- DivWRUS5394_afm = MIN(ExcessFlow3505_afm,WRsnr5394USinc_afm)
  DOCUMENT: This is the diversion for senior water rights to Permit 5394 upstream of UGRA diversion point in acre-feet/month.

- DivWRUSRunRiver_afm = MIN(ExcessFlow5394_afm,WRsnrRunRiverUSinc_afm)
  DOCUMENT: This is the diversion for water rights senior to Run of River upstream of UGRA diversion point in acre-feet/month.

- DivWRUS_afm =
  DivWRUS1996_afm+DivWRUS3505_afm+DivWRUS5394_afm+DivWRUSRunRiver_afm
  DOCUMENT: Diversion by upstream senior water rights holders in acre-feet/month.

- ExcessFlow1996_afm = SurfaceWaterInflow_afm-DivWRUS1996_afm-Div1996_afm
  DOCUMENT: This is the streamflow in excess of the amount needed to satisfy upstream senior water rights holders and Permit 1996A diversions in acre-feet/month.

- ExcessFlow3505_afm = ExcessFlow1996_afm-DivWRUS3505_afm-Div3505_afm
  DOCUMENT: This is the flow in acre-feet/month in excess of needed for diversions 1996 and 3505 and associated senior upstream water rights.

- ExcessFlow5394_afm = ExcessFlow3505_afm-DivWRUS5394_afm-Div5394_afm
  DOCUMENT: This is the flow in excess of needed to meet senior permits and diversions associated with Permit 5394 direct use in acre-feet/month.

- FlowAvail1996_afm = Max(0,SurfaceWaterInflow_afm-WRsnr1996AUS_afm)
DOCUMENT: This is the quantity of water available for diversion under Permit 1996A after upstream senior water rights holders have been served in acre-feet/month.

- FlowAvail3505_afm = MAX(0,ExcessFlow1996_afm-WRsnr3505USinc_afm)
DOCUMENT: This is the flow available for diversion under Permit 3505 in acre-feet/month).

- FlowAvail5394_afm = MAX(0,ExcessFlow3505_afm-WRsnr5394USinc_afm-Instream5394_afm)
DOCUMENT: This is the available flow for diversions associated with Permit 5394 in acre-feet/month.

- FlowAvailLatent_afm = MAX(0,ExcessFlow5394_afm-Instream5394c_afm-WRsnrRunRiverUSinc_afm)
DOCUMENT: This is the flow available for latent diversions associated with Permit 5394 in acre-feet/month.

- Injection_afm = InjectionA_afm+InjectionB_afm
DOCUMENT: This is the total quantity of water available for aquifer injection in acre-feet/month.

- Instream5394a_afm = cfs_to_afm*Instream5394a_cfs
DOCUMENT: This is one set of minimum instream flow requirements associated with Permit 5394 in acre-feet/month. This value varies by month.

- Instream5394b_afm = cfs_to_afm*Instream5394b_cfs
DOCUMENT: This is one set of instream flow requirements associated with Permit 5394 in acre-feet/month.

- Instream5394b_cfs = 50
DOCUMENT: This is one set of instream flow requirements for Permit 5394 in cfs. If inflows exceed 50 cfs, then at least 50 cfs must be released.

- Instream5394c_afm = 3630
- Instream5394Latent_afm = cfs_to_afm*Instream5394Latent_cfs
DOCUMENT: This is one set of instream flow requirements for Permit 5394 in acre-feet/month. If the water right allowed by 5394 is not available in any given month the shortfall (or latent right) can be extracted in a later month that year provided the instream flow is at least this value..

- Instream5394Latent_cfs = 60
DOCUMENT: This is one set of instream flow requirements for Permit 5394 in cubic feet per second. If the water right allowed by 5394 is not available in any given month the shortfall (or latent right) can be extracted in a later month that year provided the instream flow is at least this value (cfs).

- Instream5394_afm = IF SurfaceWaterInflow_afm>Instream5394b_afm THEN Instream5394b_afm ELSE Instream5394a_afm
  DOCUMENT: This is the instream flow requirement for Permit 5394 in acre-feet/month.

- MaxDivRate3505_afm = cfs_to_afm*MaxDivRate3505_cfs
  DOCUMENT: This is the maximum diversion rate (acre feet per month) associated with Permit 3505.

- MaxDivRate3505_cfs = 9.7
  DOCUMENT: This is the maximum diversion rate (cfs) associated with Permit 3505.

- MaxDivRateComb_afm = cfs_to_afm*MaxDivRateComb_cfs
  DOCUMENT: This is the combined maximum diversion rate in acre-feet/month of Permits 3505 and 5394.

- MaxDivRateComb_cfs = 15.5
- mgd_to_afm = 30.5*1e6/7.48/43560
  DOCUMENT: Converts mgd to acre feet per month.

- Month = IF mod(time,12)=0 then 12 else mod(time,12)
  DOCUMENT: This is the month of the simulation to determine the monthly demand factor and relevant instream flow requirements..

- ResidDemand3505_afm = MAX(0,DemMunKerrville_afm-Div1996_afm)
  DOCUMENT: This is the residual demand for water under Permit 3505 in acre-feet/month.

- ResidDemand5394_afm = MAX(0,DemMunTot_afm-Div1996_afm-Div3505_afm)
  DOCUMENT: This is the residual demand not fulfilled by prior diversions (3505 adn 1996) in acre-feet/month.

- ResidDemandLatent_afm = DemMunTot_afm-Div1996_afm-Div3505_afm-Div5394_afm
  DOCUMENT: This is the residual demand not fulfilled by prior diversions in acre-feet/month.

- RunAvgAnnGWExt_afy = CumGW_Ext_af/(time/12)
  DOCUMENT: This is the running average of annual ground water extractions in acre-feet/year.

- RunAvgAnnSWDiv_afy = CumSWDiv_af/(time/12)
  DOCUMENT: This is the running average of annual surface water diversions in acre-feet/year.

- SimYear = 1934+(time-1)/12
  DOCUMENT: This is the simulation year (year of historical record). The simulation starts in 1934.

- SWDisch_afm = SurfaceWaterInflow_afm-DiversionUSWR_afm-DiversionCitySW_afm-Injection_afm
  DOCUMENT: This is the computed surface water discharge in acre-feet/month of the Guadalupe River below UGRA diversion point.

- SWShortfall_afm = DemMunTot_afm-DiversionCitySW_afm
  DOCUMENT: This is the surface water shortfall (the difference between demand and surface water available) in acre-feet/month.

- SWTotalExraction_mgd = SWTotalExtraction_afm/mgd_to_afm
  DOCUMENT: This is the rate of surface water extraction in a given month (mgd).

- SWTotalExtraction_afm = ASRInj_afm+DiversionCitySW_afm
  DOCUMENT: This is the total quantity of surface water extracted in a given month (acft/month). It is the sum of surface water diversions to meet demand and surface water diversions for ASR injections.

- WR1996A_afm = WR1996A_afy*DemFactorMun
  DOCUMENT: Quantity of monthly water right held by Kerrville in acre-feet/month.

- WR1996A_afy = 150
  DOCUMENT: Quantity of annual water right held by Kerrville in acre-feet/year.

- WR3505_afm = WR3505_afy*DemFactorMun
  DOCUMENT: Quantity of monthly water right held by UGRA under Permit 3505 in acre-feet/month.

- WR3505_afy = 3603
  DOCUMENT: Quantity of annual water right held by UGRA under Permit 3505 in acre-feet/year.

- WR5394_afm = WR5394_afy*DemFactorMun
  DOCUMENT: Quantity of monthly water right held by UGRA Permit 5394 in acre-feet/month.

- WR5394_afy = 2761
  DOCUMENT: Quantity of annual water right held by UGRA in acre-feet/year. To be used for Kerrville (1,100 afy) and municipal areas outside Kerrville within Kerr County (1,661 afy).

- WRRunRiver_afm = DemFactorMun*WRRunRiver_afy
  DOCUMENT: Quantity of monthly water right held by UGRA for injection into aquifer in acre-feet/month.

- WRRunRiver_afy = 1408
  DOCUMENT: Quantity of annual water right held by UGRA for injection into aquifer in acre-feet/year.

- WRsnr1996AUS_afm = WRsnr1996AUS_afy*DemFactorMun
  DOCUMENT: Quantity of monthly municipal water rights senior to 1996A upstream of UGRA diversion in acre-feet/month..

- WRsnr1996AUS_afy = 10
  DOCUMENT: Quantity of annual municipal water rights senior to 1996A upstream of UGRA diversion in acre-feet/year..

- WRsnr3505USinc_afm = WRsnr3505US_afm-WRsnr1996AUS_afm
  DOCUMENT: Incremental monthly quantity of water right between 1996A and 3505 upstream of UGRA diversion in acre-feet/month.

- WRsnr3505US_afm = WRsnr3505US_afy*DemFactorMun
  DOCUMENT: Quantity of monthly municipal water rights senior to 3505 upstream of UGRA diversion in acre-feet/month..

- WRsnr3505US_afy = 128
  DOCUMENT: Quantity of annual municipal water rights senior to 3505 upstream of UGRA diversion in acre-feet/year..

- WRsnr5394USinc_afm = 0
  DOCUMENT: Incremental quantitiy of monthly water right between 3505 and 5394 upstream of UGRA diversion point in acre-feet/month.

- WRsnr5394US_afm = WRsnr5394US_afy*DemFactorMun
  DOCUMENT: Quantity of monthly municipal water rights senior to 5394 upstream of UGRA diversion in acre-feet/month..

- WRsnr5394US_afy = 125
  DOCUMENT: Quantity of annual municipal water rights senior to 5394 upstream of UGRA diversion in acre-feet/year..

- WRsnrRunRiverUSinc_afm = WRsnrRunRiverUS_afm-WRsnr5394US_afm
  DOCUMENT: Incremental quantity monthly water right between 5394 and Run of River upstream of UGRA diversion point in acre-feet/month.

- WRsnrRunRiverUS_afm = WRsnrRunRiverUS_afy*DemFactorMun
  DOCUMENT: Quantity of monthly municipal water rights senior to Run of River upstream of UGRA diversion in acre-feet/month..

- WRsnrRunRiverUS_afy = 8647
  DOCUMENT: Quantity of annual municipal water rights senior to Run of River upstream of UGRA diversion in acre-feet/year..

WRsupplemental_afm = WRsupplemental_afy*DemFactorMun
DOCUMENT: Supplemental water rights purchased to augment existing supply (acre-feet/month). These rights assumed to be subject to instream flow reqiurements similar to 5394 for the purpose of modeling.

WRsupplemental_afy = 0
DOCUMENT: Enter the quantity of additional water rights to be purchased (acft/yr). (Existing = 0 acft/yr).

WTPAvailLatent_afm = MAX(0,WTPCap_afm-Div5394_afm-Div3505_afm-Div1996_afm)
DOCUMENT: This is the available capacity to treat diversions associated with latent rights in acre-feet/month.

WTPCapAvail3505_afm = WTPCap_afm-Div1996_afm
DOCUMENT: This is the WTP capacity available for treating diversions with Permit 3505 in acre-feet/month.

WTPCapAvail5394_afm = WTPCap_afm-Div1996_afm-Div3505_afm
DOCUMENT: This is the available capacity to treat diversions associated with Permit 5394 in acre-feet/month.

WTPCap_afm = WTPCap_mgd*mgd_to_afm
DOCUMENT: Water treatment plant capacity in acft/month.

WTPCap_mgd = 5
DOCUMENT: Enter the water treatment plant capacity to be analyzed in mgd. (Existing WTP Cap = 5 mgd, the WTP capacity could be reasonably expanded to 10, 15, and 20 mgd).

DemFactorInd = GRAPH(Month)
(1.00, 0.06), (2.00, 0.07), (3.00, 0.08), (4.00, 0.09), (5.00, 0.08), (6.00, 0.09), (7.00, 0.1), (8.00, 0.1), (9.00, 0.1), (10.0, 0.08), (11.0, 0.07), (12.0, 0.08), (13.0, 0.08)
DOCUMENT: Monthly demand factor for industrial uses (fraction of annual demand).

DemFactorIrr = GRAPH(Month)
(1.00, 0.019), (2.00, 0.025), (3.00, 0.053), (4.00, 0.078), (5.00, 0.096), (6.00, 0.159), (7.00, 0.197), (8.00, 0.178), (9.00, 0.103), (10.0, 0.051), (11.0, 0.021), (12.0, 0.02), (13.0, 0.02)
DOCUMENT: Monthly demand factor for irrigation uses (fraction of annual demand).

DemFactorMining = GRAPH(Month)
(1.00, 0.083), (2.00, 0.083), (3.00, 0.083), (4.00, 0.083), (5.00, 0.084), (6.00, 0.084), (7.00, 0.084), (8.00, 0.084), (9.00, 0.083), (10.0, 0.083), (11.0, 0.083), (12.0, 0.083), (13.0, 0.083)
DOCUMENT: Monthly demand factor for mining uses (fraction of annual demand).

⊘ DemFactorMun = GRAPH(Month)
(1.00, 0.063), (2.00, 0.06), (3.00, 0.07), (4.00, 0.08), (5.00, 0.081), (6.00, 0.094), (7.00, 0.118), (8.00, 0.131), (9.00, 0.095), (10.0, 0.078), (11.0, 0.066), (12.0, 0.064), (13.0, 0.064)
DOCUMENT: Monthly demand factor for municipal uses (fraction of annual demand).

⊘ DemInd_afy = GRAPH(DemandYear)
(1990, 28.0), (2000, 30.0), (2010, 33.0), (2020, 36.0), (2030, 38.0), (2040, 41.0), (2050, 44.0), (2060, 44.0)
DOCUMENT: Total ANNUAL industrial demand in Kerr County (acre-feet/year).

⊘ DemIrr_afy = GRAPH(DemandYear)
(1990, 850), (2000, 822), (2010, 796), (2020, 770), (2030, 745), (2040, 721), (2050, 697), (2060, 697)
DOCUMENT: Total ANNUAL demand by irrigation in Kerr County in acre-feet/year.

⊘ DemLivest_afy = GRAPH(DemandYear)
(1990, 382), (2000, 526), (2010, 526), (2020, 526), (2030, 526), (2040, 526), (2050, 526), (2060, 526)
DOCUMENT: Total ANNUAL livestock demand in Kerr County in acre-feet/year.

⊘ DemMiining_afy = GRAPH(DemandYear)
(1990, 73.0), (2000, 176), (2010, 122), (2020, 110), (2030, 103), (2040, 102), (2050, 105), (2060, 105)
DOCUMENT: Total ANNUAL mining demand in Kerr County in acre-feet/year.

⊘ DemMunKerrvESA_afy = GRAPH(DemandYear)
(1990, 0.00), (2000, 210), (2010, 604), (2020, 1064), (2030, 1222), (2040, 1327), (2050, 1476), (2060, 1476)
DOCUMENT: Total ANNUAL municipal demand in areas that may potentially be served by Kerrville in the future in acre-feet/year.

⊘ DemMunKerrv_afy = GRAPH(DemandYear)
(1990, 3547), (2000, 4802), (2010, 5499), (2020, 6224), (2030, 7095), (2040, 7854), (2050, 8705), (2060, 8705)
DOCUMENT: Total ANNUAL municipal demand in Kerrville without extended service areas in acre-feet/year.

⊘ DemMunOther_afy = GRAPH(DemandYear)
(1990, 2274), (2000, 3589), (2010, 3547), (2020, 3303), (2030, 3460), (2040, 3760), (2050, 4154), (2060, 4154)
DOCUMENT: Total ANNUAL municipal demand in areas outside of Kerrville and its potential extended service area in acre-feet/year.